TEAM 2

Field Day 1 Presentation Order: Reference Reach

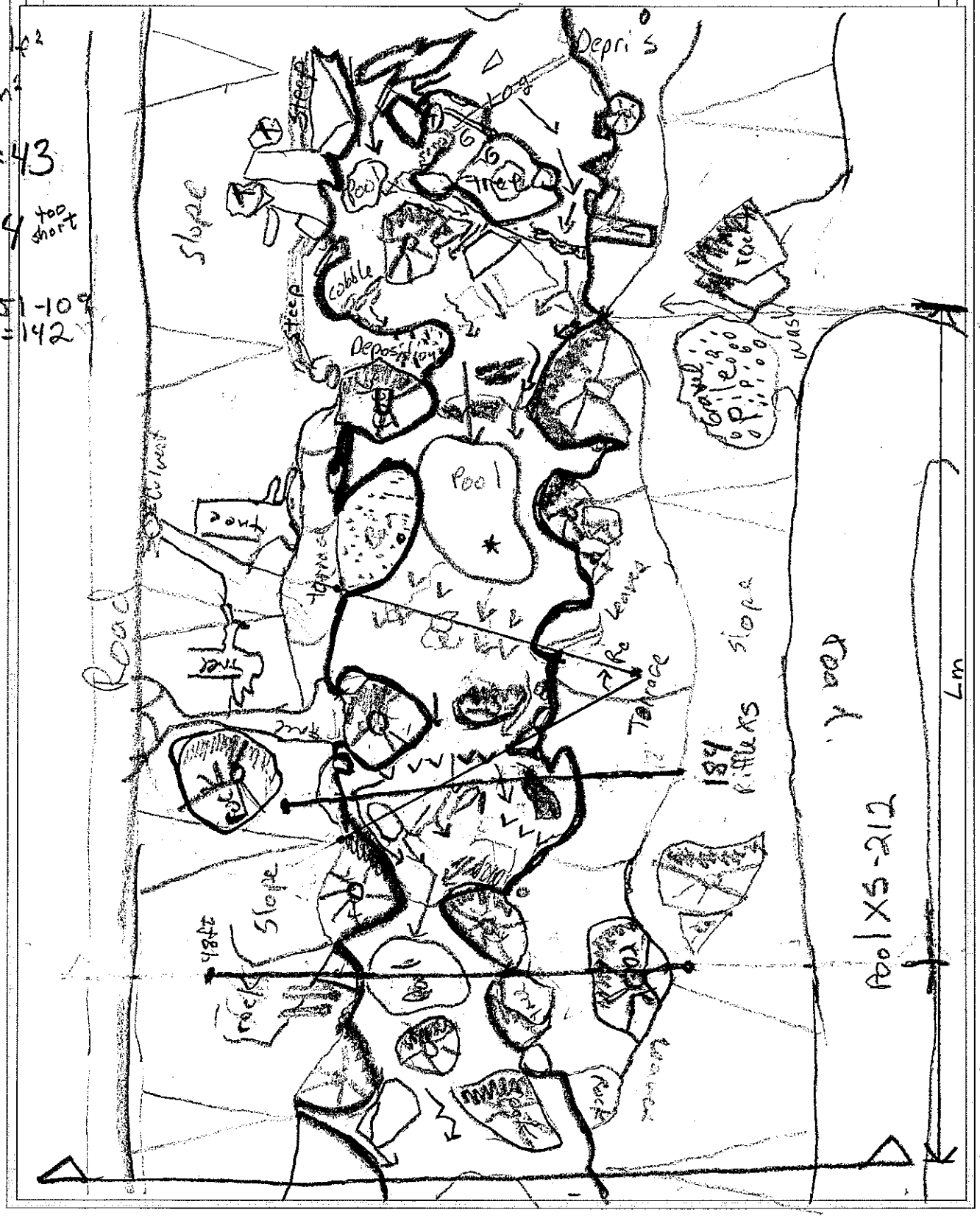
River Morphology and Applications

- Sketch Map
- Cross-sections
  - Riffle cross-section
  - Pool cross-section
- Longitudinal Profile
- Pebble Counts
  - Representative pebble count
  - Riffle pebble count
- Velocity (Worksheet A-2)
- Stream Classification (Worksheet A-1)
- Dimensionless Ratios (Worksheet A-3)

AREA-SITE LOCATION....REACH MAP Page 1

Stream: Sharman Branch Reach: Group 2

Drawn By: C. Skalda Date: 4-28-09



$A_{BF} \approx 3\ ft^2$

$DA = 3.6\ m^2$

$W_{BLT} = 43$

$R_c = 44$ too short

$L_m = 251 - 109 = 142$ meander wavelength

$V_L = 241$

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Sharman Branch
Group 2

Area-site SKETCH - Page 2

Page 2
4-28-09

Riffle XS

Pool XS

Sharman's Branch Team 2 4/28/09

Worksheet A-1. Field Form for Level II Stream Classification.

Stream: Sharman's Branch	
Basin: Antietam Creek Drainage Area:	acres 3.6 mi²
Location: Washington County, Maryland	
Twp. & Rge:	Sec. & Qtr.:
Cross-Section Monuments (Lat./Long.):	Date: 4/28/09
Observers: TEAM 2	Valley Type: VI

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 ($d_{bkf} = A / W_{bkf}$).	1.6	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	40.5	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	15.6	ft/ft
Maximum DEPTH (d_{max}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	2.42	ft
WIDTH of Flood-Prone Area (W_{fpa}) Twice maximum DEPTH, or ($2 \times d_{max}$) = the stage/elevation at which flood-prone area WIDTH is determined in a riffle section.	52.0	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	2.1	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.	145	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.	0.042	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).	1.04	

Stream Type B2/1 **See Classification Key**

based on percentile of pebbles counted

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Sharman's Branch Team 2 4/28/09

Worksheet A-3. Morphological relations, including dimensionless ratios of river reach sites.

Stream: Sharmans Branch Location:

Observers: Date: Valley Type: Stream Type:

River Reach Summary Data

Channel Dimension

Mean Riffle Depth (d_{bkf})	1.6	ft	Riffle Width (W_{bkf})	25.1	ft	Riffle Area (A_{bkf})	40.6	ft^2
Mean Pool Depth (d_{bkfp})	2.7	ft	Pool Width (W_{bkfp})	23.6	ft	Pool Area (A_{bkfp})	63.5	ft^2
Mean Pool Depth/Mean Riffle Depth	1.7	d_{bkfp}/d_{bkf}	Pool Width/Riffle Width	.94	W_{bkfp}/W_{bkf}	Pool Area/Riffle Area	1.6	A_{bkfp}/A_{bkf}
Max Riffle Depth (d_{maxrif})	2.5	ft	Max Pool Depth (d_{maxp})	4.4	ft	Max Riffle Depth/Mean Riffle Depth	1.6	
Max Pool Depth/Mean Riffle Depth	2.75		Point Bar Slope	N/A	ft/ft	Inner Berm Width (W_{ib})	21	ft
Inner Berm Depth (d_{ib})	1.3	ft	Inner Berm Width/Depth Ratio	16	W_{ib}/d_{ib}	Inner Berm Area (A_{ib})	26.7	ft^2
Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	3.63	ft/s	Estimation Method	Jarrett				
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	197	cfs	Drainage Area	3.6	mi^2			

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Meander Wavelength (L_m)	142	109	257	ft	Meander Length Ratio (L_m/W_{bkf})	5.7		
Radius of Curvature (R_c)	44	44	44	ft	Radius of Curvature/Riffle Width (R_c/W_{bkf})	1.75		
Belt Width (W_{blt})	43	43	43	ft	Meander Width Ratio (W_{blt}/W_{bkf})	1.71		
Individual Pool Length	14.8	10.5	17	ft	Pool Length/Riffle Width	.59		
Pool to Pool Spacing	84.5	72.5	96.5	ft	Pool to Pool Spacing/Riffle Width	3.4		
Riffle Length	39.6	22	59.5	ft	Riffle Length/Riffle Width	1.57		

Channel Profile

Valley Slope (VS)	4.31%	ft/ft	Average Water Surface Slope (S)	4.14%	ft/ft	Sinuosity (VS/S)	1.04	
Stream Length (SL)	251	ft	Valley Length (VL)	241	ft	Sinuosity (SL/VL)	1.04	
Low Bank Height (LBH)	start 2.2	ft	Max Riffle Depth	start 2.2	ft	Bank-Height Ratio (BHR) (LBH/Max Riffle Depth)	start 1	
	end 1.9	ft		end 1.9	ft		end 1	

Facet Slopes	Mean	Min	Max		Dimensionless Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	5.8	4.4	7.9	ft/ft	Riffle Slope/Average Water Surface Slope (S_{rif}/S)	1.4	1.06	1.7
Run Slope (S_{run})				ft/ft	Run Slope/Average Water Surface Slope (S_{run}/S)			
Pool Slope (S_p)	.33	0	.65	ft/ft	Pool Slope/Average Water Surface Slope (S_p/S)	.08	0	.16
Glide Slope (S_g)	.2			ft/ft	Glide Slope/Average Water Surface Slope (S_g/S)	.05		

