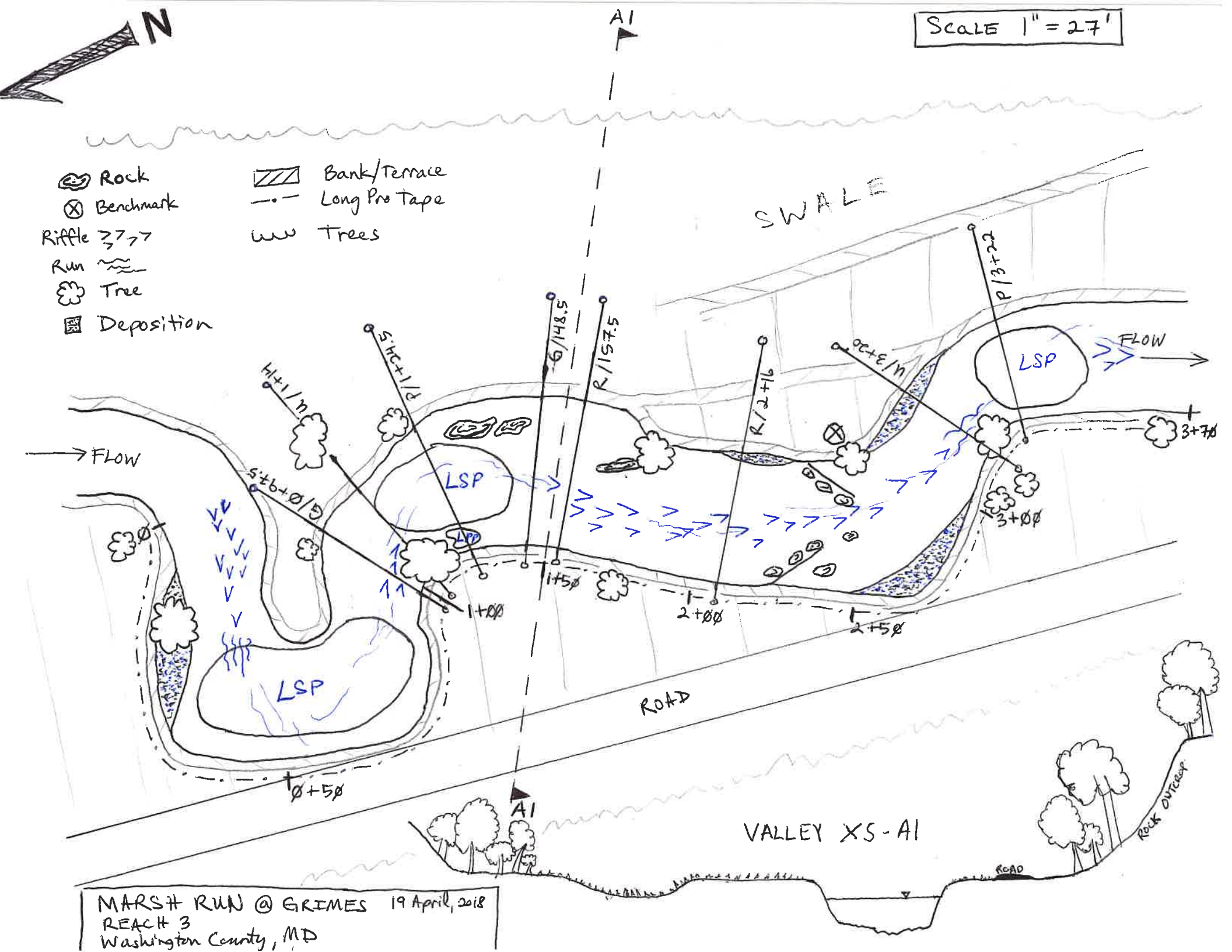
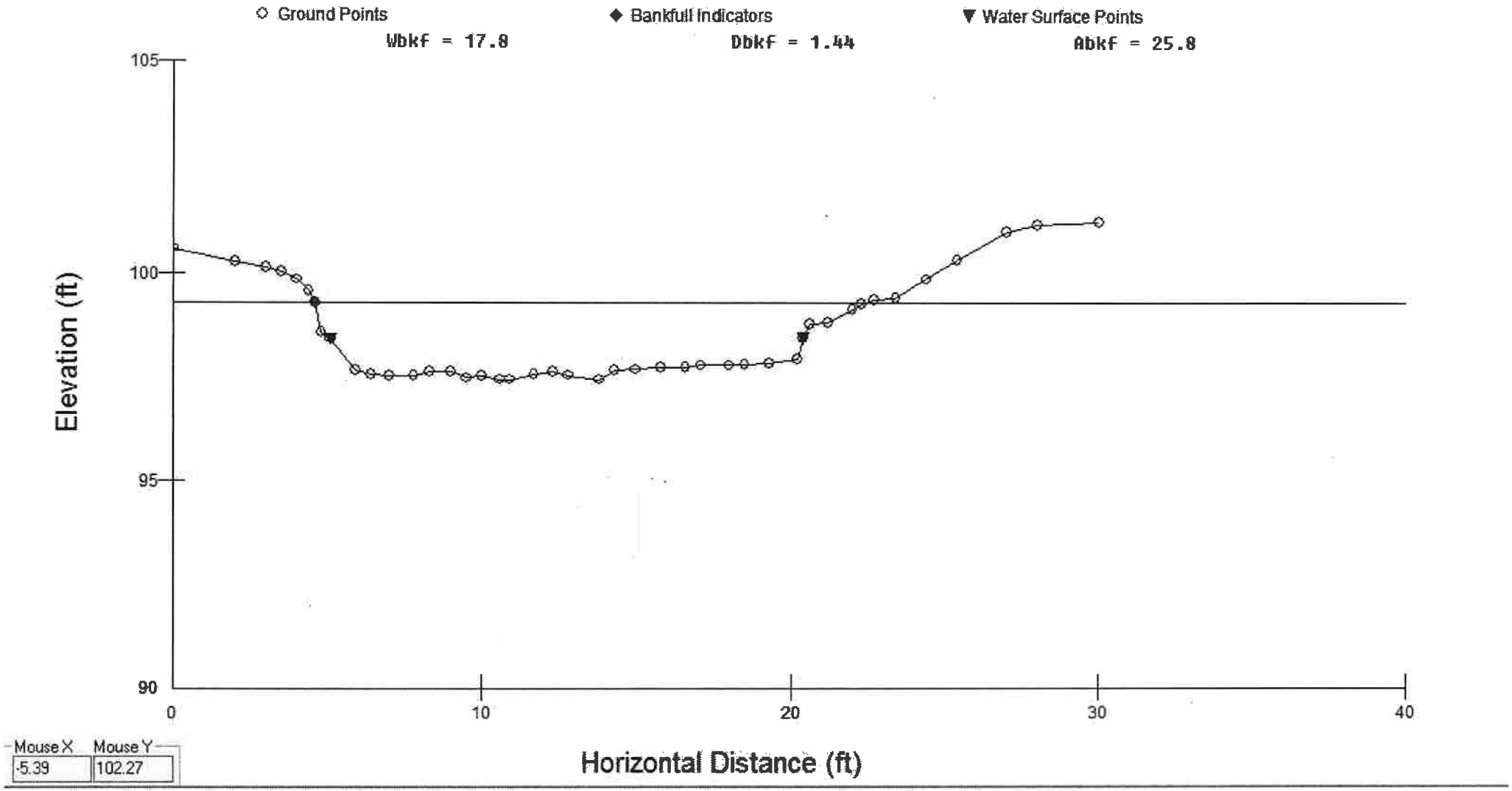
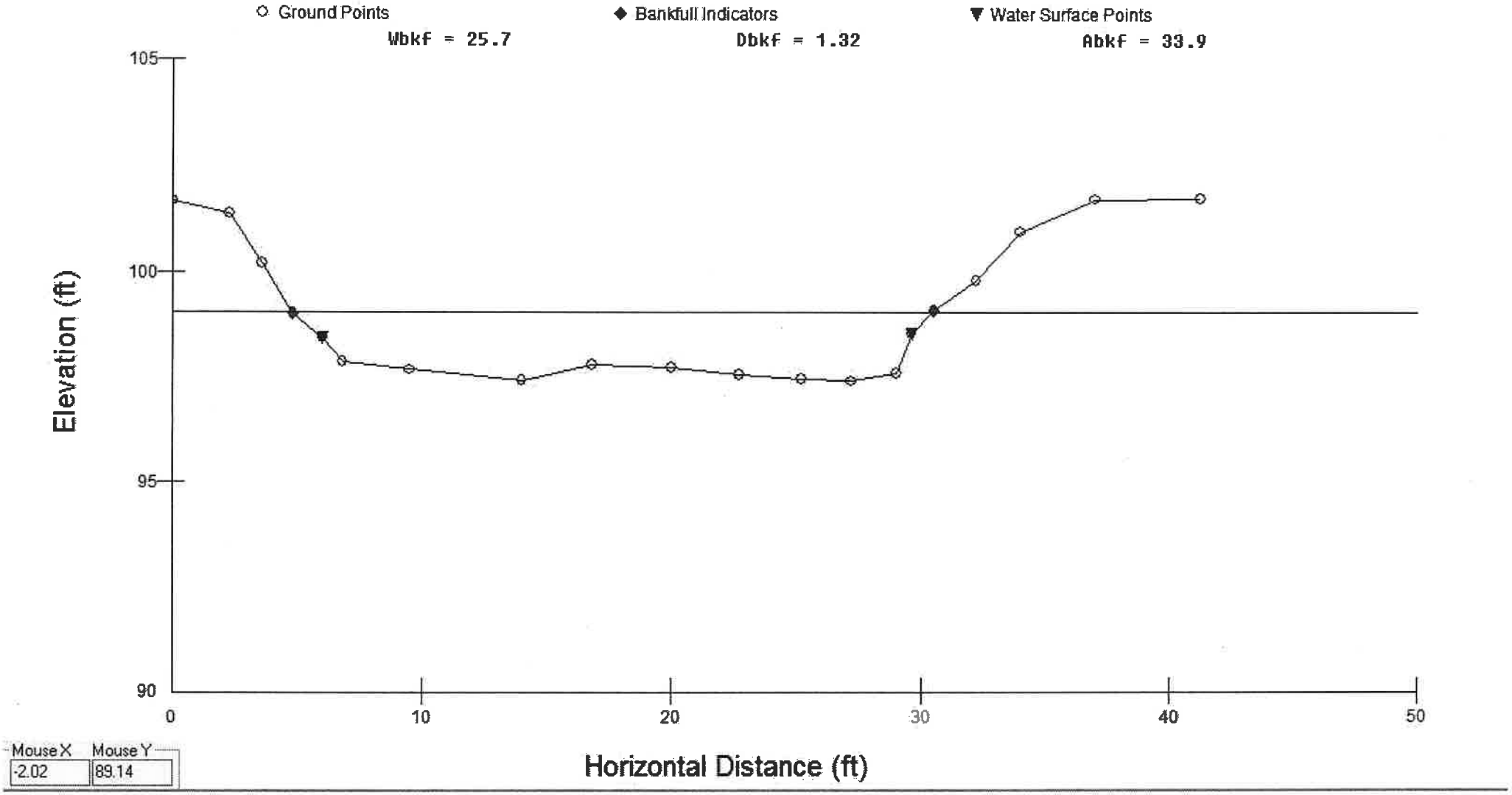


