FLOOD CONTROL DISTRICT
of MARICOPA COUNTY

ADVANCED APPLICATIONS OF HEC-2

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Sponsored By: The Technical Training Group
of the Hydrology Division

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Synopsis of HEC-2 Advanced Short Course

This intensive short course concentrates on advanced techniques of hydraulic modeling using HEC-2 that are generally not taught in the Basic HEC-2 course or not in as much detail. These advanced techniques often utilize little known but helpful capabilities of HEC-2. The contents of the short course addresses problems that are often encountered by the practicing hydraulic engineer and are drawn from the extensive experience of the course instructor.

Although knowledge of the theoretical bases of hydraulics and hydraulic modeling are important, the short course emphasis is on the practical application of HEC-2. Each subject is discussed in terms of real-life applications, descriptions of the physical phenomenon being modeled, and the use of HEC-2 to properly simulate the phenomenon. Computer workshops are presented to the participants immediately after the lecture so as to get a "hands on" experience of what has been taught and to utilized the knowledge gained.

ADVANCED WATER SURFACE PROFILE COMPUTATIONS USING HEC-2

Instructor:

David T. Williams, P.E.
WEST Consultants, Inc., Carlsbad, CA

Day 1

8:00 - 8:15 am	Administration, Introductions
8:15 - 9:15 am	Channel Geometry and Hydraulic Losses for Natural Conditions - Guidance on geometric considerations for HEC-2 applications for natural conditions
9:15 - 9:30 am	Break
9:30 - 10:00 am	HEC-2 Application in Hydraulic Design - Considerations in flood control channel design and analyses using HEC-2
10:00 - 11:00 am	Advanced Bridge Modeling Techniques - Debris loadings on bridges, skewed bridge angles, unusual bridge structures, when to use normal or special bridge method.
11:00 - 11:30 am	General Comments and Guidelines for HEC-2 Applications - Summary
11:30 - 12:30 pm	Lunch
12:30 - 1:30 pm	Split Flow Analysis - Usage for overtopping and divided flow, assumptions, data setup, modeling guidelines, output analysis.
1:30 - 2:45 pm	Workshop 6, Split Flow
2:45 - 3:00 pm	Break
3:00 - 3:15 pm	Workshop 6 Review
3:15 - 4:00 pm	Analysis of Multiple Culverts of Varying Sizes and Elevations
4:00 - 5:30 pm	Workshop 7, Multiple Culverts
5:30 - 6:00 pm	Workshop 7 Review

Day 2

8:00 - 9:15 am	Supercritical Flow - HEC-2 limitations, data setup, analysis of superelevation, design criteria, modeling guidelines
9:15 - 9:30 am	Break
9:30 - 10:30 am	Federal Emergency Management Agency (FEMA) Definitions, Rules and Regulation for Study Contractors - Review of important definitions, study contractors' manual, types of FIS studies, relative costs, modeling and documentation requirements.
10:30 - 11:30 pm	HEC-2 Floodway Determination for Unusual Hydraulic Situations - Tributary Analysis, Islands in the Floodplains and Floodways, "Breakout" areas, flood zone designations.
11:30 - 12:30 pm	Lunch
12:30 - 3:00 pm	Workshop 8, Floodway Determination Optimization and Plotting
3:00 - 3:15 pm	Break
3:15 - 3:30 pm	Workshop 8 Review
3:30 - 5:30 pm	Workshop 9, Output Analysis - Outputs of HEC-2 are analyzed for completeness, modeling techniques, correctness, and suggestions for improvements are solicited from participants. Three examples will be examined.
5:30 - 6:00 pm	Final Questions and Wrap-up, Administration

ADVANCED WATER SURFACE PROFILE COMPUTATION USING HEC-2

CHANNEL GEOMETRY FOR NATURAL CONDITIONS

by David T. Williams
WEST Consultants, Inc.

1. REFERENCES

a. "Advanced Water Surface Profile Computation Using HEC-2," The Hydrologic Engineering Center, Davis, CA, 1982

b. Department of the Army, Office of the Chief of Engineers, "Backwater Curves in River Channels," EM 1110-2-1409, Washington, DC. 1959.

c. "HEC-2, Water Surface Profiles," Users Manual, The Hydrologic Engineering Center, Davis, CA, 1976.

2. OBJECTIVES

The objective of this section is to point out and give guidance on the important geometric considerations associated with numerical modeling of natural channels and understanding of stream behavior.

3. CROSS SECTIONS

A. Map and Field Location

Make sure that the orientation and placement of the cross section on the map or quad sheets are as described in the field note. Checks can be made by noting the contour elevations and distances on the quad sheets and comparing them with the graphs of the encoded cross sections. This will also be a check to see if the cross section is from left to right or vice versa.

B. Channel and Overbank Limits

Sometimes its hard to delineate the channel from the overbanks. A good rule of thumb is to partition the cross section into areas of similar n values and then determine the channel and overbank limits. HEC-2's normal n value assignment is for the channel and both overbanks. If significant areas have differing roughnesses, the use of the NH cards are recommended, which varies n by distance across the cross section.

C. Cross Section Orientation

If the cross section is skewed more than 18 degrees from the perpendicular of the flow line, either the cross section needs to be resurveyed or reduced by an appropriate multiplier.

D. Cross Section Representation

Remembering that each cross section in a model is assumed to be representative of the geometry half way to the upstream and downstream cross sections, the cross section should be located at the places that fully describes the geometry of the reach.

4. REACH LENGTHS AND FLOW LINES

Quad sheets should be overlayed with mylar or other transparent film and flow lines sketched for low, bankfull, and flood discharges. For any subsection, such as the channel or overbanks, the representative reach length should be along the flow line that represents the center of mass of the water in the subsection. If necessary, do not hesitate to change reach lengths for different discharges.

5. INEFFECTIVE FLOW AREAS

Inspection of the flow lines will help in determining ineffective flow areas. Also check if natural or artificial levees are truly tied into high ground.

6. FLOW DISTRIBUTION

Look at the velocities and flow percent of the main channel and overbank areas. If the prototype is fairly uniform in the longitudinal direction, the velocities and flow distribution of the channel and overbanks should be fairly consistent also. If severe changes occur from cross section to cross section (e.g., all the flow goes from overbank to channel or vice versa), there should be a physical (geometric, roughness, etc.) reason for the changes. If not, the model should be inspected for input data errors or unreasonable values for input variables.

ADVANCED WATER SURFACE PROFILES USING HEC-2

HYDRAULIC LOSSES
FOR NATURAL CONDITIONS

by David T. Williams
WEST Consultants. Inc.

1. REFERENCES (Listed Alphabetically by Author)

a. Arcement, G. T., and Schneider, V. R., "Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains," U. S. Department of Transportation, Federal Highway Administration, Report No. FHWA-TS-84-204. 1984.

b. Barnes, H. H., Jr., "Roughness Characteristics of Natural Channels," USGS Water Supply Paper 1849, Washington D.C., 1967.

c. Chow, V. T., "Open Channel Hydraulics," McGraw-Hill, New York, 1959.

d. Cowan, W. L., "Estimating Hydraulic Roughness Coefficients," Agricultural Engineering, Vol. 37, No. 7, July, 1954.

e. Department of the Army, Office of the Chief of Engineers, "Hydraulic Design of Flood Control Channels," Engineering Manual (EM) 1110-2-1601, Washington, DC, 1970.

f. Henderson, F. M., "Open Channel Flow," MacMillan Publishing, New York, 1966.

g. Heil, H. R., Jr., "A Method for Adjusting Values of Manning's Roughness Coefficients for Flooded Urban Areas," USGS Journal of Research, Vol. 5, No. 5, 1977.

h. Limerinos, J. T., "Determination of the Manning Coefficient from Measured Bed Roughness in Natural Channels," USGS Water Supply Paper 1898B, 1970.

i. Pasche, E., and Rouve, G., "Overbank Flow With Vegetatively Roughened Flood Plains," Journal of Hydraulic Engineering, ASCE, Vol. 111, No. 9, Sept., 1985.

j. Simons, D. B., and Richardson. E. V., "Resistance to Flow in Alluvial Channels," Professional Paper 422-J, USGS, Washington DC, 1966.

k. Vanoni, V. A., ed., "Sedimentation Engineering," ASCE No. 54, American Society of Civil Engineers, New York, New York, 1975.

2. OBJECTIVES

To present the important parameters that affect hydraulic losses and to identify the relative effects on hydraulic computations.

3. GENERAL

Hydraulic losses can be grouped into three types of losses.

A. Hydraulic roughness (friction loss)

1) Surface roughness

2) Bedform roughness

B. Geometric related losses

C. Hydraulic transients

These losses are not mutually exclusive in that they can occur together in space and time. An understanding of the relative contributions of each of these losses is essential if proper predictions of other flow conditions (especially unmeasured conditions) are to be made.

A. HYDRAULIC ROUGHNESS

1. Resistance Equations.

Sometimes referred to as surface roughness, hydraulic roughness is the measure of that portion of flow resistance brought on by the friction between the fluid and the wetted perimeter thereby causing fluid energy to be dissipated. There are three generally used friction equations and are expressed in the Manning, Chezy and Darcy equations. The equations, expressed in terms of friction slope, are:

(a) Manning

$$S_f = \frac{v^2 n^2}{2.21 R^{4/3}} \qquad (1)$$

(b) Chezy

$$S_f = \frac{v^2}{C^2 R^2} \qquad (2)$$

(c) Darcy

$$S_f = \frac{fv^2}{8gR} \qquad (3)$$

The roughness coefficients are related by:

$$\frac{C}{1.486} = \frac{R^{1/6}}{n} = \frac{10.8}{f^{1/2}} \tag{4}$$

where:

S =	friction slope
v =	average flow velocity, ft/sec
R =	hydraulic radius, ft
C =	Chezy's flow resistance factor
f =	Darcy (or Darcy-Weisbach) friction factor
g =	acceleration due to gravity, ft/sec^2

B. SURFACE ROUGHNESS

The roughness coefficient most frequently used for natural channels is Manning's n value. Numerous textbooks and guides give recommended values for different types of streams. Chow, Henderson, and lately Limerinos are the most popular. Note from equation (4) that Manning's n varies with the hydraulic radius, which requires an evaluation of n for various discharges and resulting depths. This make the extrapolation of a rating curve to unmeasured discharges and depths fairly difficult. A better method is the use of a roughness indicator, k, which does not change with hydraulic radius. The boundary surface roughness, k, which is a physical representation of the height of the roughness elements, is related to the Chezy roughness coefficient by:

$$C = 32.6 \log_{10} \left[\frac{12.2}{k} \right] \tag{5}$$

Note that this is for hydraulically rough channels, which is the usual field case. Various publications, such as Chow and Henderson, give typical values for different surfaces. Natural river beds have k ranging from 0.1 to 3.0 (Chow). Plate 3 of EM 1110-2-1601 shows a graph relating k to various hydraulic parameters. This k is different from the equivalent roughness k, which takes into account the resistance contributions of bedforms, turbulence and eddies. However, the k analysis is usually the best approach because once it is established, it stays relatively constant for the same bedform and varying hydraulic parameters.

C. FORM ROUGHNESS

It has long been recognized that form roughness, e.g., dunes and ripples, contribute to the overall resistance to flow (Fig. 1). The ASCE Manual 54 identifies many researchers that have developed methods for bedform prediction and the resulting bedform resistance. Some interesting observations about bedforms were made by Simons and Richardson. To get a feel for the Manning's n, the Darcy friction factor f quoted in Simons and Richardson is converted to n, assuming a hydraulic radius of 5 feet. Referring to Figure 1, the following observations were made.

(1) Plane bed without sediment movement.

Flow resistance is relatively small. Use of k based upon grain size is appropriate or the Strickler equation, n= 0.034d, where d is the median sediment size of the bed in feet. Limerinos' relationship is also adequate.

(2) Ripples.

Resistance to flow is large and as depth increases, resistance to flow decreases. Resistance is also independent of grain size because form roughness is much greater than surface roughness. Ripples do not occur in streams having a median bed material greater than 0.6 mm. ($0.05 < f < 0.13$; $0.027 < n < 0.04$)

(3) Dunes.

Resistance to flow is large but less than for ripples. The resistance to flow increases with increasing depth for median bed size greater than 0.3 mm and decreases with increasing depth for finer bed size. Dunes are the dominant bedform in the field and are out of phase with the water surface. ($0.04 < f < 0.16$; $0.024 < n < 0.048$)

(4) Plane bed with sediment movement.

Resistance to flow is slightly less than for plane bed without movement and is related to the grain size. ($0.02 < f < 0.03$; $0.017 < n < 0.021$)

(5) Antidunes.

If the antidunes waves do not break (often called standing waves), they are in phase with the water elevation and have flow resistance slightly higher than for a plane bed. If the antidune waves break, the resistance is relatively high. Note that since the water surface and bed are in phase, the Froude number is greater than 1. ($0.02 < f < 0.035$; $0.017 < n < 0.023$ for standing waves and $0.03 < f < 0.07$; $0.021 < n < 0.032$ for breaking waves.)

6. Chutes and Pools.

This condition only occurs in very steep slopes. Flow resistance is very high. ($0.07 < f < 0.09$; $0.032 < n < 0.036$)

D. BEDFORM PREDICTION.

Various investigators have developed bedform predictors and are described in Simons and Richardson (e.g., Fig. 2). These relationship are empirical, site specific and do not take into account all variables of importance. They should be used only as indicators of bed behavior and not as design parameters.

E. RECOMMENDED PROCEDURES FOR FLOW RESISTANCE INCLUDING BED FORMS

(1) Make a first guess of Manning's n using Chow or other guidelines.

(2) Compute hydraulic parameters and using the bed sediment size, determine the bedform.

(3) Use the range of f or n and the hydraulic radius to determine the Manning n. If the assumed and computed n are close, go to (4), if not, go to (2) above.

(4) Compare the resulting n with the range of n for the stream type using Chow or other guides. If outside the range, reevaluate the sediment size, or investigate if the f used is reasonable. To maximize the water elevation and minimize the velocity, use the high end of the f range. For the opposite effect, use the low end of the f range.

F. COMPOUND AND COMPOSITE VALUES OF HYDRAULIC LOSSES.

Channel, bank and overbank areas usually have varying roughnesses. In the case of channels and overbanks, they are treated as separate conveyance areas of which the total discharge is the sum of the separate discharges as if they were two different channels. These conditions are usually referred to as compound channels. A composite channel is a conveyance area with varying roughness of which a single composite roughness is used to represent the overall flow resistance. According to Chow (pg. 136) there are many ways to compute an equivalent Manning's n but the recommended procedure is that presented in EM 1110-2-1601, pg 6. Note that the alpha method (energy correction) does make some compensation in energy due to the variation in the velocities of subsections; however, this does not take into account all the mutual influences of the subsections and does not bring about the determination of a representative Manning's n. HEC-2 delineates a cross-section into a compound channel consisting of up to 2 overbanks and a main channel with a Manning n assigned to each subsection. The channel is usually composed of a stream bed and banks with varying roughness. HEC-2 does not vary the n within the channel as a function of the velocity but only with the overbanks. If there are significant roughness differences within the channel and the banks contribute a significant portion of the total roughness, the equivalent Manning n must be computed externally according to pg 6 of EM 111-2-1601.

G. VEGETATION

Vegetative resistance is usually associated with overbank roughness. Often the bank can contribute vegetative resistance as pointed out in the above paragraph, and if so, the above analysis is required. Excellent references on Manning's n for overbanks are Arcement and Schneider, Barnes, and Pasche and Rouve.

H. URBAN AREAS

Not much research has been done in determining flow resistance in urban areas. Heil developed a method based upon assumed spacings and distances between buildings, taking into account the alignment of the streets to the flow. However, this method has not been fully tested.

I. SEASONAL VARIATIONS

The changing of the seasons cause the vegetation and foliage density to change. The change also changes the Manning n. This becomes important when calibrating a rating curve in which the points on the curve are from different seasons. If there is a significant difference, a separate rating curve for each season should be generated and n values calibrated and interpolated/extrapolated based upon these rating curves.

4. GEOMETRIC RELATED RESISTANCE

A. Channel contractions and expansions

If the channel width transition slopes inward or outward at a slope of is 1:4, then 0.1 and 0.3 are recommended by Chow for contraction and expansion coefficients, respectively. These values should be increased for more abrupt transitions. The maximum values, such as at 90 degree angles, are 0.6 and 0.8 for contraction and expansion, respectively, although EM 1110-2-1601 has a maximum of 0.3 for contractions. Note also that these values are for subcritical flows and separate analysis is required for supercritical flow of various types of transitions.

B. Channel alignment

Hydraulic losses occur in bends and meanders due to induced secondary flows. For a ratio of radius of curvature to channel width greater than 3, bend losses are negligible. Scobey (referenced in EM 1110-2-1601) recommended that n be increased 0.001 for each 20 degree of curvature per 100 feet of curvature, up to a maximum of 0.003. Cowan suggested that for meandering, the total n value be multiplied by 1.15 to 1.3 for appreciable to severe meandering, respectively, with a sinuosity (ratio of channel length to valley length) of 1.2-1.5 being appreciable and severe being a sinuosity greater than 1.5.

C. Other losses related to geometry

Irregular channels are channels that vary in elevation laterally along a cross section. An example is a channel with alternating sand or gravel bars. This tends to increase the roughness but no quantitative guidance is available. Bridges cause head loss but since there are sufficient references, this will not be covered. Junctions of rivers with tributaries create hydraulic losses but again, no quantitative guidance is available. Knowledge of these types of losses, although no guidance is give, help you in understanding the physical phenomena, and thus, help in understanding the relationship between the prototype and the model.

5. HYDRAULIC TRANSIENTS

A. Hydraulic Jumps.

EM 1110-2-1601 contains information on estimating the losses associated with hydraulic jumps. Note that HEC-2 does not make transitions from super to subcritical flow, therefore it cannot predict the location and head loss due to a hydraulic jump. The location must be determined externally by using the intersection of the subcritical water surface profile with the sequent depth of the supercritical water surface profile.

B. Surges.

Surges are small hydraulic jumps that move upstream or downstream and are under unsteady flow conditions. Since there are associated hydraulic losses, areas where these occur must be identified. Again, this cannot be done using HEC-2.

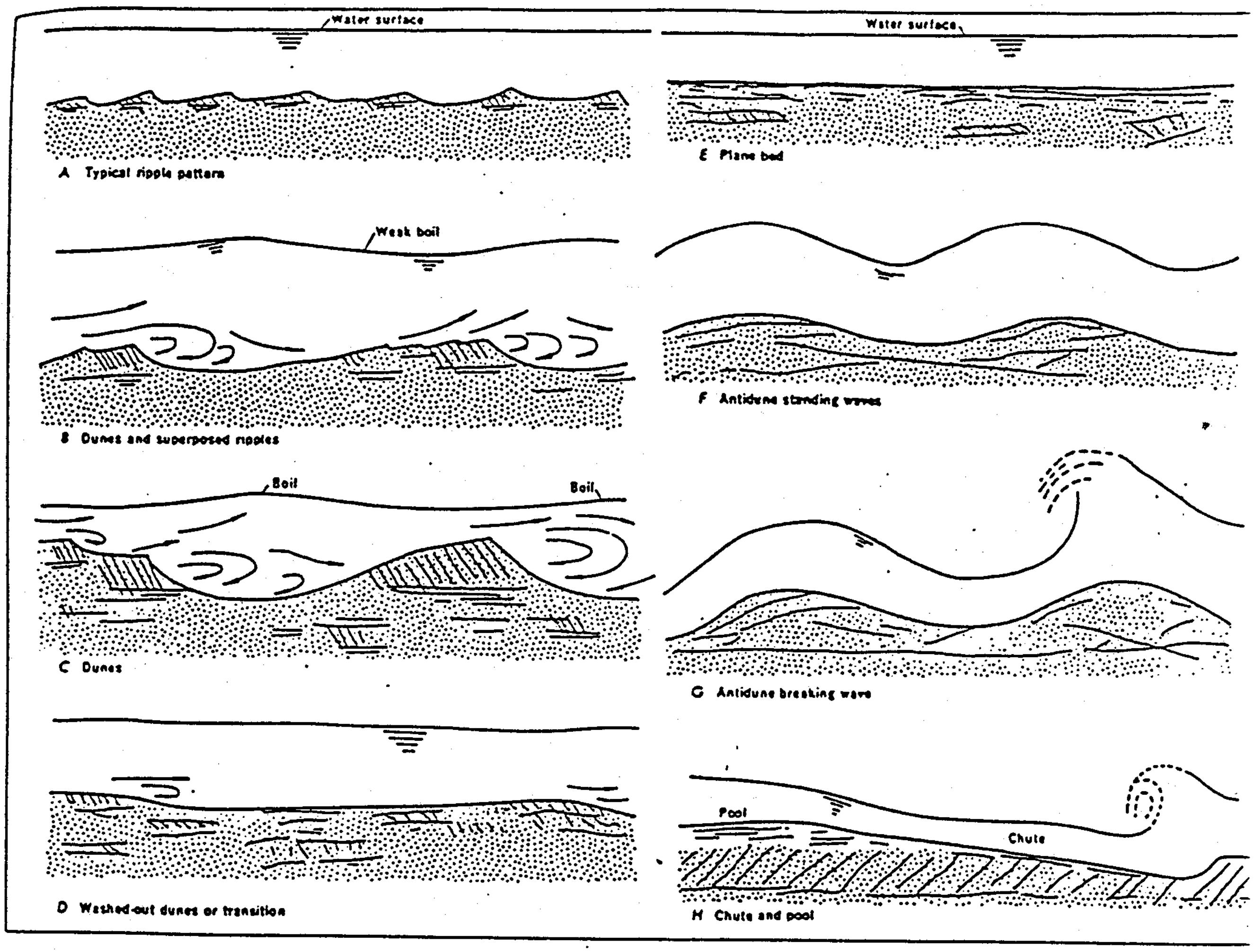


Figure 1. Forms of bed roughness in an alluvial channel. (After Simons and Richardson, 1966)

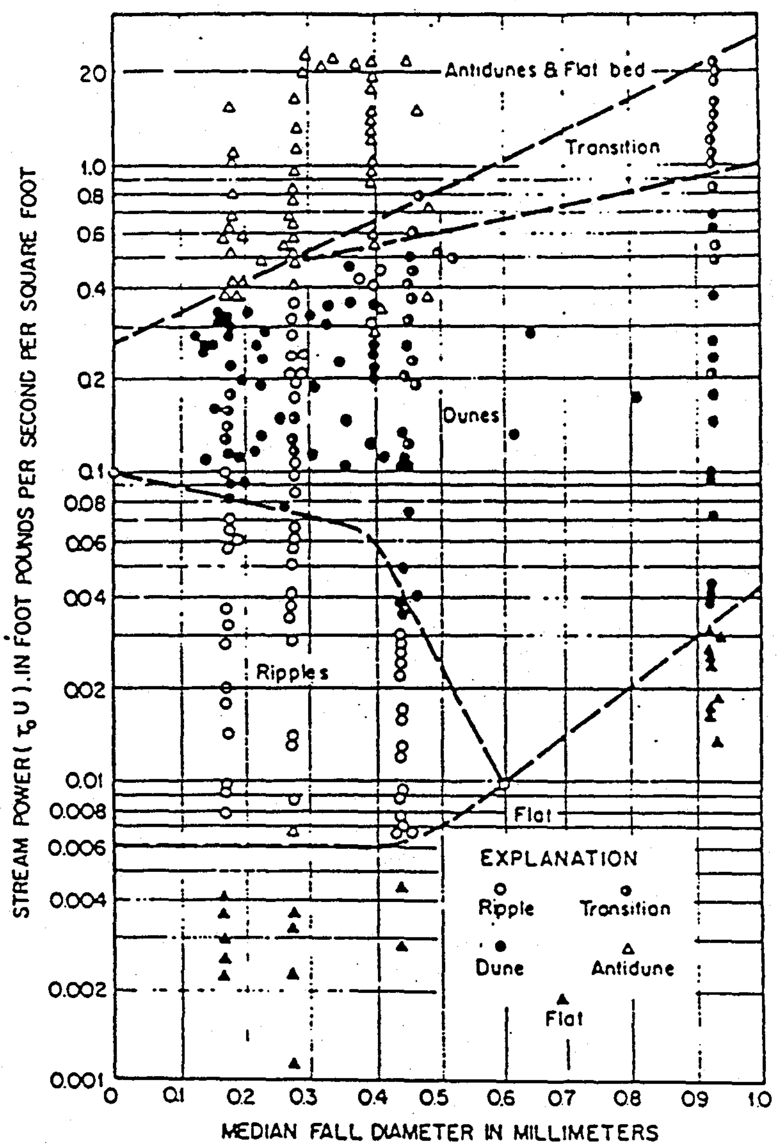


Figure 2. Relation of bed form to stream power and median fall diameter of bed sediment (after Simons and Richardson, 1966).

1. CALCULATE THE AVERAGE VELOCITY, $\bar{V}$.

$\bar{V} = Q_T/A$

$\bar{V} = (20,000)/(1864.0) = 10.7$ FPS

2. CALCULATE THE DISCHARGE THROUGH EACH SUB-SECTION, Q_n.

$$Q_n = \frac{Q_T(CR^{1/2})_n A_n}{\Sigma[(CR^{1/2})_i A_i]} = \frac{20,000(CR^{1/2})_n A_n}{349,600}$$

$Q_1 = 0.0572(34400) = 1968$ CFS
$Q_2 = 0.0572(165200) = 9449$
$Q_3 = 0.0572(126400) = 7230$
$Q_4 = 0.0572(13900) = 795$
$Q_5 = 0.0572(9700) = 555$
$\Sigma Q_n = 19,997$

3. CALCULATE THE VELOCITY THROUGH EACH SUB-SECTION

$$V_n = \frac{Q_n}{A_n}$$

$V_1 = (1968)/(225.0) = 8.7$ FPS
$V_2 = (9449)/(700.0) = 13.5$
$V_3 = (7230)/(655.0) = 11.0$
$V_4 = (795)/(104.0) = 7.6$
$V_5 = (555)/(180.0) = 3.1$

4. CALCULATE THE MEAN SLOPE OF ENERGY GRADE LINE, S.

$$S = \frac{(\bar{V})^2}{(CR^{1/2})^2_{MEAN}}$$

$$(CR^{1/2})_{MEAN} = \frac{\Sigma[(CR^{1/2})_i A_i]}{A} = \frac{349,600}{1864.0} = 188$$

$S = (10.7)^2/(188)^2 = 0.00324$

5. CALCULATE THE MEAN HYDRAULIC RADIUS, $\bar{R}$.

$$\bar{R} = \frac{\Sigma[(CR^{3/2})_i A_i]}{\Sigma[(CR^{1/2})_i A_i]}$$

$\bar{R} = (4.13 \times 10^6)/(0.3496 \times 10^6) = 11.8$ FT

6. CALCULATE THE AVERAGE SHEAR FORCE $\bar{\tau}_0$

$\bar{\tau}_0 = \gamma \bar{R} S$
$= (62.5)(11.8)(0.00324) = 2.39$ LB/FT^2

ALPHA METHOD
HYDRAULIC PROPERTIES

Plate IV-3

1. CALCULATE ENERGY CORRECTION FACTOR

$$\alpha = \frac{A^2 \Sigma \left[(CR^{1/2})_i^3 A_i\right]}{\left[\Sigma (CR^{1/2})_i \; ^3 \; A_i\right]} \qquad \text{(EQUATION IV-12)}$$

FROM PLATE IV-1

$$A^2 = (\Sigma A_i)^2 = (1864.0)^2 = 3.47 \times 10^6$$

$$\Sigma \left[(CR^{1/2})_i^3 A_i\right] = 15.00 \times 10^9$$

$$\left[\Sigma (CR^{1/2})_i A_i\right]^3 = (349.6 \times 10^3)^3 = 42.7 \times 10^{15}$$

$$\alpha = \frac{(3.474 \times 10^6)(15.00 \times 10^9)}{42.7 \times 10^{15}} = 1.22$$

2. EFFECTIVE k (α NEGLECTED)

$$C^2 = 32.6 \log_{10} 12.2 \frac{R}{k} = \frac{\gamma \bar{V}^2}{\bar{\tau}_0} \qquad \text{(EQUATIONS (6) AND (31))}$$

FOR $\bar{V} = 10.7$ AND $\bar{\tau}_0 = 2.39$ (PLATE IV-3)

$$C = \frac{\left(62.5 \times \overline{10.7}^2\right)^{1/2}}{2.39} = 54.7$$

FOR $C = 54.7$, $\frac{R}{k} = 3.9$ (PLATE IV-2)

FOR $\bar{R} = 11.8$ (PLATE IV-3)

$$k = 3.03 \text{ FT}$$

3. EFFECTIVE k (α CONSIDERED)

$$\alpha \frac{\bar{V}^2}{2g} = \frac{(1.22)(10.7)^2}{64.4} = 2.17 \text{ FT}$$

$$V^1 = (64.4 \times 2.17)^{1/2} = 11.8 \text{ FPS}$$

$$C = \left[\frac{(62.5)(11.8)^2}{2.39}\right]^{1/2} = 60.3$$

$$\frac{R}{k} = 5.8 \qquad \text{(PLATE IV-2)}$$

$$k = 2.03 \text{ FT FOR } \bar{R} = 11.8 \text{ FT}$$

4. CALCULATE MANNING'S n (α NEGLECTED)

$$n = \frac{1.486 \bar{R}^{2/3} S^{1/2}}{\bar{V}} = \frac{(1.486)(11.8)^{2/3}(0.00524)^{1/2}}{10.7}$$

$$= 0.041$$

ALPHA METHOD
BACKWATER COMPUTATION DATA

Plate IV-4

ADVANCED WATER SURFACE PROFILE COMPUTATIONS USING HEC-2

FLOOD CONTROL CHANNEL DESIGN: CONCEPTS AND APPLICATION

by

David T. Williams
WEST Consultants, Inc.

OBJECTIVES: To inform the students of the important concepts associated with safe and efficient flood control channel design, channel stability, and how HEC-2 can be used to assess channel stability.

REFERENCES:

1. Dury, G. H., "Principles of Unfit Streams," U.S. Geological Professional Paper 452-A, 1964.

2. Kahn, H. R., "Laboratory Study of River Morphology," Ph.D. Dissertation, Colorado State University, Ft. Collins, CO. 1971.

3. Lane, E. W., "A study of the Shape of Channels Formed by Natural Streams Flowing in Erodible Material," MRD Series No. 9, U.S. Army Engineer Division, Missouri River, Omaha, NE, 1957.

4. Leopold, L. B., and Maddock, T. Jr., "Hydraulic Geometry of Stream Channels and Some Physiographic Implications," U.S. Geological Survey Professional Paper 242, 1953.

5. U.S. Army Corps of Engineers, "Hydraulic Design of Flood Control Channels," EM 1110-2-1601, Office of the Chief of Engineers, Washington, D.C., July 1970.

I. DESIGN OF CONCRETE LINED CHANNELS

A. Rotation of Cross Section at Curves

When the alignment has curves which result in superelevation of the water, rotate the channel with the pivot at the inside corner so that the design thalweg is on the inside of the channel, not at the center-line of the channel (See Figure 1). This prevents the water from collecting in a depression under low flows and, under high flow conditions, reduces excessive simultaneous lowering and raising of the water as it goes around the curve.

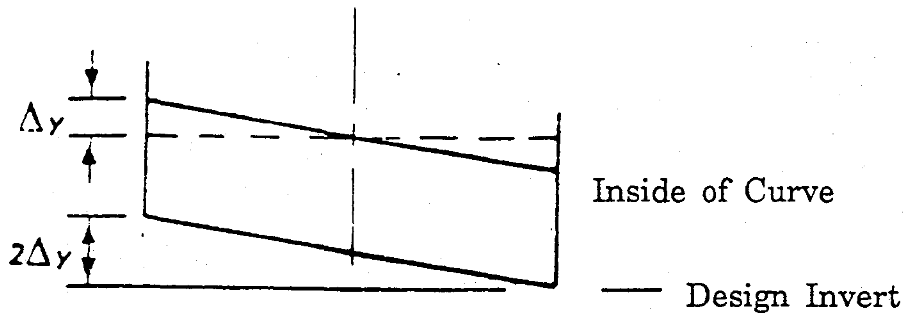


Figure 1. Rotation of Channel for Curves

B. Design Considerations based on Equivalent Roughness k

Note that a new HEC-2 capability is the ability to specify roughness with an equivalent 'k' value rather than a Manning's 'n'. The 'k' should be used for all concrete lined channel analysis, especially for conditions involving both riprap, concrete and benches within the same cross section.

1. Froude No., F, and Flow depth, D, Proximity to Critical depth, d_c

   a. For subcritical flow conditions,

      $F < 0.86$ and $D > 1.1d_c$

   b. For supercritical flow conditions,

      $F > 1.13$ and $D < 0.9d_c$

   c. For evaluation of proximity to critical depth, use $k = 0.002$ for subcritical flow and $k = 0.007$ for supercritical conditions and make sure (a) and (b) above are not violated.

2. Evaluation of Discharge Capacity and Maximum Velocity

   a. To determine discharge capacity of a channel, use $k = 0.007$. Also use this for determining freeboard encroachment of the resulting water surface elevation, evaluation of undular hydraulic jump conditions, and the upstream extent of hydraulic jumps.

b. To evaluate the maximum velocity, use k = 0.002. Use the resulting velocity for determining superelevation, minimum radius of curvature, minimum length of spiral, maximum wall flare at transitions, design of riprap used for transitions, and the downstream extent of hydraulic jumps.

C. Isolation of Hydraulic Jump Locations

For concrete lined channel, stilling basins may not be required to induce hydraulic jumps at a specific location. Consider using a steep slope just upstream (keep Froude number above 1.7) from the desired jump location and then use a low mild slope until the thalweg reaches the design thalweg profile. This keeps the hydraulic jump at the desired location. This analysis must be performed for the whole range of anticipated flows.

II. DESIGN OF ALLUVIAL AND VEGETATED CHANNELS

A. Composite Channels

When channels and overbanks have varying roughnesses within the cross section, a single valued Manning's 'n' cannot reproduce the roughness for a full range of flow depths. This situation should be modeled using the NV records and 'k' roughness.

B. Time Dependent Analysis of Vegetative Roughness

1. Beginning of Project

Although the final design may call for a fully vegetative bank, berm, or overbank, such as with brush, willows, etc., this situation may not occur until 5 to 10 years after construction. The roughness variable used in the HEC-2 model should reflect this condition for erosive conditions.

2. Mature and Unmaintained Vegetation Analysis

If local authorities promise to maintain the vegetation of the channel, bank and overbank areas, the roughness used in the HEC-2 model would probably reflect this. Future economic or social conditions may cause the locals to "forget" this promise and full vegetative growth may occur. A good practice is to compute the water surface elevation under these conditions and place them in your report to let all concerned authorities know what the consequences are for a unmaintained channel.

3. Seasonal Changes

When calibrating roughness to high water marks, be sure to identify the season that the flood occurred. If the 'n' calibration was for a winter discharge (sparse vegetation condition), and that same discharge occurred in the spring, the water surface elevations would probably be higher than was modeled because the 'n' value would have been underestimated for the spring condition (dense vegetation condition). The same analysis should be made for extrapolation of rating curves to unmeasured discharges.

III. MISCELLANEOUS DESIGN CONSIDERATIONS

A. Debris Control at Bridges

Sloping pier extensions similar to those shown in Appendix III of EM 1110-2-1601 should be used if there are severe debris problems. Connecting piers in the stream direction to make single continuous piers is also advised to reduce energy and momentum losses.

B. Channel Confluences

For both sub and supercritical confluences, the joining angle should not be more than 12 degrees (see EM 1110-2-1601). This reduces impinging flow from tributaries which can cause bank failure on the opposite main stem bank. This is especially important if a large flow occurs on a tributary while the main stem flow is small.

C. Return Flows

When water exits the channel under high flow conditions, provisions must be made to return the water in a controlled fashion as the flood recedes.

IV. IMPORTANT HYDRAULIC PARAMETERS OBTAINED DIRECTLY FROM HEC-2 FOR STABILITY ANALYSIS

A. Average and Subsectional Velocity

Cross section and channel velocities are often used for design of stable channels, e.g., permissible velocity criterion.

B. Normal, Critical, and Actual Depth

These water depths are used to determine the flow regime, e.g., M1, M2, S1, etc. curves. See section VIB for use in stable channel analysis.

C. River Width

This parameter is useful to determine expansion and contraction points to evaluated potential scour/deposition and bank failure points. It can also give indications of changes in slope and/or alluvial material.

D. Shear Stress

$$\tau_o = \gamma R_h S$$

This parameter is used in the maximum permissible shear stress analysis for stable channel design. This is also used in incipient motion analysis.

E. Stream Power

$$\tau V$$

Stream power can be used to evaluated sediment transport potential and geomorphic patterns as discussed later.

V. IMPORTANT PARAMETERS OBTAINED INDIRECTLY FROM HEC-2 FOR STABILITY ANALYSIS

A. Bank-full Discharge

Run a series of discharges until the water surface elevation exceeds the channel limit elevations. This approximates the "bank-full discharge" and is sometimes equated to the 2.33 year frequency flood. This discharge is used for stability analysis discussed later. The bank-full discharge can also be the most critical condition for stable channel design, even more so than the 100 year discharge.

B. Toe Velocities at Bends

Use analytical relations using average channel velocity, radius of curvature and river width to obtain toe velocity. This is then used for toe protection design, an important bank stability consideration.

C. Sinuosity

HEC-2 can print out channel distance. This value, divided by the valley distance, produces the sinuosity. It is used as an indicator of channel stability conditions as described later.

D. Sediment Transport

The hydraulic parameters of HEC-2 can be coupled with the streambed gradation to determine potential sediment transport of <u>bed material</u> load. The changes in the sediment transport along a reach for pre- and post project conditions will indicate scour and deposition areas. This is discussed further in section VIF.

VI. CHANNEL STABILITY INDICATORS AND USES

A. Shear stress

Use critical shear relationships such as Shields' diagram to determine if there is an erosion or deposition problem.

B. Normal, Critical and Actual Depth

For alluvial streams with cobble and finer sized streambeds, scour usually occurs when the actual depth is greater than the normal depth (M-2 curve). Scour also occurs under M3 and all critical and supercritical flow conditions. Exceptions are streams with geological controls or very large bed material in relationship to flow depth. Deposition usually occurs under M-1 curve conditions (e.g., reservoirs).

C. Bank-Full Discharge

1. Stream meander wavelength

Stream wavelength is the valley length of a full meander cycle. In Figure 2, the line shown is the regression line of stability. To use this graph for project conditions, determine the bank-full discharge, read the meander wavelength and compare it with the project condition. If they significantly differ, the project channel will probably change its meander pattern, which could cause stability problems.

2. Channel Slope

To use Figure 3, compute the mean discharge and slope of the project, plot it on the figure, and determine the stream type. Compare the results with the pre-project condition to see if the project has a different stream type. If it does, the channel will change to attain this condition. Be aware that braided and intermediate streams are inherently unstable and their configurations are hard to predict.

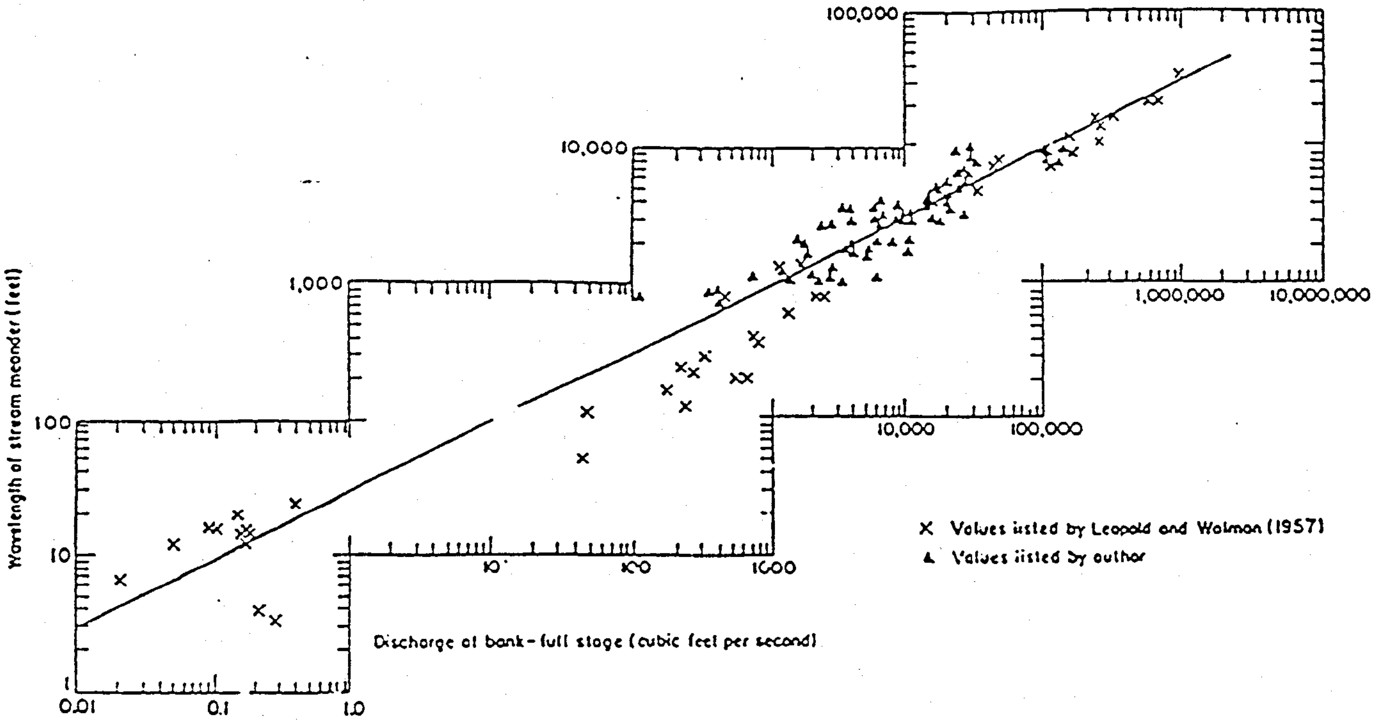


Figure 2. Relations between wavelength and bankfull discharge. (From Dury, 1964).

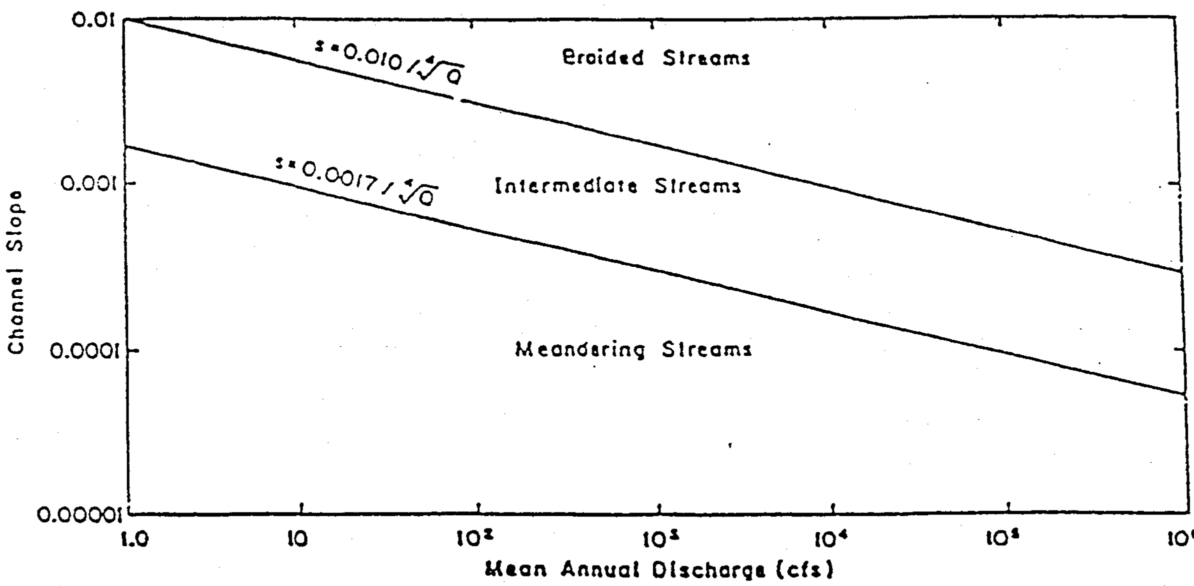


Figure 3. Lane's (1957) relation between channel patterns, channel gradient, and mean discharge.

D. Stream Power and Sinuosity

The relation between stream power and sinuosity is shown in Figure 4. Compute the stream power (use bank-full conditions) and sinuosity for the post-project conditions. Plot the predicted sinuosity from Figure 4 and compare to the project sinuosity. If the sinuosities are significantly different, there is a good chance for unstable conditions as the channel tries to achieve this sinuosity.

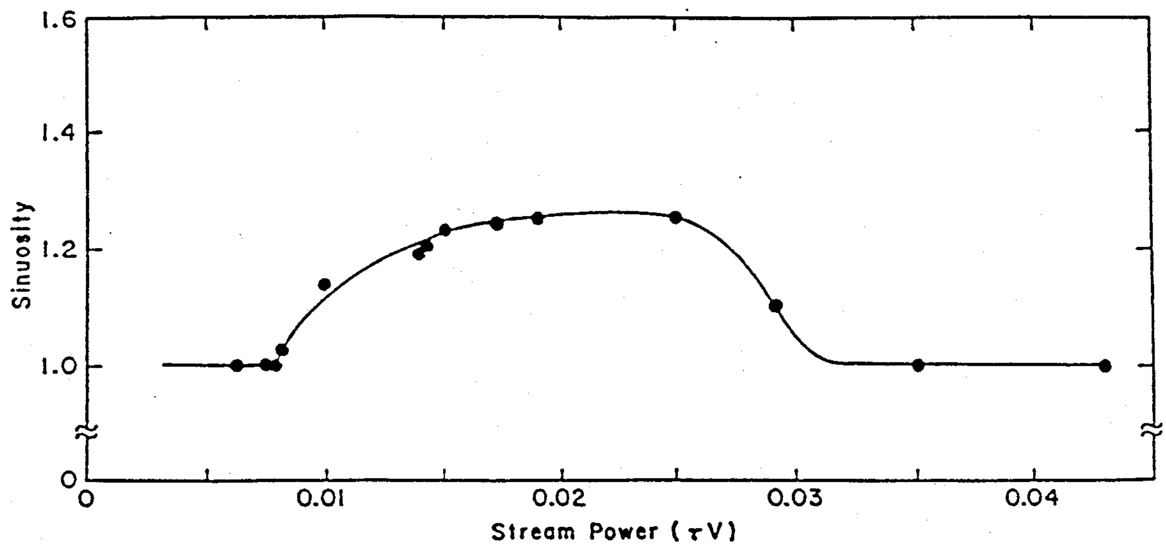


Figure 4. Relation between sinuosity and stream power. (Data from Khan, 1971)

E. Slope and Sinuosity

Some flume studies were performed that related sinuosity to slope as shown in Figure 5. Use the project conditions slope to determine the predicted project sinuosity and channel form using Figure 5. Compare this with the actual project sinuosity and channel form and if they differ, channel stability problems may occur.

F. Sediment Transport Changes

The sediment transport relations in the "CORPS" system of programs can be used to evaluate the effects of sediment transport on the project. Sediment load curves for a range of flows can be produced under both pre- and post project conditions. Integrating the load curves with a flow-duration curve (or a new project flow-duration curve) results in average annual sediment yields for the reach, and the difference between the pre- and post project conditions can be an indicator of maintenance dredging requirements or scour potential.

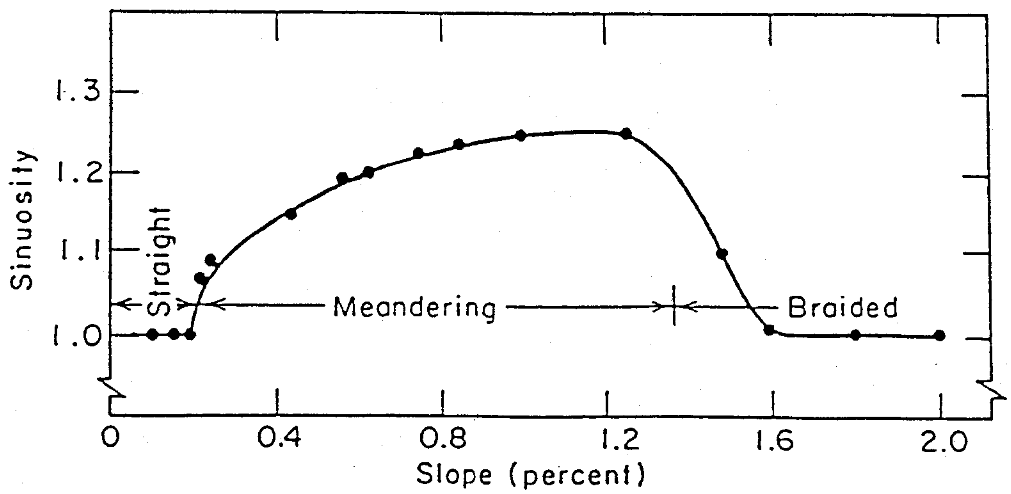


Figure 5. Relation between channel sinuosity and flume slope. (From Schumm and Khan, 1971)

ACCURACY OF COMPUTED WATER SURFACE PROFILES

HEC RESEARCH INVESTIGATION

Problem Addressed: Water surface profiles computed by the usual step-backwater methods inherently contain error that result from several factors. A research study was undertaken to investigate the problem. The study was performed for one-dimensional, steady flow, rigid boundary hydraulics (HEC-2) considering error effects of mapping technology and accuracy and reliability of Manning's coefficient. The mapping technology considered was field surveys, aerial spot elevations, and aerial topo maps for contour intervals (accuracies) of 2, 5, and 10 feet. The study also developed mapping accuracy guidelines for desired computed profile accuracy and a procedure for determining the areal extent of needed data collection.

Approach: Actual data HEC-2 data sets were obtained from Corps district offices, edited for consistency, and profiles computed that became the base condition (error free) profiles. About 100 data sets were ultimately used that represented a broad range of stream sizes and types. An analysis procedure (termed Monte Carlo simulation) was developed for statistically altering the basic stream geometry for various map technologies and accuracy standards. The analysis procedure also included a means of accounting for the reliability of the Manning's roughness coefficient. Water surface profiles were then computed for the base condition data sets and the statistically altered data sets. The resulting errors in the computed profiles were analyzed by regression analysis and prediction equations derived. It is thus possible to predict the inherent error in computed HEC-2 profiles for the factors of map technology and accuracy standard and reliability of Manning's coefficient. Similar analysis produced a set of prediction equations for determining the areal extent of needed data collection. The research study was performed for the Federal Highway Administration and the technical report is in internal review draft form. It will be published later this calendar year.

SCOPE / PURPOSE OF INVESTIGATION

* NATURE OF PROFILE ERRORS

* QUANTIFY RELATIONSHIPS

  > MAPPING TECHNOLOGY/ACCURACY – PROFILE

  > MANNING'S COEFFICIENT – PROFILE

* DEVELOP MAPPING ACCURACY NEEDS GUIDELINES

* AREAL EXTENT OF DATA COLLECTION

OVERALL STRATEGY

* STUDY BOUNDS / ASSUMPTIONS

  > FLOW IS 1 % CHANCE EXCEEDANCE FREQUENCY

  > NO ERRORS IN DISCHARGE VALUES

  > NATURAL STREAM GEOMETRY, ONE-DIMENSIONAL, GRADUALLY VARIED, RIGID BOUNDARY FLOW CONDITIONS. ONLY SUBCRITICAL FLOW.

  > INCREMENT OF ERROR IMPACT DUE TO LOCAL OBSTRUCTION (BRIDGES, CULVERTS, DAMS, RADICAL BENDS) NOT INCLUDED.

SUMMARY OF FINDINGS

* MAP DATA ARE MORE ACCURATE THAN GENERALL PERCEIVED

* AERIAL SPOT ELEVATION TECHNOLOGY – ATTRACTIVE FOR X – SECTION DATA

* COMPUTATION LOCATIONS (X – SECTION SPACING) IMPORTANT .. INTEGRATION

SUMMARY CONTINUED 1

* MANNING'S COEFFICIENT INACCURACY CAN OVERSHADOW MAP ACCURACY ISSUE

* CAN PREDICT PROFILE ACCURACY FROM MAP/ACCURACY SPECS/STREAM

* CAN PREDICT DATA COLLECTION EXTENT FROM STREAM CHARACTERISTICS

BASIC DATA – BASE CONDITION

* COLLECT HEC–2 DATA SETS

> 140 SETS, 100 USED

* CLEAN UP / HOMOGENIZE

> REMOVE BRIDGES, SIMPLE X – SECTIONS, ADJUST LENGTHS

> EDIT TO 1 % FLOW, SIMILAR EXPANSION/ CONTRACTION

> VERIFY, PLOT, EXECUTE

* BASE PROFILE (ERROR FREE COMPARISON)

> FRICTION APPROXIMATION EQUATIONS

> PROFILE EQUATION INTEGRATION

SURVEY TECHNOLOGY / ACCURACY

* FIELD SURVEYS – NO ERRORS

* AERIAL SPOT ELEVATIONS – STANDARDS
    > 2, 5, 10 FT. CONTOUR INTERVALS
    > 90 % ALL ELEVATIONS – 1/4 CONTOUR
    > 100 % WITHIN 1/2 CONTOUR INTERVAL

* AERIAL TOPO MAPS
    > 2, 5, 10 FT. CONTOUR INTERVALS
    > 90 % ALL ELEVATIONS – 1/2 CONTOUR
    > 100 % WITHIN 1 CONTOUR INTERVAL

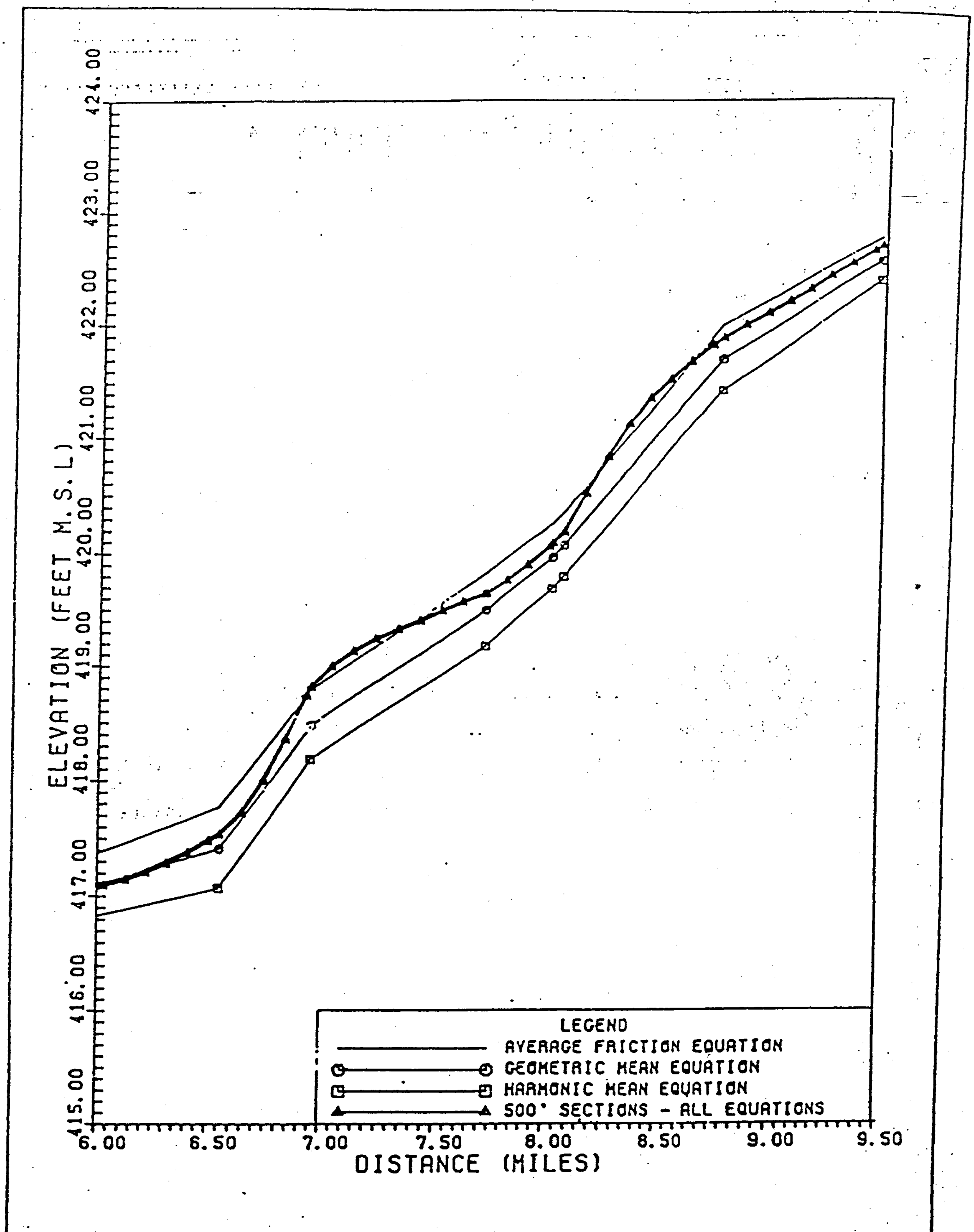


FIGURE 4.2 Profiles Using Alternative Friction Equations

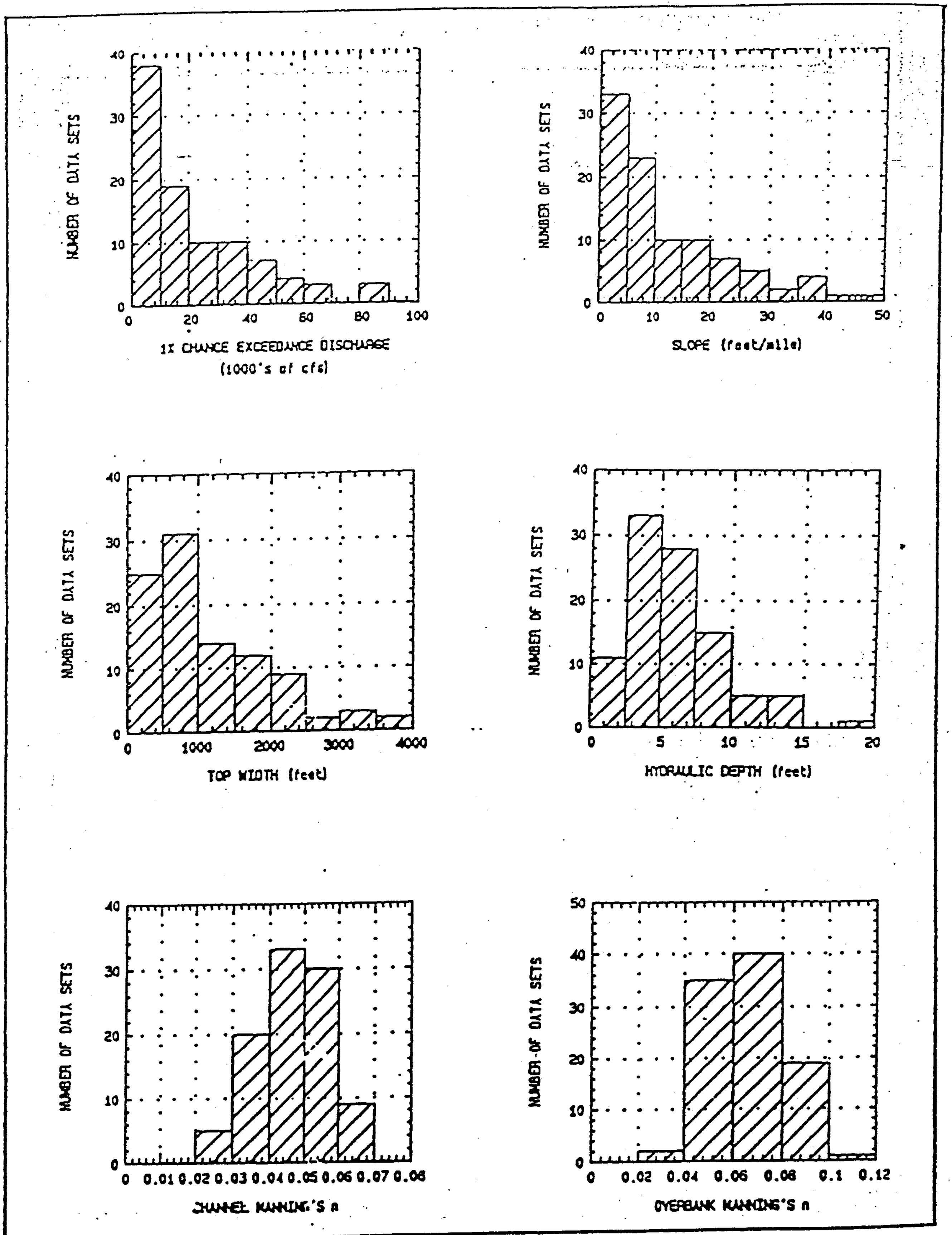


FIGURE 4.4 Distribution of Hydraulic Variables

TABLE 5.2

AERIAL SURVEY PROCEDURES

VERTICAL (ELEVATION) ACCURACY[1]

Aerial survey map accuracy for spot elevations and topographic maps is defined by the mapping industry standard. Standard Map Accuracy is described by the following criteria:

1. The plotted position of all coordinate grid ticks and monuments, except benchmarks, will be within 0.01 inch from their calculated positions.

2. Al least 90 percent of all well-defined planimetric features shall be within 0.033 inch of their true positions, and all shall be within 0.066 inch of their true positions.

3. At least 90 percent of all contours shall be within one-half contour of true elevations, and all contours shall be within one contour interval of true elevation, except as follows:

   For mapping at scales of 1" = 100' or larger in areas where the ground is completely obscured by dense brush or timber, 90 percent of all contours shall be within one contour interval or one-half the average height of the ground cover, whichever is the greater, of true elevation. All contours shall be within two contour intervals or the average height of the groundcover, whichever is the greater, of true elevation. Contours in such areas shall be indicated by dashed lines.

   Any contour which can be brought within the specified vertical tolerance by shifting its plotter position .033 inch shall be accepted as correctly plotted.

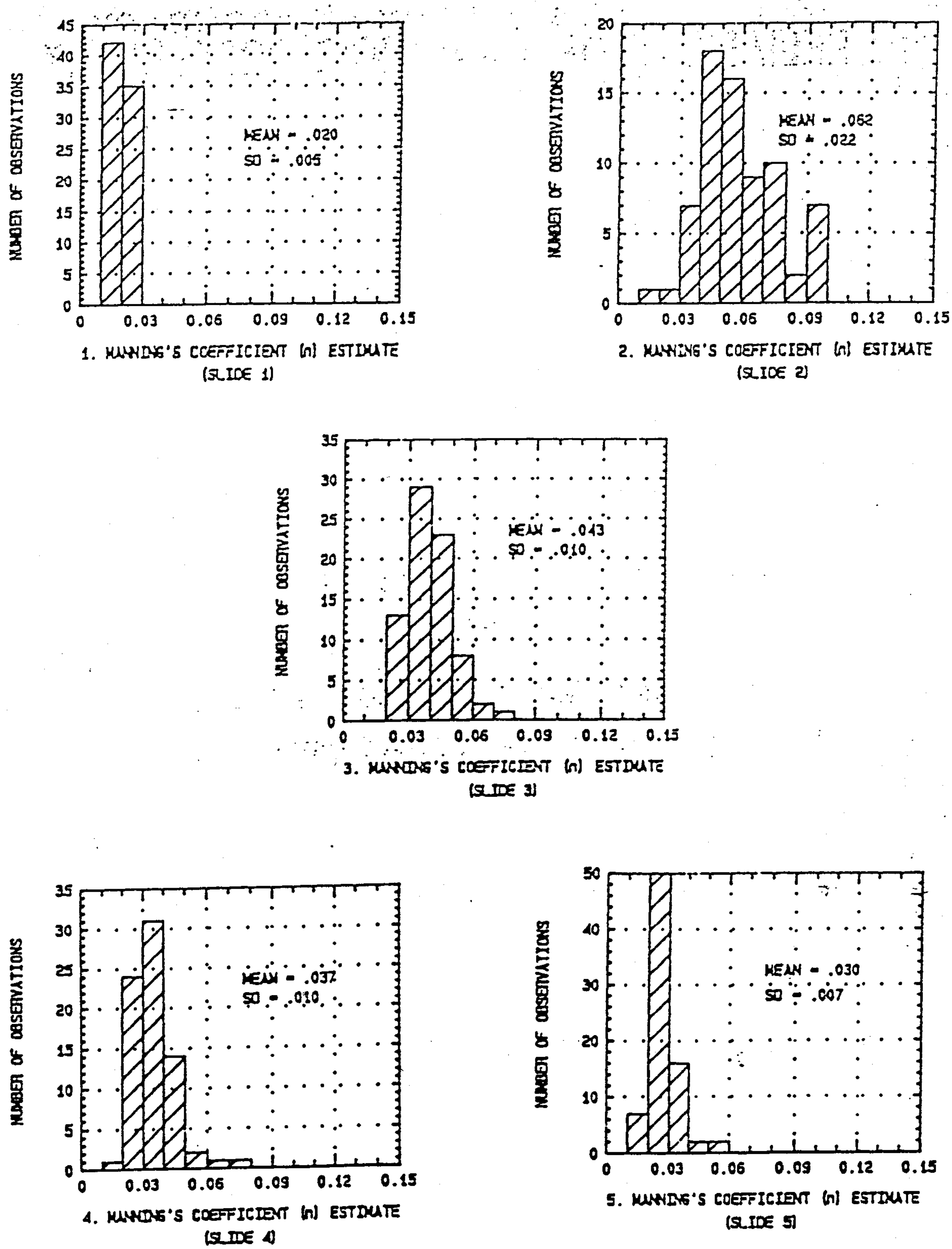
   At least 90 percent of all spot elevations shall be within one-fourth the specified contour interval of their true elevation, and all spot elevations shall be within one-half the contour interval of their true elevation, except that for 5-foot contours 90 percent shall be within 1.0 foot and all shall be within 2.0 feet.

[1]Source: Brochure from Cartwright Aerial Surveys Inc., Sacramento, California.

RELIABILITY OF MANNING'S COEFFICIENT

* EXPERIMENT PERFORMED
  > 10 STREAMS – PHOTOS, GUIDE MANUAL
  > ESTIMATE CHANNEL AND OVERBANK N
  > HEC STAFF, TRAINING COURSE ATTENDEES

* RESULTS ACHIEVED
  > N VALUE ESTIMATES, AND VARIABILITY
  > STANDARD DEVIATION EQUATION
  > RELIABILITY CRITERIA, NR = 0 KNOW PERFECTLY,
  NR = 1 EXPERIENCED FIELD OBSERVATION



Slide number corresponds to slide number on Table 5.4.