Feature Midpoint[a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Max Riffle Depth (d_{maxrif})	3.0	2.3	4.3	ft	Max Riffle Depth/Mean Riffle Depth (d_{maxrif}/d_{bkf})	1.88	1.43	2.7
Max Run Depth (d_{maxrun})				ft	Max Run Depth/Mean Riffle Depth (d_{maxrun}/d_{bkf})			
Max Pool Depth (d_{maxp})	5.5	4.8	6.8	ft	Max Pool Depth/Mean Riffle Depth (d_{maxp}/d_{bkf})	3.4	3	4.25
Max Glide Depth (d_{maxg})	2.8			ft	Max Glide Depth/Mean Riffle Depth (d_{maxg}/d_{bkf})			

Channel Materials

	Reach[b]	Riffle[c]	~~Bar~~ pool		Reach[b]	Riffle[c]	~~Bar~~ pool	Protrusion Height[d]	
% Silt/Clay	0	.02	0	D_{16}	38	41	36	120	mm
% Sand	7.8	1.2	3.2	D_{35}	80	100	68	195	mm
% Gravel	26.3	24.1	32.3	D_{50}	145	820	86	260	mm
% Cobble	28.9	26.5	35.5	D_{84}	1300	1750	2450	475	mm
% Boulder	33.3	41.0	12.9	D_{95}	2850	7800	2900	750	mm
% Bedrock	9.7	7.2	16.1	D_{100}	5000+	3000+	3000+	1024	mm

[a] Min, max, mean depths are ave. mid-point values except pools: 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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Sharman's Branch Team 2 4/28/09

Cross-Sections

Cross-section Overview **A15**
Cross-section Instructions **A18**
Cross-section Forms **A20**

~ 31 ft² – Hydraulic curves
1.85 SW-BF @ riffle
1.8 SW @ glide
1.8 SW @ pool tail
1.8 SW @ top of reach

50' up & down from XS = protrusion measurements

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SURVEY DATA ⟹ **CROSS - SECTION 1**

Team 2

SITE: Sharman's Branch Washington County, MD Date: 4/28/09

Location: 184.1' in riffle (Reach 2 - 252' total length)

Party / Notes: Noble, Rich, & Greenup HUC:

Item	Distance, Point, or STATION ft	Back-Sight BS ft	Height of Instrument HI ft	Fore-Sight FS ft	Elevation ft	REMARKS / COMMENTS / NOTES	
1	6'				6.15	LB FPW edge	
2	9'				6.4		
3	14'				6.9		
4	20'				7.73		
5	25'				8.12		
6	26.5'				8.32	BF	0.
7	27'				8.36	Slope break	0.04
8	27.5'				8.42	↓	0.1
9	28'				8.52	↓	0.2
10	29'				8.89	~ active channel	0.57
11	29.5'				9.4		1.08
12	30				9.8		1.48
13	31.5				10.1	LEW	1.78
14	33				10.19		1.82
15	35				10.19		1.87
16	36				10.33		2.01
17	37				10.51		2.19
18	38.8				10.61	(low flow thalweg)	2.29
19	39.5				10.36		2.04
20	40.5				10.74	thalweg	
21	42				10.16		
22	44				10.21		
23	45				10.43		
24	45.5				10.66		
25	46.0				9.79	↑	
26	46.5				9.83	rock	
27	47.5				10.49		
28	48.5				11.37		

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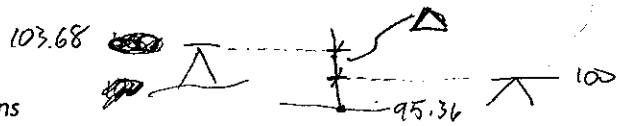

Team 2

SURVEY DATA ⟹ **CROSS - SECTION 2**

SITE: Sharman's Branch, Reach 2, Pool X-S Date: 4/28/08

Item	STATION ft	B S ft	H I ft	F S ft	Elevation ft	NOTES / COMMENTS / REMARKS
29		foresight (9.69)		backsite (8.32)	= (100 - 3.68) 96.32	Longpro position 211.6'
30	XS BF					
31	0			92.69	3.63	LB pin
32	3			93.1	3.22	large boulder / bedrock
33	7			92.42	3.90	↓
34	9			91.44	4.88	↓
35					6.19	lower bank
36	11			89.89	6.48	BF
37	12			89.71	6.61	
38	12.3			90.38	5.94	boulder
39	16			90.28	6.04	↓
40	17			89.63	6.69	↓
41	18			87.72	8.16	channel
42	20			87.58	8.79	
43	21			87	9.32	
44	22			86.7	9.62	
45	23			86.68	9.64	
46	24			86.5	9.82	
47	25			86.2	10.12	
48	26			85.77	10.55	
49	27			85.41	10.91	
50	28			85.86	10.46	
51	29			86.09	10.23	
52	30			86.36	9.96	
53	31			86.57	9.75	
54	32			86.67	9.65	
55	33			86.78	9.54	
56	34			86.74	9.58	
57	35			86.74	9.58	
58	36			87.61	8.71	
59	37			88.29	8.03	REW

LEW
7.90 water surface
-6.48
1.42

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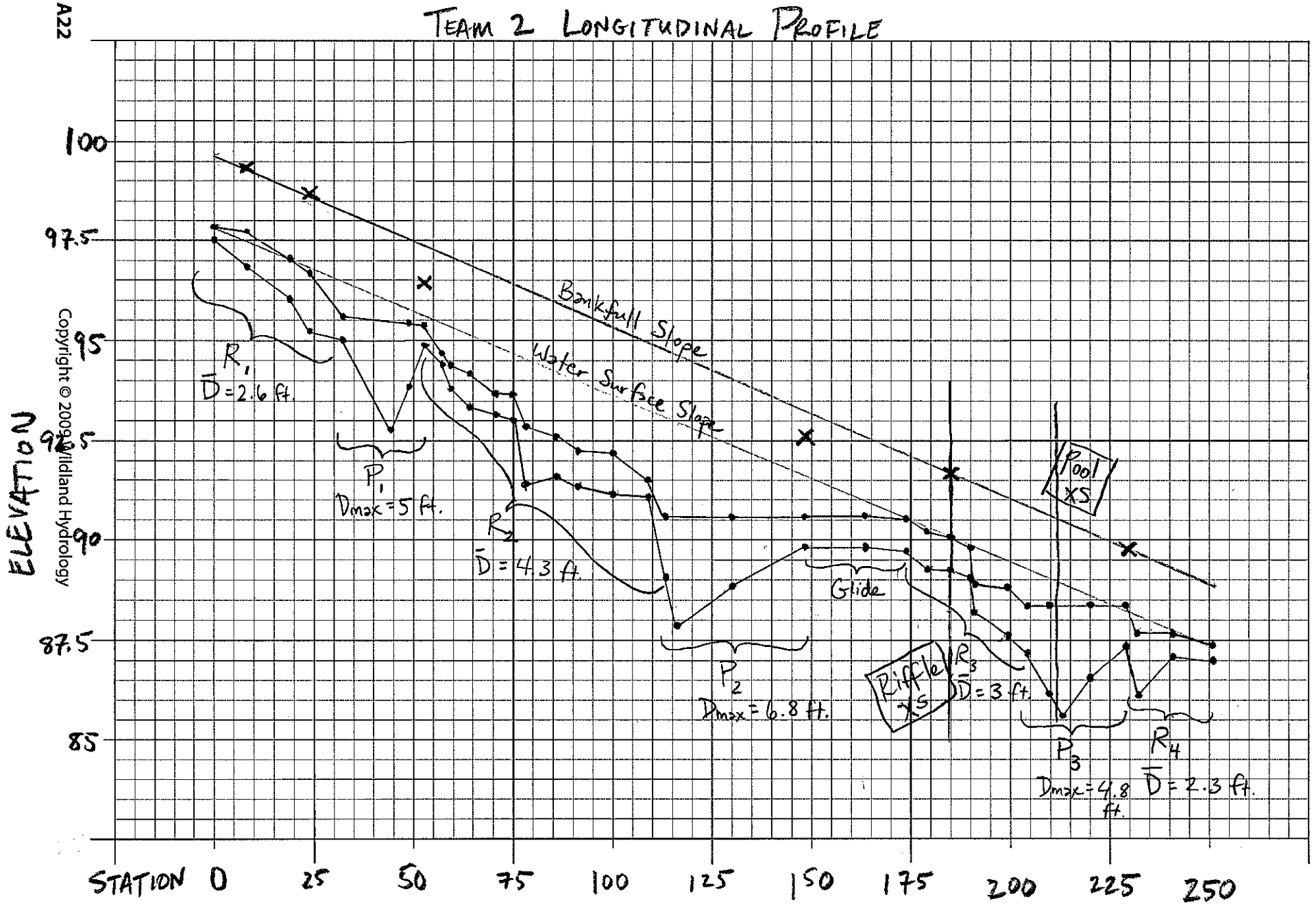
Sharman's Branch

