FAN

An Alluvial Fan Flooding Computer Program

User's Manual and Program Disk

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SECTION 1 — INTRODUCTION

1.1 BACKGROUND AND PURPOSE

In 1968, the National Flood Insurance Program (NFIP) was created as a multifaceted program for addressing the rising costs of flood damage. Since the passage of the Flood Disaster Protection Act of 1973, a major emphasis of the NFIP, which is administered by the Federal Emergency Management Agency (FEMA), has been identifying and mapping flood hazards in flood-prone communities nationwide. This identification and mapping effort has resulted in the evaluations of flood risks by detailed methods in more than 11,000 communities and evaluations by approximate methods for an additional 7,000 communities.

The flood risk data that were developed from these evaluations have been published on Flood Insurance Rate Maps (FIRMs) and in Flood Insurance Study (FIS) reports. These data provide the basis for flood insurance premium rates as well as for local floodplain management measures required for participation in the NFIP.

By 1979, FEMA recognized that standard procedures for evaluating riverine flood risks could not be used to evaluate flood risks attendant to alluvial fan flooding. Alluvial fan flooding is flooding that occurs on the surface of an alluvial fan or similar landform which originates at the "apex" and is characterized by high-velocity flows; active processes of erosion, sediment transport, and deposition; and unpredictable flow paths. Apex means a point on an alluvial fan or similar landform below which the flow path of the major stream that formed the fan becomes unpredictable and alluvial fan flooding can occur.

Some of the flood hazards associated with alluvial fan flooding are flash flooding, unpredictable flow paths, and a high velocity of flow coupled with the material of the landforms being highly susceptible to erosion. FEMA recognized these significant floods hazards and the high level of interest in development on alluvial fans, and adopted, for flood insurance purposes, a methodology for evaluating and mapping flood hazards on alluvial fans.

The computer program, FAN, discussed in this manual, was developed by FEMA to assist users in applying this methodology.

1.2 MANUAL FORMAT

This manual is comprised of six sections and two appendixes. The topics covered are described below.

- Section 1 Introduction
- Section 2 Derivation of the method for mapping special flood hazards on alluvial fans
- Section 3 Description of the FAN Program
- Section 4 Input requirements and output
- Section 5 FAN Program example runs
- Section 6 References
- Appendix A Supplement to Derivation
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1.3 UNDERSTANDING THE METHODOLOGY

The FEMA methodology for determining flood hazards from alluvial fan flooding is simply the application of the definition for the 100-year flood. The application of the definition that is used in the FAN program is discussed in Section 2. The following analogy is presented to familiarize program users with such an application.

A small structure is to be built at a point on the surface of and 477 feet from, the center of a large cone. However, a man who lives at the peak of the cone makes building this structure a problem. The man has a collection of iron balls, ranging in diameter from 10 to 60 feet. Once a year, this man rolls a die and, depending on the outcome of the roll, chooses a ball from his collection. If he rolls a "1" he chooses a 10-foot-diameter ball; if he rolls a "2" he chooses a 20-foot-diameter ball; and so on. The man takes the chosen ball, places it at the peak of the cone, and lets it go. The ball rolls down the cone, taking an unpredictable path, and flattens anything in its way.
The structure could be built so that it will withstand the impact of an iron ball — but it is not practical to construct it to withstand the impact of a ball with a diameter of more than 20 feet. Therefore, the risk in any given year of being hit by a ball that has a diameter of more than 20 feet must be calculated. Two uncertainties are to be considered in this calculation:

1. The outcome of the roll of the die is unknown.

2. The path that the ball will follow is unknown.

Because the probability of a ball taking any one path is the same as the probability of it taking any other path, the probability of our structure being hit by the ball is equal to the diameter of the ball divided by the circumference of the cone at the point on which the structure is to be built. At the building site, the circumference of the cone is 3,000 feet. Thus, if the man rolled a "2," then the probability of the 20-foot-diameter ball hitting the structure is 20 ÷ 3,000 or 0.0067. The probability of a "2" being rolled is 0.1666.

To account for both uncertainties, the definition of conditional probability is applied. If $P(A)$ is the probability that event A will occur and $P(B)$ is the probability that event B will occur, then the probability that event A will occur, given that event B has occurred, is $P(AB) \div P(B)$ and is written $P(A|B)$. $P(AB)$ is the event of both A and B occurring together.

For the example, AB denotes the event that a certain number was rolled and the structure is hit by the corresponding ball. This is the event whose probability is to be computed. Thus, not knowing whether event B will occur, the probability that events A and B will occur can be calculated as the product $P(A|B)\ P(B) = P(AB)$. The probability of the structure being hit by a 20-foot-diameter ball can be calculated by multiplying the conditional probability given above by the probability that a "2" will be rolled. Therefore, the probability of the structure being hit by a 20-foot-diameter ball in any given year is 0.0067 ÷ 6 = 0.0011.

Before calculating the probability of the structure being demolished, several events that would result in its destruction should be noted. Specifically, the structure will be destroyed if hit by a 30-, 40-, 50-, or 60-foot-diameter ball. Using the nomenclature established above, the probability of event C or event D occurring is written $P(C \cup D) = P(C) + P(D) - P(CD)$. In the example, C would denote the event that a certain number is rolled and the structure is hit by the ball (denoted AB above); D would denote the event that a different number is rolled and the structure is hit by the ball corresponding to that number. One roll of the die cannot result in two different numbers; therefore, when C includes the event of rolling one number and D includes the event of rolling another, the probability would be calculated as $P(CD) = 0$.

In that case, $P(C \cup D) = P(C) + P(D)$. Therefore, the probability that the structure will be destroyed in any given year is the sum of the probabilities of it being hit by a 30-, 40-, 50-, or 60-foot-diameter ball:

$$P(\text{destruction}) = \sum_{k=3}^{6} P_k(\text{destruction} \mid D = 10k)\, P(D = 10k)$$

where P_k is the probability of our structure being hit by a ball of diameter $D = 10k$ feet.

Thus,

$$P(\text{destruction}) = \sum_{k=3}^{6} \left(\frac{10k}{2\pi(477)}\right)\left(\frac{1}{6}\right)$$

$$= \frac{10}{5724\pi} \sum_{k=3}^{6} k$$

$$= \frac{180}{5724\pi}$$

$$= 0.01$$

A 30-foot-diameter ball could be called the 100-year ball. It is the ball with the diameter that is expected to be equaled or exceeded at the building site once in 100 years, on the long-term average. Because the probability of destruction at a given point depends on the circumference of the cone at that point, other locations on the cone will have 100-year balls of different diameters. If regions of the cone defined by their respective 100-year balls are to be mapped, the probability of destruction must be set equal to 0.01 and the equation for the circumference of the cone for each size of ball must be solved.

For example, if the 20-foot-diameter ball region is defined as that region bounded by the circles where the 100-year ball has a 20- or 30-foot-diameter, then it is the surface of the frustum that is bounded by circles of radii, r, and is computed as follows:

$$r = \frac{1}{0.01} \sum_{k=2}^{6} \left(\frac{10k}{2\pi}\right)\left(\frac{1}{6}\right) = 530 \text{ feet}$$

$$r = \frac{1}{0.01} \sum_{k=3}^{6} \left(\frac{10k}{2\pi}\right)\left(\frac{1}{6}\right) = 477 \text{ feet}$$

Thus, the map of the cone will show concentric circles separating the different regions defined by their respective 100-year balls.

If the man is replaced by Mother Nature, the die by a flood-frequency curve, the balls by the maximum peak discharge of the year, and the cone represents an area subject to alluvial fan flooding, a method for mapping special flood hazards on an alluvial fan can be derived. The approach is the same as that just described. However, the derivation is more complex and is presented in Section 2 and Appendix A.

SECTION 2 — DERIVATION

The FEMA methodology for determining flood hazards from alluvial fan flooding is simply the application of the definition of a 100-year flood. The location of the flow path during an alluvial fan flooding event is unpredictable. To determine the probability of a given point on the fan surface being flooded as a result of a storm over the watershed, the probability of the storm occurring and the probability that the flowpath of the floodwaters including that point must be considered. This section presents the derivation that is the basis for how the FAN program computes the magnitude of 100-year flood hazards in areas subject to alluvial fan flooding. If users are to recognize assumptions made in the program that are not consistent with the particular field conditions that are being analyzed and make the appropriate adjustments in their analyses, they must understand the derivation presented in this section and in Appendix A.

In the program, the assumptions made are: (1) The maximum peak discharge at the apex of the alluvial fan in any given year is independent of the peak discharge there in any other year; and (2) Those peak discharges are identically distributed from year to year. In short, the peak flows at the apex are independent and identically distributed. The floodpaths at a given elevation (i.e., on a given contour) are also assumed to be independent and identically distributed. Those assumptions lead to a definition of the 100-year flood discharge at a given point on the alluvial fan as the discharge that is expected to be exceeded at that point with a probability of 0.01 in any given year.

To illustrate the use of that definition, a simple problem that is somewhat analogous to that of defining flood hazards from alluvial fan flooding was presented in Section 1.3. This section presents the derivation of a method for mapping special flood hazards on the alluvial fan. Appendix A presents a supplement to the derivation.

2.1 BASIC APPROACH

Let H be a random variable denoting the occurrence of flooding at a given point subject to alluvial fan flooding. That is,

$$H = \begin{matrix} 1 \text{ if the point is flooded} \\ 0 \text{ if the point is not flooded} \end{matrix} \quad (2.1)$$

Let Q be a random variable denoting the peak discharge resulting from a storm over the watershed. If f_Q is the probability density function (pdf) of Q, then the probability of the point being inundated by a flood with a peak discharge of at least q_0 cubic feet per second (cfs) is

$$P(H=1) = \int_{q_0}^{\infty} P_{H|Q}(1,q)\, f_Q(q)\, dq \quad (2.2)$$

where $P_{H|Q}(1,q)$ is the probability of the point being flooded, given that the peak discharge is q cfs.

The 100-year flood discharge at a given point is defined as that discharge, q_{100}, for which the probability of the point being flooded by at least q_{100} cfs is 0.01 in any given year. That is, for each point subject to alluvial fan flooding, the 100-year flood discharge is that q_{100} which satisfies

$$0.01 = \int_{q_{100}}^{\infty} P_{H|Q}(1,q)\, f_Q(q)\, dq \qquad (2.3)$$

Therefore, if the probability of a given point being flooded by a given discharge varies with its location, then so does the magnitude of the 100-year flood discharge.

If the 100-year flood discharge is to be quantified and the flood insurance zones are to be mapped, the functions in the integrand in Equation (2.2) must be defined. The FAN program defines the conditional probability, $P_{H|Q}$ (1,q), as the ratio of the channel width formed by q cfs, w(q), and the width of the area subject to alluvial fan flooding, W, at the elevation of the point of concern. That is,

$$P_{H|Q}(1,q) = \frac{w(q)}{W} \qquad (2.4)$$

The width, W, is called the contour width.

When the contour width is much greater than the channel width [W>>w(q)], Equation (2.4) is equivalent to saying that each point on the contour has the same probability of being flooded. The definition of $P_{H|Q}(1,q)$ that is assumed in the FAN program depends on the function w(q) describing a relationship between channel width and peak discharge. This function can be derived from the assumptions outlined by Dawdy (Reference 1).

Consider a constant discharge, q, that creates a rectangular channel and flows at critical depth. Also, assume that this flow erodes the sides of the channel, resulting in an increase in channel width. Because the discharge is constant, an increase in channel width, w, must be accompanied by a decrease in depth, d, if the energy of a unit volume of water is to remain minimum. If this erosion continues until the change in width per change in depth equals -200, then the channel shape satisfies

$$\frac{dw}{dd} = -200 \qquad (2.5)$$

where $\frac{d}{dd}$ denotes differentiation with respect to depth.

Using Equation (2.5) to define channel shape, the width, $w(q)$, of a rectangular channel carrying a discharge q at critical velocity can be written

$$w(q) = 9.408\, q^{2/5} \quad (2.6)$$

The derivations of this equation are presented in Appendix A.

Thus, given that a storm will produce a peak discharge of q cfs, the program assumes that the probability of a point being inundated by that flood is

$$P_{H|Q}(1, q) = \frac{w(q)}{W}$$

$$= 9.408\, \frac{q^{2/5}}{W} \quad (2.7)$$

where W is the width of the area subject to alluvial fan flooding at the elevation of the contour on which the point lies — the contour width.

The pdf of Q, f_Q, must also be defined. The log-Pearson Type III distribution is used to define flood frequency in the program.

Let $Y = \log_{10} Q$. Thus, the probability that a storm producing a peak discharge of at least q_0 in any given year is

$$P(Q > q_0) = \int_{y_0}^{\infty} \frac{\lambda^k (y-m)^{k-1}}{\Gamma(k)}\, e^{-\lambda(y-m)}\, dy \quad (2.8)$$

where λ, k, and m are the three parameters of the Pearson Type III distribution, $\Gamma(\bullet)$ is the gamma function, and y is the base 10 logarithm of the discharge, q. Using y in the depth-discharge relationship assumed above yields

$$w(y) = 9.408(10)^{0.4y}$$

$$= 9.408\, e^{0.4\, y \ln 10}$$

$$= 9.408 e^{0.92y} \quad (2.9)$$

Using Equation (2.2), the pdf defined by the assumptions, the 100-year flood discharge at any point can be defined. It is that discharge, q_{100}, that has a base 10 logarithm such that $\log_{10} q_{100} = y_{100}$ and

$$0.01 = P(H=1) = \int_{y_{100}}^{\infty} 9.408 \frac{e^{0.92y}}{W} \frac{\lambda^k (y-m)^{k-1}}{\Gamma(k)} e^{-\lambda(y-m)} dy \qquad (2.10)$$

where W is the contour width at the elevation of the point of interest. Rearranging Equation (2.10) yields

$$0.01 = \frac{9.408C}{W} \int_{y_{100}}^{\infty} \frac{(\lambda')^k (y-m)^{k-1}}{\Gamma(k)} e^{-\lambda'(y-m)} dy \qquad (2.11)$$

where

$$C = \frac{e^{0.92m} \lambda^k}{(\lambda - 0.92)^k} \qquad (2.12)$$

and

$$\lambda' = \lambda - 0.92 \qquad (2.13)$$

A complete version of the derivation from Equation (2.11) to Equation (2.12) is presented in Appendix A.

Note that the integrand above is the Pearson Type III distribution assumed in Equation (2.8) for $\log_{10}Q$ with a change in the scaling parameter from λ to $\lambda' = \lambda - 0.92$. λ is referred to as the scaling parameter because changing it is equivalent to rescaling the random variable. For example, the integral in Equation (2.11) is the probability [defined by Equation (2.8)] that $10^{-0.92m/\lambda'} Q^{\lambda/\lambda'}$ exceeds q_{100} at the apex. Also, note that the C in Equation (2.12) may be undefined for values of λ between and including 0 and 0.92.

When the skew of the flood-frequency curve is 0, f_Q is log-normal. Therefore, instead of Equation (2.10), we have

$$0.01 = \int_{y_{100}}^{\infty} 9.408 \frac{e^{0.92y}}{W} \frac{e^{-\frac{1}{2}\left(\frac{y-\mu}{\sigma}\right)^2}}{\sigma\sqrt{2\pi}} dy \qquad (2.14)$$

where μ is the mean of Y and σ is the standard deviation.

Equation (2.14) can be rearranged to

$$0.01 = \frac{9.408\,C}{W} \int_{y_{100}}^{\infty} \frac{e^{-\frac{1}{2}\left(\frac{y-\mu'}{\sigma}\right)^2}}{\sigma\sqrt{2\pi}}\,dy \tag{2.15}$$

where

$$C = e^{0.92\mu + 0.42\sigma^2} \tag{2.16}$$

and

$$\mu' = \mu + 0.92\sigma^2 \tag{2.17}$$

The derivation for Equation (2.15) is provided in Appendix A.

Note that the integrand above is the normal distribution describing the pdf of $\log_{10} Q$ with a change in the mean from μ to $\mu' = \mu + 0.92\sigma^2$. Again, the change is equivalent to rescaling the random variable. That is, the integral in Equation (2.15) is the probability that $10^{0.92\sigma^2}\,Q$ exceeds q_{100} at the apex.

Thus, by defining the flood-frequency distribution and the boundaries within which all possible flood paths lie, a 100-year flood can be defined for any point subject to alluvial fan flooding. That flood is defined by FEMA in terms of velocity, v, and energy depth, D. Energy depth is the specific energy above the bottom of the rectangular channel. The discharge associated with an energy depth of D feet is

$$q = 274.4\,D^{2.5} \tag{2.18}$$

Similarly, the discharge associated with a velocity, v, is

$$q = 0.1289v^5 \tag{2.19}$$

Thus, to find the contour on which, in any given year, each point has a 0.01 probability of being inundated by a flood whose energy depth exceeds 0.5 foot, Equation (2.11) [or Equation (2.15) if the skew is zero] should be solved for the contour width, W, with

$$y_{100} = \log_{10}[(274.4)(0.5)^{2.5}]$$

$$= \log_{10}(48.5) \tag{2.20}$$

That is,

$$W_{0.5} = \frac{9.408C}{0.01} \; P(Z > \log_{10} 48.5) \tag{2.21}$$

where C is given by Equation (2.12) [or (2.16) if the skew is zero] and $P(Z > \log_{10} q)$ represents the integral in Equation (2.11) [or (2.15) if the skew is zero]. The contour width corresponding to a 100-year energy depth of 1.5 feet is

$$W_{1.5} = 940.8\,C\; P(Z > \log_{10} 756) \tag{2.22}$$

The flood insurance zone for the area bounded by lines at the elevations where the contour widths are $W_{0.5}$ and $W_{1.5}$ is labeled as "ZONE AO, DEPTH 1". All contour widths corresponding to energy depths of the form $D = n + 0.5$, where n is an integer, and satisfying the condition

$$274.4\, D^{2.5} < Q_{100} \tag{2.23}$$

are computed, and the flood insurance zones are labeled accordingly. The upper limit defined by Condition (2.23) is simply a reiteration of the fact that, in any given year, the probability of being hit by a flood with a depth greater than that created by the 100-year flood discharge at the apex, Q_{100}, is less than or equal to 0.01. Condition (2.23) is discussed further in Subsection 2.3.

The flood insurance zones in areas subject to alluvial fan flooding are also labeled with the 100-year flood velocities. The velocity zone boundary widths are computed using a method similar to the one used to compute the depth zone boundary widths. For example, the width corresponding to a 100-year velocity of 3.5 fps is computed by first determining the discharge associated with that velocity

$$q = (0.1289)(3.5)^5 = 67.7 \tag{2.24}$$

and then computing the width

$$W = 940.8\,C\;P(Z > \log_{10} 67.7) \tag{2.25}$$

All contour widths corresponding to velocities of the form $v = n + 0.5$, where n is an integer, and satisfying the condition

$$48.5 < 0.1289v^5 < Q_{100} \tag{2.26}$$

are computed, and the flood insurance zones are labeled accordingly. Setting the lower limit at 48.5 cfs is equivalent to saying that floods with energy depths of less than 0.5 foot do not create the special flood hazards associated with A zones on FIRMs.

2.2 AVULSIONS

During a flood, the flow may abandon one path and follow a new one. That occurrence, termed an avulsion, can result from floodwater overtopping a channel bank and creating a new channel. The overtopping may be caused by the sudden deposition of sediment and/or debris or by the undercutting and subsequent failure of a channel bank. Because points below the avulsion may be in the path taken by the floodflow either before or after the avulsion occurs, their probability of being hit by the flood is greater than if the avulsion had not occurred.

That increase in probability is accounted for by multiplying 1 plus the probability of an avulsion by the probability of being hit. Thus, if, during any flood, the probability of an avulsion is 0.5, the probability $P(H=1)$, would be multiplied by the factor 1.5, the avulsion factor. Including the notion of an avulsion factor in our previous discussion yields a probability that a point will be hit by a flood of a magnitude greater than q cfs in any given year of

$$P(H=1) = \frac{9.408AC}{W}\;P(Z > \log_{10} q) \tag{2.27}$$

where A is the avulsion factor.

Accounting for the uncertainty of an avulsion by using a constant factor implies that the avulsion occurs during the peak of the flood and upfan of the point in question. Because we use the program to model the entire area subject to alluvial fan flooding, the latter implication is equivalent to saying that the avulsion occurs at the apex.

2.3 CORRECTION FOR HIGH FLOW VALUES

Without Condition (2.23),

$$274.4\ D^{2.5} < Q_{100} \tag{2.23}$$

contour widths that correspond to discharges greater than the 100-year flood discharge at the apex could be calculated. This is seen by considering the general form of Equation (2.21), including an avulsion factor

$$W = 940.8\ ACP(Z > \log_{10} q) \tag{2.28}$$

Note that when $P(Z > \log_{10} q)$ is greater than 0, W is greater than 0. Also note that $P(Z > \log_{10} q)$ is greater than 0 for all q when the skew of the flood-frequency curve is zero; for all $q > 10^m$ when the skew is greater than zero; and for all $q < 10^m$ when the skew is less than zero, where m is the Pearson Type III parameter in Equation (2.8).

Thus, for discharge values greater than the 100-year flood discharge at the apex, there are values for W that satisfy Equation (2.28). This implies that the probability of a point being hit by a flood of a magnitude greater than the 500-year flood discharge at the apex is 0.01 in any given year. The root of this contradiction is seen by reviewing the definition of the conditional probability given by Equation (2.4):

$$P_{H|Q}(1,q) = \frac{w(q)}{W} \tag{2.4}$$

For very large values of q and relatively small values of W, w (q) may be greater than W. In that case, the probability given by Equation (2.4) of a given point being hit by q cfs, given that that discharge is realized at the apex, is

$$P_{H|Q}(1,q) = \frac{w(q)}{W} > 1 \tag{2.29}$$

which is absurd.

To avoid small errors introduced by the contradiction in Equation (2.29), the calculation of the contour width must be adjusted. If q_W denotes the discharge that creates a channel as wide as the contour width, the probability given by Equation (2.11) can be corrected by replacing the upper limit of the integral with $\log_{10}q_W$ and adding the probability that q_W is exceeded at the apex. That is, find the contour width, W, such that

$$0.01 = \frac{9.408\,C}{W}\,P(\log_{10}q_W > Z > \log_{10}q_i) + P(Q > q_W)$$

$$= \frac{9.408\,C}{W}\left[P(Z > \log_{10}q_i) - P(Z > \log_{10}q_W)\right] + P(Q > q_W) \qquad (2.30)$$

where q_i is the discharge associated with the depth or velocity being investigated, $P(Z > \log_{10}q_i)$ is the integral in Equation (2.11), and $P(Q > q_W)$ is given by Equation (2.8).

Including an avulsion factor, A, gives the final expression of the problem to be solved. That is, for each q_i associated with the depths and velocities described above, the contour width, W, that satisfies the following equation is found:

$$0.01 = \frac{9.408\,AC}{W}\left[P(Z > \log_{10}q_i) - P(Z > \log_{10}q_W)\right] + P(Q > q_W) \qquad (2.31)$$

The W given by Equation (2.31) and the W given by Equation (2.28) differ by a small amount — negligible in most cases. For avulsion factors greater than 1.0, a solution of Equation (2.31) is not the exact solution to the problem. However, the error introduced by using avulsion factors greater than 1.0 is much smaller than the difference between widths given by Equations (2.28) and (2.31). It is mentioned here only as a matter of detail.

If the path taken by the floodflow is as wide as the alluvial fan at some elevation, then avulsions above that elevation are impossible. Thus, for widths between 9.408 $q_W^{2/5}$ and 18.816 $q_W^{2/5}$, the avulsion factor accounts for more risk than is present. Again, the more risk is negligible.

2.4 MULTIPLE CHANNELS

On many alluvial fans, floods do not remain within a single channel from the apex down to the toe. Instead, a flood may be carried by a single channel to some point down the fan and then by several channels below that point. The point at which the single channel becomes multiple channels is referred to as the bifurcation point. Analyses of several well-documented alluvial fan flooding events indicate that the cumulative width of the multiple channels is 3.8 times the width of the single channel above the bifurcation point (Reference 2). Therefore, in the multiple-channel region, we redefine the width-discharge relationship given by Equation (2.7) as

$$w(q) = (3.8)(9.408)\,q^{2/5} = 35.7504\,q^{2/5} \tag{2.32}$$

Note that the multiple channels may be regarded as equivalent to a single channel with a width 3.8 times greater than the width of a single channel above the bifurcation point.

In addition, it is assumed that the depth and velocity of floodflows in the multiple-channel region can be estimated using Manning's equation with the friction slope set equal to the slope of the alluvial fan (i.e., a normal depth approximation). Thus, the relationship between depth of water, d, and discharge, q, is defined as

$$d = 0.0922\,n^{0.6}\,s^{-0.3}\,q^{0.36} \tag{2.33}$$

where n is the roughness coefficient (Manning's "n") and s is the slope of the alluvial fan.

The velocity-discharge relationship can be written

$$v = 0.3033\,n^{-0.6}\,s^{0.3}\,q^{0.24} \tag{2.34}$$

The velocity head can be computed from Equation (2.34):

$$\frac{v^2}{2g} = \frac{1}{2g}\left(0.3033\,n^{-0.6}\,s^{0.3}\,q^{0.24}\right)^2$$

$$= 0.00143\,n^{-1.2}\,s^{0.6}\,q^{0.48} \tag{2.35}$$

Therefore, the energy depth, D, in the multiple-channel region is

$$D = d + \frac{v^2}{2g}$$

$$= 0.0922\,n^{0.6}\,s^{-0.3}\,q^{0.36} + 0.00143\,n^{-1.2}\,s^{0.6}\,q^{0.48} \tag{2.36}$$

To find the discharges associated with the energy depths used to map the depth zone boundaries in the multiple-channel region, Equation (2.36) must be solved for $D = n + 0.5$, where n is an integer. Those discharges are bounded above by Q_{100}. Similarly, to determine the discharges associated with the velocities used to map the velocity zone boundaries in the multiple-channel region, Equation (2.34) must be solved for $v = n + 0.5$, where n is an integer. The discharge values given by Equation (2.34) are restricted to values less than Q_{100} and greater than the discharge that satisfies Equation (2.36) with $D = 0.5$. The restrictions on the discharges are analogous to Conditions (2.23) and (2.26) for the single-channel region.

The problem to be solved for the multiple-channel region is the same as that expressed by Equation (2.31) with the expression in brackets multiplied by 3.8. That is, for each q_i associated with the depths and velocities just described, the contour width, W, that satisfies

$$0.01 = \frac{35.7504\,AC}{W}\left[P(Z > \log_{10} q_i) - P(Z > \log_{10} q_W)\right] + P(Q > q_W) \qquad (2.37)$$

must be found. The FAN program computes the contour widths, corresponding to the depths and velocities of interest, that satisfy Equation (2.31) for the single-channel region [and Equation (2.37) for the multiple-channel region]. The values of cumulative distribution functions (CDFs), denoted $P(\bullet)$ in those equations, are determined by linear interpolation using the Pearson Type III tables published in Guidelines for Determining Flood Flow Frequency, Bulletin No. 17B (Reference 3). The tables in the program contain the number of standard deviations (k-values) that a given value of the random variable is from the mean. The tables in the program contain k-values corresponding to various values of the CDF for skew values varying by 0.1 and ranging from -4.1 to 4.1.

SECTION 3 — FAN PROGRAM DESCRIPTION

3.1 PROGRAM PURPOSE

The primary purpose of the FAN program is to compute the contour widths corresponding to the flood insurance zone boundaries (for example, the width of the area subject to alluvial fan flooding where the 100-year flood depth is 1.5 feet — the boundary between the 1- and 2-foot-depth zones). That purpose is accomplished by (1) using Equations (2.18) and (2.36) to determine the discharge (q) value that corresponds to each energy depth (D) value for the single- and multiple-channel regions, respectively; (2) using Equations (2.19) and (2.34) to determine the q value that corresponds to each velocity (v) value for the single-and multiple-channel regions, respectively; and (3) using Equations (2.31) and (2.37) to determine the contour width (W) value for the single- and multiple-channel regions, respectively.

Probabilities, denoted P(•) in Equations (2.31) and (2.37), are computed using the Pearson Type III tables published in Guidelines for Determining Flood Flow Frequency (Reference 2). To use those tables, the program must define the flood-frequency curve in terms of its mean (μ), standard deviation (σ), and skew coefficient (G). The tables consist of pairs of probabilities and numbers (k-values) of standard deviations between the corresponding value and the mean of the random variable for each skew value.

Given the statistics of the Pearson Type III distribution, the discharge, q_p, that has a probability of being exceeded in any given year is given by

$$\log_{10} q_p = \sigma k + \mu \tag{3.1}$$

Similarly, given a discharge, q, and the Pearson Type III statistics, the probability is determined by computing k from Equation (3.1) and finding the corresponding probability through linear interpolation.

Because the contour width depends on the probability that the rescaled (transformed) random variable exceeds the discharge in question [see Equation (2.11)], the mean, standard deviation, and skew coefficient of the rescaled random variable must be calculated to use the tables. For random variables that are Pearson Type III distributed, those statistics are related to the parameters of the distribution by

$$\mu = m + \frac{k}{\lambda} \tag{3.2}$$

$$\sigma = \frac{\sqrt{k}}{\lambda} \tag{3.3}$$

$$G = \frac{2}{\sqrt{k}} \tag{3.4}$$

Note that the skew coefficient, G, is independent of the scaling parameter, λ, and, therefore, is the same for both distributions. The mean and standard deviation of the rescaled random variable are found by replacing λ with $\lambda' = \lambda - 0.92$ in Equations (3.2) and (3.3), respectively.

3.2 PROGRAM STRUCTURE

Program flow is controlled by a DOS batch file, named FAN.BAT, that calls four programs written in BASIC (see Appendix B for listings). Compiled versions of those programs, PEARSN.EXE, FANINP.EXE, FANRUN.EXE, and AGAIN.EXE, reside in a directory named AL-FAN on the diskette that accompanies this manual. The order in which FAN calls those programs is shown in Figure 3-1.

