MONITORING YEAR 4 ANNUAL REPORT

Final

SHAKE RAG MITIGATION SITE

Madison County, NC
DEQ Contract No. 7190
DMS Project No. 100018
USACE Action ID No. SAW-2017-01570
DWR Certification No. 17-1157
RFP# 16-006991 (September 16, 2016)

French Broad River Basin
HUC 06010105

Data Collection Period: January – October 2023
Draft Submission Date: November 30, 2023
Final Submission Date: January 4, 2024

PREPARED FOR:

NC Department of Environmental Quality
Division of Mitigation Services
1652 Mail Service Center
Raleigh, NC 27699-1652

PREPARED BY:

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Phone: 704.332.7754
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January 4, 2024

Mr. Matthew Reid
Western Project Manager
Asheville Regional Office
2090 U.S. 70 Highway
Swannanoa, NC 28778-8211

RE: Draft MY4 Report Review
Shake Rag Mitigation Site, Madison County
French Broad River Basin: 06010105
DMS Project ID No. 100018
DEQ Contract #7190

Dear Mr. Reid:

Wildlands Engineering, Inc. (WEI) has reviewed the Division of Mitigation Services (DMS) comments from the Draft Monitoring Year (MY) 4 report for the Shake Rag Mitigation Site. DMS' comments are noted below in **bold**. Wildlands' responses to those comments are noted in *italics*.

Please ensure the Monitoring Phase Performance Bond has been updated and approved by Kristie Corson before invoicing for Task 10.

Wildlands' response: WEI will ensure that the performance bond has been updated and approved before invoicing.

Recommend adding a short discussion regarding the MY4 IRT site visit that occurred on June 22, 2023. Please note that the meeting minutes are included in Appendix 6.

Wildlands' response: Additional text regarding the MY4 IRT site visit that occurred on June 22, 2023, was added to relevant topics discussed in Section 1.2.4.

DMS appreciates WEI's effort to address the stunted tree growth. Please include updates in MY5 regarding success and lessons learned with the tree booster and "repellex" treatments.

Wildlands' response: WEI will continue to document efforts to address stunted tree growth and provide an update in MY5 regarding the tree booster and "repellex" treatments.

Does WEI have any before/after pics of the UT3 side slope areas of poor growth that received reseeding and compost tea in MY4? Please add this area to the MY4 CCPV.

Wildlands' response: Before/after photos of the UT3 side slope areas have been added to a photolog in Appendix 2. This area of improved herbaceous cover has been added to the MY4 CCPV (Figure 3.2).

Recommend updating replant discussion to state that it was three areas totaling 0.2 acres to coincide with CCPV polygons.

Wildlands' response: Text has been updated in Section 1.2.4.

DMS appreciates the Conservation Easement Boundary Issue Table that was included in the MY4 report. Please include the resolved conservation easement boundary issues on the MY4 CCPV.

Wildlands' response: The resolved conservation easement boundary issues have been added to the MY4 CCPV figures.

Instream vegetation on UT8 was an IRT concern at the 2023 Credit Release Meeting. Can WEI please provide an update on the documented instream vegetation?

Wildlands' response: The observed instream vegetation in UT8 has continued to improve as the woody stems along the banks have become established and begun to shade out the stream. The instream vegetation consisted of native hydrophytic species. WEI will continue to monitor UT8 in MY5.

Electronic Support Files:

The submission is missing all photo points, visual stream assessment tables, and vegetation condition assessment table, please submit with final.

Wildlands' response: The photo points, visual stream assessment tables, and vegetation condition assessment table are included in the final support files.

The visual vegetation table included in the report indicates minor areas of invasives and low stem density requiring spatial submission. Please check the database submitted for corrupted or missing files and re-submit.

Wildlands' response: The areas of invasives and low stem density are included in the GIS support files geodatabase "MY4.gdb" and saved in a feature layer named "VAOC_Polygon".

Note: WEI downloaded gage data at the Site in mid-December 2023, and updated the hydrology plots in the report. The additional data did not change the originally reported hydrology results.

Enclosed please find two (2) hard copies and one (1) electronic copy on USB of the Final Monitoring Report. Please contact me at 828-774-6221 x 107 if you have any questions.

Sincerely,

Mimi Caddell

Mimi Caddell
Environmental Scientist
mcaddell@wildlandseng.com

EXECUTIVE SUMMARY

Wildlands Engineering, Inc. (Wildlands) implemented a full-delivery stream mitigation project at the Shake Rag Mitigation Site (Site) for the North Carolina Department of Environmental Quality (DEQ) Division of Mitigation Services (DMS). The project restored, enhanced, and preserved a total of 9,273 linear feet (LF) of perennial and intermittent stream in Madison County, NC. The Site is located within the DMS targeted watershed for the French Broad River Basin Hydrologic Unit Code (HUC) 06010105110020 and the NC Division of Water Resources (NCDWR) Subbasin 04-03-04. The project is providing 6,655.600 stream mitigation units (SMUs) for the French Broad River Basin HUC 06010105 (French Broad 05).

The watershed has a long history of agricultural activity and most of the stressors to stream functions are related to historic and current land use practices. Prior to construction, the major stream stressors for the Site were livestock trampling and fecal coliform inputs, stream bed incision and bank scour, a lack of stabilizing stream bank and riparian vegetation, and ditching and/or piping from agricultural activities. The effects of these stressors resulted in degraded water quality and habitat throughout the Site's watershed when compared to reference conditions. The project approach for the Site focused on evaluating the Site's existing functional condition, its potential for recovery, and need for intervention.

The project goals defined in the mitigation plan (Wildlands, 2019) were established with careful consideration of 2009 French Broad River Basin Restoration Priorities (RBRP) goals and objectives to address stressors identified in the watershed. The established project goals include:

- Improve stream channel stability,
- Exclude livestock from stream channels,
- Reconstruct channels and flood-prone areas with appropriate geomorphology,
- Improve in-stream habitat,
- Reduce sediment and nutrient input from adjacent cattle pastures and unpaved roads,
- Restore and enhance native riparian and upland vegetation, and
- Permanently protect the Site from harmful uses.

The Site construction and as-built surveys were completed between December 2019 and February 2020. Monitoring Year (MY) 4 data collection and site visits were completed between January and October 2023 to evaluate the current conditions of the project.

The Site is meeting most of the required stream, vegetation, and hydrology success criteria for MY4. While vegetation plots were not assessed this year, the Site is expected to meet the interim MY5 requirement of 260 stems per acre. At least one bankfull event was documented along UT2 Reach 2, UT4, and Shake Rag Branch Reach 5 in MY4. The MY4 visual assessments revealed that treatments have been successful in reducing populations of invasive species on the Site. Stream repairs completed in April 2022 (MY3) continue to function as designed. All documented conservation easement boundary issues or encroachments were resolved in MY4. Wildlands will continue to monitor these areas and adaptive management actions will be implemented as necessary throughout the seven-year monitoring period to sustain the ecological health of the Site.

SHAKE RAG MITIGATION SITE

Monitoring Year 4 Annual Report

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APPENDICES

*Content not required for Monitoring Year 4 Report

Section 1: PROJECT OVERVIEW

The Shake Rag Mitigation Site (Site) is located in Madison County approximately 19 miles north of Asheville and 4 miles northeast of the town of Mars Hill in the French Broad River Basin HUC 06010105110020 and NCDWR Subbasin 04-03-04 (Figure 1). Located in the Blue Ridge belt within the Blue Ridge physiographic province (NCGS, 1985), the project watershed is dominated by agricultural and steep forested land.

The Site encompasses three primary drainage areas including Shake Rag Branch (SRB), UT1, and UT6, all of which are comprised of smaller valleys. All project stream reaches within these drainages originate from steep, forested headwater valleys before transitioning to open pastureland situated in wider valley bottoms further downstream. The valley of Shake Rag Branch begins as a steep, colluvial, V-shaped valley, which gradually widens into a moderately confined alluvial bottom as it moves downstream. UT1A, UT3, UT4, and UT8 have steep valleys with much broader valley bottoms, while UT1, UT2, UT5, UT6, and UT7 flow through steep, colluvial, V-shaped valleys for their entire length in the project area. Shake Rag Branch drains 163 acres, UT1 drains 70 acres, and UT6 drains 43 acres of rural land.

Prior to construction activities, the Site was in hay production in the valley bottom, with cattle grazing along valley side slopes and access to the steeper forested areas. Riparian buffers were absent except in the steepest upper portions of the Site. The streams throughout the Site were in various stages of impairment related to the current and historical agricultural uses. Many of the streams were buried in rock-lined channels or pipes approximately 50 years ago. Pre-construction conditions are outlined in Table 4 of Appendix 1 and Table 11 of Appendix 4.

The final mitigation plan was submitted and accepted by DMS in January of 2019 and the IRT in March of 2019. Construction activities were completed in January 2020 by Baker Grading & Landscaping, Inc. Kee Mapping & Surveying, PLLC. completed the as-built survey in February 2020. Planting was completed following construction in the January 2020 by Bruton Natural Systems, Inc. A conservation easement has been recorded and is in place on 18 acres. The project is providing 6,655.600 SMUs for the French Broad River Basin HUC 06010105 (French Broad 05). Post-construction annual monitoring will be conducted for seven years with close-out anticipated to commence in 2027 given the success criteria are met.

Directions and a map of the Site are provided in Figure 1 and project components are illustrated for the Site in Figure 2.

1.1 Project Goals and Objectives

The Site is providing numerous ecological benefits within the French Broad River Basin. The project goals were established with careful consideration to address stressors that were identified in the RBRP (EEP, 2009).

The following project specific goals and objectives outlined in the mitigation plan (Wildlands, 2019) include:

Goals	Objectives
Improve the stability of stream channels.	Reconstruct stream channels slated for restoration with stable dimensions and appropriate depth relative to the existing flood-prone area. Add bank revetments and in-stream structures to protect restored/enhanced streams.
Exclude livestock from stream channels.	Install livestock fencing and watering systems as needed to exclude livestock from stream channels and riparian areas.
Reconstruct channels and flood prone areas with appropriate geomorphology.	Daylight buried or piped streams, remove man-made impoundments, and restore historic valley profiles. Reconstruct stream channels with bankfull dimensions and construct flood-prone areas consistent with reference reach findings.
Improve instream habitat.	Install habitat features such as cascading riffle-pool sequences, lunker logs, and brush toes on restored reaches. Add woody materials to channel beds. Construct pools of varying depth. Remove online farm pond.
Reduce sediment and nutrient input from adjacent cattle grazing areas and unpaved roads.	Construct one step-pool conveyance BMP to treat contributing 17-acre drainage area that is subject to nutrient and fecal coliform loading from cattle. Relocate unpaved roads outside of riparian corridor. Grade and plant forested buffer with native vegetation.
Restore and enhance native riparian and upland vegetation.	Convert active hay fields and cattle pasture to forested riparian buffers along all Site streams, which will slow and treat runoff from adjacent agriculture before entering streams. Protect and enhance existing forested riparian buffers. Treat invasive species.
Permanently protect the Site from harmful uses.	Establish a conservation easement on the Site. Exclude livestock from Site streams.

1.2 Monitoring Year 4 Data Assessment

Annual monitoring for MY4 was conducted between January and October 2023 to assess the condition of the project. The stream, vegetation, and hydrologic success criteria for the Site follows the approved success criteria presented in the Shake Rag Mitigation Plan (Wildlands, 2019).

1.2.1 Vegetation Assessment

MY4 is a reduced monitoring year that does not require detailed vegetation inventory and analysis. Visual assessments reveal that herbaceous cover is becoming well established and planted bare roots and live stakes appear healthy. Prior years' vegetation plot data has been included in Appendix 3. Please refer to Appendix 2 for visual assessment tables and Current Condition Plan View (CCPV) Figures 3.0-3.4.

1.2.2 Stream Assessment

MY4 is a reduced monitoring year that does not require morphological surveys; therefore, the stream cross-section surveys were not performed this year. Visual assessments reveal that project streams are

functioning as designed. Prior years' morphological summary data and plots has been included in Appendix 4. Refer to Appendix 2 for the visual stability assessment tables, CCPV figures, and reference photographs.

1.2.3 Stream Hydrology Assessment

Automated pressure transducers were installed to document stream hydrology within restoration and/or enhancement level I mitigation reaches throughout the seven-year monitoring period. Henceforth, these devices are referred to as "crest gages (CG)" for those recording bankfull events and "stream gages (SG)" for those recording baseflow. The daily precipitation data was collected from the nearest NC Climate Retrieval and Observations Network of the Southeast Database (NC CRONOS) Station, Mars Hill 6.8 E, NC which is located approximately 5 miles from the Site as the crow flies.

Bankfull Events

At the end of the seven-year monitoring period, four or more bankfull flow events must have occurred in separate years within the restoration reaches. A total of 5 CGs were installed along restoration and enhancement I reaches. The transducers are programmed to record data every 30 minutes due to the steep, flashy nature of the Site. In MY4, all restoration reaches, except for UT1 Reach 2 and UT3 Reach 2, recorded at least one bankfull event that were documented by crest gage data. So far through MY4, UT2 Reach 2 has recorded 4 bankfull events in separate years and has met the bankfull performance standard. The remaining reaches have partially met the performance standard. UT1 Reach 2, UT4, and Shake Rag Branch Reach 5 have recorded 3 bankfull events in separate years, and UT3 Reach 2 has had 1 bankfull event.

Baseflow Monitoring

Consistent flow must be documented in the restored intermittent channel (UT8) at the Site. Under periods of normal rainfall, stream flow must be documented to occur every year for at least 30 consecutive days during the seven-year monitoring period. An automated SG was installed at as-built within the upper third of UT8 to monitor baseflow. On UT8, 353 consecutive days were documented in MY4 indicating that this channel exceeded the success criteria for intermittent channels.

Please refer to Appendix 5 for hydrology summary data and plots.

1.2.4 Adaptive Management Activities

Stream

Stream repairs were completed in April 2022 (MY3) to address localized instances of bed and bank instability and structure piping that were first identified in 2021 (MY2). This year's visual assessment in MY4 revealed that repairs appear to be stable and functioning as designed. Please refer to Appendix 6 for Table 16 summarizing the MY3 repair work locations and their updated status for MY4.

During the MY4 IRT site walk on June 22, 2023, seasonal piping of some in-stream drop structures was discussed during low flow time of the year (typically during the summer and early fall) but is not an issue for overall stream stability. IRT site walk meeting minutes are included in Appendix 6. Other stream areas of minor concern will continue to be monitored in future years for signs of instability. Please refer to Appendix 2 for stream stability tables and CCPV Figures 3.0 – 3.4.

Vegetation

MY4 visual assessments reveal that over 99% of the conservation easement is unaffected by invasive plant populations. Invasive species previously found on the Site included multiflora rose (*Rosa multiflora*), princess tree (*Paulownia tomentosa*), tree of heaven (*Ailanthus altisima*), Chinese silver grass (*Miscanthus sinensis*), wineberry (*Rubus phoenicolasius*), Japanese honeysuckle (*Lonicera japonica*), and Asian bittersweet (*Celastrus orbiculatus*). Invasive species treatments were completed in

the spring and August 2023 with efforts focusing on wineberry, tree of heaven, Asian bitterweet, and scattered clusters of multiflora rose and blackberry (*Rubus sp*.) throughout the Site. These treatments were highly effective in reducing the size and density of invasive species populations within the conservation easement. A few scattered resprouts of tree of heaven exist on site but are well below the mapping threshold; therefore, they are not depicted on the Current Condition Plan View (CCPV) Figures. Additional treatments will continue through closeout as needed to help manage and eliminate remaining invasive species populations on the Site.

During the MY4 IRT site walk on June 22, 2023, the IRT requested that Wildlands continue to document efforts made during the monitoring period to improve stem height and growth. Several efforts have been made in MY4 to address stunted tree growth throughout the Site. In Spring 2023, tree boosters and "repellex" tablets were added to stems to help promote tree growth and as an attempt to deter deer browsing. Additionally, ring sprays were conducted in areas where herbaceous competition was noted to be interfering with stem growth. Previously reported areas of poor herbaceous cover, located on the steep side slopes of UT3 and Shake Rag Branch, have improved after reseeding with a cover crop mix and applying compost tea in MY4. In January and April 2023, approximately 65 trees were supplementally planted in scattered areas totaling approximately 0.2 acres (less than 2% of the planted acreage) across the Site and are depicted on the CCPV figures.

See the table below for the approved planted species and quantities. Vegetation areas of concern are documented on Table 7 and shown on the CCPV Figures 3.0 – 3.4 in Appendix 2.

Supplemental Planting List – January and April 2023				
Scientific Name	**Common Name**	**Size**	**Wetland Indicator Status**	**Quantity**
Betula nigra	River birch	1 and 7-gallon container	FACW	10
Calycanthus floridus	Sweet shrub	1-gallon container	FACU	5
Carpinus caroliniana	Ironwood	1-gallon container	FAC	3
Diospyros virginiana	Persimmon	1-gallon container	FAC	15
Liriodendron tulipifera	Tulip poplar	7-gallon container	FACU	5
Nyssa sylvatica	Black gum	7-gallon container	FAC	5
Platanus occidentalis	Sycamore	1-gallon container	FACW	10
Physocarpus opulifolius	Ninebark	1-gallon container	FACW	2
Quercus alba	White oak	Bare root	FACU	10

Conservation Easement

In MY4, Wildlands inspected the conservation easement in its entirety with the unfenced boundary walked numerous times to ensure compliance. All boundary issues discovered during site walks have been resolved and consisted of fallen trees on the fence line and a few small encroachments such as scalloped mowing and adjacent farm road/waterline maintenance. Supplemental planting was only needed in one encroachment area along UT4; all other mowing encroachments were very narrow (less than 3 feet into the easement). As a preemptive action, signposts were also added to the left boundary along Shake Rag Branch Reach 5 to clarify the easement line. Additionally, there was one isolated occurrence of cows found in the easement, but it was quickly rectified. Though some herbivory was noted, no permanent damage to the vegetation was observed. During the MY4 IRT site walk, DMS requested that Wildlands continue to document issues and landowner discussions regarding easement

compliance. Refer to the table below for the encroachment type, description, management action, and status. Representative photos of the resolved easement boundary issues are included in Appendix 2.

MY4 (2023) Conservation Easement Boundary Issues			
Issue Location	**Issue Description**	**MY4 Management Action**	**Current Status**
UT6 right boundary near STA 604+00	Fallen trees on fence discovered in winter 2023.	Trees removed from fence (winter 2023). Fence wire repaired (June 2023)	Resolved
UT3 upper boundary above STA 300+00	Fallen trees on fence discovered in spring 2023.	Trees removed from fence (June 2023). Fence wire repaired (October 2023).	Resolved
UT4 right boundary near STA 404+75	Encroachment discovered related to adjacent farm road and water line maintenance in winter 2023.	Conversations with landowner clarifying easement boundary restrictions. Subsequently, the pipe was removed (winter – spring 2023). Reseeding and a few container trees added to the disturbed area (April 2023).	Resolved
UT4 left boundary above crossing	Previously reported in MY3 (October 2022). Slight scalloped mowing in easement.	Additional posts added along boundary (fall 2022, March 2023). Landowner communication (winter – spring 2023).	Resolved
Corners at crossings along UT4, Shake Rag Branch Reach 5	Previously reported in MY3 (October 2022). Landowner cut across corners near some crossings while mowing.	Landowner communication (winter – spring 2023).	Resolved
UT1 Reach 2 & UT2 Reach 2 below crossings	Cows briefly in the easement due to a gate that was left open (October 2023).	Cows removed from easement and gate securely fastened (October 2023). No permanent damage to vegetation.	Resolved

1.3 Monitoring Year 4 Summary

The Site is meeting most of the required stream, vegetation, and hydrology success criteria for MY4. While vegetation plots were not assessed this year, the Site is expected to meet the interim MY5 requirement of 260 stems per acre. At least one bankfull event was documented along UT2 Reach 2, UT4, and Shake Rag Branch Reach 5 in MY4. The MY4 visual assessments revealed that treatments have been successful in reducing populations of invasive species on the Site. Stream repairs completed in April 2022 (MY3) continue to function as designed. All documented conservation easement boundary issues or encroachments were resolved in MY4. Wildlands will continue to monitor these areas and adaptive management actions will be implemented as necessary throughout the seven-year monitoring period to sustain the ecological health of the Site.

Section 2: METHODOLOGY

Geomorphic data were collected following the standards outlined in The Stream Channel Reference Site: An Illustrated Guide to Field Techniques (Harrelson et al., 1994) and in the Stream Restoration: A Natural Channel Design Handbook (Doll et al., 2003). All Integrated Current Condition Mapping was recorded using a Trimble handheld GPS with sub-meter accuracy and processed using Pathfinder and ArcGIS. Stream gages were installed in riffles and monitored quarterly. Hydrologic monitoring instrument installation and monitoring methods are in accordance with the United States Army Corps of Engineers (USACE, 2003) standards. Vegetation monitoring protocols followed the Carolina Vegetation Survey-EEP Level 2 Protocol (Lee et al., 2008).

Section 3: REFERENCES

Doll, B.A., Grabow, G.L., Hall, K.A., Halley, J., Harman, W.A., Jennings, G.D., and Wise, D.E. 2003. Stream Restoration A Natural Channel Design Handbook.

Harrelson, Cheryl C; Rawlins, C.L.; Potyondy, John P. 1994. *Stream Channel Reference Sites: An Illustrated Guide to Field Technique.* Gen. Tech. Rep. RM-245. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 61 p.

Lee, Michael T., Peet, Robert K., Steven D., Wentworth, Thomas R. 2008. CVS-EEP Protocol for Recording Vegetation Version 4.2. Retrieved from: http://cvs.bio.unc.edu/protocol/cvs-eep-protocol-v4.2-lev1-2.pdf

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North Carolina Division of Mitigation Services (DMS), June 2017. DMS Stream and Wetland Mitigation Plan Template and Guidance.

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Rosgen, D. L. 1994. A classification of natural rivers. *Catena* 22:169-199.

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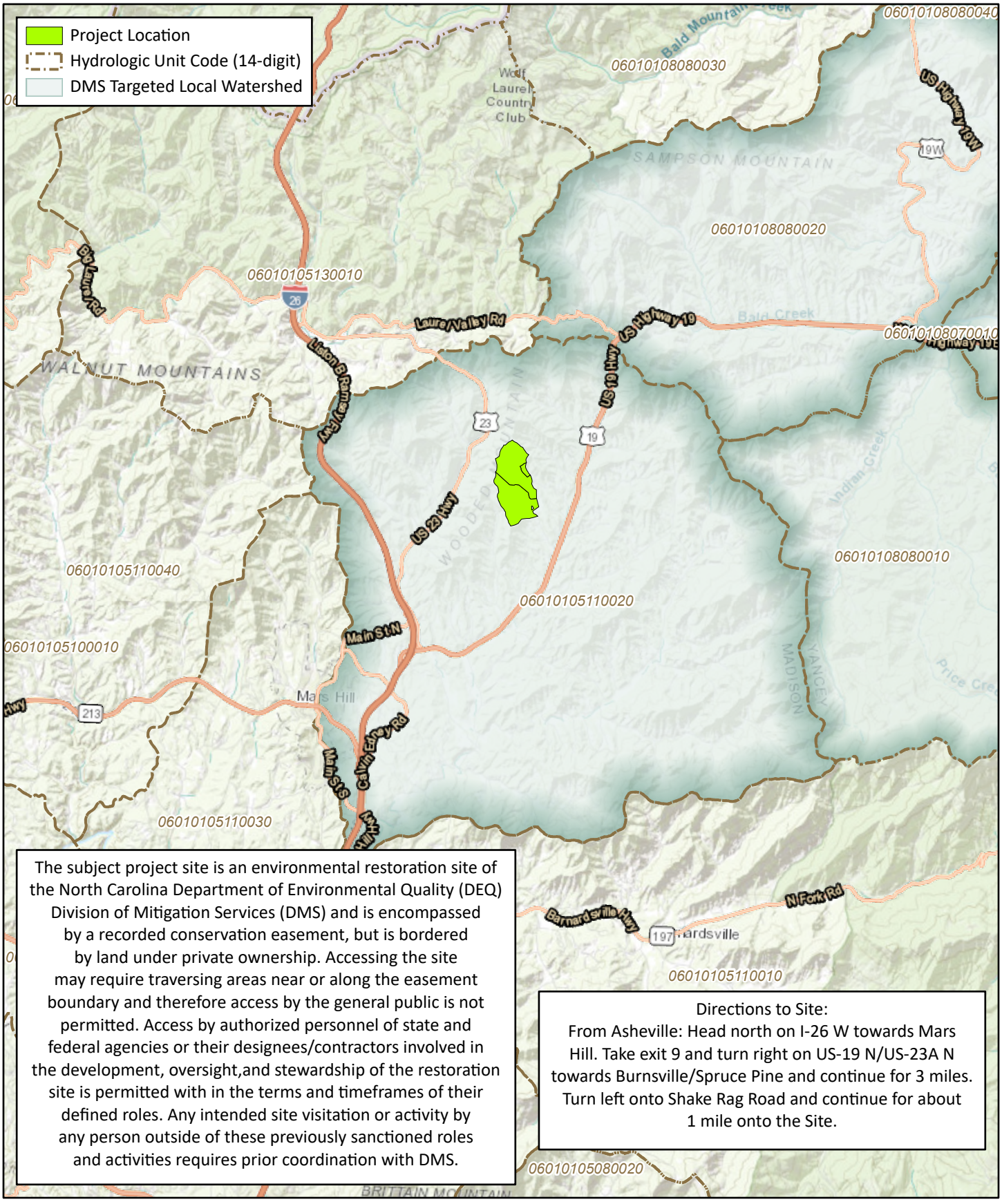
Wildlands Engineering, Inc (Wildlands), 2022. Shake Rag Mitigation Site Monitoring Year 2 Annual Report. DMS, Raleigh, NC.

Wildlands Engineering, Inc (Wildlands), 2020. Shake Rag Mitigation Site As-Built Baseline Monitoring Report. DMS, Raleigh, NC.

Wildlands Engineering, Inc (Wildlands), 2019. Shake Rag Mitigation Site Mitigation Plan. DMS, Raleigh, NC.

APPENDIX 1. General Figures and Tables



The subject project site is an environmental restoration site of the North Carolina Department of Environmental Quality (DEQ) Division of Mitigation Services (DMS) and is encompassed by a recorded conservation easement, but is bordered by land under private ownership. Accessing the site may require traversing areas near or along the easement boundary and therefore access by the general public is not permitted. Access by authorized personnel of state and federal agencies or their designees/contractors involved in the development, oversight,and stewardship of the restoration site is permitted with in the terms and timeframes of their defined roles. Any intended site visitation or activity by any person outside of these previously sanctioned roles and activities requires prior coordination with DMS.

