IMPROVED DESIGN PROCEDURES FOR VEGETATION LINED CHANNELS

By

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1967

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
July, 1980

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PREFACE

The outcome of the work reported in this thesis was the production of 21 nomographs for the design of vegetation lined parabolic, triangular, and trapezoidal channels. The graphical design procedure based upon the use of the nomographs that were developed proved to be a time saving procedure without any significant loss in accuracy.

The author wishes to extend sincere thanks to his major adviser, Dr. James E. Garton, Professor in Agricultural Engineering, for the guidance, inspiration, and most competent counseling during the course of this study and in the preparation of this manuscript. Appreciation is also extended to Dr. Richard H. DeVries, Professor in Civil Engineering, and Dr. C. T. Haan, Head of the Department of Agricultural Engineering, for serving on the advisory committee and reviewing the final draft.

Further thanks are extended to Dr. C. T. Haan for providing the assistantship during my graduate program and to the Principal of the University of Natal, Republic of South Africa, for granting me 12 months sabbatical leave to pursue the program. Also, to Jack Fryrear, Supervisor of Drafting Services, Department of Agricultural Engineering, for his help in reproducing the final copies of the nomographs, my grateful thanks.

Finally to my wife, Maryann, and children, Jeremy, Trevor, and Cindy (born in Stillwater), for their many sacrifices, understanding, love, and moral support during my sabbatical leave, this thesis is dedicated.

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CHAPTER I

INTRODUCTION

The Problem

In the 1940's, the United States Department of Agriculture-Soil Conversation Services (USDA-SCS) conducted experiments at Spartenburg, South Carolina, and the Stillwater Outdoor Hydraulic Laboratory, Oklahoma, on vegetation lined channels. The results of these experiments provided the information which led to the compilation of the Handbook of Channel Design for Soil and Water Conservation (USDA, 1954). The semi-graphic design for parabolic channels, triangular channels, and trapezoidal channels presented in this handbook have been widely used since its publication.

In more recent years, other more sophisticated analytic design procedures which make use of the modern computer in varying degrees were developed. The art of estimating the velocity in a channel lined with vegetation was replaced by the science of estimating the velocity of flow in such channels. The methods available to designers for the design of vegetated channels are now either bothersome, semi-graphic, iterative procedures, or more sophisticated procedures requiring the use of a computer.

Scope of Investigation

The research project described in this thesis was an attempt to develop a simple design technique for the design of vegetated channels using all the knowledge available at the time. Current techniques and design aids were examined. These were simplified to produce design solutions within the bounds of practical application and implementation. Use was made of the familiar retardance classes and related standard curves found in most texts in preference to other more recently developed models for the n-VR relationships. The original standard curves produced by Ree and Palmer (1949) were used without modification. No new data were collected or used and the design technique developed was kept as simple as possible to facilitate its use in the field or field office where the main design facility is a regular pocket or desk calculator.

A large number of hypothetical channels were designed and a bank of solutions covering a range of conditions was generated using a computer. From this data, nomographs were compiled to provide graphical solutions to most of the design situations commonly encountered.

Objectives

The objectives of this project were: (1) to develop a simple analytical design procedure within the capabilities of a scientific calculator and (2) to develop a purely graphical design procedure from computer synthesized data.

CHAPTER II

LITERATURE REVIEW

Introduction

This chapter provides some background to the problems related to flow in vegetated channels and channel design that researchers have sought to solve. The inclusion of this historical development to the present state of the art was considered desirable because some of the earlier researchers did not consider that their work provided infallable answers to all the design problems related to vegetation lined channels (Ree, 1979). The findings of some of the earlier researchers, however, were widely accepted and there followed a period in which little further interest was shown in this field.

Analytical considerations of fluid flow and the development of such aspects of the principles of momentum and energy are not included. The material in this chapter was confined to the state of the art with respect to the application of the presently accepted principles of fluid flow in the design of vegetated channels. The concluding section contains a summary of the techniques that can be used to construct nomographs for several forms of mathematical equations.

Background

The design problem for grassed lined channels is more complicated than for bare and other non-vegetation lined channels. Although the

Manning formula for open channels can be used, it has been shown that the value of the retardance coefficient does not remain constant (Ree and Palmer, 1949). Under the influence of velocity and depth of flow, the vegetation tends to bend and oscillate as water passes. The retardance of flow in open channels due to vegetation thus varies with these two parameters, as well as such vegetative characteristics as stage of growth, condition (cut or uncut), plant density, and blade and stem flexibility (Ree and Palmer, 1949; Frevert, 1955). These parameters are difficult to quantify. The earlier workers in this field succeeded in classifying the vegetation most often used to line channels into five retardance classes (Ree, 1949).

Most of the earlier experimental work on vegetation lined channels was conducted by the USDA Soil Conservation Services at Spartanburg, South Carolina, and the Stillwater Outdoor Hydraulic Laboratory, Stillwater, Oklahoma. In 1946, it was determined that sufficient information was available from these experiments to permit the development of a handbook for the design of channels lined with vegetation. The handbook produced was revised in 1954 and supplemented by data, graphical methods, and design charts useful in the design of vegetated channels. This resulted in the publication of the Handbook of Channel Design for Soil and Water Conservation (USDA, 1954).

Vegetation Lined Channels

The work of Ree (1949) played a major role in the development of the Handbook of Channel Design for Soil and Water Conservation (USDA, 1954). He showed that in both small and large channels, the Manning number (n) varied with the product of the channel hydraulic radius and the velocity of flow in the channel (V). The retardance curves in the Handbook of Channel Design for Soil and Water Conservation (USDA, 1954) shown in Figure 1 were developed by Ree (1949) from the work done by Ree and Palmer (1949) who produced the experimental n-VR curves for a variety of vegetative linings shown in Figures 2 through 5. In these figures it can be seen that the same range of flow was not used for all the vegetative linings tested. The extrapolation of the average n-VR curves for each retardance class, therefore, could not be done with great confidence. These curves have, however, received widespread recognition and are often referred to as the Standard Retardance Curves. They form the basis of the design procedure outlined in the Handbook of Channel Design for Soil and Water Conservation (USDA, 1954). Further work by Ree (1960) showed that for submerged vegetation the typical n-VR relationships of the standard retardance curves was observed to hold. When the vegetation remained upright and was not disturbed by the flow, the n value bore no consistent relationship to the product of VR.

The Handbook of Channel Design for Soil and Water Conservation (USDA, 1954) contains a summary of all the work on vegetation lined channels done prior to its publication. In this handbook, it is also noted that for shallow flow, through upright vegetation with no submergence, Manning's n ceases to be related to VR. Valuable guides to the selection of vegetal retardance (Table I) and the permissible velocities for channels lined with vegetation (Table II) are contained in the handbook. The classification of vegetal covers as to the degree of retardance (Table III) is also contained in the handbook. The semigraphic design procedure outlined in this publication is used by most hydraulicians in the design of channels lined with vegetation.

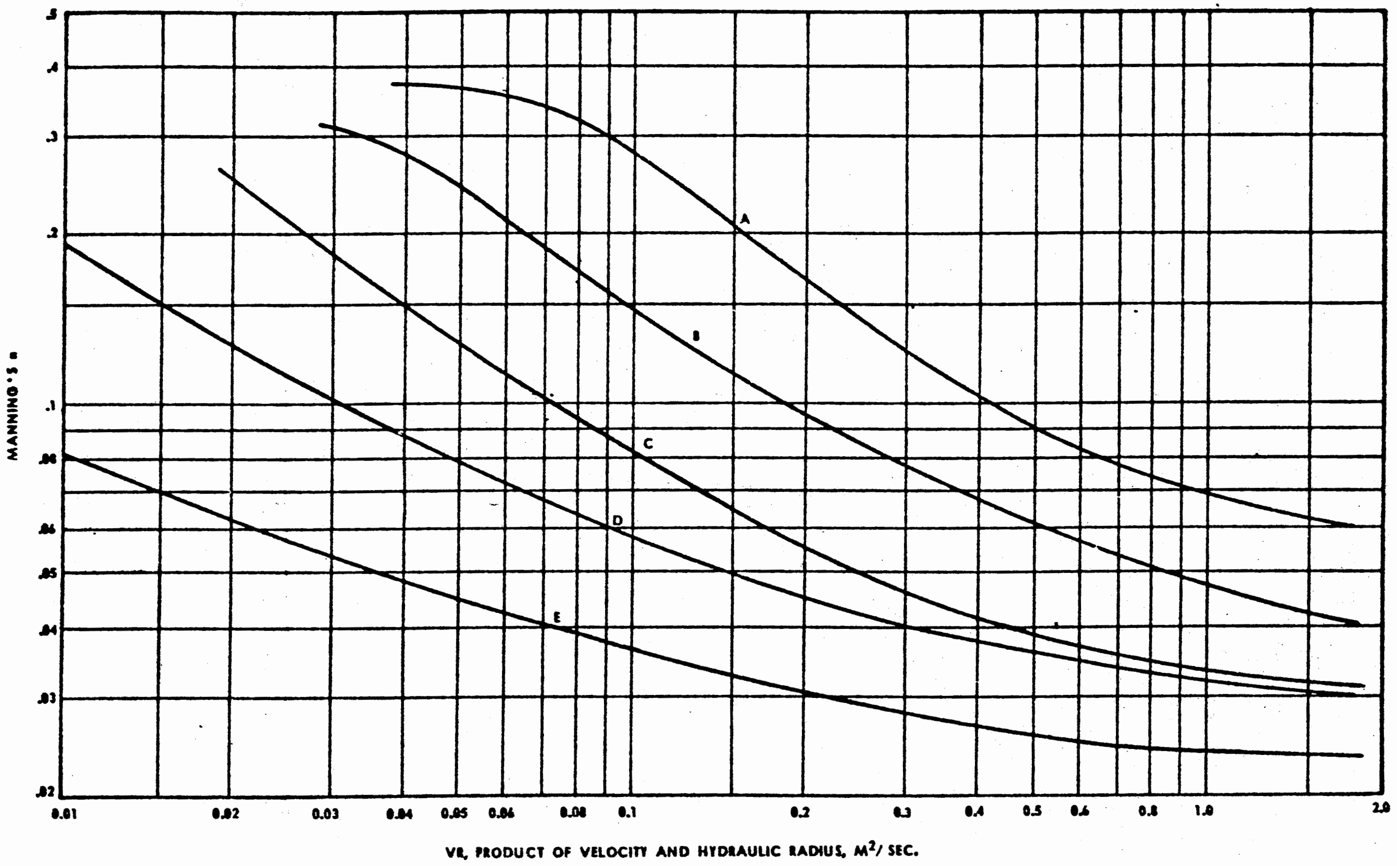


Figure 1. n-VR Curves for the Standard Retardance Curves (USDA, 1954)

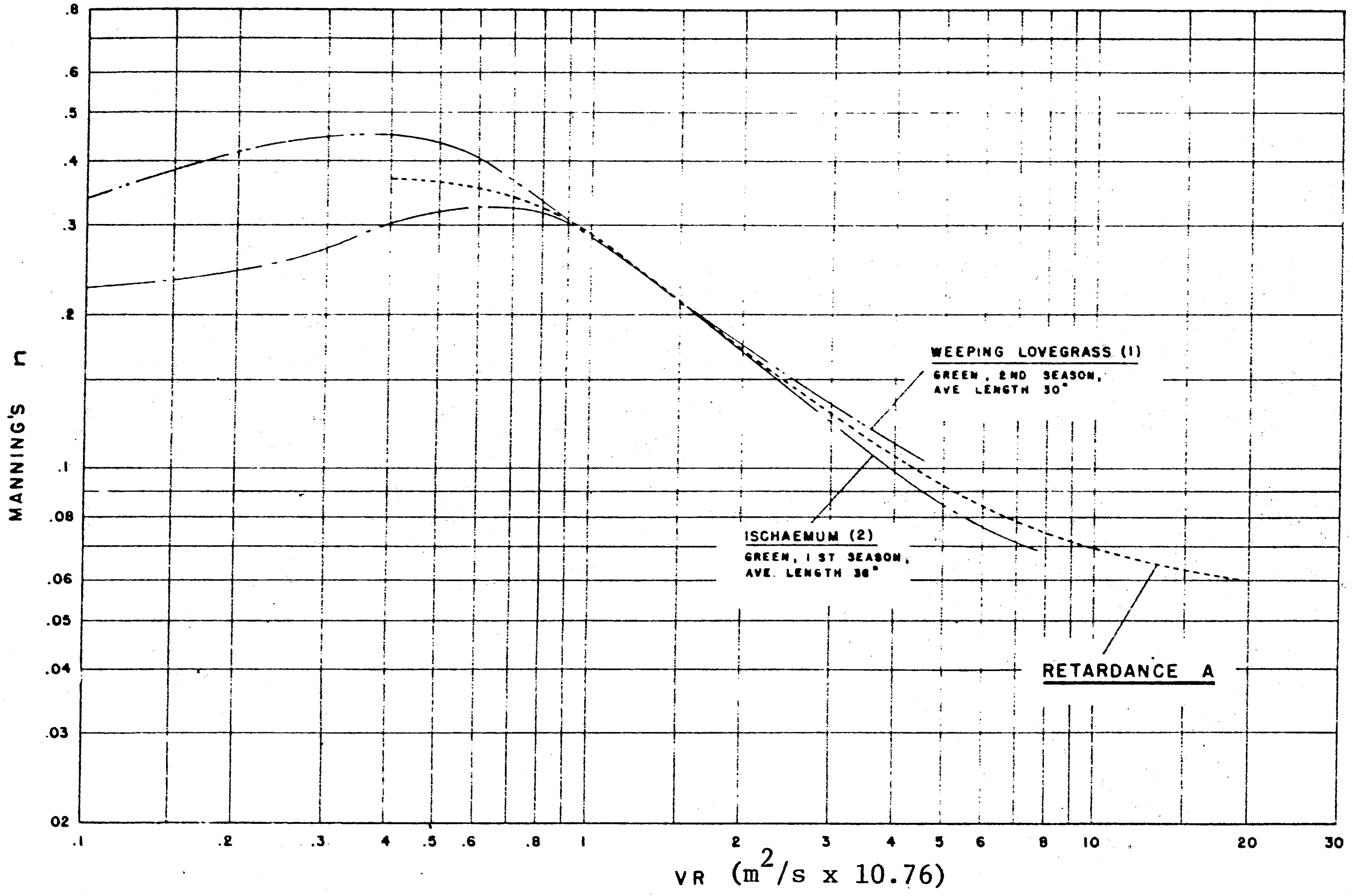


Figure 2. Experimental n-VR Curves for Very High Vegetal Retardance (after USDA, 1954)

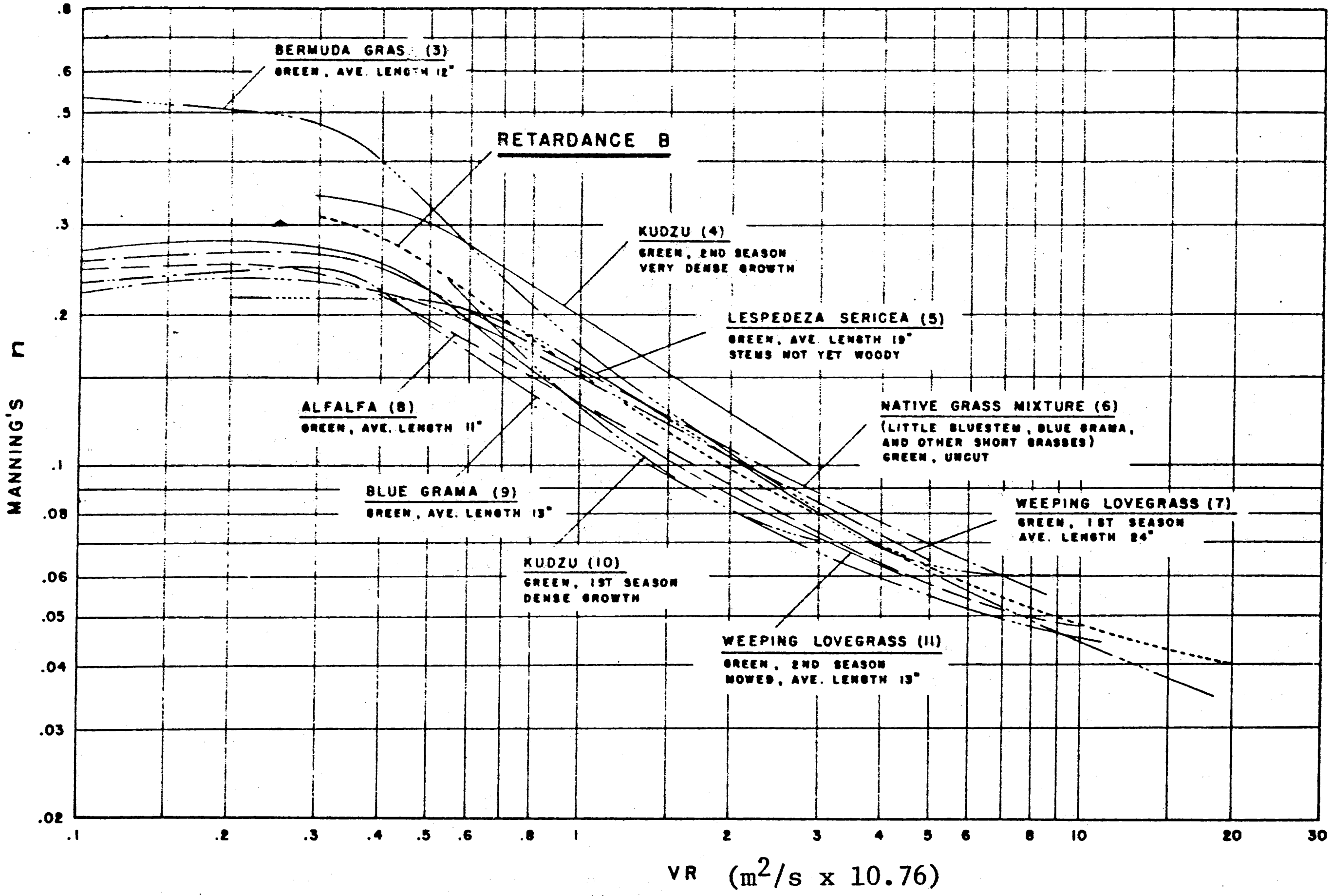


Figure 3. Experimental n-VR Curves for High Vegetal Retardance (after USDA, 1954)

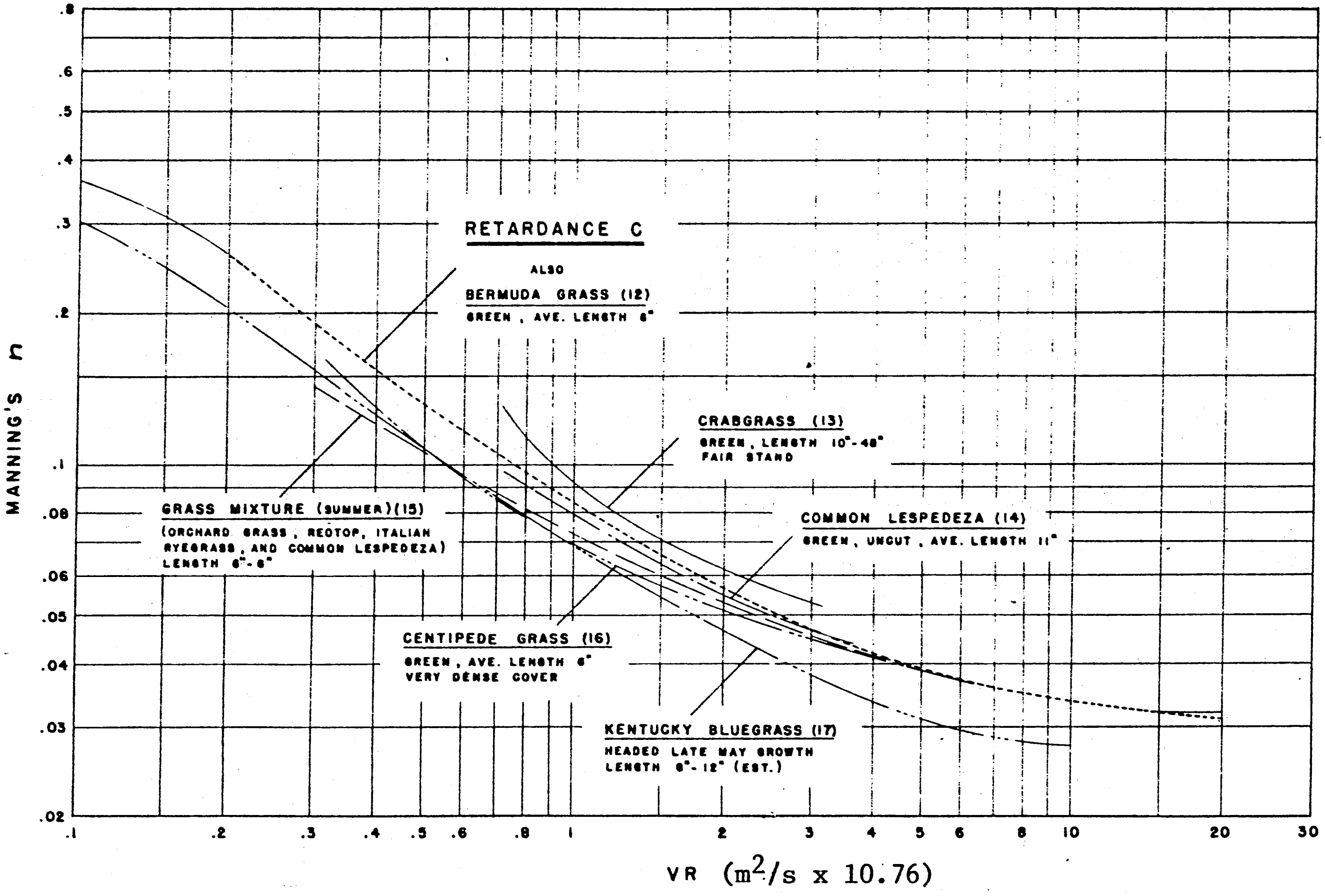


Figure 4. Experimental n-VR Curves for Moderate Vegetal Retardance (after USDA, 1954)

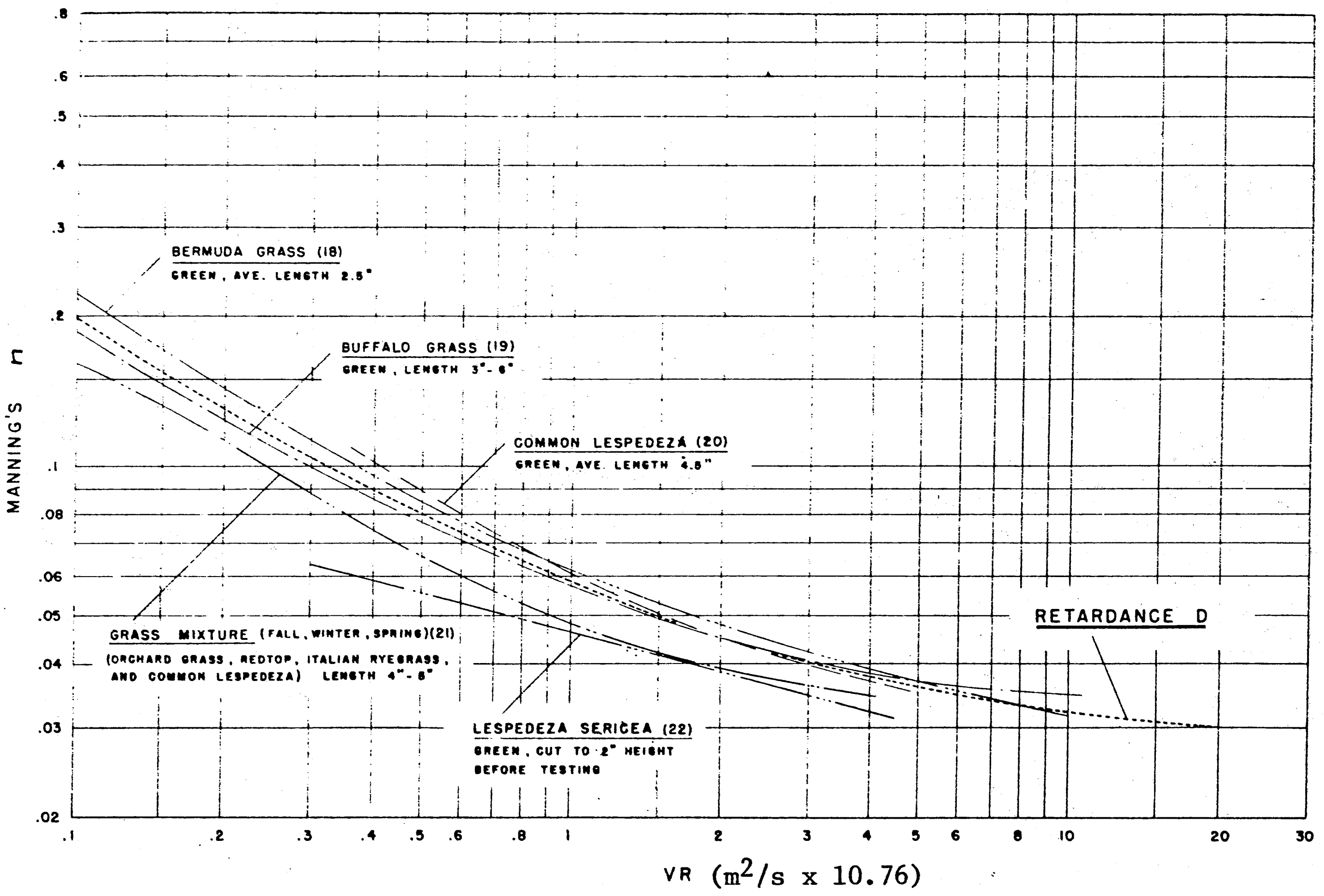


Figure 5. Experimental n-VR Curves for Low and Very Low Vegetal Retardance (after USDA, 1954)

TABLE I

GUIDE TO SELECTION OF VEGETAL RETARDANCE

Stand	Average Length of Vegetation (mm)	Degree of Retardance
Good	Longer than 760	A
	250-600	B
	150-200	C
	50-150	D
	< 50	E
Fair	Longer than 760	B
	250-600	C
	150-250	D
	50-150	D
	< 50	E

Source: USDA (1954).

TABLE II

PERMISSIBLE VELOCITIES FOR CHANNELS LINED WITH VEGETATION[1]

Cover	Slope Range[2] (%)	Erosion Resistant Soils (m/s)	Easily Eroded Soils (m/s)
Bermudagrass	0-5	2.50	1.80
	5-10	2.10	1.50
	Over 10	1.80	1.20
Buffalograss Kentucky bluegrass Smooth brome Blue grama	0-5	2.10	1.50
	5-10	1.80	1.20
	Over 10	1.50	0.90
Grass mixture	0-5[2]	1.50	1.20
	5-10	1.20	0.90
Lespedeza sericea Weeping lovegrass Yellow bluestem Kudzu Alfalfa Crabgrass	0-5[3]	1.10	0.75
Common lespedeza[4] Sudangrass[4]	0-5[5]	1.10	0.75

[1] Use velocities exceeding 1.5 m/s only where good covers and proper maintenance can be obtained.

[2] Do not use on slopes steeper than 10 percent, except for side slopes in a combination channel.

[3] Do not use on slopes steeper than five percent, except for side slopes in a combination channel.

[4] Annuals--used only on mild slopes or as temporary protection until permanent covers are established.

[5] Use on slopes steeper than five percent is not recommended.

Source: USDA (1954).

TABLE III

CLASSIFICATION OF VEGETAL COVERS AS TO DEGREE OF RETARDANCE

Retardance	Cover	Condition
A	Weeping lovegrass	Excellent stand, tall (average 760 mm)
	Yellow bluestem Ischaemum	
B	Kudzu	Very dense growth, uncut
	Bermudagrass	Good stand, tall (average 300 mm)
	Native grass mixture (little bluestem, blue grama, and other long and short midwest grasses)	Good stand, unmowed
	Weeping lovegrass	Good stand, tall (average 610 mm)
	Lespedeza sericea	Good stand, not woody, tall (average 480 mm)
	Alfalfa	Good stand, uncut (average 280 mm)
	Weeping lovegrass	Good stand, mowed (average 330 mm)
	Kudzu	Dense growth, uncut
	Blue grama	Good stand, uncut (average 330 mm)
C	Crabgrass	Fair stand, uncut (250 to 1,220 mm)
	Bermudagrass	Good stand, mowed (average 150 mm)
	Common lespedeza	Good stand, uncut (average 280 mm)
	Grass-legume mixture--summer (orchard grass, redtop, Italian ryegrass, and common lespedeza)	Good stand, uncut (150 to 200 mm)
	Centipedegrass	Very dense cover (average 150 mm)
	Kentucky bluegrass	Good stand, headed (150 to 300 mm)

TABLE III (Continued)

Retardance	Cover	Condition
D	Bermudagrass	Good stand, cut to 65 mm height
	Common lespedeza	Excellent stand, uncut (average 115 mm)
	Buffalograss	Good stand, uncut (75 to 150 mm)
	Grass-legume mixture--fall, spring (Orchardgrass, redtop, Italian ryegrass, and common lespedeza)	Good stand, uncut (100 to 125 mm)
	Lespedeza sericea	After cutting to 50 mm height. Very good stand before cutting.
E	Bermudagrass	Good stand, cut to 38 mm height
	Bermudagrass	Burned stubble

Source: USDA (1954).

Ree and Crow (1977) conducted experiments to determine values of Manning's n for vegetated waterways of flat slopes planted to row crops. Their results showed a marked variation of n over the range of flows used. Up to a fivefold change was observed. The retardance of the vegetation in the channels tested varied through the three highest standard retardance classes (A, B, and C) shown in Figure 1. The n-VR relationships, however, were not altogether consistent with the standard retardance curves. The value of the Manning's n was found to peak at a VR value below one and then decrease markedly as VR increased (Figure 6). The variables that caused this phenomena were not identified.

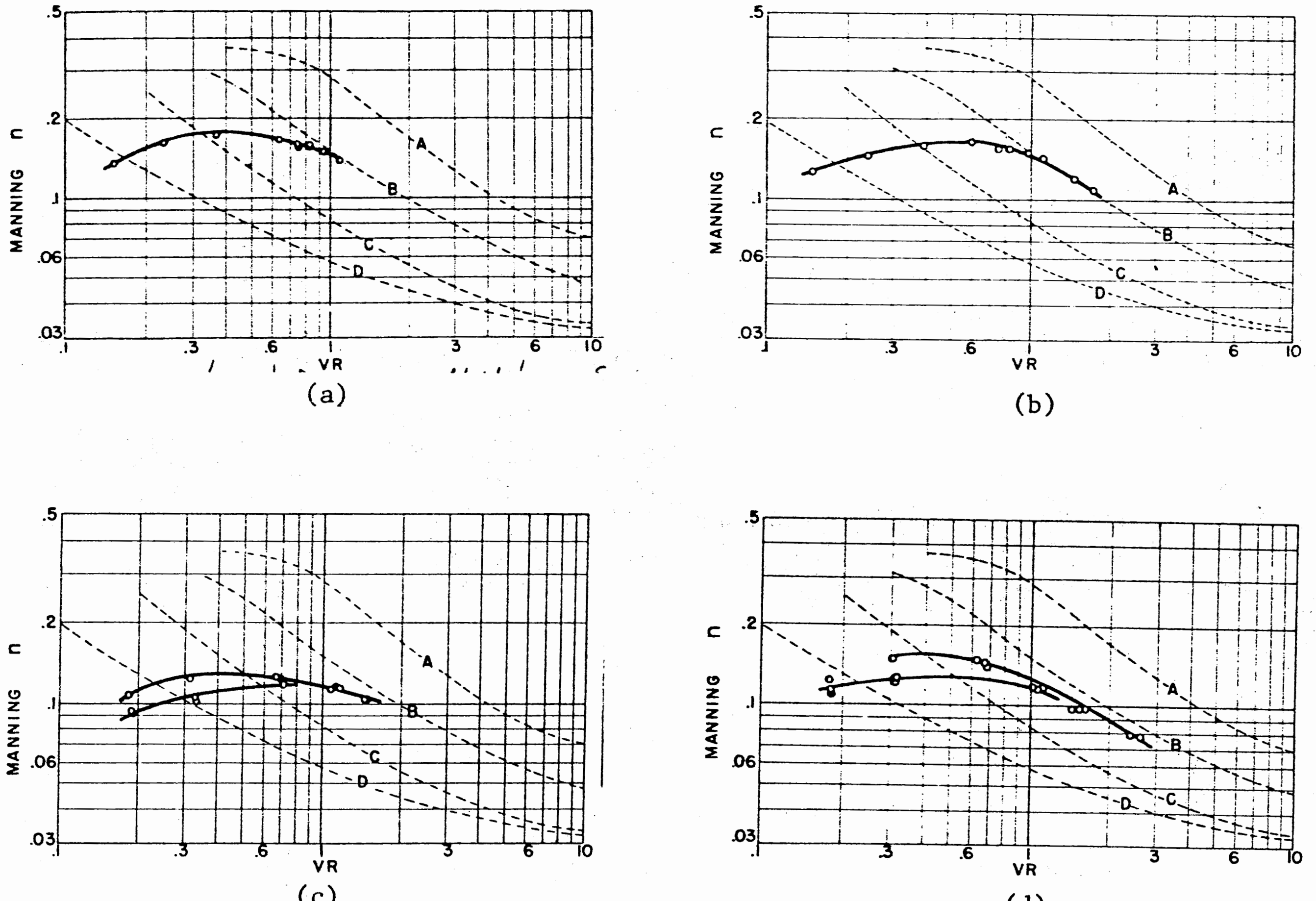
Kao and Barfield (1978) conducted experiments on simulated dense vegetation to determine the hydraulic properties of flow at small non-submerging depths. Their results (Figure 7) supported the evidence that Manning's n increased to a peak and then decreased as VR increased. They suggested that the standard retardance curves were not intended for use and should not be used for shallow flow applications.

The empirical curves of Ree and Palmer (1949) are widely used to determine Manning's n and feature in most design procedures (USDA, 1954; Frevert, 1955; Chow, 1959; Henderson, 1966). Such procedures range from the semi-graphic iterative processes to sophisticated computer models. Several mathematical models describing the n-VR curves portrayed in the <u>Handbook of Channel Design for Soil and Water Conservation</u> (USDA, 1954) have been suggested.

Gwinn and Ree (1979) presented the relationship

$$n = 1/(2.08 + 2.30x + 6\ln(VR)) \qquad 0.02 < n < 0.2 \qquad (1)$$

where x = -0.5, 2, 5, 7, 11, for the A, B, C, D, E, retardance classes respectively. It was stated that for Manning's n less than 0.2 the n-VR



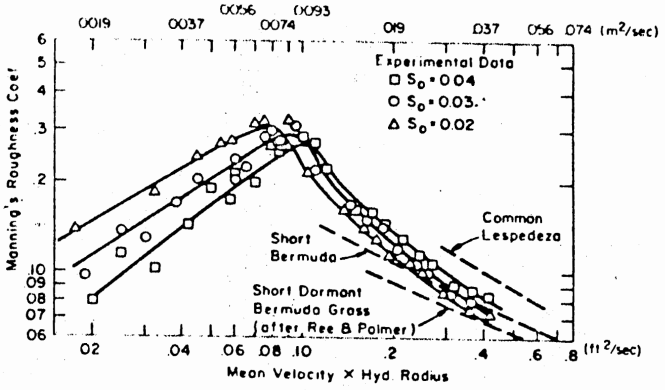
(a)

(b)

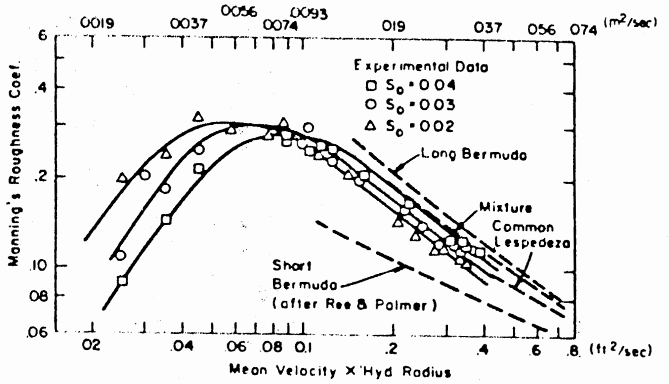
(c)

(d)

Figure 6. Experimental n-VR Curves for Row Crops (Ree and Crow, 1977)

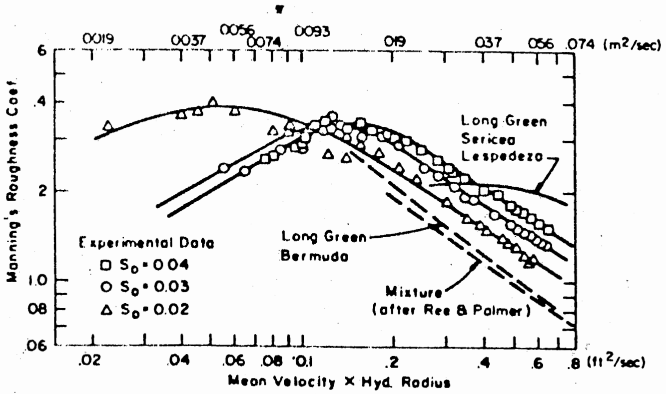


(a) Plot of Manning's roughness coefficient vs. the product of mean velocity and hydraulic radius (soft blade, 13,170 blades/ m^2)

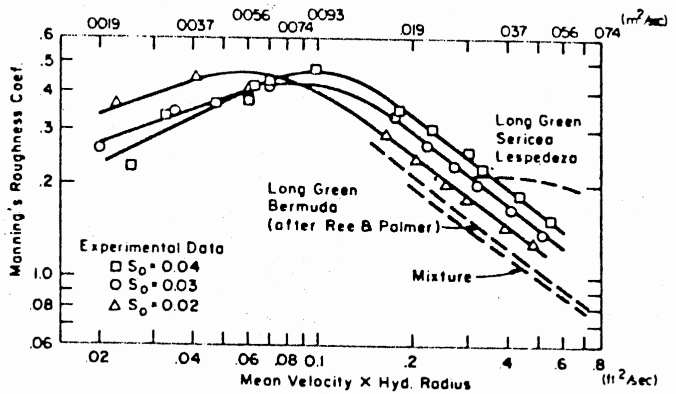


(b) Plot of Manning's coefficient vs. the product of mean velocity and hydraulic radius (medium stiff blade, 13,170 blades/ m^2).

Figure 7. Experimental n-VR Curves for Simulated Vegetation (Kao and Barfield (1978))



(c) Plot of Manning's roughness coefficient vs. the product of mean velocity and hydraulic radius (stiff blade, 13,170 blades/m^2).



(d) Plot of Manning's roughness coefficient vs. the product of mean velocity and hydraulic radius (stiff blade, 24,000 blades/m^2).

Figure 7 (Continued)

curves produced using this relationship fell within the experimental results from which the standard retardance curves were derived (Figures 2 through 5).

Temple (1979) suggested that the relationship

$$\ln(n) = [0.01329 \ln^2(R_v) - 0.09543\, c \ln(R_v) + 0.2971] - 4.16 \tag{2}$$

where R_v = (VR/kinematic viscosity) x 10^{-5}

C = 10.0, 7.643, 5.601, 4.436, 2.867 for the A, B, C, D, E, retardancy classes respectively

would produce curves with similar limitations of Manning's n. This was not considered a serious constraint as most designs provided for maximum and not minimum flow conditions. Temple (1980) suggested that the above relationship with

C = 10.0, 8.0, 6.0, 4.0, and 2.0

would produce a more orderly family of retardance curves (Figure 8) which would still be within the experimental results from which the standard retardance curves were derived.