The Hydrologic Engineering Center
December 1986

FIGURE 5.5 Manning's Coefficient Estimates

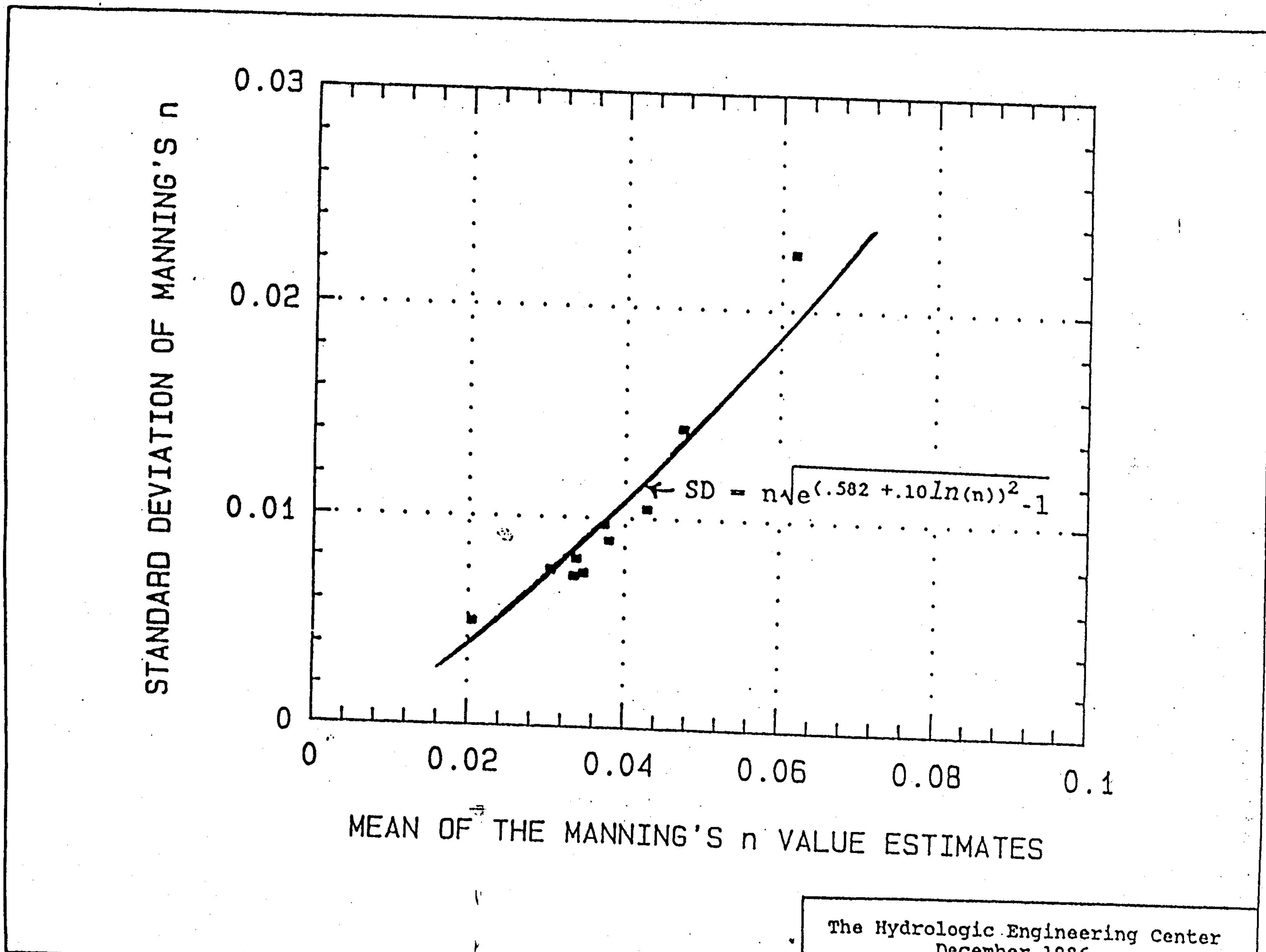


FIGURE 5.6 Manning's Coefficient vs. Standard Deviation

MONTE CARLO EXAMPLE

* RECOMPUTE ALTERNATIVE "LIKELY" GEOMETRY FOR MAP ACCURACY STATISTICS

* REVISE (SIMULTANEOUSLY) N VALUES BASED ON CONFIDENCE, STATISTICS

* COMPUTE PROFILE(S)

* COMPARE WITH BASE AND COMPUTE ERRORS

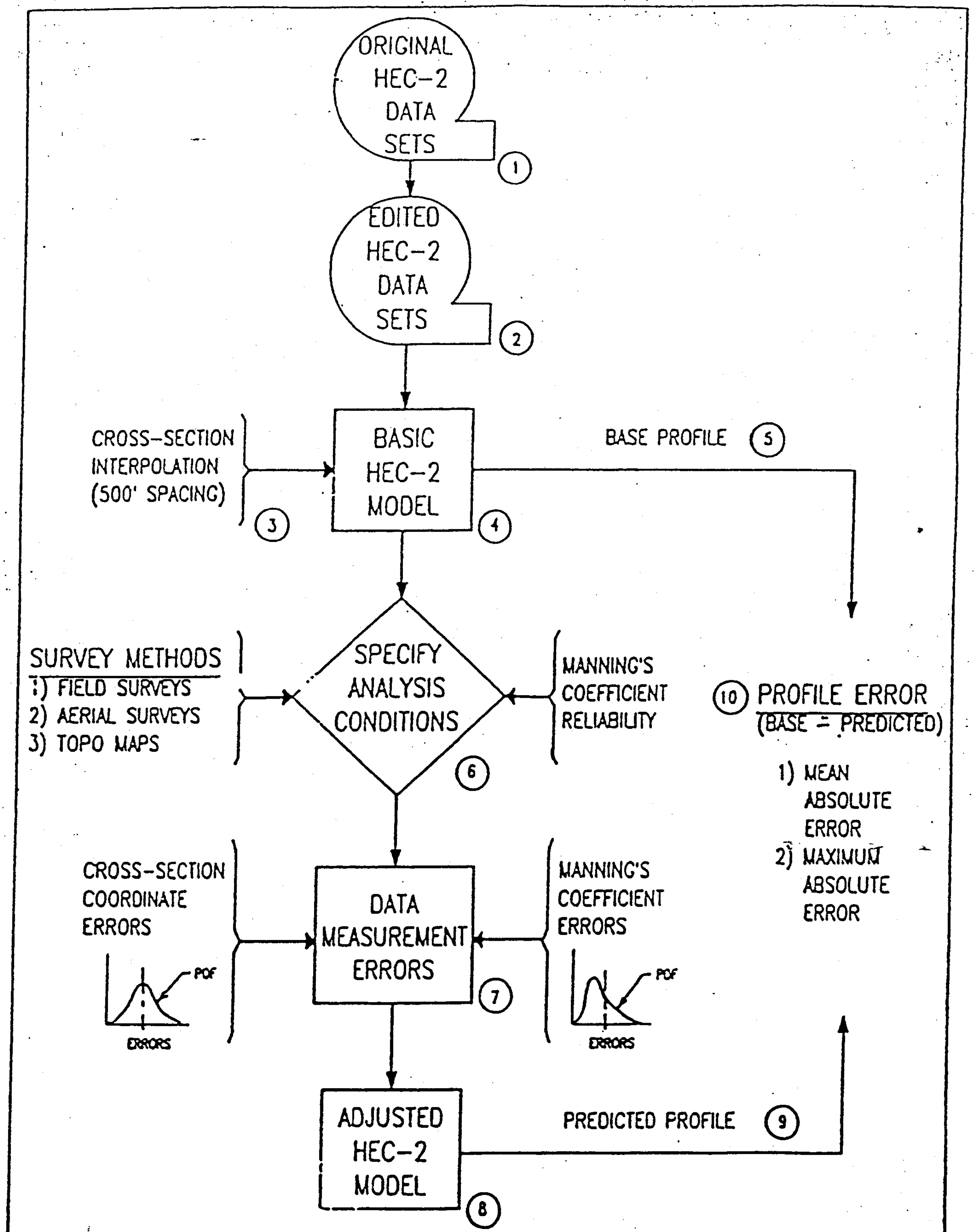


FIGURE 3.1 Profile Accuracy Analysis Schematic

ERROR ANALYSIS RESULTS

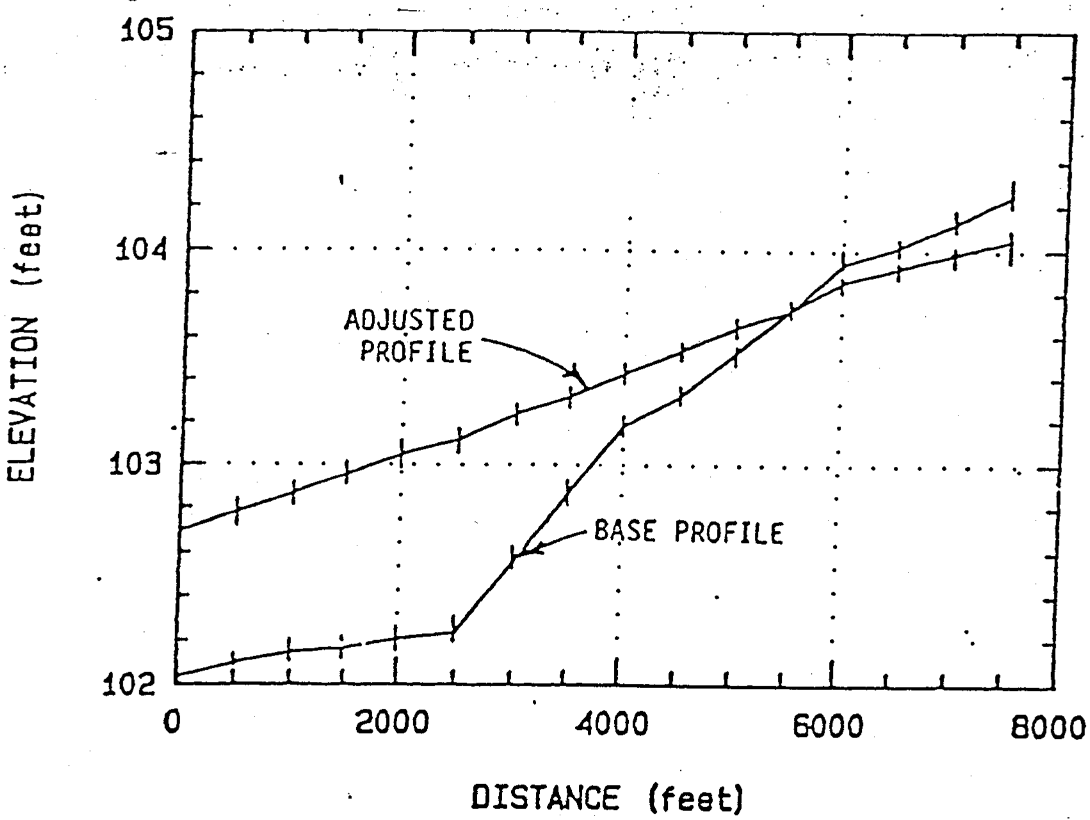
* 50,000 HEC-2 RUNS (WHEW!)

* MEAN / MAXIMUM ERRORS - EACH STREAM, EACH ERROR CONDITION (21) .. TECHNOLOGY, ACCURACY, MANNING'S N CONFIDENCE

* REGRESSION WITH STREAM PARAMETERS - DERIVE PREDICTION EQUATIONS

* TEST RELIABILITY OF EQUATIONS

* ADAPT RESULTS TO NOMOGRAPHS



CALCULATION No.	DISTANCE (ft.)	BASE PROFILE ELEV.	ADJUSTED PROFILE ELEV.	ERROR (ft.)	ABSOLUTE ERROR (ft.)
1	500	102.10	102.78	-.68	.68
2	1000	102.15	102.87	-.72	.72
3	1500	102.17	102.96	-.79	.79
4	2000	102.21	103.05	-.84	.84
5	2500	102.24	103.12	-.88	.88
6	3000	102.56	103.24	-.68	.68
7	3500	102.87	103.32	-.45	.45
8	4000	103.18	103.43	-.25	.25
9	4500	103.32	103.54	-.22	.22
10	5000	103.53	103.65	-.12	.12
11	5500	103.73	103.73	.00	.00
12	6000	103.94	103.86	.08	.08
13	6500	104.02	103.92	.10	.10
14	7000	104.13	103.99	.14	.14
15	7500	104.25	104.05	.20	.20
					6.15 ft.

Reach Absolute Mean Error = 6.15/15 = .41 feet
Reach Absolute Maximum Error = .88 feet

FIGURE 6.1 Profile Error Analysis Example

SURVEY ACCURACY NEEDED: SPECIFIED PROFILE ACCURACY					
HYD DEPTH = 5 FT		N KNOWN		N ESTIMATED	
SLOPE FT/MI	ACCRCY FT	AERIAL CNTR	TOPO CNTR	AERIAL CNTR	TOPO CNTR
1	0.1	10	2	NA	NA
1	1.0	10	10	10	2
1	2.0	10	10	10	10
10	0.1	5	2	NA	NA
10	1.0	10	10	2	NA
10	2.0	10	10	10	5
50	0.1	5	2	NA	NA
50	1.0	10	5	NA	NA
50	2.0	10	10	10	2

* PROFILE ACCURACY RESULT EXAMPLE

SLOPE = 10'/MILE, HYD DPTH = 5.0'

	MEAN ERROR - FT.			
	N KNOWN		N ESTIMATED	
	CNTR = 2	CNTR = 10	CNTR = 2	CNTR = 10
FIELD	0.0	0.0	1.0	1.0
AERIAL	0.1	0.2	1.0	1.2
TOPO	.1	1.0	1.4	3.0

* EXTENT DATA COLLECTION EXAMPLE

SLOPE = 10.0'/MILE, HYD DPTH = 5.0', HL = 5'

> DOWNSTREAM REACH LENGTH = 2,900 FT.

> UPSTREAM REACH LENGTH = 5,900 FT.

TABLE 6.4

Field Survey
Water Surface Profile Errors

Stream Slope (ft./mi.)	Manning's Coefficient Reliability (Nr)	Profile Error Emean* (ft.)
1	.0	.0
1	.5	.36
1	1.0	.57
10	.0	.0
10	.5	.47
10	1.0	.74
30	.0	.0
30	.5	.53
30	1.0	.83

*Emean = Mean absolute reach error for hydraulic depth of 5 feet.

TABLE 6.5

Aerial Survey Method Effect
On Water Surface Profile Accuracy

Stream Slope (ft./mi.)	Contour Interval (feet)	Emean* for Nr = 0 (feet)	Emean* for Nr = 1 (feet)
1	2	.02	.59
1	5	.04	.61
1	10	.07	.64
10	2	.06	.75
10	5	.13	.78
10	10	.22	.83
30	2	.10	.85
30	5	.22	.88
30	10	.39	.93

*Emean = Reach mean absolute error where hydraulic depth is assumed to be 5 feet.

TABLE 6.6

Topographic Map Effect On Water Surface Profile Accuracy

Stream Slope (ft./mi.)	Contour Interval (feet)	Emean* for Nr = 0 (feet)	Emean* for Nr = 1 (feet)
1	2	.09	.95
1	5	.28	1.19
1	10	.63	1.58
10	2	.16	1.28
10	5	.47	1.60
10	10	1.07	2.13
30	2	.21	1.48
30	5	.61	1.84
30	10	1.38	2.46

*Emean = Reach mean absolute error where hydraulic depth is assumed to be 5.0 feet.

TABLE 6.7

SURVEY ACCURACY REQUIREMENTS[1]
FOR SPECIFIED PROFILE ACCURACIES
(Hydraulic Depth is 5 Feet)

		Manning's n-value Reliability - Nr = 0		Manning's n-value Reliability - Nr = 1	
Stream Slope (ft./mi.)	Profile Accuracy Emean[2] (feet)	Aerial Survey Contour Interval	Topo Map Contour Interval	Aerial Survey Contour Interval	Topo Map Contour Interval
1	.1	10 foot	N.A.	N.A.	N.A.
1	.5	10 foot	5 foot	N.A.	N.A.
1	1.0	>10 foot	10 foot	10 foot	2 foot
1	1.5	>10 foot	10 foot	10 foot	5 foot
1	2.0	>10 foot	10 foot	>10 foot	10 foot
10	.1	2 foot	N.A.	N.A.	N.A.
10	.5	10 foot	5 foot	N.A.	N.A.
10	1.0	10 foot	5 foot	10 foot	N.A.
10	1.5	>10 foot	10 foot	10 foot	2 foot
10	2.0	>10 foot	10 foot	10 foot	5 foot
30	.1	2 foot	N.A.	N.A.	N.A.
30	.5	10 foot	2 foot	N.A.	N.A.
30	1.0	10 foot	5 foot	10 foot	N.A.
30	1.5	>10 foot	10 foot	10 foot	2 foot
30	2.0	>10 foot	10 foot	10 foot	5 foot

[1]Denotes maximum survey contour interval to produce desired accuracy.
[2]Emean is mean absolute reach error.

Computed Water Surface Profile Accuracy System

FILE MANAGEMENT AND SYSTEM UTILITIES
- A. File Management
- B. System Environment

CROSS SECTION PROPERTIES
- C. **Cross Section Data Entry**
- D. Hydraulic Variables Data Entry
- E. Cross Section Plot
- F. Cross Section Report
- G. Hydraulic Variable Report
- H. Rating Table
- I. Rating Curve

STUDY REACH DELINEATION
- J. Study Limit Report

PROFILE ERROR ANALYSIS
- K. Error Report

COST COMPARISON
- L. Cost Report
- M. Optional Costs

Use arrow keys to highlight selection. Press <ENTER>

1Help 2Prtscr 3Index 4 5 6 7 8 9 10Quit

ADVANCED BRIDGE MODELING TECHNIQUES

Reference: HEC-2 Users Manual, Appendix IV, especially the section on Bridge Problems and Suggested Approaches.

1. MULTIPLE BRIDGE OPENINGS

a. Does one energy and water surface elevation apply?

b. Can the bridge be modeled as a trapezoid for low flow?

c. Would the bridge openings all be under pressure flow at one time?

d. Generally, the Normal Bridge Option would be used initially.

e. Assume a one-dimensional solution applies and evaluate the computed results. The distribution of flow through the several sections in the bridge model would be the primary basis for evaluation.

f. Divided flow analysis would be required if a one-dimensional solution does not apply. Each flow path would have to be computed separately.

g. Special Bridge coding (without a pier width) can be used to obtain a Standard-step solution for low flow, but the solution is not equivalent to the solution from the multiple bridge sections usually used for Normal Bridge.

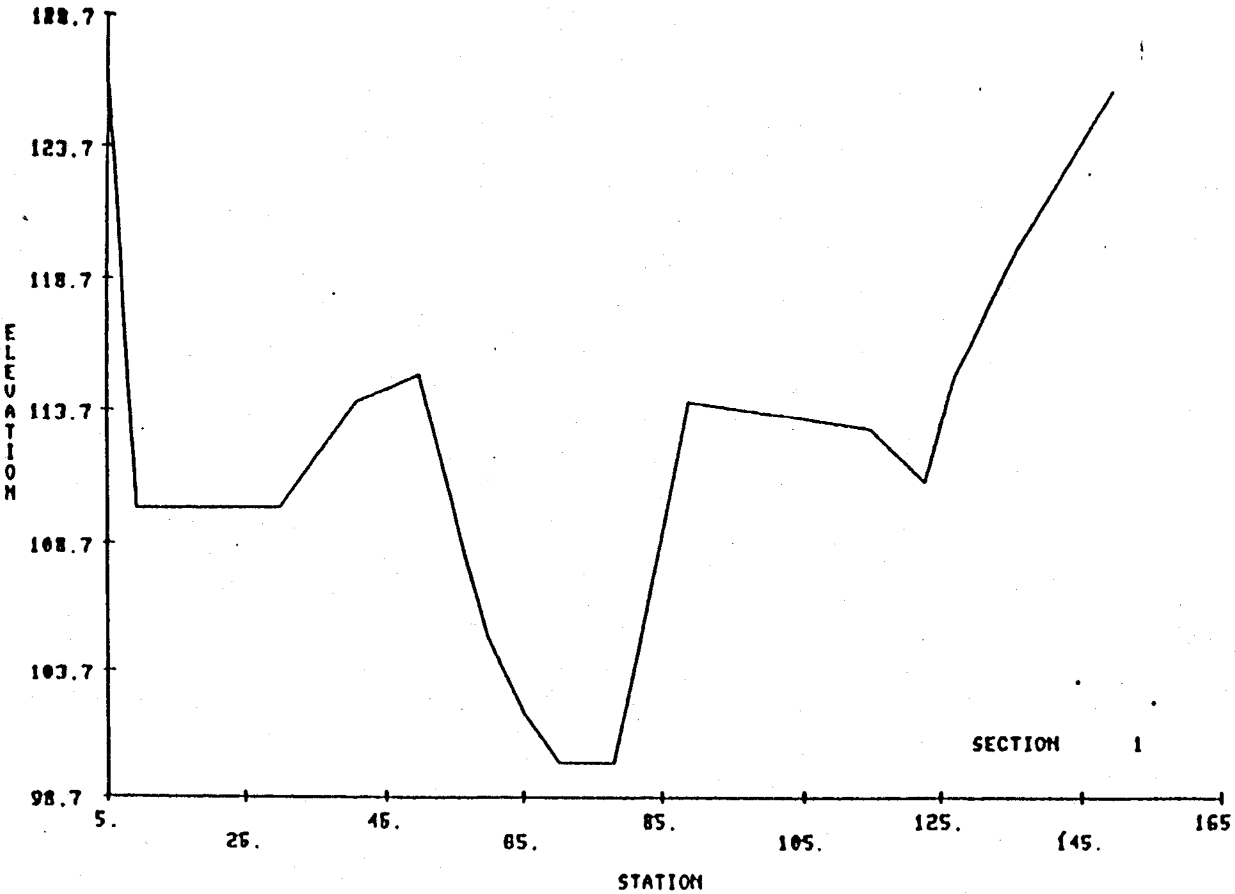


Figure 1. Natural Cross-Section Downstream from Bridge

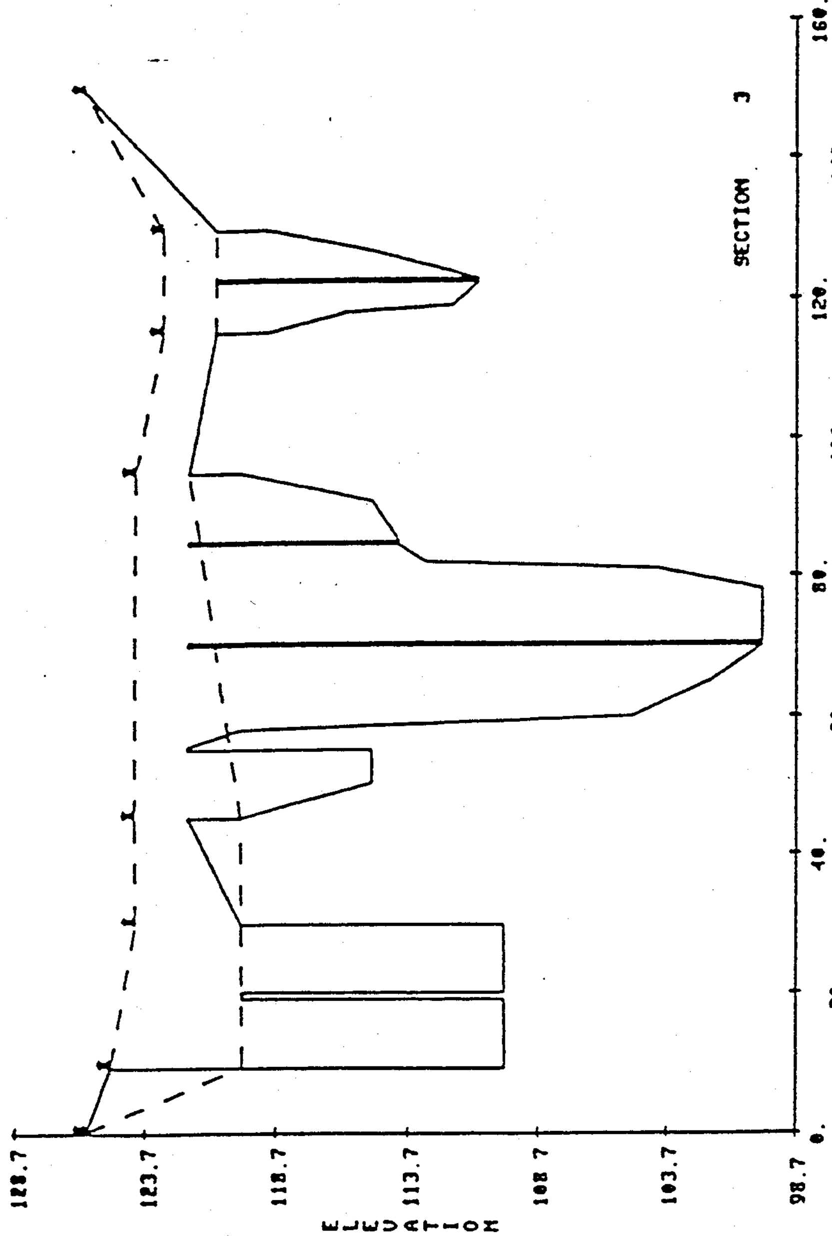
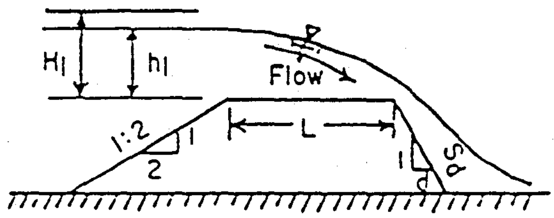


Figure 2. Bridge Section for Normal Bridge Routine

a. A cross section located at the weir/dam crest generally produces a critical depth solution. Several cross sections should be located immediately upstream from the section at the crest.

b. Special Bridge can be used to obtain a weir flow solution. Data are required for the low flow and pressure flow solution. Minimum areas are defined for the trapezoid and orifice area. The final solution will be based on Weir and Pressure flow.



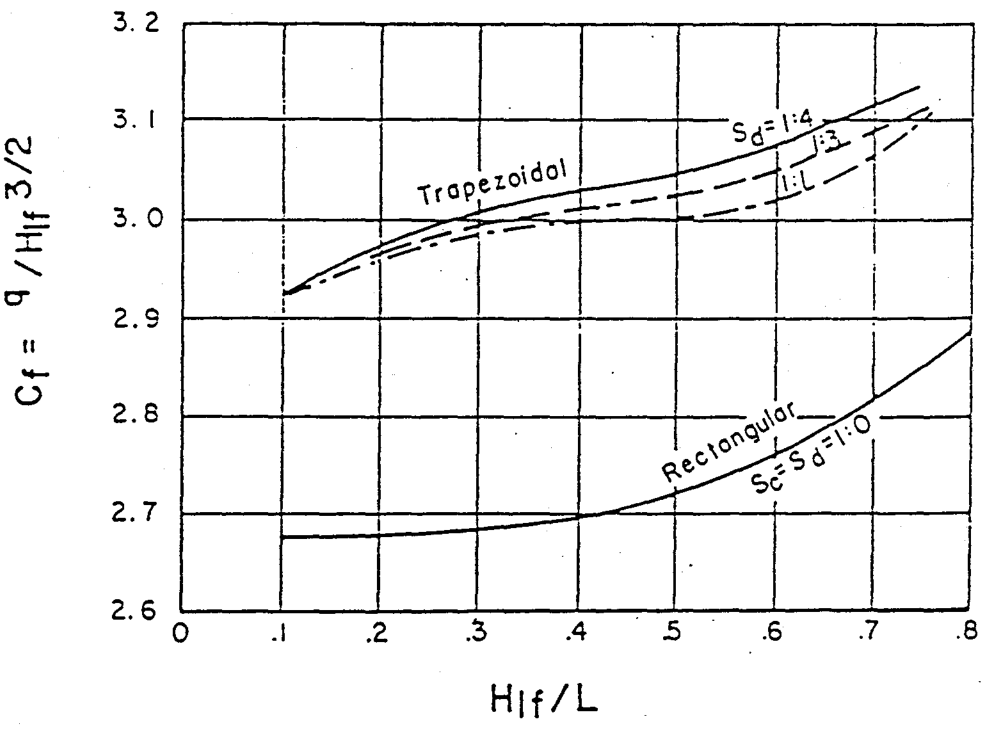


Figure 3. Water Surface Profile Over Low Dam or Weir

3. PERCHED BRIDGES

a. Perched bridges are raised above the flood plain at the river crossing (see below).

b. Does the approach roadway act like a weir, or does the overbank-flow pass over the approach roadway?

Special Bridge provides an overflow based on the weir equation. The combined low-flow and weir flow solution is the most difficult. The basis for the solution is different for the two equations and requires a good estimate of the flow distribution downstream from the bridge.

Normal Bridge provides a conveyance-based solution. If the approach road is a minor obstruction to overbank flow, the flow distribution based on conveyance is more appropriate.

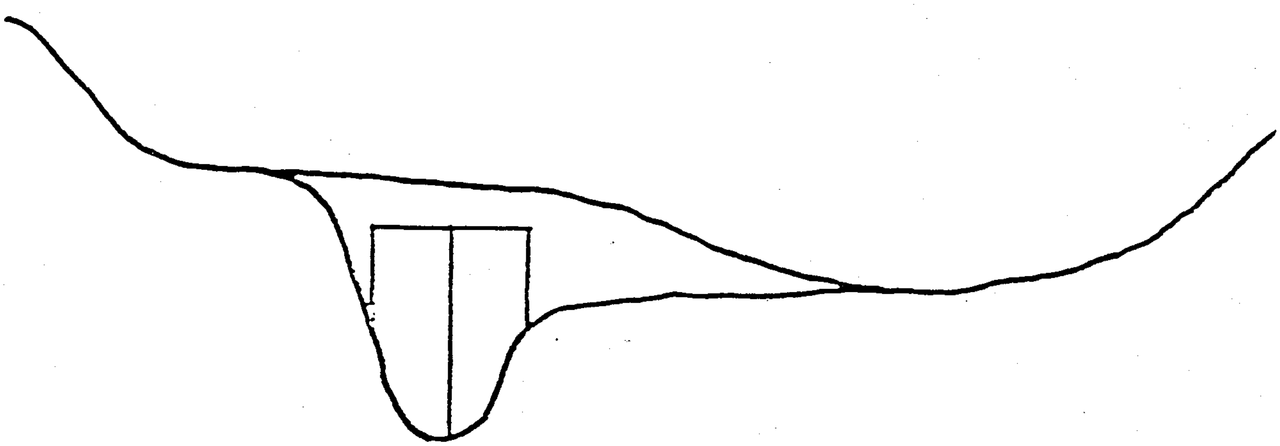


Figure 4. Wide Flood Plain with Perched Bridge

4. LOW WATER BRIDGES

a. Low water bridges are only designed to pass low flows under the bridge.

b. Under flood flows, the bridge would be completely submerged.

Special Bridge would solve the flood flow problem as pressure and weir flow, with a high submergence correction.

Normal Bridge solution would be conveyance-based. The bridge deck would be like an obstruction to flow. In some cases the bridge would be a minor concern because the majority of the flow would be over the top of the bridge.

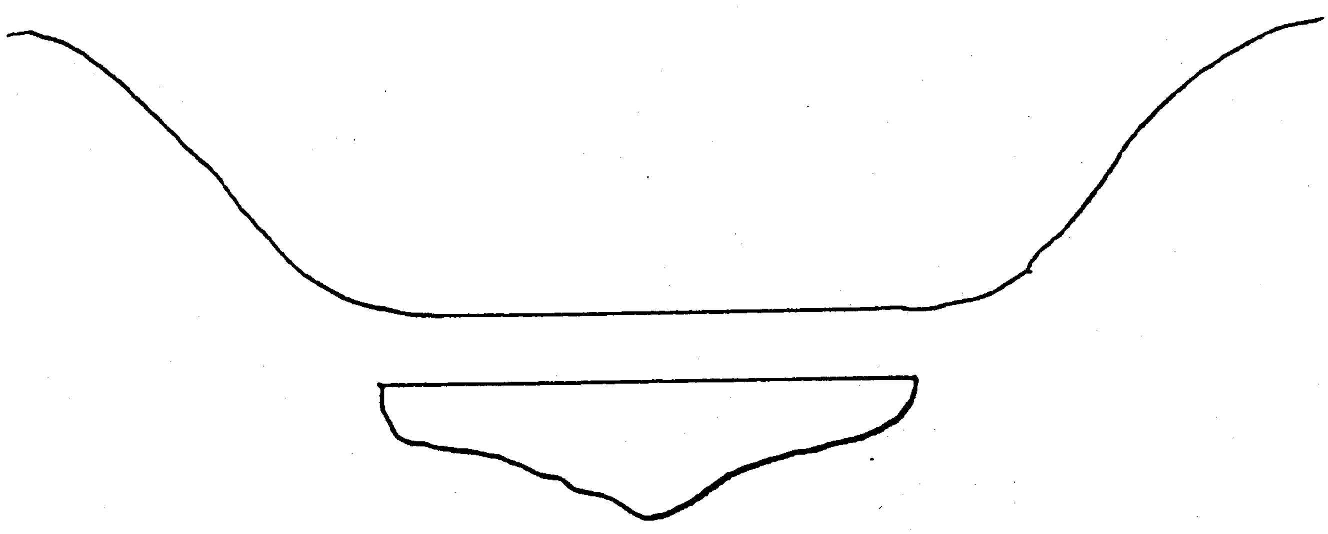


Figure 5. Low Water Bridge Section

5. BRIDGES ON A SKEW

Bridges crossing rivers at an angle, other than normal to the flow lines, are usually defined perpendicular to the flow.

Normal Bridge input can be adjusted by using the variables PXSECR (X1.8) for the GR data and BSQ (X2.9) for the BT data. The cosine of the angle is used as the multiplying factor for the horizontal stationing in the section to define the normal projection of the section.

Special Bridge input (SB record) are not modified by the cross section adjustments described above. Required adjustments must be made prior to input.

The following diagrams, from "Hydraulics of Bridge Waterways" (reference j) illustrate the concept of defining the normal projection for skewed bridge crossings. In model testing, skewed crossings with angles up to 20^{o} showed no objectionable flow patterns. Curves of Incremental backwater coefficient for skew indicates a minor adjustment for angles up to 30^{o}.

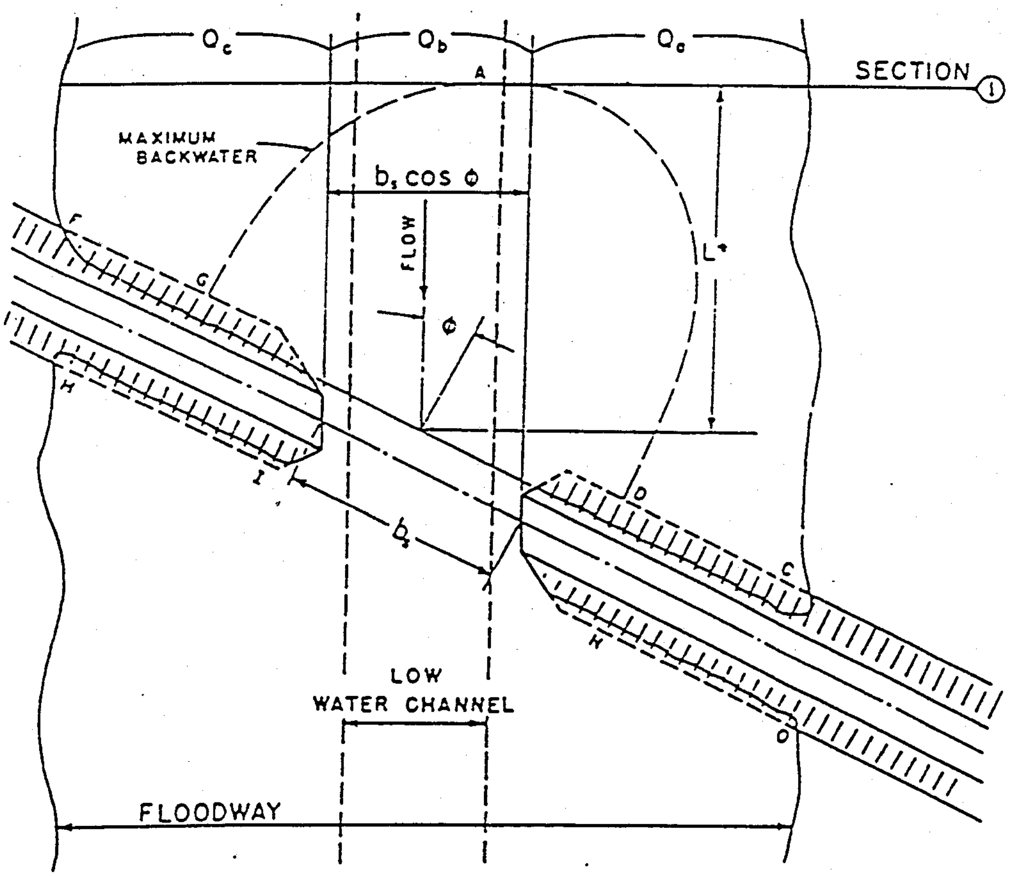


Figure 9.—Skewed crossings.

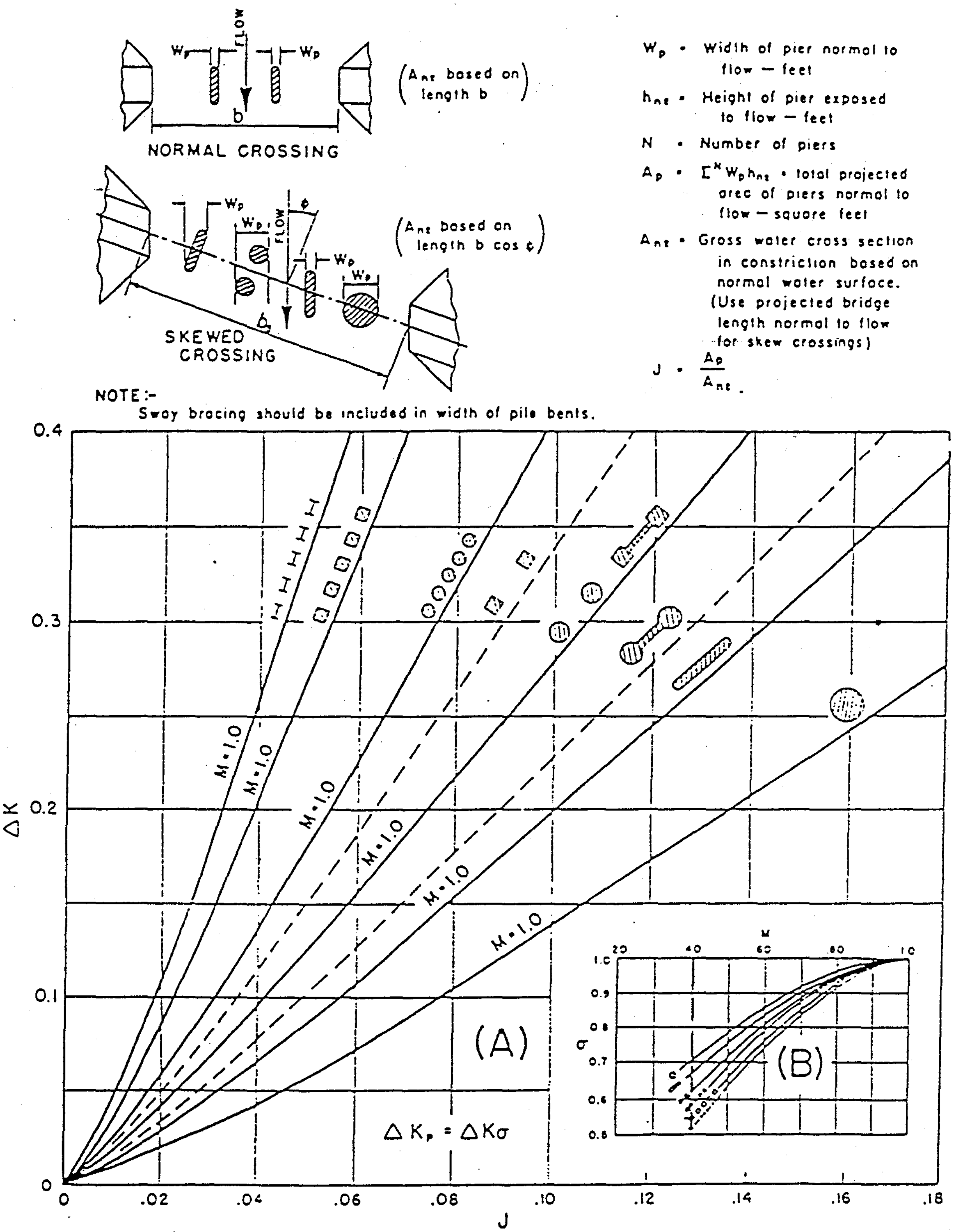


Figure 7.—Incremental back-water coefficient for piers.

Figures from: "Hydraulics of Bridge Waterways" by Feder

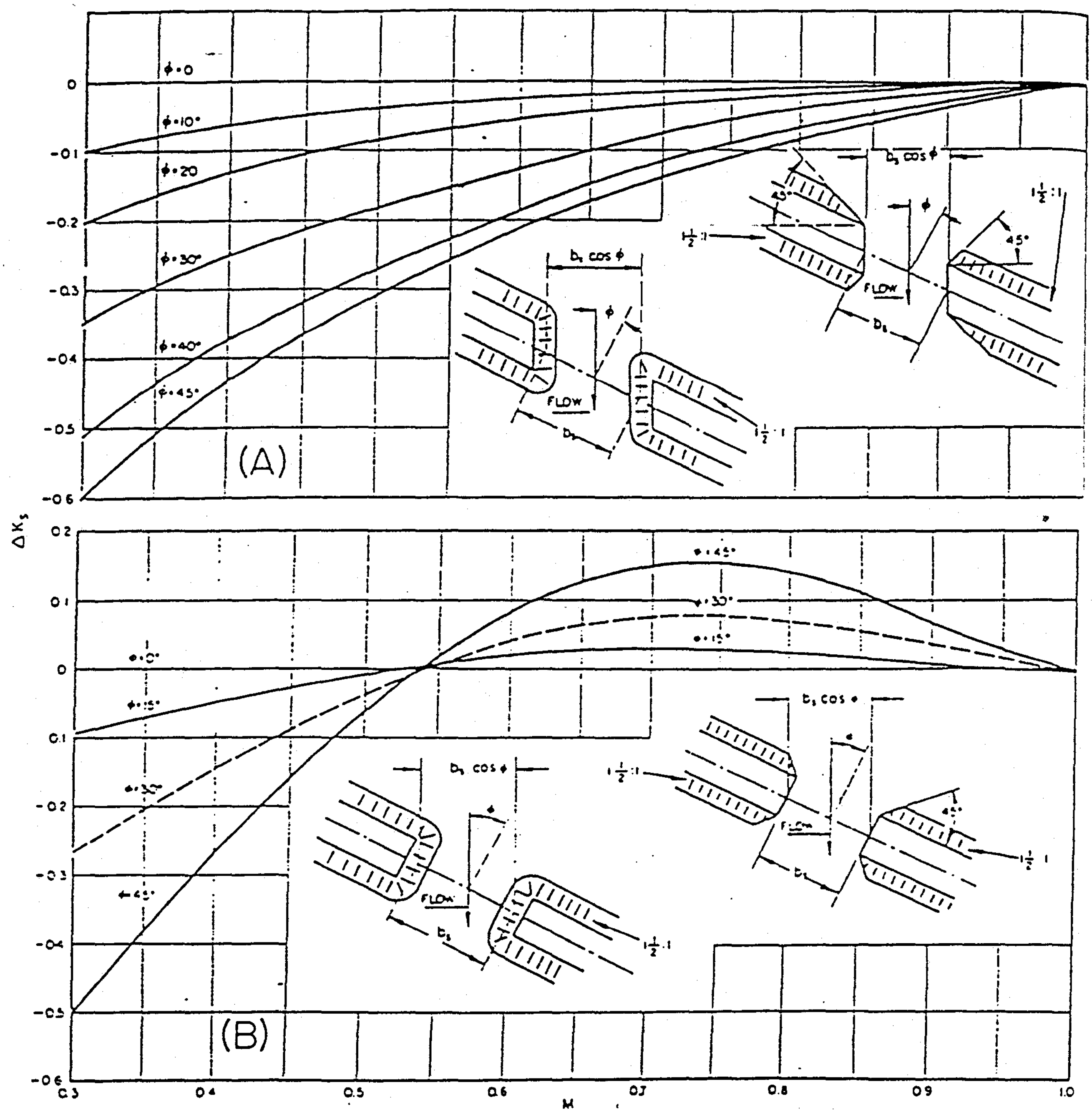


Figure 10.—Incremental backwater coefficient for skew.

Figures from: "Hydraulics of Bridge Waterways"

6. PARALLEL BRIDGES

The hydraulic losses through two bridges, close together, is less than twice the losses from one bridge. Model results, shown in reference j, indicate the loss from two bridges ranging from 1.3 to 1.55 times the loss from one.

A primary factor in the lower losses is the lack of expansion and contraction between the bridges. Using an average expansion rate of 1:4 and a contraction rate of 1:1, a modeler could approximate the degree of expansion on effective flow between bridges.

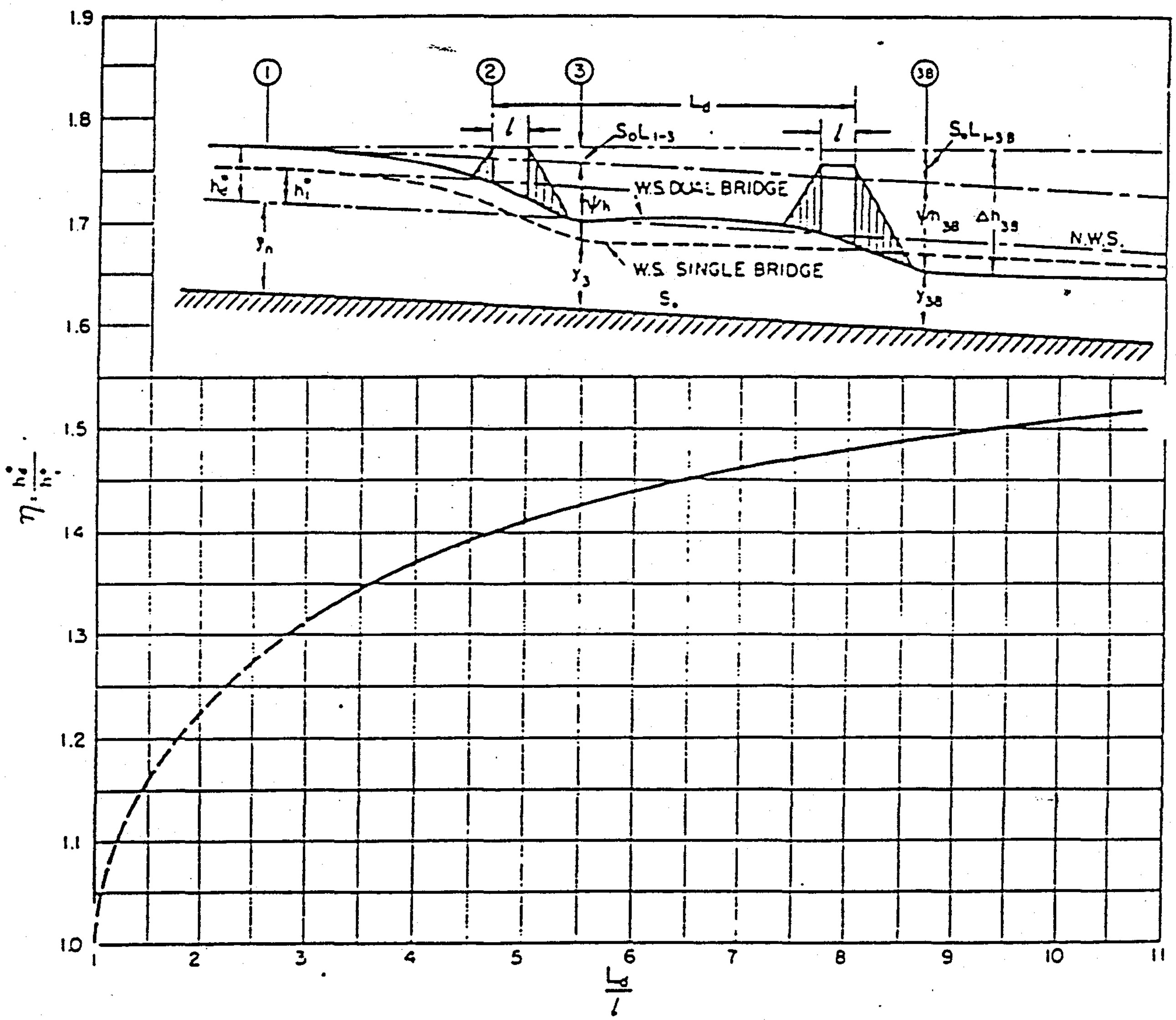


Figure 14.—Backwater multiplication factor for dual bridges.

Figure from: "Hydraulics of Bridge Waterways"

7. SPUR DIKES

Spur dikes are used on the upstream side of a bridge to prevent scour from flow traveling along the upstream side of the roadway embankments. The dikes direct the flow into the bridge opening.

Spur dikes can be modeled in HEC-2 by adding an additional section upstream from the bridge. The section would represent the entrance into the spur dikes. A friction based energy solution would be computed for the step from the bridge to the spur dike entrance.

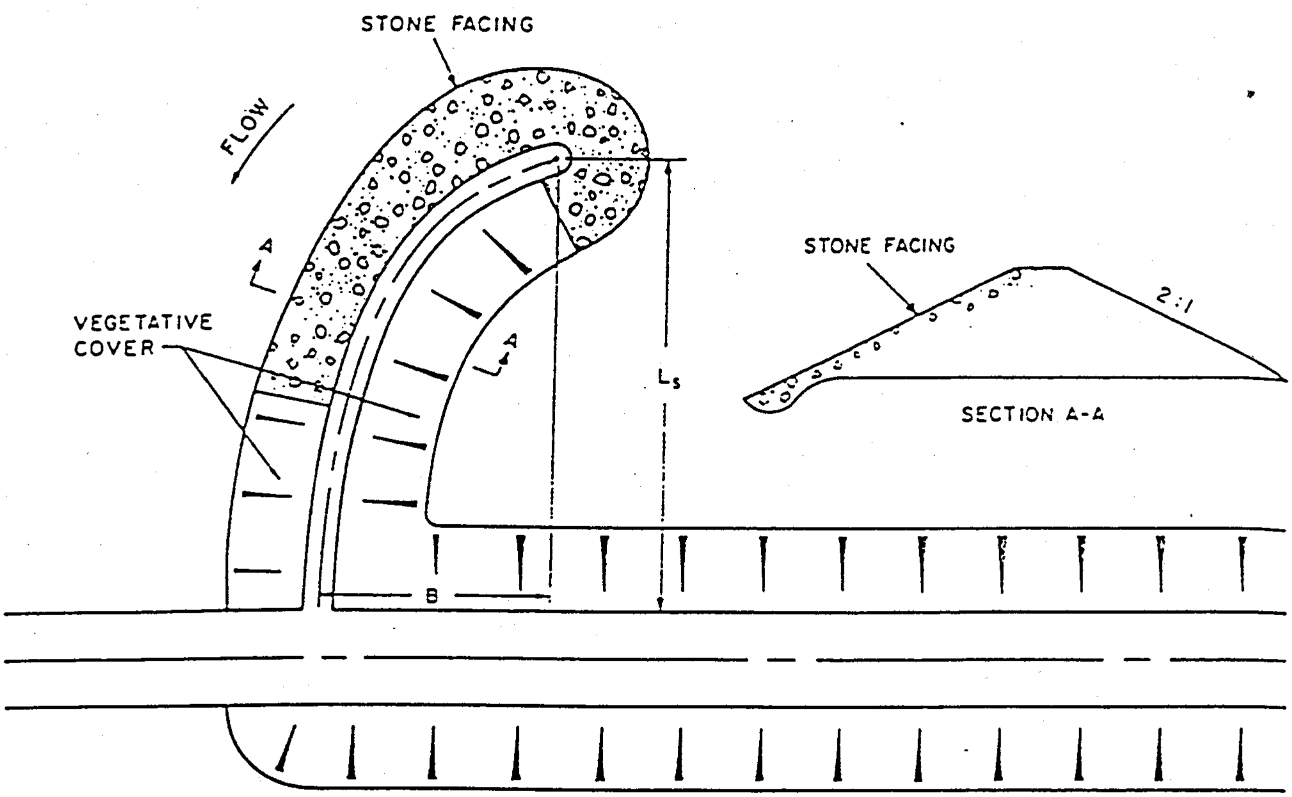


Figure 33.—Plan and cross section of spur dike.

Figure from: "Hydraulics of Bridge Waterways"

8. REFERENCES

a. "Backwater Curves in River Channels," Engineering Manual 1110-2-1409, U.S. Army Corps of Engineers, December 1959.

b. "Computer Determination of Flow through Bridge," Eichert, B.S. and Peters, J.C., ASCE, J. Hydraulics Div., Vol. 96, No. HY7, July 1970.

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d. "Handbook of Concrete Culvert Pipe Hydraulics," Portland Cement Association, 1964.

e. "Handbook of Hydraulics," Horace W. King and Ernest F. Brater, Fifth Edition, McGraw-Hill Book Co., 1963.

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g. "HEC-2, Water Surface Profiles," Users Manual, The Hydrologic Engineering Center, September 1982.

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j. "Hydraulics of Bridge Waterways," Hydraulic Branch, Bridge Division, Office Engineering and Operations,m Bureau of Public Roads, 1970.

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SOME COMMENTS ON APPLICATION OF HEC-2

Introduction

Most difficulties with application of HEC-2 are due to inaccurate descriptions of the geometry of flow at bridges and elsewhere; that is, cross sections are not representative of effective flow areas or reach lengths are too long. The following paragraphs pertain to cross section specification and spacing. Inasmuch as thorough evaluation of program results is essential for effective application of HEC-2, guidelines are provided that delineate an approach for reviewing HEC-2 output.

Considerations in Cross Section Designation

The essence of water surface profile calculation is the maintenance of an energy budget from cross section to cross section. The most important and difficult aspect of maintaining the energy budget is the determination of energy losses that occur in reaches between adjacent cross sections. It is the determination of energy losses that imposes constraints on the permissible length of reach between cross sections and consequently on the number of cross sections required for a study.

The distance between cross sections is too long if hydraulic properties of the flow change too radically from cross section to cross section. A variable in the HEC-2 computer output that deserves particular attention is SLOPE, the slope of the energy line at a cross section. If, from one cross section to the next one upstream, SLOPE decreases by more that 50% or increases by more more than 100%, the reach length may be too long for accurate determination of energy losses caused by boundary friction.

The option in HEC-2 for generating interpolated cross sections should be used with caution. The option bases the shape of the interpolated cross section on the 'current' cross section and on the main-channel area of the 'previous' cross section, but does not account directly for the shape of the 'previous' cross section. Consequently, whenever an interpolated cross section is generated, it should be carefully reviewed. Also, the criterion of using the change in velocity head for determining when to generate cross sections is not foolproof; other criteria such as considering the per cent change in SLOPE as indicated above can also be useful.

Bridges are in many cases a major source of energy loss and must therefore receive careful attention in calculating profiles. The major influence of a bridge is how it causes the flow to contract and expand. Cross section designation and spacing must be done judiciously so that only the truly 'effective' flow areas are considered.

Several questions arise with regard to the accuracy required for defining cross sections. Should sections be surveyed or are sections from USGS quad sheets adequate? Can necessary sections be obtained simply by moving and adjusting surveyed sections? Unfortunately, there are not easy answers to these questions, and in many cases, they are best answered by sensitivity analysis. That is, replace surveyed cross sections with cross sections obtained from quad sheets; if the impact on the water surface profile is minimal, quad sheets may be a good source for defining intermediate cross sections. One sensitivity study conducted by the HEC indicated that use of cross sections from quad sheets in lieu of surveyed sections can have a very significant impact (>1.5ft.) on the water surface profile.

GUIDELINES FOR ANALYSING OUTPUT FROM HEC-2

1. Review the Summary Printout and note locations where:

   a. critical depth occurs.

   b. radical changes in topwidth occur from one section to another.

   c. radical changes in energy slope (SLOPE) occur from one section to another.

   d. there are bridges.

   e. multiple profiles cross or where other anomalies are apparent.

2. Review profile plots to detect inconsistencies in flow profiles and gross errors in invert and bank elevations.

3. Review the regular (section by section) printout and mark, for later reference, locations determined in 1 above. Also mark all special notes.

4. At locations where critical depth occurs:

   a. if critical depth occurs at isolated cross sections throughout the run, check the geometry of these cross sections; also check the change in energy slope in reaches adjacent to the cross sections to determine if additional cross sections are needed.

   b. if critical depth occurs at several cross sections in sequence, it is likely that a reach of supercritical flow exists and a supercritical run through the reach may be warranted.

5. At locations where radical changes in topwidth occur, determine with the aid of a topographic map the paths that the flow is likely to follow and modify cross sections and reach lengths accordingly. Flow distribution should not vary too greatly from one cross section to the next. That is, it is probably unreasonable for 70% of the flow to be in the left overbank portion of one cross section and none of the flow in the left overbank portion of an adjacent cross section. Ponding areas should not be included in cross sections. Long reaches of divided flow require special treatment.

6. At locations where radical changes in energy slope occur (e.g., a change of 50-100% from one cross section to the next), the computation for friction loss will be inaccurate and it is probable that cross section geometry is not properly described and/or additional cross sections are required.

7. At bridges:

   a. check consistency of flow type (from special bridge routine) with bridge and cross section geometry.

   b. check for proper application of effective area option where used.

   c. check reasonableness of energy loss through bridge and in adjacent reaches.

8. Where special notes are printed out, determine cause of notes and modify cross section geometry, etc., if necessary.

LITTLE KNOWN HEC-2 OPTIONS

1. Creation of HEC-2 input file from free formatted file - FR and $FREE records

2. Compute Manning's 'n' values from known water surface elevations - J1.3 and X2.2

3. Runs in metric and English units - J1.6

4. Multiply all discharges by a certain factor - J1.10

5. Multiply all Manning's 'n' by a factor - J2.6

6. Compute critical depth even if the actual flow is not critical; can specify a certain percentage of actual to critical depth to activate this option - J2.7

7. Generate an updated geometry from PXSECR and PXSECE (X1.8 and X1.9) and channel improvement - J2.8

8. Output of storage-discharge records for input in HEC-1 for modified-Puls routing - J4

9. Specify starting station of the first cross section in miles or feet (meters) - J6.4 and J6.5

10. Can use equivalent roughness 'k' instead of Manning's 'n'

11. Specify change in water surface elevation from downstream cross section to present regardless of what was computed; constant for all profile runs - X2.6

12. Increase all elevations of a cross section to a specified elevation to simulate sediment deposition or filling in - X3.2

13. Increment of elevation to add to the downstream water surface elevation to obtain the elevation of the current cross section or specify a water surface elevation regardless of computations; can vary by profile runs - X5

FORM FOR CHECKING OVERBANK
FLOW CONSISTENCY IN HEC-2

		Q=		Q=		Q=		Q=	
Section Number	Bridge	Left	Right	Left	Right	Left	Right	Left	Right

APPLICATION OF HEC-2 FOR SPLIT FLOW ANALYSIS

I. Split flows are flows that leave the main river flow and take a completely separate path from that taken by the main river flow.

II. Common causes of split flows

- Split flows caused by high ground or islands

- Split flows caused by overtopping of levees

- Split flows caused by overtopping of watershed divides

- Split flows caused by flow diversion structures

III. Common split flow solution methods

- Iterative one dimensional steady state manual method

  1. Make an assumption of the amount of flow lost for each reach.

  2. Remove the flow lost from the backwater model and execute the backwater program to determine the water surface elevations.

  3. Based on the computed water surface elevations, compute the flows lost for each reach.

  4. Compare the assumed with the computed lost flows and if they are not within a certain tolerance, take the assumed and computed values and determine a new assumed value.

  5. Repeat steps one thru four until the accuracy required is met.

- Graphical interpolation for divided flow past an island.

  1. The total discharge is proportioned between the channels arbitrarily.

  2. The water surface elevation for the total flow is determined for the downstream cross section.

  3. Water surface profiles are calculated up each channel for each assumed discharge.

  4. The resulting water surfaces at the upstream section where the full flow exists are plotted for each channel.

  5. The individual rating curves are totaled and a total flow rating curve is produced.

  6. The upstream water surface is determined from the total flow rating curve and the individual channel flows are determined by intersecting the channel curves at the upstream water surface elevation.

- Unsteady state two or three dimensional dynamic computer models.

- Approximate routing methods.

IV. HEC-2 split flow option is a computerized version of the "Iterative one dimensional steady state manual method".

- Can handle up to 100 split flows simultaneously.

- Can handle multiple profiles.

- Three different methods for determining flow losses

  1. Weir flow assumption.

  2. Normal depth assumption.

  3. Rating curve assumption.

- Has the capability of returning or not returning the individual split flows further downstream.

- Option of using either the energy elevation or water surface elevation.

- The starting water surface elevation can now be based on a rating curve.

V. HEC-2 split flow input format.

- Uses standard HEC input format

  1. First field contains a two character card identifier.

  2. Second field has six columns and the next nine fields are eight columns long.

- The HEC-2 split flow data cards vary from the standard HEC format in that groups of cards are always preceded by a title card and the title card is required. In other words the order that the cards are input is fairly rigid.

- The split flow data cards must be the first cards read by the HEC-2 backwater program.

- The split flow data cards must be preceded by an SF title card and terminated by an EE card. The HEC-2 standard data cards should immediately follow the EE card.

VI. Split flow data cards used

- Card SF - Title card used to activate the use of the split flow option. Must be the first input data card in the deck and only one card can be used.

- Job Card Set

  JC Card - The JC card is used to tell the program that a JP card follows.

  JP Card - The JP card is used to set several job parameters dealing with the split flow computations. The JC and JP cards are optional and can be placed anywhere in the split flow data or completely left out.

- Weir Reach Card Set

  TW Card - The TW card is used to tell the program that WS and WC cards follow. It also serves a useful purpose as a title card used to identify the location of the weir.

  WS Card - The WS card contains information dealing with the number of points describing the weir, weirflow coefficient, location of the upstream and downstream limits of the weir in relation to section numbers as used in the X1 cards, and the section number where the flow returns.

  WC Card - The WC card is used to input the weir coordinates. The coordinate points must start at the downstream end and proceed upstream.

- Normal Depth Card Set

  TN Card - The TN card is used to tell the program that NS and NG cards follow. It also serves a useful purpose as a title card used to identify the location of the overflow reach.

NS Card - The NS card is similar to the WS card with the exception that instead of having the weirflow coefficient, it has the energy slope and 'n' value.

NG Card - The NG card is used to input the normal depth cross section coordinates. The coordinate points must start at the downstream end and proceed upstream.

- Rating Curve Reach Card

TC Card - The TC card is used to tell the program that CS and CR cards follow. It also serves a useful purpose as a title card used to identify the location of the overflow reach.

CS Card - The CS card is similar to the WS card with the exception that the location (upstream and downstream) is a point location and therefore the values entered for USSNO and DSSNO are normally equal.

CR Card - The CR card is used to input the outflow rating curve.

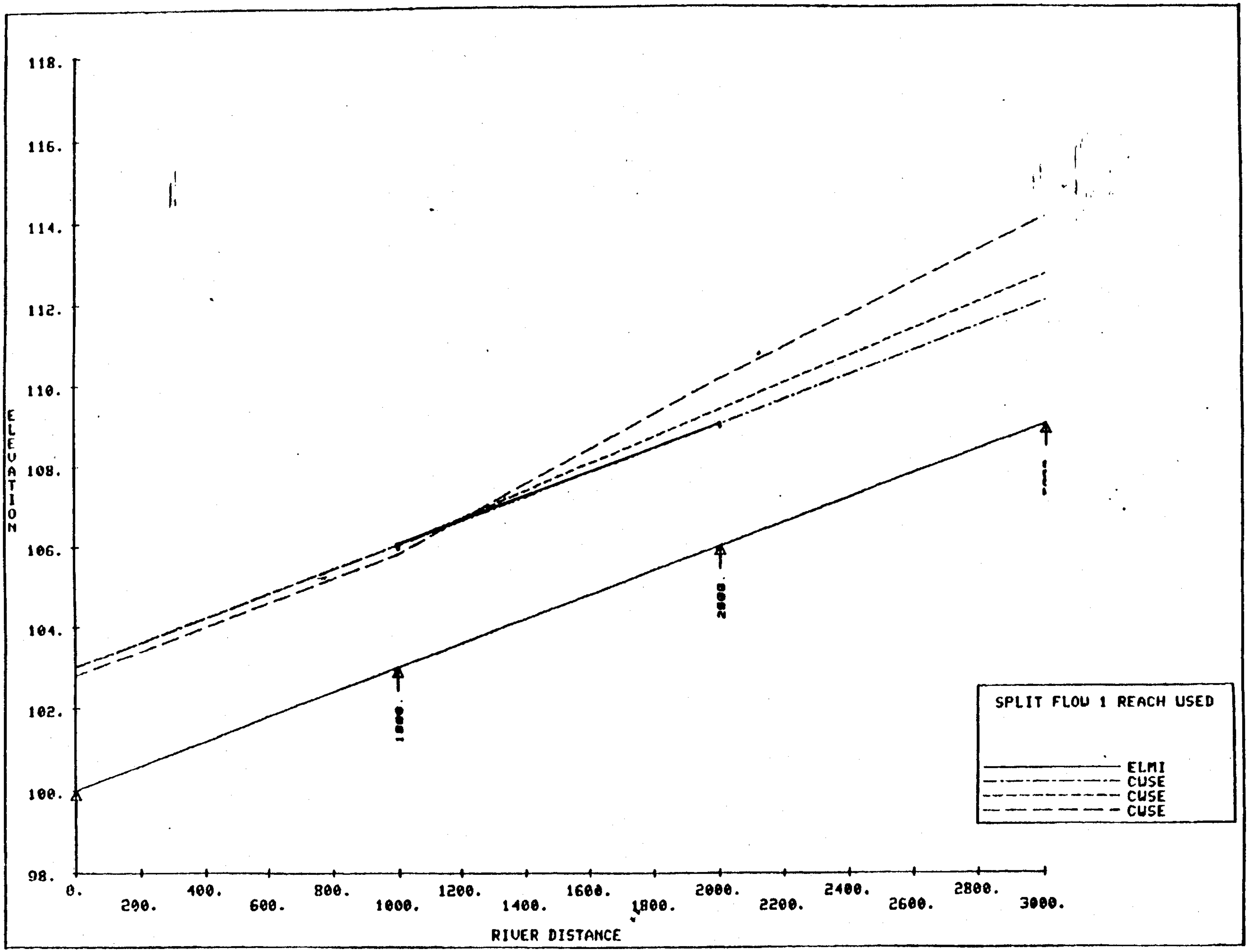
- Card EE - This card is required to terminate the reading of split flow data.

VII. Some additional data cards have been added to the standard HEC-2 input data cards which are needed to facilitate the use of the split flow option.

- JR Card - Starting Rating Curve card. The JR card is used to input a rating curve that is to be used to start the backwater. The JR card follows the J1 Card and is read when the STRT value on the J1 Card is greater than a value of one. The STRT value in this case is used to indicate the number of rating curve values that will be read on the JR card.

- JS Card - Starting Split Flow Assumption Card. The JS card is used to specify the starting assumed lost discharges for each reach defined in the split flow data set. The JS card follows the JI or JR cards. It is an optional card. If left out, the program assumes for its first trial that no flow is being lost

- RC Card - Rating Curve Card. The RC card is used to input a rating curve at any cross section, which will be used instead of calculating a backwater answer.



118.
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114.
112.
110.
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ELEVATION
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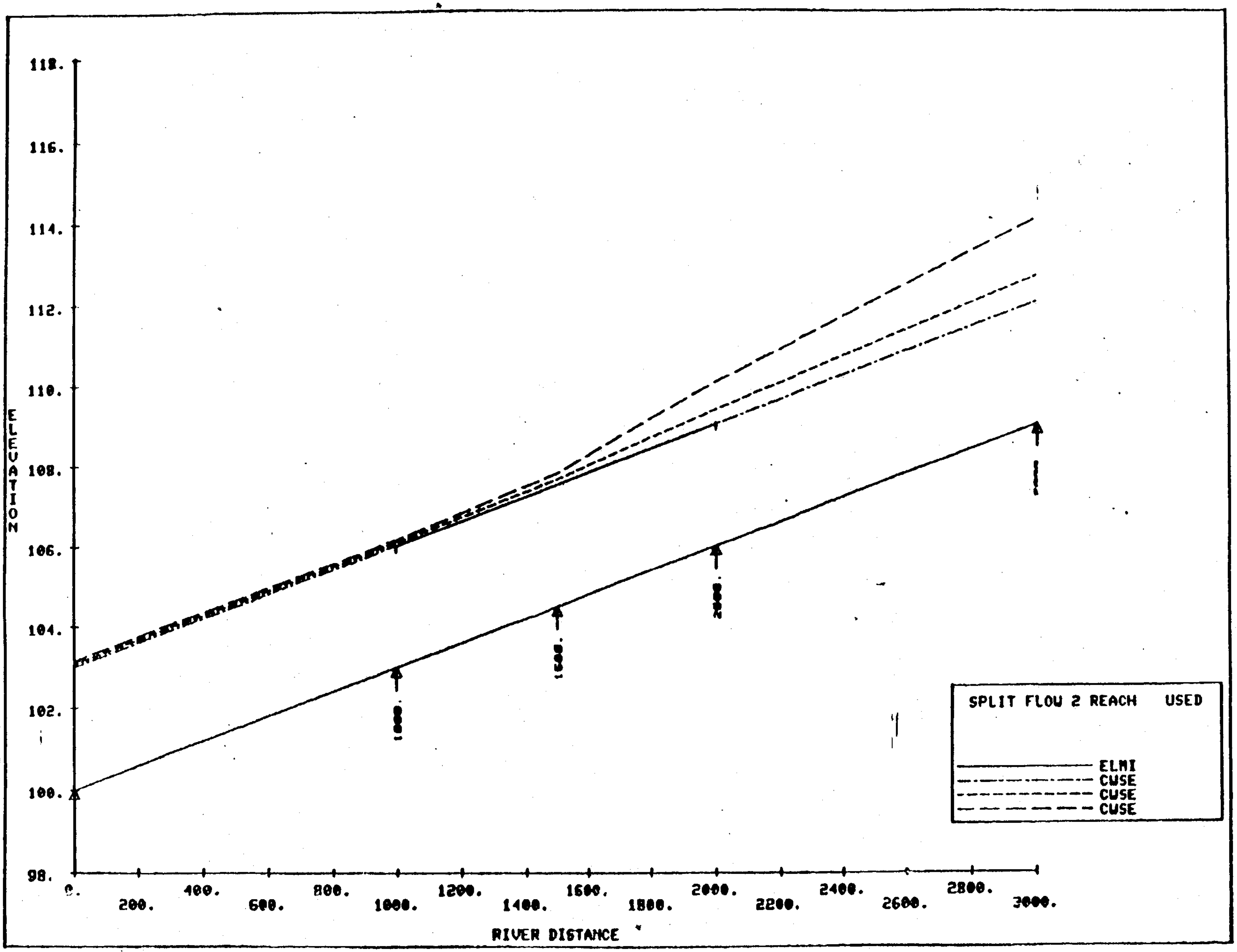
1400.
1600.
1800.
2000.
2200.
2400.
2600.
2800.
3000.
RIVER DISTANCE
SPLIT FLOW 1 REACH USED
ELMI
CWSE
CWSE
CWSE



118.
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2600.
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3000.
RIVER DISTANCE
SPLIT FLOW 2 REACH USED
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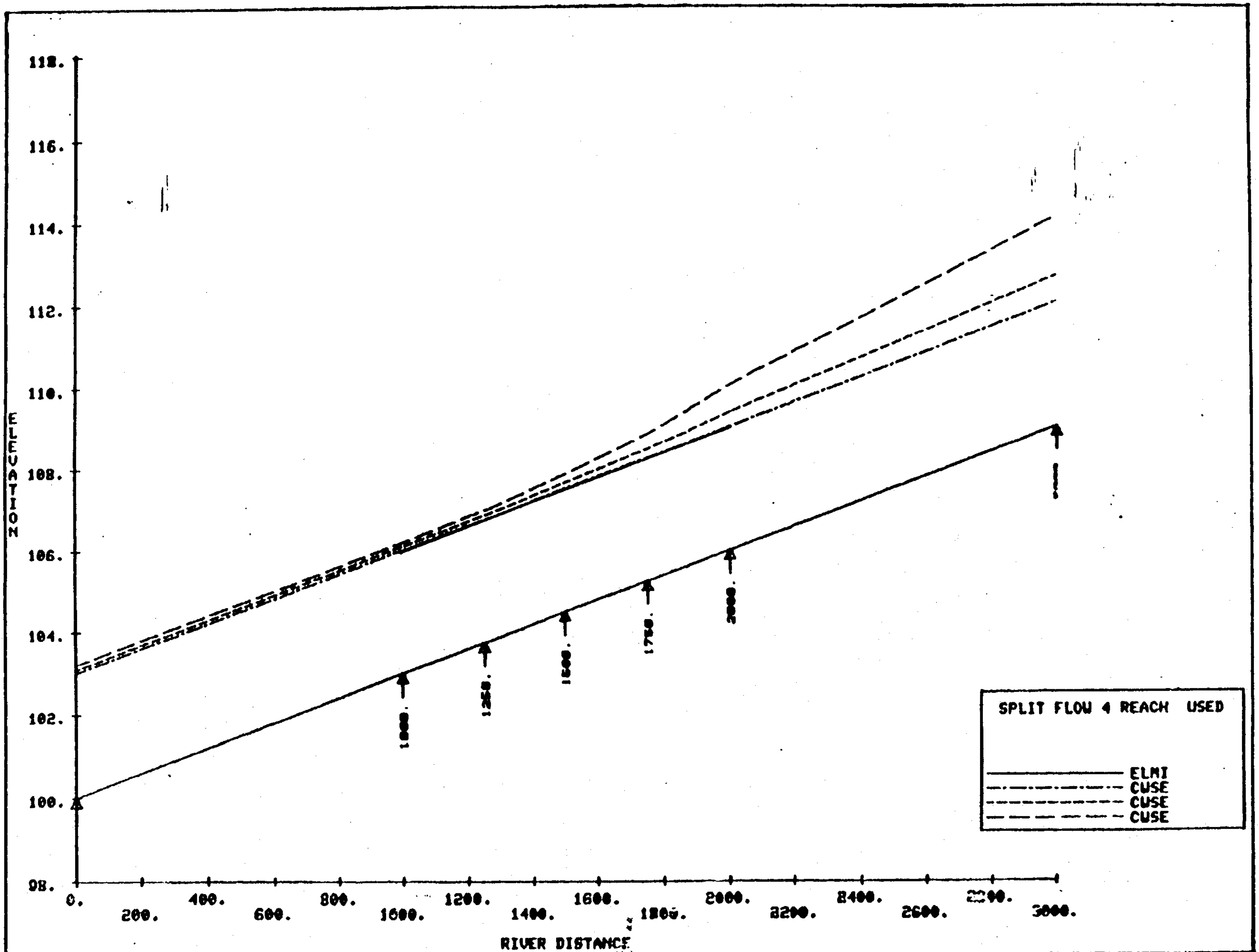
CWSE
CWSE
CWSE

8


SPLIT FLOW 4 REACH USED
ELMI
CWSE
CWSE
CWSE
ELEVATION
RIVER DISTANCE
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116.
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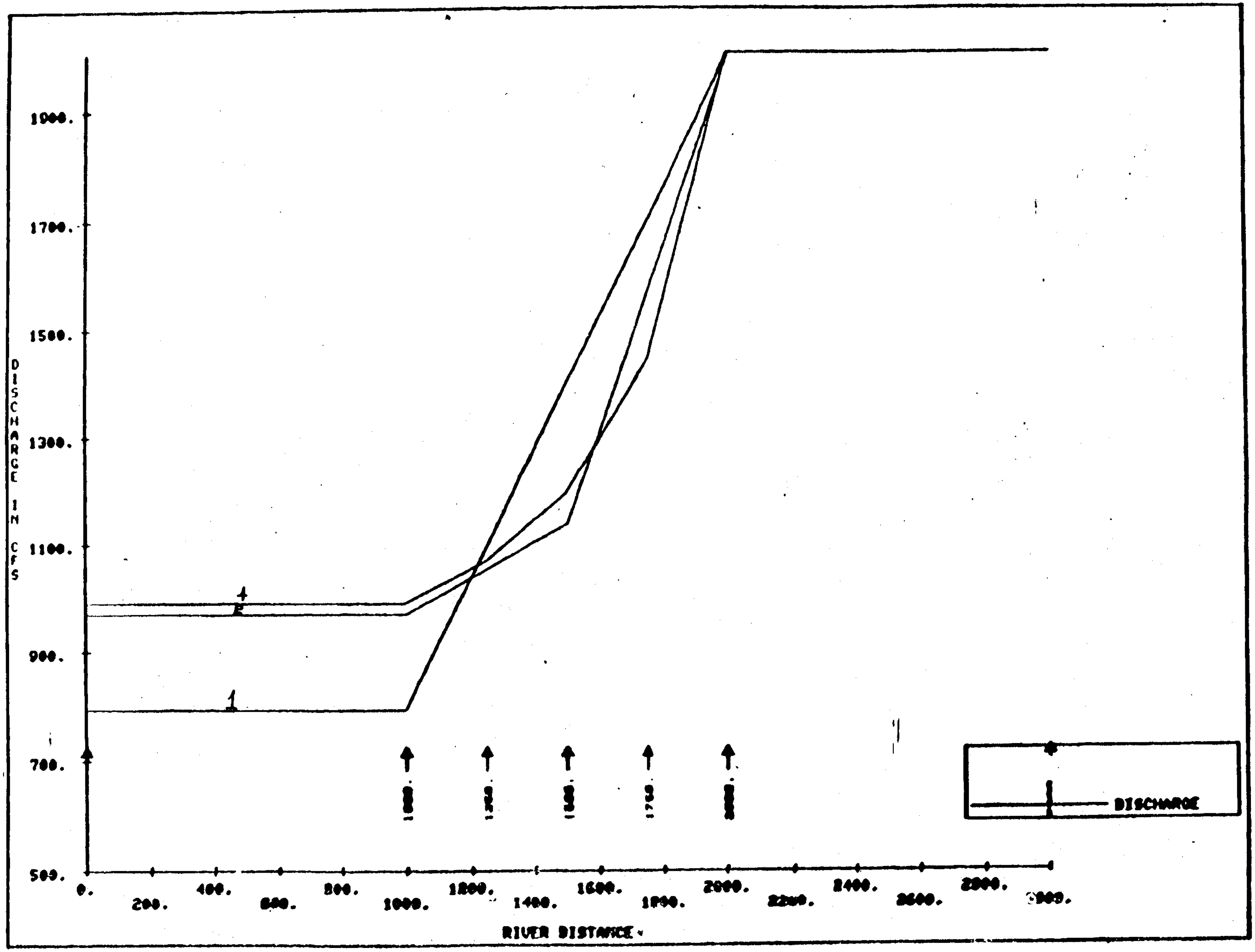
1750.
2000.