Directions to Site:
From Asheville: Head north on I-26 W towards Mars Hill. Take exit 9 and turn right on US-19 N/US-23A N towards Burnsville/Spruce Pine and continue for 3 miles. Turn left onto Shake Rag Road and continue for about 1 mile onto the Site.

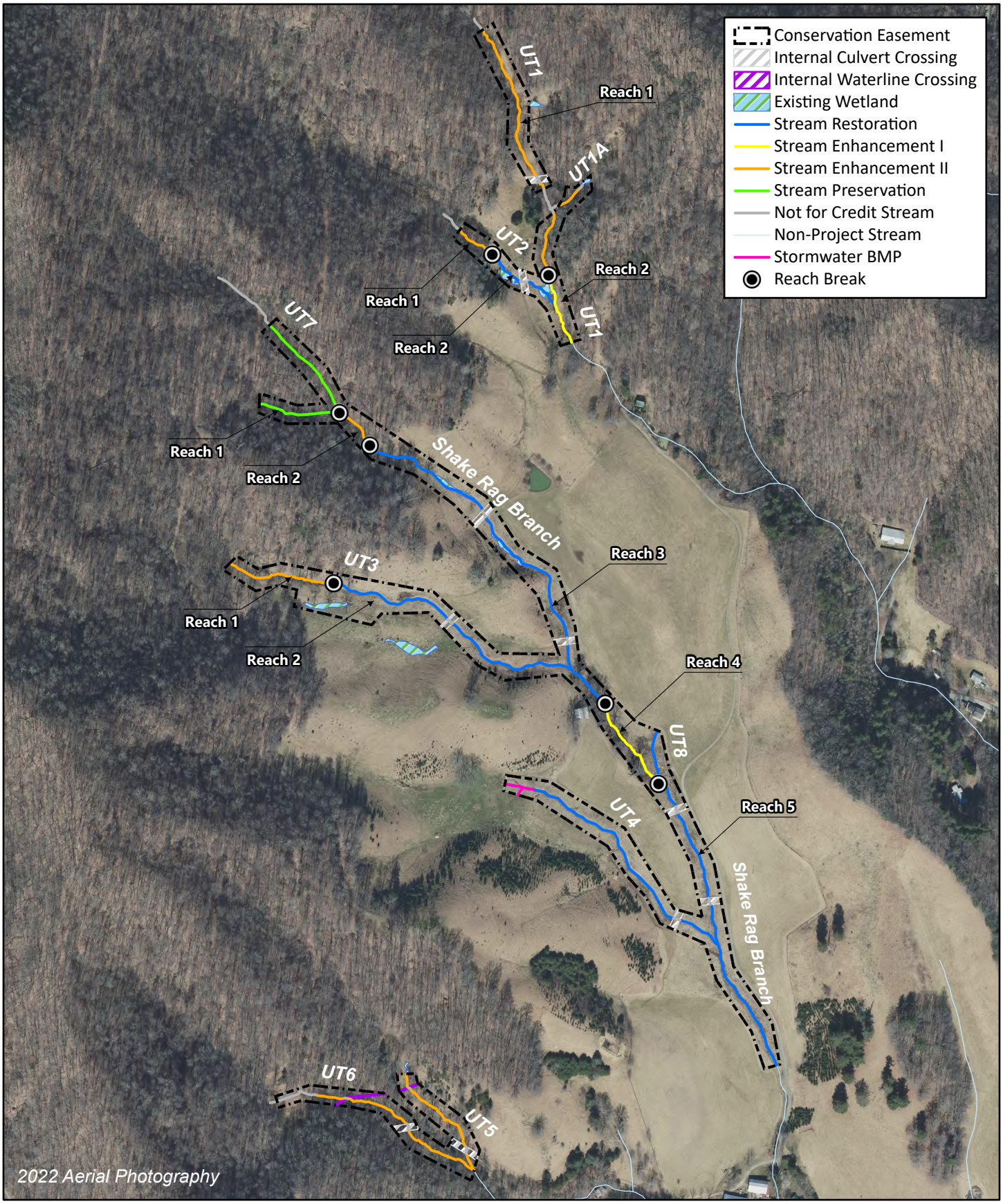
WILDLANDS ENGINEERING

0 1 2 Miles

N

Figure 1 Project Vicinity Map
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Madison County, NC



WILDLANDS ENGINEERING

0 250 500 Feet

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Figure 2 Project Component/Asset Map
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Madison County, NC

Table 1. Mitigation Assets and Components

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Project Components								
Project Area/Reach	**Existing Footage (LF) or Acreage[1]**	**Mitigation Plan Footage/ Acreage**	**Mitigation Category**	**Restoration Level**	**Priority Level**	**Mitigation Ratio (X:1)**	**As-Built Footage/ Acreage[2]**	**Comments**
Shake Rag Branch R1	312	312	Cold	Preservation	N/A	10.000	312	N/A
Shake Rag Branch R2	175	175	Cold	Enhancement II	N/A	2.500	175	N/A
Shake Rag Branch R3	1,451	1,393	Cold	Restoration	P1	1.000	1,391	N/A
Shake Rag Branch R4	385	385	Cold	Enhancement I	N/A	1.500	385	N/A
Shake Rag Branch R5	1,216	1,134	Cold	Restoration	P1, P2	1.000	1,134	N/A
UT1 R1	934	907	Cold	Enhancement II	N/A	2.500	907	N/A
UT1 R2	255	278	Cold	Enhancement I	N/A	1.500	278	N/A
UT1A	100	100	Cold	Enhancement II	N/A	2.500	100	N/A
UT2 R1	164	164	Cold	Enhancement II	N/A	2.500	164	N/A
UT2 R2	296	304	Cold	Restoration	P1	1.000	304	N/A
UT3 R1	426	426	Cold	Enhancement II	N/A	2.500	426	N/A
UT3 R2	1,387	1,019	Cold	Restoration	P1	1.000	1,019	N/A
UT4	910	930	Cold	Restoration	P1	1.000	930	N/A
UT5	483	439	Cold	Enhancement II	N/A	2.500	444	N/A
UT6	707	673	Cold	Enhancement II	N/A	2.500	670	N/A
UT7	428	428	Cold	Preservation	N/A	10.000	428	N/A
UT8	210	206	Cold	Restoration	P1	1.000	206	N/A

Project Credits							
Restoration Level	**Stream**			**Riparian Wetland**		**Non-Riparian Wetland**	**Coastal Marsh**
	Warm	**Cool**	**Cold**	**Riverine**	**Non-Riv**		
Restoration	N/A	N/A	4,986.000	N/A	N/A	N/A	N/A
Re-establishment				N/A	N/A	N/A	N/A
Rehabilitation				N/A	N/A	N/A	N/A
Enhancement				N/A	N/A	N/A	N/A
Enhancement I	N/A	N/A	442.000				
Enhancement II	N/A	N/A	1,153.600				
Creation				N/A	N/A	N/A	N/A
Preservation	N/A	N/A	74.000	N/A	N/A	N/A	
Totals	**N/A**	**N/A**	**6,655.600**	**N/A**	**N/A**	**N/A**	**N/A**

Notes:

1. Some or all of SRB Reach 3, UT3 Reach 2, UT4, and UT8 were previously buried in rock-lined channels or pipes. Reported exiting lengths are estimates based upon land owner communication, remote sensing, and field verification to approximate the subsurface location and alignment.

2. The Site contains 12 internal easement crossings. This value excludes the affected length of proposed stream centerline within each crossing.

Table 2. Project Activity and Reporting History

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Activity or Report		Data Collection Complete	Completion or Delivery
Institution Date		N/A	May 2017
404 Permit		June 2019	June 2019
Mitigation Plan		February - October 2018	March 2019
Final Design - Construction Plans		June 2019	June 2019
Construction		July 2019 - January 2020	January 2020
Bare root and live stake plantings for reach/segments		December 2020	December 2020
Baseline Monitoring Document (Year 0)		December 2019 - March 2020	April 2020
Stream Repair/Maintenance		Spring 2020 & November 2020	November 2020
Year 1 Monitoring	Stream Survey	October 2020	November 2020
	Vegetation Survey	October 2020	
Invasive Species Treatment		June 2021	June 2021
Year 2 Monitoring	Stream Survey	June 2021	November 2021
	Vegetation Survey	August 2021	
Stream Repair/Maintenance		April 2022	April 2022
Invasive Species Treatment		March, September 2022	September 2022
Conservation Easement Boundary Maintenance		October 2022	October 2022
Year 3 Monitoring	Stream Survey	May 2022	November 2022
	Vegetation Survey	August 2022	
Invasive Species Treatment		Spring 2023 & August 2023	August 2023
Conservation Easement Boundary Maintenance		April, June, October 2023	October 2023
Supplemental soil amendments, seeding, and container tree planting		January, April, May, August 2023	August 2023
Year 4 Monitoring	Stream Survey	N/A	November 2023
	Vegetation Survey	N/A	
Year 5 Monitoring	Stream Survey		
	Vegetation Survey		
Year 6 Monitoring	Stream Survey		
	Vegetation Survey		
Year 7 Monitoring	Stream Survey		
	Vegetation Survey		

Table 3. Project Contact Table

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Designers Jake McLean, PE, CFM	**Wildlands Engineering, Inc.** 1430 South Mint Street, Suite 104 Charlotte, NC 28203 704.332.7754
Construction Contractors	**Baker Grading & Landscaping, Inc.** 1000 Bat Cave Road Old Fort, NC 28762
Planting Contractor	**Bruton Natural Systems, Inc.** PO Box 1197 Freemont, NC 27830
Seeding Contractor	**Baker Grading & Landscaping, Inc.**
Seed Mix Sources	**Baker Grading & Landscaping, Inc.**
Nursery Stock Suppliers Bare Roots Live Stakes Herbaceous Plugs	**Bruton Natural Systems, Inc.**
Monitoring Performers Monitoring, POC	**Wildlands Engineering, Inc.** Mimi Caddell 704.332.7754

Table 4. Project Information and Attributes
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Project Information	
Project Name	Shake Rag Mitigation Site
	Madison County
Project Area (acres)	18.000
Project Coordinates (latitude and longitude)	35° 52' 41"N 82° 29' 47"W
Planted Acreage (Acre of Woody Stems Planted)	9.5
Project Watershed Summary Information	
Physiographic Province	Blue Ridge
River Basin	French Broad
USGS Hydrologic Unit 8-digit	06010105
USGS Hydrologic Unit 14-digit	06010105110020
DWR Sub-basin	04-03-04
Project Drainage Area (acres)	70 (UT1), 163 (Shake Rag Branch), 43 (UT6)
Project Drainage Area Percentage of Impervious Area	<1% (UT1), <1% (Shake Rag Branch), <1% (UT6)
2011 NLCD Land Use Classification	UT1: Forest (95%),Pasture/Hay (5%), Shrubland (0%), Urban (0%) Shake Rag Branch: Forest (49%), Pasture/Hay (49%), Shrubland (1%), Urban (1%) UT6: Forest (99%), Pasture/Hay (1%), Shrubland (0%), Urban (0%)

Reach Summary Information

Parameters	Shake Rag Branch					UT3		UT4	UT7	UT8
	R1	R2	R3	R4	R5	R1	R2			
Length of reach (linear feet) - Post-Restoration	312	175	1,391	385	1,134	426	1,019	930	428	206
Valley confinement (Confined, moderately confined, unconfined)	Confined	Moderately confined				Confined	Confined	N/A	Confined	N/A
Drainage area (acres)	10	26	76	77	163	12	38	32	13	19
Perennial, Intermittent, Ephemeral	P	P	P	P	P	P	P	P	P	P
NCDWR Water Quality Classification	WS-II; HQW									
Morphological Description (stream type) - Pre-Restoration	-	A4a+	A4a+	A4/B4a	A4	A4a+/B4a	A4a+	-	-	-
Morphological Description (stream type) - Post-Restoration	-	A4a+	A4a+/B4a	A4/B4a	A4/B4a	A4a+/B4a	A4a+/B4a	A4a+/B4a	-	A4/B4a
Evolutionary trend (Simon's Model) - Pre- Restoration	I	VI	II/III	V/VI	III/IV/V	VI	II/III/IV	II	I	II
FEMA classification	None									

Parameters	UT1		UT1A	UT2		UT5	UT6
	R1	R2		R1	R2		
Length of reach (linear feet) - Post-Restoration	907	278	100	164	304	444	670
Valley confinement (Confined, moderately confined, unconfined)	Confined	Moderately confined	Confined	Moderately Confined	Confined	Moderately confined	Moderately confined
Drainage area (acres)	38	70	6	29	31	18	25
Perennial, Intermittent, Ephemeral	P	P	P	P	P	P	P
NCDWR Water Quality Classification	WS-II; HQW						
Morphological Description (stream type) - Pre-Restoration	A4a+	A4a+	A4a+	A4a+/B4a	A4a+	B4a	B4a
Morphological Description (stream type) - Post-Restoration	A4a+	A4a+/B4a	A4a+	A4a+/B4a	A4a+/B4a	B4a	B4a
Evolutionary trend (Simon's Model) - Pre- Restoration	VI	V/VI	I	VI	II/III	VI	VI
FEMA classification	None						

Regulatory Considerations

Regulation	Applicable?	Resolved?	Supporting Documentation
Waters of the United States - Section 404	Yes	Yes	USACE Action ID# SAW-2017-00100
Waters of the United States - Section 401	Yes	Yes	DWR# 17-1157
Division of Land Quality (Erosion and Sediment Control)	Yes	Yes	NPDES Construction Stormwater General Permit NCG010000
Endangered Species Act	Yes	Yes	Categorical Exclusion Document in Mitigation Plan
Historic Preservation Act	Yes	Yes	Categorical Exclusion Document in Mitigation Plan
Coastal Zone Management Act (CZMA)/Coastal Area Management Act (CAMA)	No	N/A	N/A
FEMA Floodplain Compliance	No	N/A	N/A
Essential Fisheries Habitat	No	N/A	N/A

Table 5a. Monitoring Component Summary

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Shake Rag Branch, UT3, UT4, UT8, and UT7

Parameter	Monitoring Feature	Quantity / Length by Reach										Frequency	Notes
		Shake Rag Reach 1	Shake Rag Reach 2	Shake Rag Reach 3	Shake Rag Reach 4	Shake Rag Reach 5	UT3 Reach 1	UT3 Reach 2	UT4	UT8	UT7		
Dimension	Riffle Cross-Section	N/A	N/A	2	1	1	N/A	1	1	1	N/A	Year 1, 2, 3, 5, and 7	1
	Pool Cross-Section	N/A	N/A	1	0	1	N/A	1	1	0	N/A		
Pattern	Pattern	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2
Profile	Longitudinal Profile	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Substrate	Reach Wide (RW) Pebble Count	N/A	N/A	1 RW	1 RW	1 RW	N/A	1 RW	1 RW	1 RW	N/A	N/A	3
Hydrology	Crest Gage (CG) and or/Stream Gage (SG)	N/A	N/A	1 CG			N/A	1 CG	1 CG	1 SG	N/A	Semi-Annual	4
Vegetation	CVS Level 2/Mobile plots	N/A	7 (4 permanent, 3 mobile)								N/A	Year 1, 2, 3, 5, and 7	5
Visual Assessment		Yes										Semi-Annual	
Exotic and Nuisance Vegetation												Semi-Annual	6
Project Boundary												Semi-Annual	7
Reference Photos	Photographs	21										Annual	

Notes:

1. Cross-sections were permanently marked with rebar to establish location. Surveys include points measured at all breaks in slope, including top of bank, bankfull, edge of water, and thalweg.

2. Pattern and profile will be assessed visually during semi-annual site visits. Longitudinal profile was collected during as-built baseline monitoring survey only, unless observations indicate widespread lack of vertical stability (greater than 10% of reach is affected) and profile survey is warranted in additional years to monitor adjustments or survey repair work.

3. Riffle 100-count substrate sampling were collected during the baseline monitoring only. A reachwide pebble count will be performed on each restoration or enhancement I reach during during the baseline monitoring only.

4. Crest gages and/or stream gages will be inspected and downloaded quarterly or semi-annually, evidence of bankfull events will be documented with a photo when possible. Transducers, if used, will be set to record stage once every 2 hours. The proposed gage on UT8 will be used for the sole purpose of documenting consecutive flow - an alternative proven method (e.g. game camera) may be used if agreed by IRT to be sufficient to demonstrate this requirement.

5. Both mobile and permanent vegetation plots will be utilized to evaluate the vegetation performance for 2% of the open areas planted acreage. Permanent vegetation monitoring plot assessments will follow CVS Level 2 protocols. Mobile vegetation monitoring plot assessments will document number of planted stems and species using a circular or 100 m2 square/rectangular plot. Planted shaded areas will be visually assessed.

6. Locations of exotic and nuisance vegetation will be mapped.
7. Locations of vegetation damage, boundary encroachments, etc. will be mapped.

Table 5b. Monitoring Component Summary

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

UT1, UT1A, UT2, UT5, and UT6

Parameter	Monitoring Feature	Quantity / Length by Reach							Frequency	Notes
		UT1 Reach 1	UT1 Reach 2	UT1A	UT2 Reach 1	UT2 Reach 2	UT5	UT6		
Dimension	Riffle Cross-Section	N/A	1	N/A	N/A	1	N/A	N/A	Year 1, 2, 3, 5, and 7	1
	Pool Cross-Section	N/A	0	N/A	N/A	0	N/A	N/A		
Pattern	Pattern	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2
Profile	Longitudinal Profile	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Substrate	Reach Wide (RW) Pebble Count	N/A	1 RW	N/A	N/A	1 RW	N/A	N/A	N/A	3
Stream Hydrology	Crest Gage (CG) and/or Stream Gage (SG)	N/A	1 CG	N/A	N/A	1 CG	N/A	N/A	Semi-Annual	4
Vegetation	CVS Level 2/Mobile Plots	2 (1 permanent, 1 mobile)					N/A	N/A	Year 1, 2, 3, 5, and 7	5
Visual Assessment		Yes							Semi-Annual	
Exotic and Nuisance Vegetation									Semi-Annual	6
Project Boundary									Semi-Annual	7
Reference Photos	Photographs	9							Annual	

Notes:

1. Cross-sections were permanently marked with rebar to establish location. Surveys include points measured at all breaks in slope, including top of bank, bankfull, edge of water, and thalweg.

2. Pattern and profile will be assessed visually during semi-annual site visits. Longitudinal profile was collected during as-built baseline monitoring survey only, unless observations indicate widespread lack of vertical stability (greater than 10% of reach is affected) and profile survey is warranted in additional years to monitor adjustments or survey repair work.

3. Riffle 100-count substrate sampling were collected during the baseline monitoring only. A reachwide pebble count will be performed on each restoration or enhancement I reach during the baseline monitoring only.

4. Crest gages and/or stream gages will be inspected and downloaded quarterly or semi-annually, evidence of bankfull events will be documented with a photo when possible. Transducers, if used, will be set to record stage once every 2 hours. The proposed gage on UT8 will be used for the sole purpose of documenting consecutive flow - an alternative proven method (e.g. game camera) may be used if agreed by IRT to be sufficient to demonstrate this requirement.

5. Both mobile and permanent vegetation plots will be utilized to evaluate the vegetation performance for 2% of the open areas planted acreage. Permanent vegetation monitoring plot assessments will follow CVS Level 2 protocols. Mobile vegetation monitoring plot assessments will document number of planted stems and species using a circular or 100 m2 square/rectangular plot. Planted shaded areas will be visually assessed with permanent vegetation photo points along UT5 and UT6.

6. Locations of exotic and nuisance vegetation will be mapped.

7. Locations of vegetation damage, boundary encroachments, etc. will be mapped.

APPENDIX 2. Visual Assessment Data

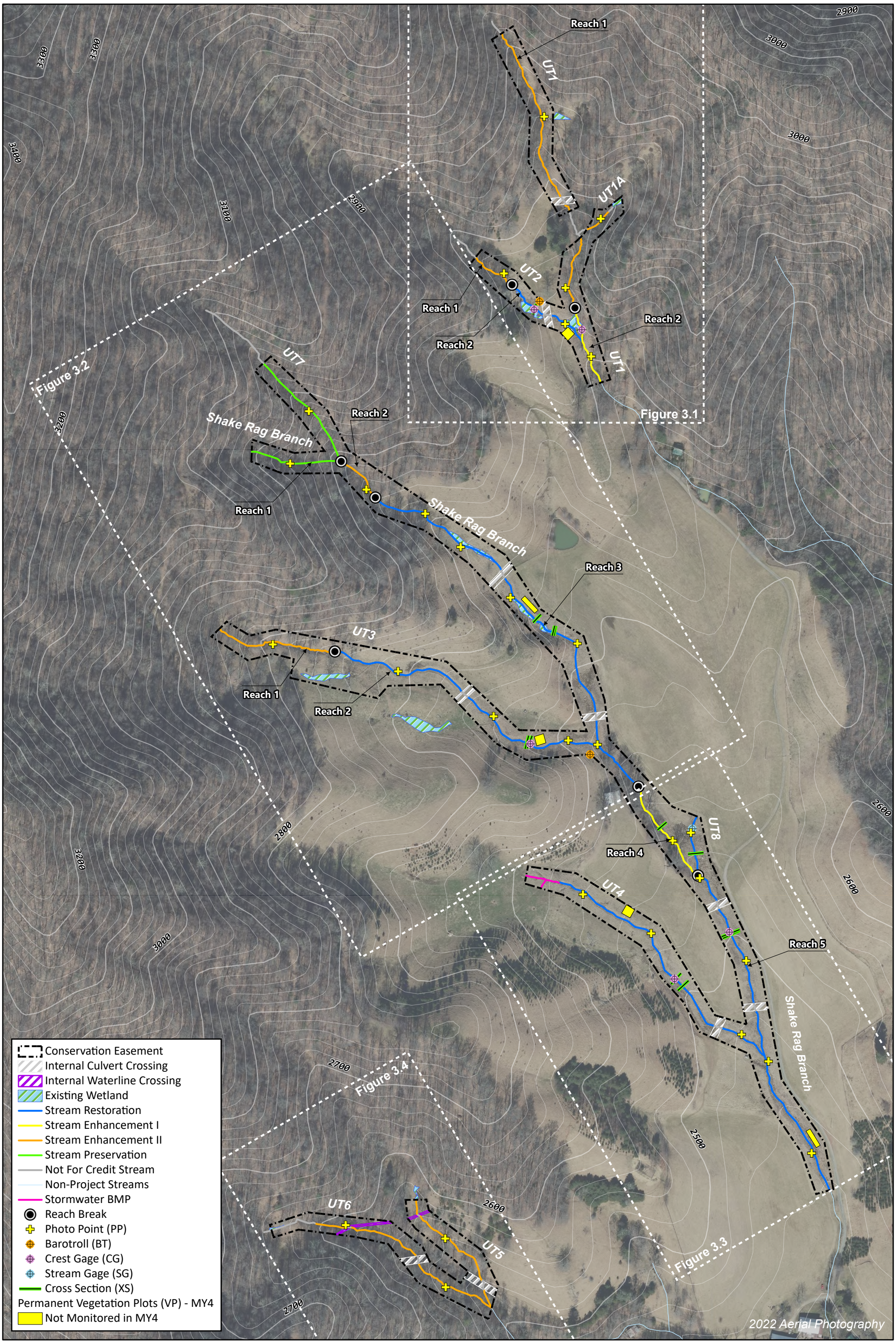
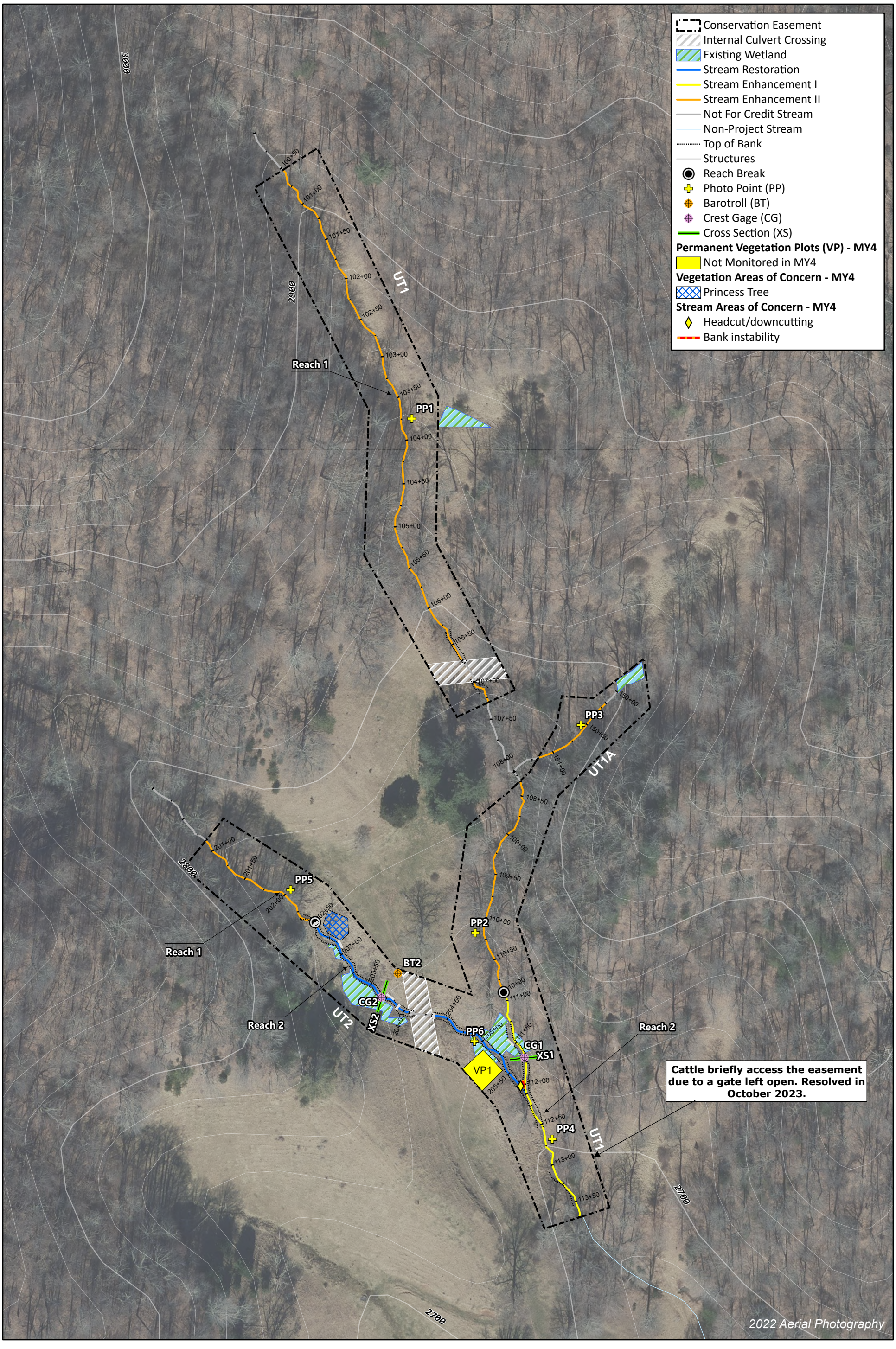


