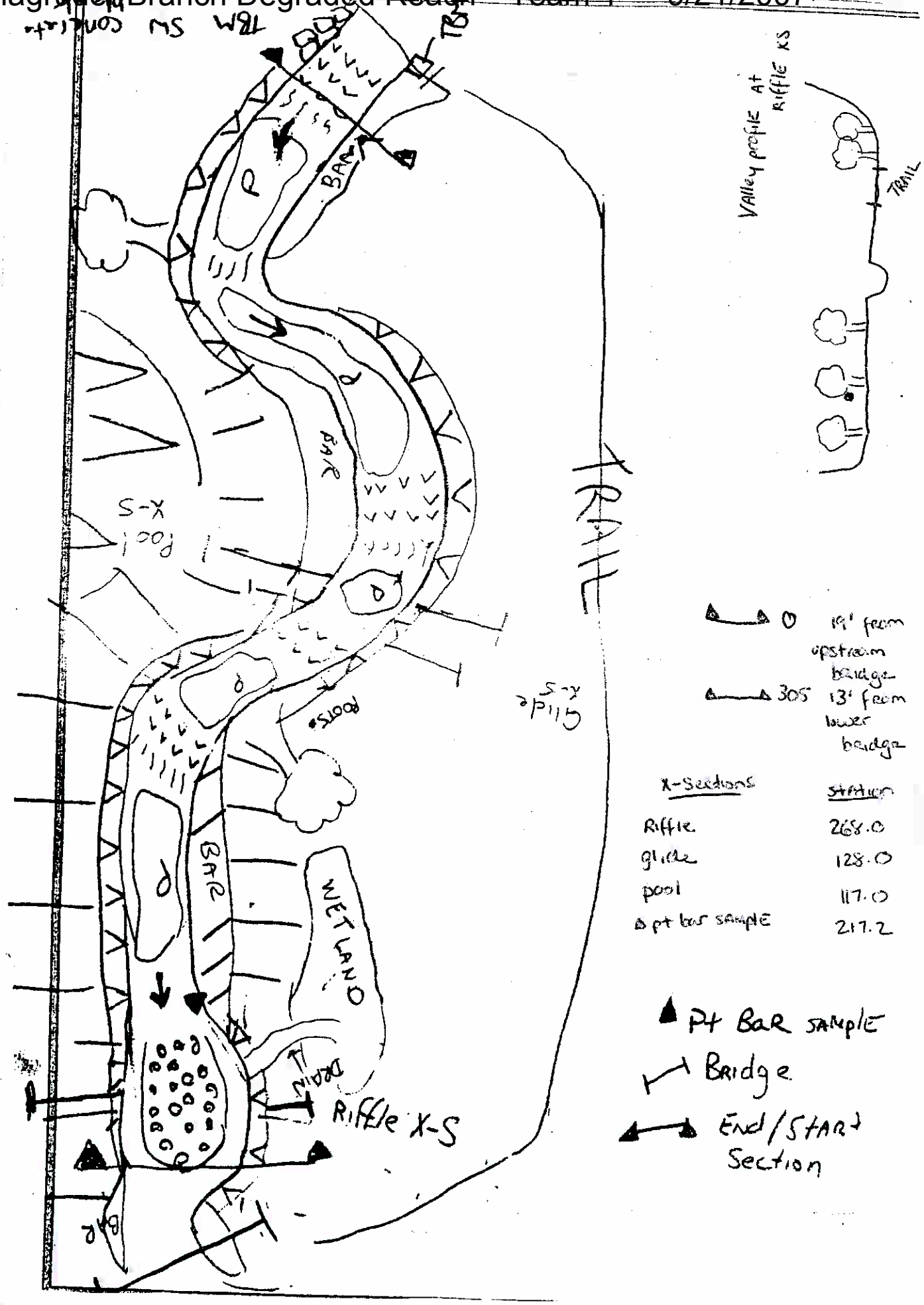
River Assessment and Monitoring
NCTC - Shepherdstown, WV
9/17 – 9/27/2007

Team 4
Day 3
Magruder Branch
Degraded Reach

Magruder Branch Degraded Reach Team 4 9/21/2007

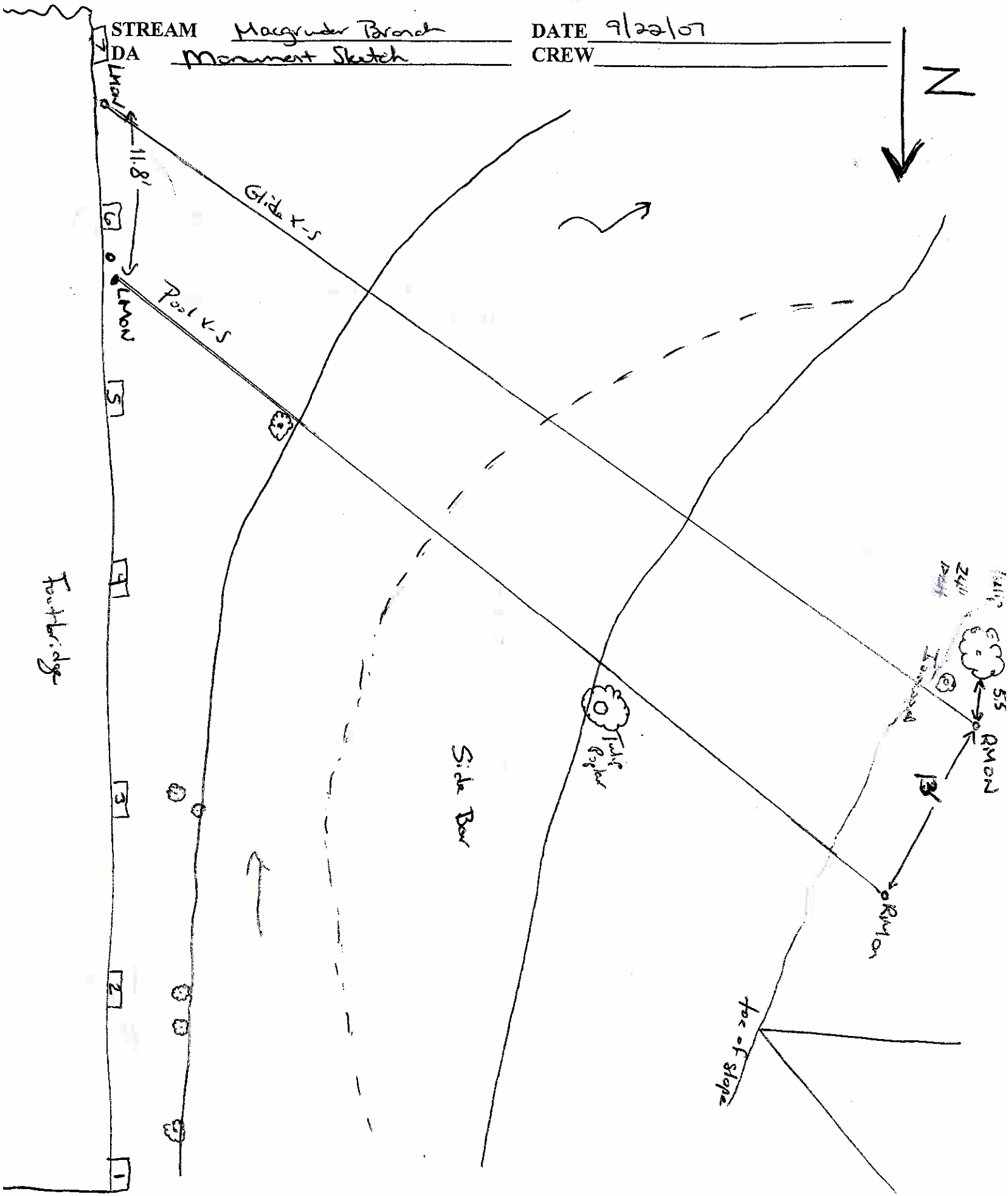


Magruder Branch Degraded Reach Team 4 9/21/2007

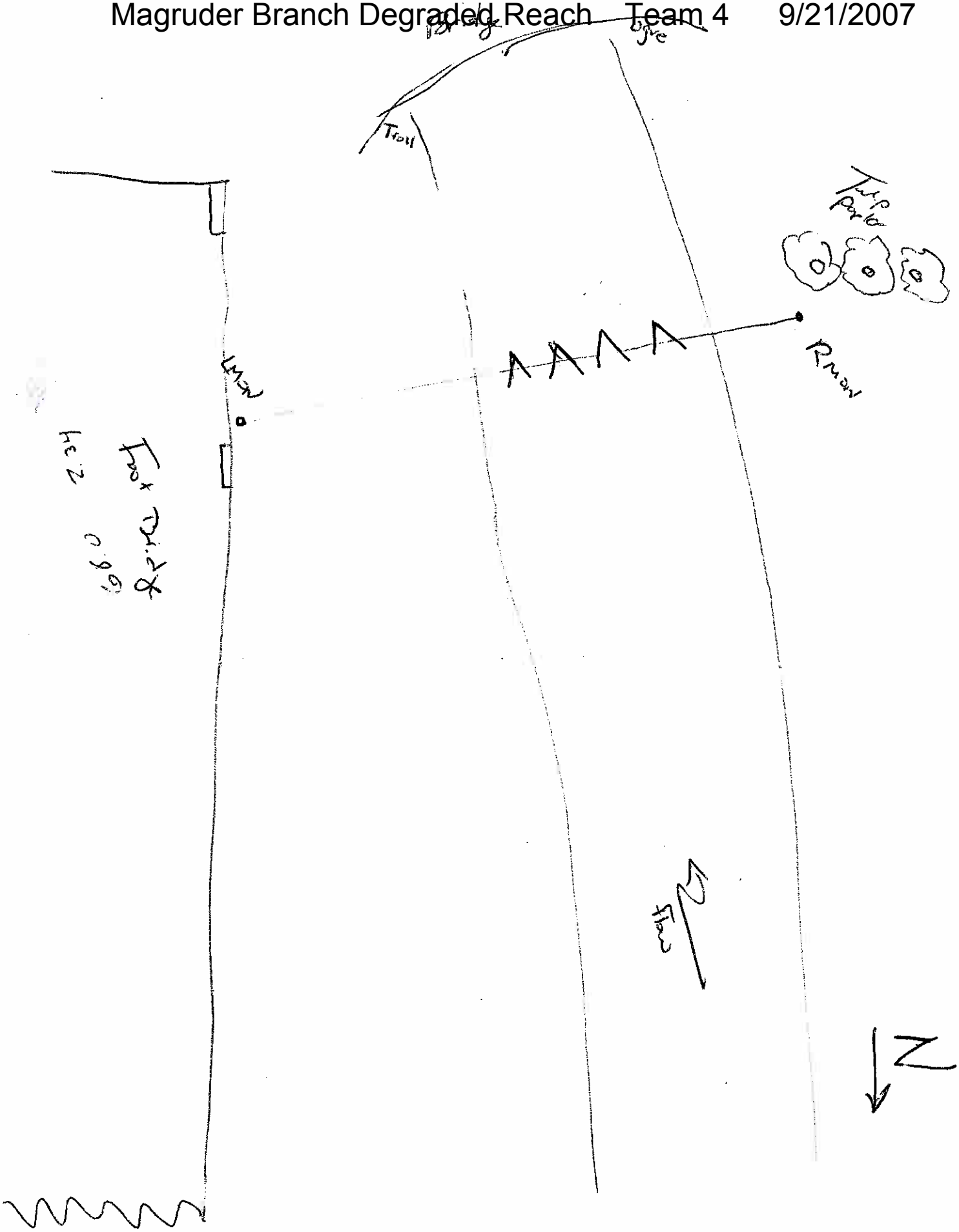
SITE SKETCH

STREAM Macgruder Branch DATE 9/22/07

DA Monument Sketch CREW

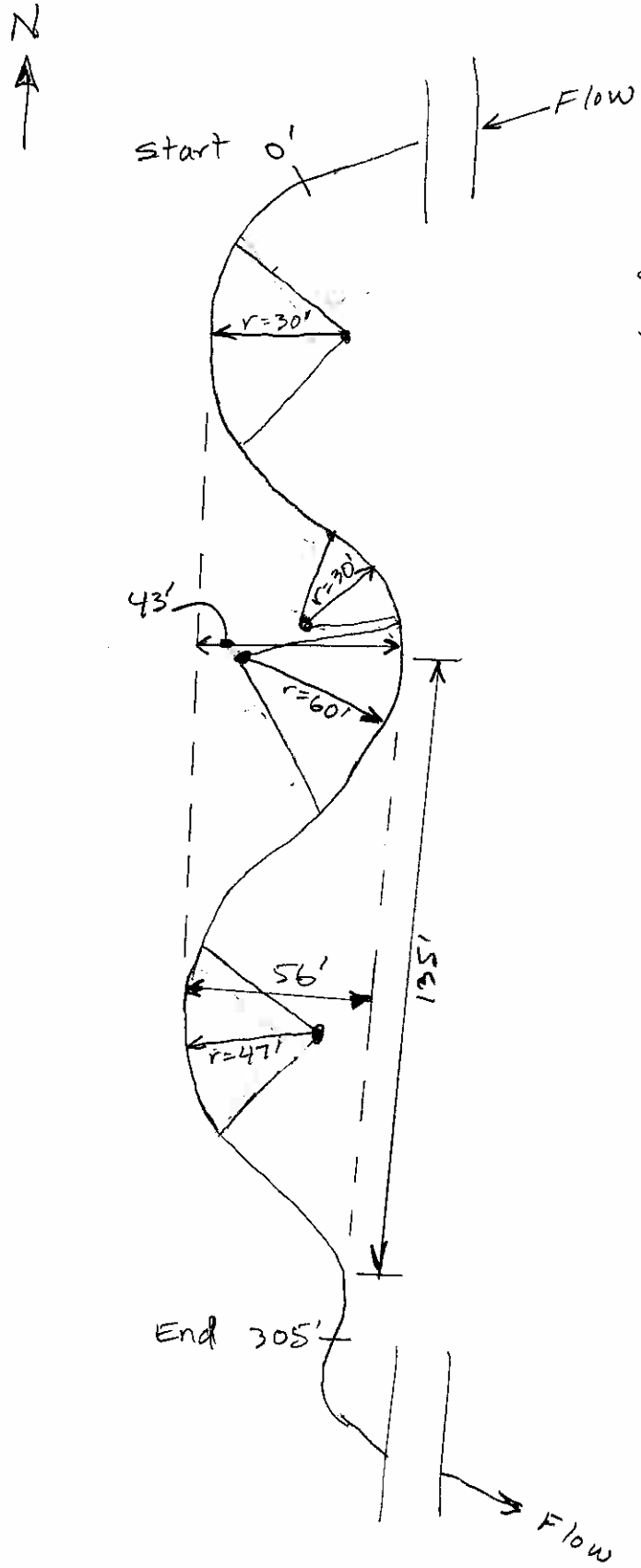


Magruder Branch Degraded Reach Team 4 9/21/2007



Magruder Branch Degraded Reach Team 4 9/21/2007

Macgruder
Team 4
Plan Form
Geometry



SL = 305'
VL = 281'

Team 4, Reach 4 9/25/07
Macgruder

Wave Length = 135 ft

Meander Belt Width = 43 ft, 56 ft.

Radius Curvature = 30', 30', 47', 60'

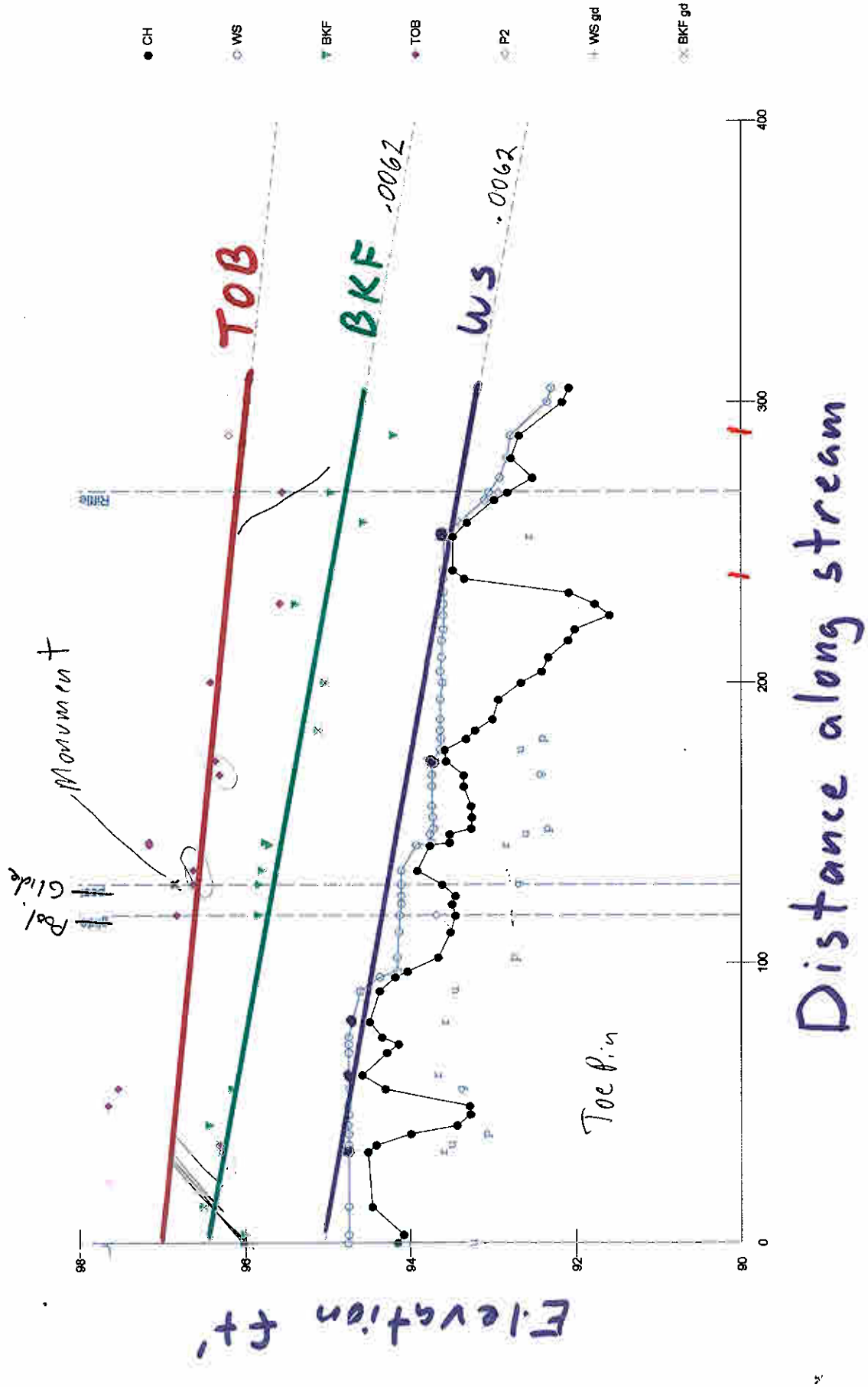
Meander width ratio = $\frac{MBW}{W_{bkf}}$ = 1.99

R_c ratio = $\frac{R_c}{W_{bkf}}$.

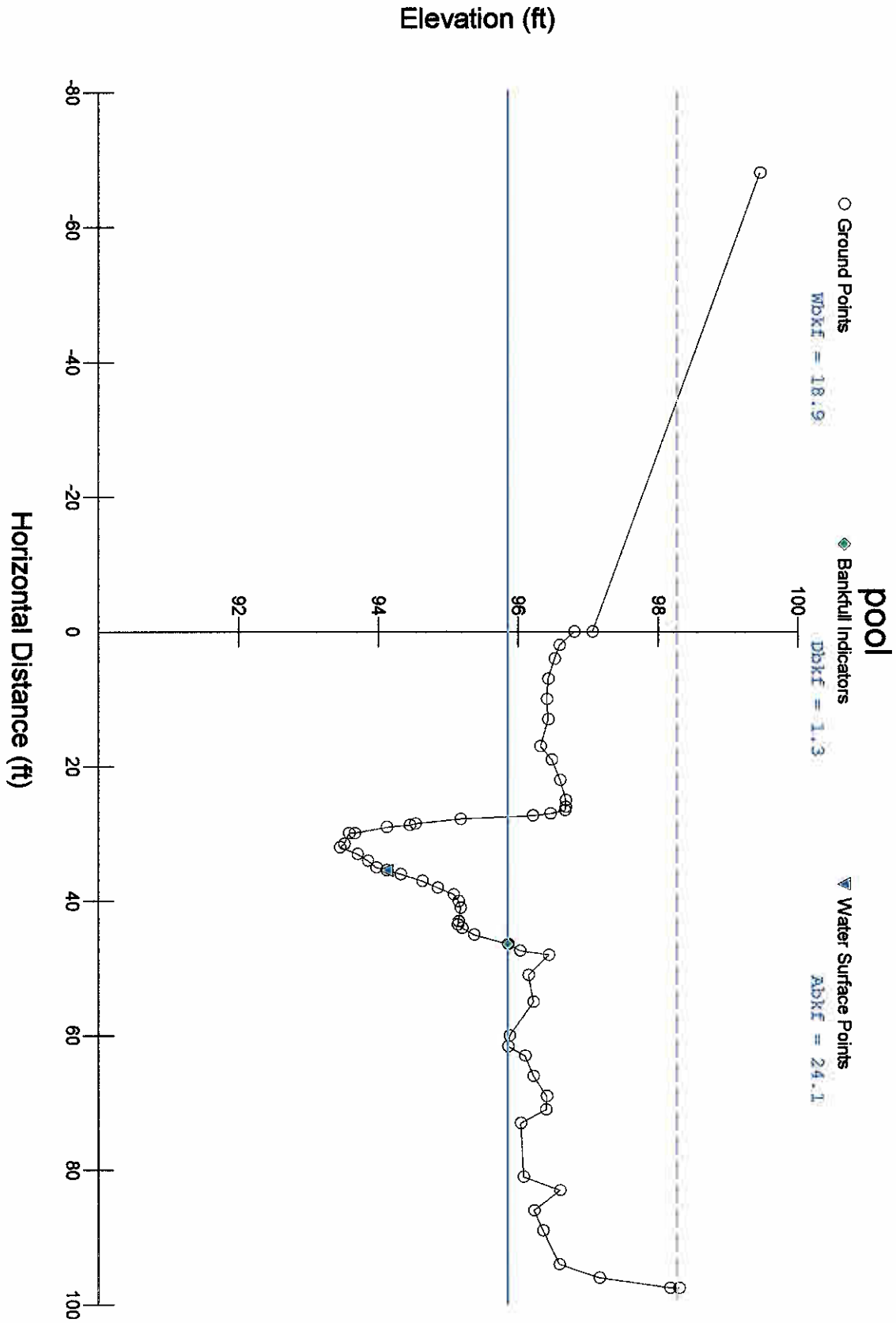
W_{bkf} = 25.1 ft

$K = \frac{SL}{VL} = \frac{326'}{281'} = 1.16$

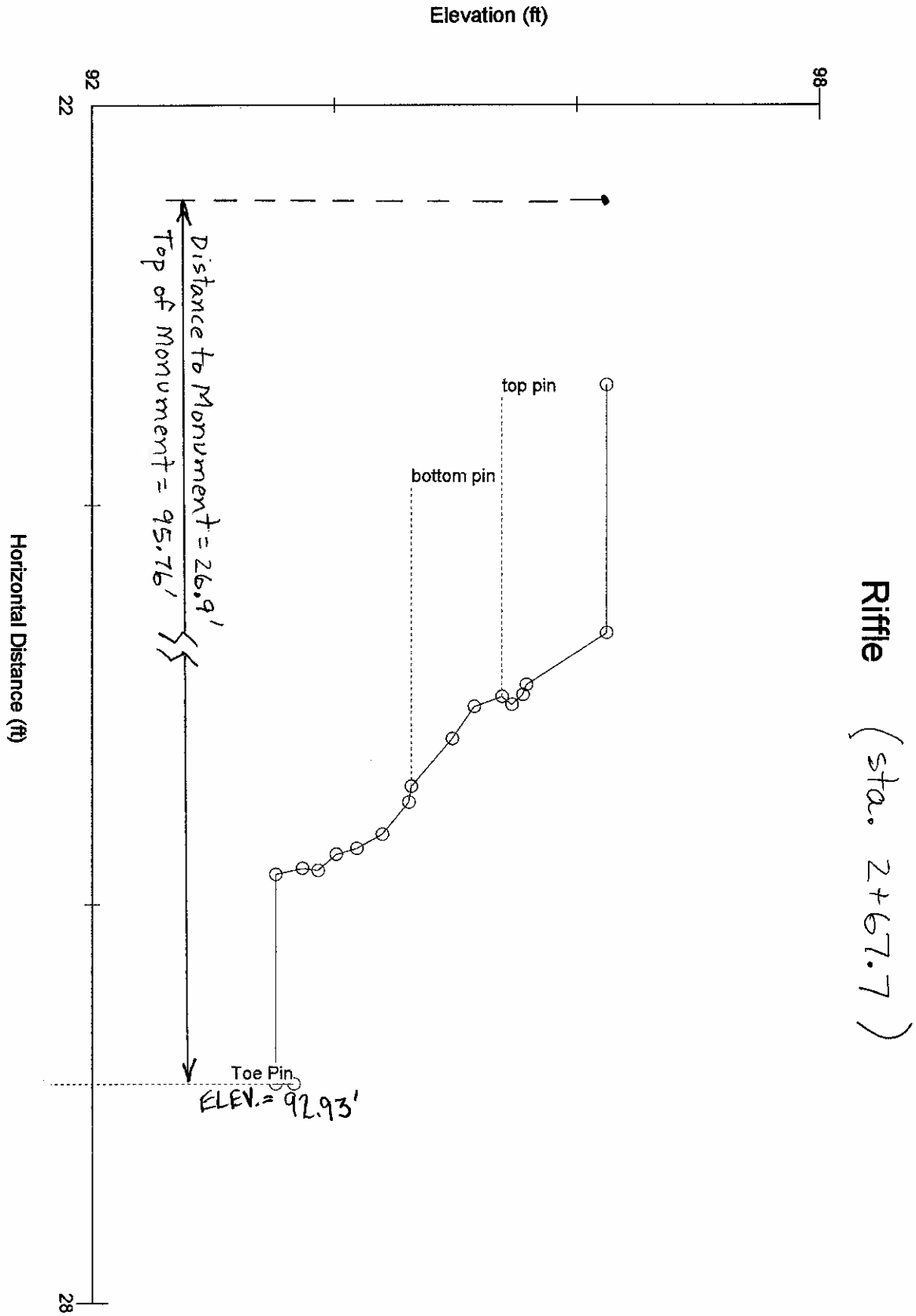
Magruder Branch Degraded Reach Team 4 9/21/2007



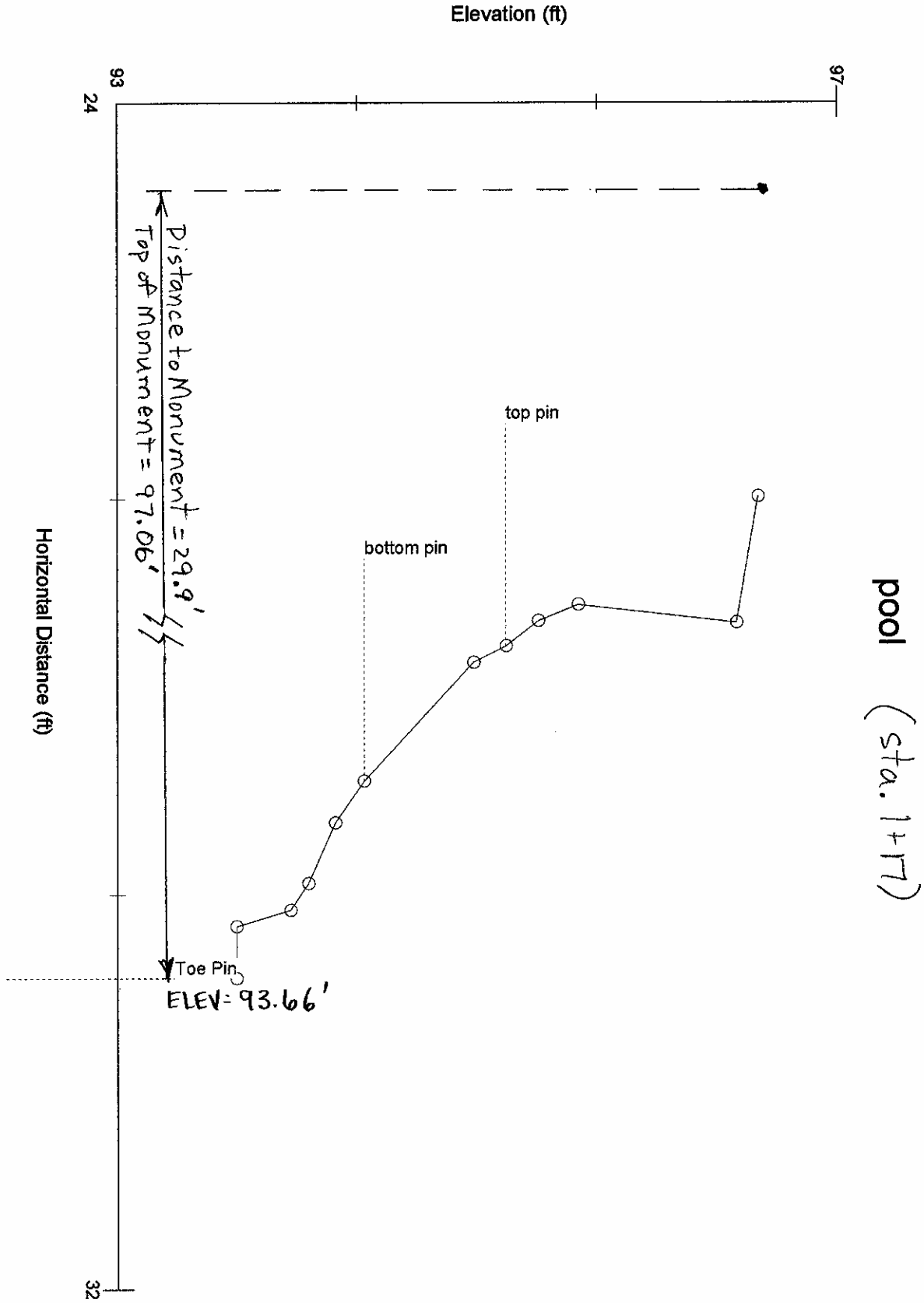
Magruder Branch Degraded Reach Team 4 9/21/2007

