Appendix C Examples of Quantitative Stability Evaluation

C-1. Introduction

a. This fictional example illustrates a preliminary stability evaluation, using methods and approaches outlined in Chapter 5, for an existing channel, Varmint Creek, that is to be modified for flood control. To simplify the presentation, the analysis is given only for a reach at the downstream end of the project. In an actual case, the channel would be divided into reaches according to significant changes in hydrology, sediment inflows, slope, cross section, or roughness.

b. It is advisable to use several methods to analyze channel stability and then compare results. However, not all methods are applicable to every channel. In this example, analyses are conducted to assess which stability criteria may or may not be applicable. The next step is to use those methods that are judged applicable to assist in checking or determining the properties of a modified channel and the need for erosion control measures.

c. The format of the example follows loosely the systematic procedures outlined in paragraphs 5-10 through 5-12. In practice, descriptions would be supplemented with maps and photographs.

C-2. Description of Area and Existing Channel System

a. Drainage basin. The project area is 320 square miles at the downstream end. Slopes are generally flat. Soils are sandy soils with no rock outcrops. Land use upstream of the project is primarily row crops and pasture. The floodplain adjacent to the channel is wooded throughout the project length. One major tributary enters Varmint Creek near the upstream end of the project. There are no existing reservoirs, flood control works, or bank protection. Varmint Creek enters a lake 5 miles downstream of the project. The basin lies on the margin of a major metropolitan area and the land will be developed into low-density subdivisions. Very significant changes in land use are therefore expected during the life of the project.

b. Project reach. The existing single channel has an irregular sinuous planform but no clearly recognizable meander bends. The invert slope is 2.5 ft/mile or 0.00047. A representative bank-full cross section has a bottom width of 50 ft, surface width of 170 ft, and depth of 12 ft. The low-flow channel averages 20 ft wide by 2 ft deep. There are frequent sandy point bars with growth of grass and low brush, but no extensive deposits of fresh sand on the channel bottom. Bed and bank material is largely sand, with enough silt and clay to support dense brush on banks and point bars. Large trees on floodplain extend back 100 to 200 ft from top of banks, except for occasional recent clearings.

c. Hydrology. The mean annual rainfall is 45 in. Mean monthly temperatures range from 50 to 80 degrees Fahrenheit. The stream gauge near the downstream end of the project has 45 years of record. The largest known flood peak was 26,000 cfs in 1929. The largest recent flood was 10,000 cfs in 1984. Flood hydrology is expected to change considerably as a result of predicted basin land use change from crop and pasture to urban residential. Table C-1 shows both existing and predicted flood frequency estimates.

Table C-1
Flood Frequencies for Varmint Creek

	Peak Discharge, cfs	
Flood Frequency, Years	Existing Conditions	Future Conditions
2	4,500	15,000
10	12,500	24,000
50	26,000	42,000

d. Sediment. The stream gauge has a 10-year record of suspended sediment with a mean annual yield 48,000 tons or 150 tons per square mile, mostly a wash load of silt and clay. There are no data on bed load. Bed material is medium to coarse sand, D_{50} = 0.5 mm. Bank material consists mainly of fine to medium sand with about 10 percent silt/clay.

e. Hydraulic roughness. The overall Manning's *n* for the existing channel is estimated to be 0.04 at bank-full stage, based partly on calibration against high-water marks using HEC-2. For overbank flow on the floodplain, the estimate is 0.08. The high channel roughness is due partly to dunes and ripples in the sand bed, partly to brush vegetation between the low-water channel and the floodplain, and partly to channel irregularities involving flow expansions and eddy formation.

C-3. Existing Instabilities

No serious sheet erosion or significant point sources of sediment were observed during a basin reconnaissance. There is very little bank instability in the project length of channel where natural tree and brush vegetation remains on the floodplain. Where vegetation has recently been cleared locally by landowners, some slumping and erosion have occurred.

C-4. Key Features of Proposed Project

a. The initial basic proposal is to widen and deepen the existing channel while maintaining the existing alignment and slope. The initially proposed trapezoidal cross section has a 200-ft bottom width, 1V:3H side slopes, and a 16-ft depth. It is designed to carry the future conditions 10-year flood within the channel, assuming a Manning *n* value of 0.03.

b. This initial proposal has been developed to meet hydrologic and hydraulic criteria, without special regard to stability evaluation. Based on general principles of channel response (Chapter 2) and experience elsewhere (Chapter 3), it might be expected to cause considerable problems with stability unless erosion control measures are incorporated (Chapter 6). The much larger in-channel discharge and the reduced channel roughness under future conditions will lead to considerably greater velocities; and the existing vegetation, which provides a certain degree of erosion protection, will be removed by channel enlargement.

C-5. Screening of Methods for Analysis of Existing Channel

In the following paragraphs, several technical approaches described in paragraph 5-3 are applied in skeleton form to the existing channel under bank-full conditions. In practice, computations would be more extensive.

a. Allowable velocity-depth approach.

(1) Compute bank-full mean velocity by Manning formula

$$A = 12(50 + 170)/2 = 1{,}320 \text{ square feet } (\text{ft}^2) \quad \text{(C-1)}$$

$$P = 50 + 2\sqrt{12^2 + 60^2} = 172.4 \text{ ft} \quad \text{(C-2)}$$

$$R = A/P = 1320/172.4 = 7.66 \text{ ft} \quad \text{(C-3)}$$

$$V = 1.486 \times 7.66^{.667} \times 0.00047^{.5}/0.04 = 3.1 \text{ ft/second (sec)} \quad \text{(C-4)}$$

where

A = cross-section area

P = wetted parameter

R = hydraulic radius

V = mean velocity

(2) According to Figure 5-5, the allowable mean velocity for no significant erosion, using a grain size of 0.5 mm and a depth of 12 ft, is approximately 2.9 ft/sec. Comparison with the computed cross-sectional mean velocity of 3.1 ft/sec suggests that even under bank-full conditions the potential for bed erosion is relatively small. This result does not appear to conflict seriously with field observations. However, local mean-on-vertical velocities will be considerably higher in the center of the channel, where local roughness is likely to be substantially less than the assumed overall value, and near the outer bank in bends.

b. Allowable shear stress (tractive force) approach.

(1) Compute average boundary shear stress:

$$\gamma R S = 62.4 \times 7.66 \times 0.00047 = 0.22 \text{ pounds (lb)/ft}^2 \quad \text{(C-5)}$$

where

γ = specific weight of water

s = slope

(2) The boundary Reynolds number based on grain size (Figure 5-3) works out to approximately 20, for which the curve in Figure 5-3 indicates a Shields number (dimensionless shear stress) of 0.033 for beginning of bed movement. The allowable shear stress is then computed as

$$0.033 \times 62.4 \times 1.6 \times 0.5/304.8 = 0.0056 \text{ lb/ft}^2 \quad \text{(C-6)}$$

(3) According to this crude application, therefore, the channel bed should be highly erodible because the actual shear stress at bankfull is about 60 times greater than allowable for no erosion. However, crude application of the Shields diagram is very misleading for this type of natural channel, because the diagram implies a flat bed with total roughness determined by the sand grains, which would result in a Manning's n value on the order of 0.015. The estimated actual Manning's n is much larger because it is largely determined by bed forms, channel irregularities, and vegetation.

(4) A more realistic assessment using the allowable shear stress approach can be arrived at using empirical data based on field observations. In the absence of data based on local experience, use could be made of a diagram for canals in granular materials that has been reproduced widely in the literature (Figure C-1). Using the upper curve for canals with high fine sediment content, the allowable shear stress is approximately 0.09 lb/ft^2, which is much closer to the computed average channel value of 0.22 lb/ft^2. The ratio of actual to allowable shear stress is still substantial, suggesting active bed transport under bank-full conditions.

(5) More extensive computations for a range of conditions can be facilitated using the personal computer program SAM as referred to in Chapter 5. Table C-2 shows example results, in terms of hydraulic parameters for the existing channel and overbank at a number of discharges ranging from existing bankfull to future conditions 50-year flood.

c. Empirical relationships for channel properties.

(1) Bank-full discharge Q can be estimated as

$$\begin{aligned} Q &= V \times A = 3.1 \times 1{,}320 \\ &= 4{,}092 \text{ cubic feet per second (cfs)} \end{aligned} \tag{C-7}$$

This is close to the estimated 2-year flood peak of 4,500 cfs. The 2-year flood will therefore be adopted as the channel-forming discharge for purposes of checking against Figures 5-9 through 5-11. On this basis, the existing bank-full surface width, mean depth, and slope are shown plotted on those charts in Figure C-2.

(2) The width point is near Curve 3 for sandy alluvial banks, which appears compatible with the actual situation. The mean depth is close to the curve for coarse sand. The slope is somewhat high but not unexpectedly so, given that there is probably significant bed material transport under bank-full flows.

