

Modified Level II Streambed-Scour Analysis for Structure I-74-129-4298 Crossing Clifty Creek in Decatur County, Indiana

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and ROBERT L. MILLER

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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	U. S. Geological Survey
WSPRO	Water Surface PROfile model

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By David C. Voelker, Bret A. Robinson, *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-74-129-4298 on Interstate 74 crossing Clifty Creek in Decatur County, Indiana, are presented. The site is near the town of Adams in the northwestern part of Decatur 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 34.3 feet for the modeled discharge of 12,600 cubic feet per second and approximately 43.9 feet for the modeled discharge of 17,000 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-74-129-4298.

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 Adams in the northwestern part of Decatur County. The drainage area for the site is approximately 59.1 mi² (provided by INDOT). The predominant land use in the basin is agricultural; in the immediate vicinity of the bridge, the land is predominantly agricultural with some wooded land nearby.

Within the immediate vicinity of the bridge, Clifty Creek has a channel-bed slope of approximately 0.00085 ft/ft. The channel banks consist of silt-clay. Test borings summarized on the bridge plans describe the channel-bed material as predominately clay; however, at the time of the Level I site visit on June 23, 1992, the channel-bed material was described as bedrock. The banks were observed to have 40 to 55 percent woody vegetative cover. The field report noted that the banks were experiencing fluvial erosion.

The Interstate 74 crossing of Clifty Creek is a 192-ft-long, multi-lane bridge consisting of three spans supported by concrete and steel piers and sloping concrete 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 USGS 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-74-129-4298 crossing Clifty Creek in Decatur 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 discharge⁵ is 12,600 cubic feet per second							
1	108+63	864	27.1	7.2	34.3	855.6	826.2
2	109+35	864	27.1	7.2	34.3	856.0	826.2
Modeled discharge is 17,000 cubic feet per second							
1	108+63	864	36.1	7.8	43.9	855.6	816.6
2	109+35	864	36.1	7.8	43.9	856.0	816.6

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

²Stationing is the center line of the pier as determined from the bridge plans. Stationing from bridge plan, 108+63, represents a point 10,863 feet from an arbitrary starting location referenced on the bridge plans.

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

⁴Worst-case bed elevation is computed by subtracting the worst-case total-scour depth from the lowest initial bed elevation in the bridge opening (860.5 feet).

⁵Not a 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.

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-74-129-4298.
- 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 Clifty Creek I-74-129-4298
T2 County: Decatur Quad: Adams, Ind 139B
T3 07-15-97 David C. Voelker
SI 0
Q 12600 17000
SK .00085 .00085
XS EXIT 0 30
GR 10387 920 10533 910 10571 900 10641 890 10701 870 10875 868
GR 10919 869 10933 861.8 10954 850.5 10975 850.5 10993 861.8
GR 11005 867.8 11122 868 11189 869 12637 900
N .120 .035 .045
SA 10915 11000
XS FULL 200 30
GR 10387 920 10533 910 10571 900 10641 890 10701 870 10875 868
GR 10919 869 10933 861.8 10954 850.5 10975 850.5 10993 861.8
GR 11005 867.8 11122 868 11189 869 12637 900
N .120 .035 .045
SA 10915 11000
BR BRDGE 200 882.8 30
GR 10812 0883.6 10842 0869.1 10854 0869.0 10862 0865.1 10864 0864.2
GR 10870 0861.8 10889 0860.5 10909 0860.5 10930 0861.8 10934 0863.9
GR 10936 0865.0 10942 0867.6 10950 0867.4 10956 0867.6 10986 0882.0
GR 10812 0883.6
N .035
PD 0 864 4 1
CD 3 132 2 881
DC 0 BRDGE 10855 10943 10790 10895
DP 10812 10986 2 * * 1 1 1.1
DP 10812 10986 2 * * 1 1 1.1
XS APPR 532 30
GR 10376 900 10407 890 10468 880 10499 870 10735 868 10879 869
GR 10892 861.8 10909 850.5 10929 850.5 10945 861.8 10956 867.8
GR 10995 868 11039 869 12461 900
N .120 .035 .045
SA 10790 10895
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/ 6/97 9:41 am Version V050196
 Input File: 4298.dat Output File: 4298.LST

```

*-----*
T1      I-74 OVER CLIFTY CREEK                I-74-129-4298
T2      COUNTY: DECATUR                       QUAD: ADAMS, IND 139B
T3      07-15-97                             DAVID C. VOELKER
SI      0
Q       12600      17000
  