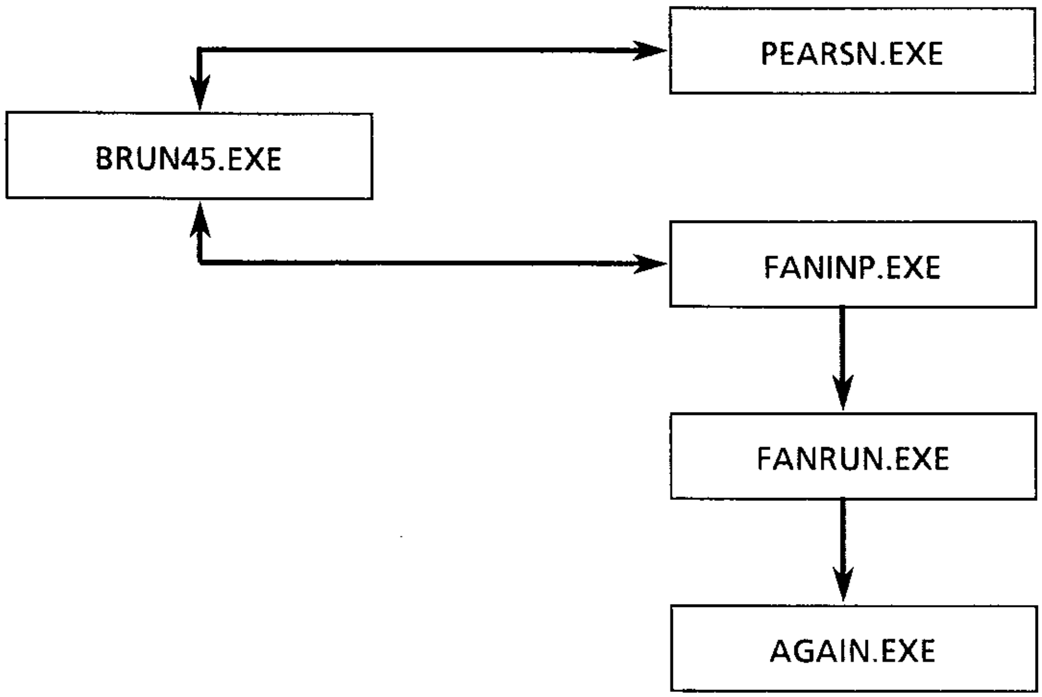


Figure 3-1. Flow of FAN.BAT

PEARSN.EXE assigns the k-values of the Pearson Type III tables. FANINP.EXE accepts the input data and defines the flood-frequency curve. These programs interact through BRUN45.EXE, a copyrighted program of Microsoft Corporation, 1982-88. After the flood-frequency curve has been defined, FANRUN.EXE computes the flood risk data. AGAIN.EXE, a short program, gives users the option to make another run.

3.3 PROGRAM FLOW

Figure 3-2 shows the flow of the FANRUN.BAS program. The flow of the contour width computations corresponding to the selected energy depth and selected velocity is shown in Figure 3-3 and 3-4, respectively. The numbers shown in each box are the line numbers of FANRUN.BAS that perform the given task. A listing of the program is given in Appendix B.

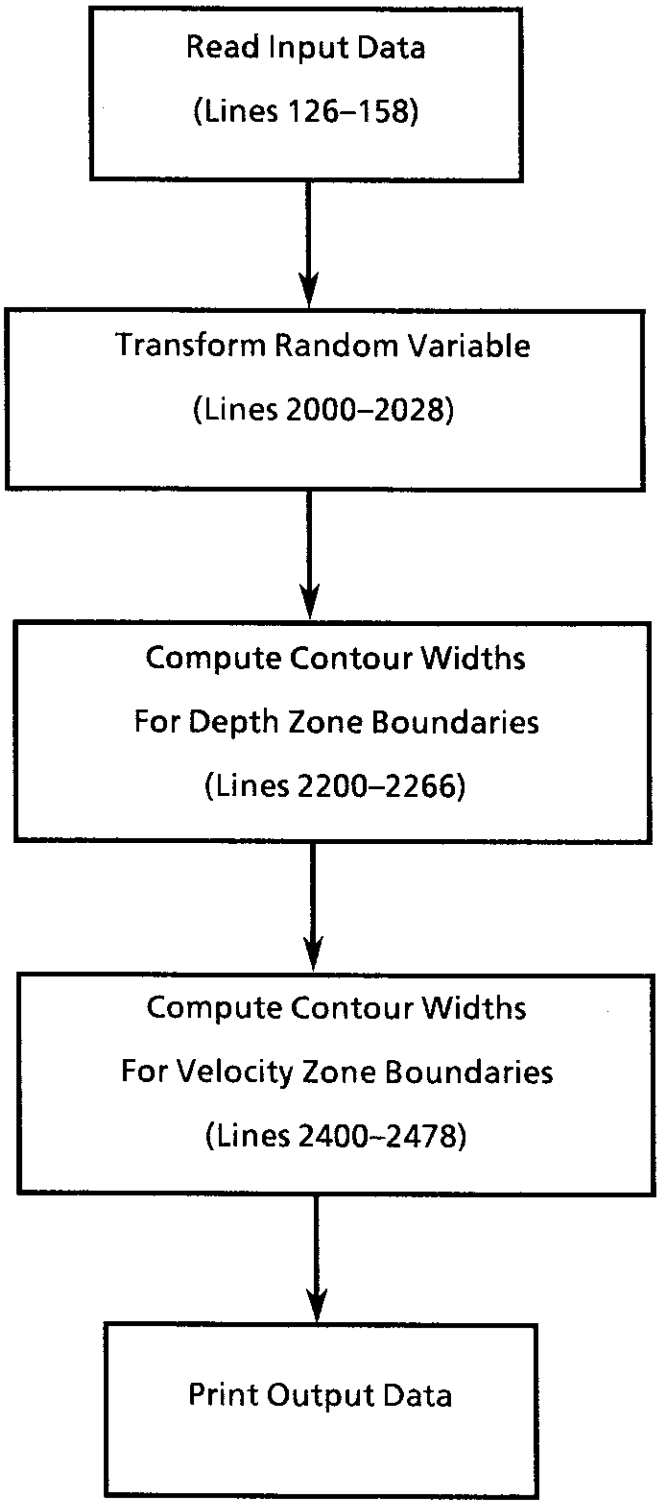


Figure 3—2. Flow of FANRUN.BAS Program

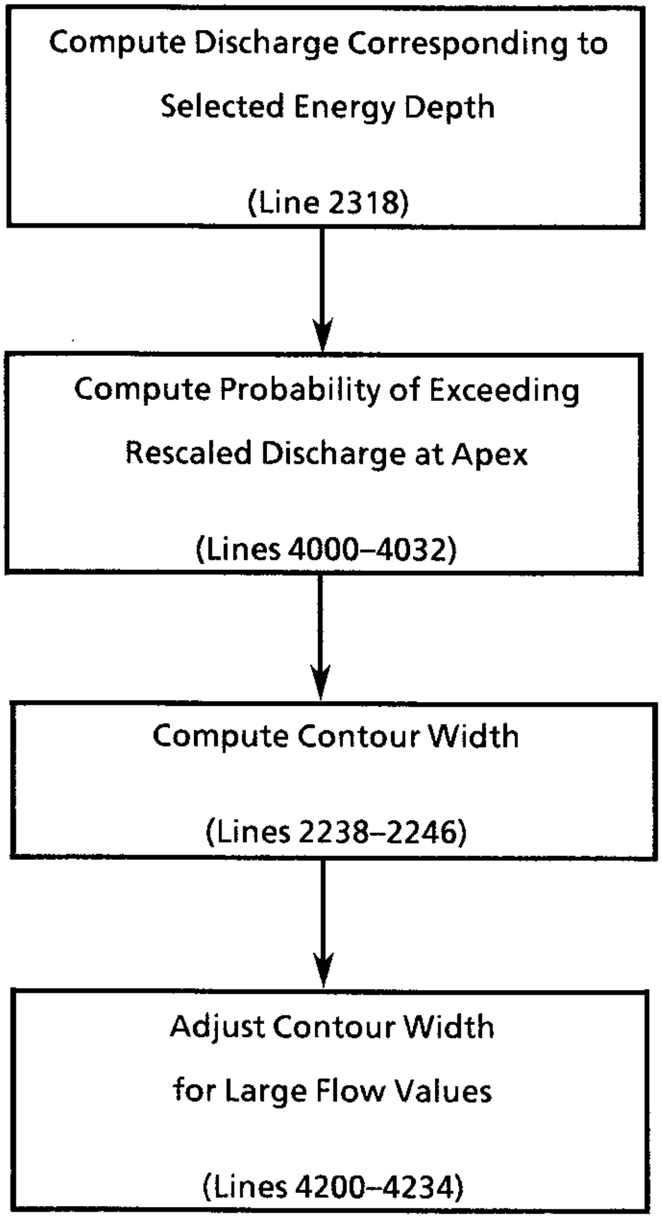


Figure 3—3. Flow of Contour Width Computations Corresponding to Selected Energy Depth

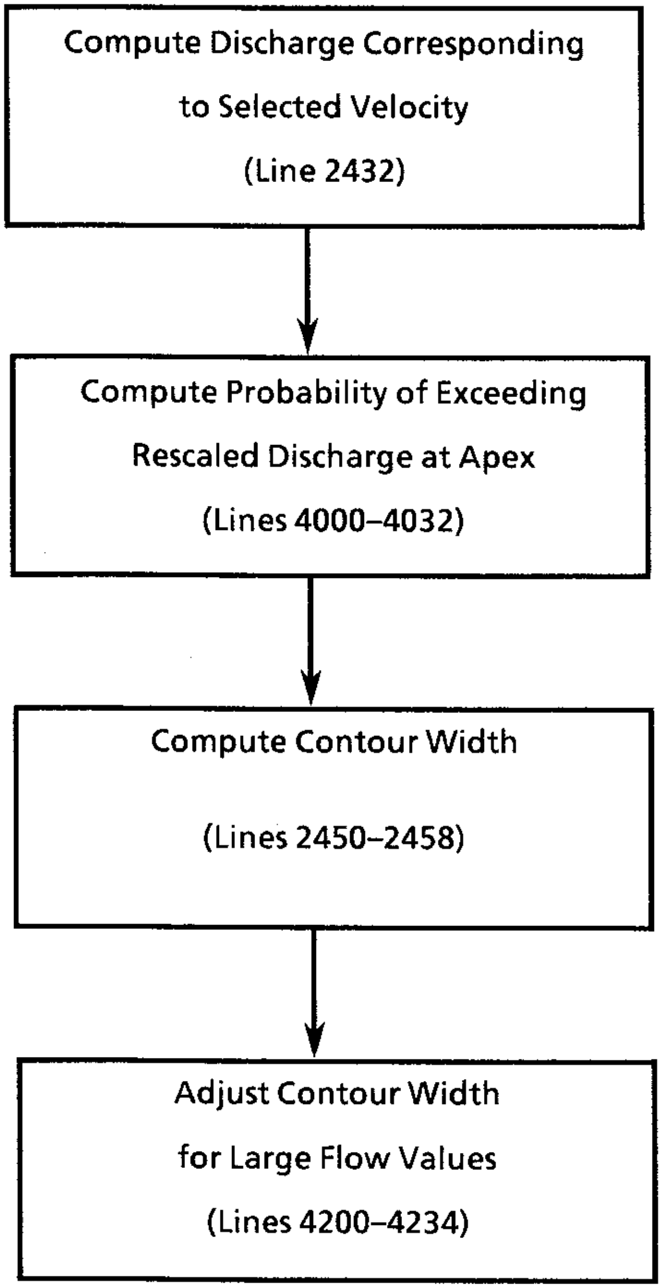


Figure 3—4. Flow of Contour Width Computations Corresponding to Selected Velocity

3.4 HARDWARE AND SOFTWARE REQUIREMENTS

The FAN program can be run on any IBM personal computer (PC) or any IBM-compatible PC that uses DOS release 2.0 or higher. The program, which is supplied on the 5-1/4-inch diskette that accompanies this manual, is compatible with fixed- and floppy-disk systems. This version of the program was written for single-user systems.

3.4.1 INSTALLATION

The program can be installed on another disk (hard or floppy) by inserting the enclosed diskette in Drive A and typing

A:INSTALL <*drive*>:

and pressing [ENTER]. The notation <*drive*> represents the letter of the drive. If Drive C is the hard disk in the system, the program can be installed on the hard disk by typing

A:INSTALL C:

If a properly formatted floppy diskette is inserted in Drive B, the program can be installed by typing

A:INSTALL B: [ENTER]

which copies the program onto that diskette.

The installation process copies the batch file FAN.BAT to the root directory of the disk in the specified drive and creates a directory, AL-FAN. The executable files associated with the program are copied into that new directory.

3.4.2 RUNNING THE PROGRAM

The program is run by typing **FAN** in response to the prompt for the root directory of the correct drive. If the prompt is for the correct drive but not the root directory, the user can access the root directory by entering **CD**.

For example, if the user inserts the diskette that accompanies this manual in Drive A and enters **A**, one of the following will appear on the screen:

A:\> or A:\AL-FAN>

The first prompt, A:\>, is for the root directory. If A:\> appears, entering **FAN** in response to that prompt will allow the user run the program. If A:\AL-FAN> appears, entering **CD** accesses the root directory.

The user is guided by prompts on the screen. The examples provided in Section 5 illustrate the interaction between the user and the program.

SECTION 4 — FAN PROGRAM INPUT AND OUTPUT

4.1 INPUT REQUIREMENTS

The input data required to run the FAN program are entered as responses to prompts. Data should be entered one value at a time. Values are entered by pressing **ENTER**. Responses to yes or no questions may be entered by pressing **Y** or **N** (capital or lower case), and then pressing **ENTER**.

The minimum input data required are flood-frequency data and the avulsion factor. If the user chooses to compute contour widths for the multiple-channel region, the alluvial fan slope and the roughness coefficient (Manning's "n") are also required.

4.1.1 Options for Entering Flood-Frequency Data

The program offers two options for entering flood-frequency data. Once the flood-frequency curve is defined, the program computes the 100-year flood discharge. If the 100-year flood discharge value is less than 50 (cfs) or greater than 500,000 cfs, the program will not run. If the 100-year flood discharge value is within that range, the program computes the product of the standard deviation and skew coefficient to see if the transformation constant, C, can be defined. [See Equation (2.12)] If that product is greater than 2.1, the program will not run.

4.1.1.1 Option 1 — Entering Statistics of the Distribution

Option 1 for defining the flood-frequency curve is to enter the mean, standard deviation, and skew coefficient. Standard deviations cannot be less than 0.1 and skew coefficients must be within the range of -4.1 to 4.1.

4.1.1.2 Option 2 — Entering Pairs of Recurrence Intervals and Discharge Values

Option 2 for defining the flood-frequency curve is to enter a minimum of three pairs of recurrence intervals and discharge values. The program finds the "best fit" of those data to a log-Pearson Type III distribution. The best fit is the log-Pearson Type III distribution that results in the maximum correlation coefficient of a least-squares fit of the data. Restrictions on the input data are as follows:

- Recurrence intervals must be between 1.001 and 1,000 years.
- Each recurrence interval may be entered only once (e.g., two 10-year flood discharge values cannot be entered).
- Discharge values must be greater than zero.
- Discharge values cannot decrease as the recurrence interval increases (e.g., if the 100-year flood discharge value is 1,000 cfs, the 90-year flood discharge value cannot be 2,000 cfs).

The least-squares fit is the straight line through a set of data pairs that minimizes the sum of the squares of the differences between the given values in the range of the data and the corresponding values predicted by the straight line. For each skew value tested, the program computes the k-values that correspond to the entered recurrence intervals and the base 10 logarithms of the entered discharges. The resulting pairs of data are then fit to the line defined by Equation (3.1), and the correlation coefficient is computed. The skew value that results in the greatest correlation coefficient is the skew of the flood-frequency curve. That skew value is found by treating the correlation coefficient as a function of skew with, at most, one critical point—its maximum. The mean and standard deviation of the flood-frequency curve are the slope and intercept, respectively, of the least-squares fit line for the chosen skew value.

4.1.2 Avulsion Factor

The avulsion factor may take any value. However, because the contour widths are proportional to the avulsion factor, using an avulsion factor of 0 will result in all contour widths being 0. Therefore, if the user enters a value of 0, the program will change it to 1.0.

4.1.3 Data Requirements for the Multiple-Channel Option

If the user chooses to compute contour widths for the multiple-channel region, additional data are required. Specifically, the user must supply the alluvial fan slope value and the roughness coefficients to be used in Manning's equation. The alluvial fan slope values (dimensionless) are restricted to a range of 0.000001 to 1.0; roughness coefficients are restricted to a range of 0.001 to 1.0. If the user enters a value outside those ranges, a message on the screen will advise the user that the input is too small or too large and instruct the user to re-enter the values.

4.2 OUTPUT

Output from a run consists of two or three pages, depending on the options chosen by the user. The output is written to a file named FAN.OUT. When a run is completed, the user is given three options; (1) to view the output on the screen, (2) to print the output, and (3) to make another run. When a new run is executed the file FAN.OUT is erased to make room for the new output. Thus, if the user wishes to save the output from a previous run, the option to print the output must be selected.

4.2.1 Flood-Frequency Data and Avulsion Factor

The first page of output data lists the avulsion factor and information pertaining to the flood-frequency curve. The flood-frequency data consists of the following:

- The option chosen to define the flood-frequency curve (If the option to enter pairs of flood-frequency data was selected, those data and the discharges corresponding to the entered recurrence intervals and defined by the least-squares fit of the data are listed.)

- The mean, standard deviation, and skew of the flood-frequency curve

- The 10-, 50-, 100-, and 500-year flood discharges (for use in the "Summary of Discharges" table in the FIS report)

- The scale change in (i.e., transformation of) the random variable denoting $\log_{10} Q$, the statistics of the distribution of the changed random variable, and the transformation constant (C)

4.2.2 Single-Channel Region Mapping Parameters

The second page of the output data lists the special flood hazard information for the flood insurance zone boundaries in the single-channel region. The information for the depth zones is given first; the information for the velocity zones is given second. That information is in tabular form and consists of the following:

- 100-year energy depths and velocities
- Depth of water associated with each energy depth or velocity
- Discharge associated with each energy depth or velocity
- Probability that that discharge is exceeded at the apex
- Probability that the "rescaled discharge" is exceeded at the apex
- Contour width associated with each energy depth or velocity

4.2.3 Multiple–Channel Region Mapping Parameters

The third page of the output data lists the special flood hazard information for the multiple-channel region, and consists of the following:

- Slope of the alluvial fan
- Roughness coefficient used in the energy depth and velocity computations
- 100-year energy depths and velocities
- Depth of water associated with each energy depth or velocity
- Discharge associated with each energy depth or velocity
- Probability that that discharge is exceeded at the apex
- Probability that the "rescaled discharge" is exceeded at the apex
- Contour width associated with each energy depth or velocity

SECTION 5 — FAN PROGRAM EXAMPLE RUNS

5.1 INTRODUCTION

The example runs in this section illustrate the interaction between the user and the FAN program. The alluvial fan used in the examples is shown in Figure 5–1. The flood-frequency curve for these examples is log-normal with a standard deviation of 1.0 and a 2-year flood discharge of 10 cfs. Therefore, the distribution has a mean of 1.0 and a skew of 0. The flood-frequency curve is shown in Figure 5–2. The slope of the alluvial fan is 0.085 and the roughness coefficient is 0.05. The avulsion factor is 1.0.

Two examples have been selected to demonstrate the various options. In Example Number 1 (Subsection 5.2), the mean, standard deviation, and skew coefficient are used to define the flood-frequency curve; the option of computing contour widths for the multiple-channel region is not chosen. In Example Number 2 (Subsection 5.3), flood-frequency data are entered in the form of pairs of recurrence interval and discharge values. The option of computing contour widths for the multiple-channel region is chosen. In the examples, user-supplied information is denoted by bold print.

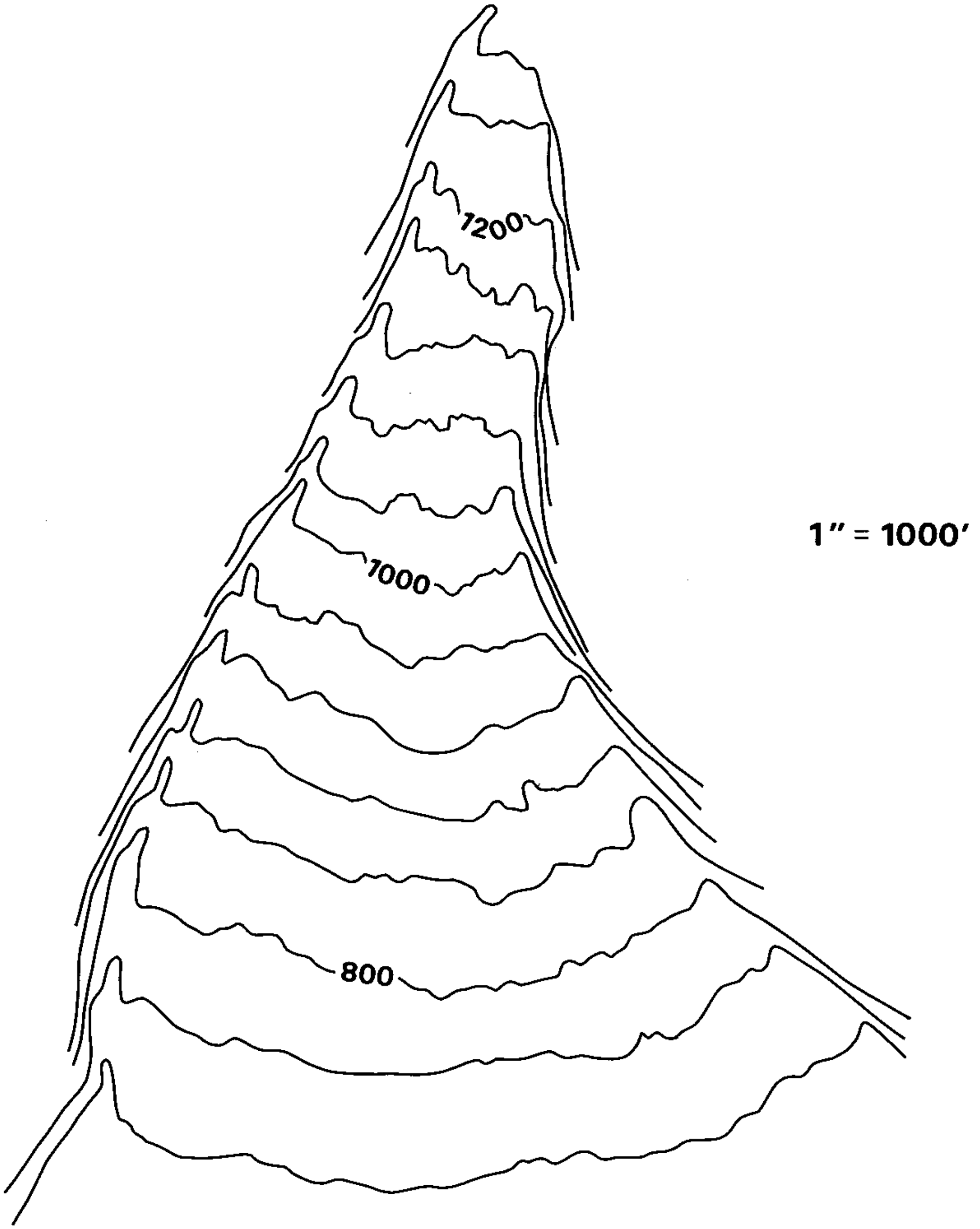


Figure 5—1. Example Alluvial Fan

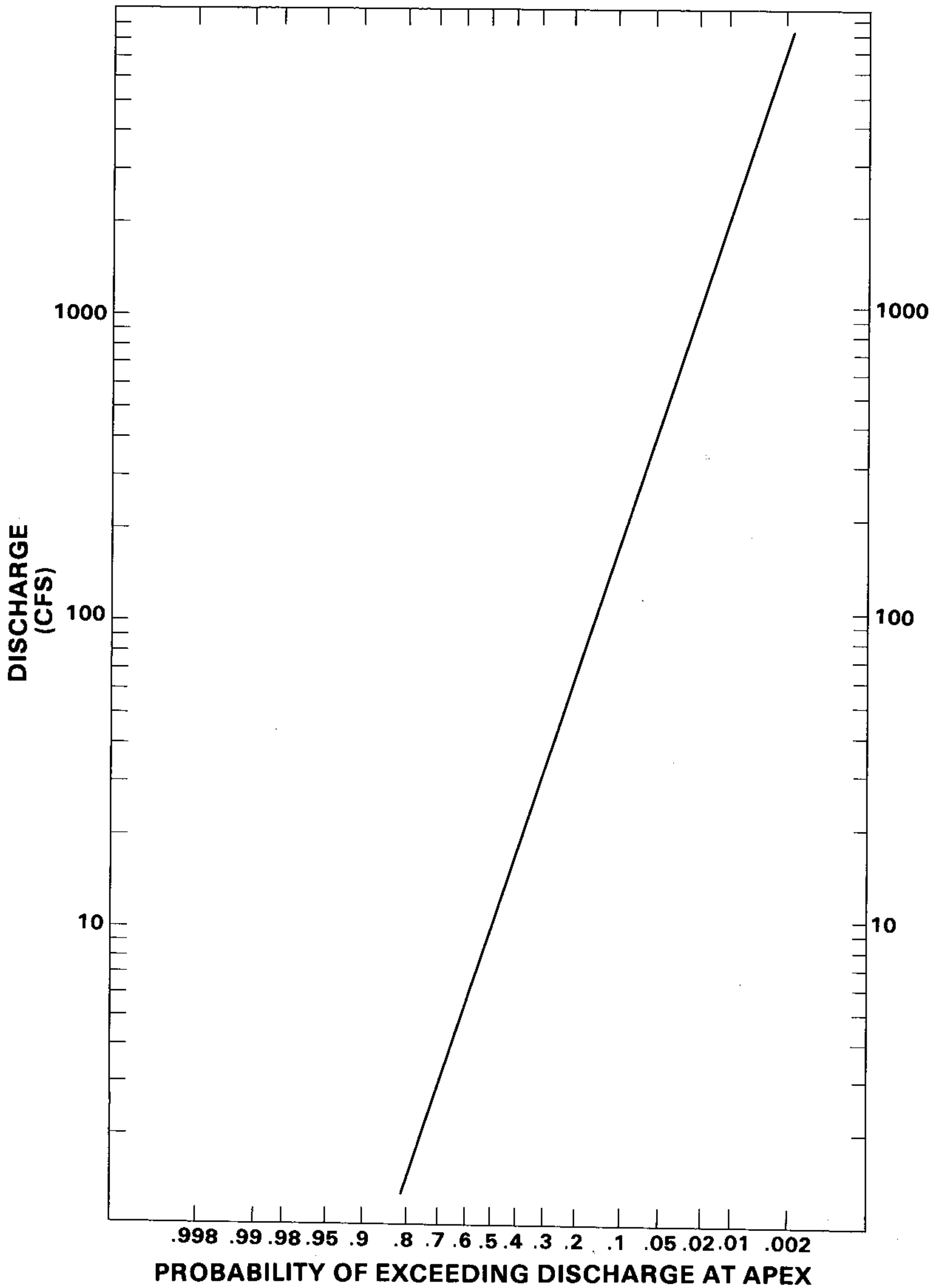


Figure 5—2. Example Flood-Frequency Curve

5.2 EXAMPLE 1 — FLOOD-FREQUENCY CURVE DEFINED BY MEAN, STANDARD DEVIATION, AND SKEW COEFFICIENT

When the user types **FAN**, the batch file is called, the program begins to run, and the following message appears on the screen:

```
ALLUVIAL FAN FLOODING COMPUTER PROGRAM

In response to prompts, enter data one
value at a time, then press enter.

Answer yes-or-no questions with the
corresponding letters (i.e., Y or N).



PEARSON TYPE-III TABLES BEING LOADED.......
```

While that message is on the screen, the program assigns the k-values of the Pearson Type III distributions. That process takes a few seconds to complete. When the k-values have been assigned, the message changes.

```
ALLUVIAL FAN FLOODING COMPUTER PROGRAM

In response to prompts, enter data one
value at a time, then press enter.

Answer yes-or-no questions with the
corresponding letters (i.e., Y or N).



PRESS ENTER TO PROCEED..................   [ENTER]
```

If the user presses ENTER , the screen is cleared and the first prompt appears. The user is asked to enter the name of the alluvial fan. Therefore, **Example Number 1** is entered.

Press F1 and then press ENTER to exit

ENTER THE NAME OF THE ALLUVIAL FAN

EXAMPLE NUMBER 1 ENTER

The next prompt concerns the multiple-channel option. In the first example, contour widths will be computed for the single-channel region only. Therefore, the answer to the prompt is "N."

Press F1 and then press ENTER to exit

DO YOU WISH TO COMPUTE ZONE BOUNDARIES

FOR MULTIPLE CHANNELS (Y/N)? **N** ENTER

Next, the user is asked to enter the avulsion factor. An avulsion factor of 1.0 is entered.

```
Press F1 and then press ENTER to exit

ENTER AVULSION FACTOR 1        [ENTER]
```

The next prompt concerns the option for defining the flood-frequency curve. The flood-frequency curve is to be defined by statistics; therefore, Option 1 is selected.

```
Press F1 and then press ENTER to exit


YOU MAY DEFINE THE FLOOD FREQUENCY CURVE BY:

(1).... ENTERING THE MEAN, STANDARD DEVIATION, AND SKEW COEFFICIENT
        OF THE PEARSON TYPE-III DISTRIBUTION

(2).... ENTERING (AT LEAST THREE) PAIRS OF RETURN INTERVALS AND DISCHARGES

PLEASE ENTER OPTION NUMBER (1 OR 2) 1        [ENTER]
```

After choosing Option 1, three statistics are to be entered, one value at a time, beginning with the mean.

```
Press F1 and then press ENTER to exit

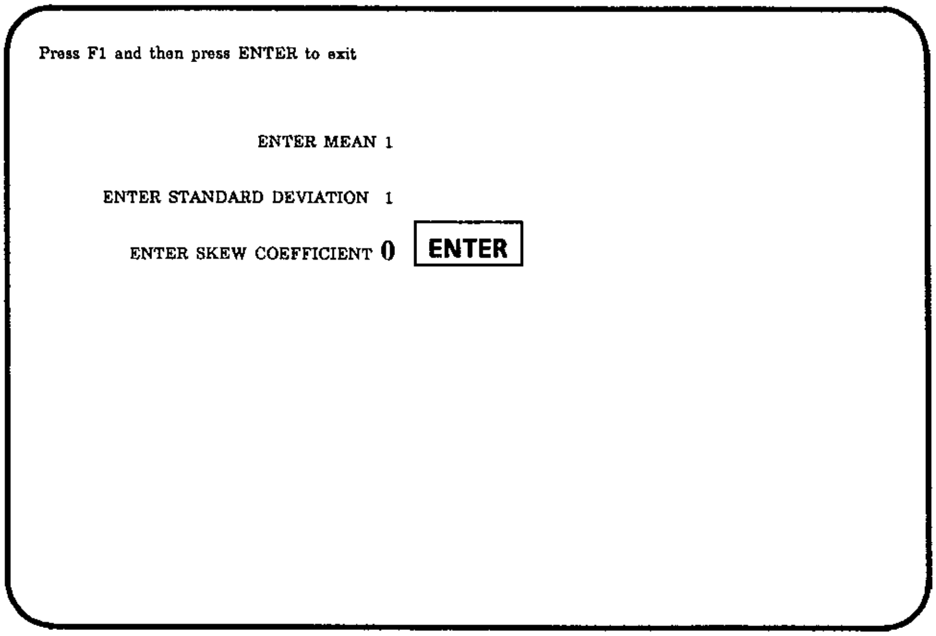
ENTER MEAN 1    [ENTER]
```

The mean remains on the screen, and the user is prompted to enter the standard deviation.

