Geomorphic Assessment at Versailles Lake Dam

Versailles Lake Dam Decommissioning Study

Date:
November 17, 2025

Prepared for:
Indiana Department of Natural Resources

Prepared by:
Stantec Consulting

Project/File:
173411095

Stantec

1 Introduction

Stantec conducted a geomorphic assessment of Laughery Creek on August 14th and 15th 2025. This report describes results of analysis of the data collected during this geomorphic assessment and conclusions which can be used in design of the Versailles Lake Dam Decommissioning. For an overview of the site and data collection points, See **Attachment 1**.

Table 1 : Abbreviation Table

Complete Term	Abbreviation
Feet	ft
Square Feet	ft^2
Feet per Second	ft/s
Cubic Feet per Second	cfs
Millimeters	mm
Protrusion	P

2 Data Collected and Results of Analysis

2.1 Profile

Longitudinal profile data were collected in three separate mobilizations: a geomorphic assessment upstream of the reservoir influence (August 2025), a bathymetric and topographic survey (April-June 2025), and bathymetric data collection within the lake during a previous phase of dam assessment. Riffle crest elevations documented above and below the reservoir and the dam were used to estimate a system slope of Laughery Creek. The estimated slope from the analysis was 0.15%, see **Figure 1**. This system slope was further confirmed using LiDAR data covering approximately 4 miles of Laughery Creek and the pre-dam topography as shown in the 1946 USGS Milan Indiana Topographic Quadrangle. The profile slope was used both in estimating bankfull discharge and in estimating reservoir sediment wedge shape. The full profile shows that the reservoir extends approximately 4 miles upstream of the dam during low flow conditions.**.** Excess deposition and a lower system slope are evident for an additional 3,500 feet upstream of reservoir extents, indicating influence from the dam.

A ”Detailed Upstream Longitudinal Profile” was also collected during assessment, see **Figure 2**. This detailed longitudinal profile is useful for 30% design purposes, but desktop review suggests that a reference reach be identified to further develop geomorphic relationships for 60% and Final design of Laughery Creek.

