FHWA-EPD-86-114

Computer Program
Hydraulics of Bridge Waterways

PROGRAM HY-4

1969

U.S. Department
of Transportation
Federal Highway Administration

FEDERAL HIGHWAY ADMINISTRATION

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HNG-31/9-82(200)

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
HY-4	–	

4. Title and Subtitle	5. Report Date
Computer Program for Hydraulics of Bridge Waterways	1969
	6. Performing Organization Code
	8. Performing Organization Report No.
7. Author(s) Murray L. Corry, Johnny L. Morris and Kenneth H. Welty	
9. Performing Organization Name and Address Federal Highway Administration Hydraulics Branch, HNG-31 400 7th Street, SW. Washington, D.C. 20590	10. Work Unit No. (TRAIS) 11. Contract or Grant No. 13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address Same	14. Sponsoring Agency Code

15. Supplementary Notes

HDS No. 1, Hydraulics of Bridge Waterways, by J. N. Bradley provides the technical basis for this program.

16. Abstract

HY-4 provides documentation for a mainframe computer program that calculates the backwater created by a bridge constriction on the basis of a single-cross section. The computer program is based on the design procedures and equations published in HDS No. 1, Hydraulics of Bridge Waterways. This program was developed for the IBM 360 computer using the problem oriented FORTRAN IV (G) level language. A complete program listing is included as Appendix A.

The program consists of two parts. Part I analyzes the natural stream section and produces, at the user's option, the cross section and rating curve plots. After the proposed bridge opening geometry has been superimposed on the flood plain, Part II of the program performs a hydraulic analysis of the constricted bridge waterway opening and determines the velocities and backwater for selected discharges and bridge lengths. The program considers the type of wingwall abutments, piers, eccentricity and skew in the backwater calculations.

17. Key Words	18. Distribution Statement
Hydraulics of Bridge Waterway, Computation of Backwater, Loss Coefficients	This document is available to the U.S. public through the National Technical Information Service, Springfield, VA 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	94	

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U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

A COMPUTER PROGRAM FOR

HYDRAULICS OF BRIDGE WATERWAYS

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Reprinted December 1980

ABSTRACT

This program is used for the hydraulic analysis of bridge waterways to determine the backwater produced by a bridge. The program consists of two parts. Part I analyzes the natural stream section and produces, at the user's option, typical stage-discharge information and cross section and rating curve plots. Part II analyzes the constricted waterway opening and determines velocities and backwater heights for given discharges and bridge lengths. The program was developed for the IBM 360 computer using the problem oriented FORTRAN IV (G) level language.

PREFACE

This manual presents the revised documentation for the computer program, "Hydraulics of Bridge Waterways" (HY-4), originally published in March 1964. This revision incorporates recent changes in the method of computing backwater and also provides a more general purpose program with added subroutines for graphic output.

The program was developed for the IBM 360 computer using the problem oriented FORTRAN IV (G) level language. A complete program listing is included as Appendix A.

The program analyzes the natural and constricted cross section and outputs, at the user's option, stage-discharge, velocity, and backwater information as well as cross section and rating curve plots. Bridge backwater is computed using the revised method presented in the publication, "Hydraulics of Bridge Waterways."*

ACKNOWLEDGEMENTS

The authors are indebted to Mr. J. N. Bradley for the engineering method used in the analysis of bridge backwater and for his efforts in testing the computer program.

* Bureau of Public Roads, HDS No. 1, "Hydraulics of Bridge Waterways", revised 1969, (available from Government Printing Office early 1971).

CONTENTS

INTRODUCTION

This program is part of the Hydraulic Design Subsystem of TIES. It supplies three of the five computer processes required in the bridge waterway portion of the Hydraulic Design Subsystem (figure 1), and thus can aid in fulfilling some of the requirements of Public Roads IM 20-1-67 dated April 26, 1967, entitled, "Evaluation of Flood Hazards - Federally Financed Highways." This IM requires that "...all Federal and Federal-aid highway plans submitted for approval after January 1, 1968, shall show the magnitude, frequency and pertinent water surface elevations for the design flood and, if available, similar data for the maximum flood of record for all structures and roadway embankments that cross flood plains or encroach on rivers and streams having a design flood of more than 500 cubic feet per second. Reports showing hydrologic and hydraulic data and design computations for each stream and river crossing or encroachment on a flood plain shall be filed with the design computations of the project and such reports shall be made available to the Bureau of Public Roads on request."

The program is built-up of a main or control subroutine, and seven subordinate subroutines. Utilizing subroutines gives the user the option of dealing only with those portions necessary for the solution of a particular problem. Figure 2 is a simplified flow chart of the system.

FIGURE I – PARTIAL HYDRAULIC DESIGN SUBSYSTEM BRIDGE WATERWAY PROCESS

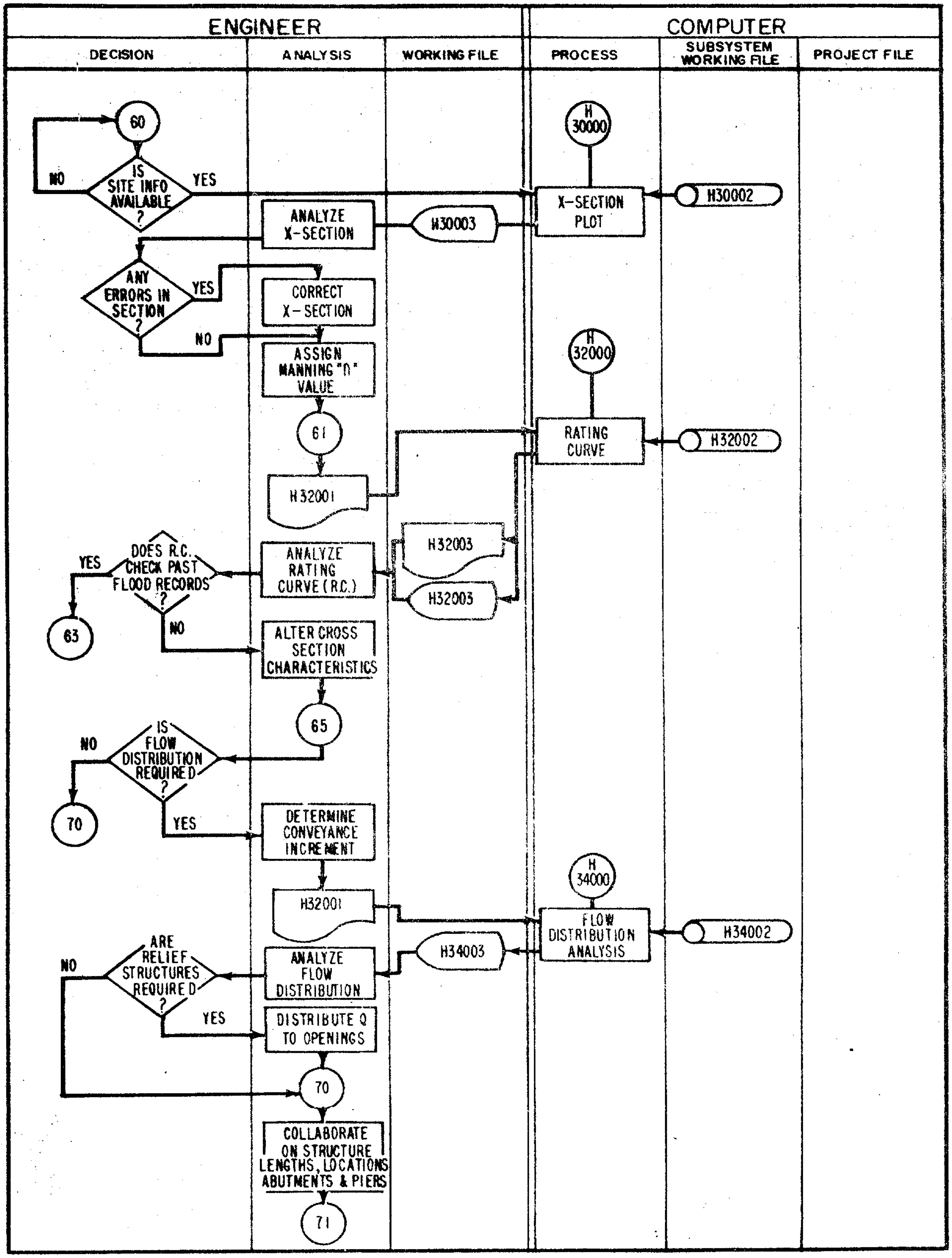


FIGURE I-(CONT'D) PARTIAL HYDRAULIC DESIGN SUBSYSTEM
BRIDGE WATERWAY PROCESS

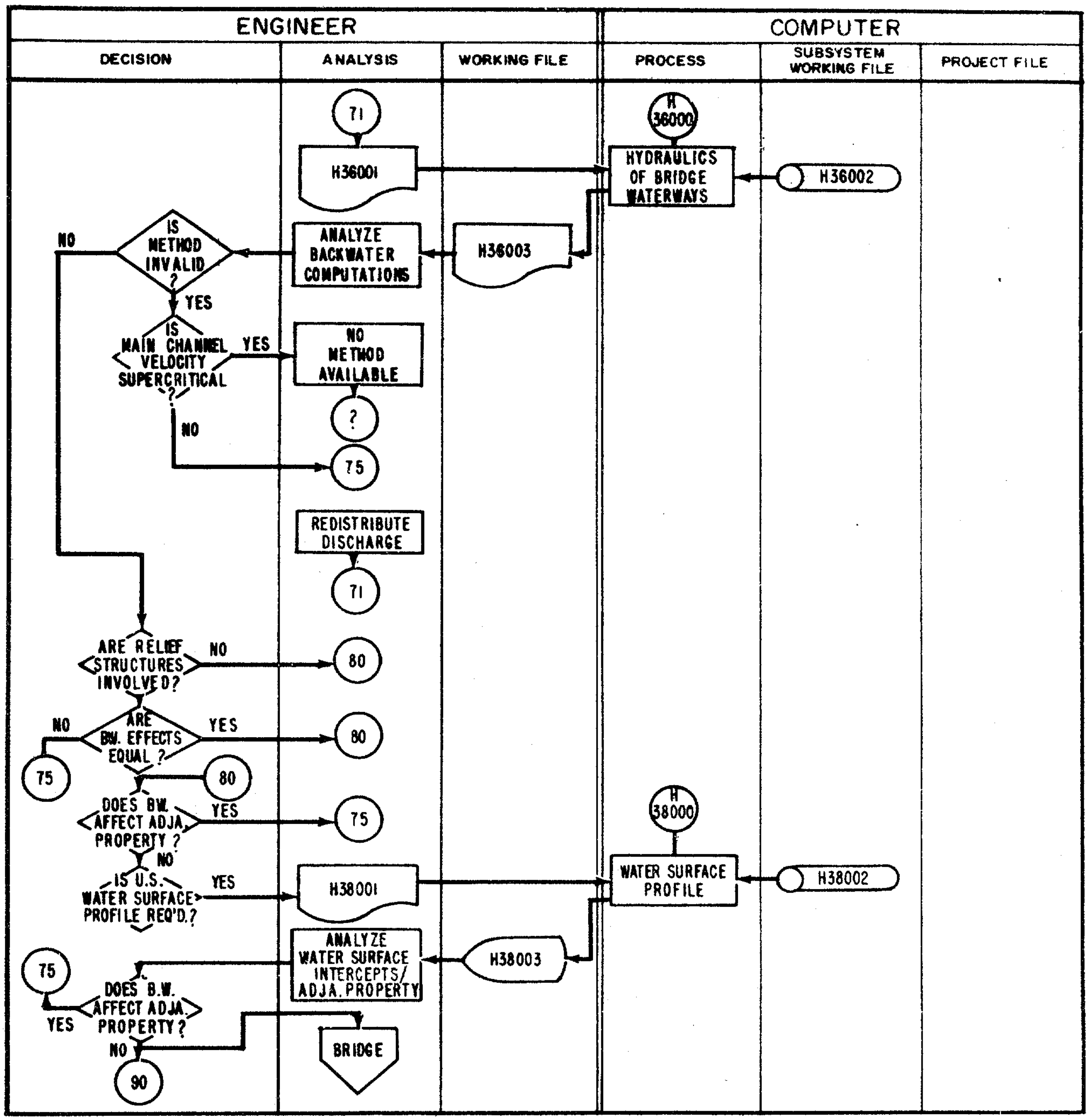
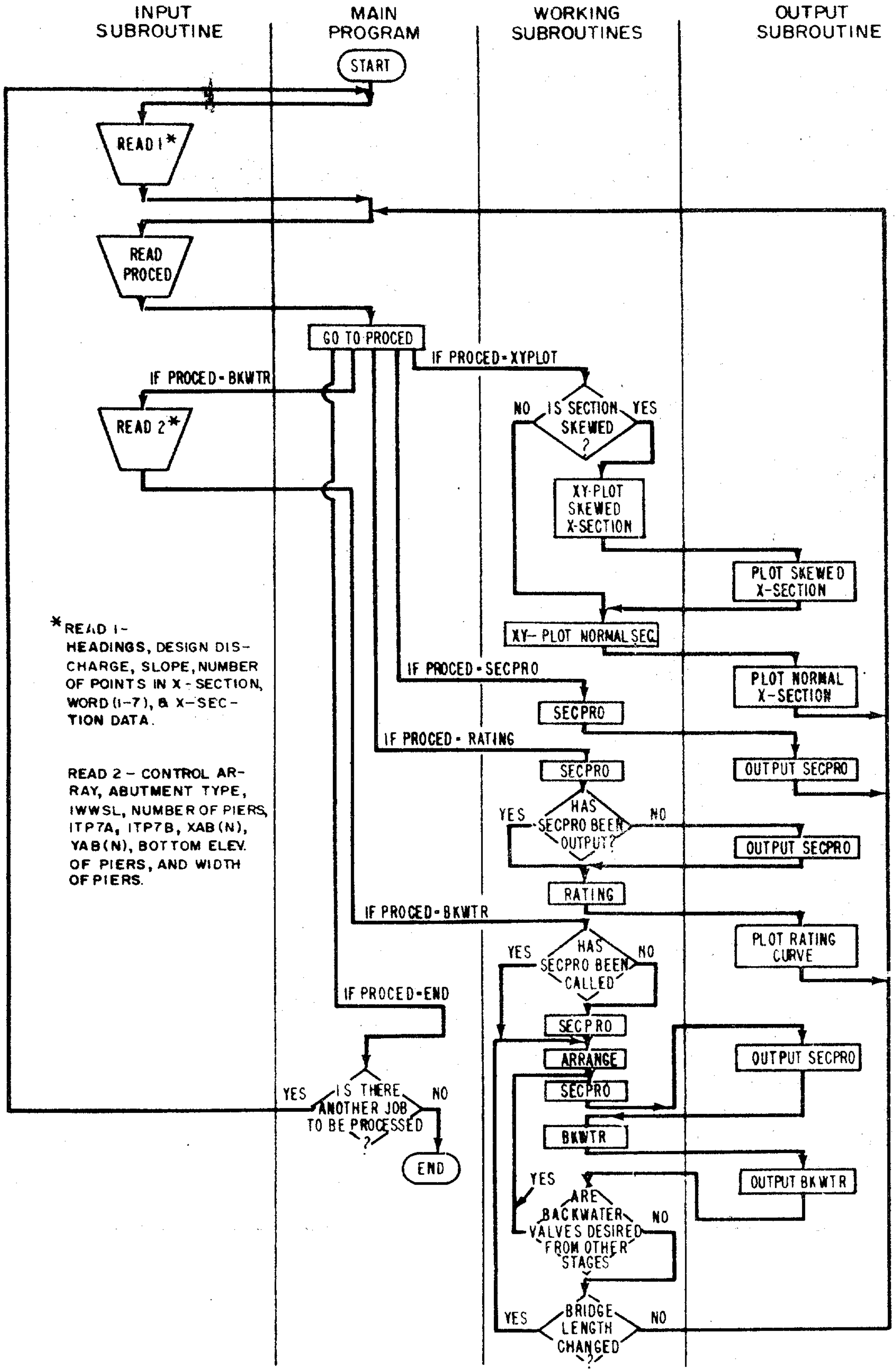


FIGURE 2. FLOW CHART HY-4-69



*READ 1- HEADINGS, DESIGN DISCHARGE, SLOPE, NUMBER OF POINTS IN X-SECTION, WORD (1-7), & X-SECTION DATA.

READ 2 - CONTROL ARRAY, ABUTMENT TYPE, IWWSL, NUMBER OF PIERS, ITP7A, ITP7B, XAB(N), YAB(N), BOTTOM ELEV. OF PIERS, AND WIDTH OF PIERS.

MAIN SUBROUTINE

The function of this subroutine is to maintain the input and storage of data and to call on the subordinate subroutines as required for problem solution. To understand the capabilities and order of execution of the entire system, the designer should become fully acquainted with the operation of this subroutine and its utilization of the input data.

Data Storage - All data are stored in blank common with the exception of the constants used in the plotting subroutines and the TABLE array. These values are initialized in labeled common by use of the BLOCK DATA subroutine. The curve fitting constants used in the backwater calculations are also initialized by a DATA statement in the BACKWATER subroutine.

Data Input - The first three data requirements are common to all the subroutines. The remaining data requirements will depend on the subroutine(s) used and the order of their use. The arrangement of the data on each card and suggested input sheets are contained in Appendix B.

HEADING CARD

The initial card submitted by the user contains the job description or headings, the design discharge, the channel slope, in feet per foot, and the number of points in the cross section (NMAX).

The maximum number of cross section points allowed has been restricted to 96. An error message and program termination will result if more are submitted.

WORD CARD

Following this is a card containing the WORD array:

WORD (1) - the minimum stage.

WORD (2) - the stage increment. An input of zero will cause calculations and printout of the section properties, backwater, etc. for WORD (1) only.

WORD (3) - an input of 1.0 indicates the section is skewed.

- an input of 2.0 indicates the section is not skewed.

WORD (4) - the skew angle in degrees--input as zero if the section is not skewed.

WORD (5) - an input of 1.0 indicates that backwater values are desired for more than one stage. An input of 2.0 indicates that backwater values are desired for the design stage only. Also, when WORD (2) is input as 0.0, WORD (5) equals 2.0.

WORD (6) - when WORD (6) = 1.0 the channel slope is calculated using the formula below. When WORD (6) = 2.0 the slope calculation is not performed.

$$\text{Slope} = (\text{Discharge submitted/Total conveyance})^2$$

If the discharge and stage are known values, this formula can be used to determine the accuracy of the value assigned to the slope, assuming the channel roughness is properly represented.

WORD (7) - this control enables the user to obtain output for several bridge sites with one computer submission. When WORD (7) = 1 only one data set (bridge problem) is being submitted. When WORD (7) = 2, more than one data set is being submitted.

The last data submission (bridge problem) must contain WORD (7) = 1.

CROSS SECTION DATA CARD(S)

The next group of cards contain NMAX sets of cross section and Manning's "n" data. This information is submitted three sets to a card. One set contains the horizontal distance from datum, X, vertical distance above datum, YG, and the value of Manning's "n", CN. To insure that the cross section data are positive, the horizontal and vertical datum planes must be selected to the left and below the waterway cross section. The Manning's "n" values cover the point where listed and the area between this point and the previous point. Therefore, the initial "n" value covers the initial cross section point only.

ENDDATA CARD

The last card of this data submission must be an "ENDDATA" card, which informs the computer that all cross section data have been submitted.

The program uses a card-to-disk routine to input the cross section data. This is done in order to manipulate and reuse this information. The card-to-disk portion may be replaced by card-to-tape routine if disk units are not available.

SUBROUTINE DESIGNATION (PROCED) CARD(S)

The next data card, or cards, contain the computer designations for the subroutines to be used:

SUBROUTINE NAME	COMPUTER DESIGNATION
Cross Section Plot	XYPL
Section Properties	SECP
Rating Curve	RATI
Backwater Computations	BKWT
END	END

The ARRANGE subroutine cannot be called by inputing a computer designation; it is controlled internally by the BACKWATER subroutine. Its operation is explained in a later section.

The submitted subroutine designation is compared with the subroutine list stored in the TABLE array. When a match occurs, the appropriate subroutine is called; however, if no match is found, program termination and an error message results.