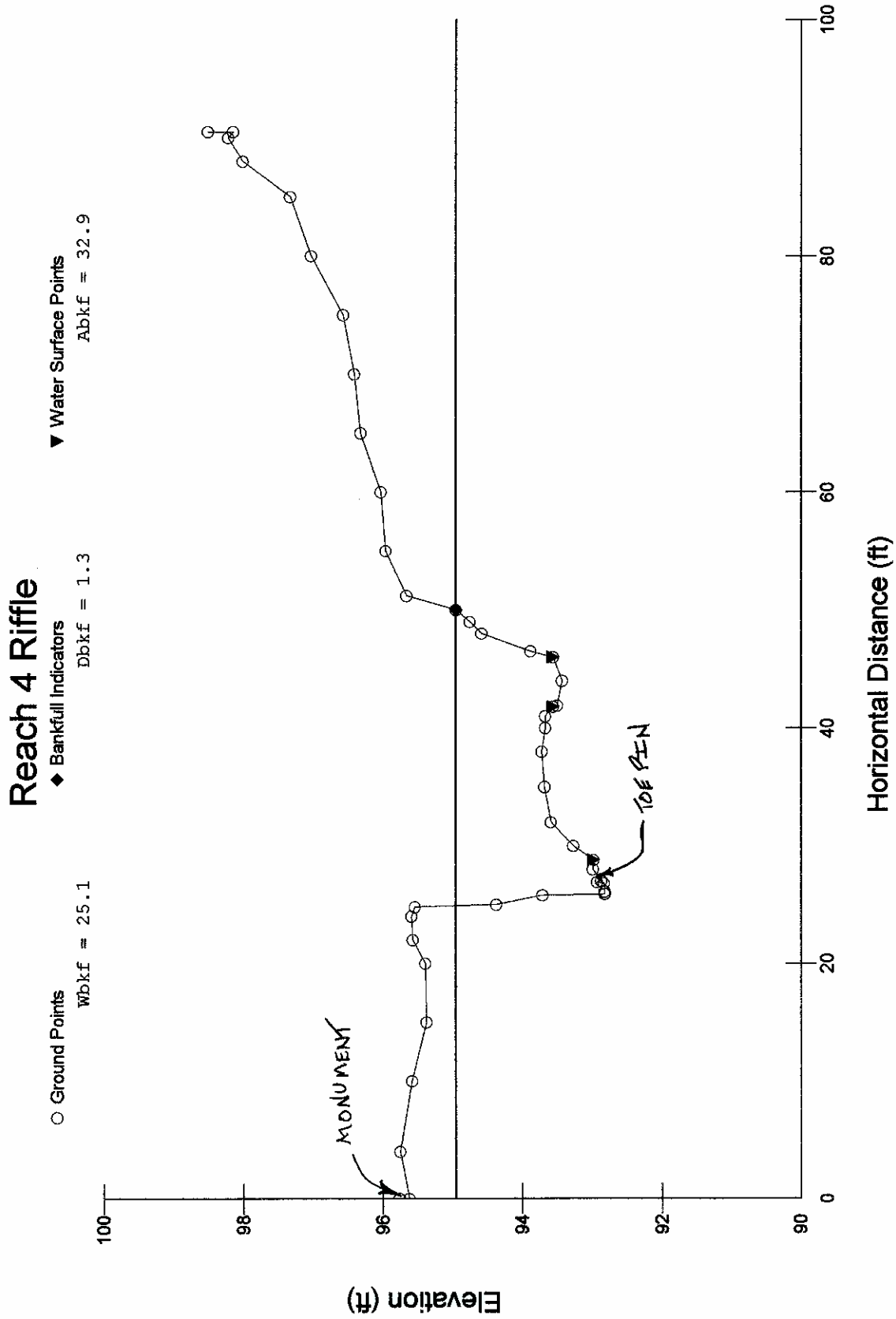


Magruder Branch Degraded Reach Team 4 9/21/2007

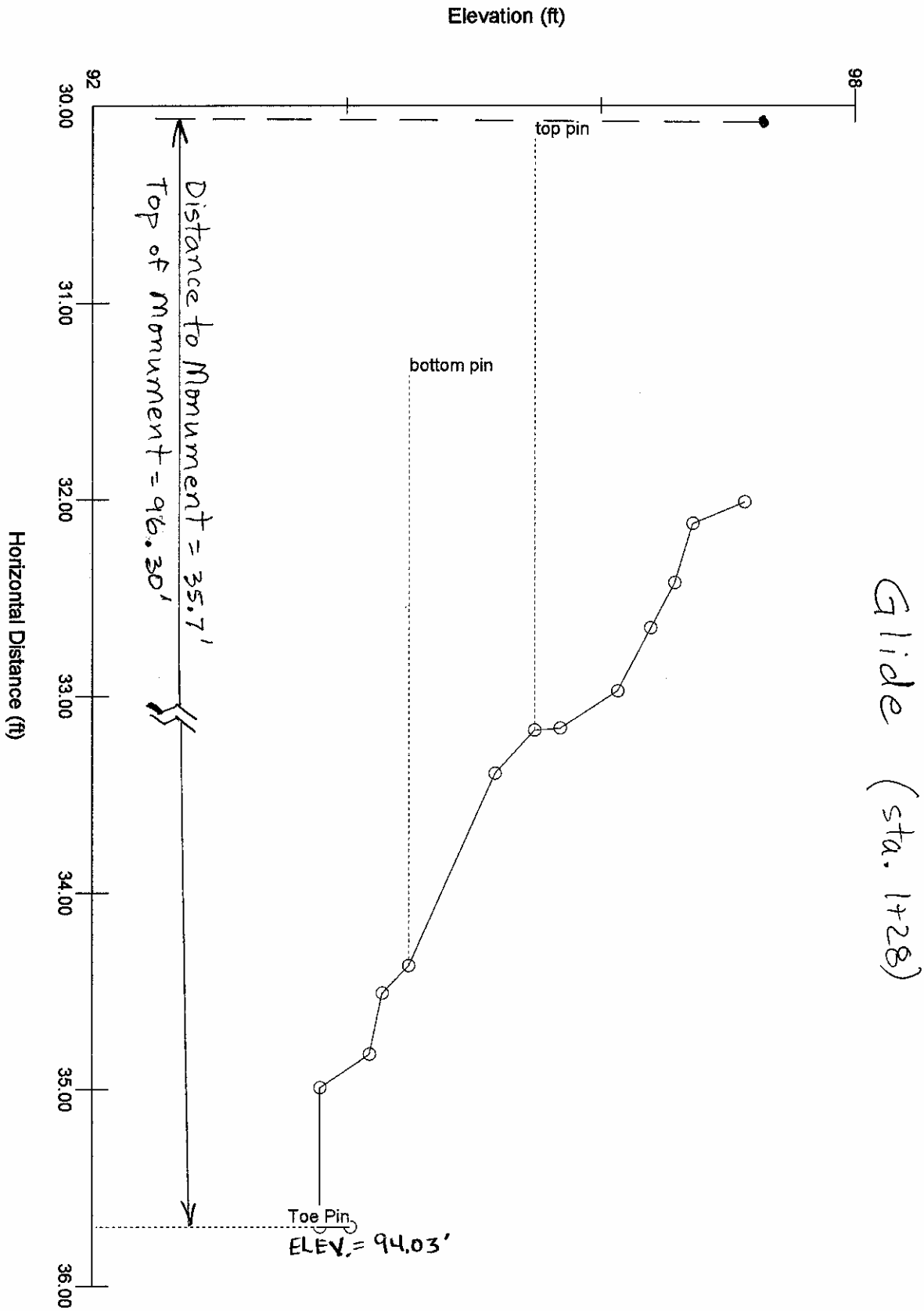


Magruder Branch Degraded Reach Team 4 9/21/2007

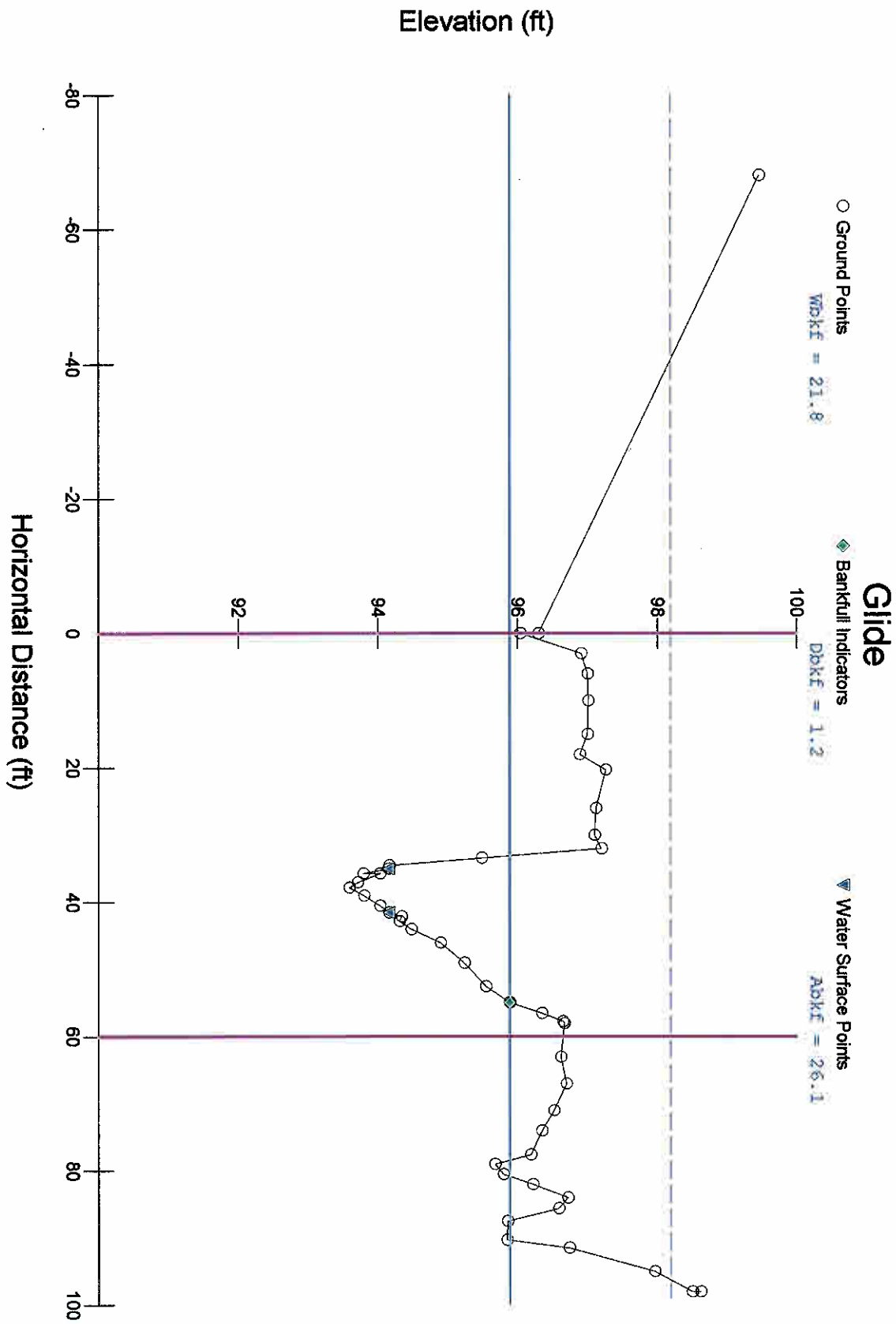



Reach 4 Riffle
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 25.1
Dbkf = 1.3
Abkf = 32.9
MONUMENT
TOE PIN
Elevation (ft)
100
98
96
94
92
90
0
20
40
60
80
100
Horizontal Distance (ft)

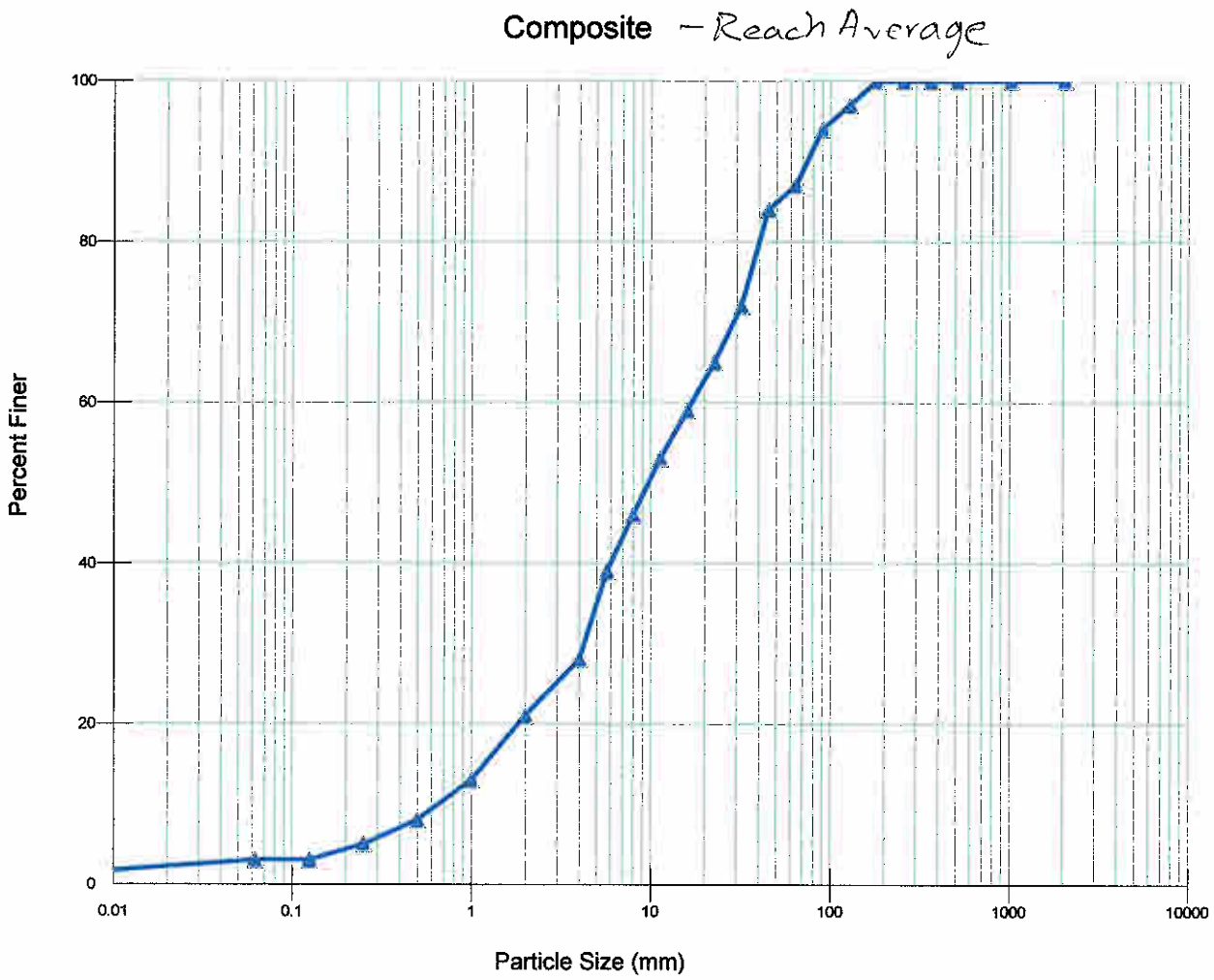
Magruder Branch Degraded Reach Team 4 9/21/2007



