BRIDGE-SCOUR ANALYSIS ON CUCHILLO NEGRO CREEK AT THE INTERSTATE 25 CROSSING NEAR TRUTH OR CONSEQUENCES, NEW MEXICO

By Scott D. Waltemeyer

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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square foot (ft^2)	0.09290	square meter
square mile (mi^2)	2.590	square kilometer
cubic foot (ft^3)	0.02832	cubic meter
acre-foot (acre-ft)	1,233	cubic meter
foot per second (ft/s)	0.3048	meter per second
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
ton (short)	0.9072	metric tons
tons per day (tons/day)	0.9072	metric tons per day

Temperature in degrees Fahrenheit (°F) can be converted to degrees Celsius (°C) by the equation:

$$°C = 5/9\ (°F - 32)$$

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.

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ABSTRACT

A sediment-transport model that simulates channel change was applied to a reach of Cuchillo Negro Creek at the Interstate 25 crossing near Truth or Consequences, New Mexico. A 5,340-foot reach extending upstream and downstream from the crossing was modeled using the Bridge-Stream Tube model for Alluvial River Simulation (BRI-STARS).

The Federal Highway Administration has recommended that simulations of bed scour be based on extreme events such as the 500-year peak discharge. The 100-year peak discharge was estimated to be 6,290 cubic feet per second. The 500-year peak discharge was estimated to be 10,700 cubic feet per second for the Cuchillo Negro Creek site. The regional maximum-peak discharge was estimated to be 81,700 cubic feet per second, based on maximum-peak discharge data for 259 streamflow-gaging stations in New Mexico.

A bed-material sample was collected at the bed surface and at 13 feet below the bed surface, which was a depth greater than the anticipated scour depth. The median diameter was 4.6 millimeters at the bed surface and 9.0 millimeters 13 feet below the bed surface. Bed-material particle-size distribution was determined for six size classes ranging from 1 to 30 millimeters. Bed-material discharge was estimated at 18,770 tons per day using hydraulic properties, water temperature, and Yang's equation.

Channel-change simulations showed a maximum channel fill of 0.13 foot for a 500-year flood. Maximum contraction and channel scour of 1.38 feet were simulated for the regional maximum-peak discharge flood. Maximum total scour was simulated to be 5.72 feet for the 500-year flood and 8.74 feet for the regional maximum-peak discharge flood. The simulations showed about 10 feet of pile freeboard remaining after passage of the 500-year flood.

Historically, degradation has occurred at the bridges and the simulations of present channel conditions did not show the prior degradation. A hypothesis that the channel thalweg was not at equilibrium during the prior gravel mining was evaluated. Representation of present channel conditions was modified to simulate an excavation extending from about 500 feet below the downstream bridge to the end of the study reach. Simulations of the 500-year flood showed that degradation occurs at the upstream end of the hypothetical gravel mining area. The simulations showed a degradation at the peak discharge and a continuation of degradation throughout the flow event. The simulations used to evaluate this hypothesis show that the channel thalweg was not at equilibrium during the gravel mining and that bed material was subject to transport into the excavated area.

INTRODUCTION

Scour is defined as a lowering of the streambed below a natural level or below an assumed datum. Scour depth is the depth of bed material removed below the natural level or assumed datum. Total scour at or near bridges may result from a summation of scour from three categories of scour:

(1) Pier scour--streambed erosion caused by vortices and eddies around piers and abutments, which obstructs the flow path;
(2) Contraction scour--streambed erosion from increased flow velocities in or near bridge openings caused by contracted flow from approach embankments and piers; and
(3) Channel scour--progressive degradation of the streambed from a natural process or from some change in the control of the channel.

The Transportation Research Board of the National Research Council has implemented research efforts that address the problem of scour at bridge crossings in the United States. These efforts were identified after a major bridge crossing failure. Subsequently the Federal Highway Administration issued a technical advisory that provided policy and procedures for State highway departments to evaluate the vulnerability of the Federal Interstate Highway System to bridge failure due to potential scour. The National Cooperative Highway Research Program contracted for the development of the Bridge Stream Tube model for Alluvial River Simulations (BRI-STARS) (Molinas, 1990). The model is to be used for sediment-transport analysis at bridge sites classified as scour critical. The Federal Highway Administration presented these policies and procedures in Hydraulic Engineering Circular No. 18 (HEC-18) (Richardson and others, 1991).

In response to the technical advisory, the New Mexico State Highway and Transportation Department has identified about 30 scour-critical bridge locations in New Mexico. To address these concerns, the U.S. Geological Survey, in cooperation with the New Mexico State Highway and Transportation Department, conducted a study at one of these bridge locations, Cuchillo Negro Creek at the Interstate 25 crossing near Truth or Consequences, New Mexico. This scour-critical site also was selected because of a gravel mining operation immediately downstream and the newly constructed Cuchillo Negro Creek Dam upstream. Because this study was a prototype for a proposed statewide program, three theoretical peak-discharge situations were considered for comparing and evaluating extreme events: the 100-year peak discharge, the 500-year peak discharge, and the regional maximum-peak discharge. The development of the regional maximum-peak discharge was presented as a comparison with the 500-year peak discharge as an extreme event.

Purpose and Scope

This report presents prototype bridge-scour analysis results for the Cuchillo Negro Creek site at the Interstate 25 crossing near Truth or Consequences, New Mexico. The analysis includes development of theoretical flood hydrographs for the 100-year peak discharge, 500-year peak discharge, and a regional maximum-peak discharge. The flood hydrographs are used in the simulation of sediment-discharge and bridge scour at the site during these flood conditions.

Description of Study Site

The Interstate 25 bridges at the Cuchillo Negro Creek site were completed in 1970. The bridges are located about 5.3 mi downstream from Cuchillo Negro Creek Dam and about 1.5 mi north of Truth or Consequences. The drainage area at the site is 341 mi^2, which includes 16.6 mi^2 downstream from the dam. Cuchillo Negro Creek Dam, a flood-detention dam constructed by the U.S. Army Corps of Engineers, was completed in 1991. The reservoir formed by the dam has a capacity of 13,500 acre-ft at the spillway crest and a calculated sediment trap efficiency of 34 percent (U.S. Army Corps of Engineers, 1988). The degradation of the 5.3-mi reach downstream from the dam is expected to be a long-term process as the trap efficiency of the dam changes. The study reach and dam are shown in figure 1. The channel has a steep gradient, consisting of mostly gravel, and a wide, flat bottom insensitive to stage changes of the stage-discharge rating.

THEORETICAL INSTANTANEOUS PEAK DISCHARGE

The determination of peak discharge is critical to the analysis of bridge scour. The Federal Highway Administration recommends, in HEC-18, that bridge scour be evaluated for an extreme event, such as the 500-year peak discharge.

One-Hundred- and Five-Hundred-Year Peak Discharge

The 100-year peak discharge was used to determine the extreme event, or 500-year peak discharge, for the study site. To estimate the 500-year peak discharge from the 100-year peak discharge, the ordinate ratio of the peak-discharge frequencies is used, which is the ratio between the discharge ordinate of the probability density function for the 100-year peak discharge and the discharge ordinate of the probability density function for the 500-year peak discharge. The following discussion describes the determination of those peak discharges for the Cuchillo Negro Creek site at the Interstate 25 crossing.

