LERA-CHAN

USER'S MANUAL FOR THE

HYDRAULIC DESIGN PACKAGE FOR CHANNELS (SAM)

by
William A. Thomas, Ronald R. Copeland, Nolan K. Raphelt and
Dinah N. McComas

Hydraulics Laboratory

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
PO Box 631, Vicksburg, Mississippi 39180-0631

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RAJ SHAH

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1. INTRODUCTION.

1.1 Purpose. The purpose of this system of computer programs is to calculate the width, depth, slope and n-values for stable channels in alluvial material.

1.2 Stable Flood Control Channels. As presented in Simons and Sentürk (1976) and ASCE (1977), the design of a stable channel focuses on the erosion process. However, that is only one of the five fundamental processes embodied in sedimentation. This computer program system, referred to as SAM, provides the computational capability to include four of those five processes: erosion, entrainment, transportation and deposition. Only compaction of the deposited bed sediments is omitted.

Channel stability can then be evaluated in terms of the cost of maintaining the constructed width, depth, slope, and hydraulic roughness.

Whereas the approach in this document follows some of the work of Chang (1980), it deviates substantially in that minimum stream power is not forced. Rather, the designer can deviate from that concept if such a deviation is necessary to meet project constraints. Maintenance is the primary point of justification.

1.3 Structure of SAM. SAM consists of 6 modules. The three major modules provide the calculating power of the package:

HYDRAULIC CALCULATIONS AND STABLE CHANNEL DIMENSIONS, SAM.hyd. The calculation of normal depth and composite hydraulic parameters from distributed roughness, including bed roughness predictors, uses the Alpha Method. Stable channel dimensions refer to channel width, depth and slope. This calculation uses analytical equations which include bed material transport and which separates total hydraulic roughness into bank and bed components.

SEDIMENT TRANSPORT, SAM.sed. The calculation of bed material discharge curves uses sediment transport theories.

SEDIMENT YIELD, SAM.yld. The Flow-Duration Sediment-Discharge Rating Curve Method is used for calculating sediment yield, (Corps of Engineers, 1989).

The other three utility codes provide assistance to the user:

PREPARE INPUT FILES, PSAM. PSAM is a series of input screens for creating input files for the three major modules of the SAM package. It provides user-friendly input menus and writes the created data files into the format the computer code expects.

CALCULATE REACH AVERAGES FROM HEC-2'S TAPE95, SAM.m95. SAM.m95 reads the binary file created by HEC-2, uses that file to compute average parameters, and writes those parameters into an input file for SAM.sed.

GUIDANCE IN TRANSPORT FUNCTION SELECTION, SAM.aid. SAM.aid provides guidance in the selection of the most applicable sediment transport function(s) to use with a given project, based on five screening parameters: d_{50}, slope, velocity, width, and depth.

1.4 Typical Results from the Application of SAM. A small creek is to be "improved" for flood control by enlarging the cross section. The question addressed by SAM is, "Will the project channel be stable?" The answer is determined by calculating the trap efficiency of the proposed channel.

First, hydraulic parameters were calculated for the existing channel approaching the project area using the SAM.hyd module. Results are shown in the first 9 columns of Table 1. Next the bed material sediment load was calculated using the results of hydraulic calculations and the SAM.sed module. This is tabulated in the last column of Table 1.

TABLE 1. Calculated Inflowing Sand Discharge to Project

N	Q cfs	Normal* Depth ft	Top Width ft	Area sqft	R ft	n-value	Velocity fps	Shear Stres #/sqft	Sand Transport Tons/Day
1	5	0.28	16.3	4	0.27	0.0217	1.16	0.028	5
2	10	0.43	17.0	7	0.42	0.0233	1.45	0.043	20
3	20	0.67	18.1	11	0.65	0.0249	1.80	0.066	50
4	25	0.77	18.6	13	0.75	0.0255	1.94	0.075	70
5	100	1.33	21.2	24	1.29	0.0171	4.14	0.131	700
6	500	3.41	30.9	78	3.16	0.0202	6.38	0.319	5800
7	3680	9.82	123.5	381	8.55	0.0259	9.66	0.864	59000

* The channel slope is 0.00166.

The width, depth and slope of the Project Channel was furnished by its designer. The channel was sized to convey the 100-yr frequency flood, 12,430 cfs. The design cross section is a trapezoid with a 100-ft bottom width and 1V:3H side slopes. The bottom slope is 0.0004 ft/ft. The channel bottom is to be grass lined except for a 10-ft wide strip along the center that is expected to be too wet to sustain vegetation. However, sand is expected to cover the grass during floods. This cross section was analyzed by SAM using the same procedure described above for the approach reach. Results are shown in Table 2.

TABLE 2. Sand Transport through the Project Channel

N	Q cfs	Normal* Depth ft	Top Width ft	Area sqft	R ft	n-value	Velocity fps	Shear Stres #/sqft	Sand Transport Tons/Day
1	5	0.35	70.8	13	0.23	0.0281	0.40	0.006	0
2	10	0.47	93.9	22	0.29	0.0286	0.45	0.007	0
3	20	0.60	100.6	35	0.39	0.0280	0.57	0.010	0
4	25	0.66	100.9	41	0.44	0.0279	0.62	0.011	1
5	100	1.20	104.2	97	0.96	0.0279	1.04	0.024	40
6	500	2.74	113.4	264	2.44	0.0284	1.90	0.061	600
7	3680	6.96	138.8	797	6.43	0.0223	4.62	0.160	14000

Project stability was assessed by using trap efficiency. First, the annual bed material sediment yield was calculated for both existing and project channels using the SED.yld module. That module uses the Flow-Duration Sediment-Discharge Rating Curve Method for calculating sediment yield (Corps of Engineers, 1989). The sediment discharge rating curves, in this case, are the bed material transport rates shown in Tables 1 and 2. The Flow-Duration data is shown in the following table. It is the same for both existing and project conditions in this case. Flow-duration values were calculated with generalized coefficients for ungaged watersheds in the area of this project.

TABLE 3. Annual Flow-Duration Table

Time*	1	5	10	15	20	30
Q, cfs	100	12	6	4	3	1

* percent of time flow is greater than or equal to Q

By forecasting the amount of sediment entering the project area and calculating the amount of sediment that the project will transport out of the project area, the trap efficiency of the project reach can be estimated. A negative trap efficiency would signify that bed material sediment will be eroded from the project reach. A positive value would signify that bed material sediment will deposit in the project reach. Average annual maintenance cost for removing sediment deposits can be estimated from this sediment budget.

In this case, the average annual sand yield to the project is 2600 cubic yards per year. The calculated volume that the project channel can transport is 85 cubic yards per year. That converts to a trap efficiency of 97% which indicates a potential stability problem with this design. Long term maintenance will be required to remove these deposits.

1.5 Computer Requirements. SAM.hyd is about 22,000 lines of Fortran code and compiles forming an executable of about 322k. SAM.sed is about 12,000 lines of Fortran and compiles forming an executable of about 344K. SAM.yld is about

6300 lines of Fortran and compiles forming an executable of about 113K. The executable for PSAM is about 250K, for SAM.m95 is about 67K, and for SAM.aid is about 67K. Data files link the modules together. Results are written to DSS for plotting.

1.6 Files. The program operates interactively. However it saves the input data in an ASCII file which can be edited and re-read to minimize typing in data. It uses an ASCII file to pass data from module to module.9

2. HYDRAULIC CALCULATIONS AND STABLE CHANNEL DIMENSIONS.

2.1 Purpose. The purpose of this module is to provide hydraulic design engineers with a method, based on state of the art theory, for rapidly calculating channel size in both fixed and mobile boundary streams.

SAM.hyd solves the steady state, normal-depth, Manning Equation, using the alpha method to transform complex geometry into composite, 1-Dimensional hydraulic parameters. It allows roughness to be calculated by several different options, including the Moody Diagram. Riprap will be sized automatically if needed for stability.

SAM.hyd provides the option of calculating riprap size, either by the Maynord equations or through testing the results of the normal depth calculations against the Shield's Diagram for particle stability.

SAM.hyd also contains an analytical procedure for calculating stable channel dimensions. It is based on the Brownlie equations for sediment transport and bed roughness. This calculation provides a table of channel width-depth-slope dimensions which are in equilibrium with the inflowing sediment load.

2.2 Options for Solving Manning's Equation. Equation 2.1 is the usual form of the Manning Equation. This shows water discharge to be the dependent variable. However, SAM allows any of the variables on the right hand side to become the dependent variable except for side slope, z. For example, SAM was written to calculate Normal Depth, D, in complex geometry. That is, SAM inspects each input record type and determines which variables have been prescribed. Whichever record type is omitted allows SAM to select the dependent variable.

$$Q = f(D, n, W, z, S) \qquad (2.1)$$

where

Q = water discharge
D = water depth
n = n-value
W = bottom width
z = side slopes of the channel
S = energy slope

Normal Depth will be calculated when all variables except Water Surface elevation are prescribed; i.e., the WS-record is omitted.

Flow Distribution will be calculated when all variables are prescribed. However, the flow distribution is calculated each time the Manning equation is solved, and it can be requested during any of the calculations.

Bottom Width of the channel will be calculated when all variables except bottom width are prescribed on the CT-record.

Energy Slope will be calculated when all variables except slope are prescribed; i.e., the ES-record is omitted.

Hydraulic Roughness (n-values and Ks values) will be calculated when all variables except n-value are prescribed. The KN-KS record value(s) are less than 0.

Water discharge will be calculated when all variables except water discharge are prescribed; i.e., the QW-record is omitted.

These calculations are described in paragraphs 2.5 through 2.10, respectively. Other SAM.hyd calculation options are described next.

Composite Hydraulic radius and/or n-value can be calculated by four options: (1) Alpha method, (2) Equal Velocity method, (3) Total Force method and (4) Conveyance method.

Bed Roughness Prediction is made with Brownlie's method. It uses velocity, hydraulic radius, slope, particle specific gravity, d_{50} and the geometric standard deviation of the bed sediment mixture.

Cross Section Velocity is printed for comparison with the velocity criteria for stable channel design.

Shear Stress is printed for comparison with the boundary shear stress criteria for stable channel design.

Riprap Size can be requested if the calculated bed shear stress is greater than Shield's critical value.

Effective Width, Depth and Velocity are calculated, printed and written to a file for use in sediment transport calculations.

Equivalent Hydraulic Radius and n-Value are calculated and printed for each subsection in the cross section after the normal depth calculations are finished.

Geometry can be simple, as defined by a Channel Template,or complex, as prescribed with X1/GR-record data sets from HEC-2/HEC-6 or with multiple CT-records. In either case it can be transformed into "Effective Hydraulic Parameters" for sediment transport calculations.

2.3 Options for Calculating Riprap. Riprap calculations are made using the Maynord equations. Two procedures are available. When flow velocity and depth are known, the riprap size is calculated directly. When water discharge and cross section are given, riprap size is determined by a more complicated calculation, since n-value becomes a function of riprap size.

SAM.hyd also has the ability to determine whether or not riprap is required. The program evaluates the calculated bed shear stress and the Shield's critical value. If the calculated bed shear stress is greater than Shield's critical value is, SAM.hyd will notify the user that riprap is required. At this point the user may alter the data file to request riprap calculations.

The 12-standard riprap sizes from EM 1110-2-1601 (see Table 6) are coded into SAM. The user can also specify quarry run riprap.

The riprap calculations are described in detail in sections 2.11 and 2.12 of the manual.

2.4 Options for Calculating Stable Channel Dimensions. Stable channel dimensions refer to combinations of width, depth and slope for which the resulting hydraulic parameters will transport the inflowing bed material load. Water discharge must be prescribed.

Acceptable channel dimensions are printed for a wide range of widths for the prescribed water discharge and sediment inflow.

Regime Width is the midpoint value in the channel dimensions table. It is calculated from the prescribed water discharge as though that were the channel forming discharge.

Minimum Stream Power criteria is imposed and the resulting width, depth and slope are printed.

The Stable Channel Dimensions option of SAM.hyd is described in section 2.13 of the manual.

2.5 Normal Depth Calculations. Normal depth calculations use both the Chezy and the Manning equations. First the composite properties are calculated based on the Chezy equation because of the simpler powers involved. Then the Chezy C is converted to an n-value and normal depth is calculated using the Manning equation.

2.5.1 Geometry. There are two options for coding the cross section. One is a channel template, a CT-record, which prescribes bottom width and side slopes for a simple triangular, rectangular or trapezoidal+whape. Up to 3 CT-records can be stacked to form a compound cross section shape. For example, a low flow channel can be coded on the first CT-record followed by a normal flow channel CT-record followed by a high flow berm CT-record, see Figure 1a. The other option for coding the cross section is to read the station and elevation coordinates from X1- GR- records in HEC-2/HEC-6 format. The Little Rock District format of A- and G- records can be read, also. Figure 1b shows a typical complex cross section that would be coded in HEC-2 format, for example.

2.5.2 Hydraulic Roughness Equations. Hydraulic roughness can be prescribed directly with n-values or it can be related to physical properties of the cross section by one of the following hydraulic roughness equations:

0. n-values
1. Moody Diagram (Keulegan equations)
2. Strickler Equation
3. Limerinos Equation
4. Brownlie's Bed Roughness Equations
5-9. Five Soil Conservation Service equations for grass lined channels

Each channel problem is unique and no one predictor should be considered as "best". Be cautious and justify which is the most likely n-value for each study.

2.5.2.1 Manning n-Value. This option allows the hydraulic roughness to be coded as n-values. The n-values are immediately converted to k_s using the Strickler equation. However, this option has the advantage of allowing the use of historical data.

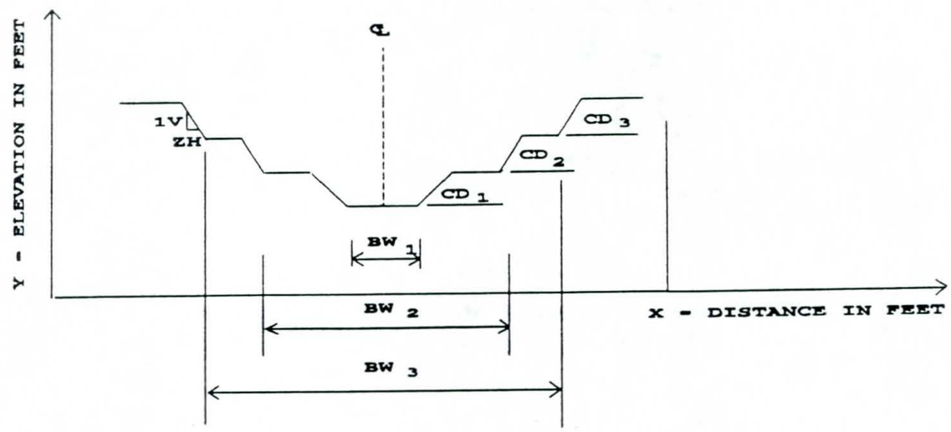

Figure 1a. Complex Geometry, multiple CT-records.

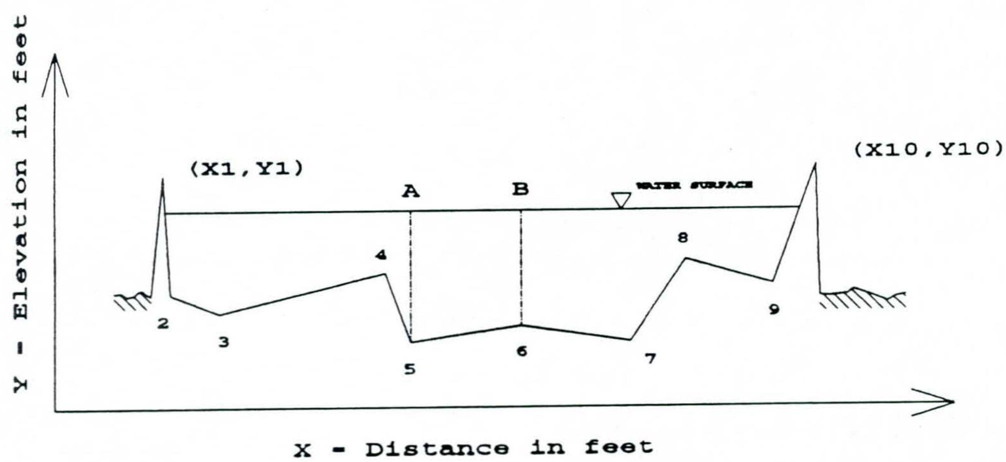

Figure 1b. Complex geometry, X1/GR-records.

The trapezoidal element 'AB(6)(5)' in this figure is called a "panel" in this document.

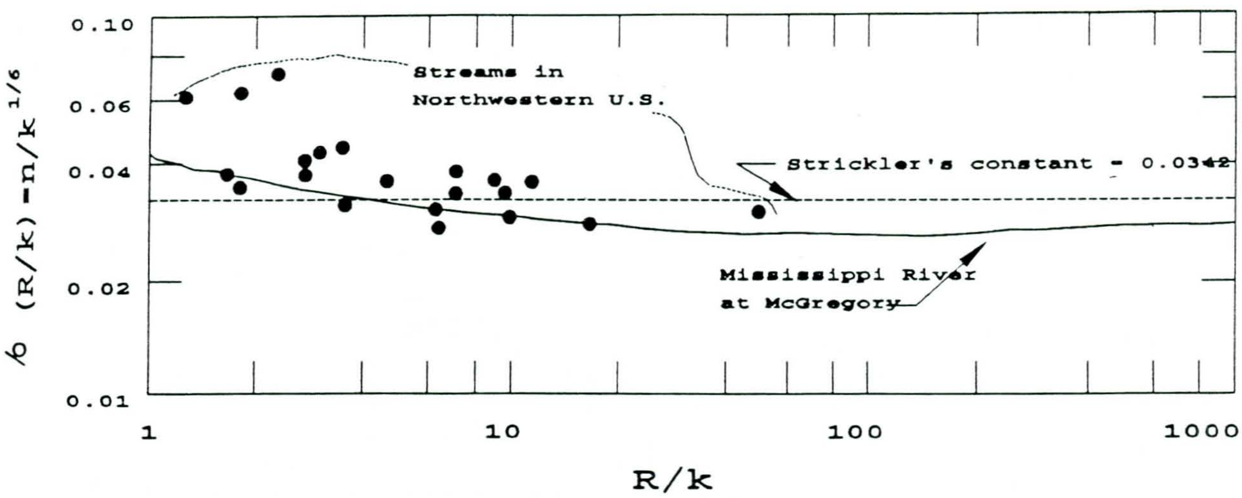

Figure 2. The Strickler Function (Chow, 1959), used with permission from McGraw-Hill Book Company, Inc.

2.5.2.2 <u>Strickler Equation.</u> The Strickler equation, (Chow, 1959), is shown in figure 2. Notice that the effective surface roughness height, k_s, is correlated with the d_{50} of the bed sediment in this figure. However, k_s can be correlated with other measures of the surface roughness depending on what is representative of the surface roughness height of the boundary materials. For example, riprap research at WES has shown that the Strickler Equation will give satisfactory n-values when k_s is taken to be the d_{90} of the stone.

$$n = STRIC(k_s)^{1/6} \tag{2.2}$$

where

STRIC = 0.034 for Riprap Size Calculations where $k_s = d_{90}$
= 0.038 for Discharge Capacity of Riprapped Channels where k_s is d_{90}

k_s = Effective Surface Roughness, ft

2.5.2.3 <u>Effective Surface Roughness Height, ks.</u> For the design of concrete channels the suggested values for k_s are shown in EM 1110-2-1601. For the case of channels in natural materials, there are no tables of generally accepted k_s-values as there are for Manning's n-values. Moreover, there is no generally accepted technique for measuring this property geometrically. The work that has been done to date seems to have adopted some variable or the other and regressed on it to develop the necessary coefficients for k_s. For example, in sand bed channels d_{50} is suggested as being k_s, (Chow, 1959).

Because of the present lack of a technique to measure k_s directly, the most reliable way to determine it is to use the Strickler equation and calculate it from Manning's n-value.

2.5.2.4 <u>Relative Roughness.</u> Relative roughness refers to the ratio of the effective surface roughness height, k_s, to the hydraulic radius, R. The relative roughness parameter, R/k_s, is shown on the Moody diagram, for example.

2.5.2.5 <u>Moody Diagram.</u> The Moody diagram is shown in EM 1110-2-1601. The plate is entitled "Open Channel Flow, Resistance Coefficients." Three resistance equations are shown: Fully Rough Flow, Smooth Flow and Transition Zone.

2.5.2.5.1 <u>Fully Rough Flow.</u> SAM calculates hydraulic roughness as a Chezy coefficient, and converts it to an n-value. Relative roughness is correlated with Chezy's C using the following equation for the condition of fully rough flow:

$$C = 32.6 \log_{10}\left(\frac{12.2\,R}{k_s}\right) \tag{2.3}$$

where

C - Chezy Coefficient
R - Hydraulic Radius, ft
k_s - Effective Surface Roughness, ft

This equation is based on the classic work of Keulegan in which he derived the equations for the mean velocity of turbulent flow in open channels, (Chow, 1959). Chow shows it written in the form of Keulegan's velocity distribution equation as follows:

$$V = U_*\left(6.25 + 5.75 \log_{10}\left(\frac{R}{k_s}\right)\right) \tag{2.4}$$

$$U_* = \sqrt{gRS} \tag{2.5}$$

where

6.25 - Coefficient for fully rough flow
g - acceleration of gravity
U_* - Boundary shear velocity
S - Slope

Substituting a variable, A_r, for the constant, 6.25, in the above equation; substituting the Chezy equation for velocity; and substituting the boundary shear velocity equation for U_* gives

$$\frac{V}{U_*} = \frac{C}{\sqrt{g}} = A_r + 5.75 \log_{10}\left(\frac{R}{k_s}\right) \tag{2.6}$$

$$C = \sqrt{g}\left(A_r + 5.75 \log_{10}\left(\frac{R}{k_s}\right)\right) \tag{2.7}$$

> From Keulegan's study of Bazin's data, the value of A_r was found to have a wide range, varying from 3.23 to 16.92. Thus, a mean value of 6.25 may be used.
>
> ...
>
> A further study was made by Iwagaki on experimental data obtained from many sources. The results of the study have disclosed that resistance to turbulent flow in open channels becomes obviously larger than that in pipes with increase in the Froude number. Iwagaki reasoned that this is due to the increased instability of the free surface at high Froude numbers.... (Chow, 1959, p204)

The Iwagaki relationship is shown in Figure 3. It can be written in the form shown in EM 1110-2-1601 as follows:

$$C = 32.6 \log_{10}\left(10^{\sqrt{g}A_r/32.6}\left(\frac{R}{k_s}\right)\right) \tag{2.8}$$

2.5.2.5.2 Smooth Flow. The comparable form of the equation for "Smooth Flow" is

$$C = 32.6 \log_{10}\left(10^{\sqrt{g}A_s/32.6}\left(\frac{R_n}{C}\right)\right) \tag{2.9}$$

where

A_s = Iwagaki Coefficient for smooth flow

R_n = Reynolds Number = $\frac{4RV}{\text{Kinematic Viscosity}}$

SAM does not solve the equation for Smooth Flow, but it does solve the Transition Zone equation.

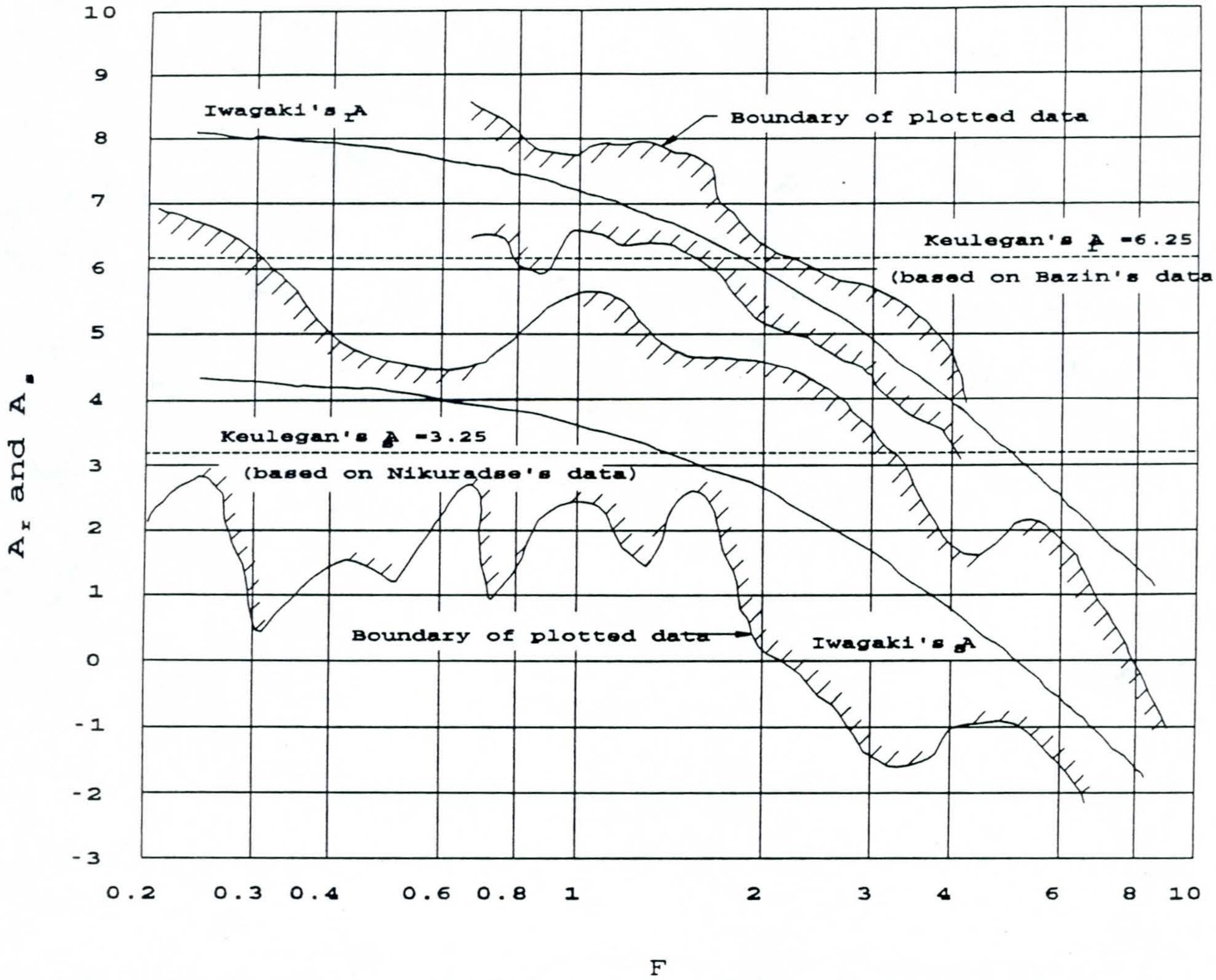

Figure 3. The Iwagaki relationship (Chow, 1959), used with permission from McGraw-Hill Book Company, Inc.

2.5.2.5.3 <u>Transition Zone.</u> The limit of the Fully Rough Zone is shown in EM 1110-2-1601 as

$$\left(\frac{R_n}{C} / \frac{R}{K}\right) > 50 \qquad (2.10)$$

The roughness equation in the transition zone is a combination of the equations for Smooth and Fully Rough flow as follows.

$$C = -32.6 \log_{10} \left(\frac{C}{R_n \, 10^{\sqrt{8} A_s / 32.6}} + \frac{k_s}{R \, 10^{\sqrt{8} A_r / 32.6}} \right) \tag{2.11}$$

2.5.2.5.4 A_r and A_s Coefficients. When the values of A_r and A_s are 6.2411 and 4.1134 the coefficients in the roughness equations are 12.2 and 5.2, respectively. These are the values shown in EM 1110-2-1601.

The curves for Iwagaki's coefficients are not fitted with equations in Chow. The following equation for the A_r-curve was obtained from Powell (OCE, Unpublished, 1986).

$$A_r = -27.058 \log_{10} (F_r + 9) + 34.289 \tag{2.12}$$

where F_r = Froude Number. Data ranged from $0.2 < F_r < 8.0$.

Using a similar form, the equation for the A_s-curve is

$$A_s = -24.739 \log_{10} (F_r + 10) + 29.349 \tag{2.13}$$

2.5.2.5.5 Range of Applicability. When the relative roughness value is less than 2, SAM automatically switches from the Moody Diagram to the Strickler equation. This switch is based on unpublished research of Maynord (WES).

2.5.2.6 Limerinos n-Value Predictor. Limerinos developed an empirical, relative roughness equation for gravel bed streams using field data (Limerinos, 1970). He correlated n-values with hydraulic radius and bed sediment size. The resulting equation is shown below along with the conversion to Chezy C.

$$n = \frac{0.0925 \, R^{1/6}}{1.16 + 2.0 \log_{10} \left(\frac{R}{d_{84}} \right)} \tag{2.14}$$

$$C = \frac{1.486\ R^{1/6}}{n} \qquad (2.15)$$

where

d_{84} = the particle size for which 84% of the sediment mixture is finer (Data ranged from 1.5mm to 250mm)

n = Manning's n value
Data ranged from .02 to 0.10

R = Hydraulic radius
Data ranged from 1 to 6 feet

C = Chezy C.

Grain sizes in Limerinos's data ranged from Very Course Sand to Large Cobbles. Consequently, it follows that this equation is applicable to gravel/cobble bed streams and to bed regimes similar to those found in such streams within the energy spectrum contained in Limerinos' field data. Predicted n-values are sufficiently larger than those predicted by the Strickler equation that some loss other than grain roughness must have been present. However, Limerinos's equation is not applicable to lower regime flow nor does it forecast the transition between upper and lower regimes.

Burkham and Dawdy (1976) showed the Limerinos equation could be used in sand bed streams for upper regime flow. In that analysis they extended the range of the relative roughness parameter as follows.

$$600 < \frac{R}{d_{84}} < 10,000 \qquad (2.16)$$

2.5.2.7 <u>The Brownlie Bed-roughness Predictor.</u> In sediment transport calculations it is important to link n-values to the bed regime. This is particularly true when hydraulic conditions shift between upper regime and lower regime flow. There are several methods in ASCE Manual 54 which express n-value in terms of sediment parameters, but Brownlie (1983) is the only method that calculates the transition. This method post dates the ASCE Manual 54.

Brownlie sought to reconstitute the most fundamental process, the discontinuity in the graph of hydraulic radius vs velocity, figure 4. (Brownlie, 1983). In the process of this research, he collected the known sediment data sets - 77 in all containing 7027 data points. Of the total, 75% were from flume studies and 25% from field tests. He used 22 of these data sets and demonstrated a remarkable agreement with both field and laboratory data.

Brownlie's basic equations were modified for SAM to display bed roughness as a coefficient times the grain roughness. The units can be either English or metric.

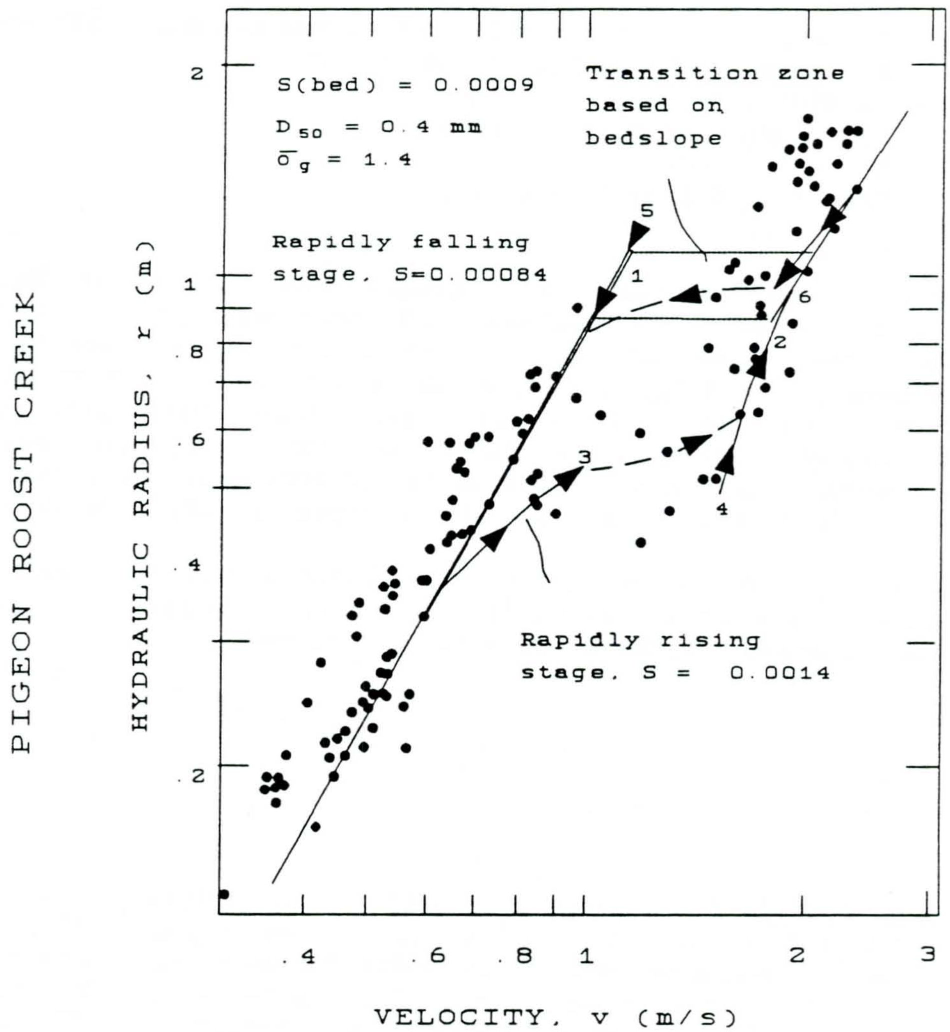

Figure 4. Velocity versus Hydraulic Radius in a Mobile Bed Stream, used with permission of California Institute of Technology.

$$n = [\text{BED-FORM ROUGHNESS}] * [\text{STRICKLER GRAIN ROUGHNESS}] \tag{2.17}$$

This makes it easy to compare the results with the skin friction for fixed bed systems as presented in the Moody Diagram. The resulting form of the equations for lower and upper regime are:

LOWER REGIME FLOW:

$$n = \left[1.6940 \left(\frac{R}{d_{50}}\right)^{0.1374} S^{0.1112}\ \sigma^{0.1605}\right] \frac{d_{50}{}^{0.167}}{29.3} \tag{2.18}$$

UPPER REGIME FLOW:

$$n = \left[1.0213 \left(\frac{R}{d_{50}}\right)^{0.0662} S^{0.0395}\ \sigma^{0.1282}\right] \frac{d_{50}{}^{0.167}}{29.3} \tag{2.19}$$

where

- d_{50} = the particle size for which 50% of the sediment mixture is finer.
- R = hydraulic radius of the bed portion of the cross section.
- S = bed slope i.e. probably the energy slope would be more representative if flow is non-uniform.
- σ = the geometric standard deviation of the sediment mixture, where

$$\sigma = 0.5 \left(\frac{d_{84}}{d_{50}} + \frac{d_{50}}{d_{16}}\right) \tag{2.20}$$

TRANSITION FUNCTION:

If the slope is greater than 0.006, flow is always UPPER REGIME. Otherwise, the transition is correlated with the grain Froude number as follows:

$$F_g = \frac{V}{\sqrt{(s_s-1)\, g\, d_{50}}} \qquad (2.21)$$

$$F_g' = \frac{1.74}{S^{1/3}} \qquad (2.22)$$

if $F_g \leq F_g'$ LOWER REGIME FLOW

if $F_g > F_g'$ UPPER REGIME FLOW

where

F_g - grain Froude number.
s_s - specific gravity of sediment particles.
V - velocity of flow.
S - bed slope

The transition occurs over a range of hydraulic radii and not at a point. Over this range, then, it is a double valued function, and the transition test will give different regimes depending on which equation is being solved for roughness at that iteration. That is realistic since one expects the rising side of a hydrograph to trigger the transition at a different discharge than does the falling side. However, it makes a terrible numerical problem because the calculations will fail to converge in the transition zone resulting in the note

ABNORMAL TERMINATION IN THE NORMAL DEPTH CALCULATIONS.

When such occurs, inspect the maximum and minimum values printed. Usually, the depths are the same whereas the discharges are significantly different. That signifies the transition has been located from both the upper regime and the lower regime curves, and the results are the best that can be achieved.

2.5.2.8 Soil Conservation Service (SCS) Roughness for Grass Cover. Hydraulic roughness curves for five types of grass cover were published by SCS in 1954, figure 5. Each curve type, A through E, refers to grass conditions described in table 4.

TABLE 4. Characteristics of Grass Cover.

