Modified Level II Streambed-Scour Analysis for Structure I-70-148-4528 Crossing West Fork of East Fork Whitewater River in Wayne County, Indiana

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

Prepared in cooperation with the
INDIANA DEPARTMENT OF TRANSPORTATION

U.S. GEOLOGICAL SURVEY
Open-File Report 97-313

Indianapolis, Indiana
1997

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
Gordon P. Eaton, Director

For additional information, write to:
District Chief
U.S. Geological Survey
Water Resources Division
5957 Lakeside Boulevard
Indianapolis, IN 46278-1996

Copies of this report can be purchased from:
U.S. Geological Survey
Branch of Information Services
Box 25286
Federal Center
Denver, CO 80225

CONTENTS

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	U. S. Geological Survey
WSPRO	Water Surface PROfile model

Modified Level II Streambed-Scour Analysis for Structure I-70-148-4528 Crossing West Fork of East Fork Whitewater River in Wayne County, Indiana

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

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-70-148-4528 on Interstate 70 crossing West Fork of East Fork Whitewater River in Wayne County, Indiana, are presented. The site is near the city of Richmond in the eastern part of Wayne 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 19.8 feet for the modeled discharge of 6,000 cubic feet per second and approximately 26.5 feet for the modeled discharge of 7,900 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-70-148-4528.

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 city of Richmond in the eastern part of Wayne County. The drainage area for the site is approximately 16.7 mi^2 (estimated using Hoggatt, 1975, and USGS 7.5-minute topographic data). The predominant land use in the basin is agricultural; in the immediate vicinity of the bridge, the land is predominantly forest with some pasture land nearby.

Within the immediate vicinity of the bridge, West Fork of East Fork Whitewater River has a channel-bed slope of approximately 0.00421 ft/ft. The channel-bed material is sand, and the channel banks consist of gravel and sand. At the time of the Level I site visit on July 9, 1992, the banks were observed to have 5 to 75 percent woody vegetative cover; the field report noted that the banks were experiencing fluvial erosion.

The Interstate 70 crossing of West Fork of East Fork Whitewater River is a 232-ft-long, multi-lane bridge consisting of five 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 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, 1959) 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-70-148-4528 crossing West Fork of East Fork Whitewater River in Wayne 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 6,000 cubic feet per second							
2	379+98	985	12.3	7.5	19.8	970.8	959.2
3	380+67	985	12.3	7.5	19.8	971.8	959.2
Modeled discharge is 7,900 cubic feet per second							
2	379+98	985	18.4	8.1	26.5	970.8	952.5
3	380+67	985	18.4	8.1	26.5	971.8	952.5

[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, 379+98, represents a point 37,998 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 (979.0 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.

Model runs also indicate that pier one and pier four, as shown on the bridge plans, are high enough in elevation that they are not within the area of flow for the discharges modeled. Therefore, these two piers were not evaluated for scour.

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, 1959, Bridge plans Interstate Route 70: Bridge File I-70-148-4528.

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-70 OVER WEST FK OF THE EAST FK WHITEWATER RIVER  I70-148-4528
T2         COUNTY: WAYNE                              QUAD: RICHMOND
T3         07-09-97                                    R L Miller
SI         0
Q            6000  7900
SK            .00421   .00421
*          SRD SKEW  (EK)  (CK)  (VSLOPE)
XS   EXIT   0
GR        37046 1000  37081 990  37860 984  37940 984  37955 985  37982 986
GR        38035 986  38065 985  38072 984  38084 981 38100 980  38108 979
GR        38120 979  38130 980  38145 985  38160 990  38190 1000
N           .100    .045
SA               38065
XS   FULLV  241
GR        37046 1000  37081 990  37860 984  37940 984  37955 985  37982 986
GR        38035 986  38065 985  38072 984  38084 981 38100 980  38108 979
GR        38120 979  38130 980  38145 985  38160 990  38190 1000
N           .100    .045
SA               38065
BR   BRDGE   241    1016.9  30
GR       37919 1014.6  37922 1014.6  37992 0985.0  37999 0985.0  38013 0978.8
GR       38050 0978.8  38063 0984.9  38069 0985.0  38139 1018.4  38141 1018.4
GR        38142 1019.1  37919 1014.6
N            .040
PD          985 5.4  1
PD          1003 5.4 2
PD          1003 8.1 3
PD          1005 8.1 4
PD          1005 10.8 5
CD          3      124      2   1015
DC   BRDGE   37999 38063 37875 37950 * 10.8
DP   BRDGE 37919 38142  2.7 * * 1.0 1.0 1.1
DP   BRDGE 37919 38142  2.7 * * 1.0 1.0 1.1
XS   APPR    606
GR        37031 1020  37096 1000  37345 990  37627 987  37687 986 37707 986
GR        37780 987  37875 986  37900 979  37935 979  37950 985  38025 985
GR        38055 990  38155 1015
N               .100    .045   .120
SA                 37875   37935
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/ 5/97  7:27 am     Version V050196
           Input File: 4528.dat       Output File: 4528.LST
   *-------------------------------------------------------------*
T1         I-70 OVER WEST FK OF THE EAST FK WHITEWATER RIVER  I70-148-4528
T2         COUNTY: WAYNE                                QUAD: RICHMOND
T3         07-09-97                                      R L MILLER
SI         0
Q            6000  7900