N
A1
SCALE 1" = 27'
Rock
Benchmark
Riffle
Run
Tree
Deposition
Bank/Terrace
Long Pro Tape
Trees
SWALE
FLOW
FLOW
LSP
LSP
LSP
LPP
U/1+14
P/1+34.5
G/148.5
R/157.5
R/2+16
U/3+30
P/3+22
G/0+97.5
0+50
1+00
1+50
2+00
2+50
3+00
3+70
ROAD
A1
VALLEY XS-A1
ROAD
ROCK OUTCROP
MARSH RUN @ GRIMES 19 April, 2018
REACH 3
Washington County, MD

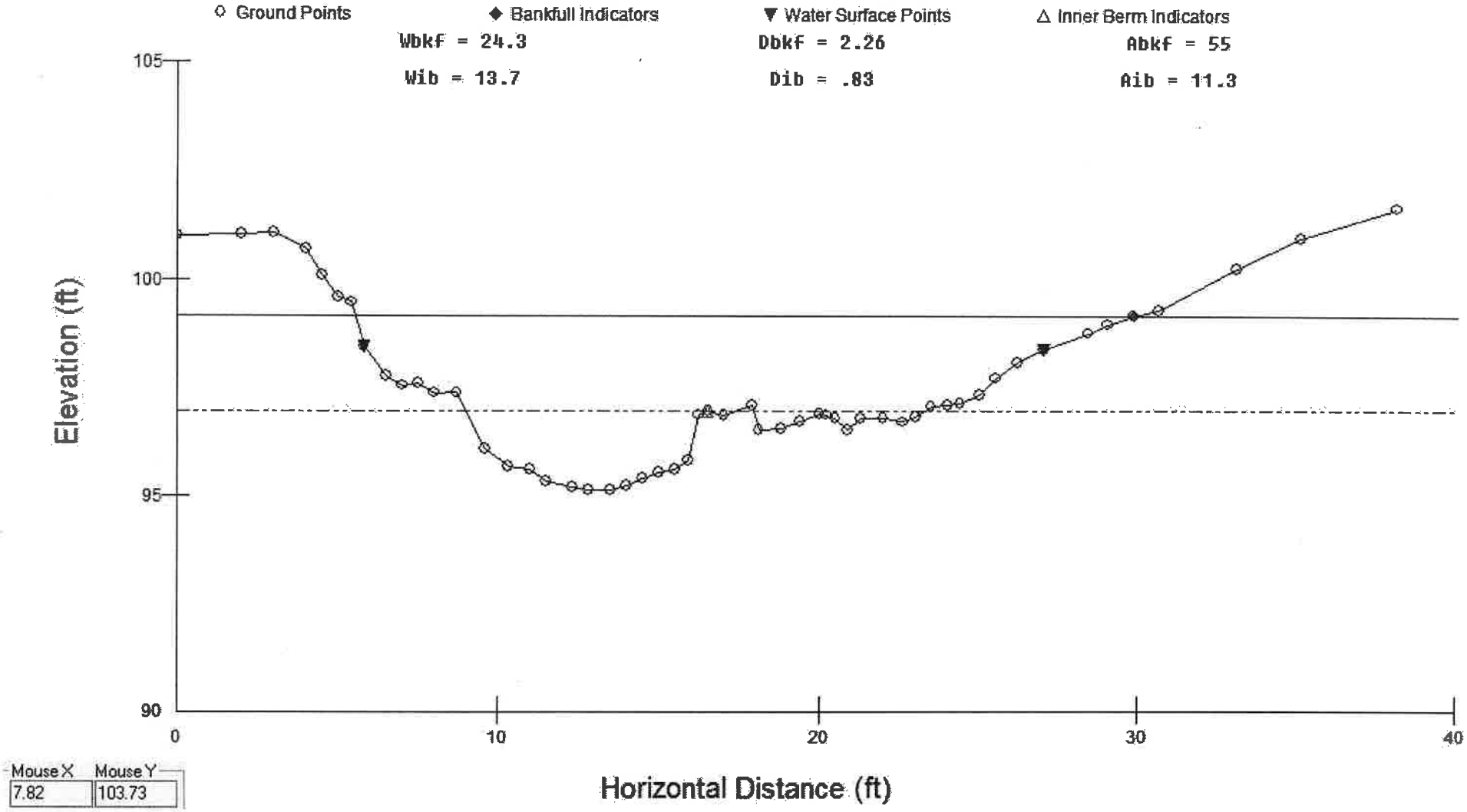
# Glide 1


Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 17.8
Dbkf = 1.44
Abkf = 25.8
105
100
95
90
Elevation (ft)
0
10
20
30
40
Horizontal Distance (ft)
Mouse X
Mouse Y
-5.39
102.27