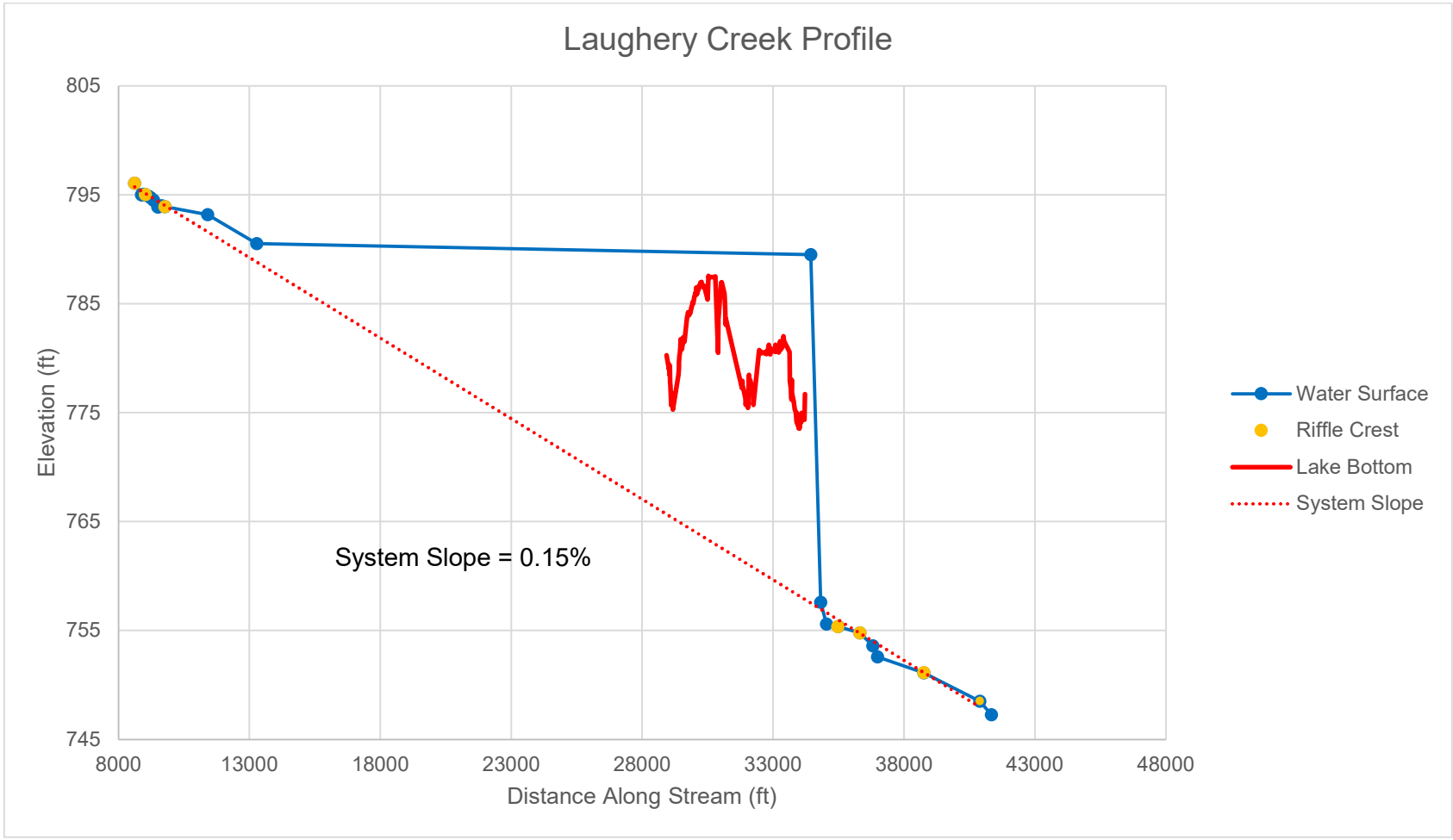


Figure 1 : Laughery Creek Profile

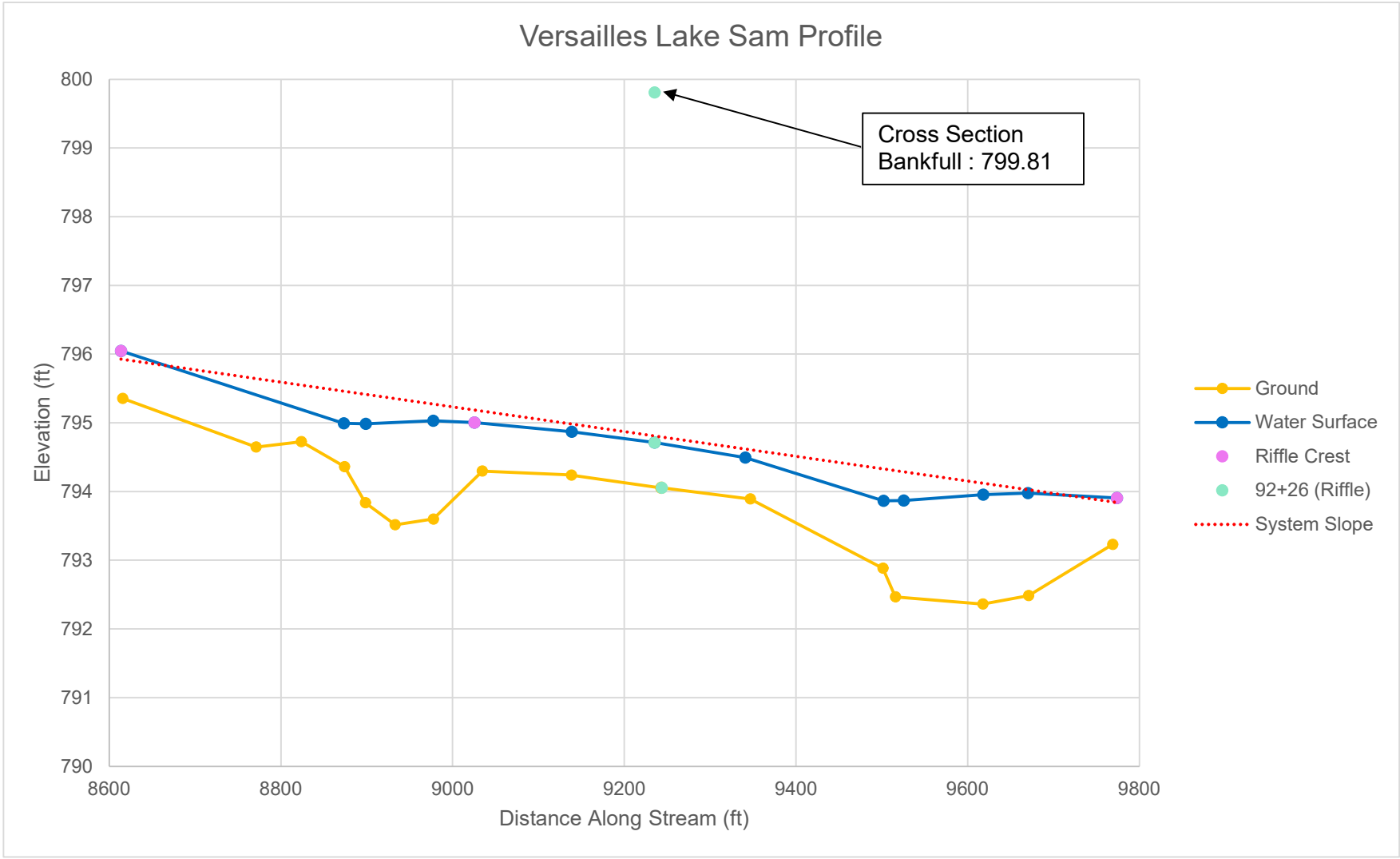


Figure 2 : Detailed Upstream Longitudinal Profile

2.2 Dimension

Three cross sections were measured upstream of the dam influence (US Riffle STA 09+53, US Riffle STA 92+26, and US Pool STA 14+00). Bankfull indicators were difficult to identify in the field due in part to lack of recent lateral migration and therefore point bar deposition. Bankfull stage was evaluated during desktop review in comparison to the USGS Regional Bankfull-Channel Dimensions of Non-Urban Wadeable Streams in Indiana (SIR – 5078). A lower stage, corresponding to a grade break documented in the field, was used for the bankfull elevation. The drainage area of Laughery Creek at the assessed reach is near the upper limit of data used to develop regional curves, but a cross section on Laughery Creek downstream of the dam was used in development of the regional curves. Stantec visited the reach in which the cross section used in the regional curve dataset is located (based on coordinates provided in the USGS Report) and qualitatively confirmed the bankfull stage presented in **Table 2**.

Table 2 : Dimension Summary Table

Cross Section STA.	BKF Mean Depth (ft)	BKF Max Depth (ft)	BKF Width (ft)	Width-To-Depth Ratio	BKF Area (ft^2)	Floodprone Width
09+53 (Riffle)	4.44	6.30	118.66	26.73	526.75	523
14+00 (Pool)	5.90	8.66	109.70	18.59	647.10	782
92+26 (Riffle)	4.67	5.73	119.19	25.52	556.70	401

Laughery Creek in the reach assessed has a moderate width to depth ratio (25.52-26.73). The stream has access to a floodplain and is slightly entrenched with an entrenchment ratio of between 3.36 and 4.41 The channel is incised, with a bank height ratio of approximately 1.4. Bank erosion upstream of the hydraulic backwater influence of the dam was minimal, but channel widening and/or meandering and subsequent mid-channel deposition was apparent within approximately 3,500 linear feet of the extent of the reservoir at low flow. Field observations did not yield a readily apparent cause for the degree of channel incision measured, but potential causes include vertical degradation of the bed or lateral expansion and subsequent lowering of the bankfull stage.

Figure 3 : US Riffle - STA 09+53

Figure 4 : US Riffle: STA. 92+26

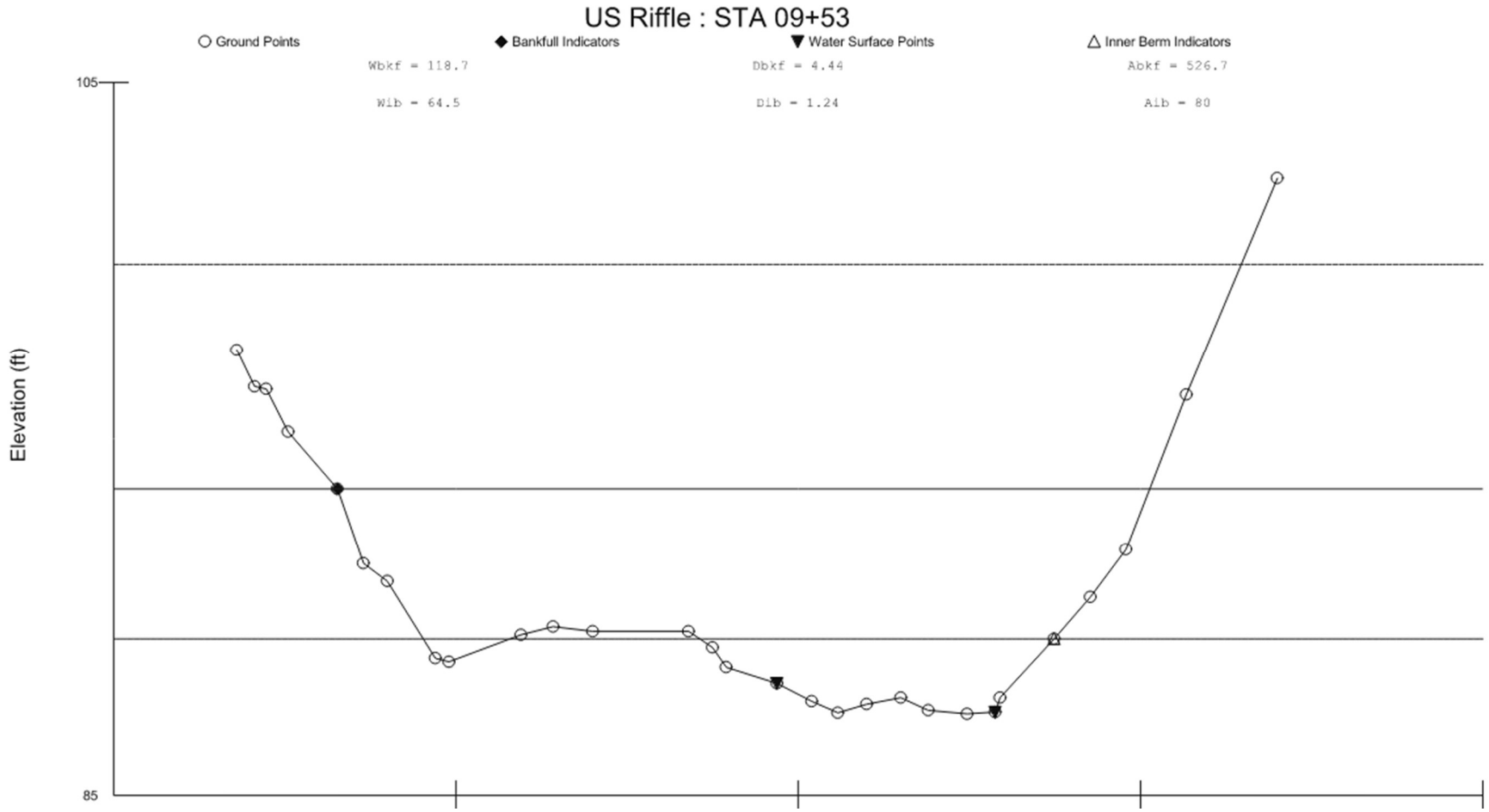


Figure 5: Upstream Riffle – STA 09+53 Cross Section

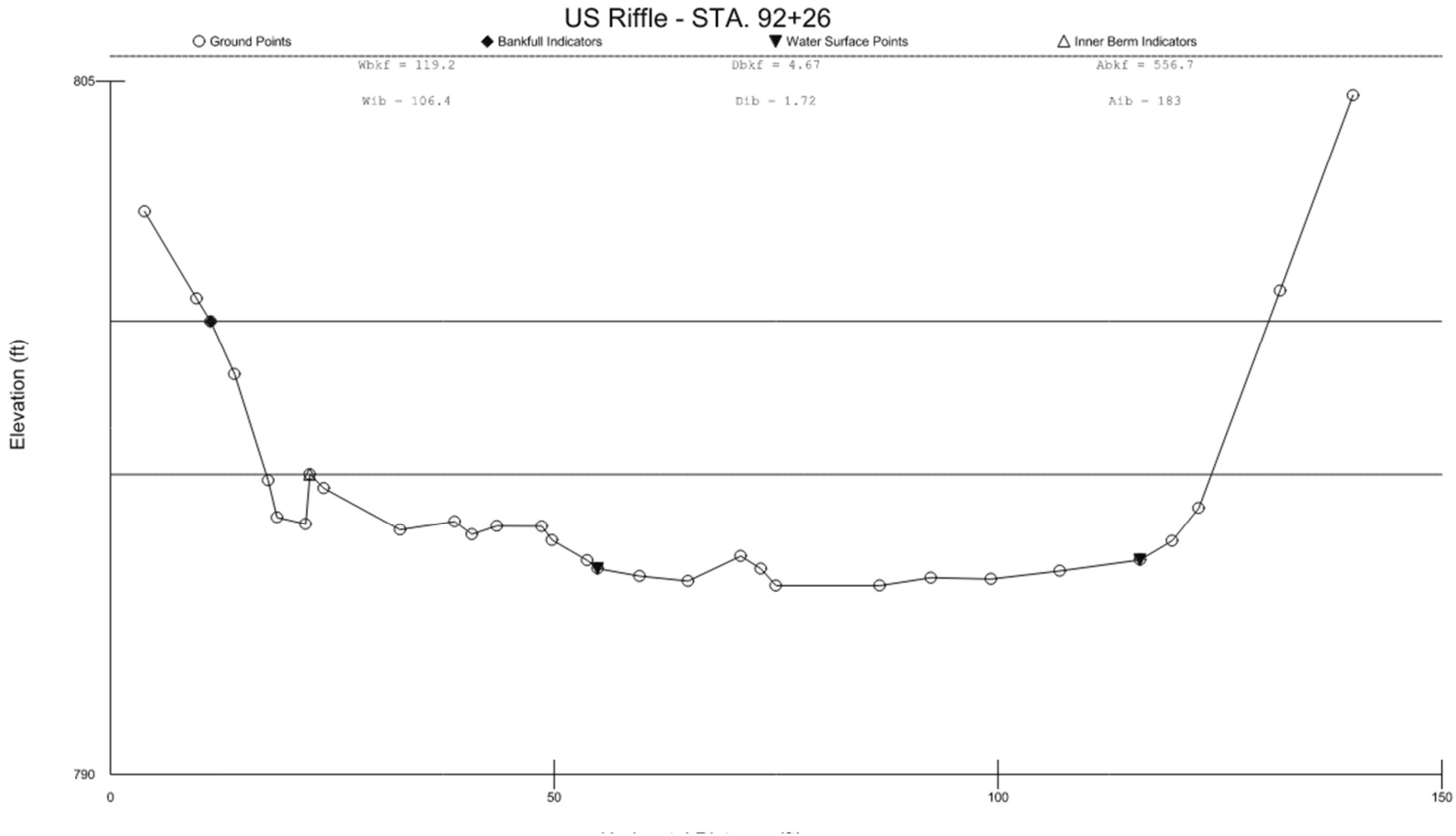


Figure 6 : US Riffle – STA. 92+26 Cross Section

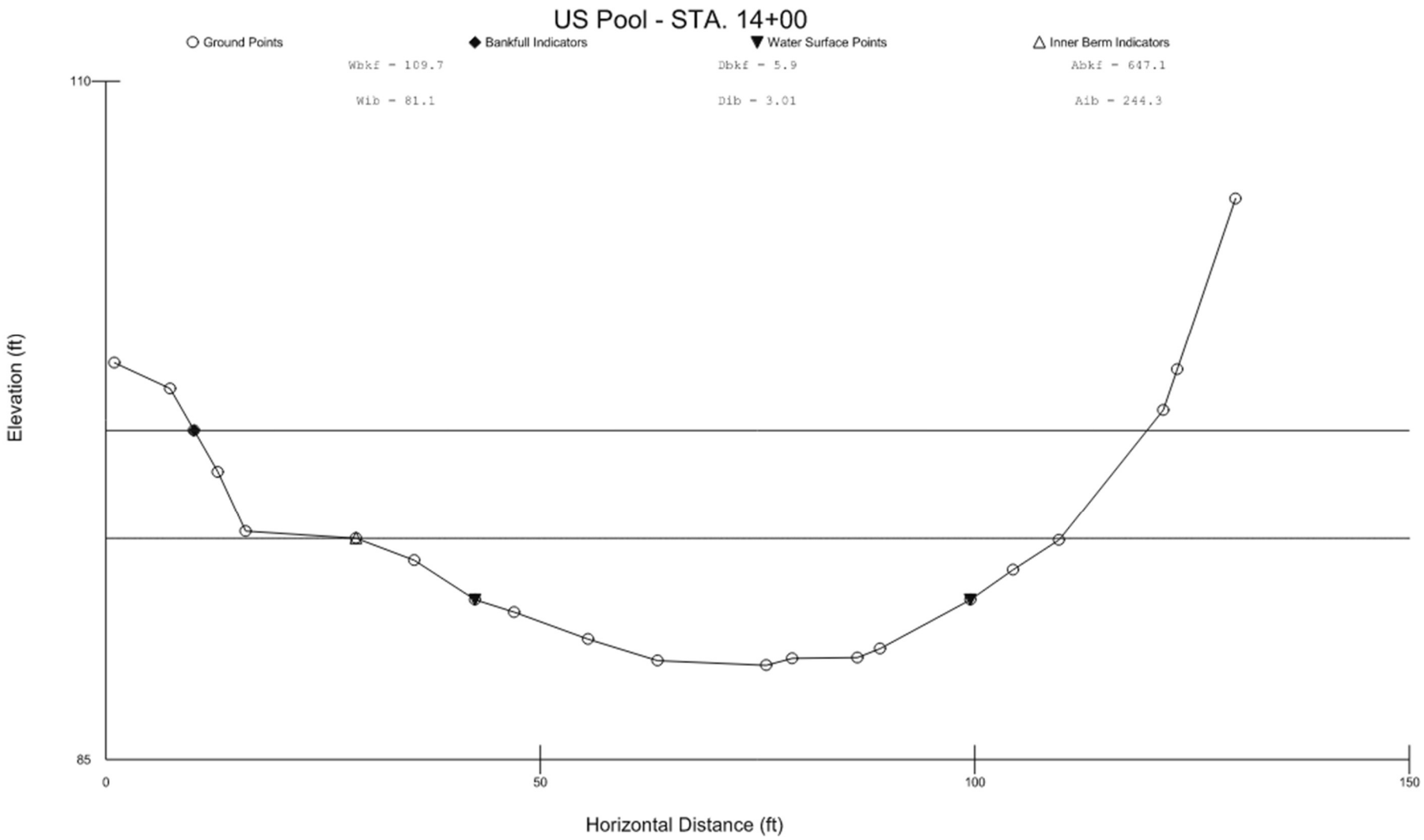


Figure 7 : US Pool - STA. 14+00 Cross Section

2.3 Particles

Particle data were collected both upstream and downstream of the dam.

