



U.S. ENVIRONMENTAL PROTECTION AGENCY

Watershed Assessment of River Stability & Sediment Supply (WARSSS)

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Bank Erosion Prediction (BEHI, NBS)

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The prediction of stream bank erosion rates uses the "Bank Assessment for Non-point source Consequences of Sediment" (BANCS) method. This method as published by Rosgen (2001a) utilizes two bank erodibility estimation tools: the **Bank Erosion Hazard Index (BEHI)**, and **Near Bank Stress (NBS)**. The application involves evaluating the bank characteristics and flow distribution along river reaches and mapping various risk ratings commensurate with bank and channel changes. An estimate of erosion rate is made, and then multiplied times the bank height times the length of bank of a similar condition, providing an estimate of cubic yards and/or tons of sediment/year. This information can be compared to the sediment yield data to apportion the amount of sediment potentially contributed by streambanks.

The relationships developed to convert measurements of streambank variables into risk categories are shown along with bank erosion and bank angle illustrations in **Figures 112 to 114** (Rosgen, 2001a). A sketch of a streambank and some of the variables surveyed and calculated is shown in **Worksheet 20** (PDF, 38 kb, 1 p.). The use of channel materials, bank stratification and all of the variable ratios and ranges are summarized in the Bank Erosion Hazard Index (BEHI) form (**Worksheet 21**, PDF, 40 kb, 1 p.).

Figure 112. Streambank erodibility criteria used for the BEHI rating (Rosgen 1996, 2001a)