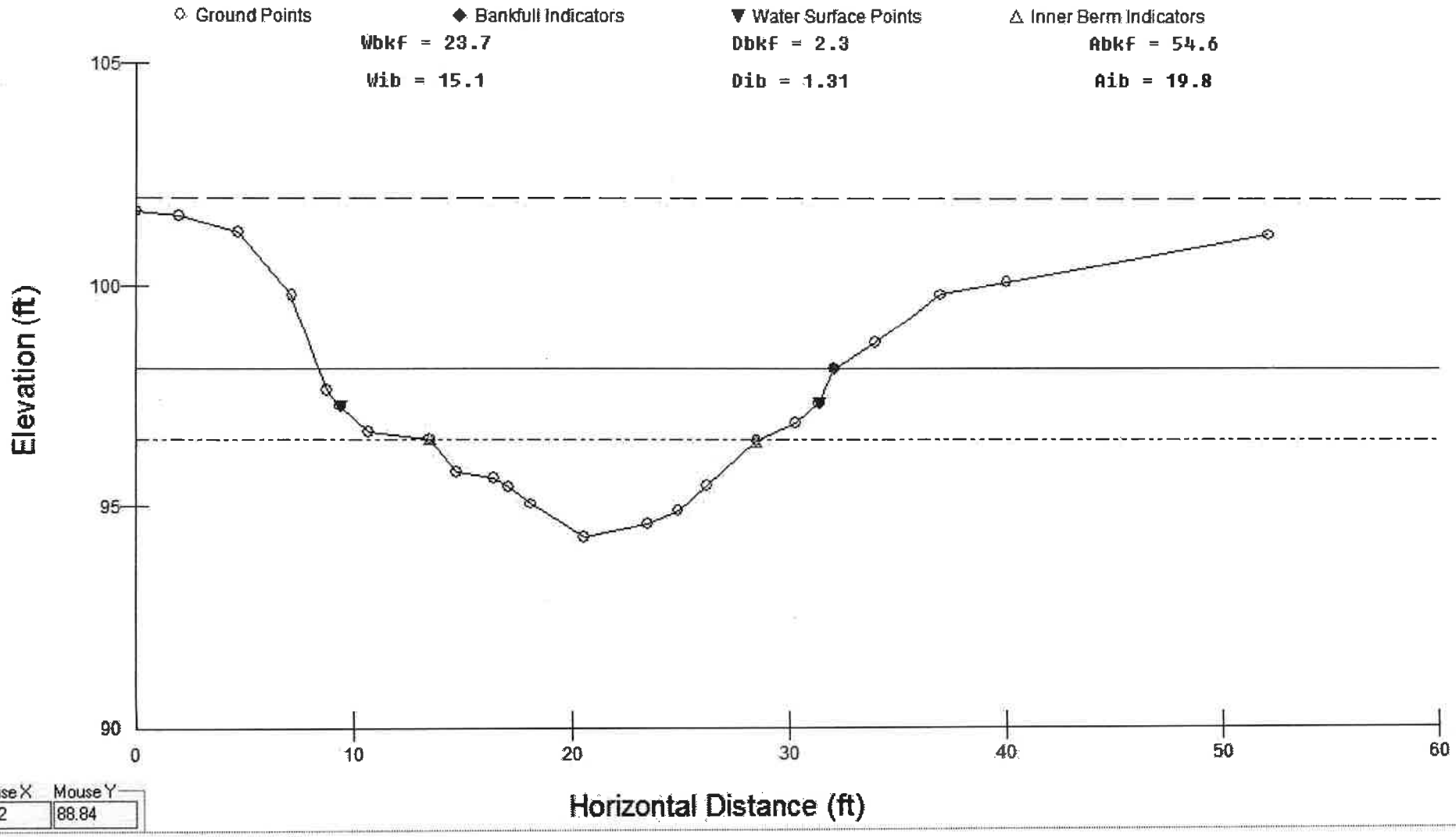
# Reach 3, Glide 2 - Sta. 01+48.5



# Pool 1

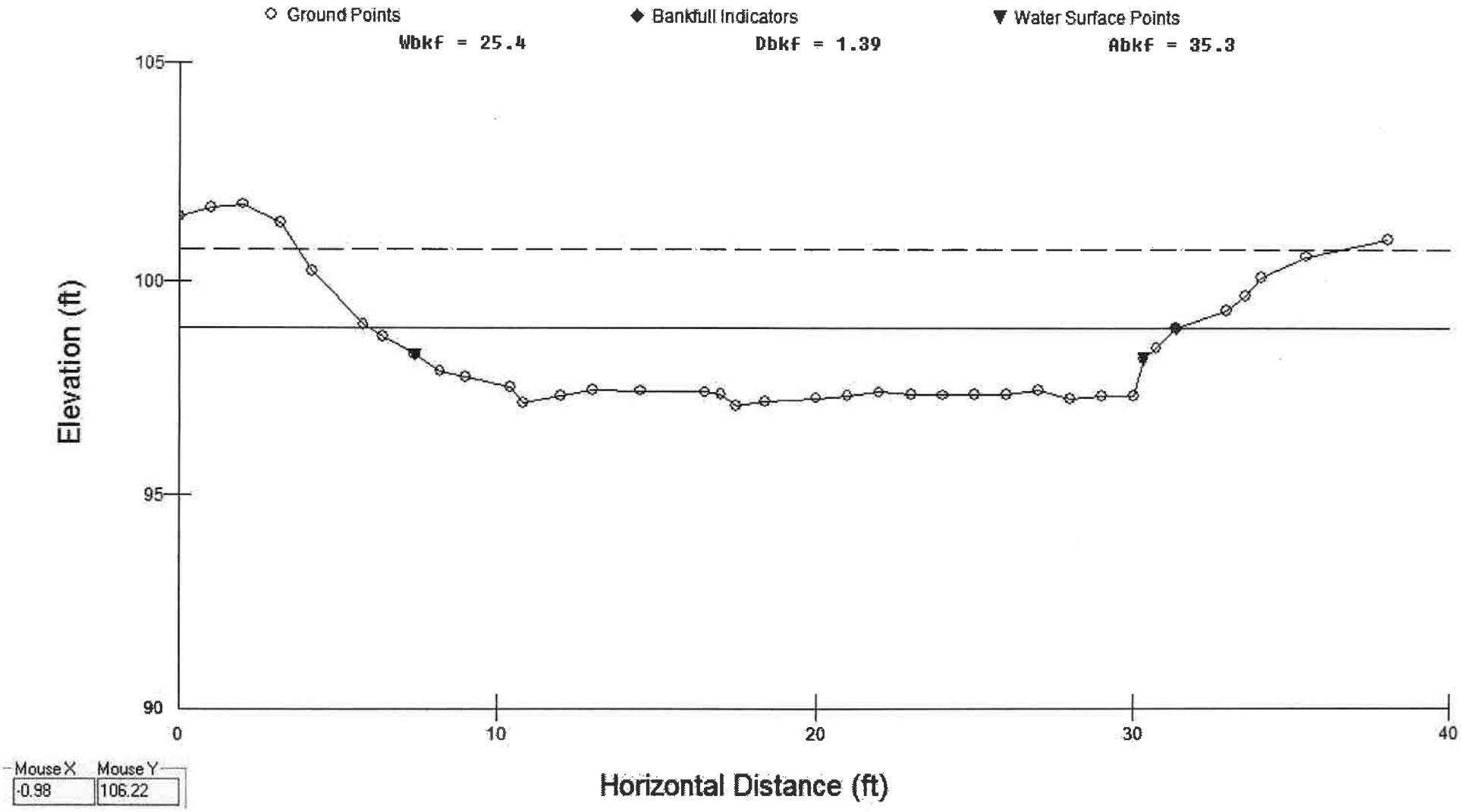

Ground Points
Bankfull Indicators
Water Surface Points
Inner Berm Indicators
Wbkf = 24.3
Wib = 13.7
Dbkf = 2.26
Dib = .83
Abkf = 55
Aib = 11.3
105
100
95
90
Elevation (ft)
0
10
20
30
40
Horizontal Distance (ft)
Mouse X
7.82
Mouse Y
103.73