DISCHARGE IN CFS
1900.
1700.
1500.
1300.
1100.
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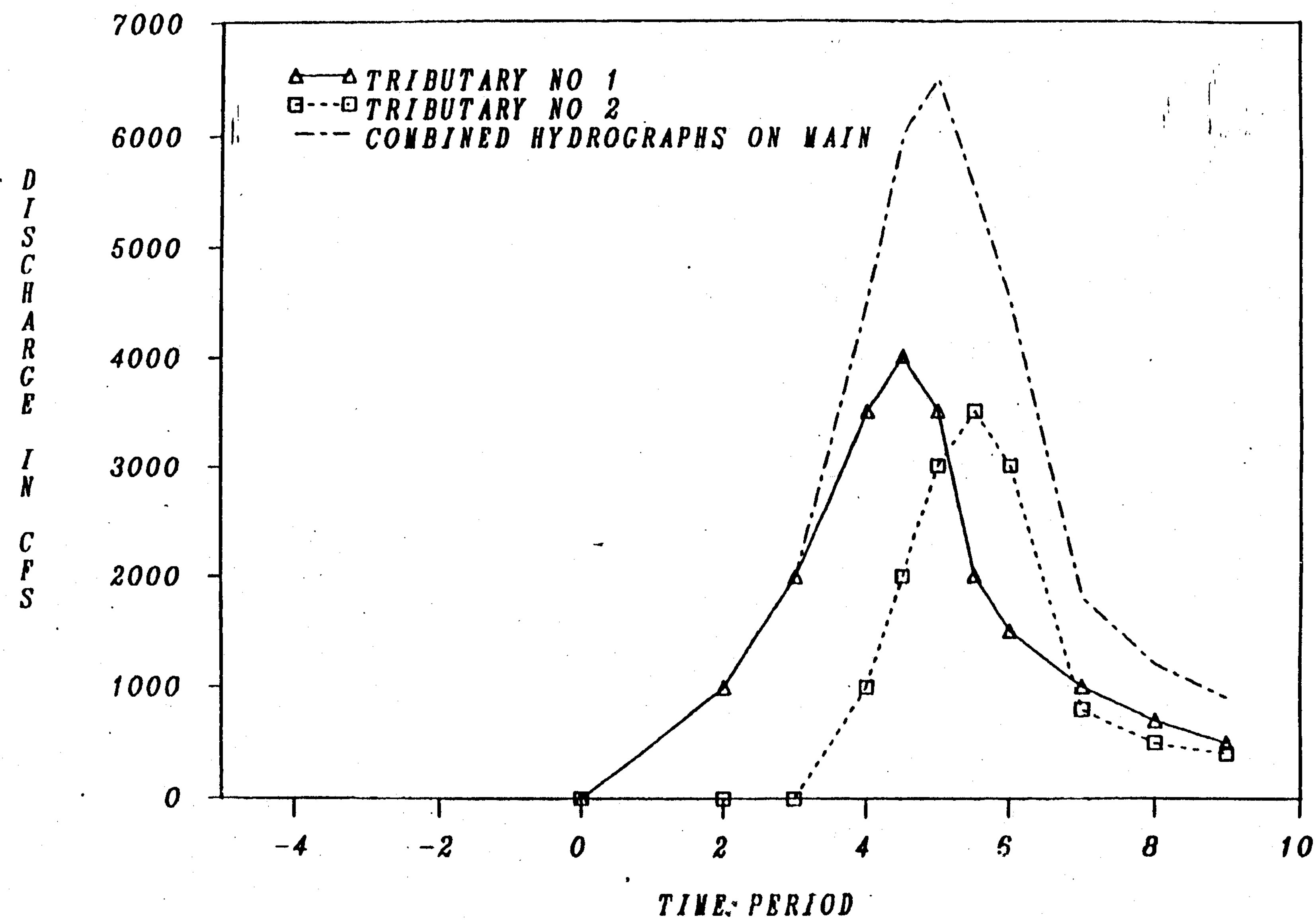
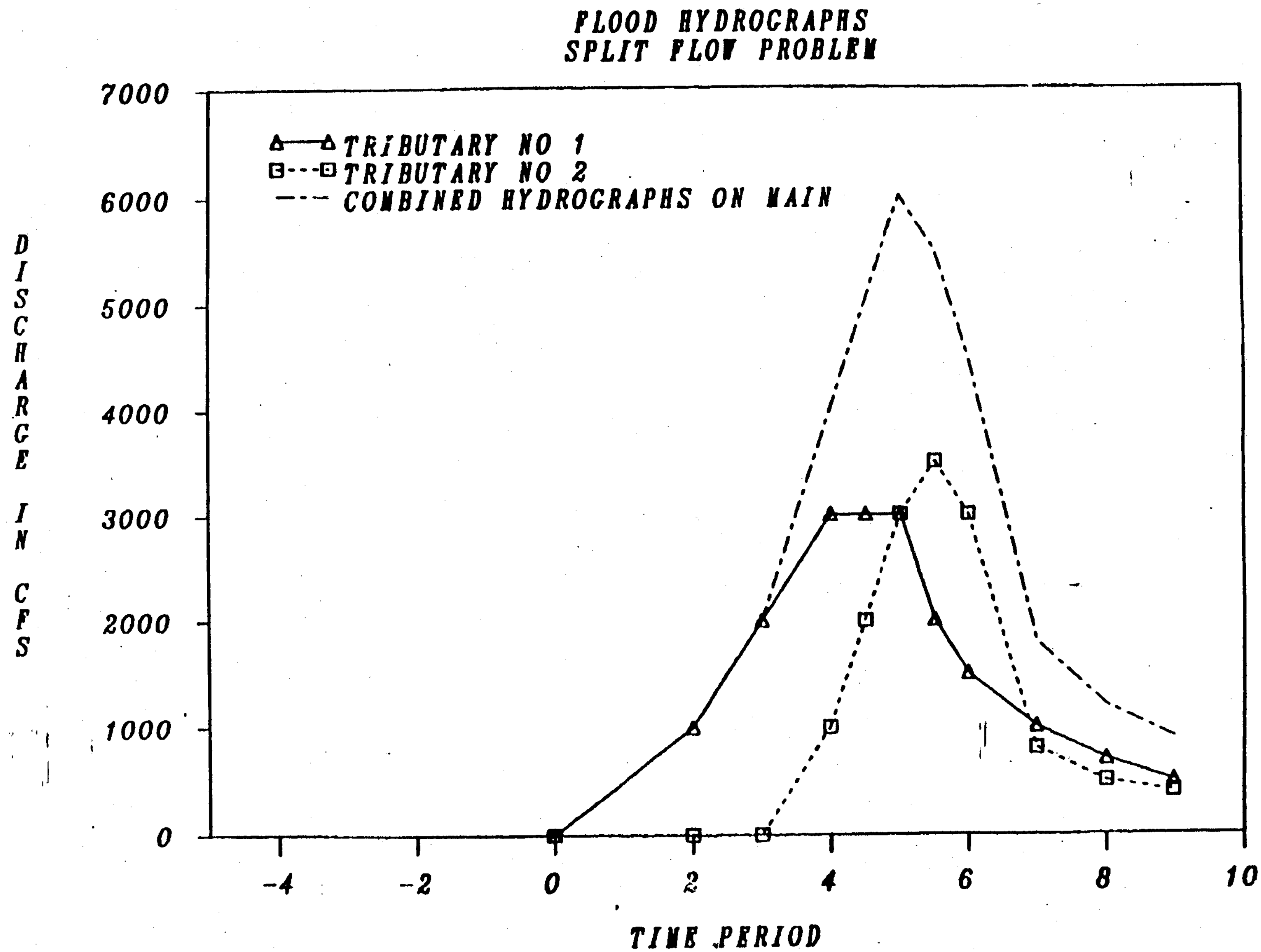
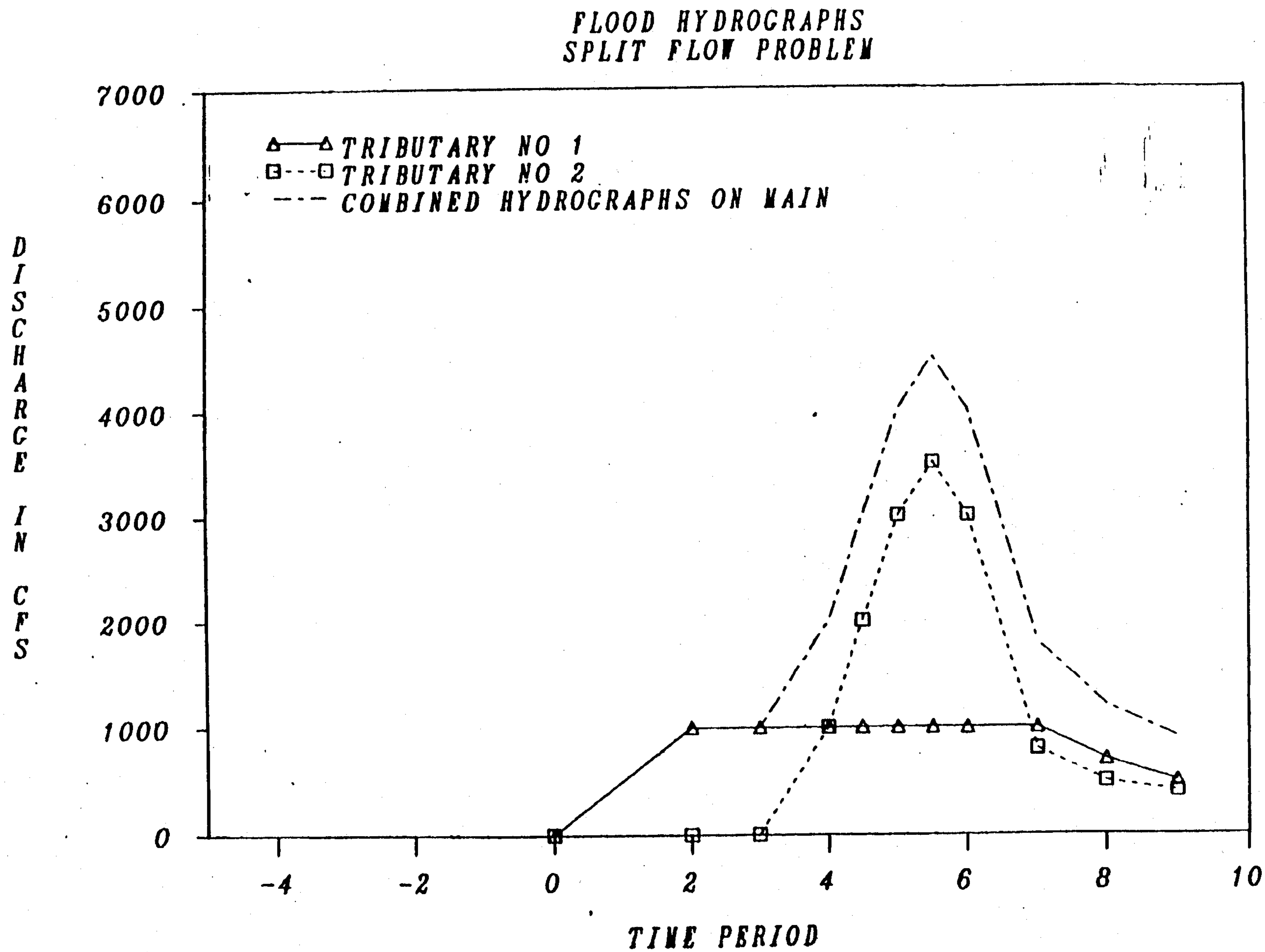
RIVER DISTANCE
4
2
1
DISCHARGE

FLOOD HYDROGRAPHS
SPLIT FLOW PROBLEM




FLOOD HYDROGRAPHS
SPLIT FLOW PROBLEM
TRIBUTARY NO 1
TRIBUTARY NO 2
COMBINED HYDROGRAPHS ON MAIN
DISCHARGE IN CFS
7000
6000
5000
4000
3000
2000
1000
0
-4
-2
0
2
4
6
8
10
TIME PERIOD


FLOOD HYDROGRAPHS
SPLIT FLOW PROBLEM
TRIBUTARY NO 1
TRIBUTARY NO 2
COMBINED HYDROGRAPHS ON MAIN
DISCHARGE IN CFS
TIME PERIOD
7000
6000
5000
4000
3000
2000
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0
-4
-2
0
2
4
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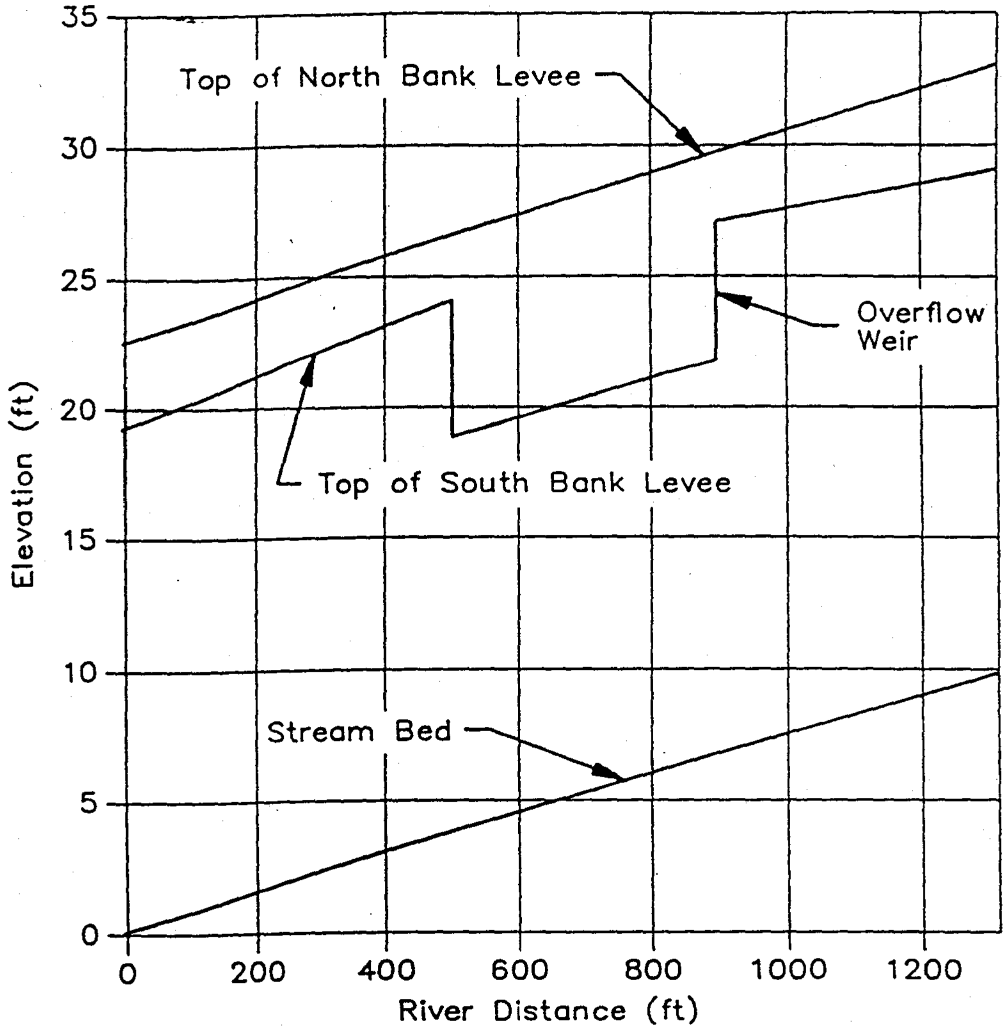
10

Profiles of Levees and Overflow Weir




```
SF    SPLIT-FLOW DATA
TW    SOUTH BANK LEVEE BETWEEN CROSS SECTIONS 3 AND 4
WS      2        3        4        -1        3.4
WC      0       27      400        28
TW    FLOODWAY OVERFLOW SECTION
WS      2        2        3        -1        2.7
WC      0       19      400        22
TW    SOUTH BANK LEVEE BETWEEN CROSS SECTIONS 1 AND 2
WS      2        1        2        -1        3.4
WC      0       19      500        24
```

ADVANCED WATER SURFACE PROFILE COMPUTATIONS USING HEC-2

MULTIPLE CULVERTS OF VARYING SIZES AND ELEVATIONS

Note: Selected portions of this presentation are from the BOSS HEC-2 User's Manual and used with special permission.

A. Limitations of HEC-2 Culvert Option

1. Culvert size and shape must remain the same over the length of the culvert.

2. Culvert must have a uniform bottom slope which cannot be negative.

3. Culvert shapes other than box or circular cannot be explicitly modeled.

4. Mixed sizes and shapes at the same cross section cannot be modeled.

5. Culvert option cannot be used in a supercritical profile analysis.

B. Changing Shapes and Sizes Within the Culvert Length

Since the barrel flow capacity of a culvert is generally greater than the inlet, the size of the culvert at the entrance and the inlet conditions generally control. Model the actual culvert size at the inlet. If the barrel size is larger past the inlet, and assuming the transition losses from one size to the other is negligible, no further analysis is required. If the barrel is smaller (or less efficient shape) past the inlet, externally determine the headwater elevation required to pass the flow through the barrel for no inlet loss conditions (assume whole barrel length is the smaller size). This can be done in HEC-2 by using the most optimum inlet configuration. Use the higher headwater elevation results of the two models.

Note that for unusual shapes, simply modeling with an equivalent culvert with the same cross section area will not truly reflect the entrance losses. This type of analysis should be done external to HEC-2 and the resulting headwater elevation entered on the X5 record. If a range of discharges is to be analyzed, perform this external analysis for at least the minimum, maximum and 2 intermediate discharges and enter the resulting rating curve on the RC record for the cross section. The external analysis cannot easily be performed if there is weir flow over a bridge.

C. Changing Bottom Slopes

For small changes in slope (less than 20 degrees), the slope from the entrance to the exit should be used. If a section of pipe with one slope is much longer than another section with another slope, you may want to obtain the average slope by multiplying each length by its slope, summing them, and dividing the result by the total length. The culvert length should be the actual flow length, not the straight line distance between the entrance and the exit.

D. Varying Multiple Culverts

Although culverts should ideally be of the same size and placed at the same elevation as shown in Figure1, they are often placed at different elevations and with different sizes as depicted in Figure 2. HEC-2 cannot model these types of situations; however, there is a technique that usually gives reasonable results. This technique is based upon the fact that each culvert's flow capacity is determined by the same headwater elevation and its individual inlet condition. The procedure is as follows:

1. Break the design discharge into a series of smaller discharges with the smallest discharge based upon the smallest expected flow capacity of any culvert being analyzed. For instance, if the design flow is 1000 cfs and the lowest discharge of a culvert is estimated to be 100 cfs, a series of acceptable discharges would be 50, 100, 250, 500, 750 and 1000 cfs. Note that any discharge can be added to another discharge to total the design discharge.

2. Execute HEC-2 for a single culvert with the series of discharges using the multiple profile option. For each culvert, make a copy of the input, change the culvert characteristics, and execute HEC-2 again for multiple profiles.

3. Plot the headwater elevation on the y axis and the discharge on the x axis for each culvert on the same graph sheet.

4. For a given elevation, determine the discharge of all culverts and add together. Plot this discharge along the same elevation. Do this for a range of elevations and plot the total rating curve.

5. For the design discharge on the x axis, determine the headwater elevation using the generated total rating curve.

6. If the analysis is for a single discharge, enter the headwater elevation on the X5 record at the upstream end of the culvert cross section.

7. If the analysis is for a range of flows, enter the total rating curve at the upstream culvert cross section using the RC records.

Note that the culverts should be far enough apart such that there is no influence of the flow patterns of one on the other.

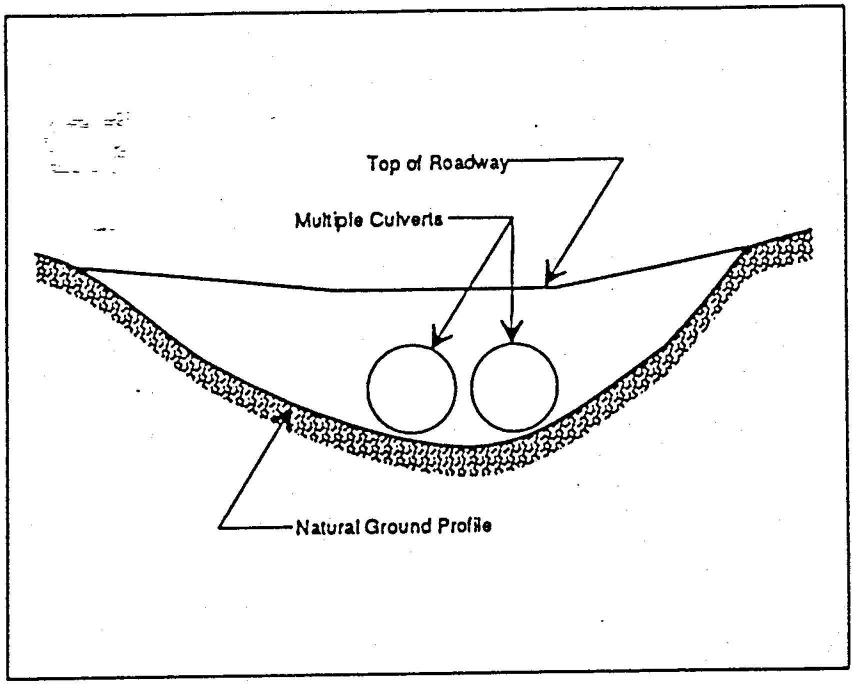


Figure 2. Multiple Culvert of Same Sizes

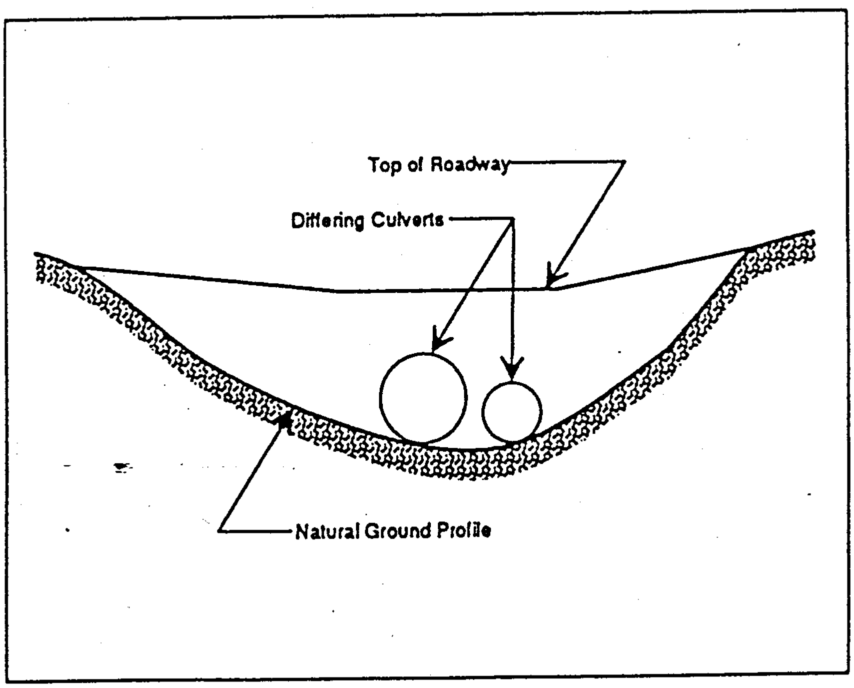
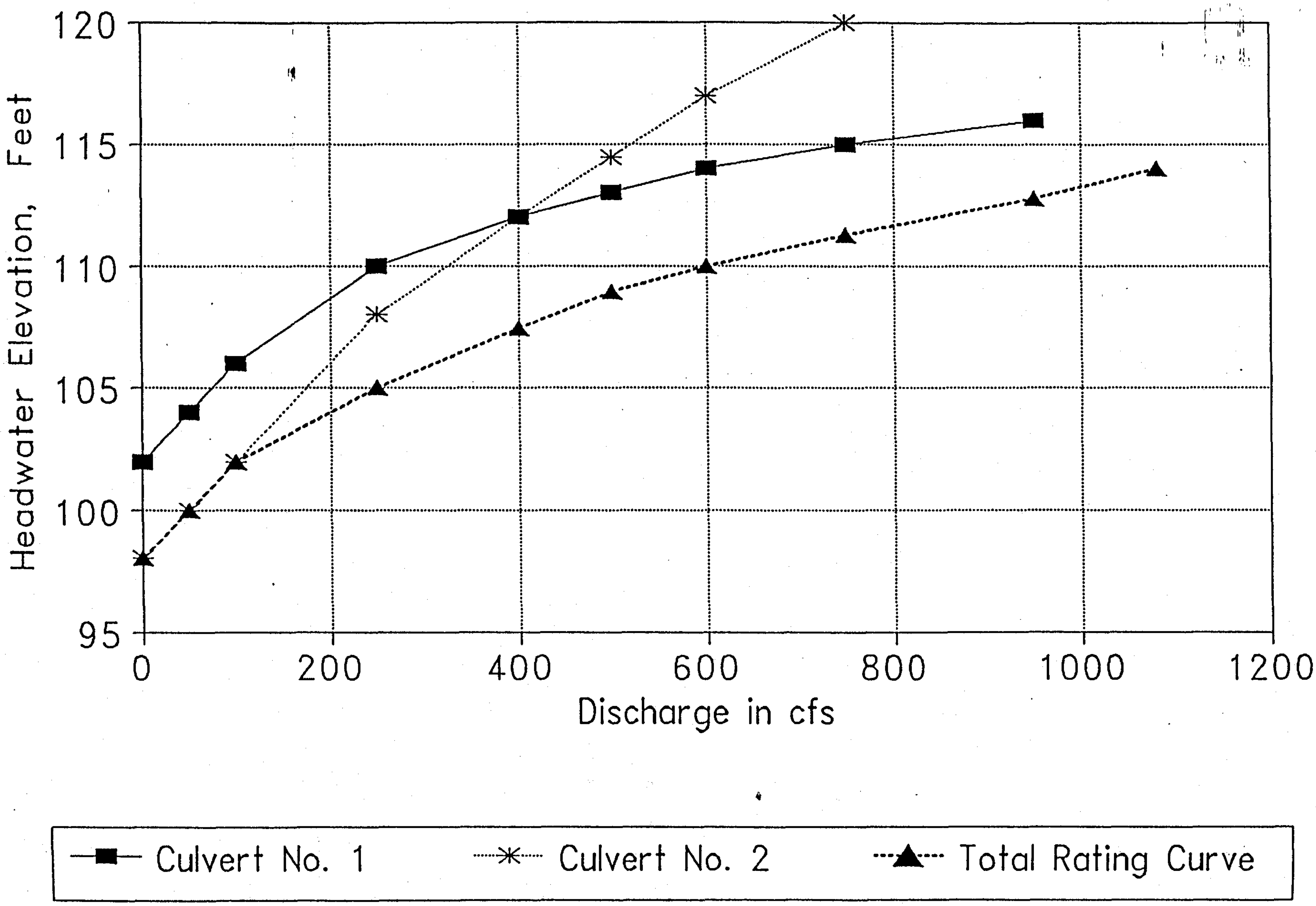


Figure 2. Multiple Culverts with Differing Sizes

MULTIPLE CULVERTS WITH VARYING SIZES
HEC-2 ADVANCED COURSE EXAMPLE



APPLICATION OF HEC-2
FOR SUPERCRITICAL STREAMS

1. Profile Determination on Steep Streams

   a. Program limitations (supercritical analysis)

      (1) Gradually varied flow

      (2) Streambed slope less than 1:10

      (3) Rigid boundary

      (4) Data must be manually reordered to convert from a subcritical model to a supercritical model

   b. Steep streams profile types

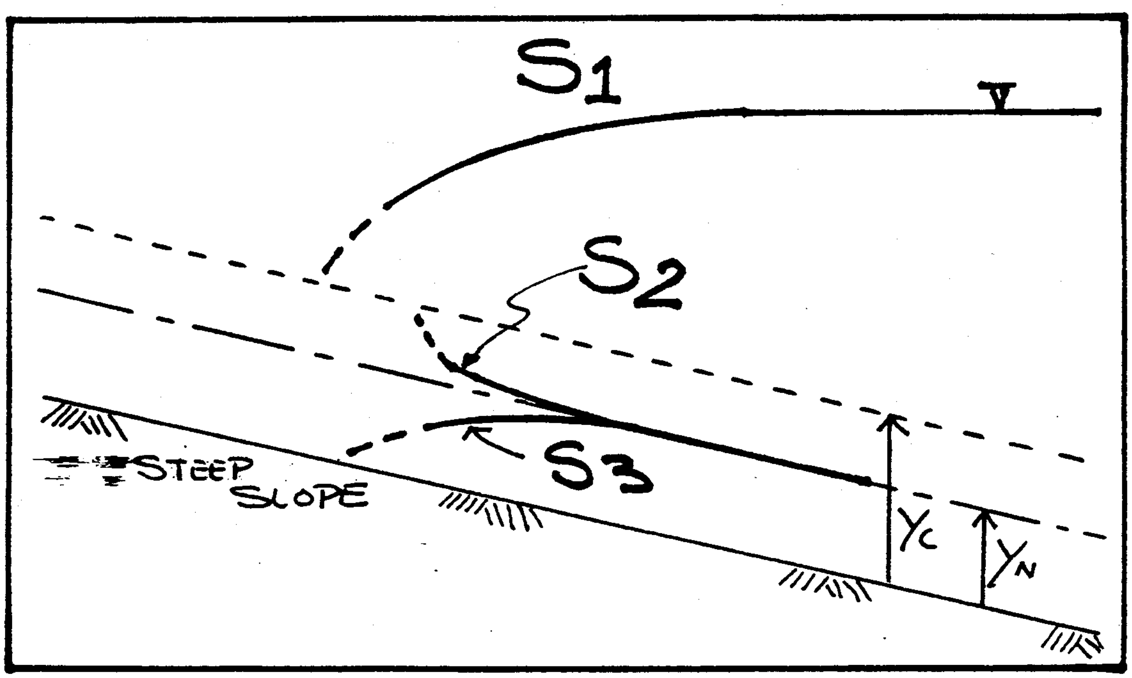


Figure 1. Steep Slope Profile Types

(1) S1 curve, a subcritical water surface profile which occurs on steep streams. Control is from downstream, can be analyzed by HEC-2 with backwater computations.

(2) S2 curve, a supercritical profile, below critical depth and above normal depth. Control is from upstream. Analyzed by HEC-2 as a supercritical profile (down water computations).

(3) S3 curve, a supercritical profile, below normal depth. Control is upstream. Analyzed by HEC-2 as a supercritical profile.

c. Application of HEC-2 to steep streams

(1) Supercritical analysis specified by variable IDIR = 1 (J1.4)

(2) Starting conditions may be slope area, known water surface elevation or critical depth

(3) Cross section data must be entered from upstream to downstream. The cross sections of a previously developed subcritical model must be reversed in order. (See example 1 and 2) repeated cross sections of a converted subcritical model must be revised, particularly if cross section modification factors PXSECR (X1.8) and PSXECE (X1.9) were used.

(4) Supercritical special bridge models converted from subcritical models must be reordered. The X2 and BT cards associated with the upstream cross section of a subcritical run must be inserted with the downstream cross section. (See examples 3 and 4.)

d. Example HEC-2 applications

<u>Example 1</u>, Miners Creek Backwater

This example is an HEC-2 subcritical (backwater) analysis of a stream with a steep reach between two mild reaches. Notice the "critical depth assumed" messages for cross sections 204 thru 207. See Figure 2 for profile plot.

<u>Example 2</u>, Miners Creek Downwater

This example is an HEC-2 supercritical analysis of the Miners Creek data set from Example 1. The following changes have been made to convert the Example 1 data set:

(1) J1.4 = 1

(2) Critical depth start (J1.5= -1)

(3) Cross section data reordered, the upstream cross section, #306, the last cross section of the Example 1 data set, is first cross section of the supercritical data set.

(4) The X1 cards (X1.2-X1.4 and X1.9) have been modified to account for repeated "GR" data. Observe that it is not necessary to change reach lengths (X1.5-X1.7).

Notice that the "critical depth assumed" messages now occur for cross sections of the two mild reaches. See Figure 3 for profile plot.

<u>Example 3</u>

This example is an HEC-2 supercritical special bridge model. Notice the weir and low flow solution for the 5000 cfs profile. See Figure 4, cross section plot and Figure 5 profile plot.

<u>Example 4</u>

For this example the X2 card variables "ELLC" and "ELTRD" of the previous (Example 3) supercritical special bridge model have been raised above the highest anticipated energy grade elevation at cross section 202. For the given discharges, the resulting "CLASS C" low flow computations, provides a more reasonable solution. See Figure 6, cross section plot and Figure 7 profile plot.

2. Practical Considerations

a. ~~Natural~~ channels

(1) To what extent does supercritical flow occur in natural alluvial channels?

(2) Determination of Manning's n coefficient.

(3) Scour vs HEC-2 rigid boundary hydraulics

b. Improved channels

(1) Superelevation

(2) Hydraulic jump calculations

(3) Standing waves

3. Resources - References

<u>Basic Hydraulic Texts</u>

a. Open-Channel Hydraulics, V. T. Chow, 1959

b. Open Channel Flow, F. M. Henderson, 1966

<u>Design Manuals</u>

a. EM 1110-2-1601, Hydraulic Design of Flood Control Channels, ~~1 July~~ 1970, U.S. Army Corps of Engineers

b. Design of Open Channels, Technical Release No. 25, October 1977, Soil Conservation Service.

<u>Mobile Boundary Hydraulics</u>

a. Sedimentation Engineering, ASCE Manual No. 54, V. A. Vanoni Editor, 1975.

b. Sediment Transport Technology, D. B. Simons and ~~F.~~ Senturk, 1977.

EXAMPLE 1

HEC-2 Input

```
T1        MINERS CREEK AT ELDORADO FLATS
T2
T3        MINERS CREEK BACKWATER
J1                                          .001                          3000     110
J2      -1       0      -1       0       0       0      -1
J3      38      43       1       2      26      58      62
J6       1

NC     .06     .06    .035      .1      .3
X1     101       8     310     370
GR     120       0     115      10     110     310     100     320     100
GR     110     370     115     670     120     680

X1     102       0       0       0    2000    2000    2000       0       2

NC     .05     .05    .015
X1     201       8     110     170      10      10      10
GR     122       0     117      10     112     110     102     120     102
GR     112     170     117     270     122     280

X1     202       0       0       0     100     100     100       0       1

X1     203       0       0       0     100     100     100       0       1

X1     204       0       0       0     500     500     500       0       5

X1     205       0       0       0     500     500     500       0       5

X1     206       0       0       0     500     500     500       0       5

X1     207       0       0       0     100     100     100       0       1

NC     .06     .05    .035      .1      .3
X1     301       8     310     370       1       1       1
GR     140       0     135      10     130     310     120     320     120
GR     130     370     135     670     140     680

X1     302       0       0       0     100     100     100       0    0.01

X1     303       0       0       0     100     100     100       0    0.01

X1     304       0       0       0    1000    1000    1000       0      .1

X1     305       0       0       0    1000    1000    1000       0      .1

X1     306       0       0       0    1000    1000    1000       0      .1
EJ
   ** BLANK CARD **
   ** BLANK CARD **
   ** BLANK CARD **
ER
```

Example 1 Continued

```
****************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED  MAY 1981
  ERROR CORR -  01,02,03,04
  MODIFICATION -  50,51,52,53,54, *, *,96
****************************************************
```

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

MINERS CREEK BACKWATER

SUMMARY PRINTOUT

	SECNO	Q	CWSEL	CRIWS	VCH	KRATIO	IHLEQ
	101.000	3000.00	110.84	105.32	5.42	0.00	4.00
	102.000	3000.00	112.85	107.30	5.41	1.00	4.00
	201.000	3000.00	112.85	107.30	5.44	2.32	4.00
	202.000	3000.00	112.78	108.30	6.16	0.82	2.00
	203.000	3000.00	112.68	109.32	7.10	0.81	2.00
*	204.000	3000.00	114.32	114.32	12.45	0.44	4.00
*	205.000	3000.00	119.32	119.32	12.44	1.00	4.00
*	206.000	3000.00	124.32	124.32	12.44	1.00	4.00
*	207.000	3000.00	125.32	125.32	12.44	1.00	4.00
	301.000	3000.00	125.33	125.32	12.43	0.43	2.00
	302.000	3000.00	127.29	125.33	8.73	1.69	4.00
	303.000	3000.00	127.86	125.35	7.99	1.14	4.00
	304.000	3000.00	130.25	125.44	5.91	1.55	4.00
	305.000	3000.00	131.44	125.54	5.15	1.25	4.00
	306.000	3000.00	132.27	125.66	4.64	1.17	4.00

SUMMARY OF ERRORS

```
CAUTION  SECNO=  204.000  PROFILE= 1  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=  204.000  PROFILE= 1  MINIMUM SPECIFIC ENERGY

CAUTION  SECNO=  205.000  PROFILE= 1  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=  205.000  PROFILE= 1  MINIMUM SPECIFIC ENERGY

CAUTION  SECNO=  206.000  PROFILE= 1  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=  206.000  PROFILE= 1  MINIMUM SPECIFIC ENERGY

CAUTION  SECNO=  207.000  PROFILE= 1  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=  207.000  PROFILE= 1  MINIMUM SPECIFIC ENERGY
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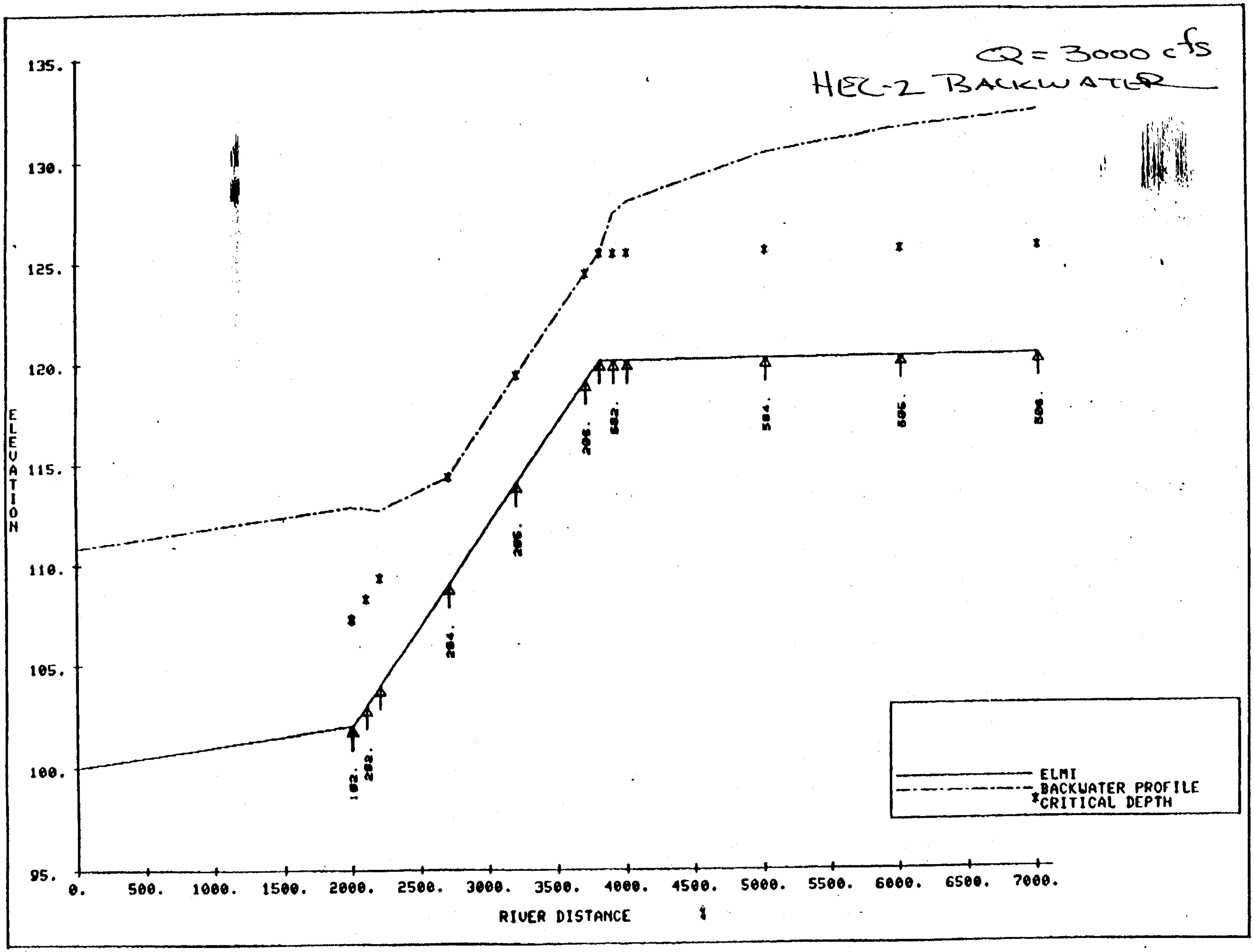


Figure 2, Miners Creek Backwater

EXAMPLE 2

HEC-2 Input

```
T1        MINERS CREEK AT ELDORADO FLATS
T2
T3        MINERS CREEK DOWNWATER
J1                                1       -1                        3000      110
J2     -1              -1
J3     38       43      1         2       26        5       58        62
J6      1

NC    .06      .06    .035       .1       .3
X1    306        8     310      370     1000     1000     1000         0      .32
GR    140        0     135       10      130      310      120       320      120
GR    130      370     135      670      140      680

X1    305        0       0        0     1000     1000     1000         0      -.1

X1    304        0       0        0     1000     1000     1000         0      -.1

X1    303        0       0        0      100      100      100         0     -.01

X1    302        0       0        0      100      100      100         0     -.01

X1    301        0       0        0        1        1        1                -.01

NC    .05      .05    .015
X1    207        8     110      170      100      100      100         0        1
GR    122        0     117       10      112      110      102       120       10
GR    112      170     117      270      122      280

X1    206        0       0        0      500      500      500         0       -1

X1    205        0       0        0      500      500      500         0       -5

X1    204        0       0        0      500      500      500         0       -5

X1    203        0       0        0      100      100      100         0       -5

X1    202        0       0        0      100      100      100         0       -1

X1    201                                            10       10                -1

NC    .06      .06    .035       .1       .3
X1    102        8     310      370     2000     2000     2000         0        2
GR    120        0     115       10      110      310      100       320      100
GR    110      370     115      670      120      680
                                                                                -2
X1    101
EJ
   ** BLANK CARD **
   ** BLANK CARD **
   ** BLANK CARD **
ER
```

MINERS CREEK DOWNWATER

SUMMARY PRINTOUT

	SECNO	Q	CWSEL	CRIWS	VCH	10K*S	KRATIO	IHLEQ
*	306.000	3000.00	125.64	125.64	12.45	119.91	0.00	3.00
*	305.000	3000.00	125.54	125.54	12.44	119.70	1.39	3.00
*	304.000	3000.00	125.44	125.44	12.44	119.74	1.40	3.00
*	303.000	3000.00	125.43	125.43	12.44	119.73	1.39	3.00
*	302.000	3000.00	125.42	125.42	12.44	119.73	1.45	3.00
*	301.000	3000.00	125.41	125.41	12.44	119.73	1.45	3.00
	207.000	3000.00	124.96	125.32	13.45	27.81	0.48	3.00
	206.000	3000.00	123.19	124.32	16.18	48.79	1.32	2.00
	205.000	3000.00	117.49	119.32	19.79	90.66	1.36	2.00
	204.000	3000.00	112.40	114.32	20.32	98.33	1.04	2.00
	203.000	3000.00	107.39	109.32	20.41	99.69	1.01	2.00
	202.000	3000.00	106.38	108.32	20.42	99.86	1.00	2.00
	201.000	3000.00	105.39	107.32	20.42	99.80	1.00	3.00
	102.000	3000.00	105.55	107.32	19.38	462.34	2.15	2.00
*	101.000	3000.00	105.34	105.34	12.40	118.59	0.71	3.00

SUMMARY OF ERRORS

```
CAUTION  SECNO=  306.000  PROFILE= 1  CRITICAL DEPTH ASSUMED

CAUTION  SECNO=  305.000  PROFILE= 1  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=  305.000  PROFILE= 1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION  SECNO=  305.000  PROFILE= 1  20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION  SECNO=  304.000  PROFILE= 1  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=  304.000  PROFILE= 1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION  SECNO=  304.000  PROFILE= 1  20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION  SECNO=  303.000  PROFILE= 1  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=  303.000  PROFILE= 1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION  SECNO=  303.000  PROFILE= 1  20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION  SECNO=  302.000  PROFILE= 1  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=  302.000  PROFILE= 1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION  SECNO=  302.000  PROFILE= 1  20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION  SECNO=  301.000  PROFILE= 1  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=  301.000  PROFILE= 1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION  SECNO=  301.000  PROFILE= 1  20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION  SECNO=  101.000  PROFILE= 1  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=  101.000  PROFILE= 1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION  SECNO=  101.000  PROFILE= 1  20 TRIALS ATTEMPTED TO BALANCE WSEL
```

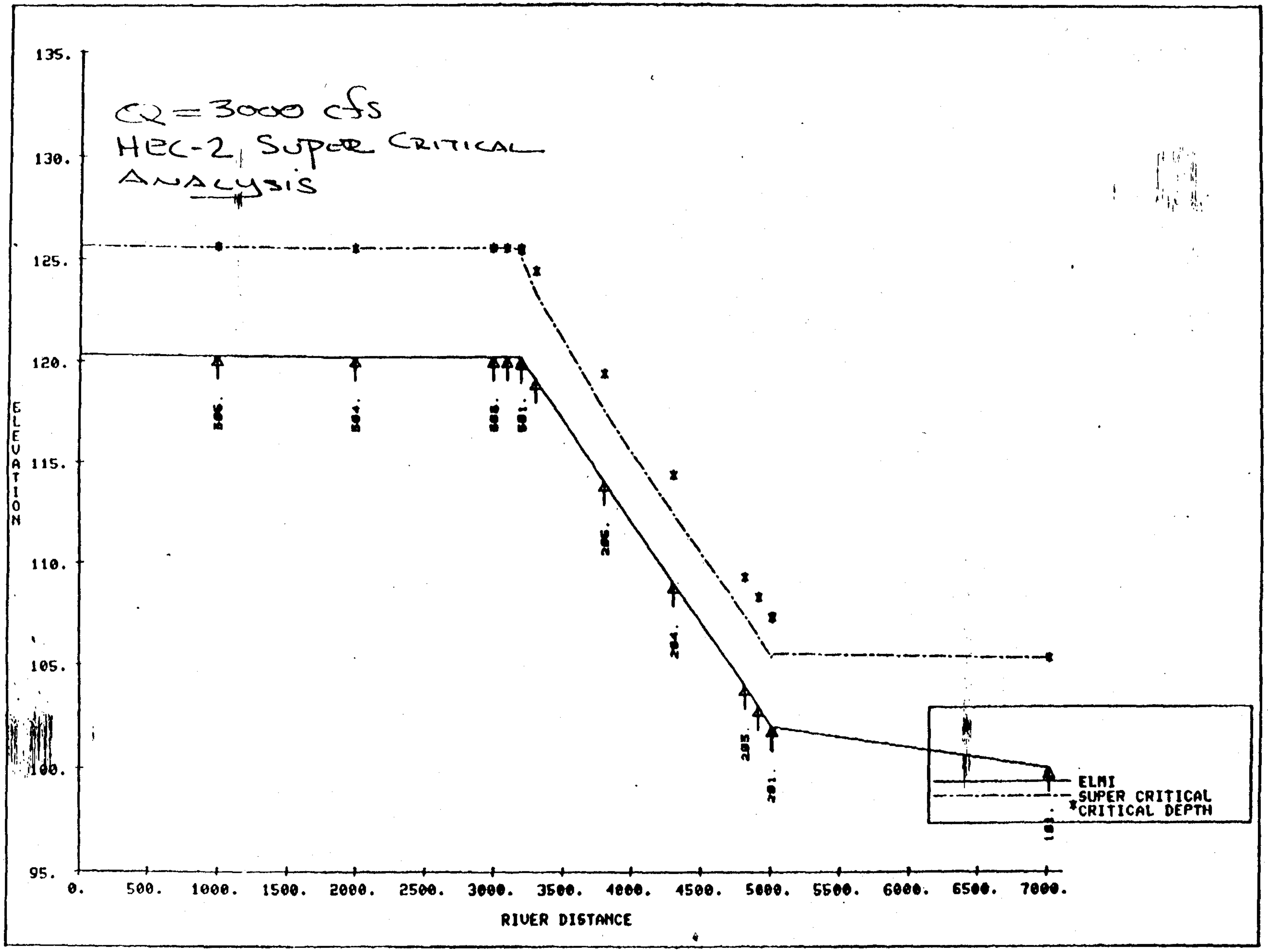


Figure 3, Example 2

T1 MINERS CREEK AT ELDORADO FLATS
T2
T3 MINERS CREEK DOWNWATER

EXAMPLE 3

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0.	0.	0.	1.	-1.000000	0.00	0.0	3000.	110.000	0.000
J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	1.000	0.000	-1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
J3	VARIABLE CODES FOR SUMMARY PRINTOUT									
	38.000	43.000	1.000	2.000	26.000	5.000	58.000	62.000	0.000	0.000
J6	IHLEQ	ICOPY								
	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

NC	0.050	0.050	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	207.000	8.000	110.000	170.000	100.000	100.000	100.000	0.000	0.000	0.000
GR	122.000	0.000	117.000	10.000	112.000	110.000	102.000	120.000	102.000	160.000
GR	112.000	170.000	117.000	270.000	122.000	280.000	0.000	0.000	0.000	0.000
X1	206.000	0.000	0.000	0.000	500.000	500.000	500.000	0.000	-1.000	0.000
X1	205.000	0.000	0.000	0.000	500.000	500.000	500.000	0.000	-5.000	0.000
X1	204.000	0.000	0.000	0.000	40.000	40.000	40.000	0.000	-5.000	0.000
X1	203.000	8.000	120.000	160.000	25.000	25.000	25.000	0.000	-0.400	0.000
X3	10.000	0.000	0.000	0.000	0.000	0.000	0.000	102.000	102.000	0.000
GR	111.000	0.000	106.000	10.000	100.600	120.000	90.600	120.000	90.600	160.000
GR	100.600	160.000	106.000	270.000	111.000	280.000	0.000	0.000	0.000	0.000
SB	0.900	1.560	3.000	0.000	40.000	2.000	380.000	0.000	90.600	90.350
X1	202.000	0.000	0.000	0.000	160.000	160.000	160.000	0.000	-0.250	0.000
X2	0.000	0.000	1.000	100.600	102.000	0.000	0.000	0.000	0.000	0.000
X3	10.000	0.000	0.000	0.000	0.000	0.000	0.000	101.000	101.000	0.000
BT	6.000	0.000	111.000	110.750	10.000	106.000	105.750	120.000	102.000	100.600
BT	160.000	102.000	100.600	270.000	106.000	105.750	280.000	111.000	110.750	0.000
X1	201.000	0.000	0.000	0.000	1000.000	1000.000	1000.000	0.000	-1.600	0.000
X1	200.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-10.000	0.000
EJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Example 3 Continued

*SECNO 203.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA= 102.00 ELREA= 102.00

203.00	5.25	95.45	98.03	0.00	104.24	8.79	0.36	0.00	100.20
5000.	0.	5000.	0.	0.	210.	0.	6.	1.	100.20
0.01	0.00	23.79	0.00	0.050	0.015	0.050	0.015	90.20	120.00
0.008612	40.	40.	40.	5	14	0	0.00	40.00	160.00

SPECIAL BRIDGE

SB XK	XKOR	COFQ	RDLEN	BWC	BWP	BAREA	SS	ELCHU	ELCHD
0.90	1.56	3.00	0.00	40.00	2.00	380.00	0.00	90.60	90.35

*SECNO 202.000
6840,FLOW IS BY WEIR AND LOW FLOW
6870 D.S. ENERGY OF 104.24 HIGHER THAN COMPUTED ENERGY OF 103.90

3301 HV CHANGED MORE THAN HVINS

3420 BRIDGE W.S.= 95.45 BRIDGE VELOCITY=, 23.33 CALCULATED CHANNEL AREA=, 184.

EGPRS	EGLWC	H3	QWEIR	QLOW	BAREA	TRAPEZOID AREA	ELLC	ELTRD
99.64	103.90	0.00	605.	4410.	380.	380.	100.60	102.00

202.00	12.98	102.93	0.00	0.00	104.24	1.31	0.00	0.00	99.95
5000.	78.	4844.	78.	90.	519.	90.	6.	1.	99.95
0.01	0.87	9.33	0.87	0.050	0.015	0.050	0.015	89.95	59.37

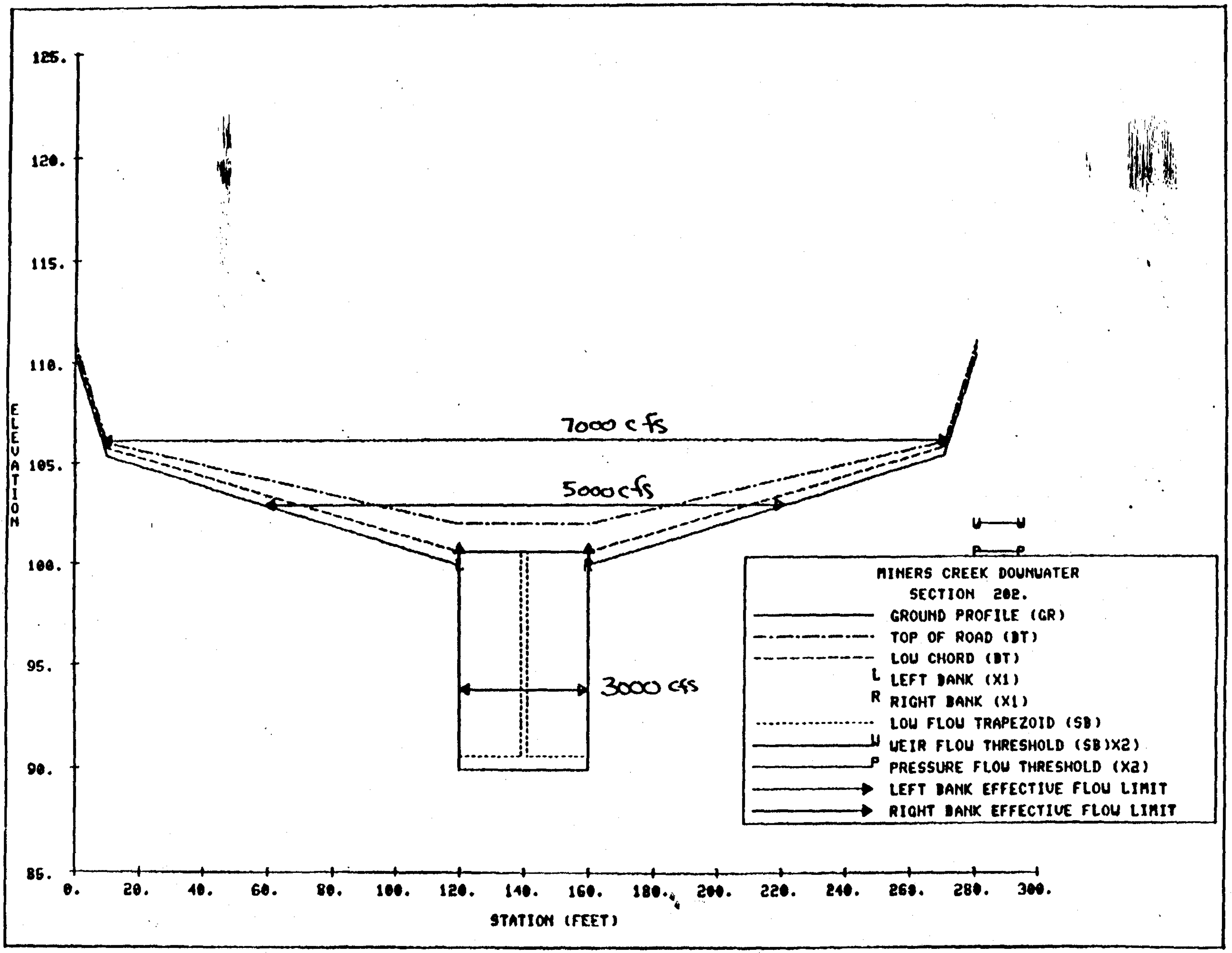


Figure 4, Example 3

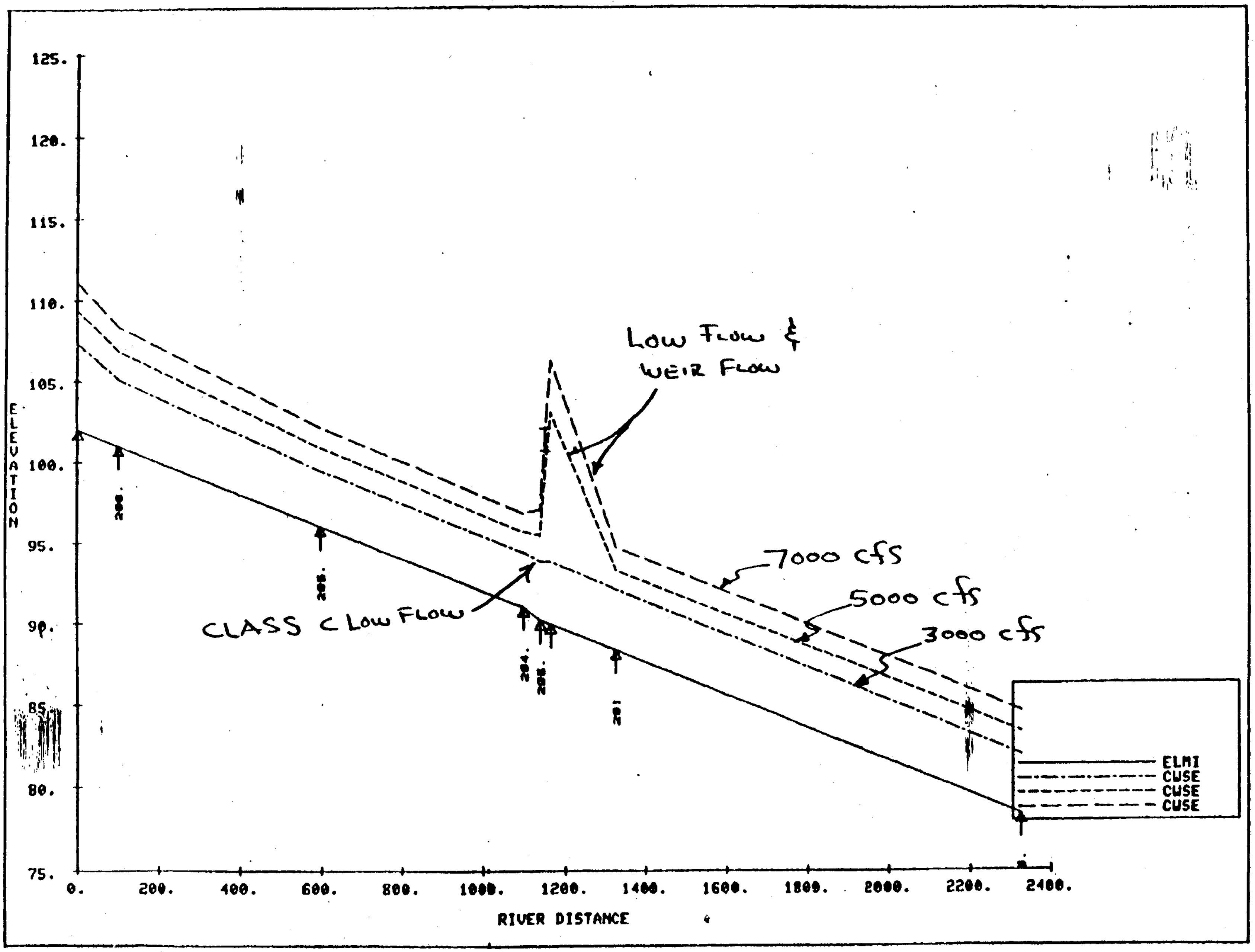


Figure 5, Examp'

T	MINERS CREEK AT ELDORADO FLATS	
T2		EXAMPLE 4
T3	MINERS CREEK DOWNWATER	

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0.	0.	0.	1.	-1.000000	0.00	0.0	3000.	110.000	0.000

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	1.000	0.000	-1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

J3 VARIABLE CODES FOR SUMMARY PRINTOUT

38.000	43.000	1.000	2.000	26.000	5.000	58.000	62.000	0.000	0.000

J6	IHLEQ	ICOPY								
	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

NC	0.050	0.050	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	207.000	8.000	110.000	170.000	100.000	100.000	100.000	0.000	0.000	0.000
GR	122.000	0.000	117.000	10.000	112.000	110.000	102.000	120.000	102.000	160.000
GR	112.000	170.000	117.000	270.000	122.000	280.000	0.000	0.000	0.000	0.000
X1	206.000	0.000	0.000	0.000	500.000	500.000	500.000	0.000	-1.000	0.000
X1	205.000	0.000	0.000	0.000	500.000	500.000	500.000	0.000	-5.000	0.000
X1	204.000	0.000	0.000	0.000	40.000	40.000	40.000	0.000	-5.000	0.000
X1	203.000	8.000	120.000	160.000	25.000	25.000	25.000	0.000	-0.400	0.000
X3	10.000	0.000	0.000	0.000	0.000	0.000	0.000	102.000	102.000	0.000
GR	111.000	0.000	106.000	10.000	100.600	120.000	90.600	120.000	90.600	160.000
GR	100.600	160.000	106.000	270.000	111.000	280.000	0.000	0.000	0.000	0.000
SB	0.900	1.560	3.000	0.000	40.000	2.000	380.000	0.000	90.600	90.350
X1	202.000	0.000	0.000	0.000	160.000	160.000	160.000	0.000	-0.250	0.000
X2	0.000	0.000	1.000	120.600	122.000	0.000	0.000	0.000	0.000	0.000
X3	10.000	0.000	0.000	0.000	0.000	0.000	0.000	101.000	101.000	0.000
BT	6.000	0.000	111.000	110.750	10.000	106.000	105.750	120.000	102.000	100.600
BT	160.000	102.000	100.600	270.000	106.000	105.750	280.000	111.000	110.750	0.000
X1	201.000	0.000	0.000	0.000	1000.000	1000.000	1000.000	0.000	-1.600	0.000
X1	200.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-10.000	0.000
EJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Example 4 Continued

*SECNO 203.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=   102.00 ELREA=   102.00

203.00	5.25	95.45	98.03	0.00	104.24	8.79	0.36	0.00	100.20
5000.	0.	5000.	0.	0.	210.	0.	6.	1.	100.20
0.01	0.00	23.79	0.00	0.050	0.015	0.050	0.015	90.20	120.00
0.008612	40.	40.	40.	5	14	0	0.00	40.00	160.00

SPECIAL BRIDGE

SB XK	XKOR	COFQ	RDLEN	BWC	BWP	BAREA	SS	ELCHU	ELCHD
0.90	1.56	3.00	0.00	40.00	2.00	380.00	0.00	90.60	90.35

*SECNO 202.000

3301 HV CHANGED MORE THAN HVINS

CLASS C LOW FLOW

3420 BRIDGE W.S.=   96.07 BRIDGE VELOCITY=,   23.52   CALCULATED CHANNEL AREA=,   208.

EGPRS	EGLWC	H3	QWEIR	QLOW	BAREA	TRAPEZOID AREA	ELLC	ELTRD
0.00	103.29	0.00	0.	5000.	380.	1140.	120.60	122.00

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=   101.00 ELREA=   101.00

202.00	5.60	95.55	0.00	0.00	103.29	7.75	0.94	0.00	99.95
5000.	0.	5000.	0.	0.	224.	0.	6.	1.	99.95
0.01	0.00	22.34	0.00	0.050	0.015	0.050	0.015	89.95	120.00
0.007112	25.	25.	25.	0	0	0	0.00	40.00	160.00

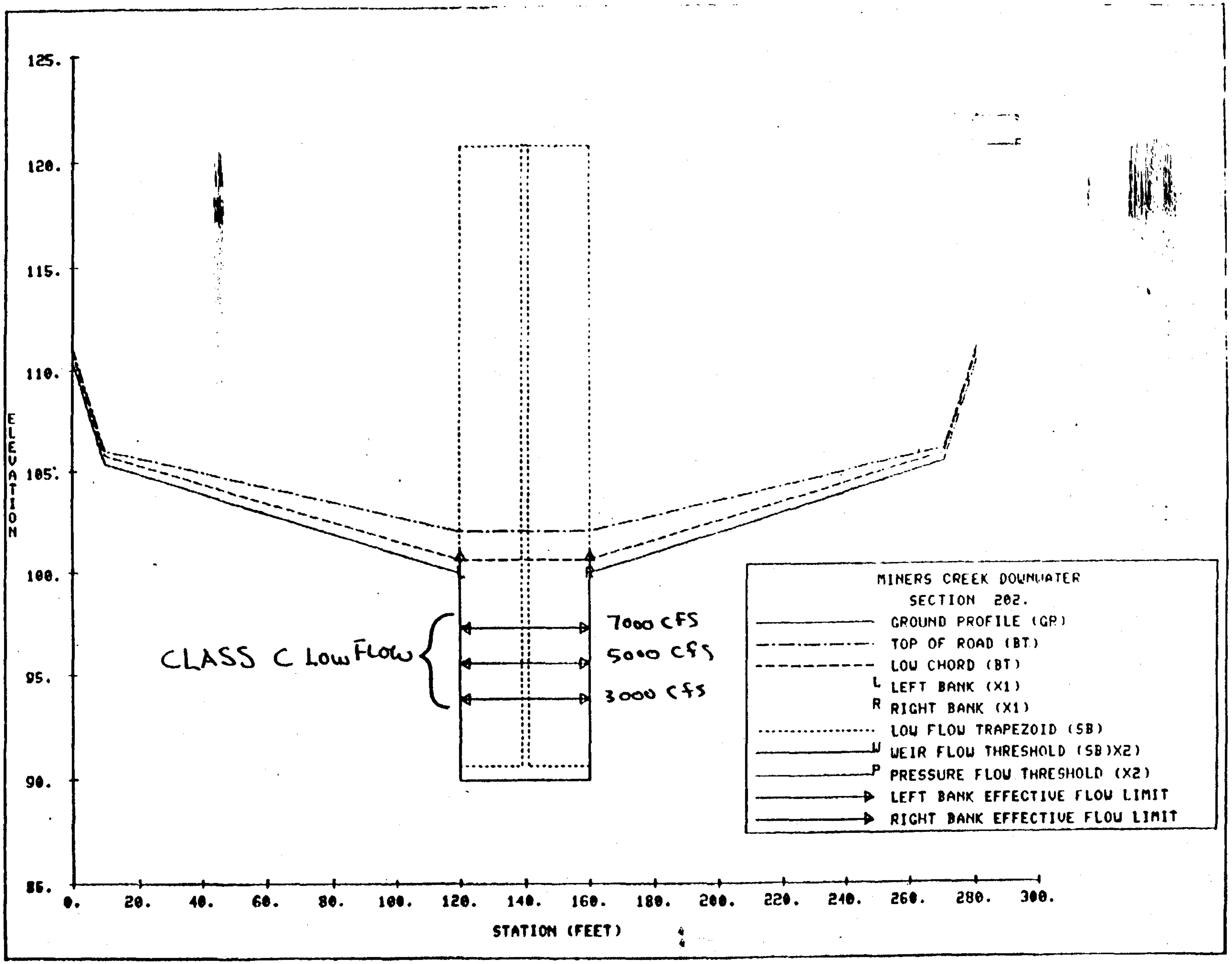


Figure 6, Example 4

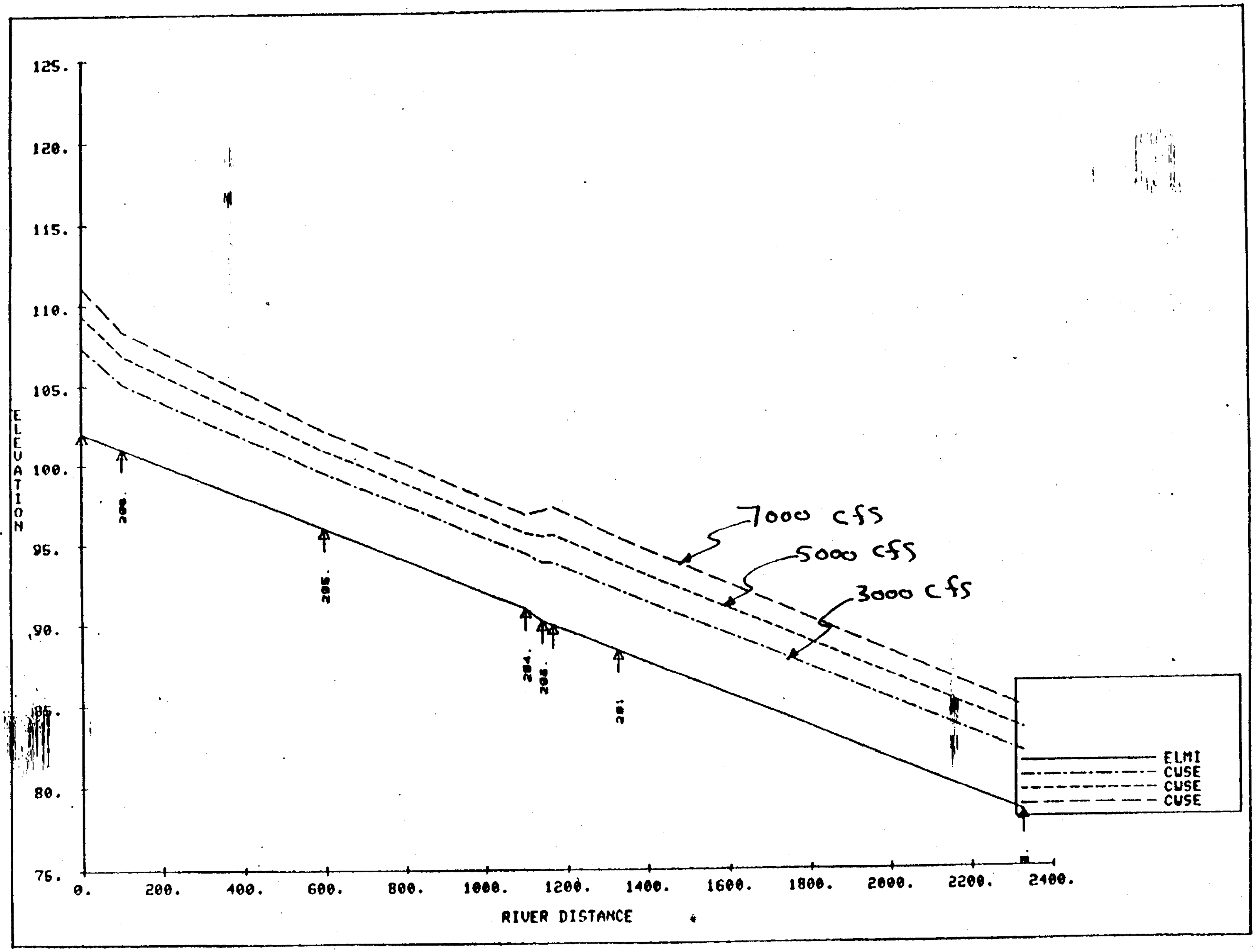

ELEVATION
125.
120.
115.
110.
105.
100.
95.
90.
85.
80.
75.
0.
200.
400.
600.
800.
1000.
1200.
1400.
1600.
1800.
2000.
2200.
2400.
RIVER DISTANCE
7000 cfs
5000 cfs
3000 cfs
ELMI
CUSE
CUSE
CUSE

Figure 7, [illegible]le 4

EASY PROCEDURE TO BUILD DOWNWATER MODELS

from

HEC-2 BACK WATER MODELS

Backwater Model

1. J2.8 = -1 TAPE 16

Tape 16 Model

2. Use COED to Reorder Data Set

   i.e. X ,B,U /X1/,U /GR/,N/ST,F EJ,U,EN,PUT NEWFILE.DAT,RE,

   X 999

3. Check revised data, this procedure may not move the last cross section correctly.

ADVANCED WATER SURFACE PROFILE COMPUTATIONS USING HEC-2

FEMA DEFINITIONS

References:

"Appeals, Revisions, and Amendments to Flood Insurance Maps, a Guide for Community Officials," FIA - 12, FEMA, January 1990.

"Guidelines and Specifications for Study Contractors," FEMA 37, FEMA, March 1991, (soon to be revised)

BFE - Base Flood Elevations - Water surface elevations for a base flood (usually 100 year) determined by a detailed hydraulic study through a FIS.

FBFM - Flood Boundary and Floodway Map - Usually an Exhibit of the FIS study, it is a map with the results of a detailed FIS study showing the 100 and sometimes 500 year flood boundaries and the 100 year floodway.

FHBM - Flood Hazard Boundary Maps - Maps showing the approximate delineation of areas subject to inundation by the base (100 year) flood.

FIRM - Flood Insurance Rate Map - Maps showing potential inundation areas upon which flood insurance rates are based. These have zones designating relative flooding hazards and flow depths. These are usually based upon a detailed study but could be based upon a FHBM established from an approximate study.

FIS - Flood Insurance Study - A detailed engineering flood study performed for or submitted to FEMA to refine the 100 year floodplain boundaries with BFE and presented on a FIRM and a FIS report.

NFIP - National Flood Insurance Program

SFHA - Special Flood Hazard Areas - Areas subject to inundation by the 100 year flood as shown by FHBMs. Usually designated as "Zone A."

APPEAL

A challenge to proposed BFE (Base Flood Elevations) determinations during a formal 90 day appeal period. The changes that result from successful appeals are incorporated into the FIRM, FIS report, and/or FBFM (Flood Boundary and Floodway Map) before publication. If the challenge does not address BFE, but does address other flood risk information, such as the 100 -year floodway, it is considered a "protest". Note: rarely is an appeal successful.

MAP REVISION

A change to an effective NFIP (National Flood Insurance Program) map. The effective map for a community is the latest map issued by FEMA for the community. NFIP maps, including BFEs, base flood depths, floodway, and other flood risk information they may contain, become effective after they are published and distributed. The effective date is shown in the title box of each panel of the map and may be labeled as "Effective Date," "Revised," or "Map Revised." When a map revision is warranted, FEMA will either revise and republish the affected map panels (and, if necessary, the FIS report) or issue a letter, referred to as a **Letter of Map Revision (LOMR)**, that describes the changes and officially revises the effective map.

CONDITIONAL MAP REVISION

A response to a request that FEMA determine whether a proposed project, such as a flood control structure, would warrant a revision to an effective NFIP map after the project is completed. A proposed structural modification could consist of a proposed floodplain improvement project or simply the proposed placement of fill for the elevation of one or more structures or parcels of land. Fees are charged for review of requests that are based on proposed or future actions. FEMA's comments on such requests are known as conditional determinations. When such conditional determinations are warranted, they are issued in letters, referred to as **Conditional Letters of Map Revisions (CLOMR)**. CLOMRs describe the effect(s) that the proposed project would have on the effective NFIP map. A conditional determination does not revise an effective NFIP map.

MAP AMENDMENT

The exclusion of an individual structure and/or a legally described parcel of land that was inadvertently included in the SFHA (Special Flood Hazard Areas) shown on the effective FHBM or FIRM. When FEMA determines that the structure or parcel has been inadvertently included in the SFHA, FEMA issues a letter, referred to as a **Letter of Map Amendment (LOMA)**. A LOMA excludes the structure and/or parcel of land that was inadvertently included in the SFHA and officially amends the effective NFIP map.

ADVANCED WATER SURFACE PROFILES COMPUTATIONS
USING HEC-2

HEC-2 Floodplain and Floodway Determination
for Unusual Hydraulic Conditions

References:

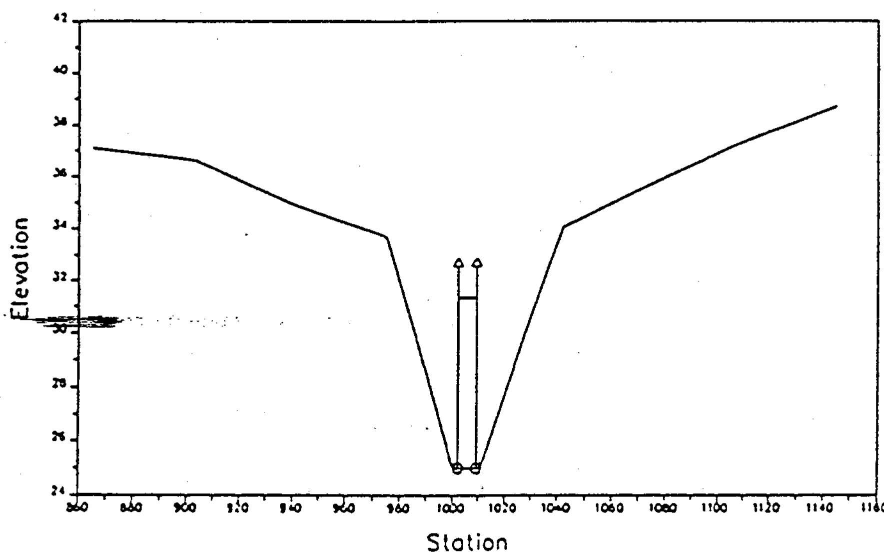
"Floodway Determination Using Computer Program HEC-2," The Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, CA, January 1988.

"Guidelines and Specifications for Study Contractors," FEMA 37, FEMA, March 1991

I. GENERAL FLOODWAY MODELING CONSIDERATIONS

A. Bridges

If a bridge is modeled with X3 records using elevations of effective flow at the cross sections upstream and downstream of a bridge, this can cause an error in the presentation of the actual water surface top width. If the water surface is below the elevation of the specified elevation used to define ineffective flow area, the starting and ending stations of the water surface as well as the top width on all tables will be confined to the area of effective flow even though the actual water surface extends beyond. If this occurs, take out the X3 record and use high "n" values for these areas using the NC or NH records. If the analysis includes another discharge that results in effective flow beyond these limits, it may be necessary to create a separate model. In general, two models would be required if the flow range changes significantly.



Example of Top Width Errors for Bridges

B. Floodway Widths and Pattern

The HEC-2 will often exactly hit your target elevation difference but produces unusual flow patterns. Remembering from bridge hydraulics, the contraction of a floodway should not be more than a 1 to 1 ratio and an expansion should not be more than a 1 to 4 ratio. If the HEC-2 results violate these criteria, lower the target of the downstream cross section for a contraction or the upstream cross section for an expansion. By using this rule of thumb and knowing the reach length, you should know what the maximum change in width should be from one cross section to another. By looking at the floodway width from floodway Table 200, knowing the allowable change, and adjusting the targets accordingly, modification to the HEC-2 model after plotting will be minimized.

C. Long Computational Reaches

If the HEC-2 input has over 25 cross section, the analysis may be quicker if the T1 through ER records at the end of the file were copied to a point after about the 25th cross section. Note that this will cause EDIT2 to report an error but it will still execute. The ER record will prevent the analysis from proceeding past the 25th cross section, thus saving time. When your adjustments to the model reaches this cross section, remove the records and the rest of the cross section will be part of the computation. If the model is excessively long, say over 100 cross section, break it into segments where the last cross section of a downstream segment is the starting cross section of the next upstream segment. The resulting water surface elevations of the last cross section (downstream segment) are the starting water surface elevations of the first cross section of the upstream segment.

D. Flows near Critical Depth.

For steep streams, the change in energy grade line should be used for the 1 foot rise criterion. Method 6 determines floodways using the difference in energy grade instead of water surface. Using Method 6 may cause difficulty at crossings that use the special bridge or special culvert method, especially for flow at or near critical depth. This will become evident when you make large changes in the target energy difference on the ET record and there is no change in the elevations. This is because the numerical method used in the optimization has difficulty due to the large changes in flow depth for small changes in energy near critical flow (recall the energy diagram). When this occurs, use Method 4 or 5 and be prepared to make large target changes.

E. Procedure for Floodways with Additional Criteria

Some jurisdictions require criteria other than just water elevation increase. San Diego County requires that the floodway must include overbank portions with flow velocities greater than 6 feet per second. Another is that the floodway cannot encroach upon the 10 year floodplain. Some counties require the portions of the floodplain with depths greater than a specified depth (5 to 10 feet) must be within the floodway. This information can be output from HEC-2 by entering 15 in field 10 of the J2 record.

HEC-2 OUTPUT USING 15 ON J2.10

