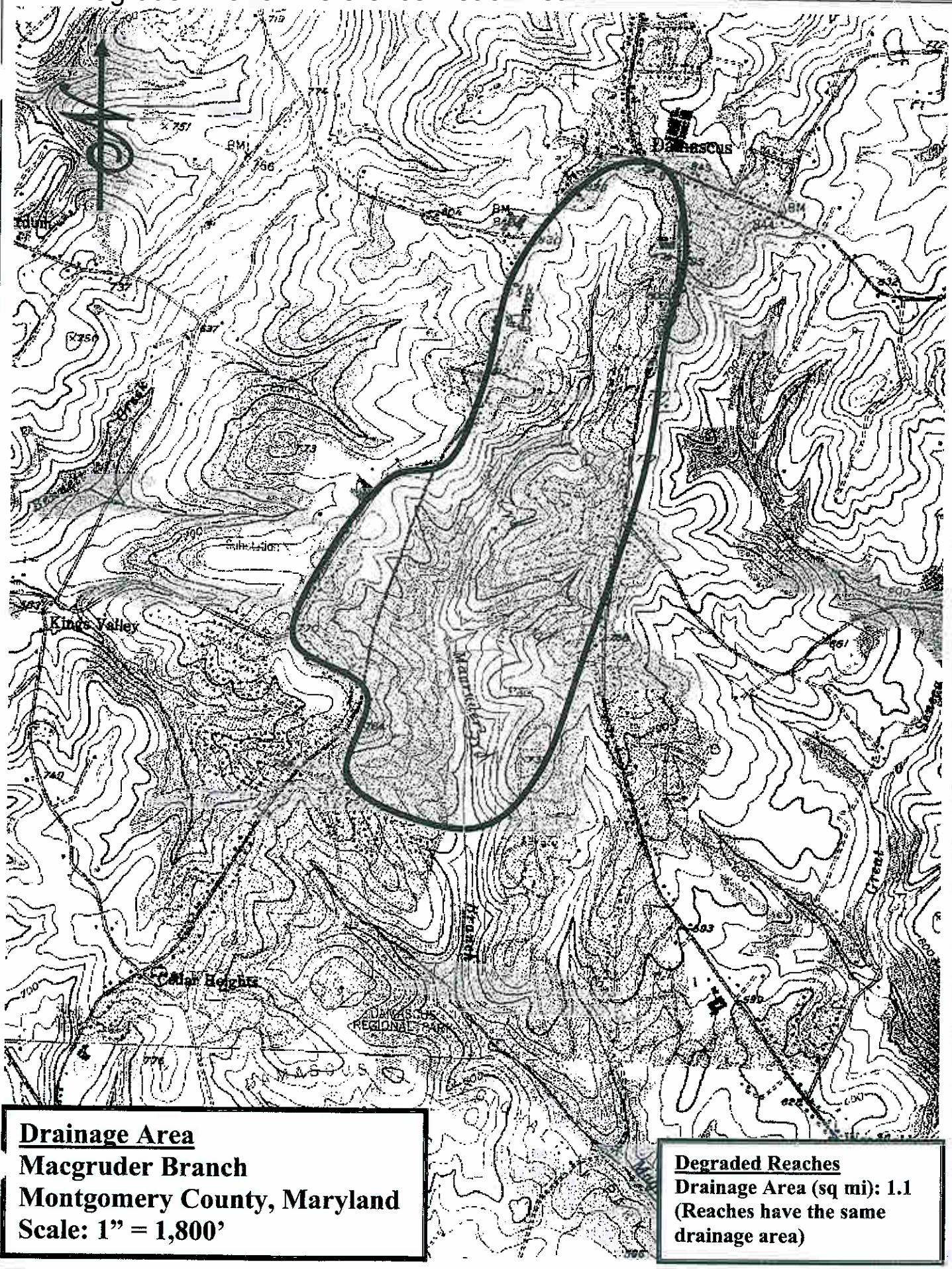
River Assessment and Monitoring
NCTC - Shepherdstown, WV
9/17 – 9/27/2007

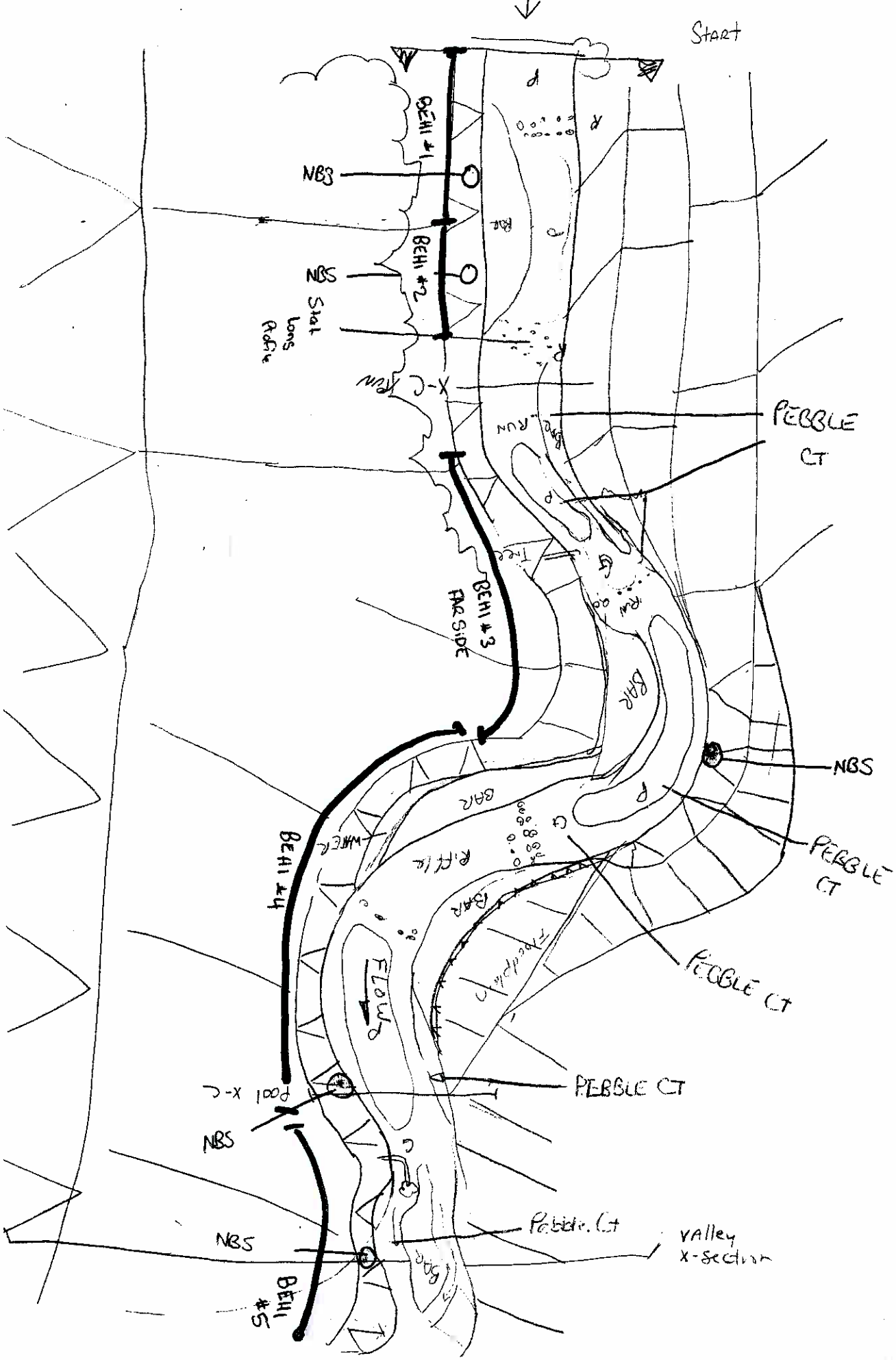
Team 4
Day 1
Magruders Branch
Reference Reach



Drainage Area
Macgruder Branch
Montgomery County, Maryland
Scale: 1" = 1,800'

Degraded Reaches
Drainage Area (sq mi): 1.1
(Reaches have the same drainage area)

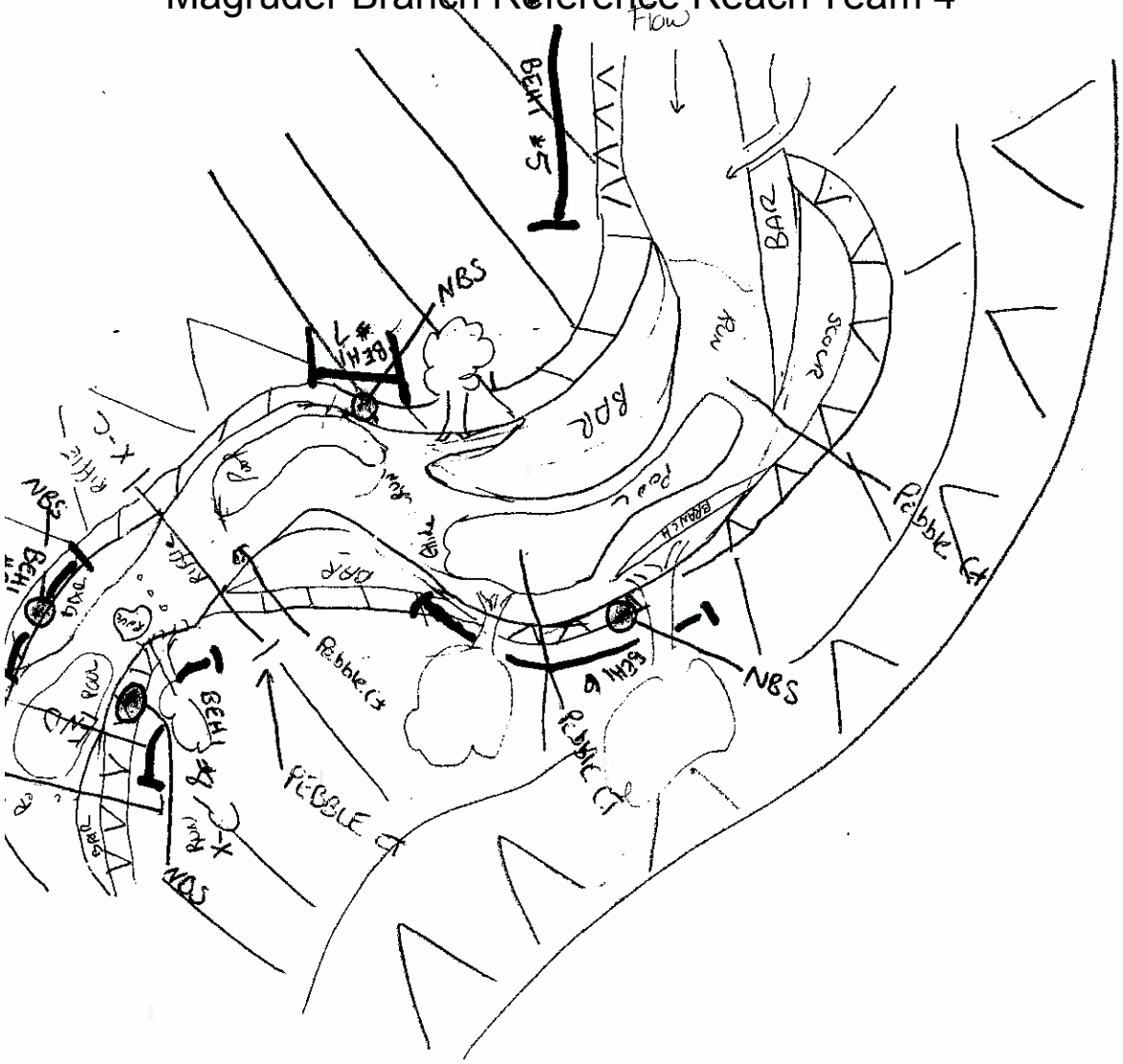
Magruder Branch Reference Reach Team 4 9/18/2007



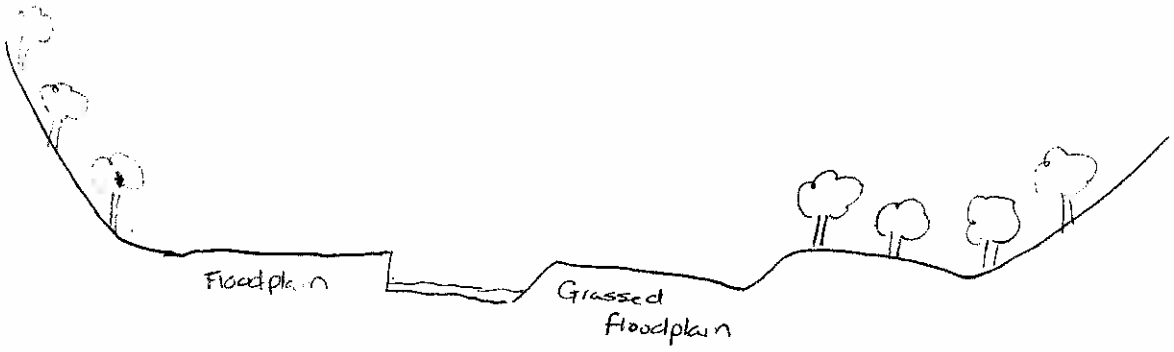
CREEK
Sect #4
9/18/07
TEAM 4
Magruder
Branch