(3) These comparisons indicate that the properties (hydraulic geometry) of the existing bank-full channel are sufficiently close to general empirical relationships that these may be used in an initial assessment of the proposed project channel.

d. Analytical relationships for channel properties.

(1) A manual check against analytical relationships for alluvial channel properties can be made using the tables of White, Paris, and Bettess (1981b). Using the table for 0.5 mm sand (Table C-3) and entering with a discharge of 130 centimeters per second (cms) (4,500 cfs) and a slope of 0.00047 (0.47 per 1,000), the associated bed sediment concentration can be determined by graphical interpolations to be approximately 180 parts per million (ppm) by weight - not a large concentration for a sand-bed stream. The predicted bank-full surface width is roughly 50 meters (m) (164 ft) which is nearly right. The predicted bankfull depth is roughly 2.5 m (8 ft), which is too low. (As previously noted, the actual depth is high because of additional roughness caused by vegetation.)

(2) Analytical predictions can also be checked using an option in the computer program SAM, as described in paragraph 5-6. The channel-forming discharge and the bed sediment grain size are input with trial values of bed sediment concentration; required secondary input parameters for this procedure are the average side slope and roughness of the banks, adopted here as 1V:5H and 0.045, respectively. For each trial value of sediment concentration, a table of alternative, hydraulically feasible channel properties is obtained, as in Table C-4. The sediment concentration C is varied until a plot of tabulated slope versus width passes through the data point representing the actual channel (Figure C-3). In this case a reasonable match was obtained with a sediment concentration of 150 ppm, which checks reasonably against the result in (1) above using the White tables. Table C-4, obtained using this concentration, approximates the actual channel properties on the fourth line.

(3) The SAM method does not give a unique solution of channel width, depth, and slope unless the hypothesis of minimum stream power is accepted. Results using this hypothesis are shown in the last line of Table C-4. In this case, minimum stream power appears to require a much wider, shallower, and flatter channel than actually exists. It can be argued that minimum stream power hypothesis is not applicable because of high roughness due to in-channel vegetation and because the banks are partly protected by vegetation.