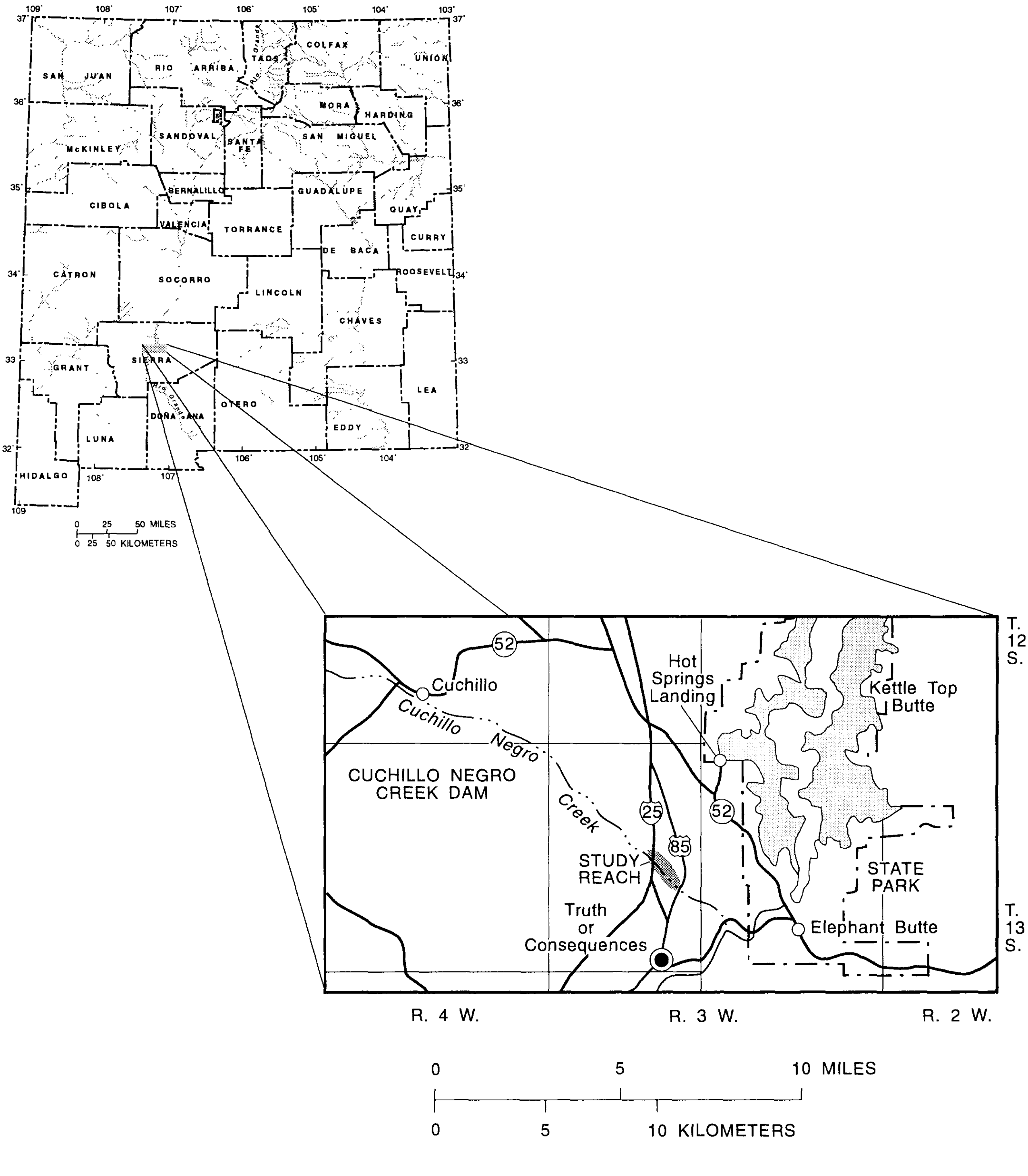

Figure 1.--Location of Interstate 25 bridge crossing, scour study reach, and Cuchillo Negro Creek Dam, New Mexico.

The 100-year peak discharge at the bridge is determined from the sum of the discharge at the dam and the discharge from the intervening drainage area downstream from the dam. The 100-year design outflow hydrograph for Cuchillo Negro Creek Dam, presented in a design memorandum of the U.S. Army Corps of Engineers (1988), was used for estimating the 100-year and 500-year peak discharges at the Cuchillo Negro Creek Interstate 25 crossing. The 100-year peak discharge from the dam is 2,700 ft^3/s. The discharge for the intervening drainage area downstream from the dam (16.6 mi^2 between Cuchillo Negro Creek Dam and the Interstate 25 crossing) was estimated using the regional regression equation for region 7 presented by Waltemeyer (1986):

$$Q_{100} = 932\, A^{0.48} \qquad (1)$$

where Q_{100} = peak discharge for the 100-year recurrence interval, in cubic feet per second; and
A = drainage area, in square miles.

The 100-year peak discharge from this area thus is estimated to be 3,590 ft^3/s. The peak discharge from the dam (2,700 ft^3/s) plus the peak discharge from the intervening drainage area (3,590 ft^3/s) is 6,290 ft^3/s.

The 500-year peak discharge was determined from the recommended ratio of 1.7 times the 100-year peak discharge (Richardson and others, 1991). The ordinate ratio for the New Mexico regional regression equation is 1.5 (Waltemeyer, 1986), which is considered in close agreement with the HEC-18-recommended ratio of 1.7. Nevertheless, the 1.7 ratio was used for a conservative estimate, and the 500-year peak discharge of 10,700 ft^3/s is estimated for the site.

Regional Maximum-Peak Discharge

For the design of major structures, unit-hydrograph techniques and an estimate of the probable maximum precipitation (PMP) are used to determine the probable maximum flood. As an alternative to determining the probable maximum flood from the PMP data, a regional maximum-peak discharge can be developed from observed maximum-peak discharge data. Maximum floodflows in the conterminous United States (Crippen and Bue, 1977) have been reported and may better represent an extreme event. Maximum floodflows were determined for this study and termed regional maximum-peak discharge; data are presented for New Mexico based on observed maximum-peak discharge data given in the peak-flow file section of WATSTORE (Water-Data Storage and Retrieval System) (Dempster, 1981). Maximum annual peak discharges for 259 unregulated streamflow-gaging stations in New Mexico as related to drainage area (Dempster, 1983) were used to construct an envelope curve or upper limit of maximum-peak discharge (fig. 2). The maximum-peak discharge of each annual series or the maximum-peak discharge of record and the threshold of this relation are known as the regional maximum-peak discharge. The envelope curves from Crippen and Bue (1977) that apply to New Mexico were for regions 12, 13, and 14 (fig. 2). The curves for regions 13 and 14 plot fairly closely to the curve used in this study, but the curve for region 12 is considerably higher. In the determination of the curve for region 12, maximum-peak discharge data for seven gaging stations were used, for region 13 data for five gaging stations were used, and for region 14 data for six gaging stations were used. The maximum-peak discharge data used for this study better define an envelope curve of regional maximum-peak discharge for New Mexico.

The regional maximum-peak discharge curve derived from New Mexico streamflow records is considered a better estimate than the curves from Crippen and Bue (1977). The following relation was developed from the New Mexico envelope curve and used for estimating the regional maximum-peak discharge for the Cuchillo Negro Creek site:

$$Q_{max} = 3{,}715A^{0.53} \quad (2)$$

where Q_{max} = regional maximum-peak discharge, in cubic feet per second; and
A = drainage area, in square miles.

The regional maximum-peak discharge for the 341-mi^2 drainage area of the Cuchillo Negro Creek site thus is estimated to be 81,700 ft^3/s. The assumption was made that for a flood of this magnitude, the upstream reservoir would have little attenuation effect on the flood hydrograph.

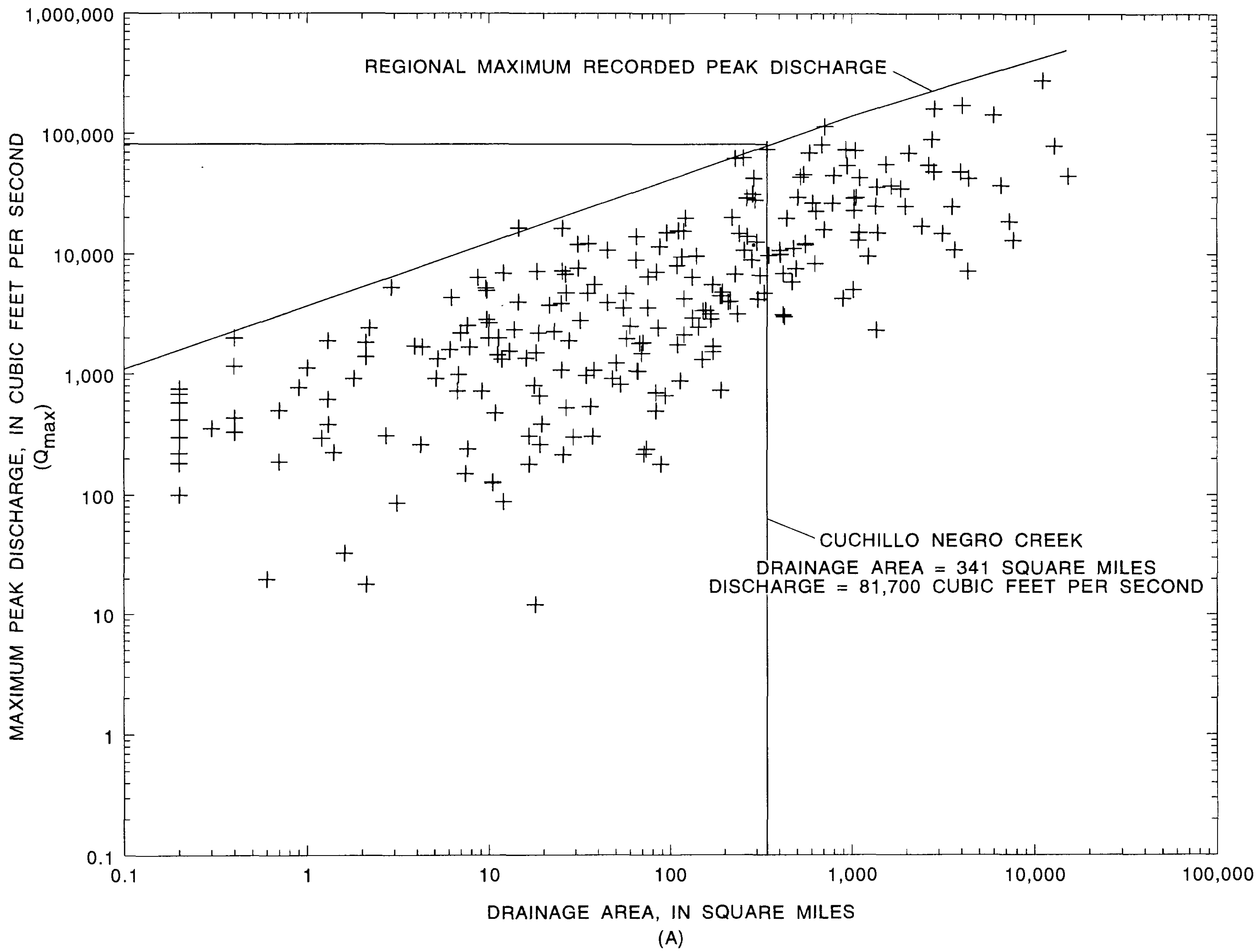

Figure 2.--Envelope curves and relation between maximum annual peak discharge and drainage area for unregulated streams in New Mexico.