Magruder Branch Reference Reach Team 4 9/18/2007

TEAM 4
9/18/07



Valley Profile



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Mac Gruder Crk
Section #4
9/18/07

VALLEY
LENGTH (VL) =
290'

SL = 386'

SINUOSITY (K) = 386/290 = 1.33

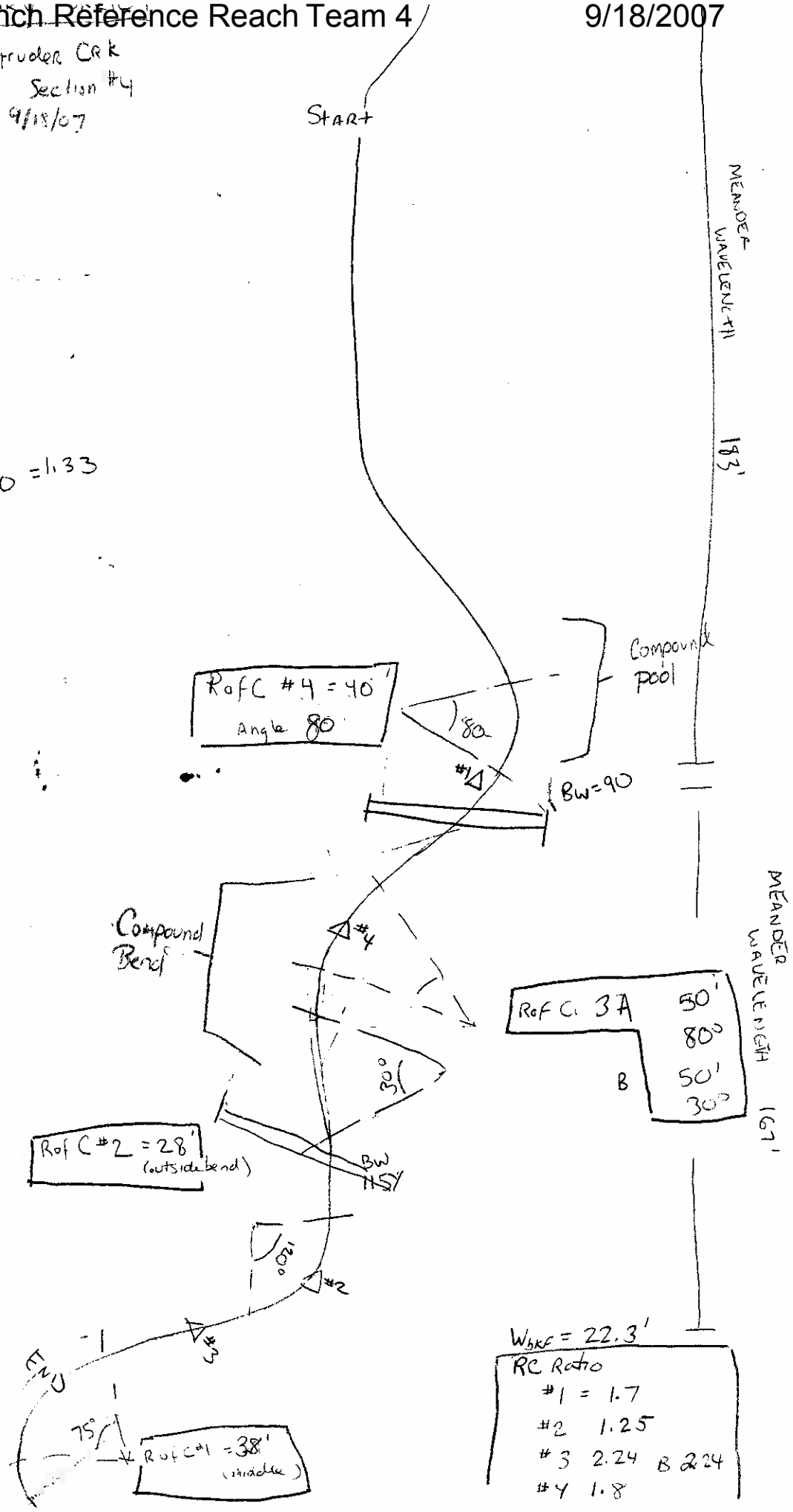
BW1 = 90
BW2 = 115

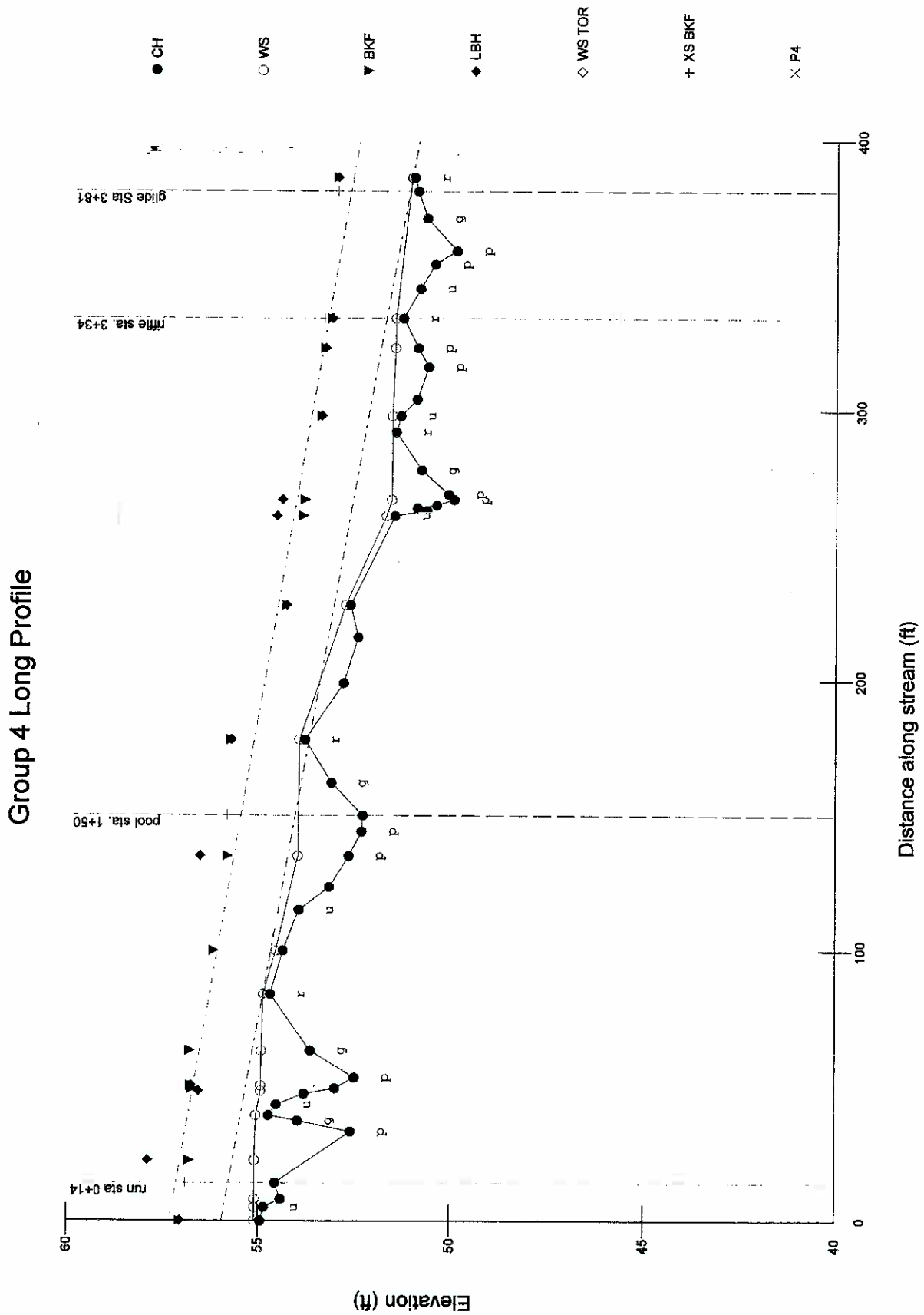
Δ BAR SLOPE #1
8%

Δ #2 22%

Δ #3 10%

Δ #4 20%




Group 4 Long Profile
CH
WS
BKF
LBH
WS TOR
XS BKF
P4
run sta 0+14
pool sta 1+50
riffle sta 3+34
glide Sta 3+81
Elevation (ft)
Distance along stream (ft)
60
55
50
45
40
0
100
200
300
400

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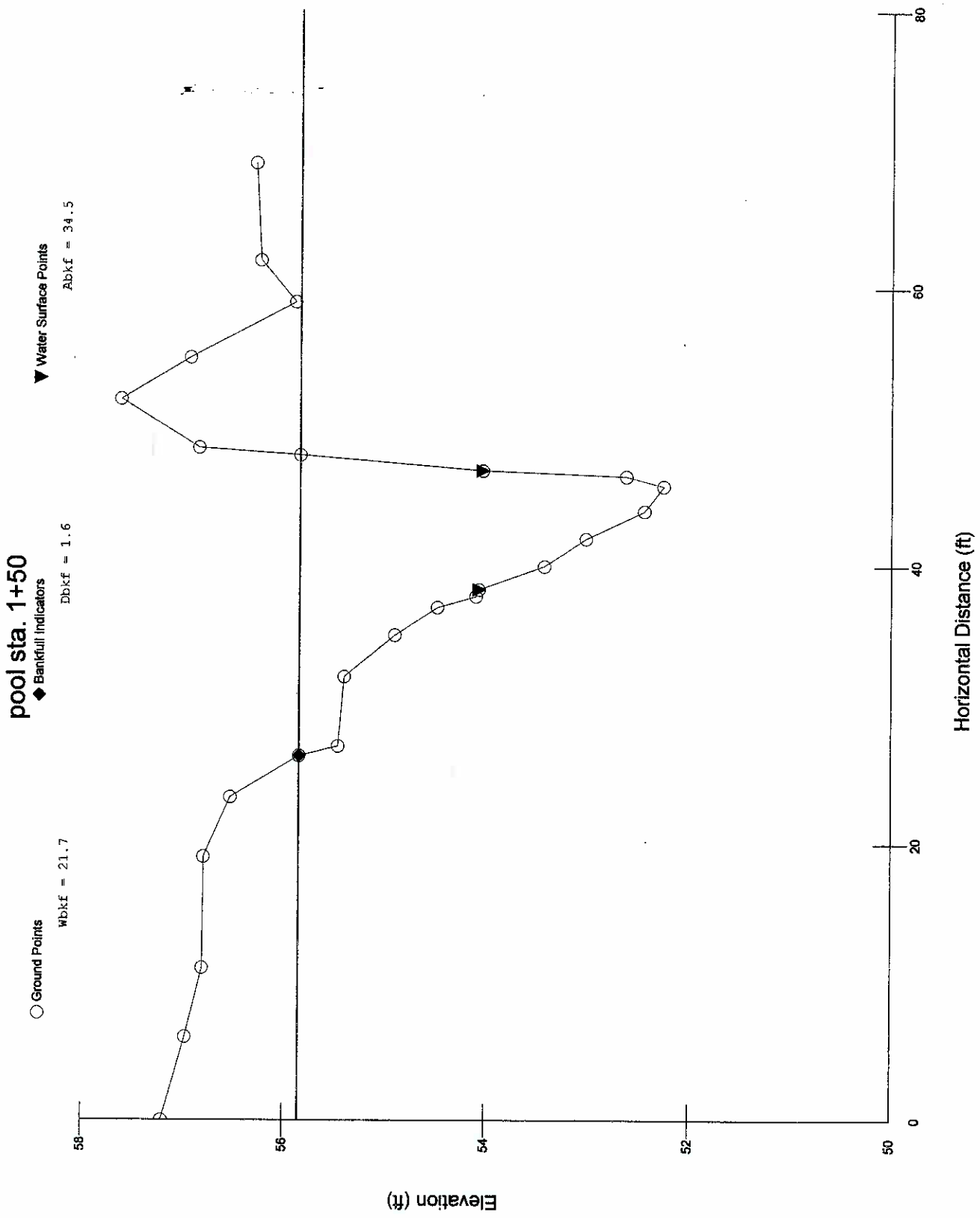
pool sta. 1+50
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 21.7
Dbkf = 1.6
Abkf = 34.5
Elevation (ft)
58
56
54
52
50
0
20
40
60
80
Horizontal Distance (ft)