Type	Cover	Condition
A	Weeping lovegrass............	Excellent stand, tall (average 30 in.)
	Yellow bluestem Ischaemum....	Excellent stand, tall (average 36 in.)
B	Kudzu	Very dense growth, uncut
	Bermudagrass.................	Good stand, tall (average 12 in.)
	Native grass mixture (little bluestem, blue grama, other long and short midwest grasses)	Good stand, unmowed
	Weeping lovegrass............	Good stand, tall (average 24 in.)
	Lespedeza sericea............	Good stand, not woody, tall (average 19 in.)
	Alfalfa......................	Good stand uncut (average 11 in.)
	Weeping lovegrass............	Good stand, mowed (average 13 in.)
	Kudzu........................	Dense growth, uncut
	Blue grama...................	Good stand, uncut (average 13 in.)
C	Crabgrass....................	Fair stand, uncut (10 to 48 in.)
	Bermudagrass.................	Good stand, mowed
	Common lespedeza.............	Good stand, uncut (average 11 in.)
	Grass-legume mixture--summer (orchard grass, redtop, Italian ryegrass and common lespedeza)	Good stand, uncut (6 to 8 in.)
	Centipedegrass...............	Very dense cover (average 6 in.)
	Kentucky bluegrass...........	Good stand headed (6 to 12 in.)
D	Bermudagrass.................	Good stand, cut to 2.5-inch height
	Common lespedeza.............	Excellent stand, uncut (average 4.5 in.)
	Buffalograss.................	Good stand, uncut (3 to 6 in.)
	Grass-legume mixture--fall, spring (Orchardgrass, redtop, Italian ryegrass, and common lespedeza)	Good stand, uncut (4 to 5 in.)
	Lespedeza sericea............	After cutting to 2-inch height; very good stand before cutting
E	Bermudagrass.................	Good stand, cut to 1.5-inch height
	Bermudagrass.................	Burned stubble

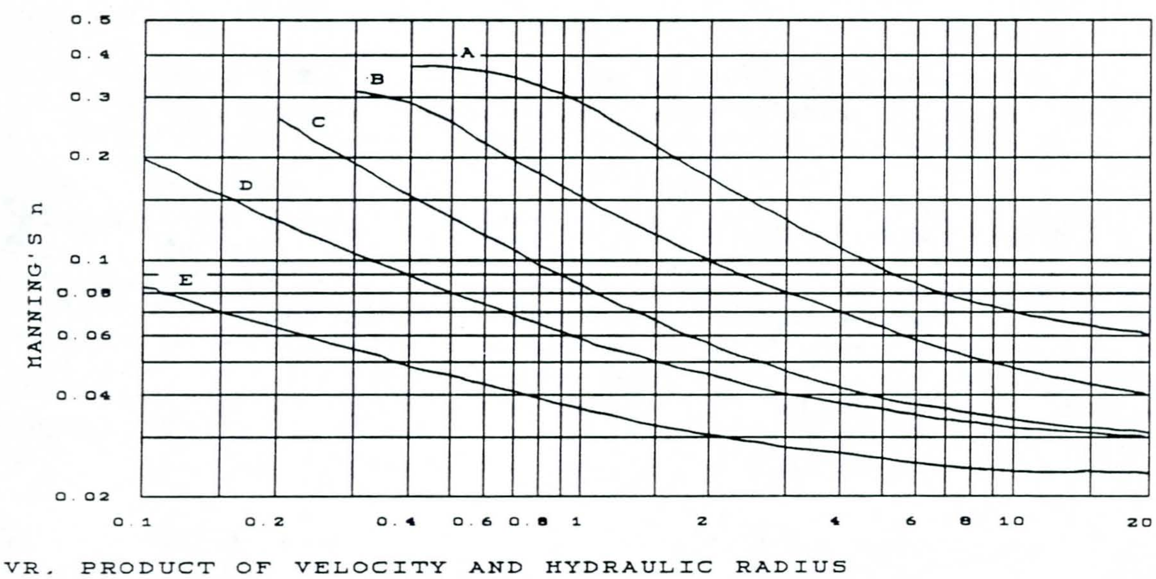

Figure 5. n-Value Relationships for Grass Cover.

2.5.3 Distribution of Hydraulic Roughness. Hydraulic roughness should be prescribed between each pair of coordinates, i.e., each panel, as shown in figure 6. This makes it important to establish which portion of the channel cross section is bed and which is banks because the bed roughness predictors apply only to the channel bed co-ordinates. That is, typically the vegetation roughness and bank angle do not permit the bed load to move along the banks. Therefore, the Limerinos or Brownlie n-value equations should not be assigned to the channel banks.

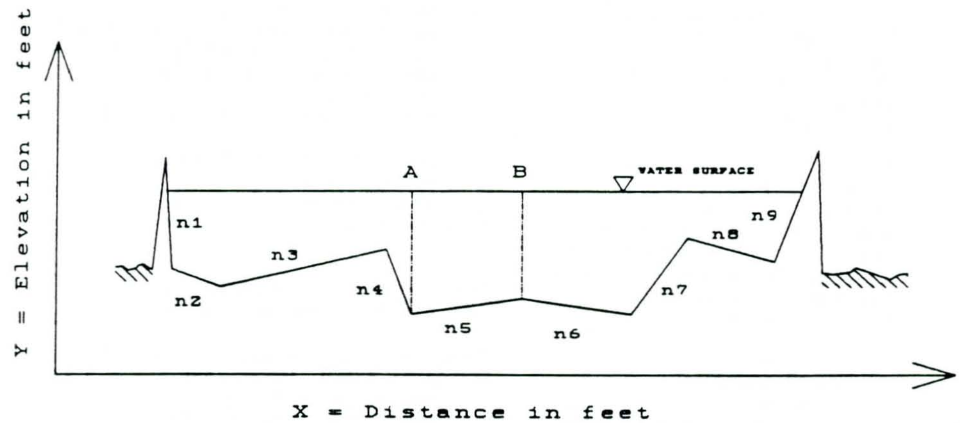

Figure 6. Prescribing Hydraulic Roughness.

The point bar is a natural source-sink zone for sediment transport. Consequently, it is a location at which Limerinos and Brownlie equations apply.

None of the n-value equations account for momentum or bend losses. Presently, the only technique for bend losses is to increase the n-values by some factor. Chow (1959) presents the Cowan method for including bend losses.

2.5.4 Composite Hydraulic Properties. The calculations which transform the complex geometry and roughness into representative, 1-dimensional hydraulic parameters for the normal depth calculations is called Compositing Hydraulic Parameters. That is, in a complex cross section the composite hydraulic radius includes, in addition to the usual geometric element property, the variation of both depth and n-values. There are several methods in the literature for compositing. The "Alpha Method" was selected as the default for SAM. It is developed in EM 1110-2-1601. Three other methods are provided as options: equal velocity, total force and conveyance.

2.5.4.1 Alpha Method. The Chezy equation forms the basis for this method. The cross section is partitioned into panels between coordinate points. All panels are assumed to be vertical. The cross section is not subdivided between channel and overbanks for this calculation.

Calculations always begin at the first panel in the cross section, and the geometric properties are calculated and saved for each wet panel across the section. The hydraulic radius and Chezy-C are then calculated and the compositing parameters summed. Computations move panel by panel to the end of the cross section. The method is summarized below.

```
        SECTION 4.  CALCULATE AVERAGE HYDRAULIC PROPERTIES

              (NOTE:       SUMA = Total area of flow
                           SUMP = Total wetted perimeter
                           SUMW = Total width at water surface)

        HR = SUMA/SUMP
        DCEL = SUMA / SUMW
        VAVG = QTRUE / SUMA
        FN = VAVG  / SQRT (ACGR * DCEL)
        AR = 10. -3 * SQRT(FN)

        SECTION 5.  CALCULATE COMPOSITE HYDRAULIC PROPERTIES
        PART 5.1    SUM ELEMENT VALUES
        TCRA = 0.
        TRCRA = 0.
        DO 4000 L = 1, all panels
        CHEZ(L) = 0.
        TZR(L) = 0.
        IF(TZP(L) .GT. 0.) TZR(L) = TZA(L)/TZP(L)
        IF(TZR(L) .LE. 0.) GO TO 4000
        CALL HYDRUF(AR, HR, SQRG, N, L, CHEZ)
        TZCRA(L) = CHEZ(L) * SQRT(TZR(L)) * TZA(L)
        TCRA = TCRA + TZCRA(L)
        TRCRA = TRCRA + TZR(L) * TZCRA(L)
4000  CONTINUE

        PART 5.2  CALCULATE COMPOSITE HYD RADIUS and n-VALUE; RC and XNM
        CRM = TCRA / SUMA
        SLOF = (VAVG/CRM)**2
        RTCRA = 1. / TCRA
        RC = TRCRA * RTCRA
        TAUM = UWWA(N) * RC * SLOF
        RHS = 10**(((VAVG(N)/(SQRG*SQRT(TAUM/UWWA(N)))) -AR) / 5.75)
        HRKM =  RC / RHS
        XNM = 1.486 * (RC**.66667) * SQRT(SLOF) / VAVG(N)
```

The alpha method fails when there is a vertical wall. Presently SAM forces the hydraulic radius to be half the wetted perimeter when that occurs. However, the theory has broken down, and one of the other methods should be requested (see TR-record).

2.5.4.2 <u>Equal Velocity Method.</u> Perhaps a more rational method for vertical walls is the Equal Velocity Method. It was proposed by Horton, and independently by Einstein, (Chow, 1959), and is one which prevents divide by zero.

$$\bar{n} = \frac{\left(p_1\, n_1^{1.5} + P_2\, n_2^{1.5} + \cdots + p_n\, n_n^{1.5}\right)^{2/3}}{P^{2/3}} \qquad (2.23)$$

where

$\bar{n}$ - the composite n-value for the section
p_n - Wetted perimeter in wet panel n
n_n - n-value in wet panel n
P - Total wetted perimeter in cross section

Since only wetted perimeter, and not hydraulic radius, appears in this equation, it is always well behaved.

2.5.4.3 Total Force Method. This method was proposed by Pavlovskii, by Muhlhofer, and by Einstein and Banks, (Chow, 1959). It is based on the hypothesis that the total force resisting the flow is equal to the sum of the forces resisting the flow in each panel. The resulting composite n-value is

$$\bar{n} = \frac{\left(p_1 n_1^2 + P_2 n_2^2 + \cdots + p_n n_n^2\right)^{1/2}}{P^{1/2}} \qquad (2.24)$$

where

p_n - Wetted perimeter in wet panel n
n_n - n-value in wet panel n
P - Total wetted perimeter in cross section

2.5.5 Sub-sections. When the channel is separated from the overbanks so calculations can be confined to strips having similar hydraulic properties, the technique forms subsections within the cross section. The conveyance for each subsection can be calculated and the values added to provide the conveyance for the entire cross section. HEC-2 and HEC-6 work in this fashion. It is called the Conveyance Method of calculating the water surface profile.

> James and Brown, Figure 7, reported that the "Manning or Chezy equations do not accurately predict the stage-discharge relation in a channel-floodplain configuration for shallow depths on the floodplain (1.0 < Y/D < 1.4) without adjustments to either the resistance coefficient or the hydraulic radius. ...the effects of geometry seem to disappear at the higher stages, i.e., for Y/D > 1.4, it no longer became necessary to make any correction to the basic equations." (1977, p24)

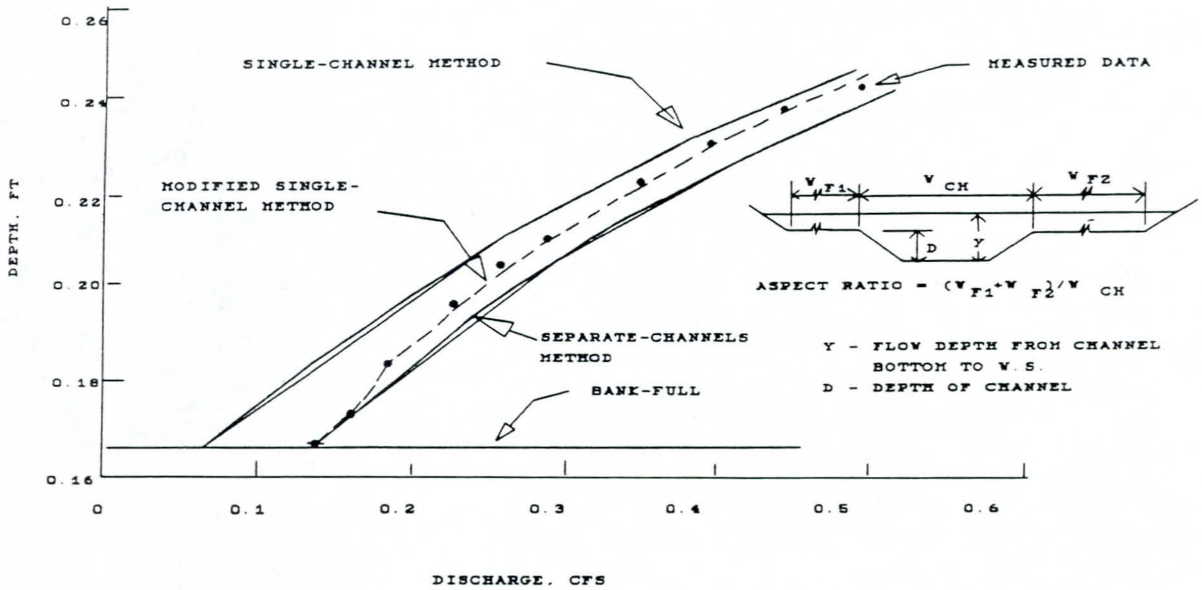

Figure 7. Comparison of measured data and theoretical methods.

Figure 7 summarizes that finding. The subsection approach does not provide the necessary corrections to overcome this deficiency, but it is common practice at the present. SAM ignores these subdivisions until computations are completed, and then it transforms the composited hydraulic parameters into equivalent subsection values for use in HEC-2 or HEC-6.

2.5.6 Effective Hydraulic Parameters for Sediment Transport. The problem of obtaining hydraulic parameters is critical when making sediment transport calculations involving complex cross sections. The velocity, depth, width and slope are needed for subsections having similar hydraulic properties. This requirement leads to a compositing technique called "EFFECTIVE WIDTH and DEPTH." In SAM the slope can be either the bed slope or the water surface slope or the energy line slope since all are parallel in normal depth computations. The following equations are illustrated in figure 8.

$$EFD = \frac{\Sigma\, D_i\, a_i\, D_i^{2/3}}{\Sigma\, a_i\, D_2^{2/3}} \qquad (2.25)$$

$$EFW = \frac{\Sigma\, a_i\, D_i^{2/3}}{EFD^{5/3}} \qquad (2.26)$$

where

a_i = Area of panel i, $\Delta X * D_i$
d_i = Average depth of panel, i, (A1 + B1) * 0.5
EFD = Effective Depth of the cross section
EFW = Effective Width of the cross section

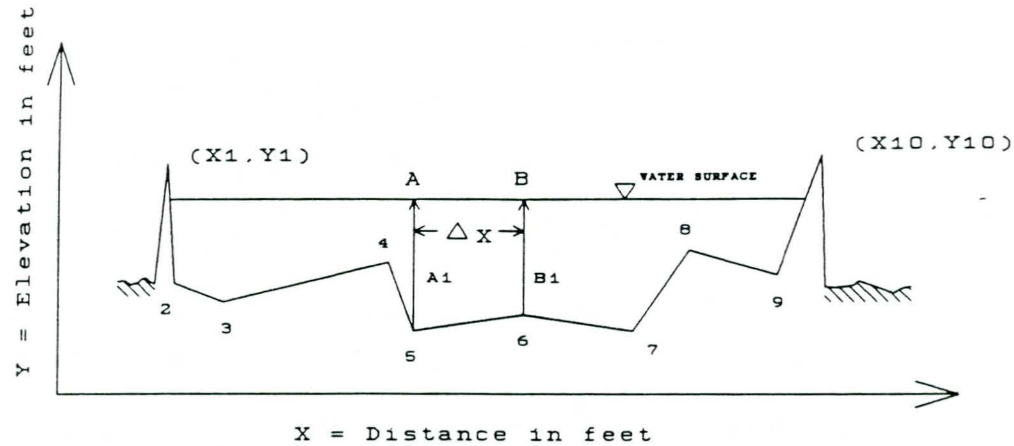

Figure 8. Calculating Effective Depths and Widths.

These effective values are calculated after the normal depth has been determined. At this point it is necessary to subdivide the cross section between channel and overbanks. Whereas all three values are calculated for each strip, only the channel values are written into the sediment transport input file.

2.5.7 Execution. SAM executes by reading a batch file. The main SAM menu is activated by typing

SAM

The following screen will appear.

```
HYDRAULIC DESIGN PACKAGE FOR FLOOD CONTROL CHANNELS MENU

                                              MENU 1 OF 2
        -> 1 -  SAM.hyd   Hydraulic Calculations

           2 -  SAM.sed   Sediment Transport Calculations

           3 -  SAM.yld   Sediment Yield Calculations

           4 -  Plot      From SAM.hyd, SAM.sed, and SAM.m95

           5 -  PSAM      Prepare SAM Input Files

           6 -  SAM.m95   Use TAPE95 to Prepare SAM.sed Input

           7 -  LIST      View files

           8 -  EXIT      To DOS

              Calculate Hydraulic Parameters

April 2, 1993 10:10:54 am        NUM             Memory: 568 K

                     Press H for Help
```

Figure 9. SAM MENU, Page 1.

SAM.hyd reads an input data file and uses the input records to determine which calculation to make. This version of SAM provides three methods for preparing the input data file:

Method 1 An editor, such as COED, can be used to create the input data file using instructions for each record that are shown in appendix C of this manual.

Method 2 Tutor, in the three main SAM modules, uses the conversational mode to lead the engineer step by step in preparing input. To use tutor, be sure no default file name exists in the directory (see paragraph 2.5.7.1), then execute the hydraulics calculations from the menu. When the program fails to locate a default input filename or [hyd.in], it will enter the conversational mode automatically and initiate prompts for input data. After a data set is created in this manner, it can be saved for subsequent use.

Method 3 The third approach, called PSAM on the SAM main menu (Figure 9) uses screen menus.

2.5.7.1 Default Filename Systems. SAM uses both a system of default filenames and an automatic filename transfer procedure.

2.5.7.1.1 Standard default names. The default filename for SAM.hyd input is hyd.in and for output is hyd.out.

2.5.7.1.2 Automatic Filename Transfer. The automatic filename transfer procedure in SAM creates a file, FILES.SAM, in the working directory which both keeps track of the last used file and provides a systematic way of naming various input and output files. The current input filename is written into FILES.SAM either by naming the file while in PSAM or by a run through SAM.hyd. PSAM, SAM.hyd, and SAM.sed all look in FILES.SAM for the name of the input data file. That file is considered the current input filename, and computations on that file proceed automatically when it is present. The output files from SAM.hyd are named after the input file, with special extensions. The first two letters of the extension become "ho" for the hydraulics output, and "si" for the sediment module input. See Table 5 for an example. There are three ways to change this automatic input data filename.

1. Run PSAM and attach a new data filename.
2. Run the SAM module and, after the default computations attach a new input filename at the command prompt.
3. Delete FILES.SAM, run SAM.hyd, and attach a new input filename at the command prompt.

The user cannot alter the automatic output filenames.

Table 5. Examples of default filenames for Automatic Filename Transfer system for SAM.hyd.

INPUT FILENAME	HYDRAULICS OUTPUT	SEDIMENT INPUT
hydpcin.in	hydpcin.ho	hydpcin.si
hydpcin.lib	hydpcin.hob	hydpcin.sib
clearcrk.dat	clearcrk.hot	clearcrk.sit

2.5.7.2 Execution when a Default Filename Exists. Select SAM.hyd from the SAM menu. The program will "OPEN" the default input data file and execution will follow automatically. Selective printout will scroll to the screen. All printout will be saved in the default output filename which can be inspected with LIST, COED, or a system editor. When computations have finished the following will be on the screen:

```
...END OF JOB...    Printout is in FILE  [ default filename ]

SAM.hyd.main   Options:
End   Help   Run   Tau   Tutor   Attach[inputfile]   Save[inputfile]
```

Figure 10. SAM.hyd Main Menu

At this point, the run can be ended by typing end , and the complete output can be inspected using LIST or COED, both on the SAM menu.

Another option is to modify input data while still in SAM.hyd using the tutor and then execute that data set using the run command. A third option is to attach another input data file, while still in SAM.hyd, using the at command and then execute that data set using the run command. Output will continue to be added to the printout file until the end command is entered. However, if the tutor were used to modify the input data file, it will be physically changed, so save input data in a permanent filename before modifying it.

NOTE: DO NOT use tu (SAM tutor) with an input file of stacked jobs. All input after the first job in the file will be lost.

2.5.7.3 Execution when a Default Filename Does Not Exist. Select SAM.hyd from the SAM menu. If there are no filenames in FILES.SAM, the program will display the following message.

```
WARNING IN SUBROUTINE FINAME.
<< NO HYDRAULIC DATA FILE_NAME IN   [files.sam]  >>.

      HYDRAULIC INPUT file = hyd.in
          PRINTOUT TO file = hyd.out
SEDIMENT INPUT WRITEN TO file = sed.in

PRESS RETURN TO CONTINUE
```

The program then looks for the standard default filename, hyd.in, to run automatically. Note that the message above indicates the default filenames the program will now use. If hyd.in is not found, the following message appears.

```
Msg 1:  HYD. READING INPUT DATA FROM FILE [  hyd.in        ] THIS DIRECTORY.

Msg 2:  HYD.main >>Data File [    hyd.in        ]  Does not Exist.


SAM.hyd.main   Options:
END    Help   Run   Tau   Tutor   Attach[inputfile]   Save[inputfile]
```

At this point three options allow execution, at, tu, or ru [*filename*]. To utilize the at option, type at *filename*. The program responds with

```
Msg 1:  HYD. READING INPUT DATA FROM FILE [ filename ] THIS DIRECTORY.
```

If this file exists, the next message will be the "SAM.hyd.main Options" shown above. If this file does not exist, both Msg 2 and the SAM.hyd.main options will appear. The next step is the same in either case.

To utilize the ru [*filename*] option, type ru [*filename*]. The program will attach and run the file *filename*. If the file does not exist, both MSG2 and the SAM.hyd.main options will appear.

To utilize the tutor option, type TU and the following menu will appear. Select the desired computation and the tutor will prompt for input.

```
HYD 1.3  TYPE:
         sc    Stable Channel Dimensions
         nd    Normal Depth Calculations
         bw    Bottom Width Calculations
         es    Energy Slope Calculations
         ks    Roughness Calculations
         qw    Discharge Calculations
         fd    Flow Distribution
         rd    Riprap Size given Q and Cross Section
         rs    Riprap Size given Vel and Depth
```

2.5.8 Preparing Input Data Files With Tutor. To access the tutor when first executing SAM.hyd, be sure neither the filename hyd.in nor the FILES.SAM exists. When the input data set is complete, the following menu will appear.

```
Input is complete.

TYPE
      ru  overwrite existing file and EXECUTE.
      sa  will overwrite existing file
      sa  [filename]   will create  [filename]
      sa! [filename] will overwrite [filename]
      en  return to hyd.main menu.
```

If no hyd.in had existed ru, sa, and sa! would write the newly created file into hyd.in. If tutor had been accessed after having attached or run a file, ru and sa will overwrite that file. Note that en will not save the file just created.

2.5.9 Modifying Existing Input Data Files. Tutor can also be used to modify an existing data set. It will display each value on the screen and allow it to either be modified or retained. However, if a data file needs to be modified before it is executed, assign a filename other than the default filename. When execution begins and a default file can not be opened, the program will branch to the conversational mode. The desired data file can then be attached and modified before execution is initiated.

A simple editor is being developed to aid the flow of work by allowing minor changes to the data set without waiting for the interactive question/ answer style of tutor .

2.5.10 Sample Input Data Sets. The following examples illustrate input data for normal depth calculations.

```
TI   TEST NO. 1A CALCULATE NORMAL DEPTH RATING CURVE FOR TRAPEZOID (CT-RECORD)
TI               100-ft BOTTOM, 3:1 SIDE SLOPES, n-VALUE = .025, SLOPE = .00521
TI               W. A. THOMAS, WES, 28 January 1991
TI 1       2       3       4       5       6       7       8       9       10
F#345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
CT   100      10       3       3       0    .025
QW   100    1000    5000   10000   20000
ES521E-6
WT    50
$$END

TI   TEST NO. 1B SAME AS 1A EXCEPT USING X1- GR- RECORDS FOR GEOMETRY
TI               W. A. THOMAS, WES, 28 July 1990
TI 1       2       3       4       5       6       7       8       9       10
F#345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
X1     1       4
GR    10    -80.       0    -50.       0     50.      10     80.
NE     0
KN  .025
QW  5000
ES521E-6
WT    50
$$END

TI   TEST NO. 1C SAME AS 1A EXCEPT USING BROWNLIE n-VALUE FOR BED AND MOODY FOR
TI               BANKS
TI               W. A. THOMAS, WES, 28 July 1990
TI               PRINT FLOW DISTRIBUTION
F#345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
TR             1
TR                            -1
CT   100      10       3       3       4               1      .5       1      .5
PF                             1      .8      98     .48      50     .25      16
QW   100    1000    5000   10000   20000
ES521E-6
WT    50
$$END

TI  TEST NO. 1D Calculate normal depth in a Concrete lined, Rectangular Channel
TI              Tubeworm roughness below Sea Level
TI              Fish rests in Center of Channel
TI              W. A. Thomas, WES, 3 March 1991
F#345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
TR     2
X1     1       8
GR    12   -16.5       0   -16.5     -12   -16.5     -12      -2     -12       2
GR   -12    16.5       0    16.5      12    16.5
KS  .007     .10    .007    .035    .007     .10    .007
NE     1       1       1       1       1       1       1
QW  6900
ES380E-5
WT    55
$$END
```

2.5.11 Sample Output Data. Results are printed to the screen as the program executes. Also, printout is saved in the appropriate default output file, see Table 5. The hydraulic parameters needed for sediment transport calculations are written into the default sediment input file along with the other data needed for calculating sediment transport capacity.

NOTE: Be sure to code the PF-record into hyd.in so the hydraulics code will write it into sed.in with the other records.

The following output description refers to the output of TEST 1C, as given. Note that the table numbers may change depending on the calculations required by the input data set.

```
*********************************************************
*                                                       *
*     HYDRAULIC DESIGN PACKAGE FOR FLOOD CONTROL        *
*                  CHANNELS (SAM)                       *
*                                                       *
*               HYDRAULIC CALCULATIONS                  *
*     VERSION 3.04                    7 April 1992      *
*                                                       *
*                  A Product of the                     *
*     Flood Control Channels Research Program           *
*Hydraulics Laboratory, Waterways Experiment Station*
*********************************************************

Msg 1:  HYD. READING INPUT DATA FROM FILE [  hyd.in  ] THIS DIRECTORY.

TABLE  1.  LIST INPUT DATA.

TI    TEST NO. 1C SAME AS 1A EXCEPT USING BROWNLIE n-VALUE FOR BED AND MOODY FOR
TI               BANKS
TI               W. A. THOMAS, WES, 28 July 1990
TI               PRINT FLOW DISTRIBUTION
F#345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
TR             1
TR                              -1
CT    100      10       3       3       4               1      .5       1      .5
PF                              1      .8      98     .48      50     .25      16
QW    100    1000    5000   10000   20000
ES521E-6
WT     50
$$END

INPUT IS COMPLETE.

BED SEDIMENT GRADATION CURVE, PERCENT FINER.
SIZE, MM=      .250    .500   1.000
   %,   =    16.000  53.836 100.000

D84(mm)=      .786  D50(mm)=      .466  D16(mm)=      .250  Geom Std Dev=    1.8

                        TABLE  2-1.  CROSS SECTION PROPERTIES
 #     STATION      ELEV   ROUGHNESS  N-VALUE :      GROUND     : DELTA Y   RIPRAP
         FT          FT      HEIGHT   EQUATION :SLOPE     ANGLE :    FT    Dmax*[ ]

 1     -80.0     10.00
                          .5000          MOODY   -3.00    -18.4   -10.00       .0
 2     -50.0       .00
                          .1529E-02  BROWNLIE      .00       .0      .00       .0
 3      50.0       .00
                          .5000          MOODY    3.00     18.4    10.00       .0
 4      80.0     10.00

        TOP      MINIMUM      TOTAL
       WIDTH      ELEV        DEPTH
       160.0       .00        10.00

  TABLE  2-2.  PHYSICAL PROPERTIES.
  ACCELERATION OF GRAVITY =  32.174


  TABLE  2-3.  PROPERTIES OF THE WATER

 #  TEMP     RHO     VISCOSITY  UNIT WT
    DEG F  #-S/FT4    SF/SEC    WATER
                     *100000    #/FT3

 1   50.     1.940      1.411   62.411
 2   50.     1.940      1.411   62.411
 3   50.     1.940      1.411   62.411
 4   50.     1.940      1.411   62.411
 5   50.     1.940      1.411   62.411
```

TABLE 8-1. CALCULATE NORMAL DEPTH USING COMPOSITE PROPERTIES BY ALPHA METHOD.

**** N	Q	WS ELEV	TOP WIDTH	COMPOSITE R	SLOPE	COMPOSITE n-Value	VEL	FROUDE NUMBER	SHEAR STRESS
	CFS	FT	FT	FT	ft/ft		FPS		#/SF
**** 1	100.	.76	104.6	.76	.000521	.0220	1.28	.26	.02

TABLE 8-2. FLOW DISTRIBUTION. Q = 100.000 ALFA= 1.018

STATION	INC. %Q	area sqft	perm ft	r= a/p	Ks ft	n value	vel fps	tau #/sf	CMT
-80.0									
	.49	.9	2.4	.36	.5000	.0344	.57	.01	R S
-50.0									
	99.01	76.3	100.0	.76	.1994	.0218	1.30	.02	RLB
50.0									
	.49	.9	2.4	.36	.5000	.0344	.57	.01	R S
80.0									
	100.00	78.0	104.8	.76	.2077	.0220	1.28	.02	

**** 2	1000.	3.32	119.9	3.22	.000521	.0270	2.73	.27	.10

TABLE 8-2. FLOW DISTRIBUTION. Q = 1000.00 ALFA= 1.032

STATION	INC. %Q	area sqft	perm ft	r= a/p	Ks ft	n value	vel fps	tau #/sf	CMT
-80.0									
	2.96	16.6	10.5	1.58	.5000	.0287	1.79	.05	R K
-50.0									
	94.08	332.5	100.0	3.32	.7046	.0267	2.83	.11	RLB
50.0									
	2.96	16.6	10.5	1.58	.5000	.0287	1.79	.05	R K
80.0									
	100.00	365.7	121.0	3.22	.7445	.0270	2.73	.10	

ABNORMAL TERMINATION OF NORMAL DEPTH CALCULATION.
SUCCESSIVE ITERATIONS ARE NOT IMPROVING THE CONVERGENCE.

QTRUE= 5000.00 QMIN= 3914.76 QMAX= 6610.00
DEPTH= 7.637 DPMIN= 7.637 DPMAX= 7.638
NMIN= 7 NMAX= 7

**** 3	5000.	7.64	145.8	7.07	.000521	.0299	5.33	.35	.23

TABLE 8-2. FLOW DISTRIBUTION. Q = 5000.00 ALFA= 1.036

STATION	INC. %Q	area sqft	perm ft	r= a/p	Ks ft	n value	vel fps	tau #/sf	CMT
-80.0									
	7.13	87.5	24.2	3.62	.5000	.0275	4.07	.20	R K
-50.0									
	85.75	763.7	100.0	7.64	1.371	.0299	5.61	.41	RLB
50.0									
	7.13	87.5	24.2	3.62	.5000	.0275	4.07	.20	R K
80.0									
	100.00	938.7	148.3	7.07	1.355	.0299	5.33	.37	

TABLE 8-4. HYDRAULIC PARAMETERS FOR SEDIMENT TRANSPORT

N	STRIP NO	EFFECTIVE WIDTH	EFFECTIVE DEPTH	SLOPE	EFFECTIVE VELOCITY
1	1	102.65	.76	.0005210	1.29
2	1	111.73	3.23	.0005210	2.77
3	1	127.56	7.16	.0005210	5.48
4	1	135.47	8.98	.0005210	8.22
5	1	148.52	13.26	.0005210	10.15

TABLE 8-5. EQUIVALENT HYDRAULIC PROPERTIES USING CONVEYANCE METHOD

N	STRIP NO	HYDRAULIC RADIUS ft	MANNING n-VALUE	.........SUBSECTION........... DISCHARGE cfs	AREA sqft	VELOCITY fps
1	1	.74	.0217	100.00	78.02	1.28
2	1	3.02	.0259	1000.00	365.67	2.73
3	1	6.33	.0218	5000.00	938.71	5.33
4	1	7.78	.0167	10000.00	1257.17	7.95
5	1	12.28	.0181	20000.00	2004.22	9.98

...END OF JOB...   Printout is in FILE [hyd.out]

2.5.11.1 General Tables. The banner will reflect the version and date of the particular code being used. Table 1 simply echoes the input. Table 2-1 gives information on the cross-section properties before any calculations are made. Table 2-3 shows the properties of water as calculated from the temperature at sea level elevation.

2.5.11.2 Normal Depth Table. Table 8-1 gives the calculated normal depth. The hydraulic radius (R) and the n-value are both composited by the alpha method. Other results in Table 8-1 are calculated as follows:

$$\text{velocity} = \text{discharge/area}$$

$$\text{Froude number} = \text{average velocity}/\sqrt{\text{effective depth} * g}$$

$$\text{Boundary shear stress} = \text{unit weight of water} * \text{composite hydraulic radius} * \text{slope}$$

2.5.11.3 Flow Distribution Table. Table 8-2 gives the flow distribution. The percent of discharge is given for each panel of the cross-section, calculated by

$$\%Q = \text{total } Q * (\text{conveyance in the panel/total conveyance}) * 100$$

Area, perimeter, and hydraulic radius are described in paragraph 2.5.12.1. Tau is calculated as

$$\text{Tau} = \text{Unit weight of water} * \text{average depth in the panel} * \text{slope}.$$

The CMT column consists of 3 columns of single letter codes. The first column refers to the flow type:

R - rough
S - smooth
T - transitional.

The middle column key is

U - upper bed regime
L - lower bed regime
G - indicates the roughness equation flagged in the last column is a grass equation.

The last column indicates the roughness equation used for the panel

B - Brownlie
K - Keulegan
L - Limerinos
S - Strickler
A,B,C,D,E - various grass equations if the middle column was a G.

At the bottom of the table are summaries. The numbers below the solid line are totals for the column. The numbers below the dashed line are composite values for the cross-section.

For Q = 100 notice that the panel between stations 50.0 and 80.0 has a calculated n-value of 0.0344 and that the comment column shows "R S", indicating that the Strickler method was used. The input data requested Moody but SAM will not apply Moody if $k_s/r < 3$. It automatically substitutes Strickler.

The Normal Depth Table and the Flow Distribution Table are repeated for every discharge prescribed on the QW-record. The lines of the Normal Depth Tables are distributed between the Flow Distribution Tables, but each line begins with "******". The printout for discharges 4 and 5 have been omitted here. The printout for discharges 2 and 3 are given to illustrate the message printed out when computations fail to converge. The output shows the following example:

```
ABNORMAL TERMINATION OF NORMAL DEPTH CALCULATION.
SUCCESSIVE ITERATIONS ARE NOT IMPROVING THE CONVERGENCY.
        QTRUE=  5000.00  QMIN=  3914.76  QMAX=  6610.00
        DEPTH=     7.637 DPMIN=    7.637 DPMAX=    7.638
                    NMIN=        7  NMAX=        7
```

The computations tried a depth of 7.637-ft and the resulting discharge was 3914.76. It tried a depth of 7.638-ft and the discharge came out 6610.00 cfs. That difference of .001-ft is considered close enough for engineering work; however, the normal convergence criteria requires the calculated discharge to be within 0.5% (i.e. 25 cfs in this example) of QTRUE.

Consequently, the abnormal termination note is printed. The reason for the discontinuity is not printed, but when using the Brownlie Bed Roughness predictor depths become double valued in the transition zone. That is probably the case here.

2.5.11.4 Hydraulic Parameters for Sediment Transport Table. The results printed in Table 8-4 are explained in paragraph 2.5.6.

2.5.11.5 Equivalent Hydraulic Properties using Conveyance Method. The values in Table 8-5 are calculated the same as they are calculated in HEC-2. Notice that the hydraulic radius values given here are less than the composite values shown in Table 8-1. This illustrates the significance of compositing the hydraulic properties across the cross-section using the Alpha Method.

2.5.12 Plot. The following hydraulic plots are available:

Discharge versus Effective Velocity
Stage versus n-Value
Stage versus Average Velocity in Cross section
Stage versus Effective Velocity
Stage versus Discharge
Stage versus Width
Stage versus Effective Width
Stage versus Hydraulic Radius
Cross Section Geometry

Figure 11. Hydraulic Parameters Which Can Be Plotted

SAM.hyd has no plotting capability. It writes a HECDSS input file to TAPE96 which is automatically read by an HECDSS utility after SAM.hyd has completed and returned control to the menu. Plotting is done by executing the HECDSS program from the main menu. The following example starts with an image of the main menu and illustrates the steps required to plot stage vs n-value.

```
HYDRAULIC DESIGN PACKAGE FOR FLOOD CONTROL CHANNELS MENU

                                                    MENU 1 OF 2
          1 -  SAM.hyd    Hydraulic Calculations

          2 -  SAM.sed    Sediment Transport Calculations

          3 -  SAM.yld    Sediment Yield Calculations

       -> 4 -  Plot       From SAM.hyd, SAM.sed, and SAM.m95

          5 -  PSAM       Prepare SAM Input Files

          6 -  SAM.m95    Use TAPE95 to Prepare SAM.sed Input

          7 -  LIST       View files

          8 -  EXIT       To DOS

      Run DSPLAY Program to Plot SAM Calculations

April 2, 1993 10:11:02 am        NUM              Memory: 568 K

                     Press H for Help
```

Figure 12. Execute the Plotting Option

The following screen appears when the plotting option is selected.

```
PC DSPLAY - Version 2.0.4
DSS Version: 6-GM
device drivers:
                VGA Display
                HP LaserJet Printer

    Version Date: 24 April 1991


-----DSS---ZOPEN:  Existing File Opened,  File: HYD.DSS
                   Unit:  71;  DSS Version: 6-GN
D>
```

Figure 13. HECDSS Plotting Screen

Type CA.an to catalog the available plot files and display the listing on the screen.

The resulting catalog is shown in the following figure. Reference number 1, "STAGE - NVALUE," is a plot of the Water Surface Elevation versus the Composite n-value from SAM.hyd. Other plots are identified by their reference numbers, i.e. 2 - 8. Number 8, "CROSS-SECTION NUMBER" is a plot of the cross section. The reference numbers and tag numbers will vary, but the desired plot can usually be identified by the pathname.

Ref No.	TAG	Record Pathname
1	T4	///STAGE - DISCHARGE////
2	T3	///STAGE - EFFECTIVE VELOCITY
3	T6	///STAGE - EFFECTIVE WIDTH////
4	T7	///STAGE - HYDRAULIC RADIUS////
5	T1	///STAGE - NVALUE////
6	T2	///STAGE - VELOCITY////
7	T5	///STAGE - WIDTH////
8	T8	//CROSS-SECTION NUMBER .00/X - Y////

Figure 14. HECDSS Complete Catalog of Record Pathnames in file HYD.DSS

NOTE: This is the first time this DSS file was cataloged and the command should be **CA.an** to produce a "tidy" listing of the plots. The **an** option displays the tidy abbreviated listing when the file is new. The **an** can be omitted after the first time the file is cataloged.

PL 1 — will plot the stage versus n-value graph on the screen. (The example is shown in Figure 15.)