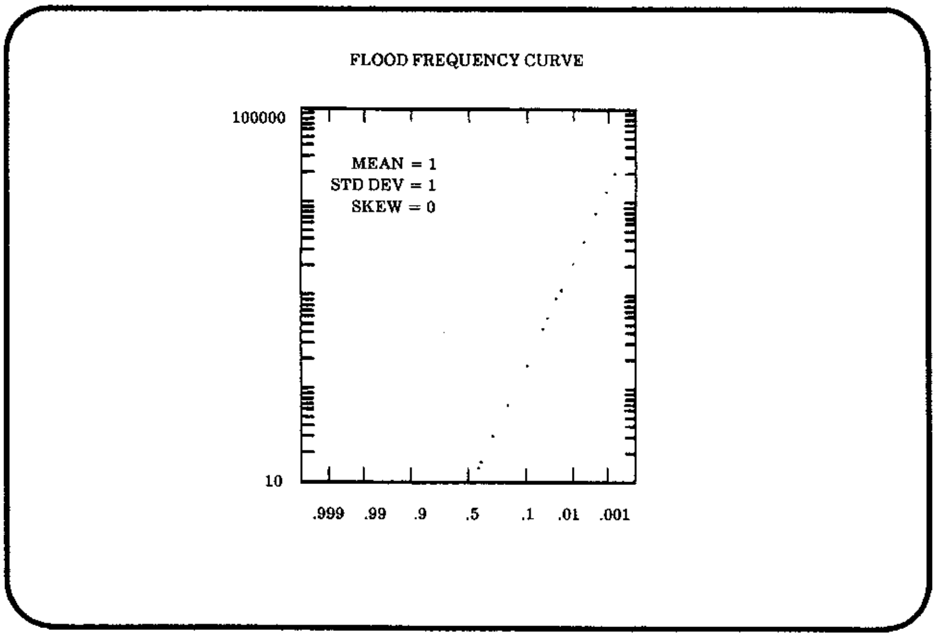
```
Press F1 and then press ENTER to exit

                    ENTER MEAN 1
  ENTER STANDARD DEVIATION 1    [ENTER]
```

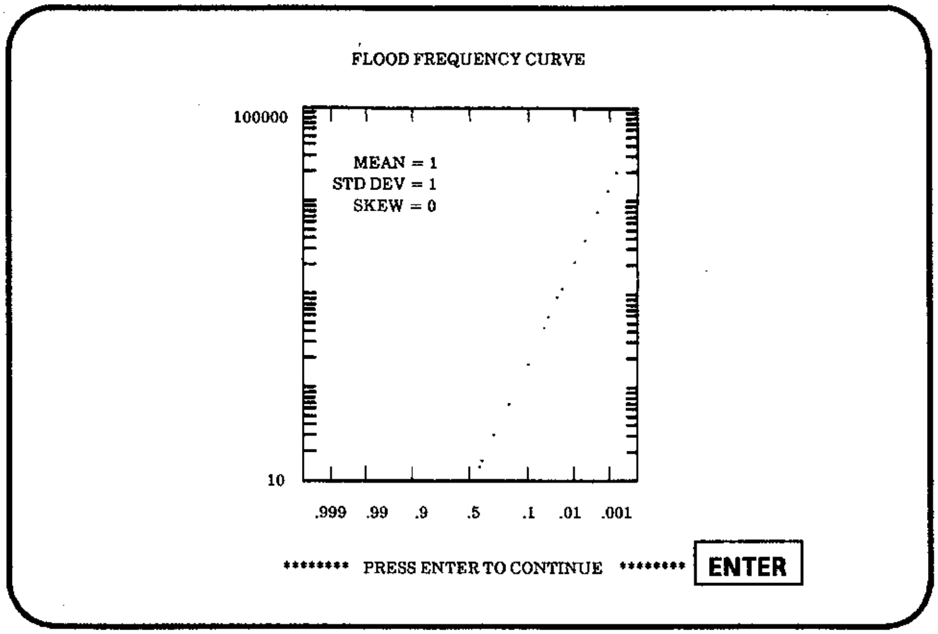
The mean and standard deviation remain on the screen, and the user is prompted to enter the skew coefficient.



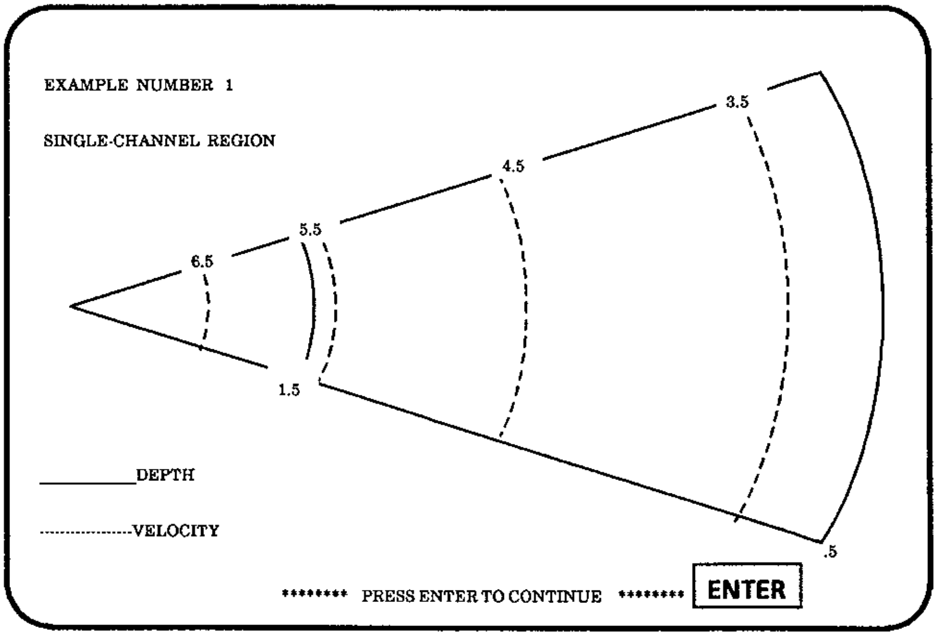
Entering the skew coefficient completes the data entry requirements. The screen is cleared and the flood-frequency curve is drawn.



When the computations of the contour widths are complete, the message "PRESS ENTER TO CONTINUE" appears at the bottom of the screen.



Pressing ENTER , clears the screen, and a picture of an alluvial fan (with simple boundaries) is drawn. The depth (solid lines) and velocity (dashed lines) zone boundaries with the computed contour widths for the single-channel region are drawn on the alluvial fan. When the picture is complete, the "PRESS ENTER TO CONTINUE" message appears again.



When [ENTER] is pressed, a prompt asks the user if he/she would like to view the output. Instead of viewing the output, the user chooses to print it out. Therefore, an "N" is entered.

```
DO YOU WISH TO VIEW SOME OUTPUT (Y/N)? N   [ENTER]
```

In response to the next prompt, "Y" is entered to activate the printing option.

```
DO YOU WISH TO PRINT THE OUTPUT (Y/N)? Y   [ENTER]
```

As a result of this response, the output file is sent to the printer. A final prompt gives the user the option to make another run.

DO YOU WISH TO MAKE ANOTHER RUN (Y/N)? Y ENTER

By responding "Yes" to the prompt, the program returns the user to the beginning.

5.3 EXAMPLE 2 — FLOOD-FREQUENCY CURVE DEFINED BY PAIRS OF RECURRENCE INTERVALS AND DISCHARGES

ALLUVIAL FAN FLOODING COMPUTER PROGRAM

In response to prompts, enter data one value at a time, then press enter.

Answer yes-or-no questions with the corresponding letters (i.e., Y or N).

PEARSON TYPE-III TABLES BEING LOADED.......

Again, the program assigns the k-values of the Pearson Type III distributions, and the message changes.

ALLUVIAL FAN FLOODING COMPUTER PROGRAM

In response to prompts, enter data one value at a time, then press enter.

Answer yes-or-no questions with the corresponding letters (i.e., Y or N).

PRESS ENTER TO PROCEED.................. ENTER

The same procedure is followed as for the first example run. Therefore, the first entry is the alluvial fan name.

Press F1 and then press ENTER to exit

ENTER THE NAME OF THE ALLUVIAL FAN

EXAMPLE NUMBER 2 ENTER

For this example, the multiple-channel option is to be used. Therefore, the answer to the next prompt is "Yes."

Press F1 and then press ENTER to exit

DO YOU WISH TO COMPUTE ZONE BOUNDARIES

FOR MULTIPLE CHANNELS (Y/N)? **Y** ENTER

Having selected the multiple-channel option, the user is first asked to enter the slope of the alluvial fan.

```
Press F1 and then press ENTER to exit

ENTER SLOPE OF ALLUVIAL FAN  .085        [ENTER]
```

The slope is displayed, and the user is prompted to enter the n-value.

```
Press F1 and then press ENTER to exit

SLOPE = .085

ENTER ROUGHNESS COEFFICIENT (N-VALUE) .05        [ENTER]
```

The slope and n-value are displayed, and the user is asked to enter the avulsion factor.

```
Press F1 and then press ENTER to exit

MULTIPLE CHANNEL PARAMETERS:
                         SLOPE = .085
                       N-VALUE = .05

ENTER AVULSION FACTOR 1        [ENTER]
```

The user now chooses the option for determining the flood-frequency curve. For this example, Option 2, least-squares fit of data, is selected.

```
Press F1 and then press ENTER to exit

YOU MAY DEFINE THE FLOOD FREQUENCY CURVE BY:

(1).... ENTERING THE MEAN, STANDARD DEVIATION, AND SKEW COEFFICIENT
        OF THE PEARSON TYPE-III DISTRIBUTION

(2).... ENTERING (AT LEAST THREE) PAIRS OF RECURRENCE INTERVALS AND DISCHARGES

PLEASE ENTER OPTION NUMBER (1 OR 2) 2        [ENTER]
```

The first prompt in Option 2 asks for the number of pairs of data to be entered.

```
Press F1 and then press ENTER to exit

HOW MANY PAIRS OF DISCHARGES AND
RECURRENCE INTERVALS DO YOU WISH TO ENTER? 6        ENTER
```

Next, the user is asked to enter the first recurrence interval.

```
Press F1 and then press ENTER to exit

HOW MANY PAIRS OF DISCHARGES AND
RECURRENCE INTERVALS DO YOU WISH TO ENTER? 6

ENTER RECURRENCE INTERVAL NUMBER 1  2       ENTER
```

The user is then asked to enter the corresponding discharge.

```
Press F1 and then press ENTER to exit

HOW MANY PAIRS OF DISCHARGES AND
RECURRENCE INTERVALS DO YOU WISH TO ENTER? 6

ENTER RECURRENCE INTERVAL NUMBER 1      2

      ENTER 2 - YEAR DISCHARGE                      10 [ENTER]
```

After the discharge is entered, the screen is cleared and the first pair of data is displayed; the user is prompted to enter the next recurrence interval.

```
Press F1 and then press ENTER to exit

          DATA PAIR                RECURRENCE INTERVAL     DISCHARGE
              1                             2                  10


ENTER RECURRENCE INTERVAL NUMBER 2           5 [ENTER]
```

Again, the user is asked to enter the corresponding discharge.

Press F1 and then press ENTER to exit

DATA PAIR	RECURRENCE INTERVAL	DISCHARGE
1	2	10

ENTER RECURRENCE INTERVAL NUMBER 2 5

ENTER 5 - YEAR DISCHARGE 69 ENTER

The same procedure continues until all of the data have been entered (six pairs in this example).

Press F1 and then press ENTER to exit

DATA PAIR	RECURRENCE INTERVAL	DISCHARGE
1	2	10
2	5	69

ENTER RECURRENCE INTERVAL NUMBER 3 10 ENTER

Press F1 and then press ENTER to exit

DATA PAIR	RECURRENCE INTERVAL	DISCHARGE
1	2	10
2	5	69

ENTER RECURRENCE INTERVAL NUMBER 3 10

ENTER 10 - YEAR DISCHARGE **191** **ENTER**

Press F1 and then press ENTER to exit

DATA PAIR	RECURRENCE INTERVAL	DISCHARGE
1	2	10
2	5	69
3	10	191

ENTER RECURRENCE INTERVAL NUMBER 4 **20** **ENTER**

Press F1 and then press ENTER to exit

DATA PAIR	RECURRENCE INTERVAL	DISCHARGE
1	2	10
2	5	69
3	10	191

ENTER RECURRENCE INTERVAL NUMBER 4 20

ENTER 20 - YEAR DISCHARGE **441** **ENTER**

Press F1 and then press ENTER to exit

DATA PAIR	RECURRENCE INTERVAL	DISCHARGE
1	2	10
2	5	69
3	10	191
4	20	441

ENTER RECURRENCE INTERVAL NUMBER 5 **50** **ENTER**

Press F1 and then press ENTER to exit

DATA PAIR	RECURRENCE INTERVAL	DISCHARGE
1	2	10
2	5	69
3	10	191
4	20	441

ENTER RECURRENCE INTERVAL NUMBER 5 50

ENTER 50 - YEAR DISCHARGE **1132** ENTER

Press F1 and then press ENTER to exit

DATA PAIR	RECURRENCE INTERVAL	DISCHARGE
1	2	10
2	5	69
3	10	191
4	20	441
5	50	1132

ENTER RECURRENCE INTERVAL NUMBER 6 **100** ENTER

Press F1 and then press ENTER to exit

DATA PAIR	RECURRENCE INTERVAL	DISCHARGE
1	2	10
2	5	69
3	10	191
4	20	441
5	50	1132

ENTER RECURRENCE INTERVAL NUMBER 6 100

ENTER 100 - YEAR DISCHARGE **212** **ENTER**

Note an error has been made in entering the 100-year flood discharge. The program notifies us of the error with the following screen.

Press F1 and then press ENTER to exit

SORRY, DISCHARGE VALUES CANNOT DECREASE WITH INCREASING RECURRENCE INTERVALS

THE 100 - YEAR DISCHARGE (212 CFS) IS LESS THAN
THE 50 - YEAR DISCHARGE (1132 CFS)

DATA PAIR	RECURRENCE INTERVAL	DISCHARGE
5	50	1132
6	100	212

WHICH PAIR OF DATA DO YOU WISH TO CHANGE --
DATA PAIR NUMBER 5 OR DATA PAIR NUMBER 6 ? **6** **ENTER**

The user is then prompted to re-enter the recurrence interval first.

```
Press F1 and then press ENTER to exit

SORRY DISCHARGE VALUES CANNOT DECREASE WITH INCREASING RECURRENCE INTERVALS

THE 100 - YEAR DISCHARGE ( 212 CFS ) IS LESS THAN
THE  50 - YEAR DISCHARGE ( 1132 CFS )

          DATA PAIR              RECURRENCE INTERVAL      DISCHARGE
              5                                  50           1132
              6                                 100            212

WHICH PAIR OF DATA DO YOU WISH TO CHANGE --
DATA PAIR NUMBER 5 OR DATA PAIR NUMBER  6 ?  6

RE--ENTER RECURRENCE INTERVAL NUMBER  6      100  [ENTER]
```

Now, the discharge value that was entered incorrectly is corrected.

```
Press F1 and then press ENTER to exit

SORRY, DISCHARGE VALUES CANNOT DECREASE WITH INCREASING RECURRENCE INTERVALS

THE 100 - YEAR DISCHARGE ( 212 CFS ) IS LESS THAN
THE  50 - YEAR DISCHARGE ( 1132 CFS )

          DATA PAIR              RECURRENCE INTERVAL      DISCHARGE
              5                                  50           1132
              6                                 100            212

WHICH PAIR OF DATA DO YOU WISH TO CHANGE -
DATA PAIR NUMBER 5 OR DATA PAIR NUMBER  6 ?  6

RE--ENTER RECURRENCE INTERVAL NUMBER  6      100
ENTER 100 - YEAR DISCHARGE                              2120  [ENTER]
```

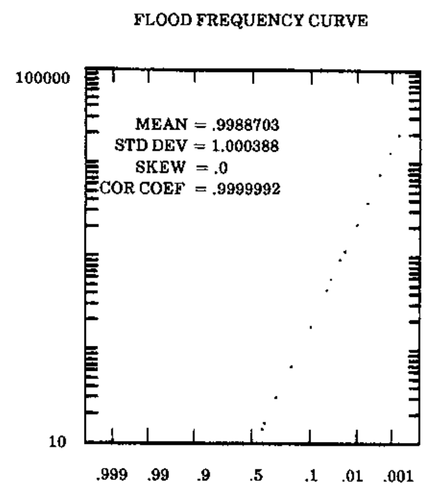
The user may review the final set of data pairs. If no revisions are necessary, an "N" is entered.

Press F1 and then press ENTER to exit

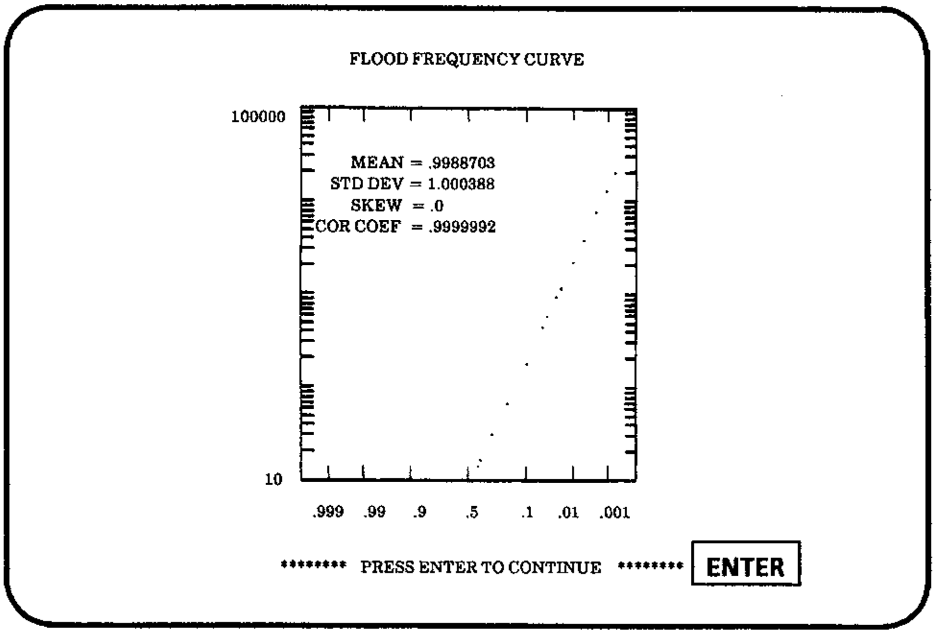
DATA PAIR	RECURRENCE INTERVAL	DISCHARGE
1	2	10
2	5	69
3	10	191
4	20	441
5	50	1132
6	100	2120

DO YOU WISH TO CHANGE ANY DATA (Y/N)? **N** **ENTER**

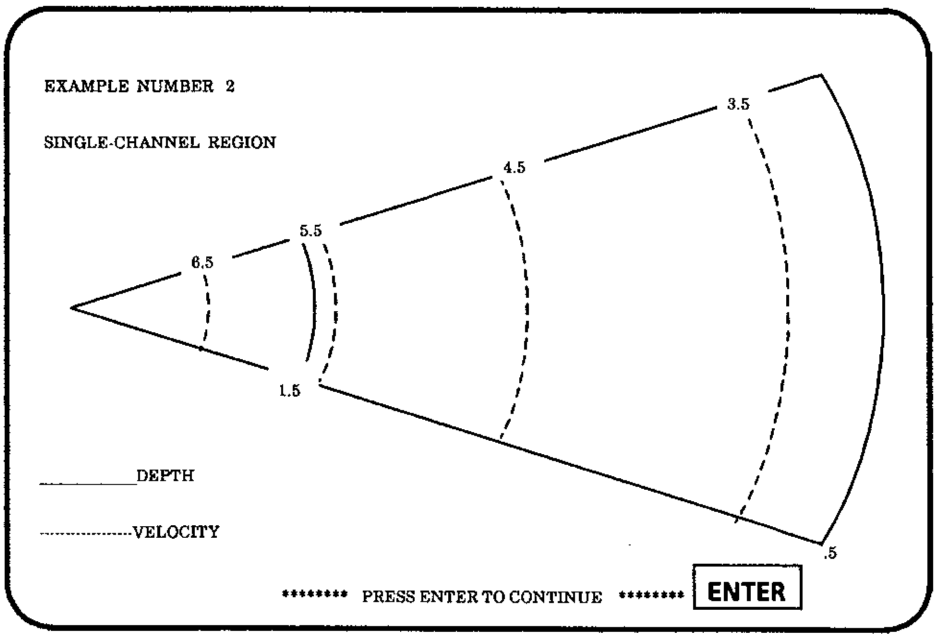
Entering "N" completes the data entry requirements. When the computation of the flood-frequency curve is complete, the statistics are displayed and the curve is drawn.



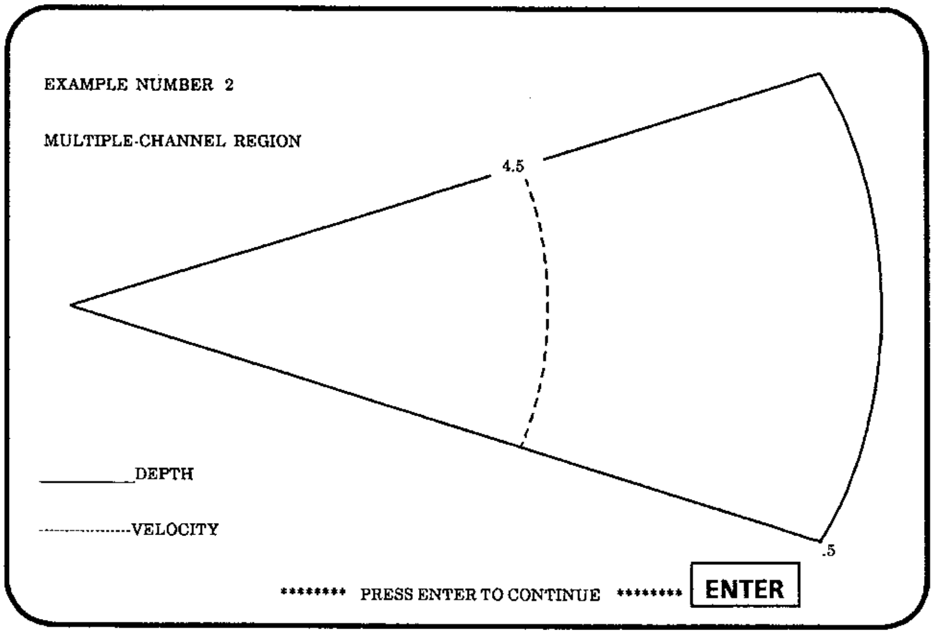
As in the first example, when the computations of the contour widths are completed, a message appears at the bottom of the screen.



By pressing ENTER, the user clears the screen and the picture of the the alluvial fan is drawn.



By pressing ENTER, the user clears the screen and the picture is drawn again—this time with the boundaries for the zones for the multiple-channel region shown.



The run is complete. The user is asked again if he/she wants to view the output. The answer is "No," so an "N" is entered.

DO YOU WISH TO VIEW SOME OUTPUT DATA (Y/N)? N **ENTER**

The next prompt asks if the user wishes to print the output.

```
DO YOU WISH TO PRINT THE OUTPUT (Y/N)? Y    [ENTER]
```

By entering "Y", the user sends the output file to the printer.
Before exiting, the program will ask the user if another run is to be made.

```
DO YOU WISH TO MAKE ANOTHER RUN (Y/N)? N    [ENTER]
```

By entering "N", the user returns control to DOS.

5.4 OUTPUT FROM EXAMPLES

The output data for the two examples are presented in Figures 5-3 to 5-7.

To demonstrate that the contour widths given in the last column (Width) of the second and third pages of the output do indeed satisfy Equation (2.31) (or Equation (2.37) for the multiple-channel region), the calculation for the contour width of 623 feet corresponding to an energy of 1.5 feet will be reproduced. Note that at critical flow the depth of water in a wide rectangular channel is two-thirds of the energy. Thus, the depth in the second column of the output is 1.0 foot, as shown in Figure 5-4. The discharge associated with alluvial fan flooding with an energy of 1.5 feet in the single-channel region is determined below (see Equation 2.18).

$$
\begin{aligned}
q &= 274.4D^{2.5} \\
&= 274.4(1.5)^{2.5} \\
&= 756 \text{ cfs}
\end{aligned}
\qquad (5.1)
$$

This discharge is given in the third column of the output (Figure 5-4.).

The fourth and fifth columns of the output are the probabilities that 756 cfs is exceeded at the apex by the discharge, Q, and by 8.3176 times the first power of the discharge, 8.3176 $Q^{1.0000}$, respectively. Table 5-1 shows the information used by the program to calculate those probabilities.

```
                    EXAMPLE NUMBER 1

                AVULSION FACTOR = 1.0000


FLOOD FREQUENCY CURVE DEFINED BY MEAN, STANDARD DEVIATION, AND SKEW

                              MEAN =  1.000000
                STANDARD DEVIATION =  1.000000
                              SKEW =  0.0


SUMMARY OF DISCHARGES:

                 10-YEAR DISCHARGE =    191
                 50-YEAR DISCHARGE =   1132
                100-YEAR DISCHARGE =   2120
                500-YEAR DISCHARGE =   7554


  STATISTICS AFTER TRANSFORMATION OF Y=LOG(Q) TO Z=0.9200+LOG(Q)

                         MEAN OF Z =  1.920000
                STANDARD DEVIATION =  1.000000
                              SKEW =  0.000000
           TRANSFORMATION CONSTANT =  3.819044
```

Figure 5—3. Page 1 of Output for Example Number 1

SINGLE-CHANNEL REGION

ENERGY (FT)	DEPTH (FT)	DISCHARGE (CFS)	PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: 1.0000 Q	8.3176 Q	WIDTH (FT)
0.5	0.3	49	0.24912	0.59255	2129
1.5	1.0	756	0.03083	0.17341	623

VELOCITY (FT/SEC)	DEPTH (FT)	DISCHARGE (CFS)	PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: 1.0000 Q	8.3176 Q	WIDTH (FT)
3.5	0.4	68	0.20348	0.53549	1924
4.5	0.6	238	0.08696	0.32512	1166
5.5	0.9	649	0.03560	0.18853	676
6.5	1.3	1496	0.01556	0.10608	366

Figure 5—4. Page 2 of Output for Example Number 1

EXAMPLE NUMBER 2

AVULSION FACTOR = 1.0000

FLOOD FREQUENCY CURVE DEFINED BY LEAST-SQUARES FIT OF DATA

RETURN INTERVAL (YEARS)	INPUT DISCHARGE (CFS)	BEST FIT DISCHARGE (CFS)
2	10	10
5	69	69
10	191	191
20	441	441
50	1132	1131
100	2120	2119

MEAN = 0.998870
STANDARD DEVIATION = 1.000388
SKEW = 0.0

SUMMARY OF DISCHARGES:

10-YEAR DISCHARGE = 191
50-YEAR DISCHARGE = 1131
100-YEAR DISCHARGE = 2119
500-YEAR DISCHARGE = 7553

STATISTICS AFTER TRANSFORMATION OF Y=LOG(Q) TO Z=0.9207+LOG(Q)

MEAN OF Z = 1.919584
STANDARD DEVIATION = 1.000388
SKEW = 0.000000
TRANSFORMATION CONSTANT = 3.816320

Figure 5—5. Page 1 of Output for Example Number 2

SINGLE-CHANNEL REGION

ENERGY (FT)	DEPTH (FT)	DISCHARGE (CFS)	PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: 1.0000 Q	8.3313 Q	WIDTH (FT)
0.5	0.3	49	0.24885	0.59235	2127
1.5	1.0	756	0.03080	0.17340	623

VELOCITY (FT/SEC)	DEPTH (FT)	DISCHARGE (CFS)	PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: 1.0000 Q	8.3313 Q	WIDTH (FT)
3.5	0.4	68	0.20322	0.53532	1922
4.5	0.6	238	0.08688	0.32503	1165
5.5	0.9	649	0.03557	0.18852	676
6.5	1.3	1496	0.01555	0.10609	366

Figure 5—6. Page 2 of Output for Example Number 2

MULTIPLE-CHANNEL REGION

SLOPE = 0.0850000
N-VALUE = 0.0500000

ENERGY (FT)	DEPTH (FT)	DISCHARGE (CFS)	PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: 1.0000 Q	8.3313 Q	WIDTH (FT)
0.5	0.3	426	0.05206	0.24163	3277

VELOCITY (FT/SEC)	DEPTH (FT)	DISCHARGE (CFS)	PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: 1.0000 Q	8.3313 Q	WIDTH (FT)
4.5	0.4	925	0.02465	0.15351	2085

Figure 5—7. Page 3 of Output for Example Number 2

Table 5–1. Probabilities and Corresponding Values of k (Skew = 0)

Probability	k
0.9999	-3.71902
0.9995	-3.29053
0.9990	-3.09023
0.9980	-2.87816
0.9950	-2.57583
0.9900	-2.32635
0.9800	-2.05375
0.9750	-1.95996
0.9600	-1.75069
0.9500	-1.64485
0.9000	-1.28155
0.8000	-0.84162
0.7000	-0.52440
0.6000	-0.25335
0.5704	-0.17733
0.5000	0.00000
0.4296	0.17733
0.4000	0.25335
0.3000	0.52440
0.2000	0.84162
0.1000	1.28155
0.0500	1.64485
0.0400	1.75069
0.0250	1.95996
0.0200	2.05375
0.0100	2.32635
0.0050	2.57583
0.0020	2.87816
0.0010	3.09023
0.0005	3.29053
0.0001	3.71902

Note that $\log_{10}$ (756) is 2.87852 and is, therefore, 1.87852 standard deviations (of 1.0) from the mean 1.0. Thus, the probability of 756 cfs being exceeded at the apex by Q is 0.03083, and is computed as follows:

$$P(Q>756) = \left(\frac{1.95996-1.87852}{1.95996-1.75069}\right)(0.040-0.025) + 0.025$$

$$= 0.03083 \qquad (5.2)$$

This is given in the fourth column of the output, shown in Figure 5-4.