```
FLOW DISTRIBUTION FOR SECNO=  35100.00          CWSEL=     703.04

STA=        64.       92.      115.      150.      160.      360.      381.
  PER Q=          .5       5.2      50.0       3.9      39.3       1.0
   AREA=        53.9     203.2     544.3      88.4    1567.2      80.8
    VEL=          .8       2.1       7.4       3.6       2.0       1.0
  DEPTH=         1.9       8.8      15.6       8.8       7.8       3.9
```

The following is a procedure to perform this type of analysis for a single discharge.

1. Make a natural condition HEC-2 run (profile 1) with 15 in the J2.10 field.

2. Run a profile 2 using floodway optimization Method 4, 5, or 6 and perform only a cursory optimization.

3. From the natural run output (profile 1), for each cross section, identify the left and right most stations that completely contain the criteria that are violated. Compare these stations with the resulting floodway stations from the profile 2 run.

4. For those cross sections that have criterion violations beyond the floodway limits, enter the stations obtained from 3 above as left and right limits of the floodway using the ET record and method 1 for profile 3 run. Make sure that these stations cannot encroach into the channel limits. Note that if you skip step 2 and go straight to step 3 and enter the limits in Method 1, you may be specifying floodway widths that may be smaller than the results of optimization.

5. For the other cross sections, use Method 4, 5 or 6. Run profile 3 and optimize the floodway by plotting the results and making adjustments. Remember that the cross section immediately after a cross section that uses Method 1 must have a new ET record with a Method specified - if not, it will use the encroachment limits of the previous cross section.

6. After optimization, a fourth profile should be prepared using Method 1.

7. Check results for water surface elevation change criterion.

The input file should look like the following:

EXAMPLE OF HEC-2 INPUT FOR FLOODWAY ANALYSIS

```
T1       HEC-2 ADVANCED COURSE FOR ASCE
T2       EXAMPLE OF FLOODWAY ANALYSIS FOR CRITERIA OTHER THAN WATER ELEVATION
T3       CHANGE.  CREATED BY DAVID WILLIAMS, WEST CONSULTANTS, (619) 431-8113
T4       CROSS SECTION 2 HAS VELOCITY GREATER THAN 6 FPS BEYOND INITIAL FLOODWAY
J1                                                                     550
*        PLACE 15 IN FIELD 10 OF J2 RECORD TO GET FLOW DISTRIBUTION PRINTOUT
J2       1              -1                                                       15
QT       4     1000     1000     1000     1000
NC
*        USE ENCROACHMENT METHOD 4, TARGET FOR SECOND PROFILE
ET                      10.4     10.4     9.1                              75      250
X1       1
GR
*        REST OF GR RECORDS
*
*        NEXT SECTION HAS VELOCITY GREATER THAN 6 FT/SEC BETWEEN STA 100 AND 350
ET                      10.4     9.1      9.1                              100     350
X1       2
GR
*        REST OF GR RECORDS
*
*        NEXT SECTION HAS NO FLOODWAY RESTRICTIONS FOR VELOCITY
ET                      10.4     10.4     9.1                              25      175
X1       3
GR
*        REST OF GR RECORDS AND CROSS SECTIONS
*
EJ
T1       HEC-2 ADVANCED COURSE FOR ASCE
T2       EXAMPLE OF FLOODWAY ANALYSIS FOR CRITERIA OTHER THAN WATER ELEVATION
T3       CHANGE.  CREATED BY DAVID WILLIAMS, WEST CONSULTANTS, (619) 431-8113
T4       PROFILE NUMBER 2 - READS FIELD 3 OF QT AND ET RECORDS - METHOD 4
J1              3                                                     551
J2       2              -1                                                       15
T1       HEC-2 ADVANCED COURSE FOR ASCE
T2       EXAMPLE OF FLOODWAY ANALYSIS FOR CRITERIA OTHER THAN WATER ELEVATION
T3       CHANGE.  CREATED BY DAVID WILLIAMS, WEST CONSULTANTS, (619) 431-8113
T4       PROFILE NUMBER 3 - READS FIELD 4 OF QT AND ET RECORDS
T5       METHOD 4 EXCEPT WHERE VELOCITY EXCEEDS 6 FT/SEC
J1              4                                                     551
J2       3              -1                                                       15
T1       HEC-2 ADVANCED COURSE FOR ASCE
T2       EXAMPLE OF FLOODWAY ANALYSIS FOR CRITERIA OTHER THAN WATER ELEVATION
T3       CHANGE.  CREATED BY DAVID WILLIAMS, WEST CONSULTANTS, (619) 431-8113
T4       PROFILE NUMBER 4 - READS FIELD 5 OF QT AND ET RECORDS - METHOD 1
J1              5                                                     551
J2       15             -1                                                       15
ER
```

II. CONSIDERATIONS DIRECTLY RELATED TO FEMA STUDY REQUIREMENTS

A. Levee Analysis

1. General

The following applies to the evaluation of earthen riverine levees against the 100 year flood event. Evaluations of other related structures such as concrete dikes, floodwalls, and seawalls must be coordinated with the regional FEMA Project Officer. In general, levees must meet requirements based upon adequacy of freeboard, structural design analysis, interior drainage, operations, and maintenance. They must be certified according to FEMA regulations or another federal agency before they are considered as flood protection in the detailed hydraulic analysis.

2. Levees That Are Certified Adequate

If a levee is certified by FEMA as adequate to protect from the 100 year flood, the HEC-2 analysis, i.e., determination of the floodplain and floodway, should included the levee.

3. Levees That Are Not Certified Adequate

If the levee is not certified, the following are key points in the required analysis.

a. If the 100 year flood elevations with the levee are higher than the top of the levee, the flood elevations on the river side of the levee are considered to be equal to the top of the levee.

b. The 100 year flood elevations for the landward side are then computed as if the levee did not exist.

c. If the 100 year flood elevations with the levee are lower than without the levee, the without levee elevations are to be accepted.

d. Floodways are to be computed as if the levees did not exist.

e. If there are levees on both sides, the analyses must consider if both fail simultaneously, if the right side fails and the left does not, if the left side fails and the right does not, and if both do not fail.

B. Highwater Marks

If highwater marks are available for large floods, the HEC-2 model results should match them within 0.5 feet.

C. Tributaries

For starting water surface elevations of tributaries used in floodway analysis, normal depth (J1.5) should be used unless a coincident peak situation is assumed or the tributary flow is higher than the corresponding main stream events. The assumption of coincident peaks may be appropriate if the following conditions are met.

1. the ratio of the drainage areas lies between 0.6 and 1.4

2. the times of peaks flows are similar for the two combined watersheds

3. the likelihood of both watersheds being covered by the storm being modeled are high

Use gage records if available to determine if coincident peaks occur.

D. Supercritical Channels

Even though a natural stream may flow at supercritical conditions, a subcritical flow model computing at critical depth should always be used. For modified channel, which should have been designed for supercritical conditions, can be modeled as supercritical. If the channel modifications with initial low "n" values causes sediment deposition, consideration must be made to the possible change in the roughness coefficients due to growth of vegetation. For lined channels without vegetation, a "k" roughness (KH record) should be used instead of Manning's "n".

The analysis must extend upstream and downstream of the project to have a smooth transition between subcritical and supercritical profiles. The water surface elevations from the subcritical profiles downstream of the project should be drawn horizontally until they cross the supercritical profiles to eliminate drawdowns.

E. Split Flow Analysis

Split flow analysis should be considered when banks overflow the main stream and the water takes a different path outside the study limits. The analysis should take into consideration the reduction in flow to downstream areas in respect to the floodplain and floodway determination. Overflow areas should be analyzed as a separate model with its own floodplain and floodway or a note should be made on the FIRM or FBFM stating that the area should be unencroached until such a study is performed. In general, a detailed analysis of the overflow area should be made within the study effort if over 50% of the flow is lost to the overflow area.

F. Plotting Floodplains and Floodways

Use Table 115 (use SUMPO) for plotting the floodway and the centerline of the channel. The centerline, which is not always the thalweg (lowest point of the section), is midway between the channel stations. The top width in Table 115 is the distance from the starting and ending stations of the water surface. The top width from other tables has the lengths of "islands" subtracted out. If the water surface is below the elevation of the bank stations, the top width of the floodway in Table 115 could be larger than the actual top width since HEC-2 will not encroach beyond the bank stations. This also goes for the starting and ending station of the water surface from other tables, which will not be the same as the left and right encroachment stations in Table 115.

TABLE 115 FROM HEC-2

```
*-----------------------------------*
|             S U M P O             |
|                                   |
|   Interactive Summary Printout    |
|   for MS/PC-DOS micro computers   |
|             May 1991              |
*-----------------------------------*
1
```

Floodway width summary: NORTH BUFFALO CREEK, Q =
Profile No. 2

Section Number	Elevation Increase	Top Width	Left Encroach Station	Left Sta Distance From Center	Center Station	Right Sta Distance From Center	Right Encroach Station
29900.000	1.00	352.73	155.27	328.73	484.00	24.00	508.00
33700.000	.95	300.41	127.16	137.84	265.00	162.58	427.58
35100.000	.87	228.48	114.24	18.26	132.50	210.23	342.73
36200.000	.86	175.95	187.37	62.63	250.00	113.32	363.32
36950.000	.88	236.57	100.62	111.88	212.50	124.69	337.19
37000.000	.50	236.57	100.62	111.88	212.50	124.69	337.19
37200.000	.58	277.13	88.85	123.65	212.50	153.48	365.98
40150.000	.95	132.17	95.00	25.00	120.00	107.17	227.17

G. Interpolated Cross Sections by HVINS

As stated in the Basic Course lectures, do not use HVINS (velocity head difference) to interpolate cross sections for your production runs (J1 record). For natural and encroached conditions, the number of interpolated cross sections can differ, thereby resulting in unreasonable surcharge values.

If this is the case, do not use the HVINS option. If interpolated cross sections are required, use the output from the HVINS run to obtain the parameters of the interpolated cross sections. From this information, add the required interpolated cross sections using the PXSECR and PXSECE variable on the X1 record.

H. Friction Loss Computations

In the Basic Course, the use of the option for allowing HEC-2 to select the appropriate friction loss equation was recommended (J6.1). For encroachment runs, the friction method used under this option can differ from the natural runs for the same discharge and cross section. This can cause unreasonable surcharge results.

For the natural and encroachment runs, use the option and look at the output variable IHLEQ to see what method is used the most often throughout the reach. Input that method, run again and check if it significantly changes the water surface elevations for both runs as compared to the original runs. If no significant change, use the method. Otherwise, it is recommended that the default (J6.1 = 0) be used for both runs.

I. Composite Manning's "n" in Main Channels

NH records can be used to subdivide the main channel into smaller "n" segments. In normal cases, the incremental conveyance method (default method) is used. However, if the channel bank slopes are steeper than 5H to 1V, a composite "n" for the channel is computed.

If a run is made in which the encroachments are set (any encroachment method) at any of the channel stations, the program thinks that the channel slope is steeper than 5H ~~to 1V.~~ If NH records were used within the channel, a composite "n" value would be computed whereas the natural condition may not have used a composite "n" for its computations. The difference in the "n" for the channel for these two runs could be significantly different, resulting in unrealistic surcharge values. The composite "n" is printed out as XNCH in the output. The composite computations can be controlled by the SUBDIV variable on the J6 record.

If the automatic encroachment methods show the encroachment limits at the channel limits and NH records were used within the channel, use Method 1 to move the limits one foot outside the channel.

J. Bridge Encroachments

For those bridges using the Special Bridge routine, encroachment will not be allowed within the lateral limits of the BT records unless .01 is added to the ET record. Not allowing encroachment of the bridge (and approach roads) may produce an unreasonably shaped floodway and result in an incorrect energy grade (and resulting surcharge). It is recommended that the bridge encroachment option always be used. This does not affect bridges using the normal bridge routine..

FLOODWAY CONCEPT APPLICATION IN UNIQUE SITUATIONS

EXECUTIVE SUMMARY

OVERVIEW

The basis and application of the floodway concept, in various flood plain situations, were reviewed. The purpose was to answer two fundamental questions:

1. Can the application of the floodway concept achieve the intended purpose of the floodway, as defined by FEMA?

2. If yes, what are the most appropriate methods for determining the floodway limits?

The Federal Emergency Management Agency (FEMA) defines a floodway as "the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water-surface elevation more than a designated height." The floodway determination is based on an evaluation of the stream's conveyance and an assessment of the impact of development on the base flood elevation.

This study reviewed the floodway concept, computation process, and computational assumptions of the current procedures. The ideal application situation and the modeling process were defined. Even with ideal applications, several computation and application problems were identified. The application problems resulting from unique situations were reviewed and grouped into general categories. Each category was then analyzed to determine:

1. Applicability of the floodway concept

2. Floodway computation problems

3. Floodway application problems

4. Recommended procedures

The feasibility of developing a simplified floodway procedure was also examined. This procedure is intended to apply to normal situations when a detailed floodway has not been computed.

L-1209/VRB/88

MODEL ASSUMPTIONS

The adopted computation process and the modeling assumptions were reviewed to determine the applicability of the analytical procedures. The computer programs used to compute the water surface profiles are intended for steady, gradually varied flow. The assumptions of the one-dimensional water surface profile programs include:

* **Steady flow** - flood discharge changes slowly with time.

* **Gradually varied flow** - flood flow changes gradually along the length of the stream.

* **One-dimensional flow** - a single water surface elevation across the cross section.

* **Small slope** - channel slope is less than 1 in 10.

* **Rigid boundary** - flow boundary does not change appreciably with flow.

The ideal floodway application is one in which the assumptions of the modeling process are generally met. Some floodway computation problems are a direct result of applications that fail to meet these assumptions.

COMPUTATION PROBLEMS

With the ideal floodway application defined, the sources of computational and application problems were identified. There are numerous computation problems that result from limited and incorrectly formulated model data. Because the programs will execute with limited data, the computations can proceed. Also, it is not always obvious how much data is required to compute the water surface profiles with sufficient accuracy.

Model calibration is an important but time consuming task. Historic flood flows and flood level data are required. The input data may need several cycles of adjustment and execution before the results reasonably reproduce available historic information. Without this process, the computed profiles have considerable uncertainty. The selected Manning's "n" values may be the most significant data in the profile computation process. The adjustment of this model parameter is a major part of the calibration process.

The refinement of the computed floodway often requires many cycles to adjust those stations that define the limits of encroachment and then to compute the water surface profile in order to determine the impact of the estimated floodway. In those states with additional criteria for floodway determination, the process will also require evaluating the results based on the added requirements. The problem becomes increasingly complex when local development plans and more subjective considerations are added. In summary:

* The computation of floodways is a complicated problem.

* Proper model development and calibration are essential to the floodway computation.

* Many problems are a direct result of inadequate models.

* The model computations may not consider all the effects of development that should be considered.

* Beyond the initial floodway computations, there are numerous, more subjective refinements that could be made to the model.

PROBLEM CLASSIFICATION

Grouping unique situations into general categories does not provide a complete classification system; however, there are certain fundamental problems that cause difficulty when applying the current procedure. These application problems were generally defined and placed into the following categories:

1. Low gradient streams - usually with low velocity, long duration floods over a wide area.

2. Flood overflow situations - including overflow at drainage divides and on leveed streams.

3. Alluvial streams - with movable boundaries.

4. High velocity streams - flowing at supercritical and subcritical velocities.

5. Developed flood plains - with development in the potential floodway zone.

ALTERNATIVE FLOODWAY PROCEDURES

Potential alternative floodway procedures were reviewed. Numerous alternatives have been, and are still being, proposed. Some states have adopted a lower maximum change in water surface elevations, and others have additional or different criteria. The potential alternatives considered include:

1. Modified Floodway criteria - either alter current standards or include additional considerations.

2. Depth and velocity criteria - instead of conveyance based floodway computations.

3. Valley storage criteria - defining the floodway based on storage removed, rather than conveyance.

4. Strip development criteria - allowing development along strips of land that meet hazard criteria.

5. Density Floodway criteria - based on the density of development in the flood plain overbanks.

6. Flood bypass - in situations where there is a natural overflow area.

7. Channel modification - a potential floodway alternative.

UNIQUE SITUATION APPLICATIONS

Each of the general application problems was then analyzed to define: (1) the applicability of the floodway concept, (2) the applicability of the computation process, (3) possible adjustments or alternatives to the concept or computation process, and (4) recommended procedures. While it is extremely difficult to define general solutions to unique and variable application problems, major common problems have been defined. The floodway concept applicability and general solution approach are provided. The following information summarizes the study recommendations.

LOW GRADIENT STREAMS. The current floodway procedures are generally applicable. If the flow direction can be defined, the floodway computations can proceed. In some situations, there are complicated flow patterns that must be solved before the computations can proceed. Some flow distribution problems can be solved using the procedures outlined for Flood Overflow Situations.

Wide floodways can be expected when the current procedure is applied to wide flood plains. An alternative to the computed floodway is a maximum depth criterion that would allow development on flood plain overbanks when base flood depths are estimated to be one foot or less. Increasing the depth criterion beyond one foot would require profile computations to ensure that the maximum allowable change in water surface elevation is not exceeded. The use of a depth criterion greater than one foot is discouraged.

FLOOD OVERFLOW SITUATIONS. Three general overflow conditions were defined: (1) drainage divide, (2) perched streams, and (3) leveed streams. The floodway concept can apply when the overflow is limited and predictable. An estimate of the flow lost at the overflow is made, and then the floodway is computed based on the remaining flow in the main flood channel.

Drainage divides, if localized, may be evaluated using the Split Flow computer procedure, depending on what controls the overflow discharge. Three approaches are described, along with applicable situations. If these procedures apply, the floodway computations can proceed. Procedures for modeling divided flow around islands are also reviewed.

Perched streams may not be appropriate for the procedures listed above because the overflow may be distributed over a wide area and may not be predictable. Two-dimensional modeling procedures may be appropriate; however, they should only be considered when there is considerable development expected. The simplified shallow flooding procedures, described in Appendix 2 of the FEMA Guidelines are generally recommended.

Leveed streams can be modeled using the Split Flow procedure; however, the procedures presented in the Guidelines are recommended. The uncertainty of the overflow location and levee condition make the overflow computations questionable.

Following the Guidelines, the levee is first evaluated for certification. If certified, the floodway is defined at the landward toe of the levee. If not, the base flood profile is computed as if the levee were not there. The floodway can be computed based on the same assumption.

ALLUVIAL STREAMS. This category is the most difficult to classify; it is a matter of degree. The rigid boundary assumption does not acknowledge the potential for river systems to move both laterally and vertically. While the floodway procedures may appear applicable, the question is whether channel changes will make the computed results wrong or meaningless.

A key to determining if floodway procedures apply is the determination of the stream stability. Three levels of analysis are described. The Level I qualitative geomorphic analysis is recommended for alluvial streams. The analysis relies on common sense and practical experience; therefore, a study contractor should have sufficient training and experience in this area.

Alluvial Fans - While new mathematical models are being developed to simulate flooding on an unbounded plain, these procedures are still in the developmental stage. The continued development and testing of models is encouraged. However, until the procedures and computer programs are in general use, the current FEMA Guideline procedures should be used for general studies on alluvial fans.

Braided Streams - The lack of stability of the various stream paths in a braided stream make it very difficult to consider them separately for floodway definition. The general case should consider the braided streams as a whole channel. Under the Guidelines, floodway definition must be outside the channel; therefore, all of the braided streams would be in the floodway. Additionally, the suggested procedures for alluvial streams should be followed.

<u>Alluvial Streams</u> - The assessment of the study reach is essential in determining the proper study procedure. Level I Qualitative Geomorphic Analysis is recommended. The study report presented three considerations for applying the floodway procedures. The first, the applicability of the "ideal floodway" model, is an engineering decision that can be made prior to an assessment of channel stability. The second two depend on an assessment.

The validity of the computed water surface elevations and resulting conveyance and velocities cannot be determined with the rigid-boundary model approach. However, sensitivity of the computed values can be determined by modifying the Manning's "n" values to reflect changes in bed form and by modifying cross sections to reflect debris accumulation. If an assessment determines that these types of changes are likely, then an attempt to quantify and evaluate the impacts should be made.

<u>Migration, Bank Instability and Erosion Hazards</u> - The Level I assessment should provide some indication of relative channel stability. From the available information using the current floodway computation procedures, the channel and overbank velocities and the setback distance of the floodway line should be evaluated. The change in velocities under proposed floodway conditions should be reviewed for the impact on channel stability. References are provided to estimate permissible channel design velocities. The stream assessment should provide sufficient information for defining reasonable velocity limits.

The use of minimum setbacks is a protective measure reflecting the potential for the stream to shift into the fringe area. The history of the stream, from the stream assessment, is the best indicator for future expectation. Present math models to predict lateral migration are developing, but they are not practical for general floodway analysis. In the absence of a local setback standard, the historic stream migration should be considered when setting the floodway limits. A minimum setback should be included as a safety factor to account for the uncertainty in the engineering procedures used.

HIGH VELOCITY - SUPERCRITICAL FLOW. Supercritical flow is a very challenging computational problem, as well as a very hazardous condition for flood plain development and use. Flood plain development should be limited, or completely discouraged.

If overbank area is limited, no floodway should be computed. The flood plain should be treated as the floodway. If the cross-sectional shape does not clearly divide into channel and overbank, then cross-sectional areas with depths less than three feet and flow velocities less than three feet per second can be evaluated as overbank areas.

If there are overbank areas, initial floodway definition should be based on fringe areas less than 3 feet deep and with a velocity of less than 3 feet per second. It is unlikely these areas contain supercritical flow. Energy and water surface profile elevations should be evaluated for floodway impact analysis.

If conveyance based floodway computations are performed, the change in energy elevation should be the basis for evaluation. This is consistent with the present FEMA Guidelines.

The total energy elevation is recommended as the operational base flood elevation for supercritical streams. The computed energy elevation is probably closer to the actual water surface elevation along the flood plain fringe.

HIGH VELOCITY - SUBCRITICAL FLOW. If flow depths are less than 1.1 times critical depth, then use the procedures for supercritical flow. If flow depths are greater than 1.1 times critical depth, use flood encroachment procedures, but also use change in energy elevation as an evaluation criterion.

<u>Critical depth solutions</u> may appear in high velocity water surface profile computations because the input data are not adequate. Therefore, study contractors should be encouraged to improve the model, by adding cross sections and other refinements, in order to eliminate assumed critical depth solutions.

The change in energy or water surface elevation should not be the only criterion. Given the potential hazards of flow depths and velocity, as well as the floodway profile response to any changes in cross sections, the floodway evaluation should also consider velocity and depth in the floodway fringe. While this is not required by the Guidelines, it is encouraged as an added consideration for high velocity streams. Maximum values of 3 feet of depth and a velocity of 3 feet per second are recommended for supplemental evaluation.

DEVELOPED FLOOD PLAINS. The floodway concept is applicable; however, floodway modeling procedures require special handling of the development. Two simple procedures are applicable when development is fairly complete and uniform: (1) model buildings as a block development assuming that there is no flow between the buildings in a block, and (2) model buildings with adjusted Manning's coefficient.

Modeling buildings can require added cross-sectional data. Some simplifying approaches may interfere with floodway computations. Modeling buildings within cross-sectional data is preferable because it is more physically based. However, using adjusted Manning's "n" values is recommended when flood plain buildings are extensive and fairly uniformly located on the overbanks.

Floodway modeling at bridge crossings is a complex problem. Floodway computation problems occur when the base flood discharge passes under the bridge, either as low flow or pressure flow. To model the contraction and expansion of flow, the cross sections must be adjusted to define only the available conveyance area in the immediate vicinity of the bridge. Usually, the conveyance based encroachment calculations at these locations have no meaning and should be ignored for floodway delineation purposes. If the base flood also flows over the bridge and/or roadway approaches, the overflow is usually modeled as weir flow. The conveyance in the overbank areas immediately upstream and downstream from the bridge is usually considered effective. Therefore, the conveyance-based encroachment calculation can be performed, and to be consistent, the bridge overflow should also be limited to the floodway width computed for the upstream and downstream cross sections.

Floodway application using current procedures may not seem appropriate when flood plain development is fairly complete. The assumption that the presently developed fringe area is going to become completely blocked by future construction may not apply. If the adjusted "n" value approach is used, the impact of a single added building cannot be evaluated.

Establishing an alternative floodway approach for the developed flood plain would create administrative problems. The basis for determining when a flood plain is fully or near fully developed would require arbitrary rules that may be subject to continued debate. Even though the existing development may be extensive and floodway computation may not seem that logical, the floodway computation is recommended.

SIMPLIFIED FLOODWAY PROCEDURE

A second component of this study was the evaluation of potential procedures to estimate a floodway with a minimum amount of data. A simplified procedure is intended for use in those areas where a floodway has not been determined, but the local community needs some definition of the floodway on which to base their zoning. A literature review was performed to identify potential concepts on which to base a simplified procedure. Also, the HEC-2 data sets, utilized in an HEC study of water surface profile accuracy, were analyzed with traditional floodway computations to evaluate the potential for developing a regression equation approach.

Simplified equations were developed to predict the conveyance reduction allowable given a target change in water surface elevation and the change in water surface elevation given a conveyance reduction value. The equation parameters are ratio of conveyance reduction, change in elevation, 1-percent chance flood discharge, and average slope of the reach. The adjusted determination coefficients for the equations were 0.84 and 0.83, respectively. This indicates that 84 percent of the variance in conveyance reduction is explained by the equation.

With refinement and testing, this type of equation could provide simple floodway estimates. With readily available information, these equations could provide conveyance reduction values. In a simple interactive computer program, the actual floodway width could be defined, relative to the flood plain.

FEDERAL EMERGENCY MANAGEMENT AGENCY
FEDERAL INSURANCE ADMINISTRATION

REVISIONS TO NATIONAL FLOOD INSURANCE PROGRAM MAPS

Application/Certification Forms and Instructions for Conditional Letters of Map Revision, Letters of Map Revision, and Physical Map Revisions

FEDERAL EMERGENCY MANAGEMENT AGENCY **REVISION REQUESTOR AND COMMUNITY OFFICIAL FORM**	*O.M.B. Burden No 3067-0148* *Expires July 31, 1994*	*FEMA USE ONLY*

PUBLIC BURDEN DISCLOSURE NOTICE

Public reporting burden for this form is estimated to average 2.13 hours per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing and reviewing the form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden, to: Information Collections Management, Federal Emergency Management Agency, 500 C Street, S.W., Washington, DC 20472; and to the Office of Management and Budget, Paperwork Reduction Project (3067-0148), Washington, DC 20503.

1. OVERVIEW

1. The basis for this revision request is (are): *(check all that apply)*
   - ☐ Physical change
     - ☐ Existing
     - ☐ Proposed
   - ☐ Improved methodology
   - ☐ Improved data
   - ☐ Floodway revision
   - ☐ Other ______________________________

     Explain ______________________________
2. Flooding Source: ______________________________
3. Project Name/Identifier: ______________________________
4. FEMA zone designations affected: ______________________________
   (example: A, AH, AO, A1-A30, A99, AE, V, V1-30, VE, B, C, D, X)
5. The NFIP map panel(s) affected for all impacted communities is (are):

Community No.	Community Name	County	State	Map No.	Panel No.	Effective Date
EX: 480301	Katy,City	Harris, Fort Bend	TX	480301	0005D	02/08/83
480287	Harris County	Harris	TX	48201C	0220G	09/28/90

6. The area of revision encompasses the following types of flooding, structures, and associated disciplines: *(check all that apply)*

Types of Flooding
- ☐ Riverine
- ☐ Coastal
- ☐ Alluvial Fan
- ☐ Shallow Flooding *(e.g. Zones AO and AH)*
- ☐ Lakes

Affected by wind/wave action
- ☐ Yes
- ☐ No

Structures
- ☐ Channelization
- ☐ Levee/Floodwall
- ☐ Bridge/Culvert
- ☐ Dam
- ☐ Coastal
- ☐ Fill
- ☐ Pump Station
- ☐ None
- ☐ Channel Relocation
- ☐ Excavation
- ☐ Other *(describe)*

Disciplines*
- ☐ Water Resources
  - ☐ Hydrology
  - ☐ Hydraulics
  - ☐ Sediment Transport
  - ☐ Interior Drainage
- ☐ Structural
- ☐ Geotechnical
- ☐ Land Surveying
- ☐ Other *(describe)*

☐ Other(describe)______________ ______________ ______________

*** Attach completed "Certification by Registered Professional Engineer and/or Land Surveyor" Form for each discipline checked. (Form 2)**

2. FLOODWAY INFORMATION

7. Does the affected flooding source have a floodway designated on the effective FIRM or FBFM? ☐ Yes ☐ No
8. Does the revised floodway delineation differ from that shown on the effective FIRM or FBFM ☐ Yes ☐ No

   If yes, give reason: ______________________________

FEDERAL EMERGENCY MANAGEMENT AGENCY
CERTIFICATION BY REGISTERED PROFESSIONAL ENGINEER AND/OR LAND SURVEYOR FORM

O.M.B. Burden No. 3067-0148
Expires July 31, 1994

FEMA USE ONLY

PUBLIC BURDEN DISCLOSURE NOTICE

Public reporting burden for this form is estimated to average . 23 hour per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing and reviewing the form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden, to: Information Collections Management, Federal Emergency Management Agency, 500 C Street, S.W., Washington, DC 20472; and to the Office of Management and Budget, Paperwork Reduction Project (3067- 0148), Washington, DC 20503.

1. This certification is in accordance with 44 CFR Ch. I, Section 65.2
2. I am licensed with an expertise in ______________________
   [example: water resources *(hydrology, hydraulics, sediment transport, interior drainage)** structural, geotechnical, land surveying.]
3. I have __________ years experience in the expertise listed above.
4. I have ☐ prepared ☐ reviewed the attached supporting data and analyses related to my expertise.
5. I ☐ have ☐ have not visited and physically viewed the project.
6. In my opinion, the following analyses and /or designs, is/are being certified:
   ____
7. Base upon the following review, the modifications in place have been constructed in general accordance with plans and specifications.

   Basis for above statement: (check all that apply)

   a. ☐ Viewed all phases of actual construction.
   b. ☐ Compared plans and specifications with as-built survey information.
   c. ☐ Examined plans and specifications and compared with completed projects.
   d. ☐ Other ______________________
8. All information submitted in support of this request is correct to the best of my knowledge. I understand that any false statement may be punishable by fine or imprisonment under Title 18 of the United States Code, Section 1001.

Name: ______________________
(please print or type)

Title: ______________________
(please print or type)

Registration No. ______________ Expiration Date: ______________

State ______________

Type of License ______________

____
Signature

____
Date

____
Seal
(Optional)

*Specify Subdiscipline

Note: Insert not applicable (N/A) when statement does not apply.

FEDERAL EMERGENCY MANAGEMENT AGENCY

HYDROLOGIC ANALYSIS FORM

O.M.B. Burden No. 3067-0148
Expires July 31, 1994

FEMA USE ONLY

PUBLIC BURDEN DISCLOSURE NOTICE

Public reporting burden for this form is estimated to average 3.67 hours per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing and reviewing the form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden, to: Information Collections Management, Federal Emergency Management Agency, 500 C Street, S.W., Washington, DC 20472; and to the Office of Management and Budget, Paperwork Reduction Project (3067-0148), Washington, DC 20503.

Community Name: ______________________________

Flooding Source: ______________________________
(One form for each flooding source)

Project Name /Identifier: ______________________________

1. HYDROLOGIC ANALYSIS IN FIS

☐ Approximate study stream (Zone A)
☐ Detailed study stream (briefly explain methodology) ______________________________

____

2. REASON FOR NEW HYDROLOGIC ANALYSIS

☐ No existing analysis
☐ Improved data *(see data revision on page 3)*
☐ Changed physical conditions of watershed *(explain)* ______________________________

____

____

☐ Alternative methodology *(justify why the revised model is better than model used in the effective FIS)*

____

____

☐ Evaluation of proposed conditions (CLOMRs only) (explain) ______________________________

____

☐ Other ______________________________

____

If a computer program/model was used in revising the hydrologic analysis, please provide a diskette with the input files for the 10-, 50-, 100 - and 500-year recurrence intervals.

Only the 100-year recurrence interval need be included for SFHAs designated as Zone A.

3. APPROVAL OF ANALYSIS

☐ Approval of hydrologic analysis, including the resulting peak discharge value (s) has been provided by the appropriate local, state, or Federal Agency. (i.e., ______________________________

______________________________)

Attach evidence of approval.

☐ Approval of the hydrologic analysis is not required by any local, State, or Federal Agency.

FEDERAL EMERGENCY MANAGEMENT AGENCY **RIVERINE HYDRAULIC ANALYSIS FORM**	*O.M.B. Burden No. 3067-0148* *Expires July 31, 1994*	**FEMA USE ONLY**

PUBLIC BURDEN DISCLOSURE NOTICE

Public reporting burden for this form is estimated to average 2.25 hours per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing and reviewing the form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden, to: Information Collections Management, Federal Emergency Management Agency, 500 C Street, S.W., Washington, DC 20472; and to the Office of Management and Budget, Paperwork Reduction Project (3067-0148), Washington, DC 20503.

Community Name: ____________________

Flooding Source: ____________________
(One form for each flooding source)

Project Name/Identifier: ____________________

1. REACH TO BE REVISED

Downstream limit: ____________________

Upstream limit: ____________________

2. EFFECTIVE FIS

☐ Not studied

☐ Studied by approximate methods

Downstream limit of study ____________________

Upstream limit of study ____________________

☐ Studied by detailed methods

Downstream limit of study ____________________

Upstream limit of study ____________________

☐ Floodway delineated

Downstream limit of Floodway ____________________

Upstream limit of Floodway ____________________

3. HYDRAULIC ANALYSIS

Why is the hydraulic analysis different from that used to develop the FIRM. *(Check all that apply)*

☐ Not studied in FIS

☐ Improved hydrologic data/analysis. Explain: ____________________

☐ Improved hydraulic analysis. Explain: ____________________

☐ Flood control structure. Explain: ____________________

☐ Other. Explain: ____________________

FEDERAL EMERGENCY MANAGEMENT AGENCY **RIVERINE/COASTAL MAPPING FORM**	O.M.B. Burden No. 3067-0148 Expires July 31, 1994	FEMA USE ONLY

PUBLIC BURDEN DISCLOSURE NOTICE

Public reporting burden for this form is estimated to average 1.5 hours per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing and reviewing the form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden, to: Information Collections Management, Federal Emergency Management Agency, 500 C Street, S.W., Washington, DC 20472; and to the Office of Management and Budget, Paperwork Reduction Project (3067-0148), Washington, DC 20503.

Community Name: ____________________

Flooding Source: ____________________

Project Name/Identifier: ____________________

1. MAPPING CHANGES

1. A topographic work map of suitable scale, contour interval, and planimetric definition must be submitted showing *(indicate N/A when not applicable)*:

		Included		
A.	Revised approximate 100-year floodplain boundaries (Zone A)	☐ Yes	☐ No	☐ N/A
B.	Revised detailed 100- and 500-year floodplain boundaries	☐ Yes	☐ No	☐ N/A
C.	Revised 100-year floodway boundaries	☐ Yes	☐ No	☐ N/A
D.	Location and alignment of all cross sections used in the revised hydraulic model with stationing control indicated	☐ Yes	☐ No	☐ N/A
E.	Stream alignments, road and dam alignments	☐ Yes	☐ No	☐ N/A
F.	Current community boundaries	☐ Yes	☐ No	☐ N/A
G.	Effective 100- and 500-year floodplain and 100-year floodway boundaries from the FIRM/FBFM reduced or enlarged to the scale of the topographic work map	☐ Yes	☐ No	☐ N/A
H.	Tie-ins between the effective and revised 100- and 500-year floodplains and 100-year floodway boundaries	☐ Yes	☐ No	☐ N/A
I.	The requestor's property boundaries and community easements	☐ Yes	☐ No	☐ N/A
J.	The signed certification of a registered professional engineer	☐ Yes	☐ No	☐ N/A
K.	Location and description of reference marks	☐ Yes	☐ No	☐ N/A
L.	Vertical datum (example: NGVD, NAVD etc.)	☐ Yes	☐ No	☐ N/A
M.	Coastal zone designations tie into adjacent areas not being revised	☐ Yes	☐ No	☐ N/A
N.	Location and alignment of all coastal transects used to revise the coastal analyses	☐ Yes	☐ No	☐ N/A

If any of the items above are marked no or N/A, please explain: ____________________

____

____

2. What is the source and date of the updated topographic information *(example: orthophoto maps, July 1985; field survey, May 1979, beach profiles, June 1987, etc.)*? ____________________

3. What is the scale and contour interval of the following workmaps?
   a. Effective FIS ____________ scale ____________ Contour interval
   b. Revision Request ____________ scale ____________ Contour interval

NOTE: Revised topographic information must be of equal or greater detail.

4. Attach an annotated FIRM and FBFM at the scale of the effective FIRM and FBFM showing the revised 100-year and 500-year floodplains and the 100-year floodway boundaries and how they tie into those shown on the effective FIRM and FBFM downstream and upstream of the revision or adjacent to the area of revision for coastal studies.

Attach additional pages if needed.

FEDERAL EMERGENCY MANAGEMENT AGENCY **BRIDGE/CULVERT FORM**	*O.M.B. Burden No. 3067-0148* *Expires July 31, 1994*	**FEMA USE ONLY**

PUBLIC BURDEN DISCLOSURE NOTICE

Public reporting burden for this form is estimated to average 2 hours per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing and reviewing the form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden, to: Information Collections Management, Federal Emergency Management Agency, 500 C Street, S.W., Washington, DC 20472; and to the Office of Management and Budget, Paperwork Reduction Project (3067-0148), Washington, DC 20503.

Community Name: ______________________

Flooding Source: ______________________

Project Name/Identifier: ______________________

1. IDENTIFIER

1. Name of roadway, railroad, etc.: ______________________
2. Location of bridge/culvert along flooding source (in terms of stream distance or cross-section identifier): ______________________
3. This revision reflects *(check one of the following)*:
   - ☐ New bridge/culvert not modeled in the FIS
   - ☐ Modified bridge/culvert previously modeled in the FIS
   - ☐ New analysis of bridge/culvert previously modeled in the FIS

   (Explain why new analysis was performed) ______________________

2. BACKGROUND

Provide the following information about the structure:

1 Dimension, material, and shape (e.g. two 10 x 5 feet reinforced concrete box culvert; three 30-foot span bridge with 2 rows of two 3- foot diameter circular piers; 40-foot wide ogee shape spillway) ______________________

2. Entrance geometry of culvert/type of bridge opening (e.g. 30° - 75° wing walls with square top edge, sloping embankments and vertical abutments) ______________________

3. Hydraulic model used to analyze the structure (*e.g., HEC-2 with special bridge routine, WSPRO, HY8*) ______________________

If different than hydraulic analysis for the flooding source, justify why the hydraulic analysis used for the flooding source could not analyze the structure(s). *(Attach justification)*

Note: If any items do not apply to submitted hydraulic analysis, indicate by N/A
*** One form per new/revised bridge/culvert**

FEDERAL EMERGENCY MANAGEMENT AGENCY **CHANNELIZATION FORM**	*O.M.B. Burden No. 3067-0148* *Expires July 31, 1994*	**FEMA USE ONLY**

PUBLIC BURDEN DISCLOSURE NOTICE

Public reporting burden for this form is estimated to average 1.75 hours per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing and reviewing the form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden, to: Information Collections Management, Federal Emergency Management Agency, 500 C Street, S.W., Washington, DC 20472; and to the Office of Management and Budget, Paperwork Reduction Project (3067-0148), Washington, DC 20503.

Community Name: ______________________

Flooding Source: ______________________

Project Name/Identifier: ______________________

1. EXTENT OF CHANNELIZATION

Downstream limit: ______________________

Upstream limit: ______________________

2. CHANNEL DESCRIPTION

1. Describe the inlet to the channel ______________________

2. Briefly describe the shape of the channel *(both cross sectional and planimetric configuration)* and its lining *(channel bottom and sides)* ______________________

3. Describe the outlet from the channel ______________________

4. The channelization includes:

   - ☐ Levees *(Attach Levee Form)*
   - ☐ Drop structures
   - ☐ Superelevated sections
   - ☐ Transitions in cross sectional geometry
   - ☐ Debris basin/detention basin
   - ☐ Energy dissipater
   - ☐ Other ______________________

5. Attach the following:

   a. Certified engineering drawings showing channel alignment and locations of inlet, outlet, and items checked in item 4

   b. Typical cross sections and profiles of channel banks and invert

FEDERAL EMERGENCY MANAGEMENT AGENCY **COASTAL ANALYSIS FORM**	*O.M.B. Burden No. 3067-0148* *Expires July 31, 1994*	**FEMA USE ONLY**

PUBLIC BURDEN DISCLOSURE NOTICE

Public reporting burden for this form is estimated to average 1.0 hour per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing and reviewing the form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden, to: Information Collections Management, Federal Emergency Management Agency, 500 C Street, S.W., Washington, DC 20472; and to the Office of Management and Budget, Paperwork Reduction Project (3067-0148), Washington, DC 20503.

Community Name: ____________________

Flooding Source: ____________________

Project Name/Identifier: ____________________

COASTLINE TO BE REVISED

Describe limits of study area: ____________________

____

____

____

EFFECTIVE FIS

The area being revised was:*

- ☐ studied in the FIS by approximate methods
- ☐ studied in the FIS with only the stillwater surge elevation designated
- ☐ studied in the FIS by detailed methods with:
  - ☐ wave runup computations
  - ☐ wave height computations
  - ☐ dune erosion computations
  - ☐ storm surge modeling. Specify model used:
    - ☐ SPLASH
    - ☐ SLOSH
    - ☐ TTSURGE
    - ☐ WIFM
    - ☐ FEMA STORM SURGE
    - ☐ OTHER ____________

*Check all that apply

REVISED ANALYSIS

Check all analyses used to prepare the revision:

- ☐ Stillwater elevation determinations (complete Section 1)
- ☐ Erosion considerations (complete Section 2)
- ☐ Wave height analysis (complete Sections 2 and 3)
- ☐ Wave runup analysis (complete Sections 2 and 3)
- ☐ New shore protection structures (attach completed Coastal Structures Form)
- ☐ Other

If other, give basis of revision request with an explanation:

____

____

FEDERAL EMERGENCY MANAGEMENT AGENCY **DAM FORM**	*O.M.B. Burden No. 3067-0148* *Expires July 31, 1994*	**FEMA USE ONLY**

PUBLIC BURDEN DISCLOSURE NOTICE

Public reporting burden for this form is estimated to average 0.5 hour per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing and reviewing the form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden, to: Information Collections Management, Federal Emergency Management Agency, 500 C Street, S.W., Washington, DC 20472; and to the Office of Management and Budget, Paperwork Reduction Project (3067-0148), Washington, DC 20503.

Community Name: ______________________________

Flooding Source: ______________________________

Project Name/Identifier: ______________________________

IDENTIFIER

Name of Dam: ______________________________

Location of dam along flood source (in terms of stream distance or cross section identifier):

____

____

____

Check one of the following:

- ☐ Existing dam
- ☐ New dam
- ☐ Modifications of existing dam (describe modifications) ______________________________

____

____

Was the dam designed by _____Federal agency _____State agency _____Local government agency _____Private organization?

BACKGROUND

Does the dam have dedicated flood control storage? ☐ Yes ☐ No

Does the project involve revised hydrology? ☐ Yes ☐ No

If yes, complete Hydrologic Analysis Form and include calculations of the 100-year inflow flood hydrograph routed through the dam with the beginning pool at the normal pool elevation (spillway crest elevation for ungated spillway). Include any inflow hydrograph bulking by watershed sediment yield and provide necessary debris and sediment yield analysis.

Does the revised hydrology affect the 100-year water-surface elevation behind the dam or downstream of the dam? ☐ Yes ☐ No

If yes, complete the Riverine Hydraulic Analysis Form and complete the table shown on the following page.

FEDERAL EMERGENCY MANAGEMENT AGENCY **ALLUVIAL FAN FLOODING FORM**	*O.M.B. Burden No. 3067-0148* *Expires July 31, 1994*	**FEMA USE ONLY**

PUBLIC BURDEN DISCLOSURE NOTICE

Public reporting burden for this form is estimated to average 1.0 hour per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing and reviewing the form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden, to: Information Collections Management, Federal Emergency Management Agency, 500 C Street, S.W., Washington, DC 20472; and to the Office of Management and Budget, Paperwork Reduction Project (3067-0148), Washington, DC 20503.

Community Name: ______________________________

Flooding Source: ______________________________

Project Name/Identifier: ______________________________

AREA TO BE REVISED

Downstream limit: ______________________________

Upstream limit: ______________________________

Describe flood zone designation as shown on the effective FIRM for area to be revised *(i.e. Zone AO with depth and velocity, Zone AO with depth, or Zone A)* ______________________________

Attach a topographic map(s) which show the following items:

- ☐ The revised flood boundaries with revised depths and velocities (if applicable) that tie into the effective boundaries
- ☐ The correct alignment and location of all structural features

STRUCTURAL FLOOD CONTROL MEASURES

The following structures are proposed or built: *(Check all that apply).*

- ☐ Channelization *(Attach completed form)*
- ☐ Levee/Floodwall *(Attach completed form)*
- ☐ *Dam* *(Attach completed form)*
- ☐ *Sedimentation Basin*
- ☐ *Other (describe)* ______________________________

Have the impacts and the design and maintenance requirements of the structural measures been reviewed and approved by all impacted communities and by state and local agencies that have jurisdiction over flood control activities? ☐ Yes ☐ No

Attach copies of letters stating communities' and agencies' approval.

FEDERAL EMERGENCY MANAGEMENT AGENCY **COASTAL STRUCTURES FORM**	*O.M.B. Burden No. 3067-0148* *Expires July 31, 1994*	**FEMA USE ONLY**

PUBLIC BURDEN DISCLOSURE NOTICE

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Community Name: ____________________

Flooding Source: ____________________

Project Name/Identifier: ____________________

BACKGROUND

Name of structure (if applicable): ____________________

Structure location: ____________________

____

Type of structure:

- ☐ Levee/dike*
- ☐ Revetment
- ☐ Breakwater
- ☐ Other ____________________
- ☐ Bulkhead
- ☐ Seawall
- ☐ Soft Shore Protection (i.e., sand dunes)

*Note: If the coastal structure is a levee/floodwall, complete the Levee/Floodwall System Analyses Form. The remainder of this form does not need to be completed.

Material structure is composed of:

- ☐ Stone
- ☐ Concrete
- ☐ Sand
- ☐ Earthen fill
- ☐ Steel
- ☐ Other

Is structure:

☐ New ☐ Existing ☐ Proposed

If existing, describe in detail the modifications being made to the structure and the purpose of the modifications. ____________________

____

Copies of certified "as-built" plans ☐ are ☐ are not being submitted. If "as-built" plans are not available for submittal, please explain why and submit a sketch with general structure dimensions including: face slope, height, length, depth, and toe elevation referenced to the appropriate datum (example: NGVD 1929, NAVD 1988, etc.).

Has a Federal agency with responsibility for the design of coastal flood protection structures designed or certified that the structure(s) has/have been adequately designed and constructed to provide protection against the base (100-year) flood?

☐ Yes ☐ No

If yes, specify the name of the agency and dates of project completion and/or certification. No other sections of this form need to be completed. If yes: ____________________

____

FEDERAL EMERGENCY MANAGEMENT AGENCY **LEVEE/FLOODWALL SYSTEM ANALYSES FORM**	*O.M.B. Burden No. 3067-0148* *Expires July 31, 1994*	**FEMA USE ONLY**

PUBLIC BURDEN DISCLOSURE NOTICE

Community Name: ______________________________

Flooding Source: ______________________________

Project Name/Identifier: ______________________________

REACH TO BE REVISED

Downstream limit: ______________________________

Upstream limit: ______________________________

This Levee/Floodwall analysis is based on:

- ☐ upgrading of an existing levee/floodwall system
- ☐ a newly constructed levee/floodwall system
- ☐ reanalysis of an existing levee/floodwall system

LEVEE/FLOODWALL SYSTEM ELEMENTS

1. Levee elements and locations are:

   - ☐ earthen embankment, dike, berm etc. Station__________ to__________
   - ☐ structural floodwall Station__________ to__________
   - ☐ other (describe)__________________ Station__________ to__________

   Structural Type:

   - ☐ monolithic cast-in place reinforced concrete
   - ☐ reinforced concrete masonry block
   - ☐ sheet piling
   - ☐ other (describe)______________________________

2. Has this levee/floodwall system been certified by a Federal agency to provide protection against the 100-year flood event?

   ☐ Yes ☐ No

   If yes, by which agency?______________________________

   If yes, complete only the interior drainage section on pages 7 and 8 of this form and the operation and maintenance section of Revision Requestor and Community Official Form.

FEDERAL EMERGENCY MANAGEMENT AGENCY **PROPERTY INFORMATION**	*O.M.B. Burden No. 3067-0147* *Expires September 30, 1994*	**FEMA USE ONLY**

PUBLIC BURDEN DISCLOSURE NOTICE

Public reporting burden for this form is estimated to average 1.63 hours per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing and reviewing the form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden, to: Information Collections Management, Federal Emergency Management Agency, 500 C Street, S.W., Washington, DC 20472; and to the Office of Management and Budget, Paperwork Reduction Project (3067-0147), Washington, DC 20503.

This form may be completed by the property owner, registered land surveyor, or registered professional engineer

1. Community Name:________________________ County:__________ State:__________

   Community Number:________________________ Panel or Map Number:__________

   Effective Date:__________

2. Street Address of Property:________________________

   ____

3. Description of Property Lot and Block (if a street address cannot be provided):__________

   ____

   ____

4. Are you requesting that the SFHA designation be removed from (a) all of the land within the bounds of the property, (b) a portion of land within the bounds of the property *(metes and bounds description is required)*, or (c) the structure(s) on the property? *(Answer "a," "b," or "c")*__________

5. Is this request for (a) a single residential structure or lot, (b) a single commercial structure or lot, (c) multiple structures or lots? *(Answer "a", "b" or "c")*__________

6. Is this request for (a) existing conditions or (b) proposed project? *(Answer "a" or "b")*__________

7. Has fill been placed in an identified SFHA?__________ If yes, when?__________

8. For proposed projects, will fill be placed to elevate this land or structure(s)?__________

9. Do you know of previous requests that have been submitted to FEMA for this property or adjacent properties?

   ____

   If yes, what was the date of FEMA's response letter?__________

FEDERAL EMERGENCY MANAGEMENT AGENCY **ELEVATION INFORMATION**	*O.M.B. Burden No. 3067-0147* *Expires September 30, 1994*	**FEMA USE ONLY**

PUBLIC BURDEN DISCLOSURE NOTICE

Public reporting burden for this form is estimated to average .63 hour per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing and reviewing the form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden, to: Information Collections Management, Federal Emergency Management Agency, 500 C Street, S.W., Washington, DC 20472; and to the Office of Management and Budget, Paperwork Reduction Project (3067-0147), Washington, DC 20503.

This form must be completed by a registered professional engineer or licensed land surveyor. These forms should not be used for request involving Channelization, Bridges/Culverts, or Fill in the FEMA-Designated Floodway. Forms entitled Revisions to National Flood Insurance Program Maps (RSD-1) should be used.

(See page 6 of instructions for details)

1. Community Name: ______________________________

2. Legal Description of Property: ______________________________

____

3. Flooding Source: ______________________________

4. Based on the FIRM, this property is located in Zone(s) ______________________________

5. Is any portion of this property located in the regulatory floodway? ☐ Yes ☐ No

   Are any structures *(existing or proposed)* located in the regulatory floodway? ☐ Yes ☐ No

6. Is this area subject to land subsidence or uplift? ☐ Yes ☐ No, If yes, what is the date of the current releveling? ______________________________

7. What is the BFE for this property? (*Provide elevation to nearest tenth of a foot and datum*)*

   ______________ Elevation ______________ Datum

8. How was the BFE determined ? *(attach a copy of the Flood Profile or table from the FIS report, if appropriate, or other necessary supporting information including Forms 3 and 4 from forms entitled, "Revisions to National Flood Insurance Program Maps"* (RSD-1)).

   ____

   ____

   ____

   ____

9. If this request is to remove the SFHA designation from a parcel of land or lot(s), what is the existing or <u>proposed</u> elevation of the lowest grade; that is, the lowest ground on the property? (Provide elevation to nearest tenth of a foot and datum)* ______________ Elevation ______________ Datum

10. If this request is to remove the SFHA designation from a structure(s), what is the elevation of the existing or <u>proposed</u> lowest adjacent grade; that is, the lowest ground touching the structure? (Provide elevation to nearest tenth of a foot and datum)* ______________ Elevation ______________ Datum

11. If fill has been/will be placed to elevate the structure(s) on this property, what is the existing or <u>proposed</u> elevation of the lowest floor, including basement? (Provide elevation to nearest tenth of a foot and datum)*

    ______________ Elevation ______________ Datum

***For multiple lots/structures, complete the appropriate column(s) of the Summary of Elevations-Individual Lot Breakdown form, identifying the elevation for each lot/structure. To support items 9, 10, and 11, please note a map (certified by a licensed surveyor or registered professional engineer) may be required to relate the ground elevations and locations of structures or lots. The map should indicate whether it reflects "as-built" or "proposed" conditions.**

FEDERAL EMERGENCY MANAGEMENT AGENCY **CERTIFICATION OF FILL PLACEMENT**	*O.M.B. Burden No. 3067-0147* *Expires September 30, 1994*	**FEMA USE ONLY**

PUBLIC BURDEN DISCLOSURE NOTICE

Public reporting burden for this form is estimated to average .35 hour per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing and reviewing the form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden, to: Information Collections Management, Federal Emergency Management Agency, 500 C Street, S.W., Washington, DC 20472; and to the Office of Management and Budget, Paperwork Reduction Project (3067-), Washington, DC 20503.

______________________________ Community Name

______________________________ Property Name or Address

The Fill is: ☐ Existing ☐ Proposed

I hereby certify that fill placed on the property to raise the ground surface to or above the base *(100-year)* flood elevation in order to gain exclusion from a Special Flood Hazard Area *(100-year floodplain)* meets the criteria of Title 44 of the Code of Federal Regulations, Section 65.5(a) (6), listed below. For proposed fill, I hereby certify that it is designed in accordance with these criteria.

1. That the fill has been compacted to 95 percent of the maximum density obtainable with the Standard Proctor Test method or an acceptable equivalent method for *(check one of the following)*

_____ a. Fill pads prepared for the foundations of residential or commercial structures

_____ b. Entire legally defined parcel *(Note: if the location of fill pads has not been determined, the fill over the entire legally defined parcel must be compacted to the above criteria).*

______________________________ Name (Please print or type)

______________________________ Signature

______________________________ Date

______________________________ Community Official's Title or Engineer's Seal/Registration Number

2. That fill slopes for granular materials are not steeper than one vertical on one-and-one-half horizontal *(steeper slopes must be justified)*; and

3. That adequate erosion protection is provided for fill slopes exposed to moving flood waters *(slopes exposed to flows with velocities of up to 5 feet per second (fps) during the 100-year flood must, at a minimum, be protected by a permanent cover of grass, vines, weeds, or similar vegetation; slopes exposed to flows with velocities greater that 5 fps during the 100-year flood must, at a minimum, be protected by appropriately designed stone, rock, concrete, or other durable products).*

______________________________ Name (Please print or type)

______________________________ Signature

______________________________ Date

______________________________ Community Official's Title or Engineer's Seal/Registration Number

FEDERAL EMERGENCY MANAGEMENT AGENCY **COMMUNITY ACKNOWLEDGMENT OF REQUESTS INVOLVING FILL**	*O.M.B. Burden No. 3067-0147* *Expires September 30, 1994*	**FEMA USE ONLY**

PUBLIC BURDEN DISCLOSURE NOTICE

Public reporting burden for this form is estimated to average .88 hour per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing and reviewing the form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden, to: Information Collections Management, Federal Emergency Management Agency, 500 C Street, S.W., Washington, DC 20472; and to the Office of Management and Budget, Paperwork Reduction Project (3067-0147), Washington, DC 20503.

____________________ Community Name

____________________ Property Name or Address

We hereby acknowledge receipt and review of this Letter of Map Revision request and have found that the completed or proposed project meets or is designed to meet all of the community's applicable floodplain management regulations, including the requirement that no fill be placed in the adopted regulatory floodway. We understand that this request is being forwarded to FEMA for a possible map revision. For proposed projects, we understand that FEMA is being asked to provide comments on the potential effects of this project on the flood hazards of our community.

Community comments on the proposed project: ____________________

Community Official's Name: ____________________
(please print or type)

Address: ____________________
(please print or type)

Daytime Telephone Number: ____________________

____________________ Community Official's Signature

__________ Date

____________________ Community Official's Title

FEDERAL EMERGENCY MANAGEMENT AGENCY **SUMMARY OF ELEVATIONS-INDIVIDUAL LOT BREAKDOWN**	*O.M.B. Burden No. 3067-0147* *Expires September 30, 1994*	***FEMA USE ONLY***

PUBLIC BURDEN DISCLOSURE NOTICE

Public reporting burden for this form is estimated to average .67 hour per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing and reviewing the form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden, to: Information Collections Management, Federal Emergency Management Agency, 500 C Street, S.W., Washington, DC 20472; and to the Office of Management and Budget, Paperwork Reduction Project (3067- 0147), Washington, DC 20503.

______________________________ Community Name

______________________________ Property Name or Address

LOT NUMBER	BLOCK NUMBER	LOWEST LOT ELEVATION[1]	LOWEST FLOOR ELEVATION[2] (INCLUDING BASEMENT)	LOWEST ADJACENT GRADE TO STRUCTURE[3]	100-YEAR FLOOD ELEVATION	SOURCE OF 100-YEAR FLOOD ELEVATION	FOR FEMA USE ONLY

[1] For requests that an entire parcel of land be removed from the SFHA; if the request involves an area described by metes and bounds, provide the lowest elevation within that area

[2] For requests that a structure that has been elevated by fill be removed from the SFHA

[3] For requests that a structure be removed from the SHFA.

FEMA Form 81-87D, JUL 93

WORKSHOP NO. 6

SPLIT FLOW

SPLIT FLOW PROBLEM

USING HEC-2

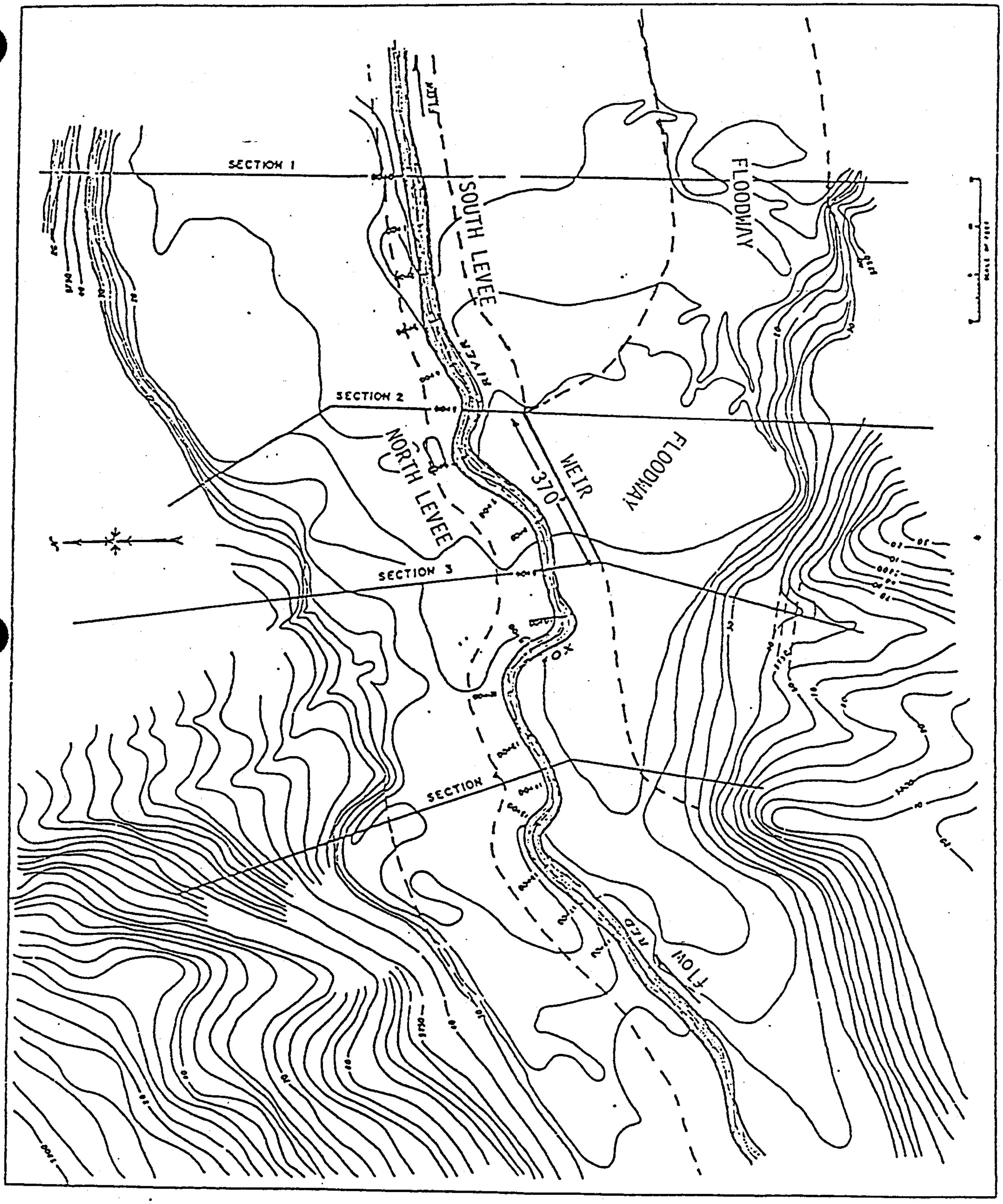
Problem Description

A plan view of the levee system and floodway of the Red Fox River is shown in figure 1. Plots of cross sections are shown in figure 2 through 5 which depict the location and height of the levees. A profile plot of the stream bed, levees, and overflow weir are shown in figure 6. Channel distances between cross sections are as follows:

Sections	Distance Feet
1	
	500
2	
	400
3	
	400
4	

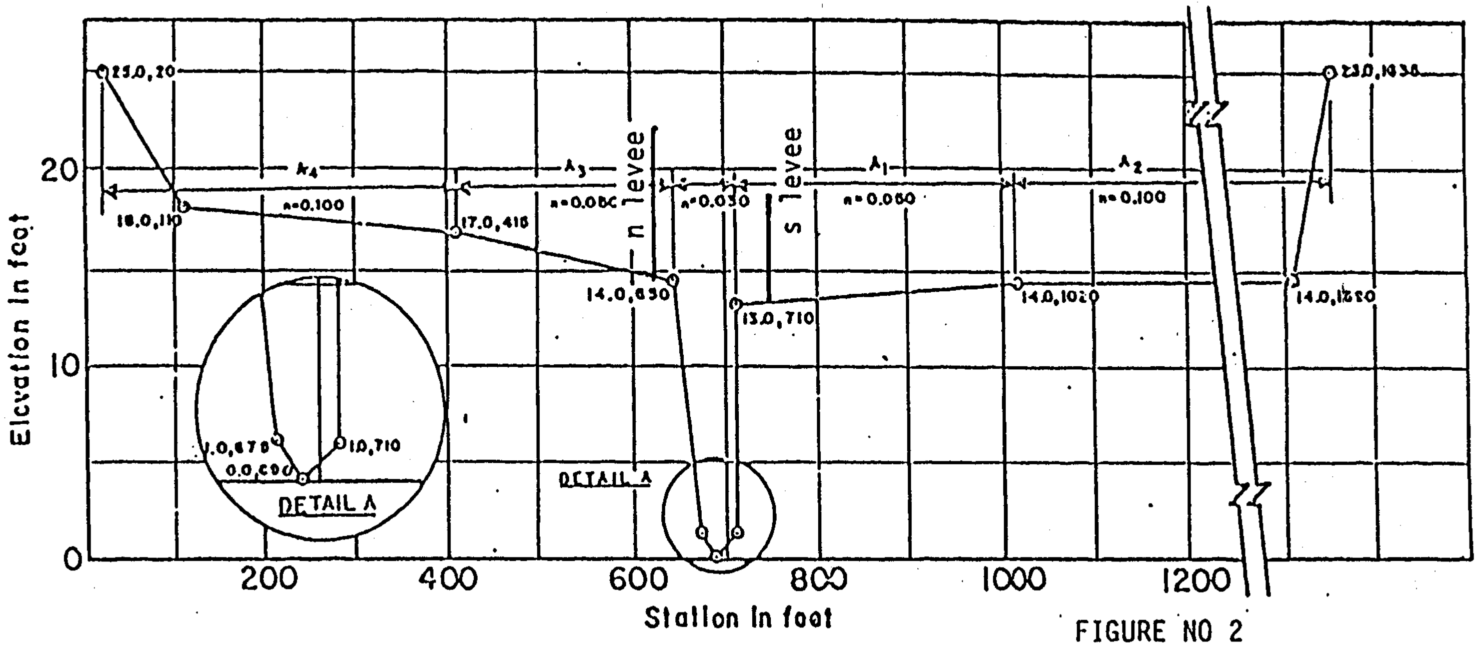
Problem

Prepare the necessary HEC-2 input data cards to determine the water surface profiles and the discharges diverted down the floodway. Determine the above data for discharges of 7000 cfs, 24000 cfs, and 40000 cfs. Specify expansion and contraction coefficient of 0.3 and 0.1 respectively. Use a normal depth start using an energy slope of .005 ft/ft. Use a weir coefficient of 3.4 for the levee and 2.7 for the overflow weir.



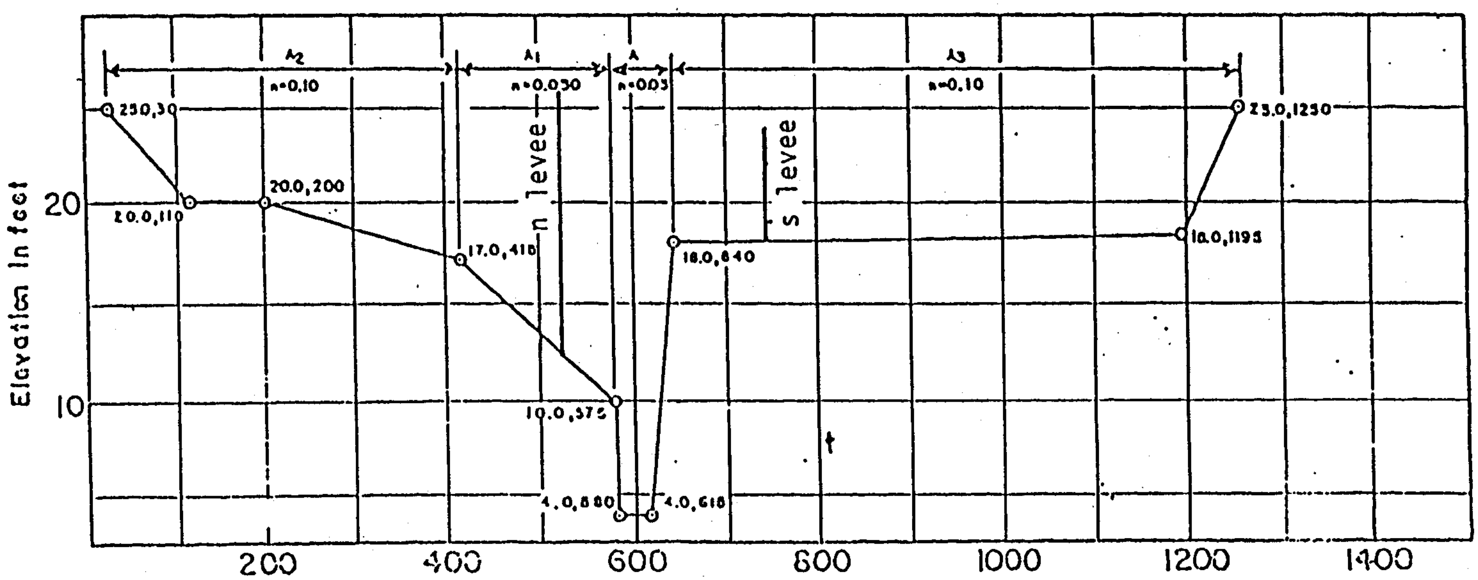
Plan view of the Red Fox River, Colorado

FIGURE NO 1



Cross section No. 1

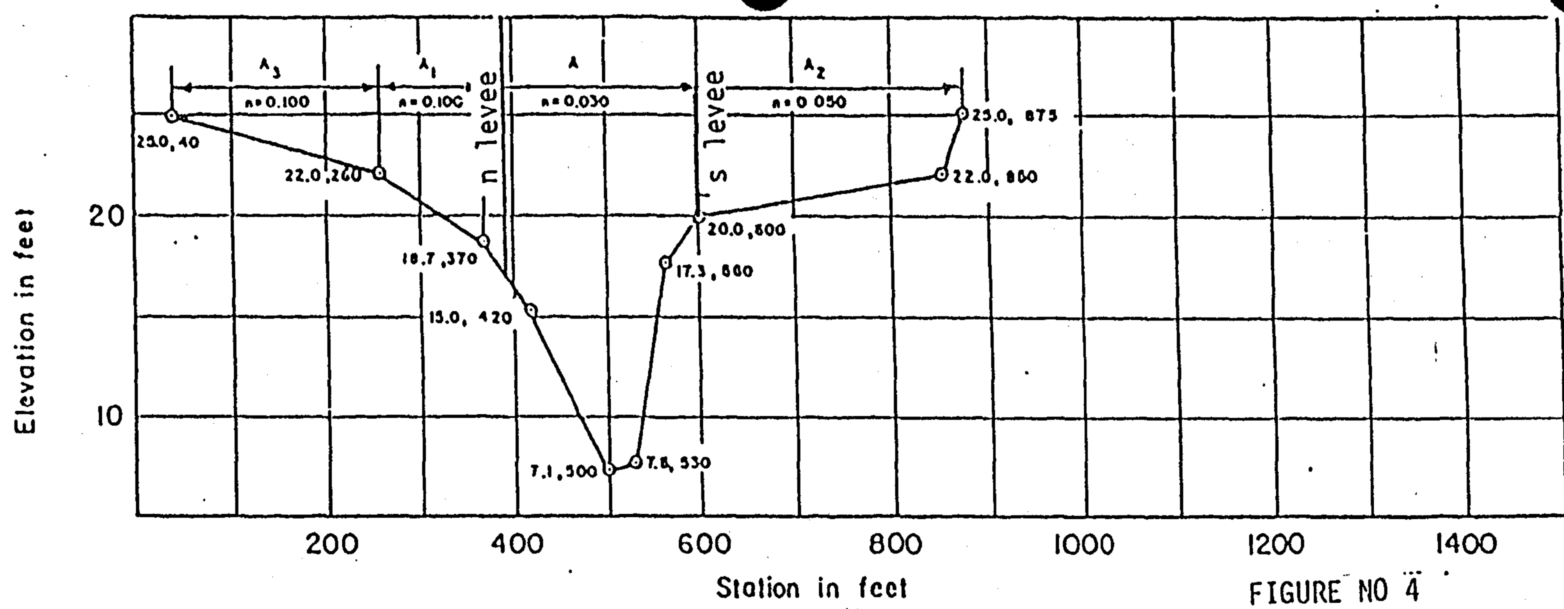
FIGURE NO 2



S ... on in feet

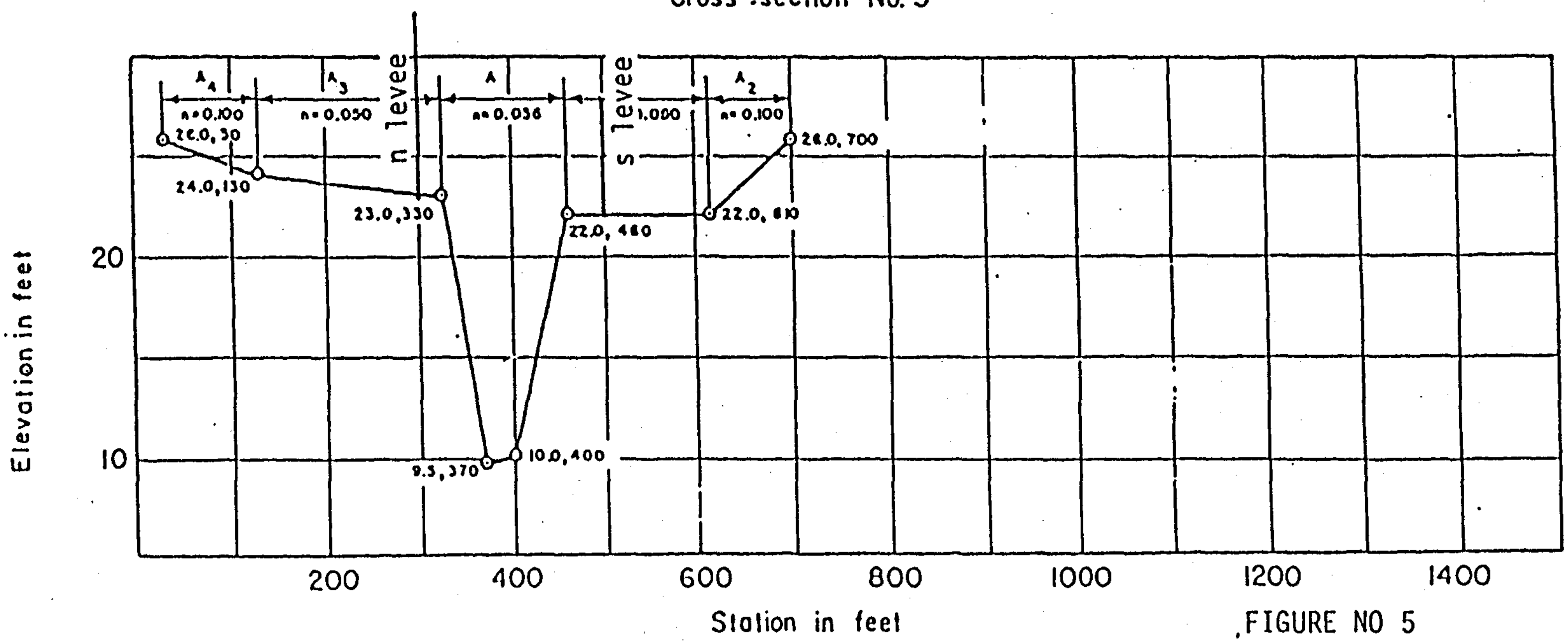
C ... ction No. 2

FIGURE NO 3



Cross section No. 3

FIGURE NO 4



Cross section No. 4

FIGURE NO 5

RED FOX RIVER, COLORADO

PROFILE PLOT OF RED FOX RIVER
SPLIT FLOW PROBLEM

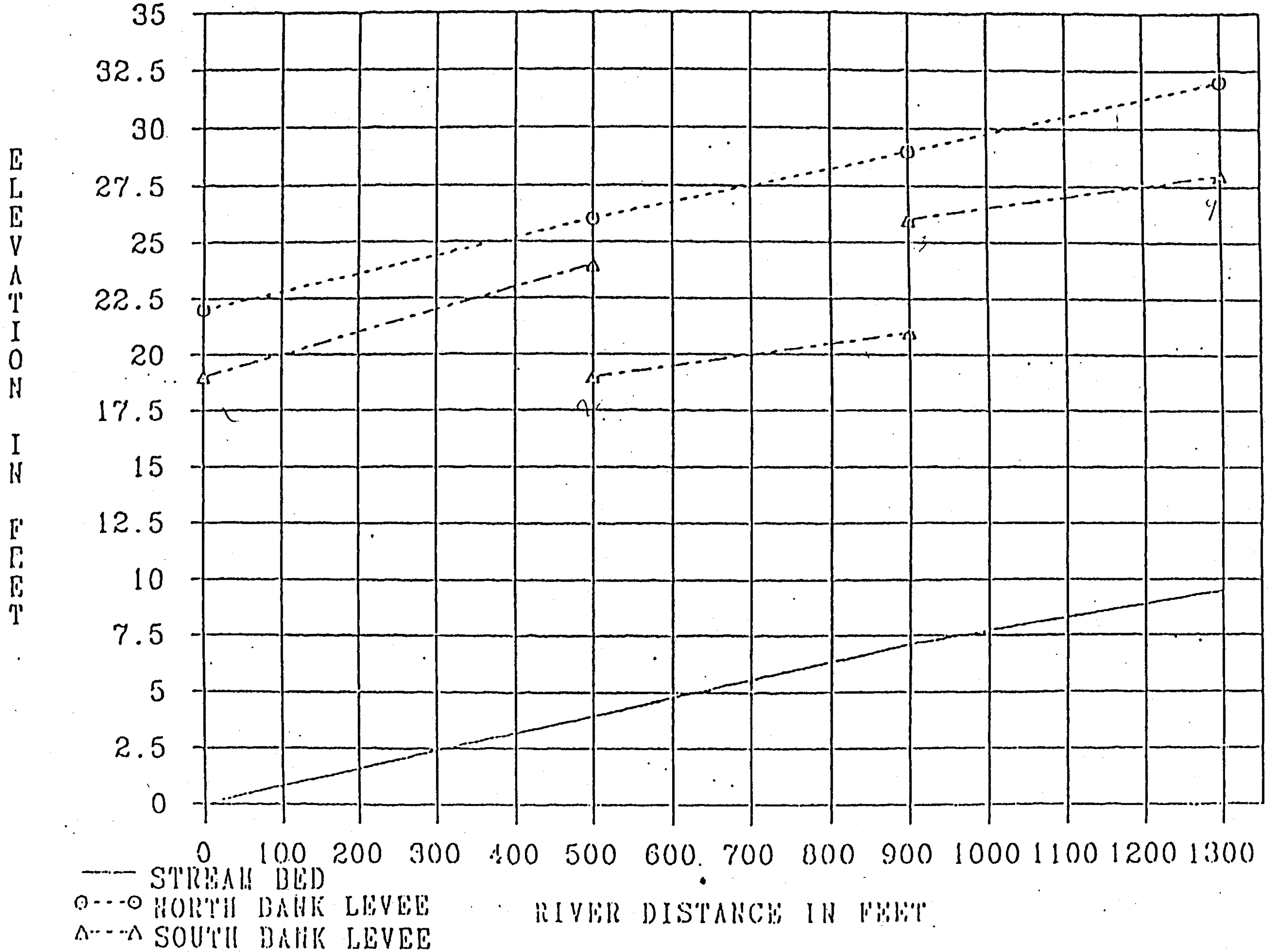


FIGURE NO 6

WORKSHOP NO. 7

MULTIPLE CULVERT ANALYSIS

WORKSHOP 7

MULTIPLE CULVERT PROBLEM USING HEC-2

Note: This workshop is adapted from example problem 8 of the BOSS HEC2 software package.

Two 40 foot long culverts are located between cross sections 4860 and 4900 as shown in Figure 1. These culverts are covered by a road as shown in Figure 2. One culvert is a 5 foot diameter circular corrugated pipe projecting from fill as shown in Figure 3.6, Appendix IV, page 22 of the HEC-2 Manual. Its downstream and upstream invert elevations are 235 and 236 feet, respectively. The other culvert is a 4 ft. x 4 ft. box concrete culvert with 30 degree flared wingwalls as shown in Figure 3.8, Appendix IV, page 23. Its downstream and upstream invert elevations are 227 and 227.5 feet, respectively. It is judged that flow over the road would act like a weir up to elevation 247.5.

Using the provided information and the partially completed HEC-2 input file, determine the water surface profile of discharges of 100, 250, and 450 cfs using the following procedure.

1. Create BT records to simulate the road elevations at cross section 4900.

2. With an SC record just before cross section 4900, run discharges of 50, 100, 200, and 300 cfs for each culvert by itself and note the headwater elevations for each discharge.

3. Create a headwater elevation versus discharge plot for each culvert on the same graph. Add the discharges for a given head to create a total discharge versus headwater elevation. From this curve, obtain the headwater elevations for 100, 250, and 450 cfs.

4. Place an X5 record at cross section 4900 and place the appropriate headwater elevation for the discharges. Leave in the SC record. The starting water surface elevation at cross section 2900 are 229, 231.5, 233 ft or 100, 250 and 450 cfs, respectively.

5. Plot the water surface profiles and check for reasonableness of the results.

Questions and Discussions:

1. What are some limitations with this type of analysis of multiple culverts?

2. What would you do if the culverts changed in size or shape under the road?

3. What would you do if the culverts changed slopes under the road?

4. Why does the rating curve at the upstream end of the culverts bend over so much?

5. Ideally, should the cross section locations be adjusted for this analysis?

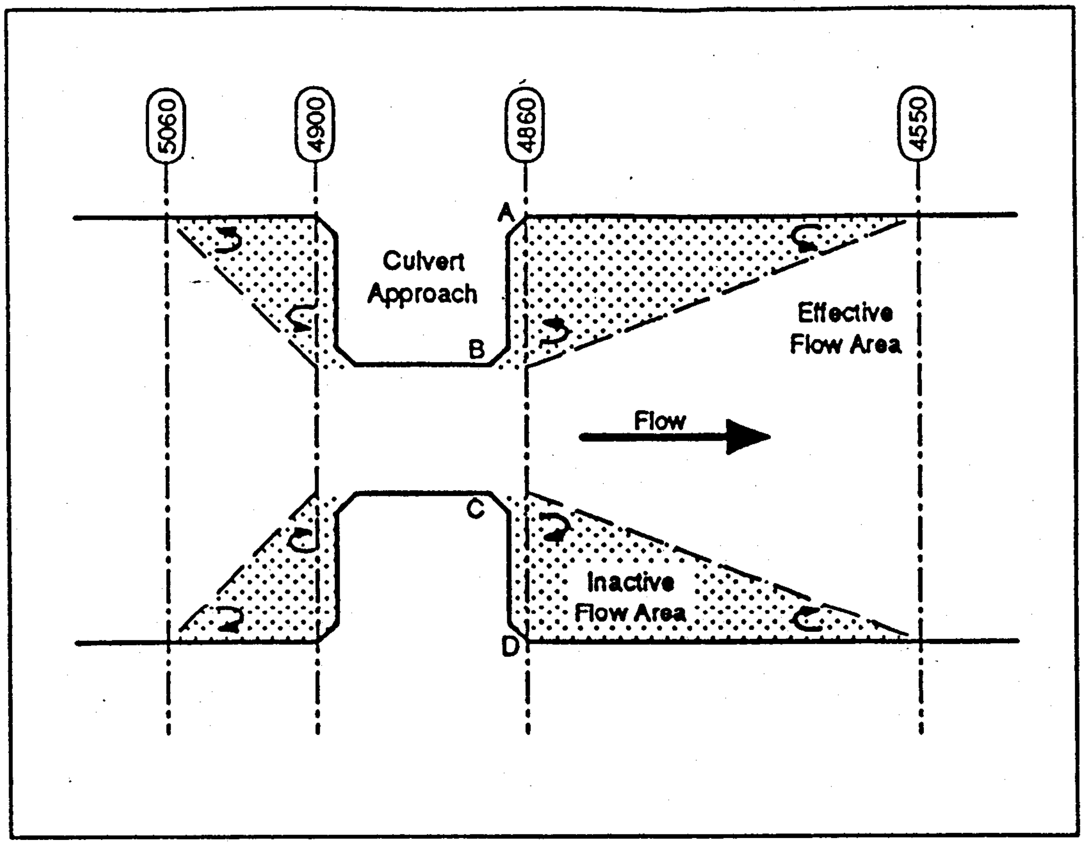


Figure 1. Cross section Layout of Culverts

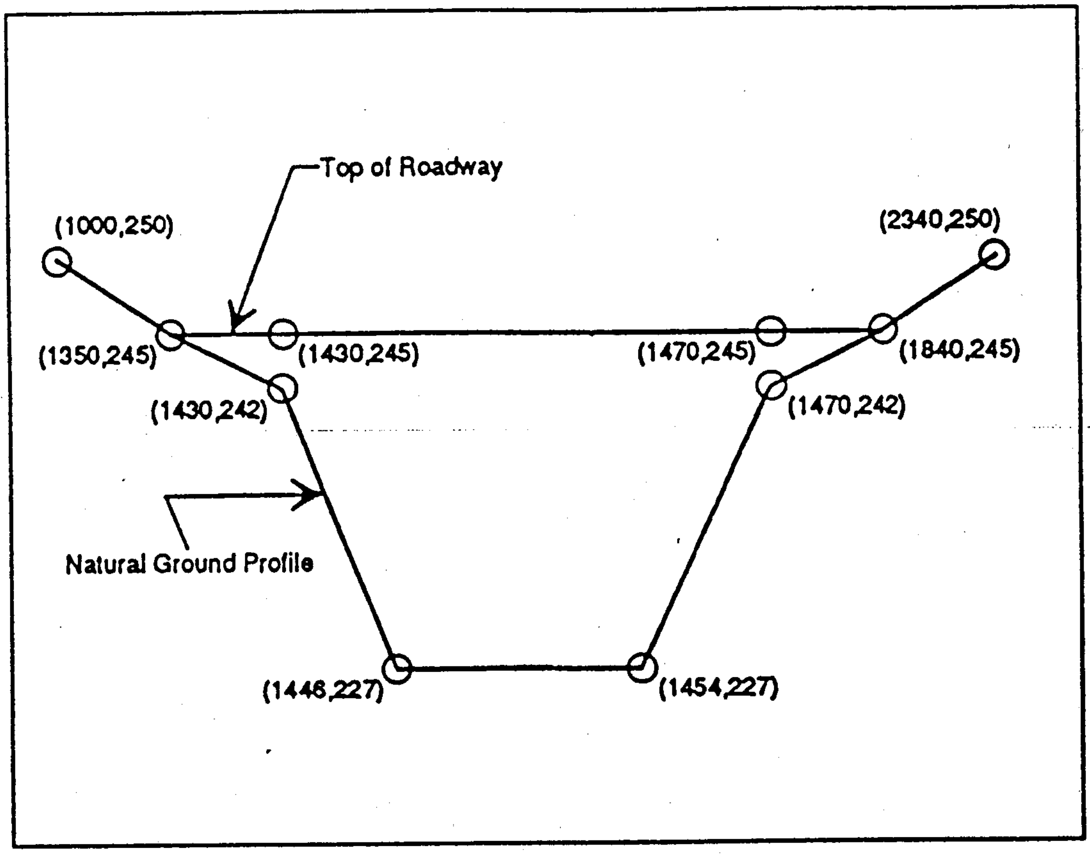


Figure 2. Cross section Geometry at Culverts

WORKSHOP NO. 8

FLOODWAY DETERMINATION, OPTIMIZATION, AND PLOTTING

WORKSHOP 8

FLOODWAY DETERMINATION, OPTIMIZATION, AND PLOTTING

In this workshop, a floodway optimization will be completed for cross sections 1.80 to 3.06 of Sample Creek (See Fig. 4). Cross section plots are provided following Fig. 4.

<u>PROCEDURE:</u>

1. In Menu2, pull up the Workshop 8 HEC-2 input file (WKSHP8I.DAT) into EDIT2 to review.

   Notice the following:

   a) A value of -1 in field J2.7 will compute critical depth at all cross sections.

   b) A value of 15 in field J2.10 will print out a flow distribution for all cross sections.

   c) An ET record is placed above each cross section's X1 record for encroachment computations in profile 2. The value of 10.6 in the first ET record indicates that an optimization scheme will be used to obtain a 1.0 foot (10 tenths) increase in energy grade elevation. This criteria will be used for all remaining cross sections unless changed on subsequent cross sections.

2. Hit CTRL-F10 and ENTER to quit without saving.

3. Run the HEC-2 input file.

4. Assume a criteria is given that the velocity in the floodplain fringe after encroachment must not exceed 6 ft/sec. Display the output to console. Page down to the output for profile 1 (natural conditions) and check velocities in the flow distribution printout for each cross section (see Fig. 1). Make a note of the stations where the criteria is exceeded.

5. For the cross sections where the velocity criteria was exceeded, go to Summary Table 110 in the output (see Fig. 2). Using the channel bank stations, STCHL and STCHR, check to see if the velocity greater than 6 ft/sec occurred within the channel bank stations or in the overbanks. No adjustments for encroachment are necessary if the velocity exceeded the criteria within the channel bank stations. Otherwise, make a note to check the station after floodway optimization to make sure that this criteria is satisfied. It may be necessary to use method 1 to set the encroachment stations at some cross sections to meet this criteria.

WORKSHOP 8

FLOODWAY DETERMINATION,
OPTIMIZATION, AND PLOTTING

PROCEDURE (cont'd):

6. Plot the limits of the natural floodplain computed for profile 1 from station 1.80 to 3.06 on Fig. 4 using the starting and ending stations of the water surface. The centerline channel station is shown on Fig. 4 with a dotted line and the zero station is marked on each cross section line. A SUMPO table was created (see Fig. 3) showing the cross section numbers, the starting and ending stations of the water surface (SSTA and ENDST), the computed water surface elevation (CWSEL), and the computed critical water surface elevation (CRIWS).

   Notice in Fig. 3 that the computed water surface elevation at most of the cross sections is at or near critical depth. Therefore, in addition to checking for a 1.0 foot increase in water surface elevation between the natural run and the encroachment run, it will also be important to make sure that the difference in energy grade elevation does not exceed 1.0 foot.

7. Return to Summary Table 110 (try entering "/TABLE_110" at the command line in LIST). For each cross section, check the difference in water surface elevation, the difference in energy grade elevation, and the top width for profiles 1 and 2 (natural and encroachment runs).

   Notice that the criteria for 1.0 difference in water surface elevation and energy grade elevation has been exceeded through the bridge sections 1.90 to 1.98. Also, in this area, the top width for the floodway varies between 170 and 370 feet. A smooth transition meeting realistic expansion and contraction criteria should be a goal.

8. Return to EDIT2 and begin optimizing encroachment for profile 2 in the input file. Try using a lower energy grade target in method 6 (i.e. 8.6) or switch to method 4 (i.e. 10.4) to control changes in water surface elevation where necessary. (HINTS: try an 8.6 for cross section 1.90). Remember that an encroachment method is on until turned off at a subsequent cross section in the input file.

9. Run HEC-2 and review the output in Table 110 to check your progress. Continue step 8 until reasonable results are achieved and elevation criteria are met.

10. Plot the profile 2 floodway using the left and right encroachment stations (STENCL, STENCR) in Table 110.

11. It may be necessary to smooth the floodway where ineffective flow areas would occur or to have more uniform width transitions over a series of cross sections.

PROCEDURE (cont'd):

11. (cont'd) Pencil in the revisions to the floodway.

12. Return to EDIT2 and remove the ER record from line 417 to allow computation of profile 3. At each ET record, input a "9.1" in field 4 and the left and right encroachment stations in fields 9 and 10. (see example in cross section 1.70). Use the optimized encroachment stations of profile 2 from Table 110, along with any revised stations from smoothing in step 11, or from the velocity criteria in step 5.

13. Run HEC-2 again and verify that none of the water surface elevation and energy grade elevation difference criteria have been exceeded using method 1.

FIG. 1

WORKSHOP 8

*SECNO 1.900

3265 DIVIDED FLOW

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = .45

1.900	2.47	737.27	737.27	.00	737.64	.37	5.74	.05	737.60
900.0	.0	104.0	795.9	.0	11.8	195.8	5.0	4.7	739.20
.06	.00	8.84	4.06	.000	.030	.050	.000	734.80	604.69
.025660	510.	495.	495.	3	16	0	.00	286.23	980.10

FLOW DISTRIBUTION FOR SECNO= 1.90 CWSEL= 737.27

STA=	605.	628.	720.	779.	817.	890.	958.	979.	980.
PER Q=	11.6	.6	7.5	11.9	36.9	28.9	2.6	.0	
AREA=	11.8	3.2	25.1	27.8	71.0	59.8	8.8	.0	
VEL=	8.8	1.6	2.7	3.8	4.7	4.4	2.7	.0	
DEPTH=	1.4	.0	.4	.7	1.0	.9	.4	.0	

CCHV= .300 CEHV= .500
*SECNO 1.910

3265 DIVIDED FLOW

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 3.08

1.910	2.71	737.81	737.33	.00	737.92	.10	.20	.08	739.60
900.0	.0	263.2	636.8	.0	68.5	354.2	5.3	4.9	739.20
.06	.00	3.84	1.80	.000	.030	.050	.000	735.10	587.20
.002712	40.	40.	40.	2	10	0	.00	347.39	988.04

FIG. 2

WORKSHOP 8

SUMMARY PRINTOUT TABLE 110
PROFILES 1 AND 2
ENCROACMENT METHOD 10.6

THIS RUN EXECUTED 22JAN93 18:18:58
****
HEC-2 WATER SURFACE PROFILES

Version 4.6.2; May 1991
****

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

SAMPLE CREEK

SUMMARY PRINTOUT TABLE 110

	SECNO	CWSEL	DIFKWS	EG	TOPWID	QLOB	QCH	QROB	PERENC	STENCL	STCHL	STCHR	STENCR
	1.700	729.98	.00	730.41	168.98	.09	789.39	110.52	.00	.00	1316.10	1362.70	.00
	1.700	730.98	1.00	731.34	46.60	.00	900.00	.00	.12	1316.10	1316.10	1362.70	1362.70
	1.800	731.66	.00	731.85	238.36	.00	265.18	634.82	.00	.00	942.50	980.00	.00
*	1.800	732.66	1.00	732.85	158.43	.00	390.28	509.72	.44	942.50	942.50	980.00	1113.80
*	1.900	737.27	.00	737.64	286.23	.00	104.05	795.95	.00	.00	604.40	628.00	.00
*	1.900	738.42	1.15	738.64	191.09	.00	134.90	765.10	.67	604.40	604.40	628.00	819.94
*	1.910	737.81	.00	737.92	347.39	.00	263.21	636.79	.00	.00	576.60	628.00	.00
*	1.910	738.61	.80	738.92	170.31	.00	543.09	356.91	.61	576.60	576.60	628.00	766.89
	1.920	737.85	.00	737.94	350.99	.00	59.48	840.51	.00	.00	602.80	614.80	.00
*	1.920	738.98	1.13	739.01	350.71	.00	22.18	877.82	.05	602.80	602.80	614.80	958.72
	1.930	737.98	.00	738.05	357.89	.00	55.90	844.10	.00	.00	602.80	614.80	.00
*	1.930	739.00	1.02	739.05	265.68	.00	33.46	866.54	.40	602.80	602.80	614.80	873.43
	1.940	738.00	.00	738.07	358.15	.00	178.84	721.16	.00	.00	576.60	628.00	.00
*	1.940	739.04	1.04	739.06	373.14	.00	163.71	736.29	.05	576.60	576.60	628.00	957.49

FIG. 2 (cont'd.)

WORKSHOP 8

SUMMARY PRINTOUT TABLE 110
ENCROACMENT METHOD 10.6

	SECNO	CWSEL	DIFKWS	EG	TOPWID	QLOB	QCH	QROB	PERENC	STENCL	STCHL	STCHR	STENCR
*	1.980	739.61	.00	739.92	460.22	.09	268.91	631.01	.00	.00	684.80	703.70	.00
*	1.980	740.45	.84	740.92	198.17	.00	404.35	495.65	.65	684.80	684.80	703.70	882.97
*	2.000	743.50	.00	743.52	860.98	.00	142.15	757.85	.00	.00	721.90	753.70	.00
*	2.000	743.97	.47	744.53	179.50	.00	532.70	367.30	.78	721.90	721.90	753.70	901.81
*	2.020	744.61	.00	744.63	748.14	.00	68.31	831.69	.00	.00	736.70	763.40	.00
*	2.020	745.12	.51	745.63	165.34	.00	387.06	512.94	.86	736.70	736.70	763.40	902.04
*	2.080	749.77	.00	750.00	351.32	.00	286.48	613.52	.00	.00	1112.30	1139.70	.00
*	2.080	750.45	.68	751.00	194.28	.00	512.13	387.87	.59	1112.30	1112.30	1139.70	1306.58
*	3.000	758.59	.00	758.91	623.35	.00	336.74	563.26	.00	.00	1112.30	1137.80	.00
*	3.000	759.25	.67	759.91	142.39	.00	523.15	376.85	.49	1112.30	1112.30	1137.80	1254.69
*	3.010	765.09	.00	765.65	261.10	.00	605.64	294.36	.00	.00	611.90	637.80	.00
*	3.010	765.24	.15	766.65	45.27	.00	854.29	45.71	.30	611.90	611.90	637.80	657.18
*	3.020	766.25	.00	766.50	389.82	.00	112.43	787.57	.00	.00	589.10	645.10	.00
*	3.020	766.91	.66	767.50	126.85	.00	436.58	463.42	.56	589.10	589.10	645.10	715.95
*	3.030	766.53	.00	767.02	340.80	.00	688.42	211.58	.00	.00	601.40	644.60	.00
*	3.030	767.04	.51	767.79	43.20	.00	900.00	.00	.24	601.40	601.40	644.60	644.60
*	3.060	769.83	.00	770.13	394.09	42.15	172.51	685.34	.00	.00	476.40	499.70	.00
*	3.060	770.77	.94	771.13	104.34	.00	271.56	628.44	.50	476.40	476.40	499.70	580.74

FIG. 3

WORKSHOP 8

PROFILE 1
NATURAL RUN FLOODPLAIN