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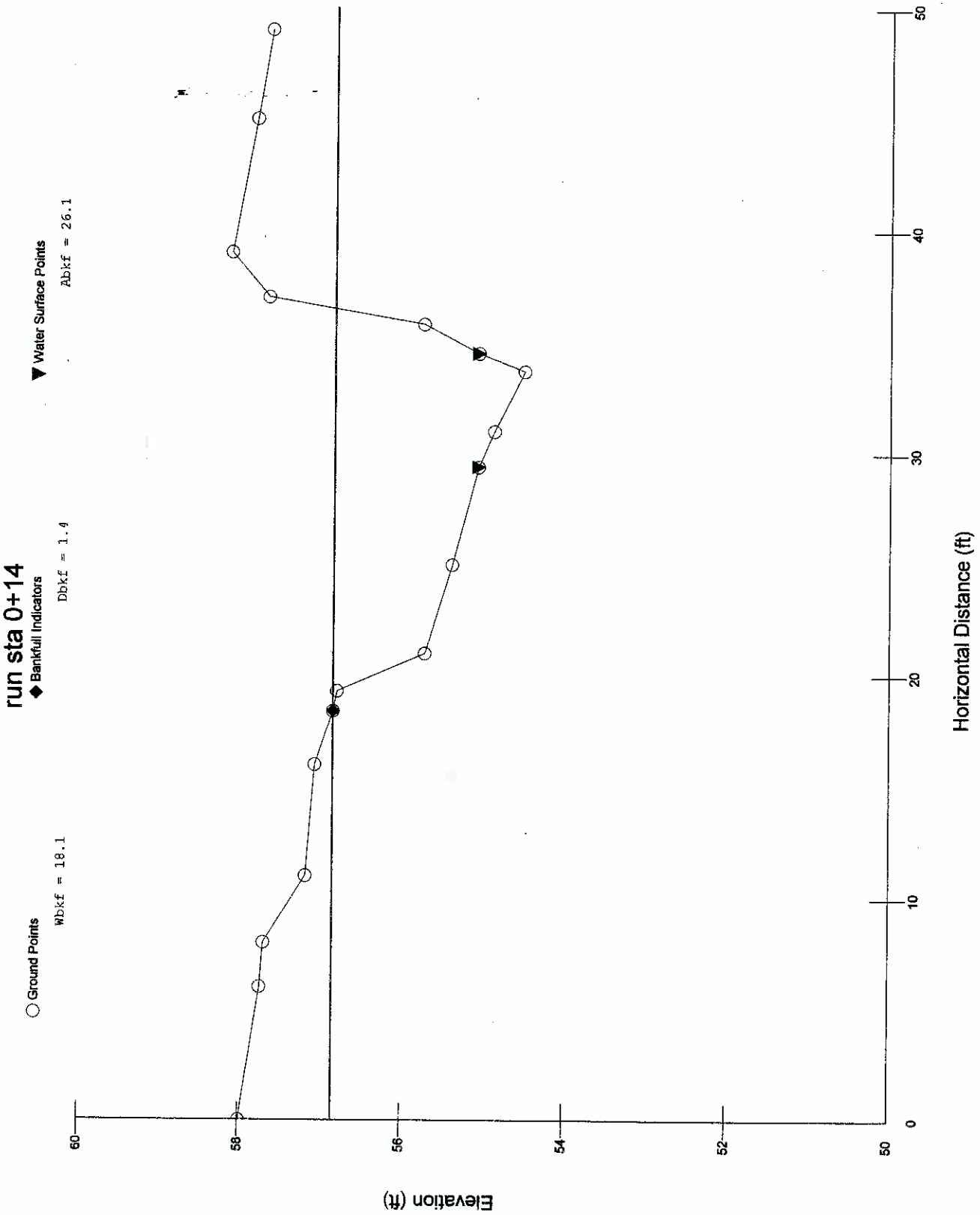
run sta 0+14
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 18.1
Dbkf = 1.9
Abkf = 26.1
Elevation (ft)
60
58
56
54
52
50
Horizontal Distance (ft)
0
10
20
30
40
50

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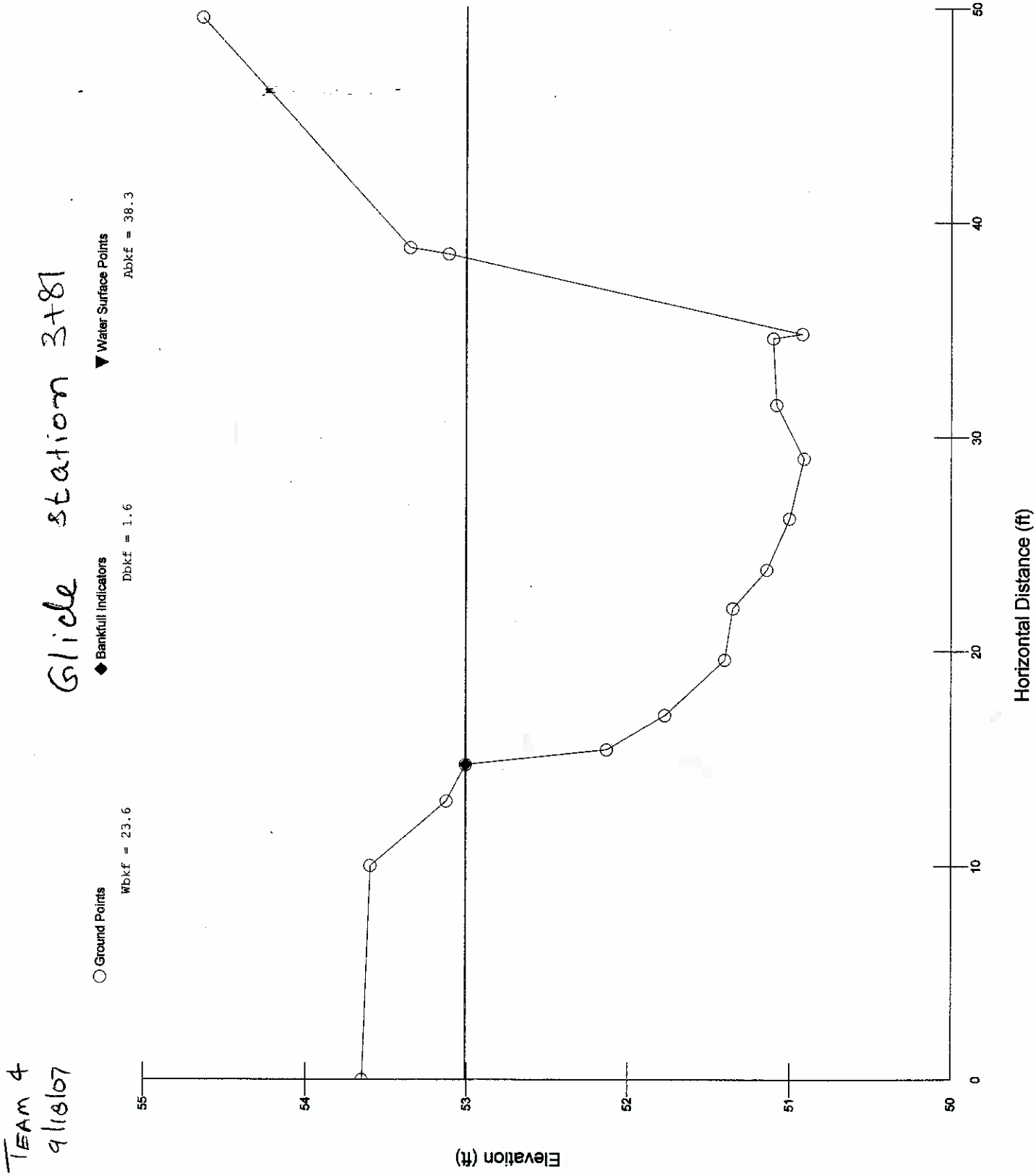
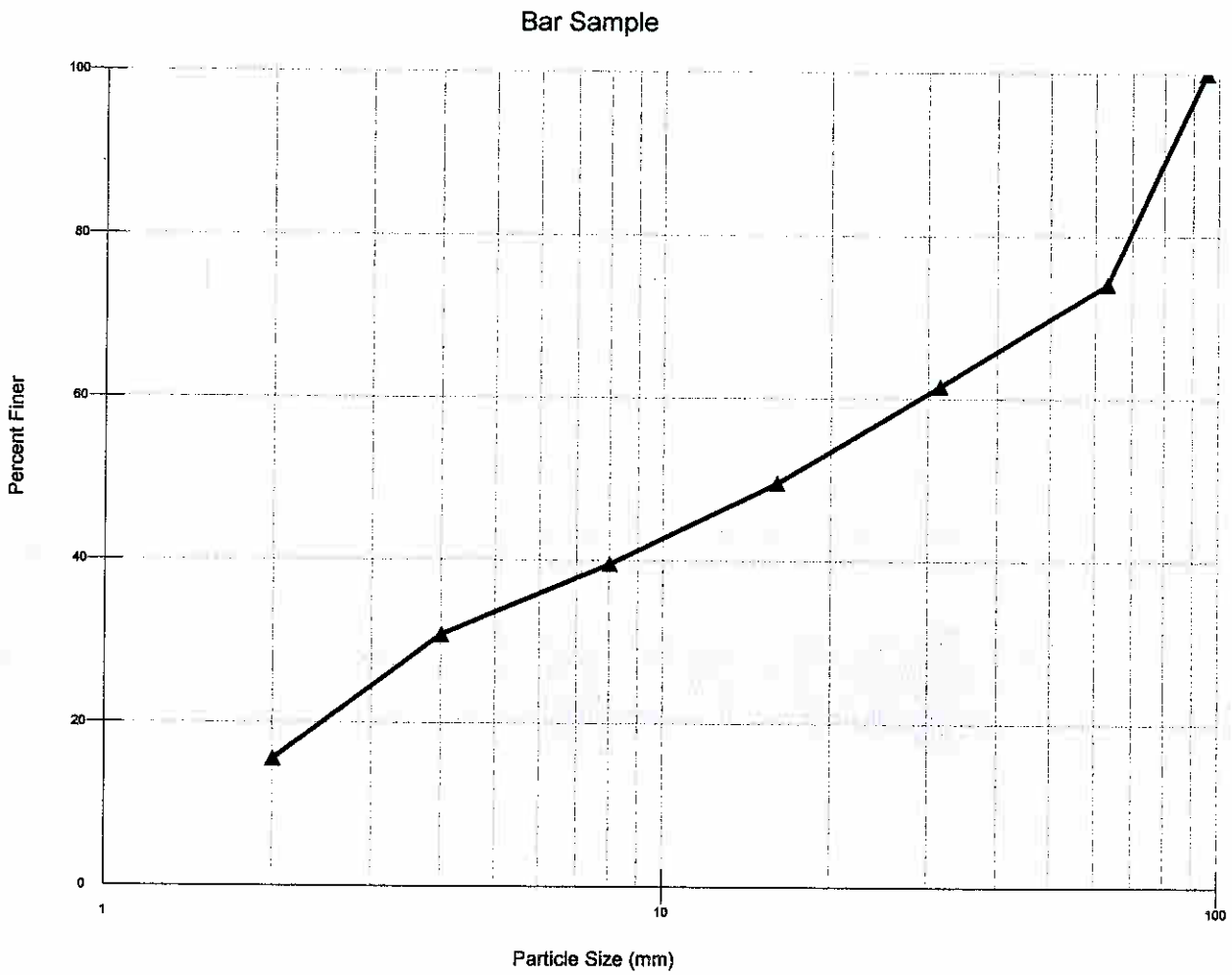

Glide station 3+81
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 23.6
Dbkf = 1.6
Abkf = 38.3
Elevation (ft)
55
54
53
52
51
50
Horizontal Distance (ft)
0
10
20
30
40
50
TEAM 4
9/18/07

Magruder Branch Reference Reach Team 4 9/18/2007

TEAM 4
9/18/07



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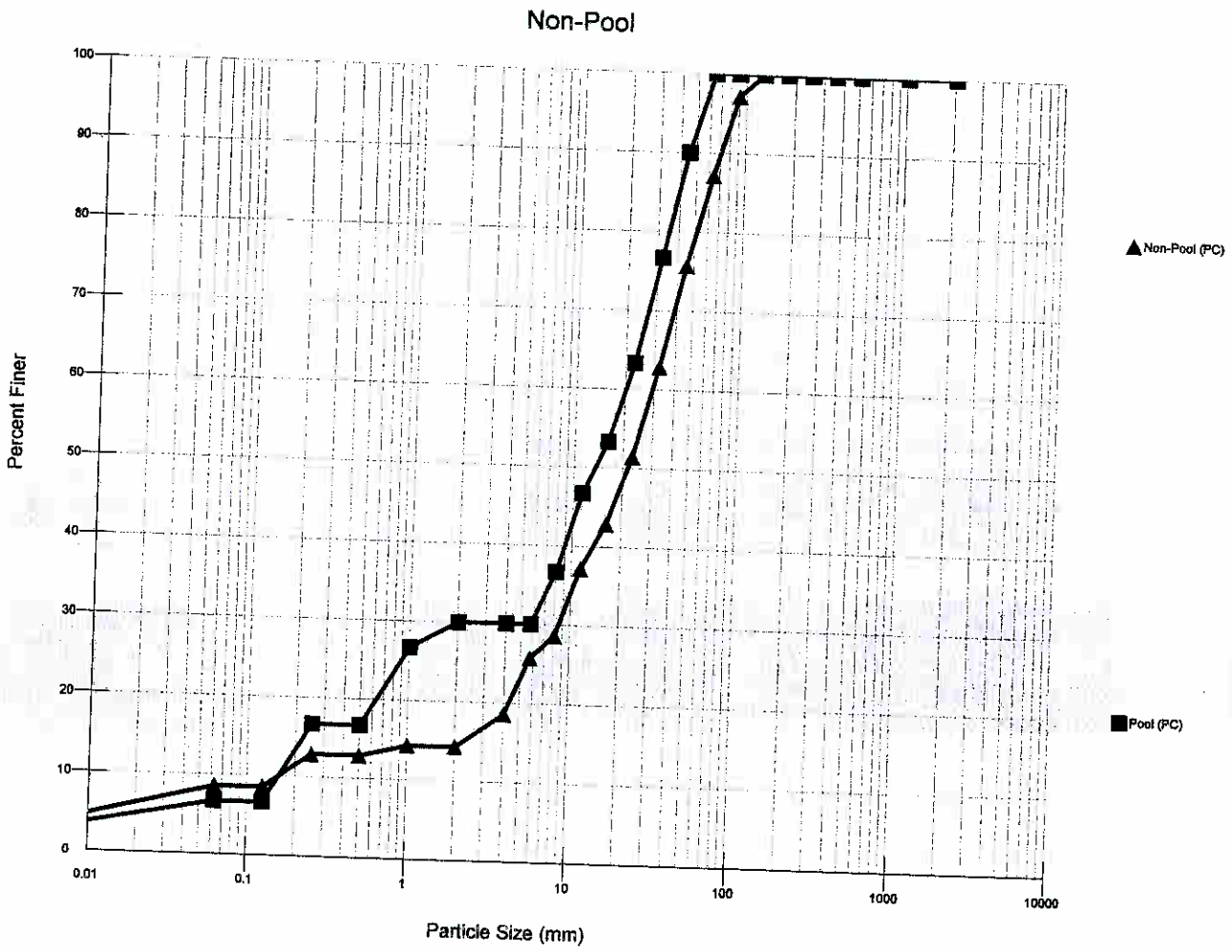