At this point, all the data necessary to use the Cross Section Plot, Section Properties, and Rating Curve subroutines have been submitted with the exception of an "END" card. If the BACKWATER subroutine is not to be used the "END" card should be input at this point. However, if the BACKWATER subroutine is used, additional bridge information and the Control array (CONTRL) are necessary and the "END" card will follow these additional data.

CONTRL CARD

The first additional card contains the CONTRL array. This array gives the user the option of obtaining several values of backwater for differing bridge lengths and stages with one data submission.

CONTRL (1) - contains the amount of increase or decrease in bridge length desired, i. e., 5 percent is input at 0.05. The original bridge length is not used to determine new bridge lengths except for the initial change, i.e., the incremental change is applied to the initial length to determine the second value; the third length is then determined for the second bridge length, not from the original value, and so on.

CONTRL (2) - contains a "1.0" if it is desired to increase the originally submitted bridge length.

- contains a "2.0" if a decrease in bridge length is desired.

CONTRL (3) - if input as a "3.0," the left abutment will be moved.

- if input as a "4.0," the right abutment will be moved.

- if input as a "5.0," both abutments will be moved.

Each abutment will be moved according to the value input into CONTRL (1). If CONTRL (3) is input as a "3.0" or "4.0," the total increment desired is input as CONTRL (1); however, if CONTRL (3) is input as a "5.0," only half the total increment should be input into CONTRL (1).

CONTRL (4) - contains the number of times the increase or decrease is to be applied.

CONTRL (5) - this control is used in conjunction with WORD (5) to limit the number of stages for which backwater will be computed. For example, the program defines the stage just above the design stage as YTE1; if CONTRL (5) is input as a 2.0, then the program will subtract twice the stage increment (YSINC) from YTEL and use this value to begin computing backwater. Backwater values will then be obtained from this stage to the maximum stage (YSMAX) in increments of YSINC. (YSMAX is not an input value; its calculation is explained in the section on RATING CURVE development).

When backwater is not desired for more than one bridge length, input 0.0 into CONTRL's (1-4), and, if backwater is desired for only one stage, CONTRL (5) is also input as 0.0.

The program has no way of increasing or decreasing the number of piers as the bridge length is varied. For this reason, it is recommended that the total change in bridge length not exceed 20 percent of the original length. If a greater change is desired, a new submission with new pier arrangement should be made.

BRIDGE DATA CARDS

The following data cards supply the bridge information:

ABTYP - Abutment type. This is coded as either a 5.0 for a wingwall abutment or a 6.0 for a spillthrough abutment.

IWWSL - Designates the specific base backwater curve to be used.

IWWSL = 1 for all spillthrough, 45° and 60° WW and 30° and 90° WW bridges longer than 200 feet.
= 2 for 30° WW less than 200 feet.
= 3 for 90° WW less than 200 feet.

The bridge length is computed within the program and used together with the IWWSL input to select the correct base backwater curve (page 18). If the bridge length is changed when determining the backwater for varying conditions, the base curve designation may differ from the input value, i.e., if the bridge length varies from above to below 200 feet for a 30° WW. The curve used for each backwater calculation is indicated in the output.

NPR - Number of piers in the cross section. A zero is input if no piers are involved.

ITP7A - Designates the curve number (1 through 8) used to obtain the incremental backwater coefficient for the piers (figure 5A).

ITP7B - Designates the curve indicating the bent type (1 through 6) used (figure 5B).

ABUTMENT DATA CARDS

The next two cards contain the abutment data: (see figure 3)

XAB - (1 through 4) - the station (X-coordinate) for the intersection of the abutments with the ground line beginning with the left abutment as XAB (1), etc.

YAB - (1 through 6) - the elevation (Y-coordinate) for the intersection points of the abutments and the ground line, beginning on the left, are input into YAB (1 through 4). YAB (5 and 6) contain the elevations of the top or bridge contact points for the left and right abutments, respectively.

For bridges with vertical abutments, XAB (1), YAB (1), XAB (4), and YAB (4) are input as zero and XAB (2), YAB (2), XAB (3), and YAB (3) contain the distance and elevation data. (figure 3)

PIER DATA CARDS

The next card(s) contain(s) the base elevation of each pier (BELPR). This is the elevation of the ground at the point where the center of the pier intersects the ground line.

The next to last card(s) required contain(s) the average width of each pier (WPR) normal to the flow. If no piers are involved BELPR and WPR must be input as zero. Figure 3A shows the card arrangement when the program is ready to run.

END OF JOB CARD

The last card for each problem submission is an "END" designation.

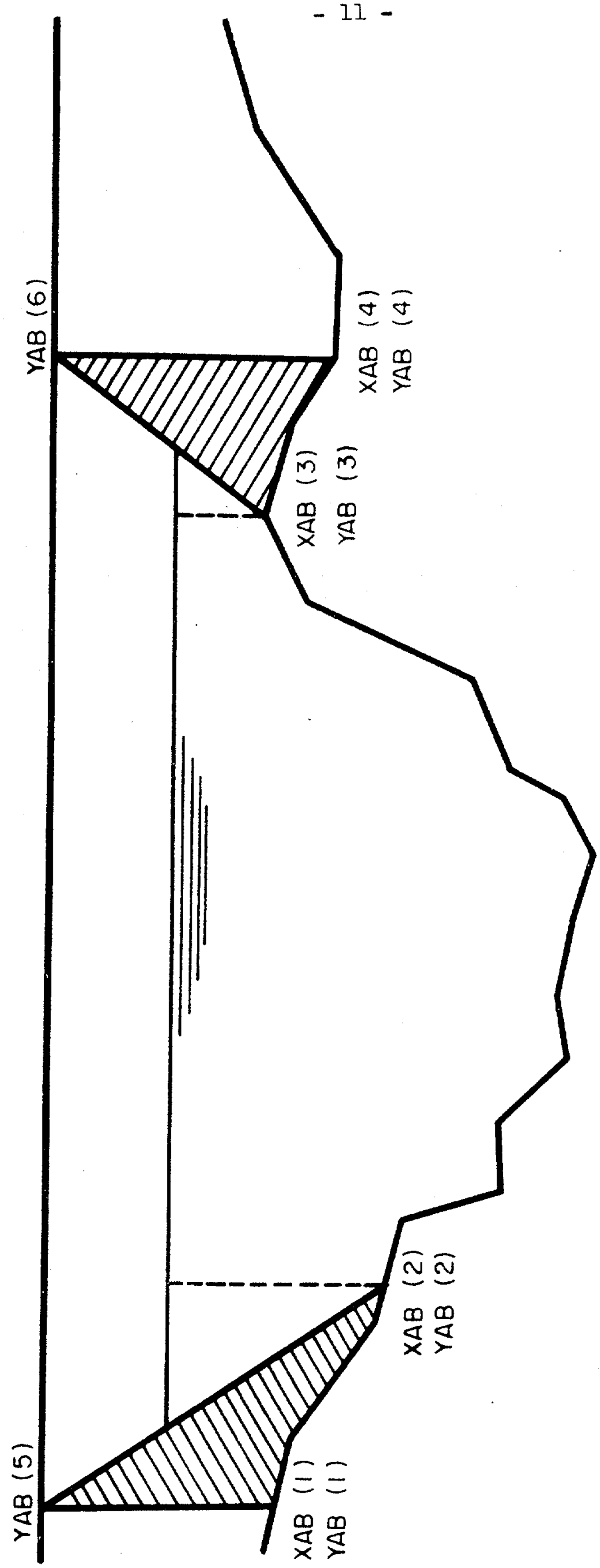


FIGURE 3

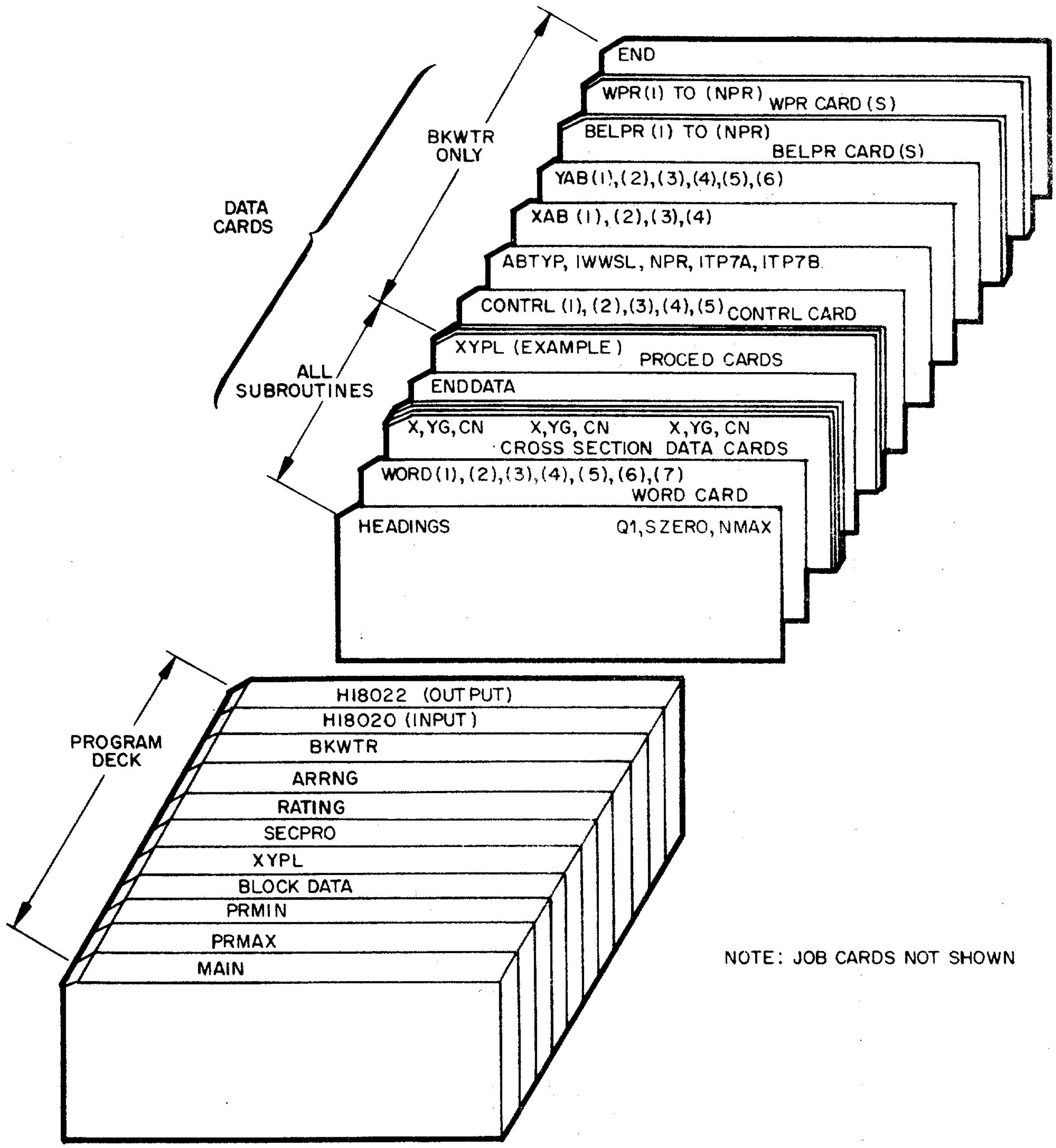


FIGURE 3A—CARD SEQUENCE OUTLINE

CROSS SECTION PLOTTING SUBROUTINE (XYPL)

This subroutine outputs a listing of the input cross section data and a printer plot of the cross section. The vertical scale of the plot is set at either 5 or 10 feet per inch, depending on the maximum YG difference, and the horizontal scale is fixed at 60 feet per inch.

Storage allocation restricts plotting to sections under 3000 feet in length. In addition, sections not beginning at station zero, even if less than 3000 feet, will not be plotted if the maximum X value exceeds 3000 feet. In this case, the limitation can be overcome by adjusting the stationing to begin at zero. If the section exceeds the 3000-foot limitation, an error message will result without program termination. This restriction does not effect the other subroutines.

If the submitted cross section is skewed, the program will plot the skewed section, calculate the normal values for the X array, and plot the normal cross section. The YG and "n" values are assumed to be the same for the skewed and normal sections.

The data listing and the cross section plot offer a convenient means of checking the accuracy of the input data.

SECTION PROPERTIES SUBROUTINE (SECPR)

This subroutine is used by all other subroutines except the cross section plot. The subroutine calculates the area, wetted perimeter, hydraulic radius, conveyance, discharge and velocity for each subsection; the total area, total conveyance and total discharge for each stage; and the stage corresponding to the design discharge.

The program contains internal controls which eliminate duplication of output. Therefore, the output obtained depends on which subroutine is used and the order of use. For example, if the initial call is for a rating curve, the output will contain all the section properties and the rating curve. If this is followed by a call for the section properties, no output will result and the message "REQUEST IGNORED - DESIRED OUTPUT OBTAINED FROM A PREVIOUS REQUEST" will be printed. If, however, the section properties subroutine is called first and the rating curve second, the section properties will be output from the section properties request and only a rating curve plot will result from the rating curve request. In addition, the backwater subroutine only outputs the section properties for the stage where backwater is being calculated. Therefore, if a complete output is desired, the backwater request should be preceded by a request for either the section properties or a rating curve.

This subroutine, like the cross section plot subroutine, will calculate the normal x-values if a skewed cross section is submitted. These normalized "x" values are then used in determining the section properties.

RATING CURVE (RATI)

A request for this subroutine results in the section properties being calculated for a number of water surface elevations, beginning at the minimum value (YSMIN) submitted and increasing to a maximum (YSMAX) by the increment YSINC. The maximum stage (YSMAX) is defined by the program as the stage corresponding to a discharge 1.15 times the design discharge.

The subroutine always outputs a stage-discharge curve and may also output the section properties for each stage, if these values have not been previously obtained.

ARRANGE SUBROUTINE (ARRNG)

This subroutine gives the user the option of changing the bridge length and thus obtain backwater values for differing lengths from one data submission.

The function of this subroutine is to insert the abutment points in the original cross section and add an increment of 0.0001 to the Manning's "n" value for the next cross section to the right of the abutment location. This "n" change is necessary in order to provide needed information for computing backwater.

The insertion of the additional cross section points (abutments), with new values of roughness, may cause slight variations in the section properties compared to those obtained from the original cross section. However, the differences are generally small and can be neglected.

The subroutine is controlled by the BACKWATER subroutine and no separate data submission is required for its operation.

BACKWATER SUBROUTINE (BKWT)

The BACKWATER subroutine is based on the revised publication, "Hydraulics of Bridge Waterways," (HDS No. 1).[1] The limitations listed in that manual also apply to this program.

(1) Bureau of Public Roads, HDS No. 1, "Hydraulics of Bridge Waterways," revised 1969, (available from Government Printing Office early 1971)

Although HDS No. 1 is applicable to a variety of bridge waterway problems, this subroutine applies strictly to subcritical flow through the bridge constriction.(2) The program determines the value of the Froude number at the constricted section from:

$$F_n = \frac{V_{n2}}{(gD_m)^{1/2}}$$

Where: $V_{n2} = \dfrac{\text{Design Discharge}}{A_{n2}}$

A_{n2} = Area of flow in the constriction below the normal water surface at section 2

g = Acceleration of gravity

$$D_m = \frac{\text{Area } (A_{n2})}{\text{Top Width}}$$

If this value exceeds 0.9, indicating the flow is close to supercritical, the method cannot be used and a "Design Method Invalid" message will result. If several values of backwater are to be obtained from the one data submission, the program will continue to increment the bridge length and/or stage and recalculate the Froude number for each condition. This may result in the invalid message for each stage and bridge length. However, a bridge length or stage may be obtained where the constricted section Froude number is less than 0.9, in which case the program will calculate and output the approximate backwater values.

In addition to the section properties, this subroutine outputs the bridge length, the abutment positions, the bridge opening at design state, the base backwater curve used, the discharge to the left, right and through the bridge opening, the ALPHA values calculated, the area of the piers below the water surface, the backwater coefficient, the area and mean velocity for normal depth through the bridge opening, the discharge ratio, the initial and final backwater approximations, and the number of iterations involved in obtaining the final backwater value.

---

(2) The revised HDS No. 1 contains a suggested method for computing backwater when supercritical flow conditions are encountered.

The initial backwater approximation is obtained from:

$$\text{BKAP1} = (\text{total backwater coefficients}) \times \frac{(V_{n2})^2}{2g} \times (\text{ALPHA2})$$

An incremental area is then calculated:

AA1 = BKAP1 x WIDTH of section, and a second approximation of backwater obtained:

$$\text{BKAP2} = \text{BKAP1} + \left[\frac{A_{n2}{}^2}{\text{ATOT}^2} - \frac{A_{n2}{}^2}{(\text{ATOT} + \text{AA1})^2} \right] (\text{ALPHA}) \; \frac{(V_{n2})^2}{2g}$$

A second incremental area is obtained using BKAP2 and a third approximation of backwater (BKAP3) calculated:

$$\text{BKAP3} = \text{BKAP1} + \left[\frac{A_{n2}{}^2}{\text{ATOT}^2} - \frac{A_{n2}{}^2}{(\text{ATOT} + \text{AA2})^2} \right] (\text{ALPHA}) \; \frac{(V_{n2})^2}{2g}$$

BKAP3 is then compared with BKAP2. If the difference, (BKAP3 - BKAP2), is greater than 0.05, iteration continues. If the difference is equal or less than 0.05, the BKAP3 value is output as the final backwater approximation.

INPUT, OUTPUT SUBROUTINES

The H18020 (input) and H18022 (output) subroutines contain all the input, output and format statements for the entire program.

MATHEMATICAL EQUATIONS

The curves in figures 4, 5A and B, 6, 7, 8, and 9 are represented by equations in the program. These equations were derived using a curve fitting computer program developed by the Bureau of Public Roads. The figures correspond to figures 6, 7, 8, 9, and 10 in the publication, "Hydraulics of Bridge Waterways."