The screen will remain the active device until a "Device Command" is issued. To get a hard copy of a plot, first type the Device Command then the plot command, as follows:

DEV PR — sends the plot to the printer.

PL 1 — will plot number 1 on the printer. (This takes about 3.5 minutes on an HP LaserJet III printer.)

DEV SC — will return plots to the screen. (It is not necessary to return to screen until all plots have been copied.)

Another type plot is to graph 2 or more lines on the same plate. That can be produced by typing 2 reference numbers after the plot command.

PL 2,3

Figure 16 is an example showing the average velocity and the effective channel velocity over-plotted.

Symbols are added to the plots using the command

SY,0,1 — for no symbol on curve 1 and a circle on curve 2.

The legend is produced automatically using strings from DSS Pathnames. The pathname parts A, B, and F are available to the user to alter, see Appendix C.

FI will finish DSS, returning control to the SAM menu.

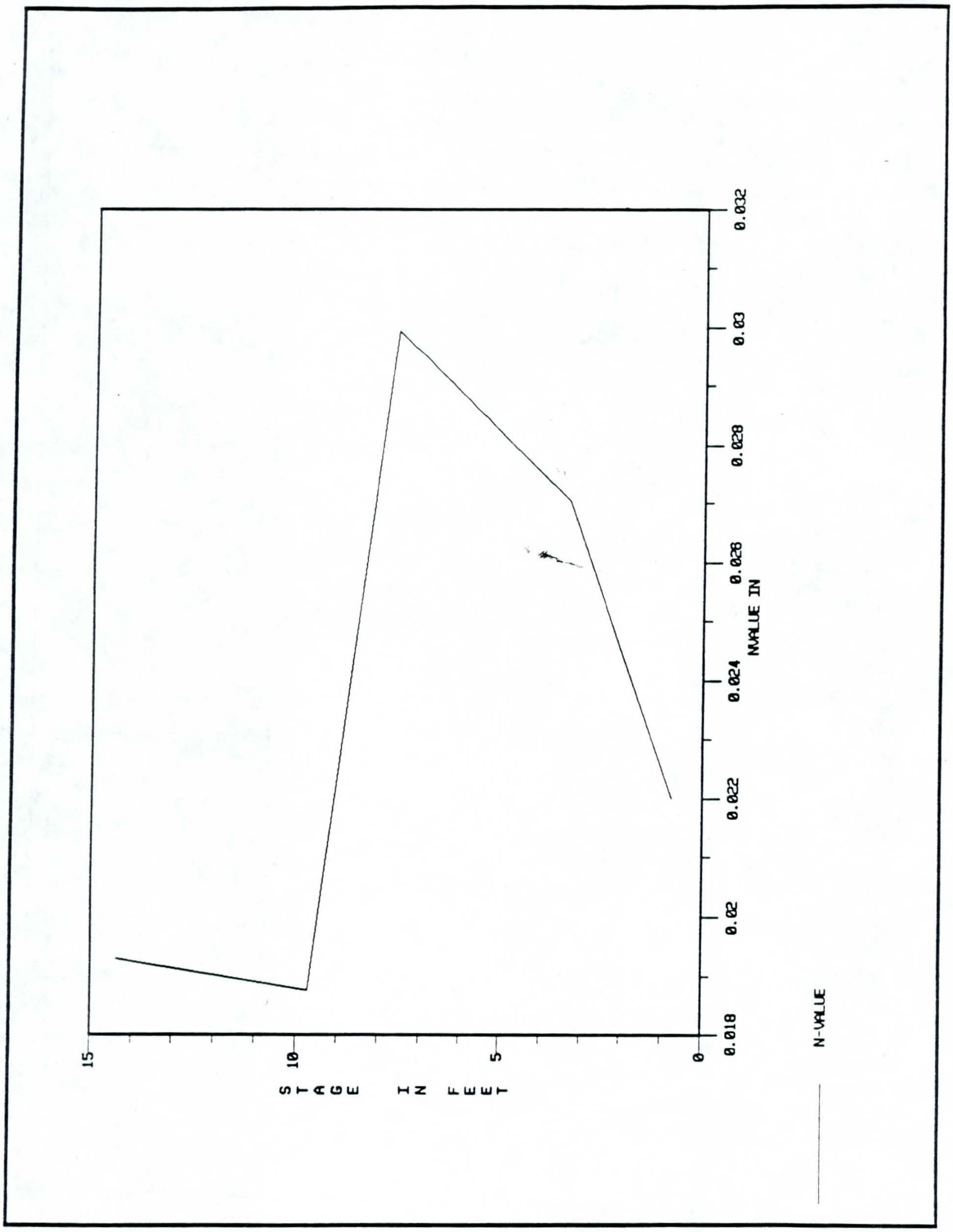

Figure 15. Stage versus Composite n-Value, from Test 1C

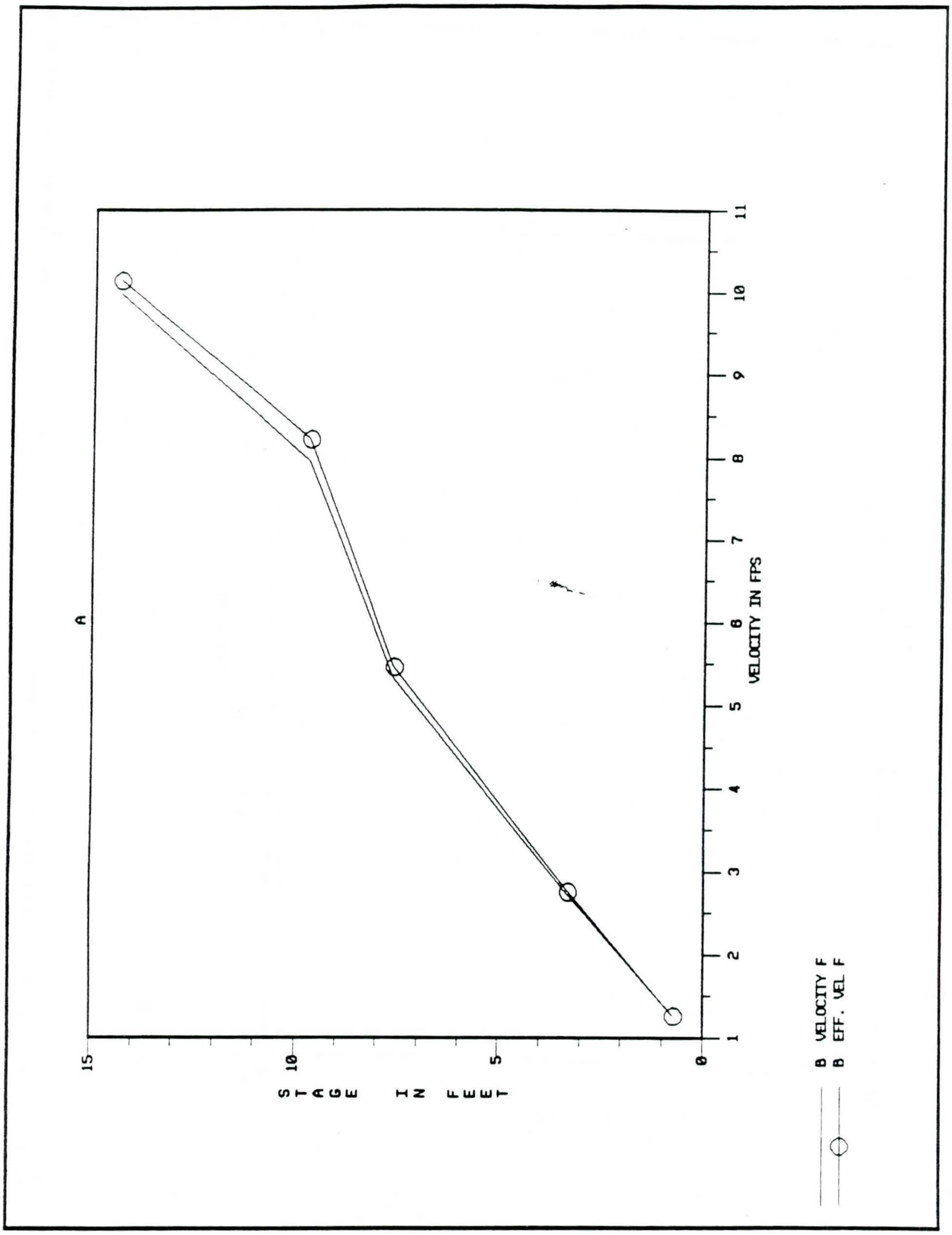

Figure 16. Stage versus Flow Velocity, from Test 1C

2.6 Flow Distribution Across the Cross Section. Flow distribution across the cross section is calculated each time any of the variables in the Manning equation are calculated. In addition, flow distribution will be calculated if all variables in the Manning Equation are prescribed. It uses the alpha method (Corps of Engineers, 1970). The algorithm is presented below:

```
C     SECTION 6.  DISTRIBUTE FLOW BY ALPHA-METHOD
      NOTRUF = 0.
      SUMQ = 0.
      DO 4151 ISS = 1,NSS
      IXSS = LSS(ISS)
      IXSE = LSS(ISS+1)-1

      SUBQAL(ISS) = 0.
      IF(IXSS .GT. IXSE) GO TO 4151
      DO 4150 L = IXSS, IXSE
      IF(TZP(L) .GT. 0.) THEN
        IF(TZA(L) .GT. 0.) THEN
          TZQ = QTRUE * TZCRA(L) * RTCRA
          SUBQAL(ISS) = SUBQAL(ISS) + TZQ
          TZV(L) = TZQ / TZA(L)
C
          A1 = ECEL - Y(L)
          B1 = ECEL - Y(L+1)
          IF(A1 .LT. 0.) A1 = 0.
          IF(B1 .LT. 0.) B1 = 0.
          TZTAU(L) = UWWA(N) * 0.5 * (A1+B1) * SLOF
C
C       CHECK IF FLOW FULLY ROUGH (EM 1601, PL 3)
          REY = TZV(L) * TZR(L) / XNUA(N)
          RRR = TZR(L) / HRK(L)
          IF (RRR .GT. 0.) THEN
            FLOWTY = (REY / CHEZ(L)) / RRR
          ELSE
            FLOWTY = 0.
          ENDIF
          IF( FLOWTY .LT. 50.) THEN
            IDFT = 'T/S'
            NOTRUF = 1.
          ELSE
            IDFT = '  R'
          ENDIF
        ELSE
          IDFT = 'V:0'
          TZQ = 0.
          TZR(L) = 0.
          TZV(L) = 0.
          TZTAU(L) = 0.
        ENDIF
      ELSE
        IDFT = 'DRY'
        TZQ = 0.
        TZN(L) = 0.
        TZR(L) = 0.
        TZV(L) = 0.
        TZTAU(L) = 0.
      ENDIF
C
      IF(KSW(6) .GT. 0) THEN
        QINC = TZA(L)*TZV(L)
        PCINCQ = QINC/Q(N)*100.
        SUMQ = SUMQ + QINC
        WRITE (LP,4110) X(L)
 4110 FORMAT (1X, F9.1)
        WRITE (LP,4120) PCINCQ, TZA(L), TZP(L), TZR(L), HRK(L),
     .           TZN(L), TZV(L), TZTAU(L), IDFT, IDRR(L)
 4120 FORMAT (5X,1X,F8.2,F10.1,F8.1,F8.2,1X,G10.4,1X,F6.4,F6.2,F8.2,1X,
     .          A3,A2)
      ENDIF
 4150 CONTINUE
 4151 CONTINUE
```

```
C
      IF(KSW(6) .GT. 0) THEN
        WRITE (LP,4110) X(IXSE+1)
        WRITE (LP,4140)
 4140 FORMAT ( '                                                 ------ ---------- -----'
     .-- ----- -------')
        PCTQ = SUMQ/Q(N)*100.
        WRITE (LP,4120)  PCTQ, SUMA,SUMP,RC,HRKM,XNM,VAVG(N),TAUM
        WRITE (LP, 4115) DASH
 4115   FORMAT (A)
      ENDIF
C
      IF(KSW(6) .GT. 0) THEN
        IF(NOTRUF .GT.0) THEN
          REYM = RC * VAVG(N) / XNUA(N)
          REYMPR = REYM * .00001
          WRITE (LP,4160) REYMPR
 4160     FORMAT (
     .' NOTE:  FLOW NOT FULLY ROUGH.  COMPOSITE REYNOLDS NO. = ',F10.5,
     .' * 10**5' )
        ENDIF
      ENDIF
```

2.6.1 <u>Sample Input Data.</u> The following example shows input data for calculating flow distribution when all variables in Manning equation are prescribed with input data. The only difference between this data set and the normal depth data set is that this set includes a WS-record.

```
TI      TEST NO. 2  FLOW DISTRIBUTION AT PRESCRIBED STAGES
TI      Same as 1C with the addition of a WS-record
F#345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
TR             1
CT   100      10       3       3       4               1      .5       1      .5
PF                             1      .8      98     .48      50     .25      16
QW 10000
WS  9.73
ES521E-6
WT    50
$$END
```

2.6.2 <u>Sample Output Data.</u> See paragraphs 2.5.11.1 through 2.5.11.5 for the description of the output tables from these calculations. In particular, paragraph 2.5.11.3 describes the flow distribution tables.

2.7 Bottom Width Calculation-Fixed Bed. This option allows bottom width to become the dependent variable in the Manning equation:

$$W = f(Q, n, D, z, S) \tag{2.27}$$

where

Q - water discharge
D - water depth
z - side slopes of the channel
n - n-value
S - energy slope

This bottom width calculation does not consider sediment transport. That calculation is presented in "MODULE 1: STABLE CHANNEL DIMENSIONS."

2.7.1 Geometry input. Only the CT-record is permitted for inputting geometry in this calculation, but the calculations may be made for either a simple or a compound channel. The field prescribing bottom width must be left blank in all CT-records used. All other fields are coded as described in the input instructions.

Simple Channel. To calculate bottom width for a simple channel, use only 1 CT-record and put only 1 discharge on the QW-record.

Compound Channel. To calculate bottom width for a compound channel, use 2 or 3 CT-records. Remember that the first prescribes the low flow channel, the second the normal flow channel, and the third the high flow berm. The number of discharges on the QW-record must match the number of CT-records, and the discharges must be in the same order, first for the low flow channel, second for the normal flow and third for the high flow berm.

NOTE: 1. The requirements for the QW-record in this calculation are different from those for the usual use of the QW-record.

2. No WS-record is to be coded for this bottom width calculation option. The program determines water surface from the channel depth coded on the CT-record.

2.7.2 Roughness, Compositing, Execution, and Plotting. These are handled the same as described for normal depth calculations.

2.7.3 Sample Input Data. The following example shows input data when calculating bottom width. The difference between this input and that required to calculate normal depth is bottom width, CT-1, is left blank.

```
TI    TEST NO. 3A  CALCULATE BOTTOM WIDTH IN SIMPLE X-SECTION
TI                 W. A. Thomas, WES, 3 March 1991
TI     1       2       3       4       5       6       7       8       9      10
F#345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
CT               3       3       3       4               2      .3       2      .3
BL    .20
RR   2.65                        1
RC     .5        1     1.5     2.0     2.5       3       4       5       6       7
RC      8        9
PF                               1      .8      98     .48      50     .25      16
QW   6000
ES  .0050
WT    65.
$$END

TI   TEST NO. 3B  CALCULATE WIDTH OF COMPOUND CHANNEL X-SECTION
TI                W. A. THOMAS, WES, 16 November 1989
F#345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
CT               2       1       1       4               2      .3       2      .3
CT               6     1.5     1.5       5               5               5
RT                     1.0             1.0
RR   2.65                        1
RC     .5        1     1.5     2.0     2.5       3       4       5       6       7
RC      8        9
PF                               1      .8      98     .48      50     .25      16
BL    .20
QW    100    10000
ES  .0005
WT     65
$$END
```

2.7.4. Sample Output Data. The following example is taken from the output from Test 3A, above. See paragraphs 2.5.11.1 through 2.5.11.5 for the description of the general output tables from these calculations. However, note that table series "8-x" has become "5-x". The information contained in the two series of tables is the same, with the title of the "x-1" table flagging both the calculation performed and the compositing method used. The calculated bottom width is shown in Table 5-1 as "Bottom Width," and is not flagged as having been calculated.

TABLE 5-1. CALCULATE BOTTOM WIDTH USING COMPOSITE PROPERTIES BY ALPHA METHOD.

**** N	Q CFS	WS ELEV FT	BOTTOM WIDTH FT	R FT	SLOPE ft/ft	n Value	VEL FPS	FROUDE NUMBER	SHEAR STRESS #/SF
**** 1	6000.	3.00	153.1	2.97	.005000	.0175	12.34	1.27	.92

TABLE 5-4. HYDRAULIC PARAMETERS FOR SEDIMENT TRANSPORT

Q NO	STRIP NO	STRIP Q CFS	---EFFECTIVE--- WIDTH FT	DEPTH FT	SLOPE FT/FT	n-VALUE	EFF. VEL. FPS	Froude NO	TAU #/SF
1	1	6000.	164.	2.95	.005000	.0170	12.45	1.28	.918

TABLE 5-5. EQUIVALENT HYDRAULIC PROPERTIES USING CONVEYANCE METHOD

N	STRIP NO	HYDRAULIC RADIUS ft	MANNING n-VALUE	.........SUBSECTION........... DISCHARGE cfs	AREA sqft	VELOCITY fps
1	1	2.83	.0170	6000.00	486.35	12.34

2.7.5 Blench Regime Equations. These regime equations are shown in ASCE Manual 54. The basic three channel dimensions, width, depth and slope are calculated.

$$WIDEBL = \left(\frac{FB\ Q(N)}{FS}\right)^{0.5}$$

$$DEPBL = \left(\frac{FS\ Q(N)}{FB^2}\right)^{0.333333}$$

$$SLOBL = \frac{FB^{0.875}}{\frac{3.63\ ACGR}{XNUA(N)^{0.25}}\ WIDEBL^{0.25}\ DEPBL^{0.125}\left(1+\frac{REGCON}{2330.}\right)}$$

The results depend on the water discharge, Q(N), a coefficient, FB, and a factor describing the channel boundary material, FS. The variable, REGCON, is sediment concentration, ACGR is acceleration of gravity, and XNUA is kinematic viscosity.

The results are regime values only if Q(N) is the channel forming discharge. However, any discharge will have a corresponding width, depth and slope depicted by these equations.

The following shows results from these equations, from TEST 3A. The other values are calculated from the width, depth and slope using Manning's equation. The last note, "NO LOCATIONS SPECIFIED FOR RIPRAP," occurs when riprap is required but there are no RT-records in the data set.

TABLE 3. BLENCH REGIME-CHANNEL DIMENSIONS (ASCE MANUAL 54).
FB= .95 FS= .20

N	Q CFS	REGIME DEPTH FT	REGIME WIDTH FT	R FT	REGIME SLOPE ft/ft	n Value	VEL FPS	FROUDE NUMBER	SHEAR STRESS #/SF
1	6000.	11.00	168.8	9.73	.000098	.0207	3.23	.17	.06

SHIELDS PARAMETER INDICATES RIPRAP IS REQUIRED.

DETERMINE RIPRAP SIZE FOR A GIVEN WATER DISCHARGE

USING GRADED RIPRAP TABLES FROM EM 1110-2-1601

NO LOCATIONS WERE SPECIFIED FOR RIPRAP.
N, Q(N), AND WS(N) = 1 6000. 3.00

...END OF JOB... Printout is in FILE [hyd.out]

2.8 Energy Slope Calculation. This option allows the energy slope to become the dependent variable in the Manning equation:

$$S = f(Q, n, W, D, z) \tag{2.28}$$

The calculations are trial and error and use the secant method for convergence.

$$X_3 = X_2 - \left(\frac{f(X_2)}{f(X_2) - f(X_1)} \right) (X_2 - X_1) \tag{2.29}$$

where

X_1 = is the first trial value of slope
$f(X_3)$ = is the calculated depth using slope = X_1
X_2 = is the second trial value of slope
$f(X_2)$ = is the calculated depth using slope = X_2
X_3 = is the next trial value of slope.

The Blench Regime equation is used for the first trial. The present formulation of this convergence scheme is not very robust. It fails on divide by zero when $f(X_2)$ equals $f(X_1)$. The Brownlie n-value relationships often allow convergence to fail since that method allows $f(X_1)$ to equal $f(X_2)$ at the transition between lower and upper regime flow. A message is printed when convergence fails.

2.8.1 Geometry, Roughness, Compositing, Execution, and Plotting. These are handled the same as presented for normal depth calculations above.

2.8.2 Sample Input Data. The following example shows input data when calculating energy slope. Notice that it is the same as shown for Normal Depth except that the WS-record is present and the ES-record is missing. That is what tells SAM to calculate the slope.

```
TI    TEST NO. 4  CALCULATE ENERGY SLOPE
TI                n from STRICKLER
TI                W. A. THOMAS, WES, 26 July 1990
TI  1       2       3       4       5       6       7       8       9      10
F#345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
CT    100      10       3       3       2     .02       2      .2       2      .2
QW   4050
WS   3.07
WT     55
$$END
```

2.8.3. Sample Output Data. See paragraphs 2.5.11.1 through 2.5.11.5 for the description of the output tables from these calculations. However, note that table series "8-x" has become "6-x". The information contained in the two series of tables is the same, with the title of the "x-1" table flagging both the calculation performed and the compositing method used. The calculated slope is shown in Table 5-1 as "Slope," and is not flagged as having been calculated.

TABLE 6-1. CALCULATE ENERGY SLOPE USING COMPOSITE PROPERTIES BY ALPHA METHOD.

****	N	Q	WS ELEV	TOP WIDTH	R	SLOPE	n Value	VEL	FROUDE NUMBER	SHEAR STRESS
		CFS	FT	FT	FT	ft/ft		FPS		#/SF
****	1	4050.	3.07	118.4	3.00	.005290	.0185	12.11	1.24	.99

TABLE 6-4. HYDRAULIC PARAMETERS FOR SEDIMENT TRANSPORT

Q NO	STRIP NO	STRIP Q	---EFFECTIVE--- WIDTH	DEPTH	SLOPE	n- VALUE	EFF. VEL.	Froude NO	TAU
		CFS	FT	FT	FT/FT		FPS		#/SF
1	1	4050.	111.	2.98	.005290	.0177	12.27	1.25	.983

TABLE 6-5. EQUIVALENT HYDRAULIC PROPERTIES USING CONVEYANCE METHOD

N	STRIP NO	HYDRAULIC RADIUS	MANNING n-VALUE	.........SUBSECTION........... DISCHARGE	AREA	VELOCITY
		ft		cfs	sqft	fps
1	1	2.80	.0177	4050.00	334.43	12.11

...END OF JOB...   Printout is in FILE [hyd.out]

2.9 Hydraulic Roughness Calculation. This option allows the n-value to become the dependent variable in the Manning equation.

$$n = f(Q, W, D, z, S) \tag{2.30}$$

This calculation, like the other solutions of the Manning equation which involve compositing, are trial and error. A simple solution of the Manning equation is used to calculate the first trial k_s. It uses the secant method for convergence as follows.

$$X_3 = X_2 - \left(\frac{f(X_2)}{f(X_2) - f(X_1)} \right) (X_2 - X_1) \tag{2.31}$$

where

X_1 = is the first trial value of k_s
$f(X_1)$ = is the difference between Qtrue and the calculated Q for X_1
X_2 = is the second trial value of k_s
$f(X_2)$ = is the difference between Qtrue and calculated Q for X_2
X_3 = is the next trial value of k_s.

Of the several equations for hydraulic roughness, the Strickler equation is the most likely to converge. The Keulegan equation can be used if flow is fully rough; otherwise it can not solve for a k_s value.

The following error message is printed when the automatic convergence algorithm fails.

TABLE 7-1. CALCULATE HYDRAULIC ROUGHNESS USING COMPOSITE PROPERTIES BY ALPHA METHOD.
n-VALUE COMPUTATIONS DID NOT CONVERGE.

CONVERGENCE LOOP:

Trial No	X1 = Ks1	Qtrue-Qtry1	X2 = Ks2	Qtrue-Qtry2
21	2.2105	-1626.7	3.1066	2227.5

The program tried 21 iterations to converge on the proper ks-value. Computations are aborted after 20 tries. The recourse is a manual trial and error approach in which k_s is assumed and the resulting water surface elevations are calculated using the normal depth procedure.

2.9.1 Geometry, Compositing, Execution, and Plotting. These are handled the same as described for normal depth calculations above.

2.9.2 Sample Input Data. The following example shows input data when calculating k_s. Note the KS record in Test 5B. The negative flags the program to make the hydraulic roughness calculations. The absolute value, i.e., 5, tells the program the ratios of roughness in that element to the composite roughness. For example, if all values on the KS-record were -1- then the roughness in each panel will be equal proportions of the composite.

```
TI    TEST NO. 5A  CALCULATE Ks FROM BARNES n-VALUE
TI                 Esopus Creek at Coldbrook, NY
TI                 WA Thomas, 4 August 1991
F#345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
TR       2       1
CT     301      10       0       0       1      -1       1      -1       1     -1.
QW   13900
WS     5.3
ES340E-5
WT      50
$$END

TI    TEST NO. 5B  CALCULATE Ks
TI                 Esopus Creek, using measured x-section coordinates
TI                 Barnes, p 34
F#345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
TR               1
TR                              -1
X1       1       7
GR      16       0    12.6      40    12.4      65     9.5      80     8.8     200
GR     8.8     290      16     320
KS              -.5     -1      -1      -1      -1
NE       9       2       1
QW   13900
WS    15.6
ES340E-5
WT      50
$$END
```

2.9.3 Output Data. See paragraphs 2.5.11.1 through 2.5.11.5 for the description of the output tables from these calculations.

2.10 Water Discharge Calculation. This option allows the water discharge to become the dependent variable in the Manning equation.

$$Q = f(n, W, D, z, S) \tag{2.32}$$

This calculation, like the other solutions of the Manning equation which involve compositing, are trial and error. It uses the secant method for convergence.

$$X_3 = X_2 - \left(\frac{f(X_2)}{f(X_2) - f(X_1)} \right) (X_2 - X_1) \tag{2.33}$$

where

X_1 - is the first trial value of Q

$f(X_1)$ - is the difference between the calculated depth for X_1 and the true depth

X_2 - is the second trial value of Q

$f(X_2)$ - is the difference between the calculated depth for X_2 and the true depth

X_3 - is the next trial value of Q.

When convergence fails, assume a range of discharges and use the normal depth calculations to arrive at the correct value.

2.10.1 Sample Input Data. The following example shows input data when calculating Q.

```
TI   TEST NO. 6 CALCULATE WATER DISCHARGE
TI              n from STRICKLER
TI              W. A. THOMAS, WES, 26 July 1990
TI  1       2       3       4       5       6       7       8       9      10
F#345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
CT   100      10       3       3       2     .02       2      .2       2      .2
WS  3.07
ES520E-6
WT    55
$$END
```

2.10.2. <u>Sample Output Data.</u> See paragraphs 2.5.11.1 through 2.5.11.5 for the description of the output tables from these calculations. However, note that table series "8-*x*" has become "9-*x*". The information contained in the two series of tables is the same, with the title of the "*x*-1" table flagging both the calculation performed and the compositing method used. The calculated water discharge is show in Table 9-1 as "Q," and is not flagged as having been calculated.

TABLE 9-1. CALCULATE WATER DISCHARGE USING COMPOSITE PROPERTIES BY ALPHA METHOD.

**** N	Q CFS	WS ELEV FT	TOP WIDTH FT	R FT	SLOPE ft/ft	n Value	VEL FPS	FROUDE NUMBER	SHEAR STRESS #/SF
**** 1	1280.	3.07	118.4	3.01	.000520	.0185	3.82	.39	.10

TABLE 9-4. HYDRAULIC PARAMETERS FOR SEDIMENT TRANSPORT

Q NO	STRIP NO	STRIP Q CFS	---EFFECTIVE--- WIDTH FT	DEPTH FT	SLOPE FT/FT	n-VALUE	EFF. VEL. FPS	Froude NO	TAU #/SF
1	1	1280.	111.	2.99	.000520	.0177	3.87	.39	.097

TABLE 9-5. EQUIVALENT HYDRAULIC PROPERTIES USING CONVEYANCE METHOD

N	STRIP NO	HYDRAULIC RADIUS ft	MANNING n-VALUE	.........SUBSECTION........... DISCHARGE cfs	AREA sqft	VELOCITY fps
1	1	2.81	.0177	1279.85	335.21	3.82

...END OF JOB...   Printout is in FILE [hyd.out]

2.11 Riprap Size for a Given Velocity and Depth (RS-Record). When flow velocity and depth are known, the riprap size is calculated using the Maynord equations:

$$D_{ratio} = SAFEF * CIF \left(\sqrt{SCRR} \left(\frac{V_{CR} * VSSVAG}{\sqrt{ACGR * DP}} \right) \right)^{2.5} \qquad (2.34)$$

$$d_{30CR} = COEF_2 * CV * CTH * D_{ratio} * DP \qquad (2.35)$$

where

ACGR - Acceleration of gravity
d_{30CR} - Critical D30 (i.e. Smallest d_{30}) size for stable riprap
DP - Water depth
d_{ratio} - Ratio of stable d_{30}/Water Depth
CIF - Coefficient of incipient failure (0.30)
$COEF_2$ - Correction for side slope steepness
SAFEF - Safety factor
V_{CR} - Critical velocity for stone size exceeds average velocity in bend sections, distributed flow velocity in straight channels.
CV - vertical velocity coefficient
- 1.283 for straight channels
- 1.283 - 0.2 $\log_{10}$ (RW) for bends
- 1.0 for RW>26
CTH - coefficient for riprap thickness
- 1.44 - 0.58 * DMXRTO + 0.14 * $DMXRTO^2$ where 1 < DMXRTO < 2
VSSVAG - bend correction for average velocity
- 1 for straight channel
- 1.71 - 0.78 $\log_{10}$ (RW) for trapezoidal channels where 0.82 < VSSVAG < 1.48
- 1.74 - 0.52 $\log_{10}$ (RW) for natural channels where 0.90 < VSSVAG < 1.58
RW - bend radius/top width
DMXRTO - layer thickness/D_{max}
SCRR - correction factor for submergence
- unit weight of water/(unit weight of riprap - unit weight of water)

2.11.1 Riprap Gradation Tables. The size and specific gravity of available riprap are needed for this calculation, and the 12-standard riprap sizes shown in EM 1110-2-1601 are coded as shown in the following table. Calculations begin with the smallest size stone and continue down the table until a stable size is reached.

TABLE 6. Graded Riprap Sizes

Layer No.	DMAX[1] in	D30[1] ft	D50[1] ft	D90[1] ft	POROSITY[2] %
1	12	0.48	0.58	0.70	38
2	15	0.61	0.73	0.88	38
3	18	0.73	0.88	1.06	38
4	21	0.85	1.03	1.23	38
5	24	0.97	1.17	1.40	38
6	27	1.10	1.32	1.59	38
7	30	1.22	1.46	1.77	38
8	33	1.34	1.61	1.94	38
9	36	1.46	1.75	2.11	38
10	42	1.70	2.05	2.47	38
11	48	1.95	2.34	2.82	38
12	54	2.19	2.63	3.17	38

Notes:
[1] These values were taken from EM 1110-2-1601, paragraph 14.
[2] These values are estimated from one set of field data.

2.11.2 <u>Quarry-Run Stone.</u> Up to 5 sizes of quarry run riprap can be encoded (see RQ-Records). These gradations should be entered one size per record starting with the smallest and ending with the largest size. When these are present, riprap size computations use the quarry run stone.

2.11.3 <u>Sample Input Data.</u> Required input data are: velocity, depth, width, side slope, bend radius and whether the cross section is natural or trapezoidal. The following example shows input data.

```
TI  TEST NO. 7A Simple Riprap Design  GIVEN VELOCITY AND DEPTH
TI              Problem 1 Appendix H, EM 1101-2-1601
TI              ETL 1110-2-120 gradations
TI              W. A. THOMAS, WES, 19 April 1991
F#345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
RS  7.1      15       2     200
RR  2.65    620               0
$$END

TI  TEST NO. 7B Simple Riprap Design with 155 # stone
TI              W. A. THOMAS, WES, 7 December 1989
F#345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
RS    8      20       2     500
RR  2.48   1700               1
$$END

TI  TEST NO. 7C Simple Riprap Design, 155 # stone @ 7 fps
TI              W. A. THOMAS, WES, 7 December 1989
F#345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
RS    7      20       2     500
RR  2.48   1700               1
$$END

TI  TEST NO. 7D Simple Riprap Design, 155# @ 7 fps, 1V:1.5H Side Slope
TI              W. A. THOMAS, WES, 7 December 1989
F#345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
RS    7      20     1.5     500
RR  2.48   1700               1
$$END
```

```
TI  TEST NO. 7E Simple Riprap Design, 155# @ 7 fps, 1V:1.5H, 1.5*DMAX Thickness
TI              W. A. THOMAS, WES, 7 December 1989
F#345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
RS     7      20      1.5      500      1.5
RR  2.48    1700                 1
$$END

TI  TEST NO. 7F Simple Riprap Design given Velocity and Depth--Quarry Run Stone
TI              W. A. Thomas, WES, 15 February 1991
F#345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
RS     8      20        2      500        1
RR          1700                 0        0      0
RQ  14.4    12.4      7.0      4.1       38   0.00
RQ  20.0    17.8     11.0      7.4       38   0.00
WT    60
$$END
```

2.11.4 Execution and Plotting. Execution is handled the same as presented for normal depth calculations above. There is no plotting with this calculation.

2.11.5. Sample Output Data. The following example is taken from the output from Test 7A. See paragraph 2.5.11.1 for the description of Tables 1 and 0-3. The output shown below is the additional, riprap output. The first line describes the calculation being performed. The next line states the source of the riprap sizes tested. It would have stated "USING QUARRY RUN RIPRAP" if that had been prescribed. The first table shown describes the necessary riprap size as determined by the calculations. The second, longer table describes both the riprap and some of its effects as well as some of the factors used in the calculations.

```
RIPRAP SIZE FOR A GIVEN VELOCITY AND DEPTH

       USING GRADED RIPRAP TABLES FROM EM 1110-2-1601

 LAYER  D30CR  DMAXRR    D30    D50    D90    WIDTH    CY/FT  TONS/FT    $/FT
   #     FT      IN      FT     FT     FT      FT
   3     .62   18.00    .73    .88   1.06    33.54    1.863     .095     .00

RIPRAP SIZE       = LAYER#  3             DMAX, INCHES         =      18.
  VELOCITY, FT    =       7.10            VSS/VAVG             =     1.484
  BEND RADIUS,FT  =       620.            TOP WIDTH, FT        =      200.
  R/W             =      3.100            VERT VEL CORR, Cv    =     1.185
  LOCAL DEPTH, FT=       15.00            DESIGN DEPTH         =     12.00
  SAFETY FAC, Sf  =       1.10            STABILITY COEF, Cs   =      .300
  THICKNESS, IN   =      18.00            THICKNESS COEF, Cv   =     1.500
  SIDE SLOPE      =       2.00            SIDE SLOPE CORR, K1=       1.180
  SP.GR. RIPRAP   =       2.65            POROSITY, %          =     38.00
  CHANNEL TYPE    =    NATURAL            COST PER FOOT,$/FT   =       .00

...END OF JOB...     Printout is in FILE [  hyd.out  ]
```

2.12 Riprap Size for a Given Discharge and Cross Section Shape. Riprap size is a more complicated calculation when water discharge and cross section are given than it is when the flow velocity and depth are given. That is because n-value becomes a function of riprap size. The computational procedure is as follows.

The computations begin with the unprotected channel. The bed sediment size is determined as the d_{50} from the PF-record. Hydraulic roughness equations are assigned and either n-values or k_s values prescribed as required for normal depth computations. If the Strickler equation is one which was selected for hydraulic roughness, the Strickler coefficient is 0.034, the value for natural sediment where $k_s = d_{50}$ (Chow, 1959). Normal depth is calculated using the alpha method, and flow is distributed across the section. Stability of the bed sediment is then calculated at each cross section coordinate using the distributed velocity and the depth at that point. Shield's Diagram is used to test for particle stability as follows.

```
FUNCTION shield(GSIZE,N,TDF,NLP)

SCSPEP = (SPGS-SPGF)/SPGF
COEFB = ( SQRT(SCSPEP*ACGR * GSIZE**3) / XNU )**(-.6)
TAUSTR = 0.22 * COEFB + 0.06 * (10**(-7.7*COEFB))
SHIELD = TAUSTR * UWW * (SPGS-SPGF) * GSIZE
```

where

ACGR - Acceleration of gravity
SPGF - Specific gravity of fluid
SPGS - Specific gravity of sediment particle
GSIZE - Particle size
XNU - Kinematic viscosity
TAUSTR - Dimensionless shear stress, Tau Star
UWW - Unit weight of water

If this test shows that the actual bed shear stress exceeds the critical value, SHIELD, the bed sediment is diagnosed as unstable and the computations will solve the riprap equation to find the smallest riprap size that will be stable.

Riprap computations begin with the smallest rock size. The hydraulic roughness equation, in each panel which was designated as having riprap, is automatically changed to the Strickler equation and the coefficient, STRIC, is set equal to 0.034. Normal depth is calculated for the resulting n-values. The alpha method is used to calculate normal depth and flow is distributed across the section. The riprap size equation is solved at each coordinate point. When the resulting size is stable in each panel, riprap computations are finished. Otherwise, computations move to the next larger riprap size and the procedure is repeated.

After the stable stone size is determined, a stage discharge curve is calculated for the riprapped channel. The Strickler coefficient, which was 0.034 when determining stone size, is increased to 0.038 in this calculation for flow capacity. This calculation determines the rating curve with the selected riprap in place.

When quarry run stone is prescribed (see RQ-Records), those stone sizes are used in lieu of the gradation tables encoded in SAM. It does not matter to the program whether the stone is quarry run or just graded; either way, the output is labeled "quarry run."

