Assessing Bank Erosion Potential Using Rosgen's
Bank Erosion Hazard Index (BEHI)

Overview

While stream bank erosion is a natural process that occurs in every watershed, excessive erosion has serious adverse consequences for the physical and biological function of streams and rivers. Eroding streambanks can be a major source of sediment to a stream (up to 80% of the annual load; Simon and Thorne, 1996), and human activities such as urbanization or dam construction can accelerate bank erosion rates by more than an order of magnitude. It is often difficult, however, to distinguish between streambanks that are eroding at a natural rate from those that are or have the potential to erode at unnaturally high rates due to altered watershed hydrology or sediment loads. The **Bank Erosion Hazard Index** (**BEHI**), developed by Dave Rosgen of Wildland Hydrology, Inc. (Rosgen, 2001), is one of several procedures for assessing streambank erosion condition and potential. It assigns point values to several aspects of bank condition and provides an overall score that can be used to inventory stream bank condition over large areas, prioritize eroding banks for remedial actions etc.

Procedure

Below are descriptions of two BEHI procedures. The first describes the complete BEHI procedure created by Rosgen, including identification of bankfull width. The second describes a modified BEHI procedure, which does not require identification of bankfull width. The modified BEHI procedure is intended for use by workers who lack experience in identifying bankfull indicators, including volunteer monitors. Correctly identifying appropriate bankfull indicators requires considerable experience, and is the most subjective step in the original BEHI procedure.

In truth, both procedures described here are modified, in that the step of calculating BEHI scores have been simplified. This simplification is intended to remove some unnecessary subjectivity from the field observations, without overly reducing the utility of the procedure.

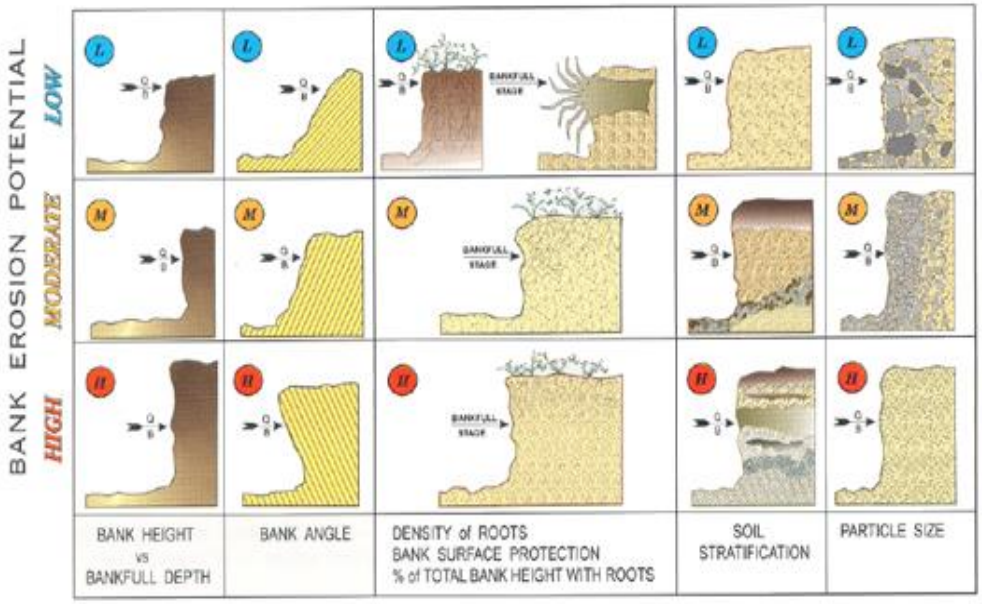
Complete BEHI procedure

The complete BEHI procedure consists of five metrics; four observational and one requiring some measurements. They are:

1. Ratio of bank height to bankfull height
2. Ratio of root depth to bank height
3. Root density, in percent
4. Bank angle, in degrees
5. Surface protection, in percent

A brief description of each metric is provided on the next page. Note: Point values for these metrics should only be assigned after a sufficient length of the stream channel (i.e. the stream reach) has been examined (at least 100 feet; two - three meander lengths is preferable), so that representative conditions are identified. Conditions on both banks should be assessed, and scored separately if they are consistently different.

1. Ratio of bank height to bankfull height: The ratio of bank height (**BH**) to bankfull height is the most challenging of the BEHI metrics, as it requires accurate identification of bankfull indicators. A full discussion of different bankfull indicators is beyond the scope of this document, but it is thoroughly discussed in Williams (1978), and a useful free video is available from the U.S. Forest Service (2003). Common bankfull indicators in stable streams include top of bank, top of point bars, and other changes in channel slope. Vegetative indicators are seldom useful in southern streams. Bankfull indicators in unstable streams (i.e., incising or aggrading streams) can be more difficult to identify, but are usually less than top of bank.



Stream Bank Erodibility Factors
(Rosgen 1993d)

2. Ratio of root depth to bank height: Root depth (**RDH**) is the ratio of the average plant root depth to the bank height, expressed as a percent (e.g. roots extending 2 feet into a 4 foot tall bank = 0.50).