DEVELOPMENT OF FLOOD HYDROGRAPHS

Bridge-scour analysis includes factors such as sediment-transport and local scour calculations at the bridges. Sediment-transport modeling requires flood hydrographs. Because the site is ungaged and as an alternative to rainfall/runoff modeling to estimate flow for a hydrograph, a synthetic (dimensionless) hydrograph approach using flood volumes was used for this prototype study. Theoretical flood hydrographs were determined for the 100-year peak discharge, 500-year peak discharge, and regional maximum-peak discharge. Flood volumes were estimated from the peak discharge and then used in a synthetic-hydrograph technique. Flood hydrographs were discretized for model input.

Theoretical Flood Hydrograph

Relations between peak discharge and flood volume have been determined from measured streamflow data for other areas. Such relations were determined for unregulated basins in the eastern part of Colorado (Livingston and Minges, 1987) and in Wyoming (Craig and Rankl, 1978). The following equation (Livingston and Minges, 1987) was used to estimate flood volume from a peak discharge:

$$V = 0.222\, Q_p^{0.866} \tag{3}$$

where V = flood volume, in acre-feet; and
Q_p = peak discharge, in cubic feet per second.

Synthetic hydrograph constants were used to develop the flood hydrograph from the following equations (Livingston and Minges, 1987):

$$Q' = Q_p/60 \tag{4}$$

where Q' = discharge constant, in cubic feet per second per discharge unit; and

$$T' = 0.746\, V/Q' \tag{5}$$

where T' = time constant, in minutes per time unit.

The dimensionless discharge and time units of the synthetic hydrograph and the calculations for the 500-year flood hydrograph using the 500-year peak discharge (10,700 ft^3/s) are listed in table 1. The same technique was used to develop the flood hydrographs for the 100-year and regional maximum-peak discharge shown in figure 3.

Table 1.--Example calculation of a synthetic hydrograph for the estimated 500-year peak discharge at the Cuchillo Negro Creek Interstate 25 crossing

Dimensionless hydrograph[1]		Constants[2]		Synthetic hydrograph[3]	
Time unit, t	Discharge unit q	Time constant (T′), in minutes per time unit	Discharge constant (Q′), in cubic feet per second per discharge unit	Time (t x T′), in minutes	Discharge (q x Q′), in cubic feet per second
0	0	2.87	178	0	0
3	5.6	2.87	178	8.61	997
5	13	2.87	178	14.4	2,310
7	25	2.87	178	20.1	4,450
10	49	2.87	178	28.7	8,720
11	57	2.87	178	31.6	10,100
12	60	2.87	178	34.4	10,700
13	59	2.87	178	37.3	10,500
14	55	2.87	178	40.2	9,790
18	38	2.87	178	51.7	6,760
23	23	2.87	178	66.0	4,090
30	12	2.87	178	86.1	2,140
40	5.2	2.87	178	115	926
50	2.0	2.87	178	144	356
60	0.5	2.87	178	172	89
70	0	2.87	178	201	0

[1]Livingston and Minges (1987).

[2]Based on an estimated 500-year peak discharge of 10,700 cubic feet per second and flood volumes of 685 acre-feet, the time and discharge constants are calculated as follows:

$Q' = Q_p / 60 = 10{,}700 / 60 = 178$ cubic feet per second per discharge unit; and
$T' = 0.746\ V / Q' = 0.746\ (685) / 178 = 2.87$ minutes per time unit.

[3]Synthetic hydrograph shown in figure 3.

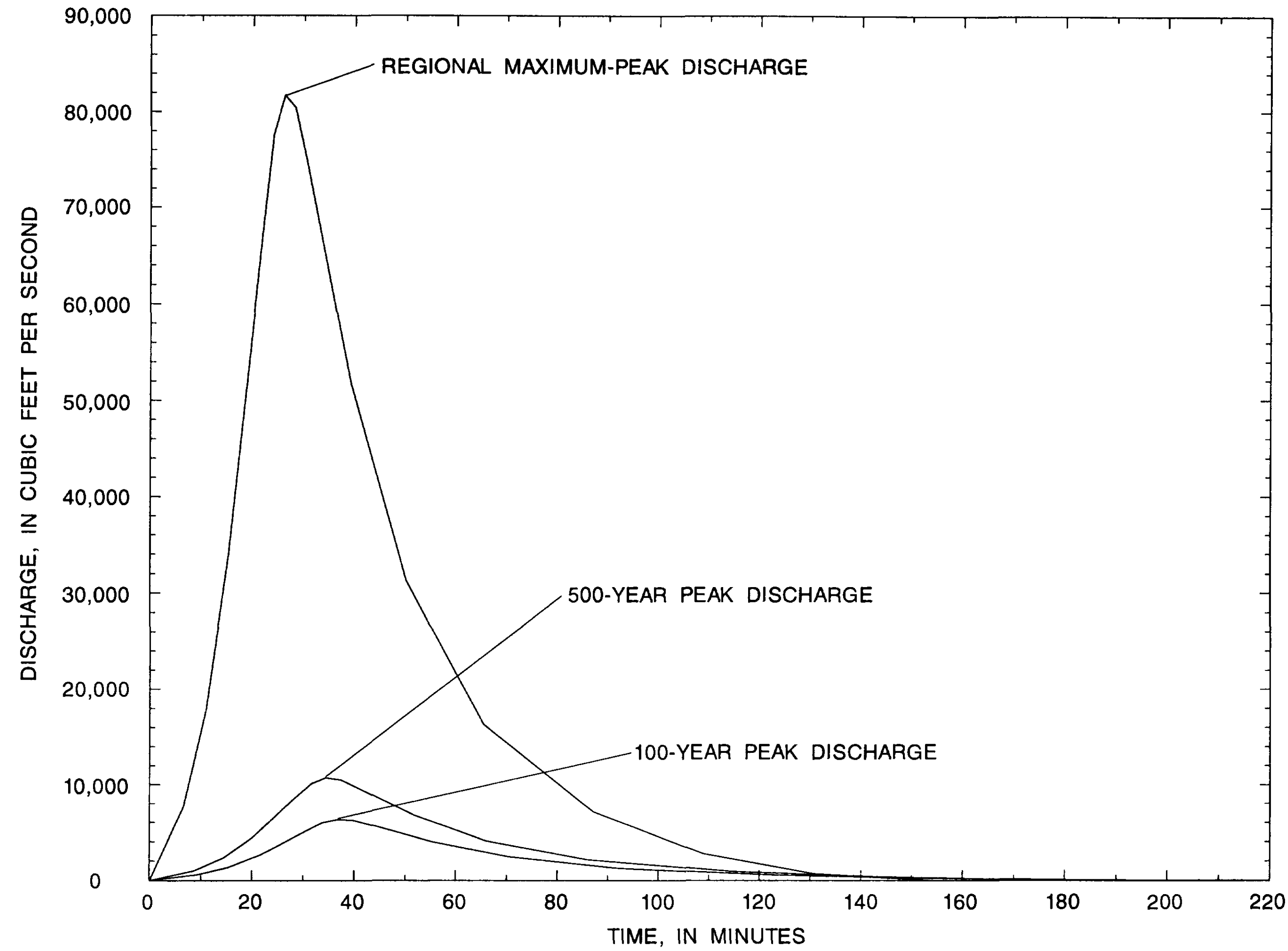

Figure 3.--Selected estimated synthetic flood hydrographs for the Cuchillo Negro Creek Interstate 25 crossing.

Discretization of Flood Hydrographs

The outflow from Cuchillo Negro Creek Dam was incorporated into the recession of the synthetic flood hydrographs, and the combined hydrographs were discretized for entry into the model. The 100-year outflow is a constant discharge of 2,700 ft^3/s. The 500-year flood hydrograph was determined on the same basis, using an ordinate ratio of 1.7 to obtain the 500-year outflow from Cuchillo Negro Creek Dam. The synthetic flood hydrograph for the regional maximum-peak discharge recession was drawn using graphical interpolation from the trends of the 100-year and 500-year flood hydrographs.

Discretization of the input flood hydrograph is a procedure required by the model. Graphical discretization methods were used for a fixed time increment or duration of 7.5 minutes for the 100-year and 500-year flood hydrographs and 5 minutes for the regional maximum-peak discharge, as shown in table 2. The duration of each combined hydrograph was 225 minutes; therefore, each hydrograph was broken into 30 discrete increments of constant discharges for the 100- and 500-year hydrographs and 45 increments for the regional maximum-peak discharge hydrograph as shown in attachment A (attachments A and B are in the back of the report) and table 2.

