**Worksheet 3-11.** Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.

| | | | |
|---|---|---|---|
| Stream: | **Holmes Run** | Location: | **BEHI #1** |
| Station: | **50 ft** | Observers: | **Biggs/Hepp** |
| Date: | **3/27/18** | Stream Type: **Outfall** | Valley Type: **VI** |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | **Study Bank Height / Bankfull Height ( C )** | | **BEHI Score (Fig. 3-7)** |
| **Study Bank Height** (ft) = | **8.00 (A)** | **Bankfull Height** (ft) = | **0.25 (B)** | ( A ) / ( B ) = | **32.00 (C)** | **10.0** |
| | | | | **Root Depth / Study Bank Height ( E )** | | |
| **Root Depth** (ft) = | **6.00 (D)** | **Study Bank Height** (ft) = | **8.00 (A)** | ( D ) / ( A ) = | **0.75 (E)** | **2.6** |
| | | | | **Weighted Root Density ( G )** | | |
| | | **Root Density** as % = | **20.00 (F)** | ( F ) × ( E ) = | **15 (G)** | **8.0** |
| | | | | **Bank Angle ( H )** | | |
| | | | | **Bank Angle** as *Degrees* = | **60 (H)** | **3.9** |
| | | | | **Surface Protection ( I )** | | |
| | | | | **Surface Protection** as % = | **5% ( I )** | **10.0** |

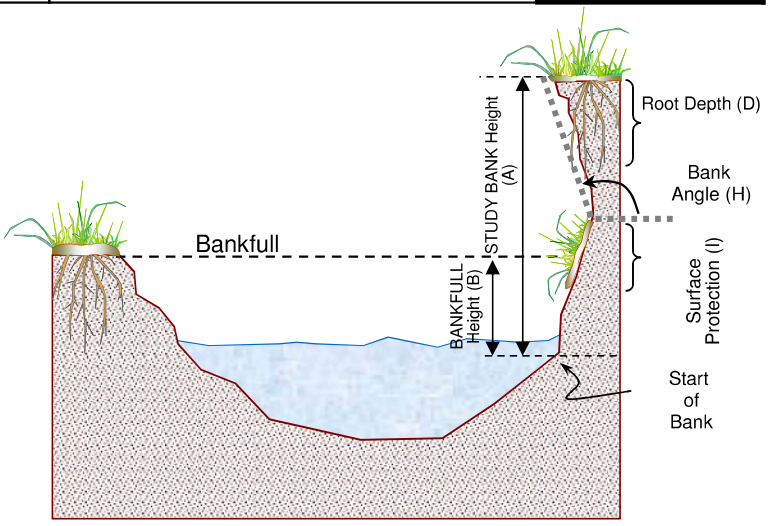
**Bank Material Adjustment:**

**Bedrock** (Overall Very Low BEHI)
**Boulders** (Overall Low BEHI)
**Cobble** (Subtract 10 points if uniform medium to large cobble)
**Gravel or Composite Matrix** (Add 5–10 points depending on percentage of bank material that is composed of sand)
**Sand** (Add 10 points)
**Silt/Clay** (no adjustment)

**Bank Material Adjustment:** **10**

**Stratification Adjustment**
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage

| Very Low | Low | Moderate | High | Very High | Extreme | | |
|---|---|---|---|---|---|---|---|
| 5 – 9.5 | 10 – 19.5 | 20 – 29.5 | 30 – 39.5 | 40 – 45 | 46 – 50 | **Adjective Rating and Total Score** | **Very High 44.5** |



**Worksheet 3-12.** Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

## Estimating Near-Bank Stress ( NBS )

Stream: **Holmes Run** Location: **BEHI #1**

Station: **50 ft** Stream Type: **Outfall** Valley Type: **VI**

Observers: **Biggs/Hepp** Date: **3/27/18**

### Methods for Estimating Near-Bank Stress (NBS)

| | | |
|---|---|---|
| (1) Channel pattern, transverse bar or split channel/central bar creating NBS | Level I | Reconaissance |
| (2) Ratio of radius of curvature to bankfull width ( $R_c$ / $W_{bkf}$ ) | Level II | General prediction |
| (3) Ratio of pool slope to average water surface slope ( $S_p$ / S ) | Level II | General prediction |
| (4) Ratio of pool slope to riffle slope ( $S_p$ / $S_{rif}$ ) | 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 ( $\tau_{nb}$ / $\tau_{bkf}$ ) | 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

Extensive deposition (continuous, cross-channel)…….…….…….. ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…….……..NBS = Extreme

**Level II**

**(2)**

| Radius of Curvature $R_c$ (ft) | Bankfull Width $W_{bkf}$ (ft) | *Ratio* $R_c$ / $W_{bkf}$ | Near-Bank Stress (NBS) |
|---|---|---|---|
| | | | |