Figure 3.0 Current Condition Plan View Map (Key)
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Madison County, NC



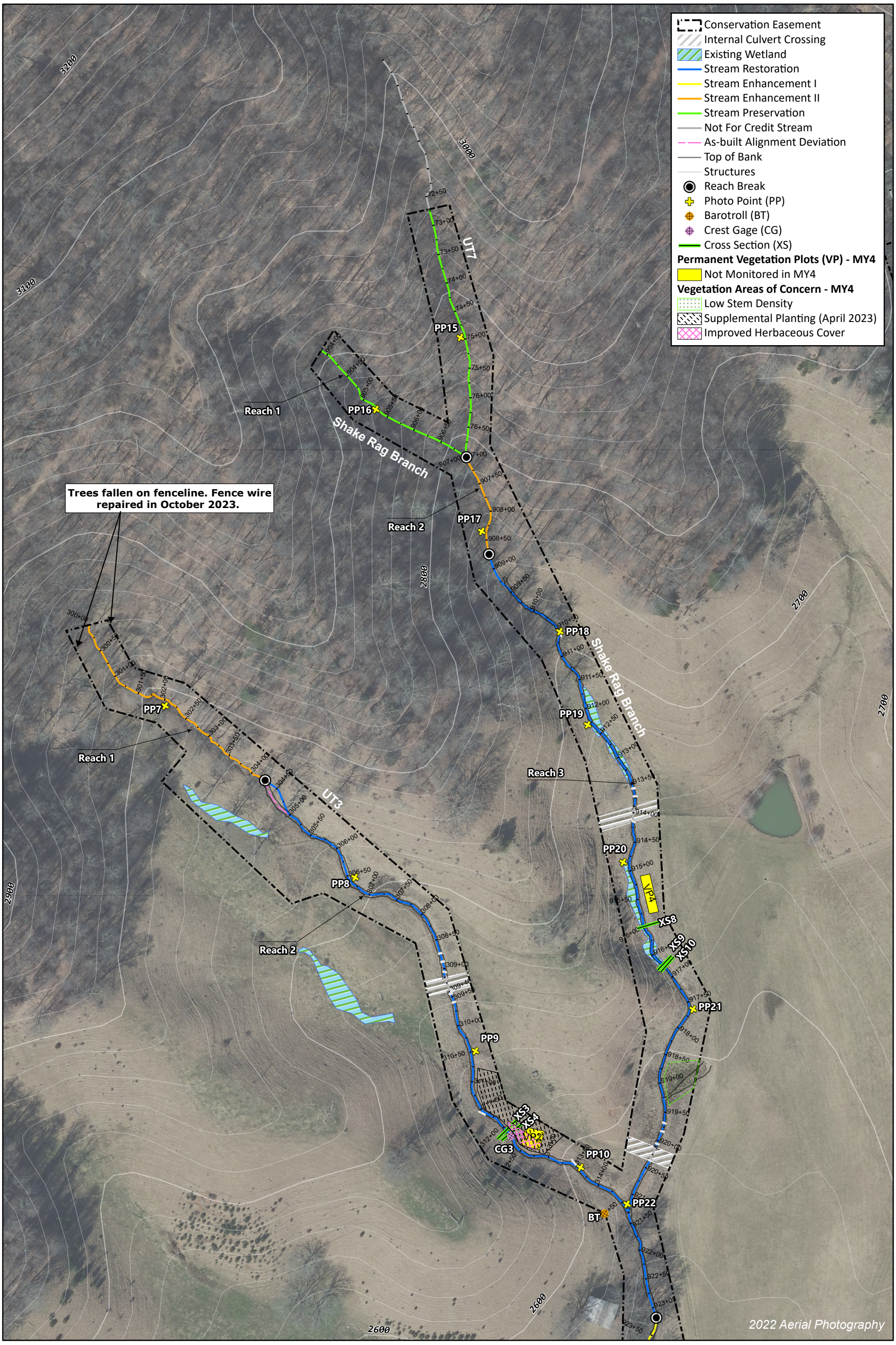
WILDLANDS ENGINEERING

0 100 200 Feet

N

Figure 3.1 Monitoring Plan View Map
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Madison County, NC

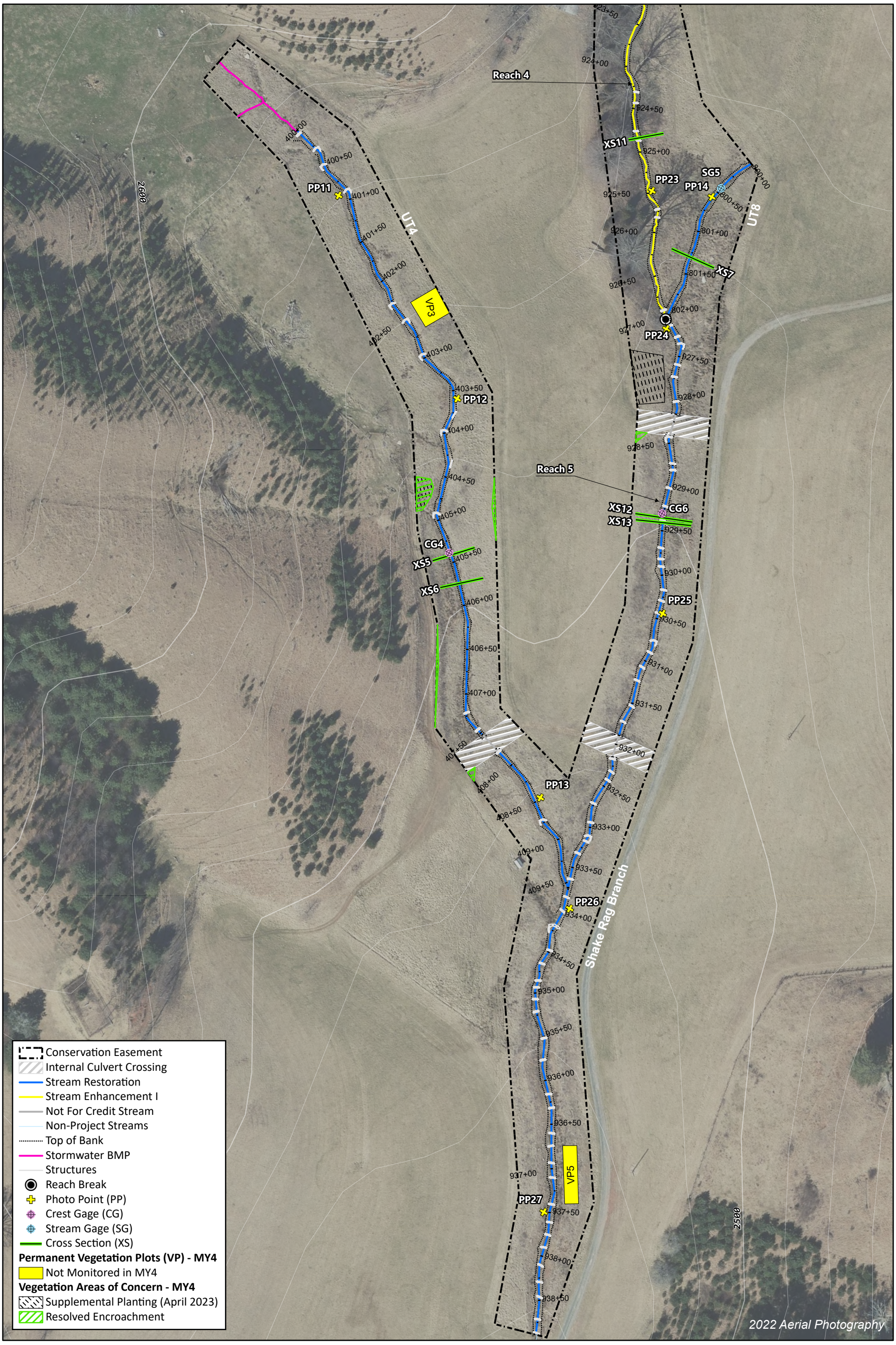


WILDLANDS ENGINEERING

0 150 300 Feet

Figure 3.2 Monitoring Plan View Map
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Madison County, NC

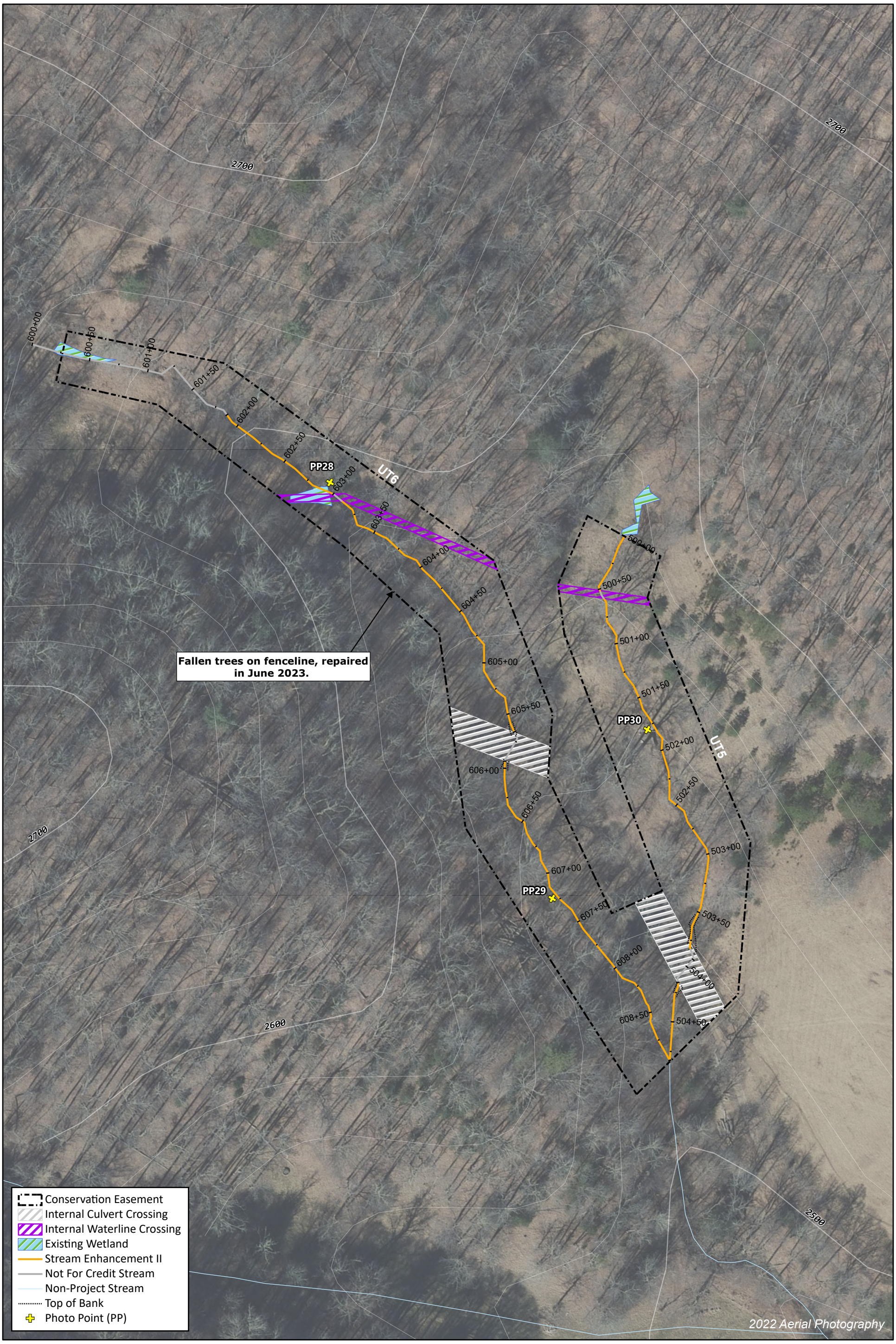


WILDLANDS ENGINEERING

0 100 200 Feet

Figure 3.3 Monitoring Plan View Map
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Madison County, NC



WILDLANDS ENGINEERING

0 75 150 Feet

Figure 3.4 Monitoring Plan View Map
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Madison County, NC

Table 6a. Visual Stream Morphology Stability Assessment Table

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Date of Last Visual Assessment: October 2023
Reach: UT1 Reach 2
Assessed Length: 278

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-Built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjust % for Stabilizing Woody Vegetation
1. Bed[1]	1. Vertical Stability (Riffle and Run units)	Aggradation			0	0	100%			
		Degradation			0	0	100%			
	2. Riffle Condition	Texture/Substrate	1	1			100%			
	3. Step Pool Condition	Depth Sufficient	0	0			N/A			
		Length Appropriate	0	0			N/A			
	4. Thalweg Position	Thalweg centering at upstream of meander bend (Run)	N/A	N/A			N/A			
		Thalweg centering at downstream of meander bend (Glide)	N/A	N/A			N/A			
2. Bank	1. Scoured/Eroded	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			1	10	98%	0	0	98%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	1	10	98%	0	0	98%
3. Engineered Structures[1]	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	2	2			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill	1	1			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	1	1			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%.	2	2			100%			
	4. Habitat	Pool forming structures maintaining ~Max Pool Depth : Bankfull Depth ≥ 1.6 Rootwads/logs providing some cover at baseflow.	1	1			100%			

[1]Cascading riffle sections evaluated as one riffle under the bed category and as one grade control under the engineered structures category.

Table 6b. Visual Stream Morphology Stability Assessment Table

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Date of Last Visual Assessment: October 2023
Reach: UT2 Reach 2
Assessed Length: 304

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-Built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjust % for Stabilizing Woody Vegetation
1. Bed[1]	1. Vertical Stability (Riffle and Run units)	Aggradation			0	0	100%			
		Degradation			0	0	100%			
	2. Riffle Condition	Texture/Substrate	2	2			100%			
	3. Step Pool Condition	Depth Sufficient	2	2			100%			
		Length Appropriate	2	2			100%			
	4. Thalweg Position	Thalweg centering at upstream of meander bend (Run)	N/A	N/A			N/A			
		Thalweg centering at downstream of meander bend (Glide)	N/A	N/A			N/A			
2. Bank	1. Scoured/Eroded	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures[1]	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	6	6			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill	4	4			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	4	4			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%.	6	6			100%			
	4. Habitat	Pool forming structures maintaining ~Max Pool Depth : Bankfull Depth ≥ 1.6 Rootwads/logs providing some cover at baseflow.	4	4			100%			

[1]Cascading riffle sections evaluated as one riffle under the bed category and as one grade control under the engineered structures category.

Table 6c. Visual Stream Morphology Stability Assessment Table

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Date of Last Visual Assessment: October 2023
Reach: UT3 Reach 2
Assessed Length: 1,019

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-Built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjust % for Stabilizing Woody Vegetation
1. Bed[1]	1. Vertical Stability (Riffle and Run units)	Aggradation			0	0	100%			
		Degradation			0	0	100%			
	2. Riffle Condition	Texture/Substrate	2	2			100%			
	3. Step Pool Condition	Depth Sufficient	5	5			100%			
		Length Appropriate	5	5			100%			
	4. Thalweg Position	Thalweg centering at upstream of meander bend (Run)	N/A	N/A			N/A			
		Thalweg centering at downstream of meander bend (Glide)	N/A	N/A			N/A			
2. Bank	1. Scoured/Eroded	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures[1]	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	9	9			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill	7	7			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	7	7			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%.	9	9			100%			
	4. Habitat	Pool forming structures maintaining ~Max Pool Depth : Bankfull Depth ≥ 1.6 Rootwads/logs providing some cover at baseflow.	7	7			100%			

[1]Cascading riffle sections evaluated as one riffle under the bed category and as one grade control under the engineered structures category.

Table 6d. Visual Stream Morphology Stability Assessment Table

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Date of Last Visual Assessment: October 2023
Reach: UT4
Assessed Length: 930

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-Built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjust % for Stabilizing Woody Vegetation
1. Bed[1]	1. Vertical Stability (Riffle and Run units)	Aggradation			0	0	100%			
		Degradation			0	0	100%			
	2. Riffle Condition	Texture/Substrate	3	3			100%			
	3. Step Pool Condition	Depth Sufficient	13	13			100%			
		Length Appropriate	13	13			100%			
	4. Thalweg Position	Thalweg centering at upstream of meander bend (Run)	N/A	N/A			N/A			
		Thalweg centering at downstream of meander bend (Glide)	N/A	N/A			N/A			
2. Bank	1. Scoured/Eroded	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures[1]	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	18	18			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill	16	16			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	16	16			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%.	18	18			100%			
	4. Habitat	Pool forming structures maintaining ~Max Pool Depth : Bankfull Depth ≥ 1.6 Rootwads/logs providing some cover at baseflow.	15	15			100%			

[1]Cascading riffle sections evaluated as one riffle under the bed category and as one grade control under the engineered structures category.

Table 6e. Visual Stream Morphology Stability Assessment Table

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Date of Last Visual Assessment: October 2023
Reach: UT8
Assessed Length: 206

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-Built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjust % for Stabilizing Woody Vegetation
1. Bed	1. Vertical Stability (Riffle and Run units)	Aggradation			0	0	100%			
		Degradation			0	0	100%			
	2. Riffle Condition	Texture/Substrate	16	16			100%			
	3. Step Pool Condition	Depth Sufficient	16	16			100%			
		Length Appropriate	16	16			100%			
	4. Thalweg Position	Thalweg centering at upstream of meander bend (Run)	N/A	N/A			N/A			
		Thalweg centering at downstream of meander bend (Glide)	N/A	N/A			N/A			
2. Bank	1. Scoured/Eroded	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures[1]	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	16	16			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill	16	16			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	16	16			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%.	16	16			100%			
	4. Habitat	Pool forming structures maintaining ~Max Pool Depth : Bankfull Depth ≥ 1.6 Rootwads/logs providing some cover at baseflow.	16	16			100%			

[1]Excludes constructed riffles since they are evaluated in section 1.

Table 6f. Visual Stream Morphology Stability Assessment Table

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Date of Last Visual Assessment: October 2023
Reach: Shake Rag Branch Reach 3
Assessed Length: 1,391

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-Built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjust % for Stabilizing Woody Vegetation
1. Bed[1]	1. Vertical Stability (Riffle and Run units)	Aggradation			0	0	100%			
		Degradation			0	0	100%			
	2. Riffle Condition	Texture/Substrate	3	3			100%			
	3. Step Pool Condition	Depth Sufficient	7	7			100%			
		Length Appropriate	7	7			100%			
	4. Thalweg Position	Thalweg centering at upstream of meander bend (Run)	N/A	N/A			N/A			
		Thalweg centering at downstream of meander bend (Glide)	N/A	N/A			N/A			
2. Bank	1. Scoured/Eroded	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures[1]	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	10	10			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill	10	10			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	10	10			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%.	10	10			100%			
	4. Habitat	Pool forming structures maintaining ~Max Pool Depth : Bankfull Depth ≥ 1.6 Rootwads/logs providing some cover at baseflow.	7	7			100%			

[1]Cascading riffle sections evaluated as one riffle under the bed category and as one grade control under the engineered structures category.

Table 6g. Visual Stream Morphology Stability Assessment Table

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Date of Last Visual Assessment: October 2023
Reach: Shake Rag Branch Reach 4
Assessed Length: 385

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-Built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjust % for Stabilizing Woody Vegetation
1. Bed[1]	1. Vertical Stability (Riffle and Run units)	Aggradation			0	0	100%			
		Degradation			0	0	100%			
	2. Riffle Condition	Texture/Substrate	1	1			100%			
	3. Step Pool Condition	Depth Sufficient	7	7			100%			
		Length Appropriate	7	7			100%			
	4. Thalweg Position	Thalweg centering at upstream of meander bend (Run)	N/A	N/A			N/A			
		Thalweg centering at downstream of meander bend (Glide)	N/A	N/A			N/A			
2. Bank	1. Scoured/Eroded	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures[1]	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	8	8			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill	8	8			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	8	8			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%.	8	8			100%			
	4. Habitat	Pool forming structures maintaining ~Max Pool Depth : Bankfull Depth ≥ 1.6 Rootwads/logs providing some cover at baseflow.	7	7			100%			

[1]Cascading riffle sections evaluated as one riffle under the bed category and as one grade control under the engineered structures category.

Table 6h. Visual Stream Morphology Stability Assessment Table

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Date of Last Visual Assessment: October 2023
Reach: Shake Rag Branch Reach 5
Assessed Length: 1,134

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-Built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjust % for Stabilizing Woody Vegetation
1. Bed[1]	1. Vertical Stability (Riffle and Run units)	Aggradation			0	0	100%			
		Degradation			0	0	100%			
	2. Riffle Condition	Texture/Substrate	57	57			100%			
	3. Step Pool Condition	Depth Sufficient	59	59			100%			
		Length Appropriate	59	59			100%			
	4. Thalweg Position	Thalweg centering at upstream of meander bend (Run)	N/A	N/A			N/A			
		Thalweg centering at downstream of meander bend (Glide)	N/A	N/A			N/A			
2. Bank	1. Scoured/Eroded	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures[1]	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	59	59			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill	59	59			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	59	59			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%.	59	59			100%			
	4. Habitat	Pool forming structures maintaining ~Max Pool Depth : Bankfull Depth ≥ 1.6 Rootwads/logs providing some cover at baseflow.	59	59			100%			

[1]Excludes riffles since they are evaluated in section 1.

Table 7. Vegetation Condition Assessment Table

Shake Rag Mitigation Site

DMS Project No. 100018

Monitoring Year 4 - 2023

Date of Last Visual Assessment: October 2023

Planted Acreage **9.5**

Vegetation Category	Definitions	Mapping Threshold (acres)	Number of Polygons	Combined Acreage	% of Planted Acreage
Bare Areas[1]	Very limited cover of both woody and herbaceous material	0.1	0	0.00	0.0%
Low Stem Density Areas[1]	Woody stem densities clearly below target levels based on MY3, 5, or 7 stem count criteria.	0.1	1	0.07	0.7%
		Total	**1**	**0.07**	**0.7%**
Areas of Poor Growth Rates or Vigor	Areas with woody stems of a size class that are obviously small given the monitoring year.	0.1	0	0.00	0.0%
		Cumulative Total	**1**	**0.07**	**0.7%**

Easement Acreage **18.0**

Vegetation Category	Definitions	Mapping Threshold (SF)	Number of Polygons	Combined Acreage	% of Easement Acreage
Invasive Areas of Concern	Areas or points (if too small to render as polygons at map scale).	1000	1	0.02	0.1%
Easement Encroachment Areas	Areas or points (if too small to render as polygons at map scale).	none	0	0.00	0.00%

[1]Areas mapped with bare area and low stem density are less than 0.1 acres.

Stream Photographs
MY4

	
Photo Point 1 – UT1 Reach 1, view upstream *(04/28/2023)*	**Photo Point 1** – UT1 Reach 1, view downstream *(04/28/2023)*
	
Photo Point 2 – UT1 Reach 1, view upstream *(04/28/2023)*	**Photo Point 2** – UT1 Reach 1, view downstream *(04/28/2023)*
	
Photo Point 3 – UT1A, view upstream *(04/28/2023)*	**Photo Point 3** – UT1A, view downstream *(04/28/2023)*

	
Photo Point 4 – UT1 Reach 2, view upstream *(04/28/2023)*	**Photo Point 4** – UT1 Reach 2, view downstream *(04/28/2023)*
	
Photo Point 5 – UT2 Reach 1, view upstream *(04/28/2023)*	**Photo Point 5** – UT1 Reach 1, view downstream *(04/28/2023)*
	
Photo Point 6 – UT2 Reach 2, view upstream *(04/28/2023)*	**Photo Point 6** – UT2 Reach 2, view downstream *(04/28/2023)*

	
Photo Point 7 – UT3 Reach 1, view upstream *(04/28/2023)*	**Photo Point 7** – UT3 Reach 1, view downstream *(04/28/2023)*
	
Photo Point 8 – UT3 Reach 2, view upstream *(04/28/2023)*	**Photo Point 8** – UT3 Reach 2, view downstream *(04/28/2023)*
	
Photo Point 9 – UT3 Reach 2, view upstream *(04/28/2023)*	**Photo Point 9** – UT3 Reach 2, view downstream *(04/28/2023)*

	
Photo Point 10 – UT3 Reach 2, view upstream *(04/28/2023)*	**Photo Point 10** – UT3 Reach 2, view downstream *(04/28/2023)*
	
Photo Point 11 – UT4, view upstream *(04/28/2023)*	**Photo Point 11** – UT4, view downstream *(04/28/2023)*
	
Photo Point 12 – UT4, view upstream *(04/28/2023)*	**Photo Point 12** – UT4, view downstream *(04/28/2023)*

	
Photo Point 13 – UT4, view upstream *(04/28/2023)*	**Photo Point 13** – UT4, view downstream *(04/28/2023)*
	
Photo Point 14 – UT8, view upstream *(04/28/2023)*	**Photo Point 14** – UT8, view downstream *(04/28/2023)*
	
Photo Point 15 – UT7, view upstream *(04/28/2023)*	**Photo Point 15** – UT7, view downstream *(04/28/2023)*

	
Photo Point 16 – SRB Reach 1, view upstream *(04/28/2023)*	**Photo Point 16** – SRB Reach 1, view downstream *(04/28/2023)*
	
Photo Point 17 – SRB Reach 2, view upstream *(04/28/2023)*	**Photo Point 17** – SRB Reach 2, view downstream *(04/28/2023)*
	
Photo Point 18 – SRB Reach 3, view upstream *(04/28/2023)*	**Photo Point 18** – SRB Reach 3, view downstream *(04/28/2023)*

	
Photo Point 19 – SRB Reach 3, view upstream *(04/28/2023)*	**Photo Point 19** – SRB Reach 3, view downstream *(04/28/2023)*
	
Photo Point 20 – SRB Reach 3, view upstream *(04/28/2023)*	**Photo Point 20** – SRB Reach 3, view downstream *(04/28/2023)*
	
Photo Point 21 – SRB Reach 3, view upstream *(04/28/2023)*	**Photo Point 21** – SRB Reach 3, view downstream *(04/28/2023)*

Photo Point 22 – SRB Reach 3, view upstream *(04/28/2023)*

Photo Point 22 – UT3 Reach 2, view upstream *(04/28/2023)*

Photo Point 22 – SRB Reach 3, view downstream *(04/28/2023)*

Photo Point 23 – SRB Reach 4, view upstream *(04/28/2023)*

Photo Point 23 – SRB Reach 4, view downstream *(04/28/2023)*

	
Photo Point 24 – SRB Reach 4, view upstream *(04/28/2023)*	**Photo Point 24** – SRB Reach 5, view downstream *(04/28/2023)*
	