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

SK             .00421   .00421

   ************************  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-70 OVER WEST FK OF THE EAST FK WHITEWATER RIVER  I70-148-4528
       COUNTY: WAYNE                               QUAD: RICHMOND
         07-09-97                                    R L MILLER

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

XS   EXIT   0
GR        37046 1000  37081 990  37860 984  37940 984  37955 985  37982 986
GR        38035 986  38065 985  38072 984  38084 981 38100 980  38108 979
GR        38120 979  38130 980  38145 985  38160 990  38190 1000
N           .100    .045
SA               38065

 ***   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 (17 pairs)
     X          Y             X          Y             X          Y
----------  ----------   ----------  ----------   ----------  ----------
 37046.000    1000.000    37081.000     990.000    37860.000     984.000
 37940.000     984.000    37955.000     985.000    37982.000     986.000
 38035.000     986.000    38065.000     985.000    38072.000     984.000
 38084.000     981.000    38100.000     980.000    38108.000     979.000
 38120.000     979.000    38130.000     980.000    38145.000     985.000
 38160.000     990.000    38190.000    1000.000
----------  ----------   ----------  ----------   ----------  ----------
```

WSPRO OUTPUT

```
                Minimum and Maximum X,Y-coordinates
 Minimum X-Station:   37046.000  ( associated Y-Elevation: 1000.000 )
 Maximum X-Station:   38190.000  ( associated Y-Elevation: 1000.000 )
 Minimum Y-Elevation:   979.000  ( associated X-Station:  38120.000 )
 Maximum Y-Elevation:  1000.000  ( associated X-Station:  37046.000 )

                  Roughness Data (  2 SubAreas )
                          Roughness   Horizontal
                 SubArea  Coefficient  Breakpoint
                 -------  -----------  ----------
                    1         .100        ---
                              ---        ********
                    2         .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-70 OVER WEST FK OF THE EAST FK WHITEWATER RIVER  I70-148-4528
      COUNTY: WAYNE                              QUAD: RICHMOND
        07-09-97                                    R L MILLER

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

XS   FULLV  241
GR        37046 1000  37081 990  37860 984  37940 984  37955 985  37982 986
GR        38035 986  38065 985  38072 984  38084 981 38100 980  38108 979
GR        38120 979  38130 980  38145 985  38160 990  38190 1000
N           .100     .045
SA               38065

 ***   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:      241.   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 (17 pairs)
     X          Y           X          Y           X          Y
----------  ----------  ----------  ----------  ----------  ----------
 37046.000   1000.000    37081.000    990.000    37860.000    984.000
 37940.000    984.000    37955.000    985.000    37982.000    986.000
 38035.000    986.000    38065.000    985.000    38072.000    984.000
```

WSPRO OUTPUT

```
 38084.000     981.000    38100.000     980.000    38108.000     979.000
 38120.000     979.000    38130.000     980.000    38145.000     985.000
 38160.000     990.000    38190.000    1000.000
---------- ---------- ---------- ---------- ---------- ----------