4/28/09

A22

TEAM 2 LONGITUDINAL PROFILE



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p.2
Team 2

SURVEY DATA ⟹ **CROSS - SECTION 1**

SITE: Sharman's Branch Date: 4/28/01

Location:

Party / Notes: HUC:

Item	Distance, Point, or STATION ft	Back-Sight BS ft	Height of Instrument HI ft	Fore-Sight FS ft	Elevation ft	REMARKS / COMMENTS / NOTES
1	49				10.11	REW
2	49.5				9.28	
3	50				8.98	
4	51				8.69	~ active channel, below elev
5	52				8.12	
6	57'				6.15	RB FPW
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						

large boulder/ bedrock

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SURVEY DATA ⟹ **CROSS - SECTION 2**

Team 2

SITE: Shearman's Branch, Reach 2, Pool XS Date: 4/28/09

Item	STATION ft	B S ft	H I ft	F S ft	Elevation ft	NOTES / COMMENTS / REMARKS
29	39			89.29	7.08	out of channel/bed rock
30	40			91.65	4.67	
31	41			91.39	4.98	
32	42			91.92	4.40	
33	43			92.16	4.16	
34	44			92.79	3.58	
35	45			93.81	2.51	
36						
37						
38						
39						
40						
41						
42						
43						
44						
45						
46						
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58						
59						

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TEAM 2

XS2
211.6 ft

Longitudinal Profile

Longitudinal Profile Overview A29
Longitudinal Profile Instructions A30
Plan and Profile Diagram of Longitudinal Profile A31
Longitudinal Profile Forms A34

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slope = .042 (length & depth & slope)

Team 2

SURVEY DATA → LONGITUDINAL PROFILE 1

SITE: Sharman's Branch **Date:** 9/28/09

Location: Reach 2

Party / Notes: HUC:

	Distance, Point, or STATION ft	Back-Sight BS ft	Height of Instru-ment HI ft	Thalweg Fore-Sight FS ft	Thalweg Elevation Elev. ft	Water Surface Fore-Sight FS ft	Water Surface Elevation Elev. ft	Bankfull Fore-Sight FS ft	Bankfull Elevation Elev. ft	Low Bank HI Fore-Sight FS ft	Low Bank HI Elevation Elev. ft	NOTES e.g. Riffle Run Pool Glide
1	0.0			2.50	97.5	2.18	97.82	—				top of riffle
2	8.0			3.07	96.93	2.34	97.66	0.70	99.3			1.64 R1
3	19.0			3.98	96.02	2.96	97.04					
4	24.0			4.77	95.23	3.33	96.67	1.29	98.71			2.0
5	32.0			5.01	94.99	4.46	95.54					top of pool
6	44.0			7.23	92.77							dmax pool P1
7	49.0			6.15	93.85	4.57	95.43					bottom of glide
8	52.5			5.10	94.9	4.58	95.42	3.58	96.42			top of riffle 1.0
9	57.0			5.62	94.38	5.34	94.66					after log
10	58.5			6.18	93.82	5.57	94.43					
11	64.0			6.62	93.38	5.83	94.17					
12	70.5			6.89	93.11	6.38	93.62					
13	75.0			6.98	93.02	6.35	93.65					R2
14	78.0			8.55	91.45	7.17	92.83					
15	85.5			8.45	91.55	7.47	92.53					
16	91.5			8.65	91.35	7.73	92.27					mini pool
17	100.00			8.84	91.16	7.80	92.2					
18	109.0			8.96	91.04	8.5	91.5					
19	113.0			10.95	89.05	9.43	90.57					Top of P2
20	116.5			12.12	87.88							D-Max P2
21	130.0			11.2	88.8	9.36	90.64					Bottom Glide 2.0
22	148.0			10.2	89.8	9.42	90.58	7.43	92.57			R3
23	163.0			10.19	89.81	9.41	90.59					
24	174.0			10.28	89.72	9.47	90.53					
25	179.0			10.74	89.26	9.8	90.2					
26	185			10.72	89.28	9.94	90.06	8.33	91.67			Cross-section 1.61
27	190			10.97	89.03	10.2	89.8					

Glide L 26 S .05 Bankfull 2.8

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Team 2

Profile 1 P2

SURVEY DATA ⟹ **LONGITUDINAL PROFILE**

SITE: Sharman's Branch Date: 4/28/09

Location: Reach 2

Party / Notes: HUC:

	Distance, Point, or	Back-Sight	Height of Instru-ment	Thalweg		Water Surface		Bankfull		Low Bank HI		NOTES e.g. Riffle Run Pool Glide
				Fore-Sight	Elevation	Fore-Sight	Elevation	Fore-Sight	Elevation	Fore-Sight	Elevation	
	STATION	BS	HI	FS	Elev.	FS	Elev.	FS	Elev.	FS	Elev.	
	ft	ft	ft	ft	ft	ft	ft	ft	ft	ft	ft	
55	191			11.79	88.21	11.09	88.91					
56	199			12.38	87.62	11.18	88.82					
57	204			12.78	87.22	11.59	88.41					
58	209.5			13.79	86.21	11.59	88.41					top of pool
59	213			14.37	85.63							dmax; top of glide
60	220			13.46	86.54	11.59	88.41					
* 61	229			12.65	87.35	11.61	88.39	10.24	89.76			top of step
62	232			13.85	86.15	12.3	87.7					bottom of step
63	241			12.92	87.08	12.34	87.66					
64	251			13.0	87	12.57	87.43					
65												
66												
67												
68												
69												
70												
71												
72												
73												
74												
75												
76												
77												
78												
79												
80												
81												

P3

1.4

R4

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Representative Sample — 70% riffle (non pool) 30% pool — Team 2

Site: Sharman's Branch — Date: 4/28/09

Location: Reach 2 — HUC: _____

Party: JD + JC

Dot Count for RIFFLE (1) POOL (2) COMP. (3)

Inches	PARTICLE	Millimeters		RIFFLE (1) TOT #	RIFFLE (1) ITEM %	RIFFLE (1) % CUM	POOL (2) TOT #	POOL (2) ITEM %	POOL (2) % CUM	COMPOSITE (3) TOT #	COMPOSITE (3) ITEM %	COMPOSITE (3) % CUM
	Silt / Clay	< .062	S/C									
	Very Fine	.062 - .125	SAND									
	Fine	.125 - .25	SAND	1	1.2	1.2	1	3.2	3.2	2	1.8	1.8
	Medium	.25 - .50	SAND									
	Coarse	.50 - 1.0	SAND									
.04 - .08	Very Coarse	1.0 - 2	SAND									
.08 - .16	Very Fine	2 - 4	GRAVEL									
.16 - .22	Fine	4 - 5.7	GRAVEL									
.22 - .31	Fine	5.7 - 8	GRAVEL	2	2.4	3.6	0	0	3.2	2	1.8	3.6
.31 - .44	Medium	8 - 11.3	GRAVEL									
.44 - .63	Medium	11.3 - 16	GRAVEL									
.63 - .89	Coarse	16 - 22.6	GRAVEL	3	3.6	7.2	2	6.5	9.7	5	4.4	8.0
.89 - 1.3	Coarse	22.6 - 32	GRAVEL	2	2.4	9.6	1	3.2	12.9	3	2.6	10.6
1.3 - 1.8	Very Coarse	32 - 45	GRAVEL	8	9.6	19.2	3	9.7	22.6	11	9.6	20.2
1.8 - 2.5	Very Coarse	45 - 64	GRAVEL	5	6.0	25.2	4	12.9	35.5	9	7.9	28.1
2.5 - 3.5	Small	64 - 90	COBBLE	7	8.4	33.6	6	19.4	54.9	13	11.4	39.5
3.5 - 5.0	Small	90 - 128	COBBLE	9	10.8	44.4	2	6.5	61.4	11	9.6	49.1
5.0 - 7.1	Large	128 - 180	COBBLE	4	4.8	49.2	1	3.2	64.6	5	4.4	53.5
7.1 - 10.1	Large	180 - 256	COBBLE	2	2.4	51.6	2	6.5	71.1	4	3.5	57.0
10.1 - 14.3	Small	256 - 362	BOULDER	5	6.0	57.6	1	3.2	74.3	6	5.3	62.3
14.3 - 20	Small	362 - 512	BOULDER	3	3.6	61.2	0			3	2.6	64.9
20 - 40	Medium	512 - 1024	BOULDER	11	13.9	74.6	0			11	9.6	74.5
40 - 80	Large-Vry Large	1024 - 2048	BOULDER	15	18.2	92.8	3	9.7	84	18	15.8	90.3
	Bedrock		BDRK	6	7.2	100	5	16.1	100	11	9.6	100
			TOTAL→	83	100	-	31	100		114	100	

Stream Type: **Valley Type:**

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x-sec

Pertusion

Site: Sharman's Branch Date: 9/28/09

Location: Reach 2 HUC:

