Modified Level II Streambed-Scour Analysis for Structure I-465-165-4442 Crossing Lick 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 97-314

Indianapolis, Indiana
1997

U.S. DEPARTMENT OF THE INTERIOR
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Denver, CO 80225

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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 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-465-165-4442 in Indianapolis where Carson Avenue crosses Lick Creek are presented. The site is in the city of Indianapolis in the southeastern 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 8.4 feet for the modeled discharge of 6,890 cubic feet per second and approximately 10.5 feet for the modeled discharge of 9,640 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-465-165-4442.

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 in the city of Indianapolis in the southeastern part of Marion County. The drainage area for the site is approximately 16.1 mi^2 (Merril Dougherty, Indiana Department of Transportation, written commun., 1996). The predominant land use in the basin is urban; in the immediate vicinity of the bridge, the land is predominantly urban.

Within the immediate vicinity of the bridge, Lick Creek has a channel-bed slope of approximately 0.0011 ft/ft. The channel-bed material is gravel, silt-clay, and sand; the channel banks consist of gravelly sandy silt-clay and concrete. At the time of the Level I site visit on July 24, 1995, the banks were observed to have 0 to 25 percent woody vegetative cover; the field report noted that the banks were experiencing some fluvial erosion.

The Carson Avenue crossing of Lick Creek and Interstate 465 is a 417-ft-long, multi-lane bridge consisting of seven 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.

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, 1962, 1981) 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-465-165-4442 crossing Lick 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 6,890 cubic feet per second							
1	16+81	736	2.6	5.8	8.4	728.5	726.3
2	17+61	740	2.6	5.8	8.4	728.6	726.3
Modeled discharge is 9,640 cubic feet per second							
1	16+81	736	4.2	6.3	10.5	728.5	724.2
2	17+61	740	4.2	6.3	10.5	728.6	724.2

[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, 16+81, represents a point 1,681 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 (734.7 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.

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, 1962, Bridge plans Interstate Route 465: Bridge File I-465-165-4442.

Indiana State Highway Commission, 1981, Bridge plans Interstate Route 465: Bridge File I-465-165-4442.

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        Carson Ave Over Lick Creek and I-465  I-465-165-4442
T2        County: Marion                        Quad: Beech Grove 124 B
T3        4-10-97                               Bret A. Robinson
SI        0
Q         6980
Q         9640
SK        .0011 .0011
XS   EXIT 0 0
GR        937 750  1054 740  1677 740  1694 740  1706 735  1730 734.5
GR        1756 735  1770 740  1810 740  1845 750  1906 760
N         .100 .035
SA        1692
XS   FULLV 150 0
GR        937 750  1054 740  1677 740  1694 740  1706 735  1730 734.5
GR        1756 735  1770 740  1810 740  1845 750  1906 760
N         .100 .035
SA        1692
BR   BRDGE 150 760 0
GR        1628 0760.2  1628 0759.1  1630 0759.0  1630 0758.4  1633 0758.3
GR        1672 0739.8  1691 0739.7  1703 0734.7  1754 0734.7  1765 0739.8
GR        1795 0739.8  1808 0747.0  1819 0747.9  1880 0749.8  1894 0749.0
GR        1933 0749.0  1951 0750.2  1991 0748.7  2008 0747.9  2045 0765.2
GR        2047 0765.2  2048 0765.4  2049 0765.4  2049 0765.7  2038 0765.9
GR        2024 0766.0  2000 0766.3  1974 0766.3  1942 0766.4  1916 0766.3
GR        1880 0766.1  1835 0765.5  1814 0765.3  1783 0764.7  1752 0764.1
GR        1718 0763.1  1682 0762.1  1647 0760.9  1630 0760.2  1628 0760.2
N         .034
PD        736.2 2 1
PD        740   2 2
PD        740   4 3
PD        747   4 4
PD        747   6 5
CD        3 110 2 758.3
*          LXBr RXBr LXApp RXApp * TPierW
DC 0 BRDGE 1692 1766 1695 1770 * 6
*         LPierEdge RPierEdge PierWdth * * K1 K2 K3(1.1)
DP        1628 2049 2 * * 1 1 1.1
DP        1628 2049 2 * * 1 1 1.1
XS   APPR 410 0
GR        968 760  1024 755  1114 750  1230 745  1675 740  1695 740  1706 735
GR        1730 734.5  1755 735  1769 740  1799 740  1804 750  1862 760
N         .100 .035
SA        1695
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  9:56 am     Version V050196
          Input File: 4442.dat       Output File: 4442.LST
   *-------------------------------------------------------------*
T1        CARSON AVE OVER LICK CREEK AND I-465  I-465-165-4442
T2        COUNTY: MARION                        QUAD: BEECH GROVE 124 B
T3        4-10-97                               BRET A. ROBINSON
SI        0
Q         6980
Q         9640