Photo Point 25 – SRB Reach 5, view upstream *(04/28/2023)*	**Photo Point 25** – SRB Reach 5, view downstream *(04/28/2023)*
	
Photo Point 26 – SRB Reach 5, view upstream *(04/28/2023)*	**Photo Point 26** – SRB Reach 5, view downstream *(04/28/2023)*

	
Photo Point 27 – SRB Reach 5, view upstream *(04/28/2023)*	**Photo Point 27** – SRB Reach 5, view downstream *(04/28/2023)*
	
Photo Point 28 – UT6, view upstream *(06/14/2023)*	**Photo Point 28** – UT6, view downstream *(06/14/2023)*
	
Photo Point 29 – UT6, view upstream *(06/14/2023)*	**Photo Point 29** – UT6, view downstream *(06/14/2023)*

	
Photo Point 30 – UT5, view upstream *(06/14/2023)*	**Photo Point 30** – UT5, view downstream *(06/14/2023)*

Culvert Crossing Photographs
MY4

	
Culvert Crossing – UT1 Reach 1 at STA 106+75, inlet view *(04/28/2023)*	**Culvert Crossing** – UT1 Reach 1 at STA 106+75, outlet view *(04/28/2023)*
	
Culvert Crossing – UT2 Reach 2 at STA 204+15, inlet view *(04/28/2023)*	**Culvert Crossing** – UT2 Reach 2 at STA 204+15, outlet view *(04/28/2023)*
	
Culvert Crossing – UT3 Reach 2 at STA 309+25, inlet view *(04/28/2023)*	**Culvert Crossing** – UT3 Reach 2 at STA 309+25, outlet view *(04/28/2023)*

	
Culvert Crossing – UT4 at STA 407+75, inlet view *(04/28/2023)*	**Culvert Crossing** – UT4 at STA 407+75, outlet view *(04/28/2023)*
	
Culvert Crossing – UT5 at STA 504+00, inlet view *(6/15/2023)*	**Culvert Crossing** – UT5 at STA 504+00, outlet view *(6/15/2023)*
	
Culvert Crossing – UT6 at STA 605+75, inlet view *(6/15/2023)*	**Culvert Crossing** – UT6 at STA 605+75, outlet view *(6/15/2023)*

	
Culvert Crossing – SRB Reach 3 at STA 914+00, inlet view *(04/28/2023)*	**Culvert Crossing** – SRB Reach 3 at STA 914+00, outlet view *(04/28/2023)*
	
Culvert Crossing – SRB Reach 3 at STA 920+25, inlet view *(04/28/2023)*	**Culvert Crossing** – SRB Reach 3 at STA 920+25, outlet view *(04/28/2023)*
	
Culvert Crossing – SRB Reach 5 at STA 928+25, inlet view *(04/28/2023)*	**Culvert Crossing** – SRB Reach 5 at STA 928+25, outlet view *(04/28/2023)*

	
Culvert Crossing – SRB Reach 5 at STA 932+00, inlet view *(04/28/2023)*	**Culvert Crossing** – SRB Reach 5 at STA 932+00, outlet view *(04/28/2023)*

Stream and Crest Gage Photographs
MY4

	
Crest Gage 1, UT1 Reach 2 – *(02/20/2023)*	**Crest Gage 2, UT2 Reach 2** – *(02/20/2023)*
	
Crest Gage 3, UT3 Reach 2 – *(02/20/2023)*	**Crest Gage 4, UT4** – *(02/20/2023)*
	
Stream Gage 5, UT8 – *(02/20/2023)*	**Crest Gage 6, Shake Rag Branch Reach 5** – *(02/20/2023)*

Conservation Easement Boundary Photographs
MY4

Posts added along CE Boundary – UT4, view up-valley *(10/02/2023)*

Posts added along CE Boundary – UT4, view up-valley *(10/02/2023)*

Encroachment resolved – UT4, view up-valley *(10/02/2023)*

Easement along farm road – UT4, view up-valley *(08/24/2023)*

Pipe removed from easement – UT4, view up-valley *(10/02/2023)*

Easement along farm road – SRB R5, view down-valley *(10/02/2023)*

Improved Areas of Concern Photographs
MY4

	
Poor herbaceous cover – UT3 Reach 2 near VP2 *(12/03/2021)*	**Herbaceous cover improving** – UT3 Reach 2 near VP2 *(4/28/2023)*

APPENDIX 3. Vegetation Plot Data

Vegetation assessment and analysis not required in Monitoring Year 4

Monitoring Year 3 data included for reference

Table 8. Vegetation Plot Criteria Attainment

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

MY3 Permanent Vegetation Plot	MY3 Success Criteria Met (Y/N)	Tract Mean	Overal Mean
1	Y	100%	100%
2	Y		
3	Y		
4	Y		
5	Y		
MY3 Mobile Vegetation Plot	**MY3 Success Criteria Met (Y/N)**	**Tract Mean**	
1	Y	100%	
2	Y		
3	Y		
4	Y		

Table 9. CVS Permanent Vegetation Plot Metadata

Shake Rag Mitigation Site

DMS Project No. 100018

Monitoring Year 4 - 2023

Database Name	cvs-eep-entrytool-v2.5.0 Shake Rag MY3.mdb
Database Location	L:\Active Projects\005-02164 Shake Rag\Monitoring\Monitoring Year 3\Vegetation Assessment
Computer Name	MIMI-PC
File Size	73781248
DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT----------	
Metadata	Description of database file, the report worksheets, and a summary of project(s) and project data.
Proj, planted	Each project is listed with its PLANTED stems per acre, for each year. This excludes live stakes.
Proj, total stems	Each project is listed with its TOTAL stems per acre, for each year. This includes live stakes, all planted stems, and all natural/volunteer stems.
Plots	List of plots surveyed with location and summary data (live stems, dead stems, missing, etc.).
Vigor	Frequency distribution of vigor classes for stems for all plots.
Vigor by Spp	Frequency distribution of vigor classes listed by species.
Damage	List of most frequent damage classes with number of occurrences and percent of total stems impacted by each.
Damage by Spp	Damage values tallied by type for each species.
Damage by Plot	Damage values tallied by type for each plot.
Planted Stems by Plot and Spp	A matrix of the count of PLANTED living stems of each species for each plot; dead and missing stems are excluded.
ALL Stems by Plot and spp	A matrix of the count of total living stems of each species (planted and natural volunteers combined) for each plot; dead and missing stems are excluded.
PROJECT SUMMARY----------	
Project Code	100018
Project Name	Shake Rag Mitigation Site
Description	Stream mitigation site located in Madision County, NC
River Basin	French Broad River Basin
Length(ft)	9,273 LF
Stream-to-edge Width (ft)	3 - 8
Area (sq m)	38445
Required Plots (calculated)	5
Sampled Plots	5
Required Plots (calculated)	5
Sampled Plots	5

Table 10a. Planted and Total Stem Counts
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Current Permanent Vegetation Plot Data (MY3 2022)																	
Scientific Name	**Common Name**	**Species Type**	**Permanent Plot 1**			**Permanent Plot 2**			**Permanent Plot 3**			**Permanent Plot 4**			**Permanent Plot 5**		
			PnoLS	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**
Acer negundo	Boxelder	Tree															6
Acer rubrum	Red Maple	Tree															
Betula nigra	River Birch	Tree	1	1	1	2	2	2	1	1	1	2	2	2	3	3	3
Diospyros virginiana	American Persimmon	Tree	2	2	2				1	1	1						
Fagus grandifolia	American Beech	Tree	1	1	1												
Fraxinus pennsylvanica	Green Ash	Tree				1	1	1	3	3	3	3	3	3			
Gleditsia triacanthos	Honey Locust	Shrub Tree						1									
Liriodendron tulipifera	Tulip Poplar	Tree	1	1	7	3	3	7	3	3	3	2	2	2	2	2	2
Nyssa sylvatica	Black Gum	Tree				1	1	1	1	1	1	1	1	1	3	3	3
Platanus occidentalis	Sycamore	Tree	3	3	7	1	1	1	2	2	2	2	2	2	2	2	2
Quercus alba	White Oak	Tree	3	3	3										1	1	1
Quercus falcata	Southern Red Oak	Tree	1	1	1	2	2	2	1	1	1	1	1	1	1	1	1
Quercus rubra	Red Oak	Tree	2	2	2	1	1	1	1	1	1	2	2	2	3	3	3
		Stem count	14	14	24	11	11	16	13	13	13	13	13	13	15	15	21
		size (ares)		1			1			1			1			1	
		size (ACRES)		0.0247			0.0247			0.0247			0.0247			0.0247	
		Species count	8	8	8	7	7	8	8	8	8	7	7	7	7	7	8
		Stems per ACRE	567	567	971	445	445	647	526	526	526	526	526	526	607	607	850

Permanent Vegetation Plots Annual Mean													
Scientific Name	**Common Name**	**Species Type**	**MY3 (2022)**			**MY2 (2021)**			**MY1 (2020)**			**MY0 (2020)**		
			PnoLS	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**
Acer negundo	Boxelder	Tree			6						10			
Acer rubrum	Red Maple	Tree						2						
Betula nigra	River Birch	Tree	9	9	9	9	9	9	10	10	10	12	12	12
Diospyros virginiana	American Persimmon	Tree	3	3	3	3	3	3	3	3	3	3	3	3
Fagus grandifolia	American Beech	Tree	1	1	1	1	1	1	1	1	1	3	3	3
Fraxinus pennsylvanica	Green Ash	Tree	7	7	7	7	7	7	7	7	7	7	7	7
Gleditsia triacanthos	Honey Locust	Shrub Tree			1			1						
Liriodendron tulipifera	Tulip Poplar	Tree	11	11	21	12	12	17	12	12	24	12	12	12
Nyssa sylvatica	Black Gum	Tree	6	6	6	6	6	6	7	7	7	8	8	8
Platanus occidentalis	Sycamore	Tree	10	10	14	10	10	13	10	10	10	10	10	10
Quercus alba	White Oak	Tree	4	4	4	4	4	4	4	4	4	4	4	4
Quercus falcata	Southern Red Oak	Tree	6	6	6	6	6	6	6	6	6	1	1	1
Quercus rubra	Red Oak	Tree	9	9	9	9	9	9	10	10	10	15	15	15
		Stem count	66	66	87	67	67	78	70	70	92	75	75	75
		size (ares)		5			5			5			5	
		size (ACRES)		0.124			0.124			0.124			0.124	
		Species count	10	10	12	10	10	12	10	10	11	10	10	10
		Stems per ACRE	534	534	704	542	542	631	567	567	745	607	607	607

Color for Density

Exceeds requirements by 10%
Exceeds requirements, but by less than 10%
Fails to meet requirements, by less than 10%
Fails to meet requirements by more than 10%
Volunteer species included in total

PnoLS: Number of planted stems excluding live stakes
P-all: Number of planted stems including live stakes
T: Total stems

Table 10b. Planted and Total Stem Counts
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Current Mobile Vegetation Plot Data (MY3 2022)						
Scientific Name	**Common Name**	**Species Type**	**Mobile Plot 1**	**Mobile Plot 2**	**Mobile Plot 3**	**Mobile Plot 4**
			PnoLS	**PnoLS**	**PnoLS**	**PnoLS**
Acer negundo	Boxelder	Tree				
Acer rubrum	Red Maple	Tree				
Betula nigra	River Birch	Tree	3	1	3	1
Diospyros virginiana	American Persimmon	Tree				
Fagus grandifolia	American Beech	Tree	1			
Fraxinus pennsylvanica	Green Ash	Tree			2	2
Gleditsia triacanthos	Honey Locust	Shrub Tree				
Liriodendron tulipifera	Tulip Poplar	Tree	4	1	2	2
Nyssa sylvatica	Black Gum	Tree		2		1
Oxydendum arboreum	Sourwood	Tree				1
Platanus occidentalis	Sycamore	Tree	1	1	6	1
Quercus alba	White Oak	Tree	1			
Quercus falcata	Southern Red Oak	Tree	2	3	2	
Quercus rubra	Red Oak	Tree			2	2
		Stem count	12	8	17	10
		size (ares)	1	1	1	1
		size (ACRES)	0.0247	0.0247	0.0247	0.0247
		Species count	6	5	6	7
		Stems per ACRE	486	324	688	405

Mobile Vegetation Plots Annual Mean						
Scientific Name	**Common Name**	**Species Type**	**MY3 (2022)**	**MY2 (2021)**	**MY1 (2020)**	**MY0 (2020)**
			PnoLS	**PnoLS**	**PnoLS**	**PnoLS**
Acer negundo	Boxelder	Tree				
Acer rubrum	Red Maple	Tree				
Betula nigra	River Birch	Tree	8	5	7	6
Diospyros virginiana	American Persimmon	Tree		3	3	
Fagus grandifolia	American Beech	Tree	1		4	3
Fraxinus pennsylvanica	Green Ash	Tree	4	4	3	1
Gleditsia triacanthos	Honey Locust	Shrub Tree				
Liriodendron tulipifera	Tulip Poplar	Tree	9	4	4	7
Nyssa sylvatica	Black Gum	Tree	3	1	3	8
Oxydendum arboreum	Sourwood	Tree	1			
Platanus occidentalis	Sycamore	Tree	9	6	11	9
Quercus alba	White Oak	Tree	1	7		3
Quercus falcata	Southern Red Oak	Tree	7	5	3	
Quercus rubra	Red Oak	Tree	4	6	8	17
		Stem count	47	41	46	54
		size (ares)	4	4	4	4
		size (ACRES)	0.099	0.099	0.099	0.099
		Species count	10	9	9	8
		Stems per ACRE	476	415	465	546

Color for Density

Exceeds requirements by 10%
Exceeds requirements, but by less than 10%
Fails to meet requirements, by less than 10%
Fails to meet requirements by more than 10%
Volunteer species included in total

PnoLS: Number of planted stems excluding live stakes
P-all: Number of planted stems including live stakes
T: Total stems

Table 10c. Planted and Total Stem Counts
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Overall Annual Mean						
Scientific Name	**Common Name**	**Species Type**	**MY3 (2022)**	**MY2 (2021)**	**MY1 (2020)**	**MY0 (2020)**
			PnoLS	**PnoLS**	**PnoLS**	**PnoLS**
Acer negundo	Boxelder	Tree				
Acer rubrum	Red Maple	Tree				
Betula nigra	River Birch	Tree	17	14	17	18
Diospyros virginiana	American Persimmon	Tree	3	6	6	3
Fagus grandifolia	American Beech	Tree	2	1	5	6
Fraxinus pennsylvanica	Green Ash	Tree	11	11	10	8
Gleditsia triacanthos	Honey Locust	Shrub Tree				
Liriodendron tulipifera	Tulip Poplar	Tree	20	16	16	19
Nyssa sylvatica	Black Gum	Tree	9	7	10	16
Oxydendum arboreum	Sourwood	Tree	1			
Platanus occidentalis	Sycamore	Tree	19	16	21	19
Quercus alba	White Oak	Tree	5	11	4	7
Quercus falcata	Southern Red Oak	Tree	13	11	9	1
Quercus rubra	Red Oak	Tree	13	15	18	32
		Stem count	113	108	116	129
		size (ares)	9	9	9	9
		size (ACRES)	0.222	0.222	0.222	0.222
		Species count	11	10	10	10
		Stems per ACRE	508	486	522	580

Color for Density
Exceeds requirements by 10%
Exceeds requirements, but by less than 10%
Fails to meet requirements, by less than 10%
Fails to meet requirements by more than 10%
Volunteer species included in total

PnoLS: Number of planted stems excluding live stakes
P-all: Number of planted stems including live stakes
T: Total stems

Table 10d. Planted Stem Average Heights

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Average Stem Height (ft) by Plot				
	MY0	**MY1**	**MY2**	**MY3**
Permanent Plot 1	2.4	2.7	2.6	3.2
Permanent Plot 2	2.4	1.9	1.8	1.9
Permanent Plot 3	2.5	2.8	2.9	3.5
Permanent Plot 4	2.4	2.8	3.2	4.0
Permanent Plot 5	2.6	2.1	2.2	2.5
Permanent Plot Site Average	**2.5**	**2.5**	**2.5**	**3.0**
Mobile Plot 1	1.9	2.5	2.4	2.8
Mobile Plot 2	2.0	2.6	1.9	2.9
Mobile Plot 3	1.8	2.9	2.3	3.1
Mobile Plot 4	2.3	2.6	1.8	3.1
Mobile Plot Site Average	**2.0**	**2.7**	**2.1**	**3.0**
Overall Site Average	**2.3**	**2.5**	**2.3**	**3.0**

APPENDIX 4. Morphological Summary Data and Plots

Morphological assessment and analysis not required in Monitoring Year 4.
Monitoring Year 3 data included for reference

Table 11a. Baseline Stream Data Summary
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

UT1 Reach 2, UT2 Reach 2, UT3 Reach 2, UT4

		Pre-Restoration Condition								Design								As-Built/Baseline							
Parameter	**Gage**	**UT1 Reach 2**		**UT2 Reach 2**		**UT3 Reach 2**		**UT4**		**UT1 Reach 2**		**UT2 Reach 2**		**UT3 Reach 2**		**UT4**		**UT1 Reach 2**		**UT2 Reach 2**		**UT3 Reach 2**		**UT4**	
		Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Dimension and Substrate - Riffle																									
Bankfull Width (ft)	N/A	5.3		3.1		4.5		N/A[1]		5.5		5.5		5.9		6.1		4.7		3.2		6.0		6.7	
Floodprone Width (ft)		15.7		21.6		7.2		N/A[1]		8	15	8	12	8	13	9	13	10		10		13		11	
Bankfull Mean Depth (ft)		0.8		0.5		0.5		N/A[1]		0.4		0.4		0.4		0.4		0.3		0.2		0.3		0.3	
Bankfull Max Depth (ft)		1.0		1.3		1.0		N/A[1]		0.5		0.5		0.6		0.6		0.4		0.3		0.6		0.6	
Bankfull Cross-sectional Area (ft^2)		4.3		1.6		2.3		N/A[1]		2.0		2.0		2.3		2.4		1.2		0.6		1.9		2.3	
Width/Depth Ratio		6.4		6.0		9.1		N/A[1]		15.0		15.0		15.0		15.0		18.4		16.9		18.4		19.7	
Entrenchment Ratio		3.0		7.0		1.6		N/A[1]		1.4	2.2	1.4	2.2	1.4	2.2	1.4	2.2	2.1		3.1		2.1		1.6	
Bank Height Ratio		1.0		1.0		2.7		N/A[1]		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0	
D_{50} (mm)		100		6		75		N/A[1]		---		---		---		---		64.0		67.4		61.8		71.7	
Profile																									
Riffle Length (ft)	N/A																								
Riffle Slope (ft/ft)										0.096	0.252	0.063	0.152	0.043	0.176	0.057	0.171	0.080	0.241	0.078	0.266	0.015	0.339	0.037	0.292
Pool Length (ft)																									
Pool Max Depth (ft)		1.4		---		1.2		N/A[1]		0.8	1.8	0.7	1.3	0.8	1.4	0.8	1.4	0.4	1.8	0.7	1.7	0.5	2.1	0.7	2.0
Pool Spacing (ft)		9	28	---		8	16	N/A[1]		8	17	6	14	6	15	9	18	7	20	7	22	5	36	14	34
Pool Volume (ft^3)																									
Pattern																									
Channel Beltwidth (ft)	N/A	N/A[2]		N/A[2]		N/A[2]		N/A[1]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]	
Radius of Curvature (ft)		N/A[2]		N/A[2]		N/A[2]		N/A[1]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]	
Rc/Bankfull Width (ft/ft)		N/A[2]		N/A[2]		N/A[2]		N/A[1]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]	
Meander Length (ft)		N/A[2]		N/A[2]		N/A[2]		N/A[1]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]	
Meander Width Ratio		N/A[2]		N/A[2]		N/A[2]		N/A[1]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]	
Substrate, Bed and Transport Parameters																									
Ri%/Ru%/P%/G%/S%	N/A																								
SC%/Sa%/G%/C%/B%/Be%																									
$D_{16}/D_{35}/D_{50}/D_{84}/D_{95}/D_{100}$		0.5/15-20/100/ 300-400/>1400		0.25/0.7/5.5/ 15/250		20-25/45/75/ 150/270		N/A[1]										0.3/2/12.8/90/ 180/512		0.4/4/25.4/99.5/ 202.4/>2048		0.3/0.73/7.1/ 155.5/315.2/512		0.3/1.34/20.7/ 154.8/272.5/512	
Reach Shear Stress (Competency) lb/ft^2		2.6		3.3		4.1		2.8		3.8		3.3		4.1		2.8		2.0		1.8		3.7		2.3	
Max part size (mm) mobilized at bankfull										311		366		428		322		99		90		181		112	
Stream Power (Capacity) W/m^2																									
Additional Reach Parameters																									
Drainage Area (SM)	N/A	0.11		0.05		0.06		0.05		0.11		0.05		0.06		0.05		0.11		0.05		0.06		0.05	
Watershed Impervious Cover Estimate (%)		<1%								<1%								<1%							
Rosgen Classification		A4a+		A4a+		A4a+		N/A[1]		A4a+/B4a		A4a+/B4a		A4a+/B4a		A4a+/B4a		A4a+/B4a		A4a+/B4a		A4a+/B4a		A4a+/B4a	
Bankfull Velocity (fps)		8.1		7.4		8.3		N/A[1]		6.4		7.2		8.1		6.7		5.3		4.8		7.6		5.9	
Bankfull Discharge (cfs)		35		12		19		N/A[1]		13		14		19		16		6		3		21		14	
Q-NFF regression (2-yr)		---		---		---		---																	
Q-USGS extrapolation (1.2-yr)		16		9		10		9		---		---		---		---									
Max Q-Mannings		44		12		19		---		---		12		19		N/A[1]									
Valley Slope (ft/ft)		0.1262		0.1520		0.1757		0.1102		0.1164		0.1659		0.176		0.1102		---		---		---		---	
Channel Thalweg Length (ft)		255		296		1,387[1]		910[1]		278		304		1,019		930		278		304		1,019		930	
Sinuosity		1.05		1.01		1.03		N/A[1]		1.03		1.07		1.05		1.02		1.03		1.07		1.05		1.02	
Bankfull/Channel Slope (ft/ft)		0.1200		0.1500		0.1700		N/A[1]		0.1130		0.1550		0.1650		0.1080		0.1279		0.1592		0.1643		0.1093	

1. Some or all of UT3 Reach 2 and UT4 had been previous buried in rock-lined channel or pipes so cross-section data could not be collected. Reported lengths are estimates based upon land owner communiction, remote sensing, and field verification.

2. Pattern data is not applicable for A-type and B-type channels

SC: Silt/Clay <0.062 mm diameter particles
(---): Data was not provided
N/A: Not Applicable

Table 11b. Baseline Stream Data Summary
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

UT8, Shake Rag Branch

		Pre-Restoration Condition								Design								As-Built/Baseline							
Parameter	**Gage**	**UT8**		**Shake Rag Branch Reach 3**		**Shake Rag Branch Reach 4**		**Shake Rag Branch Reach 5**		**UT8**		**Shake Rag Branch Reach 3**		**Shake Rag Branch Reach 4**		**Shake Rag Branch Reach 5**		**UT8**		**Shake Rag Branch Reach 3**		**Shake Rag Branch Reach 4**		**Shake Rag Branch Reach 5**	
		Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Dimension and Substrate - Riffle																									
Bankfull Width (ft)	N/A	N/A[1]		3.3		5.1		6.7		5.2		5.8		7.2		8.8		5.3		5.2	5.5	7.6		8.1	
Floodprone Width (ft)		N/A[1]		25		15		9		7	11	8	13	10	16	12	19	36		10		19		46	
Bankfull Mean Depth (ft)		N/A[1]		0.5		0.6		0.7		0.4		0.4		0.5		0.6		0.3		0.3		0.5		0.4	
Bankfull Max Depth (ft)		N/A[1]		0.9		0.9		1.5		0.5		0.6		1.4		0.8		0.5		0.6		0.9		0.8	
Bankfull Cross-sectional Area (ft^2)		N/A[1]		1.7		2.9		5.0		1.9		2.4		3.6		5.1		1.4		1.6	1.7	4.0		3.5	
Width/Depth Ratio		N/A[1]		6.2		9.0		9.0		15.0		14.0		15.0		15.0		19.9		16.6	17.5	14.6		18.4	
Entrenchment Ratio		N/A[1]		7.5		2.9		1.3		1.4	2.2	1.4	2.2	1.4	2.2	1.4	2.2	6.8		1.8	1.9	2.5		5.8	
Bank Height Ratio		N/A[1]		1.1		1.0		3.1		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0	
D_{50} (mm)		N/A[1]		N/A[1]		---		10-20		---		---		---		---		24.7		75.9	84.1	72.7		101.2	
Profile																									
Riffle Length (ft)	N/A																								
Riffle Slope (ft/ft)										0.045	0.161	0.064	0.166	0.065	0.120	0.040	0.123	0.012	0.151	0.052	0.421	0.038	0.094	0.040	0.143
Pool Length (ft)																									
Pool Max Depth (ft)		N/A[1]		---		---		1.8		0.7	1.3	0.8	1.4	1.0	1.8	1.2	2.0	0.7	1.4	0.4	2.2	0.8	1.9	0.8	2.4
Pool Spacing (ft)		N/A[1]		---		---		7	18	8	18	9	17	11	25	11	31	5	18	8	51	9	86	7	47
Pool Volume (ft^3)																									
Pattern																									
Channel Beltwidth (ft)	N/A	N/A[1]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]	
Radius of Curvature (ft)		N/A[1]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]	
Rc/Bankfull Width (ft/ft)		N/A[1]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]	
Meander Length (ft)		N/A[1]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]	
Meander Width Ratio		N/A[1]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]	
Substrate, Bed and Transport Parameters																									
Ri%/Ru%/P%/G%/S%	N/A																								
SC%/Sa%/G%/C%/B%/Be%																									
$D_{16}/D_{35}/D_{50}/D_{84}/D_{95}/D_{100}$		N/A[1]		N/A[1]		---		1-2/8-9/10-20/ 90-100/180										0.1/0.3/5.7/ 35.5/78.3/180		0.3/2/14.6/ 110.1/207.2/512		0.3/1.3/14.6/ 105.8/237.7/512		0.4/1.6/21.1/ 157.9/243.4/512	
Reach Shear Stress (Competency) lb/ft^2		---		3.2		---		2.4		---		3.2		---		2.4		1.2		2.5	2.6	2.4		1.8	
Max part size (mm) mobilized at bankfull										---		357		---		288		60		122	126	120		86	
Stream Power (Capacity) W/m^2																									
Additional Reach Parameters																									
Drainage Area (SM)	N/A	0.03		0.06		0.12		0.24		0.03		0.06		0.12		0.25		0.03		0.06		0.12		0.25	
Watershed Impervious Cover Estimate (%)		<1%								<1%								<1%							
Rosgen Classification		N/A[1]		A4a+		A4/B4a		A4		A4/B4a		A4a+/B4a		A4/B4a		A4/B4a		A4/B4a		A4a+/B4a		A4/B4a		A4/B4a	
Bankfull Velocity (fps)		N/A[1]		9.6		8.1		6.8		5.5		7.1		6.8		6.6		4.2		6.1	6.2	6.6		5.4	
Bankfull Discharge (cfs)		N/A[1]		16		23		34		10		17		24		34		6		10	11	26		19	
Q-NFF regression (2-yr)		---		---		---		---																	
Q-USGS extrapolation (1.2-yr)		6		10		17		29		---		---		---		---									
Max Q-Mannings		---		16		24		34		N/A[1]		16		24		34									
Valley Slope (ft/ft)		0.0901		0.1317		0.0976		0.0685		0.0901		0.1523		0.0832		0.0685		---		---		---		---	
Channel Thalweg Length (ft)		210[1]		1,451[1]		385		1,216		206		1,393		385		1,134		206		1,345		385		1,134	
Sinuosity		N/A[1]		1.03		1.07		1.04		1.06		1.03		1.08		1.01		1.06		1.03		1.08		1.01	
Bankfull/Channel Slope (ft/ft)		N/A[1]		0.1275		0.0913		0.0659		0.0850		0.1360		0.0770		0.0660		0.0761		0.1341		0.0775		0.0660	

1. Some or all of SRB Reach 3 and UT8 had been previous buried in rock-lined channel or pipes so cross-section data could not be collected. Reported lengths are estimates based upon land owner communiction, remote sensing, and field verification.