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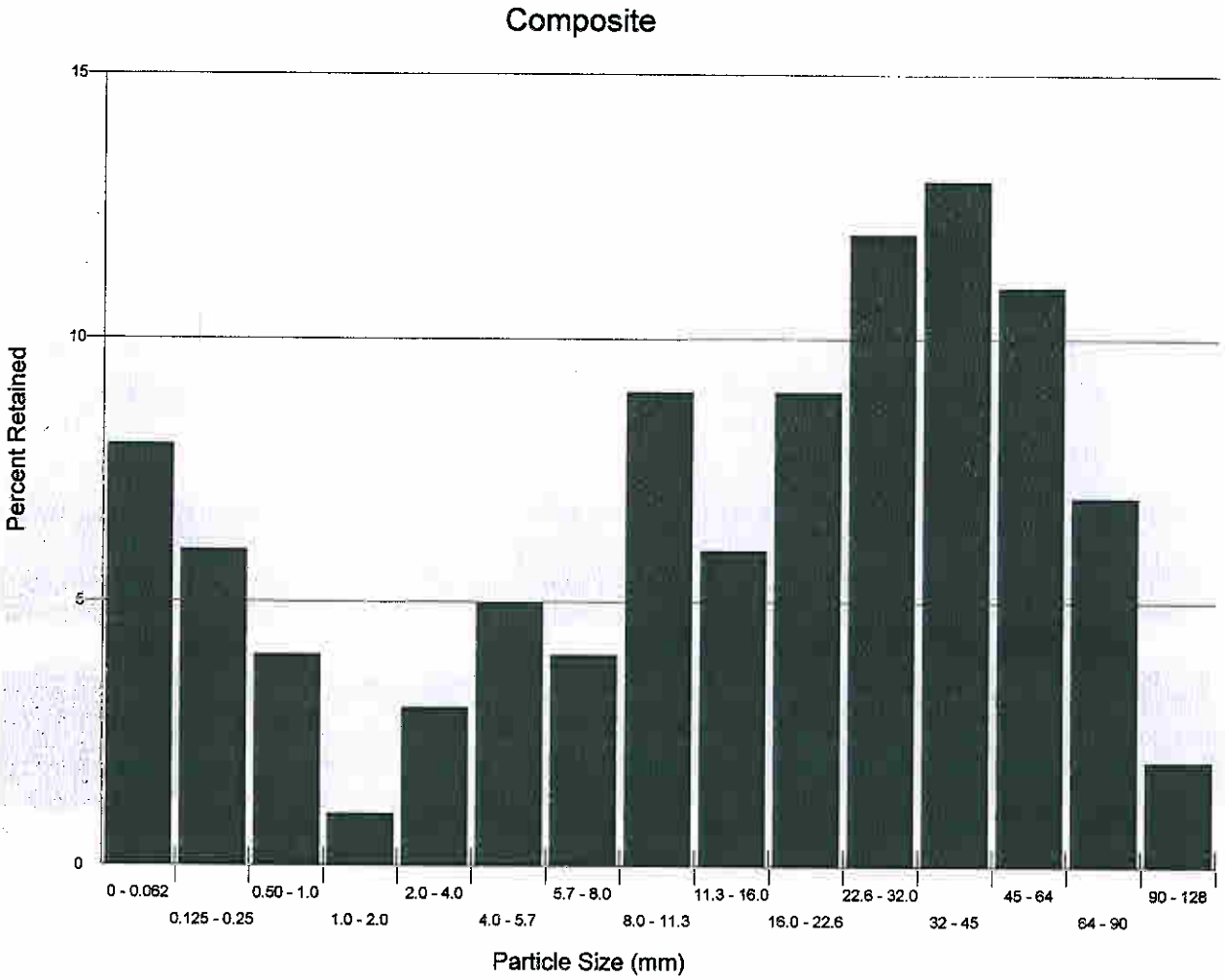
9/18/07



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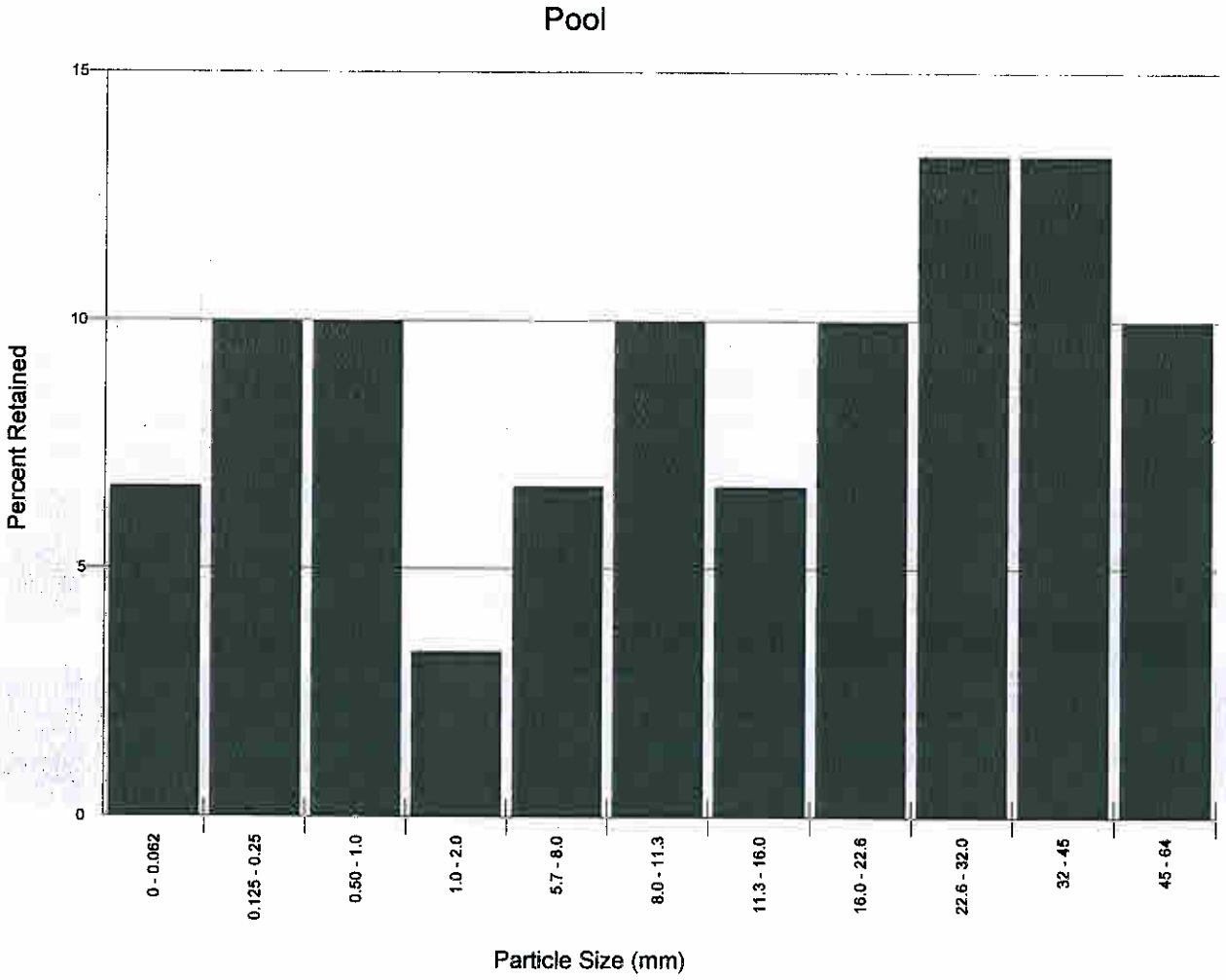

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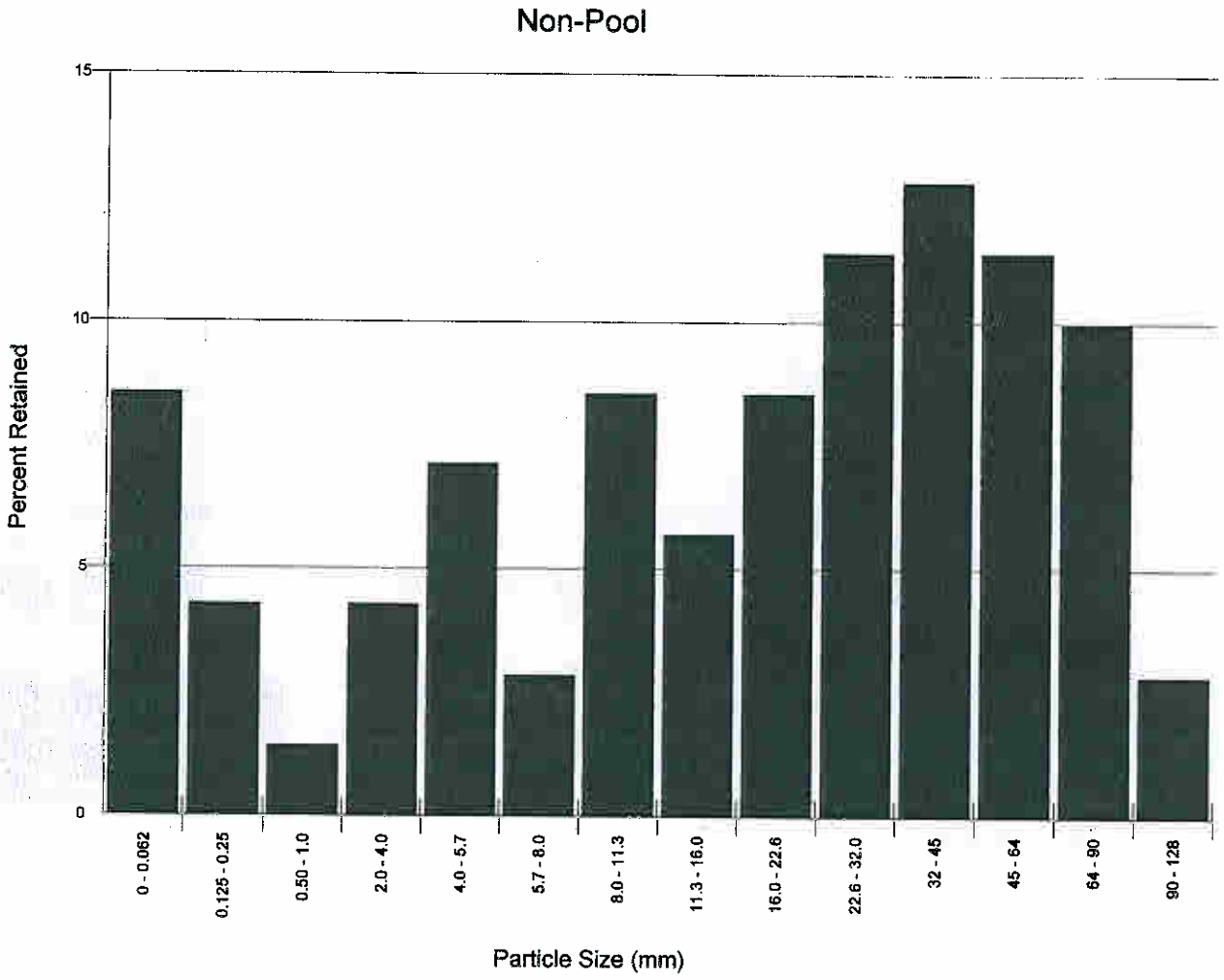