Magruder Branch Degraded Reach Team 4 9/21/2007

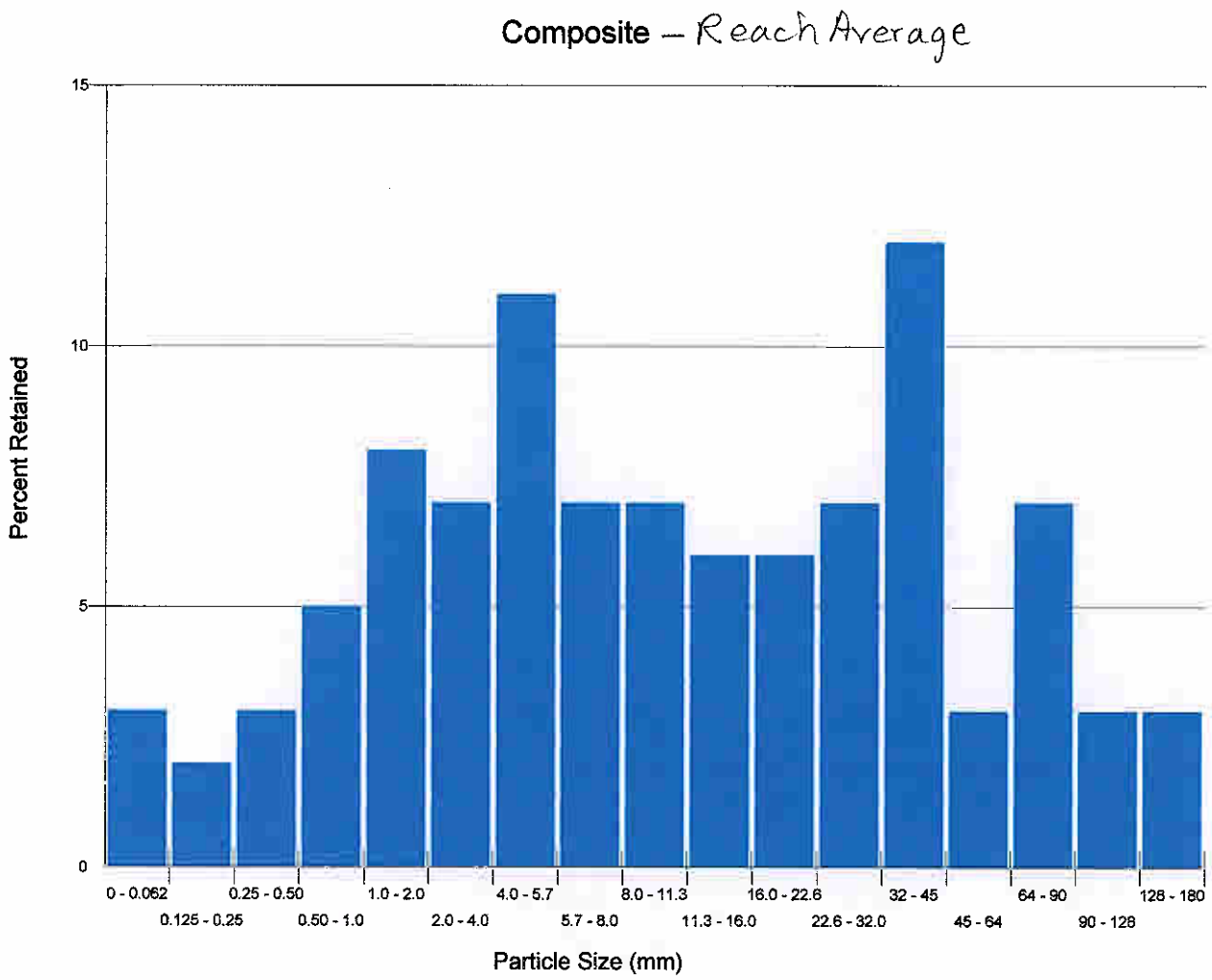


Magruder Branch Degraded Reach Team 4 9/21/2007

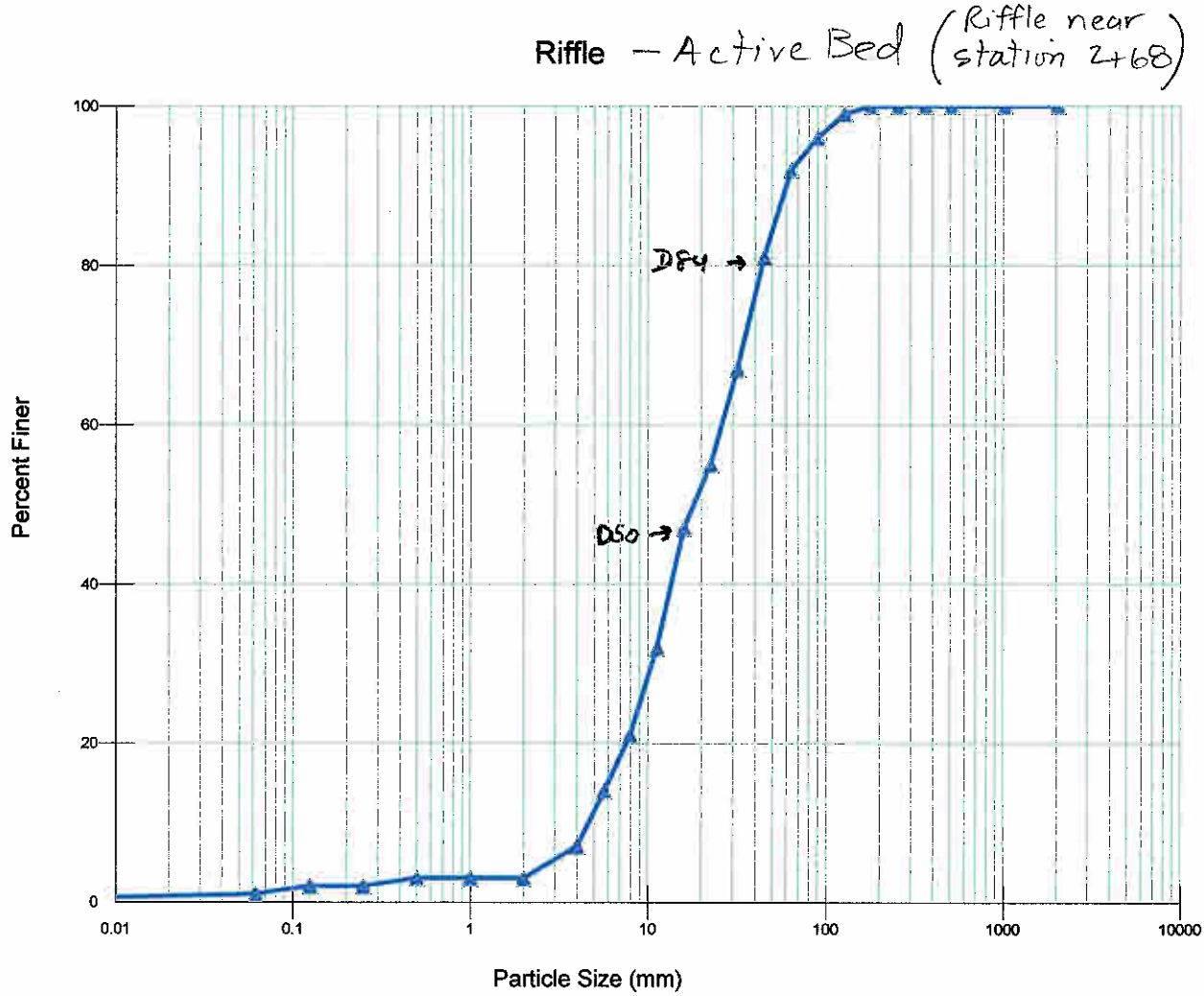


D50 9.89
D84 45.
D95 102.67

Magruder Branch Degraded Reach Team 4 9/21/2007

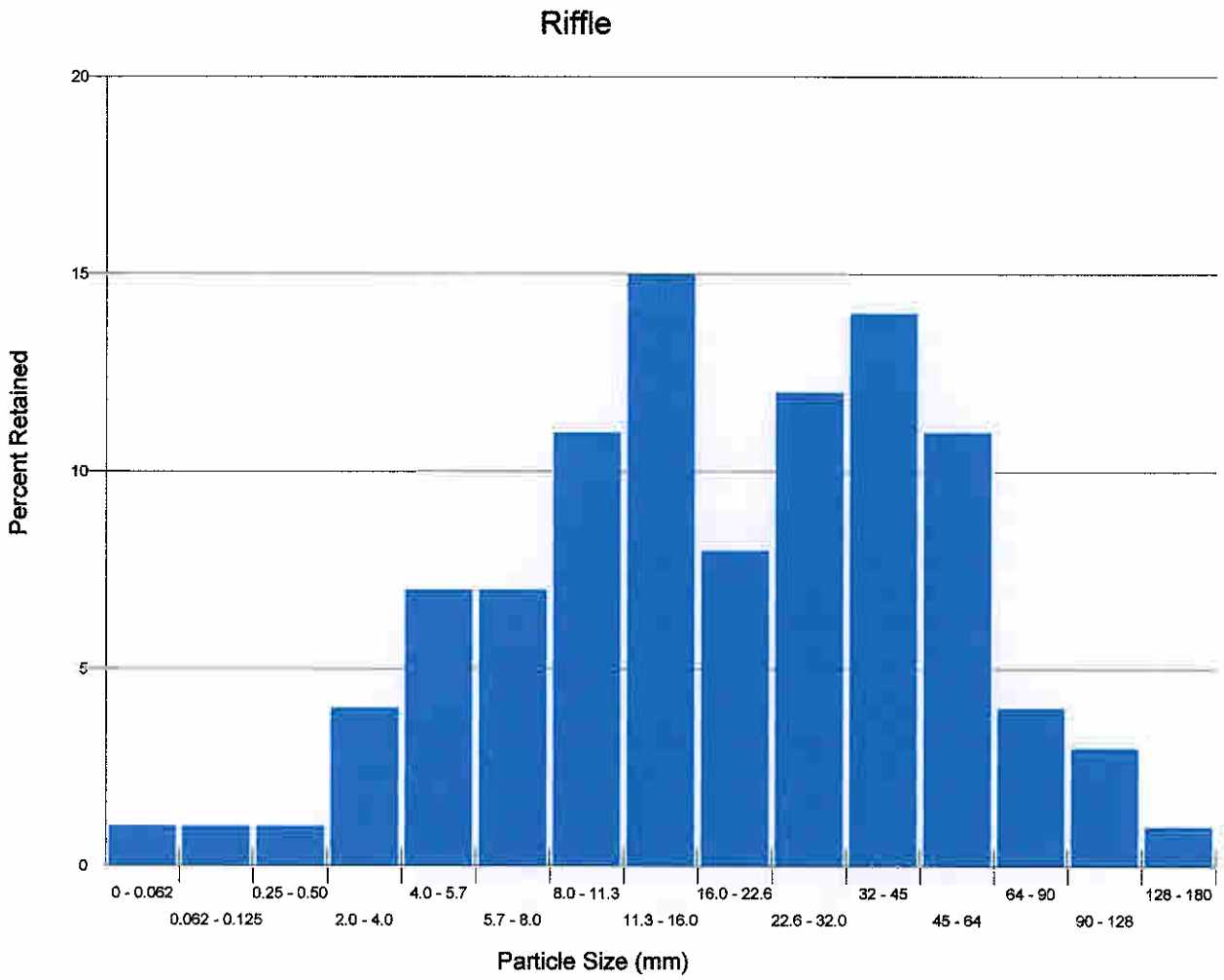


Magruder Branch Degraded Reach Team 4 9/21/2007

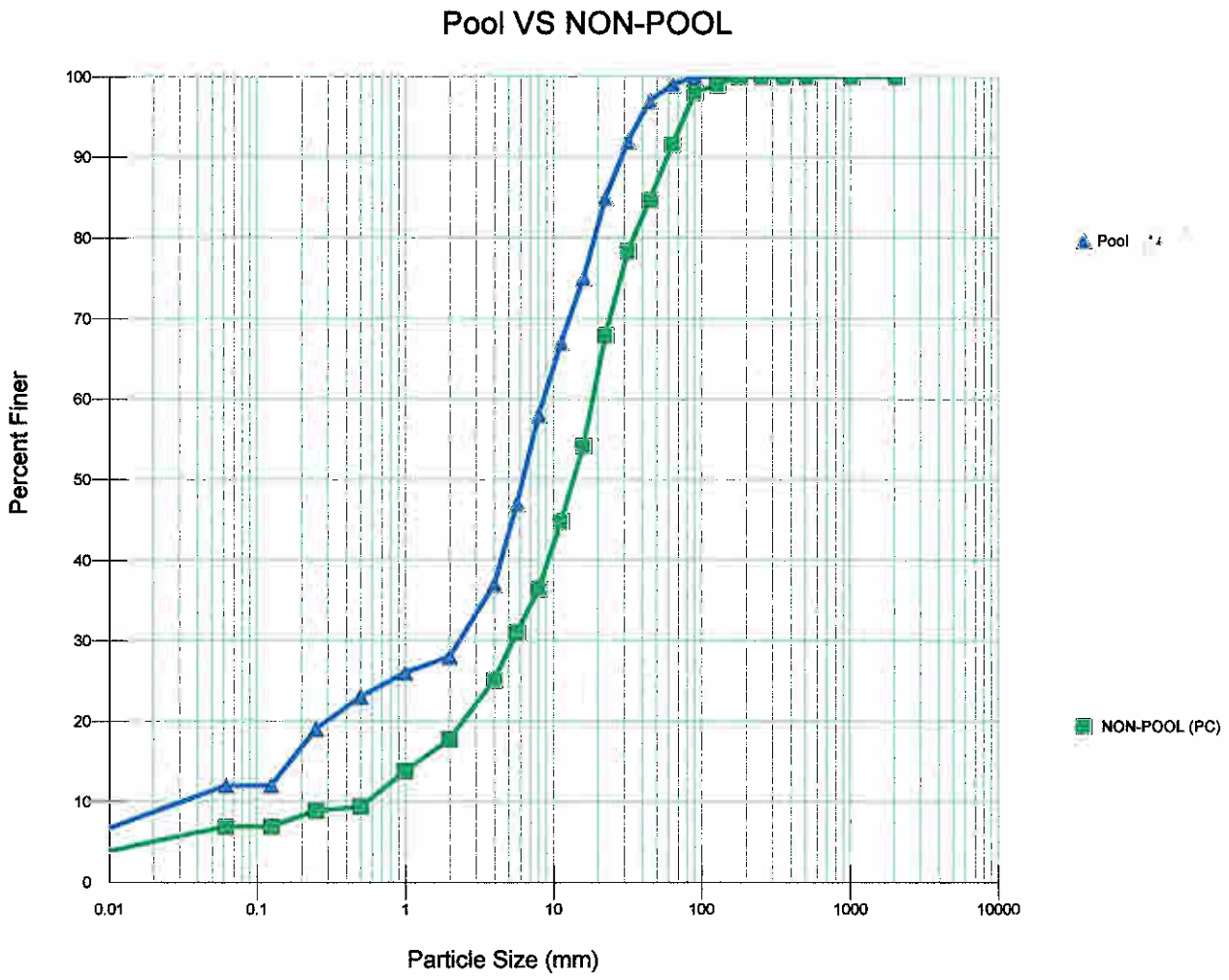


D50 18.48
D84 50.18
D95 83.5

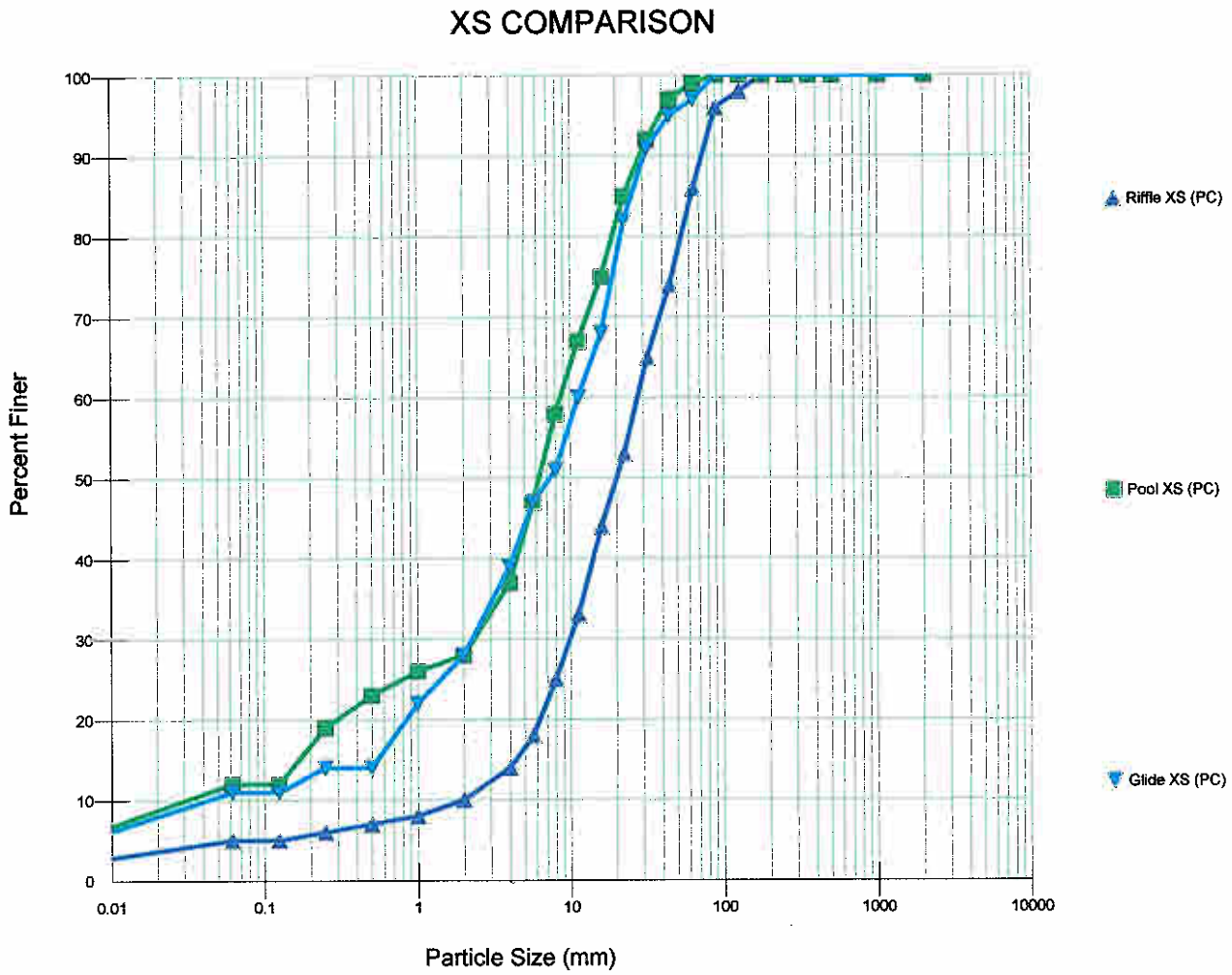
Magruder Branch Degraded Reach Team 4 9/21/2007



Magruder Branch Degraded Reach Team 4 9/21/2007

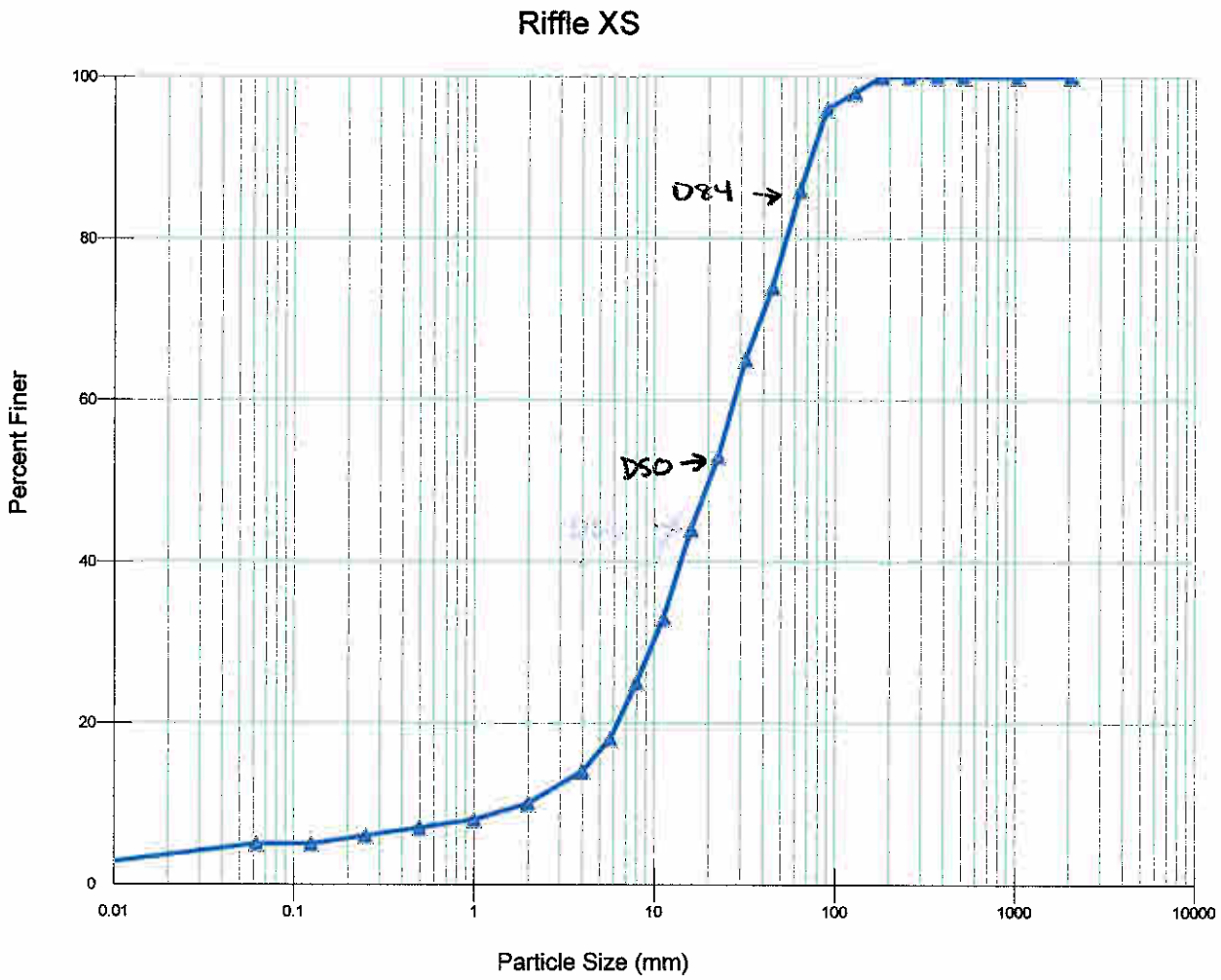


Magruder Branch Degraded Reach Team 4 9/21/2007



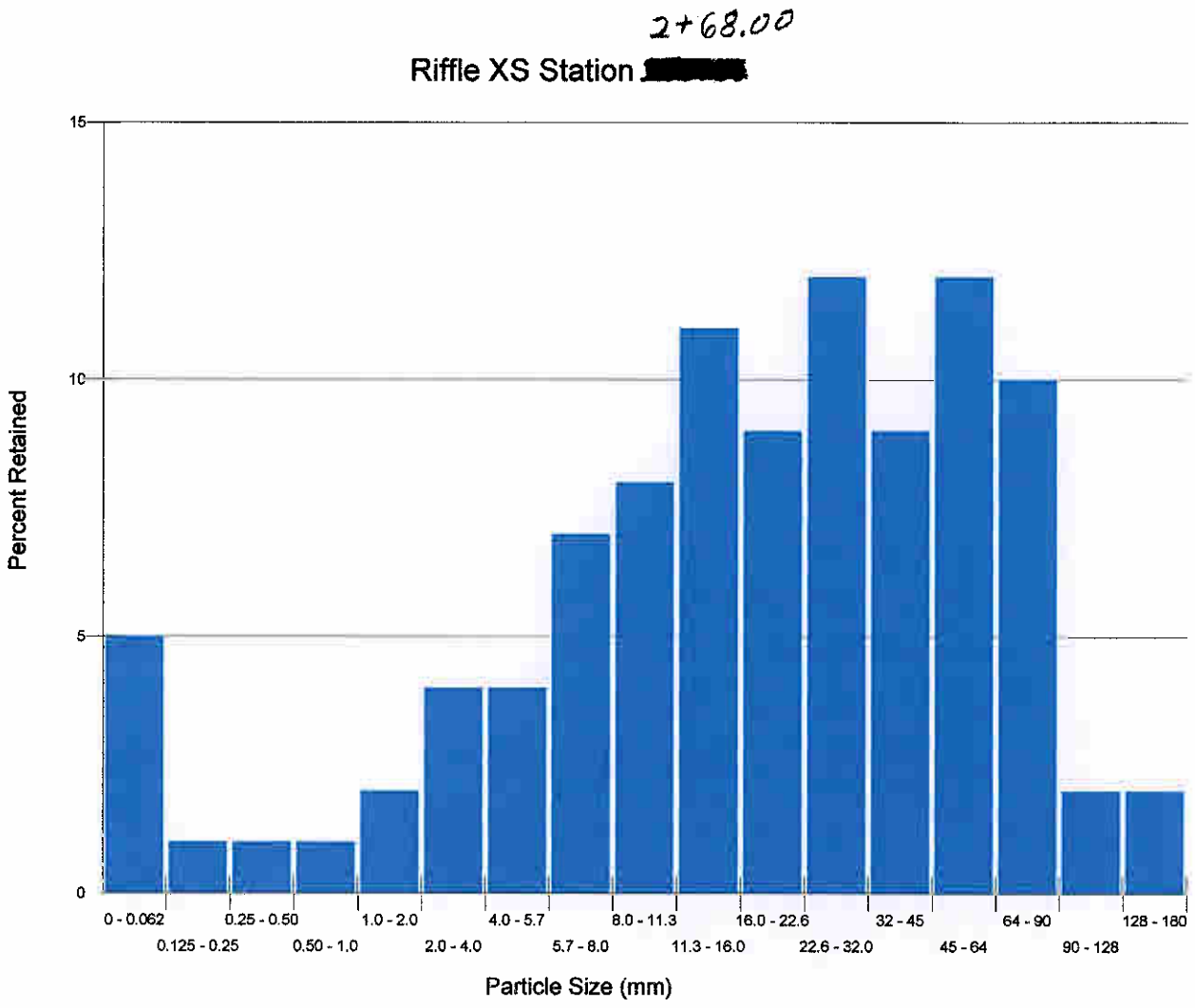
	Riffle	Pool	Glide
D50	20.4	6.33	7.42
D84	60.83	21.94	24.69
D95	87.4	39.8	45.0

Magruder Branch Degraded Reach Team 4 9/21/2007

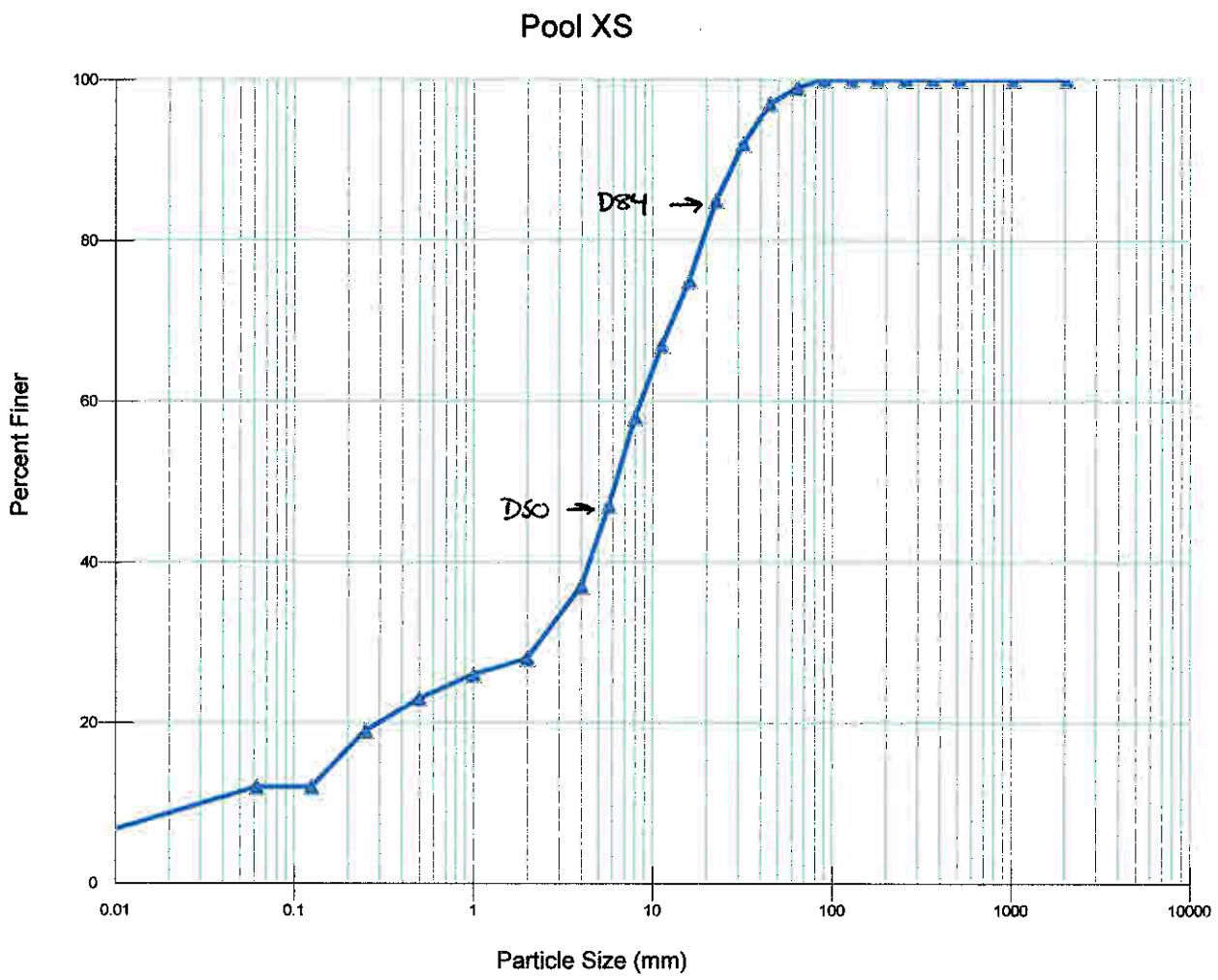


D50 = 20.4
D84 = 60.83
D95 87.4

Magruder Branch Degraded Reach Team 4 9/21/2007



Magruder Branch Degraded Reach Team 4 9/21/2007



D50 = 6.33

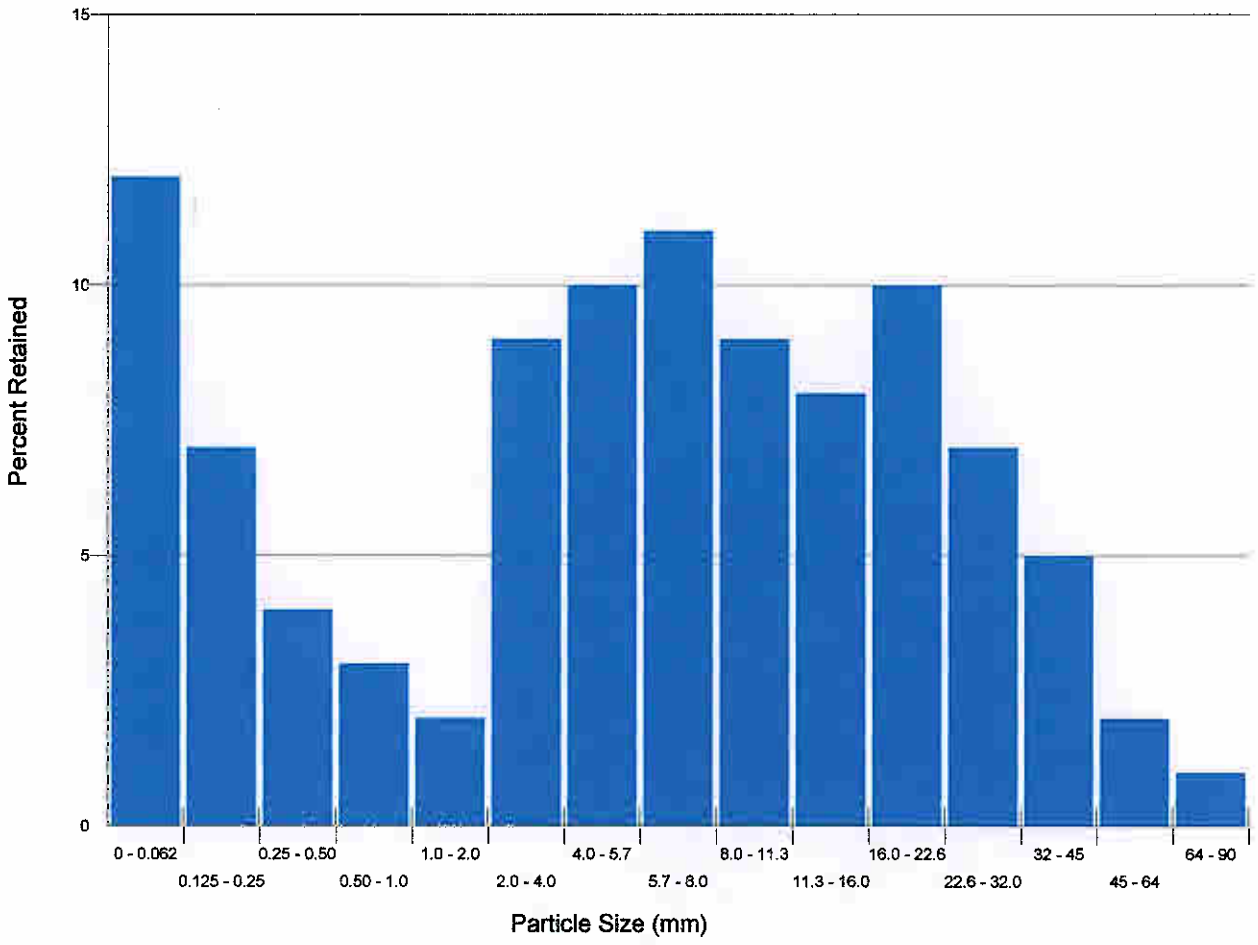
D84 = 21.94

D95 = 39.8

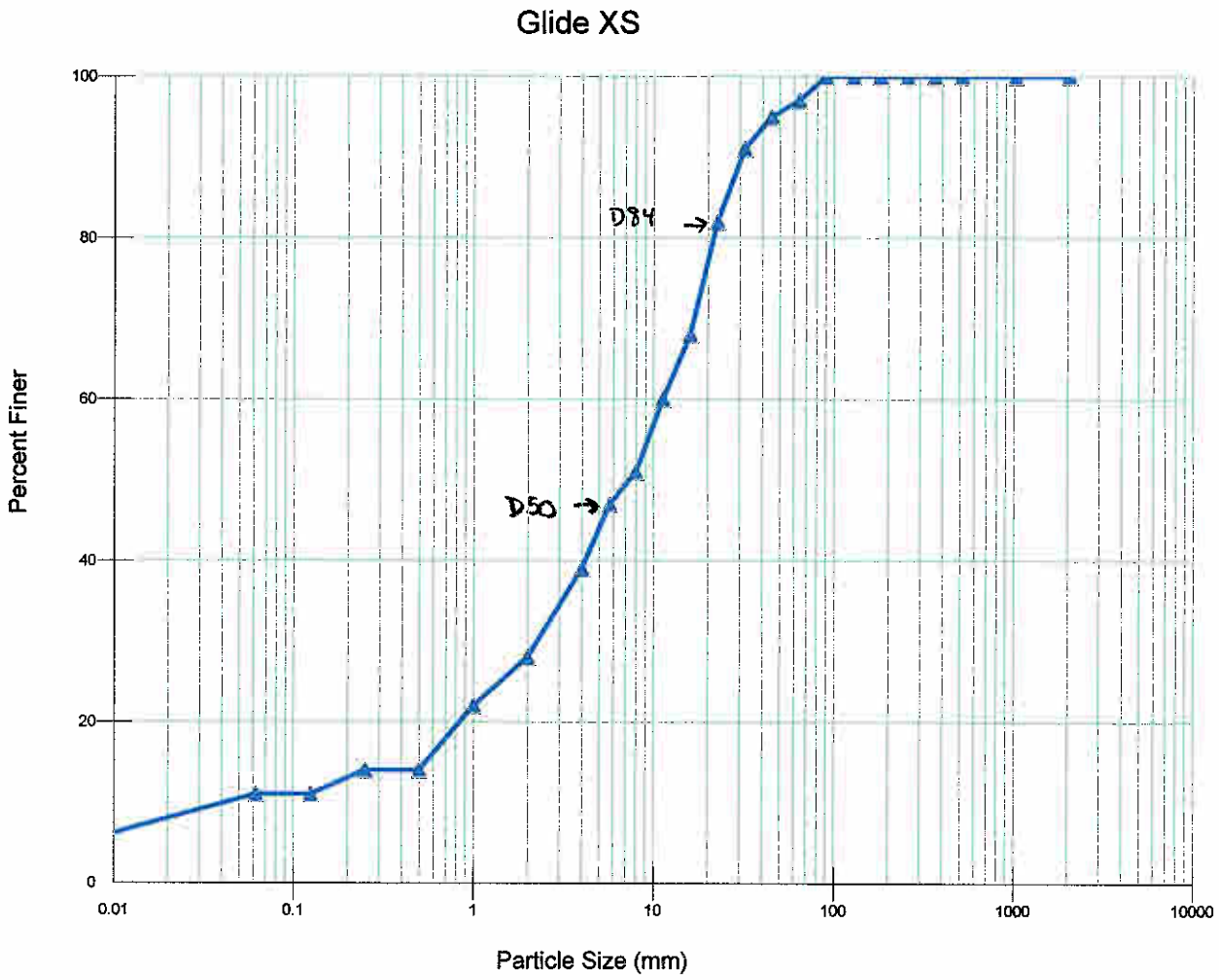
Magruder Branch Degraded Reach Team 4 9/21/2007

1+17.00

Pool XS Station [redacted]



Magruder Branch Degraded Reach Team 4 9/21/2007



D50 = 7.42

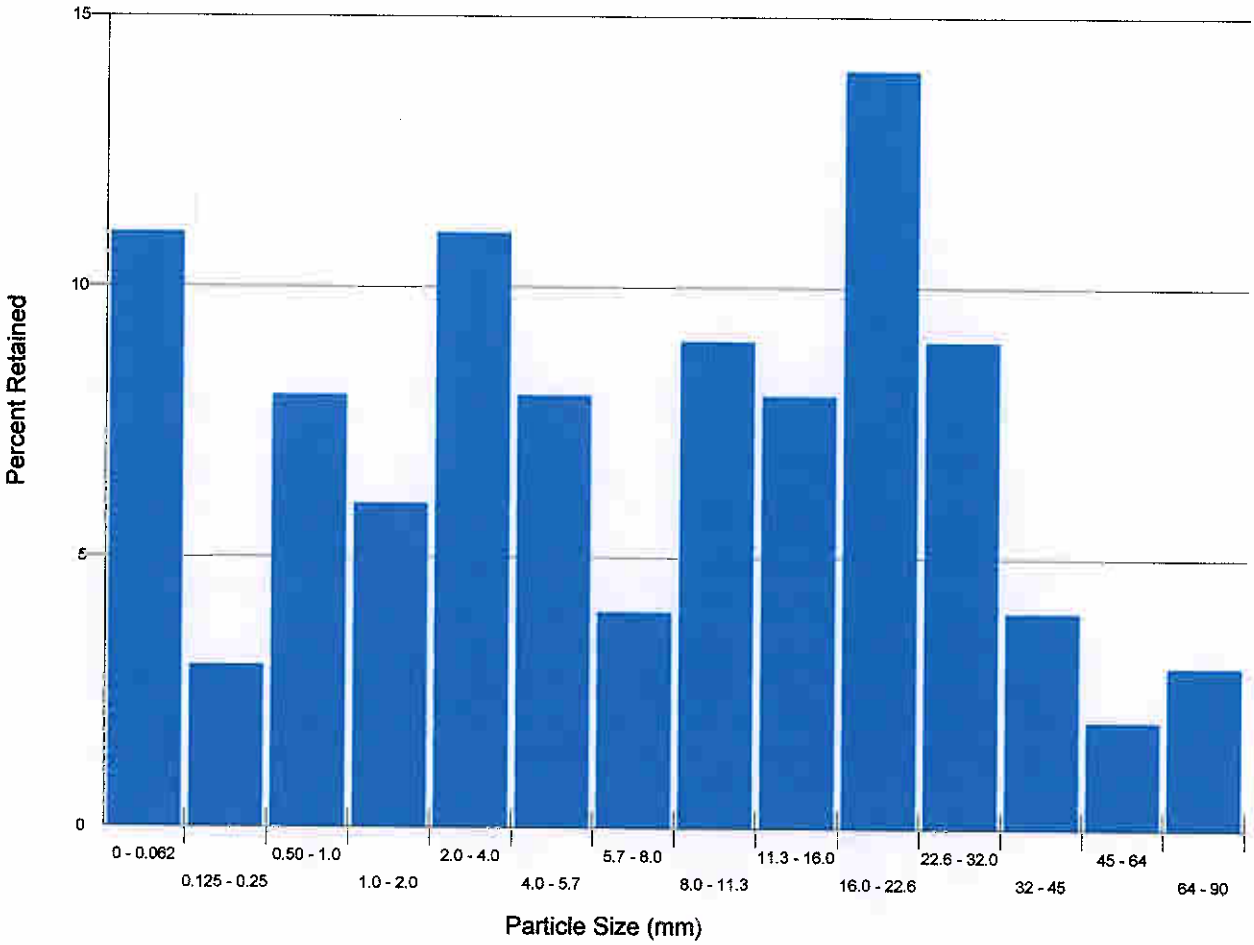
D84 = 24.69

D95 = 45

Magruder Branch Degraded Reach Team 4 9/21/2007

1+28.00

Glide XS Station [redacted]



Magruder Branch Degraded Reach Team 4 9/21/2007

Worksheet 5-14. Bar sample data collection and sieve analysis form.

