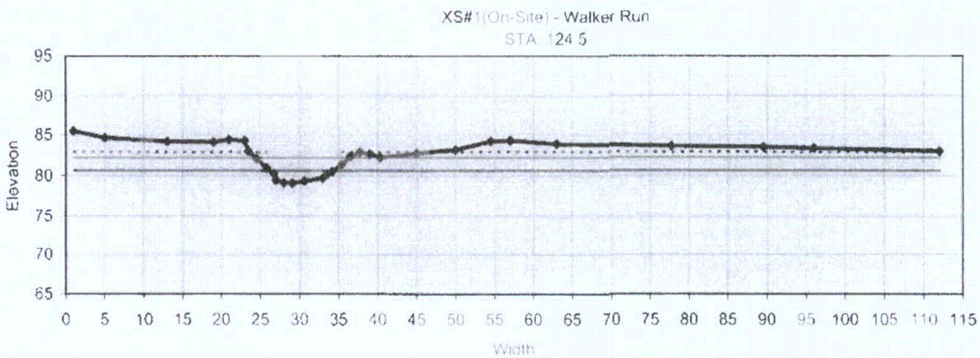
APPENDIX A

Geomorphic Plots of Channel Cross Sections and Longitudinal Profiles

On-Site Cross-Sections and Longitudinal Profile with Photo-documentation

Cross Section 1



Bankfull Dimensions

8.8	x-section area (ft.sq.)
8.2	width (ft)
1.1	mean depth (ft)
1.6	max depth (ft)
9.3	wetted parimeter (ft)
0.9	hyd radi (ft)
7.6	width-depth ratio

Flood Dimensions

12.0	W flood prone area (ft)
1.5	entrenchment ratio
3.8	low bank height (ft)
2.4	low bank height ratio

Materials

---	D50 (mm)
---	D84 (mm)
10	threshold grain size (mm).

Bankfull Flow

2.8	velocity (ft/s)
25.0	discharge rate (cfs)
0.51	Froude number

Flow Resistance

0.030	Manning's roughness
0.11	D'Arcy-Weisbach fric.
---	resistance factor u/u*
---	relative roughness

Forces & Power

0.35	channel slope (%)
0.21	shear stress (lb/sq ft.)
0.33	shear velocity (ft/s)
0.67	unit strm power (lb/ft/s)

Cross Section

reference ID	1	
instrument height	88.24	
longitudinal station	124.5	

Bankfull Stage

FS	7.6	= 80.64 elev
elevation		80.10

Low Bank Height

FS	5.33	= 82.91 elev
elevation		

Flood Prone Area

width fpa		12.0

Channel Slope

percent slope	0.35	0.37

Flow Resistance

Manning's "n"	0.03
D'Arcy - Weisbach "f"	

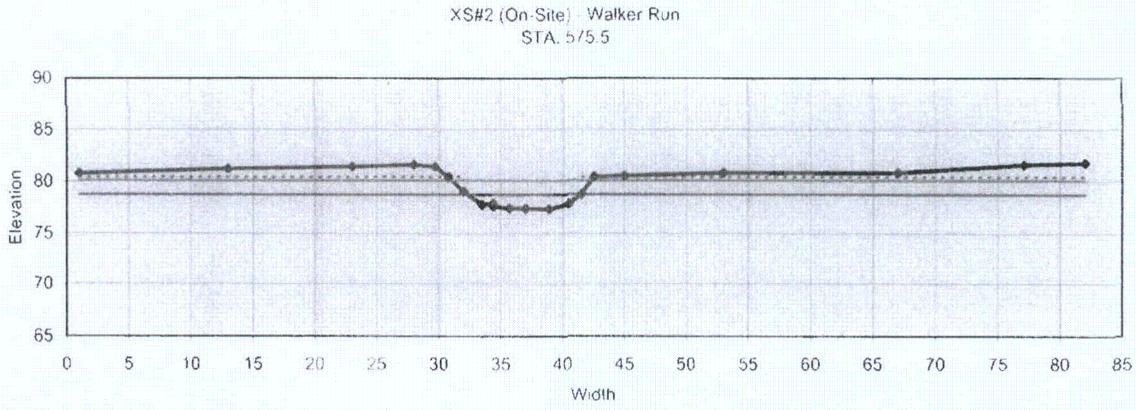
Note:

Distance (ft)	BS (ft)	HI (ft)	FS (ft)	Elevation (ft)	Omit Bkf	Notes
1		88.24	2.76	85.48		L Pin
5		88.24	3.59	84.65		
13		88.24	4.03	84.21		
19		88.24	4.1	84.14		
21		88.24	3.84	84.4		
23		88.24	3.94	84.3		LTOB
23.5		88.24	5.26	82.98		
24.5		88.24	6.13	82.11		
25.8		88.24	7.31	80.93		
26.7		88.24	7.98	80.26		LEW
27		88.24	8.78	79.46		
28		88.24	9.12	79.12		
29.1		88.24	9.17	79.07		
30.6		88.24	8.9	79.34		
33		88.24	8.56	79.68		
33.6		88.24	7.99	80.25		REW
34.2		88.24	7.71	80.53		
35.4		88.24	6.88	81.36		
36.5		88.24	5.91	82.33		
37.7		88.24	5.33	82.91		RTOB
39		88.24	5.61	82.63		
40.3		88.24	6.01	82.23		
45		88.24	5.5	82.74		
50		88.24	5.07	83.17		
54.5		88.24	4.02	84.22		
57		88.24	3.89	84.35		
63		88.24	4.34	83.9		
77.7		88.24	4.59	83.65		
89.5		88.24	4.69	83.55		R Pin
96		88.24	4.86	83.38		cornfield
112		88.24	5.21	83.03		


Cross section #1 looking upstream


Cross section #1 looking downstream

Cross Section 2



Bankfull Dimensions

9.4	x-section area (ft.sq.)
9.1	width (ft)
1.0	mean depth (ft)
1.3	max depth (ft)
10.1	wetted parimeter (ft)
0.9	hyd radi (ft)
8.9	width-depth ratio

Flood Dimensions

11.2	W flood prone area (ft)
1.2	entrenchment ratio
3.0	low bank height (ft)
2.3	low bank height ratio

Materials

---	D50 (mm)
---	D84 (mm)
10	threshold grain size (mm):

Bankfull Flow

2.8	velocity (ft/s)
26.1	discharge rate (cfs)
0.51	Froude number

Flow Resistance

0.030	Manning's roughness
0.11	D'Arcy-Weisbach fric.
---	resistance factor u/u*
---	relative roughness

Forces & Power

0.35	channel slope (%)
0.20	shear stress (lb/sq ft.)
0.32	shear velocity (ft/s)
0.62	unit strm power (lb/ft/s)

Cross Section

reference ID: 2
instrument height: 88.24
longitudinal station: 575.5

Bankfull Stage

FS: 9.5 = 78.74 elev
elevation: 78.57

Low Bank Height

FS: 7.81 = 80.43 elev
elevation:

Flood Prone Area

width fpa: 11.2

Channel Slope

percent slope: 0.35

Flow Resistance

Manning's "n": 0.03
D'Arcy - Weisbach "f":

Note:

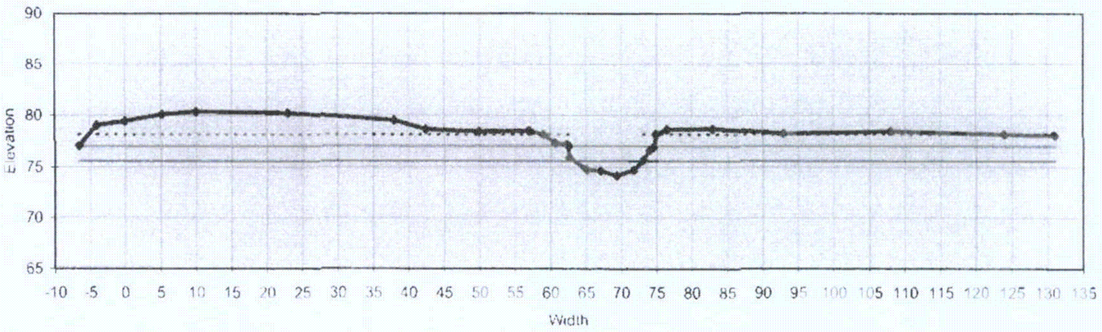
Distance (ft)	BS (ft)	HI (ft)	FS (ft)	Elevation (ft)	Omit Bkf	Notes
1		88.24	7.49	80.75		L Pin
13		88.24	7.04	81.2		
23		88.24	6.85	81.39		
28		88.24	6.64	81.6		
29.7		88.24	6.85	81.39		LTOB
30.8		88.24	7.85	80.39		
32		88.24	9.22	79.02		
33.5		88.24	10.46	77.78		
34.4		88.24	10.37	77.87		LEW
34.4		88.24	10.58	77.66		
35.7		88.24	10.79	77.45		
37		88.24	10.82	77.42		
38.9		88.24	10.85	77.39		
40.5		88.24	10.37	77.87		REW
41.5		88.24	9.47	78.77		
42.5		88.24	7.81	80.43		RTOB
45		88.24	7.71	80.53		
53		88.24	7.42	80.82		
67		88.24	7.42	80.82		
77.1		88.24	6.67	81.57		R Pin
82		88.24	6.46	81.78		

Cross section #2 looking upstream

Cross section #2 looking downstream

Cross Section 3

XS#3 (On-Site) - Walker Run
STA. 1171.6



Bankfull Dimensions

8.7	x-section area (ft sq.)
9.7	width (ft)
0.9	mean depth (ft)
1.4	max depth (ft)
10.3	wetted parimeter (ft)
0.8	hyd radi (ft)
10.9	width-depth ratio

Flood Dimensions

12.1	W flood prone area (ft)
1.2	entrenchment ratio
4.0	low bank height (ft)
2.8	low bank height ratio

Materials

---	D50 (mm)
-	D84 (mm)
10	threshold grain size (mm)

Bankfull Flow

2.7	velocity (ft/s)
23.4	discharge rate (cfs)
0.52	Froude number

Flow Resistance

0.030	Manning's roughness
0.11	D'Arcy-Weisbach fric
---	resistance factor u/u*
---	relative roughness

Forces & Power

0.37	channel slope (%)
0.19	shear stress (lb/sq ft.)
0.32	shear velocity (ft/s)
0.56	unit strm power (lb/ft/s)

Cross Section

reference ID	3	
instrument height	89.09	
longitudinal station	1171.6	

Bankfull Stage

FS	13.5	= 75.59 elev
elevation		76.55

Low Bank Height

FS	10.92	= 78.17 elev
elevation		

Flood Prone Area

width fpa		12.1

Channel Slope

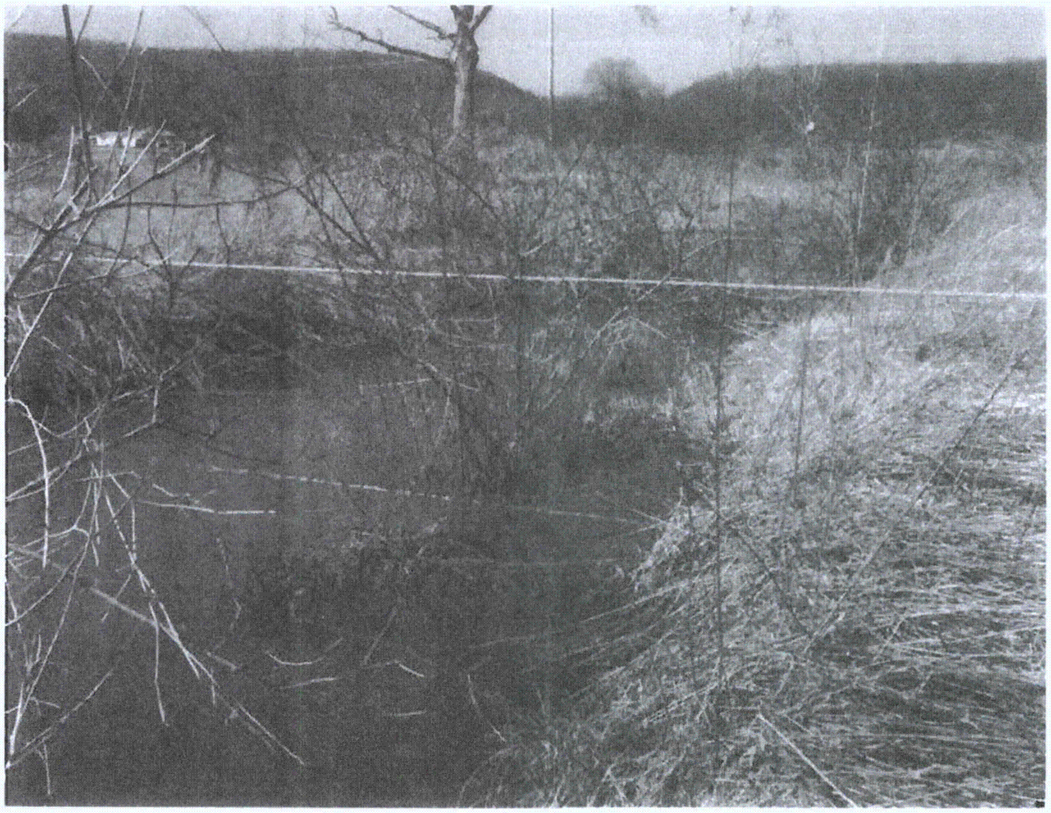
percent slope	0.37	0.37

Flow Resistance

Manning's "n"	0.03
D'Arcy - Weisbach "f"	

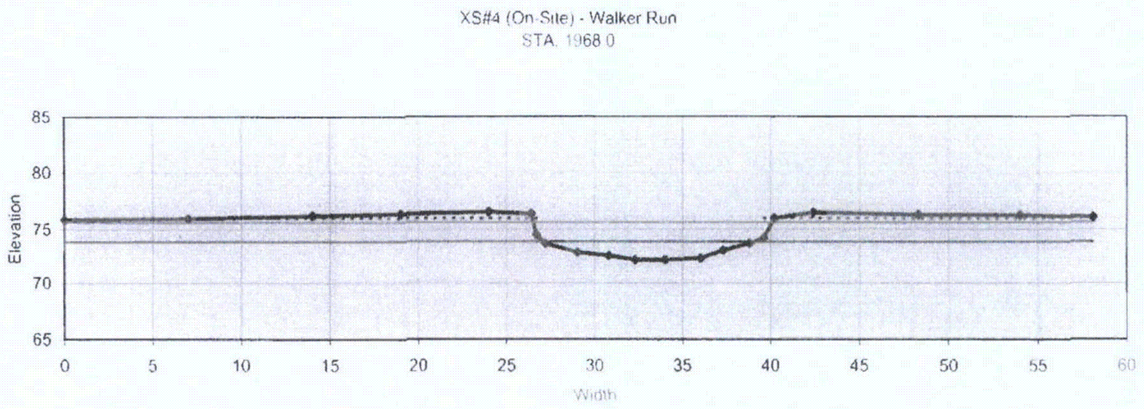
Note:

Distance (ft)	BS (ft)	HI (ft)	FS (ft)	Elevation (ft)	Omit Bkf	Notes
-6.6		89.09	12.03	77.06		Pond WS
-4		89.09	10.04	79.05		
0		89.09	9.65	79.44		
5.2		89.09	9	80.09		L Pin
10		89.09	8.72	80.37		
23		89.09	8.83	80.26		
38		89.09	9.58	79.51		
42.5		89.09	10.4	78.69		
50		89.09	10.62	78.47		
57		89.09	10.57	78.52		
59		89.09	10.92	78.17		
60.6		89.09	11.73	77.36		LBKFL?
62.2		89.09	11.9	77.19		
62.4		89.09	12.01	77.08		LEW
62.6		89.09	13.18	75.91		
65		89.09	14.35	74.74		
67		89.09	14.47	74.62		
69.3		89.09	14.93	74.16		
71.7		89.09	14.4	74.69		
73.1		89.09	13.42	75.67		
74		89.09	12.42	76.67		
74.5		89.09	12.12	76.97		REW
75		89.09	10.88	78.21		RTOB
76.5		89.09	10.4	78.69		
83		89.09	10.34	78.75		
93		89.09	10.81	78.28		
108		89.09	10.6	78.49		
124		89.09	10.9	78.19		
131		89.09	11	78.09		R Pin


Cross section #3 looking upstream


Cross section #3 looking downstream

Cross Section 4



Bankfull Dimensions

14.2	x-section area (ft.sq.)
12.0	width (ft)
1.2	mean depth (ft)
1.7	max depth (ft)
12.8	wetted parimeter (ft)
1.1	hyd radi (ft)
10.2	width-depth ratio

Flood Dimensions

13.6	W flood prone area (ft)
1.1	entrenchment ratio
3.8	low bank height (ft)
2.2	low bank height ratio

Materials

---	D50 (mm)
---	D84 (mm)
12	threshold grain size (mm):

Bankfull Flow

3.1	velocity (ft/s)
44.6	discharge rate (cfs)
0.53	Froude number

Flow Resistance

0.030	Manning's roughness
0.10	D'Arcy-Weisbach fric.
---	resistance factor u/u*
---	relative roughness

Forces & Power

0.35	channel slope (%)
0.24	shear stress (lb/sq.ft.)
0.35	shear velocity (ft/s)
0.81	unit strm power (lb/ft/s)

Cross Section

reference ID	4	
instrument height	80.77	---
longitudinal station	1968	---

Bankfull Stage

FS	6.9	= 73.87 elev
elevation		73.85

Low Bank Height

FS	4.8	= 75.97 ele
elevation		

Flood Prone Area

width fpa		13.6

Channel Slope

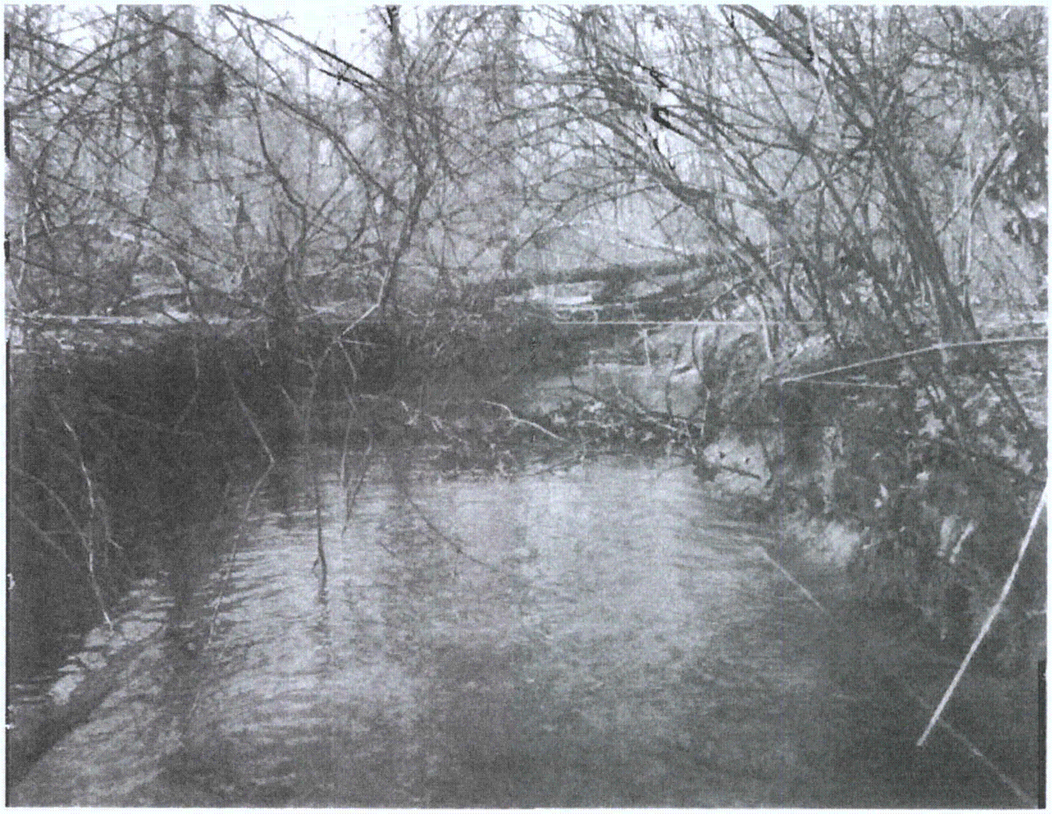
percent slope	0.35	0.34

Flow Resistance

Manning's "n"	0.03	---
D'Arcy - Weisbach "f"		---

Note:

Distance (ft)	BS (ft)	HI (ft)	FS (ft)	Elevation (ft)	Omit Bkf	Notes
0		80.77	4.91	75.86		L Pin
7		80.77	4.83	75.94		
14		80.77	4.57	76.2		
19		80.77	4.4	76.37		
24		80.77	4.23	76.54		
26.4		80.77	4.39	76.38		LTOB
26.7		80.77	6.33	74.44		
27.2		80.77	7.1	73.67		LEW
29		80.77	7.92	72.85		
30.8		80.77	8.24	72.53		
32.3		80.77	8.63	72.14		
34		80.77	8.62	72.15		
36		80.77	8.49	72.28		
37.3		80.77	7.76	73.01		
38.8		80.77	7.07	73.7		REW
39.6		80.77	6.6	74.17		
40.2		80.77	4.8	75.97		RTOB
42.4		80.77	4.29	76.48		
48.3		80.77	4.5	76.27		
54		80.77	4.51	76.26		
58.1		80.77	4.67	76.1		R Pin

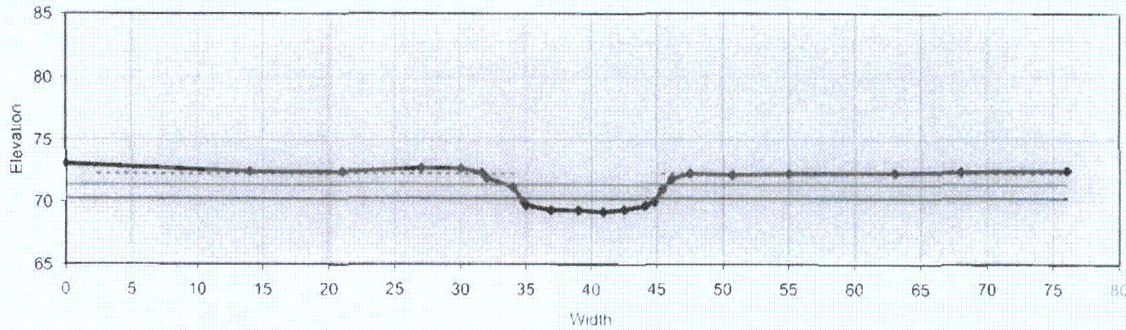


Cross section #4 looking upstream

Cross section #4 looking downstream

Cross Section 5

XS#5 (On-Site) - Walker Run
Station 3075.2



Bankfull Dimensions	
8.5	x-section area (ft.sq.)
10.4	width (ft)
0.8	mean depth (ft)
1.1	max depth (ft)
10.9	wetted parimeter (ft)
0.8	hyd radi (ft)
12.6	width-depth ratio

Flood Dimensions	
12.2	W flood prone area (ft)
1.2	entrenchment ratio
3.0	low bank height (ft)
2.8	low bank height ratio

Materials	
---	D50 (mm)
---	D84 (mm)
8	threshold grain size (mm)

Bankfull Flow	
2.5	velocity (ft/s)
21.1	discharge rate (cfs)
0.50	Froude number

Flow Resistance	
0.030	Manning's roughness
0.1[illegible]	D'Arcy-Weisbach fnc
---	resistance factor u/u*
---	relative roughness

Forces & Power	
0.35	channel slope (%)
0.17	shear stress (lb/sq.ft.)
0.30	shear velocity (ft/s)
0.44	unit strm power (lb/ft/s)

