

Knife River Bank Erosion Hazard Index (BEHI)

05/2022



On May 25th, 2022, field scientists Emma Burgeson and Lara Scott collected field measurements to conduct a Bank Erosion Hazard Index (BEHI) analysis (Appendix 1) on three degrading banks. These banks occur between County Road 11 and County Road 9 on the main stem of the Knife River near Two Harbors, MN. Each of the three banks have similar geomorphic characteristics. The average height is 25 ft, with a range from 20-40ft at the highest point. The vegetation above these banks consists of shrubs, aspen, and dying balsam fir that no longer provide support to the bank with their root mass. Each of the banks is laden with trees that are either partially or entirely slumped into the river.

The factors needed for the BEHI analysis were either collected in the field or calculated based on existing literature. Three cross sections were taken along the length of the bank to determine bankfull depth. Bank length, total bank height, and angle were also measured in the field (Table 1). The average root depth was calculated for the two primary species atop the bank: *Abies balsamea* (Balsam Fir) and *Alnus incana* (Speckled Alder).

The bank height ratio and root depth ratio ranked in the Extreme hazard category for all three banks. Surface protection was ranked in the Very High hazard category in two of the three, and bank angle was the only factor to rank in the Low category. Despite most of the factors indicating that the erosion hazard for this bank is high, the overall BEHI score ranked low for all three banks given the material adjustment for clay. While the adhesion of clay makes it more stable than sand or gravel, the active degradation and recent flooding conditions warrant serious consideration of the impacts to the water quality and thus aquatic organism habitat downstream of this bank.

Yearly Sediment Contribution to the Stream

Yearly sediment contribution to the stream was calculated using an erosion rate of 8cm/year (Hall, 2016). The estimated material eroded from the upstream bank is 32 tons/year, 121 tons/year from the powerline bank, and 49 tons/year from the downstream bank.

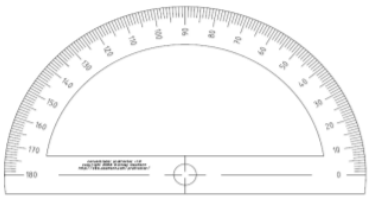
BEHI Field Worksheet – Upstream of Powerline Bank

BEHI Field Form - Complete

Location description: 0.5 miles South of Valley Rd, Analysis by: Emma Burgeson, Lara Scott Date: 5.25.2022
Lake County MN Latitude: 47° 1'31.01"N Longitude: 91°44'24.36"W

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: 37 – 20 = 17

Very low ≤ 9.5	Low 10 - 19.5	Moderate 20 - 29.5	High 30 - 39.5	Very high 40 - 45	Extreme > 45
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Comments: Without the material adjustment, this bank would have fallen into the Very High hazard category. The bank was actively slumping into the river with no bench formed. While a small section of the bank had some grasses and shrubs at the toe of the slope, the majority of the bank was clay actively slumping into the river with no bench formation. Additionally, trees from the top of the bank continue to fall into the river.

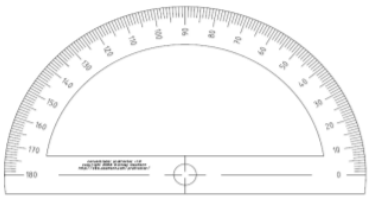
BEHI Field Worksheet – Powerline Bank

BEHI Field Form - Complete

Location description: 0.8 miles South of Valley Rd, Lake County MN Analysis by: Emma Burgeson, Lara Scott Date: 5.25.2022
 Latitude: 47° 1'16.25"N Longitude: 91°44'35.19"W

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: $37 - 20 = 17$

Very low ≤ 9.5	Low 10 - 19.5	Moderate 20 - 29.5	High 30 - 39.5	Very high 40 - 45	Extreme > 45
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Comments: Without the material adjustment, this bank would have fallen into the Very High hazard category. The bank was actively slumping into the river with no bench formed. While a small section of the bank had some grasses and shrubs at the toe of the slope, the majority of the bank was clay actively slumping into the river with no bench formation. Additionally, trees from the top of the bank continue to fall into the river.

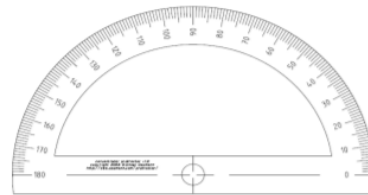
BEHI Field Worksheet – Downstream Bank from Powerline

BEHI Field Form - Complete

Location description: 1 mile South of Valley Rd, Lake County MN Analysis by: Emma Burgeson, Lara Scott Date: 5.25.2022
 Latitude: 47° 1'11.84"N Longitude: 91°44'29.31"W

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: 39 – 20 = 19

Very low ≤ 9.5	Low 10 - 19.5	Moderate 20 - 29.5	High 30 - 39.5	Very high 40 - 45	Extreme > 45
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Comments: Without the material adjustment, this bank would have fallen into the Very High hazard category. The bank was actively slumping into the river with no bench formed. While a small section of the bank had some grasses and shrubs at the toe of the slope, the majority of the bank was clay actively slumping into the river with no bench formation. Additionally, trees from the top of the bank continue to fall into the river.

References

Hall, L. (2016). Monitoring Bluff Erosion Rates Using Terrestrial Laser Scanning on Minnesota's North Shore Streams. <https://conservancy.umn.edu/handle/11299/181794>

Rosgen, D. L. (2001, March). A practical method of computing streambank erosion rate. In *Proceedings of the Seventh Federal Interagency Sedimentation Conference* (Vol. 1).

West Virginia Department of Environmental Protection. BEHI Overview and field worksheet. <https://dep.wv.gov/WWE/getinvolved/sos/Documents/SOPs/BEHI-Overview.pdf>