Table 2.--Synthetic and discretized 100-year, 500-year, and regional maximum-peak discharge flood data for the Cuchillo Negro Creek Interstate 25 crossing

[Time is in minutes; discharge is in cubic feet per second]

100-year				500-year				Regional maximum-peak discharge			
Synthetic		Discretized		Synthetic		Discretized		Synthetic		Discretized	
Time	Discharge	Time	Discharge	Time	Discharge	Time	Discharge	Time	Discharge	Time	Discharge
0	0	0	0	0	0	0	0	0	0	0	0
9.21	588	7.50	450	8.61	997	7.50	825	6.54	7,630	5.0	5,900
15.4	1,360	15.0	1,250	14.4	2,310	15.0	2,380	10.9	17,700	10.0	15,300
21.5	2,620	22.5	2,900	20.1	4,450	22.5	5,500	15.3	34,000	15.0	32,200
30.7	5,140	30.0	4,900	28.7	8,720	30.0	9,400	21.8	66,700	20.0	57,500
33.8	5,980	37.5	6,290	31.6	10,100	37.5	10,600	24.0	77,600	25.0	81,300
36.8	6,300	45.0	5,450	34.4	10,700	45.0	8,450	26.2	81,700	30.0	77,000
39.9	6,200	52.5	4,400	37.3	10,500	52.5	6,550	28.3	80,400	35.0	63,500
43.0	5,780	60.0	3,480	40.2	9,790	60.0	5,050	30.5	74,900	40.0	50,500
55.3	3,990	67.5	2,750	51.7	6,760	67.5	4,590	39.2	51,800	45.0	41,000
70.6	2,420	75.0	2,700	66.0	4,090	75.0	4,590	50.1	31,300	50.0	32,200
92.1	1,260	82.5	2,700	86.1	2,140	82.5	4,590	65.4	16,300	55.0	26,300
123	546	90.0	2,700	115	926	90.0	4,590	87.2	7,080	60.0	21,400
154	210	97.5	2,700	144	356	97.5	4,590	109	2,720	65.0	17,000
184	52.5	105.0	2,700	172	89	105.0	4,590	131	681	70.0	13,800
215	0	112.5	2,700	201	0	112.5	4,590	153	0	75.0	11,000
--	--	120.0	2,700	--	--	120.0	4,590	--	--	80.0	9,000
--	--	128.5	2,700	--	--	128.5	4,590	--	--	85.0	7,600

Table 2.--Synthetic and discretized 100-year, 500-year, and regional maximum-peak discharge flood data for the Cuchillo Negro Creek Interstate 25 crossing--Concluded

100-year				500-year				Regional maximum-peak discharge			
Synthetic		Discretized		Synthetic		Discretized		Synthetic		Discretized	
Time	Discharge	Time	Discharge	Time	Discharge	Time	Discharge	Time	Discharge	Time	Discharge
--	--	135.0	2,700	--	--	135.0	4,590	--	--	90.0	6,800
--	--	142.5	2,700	--	--	142.5	4,590	--	--	95.0	5,900
--	--	150.0	2,700	--	--	150.0	4,590	--	--	100	5,900
--	--	158.5	2,700	--	--	158.5	4,590	--	--	105	5,900
--	--	165.0	2,700	--	--	165.0	4,590	--	--	110	5,900
--	--	172.5	2,700	--	--	172.5	4,590	--	--	115	5,900
--	--	180.0	2,700	--	--	180.0	4,590	--	--	120	5,900
--	--	188.5	2,700	--	--	188.5	4,590	--	--	125	5,900
--	--	195.0	2,700	--	--	195.0	4,590	--	--	130	5,900
--	--	202.5	2,700	--	--	202.5	4,590	--	--	135	5,900
--	--	210.0	2,700	--	--	210.0	4,590	--	--	140	5,900
--	--	218.5	2,700	--	--	218.5	4,590	--	--	---	---
--	--	225.0	2,700	--	--	225.0	4,590	--	--	225	5,900

BRIDGE-SCOUR ANALYSIS

Simulations of sediment transport associated with channel scour or deposition and local bridge scour were performed using the Bridge-Stream Tube model for Alluvial River Simulation (BRI-STARS) computer model (Molinas, 1990). The sediment-transport equation presented by Yang (1984) was selected in the model because of its application to the gravel-size material. The Colorado State University equation, presented by Richardson and others (1991), was selected for the pier-scour calculations. Contraction scour was computed and combined with channel change as part of the sediment-transport computation.

Sediment Transport

Sediment transport was simulated for a 5,340-ft reach beginning 1,800 ft upstream from the Cuchillo Negro Creek Interstate 25 crossing and ending at the approach of the U.S. Highway 85 crossing (fig. 1), near a local gravel mining operation. This downstream gravel mining operation may affect the reach upstream at the bridge because of the increased slope of the thalweg of the creek downstream from the bridge. Bed material in the channel is in abundant supply. Data describing bed-material size distribution as determined and shown below were input to the model. Bed-material discharge was estimated using the computer program "Sediment-Discharge" (SEDDISCH) by Stevens (1989). Parameters for the computations included channel top width, average depth, average velocity, water temperature, water-surface slope, and median particle-size (D_{50}) for Yang's gravel equation (Yang, 1984). Results indicated a sediment discharge of 18,770 tons per day entering the reach.

Bed-material size distribution is a component of the sediment-transport equation used in the BRI-STARS model. One bed-material sample was collected at the streambed surface and another sample was collected, by excavating a hole with a backhoe, 13 ft below the surface to determine particle-size distribution. The sampling location was at the bridge approach section and the depth of anticipated scour was expected not to exceed 13 ft. Bed material in the channel is equally distributed across the channel and has no armored layer of nonerodible material. Drilling reports substantiate that the same gravel-size material is found at depths greater than 100 ft (Randy Menear, Bartoo Sand and Gravel, Inc., oral commun., 1993). Therefore, bedrock would not be penetrated in the possible scour zone.

U.S. standard size sieves were used for the particle-size analysis as presented by Guy and Norman (1970). Six size classes ranging from 1 to 30 millimeters were used. The material was separated by hand shaking; a mechanical shaker was not needed. The particle-size distribution is shown in figure 4 and in the table following figure 4.

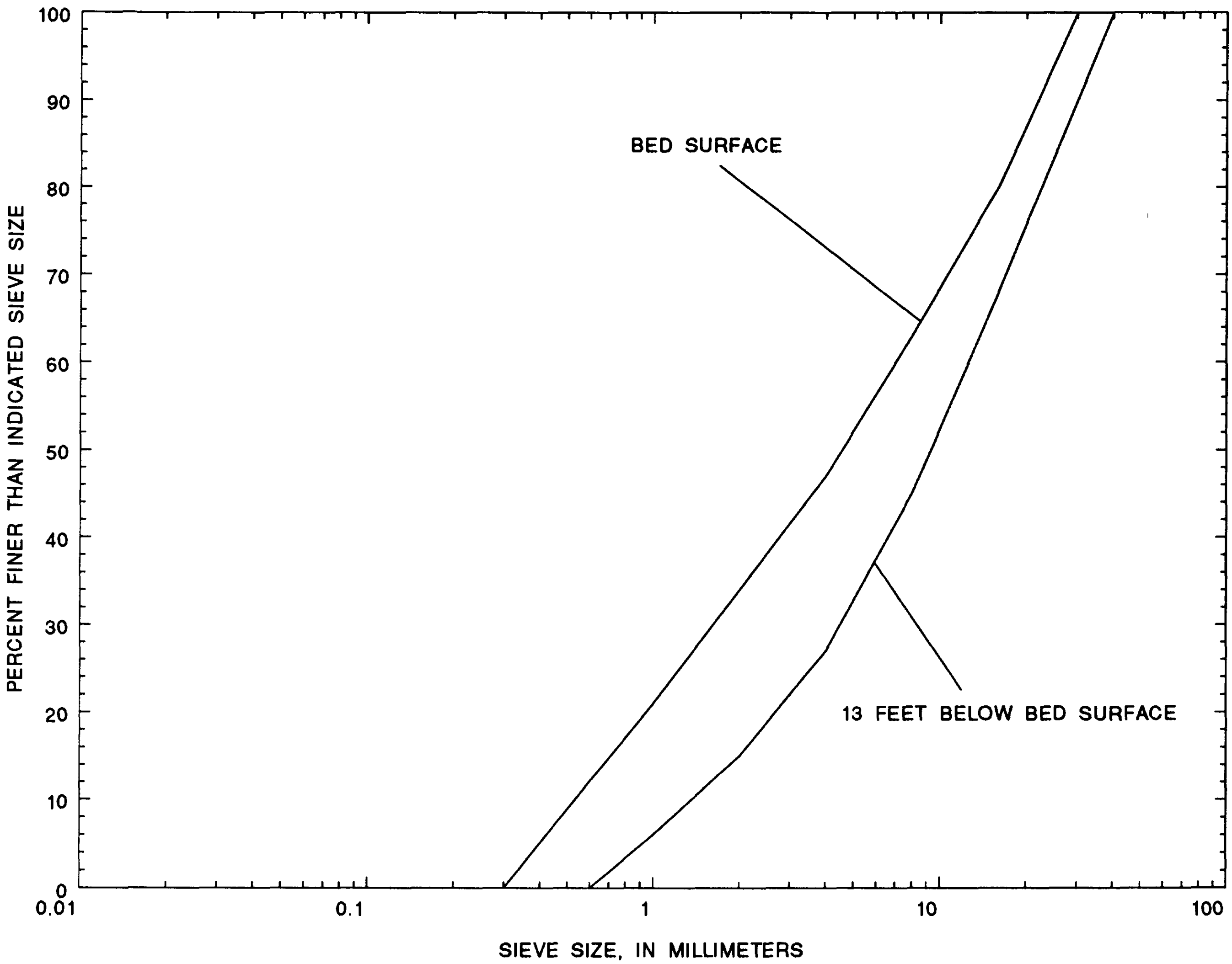

Figure 4.--Particle-size distribution for the bed material at the Cuchillo Negro Creek Interstate 25 crossing.