2. Pattern data is not applicable for A-type and B-type channels

SC: Silt/Clay <0.062 mm diameter particles
(---): Data was not provided
N/A: Not Applicable

Table 11c. Reference Reach Data Summary
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Parameter	Gage	Reference Reach Data											
		Ironwood Tributary		UT to South Fork Fishing Creek		UT to Austin Branch (upstream)		UT to Austin Branch (downstream)		UT to Gap Branch		UT to Hampton Creek	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Riffle													
Bankfull Width (ft)	N/A	5.0		4.1		6.7		6.2		6.2		6.8	
Floodprone Width (ft)		10		7		18		27		21		12	
Bankfull Mean Depth		0.6		0.4		0.5		0.7		0.6		0.7	
Bankfull Max Depth		0.8		0.7		0.8		1.2		1.0		1.0	
Bankfull Cross-sectional Area (ft^2)		2.7		1.8		3.6		4.4		3.8		4.6	
Width/Depth Ratio		9.1		9.3		12.8		8.8		10.1		10.0	
Entrenchment Ratio		2.1		1.7		2.6		4.3		3.4		1.7	
Bank Height Ratio		1.3		1.0		1.0		1.0		1.0		1.0	
D50 (mm)		0.9		1.2		59		59		19		Coarse gravel	
Profile													
Riffle Length (ft)	N/A	---		---		---		---		---		---	
Riffle Slope (ft/ft)		---		0.0240	0.2000	0.0810	0.2900	0.0250	0.0730	0.0110	0.1400	0.0500	0.1000
Pool Length (ft)		---		---		---		---		---		---	
Pool Max Depth (ft)		---		---		1.7		1.7		1.6		1.3	
Pool Spacing (ft)		---		6	32	10	17	14	31	18	27	11	19
Pool Volume (ft^3)													
Pattern													
Channel Beltwidth (ft)	N/A	---		---		---		---		---		---	
Radius of Curvature (ft)		---		---		---		---		---		---	
Rc/Bankfull Width (ft/ft)		---		---		---		---		---		---	
Meander Length (ft)		---		---		---		---		---		---	
Meander Width Ratio		---		---		---		---		---		---	
Substrate, Bed and Transport Parameters													
Ri%/Ru%/P%/G%/S%	N/A												
SC%/Sa%/G%/C%/B%/Be%													
d16/d35/d50/d84/d95/d100		0.26/0.5/0.91/19/ 97/128		0.1/0.3/1.2/11/ 24/64		11/42/59/130/ 170/256		11/42/59/130/ 170/256		0.4/8/19/102.3/ 257/>2048		---	
Reach Shear Stress (Competency) lb/ft^2													
Max part size (mm) mobilized at bankfull													
Stream Power (Capacity) W/m^2													
Additional Reach Parameters													
Drainage Area (SM)	N/A	0.03		0.02		0.12		0.12		0.04		0.25	
Watershed Impervious Cover Estimate (%)		---		---		---		---		---		---	
Rosgen Classification		A5a+		B5a		A4/B4a		A4/B4a		A4/B4a		A4/B4a	
Bankfull Velocity (fps)		4.9		4.1		7.3		6.2		5.0		6.6	
Bankfull Discharge (cfs)		13		8		26		27		19		31	
Q-NFF regression (2-yr)													
Q-USGS extrapolation (1.2-yr)													
Q-Mannings													
Valley Slope (ft/ft)		0.1418		0.1025		0.1000		0.0480		---		0.0840	
Channel Thalweg Length (ft)		---		---		---		---		---		---	
Sinuosity		1.2		1.25		1.00		1.20		---		1.10	1.20
Water Surface Slope (ft/ft)		---		---		---		---		---		---	
Bankfull/Channel Slope (ft/ft)		0.1139		0.0815		0.0986		0.0400		0.0680		0.0650	

SC: Silt/Clay <0.062 mm diameter particles
(---): Data was not provided
N/A: Not Applicable

Table 12a. Morphology and Hydraulic Summary (Dimensional Parameters - Cross-Section)

Shake Rag Mitigation Site

DMS Project No. 100018

Monitoring Year 4 - 2023

	UT1 Reach 2 Cross-Section 1, Riffle								UT2 Reach 2 Cross-Section 2, Riffle								UT3 Reach 2 Cross-Section 3, Riffle							
Dimension and Substrate	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**	**MY7**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**	**MY7**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**	**MY7**
Bankfull Elevation	*2709.81*	*2709.77*	*2709.75*	*2709.77*	N/A				*2738.54*	*2738.65*	*2738.70*	*2738.63*	N/A				*2617.65*	*2617.72*	*2617.44*	*2617.25*	N/A			
Low Bank Elevation	*2709.81*	*2709.86*	*2709.84*	*2709.75*					*2738.54*	*2738.74*	*2738.70*	*2738.63*					*2617.65*	*2617.60*	*2617.61*	*2617.36*				
Bankfull Width (ft)	4.7	5.0	5.3	3.0					3.2	3.0	3.0	2.6					6.0	3.7	6.3	3.3				
Floodprone Width (ft)	10	13	14	11					10	12	10	13					13	12	16	13				
Bankfull Mean Depth (ft)	0.3	0.3	0.3	0.4					0.2	0.3	0.2	0.2					0.3	0.4	0.4	0.7				
Bankfull Max Depth (ft)	0.4	0.6	0.6	0.5					0.3	0.4	0.3	0.5					0.6	0.6	1.2	1.1				
Bankfull Cross-Sectional Area (ft^2)	1.2	1.6	1.7	1.1					0.6	0.8	0.6	0.6					1.9	1.4	2.8	2.3				
Bankfull Width/Depth Ratio	18.4	15.4	16.7	8.1					16.9	10.7	16.3	10.4					18.4	9.7	14.4	4.7				
Bankfull Entrenchment Ratio	2.1	2.6	2.7	3.7					3.1	4.1	3.1	5.2					2.1	3.3	2.5	4.1				
Bankfull Bank Height Ratio	1.0	1.2	1.2	1.0					1.0	1.3	1.0	1.0					1.0	0.8	1.2	1.1				

	UT3 Reach 2 Cross-Section 4, Pool								UT4 Cross-Section 5, Riffle								UT4 Cross-Section 6, Pool							
Dimension and Substrate	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**	**MY7**	**Base[2]**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**	**MY7**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**	**MY7**
Bankfull Elevation	*2616.07*	*2616.04*	*2616.06*	*2616.11*	N/A				*2503.27*	*2503.37*	*2503.36*	*2503.40*	N/A				*2499.51*	*2499.56*	*2499.61*	*2499.27*	N/A			
Low Bank Elevation	*2616.07*	*2616.04*	*2616.06*	*2616.11*					*2503.27*	*2503.23*	*2503.24*	*2503.28*					*2499.51*	*2499.56*	*2499.61*	*2499.27*				
Bankfull Width (ft)	5.4	4.2	3.5	4.5					8.3	7.5	8.3	8.3					5.9	5.2	6.0	4.3				
Floodprone Width (ft)	---	---	---	---					14	13	13	13					---	---	---	---				
Bankfull Mean Depth (ft)	0.7	0.5	0.5	0.4					0.5	0.4	0.4	0.4					0.7	0.8	0.7	0.6				
Bankfull Max Depth (ft)	1.1	0.9	1.0	0.7					0.8	0.7	0.7	0.7					1.0	1.2	1.1	0.8				
Bankfull Cross-Sectional Area (ft^2)	4.0	2.1	1.8	2.0					4.3	3.1	3.3	3.3					4.4	4.1	4.4	2.5				
Bankfull Width/Depth Ratio	7.3	8.3	6.7	10.0					16.2	17.8	21.0	21.0					7.9	6.7	8.2	7.5				
Bankfull Entrenchment Ratio	---	---	---	---					1.7	1.7	1.6	1.6					---	---	---	---				
Bankfull Bank Height Ratio	---	---	---	---					1.0	0.8	0.9	0.9					---	---	---	---				

	UT8 Cross-Section 7, Riffle							
Dimension and Substrate	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**	**MY7**
Bankfull Elevation	*2520.23*	*2520.23*	*2520.32*	*2520.35*	N/A			
Low Bank Elevation	*2520.23*	*2520.23*	*2520.24*	*2520.30*				
Bankfull Width (ft)	5.3	4.2	5.0	5.2				
Floodprone Width (ft)	36	37	35	37				
Bankfull Mean Depth (ft)	0.3	0.3	0.2	0.2				
Bankfull Max Depth (ft)	0.5	0.5	0.4	0.6				
Bankfull Cross-Sectional Area (ft^2)	1.4	1.4	0.9	1.1				
Bankfull Width/Depth Ratio	19.9	12.8	26.2	24.1				
Bankfull Entrenchment Ratio	6.8	8.6	7.0	7.0				
Bankfull Bank Height Ratio	1.0	1.0	0.8	0.9				

[1]MY1-MY7 Bank Height Ratio is calculated based on the As-built (MY0) cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document provided by the NCIRT and NCDMS (9/2018). The remainder of the cross-section dimension parameters were calculated based on the current low bank height.

[2]Cross-section dimensions updated in MY1.

Table 12b. Morphology and Hydraulic Summary (Dimensional Parameters - Cross-Section)

Shake Rag Mitigation Site

DMS Project No. 100018

Monitoring Year 4 - 2023

	Shake Rag Branch Reach 3 Cross-Section 8, Riffle								Shake Rag Branch Reach 3 Cross-Section 9, Riffle								Shake Rag Branch Reach 3 Cross-Section 10, Pool							
Dimension and Substrate	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**	**MY7**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**	**MY7**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**	**MY7**
Bankfull Elevation	*2632.06*	*2631.95*	*2632.08*	*2631.98*	N/A				*2621.09*	*2620.96*	*2621.01*	*2621.00*	N/A				*2620.50*	*2620.23*	*2620.64*	*2620.42*	N/A			
Low Bank Elevation	*2632.06*	*2631.95*	*2632.01*	*2631.98*					*2621.09*	*2620.96*	*2621.11*	*2621.17*					*2620.50*	*2620.23*	*2620.64*	*2620.42*				
Bankfull Width (ft)	5.2	3.1	3.3	3.8					5.5	4.8	6.0	6.1					4.0	4.0	4.2	3.7				
Floodprone Width (ft)	10	11	10	10					10	9	11	14					---	---	---	---				
Bankfull Mean Depth (ft)	0.3	0.5	0.4	0.4					0.3	0.4	0.4	0.4					0.8	0.7	0.9	0.8				
Bankfull Max Depth (ft)	0.6	0.8	0.7	0.8					0.6	0.6	0.7	1.1					1.1	1.0	1.4	1.0				
Bankfull Cross-Sectional Area (ft^2)	1.6	1.6	1.4	1.6					1.7	1.7	2.3	2.7					3.0	2.8	3.8	2.9				
Bankfull Width/Depth Ratio	16.6	5.8	8.2	9.4					17.5	13.6	15.5	13.8					5.3	5.7	4.6	4.6				
Bankfull Entrenchment Ratio	1.9	3.6	3.0	2.7					1.8	1.9	1.8	2.3					---	---	---	---				
Bankfull Bank Height Ratio	1.0	1.0	0.9	1.0					1.0	1.0	1.2	1.2					---	---	---	---				
	Shake Rag Branch Reach 4 Cross-Section 11, Riffle								**Shake Rag Branch Reach 5 Cross-Section 12, Riffle**								**Shake Rag Branch Reach 5 Cross-Section 13, Pool**							
Dimension and Substrate	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**	**MY7**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**	**MY7**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**	**MY7**
Bankfull Elevation	*2530.35*	*2530.43*	*2530.37*	*2530.46*	N/A				*2500.82*	*2500.82*	*2500.78*	*2500.80*	N/A				*2500.20*	*2500.12*	*2499.98*	*2499.96*	N/A			
Low Bank Elevation	*2530.35*	*2530.36*	*2530.25*	*2530.33*					*2500.82*	*2500.82*	*2500.76*	*2500.77*					*2500.20*	*2500.12*	*2499.98*	*2499.96*				
Bankfull Width (ft)	7.6	7.8	7.3	7.1					8.1	8.0	7.2	6.8					7.2	7.1	6.9	7.0				
Floodprone Width (ft)	19	16	14	17					46	46	46	52					---	---	---	---				
Bankfull Mean Depth (ft)	0.5	0.4	0.4	0.4					0.4	0.4	0.5	0.5					1.1	1.3	1.2	1.0				
Bankfull Max Depth (ft)	0.9	0.6	0.6	0.7					0.8	0.9	0.9	1.1					1.9	1.9	1.8	1.5				
Bankfull Cross-Sectional Area (ft^2)	4.0	3.4	3.0	3.0					3.5	3.5	3.4	3.3					8.1	8.9	8.0	6.6				
Bankfull Width/Depth Ratio	14.6	18.0	18.1	17.1					18.4	18.2	15.5	14.0					6.4	5.7	6.0	7.3				
Bankfull Entrenchment Ratio	2.5	2.1	1.9	2.4					5.8	5.7	6.4	7.6					---	---	---	---				
Bankfull Bank Height Ratio	1.0	0.9	0.8	0.8					1.0	1.0	1.0	1.0					---	---	---	---				

[1]MY1-MY7 Bank Height Ratio is calculated based on the As-built (MY0) cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document provided by the NCIRT and NCDMS (9/2018). The remainder of the cross-section dimension parameters were calculated based on the current low bank height.

Table 13a. Monitoring Data - Stream Reach Data Summary
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

UT1 Reach 2

Parameter	As-Built/Baseline		MY1		MY2		MY3		MY4		MY5		MY6		MY7	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Riffle[2]																
Bankfull Width (ft)	4.7		5.0		5.3		3.0									
Floodprone Width (ft)	10		13		14		11									
Bankfull Mean Depth (ft)	0.3		0.3		0.3		0.4									
Bankfull Max Depth (ft)	0.4		0.6		0.6		0.5									
Bankfull Cross-sectional Area (ft^2)	1.2		1.6		1.7		1.1		N/A							
Width/Depth Ratio	18.4		15.4		16.7		8.1									
Entrenchment Ratio	2.1		2.6		2.7		3.7									
Bank Height Ratio	1.0		1.2		1.2		1.0									
D_{50} (mm)	64.0															
Profile																
Riffle Length (ft)																
Riffle Slope (ft/ft)	0.080	0.241														
Pool Length (ft)																
Pool Max Depth (ft)	0.4	1.8														
Pool Spacing (ft)	7	20														
Pool Volume (ft^3)																
Pattern																
Channel Beltwidth (ft)	N/A[1]															
Radius of Curvature (ft)	N/A[1]															
Rc/Bankfull Width (ft/ft)	N/A[1]															
Meander Length (ft)	N/A[1]															
Meander Width Ratio	N/A[1]															
Substrate, Bed and Transport Parameters																
Ri%/Ru%/P%/G%/S%																
SC%/Sa%/G%/C%/B%/Be%																
$D_{16}/D_{35}/D_{50}/D_{84}/D_{95}/D_{100}$	0.3/2/12.8/90/180/512		0.4/18.4/34.8/87.7/143.4/512		0.3/1.3/8.0/81.3/128/180		N/A		N/A							
Reach Shear Stress (Competency) lb/ft^2	2.0															
Max part size (mm) mobilized at bankfull	99															
Stream Power (Capacity) W/m^2																
Additional Reach Parameters																
Drainage Area (SM)	0.11															
Watershed Impervious Cover Estimate (%)	<1%															
Rosgen Classification	A4a+/B4a															
Bankfull Velocity (fps)	5.3															
Bankfull Discharge (cfs)	6.4															
Valley Slope (ft/ft)	---															
Channel Thalweg Length (ft)	278															
Sinuosity	1.03															
Bankfull/Channel Slope (ft/ft)	0.1279															

[1]Pattern data is not applicable for A-type and B-type channels

[2]MY1-MY7 Bank Height Ratio is calculated based on the As-built (MY0) cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document provided by the NCIRT and NCDMS (9/2018). The remainder of the cross-section dimension parameters were calculated based on the current low bank height.

SC: Silt/Clay <0.062 mm diameter particles

(---): Data was not provided

N/A: Not Applicable

Table 13b. Monitoring Data - Stream Reach Data Summary
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

UT2 Reach 2

Parameter	As-Built/Baseline		MY1		MY2		MY3		MY4		MY5		MY6		MY7	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Riffle[2]																
Bankfull Width (ft)	3.2		3.0		3.0		2.6									
Floodprone Width (ft)	10		12		10		13									
Bankfull Mean Depth (ft)	0.2		0.3		0.2		0.2									
Bankfull Max Depth (ft)	0.3		0.4		0.3		0.5									
Bankfull Cross-sectional Area (ft^2)	0.6		0.8		0.6		0.6		N/A							
Width/Depth Ratio	16.9		10.7		16.3		10.4									
Entrenchment Ratio	3.1		4.1		3.1		5.2									
Bank Height Ratio	1.0		1.3		1.0		1.0									
D_{50} (mm)	67.4															
Profile																
Riffle Length (ft)																
Riffle Slope (ft/ft)	0.078	0.266														
Pool Length (ft)																
Pool Max Depth (ft)	0.7	1.7														
Pool Spacing (ft)	7	22														
Pool Volume (ft^3)																
Pattern																
Channel Beltwidth (ft)	N/A[1]															
Radius of Curvature (ft)	N/A[1]															
Rc/Bankfull Width (ft/ft)	N/A[1]															
Meander Length (ft)	N/A[1]															
Meander Width Ratio	N/A[1]															
Substrate, Bed and Transport Parameters																
Ri%/Ru%/P%/G%/S%																
SC%/Sa%/G%/C%/B%/Be%																
$D_{16}/D_{35}/D_{50}/D_{84}/D_{95}/D_{100}$	0.4/4/25.4/99.5/ 202.4/>2048		0.7/10.2/33.9/105.6/ 158.4/512		0.1/1.7/14.1/107.3/ 165.3/362		N/A		N/A							
Reach Shear Stress (Competency) lb/ft^2	1.84															
Max part size (mm) mobilized at bankfull	90															
Stream Power (Capacity) W/m^2																
Additional Reach Parameters																
Drainage Area (SM)	0.05															
Watershed Impervious Cover Estimate (%)	<1%															
Rosgen Classification	A4a+/B4a															
Bankfull Velocity (fps)	4.8															
Bankfull Discharge (cfs)	3.0															
Valley Slope (ft/ft)	---															
Channel Thalweg Length (ft)	304															
Sinuosity	1.07															
Bankfull/Channel Slope (ft/ft)	0.1592															

[1]Pattern data is not applicable for A-type and B-type channels

[2]MY1-MY7 Bank Height Ratio is calculated based on the As-built (MY0) cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document provided by the NCIRT and NCDMS (9/2018). The remainder of the cross-section dimension parameters were calculated based on the current low bank height.

SC: Silt/Clay <0.062 mm diameter particles

(---): Data was not provided

N/A: Not Applicable

Table 13c. Monitoring Data - Stream Reach Data Summary
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

UT3 Reach 2

Parameter	As-Built/Baseline		MY1		MY2		MY3		MY4		MY5		MY6		MY7	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Riffle[2]																
Bankfull Width (ft)	6.0		3.7		6.3		3.3									
Floodprone Width (ft)	13		12		16		13									
Bankfull Mean Depth (ft)	0.3		0.4		0.4		0.7									
Bankfull Max Depth (ft)	0.6		0.6		1.2		1.1									
Bankfull Cross-sectional Area (ft^2)	1.9		1.4		2.8		2.3		N/A							
Width/Depth Ratio	18.4		9.7		14.4		4.7									
Entrenchment Ratio	2.1		3.3		2.5		4.1									
Bank Height Ratio	1.0		0.8		1.2		1.1									
D_{50} (mm)	61.8															
Profile																
Riffle Length (ft)																
Riffle Slope (ft/ft)	0.015	0.339														
Pool Length (ft)																
Pool Max Depth (ft)	0.5	2.1														
Pool Spacing (ft)	5	36														
Pool Volume (ft^3)																
Pattern																
Channel Beltwidth (ft)	N/A[1]															
Radius of Curvature (ft)	N/A[1]															
Rc/Bankfull Width (ft/ft)	N/A[1]															
Meander Length (ft)	N/A[1]															
Meander Width Ratio	N/A[1]															
Substrate, Bed and Transport Parameters																
Ri%/Ru%/P%/G%/S%																
SC%/Sa%/G%/C%/B%/Be%																
$D_{16}/D_{35}/D_{50}/D_{84}/D_{95}/D_{100}$	0.3/0.73/7.1/ 155.5/315.2/512		1.5/10.4/35.4/121.2/ 179.7/512		SC/1.8/11.2/96.7/ 151.5/512		N/A		N/A							
Reach Shear Stress (Competency) lb/ft^2	3.68															
Max part size (mm) mobilized at bankfull	181															
Stream Power (Capacity) W/m^2																
Additional Reach Parameters																
Drainage Area (SM)	0.06															
Watershed Impervious Cover Estimate (%)	<1%															
Rosgen Classification	A4a+/B4a															
Bankfull Velocity (fps)	7.6															
Bankfull Discharge (cfs)	21.0															
Valley Slope (ft/ft)	---															
Channel Thalweg Length (ft)	1,019															
Sinuosity	1.05															
Bankfull/Channel Slope (ft/ft)	0.1643															

[1]Pattern data is not applicable for A-type and B-type channels

[2]MY1-MY7 Bank Height Ratio is calculated based on the As-built (MY0) cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document provided by the NCIRT and NCDMS (9/2018). The remainder of the cross-section dimension parameters were calculated based on the current low bank height.

SC: Silt/Clay <0.062 mm diameter particles

(---): Data was not provided

N/A: Not Applicable

Table 13d. Monitoring Data - Stream Reach Data Summary
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

UT4

Parameter	As-Built/Baseline		MY1		MY2		MY3		MY4		MY5		MY6		MY7	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Riffle[2]																
Bankfull Width (ft)	8.3		7.5		8.3		8.3		N/A							
Floodprone Width (ft)	14		13		13		13									
Bankfull Mean Depth (ft)	0.5		0.4		0.4		0.4									
Bankfull Max Depth (ft)	0.8		0.7		0.7		0.7									
Bankfull Cross-sectional Area (ft^2)	4.3		3.1		3.3		3.3									
Width/Depth Ratio	16.2		17.8		21.0		21.0									
Entrenchment Ratio	1.7		1.7		1.6		1.6									
Bank Height Ratio	1.0		0.8		0.9		0.9									
D_{50} (mm)	71.7															
Profile																
Riffle Length (ft)																
Riffle Slope (ft/ft)	0.037	0.292														
Pool Length (ft)																
Pool Max Depth (ft)	0.7	2.0														
Pool Spacing (ft)	14	34														
Pool Volume (ft^3)																
Pattern																
Channel Beltwidth (ft)	N/A[1]															
Radius of Curvature (ft)	N/A[1]															
Rc/Bankfull Width (ft/ft)	N/A[1]															
Meander Length (ft)	N/A[1]															
Meander Width Ratio	N/A[1]															
Substrate, Bed and Transport Parameters																
Ri%/Ru%/P%/G%/S%																
SC%/Sa%/G%/C%/B%/Be%																
$D_{16}/D_{35}/D_{50}/D_{84}/D_{95}/D_{100}$	0.3/1.34/20.7/ 154.8/272.5/512		0.4/5.0/10.7/120.7/ 169.2/256		0.6/13.3/53.7/137/ 209.3/362		N/A		N/A							
Reach Shear Stress (Competency) lb/ft^2	2.28															
Max part size (mm) mobilized at bankfull	112															
Stream Power (Capacity) W/m^2																
Additional Reach Parameters																
Drainage Area (SM)	0.05															
Watershed Impervious Cover Estimate (%)	<1%															
Rosgen Classification	A4a+/B4a															
Bankfull Velocity (fps)	5.9															
Bankfull Discharge (cfs)	13.6															
Valley Slope (ft/ft)	---															
Channel Thalweg Length (ft)	930															
Sinuosity	1.02															
Bankfull/Channel Slope (ft/ft)	0.1093															

[1]Pattern data is not applicable for A-type and B-type channels

[2]MY1-MY7 Bank Height Ratio is calculated based on the As-built (MY0) cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document provided by the NCIRT and NCDMS (9/2018). The remainder of the cross-section dimension parameters were calculated based on the current low bank height.