# Reach 3, Pool 2 - Sta. 03+32

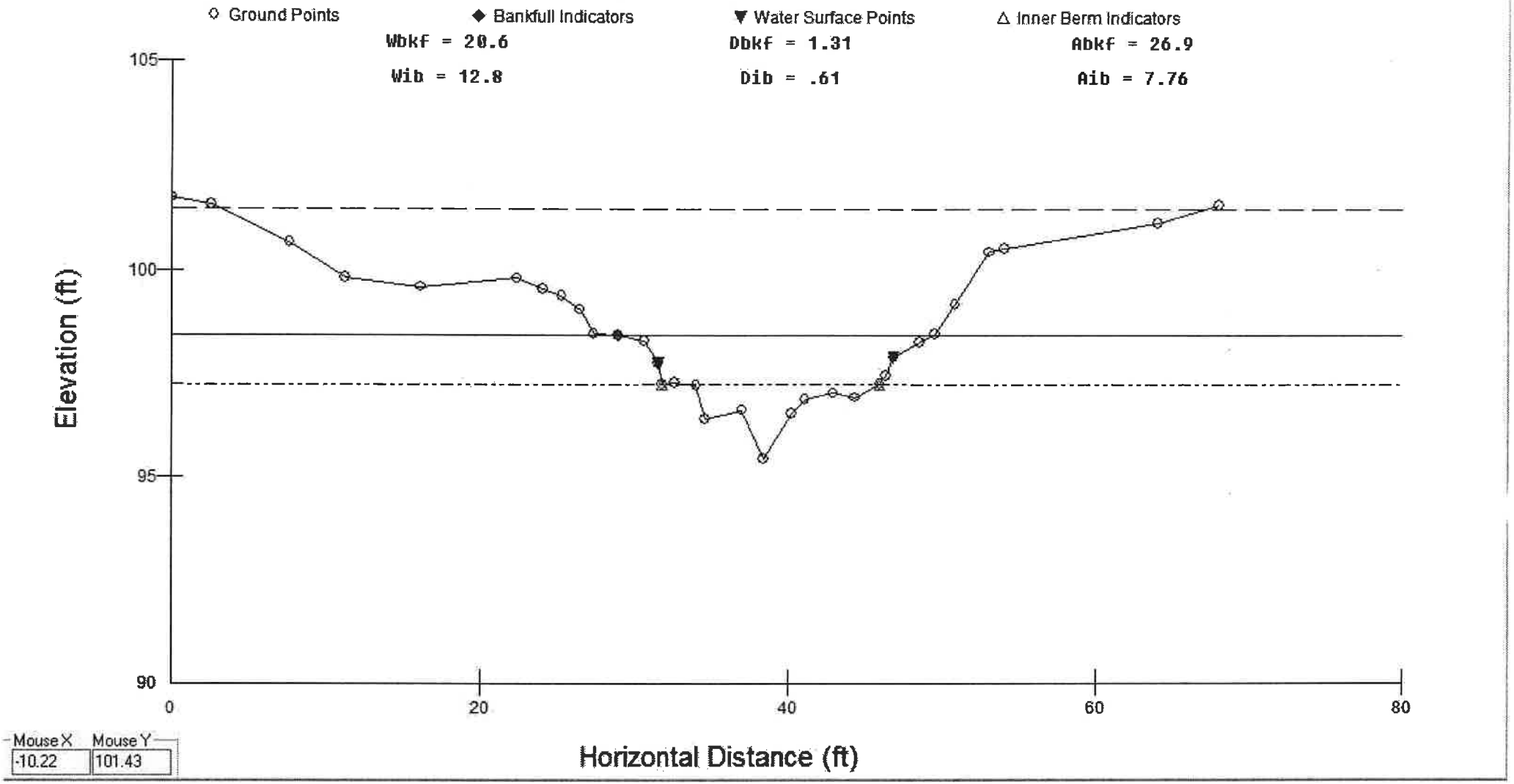



| Mouse X | Mouse Y |
|---|---|
| -6.72 | 88.84 |

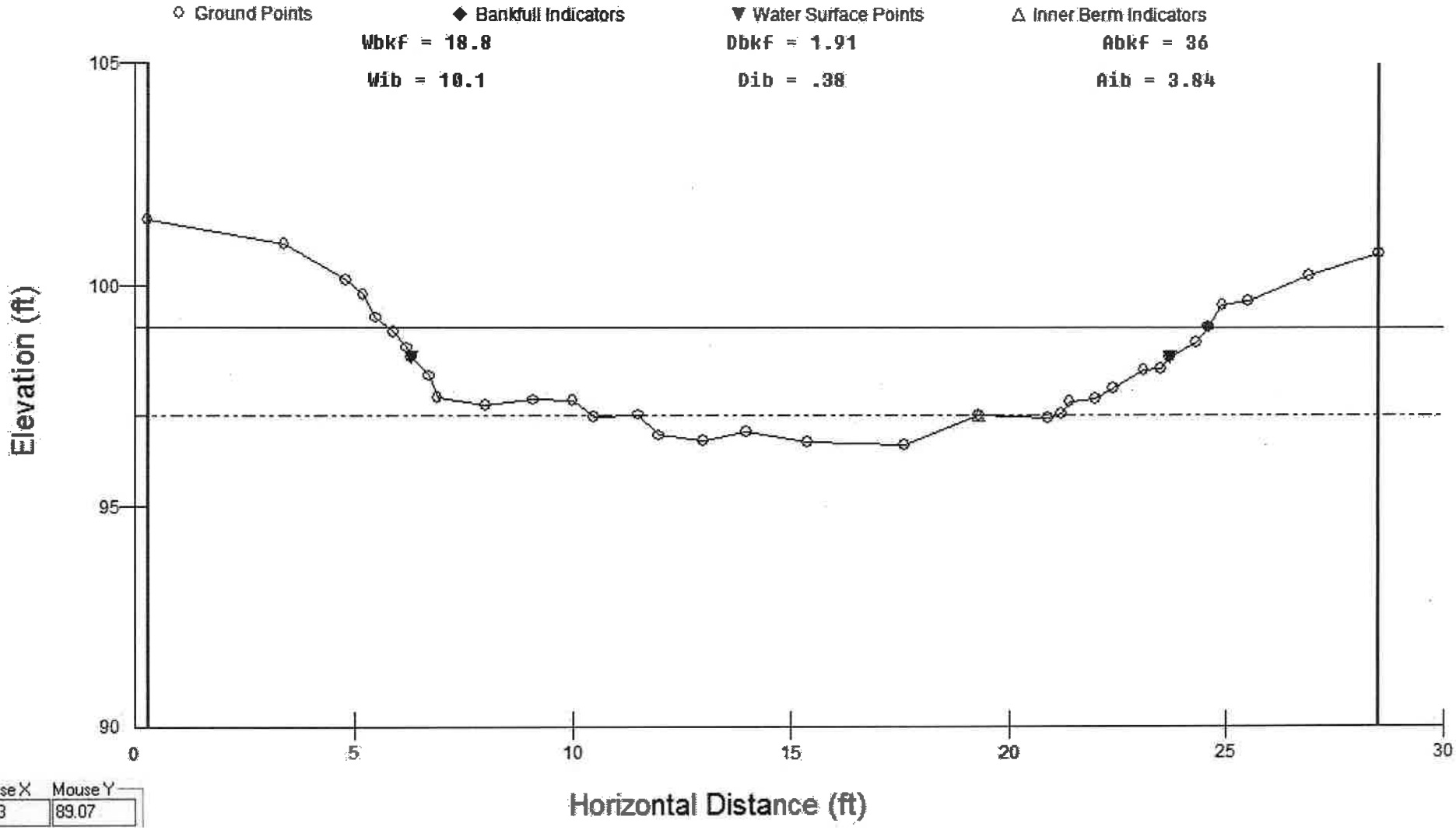
# Riffle 1


Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 25.4
Dbkf = 1.39
Abkf = 35.3
105
100
95
90
Elevation (ft)
0
10
20
30
40
Horizontal Distance (ft)
Mouse X
Mouse Y
-0.98
106.22