To reconstitute the normal depth calculated for a riprapped cross section would require inputting the Strickler Coefficient. That capability is not provided. Therefore, use the Strickler roughness equation and increase the k_s as follows:

$$k_s = D_{90} * 1.949 \qquad (2.36)$$

This comes from the relationship:

$$0.034 * (d_{90} * e)^{1/6} = 0.038 * d_{90}^{1/6} \qquad (2.37)$$

$$e = 1.949$$

2.12.1 Sample Input Data. The required input data for riprap size calculations are particle size on the channel bed, specific gravity of the riprap and thickness of the riprap by panel. (See PF-, RR-, and RT-records.) The other data in this file is required to perform the normal depth calculations and produce the water velocity and depth in each panel.

```
TI  TEST NO. 8A Riprap Design, Graded Stone
TI              Calculate Bank n from Moody Diagram, Bed n- from Brownlie
TI              W. A. THOMAS, WES, 5 February 1991
F#345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
TR
TR                                    -1
X1      1       4
GR     20     -60       0       0       0     140      20     200
KS     .3       0      .3
NE      1       4       1
RT      1       1       1
RR   2.65                       1
RC     .5       1     1.5     2.0     2.5       3       4       5       6       7
RC      8       9
PF                              1      .8      98     .48      50     .25      16
BL    .20
QW   5000   10000   15000
ES   .010
WT     65
$$END
```

```
TI  TEST NO. 8B  Riprap Design, Quarry Run Stone
TI               Calculate Bank n from Moody Diagram, Bed n- from Brownlie
TI               W. A. THOMAS, WES, 5 February 1991
F#345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
X1     1       4
GR    20     -60       0       0       0     140      20     200
KS    .3       0      .3
NE     1       4       1
RT     1       1       1
RR  2.65                       1
RC    .5       1     1.5     2.0     2.5       3       4       5       6       7
RC     8       9
RQ  14.4    12.4      7.     4.1      38     .85
RQ  20.0    17.8    11.0     7.4      38    1.42
RQ  28.0    21.7    13.5     8.3      38    2.05
RQ  38.5    29.6    20.1    14.5      38    2.96
PF                             1      .8      98     .48      50     .25      16
QW  5000   10000   15000
ES  .010
WT    65
$$END

TI  TEST NO. 8C  Riprap Design in a Trapezoidal Channel; Problem 2 App. H -1601
TI               ETL 1110-2-120 gradations
TI               W. A. Thomas, WES, 19 April 1991
F#345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
CT   140      15       2       2       0    .025       0    .025       0    .025
BR 1.E-7   1.E-7   1.E-7
RT     1       1       1
RR           500               1       0       0
QW 13500
ES .0017
$$END
```

2.12.2 <u>Geometry, Roughness, Compositing, and Plotting.</u> These are handled the same as described above for normal depth calculations without riprap.

2.12.3 <u>Execution.</u> Riprap size is determined automatically when the RR-, RT- and PF-records are included in the data sets for normal depth calculations, bottom width calculations, energy slope calculations and water discharge calculations. The PF-record is required because the program tests bed particles against the Shield's diagram to determine whether or not riprap is needed.

2.12.4. <u>Sample Output Data.</u> The following example is taken from the output from Test 8C. See paragraph 2.5.11.1 for the description of the Tables 1 and 0-3. The output for these calculations is threefold. It provides 1), the normal depth calculations as described in paragraphs 2.5.11.1 through 2.5.11.5; 2), the riprap calculations as discussed above; and 3), the normal depth calculations again, with the given riprap size in place.

TABLE 8-1. CALCULATE NORMAL DEPTH USING COMPOSITE PROPERTIES BY ALPHA METHOD.

**** N	Q CFS	WS ELEV FT	TOP WIDTH FT	COMPOSITE R FT	SLOPE ft/ft	COMPOSITE n-Value	VEL FPS	FROUDE NUMBER	SHEAR STRESS #/SF
**** 1	13500.	8.71	174.8	8.38	.001700	.0255	9.85	.60	.89

TABLE 8-4. HYDRAULIC PARAMETERS FOR SEDIMENT TRANSPORT

Q NO	STRIP NO	STRIP Q CFS	---EFFECTIVE--- WIDTH FT	---EFFECTIVE--- DEPTH FT	SLOPE FT/FT	n- VALUE	EFF. VEL. FPS	Froude NO	TAU #/SF
1	1	13500.	161.	8.39	.001700	.0242	10.02	.61	.890

TABLE 8-5. EQUIVALENT HYDRAULIC PROPERTIES USING CONVEYANCE METHOD

N	STRIP NO	HYDRAULIC RADIUS ft	MANNING n-VALUE	SUBSECTION DISCHARGE cfs	SUBSECTION AREA sqft	SUBSECTION VELOCITY fps
1	1	7.66	.0242	13500.00	1370.44	9.85

DETERMINE RIPRAP SIZE FOR A GIVEN WATER DISCHARGE

USING GRADED RIPRAP TABLES FROM EM 1110-2-1601

LAYER #	D30CR FT	DMAXRR IN	D30 FT	D50 FT	D90 FT	WIDTH FT	CY/FT	TONS/FT	$/FT
3	.67	18.00	.73	.88	1.06	188.27	10.460	.536	.00

RIPRAP SIZE	= LAYER# 3	DMAX, INCHES	= 18.
VELOCITY, FT	= 7.74	VSS/VAVG	= 1.354
BEND RADIUS,FT	= 500.	TOP WIDTH, FT	= 175.
R/W	= 2.860	VERT VEL CORR, Cv	= 1.192
LOCAL DEPTH, FT	= 10.79	DESIGN DEPTH	= 8.64
SAFETY FAC, Sf	= 1.10	STABILITY COEF, Cs	= .300
THICKNESS, IN	= 18.00	THICKNESS COEF, Cv	= 1.500
SIDE SLOPE	= 2.00	SIDE SLOPE CORR, K1	= 1.180
SP.GR. RIPRAP	= 2.65	POROSITY, %	= 38.00
CHANNEL TYPE	= TRAPEZOID	COST PER FOOT,$/FT	= .00

TABLE 8-1. CROSS SECTION PROPERTIES

#	STATION FT	ELEV FT	ROUGHNESS HEIGHT	N-VALUE EQUATION	GROUND SLOPE	GROUND ANGLE	DELTA Y FT	RIPRAP Dmax*[ ]
1	-100.0	15.00						
			1.060	STRICKLE	-2.00	-26.6	-15.00	1.0
2	-70.0	.00						
			1.060	STRICKLE	.00	.0	.00	1.0
3	70.0	.00						
			1.060	STRICKLE	2.00	26.6	15.00	1.0
4	100.0	15.00						

HYDRAULIC PROPERTIES WITH RIPRAP IN PLACE. STRICKLER COEFFICIENT = .038

**** N	Q CFS	WS ELEV FT	TOP WIDTH FT	COMPOSITE R FT	SLOPE ft/ft	COMPOSITE n-Value	VEL FPS	FROUDE NUMBER	SHEAR STRESS #/SF
**** 1	13500.	11.10	184.4	10.58	.001700	.0394	7.50	.41	1.12

TABLE 8-4. HYDRAULIC PARAMETERS FOR SEDIMENT TRANSPORT

Q NO	STRIP NO	STRIP Q CFS	---EFFECTIVE--- WIDTH FT	DEPTH FT	SLOPE FT/FT	n-VALUE	EFF. VEL. FPS	Froude NO	TAU #/SF
1	1	13500.	166.	10.60	.001700	.0366	7.66	.41	1.124

TABLE 8-5. EQUIVALENT HYDRAULIC PROPERTIES USING CONVEYANCE METHOD

N	STRIP NO	HYDRAULIC RADIUS ft	MANNING n-VALUE	SUBSECTION DISCHARGE cfs	SUBSECTION AREA sqft	SUBSECTION VELOCITY fps
1	1	9.50	.0366	13500.00	1800.83	7.50

...END OF JOB... Printout is in FILE [hyd.out]

2.13 Stable Channel Dimensions (GC-Record). There is presently one analytical procedure in SAM for calculating stable channel dimensions. It was developed by R. R. Copeland, of the Hydraulics Laboratory, WES. (Report in Preparation)

2.13.1 Basic Equations. The method uses the sediment transport and resistance equations developed by Brownlie (1981). The equations are dimensionless, and can be used with any consistent set of units.

Upper regime:

$$R_b = 0.2836\, d_{50}\, q_*^{0.6248}\, S^{-0.2877}\, \sigma^{0.0813} \tag{2.38}$$

Lower regime:

$$R_b = 0.3742\, d_{50}\, q_*^{0.6539}\, S^{-0.2542}\, \sigma^{0.1050}$$

$$q_* = \frac{V\,D}{\sqrt{g\,d_{50}^3}} \tag{2.39}$$

where:

- R_b - hydraulic radius associated with the bed
- d_{50} - median grain size
- S - slope
- σ - geometric bed material gradation coefficient
- V - average velocity
- D - water depth
- g - acceleration of gravity

To determine if upper or lower regime flow exists for a given set of hydraulic conditions, a grain Froude number F_g and a variable F_g' were defined by Brownlie. According to Brownlie, upper regime occurs if $S > 0.006$ or if $F_g > 1.25F_g'$, and lower regime occurs if $F_g < 0.8F_g'$. Between these limits is the transition zone. In the analytical method, $F_g = F_g'$ is used to distinguish between upper and lower regime flow. The program will inform the user which regime is being assumed in the calculations and if the bed forms are in the transition zone.

$$F_g = \frac{V}{\sqrt{g\, d_{50}\left(\frac{\gamma_s-\gamma}{\gamma}\right)}} \tag{2.40}$$

$$F_g' = \frac{1.74}{S^{.3333}}$$

where: γ_s - specific weight of sediment
γ - specific weight of water

The hydraulic radius of the side slope is calculated using Manning's equation:

$$R_s = \left(\frac{V\, n_s}{1.486\ S^{0.5}}\right)^{1.5} \tag{2.41}$$

where: R_s - hydraulic radius associated with the side slopes, ft
V - average velocity, fps
n_s - Manning's roughness coefficient for the bank

If the roughness height k_s of the bank is known, then it can be used instead of Manning's roughness coefficient to define bank roughness. The model uses Strickler's equation to calculate the bank roughness coefficient:

$$n_s = 0.039\ k_s^{\frac{1}{6}} \tag{2.42}$$

where k_s is the roughness height, in ft. For riprap, k_s should be set equal to the minimum design D_{90}.

Composite hydraulic parameters are partitioned in the manner proposed by Einstein (1950):

$$A = R_b P_b + R_s P_s \tag{2.43}$$

where: A - total cross-sectional area
P_b - perimeter of the bed
P_s - perimeter of the side slopes

This method assumes that the average velocity for the total cross section is representative of the average velocity in each subsection.

Concentration, C, in ppm, is calculated using the Brownlie sediment transport equation, which is also a regression equation, and is based on the same extensive set of flume and field data used to develop his resistance equations. This equation was chosen because of its compatibility with the resistance equations, which are coupled with the sediment transport equation in the numerical solution:

$$C = 9022 \, (F_g - F_{go})^{1.978} \, S^{0.6601} \left(\frac{R_b}{d_{50}} \right)^{-0.3301} \tag{2.44}$$

$$F_{go} = \frac{4.596 \, \tau_{*o}^{0.5293}}{S^{0.1405} \, \sigma^{0.1606}} \tag{2.45}$$

$$\tau_{*o} = \frac{\gamma \, R_b \, S}{(\gamma_s - \gamma) \, d_{50}} \tag{2.46}$$

A typical cross section, with the critical hydraulic parameters labeled, is shown in Figure 17. The concentration calculated from the sediment transport equation applies only vertically above the bed. Total sediment transport in weight per unit time is calculated by the following equation:

$$Q_s = \gamma \, C \, B \, D \, V \tag{2.48}$$

where: Q_s - sediment transport in weight/time
B - base width

An average concentration for the total discharge is then calculated:

$$\overline{C} = \frac{Q_s}{0.0027 \, Q} \tag{2.49}$$

where: $\bar{C}$ - concentration using the total discharge in ppm
Q_s - sediment transport in tons/day
Q - discharge in cfs

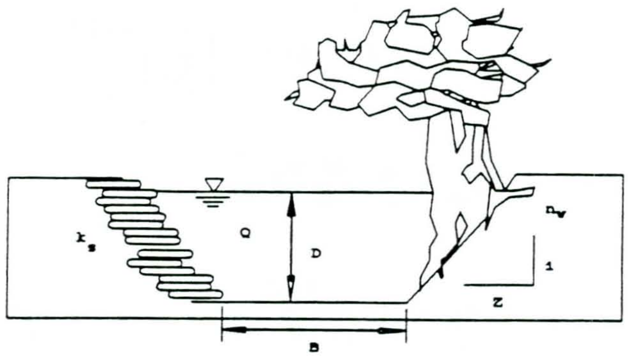

Figure 17. Typical Cross-Section used in Analytical Method.

2.13.2 Range of Solutions. The stable channel dimensions are calculated for a range of widths. The family of slope-width solutions that satisfy the resistance and sediment transport equations for the design discharge is illustrated by figure 18. Different water and sediment discharges will produce different stability curves.

In the calculations, the median value defaults to the regime width for the prescribing water discharge using equation 2.50. The values for bottom width in Table 4-1 are calculated by dividing the median width by 10, then incrementing by the result until there are 21 widths in the table. For example, if the median width is 120 feet, the first value in the table is 12 feet, the second is 24 feet, the 36 feet, etc. The bottom width values can be manipulated by prescribing the median width (see Appendix C, the GC-record).

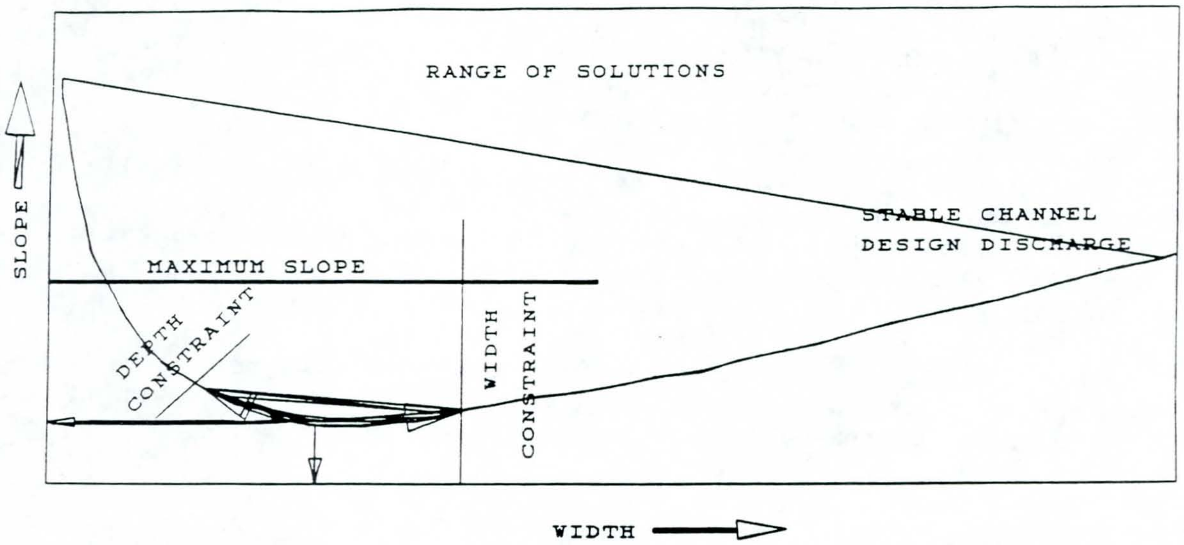

Figure 18. Stability Curve for Design Discharge.

2.13.3 Inflowing Water Discharge. The design discharge is critical in determining appropriate dimensions for the channel. Investigators have proposed different methods for estimating that design discharge. The 2-year frequency flood is sometimes used for perennial streams. For ephemeral streams the 10-year frequency is some times used. The 'bankfull' discharge is sometimes suggested, but there is no generally accepted method, in the Corps of Engineers, for determining the channel forming discharge. (See EM 1110-2-4000, Design Features to Reduce Flooding, Chapter 4.)

2.13.4 Inflowing Sediment Discharge. This calculation of channel dimensions requires the concentration of the inflowing bed material load. It is best if SAM.hyd is allowed to calculate the sediment concentration based on hydraulic conditions in the sediment supply reach. The bed-material composition is defined by the median grain size and the gradation coefficient.

2.13.5 Other Input Requirements.

2.13.5.1 Valley Slope. Valley slope is the maximum possible slope for the channel invert. This value is used in the test for sediment deposition. If the required slope exceeds the prescribed valley slope, the following message is printed:

```
>>>>MINIMUM SLOPE IS GREATER THAN VALLEY SLOPE - THIS IS A SEDIMENT TRAP <<<<
```

2.13.5.2 Bank Slopes and Roughness. This analytical channel computation assumes all bed material transport occurs over the bed of the cross section and that none occurs above the side slopes. Therefore, the portion of water conveyed above the side slopes expends energy but does not transport sediment, making "Flow Distribution" and extremely important calculation. The input parameters for flow distribution are bank angle and bank roughness. The recommended procedure to use for this is that discussed in Appendix J of EM 1110-2-16-1. (Any bank roughness input for the bed will be disregarded by the calculations.) For maximum transport of sediment use the steepest bank angle allowed b y bank stability requirements.

2.13.5.3 <u>Median Width.</u> This is an optional input value. Normally the median width is calculated by the program as discussed above. However, to change from that, code a value as *FIXBAM* on the GC-record. The program will divide that value by 10 and calculate a table of 21 widths by incrementing the result of that division.

2.13.6 <u>Compositing.</u> This procedure does not use the alpha method for compositing. It is involved only with the channel sub-section and uses Einstein's Law-of-the-wall to separate wall and bed losses.

2.13.7 <u>Execution.</u> Procedures are the same as for the normal depth calculations above. Execute SAM.hyd from the main menu: "HYDRAULIC CALCULATIONS." If a GC-record(s) is present in the input file, the code will select the stable channel calculations.

If no default file is present, the code offers to either attach a file or tutor the user in the preparation of one, conversationally.

2.13.8 Sample Input Data. The following example shows input data to calculate channel dimensions with the Copeland Procedure.

```
TI   TEST NO. 9A  CALCULATE GEOMETRY USING COPELAND'S PROCEDURE
TI                W. A. THOMAS, WES, 21 April 1990
TI 1       2       3       4       5       6       7       8       9       10
F#345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
CT    15      10    1.65     3.0       4               1       2       1       2
PF                             1      .8      98     .48      50     .25      16
ES162E-6
GC  3680         .000162       3       3       2      .7       2      .7
WT    60
$$END

TI   TEST NO. 9B  CALCULATE GEOMETRY USING COPELAND'S PROCEDURE
TI                W. A. THOMAS, WES, 21 April 1990
TI 1       2       3       4       5       6       7       8       9       10
F#345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
TR
TR                            -1
CT    15      10    1.65     3.0       4               1       2       1       2
PF                             1      .8      98     .48      50     .25      16
ES162E-6
GC  3680         .000162       3       3       2      .7       2      .7
GC  6530         .000162       3       3       0     .05       0     .05
WT    60
$$END

TI   TEST NO. 9C  CALCULATE GEOMETRY USING COPELAND'S PROCEDURE
TI                W. A. THOMAS, WES, 21 April 1990
TI 1       2       3       4       5       6       7       8       9       10
F#345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
GC  3680     100 .000162       3       3       2      .7       2      .7
PF                             1      .8      98     .48      50     .25      16
WT    60
$$END
```

2.13.9 Sample Output. The output for Test 9A contains several of the general tables described in paragraph 2.5.11.1 as well as the following printout.

```
CALCULATE CHANNEL WIDTH, DEPTH AND SLOPE BY COPELAND METHOD.  GC-RECORD # 1

CALCULATE INFLOWING SEDIMENT CONCENTRATION, PPM.

INFLOWING WATER DISCHARGE, CFS      =  3680.000
BASE WIDTH                          =  15.00000
CHANNEL SLOPE, FT/FT                =  .00016200

                                     LEFT BANK  RIGHT BANK
SIDE SLOPE                          =     1.650      3.000
Ks, FT                              =  2.000      2.000
n-VALUE                             =    .03839     .03839


CALCULATE STABLE CHANNEL DIMENSIONS.
MEDIAN BED SIZE ON BED, MM          =     .46607
GRADATION COEFFICIENT               =     1.776
VALLEY SLOPE, FT/FT                 =  .00016200

                                     LEFT BANK  RIGHT BANK
SIDE SLOPE                          =     3.000      3.000
Ks, FT                              =  .7000      .7000
n-VALUE                             =    .03223     .03223
```

TABLE 4-1. STABLE CHANNELS FOR Q= 3680.0 C,ppm= 17.53 D50= .466

K:	BOTTOM WIDTH FT	DEPTH FT	ENERGY SLOPE FT/FT	CMPOS"T: n-Value	HYD RADIUS FT	VEL FPS	FROUDE NUMBER	SHEAR STRESS #/SF	BED * REGIME
1	12.	18.9	.000174	.0317	9.86	2.84	.12	.21	TL
2	24.	18.3	.000126	.0312	10.35	2.54	.10	.14	LO
3	36.	17.4	.000106	.0306	10.50	2.40	.10	.12	LO
4	48.	16.4	.000095	.0301	10.49	2.31	.10	.10	LO
5	60.	15.4	.000089	.0295	10.38	2.25	.10	.09	LO
6	72.	14.4	.000084	.0291	10.20	2.21	.10	.08	LO
7	84.	13.6	.000081	.0286	9.97	2.17	.10	.07	LO
8	96.	12.8	.000080	.0282	9.72	2.14	.11	.06	LO
9	108.	12.1	.000078	.0278	9.44	2.11	.11	.06	LO
10	120.	11.4	.000078	.0275	9.17	2.09	.11	.06	LO
11	132.	10.8	.000077	.0272	8.88	2.07	.11	.05	LO
12	144.	10.3	.000077	.0269	8.61	2.04	.11	.05	LO
13	156.	9.8	.000078	.0266	8.34	2.02	.11	.05	LO
14	168.	9.4	.000078	.0264	8.08	2.01	.12	.05	LO
15	180.	9.0	.000079	.0261	7.83	1.99	.12	.04	LO
16	192.	8.6	.000079	.0259	7.59	1.97	.12	.04	LO
17	204.	8.2	.000080	.0258	7.36	1.95	.12	.04	LO
18	216.	7.9	.000081	.0256	7.14	1.94	.12	.04	LO
19	228.	7.6	.000082	.0254	6.93	1.92	.12	.04	LO
20	240.	7.4	.000083	.0253	6.74	1.91	.12	.04	LO
	RESULTS AT MINIMUM STREAM POWER								
21	138.	10.6	.000077	.0270	8.75	2.06	.11	.05	LO

* REGIMES: LO=LOWER, TL=TRANSITIONAL-LOWER, TU=TRANSITIONAL-UPPER, UP=UPPER.

...END OF JOB... Printout is in FILE [hyd.out]

2.13.10 Results. The family of widths, depths, and slopes which satisfies the sediment transport and resistance equations is shown in Table 4-1, above. It is important to consider river morphology when interpreting these calculated values.

That is, each line in the table satisfies the governing equations, but natural rivers tend toward a regime width. Consequently, the calculations start with the regime width as determined by the following equation:

$$B = 2.0\ Q^{0.5} \qquad (2.50)$$

For the water discharge in this example, the equation gives 120 feet. Next, the regime width is divided by 10, to provide a starting value for the table, 12-ft in this case. The rest of the table is produced by adding the 12-ft increment to each successive width and repeating the depth-slope n-value calculations. Note the last column in the table, "Flow Regime." Four conditions are possible:

LO - Lower regime (i.e. ripples and dunes)
TL - Transition zone, Lower regime selected (bed forms tend toward ripples and dunes.)
TU - Transition zone, Upper regime selected (Bed forms tend toward plain bed.)
UP - Upper regime selected (Plain bed and antidunes)

Channel dimensions corresponding to minimum stream power, $Q*\bar{S}$, (which also corresponds to minimum slope), are presented at the bottom of the table. In this example the energy slope reaches a minimum value at about the regime width. However, that is not always the case. Much depends on the bank roughness.

It is important to be consistent in the selection of channel dimensions. That is, once a width is selected, the depth and slope are fixed. That allows the designer to select specific project constraints, such as right-of-way or bank height or minimum bed slope, and then arrive at a consistent set of channel dimensions.

If the calculations indicate that the slope of the project channel needs to be less than the natural terrain, the slopes in the table can be used to aid in spacing drop structures or introducing curvature into the project alignment.

2.13.11 Plotting. The Width versus Slope relationship can be plotted. The DSS file is written automatically after execution of SAM.hyd is completed. It should be plotted using procedures described in the section on Normal Depth, this chapter. Figure 19 shows typical results.

2.13.11.1 Manipulating the Y-axis Label. The user can alter the axes labels once in the DSS plotting option with the YL or XL command. The command, YL, *string* , will replace the default y-axis label with *string* . To also rotate the letter position, as shown in Figure 19, use ".R" after the command, i.e., YL.R, *string* .

2.13.11.2 Legend. The water discharge is assigned to the DSS pathname automatically so multiple GC-records will be written into the DSS file.

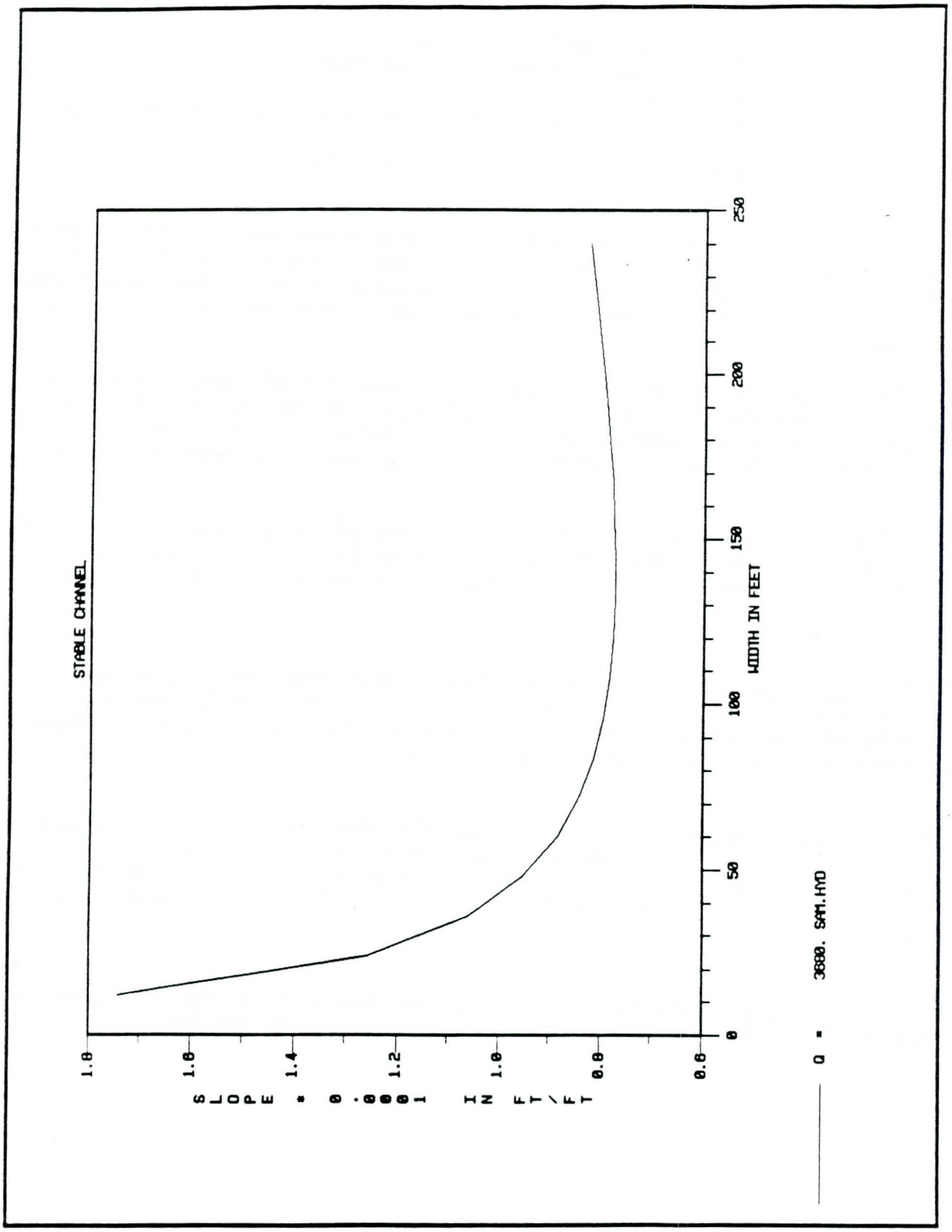

Figure 19. Sample Plot of Width - Slope Results, from Test 9A

3. SEDIMENT TRANSPORT CALCULATIONS.

3.1 Purpose. The purpose of this module is to provide sediment discharge rating curves for the bed material load using sediment transport functions.

3.2 Sediment Transport Functions. The following have been incorporated into SAM. Except for Brownlie, these are functions from HEC-6. Some are identified as "d_{50}" which means the original version was for a single grain size. That capability is provided herein, but the HEC-6 versions of the functions calculate by grain size class.

Table 7. Sediment Transport Functions available in SAM.sed.

ACKER-WHITE.
ACKER-WHITE, D50
BROWNLIE
COLBY
LAURSEN(COPELAND)
LAURSEN(MADDEN),1985
MPM(1948).
MPM(1948),D50
TOFFALETI.
TOFFALETI-MPM
TOFFALETI-SCHOKLITSC
YANG.
YANG,D50

Acker-White, D50	is a single grain size function for sand bed streams.
Acker-White	is a version of Acker-White, D50, which has been modified, at WES, for multiple grain size calculations on sand and/or gravel bed streams.
Brownlie	is a single grain size function for sand transport.
Colby	is a single grain size function for sand transport in streams and small rivers.

Laursen(Copeland) is a modification to Laursen's function to extend its range to larger gravel sizes.

Laursen(Madden),(1985) is a multiple grain size function developed by E. M. Laursen and modified by Edward B. Madden for sand bed transport. It has been used for mixtures of sand and gravel. The 1963 modification is included in this version.

MPM -- Meyer-Peter and Muller(1948) is a multiple grain size function for gravel bed rivers. It is not valid when appreciable suspended load is present.

MPM -- Meyer-Peter and Muller(1948), D50 is a version of the multiple grain size function MPM which has been modified, at WES, using a single grain size funciton.

Toffaleti is a multiple grain size function for sand bed rivers. It is not valid for gravel transport.

Toffaleti-MPM is a combined function for sand and gravel bed streams. The sand portion is calculated by the Toffaleti function which is combined with the gravel portion calculated by Meyer-Peter and Muller(1948).

Toffaleti-Schoklitsch is a combined function for sand and gravel bed streams. The sand portion is calculated by the Toffaleti function which is then combined with the gravel portion calculated by Schoklitcsh.

Yang is a version of Yang, D50, which has been modified, at WES, for multiple gran size calculations.

Yang, D50 is a single grain size function for sand transport in streams and small rivers.

This is not an exhaustive list of transport functions. They were selected from the literature and based on experience. It does not imply that those not selected are deficient. The objective was to provide designers with a "few" acceptable methods whose use could be supported. The criteria for selection were

a. to cover a broad range of particle sizes,

b. to cover a broad range of hydraulic conditions,

c. to calculate sediment transport by partitioning the mixture into size classes and summing the rate of each to get the total except when d_{50}

functions are requested, and

d. to have a history of being reliable when used within the range of data for which each was calibrated.

The Brownlie function is included here because it is being used in the analytical method for calculating channel width, depth and slope in SAM.hyd. It is a single grain size function.

All of these functions operate from a common data base. The functional form is

$$GS_i = f(V, D, S, W, d_r, d_i, PI_i, s_s, T, s_f) \qquad (3.1)$$

where

- D - water depth
- d_i - sediment particle size in class i
- d_r - representative particle size for the mixture
- GS_i - transport rate for size class i
- s - energy slope
- s_s - specific gravity of sediment particles
- S_f - specific gravity of fluid
- T - temperature of fluid
- V - flow velocity
- W - width of portion of cross section which is transporting bed material sediment
- PI_i - percentage of total sediment particle in size class i

3.3 SAM.aid - Guidance in transport function selection. The sediment transport functions listed above are likely to yield widely varying results when applied to the same set of data. That makes it difficult to select one for a study. A computer program to aid in selecting the most appropriate function, called SAM.aid is under development. It is executed from the SAM MENU.

The traditional approach in selecting a function is to collect field data in the project reach and screen the available transport functions to find those developed from a similar range of data. Test those functions which pass the screening test to find out which provide the best reconstitution of the field measurements. Select the function for the study based on those results. In cases where none are acceptable, it is common practice to modify the coefficients, within limits of reason, as required to match the field measurements.

That approach is usually not possible at today's projects usually because they are on small ungaged streams or because field data is too limited. Therefore, the approach proposed in SAM is to use calculated hydraulic parameters through the project area, to take samples of the bed sediment from the proposed project site, and to screen the transport functions by comparing "screening parameters" to a library of test data which has been compiled from the literature and encoded into SAM.

The screening parameters are:

(velocity, depth, slope, width, and d_{50})

First, test data sets that match the screening parameters of the project are identified. Then, each data set is inspected to determine which transport functions did the best in reconstituting the measured transport rates. The functions are then ranked from best to worst. The best three are listed.

The library of test data was obtained from Brownlie (1981). It includes the test data sites listed in Table 8.

Table 8. Data Sets for Testing Sediment Transport Functions, Brownlie(1981)

Abbreviation in SAM.aid	Data Set
ACP	ACOP Data of Mahmood et al. (1979)
AMC	American Canal Data of Simons (1957)
ATC	Atchafalaya River Data of Toffaleti (1986)
CHI	India Canal Data Published by Chitale (1966)
CHO/CHP	India Canal Data of Chaudry et al. (1970)
COL	Colorado River Data of U.S. Bureau of Reclamation(1958)
HII	Hii River Data of Shinohara and Tsubaki (1959)
LEO	River Data of Leopold (1969)
MID	Middle Loup River Data of Hubbell and Matejka (1959)
MIS	Mississippi River Data of Toffaleti (1968)
MOR	Missouri River Data of shen et al. (1978)
MOU	Mountain Creek Data of Einstein (1944)
NED	Rio Magdalena and Canal del Dique Data of NEDECO (1973)
NIO	Niobrara River Data of Colby and Hembree
NSR	N. Saskatchewan R. and Elbow R. Data of Samide (1971)
OAK	Oak Creek Data of Milhous (1973)
POR	Portugal River Data of Da Cunha (1969)
RED	Red River Data of Toffaleti (1968)
RGC	Rio Grande Conveyance Channel Data-Culbertson et al.(1976)
RGR	Rio Grande Data of Nordin and Beverage (1965)
RIO	Rio Grande near Bernalillo Data given by Toffaleti (1968)
SNK	Snake and Clearwater River Data of Seitz (1976)
TRI	Trinity River Data of Knott (1974)

3.4 Specifications of Sediment Transport Functions. In addition to the SAM.-aid program, Tables 9 through 13 summarize the range of data used in the Colby, Laursen (Madden), Meyer-Peter-Muller, Toffaleti, and Yang functions.

Table 9. Colby Transport Function

Parameter	Data Range
Particle Size Range, mm	0.1 - 0.9
Multiple Size Classes	No
Velocity, fps	1 - 10
Depth, ft	0.1 - 100
Slope, ft per ft	
Width, ft	
Water Temperature, Deg F	32 - 100
Correction for Fines, ppm	10,000 - 200,000

Table 10. Laursen(Madden),(1985)

Parameter	River Data	Flume Data
Particle Size Range, mm	0.28 - 0.86	0.011 - 4.08
Multiple Size Classes	Yes	
Velocity, fps	not published	
Depth, ft	.1 to 50	.1 to 2
Slope, ft per ft		
Width, ft		.8 to 3
Water Temperature, Deg F	not published	
Correction for Fines, ppm	none	

Table 11. Meyer-Peter and Muller

Parameter	Data Range
Particle Size Range, mm	0.4 to 30
Particle Specific gravity	1.25 to 4
Multiple Size Classes	yes
Velocity, fps	not published
Depth, ft	0.03 to 3.9
Slope, ft per ft	0.0004 to 0.02
Width, ft	
Water Temperature, Deg F	not published
Correction for Fines, ppm	none

Table 12. Toffaleti

Parameter	River Data	Flume Data
Particle Size Range, mm	.1 - .5	0.3 to 9.3
Multiple Size Classes	Yes	Yes
Velocity, fps	not published	
Depth, ft	1 to 50	.1 to 2
Slope, ft per ft		
Width, ft		.8 to 8
Water Temperature, Deg F	not published	
Correction for Fines, ppm	none	

Table 13. Yang

Parameter	River Data	Flume Data
Particle Size Range, mm	.152 - 1.35	
Multiple Size Classes	no	
Velocity, fps		
Depth, ft		
Slope, ft per ft		
Width, ft		
Water Temperature, Deg F		
Correction for Fines, ppm	none	

3.5 Correction for Sand Transport in High Concentration of Fines. Colby showed a significant increase in the transport capacity of sands when high concentrations (Cf > 10,000 ppm) of fine sediments (wash load) were present. The correction factor ranged up to 100 times the normal transport as the water depth and fines-concentration increased. Parameters tested range from

concentrations up to 200,000 ppm
velocities up to 10 fps
depths up to 100 ft
grain sizes up to 0.9 mm.

At present, only the Colby function contains a correction for fines.

The sediment parameters are specific gravity, particle size and particle shape. The specific gravity defaults to 2.65, the particle shape factor defaults to .667, and particle sizes are read from the PF-record. If the Percent Finer record is not in the hydraulics input file, it must be coded into the sediment input file before SAM.sed will execute.

When the sediment input file is written by SAM.hyd or SAM.t95, the Laursen (Madden) function is the only function that defaults to "YES".

3.6 Execution. SAM.sed executes from the SAM menu, see Figure 9. This version of SAM provides 3 methods for preparing the input data file, either through an editor such as COED, the SAM.sed tutor, or PSAM. Execution and the default filename system is the same as that described for SAM.hyd, see section 2.5.7. The only differences are in the filename extensions, which are shown below, in Table 14.

Table 14. Examples of default filenames for Automatic Filename Transfer system in SAM.sed.