Cross Section

reference ID	5	
instrument height	79.67	---
longitudinal station	3075.2	---

Bankfull Stage

FS	9.4	= 70.27 elev
elevation		70.09

Low Bank Height

FS	7.44	= 72.23 elev
elevation		

Flood Prone Area

width fpa		12.2

Channel Slope

percent slope	0.35	0.37

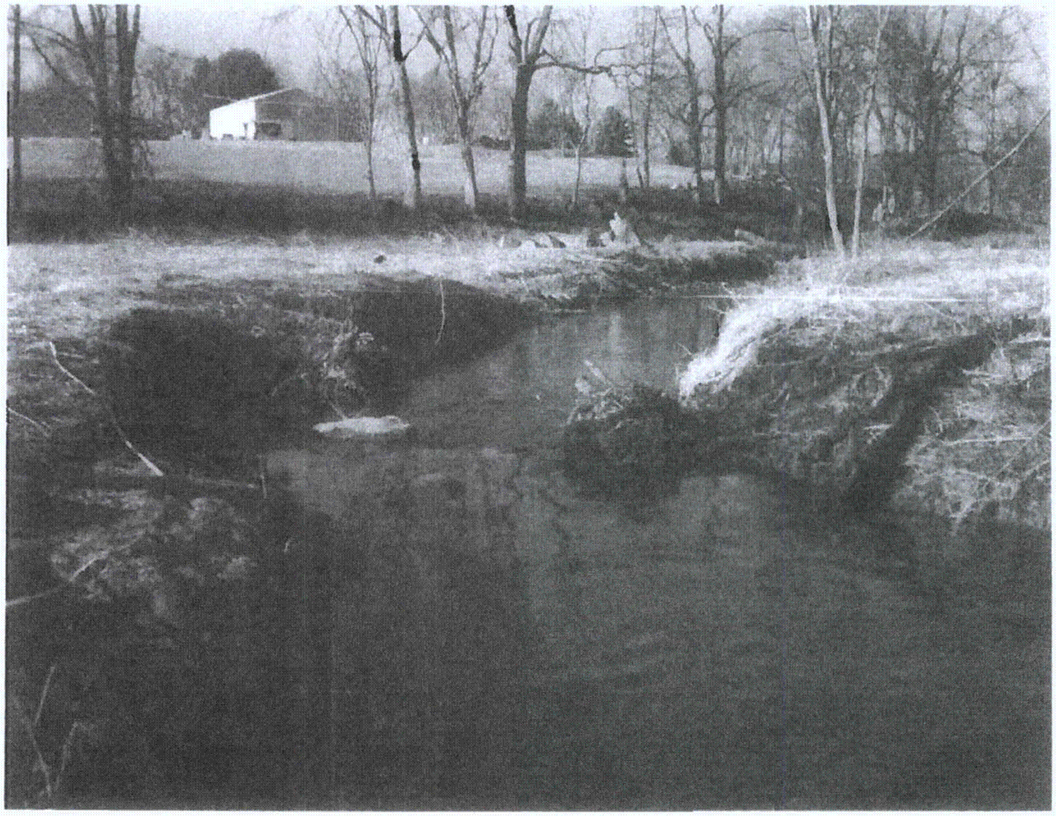
Flow Resistance

Manning's "n"	0.03	---
D'Arcy - Weisbach "f"		---

Note:

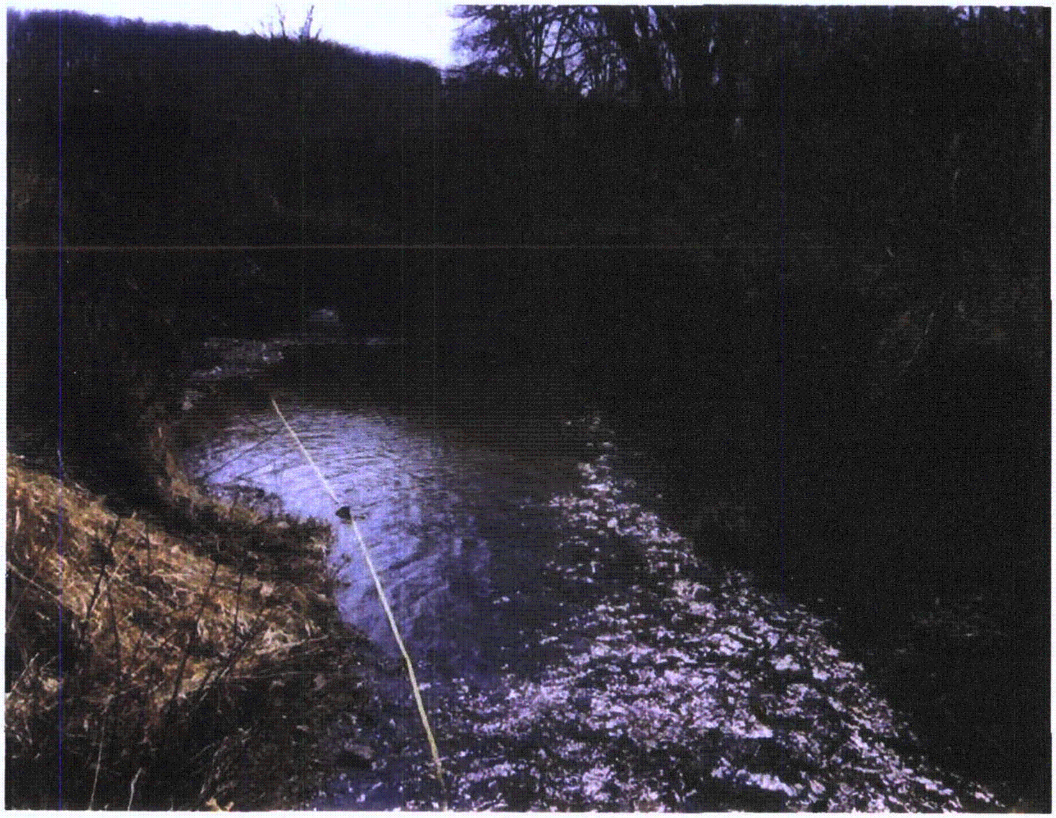
Distance (ft)	BS (ft)	HI (ft)	FS (ft)	Elevation (ft)	Omit Bkf	Notes
0		79.67	6.66	73.01		LB Pin
14		79.67	7.28	72.39		
21		79.67	7.31	72.36		
27		79.67	6.99	72.68		
30		79.67	7.03	72.64		LTOB
31.6		79.67	7.36	72.31		
32		79.67	7.77	71.9		
34		79.67	8.5	71.17		
34.8		79.67	9.66	70.01		LEOW
35		79.67	9.94	69.73		
36.9		79.67	10.33	69.34		
39		79.67	10.34	69.33		
40.9		79.67	10.48	69.19		
42.5		79.67	10.29	69.38		
44.1		79.67	10	69.67		
44.8		79.67	9.69	69.98		
45.4		79.67	8.72	70.95		
46.1		79.67	7.87	71.8		RTOB
47.5		79.67	7.44	72.23		
50.7		79.67	7.55	72.12		
55		79.67	7.42	72.25		
63		79.67	7.4	72.27		
68		79.67	7.31	72.36		
76		79.67	7.21	72.46		


Cross section #5 looking upstream

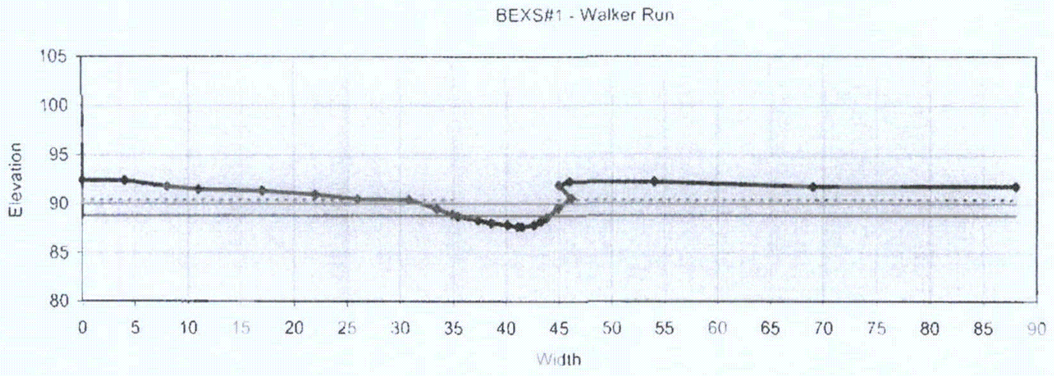

Cross section #5 looking downstream

Bank Erosion Cross-Sections and Longitudinal Profiles with Photo-documentation


Bank erosion cross section #1 looking upstream


Bank erosion cross section #1 looking downstream

Cross Section 1



Bankfull Dimensions	
6.0	x-section area (ft.sq.)
8.9	width (ft)
0.7	mean depth (ft)
1.2	max depth (ft)
9.3	wetted parimeter (ft)
0.6	hyd radi (ft)
13.0	width-depth ratio

Flood Dimensions	
13.4	W flood prone area (ft)
1.5	entrenchment ratio
2.8	low bank height (ft)
2.4	low bank height ratio

Materials	
---	D50 (mm)
---	D84 (mm)
16	threshold grain size (mm)

Bankfull Flow	
3.3	velocity (ft/s)
20.1	discharge rate (cfs)
0.73	Froude number

Flow Resistance	
0.030	Manning's roughness
0.12	D'Arcy-Weisbach fric.
---	resistance factor u/u*
---	relative roughness

Forces & Power	
0.8	channel slope (%)
0.32	shear stress (lb/sq.ft.)
0.41	shear velocity (ft/s)
1.13	unit strm power (lb/ft/s)

Cross Section

reference ID	1	
instrument height	100	
longitudinal station	96 BEXS1	---

Bankfull Stage

FS	11.15	= 88.85 elev
elevation		#VALUE!

Low Bank Height

FS	9.56	= 90.44 elev
elevation		

Flood Prone Area

width fpa		13.4

Channel Slope

percent slope	0.8	1.5

Flow Resistance

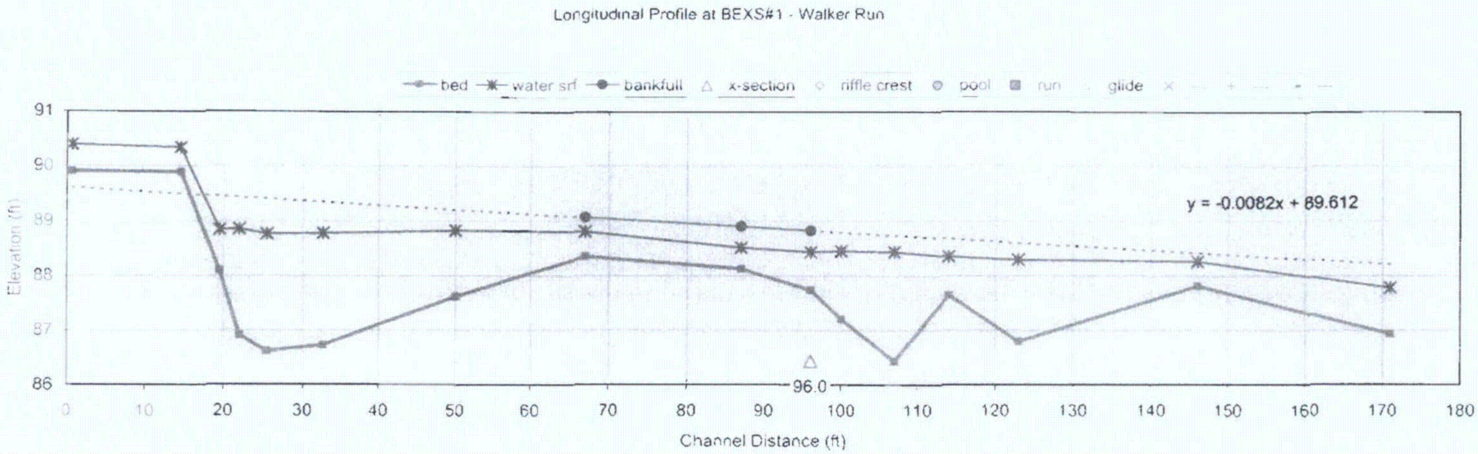
Manning's "n"	0.03	
D'Arcy - Weisbach "f"		

Note:

BP = Bank Pin; shot in control point along road between yield sign and bridge (HR=1.80'; elev.=98.20')

Distance (ft)	BS (ft)	HI (ft)	FS (ft)	Elevation (ft)	Omit Bkf	Notes
0		100	7.58	92.42		L Pin
4		100	7.55	92.45		
8		100	8.18	91.82		
11		100	8.47	91.53		
17		100	8.64	91.36		
22		100	8.98	91.02		
26		100	9.48	90.52		
30.8		100	9.56	90.44		LTOB
33.4		100	10.44	89.56		
34.9		100	11.04	88.96		LBKFL
35.4		100	11.24	88.76		LEW
37.3		100	11.61	88.39		
38.6		100	11.9	88.1		
40.1		100	12.12	87.88		
41.1		100	12.27	87.73		Thalweg
41.5		100	12.32	87.68		
42.6		100	12.11	87.89		R Toe
43.3		100	11.71	88.29		REW
43.8		100	11.35	88.65		BP (bot.)
44.9		100	10.38	89.62		BP (mid.)
46.15		100	9.37	90.63		BP (top)
45		100	8.05	91.95		RTOB
46		100	7.69	92.31		
54		100	7.69	92.31		
69		100	8.21	91.79		
88		100	8.19	91.81		R Pin

Longitudinal Slope Profile



	slope (%)	slope ratio	length (ft)	length ratio	pool-pool spacing (ft)	p-p ratio
reach	1.5	---	171.0 (15.3 channel widths)	---	---	---
riffle	---	---	---	---	---	---
pool	---	---	---	---	---	---
	---	---	---	---	---	---
	---	---	---	---	---	---

notes	cross section ID	bed feature	station	station	Benchmark Elevation 100 / Turning Points: BS	HI	FS	FS bed	water	FS bankfull	user defined: FS	FS	FS	azimuth AZ	ELEV bed	ELEV water srf	ELEV bankfull	ELEV ---	ELEV ---	ELEV ---
back sight to benchmark					0	100														
bridge invert (u/s)			0.7			100		10.1	0.49						89.9	90.39				
			14.5			100		10.11	0.45						89.89	90.34				
bridge invert (d/s)			19.5			100		11.91	0.75						88.09	88.84				
			22			100		13.09	1.94						86.91	88.85				
			25.5			100		13.39	2.15						86.61	88.76				
gas line (above ground)			32.6			100		13.28	2.05						86.72	88.77				
			50			100		12.39	1.21						87.61	88.82				
Begin Study Bank			67			100		11.66	0.46	10.94					88.34	88.8	89.06			
			87			100		11.88	0.39	11.1					88.12	88.51	88.9			
BEXS#1	BEXS1		96			100		12.27	0.7	11.18					87.73	88.43	88.82			
			100			100		12.8	1.25						87.2	88.45				
			107			100		13.57	2						86.43	88.43				
			114			100		12.36	0.71						87.64	88.35				
End Study Bank			123			100		13.21	1.5						86.79	88.29				
HOR			146			100		12.19	0.45						87.81	88.26				
TOR			171			100		13.07	0.85						86.93	87.78				
						100														

Bank Erosion Prediction

Stream	Cross Section	Date
Walker Run	BExs # 1	3/18 09

5520 ft³

Near Bank Stress Rating

Mean Shear Stress	
Bankfull Hydraulic Radius (ft) R	0.6
Water Surface Facet Slope (ft/ft) S	0.007
Shear Stress (lb/ft²) $\tau = \gamma RS$ γ=62.4lb/ft³	0.26

Near Bank Shear Stress	
Bankfull Hydraulic Radius (ft) R (near bank 1/3)	1.3
Near Bank Water Surface Slope (ft/ft) S	0.004
Shear Stress (lb/ft²) τ near bank= γRS	0.32

Near Bank Stress/ Mean Shear Stress (τ near bank/τ)	123

Conversion of Numerical Indices to Adjective Ratings

Near Bank Stress Rating	Near Bank Stress/Mean Shear Stress
Very Low	<0.8
Low	0.8 - 1.05
Moderate	1.06 - 1.14
High	1.15 - 1.19
Very High	1.2 - 1.6
Extreme	>1.6
Near Bank Stress Rating	Very High

Stream Bank Erodibility Rating

BEHI Rating	High

Bank Erosion Prediction at Cross Section

A	B	C	D
Lateral Erosion at Cross Section (feet/year)	Bank Height (feet)	Length of Bank (feet)	Predicted Erosion feet³
1.75	4.06	1	5.07 ft³/yr

Circle graph used: Colorado Yellowstone

Column A:	Use Stream Bank Erodibility Rating and Near Bank Stress Rating in conjunction with Figure 6-27 in Rosgen, 1996.
Column B:	Study Bank Height (Use Cross Section Plot: top of bank - toe of bank)
Column C:	Input 1 foot for point erosion @ cross section
Column D:	Columns A*B*C

BEHI Variable Worksheet

Stream: Walker Run	Cross Section: BEXS#1	Date: 3/18/09	Observers: BRU, EPJ

Bank Height/Max Depth Bankfull (C)

Highest Bank Height (ft)	4.27 A	Max Bankfull Depth (ft)	1.3 B	A/B	3.28 C

Root Depth/Bank Height (F)

Root Depth (ft)	1.0 D	Study Bank Height (ft)	4.06 E	D/E	0.251 F

Weighted Root Density (H)

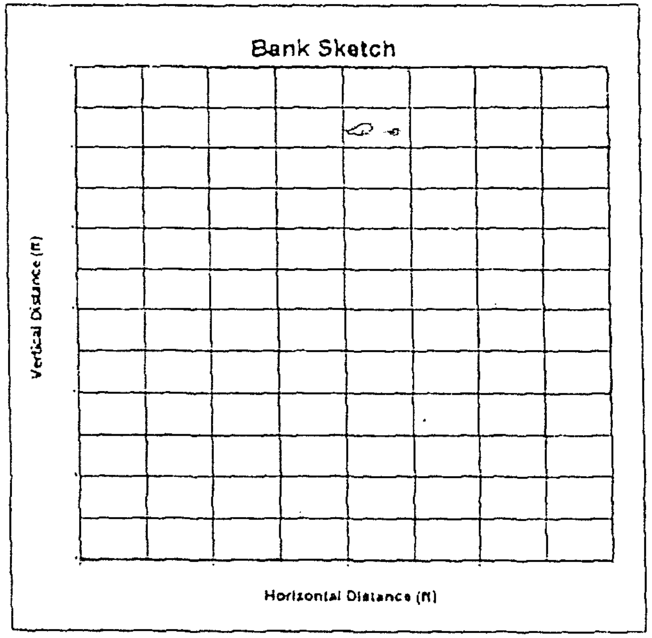
Root Density (%)	< 5% G	G*F	1.25 H

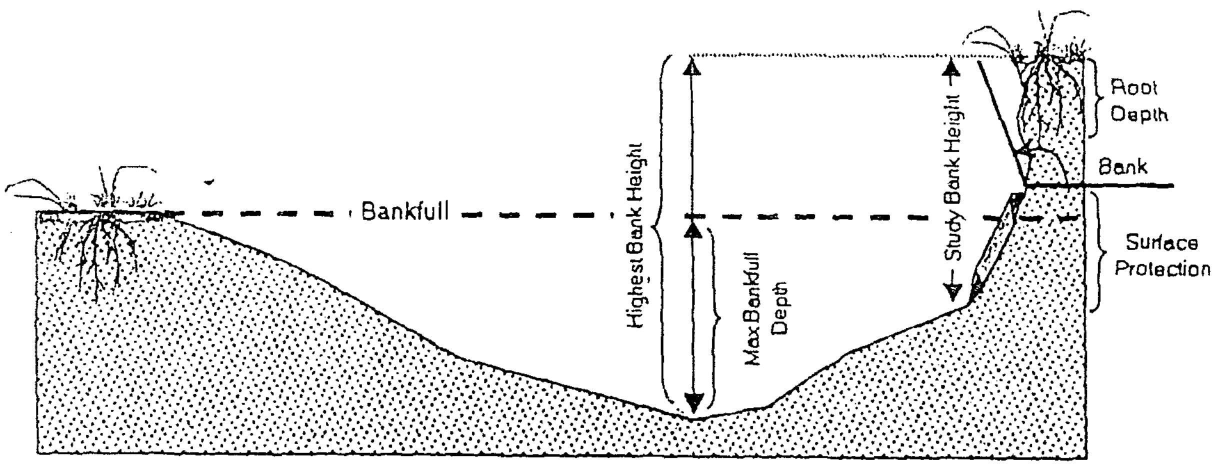
Bank Angle (I)

Bank Angle (Degrees)	75° I

Weighted Surface Protection (K)

Height of Bank Protection (ft)	0.5 J	J/E	0.15 K





Bank Erodibility Hazard Rating Guide

Stream Walker Run Reach BEXS # Date 3/18/09 Crew BRU, EPS

Bank Erosion Potential	Bank Height (ft): / Bankfull Height (ft):		Bank Height/ Bankfull Ht	Root Depth/ Bank Height	Root Density %	Bank Angle (Degrees)	Surface Protection%
	VERY LOW	Value	1.0-1.1	1.0-0.9	100-80	0-20	100-80
		Index	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9
		Choice	V: I:	V: I:	V: I:	V: I:	V: I:
	LOW	Value	1.11-1.19	0.89-0.5	79-55	21-60	79-55
		Index	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9
		Choice	V: I:	V: I:	V: I:	V: I:	V: I:
	MODERATE	Value	1.2-1.5	0.49-0.3	54-30	61-80	54-30
		Index	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9
		Choice	V: I:	V: I:	V: I:	V: 75 I: 5.5	V: I:
	HIGH	Value	1.6-2.0	0.29-0.15	29-15	81-90	29-15
		Index	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9
		Choice	V: I:	V: 0.25 I: 7	V: I:	V: I:	V: 15 I: 7.9
	VERY HIGH	Value	2.1-2.8	0.14-0.05	14-5.0	91-119	14-10
		Index	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0
		Choice	V: I:	V: I:	V: 5% I: 9	V: I:	V: I:
	EXTREME	Value	>2.8	<0.05	<5	>119	<10
		Index	10	10	10	10	10
		Choice	V: 3.78 I: 10	V: I:	V: I:	V: I:	V: I:
	V = value, I = index					SUB-TOTAL (Sum one index from each column)	39.4

Bank Material Description:

Bank Materials

- Bedrock (Bedrock banks have very low bank erosion potential)
- Boulders (Banks composed of boulders have low bank erosion potential)
- Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)
- Sand (Add 10 points)
- Silt Clay (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT 0

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT 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

Bank location description (circle one)

Straight Reach Outside of Bend

GRAND TOTAL BEHI RATING 39.4

Table 1. Documentation of ratios and derived values for near-bank stress

Stream: Location: Date: Crew:

Method 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 (See NBS #1). NBS = Extreme						
Method 2	Radius of Curvature Rc (feet)	Bankfull Width W_{bkf} (feet)	Ratio Rc/W	Method 3	Pool Slope S_p	Average Slope S	Ratio S_p/S
Method 4	Pool Slope S_p	Riffle Slope S_{rif}	Ratio S_p/S_{rif}	Method 5	Near-Bank Max Depth d_{nb} (feet)	Mean Depth d (feet)	Ratio d_{nb}/d
Method 6	Near-Bank Max Depth d_{nb} (feet)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d (feet)	Average Slope S	Bankfull Shear Stress τ (lb/ft^2)	Ratio τ_{nb}/τ
	1.3	0.004	0.32	0.6	0.007	0.26	1.23
Method 7	Velocity Gradient						