Party: Team 2

Inches	PARTICLE	Millimeters		Dot Count for RIFFLE 1	POOL 2	COMP. 3	RIFFLE (1) TOT #	RIFFLE (1) ITEM %	RIFFLE (1) % CUM	POOL (2) TOT #	POOL (2) ITEM %	POOL (2) % CUM	COMPOSITE (3) TOT #	COMPOSITE (3) ITEM %	COMPOSITE (3) % CUM
							Reach:			Reach:			Reach:		
							Date:			Date:			Date:		
	Silt / Clay	< .062	S/C												
	Very Fine	.062 - .125	SAND												
	Fine	.125 - .25													
	Medium	.25 - .50													
	Coarse	.50 - 1.0			2										
.04 - .08	Very Coarse	1.0 - 2													
.08 - .16	Very Fine	2 - 4	GRAVEL												
.16 - .22	Fine	4 - 5.7													
.22 - .31	Fine	5.7 - 8													
.31 - .44	Medium	8 - 11.3					1								
.44 - .63	Medium	11.3 - 16			1										
.63 - .89	Coarse	16 - 22.6			1										
.89 - 1.3	Coarse	22.6 - 32			1										
1.3 - 1.8	Very Coarse	32 - 45			3		1								
1.8 - 2.5	Very Coarse	45 - 64			6		3								
2.5 - 3.5	Small	64 - 90	COBBLE		4		6								
3.5 - 5.0	Small	90 - 128			6		8								
5.0 - 7.1	Large	128 - 180			4		15								
7.1 - 10.1	Large	180 - 256			5		5								
10.1 - 14.3	Small	256 - 362	BOULDER		2		20								
14.3 - 20	Small	362 - 512			4		31								
20 - 40	Medium	512 - 1024			5		10								
40 - 80	Large-Vry Large	1024 - 2048			19										
	Bedrock		BDRK		37										
Stream Type:			Valley Type:			TOTAL→									

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$D_{95} = 2700$ $D_{35} = 68$ $D_{16} = 36$ pool $D_{50} = 86$ $D_{84} = 2450$

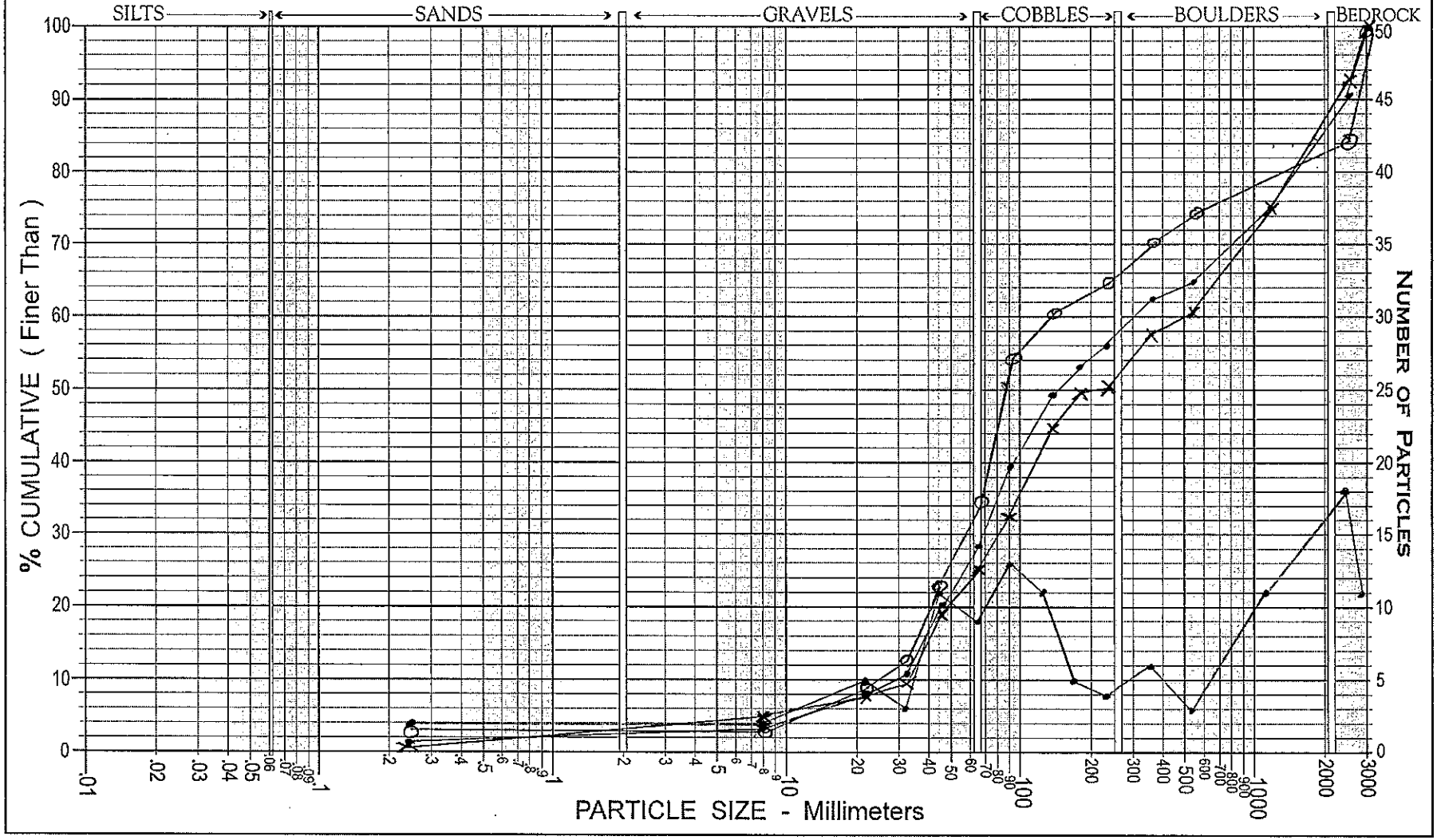
$D_{95} = 2800$ $D_{35} = 100$ $D_{16} = 41$ riffle $D_{50} = 220$ $D_{84} = 1250$

$D_{95} = 2850$ $D_{35} = 80$ $D_{16} = 38$ total $D_{50} = 145$ $D_{84} = 1300$

LOCATION: Sharman's Branch PEBBLE COUNT DATA Date: 4-28-09

REACH: #2 PARTY: JO + JC

Stream Type: B3/1 Valley Type: HUC:



Sharman's Branch

• total
X riffle
O pool

Team 2

4/28/09

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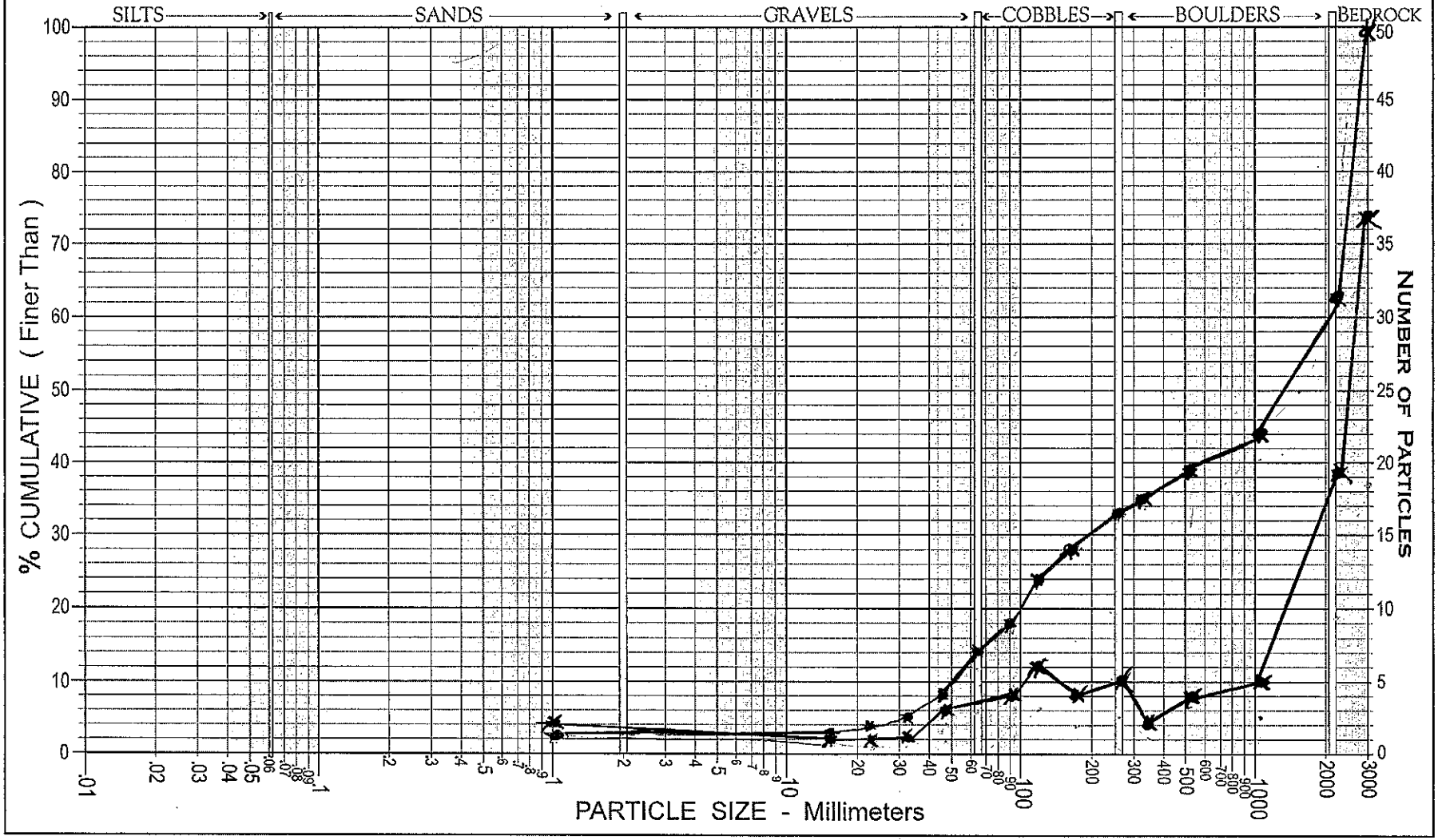
Pebble count D84 = 28.00
D50 = 13.50
D16 = 7.5