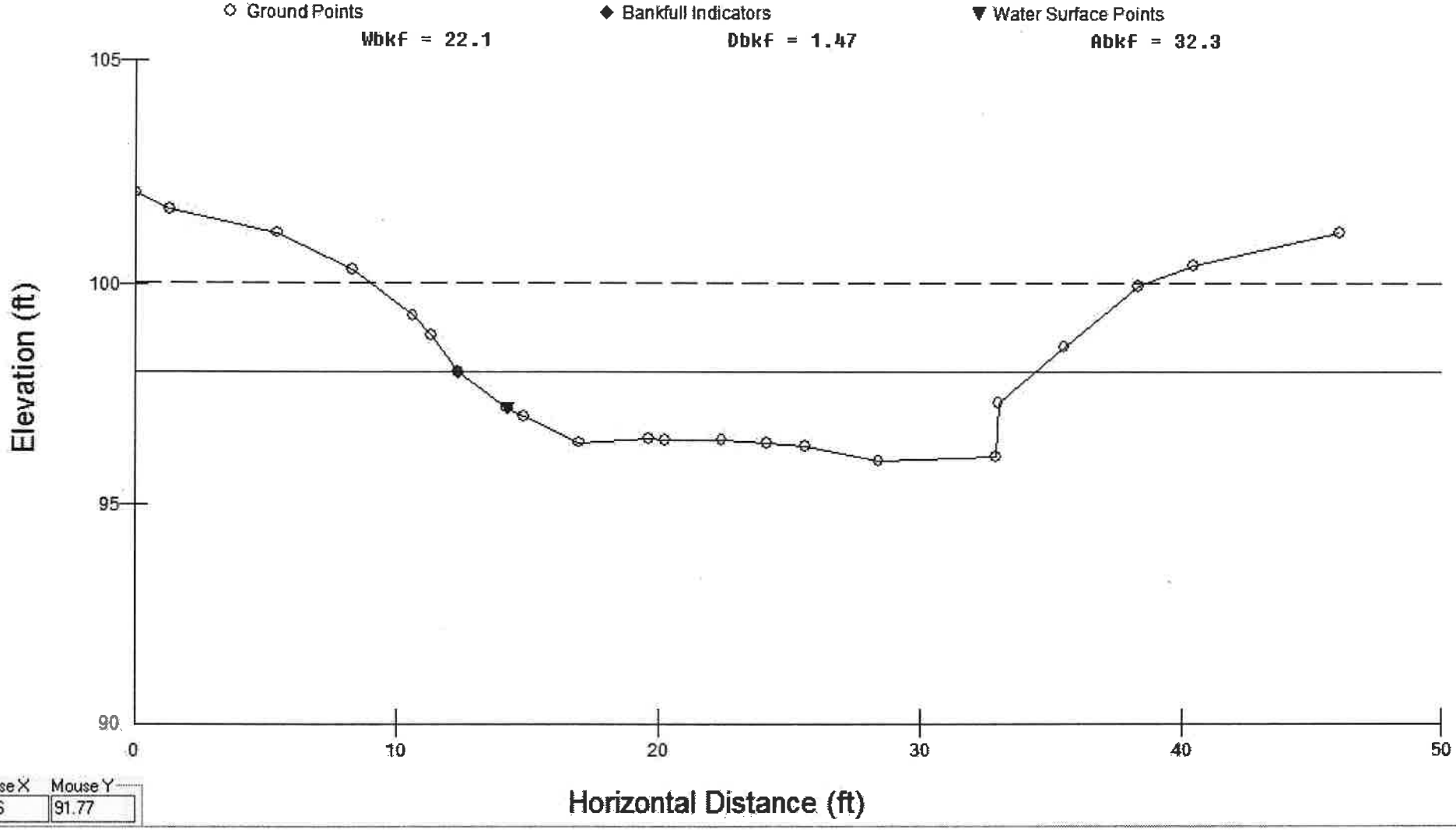
# Reach 3, Riffle 2 - Sta. 02+16



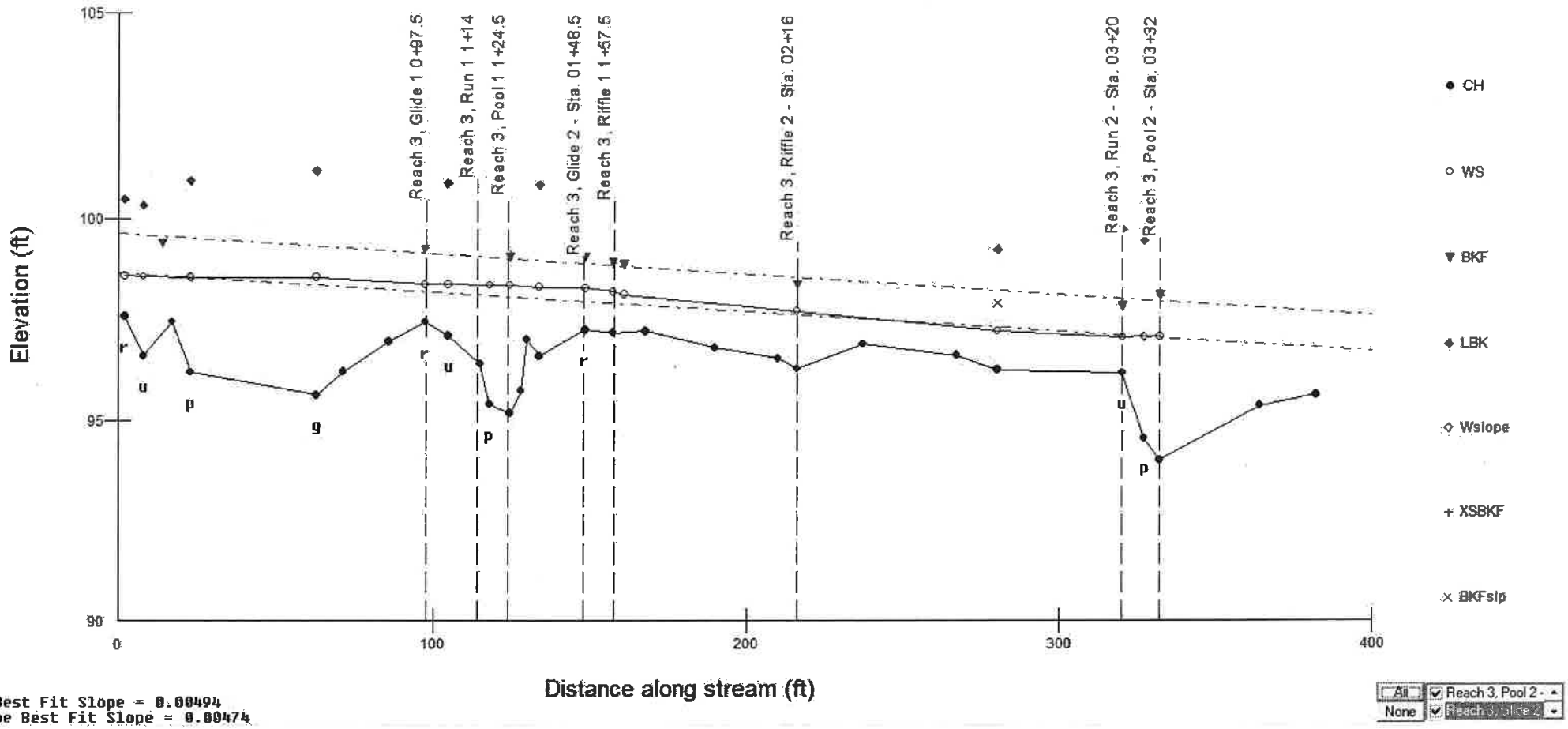
# Run 1 1+14


Ground Points
Bankfull Indicators
Water Surface Points
Inner Berm Indicators
WbkF = 18.8
Wib = 10.1
DbkF = 1.91
Dib = .38
AbkF = 36
Aib = 3.84
Elevation (ft)
105
100
95
90
0
5
10
15
20
25
30
Horizontal Distance (ft)
Mouse X
Mouse Y
-3.53
89.07

# Reach 3, Run 2 - Sta. 03+20



# Reach 3




BKF Best Fit Slope = 0.00494
Wslope Best Fit Slope = 0.00474

**Worksheet 2-2.** Computations of velocity and bankfull discharge using various methods (Rosgen, 2006b; Rosgen and Silvey, 2007).

## Bankfull VELOCITY & DISCHARGE Estimates

| | | | | | |
|---|---|---|---|---|---|
| Stream: | Marsh Run | | | Location: | Reach - Reach_3 |
| Date: | 4/19/2018 | Stream Type: | F4 | Valley Type: | U-AL-FD |
| Observers: | Group 3 | | | HUC: | |

| INPUT VARIABLES | | | OUTPUT VARIABLES | | |
|---|---|---|---|---|---|
| Bankfull Riffle Cross-Sectional AREA | 35.31 | $A_{bkf}$ ($ft^2$) | Bankfull Riffle Mean DEPTH | 1.39 | $d_{bkf}$ (ft) |
| Bankfull Riffle WIDTH | 25.37 | $W_{bkf}$ (ft) | Wetted PERMIMETER ~ $(2 * d_{bkf}) + W_{bkf}$ | 26.75 | $W_p$ (ft) |
| $D_{84}$ at Riffle | 80.25 | Dia. (mm) | $D_{84}$ (mm) / 304.8 | 0.26 | $D_{84}$ (ft) |
| Bankfull SLOPE | 0.0049 | $S_{bkf}$ (ft / ft) | Hydraulic RADIUS $A_{bkf} / W_p$ | 1.32 | R (ft) |
| Gravitational Acceleration | 32.2 | g (ft / $sec^2$) | Relative Roughness R(ft) / $D_{84}$ (ft) | 5.02 | R / $D_{84}$ |
| Drainage Area | 18.9 | DA ($mi^2$) | Shear Velocity $u^* = (gRS)^{½}$ | 0.458 | u* (ft/sec) |

| ESTIMATION METHODS | Bankfull VELOCITY | | Bankfull DISCHARGE | |
|---|---|---|---|---|
| 1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * Log\{R/D_{84}\}]u^*$ | 3.11 | ft / sec | 109.91 | cfs |
| 2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 2-18, 2-19) $u = 1.49*R^{2/3}*S^{1/2}/n$ $n =$ 0.039 | 3.22 | ft / sec | 113.84 | cfs |
| 2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 2-20) $u = 1.49*R^{2/3}*S^{1/2}/n$ $n =$ 0.041 | 3.07 | ft / sec | 108.26 | cfs |
| 2. Roughness Coefficient: c) Manning's *n* from Jarrett (USGS): $u = 1.49*R^{2/3}*S^{1/2}/n$ $n = 0.39*S^{0.38}*R^{-0.16}$ Note: This equation is applicable to steep, step/pool, high boundary roughness, cobble- and boulder-dominated stream systems; i.e., for Stream Types A1, A2, A3, B1, B2, B3, C2 & E3 $n =$ 0.050 | 2.54 | ft / sec | 89.51 | cfs |
| 3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) Manning's Limerinos n=0.0376 | 3.34 | ft / sec | 118.08 | cfs |
| 3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) Darcy-Weisbach (Leopold, Wolman and Miller) | 3.28 | ft / sec | 115.86 | cfs |
| 4. Continuity Equations: a) Regional Curves u = Q / A Return Period for Bankfull Discharge Q = 2.2 year | 3.23 | ft / sec | 114.00 | cfs |
| 4. Continuity Equations: b) USGS Gage Data u = Q / A | 3.23 | ft / sec | 114.00 | cfs |

**Protrusion Height Options for the $D_{84}$ Term in the Relative Roughness Relation (R/$D_{84}$) – Estimation Method 1**

| | |
|---|---|
| Option 1. | For **sand-bed** channels: Measure 100 "**protrusion heights**" of sand dunes from the downstream side of feature to the top of feature. Substitute the $D_{84}$ sand dune protrusion height in ft for the $D_{84}$ term in method 1. |
| Option 2. | For **boulder-dominated** channels: Measure 100 "**protrusion heights**" of boulders on the sides from the bed elevation to the top of the rock on that side. Substitute the $D_{84}$ boulder protrusion height in ft for the $D_{84}$ term in method 1. |
| Option 3. | For **bedrock-dominated** channels: Measure 100 "**protrusion heights**" of rock separations, steps, joints or uplifted surfaces above channel bed elevation. Substitute the $D_{84}$ bedrock protrusion height in ft for the $D_{84}$ term in method 1. |
| Option 4. | For **log-influenced** channels: Measure "**protrustion heights**" proportionate to channel width of log diameters or the height of the log on upstream side if embedded. Substitute the $D_{84}$ protrusion height in ft for the $D_{84}$ term in method 1. |

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**Worksheet 2-3.** Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

| | | | | |
|---|---|---|---|---|
| Stream: | **Marsh Run, Reach - Reach_3** | | | |
| Basin: | Drainage Area: **12096** acres | | **18.9** | $mi^2$ |
| Location: | | | | |
| Twp.&Rge: **;** | Sec.&Qtr.: **;** | | | |
| Cross-Section Monuments (Lat./Long.): | **0 Lat / 0 Long** | | Date: **04/19/18** | |
| Observers: **Team 3** | | | Valley Type: U-AL-FD | |

| | | |
|---|---|---|
| **Bankfull WIDTH ($W_{bkf}$)**<br>WIDTH of the stream channel at bankfull stage elevation, in a riffle section. | **25.37** | ft |
| **Bankfull DEPTH ($d_{bkf}$)**<br>Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$). | **1.39** | ft |
| **Bankfull X-Section AREA ($A_{bkf}$)**<br>AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section. | **35.31** | $ft^2$ |
| **Width/Depth Ratio ($W_{bkf} / d_{bkf}$)**<br>Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section. | **18.25** | ft/ft |
| **Maximum DEPTH ($d_{mbkf}$)**<br>Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section. | **1.81** | ft |
| **WIDTH of Flood-Prone Area ($W_{fpa}$)**<br>Twice maximum DEPTH, or ($2 \times d_{mbkf}$) = the stage/elevation at which flood-prone area WIDTH is determined in a riffle section. | **32.61** | ft |
| **Entrenchment Ratio (ER)**<br>The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH ($W_{fpa} / W_{bkf}$) (riffle section). | **1.29** | ft/ft |
| **Channel Materials (Particle Size Index ) $D_{50}$**<br>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. | **2048** | mm |
| **Water Surface SLOPE (S)**<br>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. | **0.00474** | ft/ft |
| **Channel SINUOSITY (k)**<br>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). | **1.45** | |

***Stream Type*** **F 1** (See **Figure 2-14**)

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**Worksheet 2-4a.** Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2007; Rosgen, 2008).