The curves of figure 4 are replaced by the equation for the backwater coefficient:

$$AKB = AKBA_{(IWWSL)} + [AKBB_{(IWWSL)}] [DRM] + [AKBC_{(IWWSL)}] [DRM]^2 + [AKBD_{(IWWSL)}] [DRM]^3$$

where AKB = Backwater coefficient K_b

AKBA, AKBB, AKBC, and AKBD = Coefficients determined by polynomial curve fitting

IWWSL = Control to determine which coefficients are being used

C O E F F I C I E N T S

Curve number	AKBA	AKBB	AKBC	AKBD
1	3.5233068	-5.6472178	1.2936649	0.81928158
2	3.55656628	-5.3270750	0.74911308	1.0127993
3	3.8474216	-6.0962954	1.7707281	0.47598726

The curves for figure 5A are replaced by the equation for the nonadjusted value of the incremental backwater coefficient for the piers:

$$DLTAK = DTAA_{(ITP7A)} + [DTAB_{(ITP7A)}] [RTIOJ]$$

where DLTAK = Nonadjusted backwater coefficient for the piers

DTAA and DTAB = Coefficients for the equation

ITP7A = Control to determine which coefficients are to be used

RTIOJ = Ratio of area obstructed by piers to gross area of bridge waterway below the normal water surface

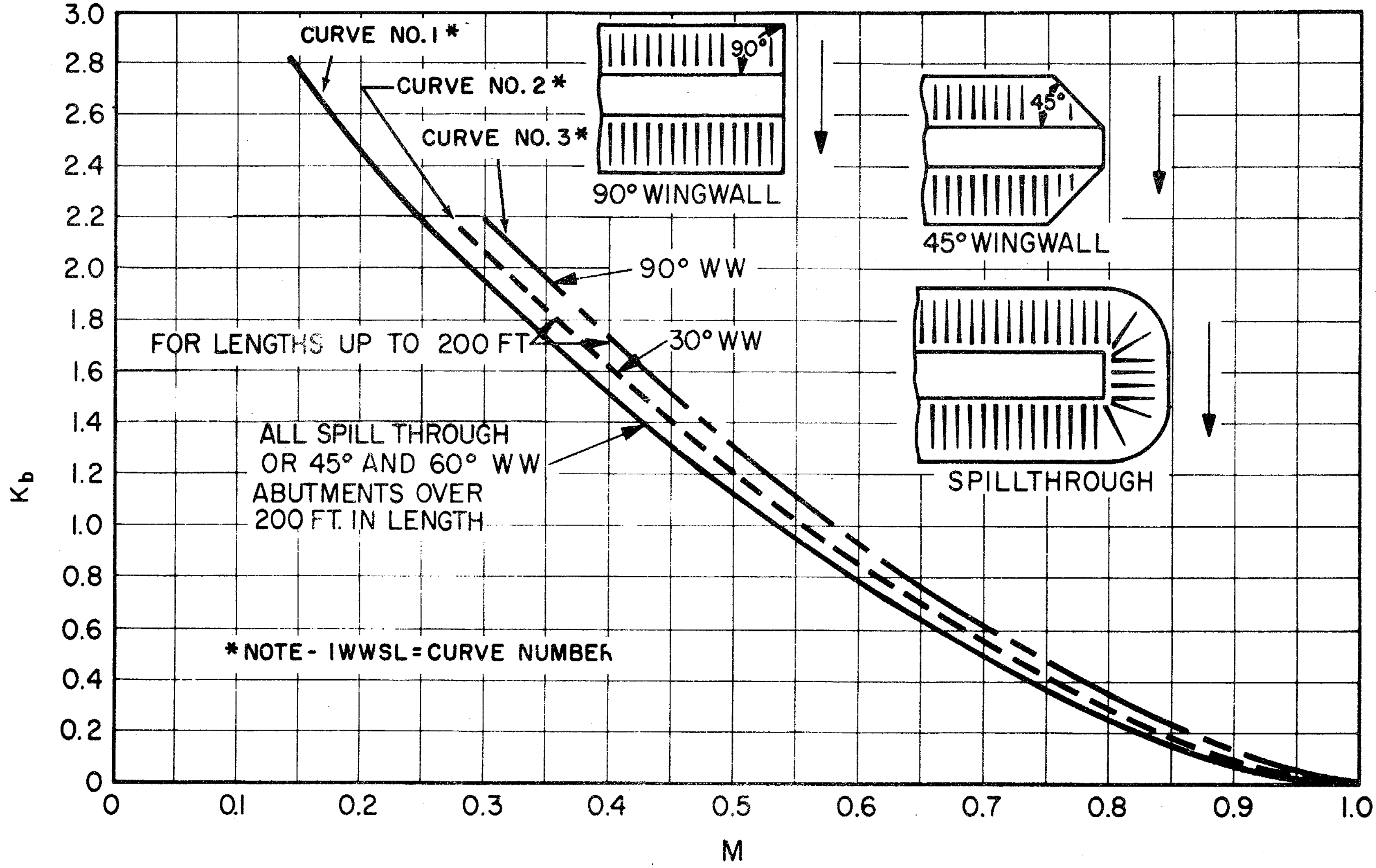
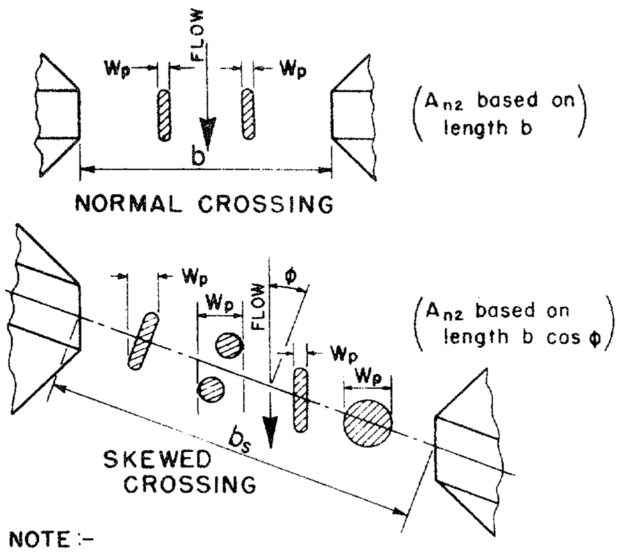


FIG. 4 - BASE CURVES FOR SPILLTHROUGH AND WINGWALL ABUTMENTS



W_p = Width of pier normal to flow — feet

h_{n2} = Height of pier exposed to flow — feet

N = Number of piers

A_p = $\Sigma^N W_p h_{n2}$ = total projected area of piers normal to flow — square feet

A_{n2} = Gross water cross section in constriction based on normal water surface. (Use projected bridge length normal to flow for skew crossings)

$$J = \frac{A_p}{A_{n2}}$$

NOTE :-
Sway bracing should be included in width of pile bents.

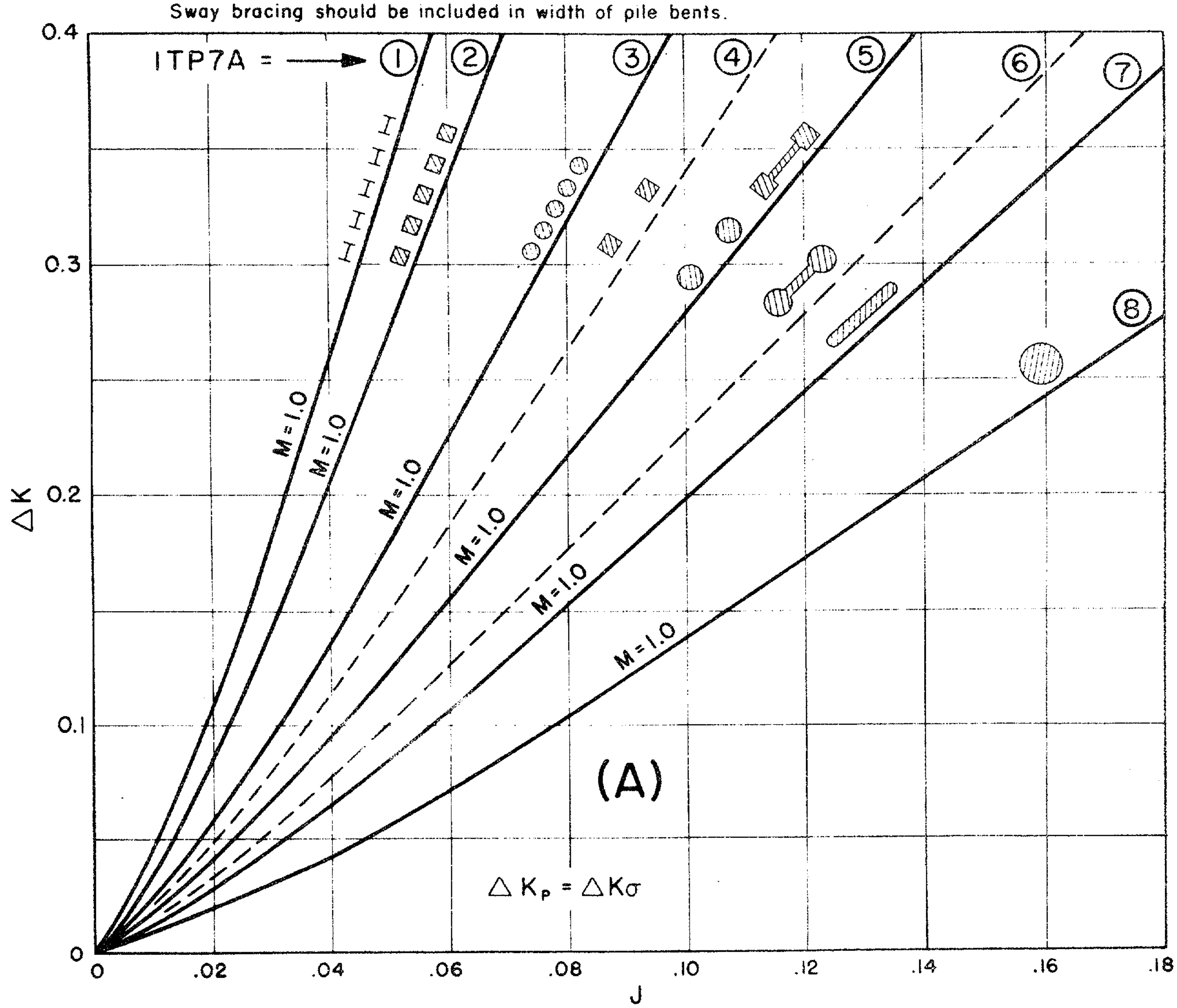


FIG. 5A- INCREMENTAL BACKWATER COEFFICIENT FOR PIERS

C O E F F I C I E N T S

Curve Number (ITP7A)	DTAA	DTAB
1	-0.05968	8.06452
2	-0.05395	6.57895
3	-0.04907	4.62963
4	-0.03939	3.78788
5	-0.02593	3.08642
6	-0.02564	2.56410
7	-0.02844	2.29358
8	-0.02978	1.68539

The value of SIGMA, the multiplication factor for influence of M on the backwater coefficient for piers, is determined by the equation which replaces the curve of figure 5B. It is:

$$SIGMA = SCA_{(ITP7B)} + [SCB_{(ITP7B)}][DRM] + [SCC_{(ITP7B)}][DRM]^2 + [SCD_{(ITP7B)}][DRM]^3$$

Where

SIGMA = Multiplication factor

SCA, SCB, SCC, and SCD = Coefficients for the equation

ITP7B = Controls which coefficients are used

DRM = Bridge opening ratio

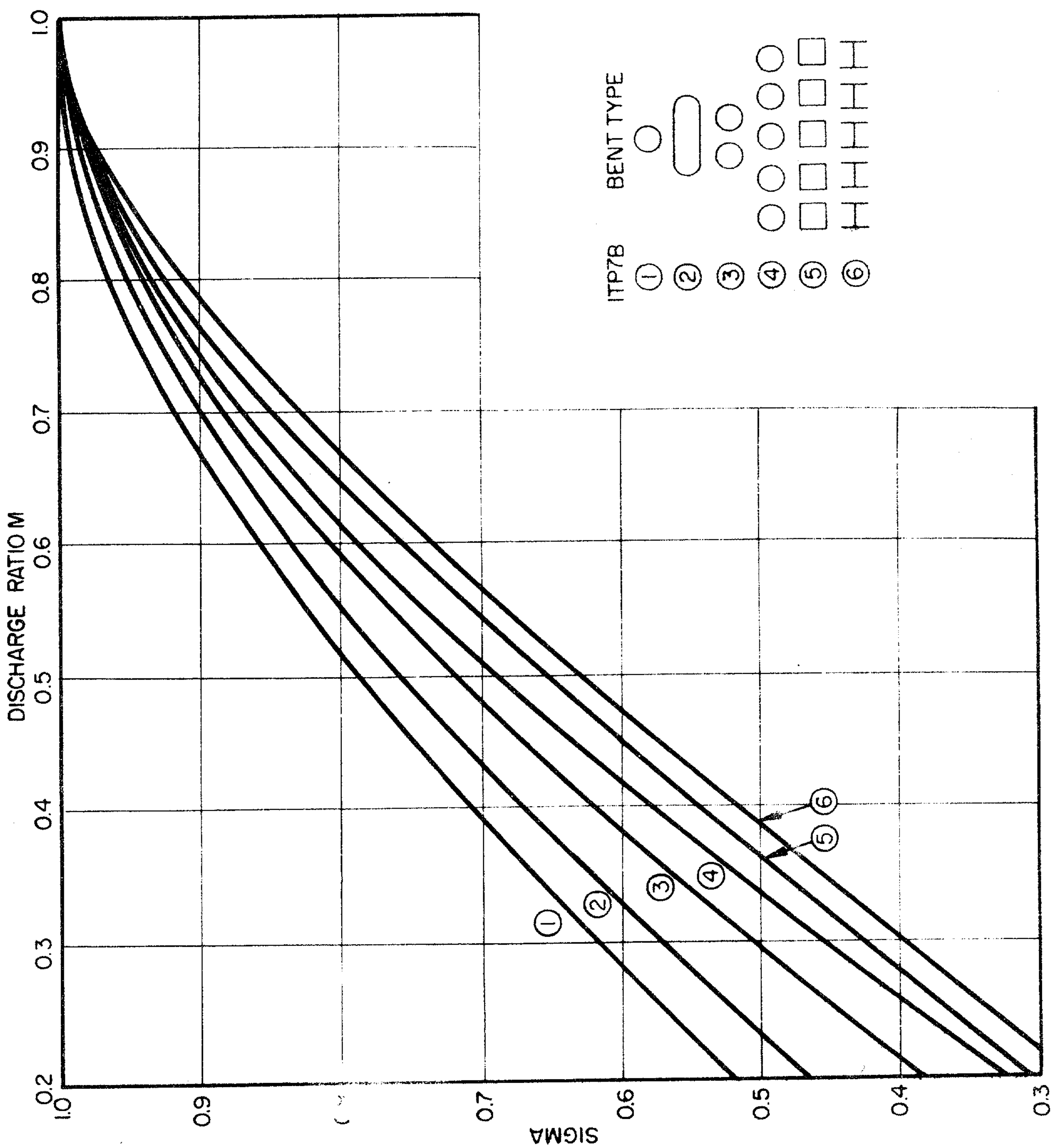

DISCHARGE RATIO M
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
SIGMA
1.0
0.9
0.7
0.6
0.5
0.4
0.3
ITP7B
BENT TYPE
①
②
③
④
⑤
⑥

FIGURE 5B

C O E F F I C I E N T S

Curve Number (ITP7B)	SCA	SCB	SCC	SCD
1	.327245	.989413	.044095	-.361134
2	.238817	1.174765	-.136850	-.277804
3	.146077	1.232713	.035751	-.416684
4	.056796	1.383878	-.023734	-.416702
5	.174052	.607318	1.190511	-.972239
6	.099387	.837630	.841710	-.777799

The incremental backwater coefficient, normally taken from the eccentricity curves of figure 6, is replaced by the equation:

$$DKA = ECA_{(IEC)} + [ECB_{(IEC)}]\,[DRM] + [ECC_{(IEC)}]\,[DRM]^2 + [ECD_{(IEC)}]\,[DRM]^3$$

where

DKE = Eccentricity backwater coefficient

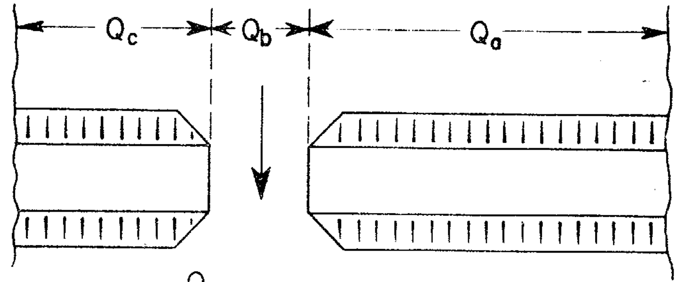
ECA, ECB, ECC, and ECD = Equation coefficients

IEC = Controls coefficients to be used in the equation

DRM = Bridge opening ratio

C O E F F I C I E N T S

Curve Number (IEC)	ECA	ECB	ECC	ECD
1	0.019508	-0.002953	0.032035	-0.048822
2	0.058524	-0.077194	0.218074	-0.199495
3	0.118143	-0.155989	0.422079	-0.383839
4	0.205484	-0.266695	0.683660	-0.619530



$$e = \left(1 - \frac{Q_c}{Q_a}\right) \quad \text{where} \quad Q_c < Q_a \quad \text{or}$$

$$e = \left(1 - \frac{Q_a}{Q_c}\right) \quad \text{where} \quad Q_a < Q_c$$

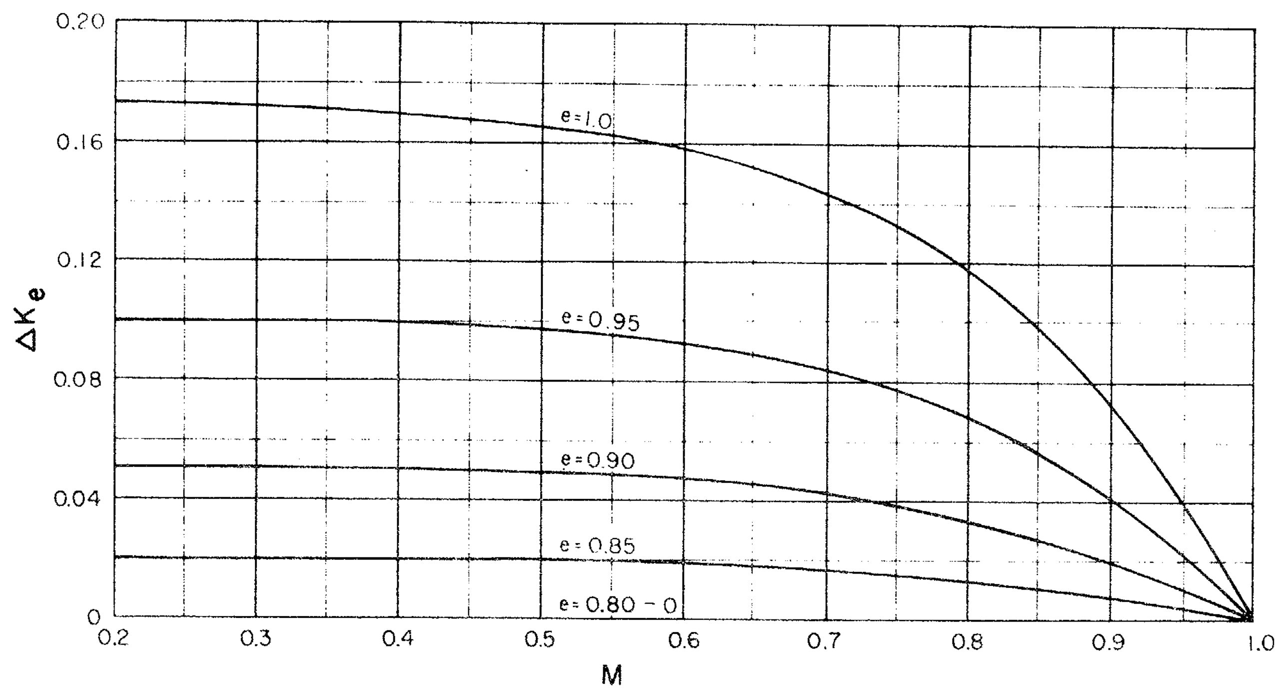


FIG. 6 - INCREMENTAL BACKWATER COEFFICIENT FOR ECCENTRICITY

The incremental backwater coefficient for skew (curves of figures 7 and 8) are replaced by the equation:

$$DKS = SKA_{(ISKW)} + [SKB_{(ISKW)}] [DRM] + [SKC_{(ISKW)}] [DRM]^2$$

where DKS = Backwater coefficient for skew

SKA, SKB, and SKC = Equation coefficients

ISKW = Controls which coefficients are used

DRM = Bridge opening ratio

C O E F F I C I E N T S

Curve Number (ISKW)	Figure	SKA	SKB	SKC
1	7	-0.155585	0.341092	-0.186555
2		-0.524091	1.099576	-0.574564
3		-0.868571	1.808105	-0.936619
4	8	-0.248466	0.485294	-0.239237
5		-0.730913	1.387357	-0.655494
6		-1.263679	2.311828	-1.039593

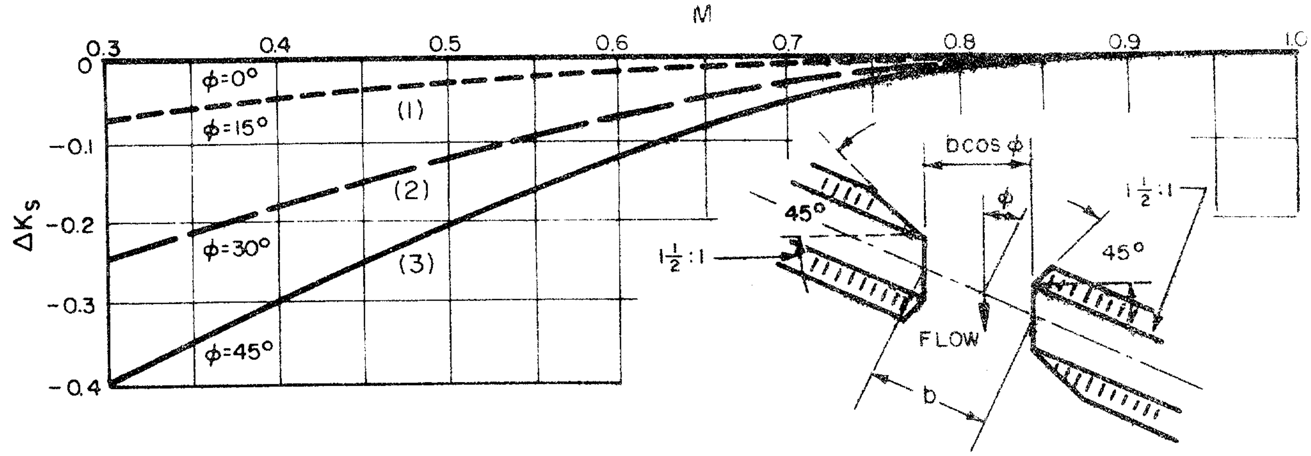


FIGURE 7 – INCREMENTAL BACKWATER COEFFICIENT FOR SKEW, WINGWALL ABUTMENTS

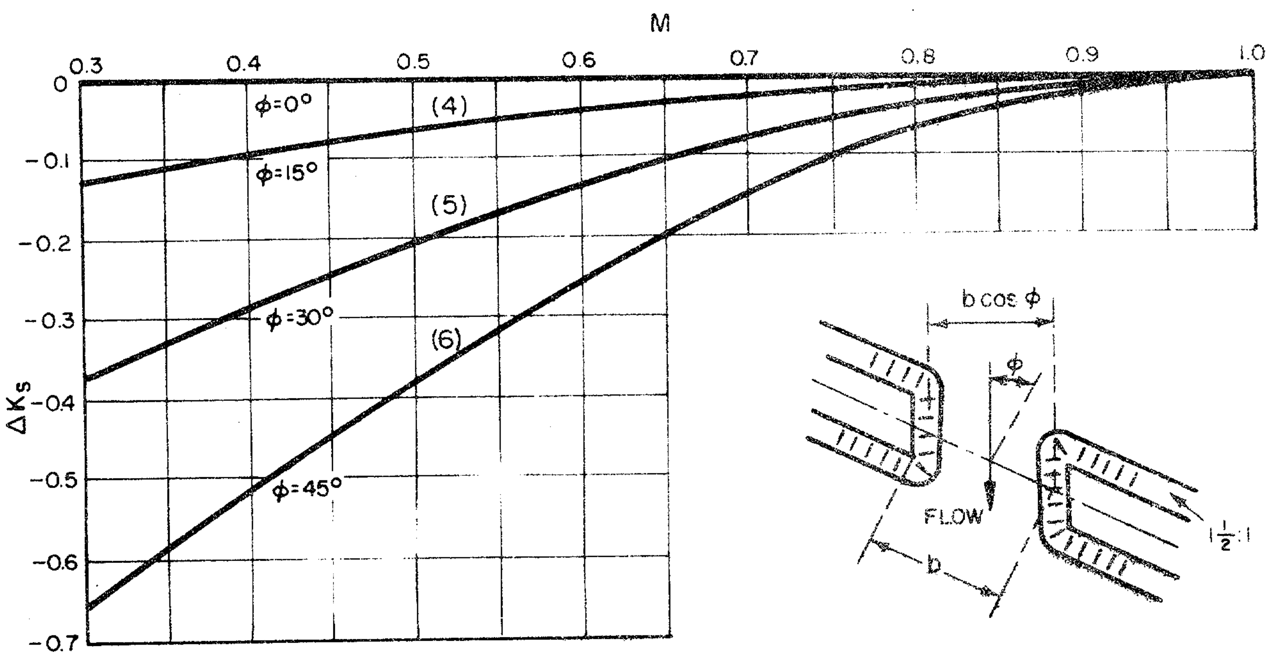


FIGURE 8 – INCREMENTAL BACKWATER COEFFICIENT FOR SKEW, SPILLTHROUGH ABUTMENTS

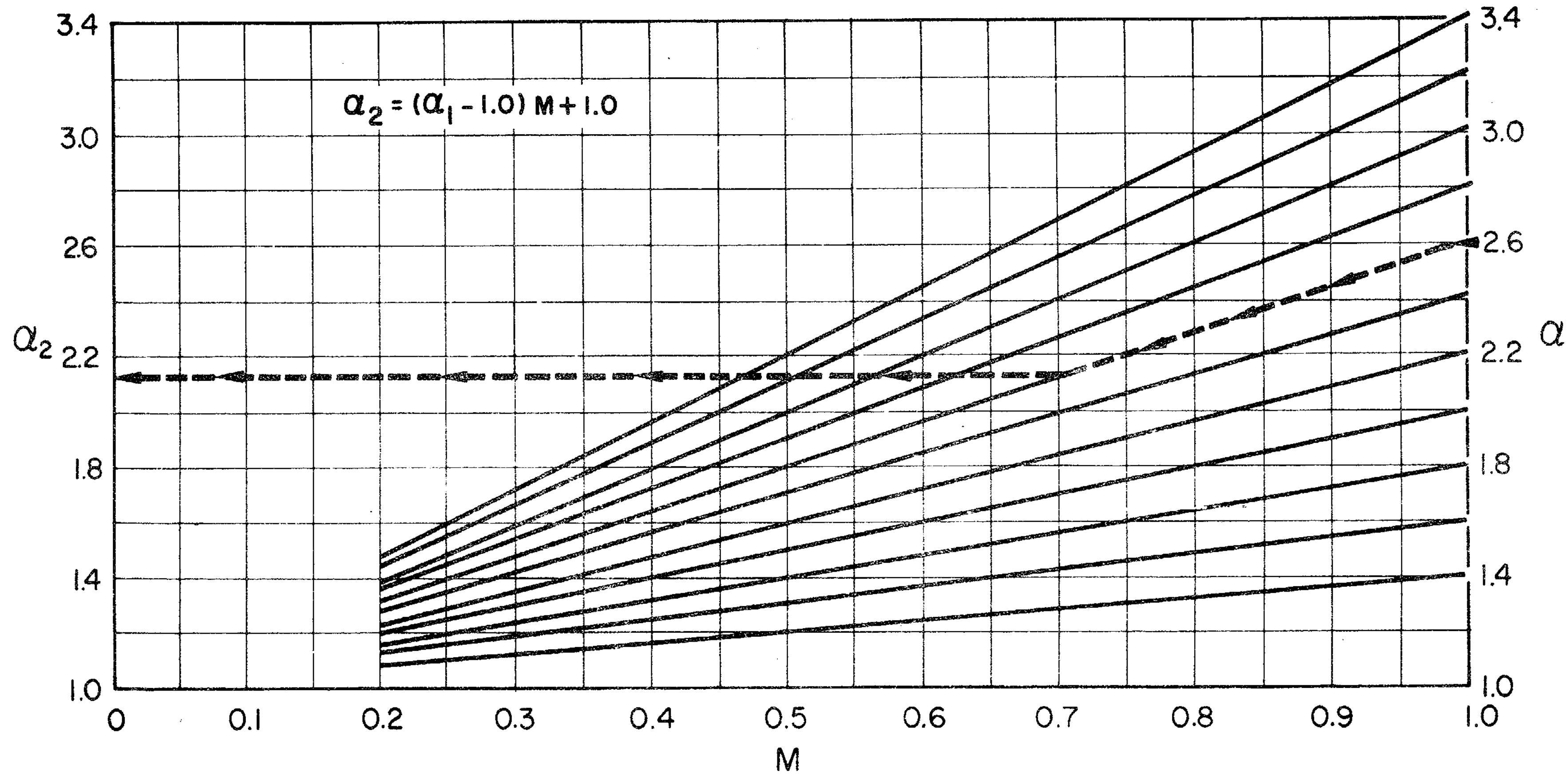


FIG 9-CHART FOR ESTIMATING VELOCITY-HEAD COEFFICIENT α_2

PROGRAMING PROCEDURES

The following steps suggest a method that may be used to put this program into production on a FORTRAN programing system.

1. Review the FORTRAN program listing that follows and note changes to the program that appear to be necessary. In many cases changes will have to be made so that the program can be compiled and run on the user's equipment. Normally, the changes that are needed will be limited to those operations that bring information into the computing system or transfer results out of the system. As an example, it may be necessary to change all WRITE statements included in the attached listing to PUNCH statements. The FORMAT statements controlling the arrangement of input and output information must be checked carefully and if computer controlled line printers are to be used, special attention should be given to the printer carriage control codes.

2. Keypunch or type the source FORTRAN program. The source program is then compiled to obtain the object program. The compilation of a source FORTRAN program is a routine operation of most computing centers equipped to handle FORTRAN compilation. Any special instructions needed to perform this step can readily be found with the operating instructions that are furnished with the FORTRAN compiler programs.

3. Data pertaining to a specific problem should be keypunched according to the specifications or card arrangements that are given in the separate FORMAT statements.

   Each data set consists of the items that were discussed previously. Any number of data sets can be assembled and submitted for processing at one time. For a clear understanding of the data set items and their order, the reader should carefully study the separate READ instructions and the data card listing together with the example problem.

Appendix B

Suggested Input Sheets

SUGGESTED DATA INPUT SHEETS

HEADING CARD

← PROJECT

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

IDENTIFICATION →

31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60

DESIGN Q* C.F.S.								CHANNEL SLOPE FT/FT								NO. X-SEC.* POINTS			
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
									•										

*NOTE: VALUES ARE RIGHT ADJUSTED – NO DECIMAL

WORD CARD

WORD (1) MIN. STAGE ELEV.

1	2	3	4	5	6	7	8
					•		

WORD (2) STAGE INCREMENT

9	10	11	12
		•	

WORD (3) SECTION SKEWED?

13	14	15	16
		•	

YES – 1.ϕ
NO – 2.ϕ

WORD (4) SKEW ANGLE O°

17	18	19	20
		•	

WORD (5) BKWT. MORE ONE STAGE?

21	22	23	24
		•	

YES – 1.ϕ
NO – 2.ϕ

WORD (6) SLOPE CALCULATED?

25	26	27	28
		•	

YES – 1.ϕ
NO – 2.ϕ

WORD (7) MORE JOBS?

29	30	31	32
		•	

YES – 2.ϕ
NO – 1.ϕ

CROSS SECTION DATA CARD(S)

DISTANCE TO X-SEC. POINT FROM REFERENCE	GROUND ELEV. AT X-SEC. PT.	MANNING'S ROUGHNESS COEFFICIENT	DISTANCE TO X-SEC. POINT FROM REFERENCE	GROUND ELEV. AT X-SEC. PT.	MANNING'S ROUGHNESS COEFFICIENT	DISTANCE TO X-SEC. POINT FROM REFERENCE	GROUND ELEV. AT X-SEC. PT.	MANNING'S ROUGHNESS COEFFICIENT
1 8	9 15	16 21	22 29	30 36	37 42	43 50	51 57	58 63
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
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.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.

END DATA CARD

1	2	3	4	5	6	7
E	N	D	D	A	T	A

SUBROUTINE DESIGNATION (PROCED) CARD(S)

1	2	3	4

CONTRL CARD

CONTRL (1)
%CHANGE
BRIDGE LENGTH

1	2	3	4	5
	•			

CONTRL (2)
INCREASE-1.ϕ
DECREASE-2.ϕ

6	7	8	9	10
			•	

CONTRL (3)
ABUT. MOVED ?
LT-3, RT-4, BOTH-5

11	12	13	14	15
			•	

CONTRL (4)
NO. OF
CHANGES

16	17	18	19	20
			•	

CONTRL (5)
NO. OF
BKWT. STAGES

21	22	23	24	25
			•	

BRIDGE DATA CARD

ABUTMENT TYPE WW-5.0; S.T. -6.0	BASE BKWT. CURVE NO. 45° & 60° WW=1; 30° WW = 2 90° WW = 3; ALL S.T. = 1	NO. OF PIERS IN CROSS SECTION
Columns 1–9	Columns 10–18	Columns 19–27
Entry: columns 6, 7 . 8	Entry: column 18	Entry: columns 26, 27

PIER TYPE (SEE FIGURE 5A)	BENT TYPE (SEE FIGURE 5B)
Columns 28–36	Columns 37–45
Entry: column 36	Entry: column 45

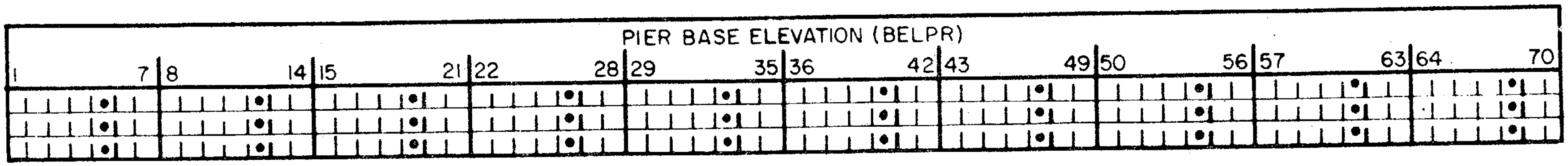
ABUTMENT DATA CARDS

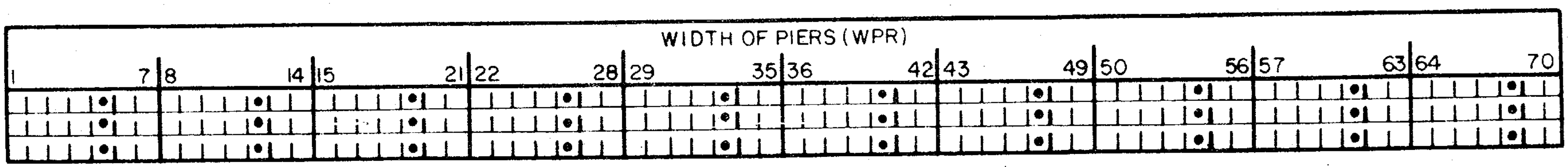
STA. LT. FACE LT. ABUT. AT GROUND XAB(1)	STA. RT. FACE LT ABUT. AT GROUND XAB(2)	STA. LT. FACE RT. ABUT. AT GROUND XAB(3)	STA. RT. FACE RT ABUT. AT GROUND XAB(4)
Columns 1–8 (• after 6)	Columns 9–16 (• after 14)	Columns 17–24 (• after 22)	Columns 25–32 (• after 30)

ELEV. LT. FACE LT. ABUT. AT GROUND YAB(1)	ELEV. RT. FACE LT ABUT. AT GROUND YAB(2)	ELEV. LT. FACE RT. ABUT. AT GROUND YAB(3)	ELEV. RT. FACE RT. ABUT. AT GROUND YAB(4)
Columns 1–8 (• after 6)	Columns 9–16 (• after 14)	Columns 17–24 (• after 22)	Columns 25–32 (• after 30)

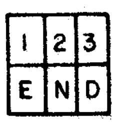
ELEV. BRIDGE LT. ABUTMENT YAB(5)	ELEV. BRIDGE RT. ABUTMENT YAB(6)
Columns 33–40 (• after 38)	Columns 41–48 (• after 46)

PIER DATA CARDS





END OF JOB CARD



Appendix C

Sample Problem

DATA INPUT

HEADING CARD

PROJECT

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
E	X	A	M	P	L	E		P	R	O	B	L	E	M					J	O	E		B	R	A	D	L	E	Y

IDENTIFICATION

31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
	E	C	C	E	N	T	R	I	C		C	R	O	S	S	I	N	G											

DESIGN Q* C.F.S.								CHANNEL SLOPE FT/FT								NO. X-SEC.* POINTS			
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
			9	8	3	Ø	Ø		.	Ø	Ø	Ø	2	4	Ø			4	1

*NOTE: VALUES ARE RIGHT ADJUSTED – NO DECIMAL

WORD CARD

WORD (1) MIN. STAGE ELEV.

1	2	3	4	5	6	7	8
		6	4	7	.	Ø	Ø

WORD (2) STAGE INCREMENT

9	10	11	12
	3	.	Ø

WORD (3) SECTION SKEWED?

13	14	15	16
	2	.	Ø

YES – 1.ϕ
NO – 2.ϕ

WORD (4) SKEW ANGLE 0°

17	18	19	20
	Ø	.	Ø

WORD (5) BKWT. MORE ONE STAGE?

21	22	23	24
	1	.	Ø

YES – 1.ϕ
NO – 2.ϕ

WORD (6) SLOPE CALCULATED?

25	26	27	28
	2	.	Ø

YES – 1.ϕ
NO – 2.ϕ

WORD (7) MORE JOBS?

29	30	31	32
	1	.	Ø

YES – 2.ϕ
NO – 1.ϕ

CROSS SECTION DATA CARD(S)

DISTANCE TO X-SEC. POINT FROM REFERENCE (1–8)	GROUND ELEV. AT X-SEC. PT. (9–15)	MANNING'S ROUGHNESS COEFFICIENT (16–21)	DISTANCE TO X-SEC. POINT FROM REFERENCE (22–29)	GROUND ELEV. AT X-SEC. PT (30–36)	MANNING'S ROUGHNESS COEFFICIENT (37–42)	DISTANCE TO X-SEC. POINT FROM REFERENCE (43–50)	GROUND ELEV. AT X-SEC. PT. (51–57)	MANNING'S ROUGHNESS COEFFICIENT (58–63)
0.00	658.00	.0450	70.00	642.00	.0450	80.00	639.00	.0450
110.00	653.00	.0300	150.00	632.00	.0300	160.00	631.70	.0300
320.00	632.50	.0300	360.00	632.40	.0300	400.00	632.30	.0300
430.00	631.80	.0300	470.00	631.70	.0300	550.00	631.00	.0300
580.00	643.80	.0500	660.00	644.00	.0600	710.00	642.00	.0600
750.00	642.50	.0320	840.00	642.10	.0320	940.00	643.00	.0300
960.00	638.50	.0300	980.00	643.60	.0300	1130.00	643.00	.0350
1190.00	643.70	.0350	1260.00	643.20	.0350	1320.00	643.00	.0600
1360.00	643.70	.0600	1370.00	641.00	.0600	1380.00	644.00	.0600
1490.00	647.00	.0400	1520.00	646.70	.0400	1530.00	645.50	.0400
1550.00	646.80	.0400	1620.00	647.50	.0400	1730.00	646.00	.0400
1910.00	644.50	.0450	2130.00	647.00	.0450	2420.00	646.40	.0450
2540.00	651.00	.0450	2600.00	652.00	.0450	2630.00	652.40	.0450
2730.00	654.00	.0450	2800.00	658.00	.0450	.	.	.
.	.	.	.	.	.	.	.	.
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.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.

END DATA CARD

1	2	3	4	5	6	7
E	N	D	D	A	T	A

SUBROUTINE DESIGNATION (PROCED) CARD(S)

1	2	3	4
X	Y	P	L

1	2	3	4
R	A	T	/

1	2	3	4
B	K	W	T

CONTRL CARD

CONTRL (1)
%CHANGE
BRIDGE LENGTH

1	2	3	4	5
	•	Ø	3	5

CONTRL (2)
INCREASE-1.ϕ
DECREASE-2.ϕ

6	7	8	9	10
		2	•	Ø

CONTRL (3)
ABUT. MOVED ?
LT-3, RT-4, BOTH-5

11	12	13	14	15
		5	•	Ø

CONTRL (4)
NO. OF
CHANGES

16	17	18	19	20
		/	•	Ø

CONTRL (5)
NO. OF
BKWT. STAGES

21	22	23	24	25
		/	•	Ø

BRIDGE DATA CARD

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
ABUTMENT TYPE WW–5.0; S.T.–6.0									BASE BKWT. CURVE NO. 45° & 60° WW=1; 30° WW=2 90° WW=3; ALL S.T.=1									NO. OF PIERS IN CROSS SECTION								
					6	.	Ø										1								1	6

28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
PIER TYPE (SEE FIGURE 5A)									BENT TYPE (SEE FIGURE 5B)								
								4									5

ABUTMENT DATA CARDS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
STA. LT. FACE LT. ABUT. AT GROUND XAB(1)								STA. RT. FACE LT ABUT. AT GROUND XAB(2)								STA. LT. FACE RT. ABUT. AT GROUND XAB(3)								STA. RT. FACE RT. ABUT. AT GROUND XAB(4)							
				Ø	.	Ø	Ø					1	.	Ø	Ø		1	2	8	Ø	.	Ø	Ø		1	3	Ø	Ø	.	Ø	Ø

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
ELEV. LT. FACE LT. ABUT. AT GROUND YAB(1)								ELEV. RT. FACE LT ABUT. AT GROUND YAB(2)								ELEV. LT. FACE RT. ABUT. AT GROUND YAB(3)								ELEV. RT. FACE RT. ABUT. AT GROUND YAB(4)							
		6	5	8	.	Ø	Ø			6	5	7	.	Ø	Ø			6	4	3	.	2	Ø			6	4	3	.	2	Ø

33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
ELEV. BRIDGE LT. ABUTMENT YAB(5)								ELEV. BRIDGE RT. ABUTMENT YAB(6)							
		6	5	8	.	Ø	Ø			6	5	8	.	Ø	Ø

PIER DATA CARDS

PIER BASE ELEVATION (BELPR)

1–7	8–14	15–21	22–28	29–35	36–42	43–49	50–56	57–63	64–70
632.00	632.30	643.80	644.00	642.30	642.60	642.30	642.30	642.70	638.60
643.30	643.20	643.10	643.30	643.80	643.30	.	.	.	.
.	.	.	.	.	.	.	.	.	.