A total of two active bed riffle pebble counts were collected upstream of the dam. The D_{50} for the upstream riffles, classification, and downstream riffles are as follows: 37.2 mm, 29.31 mm, and 32.0 mm. Cobble and small boulder sized substrates are present in Laughery Creek.

Exposed banks near the valley edge suggest that this colluvium is weathered limestone bedrock. Because the material originates in lenses, the resulting rocks are flat and platy. As protrusion is used in estimation of roughness, and many of the larger, platy particles lay such that their protruding axis was their A axis, the A axis (or "protrusion") was also measured.

Active bed riffle pebble count data are summarized in **Table 3**, **Figure 8**, **Figure 9**, and **Figure 10.**

Table 3 : Pebble Count Data Summary

Data Set	D_{50} (mm)	D_{84} (mm)	D_{90} (mm)
US Riffle – STA. 09+53	37.2	88.4	109.42
US Riffle – STA. 92+26	32.0	119.06	145.33
US Riffles – STA. 92+26 (Protrusion Values)	22.32	56.49	79.07

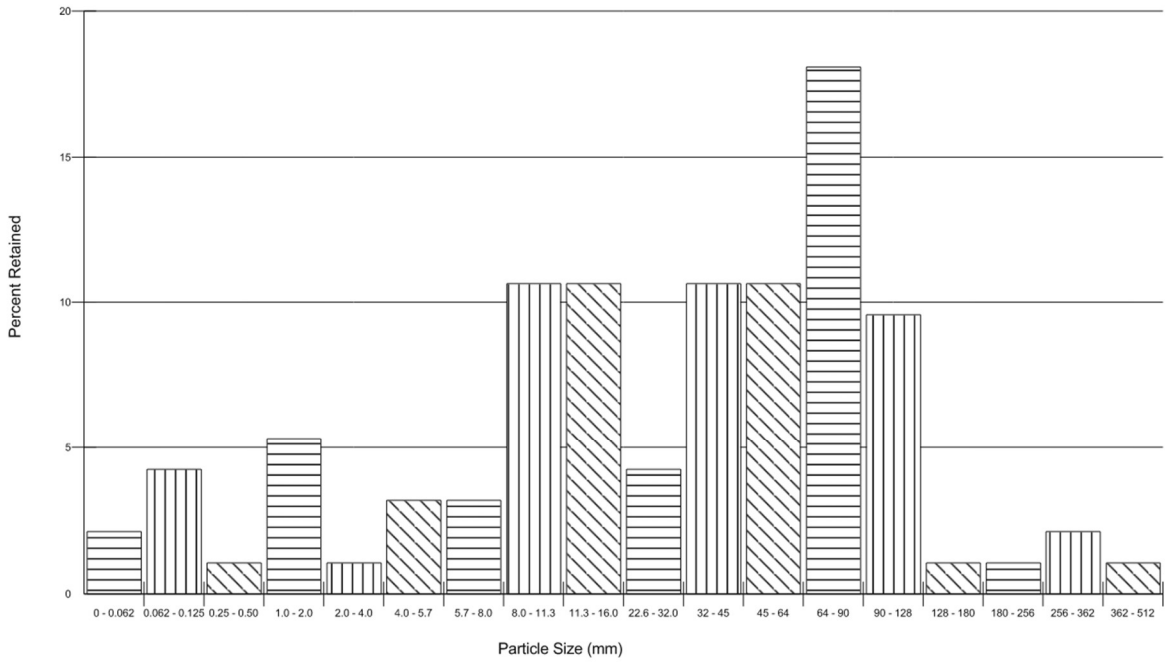


Figure 8 : US Riffle - STA. 09+53 Particle Distribution

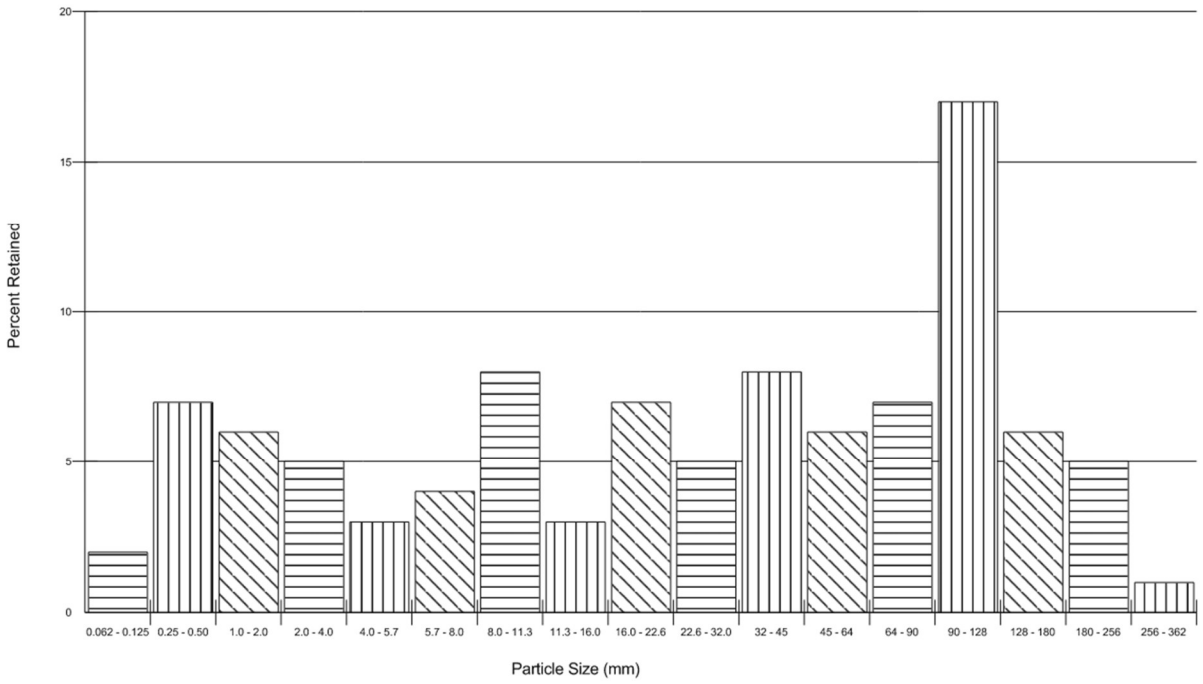


Figure 9 : US Riffle STA. 92+26 Particle Distribution

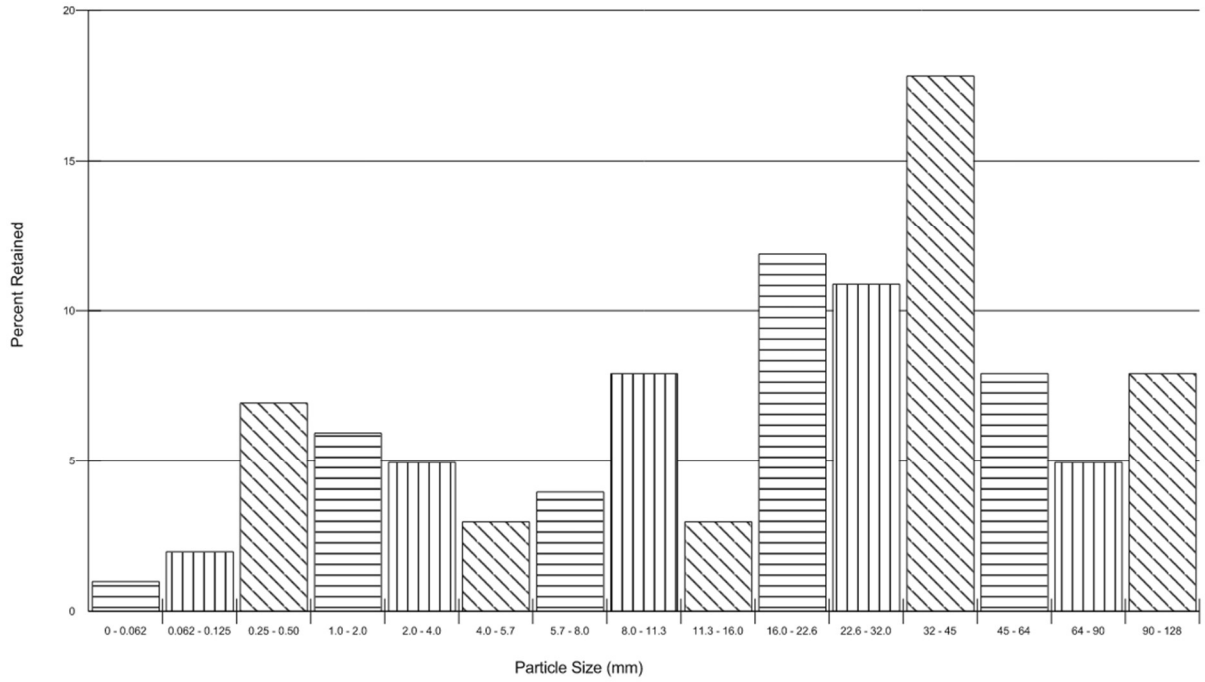


Figure 10 : US Riffle STA. 92+26 Particle Distribution (Protrusion Values)

A reachwide pebble count was conducted within the same reach in which the Detailed Upstream Longitudinal Profile was assessed. 50 particles within pools and 50 particles in riffles were collected and measured, approximating the 45.2% riffle and 54.8% pool observed within the reach. D50 value for the reachwide pebble count was 29.31mm (gravel).

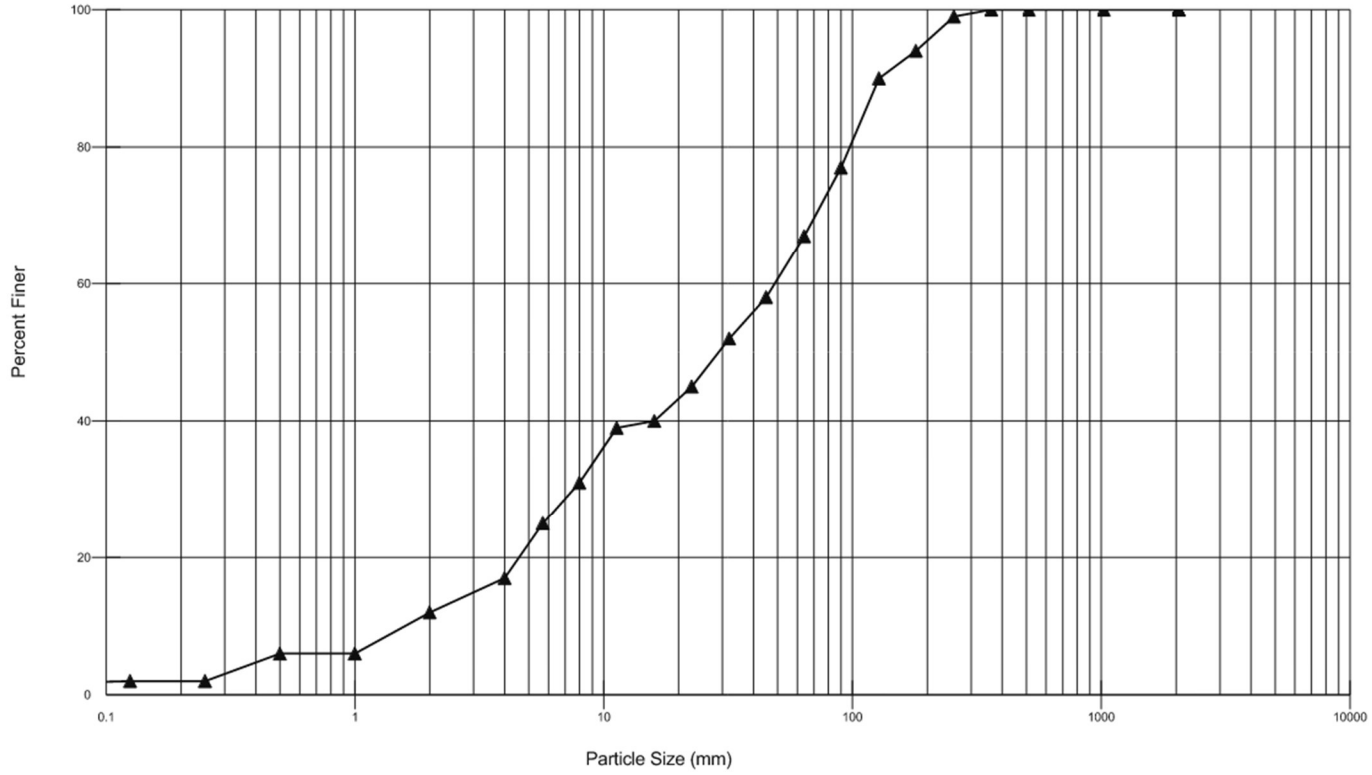


Figure 11 : Reach-Wide Classification Pebble Count (B-Axis Values)

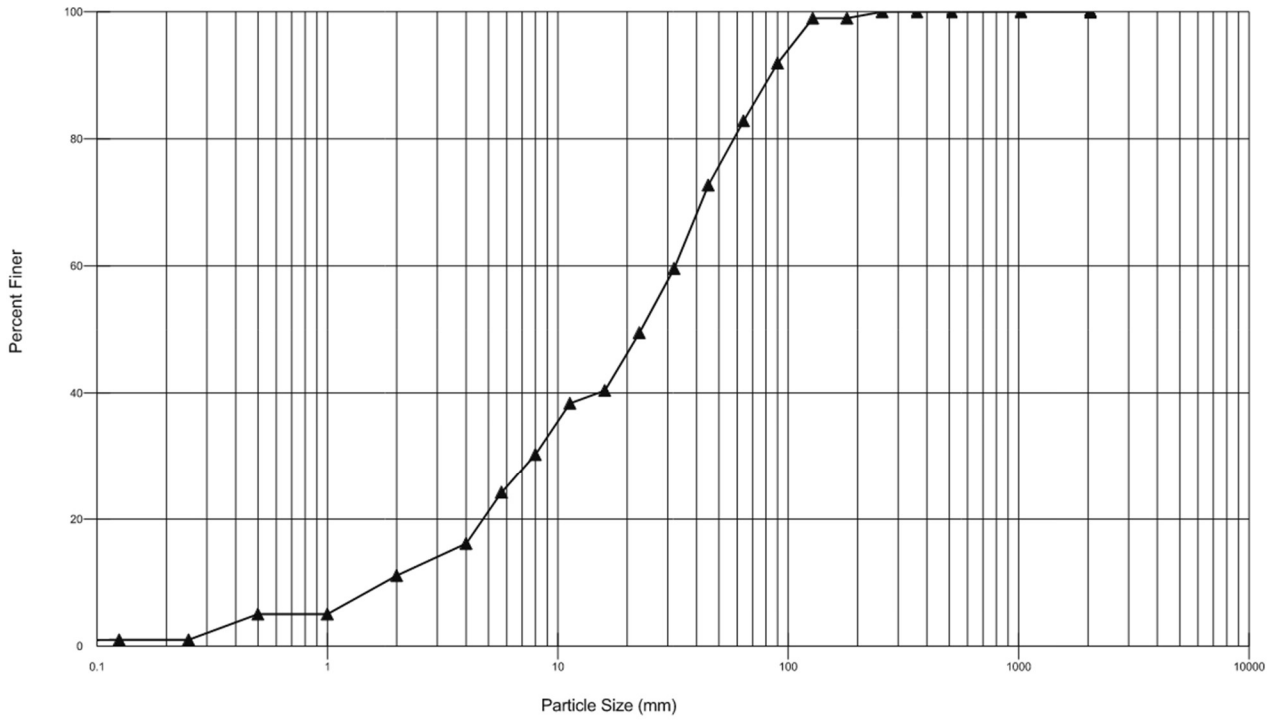


Figure 12 : Reach-Wide Classification Pebble Count (Protrusion Values)

Sediment was collected from 5 depositional bars, two upstream of the dam and three downstream. See **Table 4** for a summary of the data and **Attachment 2** for the full, raw data set. The average gradation across samples upstream of the dam was 51.2 percent gravel, 44.2 percent sand, and 4.6 percent fines. The average gradation across samples downstream of the dam within the park boundary was 67.1 percent gravel, 26.35 percent sand, and 12.9 percent fines. **Figure 13** depicts a typical depositional bar downstream of the dam while **Figure 14** depicts a typical bar from upstream of the dam.

Table 4 : Bar Sample Data Summary

Bar Sample #	D_{50} (mm)	D_{84} (mm)	D_{95} (mm)	Largest Particles(mm)
Upstream				
1	8.5	32.0	55.0	51, 56, 58
2	1.9	23.0	37.0	61,71,72, 82
Downstream				
3	20.0	51.0	65.0	95,90,72, 100
4	8.3	30.0	46.0	84,80,65, 140
5	4.6	37.0	60.0	150-45P, 90-22P, 90, 70, 58

Figure 13 : Bar Sample #3

Figure 14 : Bar Sample #1

2.4 Velocity, Discharge, and Competence

The velocity and discharge of the two riffle sections were calculated using the Manning's Equation. Cross section data was utilized for the hydraulic radius. Manning's roughness coefficient "n" was estimated at 0.03 utilizing the particle data in the Limerinos equation.

Table 5 : Riffle Velocity and Discharge

Cross Section STA.	Bankfull Velocity (ft/s)	Bankfull Discharge (cfs)
09+53 (Riffle)	5.1	2672.2
92+26 (Riffle)	5.2	2913.2

The competence of Laughery Creek at each riffle cross section was estimated using both the Sheilds and Colorado Equations.

Table 6 : Stream Competence

Cross Section STA.	Competence (Shields, mm)	Competence (Colorado, mm)
09+53	31.2	79.7
92+26	32.9	82.7

3 Characterization of System

3.1 Stream Type

After analyzing the profile, dimension, and particle data Laughery Creek can be described as a C4. Rosgen describes a C4 stream as having gravel channel material, being slightly entrenched, moderate to high width/depth ratio, and moderate to high sinuosity.

4 Conclusions

Stantec conducted a geomorphic assessment collecting profile, dimension, and particle data from Laughery Creek up and down stream of the Versailles Lake Dam. The assessment identified the reservoir backwater extent and that an additional 3,500 ft of stream is influenced by the dam.

The reach-wide pebble count data indicates that median particle in the active bed of the stream is gravel-sized. The bed does contain colluvium, likely sourced from weathered layers of limestone apparent in the valley margins. Bar samples contain up to 50% sand upstream of the dam, but were generally coarser below the dam as to be expected as the dam traps sand.

Bankfull velocity and discharge were determined to be between 5.1-5.2 ft/s and 2672-2913 cfs respectively. Competence of the stream was approximately 32 mm per Shields Equation and 81 mm per the Colorado Equation. This suggests that greater than 50% of the armor layer of the active bed in the riffles assessed are mobile at bankfull stage. In each of the five bar samples, when utilizing the Colorado Curve, more than 95% of the particles are mobile at bankfull stage.

After assessing all the data collected throughout the geomorphic assessment, Laughery Creek can be described as a C4 stream type.

5 References

Natural Resources Conservation Service. (2007). *Stream Restoration Design National Engineering Handbook: Rosgen Geomorphic Channel Design*. U.S. Department of Agriculture.

Stantec Consulting Services Inc.

Jim Moyer
Senior Project Manager
Phone: (513) 619-6451
Jim.Moyer@stantec.com

Jonah Reeves
Civil EIT
Phone: (614) 485-5040
Jonah.Reeves@stantec.com

Attachment 1
Geomorphic Assessment Map

Legend

- Bar Sample Locations
- Versailles Lake Dam
- Profile Centerline
- Riffle Cross Section : STA. 09+53
- Riffle Cross Section : STA. 92+26
- Pool Cross Section : STA. 14+00

Notes

1. Coordinate System: NAD 1983 CORS96 StatePlane Indiana East FIPS 1301 Ft US

2. Riffle stations defined from working survey alignment

N

0 2,000 4,000 Feet

(At original document size of 11x17)
1 IN = 2,000 FT

Attachment 1

Versailles Lake Dam Removal

Geomorphic Assessment

Versailles State Park

Versailles, IN

Stantec

Reference: **Versailles Lake Dam – Geomorphic Assessment Report**

Attachment 2
Bar Sample Data

Attachment 2

Stantec

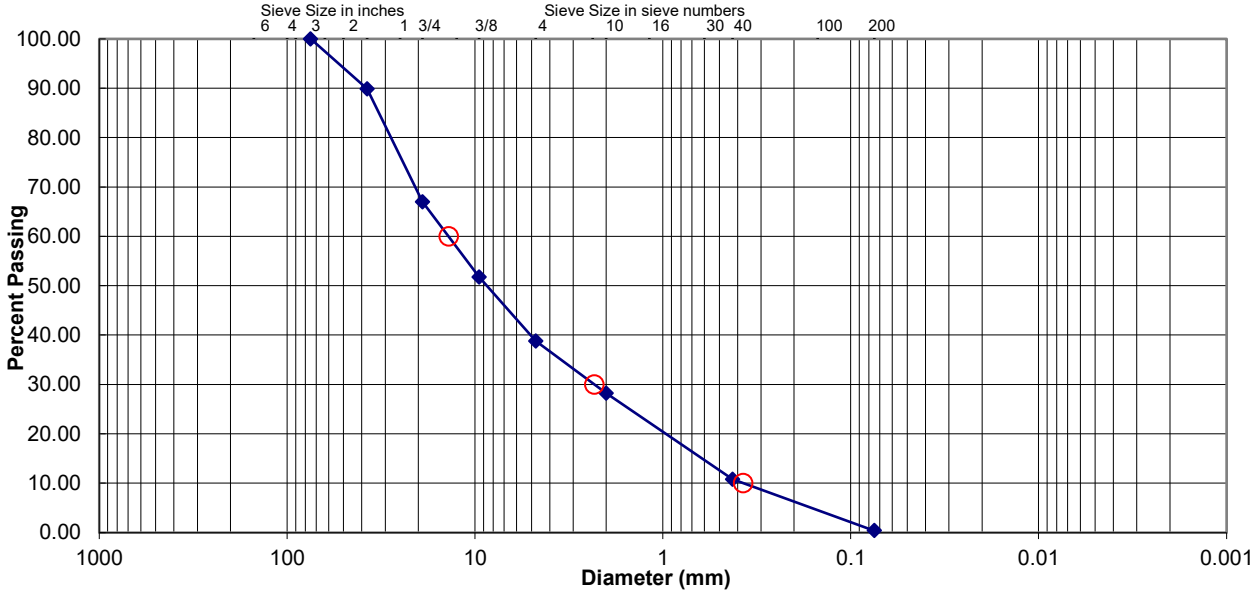
Gradation Analysis
ASTM D 422

Project Name	Versailles Dam Decommissioning Phase 1	Project Number	173411095
Source	Sediment Sample #1	Lab ID	25
Preparation Method	ASTM D 1140 Method A	Date Received	09-15-2025
Soak Time (min)	1200	Preparation Date	09-16-2025
Particle Shape	Angular	Test Date	07-17-2025
Particle Hardness	Hard and Durable		
Sample Dry Mass (g)	4639.50	Analysis Based on Total Sample.	
Moisture Content (%)	0.0		

Sieve Size	Grams Retained	% Retained	% Passing
3"	0.00	0.0	100.0
1 1/2"	469.84	10.1	89.9
3/4"	1060.50	22.9	67.0
3/8"	706.37	15.2	51.8
No. 4	603.36	13.0	38.8
No. 10	489.94	10.6	28.2
No. 40	810.38	17.5	10.8
No. 200	480.44	10.4	0.4
Pan	18.67	0.4	---

% Gravel	61.2
% Sand	38.4
% Fines	0.4
Fines Classification	N/A
D_{10} (mm)	0.3743
D_{30} (mm)	2.3130
D_{60} (mm)	13.8056
Cu	36.88
Cc	1.04

Particle Size Distribution



Comments

Reviewed By REL

Stantec

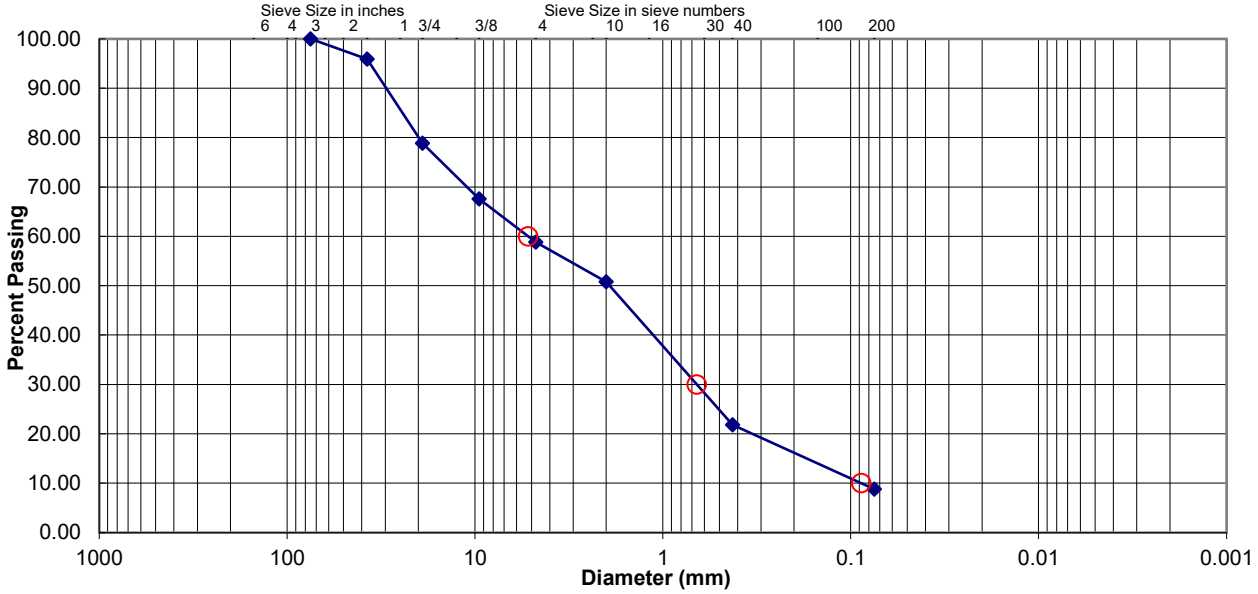
Gradation Analysis
ASTM D 422

Project Name	Versailles Dam Decommissioning Phase 1	Project Number	173411095
Source	Sediment Sample #2	Lab ID	26
Preparation Method	ASTM D 1140 Method A	Date Received	09-15-2025
Soak Time (min)	1200	Preparation Date	09-16-2025
Particle Shape	Angular	Test Date	09-17-2025
Particle Hardness	Hard and Durable		
Sample Dry Mass (g)	5727.50	Analysis Based on Total Sample.	
Moisture Content (%)	0.0		

Sieve Size	Grams Retained	% Retained	% Passing
3"	0.00	0.0	100.0
1 1/2"	235.12	4.1	95.9
3/4"	975.99	17.0	78.9
3/8"	644.46	11.3	67.6
No. 4	503.05	8.8	58.8
No. 10	461.64	8.1	50.8
No. 40	1659.00	29.0	21.8
No. 200	744.00	13.0	8.8
Pan	504.24	8.8	---

% Gravel	41.2
% Sand	50.0
% Fines	8.8
Fines Classification	N/A
D_{10} (mm)	0.0880
D_{30} (mm)	0.6591
D_{60} (mm)	5.2138
Cu	59.26
Cc	0.95

Particle Size Distribution



Comments

Reviewed By REL

Stantec

Gradation Analysis

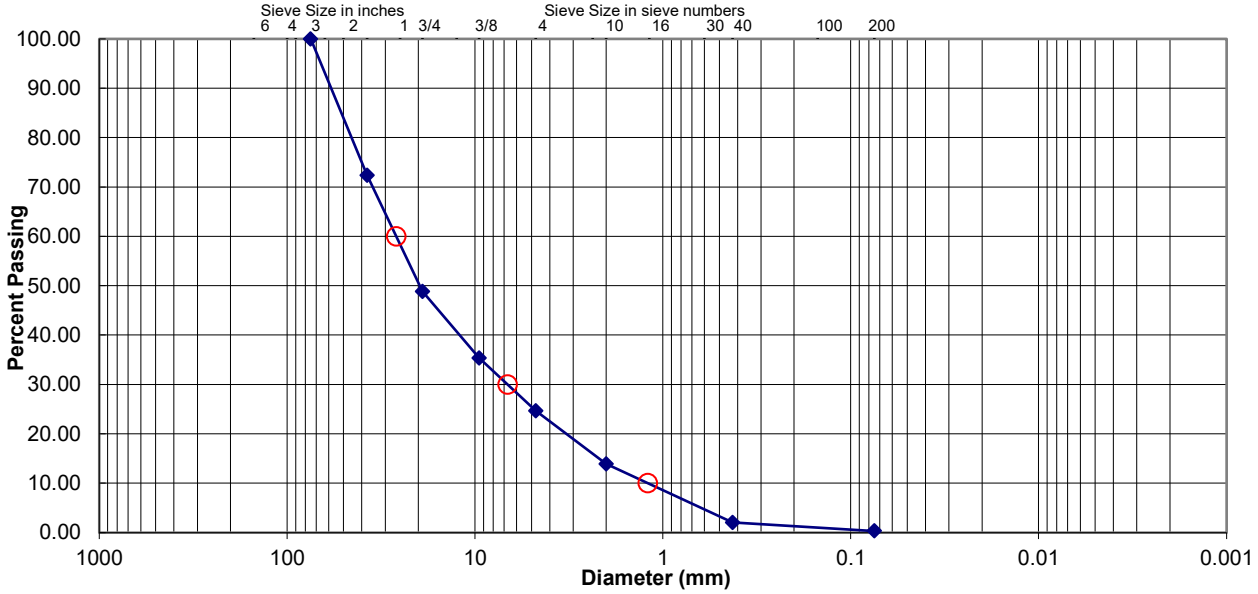
ASTM D 422

Project Name	Versailles Dam Decommissioning Phase 1	Project Number	173411095
Source	Sediment Sample #3	Lab ID	27
Preparation Method	ASTM D 1140 Method A	Date Received	09-15-2025
Soak Time (min)	1200	Preparation Date	09-16-2025
Particle Shape	Angular	Test Date	09-17-2025
Particle Hardness	Hard and Durable		
Sample Dry Mass (g)	4459.50	Analysis Based on Total Sample.	
Moisture Content (%)	0.0		

Sieve Size	Grams Retained	% Retained	% Passing
3"	0.00	0.0	100.0
1 1/2"	1232.00	27.6	72.4
3/4"	1049.50	23.5	48.8
3/8"	601.08	13.5	35.4
No. 4	476.84	10.7	24.7
No. 10	480.29	10.8	13.9
No. 40	529.50	11.9	2.0
No. 200	75.79	1.7	0.3
Pan	14.50	0.3	---