Also note that $\log_{10}$ (756) is 0.95852 standard deviations (of 1.0) from the mean 1.92 (See Equation 2.17). Thus, the probability of 8.3176 $Q^{1.0000}$ exceeding 756 cfs at the apex is 0.17342, and is computed as follows:

$$P(8.3176\, Q^{1.0000} > 756) = \left(\frac{1.28155 - 0.95852}{1.28155 - 0.84162}\right)(0.2000 - 0.1000) + 0.1000$$

$$= 0.17342 \qquad (5.3)$$

This is given in the fifth column of the output. (The 0.00001 difference between the value above and that shown in Figure 5-4 arises from rounding the discharge value and its base 10 logarithm.) The latter probability could also be calculated using the change in scale of Q. That is,

$$P(8.3176\, Q^{1.0000} > 756) = P(Q > 756/8.3176 = 90.89) \qquad (5.4)$$

Because $\log_{10}$ (90.89) is 1.95852 and is, therefore, 0.95852 standard deviations (of 1.0) from the mean 1.0, Equation (5.3) holds for the rescaled discharge and the flood-frequency curve defined at the apex for Q.

Equation (5.3) defines the probability denoted $P(Z > \log_{10} q_i)$ in Equation (2.31). The transformation constant C in Equation (2.31) is defined by Equation (2.16)

$$C = e^{0.92\mu + 0.42\sigma^2}$$

$$= e^{0.92 + 0.42}$$

$$= 3.819044 \qquad (5.5)$$

This is given on the first page of the output (see Figure 5-3). The avulsion factor in the examples is 1.0.

The correction for high flow values is accomplished by calculating the value of the discharge (denoted q_w in equation (2.31)) that would create a channel as wide as the contour width, 623 feet. By using Equation (2.6), q_w is determined by

$$q_w = \left(\frac{W}{9.408}\right)^{2.5}$$

$$= \left(\frac{623}{9.408}\right)^{2.5}$$

$$= 35684 \text{ cfs} \tag{5.6}$$

The k-values that correspond to q_w , and the rescaled q_w are

$$\log_{10}(35684) - 1.0 = 3.55247 \tag{5.7}$$

and

$$\log_{10}(35684) - 1.92 = \log_{10}(35684/8.3176) - 1.0$$

$$= 2.63247 \tag{5.8}$$

Therefore, the two probabilities, $P(Q>q_w)$ and $P(Z> \log_{10} q_w)$ in Equation (2.31) are

$$P(Q>q_w) = \left(\frac{3.71902-3.55247}{3.71902-3.29053}\right)(0.0005-0.0001) + 0.0001$$

$$= 0.00026 \tag{5.9}$$

and

$$P(Z>\log_{10}q_w) = P\left(8.3176Q^{1.0000}>35684\right)$$

$$= \left(\frac{2.87816-2.63247}{2.87816-2.57583}\right)(0.0050-0.0020) + 0.0020$$

$$= 0.00444 \tag{5.10}$$

Thus, the probability that a point on the contour at which the area subject to flooding is 623 feet wide will be inundated by a flood discharge of 756 cfs or more is from Equation (2.31)

$$P(H=1) = \frac{9.408\ AC}{W}\left[P(Z > \log_{10} q_i) - P(Z> \log_{10}q_w)\right] + P(Q > q_w)$$

$$= \frac{(9.408)(1.0)(3.819044)}{623}\left[0.17342 - 0.00444\right] + 0.00026$$

$$= 0.01001 \qquad (5.11)$$

Carrying out the calculations to a precision of eight significant figures yields a value of 0.01000021 for the probability. A calculation without the large flow correction, but with the same precision, yields a probability of 0.01000068.

5.5 DELINEATING FLOOD INSURANCE ZONE BOUNDARIES

FEMA designates areas subject to 100-year alluvial fan flooding as Zone AO, with 100-year flood depths and velocities shown. The depths shown are summations of the pressure heads and velocity heads. Depths are rounded to the nearest whole foot and velocities are rounded to the nearest foot per second (fps). Thus, the area subject to alluvial fan flooding with 100-year flood depths between 1.5 and 2.5 feet and 100-year flood velocities between 5.5 and 6.5 fps is labeled:

ZONE AO
(DEPTH 2)
(VELOCITY 6 FPS)

The net output data of the FAN program are the energies (labeled DEPTH on the FIRM), velocities, and the corresponding widths. The latter are the widths of the area subject to alluvial fan flooding at which the corresponding energy or velocity has a 1-percent chance of being exceeded in any given year. To delineate the flood insurance zone boundaries, the elevation at which the area subject to alluvial fan flooding has a width equal to the width in the output must be determined. To shorten the terminology, that width is referred to as the contour width (because it is measured along a contour).

The contour width is not the length of the contour, including every bend and wind, between the boundaries of the area subject to flooding. Instead, it is the length of a "smoothed" contour that has the same general alignment as the "true" contour. Figure 5-8 shows the alluvial fan used in the previous examples with the boundaries of the area subject to flooding. Figure 5-9 shows the same fan with "smoothed" contours for width measurements.

The output data from Example Number 1 will be used to demonstrate. To delineate the boundary between the zones where the 100-year flood depths are 1 foot and less than 1 foot, the elevation at which the contour width is 2,129 feet is located. To delineate the boundary between the zones where the 100-year flood depths are 1 foot and 2 feet, the elevation at which the contour width is 623 feet is located. The zone boundaries are delineated at those elevations using the alignments suggested by the smooth contours on Figure 5-9. The area between those boundaries will be labeled "DEPTH 1." The area above the 623-foot-long boundary will be labeled "DEPTH 2." Note that, in the example, the 100-year flood discharge at the apex is 2,120 cfs. Therefore, the maximum 100-year flood depth is 2.26 feet and, so, the maximum depth labeled is 2 feet. (See Condition 2.23.)

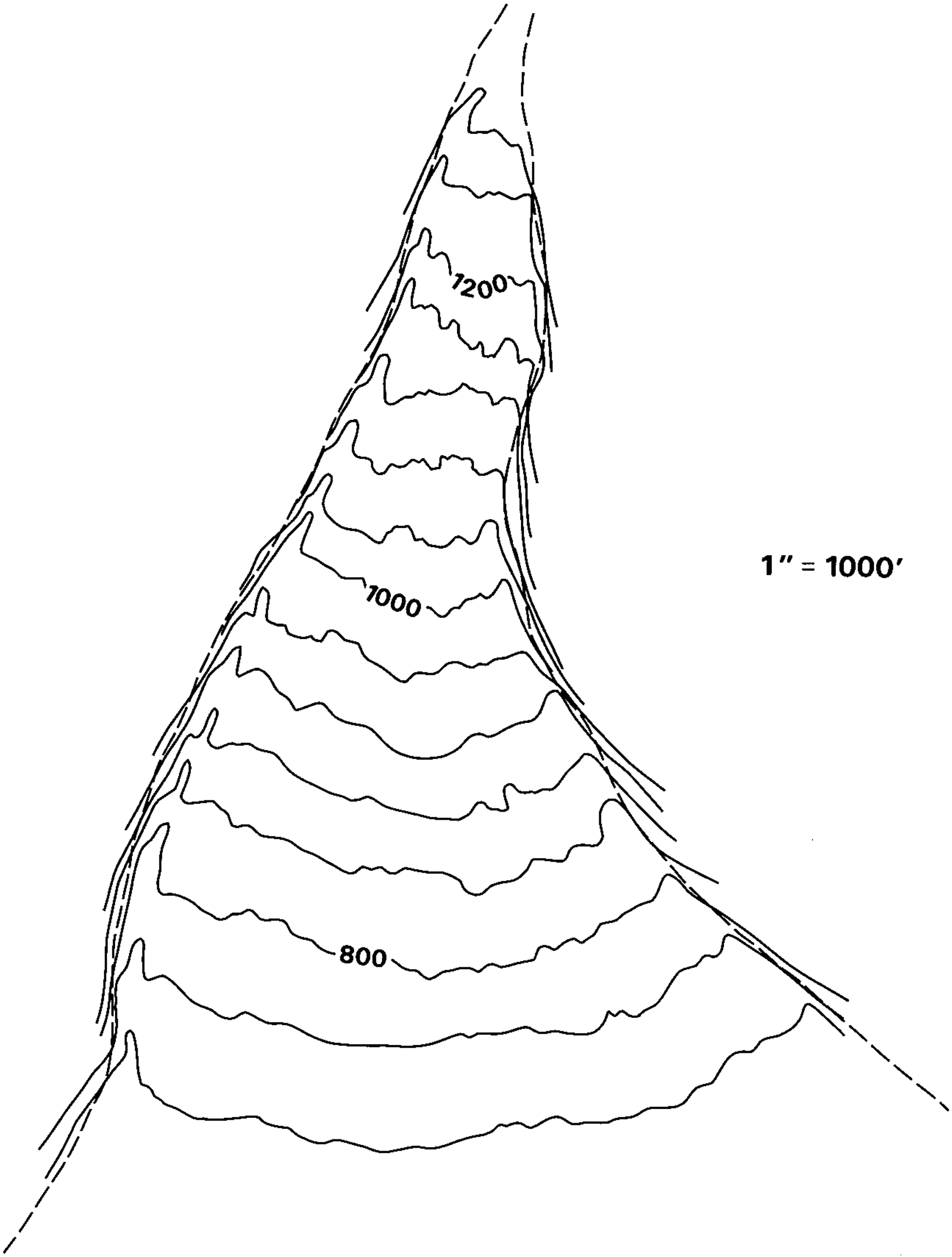


Figure 5—8. Alluvial Fan Boundaries

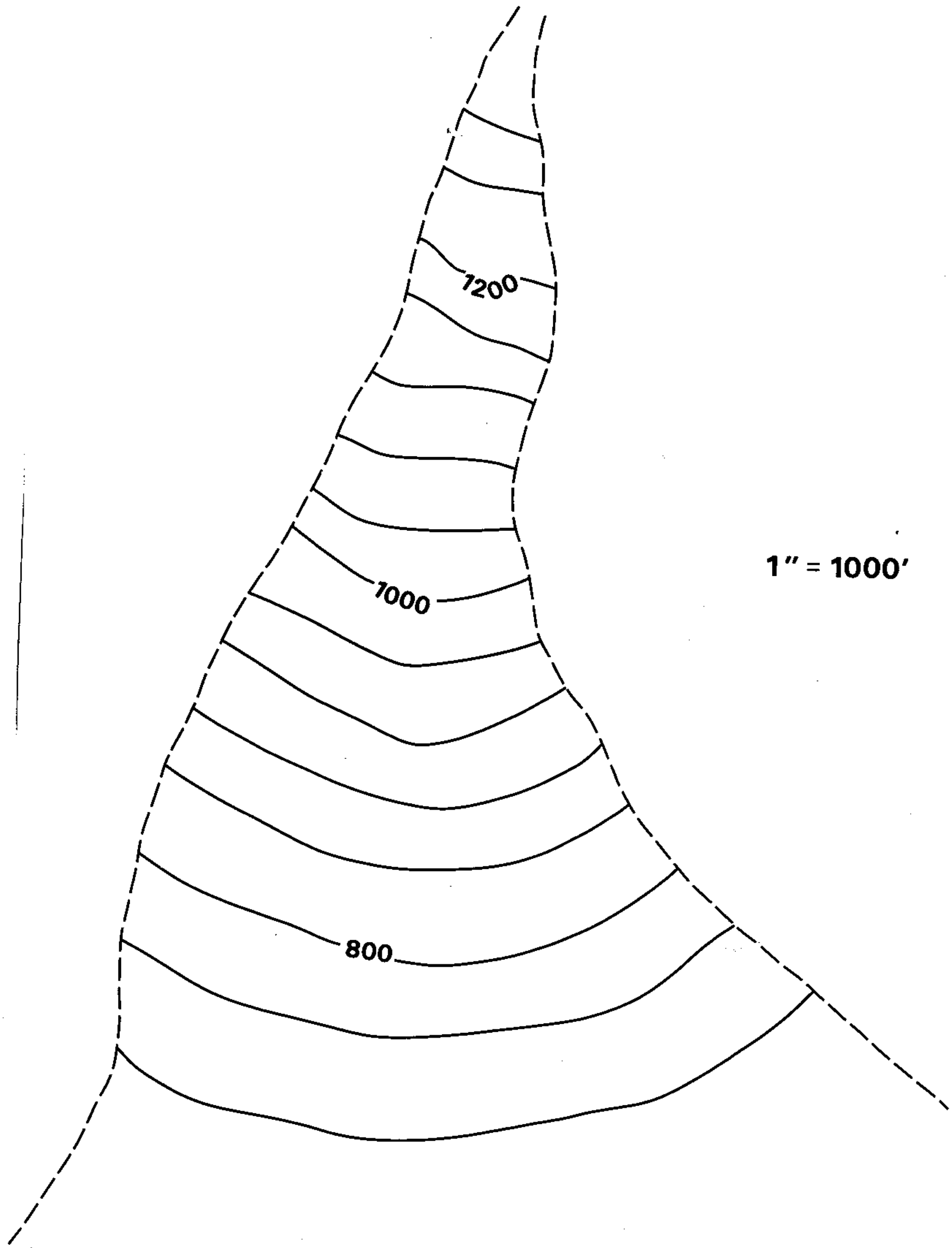


Figure 5—9. "Smooth" Contours for Width Measurements

The delineations of the depth zone boundaries for this single-channel region are shown on Figure 5-10. The same procedure is followed to delineate the velocity zone boundaries. The velocity zone boundaries subdivide the depth zones. The end result is a map depicting a series of regions defined by pairs of 100-year flood depths and velocities. Figure 5-11 shows that result with the appropriate labels in the flood insurance zones.

In multiple-channel regions, the widths resulting from the multiple-channel analysis are used. In Example Number 2, the multiple-channel region is the area with elevations below 1,180 feet. Because the area subject to flooding is 1,050 feet wide at that elevation, all widths greater than 1,050 feet are taken from the multiple-channel output data. For example, the boundary between the 4-fps and 5-fps zones is where the area subject to flooding is 2,085 feet wide--not 1,165 feet wide (single-channel region); the boundary between the 1-foot depth zone and areas where 100-year flood depths are less than 0.5 foot is where the area subject to flooding is 3,277 feet wide--not 2,127 feet wide (single-channel region). Figure 5-12 shows the results corresponding to Example Number 2 with bifurcation points at elevation 1,180 feet.

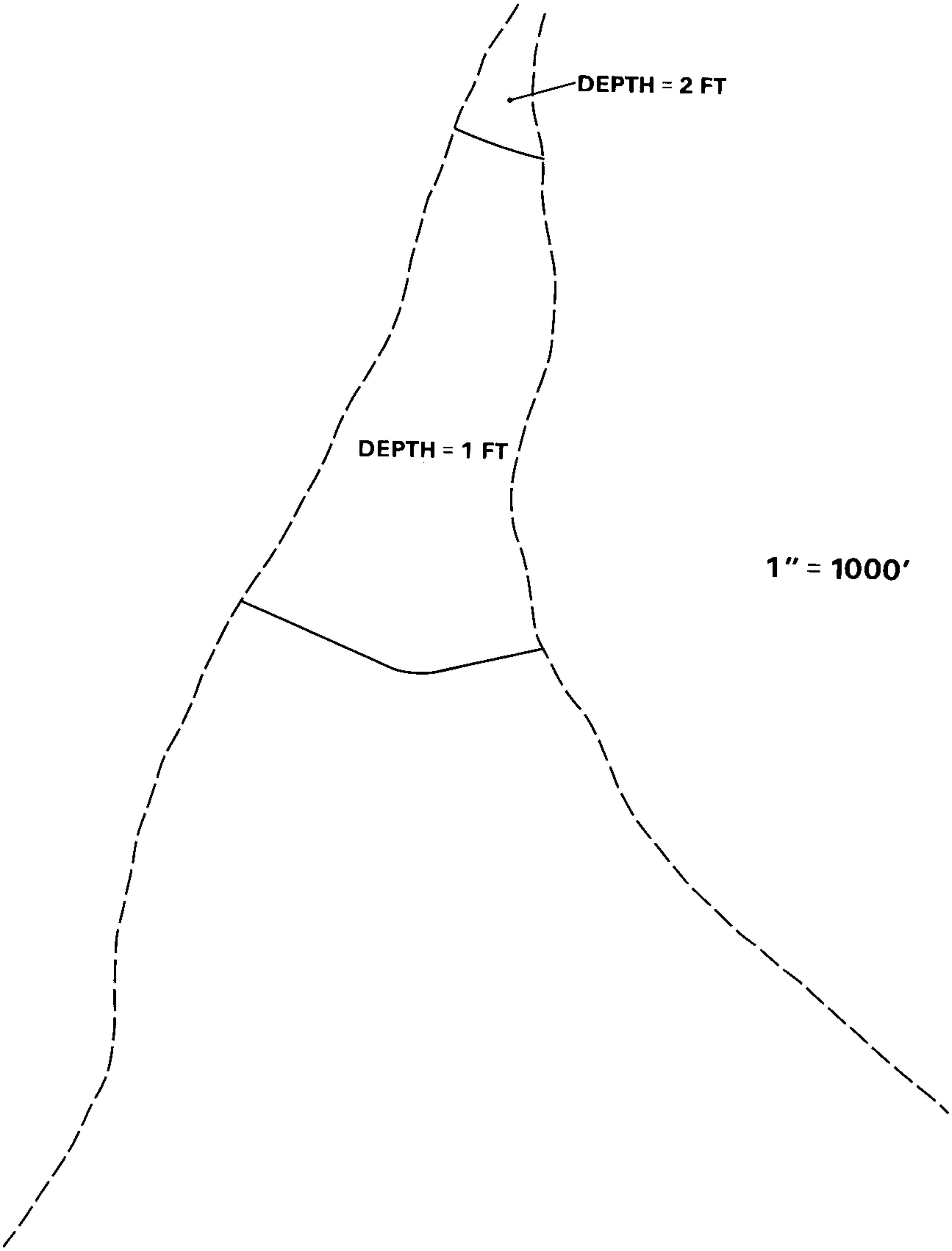


Figure 5—10. Depth Zone Boundaries (Single-Channel Region)

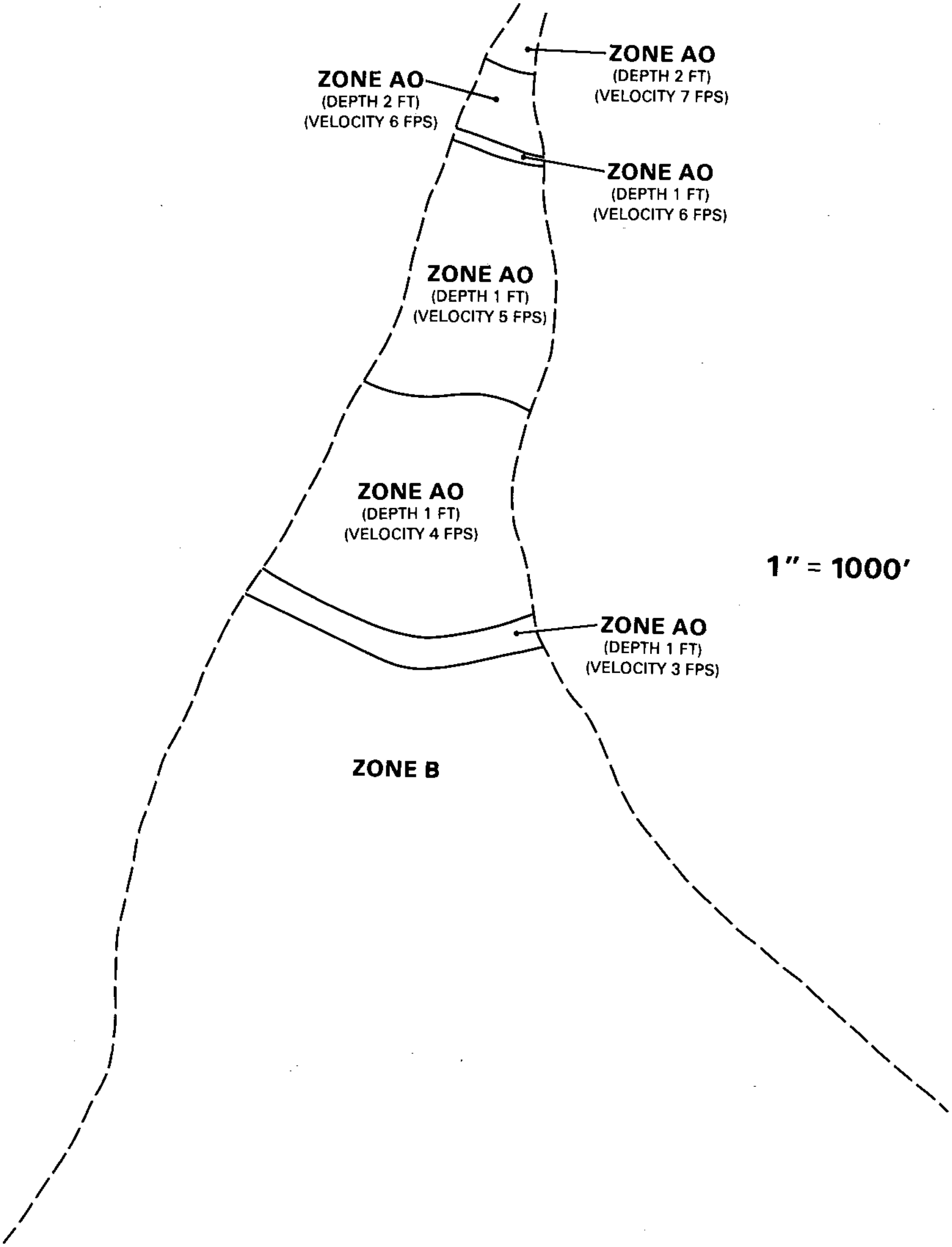


Figure 5—11. Flood Insurance Zones (Single-Channel Region)

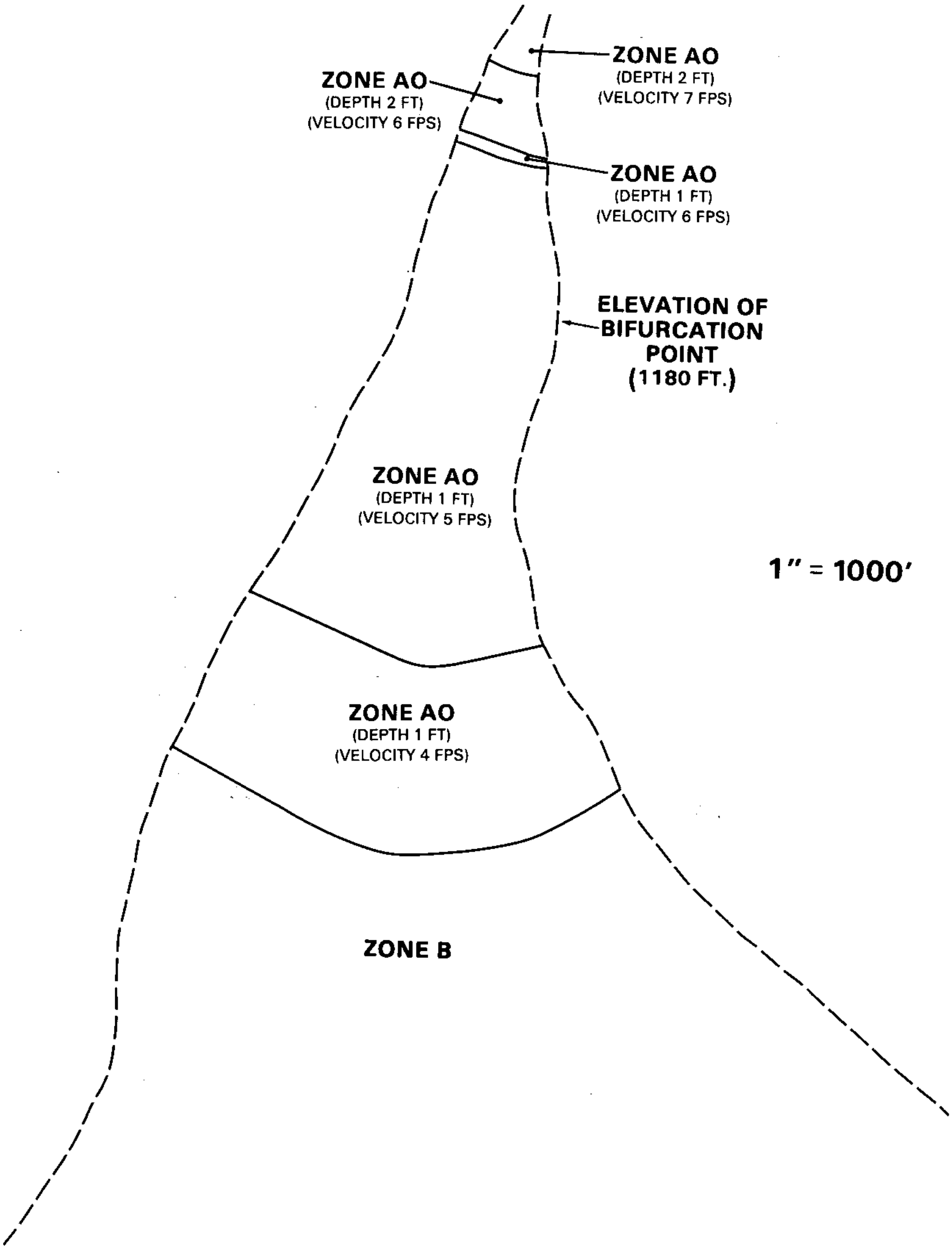


Figure 5—12. Flood Insurance Zones (Multiple-Channels Region)

SECTION 6 — REFERENCES

1. David R. Dawdy, "Flood Frequency Estimates on Alluvial Fans," in Journal of Hydraulics Division, ASCE, Proceedings, Vol. 105, No. HYII, 1979, pp 1407-1413.

2. DMA Consulting Engineers, Alluvial Fan Flooding Methodology, An Analysis, prepared for Federal Emergency Management Agency, 1985.

3. Interagency Advisory Committee on Water Data, Hydrology Subcommittee, Bulletin No. 17B, Guidelines for Determining Flood Flow Frequency, 1982.

APPENDIX A — SUPPLEMENT TO DERIVATION

A.1 HYDRAULIC CHARACTERISTICS: SINGLE-CHANNEL REGION

Recall that, at critical depth, the water depth, d, in a rectangular channel is twice the velocity head, $v^2/2g$. Thus, for a constant discharge, q, flowing at critical velocity, v, in a rectangular channel of cross-sectional area, A, and width, w,

$$d = 2\left(\frac{v^2}{2g}\right) = \frac{1}{g}v^2$$

$$= \frac{1}{g}\left(\frac{q}{A}\right)^2$$

$$= \frac{1}{g}\frac{q^2}{d^2w^2} \qquad \text{(A.1)}$$

where g is the acceleration of gravity.