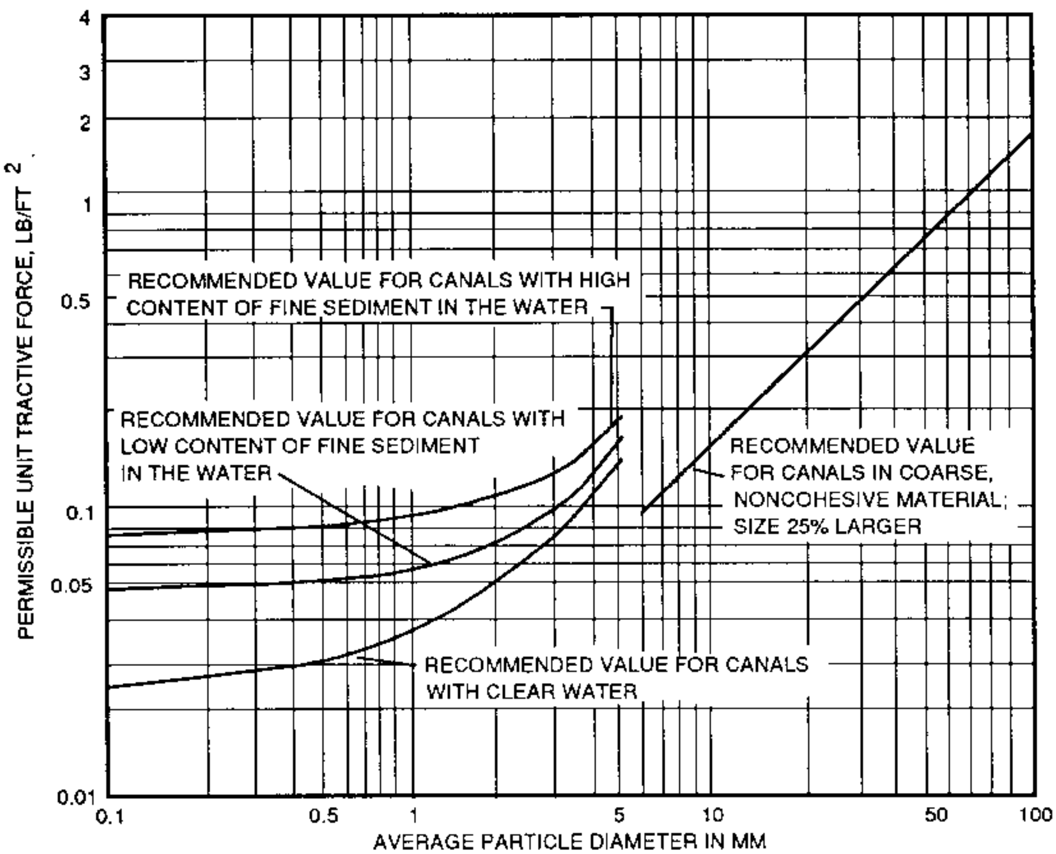

Figure C-1. Allowable shear stresses (tractive forces) for canals in granular materials (Chow 1959), courtesy of McGraw-Hill)

e. Conclusions regarding appropriate methods.

(1) The allowable velocity and allowable shear stress methods appear to be of limited applicability, because the channel probably has an appreciable bed sediment concentration under bankfull conditions, as well as a rather nonuniform transverse distribution of roughness and velocity due to the presence of in-channel vegetation.

(2) Empirical relationships for the properties of channels with small bed material loads appear to fit the existing channel well with respect to width. Depth is greater than predicted, probably because of high roughness. Slope is also greater than predicted, probably because of bed sediment inflows and transport.

(3) Analytical methods exemplified by the White tables and the SAM computer program allow better matching of channel properties by using bed sediment concentration as a variable. Reasonable matching is obtained with a concentration of around 150 ppm by weight.

C-6. Preliminary Evaluation of Proposed Project Channel

a. The initially proposed bank-full surface width (see C-4 above) is 200 + 6 × 16 = 296 ft, and the computed mean depth is 13.4 ft. These are plotted on the width and depth charts of Figure C-2 assuming the future-conditions 2-year flood of 15,000 cfs as channel forming. The placement in relation to the curves is similar to that of the existing channel, suggesting that the proposed width and depth are acceptable on a preliminary basis. For similar placement on the slope chart, however, the slope of the proposed channel would have to be reduced to around 0.00035.

Table C-2
Computed Hydraulic Parameters Using SAM Program

				Top Composite		Slope Composite				
		Q cfs	Water Surface Elevation ft	Width ft	R ft	ft/ft	n value	Velocity fps	Froude Number	Sheer Stress lb/ft^2
Channel OB	Strip No.			Effective Width	Effective Depth	Slope	n value	Effective Velocity		
Channel	1	4500.	12.14	1661.4	10.70	.000470	.0561	2.79	.15	.31
OB	1	4479		121	10.66	.000470	.0410	3.45		
	2	21		1490	.14	.000470	.0799	.11		
Channel	2	12500.	15.58	1695.8	9.24	.000470	.0841	1.69	.08	.27
OB	1	7424		145	13.11	.000470	.0425	3.90		
	2	5076		1500	3.58	.000470	.0759	.95		
Channel	3	15000.	16.31	1703.1	9.34	.000470	.0820	1.74	.08	.27
OB	1	8116		149	13.64	.000470	.0428	3.99		
	2	6884		1502	4.30	.000470	.0796	1.07		
Channel	4	24000.	18.42	1724.2	10.18	.000470	.0775	1.96	.09	.30
OB	1			160	15.21	.000470	.0429	4.30		
	2			1508	6.40	.000470	.0789	1.40		
Channel	5	26000.	18.84	1728.4	10.42	.000470	.0769	2.00	.09	.31
OB	1	10961		162	15.52	.000470	.0429	4.35		
	2	15039		1510	6.81	.000470	.0789	1.46		
Channel	6	42000.	21.71	1740.0	12.45	.000470	.0741	2.34	.10	.36
OB	1	14859		1758	17.83	.000470	.0436	4.76		
	2	27141		1518	9.67	.000470	.0789	1.85		

b. Use of the White data (Table C-3) for a discharge of 425 cms (15,000 cfs) and a sediment concentration of 150 ppm suggests a surface width of about 90 m (295 ft), a depth of about 3.8 m (12.5 ft), and a slope of about 0.00035. The width and slope check well with the analysis in *a* above.

c. The SAM computer program, using the same bed sediment grain size (0.5 mm) and concentration (150 ppm) as for the existing channel, produces the lower curve shown in Figure C-3. For minimum stream power (corresponding to minimum slope), the channel properties are *bottom* width 280 ft, depth 13 ft, and slope 0.00020. As in the case of the existing channel (see C-5 above), the minimum stream power hypothesis requires a wider, shallower, and flatter channel.