Table 2. Converting Ratio Values to an Overall Near-Bank Stress Rating

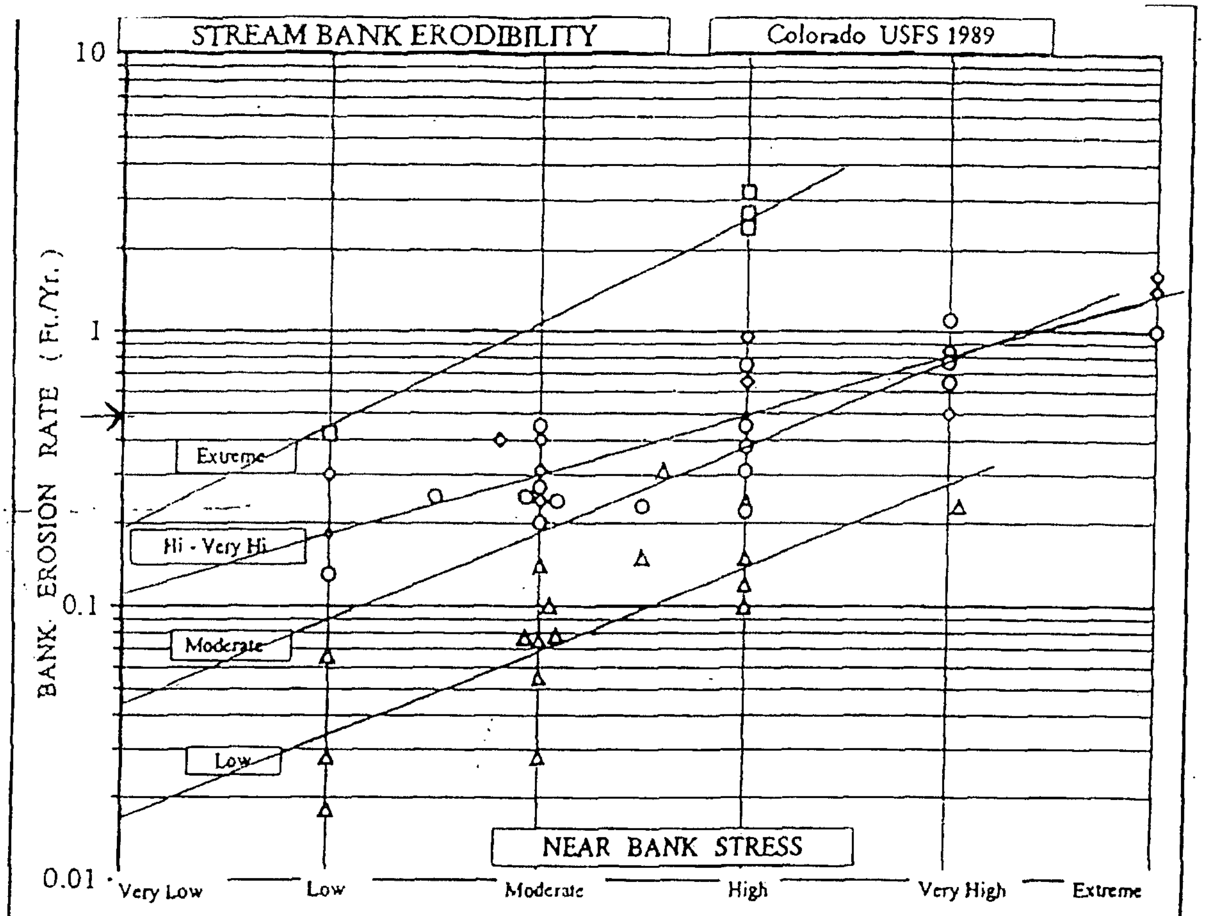
Method Number	1	2	3	4	5	6	7
Rating*							
Very Low	N/A	>3.0	< 0.20	< 0.4	<1.0	<0.8	<1.0
Low	N/A	2.21 - 3.0	0.20 - 0.40	0.41 - 0.60	1.0 - 1.5	0.8 - 1.05	1.0 - 1.2
Moderate	N/A	2.01 - 2.2	0.41 - 0.60	0.61 - 0.80	1.51 - 1.8	1.06 - 1.14	1.21 - 1.6
High	See (1) Above	1.81 - 2.0	0.61 - 0.80	0.81 - 1.0	1.81 - 2.5	1.15 - 1.19	1.61 - 2.0
Very High	See (1) Above	1.5 - 1.8	0.81 - 1.0	1.01 - 1.2	2.51 - 3.0	1.20 - 1.60	2.01 - 2.3
Extreme	See (1) Above	< 1.5	> 1.0	> 1.2	> 3.0	> 1.6	> 2.3

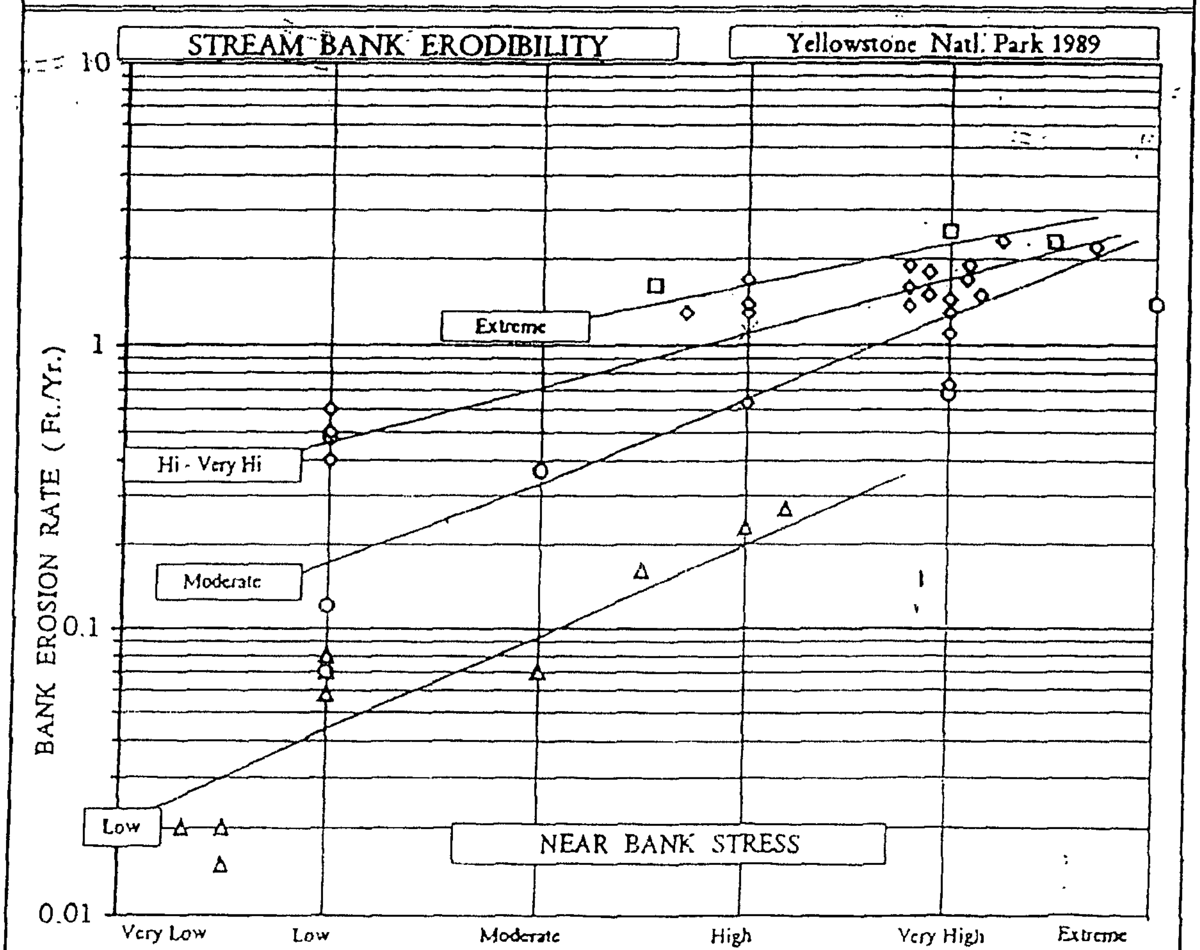
*Circle the dominant near-bank stress rating selected.

Methods for Estimating Near-Bank Stress

1. Transverse bar or split channel/central bar creating NBS/high velocity gradient: Level I - Reconnaissance.
2. Channel pattern (Rc/W): 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}). Near bank = 1/3 of channel width at study site. Level III - Detailed Prediction
7. Velocity profiles/Isovels/Velocity gradient: Level IV - Validation.

Note: Only select the method(s) appropriate for level of assessment and site conditions. It is not necessary to select all methods to obtain an average near-bank stress rating.

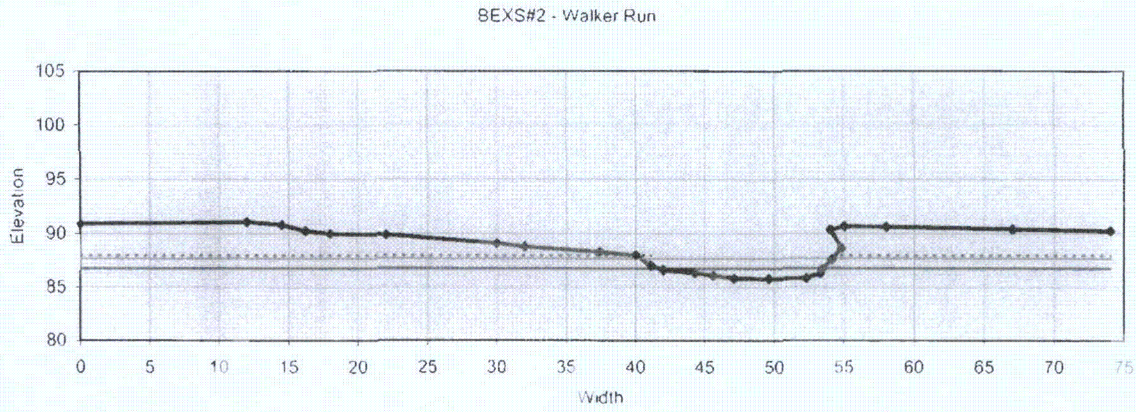

STREAM BANK ERODIBILITY
Colorado USFS 1989
BANK EROSION RATE (Ft./Yr.)
10
1
0.1
0.01
Extreme
Hi - Very Hi
Moderate
Low
NEAR BANK STRESS
Very Low
Low
Moderate
High
Very High
Extreme


STREAM BANK ERODIBILITY
Yellowstone Natl. Park 1989
BANK EROSION RATE (Ft./Yr.)
10
1
0.1
0.01
Extreme
Hi - Very Hi
Moderate
Low
NEAR BANK STRESS
Very Low
Low
Moderate
High
Very High
Extreme

Bank erosion cross section #2 looking upstream

Bank Erosion cross section #2 looking downstream

Cross Section 2



Bankfull Dimensions

7.7	x-section area (ft.sq.)
11.7	width (ft)
0.7	mean depth (ft)
0.9	max depth (ft)
12.2	wetted parimeter (ft)
0.6	hyd radi (ft)
17.8	width-depth ratio

Flood Dimensions

13.8	W flood prone area (ft)
1.2	entrenchment ratio
2.1	low bank height (ft)
2.3	low bank height ratio

Materials

---	D50 (mm)
---	D84 (mm)
14	threshold grain size (mm):

Bankfull Flow

3.1	velocity (ft/s)
23.8	discharge rate (cfs)
0.69	Froude number

Flow Resistance

0.030	Manning's roughness
0.12	D'Arcy-Weisbach fric.
---	resistance factor u/u*
---	relative roughness

Forces & Power

0.72	channel slope (%)
0.28	shear stress (lb/sq.ft.)
0.38	shear velocity (ft/s)
0.92	unit strm power (lb/ft/s)

Cross Section

reference ID: 2
instrument height: 95.7
longitudinal station: 104 BEXS2 ---

Bankfull Stage

FS: 9 = 86.7 elev
elevation: #VALUE!

Low Bank Height

FS: 7.79 = 87.91 elev
elevation:

Flood Prone Area

width fpa: 13.8

Channel Slope

percent slope: 0.72 1.5

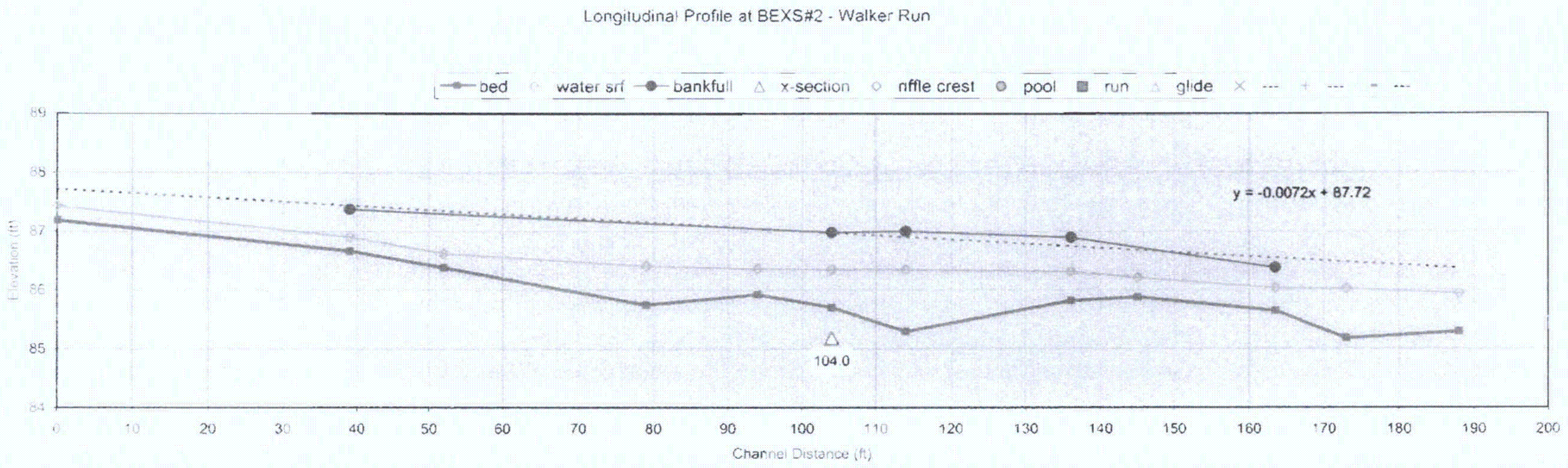
Flow Resistance

Manning's "n": 0.03
D'Arcy - Weisbach "f":

Note:
Used BM3 (elev.=94.66') as TP; got FS HR=1.04 therefore HI=95.70'.

Distance (ft)	BS (ft)	HI (ft)	FS (ft)	Elevation (ft)	Omit Bkf	Notes
0		95.7	4.82	90.88	☐	L Pin
12		95.7	4.64	91.06	☐	
14.5		95.7	4.91	90.79	☐	
16.2		95.7	5.49	90.21	☐	
18		95.7	5.75	89.95	☐	
22		95.7	5.82	89.88	☐	
30		95.7	6.67	89.03	☐	
32		95.7	6.99	88.71	☐	
37.4		95.7	7.45	88.25	☐	
40		95.7	7.79	87.91	☐	LTOB
41.1		95.7	8.72	86.98	☐	LBKFL?
42		95.7	9.1	86.6	☐	
44.3		95.7	9.38	86.32	☐	LEW
45.6		95.7	9.62	86.08	☐	
47.1		95.7	9.89	85.81	☐	
49.6		95.7	9.92	85.78	☐	
52.3		95.7	9.86	85.84	☐	R Toe
53.3		95.7	9.41	86.29	☐	REW
53.4		95.7	9.04	86.66	☐	BP (bot.)
54.1		95.7	8.16	87.54	☐	BP (mid.)
54.8		95.7	7.11	88.59	☐	BP (top)
54		95.7	5.35	90.35	☐	RTOB
55		95.7	5.05	90.65	☐	
58		95.7	5.1	90.6	☐	
67		95.7	5.31	90.39	☐	
74		95.7	5.48	90.22	☐	R Pin
					☐	
					☐	

Longitudinal Slope Profile



	slope (%)	slope ratio	length (ft)	length ratio	pool-pool spacing (ft)	p-p ratio
reach	0.79	---	188.0 (16.9 channel widths)	---	---	---
riffle	---	---	---	---	---	---
pool	---	---	---	---	---	---
	---	---	---	---	---	---
	---	---	---	---	---	---

notes	cross section ID	bed feature	station	station	Benchmark Elevation 95.7 / Turning Points BS	HI	FS	FS bed	water	FS bankfull	user defined FS	FS	FS	azimuth AZ	ELEV bed	ELEV water srf	ELEV bankfull	ELEV ---	ELEV ---	ELEV ---
back sight to benchmark					0	95.7														
			0			95.7		8.52	0.25						87.18	87.43				
			39			95.7		9.04	0.24	8.33					86.66	86.9	87.37			
Begin Study Bank			52			95.7		9.32	0.24						86.38	86.62				
			79			95.7		9.96	0.67						85.74	86.41				
			94			95.7		9.78	0.44						85.92	86.36				
BEXS#2	BEXS2		104			95.7		10	0.65	8.72					85.7	86.35	86.98			
			114			95.7		10.41	1.06	8.7					85.29	86.35	87			
			136			95.7		9.88	0.49	8.81					85.82	86.31	86.89			
End Study Bank			145			95.7		9.82	0.33						85.88	86.21				
			163.5			95.7		10.05	0.38	9.32					85.65	86.03	86.38			
			173			95.7		10.52	0.84						85.18	86.02				
buried log exposed (right)			188			95.7		10.41	0.65						85.29	85.94				

Bank Erosion Prediction

Stream	Cross Section	Date
Walker Run	BEXS # 2	3/18/09

Near Bank Stress Rating

Mean Shear Stress	
Bankfull Hydraulic Radius (ft) R	1.6
Water Surface Facet Slope (ft/ft) S	0.008
Shear Stress (lb/ft^2) $\tau = \gamma RS$ $\gamma = 62.4 lb/ft^3$	0.29

Near Bank Shear Stress	
Bankfull Hydraulic Radius (ft) R (near bank 1/3)	0.9
Near Bank Water Surface Slope (ft/ft) S	0.005
Shear Stress (lb/ft^2) τ near bank= γRS	0.28
Near Bank Stress/ Mean Shear Stress (τ near bank/τ)	0.96

Conversion of Numerical Indices to Adjective Ratings

Near Bank Stress Rating	Near Bank Stress/Mean Shear Stress
Very Low	<0.8
Low	0.8 - 1.05
Moderate	1.06 - 1.14
High	1.15 - 1.19
Very High	1.2 - 1.6
Extreme	>1.6
Near Bank Stress Rating	Low

Stream Bank Erodibility Rating

BEHI Rating	High

Bank Erosion Prediction at Cross Section

A	B	C	D
Lateral Erosion at Cross Section (feet/year)	Bank Height (feet)	Length of Bank (feet)	Predicted Erosion $feet^3$
0.45	4.51	1	2.02 ft^3/yr.

Circle graph used: Colorado Yellowstone

Column A:	Use Stream Bank Erodibility Rating and Near Bank Stress Rating in conjunction with Figure 6-27 in Rosgen, 1996
Column B:	Study Bank Height (Use Cross Section Plot: top of bank - toe of bank)
Column C:	Input 1 foot for point erosion @ cross section
Column D:	Columns A*B*C

130 ft^3; ...

BEHI Variable Worksheet

Stream: Walker Run	Cross Section: DEXS #2	Date: 3/18/09	Observers: BRU, EPJ

Bank Height/Max Depth Bankfull (C)

Highest Bank Height (ft)	4.57 A	Max Bankfull Depth (ft)	0.9 B	A/B	5.08 C

Root Depth/Bank Height (F)

Root Depth (ft)	2.2 D	Study Bank Height (ft)	4.51 E	D/E	0.49 F

Weighted Root Density (H)

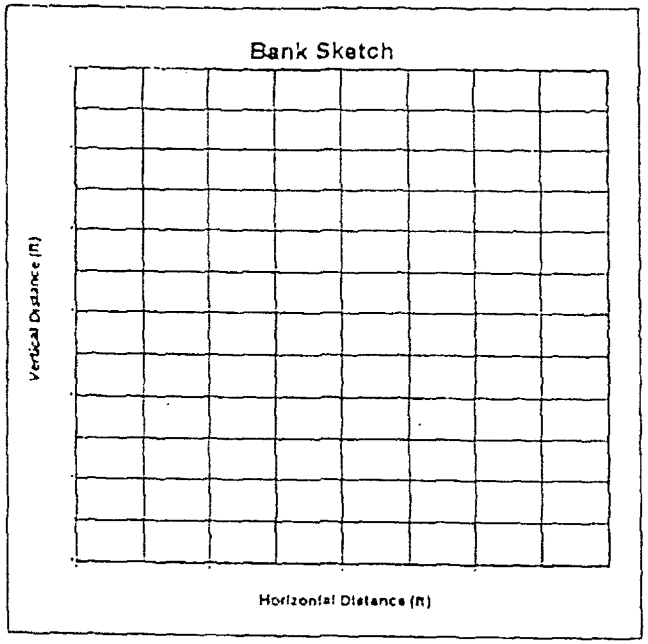
Root Density (%)	8 G	G*F	3.92 H

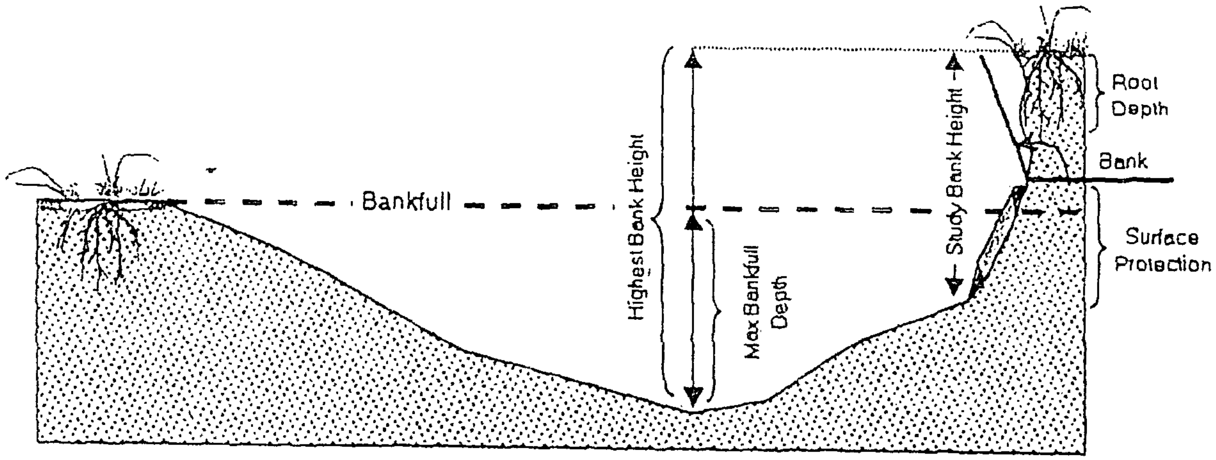
Bank Angle (I)

Bank Angle (Degrees)	85 I

Weighted Surface Protection (K)

Height of Bank Protection (ft)	0.8 J	J/E	0.18 K





Bank Erodibility Hazard Rating Guide

Stream Walker Run Reach BEXS # 2 Date 3/18/09 Crew BRU, EPS

Bank Erosion Potential	Bank Height (ft): / Bankfull Height (ft):	Bank Height/ Bankfull Ht	Root Depth/ Bank Height	Root Density %	Bank Angle (Degrees)	Surface Protection%
VERY LOW	Value	1.0-1.1	1.0-0.9	100-80	0-20	100-80
	Index	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
LOW	Value	1.11-1.19	0.89-0.5	79-55	21-60	79-55
	Index	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
MODERATE	Value	1.2-1.5	0.49-0.3	54-30	61-80	54-30
	Index	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9
	Choice	V: I:	V: 0.49 I: 4	V: I:	V: I:	V: I:
HIGH	Value	1.6-2.0	0.29-0.15	29-15	81-90	29-15
	Index	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9
	Choice	V: I:	V: I:	V: I:	V: 85 I: 7.0	V: 18% I: 7.75
VERY HIGH	Value	2.1-2.8	0.14-0.05	14-5.0	91-119	14-10
	Index	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0
	Choice	V: I:	V: I:	V: 8% I: 8.75	V: I:	V: I:
EXTREME	Value	>2.8	<0.05	<5	>119	<10
	Index	10	10	10	10	10
	Choice	V: 5.08 I: 10	V: I:	V: I:	V: I:	V: I:
	V = value, I = index				SUB-TOTAL (Sum one index from each column)	37.5

Bank Material Description:

Bank Materials

- **Bedrock** (Bedrock banks have very low bank erosion potential)
- **Boulders** (Banks composed of boulders have low bank erosion potential)
- **Cobble** (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- **Gravel** (Add 5-10 points depending percentage of bank material that is composed of sand)
- **Sand** (Add 10 points)
- **Silt Clay** (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT: 0

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT: 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

Bank location description (circle one)

Straight Reach Outside of Bend

GRAND TOTAL BEHI RATING: 37.5

Table 1. Documentation of ratios and derived values for near-bank stress

Stream: Location: Date: Crew:

Method 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 (See NBS #1). NBS = Extreme						
Method 2	Radius of Curvature Rc (feet)	Bankfull Width W_{bkf} (feet)	Ratio Rc/W	Method 3	Pool Slope S_p	Average Slope S	Ratio S_p/S
Method 4	Pool Slope S_p	Riffle Slope S_{rif}	Ratio S_p/S_{rif}	Method 5	Near-Bank Max Depth d_{nb} (feet)	Mean Depth d (feet)	Ratio d_{nb}/d
Method 6	Near-Bank Max Depth d_{nb} (feet)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d (feet)	Average Slope S	Bankfull Shear Stress τ (lb/ft^2)	Ratio τ_{nb}/τ
	1.3	0.004	0.32	0.6	0.007	0.26	1.23
Method 7	Velocity Gradient						