SC: Silt/Clay <0.062 mm diameter particles

(---): Data was not provided

N/A: Not Applicable

Table 13e. Monitoring Data - Stream Reach Data Summary
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

UT8

Parameter	As-Built/Baseline		MY1		MY2		MY3		MY4		MY5		MY6		MY7	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Riffle[2]																
Bankfull Width (ft)	5.3		4.2		5.0		5.2		N/A							
Floodprone Width (ft)	36		37		35		37									
Bankfull Mean Depth (ft)	0.3		0.3		0.2		0.2									
Bankfull Max Depth (ft)	0.5		0.5		0.4		0.6									
Bankfull Cross-sectional Area (ft^2)	1.4		1.4		0.9		1.1									
Width/Depth Ratio	19.9		12.8		26.2		24.1									
Entrenchment Ratio	6.8		8.6		7.0		7.0									
Bank Height Ratio	1.0		1.0		0.8		0.9									
D_{50} (mm)	24.7															
Profile																
Riffle Length (ft)																
Riffle Slope (ft/ft)	0.012	0.151														
Pool Length (ft)																
Pool Max Depth (ft)	0.7	1.4														
Pool Spacing (ft)	5	18														
Pool Volume (ft^3)																
Pattern																
Channel Beltwidth (ft)	N/A[1]															
Radius of Curvature (ft)	N/A[1]															
Rc/Bankfull Width (ft/ft)	N/A[1]															
Meander Length (ft)	N/A[1]															
Meander Width Ratio	N/A[1]															
Substrate, Bed and Transport Parameters																
Ri%/Ru%/P%/G%/S%																
SC%/Sa%/G%/C%/B%/Be%																
$D_{16}/D_{35}/D_{50}/D_{84}/D_{95}/D_{100}$	0.1/0.3/5.7/ 35.5/78.3/180		SC/0.4/18.3/53.4/ 79/362		SC/0.3/12.6/70.5/ 113.5/256		N/A		N/A							
Reach Shear Stress (Competency) lb/ft^2	1.23															
Max part size (mm) mobilized at bankfull	60															
Stream Power (Capacity) W/m^2																
Additional Reach Parameters																
Drainage Area (SM)	0.03															
Watershed Impervious Cover Estimate (%)	<1%															
Rosgen Classification	A4/B4a															
Bankfull Velocity (fps)	4.2															
Bankfull Discharge (cfs)	6.0															
Valley Slope (ft/ft)	---															
Channel Thalweg Length (ft)	206															
Sinuosity	1.06															
Bankfull/Channel Slope (ft/ft)	0.0761															

[1]Pattern data is not applicable for A-type and B-type channels

[2]MY1-MY7 Bank Height Ratio is calculated based on the As-built (MY0) cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document provided by the NCIRT and NCDMS (9/2018). The remainder of the cross-section dimension parameters were calculated based on the current low bank height.

SC: Silt/Clay <0.062 mm diameter particles

(---): Data was not provided

N/A: Not Applicable

Table 13f. Monitoring Data - Stream Reach Data Summary
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Shake Rag Branch Reach 3

Parameter	As-Built/Baseline		MY1		MY2		MY3		MY4		MY5		MY6		MY7	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Riffle[2]																
Bankfull Width (ft)	5.2	5.5	3.1	4.8	3.3	6.0	3.8	6.1								
Floodprone Width (ft)	10		9	11	10	11	10	14								
Bankfull Mean Depth (ft)	0.3		0.4	0.5	0.4		0.4									
Bankfull Max Depth (ft)	0.6		0.6	0.8	0.7		0.8	1.1								
Bankfull Cross-sectional Area (ft^2)	1.6	1.7	1.6	1.7	1.4	2.3	1.6	2.7	N/A							
Width/Depth Ratio	16.6	17.5	5.8	13.6	8.2	15.5	9.4	13.8								
Entrenchment Ratio	1.8	1.9	3.6	1.9	1.8	3.0	2.3	2.7								
Bank Height Ratio	1.0		1.0		0.9	1.2	1.0	1.2								
D_{50} (mm)	75.9	84.1														
Profile																
Riffle Length (ft)																
Riffle Slope (ft/ft)	0.052	0.421														
Pool Length (ft)																
Pool Max Depth (ft)	0.4	2.2														
Pool Spacing (ft)	8	51														
Pool Volume (ft^3)																
Pattern																
Channel Beltwidth (ft)	N/A[1]															
Radius of Curvature (ft)	N/A[1]															
Rc/Bankfull Width (ft/ft)	N/A[1]															
Meander Length (ft)	N/A[1]															
Meander Width Ratio	N/A[1]															
Substrate, Bed and Transport Parameters																
Ri%/Ru%/P%/G%/S%																
SC%/Sa%/G%/C%/B%/Be%																
$D_{16}/D_{35}/D_{50}/D_{84}/D_{95}/D_{100}$	0.3/2/14.6/ 110.1/207.2/512		0.4/18.4/34.8/87.7/ 143.4/1024		0.1/1.4/11/121.7/ 193.1/362		N/A		N/A							
Reach Shear Stress (Competency) lb/ft^2	2.5	2.6														
Max part size (mm) mobilized at bankfull	122	126														
Stream Power (Capacity) W/m^2																
Additional Reach Parameters																
Drainage Area (SM)	0.06															
Watershed Impervious Cover Estimate (%)	<1%															
Rosgen Classification	A4a+/B4a															
Bankfull Velocity (fps)	6.1	6.2														
Bankfull Discharge (cfs)	10	11														
Valley Slope (ft/ft)	---															
Channel Thalweg Length (ft)	1,345															
Sinuosity	1.03															
Bankfull/Channel Slope (ft/ft)	0.1341															

[1]Pattern data is not applicable for A-type and B-type channels

[2]MY1-MY7 Bank Height Ratio is calculated based on the As-built (MY0) cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document provided by the NCIRT and NCDMS (9/2018). The remainder of the cross-section dimension parameters were calculated based on the current low bank height.

SC: Silt/Clay <0.062 mm diameter particles

(---): Data was not provided

N/A: Not Applicable

Table 13g. Monitoring Data - Stream Reach Data Summary
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Shake Rag Branch Reach 4

Parameter	As-Built/Baseline		MY1		MY2		MY3		MY4		MY5		MY6		MY7	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Riffle[2]																
Bankfull Width (ft)	7.6		7.8		7.3		7.1									
Floodprone Width (ft)	19		16		14		17									
Bankfull Mean Depth (ft)	0.5		0.4		0.4		0.4									
Bankfull Max Depth (ft)	0.9		0.6		0.6		0.7									
Bankfull Cross-sectional Area (ft^2)	4.0		3.4		3.0		3.0		N/A							
Width/Depth Ratio	14.6		18.0		18.1		17.1									
Entrenchment Ratio	2.5		2.1		1.9		2.4									
Bank Height Ratio	1.0		0.9		0.8		0.8									
D_{50} (mm)	72.7															
Profile																
Riffle Length (ft)																
Riffle Slope (ft/ft)	0.038	0.094														
Pool Length (ft)																
Pool Max Depth (ft)	0.8	1.9														
Pool Spacing (ft)	9	86														
Pool Volume (ft^3)																
Pattern																
Channel Beltwidth (ft)	N/A[1]															
Radius of Curvature (ft)	N/A[1]															
Rc/Bankfull Width (ft/ft)	N/A[1]															
Meander Length (ft)	N/A[1]															
Meander Width Ratio	N/A[1]															
Substrate, Bed and Transport Parameters																
Ri%/Ru%/P%/G%/S%																
SC%/Sa%/G%/C%/B%/Be%																
$D_{16}/D_{35}/D_{50}/D_{84}/D_{95}/D_{100}$	0.3/1.3/14.6/ 105.8/237.7/512		0.7/10.2/33.9/105.6/ 158.4/512		0.8/12.5/45/157.1/ 241.4/362		N/A		N/A							
Reach Shear Stress (Competency) lb/ft^2	2.4															
Max part size (mm) mobilized at bankfull	120															
Stream Power (Capacity) W/m^2																
Additional Reach Parameters																
Drainage Area (SM)	0.12															
Watershed Impervious Cover Estimate (%)	<1%															
Rosgen Classification	A4/B4a															
Bankfull Velocity (fps)	6.6															
Bankfull Discharge (cfs)	26															
Valley Slope (ft/ft)	---															
Channel Thalweg Length (ft)	385															
Sinuosity	1.08															
Bankfull/Channel Slope (ft/ft)	0.0775															

[1]Pattern data is not applicable for A-type and B-type channels

[2]MY1-MY7 Bank Height Ratio is calculated based on the As-built (MY0) cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document provided by the NCIRT and NCDMS (9/2018). The remainder of the cross-section dimension parameters were calculated based on the current low bank height.

SC: Silt/Clay <0.062 mm diameter particles

(---): Data was not provided

N/A: Not Applicable

Table 13h. Monitoring Data - Stream Reach Data Summary
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Shake Rag Branch Reach 5

Parameter	As-Built/Baseline		MY1		MY2		MY3		MY4		MY5		MY6		MY7	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Riffle[2]																
Bankfull Width (ft)	8.1		8.0		7.2		6.8		N/A							
Floodprone Width (ft)	46		46		46		52									
Bankfull Mean Depth (ft)	0.4		0.4		0.5		0.5									
Bankfull Max Depth (ft)	0.8		0.9		0.9		1.1									
Bankfull Cross-sectional Area (ft^2)	3.5		3.5		3.4		3.3									
Width/Depth Ratio	18.4		18.2		15.5		14.0									
Entrenchment Ratio	5.8		5.7		6.4		7.6									
Bank Height Ratio	1.0		1.0		1.0		1.0									
D_{50} (mm)	101.2															
Profile																
Riffle Length (ft)																
Riffle Slope (ft/ft)	0.040	0.143														
Pool Length (ft)																
Pool Max Depth (ft)	0.8	2.4														
Pool Spacing (ft)	7	47														
Pool Volume (ft^3)																
Pattern																
Channel Beltwidth (ft)	N/A[1]															
Radius of Curvature (ft)	N/A[1]															
Rc/Bankfull Width (ft/ft)	N/A[1]															
Meander Length (ft)	N/A[1]															
Meander Width Ratio	N/A[1]															
Substrate, Bed and Transport Parameters																
Ri%/Ru%/P%/G%/S%																
SC%/Sa%/G%/C%/B%/Be%																
$D_{16}/D_{35}/D_{50}/D_{84}/D_{95}/D_{100}$	0.4/1.6/21.1/ 157.9/243.4/512		0.5/3.7/11/61.2/ 113.8/180		0.3/9.9/16.7/85.7/ 160.7/512		N/A		N/A							
Reach Shear Stress (Competency) lb/ft^2	1.8															
Max part size (mm) mobilized at bankfull	86															
Stream Power (Capacity) W/m^2																
Additional Reach Parameters																
Drainage Area (SM)	0.25															
Watershed Impervious Cover Estimate (%)	<1%															
Rosgen Classification	A4/B4a															
Bankfull Velocity (fps)	5.4															
Bankfull Discharge (cfs)	19															
Valley Slope (ft/ft)	---															
Channel Thalweg Length (ft)	1,134															
Sinuosity	1.01															
Bankfull/Channel Slope (ft/ft)	0.0660															

[1]Pattern data is not applicable for A-type and B-type channels

[2]MY1-MY7 Bank Height Ratio is calculated based on the As-built (MY0) cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document provided by the NCIRT and NCDMS (9/2018). The remainder of the cross-section dimension parameters were calculated based on the current low bank height.

SC: Silt/Clay <0.062 mm diameter particles

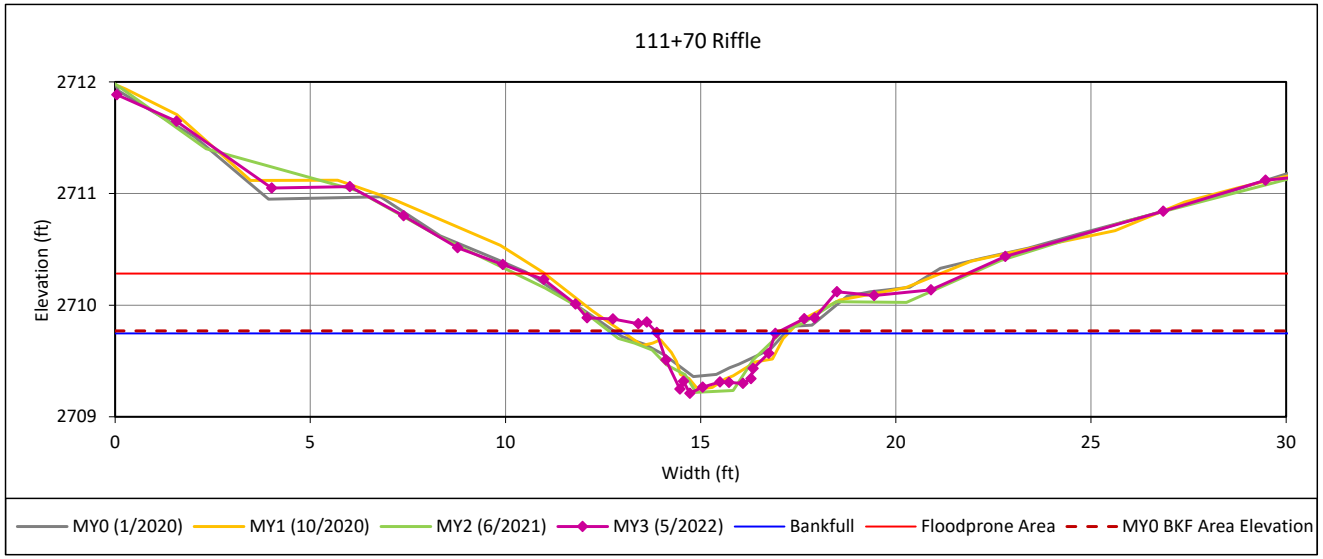
(---): Data was not provided

N/A: Not Applicable

Cross-Section Plots

Shake Rag Mitigation Site
NCDMS Project No. 100018
Monitoring Year 4 - 2023

Cross-Section 1-UT1 Reach 2



Bankfull Dimensions	
1.1	x-section area (ft.sq.)
3.0	width (ft)
0.4	mean depth (ft)
0.5	max depth (ft)
3.4	wetted perimeter (ft)
0.3	hydraulic radius (ft)
8.1	width-depth ratio
11.3	W flood prone area (ft)
3.7	entrenchment ratio
1.0	low bank height ratio

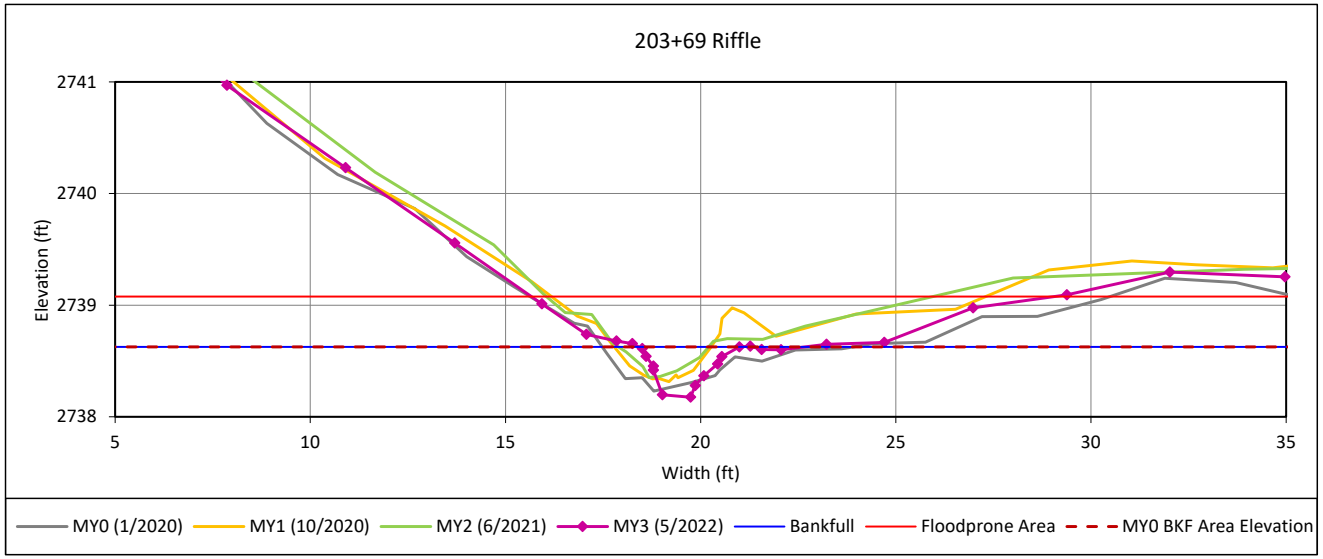
Survey Date: 5/2022
Field Crew: Wildlands Engineering

View Downstream

Cross-Section Plots

Shake Rag Mitigation Site
NCDMS Project No. 100018
Monitoring Year 4 - 2023

Cross-Section 2-UT2 Reach 2



Bankfull Dimensions	
0.6	x-section area (ft.sq.)
2.6	width (ft)
0.2	mean depth (ft)
0.5	max depth (ft)
2.8	wetted perimeter (ft)
0.2	hydraulic radius (ft)
10.4	width-depth ratio
13.4	W flood prone area (ft)
5.2	entrenchment ratio
1.0	low bank height ratio

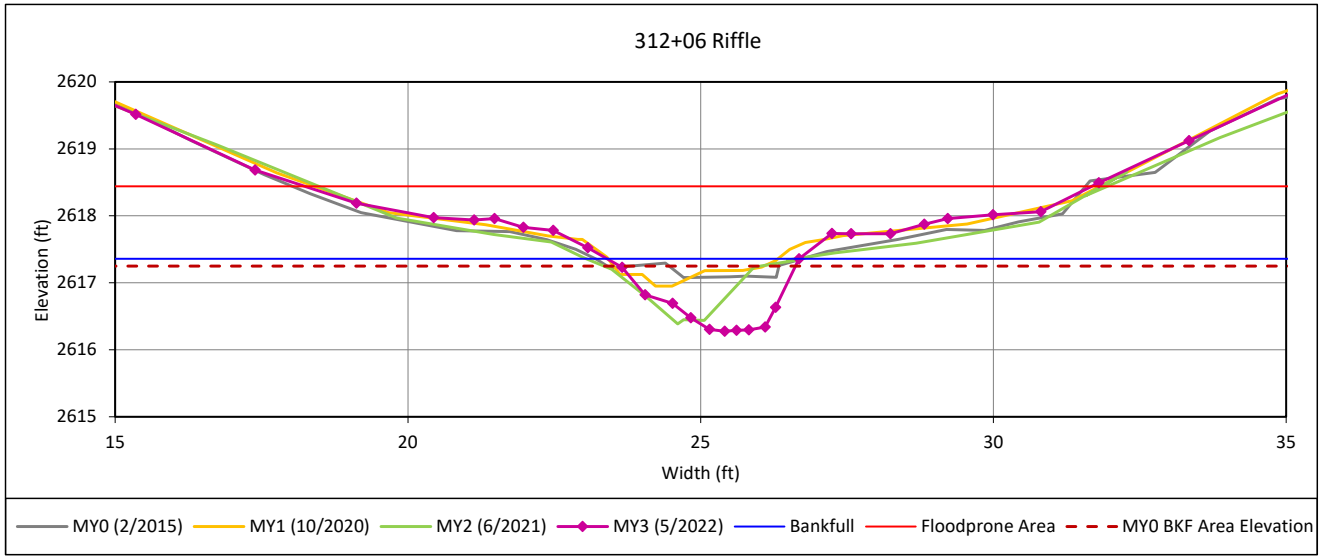
Survey Date: 5/2022
Field Crew: Wildlands Engineering

View Downstream

Cross-Section Plots

Shake Rag Mitigation Site
NCDMS Project No. 100018
Monitoring Year 4 - 2023

Cross-Section 3-UT3 Reach 2



Bankfull Dimensions	
2.3	x-section area (ft.sq.)
3.3	width (ft)
0.7	mean depth (ft)
1.1	max depth (ft)
4.2	wetted perimeter (ft)
0.5	hydraulic radius (ft)
4.7	width-depth ratio
13.4	W flood prone area (ft)
4.1	entrenchment ratio
1.1	low bank height ratio

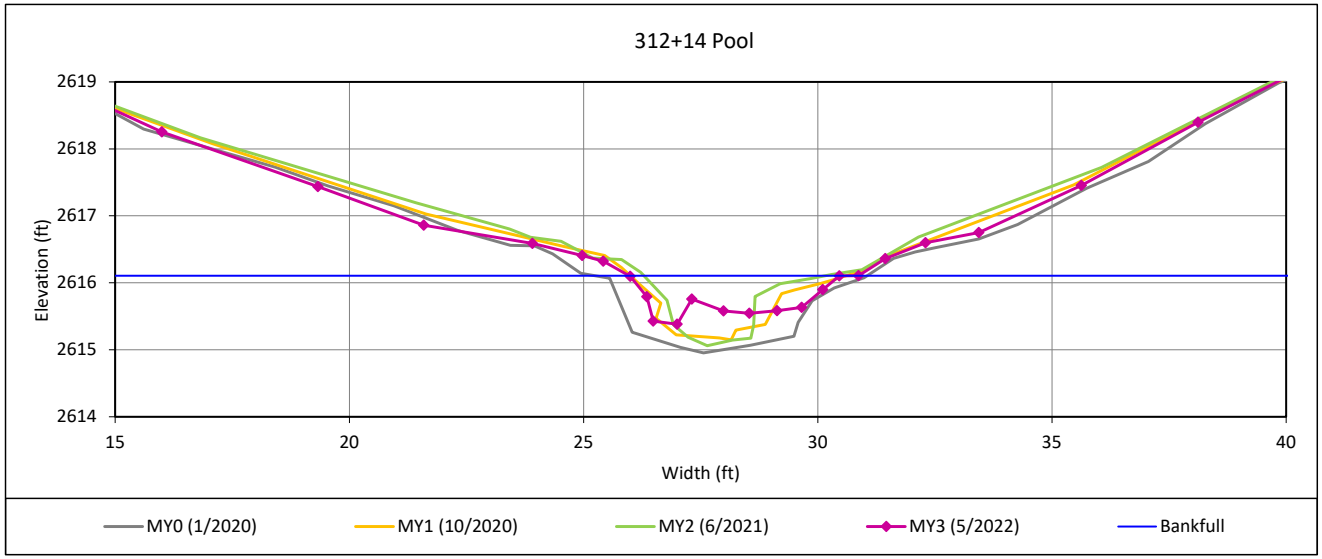
Survey Date: 5/2022
Field Crew: Wildlands Engineering
Note: Survey captures MY3 repairs with current low top of bank

View Downstream

Cross-Section Plots

Shake Rag Mitigation Site
NCDMS Project No. 100018
Monitoring Year 4 - 2023

Cross-Section 4-UT3 Reach 2



Bankfull Dimensions	
2.0	x-section area (ft.sq.)
4.5	width (ft)
0.4	mean depth (ft)
0.7	max depth (ft)
5.2	wetted perimeter (ft)
0.4	hydraulic radius (ft)
10.0	width-depth ratio

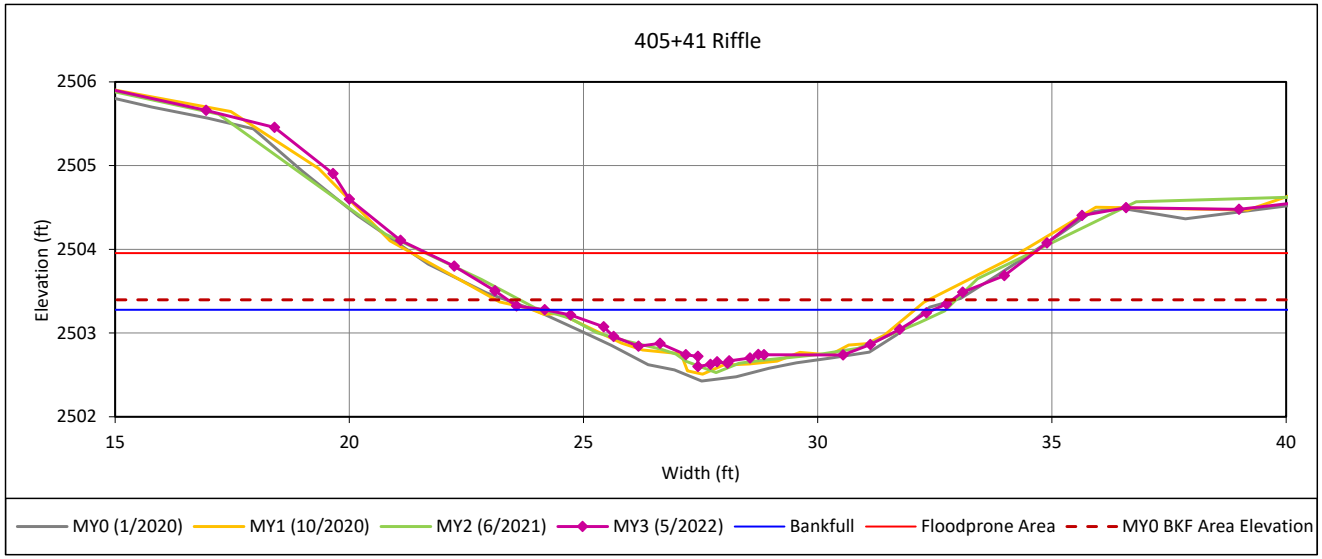
Survey Date: 5/2022
Field Crew: Wildlands Engineering

View Downstream

Cross-Section Plots

Shake Rag Mitigation Site
NCDMS Project No. 100018
Monitoring Year 4 - 2023

Cross-Section 5-UT4



Bankfull Dimensions	
3.3	x-section area (ft.sq.)
8.3	width (ft)
0.4	mean depth (ft)
0.7	max depth (ft)
8.6	wetted perimeter (ft)
0.4	hydraulic radius (ft)
21.0	width-depth ratio
12.9	W flood prone area (ft)
1.6	entrenchment ratio
0.9	low bank height ratio

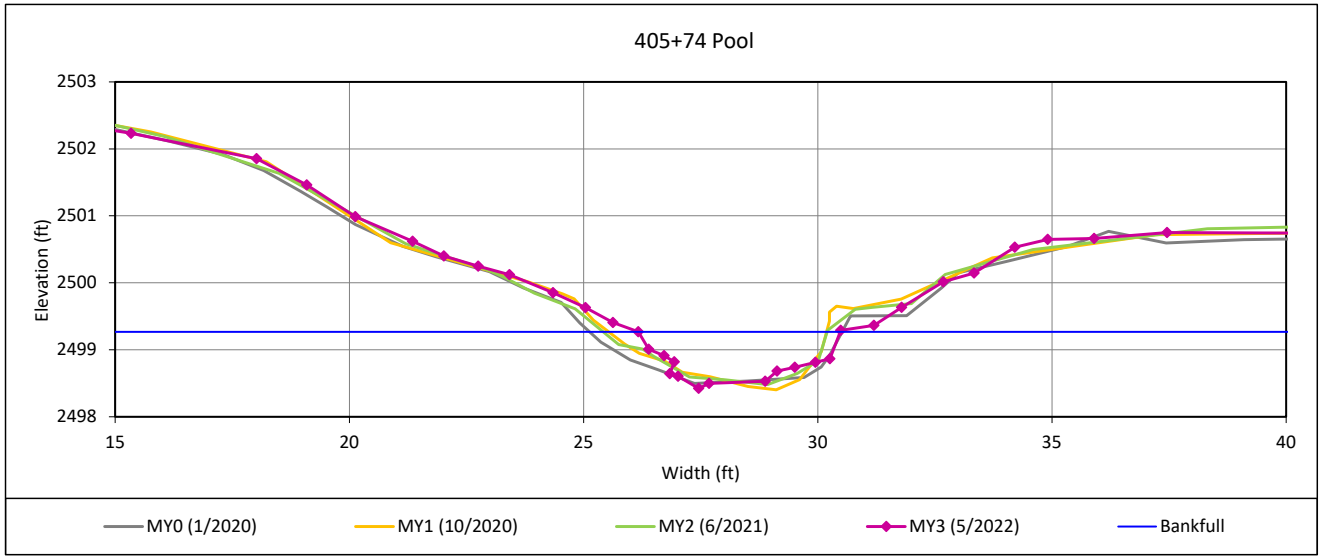
Survey Date: 5/2022
Field Crew: Wildlands Engineering