d. Hydraulic calculations using the Manning formula indicate that the mean channel velocity at 2-year flood conditions is increased from about 3.2 ft/sec in the existing channel to about 5.1 ft/sec in the proposed channel.

e. These preliminary indications from several methods of analysis suggest that the proposed channel is likely to encounter stability problems and that consideration needs to be given to two design features: bank protection to prevent widening and the development of meandering, and grade controls to reduce the effective hydraulic slope.

f. Consideration also needs to be given to erosion potential under 10-year and higher flow conditions. The proposed channel has a bank-full capacity of 24,000 cfs, the future-conditions 10-year flood (see C-4 above). For this flow the mean velocity is over 6 ft/sec, about twice that in the existing bank-full channel.

g. The question arises as to whether it is appropriate to assume the same bed sediment concentration for the future-conditions channel as for the existing channel. Depending on various factors that are difficult to predict, future sediment concentrations might be greater or smaller than existing.

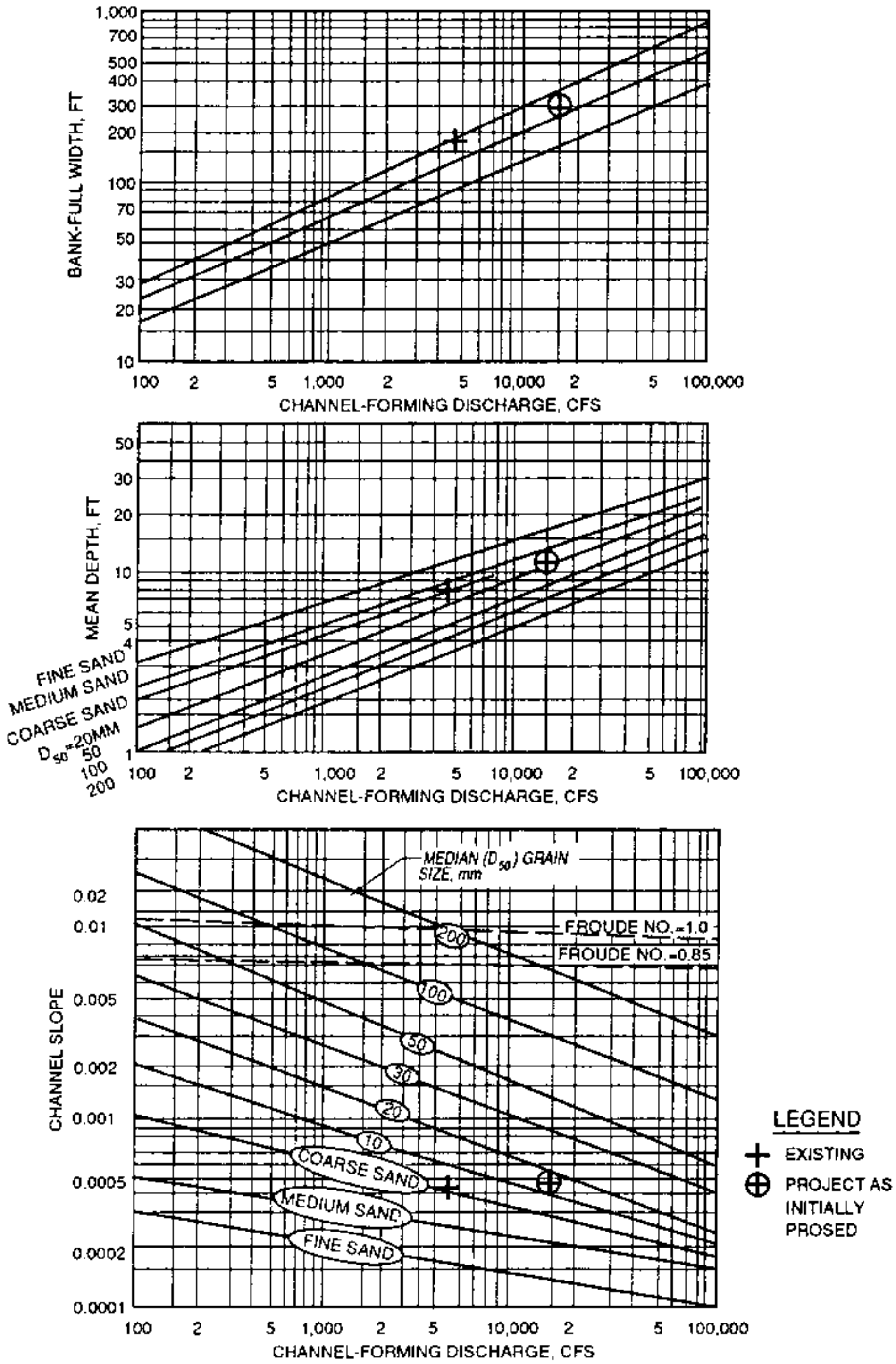

Figure C-2. Varmint Creek channel properties compared with tentative width, depth, and slope charts from paragraph 5-5

Table C-3
Table of Predicted Channel Properties for 0.5 mm Bed Material From White, Paris, and Bettess (1981b)

SAND SIZE 0.50 MILLIMETRES

AREA OF TABLE ENCOMPASSING VARMINT CREEK EXISTING CHANNEL

SEDIMENT CONCENTRATION (PPM)	DISCHARGE (CUMECS) 0.5	1.0	2.0	5.0	10.0	20.0	50.0	100.0	200.0	500.0	1000.0
10	0.45	0.47	0.50	0.53	0.56	0.60	0.64	0.68	0.73	0.81	0.86
	0.237	0.191	0.156	0.121	0.101	0.086	0.070	0.060	0.053	0.045	0.040
	0.46	0.62	0.81	1.15	1.51	1.96	2.76	3.57	4.59	6.60	8.24
	2.4	3.4	5.0	8.2	11.8	17.1	28.2	41.0	59.8	93.8	141.9
	0.323	0.321	0.322	0.320	0.324	0.329	0.338	0.346	0.354	0.370	0.376
20	0.47	0.49	0.52	0.56	0.60	0.63	0.69	0.74	0.79	0.88	0.95
	0.309	0.256	0.214	0.171	0.146	0.126	0.106	0.094	0.083	0.073	0.066
	0.42	0.56	0.73	1.05	1.36	1.76	2.47	3.20	4.12	5.74	7.35
	2.5	3.6	5.3	8.5	12.4	17.9	29.3	42.2	61.1	99.2	143.3
	0.372	0.372	0.375	0.381	0.387	0.395	0.405	0.415	0.424	0.436	0.445
40	0.49	0.52	0.55	0.60	0.64	0.68	0.75	0.81	0.88	0.98	1.09
	0.425	0.360	0.307	0.253	0.222	0.196	0.168	0.151	0.137	0.122	0.113
	0.38	0.51	0.66	0.93	1.21	1.57	2.20	2.84	3.64	5.06	6.67
	2.7	3.8	5.5	9.0	13.0	18.6	30.2	43.3	62.3	100.4	137.7
	0.441	0.445	0.449	0.457	0.465	0.473	0.485	0.494	0.502	0.513	0.522
60	0.50	0.53	0.57	0.62	0.67	0.72	0.80	0.87	0.94	1.06	1.16
	0.524	0.449	0.389	0.326	0.289	0.258	0.225	0.204	0.187	0.168	0.156
	0.36	0.47	0.61	0.87	1.13	1.46	2.03	2.63	3.38	4.70	6.07
	2.8	4.0	5.7	9.2	13.2	19.1	30.8	43.8	62.6	100.3	143.0
	0.490	0.494	0.500	0.509	0.517	0.526	0.536	0.545	0.553	0.561	0.567
80	0.51	0.55	0.59	0.66	0.69	0.75	0.84	0.91	0.99	1.12	1.24
	0.615	0.532	0.464	0.395	0.351	0.316	0.278	0.254	0.234	0.211	0.197
	0.34	0.45	0.59	0.87	1.07	1.38	1.93	2.48	3.20	4.46	5.71
	2.9	4.0	5.8	8.8	13.5	19.3	31.0	44.3	62.8	99.9	141.8
	0.529	0.534	0.540	0.554	0.557	0.565	0.576	0.583	0.589	0.597	0.600
100	0.52	0.57	0.60	0.66	0.72	0.78	0.87	0.95	1.04	1.18	1.30
	0.699	0.611	0.536	0.458	0.412	0.371	0.328	0.302	0.279	0.253	0.237
	0.33	0.45	0.56	0.79	1.02	1.32	1.85	2.38	3.05	4.26	5.47
	2.9	3.9	5.9	9.5	13.8	19.5	31.1	44.3	63.1	99.7	140.9
	0.562	0.571	0.573	0.582	0.589	0.597	0.607	0.613	0.618	0.624	0.627
200	0.56	0.61	0.66	0.73	0.80	0.87	0.99	1.08	1.20	1.37	1.52
	1.078	0.958	0.858	0.751	0.684	0.628	0.566	0.526	0.491	0.452	0.426
	0.29	0.38	0.49	0.69	0.89	1.15	1.61	2.06	2.67	3.72	4.76