Stream: **Marsh Run** Location: **Reach - Reach_3**

Observers: **Team 3** Date: **04/19/18** Valley Type: **U-AL-FD** Stream Type: **F 1**

**River Reach Dimension Summary Data.....1**

| Riffle Dimensions*, **, *** | Mean | Min | Max | | Riffle Dimensions & Dimensionless Ratios**** | Mean | Min | Max |
|---|---|---|---|---|---|---|---|---|
| Riffle Width ($W_{bkf}$) | 22.8 | 20.2 | 25.4 | ft | Riffle Cross-Sectional Area ($A_{bkf}$) ($ft^2$) | 30.88 | 26.45 | 35.31 |
| Mean Riffle Depth ($d_{bkf}$) | 1.35 | 1.31 | 1.39 | ft | Riffle Width/Depth Ratio ($W_{bkf}$ / $d_{bkf}$) | 16.84 | 15.44 | 18.25 |
| Maximum Riffle Depth ($d_{max}$) | 2.41 | 1.81 | 3 | ft | Max Riffle Depth to Mean Riffle Depth ($d_{max}$ / $d_{bkf}$) | 1.796 | 1.302 | 2.290 |
| Width of Flood-Prone Area ($W_{fpa}$) | 47.9 | 32.6 | 63.3 | ft | Entrenchment Ratio ($W_{fpa}$ / $W_{bkf}$) | 2.207 | 1.285 | 3.129 |
| Riffle Inner Berm Width ($W_{ib}$) | 12.8 | 12.8 | 12.8 | ft | Riffle Inner Berm Width to Riffle Width ($W_{ib}$ / $W_{bkf}$) | 0.632 | 0.632 | 0.632 |
| Riffle Inner Berm Depth ($d_{ib}$) | 0.61 | 0.61 | 0.61 | ft | Riffle Inner Berm Depth to Mean Depth ($d_{ib}$ / $d_{bkf}$) | 0.463 | 0.463 | 0.463 |
| Riffle Inner Berm Area ($A_{ib}$) | 7.76 | 7.76 | 7.76 | $ft^2$ | Riffle Inner Berm Area to Riffle Area ($A_{ib}$ / $A_{bkf}$) | 0.293 | 0.293 | 0.293 |
| Riffle Inner Berm W/D Ratio ($W_{ib}$ / $d_{ib}$) | 21 | 21 | 21 | | | | | |

| Pool Dimensions*, **, *** | Mean | Min | Max | | Pool Dimensions & Dimensionless Ratios**** | Mean | Min | Max |
|---|---|---|---|---|---|---|---|---|
| Pool Width ($W_{bkfp}$) | 24 | 23.7 | 24.3 | ft | Pool Width to Riffle Width ($W_{bkfp}$ / $W_{bkf}$) | 1.052 | 1.039 | 1.065 |
| Mean Pool Depth ($d_{bkfp}$) | 2.28 | 2.26 | 2.3 | ft | Mean Pool Depth to Mean Riffle Depth ($d_{bkfp}$ / $d_{bkf}$) | 1.689 | 1.674 | 1.704 |
| Pool Cross-Sectional Area ($A_{bkfp}$) | 54.8 | 54.6 | 55 | ft | Pool Area to Riffle Area ($A_{bkfp}$ / $A_{bkf}$) | 1.774 | 1.767 | 1.780 |
| Maximum Pool Depth ($d_{maxp}$) | 3.95 | 3.85 | 4.04 | ft | Max Pool Depth to Mean Riffle Depth ($d_{maxp}$ / $d_{bkf}$) | 2.926 | 2.852 | 2.993 |
| Pool Inner Berm Width ($W_{ibp}$) | 14.4 | 13.7 | 15.1 | ft | Pool Inner Berm Width to Pool Width ($W_{ibp}$ / $W_{bkfp}$) | 0.600 | 0.563 | 0.636 |
| Pool Inner Berm Depth ($d_{ibp}$) | 1.07 | 0.83 | 1.31 | ft | Pool Inner Berm Depth to Pool Depth ($d_{ibp}$ / $d_{bkfp}$) | 0.469 | 0.366 | 0.571 |
| Pool Inner Berm Area ($A_{ibp}$) | 15.6 | 11.3 | 19.8 | $ft^2$ | Pool Inner Berm Area to Pool Area ($A_{ibp}$ / $A_{bkfp}$) | 0.285 | 0.206 | 0.363 |
| Point Bar Slope ($S_{pb}$) | 0.319 | 0.319 | 0.319 | ft/ft | Pool Inner Berm Width/Depth Ratio ($W_{ibp}$ / $d_{ibp}$) | 14.001 | 11.460 | 16.541 |

| Run Dimensions* | Mean | Min | Max | | Run Dimensionless Ratios**** | Mean | Min | Max |
|---|---|---|---|---|---|---|---|---|
| Run Width ($W_{bkfr}$) | 22.1 | 22.1 | 22.1 | ft | Run Width to Riffle Width ($W_{bkfr}$ / $W_{bkf}$) | 0.968 | 0.968 | 0.968 |
| Mean Run Depth ($d_{bkfr}$) | 1.47 | 1.47 | 1.47 | ft | Mean Run Depth to Mean Riffle Depth ($d_{bkfr}$ / $d_{bkf}$) | 1.089 | 1.089 | 1.089 |
| Run Cross-Sectional Area ($A_{bkfr}$) | 32.3 | 32.3 | 32.3 | ft | Run Area to Riffle Area ($A_{bkfr}$ / $A_{bkf}$) | 1.047 | 1.047 | 1.047 |
| Maximum Run Depth ($d_{maxr}$) | 2.02 | 2.02 | 2.02 | ft | Max Run Depth to Mean Riffle Depth ($d_{maxr}$ / $d_{bkf}$) | 1.496 | 1.496 | 1.496 |
| Run Width/Depth Ratio ($W_{bkfr}$ / $d_{bkfr}$) | 15 | 15 | 15 | ft | | | | |

| Glide Dimensions* | Mean | Min | Max | | Glide Dimensions & Dimensionless Ratios**** | Mean | Min | Max |
|---|---|---|---|---|---|---|---|---|
| Glide Width ($W_{bkfg}$) | 21.8 | 17.8 | 25.7 | ft | Glide Width to Riffle Width ($W_{bkfg}$ / $W_{bkf}$) | 0.954 | 0.782 | 1.126 |
| Mean Glide Depth ($d_{bkfg}$) | 1.38 | 1.32 | 1.44 | ft | Mean Glide Depth to Mean Riffle Depth ($d_{bkfg}$ / $d_{bkf}$) | 1.022 | 0.978 | 1.067 |
| Glide Cross-Sectional Area ($A_{bkfg}$) | 29.8 | 25.8 | 33.9 | ft | Glide Area to Riffle Area ($A_{bkfg}$ / $A_{bkf}$) | 0.966 | 0.834 | 1.098 |
| Maximum Glide Depth ($d_{maxg}$) | 1.74 | 1.64 | 1.84 | ft | Max Glide Depth to Mean Riffle Depth ($d_{maxg}$ / $d_{bkf}$) | 1.289 | 1.215 | 1.363 |
| Glide Width/Depth Ratio ($W_{bkfg}$ / $d_{bkfg}$) | 15.9 | 12.4 | 19.5 | ft/ft | Glide Inner Berm Width/Depth Ratio ($W_{ibg}$ / $d_{ibg}$) | 0.000 | 0.000 | 0.000 |
| Glide Inner Berm Width ($W_{ibg}$) | 0 | 0 | 0 | ft | Glide Inner Berm Width to Glide Width ($W_{ibg}$/$W_{bkfg}$) | 0.000 | 0.000 | 0.000 |
| Glide Inner Berm Depth ($d_{ibg}$) | 0 | 0 | 0 | ft | Glide Inner Berm Depth to Glide Depth ($d_{ibg}$ / $d_{bkfg}$) | 0.000 | 0.000 | 0.000 |
| Glide Inner Berm Area ($A_{ibg}$) | 0 | 0 | 0 | $ft^2$ | Glide Inner Berm Area to Glide Area ($A_{ibg}$ / $A_{bkfg}$) | 0.000 | 0.000 | 0.000 |

| Step Dimensions** | Mean | Min | Max | | Step Dimensionless Ratios**** | Mean | Min | Max |
|---|---|---|---|---|---|---|---|---|
| Step Width ($W_{bkfs}$) | 0 | 0 | 0 | ft | Step Width to Riffle Width ($W_{bkfs}$ / $W_{bkf}$) | 0.000 | 0.000 | 0.000 |
| Mean Step Depth ($d_{bkfs}$) | 0 | 0 | 0 | ft | Mean Step Depth to Riffle Depth ($d_{bkfs}$ / $d_{bkf}$) | 0.000 | 0.000 | 0.000 |
| Step Cross-Sectional Area ($A_{bkfs}$) | 0 | 0 | 0 | ft | Step Area to Riffle Area ($A_{bkfs}$ / $A_{bkf}$) | 0.000 | 0.000 | 0.000 |
| Maximum Step Depth ($d_{maxs}$) | 0 | 0 | 0 | ft | Max Step Depth to Mean Riffle Depth ($d_{maxs}$ / $d_{bkf}$) | 0.000 | 0.000 | 0.000 |
| Step Width/Depth Ratio ($W_{bkfs}$ / $d_{bkfs}$) | 0 | 0 | 0 | | | | | |

*Riffle–Pool system (i.e., C, E, F stream types) bed features include riffles, runs, pools and glides.

**Step–Pool system (i.e., A, B, G stream types) bed features include riffles, rapids, chutes, pools and steps (note: include rapids and chutes in riffle category).

***Convergence-Divergence system (i.e., D stream types) bed features include riffles and pools; cross-sections taken at riffles for classification purposes.

****Mean values are used as the normalization parameter for all dimensionless ratios; e.g., minimum pool width to riffle width ratio uses the *mean* riffle width value.