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

SK        .0011 .0011

   ************************  W S P R O  ***************************
      Federal Highway Administration  -  U. S. Geological Survey
            Model for Water-Surface Profile Computations.
           Input Units: English  /  Output Units: English
   *-------------------------------------------------------------*
     CARSON AVE OVER LICK CREEK AND I-465  I-465-165-4442
   COUNTY: MARION                          QUAD: BEECH GROVE 124 B
     4-10-97                                  BRET A. ROBINSON

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

XS   EXIT 0 0
GR        937 750  1054 740  1677 740  1694 740  1706 735  1730 734.5
GR        1756 735  1770 740  1810 740  1845 750  1906 760
N         .100 .035
SA        1692

 ***   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 (11 pairs)
     X          Y          X          Y          X          Y
----------  ----------  ----------  ----------  ----------  ----------
   937.000     750.000    1054.000     740.000    1677.000     740.000
  1694.000     740.000    1706.000     735.000    1730.000     734.500
  1756.000     735.000    1770.000     740.000    1810.000     740.000
  1845.000     750.000    1906.000     760.000
----------  ----------  ----------  ----------  ----------  ----------
```

WSPRO OUTPUT

```
                Minimum and Maximum X,Y-coordinates
  Minimum X-Station:     937.000  ( associated Y-Elevation:  750.000 )
  Maximum X-Station:    1906.000  ( associated Y-Elevation:  760.000 )
  Minimum Y-Elevation:   734.500  ( associated X-Station:   1730.000 )
  Maximum Y-Elevation:   760.000  ( associated X-Station:   1906.000 )

                    Roughness Data (  2 SubAreas )
                             Roughness   Horizontal
                   SubArea  Coefficient  Breakpoint
                   -------  -----------  ----------
                      1         .100        ---
                                ---       1692.000
                      2         .035        ---
                   -------  -----------  ----------

         *-----------------------------------------------------*
         *      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
   *-------------------------------------------------------------*
       CARSON AVE OVER LICK CREEK AND I-465  I-465-165-4442
   COUNTY: MARION                          QUAD: BEECH GROVE 124 B
       4-10-97                                 BRET A. ROBINSON

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

XS   FULLV 150 0
GR        937 750  1054 740  1677 740  1694 740  1706 735  1730 734.5
GR        1756 735  1770 740  1810 740  1845 750  1906 760
N         .100 .035
SA        1692

 ***   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:      150.   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 (11 pairs)
     X          Y            X          Y            X          Y
----------  ----------   ----------  ----------   ----------  ----------
   937.000     750.000     1054.000     740.000     1677.000     740.000
  1694.000     740.000     1706.000     735.000     1730.000     734.500
  1756.000     735.000     1770.000     740.000     1810.000     740.000
  1845.000     750.000     1906.000     760.000
----------  ----------   ----------  ----------   ----------  ----------
```

WSPRO OUTPUT

```
                Minimum and Maximum X,Y-coordinates
 Minimum X-Station:     937.000  ( associated Y-Elevation:  750.000 )
 Maximum X-Station:    1906.000  ( associated Y-Elevation:  760.000 )
 Minimum Y-Elevation:   734.500  ( associated X-Station:   1730.000 )
 Maximum Y-Elevation:   760.000  ( associated X-Station:   1906.000 )

                  Roughness Data (  2 SubAreas )
                          Roughness   Horizontal
                SubArea  Coefficient  Breakpoint
                -------  -----------  ----------
                   1         .100        ---
                             ---       1692.000
                   2         .035        ---
                -------  -----------  ----------

       *-------------------------------------------------*
       *      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
 *-------------------------------------------------------------*
    CARSON AVE OVER LICK CREEK AND I-465  I-465-165-4442
 COUNTY: MARION                        QUAD: BEECH GROVE 124 B
   4-10-97                                BRET A. ROBINSON