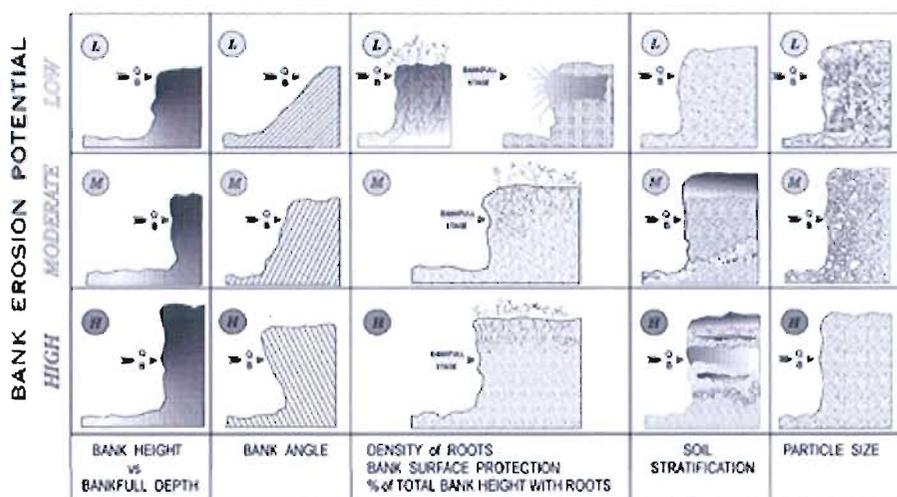


Figure 113. Illustrated examples of the five BEHI criteria

Five Common Bank Angle Scenarios

Perspective: Cross section view - left bank looking downstream

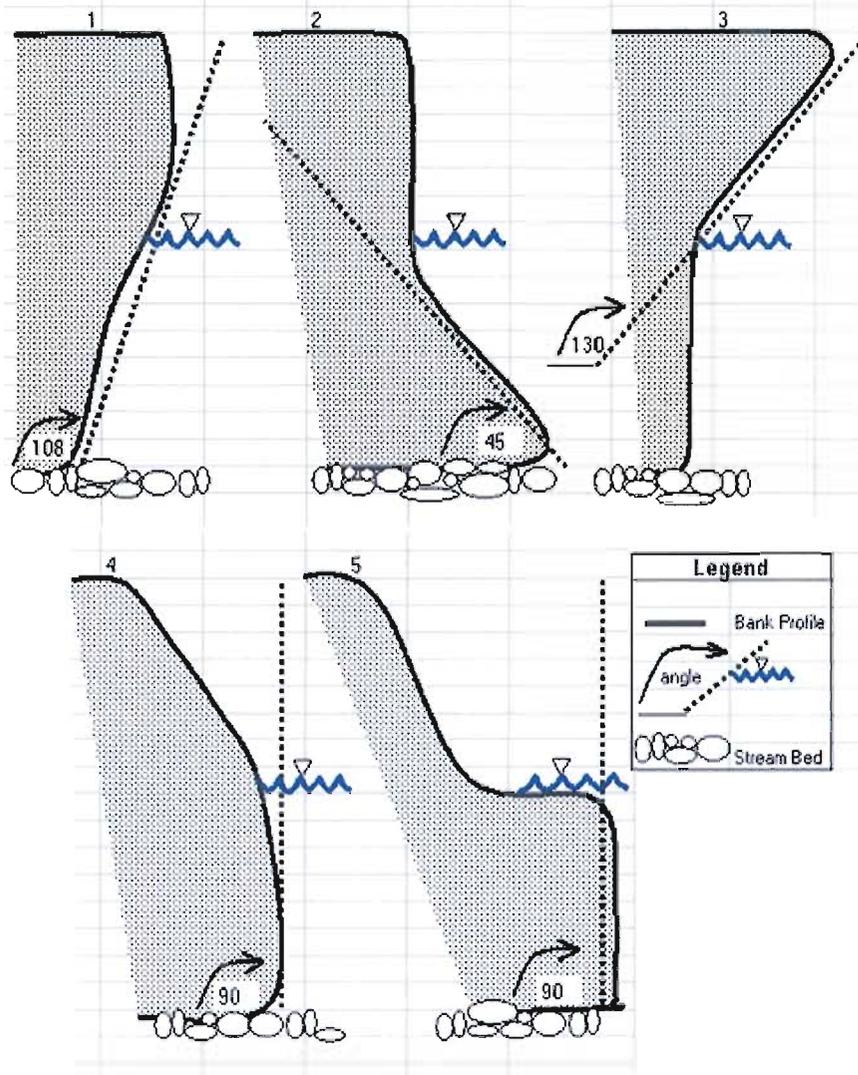


Figure 114. Common bank angle scenarios

Bank Erosion Risk Rating	Velocity Gradient	Near-bank stress/shear stress
Very Low	Less than 0.5	Less than 0.8
Low	0.5 - 1.0	0.8 - 1.05
Moderate	1.1 - 1.6	1.06 - 1.14
High	1.61 - 2.0	1.15 - 1.19
Very High	2.1 - 2.4	1.2 - 1.6
Extreme	Greater than 2.4	Greater than 1.60

Worksheet 21. Summary of bank erosion hazard index (BEHI)

Bank Erosion Hazard Rating Guide						
Stream	Reach		Date		Crew	
Bank Height (ft):	Bank Height/	Root Depth/	Root	Bank Angle	Surface	
Bankfull Height (ft):	Bankfull Ht	Bank Height	Density %	(Degrees)	Protection%	
VERY LOW	Value	1.0-1.1	1.0-0.9	100-80	0-20	100-80
	Index	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
LOW	Value	1.11-1.19	0.89-0.5	79-55	21-60	79-55
	Index	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
MODERATE	Value	1.2-1.5	0.49-0.3	54-30	61-80	54-30
	Index	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
HIGH	Value	1.6-2.0	0.29-0.15	29-15	81-90	29-15
	Index	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
VERY HIGH	Value	2.1-2.8	0.14-0.05	14-5.0	91-119	14-10
	Index	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
EXTREME	Value	>2.8	<0.05	<5	>119	<10
	Index	10	10	10	10	10
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
V = value, I = index			SUB-TOTAL (Sum one index from each column)			

Bank Material Description:

Bank Materials

- Bedrock** (Bedrock banks have very low bank erosion potential)
- Boulders** (Banks composed of boulders have low bank erosion potential)
- Cobble** (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- Gravel** (Add 5-10 points depending percentage of bank material that is composed of sand)
- Sand** (Add 10 points)
- Silt Clay** (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50
Bank location description (circle one)					GRAND TOTAL
Straight Reach Outside of Bend					

Worksheet 22A. Various field methods of estimating Near-Bank Stress risk ratings for the calculation of erosion rate.

Estimating Near-Bank Stress (NBS)								
Stream:	Location:			Date:	Crew:			
Methods for Estimating Near-Bank Stress								
(1) Transverse bar or split channel/central bar creating NBS/high velocity gradient: Level I - Reconnaissance.								
(2) Channel pattern (Rc/W): Level II - General Prediction.								
(3) Ratio of pool slope to average water surface slope (Sp/S): Level II - General Prediction.								
(4) Ratio of pool slope to riffle slope (Sp/Srif): Level II - General Prediction.								
(5) Ratio of near-bank maximum depth to bankfull mean depth (d _{nb} /d _{bkf}): Level III - Detailed Prediction.								
(6) Ratio of near-bank shear stress to bankfull shear stress (τ _{nb} /τ _{bkf}): Level III - Detailed Prediction.								
(7) Velocity profiles/Isovels/Velocity gradient: Level IV - Validation.								
Level I	(1) Transverse and/or central bars - short and/or discontinuous. NBS = High/Very High							
	(1) Extensive deposition (continuous, cross channel). NBS = Extreme Chute cutoffs, down-valley meander migration, converging flow (Figure X). NBS = Extreme							
Level II	(2)	Radius of Curvature Rc (feet)	Bankfull Width W _{bkf} (feet)	Ratio Rc/W	Near-Bank Stress			
	(3)	Pool Slope S _p	Average Slope S	Ratio S _p /S	Near-Bank Stress	Dominant Near-Bank Stress		
	(4)	Pool Slope S _p	Riffle Slope S _{rif}	Ratio S _p /S _{rif}	Near-Bank Stress			
Level III	(5)	Near-Bank Max Depth d _{nb} (feet)	Mean Depth d (feet)	Ratio d _{nb} /d	Near-Bank Stress			
	(6)	Near-Bank Max Depth d _{nb} (feet)	Near-Bank Slope S _{nb}	Near-Bank Shear Stress τ _{nb} (lb/ft ²)	Mean Depth d (feet)	Average Slope S	Shear Stress τ (lb/ft ²)	Ratio τ _{nb} /τ
Level IV	(7)	Velocity Gradient (ft/s/ft)		Near-Bank Stress				
Converting Values to a Near-Bank Stress Rating								
Near-Bank Stress Rating		Method Number						
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low		N/A See (1) Above	>3.0	< 0.20	< 0.4	<1.0	<0.8	<1.0
Low			2.21 - 3.0	0.20 - 0.40	0.41 - 0.60	1.0 - 1.5	0.8 - 1.05	1.0 - 1.2
Moderate			2.01 - 2.2	0.41 - 0.60	0.61 - 0.80	1.51 - 1.8	1.06 - 1.14	1.21 - 1.6
High			1.81 - 2.0	0.61 - 0.80	0.81 - 1.0	1.81 - 2.5	1.15 - 1.19	1.61 - 2.0
Very High			1.5 - 1.8	0.81 - 1.0	1.01 - 1.2	2.51 - 3.0	1.20 - 1.60	2.01 - 2.3
Extreme		< 1.5	> 1.0	> 1.2	> 3.0	> 1.6	> 2.3	
								Overall Near-Bank Stress Rating