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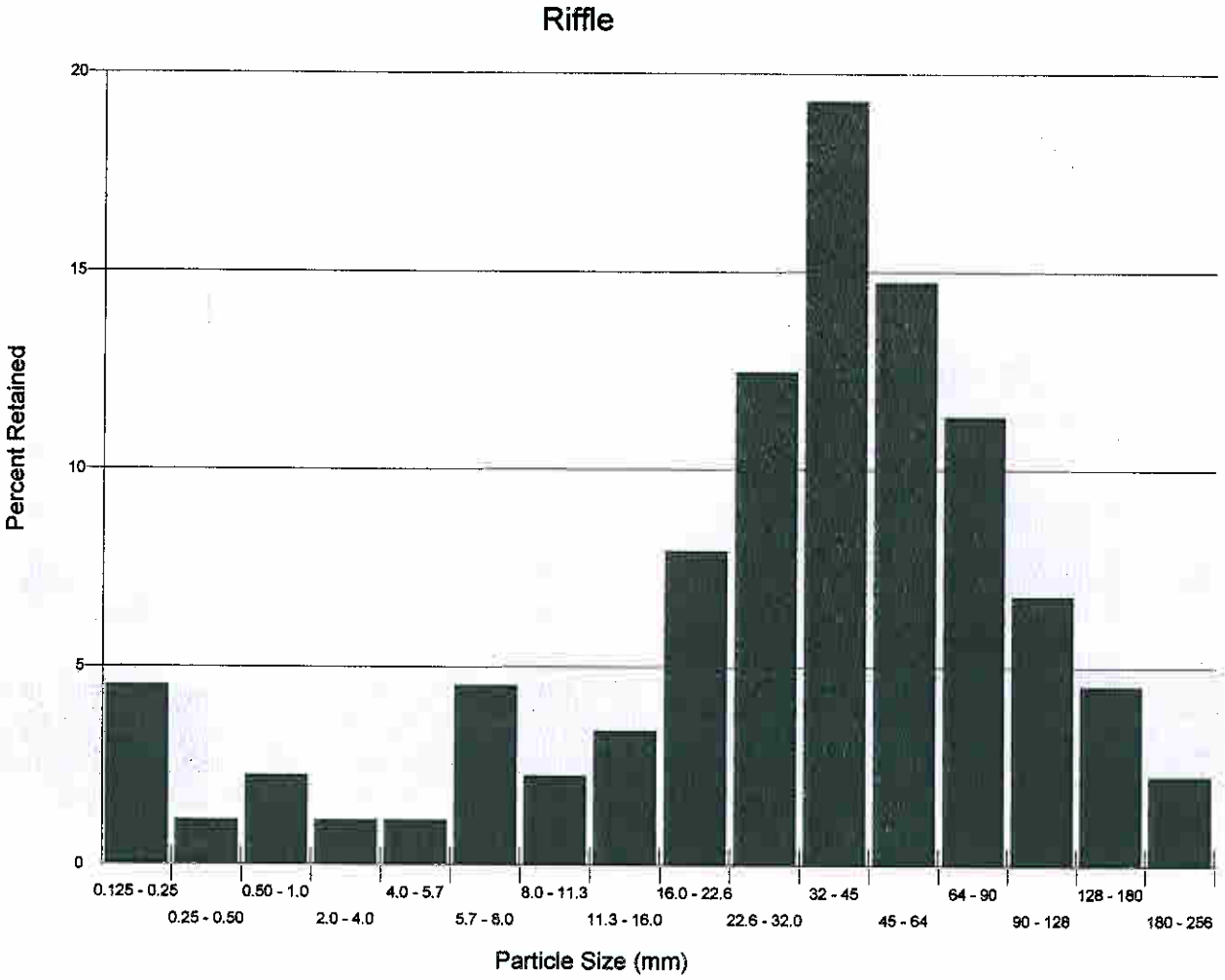

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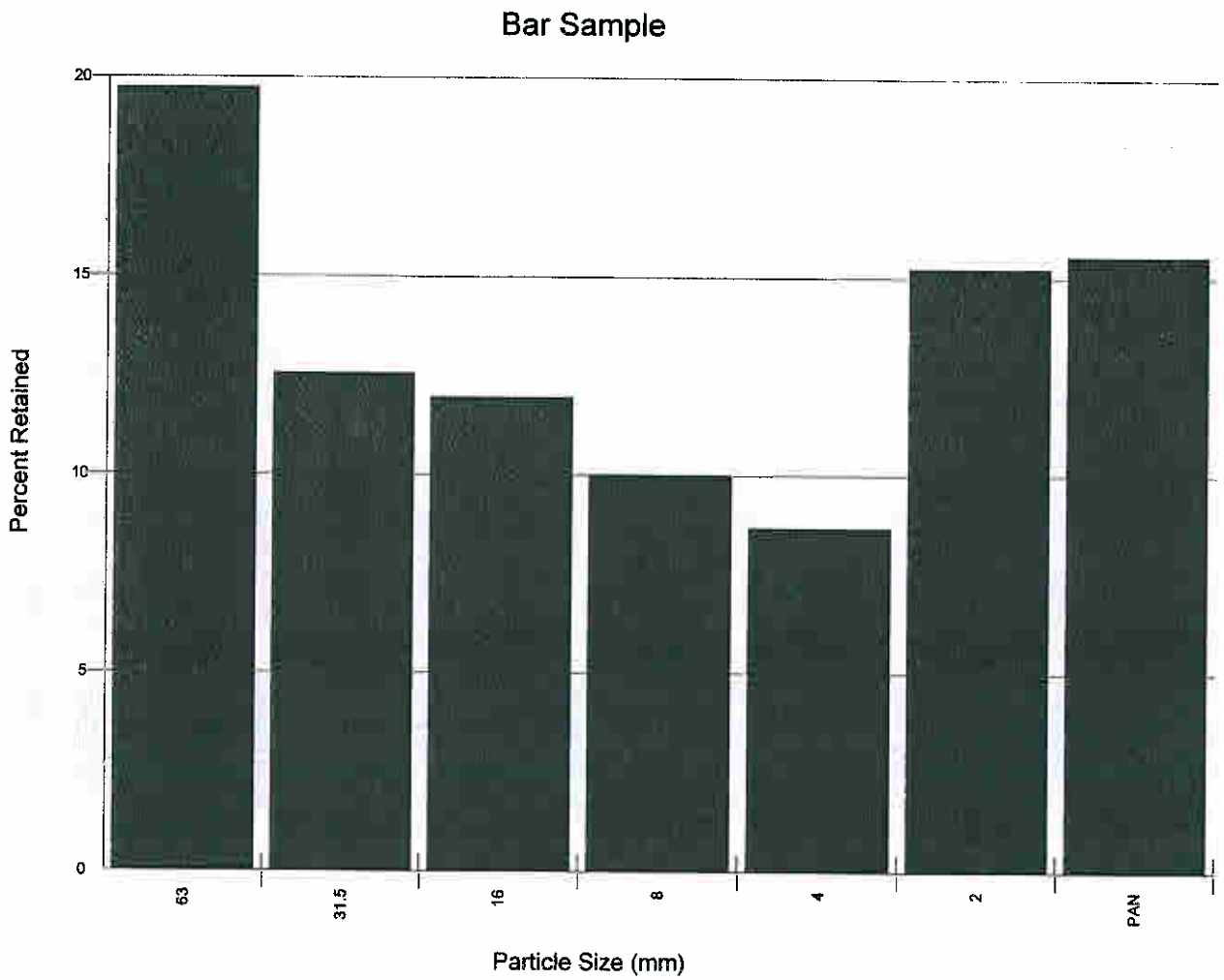
Bar Sample
Percent Retained
20
15
10
5
0
63
31.5
16
8
4
2
PAN
Particle Size (mm)

Worksheet 5-3. Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

TEAM 4
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Stream:	**Macgruder, Reach - Reach 4**			
Basin:	Drainage Area:	**1152** acres	**1.8**	mi^2
Location:				
Twp.&Rge: ;	Sec.&Qtr.: ;			
Cross-Section Monuments (Lat./Long.):	**0 Lat / 0 Long**		Date: **9/18/2007**	
Observers:			Valley Type: VIII	

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**22.35**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	**1.31**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**29.25**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**17.06**	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.	**2.07**	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).	**6.71**	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.	**18.93**	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.	**0.01245**	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).	**1.33**	

Stream Type **C 4** (See **Figure 2-14**)

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

TEAM 4
9/18/07

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

Observers: Date: **9/18/2007** 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})	22.35	ft	Riffle Area (A_{bkf})	29.25	ft^2
Mean Pool Depth (d_{bkfp})	1.59	ft	Pool Width (W_{bkfp})	21.7	ft	Pool Area (A_{bkfp})	34.51	ft^2
Mean Pool Depth/Mean Riffle Depth	1.21	d_{bkfp}/d_{bkf}	Pool Width/Riffle Width	0.97	W_{bkfp}/W_{bkf}	Pool Area / Riffle Area	1.18	A_{bkfp}/A_{bkf}
Max Riffle Depth (d_{mbkf})	2.01	ft	Max Pool Depth (d_{mbkfp})	3.58	ft	Max Riffle Depth/Mean Riffle Depth	1.53	
Max Pool Depth/Mean Riffle Depth	2.733					Point Bar Slope	15	
Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	4.69	ft/s				Estimation Method	1	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	133	cfs				Drainage Area	1.8	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Meander Length (Lm)	175	167	183	ft	Meander Length Ratio (Lm/W_{bkf})	7.83	7.47	8.19
Radius of Curvature (Rc)	39	28	50	ft	Radius of Curvature/Riffle Width (Rc/W_{bkf})	1.74	1.25	2.24
Belt Width (W_{blt})	103	90	115	ft	Meander Width Ratio (W_{blt}/W_{bkf})	4.59	4.03	5.15
Individual Pool Length	20.6	15.6	27.2	ft	Pool Length/Riffle Width	0.92	0.70	1.22
Pool to Pool Spacing	84.2	65.5	103	ft	Pool to Pool Spacing/Riffle Width	3.77	2.93	4.60
Riffle Length	26	10.8	51.3	ft	Riffle Length/Riffle Width	1.16	0.48	2.29

Channel Profile

Valley Slope (VS)	0.0166	ft/ft	Average Water Surface Slope (S)	0.01245	ft/ft	Sinuosity (VS/S)	1.33
Stream Length (SL)	386	ft	Valley Length (VL)	290	ft	Sinuosity (SL/VL)	1.33

Low Bank Height (LBH)	start	~~1.67~~ ft 1.68	Max Riffle Depth	start	1.68 ft	Bank-Height Ratio (BHR) (LBH/Max Riffle Depth)	start	~~0.99~~ 1.0
	end	~~2.25~~ ft 2.03		end	2.03 ft		end	~~1.11~~ 1.0

Facet Slopes	Mean	Min	Max		Dimensionless Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	0.024	0.023	0.024	ft/ft	Riffle Slope/Average Water Surface Slope (S_{rif} / S)	1.908	1.864	1.962
Run Slope (S_{run})	0.014	0.006	0.024	ft/ft	Run Slope/Average Water Surface Slope (S_{run} / S)	1.149	0.484	1.933
Pool Slope (S_p)	0.002	0.000	0.005	ft/ft	Pool Slope/Average Water Surface Slope (S_p / S)	0.121	0.000	0.406
Glide Slope (S_g)	0.003	0.001	0.005	ft/ft	Glide Slope/Average Water Surface Slope (S_g / S)	0.259	0.111	0.373

Feature Midpoint [a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Riffle Depth (d_{rif})	2.01	1.67	2.25	ft	Riffle Depth/Mean Riffle Depth (d_{rif} / d_{bkf})	1.53	1.27	1.72
Run Depth (d_{run})	2.41	2.25	2.62	ft	Run Depth/Mean Riffle Depth (d_{run} / d_{bkf})	1.84	1.72	2
Pool Depth (d_p)	3.58	2.79	4.31	ft	Pool Depth/Mean Riffle Depth (d_p / d_{bkf})	2.73	2.13	3.29
Glide Depth (d_g)	2.2	1.85	2.75	ft	Glide Depth/Mean Riffle Depth (d_g / d_{bkf})	1.68	1.41	2.1

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	8	0	0	D_{16}	0.75	9.78	2.06	0	mm
% Sand	11	7.95	15.57	D_{35}	9.47	27.56	5.92	0	mm
% Gravel	72	67.05	59.54	D_{50}	18.93	38.12	16.57	0	mm
% Cobble	9	25	24.9	D_{84}	51.91	84.6	75.22	0	mm
% Boulder	0	0	0	D_{95}	78.86	148.8	88.82	0	mm
% Bedrock	0	0	0	D_{100}	128	256	95	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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TEAM 4
9/18/07

Worksheet A-3. Bankfull velocity and discharge estimates.