Table 2. Converting Ratio Values to an Overall Near-Bank Stress Rating

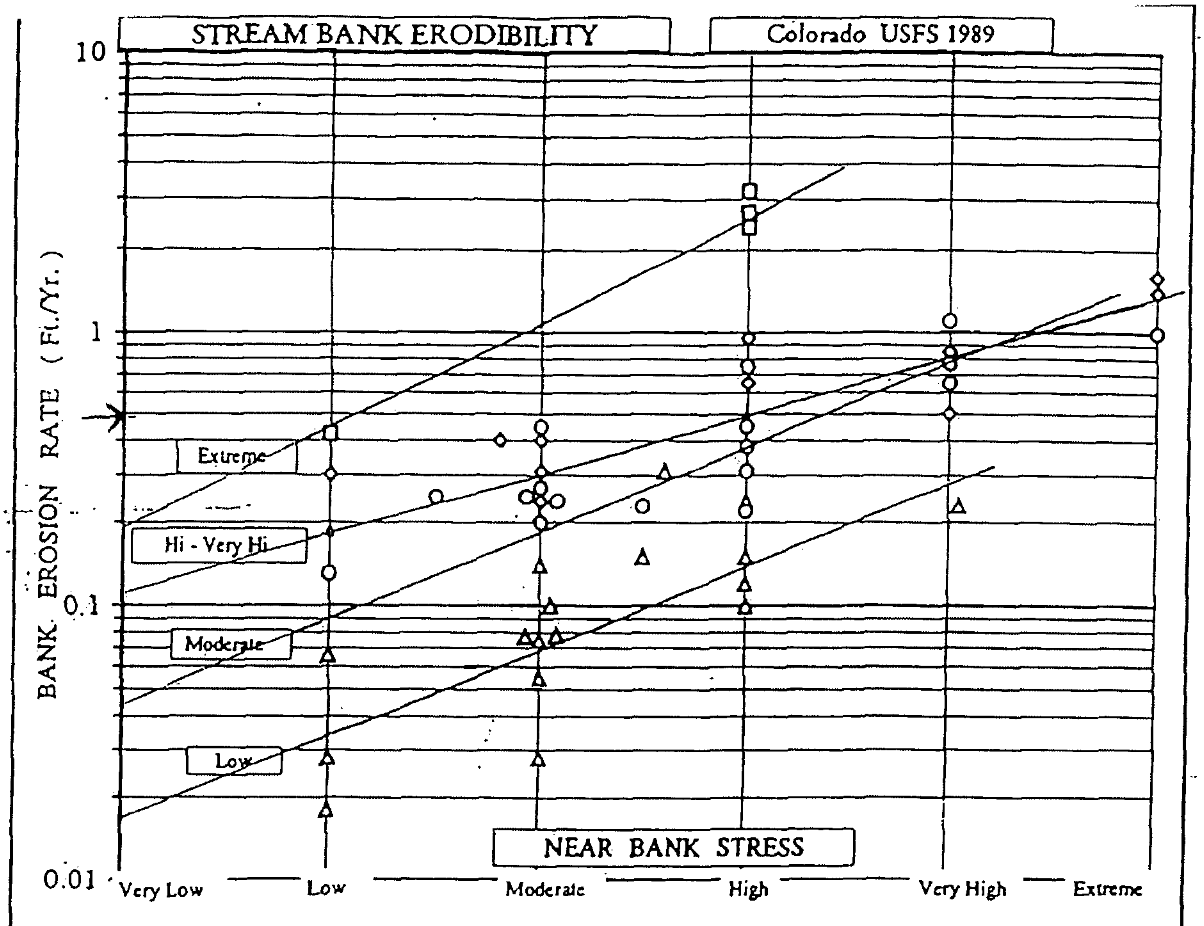
Method Number	1	2	3	4	5	6	7
Rating*							
Very Low	N/A	>3.0	< 0.20	< 0.4	<1.0	<0.8	<1.0
Low		2.21 - 3.0	0.20 - 0.40	0.41 - 0.60	1.0 - 1.5	0.8 - 1.05	1.0 - 1.2
Moderate		2.01 - 2.2	0.41 - 0.60	0.61 - 0.80	1.51 - 1.8	1.06 - 1.14	1.21 - 1.6
High	See (1) Above	1.81 - 2.0	0.61 - 0.80	0.81 - 1.0	1.81 - 2.5	1.15 - 1.19	1.61 - 2.0
Very High		1.5 - 1.8	0.81 - 1.0	1.01 - 1.2	2.51 - 3.0	1.20 - 1.60	2.01 - 2.3
Extreme		< 1.5	> 1.0	> 1.2	> 3.0	> 1.6	> 2.3

*Circle the dominant near-bank stress rating selected.

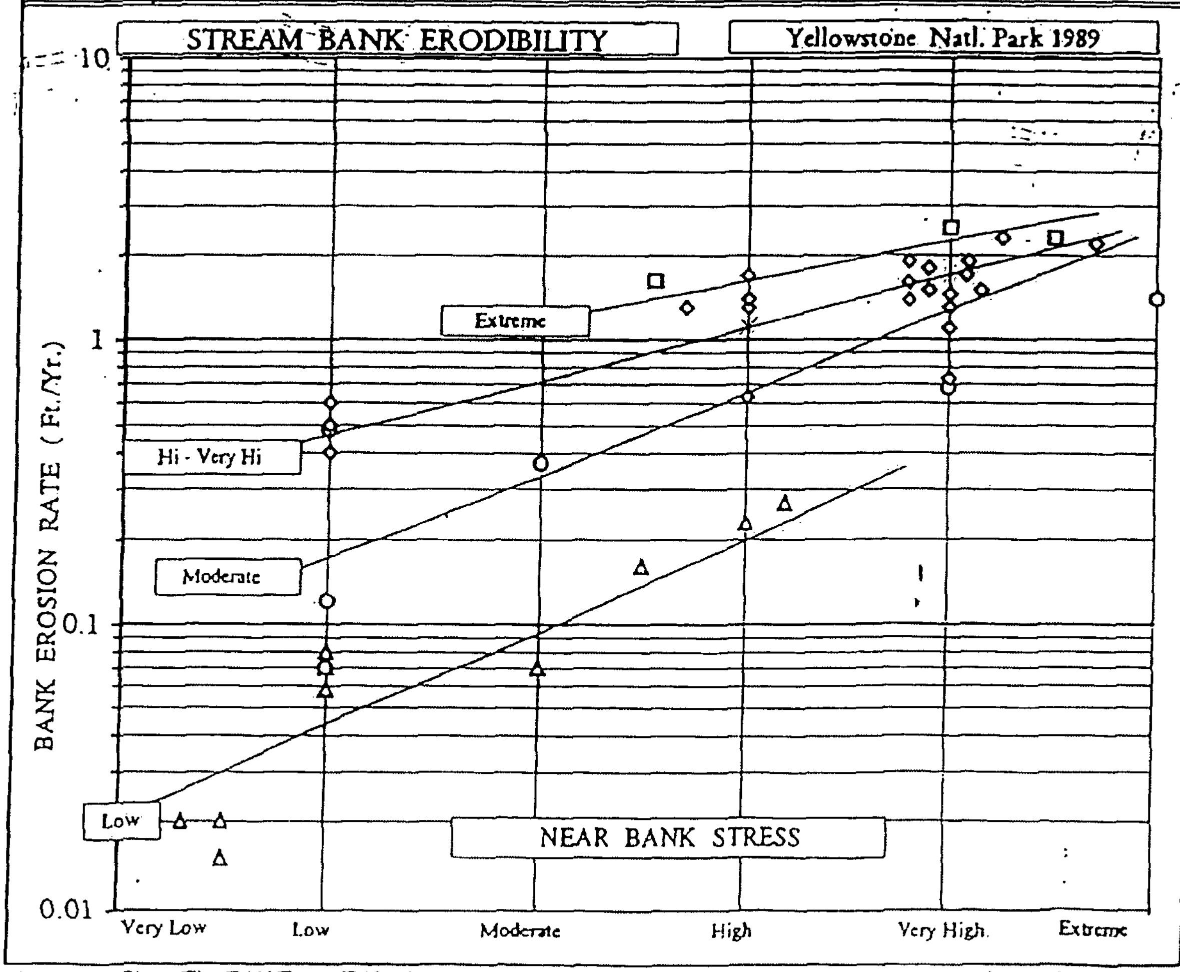
Methods for Estimating Near-Bank Stress

1. Transverse bar or split channel/central bar creating NBS/high velocity gradient: Level I - Reconnaissance.
2. Channel pattern (Rc/W): 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}). Near bank = 1/3 of channel width at study site Level III - Detailed Prediction
7. Velocity profiles/Isovels/Velocity gradient: Level IV - Validation.

Note: Only select the method(s) appropriate for level of assessment and site conditions. It is not necessary to select all methods to obtain an average near-bank stress rating.



STREAM BANK ERODIBILITY
Colorado USFS 1989
BANK EROSION RATE (Ft./Yr.)
10
1
0.1
0.01
Extreme
Hi - Very Hi
Moderate
Low
NEAR BANK STRESS
Very Low
Low
Moderate
High
Very High
Extreme

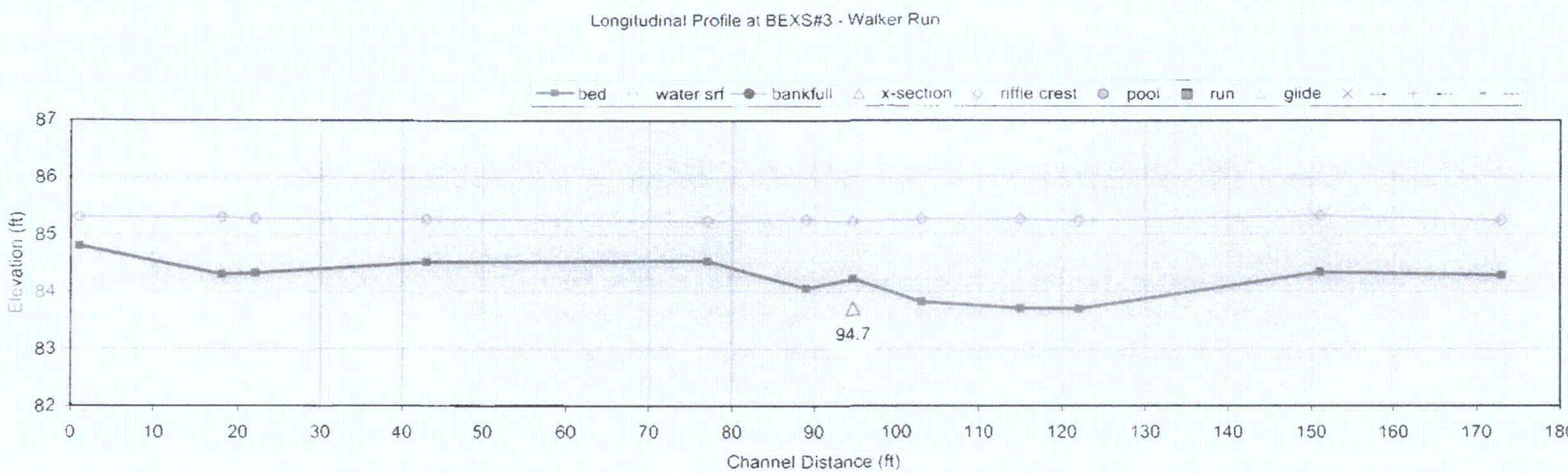


STREAM BANK ERODIBILITY
Yellowstone Natl. Park 1989
BANK EROSION RATE (Ft./Yr.)
10
1
0.1
0.01
Extreme
Hi - Very Hi
Moderate
Low
NEAR BANK STRESS
Very Low
Low
Moderate
High
Very High
Extreme

Bank erosion cross section #3 looking upstream

Bank erosion cross section#3 looking downstream

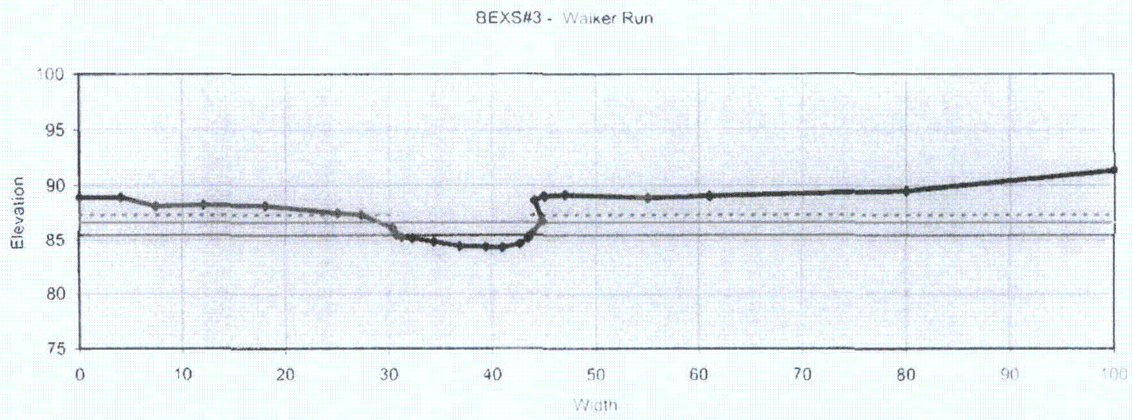
Longitudinal Slope Profile



	slope (%)	slope ratio	length (ft)	length ratio	pool-pool spacing (ft)	p-p ratio
reach	0.035	---	173.0 (15.5 channel widths)	---	---	---
riffle	---	---	---	---	---	---
pool	---	---	---	---	---	---
	---	---	---	---	---	---
	---	---	---	---	---	---

notes	cross section ID	bed feature	station	station	Benchmark Elevation 93.32 / Turning Points BS	HI	FS	FS bed	water	FS bankfull	user defined FS	FS	FS	azimuth AZ	ELEV bed	ELEV water srf	ELEV bankfull	ELEV ---	ELEV ---	ELEV ---
back sight to benchmark					0	93.32														
			1			93.32		8.52	0.5						84.8	85.3				
debris jam (small)			18			93.32		9.02	1						84.3	85.3				
			22			93.32		9	0.95						84.32	85.27				
			43			93.32		8.81	0.75						84.51	85.26				
Begin Study Bank			77			93.32		8.79	0.7						84.53	85.23				
			89			93.32		9.27	1.2						84.05	85.25				
BEXS#3	BEXS3		94.7			93.32		9.1	1						84.22	85.22				
			103			93.32		9.5	1.44						83.82	85.26				
			115			93.32		9.61	1.55						83.71	85.26				
			122			93.32		9.62	1.54						83.7	85.24				
End Study Bank			151			93.32		8.98	0.98						84.34	85.32				
			173			93.32		9.03	0.95						84.29	85.24				
						93.32														

Cross Section 3



Bankfull Dimensions

10.1	x-section area (ft sq.)
12.9	width (ft)
0.8	mean depth (ft)
1.2	max depth (ft)
13.4	wetted parimeter (ft)
0.8	hyd radi (ft)
16.5	width-depth ratio

Flood Dimensions

15.7	W flood prone area (ft)
1.2	entrenchment ratio
3.0	low bank height (ft)
2.6	low bank height ratio

Materials

---	D50 (mm)
---	D84 (mm)
0	threshold grain size (mm):

Bankfull Flow

0.2	velocity (ft/s)
1.9	discharge rate (cfs)
0.04	Froude number

Flow Resistance

0.030	Manning's roughness
0.11	D'Arcy-Weisbach fric
---	resistance factor u/u*
---	relative roughness

Forces & Power

0.002	channel slope (%)
0.00	shear stress (lb/sq.ft.)
0.02	shear velocity (ft/s)
0.00018	unit strm power (lb/ft/s)

Cross Section

reference ID: 3
instrument height: 93.32 ---
longitudinal station: ---

Bankfull Stage

FS: 7.85 = 85.47 elev
elevation: ---

Low Bank Height

FS: 5.98 = 87.34 elev
elevation:

Flood Prone Area

width fpa: 15.7

Channel Slope

percent slope: 0.002 1.5

Flow Resistance

Manning's "n": 0.03 ---
D'Arcy - Weisbach "f": ---

Note:

BS to BM4 (elev.=89.52') and got HR=3.80 therefore the HI=93.32'; valley wall continues beyond sta. 100 at even slope beginning at

Distance (ft)	BS (ft)	HI (ft)	FS (ft)	Elevation (ft)	Omit Bkf	Notes
0		93.32	4.36	88.96		L Pin
4		93.32	4.41	88.91		
7.4		93.32	5.16	88.16		
12		93.32	5.06	88.26		
18		93.32	5.15	88.17		
25		93.32	5.81	87.51		
27.3		93.32	5.98	87.34		LTOB
30.3		93.32	7.2	86.12		LBKFL?
30.8		93.32	7.85	85.47		
31.3		93.32	8.05	85.27		LEW
32.3		93.32	8.14	85.18		
34.4		93.32	8.48	84.84		
36.9		93.32	8.89	84.43		
39.4		93.32	8.97	84.35		
41		93.32	9.02	84.3		
42.7		93.32	8.69	84.63		R Toe
43.5		93.32	8.17	85.15		REW
43.8		93.32	7.71	85.61		BP (bot.)
44.8		93.32	6.53	86.79		BP (top)
44.1		93.32	4.69	88.63		RTOB
45		93.32	4.29	89.03		
47		93.32	4.18	89.14		
55		93.32	4.42	88.9		
61		93.32	4.25	89.07		R Pin
80		93.32	3.81	89.51		Toe of slop
100		93.32	2	91.32		up valley w

Bank Erosion Prediction

Stream	Cross Section	Date
Walker Run	BEXS #3	3/18/04

Near Bank Stress Rating

Mean Shear Stress	
Bankfull Hydraulic Radius (ft) R	0.8
Water Surface Facet Slope (ft/ft) S	0.00035
Shear Stress (lb/ft^2) $\tau = \gamma RS$ γ=62.4lb/ft^3	0.017

Near Bank Shear Stress	
Bankfull Hydraulic Radius (ft) R (near bank 1/3)	1.2
Near Bank Water Surface Slope (ft/ft) S	0.0003
Shear Stress (lb/ft^2) τ near bank= γRS	0.022

Near Bank Stress/ Mean Shear Stress (τ near bank/τ)	1.29

Conversion of Numerical Indices to Adjective Ratings

Near Bank Stress Rating	Near Bank Stress/Mean Shear Stress
Very Low	<0.8
Low	0.8 - 1.05
Moderate	1.06 - 1.14
High	1.15 - 1.19
Very High	1.2 - 1.6
Extreme	>1.6
Near Bank Stress Rating	Very High

Stream Bank Erodibility Rating

BEHI Rating	High

Bank Erosion Prediction at Cross Section

A	B	C	D
Lateral Erosion at Cross Section (feet/year)	Bank Height (feet)	Length of Bank (feet)	Predicted Erosion feet^3
1.75	4	1	7 ft^3/yr.

Circle graph used: Colorado Yellowstone

Column A:	Use Stream Bank Erodibility Rating and Near Bank Stress Rating in conjunction with Figure 6-27 in Rosgen, 1996
Column B:	Study Bank Height (Use Cross Section Plot: top of bank - toe of bank)
Column C:	Input 1 foot for point erosion @ cross section
Column D:	Columns A*B*C

BEHI Variable Worksheet

Stream: Walker Run	Cross Section: BEXS #3	Date: 3/18/09	Observers: BRU, EPJ

Bank Height/Max Depth Bankfull (C)

Highest Bank Height (ft)	4.33 A	Max Bankfull Depth (ft)	1.2 B	A/B	3.61 C

Root Depth/Bank Height (F)

Root Depth (ft)	2 D	Study Bank Height (ft)	4 E	D/E	0.5 F

Weighted Root Density (H)

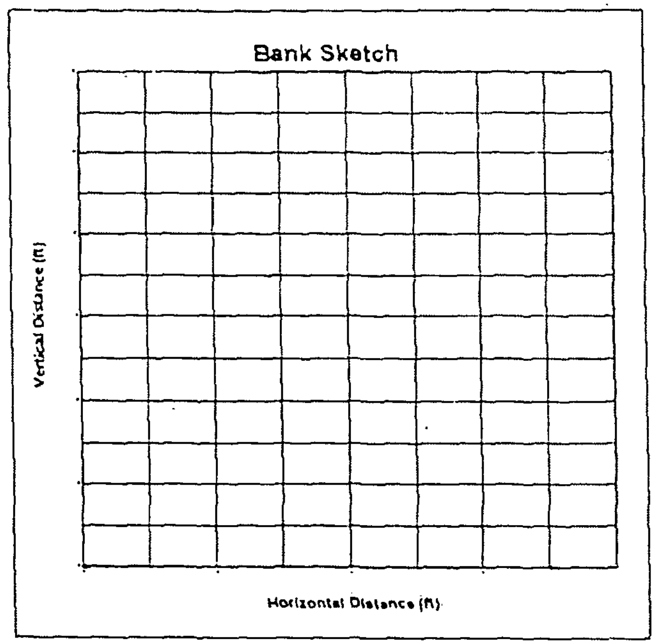
Root Density (%)	15% G	G*F	7.5 H

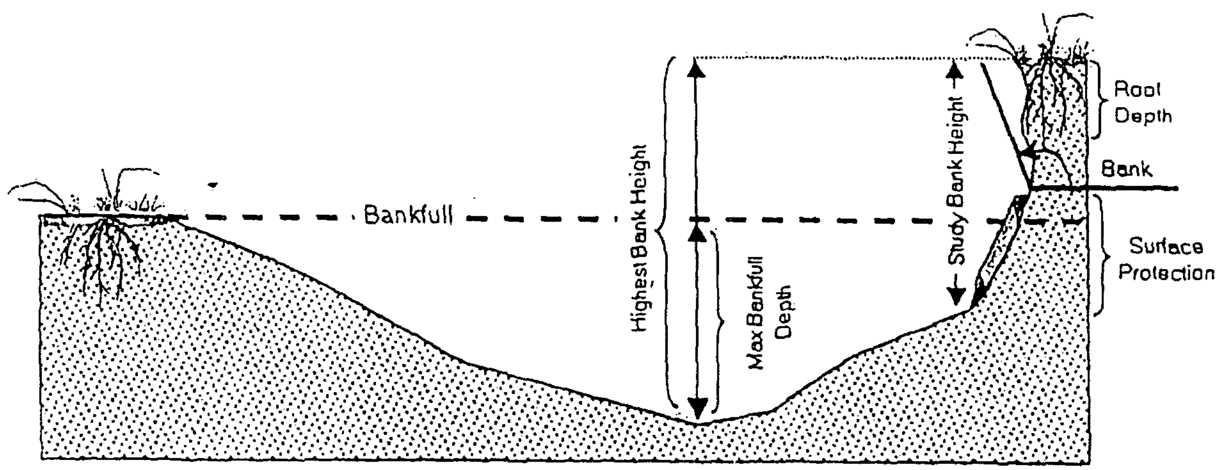
Bank Angle (I)

Bank Angle (Degrees)	90° I

Weighted Surface Protection (K)

Height of Bank Protection (ft)	0 J	J/E	0 K





Bank Erodibility Hazard Rating Guide

Stream Walker Run   Reach BEXS #3   Date 3/18/09   Crew BRU, EPS

Bank Erosion Potential

Bank Height (ft): / Bankfull Height (ft):		Bank Height/ Bankfull Ht	Root Depth/ Bank Height	Root Density %	Bank Angle (Degrees)	Surface Protection%
VERY LOW	Value	1.0-1.1	1.0-0.9	100-80	0-20	100-80
	Index	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
LOW	Value	1.11-1.19	0.89-0.5	79-55	21-60	79-55
	Index	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9
	Choice	V: I:	V: 0.5 I: 3.9	V: I:	V: I:	V: I:
MODERATE	Value	1.2-1.5	0.49-0.3	54-30	61-80	54-30
	Index	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
HIGH	Value	1.6-2.0	0.29-0.15	29-15	81-90	29-15
	Index	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9
	Choice	V: I:	V: I:	V: 15% I: 7.9	V: 90 I: 7.9	V: I:
VERY HIGH	Value	2.1-2.8	0.14-0.05	14-5.0	91-119	14-10
	Index	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
EXTREME	Value	>2.8	<0.05	<5	>119	<10
	Index	10	10	10	10	10
	Choice	V: 3.61 I: 10	V: I:	V: I:	V: I:	V: 0 I: 10
V = value, I = index					SUB-TOTAL (Sum one index from each column)	39.7

