RIVER FOCUS
WATER RESOURCE CONSULTANTS

TECHNICAL MEMO

Project: Little Tonsina Tributary ATV Trail

Date: July 15, 2026

To: David Rowland, Blackburn Industries

From: Jess Straub, River Focus, Inc.

Re: **Little Tonsina Tributary ATV Trail – Hydrologic and Hydraulic Technical Memo**

EXECUTIVE SUMMARY

This technical memo presents hydrologic and hydraulic analyses to support culvert removal and channel reconstruction for the Little Tonsina Tributary ATV Trail Project for the Copper River Watershed Project (CRWP). The project team compared its independent dataset with the 2023 U.S. Fish and Wildlife Service (USFWS) 35% H&H Report and confirmed that the USFWS values remain suitable for design. Observed differences in precipitation, slope, and geomorphic classification remain within acceptable tolerance and do not materially affect design flows.

Data Comparison Validation

Table 1. Comparison validation table between USFWS and Blackburn Industries findings

Parameter	2023 Report Findings	2026 Report Findings
Watershed Area	3.7 mi^2	3.7 mi^2
Annual Mean Precipitation	17 in	18.5 in
Reference Reach Channel Slope	N/A	3.6-4.1%
Channel Slope	3.4–4.4%	2.4-3.9%
Crossing Slope	6.5%	7.2%
Culvert/Structure	5 ft CMP	5 ft CMP
Bankfull Width	9-10.5 ft	8.45-10.5 ft
Bankfull Area	9.3–15.9 ft^2	8-10.7 ft^2
Bankfull Depth	.98-1.54 ft	1.05-1.55 ft
Stream Type	B4a/B4c	B3c
Bankfull Discharge	44-52 cfs	39-49 cfs
Calculated 2-year Discharge	51 cfs	57 cfs
Calculated 100-year Discharge	259 cfs	276 cfs
D50	59.24 mm	61.83 mm
D100	255.99 mm	255.98 mm
Dominant Bed Material	Cobble/Gravel	Gravel/Cobble

Key Findings

- **Hydrology:** Bankfull discharge estimates (39–49 cfs) and calculated 2-year flows (57 cfs) closely align with USFWS values. The 2016 USGS regression equations provide conservative design flows, providing for resilience under hydrologic uncertainty.
- **Geomorphology:** Stream type classification shifted from B4a/B4c (USFWS) to B3c (2026 memo), reflecting updated slope and cross-section measurements. This change does not alter the overall stability assessment but should be noted for design documentation.
- **Hydraulic:** Channel/reference reach slope differences and bankfull geometry variations remain within the acceptable tolerance of utilizing USFWS findings. These values support the reconstructed channel's ability to convey design flows while maintaining ecological and physical function.
- **Substrate design:** Streambed substrate material data collection showed only minimal differences between the USFWS and project team efforts. The USFWS design incorporated a factor of safety of 1.5. Combined with the adoption of higher regression-derived flows, this factor of safety yields a substrate design that is adequate for recurrence intervals of 100 years or greater, supporting long-term channel stability and durability.

Conclusion

The close agreement between data collected by the Blackburn Industries team in 2026 and the findings of the USFWS 35% H&H reports validates continued reliance on USFWS values for design.

DATA COLLECTION

The data collection occurred over two site visits. The first was conducted by River Focus on May 18th-19th, 2026, and the second was conducted by 3-Tier on June 11, 2026. Figure 1 presents the combined longitudinal profile from both survey efforts. Figure 2 through Figure 7 display the reference reach data collected.