```
*---------------------------------*
|          S U M P O              |
|                                 |
| Interactive Summary Printout    |
| for MS/PC-DOS micro computers   |
|          May 1991               |
*---------------------------------*
```

NOTE - Asterisk (*) at left of profile number indicates message in summary of errors list

SAMPLE CREEK

Summary Printout

	SECNO	SSTA	ENDST	CWSEL	CRIWS
	1.70	1316.00	1531.25	729.98	729.32
	1.80	942.20	1224.84	731.66	731.32
*	1.90	604.69	980.10	737.27	737.27
*	1.91	587.20	988.04	737.81	737.33
	1.92	586.00	988.59	737.85	737.33
	1.93	586.66	990.49	737.98	737.32
	1.94	587.57	990.76	738.00	737.31
*	1.98	683.97	1144.19	739.61	739.61
*	2.00	723.74	1608.32	743.50	743.50
*	2.02	735.59	1483.73	744.61	744.61
*	2.08	1112.07	1535.83	749.77	749.77
*	3.00	1112.33	1735.68	758.59	758.59
*	3.01	611.52	872.62	765.09	765.09
*	3.02	589.25	979.08	766.25	766.17
*	3.03	600.73	941.52	766.53	766.53
*	3.06	267.21	787.28	769.83	769.83

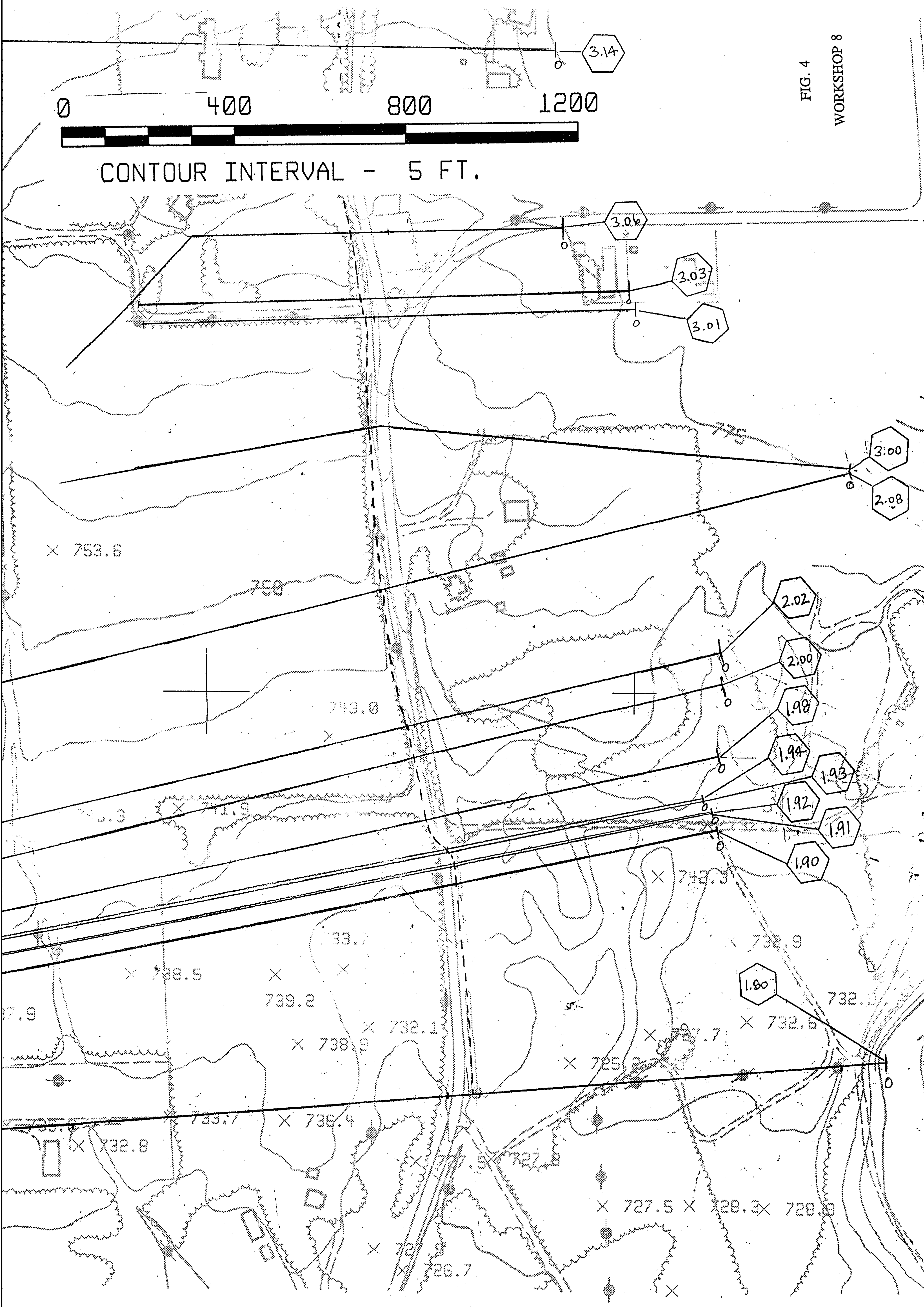
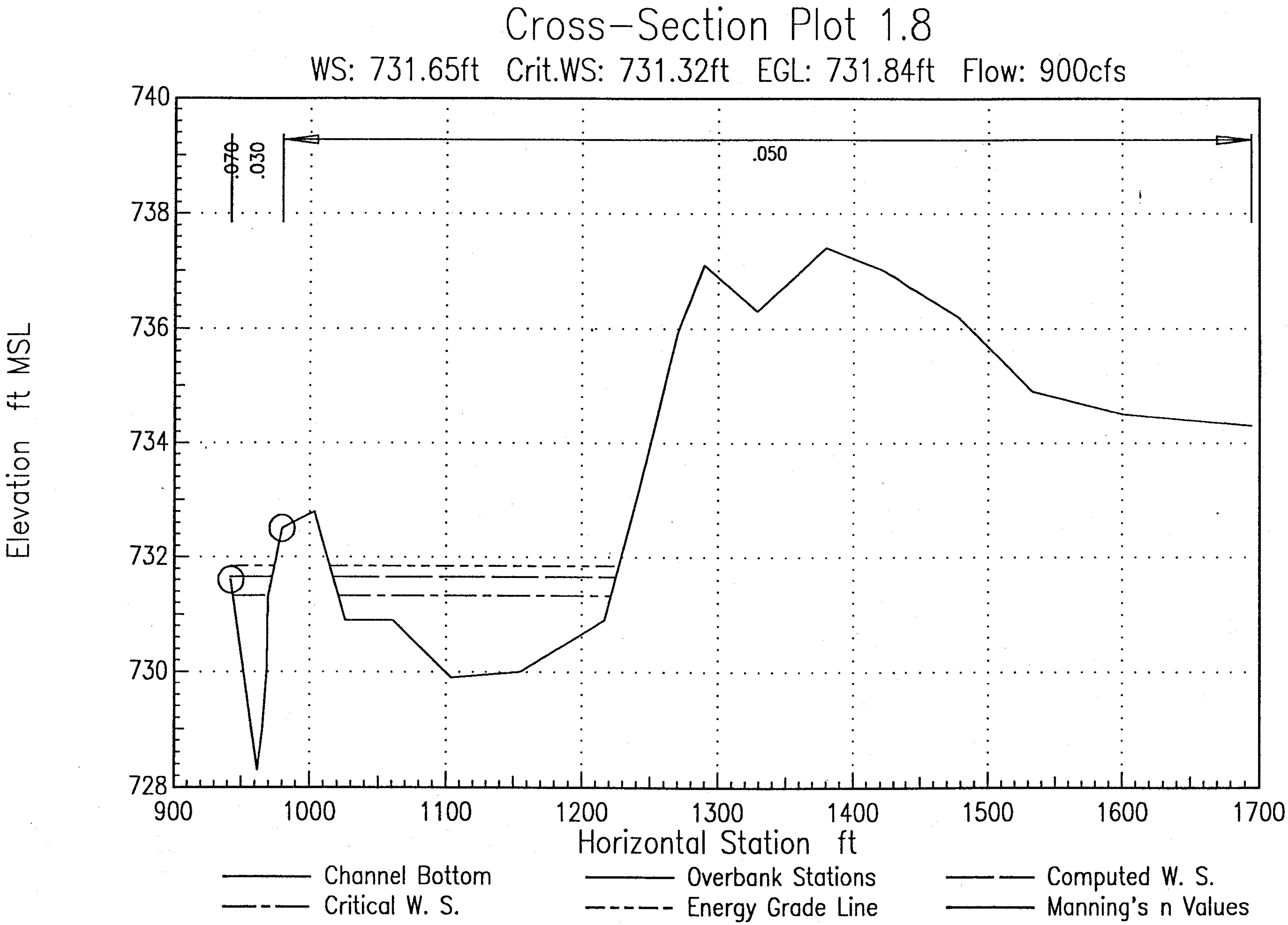
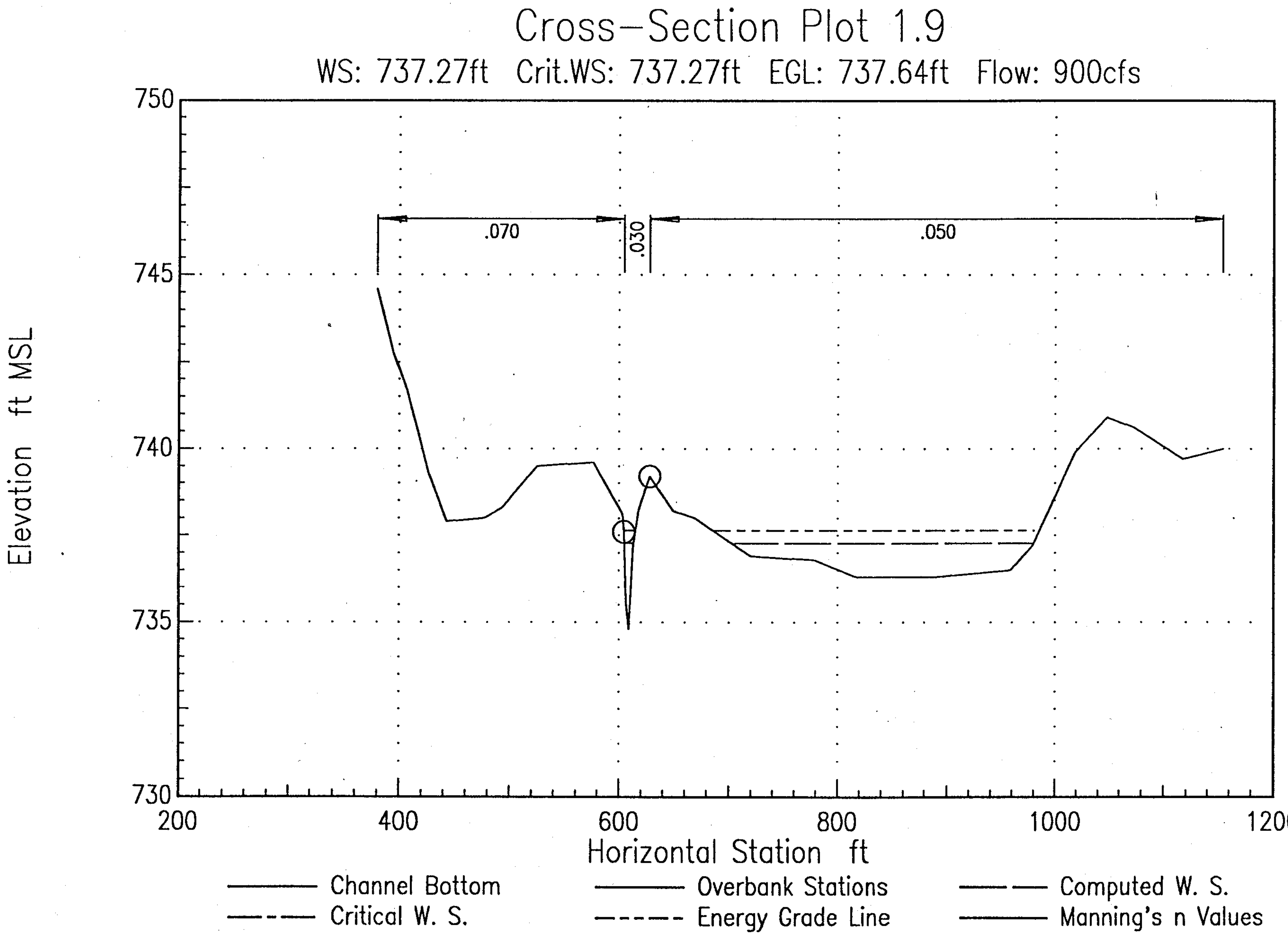


FIG. 4
WORKSHOP 8



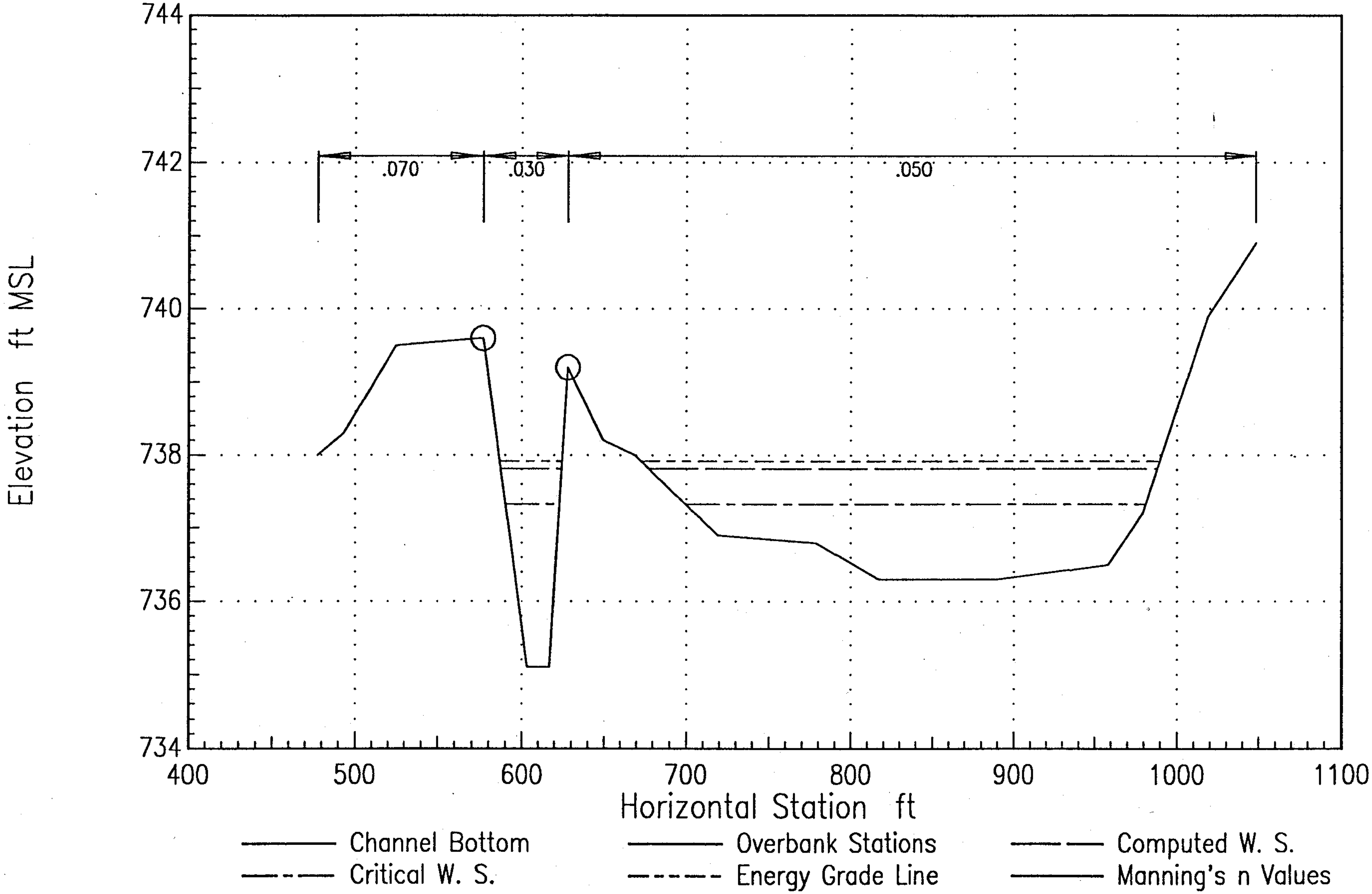
Cross-Section Plot 1.8
WS: 731.65ft Crit.WS: 731.32ft EGL: 731.84ft Flow: 900cfs
.070
.030
.050
740
738
736
734
732
730
728
Elevation ft MSL
900
1000
1100
1200
1300
1400
1500
1600
1700
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Critical W. S.
Energy Grade Line
Manning's n Values



Cross-Section Plot 1.9
WS: 737.27ft Crit.WS: 737.27ft EGL: 737.64ft Flow: 900cfs
750
745
740
735
730
Elevation ft MSL
.070
.030
.050
200
400
600
800
1000
1200
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Critical W. S.
Energy Grade Line
Manning's n Values

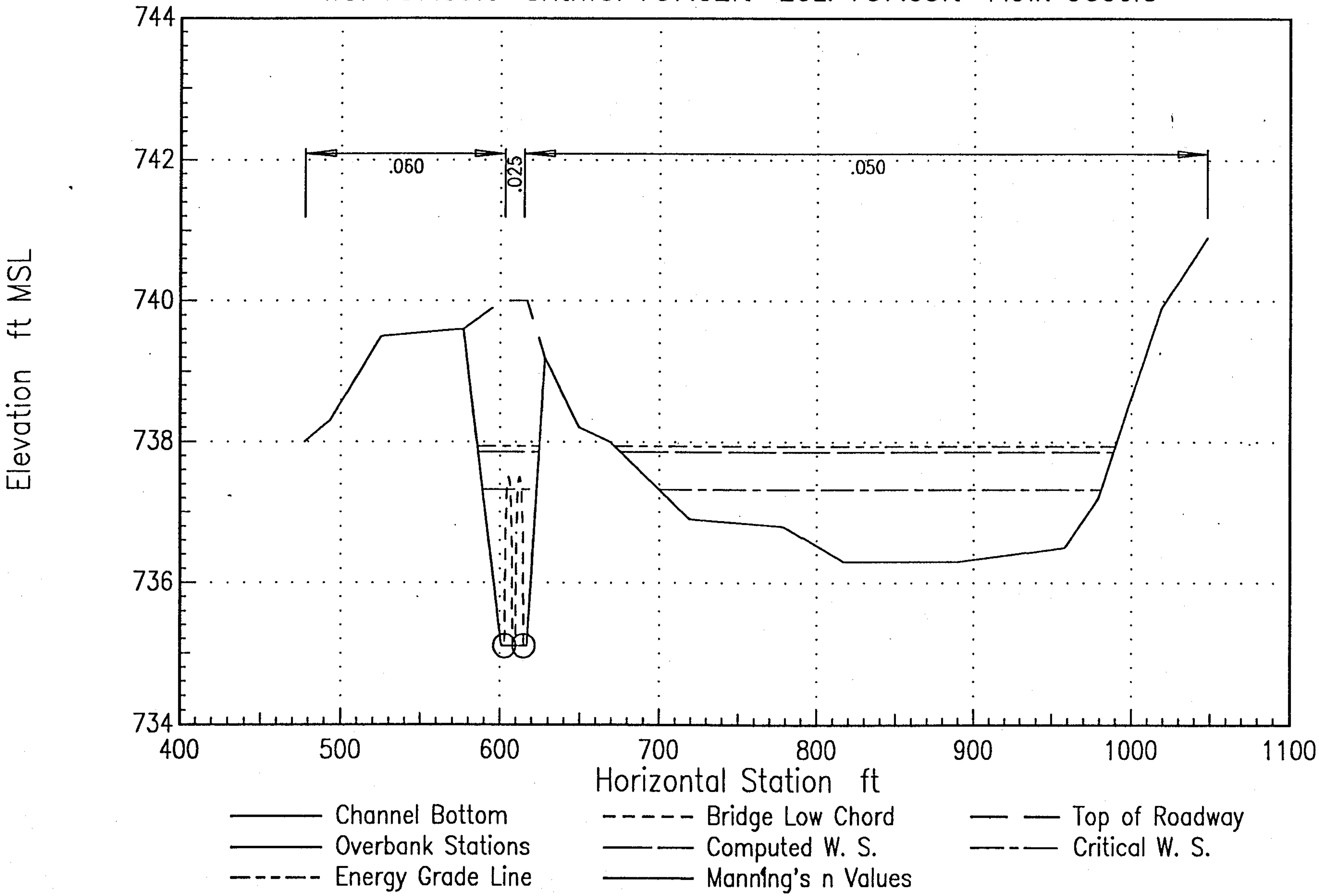
Cross-Section Plot 1.91

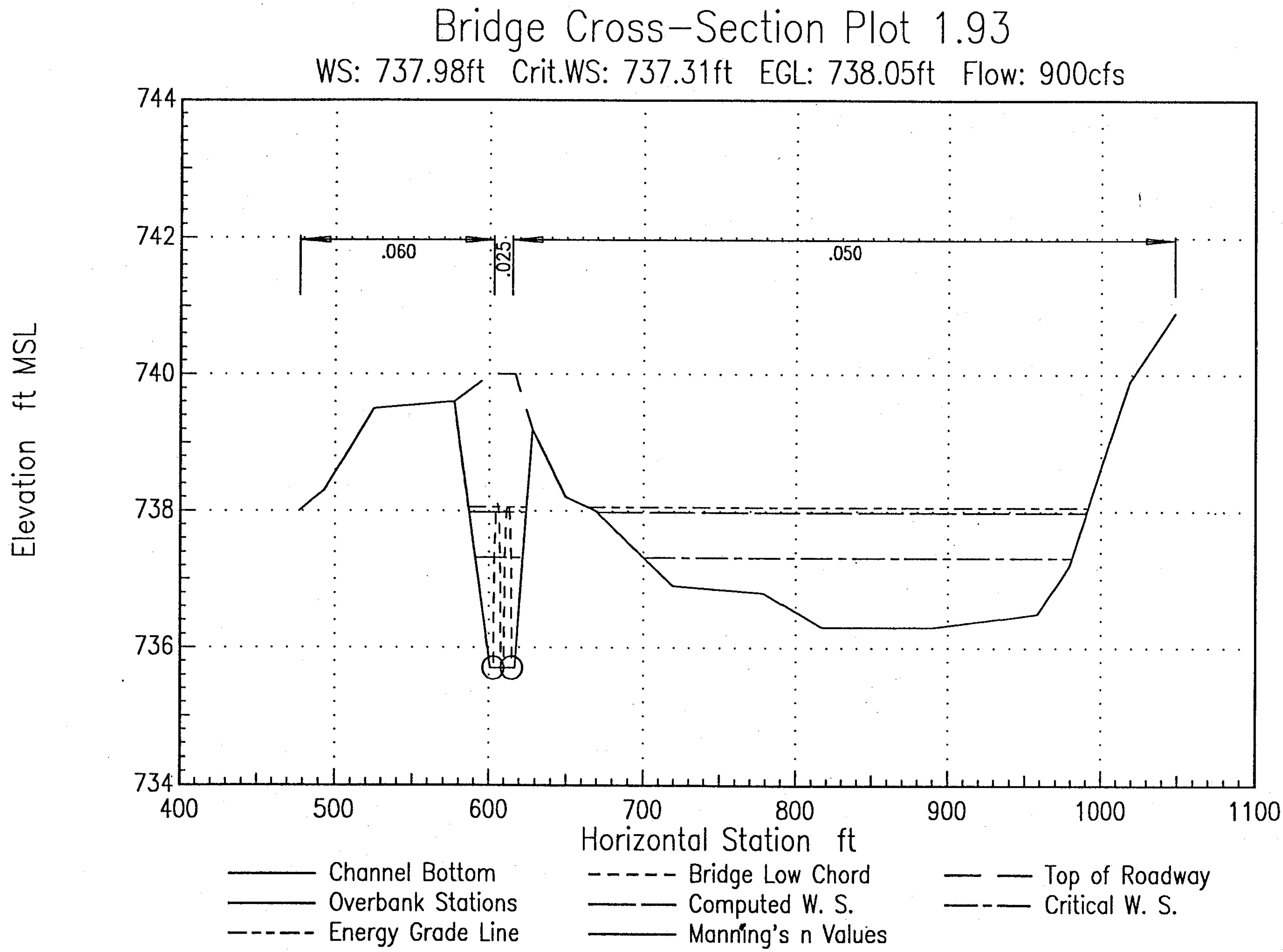
WS: 737.81ft Crit.WS: 737.33ft EGL: 737.91ft Flow: 900cfs



Bridge Cross–Section Plot 1.92

WS: 737.85ft Crit.WS: 737.32ft EGL: 737.93ft Flow: 900cfs

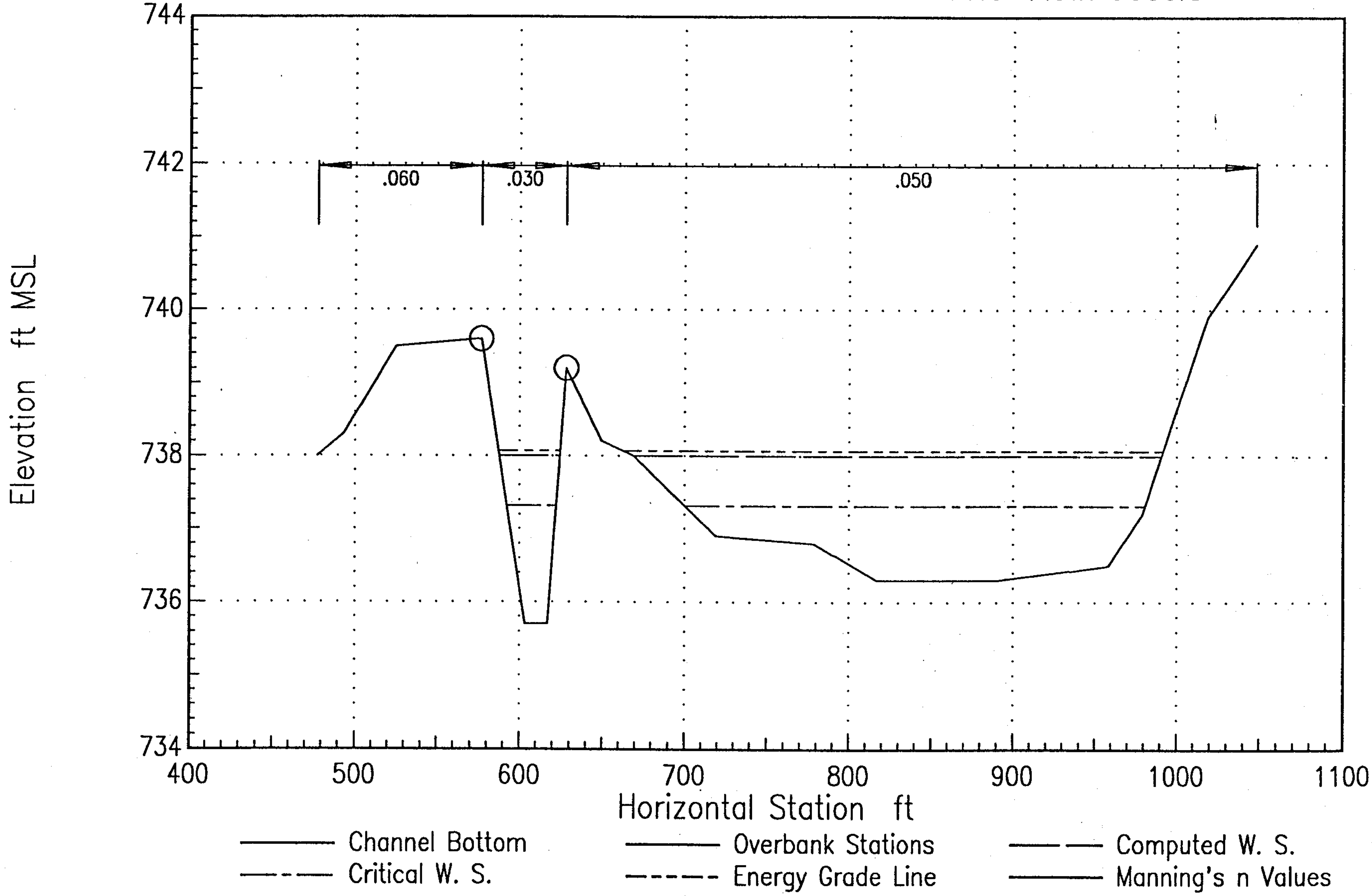


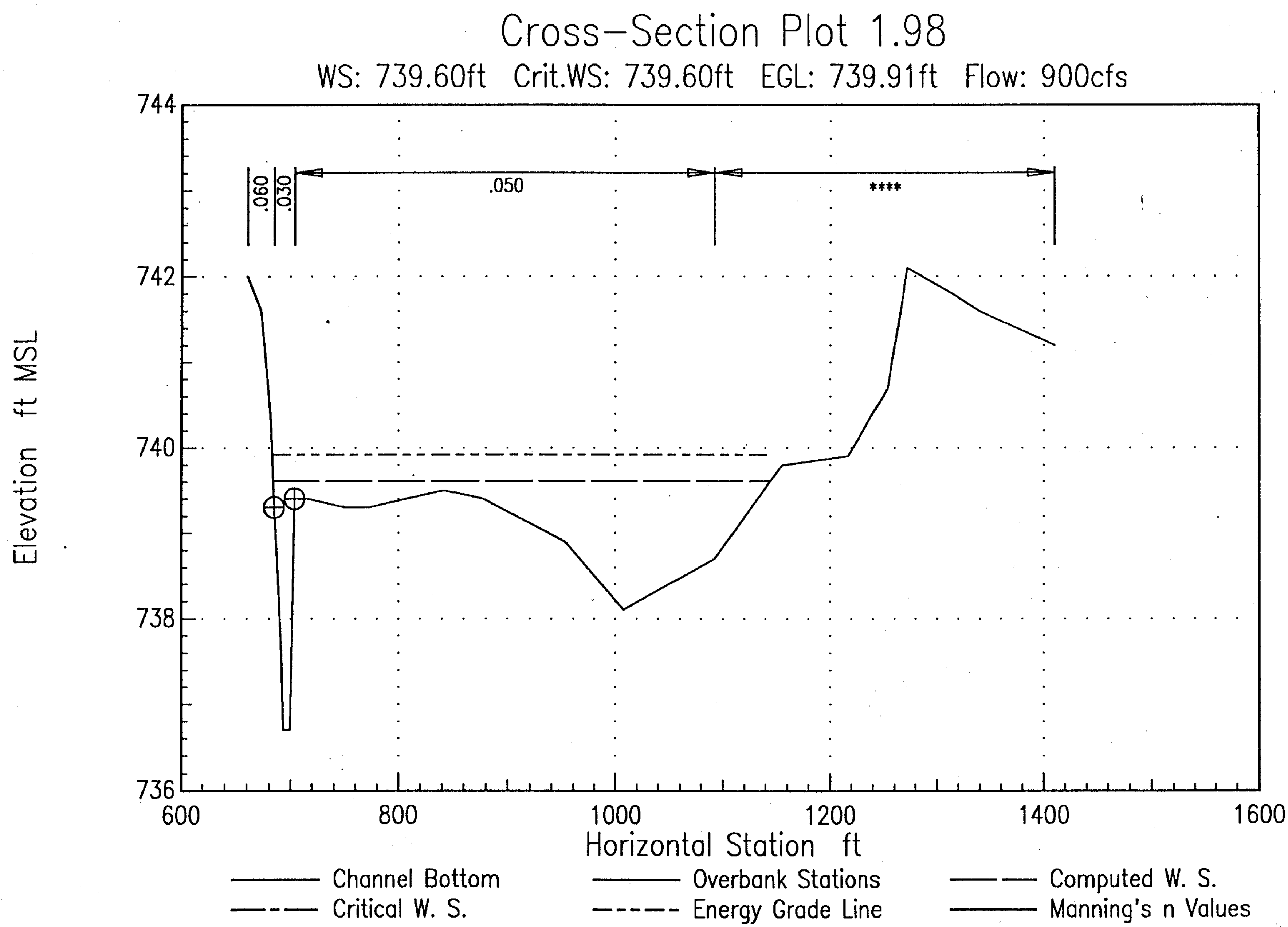


Bridge Cross-Section Plot 1.93
WS: 737.98ft Crit.WS: 737.31ft EGL: 738.05ft Flow: 900cfs
744
742
740
738
736
734
.060
.025
.050
Elevation ft MSL
400
500
600
700
800
900
1000
1100
Horizontal Station ft
Channel Bottom
Overbank Stations
Energy Grade Line
Bridge Low Chord
Computed W. S.
Manning's n Values
Top of Roadway
Critical W. S.

Cross-Section Plot 1.94

WS: 737.99ft Crit.WS: 737.31ft EGL: 738.06ft Flow: 900cfs

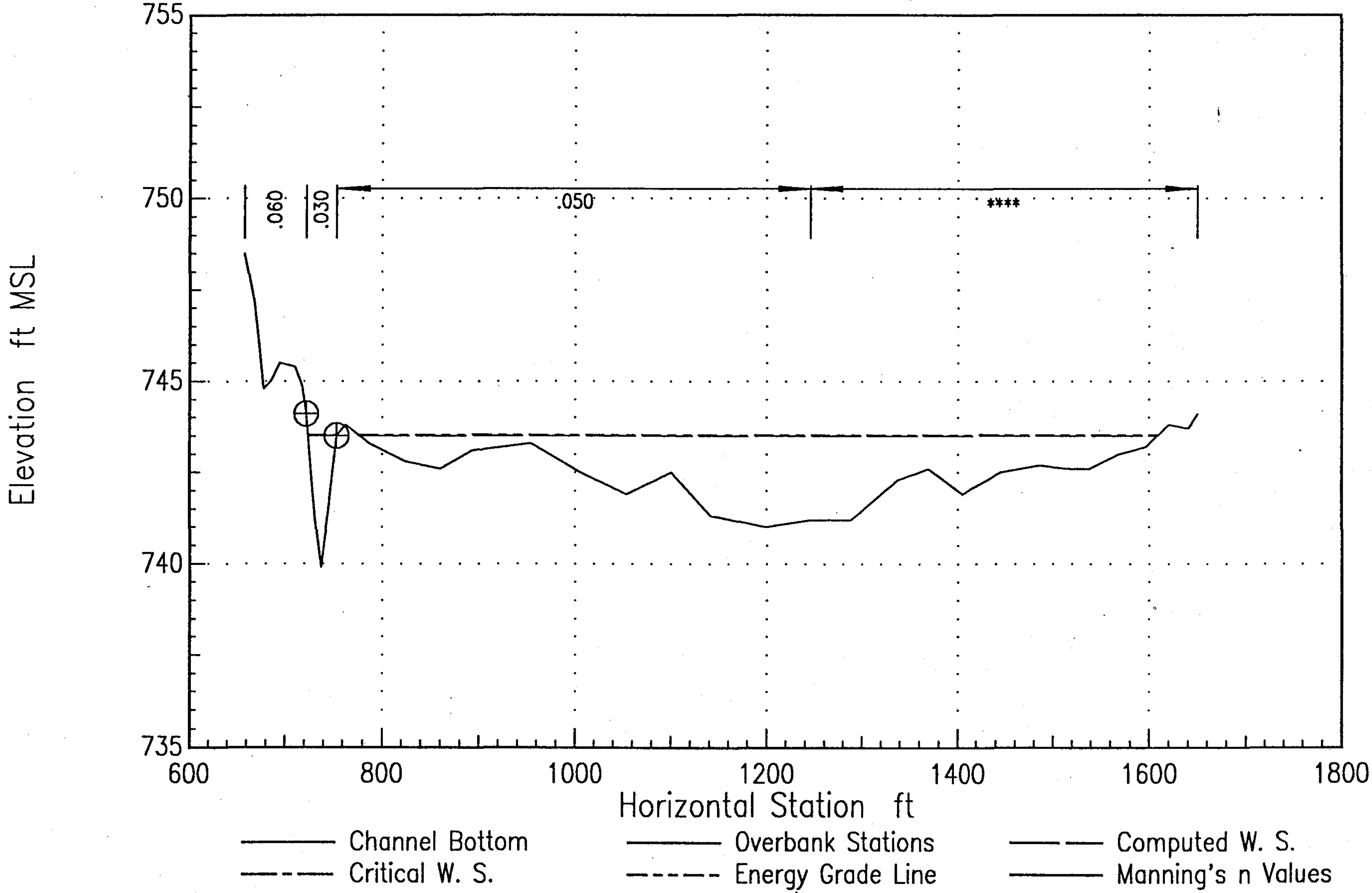


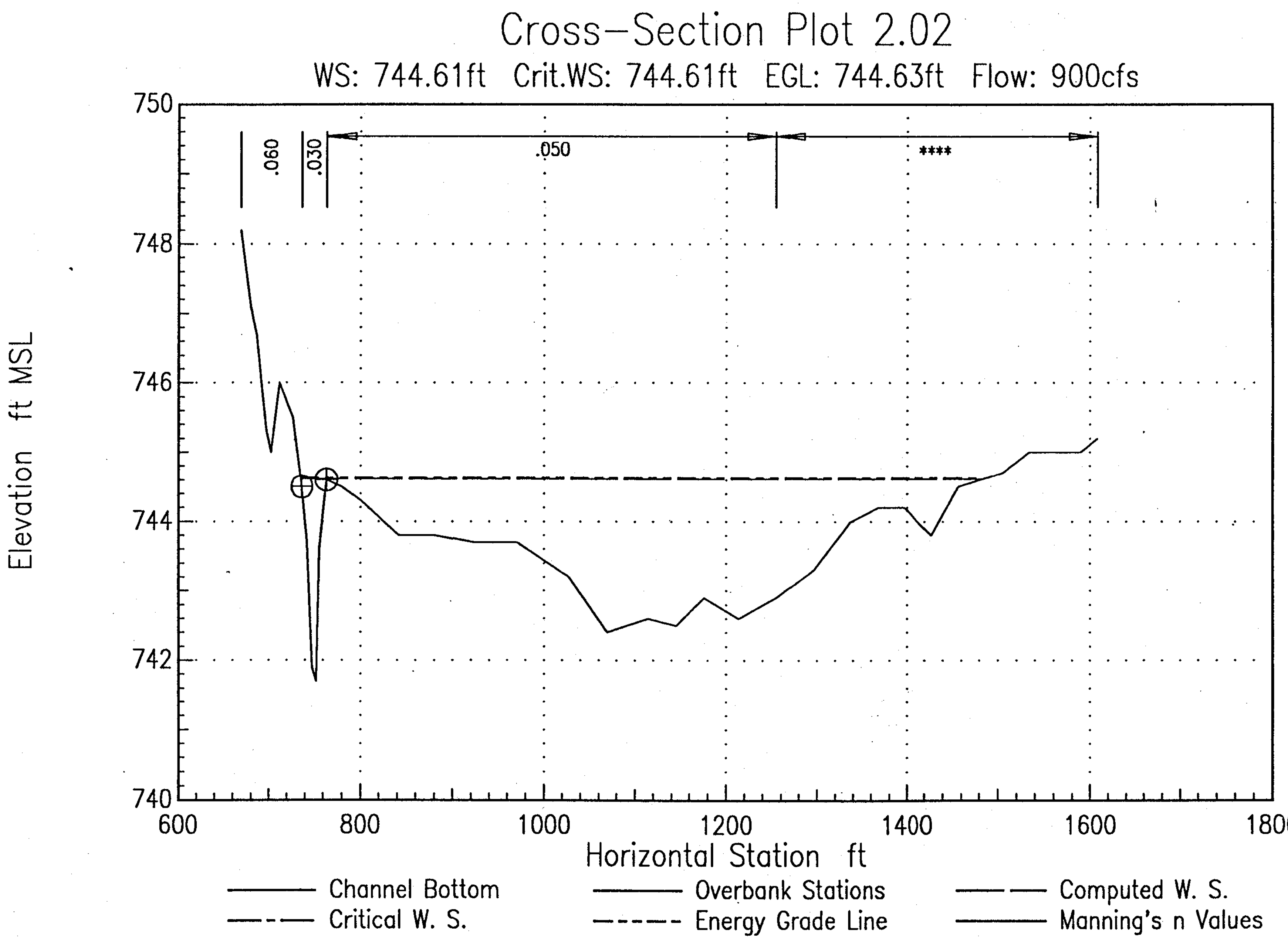


Cross-Section Plot 1.98
WS: 739.60ft Crit.WS: 739.60ft EGL: 739.91ft Flow: 900cfs
Elevation ft MSL
744
742
740
738
736
.060
.030
.050
****
600
800
1000
1200
1400
1600
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Critical W. S.
Energy Grade Line
Manning's n Values

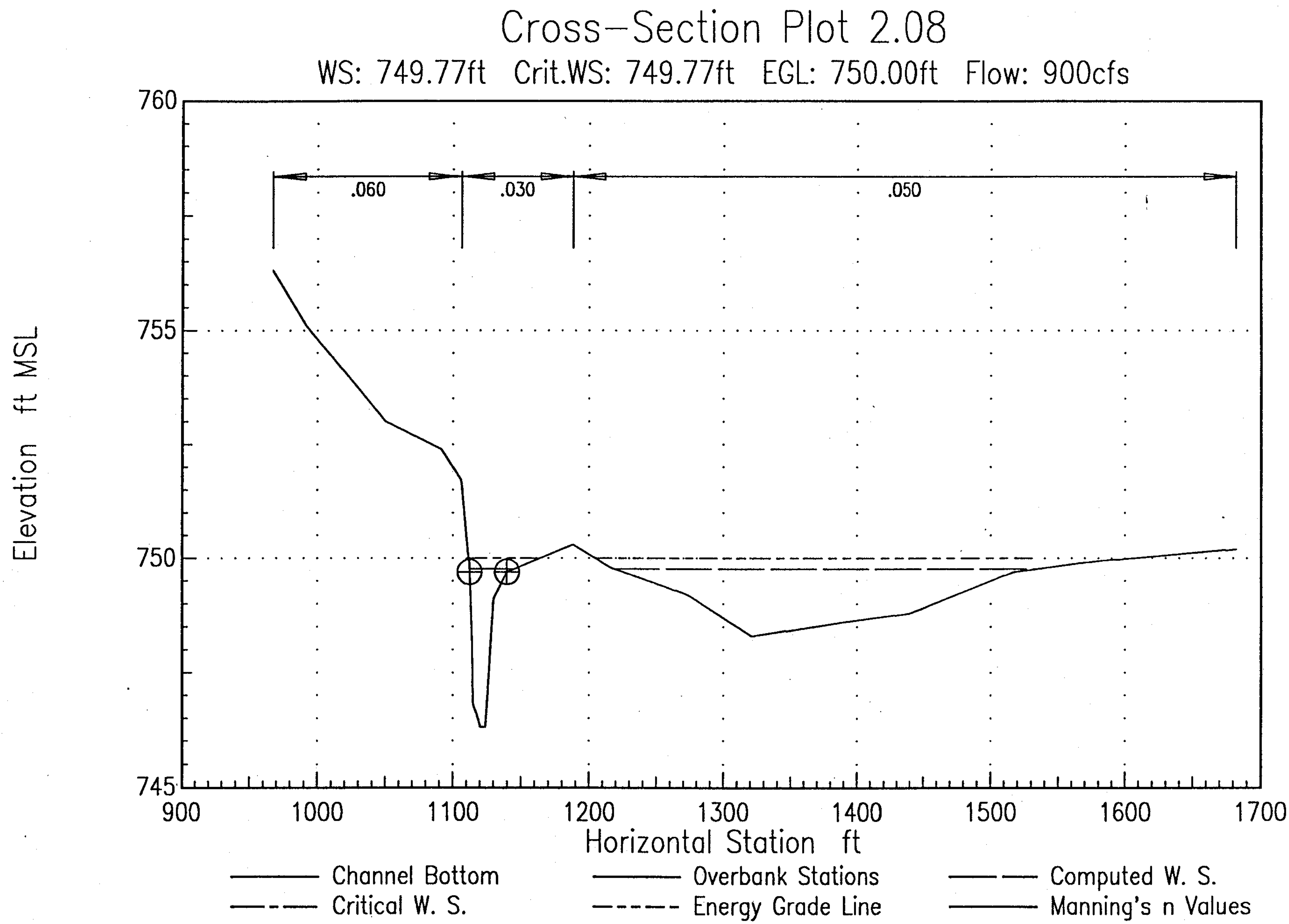
Cross-Section Plot 2

WS: 743.50ft Crit.WS: 743.50ft EGL: 743.52ft Flow: 900cfs

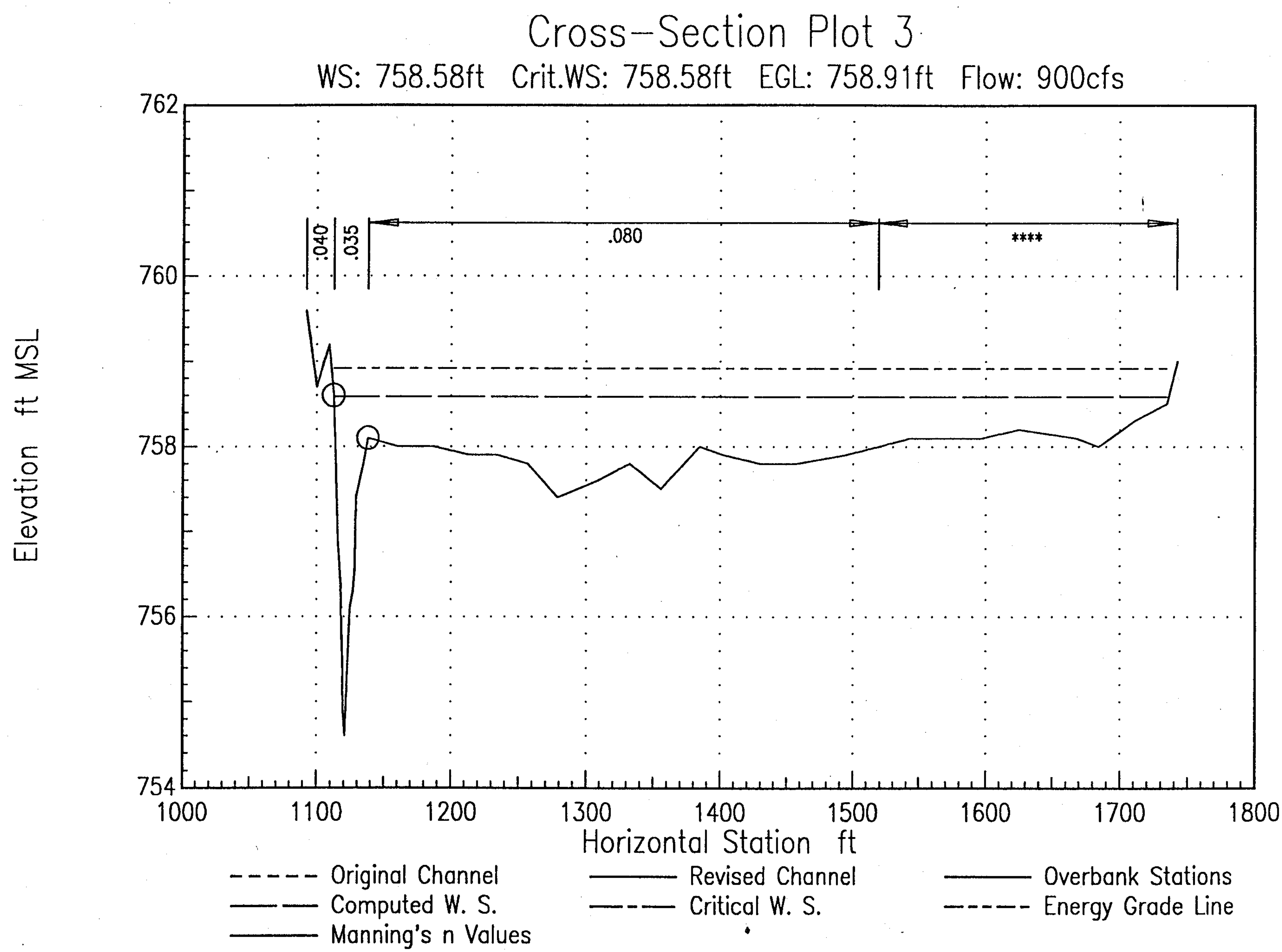




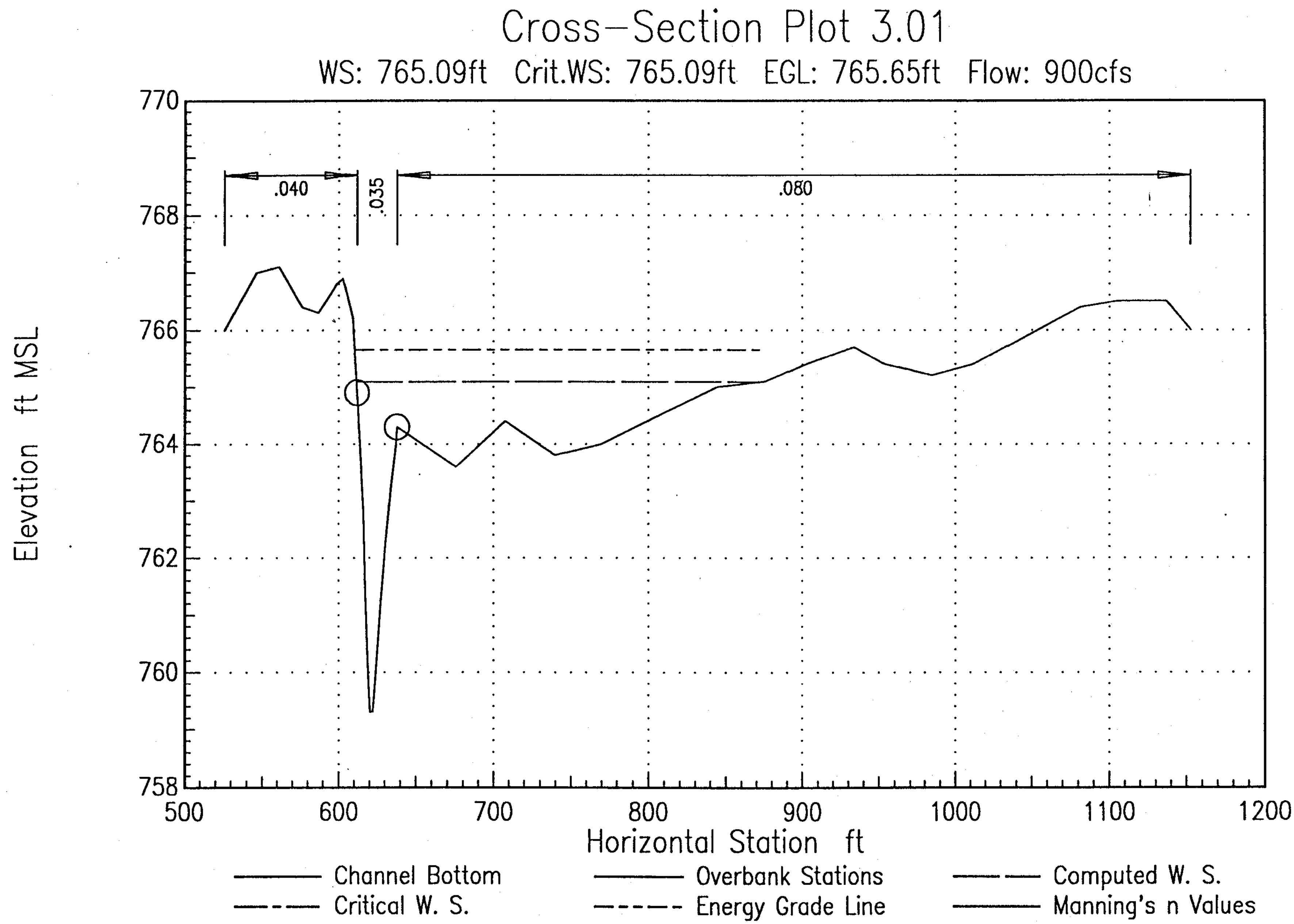
Cross-Section Plot 2.02
WS: 744.61ft Crit.WS: 744.61ft EGL: 744.63ft Flow: 900cfs
Elevation ft MSL
750
748
746
744
742
740
.060
.030
.050
****
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Critical W. S.
Energy Grade Line
Manning's n Values



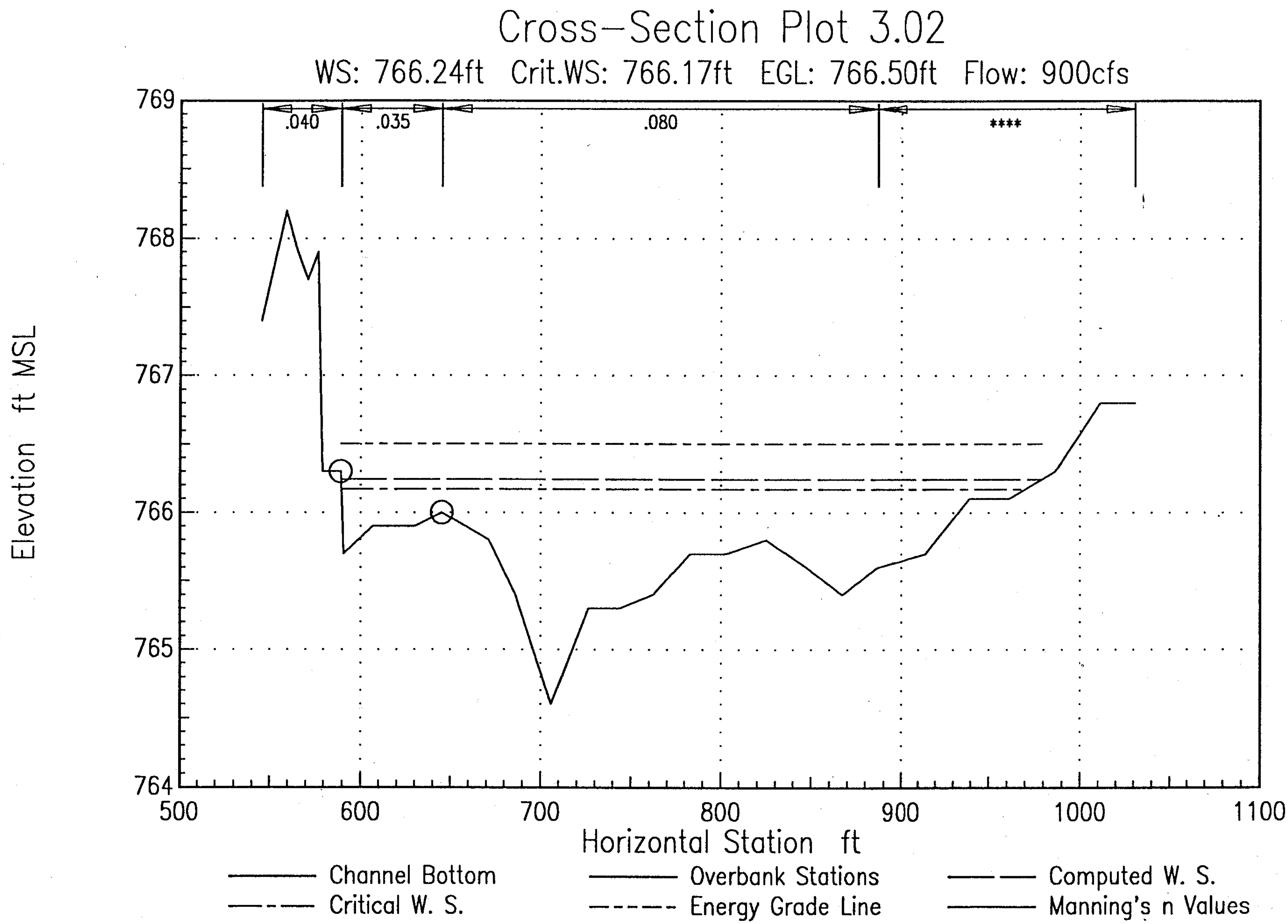
Cross-Section Plot 2.08
WS: 749.77ft Crit.WS: 749.77ft EGL: 750.00ft Flow: 900cfs
.060
.030
.050
760
755
750
745
Elevation ft MSL
900
1000
1100
1200
1300
1400
1500
1600
1700
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Critical W. S.
Energy Grade Line
Manning's n Values



Cross-Section Plot 3
WS: 758.58ft Crit.WS: 758.58ft EGL: 758.91ft Flow: 900cfs
762
760
758
756
754
Elevation ft MSL
.040
.035
.080
****
1000
1100
1200
1300
1400
1500
1600
1700
1800
Horizontal Station ft
Original Channel
Revised Channel
Overbank Stations
Computed W. S.
Critical W. S.
Energy Grade Line
Manning's n Values



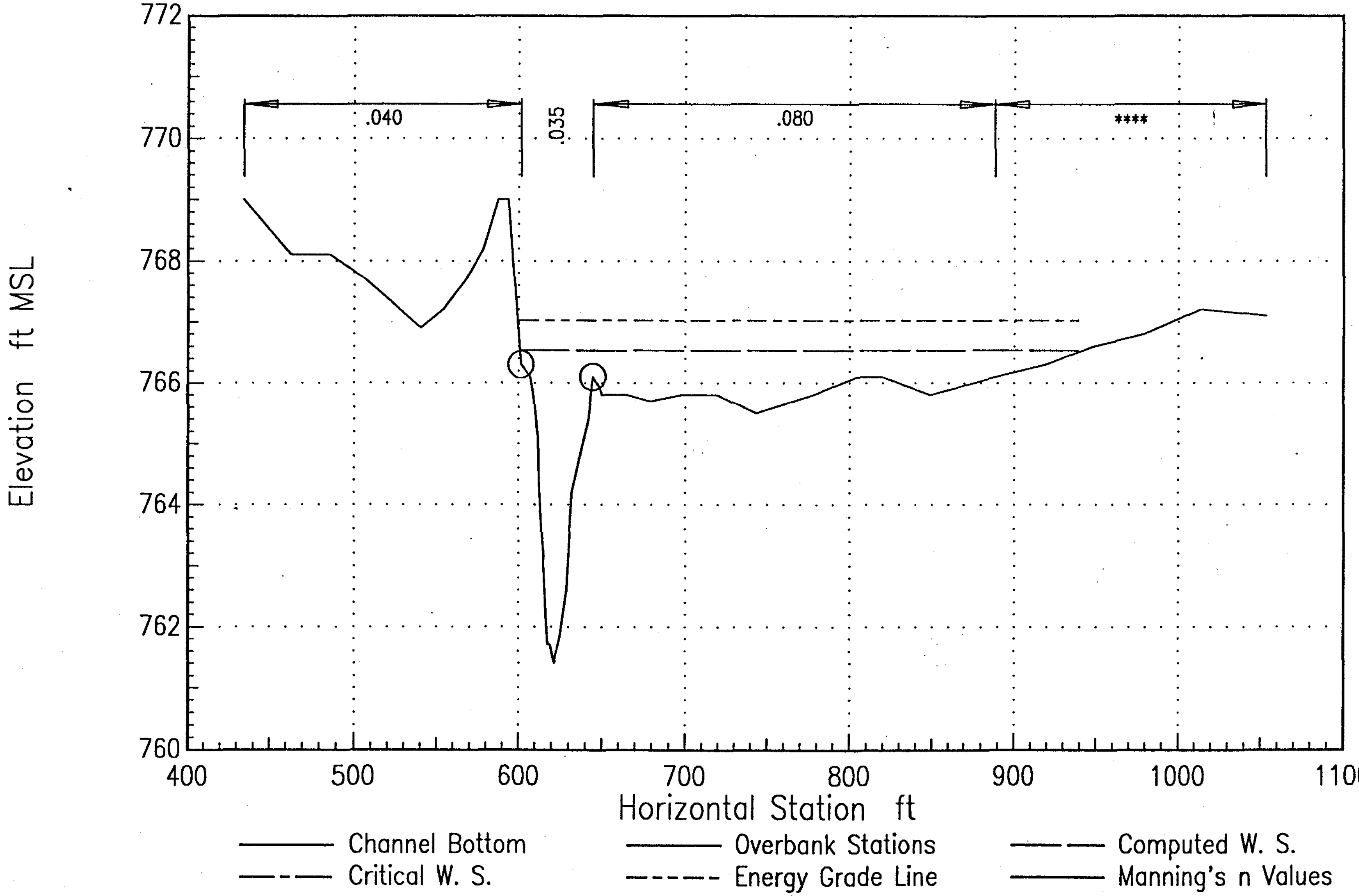
Cross-Section Plot 3.01
WS: 765.09ft Crit.WS: 765.09ft EGL: 765.65ft Flow: 900cfs
770
768
766
764
762
760
758
.040
.035
.080
500
600
700
800
900
1000
1100
1200
Elevation ft MSL
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Critical W. S.
Energy Grade Line
Manning's n Values

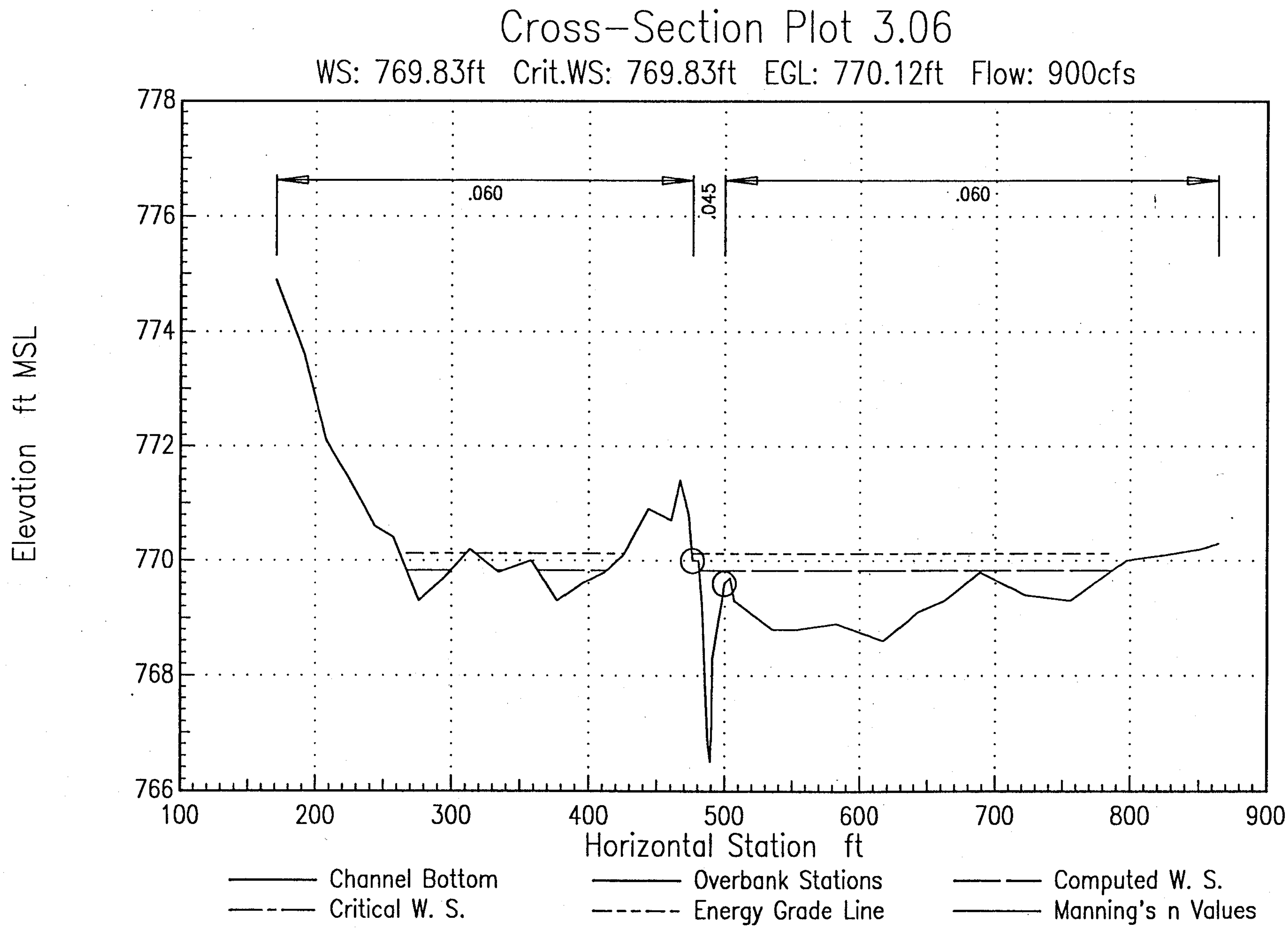


Cross-Section Plot 3.02
WS: 766.24ft Crit.WS: 766.17ft EGL: 766.50ft Flow: 900cfs
.040
.035
.080
****
769
768
767
766
765
764
500
600
700
800
900
1000
1100
Elevation ft MSL
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Critical W. S.
Energy Grade Line
Manning's n Values

Cross–Section Plot 3.03

WS: 766.53ft Crit.WS: 766.53ft EGL: 767.02ft Flow: 900cfs





Cross-Section Plot 3.06
WS: 769.83ft Crit.WS: 769.83ft EGL: 770.12ft Flow: 900cfs
Elevation ft MSL
778
776
774
772
770
768
766
.060
.045
.060
100
200
300
400
500
600
700
800
900
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Critical W. S.
Energy Grade Line
Manning's n Values

OUTPUT ANALYSIS WORKSHOP

PROBLEM 4

THIS RUN EXECUTED 25 JUL 84 11:59:

```
**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
  ERROR CORR -  01,02,03,04,05,06
  MODIFICATION -  50,51,52,53,54,55,56
**************************************************
```

T1 OUTPUT ANALYSIS WORKSHOP PROBLEM 4
T2 PERCHED BRIDGE WITH LOW OVER BANKS
T3 BAKER CREEK

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0.	0.	0.	0.	0.000000	0.00	0.0	8000.	74.500	0.000

NC	0.080	0.080	0.030	0.100	0.300	0.000	0.000	0.000	0.000	0.000
X1	1.000	12.000	200.000	250.000	0.000	0.000	0.000	0.000	0.000	0.000
GR	150.000	0.000	90.000	25.000	87.500	150.000	95.000	200.000	52.500	200.000
GR	50.000	215.000	50.000	235.000	52.500	250.000	95.000	250.000	75.000	335.000
GR	75.000	775.000	150.000	850.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	2.000	12.000	200.000	250.000	200.000	200.000	200.000	0.000	0.000	0.000
GR	150.000	0.000	90.000	25.000	87.500	150.000	95.000	200.000	52.500	200.000
GR	50.000	215.000	50.000	235.000	52.500	250.000	95.000	250.000	75.000	335.000
GR	75.000	775.000	150.000	850.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	3.000	12.000	200.000	250.000	200.000	200.000	200.000	0.000	0.000	0.000
GR	150.000	0.000	90.000	25.000	87.500	150.000	95.000	200.000	52.500	200.000
GR	50.000	215.000	50.000	235.000	52.500	250.000	95.000	250.000	75.000	335.000
GR	75.000	775.000	150.000	850.000	0.000	0.000	0.000	0.000	0.000	0.000
SB	0.900	2.040	2.700	0.000	20.000	2.000	1845.000	3.000	50.000	50.000
X1	4.000	12.000	200.000	250.000	20.000	20.000	20.000	0.000	0.000	0.000
X2	0.000	0.000	1.000	90.000	75.000	0.000	0.000	0.000	0.000	0.000
BT	8.000	0.000	150.000	150.000	25.000	90.000	90.000	150.000	87.500	87.500
BT	200.000	95.000	90.000	250.000	95.000	90.000	335.000	75.000	75.000	775.000
BT	75.000	75.000	850.000	150.000	150.000	0.000	0.000	0.000	0.000	0.000
GR	150.000	0.000	90.000	25.000	87.500	150.000	95.000	200.000	52.500	200.000
GR	50.000	215.000	50.000	235.000	52.500	250.000	95.000	250.000	75.000	335.000
GR	75.000	775.000	150.000	850.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	5.000	12.000	200.000	250.000	50.000	50.000	50.000	0.000	0.000	0.000
GR	150.000	0.000	90.000	25.000	87.500	150.000	95.000	200.000	52.500	200.000
GR	50.000	215.000	50.000	235.000	52.500	250.000	95.000	250.000	75.000	335.000
GR	75.000	775.000	150.000	850.000	0.000	0.000	0.000	0.000	0.000	0.000
EJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	LEFT/RIGHT
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

*PROF 1

CCHV= 0.100 CEHV= 0.300

*SECNO 1.000

1.00	24.50	74.50	0.00	74.50	75.20	0.70	0.00	0.00	95.00
8000.	0.	8000.	0.	0.	1188.	0.	0.	0.	95.00
0.00	0.00	6.74	0.00	0.000	0.030	0.000	0.000	50.00	200.00
0.000632	0.	0.	0.	0	0	0	0.00	50.00	250.00

*SECNO 2.000

2.00	24.63	74.63	0.00	0.00	75.33	0.70	0.13	0.00	95.00
8000.	0.	8000.	0.	0.	1194.	0.	5.	0.	95.00
0.01	0.00	6.70	0.00	0.000	0.030	0.000	0.000	50.00	200.00
0.000623	200.	200.	200.	0	0	0	0.00	50.00	250.00

*SECNO 3.000

3.00	24.77	74.77	0.00	0.00	75.46	0.69	0.12	0.00	95.00
8000.	0.	8000.	0.	0.	1200.	0.	11.	0.	95.00
0.02	0.00	6.66	0.00	0.000	0.030	0.000	0.000	50.00	200.00
0.000614	200.	200.	200.	0	0	0	0.00	50.00	250.00

SPECIAL BRIDGE

SB XK	XKOR	COFQ	RDLEN	BWC	BWP	BAREA	SS	ELCHU	ELCHD
0.90	2.04	2.70	0.00	20.00	2.00	1845.00	3.00	50.00	50.00

*SECNO 4.000
6790 POSSIBLE INVALID SOLUTION 20 TRIALS OF EG NOT ENOUGH
FINAL QWEIR + QPR = 19688. DOES NOT EQUAL ACTUAL Q = 8000.

6840,FLOW IS BY WEIR AND LOW FLOW

3265 DIVIDED FLOW

3420 BRIDGE W.S.= 75.02 BRIDGE VELOCITY=, 7.94 CALCULATED CHANNEL AREA=, 2328.

EGPRS	EGLWC	H3	QWEIR	QLOW	BAREA	TRAPEZOID AREA	ELLC	ELTRD
90.00	76.00	0.25	1193.	18495.	1845.	5520.	90.00	75.00

4.00	25.35	75.35	0.00	0.00	76.00	0.65	0.54	0.00	95.00
8000.	0.	7966.	34.	0.	1230.	153.	12.	1.	95.00
0.02	0.00	6.48	0.22	0.000	0.030	0.080	0.000	50.00	200.00
0.000571	20.	20.	20.	2	0	20	0.00	491.83	775.35

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	LEFT/RIGHT
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

*SECNO 5.000

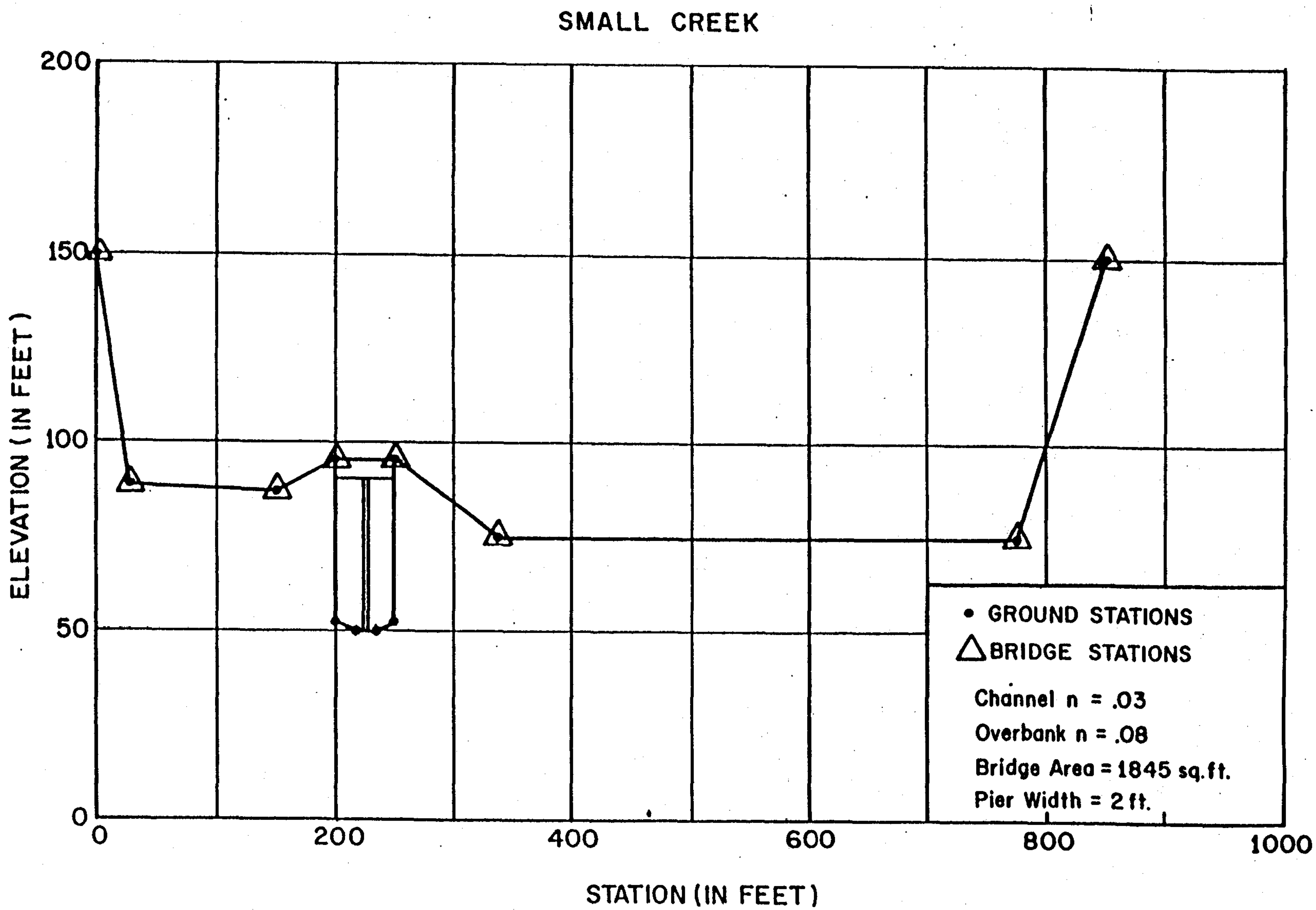
3265 DIVIDED FLOW

5.00	25.38	75.38	0.00	0.00	76.03	0.65	0.03	0.00	95.00
8000.	0.	7961.	39.	0.	1232.	168.	13.	1.	95.00
0.02	0.00	6.46	0.23	0.000	0.030	0.080	0.000	50.00	200.00
0.000568	50.	50.	50.	0	0	0	0.00	492.00	775.38

[illegible]ILE FOR STREAM BAKER CREEK

PLOTTED POINTS (BY PRIORITY)-E-ENERGY,W-WATER SURFACE,I-INVERT,C-CRITICAL W.S.,L-LEFT BANK,R-RIGHT BANK,M-LOWER END ST.

ELEVATION SECNO	CUMDIS	50.	60.	70.	80.	90.	100.	110.	120.	130.	140.
1.00	0.	I			E		L				
	10.	I			E		L				
	20.	I			E		L				
	30.	I			E		L				
	40.	I			E		L				
	50.	I			E		L				
	60.	I			E		L				
	70.	I			E		L				
	80.	I			E		L				
	90.	I			E		L				
	100.	I			E		L				
	110.	I			E		L				
	120.	I			E		L				
	130.	I			E		L				
	140.	I			E		L				
	150.	I			E		L				
	160.	I			E		L				
	170.	I			E		L				
	180.	I			E		L				
	190.	I			E		L				
2.00	200.	I			E		L				
	210.	I			E		L				
	220.	I			E		L				
	230.	I			E		L				
	240.	I			E		L				
	250.	I			E		L				
	260.	I			E		L				
	270.	I			E		L				
	280.	I			E		L				
	290.	I			E		L				
	300.	I			E		L				
	310.	I			E		L				
	320.	I			E		L				
	330.	I			E		L				
	340.	I			E		L				
	350.	I			E		L				
	360.	I			E		L				
	370.	I			E		L				
	380.	I			E		L				
	390.	I			E		L				
3.00	400.	I			E		L				
	410.	I			WE		L				
4.00	420.	I			WE		L				
	430.	I			WE		L				
	440.	I			WE		L				
	450.	I			WE		L				
	460.	I			WE		L				
5.00	470.	I			WE		L				


SMALL CREEK
ELEVATION (IN FEET)
200
150
100
50
0
0
200
400
600
800
1000
STATION (IN FEET)
• GROUND STATIONS
△ BRIDGE STATIONS
Channel n = .03
Overbank n = .08
Bridge Area = 1845 sq.ft.
Pier Width = 2 ft.

OUTPUT ANALYSIS

WORKSHOP 5

OUTPUT ANALYSIS WORKSHOP 5
ADVANCED WATER SURFACE PROFILE COMPUTATIONS
USING HEC-2

HEC-2 INPUT DATA

```
T1      EROSION EVALUATION FOR SDG&E GAS PIPELINE STREAM CROSSING
T2      WEST CONSULTANTS, INC.  JULY 1993
T3      SWEETWATER RIVER                  AT BONITA ROAD
*
*       NOTE: FIELD SURVEY FOR CHANNEL GEOMETRY WAS COMPLETED IN JULY 1993.
*       THE FIELD SURVEY DATA EXTENDS FROM STATION 100+00 (1000.0) TO
*       STATION 160+00 TO 200+OO (APPROXIMATELY) IN EACH CROSS SECTION.
*       GR POINTS WERE TAKEN FROM COUNTY OF SAN DIEGO 200 SCALE TOPOGRAPHY
*       MAPS, 1972 EDITION, TO EXTEND THE CROSS SECTIONS.
*
*       MANNING "N" VALUES ARE BASED ON FIELD SURVEY.
*       "N" VALUES OF 0.03 WERE USED WHERE GOLF COURSE GRASS IS PRESENT
*
J1      0       2       0       0   0.009       0     0.0       0  100.45
J2      1       0      -1     0.0     0.0     0.0     0.0       0     0.0      15
J6      1
NC   0.09    0.09    0.07     0.1     0.3
QT      5   48800    2500    5000   25000   50000
*    INTERPOLATED GR POINT ADDED AT STA 1113.98
X1     40      31 1113.98 1186.66     370     530   460.0     0.0     0.0
GR    105     975     100     985   95.76    1000   91.59 1112.79   88.75 1113.98
GR  86.97 1115.29   85.38 1130.88   83.53  1134.6   82.68 1140.08   82.28 1161.24
GR   86.1 1171.09   88.83 1186.66   87.43 1215.49    83.8 1221.81   83.48 1231.31
GR  87.56 1243.62   86.36 1259.51   88.67 1269.92   89.08 1318.24   86.89 1409.31
GR  86.77 1446.63    84.6 1455.92   82.36 1535.96   87.14    1627   94.03 1652.37
GR  95.09 1730.69     100 2240.69     105 2285.69     110 2325.69     115 2338.69
GR    120 2405.69
*    INTERPOLATED GR POINT ADDED AT STA 1090.94 AND 1086.62
X1     50      38 1086.62 1187.79     140     160   130.0     0.0     0.0
GR  109.4    1000   97.78 1020.19   96.34 1041.23   96.06 1069.56   94.45 1082.47
GR  90.59 1086.62   88.29 1090.94   84.06 1094.19   85.71 1117.12   84.19 1121.26
GR  83.73 1124.78   82.67 1127.32   82.08 1139.64   88.42  1151.1   90.73 1187.79
GR  87.82 1191.77   87.95  1201.1   84.91 1207.02   84.67 1230.57    83.9    1238
GR  87.35 1251.77   90.43 1258.66   87.45 1258.91   94.07 1292.43      96 1345.26
GR  93.18    1400   85.48 1466.96   84.07  1560.1   87.74 1604.71   91.06 1631.02
GR  93.62 1640.24   95.85 1656.68   95.86 1698.92     100 2238.92     105 2316.92
GR    115 2338.92     110 2358.92     120 2418.92
*       1ST CROSS-SECTION IN BRIDGE SERIES
X1     60      33 1082.27 1180.03      60     120    50.0     0.0     0.0
GR  110.8  1000.0   105.7 1027.34   91.48 1054.24   90.66 1060.75   85.91 1074.78
GR  87.92 1082.27   82.13 1099.34    82.7 1106.94   84.71 1113.18    83.5 1115.01
GR   83.0  1123.9   82.75 1126.89   82.07 1143.15   88.74 1180.03   84.54  1204.6
GR  85.43 1219.49   88.11 1227.15   87.79 1238.77   90.87 1262.23   92.21 1334.97
GR  99.76 1378.99   97.28  1403.4   95.07 1441.12   97.67 1484.53   100.6 1495.78
GR  101.4 1582.48   97.56 1597.28   96.47 1614.42   100.0 2184.42   105.0 2214.42
GR  105.0 2282.42   110.0 2324.42   115.0 2334.42
*       2ND CROSS-SECTION IN BRIDGE SERIES
NC  0.055   0.055   0.045     0.3     0.5
X1     61      33 1082.27 1180.03    15.0    15.0    15.0     0.0     0.0
X3     10
GR  110.8  1000.0   105.7 1027.34   91.48 1054.24   90.66 1060.75   85.91 1074.78
GR  87.92 1082.27   82.13 1099.34    82.7 1106.94   84.71 1113.18    83.5 1115.01
GR   83.0  1123.9   82.75 1126.89   82.07 1143.15   88.74 1180.03   84.54  1204.6
GR  85.43 1219.49   88.11 1227.15   87.79 1238.77   90.87 1262.23   92.21 1334.97
GR  99.76 1378.99   97.28  1403.4   95.07 1441.12   97.67 1484.53   100.6 1495.78
GR  101.4 1582.48   97.56 1597.28   96.47 1614.42   100.0 2184.42   105.0 2214.42
GR  105.0 2282.42   110.0 2324.42   115.0 2334.42
```

```
SB  1.25    1.56    3.0       0      20    10.8    1200     1.5   83.13   82.07
*        3RD CROSS-SECTION IN BRIDGE SERIES
*        BRIDGE SECTION
X1    62      68 1065.03 1194.45    40.0    40.0    40.0     0.0     0.0
X2                    1   108.7    99.1               0
X3    10       0       0       0       0       0       0       0       0
BT    -8     917     115       0     941     114       0     959     113       0
BT          1000- 111.47       0    1010     111       0    1115   109.3       0
BT          1280   106.8       0  1355.2   97.31       0
GR   115     917     114     941     113     959   112.4     982     112   991.5
GR 104.2    1000  103.05    1010   101.8 1020.96   96.72  1036.2   88.81 1050.22
GR 90.68 1059.69   86.87 1065.03   83.13 1097.65   83.75    1115    84.4 1132.65
GR 83.67  1175.9   86.73 1194.45   86.13 1207.72   89.97 1230.04   85.75 1236.63
GR86.498    1255   87.18 1271.74   88.73    1280   92.49    1300   95.47 1334.99
GR 97.07 1347.39   97.31  1355.2   94.79    1405   94.41 1412.63   94.53    1453
GR 94.66 1494.21   94.66    1496   94.85    1530   95.21    1596   95.52  1653.1
GR95.536    1655   95.62    1665   96.58    1777   97.14    1842   97.57    1892
GR97.776    1915   98.08    1951   98.25    1970   98.44    1993   98.75    2029
GR99.284    2090   99.28 2090.16   99.99 2172.43     100  2173.1  102.57 2193.67
GR102.60 2193.87  103.35 2199.96  103.36    2200     105  2213.1     105 2213.16
GR105.07 2214.43  109.99 2303.07     110  2303.1     110 2303.13  114.97 2334.96
GR114.98 2334.96  114.98 2334.98  114.98    2335     115  2335.1     115 2335.11
GR119.99    2395  119.99 2395.01     120  2395.1
*       4TH CROSS-SECTION IN BRIDGE SERIES
X1    70      31 1065.03 1194.45    15.0    15.0    15.0     0.0     0.0
GR   125     860     120     900     115     940     110     960     105     990
GR 104.2  1000.0   101.8 1020.96   96.72  1036.2   88.81 1050.22   90.68 1059.69
GR 86.87 1065.03   83.13 1097.65    84.4 1132.65   83.67  1175.9   86.73 1194.45
GR 86.13 1207.72   89.97 1230.04   85.75 1236.63   87.18 1271.74   92.49  1300.0
GR 95.47 1334.99   97.07 1347.39   97.31  1355.2   94.41 1412.63   94.66 1494.21
GR 95.52  1653.1   100.0 2173.10   105.0 2213.10   110.0 2303.10   115.0 2335.10
GR 120.0 2395.10
NC 0.055   0.030   0.045     0.1     0.3
*    INTERPOLATED GR POINT ADDED AT STA 1112.97
X1    80      29 1112.97 1236.27     325     240   335.0     0.0     0.0
GR 109.7    1000   94.58 1028.47   94.49 1105.28   90.15 1112.97   86.55 1119.33
GR 85.66 1136.56   83.61 1141.24   85.13 1170.28   83.29 1183.23   84.73 1185.94
GR 85.13 1203.24   86.81 1210.39   86.87 1221.41   85.58 1224.84   85.71 1227.04
GR 90.27 1236.27   90.11 1272.94   91.68 1340.48   92.98 1393.67   95.94 1436.35
GR 95.81 1500.38   94.58 1537.07   95.13 1642.37   96.38 1675.34     100 2255.34
GR   105 2265.34     110 2310.34     115 2330.34     120 2405.34
EJ


ER
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OUTPUT ANALYSIS WORKSHOP 5
ADVANCED WATER SURFACE PROFILE COMPUTATIONS
USING HEC2

HEC-2 OUTPUT

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

IHLEQ = 1. THEREFORE FRICTION LOSS (HL) IS CALCULATED AS A FUNCTION OF PROFILE TYPE, WHICH CAN VARY FROM REACH TO REACH. SEE DOCUMENTATION FOR DETAILS.

CCHV= .100 CEHV= .300

*SECNO 40.000

40.000	18.17	100.45	.00	100.45	100.83	.38	.00	.00	88.75
48800.0	2540.1	8002.2	38257.7	815.1	1136.2	8463.0	.0	.0	88.83
.00	3.12	7.04	4.52	.090	.070	.090	.000	82.28	984.10
.002942	370.	460.	530.	0	0	0	.00	1260.64	2244.74

*SECNO 50.000

50.000	18.82	100.90	.00	.00	101.42	.52	.54	.04	90.59
48800.0	998.5	11581.0	36220.5	329.8	1458.0	7295.4	34.7	4.5	90.73
.01	3.03	7.94	4.96	.090	.070	.090	.000	82.08	1014.77
.004254	140.	130.	160.	2	0	0	.00	1238.13	2252.91

*SECNO 60.000

3265 DIVIDED FLOW

3301 HV CHANGED MORE THAN HVINS

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = .63

60.000	18.61	100.68	.00	.00	102.40	1.72	.62	.36	87.92
48800.0	3345.6	22503.3	22951.1	420.2	1612.1	3886.1	52.3	7.4	88.74
.01	7.96	13.96	5.91	.090	.070	.090	.000	82.07	1036.81
.010623	60.	50.	120.	2	0	0	.00	1072.30	2188.57

CCHV= .300 CEHV= .500
*SECNO 61.000

3265 DIVIDED FLOW

1

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 1.78

61.000	19.18	101.25	.00	.00	102.59	1.34	.08	.11	87.92
48800.0	3349.2	20831.1	24619.7	445.7	1666.4	4420.4	54.5	7.8	88.74
.01	7.51	12.50	5.57	.055	.045	.055	.000	82.07	1035.76
.003369	15.	15.	15.	3	0	0	.00	1139.01	2191.90

SPECIAL BRIDGE

SB XK	XKOR	COFQ	RDLEN	BWC	BWP	BAREA	SS	ELCHU	ELCHD
1.25	1.56	3.00	.00	20.00	10.80	1200.00	1.50	83.13	82.07

*SECNO 62.000
6840, FLOW IS BY WEIR AND LOW FLOW

3301 HV CHANGED MORE THAN HVINS

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 6.32

3420 BRIDGE W.S.= 106.92 BRIDGE VELOCITY= 22.71 CALCULATED CHANNEL AREA= 1068.

EGPRS	EGLWC	H3	QWEIR	QLOW	BAREA	TRAPEZOID AREA	ELLC	ELTRD	WEIRLN
108.70	114.93	5.67	23500.	25231.	1200.	1216.	108.70	97.31	422.