LOCATION: Team 2 – Sharman's Branch PEBBLE COUNT DATA Date: 4-28-09

REACH: #2 x-section @ riffle PARTY: JO + JC

Stream Type: Valley Type: HUC:



● = cum.
X = total

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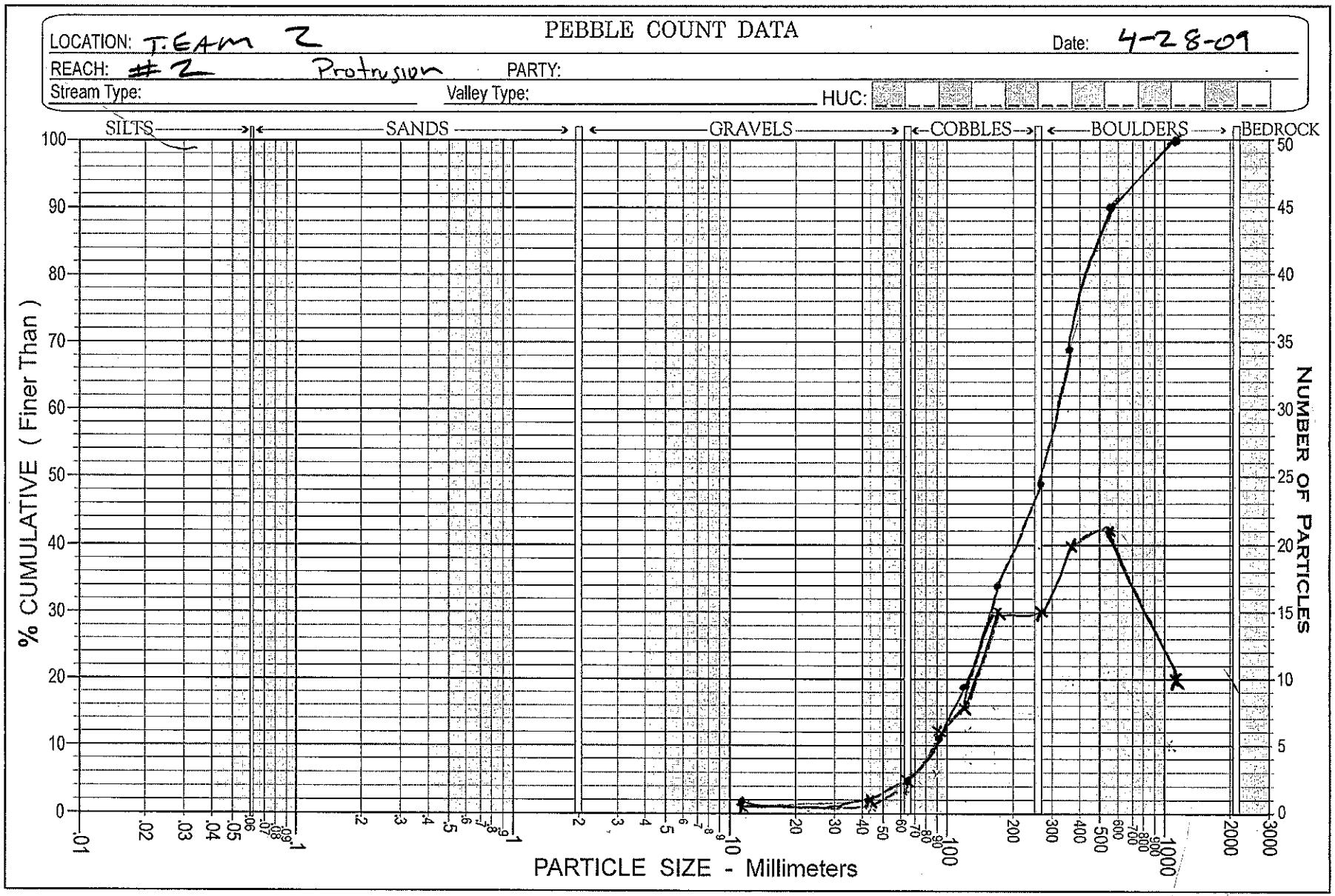
Sharmans Branch

D84 = 475 = 1.87 ft
D50 = 260 = 1.02 ft
D16 = 120 = .047 ft



X = total
● = cum

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Worksheet A-2. Computations of velocity and discharge using various methods.

Bankfull VELOCITY / DISCHARGE Estimates

Site:	Sharmans Branch	Location:	
Date:	4-28-09	Stream Type:	
Valley Type:			
Observers:		HUC:	

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Cross-sectional AREA	40.49	A_{bkf} (ft^2)	Bankfull Mean DEPTH	1.6	d_{bkf} (ft)
Bankfull WIDTH	25.12	W_{bkf} (ft)	Wetted PERIMETER ~ $2 * d_{bkf} + W_{bkf}$	26.99	W_p (ft)
Protrusion D_{84} @ Riffle / D_{50}	260 / 475	Dia. (mm)	D_{84} mm / 304.8 =	1.02 / 1.56	D_{84} (ft)
Bankfull SLOPE	0.042	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	1.5	R (ft)
Gravitational Acceleration	32.2	g (ft / sec^2)	Relative Roughness R (ft) / D_{84} (ft)	1.47 / 0.96	
Drainage AREA	3.6	DA (mi^2)	Shear Velocity $u^* = \sqrt{gRS}$	1.42	u* (ft / sec)

ESTIMATION METHODS D_{84} / D_{50}	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 \text{ Log}\{R/D_{84}\}]u^*$	5.36 / 3.88	ft / sec	217 / 157	cfs
2. Roughness Coefficient: a) Manning's 'n' from friction factor / relative roughness $u = 1.4865 * R^{2/3} * S^{1/2}/n$ n = .06 / .075	6.65 / 5.31	ft / sec	269 / 215	cfs
2. Roughness Coefficient: $u = 1.4865 * R^{2/3} * S^{1/2}/n$ b) Manning's 'n' from Jarrett (USGS): $n = 0.39 S^{.38} R^{-.16}$ n = .11 Note: This equation is for applications involving steep, step-pool, high boundary roughness, cobble- and boulder-dominated stream systems; i.e., for stream types A1, A2, A3, B1, B2, B3, C2 and E3. 1.31 2049 .299 .937	3.63	ft / sec	147	cfs
	4.85		197	← B2 typ
2. Roughness Coefficient: $u = 1.4865 * R^{2/3} * S^{1/2}/n$ c) Manning's 'n' from Stream Type B2 0.082 ← n = .074	5.39	ft / sec	218	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)		ft / sec		cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)		ft / sec		cfs
4. Continuity Equations: a) Regional Curves u = Q / A Return Period for Bankfull Discharge Q = ____ Year	5.43 / 2.96	ft / sec	220 / 120	cfs
4. Continuity Equations: b) USGS Gage Data u = Q / A		ft / sec		cfs

recalc using B2 typ

cw Piedmont O.K. / Too Low allegheny curve

Options for using the D_{84} term in the relative roughness relation (R/D_{84}), 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 ft) for the D_{84} 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 ave. boulder protrusion height (h_{bo} in ft) for the D_{84} 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 D_{84} term in estimation method 1.