Bank Material Description:

Bank Materials

Bedrock (Bedrock banks have very low bank erosion potential)
Boulders (Banks composed of boulders have low bank erosion potential)
Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt Clay (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT 0

Stratification Comments:

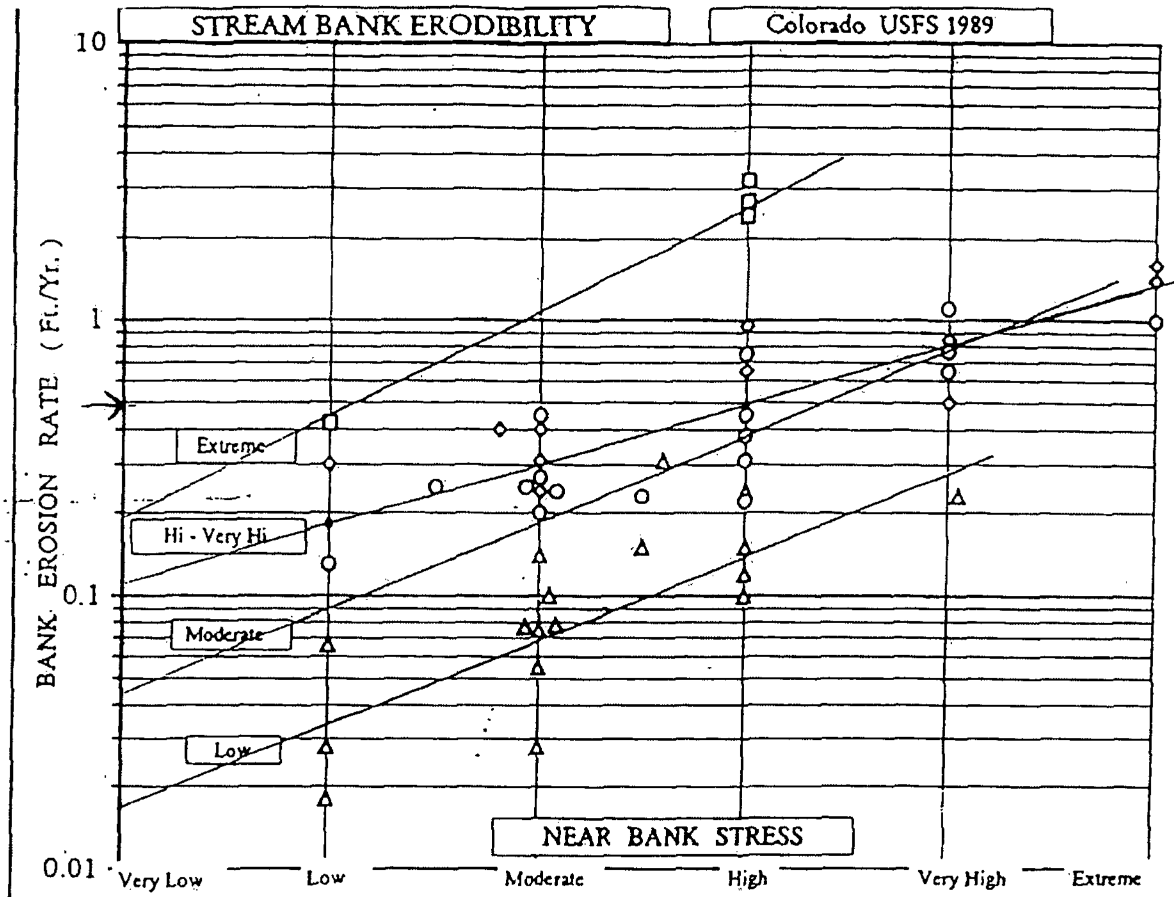
Stratification
Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT 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

Bank location description (circle one)
Straight Reach   Outside of Bend

GRAND TOTAL BEHI RATING 39.7


STREAM BANK ERODIBILITY
Colorado USFS 1989
10
1
0.1
0.01
BANK EROSION RATE (Ft./Yr.)
Extreme
Hi - Very Hi
Moderate
Low
NEAR BANK STRESS
Very Low
Low
Moderate
High
Very High
Extreme

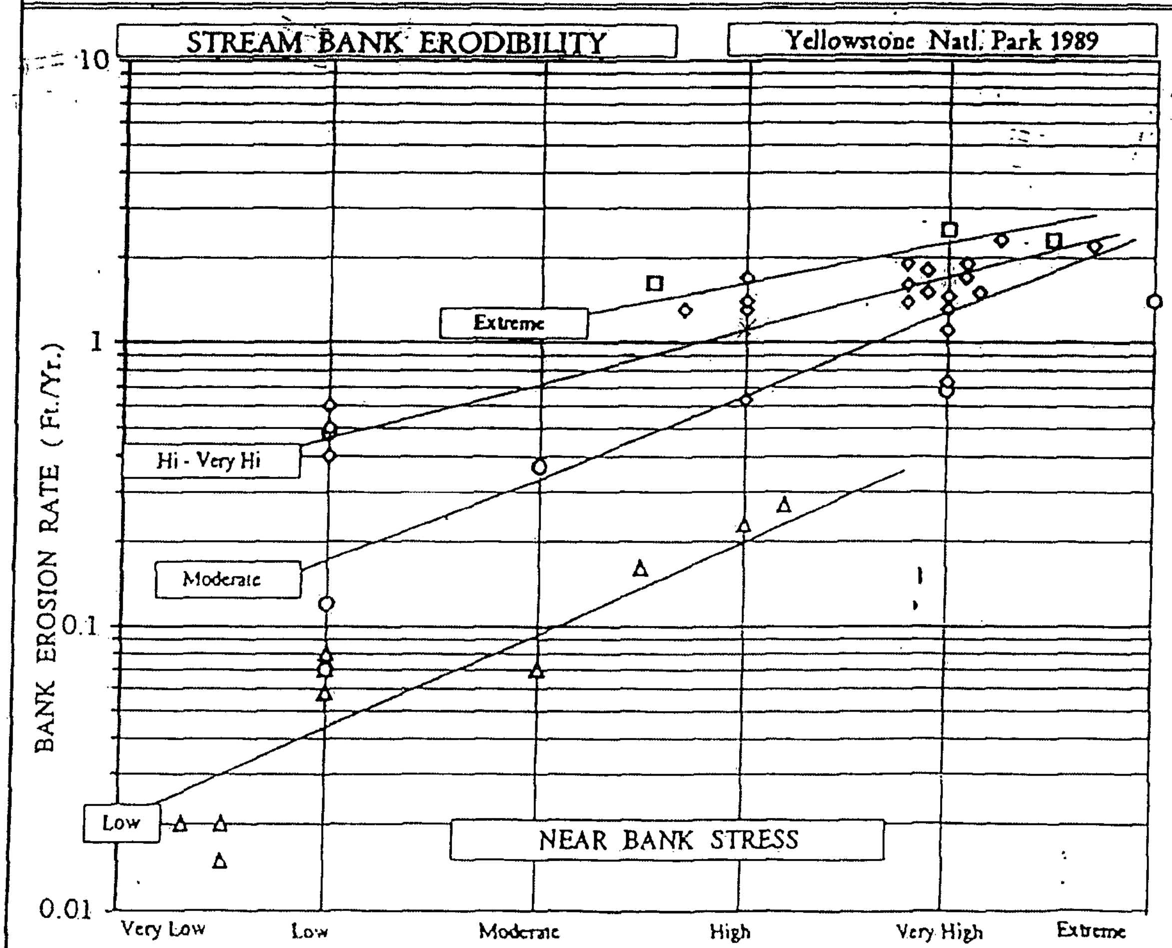

STREAM BANK ERODIBILITY
Yellowstone Natl. Park 1989
10
1
0.1
0.01
BANK EROSION RATE (Ft./Yr.)
Extreme
Hi - Very Hi
Moderate
Low
NEAR BANK STRESS
Very Low
Low
Moderate
High
Very High
Extreme

Table 1. Documentation of ratios and derived values for near-bank stress

Stream: Location: Date: Crew:

<table>
<tr><td rowspan="3">Method 1</td><td colspan="7">Transverse and/or central bars - short and/or discontinuous. NBS = High/Very High</td></tr>
<tr><td colspan="7">Extensive deposition (continuous, cross channel). NBS = Extreme</td></tr>
<tr><td colspan="7">Chute cutoffs, down-valley meander migration, converging flow (See NBS #1). NBS = Extreme</td></tr>
<tr><td rowspan="2">Method 2</td><td>Radius of Curvature Rc (feet)</td><td>Bankfull Width W_{bkf} (feet)</td><td>Ratio Rc/W</td><td rowspan="2">Method 3</td><td>Pool Slope S_p</td><td>Average Slope S</td><td>Ratio S_p/S</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Method 4</td><td>Pool Slope S_p</td><td>Riffle Slope S_{rif}</td><td>Ratio S_p/S_{rif}</td><td rowspan="2">Method 5</td><td>Near-Bank Max Depth d_{nb} (feet)</td><td>Mean Depth d (feet)</td><td>Ratio d_{nb}/d</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Method 6</td><td>Near-Bank Max Depth d_{nb} (feet)</td><td>Near-Bank Slope S_{nb}</td><td>Near-Bank Shear Stress τ_{nb} (lb/ft^2)</td><td>Mean Depth d (feet)</td><td>Average Slope S</td><td>Bankfull Shear Stress τ (lb/ft^2)</td><td>Ratio τ_{nb}/τ</td></tr>
<tr><td>1.3</td><td>0.004</td><td>0.32</td><td>0.6</td><td>0.007</td><td>0.26</td><td>1.23</td></tr>
<tr><td rowspan="2">Method 7</td><td colspan="2">Velocity Gradient</td></tr>
<tr><td colspan="2"></td></tr>
</table>

Table 2. Converting Ratio Values to an Overall Near-Bank Stress Rating

Method Number	1	2	3	4	5	6	7
Rating*							
Very Low	N/A	>3.0	< 0.20	< 0.4	<1.0	<0.8	<1.0
Low		2.21 - 3.0	0.20 - 0.40	0.41 - 0.60	1.0 - 1.5	0.8 - 1.05	1.0 - 1.2
Moderate		2.01 - 2.2	0.41 - 0.60	0.61 - 0.80	1.51 - 1.8	1.06 - 1.14	1.21 - 1.6
High	See (1) Above	1.81 - 2.0	0.61 - 0.80	0.81 - 1.0	1.81 - 2.5	1.15 - 1.19	1.61 - 2.0
Very High		1.5 - 1.8	0.81 - 1.0	1.01 - 1.2	2.51 - 3.0	1.20 - 1.60	2.01 - 2.3
Extreme		< 1.5	> 1.0	> 1.2	> 3.0	> 1.6	> 2.3

*Circle the dominant near-bank stress rating selected.

Methods for Estimating Near-Bank Stress

1. Transverse bar or split channel/central bar creating NBS/high velocity gradient: Level I - Reconnaissance.
2. Channel pattern (Rc/W): 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}). Near bank = 1/3 of channel width at study site Level III - Detailed Prediction
7. Velocity profiles/Isovels/Velocity gradient: Level IV - Validation.

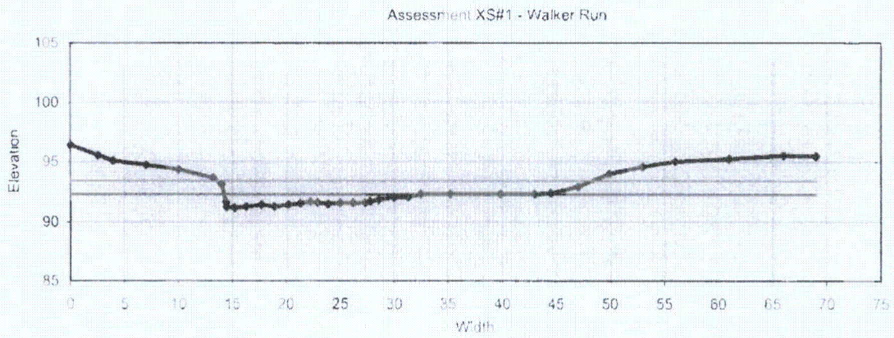
Note: Only select the method(s) appropriate for level of assessment and site conditions. It is not necessary to select all methods to obtain an average near-bank stress rating.

Assessment Reach Cross-Sections and Longitudinal Profile with Photo-documentation

Assessment reach cross section #1 looking upstream

Assessment reach cross section #1 looking downstream

Cross Section 1



Bankfull Dimensions

12.3	x-section area (ft.sq.)
18.3	width (ft)
0.7	mean depth (ft)
1.1	max depth (ft)
19.2	wetted parimeter (ft)
0.6	hyd radi (ft)
27.1	width-depth ratio

Flood Dimensions

34.7	W flood prone area (ft)
1.9	entrenchment ratio
—	low bank height (ft)
—	low bank height ratio

Materials

57	D50 Riffle (mm)
140	D84 Riffle (mm)
32	threshold grain size (mm):

Bankfull Flow

2.4	velocity (ft/s)
29.3	discharge rate (cfs)
0.52	Froude number

Flow Resistance

0.059	Manning's roughness
0.47	D'Arcy-Weisbach fric.
4.1	resistance factor u/u*
1.5	relative roughness

Forces & Power

1.6	channel slope (%)
0.64	shear stress (lb/sq.ft.)
0.58	shear velocity (ft/s)
1.6	unit strm power (lb/ft/s)

Cross Section

reference ID	1	
instrument height	100	—
longitudinal station	275	—

Bankfull Stage

FS	7.74	= 92.26 elev
elevation		—

Low Bank Height

FS		—
elevation		

Flood Prone Area

width fpa	34.7	34.7

Channel Slope

percent slope	1.6	#REF!

Flow Resistance

Manning's "n"	0.059	0.059
D'Arcy - Weisbach "f"		0.47

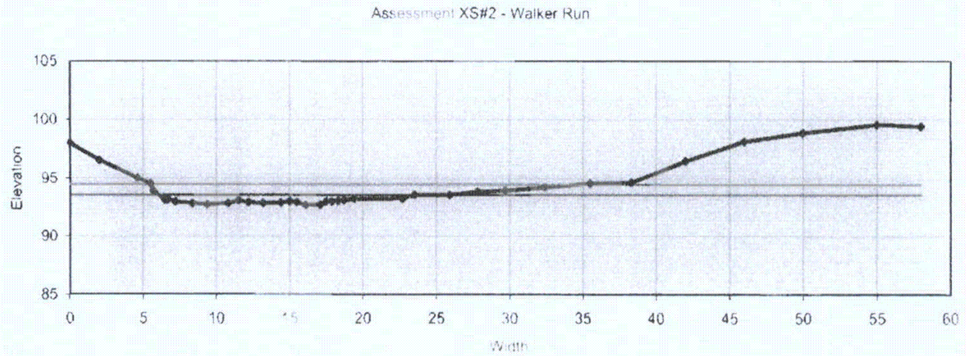
Note:

Distance (ft)	BS (ft)	HI (ft)	FS (ft)	Elevation (ft)	Omit Bkf	Notes
0		100	3.61	96.39	☐	
2.6		100	4.47	95.53	☐	
4		100	4.91	95.09	☐	
7		100	5.28	94.72	☐	
10		100	5.65	94.35	☐	
13.2		100	6.35	93.65	☐	LTOB
14		100	6.92	93.08	☐	
14.4		100	8.37	91.63	☐	
14.5		100	8.79	91.21	☐	
15.2		100	8.85	91.15	☐	
16.3		100	8.74	91.26	☐	
17.7		100	8.58	91.42	☐	
18.9		100	8.74	91.26	☐	
20.2		100	8.57	91.43	☐	
21.3		100	8.48	91.52	☐	
22.2		100	8.35	91.65	☐	
22.9		100	8.42	91.58	☐	
23.9		100	8.53	91.47	☐	
25		100	8.44	91.56	☐	
26.2		100	8.45	91.55	☐	
27.3		100	8.42	91.58	☐	
27.8		100	8.31	91.69	☐	REOW
28.6		100	8.17	91.83	☐	
30		100	7.98	92.02	☐	BKFL #1
31.3		100	7.96	92.04	☐	
32.5		100	7.74	92.26	☐	BKFL #2
35.2		100	7.74	92.26	☐	
39.8		100	7.74	92.26	☐	
43		100	7.74	92.26	☐	
44.5		100	7.65	92.35	☐	
47		100	7.12	92.88	☐	
49.9		100	6.03	93.97	☐	RTOB
53		100	5.46	94.54	☐	
56		100	4.99	95.01	☐	
61		100	4.75	95.25	☐	
66		100	4.49	95.51	☐	
69		100	4.56	95.44	☐	
					☐	

Assessment reach cross section #2 looking upstream

Assessment reach cross section #2 looking downstream

Cross Section 2



Bankfull Dimensions

9.8	x-section area (ft.sq.)
17.4	width (ft)
0.6	mean depth (ft)
0.9	max depth (ft)
17.9	wetted parimeter (ft)
0.5	hyd radi (ft)
31.0	width-depth ratio

Flood Dimensions

34.3	W flood prone area (ft)
2.0	entrenchment ratio
---	low bank height (ft)
---	low bank height ratio

Materials

57	D50 Riffle (mm)
140	D84 Riffle (mm)
27	threshold grain size (mm)

Bankfull Flow

2.0	velocity (ft/s)
19.3	discharge rate (cfs)
0.47	Froude number

Flow Resistance

0.064	Manning's roughness
0.58	D'Arcy-Weisbach fric.
3.7	resistance factor u/u*
1.2	relative roughness

Forces & Power

1.6	channel slope (%)
0.55	shear stress (lb/sq.ft.)
0.53	shear velocity (ft/s)
1.11	unit strm power (lb/ft/s)

Cross Section

reference ID	2	
instrument height	102.21	---
longitudinal station	180.1	---

Bankfull Stage

FS	8.64	= 93.57 elev
elevation		---

Low Bank Height

FS		---
elevation		

Flood Prone Area

width fpa	34.3	29.0

Channel Slope

percent slope	1.6	#REF!

Flow Resistance

Manning's "n"	0.064	0.064
D'Arcy - Weisbach "f"		0.59

Note:

Distance (ft)	BS (ft)	HI (ft)	FS (ft)	Elevation (ft)	Omit Bkf	Notes
0		102.21	4.19	98.02		
2		102.21	5.66	96.55		
4.6		102.21	7.16	95.05		
5.5		102.21	7.63	94.58		
5.7		102.21	8.29	93.92		
6.5		102.21	9.06	93.15		
6.7		102.21	9.07	93.14		LEOW
7.2		102.21	9.23	92.98		
8.4		102.21	9.37	92.84		
9.4		102.21	9.46	92.75		
10.8		102.21	9.36	92.85		
11.5		102.21	9.13	93.08		
12.2		102.21	9.28	92.93		
13.2		102.21	9.36	92.85		
14.4		102.21	9.3	92.91		
15		102.21	9.19	93.02		
15.5		102.21	9.29	92.92		
16.1		102.21	9.52	92.69		
17.1		102.21	9.5	92.71		
17.5		102.21	9.19	93.02		
17.9		102.21	9.22	92.99		
18.3		102.21	9.15	93.06		REOW
18.7		102.21	9.1	93.11		
19.4		102.21	8.99	93.22		BKFL #1
22.7		102.21	8.95	93.26		
23.5		102.21	8.64	93.57		BKFL #2
25.9		102.21	8.63	93.58		
27.8		102.21	8.37	93.84		
29.7		102.21	8.25	93.96		
32.4		102.21	7.99	94.22		
35.5		102.21	7.65	94.56		
38.3		102.21	7.56	94.65		
42		102.21	5.72	96.49		
46		102.21	4.06	98.15		
50		102.21	3.33	98.88		
55		102.21	2.65	99.56		
58		102.21	2.78	99.43		

1) Individual Pebble Count

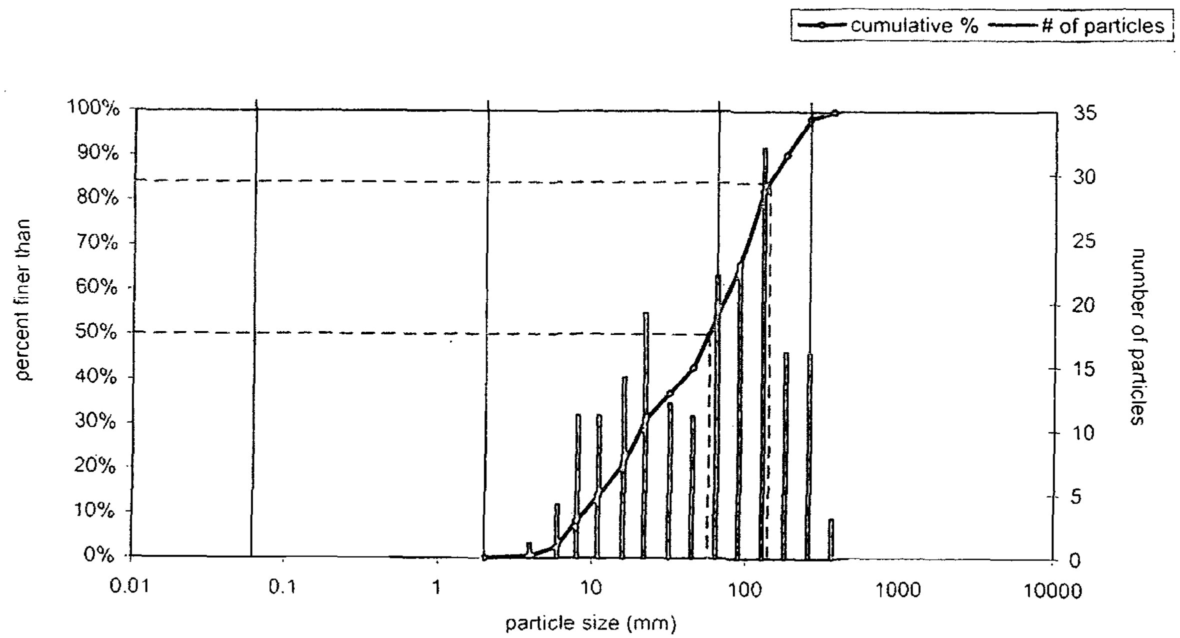
Two individual samples may be entered below. Select sample type for each.