Sieve size (millimeters)	Particle-size distribution: Percent, by weight, retained by indicated sieve size: Bed surface	13 ft below bed surface	Cumulative percent, by weight, retained by indicated sieve size[1]: Bed surface	13 ft below bed surface
1	21	6	21	6
2	13	9	34	15
4	13	12	47	27
8	16	18	63	45
16	17	23	80	68
30	20	32	100	100

[1]Distribution is shown graphically in figure 4.

The median diameter (D_{50}) was 4.6 millimeters for the bed-surface sample and 9.0 millimeters for the sample collected 13 ft below the bed surface. Material collected 13 ft below the bed surface was available for use in the model to represent material size if scour to that depth occurred. The surface bed-material size distribution was used as input to the model.

Bridge-Scour Simulations

Simulations were performed with the BRI-STARS model assuming the following conditions. BRI-STARS model documentation indicated that two stream tubes were adequate to represent the condition of a wide, flat, alluvial stream channel. Fixed boundary conditions were assumed to appraise the maximum possible vertical degradation. Channel degradation at bridge crossings is a major component for bridge failure and the maximum case scenario should be evaluated. Water temperature was assumed during model simulations to be 8 °C, based on data collected during typical summer runoff. The theoretical flows were super-critical approaching the bridges. The channel expands and the flow regime becomes sub-critical. The flow regimes from the bridges and throughout the gravel mining area are super-critical, critical, and sub-critical. Simulated water-surface levels do not encroach the setback abutments; therefore, abutment scour calculations were not required, only pier scour calculations were required. Simulation results were compared between two bridge conditions: clear conditions and 3 ft of debris accumulation on the pilings. Example input data to the model for the 500-year flood hydrograph are listed in attachment A. Selected output data from the sediment-transport and local bridge-scour computations are listed in attachment B.

Contraction and channel scour, pier scour, and total scour for the various simulations at the Cuchillo Negro Creek site are summarized in table 3. The 500-year flood hydrograph was used to evaluate the extreme-event possibility recommended by HEC-18, which resulted in a maximum channel fill of 0.13 ft at the upstream bridge. The corresponding maximum pier scour was 5.85 ft. The total scour of 5.72 ft was determined by combining the maximum channel fill with the pier scour. Initial, at-peak, and after-flow channel-bed altitude profiles and the computed 500-year water-surface profile for sediment transport are shown in figure 5. The regional maximum-peak discharge flood hydrograph also was simulated; maximum contraction and channel scour were 1.38 ft, and maximum pier scour was 7.36 ft. Maximum total scour was 8.74 ft (table 3).

Table 3.--Simulated maximum contraction, channel, pier, and total scour at the Cuchillo Negro Creek Interstate 25 crossing for various estimated conditions

[+, channel fill; -, channel scour]

Bridge conditions	Maximum contraction and channel scour or fill at bridge[1] (feet)		Maximum pier scour at bridge (feet)		Maximum total scour (feet)
	Upstream	Downstream	Upstream	Downstream	
	100-year flood				
Clear piles	-0.13	+0.25	-2.76	-2.46	-2.89
3 feet of debris	-0.13	+0.25	-6.19	-4.65	-6.32
	500-year flood				
Clear piles	+0.13	+0.03	-2.76	-2.76	-2.73
3 feet of debris	+0.13	+0.03	-5.85	-5.24	-5.72
	Regional maximum-peak discharge flood				
Clear piles	+1.57	-1.38	-2.76	-2.76	-4.14
3 feet of debris	+1.57	-1.38	-7.36	-7.36	-8.74

[1] Contraction scour is included in the channel scour or fill computation.

The simulation for the 500-year flood discharge at the Cuchillo Negro Creek site showed about 10 ft of pile freeboard remaining after maximum total scour of 8.74 ft. The freeboard determination was based on the bottom of the pile bent altitude, which is 4,325 ft above sea level, as obtained from the bridge plans of the New Mexico State Highway and Transportation Department. The bridge-site cross section showing the remaining amount of pile freeboard for the simulated 500-year flood is shown in figure 6.

The present channel conditions used for the aforementioned modeling represent a channel bed slope at equilibrium; however, previous channel degradation has been observed at the bridges. Since bridge construction, observed scour from 1970 to 1992 has been about 4 ft at the upstream bridge and about 8 ft at the downstream bridge, based on the bridge plans and existing (1992) cross-section surveys (fig. 6). No records are available to document the magnitude of the discharge that has degraded the channel at the bridge since construction. The prior channel degradation is hypothesized to result from the changing channel-bed conditions caused by downstream gravel mining. Bed material in the vicinity of the bridges was transported to the area of gravel mining. Simulations to test this hypothesis were evaluated by modeling a hypothetical gravel mining condition. Representation of present channel conditions was modified to simulate an excavation extending from about 500 feet below the downstream bridge to the end of the study reach. Simulations of the 500-year flood showed that degradation occurs at the upstream end of the hypothetical gravel mining area. The simulations showed a degradation at the peak discharge and a continuation of degradation throughout the flow event. This indicates that the channel thalweg was not at equilibrium and that bed material was subject to transport in the vicinity of the bridges and into the excavated area.

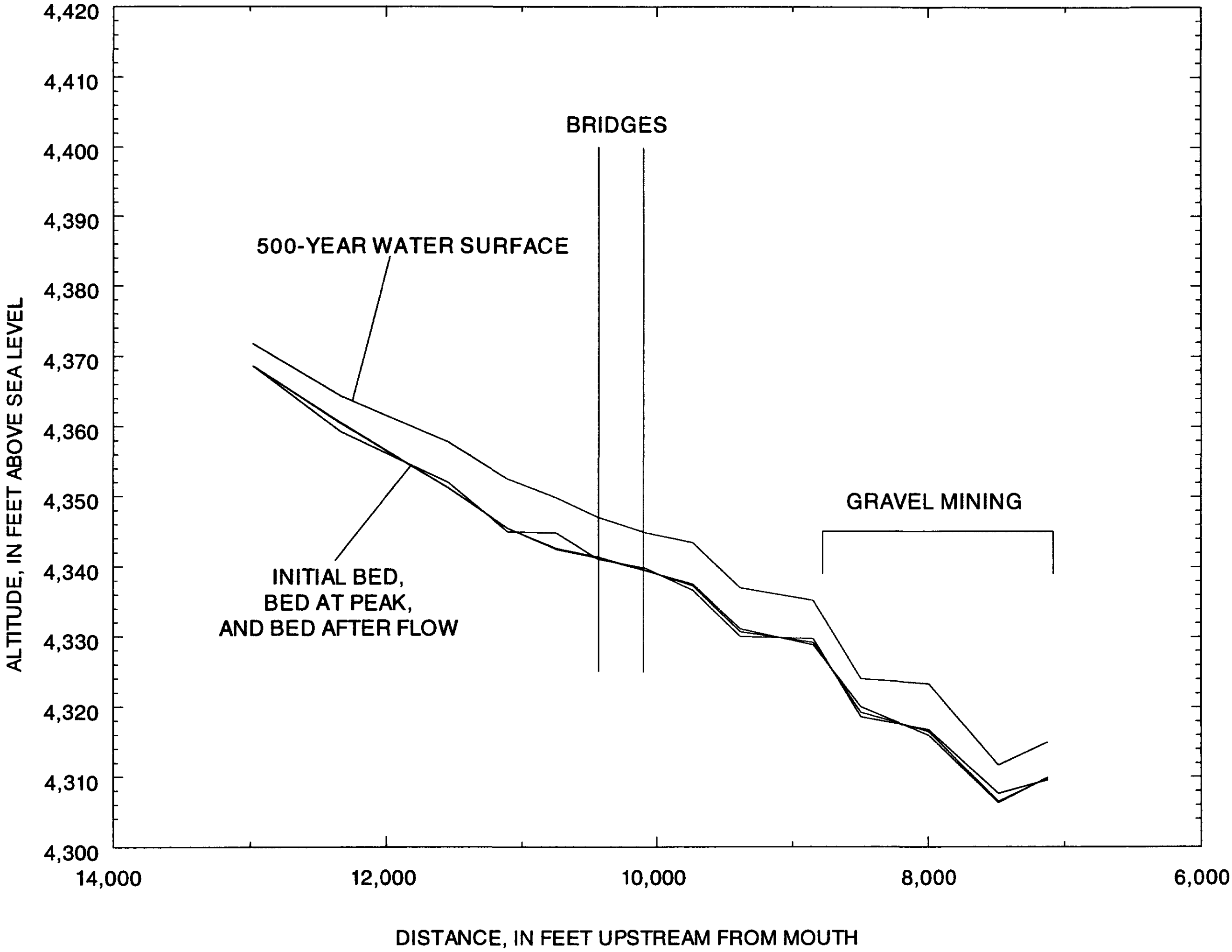

Figure 5.--Simulated initial, at-peak, and after-flow channel-bed altitude and water-surface profiles for the 500-year flood for the Cuchillo Negro Creek Interstate 25 crossing.