Point / Side BAR-BULK MATERIALS SAMPLE DATA: Size Distribution Analysis | Observers:

Stream: **MacGruder Branch** | Location: **team 4 Sta. 217+00** | Date: **9/28/07**

Subsamples	Catch Pan or BUCKET		Sieve SIZE 2 mm		Sieve SIZE 4 mm		Sieve SIZE 8 mm		Sieve SIZE 16 mm		Sieve SIZE 32 mm		Sieve SIZE 64mm		Sieve SIZE mm		Sieve SIZE mm	
	Tare weight		Tare weight		Tare weight		Tare weight		Tare weight		Tare weight		Tare weight		Tare weight		Tare weight	
	Sample weights		Sample weights		Sample weights		Sample weights		Sample weights		Sample weights		Sample weights		Sample weights		Sample weights	
	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net
1	4.2	2.2		4.6		2.3		3.6		5.5		4.9		4.8				
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
Net wt. total		2.2		4.6		2.3		3.6		5.5		4.9		4.8				
% Grand total		8		16		8		13		20		18		17				
Accum. % =<																		

SURFACE MATERIALS DATA
(Two largest particles)

No.	Dia.	WT.
1	110	1.3
2	90	1.3

Bucket + materials weight	
Bucket tare weight	
Materials weight	
Materials less than:	mm

Be sure to add separate material weights to grand total

27.9

GRAND TOTAL SAMPLE WEIGHT

Sample location notes

Sample location sketch

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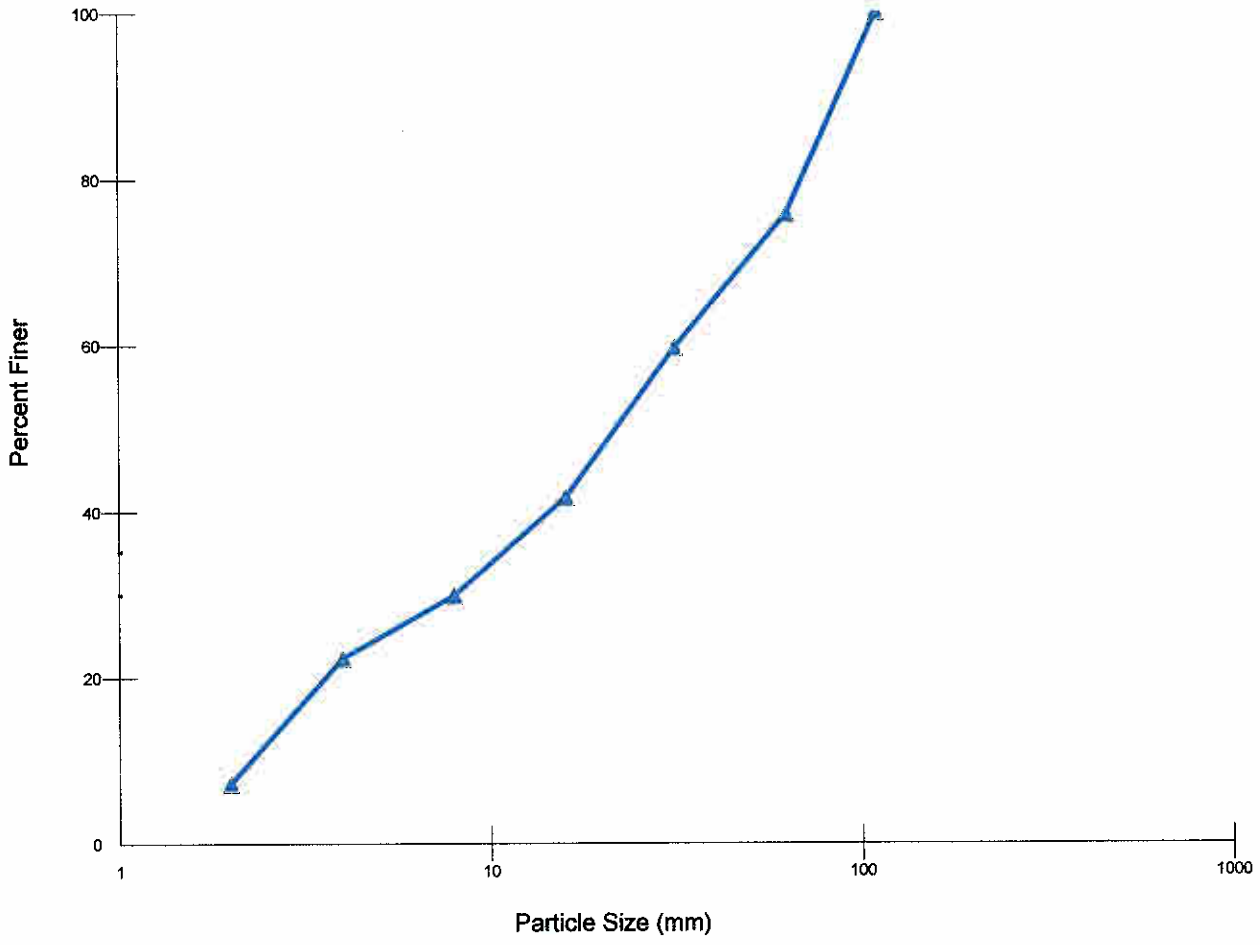
2+17.20

POINT BAR SAMPLE STA. [redacted]

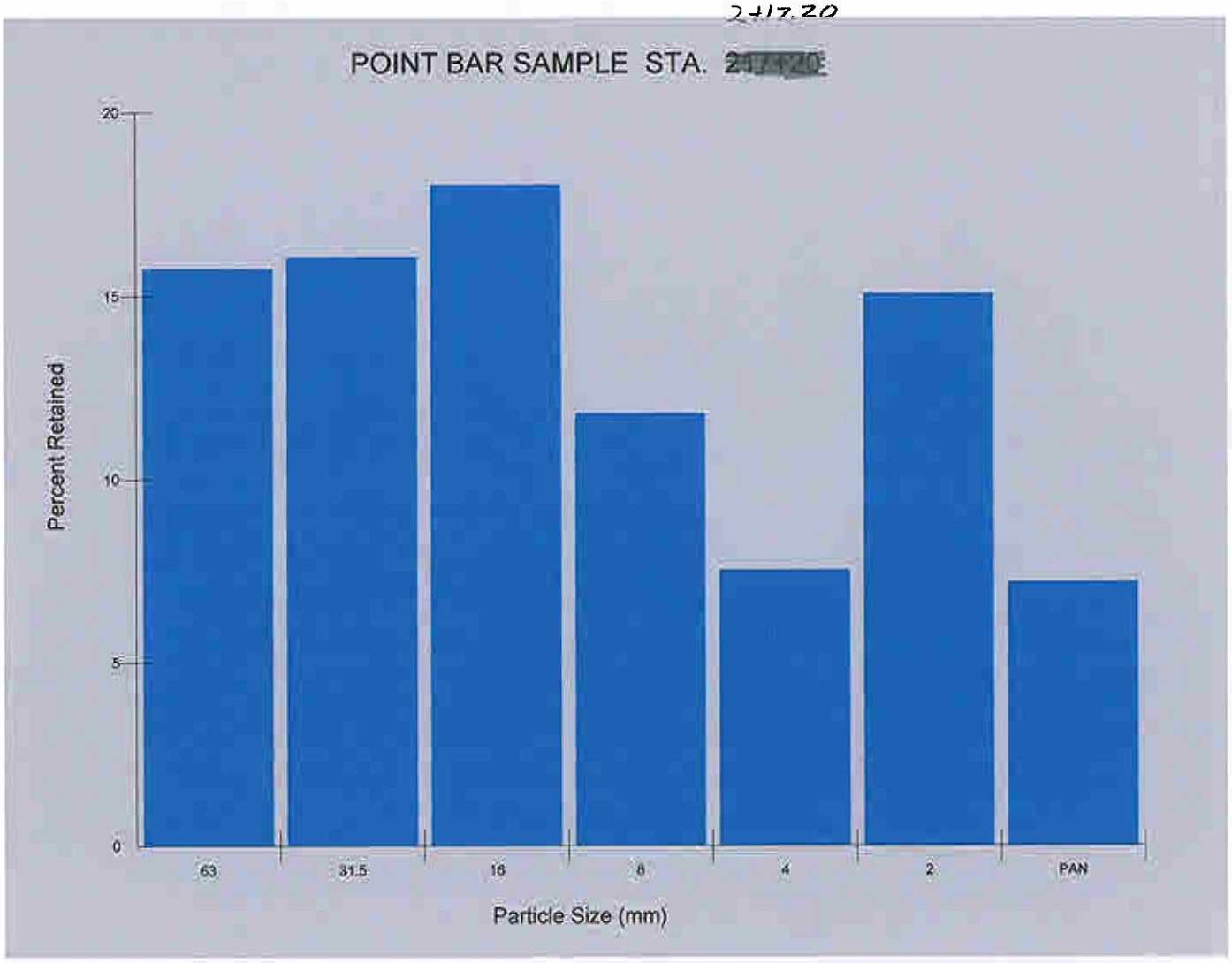


D50 = 23.19

D84 = 79.01

D95 = 100.31

Magruder Branch Degraded Reach Team 4 9/21/2007



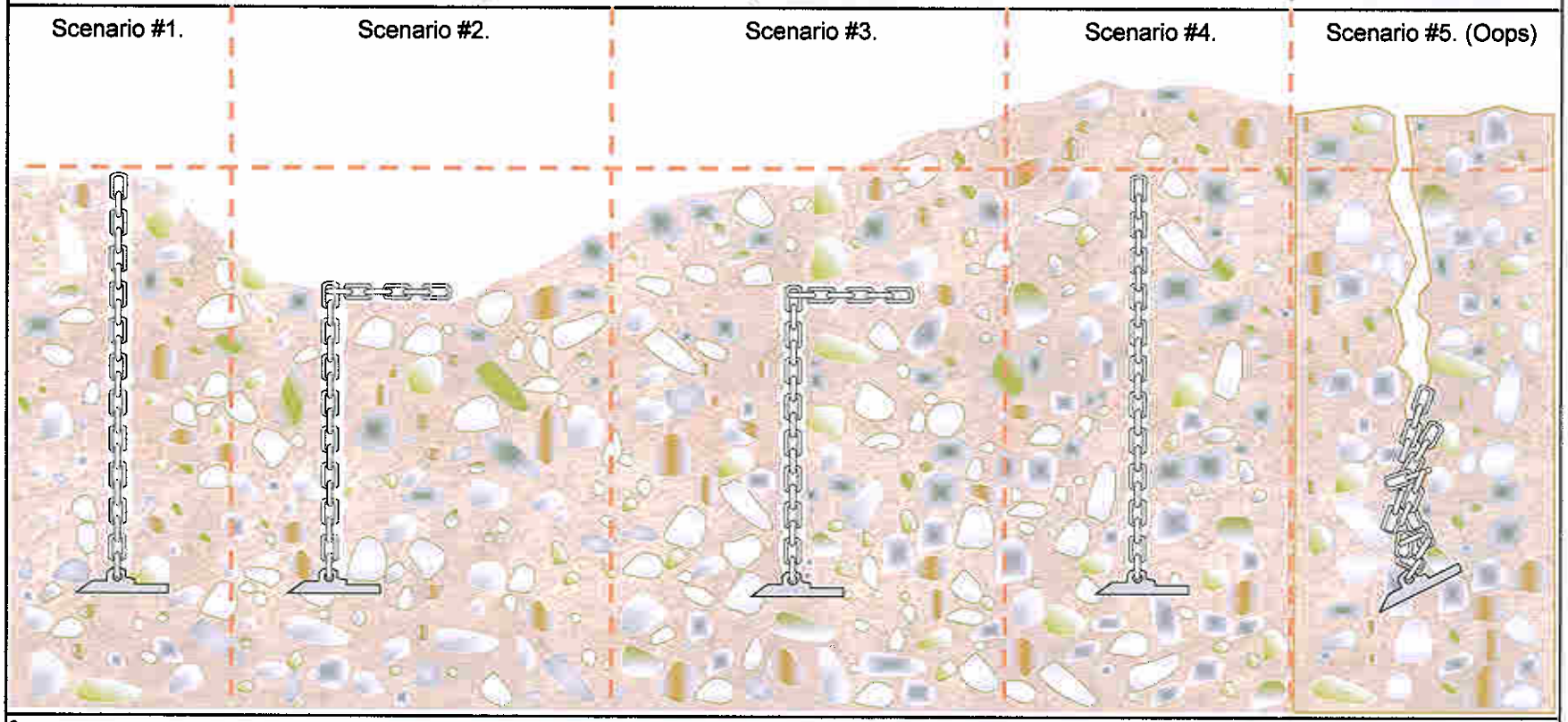
Magruder Branch Degraded Reach Team 4 9/21/2007

Worksheet 6-1. Field form for documenting scour chain results and corresponding bed-elevation changes.

Stream name: **MACGRUDER BRANCH** Location: **TEAM 4**

Observers: Stream Type: **C4** Valley Type: **VIII** Date: **9/28/07**

		Installation Data (1st Year)				Recovery Data (2nd Year)					
		From cross-section		Particles near chain		Chain recovery				Particles near chain	
		Station (ft)	Elevation (ft)	Largest (mm)	2nd Largest (mm)	Scenario # (1–5)	Scour depth[a] (ft)	Elevation[b] (ft)	Net change[c] (ft)	Largest (mm)	2nd Largest (mm)
Riffle	Chain #1	**2+68**	**93.72**	**80**	**69**						
Riffle	Chain #2	**2+68**	**94.23**	**75**	**70**						
Glide	Chain #3	**1+28**	**96.74**	**110**	**70**						
Glide	Chain #4	**1+28**	**97.25**	**80**	**60**						



[a] Scenario 2 or 3. Scenario 2: Enter length of chain exposed. Scenario 3: Enter length of chain exposed then subsequently buried.

[b] Scenario 3 or 4. Scenario 3: Enter elevation of bed at same station @ 2nd year. Scenario 4: Enter depth of material over chain.

[c] Scenario 3: Subtract 1st and 2nd year elevations to calculate net change in bed.

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Magruder Branch Degraded Reach Team 4 9/21/2007

Worksheet 5-12a. Bedload and suspended sand bed-material load transport prediction for the upstream reach, using the POWERSED model.

Stream: **Macgruder Branch, Reach 3, Reference Riffle, (Riff** Location: **Reach 3** Date: **09/18/07**

Observers: **Team 3** Stream Type: **C4** Valley Type: **VIII** Gage Station #: **01591000**

Flow-duration curve		Calculate	Hydraulic geometry				Measure	Calculate									
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Percentage of time	Daily mean discharge	Mid-ordinate stream-flow	Area	Width	Depth	Velocity	Slope	Shear stress	Stream power	Unit power	Time increment	Time increment	Daily mean bedload transport	Daily mean suspended sand transport	Time adjusted bedload transport [(13)×(14)]	Time adjusted suspended sand transport [(13)×(15)]	Time adjusted total transport [(16)+(17)]
(%)	(cfs)	(cfs)	(ft^2)	(ft)	(ft)	(ft/s)	(ft/ft)	(lb/ft^2)	(lb/s)	(lb/ft/s)	(%)	(days)	(tons/day)	(tons/day)	(tons)	(tons)	(tons)
100.0%	0.14										0%						
90.0%	5.50	2.82	2.43	9.74	0.25	1.16	0.009	0.14	1.58	0.16	10%	36.50	0.00	0.00	0.00	0.00	0.00
80.0%	7.97	6.74	4.64	13.32	0.35	1.45	0.009	0.19	3.79	0.28	10%	36.50	0.00	0.00	0.00	0.00	0.00
70.0%	9.76	8.87	5.69	14.71	0.39	1.55	0.009	0.22	4.98	0.34	10%	36.50	0.00	0.10	0.00	0.01	0.01
60.0%	12.23	11.00	6.66	15.77	0.42	1.64	0.009	0.24	6.18	0.39	10%	36.50	0.00	0.10	0.00	0.01	0.01
50.0%	15.94	14.09	7.91	16.65	0.47	1.78	0.009	0.26	7.91	0.48	10%	36.50	0.00	0.10	0.00	0.01	0.01
40.0%	19.51	17.73	9.12	16.83	0.54	1.94	0.009	0.30	9.96	0.59	10%	36.50	0.00	0.10	0.00	0.01	0.01
30.0%	24.46	21.99	10.43	16.99	0.61	2.10	0.009	0.34	12.35	0.73	10%	36.50	0.00	0.20	0.00	0.02	0.02
20.0%	31.74	28.10	12.17	17.19	0.71	2.30	0.009	0.39	15.78	0.92	10%	36.50	0.40	0.20	0.04	0.02	0.06
10.0%	43.97	37.85	14.71	17.48	0.84	2.57	0.009	0.46	21.26	1.22	10%	36.50	0.40	0.40	0.04	0.04	0.08
5.0%	61.70	52.84	18.19	17.88	1.02	2.90	0.009	0.55	29.67	1.66	5%	18.25	1.30	0.80	0.07	0.04	0.11
4.0%	68.98	65.34	20.84	18.17	1.15	3.13	0.009	0.62	36.69	2.02	1%	3.65	2.20	1.4	0.02	0.01	0.03
3.0%	79.97	74.47	22.68	18.38	1.23	3.28	0.009	0.66	41.82	2.28	1%	3.65	3.00	2.10	0.03	0.02	0.05
2.0%	103.20	91.59	25.95	18.73	1.39	3.53	0.01	0.74	51.44	2.75	1%	3.65	4.30	3.80	0.04	0.04	0.08
1.5%	123.95	113.58	29.88	19.14	1.56	3.80	0.009	0.83	63.79	3.33	1%	1.83	7.30	7.50	0.04	0.04	0.08
1.0%	156.38	140.17	43.72	36.80	1.19	3.20	0.01	0.64	78.72	2.14	1%	1.83	11.70	14.70	0.06	0.07	0.13
										Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):					124.1	124.1	248.2

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Magruder Branch Degraded Reach Team 4 9/21/2007

Worksheet 5-12b. Bedload and suspended sand bed-material load transport prediction for the potentially impaired reach, using the POWERSED model.

Stream: **Macgruder - Team 4, Reach 4, Riffle 2+67.7, (Riffle)** Location: **Reach 3** Date: **09/18/07**

Observers: Team 3 Stream Type: **C4** Valley Type: **VIII** Gage Station #: **01591000**

Flow-duration curve		Calculate	Hydraulic geometry				Measure	Calculate									
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Percentage of time	Daily mean discharge	Mid-ordinate stream-flow	Area	Width	Depth	Velocity	Slope	Shear stress	Stream power	Unit power	Time increment	Time increment	Daily mean bedload transport	Daily mean suspended sand transport	Time adjusted bedload transport [(13)×(14)]	Time adjusted suspended sand transport [(13)×(15)]	Time adjusted total transport [(16)+(17)]
(%)	(cfs)	(cfs)	(ft^2)	(ft)	(ft)	(ft/s)	(ft/ft)	(lb/ft^2)	(lb/s)	(lb/ft/s)	(%)	(days)	(tons/day)	(tons/day)	(tons)	(tons)	(tons)
100.0%	0.14										0%						
90.0%	5.48	2.81	1.67	4.76	0.35	1.67	0.005	0.12	1.09	0.23	10%	36.50	0.00	0.00	0.00	0.00	0.00
80.0%	7.94	6.71	4.51	16.52	0.27	1.50	0.006	0.10	2.60	0.16	10%	36.50	0.00	0.00	0.00	0.00	0.00
70.0%	9.72	8.83	5.75	20.53	0.28	1.51	0.006	0.10	3.42	0.17	10%	36.50	0.00	0.10	0.00	0.01	0.01
60.0%	12.19	10.96	6.57	20.64	0.32	1.64	0.006	0.12	4.24	0.21	10%	36.50	0.00	0.10	0.00	0.01	0.01
50.0%	15.88	14.04	7.67	20.80	0.37	1.82	0.006	0.14	5.43	0.26	10%	36.50	0.00	0.10	0.00	0.01	0.01
40.0%	19.44	17.66	8.84	20.97	0.42	1.98	0.006	0.15	6.83	0.33	10%	36.50	0.00	0.10	0.00	0.01	0.01
30.0%	24.37	21.91	10.11	21.16	0.48	2.15	0.006	0.18	8.48	0.40	10%	36.50	0.00	0.10	0.00	0.01	0.01
20.0%	31.63	28.00	11.80	21.42	0.55	2.37	0.006	0.20	10.83	0.51	10%	36.50	0.00	0.20	0.00	0.02	0.02
10.0%	43.81	37.72	14.21	21.80	0.65	2.65	0.006	0.24	14.59	0.67	10%	36.50	0.00	0.30	0.00	0.03	0.03
5.0%	61.48	52.65	17.55	22.31	0.79	3.00	0.006	0.29	20.37	0.91	5%	18.25	0.40	0.40	0.02	0.02	0.04
4.0%	68.73	65.11	20.08	22.64	0.89	3.24	0.006	0.32	25.19	1.11	1%	3.65	0.40	0.6	0.00	0.01	0.01
3.0%	79.68	74.21	21.81	22.82	0.96	3.40	0.006	0.35	28.71	1.26	1%	3.65	0.40	0.80	0.00	0.01	0.01
2.0%	102.82	91.25	24.95	23.29	1.07	3.66	0.01	0.39	35.30	1.52	1%	3.65	0.90	1.30	0.01	0.01	0.02
1.5%	123.50	113.16	28.88	24.25	1.19	3.92	0.006	0.43	43.78	1.81	1%	1.83	1.70	2.10	0.01	0.01	0.02
1.0%	**155.81**	**139.66**	**33.26**	**25.07**	**1.33**	**4.20**	**0.01**	**0.48**	**54.03**	**2.16**	**1%**	**1.83**	**2.60**	**3.50**	**0.01**	**0.02**	**0.03**

Notes:

Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):	18.3	65.7	84.0
Upstream total annual sediment supply (tons/yr) (**Worksheet 5-12a**):	124.0	124.0	248.0
Difference in sediment transport capacity (tons/yr) (+ or -):	-105.8	-58.3	-164.1
Stability evaluation: Aggradation, Degradation or Stable:			

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River Assessment and Monitoring: Impaired Reach 3rd Field Day

Worksheet C-18. Sediment competence calculation form to assess bed stability.

Stream: Maegruder			Stream Type:		
Location:			Valley Type:		
Observers:			Date: 9/25/07		
Enter required information					
18.48	D_{50}	Riffle bed material D_{50} (mm) Active Riffle			
23.19	$\hat{D}_{50}$	Bar sample D_{50} (mm)			
0.361 ft	D_{max}	Largest particle from bar sample (ft)	110	(mm)	304.8 mm/ft
.0062	S	Existing bankfull water surface slope (ft/ft)			
1.3	d	Existing bankfull mean depth (ft)			
1.65	γ_s	Submerged specific weight of sediment			
Select the appropriate equation and calculate critical dimensionless shear stress					
0.797	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1: $\tau^* = 0.0834\,(D_{50}/\hat{D}_{50})^{-0.872}$		
4.74	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2: $\tau^* = 0.0384\,(D_{max}/D_{50})^{-0.887}$		
N/A	τ^*	Bankfull Dimensionless Shear Stress		EQUATION USED:	N/A
Calculate bankfull mean depth required for entrainment of largest particle in bar sample					
N/A	d	Required bankfull mean depth (ft)	$d = \frac{\tau^* \gamma_s D_{max}}{S}$		
Check: ☐ Stable ☐ Aggrading ☐ Degrading					
Calculate bankfull water surface slope required for entrainment of largest particle in bar sample					
N/A	S	Required bankfull water surface slope (ft/ft)	$S = \frac{\tau^* \gamma_s D_{max}}{d}$		
Check: ☐ Stable ☐ Aggrading ☐ Degrading					
Sediment competence using dimensional shear stress					
.47	Bankfull shear stress $\tau = \gamma d S$ (lbs/ft^2) (substitute hydraulic radius, R, with mean depth, d)				
87	Moveable particle size (mm) at bankfull shear stress **(Figure C-4)**				
.6	Predicted shear stress required to initiate movement of D_{max} (110 mm) **(Figure C-4)** Colorado curve				
1.55	Predicted mean depth required to initiate movement of D_{max} (mm) $d = \frac{\tau \text{ - Predicted}}{\gamma S \text{ — } 0.0062\ ft/ft}$				
.0074	Predicted slope required to initiate movement of D_{max} (mm) $S = \frac{\tau \text{ - predicted}}{\gamma d \text{ — } 1.3}$				

62.4(1.21)(.0062)

☑ - Aggrading

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Stream:	**Macgruder Branch**				
Basin:		Drainage Area:	acres	**1.3**	mi^2
Location:	**Montgomery Co, MD**				
Twp.&Rge:		Sec.&Qtr.:	**Reach 4**		
Cross-Section Monuments (Lat./Long.):				Date:	**09/25/07**
Observers:	**Team 4**			Valley Type:	VIII

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	25.1	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	1.3	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	32.6	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	19.3	ft/ft
Maximum DEPTH (d_{mbkf}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	2.13	ft
WIDTH of Flood-Prone Area (W_{fpa}) Twice maximum DEPTH, or ($2 \times d_{mbkf}$) = the stage/elevation at which flood-prone area WIDTH is determined in a riffle section.	150	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	5.98	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the mean diameter of channel materials, as sampled from the channel surface, between the bankfull stage and Thalweg elevations.	9.9 ~~23.2~~	mm
Water Surface SLOPE (S) Channel slope = "rise over run" for a reach approximately 20–30 bankfull channel widths in length, with the "riffle-to-riffle" water surface slope representing the gradient at bankfull stage.	0.0062	ft/ft
Channel SINUOSITY (k) Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by channel slope (VS / S).	1.16 ~~1.78~~	

C4

$R = \frac{wD}{w+2D}$ D w

River Assessment and Monitoring: Impaired Reach 3rd Field Day

Worksheet C-3. Bankfull velocity and discharge estimates.

Bankfull VELOCITY / DISCHARGE Estimates

Site		Location	Macgruder
Date	9/25/07	Stream Type	
Observers		HUC	

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Cross-section AREA	32.6	A_{bkf} (SqFt)	Bankfull Mean DEPTH	1.3	D_{bkf} (Ft)
Bankfull WIDTH	25.1	W_{bkf} (Ft)	Wetted PERIMETER ~ $2*(d_{bkf} + W_{bkf})$	27.06	W_{Pbkf} (Ft)
D84 @ Riffle	50.18	Dia. (mm)	D84 mm / 304.8 =	0.165	D84 (Ft)
Bankfull SLOPE	0.0062	S (Ft / Ft)	Hydraulic RADIUS A_{bkf} / W_{Pbkf}	1.21	R (Ft)
Gravitational Acceleration	32.2	g (Ft /Sec^2)	Relative Roughness R (ft) / D84 (ft)	7.3	
Drainage AREA	1.3	DA SqMi)	Shear Velocity $u^* = \sqrt{gRS}$	.462	u* (Ft / Sec)

g = 32.2

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 \log\{R / D84\}]u^*$ $(2.83 + 5.66 \log 7.3)$ .462	3.56	Ft / Sec	116	CFS
2. Roughness Coefficient: a) Manning's 'n' from friction factor / relative roughness. $u = 1.4895*R^{2/3}*S^{1/2}/n$ $\frac{u}{u^*} = 7.7$ n = 0.04	3.33	Ft / Sec	109	CFS
2. Roughness Coefficient: b) Manning's 'n' from Jarrett (USGS): $u = 1.4895* R^{2/3}*S^{1/2}/n$ $n = 0.39S^{.38}R^{-.16}$ n = Note: This equation is for applications involving steep, step-pool, high boundary roughness, cobble-boulder-dominated stream systems; i.e., for stream types A1, A2, A3, B1, B2, B3, C2 and E3.	—	Ft / Sec	—	CFS
2. Roughness Coefficient: c) Manning's 'n' from Stream Type $u = 1.4895* R^{2/3}*S^{1/2}/n$ n = 0.04	3.33	Ft / Sec	109	CFS
3. Other Methods, ie. Hydraulic Geometry (Hey, Darcy-Weisbach, Chezy C, etc.)		Ft / Sec		CFS
3. Other Methods, ie. Hydraulic Geometry (Hey, Darcy-Weisbach, Chezy C, etc.)		Ft / Sec		CFS
4. Continuity Equations: a) Regional Curves $u = Q / A$ Return Period for Bankfull Discharge Q = 103 3.16 $\frac{103}{32.6}$ =	3.16	Ft / Sec	103	CFS
4. Continuity Equations: b) USGS Gage Data $u = Q / A$		Ft / Sec		CFS

Urban section

$\frac{u}{u_*} = \frac{3.56}{0.462}$

Options for using the D84 term in the **relative roughness relation** (R/D84), when using estimation method 1.

Option 1. For **sand-bed** channels: measure the **"protrusion height"** (h_{sd}) of sand dunes above channel bed elevations. Substitute an average sand dune protrusion height (h_{sd} in feet) for the D84 term in estimation method 1.

Option 2. For **boulder-dominated** channels: measure several **"protrusion heights"** (h_{bo}) of boulders above channel bed elevations. Substitute an average boulder protrusion height (h_{bo} in feet) for the D84 term in estimation method 1.

Option 3. For **bedrock-dominated** channels: measure several **"protrusion heights"** (h_{br}) of rock separations/steps/joints/ modified surfaces above channel bed elevations. Substitute an average bedrock protrusion height (h_{br} in feet) for the D84 term in estimation method 1.

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Magruder Branch Degraded Reach Team 4 9/21/2007

Worksheet 5-4. Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2005).