INPUT FILENAME	SEDIMENT OUTPUT	SEDIMENT YIELD INPUT
sedpcin.in	sedpcin.so	sedpcin.yi
sedpcin.lib	sedpcin.sob	sedpcin.yib
clearcrk.dat	clearcrk.sot	clearcrk.yit

3.6.1 Execution when a Default Filename exists. This is much the same as for SAM.hyd, as described in paragraph 2.5.7.2. SAM.sed will "OPEN" the default input data file and execute. Selective printout scrolls to the screen, and the entire output will be saved in the default filename. When the computations are completed, the following menu appears on the screen:

```
End of Job

sed main menu.
TYPE: at [filename] en he ru tu
```

Figure 20. SAM.sed Main Menu

This presents several options. This run can be ended by typing en , and the complete output can be inspected using LIST or COED. Another option is to modify the input data using the tutor, the tu option, which works in much the same way as the tutor in SAM.hyd.

3.6.2 Execution when the Default Filename does not exist. Select SAM.sed from the SAM menu. The search for a default filename works the same as for SAM.hyd. When SAM.sed cannot "OPEN" any default data file, it will automatically enter conversational mode and display the following message.

```
Msg 1:  SED.READING INPUT DATA FROM FILE [  sed.in  ] THIS DIRECTOR.

Msg:  SED.readfor >>Data File [  sed.in        ] Can not be read.

sed  main  menu.
  OPTIONS:  at [filename]  en  he  ru  tu
```

The at (attach) and tu (tutor) options work as they do for SAM.hyd, see paragraphs 2.5.7.3 and 2.5.8.

3.7 Sample Input Data. The input data file can be prepared with the system editor, with the Hydraulics Calculations in SAM.hyd or by reading HEC-2 output on TAPE95, SAM.t95. Of these, however, only SAM.hyd provides the data from the "effective value" equations shown in this manual. When reading TAPE95, hydraulic radius is used for Effective Depth, Water Surface Width is used for Effective Width, and Channel velocity is used for Effective Velocity.

The following example shows input data as created by running TEST 1A in SAM.hyd. Notice that this results in only the Laursen(Madden) function showing "YES." PSAM, COED, or the SAM.sed tutor can be used to modify the file to select other transport functions.

```
TI   TEST NO. 1A TEST USING "SPECIFIC" GRAIN SIZE
TI   THIS IS THE DEFAULT FILE FROM SAM.hyd: HYDRAULICS = TEST 1A IN HYDPCIN.LIB
TI                 100-ft BOTTOM, 3:1 SIDE SLOPES, n-VALUE = .025, SLOPE = .00521
TI                 W. A. THOMAS, WES, 28 January 1991
TI  1        2        3        4        5        6        7        8        9        10
F#345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
TF TOFFALETI.               NO
TF YANG.                    NO
TF ACKER-WHITE.             NO
TF COLBY                    NO
TF TOFFALETI-SCHOKLITSC     NO
TF MPM(1948).               NO
TF BROWNLIE,D50             NO
TF TOFFALETI-MPM            NO
TF LAURSEN(MADDEN),1985 YES
TF LAURSEN(COPELAND)        NO
TF YANG,D50                 NO
TF ACKER-WHITE,D50          NO
TF MPM(1948),D50            NO
VE  1.19     2.89     5.17     6.55     8.42
DE  0.82     3.11     7.50    10.71    15.66
WI  103.     111.     129.     143.     152.
QW   100     1000     5000    10000    20000
ES521E-6
WT    50
PF                               64       32       92       16     82.8        8       75
PFC    4     67.8        2     58.8        1     45.3       .5     22.8      .25      4.2
PFC .125       .8    .0625       .3        0        0
$$END
```

```
TI  TEST 1B EXAMPLE OF FORCING D50 EXACTLY;  ALL TRANSPORT FUNCTIONS TURNED ON
TI              W. A. THOMAS, WES, 10 June 1991
TI  1       2       3       4       5       6       7       8       9       10
F#345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
TF TOFFALETI.            YES
TF YANG.                 YES
TF ACKER-WHITE.          YES
TF COLBY                 YES
TF TOFFALETI-SCHOKLITSC YES
TF MPM(1948).            YES
TF BROWNLIE,D50          YES
TF TOFFALETI-MPM         YES
TF LAURSEN(MADDEN),1985 YES
TF LAURSEN(COPELAND)     YES
TF YANG,D50              YES
TF ACKER-WHITE,D50       YES
TF MPM(1948),D50         YES
VE 2.055
DE17.662
WI137.78
QW  5000
ES191E-6
WT    60
PF                                  .26
$$END
```

3.8 Output. Selected results are printed to the screen as the program executes. The printout is also saved in the default output file. Several sediment parameters needed for the sediment yield calculations are written into the default SED.yld input file.

3.8.1. Sample from sed.out file. The following output description refers to the output of the input file listed above. Table 1 echoes the input data file. Table 3 calculates the properties of water from the water temperature at sea-level. The input data is summarized in Table 2.1. Table 4.1 presents the results of the sediment transport calculations. Notice the discharges listed on the QW-record. There is a separate Table 4.1 for each water discharge listed. There will also be a separate Table 4.1 for each sediment transport function turned on in the input file. (Three iterations of Table 4.1 have been omitted here.) Table 5 is a summary of the calculated total bed-material sediment discharge, in rows according to water discharge and in columns by sediment transport function.

```
*********************************************************
*                                                       *
*     HYDRAULIC DESIGN PACKAGE FOR FLOOD CONTROL        *
*                   CHANNELS (SAM)                      *
*                                                       *
*           SEDIMENT TRANSPORT CALCULATIONS             *
*                                                       *
* VERSION 3.05                       23 DECEMBER 1992   *
*                                                       *
*                  A Product of the                     *
*     Flood Control Channels Research Program           *
*Hydraulics Laboratory, Waterways Experiment Station*
*********************************************************

Msg 1:  SED. READING INPUT DATA FROM FILE [  sed.in  ] THIS DIRECTORY.


TABLE  1.  LIST INPUT DATA.

TI   TEST NO. 1A TEST USING "SPECIFIC" GRAIN SIZE
TI   THIS IS THE DEFAULT FILE FROM SAM.hyd: HYDRAULICS = TEST 1A IN HYDPCIN.LIB
TI                100-ft BOTTOM, 3:1 SIDE SLOPES, n-VALUE = .025, SLOPE = .00521
TI                W. A. THOMAS, WES, 28 January 1991
TI  1        2        3        4        5        6        7        8        9       10
TF TOFFALETI.             NO
TF YANG.                  NO
TF ACKER-WHITE.           NO
TF COLBY                  NO
TF TOFFALETI-SCHOKLITSC   NO
TF MPM(1948).             NO
TF BROWNLIE,D50           NO
TF TOFFALETI-MPM          NO
TF LAURSEN(MADDEN),1985 YES
TF LAURSEN(COPELAND)      NO
TF YANG,D50               NO
TF ACKER-WHITE,D50        NO
TF MPM(1948),D50          NO
F#345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
VE  1.19     2.89     5.17     6.55     8.42
DE  0.82     3.11     7.50    10.71    15.66
WI  103.     111.     129.     143.     152.
QW   100     1000     5000    10000    20000
ES521E-6
WT    50
PF                              64       32       92       16     82.8        8       75
PFC    4     67.8        2    58.8        1     45.3       .5     22.8      .25      4.2
PFC .125       .8    .0625      .3        0        0
$$END
```

BED SEDIMENT FRACTIONS CALCULATED FROM PF-DATA.

NO	PERCENT FINER %	PARTICLE SIZE mm	INCREMENTAL FRACTION
5	.300	.0320	
			.0000000
6	.300	.0625	
			.0050000
7	.800	.1250	
			.0340000
8	4.200	.2500	
			.1860000
9	22.800	.5000	
			.2250000
10	45.300	1.0000	
			.1350000
11	58.800	2.0000	
			.0900000
12	67.800	4.0000	
			.0720000
13	75.000	8.0000	
			.0780000
14	82.800	16.0000	
			.0920000
15	92.000	32.0000	
			.0800000
16	100.000	64.0000	

TABLE 3. PROPERTIES OF THE WATER

#	TEMP DEG F	RHO #-S/FT4	VISCOSITY SF/SEC	UNIT WT WATER #/FT3
1	50.0	1.940	1.411	62.411
2	50.0	1.940	1.411	62.411
3	50.0	1.940	1.411	62.411
4	50.0	1.940	1.411	62.411
5	50.0	1.940	1.411	62.411

TABLE 2.1. HYDRAULIC PARAMETERS

N	TOTAL DISCHARGE	------------------EFFECTIVE DISCHARGE	VELOCITY	DEPTH	WIDTH-------------	ENERGY SLOPE
1	100.	101.	1.19	.82	103.00	.0005210
2	1000.	998.	2.89	3.11	111.00	.0005210
3	5000.	5002.	5.17	7.50	129.00	.0005210
4	10000.	10032.	6.55	10.71	143.00	.0005210
5	20000.	20042.	8.42	15.66	152.00	.0005210

TABLE 4.1 LAURSEN(MADDEN),1985 METHOD = NO. 13

SIZE CLASS no	GRAIN SIZE mm	PERCENT IN CLASS %	---------SEDIMENT TRANSPORT---------- POTENTIAL TONS/DAY	CAPACITY TONS/DAY	CONC PPM
6	.088	.50	2945.53	14.7276	54.547
7	.177	3.40	139.866	4.75546	17.613
8	.354	18.60	10.4813	1.94953	7.2205
9	.707	22.50	.100000E-06	.225000E-07	.83333E-07
10	1.414	13.50	.100000E-06	.135000E-07	.50000E-07
11	2.828	9.00	.100000E-06	.900000E-08	.33333E-07
12	5.657	7.20	.100000E-06	.720000E-08	.26667E-07
13	11.314	7.80	.100000E-06	.780000E-08	.28889E-07
14	22.627	9.20	.100000E-06	.920000E-08	.34074E-07
15	45.255	8.00	.100000E-06	.800000E-08	.29630E-07
Q, CFS =	100.000		QS, TOTAL =	21.4326	79.380

(Three iterations of TABLE 4.1 omitted here.)

TABLE 4.1 LAURSEN(MADDEN),1985 METHOD = NO. 13

SIZE CLASS no	GRAIN SIZE mm	PERCENT IN CLASS %	---------SEDIMENT TRANSPORT---------- POTENTIAL TONS/DAY	CAPACITY TONS/DAY	CONC PPM
6	.088	.50	.295481E+07	14774.1	273.59
7	.177	3.40	557919.	18969.3	351.28
8	.354	18.60	79333.3	14756.0	273.26
9	.707	22.50	8311.95	1870.19	34.633
10	1.414	13.50	2512.86	339.236	6.2822
11	2.828	9.00	1485.45	133.691	2.4758
12	5.657	7.20	852.389	61.3720	1.1365
13	11.314	7.80	38.1779	2.97788	.55146E-01
14	22.627	9.20	.100000E-06	.920000E-08	.17037E-09
15	45.255	8.00	.100000E-06	.800000E-08	.14815E-09
Q, CFS =	20000.0		QS, TOTAL =	50906.8	942.72

TABLE 5.0 SUMMARY TABLE: TOTAL BED-MATERIAL SEDIMENT DISCHARGE, TONS/DAY

Q NO	WATER DISCHARGE	TRANSPORT FUNCTIONS LAURSEN (MADDEN), 85
1	100.	21.
2	1000.	778.
3	5000.	8047.
4	10000.	20178.
5	20000.	50907.

End of Job PRINTOUT SAVED IN FILE [sed.out]

3.9 Plotting. The calculated bed material discharges and the water discharges are written into HEC's DSS for all functions selected. They can be plotted using the procedures described for SAM.hyd plots. Plot both axes as log, i.e., issue the Axis command before plotting:

```
AX LOG,LOG
```

Figure 21 presents the plot resulting from the above output.

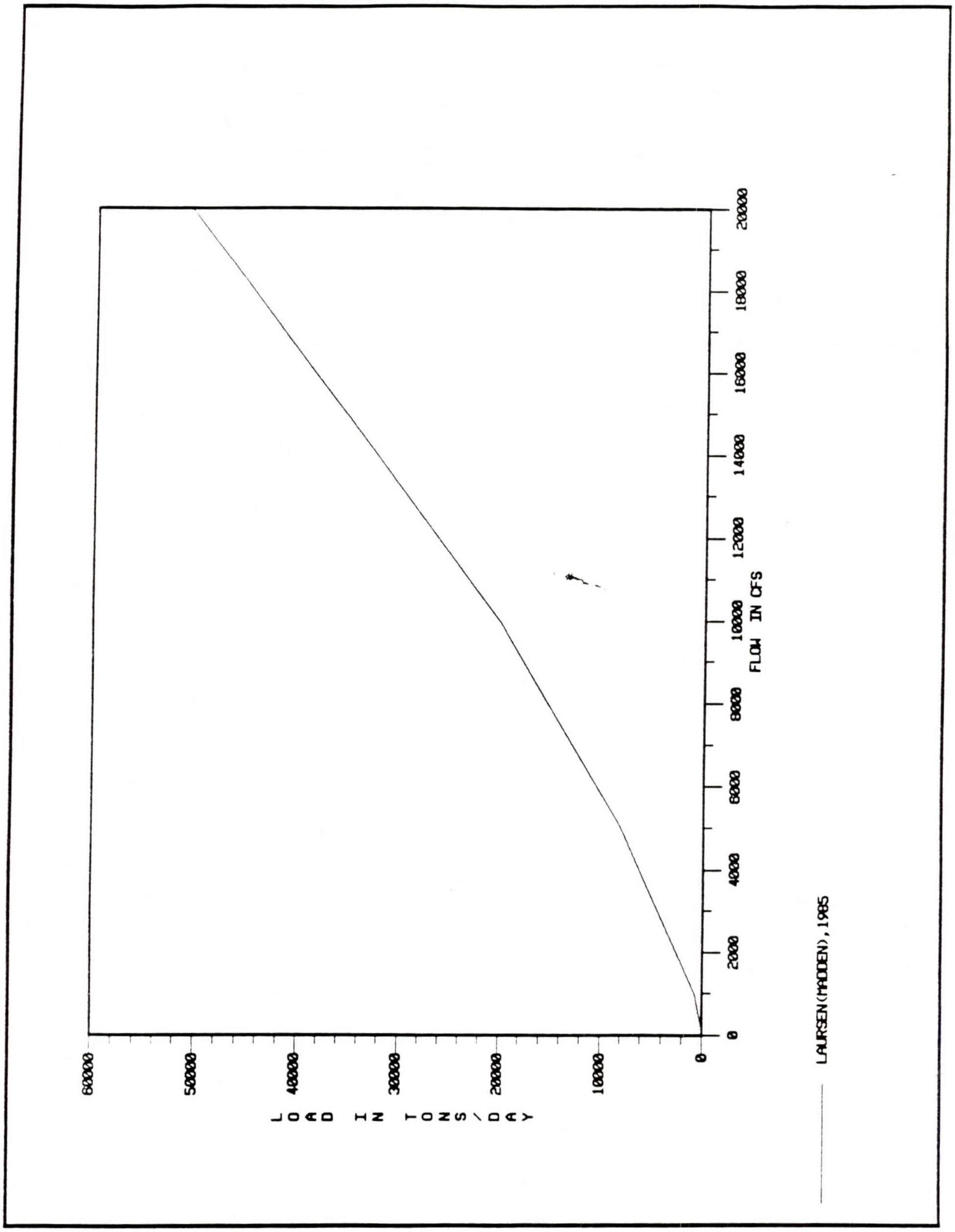

Figure 21. Sample Plot of Bed Material Discharge Rating Curve, Test 1A

4. SEDIMENT YIELD

4.1 Purpose and Scope. Sediment yield is the weight of sediment passing a cross-section during a specified period of time. Typically that is annually, but it can be a single event. This chapter presents two methods for calculating sediment yield: the FLOW DURATION CURVE method and a FLOW HYDROGRAPH method. In almost every case the real need is to forecast future conditions, and that requires parameters to be estimated.

4.2 Flow-Duration Sediment-Discharge Rating Curve Method. This is a simple integration of the flow duration curve with the sediment discharge rating curve at the outflow point from the basin. It is described in the Sediment EM (1110-2-4000).

This program uses log-linear interpolation for the (Q,%Finer) flow duration curve and log-log interpolation for the (Q,SC) sediment discharge rating curve.

4.2.1 Sample Input Data with QQ- and QD-records. The following data set illustrates input style. The flow-duration curve is coded on QQ- and QD-records. The water discharge axis is coded as QQ and the duration axis as QD. That is, a water discharge of 150 cfs is equaled or exceeded 100% of the time.

```
TI     TEST NO. 1  FILE WRITTEN BY SAM.sed
TI                 LAURSEN(MADDEN),1985
TI                 FLOW DURATION CURVE OPTION
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
QQ   150     326     633     939    1244    1550    1856    2162    2469    2774
QQ  3080    3386    3692    3998    4304    4610    4916    5222    5528    5834
QQ  6140
QD   100   44.37    14.5    6.49    3.52    2.16    1.34    0.83    0.52    0.36
QD  0.26    0.18    0.12    0.08    0.08    0.05    0.05    0.05    0.05    0.01
QD  0.00
QW   100    1000    5000   10000   20000
SC79.380    288.    596.    747.    943.
$$END
```

The sediment discharge rating curve is coded on QW- and SC-records. The water discharge axis is on QW and the corresponding sediment discharge axis is on SC.

NOTE: Always code a water discharge that is equal to or less than the smallest discharge in the QQ-records, and one that is greater than the largest discharge in the QQ-records.

4.2.2 The SC- or the QS-record. The SC-record gives sediment concentrations in mg/ℓ. The QS-record gives the sediment in tons/day, and can be used in place of the SC-record. The program reads QW- and SC-records and immediately converts the concentrations to sediment discharge. Therefore, place the QW-record before the SC- or the QS-record.

4.3 Flow Hydrograph Method. This modification of the flow-duration sediment discharge rating curve method substitutes water discharges from a hydrograph for the flow-duration curve. Those ordinates are integrated with the sediment discharge rating curve to produce the sediment yield for that event.

4.3.1 Sample Input with QH-records. Also needed in the input file is the time period between hydrograph ordinates. The time period of interest ranges from a single event to annual accumulations to the accumulation over a sufficiently long time to require project maintenance. Therefore, analyze the full range of water discharges and not just the design event.

```
TI   TEST NO. 2  HYDROGRAPH AT STATION EA5.  100-YEAR, 6HOUR RAINFALL
TI               ALBUQUERQUE ARROYOS - NORTH DIVERSION CHANNEL ANALYSIS
TI               HYDROGRAPH OPTION
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
JP    20                                   .0833
QH     0     186     407     830    1176    1595    1827    1950    2009    1883
QH  1705    1464    1254    1059     891     775     670     588     526     480
QH   449     404     369     342     311     285     253     227     208     179
QH   156   141+w     132     107      80      63      52      44      38      36
QH    36      36      36      36      36      36      36      28      19      12
QH     7       3
QW     1      10     100    1000    2000
QS  .001      73    1453   25269   64817
$$END
```

In the example the sediment discharge rating curve is coded as for the flow-duration curve method except that this data set shows the use of the QS-record. The water runoff is coded in cfs on the QH-records, and the period between ordinates, 0.083 hours, coded on the JP-record.

4.4 Flow Duration and Hydrograph Data File. It is suggested that flow duration data be coded into a separate file that can be read by SAM.yld at execution time. This allows the user to input this data once and have it used in multiple runs. There are three formats available for coding this file.

Note: Be sure the data is coded in the proper columns, per the given conditions.

4.4.1 File Name for FLow-Duration and Hydrograph Data File. The default file_name is CDFFIL, regardless of the file's format. If that file is present in the working directory, it will be attached and the data will be used automatically. If that file is not present in the working directory, and hydrology data are not coded in the input data file, the program will request a file_name for hydrology data at execution time.

4.4.2 FD Record Format. One format is via FD records. With this format, the first record in the file contains only the number of points in the file. Subsequent records are DURATION in % and Q in CFS. The following example shows column numbers, but this line must not be in the file. Each FD record must be set up with FD in the first two columns, the first number ending in column 11, and the second number, if there is one, ending in column 28.

```
          DUR             Q     = VARIABLES
           %             CFS
1234567890 234567890 234567890  = COLUMN #

FD         5
FD       100            100.
FD        10            500.
FD         5           1000.
FD         1          10000.
FD      .001          15000.
```

Table 9. Example CDFFIL file with FD-records.

4.4.3 QQ- and QD- Records Format. An alternate format for coding Flow-Duration Data is via QQ- and QD-records. Data fields on these records are described in Appendix E. An example of this style, with column numbers, is shown below, but the F# record, again, must not be in the file:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
QQ   100     900    2200    4100    7900   12800   16200   18300   19551
QD   100      87       9       6     3.6    1.84   .0400   .0050   .0003
```

Figure 10. Example CDFFIL file with QQ- and QD-records.

4.4.4 QH Record Format. The third format available uses hydrographs. Code this format using the same rules as QH-Records, Appendix E. Again, the only record type allowed in the file is QH.

4.5 Limitations. Either method of calculation, with the flow-duration or with the flow hydrograph, is limited to 2000 integration intervals. The sediment discharge rating curve is limited to 10 points.

4.6 Execution. SAM.yld executes from the SAM menu, see Figure 9. There are three methods of preparing the input file; with PSAM, through an editor such as COED, or through the SAM.yld tutor.

The default input filename comes from the FILES.SAM file as described in Section 2.5.7. The only differences are in the filename extensions, which are shown below, in Table 15.

INPUT FILENAME	SEDIMENT YIELD OUTPUT
yldpcin.in	yldpcin.yo
yldpcin.lib	yldpcin.yob
clearcrk.dat	clearcrk.yot

Table 15. Examples of default filenames for Automatic Filename Transfer system for SAM.yld.

4.6.1 Execution when the default filename exists. This is much the same as for SAM.hyd, described in paragraph 2.5.7.1. SAM.yld will "OPEN" the default input data filename and execute. Selective printout scrolls to the screen, and the entire output will be saved in the default output filename. When the computations are completed, the following menu appears on the screen:

```
...END OF JOB.

OPTIONS ARE:
at [inputfile]  end  help  run  save[inputfile] tutor
```

Figure 22. SAM.yld Main Menu

At this point the run can be ended by typing en , and the complete output can be inspected using COED or LIST. Or, the input data can be modified and rerun without leaving SAM.yld by typing tu , and using the tutor. The tutor works in much the sam way as does the tutor in SAM.hyd.

4.6.2 Execution when the default filename does not exist. When FILES.SAM does not exist, SAM.yld will attempt to "OPEN" the default input data file. If this file does not exist, the program automatically enters conversational mode and displays the following message.

```
Msg:  YLD  >>Data File [   yld.in     ] Does not exist.

SAM.yld.main OPTIONS ARE:
at [inputfile]  end  help  run  save[inputfile]  tutor
```

The at (attach) and tu (tutor) options work as they do for SAM.hyd, see paragraphs 2.5.7.2 and 2.4.8.

4.7 Output. Selected results are printed to the screen as the program executes. The printout is directed to the file default output filename.

4.7.1 Sample Output Data. The following output description refers to the output is an example of the flow-duration curve input combined with a separate FD-record file.

```
*******************************************************
*     HYDRAULIC DESIGN PACKAGE FOR FLOOD CONTROL      *
*                 CHANNELS (SAM)                      *
*                                                     *
*                                                     *
*                 SEDIMENT YIELD                      *
*  VERSION 3.05                   01 OCTOBER 1992     *
*                                                     *
*                                                     *
*                A Product of the                     *
*     Flood Control Channels Research Program         *
*Hydraulics Laboratory, Waterways Experiment Station*
*******************************************************

Msg:  YLD.main  READING INPUT DATA FROM FILE   yld.in          THIS DIRECTORY.


TABLE  1.  LIST INPUT DATA.

TI      FILE WRITTEN BY SAM.sed: TEST 1A
TI      LAURSEN(MADDEN),1985
QW   100     1000     5000    10000    20000
SC79.380     288.     596.     747.     943.
$$END

SAM.yld IS IMPORTING FLOWS FROM FILE = CDFFIL

INPUT IS COMPLETE.


TABLE 2.1  SEDIMENT DISCHARGE TABLE.

Q,CFS         =       100.0    1000.0    5000.0   10000.0   20000.0
QS,TONS/DAY =          21.4     777.6    8046.0   20169.0   50922.0


     MINIMUM Q IN Q-QS TABLE =  100.000
     MAXIMUM Q               =  20000.0


           TABLE 2.3  FLOW-DURATION TABLE
     #      CFS        %       #      CFS         %        #      CFS          %

     1    100.00    100.00     3   1000.00      5.00      5  15000.00         .00
     2    500.00     10.00     4  10000.00      1.00


TABLE 2.4  INTEGRATION PARAMETERS FOR FLOW-DURATION OPTION
           MINIMUM FLOW, CFS           =       100.00
           MAXIMUM FLOW, CFS           =     15000.08
           INTEGRATION INTERVAL, CFS   =        40.82
           NUMBER OF INTEGRATION STEPS =       365


TABLE 2.6  SPECIFIC WEIGHT OF SEDIMENT.
           IN LB/CUFT    =        93.00

           IN CY/TON     =          .80


TABLE 3.1  CALCULATED YIELDS

      TIME PERIOD,      DAYS =    364.996
      WATER YIELD,      ACFT =    390979.,  Mean Daily Flow, CFS =       540.06
      SEDIMENT YIELD, TONS =      227671.,  Mean Daily Load, T/D =         624.
```

CUYD = 181339., Mean Daily Conc, mg/l= 427.776

TABLE 3.2 DISTRIBUTION OF YIELD BY WATER DISCHARGE CLASS INTERVAL.
NO. OF CLASSES = 20 , CLASS INTERVAL = 100.00
MINIMUM Q, CFS = 15000.00, MAXIMUM Q, CFS = 745.00

CLASS	DISCHARGE CFS	SEDIMENT TONS/DAY	INCREMENT OF WATER, ACFT	%	INCREMENT OF SEDIMENT %	TONS	CU YD
	100.	21.					
1			234943.	60.09	19.13	43543.	34682.
	845.	598.					
2			13042.	3.34	2.65	6043.	4813.
	1590.	1525.					
3			6946.	1.78	1.64	3734.	2974.
	2335.	2664.					
4			6905.	1.77	1.78	4056.	3231.
	3080.	3982.					
5			6888.	1.76	1.91	4341.	3458.
	3825.	5453.					
6			6880.	1.76	2.02	4604.	3667.
	4570.	7061.					
7			6875.	1.76	2.13	4851.	3864.
	5315.	8725.					
8			6871.	1.76	2.23	5066.	4035.
	6060.	10382.					
9			6869.	1.76	2.30	5246.	4178.
	6805.	12107.					
10			6868.	1.76	2.38	5418.	4316.
	7550.	13895.					
11			6867.	1.76	2.45	5584.	4448.
	8295.	15742.					
12			6866.	1.76	2.52	5745.	4576.
	9040.	17643.					
13			6865.	1.76	2.59	5900.	4699.
	9785.	19596.					
14			8886.	2.27	3.44	7831.	6238.
	10530.	21610.					
15			9736.	2.49	3.86	8790.	7001.
	11275.	23677.					
16			9735.	2.49	3.95	8994.	7164.
	12020.	25790.					
17			9735.	2.49	4.04	9193.	7323.
	12765.	27948.					
18			9734.	2.49	4.12	9387.	7477.
	13510.	30148.					
19			9734.	2.49	4.21	9576.	7628.
	14255.	32390.					
20			9734.	2.49	30.64	69766.	55569.
	15000.	34671.					
			390979.	100.00	100.00	227671.	181339.

...END OF JOB... Printout is in FILE [yld.out]

Table 1 echoes the input data and is not shown. Tables 2.1 through 2.4 interpret the input data. Tables 3.1 and 3.2 give the calculated results. Table 3.1 gives the calculated total yield. Table 3.2 gives the calculated distribution of yield by water discharge increment. Note that immediately after the echo of the input file the program names the file from which the flows were taken

4.8 Plotting. SAM.yld does not provide any graphic output and is not expected to require any plotting capability.

APPENDIX A

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APPENDIX C: Data Records for Hydraulic Calculations

TI RECORDS

Up to 10 title records are permitted. These records are for the user's information only and are therefore optional.

Example:

```
TI    Use these title cards to define the job, the date, the Investigator, the
TI    model #, the data source, the purpose for this run, and changes from      TI     previous runs.
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
```

Field	Variable	Value	Description
0		TI	Card Identification in columns 1 and 2. Use TI for all records.

F# RECORDS

Marks each data field by column numbers, each field being 8 columns wide. There can be only 1 F# record. This record is for the user's information only and is therefore optional.

Example:

```
TI    Title cards
TI    Title cards
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
```

Field	Variable	Value	Description
0		F#	Card Identification in columns 1 and 2.

TR RECORD

The TR-Record controls the printout and selects the Compositing Method. There can be up to 2 TR-records.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
TRKSW(1)  KSW(2)  KSW(3) KSW(...)

TR             1
```

Field	Variable	Value	Description
0		TR TR	Record Identification - TRace printout. Record Identification for continuation record.
1	KSW(1)		Method for Compositing Hydraulic Radius and n-values.
		b,1 2 3 4	Composite by Alpha Method. Composite by equal velocity method. Composite by total force method. Composite by conveyance method.
2	KSW(2)	1	Print out flow distribution in each panel.
3	KSW(3)		Trace... Normal depth calculations.
4	KSW(4)		Trace... Fixed-bed bottom width calculation.
5	KSW(5)	1	Trace... CI-Option Subroutine gmsex.f: IF(KSW(5) .GT. 0)
6	KSW(6)	1	Trace... Alpha Method for Compositing Hydraulic Radius and n-values
7	KSW(7)	1	Trace... Brownlie Method, (SUBROUTINE brown)... If(KSW(7) .GT. 0)
8	KSW(8)	1	Trace... Trapezoidal Integration, (SUBROUTINE tzin).
9	KSW(9)	1,2	Trace... Copeland's analytical method for width, depth and slope.

Field	Variable	Value	Description
10	KSW(10)		Trace... Riprap Design Computations
11	KSW(11)		Trace... Water Discharge Calculations.
12	KSW(12)		Trace... n-Value Calculations.
13	KSW(13)		Trace... Slope Calculations.
14	KSW(14)		Trace... Reading Input Data.
	KSW(14)		-1 Causes the screent output to PAUSE about every 20 lines.

CT RECORD

The CT Record is an option for prescribing simple rectangular, triangular or trapezoidal, channel cross sections. Up to 3 CT-Records can be stacked to form a complex geometry. For Bottom Width caclulations, the number of discharges coded on the QW-record must equal the number of CT-records in the data file.

If riprap design is desired, include RR- and RT-records. Be sure to also include the PF-record. Riprap is calculated only if the bed is not stable, and the program uses D_{50} in Shield's curve to test for stability.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
CT    BW      CD     SSL     SSR  NEQBED   KsBED  NEQBKL   KSBKL  NEQBKR   KSBKR

CT   120      10       3       3       4               1     .25       1     .25
```

Field	Variable	Value	Description
0		CT	Record Identification - Channel Template.
1	BW	0,+	Bottom Width, Ft.
		b	Program calculates bottom width for the prescribed hydraulic parameters.
2	CD	-,0,+	Bank height, Ft.
3	SSL	+	Side Slope, Left side of channel facing downstream, 1V:[_]H.
		b	Default - 0.
4	SSR	0,+	Side Slope, Right side of channel facing downstream, 1V:[_]H.
		b	Default - 0.
5	NEQBED	0,+	Equation Number for the n-value calculation on channel bed.
		b,0	value coded in KSBED(CT-6) is n-value.
		1	Moody Diagram. Program expects Ks value for bed (CT-6).
		2	Strickler n-value equation. Program expects Ks value for bed (CT-6).
		3	Limerinos n-value equation. Program expects a D50 and D84 on BR-record.

Field	Variable	Value	Description
		4	Brownlie bed roughness equations. (NOTE: Must supply BR-record.)
		5	SCS Grass lining, type E.
		6	SCS grass, type D. Details same as for type E.
		7	SCS grass, type C. etc...
		8	SCS grass, type B.
		9	SCS grass, type A.
6	KSBED	+	If NEQBED =0, Code the Manning n-value here. If NEQBED =1 or 2, Code the surface roughness for the bed, ft, here. If NEQBED =3 or 4, This field can be blank, but program expects BR- or PF- record to prescribe the bed surface gradation. If NEQBED =5 thru 9, This field can be blank.
7	NEQBKL	0,+	Equation Number for the n-value calculation on LEFT-bank. Same rules apply as described for NEQBED.
		b	Manning n-value is coded in (CT-8).
8	KSBKL	+	Hydraulic roughness for the LEFT-bank. Same rules apply as described for KSBED (CT-6).
9	NEQBKR	0,+	Equation Number for the n-value calculation on RIGHT-bank. Same rules apply as described above for NEQBED.
		b	Manning n-value is coded in (CT-10).
10	KSBKR	0,+	Hydraulic roughness for the RIGHT-bank. Same rules apply as described above for KSBED.

CI RECORD

The CI Record provides input for the channel improvement, CHIMP, option of the program. This option simulates the modification of cross section data, GR records, by a trapeziodal excavation. Up to 3 CI-records are allowed per cross section. The channel improvements are performed in the order that the cards are specified.

> **Note:** HEC-2 allows the natural channel to be filled prior to excavation if desired, see variable BW. Low areas of the natural cross section may be filled by the sediment option in HEC-2. But neither of these options are available in SAM at this time.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
CI CLSTA   CELCH XLCH.CN   XLSS     RSS      BW

CI    50     -15              2       2      20
```

Field	Variable	Value	Description
0		CI	Record Identification - Channel Improvement.
1	CLSTA	+	Station of centerline of trapezoidal channel excavation expressed in terms of the stations used in the natural cross section descriptions, on the GR records.
		-1	Program determines CLSTA to be halfway between bank stations.
2	CELCH	+ or -	Elevation of channel invert, but not -1.
		-1	Elevation of channel invert is equal to minimum elevataion in cross section.
		.1>-CELCH>-.00001	Elevation of channel invert is based on CELCH (slope) and XLCH.CN (channel reach length). This is an HEC-2 option and is NOT NEEDED IN SAM.
3	XLCH.CN	0 or +	New channel reach length and n-value for HEC-2. (NOT NEEDED IN SAM)

Field	Variable	Value	Description
4	XLSS	0	Left side slope will be vertical.
		+	Left side slope of excavation, 1V:[_]H.
5	RSS	0 or +	Right side slope of excavation, 1V:[_]H, same as for left side.
6-10	BW	+	Bottom width of channel.
			Same as + but the old channel will be filled up to an elevation equal to the minmum bank elevation. This HEC-2 option NOT YET working in SAM.
		.01	Signals the program to stop modifications. This HEC-2 option NOT NEEDED IN SAM.

X1-RECORD

This record is used to prescribe the cross section location and the program options which are applicable to that cross section. There may be 1 X1 record for each set of GR records.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
X1   ASN     NXY   STCHL   STCHR

X1  22.5      9     337     387
```

Field	Variable	Value	Description
0	ICG,IDT	X1	Identification characters - X-Section.
1	RMILE	-,0,+	River Mile, for identification only, not for measuring distance.
2	NXY	+	Total number of coordinate points on the following GR-Record set.
3	STCHL	-,+	The station of the left bank of the channel. Use top-bank so the bank roughness will be included in the composite n-values for the channel. The value MUST equal one of the station values on GR-Record.
4	STCHR	+	Station of the right bank of the channel. Same rules as for STCHL above.

GR RECORD

This record is used when coding cross sections by coordinate point (Elev,Sta). Code stations in increasing order. Negative values are permitted, in which case "increasing order" means "the positive direction of the x-axis." There may be 20 GR records per cross section.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
GR EL(1)  STA(1)   EL(2)  STA(2)   EL(3)  STA(3)  EL(..) STA(..)

GR4496.0       0  4494.5      52  4495.3     146  4493.9     266  4492.2     337
GR4490.3     348  4490.3     360  4489.7     367    4495     387
```

Field	Variable	Value	Description
0	ICG,IDT	GR	Record Identification - GRound co-ordinates
		GR	Record Identification for continuation records, also.
1	EL(1)	-,0,+	Elevation of first coordinate, in ft.
2	STA(1)	-,0,+	Station corresponding to EL(1), in ft.
3	EL(2)	-,0,+	Elevation of second coordinate.
4	STA(2)	-,0,+	Station corresponding to EL(2).
.			
.			
.			
10	STA(5)	-,0,+	Station corresponding to EL(5).

Etc. Continue for up to 100 points. Each continuation record is identified with GR, and the format is identical for all records.

GL RECORD

This Record is used to prescribe reach lengths, if necessary. There can be up to 10 GL records.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
GLTZL(1)  TZL(2)  TZL(3) TZL(...)

GL  500     1000    1500
```

Field	Variable	Value	Description
0	ICG,IDT	GL GL	Record Identification - Reach Length. Record Identification on continuation records also.
1	TZL(1)	+ b(1)	Reach length for panel 1 in the cross section. There is no default for panel 1.
2	TZL(2)	+	Reach length for panel 2.
3	TZL(3)	+	Reach length for panel 3.
4	TZL(...)	+	Code as necessary.

If the cross section contains more than 10 panels, continue coding lengths using field 1 on each continuation GL-record. The number of values needed by the program is NXY-1 (the number of x-y points minus 1). However, the program will supply missing values by linear interpolation between values which are coded.

NE-RECORD

This record is used with the HEC-2 format (i.e. X1- GR-Records) to prescribe the n-value (i.e. hydraulic roughness) equation to use in each panel across the section. There must be NXY-1 values. Code the number from the following list of n-value equations. See Table 4, Characteristics of Grass Cover, in the text for details on the grass equations.

0 - Manning n-values are coded.
1 - Moody Diagram (Keulegan equations)
2 - Strickler Equation
3 - Limerinos Equation
4 - Brownlie Bed Roughness Predictor
5 - Grass lining, Type E
6 - Grass lining, Type D
7 - Grass lining, Type C
8 - Grass lining, Type B
9 - Grass lining, Type A

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
NE EQNV1   EQNV2   EQNV3 EQNV(...)

NE    5       5       2       2       2       3       3       1
```

Field	Variable	Value	Description
0	ICG,IDT	NE	Record Identification - N-value Equations
		NE	Record Identification on continuation records also.
1	EQNV		Roughness equation for panel 1. If equation 0 is mixed with other equations, use the KN-record, not the KS-record to prescribe the values.
		0	Manning's n-value will be coded for panel 1 on a KN-Record. (Note: It will be read and converted to Strickler's Ks. Equation 2, from the above list, will then be used in the computations.) Do not mix KN- and KS-Records at this time.
		1	Moody Diagram. Program expects Ks value for panel 1 (KS-Record). Do not mix KN- and KS-Records at this time.