In 1969, Kouwen first indicated his reservations concerning the empirical n-VR curves developed by Ree and Palmer (1949). He introduced a stiffness parameter for vegetation and suggested that this could better describe the retardance caused by vegetative linings of channels. He used various plastic strips with different mechanical properties to simulate vegetation. In 1979, Kouwen suggested that Manning's n could better be described by the equation

$$n = \frac{R^{1/6}}{g^{1/2}\,(a + b\ln k/y)} \tag{3}$$

where a & b = fitted parameters for the erect or prone condition

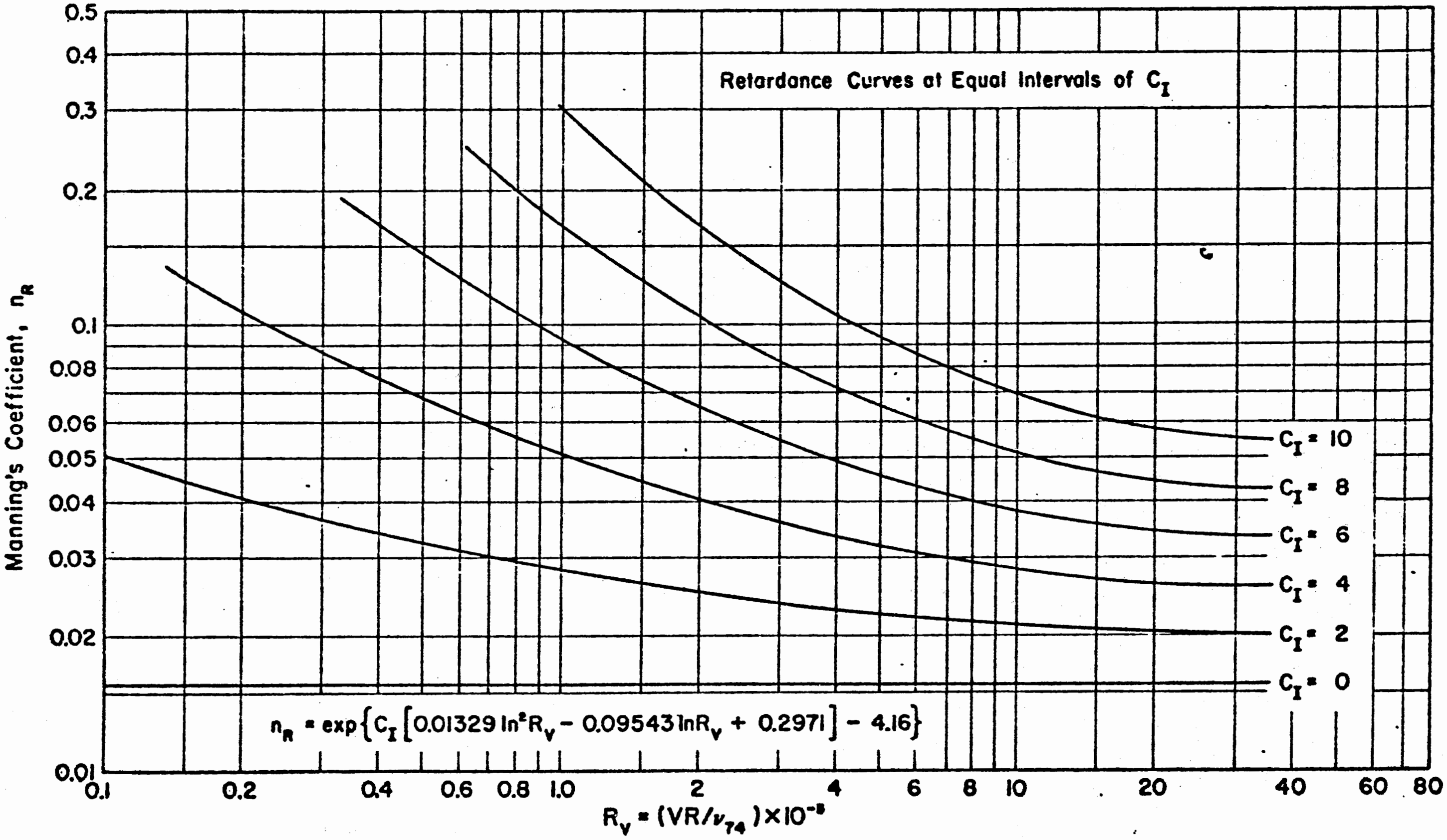


Figure 8. Simulated n-VR Curves (Temple, 1979)

k = deflected roughness height

y = normal depth of flow

Kouwen (1979) developed a method of calculating k from the stiffness and density of the vegetation and was thus able to predict n values for all types of vegetation under any flow conditions. These procedures cannot be easily applied at present, however, because the classification of vegetation by stiffness is not yet available. He stated that

> Because the method . . . [of applying his design procedure based upon the stiffness and density of vegetative linings] . . . is not lengthy or complicated, it can be applied through the use of a small programmable pocket calculator and can be incorporated in any mathematical model (p. 18).

While the above mentioned models are valuable to all researchers in their quest to understand the interaction of flow with the varying boundary conditions of an open vegetated channel, their application by field designers is limited. There is a need by field designers and professional engineers for a simple design procedure, compatible with the present day means of identifying the retardance classes of vegetation, which can be executed with the minimum of time, effort, and mathematical manipulation. With such a procedure, a designer would be able to consider several alternative channels which could accommodate the flow conditions as well as the economic or land use constraints that may prevail.

Nomography

Nomography deals with the graphical representation of mathematical relationships for the purpose of obtaining solutions. The use of nomographs cannot only save time in the repetitive solution of mathematical formulae, but also allow the interrelationships of the variables of the relationship to be analyzed quickly and easily (Levens, 1965). There are two types of nomographs: (a) the Cartesian co-ordinate chart (concurrency chart) and (b) the alignment chart.

Levens (1965) showed how a family of straight lines could be represented in both types of nomographs. Using the projective geometry principle of duality, he showed how a Cartesian co-ordinate chart could be transformed into an alignment chart (Figure 9). The duality relationship is:

> . . . for every line in the Cartesian co-ordinate system there is a corresponding point in the parallel co-ordinate system, and for every point in the Cartesian chart there is a corresponding line in the alignment chart (p. 102).

In the transformation of Cartesian charts to alignment charts, Levens (1965) emphasized that no mathematical expressions need be employed. He further showed that a family of curves, after rectification, could be transformed into an alignment chart as illustrated in Figures 10 and 11. He suggested that such alignment charts provided a simpler means of relating the variables involved. Levens pointed out that the rectification or the graphical anamorphosis of a family of curves (Figure 10) could only be performed if the family of curves could be subjected to a bilineality test. This test requires that a rectangular chain, when constructed on three adjacent curves, must form a closed loop as shown in Figure 12. Besides the parallel scale nomographs, Levens presented other forms of alignment charts together with the parametric equations governing the spacing between the axes and the scale modulii used to graduate the respective scales. These forms, illustrated in Figure 13, are the main type forms which can be repeated and combined in a single nomograph. The combination of these type forms depends upon the number and juxtaposition of the variables in the mathematical relationship which the nomograph is to represent.

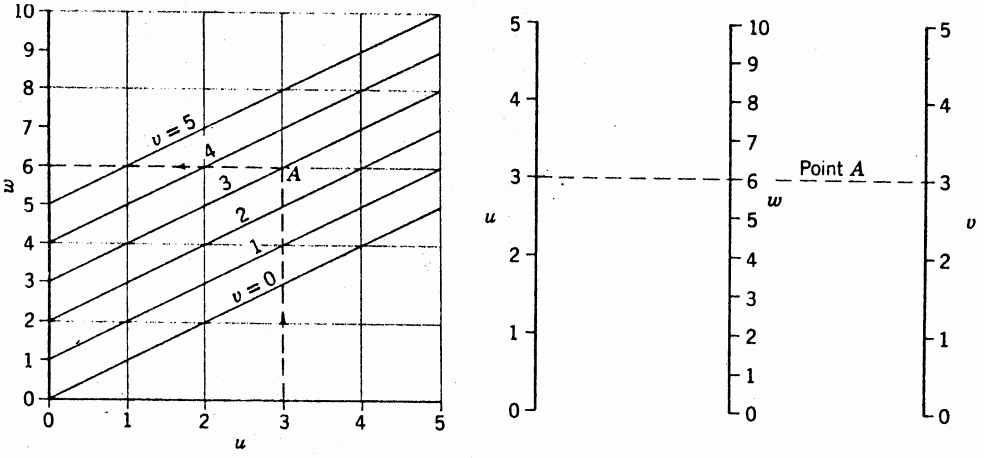


Figure 9. Transformation of a Cartesian Chart to an Alignment Chart (Levens, 1965)

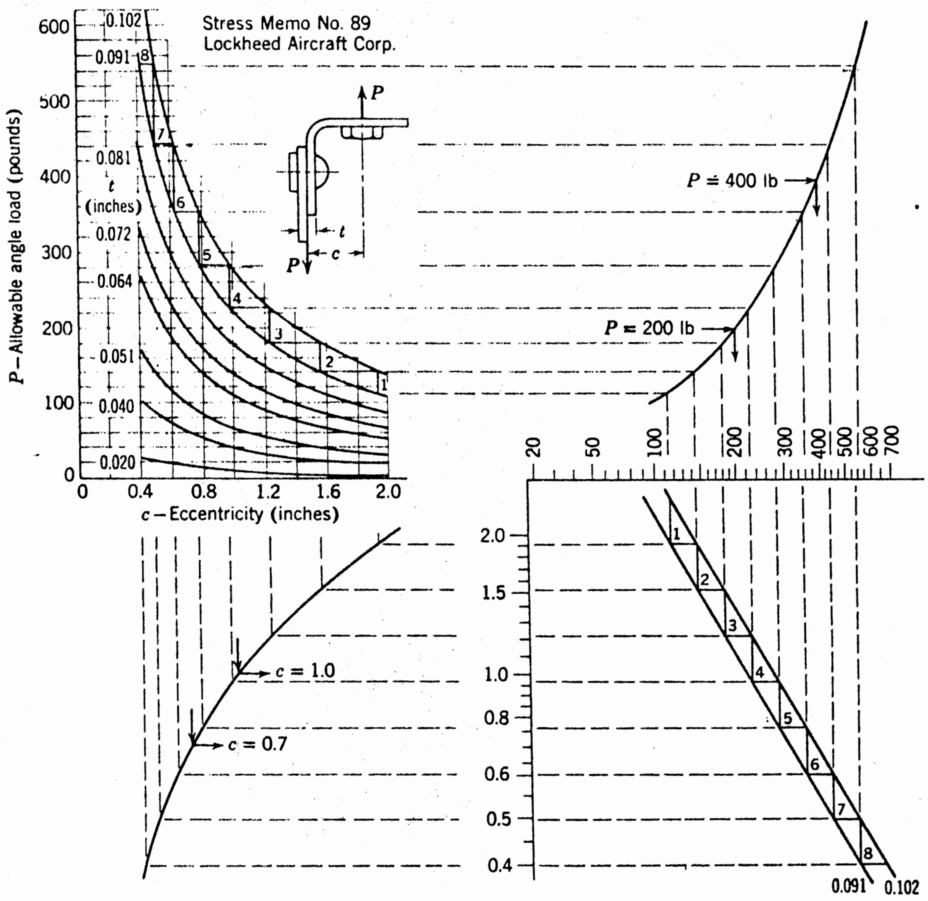


Figure 10. Rectification of Curves (Graphical Anamorphosis) (Levens, 1965)

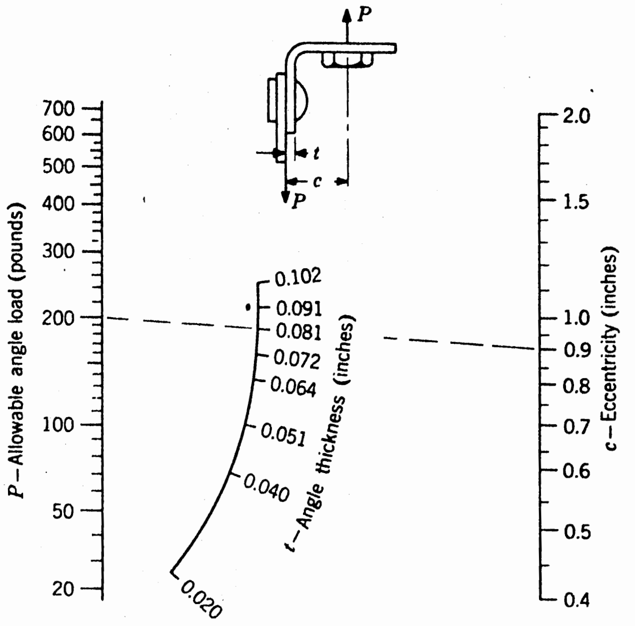


Figure 11. Nomograph Developed from the Family of Curves in Figure 10 (Levens, 1965)

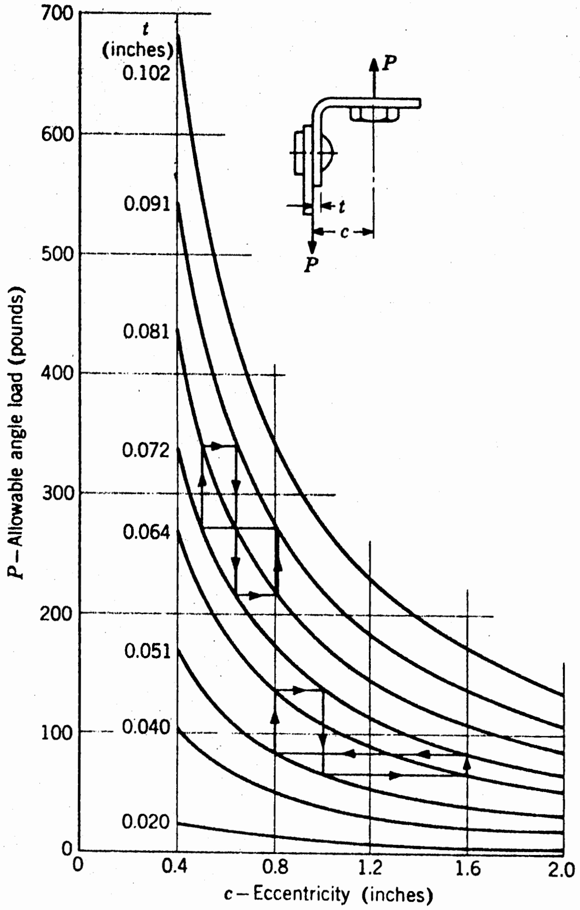


Figure 12. Bilineality Test (Levens, 1965)

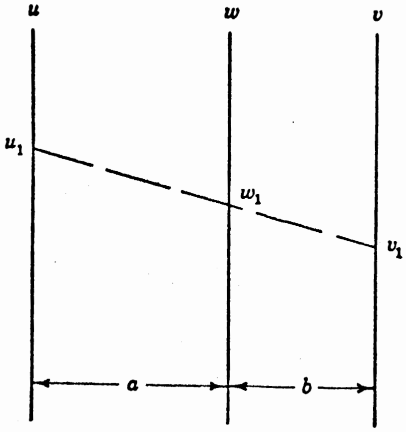
$$f_1(u) + f_2(v) = f_3(w)$$

Scale equations:

$$X_u = m_u f_1(u)$$
$$X_v = m_v f_2(v)$$
$$X_w = \frac{m_u m_v}{m_u + m_v} f_3(w)$$

Scale location:

$$\frac{a}{b} = \frac{m_u}{m_v}$$

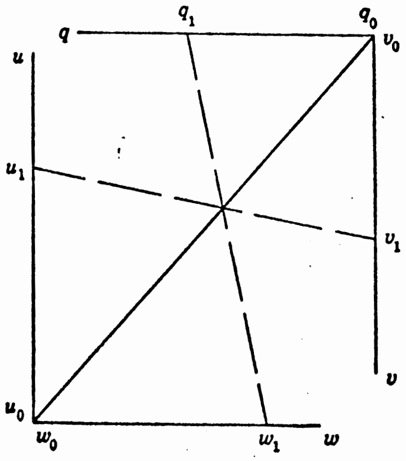


(a) Alignment chart for an equation of the form $f_1(u) + f_2(v) = f_3(w)$.

$$\frac{f_1(u)}{f_2(v)} = \frac{f_3(w)}{f_4(q)}$$

Scale equations:

$$X_u = m_u f_1(u)$$
$$X_v = m_v f_2(v)$$
$$X_w = m_w f_3(w)$$
$$X_q = m_q f_4(q)$$
$$\frac{m_u}{m_v} = \frac{m_w}{m_q}$$



(b) Proportional chart for an equation of the form $f_1(u)/f_2(v) = f_3(w)/f_4(q)$.

Figure 13. Useful Nomographic Type Forms
(Levens, 1965)

$$f_1(u) + f_2(v)f_3(w) = f_4(w)$$

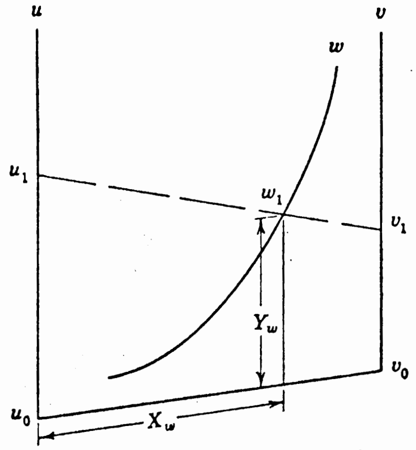
Scale equations:

$$X_u = m_u f_1(u)$$

$$X_v = m_v f_2(v)$$

$$X_w = \frac{K m_u f_3(w)}{m_u f_3(w) + m_v}$$

$$Y_w = \frac{m_u m_v f_4(w)}{m_u f_3(w) + m_v}$$



(c) Nomograph for an equation with a recurring variable of the form $f_1(u) + f_2(v)f_3(w) = f_4(w)$.

$$f_1(u) = f_2(v)f_3(w)$$

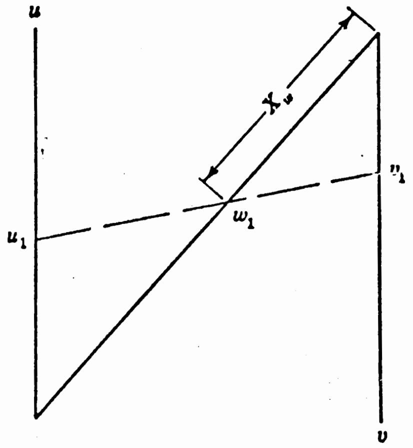
Scale equations:

$$X_u = m_u f_1(u)$$

$$X_v = m_v f_2(v)$$

$$X_w = \frac{K}{r_1 f_3(w) + 1}$$

where $r_1 = \frac{m_u}{m_v}$ and K is the length of the diagonal.



(d) Z-type chart for an equation of the form $f_1(u) = f_2(v)f_3(w)$.

Figure 13 (Continued)

CHAPTER III

RESEARCH PROCEDURE

Introduction

Although the second objective was not essentially dependent upon the successful achievement of the first, such success made the task of synthesizing the wealth of data required to draw up the graphic solutions much easier. The two objectives were pursued in their order of presentation.

Analytical Design Procedure

An iterative design procedure using the continuity equation

$$Q = VA \tag{4}$$

and the Manning equation

$$V = \frac{R^{2/3}S^{1/2}}{n} \tag{5}$$

for parabolic, triangular, and trapezoid channels was developed. The procedure developed differed from the normal trial and error procedures found in the Handbook of Channel Design for Soil and Water Conservation (USDA, 1954) and texts of open channel hydraulics (Chow, 1959; Henderson, 1966) in that (a) the hydraulic properties of the channel were described in terms of a parameter(s) related to the shape of the channel and (b) the calculated value of the velocity of flow (or output) from one iteration was used as an estimate (or input) for the following iteration.

Successive iterations resulted in the estimated and calculated values of the velocity of flow converging to the design velocity. In each iteration, the numerical value assigned to the Manning coefficient was different. The value varied with the product of the velocity and hydraulic radius as indicated by the standard retardance curves in the Handbook of Channel Design for Soil and Water Conservation (USDA, 1954).

Models for successive sections of the five curves were developed and used to determine the value of n for each iteration. The general forms of the relationships from which the models for Manning's n were developed were

$$n = a + b\ VR \qquad (6)$$

for convex sections of the retardance curves and

$$n = a + b/VR \qquad (7)$$

for concave sections of the retardance curves where a and b are constants.

The constants were determined by substituting graphically determined values of n and VR for two different points on the standard retardance curves (Figure 1) in the applicable models to obtain two equations. These were then solved simultaneously. The acceptability of these models was verified by superimposing approximately 50 values of n, calculated using the models, on the standard retardance curves (Figure 14). The models used to calculate Manning's n and the limits within which each apply are shown in Table IV.

Design procedures were developed for the three types of channels most often used for drainage and water conveyance, namely parabolic channels, triangular channels, and trapezoidal channels. The design procedures are given below.

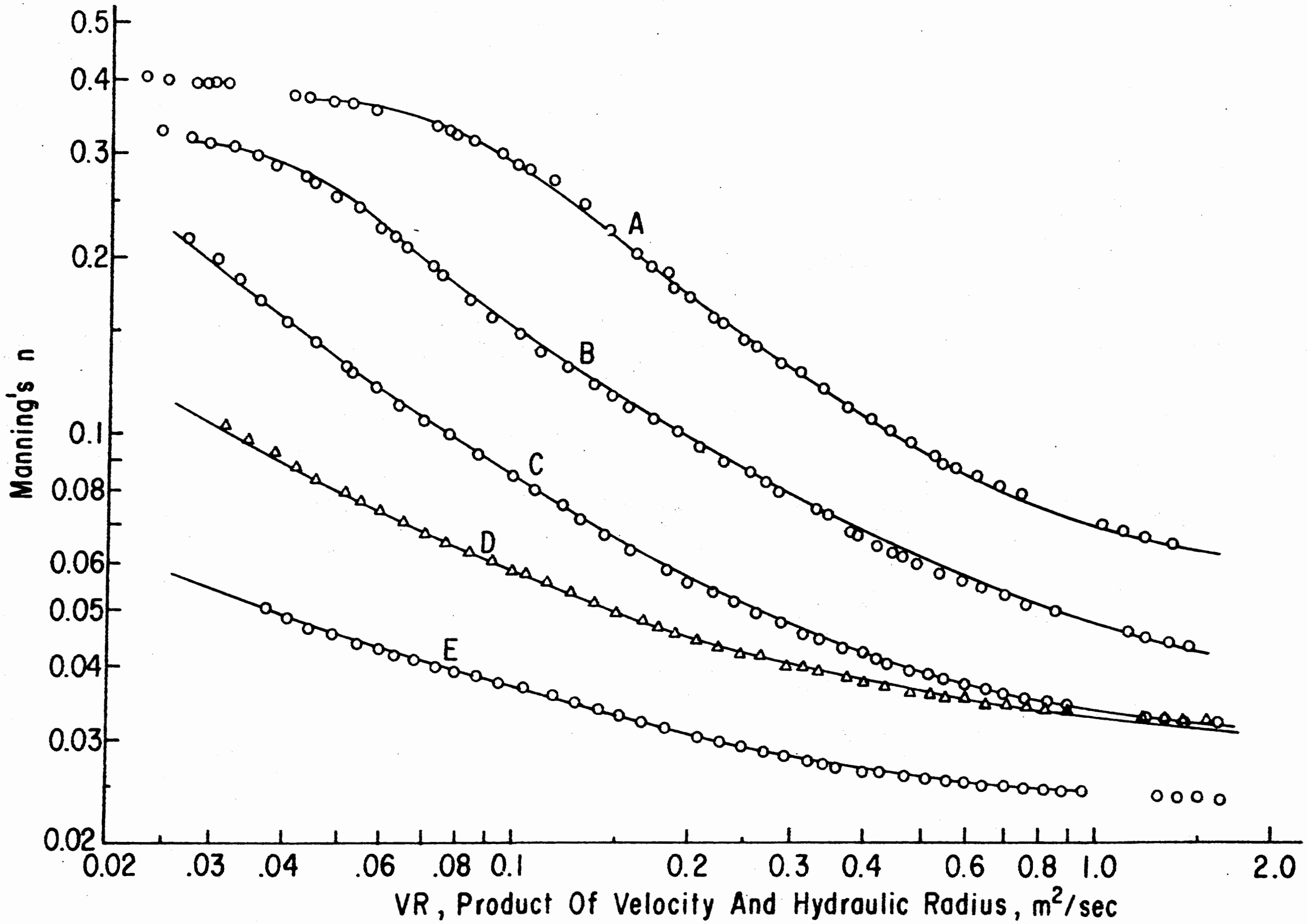


Figure 14. Comparison of Calculated Values of n with the Standard Retardance Curves

TABLE IV

MODELS OF THE STANDARD RETARDANCE CURVES

Retardance Class	Model	Limits of VR (m^2/s)
A	$n = 0.044 - 0.0139\,VR$	$VR \le 0.155$
	$n = 0.046 + 0.0024/VR$	$0.155 < VR$
B	$n = 0.403 - 0.0288/VR$	$VR \le 0.047$
	$n = 0.046 + 0.0096/VR$	$0.047 < VR < 0.186$
	$n = 0.0354 + 0.0115/VR$	$0.186 < VR$
C	$n = 0.034 + 0.0046/VR$	$VR \le 0.093$
	$n = 0.028 + 0.0051/VR$	$0.093 < VR$
D	$n = 0.038 + 0.0020/VR$	$VR \le 0.116$
	$n = 0.030 + 0.0028/VR$	$0.116 < VR$
E	$n = 0.29 + 0.0007/VR$	$VR \le 0.114$
	$n = 0.0225 + 0.0015/VR$	$0.114 < VR$

Parabolic Channels

The shape of a parabolic channel was described by the width (W) of the channel in meters for a depth of 0.305 m (1.0 foot). Wide shallow channels were thus characterized by larger values of W and deeper, narrower channels by smaller values of W. The hydraulic relationships for the channel dimensions such as depth of flow (D), flow area (A), wetter perimeter (P), and top width (T) were determined in terms of the descriptive parameter (W) as shown in Table V.

For a given discharge, channel shape, and gradient, it is suggested that the design of a parabolic channel would proceed in the following steps:

TABLE V

HYDRAULIC PARAMETERS OF PARABOLIC, TRIANGULAR, AND TRAPEZOIDAL CHANNELS

	Parabolic	Triangular	Trapezoidal
Slope Descriptor	W	Z	Z, B
Flow Area (A)	$\begin{cases} Q/V \\ 1.207\ WD^{3/2} \end{cases}$	$\begin{cases} Q/V \\ 1/2\ TD \end{cases}$	$\begin{cases} Q/V \\ BD + ZD^2 \end{cases}$
Flow Depth (D)	$0.882\ (A/W)^{2/3}$	$\sqrt{AZ}$	$(\sqrt{B^2 + 4ZA} - B)/(2Z)$
Wetted Parameter (P)	$\begin{cases} T + 8/3\ D^2/T \\ \text{approx} = T \end{cases}$	$2\sqrt{D\ 1 + Z^2}$	$2\ D\sqrt{1 + Z^2} + B$
Hydraulic Radius (R)	$\begin{cases} A/P \\ \text{approx} = 2/3\ D \end{cases}$	A/P	A/P
Top Width (T)	$1.811\ W\sqrt{D}$	$2\ ZD$	$B + 2\ ZD$
Manning's n	From Table IV		

W = width of channel (m) at 0.305 m (1 foot) depth, Z = side slope, B = bottom width.

1. estimate the velocity of flow (V_e);
2. calculate the estimated flow area (Q/V_e);
3. calculate the estimated flow depth;
4. calculate the hydraulic radius (R);
5. calculate the value of VR;
6. determine the Manning's n using the relationship in Table IV;
7. using Manning's equation, calculate the flow velocity (V_c);
8. repeat the above procedures until $V_c = V_e$.

With experience, a good initial approximation of the velocity of flow can be made, thus decreasing the number of iterations that would be required before the estimated and calculated values of the velocity of flow converge. Trial computations could be tabulated as shown in Table VI.

The velocity of flow determined in this way should be compared with the maximum allowable safe velocity (Table II) for the condition expected to prevail in the proposed channel. If the solved velocity is higher than the allowable velocity, a broader shallower channel, a reduced slope, or a change in vegetation may be needed.

Triangular Channels

The parameter used to describe triangular channels was the side slope, that is the ratio (z) of half the top width (T) to depth (D). Flatter slopes were thus characterized by large values of Z and vice versa. Relationships for the hydraulic properties of triangular channels were determined in terms of Z (the side slopes) as shown in Table V. For a given discharge capacity, channel side slope, and gradient, the design procedure should follow the same steps suggested for parabolic channels. The computation form in Table VI should be used.

TABLE VI

COMPUTATION FORM FOR THE DESIGN OF VEGETATION LINED CHANNELS

	Symbol	Trial 1	Trial 2	Trial 3	Trial 4
Channel Shape	W				
Channel Gradient	S				
Estimated Velocity	V_e				
Flow Area	A				
Flow Depth	D				
Wetted Parameter	P				
Hydraulic Radius	R				
Product of V and R	VR				
Manning's Coefficient	n				
Calculated Velocity	V_c				
Velocity Difference	ΔV				
Maximum Allowable Velocity	V_a				

Trapezoidal Channels

Two parameters were used to describe the shape of trapezoidal channels. These were the bottom width (B) and the side slope (Z). In the design of trapezoidal channels, two approaches were considered. For a predetermined side slope, a channel could be designed to carry a certain discharge by (a) choosing a preferred depth of flow and calculating the bottom width needed to provide the required channel capacity or (b) choosing a preferred bottom width and calculating the flow depth that would occur with the design discharge.

The latter approach was chosen because of the practical advantages of choosing the channel width to suit the equipment to be used in the construction. This approach was also found to be more appropriate in the generation of design data required later in the study to develop a graphical design procedure. Relationships for the hydraulic properties of trapezoidal channels were determined in terms of the side slopes (Z) and the bottom width (B) as shown in Table V. For a given discharge, channel side slope, bottom width, and gradient, the design procedure should follow the steps suggested for parabolic channels. The computation form in Table VI should again be used.

Graphical Design Procedure

Theory

The analytical design procedure which incorporated the calculation of Manning's n values dependent upon the VR values calculated in the procedure was used in developing a graphical design procedure. A computer program (Appendix D) was designed to calculate the geometric elements of a range of channels of different shapes and different discharge capacities. A schematic flow chart of the program is shown in Figure 15. This program provided the values of the velocity of flow (V), the depth of flow (D), the top width (T), the product (VR), and

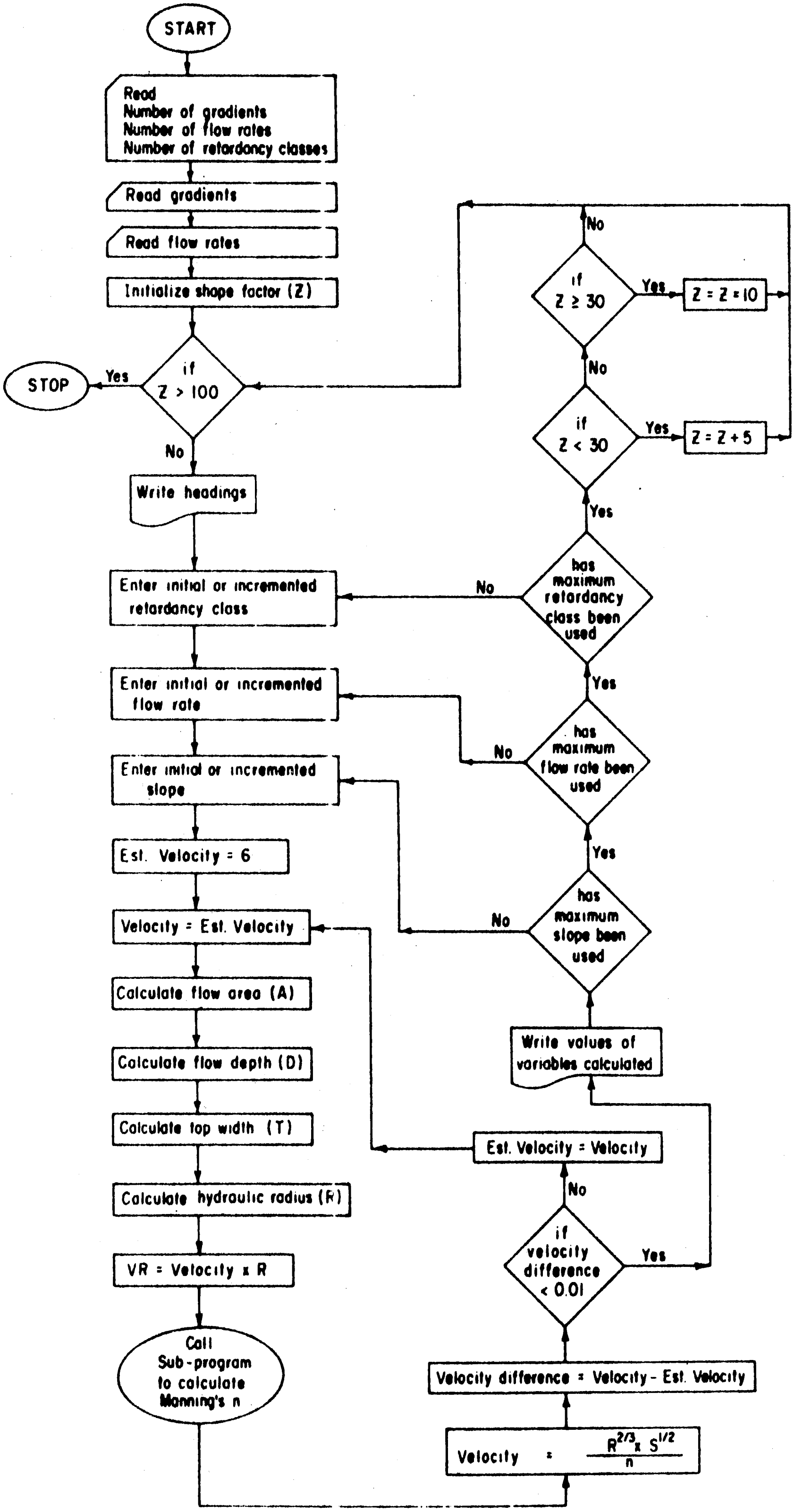


Figure 15. Schematic Flow Chart of the Program Used to Generate Data for the Construction of the Nomographs

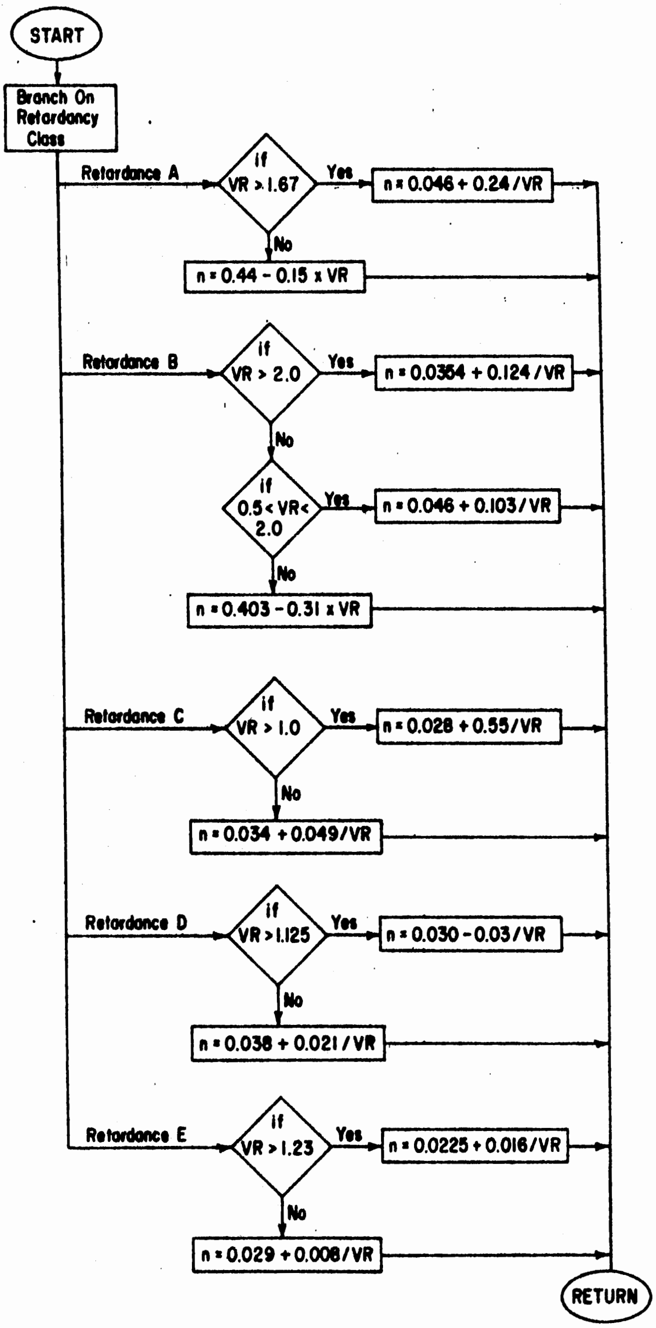


Figure 15. (Continued)

Manning's n for a series of channels for which the retardance class and shape were specified. Over 4,000 parabolic channels, triangular channels, and trapezoidal channels were designed using this program. The data thus generated were used to construct the alignment charts or nomographs in Appendices B through D. These charts were constructed in two parts, being a combination of two basic forms of alignment charts (Levens, 1965). The right-hand half of each chart was the nomographic layout for an equation having a recurring variable. The left-hand half of each chart was a Z-type chart for the product of the functions of two variables. The relationships for the left- and right-hand half of these charts are of the following forms respectively (Levens, 1965; Johnson, 1952):

$$f_1(u) = f_2(v) \cdot f_3(u) \tag{8}$$

$$f_1(u) + f_2(v)f_3(w) = f_4(w) \tag{9}$$

The Manning equation can be reduced to the above forms by the appropriate substitution of the continuity equation and the models developed for Manning's n as follows:

In Table IV for the B retardance class, we have the relationship

$$n = 0.4 - 0.03\ VR$$

Substituting the above expression in the Manning equation produces

$$0.4\ V - 0.03\ V^2R = R^{2/3}S^{1/2}$$

Multiplying through by A^2 and substituting Q for VA yields

$$0.4\ QA - 0.03\ Q^2R = A^2R^{2/3}S^{1/2}$$

Rearranging after expressing A and R in terms of W and D, according to the relationships in Table V for parabolic channels, produces

$$0.4\ Q - \frac{0.03\ Q^2}{W\sqrt{D}} = D^{13/6}WS^{1/2} \tag{10}$$

For constant gradient (S), the form of the above equation conforms with the form of equation (9) with Q as the recurring variable. Using this equation, the flow depth can be determined for a channel given the channel shape and desired discharge capacity.

A similar procedure can be used to reduce Manning's equation to an equivalent relationship in which the hydraulic radius (R) is expressed in terms of the channel slope (W) and velocity of flow (V). For parabolic channels, using the relationships in Table V, this results in the relationship

$$0.4\ Q - 0.03\ Q^2R = V^{-2}R^{2/3}S^{1/2} \tag{11}$$

The right-hand half of each chart in Figures 21 through 27 (Appendices A, B, and C) is the nomographic layout of the above relationships with an arbitrary value of 2% assigned to the channel gradient. The left-hand side of the charts provides the graphic solution for the depth (velocity) of flow in the channel with a gradient of between 0.5% and 10.0%. The above relationships were not used in the construction of the nomographs. They were subsequently deduced to confirm that the nomographic layouts used were valid.

Construction of Nomographs

The designer of nomographs for problem solution is required to be thoroughly familiar with the theory used in an analytical solution. A knowledge of the basic forms of equations and their nomographic layouts is also essential. The design technique used to design nomographs is an art which is difficult to develop in isolation. The experience and intuition of other designers are invaluable. It was the experience of the writer's major adviser that led to the choice of the nomographic layout used.

In the construction of the nomographs for the graphical design of vegetation lined channels, a large scale was initially used to graduate the depth (velocity) axis. This scale and the distances between the vertical axes of depth (velocity), pivot line, and shape parameter were chosen so as to utilize as much of an A3 size sheet as convenient. A range of shape factors was chosen and the extreme values (high and low values) of the range were suitably plotted on the appropriate axis. The anticipated mid-value of the range of channel gradients to be considered (2%) was located between the depth (velocity) of flow axis and the pivot line. Using these three points and the computer generated design data, the following steps were followed in plotting the channel capacity curve:

1. Choose the channel capacity (Q_1) to be plotted.
2. Plot the simulated depth of flow (D_{w1}) associated with a channel shape (W_1) and the channel discharge capacity chosen (Q_1) on the depth axis.
3. Draw a ray through D_{w1} and the channel gradient and produce it to cut the pivot line at P_1 (Figure 16a).
4. Join P_1 and W_1.
5. Plot another depth of flow (D_{w2}) associated with a second channel shape (W_2) and the same channel discharge capacity (Q_1) on the depth axis.
6. Draw a ray through D_{w2} and the channel gradient and produce it to cut the pivot line at P_2.
7. Join P_2 and W_2 and mark the intersection with P_1W_1.

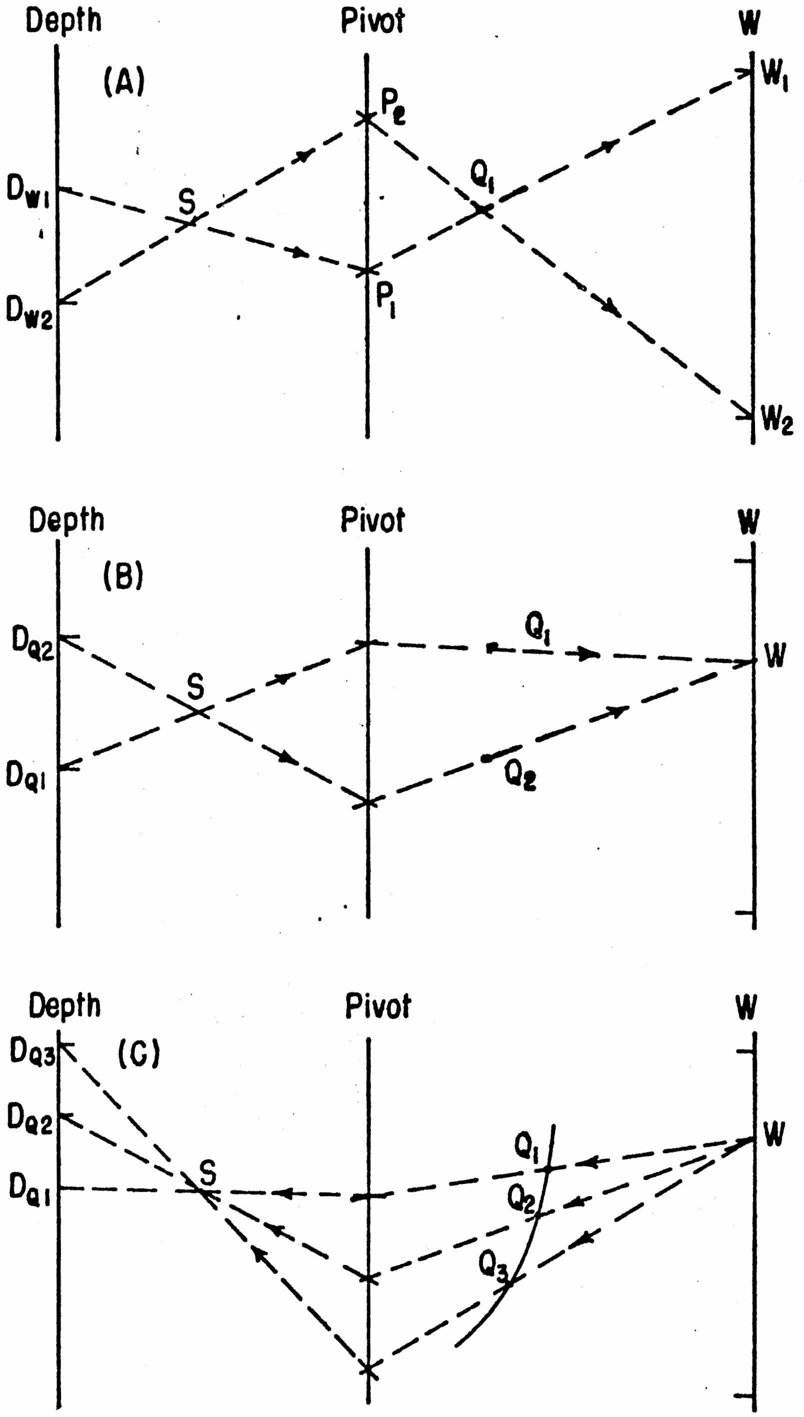


Figure 16. Nomograph Plotting Sequence

8. The point of intersection of P_1W_1 and P_2W_2 represents the point Q_1 on the channel discharge capacity curve.
9. Repeat for other values of the channel discharge capacity (Q).

Other values of the shape parameter were then plotted following a similar procedure illustrated in Figure 16b. All the channel capacities plotted by the previous procedure were used to locate the intermediate points between the extreme shape parameter values. This procedure was repeated to produce the channel discharge capacity curves for all the retardance classes.

The channel gradient curve was completed using the points plotted on the channel discharge curve as illustrated in Figure 16c. The above construction procedure conforms with the procedure suggested by Levens (1965) for the construction of alignment charts.

CHAPTER IV

RESULTS AND DISCUSSION

The hydraulic design of a grassed channel consists of two stages (Ree, 1949). The first stage is to design the channel for stability; that is, to ascertain whether the design velocity in the channel exceeds the limiting velocity for the anticipated slope, soil, and minimum cover combination. The second stage is to review the design for maximum discharge capacity; that is, to determine the increased depth of flow that would be necessary to maintain the maximum discharge capacity under the condition of highest retardance. In presenting the results of this study, a channel design will be executed to show how the design procedures developed may be applied. The design will follow the two stages described above. At the conclusion of each design, a freeboard of 0.100 m (four inches) will be added to the design depth.

Analytical Design Procedure

The analytical design procedure is based upon the calculation of the Manning's n using the models presented in Table IV. In the graphical comparison (Figure 14), the models were shown to portray the standard retardance curves satisfactorily. The use of the computation form shown in Table VI would ensure the orderly iteration of the design steps which have to be followed in order to achieve a solution. The following example illustrates how the analytical design procedure should be executed:

Given a discharge of 6.0 m^3/s (210 cfs) and a channel gradient of 2%, determine the section of the trapezoidal channel (4:1 side slopes) lined with bermudagrass expected to fall in the B retardance class.

1. Design for stability (use retardance D, Table III), try a 10 m wide channel. The number of iterations in the calculations presented in Table VII were reduced by the judicial choice of V_e in the successive calculations instead of using the preceding calculated value of V_c. The value of ΔV would depend upon the designer's discretion. The value of 1.70 m/s was compared with the permissible velocity of 1.80 m/s for the expected conditions (Table II). As the permissible velocity was not exceeded the choice of the bottom width was acceptable.

TABLE VII

CALCULATION FOR STABILITY DESIGN

	Trial 1	Trial 2	Trial 3
B	10.000	10.000	10.000
S	0.020	0.020	0.020
V_e	1.500	1.600	1.700
A	4.000	3.750	3.530
D	0.350	0.331	0.314
P	12.893	12.731	12.586
R	0.310	0.295	0.280
VR	0.465	0.471	0.477
n	0.0360	0.0359	0.0358
V_c	1.799	1.746	1.690
ΔV	0.299	0.146	0.010
V_a	1.800	1.800	1.800

2. Design for capacity (use retardance B for mature cover). The velocity calculated in this section of the procedure (Table VIII) will always be less than the velocity calculated in design for stability. After a free board of 0.100 m (four inches) was added to the design depth, the top width for the total depth (including the free board) was calculated using the relationship T = B + 2ZD in Table V. The resulting trapezoidal section would then be:

Bottom width = 10 m

Depth of channel = 0.530 m

Top width = 13.440 m

Velocity of flow = 1.19 m/s

This design procedure was used to generate the data required to construct the nomographs for the graphical design procedure.

TABLE VIII

CALCULATION FOR CAPACITY DESIGN

	Trial 1	Trial 2	Trial 3
B	10.000	10.000	
S	0.020	0.020	
V_e	1.500	1.200	1.190
A	4.000	5.000	5.040
D	0.350	0.427	0.430
P	12.893	13.522	13.546
R	0.310	0.370	0.372
VR	0.465	0.444	0.443
n	0.0602	0.0614	0.0614
V_e	1.076	1.187	1.191
ΔV	0.424	0.013	0.001
V_a	1.800	1.800	1.800

Design depth is 0.430 m.

Graphical Design Procedure

The computer program (Appendix E) was used to execute the above design procedure for a range of channel slopes, channel gradients, and discharge capacities for each of the five standard retardance classes. The iterations were terminated when the value of ΔV was equal to or less than 3.05×10^{-3} m (0.01 ft). Over 1,000 hypothetical channels for each of the four different channel types were designed and the data used to construct nomographs for the design of parabolic channels, triangular channels, and trapezoidal channels with side slopes of 4:1 and 6:1 (see Figures 21 through 27 in Appendices B through D).

The nomographs are grouped into two sections for each channel type. The first section (five charts) relates to the channel velocity. The second section (one chart for parabolic and triangular channels and four charts for trapezoidal channels) relates to the channel depth of flow. The same discharge capacities, channel gradients, and shape values are repeated on the charts in both sections.

The example introduced in the section on the analytical design procedure will be used to illustrate the use of these nomographs in the graphical design procedure.

The design for stability should proceed in the following steps:

1. Choose a desirable channel bottom width (say 10 m).
2. Choose the lowest expected retardance for the vegetal lining from Table III (retardance D).
3. Choose the trapezoidal channel velocity chart (Figure 25, Appendix D) for this retardance.
4. Draw a ray from the value 10 on the bottom width scale through

$6.0\ m^3/s$ on the flow curve and produce it to cut the pivot line at "a".

5. Draw a ray from the point "a" on the pivot line through the value of 2% on the slope scale and produce it to cut the velocity axis at 1.7 m/s.
6. Compare this velocity with the limiting velocity in Table II. Change the bottom width if the maximum allowable velocity is exceeded and repeat (4) and (5) above. If the solved velocity is extremely low the channel may be made more economical by making it narrower.

The design for maximum capacity should proceed as follows:

7. Determine the retardance class for the mature vegetal lining from Table III (retardance B).
8. Turn to the depth chart for trapezoidal channels with 4:1 side slopes (Figure 27, Appendix D).
9. Draw a ray from the value 10 on the bottom width scale through $6.0\ m^3/s$ on the D flow curve and produce it to cut the pivot line in "b".
10. Draw a ray from the point "b" on the pivot line through the 2% value on the slope curve and produce it to cut the depth axis at 0.422 m.
11. Add the freeboard of 0.100 m and calculate the top width of the channel using the relationship $T = B + 2ZD$ in Table V ($T = 13.380$).

The trapezoidal section will then be:

Bottom width = 10 m

Depth of channel = 0.522 m

Top width = 13.380 m

Velocity of flow = 1.20 m/s

This procedure can be executed in a fraction of the time required by the analytical design procedure and compares favorably with it. Reversing the procedure, the maximum discharge capacity of an existing channel can be conveniently determined.

During the construction of the nomographs it was found that in some cases it was not possible to develop a curve for low flows in channels with high retardance. In the region of low VR values, the n-VR curves do not conform to the same shape and convergence. The bilinear test also fails in this region. The nomographs cannot, therefore, be used for slow flows which have little influence on the erect condition of tall vegetation (class A retardance). When VR values of less than 0.1 are encountered, a friction factor of between 0.3 and 0.4 should be used when the class A retardance condition applies (see Figure 1). The reliability of the nomographs tends to decrease as the extremities of the curves are used.

Statistical Analysis

An average of about 240 parabolic, triangular, and trapezoidal channels were designed using both the analytical and graphical design procedures. A range of three slopes, four flow rates, and four channel shapes were used for each of the five retardance classes. The design parameters of depth and velocity, determined by the analytical and graphical design procedures, were compared. The graphical comparisons (Figures 17 through 20, Appendix A) showed that there was a good linear correlation between the values from the two procedures.

Barr et al.'s (1979) regression analysis, using a linear model with the intercept forced through the origin, was carried out on the results for the depth of flow and velocity of flow respectively. The data fitted the linear model extremely well showing a very high corrolation coefficient ($R^2 \geq 0.999$). The standard deviation of the data from the model was found to be between 0.008 and 0.014 for the depth analysis and between 0.031 and 0.070 for the velocity analysis (Tables IX and X). The coefficient of variation of all the data points in every case was less than 4.4% with a mean value of 2.475% and 3.628% for the depth and velocity comparisons respectively. With a variation of 0.986 to 1.001 in the regression coefficient of the models for all the channel types, the analysis showed that the model was a good approximation of the line of equal value. The analysis thus showed that there was no meaningful difference between the design values of depth and velocity of flow determined by means of the analytical and graphical design procedures.

TABLE IX

REGRESSION ANALYSES ON CHANNEL DEPTHS

	Parabolic	Triangular	Trapezoidal (6:1)	Trapezoidal (4:1)
Regression Coefficient	0.998	1.001	0.998	0.994
Standard Deviation	0.008	0.014	0.009	0.008
Correlation Coefficient	1.000	0.999	1.000	1.000
Coefficient of Variation	2.225	3.129	2.473	2.074

TABLE X

REGRESSION ANALYSES ON CHANNEL VELOCITY

	Parabolic	Triangular	Trapezoidal (6:1)	Trapezoidal (4:1)
Regression Coefficient	0.997	0.992	0.986	0.991
Standard Deviation	0.031	0.032	0.070	0.063
Correlation Coefficient	0.999	0.999	0.999	0.999
Coefficient of Variation	3.267	3.088	4.347	3.808

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

An iterative analytical design procedure and a graphical design procedure were developed for the design of vegetal lined parabolic, triangular, and trapezoidal channels. Simple models for the five standard retardance curves (n-VR curves) were also developed. These models were used to determine Manning's n in each iteration in the analytical design procedure which could be executed using a non-programable scientific calculator. Using a programable calculator or computer, the output of each iteration could be used as the input of the next iteration. The number of iterations, however, could be significantly reduced by the judicial choice of the value of the input to each iteration.

The analytical design procedure was used to design a large number of hypothetical channels by means of a computer. The design data generated were used to construct nomographs for the graphical design of parabolic, triangular, and trapezoidal channels. The two procedures were used to design over 900 channels. The design outputs of the two procedures (depth of flow and velocity of flow) were analyzed statistically. The regression analysis on the graphically and analytically determined depth of flow and velocity of flow showed that, within practical limits, no accuracy was forfeited when the graphical procedure was used. A considerable saving in time and greater flexibility was achieved through the use of the graphical design procedure.

Conclusions

The analytical design procedure developed could be profitably used to design vegetation lined channels using an ordinary scientific or engineer's calculator. Using the recommended computation form for successive iterations, the number of iterations could be significantly reduced.

The use of the graphical design procedure and the nomographs, developed from the computer synthesized data, vegetation lined parabolic, triangular, and trapezoidal channels can be designed in a fraction of the time required by other design procedures with no significant loss in accuracy. The method is especially suitable for field use and is more flexible than any other design procedure. The method can also be used to determine the discharge capacity of an existing channel in the field quickly and easily. Because of the speed and ease with which a designer can execute a design using this graphical design method, this method will in the future allow designers to consider many alternative designs that otherwise would possibly never be considered.

The credibility of any design procedure is as good as the data upon which it is based. The reliability with which the retardance of the vegetation in the channel is classified remains the key to success in the design of vegetated channels. In practice, such classification will be influenced by the experience and preferences of the assessor.

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APPENDIXES

APPENDIX A

GRAPHICAL COMPARISONS OF ANALYTICALLY AND GRAPHICALLY DETERMINED DEPTH OF FLOW AND VELOCITY OF FLOW

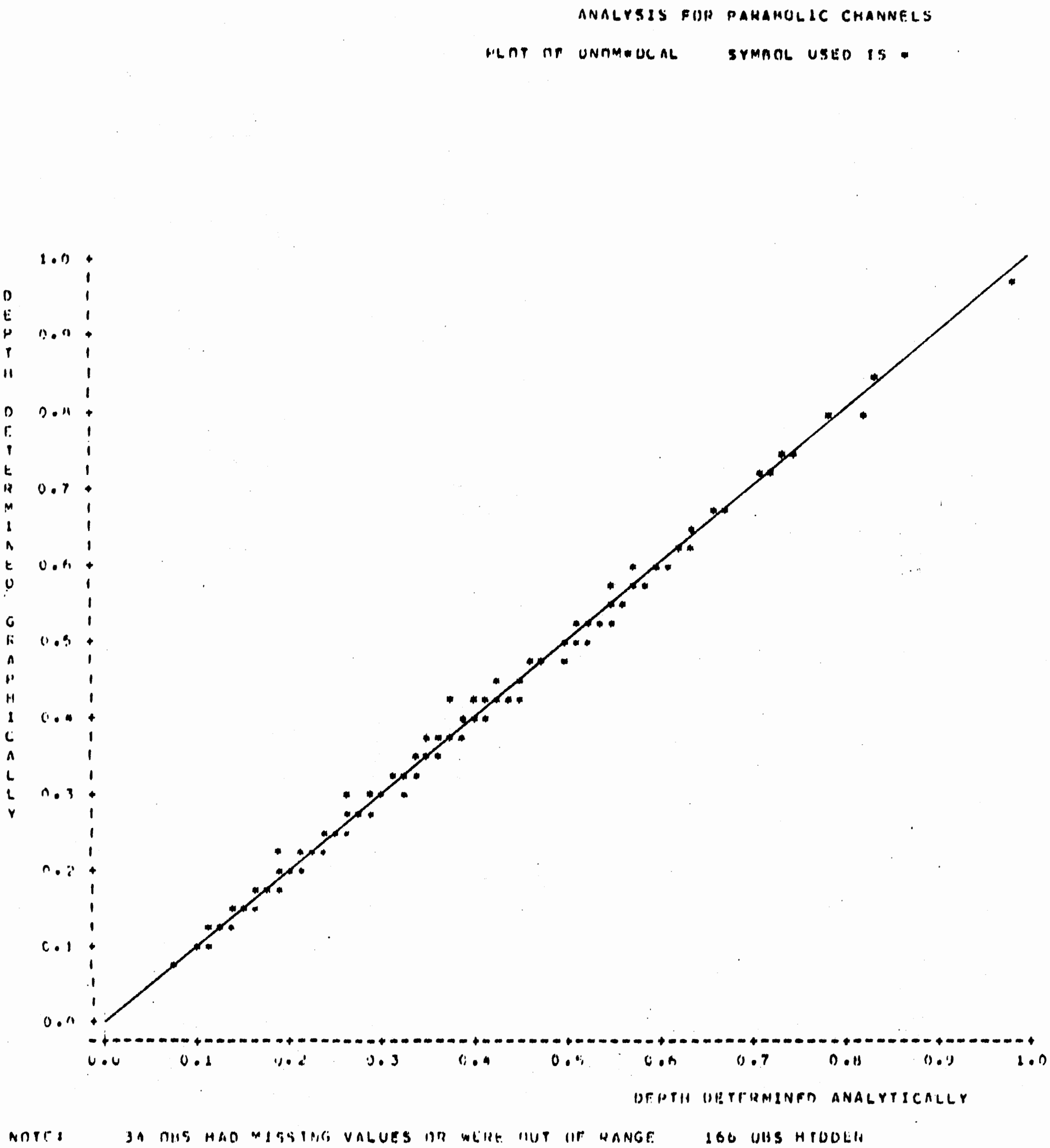
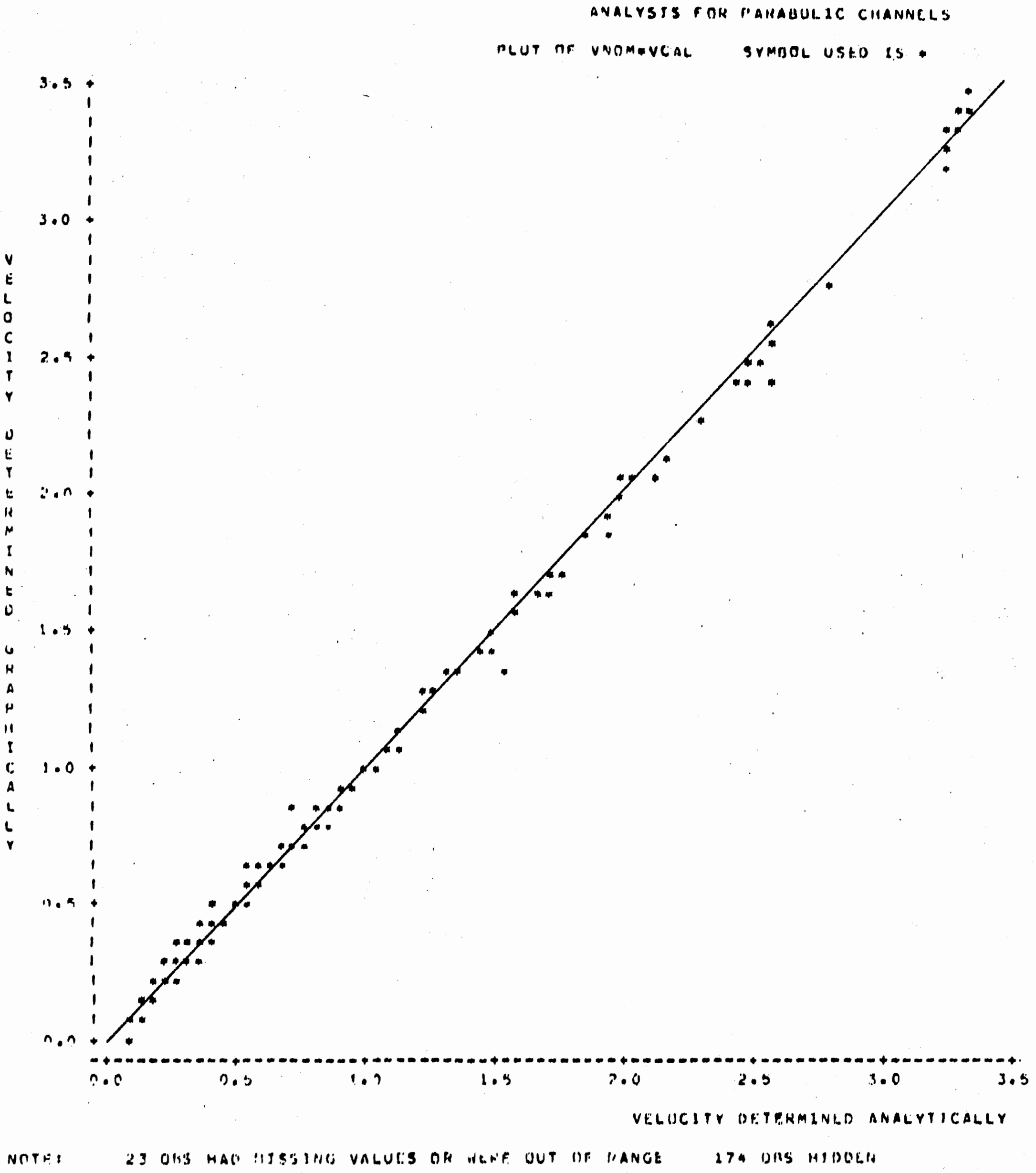


Figure 17. Analysis on Parabolic Channel Depths and Velocities



ANALYSIS FOR PARABOLIC CHANNELS

PLOT OF VNOM*VCAL   SYMBOL USED IS *

NOTE: 23 OBS HAD MISSING VALUES OR WERE OUT OF RANGE   174 OBS HIDDEN

Figure 17 (Continued)

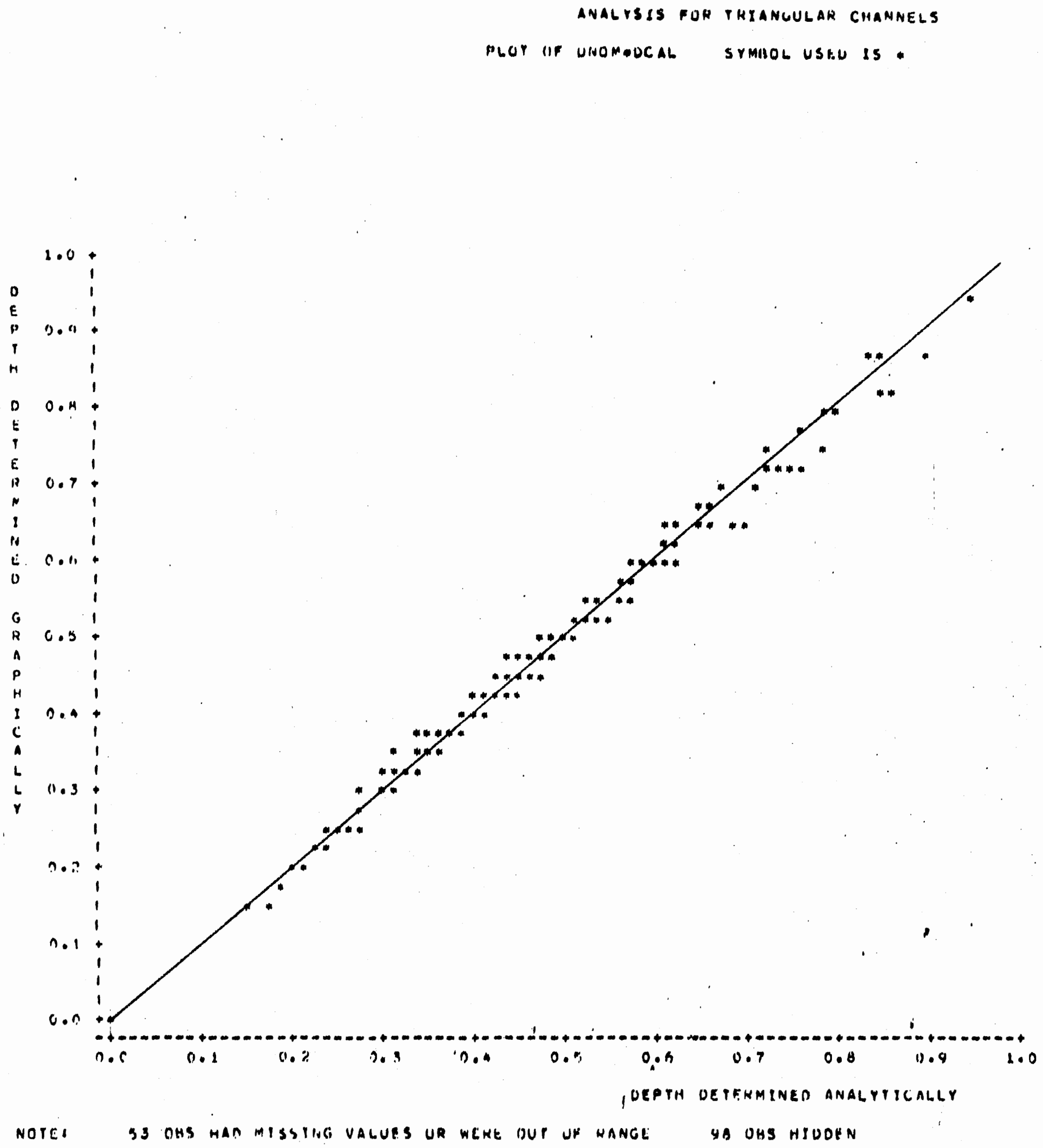


Figure 18. Analysis on Triangular Channel Depths and Velocities

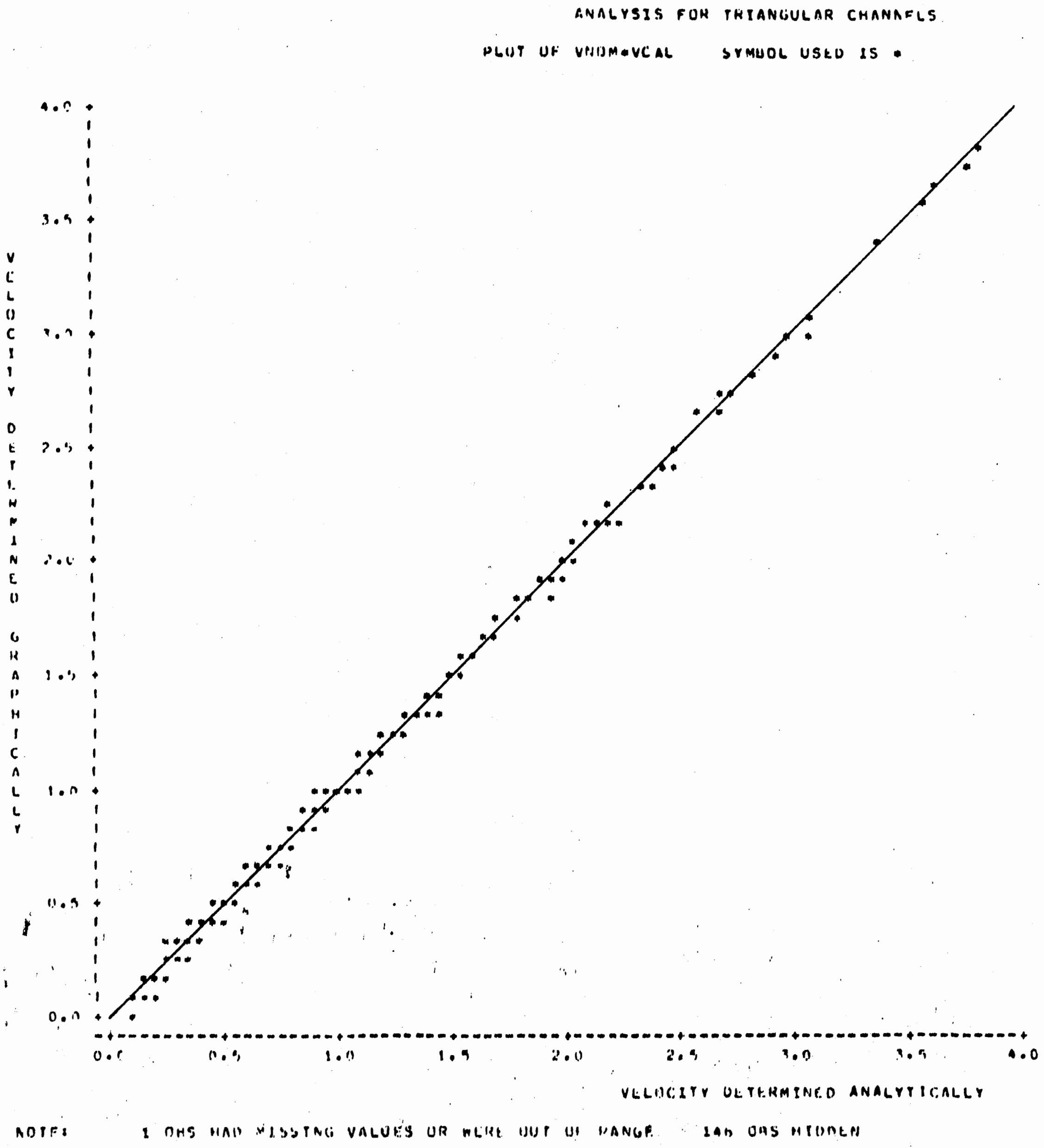
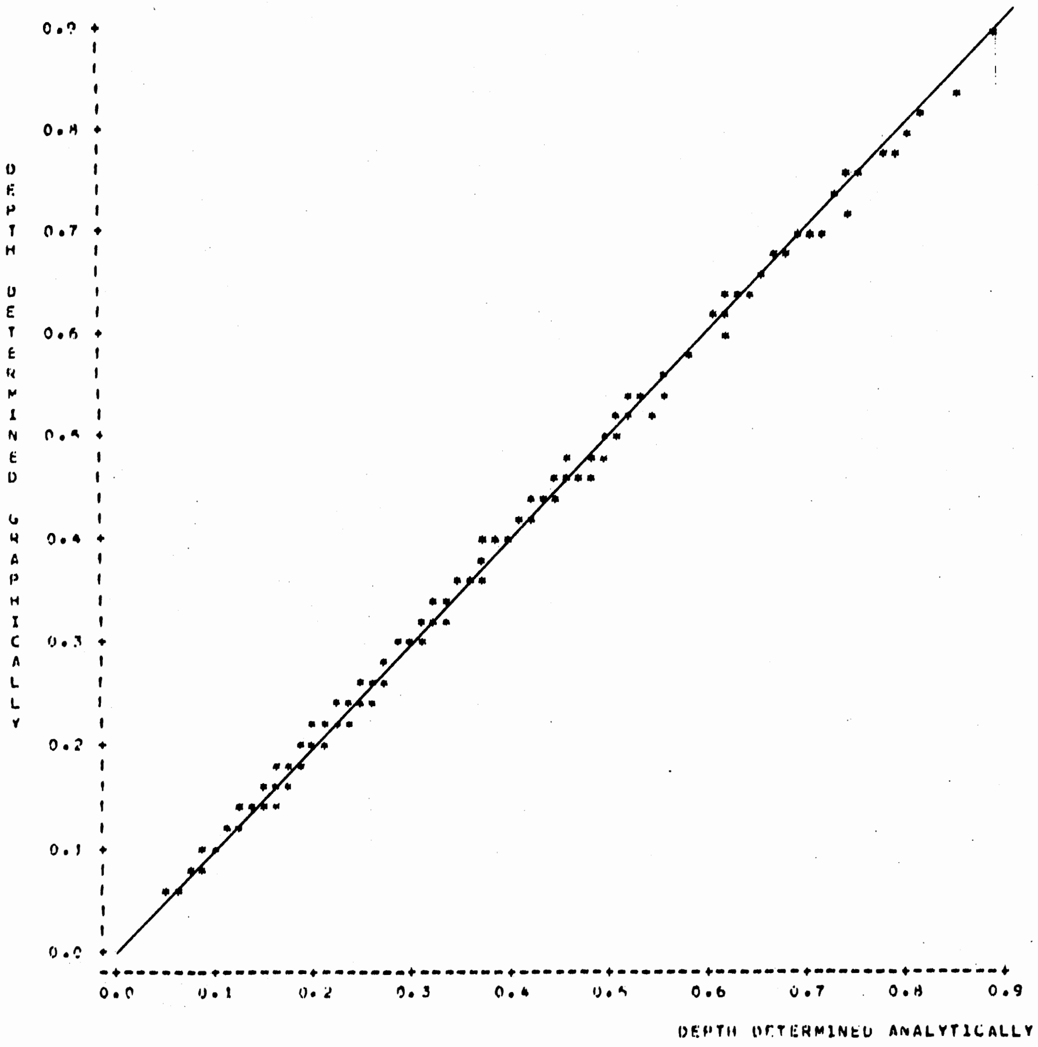


Figure 18 (Continued)

ANALYSIS FOR TRAPEZOIDAL CHANNELS
SIDE SLOPE=4:1

PLOT OF DNOM*DCAL SYMBOL USED IS *

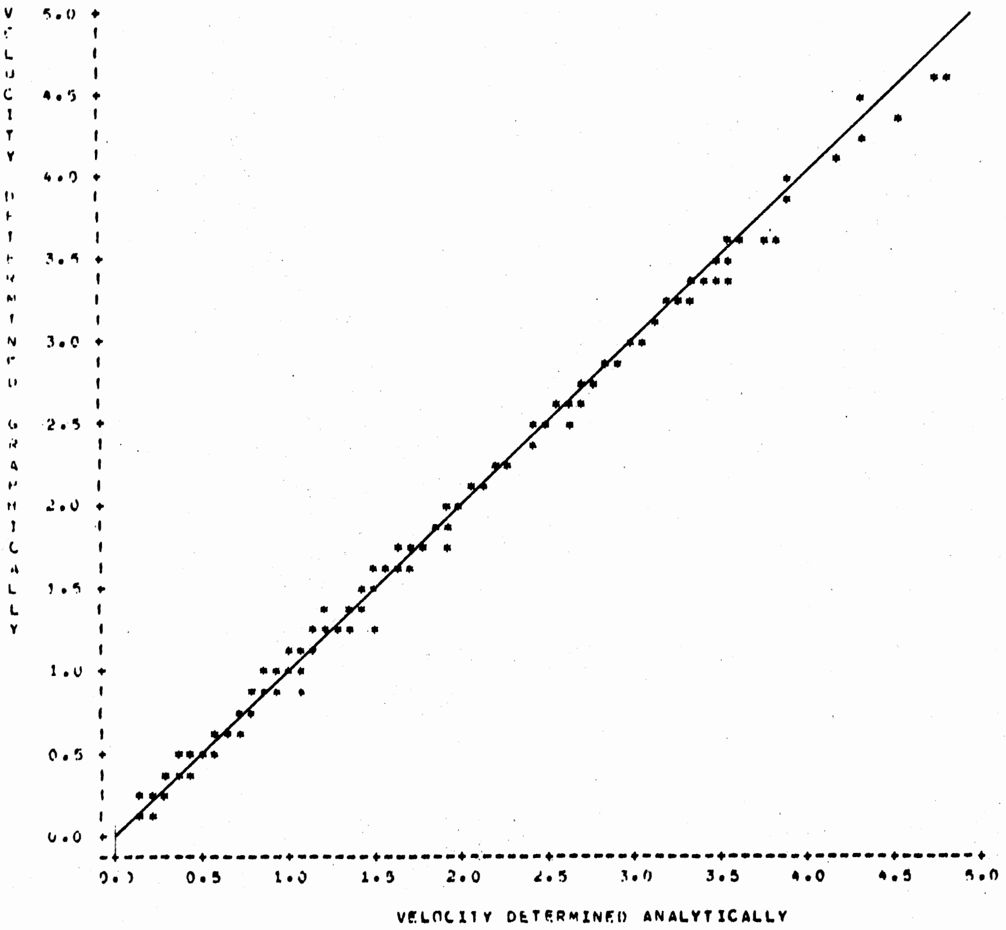


NOTE: 64 OBS HAD MISSING VALUES OR WERE OUT OF RANGE 62 OBS HIDDEN

Figure 19. Analysis on Trapezoidal Channel Depths and Velocities (4:1 Slopes)

ANALYSIS FOR TRAPEZOIDAL CHANNELS
SIDE SLOPE=4:1

PLOT OF VNOM*VCAL   SYMBOL USED IS *



NOTE: 12 OBS HAD MISSING VALUES OR WERE OUT OF RANGE   117 OBS HIDDEN

Figure 19 (Continued)