Stream: **Macgruder - Team 4, Reach - Reach 4**	Location:		
Observers:	Date: **9/26/2007**	Valley Type: **VIII**	Stream Type: **C 4**

River Reach Summary Data

Channel Dimension

Mean Riffle Depth (d_{bkf})	1.31	ft	Riffle Width (W_{bkf})	25.1	ft	Riffle Area (A_{bkf})	32.6	ft^2
Mean Pool Depth (d_{bkfp})	1.27	ft	Pool Width (W_{bkfp})	18.93	ft	Pool Area (A_{bkfp})	24.06	ft^2
Mean Pool Depth/Mean Riffle Depth	0.97	d_{bkfp}/d_{bkf}	Pool Width/Riffle Width	0.75	W_{bkfp}/W_{bkf}	Pool Area / Riffle Area	0.73	A_{bkfp}/A_{bkf}
Max Riffle Depth (d_{mbkf})	2.13	ft	Max Pool Depth (d_{mbkfp})	2.41	ft	Max Riffle Depth/Mean Riffle Depth	1.63	
Max Pool Depth/Mean Riffle Depth	1.840					Point Bar Slope	54 and 18	
Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})				3.56	ft/s	Estimation Method	Friction/Roughness	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})				116	cfs	Drainage Area	1.3	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Meander Length (Lm)	135	135	135	ft	Meander Length Ratio (Lm/W_{bkf})	5.38	5.38	5.38
Radius of Curvature (Rc)	42	30	60	ft	Radius of Curvature/Riffle Width (Rc/W_{bkf})	1.67	1.20	2.39
Belt Width (W_{blt})	50	43	56	ft	Meander Width Ratio (W_{blt}/W_{bkf})	1.99	1.71	2.23
Individual Pool Length	29.5	16.4	57.2	ft	Pool Length/Riffle Width	1.17	0.65	2.28
Pool to Pool Spacing	47.2	31.8	63.1	ft	Pool to Pool Spacing/Riffle Width	1.88	1.27	2.51
Riffle Length	21.9	2	52.3	ft	Riffle Length/Riffle Width	0.87	0.08	2.08

Channel Profile

Valley Slope (VS)	0.0072	ft/ft	Average Water Surface Slope (S)	0.0062	ft/ft	Sinuosity (VS/S)	1.16
Stream Length (SL)	305	ft	Valley Length (VL)	266	ft	Sinuosity (SL/VL)	1.15

Low Bank Height (LBH)	start	1.89	ft	Max Riffle Depth	start	1.89	ft	Bank-Height Ratio (BHR) (LBH/Max Riffle Depth) start 1
	end	3.6	ft		end	2.5	ft	end 1.44

Facet Slopes	Mean	Min	Max		Dimensionless Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	0.020	0.004	0.044	ft/ft	Riffle Slope/Average Water Surface Slope (S_{rif} / S)	3.153	0.676	7.055
Run Slope (S_{run})	0.014	0.001	0.039	ft/ft	Run Slope/Average Water Surface Slope (S_{run} / S)	2.181	0.134	6.308
Pool Slope (S_p)	0.002	0.001	0.002	ft/ft	Pool Slope/Average Water Surface Slope (S_p / S)	0.247	0.092	0.340
Glide Slope (S_g)	0.007	0.000	0.014	ft/ft	Glide Slope/Average Water Surface Slope (S_g / S)	1.073	0.053	2.206

S_g)
mean .0007
min .0000
max .0015

S_g/S
mean .12
min .000
max .237

Feature Midpoint [a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Riffle Depth (d_{rif})	2.02	1.79	2.44	ft	Riffle Depth/Mean Riffle Depth (d_{rif} / d_{bkf})	1.54	1.37	1.86
Run Depth (d_{run})	2.28	2.0	2.74	ft	Run Depth/Mean Riffle Depth (d_{run} / d_{bkf})	1.75	1.54	2.1
Pool Depth (d_p)	2.7	2.23	3.43	ft	Pool Depth/Mean Riffle Depth (d_p / d_{bkf})	2.06	1.70	2.62
Glide Depth (d_g)	1.87	1.62	2.04	ft	Glide Depth/Mean Riffle Depth (d_g / d_{bkf})	1.43	1.24	1.56

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	3	5	0	D_{16}	1.38	4.85	3.17	0	mm
% Sand	18	5	7.21	D_{35}	5.08	12.15	11.5	0	mm
% Gravel	66	76	69.21	D_{50}	9.89	20.4	23.19	0	mm
% Cobble	13	14	23.58	D_{84}	45	60.83	79.01	0	mm
% Boulder	0	0	0	D_{95}	102.67	87.4	100.31	0	mm
% Bedrock	0	0	0	D_{100}	180	180	110	0	mm

a Min, max, mean depths are the average mid-point values except pools, which are taken at deepest part of pool.
b Composite sample of riffles and pools within the designated reach.
c Active bed of a riffle.
d Height of roughness feature above bed.

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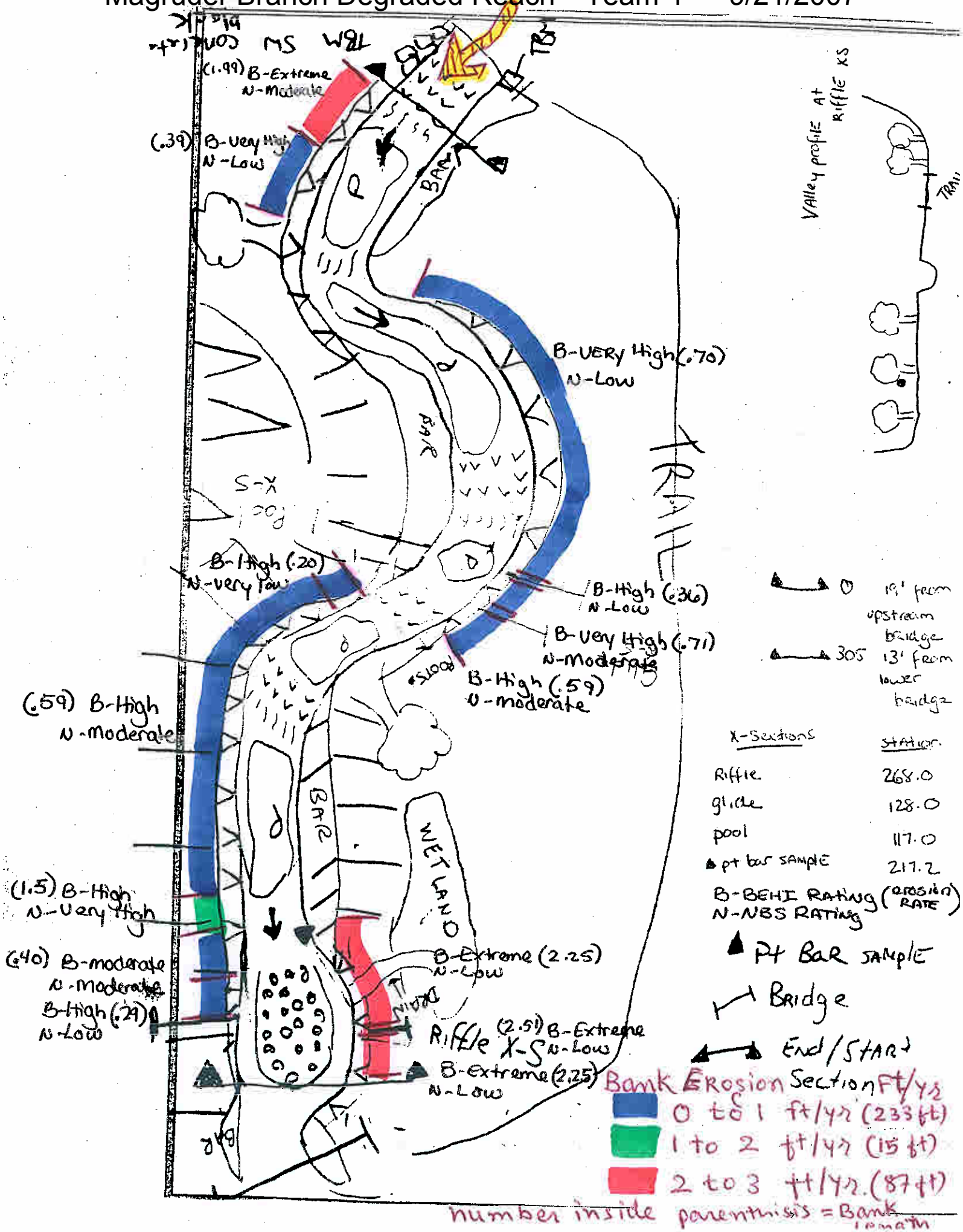

Worksheet 5-10. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	Macgruder - Team 4, Reach - Reach 4			Location:			9/25/07
Graph Used:		Total Bank Length (ft): 305				Date: ~~12/30/1999~~	
Observers:			Valley Type:			Stream Type:	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	BEHI rating (Worksheet 5-8) (adjective)	NBS rating (Worksheet 5-9) (adjective)	Bank erosion rate (Figure 5-38 or 5-39) (ft/yr)	Length of bank (ft)	Study bank height (ft)	Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)	Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1. 0+00 to 0+20 RB	Extreme	Moderate	1.9990385	20	2.6	103.95	0.25
2. 0+20 to 0+37 RB	Very High	Low	0.3997972	17	2.9	19.71	0.06
3. 0+49 to 1+40 LB	Very High	Low	0.7000864	89	3.9	243	0.13
4. 1+17 Pool XS LB	High	Low	0.3648649	1	2.96	1.08	0.05
5. 1+28 Glide XS LB	Very High	Moderate	0.7147059	1	3.4	2.43	0.12
6. 1+40 to 1+61 LB	High	Moderate	0.5985222	21	2.9	36.45	0.08
7. 1+46 to 1+61 RB	High	Very Low	0.2011765	15	1.7	5.13	0.02
8. 1+61 to 2+14 RB	High	Moderate	0.599434	53	3	95.31	0.09
9. 2+14 to 2+29 RB	High	Very High	1.5	15	4.5	101.25	0.33
10. 2+29 to 2+45 RB	Moderate	Moderate	0.4035326	16	2.3	14.85	0.04
11. 2+39 to 2+78 LB	Extreme	Low	2.0002747	39	2.8	218.43	0.27
12. 2+45 to 2+65 RB	High	Low	0.2976923	20	1.95	11.61	0.03
13. 2+68 Riffle XS LB	Extreme	Low	2.5071429	1	2.8	7.02	0.34
14. 2+78 to 3+05 LB	Extreme	Low	2.2514286	27	3.5	212.76	0.38
15.							
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					Total erosion (ft^3/yr)	1072.98	
Convert erosion in ft^3/yr to yds^3/yr {divide Total erosion (ft^3/yr) by 27}					Total erosion (yds^3/yr)	39.74	
Convert erosion in yds^3/yr to tons/yr {multiply Total erosion (yds^3/yr) by 1.3}					Total erosion (tons/yr)	51.66	
Calculate erosion per unit length of channel {divide Total erosion (tons/yr) by total length of stream (ft) surveyed}					Total erosion (tons/yr/ft)	0.1694	

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Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Macgruder - Team 4, Reach - Reach 4**	Location:	
Station:	**1+17 Pool XS LB**	Observers:	
Date:	~~12/30/99~~ 9/25/07	Stream Type:	Valley Type:

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	2.96 (A)	Bankfull Height (ft) =	2.3 (B)	(A) / (B) =	1.28696 (C)	4.57
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	0 (D)	Study Bank Height (ft) =	2.96 (A)	(D) / (A) =	0 (E)	10
Weighted Root Density (G)						
Root Density as % =	0 (F)	(F) × (E) =	0 (G)			10
Bank Angle (H)						
Bank Angle as *Degrees* =	45 (H)					3.17
Surface Protection (I)						
Surface Protection as % =	3 (I)					10

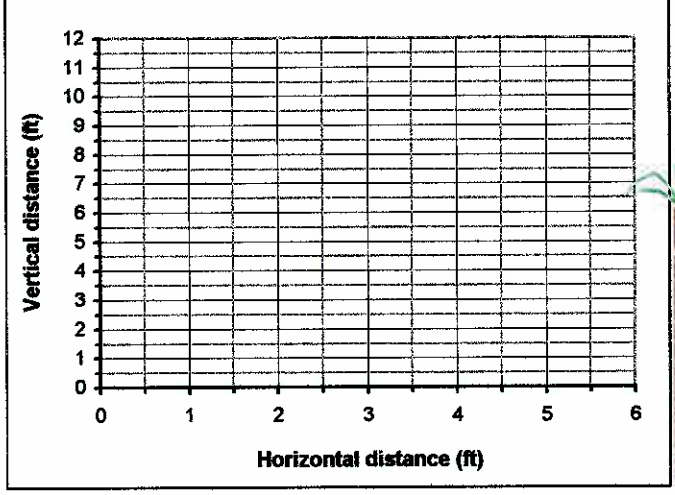
Bank Material Adjustment:

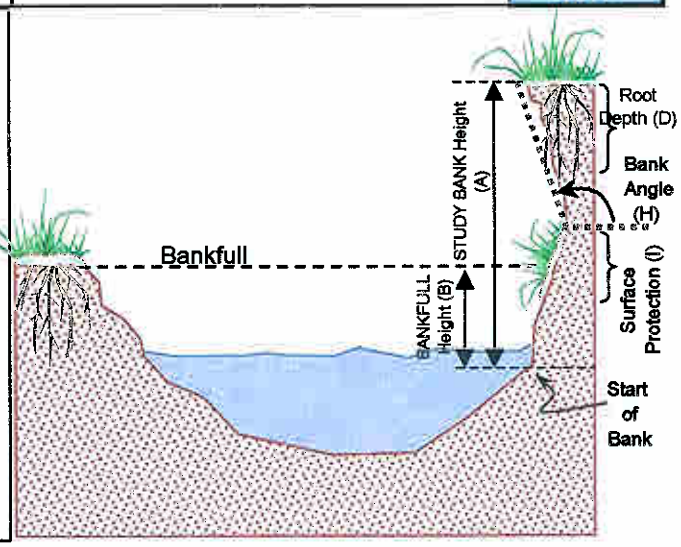
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment	0
Stratification Adjustment Add 5–10 points, depending on position of unstable layers in relation to bankfull stage	0

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**	High / 37.7

Bank Sketch





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Worksheet 5-9. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Macgruder - Team 4, Reach - Reach 4** Location:

Station: **1+17 Pool XS LB** Stream Type: Valley Type:

Observers: Date: ~~12/30/99~~ 9/25/07

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 (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
	Extensive deposition (continuous, cross-channel).....	.....NBS = Extreme
	Chute cutoffs, down-valley meander migration, converging flow.....	.....NBS = Extreme

Level II

	Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)
(2)				

	Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)
(3)				

	Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)
(4)				

Dominant Near-Bank Stress: Low

Level III

	Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)
(5)	1.66	1.3	1.28	Low

	Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)
(6)								

Level IV

	Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)
(7)		

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: Low

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Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Macgruder - Team 4, Reach - Reach 4**	Location:	
Station:	**1+28 Glide XS LB**	Observers:	
Date:	~~12/30/99~~ 9/25/07	Stream Type:	Valley Type:

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	3.4 (A)	Bankfull Height (ft) =	1.7 (B)	(A) / (B) =	2 (C)	7.9
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	0 (D)	Study Bank Height (ft) =	3.4 (A)	(D) / (A) =	0 (E)	10
Weighted Root Density (G)						
		Root Density as % =	0 (F)	(F) × (E) =	0 (G)	10
Bank Angle (H)						
				Bank Angle as *Degrees* =	50 (H)	3.41
Surface Protection (I)						
				Surface Protection as % =	0 (I)	10

Bank Material Adjustment:

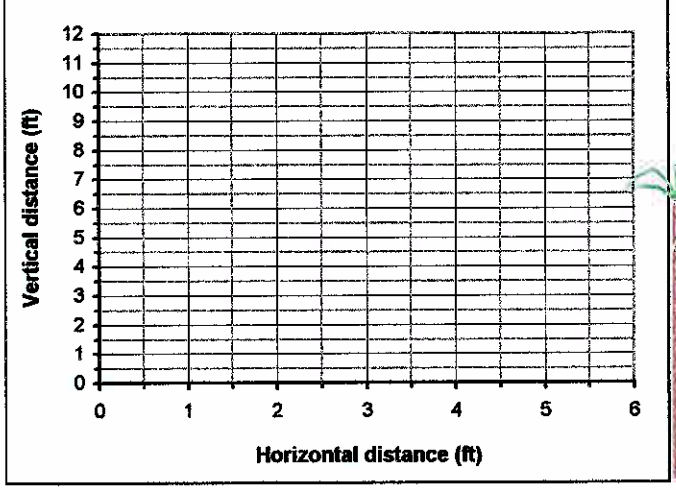
- **Bedrock** (Overall Very Low BEHI)
- **Boulders** (Overall Low BEHI)
- **Cobble** (Subtract 10 points if uniform medium to large cobble)
- **Gravel or Composite Matrix** (Add 5–10 points depending on percentage of bank material that is composed of sand)
- **Sand** (Add 10 points)
- **Silt/Clay** (no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

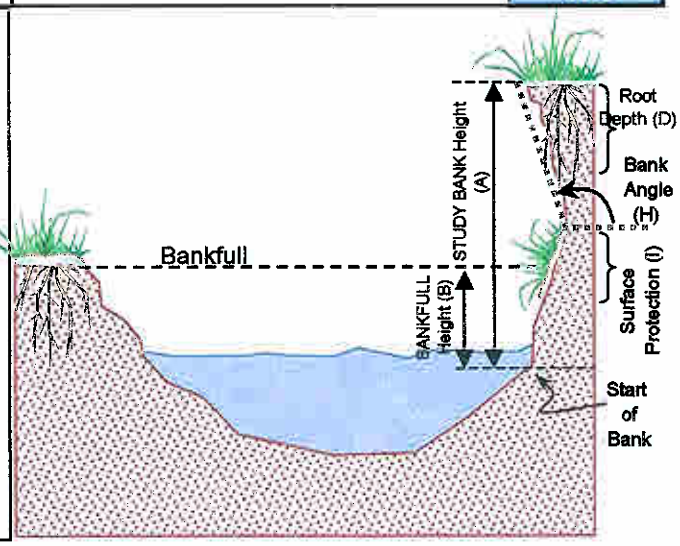
Bank Material Adjustment 0

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0

Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Very High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		41.3

Bank Sketch





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Worksheet 5-9. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Macgruder - Team 4, Reach - Reach 4** Location:

Station: **1+28 Glide XS LB** Stream Type: Valley Type:

Observers: Date: ~~12/30/99~~ 9/25/07

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 (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
	Extensive deposition (continuous, cross-channel).....	.....NBS = Extreme
	Chute cutoffs, down-valley meander migration, converging flow.....	.....NBS = Extreme

Level II

	Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)
(2)				

	Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)
(3)				

	Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)
(4)				

Dominant Near-Bank Stress: Moderate

Level III

	Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)
(5)	2.02	1.3	1.55	Moderate

	Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)
(6)								

Level IV

	Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)
(7)		

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: Moderate

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Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Macgruder - Team 4, Reach - Reach 4**	Location:	
Station:	**2+68 Riffle XS LB**	Observers:	
Date:	~~12/30/99~~ 9/25/07	Stream Type:	Valley Type:

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	2.8 (A)	Bankfull Height (ft) =	1.6 (B)	(A) / (B) =	1.75 (C)	6.71
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	0.2 (D)	Study Bank Height (ft) =	2.8 (A)	(D) / (A) =	0.07143 (E)	8.78
Weighted Root Density (G)						
		Root Density as % =	3 (F)	(F) × (E) =	0.21429 (G)	10
Bank Angle (H)						
				Bank Angle as Degrees =	75 (H)	5.4
Surface Protection (I)						
				Surface Protection as % =	3 (I)	10

Bank Material Adjustment:

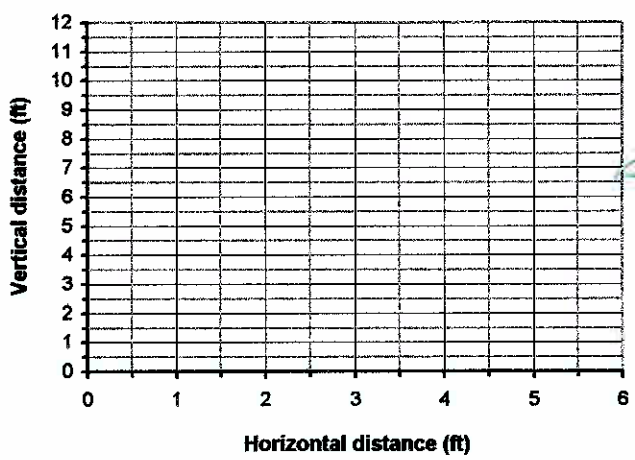
- **Bedrock** (Overall Very Low BEHI)
- **Boulders** (Overall Low BEHI)
- **Cobble** (Subtract 10 points if uniform medium to large cobble)
- **Gravel or Composite Matrix** (Add 5–10 points depending on percentage of bank material that is composed of sand)
- **Sand** (Add 10 points)
- **Silt/Clay** (no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

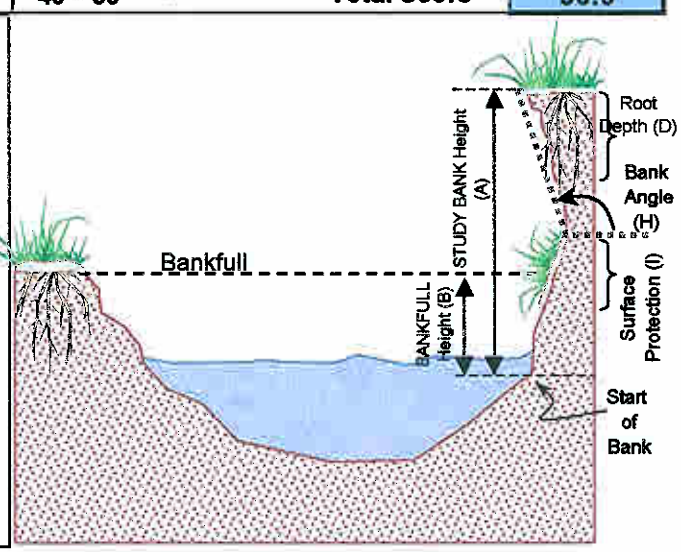
Bank Material Adjustment 5

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

Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Extreme
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		50.9

Bank Sketch





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Worksheet 5-9. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Macgruder - Team 4, Reach - Reach 4** Location:

Station: **2+68 Riffle XS LB** Stream Type: Valley Type:

Observers: Date: ~~12/30/99~~ 9/25/07

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 (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
	Extensive deposition (continuous, cross-channel).....	.....NBS = Extreme
	Chute cutoffs, down-valley meander migration, converging flow.....	.....NBS = Extreme

Level II

	Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)
(2)				

	Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)
(3)				

	Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)
(4)				

Dominant Near-Bank Stress: Low

Level III

	Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)
(5)	1.6	1.3	1.23	Low

	Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)
(6)								

Level IV

	Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)
(7)		

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: Low

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Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Macgruder - Team 4, Reach - Reach 4**	Location:	
Station:	**0+49 to 1+40 LB**	Observers:	
Date:	~~12/30/99~~ 9/25/07	Stream Type:	Valley Type:

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	3.9 (A)	Bankfull Height (ft) =	1.8 (B)	(A) / (B) =	2.16667 (C)	8.1
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	0.6 (D)	Study Bank Height (ft) =	3.9 (A)	(D) / (A) =	0.15385 (E)	7.9
Weighted Root Density (G)						
Root Density as % =	4 (F)	(F) × (E) =	0.61538 (G)			10
Bank Angle (H)						
Bank Angle as *Degrees* =	60 (H)					3.9
Surface Protection (I)						
Surface Protection as % =	3 (I)					10

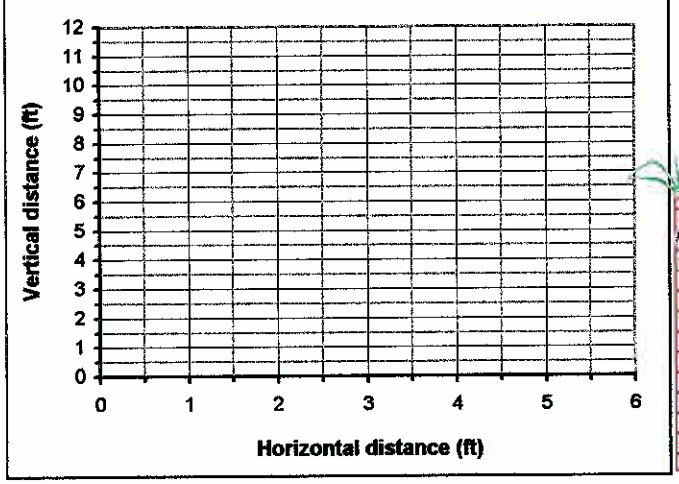
Bank Material Adjustment:

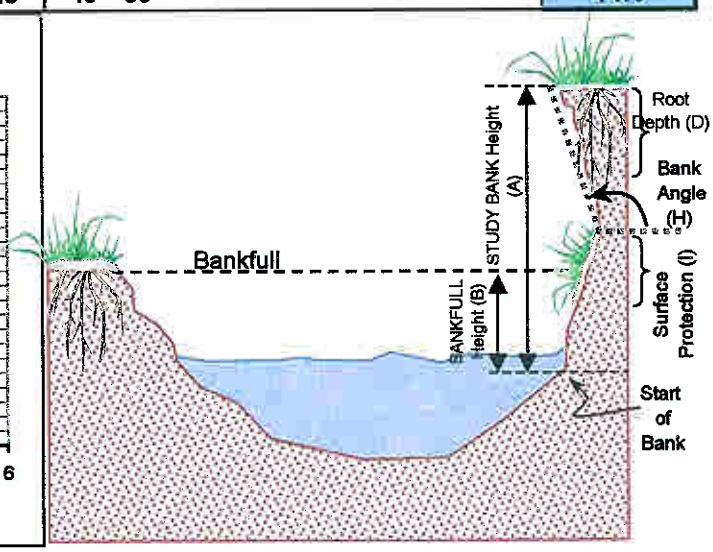
- **Bedrock** (Overall Very Low BEHI)
- **Boulders** (Overall Low BEHI)
- **Cobble** (Subtract 10 points if uniform medium to large cobble)
- **Gravel or Composite Matrix** (Add 5–10 points depending on percentage of bank material that is composed of sand)
- **Sand** (Add 10 points)
- **Silt/Clay** (no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

Bank Material Adjustment	0
Stratification Adjustment Add 5–10 points, depending on position of unstable layers in relation to bankfull stage	5

Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Very High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		44.9

Bank Sketch





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Worksheet 5-9. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Macgruder - Team 4, Reach - Reach 4** Location:

Station: **0+49 to 1+40 LB** Stream Type: Valley Type:

Observers: Date: ~~12/30/99~~ 9/25/07

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 (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
	Extensive deposition (continuous, cross-channel).....	.....NBS = Extreme
	Chute cutoffs, down-valley meander migration, converging flow.....	.....NBS = Extreme

Level II

	Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)
(2)				

	Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)
(3)				

	Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)
(4)				

Dominant Near-Bank Stress: Low

Level III

	Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)
(5)	1.9	1.3	1.46	Low

	Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)
(6)								

Level IV

	Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)
(7)		

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: Low

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Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Macgruder - Team 4, Reach - Reach 4**	Location:	
Station:	**1+40 to 1+61 LB**	Observers:	
Date:	~~12/30/99~~ 9/25/07	Stream Type:	Valley Type:

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	2.9 (A)	Bankfull Height (ft) =	1.75 (B)	(A) / (B) =	1.65714 (C)	6.28
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	2.5 (D)	Study Bank Height (ft) =	2.9 (A)	(D) / (A) =	0.86207 (E)	2.15
Weighted Root Density (G)						
		Root Density as % =	40 (F)	(F) × (E) =	34.4828 (G)	5.55
Bank Angle (H)						
				Bank Angle as *Degrees* =	130 (H)	10
Surface Protection (I)						
				Surface Protection as % =	30 (I)	5.9

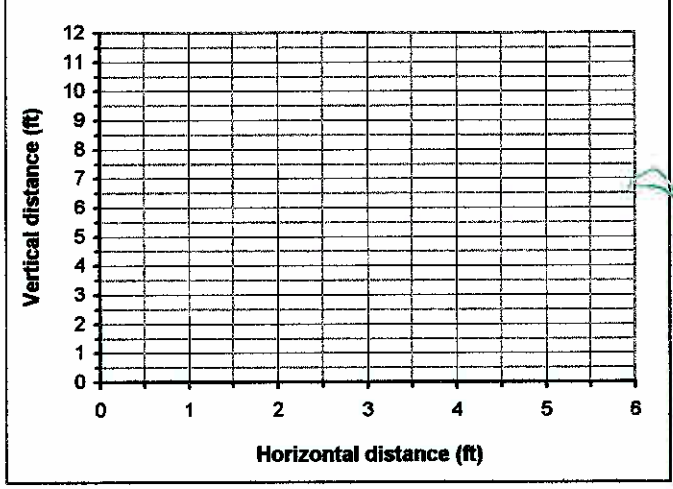
Bank Material Adjustment:

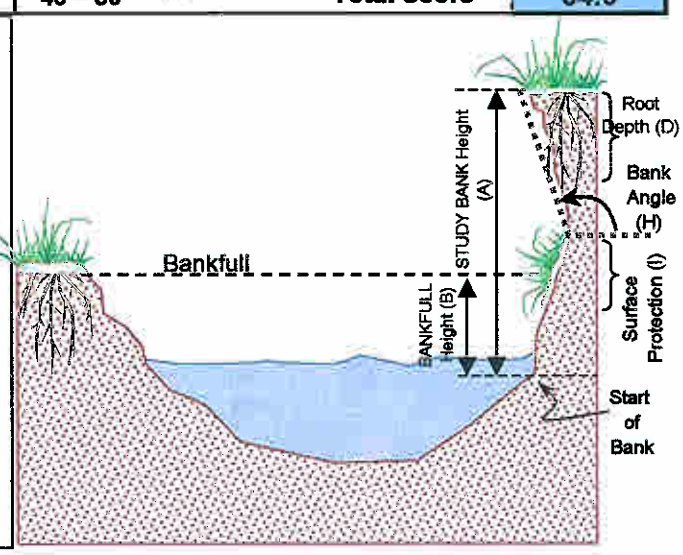
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment	0
Stratification Adjustment Add 5–10 points, depending on position of unstable layers in relation to bankfull stage	5

Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		34.9

Bank Sketch





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Worksheet 5-9. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Macgruder - Team 4, Reach - Reach 4** Location:

Station: **1+40 to 1+61 LB** Stream Type: Valley Type:

Observers: Date: ~~12/30/99~~ 9/25/07

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 (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
Extensive deposition (continuous, cross-channel).....	.....NBS = Extreme
Chute cutoffs, down-valley meander migration, converging flow.....	.....NBS = Extreme

Level II

	Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)
(2)				

	Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)
(3)				

	Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)
(4)				

Dominant Near-Bank Stress: Moderate

Level III

	Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)
(5)	2.1	1.3	1.62	Moderate

	Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)
(6)								

Level IV

	Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)
(7)		

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 Moderate

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Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Macgruder - Team 4, Reach - Reach 4**	Location:	
Station:	**2+39 to 2+78 LB**	Observers:	
Date:	~~12/30/99~~ 9/25/07	Stream Type:	Valley Type:

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	2.8 (A)	Bankfull Height (ft) =	1.6 (B)	(A) / (B) =	1.75 (C)	6.71
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	0.2 (D)	Study Bank Height (ft) =	2.8 (A)	(D) / (A) =	0.07143 (E)	8.78
Weighted Root Density (G)						
		Root Density as % =	3 (F)	(F) × (E) =	0.21429 (G)	10
Bank Angle (H)						
				Bank Angle as *Degrees* =	75 (H)	5.4
Surface Protection (I)						
				Surface Protection as % =	3 (I)	10

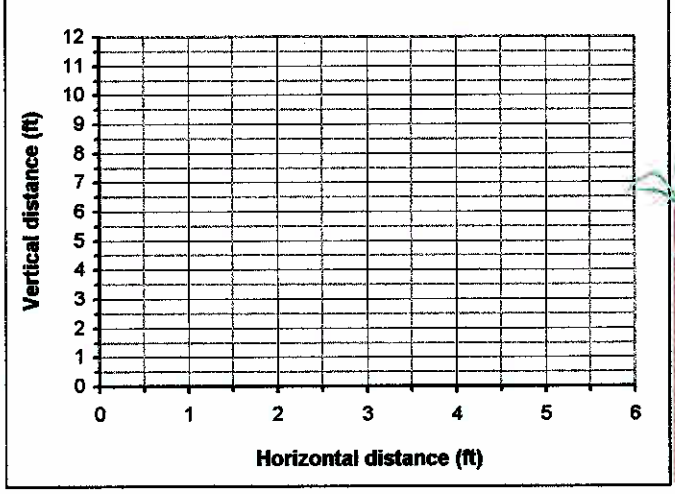
Bank Material Adjustment:

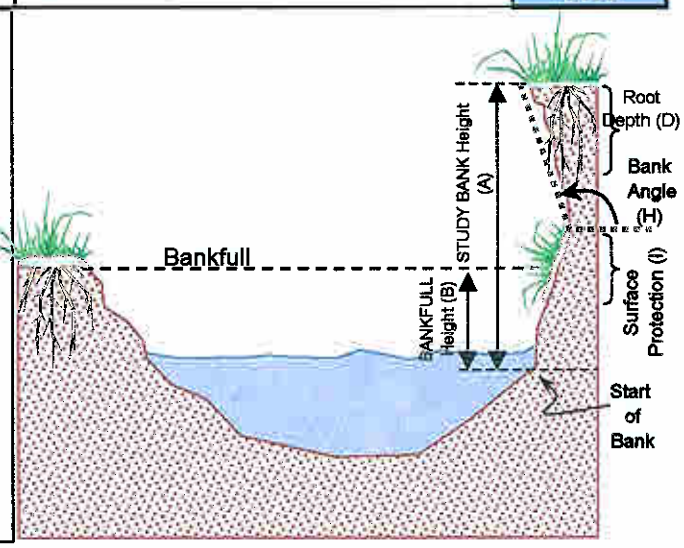
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

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

Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Extreme
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		50.9

Bank Sketch





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Worksheet 5-9. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Macgruder - Team 4, Reach - Reach 4** Location:

Station: **2+39 to 2+78 LB** Stream Type: Valley Type:

Observers: Date: ~~12/30/99~~ 9/25/07

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 (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
	Extensive deposition (continuous, cross-channel).....	.....NBS = Extreme
	Chute cutoffs, down-valley meander migration, converging flow.....	.....NBS = Extreme

Level II

	Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)
(2)				

	Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)
(3)				

	Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)
(4)				

Dominant Near-Bank Stress: Low

Level III

	Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)
(5)	1.6	1.3	1.23	Low

	Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)
(6)								

Level IV

	Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)
(7)		

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: Low

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Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Macgruder - Team 4, Reach - Reach 4**	Location:	
Station:	**2+78 to 3+05 LB**	Observers:	
Date:	~~12/30/99~~ 9/25/07	Stream Type:	Valley Type:

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	3.5 (A)	Bankfull Height (ft) =	1.6 (B)	(A) / (B) =	2.1875 (C)	8.13
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	0.2 (D)	Study Bank Height (ft) =	3.5 (A)	(D) / (A) =	0.05714 (E)	8.89
Weighted Root Density (G)						
Root Density as % =	3 (F)	(F) × (E) =	0.17143 (G)			10
Bank Angle (H)						
Bank Angle as *Degrees* =	90 (H)					7.9
Surface Protection (I)						
Surface Protection as % =	15 (I)					7.9

Bank Material Adjustment:

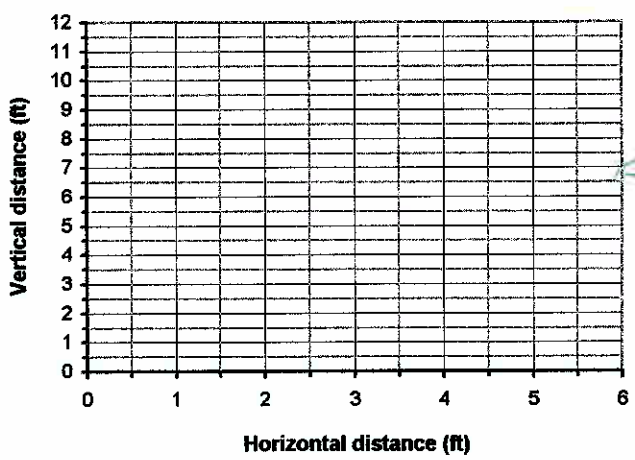
- **Bedrock** (Overall Very Low BEHI)
- **Boulders** (Overall Low BEHI)
- **Cobble** (Subtract 10 points if uniform medium to large cobble)
- **Gravel or Composite Matrix** (Add 5–10 points depending on percentage of bank material that is composed of sand)
- **Sand** (Add 10 points)
- **Silt/Clay** (no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

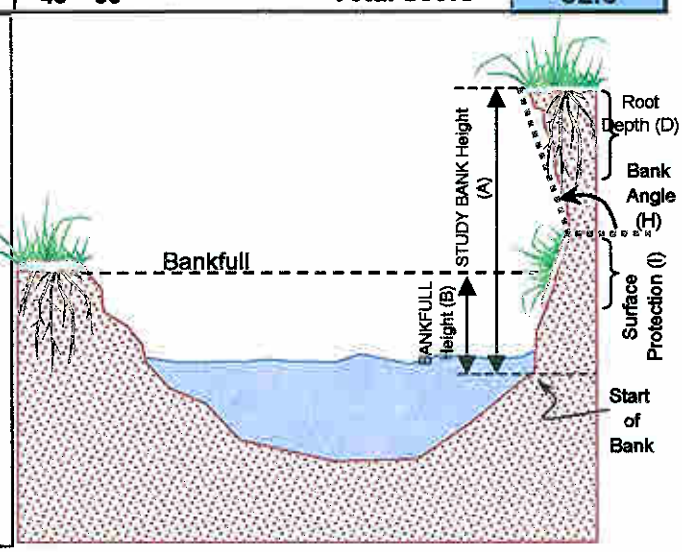
Bank Material Adjustment 10

Stratification Adjustment Add 5–10 points, depending on position of unstable layers in relation to bankfull stage: 0

Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Extreme
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		52.8

Bank Sketch





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Worksheet 5-9. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Macgruder - Team 4, Reach - Reach 4** Location:

Station: **2+78 to 3+05 LB** Stream Type: Valley Type:

Observers: Date: ~~12/30/99~~ 9/25/07

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 (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
	Extensive deposition (continuous, cross-channel).....	.....NBS = Extreme
	Chute cutoffs, down-valley meander migration, converging flow.....	.....NBS = Extreme

Level II

	Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)
(2)				

	Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)
(3)				

	Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)
(4)				

Dominant Near-Bank Stress
Low

Level III

	Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)
(5)	1.6	1.3	1.23	Low

	Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)
(6)								

Level IV

	Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)
(7)		

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 Low

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Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Macgruder - Team 4, Reach - Reach 4**	Location:	
Station:	**0+00 to 0+20 RB**	Observers:	
Date:	~~12/30/99~~ 9/25/07	Stream Type:	Valley Type:

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	2.6 (A)	Bankfull Height (ft) =	1.8 (B)	(A) / (B) =	1.44444 (C)	5.52
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	0.9 (D)	Study Bank Height (ft) =	2.6 (A)	(D) / (A) =	0.34615 (E)	5.4
Weighted Root Density (G)						
		Root Density as % =	5 (F)	(F) x (E) =	1.73077 (G)	10
Bank Angle (H)						
				Bank Angle as *Degrees* =	90 (H)	7.9
Surface Protection (I)						
				Surface Protection as % =	8 (I)	10

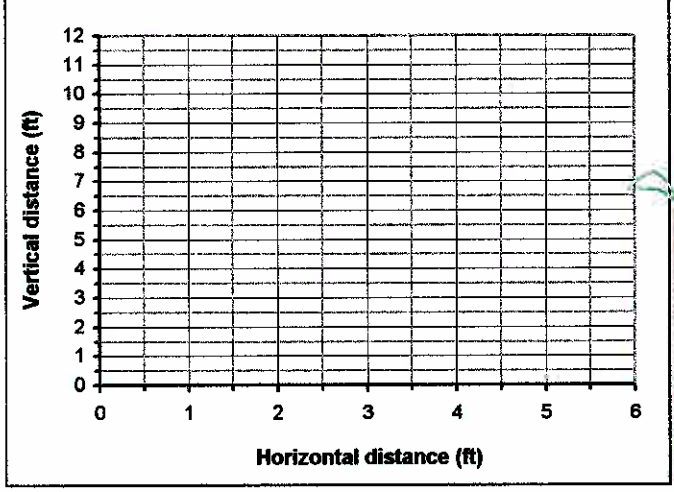
Bank Material Adjustment:

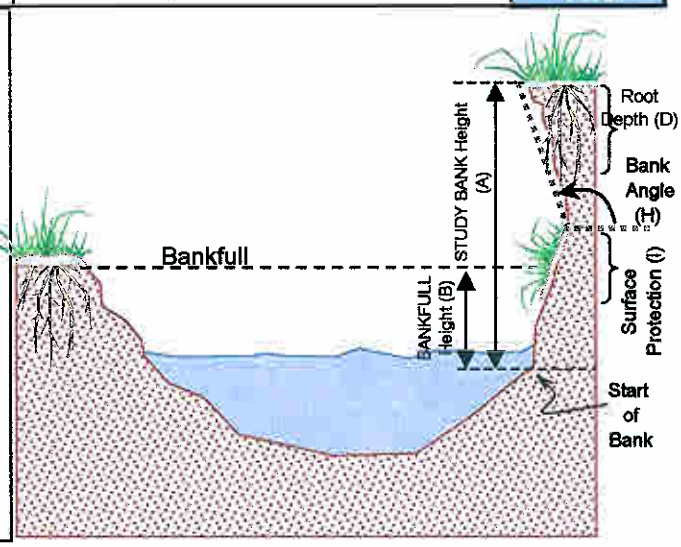
- **Bedrock** (Overall Very Low BEHI)
- **Boulders** (Overall Low BEHI)
- **Cobble** (Subtract 10 points if uniform medium to large cobble)
- **Gravel or Composite Matrix** (Add 5–10 points depending on percentage of bank material that is composed of sand)
- **Sand** (Add 10 points)
- **Silt/Clay** (no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

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

Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Extreme
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		48.8

Bank Sketch





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Worksheet 5-9. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Macgruder - Team 4, Reach - Reach 4** Location:

Station: **0+00 to 0+20 RB** Stream Type: Valley Type:

Observers: Date: ~~12/30/99~~ 9/25/07

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 (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
Extensive deposition (continuous, cross-channel).....	.....NBS = Extreme
Chute cutoffs, down-valley meander migration, converging flow.....	.....NBS = Extreme

Level II

	Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)
(2)				

	Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)
(3)				

	Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)
(4)				

Dominant Near-Bank Stress: Moderate

Level III

	Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)
(5)	2.16	1.3	1.66	Moderate

	Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)
(6)								

Level IV

	Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)
(7)		

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: Moderate

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Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Macgruder - Team 4, Reach - Reach 4**	Location:	
Station:	**0+20 to 0+37 RB**	Observers:	
Date:	~~12/30/99~~ 9/25/07	Stream Type:	Valley Type:

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	2.9 (A)	Bankfull Height (ft) =	1.8 (B)	(A) / (B) =	1.61111 (C)	6.05
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	1 (D)	Study Bank Height (ft) =	2.9 (A)	(D) / (A) =	0.34483 (E)	5.5
Weighted Root Density (G)						
		Root Density as % =	8 (F)	(F) × (E) =	2.75862 (G)	10
Bank Angle (H)						
				Bank Angle as *Degrees* =	110 (H)	8.68
Surface Protection (I)						
				Surface Protection as % =	10 (I)	9

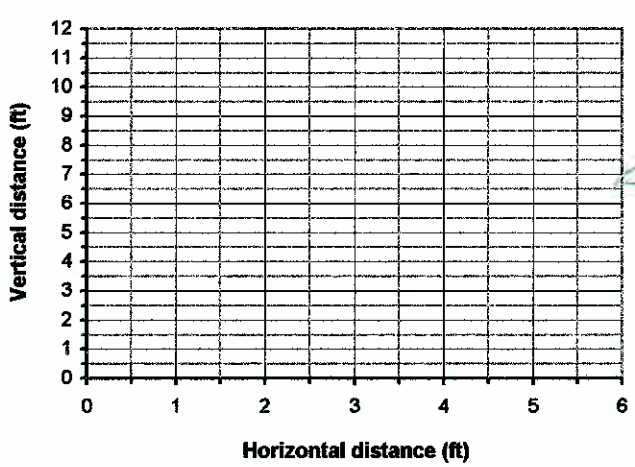
Bank Material Adjustment:

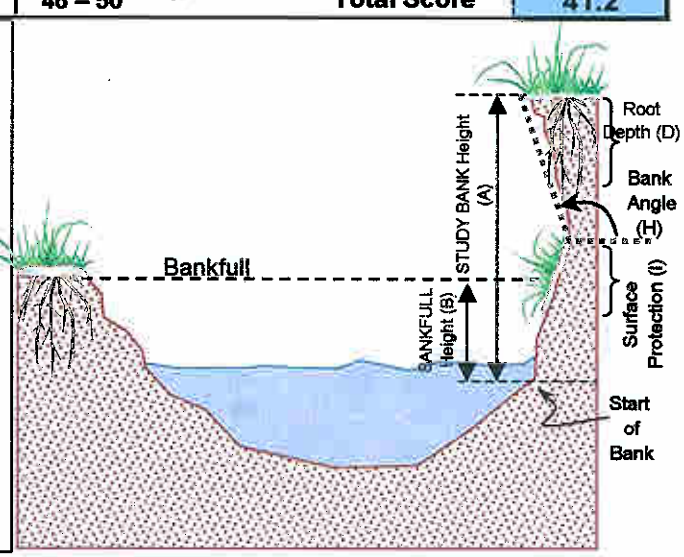
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment	0
Stratification Adjustment Add 5–10 points, depending on position of unstable layers in relation to bankfull stage	2

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 41.2

Bank Sketch





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Worksheet 5-9. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Macgruder - Team 4, Reach - Reach 4** Location:

Station: **0+20 to 0+37 RB** Stream Type: Valley Type:

Observers: Date: ~~12/30/99~~ 9/25/07

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 (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
Extensive deposition (continuous, cross-channel).....	.....NBS = Extreme
Chute cutoffs, down-valley meander migration, converging flow.....	.....NBS = Extreme

Level II

	Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)
(2)				

	Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)
(3)				

	Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)
(4)				

Dominant Near-Bank Stress
Low

Level III

	Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)
(5)	1.8	1.3	1.38	Low

	Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)
(6)								

Level IV

	Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)
(7)		

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 Low

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Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Macgruder - Team 4, Reach - Reach 4**	Location:	
Station:	**1+46 to 1+61 RB**	Observers:	
Date:	~~12/30/99~~ 9/25/07	Stream Type:	Valley Type:

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	1.7 (A)	Bankfull Height (ft) =	0.2 (B)	(A) / (B) =	8.5 (C)	10
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	0.95 (D)	Study Bank Height (ft) =	1.7 (A)	(D) / (A) =	0.55882 (E)	3.61
Weighted Root Density (G)						
		Root Density as % =	10 (F)	(F) × (E) =	5.58824 (G)	8.93
Bank Angle (H)						
				Bank Angle as Degrees =	70 (H)	4.9
Surface Protection (I)						
				Surface Protection as % =	25 (I)	6.54

Bank Material Adjustment:

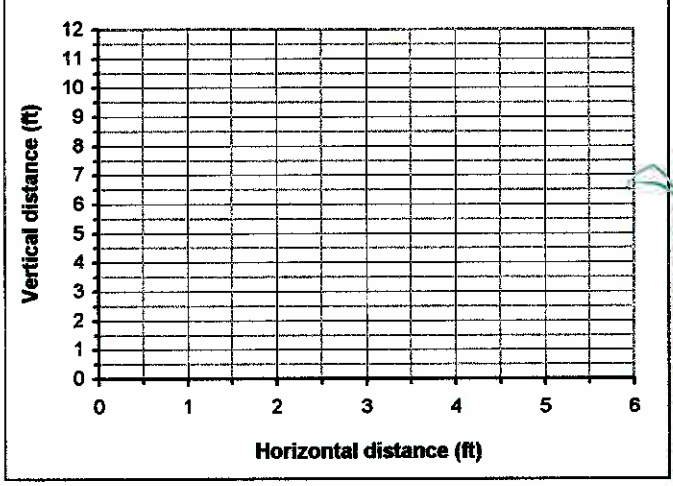
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

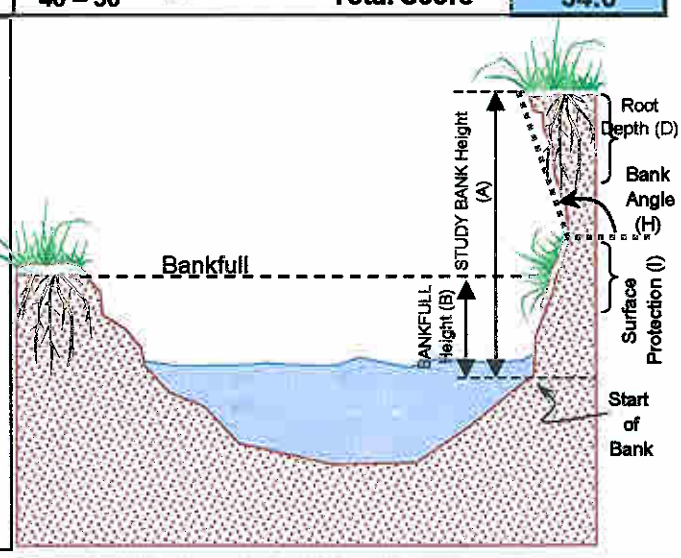
Bank Material Adjustment 0

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0

Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		34.0

Bank Sketch





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Worksheet 5-9. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Macgruder - Team 4, Reach - Reach 4** Location:

Station: **1+46 to 1+61 RB** Stream Type: Valley Type:

Observers: Date: ~~12/30/99~~ 9/25/07

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 (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
Extensive deposition (continuous, cross-channel).....	.....NBS = Extreme
Chute cutoffs, down-valley meander migration, converging flow.....	.....NBS = Extreme

Level II

	Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)
(2)				

	Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)
(3)				

	Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)
(4)				

Dominant Near-Bank Stress: Very Low

Level III

	Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)
(5)	0.2	1.3	0.15	Very Low

	Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)
(6)								

Level IV

	Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)
(7)		

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 Low

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Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Macgruder - Team 4, Reach - Reach 4**	Location:	
Station:	**1+61 to 2+14 RB**	Observers:	
Date:	~~12/30/99~~ 9/25/07	Stream Type:	Valley Type:

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	3 (A)	Bankfull Height (ft) =	1.95 (B)	(A) / (B) =	1.53846 (C)	5.72
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	1.2 (D)	Study Bank Height (ft) =	3 (A)	(D) / (A) =	0.4 (E)	4.9
Weighted Root Density (G)						
Root Density as % =	15 (F)			(F) × (E) =	6 (G)	8.89
Bank Angle (H)						
Bank Angle as *Degrees* =	75 (H)					5.4
Surface Protection (I)						
Surface Protection as % =	5 (I)					10

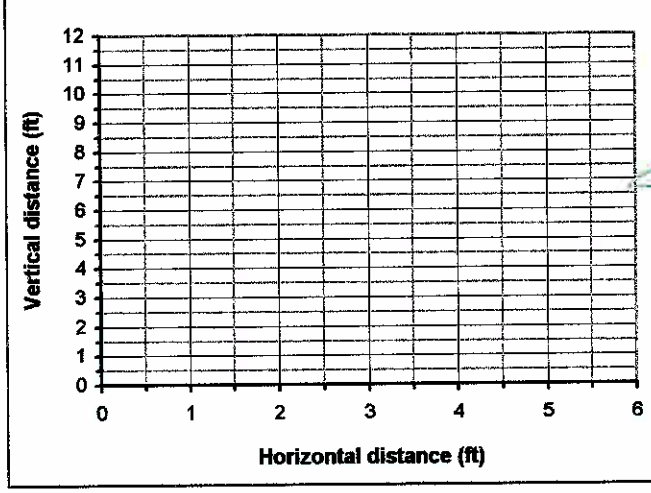
Bank Material Adjustment:

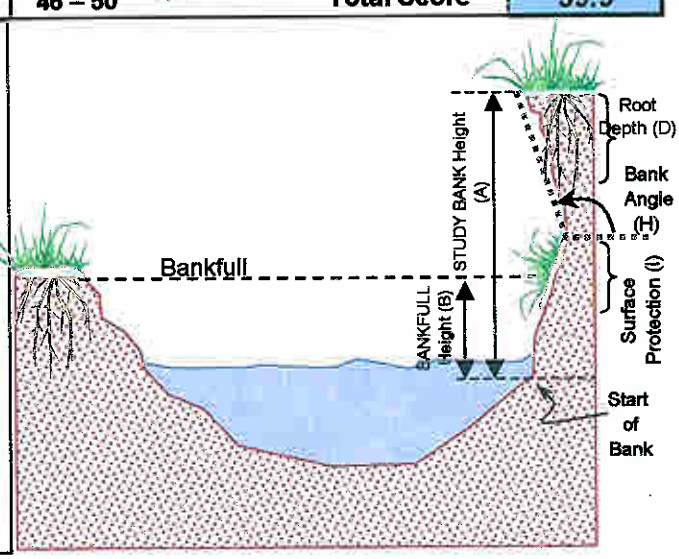
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment	2
Stratification Adjustment Add 5–10 points, depending on position of unstable layers in relation to bankfull stage	3

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**	High / 39.9

Bank Sketch





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Worksheet 5-9. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Macgruder - Team 4, Reach - Reach 4** Location:

Station: **1+61 to 2+14 RB** Stream Type: Valley Type:

Observers: Date: ~~12/30/99~~ 9/25/07

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 (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
	Extensive deposition (continuous, cross-channel).....	.....NBS = Extreme
	Chute cutoffs, down-valley meander migration, converging flow.....	.....NBS = Extreme

Level II

	Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)
(2)				

	Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)
(3)				

	Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)
(4)				

Dominant Near-Bank Stress: Moderate

Level III

	Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)
(5)	2.2	1.3	1.69	Moderate

	Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)
(6)								

Level IV

	Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)
(7)		

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 Moderate

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Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Macgruder - Team 4, Reach - Reach 4**	Location:	
Station:	**2+14 to 2+29 RB**	Observers:	
Date:	~~12/30/99~~ 9/25/07	Stream Type:	Valley Type:

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	4.5 (A)	Bankfull Height (ft) =	3.3 (B)	(A) / (B) =	1.36364 (C)	5.01
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	2.4 (D)	Study Bank Height (ft) =	4.5 (A)	(D) / (A) =	0.53333 (E)	3.75
Weighted Root Density (G)						
Root Density as % =	75 (F)	(F) × (E) =	40 (G)			5.11
Bank Angle (H)						
Bank Angle as *Degrees* =	130 (H)					10
Surface Protection (I)						
Surface Protection as % =	35 (I)					5.5

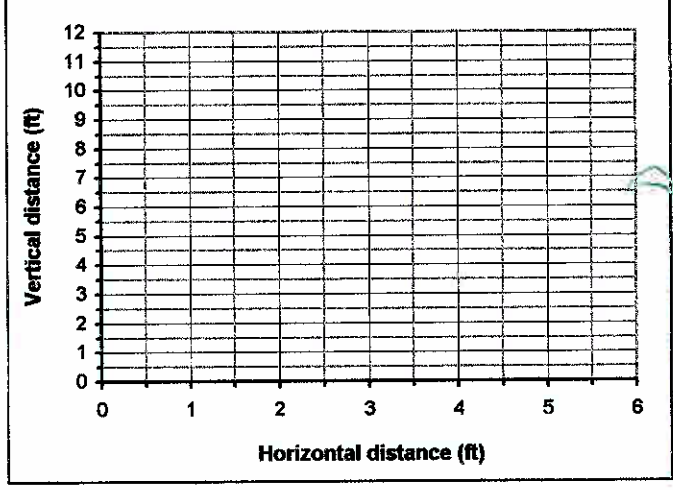
Bank Material Adjustment:

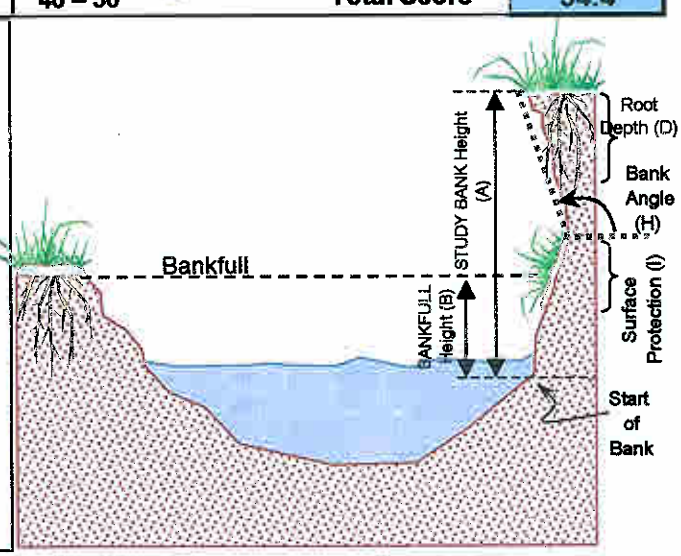
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment	2
Stratification Adjustment Add 5–10 points, depending on position of unstable layers in relation to bankfull stage	3

Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		34.4

Bank Sketch





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Worksheet 5-9. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Macgruder - Team 4, Reach - Reach 4** Location:

Station: **2+14 to 2+29 RB** Stream Type: Valley Type:

Observers: Date: ~~12/30/99~~ 9/25/07

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 (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
	Extensive deposition (continuous, cross-channel).....	.....NBS = Extreme
	Chute cutoffs, down-valley meander migration, converging flow.....	.....NBS = Extreme

Level II

	Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)
(2)				

	Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)
(3)				

	Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)
(4)				

Dominant Near-Bank Stress: Very High

Level III

	Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)
(5)	3.6	1.3	2.77	Very High

	Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)
(6)								

Level IV

	Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)
(7)		

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

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Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Macgruder - Team 4, Reach - Reach 4**	Location:	
Station:	**2+29 to 2+45 RB**	Observers:	
Date:	~~12/30/99~~ 9/25/07	Stream Type:	Valley Type:

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	2.3 (A)	Bankfull Height (ft) =	2.2 (B)	(A) / (B) =	1.04545 (C)	1.45
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	1.2 (D)	Study Bank Height (ft) =	2.3 (A)	(D) / (A) =	0.52174 (E)	3.8
Weighted Root Density (G)						
		Root Density as % =	15 (F)	(F) × (E) =	7.82609 (G)	8.69
Bank Angle (H)						
				Bank Angle as *Degrees* =	65 (H)	4.4
Surface Protection (I)						
				Surface Protection as % =	35 (I)	5.5

