LEVEL II SCOUR ANALYSIS FOR BRIDGE 42 (BAKETH00060042) on TOWN HIGHWAY 6, crossing THE BRANCH, BAKERSFIELD, VERMONT

Open-File Report 98-585

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

U.S. Department of the Interior
U.S. Geological Survey

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By ERICK M. BOEHMLER AND JAMES R. DEGNAN

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Pembroke, New Hampshire

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U.S. DEPARTMENT OF THE INTERIOR
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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Slope	
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
cubic foot (ft^3)	0.02832	cubic meter (m^3)
	Velocity and Flow	
foot per second (ft/s)	0.3048	meter per second (m/s)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
cubic foot per second per square mile [(ft^3/s)/mi^2]	0.01093	cubic meter per second per square kilometer [(m^3/s)/km^2

OTHER ABBREVIATIONS

BF	bank full	LWW	left wingwall
cfs	cubic feet per second	Max	maximum
D_{50}	median diameter of bed material	MC	main channel
DS	downstream	RAB	right abutment
elev.	elevation	RABUT	face of right abutment
f/p	flood plain	RB	right bank
ft^2	square feet	ROB	right overbank
ft/ft	feet per foot	RWW	right wingwall
FEMA	Federal Emergency Management Agency	TH	town highway
FHWA	Federal Highway Administration	UB	under bridge
JCT	junction	US	upstream
LAB	left abutment	USGS	United States Geological Survey
LABUT	face of left abutment	VTAOT	Vermont Agency of Transportation
LB	left bank	WSPRO	water-surface profile model
LOB	left overbank	yr	year

In this report, the words “right” and “left” refer to directions that would be reported by an observer facing downstream.

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

In the appendices, the above abbreviations may be combined. For example, USLB would represent upstream left bank.

LEVEL II SCOUR ANALYSIS FOR BRIDGE 42 (BAKETH00060042) ON TOWN HIGHWAY 6, CROSSING THE BRANCH, BAKERSFIELD, VERMONT

By **Erick M. Boehmler and James R. Degnan**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure BAKETH00060042 on Town Highway 6 crossing The Branch, Bakersfield, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (FHWA, 1993). Results of a Level I scour investigation also are included in appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in appendix D.

The site is in the Green Mountain section of the New England physiographic province in north-central Vermont. The 9.21-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is pasture upstream and shrubs and brush downstream. Part of the downstream left bank is a wetland.

In the study area, The Branch has a meandering channel with a slope of approximately 0.01 ft/ft, an average channel top width of 69 ft and an average bank height of 4 ft. The channel bed material ranges from sand to cobbles with a median grain size (D_{50}) of 72.7 mm (0.239 ft). The geomorphic assessment at the time of the Level I and Level II site visit on June 29, 1995, indicated that the reach was laterally unstable. There were point bars opposite cut-banks along the reach both upstream and downstream of this site. Slip-failure of the bank material was the most common type of failure at the cut-banks. Moderate fluvial erosion was observed on the upstream right bank and both downstream banks.

The Town Highway 6 crossing of The Branch is a 26-ft-long, two-lane bridge consisting of one 23-foot concrete T-beam span (Vermont Agency of Transportation, written communication, March 7, 1995). The opening length of the structure parallel to the bridge face is 21.8 ft. The bridge is supported by vertical, concrete abutments with a wingwall only on the upstream right end of the opening. The channel is skewed approximately 10 degrees to the opening while the opening-skew-to-roadway is zero degrees.

A scour hole 2.5 ft deeper than the mean thalweg depth was observed immediately downstream of the bridge during the Level I assessment. Scour protection measures at the site were type-1 (less than 12 inches diameter) and type-2 (less than 36 inches diameter) stone fill. Type-1 stone fill protection was noted on the upstream left bank while type-2 stone fill protected the upstream right bank, the upstream right wingwall, and the downstream banks. Additional details describing conditions at the site are included in the Level II Summary and appendices D and E.

Scour depths and recommended rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995) for the 100- and 500-year discharges. In addition, the incipient roadway-overtopping discharge was determined and analyzed as another potential worst-case scour scenario. Total scour at a highway crossing is comprised of three components: 1) long-term streambed degradation; 2) contraction scour (due to accelerated flow caused by a reduction in flow area at a bridge) and; 3) local scour (caused by accelerated flow around piers and abutments). Total scour is the sum of the three components. Equations are available to compute depths for contraction and local scour and a summary of the results of these computations follows.

Contraction scour for all modelled flows ranged from 0.6 to 1.8 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 8.3 to 10.5 ft at the left abutment and 9.6 to 11.5 ft at the right abutment. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

It is generally accepted that the Froehlich equation (abutment scour) gives “excessively conservative estimates of scour depths” (Richardson and others, 1995, p. 46). Usually, computed scour depths are evaluated in combination with other information including (but not limited to) historical performance during flood events, the geomorphic stability assessment, existing scour protection measures, and the results of the hydraulic analyses. Therefore, scour depths adopted by VTAOT may differ from the computed values documented herein.

Plymouth, VT. Quadrangle, 1:24,000, 1966
Photoinspected 1983

NORTH

Figure 1. Location of study area on USGS 1:24,000 scale map.

Figure 2. Location of study area on Vermont Agency of Transportation town highway map.

LEVEL II SUMMARY

Structure Number BAKETH00060042 ***Stream*** The Branch

County Franklin ***Road*** TH 6 ***District*** 8

Description of Bridge

Bridge length 26 ***ft*** ***Bridge width*** 23.4 ***ft*** ***Max span length*** 23 ***ft***

Alignment of bridge to road (on curve or straight) Straight

Abutment type Vertical, concrete ***Embankment type*** Sloping (Steep)

Stone fill on abutment? No ***Date of inspection*** 6/29/95

Description of stone fill Type-2, at the upstream end of the upstream right wingwall.

Brief description of piers/abutments The abutments and wingwall are concrete. The only wingwall is on the right end of the bridge opening upstream. There is a 2.5 foot deep scour hole immediately downstream of the downstream bridge face.

Is bridge skewed to flood flow according to Yes ***survey?*** Yes ***Angle*** 10

There is a moderate channel bend in the upstream reach with flow impacting the right bank.

6/29/95

Debris accumulation on bridge at time of Level I or Level II site visit:

	Date of inspection	***Percent of channel blocked horizontally***	***Percent of channel blocked vertically***
Level I	0	0	6/29/
Level II	95	0	0

Potential for debris Low. There was beaver activity noted in the vicinity of this site.

None were observed on 6/29/95.

Describe any features near or at the bridge that may affect flow (include observation date)

Description of the Geomorphic Setting

General topography The channel is located in a low relief valley setting with a narrow, irregular flood plain and steep valley walls on both sides.

Geomorphic conditions at bridge site: downstream (DS), upstream (US)

Date of inspection 6/29/95

DS left: Moderately sloping channel bank to an irregular overbank.

DS right: Steep channel bank to an irregular overbank.

US left: Moderately sloping channel bank and a steep valley wall.

US right: Moderately sloping channel bank and an irregular overbank.

Description of the Channel

Average top width 69 ***ft*** ***Average depth*** 4 ***ft***

Predominant bed material Gravel / Sand ***Bank material*** Gravel/Sand

Perennial and meandering with alluvial channel boundaries and a randomly varying width.

6/29/95

Vegetative co

Brush with a few trees and shrubs

DS left: Brush with a few trees and shrubs

DS right: Grass and brush with a few shrubs

US left: Grass and a few trees.

US right:

Do banks appear stable? No ***If not, describe location and type of instability and date of observation.***

On 6/29/95, cut-banks and point bars were evident on opposite sides of the channel in the reach upstream and downstream of this site. Slip-failure of the bank material is noted at the cut-banks. The channel is significantly wider in the location of the scour hole immediately downstream of the site than at other locations along the reach.

None were evident on 6/29/95.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 9.21 ***mi***^{2}

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province/section	*Percent of drainage area*
New England/Green Mountain	100

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***:

Is there a USGS gage on the stream of interest? No

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi***^{2}

Is there a lake/p [illegible] No

Calculated Discharges

Q100 1,370 ***ft***^{3}***/s*** ***Q500*** 1,900 ***ft***^{3}***/s***

The 100-year discharge is the median value selected from the range defined by several empirical flood frequency curves computed and extrapolated to the 500-year discharge (Benson, 1962; FHWA, 1983; Johnson and Tasker, 1974; Johnson and Laraway, 1971, unpublished draft; Potter, 1957a&b; and Talbot, 1887). The 500-year discharge was estimated by visually extrapolating from the 100-year discharge at the slope of the empirical flood frequency curves.

Description of the Water-Surface Profile Model (WSPRO) Analysis

Datum for WSPRO analysis (USGS survey, sea level, VTAOT plans) USGS survey

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is a chiseled "X" on top of the concrete at the right end of the downstream concrete guard rail. (elev. 498.63 ft, arbitrary survey datum). RM2 is a chiseled X on top of the concrete at the upstream end of the right abutment where the abutment joins the upstream right wingwall (elev. 497.86 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXIT2	784	3	Exit section (Overbanks generated from EXIT1 and the next section downstream
EXIT1	817	1	Exit section
FULLV	847	2	Full-valley section (Templated from EXIT1)
BRIDG	847	1	Bridge section
RDWAY	859	1	Road Grade section
APPR1	892	3	Approach section (Channel elevations adjusted)

[1] For location of cross-sections see plan-view sketch included with Level I field form, Appendix E. For more detail on how cross-sections were developed see WSPRO input file.

[2] Cross-section development: (1) survey at SRD, (2) shift of survey data to SRD, (3) modification of survey data,

Data and Assumptions Used in WSPRO Model

Hydraulic analyses of the reach were done by use of the Federal Highway Administration's WSPRO step-backwater computer program (Shearman and others, 1986, and Shearman, 1990). The analyses reported herein reflect conditions existing at the site at the time of the study. Furthermore, in the development of the model it was necessary to assume no accumulation of debris or ice at the site. Also, the flow was assumed to align with the abutments in the bridge opening. Results of the hydraulic model are presented in the Bridge Hydraulic Summary, appendix B, and figure 7.

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.040 to 0.050 and overbank "n" values ranged from 0.055 to 0.065.

The starting water surface elevations at the exit section (EXIT2) for each modeled discharge were computed based on a model of the reach between this site and the next bridge crossing downstream. The reach downstream of this site was modeled to estimate the influence of backwater, if any, from the bridge crossing downstream on the water surface and hydraulics at this site.

The surveyed approach section was moved 13 feet toward the bridge to establish the modeled approach section (APPR1), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location also provides a consistent method for determining scour variables. The elevations for the channel segment coordinates of the approach section were reduced by use of the slope (0.0317 ft/ft) between the surveyed approach channel and the bridge. Elevations for the remaining coordinates were not modified.