                Minimum and Maximum X,Y-coordinates
  Minimum X-Station:   37046.000  ( associated Y-Elevation: 1000.000 )
  Maximum X-Station:   38190.000  ( associated Y-Elevation: 1000.000 )
  Minimum Y-Elevation:   979.000  ( associated X-Station:  38120.000 )
  Maximum Y-Elevation:  1000.000  ( associated X-Station:  37046.000 )

                    Roughness Data (  2 SubAreas )
                             Roughness   Horizontal
                   SubArea  Coefficient  Breakpoint
                   -------  -----------  ----------
                      1         .100        ---
                                ---       ********
                      2         .045        ---
                   -------  -----------  ----------

          *-------------------------------------------------* -
          *      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-70 OVER WEST FK OF THE EAST FK WHITEWATER RIVER  I70-148-4528
        COUNTY: WAYNE                              QUAD: RICHMOND
          07-09-97                                   R L MILLER

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

   BR   BRDGE   241    1016.9  30
   GR        37919 1014.6  37922 1014.6  37992 0985.0  37999 0985.0  38013
0978.8
   GR        38050 0978.8  38063 0984.9  38069 0985.0  38139 1018.4  38141
1018.4
   GR        38142 1019.1  37919 1014.6
   N            .040
   PD         985 5.4  1
   PD         1003 5.4 2
   PD         1003 8.1 3
   PD         1005 8.1 4
   PD         1005 10.8 5
   CD         3      124      2   1015

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

WSPRO OUTPUT

*** Data Summary For Bridge Record BRDGE ***
SRD Location: 241. 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 (12 pairs)

X	Y	X	Y	X	Y
37919.000	1014.600	37922.000	1014.600	37992.000	985.000
37999.000	985.000	38013.000	978.800	38050.000	978.800
38063.000	984.900	38069.000	985.000	38139.000	1018.400
38141.000	1018.400	38142.000	1019.100	37919.000	1014.600

Minimum and Maximum X,Y-coordinates
Minimum X-Station: 37919.000 (associated Y-Elevation: 1014.600)
Maximum X-Station: 38142.000 (associated Y-Elevation: 1019.100)
Minimum Y-Elevation: 978.800 (associated X-Station: 38050.000)
Maximum Y-Elevation: 1019.100 (associated X-Station: 38142.000)

X-coordinates & Horizontal Breakpoints Translated by Skew Angle

X Input	X Skewed	X Input	X Skewed	X Input	X Skewed
37919.000	37936.550	37922.000	37939.150	37992.000	37999.770
37999.000	38005.830	38013.000	38017.960	38050.000	38050.000
38063.000	38061.260	38069.000	38066.450	38139.000	38127.080
38141.000	38128.810	38142.000	38129.680	37919.000	37936.550

Roughness Data (1 SubAreas)

SubArea	Roughness Coefficient	Horizontal Breakpoint
1	.040	---

Discharge coefficient parameters

BRType	BRWdth	EMBSS	EMBElv	UserCD
3	124.000	2.00	1015.000	**********

Pressure flow elevations

AVBCEL	PFElev
*********	1016.900

Abutment Parameters

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

Pier/Pile Data (5 Group(s))
Code Indicates Bridge Uses Piers

Group	Elevation	Gross Width	Number
1	985.000	5.400	1

WSPRO OUTPUT

```
                2     1003.000      5.400       2
                3     1003.000      8.100       3
                4     1005.000      8.100       4
                5     1005.000     10.800       5
              ------  ---------  -----------  ------

         *-----------------------------------------------*
         *      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-70 OVER WEST FK OF THE EAST FK WHITEWATER RIVER  I70-148-4528
       COUNTY: WAYNE                              QUAD: RICHMOND
         07-09-97                                   R L MILLER
DC   BRDGE   37999 38063 37875 37950 * 10.8
DP   BRDGE 37919 38142  2.7 * * 1.0 1.0 1.1
DP   BRDGE 37919 38142  2.7 * * 1.0 1.0 1.1

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

XS   APPR    606
GR        37031 1020  37096 1000  37345 990  37627 987  37687 986 37707 986
GR        37780 987  37875 986  37900 979  37935 979  37950 985  38025 985
GR        38055 990  38155 1015
N              .100    .045   .120
SA                37875   37935

 ***   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:      606.   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
----------  ----------  ----------  ----------  ----------  ----------
 37031.000    1020.000    37096.000    1000.000    37345.000     990.000
 37627.000     987.000    37687.000     986.000    37707.000     986.000
 37780.000     987.000    37875.000     986.000    37900.000     979.000
 37935.000     979.000    37950.000     985.000    38025.000     985.000
 38055.000     990.000    38155.000    1015.000
----------  ----------  ----------  ----------  ----------  ----------

                Minimum and Maximum X,Y-coordinates
  Minimum X-Station:   37031.000  ( associated Y-Elevation: 1020.000 )
  Maximum X-Station:   38155.000  ( associated Y-Elevation: 1015.000 )
```