Field	Variable	Value	Description
		2	Strickler n-value equation. Program expects Ks value for panel 1 (KS-Record). Do not mix KN- and KS-Records at this time.
		3	Limerinos n-value equation. Program expects Bed Gradation Data. (See PF- or BR-Records)
		4	Brownlie bed roughness equations. Program expects Bed Gradation Data. (See PF- or BR-Records)
		5	SCS Grass lining, type E. See Text for details.
		6	SCS grass lining, type D. etc...
		7	SCS grass lining, type C.
		8	SCS grass lining, type B.
		9	SCS grass lining, type A.
2	EQNV	+	Roughness equation for panel 2.
		b,0	If Manning's n-values are being used, the default is 0. However, if Manning n-values are not being used, i.e. no KN-Records, the program considers blank and 0 as missing data and will supply the equation number from the N-1 panel.
.			
.			
.			
3	EQNV	+	Continue coding roughness values until there is one for each panel in the cross section. Begin in Field 1 of each record.

KS RECORD

This record is used to prescribe the effective roughness height when calculating n-values from the Moody Diagram or the Strickler Equation, when coding cross sections in HEC-2 format, (i.e. X1- GR-Records). A roughness value is needed in each panel across the section, i.e. between each pair of coordinate points on the GR-Record. There can be up to 10 KS-records.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
KS KS(1)   KS(2)   KS(3) KS(...)

KS    .4                             10                     .007
```

Field	Variable	Value	Description
0	ICG,IDT	KS KS	Record Identification - Effective Roughness. Code on continuation records, also.
1	KS(1)	+	Effective roughness height-ft in panel 1.
		b,0	There is no default for panel 1.
		-	The negative is a flag for the program, telling it to make the hydraulic roughness calculations. The absolute value of the number in the filed tells the program the ratios of roughness in that element to the composite roughness.
2	KS(2)	+	Effective Roughness height-ft in panel 2.
		b	The either the value for KS(1) is used or the corresponding equation is for grass.
		-	See description for field 1.
. . .			
3	KS(3)	+,b,-	Continue coding Ks values until there is one for each panel in the cross section. There will be up to NXY-1 values. The program will supply missing values using the rule: KS(N) - KS(N-1). Continue in field 1 on continuation records.

KN RECORD

This record is used to prescribe the Manning's n-value, n-value equation number 0, when coding cross sections in HEC-2 format, (i.e. X1- GR-Records). An n-value is needed in each panel across the section, i.e. between each pair of coordinate points on the GR-Record. There may be up to 10 KN records per cross section. KS-record values can be put on a KN-record if the NE-record has equation 0 and other equation numbers.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
KN KN(1)   KN(2)   KN(3)  KN(..)

KN   .05
KN                                                                    .018
```

Field	Variable	Value	Description
0		KN	Record Identification - Roughness, Manning's n-values.
		KN	Record Identification on continuation records also.
1	KN(1)	+	Manning's n-value in panel 1.
		b(1)	There is no default for panel 1.
2	KN(2)	+	Manning's n-value in the panel 2.
		b	The value for KN(1) is used.
.			
.			
.			
3	KN(3)	+	Continue coding n-values until there is one for each panel in the cross section. There will be up to NXY-1 values. The program will supply missing values using the rule: KN(N) - KN(N-1).
			Continue in field 1 on continuation records.

PF RECORD

This record prescribes the gradation of the bed sediment reservoir at a cross section. Code Continuation records as PFC-record. It is not necessary that a PF-coordinate correspond to a class interval boundary - although it can. Otherwise, semi-log interpolation is used to calculate the percent finer at each class interval boundary and these are subtracted to calculate the fraction of sediment in each size class. The program assigns a percent finer = 100 to correspond with DMAX. There can be up to 18 data points, 4 PF records.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
PF¦ cmt¦     ASN     SAE    DMAX   DAXIS   PFXIS   DAXIS   PFXIS  DAXIS   ..etc
PF         308.0     1.0   18.29    9.14    95.0     1.0    94.2     .5    78.0

PFC   .25   46.7    .125    14.3   .0625     9.9    .004     4.9
```

Field	Variable	Value	Description
0	ICG,IDT	PF	Record Identification = Percent Finer
		PFC	Record Identification = Continuation record
1	ISI	al.@!	Comment field for PF record; BUT for PFC-records - see example above.
	DAXIS	+	Code the particle diameter, mm, here on continuation records.
2	RMILE	-,0,+	Identifier of this Cross Section (ie, River Mile)
3	SAE	b	SAE is not needed for this code, but it is provided for compatibility with HEC-6.
4	DMAX	+	The diameter of the maximum particle size,in MM.
		b	Not allowed -- ALWAYS code a value.
5	DAXIS(2)	+	This is the first co-ordinate point down the percent finer curve from DMAX. If this particle size is larger than 64MM, choose a point that will approximate the PF-Curve with 2-straight line segments from DMAX to 64MM.
6	PFXIS(2)	0,+	The percent finer corresponding to DAXIS(2). Code as a percent.

Field	Variable	Value	Description
7	DAXIS(3)	0,+	Continue to code points from the percent finer curve. Up to 16, including the DMAX point, are permitted. Use a continuation record when coding more than 4 points.

BR RECORD

This Record is used to prescribe the D50 and the Geometric Standard Deviation of the bed sediment. Only 1 BR record is permitted.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
BR   d84     d50     d16    DQDT    SPGS

BR   2.0     .35     .125
```

Field	Variable	Value	Description
0	ICG,IDT	BR	Record Identification - BRownlie parameters.
1	D84	+	D84 of the bed surface in mm.
2	D50	+	D50 of the bed surface in mm.
3	D16	+	D16 of the bed surface in mm.
4	DQDT		Rate of change of the water discharge hydrograph. i.e. rising side or falling side. (The Discharge at which the bed regime will transition from lower to upper and back, is different on the rising side and the falling side of the hydrograph.)
		-1	Use the upper regime equation to define this point in the transition zone.
		0	The default. Use the equation which is closest to the current point in the transition zone.
		+1	Use the lower regime equation to define this point in the transition zone.
5	SPGS	+	Specific Gravity of sediment particles.
		b	Default - 2.65

RC RECORD

This Record is used to prescribe the cost-in-place per ton of each riprap size in the Standard Gradation Table. See engineering description for more details. The program expects 12 values. For quarry run stone, code on the RQ record.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
RC RC(1)   RC(2)   RC(3)   ...   max is RC(12)

RC    .5       1     1.5     2.0     2.5       3       4       5       6       7
RC     8       9
```

Field	Variable	Value	Description
0	ICG,IDT	RC	Record Identification - Riprap Cost
1	RC(1)	+	Riprap cost for the first size of riprap in the Standard Gradation table.
2	RC(2)	+	Riprap cost for the second riprap size.
.			
.			
.			
3	RC(3)	+	Program expects up to 12 values -- one for each riprap size in the Standard Gradation Table.

RQ RECORD

This Record is used to describe quarry run riprap. There can be up to 5 RQ records.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
RQDMAXRR   D90RR   D50RR   D30RR  PORRAP   RRCPT

RQ  24.0    17.7    14.4     7.9      38
```

Field	Variable	Value	Description
0	ICG,IDT	RQ	Record Identification = RipRap--quarry run.
1	DMAXRR	+	Dmax for the quarry run riprap, in inches.
2	D90RR	+	D90 for the quarry run riprap, in inches.
3	D50RR	+	D50 for the quarry run riprap, in inches.
4	D30RR	+	D30 for the quarry run riprap, in inches.
5	PORRAP	b	Porosity, volume of voids divided by total volume expressed as percent. Default = 38.
6	RRCPT		Unit cost for the quarry run stone in place, $/ton.

RR RECORD

This Record is used to prescribe the general design parameters needed in sizing the riprap. There can be only 1 RR-record.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
RR SGRR  BENDR    BENDA  NTRAP   SAFEF   CIFRRS

RR  2.48     600              1
```

Field	Variable	Value	Description
0	ICG,IDT	RR	Record Identification - RipRap properties
1	SGRR	+	Specific gravity of the riprap
		b,0	Default - 2.65.
2	BENDR	+	Bend radius in feet.
		b,0	Default - Straight channel.
3	BENDA	+	Bend angle in degrees ...NOT NEEDED - LEAVE BLANK as of 16 May 1990...
4	NTRAP	1	Trapezoidal Cross Section in a bend - not a natural river bend.
		b,0	Default - Cross section is a Natural river bend.
5	SAFEF		Safety factor above failure. Default is Recommended.
		b,0	Default - 1.1, the EM value.
		+	Enter your own safety factor.
6	CIFRRS		Coefficient of Incipient failure. Ratio for rounded stone.
		b,0	Default - 1.25, the EM value.
		+	Enter your own value.

RS RECORD

This Record is used to prescribe the general design parameters needed to calculate the size of riprap when velocity and depth are known. There can be only 1 RS record.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
RS  VAVG      WS     SSL   SUMWWS  RSEC

RS  6.48      12       2    600      1
```

Field	Variable	Value	Description
0	ICG,IDT	RS	Record Identification - RipRap size.
1	VAVG	+	Water velocity, fps, over toe.
2	WS	+	Water depth over toe.
3	SSL	+	Side Slope (Bank slope) of revetment (1V:[Z]H).
		b	Default - 1.5
4	SUMWWS	+	Water Surface Width. Required if in a bend.
		b	Default - D*Z
5	RSEC	+	Ratio of riprap layer thickness to DMAX.
		b	Default - 1.*Dmax

RT RECORD

This Record is used to prescribe the riprap thickness across each panel in the cross section. Only those panels having a positive RT-value will get riprap. There can be up to 10 RT records.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
RT RT(1)   RT(2)   RT(3) RT(...)

RT    1       0       1
```

Field	Variable	Value	Description
0	ICG,IDT	RT	Record Identification - Riprap Thickness
		RT	Record Identification for Continuation Records, also.
1	RT(1)	+	Riprap thickness in panel 1 expressed as the ratio times Dmax, i.e. [RT]*DMAX. Values usually range from 1 to 1.5.
		b,0	Default - no riprap.
		-1	Indicates cobbles.
2	RT(2)	+	Thickness of riprap in panel 2.
		b,0	Default - no riprap.
		-1	Indicates cobbles.
.			
.			
.			
3	RT(3)	+	Continue coding RT values as above until there is one for each panel in the cross section. The program will accept NXY-1 values.
11	RT(11)	+	There are only 10 fields on a record. For panel 11, code in field 1 of the second RT-Record. etc

BL RECORD

This Record is used to request the BLENCH REGIME values for width, depth and slope using equations shown on pp 127-128 of ASCE Manual 54, "Sedimentation Engineering." There can be only 1 BL record.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
BL    FS

BL    .2
```

Field	Variable	Value	Description
0	ICG,IDT	BL	Record Identification - BLench Regime parameters.
1	FS		"Side Factor" which measures the tendency of the bank to resist erosion.
		.1	Sand banks, very little resistance to erosion.
		.2	Silty clay-loam banks, moderate resistance to erosion.
		.3	Tough Clay banks, high resistance to erosion.

QW RECORD

This record is used to prescribe water discharge(s). Caution: They must be coded from the smallest to the largest to plot rating curves. Only 1 QW record is permitted. For the Bottom Width calculations only, the number of discharges prescribed must equal the number of CT-records in the data file.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
QW  Q(1)    Q(2)    Q(3)  Q(...)

QW    10     100     1000    10000    20000    23750
```

Field	Variable	Value	Description
0		QW	Record identification - Water Discharge
1	Q(1)	+	Enter water discharge in cfs.
2-10	Q(2)-Q(10)	+	Up to 10 discharges may be entered.

WS RECORD

This record prescribes the water surface elevations. Same rules apply as for discharges coded on the QW record. There can be only 1 WS record.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
WS WS(1)   WS(2)   WS(3) WS(...)

WS   402     405  410.3
```

Field	Variable	Value	Description
0	WS		Record identification - Water Surface elevation.
1	WS(1)	+	Enter the value that goes with Q(1) when a water surface elevation is needed; enter the value in feet
2	WS(2)-WS(10)	+	Enter the water surface elevation for Q(2)-Q(10).

GZ RECORD

The GZ Record is an option which allows a gage zero elevation to be input and added to all water surface elevations. There can only be 1 GZ record.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
GZ  GZRO

GZ 129.7
```

Field	Variable	Value	Description
0		GZ	Record Identification - Gage Zero
1	GZRO	+	Gage zero reading.

ES RECORD

This record prescribes the energy slope, in ft/ft, corresponding to each discharge on the QW record. A slope is needed for each Q(i) on the QW-RECORD, but the program will fill in missing values, so it is only necessary to code those which change. There can be only 1 ES record.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
ES  S(1)    S(2)    S(3)  S(...)

ES284E-6 .000174 .000170
```

Field	Variable	Value	Description
0		ES	Record identification - Energy Slope
1	SLOA(1)	+	Energy slope corresponding with Q(1). If field width does not permit sufficiency accuracy, code in scientific notation as shown above. If 3 sigificant digits do not provide sufficient accuracy, code a dummy Q in the first field and begin the real problem in field 2.
2-10	SLOA(2)-SLOA(10)	+	The slope can change with each Q on the QW-record. However, the program will fill in missing values using the rule, ES(I) = ES(I-1), so only those which change must be coded.

WT RECORD

This record is used to prescribe the water temperature, degrees Fahrenheit. There can be only 1 WT record.
Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
WT WT(1)    WT(2)    WT(3)  WT(...)

WT    55       60       75
```

Field	Variable	Value	Description
0		WT	Record identification = Water Temperature.
1	WT(1)	+ b	Water temperature for Q(1). Default = 60.
2-10	WT(2)-WT(10)	+	A water temperature is needed for each water discharge, but only those values which change must be coded. The program will supply missing values using the rule: WT(I) = WT(I-1).

GC RECORD

The GC Record initiates Copeland's Analytical channel dimensions computations. Up to 10 GC records may be stacked in one job.
Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
GC     Q  CONPPM    SLOV   SSLAM   SSRAM  NEQLAM  BANKKL  NEQRAM  BANKKR   FIXBAM

GC  3680          .00162       3       3       2      .7       2      .7
GC  4850          .00162       3       3       0    .050       0    .050
```

Field	Variable	Value	Description
0		GC	Record Identification - Geometry by Copeland method
1	Q	+	Water discharge in cfs, for the project.
2	CONPPM	+	Design sediment concentration in PPM.
		-1,b,0	Program will calculate the DESIGN SEDIMENT CONCENTRATION using the DESIGN WATER DISCHARGE, Q (GC-1).
		-Q	When a negative value other than 1 is coded, it is interpreted as the water discharge to use for calculating the DESIGN SEDIMENT CONCENTRATION, i.e., the water discharge for the approach reach. NOTE: Channel Geometry (either GR- or CT-records), Channel Slope (ES-record) and Gradation of Bed Sediment (either BR- or PF-records) must be supplied for the Approach Channel when concentrations are to be calculated.
3	SLOV	0,+	Valley slope, used as the maximum feasible slope, in ft/ft.
4	SSLAM	0,+	Side Slope, Left side of channel facing downstream, 1V:[_]H.
5	SSRAM	0,+	Side Slope, Right side of channel facing downstream, 1V:[_]H.

Field	Variable	Value	Description	
6	NEQLAM		Code the Equation Number for the n-value calculation, Left Bank of Project Channel.	
		b,0	value coded in BANKKL(GC-7) is n-value.	
		2	value coded in BANKKL(GC-7) is "Ks" for Strickler n-value equation.	
7	BANKKL	0,+	Hydraulic Roughness Value, Left Bank	
			If NEQLAM = 0	Code as Manning n-value.
			If NEQLAM = 2	Code the surface roughness, Ks-ft.
8	NEQRAM		Code the Equation Number for the n-value calculation, Right Bank of Project Channel.	
		b,0	value coded in BANKKR(GC-9) is n-value.	
		2	value coded in BANKKR(GC-9) is "Ks" for Strickler n-value equation.	
9	BANKKR	0,+	Hydraulic Roughness, Right Bank	
			If NEQRAM = 0	Code as Manning n-value.
			If NEQRAM = 2	Code the surface roughness, Ks-ft.
10	FIXBAM	+	Option to prescribe width for median position in Table of Stable Channel Dimensions. FIXBAM/10 = incremental width used in same table.	

ZW RECORD

The ZW Record assigns the Pathname for DSS. That name will be used to store and retrieve data from DSS. It is formed from 6 parts, A through F. Parts A and F can always be assigned by the user, and usually Part B. The output location for Parts A, B, and F in relation to the plot are shown below. If no ZW record is supplied, the optional pathnames default to blank. When a record is present, if it is not present and different in every job in a stacked input file, successive SAM.hyd runs will simply overwrite the values in the DSS file.

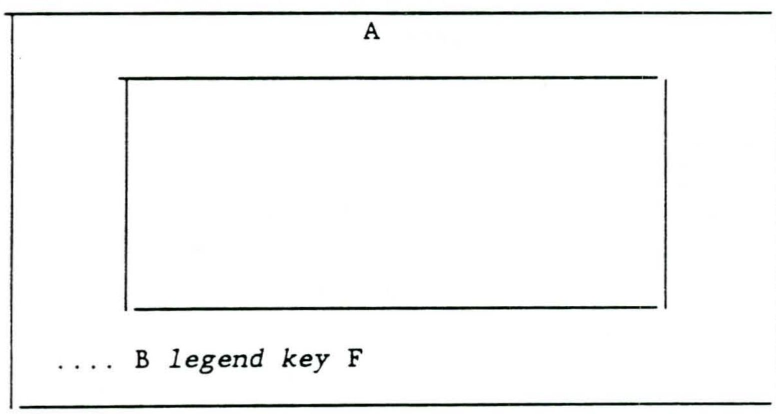
Although the record is explained on this standard format for input description, it is different from the other input records. The Pathname is made from 6 sub-strings, and each substring is separated with a "/" as shown in the following example. Always start with a / before Part A, and end with a / after Part F.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
ZW  /    A    /   B   /C/D/E/  F  /

ZW  /CLASS RIVER/TEST NO 1/C/D/E/RUN 1/
```

Field	Variable	Value	Description
0		ZW	Record Identification - Pathnames for DSS. **The names** can be up to 32 characters, but the **total pathname** must fit in 77 characters and be separated from the ZW by 1 blank. Parts C, D and E are assigned by SAM.hyd. Part B is assigned for stable channel calculations, and for cross section number.



$JOB RECORD

Jobs may be stacked one after the other by substituting the $JOB record for the $$END record at the end of each data set. Place the $$END after the last job in the stack. A stacked SAM.hyd data set will create a similarly stacked sed.in data file.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
$JOB
```

Field	Variable	Value	Description
0		$JOB	Record identification - NEW JOB.

$$END RECORD

This record signifies the end of the run.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
$$END
```

Field	Variable	Value	Description
0		$$END	Record identification - END OF RUN.

GENERAL NOTES

The following are conventions used in the record descriptions in this appendix.

al.@!	These characters in the "value" column means that any alpha or numeric characters can go in that field; generally it is a comment field.
b	This character in the "value" column indicates a blank field.

APPENDIX D: DATA RECORDS FOR SEDIMENT TRANSPORT FUNCTIONS

CONTENTS

TI RECORDS

Up to 10 title records are permitted.

Example:

```
TI    Use these title cards to define the job, the date, the Investigator, the
TI    model #, the data source, the purpose for this run, and changes from     TI    previous runs.
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
```

Field	Variable	Value	Description
0		TI	Card Identification in columns 1 and 2. Use TI for all records.

F# RECORDS

Marks each data field by column numbers, each field being 8 columns wide. There can be only 1 F# record.

Example:

```
TI    Title cards
TI    Title cards
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
```

Field	Variable	Value	Description
0		F#	Card Identification in columns 1 and 2.

TR RECORD

The TR-Record controls the printout.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
TRKSW(1)  KSW(2)  KSW(3) KSW(...)

TR     -1
```

Field	Variable	Value	Description
0		TR	Record Identification - TRace printout.
1	KSW(1)	-1	Causes only the Summary Table to be sent to the default output file.

TF RECORD

There are a series of TF-records, each representing a transport function option. Each TF record in the data set has either a YES or a NO in a column after the function names. The YES signals the program to calculate the sediment transport using that function; a no leaves that function off. Only those functions being used are required in the data set, Laursen (Madden), 1985 defaults to YES when sed.in is written by SAM.hyd. There can be up to 17 TF-records, as follows. Be sure that the "Y" of YES is in column 25, and that the "N" of NO is in column 26.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678

TF TOFFALETI.            NO
TF YANG.                 NO
TF ACKER-WHITE.          NO
TF COLBY                 NO
TF TOFFALETI-SCHOKLITSC  NO
TF MPM(1948).            NO
TF BROWNLIE,D50          NO
TF TOFFALETI-MPM         NO
TF LAURSEN(MADDEN),1985 YES
TF LAURSEN(COPELAND)     NO
TF YANG,D50              NO
TF ACKER-WHITE,D50       NO
TF MPM(1948),D50         NO
```

Field	Variable	Value	Description
0	-	TF	Record Identification - Transport Function [This name is 21 columns long and must match one in the above example in every detail--spelling, parentheses, dashes, periods and spaces.]
	YANG	YES	Transport function turned on
		NO	Transport function turned off

SG RECORD

The SG record allows user to prescribe the specific gravity of sediment particles. Some functions do not permit changing the specific gravity. Omit this record if default value is used. There can be only one SG-record.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
SG  SPGS

SG   2.0
```

Field	Variable	Value	Description
0		SG	Record Identification - Specific Gravity
1	SPGS	+	Specific Gravity of Inflowing Sediment
		b	Default - 2.65.

VE RECORD

The VE record prescribes the water velocity for up to 10 discharges. There can be only one VE-record.

For the VE, DE, WI, QW, ES, and WT records, each field represents one set of test conditions. For example, the data in the first field of these 6 records contains the hydraulic input for the first discharge; the data in the 2nd field for the second discharge etc, up to a maximum of 10 discharges. Missing data will be filled in by the program at execution time, using the rule VELA(N) = VELA(N-1).

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678  2345678
VE VELA1   VELA2   VELA3   VELA4   VELA5    ... up to 10 ...

VE  1.19    2.89    5.17    6.55    8.42
```

Field	Variable	Value	Description
0	-	VE	Record Description - Velocity, Water
1	VELA(1)	+	Enter Water Velocity in fps
2-10	VELA(2) - VELA(10)	+	Up to 10 Velocities may be entered

DE RECORD

The DE record prescribes the effective depth. There can be only one DE-record. The depths will be paired with data on the VE, WI, QW, ES, and WT records. Missing data will be filled in by the program at execution time using the rule, EFDA(N) = EFDA(N-1).

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678  2345678
DE EFDA1    EFDA2    EDFA3    EDFA4    EDFA5   ... up to 10

DE   .82     3.11     7.50    10.71    15.66
```

Field	Variable	Value	Description
0	-	DE	Record Identification = Depth, hydraulic
1	EFDA(1)	+	Enter effective depth, ft
2-10	EFDA(2)-EFDA(10)	+	Up to 10 depths may be entered

WI RECORD

The WI record prescribes the effective width, in feet. The width will be paired with data on the VE, DE, QW, ES, and WT records. Missing data will be filled in by the program at execution time using the rule, EFWA(N) = EFWA(N-1).

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678  2345678
WI EFWA1   EFWA2   EFWA3   EFWA4   EFWA5  ... up to 10

WT  103.    111.    129.    143.    152.
```

Field	Variable	Value	Description
Ø	-	WI	Record Identification - Top Width
1	EFWA(1)	+	Enter Top Width, ft
2-10	EFWA(2)- EFWA(10)	+	Up to 10 Top widths may be entered

QW RECORD

The QW record prescribes the discharge, in cfs. There can be only one QW-record The discharges will be paired with data on the VE, WI, DE, ES and WT records. Missing data will be filled in by the program at execution time using the rule, Q(N) = Q(N-1).

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
QW   Q1      Q2      Q3      Q4      Q5   ... up to 10

QW  100    1000    5000   10000   20000
```

Field	Variable	Value	Description
0	-	QW	Record Identification - Water Discharge
1	Q(1)	+	Enter discharge in cfs
2-10	Q(2)-Q(10)	+	Up to 10 discharges may be entered

ES RECORD

This record prescribes the energy slope, in ft/ft. A slope is needed for each Q(i) on the QW-RECORD, but the program will fill in missing values using the rule, S(N) = S(N-1). There can be only 1 ES record.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678  2345678
ES  S(1)    S(2)    S(3)  S(...)

ES284E-6 .000174 .000170
```

Field	Variable	Value	Description
0		ES	Record identification = Energy Slope
1	ESA(1)	+	Energy slope corresponding with Q(1). If field width does not permit sufficient accuracy, code in scientific notation as shown above. If 3 sigificant digits do not provide sufficient accuracy, code a dummy Q in the first field and begin the real problem in field 2.
2-10	ESA(2)-ESA(10)	+	The slope can change with each Q on the QW-record. However, the program will fill in missing values using the rule, ES(I) = ES(I-1), so only those which change must be coded.

WT RECORD

This record is used to prescribe the water temperature, degrees Fahrenheit. There can be only 1 WT record.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678  2345678
WT WT(1)   WT(2)   WT(3) WT(...)

WT    55      60      75
```

Field	Variable	Value	Description
0		WT	Record identification = Water Temperature.
1	WT(1)	+ b	Water temperature for Q(1). Default = 60.
2-10	WT(2)-WT(10)	+	A water temperature is needed for each water discharge, but only those values which change must be coded. The program will supply missing values using the rule: WT(I) = WT(I-1).

PF RECORD

This record prescribes the gradation of the bed sediment reservoir at a cross section. Code Continuation records as PFC-record. It is not necessary that a PF-coordinate correspond to a class interval boundary - although it can. Otherwise, semi-log interpolation is used to calculate the percent finer at each class interval boundary and these are subtracted to calculate the fraction of sediment in each size class. The program assigns a percent finer = 100 to correspond with DMAX. There can be up to 16 data points, 4 PF records.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678  2345678
PF |cmt|     ASN     SAE    DMAX   DAXIS   PFXIS   DAXIS   PFXIS DAXIS..etc
PF         308.0     1.0   18.29    9.14    95.0     1.0    94.2       .5     78.0

PFC  .25    46.7    .125    14.3   .0625     9.9    .004     4.9
```

Field	Variable	Value	Description
0	ICG,IDT	PF	Record Identification = Percent Finer
		PFC	Record Identification = Continuation record
1	ISI	al.@!	Comment field for PF record; BUT for PFC-records - see example above.
	DAXIS	+	Code the particle diameter, mm, here on continuation records.
2	RMILE	-,0,+	Identifier of this Cross Section (ie, River Mile)
3	SAE	b	SAE is not needed for this code, but it is provided for compatibility with HEC-6.
4	DMAX	+	The diameter of the maximum particle size,in MM.
		b	Not allowed -- ALWAYS code a value.
5	DAXIS(2)	+	This is the first co-ordinate point down the percent finer curve from DMAX. If this particle size is larger than 64MM, choose a point that will approximate the PF-Curve with 2-straight line segments from DMAX to 64MM.
6	PFXIS(2)	0,+	The percent finer corresponding to DAXIS(2). Code as a percent.

Field	Variable	Value	Description
7	DAXIS(3)	0,+	Continue to code points from the percent finer curve. Up to 16, including the DMAX point, are permitted. Use a continuation record when coding more than 4 points.

KL RECORD

The KL record provides an option to prescribe the hydraulic roughness for the left bank for up to 10 discharges. This record is needed only if the Brownlie sediment transport function is specified on the TF-records. This data will be paired with the VE, DE, WI, QW, ES and WT data.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678  2345678
KL  HRL1    HRL2    HRL3    HRL4    HRL5  ... up to 10

KL          .002    .05
```

Field	Variable	Value	Description
0	-	KL	Record Identification - Hydraulic Roughness, Left Bank
1	HRL(1)	+	Enter Roughness, in ft
2-10	HRL(2)-HRL(10)	+	Up to 10 Roughness values may be prescribed

KR RECORD

The KR record provides an option to prescribe the hydraulic roughness for the right bank for up to 10 discharges. This record is needed only if the Brownlie sediment transport function is specified on the TF-records. This data will be paired with the VE, DE, WI, Q, ES and WT data.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
KR  HRR1    HRR2    HRR3    HRR4    HRR5   ... up to 10

KR          .002     .05
```

Field	Variable	Value	Description
0	-	KR	Record Identification - Hydraulic Roughness, Right Bank
1	HRR(1)	+	Enter Roughness, in ft
2-10	HRR(2)-HRR(10)	+	Up to 10 Roughness values may be prescribed

ZW RECORD

The ZW Record assigns the Pathname for DSS. That name will be used to store and retrieve data from DSS. It is formed from 6 parts, A through F. Parts A and F can always be assigned by the user, and usually Part B. The output location for Parts A, B, and F in relation to the plot are shown below. If no ZW record is supplied, the optional pathnames default to blank. When a record is present, if it is not present and different in every job in a stacked input file, successive SAM.sed runs will simply overwrite the values in the DSS file.

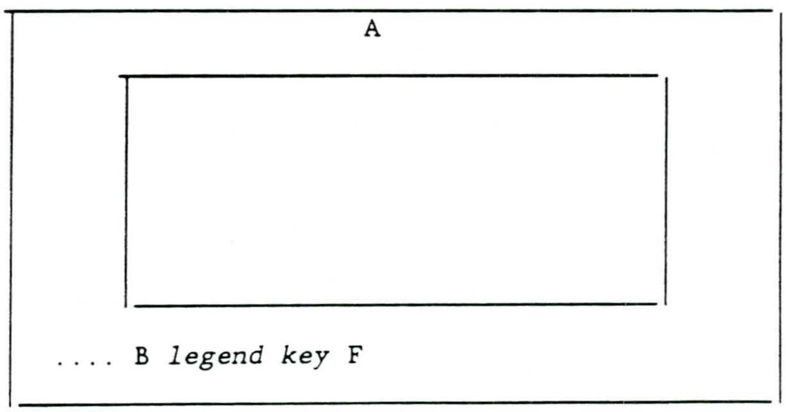
Although the record is explained on this standard format for input description, it is different from the other input records. The Pathname is made from 6 sub-strings, and each substring is separated with a "/" as shown in the following example. Always start with a / before Part A, and end with a / after Part F.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
ZW  /     A     /    B    /C/D/E/  F  /

ZW  /CLASS RIVER/LAURSEN(COPELAND)/C/D/E/RUN 1/
```

Field	Variable	Value	Description
0		ZW	Record Identification - Pathnames for DSS. The names can be up to 32 characters, but the total pathname must fit in 77 characters and be separated from the ZW by 1 blank. Parts C, D and E are assigned by SAM.sed. Part B is assigned the transport function used.



$JOB RECORD

Jobs may be stacked one after the other by substituting the $JOB record for the $$END record at the end of each data set. Place the $$END after the last job in the stack. A stacked SAM.sed data set will create a stacked yld.in data file.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
$JOB
```

Field	Variable	Value	Description
0		$JOB	Record identification - NEW JOB

$$END RECORD

This record signifies the end of the run.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
$$END
```

Field	Variable	Value	Description
0		$$END	Record identification - END OF RUN.

GENERAL NOTES

The following are conventions used in the record descriptions in this appendix.

al.@!	These characters in the "value" column means that any alpha or numeric characters can go in that field; generally it is a comment field.
b	This character in the "value" column indicates a blank field.

APPENDIX E: DATA RECORDS FOR SEDIMENT YIELD CALCULATIONS

CONTENTS

TI RECORDS

Up to 10 title records are permitted.

Example:

```
TI    Use these title cards to define the job, the date, the Investigator, the
TI    model #, the data source, the purpose for this run, and changes from      TI    previous runs.
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
```

Field	Variable	Value	Description
0		TI	Card Identification in columns 1 and 2. Use TI for all records.

F# RECORDS

Marks each data field by column numbers, each field being 8 columns wide. There can be only 1 F# record.

Example:

```
TI    Title cards
TI    Title cards
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
```

Field	Variable	Value	Description
0		F#	Card Identification in columns 1 and 2.

JP RECORD

The JP-record provides basic options for yield calculations. There can be only 1 JP-record

Example:
The following example shows typical input specifying 20 intervals for output display. The time step for a hydrograph is 5 minutes, or 0.083 hours. For all other fields the defaults are accepted, as indicated by the blank fields.

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
JP NCLCD    IFMT     NIS     RWY    YEAR     PER     UWD

JP                                       .083
```

Field	Variable	Value	Description
0		JP	Record Identification
1	NCLCD	+	Number of class intervals to use for displaying results.
		b	default = 20
2	IFMT	+	Format of input.
		b,1	Input described in these instructions.
3	NIS	+	Number of integration steps for Flow-Duration Option.
		b	default = 365 max = 2000.
4	RWY	+	Ratio to multiply times the water discharge to scale water yield value.
		b	default = 1.
5	YEAR	b,+	Time period represented by the flow duration curve in days. Usually the curve represents a year so the program defaults to 365 days. In some cases a curve may represent a day, a month or a single event in which case that number of days should be coded here.
		b	default = 365

Field	Variable	Value	Description
6	PER	+	Time between hydrograph ordinates, in hours, when using the hydrograph option.
		b	default = 24.
7	UWD	+	Specific Weight of sediment in pounds/cubic foot.
		b	default = 93.

QQ RECORD

The QQ record is the listing of all discharges, Q, to be used for this run. There can be a maximum of 10 QQ-records. Each Q will be paired with a duration, from the QD record.

Example.
The following example shows typical input specifying 21 different Q's.

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
QQ FLOW1    FLOW2    FLOW3    FLOW4    FLOW5  ... up to 2000

QQ    15      326      633      939     1244     1550     1856     2162     2469     2774
QQ  3080     3386     3692     3998     4304     4610     4916     5222     5528     5834
QQ  6140
```

Field	Variable	Value	Description
0		QQ	Record Identification - Dishcarge list
1	FLOW(1)	+	First discharge
2-10	FLOW(2) - FLOW(10)	+	Continue coding discharges, 10 per record.

QD RECORD

The QD record is the listing of the percent of time, QD, the corresponding discharge on the QQ record is equaled or exceeded. Durations do not have to be at a constant interval, and can be in increasing or decreasing order. There can be a maximum of 10 QD-records.

Example.
The following example shows typical input specifying 21 different QD's.

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
QD  DUR1    DUR2    DUR3    DUR4    DUR5   ... up to 2000

QD 100.0   44.37    14.5    6.49    3.52    2.16    1.34     .83    0.52     0.36
QD  0.26    0.18    0.12    0.08    0.08    0.05    0.05    0.05    0.05     0.01
QD  0.0
```

Field	Variable	Value	Description
0		QD	Record Identification - Discharge duration
1	DUR(1)	+	Duration for 1st discharge,
2-10	DUR(2) - DUR(10)	+	Continue coding durations, 1 for each discharge, maximum of 10 per record.

QH RECORD

The QH record is the listing of the water discharge, in cfs, by the hydrograph ordinate. There can be a maximum of 25 QH-records.

Example.
The following example shows typical input specifying 4 different QH's.

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678  2345678
QH FLOH1   FLOH2   FLOH3   FLOH4   FLOH5   ... up to 2000

QH      1     300    1300    7000
```

Field	Variable	Value	Description
0		QH	Record Identification - Discharge -- hydrograph.
1	FLOH(1)	+	Hydrograph ordinate for flow 1, cfs.
2-10	FLOH(2) - FLOH(10)	+	Hydrograph ordinate for each flow, maximum of 10 per record.

QW RECORD

The QW record is the listing of the water discharge in cfs, and will be paired with a sediment discharge from the QS or SC record. The water discharges must be in increasing order, and there can be up to 10 values. Each QW field corresponds to exactly one QW field so the two records must be in the same order. There can be only 1 QW-record.

Example.
The following example shows typical input specifying 4 different QW's.

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678  2345678
QW    Q1      Q2      Q3      Q4      Q5     ... up to 10

QW     1     300    1300    7000
```

Field	Variable	Value	Description
0		QW	Record Identification - Discharge -- water.
1	Q(1)	+	1st discharges cfs.
2-10	Q(2) - Q(10)	+	List each water discharge, in cfs; maximum of 10 per record.

QS RECORD

The QS record is the listing of the sediment discharge in tons per day, and will be paired with a water discharge from the QW record. Each QS field corresponds to exactly one QW field so the two records must be in the same order. There can be only 1 QS-record.

Example.
The following example shows typical input specifying 4 different QS's.

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
QS  QSR1    QSR2    QSR3    QSR4    QSR5    ... up to 10

QS     1     300    1300    7000
```

Field	Variable	Value	Description
0		QS	Record Identification - Discharge -- sediment.
1	QSR(1)	+	First sediment discharge, in tons per day.
2-10	QSR(2) - QSR(10)	+	Continue coding sediment discharge, 1 for each water discharge, maximum of 10 per record.

SC RECORD

The SC record is the listing of the sediment concentration in mg/l, and will be paired with a water discharge in cfs from the QW record. There can be only 1 SC-record. The SC record must follow the QW record in the data file.

Example.
The following example shows typical input specifying 4 different SC's.

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678  2345678
SC  QSR1    QSR2    QSR3    QSR4    QSR5    QSR6    QSR7    QSR8    QSR9    QSR10

SC     1       5      13      60
```

Field	Variable	Value	Description
0		SC	Record Identification - Sediment Concentration
1-10	QSR(1)- QSR(10)	+	List each sediment concentration in mg/l; maximum of 10 per record.

FD RECORD

This record is not part of the standard SAM.yld input file; rather it belongs in the Flow Duration and Hydrograph Data File (see the SAM manual, section 4.4). The default name for this file is CDFFIL. With this format, the first record in the file contains only the number of points in the file. Subsequent records are DURATION in % and Q in CFS. The following example shows column numbers, but this line must not be in the file. Each FD record must be set up with FD in the first two columns, the first number ending in column 11, and the second number, if there is one, ending in column 28.