Bridge Hydraulics Summary

Average bridge embankment elevation 500.2 *ft*
Average low steel elevation 496.8 *ft*

100-year discharge 1,370 *ft³/s*
Water-surface elevation in bridge opening 497.0 *ft*
Road overtopping? Yes *Discharge over road* 337 *ft³/s*
Area of flow in bridge opening 105 *ft²*
Average velocity in bridge opening 9.9 *ft/s*
Maximum WSPRO tube velocity at bridge 11.8 *ft/s*

Water-surface elevation at Approach section with bridge 500.5
Water-surface elevation at Approach section without bridge 496.0
Amount of backwater caused by bridge 4.5 *ft*

500-year discharge 1,900 *ft³/s*
Water-surface elevation in bridge opening 497.0 *ft*
Road overtopping? Yes *Discharge over road* 823 *ft³/s*
Area of flow in bridge opening 105 *ft²*
Average velocity in bridge opening 10.2 *ft/s*
Maximum WSPRO tube velocity at bridge 12.2 *ft/s*

Water-surface elevation at Approach section with bridge 500.9
Water-surface elevation at Approach section without bridge 496.4
Amount of backwater caused by bridge 4.5 *ft*

Incipient overtopping discharge 960 *ft³/s*
Water-surface elevation in bridge opening 497.0 *ft*
Area of flow in bridge opening 105 *ft²*
Average velocity in bridge opening 9.1 *ft/s*
Maximum WSPRO tube velocity at bridge 10.8 *ft/s*

Water-surface elevation at Approach section with bridge 499.7
Water-surface elevation at Approach section without bridge 495.5
Amount of backwater caused by bridge 4.2 *ft*

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

Scour depths were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the scour analyses for the 100- and 500-year discharges are presented in tables 1 and 2 and the scour depths are shown graphically in figure 8.

Each modeled discharge resulted in an orifice flow solution. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Thus, contraction scour was computed by use of the Chang pressure-flow scour equation (Richardson and others, 1995, p. 145-146).

For comparison, estimates of contraction scour also were computed by use of the Laursen clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20) and the Umbrell pressure-flow equation (Richardson and others, 1995, p. 144). Results of these computations are presented in appendix F. Furthermore, for those discharges resulting in unsubmerged orifice flow, contraction scour was computed by substituting estimates for the depth of flow at the downstream bridge face in the contraction scour equations. Results with respect to these substitutions also are provided in appendix F.

Abutment scour for the right abutment was computed by use of the Froehlich equation (Richardson and others, 1995, p. 48, equation 28). Variables for the Froehlich equation include the Froude number of the flow approaching the embankments, the length of the embankment blocking flow, and the depth of flow approaching the embankment less any roadway overtopping.

Scour at the left abutment was computed by use of the HIRE equation (Richardson and others, 1995, p. 49, equation 29) because the HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25. The variables used by the HIRE abutment-scour equation are defined the same as those defined for the Froehlich abutment-scour equation.

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	1.3	1.8	0.6
Depth to armoring	N/A	N/A	N/A
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour	9.5	10.4	8.3
Left abutment	10.7	11.5	9.6
Right abutment			
Pier scour	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3			

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:	1.7	1.8	1.6
Left abutment	1.7	1.8	1.6
Right abutment	--	--	--
Piers:	--	--	--
Pier 1	--	--	--
Pier 2			

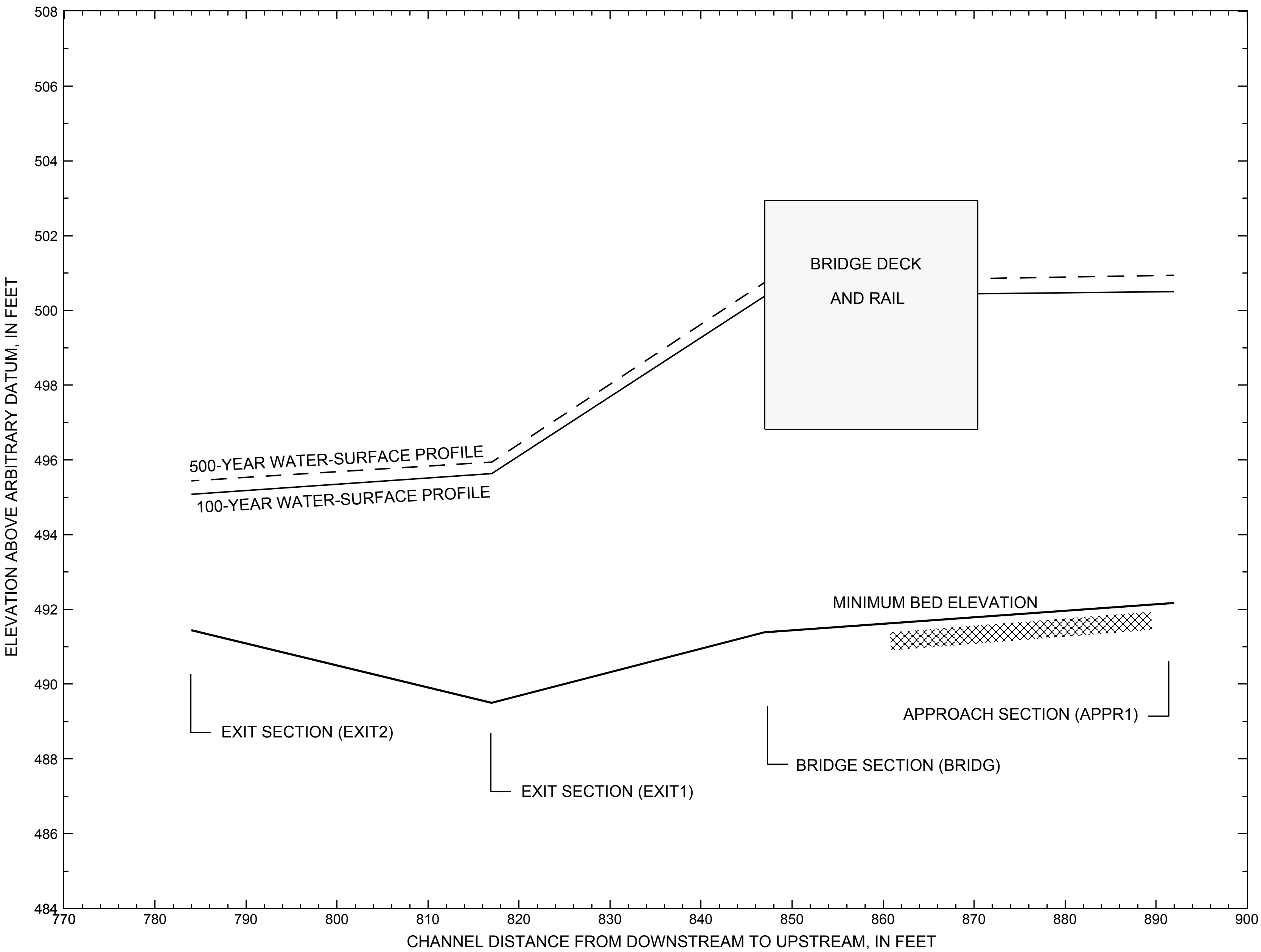

Figure 7. Water-surface profiles for the 100- and 500-year discharges at structure BAKETH00060042 on Town Highway 6, crossing The Branch, Bakersfield, Vermont.

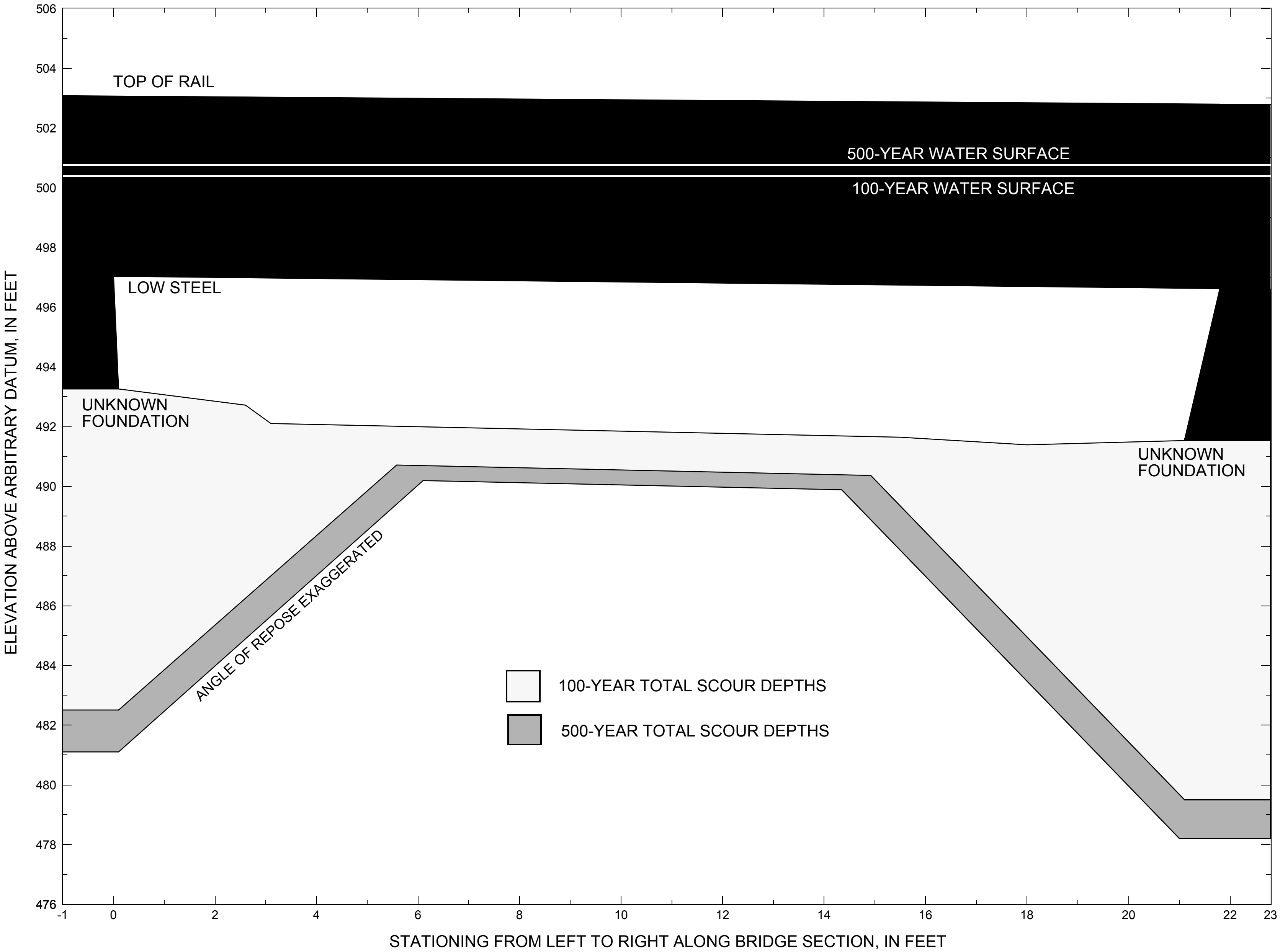

Figure 8. Scour elevations for the 100- and 500-year discharges at structure BAKETH00060042 on Town Highway 6, crossing The Branch, Bakersfield, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure BAKETH00060042 on Town Highway 6, crossing The Branch, Bakersfield, Vermont.