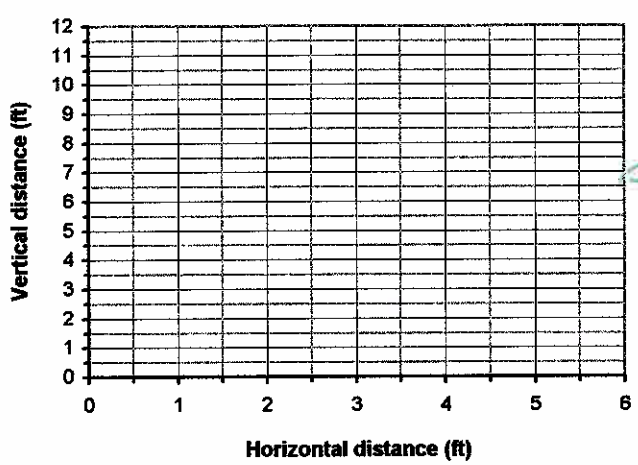
Bank Material Adjustment:

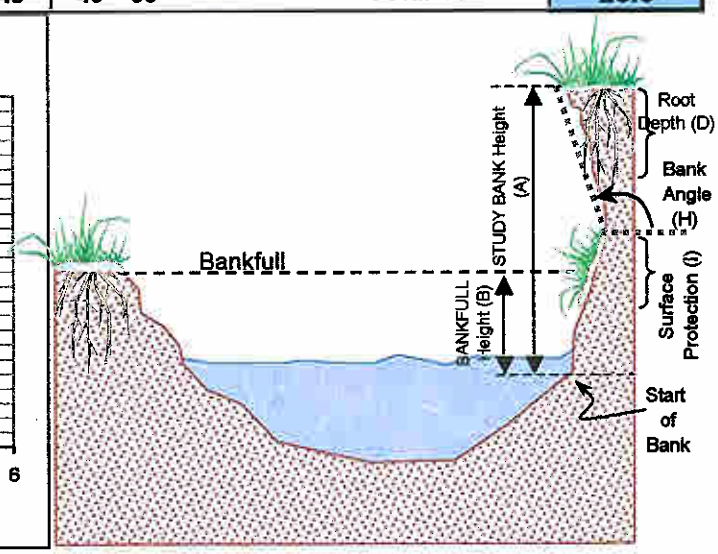
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment	2
Stratification Adjustment Add 5–10 points, depending on position of unstable layers in relation to bankfull stage	3

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**	Moderate 28.8

Bank Sketch





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Worksheet 5-9. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Macgruder - Team 4, Reach - Reach 4** Location:

Station: **2+29 to 2+45 RB** Stream Type: Valley Type:

Observers: Date: ~~12/30/99~~ 9/25/07

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 (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
	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: Moderate

Level III

(5)	Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)
	2.2	1.3	1.69	Moderate

(6)	Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{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: Moderate

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Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Macgruder - Team 4, Reach - Reach 4**	Location:	
Station:	**2+45 to 2+65 RB**	Observers:	
Date:	~~12/30/09~~ 9/25/07	Stream Type:	Valley Type:

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	1.95 (A)	Bankfull Height (ft) =	1.8 (B)	(A) / (B) =	1.08333 (C)	1.72
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	0.2 (D)	Study Bank Height (ft) =	1.95 (A)	(D) / (A) =	0.10256 (E)	8.44
Weighted Root Density (G)						
Root Density as % =	3 (F)	(F) × (E) =	0.30769 (G)			10
Bank Angle (H)						
Bank Angle as *Degrees* =	50 (H)					3.41
Surface Protection (I)						
Surface Protection as % =	3 (I)					10

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)

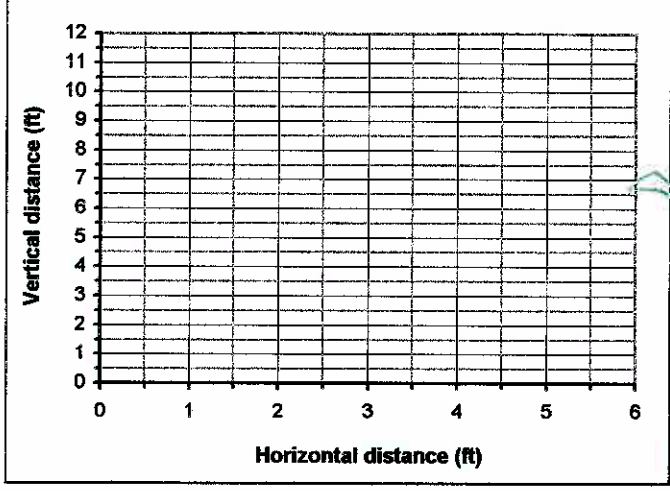
Bank Material Adjustment 0

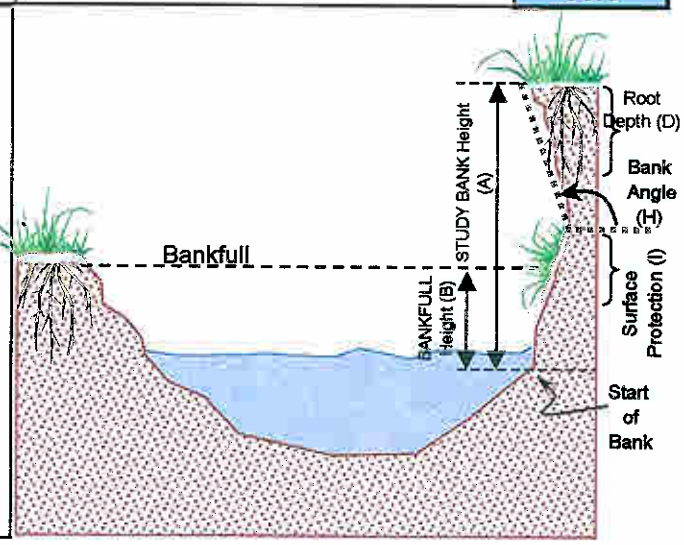
Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage: 0

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**: High, 33.6

Bank Sketch





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Worksheet 5-9. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Macgruder - Team 4, Reach - Reach 4** Location:

Station: **2+45 to 2+65 RB** Stream Type: Valley Type:

Observers: Date: ~~12/30/09~~ 9/25/07

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 (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
Extensive deposition (continuous, cross-channel).....	.....NBS = Extreme
Chute cutoffs, down-valley meander migration, converging flow.....	.....NBS = Extreme

Level II

	Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)
(2)				

	Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)
(3)				

	Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)
(4)				

Dominant Near-Bank Stress
Low

Level III

	Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)
(5)	1.82	1.3	1.4	Low

	Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)
(6)								

Level IV

	Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)
(7)		

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 Low

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a. Riparian Vegetation

Worksheet C-4. Riparian vegetation composition/density used for channel stability assessment.

Riparian Vegetation

Stream: MacGruder Location: Reach Ø4

Observers: WACIK Reference reach [ ] Disturbed (impacted reach) [X] Date: 9/25/07

Existing species composition: Flood Plain Tulip Poplar Assoc. Found in upper stream Valleys of 1st and 2nd Order Streams

Potential species composition: Expected Succession to Oak, Hickory and beech Assoc. *see Remarks

Riparian cover categories		Percent aerial cover*	Percent of site coverage**	Species composition	Percent of total species composition
1. Overstory	Canopy layer	≈ 70%	9% *	white Oak	5%
				Tulip Poplar	70%
				ASH	5%
				MAPLE	5%
				BL. WALNUT	15%
					100%
2. Understory	Shrub layer		6% *	Spicebush	75%
				Ironwood	15%
				MAPLE	5%
				Tulip Poplar	5%
					100%
3. Ground level	Herbaceous		30% *	Virginia Creeper	1%
				Fern sp.	1%
				Japanese Stiltgrass	85%
				Grass sp.	7%
				UNKNOWN	5%
					100%
	Leaf or needle litter		15%		
	Bare ground		40%		
			Column total = 100%		

*Based on crown closure.
**Based on basal area to surface area.

Remarks:

Condition, vigor and/or usage of existing reach:

- Evidence of heavy deer browse
- Spicebush unpalatable and dominant in understory.
- Stiltgrass dominant in disturbed areas over much of the site. (invasive)
- *regeneration influenced by Deer and Disturbance areas. And Succession

- Riparian Plantings should include white/red oak, beech, maple, hickory, and birch with appropriate deer overbrowsing control.

H – Canada Rush, Soft Rush, Virginia switchgrass, Joe-Pyeweed, Trout Lily
S – common Elderberry; black Haw; Rhododendron; Mt. Laurel

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b. Flow Regime

Worksheet C-5. Flow Regime variables that influence channel characteristics, sediment regime and biological interpretations.

FLOW REGIME

Stream:			Location:					
Observers:						Date:		
List ALL COMBINATIONS that APPLY.....	P2	P8						

General Category

E	Ephemeral stream channels: flows only in response to precipitation. Often used in conjunction with intermittent.
S	Subterranean stream channel: flows parallel to and near the surface for various seasons - a sub-surface flow that follows the stream bed.
I	Intermittent stream channel: one that flows only seasonally or sporadically. Surface sources involve springs, snowmelt, artificial controls, etc. Often this term is associated with flows that reappear along various locations of a reach then run subterranean.
P	Perennial stream channels: surface water persists yearlong.

Specific Category

1	Seasonal variation in streamflow dominated primarily by snowmelt runoff.
2	Seasonal variation in streamflow dominated primarily by stormflow runoff.
3	Uniform stage and associated streamflow due to spring-fed condition, backwater, etc.
4	Streamflow regulated by glacial melt.
5	Ice flows/ice torrents from ice dam breaches.
6	Alternating flow/backwater due to tidal influence.
7	Regulated streamflow due to diversions, dam release, dewatering, etc.
8	Altered due to development, such as urban streams, cut-over watersheds or vegetation conversions (forested to grassland) that change flow response to precipitation events.
9	Rain-on-snow generated runoff.

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c. Stream Size and Order

Worksheet C-6. Stream size/order categories for stratification by stream type.

Stream Size and Order			
Stream: MAC GRUDER			
Location: TEAM 4			
Observers:			
Date:			
Stream Size Category and Order ☞			S-3(4)
Category	**STREAM SIZE: Bankfull width**		**Check (✓) appropriate category**
	meters	**feet**	
S-1	0.305	<1	☐
S-2	0.3 – 1.5	1 – 5	☐
S-3	1.5 – 4.6	5 – 15	☑
S-4	4.6 – 9	15 – 30	☐
S-5	9 – 15	30 – 50	☐
S-6	15 – 22.8	50 – 75	☐
S-7	22.8 – 30.5	75 – 100	☐
S-8	30.5 – 46	100 – 150	☐
S-9	46 – 76	150 – 250	☐
S-10	76 – 107	250 – 350	☐
S-11	107 – 150	350 – 500	☐
S-12	150 – 305	500 – 1000	☐
S-13	>305	>1000	☐
Stream Order			
Add categories in parenthesis for specific stream order of reach. For example a third order stream with a bankfull width of 6.1 meters (20 feet) would be indexed as: S-4(3).			

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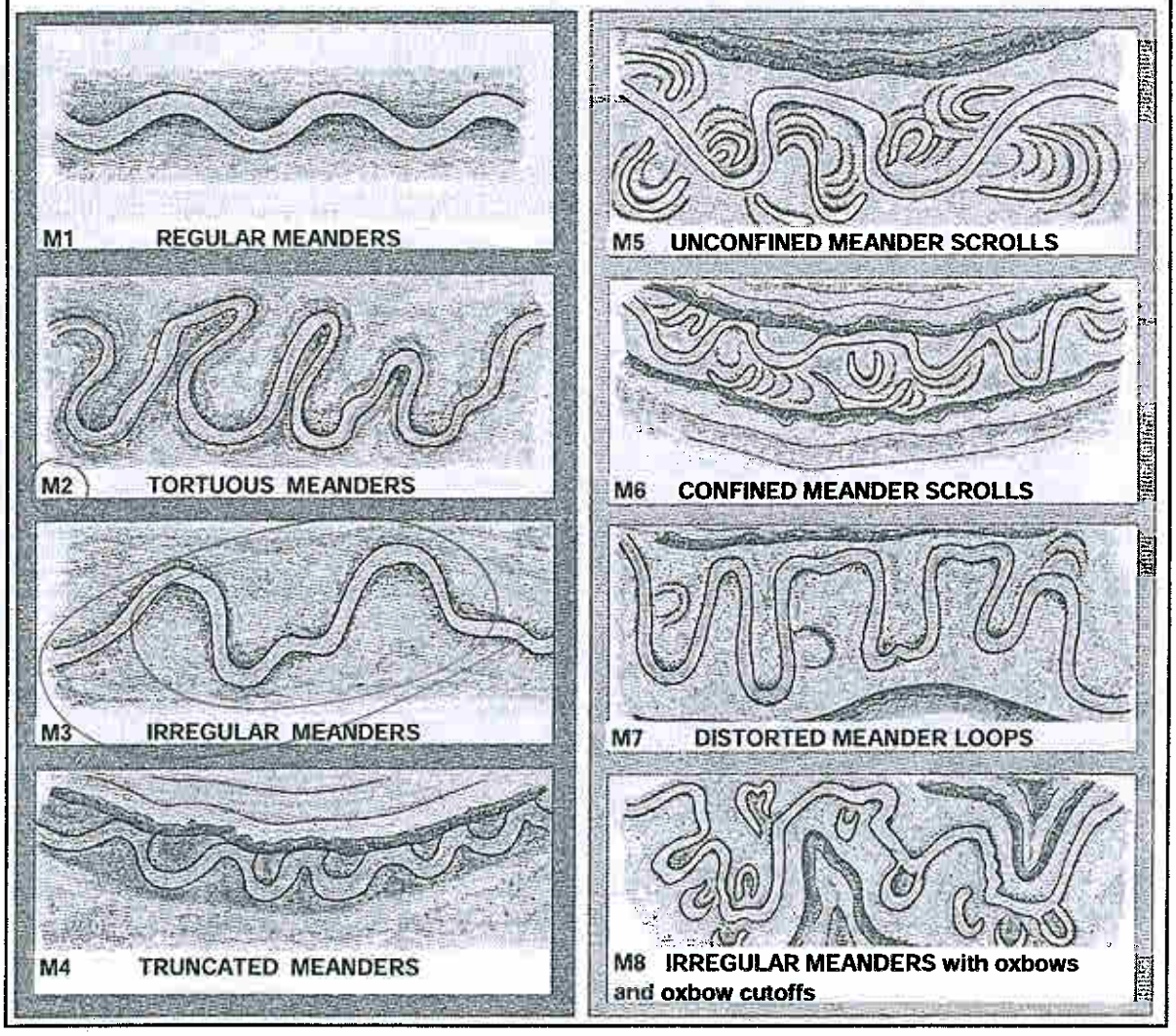
d. Meander Patterns

Worksheet C-7. Meander pattern relations used for interpretations for river stability.

Meander Patterns					
Stream: MACGRUDER		Reach: TEAM 4			
Observers:		Date:			
List ALL CATEGORIES that APPLY ☞	M3	M2			

Various Meander Pattern variables modified from Galay et al. (1973)



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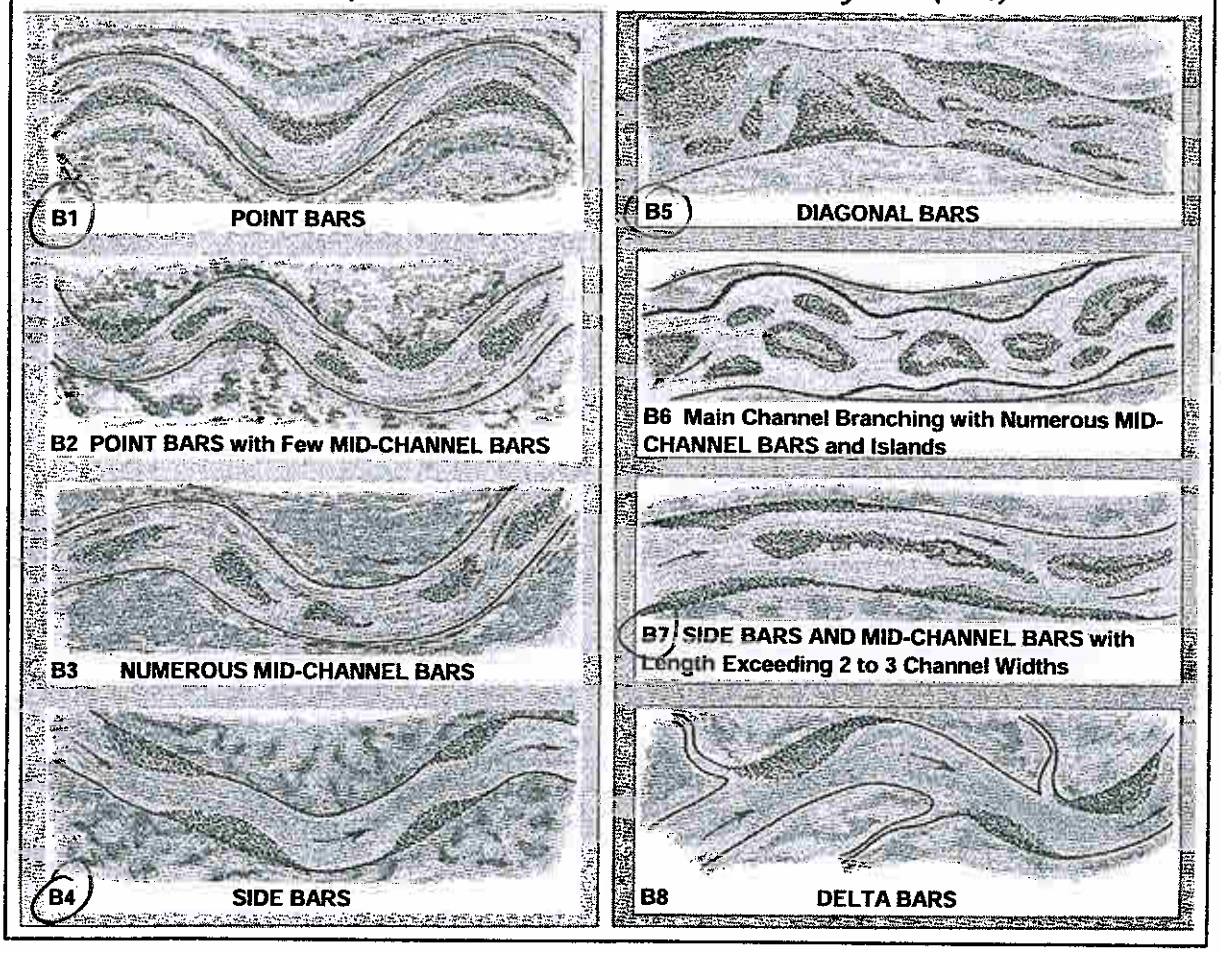
e. Depositional Patterns

Worksheet C-8. Depositional patterns used for stability assessment interpretations.

Depositional Patterns					
Stream: MAC GRUDER		Reach: TEAM 4			
Observers:		Date:			
List ALL CATEGORIES that APPLY ☞	B1	B4	B5	B7	

Various Depositional Features modified from Galay et al. (1973)



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f. Channel Blockages

Worksheet C-9. Various categories of in-channel debris, dams and/or channel blockages used to evaluate channel stability.

Channel Blockages			
Stream:		Location:	
Observers:		Date:	
Description/extent		**Materials, which upon placement into the active channel or flood-prone area, may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.**	**Check (✓) all that apply**
D1	None	Minor amounts of small, floatable material.	☐
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.	☑
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.	☑
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.	☐
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	☐
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.	☐
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	☐
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.	☐
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.	☐
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	☑

Bridges above + below reach

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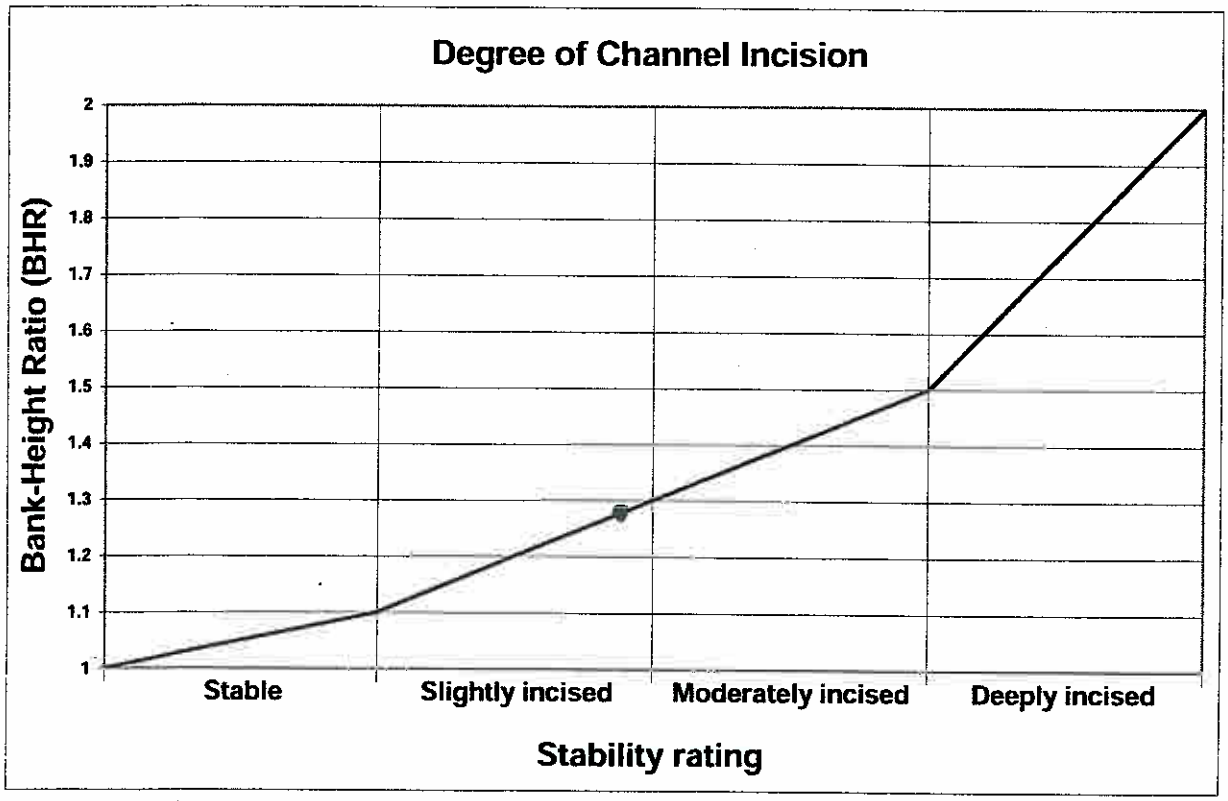
g. Degree of Channel Incision (Bank-Height Ratio)

Worksheet C-10. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings to determine degree of channel incision.

Degree of Channel Incision			
Low Bank Height:	2.72	Bank-Height Ratio:	1.27
Max Bankfull Depth:	2.13		
Degree of Channel Incision Stability Rating	Slightly Incised		



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h. Modified Pfankuch Channel Stability Rating

Worksheet C-11. Modified Pfankuch channel stability rating procedure as modified by Rosgen.

Stream: Location: Valley Type: Observers: Date:

Location	Key	Category	Excellent Description	Excellent Rating	Good Description	Good Rating	Fair Description	Fair Rating	Poor Description	Poor Rating
Upper banks	1	Landform slope	Bank slope gradient <30%. Flat	2	Bank slope gradient 30–40%.	4	Bank slope gradient 40–60%.	6	Bank slope gradient > 60%.	8
	2	Mass erosion	No evidence of past or future mass erosion.	3	Infrequent. Mostly healed over. Low future potential.	6	Frequent or large, causing sediment nearly yearlong.	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	12
	3	Debris jam potential	Essentially absent from immediate channel area.	2	Present, but mostly small twigs and limbs.	4	Moderate to heavy amounts, mostly larger sizes.	6	Moderate to heavy amounts, predominantly larger sizes.	8
	4	Vegetative bank protection	> 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass.	3	70–90% density. Fewer species or less vigor suggest less dense or deep root mass.	6	50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	9	<50% density plus fewer species & less vigor indicating poor, discontinuous and shallow root mass.	12 10
Lower banks	5	Channel capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0.	1	Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1.	2	Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3.	3	Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3.	4
	6	Bank rock content	> 65% with large angular boulders. 12"+ common.	2	40–65%. Mostly boulders and small cobbles 6–12".	4	20–40%. Most in the 3–6" diameter class.	6	<20% rock fragments of gravel sizes, 1–3" or less.	8
	7	Obstructions to flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed.	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm.	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	8
	8	Cutting	Little or none. Infrequent raw banks <6".	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	6	Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some over 24" high. Failure of overhangs frequent. 14	16
	9	Deposition	Little or no enlargement of channel or point bars.	4	Some new bar increase, mostly from coarse gravel.	8	Moderate depostion of new gravel and coarse sand on old and some new bars.	12	Extensive deposit of predominantly fine particles. Accelerated bar development.	16
Bottom	10	Rock angularity	Sharp edges and corners. Plane surfaces rough.	1	Rounded corners and edges. Surfaces smooth and flat.	2	Corners and edges well rounded in 2 dimensions.	3	Well rounded in all dimensions, surfaces smooth.	4
	11	Brightness	Surfaces dull, dark or stained. Generally not bright.	1	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright, i.e., 35–65% mixture range.	3	Predominantly bright, > 65%, exposed or scoured surfaces.	4
	12	Consolidation of particles	Assorted sizes tightly packed or overlapping.	2	Moderately packed with some overlapping.	4	Mostly loose assortment with no apparent overlap.	6	No packing evident. Loose assortment, easily moved.	8
	13	Bottom size distribution	No size change evident. Stable material 80–100%.	4	Distribution shift light. Stable material 50–80%.	8	Moderate change in sizes. Stable materials 20–50%.	12	Marked distribution change. Stable materials 0–20%. 15	16
	14	Scouring and deposition	<5% of bottom affected by scour or deposition.	6	5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	12	30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	18	More than 50% of the bottom in a state of flux or change nearly yearlong. 20	24
	15	Aquatic vegetation	Abundant growth moss-like, dark green perennial. In swift water, too.	1	Common. Algae forms in low velocity and pool areas. Moss here, too.	2	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	3	Perennial types scarce or absent. Yellow-green, short-term bloom may be present.	4
			Excellent total =	5	Good total =	12	Fair total =	15	Poor total =	79

Stream type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6
Good (Stable)	38-43	38-43	54-90	60-95	60-95	50-90	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair (Mod. unstable)	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor (Unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+

Stream type	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6
Good (Stable)	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107
Fair (Mod. unstable)	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120
Poor (Unstable)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+

Grand total =	111
Existing stream type =	
*Potential stream type =	
Modified channel stability rating =	

*Rating should be adjusted to potential stream type, not existing.

Magruder Branch Degraded Reach Team 4 9/21/2007

Silt/clay

Floodplain 170

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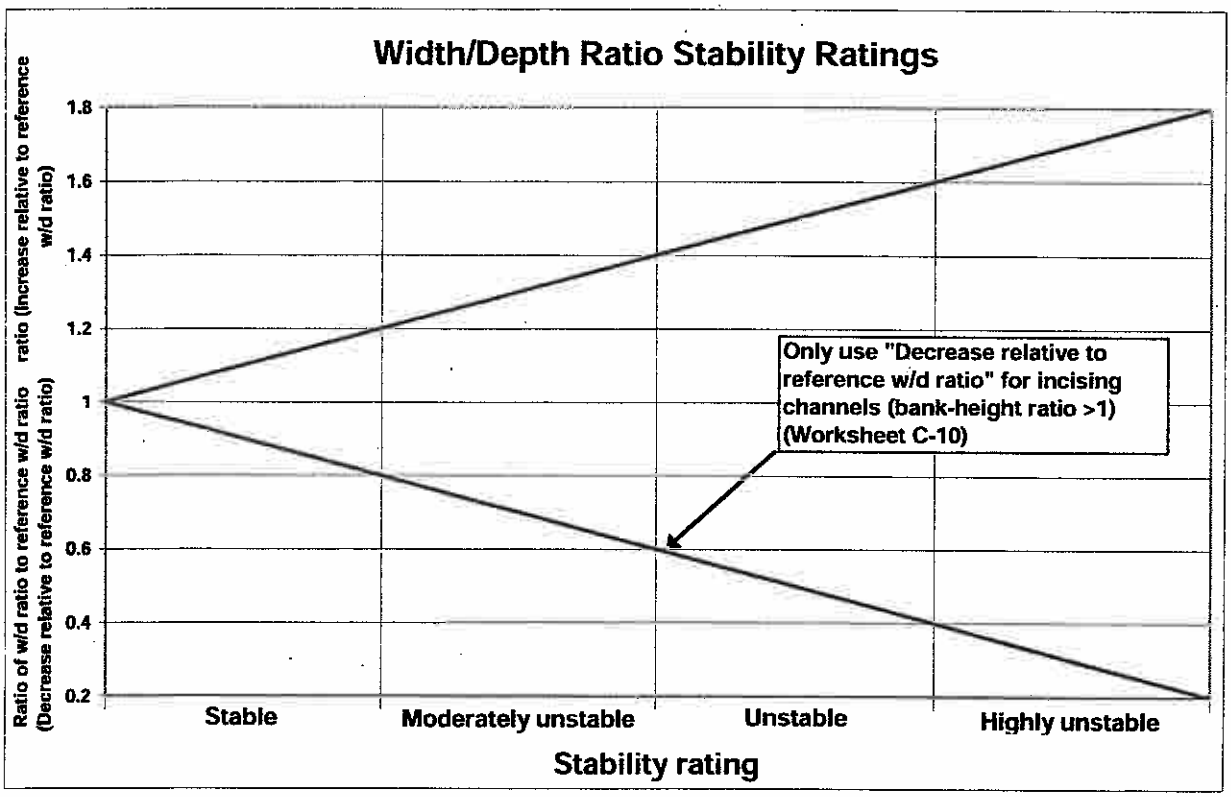
i. Width/Depth Ratio State

Worksheet C-12. Width/depth ratio state stability rating.