View Downstream

Cross-Section Plots

Shake Rag Mitigation Site
NCDMS Project No. 100018
Monitoring Year 4 - 2023

Cross-Section 6-UT4



Bankfull Dimensions	
2.5	x-section area (ft.sq.)
4.3	width (ft)
0.6	mean depth (ft)
0.8	max depth (ft)
5.1	wetted perimeter (ft)
0.5	hydraulic radius (ft)
7.5	width-depth ratio

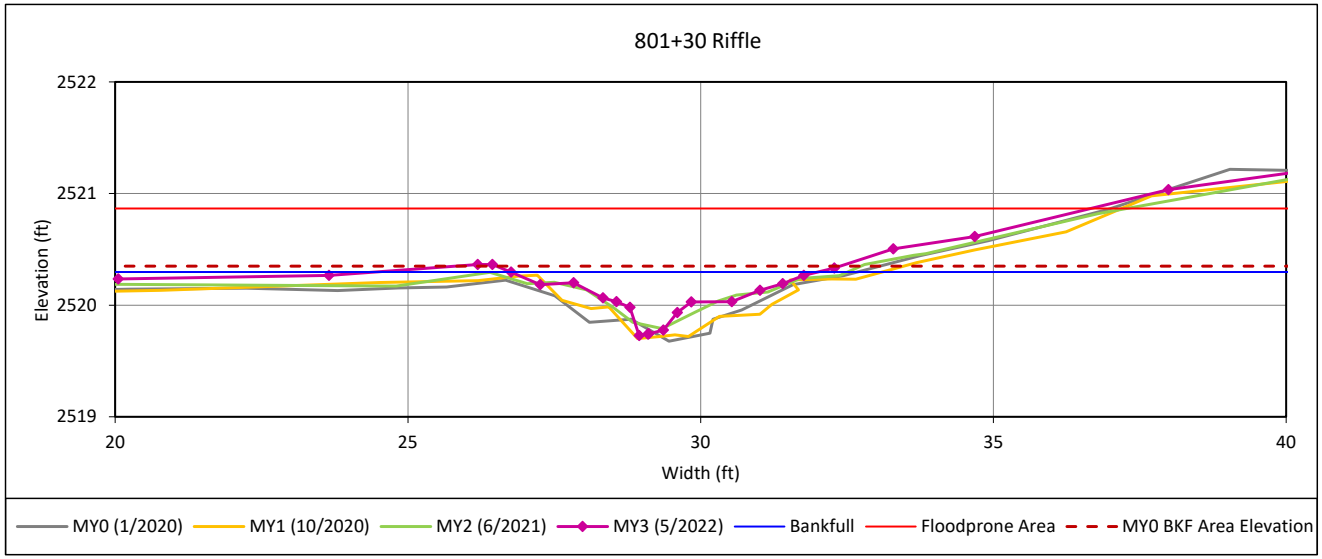
Survey Date: 5/2022
Field Crew: Wildlands Engineering

View Downstream

Cross-Section Plots

Shake Rag Mitigation Site
NCDMS Project No. 100018
Monitoring Year 4 - 2023

Cross-Section 7-UT8



Bankfull Dimensions	
1.1	x-section area (ft.sq.)
5.2	width (ft)
0.2	mean depth (ft)
0.6	max depth (ft)
5.5	wetted perimeter (ft)
0.2	hydraulic radius (ft)
24.1	width-depth ratio
36.7	W flood prone area (ft)
7.0	entrenchment ratio
0.9	low bank height ratio

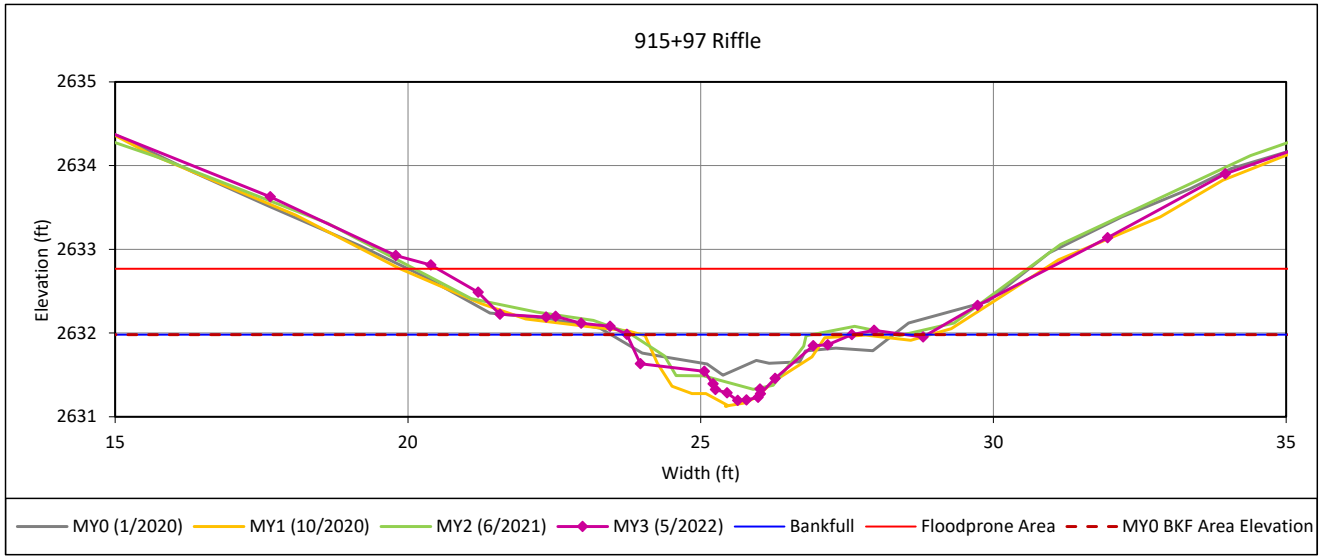
Survey Date: 5/2022
Field Crew: Wildlands Engineering

View Downstream

Cross-Section Plots

Shake Rag Mitigation Site
NCDMS Project No. 100018
Monitoring Year 4 - 2023

Cross-Section 8-Shake Rag Branch Reach 3



Bankfull Dimensions	
1.6	x-section area (ft.sq.)
3.8	width (ft)
0.4	mean depth (ft)
0.8	max depth (ft)
4.5	wetted perimeter (ft)
0.3	hydraulic radius (ft)
9.4	width-depth ratio
10.4	W flood prone area (ft)
2.7	entrenchment ratio
1.0	low bank height ratio

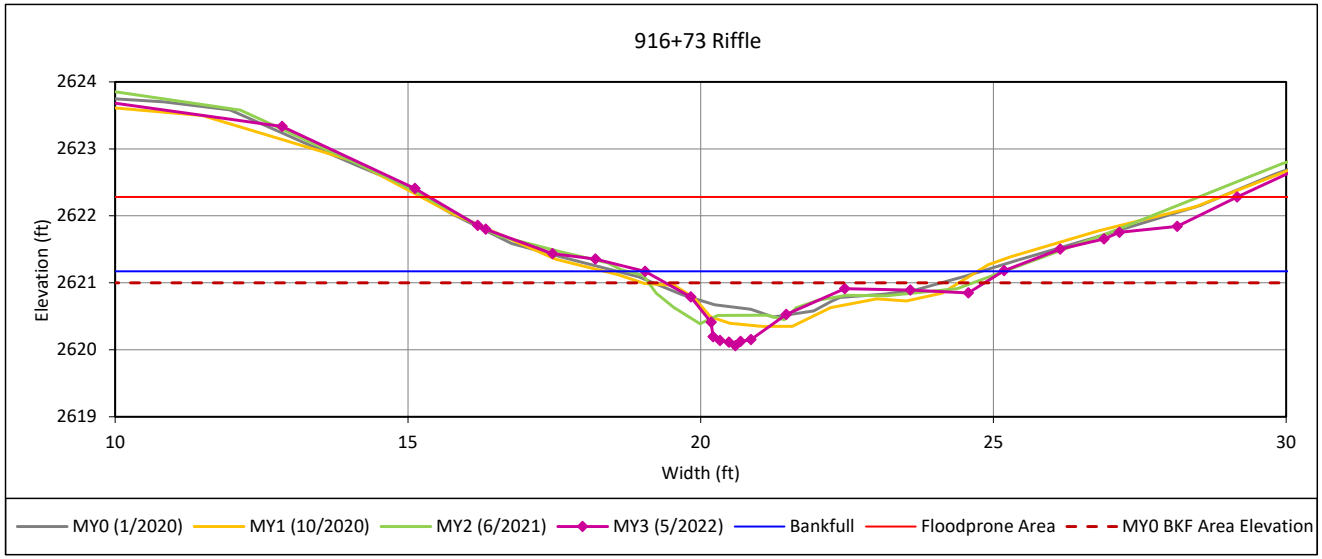
Survey Date: 5/2022
Field Crew: Wildlands Engineering

View Downstream

Cross-Section Plots

Shake Rag Mitigation Site
NCDMS Project No. 100018
Monitoring Year 4 - 2023

Cross-Section 9-Shake Rag Branch Reach 3



Bankfull Dimensions	
2.7	x-section area (ft.sq.)
6.1	width (ft)
0.4	mean depth (ft)
1.1	max depth (ft)
6.9	wetted perimeter (ft)
0.4	hydraulic radius (ft)
13.8	width-depth ratio
13.8	W flood prone area (ft)
2.3	entrenchment ratio
1.2	low bank height ratio

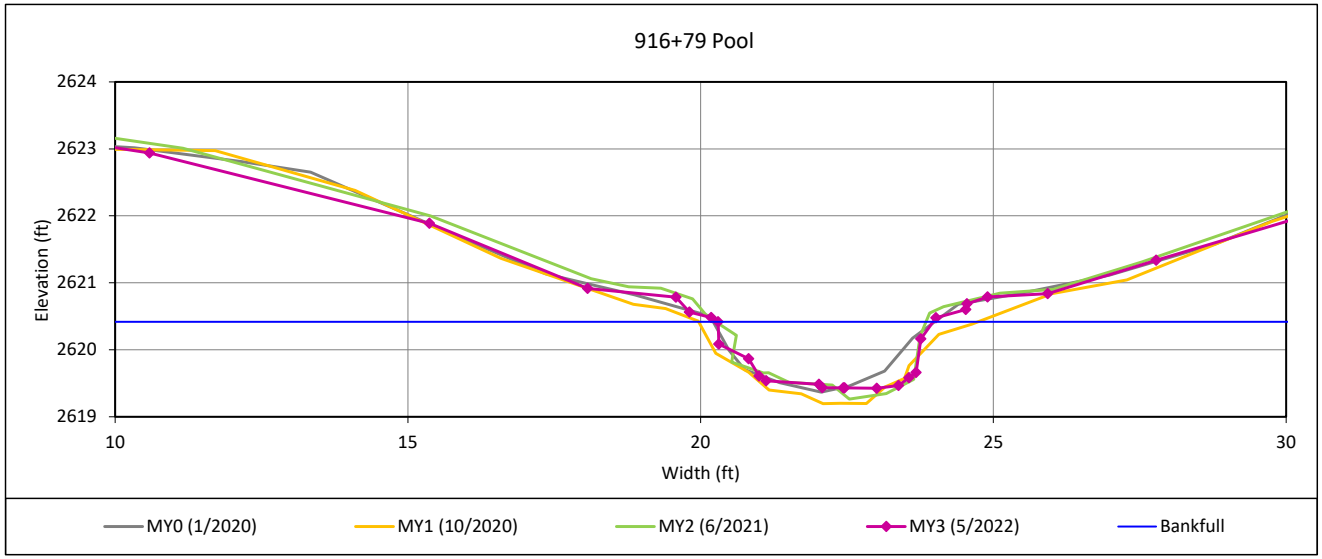
Survey Date: 5/2022
Field Crew: Wildlands Engineering

View Downstream

Cross-Section Plots

Shake Rag Mitigation Site
NCDMS Project No. 100018
Monitoring Year 4 - 2023

Cross-Section 10-Shake Rag Branch Reach 3



Bankfull Dimensions	
2.9	x-section area (ft.sq.)
3.7	width (ft)
0.8	mean depth (ft)
1.0	max depth (ft)
4.8	wetted perimeter (ft)
0.6	hydraulic radius (ft)
4.6	width-depth ratio

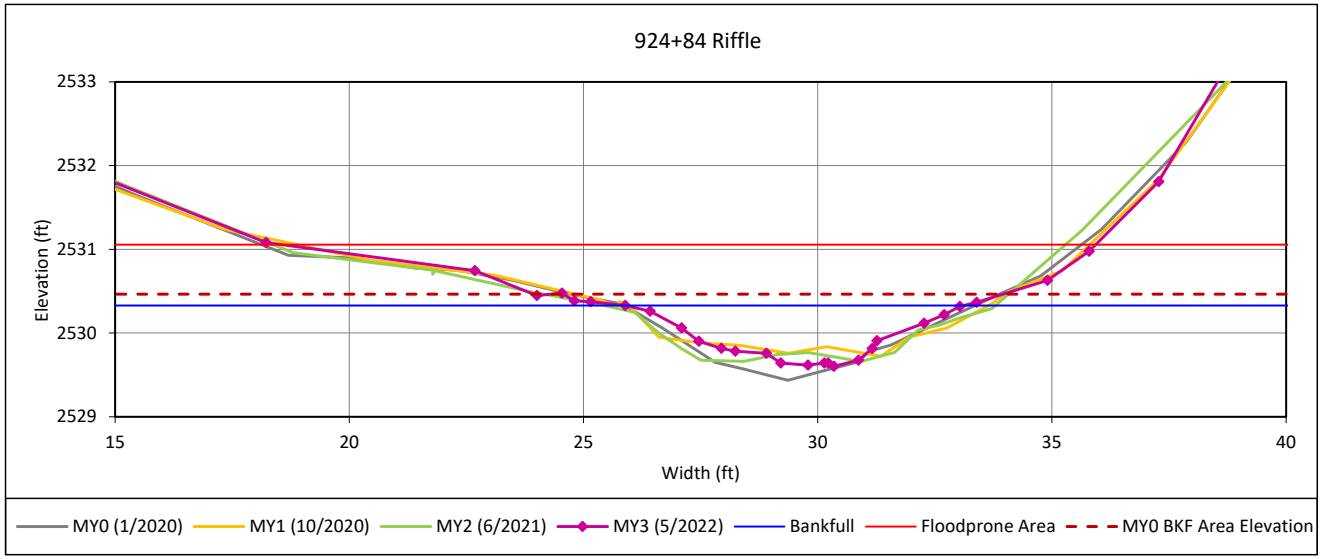
Survey Date: 5/2022
Field Crew: Wildlands Engineering

View Downstream

Cross-Section Plots

Shake Rag Mitigation Site
NCDMS Project No. 100018
Monitoring Year 4 - 2023

Cross-Section 11-Shake Rag Branch Reach 4



Bankfull Dimensions	
3.0	x-section area (ft.sq.)
7.1	width (ft)
0.4	mean depth (ft)
0.7	max depth (ft)
7.4	wetted perimeter (ft)
0.4	hydraulic radius (ft)
17.1	width-depth ratio
17.4	W flood prone area (ft)
2.4	entrenchment ratio
0.8	low bank height ratio

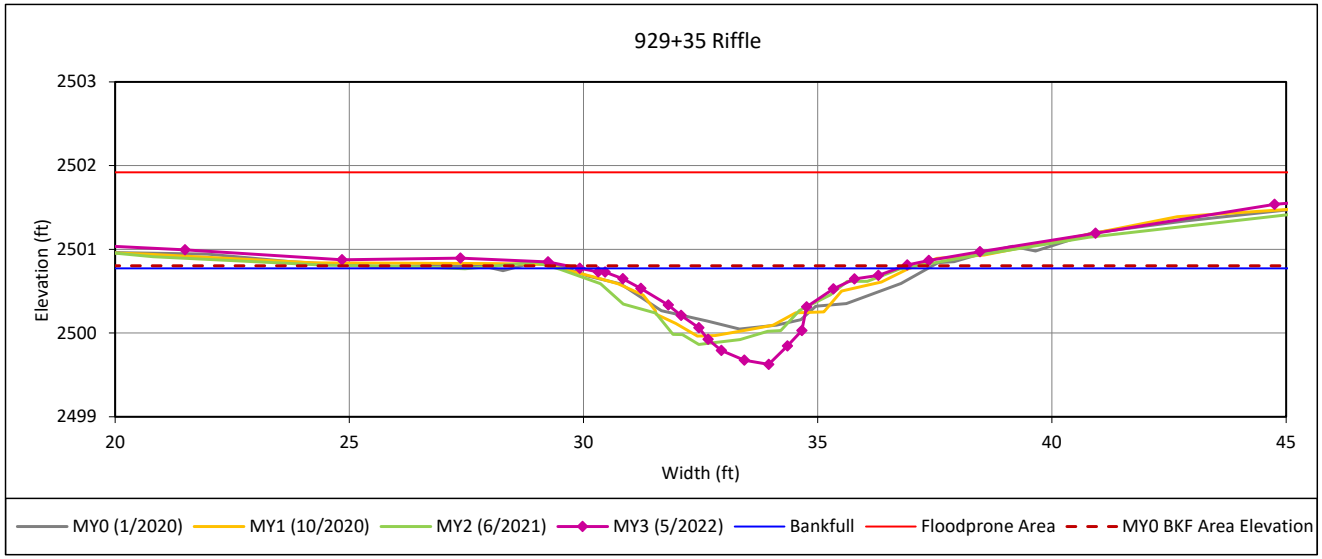
Survey Date: 5/2022
Field Crew: Wildlands Engineering

View Downstream

Cross-Section Plots

Shake Rag Mitigation Site
NCDMS Project No. 100018
Monitoring Year 4 - 2023

Cross-Section 12-Shake Rag Branch Reach 5



Bankfull Dimensions	
3.3	x-section area (ft.sq.)
6.8	width (ft)
0.5	mean depth (ft)
1.1	max depth (ft)
7.4	wetted perimeter (ft)
0.4	hydraulic radius (ft)
14.0	width-depth ratio
51.9	W flood prone area (ft)
7.6	entrenchment ratio
1.0	low bank height ratio

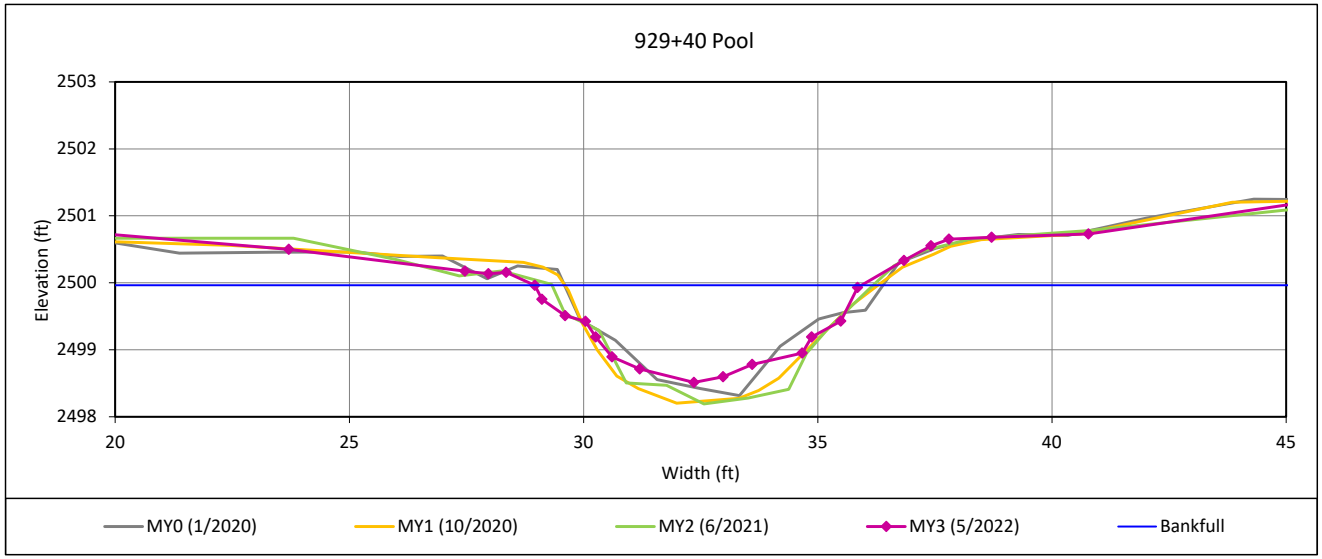
Survey Date: 5/2022
Field Crew: Wildlands Engineering

View Downstream

Cross-Section Plots

Shake Rag Mitigation Site
NCDMS Project No. 100018
Monitoring Year 4 - 2023

Cross-Section 13-Shake Rag Branch Reach 5



Bankfull Dimensions	
6.6	x-section area (ft.sq.)
7.0	width (ft)
1.0	mean depth (ft)
1.5	max depth (ft)
7.9	wetted perimeter (ft)
0.8	hydraulic radius (ft)
7.3	width-depth ratio

Survey Date: 5/2022
Field Crew: Wildlands Engineering

View Downstream

APPENDIX 5. Hydrology Summary Data and Plots

Table 14. Verification of Bankfull Events

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Reach	MY	Date of Occurrence	Date of Data Collection	Method
UT1 Reach 2	MY1	2/13/2020	2/13/2020	Crest Gage
		4/13/2020	4/13/2020	
	MY2	7/19/2021	7/19/2021	
		8/18/2021	8/18/2021	
	MY3	7/10/2022	7/10/2022	
UT2 Reach 2	MY1	2/6/2020	2/6/2020	
	MY2	7/19/2021	7/19/2021	
		8/13/2021	8/13/2021	
		8/17/2021	8/17/2021	
		10/8/2021	10/8/2021	
	MY3	5/27/2022	5/27/2022	
		6/15/2022	6/15/2022	
		7/10/2022	7/10/2022	
		9/12/2022	9/12/2022	
	MY4	8/4/2023 - 8/15/2023 [2]	8/14/2023	
		9/9/2023	9/9/2023	
UT3 Reach 2	MY2	7/19/2021	8/9/2021	Debris Wracklines[1]
UT4	MY2	7/19/2021	7/19/2021	Crest Gage
		8/7/2021	8/7/2021	
		8/17/2021	8/17/2021	
		10/8/2021	10/8/2021	
	MY3	5/27/2022	5/27/2022	
		7/10/2022	7/10/2022	
	MY4	1/4/2023	1/4/2023	
		2/17/2023	2/17/2023	
Shake Rag Branch Reach 5	MY2	7/19/2021	8/9/2021	Debris Wracklines[1]
	MY3	7/10/2022	7/10/2022	Crest Gage
	MY4	8/4/2023	8/4/2023	

[1]Photo documentation of debris wracklines are included in the electronic support files

[2]Multiple bankfull events recorded within these dates

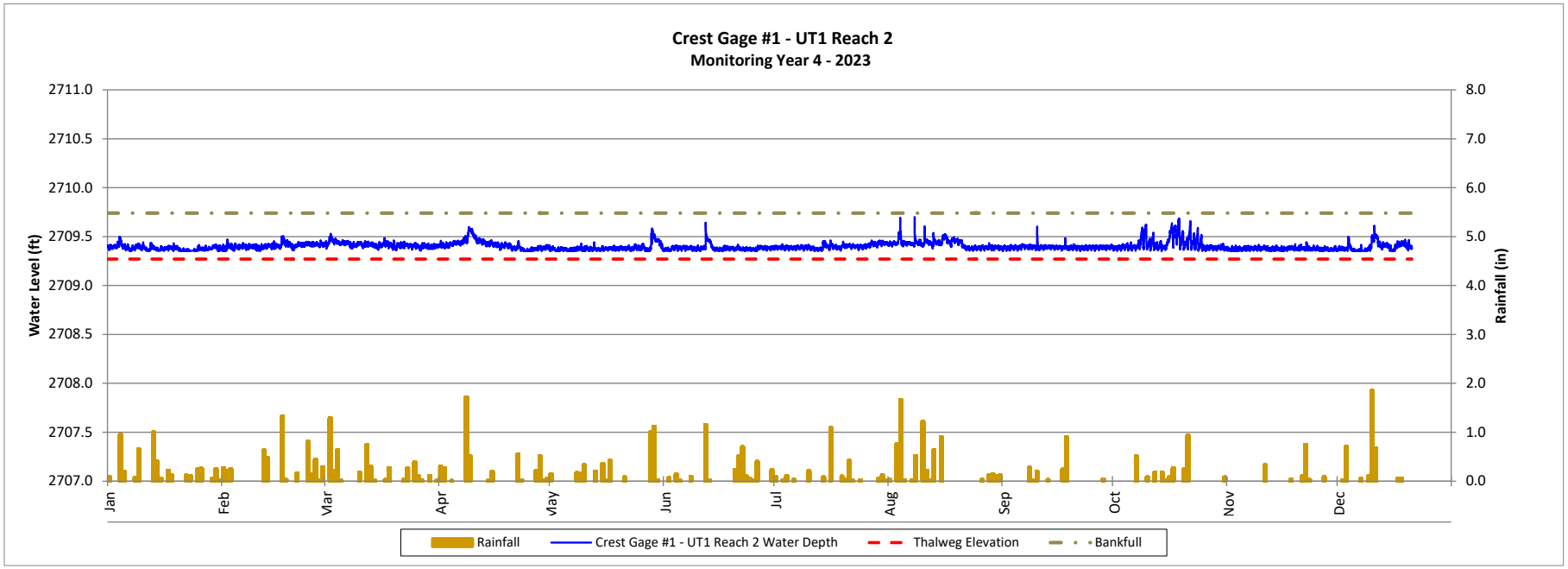
Table 15. Verification of Consecutive Flow Days

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Reach	MY	Date of Occurrence	Maximum Consecutive Days of Stream Flow	Method
UT8	MY1	1/1/2020 - 10/16/2020	289 days	Stream Gage
	MY2	1/1/2021 - 10/20/2021	292 days	
	MY3	1/1/2022 - 10/11/2022	284 days	
	MY4	1/1/2023 - 12/20/2023	353 days	