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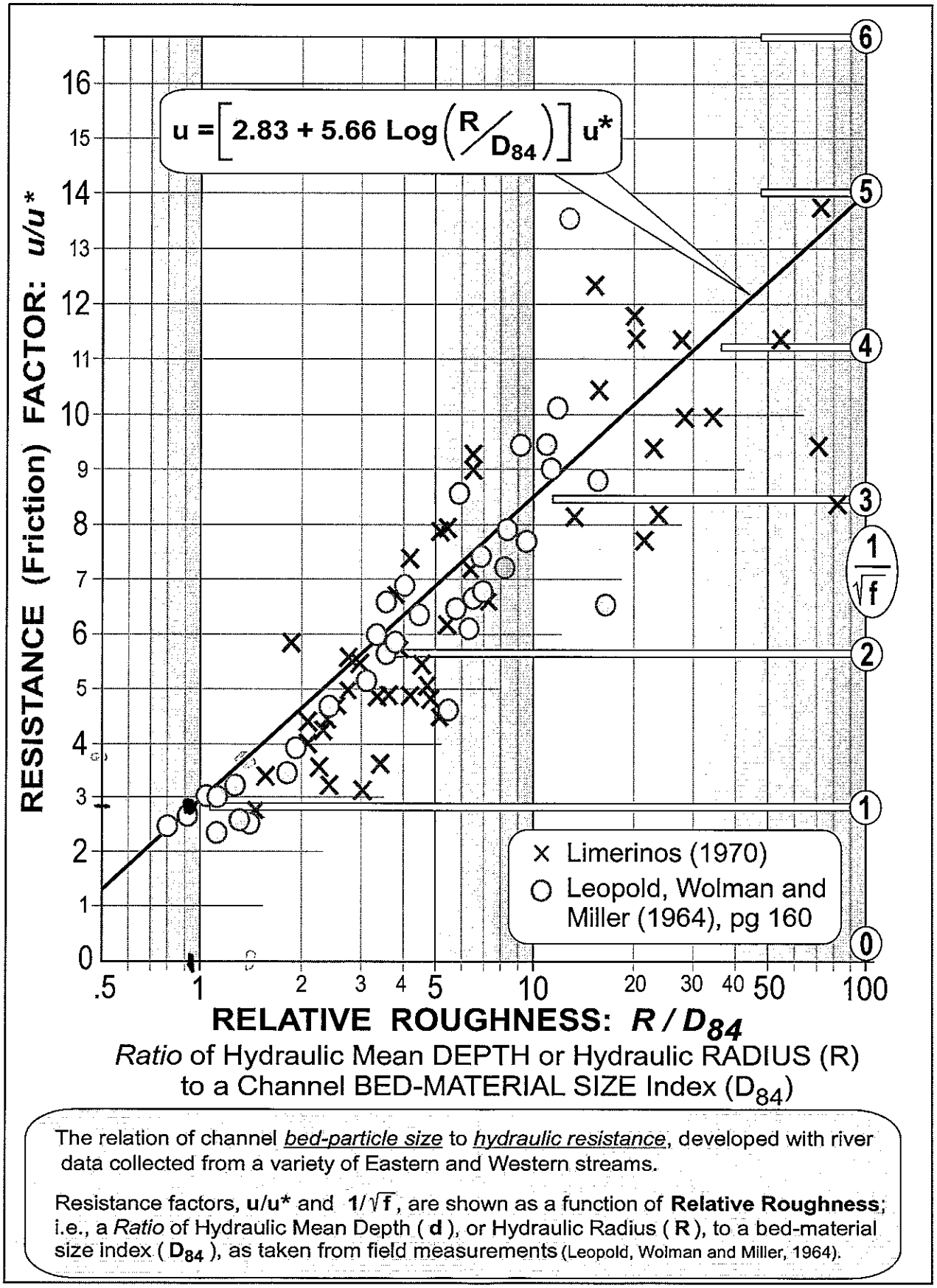

The relation of channel *bed-particle size* to *hydraulic resistance*, developed with river data collected from a variety of Eastern and Western streams.

Resistance factors, **u/u*** and $1/\sqrt{f}$, are shown as a function of **Relative Roughness**; i.e., a *Ratio* of Hydraulic Mean Depth (**d**), or Hydraulic Radius (**R**), to a bed-material size index ($\mathbf{D_{84}}$), as taken from field measurements (Leopold, Wolman and Miller, 1964).

Figure A-16. Relative roughness (R/D_{84}) vs. friction factor (u/u*) (Rosgen, 2006b; Rosgen and Silvey, 2007).

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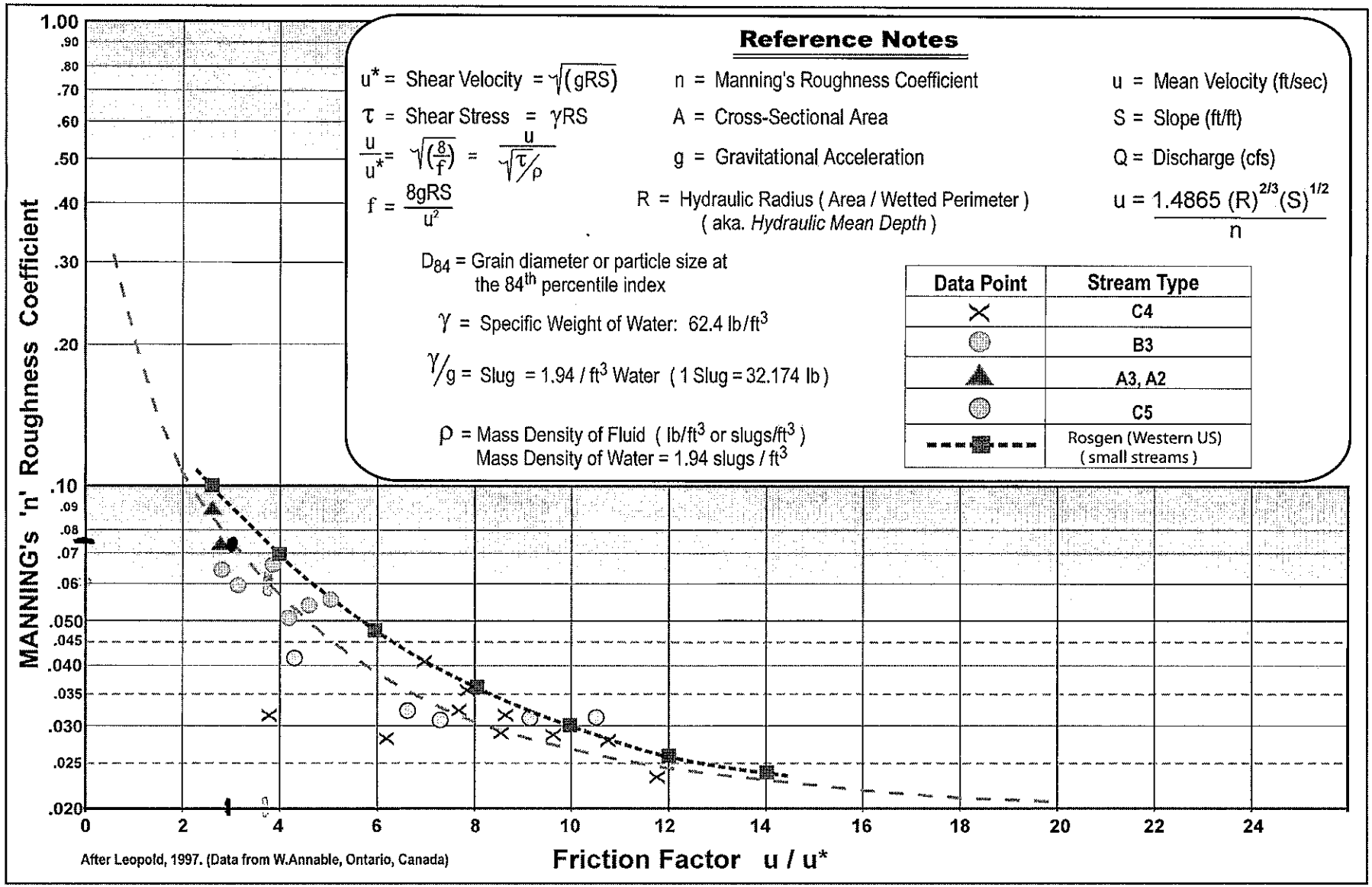

Figure A-17. Friction factor (u/u*) vs. Manning's roughness coefficient "n" (Rosgen, 2006b; Rosgen and Silvey, 2007).