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

 BR   BRDGE 150 760 0
 GR        1628 0760.2  1628 0759.1  1630 0759.0  1630 0758.4  1633 0758.3
 GR        1672 0739.8  1691 0739.7  1703 0734.7  1754 0734.7  1765 0739.8
 GR        1795 0739.8  1808 0747.0  1819 0747.9  1880 0749.8  1894 0749.0
 GR        1933 0749.0  1951 0750.2  1991 0748.7  2008 0747.9  2045 0765.2
 GR        2047 0765.2  2048 0765.4  2049 0765.4  2049 0765.7  2038 0765.9
 GR        2024 0766.0  2000 0766.3  1974 0766.3  1942 0766.4  1916 0766.3
 GR        1880 0766.1  1835 0765.5  1814 0765.3  1783 0764.7  1752 0764.1
 GR        1718 0763.1  1682 0762.1  1647 0760.9  1630 0760.2  1628 0760.2
 N         .034
 PD        736.2 2 1
 PD        740   2 2
 PD        740   4 3
 PD        747   4 4
 PD        747   6 5
 CD        3 110 2 758.3

  ***   Completed Reading Data Associated With Header Record BRDGE   ***
+++072 NOTICE:  X-coordinate # 2 increased to eliminate vertical segment.
+++072 NOTICE:  X-coordinate # 4 increased to eliminate vertical segment.
+++072 NOTICE:  X-coordinate #24 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:      150.   Cross-Section Skew:    .0   Error Code   0
Valley Slope:  *******    Averaging Conveyance By Geometric Mean.
Energy Loss Coefficients ->   Expansion:   .50   Contraction:   .00
```

X,Y-coordinates (40 pairs)

X	Y	X	Y	X	Y
1628.000	760.200	1628.100	759.100	1630.000	759.000
1630.100	758.400	1633.000	758.300	1672.000	739.800
1691.000	739.700	1703.000	734.700	1754.000	734.700
1765.000	739.800	1795.000	739.800	1808.000	747.000
1819.000	747.900	1880.000	749.800	1894.000	749.000
1933.000	749.000	1951.000	750.200	1991.000	748.700
2008.000	747.900	2045.000	765.200	2047.000	765.200
2048.000	765.400	2049.000	765.400	2049.100	765.700
2038.000	765.900	2024.000	766.000	2000.000	766.300
1974.000	766.300	1942.000	766.400	1916.000	766.300
1880.000	766.100	1835.000	765.500	1814.000	765.300
1783.000	764.700	1752.000	764.100	1718.000	763.100
1682.000	762.100	1647.000	760.900	1630.000	760.200
1628.000	760.200				

Minimum and Maximum X,Y-coordinates

```
Minimum X-Station:    1628.000  ( associated Y-Elevation:  760.200 )
Maximum X-Station:    2049.100  ( associated Y-Elevation:  765.700 )
Minimum Y-Elevation:   734.700  ( associated X-Station:   1754.000 )
Maximum Y-Elevation:   766.400  ( associated X-Station:   1942.000 )
```

Roughness Data (1 SubAreas)

SubArea	Roughness Coefficient	Horizontal Breakpoint
1	.034	---

Discharge coefficient parameters

BRType	BRWdth	EMBSS	EMBElv	UserCD
3	110.000	2.00	758.300	**********

Pressure flow elevations

AVBCEL	PFElev
*********	760.000

Abutment Parameters

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

Pier/Pile Data (5 Group(s))

Code Indicates Bridge Uses Piers

WSPRO OUTPUT

Group	Elevation	Gross Width	Number
1	736.200	2.000	1
2	740.000	2.000	2
3	740.000	4.000	3
4	747.000	4.000	4
5	747.000	6.000	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
   *-------------------------------------------------------------*
       CARSON AVE OVER LICK CREEK AND I-465  I-465-165-4442
     COUNTY: MARION                          QUAD: BEECH GROVE 124 B
        4-10-97                                 BRET A. ROBINSON
   DC 0 BRDGE 1692 1766 1695 1770 * 6
   DP         1628 2049 2 * * 1 1 1.1
   DP         1628 2049 2 * * 1 1 1.1

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

   XS   APPR 410 0
   GR         968 760  1024 755  1114 750  1230 745  1675 740  1695 740  1706
735
   GR         1730 734.5  1755 735  1769 740  1799 740  1804 750  1862 760
   N          .100 .035
   SA         1695

    ***   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:      410.   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 (13 pairs)

X	Y	X	Y	X	Y
968.000	760.000	1024.000	755.000	1114.000	750.000
1230.000	745.000	1675.000	740.000	1695.000	740.000
1706.000	735.000	1730.000	734.500	1755.000	735.000
1769.000	740.000	1799.000	740.000	1804.000	750.000
1862.000	760.000				

WSPRO OUTPUT