Therefore,

$$w^2 = \frac{q^2}{g}\frac{1}{d^3} \qquad \text{(A.2)}$$

or, writing the width as a function of depth,

$$w(d) = \frac{q}{\sqrt{g}}d^{-3/2} \qquad \text{(A.3)}$$

The condition

$$\frac{dw}{dd} = -200 \qquad \text{(A.4)}$$

where $\frac{d}{dd}$ denotes differentiation with respect to depth, yields

$$\frac{dw}{dd} = -\frac{q}{\sqrt{g}}\left(\frac{3}{2}\right)d^{-5/2} \tag{A.5}$$

That is, Condition (A.4) is satisfied when

$$d = \left[\left(\frac{q}{\sqrt{g}}\right)\left(\frac{3}{2}\right)\left(\frac{1}{200}\right)\right]^{2/5}$$

$$= 0.07056\, q^{2/5} \tag{A.6}$$

Writing the width as a function of discharge [Equation (A.3)] yields

$$w(q) = \frac{q}{\sqrt{g}}\, d^{-3/2}$$

$$= \frac{q}{\sqrt{g}}\left[\frac{3q}{400\sqrt{g}}\right]^{-3/5}$$

$$= 9.408\, q^{2/5} \tag{A.7}$$

The discharge associated with an energy depth of D feet is the discharge corresponding to a water depth of $d=2D/3$ feet in Equation (A.6):

$$\frac{2}{3}D = \left[\left(\frac{q}{\sqrt{g}}\right)\left(\frac{3}{2}\right)\frac{1}{200}\right]^{2/5} \tag{A.8}$$

That is,

$$q = 200\sqrt{g}\left(\frac{3}{2}\right)^{-3.5} D^{2.5}$$

$$= 274.4\, D^{2.5} \tag{A.9}$$

Similarly, the discharge associated with a velocity, v, is the discharge corresponding to a water depth of $d=2(v^2/2g)$ feet in Equation (A.6):

$$\frac{v^2}{2g} = \frac{1}{2}\left[\left(\frac{q}{\sqrt{g}}\right)\left(\frac{3}{2}\right)\left(\frac{1}{200}\right)\right]^{2/5} \qquad \text{(A.10)}$$

That is,

$$q = \left(\frac{400}{3\,g^2}\right) v^5$$

$$= 0.1289v^5 \qquad \text{(A.11)}$$

A.2 HYDRAULIC CHARACTERISTCS: MULTIPLE-CHANNEL REGION

Assume that the depth and velocity of floodflows can be estimated with Manning's equation with the friction slope set equal to the slope of the alluvial fan (i.e., a normal depth approximation). Thus, we define the relationship between depth and discharge as

$$q = \frac{1.486}{n} AR^{2/3} s^{1/2} \qquad \text{(A.12)}$$

where s is the slope of the alluvial fan, R is the hydraulic radius of the channel, and A is the cross-sectional area of that part of the channel under water. Assuming a wide rectangular channel, we can approximate the hydraulic radius, R, by the depth of water, d. Writing the width as

$$w(q) = (3.8)(9.408)\,q^{2/5} = 35.7504\,q^{2/5} \qquad \text{(A.13)}$$

and the area as width times depth yields

$$q = \frac{1.486}{n} w(q)\,d^{5/3} s^{1/2}$$

$$= \frac{1.486}{n} 35.7504\,q^{2/5} d^{5/3} s^{1/2}$$

$$= \frac{53.1251}{n} q^{2/5} d^{5/3} s^{1/2} \qquad \text{(A.14)}$$

Solving for d yields

$$d = \left[\frac{n}{53.1251} q^{3/5} s^{-1/2} \right]^{3/5}$$

$$= 0.0922\, n^{0.6} s^{-0.3} q^{0.36} \qquad \text{(A.15)}$$

Manning's equation for velocity, v, is

$$v = \frac{1.486}{n} R^{2/3} s^{1/2} \qquad \text{(A.16)}$$

Making the same substitution for R as before yields the depth-velocity relationship

$$v = \frac{1.486}{n} d^{2/3} s^{1/2} \qquad \text{(A.17)}$$

Using Equation (A.15) for d yields

$$v = \frac{1.486}{n} \left(0.0922\, n^{0.6} s^{-0.3} q^{0.36} \right)^{2/3} s^{1/2}$$

$$= .3033\, n^{-.6} s^{.3} q^{.24} \qquad \text{(A.18)}$$

The velocity head can be computed from Equation (A.18):

$$\frac{v^2}{2g} = \frac{1}{2g} \left(0.3033\, n^{-0.6} s^{0.3} q^{0.24} \right)^2$$

$$= 0.00143\, n^{-1.2} s^{0.6} q^{0.48} \qquad \text{(A.19)}$$

Therefore, the energy depth, D, in the multiple-channel region is

$$D = d + \frac{v^2}{2g}$$

$$= 0.0922\, n^{0.6} s^{-0.3} q^{0.36} + 0.00143\, n^{-1.2} s^{0.6} q^{0.48} \qquad \text{(A.20)}$$

A.3 DERIVATION OF EQUATION (2.11)

Rearranging

$$0.01 = P(H=1) = \int_{y_{100}}^{\infty} 9.408\, \frac{e^{0.92y}}{W}\, \frac{\lambda^k (y-m)^{k-1}}{\Gamma(k)}\, e^{-\lambda(y-m)}\, dy \qquad \text{(A.21)}$$

to

$$0.01 = \frac{9.408}{W} \int_{y_{100}}^{\infty} \frac{(y-m)^{k-1}}{\Gamma(k)} \left\{ \lambda^k e^{-\lambda(y-m)} e^{0.92y} \right\} dy \qquad \text{(A.22)}$$

suggests writing

$$\left\{ \lambda^k e^{-\lambda(y-m)} e^{0.92y} \right\}$$

as

$$\frac{(\lambda - 0.92)^k}{(\lambda - 0.92)^k}\, \lambda^k e^{-(\lambda-0.92)(y-m)} e^{0.92m}$$

which is the same as

$$\frac{e^{0.92m} \lambda^k}{(\lambda - 0.92)^k}\, (\lambda - 0.92)^k\, e^{-(\lambda-0.92)(y-m)}$$

Defining the constant

$$C = \frac{e^{0.92m} \lambda^k}{(\lambda - 0.92)^k} \qquad \text{(A.23)}$$

and the new parameter

$$\lambda' = \lambda - 0.92 \qquad \text{(A.24)}$$

yields

$$0.01 = \frac{9.408C}{W} \int_{y_{100}}^{\infty} \frac{(\lambda')^k (y-m)^{k-1}}{\Gamma(k)} e^{-\lambda'(y-m)}\, dy \qquad \text{(A.25)}$$

A.4 DERIVATION OF EQUATION (2.15)

Start with

$$0.01 = \int_{y_{100}}^{\infty} 9.408 \, \frac{e^{0.92y}}{W} \, \frac{e^{-\frac{1}{2}\left(\frac{y-\mu}{\sigma}\right)^2}}{\sigma\sqrt{2\pi}} dy \qquad \text{(A.26)}$$

Expand the square, rearrange, and add and subtract

$$\left[0.92\mu + \frac{(0.92\sigma)^2}{2}\right]$$

to the exponent.

That is, the exponent can be written

$$0.92\,y - \tfrac{1}{2}\left(\frac{y-\mu}{\sigma}\right)^2 = \frac{1}{2\sigma^2}\left\{[0.92\,y\,2\sigma^2 - y^2 + 2y\mu - \mu^2] + [2\sigma^2\,0.92\mu + (0.92\sigma^2)^2] - [2\sigma^2 0.92\mu + (0.92\sigma^2)^2]\right\}$$

$$= -\frac{1}{2\sigma^2}[y - (\mu + 0.92\sigma^2)]^2 + 0.92\mu + 0.42\sigma^2 \qquad \text{(A.27)}$$

Defining the constant

$$C = e^{0.92\mu + 0.42\sigma^2} \tag{A.28}$$

and the new mean

$$\mu' = \mu + 0.92\sigma^2 \tag{A.29}$$

yields

$$0.01 = \frac{9.408\,C}{W} \int_{y_{100}}^{\infty} \frac{e^{-\frac{1}{2}\left(\frac{y-\mu'}{\sigma}\right)^2}}{\sigma\sqrt{2\pi}}\,dy \tag{A.30}$$