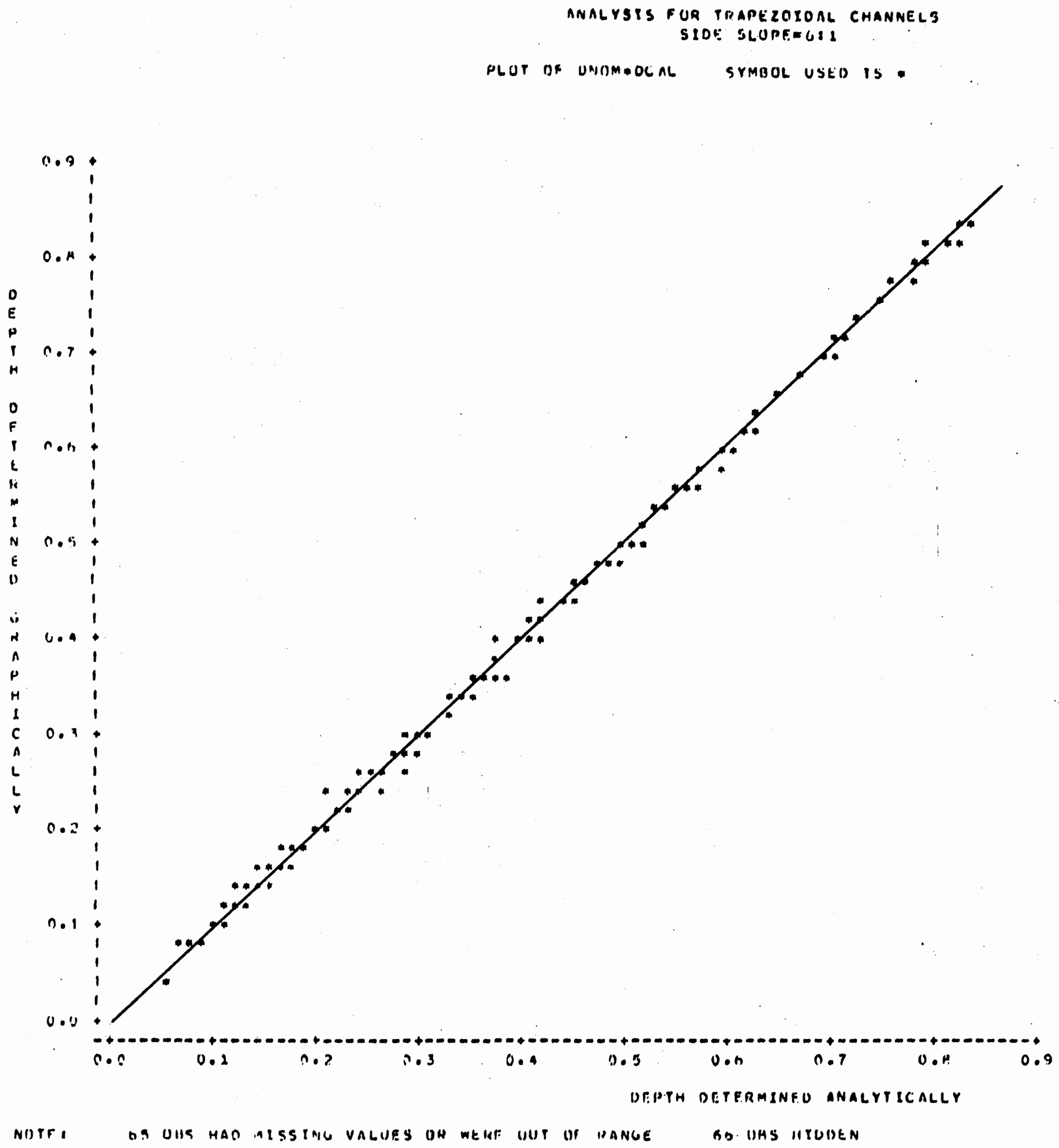
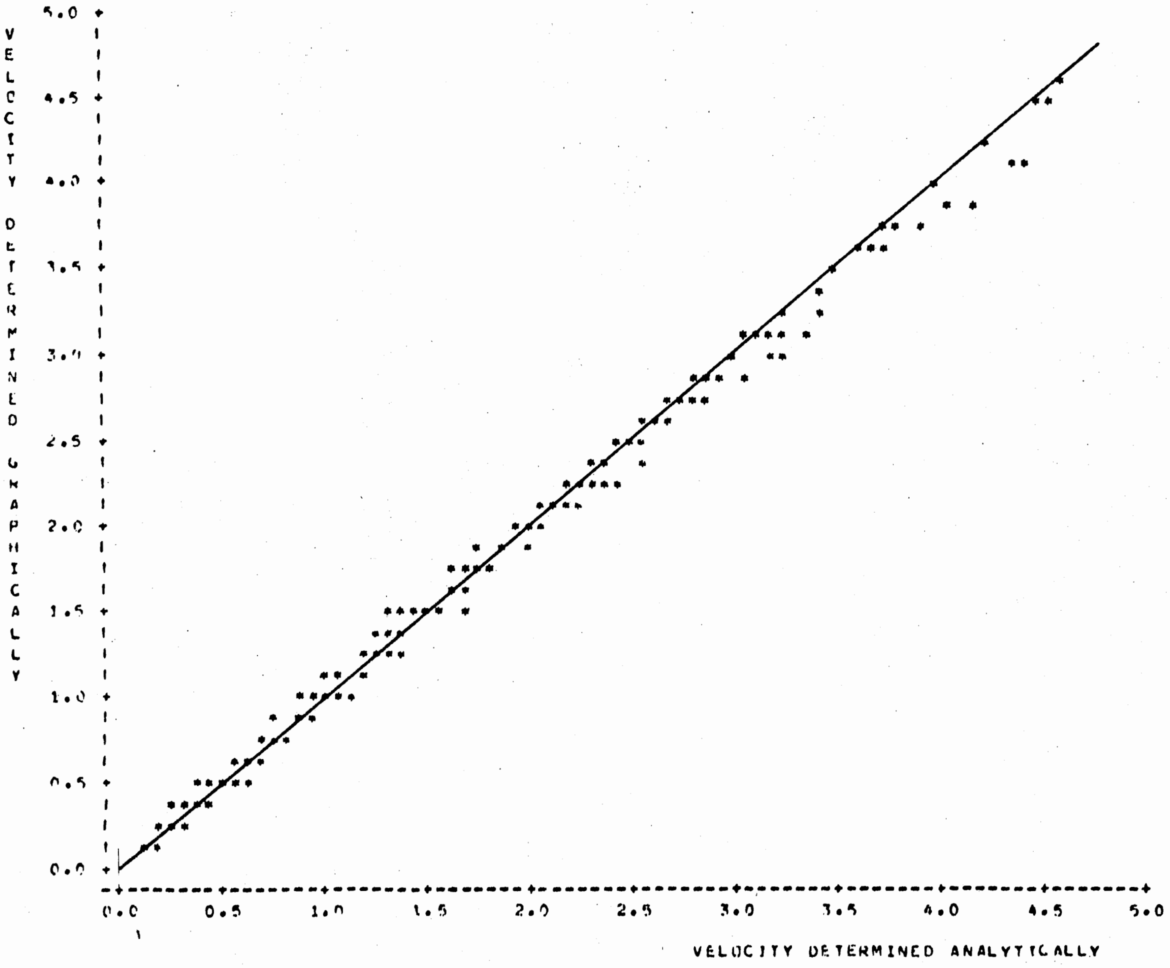


Figure 20. Analysis on Trapezoidal Channel Depths and Velocities (6:1 Slopes)

```
                    ANALYSIS FOR TRAPEZOIDAL CHANNELS
                            SIDE SLOPE=6:1

          PLOT OF VNOM*VCAL      SYMBOL USED IS *
```



```
NOTE:      9 OBS HAD MISSING VALUES OR WERE OUT OF RANGE     107 OBS HIDDEN
```

Figure 20 (Continued)

APPENDIX B

NOMOGRAPHS FOR THE DESIGN OF PARABOLIC CHANNELS

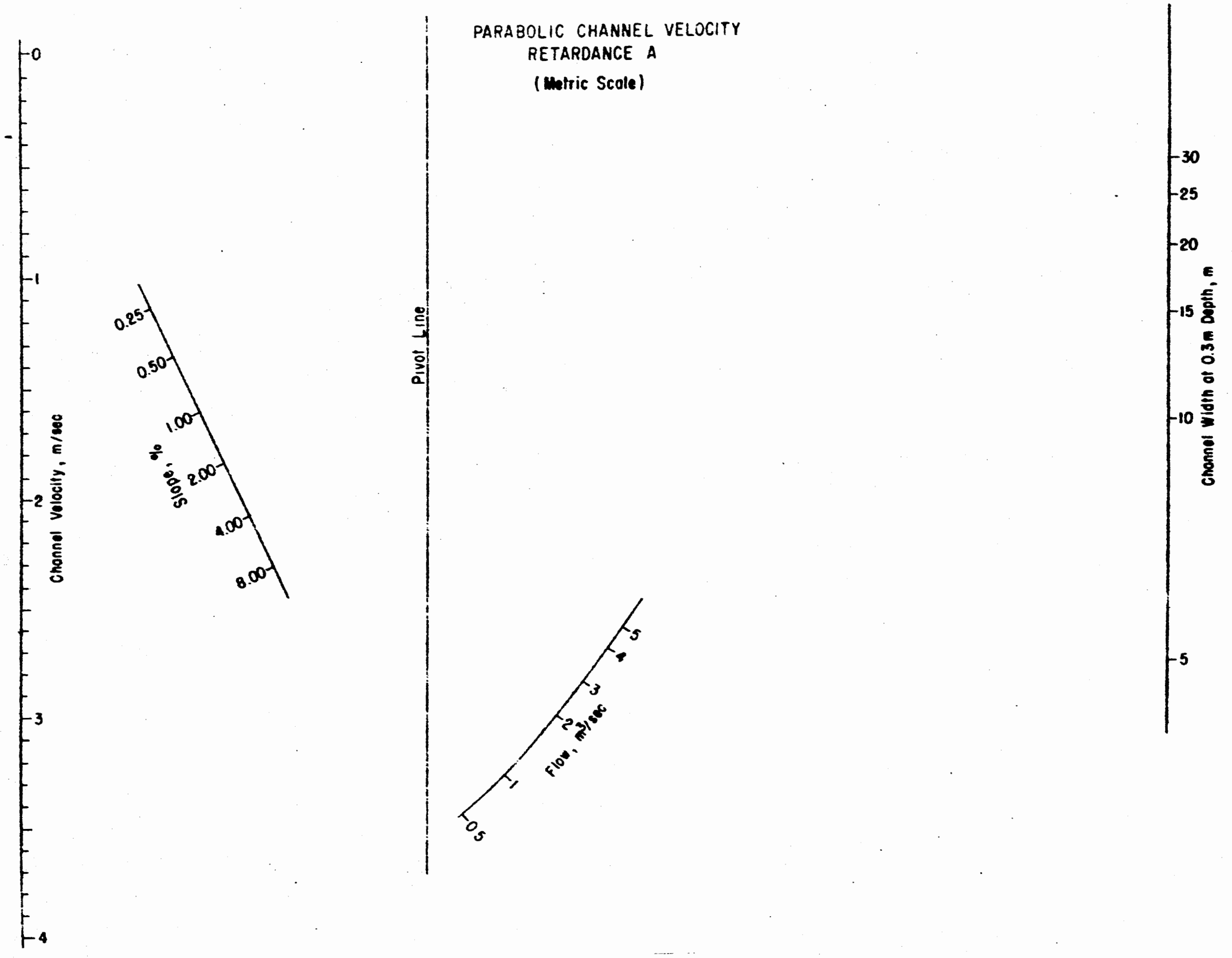


Figure 21. Solution for Parabolic Channel Velocity

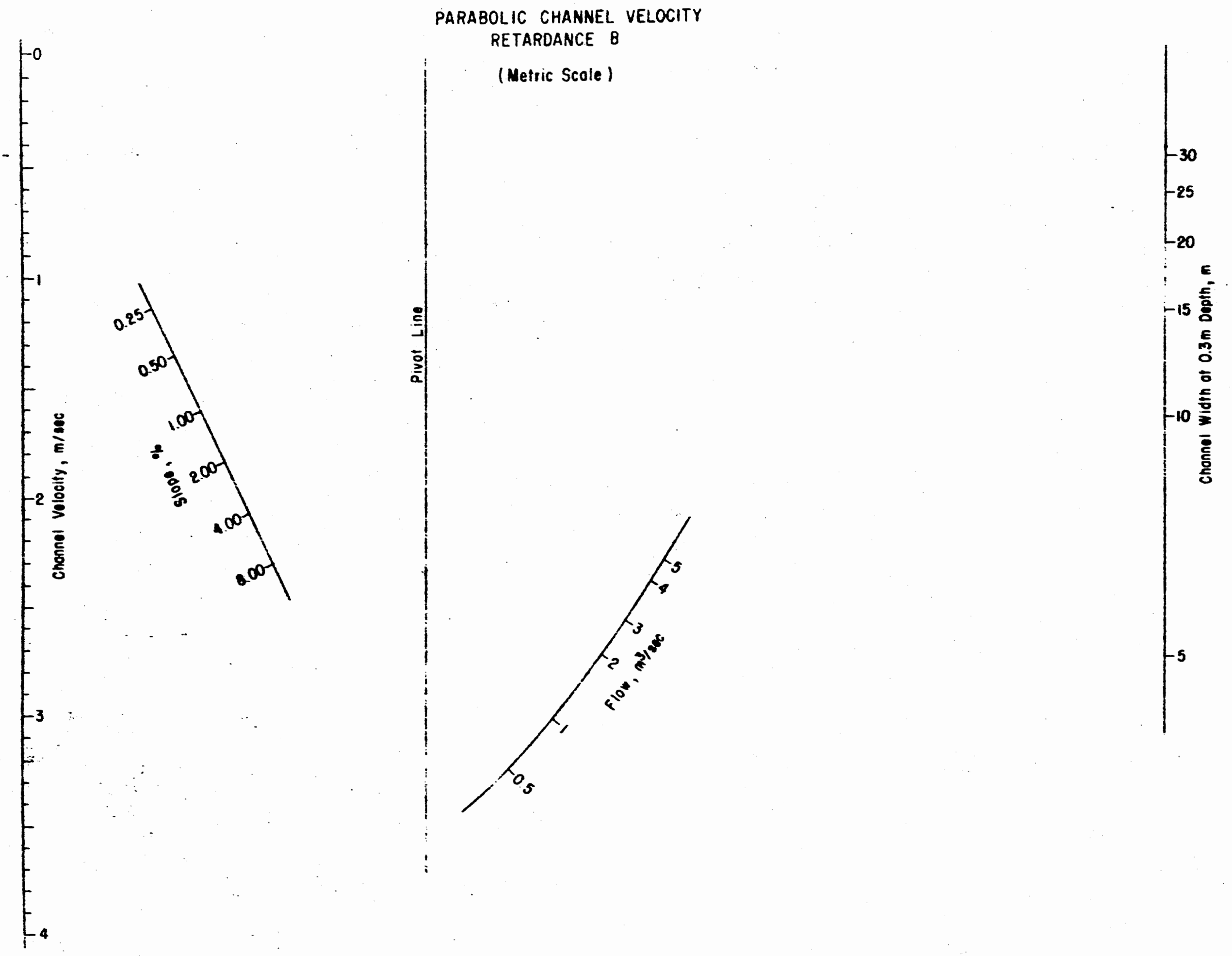


Figure 21 (Continued)

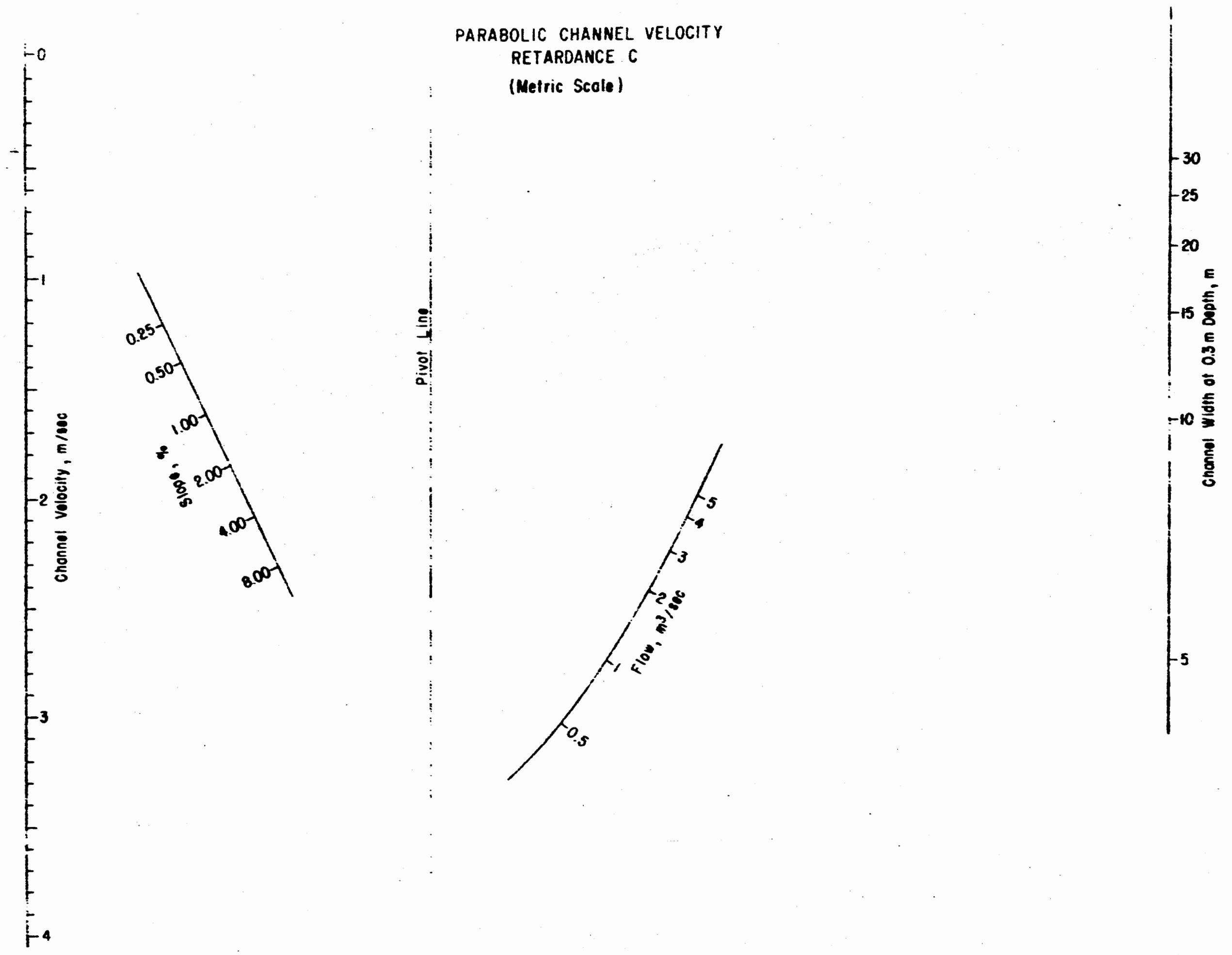

PARABOLIC CHANNEL VELOCITY
RETARDANCE C
(Metric Scale)

Figure 21 (Continued)

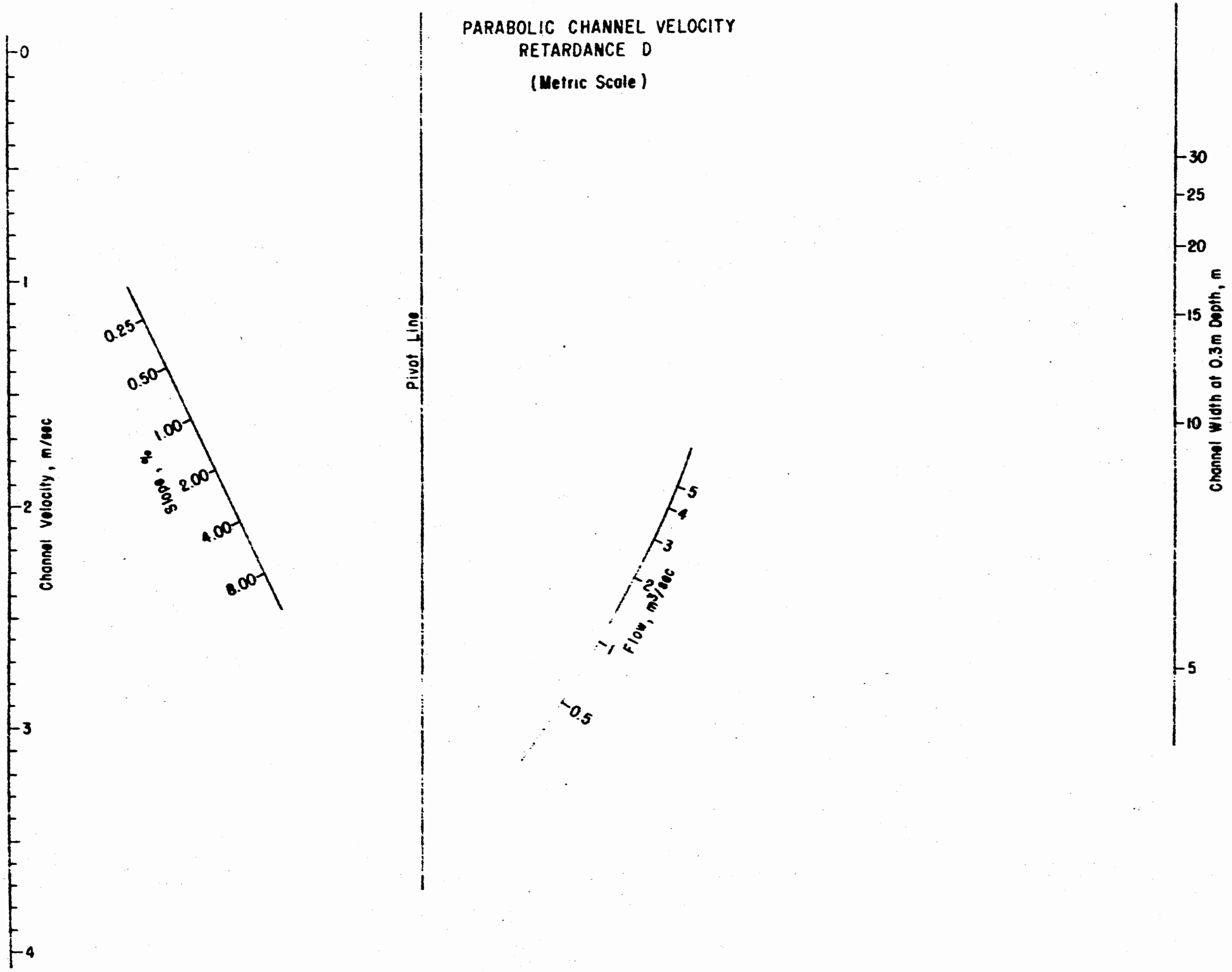

PARABOLIC CHANNEL VELOCITY
RETARDANCE D
(Metric Scale)

Figure 21 (Continued)

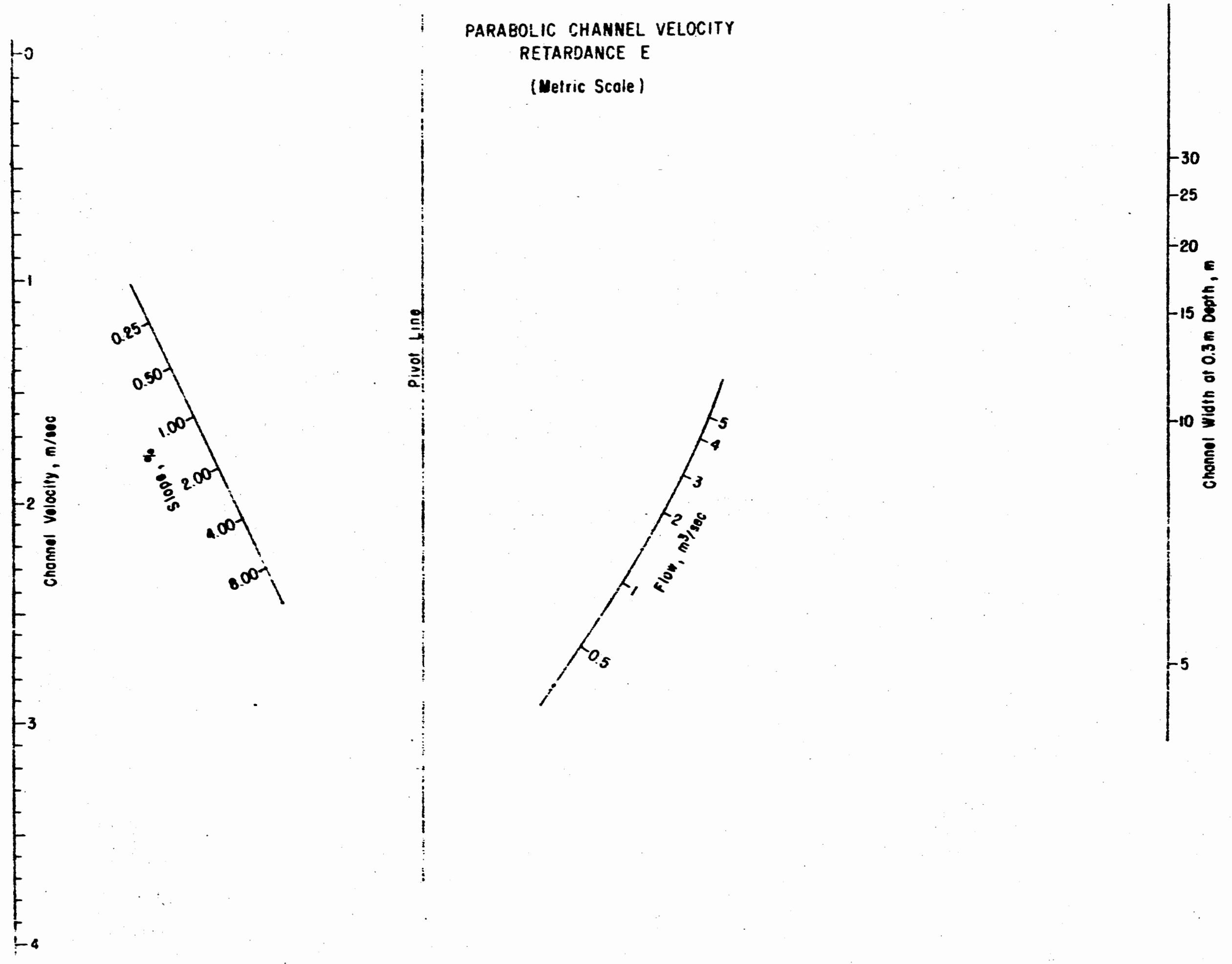


Figure 21 (Continued)

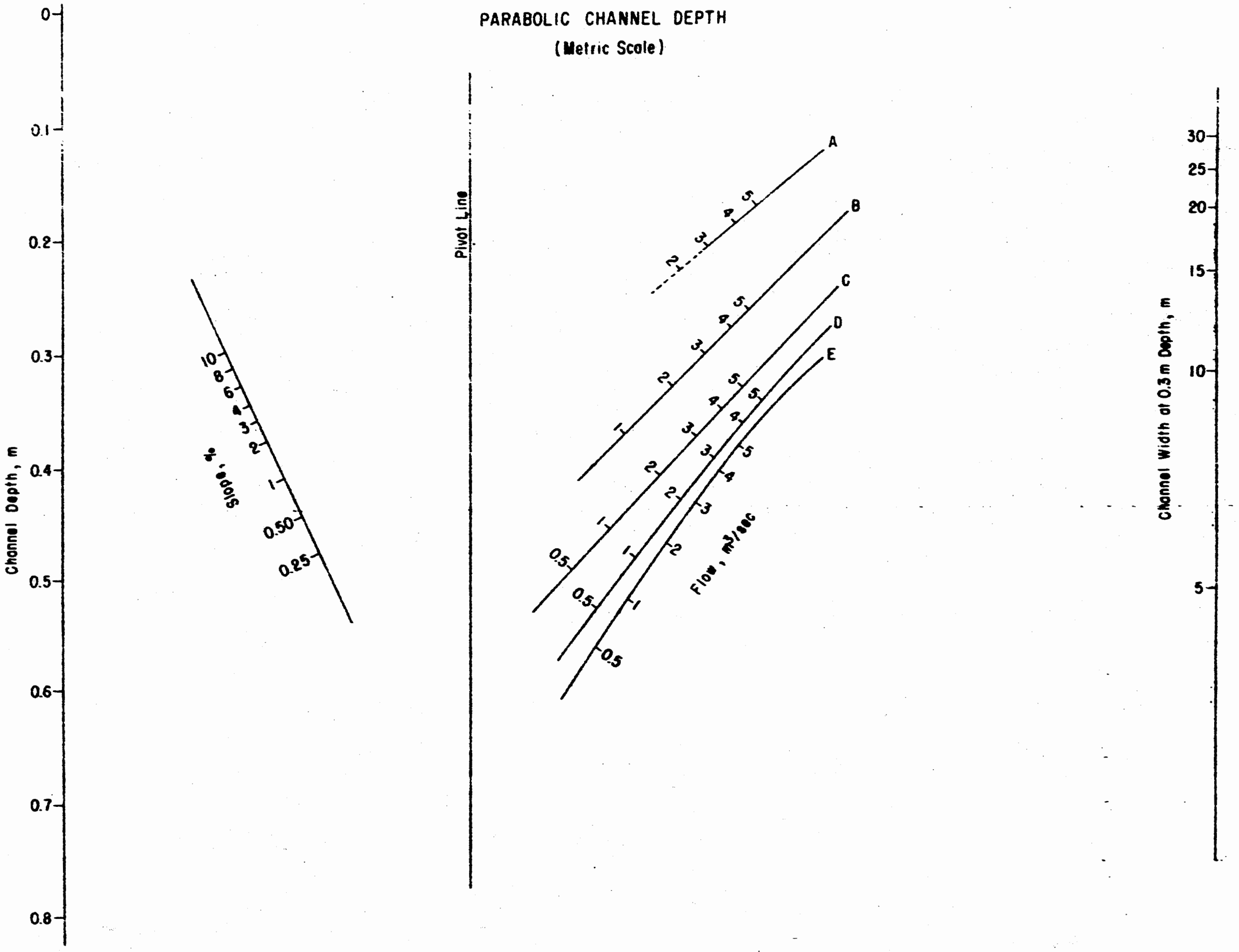


Figure 22. Solution for Parabolic Channel Depth

APPENDIX C

NOMOGRAPHS FOR THE DESIGN OF TRIANGULAR CHANNELS

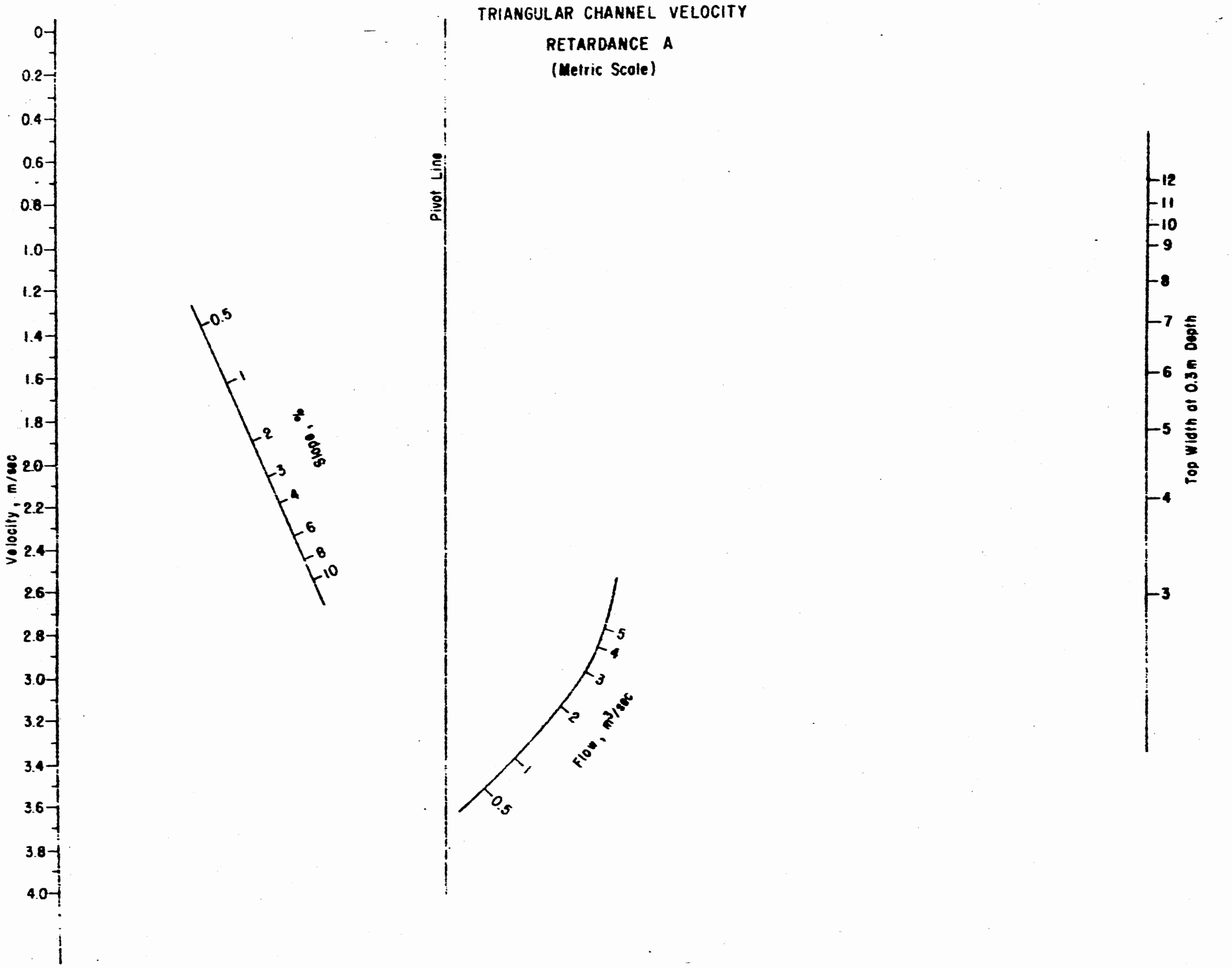


Figure 23. Solution for Triangular Channel Velocity

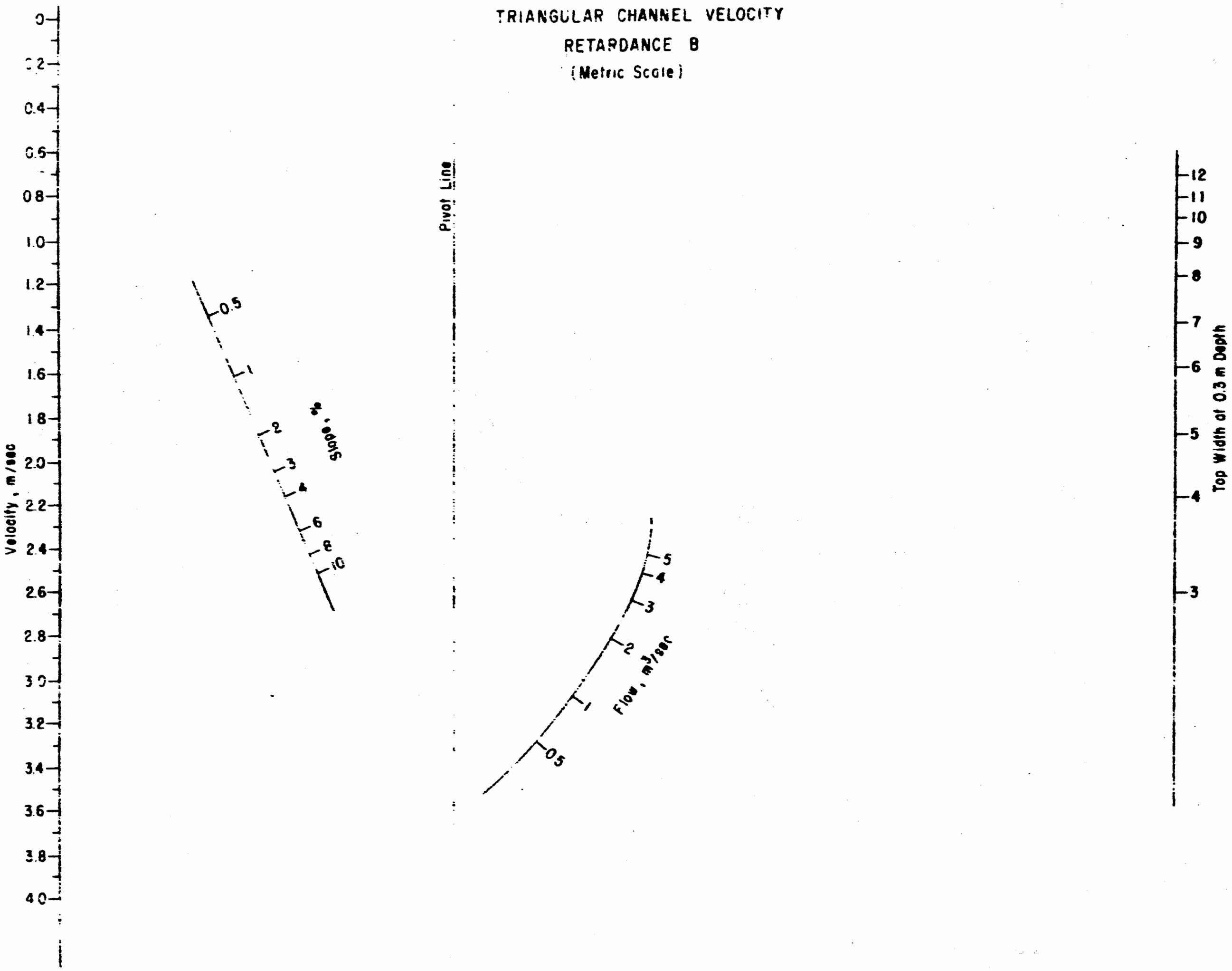


Figure 23 (Continued)

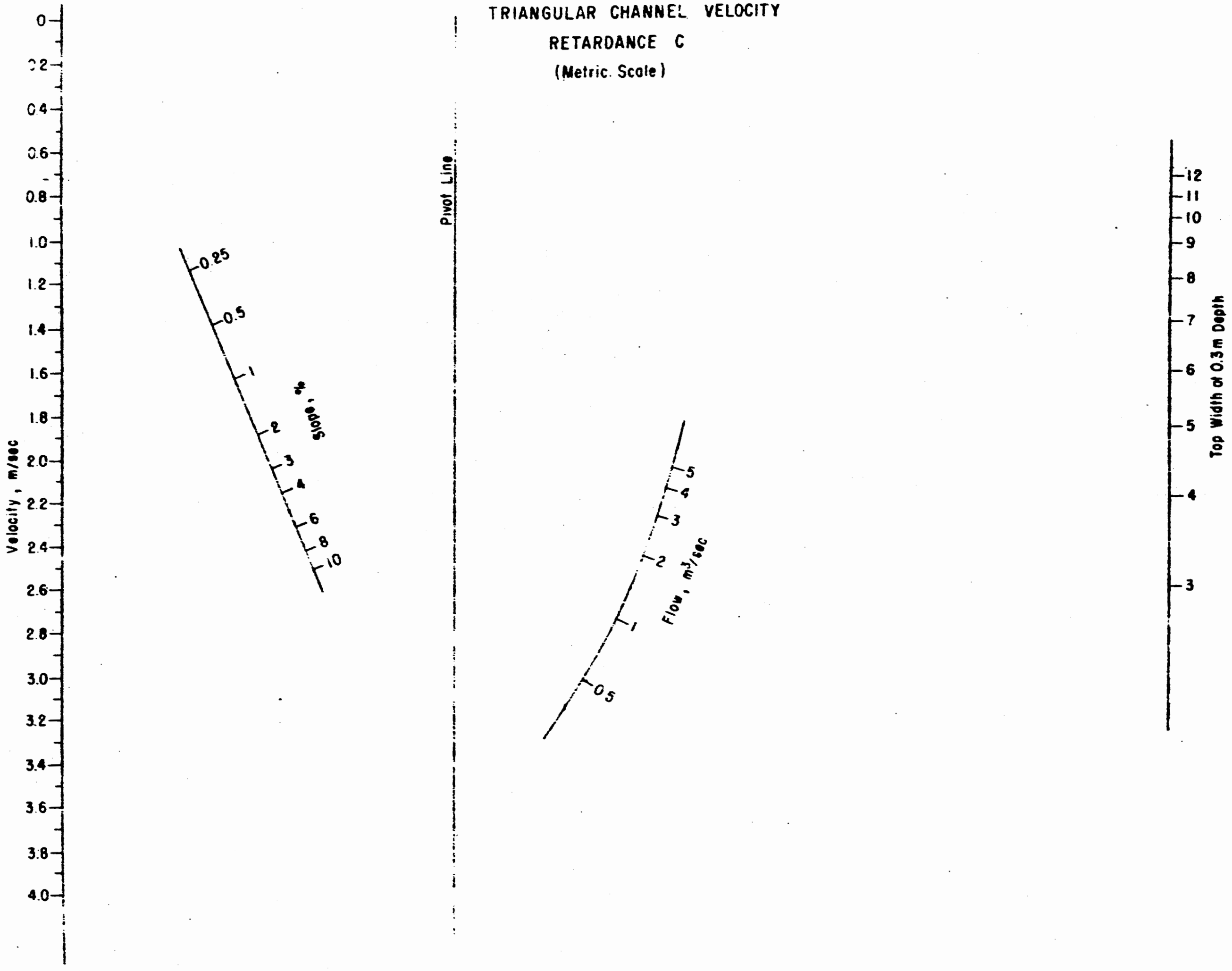


Figure 23 (Continued)