**Worksheet 2-4b.** Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2007; Rosgen, 2008).

| | | | |
|---|---|---|---|
| Stream: **Marsh Run** | | Location: **Reach - Reach_3** | |
| Observers: **Team 3** | Date: **04/19/18** | Valley Type: **U-AL-FD** | Stream Type: **F 1** |

**River Reach Summary Data.....2**

**Hydraulics**

| | | | | | |
|---|---|---|---|---|---|
| Streamflow: Estimated Mean Velocity at Bankfull Stage ($u_{bkf}$) | 3.22 | ft/sec | Estimation Method | | |
| Streamflow: Estimated Discharge at Bankfull Stage ($Q_{bkf}$) | 113.84 | cfs | Drainage Area | 18.9 | $mi^2$ |

**Channel Pattern**

| Geometry | Mean | Min | Max | | Dimensionless Geometry Ratios | Mean | Min | Max |
|---|---|---|---|---|---|---|---|---|
| Linear Wavelength ($\lambda$) | 118 | 90 | 144 | ft | Linear Wavelength to Riffle Width ($\lambda$ / $W_{bkf}$) | 5.175 | 3.947 | 6.316 |
| Stream Meander Length ($L_m$) | 169 | 147 | 193 | ft | Stream Meander Length Ratio ($L_m$ / $W_{bkf}$) | 7.399 | 6.447 | 8.465 |
| Radius of Curvature ($R_c$) | 5.3 | 29.5 | 85.5 | ft | Radius of Curvature to Riffle Width ($R_c$ / $W_{bkf}$) | 0.232 | 1.294 | 3.750 |
| Belt Width ($W_{blt}$) | 72 | 72 | 72 | ft | Meander Width Ratio ($W_{blt}$ / $W_{bkf}$) | 3.158 | 3.158 | 3.158 |
| Arc Length ($L_a$) | 88.7 | 66 | 120 | ft | Arc Length to Riffle Width ($L_a$ / $W_{bkf}$) | 3.890 | 2.895 | 5.263 |
| Riffle Length ($L_r$) | 62.2 | 6.35 | 173 | ft | Riffle Length to Riffle Width ($L_r$ / $W_{bkf}$) | 2.726 | 0.279 | 7.567 |
| Individual Pool Length ($L_p$) | 24.4 | 7.88 | 40.9 | ft | Individual Pool Length to Riffle Width ($L_p$ / $W_{bkf}$) | 1.070 | 0.346 | 1.794 |
| Pool to Pool Spacing ($P_s$) | 148 | 78 | 218 | ft | Pool to Pool Spacing to Riffle Width ($P_s$ / $W_{bkf}$) | 6.497 | 3.421 | 9.573 |

**Channel Profile**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Valley Slope ($S_{val}$) | 0.0056 | ft/ft | Average Water Surface Slope (S) | 0.00474 | ft/ft | Sinuosity ($S_{val}$ / S) | 1.45 | |
| Stream Length (SL) | 382 | ft | Valley Length (VL) | 256 | ft | Sinuosity (SL / VL) | 1.49 | |
| Low Bank Height (LBH) | start 1.95 | ft | Max Depth ($d_{max}$) | start 0.94 | ft | Bank-Height Ratio (BHR) (LBH / $d_{max}$) | start 2.07 | |
| | end 1.83 | ft | | end 0.97 | ft | | end 1.89 | |

| Facet Slopes | Mean | Min | Max | | Dimensionless Facet Slope Ratios | Mean | Min | Max |
|---|---|---|---|---|---|---|---|---|
| Riffle Slope ($S_{rif}$) | 0.006 | 0.005 | 0.007 | ft/ft | Riffle Slope to Average Water Surface Slope ($S_{rif}$ / S) | 1.228 | 1.032 | 1.422 |
| Run Slope ($S_{run}$) | 0.004 | 0.001 | 0.006 | ft/ft | Run Slope to Average Water Surface Slope ($S_{run}$ / S) | 0.871 | 0.306 | 1.224 |
| Pool Slope ($S_p$) | 0.002 | 0.001 | 0.003 | ft/ft | Pool Slope to Average Water Surface Slope ($S_p$ / S) | 0.384 | 0.211 | 0.660 |
| Glide Slope ($S_g$) | 0.002 | 0.001 | 0.004 | ft/ft | Glide Slope to Average Water Surface Slope ($S_g$ / S) | 0.420 | 0.211 | 0.838 |
| Step Slope ($S_s$) | 0.000 | 0.000 | 0.000 | ft/ft | Step Slope to Average Water Surface Slope ($S_s$ / S) | 0.000 | 0.000 | 0.000 |

| Max Depths[a] | Mean | Min | Max | | Dimensionless Depth Ratios | Mean | Min | Max |
|---|---|---|---|---|---|---|---|---|
| Max Riffle Depth ($d_{maxrif}$) | 2.19 | 1.87 | 2.49 | ft | Max Riffle Depth to Mean Riffle Depth ($d_{maxrif}$ / $d_{bkf}$) | 1.62 | 1.385 | 1.84 |
| Max Run Depth ($d_{maxrun}$) | 2.98 | 2.59 | 3.4 | ft | Max Run Depth to Mean Riffle Depth ($d_{maxrun}$ / $d_{bkf}$) | 2.21 | 1.919 | 2.52 |
| Max Pool Depth ($d_{maxp}$) | 3.83 | 3.7 | 3.96 | ft | Max Pool Depth to Mean Riffle Depth ($d_{maxp}$ / $d_{bkf}$) | 2.84 | 2.741 | 2.93 |
| Max Glide Depth ($d_{maxg}$) | 1.79 | 1.65 | 2.03 | ft | Max Glide Depth to Mean Riffle Depth ($d_{maxg}$ / $d_{bkf}$) | 1.33 | 1.222 | 1.5 |
| Max Step Depth ($d_{maxs}$) | 0 | 0 | 0 | ft | Max Step Depth to Mean Riffle Depth ($d_{maxs}$ / $d_{bkf}$) | 0 | 0 | 0 |

**Channel Materials**

| | Reach[b] | Riffle[c] | Bar | | Reach[b] | Riffle[c] | Bar | Protrusion Height[d] | |
|---|---|---|---|---|---|---|---|---|---|
| % Silt/Clay | 3 | | | $D_{16}$ | 16 | | | 19.67 | mm |
| % Sand | 11 | | | $D_{35}$ | Bedrock | | | 35.64 | mm |
| % Gravel | 7 | | | $D_{50}$ | Bedrock | | | 43.44 | mm |
| % Cobble | 2 | | | $D_{84}$ | Bedrock | | | 80.25 | mm |
| % Boulder | 1 | | | $D_{95}$ | Bedrock | | | 109 | mm |
| % Bedrock | 76 | | | $D_{100}$ | Bedrock | | | 128 | mm |

[a] Min, max & mean depths are measured from Thalweg to bankfull at mid-point of feature for riffles and runs, the deepest part of pools, & at the tail-out of glides.
[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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# Summary....*USGS GAGE STATION* Data / Records for STREAM CHANNEL CLASSIFICATION

| | | | |
|---|---|---|---|
| Station NAME: | MARSH RUN AT GRIMES, MD | Station Number: | 01617800 |
| LOCATION: | LAT 39°30'52.4" LONG 77°46'38.0" | | |
| Period of Record: | 1964 - PRESENT yrs | Mean Annual DISCHARGE: | cfs |
| Drainage AREA: | acres 18.9 mi² | Drainage Area Mn Elev: | ft |
| Reference REACH SLOPE: | 0.00474 ft/ft | Valley Type: | |
| Stream Type: | F1 | HUC: | |

## "BANKFULL" CHARACTERISTICS

| Determined from FIELD MEASUREMENT | | | Determined from GAGE DATA Analysis | | |
|---|---|---|---|---|---|
| Bankfull WIDTH ($W_{bkf}$) | 25.37 | ft | Bankfull WIDTH ($W_{bkf}$) | 21.6 | ft |
| Bankfull Mean DEPTH ($d_{bkf}$) | 1.39 | ft | Bankfull MEAN DEPTH ($d_{bkf}$) | 1.85 | ft |
| Bankfull Xsec AREA ($A_{bkf}$) | 35.31 | ft² | Bankfull Xsec AREA ($A_{bkf}$) | 39.97 | ft² |
| Wetted PERIMETER ($W_P$) | 26.75 | ft | Wetted PERIMETER ($W_P$) | 20.61 | ft |
| Bankfull STAGE (Gage Ht) | N/A | ft | Bankfull STAGE (Gage Ht) | 2.19 | ft |
| Est. Mean VELOCITY (u) | 3.22 | ft/sec | Mean VELOCITY (u) | 2.89 | ft/sec |
| Est. Bkf. DISCHARGE ($Q_{bkf}$) | 113.84 | cfs | Bankfull DISCHARGE ($Q_{bkf}$) | 113.5 | cfs |
| Bankfull DISCHARGE associated with **"field-determined"** Bankfull STAGE ( From Gage Height reading at Staff Plate and tabular Stage-Discharge curve data ) | | | | N/A | cfs |
| Recurrence Interval (Log-Pearson) associated with **"field-determined"** Bankfull Discharge | | | | 2.2 | yrs |

**From the *Annual Peak Flow Frequency Analysis* data for the Gage Station, determine:**

| | | | | | |
|---|---|---|---|---|---|
| **1.5** Year **R.I.** Discharge = | 69 | cfs | **10** Year **R.I.** Discharge = | 286 | cfs |
| **2.0** Year **R.I.** Discharge = | 100 | cfs | **25** Year **R.I.** Discharge = | 392 | cfs |
| **5.0** Year **R.I.** Discharge = | 206 | cfs | **50** Year **R.I.** Discharge = | 472 | cfs |