3. Root density: Root density (**RD**), expressed as a percent, is the proportion of the streambank surface covered (and protected) by plant roots (e.g. a bank whose slope is half covered with roots = 50 percent).

4. Surface protection: Surface protection (**SP**) is the percentage of the stream bank covered (and therefore protected) by plant roots, downed logs, branches, rocks, etc. In many streams surface protection and root density are synonymous.

5. Bank angle: Bank angle (**BA**) is the angle of the "lower bank" – the bank from the waterline at base flow to the top of the bank, as opposed to benches that are higher on the floodplain. Bank angles great than 90 percent occur on undercut banks. Bank angle can be measured with an inclinometer, though given the broad bank angle categories, visual estimates are generally sufficient. Bank angle is perhaps the metric most often estimated incorrectly.

The overall BEHI score is based on the numbers in Appendix 1 - Table 1. A complete BEHI field sheet is provided in Appendix 2 - Page five.

Modified BEHI procedure

If the field staff lack experience with identifying bank full indicators, it is recommended that the bank height/bankfull height ratio metric be dropped from the BEHI calculation, leaving four metrics:

1. Ratio of root depth to bank height
2. Root density, in percent
3. Surface protection, in percent
4. Bank angle, in degrees

The overall BEHI score is based on the numbers in Appendix 1 - Table 2. A modified BEHI field sheet is provided in Appendix 2 – Page six.

We high recommend reviewing "**Stream Stability Analysis"** of the FGM Module. Completion of this section will help you understand the important field indicators of channel stability and provide you with exposure to methods for quantifying such indicators. Go to: http://www.fgmorph.com/fg_8_1.php to learn more.

References

1. Harrelson C. C. et al. 1994. Stream Channel Reference Sites: An Illustrated Guide to Field Technique, General Technical Report RM-245, USDA - Forest Service, Rocky Mountain Forest and Range Experiment Station. Available at: http://www.stream.fs.fed.us/publications/documentsStream.html

2. Rosgen, D.L. 2001. A Practical Method of Computing Streambank Erosion Rate. Proceedings of the 7th Federal Interagency Sedimentation Conference, Vol. 2, pp. 9-15, March 25, 2001, Reno, NV. Available on the Wildland Hydrology website at: http://www.wildlandhydrology.com/html/references_.html

3. Simon, A. et al. 1996. Channel Adjustment of an Unstable Coarse-Grained Alluvial Stream: Opposing Trends of Boundary and Critical Shear Stress. Earth Surface Processes and Landforms 21:155-180.

4. US Forest Service. 2003. Identifying Bankfull Stage in Forested Streams in the Eastern United States. Available at: http://www.stream.fs.fed.us/publications/videos.html

5. Williams, G.P. 1978. Bank-Full Discharge of Rivers. Water Resources Research 14(6):1141-1154.

Appendix 1

Table 1: Complete BEHI procedure

BEHI category	Bank height	**BH score**	Root depth	**RDH score**	Root density	**RD score**	Surface protection	**SP score**	Bank angle	**BA score**	**Total score by category**
Very low	1.0 – 1.1	**1.45**	90 - 100	**1.45**	80 - 100	**1.45**	80 - 100	**1.45**	0 - 20	**1.45**	≤ 7.25
Low	1.1 – 1.2	**2.95**	50 - 89	**2.95**	55 - 79	**2.95**	55 - 79	**2.95**	21 - 60	**2.95**	7.26 – 14.75
Moderate	1.3 – 1.5	**4.95**	30 - 49	**4.95**	30 - 54	**4.95**	30 - 54	**4.95**	61 - 80	**4.95**	14.76 – 24.75
High	1.6 – 2.0	**6.95**	15 - 29	**6.95**	15 - 29	**6.95**	15 - 29	**6.95**	81 - 90	**6.95**	24.76 – 34.75
Very high	2.1 – 2.8	**8.5**	5 - 14	**8.5**	5 - 14	**8.5**	10 - 14	**8.5**	91 - 119	**8.5**	34.76 – 42.50
Extreme	> 2.8	**10**	< 5	**10**	< 5	**10**	< 14	**10**	> 119	**10**	42.51 - 50

Table 2: Modified BEHI procedure (Ratio of bank to bankfull height not included)

BEHI category	Root depth	**RDH score**	Root density	**RD score**	Surface protection	**SP score**	Bank angle	**BA score**	**Total score by category**
Very low	90 - 100	**1.45**	80 - 100	**1.45**	80 - 100	**1.45**	0 - 20	**1.45**	≤ 5.8
Low	50 - 89	**2.95**	55 - 79	**2.95**	55 - 79	**2.95**	21 - 60	**2.95**	5.8 – 11.8
Moderate	30 - 49	**4.95**	30 - 54	**4.95**	30 - 54	**4.95**	61 - 80	**4.95**	11.9 – 19.8
High	15 - 29	**6.95**	15 - 29	**6.95**	15 - 29	**6.95**	81 - 90	**6.95**	19.9 – 27.8
Very high	5 - 14	**8.5**	5 - 14	**8.5**	10 - 14	**8.5**	91 - 119	**8.5**	27.9 - 34
Extreme	< 5	**10**	< 5	**10**	< 14	**10**	> 119	**10**	34.1 - 40