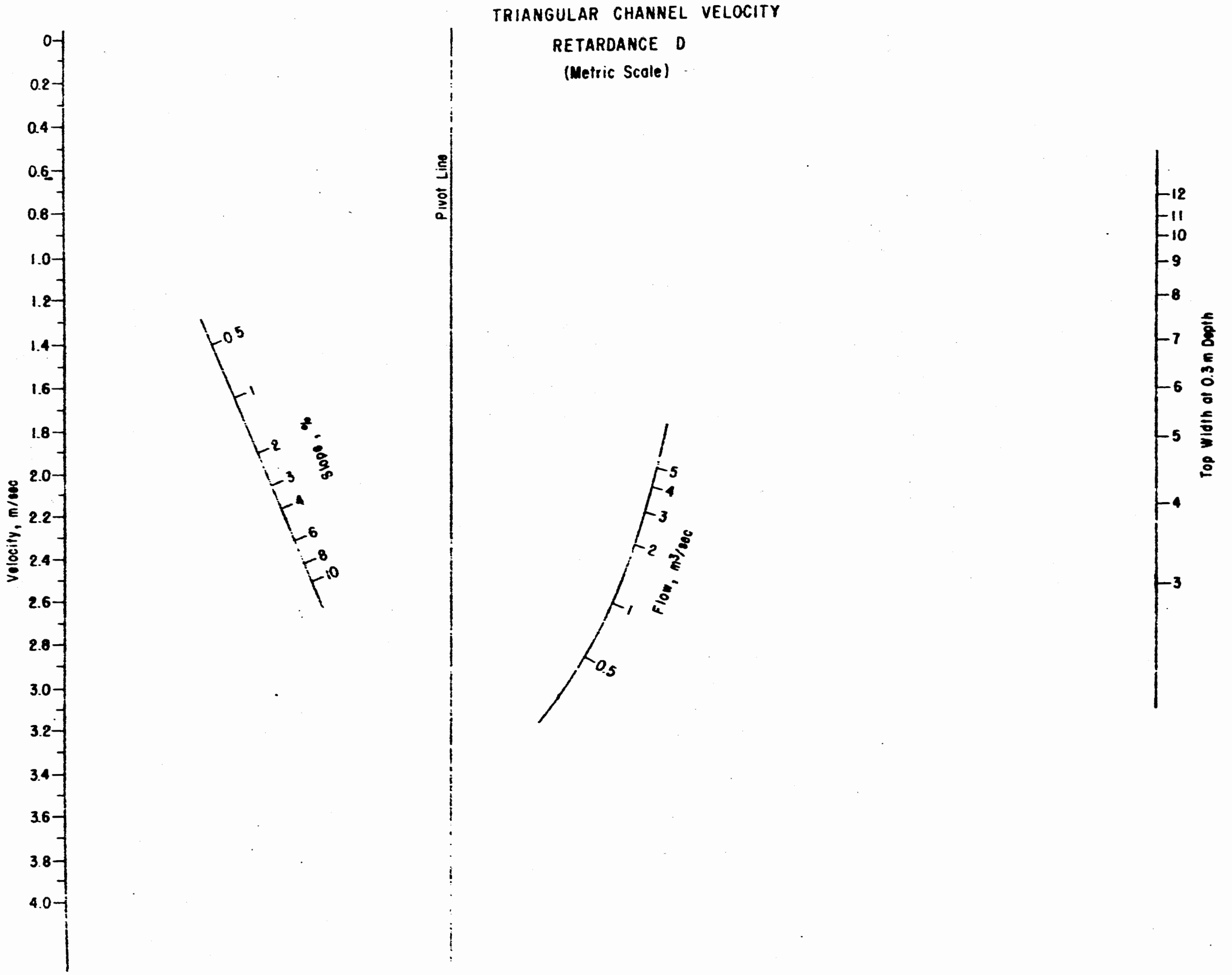
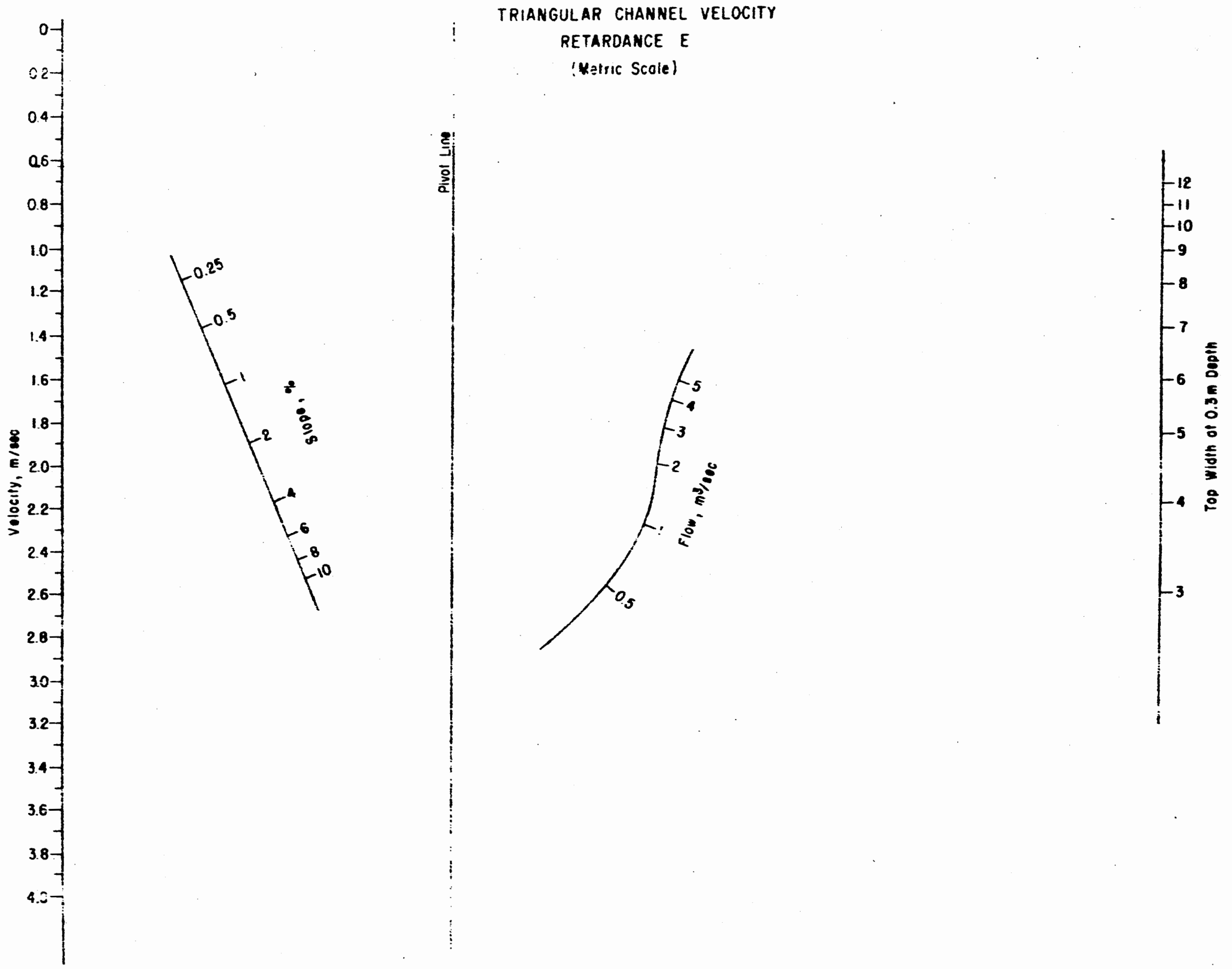


Figure 23 (Continued)



TRIANGULAR CHANNEL VELOCITY
RETARDANCE E
(Metric Scale)

Figure 23 (Continued)

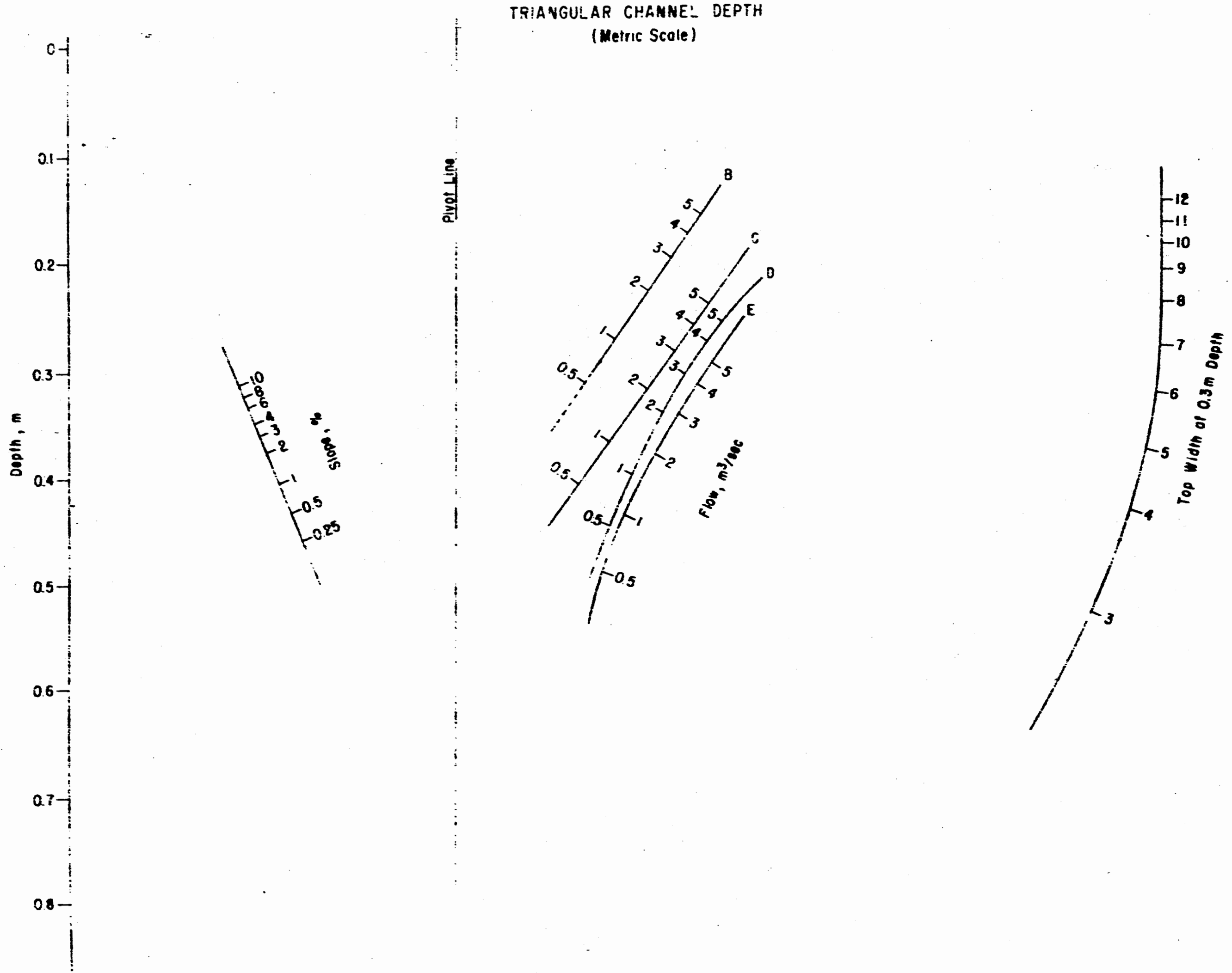


Figure 24. Solution for Triangular Channel Depth

APPENDIX D

NOMOGRAPHS FOR THE DESIGN OF TRAPEZOIDAL CHANNELS

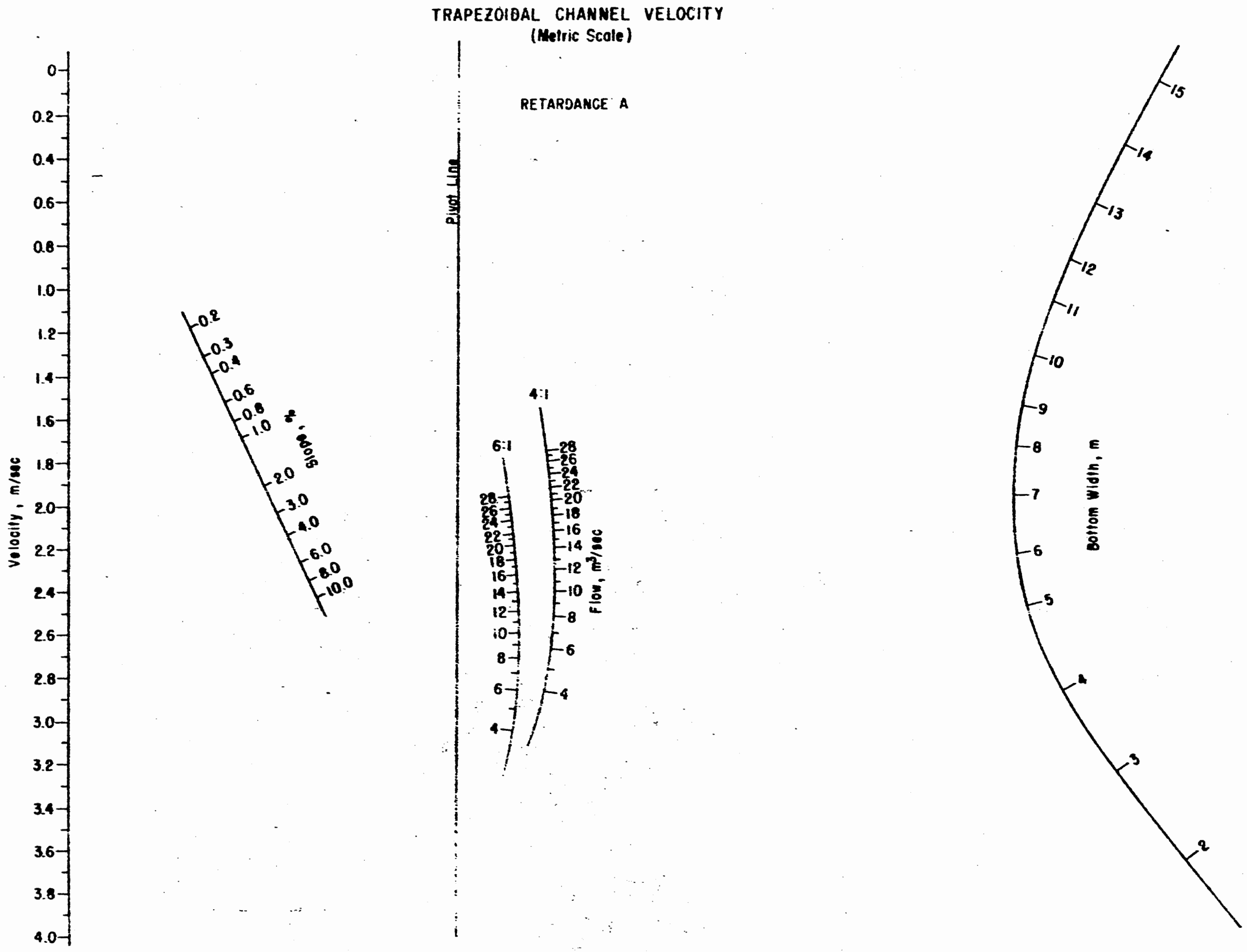


Figure 25. Solution for Trapezoidal Channel Velocity

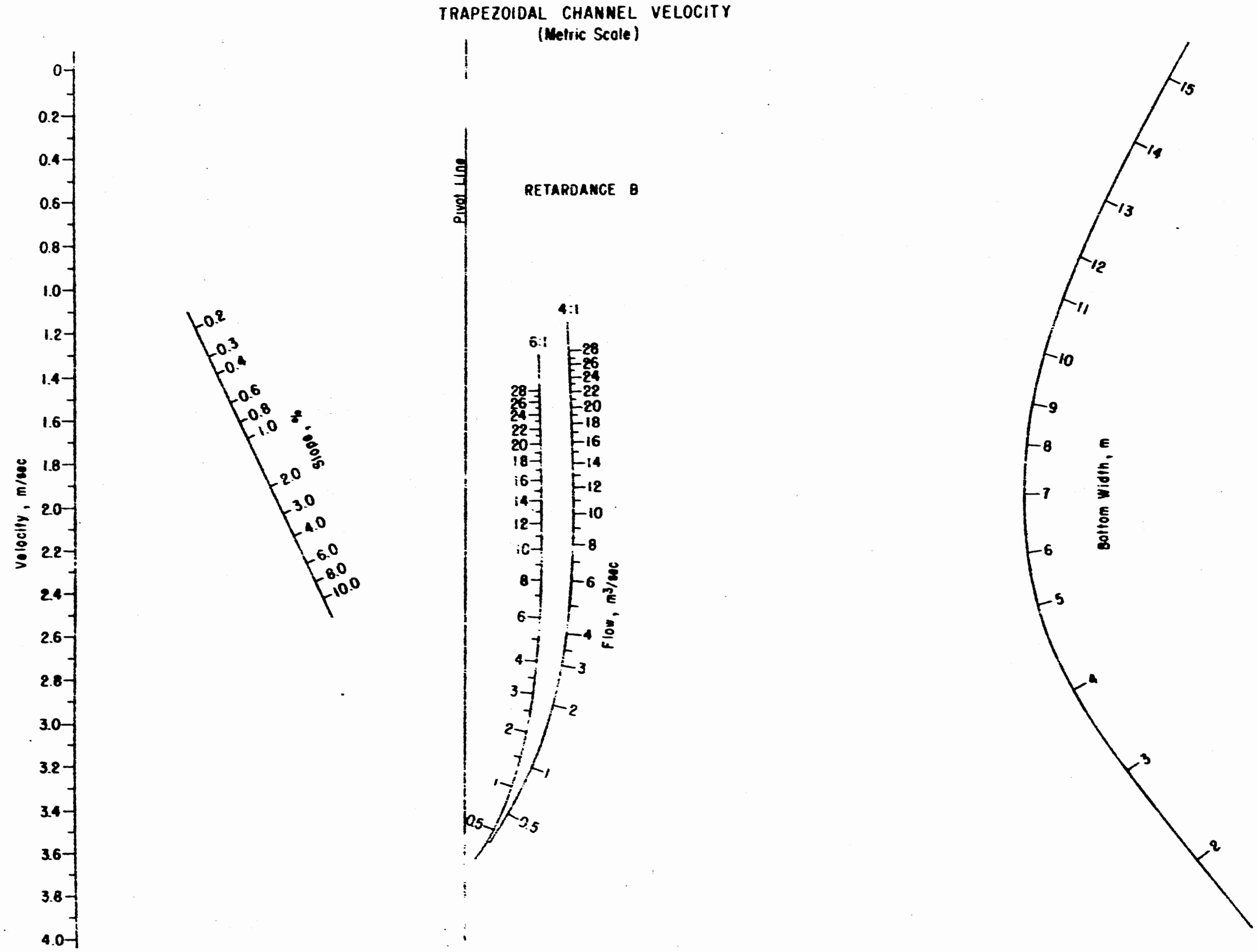


Figure 25 (Continued)

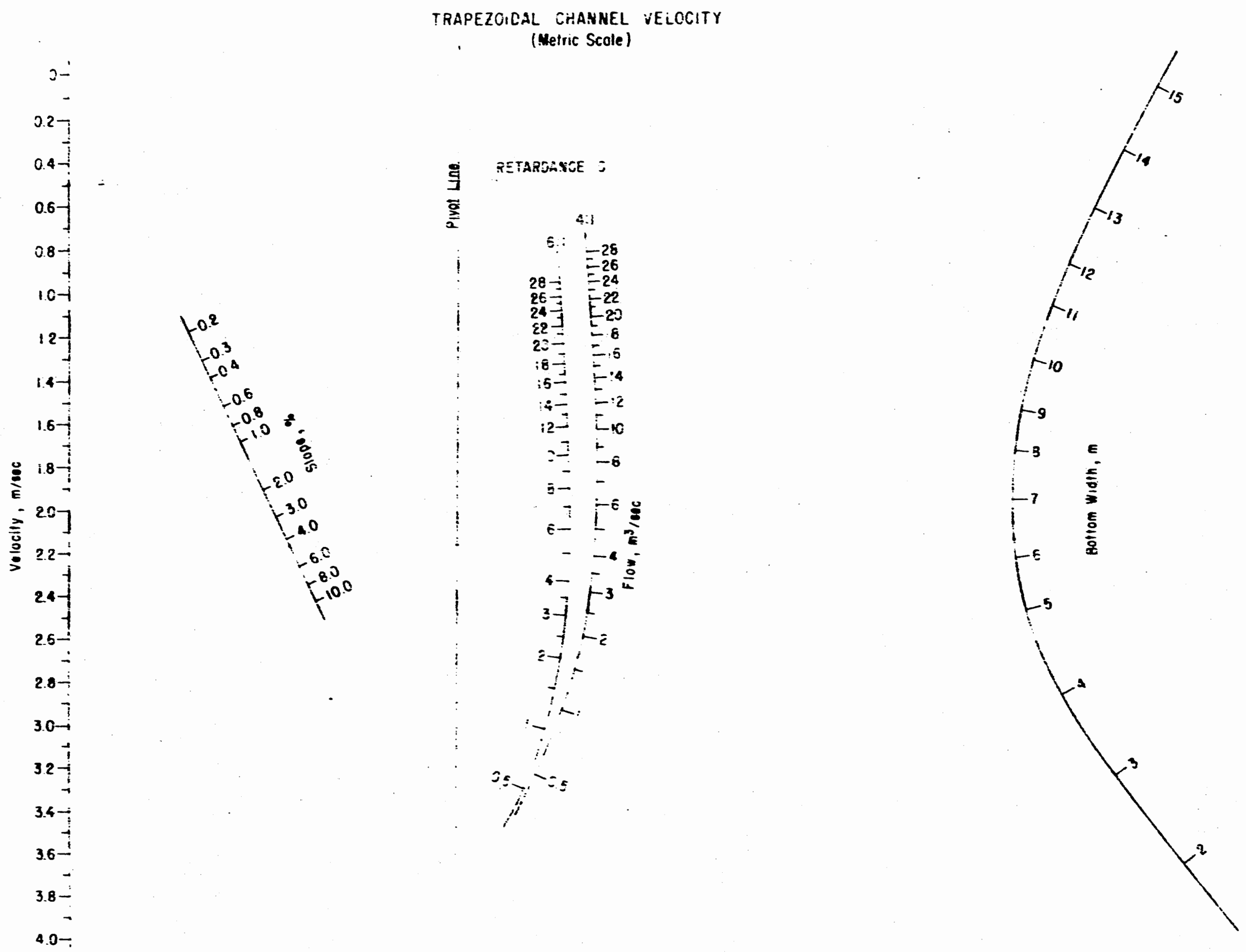


Figure 25 (Continued)

TRAPEZOIDAL CHANNEL VELOCITY
(Metric Scale)

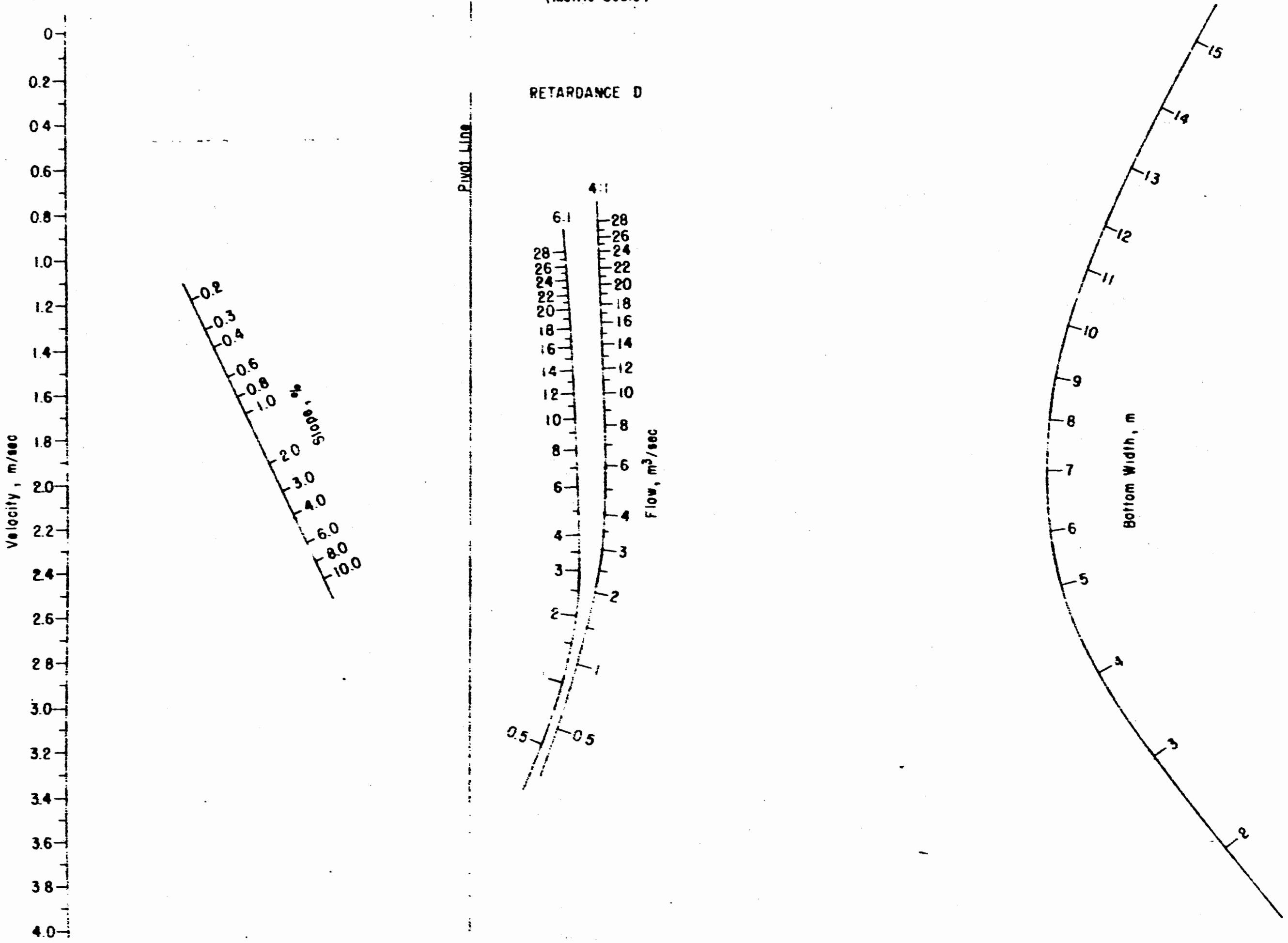


Figure 25 (Continued)

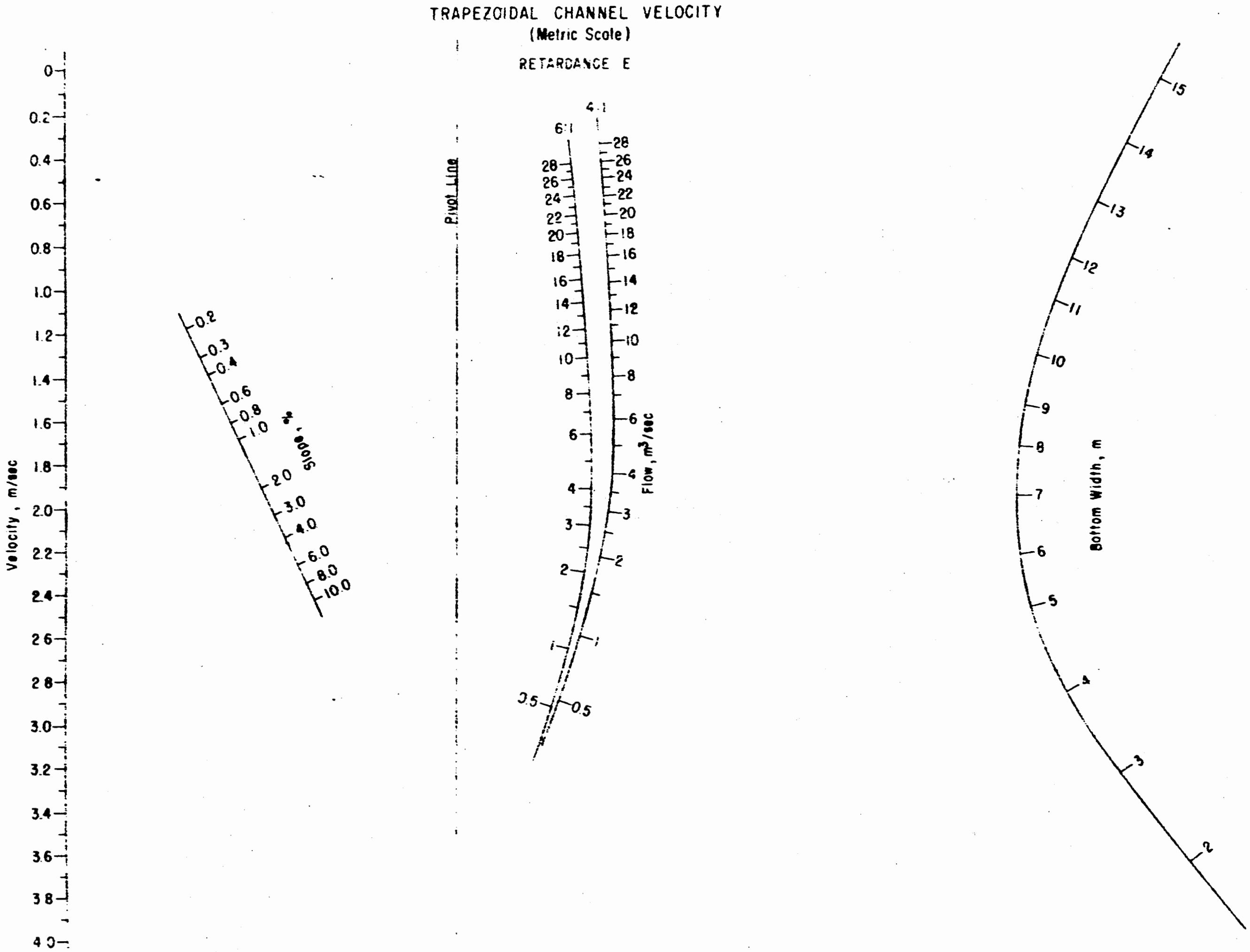


Figure 25 (Continued)

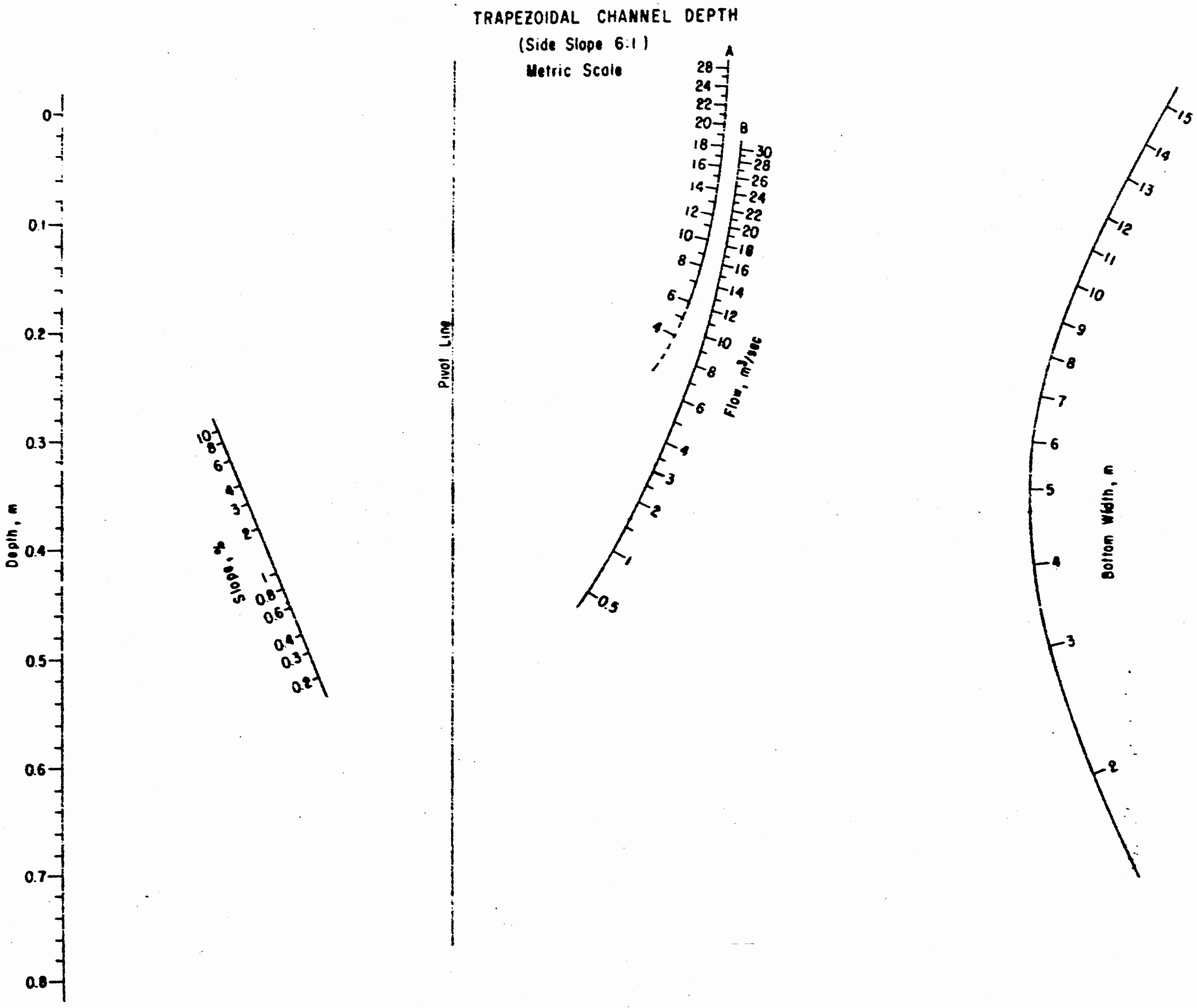


Figure 26. Solution for Trapezoidal Channel Depth (6:1 Side Slope)

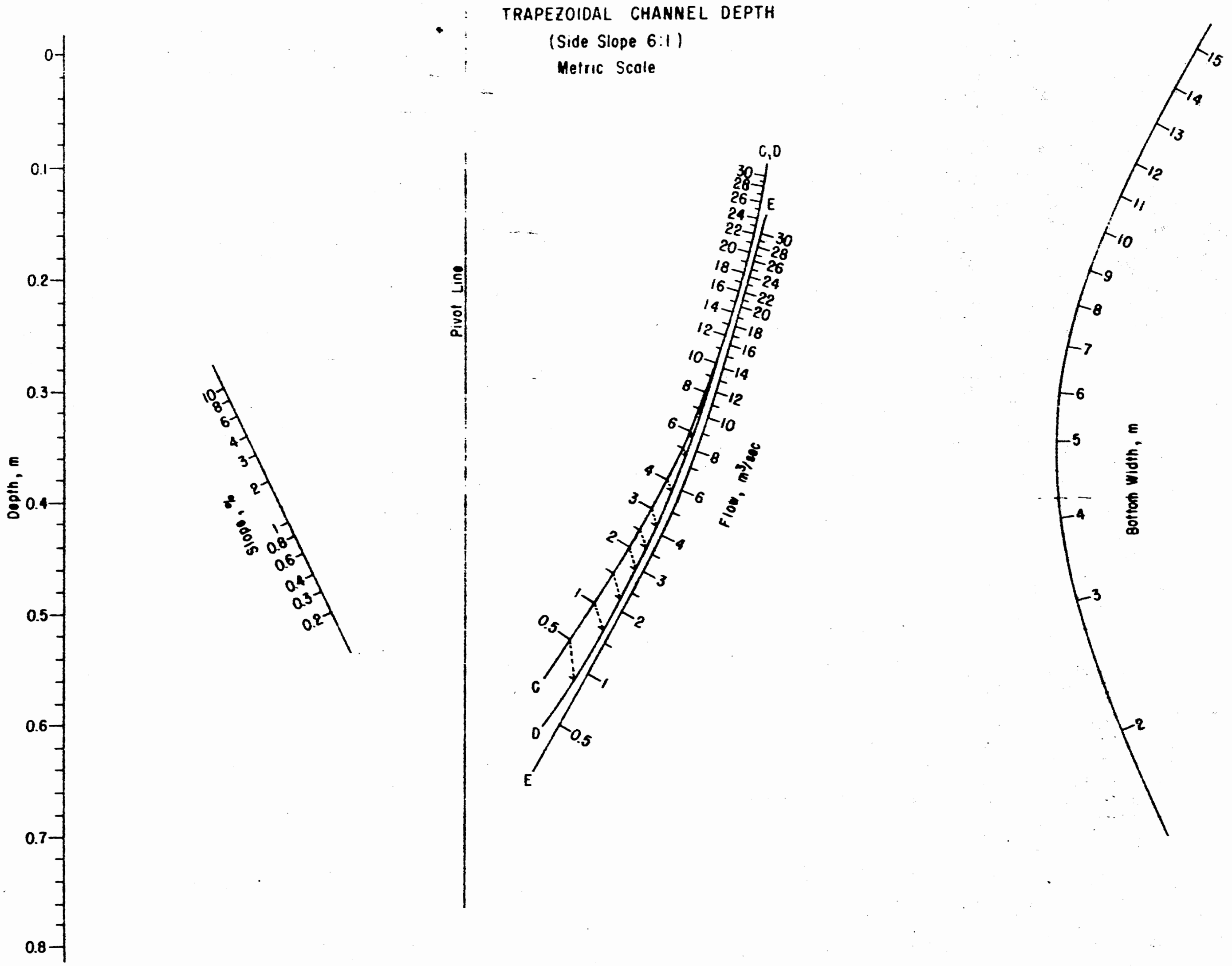


Figure 26 (Continued)

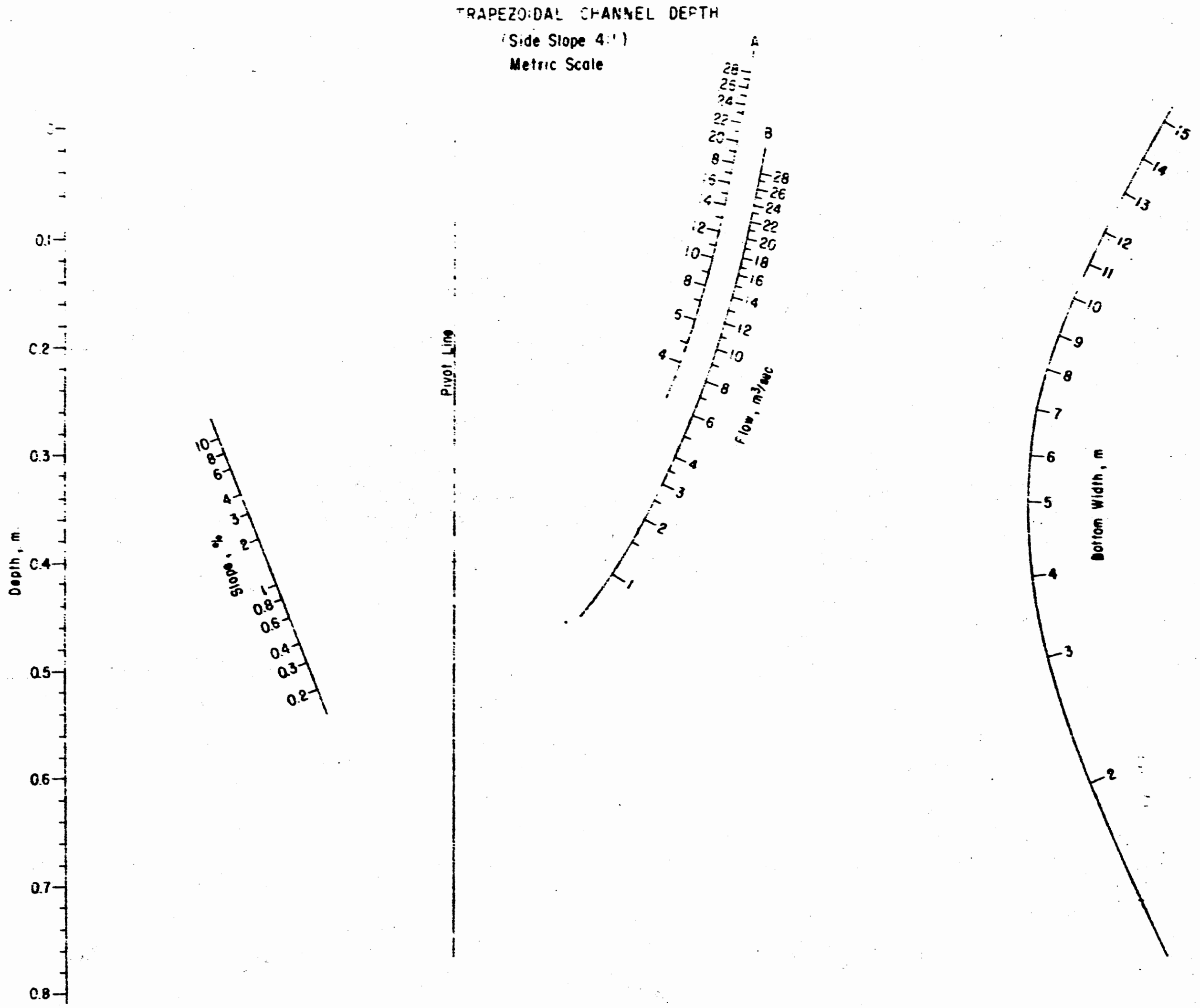


Figure 27. Solution for Trapezoidal Channel Depth (4:1 Side Slope)

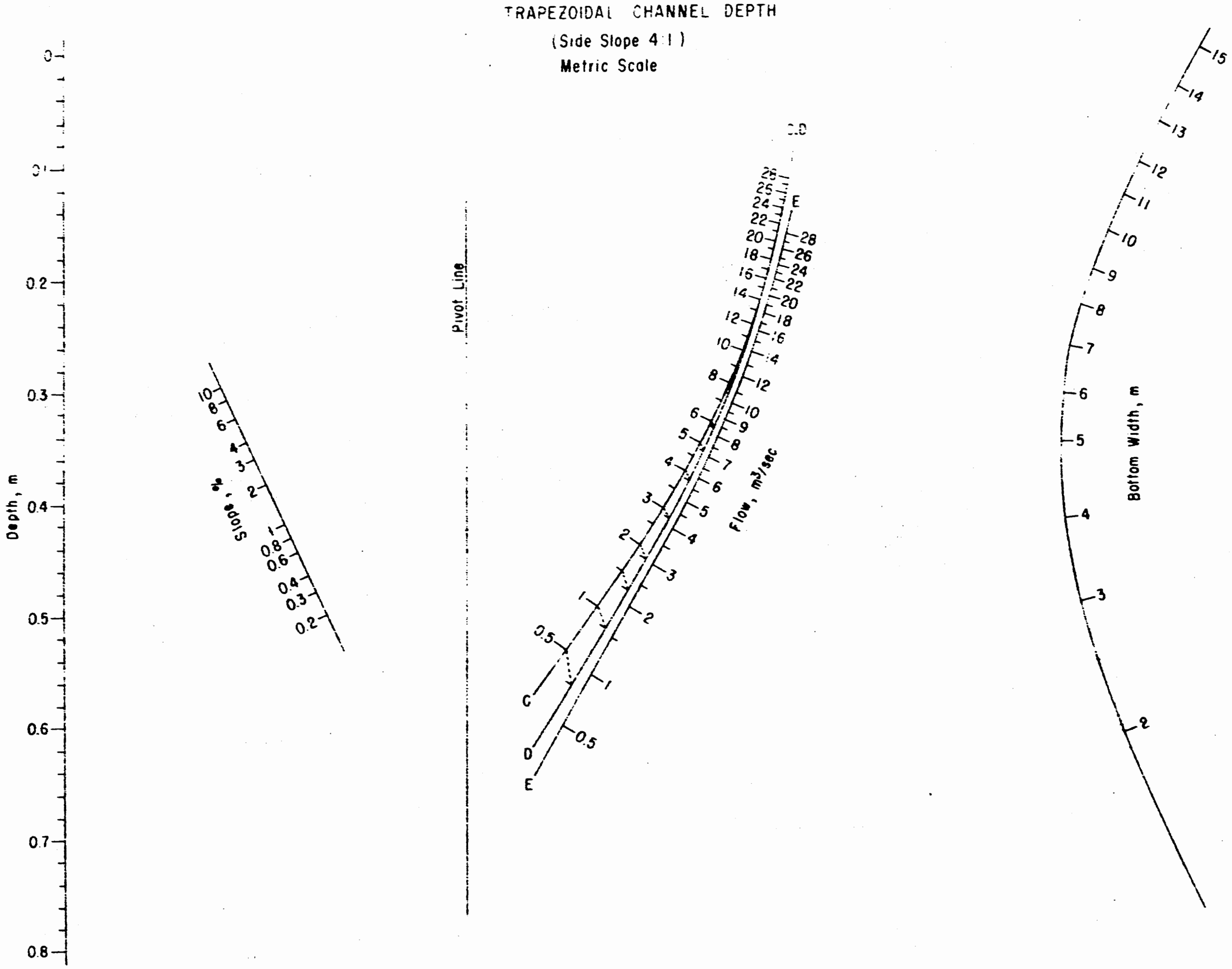


Figure 27 (Continued)

APPENDIX E

PROGRAMS USED TO GENERATE DESIGN DATA

```
C      DATA SIMULATION FOR PARABOLIC CHANNALS
C                                ********************
C      Z = TOP WIDTH AT 0.305M DEPTH (ONE FOOT)
C      DATA INPUT
C      1ST CARD DATA READ IN I2 FORMAT
C         NS=NUMBER OF SLOPES ANALYSED(MAX=16)
C         NQ=NUMBER OF FLOWS ANALYSED(MAX=16)
C         NR=NUMBER OF RETARDANCE CLASSES
C      2ND CARD
C         SLOPE DATA READ IN F5.3 FORMAT
C      3RD CARD
C         FLOW DATA READ IN F5.3 FORMAT
       DIMENSION  S(10),Q(10)
   10  READ (5,1) NS,NQ,NR
       IF (NQ) 400,400,11
   11  READ(5,3)(S(I),I=1,NS)
       READ(5,2) (Q(I),I=1,NQ)
 55    IF(B.GT.50) GO TO 10
       WRITE(6,85)Z
       WRITE(6,80)
       DO 100 I=1,NR
       WRITE(6,90)
       DO 200 J=1,NQ
       DO 300 K=1,NS
       VLAST=6.0
       CNO=0.0
 15    V=VLAST
       A=Q(J)/V
       D=(A/((2./3.)*Z))**(2./3.)
       T=Z*D**0.5
       R=2.0*D/3.0
       VR=V*R
       CALL MAN(VR,I,AN)
C      AN=MANNING N
       V=1.486*(R**(2./3. ))*(S(K)**(0.5))/AN
       DV=V-VLAST
       CNO=CNO+1.0
       IF(CNO.GT.200)GO TO 77
       VLAST=V
       IF(ABS(DV).LE.0.01)GO TO 20
       GO TO 15
 77    WRITE(6,95)V,VLAST,CNO
 20    IF(I.EQ.1)WRITE(5,30)S(K),Q(J),V,D,T,VR,AN,R,A,P
       IF(I.EQ.2)WRITE(6,40)S(K),Q(J),V,D,T,VR,AN,R,A,P
       IF(I.EQ.3)WRITE(6,50)S(K),Q(J),V,D,T,VR,AN,R,A,P
       IF(I.EQ.4)WRITE(6,60)S(K),Q(J),V,D,T,VR,AN,R,A,P
       IF(I.EQ.5)WRITE(6,70)S(K),Q(J),V,D,T,VR,AN,R,A,P
       GO TO 300
 1     FORMAT(3I2 )
 2     FORMAT(16F5.0)
 3     FORMAT(13F5.4)
 30    FORMAT(4X,'A', 7X,F7.4,4X,F7.1,4(5X,F6.2),5X,F7.5 ,3(2X,F7.2))
 40    FORMAT(4X,'B', 7X,F7.4,4X,F7.1,4(5X,F6.2),5X,F7.5 ,3(2X,F7.2))
 50    FORMAT(4X,'C', 7X,F7.4,4X,F7.1,4(5X,F6.2),5X,F7.5 ,3(2X,F7.2))
 60    FORMAT(4X,'D', 7X,F7.4,4X,F7.1,4(5X,F6.2),5X,F7.5 ,3(2X,F7.2))
 70    FORMAT(4X,'E', 7X,F7.4,4X,F7.1,4(5X,F6.2),5X,F7.5 ,3(2X,F7.2))
 80    FORMAT(1X,'RETARDANCE',3X,'SLOPE',4X,'FLOW RATE',3X, 'VELOCITY',
      *4X,'DEPTH',4X,'TOP WIDTH',6X,'VR',5X,'MANNING N')
 85    FORMAT('1'//10X,'Z=',F5.1,24X,'PARABOLIC  CHANNALS (IMP)',/10X,
      *'*********',24X,'*********************',//)
 90    FORMAT(' ')
 95    FORMAT('ABS(DV)GREATER THAN 0.01',2F10.2,F10.1)
 300   CONTINUE
 200   CONTINUE
 100   CONTINUE
       IF(Z.GE.30)Z=Z+10
       IF(Z.LT.30)Z=Z+5
       GO TO 55
 400   STOP
       END
```

```
C     DATA SIMULATION FOR TRIANGULAR CHANNELS
C                           ***************************
C     Z = SIDE SLOPE OF CHANNEL BANK
C     DATA INPUT
C     1ST CARD DATA READ IN I2 FORMAT
C        NS=NUMBER OF SLOPES ANALYSED(MAX=16)
C        NQ=NUMBER OF FLOWS ANALYSED(MAX=16)
C        NR=NUMBER OF RETARDANCE CLASSES
C     2ND CARD
C        SLOPE DATA READ IN F5.3 FORMAT
C     3RD CARD
C        FLOW DATA READ IN F5.3 FORMAT
      DIMENSION  S(10),Q(10)
   10 READ (5,1) NS,NQ,NR
      IF (NQ) 400,400,11
   11 READ(5,3)(S(I),I=1,NS)
      READ(5,2) (Q(I),I=1,NQ)
      Z = 4
   55 IF(Z.GT.25) GO TO 10
      WRITE(6,85)Z
      WRITE(6,80)
      DO 100 I= 1,NR
      WRITE(6,90)
      DO 200 J=1,NQ
      DO 300 K= 1,NS
      VLAST=6.0
      CNO=0.0
   15 V=VLAST
      A=Q(J)/V
      D=(A/Z)**0.5
      T=2*Z*D
      P=2*D*(1+Z**2)**0.5
      R=A/P
      VR=V*R
      CALL MAN(VR,I,AN)
C     AN=MANNING N
      V=1.486*(R**(2./3. ))*(S(K)**(0.5))/AN
      DV=V-VLAST
      CNO=CNO+1.0
      IF(CNO.GT.200)GO TO 77
      VLAST=V
      IF(ABS(DV).LE.0.01)GO TO 20
      GO TO 15
   77 WRITE(6,95)V,VLAST,CNO
   20 IF(I.EQ.1)WRITE(6,30)S(K),Q(J),V,D,T,VR,AN,R,A,P
      IF(I.EQ.2)WRITE(6,40)S(K),Q(J),V,D,T,VR,AN,R,A,P
      IF(I.EQ.3)WRITE(6,50)S(K),Q(J),V,D,T,VR,AN,R,A,P
      IF(I.EQ.4)WRITE(6,60)S(K),Q(J),V,D,T,VR,AN,R,A,P
      IF(I.EQ.5)WRITE(6,70)S(K),Q(J),V,D,T,VR,AN,R,A,P
      GO TO 300
    1 FORMAT(3I2 )
    2 FORMAT(16F5.0)
    3 FORMAT(13F5.4)
   30 FORMAT(4X,'A', 7X,F7.4,4X,F7.1,4(5X,F6.2),5X,F7.5 ,3(2X,F7.2))
   40 FORMAT(4X,'B', 7X,F7.4,4X,F7.1,4(5X,F6.2),5X,F7.5 ,3(2X,F7.2))
   50 FORMAT(4X,'C', 7X,F7.4,4X,F7.1,4(5X,F6.2),5X,F7.5 ,3(2X,F7.2))
   60 FORMAT(4X,'D', 7X,F7.4,4X,F7.1,4(5X,F6.2),5X,F7.5 ,3(2X,F7.2))
   70 FORMAT(4X,'E', 7X,F7.4,4X,F7.1,4(5X,F6.2),5X,F7.5 ,3(2X,F7.2))
   80 FORMAT(1X,'RETARDANCE',3X,'SLOPE',4X,'FLOW RATE',3X, 'VELOCITY',
     *4X,'DEPTH',4X,'TOP WIDTH',5X,'VR',5X,'MANNING N')
   85 FORMAT('1'//10X,'Z=',F5.1,24X,'TRIANGULAR CHANNALS (IMP)',/10X,
     *'*******',24X,'*************************',//)
   90 FORMAT(' ')
   95 FORMAT('ABS(DV)GREATER THAN 0.01',2F10.2,F10.1)
  300 CONTINUE
  200 CONTINUE
  100 CONTINUE
      IF(Z-6) 101,102,112
  101 Z=Z+1
      GO TO 55
  102 Z=Z+2
      GO TO 55
  105 Z=Z+2.5
      GO TO 55
  112 IF(Z-10) 102,105,105
  400 STOP
      END
```

```
C       DATA SIMULATION FOR TRAPEZOID CHANNELS
C                               *********************
C       B = BOTTOM WIDTH OF CHANNEL
C       Z = SIDE SLOPE OF CHANNEL BANK
C       DATA INPUT
C       1ST CARD DATA READ IN I2 FORMAT
C          NS=NUMBER OF SLOPES ANALYSED(MAX=16)
C          NQ=NUMBER OF FLOWS ANALYSED(MAX=16)
C          NR=NUMBER OF RETARDANCE CLASSES
C       2ND CARD
C          SLOPE DATA READ IN F5.3 FORMAT
C       3RD CARD
C          FLOW DATA READ IN F5.3 FORMAT
C       4TH CARD
C       BOTTOM WIDTH DATA READ IN I2 FORMAT
        DIMENSION  S(10),Q(10)
   10   READ (5,1) NS,NQ,NR
        IF (NQ) 400,400,11
   11   READ(5,3)(S(I),I=1,NS)
        READ(5,2) (Q(I),I=1,NQ)
        READ(5,4)Z
        B = 10
   55   IF(B.GT.50) GO TO 10
        WRITE(6,85)Z,B
        WRITE(6,80)
        DO 100 I=1,NR
        WRITE(6,90)
        DO 200 J=1,NQ
        DO 300 K=1,NS
        VLAST=6.0
        CNO=0.0
15      V=VLAST
        A=Q(J)/V
        D=(-B+(B**2+4*A*Z)**0.5)/(2*Z)
        P=B+2*D*(1+Z**2)**0.5
        T=B+2*Z*D
        R=A/P
        VR=V*R
        CALL MAN(VR,I,AN)
C       AN=MANNING N
        V=1.486*(R**(2./3.  ))*(S(K)**(0.5))/AN
        DV=V-VLAST
        CNO=CNO+1.0
        IF(CNO.GT.200)GO TO 77
        VLAST=V
        IF(ABS(DV).LE.0.01)GO TO 20
        GO TO 15
77      WRITE(6,95)V,VLAST,CNO
20      IF(I.EQ.1)WRITE(6,30)S(K),Q(J),V,D,T,VR,AN,R,A,P
        IF(I.EQ.2)WRITE(6,40)S(K),Q(J),V,D,T,VR,AN,R,A,P
        IF(I.EQ.3)WRITE(6,50)S(K),Q(J),V,D,T,VR,AN,R,A,P
        IF(I.EQ.4)WRITE(6,60)S(K),Q(J),V,D,T,VR,AN,R,A,P
        IF(I.EQ.5)WRITE(6,70)S(K),Q(J),V,D,T,VR,AN,R,A,P
        GO TO 300
1       FORMAT(3I2  )
2       FORMAT(16F5.0)
3       FORMAT(13F5.4)
4       FORMAT(F5.1)
30      FORMAT(4X,'A',  7X,F7.4,4X,F7.1,4(5X,F6.2),5X,F7.5 ,3(2X,F7.2))
40      FORMAT(4X,'B',  7X,F7.4,4X,F7.1,4(5X,F6.2),5X,F7.5 ,3(2X,F7.2))
50      FORMAT(4X,'C',  7X,F7.4,4X,F7.1,4(5X,F6.2),5X,F7.5 ,3(2X,F7.2))
60      FORMAT(4X,'D',  7X,F7.4,4X,F7.1,4(5X,F6.2),5X,F7.5 ,3(2X,F7.2))
70      FORMAT(4X,'E',  7X,F7.4,4X,F7.1,4(5X,F6.2),5X,F7.5 ,3(2X,F7.2))
80      FORMAT(1X,'RETARDANCE',3X,'SLOPE',4X,'FLOW RATE',3X, 'VELOCITY',
      *4X,'DEPTH',4X,'TOP WIDTH',5X,'VR',5X,'MANNING N')
85         FORMAT('1'/10X,'Z=',F5.1,3X,'B=',F5.1,14X,
      *'TRAPEZOID  CHANNELS (IMP)',/10X
      *'********',3X,'********',14X,'****************************',//)
90      FORMAT('  ')
95      FORMAT(' ABS(DV)GREATER THAN 0.01',2F10.2,F10.1)
300     CONTINUE
200     CONTINUE
100     CONTINUE
        B=B+10
        GO TO 55
400     STOP
        END
```

```
      SUBROUTINE MAN(VR,I,AN)
      GO TO (10,20,30,40,50),I
10    IF(VR.GT.1.67)GO TO 15
      AN=0.44-0.15*VR
      GO TO 70
15    AN=0.046+0.24/VR
      GO TO 70
20    IF(VR.GE.2.0)GO TO 27
      IF(VR.LT.2.0.AND.VR.GT.0.5)GO TO 25
      AN=0.403-0.31*VR
      GO TO 70
25    AN=0.046+0.103/VR
      GO TO 70
27    AN=0.0354+0.124/VR
      GO TO 70
30    IF(VR.GT.1.0)GO TO 35
      AN=0.034+0.049/VR
      GO TO 70
35    AN=0.028+0.055/VR
      GO TO 70
40    IF(VR.GT.1.125)GO TO 45
      AN=0.038+0.021/VR
      GO TO 70
45    AN=0.030+0.030/VR
      GO TO 70
50    IF(VR.GT.1.23 )GO TO 55
      AN=0.029+0.008/VR
      GO TO 70
55    AN=0.0225+0.016/VR
70    RETURN
      END
```

APPENDIX F

DATA USED IN STATISTICAL ANALYSIS

ANALYSIS FOR PARABOLIC CHANNELS

CBS	SHAPE	RET,	SLOPE	FLOW	VCAL	VNCM	V_DIFF	DCAL	DNOM	D_DIFF
1	10	A	2.0	100	.	.	.	0.792683	0.792683	0.000000
2	10	A	2.0	200	.	.	.	0.984756	0.984756	0.000000
3	10	B	0.5	25	.	.	.	0.637195	0.615854	0.021341
4	10	B	0.5	50	.	.	.	0.746951	0.740854	0.006098
5	10	B	8.0	25	.	.	.	0.304878	0.307927	-0.003049
6	10	B	8.0	50	.	.	.	0.362805	0.371951	-0.009146
7	10	B	8.0	100	.	.	.	0.451220	0.454268	-0.003049
8	10	B	8.0	200	.	.	.	0.579268	0.582317	-0.003049
9	10	C	0.5	25	0.59146	0.57927	0.01220	0.472561	0.466463	0.006098
10	10	C	0.5	50	0.86890	0.86890	0.00000	0.579268	0.579268	0.000000
11	10	C	0.5	100	1.20732	1.21951	-0.01220	0.740854	0.743902	-0.003049
12	10	C	0.5	200	1.60976	1.63110	-0.02134	.	.	.
13	10	C	2.0	25	1.01524	0.99085	0.02439	0.329268	0.329268	0.000000
14	10	C	2.0	50	1.46341	1.46341	0.00000	0.411585	0.411585	0.000000
15	10	C	2.0	100	2.00305	2.05793	-0.05488	0.527439	0.527439	0.000000
16	10	C	8.0	25	1.72561	1.66159	0.06402	0.231707	0.231707	0.000000
17	10	C	8.0	50	2.44817	2.44817	0.00000	0.292683	0.289634	0.003049
18	10	C	8.0	100	3.30793	3.35939	-0.09146	0.378049	0.381098	-0.003049
19	10	C	8.0	200	.	.	.	0.503049	0.506098	-0.003049
20	10	D	0.5	25	0.69207	0.68598	0.00610	0.426829	0.426829	0.000000
21	10	D	0.5	50	0.94817	0.94512	0.00305	0.545732	0.554878	-0.009146
22	10	D	0.5	100	1.25305	1.26524	-0.01220	0.722561	0.728659	-0.006098
23	10	D	2.0	25	1.15854	1.14329	0.01524	0.301829	0.304878	-0.003049
24	10	D	2.0	50	1.57012	1.56098	0.00915	0.393293	0.393293	0.000000
25	10	D	2.0	100	2.05793	2.08841	-0.03049	0.518293	0.521341	-0.003049
26	10	D	8.0	25	1.93293	1.90549	0.02744	0.216463	0.210366	0.006098
27	10	D	8.0	50	2.58841	2.59146	-0.00305	0.280488	0.274390	0.006098
28	10	D	8.0	100	3.36585	3.47561	-0.10976	0.375000	0.365854	0.009146
29	10	D	8.0	200	.	.	.	0.506098	0.496951	0.009146
30	10	E	0.5	25	0.91768	0.88415	0.03354	0.353659	0.365854	-0.012195
31	10	E	0.5	50	1.21951	1.20427	0.01524	0.463415	0.466463	-0.003049
32	10	F	0.5	100	1.58232	1.60061	-0.01829	0.618902	0.621951	-0.003049
33	10	F	0.5	200	2.01220	2.04268	-0.03049	0.838415	0.856707	-0.018293
34	10	F	2.0	25	1.52134	1.46341	0.05793	0.253049	0.256098	-0.003049
35	10	F	2.0	50	2.00610	1.98780	0.01829	0.332317	0.335366	-0.003049
36	10	E	2.0	100	2.57927	2.63720	-0.05793	0.445122	0.445122	0.000000
37	10	E	2.0	200	3.26829	3.35366	-0.08537	0.606707	0.609756	-0.003049
38	10	E	8.0	25	2.51220	2.43902	0.07317	0.179878	0.179878	0.000000
39	10	E	8.0	50	3.28659	3.24695	0.03963	0.240854	0.231707	0.009146
40	10	F	8.0	50	3.28659	3.24695	0.03963	0.240854	0.231707	0.009146
41	10	F	8.0	100	.	.	.	0.323171	0.314024	0.009146
42	10	F	8.0	200	.	.	.	0.439024	0.432927	0.006098
43	20	A	0.5	25	0.14024	0.09146	0.04878	.	.	.
44	20	A	0.5	50	0.22561	0.22866	-0.00305	.	.	.
45	20	A	0.5	100	0.40244	0.39634	0.00610	.	.	.
46	20	A	0.5	200	0.63720	0.62500	0.01220	.	.	.
47	20	A	2.0	25	0.24085	0.24390	-0.00305	.	.	.
48	20	A	2.0	50	0.42378	0.42683	-0.00305	.	.	.
49	20	A	2.0	100	.	.	.	0.667683	0.667683	0.000000
50	20	A	2.0	100	0.70427	0.70122	0.00305	0.792683	0.792683	0.000000
51	20	A	2.0	200	.	.	.	0.792683	0.798780	-0.006098
52	20	A	2.0	200	1.09146	1.09756	-0.00610	0.792683	0.798780	-0.006098
53	20	A	8.0	25	0.42988	0.45732	-0.02744	.	.	.
54	20	A	8.0	50	0.75305	0.76220	-0.00915	.	.	.
55	20	A	8.0	100	1.22561	1.21951	0.00610	0.460366	0.478659	-0.018293
56	20	A	8.0	200	1.85976	1.85976	0.00000	0.554878	0.570122	-0.015244
57	20	B	0.5	25	0.23171	0.19817	0.033537	0.554878	0.536585	0.018293
58	20	B	0.5	50	0.22561	0.22866	-0.003049	0.637195	0.625000	0.012195
59	20	B	0.5	100	0.59756	0.57927	0.018293	0.746951	0.740854	0.006098
60	20	B	0.5	200	0.89024	0.85366	0.036585	.	.	.
61	20	B	2.0	25	0.38110	0.38110	0.000000	0.378049	0.378049	0.000000
62	20	B	2.0	50	0.64939	0.63110	0.018293	0.518293	0.521341	-0.003049
63	20	B	2.0	100	1.02744	0.99695	0.030488	0.640244	0.640244	0.000000
64	20	B	2.0	200	1.51524	1.49390	0.021341	0.820122	0.807927	0.012195
65	20	B	8.0	25	0.68293	0.67073	0.012195	0.259146	0.268293	-0.009146
66	20	B	8.0	50	1.13720	1.09756	0.039634	0.304878	0.310976	-0.006098
67	20	B	8.0	100	1.76220	1.70732	0.054878	0.362805	0.371951	-0.009146
68	20	B	8.0	200	2.54878	2.51524	0.033537	0.451220	0.454268	-0.003049
69	20	C	0.5	25	0.37500	0.38110	-0.006098	0.402439	0.393293	0.009146
70	20	C	0.5	50	0.59146	0.60976	-0.018293	0.472561	0.475610	-0.003049
71	20	C	0.5	100	0.86890	0.86890	0.000000	0.579268	0.585366	-0.006098
72	20	C	0.5	200	1.20732	1.20427	0.003049	0.740854	0.756098	-0.015244
73	20	C	2.0	25	0.65549	0.65549	0.000000	0.277439	0.277439	0.000000
74	20	C	2.0	50	1.01524	1.02134	-0.006098	0.329268	0.332317	-0.003049
75	20	C	2.0	100	1.46341	1.46341	0.000000	0.411585	0.411585	0.000000
76	20	C	8.0	25	1.14329	1.14329	0.000000	0.192073	0.192073	0.000000
77	20	C	8.0	50	1.72561	1.71646	0.009146	0.231707	0.234756	-0.003049
78	20	C	8.0	100	2.44817	2.45427	-0.006098	0.292683	0.289634	0.003049
79	20	C	8.0	200	3.30793	3.33841	-0.030488	0.378049	0.384146	-0.006098
80	20	D	0.5	25	0.47866	0.48780	-0.009146	0.344512	0.338415	0.006098

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                                     ANALYSIS FOR PARABOLIC CHANNELS

OBS   SHAPE   RFT   SLOPE   FLOW    VCAL      VNCM      V_DIFF       DCAL       DNOM       D_DIFF

 81    20      D     0.5     50    0.69207   0.70122   -0.009146   0.426829   0.426829    0.000000
 82    20      D     2.0     25    0.81402   0.82317   -0.009146   0.240854   0.240854    0.000000
 83    20      D     2.0     50    1.15854   1.14329    0.015244   0.301829   0.304878   -0.003049
 84    20      D     2.0    100    1.57012   1.55488    0.015244   0.393293   0.393293    0.000000
 85    20      D     8.0     25    1.38110   1.37195    0.009146   0.170732   0.164634    0.006098
 86    20      D     8.0     50    1.93293   1.92073    0.012195   0.216463   0.210366    0.006098
 87    20      D     8.0    100    2.58841   2.43902    0.149390   0.280488   0.274390    0.006098
 88    20      D     8.0    100    2.58841   2.62195   -0.033537   0.280488   0.274390    0.006098
 89    20      D     8.0    200    3.36585   3.42988   -0.064024   0.375000   0.368902    0.006098
 90    20      E     0.5     25    0.66159   0.67073   -0.009146   0.277439   0.277439    0.000000
 91    20      E     0.5     50    0.91768   0.91463    0.003049   0.353659   0.353659    0.000000
 92    20      E     0.5    100    1.21951   1.21951    0.000000   0.463415   0.469512   -0.006098
 93    20      E     0.5    200    1.58232   1.58537   -0.003049   0.618902   0.631098   -0.012195
 94    20      E     2.0     25    1.10976   1.10366    0.006098   0.195122   0.195122    0.000000
 95    20      E     2.0     50    1.52134   1.49390    0.027439   0.253049   0.253049    0.000000
 96    20      E     2.0    100    2.00610   2.01829   -0.012195   0.332317   0.332317    0.000000
 97    20      E     2.0    200    2.57927   2.60671   -0.027439   0.445122   0.448171   -0.003049
 98    20      E     8.0     25    1.85976   1.82927    0.030488   0.140244   0.134146    0.006098
 99    20      E     8.0     50    2.51220   2.48476    0.027439   0.179878   0.173780    0.006098
100    20      E     8.0    100    3.28659   3.30793   -0.021341   0.240854   0.228659    0.012195
101    20      E     8.0    200     .         .          .         0.323171   0.317073    0.006098
102    30      A     2.0    100     .         .          .         0.618902   0.615854    0.003049
103    30      A     2.0    200     .         .          .         0.713415   0.716463   -0.003049
104    40      A     0.5     25    0.10366   0.07622    0.027439    .          .           .
105    40      A     0.5     50    0.14024   0.13720    0.003049    .          .           .
106    40      A     0.5    100    0.22561   0.24390   -0.018293    .          .           .
107    40      A     0.5    200    0.40244   0.41159   -0.009146    .          .           .
108    40      A     2.0     25    0.17073   0.18293   -0.012195    .          .           .
109    40      A     2.0     50    0.32012   0.27439    0.045732    .          .           .
110    40      A     2.0    100     .         .          .         0.591463   0.585366    0.006098
111    40      A     2.0    100    0.42378   0.45732   -0.033537   0.591463   0.585366    0.006098
112    40      A     2.0    200     .         .          .         0.667683   0.676829   -0.009146
113    40      A     2.0    200    0.70427   0.71646   -0.01220    0.667683   0.676829   -0.009146
114    40      A     8.0     25    0.28354   0.33537   -0.05183     .          .           .
115    40      A     8.0     50    0.42988   0.53354   -0.10366     .          .           .
116    40      A     8.0    100    0.73171   0.82317   -0.09146    0.402439   0.417683   -0.015244
117    40      A     8.0    200    1.22561   1.25000   -0.02439    0.460366   0.481707   -0.021341
118    40      B     0.5     25    0.13415   0.10671    0.02744    0.496951   0.481707    0.015244
119    40      B     0.5     25    0.22866   0.22866    0.00000    0.353659   0.341463    0.012195
120    40      B     0.5     50    0.14024   0.13720    0.00305    0.554878   0.542683    0.012195
121    40      B     0.5    100    0.37805   0.38110   -0.00305    0.637195   0.621951    0.015244
122    40      B     0.5    200    0.40244   0.41159   -0.00915    0.746951   0.740854    0.006098
123    40      B     2.0     25    0.23476   0.22866    0.00610    0.341463   0.338415    0.003049
124    40      B     2.0     50    0.38110   0.39634   -0.01524    0.378049   0.378049    0.000000
125    40      B     2.0    100    0.64939   0.65549   -0.00610    0.439024   0.432927    0.006098
126    40      B     2.0    200    1.02744   1.02134    0.00610    0.518293   0.515244    0.003049
127    40      B     8.0     25    0.42378   0.42683   -0.00305    0.234756   0.240854   -0.006098
128    40      B     8.0     50    0.68293   0.70122   -0.01829    0.271341   0.268293    0.003049
129    40      B     8.0    100    1.13720   1.12805    0.00915    0.304878   0.310976   -0.006098
130    40      B     8.0    200    1.76220   1.70732    0.05488    0.362805   0.371951   -0.009146
131    40      C     0.5     50    0.37500   0.38110   -0.00610    0.402439   0.396341    0.006098
132    40      C     0.5    100    0.59146   0.59451   -0.00305    0.472561   0.475610   -0.003049
133    40      C     0.5    200    0.86890   0.86890    0.00000    0.579268   0.591463   -0.012195
134    40      C     2.0     25    0.40244   0.41159   -0.00915    0.240854   0.240854    0.000000
135    40      C     2.0     50    0.41159   0.40244    0.00915    0.277439   0.277439    0.000000
136    40      C     2.0    100    1.01524   1.02134   -0.00610    0.329268   0.329268    0.000000
137    40      C     8.0     25    0.71037   0.73171   -0.02134    0.164634   0.167683   -0.003049
138    40      C     8.0     50    1.14329   1.15854   -0.01524    0.192073   0.195122   -0.003049
139    40      C     8.0    100    1.72561   1.71646    0.00915    0.231707   0.234756   -0.003049
140    40      C     8.0    200    2.44817   2.45427   -0.00610    0.292683   0.295732   -0.003049
141    40      D     0.5     25    0.32927   0.36585   -0.03659    0.277439   0.274390    0.003049
142    40      D     0.5     50    0.47866   0.48780   -0.00915    0.344512   0.338415    0.006098
143    40      D     0.5    100    0.69207   0.70122   -0.00915    0.426829   0.429878   -0.003049
144    40      D     2.0     25    0.56098   0.54878    0.01220    0.195122   0.195122    0.000000
145    40      D     2.0     50    0.81402   0.81402    0.00000    0.240854   0.240854    0.000000
146    40      D     2.0    100    1.15854   1.14329    0.01524    0.301829   0.304878   -0.003049
147    40      D     8.0     25    0.94817   0.92988    0.01829    0.137195   0.131098    0.006098
148    40      D     8.0     50    1.38110   1.35671    0.02439    0.170732   0.164634    0.006098
149    40      D     8.0    100    1.93293   1.89024    0.04268    0.216463   0.210366    0.006098
150    40      D     8.0    200    2.58841   2.59146   -0.00305    0.280488   0.274390    0.006098
151    40      E     0.5     25    0.48476   0.47256    0.01220    0.213415   0.216463   -0.003049
152    40      E     0.5     50    0.66159   0.67073   -0.00915    0.277439   0.274390    0.003049
153    40      E     0.5    100    0.91768   0.91463    0.00305    0.353659   0.356707   -0.003049
154    40      E     0.5    200    1.21951   1.20427    0.01524    0.463415   0.472561   -0.009146
155    40      E     2.0     25    0.80793   0.79268    0.01524    0.152439   0.149390    0.003049
156    40      E     2.0     50    1.10976   1.10366    0.00610    0.195122   0.192073    0.003049
157    40      E     2.0    100    1.52134   1.49390    0.02744    0.253049   0.253049    0.000000
158    40      E     2.0    200    2.00610   1.99695    0.00915    0.332317   0.332317    0.000000
159    40      E     8.0     25    1.31098   1.34146   -0.03049    0.109756   0.100610    0.009146
160    40      E     8.0     50    1.85976   1.82927    0.03049    0.140244   0.131098    0.009146
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ANALYSIS FOR PARABOLIC CHANNELS