Riffle Surface

Material	Size Range (mm	Count
silt/clay	0 - 0.062	
very fine sand	0.062 - 0.125	
fine sand	0.125 - 0.25	
medium sand	0.25 - 0.5	
coarse sand	0.5 - 1	
very coarse sand	1 - 2	
very fine gravel	2 - 4	1
fine gravel	4 - 6	4
fine gravel	6 - 8	11
medium gravel	8 - 11	11
medium gravel	11 - 16	14
coarse gravel	16 - 22	19
coarse gravel	22 - 32	12
very coarse gravel	32 - 45	11
very coarse gravel	45 - 64	22
small cobble	64 - 90	23
medium cobble	90 - 128	32
large cobble	128 - 180	16
very large cobble	180 - 256	16
small boulder	256 - 362	3
small boulder	362 - 512	
medium boulder	512 - 1024	
large boulder	1024 - 2048	
very large boulder	2048 - 4096	
	total particle count:	195
bedrock		1
clay hardpan		
detritus/wood		
artificial		
	total count:	196

Note:

Riffle Surface Pebble Count, Walker Run

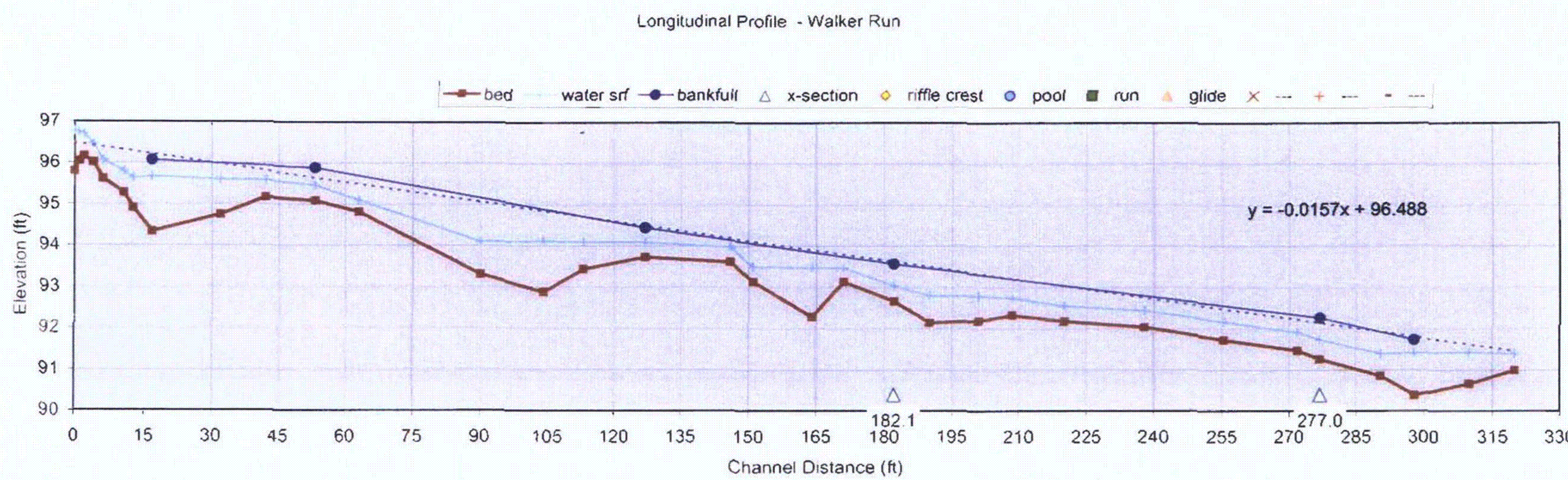


Size (mm)	
D16	12
D35	28
D50	57
D65	88
D84	140
D95	220

Size Distribution	
mean	41.0
dispersion	3.6
skewness	-0.14

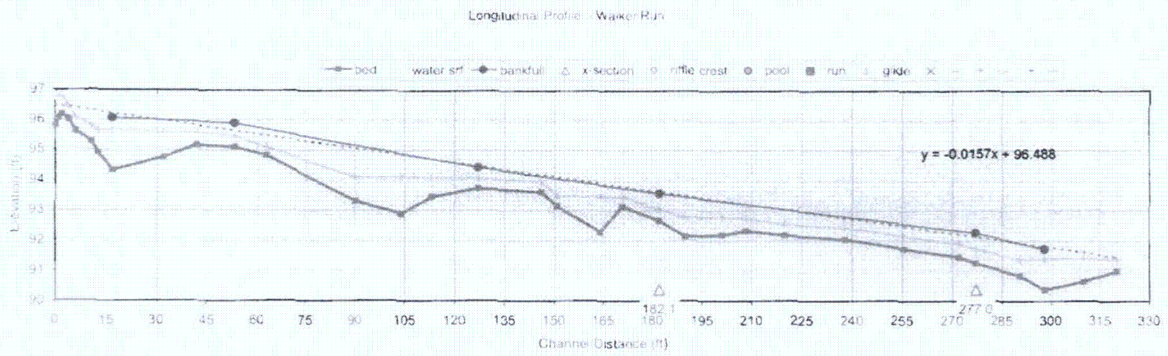
Type			
silt/clay	0%	bedrock	1%
sand	0%		
gravel	54%		
cobble	44%		
boulder	2%		

Longitudinal Slope Profile



	slope (%)	slope ratio	length (ft)	length ratio	pool-pool spacing (ft)	p-p ratio
reach	1.7	---	320.0 (20.5 channel widths)	---	---	---
riffle	---	---	---	---	---	---
pool	---	---	---	---	---	---
	---	---	---	---	---	---
	---	---	---	---	---	---

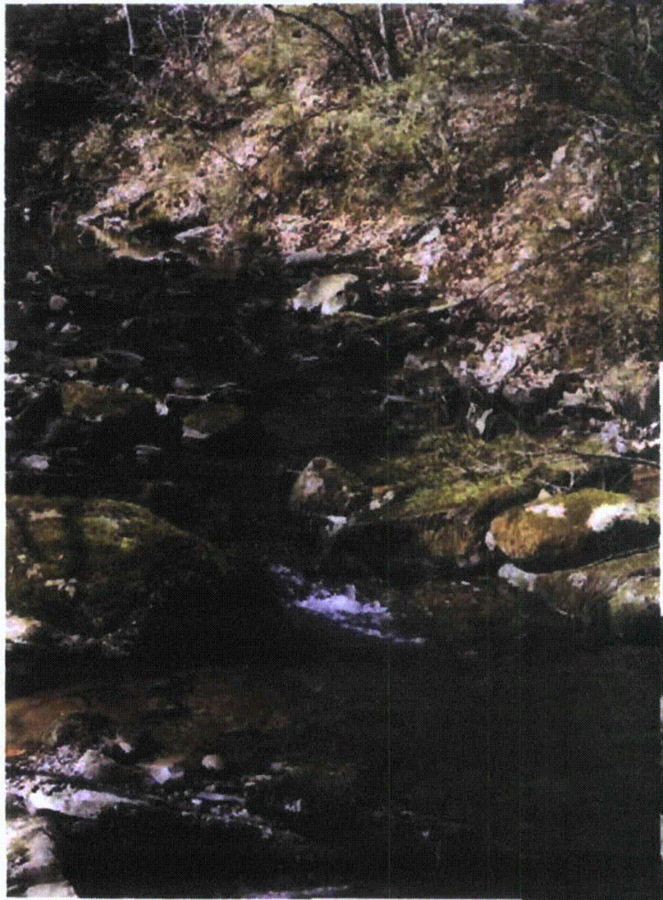
Longitudinal Slope Profile



	slope (%)	slope ratio	length (ft)	length ratio	pool-pool spacing (ft	p-p ratio
reach	1.7	—	320.0 (20.5 channel widths)	—	—	—
riffle	—	—	—	—	—	—
pool	—	—	—	—	—	—
	—	—	—	—	—	—
	—	—	—	—	—	—

notes	cross section ID	bed feature	station	station	Benchmark Elevation 100.78 Turning Points BS	HI	FS	FS bed	water	FS bankfull	user defined FS	FS	FS	azimuth AZ	ELEV bed	ELEV water srf	ELEV bankfull	ELEV —	ELEV —	ELEV —
back sight to benchmark					0	100.78														
			0			100.78		4.98	0.98						95.8	96.78				
			1			100.78		4.73	0.7						96.05	96.75				
HOR			2			100.78		4.61	0.54						96.17	96.71				
			4			100.78		4.76	0.45						96.02	96.47				
			6			100.78		5.16	0.46						95.62	96.08				
			10.5			100.78		5.5	0.53						95.28	95.81				
TOR			12.5			100.78		5.87	0.74						94.91	95.65				
Dmax			16.7			100.78		6.44	1.34	4.71					94.34	95.68	96.07			
			32			100.78		6.03	0.86						94.75	95.61				
HOR			42			100.78		5.61	0.43						95.17	95.6				
			53.2			100.78		5.69	0.38	4.89					95.09	95.47	95.89			
			63			100.78		5.96	0.29						94.82	95.11				
TOR			90			100.78		7.47	0.8						93.31	94.11				
Dmax			104			100.78		7.9	1.24						92.88	94.12				
			113			100.78		7.34	0.66						93.44	94.1				
			127			100.78		7.05	0.36	6.34					93.73	94.09	94.44			
			146			100.78		7.17	0.37						93.61	93.98				
			151			100.78		7.64	0.36						93.14	93.5				
Dmax			164			100.78		8.49	1.19						92.29	93.48				
HOR			171			100.78		7.64	0.33						93.14	93.47				
XS #2	2		182.1			100.78		8.12	0.38	7.21					92.66	93.04	93.57			
TOR			190			100.78		8.64	0.65						92.14	92.79				
			201			100.78		8.59	0.6						92.19	92.79				
HOR			208.5			100.78		8.45	0.42						92.33	92.75				
			220			100.78		8.6	0.37						92.18	92.55				
			238			100.78		8.74	0.39						92.04	92.43				
			255.5			100.78		9.05	0.43						91.73	92.16				
			272			100.78		9.31	0.43						91.47	91.9				
XS #1	1		277			100.78		9.52	0.47	8.52					91.26	91.73	92.26			
TOR			290.5			100.78		9.93	0.54						90.85	91.39				
Dmax			298			100.78		10.4	1.02	9.05					90.38	91.4	91.73			
			310			100.78		10.12	0.76						90.66	91.42				
HOR			320			100.78		9.79	0.39						91	91.39				

Walker Run Surveys:
Wild Trout Habitat Assessment



Prepared for:

PPL Bell Bend Nuclear Power Plant
Salem Township, Luzerne County, PA

Prepared by:

LandStudies

May 2009

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APPENDICES

I. INTRODUCTION

Surveys for fish species composition and the presence of wild brown trout were extended through this effort to the section of Walker Run upstream of Beach Grove Road. This section of Walker Run is significantly different than the downstream segments that were sampled previously. Casual observation shows the upstream segment to have better stream habitat quality, a higher elevational grade, and desirable riparian habitat that provides canopy cover to the stream.

The presence of wild brown trout in the downstream segment (below Beach Grove Road), as documented in earlier surveys, has raised questions regarding (1) the habitat quality in the downstream section, (2) how it compares to the upstream section, (3) whether wild brown trout are found throughout the two sections, and (4) the distribution of brown trout in the two stream sections.

The following report describes the findings of additional fish surveys and habitat assessments throughout the two sections of Walker Run, located in Salem Township, Luzerne County, PA and more specifically located upstream, within, and downstream of the proposed PP&L Bell Bend Nuclear Power Plant (BBNPP) site.

The fish surveys and habitat assessments completed through this effort were completed at three separate sampling reaches in the upstream section of Walker Run (above Beach Grove Road) and at three separate sampling reaches in the downstream section (below Beach Grove Road). Fish surveys were focused on accurately characterizing the fish species composition at each sampling reach, and the number and body length of wild brown trout. Habitat assessments were similarly completed at the same six sampling reaches. Habitat assessments consisted of completing visual characterizations of habitat quality using the EPA's Rapid Bioassessment Protocols, and completing macroinvertebrate community sampling at the same six sampling reaches. Of the six sampling reaches surveyed in this effort, sampling reach 5 was within the proposed project site.

The combination of these survey approaches across both upstream and downstream sections of Walker Run allow us to both characterize and compare the wild brown trout distribution and stream habitat quality in these two different stream sections.

II. METHODS

On March 25, 2009, Landstudies and Normandeau Associates performed the electroshocking field survey for characterizing the fish community in Walker Run, in Salem Township, Luzerne County, PA. Fish surveys were conducted using an electrofishing pram with a single or double anode probe, depending on stream reach being surveyed. The electrofishing gear was powered by a Georator unit producing 230 volt DC current with the output ranging from 2 to 5 amperes. A single electrofishing pass was made through each sampling reach. All captured fish were identified to species and brown trout were measured for total length. All fish were released. The location and stream length of each sampling reach is shown in Figure 1.

Visual habitat assessments were performed at six sampling reaches on March 31 and April 1, 2009. The high gradient habitat assessment field data sheets, which are part of the EPA's Rapid Bioassessment Protocols (RBP), were utilized for Sampling Reaches 1 through 3 in the higher elevational gradient upstream section of Walker Run. The low gradient habitat assessment field data sheets, also part of the RBP, were utilized for Sampling Reaches 4 through 6 in the downstream section of Walker Run. The RBP evaluates ten habitat quality parameters on a 0 to 20 scale, with scores of 16 to 20 indicating optimal habitat quality, scores of 11 to 15 indicating suboptimal habitat quality, scores of 6 to 10 indicating marginal habitat quality, and scores of 0 to 5 indicating poor habitat quality. The location and stream length of each habitat assessment sampling reach is shown in Figure 2.

Macroinvertebrate community surveys were performed at the six sampling reaches on March 31 and April 1, 2009. A 500-micron mesh D-frame net was used to collect stream macroinvertebrates from four separate riffle sections within each sampling reach. The four riffle sections were selected within each reach to include the spectrum of riffle habitat conditions in each reach. Macroinvertebrate sampling in the downstream section of Walker Run, and particularly in sampling reaches 5 and 6, was challenging to locate four distinct riffle habitats. In some cases, marginal riffle/run habitat was selected for macroinvertebrate sampling because higher quality riffle habitats were not present. At each reach, the four separate riffle section samples were composited into one sample to provide a stream reach characterization. The locations of the four D-net jabs at each of the six sampling reaches are shown in Figure 3.

Macroinvertebrate samples were preserved in isopropyl alcohol in the field. Samples were sorted into vials in the laboratory using a 5X illuminated magnifying lamp. All samples were sorted completely. Organisms were identified to the genus level using a stereo microscope, except for midge larvae (Family Chironomidae), nematodes (Phylum Nematoda), and segmented worms (Class Oligochaeta).

Trout spawning gravels were sampled within each of the six habitat assessment reaches. The reach was visually inspected throughout its length, and the best spawning gravel location was selected. This sampling selection was based on the location in the reach with the highest gravel concentration, the least silt and sand embeddedness, and a location preferably at a pool-riffle transition where upwelling would most likely occur. These characteristics are critical for trout to be able to construct redds in the gravel (where they will lay and fertilize eggs) and to maximize the exchange of oxygen and metabolic wastes through interstitial gravel spaces. A six-inch diameter PBC pipe was placed at the selected location (see Photo 1 in Appendix B) and the top 3-inches of enclosed gravel, cobble, silt, sand, and clay were removed from inside the PVC pipe and transferred to a plastic bag. The sampled substrate materials were allowed to dry in a flat sample tray, then photographed and the substrate composition was visually estimated. When each reach was visually inspected to select the spawning gravel location, the frequency of high quality spawning gravel locations within the reach was noted. This sampling is useful, from a trout spawning perspective, to characterize (1) the best, rather than the average, stream substrate composition in the reach, and (2) the composition of the stream substrate with depth since trout will excavate the substrate to be able to bury the eggs in the constructed redd.

III. FINDINGS

A. FISHERIES SURVEY

A total of 1,140 fish were collected and identified during the March 25, 2009 fisheries survey of Walker Run. The stream length of the sampling reaches averaged 300 feet, and totaled 1,797 feet (see Table 1). The average electroshocking time for the sampling reaches (time the shocker was turned on and sampling for fish) was 34 minutes, with a total of 203 minutes of shocking time.

A total of eight fish species were collected in the sampling (Table 1). The largest number of fish were collected in reach 6 (the most downstream sampling reach), with about 44 percent of the total number of fish in the survey. White sucker, fallfish, creek chub, and tessellated darters comprised over 95 percent of the fish collected in reach 6 (Table 2). These species are tolerant of lower water quality conditions. Fallfish and tessellated darters were not collected at any other sampling reach (Figure 4). Twice as many creek chub were collected in the downstream section of Walker Run as the upstream section, and nearly four times as many white sucker were collected in the downstream section as the upstream section (Figure 4, Table 1).

Blacknose dace and brown trout were generally collected throughout the two sections of Walker Run, although they were low in abundance in the most downstream Reach 6. Green sunfish and pumpkinseeds were more abundant in the downstream section. These latter two species are typical of warmwater conditions where riparian canopy cover is more open.

A total of 89 wild brown trout were collected in this survey (Table 1), with nearly twice as many brown trout collected from the upstream section as the downstream section (59 versus 30). Brown trout abundance in the survey collections generally decreased as you move downstream on Walker Run (Figure 5). Brown trout comprised between 13.4 and 22.2 percent of the fish population at the three upstream sampling reaches, while they comprised between 0.4 and 10.1 percent of the fish population at the three downstream sampling reaches (Table 2). These findings indicate that habitat conditions are more suitable for brown trout in the upstream section of Walker Run.

The body length data for the collected brown trout is shown in Table 3. These data, depicted graphically in Figure 6, indicate that the range of body lengths were found at all but the most downstream reach 6. The size distribution for brown trout at each sampling reach is shown in Figure 7. The greatest number of small brown trout (<= 100 mm) were collected at the most upstream sampling reach 1. A total of 21 brown trout <= 100 mm were collected in the upstream section of Walker Run, while a total of 6 brown trout <= 100 mm were collected in the downstream section. This distribution is represented graphically in Figure 8. Assuming that these smallest size brown trout do not migrate extensively from where they were born, this would suggest that the most upstream section of Walker Run has the better habitat for trout spawning and fry development.

In the previous fish survey of Walker Run, completed in July 2008, the largest number of brown trout were collected at the most upstream sampling reach in that survey. That sampling reach corresponds to the most upstream sampling reach in the downstream section of Walker Run in the current survey effort (corresponding to sampling reach 4). The July 2008 survey did not sample in the upstream section of Walker Run.

B. HABITAT ASSESSMENT

Physical habitat characterizations, using RBP field data protocols, are shown in Table 4 for each habitat assessment sampling reach. Canopy cover was shaded at the three upstream assessment reaches, while is was partly open or open at the three downstream assessment reaches. Riffles were more common in the upstream section of Walker Run than the lower section. Reach 5 is channelized with a trapezoidal channel shape. Just downstream from this channelized section in reach 5 is a beaver dam. We intentionally did not include the backwater areas from this beaver dam in our fish sampling nor in our habitat assessments because it is of poor habitat quality for both fish and