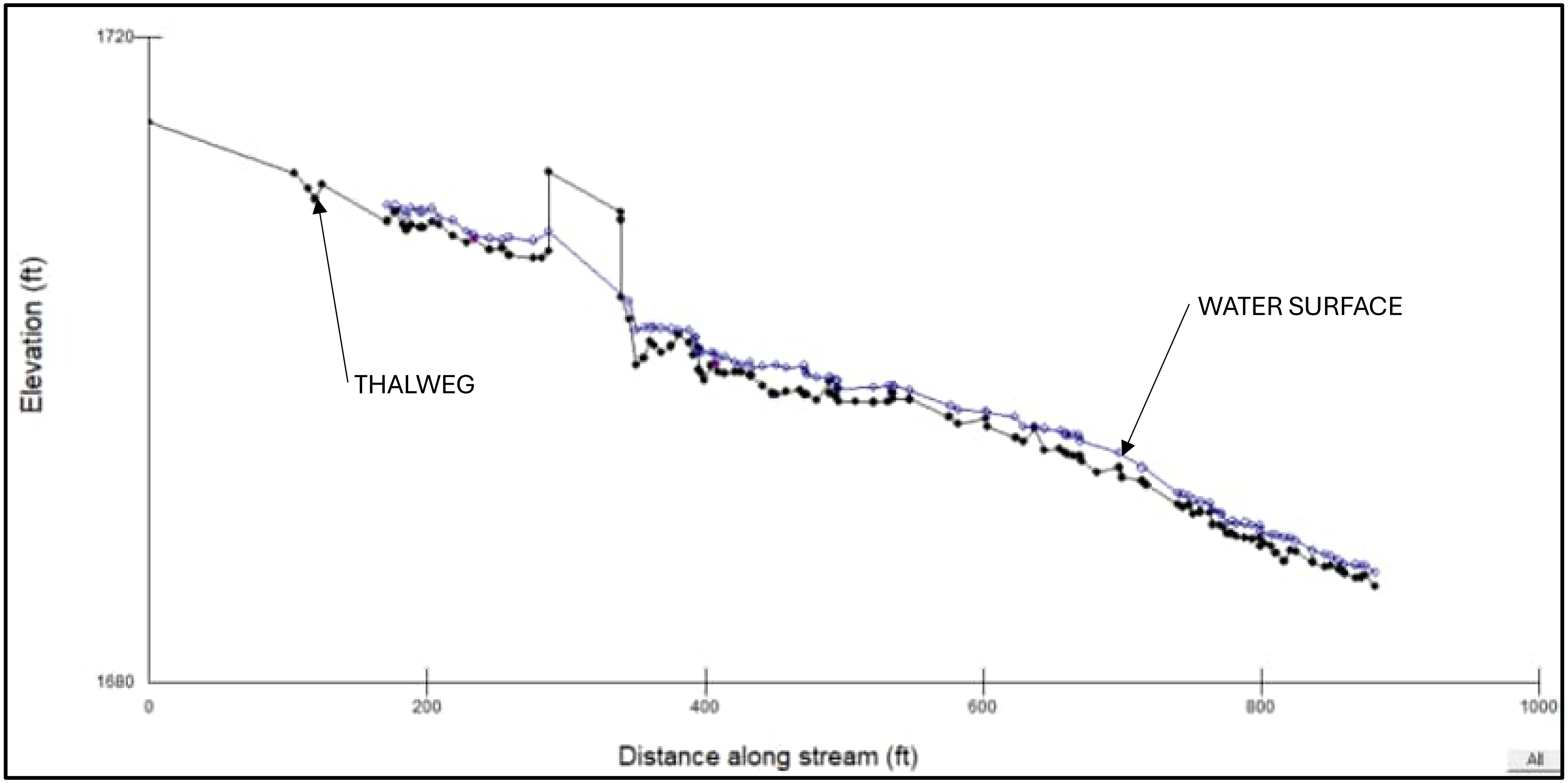

Figure 1. Crossing and Channel Longitudinal Profile

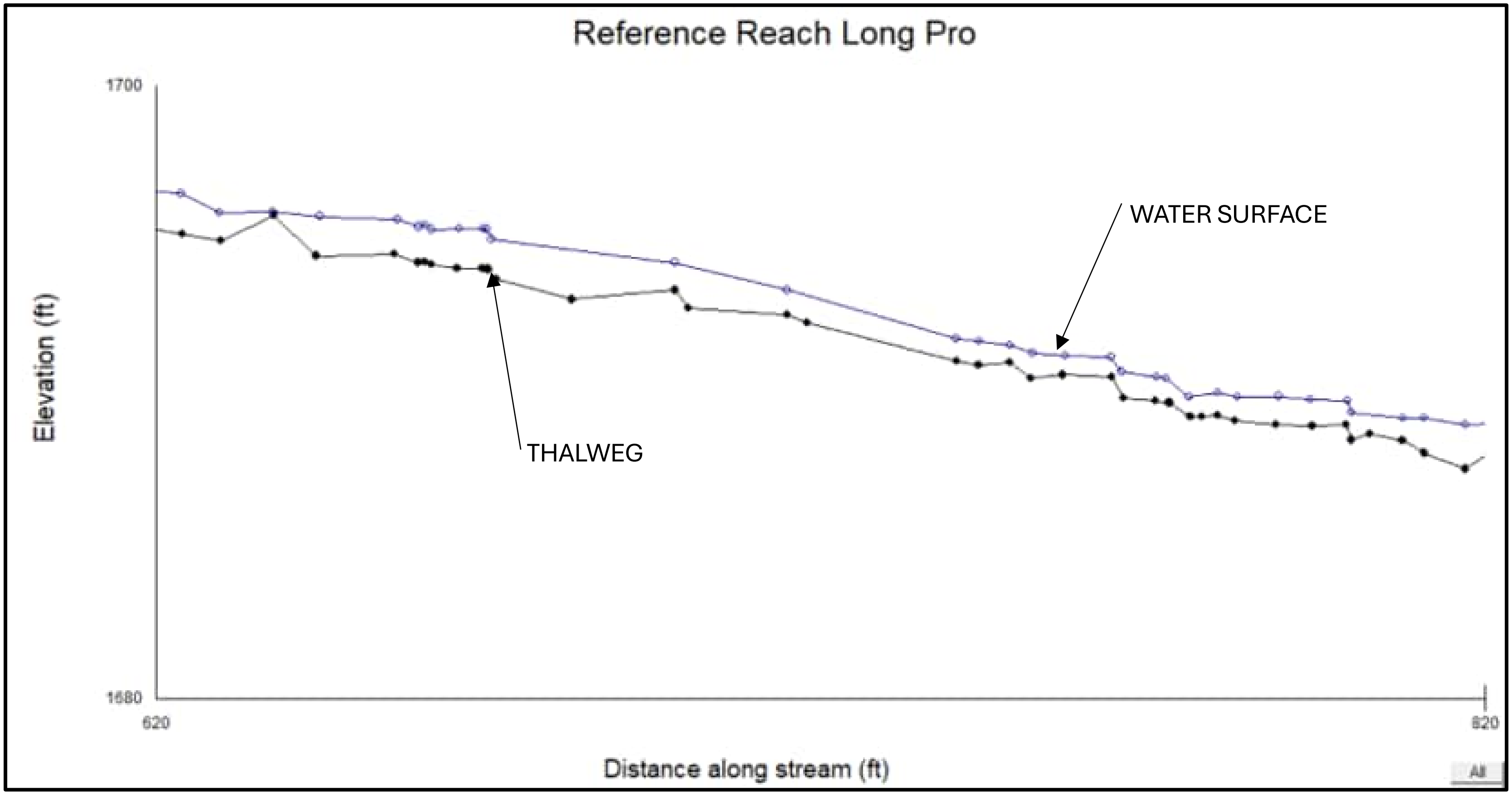

Figure 2. Reference Reach Longitudinal Profile

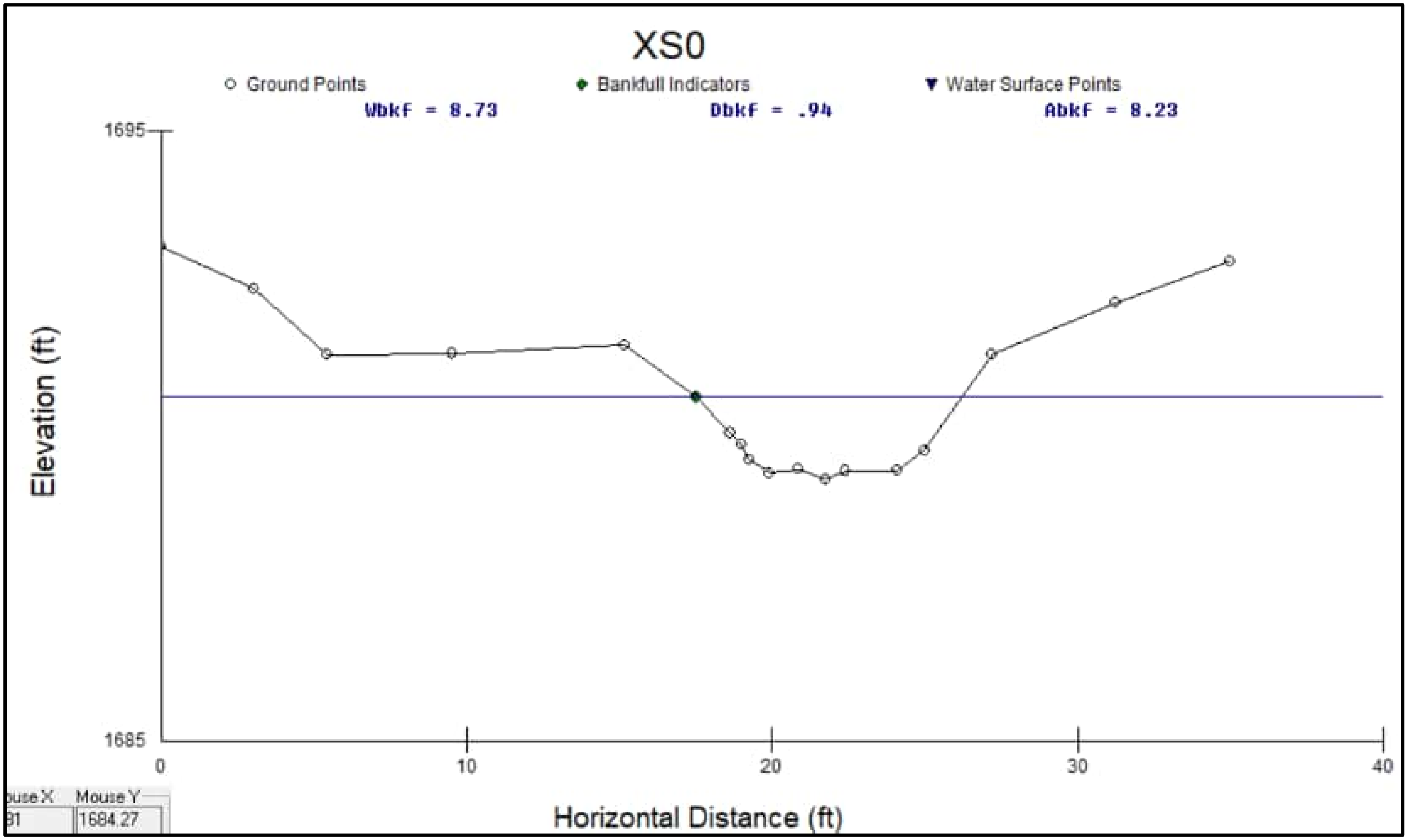

Figure 3. Cross Section #0

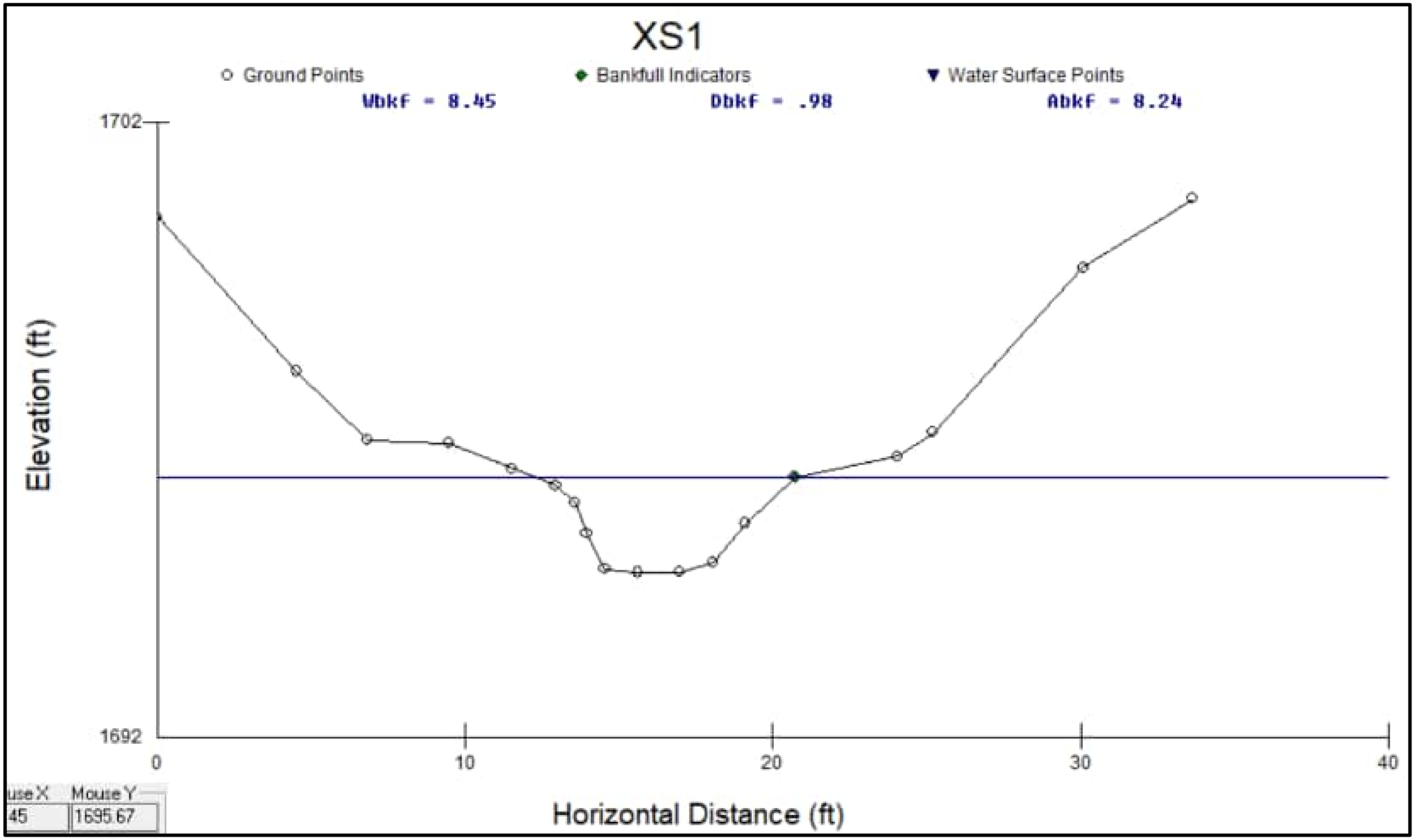

Figure 4. Cross Section #1

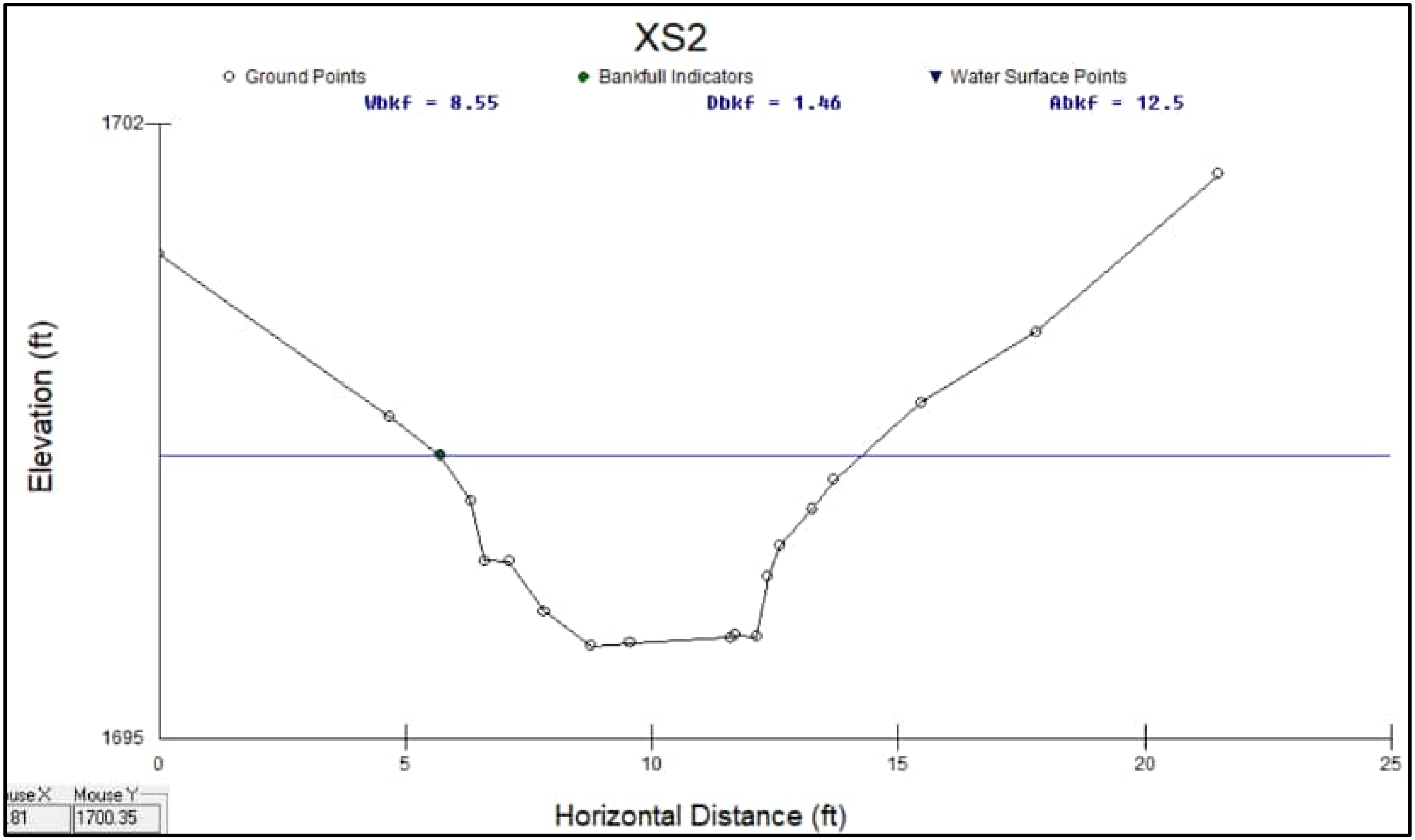

Figure 5. Cross Section #2

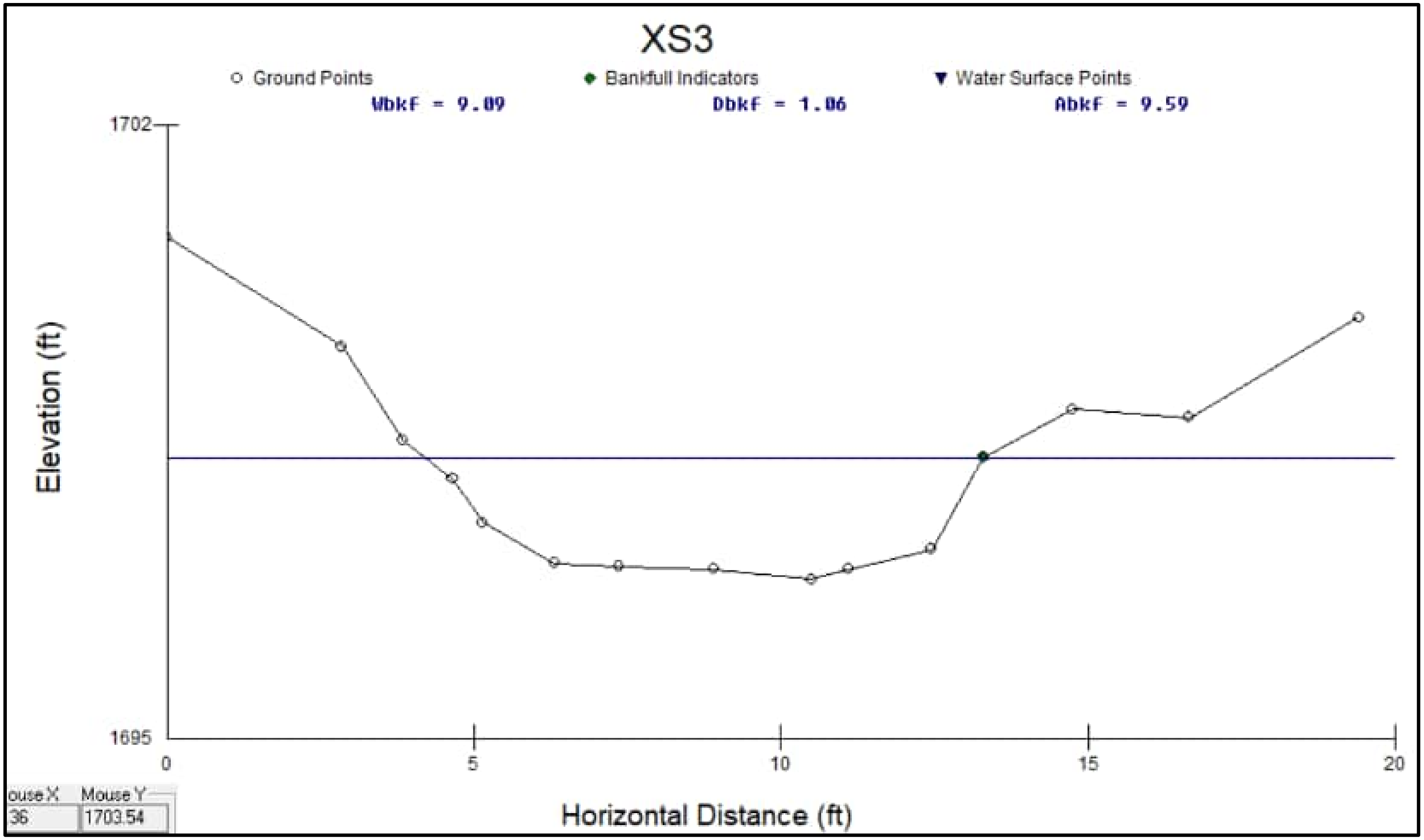

Figure 6. Cross Section #3

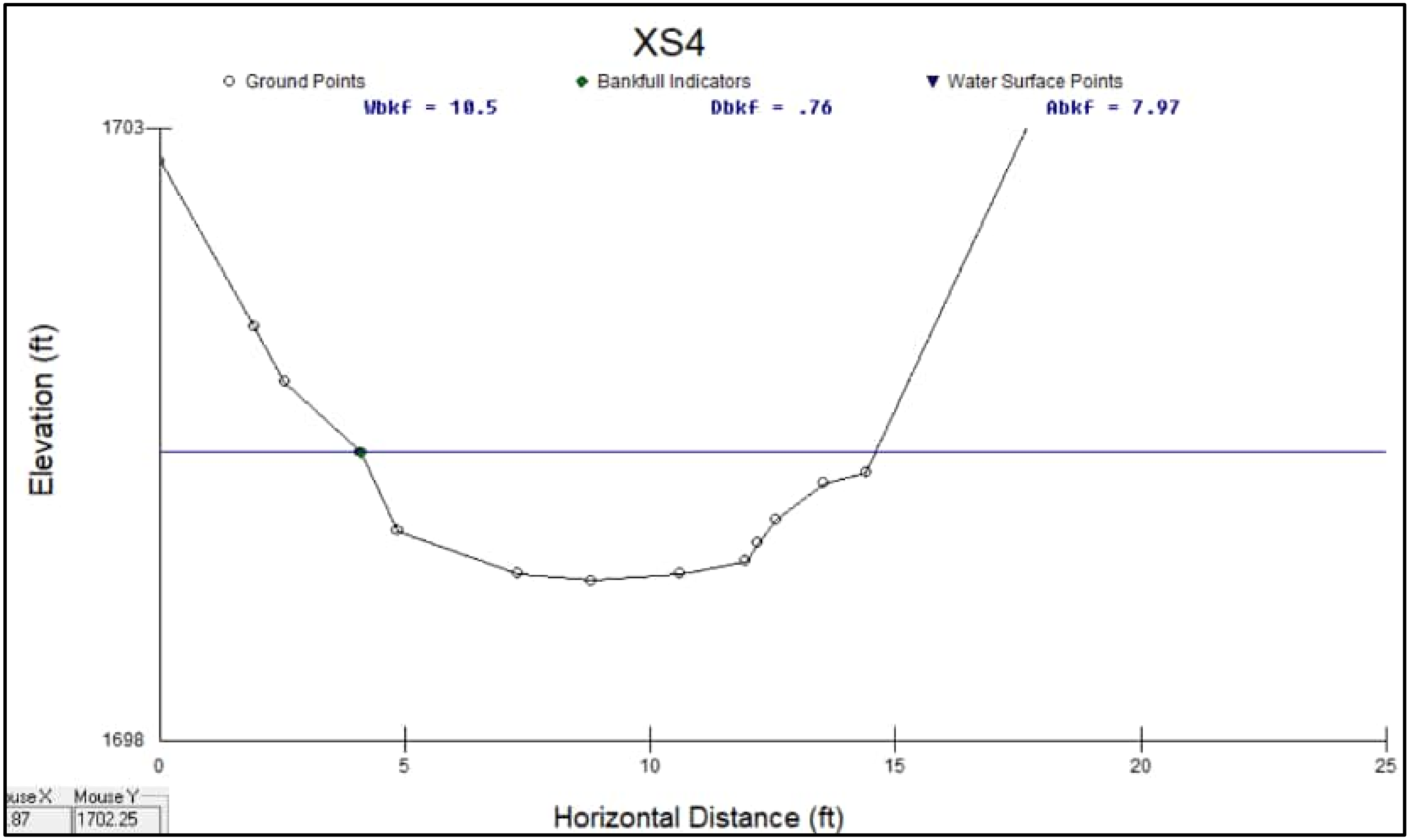