[VTAOT, Vermont Agency of Transportation; --, no data]

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-year discharge is 1,370 cubic-feet per second											
Left abutment	0.0	--	497.0	--	493.3	1.3	9.5	--	10.8	482.5	--
Right abutment	21.8	--	496.6	--	491.5	1.3	10.7	--	12.0	479.5	--

1.Measured along the face of the most constricting side of the bridge.
2.Arbitrary datum for this study.

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure BAKETH00060042 on Town Highway 6, crossing The Branch, Bakersfield, Vermont.

[VTAOT, Vermont Agency of Transportation; --, no data]

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-year discharge is 1,900 cubic-feet per second											
Left abutment	0.0	--	497.0	--	493.3	1.8	10.4	--	12.2	481.1	--
Right abutment	21.8	--	496.6	--	491.5	1.8	11.5	--	13.3	478.2	--

1.Measured along the face of the most constricting side of the bridge.
2.Arbitrary datum for this study.

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U.S. Geological Survey, 1986, Bakersfield, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Contour Interval, 6 meters, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File bake042.wsp
T2        Hydraulic analysis for structure BAKETH00060042   Date: 21-MAY-97
T3        Town Highway 6 crossing “The Branch” in Bakersfield, VT         EMB
*
J1         * * 0.005
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           1370.0   1900.0    960.0    970.0
WS          495.08   495.44    494.47   494.48
*
XS   EXIT2    784
GR         -175.2, 498.05   -163.0, 497.52   -153.1, 494.78
GR          -24.3, 494.49    -17.7, 493.08    -11.7, 491.94     -7.5, 492.31
GR           -5.5, 491.71      0.0, 491.68      3.8, 491.72      8.5, 491.71
GR           13.9, 491.91     15.6, 492.04     18.5, 492.64     26.6, 492.55
GR           29.0, 491.91     34.1, 491.44     35.7, 491.76     41.2, 494.09
GR           53.4, 494.48     84.9, 494.73    122.9, 500.73    146.3, 500.73
GR          185.3, 508.84
*           -198.5, 506.30   -125.0, 498.18    -54.9, 495.17
N           0.065         0.050         0.055
SA                 -24.3          41.2
*
XS   EXIT1    817
GR         -336.6, 506.30   -315.6, 499.43   -277.4, 498.18   -229.4, 496.84
GR         -198.5, 496.10   -125.0, 495.85    -54.9, 495.17    -20.8, 494.65
GR          -11.9, 491.84    -10.2, 491.30     -6.7, 492.20     -4.5, 491.82
GR            0.0, 491.61     11.1, 489.50     20.9, 491.91     25.8, 492.41
GR           33.5, 491.07     40.5, 491.78     44.9, 494.55     53.4, 494.48
GR           84.9, 494.73    122.9, 500.73
*
N           0.065         0.050         0.055
SA                 -20.8          44.9
*
*
XS   FULLV    847   * * *   0.0
*
*             SRD      LSEL    XSSKEW
BR   BRIDG   847    496.82       0.0
GR            0.0, 497.03      0.1, 493.26      2.6, 492.72      3.1, 492.10
GR            3.3, 492.09     15.5, 491.64     18.0, 491.39     21.1, 491.53
GR           21.8, 496.62      0.0, 497.03
*
*        BRTYPE  BRWDTH        WWANGL    WWWID
CD          1      29.1
*                       95.1     1.0
N           0.040
*
*
*             SRD    EMBWID   IPAVE
XR   RDWAY    859      23.4      2
GR         -517.1, 511.70   -427.4, 508.07   -389.6, 505.28   -308.7, 501.39
GR         -197.6, 499.74    -59.0, 499.81      0.0, 500.20      0.0, 503.08
GR           25.7, 502.80     26.5, 500.19     62.9, 500.57    122.8, 501.00
GR          161.8, 509.11
*
*
*             SRD
```

```
AS   APPR1    892
GR         -458.5, 507.13   -420.7, 502.34   -339.8, 498.45   -228.7, 496.80
GR         -128.7, 496.80    -80.0, 496.71    -57.2, 496.34    -36.7, 494.47
GR          -13.8, 494.05     -3.9, 494.28      0.0, 492.83      1.2, 492.26
GR            7.4, 492.17     10.5, 492.30     17.5, 492.19     19.0, 492.59
GR           24.1, 493.07     28.8, 494.38     44.2, 494.58     51.8, 495.16
GR           67.7, 501.55     81.3, 501.98    141.3, 502.27    180.3, 510.38
*

*            The following channel points were lowered using the slope
*            of 0.0317 over 13 feet, which is the distance between the
*            surveyed location and the expected location at one bridge
*            length upstream. This was done because the overbanks generally
*            do not lower in elevation over this distance like the main
*            channel.
*             1.2, 492.64      7.4, 492.55     10.5, 492.68     17.5, 492.57
*            19.0, 492.97
N          0.055        0.050       0.055
SA                     -3.9        67.7
*
HP 1 BRIDG 497.03 1 497.03
HP 2 BRIDG 497.03 * * 1040
HP 1 BRIDG 496.13 1 496.13
HP 2 RDWAY 500.38 * * 337
HP 1 APPR1 500.50 1 500.50
HP 2 APPR1 500.50 * * 1370
*
HP 1 BRIDG 497.03 1 497.03
HP 2 BRIDG 497.03 * * 1076
HP 1 BRIDG 496.23 1 496.23
HP 2 RDWAY 500.75 * * 823
HP 1 APPR1 500.94 1 500.94
HP 2 APPR1 500.94 * * 1900
*
HP 1 BRIDG 497.03 1 497.03
HP 2 BRIDG 497.03 * * 960
HP 1 BRIDG 495.91 1 495.91
HP 1 APPR1 499.68 1 499.68
HP 2 APPR1 499.68 * * 960
*
EX
ER
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APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

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WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File bake042.wsp
        Hydraulic analysis for structure BAKETH00060042   Date: 21-MAY-97
        Town Highway 6 crossing "The Branch" in Bakersfield, VT         EMB
           *** RUN DATE & TIME: 05-04-98  07:33

    CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =     847.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     105.    6266.     0.    52.                           0.
   497.03          105.    6266.     0.    52.  1.00     0.    22.      0.

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = BRIDG;  SRD =     847.

         WSEL     LEW     REW    AREA         K        Q    VEL
       497.03     0.0    21.8   105.3     6266.    1040.   9.88

X STA.         0.0        2.8        3.8        4.8        5.7        6.6
  A(I)             11.0        5.0        4.6        4.7        4.6
  V(I)             4.72      10.46      11.34      11.17      11.20

X STA.         6.6        7.6        8.5        9.5       10.4       11.3
  A(I)              4.7        4.6        4.7        4.6        4.6
  V(I)            11.09      11.27      11.15      11.24      11.20

X STA.        11.3       12.2       13.2       14.1       15.0       15.9
  A(I)              4.6        4.7        4.6        4.7        4.5
  V(I)            11.19      11.15      11.38      11.17      11.45

X STA.        15.9       16.8       17.6       18.5       19.3       21.8
  A(I)              4.6        4.5        4.4        4.4       11.1
  V(I)            11.26      11.51      11.74      11.76       4.69

    CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =     847.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1      90.    7168.    22.    29.                        1042.
   496.13           90.    7168.    22.    29.  1.00     0.    22.   1042.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = RDWAY;  SRD =     859.

         WSEL     LEW     REW    AREA         K        Q    VEL
       500.38  -240.7    44.7   121.5     1766.     337.   2.77

X STA.      -240.7     -199.9     -191.5     -183.5     -174.9     -166.6
  A(I)             12.3        5.3        5.1        5.4        5.2
  V(I)             1.37       3.15       3.30       3.13       3.22

X STA.      -166.6     -158.0     -149.4     -140.6     -131.7     -122.8
  A(I)              5.3        5.4        5.3        5.4        5.4
  V(I)             3.17       3.15       3.15       3.10       3.12

X STA.      -122.8     -113.6     -104.4      -95.2      -85.6      -76.1
  A(I)              5.5        5.5        5.5        5.6        5.5
  V(I)             3.06       3.08       3.07       3.00       3.05

X STA.       -76.1      -66.4      -56.5      -45.0      -27.9       44.7
  A(I)              5.6        5.6        6.0        7.2        9.3
  V(I)             3.01       3.01       2.83       2.35       1.80

    CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APPR1;  SRD =     892.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1    1316.   81814.   379.   379.                       13927.
             2     426.   41958.    69.    71.                        5996.
   500.50         1742.  123772.   448.   449.  1.16  -382.    65.  18115.

    VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APPR1;  SRD =     892.

         WSEL     LEW     REW    AREA         K        Q    VEL
       500.50  -382.4    65.1  1741.7   123772.    1370.   0.79

X STA.      -382.4     -268.0     -236.2     -210.4     -184.0     -157.3
  A(I)            229.2      106.7       95.1       97.5       98.7
  V(I)             0.30       0.64       0.72       0.70       0.69

X STA.      -157.3     -131.2     -104.6      -77.6      -53.5      -41.8
  A(I)             96.9       98.7      101.8       97.4       59.2
  V(I)             0.71       0.69       0.67       0.70       1.16

X STA.       -41.8      -31.3      -18.7       -6.7        2.3        8.3
  A(I)             62.0       78.6       77.0       62.7       50.3
  V(I)             1.10       0.87       0.89       1.09       1.36

X STA.         8.3       14.5       20.8       29.1       39.6       65.1
  A(I)             50.7       51.6       58.7       63.5      105.5
  V(I)             1.35       1.33       1.17       1.08       0.65
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WSPRO OUTPUT FILE (continued)

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WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File bake042.wsp
        Hydraulic analysis for structure BAKETH00060042   Date: 21-MAY-97
        Town Highway 6 crossing "The Branch" in Bakersfield, VT         EMB
           *** RUN DATE & TIME: 05-04-98  07:33

    CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =     847.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     105.    6266.     0.    52.                          0.
   497.03          105.    6266.     0.    52.  1.00     0.    22.      0.

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = BRIDG;  SRD =     847.

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.03     0.0    21.8   105.3    6266.    1076.  10.22

X STA.         0.0         2.8         3.8         4.8         5.7         6.6
  A(I)             11.0         5.0         4.6         4.7         4.6
  V(I)             4.88       10.82       11.74       11.56       11.59

X STA.         6.6         7.6         8.5         9.5        10.4        11.3
  A(I)              4.7         4.6         4.7         4.6         4.6
  V(I)            11.48       11.66       11.53       11.63       11.59

X STA.        11.3        12.2        13.2        14.1        15.0        15.9
  A(I)              4.6         4.7         4.6         4.7         4.5
  V(I)            11.58       11.54       11.77       11.55       11.85

X STA.        15.9        16.8        17.6        18.5        19.3        21.8
  A(I)              4.6         4.5         4.4         4.4        11.1
  V(I)            11.65       11.91       12.14       12.16        4.86

    CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =     847.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1      92.    7423.    22.    29.                       1080.
   496.23           92.    7423.    22.    29.  1.00     0.    22.   1080.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = RDWAY;  SRD =     859.

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.75  -265.6    88.0   229.2    4504.     823.   3.59

X STA.      -265.6      -204.3      -194.1      -184.4      -174.4      -164.5
  A(I)             27.9        10.0         9.8         9.9         9.9
  V(I)             1.47        4.11        4.22        4.15        4.16

X STA.      -164.5      -154.6      -144.5      -134.2      -124.1      -113.9
  A(I)              9.8        10.0        10.1         9.9         9.8
  V(I)             4.20        4.10        4.09        4.16        4.18

X STA.      -113.9      -103.6       -92.9       -82.2       -71.2       -60.3
  A(I)             10.0        10.3        10.2        10.5        10.3
  V(I)             4.11        4.01        4.04        3.93        4.00

X STA.       -60.3       -48.8       -35.3       -19.0        -1.9        88.0
  A(I)             10.4        11.2        11.9        10.6        16.9
  V(I)             3.95        3.68        3.46        3.89        2.44

    CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APPR1;  SRD =     892.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1    1485.   98432.   388.   388.                      16488.
             2     456.   46588.    70.    72.                       6603.
   500.94         1941.  145021.   458.   460.  1.13  -392.    66.  21289.

    VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APPR1;  SRD =     892.

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.94  -391.6    66.2  1940.9  145021.    1900.   0.98

X STA.      -391.6      -275.2      -244.4      -218.4      -192.7      -167.5
  A(I)            256.1       113.6       105.4       106.7       104.4
  V(I)             0.37        0.84        0.90        0.89        0.91

X STA.      -167.5      -141.6      -115.6       -90.2       -65.3       -49.3
  A(I)            107.0       107.7       106.4       107.3        75.9
  V(I)             0.89        0.88        0.89        0.89        1.25

X STA.       -49.3       -36.9       -23.7       -11.2         0.0         6.7
  A(I)             73.0        86.9        85.1        77.7        58.7
  V(I)             1.30        1.09        1.12        1.22        1.62

X STA.         6.7        13.5        20.3        28.5        39.6        66.2
  A(I)             58.6        58.4        62.6        72.1       117.2
  V(I)             1.62        1.63        1.52        1.32        0.81
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WSPRO OUTPUT FILE (continued)

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WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188             MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File bake042.wsp
        Hydraulic analysis for structure BAKETH00060042  Date: 21-MAY-97
        Town Highway 6 crossing “The Branch” in Bakersfield, VT         EMB
           *** RUN DATE & TIME: 05-04-98  07:33

    CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =     847.

     WSEL  SA#     AREA        K  TOPW   WETP  ALPH    LEW    REW     QCR
             1      105.    6266.    0.    52.                           0.
   497.03           105.    6266.    0.    52.  1.00     0.    22.      0.

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = BRIDG;  SRD =     847.

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.03     0.0    21.8   105.3    6266.     960.   9.12

X STA.        0.0        2.8        3.8        4.8        5.7        6.6
  A(I)            11.0        5.0        4.6        4.7        4.6
  V(I)            4.36       9.65      10.47      10.31      10.34

X STA.        6.6        7.6        8.5        9.5       10.4       11.3
  A(I)             4.7        4.6        4.7        4.6        4.6
  V(I)           10.24      10.40      10.29      10.38      10.34

X STA.       11.3       12.2       13.2       14.1       15.0       15.9
  A(I)             4.6        4.7        4.6        4.7        4.5
  V(I)           10.33      10.29      10.51      10.31      10.57

X STA.       15.9       16.8       17.6       18.5       19.3       21.8
  A(I)             4.6        4.5        4.4        4.4       11.1
  V(I)           10.40      10.62      10.83      10.85       4.33

    CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =     847.

     WSEL  SA#     AREA        K  TOPW   WETP  ALPH    LEW    REW     QCR
             1       85.    6614.   22.    28.                         961.
   495.91            85.    6614.   22.    28.  1.00     0.    22.    961.

    CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APPR1;  SRD =     892.

     WSEL  SA#     AREA        K  TOPW   WETP  ALPH    LEW    REW     QCR
             1     1013.   54515.  361.   362.                        9620.
             2      370.   33911.   67.    68.                        4931.
   499.68          1383.   88426.  428.   430.  1.23  -365.    63.  12733.

    VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APPR1;  SRD =     892.

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.68  -365.4    63.0  1382.5   88426.     960.   0.69

X STA.     -365.4     -249.5     -218.4     -190.2     -161.1     -131.6
  A(I)           187.3       86.3       81.3       83.8       85.1
  V(I)            0.26       0.56       0.59       0.57       0.56

X STA.     -131.6     -101.7      -71.9      -48.8      -36.0      -28.4
  A(I)            86.6       88.6       78.8       59.8       40.5
  V(I)            0.55       0.54       0.61       0.80       1.18

X STA.      -28.4      -18.9       -7.8        0.9        6.3       11.4
  A(I)            51.7       61.8       51.4       40.4       38.2
  V(I)            0.93       0.78       0.93       1.19       1.26

X STA.       11.4       16.7       22.5       30.3       40.2       63.0
  A(I)            39.3       40.9       46.6       51.7       82.5
  V(I)            1.22       1.17       1.03       0.93       0.58
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WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188             MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File bake042.wsp
        Hydraulic analysis for structure BAKETH00060042   Date: 21-MAY-97
        Town Highway 6 crossing "The Branch" in Bakersfield, VT         EMB
           *** RUN DATE & TIME: 05-04-98  07:33

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

EXIT2:XS   ******  -154.     265.  0.64 *****  495.72  495.08   1370.  495.08
      784. ******    87.   11867.  1.54 ***** *******    1.08    5.17

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "EXIT1"     KRATIO =  1.73

EXIT1:XS      33.  -102.     339.  0.34  0.25  495.97 *******   1370.  495.63
      817.    33.    91.   20498.  1.34  0.00    0.00    0.62    4.05

FULLV:FV      30.  -121.     375.  0.29  0.12  496.10 *******   1370.  495.81
      847.    30.    92.   22602.  1.41  0.00    0.01    0.58    3.65
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPR1":  TRIALS CONTINUED.
                FNTEST,FR#,WSEL,CRWS =  0.80     0.88     495.96     495.81
 ===110 WSEL NOT FOUND AT SECID "APPR1":  REDUCED DELTAY.
                     WSLIM1,WSLIM2,DELTAY =   495.31     510.38    0.50
 ===115 WSEL NOT FOUND AT SECID "APPR1":  USED WSMIN = CRWS.
                     WSLIM1,WSLIM2,CRWS =   495.31     510.38     495.81
 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "APPR1"     KRATIO =  0.43

APPR1:AS      45.   -53.     207.  0.75  0.39  496.71  495.81   1370.  495.96
      892.    45.    54.    9615.  1.10  0.23   -0.01    0.88    6.62
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   500.38       0.00      496.69     499.74
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   496.65      500.00      500.04     496.82
 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.

            <<<<<RESULTS REFLECTING THE CONSTRICTED FLOW FOLLOW>>>>>

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

BRIDG:BR      30.     0.     105.  1.52 *****  498.55  496.13   1040.  497.03
      847. ******    22.    6266.  1.00 ***** *******    0.79    9.88

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.500  0.000  496.82 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF    VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      859.    22.  0.00  0.01  500.51    0.00    337.  500.38

              Q    WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:      331.   241.  -241.     0.   0.6   0.5   3.3   2.8   0.6   2.8
   RT:        5.    18.    26.    45.   0.2   0.1   1.8   2.9   0.2   2.6

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

APPR1:AS      16.  -382.    1742.  0.01  0.03  500.51  495.81   1370.  500.50
      892.    18.    65.  123834.  1.16  0.74    0.00    0.08    0.79

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

                      <<<<<END OF BRIDGE COMPUTATIONS>>>>>

  FIRST USER DEFINED TABLE.

    XSID:CODE     SRD    LEW     REW       Q         K      AREA     VEL    WSEL
   EXIT2:XS      784.  -154.     87.   1370.   11867.      265.     5.17  495.08
   EXIT1:XS      817.  -102.     91.   1370.   20498.      339.     4.05  495.63
   FULLV:FV      847.  -121.     92.   1370.   22602.      375.     3.65  495.81
   BRIDG:BR      847.     0.     22.   1040.    6266.      105.     9.88  497.03
   RDWAY:RG      859.*******    331.    337.*********        0.     2.00  500.38
   APPR1:AS      892.  -382.     65.   1370.  123834.     1742.     0.79  500.50

    XSID:CODE   XLKQ   XRKQ       KQ
   APPR1:AS  **********************

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS      FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXIT2:XS     495.08     1.08  491.44  508.84************  0.64  495.72  495.08
   EXIT1:XS   ********     0.62  489.50  506.30  0.25  0.00  0.34  495.97  495.63
   FULLV:FV   ********     0.58  489.50  506.30  0.12  0.00  0.29  496.10  495.81
   BRIDG:BR     496.13     0.79  491.39  497.03************  1.52  498.55  497.03
   RDWAY:RG   ***************  499.74  511.70  0.00******  0.01  500.51  500.38
   APPR1:AS     495.81     0.08  492.17  510.38  0.03  0.74  0.01  500.51  500.50
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WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File bake042.wsp
        Hydraulic analysis for structure BAKETH00060042   Date: 21-MAY-97
        Town Highway 6 crossing "The Branch" in Bakersfield, VT         EMB
           *** RUN DATE & TIME: 05-04-98  07:33

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

EXIT2:XS   ******  -155.     352.  0.72 *****  496.16  495.44   1900.  495.44
      784. ******    89.   16134.  1.59 ***** *******    1.00    5.39

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "EXIT1"     KRATIO =  1.50

EXIT1:XS      33.  -151.     405.  0.50  0.31  496.44 *******   1900.  495.94
      817.    33.    93.   24206.  1.47  0.00   -0.02    0.78    4.69

FULLV:FV      30.  -204.     484.  0.39  0.16  496.61 *******   1900.  496.22
      847.    30.    94.   28283.  1.62  0.00    0.01    0.69    3.92
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPR1":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80     0.94     496.38     496.26
 ===110 WSEL NOT FOUND AT SECID "APPR1":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   495.72     510.38    0.50
 ===115 WSEL NOT FOUND AT SECID "APPR1":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =    495.72     510.38     496.26
 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPR1"     KRATIO =  0.45

APPR1:AS      45.   -59.     252.  0.98  0.45  497.35  496.26   1900.  496.37
      892.    45.    55.   12755.  1.11  0.30   -0.01    0.94    7.55
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   504.07        0.00     496.84     499.74
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   496.71     500.59     500.64     496.82
 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.
 ===265 ROAD OVERFLOW APPEARS EXCESSIVE.
                   QRD,QRDMAX,RATIO =     823.        709.    1.16

            <<<<<RESULTS REFLECTING THE CONSTRICTED FLOW FOLLOW>>>>>

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

BRIDG:BR      30.     0.     105.  1.63 *****  498.66  496.23   1076.  497.03
      847. ******    22.    6266.  1.00 ***** *******    0.82   10.23