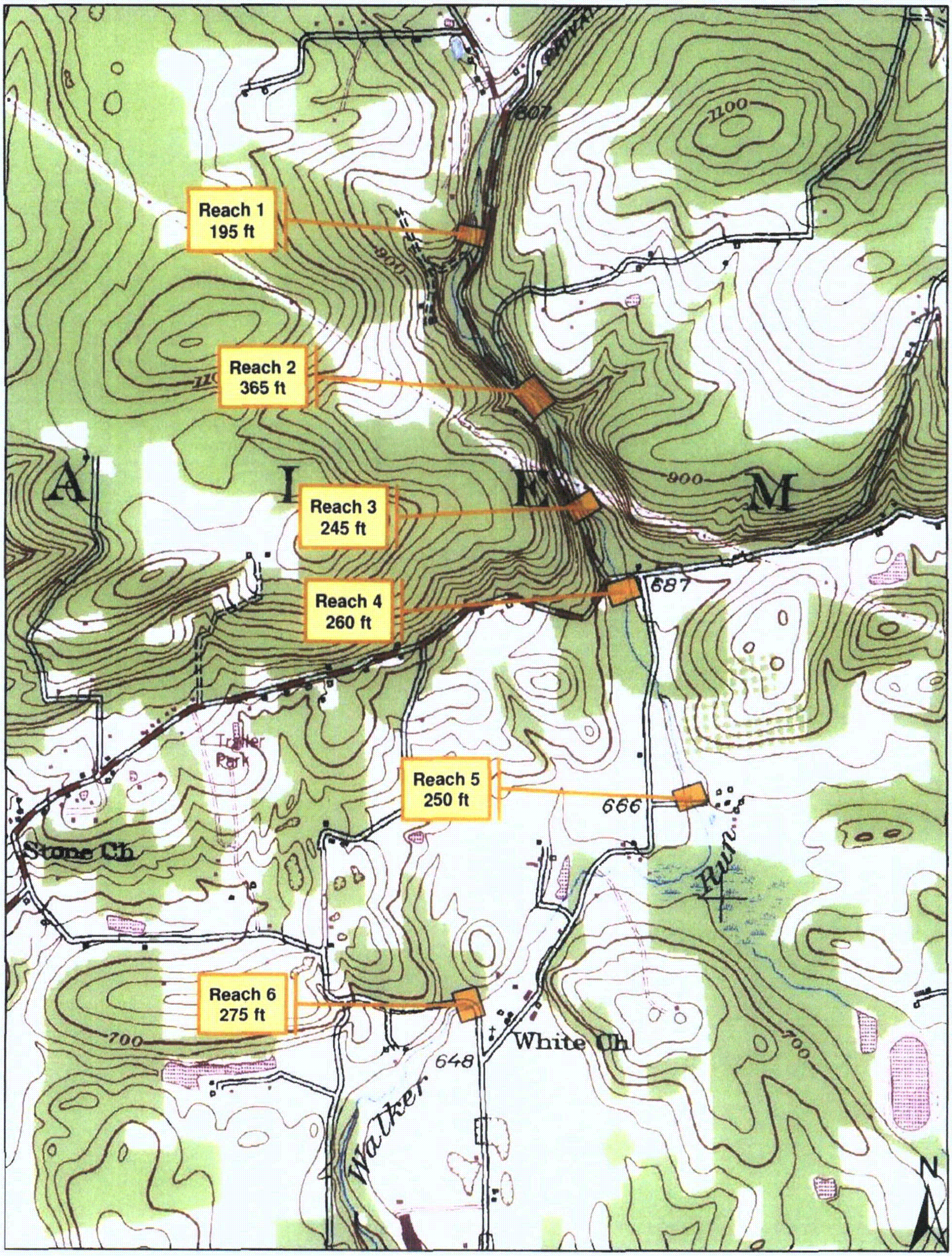


Figure 1: Location of Fish Sampling Reaches on Walker Run

Berwick USGS Topographic Quadrangle

1 inch equals 1,500 feet

Feet
0 750 1,500

LandStudies

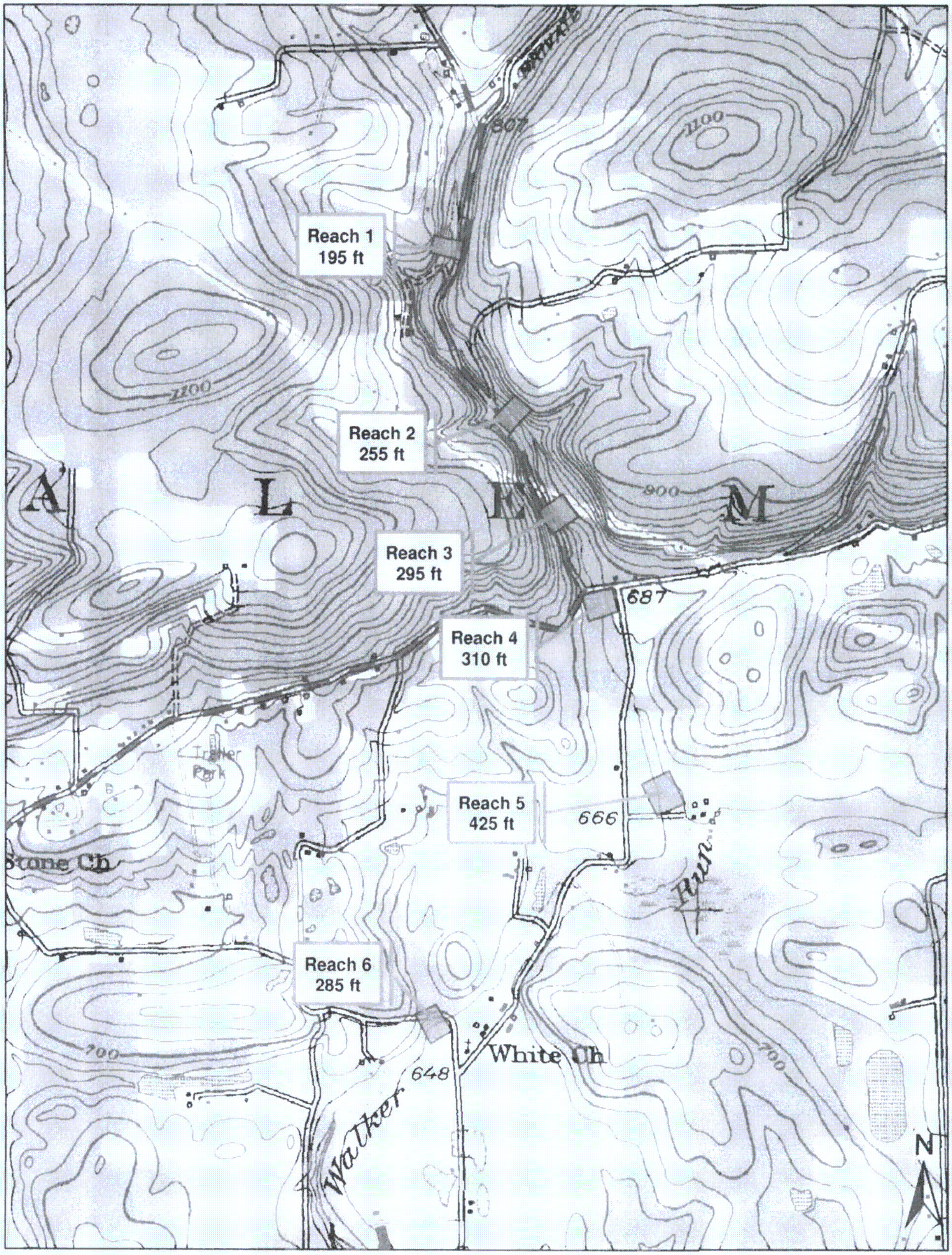


Figure 2: Location of Habitat Assessment Reaches

Berwick USGS Topographic Quadrangle

1 inch equals 1,500 feet

0 750 1,500 Feet

LandStudies

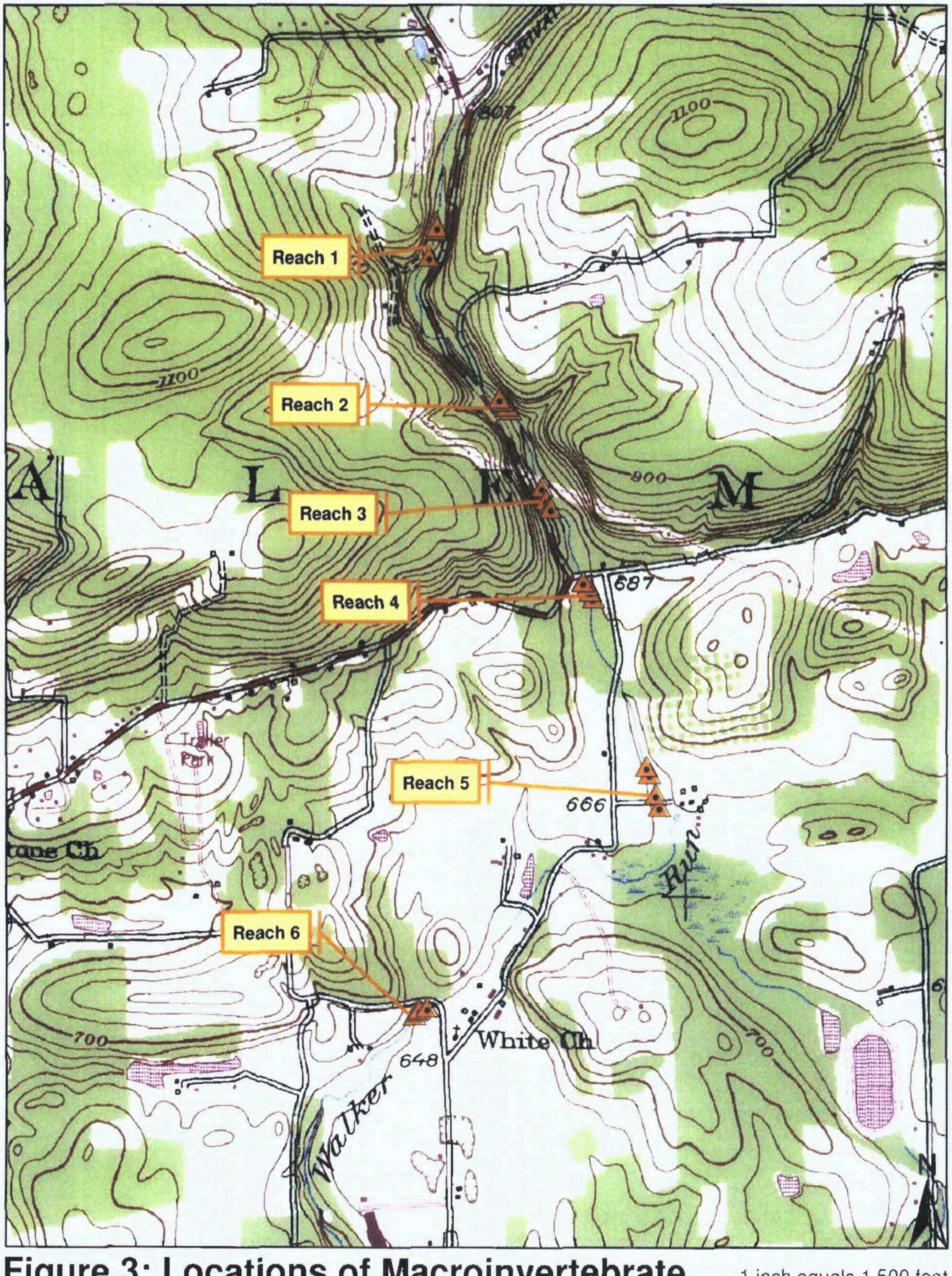


Figure 3: Locations of Macroinvertebrate Sampling on Walker Run

Berwick USGS Topographic Quadrangle

1 inch equals 1,500 feet

0 750 1,500 Feet

LandStudies

Table 1. Number of fish electroshocked in Walker Run on March 25, 2009. Electroshocking time and sampling reach length provided.

Species	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Combined
Electroshocking Time (min)	44	35	31	21	32	40	203
Sampling Reach Length (ft)	390	370	255	260	247	275	1,797
Creek Chub (*Semotilus atromaculatus*)	54	27	14	37	62	99	293
White sucker (*Catostomus commersoni*)	34	25	3	12	8	210	292
Blacknose Dace (*Rhinichthys atratulus*)	58	24	49	49	75	13	268
Fallfish (*Semotilus corporalis*)	0	0	0	0	0	115	115
Brown Trout (*Salmo trutta*)	23	22	14	11	17	2	89
Tesselated Darter (*Etheostoma olmstedi*)	0	0	0	0	0	59	59
Green Sunfish (*Lepomis cyanellus*)	3	1	0	5	6	8	23
Pumpkinseed (*Lepomis gibbosus*)	0	0	0	0	0	1	1
Total:	172	99	80	114	168	507	1,140

Figure 4. Fish Species Distribution in Walker Run

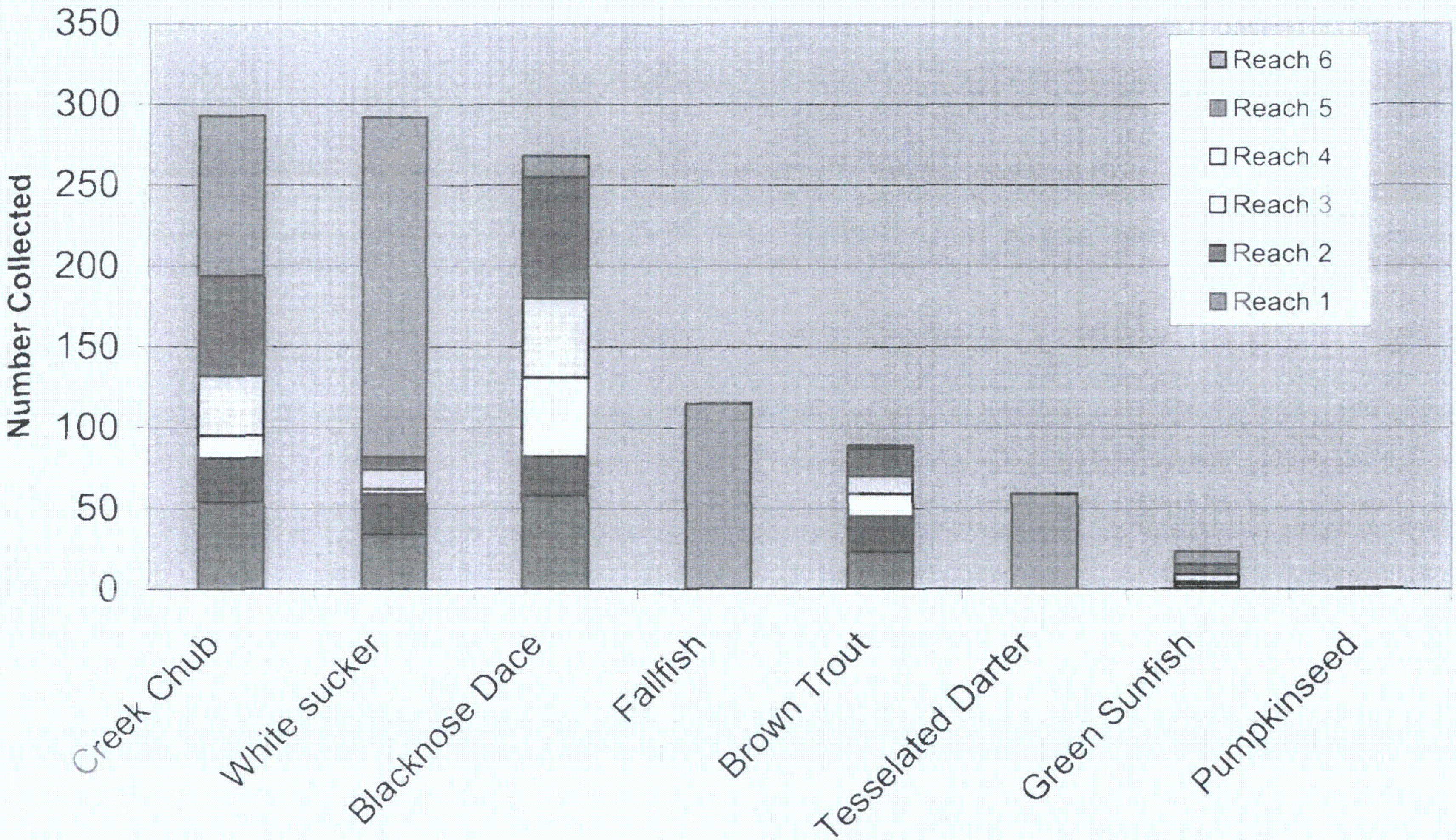
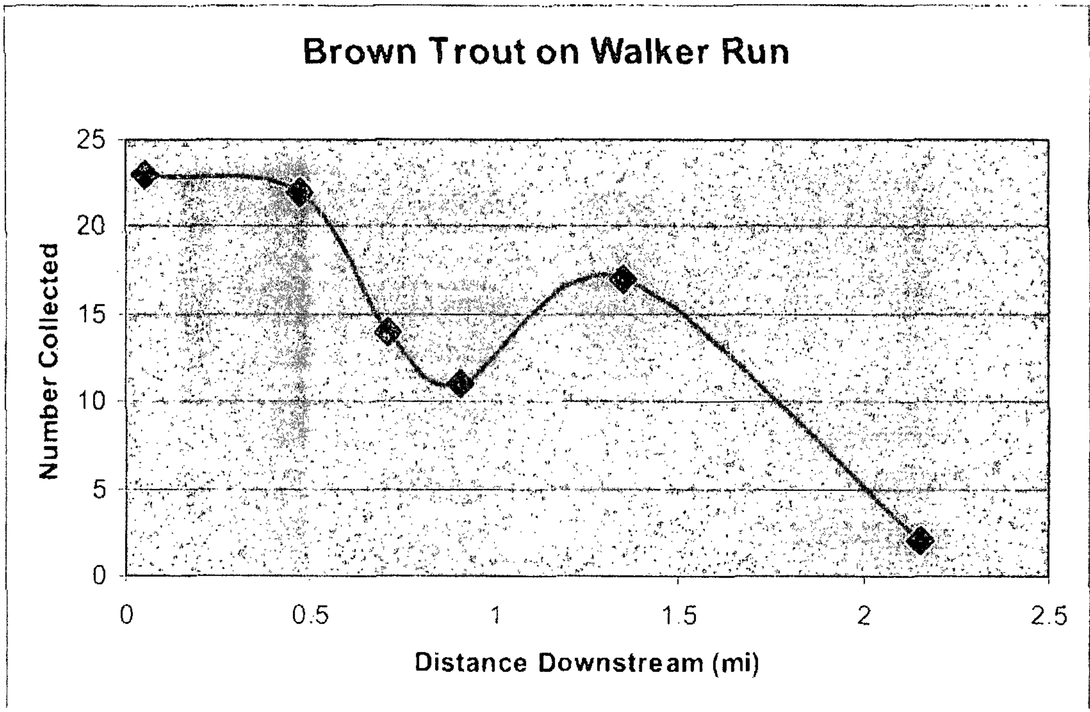


Table 2. Fish species composition at the six reaches in Walker Run, sampled on March 25, 2009. Electroshocking time and sampling reach length provided.

Species	**Reach 1**	**Reach 2**	**Reach 3**	**Reach 4**	**Reach 5**	**Reach 6**	**Combined**
Creek Chub (*Semotilis atromaculatus*)	31.4%	27.3%	17.5%	32.5%	36.9%	19.5%	25.7%
White sucker (*Catostoma commersoni*)	19.8%	25.3%	3.8%	10.5%	4.8%	41.4%	25.6%
Blacknose Dace (*Rhinichthys atratulus*)	33.7%	24.2%	61.3%	43.0%	44.6%	2.6%	23.5%
Fallfish (*Semotilus corporalis*)	0.0%	0.0%	0.0%	0.0%	0.0%	22.7%	10.1%
Brown Trout (*Salmo trutta*)	13.4%	22.2%	17.5%	9.6%	10.1%	0.4%	7.8%
Tesselated Darter (*Etheostoma olmstedi*)	0.0%	0.0%	0.0%	0.0%	0.0%	11.6%	5.2%
Green Sunfish (*Lepomis cyanellus*)	1.7%	1.0%	0.0%	4.4%	3.6%	1.6%	2.0%
Pumpkinseed (*Lepomis gibbosus*)	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.1%
Total:	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Figure 5. Wild brown trout collected along Walker Run as you move downstream.



macroinvertebrates. Visual observations indicate significant sediment deposition in the backwater areas, with extensive algal growth in these slower moving waters.

Attached algae is abundant at the two most downstream assessment reaches in Walker Run, indicating the input of nutrients from upstream agricultural land uses. Attached algae were also present at the most upstream assessment reach, indicating the input of nutrients from the agricultural land use just upstream of this reach.

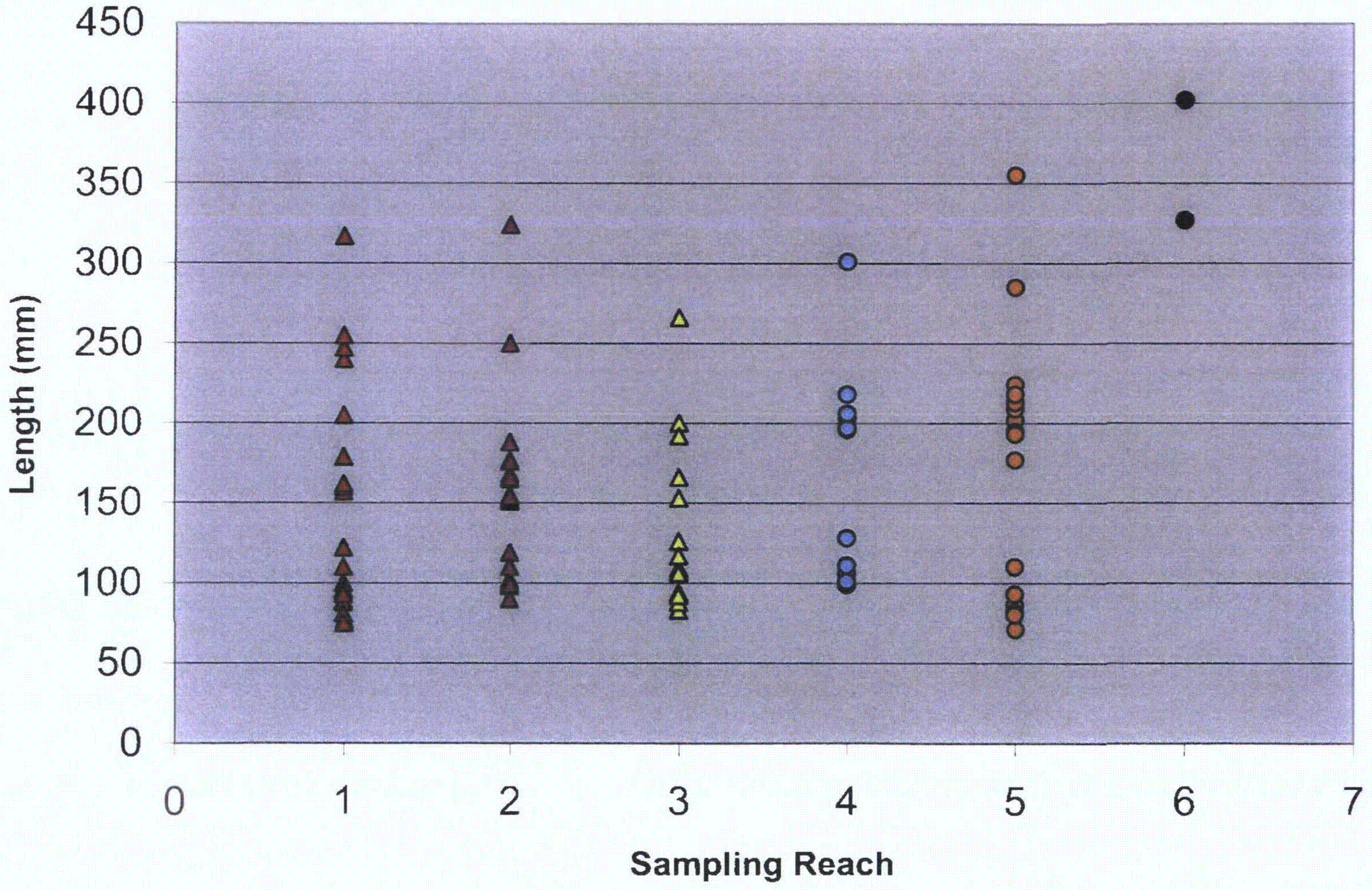
Percent embeddedness is similar at the four most upstream assessment reaches, ranging from 25 to 35 percent. Assessment reaches 5 and 6, however, have higher percent embeddedness ranging from 60 to 70 percent which is largely comprised of sand and silt. Gravel substrate in the stream bottom was more common at the four most upstream assessment reaches (20 to 30 percent of the stream bottom) compared to the two most downstream assessment reaches (5 to 10 percent). Gravels are important for wild brown trout spawning, as is a low percent embeddedness with sands and silts (less than 30 percent is optimal), and a shaded canopy cover (Raleigh et. al, 1986; Katzel and McKnight, 2001).

The RBP habitat assessment results (Table 5) indicate optimal or near-optimal habitat quality in the upper section of Walker Run, while the habitat quality is marginal in the lower section of Walker Run. The marginal habitat quality in the downstream section of Walker Run is largely due to higher embeddedness, greater sediment deposition, channel alteration, fewer riffles, very poor bank stability and vegetative protection, and the absence of significant forested riparian zones. The high streambanks, accumulation of legacy sediments, and consequent bank erosion in the downstream sections of Walker Run are a primary cause for the poor stream substrate conditions in the lower

Table 3. Body lengths of brown trout collected in Walker Run on March 25, 2009.

Reach No.	Length (mm)	Length (mm)	Length (mm)	Length (mm)	Length (mm)	Length (mm)	Count	Min (mm)	Max (mm)	No. <= 100 mm
1	317	240	179	205	247	255	23	75	317	12
	157	160	96	93	162	122				
	100	110	89	100	96	93				
	95	77	88	81	75					
2	324	155	188	166	188	250	22	90	324	5
	177	166	168	151	152	99				
	102	165	99	100	110	154				
	119	98	90	176						
3	266	107	200	153	166	192	14	83	266	4
	126	83	92	109	117	106				
	94	88								
4	203	218	301	196	197	101	11	99	301	1
	106	206	128	111	99					
5	285	209	224	213	177	218	17	71	355	5
	202	209	195	355	193	80				
	86	93	82	110	71					
6	327	402					2	327	402	0

Figure 6. Brown Trout Size Distribution in Walker Run



section of the stream. This is particularly an issue at the lower two assessment reaches (reaches 5 and 6).

Figure 7. Wild brown trout size distribution at each sampling reach.

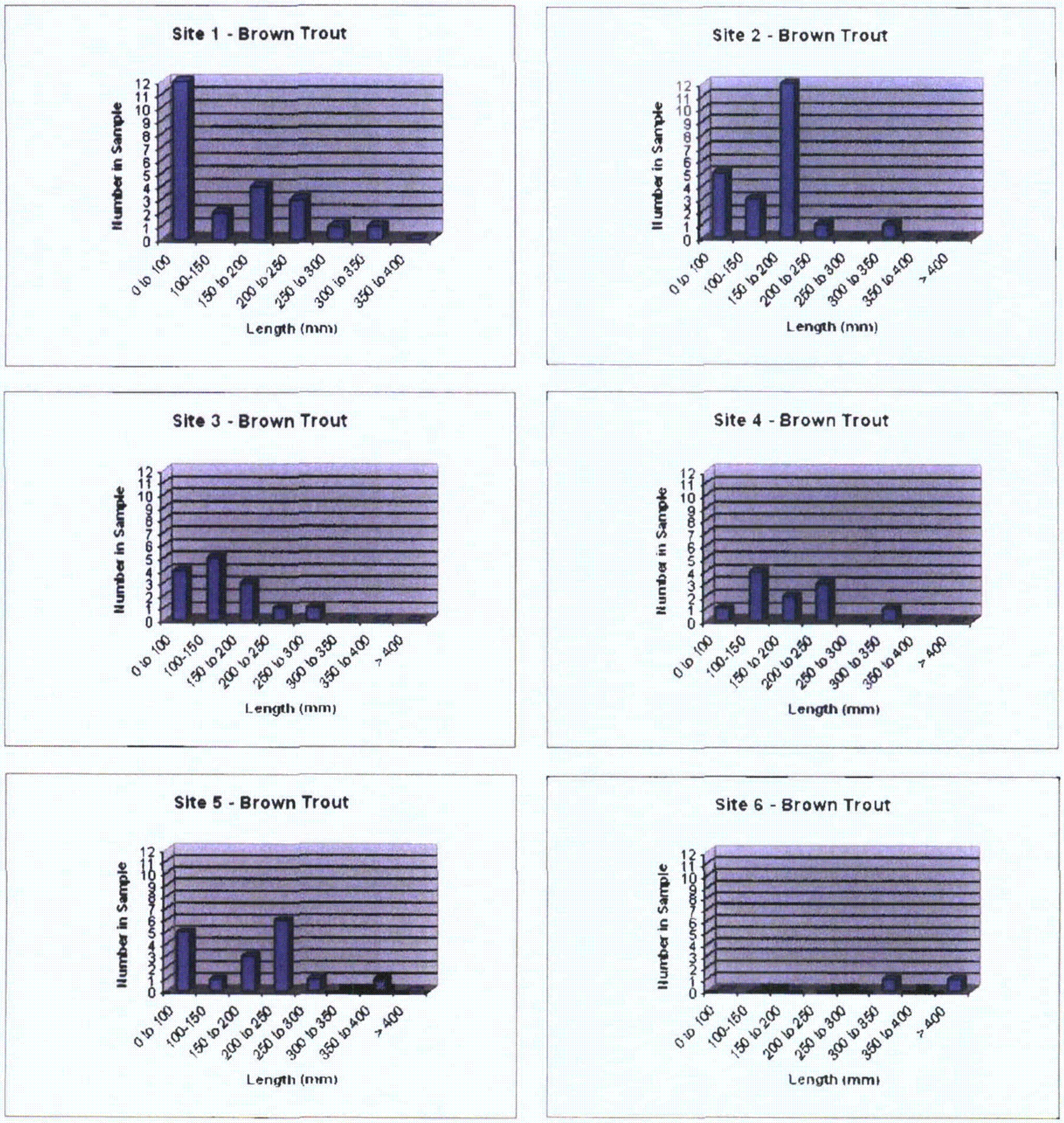
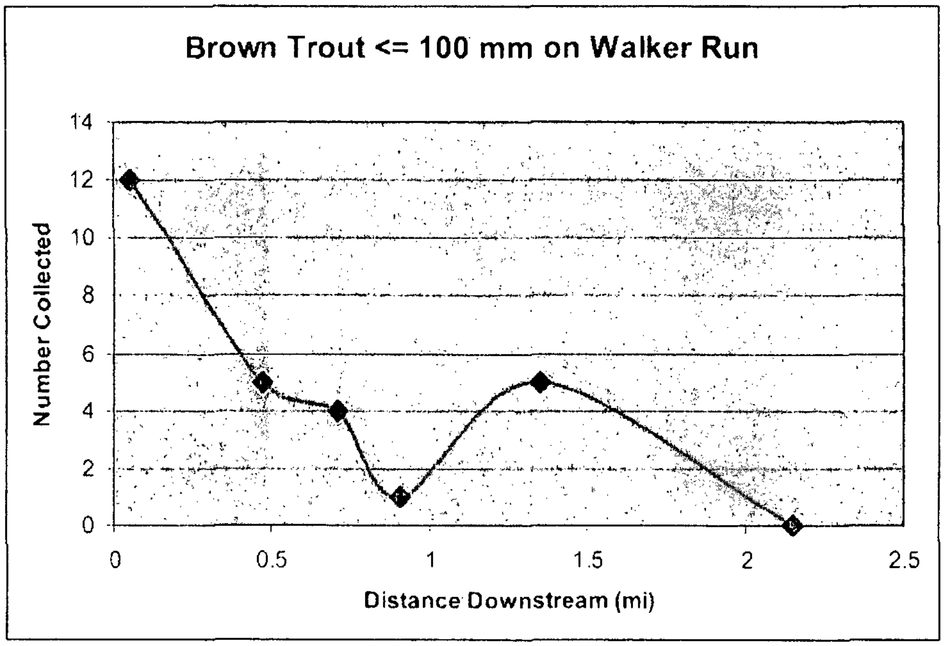


Figure 8. Wild brown trout <= 100 mm collected along Walker Run as you move downstream.