- D_{85}

- D_{50}

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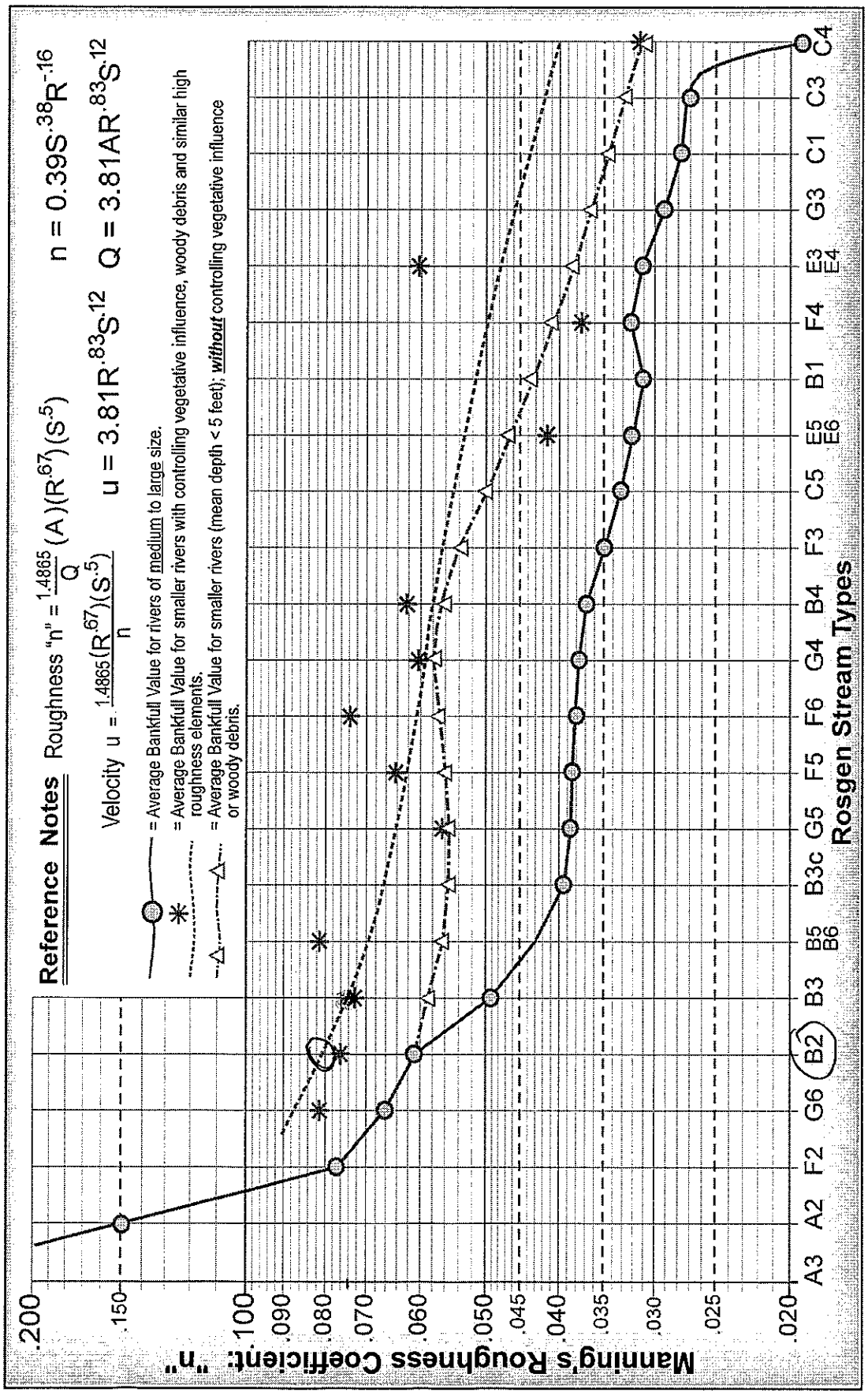

Figure A-18. Manning's "n" by stream type (Rosgen and Silvey, 2007).

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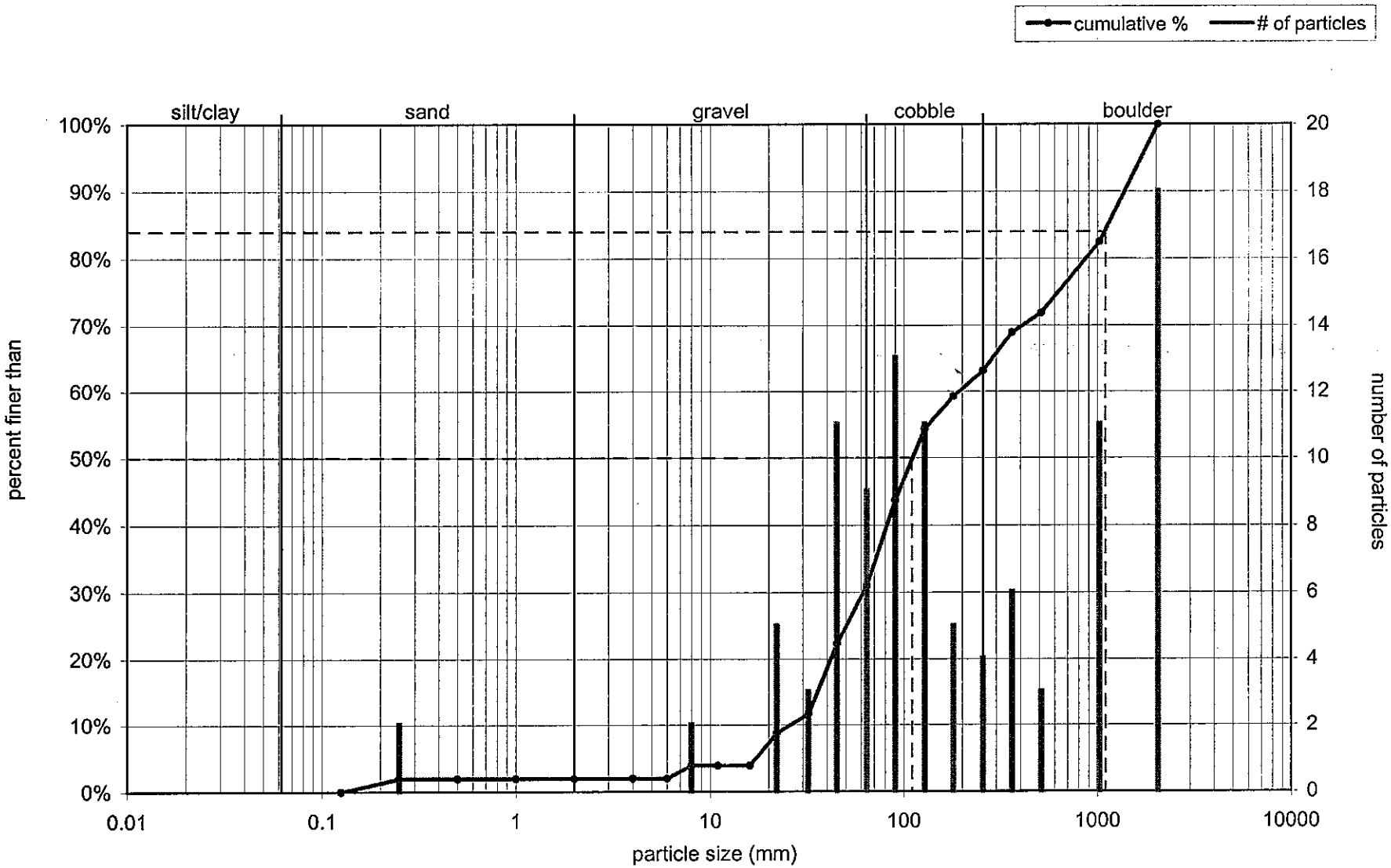
Bankfull Channel Pebble Count, ---



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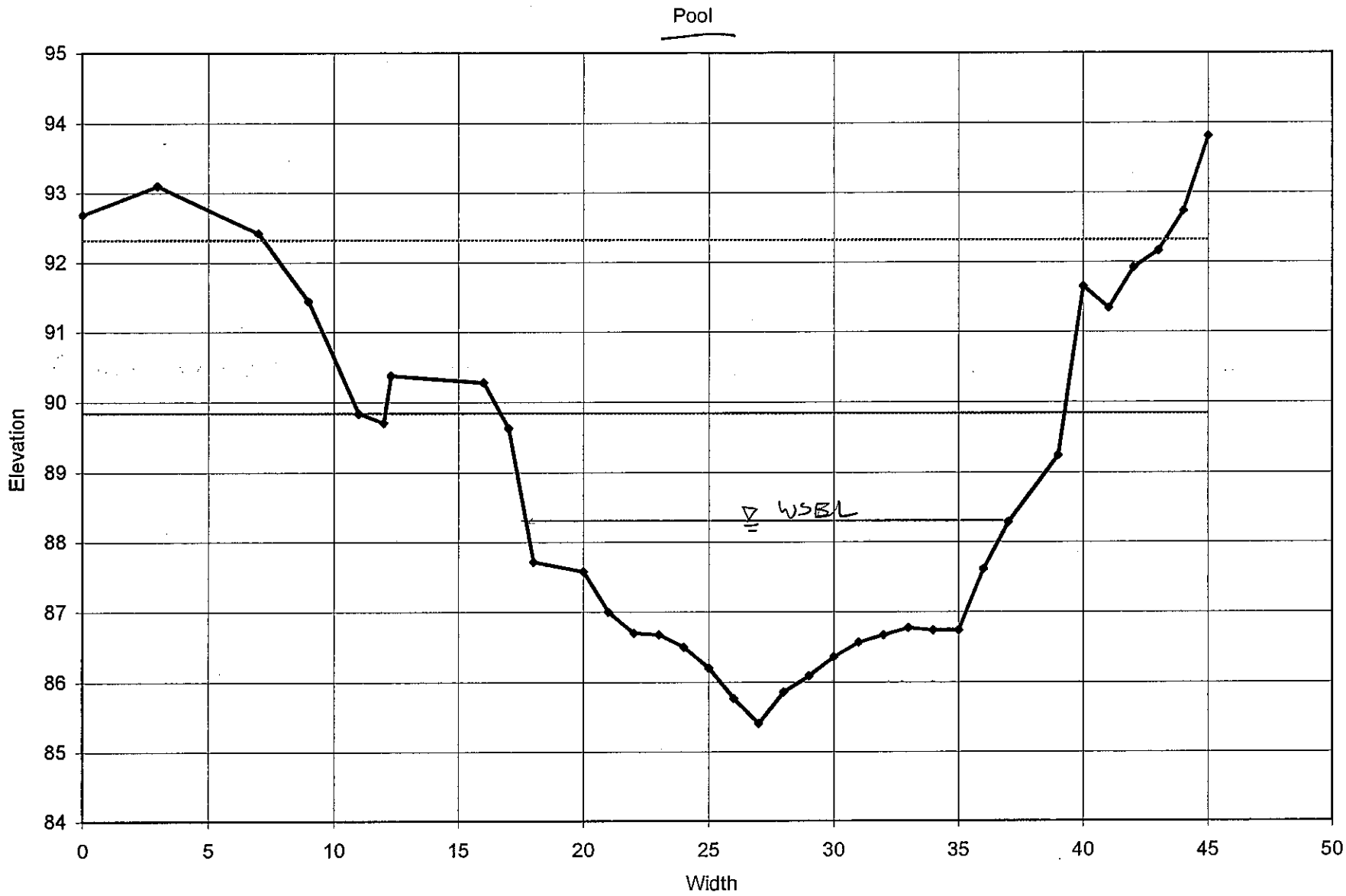