WIDTH OF PIERS (WPR)

1–7	8–14	15–21	22–28	29–35	36–42	43–49	50–56	57–63	64–70
5.50	5.50	5.00	1.75	1.75	1.75	1.75	1.75	1.75	1.75
1.75	1.75	1.75	1.75	1.75	1.75	.	.	.	.
.	.	.	.	.	.	.	.	.	.

END OF JOB CARD

1	2	3
E	N	D

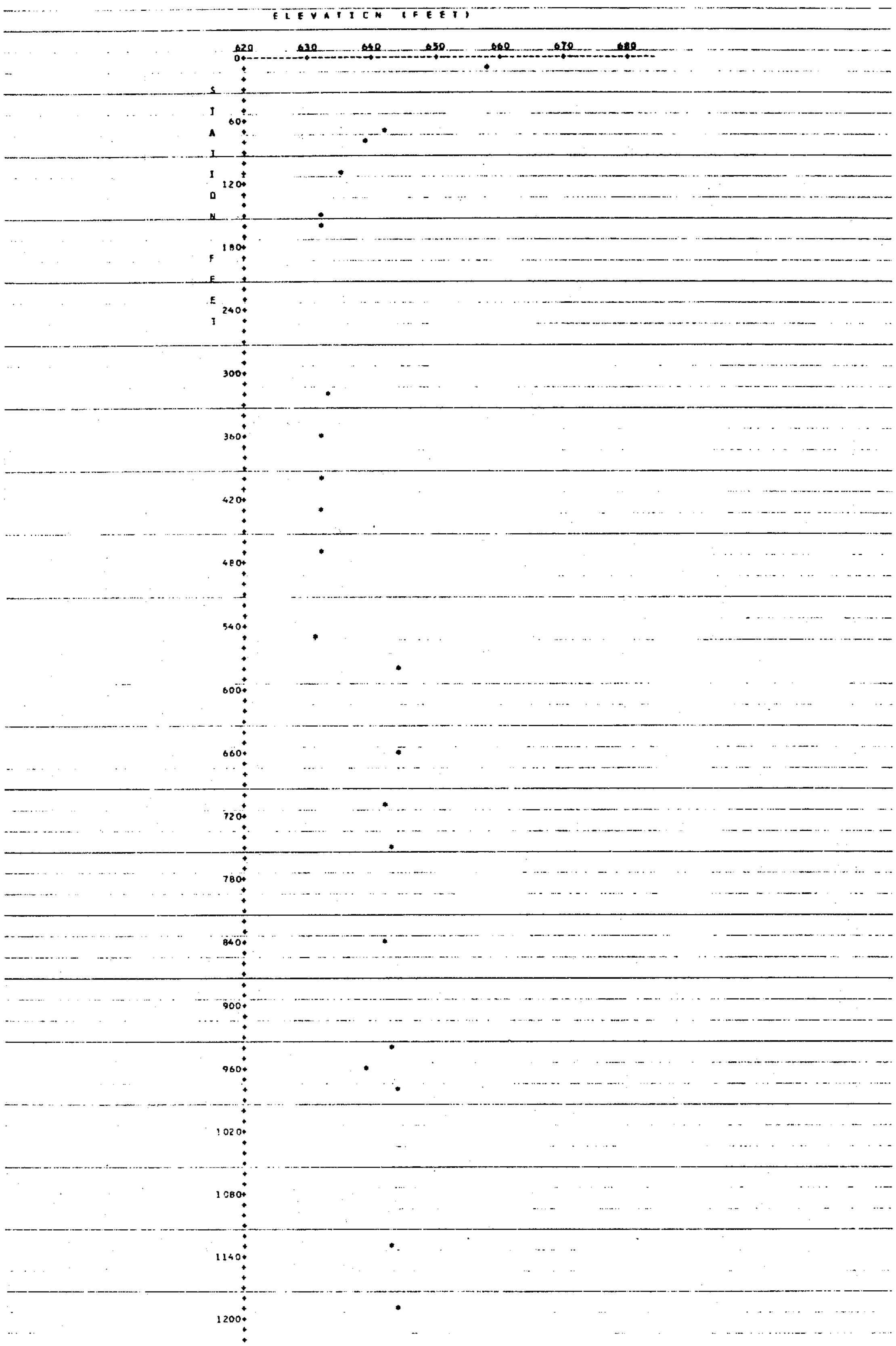
EXAMPLE PRCBLEM JOE BRADLEY ECCENTRIC CROSSING

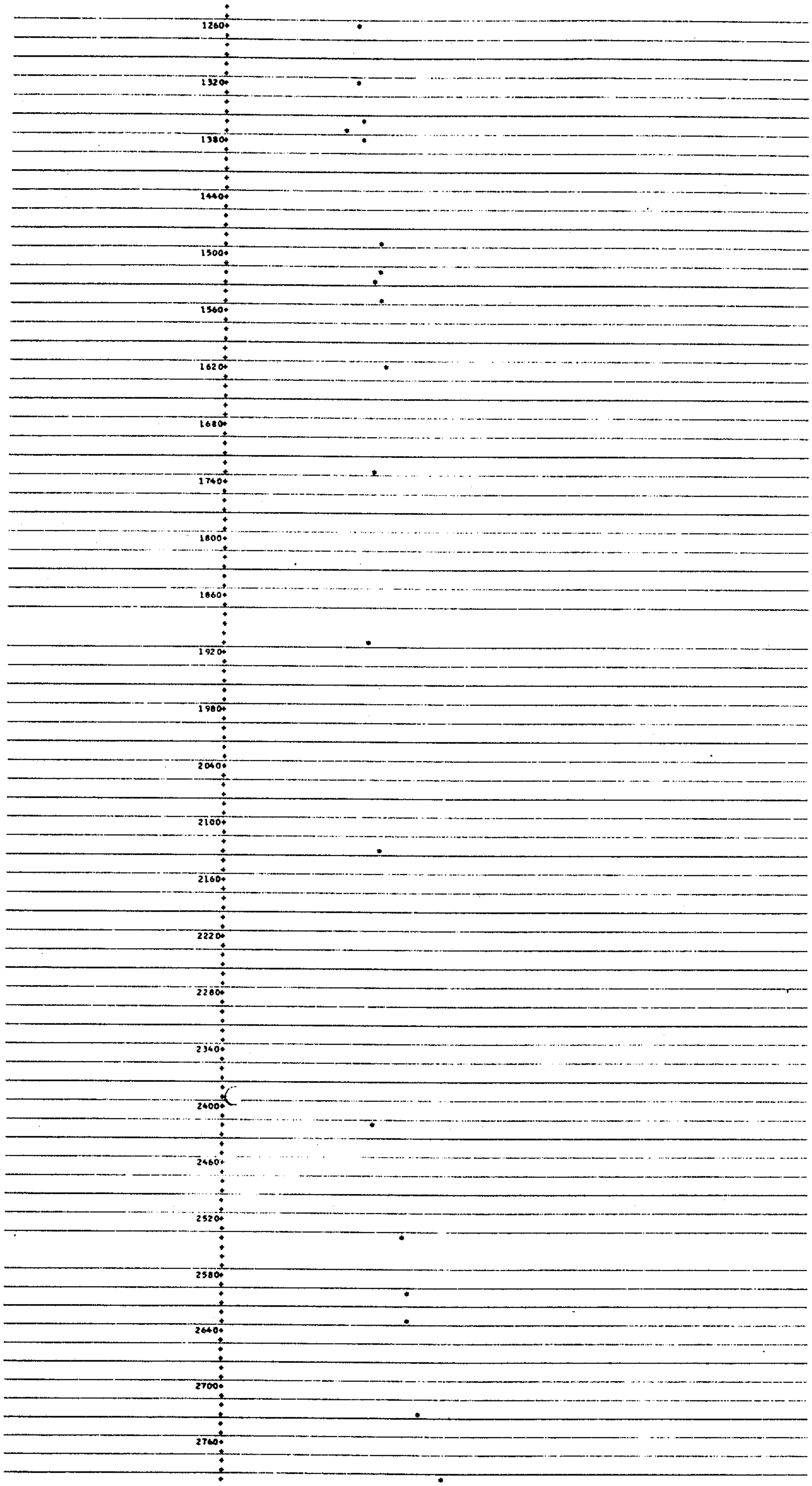
SKEW ANGLE = 0.0 DEGREES

NORMAL X-SECTION

CROSS SECTION INPUT DATA

X	YG	CN	X	YG	CN	X	YG	CN
0.0	658.00	0.0450	70.00	642.00	0.0450	80.00	639.00	0.0450
110.00	635.00	0.0300	150.00	632.00	0.0300	160.00	631.70	0.0300
320.00	632.50	0.0300	360.00	632.40	0.0300	400.00	632.30	0.0300
430.00	631.80	0.0300	470.00	631.70	0.0300	550.00	631.00	0.0300
580.00	643.80	0.0500	660.00	644.00	0.0600	710.00	642.00	0.0600
750.00	642.50	0.0320	840.00	642.10	0.0320	940.00	643.00	0.0300
960.00	638.50	0.0300	980.00	643.60	0.0300	1130.00	643.00	0.0350
1190.00	643.70	0.0350	1260.00	643.20	0.0350	1320.00	643.00	0.0600
1360.00	643.70	0.0600	1370.00	641.00	0.0600	1380.00	644.00	0.0600
1490.00	647.00	0.0400	1520.00	646.70	0.0400	1530.00	645.50	0.0400
1550.00	646.80	0.0400	1620.00	647.50	0.0400	1730.00	646.00	0.0400
1910.00	644.50	0.0450	2130.00	647.00	0.0450	2420.00	646.40	0.0450
2540.00	651.00	0.0450	2600.00	652.00	0.0450	2630.00	652.40	0.0450
2730.00	654.00	0.0450	2800.00	658.00	0.0450			


ELEVATION (FEET)
620 630 640 650 660 670 680
STATION (FEET)
0 60 120 180 240 300 360 420 480 540 600 660 720 780 840 900 960 1020 1080 1140 1200


1260
1320
1380
1440
1500
1560
1620
1680
1740
1800
1860
1920
1980
2040
2100
2160
2220
2280
2340
2400
2460
2520
2580
2640
2700
2760

EXAMPLE PROBLEM JOE BRADLEY ECCENTRIC CROSSING

PAGE 1

SKEW ANGLE = 0.0 DEGREES

INPUT DATA

STAGE ELEVATION = 647.00 FEET
SLOPE OF RIVER = 0.000240 FEET PER FOOT
DESIGN DISCHARGE = 98300.00 CFS

RESULTANT DATA

X BEGINNING	X ENDING	MANNINGS N	AREA	WETTED PER	HYD.RADIUS	CONVEYANCE	DISCHARGE	VELOCITY
48.12	70.00	0.0450	54.69	22.44				
70.00	80.00	0.0450	65.00	10.44				
SUB-SECTION TOTALS * * * * * * * * * * *			119.69	32.88	3.6402	9381.93	145.34	1.21
80.00	110.00	0.0300	300.00	30.27				
110.00	150.00	0.0300	540.00	40.11				
150.00	160.00	0.0300	151.50	10.00				
160.00	320.00	0.0300	2384.00	160.00				
320.00	360.00	0.0300	582.00	40.00				
360.00	400.00	0.0300	586.01	40.00				
400.00	430.00	0.0300	448.51	30.00				
430.00	470.00	0.0300	610.00	40.00				
470.00	550.00	0.0300	1252.00	80.00				
SUB-SECTION TOTALS * * * * * * * * * * *			6854.02	470.39	14.5709	2032616.00	31489.16	4.59
550.00	580.00	0.0500	288.00	32.62				
SUB-SECTION TOTALS * * * * * * * * * * *			288.00	32.62	8.8300	36691.70	568.43	1.97
580.00	660.00	0.0600	248.01	80.00				
660.00	710.00	0.0600	200.00	50.04				
SUB-SECTION TOTALS * * * * * * * * * * *			448.01	130.04	3.4451	25388.54	393.32	0.88
710.00	750.00	0.0320	190.00	40.00				
750.00	840.00	0.0320	423.01	90.00				
SUB-SECTION TOTALS * * * * * * * * * * *			613.01	130.00	4.7153	80302.87	1244.05	2.03
840.00	940.00	0.0300	445.01	100.00				
940.00	960.00	0.0300	125.00	20.50				
960.00	980.00	0.0300	119.00	20.64				
SUB-SECTION TOTALS * * * * * * * * * * *			689.01	141.14	4.8816	98528.19	1526.39	2.22
980.00	1130.00	0.0350	555.01	150.00				
1130.00	1190.00	0.0350	219.00	60.00				
1190.00	1260.00	0.0350	248.50	70.00				
SUB-SECTION TOTALS * * * * * * * * * * *			1022.52	280.01	3.6518	103270.50	1599.86	1.56
1260.00	1320.00	0.0600	234.00	60.00				
1320.00	1360.00	0.0600	146.00	40.01				
1360.00	1370.00	0.0600	46.50	10.36				
1370.00	1380.00	0.0600	45.00	10.44				
SUB-SECTION TOTALS * * * * * * * * * * *			471.50	120.80	3.9030	29039.08	449.87	0.95
1380.00	1490.00	0.0400	165.00	110.04				
SUB-SECTION TOTALS * * * * * * * * * * *			165.00	110.04	1.4994	8052.95	124.76	0.76
1490.00	1520.00	0.0400	4.50	30.00				
1520.00	1530.00	0.0400	9.00	10.07				
1530.00	1550.00	0.0400	17.00	20.04				
1550.00	1570.01	0.0400	2.00	20.01				
SUB-SECTION TOTALS * * * * * * * * * * *			32.51	80.13	0.4057	663.35	10.28	0.32
1656.67	1730.00	0.0400	36.67	73.34				
SUB-SECTION TOTALS * * * * * * * * * * *			36.67	73.34	0.5000	860.17	13.33	0.36
1730.00	1910.00	0.0450	315.00	180.01				
1910.00	2130.00	0.0450	275.00	220.01				
SUB-SECTION TOTALS * * * * * * * * * * *			590.00	400.02	1.4749	25316.01	392.19	0.66
2130.00	2420.00	0.0450	87.01	290.00				
2420.00	2435.65	0.0450	4.70	15.67				
SUB-SECTION TOTALS * * * * * * * * * * *			91.71	305.67	0.3000	1360.42	21.08	0.23

TOTAL AREA = 11421.60 SQUARE FEET
TOTAL CONVEYANCE = 2451466.00 CFS
TOTAL DISCHARGE = 37978.02 CFS

EXAMPLE PROBLEM   JOE BRADLEY ECCENTRIC CROSSING

SKEW ANGLE = 0.0 DEGREES

INPUT DATA

STAGE ELEVATION = 650.00 FEET
SLOPE OF RIVER = 0.000240 FEET PER FOOT
DESIGN DISCHARGE = 98300.00 CFS

RESULTANT DATA

X BEGINNING	X ENDING	MANNINGS N	AREA	WETTED PER	HYD.RADIUS	CONVEYANCE	DISCHARGE	VELOCITY
35.00	70.00	0.0450	140.00	35.90				
70.00	80.00	0.0450	95.00	10.44				
SUB-SECTION TOTALS * * * * * * * * * * *			235.00	46.34	5.0709	22979.06	355.99	1.51
80.00	110.00	0.0300	390.00	30.27				
110.00	150.00	0.0300	660.00	40.11				
150.00	160.00	0.0300	181.50	10.00				
160.00	320.00	0.0300	2864.00	160.00				
320.00	360.00	0.0300	702.00	40.00				
360.00	400.00	0.0300	706.01	40.00				
400.00	430.00	0.0300	538.51	30.00				
430.00	470.00	0.0300	730.00	40.00				
470.00	550.00	0.0300	1492.00	80.00				
SUB-SECTION TOTALS * * * * * * * * * * *			8264.02	470.39	17.5684	2776463.00	43012.79	5.20
550.00	580.00	0.0500	378.00	32.62				
SUB-SECTION TOTALS * * * * * * * * * * *			378.00	32.62	11.5893	57734.81	894.42	2.37
580.00	660.00	0.0600	488.01	80.00				
660.00	710.00	0.0600	350.00	50.04				
SUB-SECTION TOTALS * * * * * * * * * * *			838.01	130.04	6.4442	72110.56	1117.13	1.33
710.00	750.00	0.0320	310.00	40.00				
750.00	840.00	0.0320	693.01	90.00				
SUB-SECTION TOTALS * * * * * * * * * * *			1003.01	130.00	7.7152	182473.56	2826.87	2.82
840.00	940.00	0.0300	745.01	100.00				
940.00	960.00	0.0300	185.00	20.50				
960.00	980.00	0.0300	179.00	20.64				
SUB-SECTION TOTALS * * * * * * * * * * *			1109.01	141.14	7.8573	217844.19	3374.83	3.04
980.00	1130.00	0.0350	1005.01	150.00				
1130.00	1190.00	0.0350	399.00	60.00				
1190.00	1260.00	0.0350	458.50	70.00				
SUB-SECTION TOTALS * * * * * * * * * * *			1862.52	280.01	6.6517	280616.00	4347.29	2.33
1260.00	1320.00	0.0600	414.00	60.00				
1320.00	1360.00	0.0600	266.00	40.01				
1360.00	1370.00	0.0600	76.50	10.36				
1370.00	1380.00	0.0600	75.00	10.44				
SUB-SECTION TOTALS * * * * * * * * * * *			831.50	120.80	6.8830	74764.75	1158.25	1.39
1380.00	1490.00	0.0400	495.00	110.04				
1490.00	1520.00	0.0400	94.50	30.00				
1520.00	1530.00	0.0400	39.00	10.07				
1530.00	1550.00	0.0400	77.00	20.04				
1550.00	1620.00	0.0400	199.51	70.00				
1620.00	1730.00	0.0400	357.50	110.01				
SUB-SECTION TOTALS * * * * * * * * * * *			1262.51	350.17	3.6054	110624.19	1713.78	1.36
1730.00	1910.00	0.0450	855.00	180.01				
1910.00	2130.00	0.0450	935.00	220.01				
2130.00	2420.00	0.0450	957.01	290.00				
2420.00	2513.91	0.0450	169.05	93.98				
SUB-SECTION TOTALS * * * * * * * * * * *			2916.06	784.00	3.7195	231888.91	3592.41	1.23