CRS	SHAPE	RET	SLOPE	FLOW	VCAL	VNCM	V_DIFF	DCAL	DNCM	C_DIFF
161	40	E	8.0	100	2.51220	2.48476	0.02744	0.179878	0.176829	0.003049
162	40	E	8.0	200	3.28659	3.27744	0.00915	0.240854	0.234756	0.006098
163	60	A	0.5	25	0.08841	0.04573	0.04268	.	.	.
164	60	A	0.5	50	0.11585	0.09146	0.02439	.	.	.
165	60	A	0.5	100	0.16463	0.16768	-0.00305	.	.	.
166	60	A	0.5	200	0.29573	0.30488	-0.00915	.	.	.
167	60	A	2.0	25	0.14329	0.12195	0.02134	.	.	.
168	60	A	2.0	50	0.19512	0.18293	0.01220	.	.	.
169	60	A	2.0	100	.	.	.	0.560976	0.542683	0.018293
170	60	A	2.0	100	0.30488	0.33537	-0.030488	0.560976	0.542683	0.018293
171	60	A	2.0	200	.	.	.	0.618902	0.618902	0.000000
172	60	A	2.0	200	0.52744	0.53354	-0.006098	0.618902	0.618902	0.000000
173	60	A	8.0	25	0.23780	0.25915	-0.021341	.	.	.
174	60	A	8.0	50	0.32622	0.36585	-0.039634	.	.	.
175	60	A	8.0	100	0.54878	0.60976	-0.060976	0.381098	0.387195	-0.006098
176	60	A	8.0	200	0.92988	0.96037	-0.030488	0.423780	0.439024	-0.015244
177	60	B	0.5	25	0.10671	0.06098	0.045732	0.451220	0.454268	-0.003049
178	60	B	0.5	50	0.11585	0.09146	0.024390	0.524390	0.506098	0.018293
179	60	B	0.5	100	0.28659	0.27439	0.012195	0.582317	0.570122	0.012195
180	60	B	0.5	200	0.29573	0.30488	-0.009146	0.676829	0.664634	0.012195
181	60	B	2.0	25	0.17988	0.15244	0.027439	0.314024	0.320122	-0.006098
182	60	B	2.0	50	0.29878	0.27439	0.024390	0.356707	0.356707	0.000000
183	60	B	2.0	100	0.47866	0.48780	-0.009146	0.402439	0.399390	0.003049
184	60	B	2.0	200	0.79268	0.77744	0.015244	0.469512	0.466463	0.003049
185	60	B	8.0	25	0.31402	0.30488	0.009146	0.219512	0.222561	-0.003049
186	60	B	8.0	50	0.53354	0.48780	0.045732	0.243902	0.250000	-0.006098
187	60	B	8.0	100	0.85366	0.86890	-0.015244	0.283537	0.283537	0.000000
188	60	B	8.0	200	1.37500	1.34146	0.033537	0.326220	0.332317	-0.006098
189	60	C	0.5	25	0.16463	0.15244	0.012195	0.335366	0.320122	0.015244
190	60	C	0.5	50	0.28049	0.28963	-0.009146	0.371951	0.362805	0.009146
191	60	C	0.5	100	0.45732	0.45732	0.000000	0.429878	0.420732	0.009146
192	60	C	0.5	200	0.70122	0.70122	0.000000	0.512195	0.512195	0.000000
193	60	C	2.0	25	0.29573	0.27439	0.021341	0.225610	0.225610	0.000000
194	60	C	2.0	50	0.29573	0.27439	0.021341	0.256098	0.256098	0.000000
195	60	C	2.0	100	0.79268	0.79268	0.000000	0.329268	0.329268	0.000000
196	60	C	2.0	100	0.79268	0.79268	0.000000	0.295732	0.295732	0.000000
197	60	C	8.0	25	0.52744	0.53354	-0.006098	0.155488	0.155488	0.000000
198	60	C	8.0	50	0.86890	0.86890	0.000000	0.176829	0.179878	-0.003049
199	60	C	8.0	100	1.36890	1.34146	0.027439	0.207317	0.207317	0.000000
200	60	C	8.0	200	2.00915	1.98171	0.027439	0.253049	0.253049	0.000000
201	60	D	0.5	25	0.25610	0.25915	-0.003049	0.250000	0.243902	0.006098
202	60	D	0.5	50	0.38720	0.39634	-0.009146	0.304878	0.295732	0.009146
203	60	D	0.5	100	0.56098	0.56402	-0.003049	0.375000	0.368902	0.006098
204	60	D	2.0	25	0.44207	0.44207	0.000000	0.173780	0.173780	0.000000
205	60	D	2.0	50	0.65244	0.64024	0.012195	0.213415	0.213415	0.000000
206	60	D	2.0	100	0.94817	0.92988	0.018293	0.262195	0.262195	0.000000
207	60	D	8.0	25	0.75915	0.71646	0.042683	0.121951	0.118902	0.003049
208	60	D	8.0	50	1.10366	1.08232	0.021341	0.149390	0.143293	0.006098
209	60	D	8.0	100	1.59756	1.55488	0.042683	0.185976	0.179878	0.006098
210	60	D	8.0	200	2.19207	2.16463	0.027439	0.240854	0.231707	0.009146
211	60	E	0.5	25	0.39939	0.38110	0.018293	0.185976	0.189024	-0.003049
212	60	E	0.5	50	0.55183	0.50305	0.048780	0.237805	0.237805	0.000000
213	60	E	0.5	100	0.76220	0.76220	0.000000	0.304878	0.304878	0.000000
214	60	F	0.5	200	1.03659	1.02134	0.015244	0.393293	0.396341	-0.003049
215	60	F	2.0	25	0.67073	0.66159	0.009146	0.131098	0.131098	0.000000
216	60	F	2.0	50	0.90244	0.89939	0.003049	0.170732	0.167683	0.003049
217	60	F	2.0	100	1.27134	1.25000	0.021341	0.216463	0.219512	-0.003049
218	60	E	2.0	200	1.71341	1.69207	0.021341	0.283537	0.283537	0.000000
219	60	E	8.0	25	1.12195	1.11890	0.003049	0.094512	0.091463	0.003049
220	60	E	8.0	50	1.52744	1.35671	0.170732	0.121951	0.115854	0.006098
221	60	F	8.0	100	2.11585	2.07317	0.042683	0.155488	0.146341	0.009146
222	60	F	8.0	200	2.81707	2.78963	0.027439	0.201220	0.195122	0.006098
223	99	A	0.5	25	0.07317	0.03049	0.042683	.	.	.
224	99	A	0.5	50	0.09451	0.04573	0.048780	.	.	.
225	99	A	0.5	100	0.12805	0.10671	0.021341	.	.	.
226	99	A	0.5	200	0.18902	0.18293	0.006098	.	.	.
227	99	A	2.0	25	0.11890	0.09146	0.027439	.	.	.
228	99	A	2.0	50	0.15549	0.12195	0.033537	.	.	.
229	99	A	2.0	100	.	.	.	0.509146	0.509146	0.000000
230	99	A	2.0	100	0.21341	0.21341	0.000000	0.509146	0.509146	0.000000
231	99	A	2.0	200	.	.	.	0.573171	0.564024	0.009146
232	99	A	2.0	200	0.35366	0.36585	-0.012195	0.573171	0.564024	0.009146
233	99	A	8.0	25	0.19512	0.19817	-0.003049	.	.	.
234	99	A	8.0	50	0.25610	0.24390	0.012195	.	.	.
235	99	A	8.0	100	0.35976	0.40244	-0.042683	0.356707	0.362805	-0.006098
236	99	A	8.0	200	0.63415	0.64024	-0.006098	0.390244	0.402439	-0.012195
237	99	B	0.5	25	0.08537	0.03049	0.054878	0.378049	0.426829	-0.048780
238	99	B	0.5	50	0.11585	0.07622	0.039634	0.469512	0.466463	0.003049
239	99	B	0.5	100	0.19512	0.16768	0.027439	0.536585	0.518293	0.018293
240	99	B	0.5	200	0.32622	0.30488	0.021341	0.603659	0.594512	0.009146

ANALYSIS FOR PARABOLIC CHANNELS

OBS	SHAPE	RET	SLOPE	FLOW	VCAL	VNOM	V_DIFF	DCAL	DNOM	D_DIFF
241	99	B	2.0	25	0.14024	0.07622	0.064024	0.268293	0.301829	-0.033537
242	99	B	2.0	50	0.20427	0.15244	0.051829	0.326220	0.329268	-0.003049
243	99	B	2.0	100	0.34451	0.30488	0.039634	0.365854	0.362805	0.003049
244	99	B	2.0	200	0.55183	0.53354	0.018293	0.417683	0.414634	0.003049
245	99	B	8.0	25	0.23476	0.18293	0.051829	0.189024	0.213415	-0.024390
246	99	B	8.0	50	0.35061	0.32012	0.030488	0.228659	0.231707	-0.003049
247	99	B	8.0	100	0.57317	0.57927	-0.006098	0.262195	0.259146	0.003049
248	99	B	8.0	200	0.97256	0.92988	0.042683	0.292683	0.292683	0.000000
249	99	C	0.5	25	0.10671	0.07622	0.030488	0.320122	0.298780	0.021341
250	99	C	0.5	50	0.19207	0.16769	0.024390	0.341463	0.332317	0.009146
251	99	C	0.5	100	0.32012	0.32012	0.000000	0.384146	0.375000	0.009146
252	99	C	0.5	200	0.51524	0.51829	-0.003049	0.448171	0.435976	0.012195
253	99	C	2.0	25	0.19512	0.16768	0.027439	0.216463	0.210366	0.006098
254	99	C	2.0	50	0.19512	0.16768	0.027439	0.231707	0.240854	-0.009146
255	99	C	2.0	100	0.56098	0.56402	-0.003049	0.265244	0.265244	0.000000
256	99	C	8.0	25	0.35061	0.30488	0.045732	0.143293	0.143293	0.000000
257	99	C	8.0	50	0.60366	0.59451	0.009146	0.158537	0.161585	-0.003049
258	99	C	8.0	100	0.58476	0.57561	0.009146	0.192073	0.192073	0.000000
259	99	C	8.0	200	1.52134	1.50915	0.012195	0.216463	0.219512	-0.003049
260	99	D	0.5	25	0.17988	0.18293	-0.003049	0.222561	0.219512	0.003049
261	99	D	0.5	50	0.28659	0.28963	-0.003049	0.262195	0.259146	0.003049
262	99	D	0.5	100	0.42378	0.47256	-0.048780	0.320122	0.317073	0.003049
263	99	D	2.0	25	0.31707	0.28963	0.027439	0.152439	0.152439	0.000000
264	99	D	2.0	50	0.49390	0.47256	0.021341	0.182927	0.182927	0.000000
265	99	D	2.0	100	0.71646	0.71646	0.000000	0.225610	0.225610	0.000000
266	99	D	8.0	25	0.53483	0.46780	0.067073	0.106707	0.103659	0.003049
267	99	D	8.0	50	0.84146	0.77744	0.064024	0.128049	0.125000	0.003049
268	99	D	8.0	100	1.22256	1.21951	0.003049	0.158537	0.155488	0.003049
269	99	D	8.0	200	1.74390	1.72256	0.021341	0.198171	0.192073	0.006098
270	99	E	0.5	25	0.30488	0.28963	0.015244	0.158537	0.158537	0.000000
271	99	E	0.5	50	0.43598	0.41159	0.024390	0.198171	0.201220	-0.003049
272	99	E	0.5	100	0.59756	0.59451	0.003049	0.253049	0.259146	-0.006098
273	99	E	0.5	200	0.82927	0.82317	0.006098	0.326220	0.329268	-0.003049
274	99	E	2.0	25	0.51829	0.50305	0.015244	0.112805	0.112805	0.000000
275	99	E	2.0	50	0.73171	0.70122	0.030488	0.140244	0.143293	-0.003049
276	99	E	2.0	100	0.99390	0.99085	0.003049	0.182927	0.182927	0.000000
277	99	E	2.0	200	1.38110	1.38720	-0.006098	0.231707	0.231707	0.000000
278	99	E	8.0	25	0.87500	0.86890	0.006098	0.079268	0.079268	0.000000
279	99	E	8.0	50	1.21646	1.18902	0.027439	0.100610	0.097561	0.003049
280	99	E	8.0	100	1.67073	1.66159	0.009146	0.128049	0.125000	0.003049
281	99	E	8	200	2.29878	2.28659	0.0121951	0.164634	0.161585	0.00304878

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                                        ANALYSIS FOR TRIANGULAR CHANNELS                              20:59 THURSDAY, MAY 8, 1

OBS    SHAPE    RET.    SLOPE    FLOW      VCAL       VNOM        V_DIFF        DCAL        DNUM        D_DIFF

163     30       D       0.5      100    0.64329    0.65549    -0.012195    0.542683    0.548780    -0.006098
164     30       D       0.5      200    0.85061    0.85366    -0.003049    0.664634    0.673780    -0.009146
165     30       D       2.0       25    0.61890    0.62500    -0.006098    0.277439    0.274390     0.003049
166     30       D       2.0       50    0.85976    0.86890    -0.009146    0.332317    0.329268     0.003049
167     30       D       2.0      100    1.15854    1.17378    -0.015244    0.402439    0.399390     0.003049
168     30       D       2.0      200    1.50000    1.50915    -0.009146    0.503049    0.496951     0.006098
169     30       D       8.0       25    1.14024    1.18902    -0.048780    0.204268    0.198171     0.006098
170     30       D       8.0       50    1.56707    1.57012    -0.003049    0.246951    0.243902     0.003049
171     30       D       8.0      100    2.06098    2.07317    -0.012195    0.301829    0.298780     0.003049
172     30       D       8.0      200    2.61890    2.63720    -0.018293    0.381098    0.375000     0.006098
173     30       E       0.5       25    0.51829    0.47256     0.045732    0.301829    0.320122    -0.018293
174     30       E       0.5       50    0.67378    0.67073     0.003049    0.387195    0.375000     0.012195
175     30       E       0.5      100    0.89024    0.88415     0.006098    0.460366    0.475610    -0.015244
176     30       E       0.5      200    1.13720    1.12805     0.009146    0.576220    0.591463    -0.015244
177     30       E       2.0       25    0.91463    0.91463     0.000000    0.225610    0.222561     0.003049
178     30       E       2.0       50    1.21341    1.21951    -0.006098    0.277439    0.277439     0.000000
179     30       E       2.0      100    1.57012    1.57012     0.000000    0.347561    0.341463     0.006098
180     30       E       2.0      200    1.97561    1.98171    -0.006098    0.435976    0.432927     0.003049
181     30       E       8.0       25    1.64329    1.64634    -0.003049    0.170732    0.158537     0.012195
182     30       E       8.0       50    2.15549    2.14939     0.006098    0.210366    0.201220     0.009146
183     30       E       8.0      100    2.73780    2.72866     0.009146    0.262195    0.253049     0.009146
184     30       E       8.0      200    3.40244    3.41463    -0.012195    0.332317    0.326220     0.006098
185     40       A       0.5       25    0.08537    0.03049     0.054878        .           .            .
186     40       A       0.5       50    0.10671    0.03049     0.076220        .           .            .
187     40       A       0.5      100    0.13720    0.04573     0.091463        .           .            .
188     40       A       0.5      200    0.20122    0.18293     0.018293        .           .            .
189     40       A       2.0       25    0.14634    0.10671     0.039634        .           .            .
190     40       A       2.0       50    0.18598    0.07622     0.109756        .           .            .
191     40       A       2.0      100    0.25610    0.19817     0.057927        .           .            .
192     40       A       2.0      200    0.44512    0.41159     0.033537        .           .            .
193     40       A       8.0       25    0.25305    0.32012    -0.067073        .           .            .
194     40       A       8.0       50    0.33537    0.28963     0.045732        .           .            .
195     40       A       8.0      100    0.52134    0.44207     0.079268        .           .            .
196     40       A       8.0      200    0.90244    0.83841     0.064024        .           .            .
197     40       B       0.5       25    0.10366    0.03049     0.073171    0.582317    0.591463    -0.009146
198     40       B       0.5       50    0.14939    0.10671     0.042683    0.509390    0.542927    -0.033537
199     40       B       0.5      100    0.25000    0.19817     0.051829    0.753049    0.719512     0.033537
200     40       B       0.5      200    0.38720    0.35061     0.036585    0.853659    0.826220     0.027439
201     40       B       2.0       25    0.19207    0.16768     0.024390    0.429878    0.432927    -0.003049
202     40       B       2.0       50    0.31098    0.27439     0.036585    0.478659    0.478659     0.000000
203     40       B       2.0      100    0.49695    0.44207     0.054878    0.533537    0.533537     0.000000
204     40       B       2.0      200    0.75915    0.71646     0.042683    0.612805    0.609756     0.003049
205     40       B       8.0       25    0.38110    0.38110     0.000000    0.304878    0.323171    -0.018293
206     40       B       8.0       50    0.62805    0.59451     0.033537    0.335366    0.362805    -0.027439
207     40       B       8.0      100    0.96037    0.88415     0.076220    0.384146    0.405488    -0.021341
208     40       B       8.0      200    1.44817    1.37195     0.076220    0.442073    0.466463    -0.024390
209     40       C       0.5       25    0.17073    0.12195     0.048780    0.448171    0.432927     0.015244
210     40       C       0.5       50    0.28659    0.24390     0.042683    0.484756    0.496951    -0.012195
211     40       C       0.5      100    0.44207    0.41159     0.030488    0.564024    0.557927     0.006098
212     40       C       0.5      200    0.65244    0.64024     0.012195    0.661585    0.652439     0.009146
213     40       C       2.0       25    0.35671    0.35061     0.006098    0.314024    0.310976     0.003049
214     40       C       2.0       50    0.56402    0.54878     0.015244    0.353659    0.350610     0.003049
215     40       C       2.0      100    0.85366    0.83841     0.015244    0.408537    0.408537     0.000000
216     40       C       2.0      200    1.20732    1.18902     0.018293    0.484756    0.481707     0.003049
217     40       C       8.0       25    0.71646    0.76220    -0.045732    0.222561    0.213415     0.009146
218     40       C       8.0       50    1.10366    1.09756     0.006098    0.253049    0.243902     0.009146
219     40       C       8.0      100    1.60366    1.57012     0.033537    0.318780    0.324878    -0.006098
220     40       C       8.0      200    2.19512    2.16463     0.030488    0.359756    0.365854    -0.006098
221     40       D       0.5       25    0.28963    0.25915     0.030488    0.350610    0.359756    -0.009146
222     40       D       0.5       50    0.40854    0.38110     0.027439    0.423780    0.417683     0.006098
223     40       D       0.5      100    0.56402    0.56402     0.000000    0.503049    0.539146    -0.036098
224     40       D       0.5      200    0.76220    0.76220     0.000000    0.609756    0.621951    -0.012195
225     40       D       2.0       25    0.53354    0.53354     0.000000    0.256098    0.253049     0.003049
226     40       D       2.0       50    0.74695    0.74695     0.000000    0.307927    0.304878     0.003049
227     40       D       2.0      100    1.03049    1.03659    -0.006098    0.371951    0.365854     0.006098
228     40       D       2.0      200    1.35366    1.35671    -0.003049    0.457317    0.454268     0.003049
229     40       D       8.0       25    0.99695    1.02134    -0.024390    0.189024    0.182927     0.006098
230     40       D       8.0       50    1.38415    1.37195     0.012195    0.225610    0.222561     0.003049
231     40       D       8.0      100    1.85061    1.82927     0.021341    0.277439    0.274390     0.003049
232     40       D       8.0      200    2.38110    2.36280     0.018293    0.344512    0.344512     0.000000
233     40       E       0.5       25    0.46341    0.39634     0.067073    0.274390    0.298780    -0.024390
234     40       E       0.5       50    0.60061    0.57927     0.021341    0.356707    0.341463     0.015244
235     40       E       0.5      100    0.79878    0.77744     0.021341    0.420732    0.435976    -0.015244
236     40       E       0.5      200    1.03354    1.02134     0.012195    0.524390    0.542683    -0.018293
237     40       E       2.0       25    0.82622    0.79268     0.033537    0.207317    0.204268     0.003049
238     40       E       2.0       50    1.07927    1.08232    -0.003049    0.256098    0.253049     0.003049
239     40       E       2.0      100    1.41768    1.40244     0.015244    0.317073    0.314024     0.003049
240     40       E       2.0      200    1.80183    1.78354     0.018293    0.370341    0.370341     0.000000
241     40       E       8.0       25    1.45122    1.44817     0.003049    0.155488    0.146341     0.009146
242     40       E       8.0       50    1.93598    1.92073     0.015244    0.192073    0.182927     0.009146
243     40       E       8.0      100    2.49085    2.46951     0.021341    0.237805    0.228659     0.009146
244     40       E       8.0      200    3.11890    3.09451     0.024390    0.301829    0.292683     0.009146
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                                   ANALYSIS FOR TRIANGULAR CHANNELS                          20:59 THURSDAY, MAY 8,

OBS    SHAPE    HET    SLOPE    FLOW     VCAL       VNOM       V_DIFF       DCAL        DNOM        D_DIFF

  1     10       A      0.5       25    0.13415    0.07622    0.057927        .           .            .
  2     10       A      0.5       50    0.19512    0.18293    0.012195        .           .            .
  3     10       A      0.5      100    0.34756    0.33537    0.012195        .           .            .
  4     10       A      0.5      200    0.53963    0.53354    0.006098        .           .            .
  5     10       A      2.0       25    0.25000    0.24390    0.006098        .           .            .
  6     10       A      2.0       50    0.43293    0.41159    0.021341        .           .            .
  7     10       A      2.0      100    0.69207    0.68598    0.006098        .           .            .
  8     10       A      2.0      200    1.03049    1.03659   -0.006098        .           .            .
  9     10       A      8.0       25    0.50305    0.53354   -0.030488        .           .            .
 10     10       A      8.0       50    0.87805    0.94512   -0.067073        .           .            .
 11     10       A      8.0      100    1.34451    1.31098    0.033537        .           .            .
 12     10       A      8.0      200    1.92073    1.90549    0.015244        .           .            .
 13     10       B      0.5       25    0.24390    0.19817    0.045732    0.765244    0.713415     0.051829
 14     10       B      0.5       50    0.37805    0.35061    0.027439    0.701220    0.640244     0.060976
 15     10       B      0.5       50    0.37805    0.35061    0.027439    0.832317    0.862805    -0.030488
 16     10       B      0.5      100    0.57317    0.53354    0.039634    0.300000    0.300000     0.000000
 17     10       B      0.5      200    0.82012    0.80793    0.012195        .           .            .
 18     10       B      2.0       25    0.48476    0.44207    0.042683    0.539634    0.527439     0.012195
 19     10       B      2.0       50    0.73780    0.70122    0.036585    0.618902    0.640244    -0.021341
 20     10       B      2.0      100    1.08232    1.05183    0.030488    0.722561    0.719512     0.003049
 21     10       B      2.0      200    1.50000    1.49390    0.006098    0.000000    0.000000     0.000000
 22     10       B      8.0       25    0.94207    1.02134   -0.079268    0.387195    0.399390    -0.012195
 23     10       B      8.0       50    1.41768    1.35671    0.060976    0.445122    0.469512    -0.024390
 24     10       B      8.0       50    1.41768    1.35671    0.060976    0.445122    0.469512    -0.024390
 25     10       B      8.0      100    2.00915    1.93598    0.073171    0.530488    0.551829    -0.021341
 26     10       B      8.0      200    2.69817    2.71341   -0.015244    0.649390    0.667683    -0.018293
 27     10       C      0.5       25    0.43293    0.39634    0.036585    0.570122    0.557927     0.012195
 28     10       C      0.5       50    0.64024    0.64024    0.000000    0.661585    0.667683    -0.006098
 29     10       C      0.5      100    0.88720    0.88415    0.003049    0.798780    0.795732     0.003049
 30     10       C      0.5      200    1.17378    1.17378    0.000000        .           .            .
 31     10       C      2.0       25    0.83537    0.82317    0.012195    0.411585    0.408537     0.003049
 32     10       C      2.0       50    1.18598    1.17378    0.012195    0.487805    0.481707     0.006098
 33     10       C      2.0      100    1.59756    1.58537    0.012195    0.594512    0.588415     0.006098
 34     10       C      2.0      200    2.06707    2.07317   -0.006098    0.740854    0.725610     0.015244
 35     10       C      8.0       25    1.57317    1.52439    0.048780    0.298780    0.304878    -0.006098
 36     10       C      8.0       50    2.16159    2.13415    0.027439    0.362805    0.365854    -0.003049
 37     10       C      8.0      100    2.83841    2.83537    0.003049    0.448171    0.448171     0.000000
 38     10       C      8.0      200    3.60671    3.61280   -0.006098    0.560976    0.560976     0.000000
 39     10       D      0.5       25    0.55488    0.54878    0.006098    0.506098    0.512195    -0.006098
 40     10       D      0.5       50    0.75000    0.74695    0.003049    0.621951    0.612805     0.009146
 41     10       D      0.5      100    0.97561    0.96037    0.015244    0.762195    0.765244    -0.003049
 42     10       D      0.5      200    1.22866    1.21951    0.009146    0.945122    0.945122     0.000000
 43     10       D      2.0       25    1.01524    1.02134   -0.006098    0.381098    0.368902     0.012195
 44     10       D      2.0       50    1.33537    1.32622    0.009146    0.460366    0.457317     0.003049
 45     10       D      2.0      100    1.70427    1.70732   -0.003049    0.576220    0.570122     0.006098
 46     10       D      2.0      200    2.12195    2.13415   -0.012195    0.731707    0.725610     0.006098
 47     10       D      8.0       25    1.82317    1.79878    0.024390    0.277439    0.274390     0.003049
 48     10       D      8.0       50    2.35061    2.33232    0.018293    0.347561    0.344512     0.003049
 49     10       D      8.0      100    2.95122    2.94207    0.009146    0.439024    0.435976     0.003049
 50     10       D      8.0      200    3.63720    3.64329   -0.006098    0.557927    0.557927     0.000000
 51     10       E      0.5       25    0.78659    0.76220    0.024390    0.423780    0.448171    -0.024390
 52     10       E      0.5       50    1.01829    1.00610    0.012195    0.551829    0.527439     0.024390
 53     10       E      0.5      100    1.28354    1.26524    0.018293    0.664634    0.682927    -0.018293
 54     10       E      0.5      200    1.50842    1.50537    0.003049    0.844512    0.868902    -0.024390
 55     10       E      2.0       25    1.39939    1.38110    0.018293    0.317073    0.320122    -0.003049
 56     10       E      2.0       50    1.78049    1.76829    0.012195    0.399390    0.402439    -0.003049
 57     10       E      2.0      100    2.21646    2.21037    0.006098    0.506098    0.506098     0.000000
 58     10       E      2.0      200    2.71341    2.69817    0.015244    0.646341    0.643293     0.003049
 59     10       E      8.0       25    2.46037    2.45427    0.006098    0.240854    0.237805     0.003049
 60     10       E      8.0       50    3.08232    3.07927    0.003049    0.301829    0.298780     0.003049
 61     10       E      8.0      100    3.79878    3.78049    0.018293    0.387195    0.384146     0.003049
 62     10       E      8.0      200        .          .           .       0.493902    0.493902     0.000000
 63     20       A      0.5       25    0.10671    0.04573    0.060976        .           .            .
 64     20       A      0.5       50    0.13720    0.09146    0.045732        .           .            .
 65     20       A      0.5      100    0.20122    0.19817    0.003049        .           .            .
 66     20       A      0.5      200    0.35671    0.35061    0.006098        .           .            .
 67     20       A      2.0       25    0.18598    0.18293    0.003049        .           .            .
 68     20       A      2.0       50    0.25305    0.24390    0.009146        .           .            .
 69     20       A      2.0      100    0.44207    0.44207    0.000000        .           .            .
 70     20       A      2.0      200    0.70732    0.71646   -0.009146        .           .            .
 71     20       A      8.0       25    0.33537    0.42683   -0.091463        .           .            .
 72     20       A      8.0       50    0.51829    0.53354   -0.015244        .           .            .
 73     20       A      8.0      100    0.89634    0.99085   -0.094512        .           .            .
 74     20       A      8.0      200    1.36585    1.35671    0.009146        .           .            .
 75     20       B      0.5       25    0.14939    0.10671    0.042683    0.685976    0.646341     0.039634
 76     20       B      0.5       50    0.24695    0.21341    0.033537    0.722561    0.756098    -0.033537
 77     20       B      0.5      100    0.38415    0.36585    0.018293    0.856707    0.835366     0.021341
 78     20       B      0.5      200    0.58232    0.56402    0.018293        .           .            .
 79     20       B      2.0       25    0.30793    0.28963    0.018293    0.478659    0.475610     0.003049
 80     20       B      2.0       50    0.49390    0.48780    0.006098    0.536585    0.536585     0.000000
 81     20       B      2.0      100    0.75000    0.73171    0.018293    0.612805    0.640244    -0.027439
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                                  ANALYSIS FOR TRIANGULAR CHANNELS                      20:59 THURSDAY, MAY 9,

OBS   SHAPE   RET   SLOPE   FLOW   VCAL      VNOM      V_DIFF      DCAL       DNOM       D_DIFF

 82    20      B     2.0    200    1.10061   1.08232    0.018293   0.719512   0.719512    0.000000
 83    20      B     8.0     25    0.62500   0.64024   -0.015244   0.335366   0.359756   -0.024390
 84    20      B     8.0     50    0.95732   0.96037   -0.003049   0.384146   0.408537   -0.024390
 85    20      B     8.0    100    1.44207   1.40244    0.039634   0.442073   0.469512   -0.027439
 86    20      B     8.0    200    2.03659   2.01220    0.024390   0.536585   0.551829   -0.015244
 87    20      C     0.5     25    0.28354   0.25915    0.024390   0.500000   0.490854    0.009146
 88    20      C     0.5     50    0.43902   0.42683    0.012195   0.557927   0.567073   -0.009146
 89    20      C     0.5    100    0.64939   0.64024    0.009146   0.661585   0.655488    0.006098
 90    20      C     0.5    200    0.89939   0.89939    0.000000   0.792683   0.795732   -0.003049
 91    20      C     2.0     25    0.56098   0.57927   -0.018293   0.356707   0.353659    0.003049
 92    20      C     2.0     50    0.84756   0.85366   -0.006098   0.414634   0.408537    0.006098
 93    20      C     2.0    100    1.20427   1.20427    0.000000   0.484756   0.484756    0.000000
 94    20      C     2.0    200    1.61585   1.60061    0.015244   0.591463   0.591463    0.000000
 95    20      C     8.0     25    1.09756   1.12805   -0.030488   0.253049   0.262195   -0.009146
 96    20      C     8.0     50    1.59756   1.58537    0.012195   0.298780   0.304878   -0.006098
 97    20      C     8.0    100    2.17988   2.17988    0.000000   0.359756   0.387195   -0.027439
 98    20      C     8.0    200    2.86890   2.86585    0.003049   0.445122   0.451220   -0.006098
 99    20      D     0.5     25    0.40549   0.39634    0.009146   0.417683   0.426829   -0.009146
100    20      D     0.5     50    0.56402   0.54878    0.015244   0.512195   0.503049    0.009146
101    20      D     0.5    100    0.75915   0.76220   -0.003049   0.609756   0.621951   -0.012195
102    20      D     0.5    200    0.98476   0.97561    0.009146   0.759146   0.771341   -0.012195
103    20      D     2.0     25    0.74390   0.76220   -0.018293   0.307927   0.307927    0.000000
104    20      D     2.0     50    1.02744   1.02134    0.006098   0.371951   0.368902    0.003049
105    20      D     2.0    100    1.35061   1.35671   -0.006098   0.457317   0.457317    0.000000
106    20      D     2.0    200    1.71951   1.72256   -0.003049   0.573171   0.588415   -0.015244
107    20      D     8.0     25    1.37805   1.40244   -0.024390   0.225610   0.222561    0.003049
108    20      D     8.0     50    1.84451   1.82927    0.015244   0.277439   0.274390    0.003049
109    20      D     8.0    100    2.37500   2.36280    0.012195   0.344512   0.344512    0.000000
110    20      D     8.0    200    2.97866   2.98780   -0.009146   0.435976   0.448171   -0.012195
111    20      E     0.5     25    0.60061   0.54878    0.051829   0.341463   0.359756   -0.018293
112    20      E     0.5     50    0.79573   0.76220    0.033537   0.439024   0.420732    0.018293
113    20      E     0.5    100    1.03049   0.99085    0.039634   0.524390   0.542683   -0.018293
114    20      E     0.5    200    1.29573   1.25000    0.045732   0.661585   0.679878   -0.018293
115    20      E     2.0     25    1.07622   1.03659    0.039634   0.256098   0.256098    0.000000
116    20      E     2.0     50    1.41463   1.37195    0.042683   0.317073   0.317073    0.000000
117    20      E     2.0     50    1.41463   1.37195    0.042683   0.237805   0.231707    0.006098
118    20      E     2.0    100    1.79573   1.73780    0.057927   0.396341   0.396341    0.000000
119    20      E     2.0    200    2.23476   2.17988    0.054878   0.503049   0.503049    0.000000
120    20      E     8.0     25    1.92988   1.85976    0.070122   0.192073   0.182927    0.009146
121    20      E     8.0     50    2.48171   2.40854    0.073171    .          .           .
122    20      E     8.0    100    3.10976   3.01829    0.091463   0.301829   0.292683    0.009146
123    20      E     8.0    200    3.83232   3.82927    0.003049   0.384146   0.381098    0.003049
124    30      A     0.5     25    0.09146   0.03049    0.060976    .          .           .
125    30      A     0.5     50    0.10671   0.03049    0.076220    .          .           .
126    30      A     0.5    100    0.15854   0.10671    0.051829    .          .           .
127    30      A     0.5    200    0.26829   0.24390    0.024390    .          .           .
128    30      A     2.0     25    0.16159   0.15244    0.009146    .          .           .
129    30      A     2.0     25    0.16159   0.15244    0.009146    .          .           .
130    30      A     2.0     50    0.21037   0.15244    0.057927    .          .           .
131    30      A     2.0    100    0.30793   0.30488    0.003049    .          .           .
132    30      A     2.0    200    0.54573   0.53354    0.012195    .          .           .
133    30      A     8.0     25    0.28354   0.36585   -0.082317    .          .           .
134    30      A     8.0     50    0.39024   0.39634   -0.006098    .          .           .
135    30      A     8.0    100    0.67988   0.64024    0.039634    .          .           .
136    30      A     8.0    200    1.08232   1.03659    0.045732    .          .           .
137    30      B     0.5     25    0.11890   0.06098    0.057927   0.631098   0.609756    0.021341
138    30      B     0.5     50    0.18598   0.15244    0.033537   0.673780   0.704268   -0.030488
139    30      B     0.5    100    0.30183   0.27439    0.027439   0.792683   0.762195    0.030488
140    30      B     0.5    200    0.45732   0.45732    0.000000   0.905488   0.884146    0.021341
141    30      B     2.0     25    0.22866   0.22866    0.000000   0.454268   0.448171    0.006098
142    30      B     2.0     50    0.38110   0.36585    0.015244   0.500000   0.500000    0.000000
143    30      B     2.0    100    0.58841   0.56402    0.024390   0.567073   0.564024    0.003049
144    30      B     2.0    200    0.89024   0.88415    0.006098   0.652439   0.649390    0.003049
145    30      B     8.0     25    0.47256   0.47256    0.000000   0.317073   0.338415   -0.021341
146    30      B     8.0     50    0.75610   0.73171    0.024390   0.353659   0.378049   -0.024390
147    30      B     8.0    100    1.14634   1.09756    0.048780   0.405488   0.426829   -0.021341
148    30      B     8.0    200    1.67988   1.63110    0.048780   0.472561   0.496951   -0.024390
149    30      C     0.5     25    0.21646   0.18293    0.033537   0.469512   0.454268    0.015244
150    30      C     0.5     50    0.34146   0.32012    0.021341   0.512195   0.524390   -0.012195
151    30      C     0.5    100    0.52439   0.50305    0.021341   0.600610   0.594512    0.006098
152    30      C     0.5    200    0.75000   0.74695    0.003049   0.710366   0.704268    0.006098
153    30      C     2.0     25    0.43598   0.45732   -0.021341   0.329268   0.326220    0.003049
154    30      C     2.0     50    0.67378   0.67073    0.003049   0.375000   0.371951    0.003049
155    30      C     2.0    100    0.99085   0.99085    0.000000   0.435976   0.435976    0.000000
156    30      C     2.0    200    1.37195   1.37195    0.000000   0.524390   0.521341    0.003049
157    30      C     8.0     25    0.85671   0.91463   -0.057927   0.234756   0.240854   -0.006098
158    30      C     8.0     50    1.29878   1.29573    0.003049   0.271341   0.259146    0.012195
159    30      C     8.0    100    1.83537   1.81402    0.021341   0.320122   0.326220   -0.006098
160    30      C     8.0    200    2.46646   2.43902    0.027439   0.390244   0.396341   -0.006098
161    30      D     0.5     25    0.33537   0.30488    0.030488   0.375000   0.384146   -0.009146
162    30      D     0.5     50    0.46341   0.45732    0.006098   0.457317   0.454268    0.003049
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ANALYSIS FOR TRAPEZOIDAL CHANNELS
SIDE SLOPE=6:1

OBS	SHAPE	RET	SLOPE	FLOW	VCAL	VNOM	V_DIFF	DCAL	DNOM	D_DIFF
1	10	A	0.4	100	0.26829	0.35061	-0.08232	.	.	.
2	10	A	2.0	100	0.59451	0.62500	-0.03049	.	.	.
3	10	A	8.0	100	1.12500	1.00610	0.11890	.	.	.
4	10	A	0.4	500	0.71951	0.83232	-0.11280	.	.	.
5	10	A	2.0	500	1.45122	1.46341	-0.01220	.	.	.
6	10	A	8.0	500	2.58841	2.40854	0.17988	.	.	.
7	10	A	0.4	1000	0.98780	1.11585	-0.12805	.	.	.
8	10	A	2.0	1000	1.92988	1.95427	-0.02439	.	.	.
9	10	A	8.0	1000	3.38415	3.11280	0.27134	.	.	.
10	20	A	0.4	100	0.25305	0.29573	-0.04268	.	.	.
11	20	A	2.0	100	0.53049	0.51829	0.01220	.	.	.
12	20	A	8.0	100	0.95122	0.84451	0.10671	.	.	.
13	20	A	0.4	500	0.70122	0.77744	-0.07622	.	.	.
14	20	A	2.0	500	1.38720	1.35976	0.02744	.	.	.
15	20	A	8.0	500	2.42073	2.19512	0.22561	.	.	.
16	20	A	0.4	1000	0.97256	1.05793	-0.08537	.	.	.
17	20	A	2.0	1000	1.88110	1.86585	0.01524	.	.	.
18	20	A	8.0	1000	3.25000	3.00305	0.24695	.	.	.
19	30	A	0.4	100	0.22256	0.25915	-0.03659	.	.	.
20	30	A	2.0	100	0.46341	0.45732	0.00610	.	.	.
21	30	A	8.0	100	0.79878	0.74085	0.05793	.	.	.
22	30	A	0.4	500	0.67683	0.73171	-0.05488	.	.	.
23	30	A	2.0	500	1.30488	1.28963	0.01524	0.783537	0.786585	-0.003049
24	30	A	8.0	500	2.22561	2.07317	0.15244	0.518293	0.521341	-0.003049
25	30	A	0.4	1000	0.95122	1.02134	-0.07012	.	.	.
26	30	A	2.0	1000	1.81098	1.79878	0.01220	.	.	.
27	30	A	8.0	1000	3.07622	2.90244	0.17378	.	.	.
28	40	A	0.4	100	0.20122	0.22866	-0.02744	.	.	.
29	40	A	2.0	100	0.40549	0.44207	-0.03659	.	.	.
30	40	A	8.0	100	0.68293	0.67073	0.01220	.	.	.
31	40	A	0.4	500	0.64329	0.67683	-0.03354	.	.	.
32	40	A	2.0	500	1.21951	1.21037	0.00915	0.707317	0.713415	-0.006098
33	40	A	8.0	500	2.03659	1.96646	0.07012	0.463415	0.469512	-0.006098
34	40	A	0.4	1000	0.92378	0.98171	-0.05793	.	.	.
35	40	A	2.0	1000	1.72866	1.73780	-0.00915	.	.	.
36	40	A	8.0	1000	2.88720	2.80488	0.08232	.	.	.
37	40	A	2.0	20	0.17988	0.17988	0.00000	0.231707	0.237805	-0.006098
38	10	B	0.4	20	0.15244	0.18293	-0.03049	0.567073	0.567073	0.000000
39	10	B	2.0	20	0.32622	0.33537	-0.00915	0.341463	0.347561	-0.006098
40	10	B	8.0	20	0.60061	0.52439	0.07622	0.216463	0.234756	-0.018293
41	10	B	0.4	100	0.45122	0.53354	-0.08232	0.801829	0.820122	-0.018293
42	10	B	2.0	100	0.93293	0.94512	-0.01220	0.503049	0.509146	-0.006098
43	10	B	8.0	100	1.68598	1.50915	0.17683	0.332317	0.329268	0.003049
44	10	B	0.4	500	1.02439	1.12805	-0.10366	.	.	.
45	10	B	2.0	500	1.98171	1.98780	-0.00610	.	.	.
46	10	B	8.0	500	3.44817	3.20122	0.24695	.	.	.
47	10	B	0.4	1000	1.33537	1.44207	-0.10671	.	.	.
48	10	B	2.0	1000	2.54268	2.54878	-0.00610	.	.	.
49	10	B	8.0	1000	4.37805	4.08537	0.29268	.	.	.
50	20	B	0.4	20	0.13110	0.14329	-0.01220	0.484756	0.481707	0.003049
51	20	B	2.0	20	0.25610	0.25915	-0.00305	0.280488	0.286585	-0.006098
52	20	B	8.0	20	0.43902	0.41463	0.02439	0.179878	0.176829	0.003049
53	20	B	0.4	100	0.41463	0.45732	-0.04268	0.673780	0.676829	-0.003049
54	20	B	2.0	100	0.81402	0.81098	0.00305	0.408537	0.414634	-0.006098
55	20	B	8.0	100	1.39939	1.30183	0.09756	0.265244	0.265244	0.000000
56	20	B	0.4	500	0.99390	1.05183	-0.05793	.	.	.
57	20	B	2.0	500	1.88720	1.85976	0.02744	0.719512	0.719512	0.000000
58	20	B	8.0	500	3.20732	2.98780	0.21951	0.487805	0.475610	0.012195
59	20	B	0.4	1000	1.31402	1.38720	-0.07317	.	.	.
60	20	B	2.0	1000	2.46951	2.44512	0.02439	.	.	.
61	20	B	8.0	1000	4.18293	3.90244	0.28049	.	.	.
62	30	B	0.4	20	0.11585	0.11280	0.00305	0.426829	0.435976	-0.009146
63	30	B	2.0	20	0.21037	0.20122	0.00915	0.256098	0.259146	-0.003049
64	30	B	8.0	20	0.34146	0.33537	0.00610	0.164634	0.155488	0.009146
65	30	B	0.4	100	0.37195	0.39634	-0.02439	0.597561	0.597561	0.000000
66	30	B	2.0	100	0.70122	0.70732	-0.00610	0.356707	0.359756	-0.003049
67	30	B	8.0	100	1.16463	1.13720	0.02744	0.231707	0.231707	0.000000
68	30	B	0.4	500	0.95122	0.99695	-0.04573	.	.	.
69	30	B	2.0	500	1.76829	1.75915	0.00915	0.621951	0.628049	-0.006098
70	30	B	8.0	500	2.93598	2.82317	0.11280	0.414634	0.411585	0.003049
71	30	B	0.4	1000	1.28049	1.33232	-0.05183	.	.	.
72	30	B	2.0	1000	2.36890	2.34146	0.02744	0.847561	0.847561	0.000000
73	30	B	8.0	1000	3.94207	3.75000	0.19207	0.573171	0.564024	0.009146
74	40	B	0.4	20	0.10366	0.10061	0.00305	0.375000	0.402439	-0.027439
75	40	B	8.0	20	0.28659	0.30488	-0.01829	0.152439	0.143293	0.009146
76	40	B	0.4	100	0.33941	0.36585	-0.02744	0.545732	0.545732	0.000000
77	40	B	2.0	100	0.61280	0.64024	-0.02744	0.329268	0.329268	0.000000
78	40	B	8.0	100	0.99085	1.03659	-0.04573	0.213415	0.207317	0.006098
79	40	B	0.4	500	0.90244	0.94512	-0.04268	0.896341	0.902439	-0.006098
80	40	B	2.0	500	1.64634	1.66768	-0.02134	0.554878	0.564024	-0.009146