Figure 7. Cross Section #4

Reference Reach Pebble Count

During the May 2026 site visit, two pebble counts were completed, yielding a combined sample of 200 particles. The resulting pebble count and particle-size distribution for the study reach are summarized in Table 2.

Table 2. Pebble count and particle size analysis table

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	0	0.00	0.00
0.062 - 0.125	0	0.00	0.00
0.125 - 0.25	0	0.00	0.00
0.25 - 0.50	0	0.00	0.00
0.50 - 1.0	2	1.00	1.00
1.0 - 2.0	3	1.50	2.50
2.0 - 4.0	1	0.50	3.00
4.0 - 5.7	4	2.00	5.00
5.7 - 8.0	5	2.50	7.50
8.0 - 11.3	3	1.50	9.00
11.3 - 16.0	4	2.00	11.00
16.0 - 22.6	7	3.50	14.50
22.6 - 32.0	15	7.50	22.00
32 - 45	25	12.50	34.50
45 - 64	35	17.50	52.00
64 - 90	41	20.50	72.50
90 - 128	32	16.00	88.50
128 - 180	22	11.00	99.50
180 - 256	1	0.50	100.00
256 - 362	0	0.00	100.00
362 - 512	0	0.00	100.00
512 - 1024	0	0.00	100.00
1024 - 2048	0	0.00	100.00
Bedrock	0	0.00	100.00

Particle Size Analysis

D16 (mm)	24.48
D35 (mm)	45.54
D50 (mm)	61.83