**(3)**

| Pool Slope $S_p$ | Average Slope S | *Ratio* $S_p$ / S | Near-Bank Stress (NBS) |
|---|---|---|---|
| | | | |

**(4)**

| Pool Slope $S_p$ | Riffle Slope $S_{rif}$ | *Ratio* $S_p$ / $S_{rif}$ | Near-Bank Stress (NBS) |
|---|---|---|---|
| | | | |

**Dominant Near-Bank Stress**

**Very High**

**Level III**

**(5)**

| Near-Bank Max Depth $d_{nb}$ (ft) | Mean Depth $d_{bkf}$ (ft) | *Ratio* $d_{nb}$ / $d_{bkf}$ | Near-Bank Stress (NBS) |
|---|---|---|---|
| | | | |

**(6)**

| Near-Bank Max Depth $d_{nb}$ (ft) | Near-Bank Slope $S_{nb}$ | Near-Bank Shear Stress $\tau_{nb}$ ( lb/ft$^2$ ) | Mean Depth $d_{bkf}$ (ft) | Average Slope S | Bankfull Shear Stress $\tau_{bkf}$ ( lb/ft$^2$ ) | Ratio $\tau_{nb}$ / $\tau_{bkf}$ | Near-Bank Stress (NBS) |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

**Level IV**

**(7)**

| Velocity Gradient ( ft / sec / ft ) | Near-Bank Stress (NBS) |
|---|---|
| | |

### Converting Values to a Near-Bank Stress (NBS) Rating

| Near-Bank Stress (NBS) ratings | Method number (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| **Very Low** | N / A | > 3.00 | < 0.20 | < 0.40 | < 1.00 | < 0.80 | < 0.50 |
| **Low** | N / A | 2.21 – 3.00 | 0.20 – 0.40 | 0.41 – 0.60 | 1.00 – 1.50 | 0.80 – 1.05 | 0.50 – 1.00 |
| **Moderate** | N / A | 2.01 – 2.20 | 0.41 – 0.60 | 0.61 – 0.80 | 1.51 – 1.80 | 1.06 – 1.14 | 1.01 – 1.60 |
| **High** | See | 1.81 – 2.00 | 0.61 – 0.80 | 0.81 – 1.00 | 1.81 – 2.50 | 1.15 – 1.19 | 1.61 – 2.00 |
| **Very High** | (1) | 1.50 – 1.80 | 0.81 – 1.00 | 1.01 – 1.20 | 2.51 – 3.00 | 1.20 – 1.60 | 2.01 – 2.40 |
| **Extreme** | Above | < 1.50 | > 1.00 | > 1.20 | > 3.00 | > 1.60 | > 2.40 |

**Overall Near-Bank Stress (NBS) rating** **Very High**

**Worksheet 3-13.** Summary form of annual streambank erosion estimates for various study reaches.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Stream: | **Holmes Run** | | | Location: **Project Reach** | | | |
| Graph Used: | **DC Hickey Run** | Total Stream Length (ft): **50.0** | | | | Date: **3/27/18** | |
| Observers: | **Biggs/Hepp** | | Valley Type: **VI** | | | Stream Type: **Outfall** | |
| **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** | **(7)** | **(8)** |
| **Station (ft)** | **BEHI rating (Worksheet 3-11) (adjective)** | **NBS rating (Worksheet 3-12) (adjective)** | **Bank erosion rate (Figure 3-9 or 3-10) (ft/yr)** | **Length of bank (ft)** | **Study bank height (ft)** | **Erosion subtotal [(4)×(5)×(6)] ($ft^3$/yr)** | **Erosion Rate (tons/yr/ft)** |
| 1. **BEHI #1** | **Very High** | **Very High** | **1.700** | **50.0** | **8.0** | **680.00** | **0.78880** |
| 2. | | | | | | | |
| 3. | | | | | | | |
| 6. | | | | | | | |
| 7. | | | | | | | |
| 8. | | | | | | | |
| 9. | | | | | | | |
| 10. | | | | | | | |
| 11. | | | | | | | |
| 12. | | | | | | | |
| 13. | | | | | | | |
| 14. | | | | | | | |
| 15. | | | | | | | |
| Sum erosion subtotals in Column (7) for each BEHI/NBS combination | | | | | **Total Erosion ($ft^3$/yr)** | **680.00** | |
| Convert erosion in $ft^3$/yr to $yds^3$/yr {divide Total Erosion ($ft^3$/yr) by 27} | | | | | **Total Erosion ($yds^3$/yr)** | **25.19** | |
| Dry Bulk Density of the Soil is 116 lb/cf. | | | | | **Total Erosion (tons/yr)** | **39.44** | |
| Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed} | | | | | **Total Erosion (tons/yr/ft)** | **0.7888** | |