	3.0	4.3	6.2	9.9	14.0	19.9	31.6	44.8	62.5	98.1	137.9
	0.677	0.682	0.687	0.694	0.700	0.704	0.709	0.711	0.712	0.711	0.709
400	0.62	0.66	0.73	0.83	0.91	1.00	1.14	1.27	1.41	1.62	1.81
	1.734	1.572	1.427	1.274	1.176	1.092	0.998	0.938	0.882	0.819	0.778
	0.26	0.32	0.43	0.61	0.78	1.00	1.39	1.81	2.32	3.23	4.14
	3.2	4.8	6.3	10.0	14.2	20.0	31.6	43.4	61.5	95.3	133.2
	0.813	0.829	0.817	0.820	0.820	0.820	0.817	0.813	0.808	0.798	0.789
600	0.64	0.72	0.79	0.89	0.98	1.09	1.25	1.39	1.55	1.80	2.03
	2.336	2.127	1.951	1.757	1.633	1.527	1.403	1.323	1.252	1.169	1.113
	0.23	0.31	0.40	0.56	0.71	0.93	1.29	1.66	2.13	2.95	3.82
	3.4	4.5	6.4	10.1	14.2	19.7	31.1	43.3	60.4	94.1	129.1
	0.919	0.902	0.900	0.897	0.894	0.889	0.881	0.873	0.863	0.848	0.836
800	0.70	0.74	0.83	0.94	1.05	1.16	1.35	1.50	1.68	1.95	2.19
	2.897	2.660	2.449	2.220	2.074	1.943	1.797	1.697	1.609	1.507	1.438
	0.23	0.29	0.37	0.52	0.68	0.87	1.23	1.57	2.01	2.81	3.61
	3.1	4.7	6.5	10.2	14.0	19.8	30.0	42.6	59.2	91.2	126.4
	0.970	0.986	0.970	0.954	0.947	0.939	0.926	0.915	0.902	0.883	0.867
1000	0.71	0.79	0.85	1.00	1.10	1.20	1.42	1.58	1.79	2.08	2.34
	3.438	3.166	2.937	2.670	2.498	2.349	2.176	2.061	1.960	1.838	1.756
	0.21	0.28	0.35	0.50	0.64	0.79	1.16	1.49	1.94	2.69	3.45
	3.3	4.5	6.7	9.9	14.1	21.1	30.5	42.3	57.7	89.5	123.9
	1.021	1.016	1.030	0.998	0.989	0.987	0.962	0.948	0.932	0.910	0.891
2000	0.81	0.90	1.00	1.16	1.29	1.46	1.70	1.84	2.16	2.53	2.88
	5.973	5.557	5.197	4.788	4.516	4.275	3.993	3.807	3.631	3.425	3.286
	0.18	0.24	0.31	0.43	0.56	0.72	1.01	1.22	1.67	2.33	3.03
	3.4	4.7	6.5	10.1	13.9	19.1	29.3	44.4	59.4	84.6	114.4
	1.196	1.181	1.164	1.140	1.129	1.099	1.070	1.061	1.022	0.989	0.962
4000	0.94	1.05	1.18	1.37	1.55	1.74	2.06	2.32	2.71	3.13	3.54
	10.608	9.963	9.392	8.738	8.285	7.886	7.410	7.088	6.794	6.433	6.185
	0.16	0.21	0.26	0.37	0.48	0.62	0.87	1.12	1.52	2.04	2.64
	3.3	4.6	6.4	9.9	13.4	18.6	27.9	38.3	48.7	78.1	107.1
	1.382	1.352	1.323	1.282	1.250	1.218	1.174	1.141	1.102	1.063	1.045

Note: The five values given for the sediment concentration for each discharge are as follows:

Velocity, metres/sec	Slope * 1000	Depth, metres
Width, metres	Friction factor * 10	

Table C-4
Computed Alternative Sets of Stable Channel Properties Using SAM Program