D84 (mm)	117.31
D95 (mm)	158.73
D100 (mm)	255.98
Silt/Clay (%)	0
Sand (%)	2.5
Gravel (%)	49.5
Cobble (%)	48
Boulder (%)	0
Bedrock (%)	0

Total Particles = 200

D50 61.83 mm

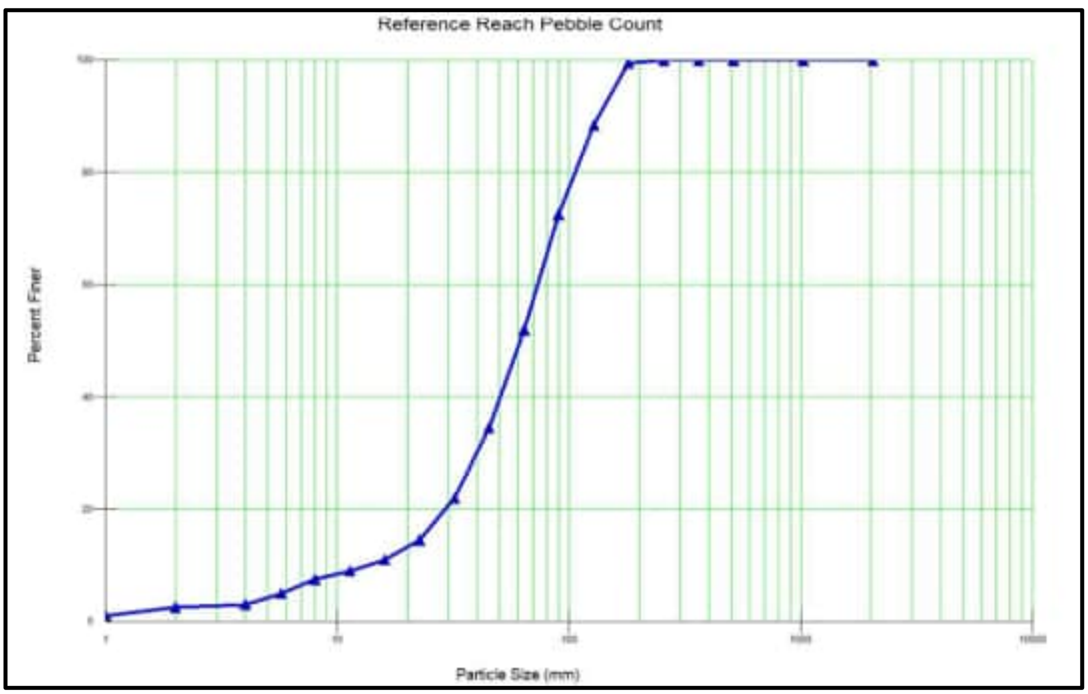

Figure 8. Pebble count and particle size analysis chart

The outputs measured in During the May 2026 site visit, two pebble counts were completed, yielding a combined sample of 200 particles. The resulting pebble count and particle-size distribution for the study reach are summarized in Table 2.