APPENDIX B — LISTING

Table of Contents for Program FAN

Table of Contents for Program FAN (Cont'd)

```
1 REM
2 REM   PPPPPPPP  EEEEEEE      AAA      RRRRRRRR   SSSSSSSS  NNN     NNN
3 REM   PPP   PPP EEE         AAAAA     RRR   RRR SSS        NNNN    NNN
4 REM   PPP   PPP EEE        AAA AAA    RRR   RRR SSS        NNNNNN  NNN
5 REM   PPPPPPPP  EEEEEE    AAA   AAA   RRRRRRRR   SSSSSSSS  NNN NNN NNN
6 REM   PPP       EEE      AAAAAAAAAAA  RRR   RRR       SSS NNN  NNNNNN
7 REM   PPP       EEE     AAA       AAA RRR    RRR      SSS NNN    NNNN
8 REM   PPP       EEEEEEE AAA       AAA RRR    RRR SSSSSSSS  NNN     NNN
9 REM
10  REM Portions (c) Copyright
11  REM Microsoft Corporation
12  REM 1982-1988
13  REM All Rights Reserved
14  REM
15  REM
16  REM ALLUVIAL FAN / Michael Baker Jr., Inc. - JULY 1990
17  REM
18  REM
19 COMMON SHARED P(), K(), KG(), KO()
20 DIM P(30), K(83, 30), KG(30), KO(30)
21 REM
22 ON KEY(1) GOSUB 10000
23 KEY(1) ON
24 CLS : KEY OFF: SCREEN 0: COLOR 10
25 LOCATE 6, 20
26 PRINT "ALLUVIAL FAN FLOODING COMPUTER PROGRAM"
28 LOCATE 9, 20
30 PRINT "In response to prompts, enter data one "
31 LOCATE 10, 20
32 PRINT "value at a time, then press enter."
34 LOCATE 14, 20
35 PRINT "Answer yes-or-no questions with the"
36 LOCATE 15, 20
37 PRINT "corresponding letters (i.e., Y or N)."
38 LOCATE 20, 20


40 REM
52 REM
54 REM     ************************************************************
56 REM                          OPEN OUTPUT FILE
58 REM     ************************************************************
60 REM
62 OPEN "FAN.IN" FOR OUTPUT AS #1
63 LOCATE 20, 20
64 COLOR 18
66 PRINT "PEARSON TYPE-III TABLES BEING LOADED"
```

```
9000 REM
9002 REM      ***************************************************************
9004 REM                    ASSIGN K VALUES FOR PEARSON TYPE 3
9006 REM      ***************************************************************
9008 REM
9012  P(0) = .9999: P(1) = .9995: P(2) = .999: P(3) = .998: P(4) = .995:
P(5) = .99: P(6) = .98
9014  P(7) = .975: P(8) = .96: P(9) = .95: P(10) = .9: P(11) = .8: P(12)
= .7: P(13) = .6
9016  P(14) = .5704: P(15) = .5: P(16) = .4296: P(17) = .4: P(18) = .3: P
(19) = .2: P(20) = .1
9018  P(21) = .05: P(22) = .04: P(23) = .025: P(24) = .02: P(25) = .01: P
(26) = .005: P(27) = .002
9020  P(28) = .001: P(29) = .0005: P(30) = .0001
9022  K(0, 0) = -3.71902: K(1, 0) = -3.50703: K(2, 0) = -3.29921: K(3, 0)
 = -3.09631: K(4, 0) = -2.89907: K(5, 0) = -2.70836: K(6, 0) = -2.52507
9024  K(0, 1) = -3.29053: K(1, 1) = -3.12767: K(2, 1) = -2.96698: K(3, 1)
 = -2.80889: K(4, 1) = -2.6539: K(5, 1) = -2.50257: K(6, 1) = -2.35549
9026  K(0, 2) = -3.09023: K(1, 2) = -2.94834: K(2, 2) = -2.80786: K(3, 2)
 = -2.66915: K(4, 2) = -2.53261: K(5, 2) = -2.39867: K(6, 2) = -2.2678
9028  K(0, 3) = -2.87816: K(1, 3) = -2.75706: K(2, 3) = -2.63672: K(3, 3)
 = -2.51741: K(4, 3) = -2.39942: K(5, 3) = -2.28311: K(6, 3) = -2.16884
9030  K(0, 4) = -2.57583: K(1, 4) = -2.48187: K(2, 4) = -2.38795: K(3, 4)
 = -2.29423: K(4, 4) = -2.20092: K(5, 4) = -2.10825: K(6, 4) = -2.01644
9032  K(0, 5) = -2.32635: K(1, 5) = -2.25258: K(2, 5) = -2.1784: K(3, 5)
= -2.10394: K(4, 5) = -2.02933: K(5, 5) = -1.95472: K(6, 5) = -1.88029
9034  K(0, 6) = -2.05375: K(1, 6) = -1.99973: K(2, 6) = -1.94499: K(3, 6)
 = -1.88959: K(4, 6) = -1.83361: K(5, 6) = -1.77716: K(6, 6) = -1.72033
9036  K(0, 7) = -1.95996: K(1, 7) = -1.91219: K(2, 7) = -1.8636: K(3, 7)
= -1.81427: K(4, 7) = -1.76427: K(5, 7) = -1.71366: K(6, 7) = -1.66253
9038  K(0, 8) = -1.75069: K(1, 8) = -1.7158: K(2, 8) = -1.67999: K(3, 8)
= -1.64329: K(4, 8) = -1.60574: K(5, 8) = -1.5674: K(6, 8) = -1.5283
9040  K(0, 9) = -1.64485: K(1, 9) = -1.61594: K(2, 9) = -1.58607: K(3, 9)
 = -1.55527: K(4, 9) = -1.52357: K(5, 9) = -1.49101: K(6, 9) = -1.45762
9042  K(0, 10) = -1.28155: K(1, 10) = -1.27037: K(2, 10) = -1.25824: K(3,
 10) = -1.24516: K(4, 10) = -1.23114: K(5, 10) = -1.21618: K(6, 10) = -1.
20028
9044  K(0, 11) = -.84162: K(1, 11) = -.84611: K(2, 11) = -.84986: K(3, 11
) = -.85285: K(4, 11) = -.85508: K(5, 11) = -.85653: K(6, 11) = -.85718
9046  K(0, 12) = -.5244: K(1, 12) = -.53624: K(2, 12) = -.54757: K(3, 12)
 = -.55839: K(4, 12) = -.56867: K(5, 12) = -.5784: K(6, 12) = -.58757
9048  K(0, 13) = -.25335: K(1, 13) = -.26882: K(2, 13) = -.28403: K(3, 13
) = -.29897: K(4, 13) = -.31362: K(5, 13) = -.32796: K(6, 13) = -.34198
9050  K(0, 14) = -.17733: K(1, 14) = -.19339: K(2, 14) = -.20925: K(3, 14
) = -.22492: K(4, 14) = -.24037: K(5, 14) = -.25558: K(6, 14) = -.27047
9052  K(0, 15) = 0!: K(1, 15) = -.01662: K(2, 15) = -.03325: K(3, 15) = -
.04993: K(4, 15) = -.06651: K(5, 15) = -.08302: K(6, 15) = -.09945
9054  K(0, 16) = .17733: K(1, 16) = .16111: K(2, 16) = .14472: K(3, 16) =
 .1282: K(4, 16) = .11154: K(5, 16) = .09478: K(6, 16) = .07791
9056  K(0, 17) = .25335: K(1, 17) = .23763: K(2, 17) = .22168: K(3, 17) =
 .20552: K(4, 17) = .18916: K(5, 17) = .17261: K(6, 17) = .15589
9058  K(0, 18) = .5244: K(1, 18) = .51207: K(2, 18) = .49927: K(3, 18) =
.486: K(4, 18) = .47228: K(5, 18) = .45812: K(6, 18) = .44352
9060  K(0, 19) = .84162: K(1, 19) = .83639: K(2, 19) = .83044: K(3, 19) =
 .82377: K(4, 19) = .81638: K(5, 19) = .80829: K(6, 19) = .7995
9062  K(0, 20) = 1.28155: K(1, 20) = 1.29178: K(2, 20) = 1.30105: K(3, 20
) = 1.30936: K(4, 20) = 1.31671: K(5, 20) = 1.32309: K(6, 20) = 1.3285
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9064  K(0, 21) = 1.64485: K(1, 21) = 1.67279: K(2, 21) = 1.69971: K(3, 21
) = 1.72562: K(4, 21) = 1.75048: K(5, 21) = 1.77428: K(6, 21) = 1.79701
9066  K(0, 22) = 1.75069: K(1, 22) = 1.78462: K(2, 22) = 1.81756: K(3, 22
) = 1.84949: K(4, 22) = 1.88039: K(5, 22) = 1.91022: K(6, 22) = 1.93896
9068  K(0, 23) = 1.95996: K(1, 23) = 2.00688: K(2, 23) = 2.0529: K(3, 23)
 = 2.09795: K(4, 23) = 2.14202: K(5, 23) = 2.18505: K(6, 23) = 2.22702
9070  K(0, 24) = 2.05375: K(1, 24) = 2.10697: K(2, 24) = 2.15935: K(3, 24
) = 2.21081: K(4, 24) = 2.26133: K(5, 24) = 2.31084: K(6, 24) = 2.35931
9072  K(0, 25) = 2.32635: K(1, 25) = 2.39961: K(2, 25) = 2.47226: K(3, 25
) = 2.54421: K(4, 25) = 2.61539: K(5, 25) = 2.68572: K(6, 25) = 2.75514
9074  K(0, 26) = 2.57583: K(1, 26) = 2.66965: K(2, 26) = 2.76321: K(3, 26
) = 2.85636: K(4, 26) = 2.949: K(5, 26) = 3.04102: K(6, 26) = 3.13232
9076  K(0, 27) = 2.87816: K(1, 27) = 2.99978: K(2, 27) = 3.12169: K(3, 27
) = 3.24371: K(4, 27) = 3.36566: K(5, 27) = 3.48737: K(6, 27) = 3.60872
9078  K(0, 28) = 3.09023: K(1, 28) = 3.23322: K(2, 28) = 3.37703: K(3, 28
) = 3.52139: K(4, 28) = 3.66608: K(5, 28) = 3.8109: K(6, 28) = 3.95567
9080  K(0, 29) = 3.29053: K(1, 29) = 3.45513: K(2, 29) = 3.62113: K(3, 29
) = 3.7882: K(4, 29) = 3.95605: K(5, 29) = 4.12443: K(6, 29) = 4.29311
9082  K(0, 30) = 3.71902: K(1, 30) = 3.93453: K(2, 30) = 4.15301: K(3, 30
) = 4.37394: K(4, 30) = 4.59687: K(5, 30) = 4.82141: K(6, 30) = 5.04718
9084  K(7, 0) = -2.35015: K(8, 0) = -2.18448: K(9, 0) = -2.02891: K(10, 0
) = -1.8841: K(11, 0) = -1.75053: K(12, 0) = -1.62838: K(13, 0) = -1.5175
2
9086  K(7, 1) = -2.21328: K(8, 1) = -2.07661: K(9, 1) = -1.94611: K(10, 1
) = -1.82241: K(11, 1) = -1.70603: K(12, 1) = -1.59738: K(13, 1) = -1.496
73
9088  K(7, 2) = -2.14053: K(8, 2) = -2.01739: K(9, 2) = -1.89894: K(10, 2
) = -1.78572: K(11, 2) = -1.67825: K(12, 2) = -1.57695: K(13, 2) = -1.482
16
9090  K(7, 3) = -2.05701: K(8, 3) = -1.94806: K(9, 3) = -1.84244: K(10, 3
) = -1.74062: K(11, 3) = -1.64305: K(12, 3) = -1.55016: K(13, 3) = -1.462
32
9092  K(7, 4) = -1.9258: K(8, 4) = -1.8366: K(9, 4) = -1.74919: K(10, 4)
= -1.6639: K(11, 4) = -1.5811: K(12, 4) = -1.50114: K(13, 4) = -1.42439
9094  K(7, 5) = -1.80621: K(8, 5) = -1.73271: K(9, 5) = -1.66001: K(10, 5
) = -1.58838: K(11, 5) = -1.51808: K(12, 5) = -1.44942: K(13, 5) = -1.382
67
9096  K(7, 6) = -1.66325: K(8, 6) = -1.60604: K(9, 6) = -1.54886: K(10, 6
) = -1.49188: K(11, 6) = -1.43529: K(12, 6) = -1.37929: K(13, 6) = -1.324
12
9098  K(7, 7) = -1.61099: K(8, 7) = -1.55914: K(9, 7) = -1.50712: K(10, 7
) = -1.45507: K(11, 7) = -1.40314: K(12, 7) = -1.35153: K(13, 7) = -1.300
42
9100  K(7, 8) = -1.48852: K(8, 8) = -1.44813: K(9, 8) = -1.4072: K(10, 8)
 = -1.36584: K(11, 8) = -1.32414: K(12, 8) = -1.28225: K(13, 8) = -1.2402
8
9102  K(7, 9) = -1.42345: K(8, 9) = -1.38855: K(9, 9) = -1.35299: K(10, 9
) = -1.31684: K(11, 9) = -1.28019: K(12, 9) = -1.24313: K(13, 9) = -1.205
78
9104  K(7, 10) = -1.18347: K(8, 10) = -1.16574: K(9, 10) = -1.14712: K(10
, 10) = -1.12762: K(11, 10) = -1.10726: K(12, 10) = -1.08608: K(13, 10) =
 -1.06413
9106  K(7, 11) = -.85703: K(8, 11) = -.85607: K(9, 11) = -.85426: K(10, 1
1) = -.85161: K(11, 11) = -.84809: K(12, 11) = -.84369: K(13, 11) = -.838
41
9108  K(7, 12) = -.59615: K(8, 12) = -.60412: K(9, 12) = -.61146: K(10, 1
2) = -.61815: K(11, 12) = -.62415: K(12, 12) = -.62944: K(13, 12) = -.634
9110  K(7, 13) = -.35565: K(8, 13) = -.36889: K(9, 13) = -.38186: K(10, 1
3) = -.39434: K(11, 13) = -.40638: K(12, 13) = -.41794: K(13, 13) = -.428
99
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9112  K(7, 14) = -.28516: K(8, 14) = -.29961: K(9, 14) = -.31368: K(10, 1
4) = -.3274: K(11, 14) = -.34075: K(12, 14) = -.3537: K(13, 14) = -.3662
9114  K(7, 15) = -.11578: K(8, 15) = -.13199: K(9, 15) = -.14807: K(10, 1
5) = -.16397: K(11, 15) = -.17968: K(12, 15) = -.19517: K(13, 15) = -.210
4
9116  K(7, 16) = .06097: K(8, 16) = .04397: K(9, 16) = .02693: K(10, 16)
= .00987: K(11, 16) = -.00719: K(12, 16) = -.02421: K(13, 16) = -.04116
9118  K(7, 17) = .13901: K(8, 17) = .12199: K(9, 17) = .10486: K(10, 17)
= 8.763001E-02: K(11, 17) = .07032: K(12, 17) = .05297: K(13, 17) = .0356
9120  K(7, 18) = .42851: K(8, 18) = .41309: K(9, 18) = .39729: K(10, 18)
= .38111: K(11, 18) = .36458: K(12, 18) = .34772: K(13, 18) = .33054
9122  K(7, 19) = .79002: K(8, 19) = .77986: K(9, 19) = .76902: K(10, 19)
= .75752: K(11, 19) = .74537: K(12, 19) = .73257: K(13, 19) = .71915
9124  K(7, 20) = 1.33294: K(8, 20) = 1.3364: K(9, 20) = 1.33889: K(10, 20
) = 1.34039: K(11, 20) = 1.34092: K(12, 20) = 1.34047: K(13, 20) = 1.3390
4
9126  K(7, 21) = 1.81864: K(8, 21) = 1.83916: K(9, 21) = 1.85856: K(10, 2
1) = 1.87683: K(11, 21) = 1.89395: K(12, 21) = 1.90992: K(13, 21) = 1.924
72
9128  K(7, 22) = 1.9666: K(8, 22) = 1.99311: K(9, 22) = 2.01848: K(10, 22
) = 2.04269: K(11, 22) = 2.06573: K(12, 22) = 2.08758: K(13, 22) = 2.1082
3
9130  K(7, 23) = 2.2679: K(8, 23) = 2.30764: K(9, 23) = 2.34623: K(10, 23
) = 2.38364: K(11, 23) = 2.41984: K(12, 23) = 2.45482: K(13, 23) = 2.4885
5
9132  K(7, 24) = 2.4067: K(8, 24) = 2.45298: K(9, 24) = 2.49811: K(10, 24
) = 2.54206: K(11, 24) = 2.5848: K(12, 24) = 2.62631: K(13, 24) = 2.66657
9134  K(7, 25) = 2.82359: K(8, 25) = 2.89101: K(9, 25) = 2.95735: K(10, 2
5) = 3.02256: K(11, 25) = 3.0866: K(12, 25) = 3.14944: K(13, 25) = 3.2110
3
9136  K(7, 26) = 3.22281: K(8, 26) = 3.31243: K(9, 26) = 3.40109: K(10, 2
6) = 3.48874: K(11, 26) = 3.5753: K(12, 26) = 3.66073: K(13, 26) = 3.7449
7
9138  K(7, 27) = 3.72957: K(8, 27) = 3.84981: K(9, 27) = 3.96932: K(10, 2
7) = 4.08802: K(11, 27) = 4.20582: K(12, 27) = 4.32263: K(13, 27) = 4.438
39
9140  K(7, 28) = 4.10022: K(8, 28) = 4.24439: K(9, 28) = 4.38807: K(10, 2
8) = 4.53112: K(11, 28) = 4.67344: K(12, 28) = 4.81492: K(13, 28) = 4.955
49
9142  K(7, 29) = 4.46189: K(8, 29) = 4.63057: K(9, 29) = 4.79899: K(10, 2
9) = 4.96701: K(11, 29) = 5.13449: K(12, 29) = 5.3013: K(13, 29) = 5.4673
5
9144  K(7, 30) = 5.27389: K(8, 30) = 5.50124: K(9, 30) = 5.72899: K(10, 3
0) = 5.95691: K(11, 30) = 6.1848: K(12, 30) = 6.41249: K(13, 30) = 6.6398
9146  K(14, 0) = -1.41753: K(15, 0) = -1.32774: K(16, 0) = -1.24728: K(17
, 0) = -1.1752: K(18, 0) = -1.11054: K(19, 0) = -1.05239: K(20, 0) = -.99
99
9148  K(14, 1) = -1.40413: K(15, 1) = -1.31944: K(16, 1) = -1.24235: K(17
, 1) = -1.1724: K(18, 1) = -1.10901: K(19, 1) = -1.05159: K(20, 1) = -.99
95
9150  K(14, 2) = -1.39408: K(15, 2) = -1.31275: K(16, 2) = -1.23805: K(17
, 2) = -1.16974: K(18, 2) = -1.10743: K(19, 2) = -1.05068: K(20, 2) = -.9
99
9152  K(14, 3) = -1.37981: K(15, 3) = -1.30279: K(16, 3) = -1.23132: K(17
, 3) = -1.16534: K(18, 3) = -1.10465: K(19, 3) = -1.04898: K(20, 3) = -.9
98
9154  K(14, 4) = -1.35114: K(15, 4) = -1.28167: K(16, 4) = -1.21618: K(17
, 4) = -1.15477: K(18, 4) = -1.09749: K(19, 4) = -1.04427: K(20, 4) = -.9
9499
9156  K(14, 5) = -1.31815: K(15, 5) = -1.25611: K(16, 5) = -1.1968: K(17,
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```
 5) = -1.14042: K(18, 5) = -1.08711: K(19, 5) = -1.03695: K(20, 5) = -.98
995
9158  K(14, 6) = -1.26999: K(15, 6) = -1.21716: K(16, 6) = -1.16584: K(17
, 6) = -1.11628: K(18, 6) = -1.06864: K(19, 6) = -1.02311: K(20, 6) = -.9
798
9160  K(14, 7) = -1.25004: K(15, 7) = -1.20059: K(16, 7) = -1.15229: K(17
, 7) = -1.10537: K(18, 7) = -1.06001: K(19, 7) = -1.0164: K(20, 7) = -.97
468
9162  K(14, 8) = -1.19842: K(15, 8) = -1.15682: K(16, 8) = -1.11566: K(17
, 8) = -1.07513: K(18, 8) = -1.03543: K(19, 8) = -.99672: K(20, 8) = -.95
918
9164  K(14, 9) = -1.16827: K(15, 9) = -1.13075: K(16, 9) = -1.09338: K(17
, 9) = -1.05631: K(18, 9) = -1.01973: K(19, 9) = -.98381: K(20, 9) = -.94
871
9166  K(14, 10) = -1.04144: K(15, 10) = -1.0181: K(16, 10) = -.99418: K(1
7, 10) = -.96977: K(18, 10) = -.94496: K(19, 10) = -.91988: K(20, 10) = -
.89464
9168  K(14, 11) = -.83223: K(15, 11) = -.82516: K(16, 11) = -.8172: K(17,
 11) = -.80837: K(18, 11) = -.79868: K(19, 11) = -.78816: K(20, 11) = -.7
7686
9170  K(14, 12) = -.63779: K(15, 12) = -.6408: K(16, 12) = -.643: K(17, 1
2) = -.64436: K(18, 12) = -.64488: K(19, 12) = -.64453: K(20, 12) = -.643
33
9172  K(14, 13) = -.43949: K(15, 13) = -.44942: K(16, 13) = -.45873: K(17
, 13) = -.46739: K(18, 13) = -.47538: K(19, 13) = -.48265: K(20, 13) = -.
48917
9174  K(14, 14) = -.37824: K(15, 14) = -.38977: K(16, 14) = -.40075: K(17
, 14) = -.41116: K(18, 14) = -.42095: K(19, 14) = -.43008: K(20, 14) = -.
43854
9176  K(14, 15) = -.22535: K(15, 15) = -.23996: K(16, 15) = -.25422: K(17
, 15) = -.26808: K(18, 15) = -.2815: K(19, 15) = -.29443: K(20, 15) = -.3
0685
9178  K(14, 16) = -.05803: K(15, 16) = -.07476: K(16, 16) = -.09132: K(17
, 16) = -.10769: K(18, 16) = -.12381: K(19, 16) = -.13964: K(20, 16) = -.
15516
9180  K(14, 17) = .01824: K(15, 17) = .00092: K(16, 17) = -.01631: K(17,
17) = -.03344: K(18, 17) = -.0504: K(19, 17) = -.06718: K(20, 17) = -.083
71
9182  K(14, 18) = .31307: K(15, 18) = .29535: K(16, 18) = .2774: K(17, 18
) = .25925: K(18, 18) = .24094: K(19, 18) = .2225: K(20, 18) = .20397
9184  K(14, 19) = .70512: K(15, 19) = .6905: K(16, 19) = .67532: K(17, 19
) = .65959: K(18, 19) = .64335: K(19, 19) = .62662: K(20, 19) = .60944
9186  K(14, 20) = 1.33665: K(15, 20) = 1.3333: K(16, 20) = 1.329: K(17, 2
0) = 1.32376: K(18, 20) = 1.3176: K(19, 20) = 1.31054: K(20, 20) = 1.3025
9
9188  K(14, 21) = 1.93836: K(15, 21) = 1.95083: K(16, 21) = 1.96213: K(17
, 21) = 1.97227: K(18, 21) = 1.98124: K(19, 21) = 1.98906: K(20, 21) = 1.
99573
9190  K(14, 22) = 2.12768: K(15, 22) = 2.14591: K(16, 22) = 2.16293: K(17
, 22) = 2.17873: K(18, 22) = 2.19332: K(19, 22) = 2.2067: K(20, 22) = 2.2
1888
9192  K(14, 23) = 2.52102: K(15, 23) = 2.55222: K(16, 23) = 2.58214: K(17
, 23) = 2.61076: K(18, 23) = 2.6381: K(19, 23) = 2.66413: K(20, 23) = 2.6
8888
9194  K(14, 24) = 2.70556: K(15, 24) = 2.74325: K(16, 24) = 2.77964: K(17
, 24) = 2.81472: K(18, 24) = 2.84848: K(19, 24) = 2.88091: K(20, 24) = 2.
91202
9196  K(14, 25) = 3.27134: K(15, 25) = 3.33035: K(16, 25) = 3.38804: K(17
, 25) = 3.44438: K(18, 25) = 3.49935: K(19, 25) = 3.55295: K(20, 25) = 3.
60517
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9198  K(14, 26) = 3.82798: K(15, 26) = 3.90973: K(16, 26) = 3.99016: K(17
, 26) = 4.06926: K(18, 26) = 4.147: K(19, 26) = 4.22336: K(20, 26) = 4.29
832
9200  K(14, 27) = 4.55304: K(15, 27) = 4.66651: K(16, 27) = 4.77875: K(17
, 27) = 4.88971: K(18, 27) = 4.99937: K(19, 27) = 5.10768: K(20, 27) = 5.
21461
9202  K(14, 28) = 5.09505: K(15, 28) = 5.23353: K(16, 28) = 5.37087: K(17
, 28) = 5.50701: K(18, 28) = 5.6419: K(19, 28) = 5.77549: K(20, 28) = 5.9
0776
9204  K(14, 29) = 5.63252: K(15, 29) = 5.79673: K(16, 29) = 5.9599: K(17,
 29) = 6.12196: K(18, 29) = 6.28285: K(19, 29) = 6.44251: K(20, 29) = 6.6
009
9206  K(14, 30) = 6.86661: K(15, 30) = 7.09277: K(16, 30) = 7.31818: K(17
, 30) = 7.54272: K(18, 30) = 7.76632: K(19, 30) = 7.98888: K(20, 30) = 8.
21034
9208  K(21, 0) = -.95234: K(22, 0) = -.90908: K(23, 0) = -.86956: K(24, 0
) = -.83333: K(25, 0) = -.8: K(26, 0) = -.76923: K(27, 0) = -.74074
9210  K(21, 1) = -.95215: K(22, 1) = -.90899: K(23, 1) = -.86952: K(24, 1
) = -.83331: K(25, 1) = -.79999: K(26, 1) = -.76923: K(27, 1) = -.74074
9212  K(21, 2) = -.95188: K(22, 2) = -.90885: K(23, 2) = -.86945: K(24, 2
) = -.83328: K(25, 2) = -.79998: K(26, 2) = -.76922: K(27, 2) = -.74074
9214  K(21, 3) = -.95131: K(22, 3) = -.90854: K(23, 3) = -.86929: K(24, 3
) = -.8332: K(25, 3) = -.79994: K(26, 3) = -.7692: K(27, 3) = -.74073
9216  K(21, 4) = -.94945: K(22, 4) = -.90742: K(23, 4) = -.86863: K(24, 4
) = -.83283: K(25, 4) = -.79973: K(26, 4) = -.76909: K(27, 4) = -.74067
9218  K(21, 5) = -.94607: K(22, 5) = -.90521: K(23, 5) = -.86723: K(24, 5
) = -.83196: K(25, 5) = -.79921: K(26, 5) = -.76878: K(27, 5) = -.74049
9220  K(21, 6) = -.93878: K(22, 6) = -.90009: K(23, 6) = -.86371: K(24, 6
) = -.82959: K(25, 6) = -.79765: K(26, 6) = -.76779: K(27, 6) = -.73987
9222  K(21, 7) = -.93495: K(22, 7) = -.89728: K(23, 7) = -.86169: K(24, 7
) = -.82817: K(25, 7) = -.79667: K(26, 7) = -.76712: K(27, 7) = -.73943
9224  K(21, 8) = -.92295: K(22, 8) = -.88814: K(23, 8) = -.85486: K(24, 8
) = -.82315: K(25, 8) = -.79306: K(26, 8) = -.76456: K(27, 8) = -.73765
9226  K(21, 9) = -.91458: K(22, 9) = -.88156: K(23, 9) = -.84976: K(24, 9
) = -.81927: K(25, 9) = -.79015: K(26, 9) = -.76242: K(27, 9) = -.7361
9228  K(21, 10) = -.86938: K(22, 10) = -.84422: K(23, 10) = -.81929: K(24
, 10) = -.79472: K(25, 10) = -.77062: K(26, 10) = -.74709: K(27, 10) = -.
72422
9230  K(21, 11) = -.76482: K(22, 11) = -.75211: K(23, 11) = -.7388: K(24,
 11) = -.72495: K(25, 11) = -.71067: K(26, 11) = -.69602: K(27, 11) = -.6
8111
9232  K(21, 12) = -.64125: K(22, 12) = -.63833: K(23, 12) = -.63456: K(24
, 12) = -.62999: K(25, 12) = -.62463: K(26, 12) = -.61854: K(27, 12) = -.
61176
9234  K(21, 13) = -.49494: K(22, 13) = -.49991: K(23, 13) = -.50409: K(24
, 13) = -.50744: K(25, 13) = -.50999: K(26, 13) = -.51171: K(27, 13) = -.
51263
9236  K(21, 14) = -.44628: K(22, 14) = -.45329: K(23, 14) = -.45953: K(24
, 14) = -.46499: K(25, 14) = -.46966: K(26, 14) = -.47353: K(27, 14) = -.
4766
9238  K(21, 15) = -.31872: K(22, 15) = -.32999: K(23, 15) = -.34063: K(24
, 15) = -.35062: K(25, 15) = -.35992: K(26, 15) = -.36852: K(27, 15) = -.
3764
9240  K(21, 16) = -.1703: K(22, 16) = -.18504: K(23, 16) = -.19933: K(24,
 16) = -.21313: K(25, 16) = -.22642: K(26, 16) = -.23915: K(27, 16) = -.2
5129
9242  K(21, 17) = -.09997: K(22, 17) = -.1159: K(23, 17) = -.13148: K(24,
 17) = -.14665: K(25, 17) = -.16138: K(26, 17) = -.17564: K(27, 17) = -.1
8939
9244  K(21, 18) = .1854: K(22, 18) = .16682: K(23, 18) = .14827: K(24, 18
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) = .12979: K(25, 18) = .11143: K(26, 18) = .09323: K(27, 18) = .07523
9246  K(21, 19) = .59183: K(22, 19) = .57383: K(23, 19) = .55549: K(24, 1
9) = .53683: K(25, 19) = .51789: K(26, 19) = .49872: K(27, 19) = .47934
9248  K(21, 20) = 1.29377: K(22, 20) = 1.28412: K(23, 20) = 1.27365: K(24
, 20) = 1.2624: K(25, 20) = 1.25039: K(26, 20) = 1.23766: K(27, 20) = 1.2
2422
9250  K(21, 21) = 2.00128: K(22, 21) = 2.0057: K(23, 21) = 2.00903: K(24,
 21) = 2.01128: K(25, 21) = 2.01247: K(26, 21) = 2.01263: K(27, 21) = 2.0
1177
9252  K(21, 22) = 2.22986: K(22, 22) = 2.23967: K(23, 22) = 2.24831: K(24
, 22) = 2.25581: K(25, 22) = 2.26217: K(26, 22) = 2.26743: K(27, 22) = 2.
2716
9254  K(21, 23) = 2.71234: K(22, 23) = 2.73451: K(23, 23) = 2.75541: K(24
, 23) = 2.77506: K(25, 23) = 2.79345: K(26, 23) = 2.81062: K(27, 23) = 2.
82658
9256  K(21, 24) = 2.94181: K(22, 24) = 2.97028: K(23, 24) = 2.99744: K(24
, 24) = 3.0233: K(25, 24) = 3.04787: K(26, 24) = 3.07116: K(27, 24) = 3.0
932
9258  K(21, 25) = 3.656: K(22, 25) = 3.70543: K(23, 25) = 3.75347: K(24,
25) = 3.80013: K(25, 25) = 3.8454: K(26, 25) = 3.8893: K(27, 25) = 3.9318
3
9260  K(21, 26) = 4.37186: K(22, 26) = 4.44398: K(23, 26) = 4.51467: K(24
, 26) = 4.58393: K(25, 26) = 4.65176: K(26, 26) = 4.71815: K(27, 26) = 4.
78313
9262  K(21, 27) = 5.32014: K(22, 27) = 5.42426: K(23, 27) = 5.52694: K(24
, 27) = 5.62818: K(25, 27) = 5.72796: K(26, 27) = 5.82629: K(27, 27) = 5.
92316
9264  K(21, 28) = 6.03865: K(22, 28) = 6.16816: K(23, 28) = 6.29626: K(24
, 28) = 6.42292: K(25, 28) = 6.54814: K(26, 28) = 6.67191: K(27, 28) = 6.
79421
9266  K(21, 29) = 6.75798: K(22, 29) = 6.9137: K(23, 29) = 7.06804: K(24,
 29) = 7.22098: K(25, 29) = 7.3725: K(26, 29) = 7.52258: K(27, 29) = 7.67
121
9268  K(21, 30) = 8.43064: K(22, 30) = 8.64971: K(23, 30) = 8.86753: K(24
, 30) = 9.08403: K(25, 30) = 9.2992: K(26, 30) = 9.51301: K(27, 30) = 9.7
25429
9270  K(28, 0) = -.71429: K(29, 0) = -.68966: K(30, 0) = -.66667: K(31, 0
) = -.64516: K(32, 0) = -.625: K(33, 0) = -.60606: K(34, 0) = -.58824
9272  K(28, 1) = -.71429: K(29, 1) = -.68966: K(30, 1) = -.66667: K(31, 1
) = -.64516: K(32, 1) = -.625: K(33, 1) = -.60606: K(34, 1) = -.58824
9274  K(28, 2) = -.71428: K(29, 2) = -.68965: K(30, 2) = -.66667: K(31, 2
) = -.64516: K(32, 2) = -.625: K(33, 2) = -.60606: K(34, 2) = -.58824
9276  K(28, 3) = -.71428: K(29, 3) = -.68965: K(30, 3) = -.66667: K(31, 3
) = -.64516: K(32, 3) = -.625: K(33, 3) = -.60606: K(34, 3) = -.58824
9278  K(28, 4) = -.71425: K(29, 4) = -.68964: K(30, 4) = -.66666: K(31, 4
) = -.64516: K(32, 4) = -.625: K(33, 4) = -.60606: K(34, 4) = -.58824
9280  K(28, 5) = -.71415: K(29, 5) = -.68959: K(30, 5) = -.66663: K(31, 5
) = -.64514: K(32, 5) = -.62499: K(33, 5) = -.60606: K(34, 5) = -.58823
9282  K(28, 6) = -.71377: K(29, 6) = -.68935: K(30, 6) = -.66649: K(31, 6
) = -.64507: K(32, 6) = -.62495: K(33, 6) = -.60603: K(34, 6) = -.58822
9284  K(28, 7) = -.71348: K(29, 7) = -.68917: K(30, 7) = -.66638: K(31, 7
) = -.645: K(32, 7) = -.62491: K(33, 7) = -.60601: K(34, 7) = -.58821
9286  K(28, 8) = -.71227: K(29, 8) = -.68836: K(30, 8) = -.66585: K(31, 8
) = -.64465: K(32, 8) = -.62469: K(33, 8) = -.60587: K(34, 8) = -.58812
9288  K(28, 9) = -.71116: K(29, 9) = -.68759: K(30, 9) = -.66532: K(31, 9
) = -.64429: K(32, 9) = -.62445: K(33, 9) = -.60572: K(34, 9) = -.58802
9290  K(28, 10) = -.70209: K(29, 10) = -.68075: K(30, 10) = -.66023: K(31
, 10) = -.64056: K(32, 10) = -.62175: K(33, 10) = -.60379: K(34, 10) = -.
58666
9292  K(28, 11) = -.66603: K(29, 11) = -.65086: K(30, 11) = -.63569: K(31
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, 11) = -.6206: K(32, 11) = -.60567: K(33, 11) = -.59096: K(34, 11) = -.5
7652
9294  K(28, 12) = -.60434: K(29, 12) = -.59634: K(30, 12) = -.58783: K(31
, 12) = -.57887: K(32, 12) = -.56953: K(33, 12) = -.55989: K(34, 12) = -.
55
9296  K(28, 13) = -.51276: K(29, 13) = -.51212: K(30, 13) = -.5107301: K(
31, 13) = -.50863: K(32, 13) = -.5058501: K(33, 13) = -.50244: K(34, 13)
= -.49844
9298  K(28, 14) = -.47888: K(29, 14) = -.48037: K(30, 14) = -.48109: K(31
, 14) = -.48107: K(32, 14) = -.48033: K(33, 14) = -.4789: K(34, 14) = -.4
7682
9300  K(28, 15) = -.38353: K(29, 15) = -.38991: K(30, 15) = -.39554: K(31
, 15) = -.40041: K(32, 15) = -.40454: K(33, 15) = -.40792: K(34, 15) = -.
41058
9302  K(28, 16) = -.26282: K(29, 16) = -.27372: K(30, 16) = -.28395: K(31
, 16) = -.29351: K(32, 16) = -.30238: K(33, 16) = -.31055: K(34, 16) = -.
31802
9304  K(28, 17) = -.20259: K(29, 17) = -.21523: K(30, 17) = -.22726: K(31
, 17) = -.23868: K(32, 17) = -.24946: K(33, 17) = -.25958: K(34, 17) = -.
26904
9306  K(28, 18) = .05746: K(29, 18) = .03997: K(30, 18) = .02279: K(31, 1
8) = .00596: K(32, 18) = -.0105: K(33, 18) = -.02654: K(34, 18) = -.04215
9308  K(28, 19) = .4598: K(29, 19) = .44015: K(30, 19) = .4204: K(31, 19)
 = .40061: K(32, 19) = .38081: K(33, 19) = .36104: K(34, 19) = .34133
9310  K(28, 20) = 1.21013: K(29, 20) = 1.19539: K(30, 20) = 1.18006: K(31
, 20) = 1.16416: K(32, 20) = 1.14772: K(33, 20) = 1.13078: K(34, 20) = 1.
11337
9312  K(28, 21) = 2.00992: K(29, 21) = 2.0071: K(30, 21) = 2.00335: K(31,
 21) = 1.99869: K(32, 21) = 1.99314: K(33, 21) = 1.98674: K(34, 21) = 1.9
7951
9314  K(28, 22) = 2.2747: K(29, 22) = 2.27676: K(30, 22) = 2.2778: K(31,
22) = 2.27785: K(32, 22) = 2.27693: K(33, 22) = 2.27506: K(34, 22) = 2.27
229
9316  K(28, 23) = 2.84134: K(29, 23) = 2.85492: K(30, 23) = 2.86735: K(31
, 23) = 2.87865: K(32, 23) = 2.88884: K(33, 23) = 2.89795: K(34, 23) = 2.
90599
9318  K(28, 24) = 3.11399: K(29, 24) = 3.13356: K(30, 24) = 3.15193: K(31
, 24) = 3.16911: K(32, 24) = 3.18512: K(33, 24) = 3.2: K(34, 24) = 3.2137
5
9320  K(28, 25) = 3.97301: K(29, 25) = 4.01286: K(30, 25) = 4.05138: K(31
, 25) = 4.08859: K(32, 25) = 4.12452: K(33, 25) = 4.15917: K(34, 25) = 4.
19257
9322  K(28, 26) = 4.84669: K(29, 26) = 4.90884: K(30, 26) = 4.96959: K(31
, 26) = 5.02897: K(32, 26) = 5.08697: K(33, 26) = 5.14362: K(34, 26) = 5.
19892
9324  K(28, 27) = 6.01858: K(29, 27) = 6.11254: K(30, 27) = 6.20506: K(31
, 27) = 6.29613: K(32, 27) = 6.38578: K(33, 27) = 6.47401: K(34, 27) = 6.
56084
9326  K(28, 28) = 6.91505: K(29, 28) = 7.03443: K(30, 28) = 7.15235: K(31
, 28) = 7.26881: K(32, 28) = 7.38382: K(33, 28) = 7.49739: K(34, 28) = 7.
60953
9328  K(28, 29) = 7.81839: K(29, 29) = 7.96411: K(30, 29) = 8.10836: K(31
, 29) = 8.25115: K(32, 29) = 8.39248: K(33, 29) = 8.53236: K(34, 29) = 8.
67079
9330  K(28, 30) = 9.93643: K(29, 30) = 10.14602: K(30, 30) = 10.35418: K(
31, 30) = 10.5609: K(32, 30) = 10.76618: K(33, 30) = 10.97001: K(34, 30)
= 11.17239
9332  K(35, 0) = -.57143: K(36, 0) = -.55556: K(37, 0) = -.54054: K(38, 0
) = -.52632: K(39, 0) = -.51282: K(40, 0) = -.5: K(41, 0) = -.4878
9334  K(35, 1) = -.57143: K(36, 1) = -.55556: K(37, 1) = -.54054: K(38, 1
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) = -.52632: K(39, 1) = -.51282: K(40, 1) = -.5: K(41, 1) = -.4878
9336  K(35, 2) = -.57143: K(36, 2) = -.55556: K(37, 2) = -.54054: K(38, 2
) = -.52632: K(39, 2) = -.51282: K(40, 2) = -.5: K(41, 2) = -.4878
9338  K(35, 3) = -.57143: K(36, 3) = -.55556: K(37, 3) = -.54054: K(38, 3
) = -.52632: K(39, 3) = -.51282: K(40, 3) = -.5: K(41, 3) = -.4878
9340  K(35, 4) = -.57143: K(36, 4) = -.55556: K(37, 4) = -.54054: K(38, 4
) = -.52632: K(39, 4) = -.51282: K(40, 4) = -.5: K(41, 4) = -.4878
9342  K(35, 5) = -.57143: K(36, 5) = -.55556: K(37, 5) = -.54054: K(38, 5
) = -.52632: K(39, 5) = -.51282: K(40, 5) = -.5: K(41, 5) = -.4878
9344  K(35, 6) = -.57142: K(36, 6) = -.55555: K(37, 6) = -.54054: K(38, 6
) = -.52631: K(39, 6) = -.51282: K(40, 6) = -.5: K(41, 6) = -.4878
9346  K(35, 7) = -.57141: K(36, 7) = -.55555: K(37, 7) = -.54054: K(38, 7
) = -.52631: K(39, 7) = -.51282: K(40, 7) = -.5: K(41, 7) = -.4878