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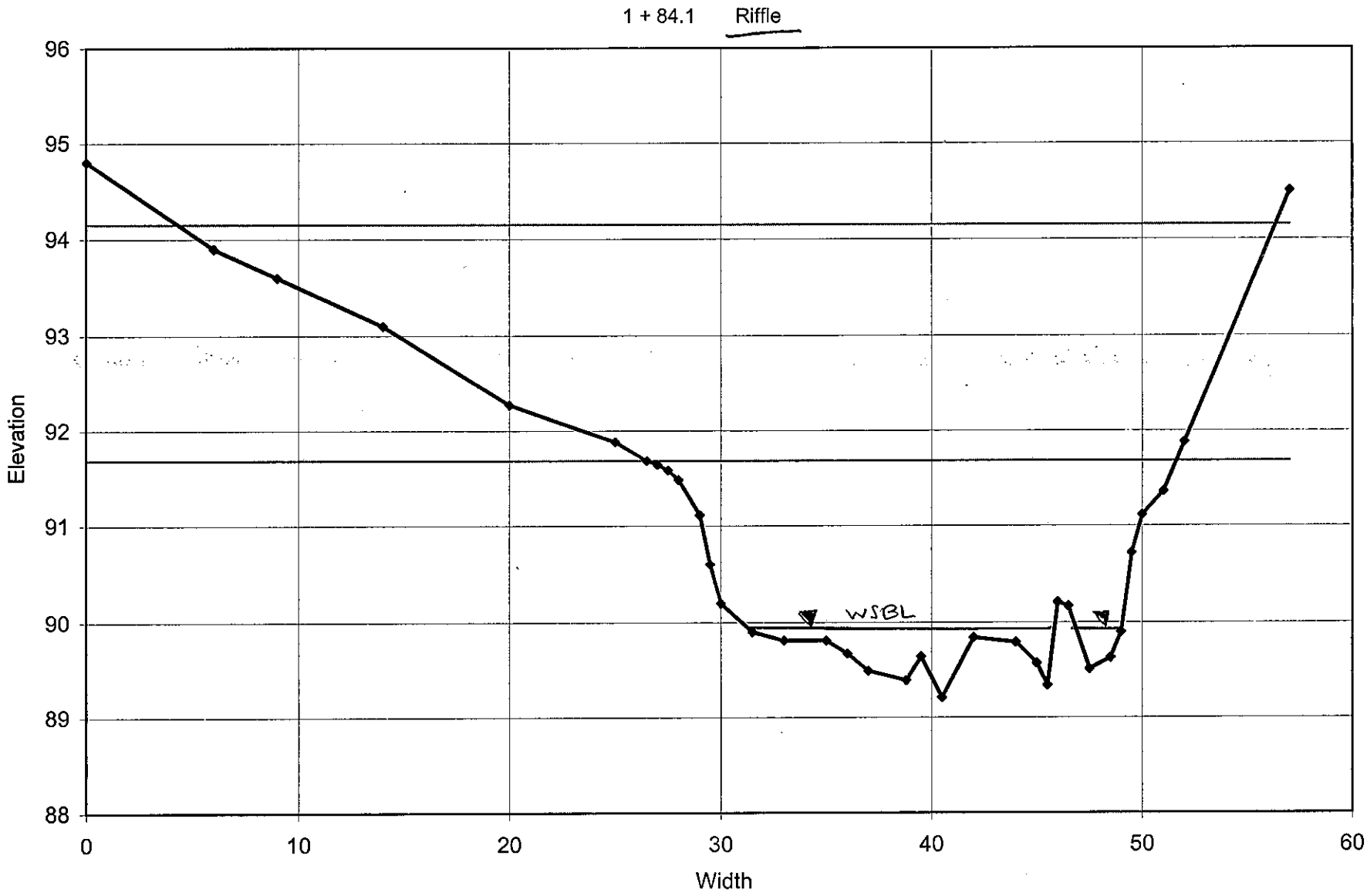
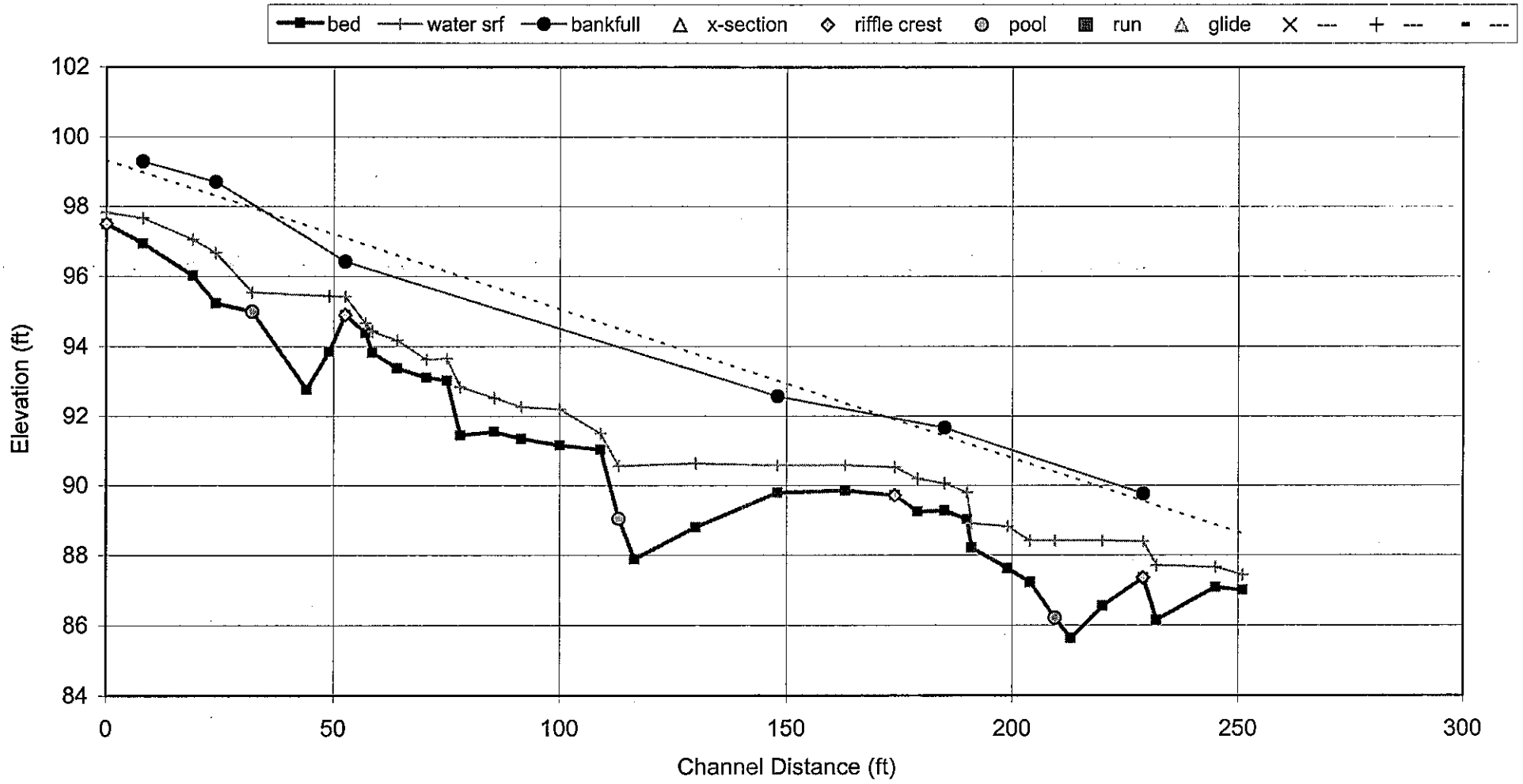
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