C. Macroinvertebrate Survey

Macroinvertebrate surveys were collected on March 31 and April 1, 2009 from four separate riffle locations within each of the 6 assessment reaches. A total of 5,680 organisms were identified within 72 taxa (Table 6). The number of taxa collected from the reaches varied from 29 in reach 1 to 46 in reach 5. Pollution tolerance values for each taxon were taken from the CBWP-MANTA EA-05-13 (2005) and from Mandaville (2002). Pollution tolerance values indicate whether organisms within a taxon are intolerant or tolerant of stream pollution.

The pollution tolerance values were utilized with the macroinvertebrate sampling results to calculate a biotic index for each stream reach. The Hilsenhof Biotic Index (HBI) provides a single metric to characterize the stream reach based on which taxa were collected there and their pollution tolerance. The HBI findings (Table 7) clearly show that the upstream four reaches have very good water quality, while the lower two reaches have good to fair water quality. The EPT Ratio is a ratio based on the percent of the total organisms collected in a reach that were either mayflies (Order Ephemeroptera), stoneflies (Order Plecoptera), or caddisflies (Order Trichoptera). These three orders of insects are generally intolerant of pollution, particularly the mayflies and stoneflies. The EPT ratio indicates that reaches 2 and 3 have the highest water quality. This finding is similarly indicated using the Percent Ephemeroptera metric and Percent Plecoptera metric.

D. Spawning Gravel Sampling

Photographs of the sampled gravels that were the best sites for potential brown trout spawning in each habitat assessment reach are shown in Figures 9 to 14. When fully dried, the composition of the gravels was visually estimated based on particle size ranges.

Table 4. Physical attributes of Walker Run using EPA's RBP parameters and characterizations.

Physical Attributes	**REACH 1**	**REACH 2**	**REACH 3**
Stream Reach Length (ft)	195	255	295
Average Stream Width (ft) - riffle	13	13	11
Average Stream Depth (ft) - riffle	0.18	0.45	0.50
Canopy Cover	shaded	shaded	shaded
Riffles - Proportion of Reach	60%	70%	60%
Runs - Proportion of Reach	10%	0%	10%
Pools - Proportion of Reach	30%	30%	30%
Channelized?	no	no	no
Dam Present?	natural	no	no
Percent Large Woody Debris	30%	15%	10%
Attached Algae Present	present	none	none
Percent Embeddedness	25%	35%	30%
Substrate (Percent Composition):			
Boulders (> 10 in)	15%	10%	20%
Cobble (2.5" to 10")	50%	60%	50%
Gravel (0.1" to 2.5")	20%	20%	20%
Sand (0.06 to 2.0 mm)	15%	10%	10%
Silt (0.004 to 0.06 mm)			
Clay (< 0.004 mm)			

Habitat Category	**REACH 4**	**REACH 5**	**REACH 6**
Stream Reach Length (ft)	310	425	285
Average Stream Width (ft) - riffle	11	13	14
Average Stream Depth (ft) - riffle	0.25	1.05	0.45
Canopy Cover (% shaded)	partly open	partly open	partly open
Riffles - Proportion of Reach	35%	5%	20%
Runs - Proportion of Reach	45%	25%	50%
Pools - Proportion of Reach	20%	70%	30%
Channelized?	no	yes	no
Dam Present?	no	no	no
Percent Large Woody Debris	0%	0%	5%
Attached Algae Present	none	present	abundant
Percent Embeddedness	30%	60%	70%
Substrate (Percent Composition):			
Boulders (> 10 in)	2%	5%	10%
Cobble (2.5" to 10")	50%	15%	40%
Gravel (0.1" to 2.5")	30%	10%	5%
Sand (0.06 to 2.0 mm)	15%	45%	20%
Silt (0.004 to 0.06 mm)	3%	25%	25%
Clay (< 0.004 mm)			

Table 5. Habitat assessments of Walker Run using EPA's RBP parameters and characterizations.

Habitat Category	REACH 1	REACH 2	REACH 3
Epifaunal substrate / available cover	14	12	13
Embeddedness / Pool Substrate (LG)	15	12	14
Velocity / Depth Regime / Pool Variability (LG)	17	14	14
Sediment deposition	16	12	13
Channel Flow Status	12	11	13
Channel alteration	20	20	20
Frequency of Riffles	14	18	14
Bank stability	19	18	15
Vegetative protection	18	18	20
Riparian vegetation zone width	20	20	15
Average Score:	**17**	**16**	**15**

Habitat Category	REACH 4	REACH 5	REACH 6	Scoring Descriptions
Epifaunal substrate / available cover	12	10	9	
Embeddedness / Pool Substrate (LG)	9	7	7	
Velocity / Depth Regime / Pool Variability (LG)	9	6	7	
Sediment deposition	12	7	8	
Channel Flow Status	11	18	11	Optimal: 20 to 16
Channel alteration	17	6	13	Suboptimal: 15 to 11
Frequency of Riffles / Channel Sinuosity (LG)	7	3	11	Marginal: 10 to 6
Bank stability	5	5	4	Poor: 5 to 0
Vegetative protection	7	7	5	
Riparian vegetation zone width	5	6	8	
Average Score:	**9**	**8**	**8**	

LG denotes low gradient streams (sites 4 through 6)

Table 6. Macroinvertebrates collected in Walker Run on March 31 and April 1, 2009. Average percent composition in the stream for each taxon and the pollution tolerance of each taxon are shown.

ORDER/CLASS	FAMILY	GENUS	WR-1	WR-2	WR-3	WR-4	WR-5	WR-6	Average Percent Composition	Tolerance Value
Turbellaria	Planariidae	*Dugesia*					1		0.0%	9.3
Nematoda								2	0.0%	10.0
Oligochaeta							21	27	0.8%	10.0
Amphipoda	Gammaridae	*Gammarus*					1	26	0.5%	6.7
Bivalvia	Sphaeriidae	*Psidium*					4		0.1%	5.7
Gastropoda	Physidae	*Physa*						2	0.0%	7.0
Gastropoda	Ancylidae	*Ferrissia*				1	1	1	0.1%	7.0
Crustacea	Cambaridae	*Cambarus*		1	3				0.1%	0.4
Megaloptera	Corydalidae	*Nigronia*	3	8	2			1	0.2%	1.4
Odonata	Gomphidae	*Stylogomphus*		2	2		1		0.1%	2.2
Coleoptera	Elmidae	*Optioservus*		3		4	2		0.2%	5.4
Coleoptera	Elmidae	*Oulimnius*		7		5	2	1	0.3%	2.7
Coleoptera	Elmidae	*Promoresia*					1	5	0.1%	2.0
Coleoptera	Elmidae	*Stenelmis*						20	0.4%	7.1
Coleoptera	Psephenidae	*Ectopria*	1				1	3	0.1%	2.2
Diptera	Blephariceridae	*Blephariceria*			1	1			0.0%	4.0
Diptera	Ceratopogonidae	*Palpomyia*					2		0.0%	6.0
Diptera	Ceratopogonidae	*Probezzia*	1		2			1	0.1%	3.0
Diptera	Ceratopogonidae	*Sphaeromias*					1		0.0%	3.6
Diptera	Chironomidae		22	44	45	159	237	591	19.3%	6.6
Diptera	Empididae	*Chelifera*						2	0.0%	7.1
Diptera	Empididae	*Clinoceera*		1		2	3	7	0.2%	7.4
Diptera	Empididae	*Hemerodromia*						1	0.0%	7.9
Diptera	Simuliidae	*Prosimulium*	274	143	173	1448	231	71	41.2%	2.4
Diptera	Simuliidae	*Stegopterna*	1		1		27	2	0.5%	2.4
Diptera	Simuliidae	*Simulium*	1			7		2	0.2%	5.7
Diptera	Tipuliidae	*Antocha*				4	3	16	0.4%	8.0
Diptera	Tipuliidae	*Dicranota*	1	1	4	1	3		0.2%	1.1
Diptera	Tipuliidae	*Hexatoma*		2		1			0.1%	1.5
Diptera	Tipuliidae	*Limnophila*		1					0.0%	4.8
Diptera	Tipuliidae	*Pseudolimnophila*	2				1	1	0.1%	2.8
Diptera	Tipuliidae	*Tipula*			1		1		0.0%	6.7
Ephemeroptera	Ameletidae	*Ameletus*	3	4	3	6	16		0.6%	2.6
Ephemeroptera	Baetidae	*Acerpenna*	3	2		1	19		0.4%	2.6
Ephemeroptera	Baetidae	*Baetis*	2	35	18	49	6	1	2.0%	3.9
Ephemeroptera	Baetidae	*Diphetor*	1	22	4	12	10		0.9%	2.3
Ephemeroptera	Baetidae	*Plauditus*		7	4	10	5		0.5%	4.0
Ephemeroptera	Ephemerellidae	*Ephemerella*	2	16	3	55	8		1.5%	2.3
Ephemeroptera	Ephemerellidae	*Eurylophella*	2	2	1	1	61	4	1.3%	4.5
Ephemeroptera	Ephemerellidae	*Serratella*	6	83	93	79	82	112	8.0%	2.8
Ephemeroptera	Ephemeridae	*Ephemera*		1					0.0%	3.0
Ephemeroptera	Heptageniidae	*Cinygmula*					3		0.1%	1.6
Ephemeroptera	Heptageniidae	*Epeorus*	30	59	84	134	15		5.7%	1.7
Ephemeroptera	Heptageniidae	*Maccaffertium*	2	19	16	4	43	22	1.9%	3.0

Table 6 (continued). Macroinvertebrates collected in Walker Run on March 31 and April 1, 2009. Average percent composition in the stream for each taxon and the pollution tolerance of each taxon are shown.

ORDER/CLASS	FAMILY	GENUS	WR-1	WR-2	WR-3	WR-4	WR-5	WR-6		Average Percent Composition	Tolerance Value
Ephemeroptera	Heptageniidae	*Stenacron*		2		6		7		0.3%	2.0
Ephemeroptera	Leptophlebiidae	*Leptophlebia*	1				22			0.4%	1.8
Ephemeroptera	Leptophlebiidae	*Paraleptophlebia*	20	54	18	10	1			1.8%	2.0
Ephemeroptera	Isonychiidae	*Isonychia*		3	3	16	1			0.4%	2.5
Plecoptera	Capniidae	*Paracapnia*					1			0.0%	2.8
Plecoptera	Chloroperlidae	*Haploperla*	1	6	1	2		1		0.2%	1.6
Plecoptera	Chloroperlidae	*Sweltsa*		2	3	2				0.1%	1.9
Plecoptera	Leuctridae	*Leuctra*		4	3	1	2			0.2%	0.4
Plecoptera	Nemouridae	*Amphinemura*	4	26	42	58	6			2.4%	3.0
Plecoptera	Nemouridae	*Ostrocerca*	1	1		3	2			0.1%	1.7
Plecoptera	Peltoperlidae	*Tallaperla*	1	1	10	7				0.3%	1.5
Plecoptera	Perlidae	*Acroneuria*	4	10	4		1			0.3%	2.5
Plecoptera	Perlodidae	*Isoperla*	1	2	24	23	3			0.9%	2.4
Plecoptera	Pteronarcidae	*Pteronarcys*			3					0.1%	1.1
Plecoptera	Taeniopterygidae	*Taeniopteryx*			1					0.0%	4.8
Trichoptera	Brachycentridae	*Micrasema*				1				0.0%	2.3
Trichoptera	Hydropsychidae	*Cheumatopsyche*	6	2	6	8	1	47		1.2%	6.5
Trichoptera	Hydropsychidae	*Diplectrona*		14	10	5				0.5%	2.7
Trichoptera	Hydropsychidae	*Hydropsyche*		3	4	16	1	16		0.7%	7.5
Trichoptera	Limnephilidae	*Hydratophylax*					1			0.0%	3.4
Trichoptera	Polycentropodidae	*Polycentropus*	1	3	1			1		0.1%	1.1
Trichoptera	Phryganeidae	*Ptilostomis*						1		0.0%	4.3
Trichoptera	Psychomyiidae	*Lype*					7			0.1%	4.7
Trichoptera	Psychomyiidae	*Psychomyia*				1		6		0.1%	4.9
Trichoptera	Philopotamidae	*Chimarra*					1	3		0.1%	4.4
Trichoptera	Philopotamidae	*Dolophilodes*		3	2	3				0.1%	1.7
Trichoptera	Uenoidae	*Neophylax*		4		8	10	3		0.4%	2.7
Trichoptera	Rhyacophiliidae	*Rhyacophila*	10	8	23	12				0.9%	2.1
		Total Organisms per Sample	407	611	618	2,166	872	1,006	=	5,680	

Tolerance Values range from 0 (species is highly intolerant of pollution) to 10 (species is highly tolerant of pollution).

Table 7. Macroinvertebrates community metrics for samples collected from Walker Run on March 31 and April 1, 2009. of each taxon are shown.

Benthic Community Metric	WR-1	WR-2	WR-3	WR-4	WR-5	WR-6
Hilsenhof Biotic Index - score interpretations provided below table	2.63	2.82	2.80	2.82	4.06	5.81
Number of Intolerent Taxa	26	34	32	30	32	18
Number of EPT Taxa	20	29	26	28	26	13
EPT Ratio	24.8%	65.1%	62.1%	24.6%	37.6%	22.3%
Percent Ephemeroptera Taxa	17.7%	50.6%	40.0%	17.7%	33.5%	14.5%
Percent Plecoptera Taxa	2.9%	8.5%	14.7%	4.4%	1.7%	0.1%
Percent Trichoptera Taxa	4.2%	6.1%	7.4%	2.5%	2.4%	7.7%
EPT to Diptera Ratio	33.4%	207.3%	169.2%	32.8%	64.4%	32.3%

Scores of 0 to 4.50 are rated good
Scores of 4.51 to 6.50 are rated fair
Scores of 6.51 to 8.50 are rated poor
Scores of 8.51 to 10.0 are rated very poor

FIGURE 9
SITE 1 SPAWNING GRAVEL SAMPLING

FIGURE 10
SITE 2 SPAWNING GRAVEL SAMPLING

FIGURE 11
SITE 3 SPAWNING GRAVEL SAMPLING

FIGURE 12
SITE 4 SPAWNING GRAVEL SAMPLING

FIGURE 13
SITE 5 SPAWNING GRAVEL SAMPLING

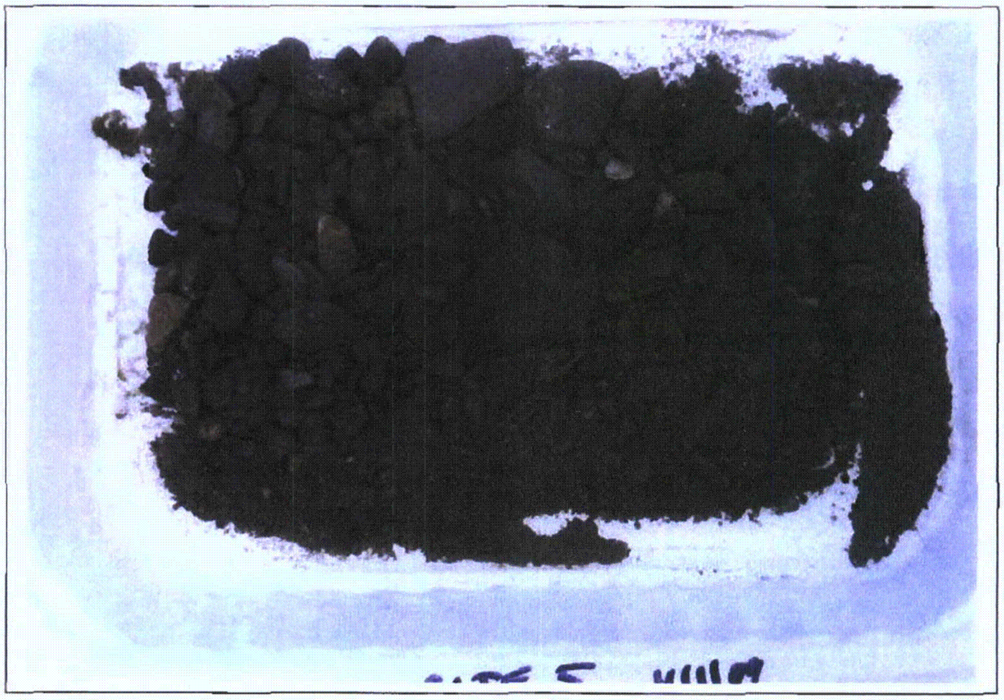
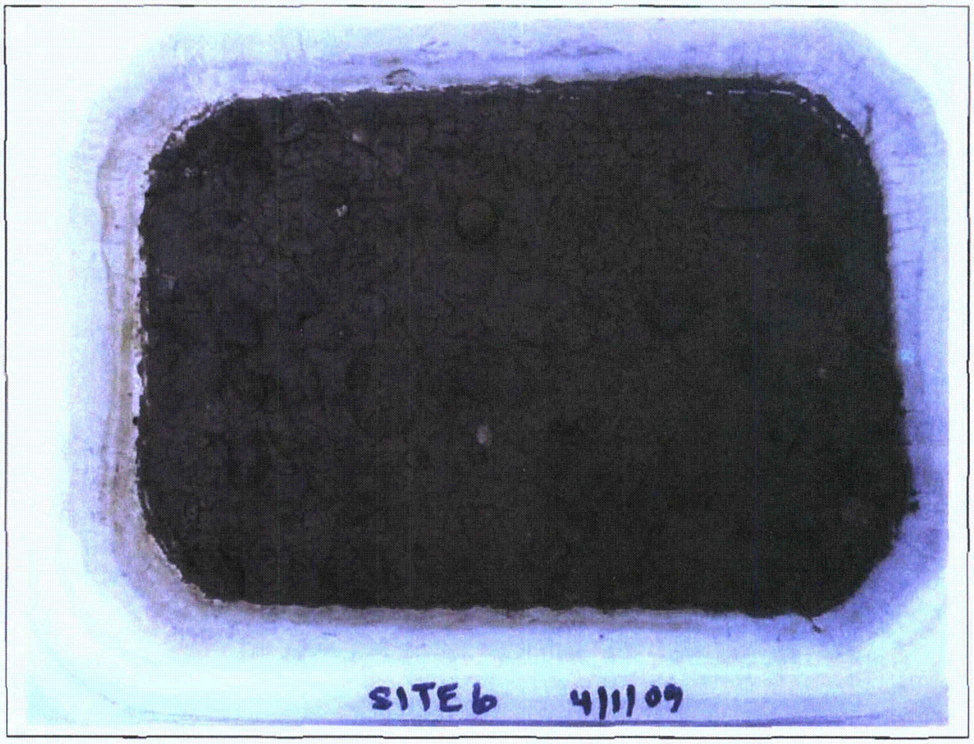


FIGURE 14
SITE 6 SPAWNING GRAVEL SAMPLING



Gravels are important for wild brown trout spawning, as is a low percent embeddedness with sands and silts (less than 30 percent is optimal), and a shaded canopy cover (Raleigh et. al, 1986; Kondolf, 2000; Katzel and McKnight, 2001). The ideal location for trout spawning will be one with a high gravel concentration, the least silt and sand embeddedness, and a location preferably at a pool-riffle transition where upwelling would most likely occur. These characteristics are critical for trout to be able to construct redds in the gravel (where they will lay and fertilize eggs) and to maximize the exchange of oxygen and metabolic wastes through interstitial gravel spaces.

The findings of the spawning gravel survey are shown in Table 8. Based on the percent composition of gravel, and the percent of silts and sands (those less than 3 mm), and the availability of high quality spawning gravel areas within the reach, the three most upstream reaches have the best gravels in terms of quality and availability (Table 8). These three reaches also have the greatest canopy cover of all the reaches (Table 4).

IV. CONCLUSIONS

The fisheries survey of Walker Run as performed at six sampling reaches extending from 0.9 miles upstream of Beach Grove Road to 1.25 miles downstream of Beach Grove Road. Three sampling reaches were in the upstream section of Walker Run (above Beach Grove Road), and the other three sampling reaches were downstream of Beach Grove Road. Sampling Reach 5 was located on the project site. A total of 89 wild brown trout were collected from Walker Run, with nearly twice as many brown trout collected in the upstream section compared to the downstream section. The greatest number of small brown trout (<= 100 mm) were collected from the upstream section (total of 21) compared to the downstream section (total of 6). These findings indicate that the upstream section of Walker Run has better habitat for brown trout spawning and fry development, and overall better habitat for brown trout populations than the downstream section of Walker Run.

The habitat assessment of Walker Run indicated optimal or near-optimal habitat quality in the upstream section of Walker Run, while the downstream section had marginal habitat quality. The poorer habitat quality in the downstream section was attributed to greater substrate embeddedness, greater sediment deposition, fewer riffle areas, channelization, and very poor bank stability and vegetative protection. These habitat characteristics in the downstream section reflect the erosion that is occurring there, caused by the presence of legacy sediments.

The habitat quality in the upstream section of Walker Run is optimal or near-optimal primarily because it is fully shaded, has low substrate embeddedness, a greater presence of gravel substrate, and more prevalent riffle areas. These habitat characteristics are critical habitat features for successful spawning of brown trout.

Macroinvertebrate survey metrics indicate excellent water quality in the four most upstream reaches, and in particular reaches 2 and 3. Water quality is good to fair in the downstream reaches of Walker Run.

Trout spawning gravel survey results indicate that the best gravels for brown trout spawning are found in the three most upstream reaches. There will probably be suitable spawning gravel areas in the three downstream reaches, although the frequency of those suitable areas appears to be significantly less than in the three upstream reaches.

Based on all the results from this survey of Walker Run, the upstream section of Walker Run (upstream of Beach Grove Road) has the best water quality, best habitat quality, the most brown trout, the greatest number of small brown trout, and the better spawning gravel areas.

Photographs of Walker Run from both the fisheries survey and the habitat assessment survey are provided in the Appendices.

Table 8. Spawning gravel sampling surveys of Walker Rur

Physical Attributes	REACH 1	REACH 2	REACH 3
Riffles - Proportion of Reach	60%	70%	60%
Runs - Proportion of Reach	10%	0%	10%
Pools - Proportion of Reach	30%	30%	30%
Availability of Spawning Gravels in Reach	Frequent	Frequent	Frequent
Percent Embeddedness in Reach	25%	35%	30%
Spawning Gravel Sample Substrate:			
Cobble (2.5" to 10")	20%	10%	10%
Gravel (0.1" to 2.5")	70%	75%	80%
Sand (0.06 to 2.0 mm)	10%	15%	10%
Silt (0.004 to 0.06 mm)	0%	0%	0%
Percent finer than 1 mm (estimated - spawning gravel sample)*	5%	5%	5%
Percent finer than 3 mm (estimated - spawning gravel sample)**	10%	10%	10%

Habitat Category	REACH 4	REACH 5	REACH 6
Riffles - Proportion of Reach	35%	5%	20%
Runs - Proportion of Reach	45%	25%	50%
Pools - Proportion of Reach	20%	70%	30%
Availability of Spawning Gravels in Reach	Present	Low	Low
Percent Embeddedness in Reach	30%	60%	70%
Spawning Gravel Sample Substrate:			
Cobble (2.5" to 10")	25%	15%	0%
Gravel (0.1" to 2.5")	50%	55%	20%
Sand (0.06 to 2.0 mm)	20%	25%	10%
Silt (0.004 to 0.06 mm)	5%	5%	70%
Percent finer than 1 mm (estimated - spawning gravel sample)*	10%	15%	75%
Percent finer than 3 mm (estimated - spawning gravel sample)**	25%	35%	80%

* Percent finer than 1 mm should be less than 14% for spawning gravels.
** Percent finer than 3 mm should be less than 30% for spawning gravels.

V. REFERENCES

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