```
                Minimum and Maximum X,Y-coordinates
  Minimum X-Station:     968.000  ( associated Y-Elevation:  760.000 )
  Maximum X-Station:    1862.000  ( associated Y-Elevation:  760.000 )
  Minimum Y-Elevation:   734.500  ( associated X-Station:   1730.000 )
  Maximum Y-Elevation:   760.000  ( associated X-Station:    968.000 )

                    Roughness Data (  2 SubAreas )
                             Roughness   Horizontal
                  SubArea  Coefficient  Breakpoint
                  -------  -----------  ----------
                     1         .100        ---
                               ---       1695.000
                     2         .035        ---
                  -------  -----------  ----------

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
    *-------------------------------------------------------------*
        CARSON AVE OVER LICK CREEK AND I-465  I-465-165-4442
    COUNTY: MARION                          QUAD: BEECH GROVE 124 B
        4-10-97                                 BRET A. ROBINSON
  EX

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

            Reach       Water Surface   Friction
     #    Discharge       Elevation      Slope          Flow Regime
    --    ---------    -------------   --------   --------------------
     1      6980.00       ********        .0011        Sub-Critical
     2      9640.00       ********        .0011        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
    *-------------------------------------------------------------*
        CARSON AVE OVER LICK CREEK AND I-465  I-465-165-4442
```

WSPRO OUTPUT

COUNTY: MARION
4-10-97

QUAD: BEECH GROVE 124 B
BRET A. ROBINSON

	WSEL EGEL CRWS	VHD HF HO	Q V FR #	AREA K SF	SRDL FLEN ALPHA	LEW REW ERR
Section: EXIT	743.936	.200	6980.000	3421.079	*********	1007.946
Header Type: XS	744.136	******	2.040	210347.30	*********	1823.777
SRD: .000	741.683	******	.309	******	3.092	******
Section: FULLV	744.114	.182	6980.000	3565.926	150.000	1005.872
Header Type: FV	744.296	.156	1.957	222779.70	150.000	1824.397
SRD: 150.000	741.683	.000	.289	.0010	3.057	.003

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

===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS AT SECID "APPR ".
KRATIO: .63

Section: APPR	744.219	.779	6980.000	1639.642	260.000	1299.477
Header Type: AS	744.998	.408	4.257	139490.40	260.000	1801.110
SRD: 410.000	742.361	.298	.690	.0016	2.763	-.003

<<< 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	743.908	1.028	6980.000	858.571	150.000	1663.340
Header Type: BR	744.936	.288	8.130	123850.90	150.000	1802.417
SRD: 150.000	741.953	.511	.577	******	1.000	.000

Specific Bridge Information	C	P/A	PFELEV	BLEN	XLAB	XRAB
Bridge Type 3 Flow Type 1						
Pier/Pile Code 0	1.0000	.027	760.000	********	********	********

	WSEL EGEL CRWS	VHD HF HO	Q V FR #	AREA K SF	SRDL FLEN ALPHA	LEW REW ERR
Section: APPR	745.249	.489	6980.000	2201.344	150.000	1224.231
Header Type: AS	745.738	.344	3.171	185162.10	157.859	1801.624
SRD: 410.000	742.361	.457	.506	.0016	3.130	-.007

Approach Section APPR Flow Contraction Information

M(G)	M(K)	KQ	XLKQ	XRKQ	OTEL

WSPRO OUTPUT

```
          .721      .161  155692.4 1661.407 1800.483  745.249
        -------- -------- --------- -------- -------- --------

            <<< 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
  *-----------------------------------------------------------*
      CARSON AVE OVER LICK CREEK AND I-465  I-465-165-4442
  COUNTY: MARION                          QUAD: BEECH GROVE 124 B
     4-10-97                                  BRET A. ROBINSON