TOTAL AREA = 18699.60 SQUARE FEET
TOTAL CONVEYANCE = 4027495.00 CFS
TOTAL DISCHARGE = 62393.74 CFS

EXAMPLE PROBLEM JOE BRADLEY ECCENTRIC CROSSING

SKEW ANGLE = 0.0 DEGREES

INPUT DATA

STAGE ELEVATION = 653.00 FEET
SLOPE OF RIVER = 0.000240 FEET PER FOOT
DESIGN DISCHARGE = 98300.00 CFS

RESULTANT DATA

X BEGINNING	X ENDING	MANNINGS N	AREA	WETTED PER	HYD.RADIUS	CONVEYANCE	DISCHARGE	VELOCITY
21.88	70.00	0.0450	264.69	49.37				
70.00	80.00	0.0450	125.00	10.44				
SUB-SECTION TOTALS * * * * * * * * * * *			389.69	59.81	6.5158	45040.85	697.77	1.79
80.00	110.00	0.0300	480.00	30.27				
110.00	150.00	0.0300	780.00	40.11				
150.00	160.00	0.0300	211.50	10.00				
160.00	320.00	0.0300	3344.00	160.00				
320.00	360.00	0.0300	822.00	40.00				
360.00	400.00	0.0300	826.01	40.00				
400.00	430.00	0.0300	628.51	30.00				
430.00	470.00	0.0300	850.00	40.00				
470.00	550.00	0.0300	1732.00	80.00				
SUB-SECTION TOTALS * * * * * * * * * * *			9674.02	470.39	20.5659	3610277.00	55930.18	5.78
550.00	580.00	0.0500	468.00	32.62				
SUB-SECTION TOTALS * * * * * * * * * * *			468.00	32.62	14.3487	82424.75	1276.92	2.73
580.00	660.00	0.0600	728.01	80.00				
660.00	710.00	0.0600	500.00	50.04				
SUB-SECTION TOTALS * * * * * * * * * * *			1228.01	130.04	9.4433	136346.19	2112.27	1.72
710.00	750.00	0.0320	430.00	40.00				
750.00	840.00	0.0320	963.01	90.00				
SUB-SECTION TOTALS * * * * * * * * * * *			1393.01	130.00	10.7151	315498.06	4887.68	3.51
840.00	940.00	0.0300	1045.01	100.00				
940.00	960.00	0.0300	245.00	20.50				
960.00	980.00	0.0300	239.00	20.64				
SUB-SECTION TOTALS * * * * * * * * * * *			1529.01	141.14	10.8330	372092.69	5764.43	3.77
980.00	1130.00	0.0350	1455.01	150.00				
1130.00	1190.00	0.0350	579.00	60.00				
1190.00	1260.00	0.0350	668.50	70.00				
SUB-SECTION TOTALS * * * * * * * * * * *			2702.52	280.01	9.6516	521932.06	8085.74	2.99
1260.00	1320.00	0.0600	594.00	60.00				
1320.00	1360.00	0.0600	386.00	40.01				
1360.00	1370.00	0.0600	106.50	10.36				
1370.00	1380.00	0.0600	105.00	10.44				
SUB-SECTION TOTALS * * * * * * * * * * *			1191.50	120.80	9.8630	136186.81	2109.80	1.77
1380.00	1490.00	0.0400	825.00	110.04				
1490.00	1520.00	0.0400	184.50	30.00				
1520.00	1530.00	0.0400	69.00	10.07				
1530.00	1550.00	0.0400	137.00	20.04				
1550.00	1620.00	0.0400	409.51	70.00				
1620.00	1730.00	0.0400	687.50	110.01				
SUB-SECTION TOTALS * * * * * * * * * * *			2312.51	350.17	6.6040	303402.31	4700.29	2.03
1730.00	1910.00	0.0450	1395.00	180.01				
1910.00	2130.00	0.0450	1595.00	220.01				
2130.00	2420.00	0.0450	1827.01	290.00				
2420.00	2540.00	0.0450	516.01	120.09				
2540.00	2600.00	0.0450	90.00	60.01				
2600.00	2630.00	0.0450	24.00	30.00				
2630.00	2667.50	0.0450	11.25	37.51				
SUB-SECTION TOTALS * * * * * * * * * * *			5458.27	937.63	5.8214	585192.75	9065.77	1.66

TOTAL AREA = 26346.50 SQUARE FEET
TOTAL CONVEYANCE = 6108399.00 CFS
TOTAL DISCHARGE = 94630.62 CFS

EXAMPLE PROBLEM JOE BRADLEY ECCENTRIC CROSSING

INPUT DATA

STAGE ELEVATION = 653.30 FEET****DESIGN STAGE****
SLOPE OF RIVER = 0.000240 FEET PER FOOT
DESIGN DISCHARGE = 98300.00 CFS
SKEW ANGLE = C.0 DEGREES

RESULTANT DATA

X BEGINNING	X ENDING	MANNINGS N	AREA	WETTED PER	HYD.RADIUS	CONVEYANCE	DISCHARGE	VELOCITY
20.55	70.00	0.0450	279.51	50.73				
70.00	80.00	0.0450	128.04	10.44				
SUB-SECTION TOTALS * * * * * * * * * * *			407.54	61.17	6.6625	47809.32	740.66	1.82
80.00	110.00	0.0300	489.11	30.27				
110.00	150.CC	0.0300	792.15	40.11				
150.00	160.00	0.0300	214.54	10.00				
160.00	320.00	0.0300	3392.60	160.00				
320.00	360.00	0.0300	834.15	40.00				
360.00	400.00	0.0300	838.15	40.00				
400.00	430.00	0.0300	637.62	30.00				
430.00	470.0C	0.0300	862.15	40.00				
470.00	550.00	0.0300	1756.30	80.00				
SUB-SECTION TOTALS * * * * * * * * * * *			9816.76	470.39	20.8693	3699515.00	57312.65	5.84
550.00	580.00	0.0500	477.11	32.62				
SUB-SECTION TOTALS * * * * * * * * * * *			477.11	32.62	14.6280	85117.06	1318.63	2.76
580.00	660.00	0.0600	752.30	80.00				
660.00	710.00	0.0600	515.19	50.04				
SUB-SECTION TOTALS * * * * * * * * * * *			1267.49	130.04	9.7469	143732.00	2226.69	1.76
710.00	750.00	0.0320	442.15	40.00				
750.00	840.00	0.0320	990.34	90.00				
SUB-SECTION TOTALS * * * * * * * * * * *			1432.49	130.00	11.0188	330545.06	5120.78	3.57
840.00	940.C0	0.0300	1075.38	100.00				
940.00	960.00	0.0300	251.07	20.50				
960.00	980.00	0.0300	245.08	20.64				
SUB-SECTION TOTALS * * * * * * * * * * *			1571.53	141.14	11.1342	389501.00	6034.12	3.84
980.00	1130.00	0.0350	1500.57	150.00				
1130.00	1190.C0	0.0350	597.22	60.00				
1190.00	1260.00	0.0350	689.76	70.00				
SUB-SECTION TOTALS * * * * * * * * * * *			2787.55	280.01	9.9553	549596.00	8514.30	3.05
1260.00	1320.00	0.0600	612.22	60.00				
1320.00	1360.00	0.0600	398.15	40.01				
1360.00	1370.00	0.0600	109.54	10.36				
1370.00	1380.00	0.0600	108.04	10.44				
SUB-SECTION TOTALS * * * * * * * * * * *			1227.95	120.80	10.1647	143201.44	2218.47	1.81
1380.00	1490.C0	0.0400	858.41	110.04				
1490.00	1520.00	0.0400	193.61	30.00				
1520.00	1530.C0	0.0400	72.04	10.07				
1530.00	1550.00	0.0400	143.08	20.04				
1550.00	1620.00	0.0400	430.77	70.00				
1620.00	1730.00	0.0400	720.91	110.01				
SUB-SECTION TOTALS * * * * * * * * * * *			2418.81	350.17	6.9075	327005.62	5065.95	2.09
1730.00	1910.00	0.0450	1449.67	180.01				
1910.00	2130.00	0.0450	1661.82	220.01				
2130.00	2420.00	0.0450	1915.09	290.00				
2420.00	2540.00	0.0450	552.45	120.09				
2540.00	2600.00	0.0450	108.22	60.01				
2600.00	2630.00	0.0450	33.11	30.00				
2630.00	2686.48	0.0450	25.53	56.49				
SUB-SECTION TOTALS * * * * * * * * * * *			5745.88	956.61	6.0065	629027.94	9744.86	1.70

TOTAL AREA = 27153.08 SQUARE FEET
TOTAL CONVEYANCE = 6345048.00 CFS
TOTAL DISCHARGE = 98296.87 CFS

EXAMPLE PROBLEM JOE BRADLEY ECCENTRIC CROSSING

SKEW ANGLE = 0.0 DEGREES

INPUT DATA

STAGE ELEVATION = 656.0C FEET
SLOPE OF RIVER = 0.000240 FEET PER FOOT
DESIGN DISCHARGE = 98300.00 CFS

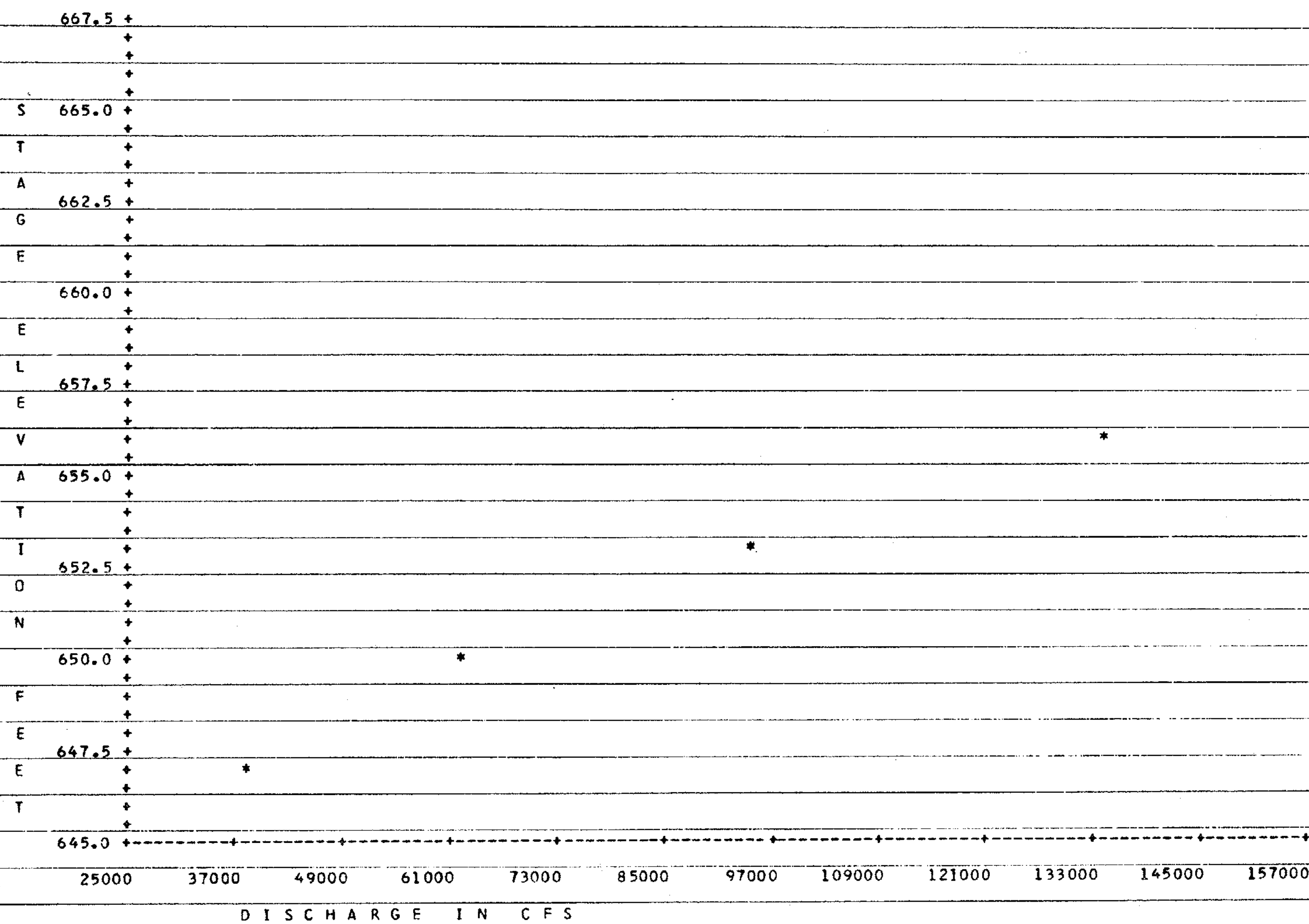
RESULTANT DATA

X BEGINNING	X ENDING	MANNINGS N	AREA	WETTED PER	HYD.RADIUS	CONVEYANCE	DISCHARGE	VELOCITY
8.75	70.00	0.0450	428.75	62.83				
70.00	80.00	0.0450	155.00	10.44				
SUB-SECTION TOTALS * * * * * * * * * * *			583.75	73.27	7.9671	77155.62	1195.29	2.05
80.00	110.00	0.0300	570.00	30.27				
110.00	150.00	0.0300	900.00	40.11				
150.00	160.00	0.0300	241.50	10.00				
160.00	320.00	0.0300	3824.00	160.00				
320.00	360.00	0.0300	942.00	40.00				
360.00	400.00	0.0300	946.01	40.00				
400.00	430.00	0.0300	718.51	30.00				
430.00	470.00	0.0300	970.00	40.00				
470.00	550.00	0.0300	1972.00	80.00				
SUB-SECTION TOTALS * * * * * * * * * * *			11084.02	470.39	23.5634	4529437.00	70169.69	6.33
550.00	580.00	0.0500	558.00	32.62				
SUB-SECTION TOTALS * * * * * * * * * * *			558.00	32.62	17.1080	110508.62	1711.99	3.07
580.00	660.00	0.0600	968.01	80.00				
660.00	710.00	0.0600	650.00	50.04				
SUB-SECTION TOTALS * * * * * * * * * * *			1618.01	130.04	12.4424	215931.19	3345.19	2.07
710.00	750.00	0.0320	550.00	40.00				
750.00	840.00	0.0320	1233.01	90.00				
SUB-SECTION TOTALS * * * * * * * * * * *			1783.01	130.00	13.7150	476100.56	7375.72	4.14
840.00	940.C0	0.0300	1345.01	100.00				
940.00	960.00	0.0300	305.00	20.50				
960.00	980.00	0.0300	299.00	20.64				
SUB-SECTION TOTALS * * * * * * * * * * *			1949.01	141.14	13.8087	557647.25	8639.04	4.43
980.00	1130.00	0.0350	1905.01	150.00				
1130.00	1190.00	0.0350	759.00	60.00				
1190.00	1260.00	0.0350	878.50	70.00				
SUB-SECTION TOTALS * * * * * * * * * * *			3542.52	280.01	12.6515	819518.81	12695.93	3.58
1260.00	1320.00	0.0600	774.00	60.00				
1320.00	1360.00	0.0600	506.00	40.01				
1360.00	1370.00	0.0600	136.50	10.36				
1370.00	1380.00	0.0600	135.00	10.44				
SUB-SECTION TOTALS * * * * * * * * * * *			1551.50	120.80	12.8431	211479.69	3276.23	2.11
1380.00	1490.C0	0.0400	1155.00	110.04				
1490.00	1520.00	0.0400	274.50	30.00				
1520.00	1530.00	0.0400	99.00	10.07				
1530.00	1550.00	0.0400	197.00	20.04				
1550.00	1620.00	0.0400	619.51	70.00				
1620.00	1730.00	0.0400	1017.50	110.01				
SUB-SECTION TOTALS * * * * * * * * * * *			3362.51	350.17	9.6025	566290.75	8772.94	2.61
1730.00	1910.00	0.0450	1935.00	180.01				
1910.00	2130.00	0.0450	2255.00	220.01				
2130.00	2420.00	0.0450	2697.01	290.00				
2420.00	2540.00	0.0450	876.01	120.09				
2540.00	2600.00	0.0450	270.00	60.01				
2600.00	2630.00	0.0450	114.00	30.00				
2630.00	2730.00	0.0450	280.00	100.01				
2730.00	2765.00	0.0450	35.00	35.06				
SUB-SECTION TOTALS * * * * * * * * * * *			8462.02	1035.19	8.1744	1137769.00	17626.24	2.08

TOTAL AREA = 34494.31 SQUARE FEET
TOTAL CONVEYANCE = 8701834.00 CFS
TOTAL DISCHARGE = 134807.94 CFS

EXAMPLE PROBLEM JOE BRADLEY ECCENTRIC CROSSING

SKEW ANGLE = 0.0 DEGREES



EXAMPLE PROBLEM JOE BRADLEY ECCENTRIC CROSSING PAGE 1

SKEW ANGLE = 0.0 DEGREES

INPUT DATA

STAGE ELEVATION = 653.00 FEET
SLOPE OF RIVER = 0.000240 FEET PER FOOT
DESIGN DISCHARGE = 98300.00 CFS

RESULTANT DATA

X BEGINNING	X ENDING	MANNINGS N	AREA	WETTED PER	HYD.RADIUS	CONVEYANCE	DISCHARGE	VELOCITY
19.40	70.00	0.0450	278.30	51.78				
70.00	80.00	0.0450	125.00	10.44				
SUB-SECTION TOTALS * * * * * * * * * * *			403.30	62.22	6.4816	46450.88	719.61	1.78
80.00	110.00	0.0300	480.00	30.27				
110.00	150.00	0.0300	780.00	40.11				
150.00	160.CO	0.0300	211.50	10.00				
160.00	320.00	0.0300	3344.00	160.00				
320.00	360.00	0.0300	822.00	40.00				
360.00	400.00	0.0300	826.01	40.00				
400.00	430.00	0.0300	628.51	30.00				
430.00	470.00	0.0300	850.00	40.00				
470.00	550.00	0.0300	1732.00	80.00				
SUB-SECTION TOTALS * * * * * * * * * * *			9674.02	470.39	20.5659	3610277.00	55930.18	5.78
550.00	580.00	0.0500	468.00	32.62				
SUB-SECTION TOTALS * * * * * * * * * * *			468.00	32.62	14.3487	82424.75	1276.92	2.73
580.00	660.00	0.0600	728.01	80.00				
660.00	710.00	0.0600	500.00	50.04				
SUB-SECTION TOTALS * * * * * * * * * * *			1228.01	130.04	9.4433	136346.19	2112.27	1.72
710.00	750.CC	0.0320	430.00	40.00				
750.00	840.00	0.0320	963.01	90.00				
SUB-SECTION TOTALS * * * * * * * * * * *			1393.01	130.00	10.7151	315498.06	4887.68	3.51
840.00	940.00	0.0300	1045.01	100.00				
940.00	960.00	0.0300	245.00	20.50				
960.00	980.00	0.0300	239.00	20.64				
SUB-SECTION TOTALS * * * * * * * * * * *			1529.01	141.14	10.8330	372092.69	5764.43	3.77
980.00	1130.00	0.0350	1455.01	150.00				
1130.00	1190.00	0.0350	579.00	60.00				
1190.00	1260.00	0.0350	668.50	70.00				
SUB-SECTION TOTALS * * * * * * * * * * *			2702.52	280.01	9.6516	521932.06	8085.74	2.99
1260.00	1280.00	0.0601	196.00	20.00				
SUB-SECTION TOTALS * * * * * * * * * * *			196.00	20.00	9.8000	22269.90	345.00	1.76
1280.00	1300.00	0.0600	196.00	20.00				
1300.00	1320.00	0.0600	198.00	20.00				
1320.00	1360.00	0.0600	386.00	40.01				
1360.00	1370.00	0.0600	106.50	10.36				
1370.00	1380.00	0.0600	105.00	10.44				
SUB-SECTION TOTALS * * * * * * * * * * *			991.50	100.81	9.8358	113118.25	1752.42	1.77
1380.00	1490.00	0.0400	825.00	110.04				
1490.00	1520.00	0.0400	184.50	30.00				
1520.00	1530.00	0.0400	69.00	10.07				
1530.00	1550.CO	0.0400	137.00	20.04				
1550.00	1620.00	0.0400	409.51	70.00				
1620.00	1730.00	0.0400	687.50	110.01				
SUB-SECTION TOTALS * * * * * * * * * * *			2312.51	350.17	6.6040	303402.31	4700.29	2.03
1730.00	1910.CO	0.0450	1395.00	180.01				
1910.00	2130.00	0.0450	1595.00	220.01				
2130.00	2420.00	0.0450	1827.01	290.00				
2420.00	2540.00	0.0450	516.01	120.09				
2540.00	2600.00	0.0450	90.00	60.01				
2600.00	2630.00	0.0450	24.00	30.00				
2630.00	2667.50	0.0450	11.25	37.51				
SUB-SECTION TOTALS * * * * * * * * * * *			5458.27	937.63	5.8214	585192.75	9065.77	1.66

TOTAL AREA = 26356.11 SQUARE FEET
TOTAL CONVEYANCE = 6109000.00 CFS
TOTAL DISCHARGE = 94640.12 CFS

BRIDGE INFORMATION INPUT
BRIDGE LENGTH = 1300.00
LEFT ABUTMENT POSITION - - XAB(1) = 0.0 YAB(1) = 658.00
XAB(2) = 1.00 YAB(2) = 657.00
RIGHT ABUTMENT POSITION - - XAB(3) = 1280.00 YAB(3) = 643.20
XAB(4) = 1300.00 YAB(4) = 643.20