9348  K(35, 8) = -.57136: K(36, 8) = -.55552: K(37, 8) = -.54052: K(38, 8
) = -.5263: K(39, 8) = -.51281: K(40, 8) = -.5: K(41, 8) = -.4878
9350  K(35, 9) = -.5713: K(36, 9) = -.55548: K(37, 9) = -.5405: K(38, 9)
= -.52629: K(39, 9) = -.51281: K(40, 9) = -.49999: K(41, 9) = -.4878
9352  K(35, 10) = -.57035: K(36, 10) = -.55483: K(37, 10) = -.54006: K(38
, 10) = -.526: K(39, 10) = -.5126101: K(40, 10) = -.49986: K(41, 10) = -.
48772
9354  K(35, 11) = -.56242: K(36, 11) = -.54867: K(37, 11) = -.53533: K(38
, 11) = -.5224001: K(39, 11) = -.5099: K(40, 11) = -.49784: K(41, 11) = -
.48622
9356  K(35, 12) = -.53993: K(36, 12) = -.52975: K(37, 12) = -.51952: K(38
, 12) = -.50929: K(39, 12) = -.49911: K(40, 12) = -.48902: K(41, 12) = -.
47906
9358  K(35, 13) = -.49391: K(36, 13) = -.48888: K(37, 13) = -.48342: K(38
, 13) = -.47758: K(39, 13) = -.47141: K(40, 13) = -.46496: K(41, 13) = -.
45828
9360  K(35, 14) = -.47413: K(36, 14) = -.47088: K(37, 14) = -.46711: K(38
, 14) = -.46286: K(39, 14) = -.45819: K(40, 14) = -.45314: K(41, 14) = -.
44777
9362  K(35, 15) = -.41253: K(36, 15) = -.41381: K(37, 15) = -.41442: K(38
, 15) = -.41441: K(39, 15) = -.41381: K(40, 15) = -.41265: K(41, 15) = -.
41097
9364  K(35, 16) = -.32479: K(36, 16) = -.33085: K(37, 16) = -.33623: K(38
, 16) = -.34092: K(39, 16) = -.34494: K(40, 16) = -.34831: K(41, 16) = -.
35105
9366  K(35, 17) = -.27782: K(36, 17) = -.28592: K(37, 17) = -.29335: K(38
, 17) = -.3001: K(39, 17) = -.30617: K(40, 17) = -.31159: K(41, 17) = -.3
1635
9368  K(35, 18) = -.0573: K(36, 18) = -7.195001E-02: K(37, 18) = -.0861:
K(38, 18) = -.09972: K(39, 18) = -.11279: K(40, 18) = -.1253: K(41, 18) =
 -.13725
9370  K(35, 19) = .32171: K(36, 19) = .30223: K(37, 19) = .2829: K(38, 19
) = .26376: K(39, 19) = .24484: K(40, 19) = .22617: K(41, 19) = .20777
9372  K(35, 20) = 1.09552: K(36, 20) = 1.07726: K(37, 20) = 1.05863: K(38
, 20) = 1.03965: K(39, 20) = 1.02036: K(40, 20) = 1.00079: K(41, 20) = .9
8096
9374  K(35, 21) = 1.97147: K(36, 21) = 1.96266: K(37, 21) = 1.95311: K(38
, 21) = 1.94283: K(39, 21) = 1.93186: K(40, 21) = 1.92023: K(41, 21) = 1.
90796
9376  K(35, 22) = 2.26862: K(36, 22) = 2.26409: K(37, 22) = 2.25872: K(38
, 22) = 2.25254: K(39, 22) = 2.24558: K(40, 22) = 2.23786: K(41, 22) = 2.
2294
9378  K(35, 23) = 2.91299: K(36, 23) = 2.91898: K(37, 23) = 2.92397: K(38
, 23) = 2.92799: K(39, 23) = 2.93107: K(40, 23) = 2.93324: K(41, 23) = 2.
9345
9380  K(35, 24) = 3.22641: K(36, 24) = 3.238: K(37, 24) = 3.24853: K(38,
24) = 3.25803: K(39, 24) = 3.26653: K(40, 24) = 3.27404: K(41, 24) = 3.28
```

```
06
9382  K(35, 25) = 4.22473: K(36, 25) = 4.25569: K(37, 25) = 4.28545: K(38
, 25) = 4.31403: K(39, 25) = 4.34147: K(40, 25) = 4.36777: K(41, 25) = 4.
39296
9384  K(35, 26) = 5.25291: K(36, 26) = 5.30559: K(37, 26) = 5.35698: K(38
, 26) = 5.40711: K(39, 26) = 5.45598: K(40, 26) = 5.50362: K(41, 26) = 5.
55005
9386  K(35, 27) = 6.64627: K(36, 27) = 6.73032: K(37, 27) = 6.81301: K(38
, 27) = 6.89435: K(39, 27) = 6.97435: K(40, 27) = 7.05304: K(41, 27) = 7.
13043
9388  K(35, 28) = 7.72024: K(36, 28) = 7.82954: K(37, 28) = 7.93744: K(38
, 28) = 8.04395: K(39, 28) = 8.1491: K(40, 28) = 8.25289: K(41, 28) = 8.3
5534
9390  K(35, 29) = 8.80779: K(36, 29) = 8.94335: K(37, 29) = 9.077501: K(3
8, 29) = 9.21023: K(39, 29) = 9.341581: K(40, 29) = 9.471541: K(41, 29) =
 9.60013
9392  K(35, 30) = 11.37334: K(36, 30) = 11.57284: K(37, 30) = 11.77092: K
(38, 30) = 11.96757: K(39, 30) = 12.1628: K(40, 30) = 12.35663: K(41, 30)
 = 12.54906


9394 FOR G = 42 TO 83
9396    FOR P = 0 TO 30
9398        K(G, P) = -K(G - 41, 30 - P)
9400    NEXT P
9402 NEXT G
9404 LOCATE 20, 20
9406 COLOR 12
9408 INPUT "PRESS ENTER TO PROCEED ...............", ERM
9410 CHAIN "FANINP"
9412 END


10000 REM   ***************************************************************
10002 REM                           QUIT PROGRAM
10004 REM   ***************************************************************
10006 OPEN "QUIT" FOR OUTPUT AS #3
10008 CLS
10010 COLOR 12
10012 FOR I = 1 TO 10: PRINT : NEXT I
10014 PRINT "                           PROGRAM TERMINATED BY USER"
10016 COLOR 7
10020 SYSTEM
11111 END
```

```
1   REM
2   REM   FFFFFFFF  AAA        NNN      NNN IIIIIIIII NNN      NNN PPPPPPPP
3   REM   FFF        AAAAA     NNNN     NNN    III    NNNN     NNN PPP     PPP
4   REM   FFF       AAA  AAA   NNNNNN   NNN    III    NNNNNN   NNN PPP     PPP
5   REM   FFFFFF AAA      AAA  NNN NNN NNN     III    NNN NNN NNN PPPPPPPP
6   REM   FFF    AAAAAAAAAAAA  NNN   NNNNNN    III    NNN   NNNNN PPP
7   REM   FFF   AAA          AAA NNN     NNNN  III    NNN    NNNN PPP
8   REM   FFF   AAA          AAA NNN      NNN IIIIIIIII NNN     NNN PPP
9   REM
10  REM
11  REM Portions (c) Copyright
12  REM Microsoft Corporation
13  REM 1982-1988
14  REM All Rights Reserved
15  REM
16  REM Alluvial Fan - Michael Baker Jr., Inc. - JULY 1990
17  REM
18  REM
19  COMMON SHARED P(), K(), KG(), K0()
20  REM
30  ON KEY(1) GOSUB 10000
31  KEY(1) ON
35  REM
74  REM
99  REM


100 REM     ************************************************************
102 REM                              INPUT DATA
104 REM     ************************************************************
105 REM
106 CLS
107 COLOR 11: PRINT "Press F1 and then press ENTER to exit": COLOR 2
108 PRINT : PRINT
109 PRINT "                    ENTER THE NAME OF THE ALLUVIAL FAN    "
110 INPUT "                    ", B$
114 CLS : MULT = 0
115 COLOR 11: PRINT "Press F1 and then press ENTER to exit": COLOR 2
116 FOR I = 1 TO 4: PRINT : NEXT I
```

```
120 REM      ***********************************************************
122 REM                          INPUT MULTIPLE-CHANNEL DATA
124 REM      ***********************************************************
126 REM
128 PRINT "DO YOU WISH TO COMPUTE ZONE BOUNDARIES"
130 INPUT "FOR MULTIPLE CHANNELS (Y/N)"; MULT$
132 IF INSTR(MULT$, "Y") = 0 AND INSTR(MULT$, "y") = 0 THEN GOTO 179
134 MULT = 1
136 CLS : COLOR 11: PRINT "Press F1 and then press ENTER to exit": COLOR
2
137 FOR I = 1 TO 4: PRINT : NEXT I
138 INPUT "ENTER SLOPE OF ALLUVIAL FAN     ", SLOPE
140 CLS : COLOR 11: PRINT "Press F1 and then press ENTER to exit": COLOR
2
141 FOR I = 1 TO 4: PRINT : NEXT I
142 IF SLOPE > 1 THEN PRINT "SLOPE ("; SLOPE; ") IS TOO LARGE" ELSE GOTO
146
144 GOTO 148
146 IF SLOPE < .000001 THEN PRINT "SLOPE ("; SLOPE; ") IS TOO SMALL" ELSE
 GOTO 152
148 FOR I = 1 TO 4: PRINT : NEXT I
150 GOTO 138
152 CLS : COLOR 11: PRINT "Press F1 and then press ENTER to exit": COLOR
2
153 FOR I = 1 TO 4: PRINT : NEXT I
154 PRINT "SLOPE ="; SLOPE
156 FOR I = 1 TO 4: PRINT : NEXT I
158 INPUT "ENTER ROUGHNESS COEFFICIENT (N-VALUE)     ", NVALUE
160 CLS : COLOR 11: PRINT "Press F1 and then press ENTER to exit": COLOR
2
161 FOR I = 1 TO 4: PRINT : NEXT I
162 IF NVALUE > 1 THEN PRINT "N-VALUE ("; NVALUE; ") IS TOO LARGE" ELSE G
OTO 166
164 GOTO 168
166 IF NVALUE < .001 THEN PRINT "N-VALUE ("; NVALUE; ") IS TOO SMALL" ELS
E GOTO 172
168 FOR I = 1 TO 4: PRINT : NEXT I
170 GOTO 158
172 CLS : COLOR 11: PRINT "Press F1 and then press ENTER to exit": COLOR
2
173 FOR I = 1 TO 4: PRINT : NEXT I
174 PRINT "MULTIPLE CHANNEL PARAMETERS :"
176 PRINT "                      SLOPE ="; SLOPE
178 PRINT "                    N-VALUE ="; NVALUE
179 COLOR 11
180 IF INSTR(MULT$, "Y") = 0 AND INSTR(MULT$, "y") = 0 THEN CLS
181 IF INSTR(MULT$, "Y") = 0 AND INSTR(MULT$, "y") = 0 THEN PRINT "Press
F1 and then press ENTER to exit"
182 COLOR 2
183 FOR I = 1 TO 4: PRINT : NEXT I
```

```
184 REM
186 REM      ************************************************************
188 REM                              INPUT AVULSION FACTOR
190 REM      ************************************************************
192 REM
194 INPUT "ENTER AVULSION FACTOR    ", AVUL
196 IF AVUL = 0 THEN AVUL = 1


199 REM
200 REM      ************************************************************
202 REM              CHOOSE OPTION FOR DEFINING FLOOD FREQUENCY CURVE
204 REM      ************************************************************
205 REM
206 CLS : COLOR 11: PRINT "Press F1 and then press ENTER to exit": COLOR
2
207 FOR I = 1 TO 4: PRINT : NEXT I
208 PRINT "YOU MAY DEFINE THE FLOOD FREQENCY CURVE BY:"
210 PRINT : PRINT
212 PRINT "(1)....ENTERING THE MEAN, STANDARD DEVIATION, AND SKEW COEFFIC
IENT"
214 PRINT "       OF THE PEARSON TYPE-III DISTRIBUTION"
216 PRINT
218 PRINT "(2)....ENTERING (AT LEAST THREE) PAIRS OF RETURN INTERVALS AND
 DISCHARGES"
220 PRINT : PRINT
222 INPUT "PLEASE ENTER OPTION NUMBER (1 OR 2)   ", PDFOPT
224 IF PDFOPT = 1 THEN GOTO 300
226 IF PDFOPT = 2 THEN GOTO 400
228 CLS : COLOR 11: PRINT "Press F1 and then press ENTER to exit": COLOR
2
229 FOR I = 1 TO 4: PRINT : NEXT I
230 PRINT "SORRY, THERE ARE ONLY TWO OPTIONS."
232 PRINT PDFOPT; " IS NOT ONE OF THEM."
234 FOR I = 1 TO 4: PRINT : NEXT I
236 GOTO 208
```

```
299 REM
300 REM      **************************************************************
302 REM                          OPTION (1)  ENTER STATISTICS
304 REM      **************************************************************
305 REM
306 CLS : COLOR 11: PRINT "Press F1 and then press ENTER to exit": COLOR
2: FOR I = 1 TO 4: PRINT : NEXT I
307 INPUT "                  ENTER MEAN  ", MU
308 PRINT
309 INPUT "   ENTER STANDARD DEVIATION  ", SIGMA
310 PRINT
311 IF SIGMA < .1 THEN GOTO 330
312 INPUT "     ENTER SKEW COEFFICIENT  ", SKEW
313 IF SKEW > 4.1 THEN GOTO 340
314 IF SKEW < -4.1 THEN GOTO 350
318 IF SKEW < 0 THEN SK = 4.1 - SKEW ELSE SK = SKEW
320 G = INT(10 * (SK + .05))
322 SKEW = G / 10
324 IF SKEW > 4.1 THEN SKEW = 4.1 - SKEW
326 GOTO 700
330 PRINT "SORRY, STANDARD DEVIATION MUST BE GREATER THAN 0.1"
332 INPUT "RE-ENTER STANDARD DEVIATION  ", SIGMA
334 GOTO 310
340 PRINT
341 PRINT "SORRY, SKEW CANNOT BE GREATER THAN 4.1"
342 INPUT "  RE-ENTER SKEW COEFFICIENT  ", SKEW
343 GOTO 313
350 PRINT
351 PRINT "SORRY, SKEW CANNOT BE LESS THAN -4.1"
352 GOTO 342
```

```
399 REM
400 REM     *************************************************************
402 REM                   OPTION (2)  ENTER PAIRS OF DATA
404 REM     *************************************************************
405 REM
406 CLS : COLOR 11: PRINT "Press F1 and then press ENTER to exit": COLOR
2
408 FOR I = 1 TO 4: PRINT : NEXT I
410 PRINT "HOW MANY PAIRS OF DISCHARGES AND"
412 INPUT "RECURRENCE INTERVALS DO YOU WISH TO ENTER"; NOF: NOF = INT(NOF
)
414 IF NOF >= 3 THEN GOTO 424
416 CLS : COLOR 11:   PRINT "Press F1 and then press ENTER to exit": PRIN
T : PRINT : COLOR 2
418 PRINT "SORRY, YOU MUST ENTER AT LEAST THREE PAIRS OF DATA."
420 PRINT NOF; " IS LESS THAN THREE."
422 GOTO 408
423 REM
424 PRINT : PRINT
426 DIM RET(NOF), Q(NOF), Y(NOF), KK(NOF), PIN(NOF)
428 FOR I = 1 TO NOF
430     PRINT "ENTER RECURRENCE INTERVAL NUMBER"; I;
432     INPUT "   ", RET(I): GOSUB 1000
434     PRINT : PRINT
436     PRINT "      ENTER"; RET(I); "- YEAR DISCHARGE";
438     INPUT "                     ", Q(I): GOSUB 2000: GOSUB 3000
440     GOSUB 480
442 NEXT
443 I = NOF
444 INPUT "              DO YOU WISH TO CHANGE ANY DATA (Y/N)"; CHGDAT$
446 IF INSTR(CHGDAT$, "Y") = 0 AND INSTR(CHGDAT$, "y") = 0 GOTO 500
448 PRINT : PRINT
450 PRINT "WHICH PAIR OF DATA ( 1 -"; NOF; ") DO YOU WISH TO";
452 INPUT " CHANGE"; CHGDAT: CHGDAT = INT(CHGDAT)
454 IF (CHGDAT >= 1) AND (CHGDAT <= NOF) THEN GOTO 464
456 CLS : COLOR 11:   PRINT "Press F1 and then press ENTER to exit": PRIN
T : PRINT : COLOR 2
458 PRINT "SORRY, THERE IS NO DATA PAIR NUMBER "; CHGDAT
460 PRINT : PRINT
462 GOSUB 482: GOTO 444
464 GOSUB 3066
476 GOSUB 480
478 GOTO 444
480 CLS : COLOR 11: PRINT "Press F1 and then press ENTER to exit": COLOR
2
481 FOR K = 1 TO 4: PRINT : NEXT K
482 PRINT "             DATA PAIR    RECURRENCE INTERVAL  DISCHARGE"
484 PRINT
486 FOR J = 1 TO I
488     PRINT USING "##################"; J; RET(J); Q(J)
490 NEXT
492 PRINT : PRINT : PRINT
494 RETURN
```

```
499 REM
500 REM      ************************************************************
502 REM                        FIND SKEW THAT GIVES BEST FIT
504 REM      ************************************************************
505 REM
506 LEFT = -4.1: RIGHT = 4.1
508 IF RIGHT - LEFT < .12 GOTO 528
510 MID = INT(10 * (RIGHT + LEFT) / 2 + .001) / 10
512 RMID = MID + .1
514 IF MID < 0 THEN G = 10 * (4.1 - MID) ELSE G = 10 * MID
516 GOSUB 600: MIDR = R
518 IF RMID < 0 THEN G = 10 * (4.1 - RMID) ELSE G = 10 * RMID
520 GOSUB 600: RMIDR = R
522 IF RMIDR < MIDR GOTO 526
524 LEFT = MID: GOTO 508
526 RIGHT = MID: GOTO 508
528 IF RMIDR > MIDR THEN SKEW = RMID ELSE SKEW = MID
530 IF SKEW < 0 THEN G = 10 * (4.1 - SKEW) ELSE G = 10 * SKEW
532 GOSUB 600
534 RMAX = R: MU = MEAN: SIGMA = STDV
550 GOTO 700


600 REM
602 REM      ************************************************************
604 REM                  GIVEN INPUT DATA (OPTION 2), COMPUTE
606 REM                  LOG(J) AND CORRESPONDING DEVIATE KK(J)
608 REM      ************************************************************
610 REM
612 FOR J = 1 TO NOF
614    Y(J) = LOG(Q(J)) / LOG(10)
616    PIN(J) = 1 / RET(J)
618    FOR I = 1 TO 30
620        IF PIN(J) < P(I) THEN GOTO 626
622        N = I: M = N - 1
624        GOTO 628
626    NEXT I
628    KK(J) = K(G, M) + (PIN(J) - P(M)) * (K(G, N) - K(G, M)) / (P(N) -
P(M))
630 NEXT J
```

```
632 REM
634 REM     *************************************************************
636 REM          GIVEN NOF PAIRS OF DATA, Y(J) AND KK(J), COMPUTE
638 REM          MEAN (Y-INTERCEPT), STANDARD DEVIATION (SLOPE),
640 REM          AND CORRELATION COEFICIENT BY METHOD OF LEAST SQUARES
642 REM     *************************************************************
644 REM
646 MK = 0: MY = 0: A = 0: B = 0: C = 0
648 FOR I = 1 TO NOF
650    MK = MK + KK(I)
652    MY = MY + Y(I)
654 NEXT
656 MEANK = MK / NOF
658 MEANY = MY / NOF
660 FOR I = 1 TO NOF
662    A = A + (KK(I) - MEANK) ^ 2
664    B = B + (Y(I) - MEANY) ^ 2
666    C = C + (KK(I) - MEANK) * (Y(I) - MEANY)
668 NEXT
670 SIGK = SQR(A / NOF): SIGY = SQR(B / NOF)
672 R = C / NOF / SIGK / SIGY
674 STDV = R * SIGY / SIGK
676 MEAN = MEANY - STDV * MEANK
678 RETURN


700 REM
702 REM     *************************************************************
704 REM                CHECK VALUE OF 100-YEAR FLOOD DISCHARGE
706 REM     *************************************************************
708 REM
709 IF (SIGMA * K(G, 25) + MU) > 6 THEN GOTO 714
710 Q100 = 10 ^ (SIGMA * K(G, 25) + MU)
712 IF Q100 < 500000! THEN GOTO 730
714 CLS : COLOR 12
716 FOR I = 1 TO 8: PRINT : NEXT I
718 PRINT "                    Q100 > 500000 cfs... PROGRAM TERMINATED":
PRINT : PRINT : PRINT
720 COLOR 15, 0: PRINT "                        Press ENTER to start over
": PRINT
721 INPUT "                     or press F1 and then ENTER to exit", MJM
722 COLOR 12
723 GOTO 100
730 IF Q100 > 50 THEN GOTO 800
732 CLS : COLOR 12
734 FOR I = 1 TO 8: PRINT : NEXT I
736 PRINT "                    Q100 < 50 cfs ...... PROGRAM TERMINATED":
 PRINT : PRINT : PRINT
738 GOTO 720
```

```
800 REM
802 REM     ****************************************************************
804 REM                        WRITE INPUT TO INPUT FILE
806 REM     ****************************************************************
808 REM
812 PRINT #1, B$
814 PRINT #1, MULT, SLOPE, NVALUE
816 PRINT #1, PDFOPT, AVUL
818 PRINT #1, NOF
820 FOR I = 1 TO NOF
822     PRINT #1, RET(I), Q(I), KK(I)
824 NEXT I
826 PRINT #1, MU, SIGMA, SKEW, RMAX
828 FOR I = 0 TO 30
830     PRINT #1, P(I)
832 NEXT I
834 FOR I = 0 TO 30
836     KO(I) = K(0, I): PRINT #1, KO(I)
838     KG(I) = K(G, I): PRINT #1, KG(I)
840 NEXT I
842 PRINT #1, Q100
850 SYSTEM
```

```
1000 REM
1001 REM    ************************************************************
1002 REM                          CHECK RECURRENCE INTERVAL
1004 REM    ************************************************************
1005 REM
1006 IF RET(I) < 1.001 GOTO 1012
1008 IF RET(I) > 1000 GOTO 1024
1010 GOTO 1030
1012 PRINT
1014 PRINT "SORRY, RECURRENCE INTERVAL CANNOT BE LESS THAN 1.001 YEAR"
1016 PRINT
1018 PRINT "RE-ENTER RECURRENCE INTERVAL";
1020 INPUT "  ", RET(I)
1022 GOTO 1000
1024 PRINT
1026 PRINT "SORRY, RECURRENCE INTERVAL CANNOT BE GREATER THAN 1000 YEARS"
1028 GOTO 1016
1030 IF I = 1 THEN RETURN
1032 FOR J = 1 TO I - 1
1034     IF RET(I) = RET(J) GOTO 1040
1036 NEXT J
1038 RETURN
1040 PRINT
1042 PRINT "SORRY, EACH RECURRENCE INTERVAL MAY BE ENTERED ONLY ONCE"
1044 PRINT RET(I); "IS ALSO RECURRENCE INTERVAL NUMBER "; J
1046 GOTO 1016


2000 REM
2001 REM      ************************************************************
2002 REM                  CHECK THAT DISCHARGE IS GREATER THAN ZERO
2004 REM      ************************************************************
2005 REM
2006 IF Q(I) > 0 THEN RETURN
2008 PRINT
2010 PRINT "DISCHARGE MUST BE GREATER THAN ZERO"
2012 PRINT
2014 PRINT "RE-ENTER"; RET(I); "- YEAR DISCHARGE";
2016 INPUT "                              ", Q(I)
2018 GOTO 2000
```

```
3000 REM
3001 REM      ****************************************************************
3002 REM                        ORDER DATA BY RECURRENCE INTERVAL
3003 REM                   AND CHECK THAT DISCHARGES DO NOT DECREASE
3004 REM      ****************************************************************
3005 IF I = 1 THEN RETURN
3006 FOR J = 1 TO I - 1
3008     IF RET(I) < RET(J) GOTO 3014
3010 NEXT J
3012 GOTO 3024
3014 RET = RET(I): Q = Q(I)
3016 FOR K = I TO J + 1 STEP -1
3018     RET(K) = RET(K - 1): Q(K) = Q(K - 1)
3020 NEXT K
3022 RET(J) = RET: Q(J) = Q
3024 IF Q(J) < Q(J - 1) GOTO 3030
3025 IF J = I THEN RETURN
3026 IF J < I AND Q(J) > Q(J + 1) GOTO 3030
3028 RETURN
3030 CLS : COLOR 11:   PRINT "Press F1 and then press ENTER to exit": PRI
NT : PRINT : COLOR 2
3032 PRINT "SORRY, DISCHARGE VALUES CANNOT DECREASE WITH INCREASING RECUR
RENCE INTERVALS"
3034 PRINT
3036 IF Q(J) < Q(J - 1) THEN L = J ELSE L = J + 1
3038 PRINT "THE"; RET(L); "- YEAR DISCHARGE ("; Q(L); " CFS ) IS LESS THA
N"
3039 PRINT "THE"; RET(L - 1); "- YEAR DISCHARGE ("; Q(L - 1); " CFS )"
3040 PRINT
3042 PRINT "             DATA PAIR    RECURRENCE INTERVAL  DISCHARGE"
3044 PRINT
3046 PRINT USING "##################"; L - 1; RET(L - 1); Q(L - 1)
3048 PRINT USING "##################"; L; RET(L); Q(L)
3050 PRINT : PRINT
3052 PRINT "WHICH PAIR OF DATA DO YOU WISH TO CHANGE -- "
3054 PRINT "DATA PAIR NUMBER"; L - 1; "OR DATA PAIR NUMBER"; L; "?";
3056 INPUT "  ", CHGDAT
3058 IF CHGDAT = L - 1 OR CHGDAT = L GOTO 3066
3060 CLS : COLOR 11:   PRINT "Press F1 and then press ENTER to exit": PRI
NT : PRINT : COLOR 2
3062 PRINT "SORRY, YOU ONLY HAVE TWO CHOICES. "; CHGDAT; "IS NOT ONE OF T
HEM."
3064 GOTO 3040
3066 IF CHGDAT = I GOTO 3074
3068 FOR K = CHGDAT TO I - 1
3070     RET(K) = RET(K + 1): Q(K) = Q(K + 1)
3072 NEXT K
3074 PRINT
3076 PRINT "RE-ENTER RECURRENCE INTERVAL NUMBER"; CHGDAT;
3078 INPUT "  ", RET(I): GOSUB 1000
3080 PRINT
3082 PRINT "ENTER"; RET(I); "- YEAR DISCHARGE";
3084 INPUT "                          ", Q(I)
3085 GOSUB 2000
3086 GOTO 3000
```

```
9999  REM
10000 REM    *****************************************************************
10002 REM                                      QUIT PROGRAM
10004 REM    *****************************************************************
10006 OPEN "QUIT" FOR OUTPUT AS #3
10008 CLS
10010 COLOR 12
10012 FOR I = 1 TO 10: PRINT : NEXT I
10014 PRINT "                             PROGRAM TERMINATED BY USER"
10016 COLOR 7
10020 SYSTEM
11111 END
```

```
1 REM
2 REM   FFFFFFFF  AAA      NNN     NNN  RRRRRRRR  UUU   UUU NNN     NNN
3 REM   FFF       AAAAA    NNNN    NNN  RRR    RRR UUU   UUU NNNN    NNN
4 REM   FFF      AAA  AAA  NNNNNN  NNN  RRR    RRR UUU   UUU NNN NNN NNN
5 REM   FFFFFF AAA    AAA  NNN NNN NNN  RRRRRRRR  UUU   UUU NNN  NNNNNN
7 REM   FFF   AAAAAAAAAAAA NNN    NNNN  RRR    RRR UUU   UUU NNN    NNNN
8 REM   FFF   AAA       AAA NNN     NNN  RRR    RRR  UUUUUUU  NNN     NNN
9 REM
10 REM
11 REM     ***********************************************************
12 REM                 SET UP CHECK FOR GRAPHICS CAPABILITIES
13 REM     ***********************************************************
14 ON ERROR GOTO 17
15 SCREEN 2:   PRESET (1, 1)
16 GOTO 19
17 GRCHK = 99
18 RESUME NEXT
19 ON ERROR GOTO 0
20 KEY OFF
100 REM
102 REM     ***********************************************************
104 REM                 GET INPUT FROM INPUT FILE - FAN.IN
106 REM     ***********************************************************
108 REM
120 DIM P(30), KG(30), K0(30)
122 OPEN "FAN.IN" FOR INPUT AS #1
124 OPEN "FAN.OUT" FOR OUTPUT AS #2
126 INPUT #1, B$
128 A$ = SPACE$(INT((71 - LEN(B$)) / 2)) + B$
130 INPUT #1, MULT, SLOPE, NVALUE
132 INPUT #1, PDFOPT, AVUL
134 INPUT #1, NOF
136 DIM RET(NOF), Q(NOF), KK(NOF)
138 FOR I = 1 TO NOF
140     INPUT #1, RET(I), Q(I), KK(I)
142 NEXT I
144 INPUT #1, MU, SIGMA, SKEW, RMAX
146 FOR I = 0 TO 30
148     INPUT #1, P(I)
150 NEXT I
152 FOR I = 0 TO 30
154     INPUT #1, K0(I), KG(I)
156 NEXT I
158 INPUT #1, Q100
850 GOSUB 6200
852 IF GRCHK < 44 THEN GOSUB 8200
854 IF GRCHK < 44 THEN GOTO 1000
900 CLS
904 LOCATE 4, 16
906 PRINT "SYSTEM NOT COMPATIBLE WITH GRAPHICS SUBROUTINES"
910 LOCATE 20, 30
911 COLOR 18
912 PRINT "PROGRAM RUNNING ..."
```

```
1000 REM
1002 REM    ************************************************************
1004 REM    ************************************************************
1006 REM    ********************    MAIN PROGRAM    ********************
1008 REM    ************************************************************
1010 REM    ************************************************************
1012 REM
1014 REM
1016 REM    ************************************************************
1018 REM    TRANSFORM RANDOM VARIABLE (Y TO Z):
1019                                        MUY = MU: SIGMAY = SIGMA
1020                                                      GOSUB 2000
1022 REM    ************************************************************
1024 REM
1026                                                      GOSUB 6400
1028 REM
1030 REM    ************************************************************
1032 REM    ASSIGN DISCHARGES AND CALCULATE ALLUVIAL FAN
1034 REM    WIDTHS FOR DEPTH ZONE BOUNDARIES:
1035                                                      GOSUB 2200
1036 REM    ************************************************************
1038 REM
1040 REM    ************************************************************
1042 REM    ASSIGN DISCHARGES AND CALCULATE ALLUVIAL FAN
1044 REM    WIDTHS FOR VELOCITY ZONE BOUNDARIES:
1045                                                      GOSUB 2400
1046 REM    ************************************************************
1048 REM
1050                                                      GOSUB 6600
1051                                  IF GRCHK < 44 THEN GOSUB 8400
1052 REM
1054 REM    ************************************************************
1056 REM    ************************************************************
1058 REM    ********************     END OF RUN     ********************
1060 REM    ************************************************************
1062 REM    ************************************************************
1064 REM
1066 REM
1068 REM    ************************************************************
1069 REM    OPTION TO VIEW AND/OR PRINT OUTPUT DATA:
1070                                                      GOSUB 9000
1072 REM    ************************************************************
1074 REM
1098 SYSTEM
```

```
1999 REM
2000 REM     ****************************************************************
2002 REM                        TRANSFORM RANDOM VARIABLE
2004 REM    ****************************************************************
2005 REM
2006 IF SKEW = 0 THEN GOTO 2022
2008 SHAPE = 4 / SKEW / SKEW
2010 SCALE = 2 / SKEW / SIGMAY
2012 TRANS = MUY - 2 * SIGMAY / SKEW
2014 MUZ = TRANS + SHAPE / (SCALE - .92)
2016 SIGMAZ = SQR(SHAPE / (SCALE - .92) / (SCALE - .92))
2018 CNST = EXP(.92 * TRANS) * (SCALE / (SCALE - .92)) ^ SHAPE
2020 GOTO 2028
2022 MUZ = MUY + .92 * SIGMAY * SIGMAY
2024 SIGMAZ = SIGMAY
2026 CNST = EXP(.92 * MUY + .42 * SIGMAY * SIGMAY)
2028 RETURN


2200 REM
2202 REM     ***************************************************************
2204 REM          SUBROUTINE TO COMPUTE CONTOUR WIDTHS FOR DEPTH ZONES
2206 REM     ***************************************************************
2208 REM
2210 DH = INT((Q100 / 274) ^ .4 + 1)
2212 DIM PHYSING(DH), PHZSING(DH), HSING(DH), QHSING(DH), WHSING(DH)
2214 DIM PHYMULT(DH), PHZMULT(DH), HMULT(DH), QHMULT(DH), WHMULT(DH)
2216 H = .5: NH = 0
2218 IF MULT = 2 THEN GOSUB 2300 ELSE Q = 274.3902 * H ^ 2.5
2220 IF Q > Q100 THEN GOTO 2262
2222 IF MULT = 2 THEN NHMULT = NH ELSE NHSING = NH
2224 NH = NH + 1
2226 Y = LOG(Q) / LOG(10)
2228 MU = MUY: SIGMA = SIGMAY: GOSUB 4000
2230 IF MULT = 2 THEN PHYMULT(NH) = P ELSE PHYSING(NH) = P
2232 MU = MUZ: SIGMA = SIGMAZ: GOSUB 4000
2234 IF MULT = 2 THEN PHZMULT(NH) = P ELSE PHZSING(NH) = P
2236 IF MULT = 2 THEN GOTO 2244
2238 HSING(NH) = H: QHSING(NH) = INT((INT(Q * 10) + 5) / 10)
2240 WHSING(NH) = AVUL * CNST * PHZSING(NH) * 940.8059
2242 GOTO 2248
2244 HMULT(NH) = H: QHMULT(NH) = INT((INT(Q * 10) + 5) / 10)
2246 WHMULT(NH) = AVUL * CNST * PHZMULT(NH) * 3575.0624#
2248 IF MULT = 2 THEN SORM = 35.750624# ELSE SORM = 9.408059
2250 IF MULT = 2 THEN W = WHMULT(NH) ELSE W = WHSING(NH)
2252 GOSUB 4200
2254 IF MULT = 2 THEN WHMULT(NH) = W ELSE WHSING(NH) = W
2256 H = H + 1
2258 IF MULT = 2 THEN NHMULT = NH ELSE NHSING = NH
2260 GOTO 2218
2262 MULT = MULT + 1
2264 IF MULT = 2 THEN GOTO 2216
2266 RETURN
```

```
2300 REM
2302 REM      *****************************************************************
2304 REM            SUBROUTINE TO COMPUTE Q(H) FOR MULTIPLE CHANNELS
2306 REM      *****************************************************************
2308 REM
2310 QL = 0: QH = Q100: QG = Q100: HL = 0
2312 HG = 9.220001E-02 * NVALUE ^ .6 * QG ^ .36 / SLOPE ^ .3 + .00143 * S
LOPE ^ .6 * QG ^ .48 / NVALUE ^ 1.2
2314 IF QH - QL < .01 THEN GOTO 2330
2315 IF QL / QH > .99999 THEN GOTO 2330
2316 IF (QG = Q100) AND (HG < H) THEN GOTO 2328
2318 IF QG = Q100 THEN HH = HG
2320 IF HG > H THEN HH = HG ELSE HL = HG
2322 IF HG > H THEN QH = QG ELSE QL = QG
2324 QG = (QH + QL) / 2
2326 GOTO 2312
2328 Q = 2 * Q100: GOTO 2332
2330 Q = (QH + QL) / 2
2332 RETURN
```

```
2400 REM
2402 REM      ************************************************************
2404 REM        SUBROUTINE TO COMPUTE CONTOUR WIDTHS FOR VELOCITY ZONES
2406 REM      ************************************************************
2408 REM
2410 DV = INT((Q100 / .12) ^ .2 - 2)
2412 DIM PVYSING(DV), PVZSING(DV), VSING(DV), QVSING(DV), WVSING(DV)
2414 DIM PVYMULT(DV), PVZMULT(DV), VMULT(DV), QVMULT(DV), WVMULT(DV)
2416 GOTO 2430
2417 IF MULT = 4 AND QHMULT(1) < 1 THEN GOTO 2474
2418 VMAX = .3033 * SLOPE ^ .3 * Q100 ^ .24 / NVALUE ^ .6
2420 VMIN = .3033 * SLOPE ^ .3 * QHMULT(1) ^ .24 / NVALUE ^ .6
2422 VT = .5
2424 IF VT > VMIN THEN GOTO 2430