Bankfull VELOCITY / DISCHARGE Estimates

Site	Macgruder Branch	Location	Montgomery, MD
Date	9/18/07	Stream Type	C4
Valley Type	VIII		
Observers	Team 4	HUC	02070008

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Cross-section AREA	29.2	A_{bkf} (SqFt)	Bankfull Mean DEPTH	1.31	D_{bkf} (Ft)
Bankfull WIDTH	22.3	W_{bkf} (Ft)	Wetted PERIMETER ~ $2 * d_{bkf} + W_{bkf}$	24.0	W_{Pbkf} (Ft)
D84 @ Riffle	84.6	Dia. (mm)	D84 mm / 304.8 =	0.28	D84 (Ft)
Bankfull SLOPE	.012	S (Ft / Ft)	Hydraulic RADIUS A_{bkf} / W_{Pbkf}	1.22	R (Ft)
Gravitational Acceleration	32.2	g (Ft /Sec^2)	Relative Roughness R (ft) / D84 (ft)	4.35	
Drainage AREA	1.8	DA (SqMi)	Shear Velocity $u^* = \sqrt{gRS}$	0.69	u* (Ft / Sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [\ 2.83 + 5.66 Log\{ R / D84 \}]u*$	4.45	Ft / Sec	130	CFS
2. Roughness Coefficient: a) Manning's 'n' from friction factor / relative roughness. $u = 1.4895*R^{2/3}*S^{1/2}/n$ n = .043	4.33	Ft / Sec	126	CFS
2. Roughness Coefficient: $u = 1.4895* R^{2/3}*S^{1/2}/n$ b) Manning's 'n' from Jarrett (USGS): $n = 0.39S^{.38}R^{-.16}$ 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: $u = 1.4895* R^{2/3}*S^{1/2}/n$ c) Manning's 'n' from Stream Type n = .031	6.01	Ft / Sec	175	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 = —	4.52	Ft / Sec	132	CFS
4. Continuity Equations: b) USGS Gage Data u = Q / A	—	Ft / Sec	—	CFS

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/uplifted 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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TEAM 4
9/18/07

River Assessment and Monitoring: Reference Reach

1st Field Day

a. Riparian Vegetation

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

Riparian Vegetation

Stream: Magruder		Location: 4	
Observers: KATY [illegible]	Reference reach ✓	Disturbed (impacted reach) ☐	Date: 9/18/07
Existing species composition: Riparian Hardwood		Potential species composition: Same	

	Riparian cover categories	Percent aerial cover*	Percent of site coverage**	Species composition	Percent of total species composition
1. Overstory	Canopy layer	65%	12%	Maples - Red	25%
				White Oaks	25%
				Ivy [illegible]	30%
				Ironwood	20%
					100%
2. Understory	Shrub layer		6%	Hickory	40%
				Beech	25%
				Ironwood	25%
				Rhododendron	10%
					100%
3. Ground level	Herbaceous		25%	Ferns	25%
				Grasses	75%
					100%
	Leaf or needle litter		6%		
	Bare ground		51%		
			Column total = 100%		

Remarks:

Condition, vigor and/or usage of existing reach:

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

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b. Flow Regime

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

FLOW REGIME

Stream: Magruder			Location: 4					
Observers:							Date: 9/18/07	
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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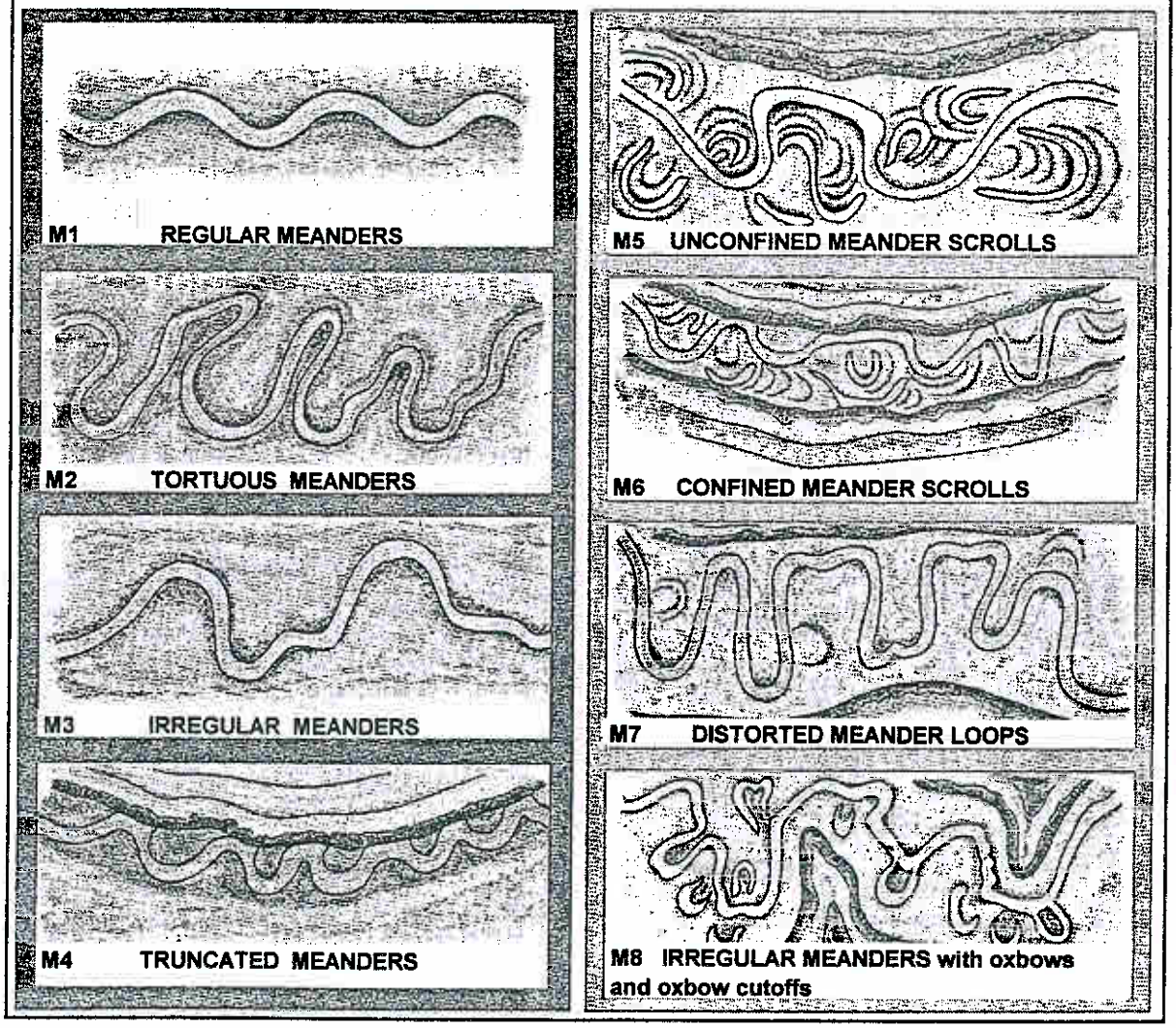
d. Meander Patterns

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

Meander Patterns					
Stream: Magruder Branch		Reach: 1			
Observers: TEAM 4		Date: 9/18/07			
List ALL CATEGORIES that APPLY	M5	M2	M3 (dominant)		

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



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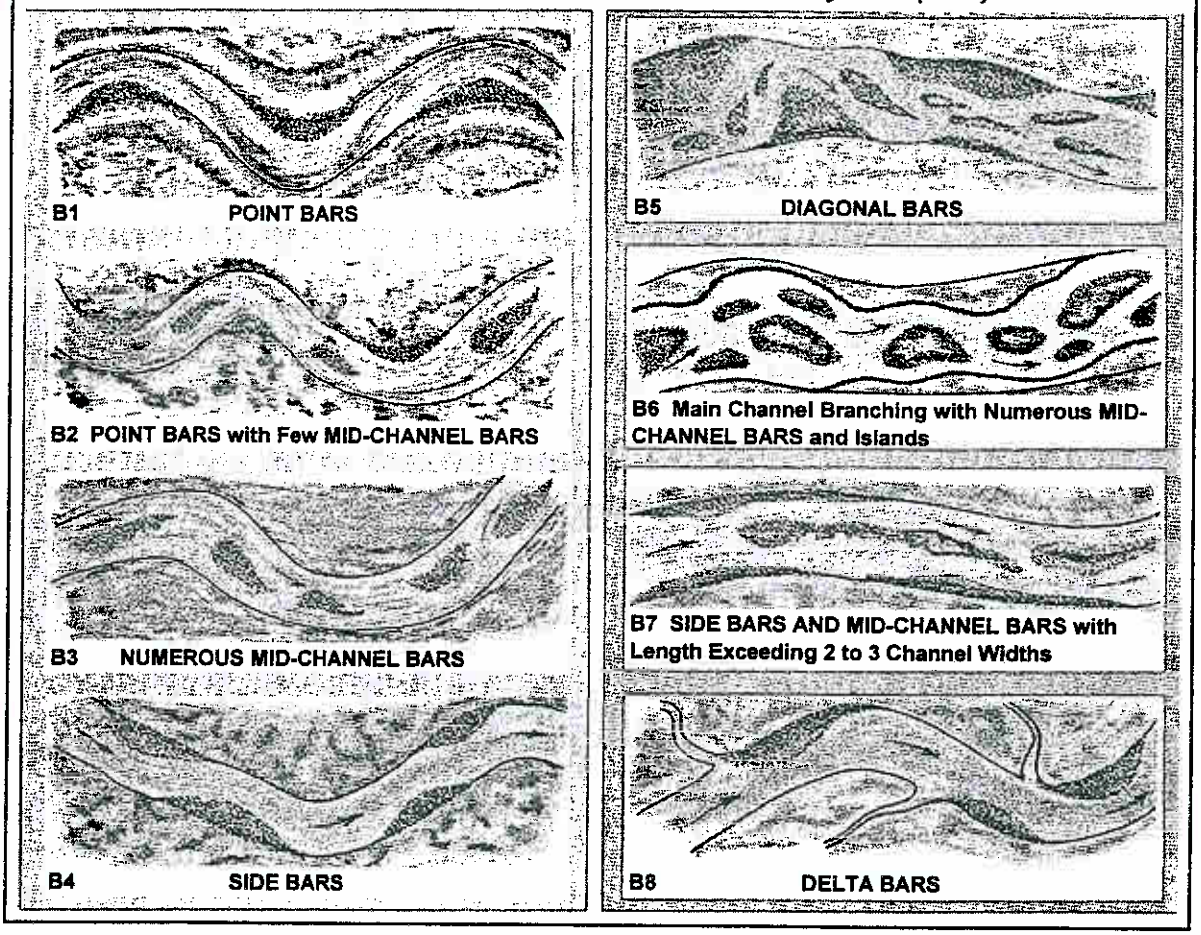
e. Depositional Patterns

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

Depositional Patterns					
Stream: Magruder Branch		Reach: "			
Observers: TEAM 4		Date: 9/18/07			
List ALL CATEGORIES that APPLY	B5	B1	B2		

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



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c. Stream Size and Order

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

Stream Size and Order			
Stream: Ma Gruder			
Location: L1			
Observers: [illegible]			
Date: 9/18/07			
Stream Size Category and Order ☞			S-4(3)
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	☑ 20'
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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TEAM 4
9/18/07

f. Channel Blockages

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

Channel Blockages			
Stream: MacGruder R		Location: 4	
Observers: Katy / Rich		Date: 9/18	
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.	☐

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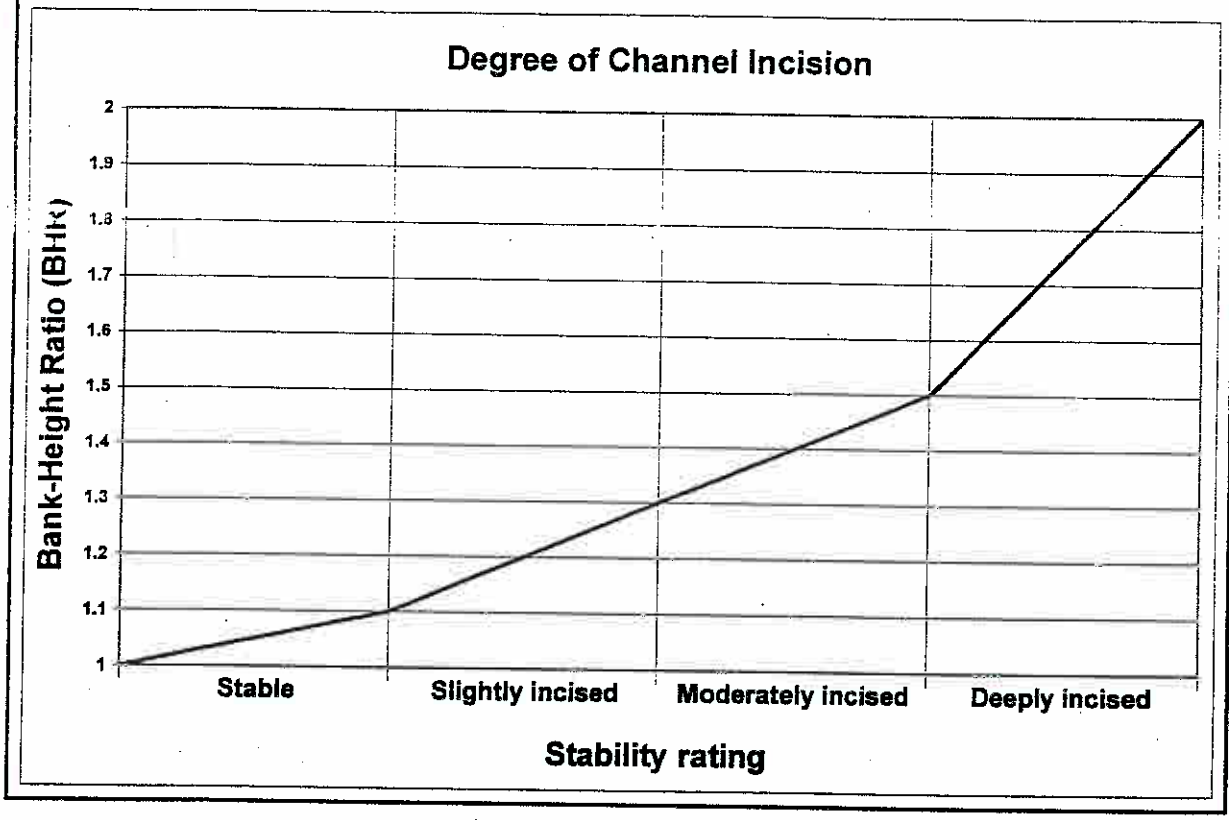
g. Degree of Channel Incision (Bank-Height Ratio) (*continued*)