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.500  0.000  496.82 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR      Q    WSEL
   RDWAY:RG     859.    22.  0.00  0.02  500.95    0.00    823.  500.75

              Q    WLEN    LEW    REW   DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     770.   266.  -266.     0.    1.0   0.8   4.3   3.6   1.0   2.9
   RT:      53.    62.    26.    88.    0.6   0.3   2.8   3.4   0.5   2.8

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

APPR1:AS      16.  -392.    1940.  0.02  0.05  500.96  496.26   1900.  500.94
      892.    19.    66.  144938.  1.13  0.94    0.00    0.09    0.98

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

                     <<<<<END OF BRIDGE COMPUTATIONS>>>>>

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW     REW      Q        K      AREA     VEL    WSEL
   EXIT2:XS     784.  -155.     89.   1900.   16134.     352.    5.39  495.44
   EXIT1:XS     817.  -151.     93.   1900.   24206.     405.    4.69  495.94
   FULLV:FV     847.  -204.     94.   1900.   28283.     484.    3.92  496.22
   BRIDG:BR     847.     0.     22.   1076.    6266.     105.   10.23  497.03
   RDWAY:RG     859.*******    770.    823.*********      0.    2.00  500.75
   APPR1:AS     892.  -392.     66.   1900.  144938.    1940.    0.98  500.94

    XSID:CODE   XLKQ   XRKQ       KQ
   APPR1:AS  ***********************

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL     WSEL
   EXIT2:XS    495.44    1.00  491.44  508.84************  0.72  496.16  495.44
   EXIT1:XS  ********    0.78  489.50  506.30  0.31  0.00  0.50  496.44  495.94
   FULLV:FV  ********    0.69  489.50  506.30  0.16  0.00  0.39  496.61  496.22
   BRIDG:BR    496.23    0.82  491.39  497.03************  1.63  498.66  497.03
   RDWAY:RG  ****************  499.74  511.70  0.00******  0.02  500.95  500.75
   APPR1:AS    496.26    0.09  492.17  510.38  0.05  0.94  0.02  500.96  500.94
```
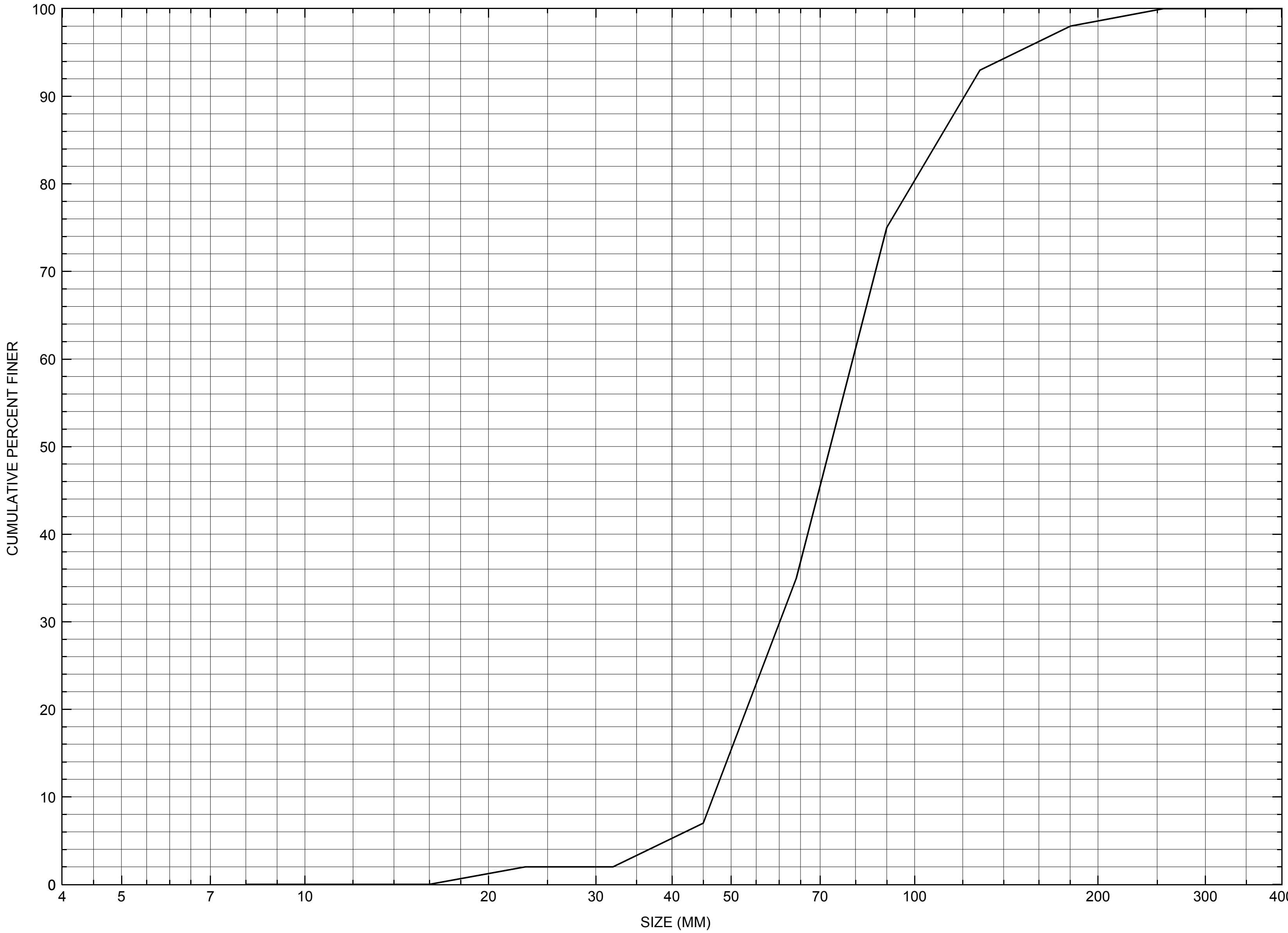

WSPRO OUTPUT FILE (continued)

```
WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188             MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File bake042.wsp
        Hydraulic analysis for structure BAKETH00060042   Date: 21-MAY-97
        Town Highway 6 crossing "The Branch" in Bakersfield, VT         EMB
           *** RUN DATE & TIME: 05-04-98  07:33

 XSID:CODE   SRDL    LEW     AREA   VHD    HF      EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO      ERR     FR#     VEL

EXIT2:XS   ******   -24.     145.  0.70 *****  495.17  494.17    960.  494.47
      784. ******    53.    7080.  1.02 ***** *******    0.86    6.63

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "EXIT1"     KRATIO =  2.27

EXIT1:XS      33.   -57.     265.  0.24  0.27  495.43 *******    960.  495.19
      817.    33.    88.   16045.  1.19  0.00    0.00    0.52    3.63

FULLV:FV      30.   -71.     285.  0.22  0.10  495.54 *******    960.  495.33
      847.    30.    89.   17318.  1.24  0.00    0.01    0.49    3.37
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPR1":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80     0.91     495.48     495.39
 ===110 WSEL NOT FOUND AT SECID "APPR1":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   494.83     510.38    0.50
 ===115 WSEL NOT FOUND AT SECID "APPR1":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   494.83     510.38     495.39
 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPR1"     KRATIO =  0.37

APPR1:AS      45.   -48.     157.  0.65  0.37  496.13  495.39    960.  495.48
      892.    45.    53.    6416.  1.11  0.22    0.00    0.91    6.11
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   495.91     498.47     498.52     496.82

 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.

            <<<<<RESULTS REFLECTING THE CONSTRICTED FLOW FOLLOW>>>>>

 XSID:CODE   SRDL    LEW     AREA   VHD    HF      EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO      ERR     FR#     VEL

BRIDG:BR      30.     0.     105.  1.30 *****  498.33  495.91    962.  497.03
      847. ******    22.    6266.  1.00 ***** *******    0.73    9.14

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   2.  0.497  0.000  496.82 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q   WSEL
   RDWAY:RG     859.         <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

 XSID:CODE   SRDL    LEW     AREA   VHD    HF      EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO      ERR     FR#     VEL

APPR1:AS      16.  -365.    1383.  0.01  0.03  499.69  495.39    960.  499.68
      892.    18.    63.   88439.  1.23  0.61    0.00    0.08    0.69

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   499.68

                     <<<<<END OF BRIDGE COMPUTATIONS>>>>>

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW      Q        K     AREA     VEL    WSEL
   EXIT2:XS     784.   -24.    53.    960.    7080.     145.    6.63  494.47
   EXIT1:XS     817.   -57.    88.    960.   16045.     265.    3.63  495.19
   FULLV:FV     847.   -71.    89.    960.   17318.     285.    3.37  495.33
   BRIDG:BR     847.     0.    22.    962.    6266.     105.    9.14  497.03
   RDWAY:RG     859.**************      0.*********       0.    2.00********
   APPR1:AS     892.  -365.    63.    960.   88439.    1383.    0.69  499.68

    XSID:CODE   XLKQ   XRKQ       KQ
   APPR1:AS  ***********************

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXIT2:XS    494.17    0.86  491.44  508.84************  0.70  495.17  494.47
   EXIT1:XS  ********    0.52  489.50  506.30  0.27  0.00  0.24  495.43  495.19
   FULLV:FV  ********    0.49  489.50  506.30  0.10  0.00  0.22  495.54  495.33
   BRIDG:BR    495.91    0.73  491.39  497.03************  1.30  498.33  497.03
   RDWAY:RG  ****************  499.74  511.70************  0.01  499.79********
   APPR1:AS    495.39    0.08  492.17  510.38  0.03  0.61  0.01  499.69  499.68
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure BAKETH00060042, in Bakersfield, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number BAKETH00060042

General Location Descriptive

Data collected by (First Initial, Full last name) E. BOEHMLER

Date (MM/DD/YY) 03 / 07 / 95

Highway District Number (I - 2; nn) 08

County (FIPS county code; I - 3; nnn) 011

Town (FIPS place code; I - 4; nnnnn) 02500

Mile marker (I - 11; nnn.nnn) 000000

Waterway (I - 6) THE BRANCH

Road Name (I - 7): -

Route Number TH006

Vicinity (I - 9) 0.1 MI TO JCT W VT108

Topographic Map Bakersfield

Hydrologic Unit Code: 02010007

Latitude (I - 16; nnnn.n) 44500

Longitude (i - 17; nnnnn.n) 72482

Select Federal Inventory Codes

FHWA Structure Number (I - 8) 10060100420601

Maintenance responsibility (I - 21; nn) 03

Maximum span length (I - 48; nnnn) 0023

Year built (I - 27; YYYY) 1923

Structure length (I - 49; nnnnnn) 000026

Average daily traffic, ADT (I - 29; nnnnnn) 000040

Deck Width (I - 52; nn.n) 234

Year of ADT (I - 30; YY) 93

Channel & Protection (I - 61; n) 5

Opening skew to Roadway (I - 34; nn) 00

Waterway adequacy (I - 71; n) 6

Operational status (I - 41; X) A

Underwater Inspection Frequency (I - 92B; XYY) N

Structure type (I - 43; nnn) 104

Year Reconstructed (I - 106) 0000

Approach span structure type (I - 44; nnn) 000

Clear span (nnn.n ft) 22.0

Number of spans (I - 45; nnn) 001

Vertical clearance from streambed (nnn.n ft) 5.5

Number of approach spans (I - 46; nnnn) 0000

Waterway of full opening (nnn.n ft^2) 121.0

Comments:

Structural inspection report of 8/23/93 indicates the structure is a concrete tee-beam type bridge. The abutments are concrete. The right abutment has alligator cracks overall, with deep spalling and section loss at the bottom on the upstream end. The upstream right wingwall has broken away from the abutment wall. The downstream right wingwall has broken away from the abutment and is missing (eroded away). Some stone fill protection has been put in its place to protect the embankment. The right abutment has a vertical crack located just left of the roadway centerline, and is undermined over nearly its entire base length about 0.5 to 1.0 foot. The left abutment has a diagonal crack 4 feet from **(Continued, page 34)**

Bridge Hydrologic Data

Is there hydrologic data available? N *if No, type ctrl-n h*   VTAOT Drainage area (mi^2): -

Terrain character: -

Stream character & type: -

Streambed material: -

Discharge Data *(cfs)*: $Q_{2.33}$ - Q_{10} - Q_{25} -

Q_{50} - Q_{100} - Q_{500} -

Record flood date *(MM / DD / YY)*: - / - / -   Water surface elevation *(ft)*: -

Estimated Discharge *(cfs)*: -   Velocity at Q - *(ft/s)*: -

Ice conditions *(Heavy, Moderate, Light)* : -   Debris *(Heavy, Moderate, Light)*: -

The stage increases to maximum highwater elevation (*Rapidly, Not rapidly*): -

The stream response is (*Flashy, Not flashy*): -

Describe any significant site conditions upstream or downstream that may influence the stream's stage: -

Watershed storage area (*in percent*): -%

The watershed storage area is: - (*1-mainly at the headwaters; 2- uniformly distributed; 3-immediatly upstream oi the site*)

Water Surface Elevation Estimates for Existing Structure:

Peak discharge frequency	$Q_{2.33}$	Q_{10}	Q_{25}	Q_{50}	Q_{100}
Water surface elevation (*ft*)	-	-	-	-	-
Velocity (*ft / sec*)	-	-	-	-	-

Long term stream bed changes: -

Is the roadway overtopped below the Q_{100}? (*Yes, No, Unknown*): U   Frequency: -

Relief Elevation (*ft*): -   Discharge over roadway at Q_{100} (ft^3/sec): -

Are there other structures nearby? (*Yes, No, Unknown*): U *If No or Unknown, type ctrl-n os*

Upstream distance (*miles*): -   Town: -   Year Built: -

Highway No. : -   Structure No. : -   Structure Type: -

Clear span (*ft*): -   Clear Height (*ft*): -   Full Waterway (ft^2): -

Downstream distance (*miles*): - Town: - Year Built: -
Highway No. : - Structure No. : - Structure Type: -
Clear span (*ft*): - Clear Height (*ft*): - Full Waterway (ft^2): -

Comments:

the downstream end. The crack is 1/2 inch wide at the top and narrows down the wall. Both of the wingwalls upstream and downstream have failed. The downstream left wingwall is tipped over in the channel and the upstream left wingwall is missing (possibly eroded away). The left abutment has fine cracks and deep spalling at the bottom upstream corner. A small gravel point bar is located along the left abutment. A "corduroy" log floor, which is deteriorating, is reported under the bridge.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **9.21** mi^2 Lake/pond/swamp area **0.04** mi^2
Watershed storage *(ST)* **0.4** %
Bridge site elevation **518** ft Headwater elevation **1910** ft
Main channel length **8.68** mi
10% channel length elevation **571** ft 85% channel length elevation **1083** ft
Main channel slope *(S)* **78.65** ft / mi

Watershed Precipitation Data

Average site precipitation - in Average headwater precipitation - in
Maximum 2yr-24hr precipitation event *(I24,2)* - in
Average seasonal snowfall *(Sn)* - ft

Bridge Plan Data

Are plans available? N* *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY)*: - / -

Project Number F151(3) Minimum channel bed elevation: -

Low superstructure elevation: USLAB - DSLAB - USRAB - DSRAB -

Benchmark location description:

-

Reference Point (*MSL, Arbitrary, Other*): - Datum (*NAD27, NAD83, Other*): -

Foundation Type: 4 (*1-Spreadfooting; 2-Pile; 3- Gravity; 4-Unknown*)

If 1: Footing Thickness - Footing bottom elevation: -

If 2: Pile Type: - (*1-Wood; 2-Steel or metal; 3-Concrete*) Approximate pile driven length: -

If 3: Footing bottom elevation: -

Is boring information available? N *If no, type ctrl-n bi* Number of borings taken: -

Foundation Material Type: 3 (*1-regolith, 2-bedrock, 3-unknown*)

Briefly describe material at foundation bottom elevation or around piles:

No foundation material information was available.

Comments:

***This bridge is shown in the plans under the project number shown above, but details on the bridge sub-structure are not present.**

Cross-sectional Data

Is cross-sectional data available? N *If no, type ctrl-n xs*

Source (*FEMA, VTAOT, Other*)? -

Comments: **NO CROSS SECTION INFORMATION**

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord to bed	-	-	-	-	-	-	-	-	-	-	-

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord to bed	-	-	-	-	-	-	-	-	-	-	-

Source (*FEMA, VTAOT, Other*)? -

Comments: **NO CROSS SECTION INFORMATION**

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord to bed	-	-	-	-	-	-	-	-	-	-	-

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord to bed	-	-	-	-	-	-	-	-	-	-	-

APPENDIX E:

LEVEL I DATA FORM

U. S. Geological Survey
Bridge Field Data Collection and Processing Form

Qa/Qc Check by: **RB** Date: **3/19/96**
Computerized by: **RB** Date: **3/20/96**
Reviewd by: **EMB** Date: **12/18/97**

Structure Number **BAKETH00060042**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **J** . **DEGNAN** Date *(MM/DD/YY)* **6** / **29** / 19**95**

2. Highway District Number **08** Mile marker **0000**

County **FRANKLIN (011)** Town **BAKERSFIELD (02500)**

Waterway *(I - 6)* **THE BRANCH** Road Name **-**

Route Number **TH 6** Hydrologic Unit Code: **02010007**

3. Descriptive comments:
Concrete guardrails are found on the bridge deck. This is a concrete T-beam bridge. The US and DS left wingwalls and the DS right wingwall have broken off. There is now stone fill protection in the location of the wingwalls. This bridge is located 0.1 mile from the junction with VT 108.

B. Bridge Deck Observations

4. Surface cover... LBUS **4** RBUS **4** LBDS **5** RBDS **5** Overall **5**
*(2b us,ds,lb,rb: **1**- Urban; **2**- Suburban; **3**- Row crops; **4**- Pasture; **5**- Shrub- and brushland; **6**- Forest; **7**- Wetland)*

5. Ambient water surface... US **2** UB **1** DS **1** *(**1**- pool; **2**- riffle)*

6. Bridge structure type **1** *(**1**- single span; **2**- multiple span; **3**- single arch; **4**- multiple arch; **5**- cylindrical culvert; **6**- box culvert; or **7**- other)*

7. Bridge length **26** *(feet)* Span length **23** *(feet)* Bridge width **23.4** *(feet)*

Road approach to bridge:

8. LB **0** RB **2** *(**0** even, **1**- lower, **2**- higher)*

9. LB **2** RB **2** *(**1**- Paved, **2**- Not paved)*

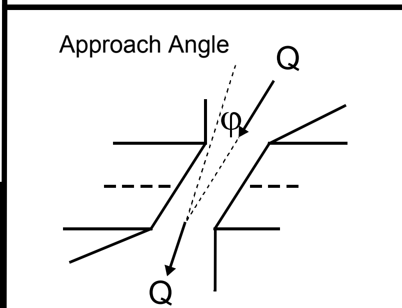
10. Embankment slope (*run / rise in feet / foot*):
US left **--** US right **--**

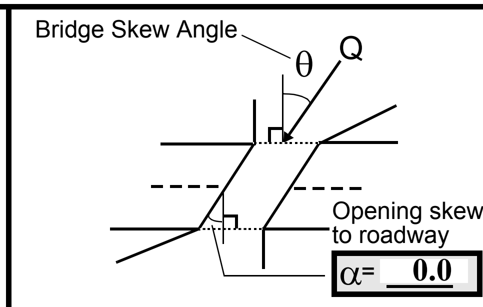
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	2	2	2	2
RBUS	0	-	0	-
RBDS	1	2	2	2
LBDS	0	-	2	2

*Bank protection types: **0**- none; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*
*Erosion: **0** - none; **1**- channel erosion; **2**- road wash; **3**- both; **4**- other*
*Erosion Severity: **0** - none; **1**- slight; **2**- moderate; **3**- severe*

Channel approach to bridge (BF):

15. Angle of approach: **10** 16. Bridge skew: **10**





17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **3**
Range? **185** feet **US** *(US, UB, DS)* to **130** feet **US**

Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **1**
Range? **75** feet **US** *(US, UB, DS)* to **0** feet **UB**

*Impact Severity: **0**- none to very slight; **1**- Slight; **2**- Moderate; **3**- Severe*

18. Bridge Type: **1a/1b**

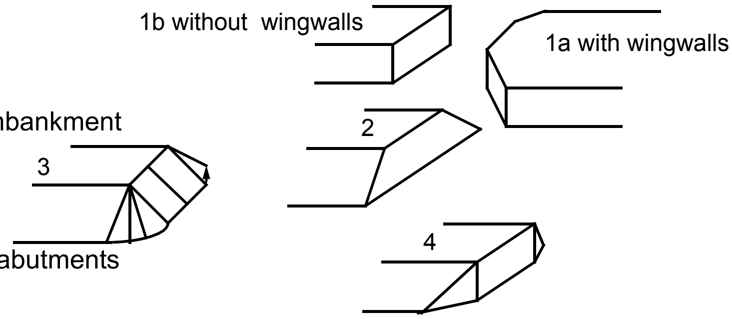
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

2- Vertical abutments and wingwalls, sloping embankment
Wingwalls parallel to abut. face

3- Spill through abutments

4- Sloping embankment, vertical wingwalls and abutments
Wingwall angle less than 90°.



19. Bridge Deck Comments (surface cover variations, measured bridge and span lengths, bridge type variations, approach overflow width, etc.)

4. The left bank DS is part wetland. The left bank US is partly shrub and brushland further upstream from the approach cross section.
5. The water surface changes from riffle to pool at the US bridge face.
17. The impact (zone 1) becomes less severe near the bridge.
18. The bridge had wingwalls but only the US right wingwall is still intact.
All protection at this site is dumped stone.