Table 2 and Figure 8 do not account for subsurface material.

Site Photos

Field photos are presented in Figure 9 through Figure 13.

Figure 9. Upstream reach (looking downstream)

Figure 10. Inlet and upstream reach (looking upstream)

Figure 11. Outlet (looking upstream)

Figure 12. Downstream reach (looking upstream)

Figure 13. Substrate with tape measurement

GEOMORPHIC ANALYSIS

Bankfull VELOCITY & DISCHARGE Estimates					
Stream:	RF 2026		Location:	Reach - Combined	
Date:		Stream Type: B3c	Valley Type:	C-CO-US	
Observers:	JS		HUC:	19020102	
INPUT VARIABLES			**OUTPUT VARIABLES**		
Bankfull Riffle Cross-Sectional AREA	8.23	A_{bkf} (ft²)	Bankfull Riffle Mean DEPTH	0.94	d_{bkf} (ft)
Bankfull Riffle WIDTH	8.73	W_{bkf} (ft)	Wetted PERMIMETER ~ $(2 * d_{bkf}) + W_{bkf}$	9.43	W_p (ft)
D_{84} at Riffle	117.31	Dia. (mm)	D_{84} (mm) / 304.8	0.38	D_{84} (ft)
Bankfull SLOPE	0.0380	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	0.87	R (ft)
Gravitational Acceleration	32.2	g (ft / sec²)	Relative Roughness R(ft) / D_{84} (ft)	2.26	R / D_{84}
Drainage Area	3.7	DA (mi²)	Shear Velocity $u^* = (gRS)^{1/2}$	1.032	u* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * \text{Log}\{R / D_{84}\}] u^*$	5.00	ft / sec	41.18	cfs
2. Roughness Coefficient: a) Manning's n from Friction Factor / Rel Roughness (Figs. 2-18, 2-19) $u = 1.49 * R^{2/3} * S^{1/2} / n$; n = 0.045	5.88	ft / sec	48.40	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 = 0.0557	4.75	ft / sec	39.10	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 =		ft / sec		cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) Darcy-Weisbach (Leopold, Wolman and Miller)	5.42	ft / sec	44.63	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) Chezy C	4.94	ft / sec	40.62	cfs
4. Continuity Equations: a) Regional Curves $u = Q / A$; Return Period for Bankfull Dischа Q = 0.0 year	0.00	ft / sec	0.00	cfs
4. Continuity Equations: b) USGS Gage Data $u = Q / A$	0.00	ft / sec	0.00	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.

Figure 14. Cross section #0 velocity and discharge geomorphic calculations

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	RF 2026			Location:	Reach - Combined
Date:		Stream Type:	B3c	Valley Type:	C-CO-US
Observers:	JS			HUC:	19020102

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	8.24	A_{bkf} (ft²)	Bankfull Riffle Mean DEPTH	0.98	d_{bkf} (ft)
Bankfull Riffle WIDTH	8.45	W_{bkf} (ft)	Wetted PERIMETER ~ $(2 * d_{bkf}) + W_{bkf}$	9.37	W_p (ft)
D_{84} at Riffle	117.31	Dia. (mm)	D_{84} (mm) / 304.8	0.38	D_{84} (ft)
Bankfull SLOPE	0.0380	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	0.88	R (ft)
Gravitational Acceleration	32.2	g (ft / sec²)	Relative Roughness R(ft) / D_{84} (ft)	2.29	R / D_{84}
Drainage Area	3.7	DA (mi²)	Shear Velocity $u^* = (gRS)^{½}$	1.038	u* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * Log\{R / D_{84}\}]\, u^*$	5.04	ft / sec	41.55	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Rela Roughness (Figs. 2-18, 2-19) $u = 1.49 * R^{2/3} * S^{1/2} / n$ *n* = 0.045	5.91	ft / sec	48.71	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* = 0.0557	4.78	ft / sec	39.35	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* =		ft / sec		cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) Darcy-Weisbach (Leopold, Wolman and Miller)	5.65	ft / sec	46.56	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) Chezy C	0.00	ft / sec	0.00	cfs
4. Continuity Equations: a) Regional Curves u = Q / A Return Period for Bankfull Discha Q = 0.0 year	0.00	ft / sec	0.00	cfs
4. Continuity Equations: b) USGS Gage Data u = Q / A	0.00	ft / sec	0.00	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.
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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.

Figure 15. Cross section #1 velocity and discharge geomorphic calculations

HYDROLOGIC ANALYSIS

The 3.78 mi^2 watershed area was delineated using the ArcGIS Watershed tool. The annual mean precipitation was obtained from the PRISM 1971–2000 dataset, yielding 465 mm (approximately 18.5 in).

CRWP Flow Measurements

Flow measurements collected at the site by CRWP cannot be used to establish a bankfull discharge because they were collected at lower flows and represent only instantaneous hydrologic conditions, not a basis for defining bankfull flow. The measured flows can support hydraulic calibration in more developed models; however, they cannot reliably inform or replace the geomorphic and regression-based methods used to determine bankfull discharge for design.

2016 USGS Regression Equations

For an ungaged stream in Alaska, the 2016 regression equations are the best fit because they are regionally calibrated, statistically robust, and formally adopted as the standard method for Alaska hydrology. Little Tonsina Tributary falls within the recommended limits of the 2016 regression equation.

Table 3. 2016 regional regression equation peak flows for project reach

Recurrence Interval	Peak flow (cfs)
2-yr	55.8
5-yr	101
10-yr	138
25-yr	190
50-yr	231
100-yr	276
200-yr	323
500-yr	389

Table 4. 2003 regional regression equation peak flows for project reach

Recurrence Interval	Peak flow (cfs)
2-yr	77
5-yr	124
10-yr	158
25-yr	205
50-yr	242
100-yr	280
200-yr	319
500-yr	374

2003 USGS Regression Equations

While the tributary falls within the applicability limits of the 2003 USGS regression equations, those methods rely on outdated datasets and lack regional calibration. Accordingly, they are retained for comparison only, with design flows based on the 2016 equations. Peak-flow estimates were calculated using Region 6 parameters, see Table 4.

Hydrologic Conclusion

The 2016 USGS regional regression equations were selected as the design hydrology because they align most closely with the geomorphic calculations and provide the most defensible estimates for this watershed.

Proposed Streambed Material

The streambed material for this project is designed to create a nature-representative mix of fines, gravels, cobbles, and occasional larger elements. This mixture is intended to maintain channel roughness, ensure structural stability, and facilitate effective fish passage. Utilizing pebble count data, River Focus established the empirical foundation necessary for applying the Fuller-Thompson equation, which was crucial for designing streambed material that accurately reflects existing channel conditions.