Worksheet A-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:	1.68	Bank-Height Ratio:	1.0
Max Bankfull Depth:	1.68		
Degree of Channel Incision Stability Rating	STABLE		



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TEAM 4
9/18/07

River Name: Macgruder
Reach Name: Reach 4
Survey Date: 09/19/2007

Upper Bank

Landform Slope:	2
Mass Wasting:	3
Debris Jam Potential:	5
Vegetative Protection:	7

Lower Bank

Channel Capacity:	1
Bank Rock Content:	2
Obstructions to Flow:	6
Cutting:	14
Deposition:	12

Channel Bottom

Rock Angularity:	2
Brightness:	2
Consolidation of Particles:	5
Bottom Size Distribution:	7
Scouring and Deposition:	18
Aquatic Vegetation:	3

Channel Stability Evaluation

Sediment Supply:	~~High~~ (default data)
Stream Bed Stability:	~~Aggrading~~ (default data)
W/D Condition:	~~High~~ (default data)
Stream Type:	C4

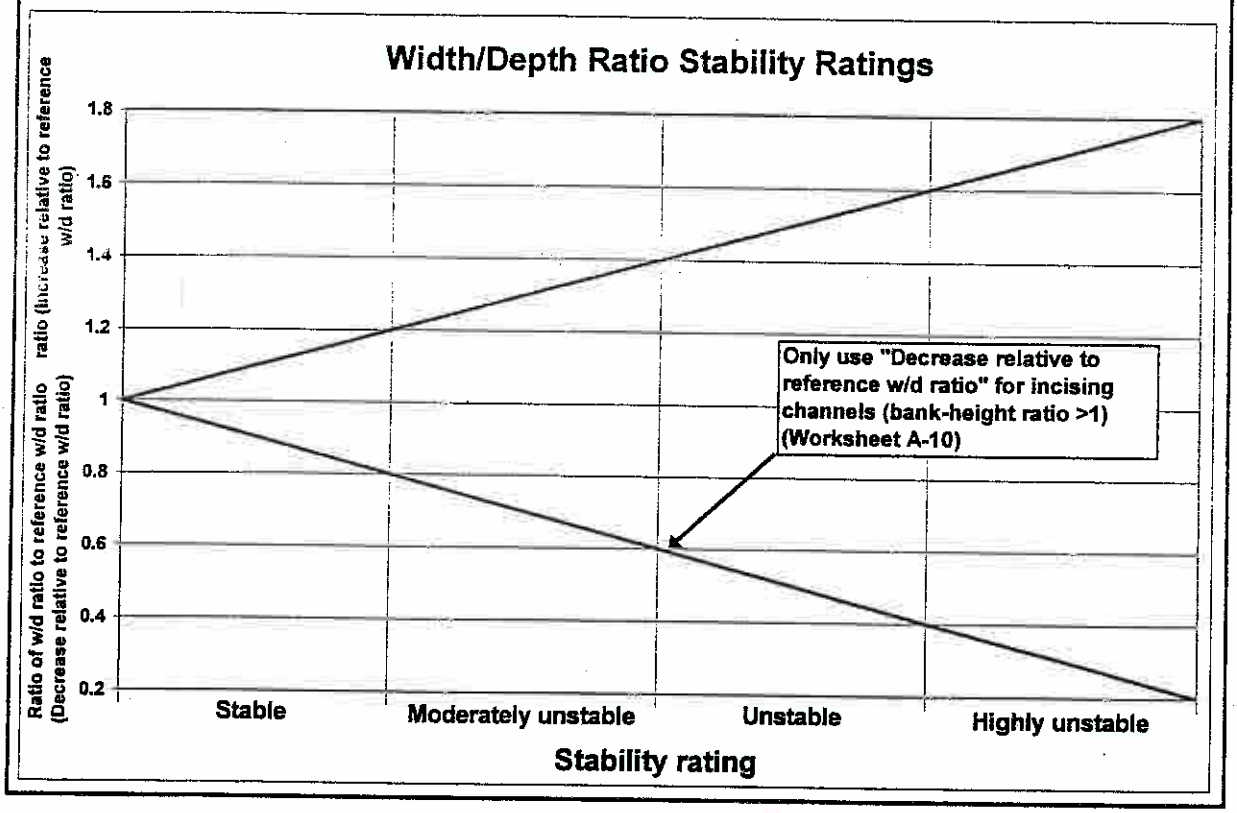
Rating - 89
Condition - Good

i. Width/Depth Ratio State (*Continued*)

Team 4
9/18/07

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

Width/Depth Ratio State			
Existing Width/Depth Ratio:		Ratio of existing w/d to reference w/d:	
Reference Width/Depth Ratio:	17		
Width/Depth Ratio State Stability Rating ☞			



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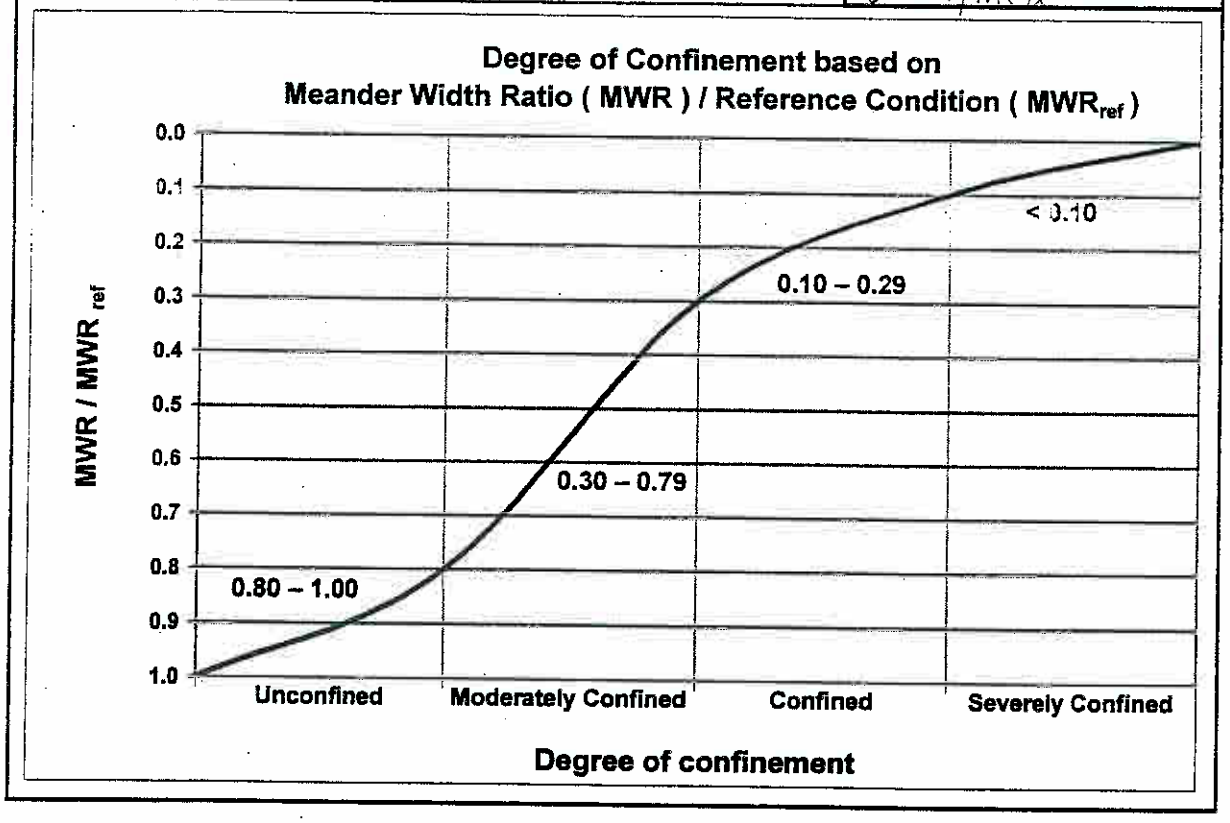
j. Degree of Channel Confinement (Meander Width Ratio (MWR)) (*Continued*)

TEAM 4
9/18/07

Worksheet A-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):	4.59	Ratio of MWR to MWRref:	1
Reference Meander Width Ratio (MWR_{ref}):	4.59		
Degree of Confinement Stability Rating	unconfined		



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

Stream:	**Macgruder, Reach - Reach 4**			Location:			
Graph Used:		Total Bank Length (ft): **386**				Date: **9/18/2007**	
Observers: TEAM 4			Valley Type: **VIII**			Stream Type: **C 4**	
(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. **behi 1**	**Moderate**	**Moderate**	**0.297931**	**15**	**2.9**	**12.96**	**0.04**
2. **behi 8lb**	**High**	**Moderate**	**0.620979**	**39**	**3.3**	**79.92**	**0.10**
3. **behi 9**	**High**	**Low**	**0.4016529**	**11**	**2.2**	**9.72**	**0.04**
4. **behi 2**	**High**	**Moderate**	**0.61875**	**24**	**3.4**	**50.49**	**0.10**
5. **behi 3lb**	**High**	**High**	**0.999551**	**70**	**3.5**	**244.89**	**0.17**
6. **behi 4**	**Very High**	**High**	**0.9996248**	**78**	**4.1**	**319.68**	**0.20**
7. **behi 5**	**High**	**Moderate**	**0.6203423**	**98**	**3.1**	**188.46**	**0.09**
8. **behi 6lb**	**High**	**Very High**	**1.4998414**	**43**	**4.4**	**283.77**	**0.32**
9. **behi 7**	**High**	**Moderate**	**0.6196231**	**41**	**4.4**	**111.78**	**0.13**
10.							
11.							
12.							
13.							
14.							
15.							
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					**Total erosion (ft^3/yr)**	**1301.67**	
Convert erosion in ft^3/yr to yds^3/yr {divide Total erosion (ft^3/yr) by 27}					**Total erosion (yds^3/yr)**	**48.21**	
Convert erosion in yds^3/yr to tons/yr {multiply Total erosion (yds^3/yr) by 1.3}					**Total erosion (tons/yr)**	**62.67**	
Calculate erosion per unit length of channel {divide Total erosion (tons/yr) by total length of stream (ft) surveyed}					**Total erosion (tons/yr/ft)**	**0.1624**	

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TEAM 4
9/18/07

River Name: Macgruder
Reach Name: Reach 4

Table 1. Bank Identification Summary

Bank	Name
1	behi 1
2	behi 2
3	behi 3lb
4	behi 4
5	behi 5
6	behi 6lb
7	behi 7
8	behi 8lb
9	behi 9

Table 2. Predicted Annual Bank Erosion Rates

Bank	BEHI Numeric Rating	BEHI Adjective Rating	NBS Adjective Rating	Length ft	Loss cu yds/yr	Loss tons/yr
1	28.8	Moderate	Moderate	15	0.55	0.72
2	31.9	High	Moderate	24	2.12	2.76
3	34.4	High	High	70	10.89	14.16
4	41.2	Very High	High	78	14.21	18.47
5	33.8	High	Moderate	98	7.88	10.24
6	31.9	High	Very High	43	11.91	15.48
7	31.9	High	Moderate	41	4.68	6.08
8	31.9	High	Moderate	39	3.34	4.34
9	33	High	Low	11	0.4	0.52
Totals				419	55.98	72.77

Total Reach Ln: 386 Total Loss (tons/yr) per ft of Reach: 0.1885

TEAM 4
9/18/07

River Name: Macgruder
Reach Name: Reach 4

Table 1. Bank Identification Summary

Bank	Name
1	behi 1
2	behi 2
3	behi 3lb
4	behi 4
5	behi 5
6	behi 6lb
7	behi 7
8	behi 8lb
9	behi 9