WSPRO OUTPUT

```
 Minimum Y-Elevation:   979.000  ( associated X-Station:  37935.000 )
 Maximum Y-Elevation:  1020.000  ( associated X-Station:  37031.000 )

                  Roughness Data (  3 SubAreas )
                          Roughness   Horizontal
                SubArea  Coefficient  Breakpoint
                -------  -----------  ----------
                   1         .100        ---
                             ---        ********
                   2         .045        ---
                             ---        ********
                   3         .120        ---
                -------  -----------  ----------

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-70 OVER WEST FK OF THE EAST FK WHITEWATER RIVER  I70-148-4528
        COUNTY: WAYNE                          QUAD: RICHMOND
          07-09-97                               R L MILLER
  EX

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

            Reach      Water Surface   Friction
     #    Discharge      Elevation      Slope         Flow Regime
    --    ---------    ------------   --------   --------------------
     1      6000.00      ********        .0042        Sub-Critical
     2      7900.00      ********        .0042        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-70 OVER WEST FK OF THE EAST FK WHITEWATER RIVER  I70-148-4528
        COUNTY: WAYNE                          QUAD: RICHMOND
```

WSPRO OUTPUT

07-09-97 R L MILLER

	WSEL EGEL CRWS	VHD HF HO	Q V FR #	AREA K SF	SRDL FLEN ALPHA	LEW REW ERR
Section: EXIT	987.645	.503	6000.000	1946.485	*********	37386.810
Header Type: XS	988.147	******	3.082	92415.31	*********	38152.930
SRD: .000	986.688	******	.629	******	3.401	******

===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS AT SECID "FULLV".
KRATIO: 1.44

Section: FULLV	988.601	.250	6000.000	2739.926	241.000	37262.640
Header Type: FV	988.851	.706	2.190	133064.00	241.000	38155.800
SRD: 241.000	986.688	.000	.404	.0029	3.354	-.002

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

Section: APPR	989.312	.575	6000.000	1978.495	365.000	37409.700
Header Type: AS	989.887	.874	3.033	113005.80	365.000	38050.870
SRD: 606.000	987.705	.162	.610	.0024	4.020	-.001

<<< 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	988.431	1.573	6000.000	604.486	241.000	37983.890
Header Type: BR	990.004	1.268	9.926	76337.74	241.000	38076.190
SRD: 241.000	986.759	.588	.693	******	1.027	-.003

Specific Bridge Information	C	P/A	PFELEV	BLEN	XLAB	XRAB
Bridge Type 3 Flow Type 1	------	-----	--------	--------	--------	--------
Pier/Pile Code 0	.9869	.031	1016.900	********	********	********

	WSEL EGEL CRWS	VHD HF HO	Q V FR #	AREA K SF	SRDL FLEN ALPHA	LEW REW ERR
Section: APPR	991.613	.160	6000.000	3626.535	241.000	37304.830
Header Type: AS	991.774	.649	1.654	220314.60	293.923	38061.450
SRD: 606.000	987.705	1.122	.259	.0024	3.768	.005

Approach Section APPR Flow Contraction Information

M(G)	M(K)	KQ	XLKQ	XRKQ	OTEL
.855	.449	121309.1	********	********	991.613

WSPRO OUTPUT

-------- -------- -------- -------- -------- --------

<<< 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-70 OVER WEST FK OF THE EAST FK WHITEWATER RIVER I70-148-4528
COUNTY: WAYNE QUAD: RICHMOND
07-09-97 R L MILLER