```
          DUR            Q       = VARIABLES      DO NOT CODE THIS LINE
           %            CFS                       DO NOT CODE THIS LINE
1234567890 234567890 234567890   = COLUMN #       DO NOT CODE THIS LINE

FD          5                                     (THIS SHOULD BE THE 1ST LINE)
FD        100              100.
FD         10              500.
FD          5             1000.
FD          1            10000.
FD       .001            15000.
```

$JOB RECORD

For stacked runs, the $JOB record indicates the end of one job--the start of a new input data set.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678  2345678
$JOB
```

Field	Variable	Value	Description
0		$JOB	Record identification - NEW JOB

$$END RECORD

This record signifies the end of the run.

Example:

```
F# 45678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678  2345678
$$END
```

Field	Variable	Value	Description
0		$$END	Record identification - END OF RUN.

GENERAL NOTES

The following are conventions used in the record descriptions in this appendix.

a1.@!	These characters in the "value" column means that any alpha or numeric characters can go in that field; generally it is a comment field.
b	This character in the "value" column indicates a blank field.

APPENDIX F
SAM MENU

F-1. Description. SAM is most conveniently run through the SAM menu, Figure F2, which will appear by typing: **SAM**. The several options on each screen of the menu can be run by moving the cursor, or highlighted bar, to the desired option and hitting enter, or simply by typing the number of the option. There is an escape to DOS on each screen. The F9 key, page up and page down keys, and the left and right arrow keys all toggle between screens. The H key displays the menu-Help. All options return the user to the menu when their respective programs are through executing. When the cursor sits on an item in the menu, a descriptive prompt for that item appears at the bottom of the menu list. Menu 1 is shown in Figure F2, and Menu 2 is in Figure F4. The prompts and their respective menu items are listed in Figures F3 and F5. Figure F1 shows the DOS Utility menu, from option 6 on Menu 2 (Figure F4).

F-2. Use. The SAM menu provides smooth manipulation of the calculating programs, the graphics and the utilities. If **C:\SAMEXE**, C:\HECEXE, and C:\FSS are placed in the path in the autoexec.bat file, then the SAM menu, and SAM, can be run from any subdirectory simply by typing SAM.

F-2.1. Menu 1. The SAM.hyd, SAM.sed, and SAM.yld options each execute a batch file that runs the respective calculation program and prepares a data file for the DSS graphics, except that SAM.yld does not utilize graphics. The Plot option loads the drivers and DSPLAY, with HYD.DSS as the default file opened. When this option is exited, the drivers are removed from memory so they do not needlessly occupy space on the PC. **NOTE:** if the PC gives a message about GSS not being the last driver loaded and creating holes that DOS could not fix, turn off the machine and start again. Option 5 runs the PSAM program which provides for the making of SAM input files via a series of menus. Option 6 executes a batch file that runs the SAM.m95 program and prepares a data file for the DSS graphics. The LIST option will prompt for the filename to open, and then run in the standard manner.

F-2.2. Menu 2. To access the second screen of the SAM menu, hit F9, page up, page down or the left or right arrow key. The COED option will prompt for the filename to open and then run in the standard manner. SAM.aid runs the guidance program. The Particle Fall Velocity option runs Corps Program H0910. It has no graphics associated with it. HEC2, if installed, can also be run without leaving this menu system. This option gives temporary control to the HEC MENU2 batch file. The DOS Utilities option will execute several DOS commands without leaving the SAM program. When this option is selected, a menu appears offering the DOS commands shown in Figure F1. Each of theses options prompt for the necessary parameters. ENDOW calls the Environmental Design of Waterways program. It is not shipped with SAM; see paragraph F-4.

F-2.3. Exiting. The EXIT TO DOS option, last on both screens, returns the user to the DOS prompt. At this point various working files will be erased in an effort to maintain effective usage of disk space. The files erased are:

TAPE96, TAPE97, TAPE98, HYD.DSC and SCRATCH.*, all of which are associated with generating the DSS files; and REREAD, which is used by all three SAM modules. If the user is familiar with DSS and wishes to look at the SCRATCH files, this can be done with list before exiting the SAM menu.

F-3. Background. The batch file containing the menu commands is SAM.MDF. It is based on Automenu Software Management System, a copyrighted software of Magee Enterprises. The files AUTOMAKE.EXE and AUTOTEMP.BAT are necessary for proper running of the SAM menu.

> NOTE: If any of the executable programs in this package are run without going through the SAM menu, the screen display may look different.

F-4. Notice. Several programs listed on the menu are not sent with the SAM package. HEC2, LIST and COED, and HECDSS and the GSS drivers are all shipped by HEC. Their phone number is (916)756-1104 and their address is:

Department of the Army
Hydrologic Engineering Center, Corps of Engineers
609 Second Street
Davis, CA 95616-4687.

ENDOW is available from the Engineering Computer Programs Library, WES, (601) 634-2581. Questions regarding ENDOW may be directed to Mr. Jerry L. Miller, CEWES-EE-R, (601) 634-3931.

Figure F1. Menu Screen for Menu 2, Option 6: DOS Utilities.

Figure F2. Menu 1 Screen for SAM.

1 - SAM.hyd Hydraulic Calculations
  Calculate Hydraulic Parameters

2 - SAM.sed Sediment Transport Calculations
  Calculate Bed Material Discharge--Multi-Function

3 - SAM.yld Sediment Yield Calculations
  Calculate Sediment Yield

4 - Plot Hydraulic and Sediment Calculations from SAM
  Run DSPLAY Program to Plot SAM Calculations

5 - PSAM Prepare SAM.hyd Input Files
  Menu-Driven - For Selected SAM.hyd Options

6 - SAM.m95 Use TAPE95 to prepare SAM.sed Input File
  Calculate Reach Averages from HEC-2's TAPE95

7 - LIST
  Look at a File using LIST

8 - EXIT TO DOS
  EXIT -- Erase Scratch Files -- Return to DOS

Figure F3. SAM menu items and their descriptive prompts, Menu 1 of 2.

Figure F4. Menu 2 Screen for SAM.

1 - COED
    Edit a File using COED

2 - SAM.aid Guidance in Transport Function Selection
    Aid Selecting Best Sediment Transport Functions

3 - Particle Fall Velocity
    Particle Fall Velocity Corps Program H0910

4 - HEC2
    Run HEC2

5 - DOS UTILITIES
    Delete, Rename, Copy ...

6 - ENDOW
    ENvironmental Design Of Waterways program

7 - EXIT TO DOS
    EXIT -- Erase Scratch Files -- Return to DOS

Figure F5. SAM menu items and their descriptive prompts, Menu 2 of 2.

APPENDIX G -- PSAM

PROGRAM OF MENUS FOR CREATING SAM INPUT FILES

G-1.1 Purpose. PSAM is a series of menus, or input screens, for creating input files for the three main SAM modules, SAM.hyd, SAM.sed, and SAM.yld. PSAM aids in the creation of input files in that it does not require that the user count columns or fields, or know exactly which records are needed for which calculations.

This appendix describes each screen and correlates the data input to fields on the respective record. Each different screen in the program is shown, with no duplication of screens. However, the description of each option will list all the screens used in that option. Table G1 is an index showing each record/screen described and its figure and section numbers. Table G2 is an index showing where each option in PSAM is discussed.

Table G1. Record/Screen Index

Figure Number	Record/description	Appendix G Section number
G1	Main Menu	2.1
G2	SAM.hyd options	3.1
G3	TI	3.2.1
G4	RS	3.2.2
G5	RR	3.2.3
G6	TR	3.3.2
G7	Geometry Option	3.3.3
G8	CT	3.3.4
G9	X1	3.3.5.1
G10	GR	3.3.5.2
G11	NE/KS	3.3.5.3
G12	PF	3.3.7
G13	QW multiple record	3.3.8
G14	RT	3.3.9
G15	ZW	3.3.10
G16	GC	3.6.2
G17	CT, modified	3.6.3
G18	ES/WT	3.6.4
G19	TF	4.3
G20	VE multiple record	4.4
G21	KL/KR	4.6
G22	SAM.yld methods	5.
G23	JP - flow duration	5.1.1
G24	QQ/QD	5.1.2
G25	QW/QS	5.1.3
G26	QW/SC	5.2.1
G27	JP - flow hydrograph	5.3.1
G28	QH	5.3.2

G-1.2 <u>Conventions.</u> The following general directions and conventions are vital to understanding how to use PSAM:

- o The user must always input a filename under which to save the created data file. There are no default filenames in PSAM.
- o Accepted default values are not printed to the file. Sometimes this results in an entire record not printing to the data file.
- o When inputting slopes, input the horizontal component of the "1V on xH" notation.
- o For all data entry screens, the up and down arrow keys will move the cursor between various input blocks. The left and right arrow keys move the cursor within one input block. Note that data entered into a block will be saved only if the block is exited via a return, or <enter>. If an arrow key is used to exit a block, data newly entered into that block will be lost.
- o For most data entry screens, the lower left corner shows which record(s) the data on that screen will go into.
- o Within a calculation option, the user can back up to a screen by using "page up"; also, when all screens have been accessed, PSAM cycles back through all screens.

G-2.1 <u>Main Menu.</u> Figure G1 is the PSAM Main Menu. To select an option the user can either scroll up or down with the arrow keys and then hit return, or simply type the number of the desired option.

Options 1, 2, and 3 will bring up the first menu of choices for the respective SAM module.

Option 4 clears PSAM of a previous data set so that the input screens will not contain any data. This is necessary only when one data set has either been loaded or created and the user wishes to start from scratch again.

Option 5 reads an existing file, notifies the user that this has been accomplished and returns the cursor to Option 1. If a data file has been read in this manner, that file's data will appear in the appropriate places in the menus.

Options 6 and 7 will both prompt for the filename under which to save the input data. However, Option 6 returns the cursor to Option 1 while Option 7 takes the user back to the SAM menu. F10 will also prompt for a filename under which to save the input data and then return the user to the SAM menu.

Option 8 returns the user to the SAM menu without saving any data.

```
                        PSAM                        Version 3.05
                      Main Menu
----------------------------------------------------------------

          1. Hydraulic Function Input
          2. Sediment Transport Input
          3. Sediment Yield Input

          4. Reset PSAM for New Data
          5. Read Existing Data File
          6. Save Data to File

          7. Exit (Saves Data File)
          8. Quit (Does Not Save Data)

----------------------------------------------------------------
  Scroll up/down then <CR> to select , or
  Type the number to select                          F10 - Exit
```

Figure G1. PSAM Main Menu.

G-3.1 <u>PSAM Main Menu Option 1 -- SAM.hyd input options.</u> Figure G2 shows the SAM design routines menu which provides access to the different types of data sets available to be created for SAM.hyd. Table G2 lists each of the available SAM.hyd calculation options and its corresponding section in the manual.

```
                       SAM Design Routines
----------------------------------------------------------------

 ->  1. RS - Riprap Size for Known Velocity & Depth
     2. RD - Riprap Size for Known Discharge & Geometry
     3.    - Add Options to Existing Data Set
     4. ND - Normal Depth Calculations
     5. BW - Bottom Width, Fixed Bed Hydraulics
     6. SC - Stable Channel Dimensions by Copeland Method
     7. ES - Energy Slope Calculations
     8. KS - Bed Roughness Calculations
     9. QW - Discharge Calculations
    10. FD - Flow Distribution Calculations

----------------------------------------------------------------
  Arrow to Move Up and Down        Type <CR> or Number to Execute

  -> Last Item Executed                              F10 to Exit
```

Figure G2. SAM.hyd Option Menu.

G-3.1.1 <u>Choices for geometry and riprap options within SAM design routines.</u> There are two areas of choice which occur frequently in the SAM.hyd input options.

G-3.1.1.1 Geometry choices. There are two methods of prescribing the geometry: with a channel template, the CT option; or with elevation-station coordinates, the X1/GR option. The user will be presented with an option screen, see Figure G7, to make this choice. Each of these methods of inputting geometry has its own flow of screens. The CT option requires only the CT screen. The X1/GR option requires the X1, GR, and NE/KS screens. Whenever this choice is available, the user will select one option via a screen, and then only the necessary screens will appear.

G-3.1.1.2 Viewing the cross-section shape. After the geometry is input, from either method, the shape of the cross section can be plotted to the screen only. At the CT- or GR-record screen, the F1 key will bring up a black and white plot of the cross section, with a scale.

G-3.1.1.3. Riprap choices. The option which allows for the addition of riprap to an existing data set is Option 3 on the SAM.hyd menu, Figure G2. This option can also be used to create a data set, adding riprap at the same time. Options 1 and 2 will also calculate riprap.

Table G2. SAM.hyd options and Manual sections.

Option	Manual
1	2.11
2	2.12
3	(varied)
4	2.5
5	2.7
6	2.13
7	2.8
8	2.9
9	2.10
10	2.6

G-3.2. Option 1 -- Riprap size for known velocity and depth. This option corresponds to section 2.11 in the manual. The screens used in this option are the TI-records, the RS-record, and the RR-record.

G-3.2.1. TI-records screen. Figure G3 defines the title records. Enter up to 10 lines of title information in this block. It is not necessary to put the record identification, TI, in the first two columns as PSAM does that when writing into the data file. The F#-record (see Appendix C, D, or E) is automatically added after the title records as a guide to field length. This screen is similar for all design routines except that the second line of text beneath the window, line **A**, changes since it echoes the design option chosen from the menu in Figure G2.

```
                 You have selected
     RS - Riprap Size for Known Velocity & Depth

 ┌──────────────────Input Title Records──────────────────┐
 │                                                       │
 │                                                       │
 │                                                       │
 └───────────────────────────────────────────────────────┘


 Record: TI
 F1=Help   F10=Exit   <CR> Enter Value   PgUp   PgDn   Page  0/ 0
```

Figure G3. TI-records.

G-3.2.2 RS-record screen. Figure G4 defines the RS-record. Items **A**, **B**, **C**, **D**, and **E** correspond to fields 1, 2, 3, 4, and 5 of the RS-record.

```
 ┌──Riprap Design Parameters──────────────────────────────────────────┐
 │ Water velocity over toe of bank                 (ft) =  A          │
 │ Depth over toe of bank                          (ft) =  B          │
 │ Slope of revetted bank                      (1 V: H)=   C          │
 │ Water surface width if location is in bend  (ft) =  D              │
 │ Ratio of stone thickness to max. stone diameter =  E  (Default = 1)│
 └────────────────────────────────────────────────────────────────────┘


 Record: RS
 F1=Help   F10=Exit   <CR> Enter Value   PgUp   PgDn   Page  2/ 0
```

Figure G4. The RS-record.

G-3.2.3 RR-record screen. Figure G5 defines the RR-record. Items **A** and **B** correspond to fields 1 and 2 on the record. Field 3 of the RR-record is left blank. Items **C**, **D**, and **E** correspond to fields 4, 5, and 6, respectively.

```
Riprap Properties
Specific gravity of riprap                              =  A     (Default = 2.65)
Bend radius, to centerline of channel (ft)              =  B
Cross section shape (0-Natural, 1-Trapezoidal)          =  C     (Default = 0)
EM safety factor                                        =  D     (Default = 1.1)
EM coefficient of incipient failure                     =  E     (Default = 0.3)
```

```
Record: RR
F1=Help    F10=Exit    <CR> Enter Value    PgUp    PgDn    Page  3/ 0
```

Figure G5. The RR-record.

G-3.3.1 Option 2 -- Riprap Size for known discharge and geometry. This option corresponds to section 2.12 in the Manual. The screens in this option are the geometry option, TI-records, the TR-record, the geometry option and associated screens, the PF-record, the RR-record, the QW-multiple record screen, the RT-record(s), and the ZW-record.

G-3.3.2. TR-record. Figure G6 defines the TR-record, which governs program printout. It is an optional record; if the user "pages down" past this screen, there will be no extra printout. However, the user also has the option of selecting a compositing method and/or selecting to print the flow distribution. The arrow pointing to the "NO" flow distribution indicates that it is the default. The Alpha method is the default compositing method. The compositing methods available in SAM are discussed in the manual in section 2.5.4.

```
Compositing Method

--> Alpha Method
    Equal Velocity Method
    Total Force Method
    Coveyance Method
```

```
Print Flow Distribution

    YES
--> NO
```

Figure G6. TR-record.

G-3.3.3. Geometry option screen. Figure G7 shows the geometry option screen. Whichever choice the user makes will bring forward the necessary screens. These two options are described in the SAM manual, section 2.5.1. This screen appears in many SAM.hyd calculation options.

```
Geometry

--> Channel Template (CT)
    Cross Section Coordinates (X1/GR)
```

Figure G7. Geometry Option.

G-3.3.4. <u>CT geometry option.</u> This option allows for the specification of geometry through up to three channel templates, CT-records. Figure G8 defines a CT-record. Items **A**, **B**, **E**, **H**, **C**, and **D** correspond to fields 1 through 6 respectively. Item **F** goes in field 7, item **G** in field 8, item **I** in field 9, and item J in field 10. If multiple CT-records are used, the first prescribes the low-flow channel, the second the normal flow channel, and the third CT-record the high flow berm. The user may page down if multiple CT-records are not needed. If items **A** through **E** are filled in, items **F** through J will default (see Appendix C, CT-record).

```
Description of Channel Template                              | To view template
                                                             | Press F1
Bottom Width (ft)                A                           |
Bank Height  (ft)                B                           | Roughness Equations
                                                             |   Default = 0
                      LEFT BANK   BED    RIGHT BANK          |
Side Slope (1V: H)       E                   H               | 0 = n values
Roughness equation       F         C         I               | 1 = Moody Diagram
Roughness value          G         D         J               | 2 = Strickler
                                                             | 3 = Limerinos
                                                             | 4 = Brownlie
                                                             | 5 = Grass lining E
                                                             | 6 = Grass lining D
                                                             | 7 = Grass lining C
                                                             | 8 = Grass lining B
                                                             | 9 = Grass lining A

Record: CT
   F10=Exit      <CR> Enter Value      PgUp      PgDn      Page 3/ 0
```

Figure G8. The CT-record.

G-3.3.5. <u>X1/GR geometry option.</u> This option allows for the inputting of geometry through elevation-station pairs. It consists of the X1- and GR-records and the NE/KS screen.

G-3.3.5.1. <u>X1-record.</u> Figure G9 defines the X1-record. Items **A**, **B**, **C**, and **D** correspond to fields 1 through 4, respectively. Item **A** is only for user identification of the cross-section and is therefore optional. The number of coordinate points on the GR-record, item **B**, should be greater than 2 and less than 101. Items C and D, if input, must each equal one of the station values put in the next menu.

G-3.3.5.2. <u>GR-record.</u> Figure G10 defines the GR-record, the listing of elevations and station coordinates. Points can simply be typed inot the table and PSAM will calculate the number of points and insert that number into item B on the X1-record. For ease of input, PSAM offers the user a paired data input format.

```
Enter the number of points in the cross section
1 < Number of Points < 101

River mile =   A

Number of points in cross section =   B

Station of left bank of channel =   C

Station of right bank of channel =   D

Record: X1
F1=Help     F10=Exit     <CR> Enter Value     PgUp     PgDn     Page  0/ 0
```

Figure G9. The X1-record.

X,Y Coordinates of Channel Cross Section

Node	Elevation (Y)	Station (X)
1	12	-16.5
2	0	-16.5
3	-12	-16.5
4	-12	-2
5	-12	2
6	-12	16.5
7	0	16.5
8	12	16.5

Press F1 to display
Cross Section

(numbers input for example only)

```
Record: GR
F1=Help     F10=Exit     <CR> Enter Value     PgUp     PgDn     Page  4/ 0
```

Figure G10. The GR-record.

G-3.3.5.3. <u>NE/KS multiple record screen.</u> Figure G11 defines the NE- and KS-records. This data is put in by panels, i.e., a panel is the space between coordinate points, as described in the SAM manual Appendix C for these records. PSAM will request the number of data entries as determined by the input to the GR-record. Note that the elevation/station combination for each endpoint for each panel is listed on the left side of the screen.

Roughness Equations and Values

Panel	Elev	Sta	Elev	Sta	Roughness Equation	n-value or Ks in ft
	between					
1	12	-16.5	0	-16.5		
2	0	-16.5	-12	-16.5		
3	-12	-16.5	-12	-2		
4	-12	-2	-12	2		
5	-12	2	-12	16.5		
6	-12	16.5	0	16.5		
7	0	16.5	12	16.5		

(these numbers are for example only -- come from the GR screen, Fig. G10)

Roughness Equations
Default = 0

0= n-values
1= Moody Diagram
2= Strickler
3= Limerinos
4= Brownlie
5= Grass lining E
6= Grass lining D
7= Grass lining C
8= Grass lining B
9= Grass lining A

Records: NE & KS
F1=Help F10=Exit <CR> Enter Value PgUp PgDn Page 5/ 0

Figure G11. The NE- and KS-records.

G-3.3.6. <u>Return to non-geometry input.</u> The following screens appear regardless of the geometry option chosen.

G-3.3.7. <u>PF-record.</u> Figure G12 shows the PF-record screen. Item **A** is descriptive and optional and corresponds to field 1 of the PF-record. Item **B** goes in field 4. It **must** have a value, as noted. Items **C** and **D** go in fields 5 and 6 respectively. Lines 2 and 3 would fill out fields 7 through 10 of this record. Data entered, as pairs, on lines 4 through 18 would appear on PFC-records, in the same manner. Since this is paired data, PSAM offers the user a paired data input format.

G-3.3.8. <u>QW multiple record screen.</u> Figure G13 shows the screen which provides for the input to four records: the QW-, WS-, ES-, and WT-records. Put one "data set" per line; SAM allows up to 10 lines. It is necessary only to code values that change. For example, if the energy slope is constant for all Q's, the code only one value and SAM will fill in the rest. The same rules apply for all these data records. See Appendix C for the rules. The water temperature defaults to 60° F if there is no input. However, if a temperature is input, it remains the default for all the subsequent WT-values according to the same rule as for the other record types on this screen.

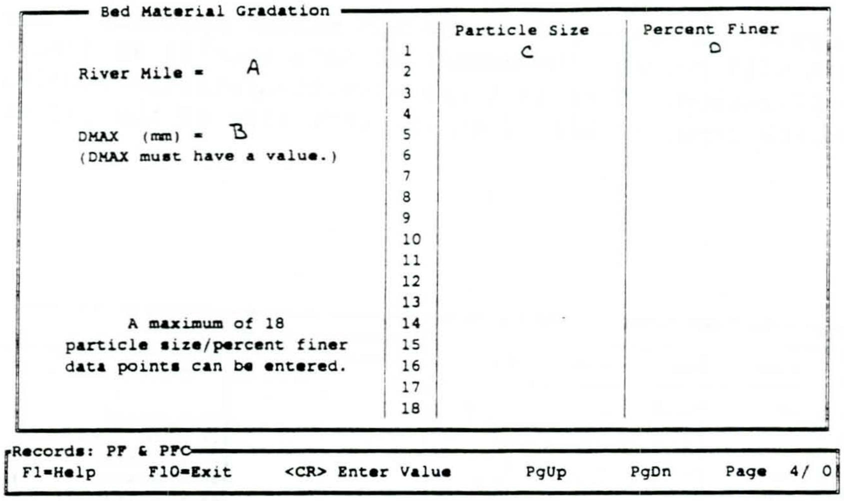


Figure G12. PF-record.

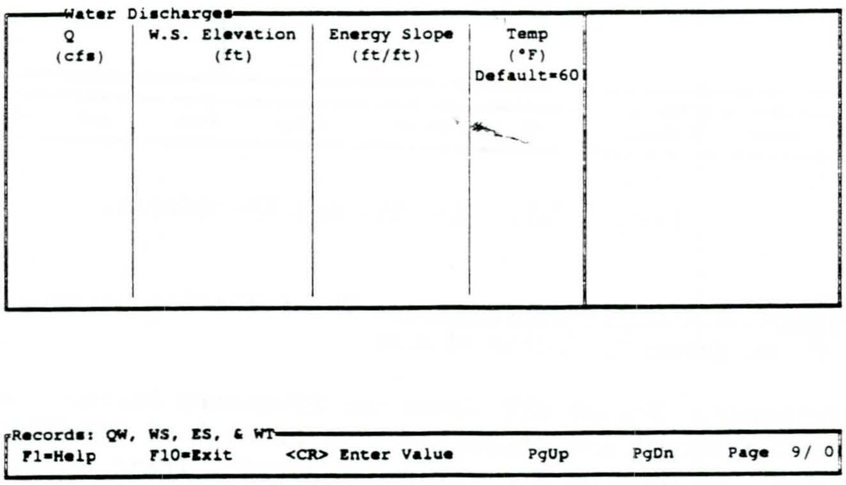


Figure G13. The QW multiple record screen.

G-3.3.9. RT-record. Figure G14 defines the RT-record. In Figure G14 the screen prompts for values for only 3 panels because for this example the geometry came from the CT-record. The first value is for the left overbank, the second is for the channel and the last is for the right overbank. However, if the geometry had come from the X1/GR option which had *x* number of panels, the RT-record would prompt for *x* values, defining those panels as for the NE/KS record.

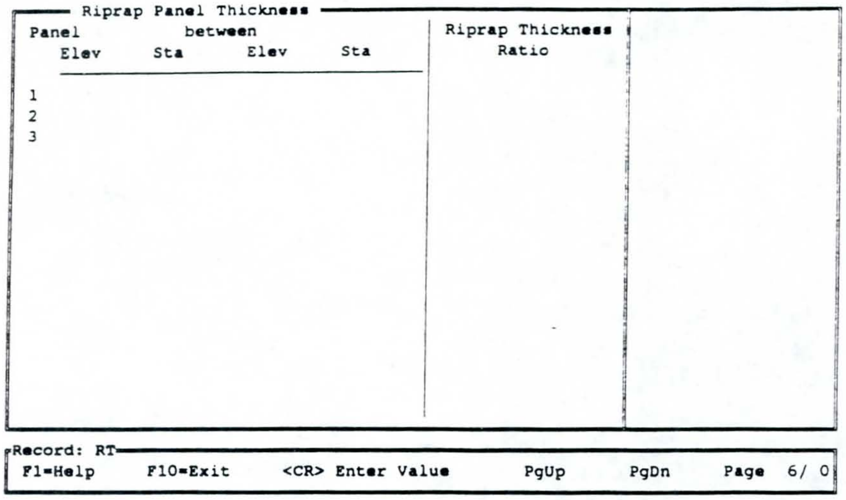


Figure G14. The RT-record.

G-3.3.10 <u>ZW-record.</u> Figure G15 shows the screen for the optional ZW-record. It is a schematic of the plot produced by DSS through the SAM menu. It allows the user to see where the descriptive data typed in would be printed on the plot. The "legend key" is set by the SAM package. This record appears in every data input option for which plotting is available. The designations "A", "B", and "F" in Figure G15 correspond to the data's position in the ZW-record.

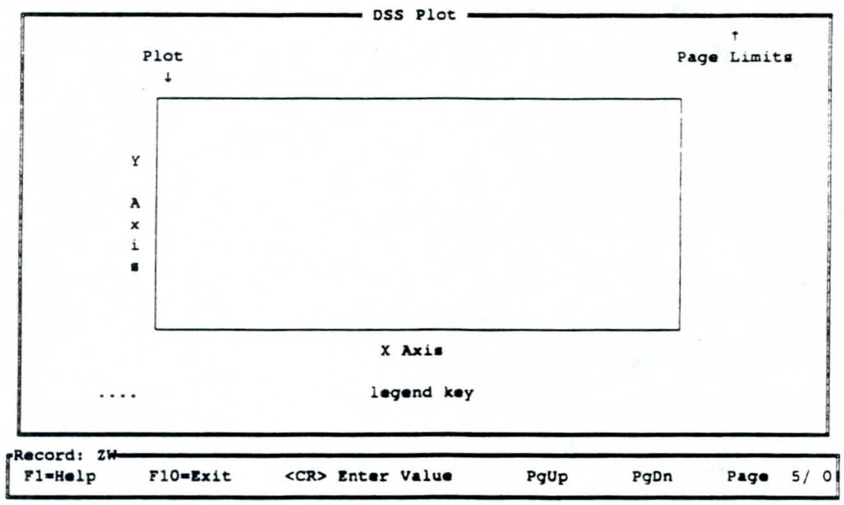


Figure G15. ZW-record.

G-3.4.1. <u>Option 4 -- normal depth calculations.</u> This option corresponds to section 2.5 in the Manual. The screens in this option are the TI- and TR-records, the geometry option, the geometry input, the QW multiple record screen, the PF- and ZW-records screens.

G-3.5.1. Option 5 -- bottom width calculations. This option corresponds to section 2.7 in the Manual. The screens in this option are the TI- and TR-records, the geometry option, the geometry input, the QW multiple record screen, the PF-record, the ZW-record, and the riprap choice screens. Note, however, that in order to allow SAM to calculate bottom width, item A, "Bottom Width," **must** be left blank on the CT-record, Figure G8. If multiple CT-records are used, item A **must** be left blank in all of them. This requirement dictates that the X1/GR geometry option is not suitable for this calculation.

G-3.6.1. Option 6 -- Stable Channel Dimensions by Copeland method. This option corresponds to section 2.13 in the Manual. The screens in this option are the TI-records, the GC-record, can include the geometry option and geometry input and associated screens, the ES/WT records and the ZW-record. The flow of screens used in this option depends on whether or not the inflowing sediment concentration is prescribed, as stated in Appendix C, on the GC-record. If the concentration is input by the user, the geometry option and the geometry input and associated screens will not appear.

G-3.6.2. Copeland's Analytical Channel Width Computation. This screen, Figure G16, defines the GC-record. Items **A** through **C** correspond with fields 1 through 3 of the GC-record. If item **B** is left blank, PSAM will return with the geometry option screens to allow the user to specify the supply reach geometry for the inflowing sediment concentration calculations. (The CT-record-screen in this case is different from that described earlier and is shown in Figure G17.) Item **D** corresponds with field 10, item **E** with field 4, H with field 5, and **F**, **G**, **I**, and **J** with fields 7 through 9, respectively.

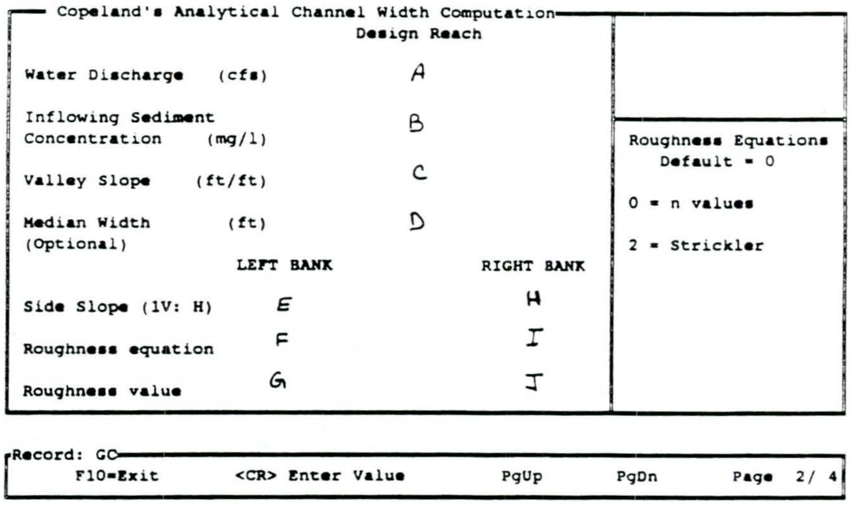


Figure G16. The GC-record screen.

G-3.6.3 Modified CT-record screen. When the inflowing sediment concentration is not specified on the GC-record, SAM.hyd expects the geometry of the supply reach in order to be able to calculate that concentration. In the calculations using the supply reach, the Brownlie equation is used for the bed, thus nullifying the need to input the bed equation and K_s on the CT-record. Therefore, these fields have been omitted from this screen in this application, Figure G-17.

```
---------- Description of Channel Template ----------
                 for Supply Reach
                                                        To view template
Bottom Width  (ft)                   000000                 Press F1

Bank Height   (ft)                   00000000
                                                        Roughness Equations
                                                           Default = 0
                        LEFT BANK           RIGHT BANK
                                                        0 = n values
Side Slope (1V: H)      00000000            00000000
                                                        2 = Strickler
Roughness equation      00000000            00000000

Roughness value         0000000.            00000000

Record: CT
 F1=Help    F10=Exit    <CR> Enter Value    PgUp    PgDn    Page  5/ 4
```

Figure G-17. Modified CT-record for the GC-option.

G-3.6.4 <u>ES/WT multiple record screen</u> This screen, Figure G18, is a subset of the QW multiple record screen. It defines the ES- and WT-records. The same rules apply as described for the QW multiple record screen.

```
-------ES and Temp Record-------
 Energy Slope  | Temperature |
   (ft/ft)     |    (°F)     |
               | Default = 60|

 .0038         | 55          |

The 1st ES value will keep only 3 non-zero digits,
   i.e. 0.012345 will be truncated to 0.0123

Records: ES & WT
 F1=Help    F10=Exit    <CR> Enter Value    PgUp    PgDn    Page  5/ 4
```

Figure G18. The ES- and WT-records.

G-3.7.1. Option 7 -- Energy slope calculations. This option corresponds to section 2.8 in the Manual. The screens in this option are the TI- and TR-records, the geometry option and input, the QW multiple record screen, and the PF- and ZW-records. Note, however, that in order to allow SAM to calculate energy slope, the "Energy Slope" column of the QW multiple record screen, Figure G13, must be left blank.

G-3.8.1. Option 8 -- Hydraulic roughness calculations. This option corresponds to section 2.9 in the Manual. The screens in this option are the TI- and TR-records, the geometry option and input, the QW multiple record screen, and the PF- and ZW-records. SAM looks at the KN- and/or KS-records to determine if roughness calculations are desired. Figure G11 lists the possible roughness equations. Equation numbers 3 through 9 can be used in some panels, but to calculate a hydraulic roughness some panels must have equation numbers 0, 1, or 2. The KS- or KN-records must contain a negative value in each panel where the roughness is to be calculated. If that value is -1, that panel is weighted as equal to the cross section average; a value of -0.5 weights that panel at 50% of the cross section's average, etc.

G-3.9.1. Option 9 -- Discharge calculations. This option corresponds to section 2.10 in the Manual. The screens in this option are the TI- and TR-records, the geometry option and input, the QW multiple record screen, and the PF- and ZW-records. Note, however, that in order to allow SAM to calculate the discharge, the "Q" column of the QW multiple record screen, Figure G13, must be left blank.

G-3.10.1. Option 10 -- Flow distribution calculations. This option corresponds to section 2.6 in the Manual. The screens in this option are the TI- and TR-records, the geometry option and input, the QW multiple record screen, and the PF- and ZW-records. If all requested data is supplied, SAM automatically calculates the flow distribution. However, these calculations can be requested in any calculation via the TR-record, Figure G6.

G-4.1. SAM.sed input options. This option, number 2 on the PSAM main menu as shown in Figure G1, corresponds to section 3 in the Manual. The screens used in this option are the TI- and TF-records, the VE multiple record screen, and the PF-, KL/KR- and ZW-records.

G-4.2. TI-records. The title data and screen, the TI-records, for SAM.sed are the same as those for SAM.hyd, see section 3.2.1.

G-4.3. TF-records screen. Figure G19 defines the TF-records which are described in section 3.2 in the Manual. The up and down arrow keys move the cursor up and down the list of no's and yes's. The user can toggle between yes and no wherever the cursor is by hitting <enter>.

```
Sediment Transport Functions

TOFFALETI.                      NO
YANG.                           NO
ACKER-WHITE.                    NO
COLBY                           NO
TOFFALETI-SCHOKLITSC            NO
MPM(1948).                      NO
BROWNLIE,D50                    NO
TOFFALETI-MPM                   NO
LAURSEN(MADDEN),1985            NO
LAURSEN(COPELAND)               NO
YANG,D50                        NO
ACKER-WHITE,D50                 NO
MPM(1948),D50                   NO
```

```
Record: TF
F1=Help    F10=Exit    <CR> Enter Value    PgUp    PgDn    Page  2/ 0
```

Figure G19. TF-records.

G-4.4. <u>VE multiple record screen.</u> Figure G20 defines the VE-, DE-, WI-, QW-, ES-, and WT-records. One line across these six data items comprise one "data set" for SAM.sed. There can be up to 10 in one input data file. The same rules apply as described for the QW multiple record screen, Figure G13, section 3.3.8.

G-4.5. <u>PF-record.</u> The PF-record data and screens for SAM.sed are the same as those for SAM.hyd, see section 3.3.7.

Hydraulic Parameters

Water Discharge (cfs)	Water Velocity (fps)	Width (ft)	Depth (ft)	Energy Slope (ft/ft)	Water Temperature Default = 60

```
Records: VE, DE, WI, QW, ES, & WT
F1=Help    F10=Exit    <CR> Enter Value    PgUp    PgDn    Page  3/ 0
```

Figure G20. VE multiple record screen.

G-4.6. KL/KR records screens. Figure G21 defines the KL- and KR-records. As stated in Appendix D in the manual, these are optional records and are needed only if the Brownlie function is selected in the TF-record screen. The first line of input, items A and B, will become part of the first "data set" as input on the VE multiple record screen, items C and D will become part of the second, etc.

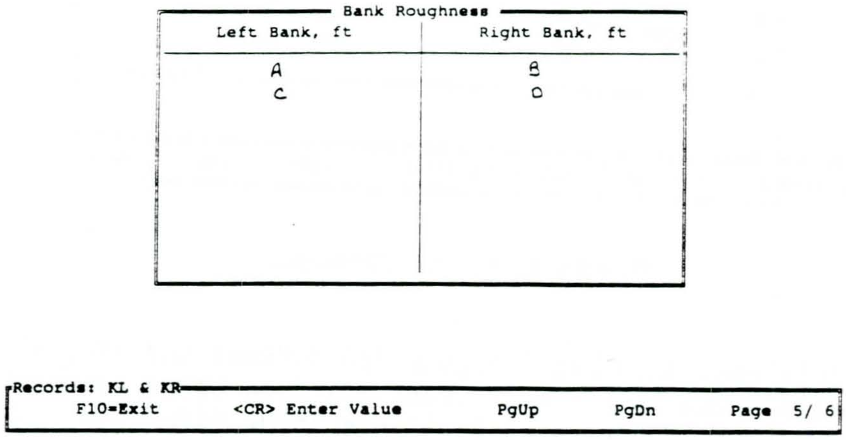


Figure G21. KL/KR record.