2426 VT = VT + 1
2428 GOTO 2424
2430 NV = 0: IF MULT = 4 THEN V = VT ELSE V = 3.5
2432 IF MULT = 4 THEN Q = 144.1315 * NVALUE ^ 2.5 * V ^ (25 / 6) / SLOPE
^ 1.25 ELSE Q = .1289 * V ^ 5
2434 IF Q > Q100 THEN GOTO 2474
2436 NV = NV + 1
2438 Y = LOG(Q) / LOG(10)
2440 MU = MUY: SIGMA = SIGMAY: GOSUB 4000
2442 IF MULT = 4 THEN PVYMULT(NV) = P ELSE PVYSING(NV) = P
2444 MU = MUZ: SIGMA = SIGMAZ: GOSUB 4000
2446 IF MULT = 4 THEN PVZMULT(NV) = P ELSE PVZSING(NV) = P
2448 IF MULT = 4 THEN GOTO 2456
2450 VSING(NV) = V: QVSING(NV) = INT((INT(Q * 10) + 5) / 10)
2452 WVSING(NV) = AVUL * CNST * PVZSING(NV) * 940.8059
2454 GOTO 2460
2456 VMULT(NV) = V: QVMULT(NV) = INT((INT(Q * 10) + 5) / 10)
2458 WVMULT(NV) = AVUL * CNST * PVZMULT(NV) * 3575.0624#
2460 IF MULT = 4 THEN SORM = 35.750624# ELSE SORM = 9.408059
2462 IF MULT = 4 THEN W = WVMULT(NV) ELSE W = WVSING(NV)
2464 GOSUB 4200
2466 IF MULT = 4 THEN WVMULT(NV) = W ELSE WVSING(NV) = W
2468 V = V + 1
2470 IF MULT = 4 THEN NVMULT = NV ELSE NVSING = NV
2472 GOTO 2432
2474 MULT = MULT + 1
2476 IF MULT = 4 THEN GOTO 2417
2478 RETURN
```

```
4000 REM
4002 REM      **************************************************************
4004 REM                  SUBROUTINE TO COMPUTE PROBABILITY
4006 REM           GIVEN LOG(Q), MEAN, STANDARD DEVIATION, AND SKEW
4008 REM      **************************************************************
4010 REM
4012 K = (Y - MU) / SIGMA
4014 IF K > KG(0) THEN GOTO 4018
4016 P = 1: GOTO 4032
4018 FOR I = 1 TO 30
4020    IF K > KG(I) THEN GOTO 4026
4022    N = I: M = N - 1
4024    GOTO 4030
4026 NEXT
4028 P = 0: GOTO 4032
4030 P = P(N) + (P(M) - P(N)) * (K - KG(N)) / (KG(M) - KG(N))
4032 RETURN


4200 REM
4202 REM      **************************************************************
4204 REM        SUBROUTINE TO ADJUST WIDTH FOR CHANNEL WIDTH > FAN WIDTH
4206 REM      **************************************************************
4208 REM
4209 WI = W: NA = 0
4210 PROB = P
4212 QW = (W / SORM) ^ 2.5
4214 Y = LOG(QW) / LOG(10)
4216 MU = MUY: SIGMA = SIGMAY: GOSUB 4000
4218 PYQW = P
4220 MU = MUZ: SIGMA = SIGMAZ: GOSUB 4000
4222 PZQW = P
4224 PRB = AVUL * CNST * SORM / W * (PROB - PZQW) + PYQW
4225 IF PRB > .01 THEN NA = W
4226 IF PRB < .01 THEN WI = W
4227 WNEW = 100 * PRB * W
4229 IF ABS(WNEW - W) < 1 OR WI - NA < 1 THEN GOTO 4234
4230 IF ABS(WNEW - W) >= WI - NA THEN W = (WI + NA) / 2 ELSE W = WNEW
4232 GOTO 4212
4234 RETURN
```

```
6200 REM
6202 REM     ************************************************************
6204 REM                         FLOOD FREQUENCY OUTPUT
6206 REM     ************************************************************
6208 REM
6210 PRINT #2, CHR$(12)
6212 PRINT #2, A$
6214 FOR I = 1 TO 2: PRINT #2, : NEXT
6216 PRINT #2, USING "                        AVULSION FACTOR = #.####"; A
VUL
6218 FOR I = 1 TO 4: PRINT #2, : NEXT
6220 IF PDFOPT = 2 GOTO 6226
6222 PRINT #2, "    FLOOD FREQUENCY CURVE DEFINED BY MEAN, STANDARD DEVIA
TION, AND SKEW"
6224 GOTO 6242
6226 PRINT #2, "    FLOOD FREQUENCY CURVE DEFINED BY LEAST-SQUARES FIT OF
 DATA"
6228 FOR I = 1 TO 2: PRINT #2, : NEXT
6230 PRINT #2, "    RETURN INTERVAL     INPUT DISCHARGE   BEST FIT DISCHA
RGE"
6232 PRINT #2, "        (YEARS)                (CFS)               (CFS)"
6234 PRINT #2,
6236 FOR K = 1 TO NOF
6238    PRINT #2, USING "         ####                 ######
######"; RET(K); Q(K); 10 ^ (SIGMA * KK(K) + MU)
6240 NEXT
6242 FOR I = 1 TO 2: PRINT #2, : NEXT
6244 PRINT #2, USING "                                   MEAN = ##.######"
; MU
6246 PRINT #2, USING "                     STANDARD DEVIATION = ##.######"
; SIGMA
6248 PRINT #2, USING "                                   SKEW = ##.#"; SKE
W
6250 FOR I = 1 TO 4: PRINT #2, : NEXT
6252 PRINT #2, "    SUMMARY OF DISCHARGES:"
6254 PRINT #2,
6256 PRINT #2, USING "                    10-YEAR DISCHARGE = ######"; 1
0 ^ (SIGMA * KG(20) + MU)
6258 PRINT #2, USING "                    50-YEAR DISCHARGE = ######"; 1
0 ^ (SIGMA * KG(24) + MU)
6260 PRINT #2, USING "                   100-YEAR DISCHARGE = ######"; 1
0 ^ (SIGMA * KG(25) + MU)
6262 PRINT #2, USING "                   500-YEAR DISCHARGE = ######"; 1
0 ^ (SIGMA * KG(27) + MU)
6264 FOR I = 1 TO 4: PRINT #2, : NEXT
6265 IF SIGMA * SKEW > 2.1 THEN GOTO 6270
6266 RETURN
6270 PRINT #2, "                  STANDARD DEVIATION TIMES SKEW GREATER T
HAN 2.1"
6272 PRINT #2, "                             WIDTHS CANNOT BE COMPUTED"
6274 PRINT #2,
6276 PRINT #2, "                                 PROGRAM TERMINATED"
6278 COLOR 10
```

```
6279 FOR I = 1 TO 4: PRINT : NEXT I
6280 PRINT "                    STANDARD DEVIATION TIMES SKEW GREATER THAN
2.1"
6282 PRINT "                                WIDTHS CANNOT BE COMPUTED"
6284 PRINT
6286 PRINT : PRINT : PRINT : COLOR 12
6290 PRINT "                                  PROGRAM TERMINATED"
6292 FOR I = 1 TO 4: PRINT : NEXT I
6294 INPUT "             DO YOU WISH TO VIEW THE FLOOD FREQENCY DATA (Y/N
)?  ", FFD$
6295 IF INSTR(FFD$, "Y") = 0 AND INSTR(FFD$, "y") = 0 THEN GOTO 9900
6296 MUY = MU: SIGMAY = SIGMA
6298 COLOR 10: GOTO 9100


6400 REM
6402 REM     ************************************************************
6404 REM                         TRANSFORMATION OUTPUT
6406 REM     ************************************************************
6408 REM
6412 IF SKEW = 0 GOTO 6420
6414 AAAA = -.92 * TRANS / (SCALE - .92): BBBB = SCALE / (SCALE - .92)
6416 PRINT #2, USING "      STATISTICS AFTER TRANSFORMATION OF Y=LOG(Q) T
O Z=#.####+#.#### LOG(Q)"; -.92 * TRANS / (SCALE - .92); SCALE / (SCALE -
 .92)
6418 GOTO 6424
6420 AAAA = .92 * SIGMAY * SIGMAY: BBBB = 1!
6422 PRINT #2, USING "      STATISTICS AFTER TRANSFORMATION OF Y=LOG(Q) T
O Z=#.####+LOG(Q)"; .92 * SIGMAY * SIGMAY
6424 PRINT #2,
6426 PRINT #2, USING "                              MEAN OF Z = ##.######"
; MUZ
6428 PRINT #2, USING "                     STANDARD DEVIATION = ##.######"
; SIGMAZ
6430 PRINT #2, USING "                                   SKEW = ##.######"
; SKEW
6432 PRINT #2, USING "                TRANSFORMATION CONSTANT = ##.######"
; CNST
6434 PRINT #2, CHR$(12)
6436 RETURN
```

```
6600 REM
6602 REM    ************************************************************
6604 REM                     DEPTH- AND VELOCITY-ZONE OUTPUT
6606 REM    ************************************************************
6608 REM
6610 PRINT #2, B$; SPC(66 - LEN(B$)); "PAGE 2"
6612 FOR I = 1 TO 4: PRINT #2, : NEXT
6614 PRINT #2, "                         SINGLE-CHANNEL REGION"
6616 PRINT #2, " _______________________________________________________________
______________"
6618 PRINT #2, : PRINT #2,
6620 PRINT #2, "                                          PROBABILITY OF DISC
HARGE"
6622 PRINT #2, "                                           BEING EXCEEDED AT
THE"
6624 PRINT #2, " ENERGY      DEPTH      DISCHARGE            APEX BY:
          WIDTH"
6626 PRINT #2, USING "  (FT)         (FT)         (CFS)
      #.####     (FT)"; BBBB
6628 PRINT #2, USING "                                               Q   ###.
#### Q"; 10 ^ AAAA
6630 PRINT #2,
6632 NN = NHSING
6634 FOR I = 1 TO NN
6636 DEPTH = 2 * HSING(I) / 3
6638 PRINT #2, USING "  ##.#       ##.#       #######       #.#####
#.#####     #########"; HSING(I); DEPTH; QHSING(I); PHYSING(I); PHZSING(I
); WHSING(I)
6640 NEXT
6642 FOR I = 1 TO 4: PRINT #2, : NEXT
6644 PRINT #2, " _______________________________________________________________
______________"
6646 PRINT #2, : PRINT #2,
6648 PRINT #2, "                                          PROBABILITY OF DISC
HARGE"
6650 PRINT #2, "                                           BEING EXCEEDED AT
THE"
6652 PRINT #2, " VELOCITY    DEPTH      DISCHARGE            APEX BY:
          WIDTH"
6654 PRINT #2, USING " (FT/SEC)     (FT)         (CFS)
      #.####     (FT)"; BBBB
6656 PRINT #2, USING "                                               Q   ###.
#### Q"; 10 ^ AAAA
6658 PRINT #2,
6660 NN = NVSING
6662 FOR I = 1 TO NN
6664 DSING = VSING(I) ^ 2 / 32.16
6666 PRINT #2, USING "  ##.#       ##.#       #######       #.#####
#.#####     #########"; VSING(I); DSING; QVSING(I); PVYSING(I); PVZSING(I
); WVSING(I)
6668 NEXT
6670 IF MULT < 5 GOTO 6742
6672 PRINT #2, CHR$(12)
6674 PRINT #2, B$; SPC(66 - LEN(B$)); "PAGE 3"
6676 FOR I = 1 TO 4: PRINT #2, : NEXT
6678 PRINT #2, "                         MULTIPLE-CHANNEL REGION"
6680 PRINT #2,
```

```
6682 PRINT #2, USING "                                      SLOPE = #.#######"; SLO
PE
6684 PRINT #2, USING "                                    N-VALUE = #.#######"; NVA
LUE
6685 IF QHMULT(1) < 1 THEN GOTO 6744
6686 PRINT #2, " ______________________________________________________
              "
_______________
6688 PRINT #2, : PRINT #2,
6690 PRINT #2, "                                              PROBABILITY OF DISC
HARGE"
6692 PRINT #2, "                                               BEING EXCEEDED AT
THE"
6694 PRINT #2, " ENERGY      DEPTH      DISCHARGE           APEX BY:
         WIDTH"
6696 PRINT #2, USING "  (FT)         (FT)         (CFS)
      #.####      (FT)"; BBBB
6698 PRINT #2, USING "                                                   Q    ###.
#### Q"; 10 ^ AAAA
6700 PRINT #2,
6702 NN = NHMULT
6704 FOR I = 1 TO NN
6706 DEPTH = .09168 * NVALUE ^ .6 * QHMULT(I) ^ .36 / SLOPE ^ .3
6708 PRINT #2, USING "  ##.#       ##.#       #######        #.#####
#.#####     #########"; HMULT(I); DEPTH; QHMULT(I); PHYMULT(I); PHZMULT(I
); WHMULT(I)
6710 NEXT
6712 FOR I = 1 TO 4: PRINT #2, : NEXT
6714 PRINT #2, " ______________________________________________________
              "
_______________
6716 PRINT #2, : PRINT #2,
6717 IF NVMULT = 0 THEN PRINT #2, USING "                   VELOCITIES BETW
EEN ##.# AND ##.# FT/SEC"; VMIN; VMAX
6718 IF NVMULT = 0 THEN GOTO 6740
6719 PRINT #2, "                                              PROBABILITY OF DISC
HARGE"
6720 PRINT #2, "                                               BEING EXCEEDED AT
THE"
6722 PRINT #2, "VELOCITY     DEPTH      DISCHARGE           APEX BY:
         WIDTH"
6724 PRINT #2, USING " (FT/SEC)      (FT)         (CFS)
      #.####      (FT)"; BBBB
6726 PRINT #2, USING "                                                   Q    ###.
#### Q"; 10 ^ AAAA
6728 PRINT #2,
6730 NN = NVMULT
6732 FOR I = 1 TO NN
6734 DMULT = .09168 * NVALUE ^ .6 * QVMULT(I) ^ .36 / SLOPE ^ .3
6736 PRINT #2, USING "  ##.#       ##.#       #######        #.#####
#.#####     #########"; VMULT(I); DMULT; QVMULT(I); PVYMULT(I); PVZMULT(I
); WVMULT(I)
6738 NEXT
6740 PRINT #2, CHR$(12)
6742 RETURN
6744 PRINT #2,
6745 PRINT #2, "     DEPTHS GREATER THAN 0.5 FOOT HAVE PROBABILITIES LESS
 THAN .01"
6746 RETURN
```

```
8200 REM
8202 REM     ************************************************************
8204 REM                      DRAW FLOOD FREQUENCY CURVE
8206 REM     ************************************************************
8208 REM
8209 CLS
8212 LOCATE 1
8214 PRINT "                          FLOOD FREQUENCY CURVE"
8215 NL$ = "NL10;"
8216 NR$ = "NR10;"
8217 BOT$ = "R25;NU5;R31;NU5;R42;NU5;R52;NU5;R52;NU5;R42;NU5;R31;NU5;R25;
"
8218 TOP$ = "L25;ND5;L31;ND5;L42;ND5;L52;ND5;L52;ND5;L42;ND5;L31;ND5;L25;
"
8220 MAG = INT(MU + KG(28) * SIGMA)
8222 PSET (170, 160)
8224 DRAW "X" + VARPTR$(BOT$)
8226 FOR J = 1 TO MAG
8228     FOR I = 2 TO 10
8230         UP = INT(144 * LOG(I / (I - 1)) / LOG(10) / MAG + .5)
8232         DRAW "U=" + VARPTR$(UP): DRAW "X" + VARPTR$(NL$)
8234     NEXT I
8236 NEXT J
8238 DRAW "X" + VARPTR$(TOP$)
8240 FOR J = 1 TO MAG
8242     FOR I = 2 TO 10
8244         DWN = INT(144 * LOG((12 - I) / (11 - I)) / LOG(10) / MAG + .
5)
8246         DRAW "D=" + VARPTR$(DWN): DRAW "X" + VARPTR$(NR$)
8248     NEXT I
8250 NEXT J
8252 LOCATE 22
8254 PRINT "                    .999 .99   .9    .5    .1   .01 .001"
8256 FOR I = 1 TO 30
8258     XX = 170 + INT(300 * (K0(30) + K0(I)) / K0(30) / 2)
8260     YY = 160 - INT(144 * (MU + KG(I) * SIGMA - 1) / MAG)
8262     IF YY > 160 OR YY < 16 THEN GOTO 8266
8264     PSET (XX, YY)
8266 NEXT I
8268 LOCATE 20, 18
8270 PRINT 10
8272 LOCATE 3, 18 - MAG
8274 PRINT 10 ^ (MAG + 1)
8276 LOCATE 5, 28: PRINT "MEAN ="; MU
8278 LOCATE 6, 25: PRINT "STD DEV ="; SIGMA
8280 LOCATE 7, 28: PRINT "SKEW ="; SKEW
8282 IF PDFOPT = 1 THEN GOTO 8286
8284 LOCATE 8, 24: PRINT "COR COEF ="; RMAX
8286 RETURN
```

```
8400 REM
8402 REM     ************************************************************
8404 REM                              DRAW FAN
8406 REM     ************************************************************
8408 REM
8410 LOCATE 25
8412 INPUT "              ********     PRESS ENTER TO CONTINUE    *******
*", KFM
8414 CLS
8418 FOR I = 1 TO 4: PRINT : NEXT I
8420 PRINT B$
8422 PRINT
8424 IF MULT = 6 THEN PRINT "MULTIPLE-CHANNEL REGION" ELSE PRINT "SINGLE-
CHANNEL REGION"
8426 PI = 3.141593
8427 IF MULT = 6 THEN NH = NHMULT ELSE NH = NHSING
8428 FOR K = 1 TO NH
8430    IF MULT = 6 THEN W = WHMULT(K) / WHMULT(1) ELSE W = WHSING(K) / W
HSING(1)
8432    R = W * 600
8433    X = INT(R * COS(-PI / 10) / 8): Y = INT((R * SIN(PI / 24) + 102)
/ 8)
8434    CIRCLE (0, 90), R, 1, -19 * PI / 10, -PI / 10
8435    LOCATE Y, X: PRINT K - .5
8436 NEXT K
8437 IF MULT = 6 THEN NV = NVMULT ELSE NV = NVSING
8438 FOR K = 1 TO NV
8439    IF MULT = 6 THEN W = WVMULT(K) / WHMULT(1) ELSE W = WVSING(K) / W
HSING(1)
8440    R = W * 600
8441    X = INT(R * COS(-PI / 10) / 8) - 1
8442    IF X < 0 OR X = 0 THEN X = 1
8443    Y = INT((-R * SIN(PI / 24) + 98) / 8): IF Y < 1 THEN Y = 1
8444    A = 19 * PI / 10
8446    B = A + 3 * PI / R
8448    IF A > 2 * PI THEN A = A - 2 * PI
8450    IF B > 2 * PI THEN B = B - 2 * PI
8452    IF A > PI / 10 AND A < PI THEN GOTO 8461
8454    IF B > PI / 10 AND B < PI THEN B = PI / 10
8456    CIRCLE (0, 90), R, 1, A, B
8458    A = B + 4 * PI / R
8460    GOTO 8446
8461    LOCATE Y, X
8462    IF MULT = 6 THEN PRINT K + VMULT(1) - 1 ELSE PRINT K + 2.5
8463 NEXT K
8464 LOCATE 18
8466 PRINT "____ DEPTH"
8468 PRINT
8470 PRINT "---- VELOCITY"
8472 MULT = MULT + 1
8474 IF MULT = 6 AND QHMULT(1) > 1 THEN GOTO 8410
8476 LOCATE 25
8478 INPUT "              ********     PRESS ENTER TO CONTINUE    *******
*", EMM
8480 RETURN
```

```
9000 REM      ************************************************************
9002 REM                  OPTION TO VIEW AND/OR PRINT OUTPUT DATA
9006 REM      ************************************************************
9008 A$ = "    " + A$
9010 SCREEN 0: COLOR 12
9020 CLS
9022 FOR I = 1 TO 8: PRINT : NEXT I
9024 INPUT "                DO YOU WISH TO VIEW SOME OUTPUT DATA (Y/N)?
", V$
9026 CLS : COLOR 10
9027 IF INSTR(V$, "Y") = 0 AND INSTR(V$, "y") = 0 THEN GOTO 9900
9028 FOR I = 1 TO 5: PRINT : NEXT
9030 PRINT
9032 PRINT : PRINT : COLOR 10
9034 PRINT "              (1)....FLOOD FREQUENCY DATA"
9036 PRINT
9038 PRINT "              (2)....TRANSFORMATION DATA"
9040 PRINT
9042 PRINT "              (3)....100-YEAR DEPTH-ZONE DATA -- SINGLE-CHANN
EL REGION"
9044 PRINT
9046 PRINT "              (4)....100-YEAR VELOCITY-ZONE DATA -- SINGLE-CH
ANNEL REGION"
9048 IF MULT < 5.5 THEN GOTO 9056 ELSE PRINT
9050 PRINT "              (5)....100-YEAR DEPTH-ZONE DATA -- MULTIPLE-CHA
NNEL REGION"
9052 PRINT
9054 PRINT "              (6)....100-YEAR VELOCITY-ZONE DATA -- MULTIPLE-
CHANNEL REGION"
9056 PRINT CHR$(11): FOR I = 1 TO 2: PRINT CHR$(31): NEXT I
9057 COLOR 12
9058 INPUT "       PLEASE SELECT, BY NUMBER, THE DATA THAT YOU WISH TO VI
EW....", SEL
9059 COLOR 10
9060 IF SEL = 1 THEN GOTO 9100
9062 IF SEL = 2 THEN GOTO 9200
9064 IF SEL = 3 THEN GOTO 9300
9066 IF SEL = 4 THEN GOTO 9400
9067 IF MULT < 5.5 THEN GOTO 9072
9068 IF SEL = 5 THEN GOTO 9500
9070 IF SEL = 6 THEN GOTO 9600
9072 CLS : PRINT : PRINT
9074 PRINT "                SORRY, THERE IS NO DATA SELECTION NUMBER "; S
EL
9076 FOR I = 1 TO 5: PRINT : NEXT I
9077 COLOR 12
9078 GOTO 9024
```

```
9100 REM
9102 REM      ************************************************************
9104 REM                          FLOOD FREQUENCY OUTPUT
9106 REM      ************************************************************
9107 REM
9108 MU = MUY: SIGMA = SIGMAY
9109 CLS : PRINT
9110 PRINT A$
9116 FOR I = 1 TO 2: PRINT : NEXT
9118 IF PDFOPT = 2 GOTO 9124
9120 PRINT "          FLOOD FREQUENCY CURVE DEFINED BY MEAN, STANDARD DEVIA
TION, AND SKEW"
9122 GOTO 9140
9124 PRINT "          FLOOD FREQUENCY CURVE DEFINED BY LEAST-SQUARES FIT OF
 DATA"
9126 FOR I = 1 TO 2: PRINT : NEXT
9128 PRINT "          RETURN INTERVAL     INPUT DISCHARGE   BEST FIT DISCHA
RGE"
9130 PRINT "              (YEARS)                 (CFS)                 (CFS)"
9132 PRINT
9134 FOR K = 1 TO NOF
9136    PRINT USING "             ####                ######
######"; RET(K); Q(K); 10 ^ (SIGMA * KK(K) + MU)
9138 NEXT
9139 GOTO 9180
9140 PRINT
9142 PRINT USING "                                            MEAN = ##.######"
; MUY
9144 PRINT USING "                              STANDARD DEVIATION = ##.######"
; SIGMAY
9146 PRINT USING "                                            SKEW = ##.#"; SKE
W
9148 FOR I = 1 TO 2: PRINT : NEXT
9150 PRINT "          SUMMARY OF DISCHARGES:"
9152 PRINT
9154 PRINT USING "                           10-YEAR DISCHARGE = ######"; 1
0 ^ (SIGMA * KG(20) + MU)
9156 PRINT USING "                           50-YEAR DISCHARGE = ######"; 1
0 ^ (SIGMA * KG(24) + MU)
9158 PRINT USING "                          100-YEAR DISCHARGE = ######"; 1
0 ^ (SIGMA * KG(25) + MU)
9160 PRINT USING "                          500-YEAR DISCHARGE = ######"; 1
0 ^ (SIGMA * KG(27) + MU)
9161 IF INSTR(FFD$, "Y") = 1 OR INSTR(FFD$, "y") = 1 THEN GOTO 9192
9162 FOR I = 1 TO 3: PRINT : NEXT I
9163 COLOR 12
9164 INPUT "   DO YOU WISH TO VIEW MORE OUTPUT DATA (Y/N)?  ", V$
9168 GOTO 9026
9180 FOR I = 1 TO 3: PRINT : NEXT I
9181 COLOR 12
9182 INPUT "              ********    PRESS ENTER TO CONTINUE    *******
*", EMM
9183 CLS : COLOR 10
9184 FOR I = 1 TO 4: PRINT : NEXT I
9185 PRINT A$
9186 FOR I = 1 TO 3: PRINT : NEXT I
```

```
9188 PRINT "    FLOOD FREQUENCY CURVE DEFINED BY LEAST-SQUARES FIT OF DAT
A"
9190 GOTO 9140
9192 FOR I = 1 TO 5: PRINT : NEXT I
9194 PRINT "                  STANDARD DEVIATION TIMES SKEW GREATER THAN
2.1"
9195 PRINT "                              WIDTHS CANNOT BE COMPUTED"
9196 PRINT : COLOR 12
9197 PRINT "                                  PROGRAM TERMINATED"
9198 PRINT : INPUT "                             PRESS ENTER TO CONTINU
E", RTP
9199 GOTO 9900


9200 REM     ***********************************************************
9201 REM                        TRANSFORMATION OUTPUT
9202 REM     ***********************************************************
9203 CLS
9204 FOR I = 1 TO 4: PRINT : NEXT
9205 PRINT A$
9206 REM
9208 FOR I = 1 TO 2: PRINT : NEXT
9210 IF SKEW = 0 GOTO 9218
9212 AAAA = -.92 * TRANS / (SCALE - .92): BBBB = SCALE / (SCALE - .92)
9214 PRINT USING "      STATISTICS AFTER TRANSFORMATION OF Y=LOG(Q) TO Z=
#.####+#.#### LOG(Q)"; -.92 * TRANS / (SCALE - .92); SCALE / (SCALE - .92
)
9216 GOTO 9222
9218 AAAA = .92 * SIGMAY * SIGMAY: BBBB = 1!
9220 PRINT USING "      STATISTICS AFTER TRANSFORMATION OF Y=LOG(Q) TO Z=
#.####+LOG(Q)"; .92 * SIGMAY * SIGMAY
9222 PRINT
9224 PRINT USING "                              MEAN OF Z = ##.######"; MU
Z
9226 PRINT USING "                     STANDARD DEVIATION = ##.######"; SI
GMAZ
9228 PRINT USING "                                   SKEW = ##.######"; SK
EW
9230 PRINT USING "                TRANSFORMATION CONSTANT = ##.######"; CN
ST
9232 FOR I = 1 TO 5: PRINT : NEXT I
9233 COLOR 12
9236 INPUT "  DO YOU WISH TO VIEW MORE OUTPUT DATA (Y/N)?  ", V$
9238 GOTO 9026
```

```
9300 REM
9301 REM     ************************************************************
9302 REM                                 DEPTH-ZONE OUTPUT DATA
9304 REM     ************************************************************
9306 CLS
9308 FOR I = 1 TO 2: PRINT : NEXT I
9310 PRINT A$
9312 FOR I = 1 TO 2: PRINT : NEXT
9314 PRINT "                                   SINGLE-CHANNEL REGION"
9316 PRINT "    ______________________________________________________________
_______________"
9318 PRINT : PRINT
9320 PRINT "                                              PROBABILITY OF DISCH
ARGE"
9322 PRINT "                                                BEING EXCEEDED AT
THE"
9324 PRINT "    ENERGY      DEPTH      DISCHARGE               APEX BY:
          WIDTH"
9326 PRINT USING "      (FT)         (FT)          (CFS)
      #.####     (FT)"; BBBB
9328 PRINT USING "                                                    Q   ###.
#### Q"; 10 ^ AAAA
9330 PRINT
9332 NN = NHSING
9334 FOR I = 1 TO NN
9336 DEPTH = 2 * HSING(I) / 3
9338 PRINT USING "      ##.#        ##.#       #######       #.#####
#.#####     #########"; HSING(I); DEPTH; QHSING(I); PHYSING(I); PHZSING(I
); WHSING(I)
9340 NEXT
9341 PRINT
9342 PRINT "                                  AVULSION FACTOR ="; AVUL
9343 FOR I = 1 TO 3: PRINT : NEXT I
9344 COLOR 12
9346 INPUT "   DO YOU WISH TO VIEW MORE OUTPUT DATA (Y/N)?  ", V$
9348 GOTO 9026
```

```
9400 REM
9401 REM      ****************************************************************
9402 REM                           VELOCITY-ZONE OUTPUT DATA
9404 REM      ****************************************************************
9406 CLS
9408 FOR I = 1 TO 2: PRINT : NEXT I
9410 PRINT A$
9412 FOR I = 1 TO 2: PRINT : NEXT I
9420 PRINT "                                SINGLE-CHANNEL REGION"
9422 PRINT "     ______________________________________________________________
___________________"
9424 PRINT : PRINT
9426 PRINT "                                                     PROBABILITY OF DISC
HARGE"
9428 PRINT "                                                      BEING EXCEEDED AT
THE"
9430 PRINT "     VELOCITY    DEPTH      DISCHARGE            APEX BY:
         WIDTH"
9432 PRINT USING "      (FT/SEC)      (FT)         (CFS)
     #.####      (FT)"; BBBB
9434 PRINT USING "                                                         Q    ###.
#### Q"; 10 ^ AAAA
9436 PRINT
9438 NN = NVSING
9440 FOR I = 1 TO NN
9442 DSING = VSING(I) ^ 2 / 32.16
9444 PRINT USING "      ##.#        ##.#       #######        #.#####
#.#####      #########"; VSING(I); DSING; QVSING(I); PVYSING(I); PVZSING(I
); WVSING(I)
9446 NEXT
9447 PRINT
9448 PRINT "                                  AVULSION FACTOR ="; AVUL
9449 FOR I = 1 TO 3: PRINT : NEXT I
9450 COLOR 12
9452 INPUT "  DO YOU WISH TO VIEW MORE OUTPUT DATA (Y/N)?  ", V$
9454 GOTO 9026
```

```
9500 REM
9501 REM      ***************************************************************
9502 REM                          DEPTH-ZONE OUTPUT DATA
9504 REM      ***************************************************************
9506 CLS
9508 FOR I = 1 TO 2: PRINT : NEXT I
9510 PRINT A$
9512 FOR I = 1 TO 2: PRINT : NEXT I
9520 PRINT "                             MULTIPLE-CHANNEL REGION"
9530 PRINT
9532 PRINT USING "                                  SLOPE = #.#######"; SLO
PE
9534 PRINT USING "                                N-VALUE = #.#######"; NVA
LUE
9536 IF QHMULT(1) < 1 THEN GOTO 9574
9538 PRINT " ________________________________________________________
               "
_______________
9540 PRINT : PRINT
9542 PRINT "                                           PROBABILITY OF DISC
HARGE"
9544 PRINT "                                            BEING EXCEEDED AT
THE"
9546 PRINT "    ENERGY      DEPTH      DISCHARGE          APEX BY:
          WIDTH"
9548 PRINT USING "     (FT)         (FT)          (CFS)
      #.####     (FT)"; BBBB
9550 PRINT USING "                                                   Q    ###.
#### Q"; 10 ^ AAAA
9552 PRINT
9554 NN = NHMULT
9556 FOR I = 1 TO NN
9558 DEPTH = .09168 * NVALUE ^ .6 * QHMULT(I) ^ .36 / SLOPE ^ .3
9560 PRINT USING "     ##.#       ##.#      #######      #.#####
#.#####     #########"; HMULT(I); DEPTH; QHMULT(I); PHYMULT(I); PHZMULT(I
); WHMULT(I)
9562 NEXT
9564 GOTO 9577
9574 PRINT
9576 PRINT "       DEPTHS GREATER THAN 0.5 FOOT HAVE PROBABILITIES LESS
 THAN .01"
9577 PRINT
9578 PRINT "                             AVULSION FACTOR ="; AVUL
9580 FOR I = 1 TO 3: PRINT : NEXT I
9584 COLOR 12
9586 INPUT "  DO YOU WISH TO VIEW MORE OUTPUT DATA (Y/N)?  ", V$
9588 GOTO 9026
```

```
9600 REM
9601 REM     ***************************************************************
9602 REM                    VELOCITY-ZONE OUTPUT DATA
9604 REM     ***************************************************************
9606 CLS
9608 FOR I = 1 TO 2: PRINT : NEXT I
9610 PRINT A$
9612 FOR I = 1 TO 2: PRINT : NEXT I
9620 PRINT "                         MULTIPLE-CHANNEL REGION"
9622 PRINT : PRINT
9624 IF NVMULT = 0 THEN PRINT USING "                    VELOCITIES BETW
EEN ##.# AND ##.# FT/SEC"; VMIN; VMAX
9626 IF NVMULT = 0 THEN GOTO 9650
9628 PRINT "                                              PROBABILITY OF DISC
HARGE"
9630 PRINT "                                               BEING EXCEEDED AT
THE"
9632 PRINT "   VELOCITY     DEPTH      DISCHARGE            APEX BY:
        WIDTH"
9634 PRINT USING "     (FT/SEC)      (FT)          (CFS)
      #.####     (FT)"; BBBB
9636 PRINT USING "                                                   Q   ###.
#### Q"; 10 ^ AAAA
9638 PRINT
9640 NN = NVMULT
9642 FOR I = 1 TO NN
9644 DMULT = .09168 * NVALUE ^ .6 * QVMULT(I) ^ .36 / SLOPE ^ .3
9646 PRINT USING "        ##.#        ##.#        #######         #.#####
#.#####      #########"; VMULT(I); DMULT; QVMULT(I); PVYMULT(I); PVZMULT(I
); WVMULT(I)
9648 NEXT
9649 PRINT
9650 PRINT "                              AVULSION FACTOR ="; AVUL
9651 FOR I = 1 TO 3: PRINT : NEXT I
9652 COLOR 12
9654 INPUT "  DO YOU WISH TO VIEW MORE OUTPUT DATA (Y/N)?  ", V$
9656 GOTO 9026


9900 REM     ***************************************************************
*****
9902 REM                        OPTION TO PRINT OUTPUT
9904 REM     ***************************************************************
*****
9906 REM
9908 REM
9910 COLOR 12
9912 FOR I = 1 TO 4: PRINT : NEXT I
9914 INPUT "                  DO YOU WISH TO PRINT THE OUTPUT (Y/N)?  ",
 PRNT$
9916 IF INSTR(PRNT$, "Y") = 0 AND INSTR(PRNT$, "y") = 0 THEN GOTO 9920
9918 OPEN "FANN" FOR OUTPUT AS #3
9920 CLS
9923 SYSTEM
```

```
1 REM
2 REM          AAA          GGGGGGGGG        AAA          IIIIIIIII  NNN       NNN
3 REM         AAAAA        GGG       GGG     AAAAA            III     NNNN      NNN
4 REM        AAA  AAA      GGG              AAA  AAA          III     NNNNNN    NNN
5 REM       AAA    AAA     GGG             AAA    AAA         III     NNN  NNN  NNN
6 REM      AAAAAAAAAAAA    GGG   GGGGGG   AAAAAAAAAAAA        III     NNN    NNNNN
7 REM     AAA          AAA GGG       GGG AAA          AAA     III     NNN      NNNN
8 REM     AAA          AAA  GGGGGGGGG    AAA          AAA IIIIIIIII  NNN       NNN
9 REM
10 CLS
20 COLOR 12
30 FOR I=1 TO 6 : PRINT : NEXT I
40 INPUT "                       DO YOU WISH TO MAKE ANOTHER RUN (Y/N)?  ",NWR
N$
50 IF INSTR(NWRN$,"Y")=0 AND INSTR(NWRN$,"y")=0 THEN GOTO 70
60 OPEN "FANN" FOR OUTPUT AS #3
70 SYSTEM
```