Table 2. Predicted Annual Bank Erosion Rates

Bank	BEHI Numeric Rating	BEHI Adjective Rating	NBS Adjective Rating	Length ft	Loss cu yds/yr	Loss tons/yr
1	28.8	Moderate	Moderate	15	0.48	0.62
2	31.9	High	Moderate	24	1.87	2.43
3	34.4	High	High	70	9.07	11.79
4	41.2	Very High	High	78	11.84	15.39
5	33.8	High	Moderate	98	6.98	9.07
6	31.9	High	Very High	43	10.51	13.66
7	31.9	High	Moderate	41	4.14	5.38
8	31.9	High	Moderate	39	2.96	3.85
9	33	High	Low	11	0.36	0.47
Totals				419	48.21	62.66

Total Reach Ln: 386 Total Loss (tons/yr) per ft of Reach: 0.1623

TEAM 4
9/18/07

River Name: Macgruder
Reach Name: Reach 4
BEHI Name: behi 2
Survey Date: 09/18/2007

Bankfull Height: 2.4 ft
Bank Height: 3.4 ft
Root Depth: 2 ft
Root Density: 30 %
Bank Angle: 130 Degrees
Surface Protection: 35 %

Bank Material Adjustment: 0

Bank Stratification Adjustment: None 0

Erosion Loss Curve: Yellowstone

NBS Method #5: Ratio of Near-Bank Maximum Bankfull Depth to Mean Bankfull Depth

NB Max Depth: 3.5 ft Mean Depth: 1.94 ft
Ratio: 1.80

BEHI Numerical Rating: 31.9
BEHI Adjective Rating: High
NBS Numerical Rating: 1.80
NBS Adjective Rating: Moderate
Total Bank Length: 24 ft
Estimated Sediment Loss: 2.12 Cu Yds per Year 1.87
Estimated Sediment Loss: 2.76 Tons per Year 2.43

TEAM 4
9/18/07

River Name: Macgruder
Reach Name: Reach 4
BEHI Name: behi 8lb
Survey Date: 09/19/2007

Bankfull Height: 2.1 ft
Bank Height: 3.3 ft
Root Depth: 1.8 ft
Root Density: 10 %
Bank Angle: 70 Degrees
Surface Protection: 12 %

Bank Material Adjustment: 0

Bank Stratification Adjustment: None 0

Erosion Loss Curve: Yellowstone

NBS Method #1: Channel Pattern and/or Depositional Features for Adjustments in Near-Bank Stress
Rating: Moderate

BEHI Numerical Rating: 31.9
BEHI Adjective Rating: High
NBS Numerical Rating:
NBS Adjective Rating: Moderate
Total Bank Length: 39 ft
Estimated Sediment Loss: 3.34 Cu Yds per Year 2.96
Estimated Sediment Loss: 4.34 Tons per Year 3.85

Team 4
9/18/07

River Name: Macgruder
Reach Name: Reach 4
BEHI Name: behi 9
Survey Date: 09/19/2007

Bankfull Height: 1.9 ft
Bank Height: 2.2 ft
Root Depth: 1.1 ft
Root Density: 10 %
Bank Angle: 90 Degrees
Surface Protection: 10 %

Bank Material Adjustment: 0

Bank Stratification Adjustment: None 0

Erosion Loss Curve: Yellowstone

NBS Method #1: Channel Pattern and/or Depositional Features for Adjustments in Near-Bank Stress
Rating: Low

BEHI Numerical Rating: 33.0
BEHI Adjective Rating: High
NBS Numerical Rating:
NBS Adjective Rating: Low
Total Bank Length: 11 ft
Estimated Sediment Loss: 0.4 Cu Yds per Year 0.36
Estimated Sediment Loss: 0.52 Tons per Year 0.47

TEAM 4
9/18/07

River Assessment and Monitoring: Impaired Reach 1st ~~2nd~~ Field Day

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

Stream: Magruder		Stream Type: C4	
Location: Reach 4		Valley Type: 8	
Observers: Greg, Tracy, Frank		Date: 9-18-07	

Enter required information

38.12	D_{50}	Riffle bed material D_{50} (mm)			
16.57	$\hat{D}_{50}$	Bar sample D_{50} (mm)			
0.3125	D_{max}	Largest particle from bar sample (ft)	95	(mm)	304.8 mm/ft
0.009	S	Existing bankfull water surface slope (ft/ft)			
1.31	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

2.3	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.0834\,(D_{50}/\hat{D}_{50})^{-0.872}$
2.5	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\,(D_{max}/D_{50})^{-0.887}$
0.017	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	2

Calculate bankfull mean depth required for entrainment of largest particle in bar sample

0.79	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

.0072	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

0.73	Bankfull shear stress $\tau = \gamma d S$ (lbs/ft^2) (substitute hydraulic radius, R, with mean depth, d)
120	Moveable particle size (mm) at bankfull shear stress **(Figure B-4)**
0.6	Predicted shear stress required to initiate movement of D_{max} (mm) **(Figure B-4)**
1.1	Predicted mean depth required to initiate movement of D_{max} (mm) $d = \frac{\tau}{\gamma S}$
0.012	Predicted slope required to initiate movement of D_{max} (mm) $S = \frac{\tau}{\gamma d}$

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TEAM 4
9/18/07

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

Stream: Macgruder Branch	Stream Type: C4
Location: Montgomery Co., MD	Valley Type: VIII
Observers: Team 4	Date: 9/18/07

Stream type changes due to successional stage shifts (Figure A-29)	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) C4 going to a wider C	☐ Moderately unstable
(G→F), (F→D), (C→F)	☑ Unstable
(C→D), (B→G), (D→G), (C→G), (E→G)	☐ Highly unstable

* Shows evidence of being a stable C in years past but now, due to lateral instability, evidence of excessive shear stress and slope, appears to be headed toward an F channel.

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Worksheet A-20. Lateral stability prediction summary.

Stream: Magruder			Stream Type: C4		
Location: Montgomery Co, Md.			Valley Type: 8		
Observers: TEAM 4			Date: 9/18/2007		
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 A-12)**	< 1.2 (2)	1.2 – 1.4 (4)	1.4 – 1.6 (6)	> 1.6 (8)	1
2 **Depositional pattern (Worksheet A-8)**	B1, B2 (1)	B4, B8 (2)	B3 (3)	B5, B6, B7 (4)	1
3 **Meander pattern (Worksheet A-7)**	M1, M3, M4 (1)		M2, M5, M6, M7, M8 (3)		3
4 **Dominant BEHI / NBS (Worksheet A-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 6 (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 A-13)**	0.8 – 1.0 (1)	0.3 – 0.79 (2)	0.1 – 0.29 (3)	< 0.1 (4)	1
				Total points	12
	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 A-21. Vertical stability prediction for excess deposition/aggradation.

Stream: McGreagor		Stream Type: C4	
Location: Montgomery Co., MD		Valley Type: 8	
Observers: Team 4		Date: 9/18/07	

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 A-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)	4
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)	5
3 W/d ratio state (Worksheet A-12)	1.0 – 1.2 (2)	1.2 – 1.4 (4)	1.4 – 1.6 (6)	>1.6 (8)	2
4 Stream succession states (Worksheet A-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 A-8)	B1 (1)	B2, B4 (2)	B3, B5 (3)	B6, B7, B8 (4)	3
6 Debris / blockages (Worksheet A-9)	D1, D2, D3 (1)	D4, D7 (2)	D5, D8 (3)	D6, D9, D10 (4)	1
				Total points	21

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 A-22. Vertical stability prediction for channel incision/degradation.

Stream: Macgruder Branch		Stream Type: C4	
Location: Montgomery Co. Md		Valley Type: 8	
Observers: TEAM 4		Date: 9/18/2007	

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 A-18)	Does not indicate excess competence (2)	Trend to move larger sizes than D_{100} of bar or > D_{84} of bed (4)	D_{100} of bed moved (6)	Particles much larger than D_{100} of bed moved (8)	6
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)	5
3 Degree of channel incision (BHR) (Workshet A-10)	1.00 – 1.10 (2)	1.11 – 1.30 (4)	1.31 – 1.50 (6)	> 1.50 (8)	2
4 Stream succession states (Worksheets A-19 and A-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 A-13)	0.80 – 1.00 (1)	0.30 – 0.79 (2)	0.10 – 0.29 (3)	< 0.10 (4)	1
				Total points	16

	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 A-23. Channel enlargement prediction summary.

Stream: Magruder Branch			Stream Type: C4		
Location: Montgomery Co, MD			Valley Type: VIII		
Observers: Team 4			Date: 9/18/07		
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 A-19)**	Stream type at potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C) (2)	(E→C) (4)	(G→F), (F→D) (6)	(C→D), (B→G), (D→G), (C→G), (E→G), (C→F) (8)	8
2 **Lateral stability (Worksheet A-20)**	Stable (2)	Moderately unstable (4)	Unstable (6)	Highly unstable (8)	4
3 **Vertical stability excess deposition/ aggradation (Worksheet A-21)**	No deposition (2)	Moderate deposition (4)	Excess deposition (6)	Aggradation (8)	6
4 **Vertical stability incision/ degradation (Worksheet A-22)**	Not incised (2)	Slightly incised (4)	Moderately incised (6)	Degradation (8)	4
				Total points	22
	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** ☐	Moderate Increase

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

Stream: McGrueger Creek		Stream Type: C4	
Location: Montgomery Co. MD		Valley Type: 8	
Observers: Team 4		Date: 9/18/07	
Overall sediment supply prediction criteria (choose corresponding points for each criterion 1–5)	**Stability rating**	**Points**	**Selected points**
1 Lateral stability (Worksheet A-20)	Stable	1	2
	Mod. unstable	2	
	Unstable	3	
	Highly unstable	4	
2 Vertical stability excess deposition/ aggradation (Worksheet A-21)	No deposition	1	3
	Mod. deposition	2	
	Excess deposition	3	
	Aggradation	4	
3 Vertical stability channel incision/ degradation (Worksheet A-22)	Not incised	1	2
	Slightly incised	2	
	Mod. Incised	3	
	Degradation	4	
4 Channel enlargement prediction (Worksheet A-23)	No increase	1	3
	Slight increase	2	
	Mod. increase	3	
	Extensive	4	
5 Pfankuch channel stability (Worksheet A-11)	Good: stable	1	1
	Fair: mod unstable	2	
	Poor: unstable	4	
		Total Points	11

	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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River Assessment and Monitoring: Reference Reach 1st Field Day

Worksheet A-25. Summary of stability condition categories.

Stream: Mc Gruder Creek			Location: Montgomery Co. MD		
Observers: Team 4		Date: 9/18/07	Stream Type: C4	Valley Type: 8	
Channel Dimension	Mean bankfull depth (ft): 1.31	Mean bankfull width (ft): 22.35	Cross-section area (ft^2): 29.25	Width of flood-prone area (ft): 150	Entrenchment ratio: 6.71
Channel Pattern	Mean (range)	MWR: 4.59	Lm/W_{bkf}: 7.83	Rc/W_{bkf}: 1.74	Sinuosity: 1.33
River Profile and Bed Features	Circle: Riffle/pool Step/pool Plane bed Convergence/divergence Dunes/antidunes/smooth bed				
	Max bankfull depth (ft): Riffle 2.01, Pool 3.58	Depth ratio (max/mean): Riffle 1.53, Pool 2.73	Pool to pool spacing: Ratio 84.2	Slope: Valley: 0.016	Average bankfull: 0.012
Level III Stream Stability Indices	Riparian vegetation	Current composition/density: Riparian Hardwoods	Potential composition/density: Same - mix conifer	Remarks: Condition, vigor and/or usage of exiting reach:	
	Flow regime: P	Stream size and order: S-4(3)	Meander pattern(s): M2, M3, M5	Depositional pattern(s): B1, B2, B5	Debris/channel blockage(s): D1, D2, D3
	Degree of incision (Bank-Height Ratio): 1	Degree of incision stability rating: Stable	Modified Pfankuch stability rating (numeric and adjective rating): 89 (Good)		
	Width/depth ratio (W/D): 17	Reference W/D ratio (W/D_{ref}): 17	Width/depth ratio state (W/D) / (W/D_{ref}): 1	W/D ratio state stability rating: stable	
	Meander Width Ratio (MWR): 4.59	Reference MWR_{ref}: 4.59	Degree of confinement (MWR / MWR_{ref}): 1	MWR / MWR_{ref} stability rating: unconfined	
Bank Erosion Summary	Length of reach studied (ft): 386'	Annual streambank erosion rate: 72.77 (tons/yr)	0.1885 (tons/yr/ft)	Curve used: Maryland	Remarks:
Sediment Capacity (POWERSED)	Sufficent capacity	Insufficient capacity	Remarks:		
Entrainment/ Competence	Largest particle from bar sample (mm): 95	$\tau = 0.73$	$\tau^* = 0.017$	Existing $depth_{bkf}$: 1.31	Required $depth_{bkf}$: 0.79
	Existing $slope_{bkf}$: 0.009	Required $slope_{bkf}$: 0.0012			
Successional Stage Shift	C → F → F_ → F__ → F___ →	Existing stream state (type): C4	Potential stream state (type): C4		
Lateral Stability	Circle: Stable	Moderately unstable	Unstable	Highly unstable	Remarks/causes:
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:
Channel Enlargement	Circle: No increase	Slight increase	Moderate increase	Extensive	Remarks/causes:
Sediment Supply (Channel Source)	Circle: Low	Moderate	High	Very high	Remarks/causes:

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