BRIDGE OPENING AT WATER SURFACE = 1273.84
BASE BACKWATER CURVE USED = 1

CALCULATED INFORMATION
PORTION OF DISCHARGE LEFT OF OPENING (QA) = 0.0 CFS
PORTION OF DISCHARGE THRU OPENING (QB) = 79183.94 CFS
PORTION OF DISCHARGE RIGHT OF OPENING (QC) = 15456.19 CFS
AREA OF PIERS BELOW WATER SURFACE = ~~1900.03 SQ FEET~~ → 510.20
ALPHA1 = 1.76
ALPHA2 = 1.64
TOTAL BACKWATER COEFFICIENT = ~~0.51~~ → 0.35
BRIDGE WATERWAY OPENING BELOW NORMAL DEPTH (AN2) = 17658.73 SQ FEET
MEAN VELOCITY THRU BRIDGE OPENING (VN2) = 5.36 FPS
DISCHARGE RATIO (M) = 0.837
BACKWATER APPROXIMATION NO.1 = ~~0.27224 FEET~~ → 0.25485
FINAL BACKWATER APPROXIMATION = ~~0.59089 FEET~~ → 0.27343
NUMBER OF ITERATIONS TO OBTAIN FINAL BACKWATER = 3

EXAMPLE PROBLEM   IOE BRADLEY ECCENTRIC CROSSING   PAGE 1

INPUT DATA

STAGE ELEVATION = 653.10 FEET****DESIGN STAGE****
SLOPE OF RIVER = 0.000240 FEET PER FOOT
DESIGN DISCHARGE = 98300.00 CFS
SKEW ANGLE = 0.0 DEGREES

RESULTANT DATA

X BEGINNING	X ENDING	MANNINGS N	AREA	WETTED PER	HYD.RADIUS	CONVEYANCE	DISCHARGE	VELOCITY
18.01	70.00	0.0450	293.84	53.21				
70.00	80.00	0.0450	128.03	10.44				
SUB-SECTION TOTALS * * * * * * * * * * * *			421.87	63.65	6.6282	49319.95	764.06	1.81
80.00	110.00	0.0300	489.09	30.27				
110.00	150.00	0.0300	792.12	40.11				
150.00	160.00	0.0300	214.53	10.00				
160.00	320.00	0.0300	3392.48	160.00				
320.00	360.00	0.0300	834.12	40.00				
360.00	400.00	0.0300	838.13	40.00				
400.00	430.00	0.0300	637.60	30.00				
430.00	470.00	0.0300	862.12	40.00				
470.00	550.00	0.0300	1756.24	80.00				
SUB-SECTION TOTALS * * * * * * * * * * * *			9816.42	470.39	20.8686	3699301.00	57309.33	5.84
550.00	580.00	0.0500	477.09	32.62				
SUB-SECTION TOTALS * * * * * * * * * * * *			477.09	32.62	14.6273	85110.56	1318.53	2.76
580.00	660.00	0.0600	752.25	80.00				
660.00	710.00	0.0600	515.15	50.04				
SUB-SECTION TOTALS * * * * * * * * * * * *			1267.40	130.04	9.7462	143713.94	2226.41	1.76
710.00	750.00	0.0320	442.12	40.00				
750.00	840.00	0.0320	990.27	90.00				
SUB-SECTION TOTALS * * * * * * * * * * * *			1432.39	130.00	11.0181	330508.56	5120.21	3.57
840.00	940.00	0.0300	1075.31	100.00				
940.00	960.00	0.0300	251.06	20.50				
960.00	980.00	0.0300	245.06	20.64				
SUB-SECTION TOTALS * * * * * * * * * * * *			1571.43	141.14	11.1335	389458.69	6033.47	3.84
980.00	1130.00	0.0350	1500.46	150.00				
1130.00	1190.00	0.0350	597.18	60.00				
1190.00	1260.00	0.0350	689.71	70.00				
SUB-SECTION TOTALS * * * * * * * * * * * *			2787.35	280.01	9.9546	549528.75	8513.26	3.05
1260.00	1280.00	0.0601	202.06	20.00				
SUB-SECTION TOTALS * * * * * * * * * * * *			202.06	20.00	10.1030	23429.45	362.97	1.80
1280.00	1300.00	0.0600	202.06	20.00				
1300.00	1320.00	0.0600	204.06	20.00				
1320.00	1360.00	0.0600	398.12	40.01				
1360.00	1370.00	0.0600	109.53	10.36				
1370.00	1380.00	0.0600	108.03	10.44				
SUB-SECTION TOTALS * * * * * * * * * * * *			1021.80	100.81	10.1364	118938.87	1842.59	1.80
1380.00	1490.00	0.0400	858.33	110.04				
1490.00	1520.00	0.0400	193.59	30.00				
1520.00	1530.00	0.0400	72.03	10.07				
1530.00	1550.00	0.0400	143.06	20.04				
1550.00	1620.00	0.0400	430.72	70.00				
1620.00	1730.00	0.0400	720.83	110.01				
SUB-SECTION TOTALS * * * * * * * * * * * *			2418.55	350.17	6.9068	326947.81	5065.05	2.09
1730.00	1910.00	0.0450	1449.54	180.01				
1910.00	2130.00	0.0450	1661.66	220.01				
2130.00	2420.00	0.0450	1914.88	290.00				
2420.00	2540.00	0.0450	552.36	120.09				
2540.00	2600.00	0.0450	108.18	60.01				
2600.00	2630.00	0.0450	33.09	30.00				
2630.00	2686.44	0.0450	25.48	56.45				
SUB-SECTION TOTALS * * * * * * * * * * * *			5745.18	956.57	6.0060	628919.31	9743.18	1.70

TOTAL AREA = 27161.49 SQUARE FEET
TOTAL CONVEYANCE = 6345170.00 CFS
TOTAL DISCHARGE = 98298.81 CFS

BRIDGE INFORMATION INPUT
BRIDGE LENGTH = 1300.00
LEFT ABUTMENT POSITION - - XAB(1) = 0.0 YAB(1) = 658.00
XAB(2) = 1.00 YAB(2) = 657.00
RIGHT ABUTMENT POSITION - - XAB(3) = 1280.00 YAB(3) = 643.20
XAB(4) = 1300.00 YAB(4) = 643.20

BRIDGE OPENING AT WATER SURFACE = 1275.65
BASE BACKWATER CURVE USED = 1

CALCULATED INFORMATION
PORTION OF DISCHARGE LEFT OF OPENING (QA) = 0.0 CFS
PORTION OF DISCHARGE THRU OPENING (QB) = 81715.56 CFS
PORTION OF DISCHARGE RIGHT OF OPENING (QC) = 16583.25 CFS
AREA OF PIERS BELOW WATER SURFACE = ~~1351.48~~ SQ FEET → 521.94
ALPHA1 = 1.76
ALPHA2 = 1.63
TOTAL BACKWATER COEFFICIENT = ~~0.52~~ → 0.36
BRIDGE WATERWAY OPENING BELOW NORMAL DEPTH (AN2) = 18044.96 SQ FEET
MEAN VELOCITY THRU BRIDGE OPENING (VN2) = 5.45 FPS
DISCHARGE RATIO (M) = 0.831
BACKWATER APPROXIMATION NO.1 = ~~0.39418~~ FEET → 0.27068
FINAL BACKWATER APPROXIMATION = ~~0.42201~~ FEET → 0.29017
NUMBER OF ITERATIONS TO OBTAIN FINAL BACKWATER = 3

EXAMPLE PROBLEM — JOE BRADLEY ECCENTRIC CROSSING

PAGE 1

SKEW ANGLE = 0.0 DEGREES

INPUT DATA

STAGE ELEVATION = 656.00 FEET
SLOPE OF RIVER = 0.000240 FEET PER FOOT
DESIGN DISCHARGE = 98300.00 CFS

RESULTANT DATA

X BEGINNING	X ENDING	MANNINGS N	AREA	WETTED PER	HYD.RADIUS	CONVEYANCE	DISCHARGE	VELOCITY
5.60	70.00	0.0450	450.80	65.90				
70.00	80.00	0.0450	155.00	10.44				
SUB-SECTION TOTALS * * * * * * * * * * *			605.80	76.34	7.9351	79855.19	1237.11	2.04
80.00	110.00	0.0300	570.00	30.27				
110.00	150.00	0.0300	900.00	40.11				
150.00	160.00	0.0300	241.50	10.00				
160.00	320.00	0.0300	3824.00	160.00				
320.00	360.00	0.0300	942.00	40.00				
360.00	400.00	0.0300	946.01	40.00				
400.00	430.00	0.0300	718.51	30.00				
430.00	470.00	0.0300	970.00	40.00				
470.00	550.00	0.0300	1972.00	80.00				
SUB-SECTION TOTALS * * * * * * * * * * *			11084.02	470.39	23.5634	4529437.00	70169.69	6.33
550.00	580.00	0.0500	558.00	32.62				
SUB-SECTION TOTALS * * * * * * * * * * *			558.00	32.62	17.1080	110508.62	1711.99	3.07
580.00	660.00	0.0600	968.01	80.00				
660.00	710.00	0.0600	650.00	50.04				
SUB-SECTION TOTALS * * * * * * * * * * *			1618.01	130.04	12.4424	215931.19	3345.19	2.07
710.00	750.00	0.0320	550.00	40.00				
750.00	840.00	0.0320	1233.01	90.00				
SUB-SECTION TOTALS * * * * * * * * * * *			1783.01	130.00	13.7150	476100.56	7375.72	4.14
840.00	940.00	0.0300	1345.01	100.00				
940.00	960.00	0.0300	305.00	20.50				
960.00	980.00	0.0300	299.00	20.64				
SUB-SECTION TOTALS * * * * * * * * * * *			1949.01	141.14	13.8087	557647.25	8639.04	4.43
980.00	1130.00	0.0350	1905.01	150.00				
1130.00	1190.00	0.0350	759.00	60.00				
1190.00	1260.00	0.0350	878.50	70.00				
SUB-SECTION TOTALS * * * * * * * * * * *			3542.52	280.01	12.6515	819518.81	12695.93	3.58
1260.00	1280.00	0.0601	256.00	20.00				
SUB-SECTION TOTALS * * * * * * * * * * *			256.00	20.00	12.8000	34758.68	538.48	2.10
1280.00	1300.00	0.0600	256.00	20.00				
1300.00	1320.00	0.0600	258.00	20.00				
1320.00	1360.00	0.0600	506.00	40.01				
1360.00	1370.00	0.0600	136.50	10.36				
1370.00	1380.00	0.0600	135.00	10.44				
SUB-SECTION TOTALS * * * * * * * * * * *			1291.50	100.81	12.8118	175754.56	2722.78	2.11
1380.00	1490.00	0.0400	1155.00	110.04				
1490.00	1520.00	0.0400	274.50	30.00				
1520.00	1530.00	0.0400	99.00	10.07				
1530.00	1550.00	0.0400	197.00	20.04				
1550.00	1620.00	0.0400	619.51	70.00				
1620.00	1730.00	0.0400	1017.50	110.01				
SUB-SECTION TOTALS * * * * * * * * * * *			3362.51	350.17	9.6025	566290.75	8772.94	2.61
1730.00	1910.00	0.0450	1935.00	180.01				
1910.00	2130.00	0.0450	2255.00	220.01				
2130.00	2420.00	0.0450	2697.01	290.00				
2420.00	2540.00	0.0450	876.01	120.09				
2540.00	2600.00	0.0450	270.00	60.01				
2600.00	2630.00	0.0450	114.00	30.00				
2630.00	2730.00	0.0450	280.00	100.01				
2730.00	2765.00	0.0450	35.00	35.06				
SUB-SECTION TOTALS * * * * * * * * * * *			8462.02	1035.19	8.1744	1137769.00	17626.24	2.08

TOTAL AREA = 34512.36 SQUARE FEET
TOTAL CONVEYANCE = 8703567.00 CFS
TOTAL DISCHARGE = 134834.75 CFS

BRIDGE INFORMATION INPUT

BRIDGE LENGTH = 1300.00
LEFT ABUTMENT POSITION - - XAB(1) = 0.0 YAB(1) = 658.00
XAB(2) = 1.00 YAB(2) = 657.00
RIGHT ABUTMENT POSITION - - XAB(3) = 1280.00 YAB(3) = 643.20
XAB(4) = 1300.00 YAB(4) = 643.20

BRIDGE OPENING AT WATER SURFACE = 1291.70
BASE BACKWATER CURVE USED = 1

CALCULATED INFORMATION

PORTION OF DISCHARGE LEFT OF OPENING (QA) = 0.0 CFS
PORTION OF DISCHARGE THRU OPENING (QB) = 105839.62 CFS
PORTION OF DISCHARGE RIGHT OF OPENING (QC) = 28995.12 CFS
AREA OF PIERS BELOW WATER SURFACE = ~~1042.20~~ SQ FEET → 626.45
ALPHA1 = 1.68
ALPHA2 = 1.53
TOTAL BACKWATER COEFFICIENT = ~~0.46~~ → 0.47
BRIDGE WATERWAY OPENING BELOW NORMAL DEPTH (AN2) = 21507.04 SQ FEET
MEAN VELOCITY THRU BRIDGE OPENING (VN2) = 6.27 FPS
DISCHARGE RATIO (M) = 0.785
BACKWATER APPROXIMATION NO.1 = ~~0.62041~~ FEET → 0.43702
FINAL BACKWATER APPROXIMATION = ~~0.45021~~ FEET → 0.46499
NUMBER OF ITERATIONS TO OBTAIN FINAL BACKWATER = 3

EXAMPLE PROBLEM JOE BRADLEY ECCENTRIC CROSSING PAGE 1

SKEW ANGLE = 0.0 DEGREES

INPUT DATA

STAGE ELEVATION = 693.00 FEET
SLOPE OF RIVER = 0.000240 FEET PER FOOT
DESIGN DISCHARGE = 98300.00 CFS

RESULTANT DATA

X BEGINNING	X ENDING	MANNINGS N	AREA	WETTED PER	HYD.RADIUS	CONVEYANCE	DISCHARGE	VELOCITY
21.87	45.50	0.0450	63.79	24.23				
SUB-SECTION TOTALS * * * * * * * * * * *			63.79	24.23	2.6322	4027.89	62.40	0.98
45.50	58.98	0.0451	93.57	13.83				
SUB-SECTION TOTALS * * * * * * * * * * *			93.57	13.83	6.7664	11066.55	171.44	1.83
58.98	70.00	0.0450	107.33	11.30				
70.00	80.00	0.0450	125.00	10.44				
SUB-SECTION TOTALS * * * * * * * * * * *			232.33	21.74	10.6853	37348.98	578.61	2.49
80.00	110.CC	0.0300	480.00	30.27				
110.00	150.00	0.0300	780.00	40.11				
150.00	160.00	0.0300	211.50	10.00				
160.00	320.00	0.0300	3344.00	160.00				
320.00	360.00	0.0300	822.00	40.00				
360.00	400.00	0.0300	826.01	40.00				
400.00	430.CC	0.0300	628.51	30.00				
430.00	470.00	0.0300	850.00	40.00				
470.00	550.00	0.0300	1732.00	80.00				
SUB-SECTION TOTALS * * * * * * * * * * *			9674.02	470.39	20.5659	3610277.00	55930.18	5.78
550.00	580.00	0.0500	468.00	32.62				
SUB-SECTION TOTALS * * * * * * * * * * *			468.00	32.62	14.3487	82424.75	1276.92	2.73
580.00	660.00	0.0600	728.01	80.00				
660.00	710.00	0.0600	500.00	50.04				
SUB-SECTION TOTALS * * * * * * * * * * *			1228.01	130.04	9.4433	136346.19	2112.27	1.72
710.00	750.00	0.0320	430.00	40.00				
750.00	840.00	0.0320	963.01	90.00				
SUB-SECTION TOTALS * * * * * * * * * * *			1393.01	130.00	10.7151	315498.06	4887.68	3.51
840.00	940.00	0.0300	1045.01	100.00				
940.00	960.00	0.0300	245.00	20.50				
960.00	980.00	0.0300	239.00	20.64				
SUB-SECTION TOTALS * * * * * * * * * * *			1529.01	141.14	10.8330	372092.69	5764.43	3.77
980.00	1130.CC	0.0350	1455.01	150.00				
1130.00	1190.00	0.0350	579.00	60.00				
SUB-SECTION TOTALS * * * * * * * * * * *			2034.01	210.01	9.6855	393745.19	6099.87	3.00
1190.00	1234.74	0.0351	423.27	44.74				
SUB-SECTION TOTALS * * * * * * * * * * *			423.27	44.74	9.4597	80427.19	1245.97	2.94
1234.74	1254.50	0.0350	191.45	19.76				
1254.50	1260.00	0.0350	53.79	5.50				
SUB-SECTION TOTALS * * * * * * * * * * *			245.25	25.26	9.7098	47554.53	736.71	3.00
1260.00	1320.00	0.0600	594.00	60.00				
1320.00	1360.00	0.0600	386.00	40.01				
1360.00	1370.00	0.0600	106.50	10.36				
1370.00	1380.00	0.0600	105.00	10.44				
SUB-SECTION TOTALS * * * * * * * * * * *			1191.50	120.80	9.8630	136186.81	2109.80	1.77
1380.00	1490.00	0.0400	825.00	110.04				
1490.00	1520.00	0.0400	184.50	30.00				
1520.00	1530.00	0.0400	69.00	10.07				
1530.00	1550.00	0.0400	137.00	20.04				
1550.00	1620.CC	0.0400	409.51	70.00				
1620.00	1730.00	0.0400	687.50	110.01				
SUB-SECTION TOTALS * * * * * * * * * * *			2312.51	350.17	6.6040	303402.31	4700.29	2.03
1730.00	1910.CO	0.0450	1395.00	180.01				
1910.00	2130.00	0.0450	1595.00	220.01				
2130.00	2420.00	0.0450	1827.01	290.00				
2420.00	2540.00	0.0450	516.01	120.09				
2540.00	2600.00	0.0450	90.00	60.01				
2600.00	2630.00	0.0450	24.00	30.00				
2630.00	2667.50	0.0450	11.25	37.51				
SUB-SECTION TOTALS * * * * * * * * * * *			5458.27	937.63	5.8214	585192.75	9065.77	1.66

TOTAL AREA = 26346.51 SQUARE FEET
TOTAL CONVEYANCE = 6115596.00 CFS
TOTAL DISCHARGE = 94742.12 CFS

BRIDGE INFORMATION INPUT
BRIDGE LENGTH = 1209.00
LEFT ABUTMENT POSITION - - XAB(1) = 45.50 YAB(1) = 647.60
XAB(2) = 58.98 YAB(2) = 644.52
RIGHT ABUTMENT POSITION - - XAB(3) = 1234.74 YAB(3) = 643.38
XAB(4) = 1254.50 YAB(4) = 643.24

BRIDGE OPENING AT WATER SURFACE = 1197.24
BASE BACKWATER CURVE USED = 1

CALCULATED INFORMATION
PORTION OF DISCHARGE LEFT OF OPENING (QA) = 195.54 CFS
PORTION OF DISCHARGE THRU OPENING (QB) = 78035.44 CFS
PORTION OF DISCHARGE RIGHT OF OPENING (QC) = 16511.19 CFS
AREA OF PIERS BELOW WATER SURFACE = ~~[illegible]~~ SQ FEET → 510.20
ALPHA1 = 1.76
ALPHA2 = 1.63
TOTAL BACKWATER COEFFICIENT = ~~[illegible]~~ → 0.37
BRIDGE WATERWAY OPENING BELOW NORMAL DEPTH (AN2) = 17080.13 SQ FEET
MEAN VELOCITY THRU BRIDGE OPENING (VN2) = 5.55 FPS
DISCHARGE RATIO (M) = 0.824
BACKWATER APPROXIMATION NO.1 = ~~[illegible]~~ FEET → 0.28763
FINAL BACKWATER APPROXIMATION = ~~[illegible]~~ FEET → 0.30847
NUMBER OF ITERATIONS TO OBTAIN FINAL BACKWATER = 3

EXAMPLE PROBLEM   JOE BRADLEY ECCENTRIC CROSSING   PAGE 1

INPUT DATA

STAGE ELEVATION = 653.29 FEET****DESIGN STAGE****
SLOPE OF RIVER = 0.000240 FEET PER FOOT
DESIGN DISCHARGE = 98300.00 CFS
SKEW ANGLE = 0.0 DEGREES