% Gravel	75.3
% Sand	24.3
% Fines	0.3
Fines Classification	N/A
D_{10} (mm)	1.2028
D_{30} (mm)	6.7112
D_{60} (mm)	26.2290
Cu	21.81
Cc	1.43

Particle Size Distribution



Comments

Reviewed By REL

Stantec

Gradation Analysis
ASTM D 422

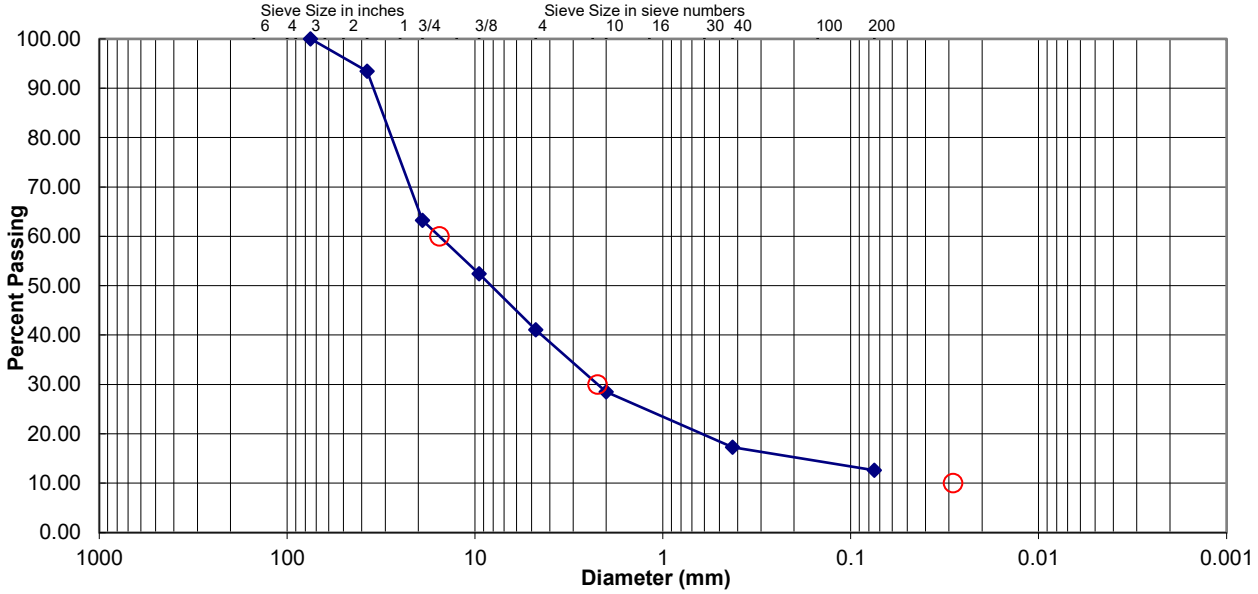
Project Name	Versailles Dam Decommissioning Phase 1	Project Number	173411095
Source	Sediment Sample #4	Lab ID	28
Preparation Method	ASTM D 1140 Method A	Date Received	09-15-2025
Soak Time (min)	1200	Preparation Date	09-16-2025
Particle Shape	Angular	Test Date	09-17-2025
Particle Hardness	Hard and Durable		
-3" Sample Dry Mass (g)	4825.50		
Moisture Content (%)	0.0		

Analysis Based on -3" Fraction Only.
(532.29g +3" material was removed)

Sieve Size	Grams Retained	% Retained	% Passing
3"	0.00	0.0	100.0
1 1/2"	316.23	6.6	93.4
3/4"	1456.33	30.2	63.3
3/8"	524.56	10.9	52.4
No. 4	547.45	11.3	41.1
No. 10	607.56	12.6	28.5
No. 40	539.25	11.2	17.3
No. 200	225.75	4.7	12.6
Pan	608.37	12.6	---

% Gravel	58.9	
% Sand	28.4	
% Fines	12.6	
Fines Classification	N/A	
D_{10} (mm)	0.0285	*Estimated
D_{30} (mm)	2.2231	
D_{60} (mm)	15.4272	
Cu	540.86	*Estimated
Cc	11.23	*Estimated

Particle Size Distribution



Comments

Reviewed By REL

Stantec

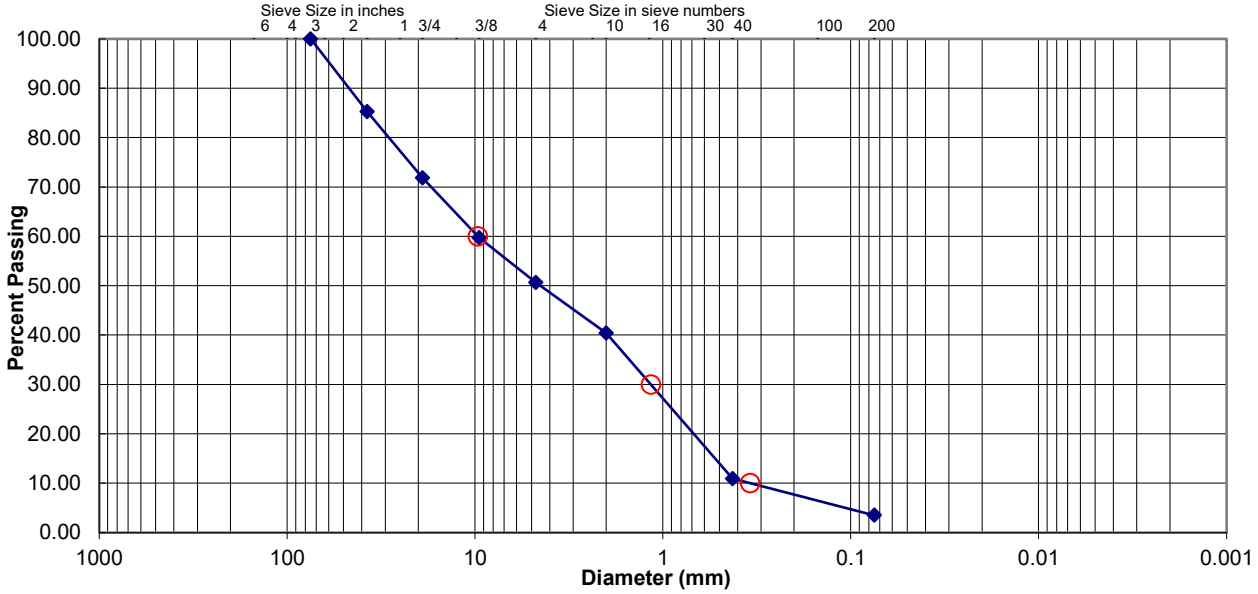
Gradation Analysis
ASTM D 422

Project Name	Versailles Dam Decommissioning Phase 1	Project Number	173411095
Source	Sediment Sample #5	Lab ID	29
Preparation Method	ASTM D 1140 Method A	Date Received	09-15-2025
Soak Time (min)	1200	Preparation Date	09-16-2025
Particle Shape	Angular	Test Date	09-17-2025
Particle Hardness	Hard and Durable		
Sample Dry Mass (g)	4340.50	Analysis Based on Total Sample.	
Moisture Content (%)	0.0		

Sieve Size	Grams Retained	% Retained	% Passing
3"	0.00	0.0	100.0
1 1/2"	638.00	14.7	85.3
3/4"	583.50	13.4	71.9
3/8"	526.15	12.1	59.7
No. 4	395.23	9.1	50.6
No. 10	442.64	10.2	40.4
No. 40	1281.00	29.5	10.9
No. 200	322.00	7.4	3.5
Pan	151.98	3.5	---

% Gravel	49.4
% Sand	47.1
% Fines	3.5
Fines Classification	N/A
D_{10} (mm)	0.3427
D_{30} (mm)	1.1568
D_{60} (mm)	9.6444
Cu	28.14
Cc	0.40

Particle Size Distribution



Comments

Reviewed By REL