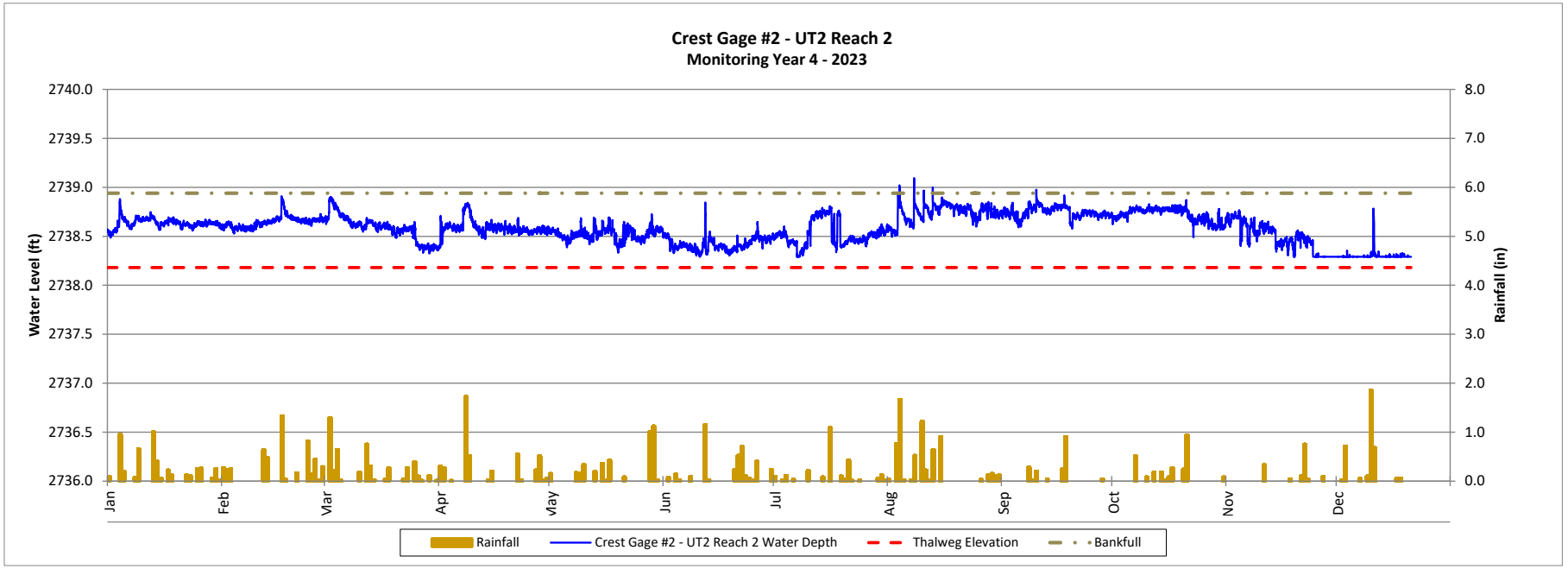
Stream and Crest Gage Plots

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023



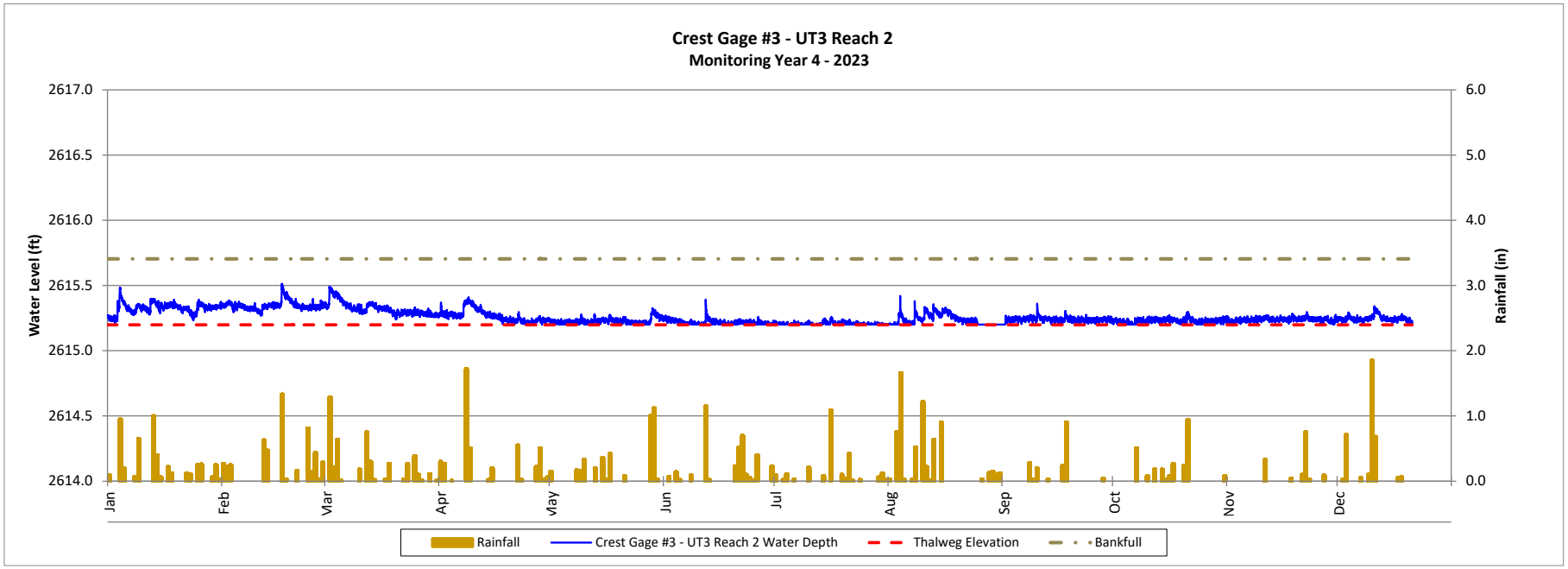
Stream and Crest Gage Plots

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023



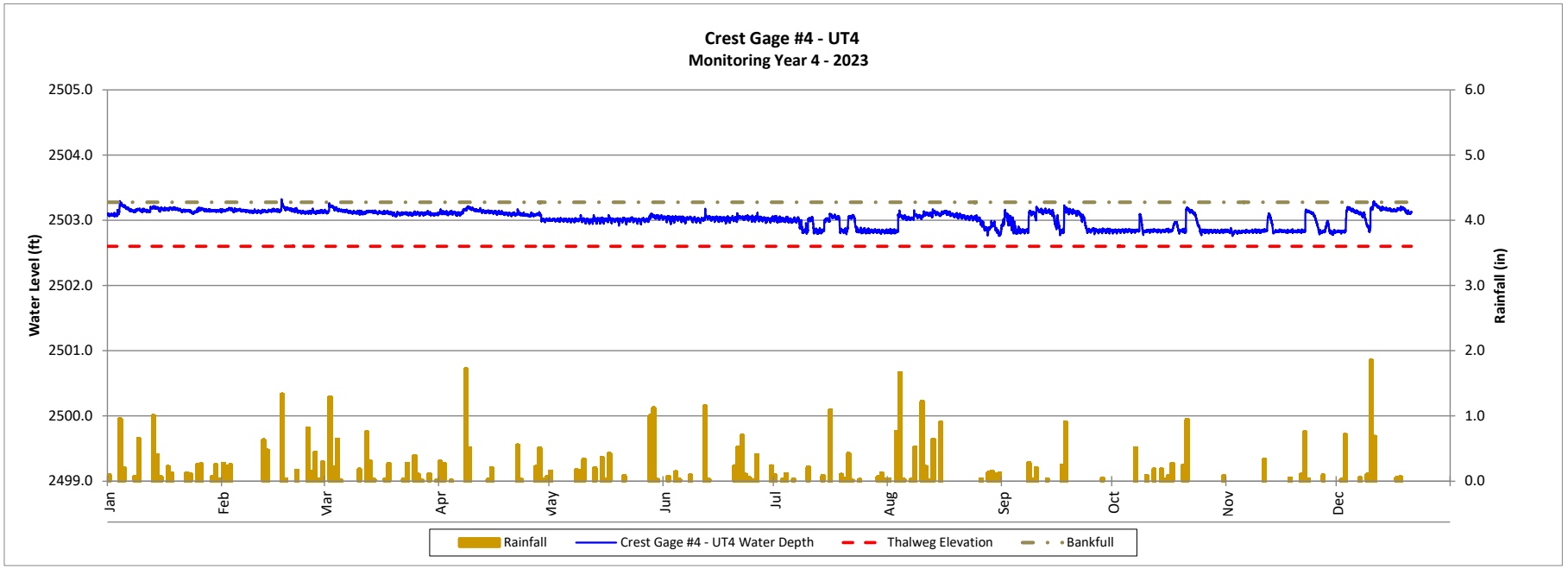
Stream and Crest Gage Plots

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023



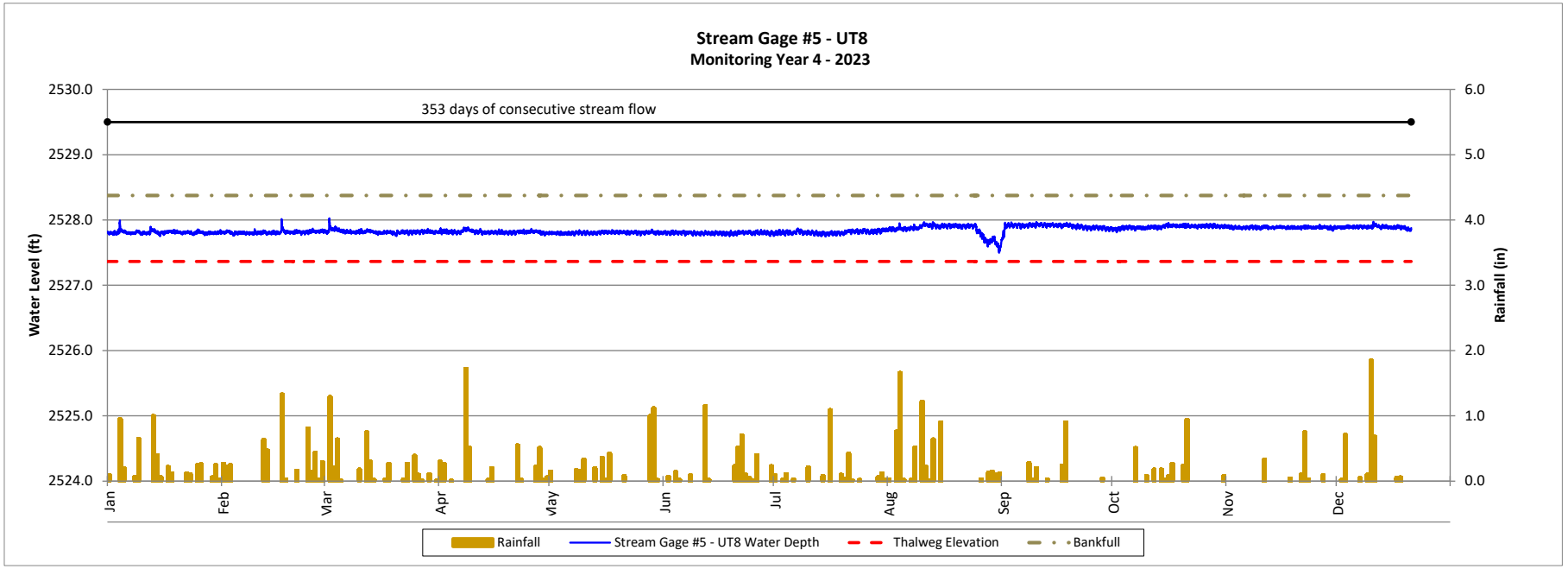
Stream and Crest Gage Plots

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023



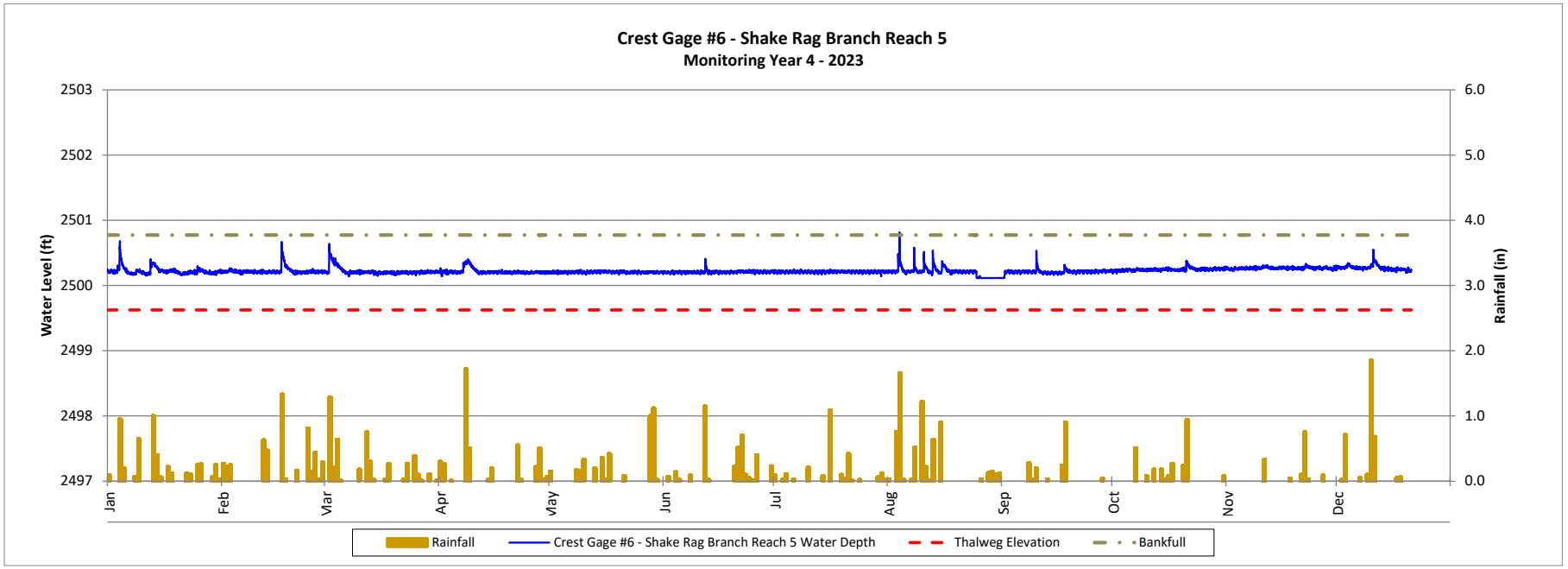
Stream and Crest Gage Plots

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023



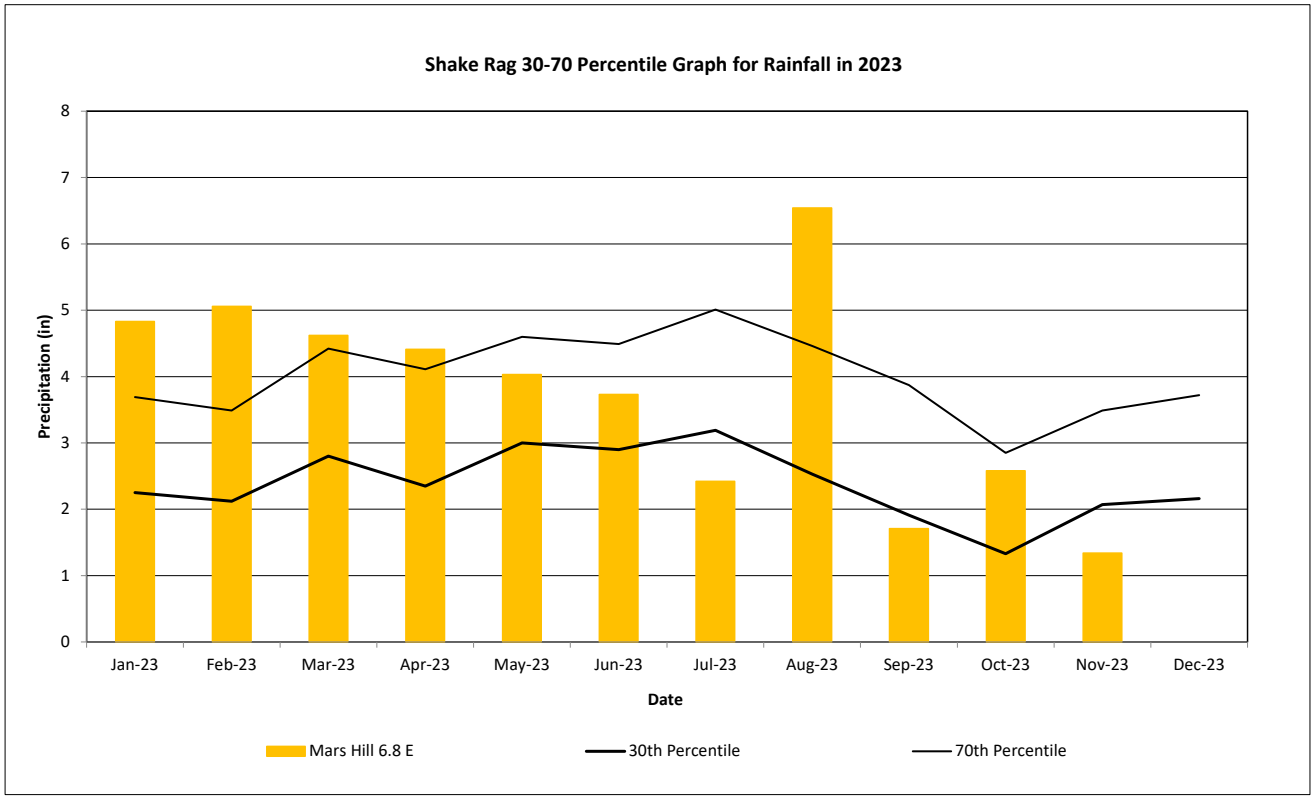
Stream and Crest Gage Plots

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023



Monthly Rainfall Data

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023



2023 rainfall collected by NC CRONOS Station, Mars Hill 6.8 E (located about 5 miles from the Site)
30th and 70th percentile rainfall data collected from WETS station Marshall, NC

APPENDIX 6. Additional Data

Table 16. Stream Repairs Status
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 4 - 2023

Reach	Station	Length (LF)	Issue mapped on MY2 (2021) CCPV	Description	MY3 (2022) Management Action	MY4 (2023) Status
UT1 Reach 2	112+00	N/A	Headcut/downcutting	Structure[1] dislodged	Reset structure boulder	Bed stable; some minor scour on bank
UT3 Reach 2	306+00	N/A	Headcut/downcutting	Structure[1] piping	Reset downstream structure	Structure is stable
	307+75	10	Bank instability	Flow on side of riffle	Regrade bank, recompact riffle material against bank	Bank revegetating and stable
	309+90	N/A	Headcut/downcutting	Riffle/structure[1] piping at head	Reset head of riffle	Riffle functioning as designed
	310+85	5	Bank instability	Minor scour	Stabilize isolated bank scour	Bank revegetating and stable
	311+25	N/A	Headcut/downcutting	Riffle material shift	Reset head of riffle, regrade bank	Bank revegetating and stable; Riffle functioning as designed
	311+75	N/A	Headcut/downcutting	Riffle material shift	Build new drop to replace eroded riffle	Structure is stable
	312+00	20	Bed instability	Flow under stone	Repair head of riffle and add substrate material	Riffle functioning as designed
	312+30	N/A	Headcut/downcutting	Riffle material shift	Add boulder footer to drop	Structure is stable
	312+70	N/A	Headcut/downcutting	Structure[1] piping	Reconstruct downstream structure, stabilize bank	Bank revegetating and stable; Riffle functioning as designed
	313+25	5	Bank instability	Minor erosion	Hand work, monitor	Bank revegetating and stable
	314+60	N/A	Headcut/downcutting	Riffle eroded	Drop ok, add splash rock by hand, monitor	Structure is stable
Shake Rag Reach 3	921+50	25	Bed instability	Structure[1] piping with bank erosion	Rebuild structures, stabilize bank	Bank revegetating; Structures are stable
	921+75	10	Bank instability			
	922+15	10	Bank instability	Minor piping right side of structure	Plug pipping structure, stabilize bank	Bank revegetating; Structure is stable
	922+50	N/A	Headcut/downcutting	Riffle material shift	Add splash rock/footer stone, regrade bank	Bank revegetating; Riffle functioning
	922+90	N/A	Headcut/downcutting	Riffle material shift	Add splash rock/footer stone, regrade bank	Bank revegetating; Riffle functioning
Shake Rag Reach 4	923+75	20	Deposition	Sediment deposition – natural valley slope break	Monitor	No longer an issue; Channel mobilized sediment
	924+00	20	Bank instability	Minor toe erosion	Stabilize bank	Bank revegetating and stable
Shake Rag Reach 5	937+75	N/A	Structure issue	Structure dislodged	Hand work, monitor	Structure is stable
UT4	400+25	N/A	Structure issue	Structure pipping	Plug pipping structure	Structure is stable
	404+25	N/A	Headcut/downcutting	Piping under repair	Plug with handwork/monitor	Structure is stable

[1] Encompassed within a cascading riffle feature, as displayed on the Shake Rag Record Drawings from as-built (4/3/2020).
Not applicable (N/A): Lengths not associated with instances (points)

MEETING NOTES

MEETING:	MY4 IRT Site Walk **SHAKE RAG Mitigation Site** French Broad 06010105; Madison County, NC DEQ Contract No. 7190 DMS Project No. 100018 USACE Action ID: SAW-2017-01570 DWR Project #: 2017-1157v1 Wildlands Project No. 005-02164
DATE:	*On-site Meeting*: Thursday, June 22, 2023 *Meeting Notes Distributed*: Wednesday, June 28, 2023
LOCATION:	Shake Rag Rd Mars Hill, NC

Attendees

Steve Kichefski, USACE	Maria Polizzi, DWR	Jake McLean, Wildlands
Erin Davis, USACE	Paul Wiesner, DMS	Joe Lovenshimer, Wildlands
Andrea Leslie, NCWRC	Harry Tsomides, DMS	Mimi Caddell, Wildlands
Mac Haupt, DWR	Matthew Reid, DMS	

Meeting Notes

The meeting began around 1pm. Maps and a brief overview of the project were presented by Wildlands and DMS at the parking area along the farm road near the downstream culvert crossing on Shake Rag Branch. From there, the group proceeded to walk the site with the goal to see representative portions of the project.

1. Paul asked Wildlands to describe any concerns they have about the project. Wildlands responded that though the site has demonstrated good stem density, the tree height has lagged for which the main cause appears to be deer browse and some competition with herbaceous vegetation. Joe described actions that the Wildlands stewardship team has taken to boost growth and give the stems a competitive advantage by adding soil amendments and repellex tablets, and conducting ring sprays in areas of dense tall fescue. Jake also asserted that there were some lessons learned in regard to managing pasture grasses during construction that has been improved upon for newer projects.
2. Another concern that was discussed was the encroachments that have occurred along the unfenced portions of the lower conservation easement boundary. Wildlands confirmed that the mowing encroachments documented in the MY3 (2022) monitoring report have been resolved by adding posts and communicating with the landowner. Jake and Matthew described additional encroachments that were first observed in January 2023 due to landowner waterline activities that caused some disturbance

of the vegetation within the portion of the UT4 easement adjacent to the farm road. Joe described actions taken to resolve the new encroachments which included reseeding and replanting container trees in those areas. The waterline, an overflow line from an upslope spring box, was redirected into the adjacent easement break near the culvert crossing (outside of the CE). Wildlands has had several successful discussions with the landowner to emphasize the importance of not disturbing any part of the conservation easement. Mimi confirmed that this will be documented in the MY4 (2023) monitoring report.

3. The group then walked to the UT4 crossing to observe where the new encroachments occurred and view the improvement in vegetation.
4. Continuing up the valley along the UT4, IRT members observed several examples of successful ring sprays with no collateral damage to the planted stems. It was noted that though some of the planted stems are small, they are healthy and showing signs of vigorous new growth this year.
5. The group walked up to the jurisdictional start of UT4 where baseflow was observed. IRT members noted some discontinuous flow under larger rock structures, but the stream was not exhibiting stability issues. Mac asked if the stream was monitored for flow. Mimi responded that since it is classified as perennial, there was no required monitoring for continuous flow and that there is a gage located downstream used to document bankfull events.
6. The group then walked back towards the lower Shake Rag Branch crossing and up the main stem's valley to the UT3 confluence. On the way, the group noted liking the large culverts and also the wetland area in the vicinity of UT8. Jake described the repairs that occurred in April 2022 to address several localized instances of dislodged, piping structures and shifted riffle material. The repairs were observed to be functioning with some flow going under a few structures. IRT members asked about reasons for the damage. Wildlands described that large storms and tropical depressions that had come through the region during MY1 and MY2. Jake added that the substrate material size class used during construction that was harvested on site was variable and sometimes lacked mid-range size classes that may have aided in embedding the cascade riffle structures and that it could have been helpful to import material during construction.
7. Continuing up UT3, improvements in herbaceous coverage were observed near VP2. Joe described stewardship efforts which consisted of reseeding with a cover crop mixes for the last three seasons and spraying the area with compost tea beginning this year.
8. IRT members expressed interest in seeing a representative example of a steep headwater stream where no restoration work was done. The group decided to walk up to the upper reaches of Shake Rag Branch to view a reference condition for the site where seasonal flow conditions could be observed. Andrea brought up the topic of aquatic organism passage and whether some discontinuity of flow is a habitat issue for these headwater systems. Steve added that there is difficulty in determining the best design approach depending on the slope and drainage area for first order streams. Jake described some lessons learned working on steep headwater tributaries to utilize in the future such as limiting the number of pools and importing material with a better size class variety.
9. Walking back down Shake Rag Branch Reach 2, Wildlands noted the successful treatment of previously dense pockets of invasive species including tree of heaven (*Ailanthus altissima*) and multiflora rose (*Rosa multiflora*).
10. The group walked back to the parking area and circled up to summarize the main discussion points during the site walk.

a. Steve was overall pleased with the site and though the low seasonal flow resulting in seeping under steep structure drops may be a habitat issue, it does not seem to be a stability issue. He indicated that he did not see a need to require any intervention scheme. (As a side note, Wildlands does do some minor handwork when piping issues are identified and thought to be due to construction related issues and not just low summertime flows).
b. Erin requested that Wildlands be sure to document all the management actions done to address low stem heights in monitoring reports and was pleased with the progress of efforts to address prior conservation easement encroachments.
c. Paul requested that Wildlands continue to document encroachment issues and keep a log of communications with the landowner regarding easement compliance discussions. This will allow for an easier transfer to DEQ stewardship when the history of the site is well documented. Paul also noted that it is preferable for these communications to remain internal between Wildlands and the landowner before needing to involve DMS.
d. Andrea had left and was not present for summary discussion.

The meeting concluded at 3:30 PM.

All Attendees listed have been copied by email. These meeting minutes were prepared by Mimi Caddell and reviewed by Jake McLean and Joe Lovenshimer on June 23, 2023, and represent the authors' interpretation of events.