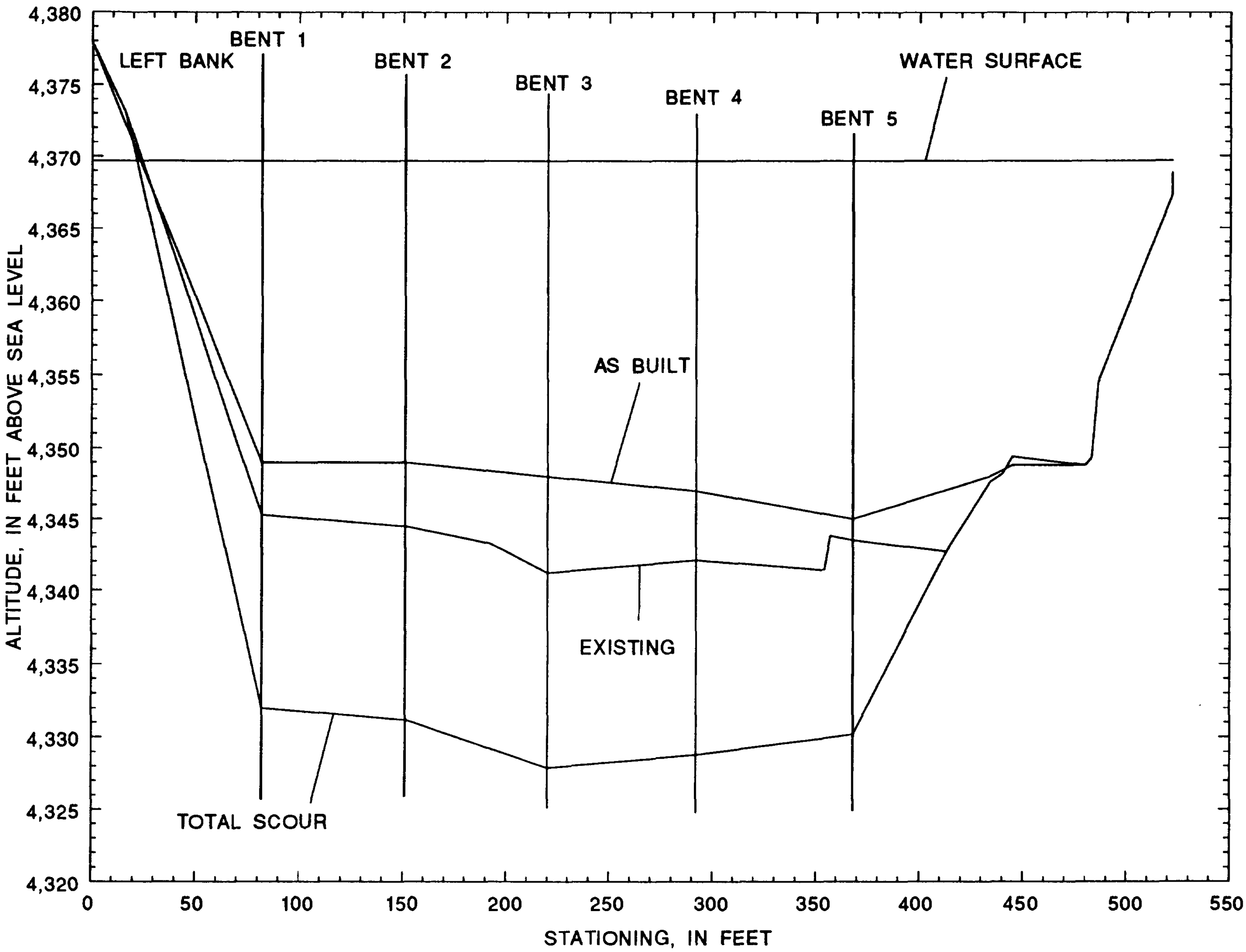

Figure 6.--Comparison of streambed after simulated total scour for the 500-year water surface with the as-built and existing upstream bridge cross section at the Cuchillo Negro Creek Interstate 25 crossing.

SUMMARY

A sediment-transport model simulating channel change was applied to a 5,340-ft reach of Cuchillo Negro Creek at the Interstate 25 crossing near Truth or Consequences, New Mexico, using the Bridge-Stream Tube model for Alluvial River Simulation (BRI-STARS). The model was used to simulate possible contraction and channel scour or deposition and pier scour at the site. The 100-year peak discharge was estimated to be 6,290 cubic feet per second. The 500-year peak discharge for the Cuchillo Negro Creek site was estimated to be 10,700 ft^3/s. The regional maximum-peak discharge for the site was estimated to be 81,700 ft^3/s, based on maximum-peak discharge data for 259 streamflow-gaging stations in New Mexico.

Synthetic flood hydrographs were developed from a flood-volume relation with peak discharge and a dimensionless hydrograph approach. The 100-year, 500-year, and regional maximum-peak discharge synthetic flood hydrographs were discretized for the model, and the estimated outflow from Cuchillo Negro Creek Dam was incorporated into the recession of the flood hydrographs.

Bed-material samples were collected at the bed surface and at 13 ft below the bed surface, which was a depth greater than the anticipated scour depth. The median diameter was 4.6 millimeters at the bed surface and 9.0 millimeters 13 ft below the bed surface. Bed-material particle-size distribution was determined for six size classes ranging from 1 to 30 millimeters. Bed-material discharge for use in the model was estimated to be 18,770 tons per day using hydraulic properties, water temperature, and Yang's gravel equation.

Channel-change simulations showed maximum channel fill of 0.13 ft for a 500-year flood. Maximum contraction and channel scour of 1.38 ft were simulated for the regional maximum-peak discharge flood. Maximum total scour was simulated to be 5.72 ft for the 500-year flood and 8.74 ft for the regional maximum-peak discharge flood. The simulations showed about 10 ft of pile freeboard after passage of the 500-year flood. Observed channel scour since bridge construction was about 4 ft around the upstream bridge and about 8 ft around the downstream bridge. The magnitude of the discharge that has degraded the channel is unknown. Therefore, the model cannot simulate scour that has occurred.

Historically, degradation has occurred at the bridges, and the simulations of present channel conditions did not show the prior observed degradation. A hypothesis that the channel thalweg was not at equilibrium during the prior gravel mining was evaluated. Representation of present channel conditions was modified to simulate an excavation extending from about 500 feet below the downstream bridge to the end of the study reach. Simulations of the 500-year flood showed that degradation occurs at the upstream end of the hypothetical gravel mining area. The simulations showed a degradation at the peak discharge and a continuation of degradation throughout the flow event. The simulations used to evaluate this hypothesis show that the channel thalweg was not at equilibrium during gravel mining and that bed material was subject to transport into the excavated area.

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Attachment A. Input data for the computer program for the sediment-transport and scour simulation of the 500-year flood hydrograph at Cuchillo Negro Creek near Truth or Consequences, New Mexico

[Datum to model output is 4,178.42 feet]

```
T1
T2
T3        500 YEAR HYDROGRAPH
NS  14.0
ST 12980    10.0     0.0     0.0    0.00    1.00
ND   1.0   590.0
XS 195.9    0.00  190.20   43.00  191.10  123.00  192.00  203.00  190.40   295.0
XS 190.4  362.00  191.40  415.00  191.80  482.00  196.90  533.00  194.80   590.0
ST 12330    18.0     0.0     0.0    0.00    1.00
ND   1.0  1007.0
XS 188.2    0.00  188.40  110.00  185.10  151.00  182.10  159.00  184.20   165.0
XS 183.3  179.00  184.40  193.00  182.60  211.00  184.40  246.00  184.70   294.0
XS 182.4  305.00  182.20  357.00  183.30  425.00  184.30  496.00  184.60   569.0
XS 188.8  591.00  187.90  799.00  187.30 1007.00
ST 11540     9.0     0.0     0.0    0.00    1.00
ND   1.0   342.0
XS 181.5    0.00  180.70  102.00  172.80  106.00  175.20  173.00  174.70   242.0
XS 176.6  244.00  182.20  299.00  181.50  318.00  184.80  342.00
ST 11100    10.0     0.0     0.0    0.00    1.00
ND   1.0   206.0
XS 181.8    0.00  173.60   53.00  167.00   58.00  169.50  107.00  170.60   111.0
XS 170.7  152.00  169.60  154.00  169.50  188.00  170.90  201.00  177.00   206.0
ST 10740    17.0     0.0     0.0    0.00    1.00
ND   1.0   419.0
XS 183.4    0.00  177.90   22.00  175.70  131.00  169.80  133.00  167.60   149.0
XS 168.7  179.00  166.50  180.00  167.10  202.00  164.00  306.00  175.90   313.0
XS 177.6  319.00  173.60  334.00  174.70  346.00  174.50  366.00  175.00   369.0
XS 174.8  393.00  174.23  419.00
ST 10430    18.0     0.0     0.0    0.00    1.00
ND   1.0   522.0
XS 199.5    0.00  194.70   16.00  166.90   82.00  166.10  151.00  164.90   192.0
XS 162.8  220.00  163.70  292.00  163.00  354.00  165.40  357.00  165.10   368.0
XS 164.3  413.00  169.20  434.00  169.80  440.00  171.00  445.00  170.40   480.0
XS 170.9  483.00  176.10  486.00  188.90  522.00
ST 10080     8.0     0.0     0.0    0.00    1.00
ND   1.0   528.0
XS 197.5    0.00  164.00   86.00  163.00  160.00  162.50  232.00  161.00   305.0
XS 162.8  378.00  168.20  457.00  186.40  528.00
ST  9730     8.0     0.0     0.0    0.00    1.00
ND   1.0   241.0
XS 172.3    0.00  159.40    0.00  159.10   79.00  160.40   91.00  160.80   162.0
XS 165.2  164.00  168.10  184.00  169.10  241.00
ST  9380    10.0     0.0     0.0    0.00    1.00
ND   1.0   207.0
```