62.000	31.73	114.86	.00	.00	114.93	.07	12.34	.00	86.87
48800.0	2076.1	11658.9	35065.1	1333.2	3946.0	19977.0	69.1	9.0	86.73
.02	1.56	2.95	1.76	.055	.045	.055	.000	83.13	934.11
.000084	40.	40.	40.	2	0	5	.00	1400.15	2334.26

```
*SECNO 70.000
    70.000     31.73    114.86       .00       .00    114.93       .07       .00       .00     86.87
   48800.0    2330.5   11610.1   34859.4    1544.3    3946.2   19975.5      77.8       9.5     86.73
       .02      1.51      2.94      1.75      .055      .045      .055      .000     83.13    940.55
   .000084       15.       15.       15.         2         0         0       .00   1393.68   2334.23


CCHV=     .100 CEHV=     .300
*SECNO 80.000
1
   07JUL94      17:59:59                                                                   PAGE    6


    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST


3280 CROSS SECTION     80.00 EXTENDED      5.19 FEET


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.55

    80.000     31.59    114.88       .00       .00    114.94       .06       .01       .00     90.15
   48800.0    2322.6    6586.9   39890.5    2099.9    3618.6   19467.6     229.1      17.5     90.27
       .06      1.11      1.82      2.05      .055      .045      .030      .000     83.29   1000.00
   .000035      325.      335.      240.         0         0         0       .00   1329.89   2329.89


1
   07JUL94      17:59:59                                                                   PAGE    7


                                                              THIS RUN EXECUTED 07JUL94    17:59:59
 **************************************
  HEC-2 WATER SURFACE PROFILES

  Version   4.6.2;  May 1991
 **************************************


 NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST


 SWEETWATER RIVER
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SUMMARY PRINTOUT TABLE 150

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
	40.000	.00	.00	.00	82.28	48800.00	100.45	.00	100.83	29.42	7.04	10414.35	8996.72
	50.000	130.00	.00	.00	82.08	48800.00	100.90	.00	101.42	42.54	7.94	9083.17	7481.66
*	60.000	50.00	.00	.00	82.07	48800.00	100.68	.00	102.40	106.23	13.96	5918.38	4734.67
*	61.000	15.00	.00	.00	82.07	48800.00	101.25	.00	102.59	33.69	12.50	6532.48	8407.90
*	62.000	40.00	97.31	108.70	83.13	48800.00	114.86	.00	114.93	.84	2.95	25256.28	53102.13
	70.000	15.00	.00	.00	83.13	48800.00	114.86	.00	114.93	.84	2.94	25465.94	53328.57
*	80.000	335.00	.00	.00	83.29	48800.00	114.88	.00	114.94	.35	1.82	25186.07	82712.05

SWEETWATER RIVER

SUMMARY PRINTOUT TABLE 150

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
	40.000	48800.00	100.45	.00	.00	.00	1260.64	.00
	50.000	48800.00	100.90	.00	.45	.00	1238.13	130.00
*	60.000	48800.00	100.68	.00	-.21	.00	1072.30	50.00
*	61.000	48800.00	101.25	.00	.57	.00	1139.01	15.00
*	62.000	48800.00	114.86	.00	13.61	.00	1400.15	40.00
	70.000	48800.00	114.86	.00	.00	.00	1393.68	15.00
*	80.000	48800.00	114.88	.00	.02	.00	1329.89	335.00

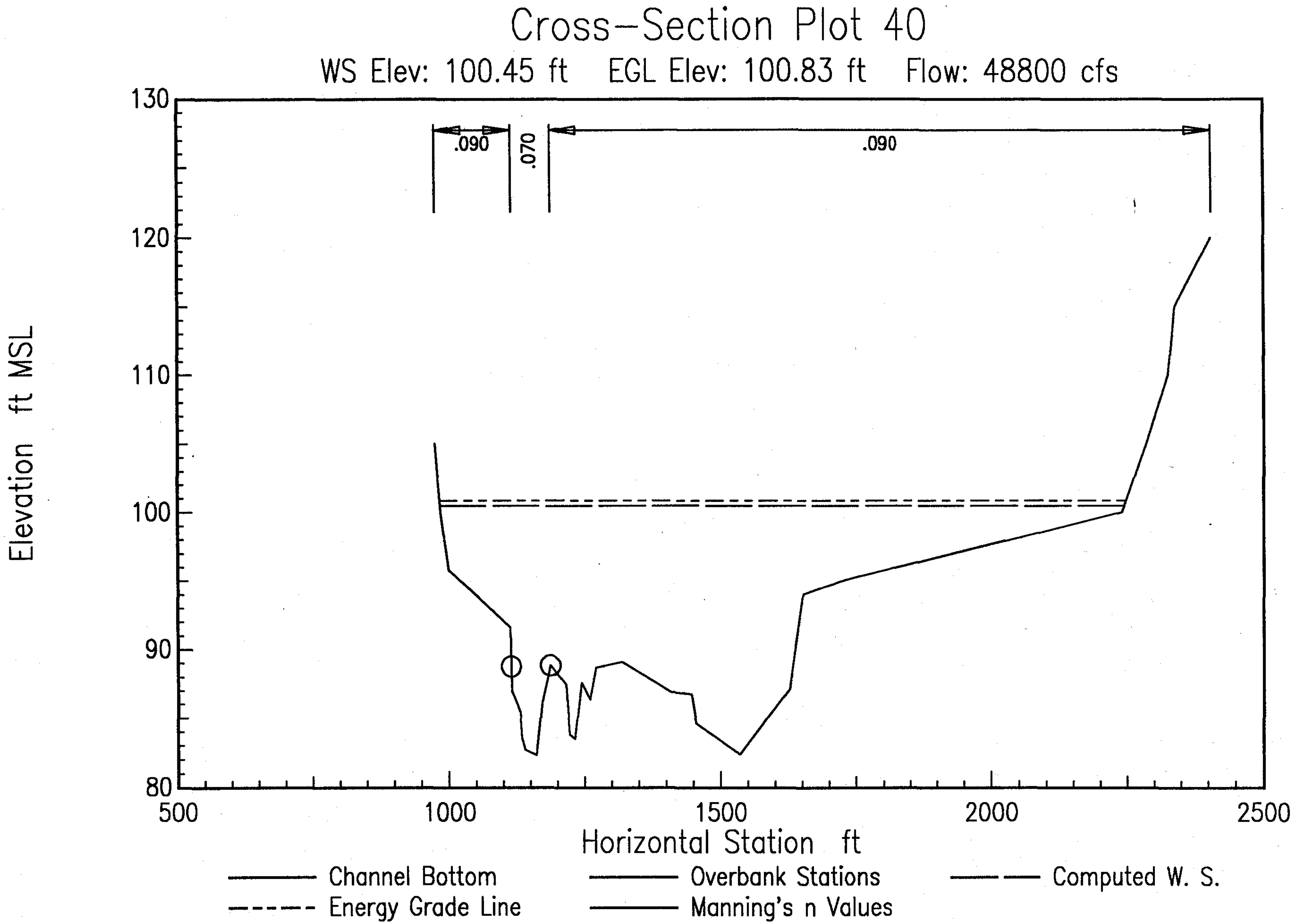
SUMMARY OF ERRORS AND SPECIAL NOTES

WARNING SECNO= 60.000 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 61.000 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 62.000 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

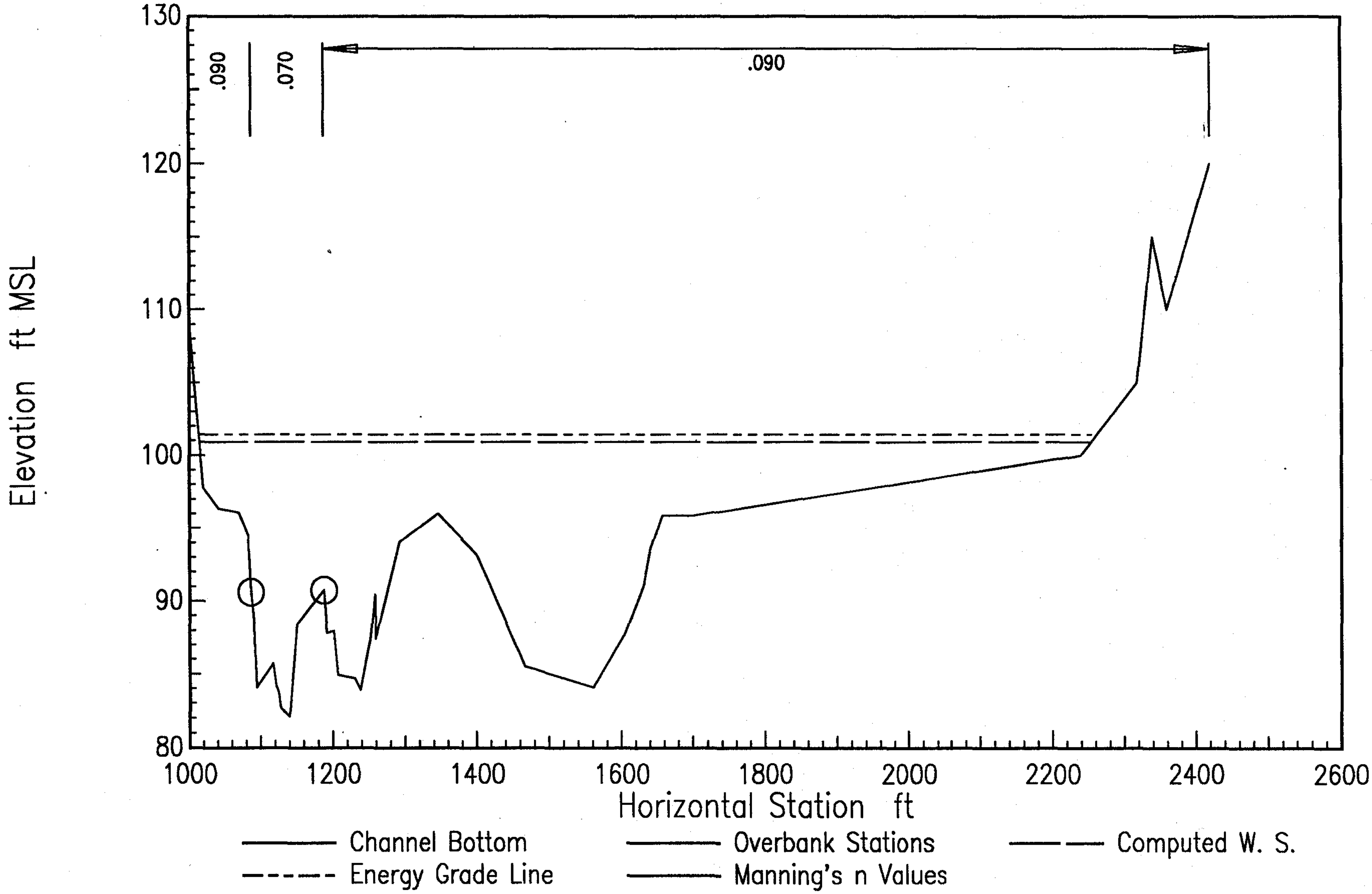
WARNING SECNO= 80.000 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

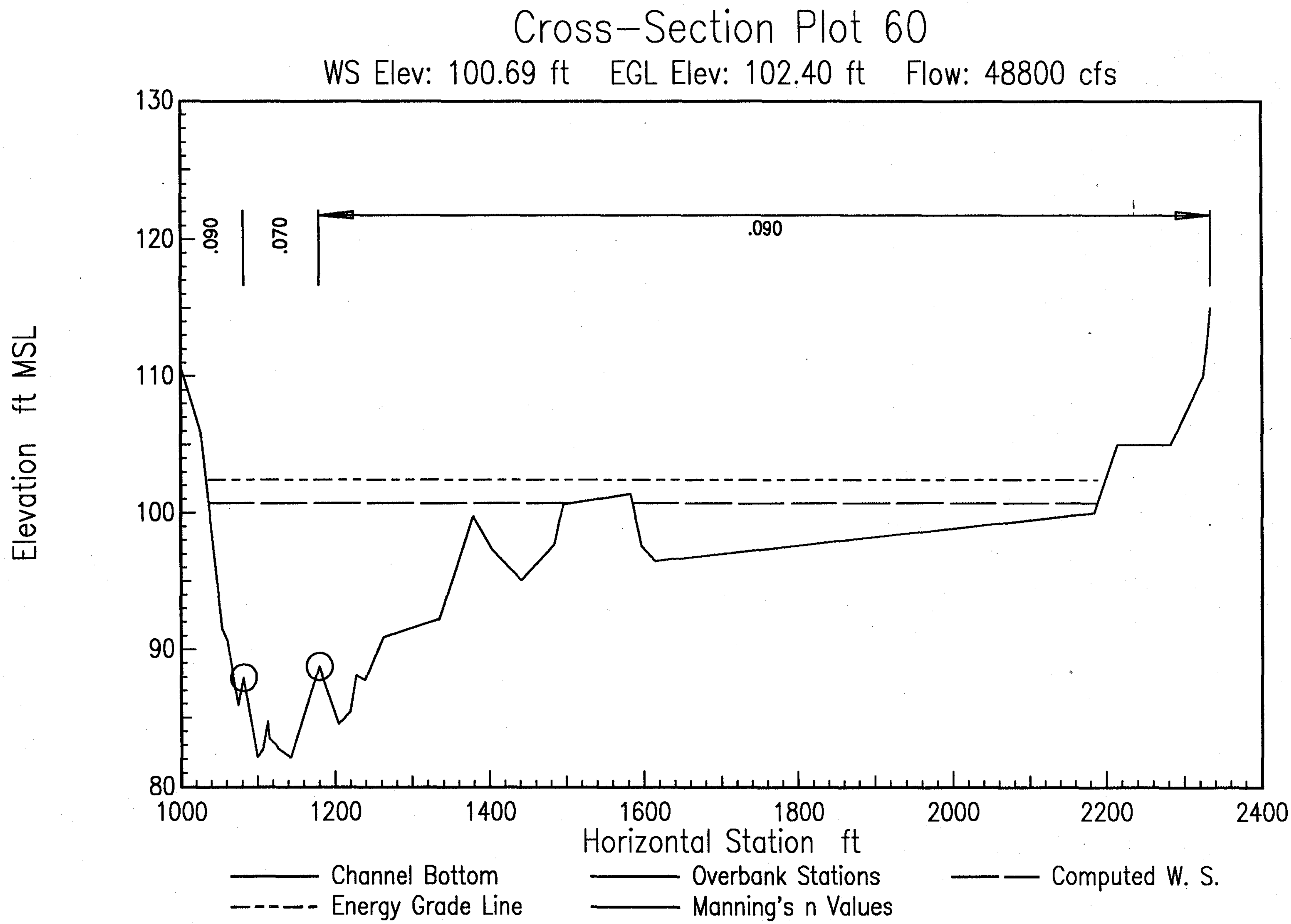


Cross-Section Plot 40
WS Elev: 100.45 ft EGL Elev: 100.83 ft Flow: 48800 cfs
.090
.070
.090
130
120
110
100
90
80
Elevation ft MSL
500
1000
1500
2000
2500
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values

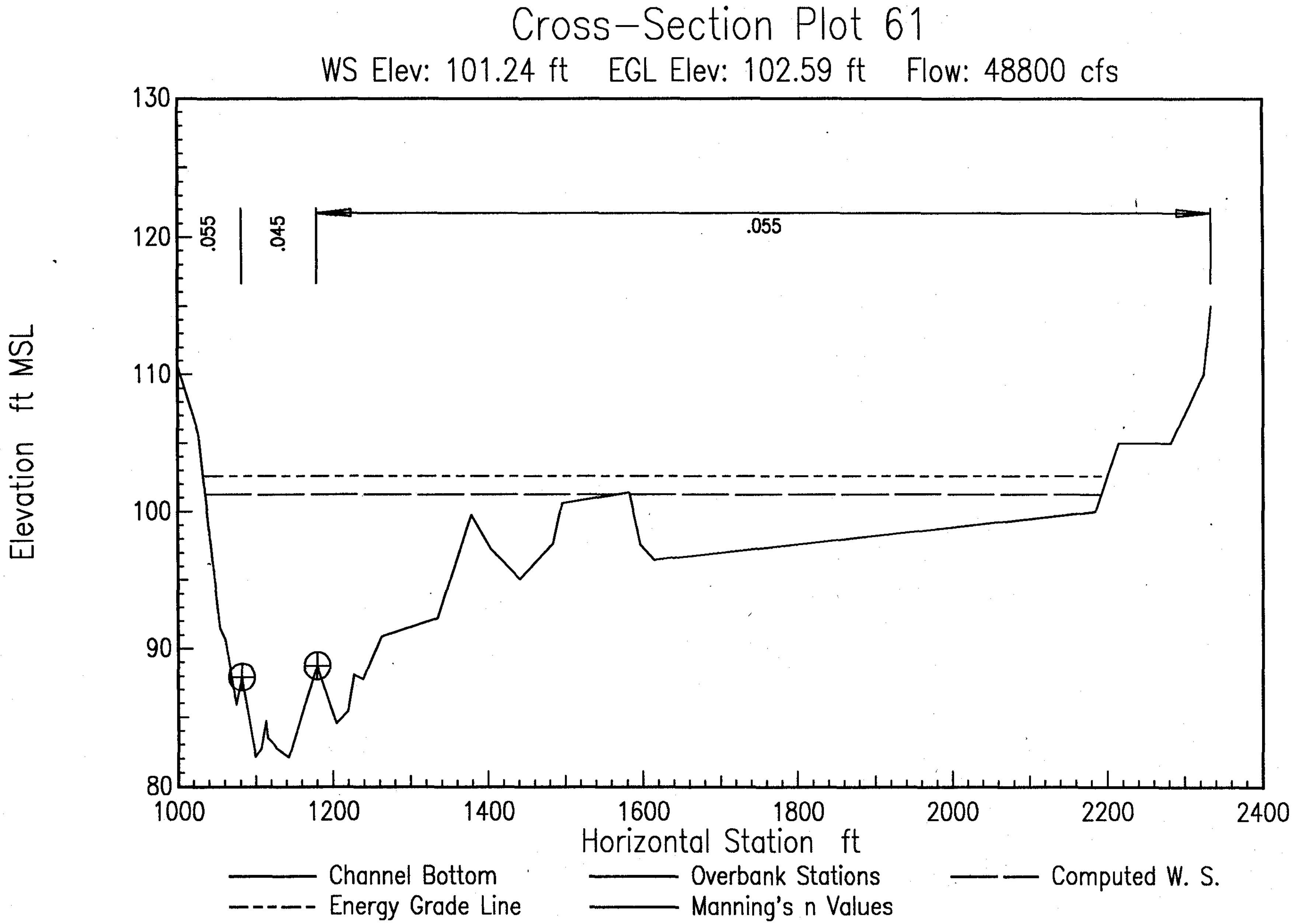
Cross-Section Plot 50

WS Elev: 100.89 ft   EGL Elev: 101.41 ft   Flow: 48800 cfs

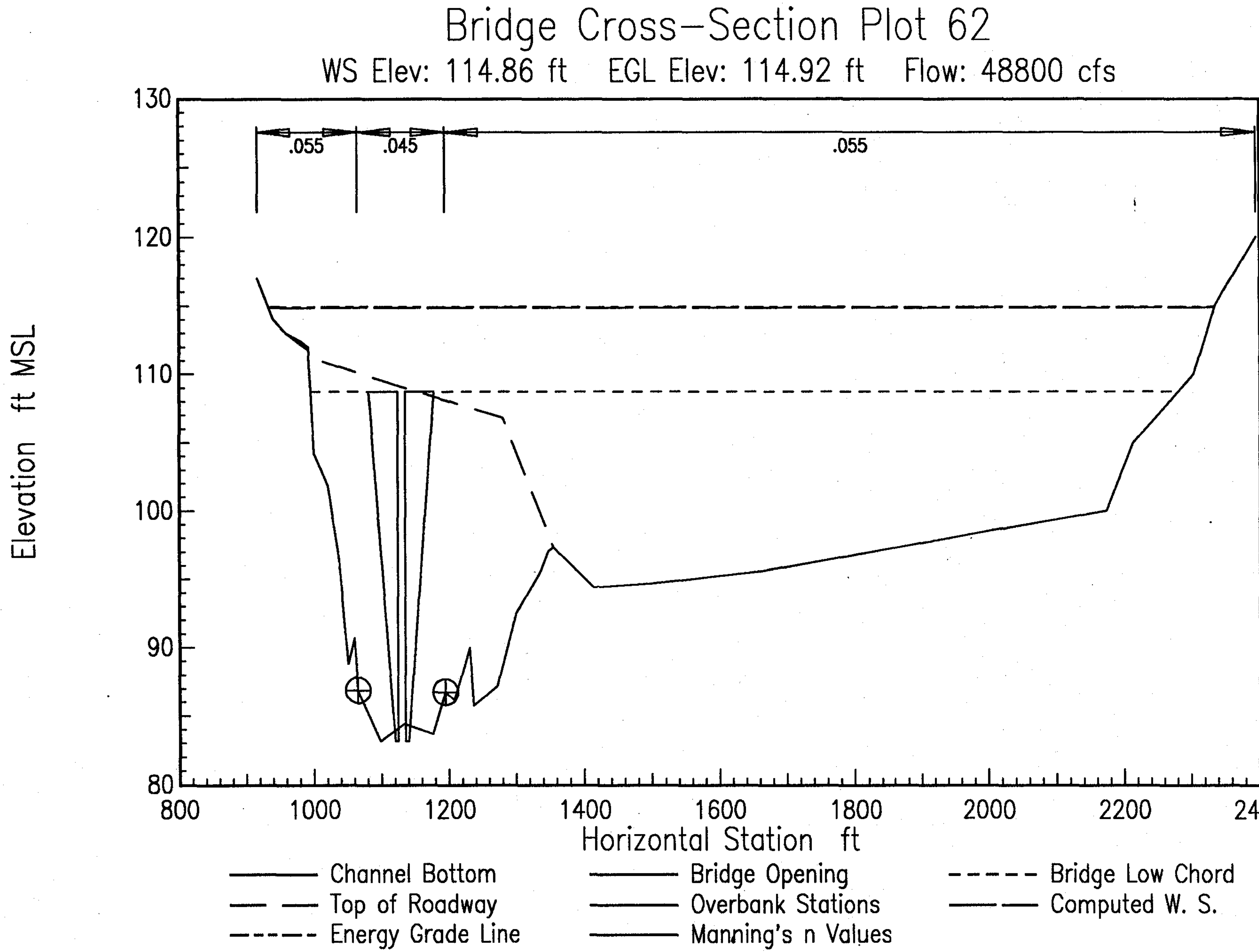




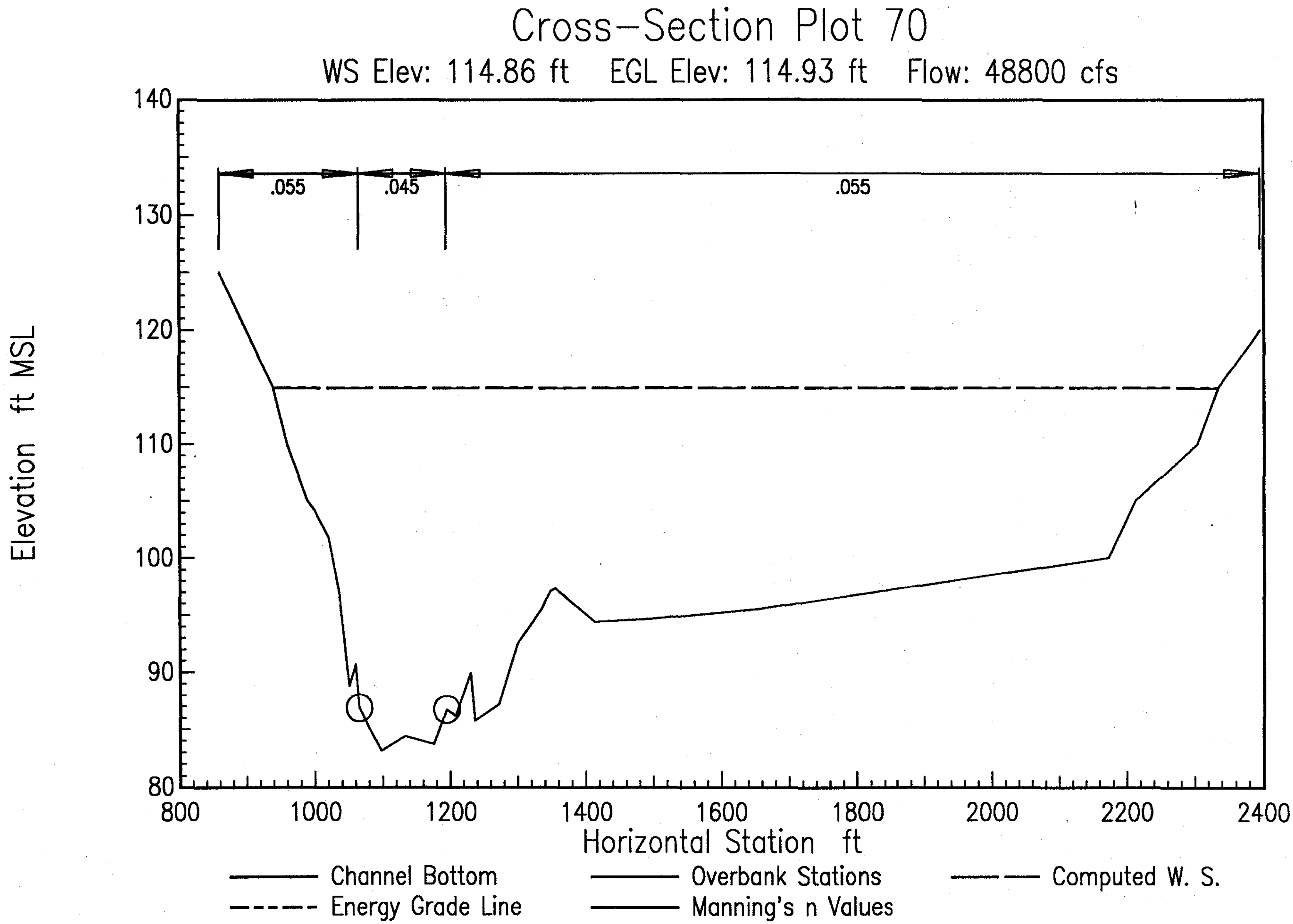
Cross-Section Plot 60
WS Elev: 100.69 ft EGL Elev: 102.40 ft Flow: 48800 cfs
Elevation ft MSL
130
120
110
100
90
80
.090
.070
.090
1000
1200
1400
1600
1800
2000
2200
2400
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values



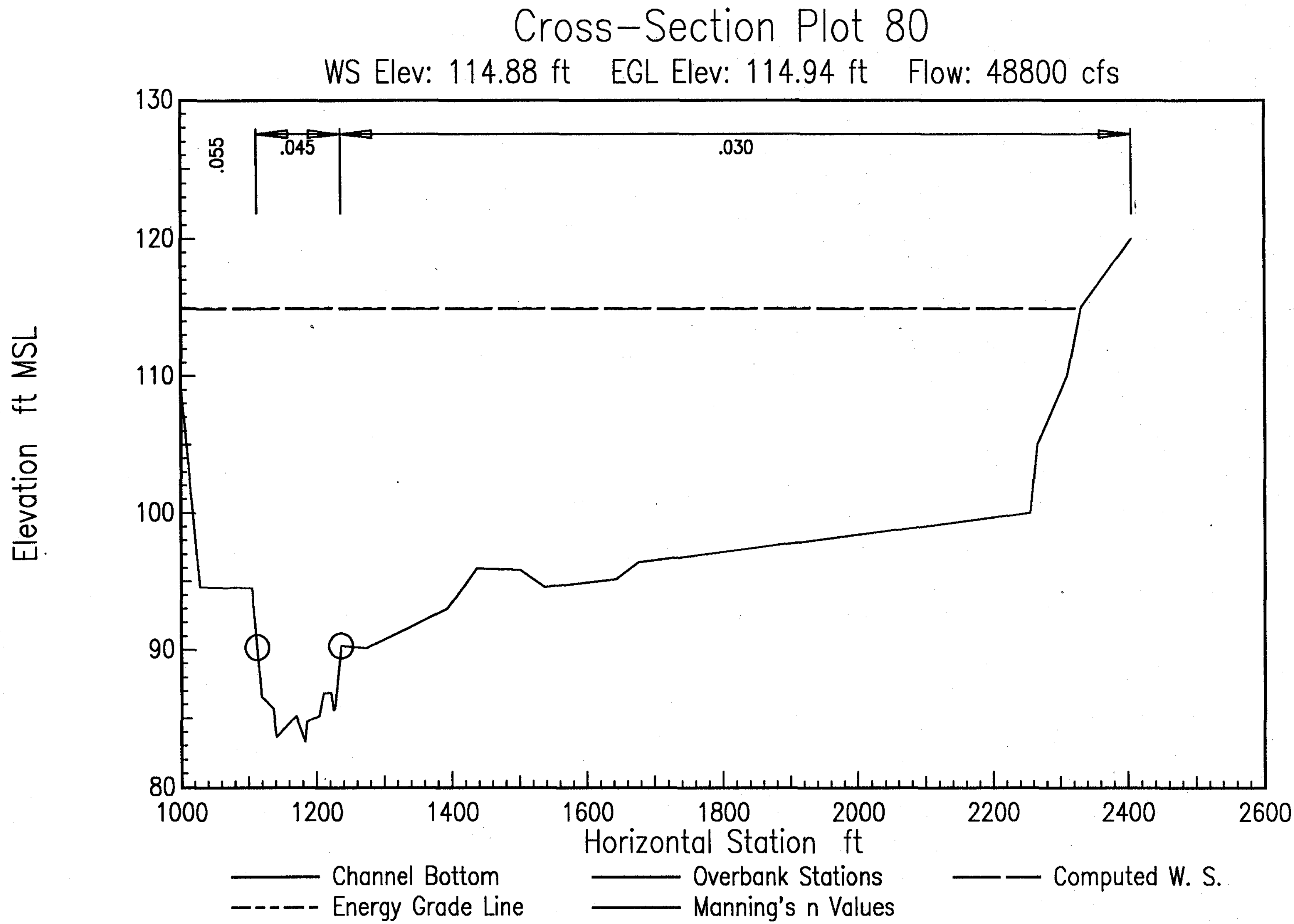
Cross-Section Plot 61
WS Elev: 101.24 ft EGL Elev: 102.59 ft Flow: 48800 cfs
130
120
110
100
90
80
Elevation ft MSL
.055
.045
.055
1000
1200
1400
1600
1800
2000
2200
2400
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values

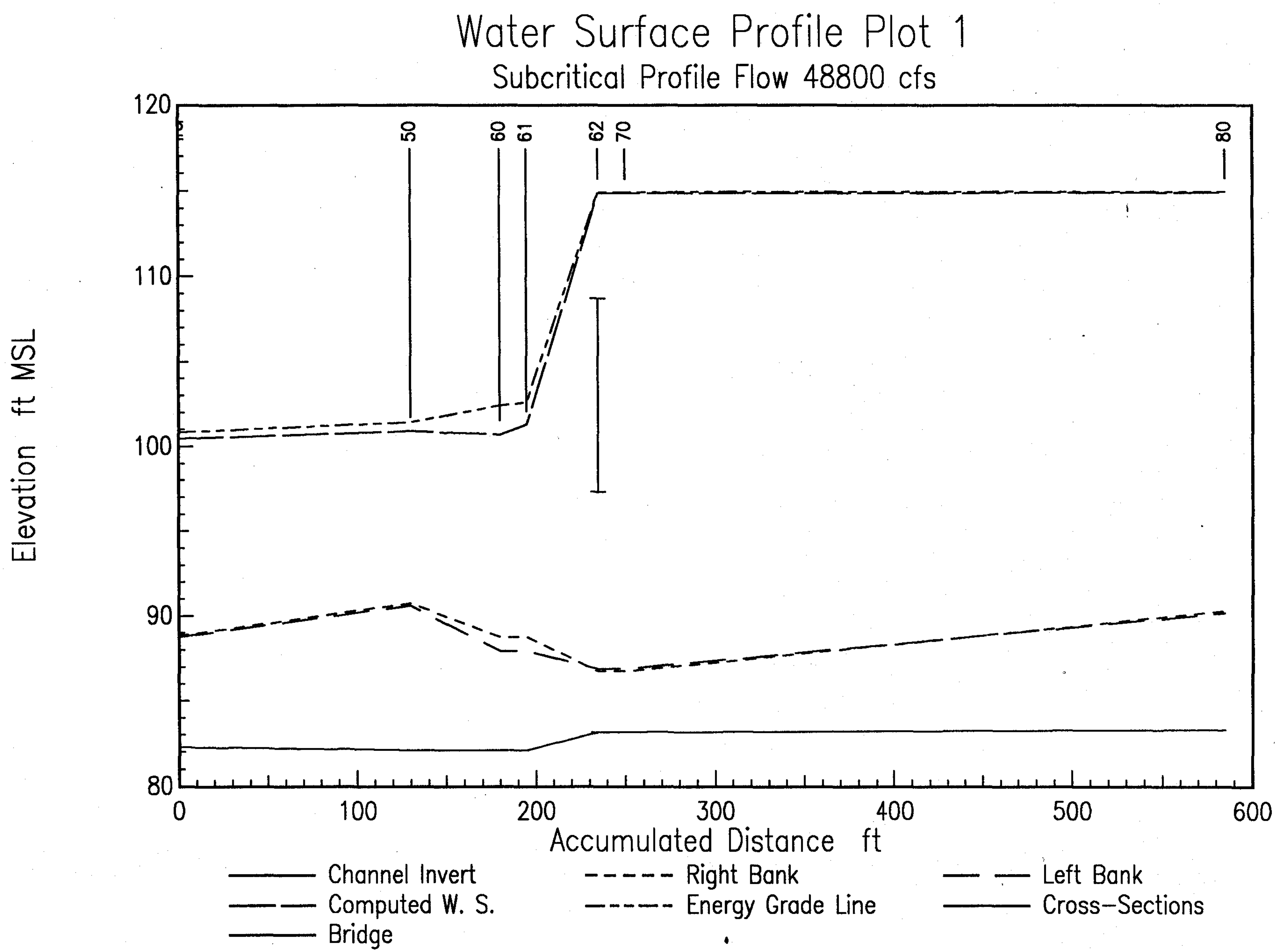


Bridge Cross-Section Plot 62
WS Elev: 114.86 ft EGL Elev: 114.92 ft Flow: 48800 cfs
.055
.045
.055
Elevation ft MSL
130
120
110
100
90
80
800
1000
1200
1400
1600
1800
2000
2200
2400
Horizontal Station ft
Channel Bottom
Top of Roadway
Energy Grade Line
Bridge Opening
Overbank Stations
Manning's n Values
Bridge Low Chord
Computed W. S.



Cross-Section Plot 70
WS Elev: 114.86 ft EGL Elev: 114.93 ft Flow: 48800 cfs
Elevation ft MSL
140
130
120
110
100
90
80
.055
.045
.055
800
1000
1200
1400
1600
1800
2000
2200
2400
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values


Cross-Section Plot 80
WS Elev: 114.88 ft EGL Elev: 114.94 ft Flow: 48800 cfs
.055
.045
.030
130
120
110
100
90
80
Elevation ft MSL
1000
1200
1400
1600
1800
2000
2200
2400
2600
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values



Water Surface Profile Plot 1
Subcritical Profile Flow 48800 cfs
120
110
100
90
80
Elevation ft MSL
50
60
61
62
70
80
0
100
200
300
400
500
600
Accumulated Distance ft
Channel Invert
Right Bank
Left Bank
Computed W. S.
Energy Grade Line
Cross-Sections
Bridge

OUTPUT ANALYSIS WORKSHOP NO. 6
ADVANCED HEC-2 SHORT COURSE

The following is the HEC-2 input and output tables for a FEMA FIS submittal. Assume that the plotting of results on maps using Method 1 is accurate. You are to determine if the input reflects modeling techniques that have been taught in the basic and advanced course for FEMA FIS studies. Look at the notes on the comment (*) records. If you see errors or bad modeling techniques, then suggest a better approach. Method 1 results are in fields 9 and 10 of the ET record. Can you explain why a 1 foot increase (surcharge) in the energy grade line was used instead of the traditional 1 foot in water surface elevation? Explain why Method 6 was used for the optimization. Also, explain why the modeler could not increase the "surcharge" to the maximum allowed at all the cross sections. Why are some of the GR records commented out in cross section 2.88?

```
*          WORKSHOP FOR OUTPUT ANALYSIS - HEC-2 ADVANCED COURSE
*       DETAILED STUDY OF BEAVER HOLLOW CREEK STARTS APPROXIMATELY 2700 FEET
*       UPSTREAM FROM CONFLUENCE OF SWEETWATER RIVER.
*
T1      HEC-2 ANALYSIS OF BEAVER HOLLOW CREEK
T2      BY WEST CONSULTANTS,INC.  ALMOST ALL X-SEC FLOWS AT CRITICAL DEPTH
T3       (FEMA,BEAVER HOLL.CRK);  FLOODWAY DETERMINED BY 1 FT. INCREASE IN E.G.L.
T4        100 YEAR WSEL FROM INTERPOLATION OF GAGE INFO AT X-SEC 2.69
J1        0       2       0       0   .0198       0      .5       0    1365       0
J2        1       0      -1       0       0       0      -1       0       0      15
J3      110     115
J6        1
QT        3    3510    3510    3510
NC      .07     .07     .03
*         SECTION 2.69    (AE-AE)
ET                 10.6     9.1                                       310.5   344.3
X1     2.69      20   310.5   344.3   280.0   289.6     270
GR1401.5      181.3  1396.9   202.7  1387.4   226.9  1378.9   252.8  1369.7   272.7
GR1368.2      274.6  1366.1   287.4  1365.9   295.4  1365.2   303.1  1363.1   306.3
GR1361.9      310.5  1359.2   314.8  1357.3   319.8  1356.2   323.8  1358.1   331.3
GR1360.3      336.7  1363.4   344.3  1369.4   357.3  1375.7   372.2  1382.2   389.2
*          SECTION 2.76    (AF-AF)
NH        4     .07   184.9     .05     200     .03   216.6     .07   232.7
ET                          9.1                                       184.9   216.6
X1     2.76      20   184.9   216.6   345.0   320.0     350
GR1379.4       97.3  1377.5   110.7  1377.2     124  1375.2   139.1  1374.5   151.7
GR1374.5      162.2  1374.6   167.1  1373.9   176.7  1373.1   180.9  1370.7   184.9
GR1365.3      190.2  1364.7     191  1364.5   192.9  1364.2   194.9  1363.3     200
GR1364.6      207.8  1371.6   216.6  1374.5   232.7  1374.9   247.7  1379.2   264.2
*        SECTION 2.84    (AG-AG)
ET                          9.1                                      218.95  260.09
NC                           .3      .5
X1     2.84      15   222.4   257.8     410   391.1   412.3
GR1392.1        168  1394.4   180.1  1393.1   192.3  1391.2   199.7  1389.5     207
GR1387.2      212.4  1382.6   222.4  1376.2   229.7  1374.9   238.1  1375.9   247.9
GR1383.4      257.8  1386.8   267.7  1388.6   275.5  1391.6   285.1  1394.1   303.2
*       SECTION 2.87    (AH-AH)
*       GR POINT ARE READ FROM TOPO
*       JUST D/S OF SPILLWAY. SOME GR POINTS WERE REVISED FROM FIELD DATA.
ET                          9.1                                         121   227.0
X1     2.87      10     175     220     170     150     170
X3       10
X4        1    1393     220
GR   1420       0.0    1400      50    1392     175 1388.16     187 1388.16     195
GR1388.2        202    1400     240    1404     270    1408     310    1420     400
```

```
SB        1.56    2.63       0      15             .1        0 1392.88 1388.16
*       SECTION 2.876   (AI-AI)
*      GR POINT ARE READ FROM TOPO, NO REAL BRIDGE STRUCTURE, USE SB FOR WEIR
*      JUST U/S OF SPILLWAY. SOME GR POINTS WERE REVISED ACCORDING TO FIELD DATA
ET                 4.4     9.1                                        120.    220.
X1 2.876    14    192.   207.1    23.5    23.5    23.5
X2           -       1 1392.88 1392.90
X3    10
BT    -8      60    1400         168.8 1396.21             192 1395.84
BT         192.1 1392.88           207 1392.88           207.1 1396.04
BT         228.5 1396.45           233    1400
GR  1420       0    1400      60 1396.21   168.8 1395.84     192 1392.88   192.1
GR1392.9     200 1392.88   207.0 1396.04   207.1    1396     213 1396.45   228.5
GR  1400     233    1404     263    1408     303    1420     383
*       SECTION 2.88 (AJ-AJ)
*
*      SECTION 2.88 IS THE COPY OF THE SECTION 2.897
*      A CONSTANT WAS SUBTRACTED FROM THE ELEVATIONS ( -.32)
ET                10.6     9.1                                        110.     275
X1  2.88      25   190.7   218.6      20      20      20              -.32
GR1412.7    79.1  1410.1    88.5  1407.1    98.2  1405.3   108.8  1401.6   116.7
GR1394.4   127.1  1394.5   139.7  1395.4   146.7  1394.9   156.4  1396.3     166
GR1396.3   173.4  1395.3   178.4    1394   184.3  1393.1   190.7  1393.3   199.2
GR1393.3   209.6  1393.4   218.6  1394.6   227.3  1393.6   239.7  1394.5   251.3
GR1397.5   263.8  1402.2   277.3  1406.6   286.6    1407   299.7  1407.2   308.9
* 1407.9   318.9  1413.4   335.7  1416.1   354.2  1417.2   370.6  1420.2   390.4
* 1422.5   416.6  1425.2     441    1429   468.4  1431.7   486.1    1436   506.5
* 1437.8   523.3  1437.2   542.9
*
*     THIS SECTION WAS NAMED BY RICK.ENGG. AS 2.89. IT SEEMS IT SHOULD BE 2.897
*     SECTION 2.897  (AK-AK)
ET                16.4     9.1                                      146.09  242.66
NC                          .1      .3
X1 2.897      25   190.7   218.6      90      90      90
GR1412.7    79.1  1410.1    88.5  1407.1    98.2  1405.3   108.8  1401.6   116.7
GR1394.4   127.1  1394.5   139.7  1395.4   146.7  1394.9   156.4  1396.3     166
GR1396.3   173.4  1395.3   178.4    1394   184.3  1393.1   190.7  1393.5   199.2
GR1393.5   209.6  1393.4   218.6  1394.6   227.3  1393.6   239.7  1394.5   251.3
GR1397.5   263.8  1402.2   277.3  1406.6   286.6    1407   299.7  1407.2   308.9
EJ
T1     HEC-2 ANALYSIS OF BEAVER HOLLOW CREEK
T2     BY WEST CONSULTANTS,INC.
T3      (FEMA,BEAVER HOLL.CRK);  METHOD 6
J1    0       3       0       0               0       0       0 1366.19       0
J2    2       0      -1       0       0       0      -1       0       0      15
T1     HEC-2 ANALYSIS OF BEAVER HOLLOW CREEK
T2     BY WEST CONSULTANTS,INC.
T3      (FEMA,BEAVER HOLL.CRK)
J1    0       4       0       0               0       0       0 1366.19       0
J2   15       0      -1       0       0       0      -1       0       0      15

ER
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ADVANCED HEC-2 SHORT COURSE
OUTPUT ANALYSIS WORKSHOP - HEC-2 RESULTS

```
 SUMMARY OF ERRORS AND SPECIAL NOTES

CAUTION SECNO=      2.690  PROFILE=  1  CRITICAL DEPTH ASSUMED

CAUTION SECNO=      2.760  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=      2.760  PROFILE=  1  MINIMUM SPECIFIC ENERGY
CAUTION SECNO=      2.760  PROFILE=  2  CRITICAL DEPTH ASSUMED
CAUTION SECNO=      2.760  PROFILE=  2  MINIMUM SPECIFIC ENERGY
CAUTION SECNO=      2.760  PROFILE=  3  CRITICAL DEPTH ASSUMED
CAUTION SECNO=      2.760  PROFILE=  3  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=      2.840  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=      2.840  PROFILE=  1  MINIMUM SPECIFIC ENERGY
CAUTION SECNO=      2.840  PROFILE=  2  CRITICAL DEPTH ASSUMED
CAUTION SECNO=      2.840  PROFILE=  2  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=      2.840  PROFILE=  2  20 TRIALS ATTEMPTED TO BALANCE WSEL
CAUTION SECNO=      2.840  PROFILE=  3  CRITICAL DEPTH ASSUMED
CAUTION SECNO=      2.840  PROFILE=  3  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=      2.870  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=      2.870  PROFILE=  1  MINIMUM SPECIFIC ENERGY
CAUTION SECNO=      2.870  PROFILE=  2  CRITICAL DEPTH ASSUMED
CAUTION SECNO=      2.870  PROFILE=  2  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=      2.870  PROFILE=  2  20 TRIALS ATTEMPTED TO BALANCE WSEL
CAUTION SECNO=      2.870  PROFILE=  3  CRITICAL DEPTH ASSUMED
CAUTION SECNO=      2.870  PROFILE=  3  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=      2.876  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=      2.876  PROFILE=  1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=      2.876  PROFILE=  1  20 TRIALS ATTEMPTED TO BALANCE WSEL
CAUTION SECNO=      2.876  PROFILE=  2  CRITICAL DEPTH ASSUMED
CAUTION SECNO=      2.876  PROFILE=  2  MINIMUM SPECIFIC ENERGY
CAUTION SECNO=      2.876  PROFILE=  3  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=      2.876  PROFILE=  3  WSEL ASSUMED BASED ON MIN DIFF
CAUTION SECNO=      2.876  PROFILE=  3  20 TRIALS ATTEMPTED TO BALANCE WSEL

WARNING SECNO=      2.880  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=      2.880  PROFILE=  2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=      2.880  PROFILE=  3  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=      2.897  PROFILE=  2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=      2.897  PROFILE=  3  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
```

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

(FEMA,BEAVER HOLL.CRK);

SUMMARY PRINTOUT TABLE 110

	SECNO	CWSEL	DIFKWS	EG	TOPWID	QLOB	QCH	QROB	PERENC	STENCL	STCHL	STCHR	STENCR
*	2.690	1366.19	1.19	1369.23	63.51	85.59	3407.34	17.07	.00	.00	310.50	344.30	.00
	2.690	1366.19	.00	1369.50	33.80	.00	3510.00	.00	.03	310.50	310.50	344.30	344.30
	2.690	1366.19	.00	1369.50	33.81	.00	3510.00	.00	33.81	310.50	310.50	344.30	344.31
*	2.760	1373.25	.00	1376.62	45.70	14.80	3478.83	16.37	.00	.00	184.90	216.60	.00
*	2.760	1373.07	-.18	1376.71	31.70	.00	3510.00	.00	.01	184.90	184.90	216.60	216.60
*	2.760	1373.07	-.18	1376.71	31.70	.00	3510.00	.00	31.70	184.90	184.90	216.60	216.60
*	2.840	1384.19	.00	1387.53	41.13	4.24	3504.86	.90	.00	.00	222.40	257.80	.00
*	2.840	1384.14	-.05	1387.55	35.40	.00	3510.00	.00	.00	222.40	222.40	257.80	257.80
*	2.840	1384.24	.05	1387.53	41.14	4.62	3504.30	1.08	41.14	218.95	222.40	257.80	260.09
*	2.870	1395.45	.00	1397.72	105.86	225.88	3268.16	15.96	.00	.00	175.00	220.00	.00
*	2.870	1395.35	-.09	1398.26	45.00	.00	3510.00	.00	.07	175.00	175.00	220.00	220.00
*	2.870	1395.57	.13	1397.72	106.00	242.91	3249.28	17.81	106.00	121.00	175.00	220.00	227.00
*	2.876	1400.51	.00	1401.98	178.36	1431.51	1578.60	499.88	.00	.00	192.00	207.10	.00
*	2.876	1400.59	.08	1402.61	102.79	1442.73	1769.92	297.35	.14	117.74	192.00	207.10	220.53
*	2.876	1400.90	.39	1402.69	100.00	1478.69	1740.68	290.62	100.00	120.00	192.00	207.10	220.00
*	2.880	1402.07	.00	1402.36	162.69	1115.69	1534.36	859.94	.00	.00	190.70	218.60	.00
*	2.880	1402.94	.87	1403.17	157.78	1137.70	1503.48	868.82	.00	116.26	190.70	218.60	274.04
*	2.880	1402.95	.88	1403.18	161.86	1138.03	1501.82	870.15	165.00	110.00	190.70	218.60	275.00
	2.897	1402.13	.00	1402.44	161.53	1121.33	1523.12	865.55	.00	.00	190.70	218.60	.00
*	2.897	1402.79	.66	1403.34	96.57	938.19	1971.79	600.02	.27	146.09	190.70	218.60	242.66
*	2.897	1402.80	.67	1403.35	96.57	938.51	1971.53	599.96	96.57	146.09	190.70	218.60	242.66

1

Floodway width summary: (FEMA,BEAVER HOLL.CRK);
Profile No. 2

Section Number	Elevation Increase	Top Width	Left Encroach Station	Left Sta Distance From Center	Center Station	Right Sta Distance From Center	Right Encroach Station
2.690	.00	33.80	310.50	16.90	327.40	16.90	344.30
2.760	-.18	31.70	184.90	15.85	200.75	15.85	216.60
2.840	-.05	35.40	222.40	17.70	240.10	17.70	257.80
2.870	-.09	45.00	175.00	22.50	197.50	22.50	220.00
2.876	.08	102.80	117.74	81.81	199.55	20.98	220.53
2.880	.87	157.78	116.26	88.39	204.65	69.39	274.04
2.897	.66	96.57	146.09	58.56	204.65	38.01	242.66

1

Floodway width summary: (FEMA,BEAVER HOLL.CRK);
Profile No. 3

Section Number	Elevation Increase	Top Width	Left Encroach Station	Left Sta Distance From Center	Center Station	Right Sta Distance From Center	Right Encroach Station
2.690	.00	33.81	310.50	16.90	327.40	16.91	344.31
2.760	-.18	31.70	184.90	15.85	200.75	15.85	216.60
2.840	.05	41.14	218.95	21.15	240.10	19.99	260.09
2.870	.13	106.00	121.00	76.50	197.50	29.50	227.00
2.876	.39	100.00	120.00	79.55	199.55	20.45	220.00
2.880	.88	165.00	110.00	94.65	204.65	70.35	275.00
2.897	.67	96.57	146.09	58.56	204.65	38.01	242.66

WORKSHOP NO. 6

SPLIT FLOW

SOLUTIONS

THIS RUN EXECUTED 28 MAY 81 13.16.47

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**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
  ERROR CORR -  01,02,03,04,05
  MODIFICATION -  50,51,52,53,54,55
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SPLIT FLOW BEING PERFORMED

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SF       SPLIT FLOW PROBLEM

TW       RIGHT BANK LEVEE BETWEEN SECTIONS 3 AND 4
WS      2      3       4       -1       3.4
WC            26     460       28

TW       RIGHT BANK FLOODWAY OVER-FLOW WEIR
WS      2      2       3       -1       2.7
WC            19     370       21

TW     RIGHT BANK LEVEE BETWEEN SECIONS 1 AND 2
WS      2      1       2       -1       3.4
WC            19     520       24
```

T1 SPLIT FLOW WORKSHOP SOLUTION
T2 ADVANCED HEC2 WORKSHOP
T3 RED FOX RIVER

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0.	2.	0.	0.	.005000	0.	0.	0.	3.800	0.
QT	3.000	7000.000	24000.000	40000.000	-0.	-0.	-0.	-0.	-0.	-0.
NC	0.	0.	0.	.100	.300	0.	0.	0.	0.	0.
NH	5.000	.100	415.000	.050	650.000	.030	710.000	.050	1020.000	.100
NH	1635.000	0.	0.	0.	0.	0.	0.	0.	0.	0.
X1	1.000	11.000	650.000	710.000	0.	0.	0.	0.	0.	0.
X3	-0.	-0.	-0.	622.000	-0.	752.000	-0.	-0.	-0.	-0.
GR	25.000	20.000	18.000	110.000	17.000	415.000	14.000	650.000	1.000	675.000
GR	0.	690.000	1.000	710.000	13.000	710.000	14.000	1020.000	14.000	1590.000
GR	25.000	1635.000	0.	0.	0.	0.	0.	0.	0.	0.
NH	4.000	.100	415.000	.050	575.000	.030	640.000	.100	1250.000	0.
X1	2.000	10.000	575.000	640.000	500.000	500.000	500.000	0.	0.	0.
X3	-0.	-0.	-0.	525.000	-0.	735.000	-0.	-0.	-0.	-0.
GR	25.000	30.000	20.000	110.000	20.000	200.000	17.000	415.000	10.000	575.000
GR	4.000	580.000	4.000	615.000	18.000	640.000	18.000	1195.000	25.000	1250.000
NC	.100	.050	.030	0.	0.	0.	0.	0.	0.	0.
X1	3.000	10.000	390.000	600.000	400.000	400.000	400.000	0.	0.	0.
X3	-0.	-0.	-0.	390.000	-0.	600.000	-0.	-0.	-0.	-0.
X4	1.000	17.200	390.000	-0.	-0.	-0.	-0.	-0.	-0.	-0.
GR	25.000	40.000	22.000	260.000	18.700	370.000	15.000	420.000	7.100	500.000
GR	7.500	530.000	17.300	560.000	20.000	600.000	22.000	850.000	25.000	875.000
NH	5.000	.100	130.000	.050	330.000	.036	460.000	.050	610.000	.100
NH	700.000	0.	0.	0.	0.	0.	0.	0.	0.	0.
X1	4.000	8.000	330.000	460.000	400.000	400.000	400.000	0.	0.	0.
X3	-0.	-0.	-0.	300.000	-0.	600.000	-0.	-0.	-0.	-0.
GR	26.000	30.000	24.000	130.000	23.000	330.000	9.500	370.000	10.000	400.000
GR	22.000	460.000	22.000	610.000	26.000	700.000	0.	0.	0.	0.
EJ	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.

```
   SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS   BANK ELEV
   Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA    LEFT/RIGHT
   TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN      SSTA
   SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID     ENDST

*PROF 1

CCHV=     .100 CEHV=     .300
1490 NH CARD USED
*SECNO 1.000

3470 ENCROACHMENT STATIONS=      622.0      752.0  TYPE=       1  TARGET=      130.000
      1.00     12.10    12.10    0.         3.80    14.87     2.76     0.        0.       14.00
     7000.        0.    7000.        0.       0.     525.       0.        0.        0.      13.00
       0.        0.     13.34    0.         .050     .030     .050     0.        0.      653.64
   .004965       0.        0.        0.        0        0        6     0.       56.36    710.00

1490 NH CARD USED
*SECNO 2.000

3301 HV CHANGED MORE THAN HVINS

3470 ENCROACHMENT STATIONS=      525.0      735.0  TYPE=       1  TARGET=      210.000
      2.00     11.11    15.11    0.       0.        16.94     1.83     1.97      .09     10.00
     7000.     823.    6177.        0.    201.       540.       0.        7.        1.      18.00
       .01     4.10    11.45    0.        .050      .030     .050     .000      4.00    525.00
   .003213     500.     500.     500.        3         0        0     0.       109.84    634.84

*SECNO 3.000

3301 HV CHANGED MORE THAN HVINS

3470 ENCROACHMENT STATIONS=      390.0      600.0  TYPE=       1  TARGET=      210.000
      3.00     10.16    17.26    0.       0.        18.05      .80     1.02      .10     17.20
     7000.        0.    7000.        0.       0.       978.       0.       15.        2. 100000.00
       .03     0.        7.16    0.        .100      .030     .050     .013      7.10    390.00
   .002060     400.     400.     400.        2         0        0     0.       169.90    559.90

1490 NH CARD USED
*SECNO 4.000

3301 HV CHANGED MORE THAN HVINS
```

SECNO Q TIME SLOPE	DEPTH QLOB VLOB XLOBL	CWSEL QCH VCH XLCH	CRIWS QROB VROB XLOBR	WSELK ALOB XNL ITRIAL	EG ACH XNCH IDC	HV AROB XNR ICONT	HL VOL WTN CORAR	OLOSS TWA ELMIN TOPWID	BANK ELEV LEFT/RIGHT SSTA ENDST

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS= 300.0 600.0 TYPE= 1 TARGET= 300.000

4.00	8.59	18.09	18.09	0.	20.87	2.78	1.62	.59	23.00
7000.	0.	7000.	0.	0.	523.	0.	22.	3.	22.00
.04	0.	13.38	0.	.100	.036	.050	.018	9.50	344.55
.011277	400.	400.	400.	20	15	0	0.	95.91	440.45

TW RIGHT BANK LEVEE BETWEEN SECTIONS 3 AND 4

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
0.	0.	0.	0.	0.	0.	2	17.259	18.091	3.000	4.000

TW RIGHT BANK FLOODWAY OVER-FLOW WEIR

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
0.	0.	0.	0.	0.	0.	2	15.109	17.259	2.000	3.000

TW RIGHT BANK LEVEE BETWEEN SECIONS 1 AND 2

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
0.	0.	0.	0.	0.	0.	2	12.105	15.109	1.000	2.000

THIS RUN EXECUTED 28 MAY 81 13.16.48

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**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
  ERROR CORR - 01,02,03,04,05
  MODIFICATION - 50,51,52,53,54,55
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T1 SPLIT FLOW WORKSHOP SOLUTION
T2 ADVANCED HEC2 WORKSHOP
T3 RED FOX RIVER

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0.	3.	0.	0.	.005000	0.	0.	0.	11.000	0.
J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	2.000	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.

```
   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST

*PROF 2

CCHV=     .100 CEHV=     .300
1490 NH CARD USED
*SECNO 1.000

3470 ENCROACHMENT STATIONS=      622.0      752.0   TYPE=        1  TARGET=       130.000
      1.00     18.30     18.30     17.91     11.00     22.98      4.68      0.        0.      14.00
    18134.      571.    16274.     1289.      115.      893.      220.        0.        0.      13.00
      0.        4.95     18.22      5.86      .050      .030      .050      0.        0.     622.00
   .004996      0.        0.        0.          0        14         0       0.      130.00    752.00

1490 NH CARD USED
*SECNO 2.000

3301 HV CHANGED MORE THAN HVINS

3470 ENCROACHMENT STATIONS=      525.0      735.0   TYPE=        1  TARGET=       210.000
      2.00     18.50     22.50      0.        0.       24.81      2.31      1.59       .24      10.00
    18134.     3557.    13789.      788.      570.     1012.      427.       19.        2.      18.00
       .01      6.24     13.62      1.84      .050      .030      .100      .000      4.00    525.00
   .002206      500.      500.      500.        2         0         0       0.      210.00    735.00

*SECNO 3.000

3301 HV CHANGED MORE THAN HVINS

3470 ENCROACHMENT STATIONS=      390.0      600.0   TYPE=        1  TARGET=       210.000
      3.00     16.95     24.05      0.        0.       25.67      1.62       .80       .07      17.20
    24000.        0.    24000.        0.        0.     2346.        0.       39.        4. 100000.00
       .02      0.       10.23      0.        .100      .030      .050      .013      7.10    390.00
   .001850      400.      400.      400.        3         0         0       0.      210.00    600.00

1490 NH CARD USED
*SECNO 4.000

3301 HV CHANGED MORE THAN HVINS
```

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	LEFT/RIGHT
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS= 300.0 600.0 TYPE= 1 TARGET= 300.000

4.00	15.69	25.19	25.19	0.	28.64	3.45	1.25	.55	23.00
24000.	238.	21492.	2270.	63.	1372.	446.	58.	6.	22.00
.03	3.76	15.67	5.09	.050	.036	.050	.018	9.50	300.00
.006443	400.	400.	400.	20	15	0	0.	300.00	600.00

TW RIGHT BANK LEVEE BETWEEN SECTIONS 3 AND 4

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
0.	0.	0.	0.	0.	0.	9	24.048	25.186	3.000	4.000

TW RIGHT BANK FLOODWAY OVER-FLOW WEIR

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
5866.49	5916.25	.84	5866.49	5916.25	.84	9	22.496	24.048	2.000	3.000

TW RIGHT BANK LEVEE BETWEEN SECIONS 1 AND 2

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
0.	0.	0.	5866.49	5916.25	.84	9	18.302	22.496	1.000	2.000

THIS RUN EXECUTED 28 MAY 81 13.16.48

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**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
  ERROR CORR -  01,02,03,04,05
  MODIFICATION -  50,51,52,53,54,55
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T1 SPLIT FLOW WORKSHOP SOLUTION
T2 ADVANCED HEC2 WORKSHOP
T3 RED FOX RIVER

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0.	4.	0.	0.	.005000	0.	0.	0.	20.000	0.

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	15.000	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.

```
 SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
 Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
 TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN      SSTA
 SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID     ENDST

*PROF 3

CCHV=     .100 CEHV=     .300
1490 NH CARD USED
*SECNO 1.000

3470 ENCROACHMENT STATIONS=      622.0      752.0  TYPE=      1  TARGET=      130.000
    1.00     20.69     20.69     0.        20.00     26.21     5.52      0.        0.        14.00
  24415.     1168.    20908.     2338.      182.     1036.      320.        0.        0.      13.00
     0.       6.41     20.18      7.31      .050      .030      .050      0.        0.      622.00
 .005024        0.        0.        0.         0         0         3      0.     130.00    752.00

1490 NH CARD USED
*SECNO 2.000

3301 HV CHANGED MORE THAN HVINS

3470 ENCROACHMENT STATIONS=      525.0      735.0  TYPE=      1  TARGET=      210.000
    2.00     20.74     24.74     0.        0.        28.26     3.51      1.84       .20     10.00
  26832.     5355.    19735.     1742.      682.     1158.      640.       23.        2.      18.00
     .01      7.85     17.04      2.72      .050      .030      .100      .000      4.00    525.00
 .002885      500.      500.      500.         2         0         0      0.     210.00    735.00

*SECNO 3.000
3280 CROSS SECTION       3.00 EXTENDED       1.35 FEET

3470 ENCROACHMENT STATIONS=      390.0      600.0  TYPE=      1  TARGET=      210.000
    3.00     19.25     26.35     0.        0.        29.43     3.08      1.14       .04     17.20
  39874.        0.    39874.        0.        0.     2830.        0.       47.        4. 100000.00
     .02     0.        14.09     0.         .100      .030      .050      .013      7.10    390.00
 .002808      400.      400.      400.         3         0         0      0.     210.00    600.00

1490 NH CARD USED
*SECNO 4.000
3280 CROSS SECTION       4.00 EXTENDED       1.98 FEET
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SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	LEFT/RIGHT
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

3301 HV CHANGED MORE THAN HVINS

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS= 300.0 600.0 TYPE= 1 TARGET= 300.000

4.00	18.48	27.98	27.98	0.	32.58	4.60	1.66	.46	23.00
40000.	939.	32515.	6546.	147.	1735.	837.	73.	6.	22.00
.02	6.38	18.74	7.82	.050	.036	.050	.018	9.50	300.00
.006738	400.	400.	400.	20	11	0	0.	300.00	600.00

TW RIGHT BANK LEVEE BETWEEN SECTIONS 3 AND 4

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
125.92	123.90	1.62	125.92	123.90	1.62	20	26.352	27.981	3.000	4.000

TW RIGHT BANK FLOODWAY OVER-FLOW WEIR

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
13041.71	13050.42	.07	13167.63	13174.32	.05	20	24.741	26.352	2.000	3.000

TW RIGHT BANK LEVEE BETWEEN SECIONS 1 AND 2

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
2417.87	2411.49	.26	15585.50	15585.81	.00	20	20.688	24.741	1.000	2.000

THIS RUN EXECUTED 28 MAY 81 13.16.49

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**************************************************
HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
ERROR CORR - 01,02,03,04,05
MODIFICATION - 50,51,52,53,54,55
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ΟTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

FOX RIVER

JMMARY PRINTOUT TABLE 150

SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10K*S	VCH	AREA	.01K
1.000	0.	0.	0.	0.	7000.00	12.10	0.	14.87	49.65	13.34	524.74	993.
1.000	0.	0.	0.	0.	18133.51	18.30	17.91	22.98	49.96	18.22	1228.42	2565.
1.000	0.	0.	0.	0.	24414.50	20.69	0.	26.21	50.24	20.18	1538.61	3444.
2.000	500.00	0.	0.	4.00	7000.00	15.11	0.	16.94	32.13	11.45	740.40	1234.
2.000	500.00	0.	0.	4.00	18133.51	22.50	0.	24.81	22.06	13.62	2009.61	3860.7
2.000	500.00	0.	0.	4.00	26832.37	24.74	0.	28.26	28.85	17.04	2480.87	4995.
3.000	400.00	0.	0.	7.10	7000.00	17.26	0.	18.05	20.60	7.16	977.54	1542.1
3.000	400.00	0.	0.	7.10	24000.00	24.05	0.	25.67	18.50	10.23	2346.28	5580.4
3.000	400.00	0.	0.	7.10	39874.08	26.35	0.	29.43	28.08	14.09	2830.30	7524.
4.000	400.00	0.	0.	9.50	7000.00	18.09	18.09	20.87	112.77	13.38	523.20	659.1
4.000	400.00	0.	0.	9.50	24000.00	25.19	25.19	28.64	64.43	15.67	1881.09	2989.
4.000	400.00	0.	0.	9.50	40000.00	27.98	27.98	32.58	67.38	18.74	2719.65	4873.

FOX RIVER

UMMARY PRINTOUT TABLE 150

SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
1.000	7000.00	12.10	0.	0.	8.30	56.36	0.
1.000	18133.51	18.30	6.20	0.	7.30	130.00	0.
1.000	24414.50	20.69	2.39	0.	.69	130.00	0.
2.000	7000.00	15.11	0.	3.00	0.	109.84	500.00
2.000	18133.51	22.50	7.39	4.19	0.	210.00	500.00
2.000	26832.37	24.74	2.24	4.05	0.	210.00	500.00
3.000	7000.00	17.26	0.	2.15	0.	169.90	400.00
3.000	24000.00	24.05	6.79	1.55	0.	210.00	400.00
3.000	39874.08	26.35	2.30	1.61	0.	210.00	400.00
4.000	7000.00	18.09	0.	.83	0.	95.91	400.00
4.000	24000.00	25.19	7.10	1.14	0.	300.00	400.00
4.000	40000.00	27.98	2.80	1.63	0.	300.00	400.00

UMMARY OF ERRORS

UTION SECNO= 4.000 PROFILE= 1 CRITICAL DEPTH ASSUMED
UTION SECNO= 4.000 PROFILE= 1 PROBABLE MINIMUM SPECIFIC ENERGY
UTION SECNO= 4.000 PROFILE= 1 20 TRIALS ATTEMPTED TO BALANCE WSEL
UTION SECNO= 4.000 PROFILE= 2 CRITICAL DEPTH ASSUMED
UTION SECNO= 4.000 PROFILE= 2 PROBABLE MINIMUM SPECIFIC ENERGY
UTION SECNO= 4.000 PROFILE= 2 20 TRIALS ATTEMPTED TO BALANCE WSEL
UTION SECNO= 4.000 PROFILE= 3 CRITICAL DEPTH ASSUMED
UTION SECNO= 4.000 PROFILE= 3 PROBABLE MINIMUM SPECIFIC ENERGY
UTION SECNO= 4.000 PROFILE= 3 20 TRIALS ATTEMPTED TO BALANCE WSEL

WORKSHOP NO. 7

MULTIPLE CULVERT ANALYSIS

SOLUTIONS

```
T1       Workshop No. 7, Solutions, 5 ft. Diameter Pipe
T2       Special Culvert Example, Adapted from BOSS Corp. Culvert Problem 8
T3       Sample Creek, Q =  50 CFS, WEST Consultants, Inc., D. Williams
J1      0       2       0       0       0       0     0.0             227
QT      4      50     100     200     300
NC   0.12    0.12    0.06     0.1     0.3
NH      4    0.15  1435.0    0.05  1472.0    0.15  2250.0    0.12  2850.0
X1   2900      11  1435.0  1472.0   750.0   600.0   850.0     1.0     0.0
GR  248.0   950.0   245.0  1160.0   240.0  1370.0   236.0  1435.0   224.0  1450.0
GR  225.0  1455.0   236.0  1472.0   240.0  1570.0   245.0  1850.0   246.0  2250.0
GR  248.0  2850.0
NC   0.15    0.15    0.05     0.0     0.0
X1   3800      11  1433.0  1470.0  1050.0   750.0   900.0     1.0     0.0
GR  250.0  1040.0   245.0  1110.0   240.0  1390.0   238.0  1433.0   227.0  1447.0
GR  226.0  1450.0   227.0  1455.0   239.0  1470.0   240.0  1530.0   245.0  1750.0
GR  246.0  2150.0
NC   0.15    0.15    0.05     0.0     0.0
*      Section 1 of culvert sequence, d/s natural channel
X1   4550       8  1430.0  1470.0   500.0   900.0   750.0     1.0     0.0
GR  250.0  1000.0   245.0  1350.0   242.0  1430.0   228.0  1446.0   228.0  1454.0
GR  242.0  1470.0   245.0  1840.0   250.0  2340.0
NC    0.0     0.0     0.0     0.6     0.8
*      Section 2 of sequence, immediately d/s of culvert
X1   4860       0     0.0     0.0   160.0   360.0   310.0     1.0     0.0
X3     10     0.0     0.0     0.0     0.0     0.0     0.0   245.0   245.0
*     This is the location of the culverts, section 3 of sequence
*     This run is for 5 foot diameter pipe
SC   1.02      .8     2.6       0       5              40     2.3     236     235
X1   4900       0     0.0     0.0    40.0    40.0    40.0     1.0     0.0
X2    0.0     0.0       2     240   245.0     0.0       0     0.0     0.0
X3     10     0.0     0.0     0.0     0.0     0.0     0.0   245.0   245.0
BT     -4    1175   247.5   247.5    1350     245     245    1840     245     245
BT           2090   247.5   247.5
*     This is section 4 of sequence, u/s of culvert, natural channel
X1   5060       0     0.0     0.0   160.0   160.0   160.0     1.0     0.0
NC    0.0     0.0     0.0     0.1     0.3
NH      4    0.08  1000.0    0.15  1432.0    0.05  1468.0    0.15  2700.0
X1   5650      10  1432.0  1468.0   535.0   620.0   590.0     1.0     0.0
GR  252.0   450.0   250.0  1000.0   245.0  1432.0   232.0  1447.0   230.0  1450.0
GR  231.0  1454.0   244.0  1468.0   245.0  1620.0   250.0  2210.0   255.0  2700.0
NH      4    0.12  1240.0    0.08  1430.0    0.05  1467.0    0.15  2850.0
X1   6350       9  1430.0  1467.0   650.0   700.0   700.0     1.0     0.0
GR  253.0   450.0   250.0  1240.0   245.0  1430.0   233.0  1445.0   231.0  1450.0
GR  232.0  1453.0   245.0  1467.0   250.0  2350.0   255.0  2850.0
EJ
T1       Workshop No. 7, Solutions
T2       Special Culvert Example, Adapted from BOSS Corp. Culvert Problem 8
T3       Sample Creek, Q = 100 CFS, WEST Consultants, Inc., D. Williams
J1      0       3       0       0       0       0     0.0     0.0     229
J2      2       0      -1     0.0     0.0     0.0     0.0     0.0     0.0
T1       Workshop No. 7, Solutions
T2       Special Culvert Example, Adapted from BOSS Corp. Culvert Problem 8
T3       Sample Creek, Q = 200 CFS, WEST Consultants, Inc., D. Williams
J1      0       4       0       0       0       0     0.0             231
J2      3       0      -1     0.0     0.0     0.0     0.0     0.0     0.0
T1       Workshop No. 7, Solutions
T2       Special Culvert Example, Adapted from BOSS Corp. Culvert Problem 8
T3       Sample Creek, Q =  300 CFS, WEST Consultants, Inc., D. Williams
J1      0       5       0       0       0       0     0.0             232
J2     15       0      -1     0.0     0.0     0.0     0.0     0.0     0.0
ER
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RESULTS OF PIPE CULVERT, 50 CFS

4860.000	2.95	230.95	.00	.00	230.98	.03	.41	.01	242.00
50.0	.0	50.0	.0	.0	33.5	.0	1.2	.6	242.00
.31	.00	1.49	.00	.000	.050	.000	.000	228.00	1442.63
.001017	160.	310.	360.	2	0	0	.00	14.74	1457.37

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

SPECIAL CULVERT

SC CUNO	CUNV	ENTLC	COFQ	RDLEN	RISE	SPAN	CULVLN	CHRT	SCL	ELCHU	ELCHD
1	.020	.80	2.60	.00	5.00	.00	40.00	2	3	236.00	235.00

CHART 2 - CORRUGATED METAL PIPE CULVERT
SCALE 3 - PIPE PROJECTING FROM FILL

*SECNO 4900.000

SPECIAL CULVERT OUTLET CONTROL
EGIC = 238.865 EGOC = 239.314 PCWSE= 230.947 ELTRD= 245.000

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 14.14

SPECIAL CULVERT

EGIC	EGOC	H4	QWEIR	QCULV	VCH	ACULV	ELTRD	WEIRLN
238.87	239.31	8.33	0.	50.	.211	19.6	245.00	0.

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 245.00 ELREA= 245.00

4900.000	11.31	239.31	.00	.00	239.31	.00	8.33	.00	242.00
50.0	.0	50.0	.0	.0	236.8	.0	1.3	.6	242.00
.36	.00	.21	.00	.000	.050	.000	.000	228.00	1433.07
.000005	40.	40.	40.	0	0	0	.00	33.86	1466.93

*SECNO 5060.000

5060.000	11.31	239.31	.00	.00	239.31	.00	.00	.00	242.00
50.0	.0	50.0	.0	.0	236.8	.0	2.2	.7	242.00
.57	.00	.21	.00	.000	.050	.000	.000	228.00	1433.07
.000005	160.	160.	160.	2	0	0	.00	33.86	1466.93

RESULTS OF PIPE CULVERT, 100 CFS

4860.000	4.16	232.16	.00	.00	232.22	.05	.43	.01	242.00
100.0	.0	100.0	.0	.0	53.2	.0	2.1	.8	242.00
.25	.00	1.88	.00	.000	.050	.000	.000	228.00	1441.23
.001130	160.	310.	360.	1	0	0	.00	17.53	1458.77

SPECIAL CULVERT

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SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

SC CUNO	CUNV	ENTLC	COFQ	RDLEN	RISE	SPAN	CULVLN	CHRT	SCL	ELCHU	ELCHD
1	.020	.80	2.60	.00	5.00	.00	40.00	2	3	236.00	235.00

CHART 2 - CORRUGATED METAL PIPE CULVERT
SCALE 3 - PIPE PROJECTING FROM FILL

*SECNO 4900.000

SPECIAL CULVERT OUTLET CONTROL
EGIC = 240.533 EGOC = 240.944 PCWSE= 232.161 ELTRD= 245.000

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 9.99

SPECIAL CULVERT

EGIC	EGOC	H4	QWEIR	QCULV	VCH	ACULV	ELTRD	WEIRLN
240.53	240.94	8.73	0.	100.	.339	19.6	245.00	0.

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 245.00 ELREA= 245.00

4900.000	12.94	240.94	.00	.00	240.94	.00	8.73	.00	242.00
100.0	.0	100.0	.0	.0	295.0	.0	2.3	.8	242.00
.29	.00	.34	.00	.000	.050	.000	.000	228.00	1431.21
.000011	40.	40.	40.	0	0	0	.00	37.59	1468.79

*SECNO 5060.000

5060.000	12.94	240.94	.00	.00	240.95	.00	.00	.00	242.00
100.0	.0	100.0	.0	.0	295.0	.0	3.4	.9	242.00
.42	.00	.34	.00	.000	.050	.000	.000	228.00	1431.21
.000011	160.	160.	160.	2	0	0	.00	37.59	1468.79

RESULTS OF PIPE CULVERT, 200 CFS

4860.000	5.86	233.86	.00	.00	233.95	.08	.45	.01	242.00
200.0	.0	200.0	.0	.0	86.2	.0	3.7	1.0	242.00
.21	.00	2.32	.00	.000	.050	.000	.000	228.00	1439.30
.001222	160.	310.	360.	2	0	0	.00	21.40	1460.70

SPECIAL CULVERT

1

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SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

SC	CUNO	CUNV	ENTLC	COFQ	RDLEN	RISE	SPAN	CULVLN	CHRT	SCL	ELCHU	ELCHD
	1	.020	.80	2.60	.00	5.00	.00	40.00	2	3	236.00	235.00

CHART 2 - CORRUGATED METAL PIPE CULVERT
SCALE 3 - PIPE PROJECTING FROM FILL

5130, EGIC= 244.38..MAY BE TOO LARGE IF INLET CONTROLS.
5135, EGOC= 243.91 ..MAY BE TOO LARGE IF OUTLET CONTROLS.
*SECNO 4900.000

SPECIAL CULVERT INLET CONTROL
EGIC = 244.375 EGOC = 243.912 PCWSE= 233.862 ELTRD= 245.000

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 9.35

SPECIAL CULVERT

EGIC	EGOC	H4	QWEIR	QCULV	VCH	ACULV	ELTRD	WEIRLN
244.38	243.91	10.43	0.	200.	.464	19.6	245.00	0.

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 245.00 ELREA= 245.00

4900.000	16.37	244.37	.00	.00	244.38	.00	10.43	.00	242.00
200.0	.0	200.0	.0	.0	431.0	.0	3.9	1.0	242.00
.24	.00	.46	.00	.000	.050	.000	.000	228.00	1430.00
.000014	40.	40.	40.	0	0	0	.00	40.00	1470.00

*SECNO 5060.000

5060.000	16.37	244.37	.00	.00	244.38	.00	.00	.00	242.00
200.0	2.9	183.8	13.3	75.2	431.0	347.8	6.3	1.8	242.00
.35	.04	.43	.04	.150	.050	.150	.000	228.00	1366.67
.000012	160.	160.	160.	2	0	0	.00	396.24	1762.91

RESULTS OF PIPE CULVERT, 300 CFS

```
  4860.000      7.08    235.08       .00       .00    235.19       .11       .46       .02    242.00
     300.0        .0     300.0        .0        .0     113.9        .0       4.8       1.1    242.00
       .19       .00      2.63       .00      .000      .050      .000      .000    228.00   1437.91
   .001296      160.      310.      360.         2         0         0       .00     24.18   1462.09

SPECIAL CULVERT

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      SECNO     DEPTH     CWSEL     CRIWS     WSELK        EG        HV        HL     OLOSS  L-BANK ELEV
          Q      QLOB       QCH      QROB      ALOB       ACH      AROB       VOL       TWA  R-BANK ELEV
       TIME      VLOB       VCH      VROB       XNL      XNCH       XNR       WTN     ELMIN  SSTA
      SLOPE     XLOBL      XLCH     XLOBR    ITRIAL       IDC     ICONT     CORAR    TOPWID  ENDST

 SC   CUNO      CUNV     ENTLC      COFQ     RDLEN      RISE      SPAN    CULVLN      CHRT       SCL     ELCHU     ELCHD
        1       .020       .80      2.60       .00      5.00       .00     40.00      2          3       236.00    235.00

 CHART  2 - CORRUGATED METAL PIPE CULVERT
 SCALE  3 - PIPE PROJECTING FROM FILL

 5140, NORMAL DEPTH EXCEEDS CULVERT HEIGHT
 5130, EGIC=  251.55..MAY BE TOO LARGE IF INLET CONTROLS.
 *SECNO 4900.000

 SPECIAL CULVERT INLET CONTROL + WEIR FLOW, EG =    245.16

 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  8.47

 SPECIAL CULVERT

       EGIC      EGOC        H4     QWEIR     QCULV       VCH     ACULV     ELTRD    WEIRLN
     251.55    243.93      9.98       86.      213.      .553      19.6    245.00      518.