A safety factor of 1.5 was incorporated into the design process to enhance stability, resulting in a consistent gradation that is both well-graded and well-mixed. The proposed streambed mix will consist of 40% fine material and 60% coarse material, see gradations in Table 5 and Table 6. Viable salvaged materials that meet the required gradation or fall within acceptable tolerances, as approved by the engineer, will be prioritized.

Table 5. Fine material gradation

Fine Material	
Size	% Passing
4 in	1.00
1.5 in	0.8 to 0.9
0.75 in	0.6 to 0.7
#4	0.3 to 0.4
#10 Sand	0.2 min

Table 6. Coarse material gradation

Coarse Material	
Size	% Passing
15 in	1.00
9 in	0.55 to 0.65
6 in	0.3 to 0.4
4 in	0.25 to 0.35

PROPOSED CONDITIONS

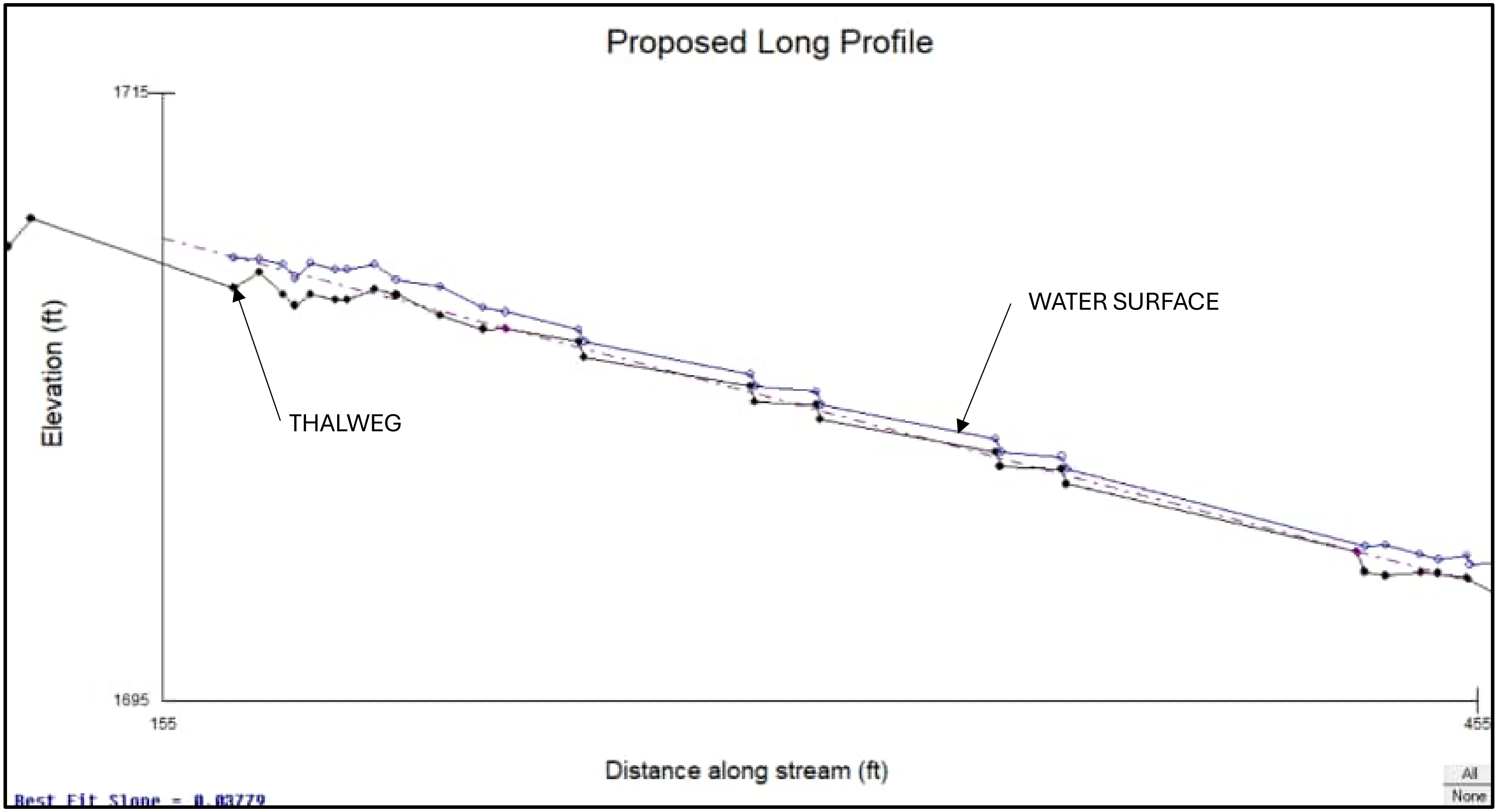

Figure 16. Proposed longitudinal profile