C. Upstream Channel Assessment

20. SRD	21. Bank height (BF) LB	21. Bank height (BF) RB	22. Bank angle (BF) LB	22. Bank angle (BF) RB	26. % Veg. cover (BF) LB	26. % Veg. cover (BF) RB	27. Bank material (BF) LB	27. Bank material (BF) RB	28. Bank erosion (BF) LB	28. Bank erosion (BF) RB
36.5	**1.5**			**6.5**	**1**	**2**	**324**	**324**	**1**	**2**

23. Bank width **20.0** 24. Channel width **20.0** 25. Thalweg depth **72.0** 29. Bed Material **342**

30 .Bank protection type: LB **1** RB **2** 31. Bank protection condition: LB **2** RB **1**

SRD - Section ref. dist. to US face *% Vegetation (Veg) cover: **1**- 0 to 25%; **2**- 26 to 50%; **3**- 51 to 75%; **4**- 76 to 100%*
*Bed and bank Material: **0**- organics; **1**- silt / clay, < 1/16mm; **2**- sand, 1/16 - 2mm; **3**- gravel, 2 - 64mm; **4**- cobble, 64 - 256mm; **5**- boulder, > 256mm; **6**- bedrock; **7**- manmade*
*Bank Erosion: **0**- not evident; **1**- light fluvial; **2**- moderate fluvial; **3**- heavy fluvial / mass wasting*
*Bank protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

32. Comments (bank material variation, minor inflows, protection extent, etc.):

30. The left bank protection consists of stone fill and broken pieces of concrete wingwall that extend about 10 feet upstream from the bridge face. It is uncertain whether or not the broken pieces of concrete are remnants of the missing wingwalls. The right bank protection stretches from 75 feet to 185 feet US along the severe impact zone. The right bank appears to have been built up with gravel from 160 feet US to the bridge.

33. Point/Side bar present? **Y** *(Y or N. if N type ctrl-n pb)* 34. Mid-bar distance: **150** 35. Mid-bar width: **7**

36. Point bar extent: **100** feet **US** *(US, UB)* to **160** feet **US** *(US, UB, DS)* positioned **0** %LB to **60** %RB

37. Material: **32**

38. Point or side bar comments (Circle Point or Side; Note additional bars, material variation, status, etc.):

The material grades from fine to coarse moving towards the right bank. There is another channel bar beginning about 15 feet US that extends to 30 feet US and is 8 feet wide. A small channel, 2 feet wide, separates it from the right bank.

39. Is a cut-bank present? **Y** *(Y or if N type ctrl-n cb)* 40. Where? **RB** *(LB or RB)*

41. Mid-bank distance: **66** 42. Cut bank extent: **55** feet **US** *(US, UB)* to **72** feet **US** *(US, UB, DS)*

43. Bank damage: **2** *(**1**- eroded and/or creep; **2**- slip failure; **3**- block failure)*

44. Cut bank comments (eg. additional cut banks, protection condition, etc.):

The cut-bank begins where the protection ends. The protection prevents a more severe cut-bank.

45. Is channel scour present? **Y** *(Y or if N type ctrl-n cs)* 46. Mid-scour distance: **66**

47. Scour dimensions: Length **17** Width **8** Depth : **1** Position **50** %LB to **100** %RB

48. Scour comments (eg. additional scour areas, local scouring process, etc.):

The scour hole is along the cut-bank. There is another small scour hole where the riffle turns to pool just US of the bridge face. It is 0.5 feet deep, 3 feet wide and 10 feet long.

49. Are there major confluences? **N** *(Y or if N type ctrl-n mc)* 50. How many? **-**

51. Confluence 1: Distance **-** 52. Enters on **-** *(LB or RB)* 53. Type **-** *(**1**- perennial; **2**- ephemeral)*

Confluence 2: Distance **-** Enters on **-** *(LB or RB)* Type **-** *(**1**- perennial; **2**- ephemeral)*

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES

D. Under Bridge Channel Assessment

55. Channel restraint (BF)? LB **2** RB ____ *(**1**- natural bank; **2**- abutment; **3**- artificial levee)*

56. Height (BF)		57 Angle (BF)		61. Material (BF)		62. Erosion (BF)	
LB	RB	LB	RB	LB	RB	LB	RB
52.0		**0.5**		**2**	**7**	**7**	**-**

58. Bank width (BF) **-** 59. Channel width (Amb) **-** 60. Thalweg depth (Amb) **90.0** 63. Bed Material **-**

*Bed and bank Material: **0**- organics; **1**- silt / clay, < 1/16mm; **2**- sand, 1/16 - 2mm; **3**- gravel, 2 - 64mm; **4**- cobble, 64 - 256mm; **5**- boulder, > 256mm; **6**- bedrock; **7**- manmade*

*Bank Erosion: **0**- not evident; **1**- light fluvial; **2**- moderate fluvial; **3**- heavy fluvial / mass wasting*

64. Comments (bank material variation, minor inflows, protection extent, etc.):

7324

The bed under the bridge is protected with logs tightly laid down from the US to the DS face perpendicular to flow. Some gravel has been deposited on the left bank side building a bar type structure. The right abutment is chipped, cracked, and scarred from the base to the low chord. The left abutment is in better condition.

65. Debris and Ice Is there debris accumulation? ____ (Y or N) 66. Where? N____ (**1**- Upstream; **2**- At bridge; **3**- Both)

67. Debris Potential -____ (**1**- Low; **2**- Moderate; **3**- High) 68. Capture Efficiency 1____ (**1**- Low; **2**- Moderate; **3**- High)

69. Is there evidence of ice build-up? 2___ (Y or N) Ice Blockage Potential Y____ (**1**- Low; **2**- Moderate; **3**- High)

70. Debris and Ice Comments:

2

The ice blockage potential is moderate because of the low velocity pool under the bridge. The capture efficiency is moderate because of the low opening.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		-	90	2	0	-	-	90.0
RABUT	1	10	90			2	5	22.0

Pushed: LB or RB *Toe Location (Loc.): **0**- even, **1**- set back, **2**- protrudes*
*Scour cond.: **0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**-undermined footing; **4**- piling exposed; **5**- settled; **6**- failed*
Materials: **1**- Concrete; **2**- Stone masonry or drywall; **3**- steel or metal; **4**- wood

79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):

0

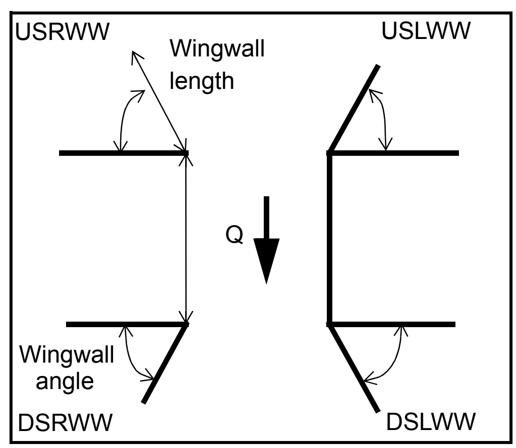
-

1

The structural inspection report of 8/23/93 indicated that the right abutment was undermined. Since then, the right abutment has settled slightly towards the US side, where the water impact is the greatest. The logs on the channel floor slope towards the right and there is less material between the on the right side compared to the left side.

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						22.0	
USRWW:	N		1		6	0.5	
DSLWW:	-		-		Y	23.5	
DSRWW:	1		5		0	23.5	



*Wingwall materials: **1**- Concrete; **2**- Stone masonry or drywall; **3**- steel or metal; **4**- wood*

82. Bank / Bridge Protection:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	-	6	N	-	-	2	-	-
Condition	N	-	1	-	-	2	-	-
Extent	1	-	6	0	2	0	0	-

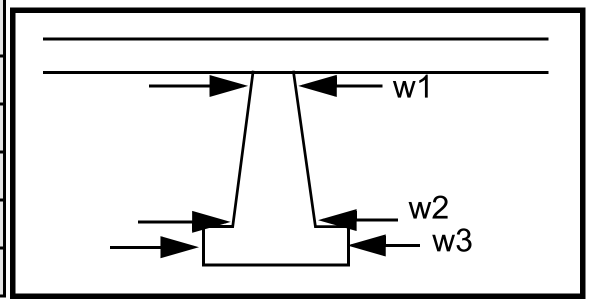
*Bank / Bridge protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank / Bridge protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*
*Protection extent: **1**- entire base length; **2**- US end; **3**- DS end; **4**- other*

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
0
-
-
0
-
-

Piers:

84. Are there piers? **Th** (Y or if N type ctrl-n pr)

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1	-			-	**95.0**	**11.0**
Pier 2	-	-	-	-	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**e US**	**walls**	**to**	**severel**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**left**	**have**	**road**	**y**	*1- Solid pier, 2- column, 3- bent*
88. Material	**and**	**falle**	**wash**	**erod**	*1- Wood; 2- concrete; 3- metal; 4- stone*
89. Shape	**both**	**n**	**ero-**	**ed**	*1- Round; 2- Square; 3- Pointed*
90. Inclined?	**the**	**back**	**sion.**	**and**	*Y- yes; N- no*
91. Attack ∠ (BF)	**DS**	**ward**	**The**	**has**	
92. Pushed	**right**	**s**	**US**	**set-**	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	**and**	**towa**	**right**	**tled.**	
95. Cross-members	**the**	**rds**	**wing**	**Ther**	*0- none; 1- laterals; 2- diagonals; 3- both*
96. Scour Condition	**DS**	**the**	**wall**	**e is a**	*0- not evident; 1- evident (comment); 2- footing exposed; 3- piling exposed; 4- undermined footing; 5- settled; 6- failed*
97. Scour depth	**left**	**bank**	**has**	**ver-**	
98. Exposure depth	**wing**	**due**	**been**	**tical**	

99. Pier comments (eg. undermined penetration, protection and protection extent, unusual scour processes, etc.):

crack in the concrete at the joint of the abutment and wingwall. The US right wingwall protection consists of some boulders at the US end of the wingwall.

N

E. Downstream Channel Assessment

100.