G-4.7. ZW-record. The ZW screen and data for SAM.sed are the same as for SAM.hyd, see paragraph 3.2.4.

G-5. SAM.yld input option. This option, number 3 on the PSAM main menu as shown in Figure G1, corresponds to section 4 in the Manual. Figure G22 shows the first screen in this option which offer choices on calculation method and sediment measurement type. The choice made at this screen will be determined by the type of data the user wishes to input. Movement between the options is done with the up and down arrows, and an option is selected by hitting <enter>. An arrow will mark the choices made. The following discussion of the screens will look at all combinations of these four choices.

G-5.1. Flow-duration Sediment Discharge rating curve method. This combination corresponds to section 4.2 in the Manual. The screens used in this option are the TI- and JP-records, QQ/QD screen, and the QW/QS screen. The TI data and screen are the same as those in SAM.hyd, see section G-3.2.1.

G-5.1.1. JP-record. Figure G23 defines the JP-record for the flow duration method. Item **A** goes in field 1, item **B** in field 4, item **C** in field 7, item **D** in field 3 and item **E** in field 5.

```
SELECT OPTION FOR CALCULATING SEDIMENT YIELD

--> Flow Duration Curve Method

    Flow Hydrograph Method
```

```
SELECT OPTION FOR SEDIMENT DISCHARGE RATING CURVE

--> Sediment Discharge Vs Water Discharge

    Sediment Concentration Vs Water Discharge
```

```
F1=Help    F10=Exit    <CR> Enter Value    PgUp    PgDn    Page  0/ 0
```

Figure G22. Calculation Methods.

G-5.1.2. QQ/QD records screens. Figure G24 defines the QQ- and QD-records for the flow duration method. The water discharge and flow duration are essentially paired data, and PSAM offers the user a paired data input format. There can be up to 100 pairs of data.

G-5.1.3. QW/QS records screen. Figure G25 defines the QW- and QS-records for the flow-duration sediment discharge rating curve method. The water discharge and sediment discharge are essentially paired data, and PSAM offers the user a paired data input format.

```
Yield Calculation Options

Number of Class Intervals for Results              A    Default =  20

Water Discharge Scale Factor                       B    Default =   1

Specific Weight of Sediment      (lb/cuft)         C    Default =  93

Number of Integration Steps                        D    Default = 365

Time period of flow duration curve  (days)         E    Default = 365
```

```
Record: JP
F1=Help    F10=Exit    <CR> Enter Value    PgUp    PgDn    Page  2/ 0
```

Figure G23. JP-record for Flow-duration methods.

Flow Duration Curve Data

	Water Discharge (cfs)	Duration (Time)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		

Records: QQ & QD

F1=Help F10=Exit <CR> Enter Value PgUp PgDn Page 3/ 0

Figure G24. QQ/QD records for Flow-Duration Method.

Sediment Discharge Rating Table

	Water Discharge (cfs)	Sediment Discharge (Tons/Day)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Records: QW & QS

F1=Help F10=Exit <CR> Enter Value PgUp PgDn Page 4/ 0

Figure G25. QW/QS records screen for flow-duration method.

G-5.2. <u>Flow-duration sediment concentration method.</u> This combination is a variation of the flow-duration sediment discharge method with the difference being that the sediment discharge is input as sediment concentrations in mg/*l*, on the SC-record. The screens used in this option are the TI, JP, QQ/QD screen, and the QW/SC screen.

G-5.2.1. <u>QW/SC record for the sediment concentration input.</u> Figure G26 defines the QW- and SC-records for inputting sediment concentrations. The water discharge and sediment concentration are paired data, and PSAM offers the user a paired data input format.

G-5.3. <u>Flow Hydrograph Sediment Discharge rating curve method.</u> This combination corresponds to section 4.3 in the Manual. The screens used in this option are the TI- and JP-records, QH screen, and the QW/QS or QW/SC screen.

G-5.3.1. <u>JP-record.</u> Figure G27 defines the JP-record for the flow hydrograph method. Item **A** goes in field 1, item **B** in field 4, item **C** in field 7, item **D** in field 6. Notice that item **D** is different from item **E** in Figure G23.

Sediment Concentration Rating Table

	Water Discharge (cfs)	Sediment Concentration (mg/l)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Records: QW & SC

F1=Help F10=Exit <CR> Enter Value PgUp PgDn Page 4/ 0

Figure G26. QW/SC record for inputting sediment concentrations.

```
                    Yield Calculation Options

 Number of Class Intervals for Results          A     Default =  20

 Water Discharge Scale Factor                   B     Default =   1

 Specific Weight of Sediment      (lb/cuft)     C     Default =  93

 Time between Hydrograph Ordinates  (hours)     D     Default = 365
```

```
Record: JP
     F10=Exit       <CR> Enter Value        PgUp        PgDn        Page  2/ 0
```

Figure G27. JP-record for flow hydrograph method.

G-5.3.2. QH screen. Figure G28 defines the QH-records for the flow hydrograph method. This screen differs from Figure G24 in that it does not offer the paired data format. There can be up to 250 data points.

```
                     Flow Hydrograph Data
      |   Water Discharge (cfs)
 1
 2
 3
 4
 5
 6
 7
 8
 9
 10
 11
 12
 13
 14
 15
 16
 17
Record: QH
 F1=Help     F10=Exit     <CR> Enter Value       PgUp      PgDn      Page  3/ 0
```

Figure G28. QH-record for flow hydrograph method.

G-5.3.3. QW/QS records screen. The QW/QS screen used for this combination of methods is the one shown in Figure G25.

G-5.4. Flow Hydrograph Sediment Concentration method. This combination is a variation of the flow hydrograph sediment discharge method with the difference being that the sediment discharge is input as sediment concentrations in mg/*l*, on the SC-record. The screens used in this option are the TI- and JP-records, QH screen, and the QW/SC screen. The JP screen used is that in Figure G27 and the QH-record screen is that in Figure G28. The QW/SC screen is that shown in Figure G26.

APPENDIX H:
SAM.m95
SUMMARIZED HEC-2 RESULTS FOR SAM.SED(MREAD95)

H-1. Description. SAM.m95 reads the binary file created by HEC-2, uses that file to compute an average velocity, width, depth, and slope, and writes these averages to an input file for SAM.sed. There are three options for computing this average, as an average using HEC-6 weighting factors, as a reach-length weighted average, and as an arithmetic average. There are also two methods of running SAM.m95, interactively, or through M95.in, which is essentially a "run control input file," (a batch file).

H-1.1. Calculation Option 1. SAM.m95 computes the average using HEC-6 weighting factors as follows:

```
C     ------------------------------------------------------
C     DO CALCULATIONS FOR OPTION 1
      W1 = 0.25
      W2 = 0.50
      W3 = 0.25
      DO 45 I=1,NPROFS
      CQCH(I)=(W1*QCH(I,1))+(W2*QCH(I,2))+(W3*QCH(I,3))
      CDCH(I)=(W1*DCH(I,1))+(W2*DCH(I,2))+(W3*DCH(I,3))
      CWID(I)=(W1*WIDTH(I,1))+(W2*WIDTH(I,2))+(W3*WIDTH(I,3))
      CCNV(I)=(W1*CNV(I,1))+(W2*CNV(I,2))+(W3*CNV(I,3))
      CDIS(I)=(W1*  Q(I,1))+(W2*  Q(I,2))+(W3*  Q(I,3))
      CACH(I)=CWID(I)*CDCH(I)
      CVEL(I)=CQCH(I)/CACH(I)
      CES(I)=(CVEL(I)*CCNV(I)/(1.486*CDCH(I)**TRD))**2
   45 CONTINUE
C     ------------------------------------------------------
```

H-1.2. Calculation Option 2. Option 2 requires the user must to input two cross section numbers. The reach-length weighted average is calculated using all the cross sections inclusive of the two given cross sections, as follows:

```
C     ---------------------------------------------------------------
C       CALCULATIONS FOR REACH-LENGTH-WEIGHTED AVERAGES OUTPUT, OPTION 2
C               AND FOR STRAIGHT AVERAGE OUTPUT, OPTION 3
C       CALCULATE FOR THE TWO ENDS
C
   27 DO 250 J=1,NPROFS
C          SET REACH LENGTH FACTORS, DEPENDENT ON OPTION #
C      RU = REACH LENGTH FOR UPPER END; RD = REACH LENGTH FOR LOWER END
       IF(IOPT .EQ. 2) THEN
         RD = XLCH(J,IQ2+1) * 0.5
         RU = XLCH(J,IQE) * 0.5
       ELSE
         RD = 1
         RU = 1
       ENDIF
C
       CQCH(J)= (QCH(J,IQ2)*RD) +
     *          (QCH(J,IQE)*RU)
       CDIS(J)=(Q(J,IQ2)*RD) +
     *         (Q(J,IQE)*RU)
       CDCH(J)=(DCH(J,IQ2)*RD) +
     *         (DCH(J,IQE)*RU)
       CWID(J)=(WIDTH(J,IQ2)*RD) +
     *         (WIDTH(J,IQE)*RU)
       CCNV(J)=(CNV(J,IQ2)*RD) +
     *         (CNV(J,IQE)*RU)
       XLCHT(J)=RD + RU
       IF(IQ2+1 .GT. IQE-1) GOTO 265
C
C      CALCULATE FOR ALL MIDDLES
C
       DO 260 I = IQ2+1,IQE-1
C         SET REACH LENGTH FACTOR, RL; IS DEPENDENT ON OPTION #
       IF(IOPT .EQ. 2) THEN
         RL= (XLCH(J,I) + XLCH(J,I+1))*0.5
       ELSE
         RL= 1
       ENDIF
       CQCH(J)= CQCH(J) + QCH(J,I)*RL
       CDCH(J)= CDCH(J) + DCH(J,I) *RL
       CDIS(J)= CDIS(J) + Q(J,I) *RL
       CWID(J)= CWID(J) + WIDTH(J,I)*RL
       CCNV(J)= CCNV(J) + CNV(J,I) * RL
       XLCHT(J)=XLCHT(J) + RL
  260  CONTINUE
  265  KBR = 1
       IF (XLCHT(J) .EQ. 0.0) GOTO 250
       CQCH(J)=CQCH(J)/XLCHT(J)
       CDIS(J) = CDIS(J)/XLCHT(J)
       CDCH(J) = CDCH(J)/XLCHT(J)
       CWID(J) = CWID(J)/XLCHT(J)
       CACH(J) = CDCH(J)*CWID(J)
       CVEL(J) = CQCH(J)/CACH(J)
       CCNV(J) = CCNV(J)/XLCHT(J)
       CES(J)  = (CVEL(J)*CCNV(J)/(1.486*CDCH(J)**TRD))**2
C     ---------------------------------------------------------------
```

H-1.3. Calculation Option 3. Option 3 requires the user to enter the list of cross sections to be averaged. It then calculates an arithmetic average using all the cross sections listed, each with a reach length of 1.0. The calculations are the same as for Option 2, above, with the exception that RL is always 1.0, making XLCHT(J) equal to the number of cross sections used.

H-2. Output. Three output files are created: OUT1, TAPE98, and SED.IN or SED.M95. If several passes are made through SAM.m95, the output will be stacked in each of these files.

H-2.1. OUT1. The output file OUT1 echoes the binary file for the cross sections used in averaging and contains the computed averages.

H-2.2. TAPE98. TAPE98, the input file for HECDSS, contains headers, the A through F path names, and the data pairs in a form that can be read and subsequently plotted by HECDSS DISPLAY.

H-2.3. SED.IN or SED.M95. The form of the third output file depends on files in the working directory. If a sed.in file exists, SAM.m95 echoes it, overwriting the existing VE, DE, WI, QW, and ES data records with the computed averages. If no sed.in file exists in the directory, a SED.M95 file is created. SED.M95 echoes the title records read from the TAPE95 used, adds the computed averages records, and ends with the job control $$END record. It is an interim file which can easily be transformed to a sed.in file by the addition of the sed.in transport function records and modifications to the title records.

H-3. Execution. SAM.m95 can be accessed from the SAM menu. It looks in the working directory for a job control file named M95.in. If this file is found, the program runs with the commands it contains. If the file is not found, the program runs interactively, asking the user for those same commands. Otherwise, SAM.m95 will prompt the user for input. In both cases, SAM.m95 will allow multiple passes and will stack the output in the specified output files. However, these multiple passes must all use the same geometry input file, i.e., the same *.T95 file.

H-3.1. Interactive execution. If SAM.m95 is run interactively it prompts the user for input.

H-3.1.1. General prompts. SAM.m95 first prints to the screen a directory, *.T95, i.e.:

```
Directory of  C:\SAMEXE
HEC2PB1   T95     15096 04-13-91  11:20a
LICKEXST  T95    142166 06-27-91  10:48a
LICKP15M  T95    184866 06-27-91  10:59a
```

The next prompt provides a message and asks for the input file to use:

```
M95.IN WAS NOT FOUND IN CURRENT DIRECTORY
  *RUN CONTROL WILL BE FROM KEYBOARD*
  TYPE IN THE TAPE95 FILE NAME
```

Enter the entire filename, including the pathname if necessary, up to 30 characters:

lickest.t95 (the program is not case-sensitive in MS-DOS operating systems).

Next it will prompt for the calculation method, or option, desired:

```
CHOOSE YOUR CALCULATION OPTION:
   1 = INPUT 1 X-SECTION NUMBER FOR THE 3-POINT AVERAGE METHOD
   2 = INPUT 2 X-SECTION NUMBERS FOR REACH-LENGTH AVERAGING
   3 = INPUT MANY X-SECTION NUMBERS FOR STRAIGHT AVERAGE METHOD
```

As soon as an appropriate number is input, SAM.m95 will display all the cross section numbers in the chosen *.T95 file, i.e.:

59.3800	59.9700	60.9100	61.8600	62.3100
62.6410	62.6810	62.6810	62.7030	62.9720
63.9570	64.2360	64.2690	64.2690	64.2790
64.5510	65.2000	65.5500	65.8000	66.1030
66.7000	66.8860	66.9180	66.9180	66.9310
67.3780	67.5600	67.8290	67.9500	68.4000
68.5620	68.9250	69.1230	69.3150	69.6090
69.7940	69.8270	69.8520	69.8520	69.8650
70.3000	70.7000	70.9200	71.3000	71.4640
71.5450	71.5450	71.5880	71.9890	72.0210
72.0210	72.0440	72.7100	73.4200	73.5900
74.0440	74.4000	74.8770		

The next series of prompts varies with the calculation option chosen. But in all three cases, when the cross section numbers have been input the program goes on to the prompt for DSS.

H-3.1.2. Option 1. The program will then prompt:

```
INPUT X-SECTION
```

Type in the desired cross section number and return.

59.3800

H-3.1.3. Option 2. When Option 2 is chosen the prompt is:

```
INPUT RANGE OF X-SECTION NUMBERS FROM __ TO __
EX: 1260.0/1600.0
```

Enter the beginning and the ending cross section numbers and return. The two numbers must be separated by a space or a forward slash, /.

```
59.38/60.9100
```

H-3.1.4. Option 3. When Option 3 is selected, the program prompts:

```
INPUT EACH X-SECTION NUMBER AND A RETURN
  HIT RETURN AGAIN WHEN THROUGH WITH LIST
```

After each cross section number is accepted by the program, the list of cross section numbers and the above prompt will scroll to the screen. A return on an empty line tells the program to go on to the DSS prompt.

H-3.1.5. Pathname for DSS. The program provides the option for specifying a component of the DSS pathname in order to create a unique pathname:

```
ENTER TEST IDENTIFIER (DEFAULT = BASE)
EXAMPLE:  TEST 12
```

The phrase entered here, i.e.,

```
PLAN 15
```

becomes part of the DSS path name. Inputting a term descriptive of the given test, such as Base, Existing, Test A, Plan B, etc., serves two functions. First it adds a descriptive line to the legend of the plot. Secondly it ensures that subsequent data processed, if given a different test identifier, will not overwrite existing data.

H-3.1.6. Ending a session. When the program has calculated the averages, they are printed to the screen, as well as to the output files. The program then prompts:

```
TYPE   EN       IF YOU ARE READY TO QUIT
       RETURN   TO PICK ANOTHER REACH
```

If EN is entered, the program terminates and returns the user to the SAM menu. To make another pass through SAM.m95, choosing perhaps different cross sections or calculation options, just hit RETURN.

H-3.2. M95.in, or batch file, execution. Currently, when SAM.m95 runs from the M95.in file, a directory of *.m95 is printed to the screen. Then the DSS identifier and the calculated averages are printed to the screen. When the program finds a $$END in the M95.in file, it terminates and returns the user to the SAM menu. The M95.in file setup is described below.

H-3.2.1. M95.in file description. The following is an example M95.in file.

```
TAPE95=LICKEXST.T95
$JOB  REACH1  OPTION1
68.9250
$JOB  REACH2  OPTION2
59.97  66.103
$JOB REACH3 OPTION3
59.38
61.86
66.7
70.3
70.7
72.71
74.4
$$END
```

The first line sets the geometry input file, the Tape95 file from HEC2, that is to be used for this series of passes through SAM.m95. Notice that the $JOB **starts** a given set of instructions instead of ending them. The calculated averages are printed to the screen at the end of every job.

H-3.2.2. $JOB record. Three items belong on the $JOB record, separated by at least one space. The first is the new job indicator, $JOB. The second item is the DSS identifier, i.e., REACH1. Currently, do not put any spaces in this identifier. The third item is the calculation option, i.e., OPTION1, again with no spaces for now.

H-3.2.3. Numeric records. The numeric records necessary after each $JOB record differ according to the calculation option chosen; they resemble the interactive input. If Option 1 is chosen, use only 1 record with only 1 cross section number on it. If Option 2 is indicated on the $JOB record, use only 1 record with 2 cross section numbers on it. If Option 3 is chosen, use multiple records with only 1 cross section per record. For this option, the program quits looking for more cross sections when it finds a $JOB or $$END.

H-3.2.4. $$END record. The $$END record indicates the end of the M95.in run control input file. SAM.m95 terminates and returns the user to the SAM menu.

H-3.3. Calculations. When SAM.m95 computes the averages, it writes them to the output files and echoes them to the screen. The following output comes from using the Option 2 input as shown above. (See the note for record type descriptions.)

	AVERAGED VALUES						
CQCH	3286.82	3986.71	4761.45	5469.16	7079.05	7880.78	9544.38
CDIS	4200.00	5620.00	7500.00	9400.00	14300.00	16900.00	23200.00
DE	12.63	14.49	16.84	18.99	23.79	25.82	29.83
WI	79.15	79.15	79.15	79.15	79.15	79.15	79.15
CCNV	.04	.04	.04	.04	.04	.04	.04
	CALCULATED VALUES						
VE	3.29	3.48	3.57	3.64	3.76	3.86	4.04
ES	.0003198	.0002970	.0002570	.0002270	.0001795	.0001693	.0001535
CACH	999.35	1147.19	1332.82	1503.35	1882.90	2043.96	2361.09
XLCHT	8078.	8078.	8078.	8078.	8078.	8078.	8078.

FILE - lickexst.t95

Stop - Program terminated.

NOTE: The records printed are as follows:

- CQCH -- averaged discharge in the channel
- CDIS -- averaged total discharge
- DE -- averaged hydraulic depth
- WI -- averaged water surface width in channel
- CCNV -- averaged channel roughness
- VE -- velocity calculated from CQCH and CACH
- ES -- slope calculated from VE, CCNV, and CQCH
- CACH -- area of the channel calculated from CQCH and WI
- XLCHT -- for Option 1:
  for Option 2: accumulated channel distance
  for Option 3: number of cross sections used in averaging

H-4. Plots. The SAM menu automatically writes TAPE98 into the HYD.DSS graphics file, This process terminates with a message printed to the screen,

? STOP - PROGRAM TERMINATED.

and returns to the SAM menu.

To view any graphics output, invoke the PLOT option on the SAM menu. The procedure is described in the body of the SAM manual.

H-5. <u>Output Examples</u>.

H-5.1. <u>OUT1</u> file.

```
NVARS =        86
IMILE =         0
IMET  =         0
File title: LICKING RIVER (EXISTING)
```

```
Summary:
     7 Profiles
    58 Cross sections
```

XSN	59.38	59.38	59.38	59.38	59.38	59.38	59.38
WS	824.89	826.89	829.43	831.71	836.69	838.76	842.80
Q	4200.00	5620.00	7500.00	9400.00	14300.00	16900.00	23200.00
QCH	3065.68	3593.03	4183.54	4749.62	6114.48	6811.28	8437.85
VE	2.88	2.96	2.99	3.04	3.17	3.28	3.55
ACH	1066.16	1212.01	1397.25	1564.13	1927.49	2078.57	2373.76
DE	14.60	16.60	19.14	21.43	26.40	28.47	32.52
ES	.0002173	.0001947	.0001643	.0001454	.0001201	.0001159	.0001142
WI	73.00	73.00	73.00	73.00	73.00	73.00	73.00
XLCH	.00	.00	.00	.00	.00	.00	.00

XSN	59.97	59.97	59.97	59.97	59.97	59.97	59.97
WS	825.70	827.60	830.01	832.21	837.08	839.14	843.16
Q	4200.00	5620.00	7500.00	9400.00	14300.00	16900.00	23200.00
QCH	3245.18	3811.88	4392.40	4940.76	6308.04	7049.05	8802.57
VE	3.25	3.31	3.26	3.24	3.28	3.38	3.65
ACH	999.54	1153.09	1348.10	1526.74	1921.37	2087.47	2413.32
DE	12.34	14.24	16.64	18.85	23.72	25.77	29.79
ES	.0003478	.0002980	.0002350	.0001964	.0001488	.0001409	.0001355
WI	81.00	81.00	81.00	81.00	81.00	81.00	81.00
XLCH	3115.20	3115.20	3115.20	3115.20	3115.20	3115.20	3115.20

XSN	60.91	60.91	60.91	60.91	60.91	60.91	60.91
WS	827.64	829.38	831.50	833.49	838.05	840.04	843.99
Q	4200.00	5620.00	7500.00	9400.00	14300.00	16900.00	23200.00
QCH	3493.42	4518.36	5724.88	6780.83	8939.43	9905.85	11446.30
VE	3.69	4.16	4.55	4.79	5.02	5.11	5.07
ACH	947.95	1087.19	1257.06	1416.20	1780.69	1939.71	2256.26
DE	11.85	13.59	15.71	17.70	22.26	24.25	28.20
ES	.0004716	.0004995	.0004943	.0004661	.0003775	.0003486	.0002812
WI	80.00	80.00	80.00	80.00	80.00	80.00	80.00
XLCH	4963.20	4963.20	4963.20	4963.20	4963.20	4963.20	4963.20

VE	3.31	3.50	3.61	3.67	3.80	3.89	4.07
DE	12.63	14.49	16.84	18.99	23.79	25.82	29.83
WI	79.15	79.15	79.15	79.15	79.15	79.15	79.15
ES	.0003606	.0003400	.0003010	.0002694	.0002135	.0001999	.0001761
XLCHT	8078.	8078.	8078.	8078.	8078.	8078.	8078.

H-5.2. TAPE98 file.

```
HYD.DSS
/ Mread95/ Path B/ Path C/ Path D/ Path E/ Path F/
1

UNT

UNT
1
                                        62.681000         832.283100
                                        62.641000         832.122700
                                        63.641000         945.124500
END
FIN
```

H-5.3. SED.IN file.

```
TI   TEST NO. 1A TEST ALL FUNCTIONS USING "SPECIFIC" GRAIN SIZE
TI   THIS FILE WRITTEN BY SAM.hyd
TI   TEST NO. 3  CALCULATE SEDIMENT RATING CURVE FOR TRAPEZOID
TI               HYDRAULICS = TEST 1A, HYD.INLIB, (CT-RECORD)
TI               100-ft BOTTOM, 3:1 SIDE SLOPES, n-VALUE = .025, SLOPE = .00521
TI               W. A. THOMAS, WES, 28 January 1991
TI  1       2       3       4       5       6       7       8       9       10
F#345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678 2345678
TF TOFFALETI.          YES
TF YANG.               YES
TF ACKER-WHITE.         NO
TF COLBY                NO
TF TOFFALETI-SCHOKLITSC NO
TF MPM(1948).           NO
TF BROWNLIE,D50         NO
TF TOFFALETI-MPM        NO
TF LAURSEN(MADDEN),1985 NO
TF LAURSEN(COPELAND)    NO
TF YANG,D50             NO
TF ACKER-WHITE,D50      NO
TF MPM(1948),D50        NO
VE  3.06    3.14    3.13    3.14    3.23    3.33    3.60
DE 13.47   15.42   17.89   20.14   25.06   27.12   31.16
WI   77.     77.     77.     77.     77.     77.     77.
QW 4200.   5620.   7500.   9400.  14300.  16900.  23200.
ES      .00028 .000246 .000200 .000171 .000134 .000128 .000125
PF                          300      32      92      16    82.8       8      75
PFC     4    67.8       2    58.8       1    45.3      .5    22.8     .25     4.2
PFC .125      .8   .0625      .3       0       0
$$END
```

H-5.4. SED.M95 file.

```
File title: LICKING RIVER (EXISTING)

VE  3.06    3.14    3.13    3.14    3.23    3.33    3.60
DE 13.47   15.42   17.89   20.14   25.06   27.12   31.16
WI   77.     77.     77.     77.     77.     77.     77.
QW 4200.   5620.   7500.   9400.  14300.  16900.  23200.
ES      .00028 .000246 .000200 .000171 .000134 .000128 .000125
$$END
```

APPENDIX I

SAM.aid

Guidance in Transport Function Selection

I-1. Description. SAM.aid is a program which provides guidance in the selection of the most applicable sediment transport function(s) to use with a given project based on five screening parameters. The program matches user input d_{50}, slope, velocity, width and depth to the database, which comes from Brownlie's test data(1981). The output is in two levels. First the test data sets that match the project's screening parameters are identified. Five screens come up, titled "THE FOLLOWING DATA MATCHED *x* OF YOUR INPUT PARAMETERS", with *x* going from 5 to 1. For each match that is found, the best three functions for that data set are given. There is also a text file associated with each Brownlie data set.

I-2. Use. After selecting SAM.aid from the SAM menu, the first screen that appears is the place to input the project's screening parameters, see Figure I-1.

THE FOLLOWING DATA MATCHED 4 OF YOUR INPUT PARAMETERS

DATA	D50	SLOPE	VELOCITY	WIDTH	DEPTH
CHO*	X		X	X	X
RGR*	X		X	X	X
NED*	X		X	X	X

DATA	BEST FUNCTION	SECOND	THIRD
CHO*	COLBY	BROWNLIE D50	ACKER-WHITE
RGR*	YANG D50	YANG	LAURSEN(COPELAND
NED*	LAURSEN (MADDEN)	BROWNLIE D50	ACKER-WHITE D50

PRESS R TO REVIEW DATA
OR ANY OTHER KEY TO CONTINUE

Figure I-1. Screen 1 in SAM.aid.

The information input here is saved as input, even if SAM.aid is exited. When the program is signalled to continue, the five screens appear in succession, showing the data sets that matched the screening parameters. There may be no match, as in Figure I-2, or there may be one or more matches, as in Figure I-3.

```
THE FOLLOWING DATA MATCHED    5  OF YOUR INPUT PARAMETERS



            NO MATCH FOUND



                                PRESS ANY KEY TO CONTINUE
```

Figure I-2. SAM.aid "No Match" screen.

```
                    SEDIMENT DISCHARGE FORMULA GUIDANCE

D50        .3
SLOPE      .0035600
VELOCITY   4.50000
WIDTH      124.000
DEPTH      7.00000000



                         PRESS C TO CHANGE INPUT
                       OR ANY OTHER KEY TO CONTINUE
```

Figure I-3. SAM.aid screen showing several matches.

When a match is found, it is possible to review the data by inputting the three letter identifier, i.e., RGR. This action would bring up Brownlie's description of the data, as in Figure I-4.

```
RGR - Rio Grande data of Nordin and Beverage (1965)
     These data were obtained from 6 stations on the Rio Grande in New
Mexico. The values of discharge, width, depth, slope, temperature, and
sediment concentration can be found in Tables 1 through 6 of Nordin and
Beverage (1965). The values of sediment concentration are for suspended
load of sizes greater than 0.062 mm (obtained with depth-integrating
samplers) with modified-Einstein bed load corrections. Bed sediment char-
acteristics were obtained from Tables 7 through 12.
     The data were collected at the following stations: records 1 through
18 at Otowi Bridge, near San Idelfson; records 19 through 88 at Cochiti;
records 89 through 158 at San Felipe; records 159 through 216 near
Bernalillo; records 217 through 270 at Albuquerque; and records 271 through
293 near Belen.
                              PRESS ANY KEY TO CONTINUE
```

Figure I-4. SAM.aid description of the matched data set.

After going through to the screen showing only one match, the user can press "C" and return to the input screen to try again, or can hit return to exit SAM.aid and return to the SAM menu.

I-3. <u>Output.</u> SAM.aid creates no output file, so the function recommendations it makes must be captured with a screen dump or handwritten.

Files for menu operation:

AUTOTEMP	BAT	AUTOCUST	COM	SAM	MDF
AUTOMAKE	EXE	AUTOMENU	COM	UTILS	EXE
DELAY	EXE	LIST.BAK			

Batch files for menu options:

M95	BAT	SAM	BAT	YLD	BAT
HYD	BAT	SED	BAT		

Files for the guidance option, SAM.aid:

SAMAID	EXE	AIDUSERD	COM	AIDINDEX	COM
AIDINFO	COM	AIDPROGD	COM		

Files for Corps program H0910, Fall Velocity:

H0910	DOC	H0910	EXE

Input/output Library files:

HYDPCIN	LIB	HYDPCOT	LIB	SEDPCOT	LIB
YLDPCIN	LIB	YLDPCOT	LIB	SEDPCIN	LIB
M95IN	EX	CDFFIL	EX		

SAM.xxx executables:

SAMSED	EXE	SAMHYD	EXE	PSAM	EXE
SAMT95	EXE	SAMYLD	EXE		

Total of 33 files.

For reference only, the following is a list of all executables:

SAMHYD	EXE	SAMT95	EXE	H0910	EXE
SAMSED	EXE	PSAM	EXE	UTILS	EXE
SAMYLD	EXE	AUTOMAKE	EXE	DELAY	EXE
SAMAID	EXE				

INSTALLATION INSTRUCTIONS FOR SAM

1. The Install procedure. Installation is accomplished by executing a batch file. The batch file installs SAM on the C: drive in a subdirectory called SAMEXE.

1.1. Needed modifications to system files. In your **AUTOEXEC.BAT** file, put C:\SAMEXE in your path statement so that SAM will be executable from any drive or directory on your system. In your **CONFIG.SYS** file, put the statement

```
DEVICE=C:\DOS\ANSI.SYS
```

to insure optimum screen output.

2. To install from drive A:. If you insert the SAM.ZIP disk in your A: drive, type

A:INSTALLA and SAM will be installed.

3. To install from drive B:. If you insert the SAM.ZIP disk in your B: drive, type

B:INSTALLB and SAM will be installed.

4. Files included. The files written to the SAMEXE directory are listed below. The .LIB files are input and output test data for SAM.hyd, SAM.sed and SAM.yld. The .EX files are example files rather than library files. The rest of the files are for installation, menus, and smooth execution.

5. DSS Information. **If your DSS works o.k., it should be fine for SAM.** Otherwise, read on. DSS versions dated 24 April 1991 or after need a newer version of the GSS drivers than do earlier versions of DSS. The newer version of the drivers changed the switch that releases the drivers from memory. Consequently, it is important to be aware of the version of the GSS drivers being used because built into the SAM menu is the new switch, "/a". The old switch was "/R". Also, before installing a new version of GSS, remove all files from the old version, especially the 'DRIVERS.EXE' in \HECEXE. The new version of GSS no longer needs to be in the machine's config.sys file, but be sure that the subdirectory that the new DRIVERS is in is part of the path, in the autoexec.bat file.

6. Help. For help, call Dinah McComas, (601) 634-2157, or Tony Thomas, (601) 634-2511; Hydraulics Laboratory, Waterways Experiment Station.

Subject: Modification to Program Documentation
File-accessing System

Date: 12 April 1993
RE: System to transfer filenames between modules and utilities on the SAM main menu.

1. File-accessing System. There is now a system to transfer the most recently accessed input data file between the different options on the SAM main menu. PSAM, SAM.hyd, SAM.sed and SAM.yld all write to the ASCII file FILES.SAM. These same 4 modules also read from this file to find the current default filename, as do several of the utilities, COED and LIST.

1.1 FILES.SAM description. This ASCII file consists of three 80-character lines. The first section of each line contains a default filename. The 80th character of each line indicates the module for which the filename is the default, with 1 being SAM.hyd, 2 being SAM.sed, and 3 being SAM.yld. The 79th character of one line will contain an asterisk, indicating either the last module run or the type of input file saved through PSAM.

The information on these three lines is written either by PSAM or one of the three main modules in SAM. The manner in which each of these modules reads from or writes to FILES.SAM is discussed in the following paragraphs.

1.2 Manner of operation from PSAM. PSAM both reads from and writes to FILES.SAM. Upon entering PSAM the user has the option of "reading in" a file. If that option is exercised, PSAM will first look to FILES.SAM for a filename-line with an asterisk. If one is found, that filename becomes the default filename, but does not have to be accepted. When the user exercises any of the "save" options in PSAM, the module will write the filename to FILES.SAM. If user has not exercised options 1, 2, or 3 on the PSAM menu, PSAM will prompt for which type of file to save, thereby discovering whether to put the filename and asterisk on lines 1, 2, or 3. Otherwise, PSAM keys on the option number last executed by the user to decide upon which line to put the filename and asterisk.

Subject: Modification to Program Documentation -- Directory capability in PSAM

Date: 13 April 1993
RE: Methods to choose a file to read into PSAM.

1. <u>Brief description.</u> PSAM now has a directory capability which is available if the "Read Existing Data File" is selected (option 5 of the PSAM main menu).

1.1 <u>Operation.</u> Upon selection of option 5 the user's screen changes, showing "Filename to load", "Directory to list", and an input bar. The up and down arrows move this bar between these two options, and the left and right arrow keys move the cursor within the bar.

1.1.1 <u>Operation with a filename.</u> If a filename appears on the first line, it was read by PSAM from FILES.SAM. If FILES.SAM was empty, the filename line on the screen will be empty. The user has three options. A return will read the filename on the line and take the user back to the PSAM main menu. A new filename can be typed over the default and read in with a return which will again take the user back to the PSAM main menu. A down arrow key will move the input bar to the directory line.

1.1.2 <u>Operation from the "directory" line.</u> When the input bar is on the directory line, the user has three options. An up arrow will return the user to the filename line. A return will list the current directory, or the user can type in a desired directory. When the directory comes on the screen, the left and right arrows move between the columns (if there is more than one), and the up and down arrows move as expected. When the desired filename is highlighted, a return will read that file and return the user to the PSAM main menu.

EXAMPLE OF FIRST SCREEN:

Filename to load:
Directory to list:

EXAMPLE OF SECOND, DIRECTORY SCREEN:

Directory: \samexe   Press <enter> to load a file

..	<DIR>	JUNK	<DIR>
AIDINDEX.COM	07-05-90	LIST.BAK	10-01-92
AIDINFO.COM	07-17-90	M95.BAT	07-02-92
AIDPROGD.COM	03-29-93	M95IN.EX	04-24-92
AIDUSERD.COM	04-10-93	PSAM.EXE	04-09-93
AUTOCUST.COM	05-15-87	SAM.BAT	05-02-91
AUTOMAKE.EXE	05-15-87	SAM.MDF	04-07-93
AUTOMENU.COM	06-22-87	SAMAID.EXE	05-13-92
AUTOTEMP.BAT	04-06-93	SAMHYD.EXE	04-01-93
CDFFIL.	03-30-93	SAMSED.EXE	04-06-93
CDFFIL.EX	12-17-92	SAMT95.EXE	07-01-92
DELAY.EXE	06-24-92	SAMYLD.EXE	02-27-93
DOC	<DIR>	SED.BAT	07-02-92
EDITLAST.EXE	04-07-93	SEDPCIN.LIB	12-17-92
FILES.SAM	02-25-93	SEDPCOT.LIB	12-18-92
H0910.DOC	06-03-88	UTILS.EXE	08-19-92
H0910.EXE	06-13-88	WORK	<DIR>
HYD.BAT	07-02-92	YLD.BAT	07-02-92
HYDPCIN.LIB	02-27-93	YLDPCIN.LIB	12-18-92
HYDPCOT.LIB	03-30-93	YLDPCOT.LIB	12-18-92

FILE LIST FOR SAM PROGRAM -- 4-22-93

FILES FOR MENU OPERATION:

```
LIST     BAK
AUTOTEMP BAT
AUTOCUST COM
AUTOMAKE EXE
AUTOMENU COM
SAM      MDF
UTILS    EXE
DELAY    EXE
EDITLAST EXE
```

BATCH FILES FOR MENU OPTIONS:

```
M95      BAT
SED      BAT
SAM      BAT
YLD      BAT
HYD      BAT
```

FILES FOR SAM.aid:

```
SAMAID   EXE
SAMAID   INI
SAMINFO  DAT
SAMGUIDE DAT
```

FILES FOR CORPS PROGRAM H0910, FALL VELOCITY:

```
H0910    DOC
H0910    EXE
```

INPUT/OUTPUT LIBRARY FILES:

```
M95IN    EX
CDFFIL   EX
HYDPCIN  LIB
YLDPCIN  LIB
HYDPCOT  LIB
SEDPCIN  LIB
YLDPCOT  LIB
SEDPCOT  LIB
```

SAM.xxx EXECUTABLES:

```
SAMT95   EXE
SAMYLD   EXE
SAMSED   EXE
PSAM     EXE
SAMHYD   EXE
```

Total of 34 files.

for reference only, the following is a list of all executables:

```
SAMT95   EXE
SAMYLD   EXE
SAMSED   EXE
PSAM     EXE
SAMHYD   EXE
UTILS    EXE
DELAY    EXE
EDITLAST EXE
```