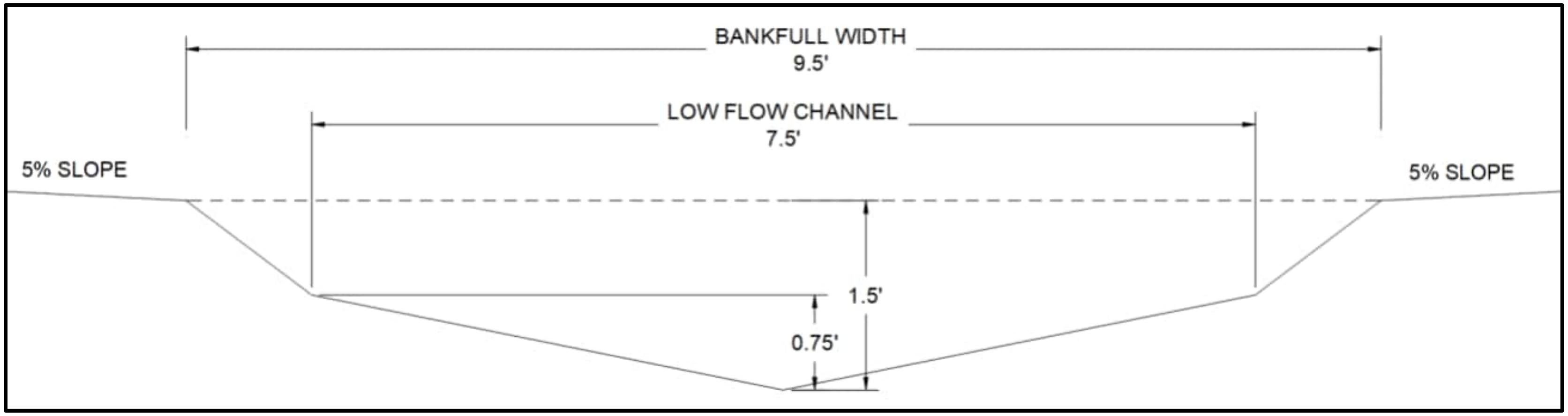

Figure 17. Proposed cross section

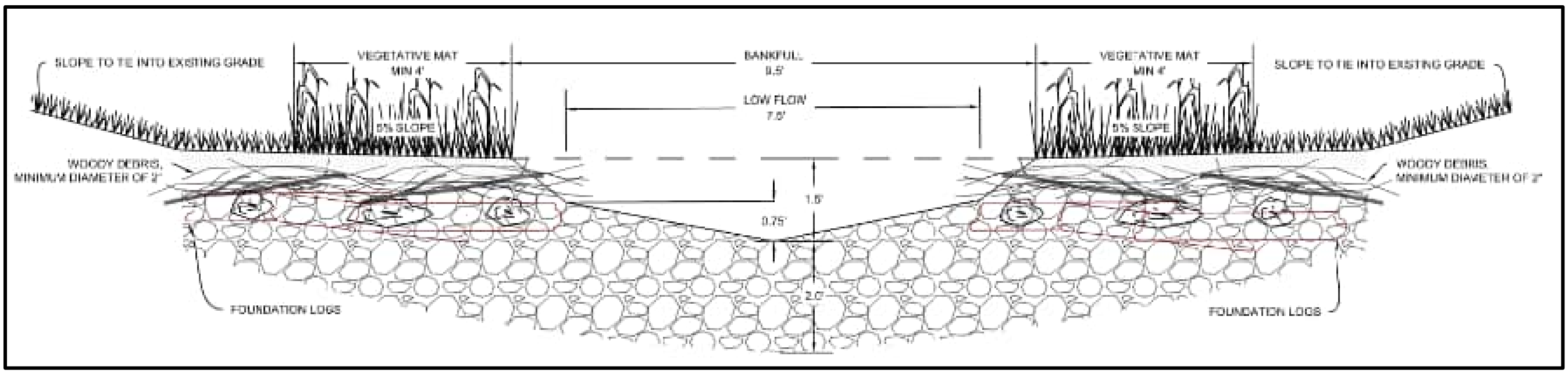

Figure 18. Proposed cross section with full detail

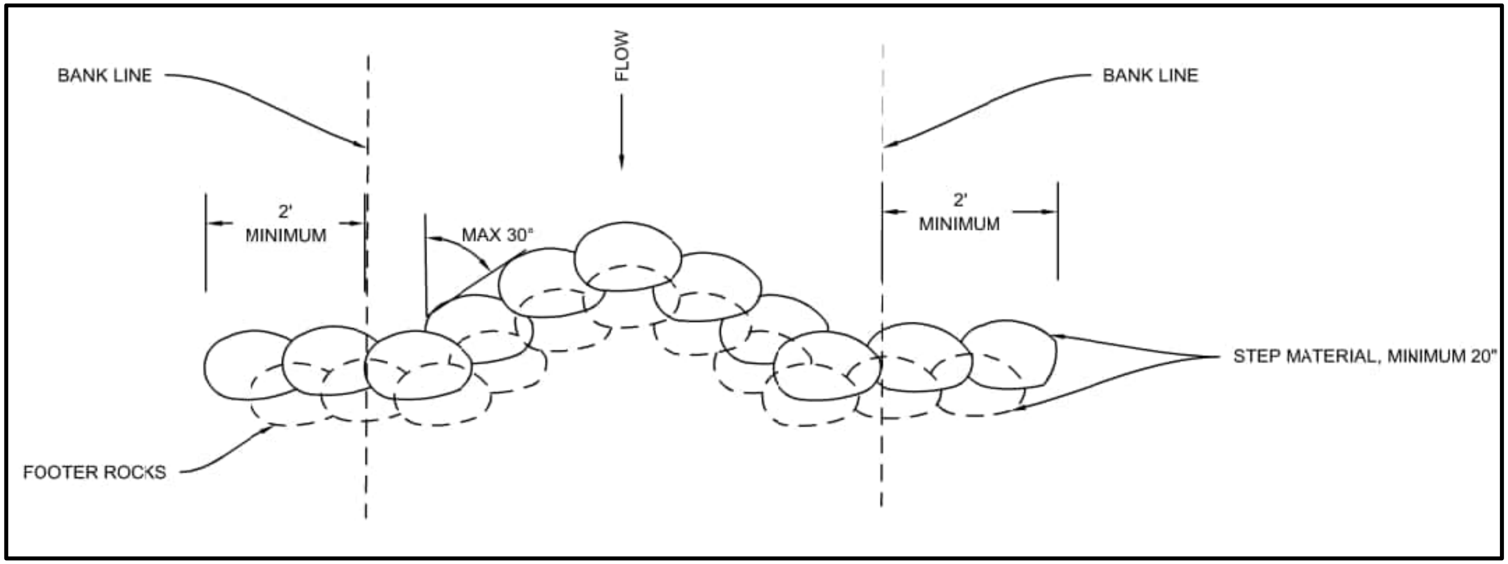

Figure 19. Proposed crested weir plan view

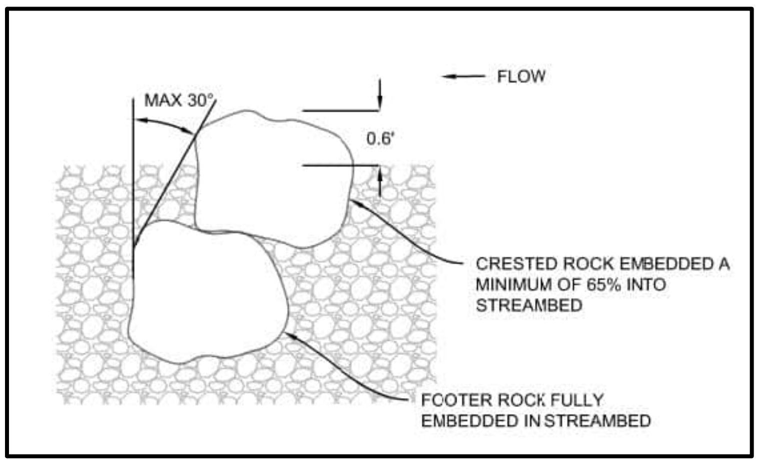

Figure 20. Proposed crested weir step profile view

REFERENCES

https://catalog.snap.uaf.edu/geonetwork/srv/eng/catalog.search#/metadata/59dc58a7-57b8-447a-8a6f-d17661c41b1e

https://www.fws.gov/alaska-culvert-design-guidelines

https://www.adfg.alaska.gov/index.cfm?adfg=fishpassage.regulations

https://www.chduero.es/documents/20126/734183/rosgen.pdf

https://wildlandhydrology.com/resources/docs/River%20Restoration%20and%20Natural%20Channel%20Design/Rosgen_Geomorphic_Channel_Design.pdf

https://pubs.usgs.gov/publication/sir20165024