   4900.000     17.16    245.16       .00       .00    245.16       .00      9.98       .00    242.00
      300.0       7.9     255.7      36.4     134.1     462.6     617.0       5.4       1.3    242.00
        .21       .06       .55       .06      .150      .050      .150      .000    228.00   1338.52
    .000018       40.       40.       40.         0         0         0       .00    517.88   1856.40

 *SECNO 5060.000
   5060.000     17.16    245.16       .00       .00    245.17       .00       .00       .00    242.00
      300.0       7.9     255.8      36.4     134.0     462.5     616.6       9.9       3.2    242.00
        .31       .06       .55       .06      .150      .050      .150      .000    228.00   1338.60
    .000018      160.      160.      160.         2         0         0       .00    517.68   1856.28
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```
T1      Workshop No. 7, Solutions, 4 x 4 ft. Concrete Culvert
T2      Special Culvert Example, Adapted from BOSS Corp. Culvert Problem 8
T3      Sample Creek, Q =  50 CFS, WEST Consultants, Inc., D. Williams
J1      0       2       0       0       0       0     0.0               227
QT      4      50     100     200     300
NC   0.12    0.12    0.06     0.1     0.3
NH      4    0.15  1435.0    0.05  1472.0    0.15  2250.0    0.12  2850.0
X1   2900      11  1435.0  1472.0   750.0   600.0   850.0     1.0     0.0
GR  248.0   950.0   245.0  1160.0   240.0  1370.0   236.0  1435.0   224.0  1450.0
GR  225.0  1455.0   236.0  1472.0   240.0  1570.0   245.0  1850.0   246.0  2250.0
GR  248.0  2850.0
NC   0.15    0.15    0.05     0.0     0.0
X1   3800      11  1433.0  1470.0  1050.0   750.0   900.0     1.0     0.0
GR  250.0  1040.0   245.0  1110.0   240.0  1390.0   238.0  1433.0   227.0  1447.0
GR  226.0  1450.0   227.0  1455.0   239.0  1470.0   240.0  1530.0   245.0  1750.0
GR  246.0  2150.0
NC   0.15    0.15    0.05     0.0     0.0
*     Section 1 of culvert sequence, d/s natural channel
X1   4550       8  1430.0  1470.0   500.0   900.0   750.0     1.0     0.0
GR  250.0  1000.0   245.0  1350.0   242.0  1430.0   228.0  1446.0   228.0  1454.0
GR  242.0  1470.0   245.0  1840.0   250.0  2340.0
NC    0.0     0.0     0.0     0.6     0.8
*     Section 2 of sequence, immediately d/s of culvert
X1   4860       0     0.0     0.0   160.0   360.0   310.0     1.0     0.0
X3     10     0.0     0.0     0.0     0.0     0.0     0.0   245.0   245.0
*    This is the location of the culverts, section 3 of sequence
*    This run is for 4 x 4 foot culvert
SC  1.015      .3     2.6       0       4       4      40     8.1   227.5     227
X1   4900       0     0.0     0.0    40.0    40.0    40.0     1.0     0.0
X2    0.0     0.0       2   231.5   245.0     0.0       0     0.0     0.0
X3     10     0.0     0.0     0.0     0.0     0.0     0.0   245.0   245.0
BT     -4    1175   247.5   247.5    1350     245     245    1840     245     245
BT           2090   247.5   247.5
*    This is section 4 of sequence, u/s of culvert, natural channel
X1   5060       0     0.0     0.0   160.0   160.0   160.0     1.0     0.0
NC    0.0     0.0     0.0     0.1     0.3
NH      4    0.08  1000.0    0.15  1432.0    0.05  1468.0    0.15  2700.0
X1   5650      10  1432.0  1468.0   535.0   620.0   590.0     1.0     0.0
GR  252.0   450.0   250.0  1000.0   245.0  1432.0   232.0  1447.0   230.0  1450.0
GR  231.0  1454.0   244.0  1468.0   245.0  1620.0   250.0  2210.0   255.0  2700.0
NH      4    0.12  1240.0    0.08  1430.0    0.05  1467.0    0.15  2850.0
X1   6350       9  1430.0  1467.0   650.0   700.0   700.0     1.0     0.0
GR  253.0   450.0   250.0  1240.0   245.0  1430.0   233.0  1445.0   231.0  1450.0
GR  232.0  1453.0   245.0  1467.0   250.0  2350.0   255.0  2850.0
EJ
T1       Workshop No. 7, Solutions
T2       Special Culvert Example, Adapted from BOSS Corp. Culvert Problem 8
T3       Sample Creek, Q = 100 CFS, WEST Consultants, Inc., D. Williams
J1      0       3       0       0       0       0     0.0     0.0     229
J2      2       0      -1     0.0     0.0     0.0     0.0     0.0     0.0
T1       Workshop No. 7, Solutions
T2       Special Culvert Example, Adapted from BOSS Corp. Culvert Problem 8
T3       Sample Creek, Q = 200 CFS, WEST Consultants, Inc., D. Williams
J1      0       4       0       0       0       0     0.0             231
J2      3       0      -1     0.0     0.0     0.0     0.0     0.0     0.0
T1       Workshop No. 7, Solutions
T2       Special Culvert Example, Adapted from BOSS Corp. Culvert Problem 8
T3       Sample Creek, Q =  300 CFS, WEST Consultants, Inc., D. Williams
J1      0       5       0       0       0       0     0.0             232
J2     15       0      -1     0.0     0.0     0.0     0.0     0.0     0.0
ER
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RESULTS OF BOX CULVERT, 50 CFS

4860.000	2.95	230.95	.00	.00	230.98	.03	.41	.01	242.00
50.0	.0	50.0	.0	.0	33.5	.0	1.2	.6	242.00
.31	.00	1.49	.00	.000	.050	.000	.000	228.00	1442.63
.001017	160.	310.	360.	2	0	0	.00	14.74	1457.37

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

SPECIAL CULVERT

SC CUNO	CUNV	ENTLC	COFQ	RDLEN	RISE	SPAN	CULVLN	CHRT	SCL	ELCHU	ELCHD
1	.015	.30	2.60	.00	4.00	4.00	40.00	8	1	227.50	227.00

CHART 8 - BOX CULVERT WITH FLARED WINGWALLS; NO INLET TOP EDGE BEVEL
SCALE 1 - WINGWALLS FLARED 30 TO 75 DEGREES

*SECNO 4900.000

SPECIAL CULVERT OUTLET CONTROL
EGIC = 230.177 EGOC = 230.717 PCWSE= 230.947 ELTRD= 245.000

5150, EG OF 230.72 LESS THAN XEG OF 230.98
SPECIAL CULVERT

EGIC	EGOC	H4	QWEIR	QCULV	VCH	ACULV	ELTRD	WEIRLN
230.18	230.72	.00	0.	50.	1.492	16.0	245.00	0.

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 245.00 ELREA= 245.00

4900.000	2.95	230.95	.00	.00	230.98	.03	.00	.00	242.00
50.0	.0	50.0	.0	.0	33.5	.0	1.2	.6	242.00
.32	.00	1.49	.00	.000	.050	.000	.000	228.00	1442.63
.001015	40.	40.	40.	3	0	0	.00	14.74	1457.37

*SECNO 5060.000

5060.000	3.10	231.10	.00	.00	231.13	.03	.15	.00	242.00
50.0	.0	50.0	.0	.0	35.9	.0	1.3	.7	242.00
.35	.00	1.39	.00	.000	.050	.000	.000	228.00	1442.45
.000837	160.	160.	160.	0	0	0	.00	15.11	1457.55

RESULTS OF BOX CULVERT, 100 CFS

```
   4860.000      4.16    232.16       .00       .00    232.22       .05       .43       .01    242.00
      100.0        .0     100.0        .0        .0      53.2        .0       2.1        .8    242.00
        .25       .00      1.88       .00      .000      .050      .000      .000    228.00   1441.23
    .001130      160.      310.      360.         1         0         0       .00     17.53   1458.77


 SPECIAL CULVERT

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     SECNO      DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
     Q          QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
     TIME       VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
     SLOPE      XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST


 SC  CUNO       CUNV      ENTLC     COFQ      RDLEN     RISE      SPAN      CULVLN    CHRT      SCL        ELCHU     ELCHD
      1          .015       .30      2.60       .00      4.00      4.00     40.00      8         1        227.50    227.00

 CHART  8 - BOX CULVERT WITH FLARED WINGWALLS; NO INLET TOP EDGE BEVEL
 SCALE  1 - WINGWALLS FLARED 30 TO 75 DEGREES

 *SECNO 4900.000

 SPECIAL CULVERT OUTLET CONTROL
 EGIC =     231.831  EGOC =     233.109  PCWSE=     232.161  ELTRD=     245.000


 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.45

 SPECIAL CULVERT

       EGIC      EGOC         H4     QWEIR     QCULV       VCH     ACULV     ELTRD    WEIRLN
     231.83    233.11        .89        0.      100.     1.427      16.0    245.00        0.



 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=       245.00 ELREA=       245.00

   4900.000      5.08    233.08       .00       .00    233.11       .03       .89       .00    242.00
      100.0        .0     100.0        .0        .0      70.1        .0       2.2        .8    242.00
        .26       .00      1.43       .00      .000      .050      .000      .000    228.00   1440.20
    .000535       40.       40.       40.         2         0         0       .00     19.60   1459.80


 *SECNO 5060.000
   5060.000      5.16    233.16       .00       .00    233.19       .03       .08       .00    242.00
      100.0        .0     100.0        .0        .0      71.8        .0       2.4        .8    242.00
        .29       .00      1.39       .00      .000      .050      .000      .000    228.00   1440.10
    .000501      160.      160.      160.         2         0         0       .00     19.80   1459.90
```

RESULTS OF BOX CULVERT, 200 CFS

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 4860.000      5.86    233.86      .00       .00    233.95      .08       .45       .01    242.00
    200.0        .0     200.0       .0        .0      86.2       .0       3.7       1.0    242.00
      .21       .00      2.32      .00      .000      .050     .000      .000    228.00   1439.30
  .001222      160.      310.     360.         2         0        0       .00     21.40   1460.70


SPECIAL CULVERT

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    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST


SC  CUNO      CUNV      ENTLC     COFQ      RDLEN     RISE      SPAN      CULVLN    CHRT      SCL       ELCHU     ELCHD
     1         .015       .30      2.60       .00      4.00      4.00     40.00     8         1       227.50    227.00

CHART  8 - BOX CULVERT WITH FLARED WINGWALLS; NO INLET TOP EDGE BEVEL
SCALE  1 - WINGWALLS FLARED 30 TO 75 DEGREES

*SECNO 4900.000

SPECIAL CULVERT OUTLET CONTROL
EGIC =    236.731  EGOC =    237.653  PCWSE=    233.862  ELTRD=    245.000


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  2.76

SPECIAL CULVERT

     EGIC      EGOC        H4     QWEIR     QCULV       VCH     ACULV     ELTRD    WEIRLN
   236.73    237.65      3.71        0.      200.     1.090      16.0    245.00        0.


3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=      245.00 ELREA=       245.00

 4900.000      9.63    237.63      .00       .00    237.65      .02      3.71       .00    242.00
    200.0        .0     200.0       .0        .0     183.4       .0       3.8       1.0    242.00
      .23       .00      1.09      .00      .000      .050     .000      .000    228.00   1434.98
  .000161       40.       40.      40.         1         0        0       .00     30.04   1465.02


*SECNO 5060.000
 5060.000      9.66    237.66      .00       .00    237.68      .02       .03       .00    242.00
    200.0        .0     200.0       .0        .0     183.9       .0       4.5       1.1    242.00
      .27       .00      1.09      .00      .000      .050     .000      .000    228.00   1434.96
  .000160      160.      160.     160.         2         0        0       .00     30.08   1465.04
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RESULTS OF BOX CULVERT, 300 CFS

4860.000	7.08	235.08	.00	.00	235.19	.11	.46	.02	242.00
300.0	.0	300.0	.0	.0	113.9	.0	4.8	1.1	242.00
.19	.00	2.63	.00	.000	.050	.000	.000	228.00	1437.91
.001296	160.	310.	360.	2	0	0	.00	24.18	1462.09

SPECIAL CULVERT

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SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

SC	CUNO	CUNV	ENTLC	COFQ	RDLEN	RISE	SPAN	CULVLN	CHRT	SCL	ELCHU	ELCHD
	1	.015	.30	2.60	.00	4.00	4.00	40.00	8	1	227.50	227.00

CHART 8 - BOX CULVERT WITH FLARED WINGWALLS; NO INLET TOP EDGE BEVEL
SCALE 1 - WINGWALLS FLARED 30 TO 75 DEGREES

*SECNO 4900.000

SPECIAL CULVERT INLET CONTROL
EGIC = 244.250 EGOC = 243.610 PCWSE= 235.080 ELTRD= 245.000

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 6.29

SPECIAL CULVERT

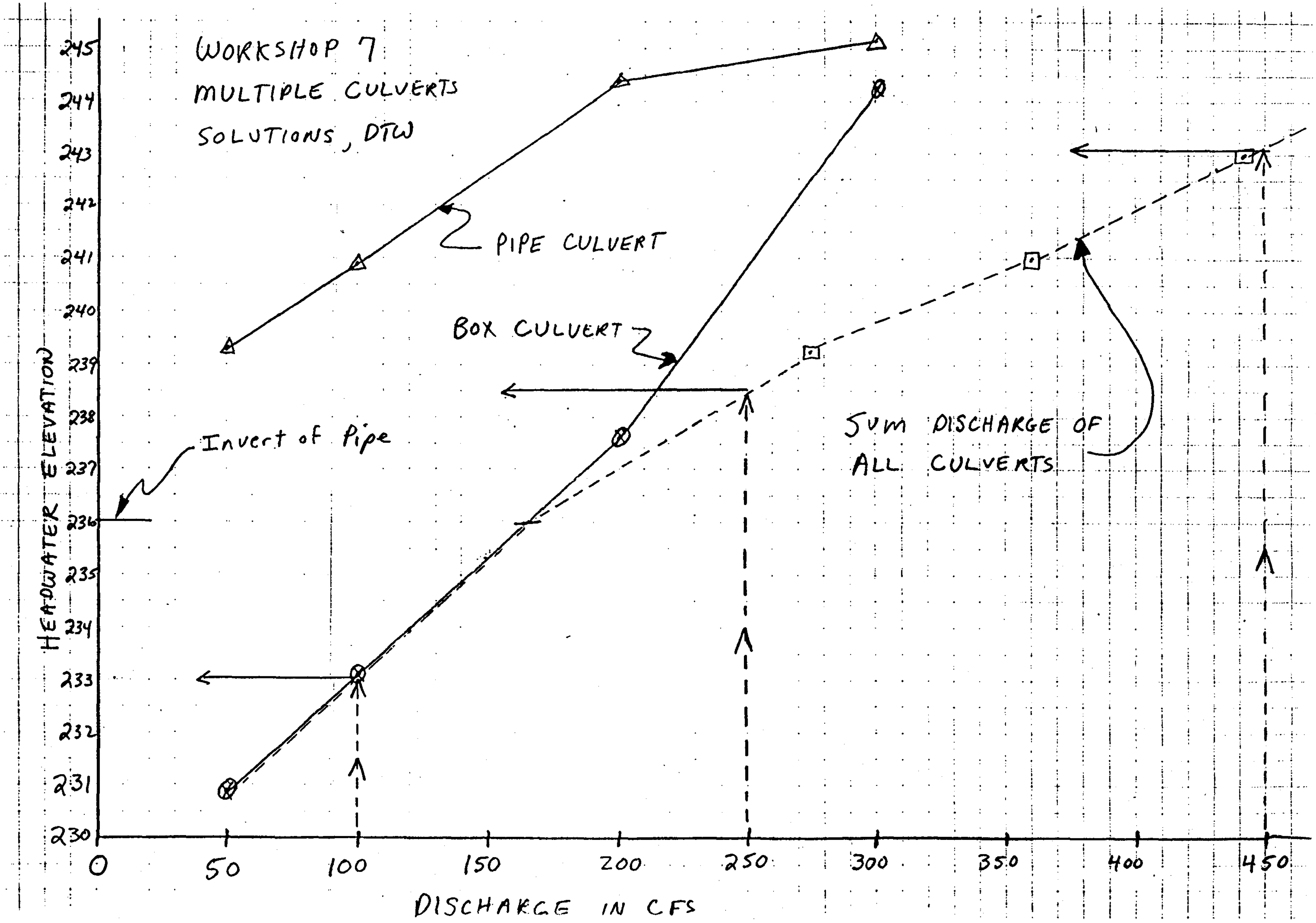
EGIC	EGOC	H4	QWEIR	QCULV	VCH	ACULV	ELTRD	WEIRLN
244.25	243.61	9.06	0.	300.	.704	16.0	245.00	0.

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 245.00 ELREA= 245.00

4900.000	16.24	244.24	.00	.00	244.25	.01	9.06	.00	242.00
300.0	.0	300.0	.0	.0	426.0	.0	5.1	1.1	242.00
.21	.00	.70	.00	.000	.050	.000	.000	228.00	1430.00
.000033	40.	40.	40.	0	0	0	.00	40.00	1470.00

*SECNO 5060.000

5060.000	16.25	244.25	.00	.00	244.26	.01	.00	.00	242.00
300.0	3.8	278.4	17.8	67.5	426.0	312.1	7.3	1.9	242.00
.28	.06	.65	.06	.150	.050	.150	.000	228.00	1370.01
.000028	160.	160.	160.	2	0	0	.00	377.47	1747.47



WORKSHOP 7
MULTIPLE CULVERTS
SOLUTIONS, DTW
PIPE CULVERT
BOX CULVERT
SUM DISCHARGE OF ALL CULVERTS
Invert of Pipe
HEADWATER ELEVATION
245
244
243
242
241
240
239
238
237
236
235
234
233
232
231
230
0
50
100
150
200
250
300
350
400
450
DISCHARGE IN CFS

```
T1       Workshop No. 7, Solutions, Combined culverts using X5 records
T2       Special Culvert Example, Adapted from BOSS Corp. Culvert Problem 8
T3       Sample Creek, Q = 100 CFS, WEST Consultants, Inc., D. Williams
J1      0       2       0       0       0       0     0.0             229
QT      3     100     250     450
NC   0.12    0.12    0.06     0.1     0.3
NH      4    0.15  1435.0    0.05  1472.0    0.15  2250.0    0.12  2850.0
X1   2900      11  1435.0  1472.0   750.0   600.0   850.0     1.0     0.0
GR 248.0   950.0   245.0  1160.0   240.0  1370.0   236.0  1435.0   224.0
1450.0
GR 225.0  1455.0   236.0  1472.0   240.0  1570.0   245.0  1850.0   246.0
2250.0
GR 248.0  2850.0
NC   0.15    0.15    0.05     0.0     0.0
X1   3800      11  1433.0  1470.0  1050.0   750.0   900.0     1.0     0.0
GR 250.0  1040.0   245.0  1110.0   240.0  1390.0   238.0  1433.0   227.0
1447.0
GR 226.0  1450.0   227.0  1455.0   239.0  1470.0   240.0  1530.0   245.0
1750.0
GR 246.0  2150.0
NC   0.15    0.15    0.05     0.0     0.0
*     Section 1 of culvert sequence, d/s natural channel
X1   4550       8  1430.0  1470.0   500.0   900.0   750.0     1.0     0.0
GR 250.0  1000.0   245.0  1350.0   242.0  1430.0   228.0  1446.0   228.0
1454.0
GR 242.0  1470.0   245.0  1840.0   250.0  2340.0
NC    0.0     0.0     0.0     0.6     0.8
*     Section 2 of sequence, immediately d/s of culvert
X1   4860       0     0.0     0.0   160.0   360.0   310.0     1.0     0.0
X3     10     0.0     0.0     0.0     0.0     0.0     0.0   245.0   245.0
*     This is the location of the culverts, section 3 of sequence
*     This run is for combined culverts using X5 records
*     Keep SC record in because the BT records are left in to simulate the road
*     and the stations are not on the GR records
SC   1.02      .8     2.6       0       5              40     2.3     236
235
X1   4900       0     0.0     0.0    40.0    40.0    40.0     1.0     0.0
X2    0.0     0.0       2     240   245.0     0.0       0     0.0     0.0
X3     10     0.0     0.0     0.0     0.0     0.0     0.0   245.0   245.0
*     Elevations obtained from headwater versus elevation graph obtained from
*     combining individual run results of the pipe and box culvert
X5      3   233.1   238.5   243.1
BT     -4    1175   247.5   247.5    1350     245     245    1840     245
245
BT           2090   247.5   247.5
*     This is section 4 of sequence, u/s of culvert, natural channel
X1   5060       0     0.0     0.0   160.0   160.0   160.0     1.0     0.0
NC    0.0     0.0     0.0     0.1     0.3
NH      4    0.08  1000.0    0.15  1432.0    0.05  1468.0    0.15  2700.0
X1   5650      10  1432.0  1468.0   535.0   620.0   590.0     1.0     0.0
GR 252.0   450.0   250.0  1000.0   245.0  1432.0   232.0  1447.0   230.0
1450.0
GR 231.0  1454.0   244.0  1468.0   245.0  1620.0   250.0  2210.0   255.0
2700.0
NH      4    0.12  1240.0    0.08  1430.0    0.05  1467.0    0.15  2850.0
X1   6350       9  1430.0  1467.0   650.0   700.0   700.0     1.0     0.0
GR 253.0   450.0   250.0  1240.0   245.0  1430.0   233.0  1445.0   231.0
1450.0
GR 232.0  1453.0   245.0  1467.0   250.0  2350.0   255.0  2850.0
EJ
T1       Workshop No. 7, Solutions
T2       Special Culvert Example, Adapted from BOSS Corp. Culvert Problem 8
T3       Sample Creek, Q = 250 CFS, WEST Consultants, Inc., D. Williams
J1      0       3       0     0       0       0       0.0     0.0   231.5
J2      2       0      -1     0.0     0.0     0.0     0.0     0.0     0.0
T1       Workshop No. 7, Solutions
T2       Special Culvert Example, Adapted from BOSS Corp. Culvert Problem 8
T3       Sample Creek, Q = 200 CFS, WEST Consultants, Inc., D. Williams
J1      0       4       0     0       0       0       0.0             233
J2     15       0      -1     0.0     0.0     0.0     0.0     0.0     0.0
ER
```

THIS RUN EXECUTED 13FEB92 10:31:20

****
HEC-2 WATER SURFACE PROFILES

Version 4.6.2; May 1991
****

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

Sample Creek, Q = 100 CF

SUMMARY PRINTOUT TABLE 150

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
	2900.000	.00	.00	.00	224.00	100.00	229.00	.00	229.06	13.32	1.98	50.49	27.40
	2900.000	.00	.00	.00	224.00	250.00	231.50	.00	231.59	12.43	2.43	102.80	70.92
	2900.000	.00	.00	.00	224.00	450.00	233.00	.00	233.15	16.83	3.16	142.58	109.70
	3800.000	900.00	.00	.00	226.00	100.00	230.36	.00	230.44	17.63	2.22	45.14	23.82
	3800.000	900.00	.00	.00	226.00	250.00	232.76	.00	232.87	16.23	2.72	91.84	62.05
	3800.000	900.00	.00	.00	226.00	450.00	234.56	.00	234.73	18.17	3.29	136.66	105.58
	4550.000	750.00	.00	.00	228.00	100.00	231.69	.00	231.77	17.85	2.22	45.09	23.67
	4550.000	750.00	.00	.00	228.00	250.00	234.01	.00	234.13	17.33	2.80	89.32	60.06
	4550.000	750.00	.00	.00	228.00	450.00	235.93	.00	236.10	18.37	3.33	135.33	105.00
	4860.000	310.00	.00	.00	228.00	100.00	232.16	.00	232.22	11.30	1.88	53.25	29.74
	4860.000	310.00	.00	.00	228.00	250.00	234.51	.00	234.60	12.64	2.49	100.41	70.32
	4860.000	310.00	.00	.00	228.00	450.00	236.48	.00	236.62	13.97	3.00	149.91	120.42
*	4900.000	40.00	100000.00	100000.00	228.00	100.00	233.10	.00	233.13	5.25	1.42	70.53	43.62
*	4900.000	40.00	100000.00	100000.00	228.00	250.00	238.50	.00	238.52	1.75	1.19	210.00	188.88
*	4900.000	40.00	100000.00	100000.00	228.00	450.00	243.10	.00	243.12	1.08	1.18	380.00	433.58
	5060.000	160.00	.00	.00	228.00	100.00	233.18	.00	233.21	4.93	1.39	72.18	45.02
	5060.000	160.00	.00	.00	228.00	250.00	238.53	.00	238.55	1.73	1.19	210.90	189.97
	5060.000	160.00	.00	.00	228.00	450.00	243.12	.00	243.14	1.04	1.17	474.58	441.30
*	5650.000	590.00	.00	.00	230.00	100.00	233.77	.00	233.98	64.47	3.65	27.43	12.45
*	5650.000	590.00	.00	.00	230.00	250.00	238.69	.00	238.76	9.02	2.20	113.45	83.26
*	5650.000	590.00	.00	.00	230.00	450.00	243.20	.00	243.26	3.99	1.88	239.99	225.26
*	6350.000	700.00	.00	.00	231.00	100.00	235.91	.00	235.99	15.96	2.16	46.40	25.03
	6350.000	700.00	.00	.00	231.00	250.00	239.32	.00	239.39	8.99	2.20	113.83	83.39
	6350.000	700.00	.00	.00	231.00	450.00	243.49	.00	243.55	4.31	1.93	233.30	216.70

1

Sample Creek, Q = 100 CF

SUMMARY PRINTOUT TABLE 150

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
	2900.000	100.00	229.00	.00	.00	.00	17.43	.00
	2900.000	250.00	231.50	2.50	.00	.00	24.42	.00
	2900.000	450.00	233.00	1.50	.00	.00	28.61	.00
	3800.000	100.00	230.36	.00	1.36	.00	16.48	900.00
	3800.000	250.00	232.76	2.39	1.26	.00	22.52	900.00
	3800.000	450.00	234.56	1.81	1.56	.00	27.08	900.00
	4550.000	100.00	231.69	.00	1.33	.00	16.44	750.00
	4550.000	250.00	234.01	2.32	1.25	.00	21.73	750.00
	4550.000	450.00	235.93	1.92	1.37	.00	26.13	750.00
	4860.000	100.00	232.16	.00	.47	.00	17.53	310.00
	4860.000	250.00	234.51	2.34	.50	.00	22.87	310.00
	4860.000	450.00	236.48	1.97	.54	.00	27.37	310.00
*	4900.000	100.00	233.10	.00	.94	.00	19.66	40.00
*	4900.000	250.00	238.50	5.40	3.99	.00	32.00	40.00
*	4900.000	450.00	243.10	4.60	6.62	.00	40.00	40.00
	5060.000	100.00	233.18	.00	.08	.00	19.85	160.00
	5060.000	250.00	238.53	5.34	.03	.00	32.06	160.00
	5060.000	450.00	243.12	4.59	.02	.00	207.78	160.00
*	5650.000	100.00	233.77	.00	.59	.00	12.04	590.00
*	5650.000	250.00	238.69	4.91	.16	.00	23.00	590.00
*	5650.000	450.00	243.20	4.51	.08	.00	33.07	590.00
*	6350.000	100.00	235.91	.00	2.14	.00	15.86	700.00
	6350.000	250.00	239.32	3.40	.63	.00	23.78	700.00
	6350.000	450.00	243.49	4.17	.29	.00	33.49	700.00

1

WORKSHOP NO. 8

FLOODWAY DETERMINATION, OPTIMIZATION, AND PLOTTING

SOLUTIONS

WORKSHOP 8
FLOODWAY SOLUTIONS
METHODS 4 & 5 OPTIMIZED FLOODWAY
TABLE 115

Floodway width summary: SAMPLE CREEK
Profile No. 2

Section Number	Elevation Increase	Top Width	Left Sta Encroach Station	Left Sta From Center	Center Station	Right Sta From Center	Right Sta Encroach Station
1.700	1.00	46.60	1316.10	23.30	1339.40	23.30	1362.70
1.800	1.00	171.30	942.50	18.75	961.25	152.55	1113.80
1.900	.97	239.87	604.40	11.80	616.20	228.07	844.27
1.910	.61	241.06	576.60	25.70	602.30	215.36	817.66
1.920	.58	212.97	602.80	6.00	608.80	206.97	815.77
1.930	.76	216.56	602.80	6.00	608.80	210.56	819.36
1.940	.73	213.45	576.60	25.70	602.30	187.75	790.05
1.980	.82	198.44	684.80	9.45	694.25	188.99	883.24
2.000	.47	179.64	721.90	15.90	737.80	163.74	901.54
2.020	.51	165.35	736.70	13.35	750.05	152.00	902.05
2.080	.68	194.28	1112.30	13.70	1126.00	180.58	1306.58
3.000	.67	142.39	1112.30	12.75	1125.05	129.64	1254.69
3.010	.08	124.72	611.90	12.95	624.85	111.77	736.62
3.020	.55	126.63	589.10	28.00	617.10	98.63	715.73
3.030	.80	125.65	601.40	21.60	623.00	104.05	727.05
3.060	.86	98.84	476.40	11.65	488.05	87.19	575.24

WORKSHOP 8
FLOODWAY SOLUTIONS
USER SPECIFIED (METHOD 1) FLOODWAY
TABLE 115

Floodway width summary: SAMPLE CREEK
Profile No. 3

Section Number	Elevation Increase	Top Width	Encroach Station	Left Sta From Center	Center Station	Right Sta From Center	Encroach Station
1.700	1.00	46.60	1316.10	23.30	1339.40	23.30	1362.70
1.800	.62	171.30	942.50	18.75	961.25	152.55	1113.80
1.900	.60	239.87	604.40	11.80	616.20	228.07	844.27
1.910	.56	268.40	576.60	25.70	602.30	242.70	845.00
1.920	.54	269.00	576.00	32.80	608.80	236.20	845.00
1.930	.58	255.00	575.00	33.80	608.80	221.20	830.00
1.940	.62	253.40	576.60	25.70	602.30	227.70	830.00
1.980	.79	198.44	684.80	9.45	694.25	188.99	883.24
2.000	.48	179.64	721.90	15.90	737.80	163.74	901.54
2.020	.51	165.35	736.70	13.35	750.05	152.00	902.05
2.080	.68	194.28	1112.30	13.70	1126.00	180.58	1306.58
3.000	.67	142.39	1112.30	12.75	1125.05	129.64	1254.69
3.010	.08	124.72	611.90	12.95	624.85	111.77	736.62
3.020	.55	126.63	589.10	28.00	617.10	98.63	715.73
3.030	.80	125.65	601.40	21.60	623.00	104.05	727.05
3.060	.56	162.24	413.00	75.05	488.05	87.19	575.24

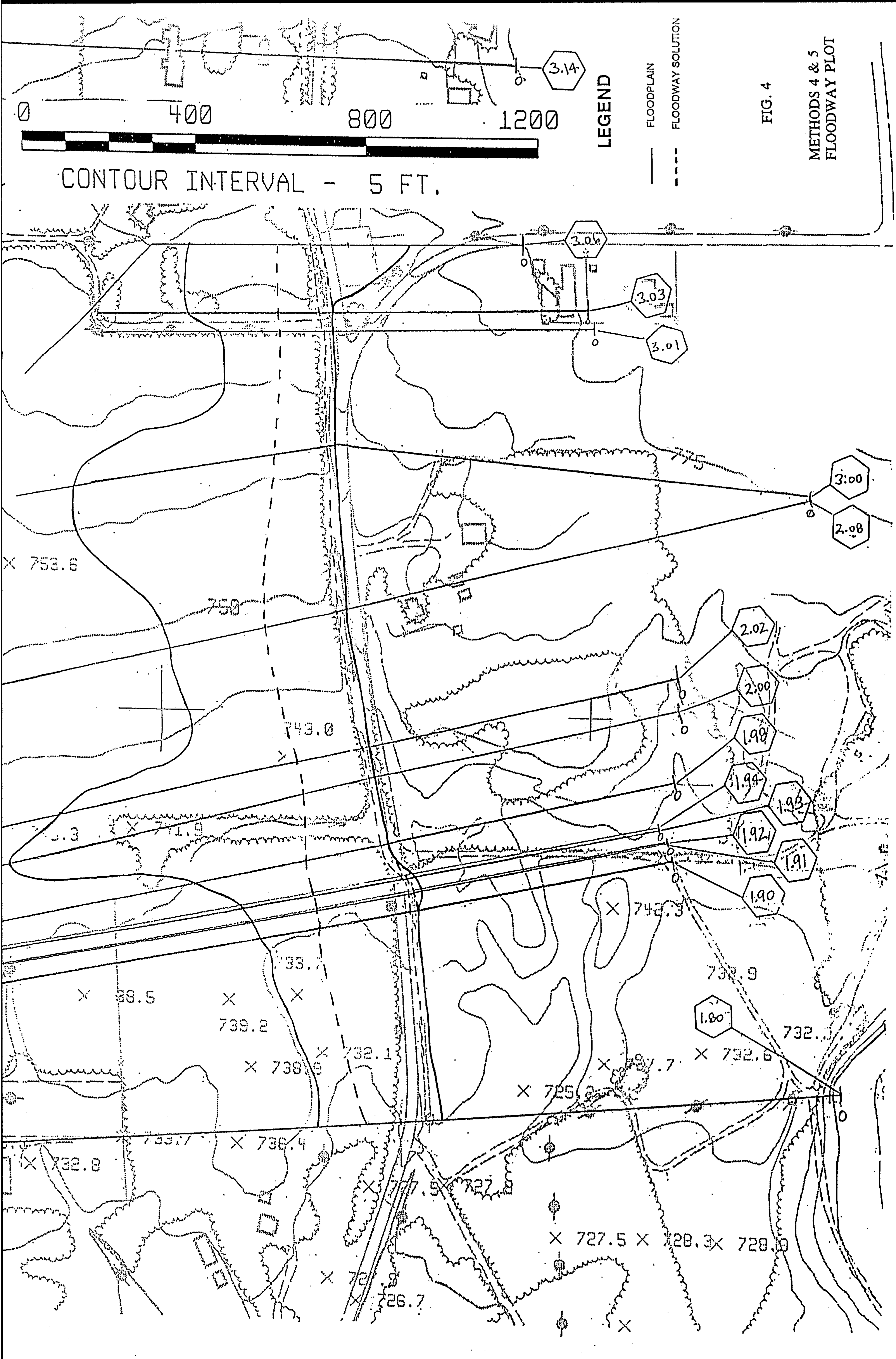


FIG. 4

METHODS 4 & 5
FLOODWAY PLOT

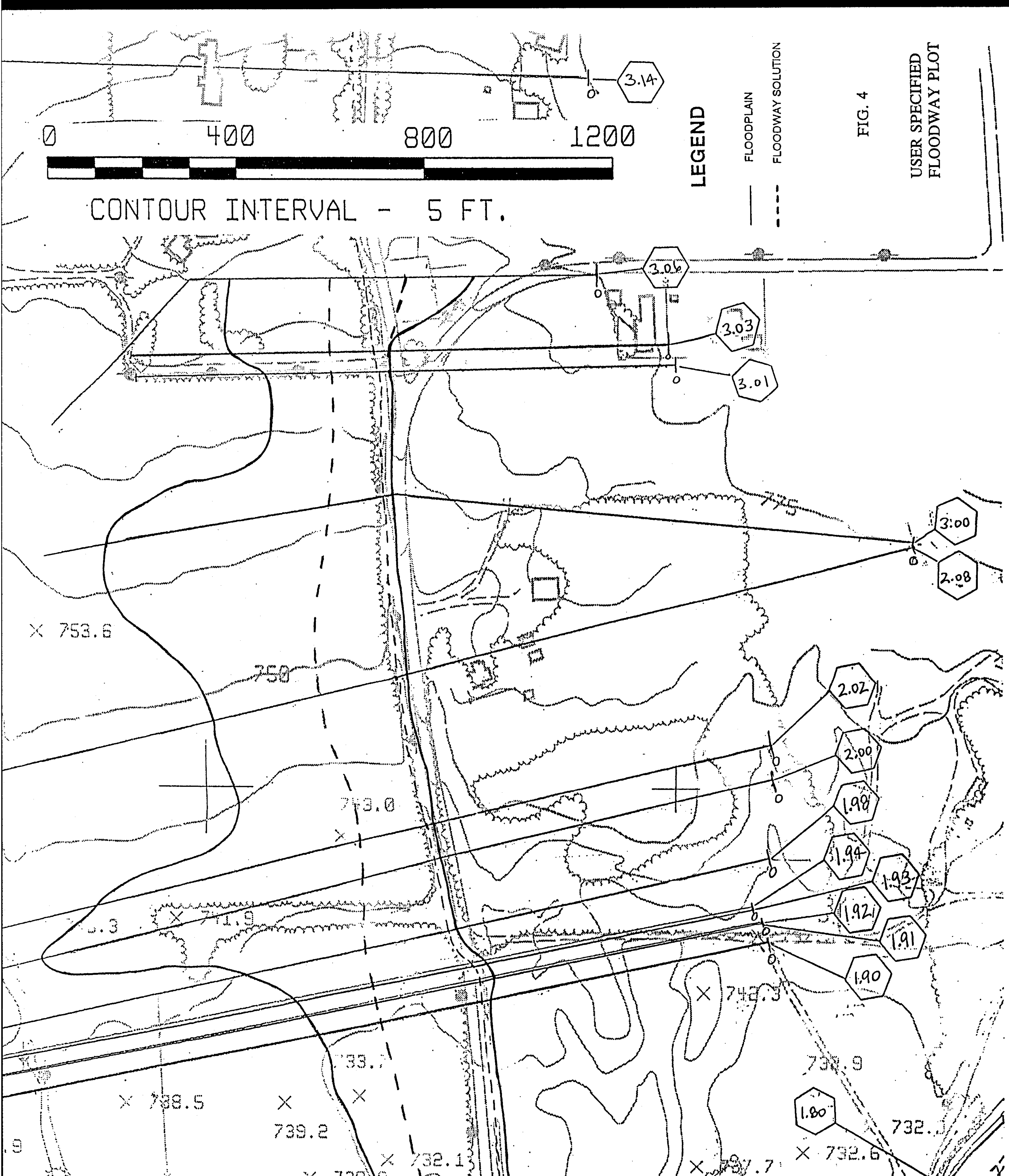


FIG. 4

USER SPECIFIED FLOODWAY PLOT

OUTPUT ANALYSIS

WORKSHOP 5 SOLUTION

Analysis of Problem

For bridge section, the output shows that the flow is by weir and low flow. This is correct since the water surface elevation at the bridge is 106.92, which is lower than ELLC (elevation of the low cord - start of pressure flow computations), which is 108.7 feet.

From the plot of cross section 62, we can see that the water surface elevation is much higher than the ELLC. A glance at the profile shows a large increase in the water elevation from cross sections 61 to 62. This is also shown in Table 150, which shows an increase of 13.61 for DIFWSX (difference in the water surface elevation from the previous cross section). It does seem reasonable that the water would "dive down" over 13 feet from cross section 62 and clear the low cord of the bridge in a distance of only 15 feet. Also, the increase in the water surface elevation from cross section 61 to 62 does not appear reasonable, given the available flow area of the right overbank area (approach road).

We suspect that BAREA for pressure flow may have been erroneously input but it is 1200 square feet as compared to TRAPEZOID AREA of 1216 square feet. Note that WEIRLN (weir length) at the bridge is 422 feet but looking at the plot of the cross section, the top width of the water is much greater than this. Also, look at Table 150, which shows a top width of 1400.15 for cross section 62 - this much greater than 422 feet. Is it reasonable for the top width to change this much in such a short distance?

The ELTRD (elevation of the top of the road to compute weir flow) from the X3 record is 97.31 feet. This appears to be the elevation of the road on the right side of the bridge but we suspect that the elevation for weir flow to start should be about 94 feet, which is the low point of the right approach road. The plot shows that the BT records represented the available area for weir flow only to station 1355 (right edge of the bridge) - also verified by the last station on the BT records as shown in the input. We suspect that the weir flow limit should extend to the right significantly beyond this point.

Solution

We can solve this problem in two ways. One is to adjust the BT records to extend the limits of the weir and change ELTRD to 94.4 feet, which is the lowest elevation of the right approach road. The results of these changes are shown in the following solution. Note that the increase in the water surface elevation from cross section 61 to 62 is now 1.28 feet and the weir length is 890 feet - much closer to the top width of 1178.98 feet at cross section 62.

The following is a better solution but we needed the results of the first solution. From the output of the solution, there is still a low flow condition and there is approximately 8 feet of water over the approach road. Note also that the downstream cross section (61) water surface elevation is 101.25 and the water surface elevation at the bridge is 101.42 feet. The weir flow over the approach road is significantly submerged, suggesting that conveyance flow is more appropriate for this area. From earlier discussions, the normal bridge routine should be used for conditions of low flow and conveyance flow, which is this situation.

OUTPUT ANALYSIS WORKSHOP 5
ADVANCED WATER SURFACE PROFILE COMPUTATIONS
USING HEC2

HEC-2 INPUT SOLUTION

```
SB  1.25    1.56     3.0       0      20    10.8    1200     1.5   83.13   82.07
*        3RD CROSS-SECTION IN BRIDGE SERIES
*        BRIDGE SECTION
X1    62      68 1065.03 1194.45    40.0    40.0    40.0     0.0     0.0
X2                     1   108.7    94.4               0
X3    10       0       0       0       0       0       0       0       0
BT   -30     917     117       0     941     114       0     959     113       0
BT          1000  111.47       0    1010     111       0    1115   109.3       0
BT          1280   106.8       0  1355.2   97.31       0 1412.63   94.41       0
BT          1494   94.66       0    1530   94.85       0    1596   95.21       0
BT          1665   95.54       0    1777   96.58       0    1842   97.14       0
BT          1892   97.57       0    1951   97.78       0    1951   98.08       0
BT          2029   98.75       0 2090.16   99.30       0 2172.43  100.01       0
BT       2193.87  102.49       0 2199.96  103.27       0 2214.43  105.17       0
BT       2303.13  110.01       0 2334.96  114.97       0 2334.98  114.98
BT       2335.11     115       0 2395.01  119.99       0  2395.1     120       0
GR   117     917     114     941     113     959   112.4     982     112   991.5
GR 104.2    1000  103.05    1010   101.8 1020.96   96.72  1036.2   88.81 1050.22
GR 90.68 1059.69   86.87 1065.03   83.13 1097.65   83.75    1115    84.4 1132.65
GR 83.67  1175.9   86.73 1194.45   86.13 1207.72   89.97 1230.04   85.75 1236.63
GR86.498    1255   87.18 1271.74   88.73    1280   92.49    1300   95.47 1334.99
GR 97.07 1347.39   97.31  1355.2   94.79    1405   94.41 1412.63   94.53    1453
GR 94.66 1494.21   94.66    1496   94.85    1530   95.21    1596   95.52  1653.1
GR95.536    1655   95.62    1665   96.58    1777   97.14    1842   97.57    1892
GR97.776    1915   98.08    1951   98.25    1970   98.44    1993   98.75    2029
GR99.284    2090   99.28 2090.16   99.99 2172.43     100  2173.1  102.57 2193.67
GR102.60 2193.87  103.35 2199.96  103.36    2200     105  2213.1     105 2213.16
GR105.07 2214.43  109.99 2303.07     110  2303.1     110 2303.13  114.97 2334.96
GR114.98 2334.96  114.98 2334.98  114.98    2335     115  2335.1     115 2335.11
GR119.99    2395  119.99 2395.01     120  2395.1
```

OUTPUT ANALYSIS WORKSHOP 5
ADVANCED WATER SURFACE PROFILE COMPUTATIONS
USING HEC2

HEC-2 OUTPUT SOLUTION

```
SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST


*PROF 1

IHLEQ = 1.  THEREFORE FRICTION LOSS (HL) IS CALCULATED AS A FUNCTION OF
PROFILE TYPE, WHICH CAN VARY FROM REACH TO REACH.  SEE DOCUMENTATION FOR
DETAILS.
0

CCHV=     .100 CEHV=     .300
*SECNO 40.000
  40.000     18.17    100.45       .00    100.45    100.83       .38       .00       .00     88.75
 48800.0    2540.1    8002.2   38257.7     815.1    1136.2    8463.0        .0        .0     88.83
     .00      3.12      7.04      4.52      .090      .070      .090      .000     82.28    984.10
 .002942      370.      460.      530.         0         0         0       .00   1260.64   2244.74

*SECNO 50.000
  50.000     18.82    100.90       .00       .00    101.42       .52       .54       .04     90.59
 48800.0     998.5   11581.0   36220.5     329.8    1458.0    7295.4      34.7       4.5     90.73
     .01      3.03      7.94      4.96      .090      .070      .090      .000     82.08   1014.77
 .004254      140.      130.      160.         2         0         0       .00   1238.13   2252.91

*SECNO 60.000

3265 DIVIDED FLOW

3301 HV CHANGED MORE THAN HVINS

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =   .63

  60.000     18.61    100.68       .00       .00    102.40      1.72       .62       .36     87.92
 48800.0    3345.6   22503.3   22951.1     420.2    1612.1    3886.1      52.3       7.4     88.74
     .01      7.96     13.96      5.91      .090      .070      .090      .000     82.07   1036.81
 .010623       60.       50.      120.         2         0         0       .00   1072.30   2188.57
```

```
CCHV=      .300 CEHV=      .500
*SECNO 61.000

3265 DIVIDED FLOW

1
   07JUL94       18:53:52                                                                                           PAGE     5

     SECNO       DEPTH       CWSEL       CRIWS       WSELK       EG          HV          HL          OLOSS       L-BANK ELEV
     Q           QLOB        QCH         QROB        ALOB        ACH         AROB        VOL         TWA         R-BANK ELEV
     TIME        VLOB        VCH         VROB        XNL         XNCH        XNR         WTN         ELMIN       SSTA
     SLOPE       XLOBL       XLCH        XLOBR       ITRIAL      IDC         ICONT       CORAR       TOPWID      ENDST

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.78

    61.000      19.18      101.25         .00         .00      102.59        1.34         .08         .11       87.92
   48800.0     3349.2     20831.1     24619.7       445.7      1666.4      4420.4        54.5         7.8       88.74
       .01       7.51       12.50        5.57        .055        .045        .055        .000       82.07     1035.76
   .003369        15.         15.         15.          3           0           0         .00     1139.01     2191.90

SPECIAL BRIDGE

SB  XK          XKOR        COFQ        RDLEN       BWC         BWP         BAREA       SS          ELCHU       ELCHD
      1.25        1.56        3.00         .00       20.00       10.80     1200.00        1.50       83.13       82.07

*SECNO 62.000
6840, FLOW IS BY WEIR AND LOW FLOW

3301 HV CHANGED MORE THAN HVINS

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.55

3420 BRIDGE W.S.=      101.42 BRIDGE VELOCITY=       10.56      CALCULATED CHANNEL AREA=        670.

  EGPRS       EGLWC        H3         QWEIR        QLOW        BAREA     TRAPEZOID       ELLC       ELTRD        WEIRLN
                                                                            AREA
     108.70      103.15         .16      41395.       7435.       1200.       1216.      108.70       94.40        890.

    62.000      19.41      102.54         .00         .00      103.15         .61         .56         .00       86.87
   48800.0     1717.4     19994.1     27088.4       384.2      2351.6      6712.9        61.8         8.9       86.73
       .01       4.47        8.50        4.04        .055        .045        .055        .000       83.13     1014.46
   .001395        40.         40.         40.          2           0           2         .00     1178.98     2193.44

*SECNO 70.000
    70.000      19.42      102.55         .00         .00      103.17         .61         .02         .00       86.87
   48800.0     1729.0     20093.2     26977.8       385.3      2354.3      6731.3        65.1         9.3       86.73
       .01       4.49        8.53        4.01        .055        .045        .055        .000       83.13     1014.30
   .001403        15.         15.         15.          1           0           0         .00     1179.31     2193.60
```

CCHV= .100 CEHV= .300
*SECNO 80.000

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 1.44

80.000	19.75	103.04	.00	.00	103.44	.40	.25	.02	90.15
48800.0	2286.8	12280.5	34232.7	803.2	2157.9	6899.8	124.4	16.4	90.27
.03	2.85	5.69	4.96	.055	.045	.030	.000	83.29	1012.54
.000678	325.	335.	240.	2	0	0	.00	1248.89	2261.42

THIS RUN EXECUTED 07JUL94 18:53:52

****
HEC-2 WATER SURFACE PROFILES

Version 4.6.2; May 1991
****

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

SWEETWATER RIVER

SUMMARY PRINTOUT TABLE 150

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
	40.000	.00	.00	.00	82.28	48800.00	100.45	.00	100.83	29.42	7.04	10414.35	8996.72
	50.000	130.00	.00	.00	82.08	48800.00	100.90	.00	101.42	42.54	7.94	9083.17	7481.66
*	60.000	50.00	.00	.00	82.07	48800.00	100.68	.00	102.40	106.23	13.96	5918.38	4734.67
*	61.000	15.00	.00	.00	82.07	48800.00	101.25	.00	102.59	33.69	12.50	6532.48	8407.90
*	62.000	40.00	94.40	108.70	83.13	48800.00	102.54	.00	103.15	13.95	8.50	9448.70	13067.68
	70.000	15.00	.00	.00	83.13	48800.00	102.55	.00	103.17	14.03	8.53	9470.83	13027.91
*	80.000	335.00	.00	.00	83.29	48800.00	103.04	.00	103.44	6.78	5.69	9860.86	18742.77

SWEETWATER RIVER

SUMMARY PRINTOUT TABLE 150

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
	40.000	48800.00	100.45	.00	.00	.00	1260.64	.00
	50.000	48800.00	100.90	.00	.45	.00	1238.13	130.00
*	60.000	48800.00	100.68	.00	-.21	.00	1072.30	50.00
*	61.000	48800.00	101.25	.00	.57	.00	1139.01	15.00
*	62.000	48800.00	102.54	.00	1.28	.00	1178.98	40.00
	70.000	48800.00	102.55	.00	.02	.00	1179.31	15.00
*	80.000	48800.00	103.04	.00	.49	.00	1248.89	335.00

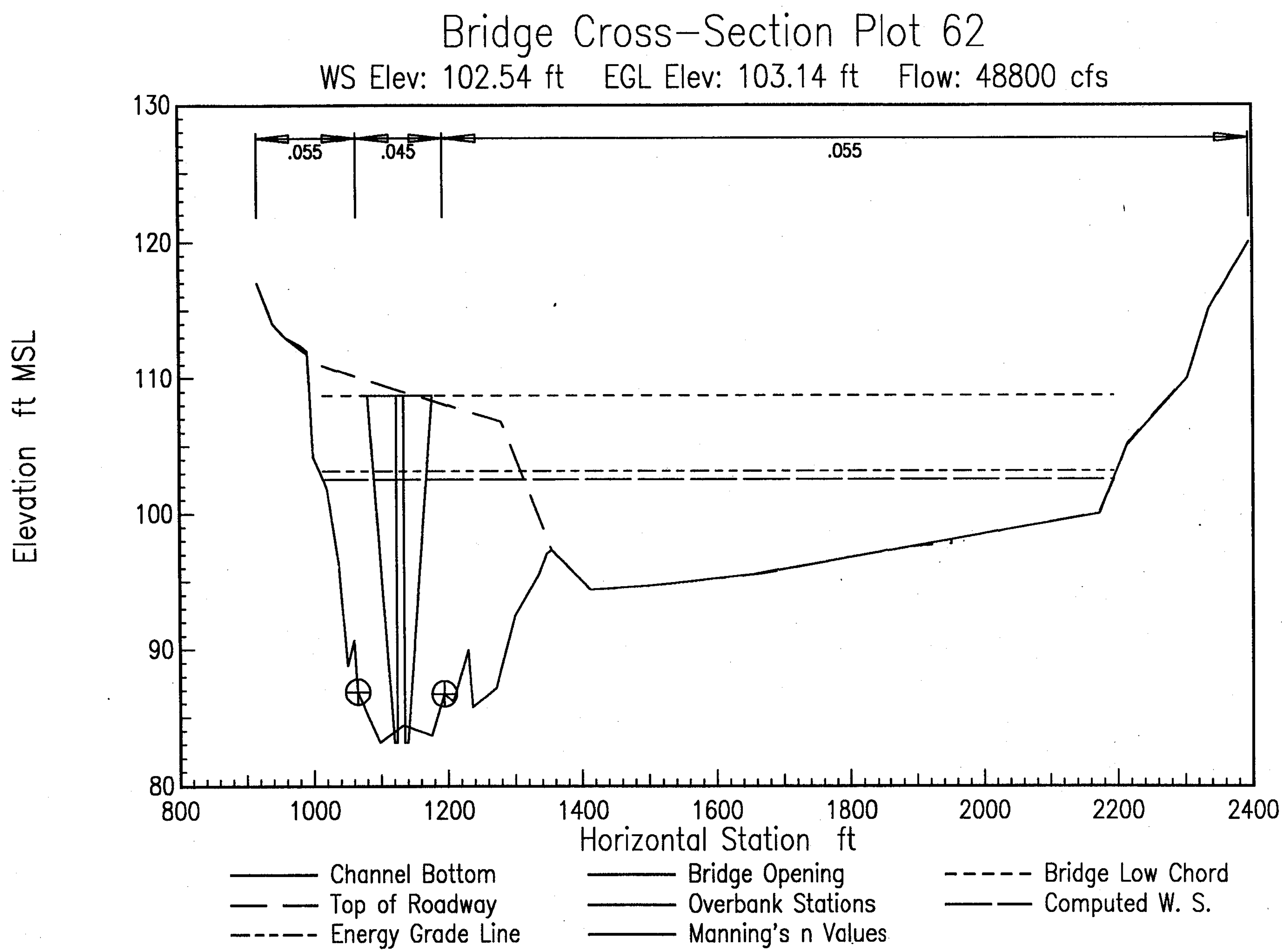
SUMMARY OF ERRORS AND SPECIAL NOTES

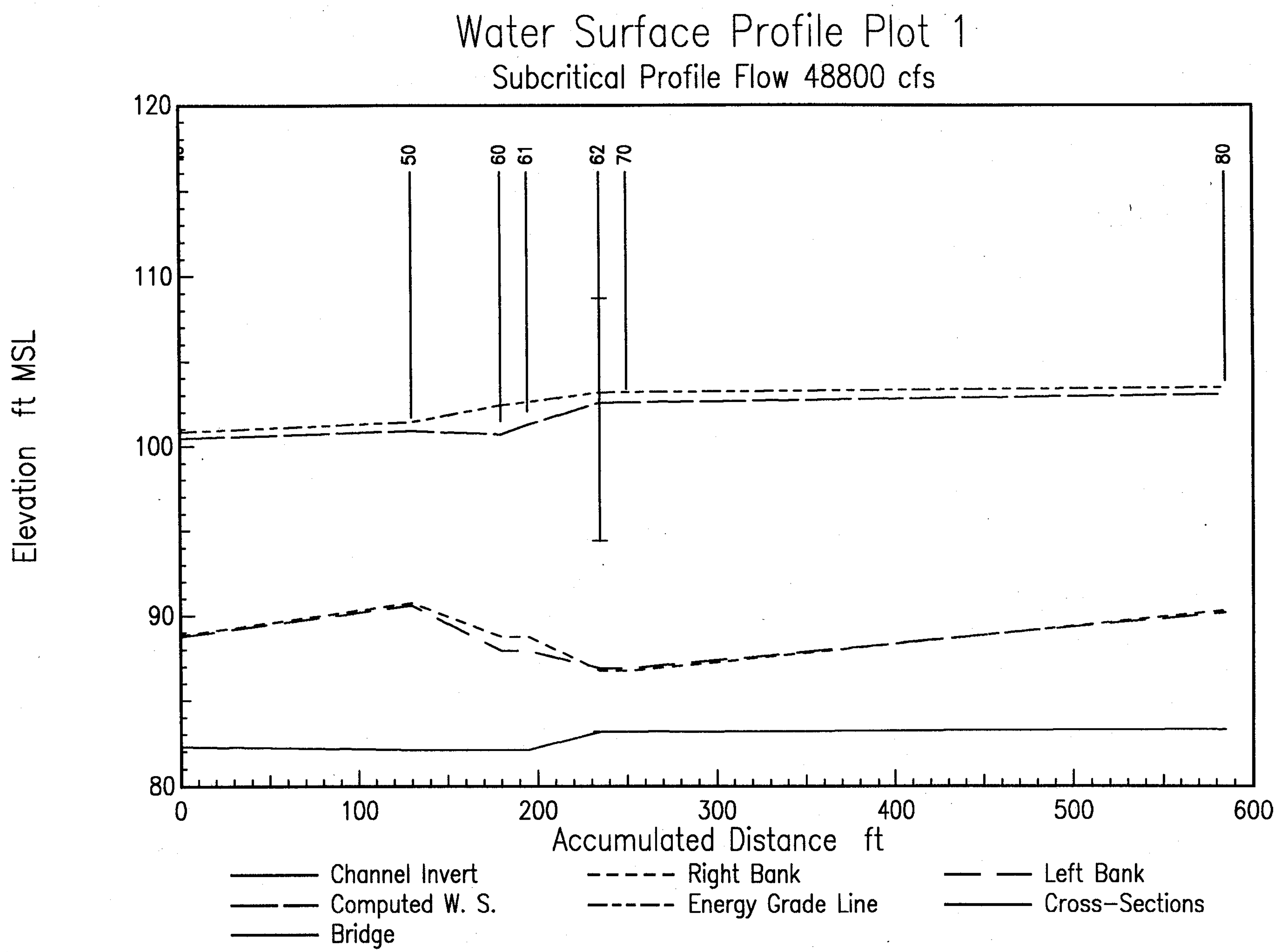
WARNING SECNO= 60.000 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 61.000 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 62.000 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 80.000 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE


Bridge Cross-Section Plot 62
WS Elev: 102.54 ft EGL Elev: 103.14 ft Flow: 48800 cfs
.055
.045
.055
Elevation ft MSL
130
120
110
100
90
80
800
1000
1200
1400
1600
1800
2000
2200
2400
Horizontal Station ft
Channel Bottom
Top of Roadway
Energy Grade Line
Bridge Opening
Overbank Stations
Manning's n Values
Bridge Low Chord
Computed W. S.



Water Surface Profile Plot 1
Subcritical Profile Flow 48800 cfs
Elevation ft MSL
Accumulated Distance ft
120
110
100
90
80
0
100
200
300
400
500
600
50
60
61
62
70
80
Channel Invert
Right Bank
Left Bank
Computed W. S.
Energy Grade Line
Cross-Sections
Bridge

OUTPUT ANALYSIS WORKSHOP NO. 6
ADVANCED HEC-2 SHORT COURSE
SOLUTIONS

1. This is a high energy stream with flows at near critical depth as evidenced by the summary of errors and special notes and a quick look at the stream profile (not included in the handout). Under these conditions, FEMA stipulates that an allowable one foot surcharge in energy be used instead of water elevation.

2. The modeler could not increase the surcharge any higher because the encroachment limits were already at the channel limits. This is evident as shown by Summary Table 110. If the variable STENCL is equal to STCHL, the left encroachment station is at the channel limits and cannot go any further. The same goes for STENCR and STCHR for the right encroachment station.

3. The variable HVINS on the J1.7 is used in the first profile run but not used in the last two. HVINS should not be used for any of the runs. See the notes for usage of interpolated cross sections.

4. The slope area method was used for the first (natural) run (see J1.5 = 0.0198 of first run), which resulted in a WSEL of 1366.19 feet. The second and third run should have increased this elevation by 1 foot (1367.19) for the beginning WSEL on the J1.9 record. Note that if the slope was left on the J1.5 record for the second and third runs, it would have used the slope area method and ignored the WSEL on the J1.9 record.

5. The J6.1 = 1 record was used that allows the program to select the energy slope method by type of profile (S1, S2, M1, M2, etc.). This causes subsequent runs to vary too much. The solution to this problem is discussed in the lectures.

6. NH records were used to subdivide the channel n values at cross section 2.76 and Method 1 shows that the encroachment stations were at the channel limits. This causes a compositing of the channel n value for the encroached condition whereas it may not be the case for the first (natural) run. Also note that the last station on the NH record is not the same as the last station of the cross section. This would have been caught using EDIT2.

7. The NC record just before cross section 2.84 should have contained n values for the channel and overbanks since they were specified on the NH records for the previous cross section and may not appropriate for cross section 2.84.

7. The ET record do not allow encroachment of bridges. In general, this should be allowed by adding 0.01 to the encroachment method (i.e., 10.41 instead of 10.4).

8. One may want to "smooth" out the floodway from cross section 2.84 to 2.87 and 2.880 and 2.897.

OUTPUT ANALYSIS WORKSHOP

PROBLEM SOLUTION 4

Analysis of Problem 4

The input listing for this problem shows five cross sections and special bridge input data. The effective area option is not being requested and the title cards indicate a perched bridge with low overbanks. the bridge cross section is shown on page 5 of the problem.

The output contains error messages at the bridge solution (See 6790 message). The final total weir flow and low flow solution gives a total discharge of 19688, while the input discharge is only 8000. The distribution of flow is bridge flow of 18495 (QPR) and weir flow of 1193 (QWEIR). Obviously the bridge flow is too large.

Comparing the BAREA (1845) with the TRAPEZOID AREA (5520) and the cross section plot (page 5 of problem) would indicate the trapezoidal model may be in error. Also, the area for the solution (See 3420 message) shows an area of 2328. The channel area for the adjacent cross sections (ACH) is 1200 ft^2 downstream and 1230. ft^2 upstream. That also points to the trapezoid as the source of the problem.

Plotting the trapezoid data indicates the trapezoid is defining the bottom of the bridge section. But when the side slopes (SS) of 3.0 are extended the trapezoid area is much larger than the bridge. A better model would be a rectangle with the bottom width (BWC) the full width of the bridge opening and with SS=0.

Solution to Problem 4

A review of the input in the problem solution shows the modified SB card with BWC=50 (SB.5) and SS=0.0 (SB.8). The remainder of the input is the same.

The output (page 5) shows a **WEIR AND LOW FLOW** solution (See 6840 message). However, the energy for the bridge solution (75.43) is lower than the downstream energy (See 6870 message). Because it is not physically possible for the upstream energy to be less than the downstream energy, the program assumes the downstream energy (75.46) as the upstream energy. Therefore, there is no structure loss computed for the bridge section.

Looking at the distribution of flow at the bridge (QPR=7644. and QWEIR=338.) indiates almost all the flow is under the bridge as low flow. Also, looking at the adjacent sections, all the flow is in the channel (QCH=8000). In fact, the computed water surface elevation (74.77) is below the top of road elevation (ELTRD=75.0). It appears that a simple low flow solution would be more logical.

The key step to the weir flow solution is the computed bridge flow energy exceeding the top of road elevation (ELTRD). By increasing that elevation (on the fifth field of the X2 card) to a value greater than the computed bridge energy elevation the program will not branch to the combined weir flow solution. Note: the actual top of road profile (BT card) is not increased; therefore, if weir flow is computed for a higher discharge profile the actual road profile would still be used for the weir calculation.

A second solution run was made using ELTRD=75.5 (See page 7). Because the low flow energy (75.48) is less than the top of road elevation, weir flow is not computed. Now, the solution is just CLASS A LOW FLOW. Also the energy for low flow (EGLWC=75.48) exceeds the downstream energy (74.77) so there is no error message 6870. All the flow is in the channel and passes under the bridge, therefore the final solution checks for continuity.

THIS RUN EXECUTED 25 JUL 84 12:05:4

```
**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
  ERROR CORR -  01,02,03,04,05,06
  MODIFICATION -  50,51,52,53,54,55,56
**************************************************
```

T1 OUTPUT ANALYSIS WORKSHOP PROBLEM 4 (SOLUTION)
T2 PERCHED BRIDGE WITH LOW OVER BANKS
T3 BAKER CREEK

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0.	0.	0.	0.	0.000000	0.00	0.0	8000.	74.500	0.000

NC	0.080	0.080	0.030	0.100	0.300	0.000	0.000	0.000	0.000	0.000
X1	1.000	12.000	200.000	250.000	0.000	0.000	0.000	0.000	0.000	0.000
GR	150.000	0.000	90.000	25.000	87.500	150.000	95.000	200.000	52.500	200.000
GR	50.000	215.000	50.000	235.000	52.500	250.000	95.000	250.000	75.000	335.000
GR	75.000	775.000	150.000	850.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	2.000	12.000	200.000	250.000	200.000	200.000	200.000	0.000	0.000	0.000
GR	150.000	0.000	90.000	25.000	87.500	150.000	95.000	200.000	52.500	200.000
GR	50.000	215.000	50.000	235.000	52.500	250.000	95.000	250.000	75.000	335.000
GR	75.000	775.000	150.000	850.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	3.000	12.000	200.000	250.000	200.000	200.000	200.000	0.000	0.000	0.000
GR	150.000	0.000	90.000	25.000	87.500	150.000	95.000	200.000	52.500	200.000
GR	50.000	215.000	50.000	235.000	52.500	250.000	95.000	250.000	75.000	335.000
GR	75.000	775.000	150.000	850.000	0.000	0.000	0.000	0.000	0.000	0.000
SB	0.900	2.040	2.700	0.000	50.000	2.000	1845.000	0.000	50.000	50.000
X1	4.000	12.000	200.000	250.000	20.000	20.000	20.000	0.000	0.000	0.000
X2	0.000	0.000	1.000	90.000	75.500	0.000	0.000	0.000	0.000	0.000
BT	8.000	0.000	150.000	150.000	25.000	90.000	90.000	150.000	87.500	87.500
BT	200.000	95.000	90.000	250.000	95.000	90.000	335.000	75.000	75.000	775.000
BT	75.000	75.000	850.000	150.000	150.000	0.000	0.000	0.000	0.000	0.000
GR	150.000	0.000	90.000	25.000	87.500	150.000	95.000	200.000	52.500	200.000
GR	50.000	215.000	50.000	235.000	52.500	250.000	95.000	250.000	75.000	335.000
GR	75.000	775.000	150.000	850.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	5.000	12.000	200.000	250.000	50.000	50.000	50.000	0.000	0.000	0.000
GR	150.000	0.000	90.000	25.000	87.500	150.000	95.000	200.000	52.500	200.000
GR	50.000	215.000	50.000	235.000	52.500	250.000	95.000	250.000	75.000	335.000
GR	75.000	775.000	150.000	850.000	0.000	0.000	0.000	0.000	0.000	0.000
EJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	LEFT/RIGHT
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

*PROF 1

CCHV= 0.100 CEHV= 0.300

*SECNO 1.000

1.00	24.50	74.50	0.00	74.50	75.20	0.70	0.00	0.00	95.00
8000.	0.	8000.	0.	0.	1188.	0.	0.	0.	95.00
0.00	0.00	6.74	0.00	0.000	0.030	0.000	0.000	50.00	200.00
0.000632	0.	0.	0.	0	0	0	0.00	50.00	250.00

*SECNO 2.000

2.00	24.63	74.63	0.00	0.00	75.33	0.70	0.13	0.00	95.00
8000.	0.	8000.	0.	0.	1194.	0.	5.	0.	95.00
0.01	0.00	6.70	0.00	0.000	0.030	0.000	0.000	50.00	200.00
0.000623	200.	200.	200.	0	0	0	0.00	50.00	250.00

*SECNO 3.000

3.00	24.77	74.77	0.00	0.00	75.46	0.69	0.12	0.00	95.00
8000.	0.	8000.	0.	0.	1200.	0.	11.	0.	95.00
0.02	0.00	6.66	0.00	0.000	0.030	0.000	0.000	50.00	200.00
0.000614	200.	200.	200.	0	0	0	0.00	50.00	250.00

SPECIAL BRIDGE

SB XK	XKOR	COFQ	RDLEN	BWC	BWP	BAREA	SS	ELCHU	ELCHD
0.90	2.04	2.70	0.00	50.00	2.00	1845.00	0.00	50.00	50.00

*SECNO 4.000
6840,FLOW IS BY WEIR AND LOW FLOW
6870 D.S. ENERGY OF 75.46 HIGHER THAN COMPUTED ENERGY OF 75.43
3420 BRIDGE W.S.= 74.79 BRIDGE VELOCITY=, 6.42 CALCULATED CHANNEL AREA=, 1190.

EGPRS	EGLWC	H3	QWEIR	QLOW	BAREA	TRAPEZOID AREA	ELLC	ELTRD
90.00	75.43	0.02	338.	7644.	1845.	1920.	90.00	75.00

4.00	24.77	74.77	0.00	0.00	75.46	0.69	0.00	0.00	95.00
8000.	0.	8000.	0.	0.	1200.	0.	12.	0.	95.00
0.02	0.00	6.66	0.00	0.000	0.030	0.000	0.000	50.00	200.00
0.000614	20.	20.	20.	2	0	2	0.00	50.00	250.00

*SECNO 5.000

5.00	24.80	74.80	0.00	0.00	75.49	0.69	0.03	0.00	95.00
8000.	0.	8000.	0.	0.	1202.	0.	13.	1.	95.00
0.02	0.00	6.65	0.00	0.000	0.030	0.000	0.000	50.00	200.00
0.000612	50.	50.	50.	0	0	0	0.00	50.00	250.00

[illegible] FOR STREAM BAKER CREEK

PLOTTED POINTS (BY PRIORITY)-E-ENERGY,W-WATER SURFACE,I-INVERT,C-CRITICAL W.S.,L-LEFT BANK,R-RIGHT BANK,M-LOWER END STA

ELEVATION SECNO	50. CUMDIS		60.	70.	80.	90.	100.	110.	120.	130.	140.	
1.00	0.	I			E		L					M
	10.	I			E		L					M
	20.	I			E		L					M
	30.	I			E		L					M
	40.	I			E		L					M
	50.	I			E		L					M
	60.	I			E		L					M
	70.	I			E		L					M
	80.	I			E		L					M
	90.	I			E		L					M
	100.	I			E		L					M
	110.	I			E		L					M
	120.	I			E		L					M
	130.	I			E		L					M
	140.	I			E		L					M
	150.	I			E		L					M
	160.	I			E		L					M
	170.	I			E		L					M
	180.	I			E		L					M
	190.	I			E		L					M
2.00	200.	I			E		L					M
	210.	I			E		L					M
	220.	I			E		L					M
	230.	I			E		L					M
	240.	I			E		L					M
	250.	I			E		L					M
	260.	I			E		L					M
	270.	I			E		L					M
	280.	I			E		L					M
	290.	I			E		L					M
	300.	I			E		L					M
	310.	I			E		L					M
	320.	I			E		L					M
	330.	I			E		L					M
	340.	I			E		L					M
	350.	I			E		L					M
	360.	I			E		L					M
	370.	I			E		L					M
	380.	I			E		L					M
	390.	I			E		L					M
3.00	400.	I			E		L					M
	410.	I			E		L					M
4.00	420.	I			E		L					M
	430.	I			E		L					M
	440.	I			E		L					M
	450.	I			E		L					M
	460.	I			E		L					M
5.00	470.	I			E		L					M

Second Solution Run
Note: ELTRD = 75.50

25 JUL 84 12:05:47

PAGE

SECNO Q TIME SLOPE	DEPTH QLOB VLOB XLOBL	CWSEL QCH VCH XLCH	CRIWS QROB VROB XLOBR	WSELK ALOB XNL ITRIAL	EG ACH XNCH IDC	HV AROB XNR ICONT	HL VOL WTN CORAR	OLOSS TWA ELMIN TOPWID	BANK ELEV LEFT/RIGHT SSTA ENDST

_PECIAL BRIDGE

SB XK	XKOR	COFQ	RDLEN	BWC	BWP	BAREA	SS	ELCHU	ELCHD
0.90	2.04	2.70	0.00	50.00	2.00	1845.00	0.00	50.00	50.00

*SECNO 4.000
CLASS A LOW FLOW

3420 BRIDGE W.S.= 74.71 BRIDGE VELOCITY=, 6.75 CALCULATED CHANNEL AREA=, 1186.

EGPRS	EGLWC	H3	QWEIR	QLOW	BAREA	TRAPEZOID AREA	ELLC	ELTRD
0.00	75.48	0.03	0.	8000.	1845.	1920.	90.00	75.50

4.00 8000. 0.02 0.000612	24.79 0. 0.00 20.	74.79 8000. 6.65 20.	0.00 0. 0.00 20.	0.00 0. 0.000 0	75.48 1202. 0.030 0	0.69 0. 0.000 0	0.03 12. 0.000 0.00	0.00 0. 50.00 50.00	95.00 95.00 200.00 250.00

*SECNO 5.000

5.00 8000. 0.02 0.000610	24.83 0. 0.00 50.	74.83 8000. 6.65 50.	0.00 0. 0.00 50.	0.00 0. 0.000 0	75.51 1204. 0.030 0	0.69 0. 0.000 0	0.03 13. 0.000 0.00	0.00 1. 50.00 50.00	95.00 95.00 200.00 250.00