Attachment A. Input data for the computer program for the sediment-transport and scour simulation of the 500-year flood hydrograph at Cuchillo Negro Creek near Truth or Consequences, New Mexico--Continued

```
XS 165.0    0.00  155.30    0.00  155.10   87.00  152.70  126.00  156.60  129.0
XS 157.3  169.00  158.50  174.00  159.40  186.00  163.20  194.00  164.70  207.0
ST  8840    11.0     0.0     0.0    0.00    1.00
ND   1.0   380.0
XS 164.2    0.00  156.00   77.00  156.30  106.00  151.40  112.00  150.90  164.0
XS 150.7  215.00  151.90  218.00  151.40  312.00  150.40  315.00  153.10  379.0
XS 168.1  380.00
ST  8490    10.0     0.0     0.0    0.00    1.00
ND   1.0   425.0
XS 156.8    0.00  146.40  101.00  145.30  188.00  142.70  206.00  141.60  299.0
XS 146.8  311.00  143.90  375.00  145.80  411.00  150.10  425.00  170.10  425.0
ST  7990    10.0     0.0     0.0    0.00    1.00
ND   1.0   421.0
XS 153.2    0.00  149.10   11.00  148.70   64.00  144.60   74.00  141.80  173.0
XS 137.5  331.00  139.90  348.00  142.70  354.00  139.80  368.00  165.80  421.0
ST  7480    10.0     0.0     0.0    0.00    1.00
ND   1.0   392.0
XS 137.0    0.00  131.90   21.00  131.20   83.00  127.90  112.00  128.10  163.0
XS 130.1  183.00  130.70  204.00  135.80  243.00  134.10  378.00  137.60  392.0
ST  7120    16.0     1.0     1.0    0.00    1.00
ND   1.0   568.0
XS 145.1    0.00  139.80   74.00  134.00  146.00  131.80  152.00  131.50  176.0
XS 135.6  187.00  134.80  271.00  134.60  307.00  132.70  315.00  133.10  322.0
XS 134.4  323.00  135.80  384.00  134.00  488.00  143.20  502.00  143.90  521.0
XS 146.0  568.00
RE      MANNING
RH0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.030
RH0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.030
RH0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300
RH0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300
RH0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.030
RH0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.030
RH0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300
RH0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.030
RH0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300
RH0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300
RH0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300
RH0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.030
RH0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.030
RH0.0300
RH0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.030
RH0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.030
RH0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.030
RH0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.0300  0.030
RH0.0300  0.0300  0.0300  0.0300  0.0300  0.0300
```

Attachment A. Input data for the computer program for the sediment-transport and scour simulation of the 500-year flood hydrograph at Cuchillo Negro Creek near Truth or Consequences, New Mexico--Continued

```
CE   0.0     0.6
CL0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.000
CL0.0000  0.0000  0.0000  1.0000
CB       THALWEG
NT   2.0
IT  45.0      1.0.0034722     .10      30
QQ       TABLE OF DISCHARGES
SS       STAGE DISCHARGE TABLE
TL  14.0
SQ   825 136.74
SQ  2380 136.92
SQ  5500 137.28
SQ  9400 137.73
SQ 10600 137.87
SQ  8450 137.62
SQ  6550 137.40
SQ  5050 137.23
SQ  4590 137.18
SQ  4590 137.18
SQ  4590 137.18
SQ  4590 137.18
SQ  4590 137.18
SQ  4590 137.18
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SQ  4590 137.18
SQ  4590 137.18
```

Attachment A. Input data for the computer program for the sediment-transport and scour simulation of the 500-year flood hydrograph at Cuchillo Negro Creek near Truth or Consequences, New Mexico--Continued

```
SQ  4590 137.18
SQ  4590 137.18
SQ  4590 137.18
SQ  4590 137.18
SQ  4590 137.18
SQ  4590 137.18
SQ  4590 137.18
SQ  4590 137.18
SQ  4590 137.18
SO      SEDIMENT TRANSPORT IS REQUESTED
QS  45.0   18770
SE   1.0    1000
TM  45.0   46.00
SF   6.0
SG 0.300   1.000
SG 1.000   2.000
SG 2.000   4.000
SG 4.000   8.000
SG 8.000  16.000
SG16.000  30.000
SD 0.210   0.130   0.130   0.160   0.170   0.200
SD 0.210   0.130   0.130   0.160   0.170   0.200
SD 0.210   0.130   0.130   0.160   0.170   0.200
SD 0.210   0.130   0.130   0.160   0.170   0.200
SD 0.210   0.130   0.130   0.160   0.170   0.200
SD 0.210   0.130   0.130   0.160   0.170   0.200
SD 0.210   0.130   0.130   0.160   0.170   0.200
SD 0.210   0.130   0.130   0.160   0.170   0.200
SD 0.210   0.130   0.130   0.160   0.170   0.200
SD 0.210   0.130   0.130   0.160   0.170   0.200
SD 0.210   0.130   0.130   0.160   0.170   0.200
SD 0.210   0.130   0.130   0.160   0.170   0.200
SD 0.210   0.130   0.130   0.160   0.170   0.200
SD 0.210   0.130   0.130   0.160   0.170   0.200
PE   1.0     2.0
PS   6.0     5.0
PP  82.0    3.20     5.0    00.0   61.00   4.600
PP 151.0    3.20     5.0    00.0   61.00   4.600
PP 220.0    3.20     5.0    00.0   61.00   4.600
PP 292.0    3.20     5.0    00.0   61.00   4.600
PP 368.0    3.20     5.0    00.0   61.00   4.600
PS   7.0     6.0
PP  32.0    3.20     5.0    00.0   61.00   4.600
PP 109.0    3.20     5.0    00.0   61.00   4.600
PP 149.0    3.20     5.0    00.0   61.00   4.600
```

Attachment A. Input data for the computer program for the sediment-transport and scour simulation of the 500-year flood hydrograph at Cuchillo Negro Creek near Truth or Consequences, New Mexico--Concluded

```
PP 189.0    3.20     5.0    00.0   61.00   4.600
PP 229.0    3.20     5.0    00.0   61.00   4.600
PP 269.0    3.20     5.0    00.0   61.00   4.600
PR   1.0     1.0
PV   5.0     0.0     0.0   0.000   0.000     0.0
PV   6.0     0.0     0.0   0.000   0.000     0.0
PV   7.0     0.0     0.0   0.000   0.000     0.0
PL      PLOTTING IS REQUESTED
PX      CHANNEL CROSS SECTION PLOTS         14.0
PW      WATER SURFACE PROFILE PLOTS          1.0
MN      NO MINIMIZATION REQUESTED
```

Attachment B. Selected output data from the computer program for the sediment-transport and scour simulation of the 500-year flood hydrograph at Cuchillo Negro Creek near Truth or Consequences, New Mexico, for one time increment at the peak discharge

[Datum to model output is 4,178.42 feet]

```
************************************************
*           BRI-STARS VER  3.3   OUTPUT        *
************************************************


          TIME STEP NO      :          5
          TIME IN DAYS      :      .0174
          DISCHARGE (CFS)   :   10600.00
```

CRITICAL DEPTH	CRITICAL W.S. ELV
3.4854	193.6854
4.2327	186.2133
7.5420	180.3260
8.1989	175.1801
7.3996	171.5516
5.1281	168.0563
4.8963	165.9533
5.7893	164.6468
7.7062	159.9898
4.7109	155.4734
6.5909	147.3915
6.7564	144.8163
7.1947	135.2440
6.2544	137.6757

```
************************************
*   NORMAL DEPTH PROPERTIES TABLE  *
************************************
```

STA. ID	BOTTOM ELEV	BOTTOM SLOPE	FLOW AREA	NORM FLOW VELOCITY	FR. NO.	NORMAL DEPTH	NORMAL W.S. ELV.
12980	190.20	.126E-01	.10755E+04	9.86	1.193	.31991E+01	.19340E+03
12330	181.98	.126E-01	.10144E+04	10.45	1.280	.38929E+01	.18587E+03
11540	172.78	.116E-01	.71857E+03	14.75	1.302	.65743E+01	.17936E+03
11100	166.98	.132E-01	.67276E+03	15.76	1.378	.70785E+01	.17406E+03
10740	164.15	.786E-02	.83408E+03	12.71	1.073	.72082E+01	.17136E+03
10430	162.93	.395E-02	.13227E+04	8.01	.768	.56525E+01	.16858E+03
10080	161.06	.535E-02	.12167E+04	8.71	.855	.53093E+01	.16637E+03
9730	158.86	.628E-02	.87561E+03	12.11	.934	.61481E+01	.16501E+03
9380	152.28	.188E-01	.62906E+03	16.85	1.651	.63345E+01	.15862E+03
8840	150.76	.282E-02	.13942E+04	7.60	.643	.60582E+01	.15682E+03
8490	140.80	.285E-01	.57357E+03	18.48	2.340	.48114E+01	.14561E+03
7990	138.06	.548E-02	.10948E+04	9.68	.957	.68961E+01	.14496E+03
7480	128.05	.196E-01	.63557E+03	16.68	1.835	.52645E+01	.13331E+03
7120	131.42	-.937E-02	.99999E+05	.00	.001	.99990E+03	.99999E+05