## MEANDER GEOMETRY

| | | | | | |
|---|---|---|---|---|---|
| Meander Wavelength ( $L_m$ ) | 169 | ft | Radius of Curvature ( $R_C$ ) | 54 | ft |
| Belt Width ( $W_{blt}$ ) | 72 | ft | Meander Width Ratio ($W_{blt}/W_{bkf}$) | 2.8 | ft/ft |

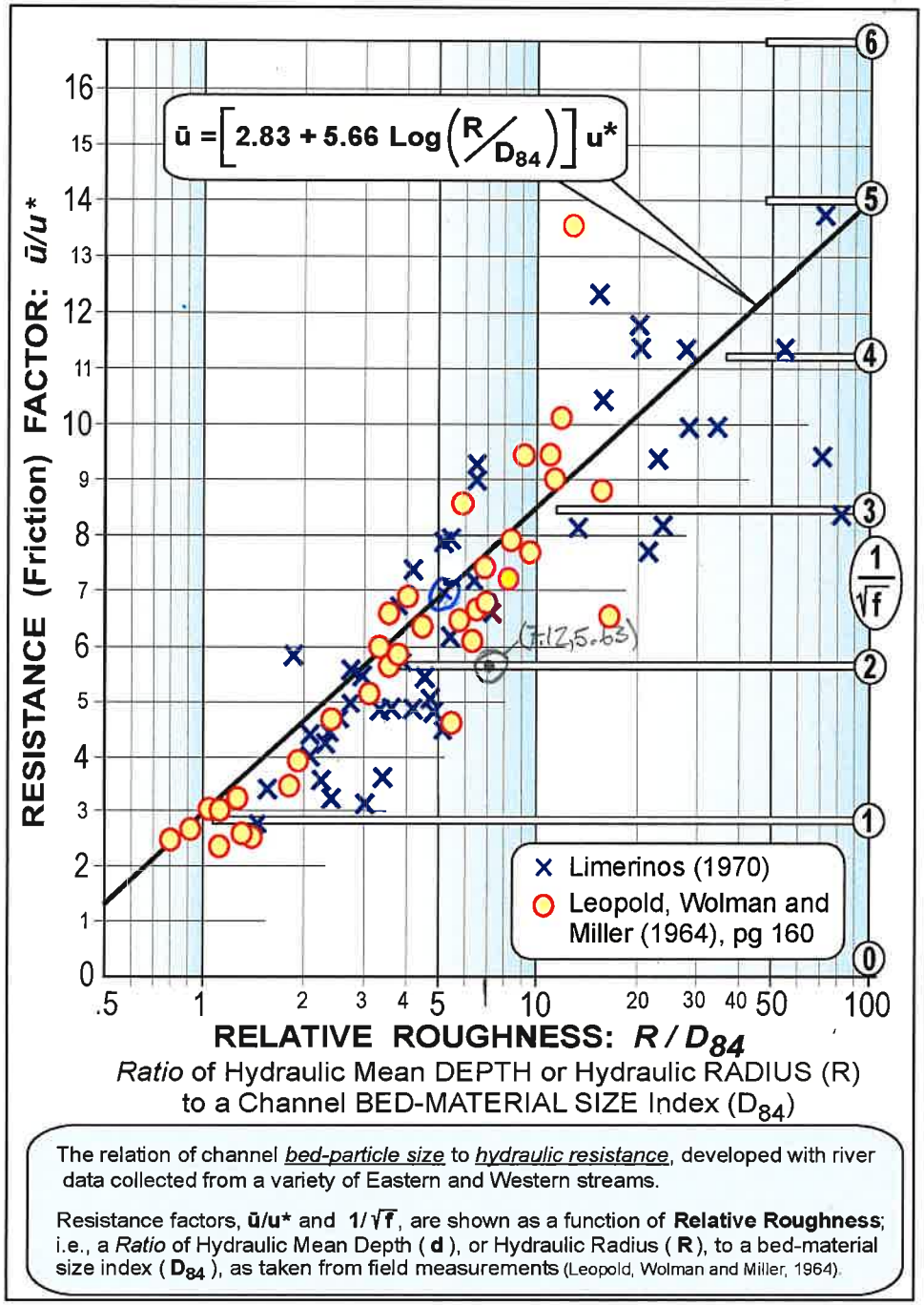
## HYDRAULIC GEOMETRY

Based on *USGS Discharge Summary Notes* data (Form 9-207) and regression analyses of measured discharge (**Q**) with the hydraulic parameters of Width (**W**), Area (**A**), Mean Depth (**d**) & Mean Velocity (**u**), determine the *intercept coefficient* (**a**) and the *slope exponent* (**b**) values for a power function of the form $Y = aX^b$, when **Y** is one of the selected hydraulic parameters and **X** is a given discharge value (**Q**).

| | Width (**W**) | Depth (**d**) | Area (**A**) | Velocity(**u**) |
|---|---|---|---|---|
| Intercept Coefficient **a** ) | 11.242 | 0.3878 | 4.5328 | 0.7202 |
| Slope Exponent **b** ) | 0.1383 | 0.3303 | 0.45 | 0.5513 |

| | | | | | |
|---|---|---|---|---|---|
| **Hydraulic Radius** $R = A / W_P$ | 1.39 | ft | **Manning's "n"** at Bankfull Stage | 0.04 | Coeff. |

$$\text{"n"} = 1.4895\ [(\text{Area})\ (\text{Hydraulic Radius}^{2/3})\ (\text{Slope})^{1/2}]\ /\ Q_{bkf}$$




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, **ū/u*** and **1/√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 B-34.** Relative roughness ($R/D_{84}$) *vs.* friction factor (ū/u*).

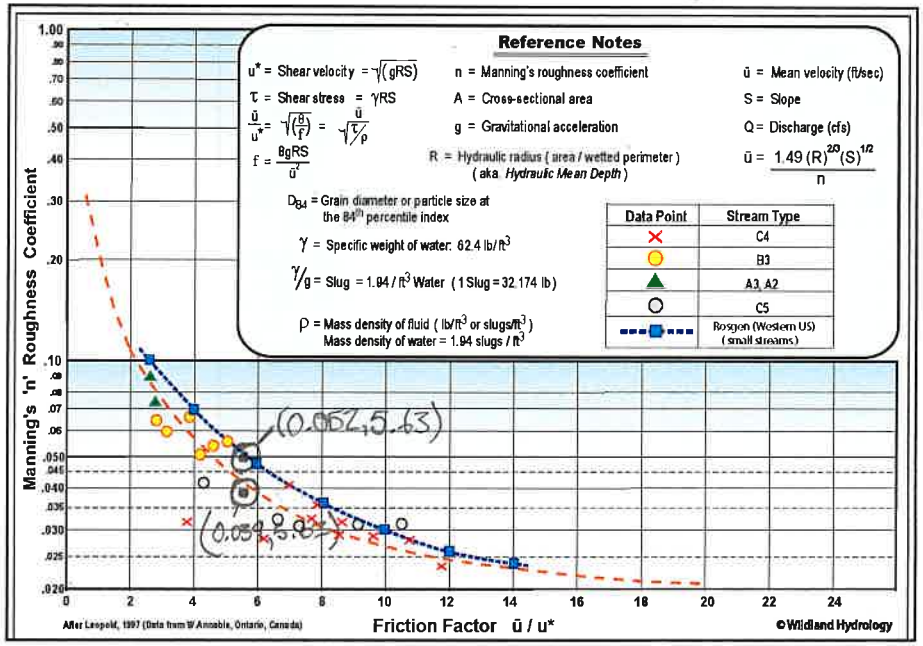



**Figure B-35.** Friction factor (ū/u*) *vs.* Manning's roughness coefficient 'n'.

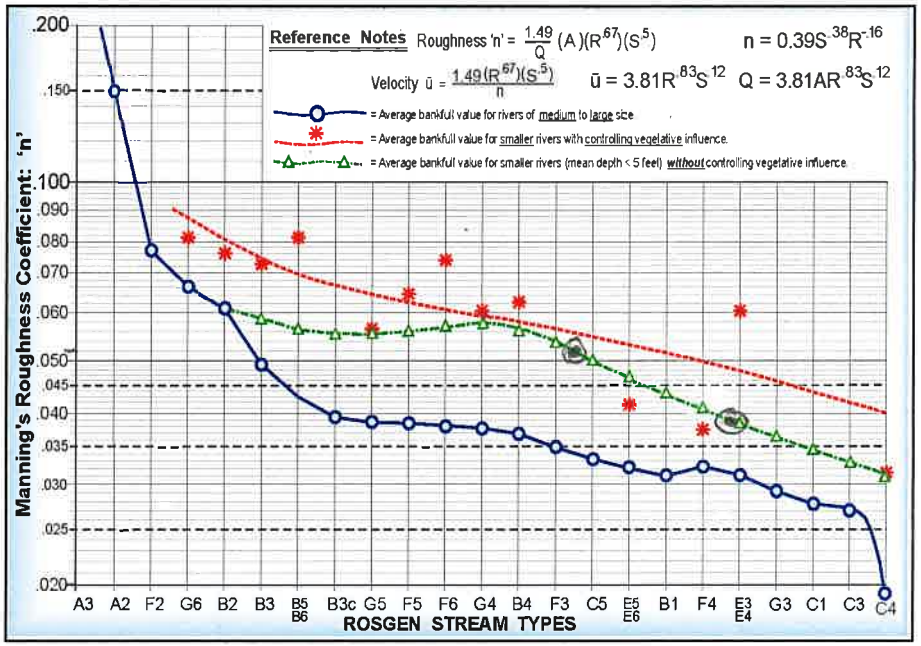



**Figure B-36.** Manning's 'n' roughness coefficient by stream type.



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