SRD	Bank height (BF) LB	Bank height (BF) RB	Bank angle (BF) LB	Bank angle (BF) RB	% Veg. cover (BF) LB	% Veg. cover (BF) RB	Bank material (BF) LB	Bank material (BF) RB	Bank erosion (BF) LB	Bank erosion (BF) RB
-	-			-	-	-	-	-	-	-

Bank width (BF) -   Channel width (Amb) -   Thalweg depth (Amb) -   Bed Material -

Bank protection type (Qmax): LB - RB -   Bank protection condition: LB - RB -

SRD - Section ref. dist. to US face   *% Vegetation (Veg) cover: **1**- 0 to 25%; **2**- 26 to 50%; **3**- 51 to 75%; **4**- 76 to 100%*
*Bed and bank Material: **0**- organics; **1**- silt / clay, < 1/16mm; **2**- sand, 1/16 - 2mm; **3**- gravel, 2 - 64mm; **4**- cobble, 64 - 256mm; **5**- boulder, > 256mm; **6**- bedrock; **7**- manmade*
*Bank Erosion: **0**- not evident; **1**- light fluvial; **2**- moderate fluvial; **3**- heavy fluvial / mass wasting*
*Bank protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

Comments (eg. bank material variation, minor inflows, protection extent, etc.):
-
-
-
-
-
-
-
-
-
-
-
-
-
-
-

101. Is a drop structure present? - (*Y or N, if N type ctrl-n ds*)   102. Distance: - feet

103. Drop: - feet   104. Structure material: - (***1**- steel sheet pile; **2**- wood pile; **3**- concrete; **4**- other*)

105. Drop structure comments (eg. downstream scour depth):
-
-
-
-
-
-

106. Point/Side bar present? - (Y or N. if N type ctrl-n pb) Mid-bar distance: - Mid-bar width: -

Point bar extent: - feet - (US, UB, DS) to - feet - (US, UB, DS) positioned - %LB to - %RB

Material: -

Point or side bar comments (Circle Point or Side; note additional bars, material variation, status, etc.):

-
-
-
-

Is a cut-bank present? N (Y or if N type ctrl-n cb) Where? O (LB or RB) Mid-bank distance: PIE

Cut bank extent: RS feet ____ (US, UB, DS) to ____ feet ____ (US, UB, DS)

Bank damage: ____ (**1**- eroded and/or creep; **2**- slip failure; **3**- block failure)

Cut bank comments (eg. additional cut banks, protection condition, etc.):

Is channel scour present? ____ (Y or if N type ctrl-n cs) Mid-scour distance: 1

Scour dimensions: Length 1 Width 23 Depth: 234 Positioned 2 %LB to 2 %RB

Scour comments (eg. additional scour areas, local scouring process, etc.):

324
2
2
3

Are there major confluences? 3 (Y or if N type ctrl-n mc) How many? The

Confluence 1: Distance bed Enters on mat (LB or RB) Type erial (**1**- perennial; **2**- ephemeral)

Confluence 2: Distance chan Enters on ges (LB or RB) Type fro (**1**- perennial; **2**- ephemeral)

Confluence comments (eg. confluence name):

m gravel to cobble moving from the scour hole pool area to the DS riffle at 55 feet DS. The bank protection consists of stone fill and broken concrete pieces that extend about 10 feet from the bridge face.

F. Geomorphic Channel Assessment

107. Stage of reach evolution ____

1- Constructed
2- Stable
3- Aggraded
4- Degraded
5- Laterally unstable
6- Vertically and laterally unstable

108. Evolution comments *(Channel evolution not considering bridge effects; See HEC-20, Figure 1 for geomorphic descriptors)*:

N

-

109. G. Plan View Sketch

- N

point bar (pb)	debris	flow (Q)	stone wall
cut-bank (cb)	rip rap or stone fill	cross-section	other wall
scour hole		ambient channel	

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number:	BAKETH00060042	Town:	Bakersfield
Road Number:	TH 6	County:	Franklin
Stream:	The Branch		

Initials EMB   Date: 5/3/98   Checked: MAI

Analysis of contraction scour, live-bed or clear water?

Critical Velocity of Bed Material (converted to English units)
Vc=11.21*y1^0.1667*D50^0.33 with Ss=2.65
(Richardson and Davis, 1995, p. 28, eq. 16)

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	1370	1900	960
Main Channel Area, ft2	426	456	370
Left overbank area, ft2	1316	1485	1013
Right overbank area, ft2	0	0	0
Top width main channel, ft	69	70	67
Top width L overbank, ft	379	388	361
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.2386	0.2386	0.2386
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	6.2	6.5	5.5
y1, average depth, LOB, ft	3.5	3.8	2.8
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	123772	145021	88426
Conveyance, main channel	41958	46588	33911
Conveyance, LOB	81814	98432	54515
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	0.0007	0.0000
Qm, discharge, MC, cfs	464.4	610.4	368.2
Ql, discharge, LOB, cfs	905.6	1289.6	591.8
Qr, discharge, ROB, cfs	0.0	0.0	0.0
Vm, mean velocity MC, ft/s	1.1	1.3	1.0
Vl, mean velocity, LOB, ft/s	0.7	0.9	0.6
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	9.4	9.5	9.2
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

Live-bed(1) or Clear-Water(0) Contraction Scour?			
Main Channel	0	0	0

Armoring
Dc=[(1.94*V^2)/(5.75*log(12.27*y/D90))^2]/[0.03*(165-62.4)]
Depth to Armoring=3*(1/Pc-1)

(Federal Highway Administration, 1993)

Downstream bridge face property	100-yr	500-yr	Other Q
Q, discharge thru bridge MC, cfs	1040	1076	960
Main channel area (DS), ft2	90	92	85
Main channel width (normal), ft	21.8	21.8	21.8
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	21.8	21.8	21.8
D90, ft	0.3960	0.3960	0.3960
D95, ft	0.4813	0.4813	0.4813
Dc, critical grain size, ft	0.5734	0.5821	0.5609
Pc, Decimal percent coarser than Dc	0.024	.022	.028
Depth to armoring, ft	N/A	N/A	N/A

Clear Water Contraction Scour in MAIN CHANNEL

y2 = (Q2^2/(131*Dm^(2/3)*W2^2))^(3/7)   Converted to English Units
ys=y2-y_bridge
(Richardson and Davis, 1995, p. 32, eq. 20, 20a)

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	1370	1900	960
(Q) discharge thru bridge, cfs	1040	1076	960
Main channel conveyance	6266	6266	6266
Total conveyance	6266	6266	6266
Q2, bridge MC discharge,cfs	1040	1076	960
Main channel area, ft2	105	105	105
Main channel width (normal), ft	21.8	21.8	21.8
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	21.8	21.8	21.8
y_bridge (avg. depth at br.), ft	4.83	4.83	4.83
Dm, median (1.25*D50), ft	0.29825	0.29825	0.29825
y2, depth in contraction,ft	4.80	4.94	4.48
ys, scour depth (y2-ybridge), ft	-0.03	0.11	-0.35

Pressure Flow Scour (contraction scour for orifice flow conditions)

Chang pressure flow equation   Hb+Ys=Cq*qbr/Vc
Cq=1/Cf*Cc   Cf=1.5*Fr^0.43 (<=1)   Cc=SQRT[0.10(Hb/(ya-w)-0.56)]+0.79 (<=1)
Umbrell pressure flow equation
(Hb+Ys)/ya=1.1021*[(1-w/ya)*(Va/Vc)]^0.6031
(Richardson and Davis, 1995, p. 144-146)

	Q100	Q500	OtherQ
Q, total, cfs	1370	1900	960
Q, thru bridge MC, cfs	1040	1076	960
Vc, critical velocity, ft/s	9.42	9.50	9.24
Va, velocity MC approach, ft/s	1.09	1.34	1.00
Main channel width (normal), ft	21.8	21.8	21.8
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	21.8	21.8	21.8
qbr, unit discharge, ft2/s	47.7	49.4	44.0
Area of full opening, ft2	105.3	105.3	105.3
Hb, depth of full opening, ft	4.83	4.83	4.83
Fr, Froude number, bridge MC	0.79	0.82	0.73
Cf, Fr correction factor (<=1.0)	1.00	1.00	1.00
**Area at downstream face, ft2	90	92	85
**Hb, depth at downstream face, ft	4.13	4.22	3.90
**Fr, Froude number at DS face	1.00	1.00	1.01
**Cf, for downstream face (<=1.0)	1.00	1.00	1.00
Elevation of Low Steel, ft	496.82	496.82	496.82
Elevation of Bed, ft	491.99	491.99	491.99
Elevation of Approach, ft	500.5	500.94	499.68
Friction loss, approach, ft	0.03	0.05	0.03
Elevation of WS immediately US, ft	500.47	500.89	499.65
ya, depth immediately US, ft	8.48	8.90	7.66
Mean elevation of deck, ft	502.94	502.94	502.94
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	0.82	0.79	0.87
**Cc, for downstream face (<=1.0)	0.79	0.79	0.79
Ys, scour w/Chang equation, ft	**1.34**	**1.75**	**0.62**
Ys, scour w/Umbrell equation, ft	-2.28	-1.82	-2.63

**=for UNsubmerged orifice flow using estimated downstream bridge face properties.

**Ys, scour w/Chang equation, ft	2.28	2.36	2.13
**Ys, scour w/Umbrell equation, ft	-1.58	-1.21	-1.70

In UNsubmerged orifice flow, an adjusted scour depth using the Laursen equation results and the estimated downstream bridge face properties can also be computed (ys=y2-ybridgeDS)

y2, from Laursen's equation, ft	4.80	4.94	4.48
WSEL at downstream face, ft	496.13	496.23	495.91
Depth at downstream face, ft	4.13	4.22	3.90
Ys, depth of scour (Laursen), ft	0.67	0.72	0.59

Abutment Scour

Froehlich's Abutment Scour
Ys/Y1 = 2.27*K1*K2*(a'/Y1)^0.43*Fr1^0.61+1
(Richardson and Davis, 1995, p. 48, eq. 28)

Characteristic	Left Abutment 100 yr Q	500 yr Q	Other Q	Right Abutment 100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	1370	1900	960	1370	1900	960
a', abut.length blocking flow, ft	382.4	391.6	365.4	43.3	44.4	41.2
Ae, area of blocked flow ft2	1227.8	1300.2	1037.7	216.9	224	185.7
Qe, discharge blocked abut.,cfs	0	0	619	0	0	149.8
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	0.70	0.88	0.60	0.89	1.11	0.81
ya, depth of f/p flow, ft	3.21	3.32	2.84	5.01	5.05	4.51
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	1	1	1	1	1	1
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	90	90	90	90	90	90
K2	1.00	1.00	1.00	1.00	1.00	1.00
Fr, froude number f/p flow	0.066	0.079	0.062	0.070	0.084	0.067
ys, scour depth, ft	14.05	15.78	12.42	**10.69**	**11.48**	**9.60**

HIRE equation (a'/ya > 25)
ys = 4*Fr^0.33*y1*K/0.55
(Richardson and Davis, 1995, p. 49, eq. 29)

a'(abut length blocked, ft)	382.4	391.6	365.4	43.3	44.4	41.2
y1 (depth f/p flow, ft)	3.21	3.32	2.84	5.01	5.05	4.51
a'/y1	119.10	117.94	128.67	8.64	8.80	9.14
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.07	0.08	0.06	0.07	0.08	0.07
Ys w/ corr. factor K1/0.55:						
vertical	**9.52**	**10.45**	**8.27**	ERR	ERR	ERR
vertical w/ ww's	7.81	8.57	6.78	ERR	ERR	ERR
spill-through	5.24	5.75	4.55	ERR	ERR	ERR

Abutment riprap Sizing

Isbash Relationship
D50=y*K*Fr^2/(Ss-1) and D50=y*K*(Fr^2)^0.14/(Ss-1)
(Richardson and Davis, 1995, p112, eq. 81,82)

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	1	1	1	1	1	1
y, depth of flow in bridge, ft	4.13	4.22	3.90	4.13	4.22	3.90
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR
Fr>0.8 (vertical abut.)	1.73	1.76	1.63	1.73	1.76	1.63