Attachment B. Selected output data from the computer program for the sediment-transport and scour simulation of the 500-year flood hydrograph at Cuchillo Negro Creek near Truth or Consequences, New Mexico, for one time increment at the peak discharge--Continued

ISWITCH	STA.	Z	WSE	ITYP
1	12980.000	190.200	193.685	1
0	12330.000	181.981	.000	0
0	11540.000	172.784	.000	0
0	11100.000	166.981	.000	0
0	10740.000	164.152	.000	0
0	10430.000	162.928	.000	0
0	10080.000	161.057	.000	0
0	9730.000	158.857	.000	0
0	9380.000	152.284	.000	0
0	8840.000	150.763	.000	0
0	8490.000	140.801	.000	0
0	7990.000	138.060	.000	0
0	7480.000	128.049	.000	0
1	7120.000	131.421	137.870	1

```
*******************************************
*     RESULTS OF BACKWATER COMPUTATIONS    *
*      DISCHARGE =    10600.00    C.F.S.   *
*******************************************
```

STA NO.	STATION (FT)	BOTTOM ELEVATN	WATER SURF. ELEVATION	FLOW AREA	AVERAGE VELOCITY	ENER. GRADE ELEVATION	FROUDE NUMBER
1	12980.0	190.20	193.69	1213.4	8.74	194.932	1.00
2	12330.0	181.98	185.83	993.4	10.67	187.821	1.32
3	11540.0	172.78	179.36	718.6	14.75	182.976	1.30
4	11100.0	166.98	174.31	710.9	14.91	178.026	1.27
5	10740.0	164.15	171.41	843.0	12.57	174.050	1.06
6	10430.0	162.93	169.00	1469.6	7.21	169.881	.66
7	10080.0	161.06	168.44	1979.0	5.36	168.916	.43
8	9730.0	158.86	164.65	816.8	12.98	167.332	1.00
9	9380.0	152.28	158.80	661.8	16.02	163.151	1.54
10	8840.0	150.76	155.47	1004.0	10.56	157.236	1.00
11	8490.0	140.80	145.76	610.2	17.37	151.557	2.20
12	7990.0	138.06	144.82	1052.3	10.07	146.601	1.02
13	7480.0	128.05	141.24	3412.0	3.11	141.411	.20
14	7120.0	131.42	137.87	1244.1	8.52	139.192	.92

STREAM TUBE NO. = 1

STA NO	AREA (SQ. FT.)	VELOCITY (FT/SEC)	HYDRAULIC DEPTH (FT)	STUBE BGN (FT)	STUBE END (FT)
1	621.48	8.53	2.42	16.71	273.49
2	494.52	10.72	2.34	140.99	352.61

Attachment B. Selected output data from the computer program for the sediment-transport and scour simulation of the 500-year flood hydrograph at Cuchillo Negro Creek near Truth or Consequences, New Mexico, for one time increment at the peak discharge--Continued

3	332.52	15.94	5.40	102.68	164.26
4	324.59	16.33	5.43	48.58	108.31
5	469.61	11.29	3.99	132.48	250.29
6	755.09	7.02	3.84	77.26	273.73
7	1017.22	5.21	5.26	74.73	268.10
8	385.81	13.74	5.64	.00	68.39
9	337.98	15.68	3.98	.00	84.87
10	479.76	11.05	3.98	107.09	227.74
11	295.19	17.95	2.39	138.33	262.05
12	595.87	8.89	2.81	73.47	285.40
13	1560.28	3.40	10.43	.00	149.63
14	588.47	9.01	3.21	97.64	281.17

STREAM TUBE NO. = 2

STA NO	AREA (SQ. FT.)	VELOCITY (FT/SEC)	HYDRAULIC DEPTH (FT)	STUBE BGN (FT)	STUBE END (FT)
1	591.89	8.95	2.60	273.49	500.85
2	498.86	10.62	2.24	352.61	575.79
3	386.05	13.73	3.61	164.26	271.11
4	386.29	13.72	4.05	108.31	203.78
5	373.36	14.20	6.22	250.29	310.32
6	714.50	7.42	4.48	273.73	433.08
7	961.75	5.51	5.07	268.10	457.93
8	431.03	12.30	4.52	68.39	163.76
9	323.86	16.37	3.42	84.87	179.48
10	524.20	10.11	3.46	227.74	379.14
11	315.03	16.82	2.42	262.05	412.07
12	456.44	11.61	4.97	285.40	377.28
13	1851.71	2.86	7.64	149.63	392.00
14	655.61	8.08	3.08	281.17	493.93

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*    SEDIMENT ROUTING RESULTS FOR STREAM TUBE NO.  1    *
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STA NO.	TOT. LOAD (TONS)	CHANGE (FT)	DIRECTN. OF CHANGE	SEDIMENT LOAD FOR SIZE FRACTIONS (CU.FT) 1	2	3	4	5	6
1	32.6	.00	DEPTH	83.	51.	51.	63.	67.	79.
2	590.3	-.08	DEPTH	4522.	1313.	149.	285.	380.	487.
3	604.0	.00	DEPTH	5057.	1472.	72.	153.	227.	322.
4	594.5	.01	DEPTH	4937.	1443.	76.	160.	236.	336.

Attachment B. Selected output data from the computer program for the sediment-transport and scour simulation of the 500-year flood hydrograph at Cuchillo Negro Creek near Truth or Consequences, New Mexico, for one time increment at the peak discharge--Continued

5	348.8	.12	DEPTH	2673.	859.	84.	153.	199.	250.
6	92.4	.09	DEPTH	646.	255.	44.	60.	58.	53.
7	24.4	.02	DEPTH	171.	81.	14.	14.	10.	5.
8	384.9	-.19	DEPTH	3067.	982.	66.	128.	176.	235.
9	816.5	-.21	DEPTH	6877.	1889.	98.	214.	325.	470.
10	330.6	.19	DEPTH	2523.	815.	82.	149.	191.	237.
11	1669.6	-.44	DEPTH	14295.	3389.	187.	449.	735.	1131.
12	283.8	.31	DEPTH	2075.	680.	98.	164.	193.	220.
13	1.7	.07	DEPTH	11.	7.	1.	0.	0.	0.
14	236.3	-.07	DEPTH	1700.	583.	86.	140.	163.	184.

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*   SEDIMENT ROUTING RESULTS FOR STREAM TUBE NO. 2   *
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STA NO.	TOT. LOAD (TONS)	CHANGE (FT)	DIRECTN. OF CHANGE	SEDIMENT LOAD FOR SIZE FRACTIONS (CU.FT) 1	2	3	4	5	6
1	32.6	.00	DEPTH	83.	51.	51.	63.	67.	79.
2	595.3	-.08	DEPTH	4521.	1311.	158.	300.	399.	508.
3	598.9	.00	DEPTH	4756.	1386.	112.	227.	321.	439.
4	551.0	.03	DEPTH	4419.	1307.	96.	193.	273.	373.
5	386.4	.10	DEPTH	3124.	993.	59.	116.	161.	218.
6	95.9	.12	DEPTH	683.	270.	40.	56.	56.	54.
7	26.7	.02	DEPTH	183.	86.	16.	17.	13.	8.
8	367.7	-.16	DEPTH	2850.	917.	79.	148.	197.	255.
9	906.9	-.22	DEPTH	7450.	2012.	133.	290.	441.	639.
10	312.5	.20	DEPTH	2347.	762.	88.	155.	193.	232.
11	1546.5	-.46	DEPTH	13288.	3206.	168.	399.	648.	987.
12	322.1	.35	DEPTH	2542.	822.	64.	117.	154.	196.
13	1.2	.07	DEPTH	8.	5.	1.	0.	0.	0.
14	208.3	-.05	DEPTH	1518.	527.	76.	120.	134.	143.

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*   RESULTS OF LOCAL PIER SCOUR COMPUTATIONS   *
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STA NO.	DISTANCE ACROSS CHANNEL	PIER WIDTH (FT)	PIER TYPE	FLOW ANGLE (DEG.)	PIER LENGTH (FT)	D50 SIZE (MM)	PIER SCOUR (FT)	MAX LOCAL SCOUR (FT)
6	82.00	3.2	5	.0	61.0	4.6	5.60	5.60
6	151.00	3.2	5	.0	61.0	4.6	5.60	5.60

Attachment B. Selected output data from the computer program for the sediment-transport and scour simulation of the 500-year flood hydrograph at Cuchillo Negro Creek near Truth or Consequences, New Mexico, for one time increment at the peak discharge--Concluded

6	220.00	3.2	5	.0	61.0	4.6	5.60	5.60
6	292.00	3.2	5	.0	61.0	4.6	5.85	5.85
6	368.00	3.2	5	.0	61.0	4.6	5.85	5.85
7	32.00	3.2	5	.0	61.0	4.6	.00	.00
7	109.00	3.2	5	.0	61.0	4.6	5.14	5.14
7	149.00	3.2	5	.0	61.0	4.6	5.14	5.14
7	189.00	3.2	5	.0	61.0	4.6	5.14	5.14
7	229.00	3.2	5	.0	61.0	4.6	5.14	5.14
7	269.00	3.2	5	.0	61.0	4.6	5.24	5.24
		(SQ. FT.)	(FT/SEC)		(FT)		(FT)	(FT)

*U.S. GOVERNMENT PRINTING OFFICE: 1995-675-309/25065