	WSEL EGEL CRWS	VHD HF HO	Q V FR #	AREA K SF	SRDL FLEN ALPHA	LEW REW ERR
Section: EXIT	988.356	.514	7900.000	2525.111	*********	37294.450
Header Type: XS	988.870	******	3.129	121735.80	*********	38155.070
SRD: .000	987.229	******	.592	******	3.377	******
Section: FULLV	989.324	.271	7900.000	3420.129	241.000	37168.810
Header Type: FV	989.595	.725	2.310	170347.00	241.000	38157.970
SRD: 241.000	987.229	.000	.396	.0030	3.267	-.001

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

Section: APPR	990.075	.643	7900.000	2496.531	365.000	37343.140
Header Type: AS	990.718	.939	3.164	142406.70	365.000	38055.300
SRD: 606.000	988.521	.186	.606	.0026	4.131	-.002

<<< 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	989.106	2.316	7900.000	667.816	241.000	37982.290
Header Type: BR	991.422	1.451	11.830	88127.75	241.000	38077.610
SRD: 241.000	988.003	1.103	.813	******	1.064	.002

Specific Bridge Information	C	P/A	PFELEV	BLEN	XLAB	XRAB
Bridge Type 3 Flow Type 1	------	-----	--------	--------	--------	--------
Pier/Pile Code 0	.9694	.033	1016.900	********	********	********

	WSEL EGEL CRWS	VHD HF HO	Q V FR #	AREA K SF	SRDL FLEN ALPHA	LEW REW ERR

WSPRO OUTPUT

```
                  --------- ------ ---------- ---------- --------- ---------
Section: APPR       993.387   .130   7900.000   5013.773   241.000 37260.670
Header Type: AS     993.517   .655      1.576  332263.70   296.430 38068.550
SRD:    606.000     988.521  1.439       .205      .0026     3.372      .012

            Approach Section APPR  Flow Contraction Information
           M( G )   M( K )     KQ       XLKQ     XRKQ     OTEL
          -------- -------- --------- -------- -------- --------
              .865     .524  157854.3 ******** ******** 993.387
          -------- -------- --------- -------- -------- --------

              <<< 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-70 OVER WEST FK OF THE EAST FK WHITEWATER RIVER  I70-148-4528
        COUNTY: WAYNE                          QUAD: RICHMOND
          07-09-97                               R L MILLER

  *** 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): 10.800
              *-----------------------------------------------*

     Scour      -- Flow --          -- Width --        --- X-Limits ---
 #   Depth  Contract Approach  Contract Approach  Side   Contract Approach
--   ------ --------- --------- -------- --------  ------ -------- --------
 1  12.334  6000.000  3182.599   53.200   75.000  Left:  ******** ********
    ..... Approach Channel Depth:   10.847 .....  Right: ******** ********
 2  18.352  7900.000  3561.743   53.200   75.000  Left:  ******** ********
    ..... Approach Channel Depth:   12.620 .....  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-70 OVER WEST FK OF THE EAST FK WHITEWATER RIVER  I70-148-4528
        COUNTY: WAYNE                          QUAD: RICHMOND
          07-09-97                               R L MILLER

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

                    Constants and Input Variables
```

WSPRO OUTPUT

Pier Width: 2.700

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	Flow	WSE	Depth	Velocity	Froude #	X-Stations Left	X-Stations Right
1	7.51	6000.000	989.553	10.753	10.412	.560	37919.000	38142.000
2	8.10	7900.000	990.545	11.745	12.075	.621	37919.000	38142.000

Localized Hydraulic Properties

********** 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-70 OVER WEST FK OF THE EAST FK WHITEWATER RIVER I70-148-4528

COUNTY: WAYNE QUAD: RICHMOND

07-09-97 R L MILLER

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

Constants and Input Variables

Pier Width: 2.700

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	Flow	WSE	Depth	Velocity	Froude #	X-Stations Left	X-Stations Right
1	7.51	6000.000	989.553	10.753	10.412	.560	37919.000	38142.000
2	8.10	7900.000	990.545	11.745	12.075	.621	37919.000	38142.000

Localized Hydraulic Properties

ER

********** Normal end of WSPRO execution. **********

********** Elapsed Time: 0 Minutes 3 Seconds **********