                    WSEL     VHD       Q         AREA      SRDL      LEW
                    EGEL      HF       V           K        FLEN      REW
                    CRWS      HO      FR #        SF       ALPHA     ERR
                  --------- ------ ---------- ---------- --------- ---------
  Section: EXIT     745.011   .226  9640.000   4306.739 *********   995.370
  Header Type: XS   745.237 ******     2.238  290533.90 *********  1827.539
  SRD:      .000    742.229 ******      .295     ******     2.899    ******

  Section: FULLV    745.186   .209  9640.000   4452.751   150.000   993.321
  Header Type: FV   745.396   .157     2.165  304672.70   150.000  1828.152
  SRD:    150.000   742.229   .000      .280      .0010     2.872      .001

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

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS AT SECID "APPR ".
        KRATIO:   .61

  Section: APPR     745.247   .934  9640.000   2200.353   260.000  1224.271
  Header Type: AS   746.181   .428     4.381  185074.00   260.000  1801.624
  SRD:    410.000   743.494   .362      .700      .0016     3.129     -.005

         <<< 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    744.877  1.494  9640.000    995.257   150.000  1661.296
  Header Type: BR   746.372   .318     9.686  155358.80   150.000  1804.167
  SRD:    150.000   743.087   .818      .655     ******     1.024      .001

  Specific Bridge Information   C      P/A    PFELEV     BLEN      XLAB      XRAB
  Bridge Type 3   Flow Type 1 ------ ------ -------- -------- -------- --------
  Pier/Pile Code  0             .9881  .027  760.000 ******** ******** ********
  ------------------------- ------ ------ -------- -------- -------- --------
```

WSPRO OUTPUT

	WSEL	VHD	Q	AREA	SRDL	LEW
	EGEL	HF	V	K	FLEN	REW
	CRWS	HO	FR #	SF	ALPHA	ERR
Section: APPR	746.795	.484	9640.000	3122.325	150.000	1188.364
Header Type: AS	747.279	.364	3.087	272169.80	161.215	1802.397
SRD: 410.000	743.494	.541	.436	.0016	3.265	-.009

Approach Section APPR Flow Contraction Information

M(G)	M(K)	KQ	XLKQ	XRKQ	OTEL
.750	.225	211294.8	1656.935	1799.802	746.795

<<< 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

CARSON AVE OVER LICK CREEK AND I-465 I-465-165-4442
COUNTY: MARION QUAD: BEECH GROVE 124 B
4-10-97 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): 6.000

#	Scour Depth	-- Flow -- Contract	Approach	-- Width -- Contract	Approach	Side	--- X-Limits --- Contract	Approach
1	2.632	6236.790	5038.526	68.000	75.000	Left:	1692.000	1695.000
	..... Approach Channel Depth:	9.512				Right:	1766.000	1770.000
2	4.173	8234.653	6084.829	68.000	75.000	Left:	1692.000	1695.000
	..... Approach Channel Depth:	11.058				Right:	1766.000	1770.000

********** W S P R O **********
Federal Highway Administration - U. S. Geological Survey
Model for Water-Surface Profile Computations.
Input Units: English / Output Units: English

CARSON AVE OVER LICK CREEK AND I-465 I-465-165-4442
COUNTY: MARION QUAD: BEECH GROVE 124 B
4-10-97 BRET A. ROBINSON

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

WSPRO OUTPUT

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 Flow	WSE	Depth	Velocity	Froude #	X-Stations Left	Right
1	5.79	6980.000	744.364	9.664	9.272	.526	1628.000	2049.000
2	6.31	9640.000	745.419	10.719	10.956	.590	1628.000	2049.000

********** W S P R O **********
Federal Highway Administration - U. S. Geological Survey
Model for Water-Surface Profile Computations.
Input Units: English / Output Units: English

CARSON AVE OVER LICK CREEK AND I-465 I-465-165-4442
COUNTY: MARION QUAD: BEECH GROVE 124 B
4-10-97 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 Depth	Localized Hydraulic Properties Flow	WSE	Depth	Velocity	Froude #	X-Stations Left	Right
1	5.79	6980.000	744.364	9.664	9.272	.526	1628.000	2049.000
2	6.31	9640.000	745.419	10.719	10.956	.590	1628.000	2049.000

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