	Stable Channels for Q = 4500.0					C,ppm = 150.0	D50 = .500		
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(2) Regime
1	13.	13.7	.000972	.0436	7.33	4.01	.19	.83	TL
2	26.	13.5	.000672	.0422	7.71	3.56	.17	.57	TL
3	39.	12.9	.000548	.0409	7.84	3.36	.16	.44	TL
4	52.	12.3	.000479	.0396	7.85	3.24	.16	.37	TL
5	65.	11.6	.000434	.0384	7.78	3.16	.16	.31	LO
6	78.	10.9	.000402	.0373	7.65	3.10	.17	.27	LO
7	91.	10.3	.000380	.0362	7.49	3.06	.17	.24	LO
8	104.	9.7	.000363	.0352	7.31	3.03	.17	.22	LO
	117.	9.2	.000351	.0343	7.11	3.00	.17	.20	LO
10	130.	8.7	.000341	.0334	6.91	2.98	.18	.19	LO
11	143.	8.3	.000334	.0327	6.70	2.96	.18	.17	LO
12	156.	7.9	.000329	.0320	6.49	2.93	.18	.16	LO
13	169.	7.5	.000325	.0313	6.29	2.92	.19	.15	LO
14	182.	7.1	.000322	.0307	6.10	2.90	.19	.14	LO
15	195.	6.8	.000321	.0302	5.91	2.88	.19	.14	LO
16	208.	6.5	.000320	.0297	5.73	2.86	.20	.13	LO
17	221.	6.3	.000319	.0293	5.55	2.84	.20	.12	LO
18	234.	6.0	.000320	.0289	5.39	2.83	.20	.12	LO
19	247.	5.8	.000320	.0285	5.23	2.81	.21	.12	LO
20	260.	5.6	.000321	.0282	5.08	2.79	.21	.12	LO
				Results at Minimum Stream Power					
21	223.	6.2	.000319	.0292	5.53	2.84	.20	.12	LO

Notes: (1) Cross Section Properties: LEFT BANK RIGHT BANK
SIDE SLOPE, [H:1V] = 5.000 5.000
Ks, FT = 5.189 5.189
n-VALUE = .04500 .04500
(2) REGIMES: LO = LOWER, TL = TRANSITIONAL-LOWER, TU = TRANSITIONAL-UPPER, UP = UPPER

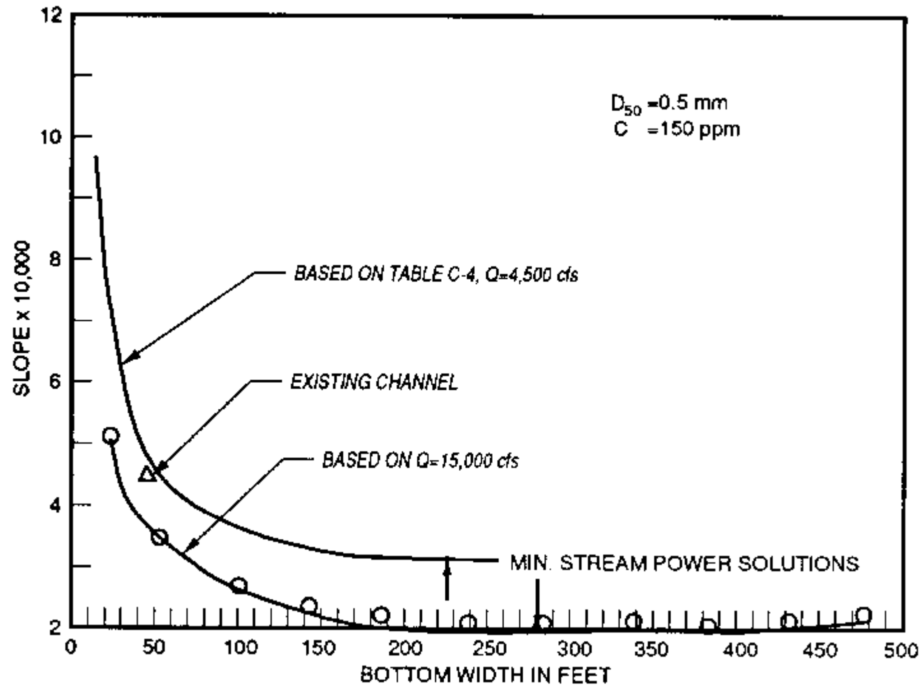

Figure C-3. Slope versus width curves for discharges of 4,500 cfs (Table C-4) and 51,000 cfs, based on output from SAM program