RESULTANT DATA

X BEGINNING	X ENDING	MANNINGS N	AREA	WETTED PER	HYD.RADIUS	CONVEYANCE	DISCHARGE	VELOCITY
20.59	45.50	0.0450	70.93	25.55				
SUB-SECTION TOTALS * * * * * * * * * * *			70.93	25.55	2.7756	4640.01	71.88	1.01
45.50	58.98	0.0451	97.54	13.83				
SUB-SECTION TOTALS * * * * * * * * * * *			97.54	13.83	7.0532	11859.46	183.73	1.88
58.98	70.00	0.0450	110.57	11.30				
70.00	80.00	0.0450	127.94	10.44				
SUB-SECTION TOTALS * * * * * * * * * * *			238.51	21.74	10.9697	39020.71	604.51	2.53
80.00	110.00	0.0300	488.83	30.27				
110.00	150.00	0.0300	791.77	40.11				
150.00	160.00	0.0300	214.44	10.00				
160.00	320.00	0.0300	3391.07	160.00				
320.00	360.00	0.0300	833.77	40.00				
360.00	400.00	0.0300	837.77	40.00				
400.00	430.00	0.0300	637.33	30.00				
430.00	470.00	0.0300	861.77	40.00				
470.00	550.00	0.0300	1755.54	80.00				
SUB-SECTION TOTALS * * * * * * * * * * *			9812.29	470.39	20.8598	3696707.00	57269.15	5.84
550.00	580.00	0.0500	476.03	32.62				
SUB-SECTION TOTALS * * * * * * * * * * *			476.03	32.62	14.6193	85032.12	1317.31	2.76
580.00	660.00	0.0600	751.54	80.00				
660.00	710.00	0.0600	514.71	50.04				
SUB-SECTION TOTALS * * * * * * * * * * *			1266.25	130.04	9.7374	143498.00	2223.06	1.76
710.00	750.00	0.0320	441.77	40.00				
750.00	840.00	0.0320	989.48	90.00				
SUB-SECTION TOTALS * * * * * * * * * * *			1431.25	130.00	11.0093	330069.00	5113.41	3.57
840.00	940.00	0.0300	1074.43	100.00				
940.00	960.00	0.0300	250.88	20.50				
960.00	980.00	0.0300	244.89	20.64				
SUB-SECTION TOTALS * * * * * * * * * * *			1379.20	[illegible]	11.1248	388950.69	6025.60	3.84
980.00	1130.00	0.0350	[illegible]	150.00				
1130.00	1190.00	0.0350	[illegible]	60.00				
SUB-SECTION TOTALS * * * * * * * * * * *			2095.79	210.01	9.9797	413883.75	6411.85	3.06
1190.00	1234.74	0.0351	436.43	44.74				
SUB-SECTION TOTALS * * * * * * * * * * *			436.43	44.74	9.7539	84639.69	1311.23	3.00
1234.74	1254.50	0.0350	197.27	19.75				
1254.50	1260.00	0.0350	55.41	5.50				
SUB-SECTION TOTALS * * * * * * * * * * *			252.68	25.26	10.0040	49980.48	774.29	3.06
1260.00	1320.00	0.0600	[illegible]	[illegible]				
1320.00	1360.00	0.0600	[illegible]	40.01				
1360.00	1370.00	0.0600	109.44	10.35				
1370.00	1380.00	0.0600	107.96	10.44				
SUB-SECTION TOTALS * * * * * * * * * * *			1226.81	120.80	10.1553	142979.37	2215.03	1.81
1380.00	1490.00	0.0400	857.36	110.06				
1490.00	1520.00	0.0400	193.33	30.00				
1520.00	1530.00	0.0400	71.94	10.07				
1530.00	1550.00	0.0400	142.89	20.04				
1550.00	1620.00	0.0400	430.10	70.00				
1620.00	1730.00	0.0400	719.86	110.01				
SUB-SECTION TOTALS * * * * * * * * * * *			2415.48	350.17	6.9280	[illegible]	5054.32	2.09
1730.00	1910.00	0.0450	1547.95	180.01				
1910.00	2130.00	0.0450	1659.72	220.01				
2130.00	2420.00	0.0450	[illegible]	290.00				
2420.00	2540.00	0.0450	[illegible]	[illegible]				
2540.00	2600.00	0.0450	[illegible]	60.01				
2600.00	2630.00	0.0450	32.83	30.00				
2630.00	2685.89	0.0450	24.99	55.90				
SUB-SECTION TOTALS * * * * * * * * * * *			5736.77	956.02	6.0007	627626.94	9723.16	1.69

TOTAL AREA = 27127.71 SQUARE FEET
TOTAL CONVEYANCE = 6345130.00 CFS
TOTAL DISCHARGE = 98298.25 CFS

BRIDGE INFORMATION INPUT
BRIDGE LENGTH = 1209.00
LEFT ABUTMENT POSITION - - XAB(1) = 45.50 YAB(1) = 647.60
XAB(2) = 58.98 YAB(2) = 644.52
RIGHT ABUTMENT POSITION - - XAB(3) = 1234.74 YAB(3) = 643.38
XAB(4) = 1254.50 YAB(4) = 643.24

BRIDGE OPENING AT WATER SURFACE = 1197.93
BASE BACKWATER CURVE USED = 1

CALCULATED INFORMATION
PORTION OF DISCHARGE LEFT OF OPENING (QA) = 213.67 CFS
PORTION OF DISCHARGE THRU OPENING (QB) = 80427.69 CFS
PORTION OF DISCHARGE RIGHT OF OPENING (QC) = 17656.94 CFS
AREA OF PIERS BELOW WATER SURFACE = ~~[illegible]~~ SQ FEET → 521.60
ALPHA1 = 1.75
ALPHA2 = 1.62
TOTAL BACKWATER COEFFICIENT = ~~[illegible]~~ → 0.38
BRIDGE WATERWAY OPENING BELOW NORMAL DEPTH (AN2) = 17432.45 SQ FEET
MEAN VELOCITY THRU BRIDGE OPENING (VN2) = 5.64 FPS
DISCHARGE RATIO (M) = 0.818
BACKWATER APPROXIMATION NO.1 = ~~[illegible]~~ FEET → 0.30510
FINAL BACKWATER APPROXIMATION = ~~[illegible]~~ FEET → 0.32694
NUMBER OF ITERATIONS TO OBTAIN FINAL BACKWATER = 3

EXAMPLE PROBLEM JOE BRADLEY ECCENTRIC CROSSING

SKEW ANGLE = 0.0 DEGREES

INPUT DATA

STAGE ELEVATION = 656.00 FEET
SLOPE OF RIVER = 0.000240 FEET PER FOOT
DESIGN DISCHARGE = 98300.00 CFS

RESULTANT DATA

X BEGINNING	X ENDING	MANNINGS N	AREA	WETTED PER	HYD.RADIUS	CONVEYANCE	DISCHARGE	VELOCITY
8.75	45.50	0.0450	154.35	37.70				
SUB-SECTION TOTALS * * * * * * * * * * *			154.35	37.70	4.0945	13086.53	202.74	1.31
45.50	58.98	0.0451	134.02	13.83				
SUB-SECTION TOTALS * * * * * * * * * * *			134.02	13.83	9.6910	20140.94	312.02	2.33
58.98	70.00	0.0450	140.39	11.30				
70.00	80.00	0.0450	155.00	10.44				
SUB-SECTION TOTALS * * * * * * * * * * *			295.39	21.74	13.5853	55734.06	863.43	2.92
80.00	110.00	0.0300	570.00	30.27				
110.00	150.00	0.0300	900.00	40.11				
150.00	160.00	0.0300	241.50	10.00				
160.00	320.00	0.0300	3824.00	160.00				
320.00	360.00	0.0300	942.00	40.00				
360.00	400.00	0.0300	946.01	40.00				
400.00	430.00	0.0300	718.51	30.00				
430.00	470.00	0.0300	970.00	40.00				
470.00	550.00	0.0300	1972.00	80.00				
SUB-SECTION TOTALS * * * * * * * * * * *			11084.02	470.39	23.5634	4529437.00	70169.69	6.33
550.00	580.00	0.0500	558.00	32.62				
SUB-SECTION TOTALS * * * * * * * * * * *			558.00	32.62	17.1080	110508.62	1711.99	3.07
580.00	660.00	0.0600	968.01	80.00				
660.00	710.00	0.0600	650.00	50.04				
SUB-SECTION TOTALS * * * * * * * * * * *			1618.01	130.04	12.4424	215931.19	3345.19	2.07
710.00	750.00	0.0320	550.00	40.00				
750.00	840.00	0.0320	1233.01	90.00				
SUB-SECTION TOTALS * * * * * * * * * * *			1783.01	130.00	13.7150	476100.56	7375.72	4.14
840.00	940.00	0.0300	1345.01	100.00				
940.00	960.00	0.0300	305.00	20.50				
960.00	980.00	0.0300	299.00	20.64				
SUB-SECTION TOTALS * * * * * * * * * * *			1949.01	141.14	13.8087	557647.25	8639.04	4.43
980.00	1130.00	0.0350	1905.01	150.00				
1130.00	1190.00	0.0350	759.00	60.00				
SUB-SECTION TOTALS * * * * * * * * * * *			2664.01	210.01	12.6855	617389.44	9564.55	3.59
1190.00	1234.74	0.0351	557.49	44.74				
SUB-SECTION TOTALS * * * * * * * * * * *			557.49	44.74	12.4596	127298.00	1972.09	3.54
1234.74	1254.50	0.0350	250.73	19.76				
1254.50	1260.00	0.0350	70.29	5.50				
SUB-SECTION TOTALS * * * * * * * * * * *			321.02	25.26	12.7097	74491.50	1154.02	3.59
1260.00	1320.00	0.0600	774.00	60.00				
1320.00	1360.00	0.0600	506.00	40.01				
1360.00	1370.00	0.0600	136.50	10.36				
1370.00	1380.00	0.0600	135.00	10.44				
SUB-SECTION TOTALS * * * * * * * * * * *			1551.50	120.80	12.8431	211479.69	3276.23	2.11
1380.00	1490.00	0.0400	1155.00	110.04				
1490.00	1520.00	0.0400	274.50	30.00				
1520.00	1530.00	0.0400	99.00	10.07				
1530.00	1550.00	0.0400	197.00	20.04				
1550.00	1620.00	0.0400	619.51	70.00				
1620.00	1730.00	0.0400	1017.50	110.01				
SUB-SECTION TOTALS * * * * * * * * * * *			3362.51	350.17	9.6025	566290.75	8772.94	2.61
1730.00	1910.00	0.0450	1935.00	180.01				
1910.00	2130.00	0.0450	2255.00	220.01				
2130.00	2420.00	0.0450	2697.01	290.00				
2420.00	2540.00	0.0450	876.01	120.09				
2540.00	2600.00	0.0450	270.00	60.01				
2600.00	2630.00	0.0450	114.00	30.00				
2630.00	2730.00	0.0450	280.00	100.01				
2730.00	2765.00	0.0450	35.00	35.06				
SUB-SECTION TOTALS * * * * * * * * * * *			8462.02	1035.19	8.1744	1137769.00	17626.24	2.08

TOTAL AREA = 34494.32 SQUARE FEET
TOTAL CONVEYANCE = 8713300.00 CFS
TOTAL DISCHARGE = 134985.50 CFS

BRIDGE INFORMATION INPUT
BRIDGE LENGTH = 1209.00
LEFT ABUTMENT POSITION - - XAB(1) = 45.50 YAB(1) = 647.60
XAB(2) = 58.98 YAB(2) = 644.52
RIGHT ABUTMENT POSITION - - XAB(3) = 1234.74 YAB(3) = 643.38
XAB(4) = 1254.50 YAB(4) = 643.24

BRIDGE OPENING AT WATER SURFACE = 1204.30
BASE BACKWATER CURVE USED = 1

CALCULATED INFORMATION
PORTION OF DISCHARGE LEFT OF OPENING (QA) = 428.87 CFS
PORTION OF DISCHARGE THRU OPENING (QB) = 103936.31 CFS
PORTION OF DISCHARGE RIGHT OF OPENING (QC) = 30620.37 CFS
AREA OF PIERS BELOW WATER SURFACE = ~~1426.00~~ SQ FEET → 626.45
ALPHA1 = 1.67
ALPHA2 = 1.52
TOTAL BACKWATER COEFFICIENT = ~~2.03~~ → 0.49
BRIDGE WATERWAY OPENING BELOW NORMAL DEPTH (AN2) = 20682.43 SQ FEET
MEAN VELOCITY THRU BRIDGE OPENING (VN2) = 6.53 FPS
DISCHARGE RATIO (M) = 0.770
BACKWATER APPROXIMATION NO.1 = ~~0.62890~~ FEET → 0.4958
FINAL BACKWATER APPROXIMATION = ~~0.64017~~ FEET → 0.52729
NUMBER OF ITERATIONS TO OBTAIN FINAL BACKWATER = 3

JOB COMPLETE

Appendix D

Definition of Terms

DEFINITIONS OF TERMS

A	- The cross-sectional area between ground elevation and water surface elevation.
ABTYP	- The type of abutment being used. A 5.0 is used to identify wingwall abutments, and 6.0 is used to represent spillthrough abutments. No other codes are possible.
ABSLO	- Abutment slope(s).
AKB	- The base curve backwater coefficient.
AKBA, AKBB, AKBC, and AKBD	- Coefficients in the mathematical equation representing the curves in figure 4.
ALPHA and ALPHA 2	- The kinetic energy coefficients.
AN2	- The cross-sectional area of flow between the abutments and below the normal water surface.
APRS	- The total area of all piers below the water surface.
ATOT	- The accumulated cross-sectional area between the ground line and the water surface for any particular stage, YS.
AT	- The accumulated area for sections with equal "n" values.
BELPR	- The base elevation of each pier. This is the elevation of the ground at the point where the center line of the pier meets the ground.
BRLN	- Bridge length.
BRLN1	- The amount of change in bridge length.
BWAP1	- An approximate backwater value computed by multiplying the total backwater coefficient times the velocity head.
BWAPF	- The final approximation of the backwater.
COEFK	- The total backwater coefficient.

CON	- The conveyance for a subsection of the cross section.
CONT	- The total conveyance.
CN	- The value of Manning's "n".
CRDS	- A control used to allow computation of backwater for stages above the design stage.
CONTRL	- An array controlling bridge incrementation.
DKE	- The value of the coefficient of eccentricity.
DKE1 and DKE2	- The values of DKE on the curves each side of the actual value. The actual value is interpolated between the two points.
DKS	- The value of the skew coefficient.
DKS1 and DKS2	- The values of DKS on the curves each side of the actual value. DKS is interpolated between the two points.
DLTAK	- The incremental backwater coefficient that relates to piers.
DRM	- The bridge opening ratio.
DTAA and DTAB	- Coefficients for the straight portion of the curves in figure 5A.
E	- The eccentricity.
ECA, ECB, ECC, and ECD	- Coefficients used to represent the eccentricity curves, figure 6.
ECON	- The constant value for eccentricity.
HEAD	- Velocity head.
HDNGS	- Headings or job description information.
IABSIS	- An array containing the label for plotting the cross section.
IABSIS2	- An array containing the label for plotting the rating curve.
ICONT	- Counter to control number of backwater calculations.

IPLOT - A plotting control for discharge values.

IPREL - An array containing the abscissa scale for the cross section plot.

IPNT - An array of symbols used in the plotting routines.

IQAXIS - Discharge values used in plotting the rating curve.

IPR - An index used for selecting subroutines.

ISTA - An array for plotting the ordinate of the cross section plot.

IEC - An integer counter designating which curve is used for eccentricity.

IPAGE - A counter which increases by one for each page of printout. Its value is printed in the upper right-hand corner of each page.

ISKW - A counter used to designate which of the given curves is used to compute the skew coefficient.

ITP7A - The number of a curve on figure 5A which represents the bent type used to calculate the incremental backwater coefficient for piers.

ITP7B - A curve designation in figure 5B.

IWWSL - The number of a curve on figure 4 used for determining the value of the backwater coefficient K.

KXY - Counter control in ARRANGE subroutine.

NBR - Number of iterations to obtain final backwater value.

NMAX - The total number of points in the cross section.

NP - An array used in XYPLOT subroutine.

NPR - The number of piers in the bridge opening.

PROCED - The subroutine designation.

Q - The discharge for each area, A, where Manning's "n", CN, remains constant.

Q1	- The design discharge for the channel as observed at the gauging stations or computed from runoff records.
QAF	- The discharge which would pass to the left of the left abutment if the bridge were not present.
QBF	- The discharge through the area AN2.
QCF	- The discharge which would pass to the right of the right abutment if the bridge were not present.
QT	- The accumulated discharge for the entire width of the channel cross section.
QTPLOT	- An array containing discharge values for various stages.
QV2	- The quantity equal to discharge times velocity squared.
R	- The hydraulic radius of each subsection.
RTIOJ	- The ratio of the total area of piers, APRS, divided by the area of the bridge opening, AN2.
SYSIN	- Input unit designation.
SYSOT	- Output unit designation.
SCA, SCB, SCC, and SCD	- Coefficients used in the third degree parabolic curve equations, figure 5B.
SIGMA	- A factor used to modify DLTAK.
SKA, SKB, and SKC	- Coefficients used in the second degree parabolic curve equation used to compute the coefficient for skew.
SKW1	- A constant value of skew angle for one of the equations representing the skew curves.
SKEW	- Skew angle, equal to WORD (4).
SLOP1	- The computed slope of the channel.
SLOPE	- SLOP1 expressed in feet per mile.
SZERO	- The input slope.

SK1	- An internal control for skewed section.
TABLE	- An array of procedure designations.
USE	- A control used to eliminate duplication of output.
V	- The computed value of velocity for each subsection of the channel cross section.
VC	- Critical velocity.
VN2	- The average velocity through the construction, QT, divided by AN2.
WORD	- An array containing the minimum stage, stage increment, skew data, and output control information.
WDTHT	- Width of section.
WP	- The wetted perimeter of any particular channel subsection.
WS	- Water surface elevation.
WPR	- The average width of each pier.
TF	- The bridge opening at the water surface.
X	- The distance to the cross section point along the X-axis from some fixed reference point.
X1	- The positive X distance from the last X station to a point where the ground line and the water line intersect (the point where YG is equal to YS).
XDB	- The X distance from the reference point to the beginning of a section.
XDE	- The X distance from the reference point to the end of a section.
XDIF	- The difference in X distances for two adjacent stations.
XAB	- The X distances to the abutment points.
Y	- The vertical leg of the triangular portion of each subsection.

YD1F1 and YD1F2	-	The vertical distances, Y, between the ground and the water surface at points X (N - 1) and X (N), respectively.
YG	-	A ground elevation or the Y distance from a fixed datum plane.
YS	-	The stage or water surface elevation.
YSINC	-	The stage increment.
YSMAX	-	The maximum stage.
YSN and YTE1	-	Water surface elevations.
YAB	-	The Y distance to the abutment points.
YQ1	-	The design stage.
YSMIN	-	The minimum stage value.

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Hydraulic Design Series

HDS No. 2 Discontinued
HDS No. 4 DESIGN OF ROADSIDE DRAINAGE CHANNELS - 1965

Hydraulic Engineering Circulars

HEC No. 1 SELECTED BIBLIOGRAPHY OF HYDRAULIC AND HYDROLOGIC SUBJECTS - December 1979
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HEC No. 3 HYDROLOGY OF A HIGHWAY STREAM CROSSING - January 1961
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HY-1, 3 and 5 Discontinued
HY-2 HYDRAULIC ANALYSIS OF PIPE-ARCH CULVERTS - May 1969
HY-4 HYDRAULICS OF BRIDGE WATERWAYS - 1969
HY-6 HYDRAULIC ANALYSIS OF CULVERTS (Box and Circular) - 1979

Calculator Design Series

CDS No. 1 HYDRAULIC DESIGN OF IMPROVED INLETS FOR CULVERTS USING PROGRAMABLE CALCULATORS, (COMPUCORP 325) - October 1980
CDS No. 2 HYDRAULIC DESIGN OF IMPROVED INLETS FOR CULVERTS USING PROGRAMABLE CALCULATORS, (HP-65) - October 1980
CDS No. 3 HYDRAULIC DESIGN OF IMPROVED INLETS FOR CULVERTS USING PROGRAMABLE CALCULATORS, (TI-59) - January 1981
CDS No. 4 HYDRAULIC ANALYSIS OF PIPE-ARCH AND ELLIPTICAL SHAPE CULVERTS USING PROGRAMABLE CALCULATORS, (TI-59) - March 1982
CDS No. 5 HYDRAULIC DESIGN OF STORMWATER PUMPING STATIONS USING PROGRAMABLE CALCULATORS, (TI-59), May 1982