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                                ANALYSIS FOR TRAPEZOICAL CHANNELS
                                        SIDE SLOPE=6:1

CHS   SHAPE   RET   SLOPE   FLOW    VCAL      VNOM      V_DIFF      DCAL       DNOM       C_DIFF
 81    40      B     8.0     500   2.68598   2.67378    0.01220    0.365854   0.365854    0.000000
 82    40      B     0.4    1000   1.23780   1.28049   -0.04268       .          .           .
 83    40      B     2.0    1000   2.25610   2.25610    0.00000    0.753049   0.762195   -0.009146
 84    40      B     8.0    1000   3.65207   3.55756    0.09451    0.503049   0.503049    0.000000
 85    10      C     0.4      20   0.27439   0.32012   -0.04573    0.387195   0.365854    0.021341
 86    10      C     2.0      20   0.54878   0.57317   -0.02439    0.231707   0.228659    0.003049
 87    10      C     8.0      20   0.96341   0.89939    0.06402    0.149390   0.161585   -0.012195
 88    10      C     0.4     100   0.71646   0.79878   -0.08232    0.597561   0.600610   -0.003049
 89    10      C     2.0     100   1.39329   1.40854   -0.01524    0.381098   0.381098    0.000000
 90    10      C     8.0     100   2.39939   2.27744    0.12195    0.256098   0.259146   -0.003049
 91    10      C     0.4     500   1.38110   1.49390   -0.11280       .          .           .
 92    10      C     2.0     500   2.59451   2.62805   -0.03354    0.731707   0.731707    0.000000
 93    10      C     8.0     500   4.41159   4.17073    0.24085    0.521341   0.496951    0.024390
 94    10      C     0.4    1000   1.73171   1.86280   -0.13110       .          .           .
 95    10      C     2.0    1000   3.22561   3.26829   -0.04268       .          .           .
 96    20      C     0.4      20   0.22256   0.23476   -0.01220    0.314024   0.301829    0.012195
 97    20      C     2.0      20   0.41463   0.41159    0.00305    0.189024   0.185976    0.003049
 98    20      C     8.0      20   0.68293   0.68598   -0.00305    0.121951   0.131098   -0.009146
 99    20      C     0.4     100   0.64939   0.67683   -0.02744    0.484756   0.472561    0.012195
100    20      C     2.0     100   1.20427   1.19512    0.00915    0.298780   0.295732    0.003049
101    20      C     8.0     100   1.99085   1.92073    0.07012    0.195122   0.204268   -0.009146
102    20      C     0.4     500   1.33841   1.39329   -0.05488       .          .           .
103    20      C     2.0     500   2.46037   2.45427    0.00610    0.594512   0.585366    0.009146
104    20      C     8.0     500   4.08841   3.90244    0.18598    0.405488   0.399390    0.006098
105    20      C     0.4    1000   1.69817   1.77744   -0.07927       .          .           .
106    20      C     2.0    1000   3.12195   3.14024   -0.01829    0.823171   0.829268   -0.006098
107    20      C     8.0    1000      .         .          .        0.573171   0.564024    0.009146
108    30      C     0.4      20   0.18293   0.18293    0.00000    0.286585   0.265244    0.021341
109    30      C     2.0      20   0.32927   0.32622    0.00305    0.170732   0.164634    0.006098
110    30      C     8.0      20   0.52744   0.52439    0.00305    0.109756   0.112805   -0.003049
111    30      C     0.4     100   0.53622   0.55451   -0.018293   0.420732   0.402439    0.018293
112    30      C     2.0     100   1.03659   1.08232   -0.045732   0.256098   0.253049    0.003049
113    30      C     8.0     100   1.67073   1.66768    0.003049   0.167683   0.173780   -0.006098
114    30      C     0.4     500   1.27744   1.30183   -0.024390   0.798780   0.795732    0.003049
115    30      C     2.0     500   2.30183   2.30183    0.000000   0.506098   0.500000    0.006098
116    30      C     8.0     500   3.74085   3.65854    0.082317   0.338415   0.341463   -0.003049
117    30      C     0.4    1000   1.64939   1.69207   -0.042683      .          .           .
118    30      C     2.0    1000   2.98476   2.98780   -0.003049   0.707317   0.713415   -0.006098
119    30      C     8.0    1000      .         .          .        0.481707   0.484756   -0.003049
120    40      C     0.4      20   0.15244   0.13415    0.018293   0.265244   0.253049    0.012195
121    40      C     2.0      20   0.26829   0.24390    0.024390   0.158537   0.155488    0.003049
122    40      C     8.0      20   0.42378   0.39634    0.027439   0.103659   0.106707   -0.003049
123    40      C     0.4     100   0.51524   0.51829   -0.003049   0.381098   0.356707    0.024390
124    40      C     2.0     100   0.90244   0.92073   -0.018293   0.231707   0.225610    0.006098
125    40      C     8.0     100   1.43598   1.47866   -0.042683   0.149390   0.158537   -0.009146
126    40      C     0.4     500   1.21037   1.21951   -0.009146   0.710366   0.698171    0.012195
127    40      C     2.0     500   2.14329   2.14939   -0.006098   0.445122   0.439024    0.006098
128    40      C     8.0     500   3.43293   3.42988    0.003049   0.295732   0.298780   -0.003049
129    40      C     0.4    1000   1.59451   1.61585   -0.021341      .          .           .
130    40      C     2.0    1000   2.83841   2.85061   -0.012195   0.625000   0.628049   -0.003049
131    40      C     8.0    1000   4.57927   4.52744    0.051829   0.420732   0.429878   -0.009146
132    10      D     0.4      20   0.37805   0.40244   -0.024390   0.307927   0.298780    0.009146
133    10      D     2.0      20   0.70732   0.71646   -0.009146   0.192073   0.185976    0.006098
134    10      D     8.0      20   1.19207   1.14939    0.042683   0.125000   0.128049   -0.003049
135    10      D     0.4     100   0.78049   0.87500   -0.094512   0.551829   0.567073   -0.015244
136    10      D     2.0     100   1.51524   1.53354   -0.018293   0.359756   0.356707    0.003049
137    10      D     8.0     100   2.54878   2.45732    0.091463   0.246951   0.243902    0.003049
138    10      D     0.4     500   1.40244   1.47866   -0.076220      .          .           .
139    10      D     2.0     500   2.59146   2.60671   -0.015244   0.734756   0.731707    0.003049
140    10      D     8.0     500   4.36280   4.16463    0.198171   0.524390   0.496951    0.027439
141    10      D     0.4    1000   1.71646   1.81098   -0.094512      .          .           .
142    10      D     2.0    1000   3.16463   3.18293   -0.018293      .          .           .
143    20      D     0.4      20   0.31402   0.32927   -0.015244   0.237805   0.225610    0.012195
144    20      D     2.0      20   0.55488   0.57927   -0.024390   0.146341   0.140244    0.006098
145    20      D     8.0      20   0.88720   0.89939   -0.012195   0.094512   0.097561   -0.003049
146    20      D     0.4     100   0.73780   0.74390   -0.006098   0.439024   0.432927    0.006098
147    20      D     2.0     100   1.33232   1.31707    0.015244   0.274390   0.271341    0.003049
148    20      D     8.0     100   2.16159   2.10061    0.060976   0.182927   0.189024   -0.006098
149    20      D     0.4     500   1.36280   1.39634   -0.033537      .          .           .
150    20      D     2.0     500   2.47256   2.46951    0.003049   0.594512   0.585366    0.009146
151    20      D     8.0     500   4.07012   3.92073    0.149390   0.408537   0.399390    0.009146
152    20      D     0.4    1000   1.68902   1.74390   -0.054878      .          .           .
153    20      D     2.0    1000   3.07317   3.06402    0.009146   0.832317   0.829268    0.003049
154    20      D     8.0    1000      .         .          .        0.579268   0.564024    0.015244
155    30      D     0.4      20   0.26220   0.25915    0.003049   0.210366   0.192073    0.018293
156    30      D     2.0      20   0.45427   0.46951   -0.015244   0.128049   0.118902    0.009146
157    30      D     8.0      20   0.71037   0.74390   -0.033537   0.082317   0.085366   -0.003049
158    30      D     0.4     100   0.66768   0.67073   -0.003049   0.375000   0.359756    0.015244
159    30      D     2.0     100   1.16768   1.17378   -0.006098   0.228659   0.225610    0.003049
160    30      D     8.0     100   1.85671   1.89024   -0.033537   0.152439   0.158537   -0.006098
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                                   ANALYSIS FOR TRAPEZOIDAL CHANNELS
                                          SIDE SLOPE=6:1

OBS   SHAPE   REP   SLOPE   FLOW    VCAL      VNOM      V_DIFF      DCAL       DNOM       D_DIFF

161    30      D     0.4     500   1.30793   1.32012   -0.012195   0.783537   0.795732   -0.012195
162    30      D     2.0     500   2.32622   2.32622    0.000000   0.500000   0.500000    0.000000
163    30      D     8.0     500   3.75610   3.71951    0.036585   0.338415   0.341463   -0.003049
164    30      D     0.4    1000   1.64634   1.67073   -0.024390    .          .           .
165    30      D     2.0    1000   2.94817   2.93598    0.012195   0.716463   0.713415    0.003049
166    30      D     8.0    1000    .         .           .        0.496951   0.484756    0.012195
167    40      D     0.4      20   0.22256   0.21341    0.009146   0.189024   0.170732    0.018293
168    40      D     2.0      20   0.38110   0.38110    0.000000   0.115854   0.106707    0.009146
169    40      D     8.0      20   0.59451   0.62500   -0.030488   0.076220   0.076220    0.000000
170    40      D     0.4     100   0.60061   0.60366   -0.003049   0.332317   0.317073    0.015244
171    40      D     2.0     100   1.03963   1.05793   -0.018293   0.204268   0.198171    0.006098
172    40      D     8.0     100   1.62805   1.68902   -0.060976   0.134146   0.137195   -0.003049
173    40      D     0.4     500   1.24695   1.24390    0.003049   0.695122   0.698171   -0.003049
174    40      D     2.0     500   2.17988   2.18598   -0.006098   0.439024   0.439024    0.000000
175    40      D     8.0     500   3.47256   3.49695   -0.024390   0.292683   0.298780   -0.006098
176    40      D     0.4    1000   1.55451   1.55146    0.003049    .          .           .
177    40      D     2.0    1000   2.81402   2.78963    0.024390   0.631098   0.628049    0.003049
178    40      D     8.0    1000   4.52134   4.49695    0.024390   0.423780   0.429878   -0.006098
179    10      F     0.4      20   0.54268   0.57317   -0.030488   0.234756   0.225610    0.009146
180    10      F     2.0      20   0.97561   1.02134   -0.045732   0.146341   0.140244    0.006098
181    10      F     8.0      20   1.60671   1.62500   -0.018293   0.097561   0.097561    0.000000
182    10      F     0.4     100   1.06707   1.11585   -0.048780   0.457317   0.469512   -0.012195
183    10      F     2.0     100   1.56037   1.59085   -0.030488   0.298780   0.295732    0.003049
184    10      F     8.0     100   3.25000   3.13415    0.115854   0.204268   0.204268    0.000000
185    10      F     0.4     500   1.76829   1.85976   -0.091463    .          .           .
186    10      F     2.0     500   3.26829   3.23171    0.036585   0.634146   0.631098    0.003049
187    10      F     8.0     500    .         .           .        0.451220   0.432927    0.018293
188    10      F     0.4    1000   2.16463   2.25610   -0.091463    .          .           .
189    10      F     2.0    1000   3.96951   3.96951    0.000000    .          .           .
190    20      F     0.4      20   0.45122   0.45732   -0.006098   0.173780   0.164634    0.009146
191    20      F     2.0      20   0.77744   0.79878   -0.021341   0.109756   0.103659    0.006098
192    20      F     8.0      20   1.21951   1.28049   -0.060976   0.070122   0.073171   -0.003049
193    20      F     0.4     100   0.96951   0.96341    0.006098   0.353659   0.344512    0.009146
194    20      F     2.0     100   1.71341   1.70732    0.006098   0.222561   0.216463    0.006098
195    20      F     8.0     100   2.73780   2.73780    0.000000   0.149390   0.149390    0.000000
196    20      F     0.4     500   1.72256   1.75305   -0.030488   0.768293   0.786585   -0.018293
197    20      F     2.0     500   3.09451   3.07927    0.015244   0.503049   0.496951    0.006098
198    20      F     8.0     500    .         .           .        0.344512   0.338415    0.006098
199    20      F     0.4    1000   2.12195   2.17073   -0.048780    .          .           .
200    20      F     2.0    1000   3.83232   3.81098    0.021341   0.713415   0.716463   -0.003049
201    20      F     8.0    1000    .         .           .        0.493902   0.484756    0.009146
202    30      F     0.4      20   0.38415   0.36585    0.018293   0.146341   0.134146    0.012195
203    30      F     2.0      20   0.64634   0.67683   -0.030488   0.091463   0.082317    0.009146
204    30      F     8.0      20   1.00000   1.06098   -0.060976   0.057927   0.042683    0.015244
205    30      F     0.4     100   0.86890   0.85976    0.009146   0.298780   0.280488    0.018293
206    30      F     2.0     100   1.50000   1.50915   -0.009146   0.182927   0.176829    0.006098
207    30      F     8.0     100   2.35671   2.42378   -0.067073   0.121951   0.125000   -0.003049
208    30      F     0.4     500   1.64634   1.64024    0.006098   0.658537   0.664634   -0.006098
209    30      F     2.0     500   2.89024   2.87500    0.015244   0.420732   0.417683    0.003049
210    30      F     8.0     500   4.62805   4.57317    0.054878   0.283537   0.283537    0.000000
211    30      F     0.4    1000   2.05793   2.07317   -0.015244    .          .           .
212    30      F     2.0    1000   3.65549   3.62805    0.027439   0.606707   0.603659    0.003049
213    30      F     8.0    1000    .         .           .        0.411585   0.411585    0.000000
214    40      F     0.4      20   0.33232   0.32012    0.012195   0.131098   0.115854    0.015244
215    40      F     2.0      20   0.55488   0.55793   -0.003049   0.079268   0.073171    0.006098
216    40      F     8.0      20   0.85671   0.89939   -0.042683   0.051829   0.039634    0.012195
217    40      F     0.4     100   0.78659   0.76220    0.024390   0.262195   0.243902    0.018293
218    40      F     2.0     100   1.33537   1.34756   -0.012195   0.161585   0.152439    0.009146
219    40      F     8.0     100   2.07622   2.15854   -0.082317   0.106707   0.091463    0.015244
220    40      F     0.4     500   1.56098   1.53659    0.024390   0.579268   0.585366   -0.006098
221    40      F     2.0     500   2.70122   2.69207    0.009146   0.365854   0.365854    0.000000
222    40      F     8.0     500   4.26829   4.28049   -0.012195   0.243902   0.253049   -0.009146
223    40      F     0.4    1000   1.98476   1.96951    0.015244   0.829268   0.847561   -0.018293
224    40      F     2.0    1000   3.47256   3.46646    0.006098   0.530488   0.530488    0.000000
225    40      F     8.0    1000    .         .           .        0.356707   0.362805   -0.006098
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ANALYSIS FOR TRAPEZOIDAL CHANNELS
SIDE SLOPE=4:1

OBS	SHAPE	RET	SLOPE	FLOW	VCAL	VNCM	V_DIFF	DCAL	DNCM	D_DIFF
1	10	A	0.4	100	0.34451	0.43902	-0.09451	.	.	.
2	10	A	2.0	100	0.73171	0.77744	-0.04573	.	.	.
3	10	A	8.0	100	1.33537	1.27134	0.06402	.	.	.
4	10	A	0.4	500	0.85671	1.00610	-0.14939	.	.	.
5	10	A	2.0	500	1.68292	1.76829	-0.08537	.	.	.
6	10	A	8.0	500	2.95122	2.85061	0.10061	.	.	.
7	10	A	0.4	1000	1.14634	1.29573	-0.14939	.	.	.
8	10	A	2.0	1000	2.20427	2.27134	-0.06707	.	.	.
9	10	A	8.0	1000	3.81707	3.65854	0.15854	.	.	.
10	20	A	0.4	100	0.31098	0.35061	-0.03963	.	.	.
11	20	A	2.0	100	0.61890	0.60976	0.00915	.	.	.
12	20	A	0.4	500	0.82317	0.89939	-0.07622	.	.	.
13	20	A	2.0	500	1.58232	1.58537	-0.00305	.	.	.
14	20	A	8.0	500	2.69512	2.56402	0.13110	.	.	.
15	20	A	0.4	1000	1.12195	1.20732	-0.08537	.	.	.
16	20	A	2.0	1000	2.12500	2.11890	0.00610	.	.	.
17	20	A	8.0	1000	3.60366	3.42073	0.18293	.	.	.
18	30	A	0.4	100	0.27439	0.28963	-0.01524	.	.	.
19	30	A	2.0	100	0.92439	0.90915	0.01524	.	.	.
20	30	A	8.0	100	0.87195	0.84451	0.02744	.	.	.
21	30	A	0.4	500	0.78049	0.82317	-0.04268	.	.	.
22	30	A	2.0	500	1.45732	1.44207	0.01524	0.789634	0.777439	0.0121951
23	30	A	8.0	500	2.42073	2.34146	0.07927	0.521341	0.524390	-0.0030488
24	30	A	0.4	1000	1.08232	1.13720	-0.05488	.	.	.
25	30	A	2.0	1000	2.01220	2.00000	0.01220	.	.	.
26	30	A	8.0	1000	3.34756	3.23171	0.11585	.	.	.
27	40	A	0.4	100	0.24085	0.25305	-0.01220	.	.	.
28	40	A	2.0	100	0.44512	0.42988	0.01524	.	.	.
29	40	A	8.0	100	0.72866	0.72256	0.00610	.	.	.
30	40	A	0.4	500	0.73171	0.76220	-0.03049	.	.	.
31	40	A	2.0	500	1.33537	1.33537	0.00000	0.704268	0.701220	0.0030488
32	40	A	8.0	500	2.17683	2.15244	0.02439	0.463415	0.472561	-0.0091463
33	40	A	0.4	1000	1.03963	1.07012	-0.03049	.	.	.
34	40	A	2.0	1000	1.89329	1.89634	-0.00305	.	.	.
35	40	A	8.0	1000	3.09756	3.05488	0.04268	.	.	.
36	10	B	0.4	20	0.19207	0.22866	-0.03659	0.560976	0.551829	0.0091463
37	10	B	2.0	20	0.39024	0.40244	-0.01220	0.329268	0.332317	-0.0030488
38	10	B	8.0	20	0.68902	0.65549	0.03354	0.210366	0.210366	0.0000000
39	10	B	0.4	100	0.54878	0.62805	-0.07927	0.820122	0.817073	0.0030488
40	10	B	2.0	100	1.09756	1.10671	-0.00915	0.509146	0.506098	0.0030488
41	10	B	8.0	100	1.91768	1.77439	0.14329	0.335366	0.335366	0.0000000
42	10	B	0.4	500	1.17988	1.29573	-0.11585	.	.	.
43	10	B	2.0	500	2.25000	2.27744	-0.02744	.	.	.
44	10	B	8.0	500	3.85671	3.65854	0.19817	.	.	.
45	10	B	0.4	1000	1.51829	1.63110	-0.11280	.	.	.
46	10	B	2.0	1000	2.85671	2.88110	-0.02439	.	.	.
47	10	B	8.0	1000	4.86890	4.57317	0.29573	.	.	.
48	20	B	0.4	20	0.15244	0.17073	-0.01829	0.460366	0.460366	0.0000000
49	20	B	2.0	20	0.28659	0.31098	-0.02439	0.271341	0.271341	0.0000000
50	20	B	8.0	20	0.47561	0.51829	-0.04268	0.176829	0.167683	0.0091463
51	20	B	0.4	100	0.48476	0.51829	-0.03354	0.664634	0.661585	0.003049
52	20	B	2.0	100	0.91463	0.91463	0.00000	0.402439	0.405488	-0.003049
53	20	B	8.0	100	1.52134	1.30488	0.21646	0.259146	0.259146	0.000000
54	20	B	0.4	500	1.13110	1.15854	-0.02744	.	.	.
55	20	B	2.0	500	2.09756	2.09756	0.00000	0.743902	0.722561	0.021341
56	20	B	8.0	500	3.49390	3.36890	0.12500	0.500000	0.487805	0.012195
57	20	B	0.4	1000	1.47866	1.54573	-0.06707	.	.	.
58	20	B	2.0	1000	2.73780	2.71951	0.01829	.	.	.
59	20	B	8.0	1000	4.56707	4.35671	0.21037	.	.	.
60	30	B	0.4	20	0.12500	0.13720	-0.01220	0.411585	0.423780	-0.012195
61	30	B	2.0	20	0.22256	0.22866	-0.00610	0.250000	0.243902	0.006098
62	30	B	8.0	20	0.35976	0.38110	-0.02134	0.161585	0.149390	0.012195
63	30	B	0.4	100	0.42073	0.42683	-0.00610	0.588415	0.585366	0.003049
64	30	B	2.0	100	0.76524	0.77744	-0.01220	0.350610	0.353659	-0.003049
65	30	B	8.0	100	1.23476	1.24390	-0.00915	0.228659	0.225610	0.003049
66	30	B	0.4	500	1.06402	1.09756	-0.03354	.	.	.
67	30	B	2.0	500	1.92378	1.92683	-0.00305	0.631098	0.628049	0.003049
68	30	B	8.0	500	3.13110	3.10366	0.02744	0.417683	0.417683	0.000000
69	30	B	0.4	1000	1.42378	1.45732	-0.03354	.	.	.
70	30	B	2.0	1000	2.58232	2.57012	0.01220	.	.	.
71	30	B	8.0	1000	4.22256	4.10366	0.11890	.	.	.
72	40	B	0.4	20	0.10976	0.19817	-0.08841	0.381098	0.393293	-0.012195
73	40	B	2.0	20	0.18902	0.18293	0.00610	0.231707	0.222561	0.009146
74	40	B	8.0	20	0.29268	0.30488	-0.01220	0.149390	0.137195	0.012195
75	40	B	0.4	100	0.36890	0.38110	-0.01220	0.530488	0.533537	-0.003049
76	40	B	2.0	100	0.64939	0.67683	-0.02744	0.323171	0.317073	0.006098
77	40	B	8.0	100	1.03963	1.08232	-0.04268	0.210366	0.201220	0.009146
78	40	B	0.4	500	0.99390	1.01524	-0.02134	0.899390	0.890244	0.009146
79	40	B	2.0	500	1.76524	1.80183	-0.03659	0.557927	0.554878	0.003049
80	40	B	8.0	500	2.82622	2.88415	-0.05793	0.365854	0.368902	-0.003049

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                         ANALYSIS FOR TRAPEZOIDAL CHANNELS
                                SIDE SLOPE=4:1

OBS  SHAPE  RET  SLOPE  FLOW   VCAL     VNOM      V_DIFF     DCAL       DNOM       C_DIFF
 81   40     B    0.4   1000  1.35976  1.38110  -0.02134
 82   40     B    2.0   1000  2.42378  2.42988  -0.00610       .          .           .
 83   40     B    8.0   1000  3.90549  3.90244   0.00305   0.765244   0.762195    0.003049
 84   10     C    0.4     20  0.32317  0.36585  -0.04268   0.509146   0.515244   -0.006098
 85   10     C    2.0     20  0.62805  0.64024  -0.01220   0.381098   0.362805    0.018293
 86   10     C    8.0     20  1.06402  1.03659   0.02744   0.228659   0.234756   -0.005098
 87   10     C    0.4    100  0.82927  0.89939  -0.07012   0.146341   0.155488   -0.009146
 88   10     C    2.0    100  1.56707  1.57622  -0.00915   0.618902   0.603659    0.015244
 89   10     C    8.0    100  2.64024  2.53354   0.10671   0.390244   0.390244    0.000000
 90   10     C    0.4    500  1.55183  1.65244  -0.10061   0.262195   0.262195    0.000000
 91   10     C    2.0    500  2.88415  2.90244  -0.01829       .          .           .
 92   10     C    8.0    500  4.85366  4.60366   0.25000   0.792683   0.786585    0.006098
 93   10     C    0.4   1000  1.93293  2.04268  -0.10976   0.554878   0.527439    0.027439
 94   10     C    2.0   1000  3.57317  3.58232  -0.00915       .          .           .
 95   20     C    0.4     20  0.25000  0.25915  -0.00915       .          .           .
 96   20     C    2.0     20  0.44817  0.45732  -0.00915   0.310976   0.292683    0.018293
 97   20     C    8.0     20  0.71951  0.73171  -0.01220   0.185976   0.189024   -0.003049
 98   20     C    0.4    100  0.72561  0.73171  -0.00610   0.118902   0.128049   -0.009146
 99   20     C    2.0    100  1.30488  1.24085   0.06402   0.484756   0.466463    0.018293
100   20     C    8.0    100  2.10671  2.09146   0.01524   0.298780   0.301829   -0.003049
101   20     C    0.4    500  1.48171  1.50915  -0.027439  0.195122   0.201220   -0.006098
102   20     C    2.0    500  2.67988  2.66768   0.012195      .          .           .
103   20     C    8.0    500  4.37805  4.24390   0.134146  0.615854   0.618902   -0.0030488
104   20     C    0.4   1000  1.87805  1.92683  -0.048780  0.417683   0.420732   -0.0030488
105   20     C    2.0   1000  3.40854  3.41463  -0.006098      .          .           .
106   30     C    0.4     20  0.19817  0.18902   0.009146      .          .           .
107   30     C    2.0     20  0.34451  0.33537   0.009146  0.277439   0.262195    0.0152439
108   30     C    8.0     20  0.54268  0.54878  -0.006098  0.167683   0.170732   -0.0030488
109   30     C    0.4    100  0.63110  0.61890   0.012195  0.109756   0.112805   -0.0030488
110   30     C    2.0    100  1.09756  0.93293   0.164634  0.417683   0.417683    0.0000000
111   30     C    8.0    100  1.73780  1.75305  -0.015244  0.253049   0.259146   -0.0060976
112   30     C    0.4    500  1.35329  1.35329   0.000000  0.167683   0.170732   -0.0030488
113   30     C    2.0    500  2.45732  2.46951  -0.012195  0.817073   0.804878    0.0121951
114   30     C    8.0    500  3.92989  3.93293  -0.003049  0.515244   0.518293   -0.0030488
115   30     C    0.4   1000  1.80488  1.80793  -0.003049  0.341463   0.347561   -0.0060976
116   30     C    2.0   1000  3.20732  3.21341  -0.006098      .          .           .
117   30     C    8.0   1000     .        .         .      0.731707   0.737805   -0.0060976
118   30     C    0.4    500  1.40854  1.40244   0.006098  0.493902   0.493902    0.0000000
119   40     C    0.4     20  0.16463  0.14024   0.024390  0.810976   0.804878    0.0060976
120   40     C    2.0     20  0.28049  0.25305   0.027439  0.262195   0.243902    0.0182927
121   40     C    8.0     20  0.43902  0.42683   0.012195  0.158537   0.158537    0.0000000
122   40     C    0.4    100  0.54878  0.54878   0.000000  0.103659   0.106707   -0.0030488
123   40     C    2.0    100  0.94512  0.94512   0.000000  0.375000   0.356707    0.0182927
124   40     C    8.0    100  1.47866  1.52439  -0.045732  0.228659   0.228659    0.0000000
125   40     C    0.4    500  1.30183  1.28659   0.015244  0.149390   0.155488   -0.0060976
126   40     C    2.0    500  2.25915  2.26829  -0.009146  0.722561   0.698171    0.0243902
127   40     C    8.0    500  3.56402  3.59756  -0.033537  0.448171   0.451220   -0.0030488
128   40     C    0.4   1000  1.72256  1.70732   0.015244  0.295732   0.301829   -0.0060976
129   40     C    2.0   1000  3.00915  3.01220  -0.003049      .          .           .
130   40     C    8.0   1000     .        .         .      0.637195   0.640244   -0.0030488
131   10     D    0.4     20  0.42378  0.45732  -0.033537  0.426829   0.432927   -0.0060976
132   10     D    2.0     20  0.78049  0.79878  -0.018293  0.314024   0.295732    0.0182927
133   10     D    8.0     20  1.28354  1.27439   0.009146  0.189024   0.192073   -0.0030488
134   10     D    0.4    100  0.50854  0.55122  -0.042683  0.125000   0.131098   -0.0060976
135   10     D    2.0    100  1.66768  1.68293  -0.015244  0.582317   0.585366   -0.0030488
136   10     D    8.0    100  2.75915  2.68902   0.070122  0.375000   0.378049   -0.0030488
137   10     D    0.4    500  1.55488  1.63110  -0.076220  0.253049   0.253049    0.0000000
138   10     D    2.0    500  2.85366  2.86585  -0.012195      .          .           .
139   10     D    8.0    500  4.76829  4.57317   0.195122  0.795732   0.786585    0.0091463
140   10     D    0.4   1000  1.89939  1.98780  -0.088415  0.560976   0.536585    0.0243902
141   10     D    2.0   1000  3.48476  3.50610  -0.021341      .          .           .
142   20     D    0.4     20  0.33841  0.34146  -0.003049      .          .           .
143   20     D    2.0     20  0.58537  0.60976  -0.024390  0.237805   0.228659    0.0091463
144   20     D    8.0     20  0.91768  0.96951  -0.051829  0.146341   0.152439   -0.0060976
145   20     D    0.4    100  0.80793  0.81098  -0.003049  0.094512   0.100610   -0.0060976
146   20     D    2.0    100  1.42073  1.42683  -0.006098  0.445122   0.435976    0.0091463
147   20     C    8.0    100  2.26524  2.28659  -0.021341  0.277439   0.280488   -0.0030488
148   20     D    0.4    500  1.49390  1.50915  -0.015244  0.182927   0.189024   -0.0060976
149   20     D    2.0    500  2.66768  2.66768   0.000000      .          .           .
150   20     D    8.0    500  4.33841  4.26829   0.070122  0.618902   0.618902    0.0000000
151   20     D    0.4   1000  1.85061  1.89634  -0.045732  0.420732   0.414634    0.0060976
152   20     D    2.0   1000  3.33841  3.33841   0.000000      .          .           .
153   30     D    0.4     20  0.27439  0.27439   0.000000      .          .           .
154   30     D    2.0     20  0.46646  0.48780  -0.021341  0.204268   0.201220    0.0030488
155   30     D    8.0     20  0.72561  0.78659  -0.060976  0.125000   0.131098   -0.0060976
156   30     D    0.4    100  0.71037  0.70427   0.006098  0.082317   0.085366   -0.0030488
157   30     D    2.0    100  1.22256  1.24085  -0.018293  0.371951   0.369902    0.0030488
158   30     D    8.0    100  1.91463  1.98171  -0.067073  0.231707   0.237805   -0.0060975
159   30     D    2.0    500  2.46646  2.46951  -0.003049  0.152439   0.158537   -0.0060976
160   30     C    8.0    500  3.92683  3.95122  -0.024390  0.512195   0.518293   -0.0060976
                                                          0.341463   0.347561   -0.0060976
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                              ANALYSIS FOR TRAPEZOIDAL CHANNELS
                                       SIDE SLOPE=4:1

OBS   SHAPE   RET   SLOPE   FLOW    VCAL      VNOM      V_DIFF       DCAL       DNOM       D_DIFF

161    30      D     0.4    1000   1.78354   1.78659   -0.003049      .          .           .
162    30      D     2.0    1000   3.15244   3.14634    0.006098   0.740854   0.737805    0.0030488
163    30      D     8.0    1000    .         .          .          0.500000   0.493902    0.0060976
164    40      D     0.4      20   0.23476   0.21341    0.021341   0.189024   0.179878    0.0091463
165    40      D     2.0      20   0.39329   0.41463   -0.021341   0.115854   0.118902   -0.0030488
166    40      D     8.0      20   0.60366   0.66463   -0.060976   0.076220   0.076220    0.0000000
167    40      D     0.4     100   0.63415   0.60976    0.024390   0.332317   0.323171    0.0091463
168    40      D     2.0     100   1.07317   1.07317    0.000000   0.204268   0.210366   -0.0060976
169    40      D     8.0     100   1.66768   1.73780   -0.070122   0.134146   0.140244   -0.0060976
170    40      D     0.4     500   1.32927   1.29573    0.033537   0.710366   0.698171    0.0121951
171    40      D     2.0     500   2.28354   2.28659   -0.003049   0.445122   0.451220   -0.0060976
172    40      D     8.0     500   3.59146   3.64329   -0.051829   0.295732   0.301829   -0.0060976
173    40      D     0.4    1000   1.71037   1.68598    0.024390      .          .           .
174    40      D     2.0    1000   2.97256   2.95732    0.015244   0.646341   0.640244    0.0060976
175    40      D     8.0    1000    .         .          .          0.432927   0.432927    0.0000000
176    10      F     0.4      20   0.59146   0.59451   -0.003049   0.240854   0.231707    0.0091463
177    10      F     2.0      20   1.05488   1.05183    0.003049   0.146341   0.152439   -0.0060976
178    10      F     8.0      20   1.69817   1.67073    0.027439   0.097561   0.100610   -0.0030488
179    10      F     0.4     100   1.17988   1.18902   -0.009146   0.481707   0.484756   -0.0030488
180    10      F     2.0     100   2.13110   2.09756    0.033537   0.310976   0.314024   -0.0030488
181    10      F     8.0     100   3.47866   3.35976    0.118902   0.210366   0.210366    0.0000000
182    10      F     0.4     500   1.96646   1.99695   -0.030488      .          .           .
183    10      F     2.0     500   3.57622   3.50610    0.070122   0.682927   0.689024   -0.0060976
184    10      F     8.0     500    .         .          .          0.478659   0.463415    0.0152439
185    20      F     0.4      20   0.47561   0.47256    0.003049   0.176829   0.170732    0.0060976
186    20      F     2.0      20   0.80488   0.82927   -0.024390   0.106707   0.112805   -0.0060976
187    20      F     8.0      20   1.24695   1.32622   -0.079268   0.070122   0.073171   -0.0030488
188    20      F     0.4     100   1.03964   1.03659    0.003049   0.362805   0.356707    0.0060976
189    20      F     2.0     100   1.79878   1.80793   -0.009146   0.225610   0.228659   -0.0030488
190    20      F     8.0     100   2.84146   2.88720   -0.045732   0.149390   0.152439   -0.0030488
191    20      F     0.4     500   1.95427   1.82927    0.125000      .          .           .
192    20      F     0.4     500   1.87195   1.88110   -0.009146   0.810976   0.804878    0.0060976
193    20      F     2.0     500   3.31402   3.29268    0.021341   0.521341   0.521341    0.0000000
194    20      F     8.0     500    .         .          .          0.353659   0.350610    0.0030488
195    20      F     2.0    1000    .         .          .          0.753049   0.756098   -0.0030488
196    20      F     8.0    1000    .         .          .          0.515244   0.509146    0.0060976
197    30      F     0.4      20   0.39634   0.38110    0.015244   0.146341   0.146341    0.0000000
198    30      F     2.0      20   0.65854   0.67683   -0.018293   0.091463   0.094512   -0.0030488
199    30      F     8.0      20   1.01829   1.08232   -0.064024   0.060976   0.060976    0.0000000
200    30      F     0.4     100   0.91768   0.88415    0.033537   0.298780   0.295732    0.0030488
201    30      F     2.0     100   1.55183   1.56707   -0.01524    0.185976   0.192073   -0.0060975
202    30      F     8.0     100   2.41159   2.51524   -0.10366    0.121951   0.131098   -0.0091463
203    30      F     0.4     500   1.75915   1.73780    0.02134    0.679878   0.673780    0.0060976
204    30      F     2.0     500   3.04269   3.03354    0.00915    0.429878   0.435976   -0.0060976
205    30      F     8.0     500    .         .          .          0.286585   0.292683   -0.0060976
206    30      F     2.0    1000    .         .          .          0.625000   0.634146   -0.0091463
207    30      F     8.0    1000    .         .          .          0.420732   0.426829   -0.0060976
208    40      F     0.4      20   0.34146   0.32012    0.02134    0.131098   0.134146   -0.0030488
209    40      F     2.0      20   0.56402   0.56402    0.00000    0.079268   0.088415   -0.0091463
210    40      F     8.0      20   0.86585   0.89939   -0.03354    0.051829   0.054878   -0.0030488
211    40      F     0.4     100   0.81707   0.77744    0.03963    0.262195   0.262195    0.0000000
212    40      F     2.0     100   1.36585   1.37195   -0.00610    0.161585   0.167683   -0.0060976
213    40      F     0.4     500   1.64939   1.61585    0.03354    0.591463   0.582317    0.0091463
214    40      F     2.0     500   2.80793   2.79878    0.00915    0.368902   0.375000   -0.0060976
215    40      F     8.0     500   4.39024   4.46646   -0.07622    0.243902   0.253049   -0.0091463
216    40      F     0.4    1000   2.11280   2.06707    0.04573    0.856707   0.844512    0.0121951
217    40      F     2.0    1000   3.64024   3.64329   -0.00305    0.542683   0.545732   -0.0030488
218    40      F     8.0    1000    .         .          .          0.362805   0.368902   -0.0060976
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VITA

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Candidate for the Degree of

Master of Science

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Biographical:

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