Width/Depth Ratio State			
Existing Width/Depth Ratio:	19.3	Ratio of existing w/d to reference w/d:	1.66
Reference Width/Depth Ratio:	11.6		
Width/Depth Ratio State Stability Rating ☞	Highly unstable		



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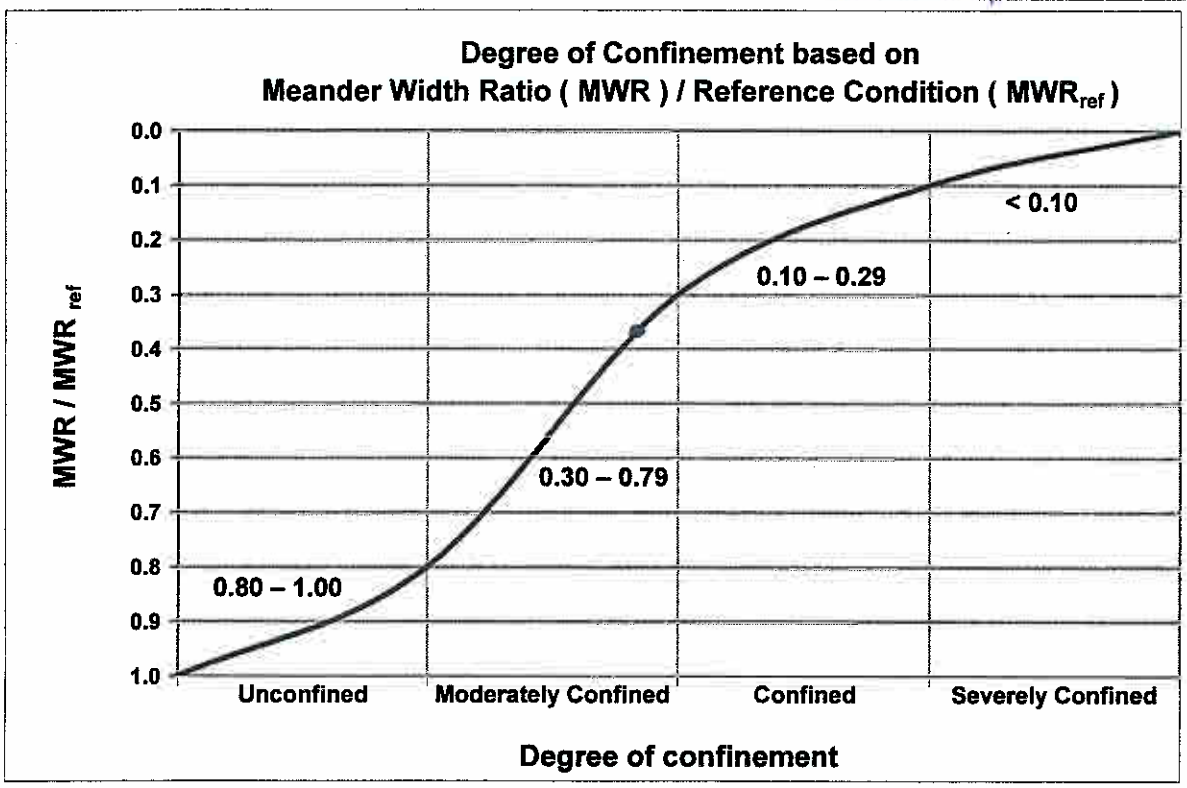
j. Degree of Channel Confinement (Meander Width Ratio (MWR))

Worksheet C-13. Degree of confinement stability ratings based on meander width ratio divided by reference meander width ratio.

Degree of Confinement			
Existing Meander Width Ratio (MWR):	1.99	Ratio of MWR to MWRref:	0.43
Reference Meander Width Ratio (MWR_{ref}):	4.59		
Degree of Confinement Stability Rating ☞	Moderately Confined		



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Worksheet C-19. Stability ratings for corresponding successional stage shifts of stream types. Check (✓) the appropriate stability rating.

Stream:	Stream Type:
Location:	Valley Type:
Observers:	Date:
Stream type changes due to successional stage shifts (Figure C-5)	**Stability rating (check appropriate rating)**
Stream type at potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C)	☐ Stable
(E→C) C - Cw	☑ Moderately unstable
(G→F), (F→D), (C→F)	☐ Unstable
(C→D), (B→G), (D→G), (C→G), (E→G)	☐ Highly unstable

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Worksheet C-20. Lateral stability prediction summary.

Stream:			Stream Type:		
Location:			Valley Type:		
Observers:			Date:		
Lateral stability criteria (choose one stability category for each criterion 1–5)	**Lateral stability categories**				**Selected points (from each row)**
	Stable	**Moderately unstable**	**Unstable**	**Highly unstable**	
1 **W/d ratio state (Worksheet C-12)**	< 1.2 (2)	1.2 – 1.4 (4)	1.4 – 1.6 (6)	> 1.6 1.67 (8)	8
2 **Depositional pattern (Worksheet C-8)**	B1, B2 (1)	B4, B8 (2)	B3 (3)	B5, B6, B7 (4)	4
3 **Meander pattern (Worksheet C-7)**	M1, M3, M4 (1)		M2, M5, M6, M7, M8 (3)		3
4 **Dominant BEHI / NBS (Worksheet C-16)**	L/VL, L/L, L/M, L/H, L/VH, M/VL (2)	M/L, M/M, M/H, L/Ex, H/L (4)	M/VH, M/Ex, H/L, H/M, H/H, VH/VL, Ex/VL VH/L (6)	H/H, H/Ex, Ex/M, Ex/H, Ex/VH, VH/VH, Ex/Ex (8)	6
5 **Degree of confinement (MWR / MWR_{ref}) (Worksheet C-13)**	0.8 – 1.0 (1)	0.3 – 0.79 (2)	0.1 – 0.29 (3)	< 0.1 (4)	2
				Total points	23
	Lateral stability category point range				
Overall lateral stability category (use total points and check stability rating)	**Stable 7 – 9** ☐	**Moderately unstable 10 – 12** ☐	**Unstable 13 – 21** ☐	**Highly unstable > 21** ☒	

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Worksheet C-21. Vertical stability prediction for excess deposition/aggradation.

Stream:	Stream Type:
Location:	Valley Type:
Observers:	Date:

Vertical stability criteria (choose one stability category for each criterion 1–6)	Vertical stability categories for excess deposition / aggradation				Selected points (from each row)
	No deposition	Moderate deposition	Excess deposition	Aggradation	
1 Sediment competence (Worksheet C-18)	Sufficient depth and/or slope to transport largest size available (2)	Trend toward insufficient depth and/or slope-slightly incompetent (4)	Cannot move D_{35} of bed material and/or D_{100} of bar material (6)	Cannot move D_{16} of bed material and/or D_{100} of bar or sub-pavement size (8)	6
2 Sediment capacity (POWERSED)	Sufficient capacity to transport annual load (2)	Trend toward insufficient sediment capacity (4)	Reduction up to 25% of annual sediment yield of bedload and/or suspended (6)	Reduction over 25% of annual sediment yield for bedload and/or suspended (8)	8
3 W/d ratio state (Worksheet C-12)	1.0 – 1.2 (2)	1.2 – 1.4 (4)	1.4 – 1.6 (6)	>1.6 1.67 (8)	8
4 Stream succession states (Worksheet C-19)	Current stream type at potential or does not indicate deposition/ aggradation (2)	(E→C) (4)	(C→High w/d C), (B→High w/d B), (C→F) (6)	(C→D), (F→D) (8)	6
5 Depositional patterns (Worksheet C-8)	B1 (1)	B2, B4 (2)	B3, B5 (3)	B6, B7, B8 (4)	4
6 Debris / blockages (Worksheet C-9)	D1, D2, D3 (1)	D4, D7 (2)	D5, D8 (3)	D6, D9, D10 (4)	4
				Total points	36

Vertical stability for excess deposition / aggradation (use total points and check stability rating)	Vertical stability category point range for excess deposition / aggradation			
	No deposition 10 – 14 ☐	Moderate deposition 15 – 20 ☐	Excess deposition 21 – 30 ☐	Aggradation > 30 ☒

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Worksheet C-22. Vertical stability prediction for channel incision/degradation.

Stream:			Stream Type:		
Location:			Valley Type:		
Observers:			Date:		
Vertical stability criteria (choose one stability category for each criterion 1–5)	**Vertical stability categories for channel incision / degradation**				**Selected points (from each row)**
	Not incised	**Slightly incised**	**Moderately incised**	**Degradation**	
1 **Sediment competence (Worksheet C-18)**	Does not indicate excess competence (2)	Trend to move larger sizes than D_{100} of bar or > D_{84} of bed 50 mm 3 (4)	D_{100} of bed moved (6)	Particles much larger than D_{100} of bed moved (8)	3
2 **Sediment capacity (POWERSED)**	Does not indicate excess capacity (2)	Slight excess energy: up to 10% increase above reference (4)	Excess energy sufficient to increase load up to 50% of annual load (6)	Excess energy transporting more than 50% of annual load (8)	2
3 **Degree of channel incision (BHR) (Workshet C-10)**	1.00 – 1.10 (2)	1.11 – 1.30 (4)	1.31 – 1.50 (6)	> 1.50 (8)	4
4 **Stream succession states (Worksheets C-19 and C-10)**	Does not indicate incision or degradation (2)	If BHR > 1.1 and stream type has w/d between 5–10 (4)	If BHR > 1.1 and stream type has w/d less than 5 (6)	(B→G), (C→G), (E→G), (D→G) (8)	2
5 **Confinement (MWR / MWR_{ref}) (Worksheet C-13)**	0.80 – 1.00 (1)	0.30 – 0.79 0.43 (2)	0.10 – 0.29 (3)	< 0.10 (4)	2
				Total points	13
	Vertical stability category point range for channel incision / degradation				
Vertical stability for channel incision/ degradation (use total points and check stability rating)	**Not incised 9 – 11** ☐	**Slightly incised 12 – 18** ☑	**Moderately incised 19 – 27** ☐	**Degradation > 27** ☐	

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Worksheet C-23. Channel enlargement prediction summary.

Stream:			Stream Type:		
Location:			Valley Type:		
Observers:			Date:		
Channel enlargement prediction criteria (choose one stability category for each criterion 1–4)	**Channel enlargement prediction categories**				**Selected points (from each row)**
	No increase	**Slight increase**	**Moderate increase**	**Extensive**	
1 **Successional stage shift (Worksheet C-19)**	Stream type at potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C) (2)	(E→C) C - Cw (4)	(G→F), (F→D) (6)	(C→D), (B→G), (D→G), (C→G), (E→G), (C→F) (8)	4
2 **Lateral stability (Worksheet C-20)**	Stable (2)	Moderately unstable (4)	Unstable (6)	Highly unstable 23 (8)	8
3 **Vertical stability excess deposition/ aggradation (Worksheet C-21)**	No deposition (2)	Moderate deposition (4)	Excess deposition (6)	Aggradation (8)	8
4 **Vertical stability incision/ degradation (Worksheet C-22)**	Not incised (2)	Slightly incised (4)	Moderately incised (6)	Degradation (8)	4
				Total points	24
	Category point range				
Channel enlargement prediction (use total points and check stability rating)	**No increase 8 – 10** ☐	**Slight increase 11 – 16** ☐	**Moderate increase 17 – 24** ☒	**Extensive > 24** ☐	

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Worksheet C-24. Overall sediment supply rating determined from individual stability rating categories.

Stream:		Stream Type:	
Location:		Valley Type:	
Observers:		Date:	
Overall sediment supply prediction criteria (choose corresponding points for each criterion 1–5)	**Stability rating**	**Points**	**Selected points**
1 Lateral stability (Worksheet C-20)	Stable	1	4
	Mod. unstable	2	
	Unstable	3	
	Highly unstable	4	
2 Vertical stability excess deposition/ aggradation (Worksheet C-21)	No deposition	1	4
	Mod. deposition	2	
	Excess deposition	3	
	Aggradation	4	
3 Vertical stability channel incision/ degradation (Worksheet C-22)	Not incised	1	2
	Slightly incised	2	
	Mod. incised	3	
	Degradation	4	
4 Channel enlargement prediction (Worksheet C-23)	No increase	1	3
	Slight increase	2	
	Mod. increase	3	
	Extensive	4	
5 Pfankuch channel stability (Worksheet C-11)	Good: stable	1	4
	Fair: mod unstable	2	
	Poor: unstable	4	
		Total Points	17

	Category point range			
Overall sediment supply rating (use total points and check stability rating)	**Low** 5 ☐	**Moderate** 6 – 10 ☐	**High** 11 – 15 ☐	**Very High** 16 – 20 ☒

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Magruder Branch Degraded Reach Team 4 9/21/2007

River Assessment and Monitoring: Impaired Reach — 3rd Field Day

Worksheet C-25. Summary of stability condition categories.

Stream: Macgruder Branch			Location: Montgomery Co		
Observers: Team 4		Date: 9/24/07	Stream Type: C4	Valley Type: VIII	
Channel Dimension	Mean bankfull depth (ft): 1.31	Mean bankfull width (ft): 25.1	Cross-section area (ft²): 32.6	Width of flood-prone area (ft): 150	Entrenchment ratio: 5.98
Channel Pattern	Mean (range)	MWR: 1.99 (1.71 – 2.23)	Lm/W_{bkf}: 5.38 (5.38–5.38)	Rc/W_{bkf}: 1.67 (1.2 – 2.39)	Sinuosity: 1.16

River Profile and Bed Features

Circle: Riffle/pool Step/pool Plane bed Convergence/divergence Dunes/antidunes/smooth bed

Max bankfull depth (ft):	Riffle	Pool	Depth ratio (max/mean):	Riffle	Pool	Pool to pool spacing:	Ratio	Slope	
	2.13	2.41		1.63	1.84		1.88	Valley: .007	Average bankfull: .006

Level III Stream Stability Indices

Riparian vegetation	Current composition/density:	Potential composition/density:	Remarks: Condition, vigor and/or usage of exiting reach:
	Tulip Poplar	Oak - Hickory - Beech	ind. oaks, beech, hickory + birch w/deer browse control/s

Flow regime:	Stream size and order: S-3(4)	Meander pattern(s): M3	Depositional pattern(s): B1, B4, B5, B7	Debris/channel blockage(s): D1, D2, D3

Degree of incision (Bank-Height Ratio): 1.27	Degree of incision stability rating: Slightly Incised	Modified Pfankuch stability rating (numeric and adjective rating): 111 (not nice Tracey says 117)

Width/depth ratio (W/D): 19.2	Reference W/D ratio (W/D_{ref}): 11.6	Width/depth ratio state (W/D) / (W/D_{ref}): 1.66	W/D ratio state stability rating: Highly Unstable
Meander Width Ratio (MWR): 1.99	Reference MWR_{ref}: 4.59	Degree of confinement (MWR / MWR_{ref}): 0.43	MWR / MWR_{ref} stability rating: Moderately Confined

Bank Erosion Summary	Length of reach studied (ft): 305	Annual streambank erosion rate: 51.7 (tons/yr)	0.17 (tons/yr/ft)	Curve used: Maryland	Remarks:

Sediment Capacity (POWERSED)	Sufficent capacity	Insufficient capacity	Remarks: Back water pool of bridge building up slug of sediment

Entrainment/ Competence	Largest particle from bar sample (mm): 110	$\tau = 0.47$	$\tau^* = N/A$	Existing $depth_{bkf}$: 1.3	Required $depth_{bkf}$: 1.55	Existing $slope_{bkf}$: .006	Required $slope_{bkf}$: .007

Successional Stage Shift	C → Cw → → → →	Existing stream state (type): C4	Potential stream state (type): C4

Lateral Stability	Circle: Stable	Moderately unstable	Unstable	Highly unstable	Remarks/causes: transverse bar blowing out banks
Vertical Stability (Aggradation)	Circle: No deposition	Moderate deposition	Excess deposition	Aggradation	Remarks/causes:
Vertical Stability (Degradation)	Circle: Not incised	Slightly incised	Moderately incised	Degradation	Remarks/causes: bridges causing wedges, floodplain trying to form
Channel Enlargement	Circle: No increase	Slight increase	Moderate increase	→ Extensive	Remarks/causes:
Sediment Supply (Channel Source)	Circle: Low	Moderate	High	Very high	Remarks/causes: backwater influence from flat slopes = aggradation w/ high % fines

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Incised at lower bridge due to fill on left bank

3. Channel Change

Worksheet C-28. Summary of annual data comparisons.

Data Comparison Form

Stream: Magruder Branch Reach: 4

Observers: Team 4 Date - Year 1: 9/24/07 Date - Year 2:

		Riffle XS:		Pool XS:		Glide XS:	
		Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Cross-section dimensions	$Width_{BKF}$	25.1		18.93		21.83	
	Mean $depth_{bkf}$	1.3		1.27		1.20	
	Width/depth ratio	19.3		14.9		18.19	
	Cross-sectional $Area_{bkf}$	32.6		24.06		26.13	
	Max $depth_{bkf}$	2.13		2.41		2.04	
Pebble count	D_{35} (mm)	5.08		4.00		3.50	
	D_{50} (mm)	9.89		6.33		7.42	
	D_{84} (mm)	45.0		21.94		24.69	
Bank Erosion	BEHI rating	Extreme		High		VERY High	
	NBS rating	Low		Low		Moderate	
	Predicted erosion (ft/yr)	2.50		0.36		0.71	
	Measured erosion (ft/yr)	—					

	Year 1	Year 2			Year 1	Year 2
Revised Pfankuch Channel Stability Rating	111		Bar Sample	D_{35} (mm)	9.27	
Bank-Height Ratio start: / end:	1.00 / 1.44			D_{50} (mm)	23.19	
Point Bar slope	0.54			D_{84} (mm)	79.01	
Riffle Length/Riffle Width	0.87			D_{100} (mm)	110.0	
Pool Length/Riffle Width	1.17					
Dimensionless Slope Ratios: S_{rif}/S	3.15		Dimensionless Depth Ratios	d_{rif}/d_{bkf}	1.54	
S_{run}/S	2.18			d_{run}/d_{bkf}	1.75	
S_p/S	.247			d_p/d_{bkf}	2.06	
S_g/S	0.12			d_g/d_{bkf}	1.43	

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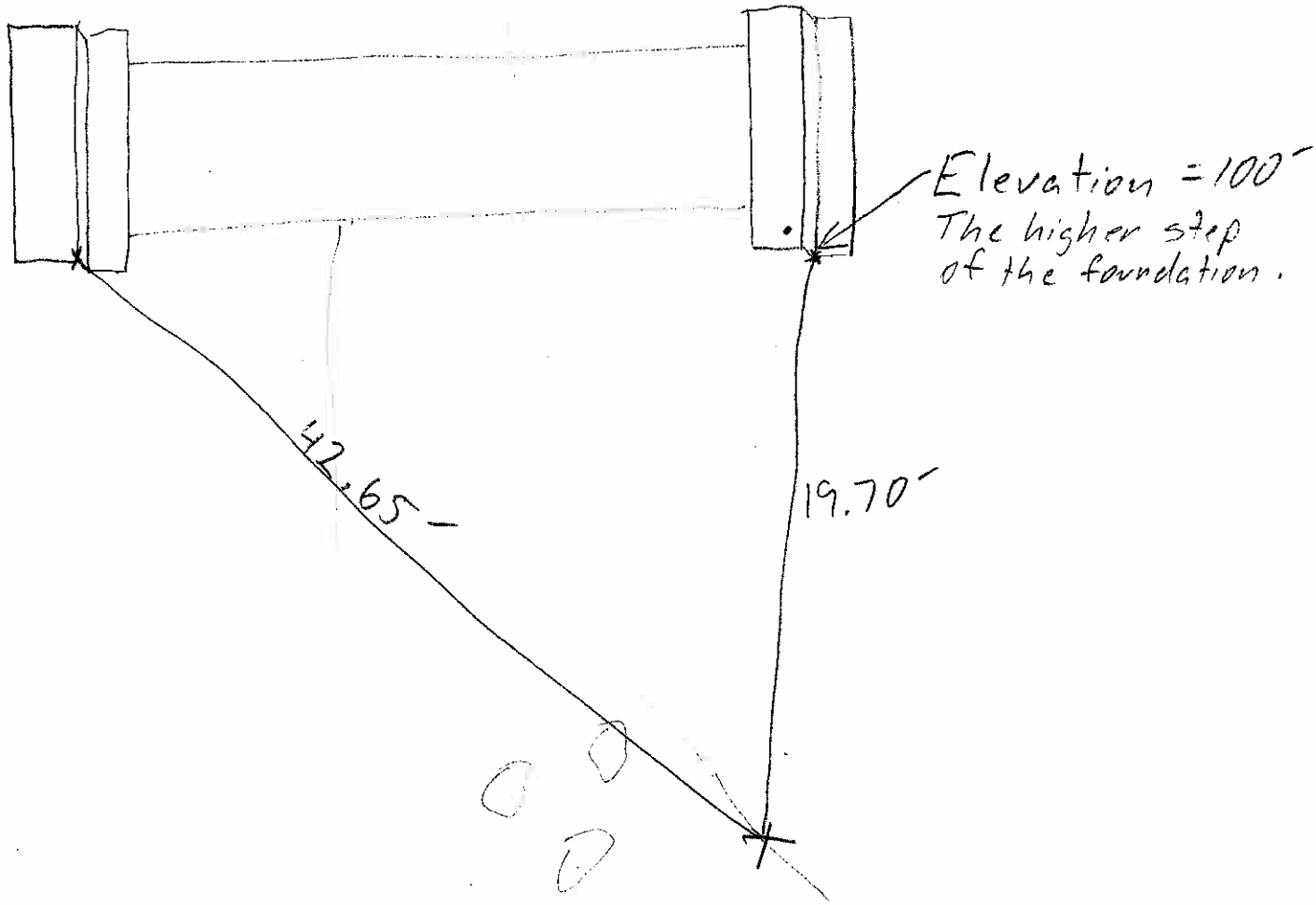
Magruder Branch Degraded Reach Team 4 9/21/2007

SITE SKETCH

STREAM MacGruder DATE 9-25-07

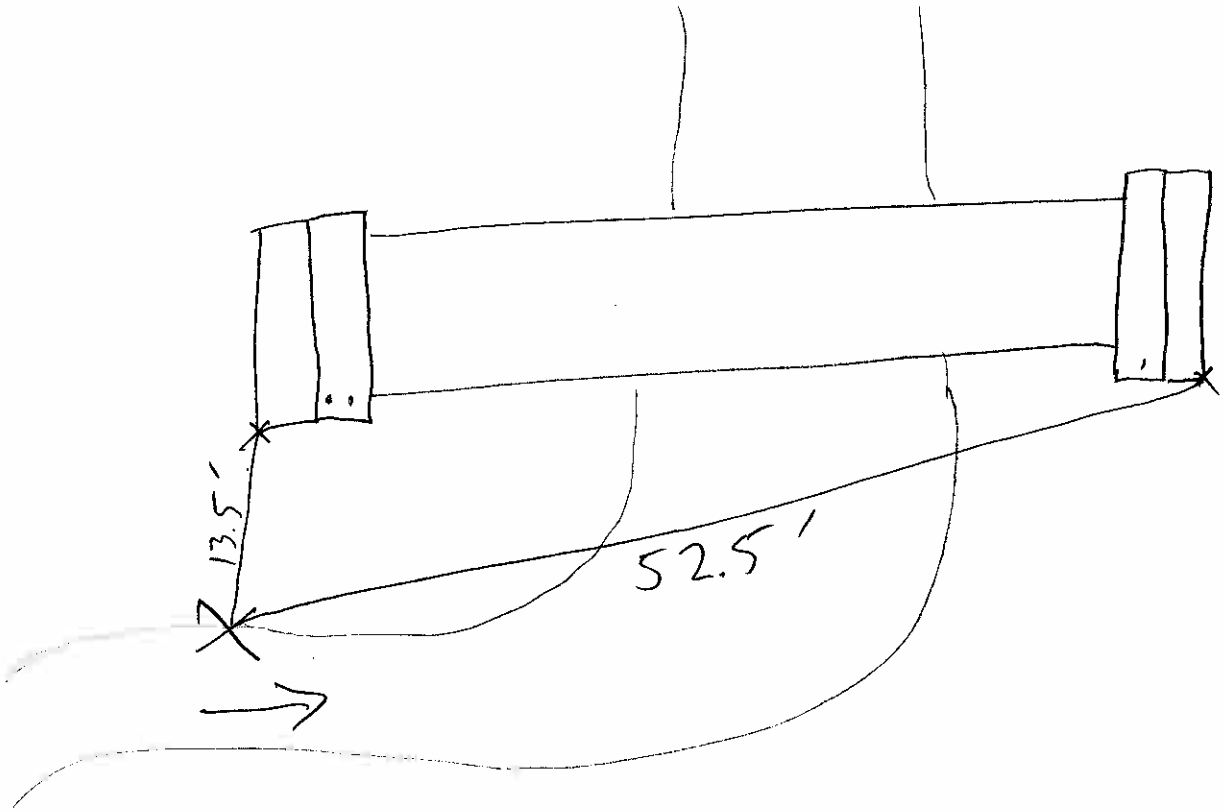
DA CREW #4



Measurements from start point (0 ft) to the corners of the bridge at the top of the reach. Tape was placed right on edge of water, left side of the stream.

over

Magruder Branch Degraded Reach Team 4 9/21/2007



Measurements from corner of bridge to end of reach (305').

Magruder Branch Degraded Reach Team 4 9/21/2007

102.5 − 5.55 = 96.97

Backsight = 2.52

EI = 100

HI = 102.52

STREAM SURVEY

LONGITUDINAL PROFILE

STREAM Magruder | DATE 9-25-07

REACH 4 | CREW Frank, Adam

100 − 5.55 = 994.5

(all measurements are in feet unless otherwise noted)

STATION	TW	WS	BKF	WS/BF	TOB	Other	Other	COMMENT
0	8.37	7.83	6.51		5.23			Tof R/BofR
3.0	8.44	7.78	6.52					
13.0	8.06	7.82	6.07*	1.6				
32.5	8.01	7.81	6.25		5.15			Tof Riffle
35.0	8.11	7.81	6.22		5.15			Tof Run
39.0	8.53	7.83						Tof Pool
42.0	9.09	7.83	6.10					CS
46.0	9.25	7.89	–					CS
FOR.Sh	5.55	=	Pool	X-Section				
BAC	4.78							
49.0	8.47	7.0	–		4.10			
55	7.45	7.02	5.60		4.27			
60	7.17	7.01						
68	7.47	7.01						
71	7.61	7.01						legs in channel
73.5	7.41	7.01						
79.0	7.26	7.05						Tof Riffle
90.0	7.38	7.15						
95.0	7.57	7.39						
97.0	7.72	7.60						Tof Run
102.0	8.09	7.60						
111	8.24	7.62						
117	8.30	7.63	5.92		4.93	8.07	Tom-	Pool XS
121	8.26	7.65						
124	8.30	7.65						
128	8.14	7.68	5.93		5.13			Tof Glide
133	7.84	7.65	5.96		5.13			
142	7.99	7.83	6.05		4.60			Tof Rif
142 –	8.23	8.01	6.0		"			
146	8.23	8.00						Tof Run
148	8.49	8.04						Tof Pool –
152	8.50	8.03						
156	8.49	8.02						
163	8.40	8.02						
167	8.40	8.07			5.45			Tof Glide
172	8.19	8.01	7.07		5.40			Tof Riff
176	8.17	8.12						Tof Run –
180	8.43	8.13						Tof Pool
183	8.54	8.12	6.64*	1.5				
TURN								

NOTATIONS

NOTE	ABBREV
Left	L
Right	R
Pin	P
Edge of Water	EW
Water Surface	WS
Channel Shot	CS
Ground Shot	GS
Thalweg	TW
Monument T/B	MON
Floodprone	FP
Bankfull	BF
Top of Bank	TOB
Slope Break	SL BRK
Scour Line	SL
Inflection Point	IP
Veg Line	VL

End Trans Bar

Bunch of garbage in it.

183 Back site = 6.64
Fore site = 6.20 * = good BKF

USFWS-CBFO
9/20/2007 2:30 PM

Long Prof XSForm

STREAM SURVEY

LONGITUDINAL PROFILE

STREAM Mag. Gruder | DATE 9-25-07

REACH 4 | CREW Frank, Adam

(all measurements are in feet unless otherwise noted)

STATION	TW	WS	BKF	WS/BF	TOB	Other	Other	COMMENT
TURN								
187	8.31	7.68						Pool CS
194	8.38	7.68						
200	8.65	7.71	6.28 *		4.90			CS
204	8.90	7.68						
209	8.98	7.70						
215	9.22	7.70						
219	9.30	7.72						
224	9.72							
228	9.54	7.72	5.93		5.74			
232	9.23							Top of Glide
237	7.97					8.62	R Channel	
241	7.83							Mid Ch bar Starts
252	7.83	7.72						Top Rif
257	8.03	7.91	6.75					
265	8.33	8.22						
273	8.79	8.40						
280	8.53	8.49						
288	8.63	8.53	7.12	1.61	3.12			Bar merges
300	9.15	8.97						
305	9.23	9.02						End Riffle

Settings

NOTATIONS

NOTE	ABBREV
Left	L
Right	R
Pin	P
Edge of Water	EW
Water Surface	WS
Channel Shot	CS
Ground Shot	GS
Thalweg	TW
Monument T/B	MON
Floodprone	FP
Bankfull	BF
Top of Bank	TOB
Slope Break	SL BRK
Scour Line	SL
Inflection Point	IP
Veg Line	VL