```

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

SK .00085 .00085

***** 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 CLIFTY CREEK                I-74-129-4298
COUNTY: DECATUR                       QUAD: ADAMS, IND 139B
      07-15-97                             DAVID C. VOELKER
  
```

```

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

```

XS  EXIT  0   30
GR  10387 920 10533 910 10571 900 10641 890 10701 870 10875 868
GR  10919 869 10933 861.8 10954 850.5 10975 850.5 10993 861.8
GR  11005 867.8 11122 868 11189 869 12637 900
N   .120 .035 .045
SA  10915 11000
  
```

*** 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: 30.0   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
10387.000	920.000	10533.000	910.000	10571.000	900.000
10641.000	890.000	10701.000	870.000	10875.000	868.000
10919.000	869.000	10933.000	861.800	10954.000	850.500
10975.000	850.500	10993.000	861.800	11005.000	867.800
11122.000	868.000	11189.000	869.000	12637.000	900.000

WSPRO OUTPUT

Minimum and Maximum X,Y-coordinates

```

Minimum X-Station:  10387.000  ( associated Y-Elevation:  920.000 )
Maximum X-Station:  12637.000  ( associated Y-Elevation:  900.000 )
Minimum Y-Elevation:  850.500  ( associated X-Station:  10975.000 )
Maximum Y-Elevation:  920.000  ( associated X-Station:  10387.000 )
    
```

X-coordinates & Horizontal Breakpoints Translated by Skew Angle

X Input	X Skewed	X Input	X Skewed	X Input	X Skewed
10387.000	10465.780	10533.000	10592.220	10571.000	10625.130
10641.000	10685.750	10701.000	10737.710	10875.000	10888.400
10919.000	10926.500	10933.000	10938.630	10954.000	10956.810
10975.000	10975.000	10993.000	10990.590	11005.000	11000.980
11122.000	11102.310	11189.000	11160.330	12637.000	12414.330

Roughness Data (3 SubAreas)

SubArea	Roughness Coefficient	Horizontal Breakpoint
1	*****	---
2	.035	-----
3	.045	-----

```

*-----*
*       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 CLIFTY CREEK                               I-74-129-4298
COUNTY: DECATUR                                     QUAD: ADAMS, IND 139B
07-15-97                                             DAVID C. VOELKER
    
```

```

*-----*
*       Starting To Process Header Record FULL       *
*-----*
    
```

```

XS  FULL 200 30
GR   10387 920 10533 910 10571 900 10641 890 10701 870 10875 868
GR   10919 869 10933 861.8 10954 850.5 10975 850.5 10993 861.8
GR   11005 867.8 11122 868 11189 869 12637 900
N    .120 .035 .045
SA    10915 11000
    
```

```

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

WSPRO OUTPUT

```

***          Data Summary For Header Record FULL          ***
SRD Location:      200.   Cross-Section Skew:  30.0   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
-----	-----	-----	-----	-----	-----
10387.000	920.000	10533.000	910.000	10571.000	900.000
10641.000	890.000	10701.000	870.000	10875.000	868.000
10919.000	869.000	10933.000	861.800	10954.000	850.500
10975.000	850.500	10993.000	861.800	11005.000	867.800
11122.000	868.000	11189.000	869.000	12637.000	900.000
-----	-----	-----	-----	-----	-----

```

          Minimum and Maximum X,Y-coordinates
Minimum X-Station:  10387.000  ( associated Y-Elevation:  920.000 )
Maximum X-Station:  12637.000  ( associated Y-Elevation:  900.000 )
Minimum Y-Elevation:  850.500  ( associated X-Station:  10975.000 )
Maximum Y-Elevation:  920.000  ( associated X-Station:  10387.000 )
    
```

X-coordinates & Horizontal Breakpoints Translated by Skew Angle					
X Input	X Skewed	X Input	X Skewed	X Input	X Skewed
-----	-----	-----	-----	-----	-----
10387.000	10465.780	10533.000	10592.220	10571.000	10625.130
10641.000	10685.750	10701.000	10737.710	10875.000	10888.400
10919.000	10926.500	10933.000	10938.630	10954.000	10956.810
10975.000	10975.000	10993.000	10990.590	11005.000	11000.980
11122.000	11102.310	11189.000	11160.330	12637.000	12414.330
-----	-----	-----	-----	-----	-----

Roughness Data (3 SubAreas)		
SubArea	Roughness Coefficient	Horizontal Breakpoint
-----	-----	-----
1	.120	---
	---	*****
2	.035	---
	---	*****
3	.045	---
-----	-----	-----

```

*-----*
*          Finished Processing Header Record FULL          *
*-----*
    
```

```

***** 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 CLIFTY CREEK                                I-74-129-4298
COUNTY: DECATUR                                       QUAD: ADAMS, IND 139B
07-15-97                                               DAVID C. VOELKER
    
```

WSPRO OUTPUT

```

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

```

BR  BRDGE 200  882.8  30
GR      10812 0883.6  10842 0869.1  10854 0869.0  10862 0865.1  10864
0864.2
GR      10870 0861.8  10889 0860.5  10909 0860.5  10930 0861.8  10934
0863.9
GR      10936 0865.0  10942 0867.6  10950 0867.4  10956 0867.6  10986
0882.0
GR      10812 0883.6
N          .035
PD 0      864   4   1
CD       3   132  2   881
  
```

```

*** Completed Reading Data Associated With Header Record BRDGE ***
*** Storing Bridge Data In Temporary File As Record Number 3 ***
  
```

```

***           Data Summary For Bridge Record BRDGE           ***
SRD Location:      200.   Cross-Section Skew: 30.0   Error Code  0
Valley Slope:  *****   Averaging Conveyance By Geometric Mean.
Energy Loss Coefficients ->  Expansion:   .50   Contraction:   .00
  
```

```

                                X,Y-coordinates (16 pairs)
      X           Y           X           Y           X           Y
-----
10812.000      883.600      10842.000      869.100      10854.000      869.000
10862.000      865.100      10864.000      864.200      10870.000      861.800
10889.000      860.500      10909.000      860.500      10930.000      861.800
10934.000      863.900      10936.000      865.000      10942.000      867.600
10950.000      867.400      10956.000      867.600      10986.000      882.000
10812.000      883.600
-----
  
```

```

                                Minimum and Maximum X,Y-coordinates
Minimum X-Station:  10812.000 ( associated Y-Elevation:  883.600 )
Maximum X-Station:  10986.000 ( associated Y-Elevation:  882.000 )
Minimum Y-Elevation:  860.500 ( associated X-Station:  10909.000 )
Maximum Y-Elevation:  883.600 ( associated X-Station:  10812.000 )
  
```

```

                                X-coordinates & Horizontal Breakpoints Translated by Skew Angle
      X Input      X Skewed      X Input      X Skewed      X Input      X Skewed
-----
10812.000      10825.000      10842.000      10850.980      10854.000      10861.370
10862.000      10868.300      10864.000      10870.030      10870.000      10875.220
10889.000      10891.680      10909.000      10909.000      10930.000      10927.190
10934.000      10930.650      10936.000      10932.380      10942.000      10937.580
10950.000      10944.510      10956.000      10949.700      10986.000      10975.680
10812.000      10825.000
-----
  
```

Roughness Data (1 SubAreas)

WSPRO OUTPUT

SubArea	Roughness Coefficient	Horizontal Breakpoint
1	.035	---

Discharge coefficient parameters

BRType	BRWidth	EMBSS	EMBELv	UserCD
3	132.000	2.00	881.000	*****

Pressure flow elevations

AVBCEL	PFElev
*****	882.800

Abutment Parameters

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

Pier/Pile Data (1 Group(s))
Code Indicates Bridge Uses Piers

Group	Elevation	Gross Width	Number
1	864.000	4.000	1

* Finished Processing Header Record BRDGE *

***** 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 CLIFTY CREEK	I-74-129-4298
COUNTY: DECATUR	QUAD: ADAMS, IND 139B
07-15-97	DAVID C. VOELKER

DC 0 BRDGE	10855	10943	10790	10895				
DP	10812	10986	2 *	1	1	1.1		
DP	10812	10986	2 *	1	1	1.1		

* Starting To Process Header Record APPR *

XS	APPR	532	30						
GR	10376	900	10407	890	10468	880	10499	870	10735 868 10879 869
GR	10892	861.8	10909	850.5	10929	850.5	10945	861.8	10956 867.8
GR	10995	868	11039	869	12461	900			
N	.120	.035	.045						
SA	10790	10895							

*** Completed Reading Data Associated With Header Record APPR ***

WSPRO OUTPUT

*** Storing X-Section Data In Temporary File As Record Number 4 ***

*** Data Summary For Header Record APPR ***
 SRD Location: 532. Cross-Section Skew: 30.0 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
10376.000	900.000	10407.000	890.000	10468.000	880.000
10499.000	870.000	10735.000	868.000	10879.000	869.000
10892.000	861.800	10909.000	850.500	10929.000	850.500
10945.000	861.800	10956.000	867.800	10995.000	868.000
11039.000	869.000	12461.000	900.000		

Minimum and Maximum X,Y-coordinates

Minimum X-Station: 10376.000 (associated Y-Elevation: 900.000)
 Maximum X-Station: 12461.000 (associated Y-Elevation: 900.000)
 Minimum Y-Elevation: 850.500 (associated X-Station: 10929.000)
 Maximum Y-Elevation: 900.000 (associated X-Station: 10376.000)

X-coordinates & Horizontal Breakpoints Translated by Skew Angle					
X Input	X Skewed	X Input	X Skewed	X Input	X Skewed
10376.000	10450.090	10407.000	10476.930	10468.000	10529.760
10499.000	10556.610	10735.000	10760.990	10879.000	10885.700
10892.000	10896.960	10909.000	10911.680	10929.000	10929.000
10945.000	10942.860	10956.000	10952.380	10995.000	10986.160
11039.000	11024.260	12461.000	12255.750		

Roughness Data (3 SubAreas)		
SubArea	Roughness Coefficient	Horizontal Breakpoint
1	.120	---
	---	*****
2	.035	---
	---	*****
3	.045	---

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.

WSPRO OUTPUT

Input Units: English / Output Units: English

I-74 OVER CLIFTY CREEK
 COUNTY: DECATUR
 07-15-97

I-74-129-4298
 QUAD: ADAMS, IND 139B
 DAVID C. VOELKER

EX

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

#	Reach Discharge	Water Surface Elevation	Friction Slope	Flow Regime
1	12600.00	*****	.0008	Sub-Critical
2	17000.00	*****	.0008	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 CLIFTY CREEK
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 07-15-97

I-74-129-4298
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 DAVID C. VOELKER

	WSEL EGEL CRWS	VHD HF HO	Q V FR #	AREA K SF	SRDL FLEN ALPHA	LEW REW ERR
Section: EXIT	874.014	.632	12600.000	3665.780	*****	10727.280
Header Type: XS	874.646	*****	3.437	432097.50	*****	11363.160
SRD: .000	866.713	*****	.468	*****	3.442	*****
Section: FULL	874.339	.450	12600.000	3874.473	200.000	10726.440
Header Type: FV	874.788	.149	3.252	494831.60	200.000	11376.290
SRD: 200.000	866.713	.000	.388	.0007	2.733	-.007

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

Section: APPR	874.855	.205	12600.000	4337.647	332.000	10543.570
Header Type: AS	875.061	.274	2.905	389459.20	332.000	11256.870
SRD: 532.000	870.363	.000	.260	.0008	1.565	-.001

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

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

WSPRO OUTPUT

	WSEL	VHD	Q	AREA	SRDL	LEW
	EGEL	HF	V	K	FLEN	REW
	CRWS	HO	FR #	SF	ALPHA	ERR
Section: BRDGE	873.644	2.765	12600.000	1042.205	200.000	10842.830
Header Type: BR	876.409	.417	12.090	183004.80	200.000	10960.610
SRD: 200.000	871.887	1.345	.790	*****	1.216	-.002

Specific Bridge Information	C	P/A	PFELEV	BLEN	XLAB	XRAB
Bridge Type 3 Flow Type 1						
Pier/Pile Code 0	.9067	.037	882.800	*****	*****	*****

	WSEL	VHD	Q	AREA	SRDL	LEW
	EGEL	HF	V	K	FLEN	REW
	CRWS	HO	FR #	SF	ALPHA	ERR
Section: APPR	877.322	.101	12600.000	6226.065	200.000	10536.950
Header Type: AS	877.423	.303	2.024	642666.60	215.889	11354.850
SRD: 532.000	870.363	.712	.163	.0008	1.582	.009

Approach Section	APPR	Flow	Contraction	Information	
M(G)	M(K)	KQ	XLKQ	XRKQ	OTEL
.831	.428	366743.3	*****	*****	877.322

<<< 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 CLIFTY CREEK I-74-129-4298
 COUNTY: DECATUR QUAD: ADAMS, IND 139B
 07-15-97 DAVID C. VOELKER

	WSEL	VHD	Q	AREA	SRDL	LEW
	EGEL	HF	V	K	FLEN	REW
	CRWS	HO	FR #	SF	ALPHA	ERR
Section: EXIT	875.851	.662	17000.000	4906.722	*****	10722.510
Header Type: XS	876.513	*****	3.465	582978.60	*****	11437.480
SRD: .000	871.010	*****	.439	*****	3.547	*****
Section: FULL	876.212	.447	17000.000	5167.035	200.000	10721.570
Header Type: FV	876.659	.146	3.290	679840.60	200.000	11452.050
SRD: 200.000	871.181	.000	.355	.0007	2.656	-.001

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

WSPRO OUTPUT

```

Section: APPR      876.688   .217  17000.000   5716.103   332.000  10538.650
Header Type: AS   876.905   .247    2.974  570237.10   332.000  11329.670
SRD:    532.000   871.132   .000    .245    .0007    1.579   -.001
  
```

<<< 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	875.224	3.956	17000.000	1232.718	200.000	10840.000
Header Type: BR	879.180	.440	13.791	233979.50	200.000	10963.460
SRD: 200.000	873.682	2.226	.890	*****	1.338	-.001

Specific Bridge Information	C	P/A	PFELEV	BLEN	XLAB	XRAB
Bridge Type 3	Flow Type 1					
Pier/Pile Code 0	.8646	.036	882.800	*****	*****	*****

	WSEL	VHD	Q	AREA	SRDL	LEW
	EGEL	HF	V	K	FLEN	REW
	CRWS	HO	FR #	SF	ALPHA	ERR
Section: APPR	880.118	.095	17000.000	8678.896	200.000	10529.140
Header Type: AS	880.213	.274	1.959	1026030.00	218.794	11465.930
SRD: 532.000	871.132	.760	.143	.0007	1.586	.007

Approach Section APPR Flow Contraction Information						
M(G)	M(K)	KQ	XLKQ	XRKQ	OTEL	
.839	.515	497154.4	*****	*****	880.118	

<<< 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 CLIFTY CREEK	I-74-129-4298
COUNTY: DECATUR	QUAD: ADAMS, IND 139B
07-15-97	DAVID C. VOELKER

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

Constants and Input Variables

WSPRO OUTPUT

```

*-----*
Bed Material Transport Mode Factor (k1):    .64
Total Pier Width Value                    (Pw):  4.000
*-----*
  
```

#	Scour		-- Flow --		-- Width --		--- X-Limits ---	
	Depth	Contract	Approach	Contract	Approach	Side	Contract	Approach
1	27.074	12600.000	2897.571	84.000	105.000	Left:	*****	*****
 Approach Channel Depth:		8.935			Right:	*****
2	36.094	17000.000	3856.883	84.000	105.000	Left:	*****	*****
 Approach Channel Depth:		11.731			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 CLIFTY CREEK                      I-74-129-4298
COUNTY: DECATUR                            QUAD: ADAMS, IND 139B
07-15-97                                    DAVID C. VOELKER
  
```

*** 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	7.23	12600.000	874.356	13.856	13.886	.657	10812.000	10986.000
2	7.76	17000.000	875.984	15.484	15.804	.708	10812.000	10986.000

```

***** 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 CLIFTY CREEK                      I-74-129-4298
COUNTY: DECATUR                            QUAD: ADAMS, IND 139B
07-15-97                                    DAVID C. VOELKER
  
```

WSPRO OUTPUT

*** 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 Depth	----- Localized Hydraulic Properties -----					-- X-Stations --	
		Flow	WSE	Depth	Velocity	Froude #	Left	Right
1	7.23	12600.000	874.356	13.856	13.886	.657	10812.000	10986.000
2	7.76	17000.000	875.984	15.484	15.804	.708	10812.000	10986.000

ER

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