Appendix 2

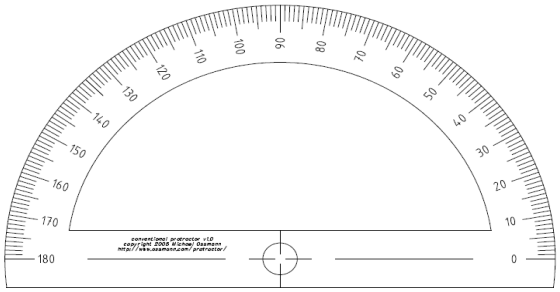
BEHI Field Form - Complete

Location description: _____ Analysis by: _____ Date: _____

_____ Latitude: _____ Longitude: _____

BEHI category	**A**		**B**		**C**		**D**		**E**	
	Bank height	**BH score**	Root depth	**RDH score**	Root density	**RD score**	Surface protection	**SP score**	Bank angle	**BA score**
Very low	1.0 – 1.1	**1**	90 - 100	**1**	80 - 100	**1**	80 - 100	**1**	0 - 20	**1**
Low	1.1 – 1.2	**3**	50 - 89	**3**	55 - 79	**3**	55 - 79	**3**	21 - 60	**3**
Moderate	1.3 – 1.5	**5**	30 - 49	**5**	30 - 54	**5**	30 - 54	**5**	61 - 80	**5**
High	1.6 – 2.0	**7**	15 - 29	**7**	15 - 29	**7**	15 - 29	**7**	81 - 90	**7**
Very high	2.1 – 2.8	**8.5**	5 - 14	**8.5**	5 - 14	**8.5**	10 - 14	**8.5**	91 - 119	**8.5**
Extreme	> 2.8	**10**	< 5	**10**	< 5	**10**	< 14	**10**	> 119	**10**

Material adjustment (F)		**Stratification adjustment (G)**		**Total Score** (Sum **A**-**G**)
Bedrock - automatically	Very low	No layer	No adjustment	
Boulder - automatically	Low	Single layer	(+) 5	
Cobble	(-) 10	Multiple layers	(+) 10	
Gravel or mostly gravel	(+) 5			
Sand or mostly sands	(+) 10			
Silt/loam	No adjustment			
Clay	(-) 20			



BEHI Category: _____

Very low	Low	Moderate	High	Very high	Extreme
≤ 9.5	10 - 19.5	20 - 29.5	30 - 39.5	40 - 45	> 45

Comments:

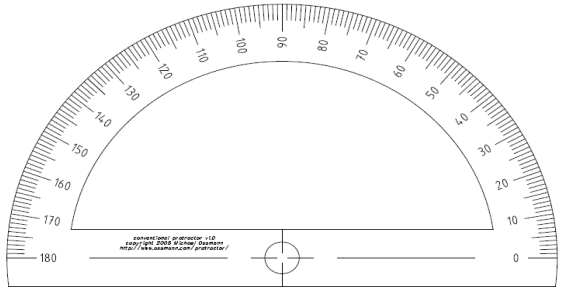
BEHI Field Form - Modified

Location description: _____ Analysis by: _____ Date: _____

Latitude: _____ Longitude: _____

BEHI category	Root depth	**RDH score**	Root density	**RD score**	Surface protection	**SP score**	Bank angle	**BA score**
Very low	90 - 100	**1**	80 - 100	**1**	80 - 100	**1**	0 - 20	**1**
Low	50 - 89	**3**	55 - 79	**3**	55 - 79	**3**	21 - 60	**3**
Moderate	30 - 49	**5**	30 - 54	**5**	30 - 54	**5**	61 - 80	**5**
High	15 - 29	**7**	15 - 29	**7**	15 - 29	**7**	81 - 90	**7**
Very high	5 - 14	**8.5**	5 - 14	**8.5**	10 - 14	**8.5**	91 - 119	**8.5**
Extreme	< 5	**10**	< 5	**10**	< 14	**10**	> 119	**10**

Material adjustment (**F**)		**Stratification adjustment** (**G**)		**Total Score** (Sum **A** - **G**)
Bedrock - automatically	Very low	No layer	No adjustment	
Boulder - automatically	Low	Single layer	(+) 5	
Cobble	(-) 10	Multiple layers	(+) 10	
Gravel or mostly gravel	(+) 5			
Sand or mostly sands	(+) 10			
Silt/loam	No adjustment			
Clay	(-) 20			



BEHI Category: _____

Very low	Low	Moderate	High	Very high	Extreme
≤ 6	6 - 12	13 - 20	21 - 28	29 - 34	> 34

Comments: