Mitigation Project Name	Crooked Creek II Stream and Wetland Restoration Site	County	Union	USACE Action ID	2011-02201
DMS ID	94687	Date Project Instituted	12/10/2010	NCDWR Permit No	2012-0064
River Basin	Yadkin	Date Prepared	8/10/2018		
Cataloging Unit	03040105				

Credit Release Milestone	Stream Credits						Wetland Credits							
	Scheduled Releases (Stream)	Warm	Cool	Cold	Anticipated Release Year (Stream)	Actual Release Date (Stream)	Scheduled Releases (Forested)	Riparian Riverine	Riparian Non-riverine	Non-riparian	Scheduled Releases (Coastal)	Coastal	Anticipated Release Year (Wetland)	Actual Release Date (Wetland)
Potential Credits (Mitigation Plan)		3,489.600						8.400						
Potential Credits (As-Built Survey)		3,489.600						8.500						
1 (Site Establishment)	N/A				N/A	N/A	N/A				N/A		N/A	N/A
2 (Year 0 / As-Built)	30%	1,046.880			2016	5/18/2016	30%	2.550			30%		2016	5/18/2016
3 (Year 1 Monitoring)	10%	348.960			2017	8/8/2017	10%	0.850			10%		2017	8/8/2017
4 (Year 2 Monitoring)	5%	174.480			2018	4/25/2018	5%	0.425			15%		2018	4/25/2018
Unreleased credits from 4 (Year 2 Monitoring)*	5%	174.480			2018	Not released	5%	0.425					2018	Not released
5 (Year 3 Monitoring)	10%				2019		10%				20%		2019	
6 (Year 4 Monitoring)	10%				2020		10%				10%		2020	
7 (Year 5 Monitoring)	15%				2021		10%				15%		2021	
8 (Year 6 Monitoring)	N/A				2022		10%				N/A		2022	
9 (Year 7 Monitoring)	N/A				2023		10%				N/A		2023	
Stream Bankfull Standard	15%	523.440			2018	4/25/2018	N/A				N/A			
Total Credits Released to Date		2,093.760						3.825						

*NOTE: IRT concerned about hydrology and vegetation success concerns decided to hold 1/2 of the stream and wetland credits for Year 2 Monitoring. 5% of the stream and wetland credits was released.

DEBITS (released credits only)

			Ratios	1	1.5	2.5	5	1	3	2	5	1	3	2	5	1	3	2	5
				Stream Restoration	Stream Enhancement I	Stream Enhancement II	Stream Preservation	Riparian Restoration	Riparian Creation	Riparian Enhancement	Riparian Preservation	Nonriparian Restoration	Nonriparian Creation	Nonriparian Enhancement	Nonriparian Preservation	Coastal Marsh Restoration	Coastal Marsh Creation	Coastal Marsh Enhancement	Coastal Marsh Preservation
As-Built Amounts (feet and acres)				1,718.000		4,429.000		6.700	3.900	1.000									
As-Built Amounts (mitigation credits)				1,718.000		1,771.600		6.700	1.300	0.500									
Percentage Released				60%		60%		45%	45%	45%									
Released Amounts (feet / acres)				1,030.800		2,657.400		3.015	1.755	0.450									
Released Amounts (credits)				1,030.800		1,062.960		3.015	0.585	0.225									
NCDWR Permit	USACE Action ID	Project Name																	
2015-0719	2015-01726	NCDOT TIP B-5243		308.000															
2002-0672	2009-00876	NCDOT TIP R-2559 / R-3329 - Monroe Bypass and Connector, Union County						1.190											
2016-0605	2012-00417	NCDOT TIP U-3440 - NC 3 Widening, Cabarrus County		19.200															
	2011-01460	NCDOT TIP U-5608 - Division 9						0.240											
2017-1250	2016-00248	NCDOT TIP P-5704						0.190											
2011-0431	2011-01237	NCDOT TIP R-2123CE - Charlotte Outer Loop						0.790											
2011-0431	2011-01237	NCDOT R-2248E - Charlotte Outer Loop		360.000		1,771.600		0.605	1.755	0.450									
Remaining Amounts (feet / acres)				343.600		885.800		0.000	0.000	0.000									
Remaining Amounts (credits)				343.600		354.320		0.000	0.000	0.000									

Contingencies (if any): None

Signature of Wilmington District Official Approving Credit Release

9/6/18
Date

1 - For NCDMS, no credits are released during the first milestone

2 - For NCDMS projects, the second credit release milestone occurs automatically when the as-built report (baseline monitoring report) has been made available to the NCIRT by posting it to the NCDMS Portal, provided the following criteria have been met:

1) Approval of the final Mitigation Plan
2) Recordation of the preservation mechanism, as well as a title opinion acceptable to the USACE covering the property
3) Completion of all physical and biological improvements to the mitigation site pursuant to the mitigation plan
4) Reciept of necessary DA permit authorization or written DA approval for porjects where DA permit issuance is not required

3 - A 15% reserve of credits is to be held back until the bankfull event performance standard has been met

MONITORING YEAR 3 ANNUAL REPORT

Final

CROOKED CREEK #2 RESTORATION PROJECT

Union County, NC
DEQ Contract 6617
DMS Project Number 94687

Data Collection Period: April – November 2018
Submission Date: December 17, 2018

PREPARED FOR:

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

PREPARED BY:

WILDLANDS
ENGINEERING

1430 South Mint Street, Suite 104
Charlotte, NC 28203

Phone: 704.332.7754
Fax: 704.332.3306

December 17, 2018

Mr. Harry Tsomides
NC Department of Environmental Quality
Division of Mitigation Services
5 Ravenscroft Dr., Suite 102
Asheville, NC 28801

RE: Crooked Creek II Mitigation Site -Year 3 Monitoring Report
Final Submittal for DMS
DMS ID 94687
DEQ Contract Number D09126S
Yadkin Pee-Dee River Basin – CU# 03040105; Union County, NC

Dear Mr. Tsomides:

Wildlands Engineering, Inc. (Wildlands) has reviewed the Division of Mitigation Services (DMS) comments and observations from the Crooked Creek II Mitigation Site Draft Year 3 Monitoring Report. The following are Wildlands responses to your comments and observations from the report noted in italics lettering.

DMS Comment; **Cover Page - Please add the DEQ Contract Number for post-construction site monitoring (6617). The contract number listed (D091326S) is for the construction and not necessary to list.**

Wildlands Response; Wildlands updated the cover page to reflect the DEQ contract number (6617).

DMS Comment; *Section 1.2.1 – Discussion includes warranty plots as meeting interim success criteria; however warranty* plots are performed for DMS to evaluate planting contract work separately, not subject to performance monitoring, and therefore should not be included. As a reminder, warranty counts for 2019 (MY04) are not part of Wildlands' monitoring contract.

Wildlands Response; Wildlands omitted the last sentence regarding the warranty plots.

DMS Comment; Section 1.2.2 – Please indicate that Carolina Silvics has performed additional invasive removal work since Wildlands' MY03 assessment.

Wildlands Response; Wildlands included the requested verbiage.

DMS Comment; Section 1.3 – Please summarize that the MY03 asset reductions were the result of one-sided easement sections at the upper and lower ends of crooked Creek, and a powerline ROW at the upper end of UT1, which had not been adjusted at the as-built stage.

Wildlands Response; Wildlands included the requested verbiage in Section 1.3.

DMS Comment; Table 1 (assets) *Crooked Creek Reaches A and B "Restoration Footage/Acres" should reflect the assets now being* generated (1335 and 2123, respectively).

Wildlands Response; Wildlands updated Table 1 to reflect the correct assets.

DMS Comment; Stream Credits should be reported to the nearest tenth, not thousandth.

Wildlands Response; Wildlands updated the stream credits to the nearest tenth.

DMS Comment; Credits column for Crooked Reach B should be 849.2, not 849.000.

Wildlands Response; Wildlands updated the credits with the correct amount.

DMS Comment; I am calculating Credits summation to be 3,242.2, not 3,442.600. Please verify and correct if necessary.

Wildlands Response; Wildlands corrected the Crooked Creek stationing which corrected the credit summation as 3,242.20.

DMS Comment; *Please add footnote to indicate UT1 crediting starts at the outer edge of the powerline ROW along* Highway 218; Crooked Creek assets have been reduced to account for one-sided easement sections at upstream and downstream ends.

Wildlands Response; Wildlands added a footnote to Table 1 with the requested verbiage.

DMS Comment; CCPVs – If possible, please improve the report format/readability as follows:
Use a stream centerline for Crooked Creek and UT2; the widened orange colors do not accurately represent the stream width; for example, sections of UT appear to be 50 feet wide.

Wildlands Response; Wildlands updated the CCPV maps by inserting a stream centerline for Crooked Creek and UT2.

DMS Comment Add station numbering for Crooked Creek and UT2.

Wildlands Response; Wildlands added station numbers for Crooked Creek and UT2.

DMS Comment Combine Sheets 1 and 2; and sheets 3,4,5; typically a project this size should not have 6 CCPVs to clearly depict monitoring features.

Wildlands Response; Wildlands combined the CCPV maps as requested.

DMS Comment; Table 15 – GW gauge #3 for 2018 indicates 29 consecutive days, above the success criteria of 17 days, however, is noted as "No" (not meeting). Also, if possible, please add a row at the bottom of this table to indicate how many gauges are meeting each year (2/10, 3/10, 4/10, etc.).

Wildlands Response; Wildlands updated the typo in Table 15 to reflect GWG 3 as "Yes" to meeting criteria. Wildlands also included a footnote as requested with the number of GWGs meeting criteria each monitoring year.

DMS Comment; please include a copy of your response letter.

Wildlands Response; Wildlands has included this response letter as part of the final report deliverable.

Enclosed please find four (4) hard copies of the Year 4 Final Monitoring Report and one (1) CD with the final corrected electronic files for DMS distribution. Please contact me at 704-332-7754 x110 if you have any questions.

Sincerely,

Kirsten Y. Gimbert

Kirsten Y. Gimbert
Project Manager
kgimbert@wildlandseng.com

EXECUTIVE SUMMARY

Wildlands Engineering, Inc. (Wildlands) completed a design bid build project at the Crooked Creek #2 Mitigation Site (Site) for the North Carolina Division of Mitigation Services (DMS) to restore and enhance 5,599 linear feet (LF) of perennial streams, enhance 1.0 acre of existing wetlands, restore and create 10.5 acres of wetlands, and restore and enhance 70,936 square feet (SF) of riparian buffer in Union County, NC. The Site is expected to generate 3,242.600 stream mitigation units (SMUs), 8.400 wetland mitigation units (WMUs), and 1.24 buffer mitigation units (BMU) for the Goose Creek watershed (Table 1). The Site is located off NC Highway 218 in the northern portion of Union County, NC in the Yadkin Pee-Dee River Basin; eight-digit Cataloging Unit (CU) 03040105 and the 14-digit Hydrologic Unit Code (HUC) 03040105040010 (Figure 1). The project streams consist of two unnamed tributaries (UT) to Crooked Creek, UT1 and UT2, and two reaches of the Crooked Creek mainstem (Reach A and Reach B) (Figure 2). Crooked Creek flows into the Rocky River 4 miles northeast of the site near Love Mill Road at the Stanly County line. The adjacent land to the streams and wetlands is primarily maintained for agricultural and residential uses.

The Site is within a Targeted Local Watershed (TLW) in the Lower Yadkin Pee-Dee River Basin Restoration Priority Plan (RBRP) (NCEEP, 2009). The Site is also located within the Goose Creek and Crooked Creek Local Watershed Plan (LWP). The final watershed management plan (WMP) for Goose Creek and Crooked Creek was completed in July 2012 (NCEEP, 2012). The stressors to watershed function identified in the WMP were sediment pollution and increases in peak stream flows resulting in impairments to aquatic habitat and aquatic life. Stream enhancement and restoration were identified as the best management opportunities to offset these impacts. Other stressors identified included nonpoint source runoff, degraded terrestrial habitat, and disconnected floodplains. Wetland enhancement and restoration was also identified as a best management opportunity to offset impacts related to these stressors. The wetland portion of the project was identified as a specific priority in the Project Atlas that accompanies the 2012 WMP.

The project goals established in the mitigation plan (Wildlands, 2013) were completed with careful consideration of goals and objectives that were described in the RBRP and to address stressors identified in the LWP. The following project goals established include:

- Improve wetland hydrologic connectivity;
- Decrease sediment input into stream;
- Create appropriate terrestrial habitat;
- Decrease water temperature and increase dissolved oxygen concentrations; and
- Decrease nutrient and adverse chemical levels.

The Site construction and as-built survey was completed in 2015. Planting and baseline monitoring activities occurred in January and February 2016. Monitoring Year (MY) 3 assessments were completed between April and November 2018, to assess the conditions of the site. The average stem density for the Site is 567 stems per acre and is therefore on track to meet the interim Year 5 requirement of 260 stems per acres. A supplemental planting of 1800 containerized 1-to 3-gallon stems were installed January 10,2018 by Carolina Silvics throughout 7.3 acres. Cross-section dimensions appear stable and functioning as designed. Groundwater hydrologic success criteria was achieved in four of the 10 groundwater monitoring gages. At least one bankfull event occurred on all monitored reaches; however, the success criteria for the project had been met in MY2.

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Section 1: PROJECT OVERVIEW

The Crooked Creek #2 Mitigation Site (Site) is located in the Yadkin Pee-Dee River Basin; eight-digit Cataloging Unit (CU) 03040105 and the 14-digit Hydrologic Unit Code (HUC) 03040105040010 (Figure 1). The Site is located off NC Highway 218 in the northern portion of Union County, NC (Figure 1). Located in the Carolina Slate Belt of the Piedmont Physiographic Province (USGS, 1998), the project watershed includes primarily agricultural forested and developed land. The drainage area for the project site is 24,619 acres.

The project streams consist of Crooked Creek and two UTs to Crooked Creek; UT1 and UT2. Stream restoration consists of UT1 and Stream Enhancement consist of UT2 and Crooked Creek.

The Site is within a Targeted Local Watershed (TLW) in the Lower Yadkin Pee-Dee River Basin Restoration Priority Plan (RBRP) (NCEEP, 2009). The Site is also located within the Goose Creek and Crooked Creek Local Watershed Plan (LWP). The final watershed management plan (WMP) for Goose Creek and Crooked Creek was completed in July 2012 (NCEEP, 2012). The stressors to watershed function identified in the WMP were sediment pollution and increases in peak stream flows resulting in impairments to aquatic habitat and aquatic life. Stream enhancement and restoration were identified as the best management opportunities to offset these impacts. Other stressors identified included nonpoint source runoff, degraded terrestrial habitat, and disconnected floodplains. Wetland enhancement and restoration was also identified as a best management opportunity to offset impacts related to these stressors. The wetland portion of the project was identified as a specific priority in the Project Atlas that accompanies the 2012 WMP.

Prior to construction activities, the streams on the Site had been channelized and the adjacent floodplain wetland areas had been cleared and ditched to provide drainage for surrounding pasture. These land use activities resulted in bank instability due to erosion and livestock access, lack of riparian buffer, and altered hydrology. Stream Incision, lateral erosion, and widening also resulted in degraded aquatic and benthic habitat, reduction in quality and acreage of riparian wetlands, and lowered dissolved oxygen levels in the stream. Table 4 in Appendix 1 and Table 6 in Appendix 2 present the post-restoration conditions in more detail.

1.1 Project Goals and Objectives

This mitigation site is intended to provide numerous ecological benefits within the Yadkin Pee-Dee River Basin. While many of these benefits are limited to the Crooked Creek project area, others, such as pollutant removal, reduced sediment loading, and improved aquatic and terrestrial habitat, have farther-reaching effects. Expected improvements to water quality and ecological processes are outlined below as project goals and objectives.

The project goals established in the mitigation plan (Wildlands, 2013) were completed with careful consideration of goals and objectives that were described in the RBRP and to address stressors identified in the LWP. The following project goals established include:

- Improve wetland hydrologic connectivity;
- Decrease sediment input into stream;
- Create appropriate terrestrial habitat;
- Decrease water temperature and increase dissolved oxygen concentrations; and
- Decrease nutrient and adverse chemical levels.

The project objectives have been defined as follows:

- Construct stream channels that will remain relatively stable over time and adequately transport their sediment loads without significant erosion or aggradation;
- Construct stream channels that maintain riffles with coarse bed material and pools with finer bed material;
- Provide aquatic and benthic habitat diversity in the form of pools, riffles, woody debris, and in-stream structures;
- Add riffle features and structures and riparian vegetation to decrease water temperatures and increased dissolved oxygen to improve water quality;
- Construct stream reaches so that floodplains and wetlands are frequently flooded to provide energy dissipation, detain and treat flood flows, and create a more natural hydrologic regime;
- Construct fencing to keep livestock out of the streams;
- Raise local groundwater table through raising stream beds and plugging agricultural drainage features;
- Perform minor grading in wetland areas as necessary to promote wetland hydrology; and Plant native tree species to establish appropriate wetland and floodplain communities and retain existing, native trees where possible.

1.2 Monitoring Year 3 Data Assessment

Annual monitoring was conducted between April and October 2018 to assess the condition of the project. The stream restoration success criteria for the Site follows the approved success criteria presented in the Crooked Creek #2 Project Mitigation Plan (Wildlands, 2013).

1.2.1 Vegetation Assessment

A total of 12 vegetation plots were established during the baseline monitoring within the project easement areas. All of the plots were installed using a standard 10 meter by 10 meter plot. The final vegetative success criteria will be the survival of 210 planted stems per acre in the riparian corridor along restored and enhanced reaches at the end of the seven year monitoring period (MY7). The interim measure of vegetative success for the Site will be the survival of at least 320 planted stems per acre at the end of year three of the monitoring period (MY3) and at least 260 stems per acre at the end of the fifth year of monitoring (MY5). Planted vegetation must average 10 feet in height in each plot at the end of the seventh year of monitoring. If this performance standard is met by MY5 and stem density is trending towards success (i.e., no less than 260 five year old stems/acre), monitoring of vegetation on the Site may be terminated provided written approval is provided by the United States Army Corps of Engineers in consultation with the NC Interagency Review Team.

The MY3 vegetation survey was completed in August 2018 which included supplemental stems. Due to poor stem density and stem mortality from the MY2 vegetation assessment, it was determined that a supplemental planting was warranted for the Site. On January 10, 2018, Carolina Silvics installed 1800 containerized, 1- to 3- gallon stems throughout 7.3 acres of the Site, which yields 247 stems/acre. The additional supplemental plantings also included the 12 permanent vegetation plots, which is 0.3 acres of the total planted 7.3 acres. A total of 88 supplemental stems were planted within the 0.3 acres; yielding 293 stems/acre or 7 new stems/plot. The MY3 vegetation plot survey resulted in an average stem density of 567 stems/acre. All 12 individual vegetation plots meet the interim requirement of 320 stems/acre for MY3, with an average of 14 stems per plot. The MY3 average stem height is 5.9 feet.

Dense herbaceous coverage continues to impact the planted stem health. The poor vigor is mainly caused by suffocation and vine strangulation, which are affecting the stem growth in several plots.

Please refer to Appendix 2 for vegetation plot photographs and the vegetation condition assessment table and Appendix 3 for vegetation data tables.

1.2.2 Vegetation Areas of Concern

The presence of invasive plant species continues to be prevalent throughout the Site, particularly along the conservation easement fence line and along Crooked Creek Reach A and B. Chinese privet (*Ligustrum sinense*) has re-sprouted. The invasive vine species, such as Chinese lantern (*Physalis spp.*), Japanese honeysuckle (*Lonicera japonica*), and morning glory (*Ipomoea sp.*), continue to impact the stem growth within the Site, especially near vegetation plots 10 and 11. The vine species are hindering the growth rate of the oak (*Quercus sp.*) trees in vegetation plot 11 by not allowing the stems to grow upright. Other invasive species noted throughout the Site include Chinaberry (*Melia* azedarach) and Johnson grass (*Sorghum halepense*). The native invasive species, cattail (*Typha latifolia*) is established in UT1 and continues to colonize in Vegetation Plot 5. This may also be impacting planted woody stem survival in vegetation plot 5, along with the dense herbaceous coverage of rice cutgrass (*Leersia oryzoides*). Invasive herbicide treatments have been conducted and will need to continue through closeout to enable the planted stems to grow within the Site. Carolina Silvics is now under contract for ongoing removal work and treatment of invasive species. Carolina Silvics has performed additional invasive removal work since Wildlands' MY3 assessment. Refer to Appendix 2 for the vegetation condition assessment table and Integrated Current Condition Plan View (CCPV).

1.2.3 Stream Assessment

MY3 Morphological surveys were conducted in April 2018. Results indicate that the channel dimensions are stable and functioning as designed. In general, the cross-sections on UT1 show little to no change in the bankfull area, maximum depth ratio, or width-to-depth ratio compared to baseline. Surveyed riffle cross-sections continue to fall within the parameters defined for channels of the appropriate Rosgen stream type (Rosgen, 1996). Refer to Appendix 2 for the visual stability assessment table, CCPV map, and stream photographs. Refer to Appendix 4 for the morphological summary data and plots.

1.2.4 Stream Areas of Concern

As mentioned in prior monitoring reports, the UT1 streambed continues to be inundated with dense herbaceous vegetation and now contains sections of cattail. This instream vegetation has created large debris jams of urban litter, which is hindering normal baseflow conditions and sediment transport process. The MY3 pebble count data indicates that UT1 has illustrated an increase in fine sediment deposition from base line. Refer to Appendix 2 for the visual assessment.

1.2.5 Hydrology Assessment

At least one bankfull event occurred on all reaches during the MY3 data collection, with the UT1 stream gage documenting multiple bankfull events. Following the hurricane events, the crest gage on Crooked Creek is missing; however, wrack lines were observed. A bankfull event was documented by photographs on November 5, 2018 during a Site visit. The success criteria of two bankfull events in separate years within the seven-year monitoring period was met during MY2. The stream gage located on UT1 recorded 103 consecutive days of baseflow. The stream gage is not part of the requirement for project success. Refer to Appendix 5 for hydrologic data and graphs.

1.2.6 Wetland Assessment

Ten groundwater monitoring gages (GWG 1-10) were installed during the baseline monitoring so that the data collected will provide an indication of groundwater levels throughout the wetland areas. The target performance criteria for wetland hydrology success consists of groundwater surface within 12

inches of the ground surface for 17 consecutive days (7.5 percent) of the defined 227 day growing season for Union County (March 23 through November 4) under typical precipitation conditions.

Four of the 10 gages (GWG 3, and GWGs 6-8) met the performance criteria for MY3, which is one more gage from MY2. GWG 3 met criteria with 29 consecutive days (13%), GWG 6 met criteria for 88 consecutive days (39%), GWGs 7 and 8 recorded 45 consecutive days (20%). The rain data obtained from a nearby USGS station indicates an average of three inches of rainfall per month from January to August; however, June and July averaged one inch each. During the hurricane events, there was average of 7.7 inches of rainfall in September and October. With normal precipitation during the upcoming winter, in addition to the recent large rain events, the wetlands may continue recharging and meet hydrologic success criteria in the upcoming monitoring years. Refer to Appendix 5 for the groundwater hydrology data and plots.

1.2.7 Wetland Areas of Concern

The headcut located in the Wetland Creation Zone B area, between GWG 8 and vegetation plot 7, has decreased in size since the repair work completed in February 15, 2018. The repair consisted of straw waddles, juncus plugs and placement of live stakes. Straw bales were also placed in the eroded ditch that had developed and backfilled with dirt and herbaceous material. Since the repair, the herbaceous groundcover has become established and the trees have increased in size, especially the bald cypress (*Taxodium distichum*). This area will continue to be monitored.

1.3 Monitoring Year 3 Summary

The MY3 asset reductions were the result of one-sided easement sections at the upper and lower ends of Crooked Creek, and a powerline right-of-way at the upper end of UT1, which had not been adjusted at the as-built stage. The restored streams within the Site appear stable and functioning as designed. The average stem density of 567 stems/acre is on track to meeting the MY7 success criteria. Four of the 10 groundwater gages met the performance criteria in MY3. The bankfull performance criteria was met in MY2. The UT1 stream gage documented 103 consecutive days of baseflow; however, UT1 contains vegetation over-growth and the jurisdictional nature of this restoration tributary may become a concern. In addition, the Site will continue to be treated for invasive species.

Summary information and data related to the performance of various project and monitoring elements can be found in the tables and figures in the report appendices. Narrative background and supporting information formerly found in these reports can be found in the Mitigation Plan documents available on DMS's website. All raw data supporting the tables and figures in the appendices are available from DMS upon request.

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. Crest gages and pressure transducers were installed in surveyed riffle cross-sections during annual site visits. 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

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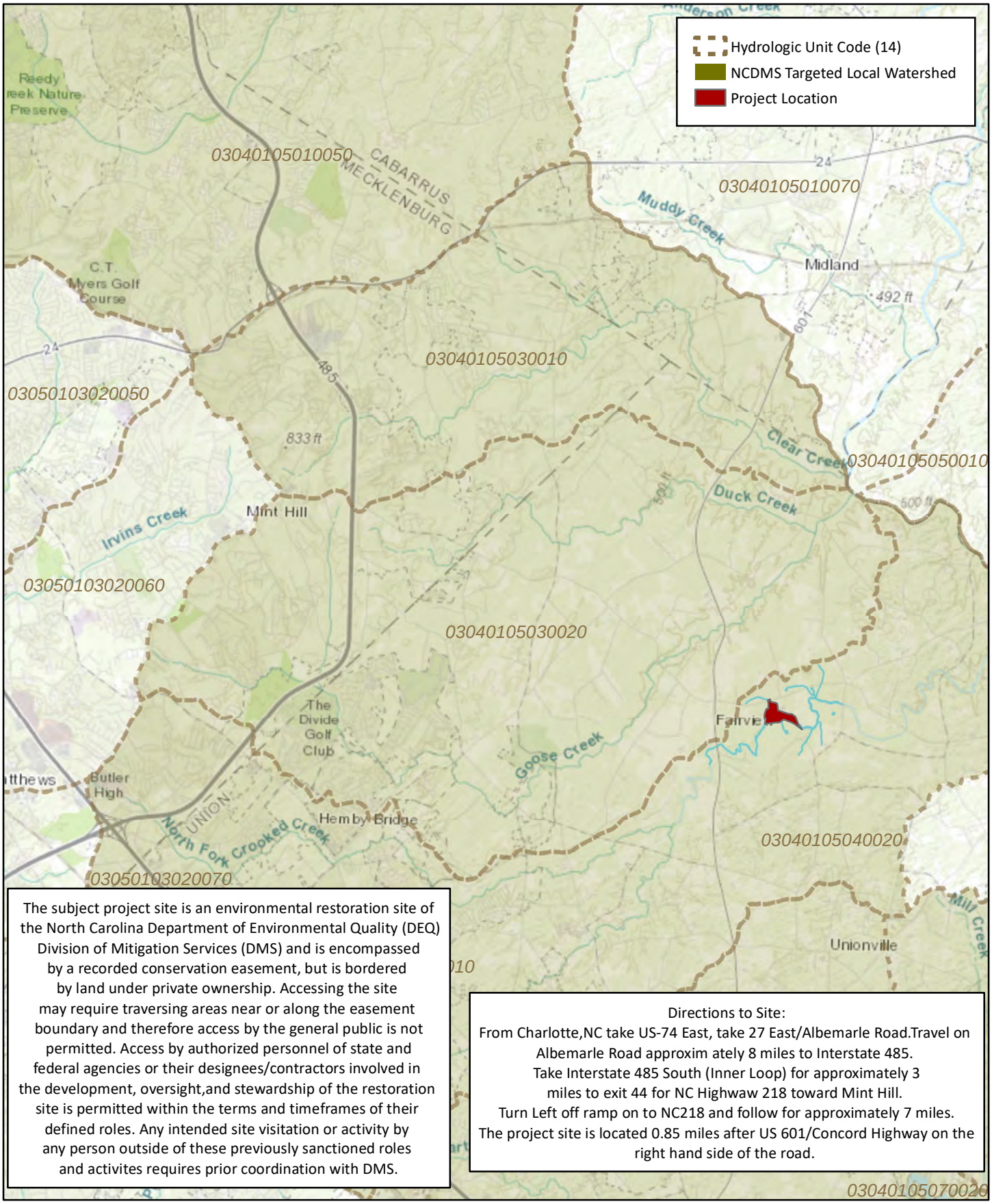
APPENDIX 1. General Figures and Tables

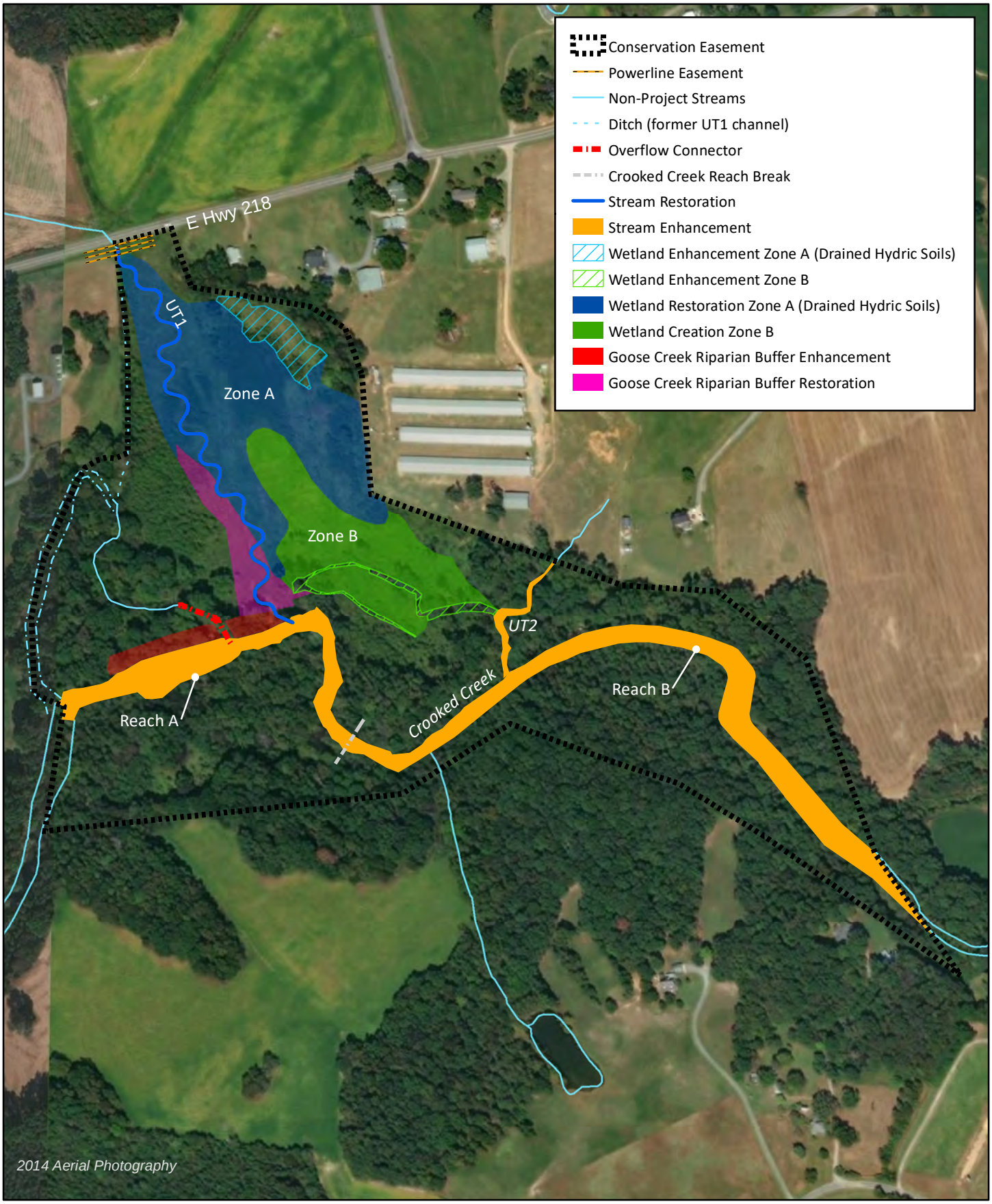


WILDLANDS ENGINEERING

0 0.5 1 Mile

N

Figure 1 Project Vicinity Map
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 3 - 2018
Union County, NC



WILDLANDS ENGINEERING

0 200 400 Feet

N

Figure 2 Project Component/Asset Map
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 3 - 2018
Union County, NC

Table 1. Project Components and Mitigation Credits
Crooked Creek #2 Restoration Project Site
DMS Project No. 94687
Monitoring Year 3 - 2018

Mitigation Credits									
	Stream		Riparian Wetland		Non-Riparian Wetland		Buffer (sqft)	Nitrogen Nutrient	Phosphorous Nutrient Offset
Type	R	RE	R	RE	R	RE			
Totals	3,242.2	N/A	7.900	0.500	N/A	N/A	54,135.33	N/A	

Project Components							
Reach ID	As-Built Stationing/ Location	Existing Footage/ Acreage	Approach	Restoration or Restoration Equivalent	Restoration Footage/ Acreage	Mitigation Ratio	Credits[1] (SMU/ WMU)
STREAMS							
Crooked Creek Reach A	202+20-215+55	1,555 LF	N/A	Enhancement II	1,335	2.5:1	534.000
Crooked Creek Reach B	215+55-236+78	2,404 LF	N/A	Enhancement II	2,123	2.5:1	849.200
UT1	100+47-117+18	1,762 LF	P1	Restoration	1,671	1:1	1,671.000
UT2	300+00-305+60	470 LF	N/A	Enhancement II	470	2.5:1	188.000
WETLANDS							
Zone A (Drained Hydric Soils)	N/A	0.7 AC		Enhancement	0.7	2:1	0.350
Zone A (Drained Hydric Soils)	N/A	N/A		Restoration	6.6	1:1	6.600
Zone B	N/A	0.3 AC		Enhancement	0.3	2:1	0.150
Zone B	N/A	N/A		Creation	3.9	3:1	1.300
BUFFER							
Goose Creek Buffer	N/A	25,201 sqft		Enhancement	25,201 sqft	3:1	8,400.33 sqft
Goose Creek Buffer	N/A	N/A		Restoration	45,735 sqft	1:1	45,735 sqft

Component Summation						
Restoration Level	Stream (LF)	Riparian Wetland (acres)		Non-Riparian (acres)	Buffer (square feet)	Upland (acres)
		Riverine	Non-Riverine			
Restoration	1,671	6.6			45,735	
Enhancement		1.0			25,201	
Enhancement I						
Enhancement II	3,928					
Creation		3.9				

1 No credit generated where only one side of stream is buffered per email from Harry Tsomides dated October 15, 2018.

2 UT1 rediting starts at the outer edge of the powerline right-of-way along Hwy 218; Crooked Creek assets have been reduced to account for one-side easement sections at upstream and downstream ends.

Table 2. Project Activity and Reporting History
Crooked Creek #2 Restoration Project Site
DMS Project No. 94687
Monitoring Year 3 - 2018

Activity or Report		Data Collection Complete	Completion or Scheduled Delivery
Mitigation Plan		June 2011	August 2013
Final Design - Construction Plans		August 2011	April 2014
Construction		January 2015 - April 2015	January 2015 - April 2015
Temporary S&E mix applied to entire project area[1]		January 2015 - March 2015	January 2015 - March 2015
Permanent seed mix applied to reach/segments		January 2015 - March 2015	January 2015 - March 2015
Bare root and live stake plantings for reach/segments		January 2016	January 2016
Baseline Monitoring Document (Year 0)		January - February 2016	May 2016
Year 1 Monitoring	Stream Survey	August 2016	November 2016
	Vegetation Survey	September 2016	
Year 2 Monitoring	Stream Survey	April 2017	November 2017
	Vegetation Survey	August 2017	
Year 3 Monitoring	Invasive Treatment	January 2018	November 2018
	Supplemental Planting		
	Stream Survey	April 2018	
	Vegetation Survey	August 2018	
Year 4 Monitoring	Stream Survey	2019	November 2019
	Vegetation Survey	2019	
Year 5 Monitoring	Stream Survey	2020	November 2020
	Vegetation Survey	2020	
Year 6 Monitoring	Stream Survey	2021	November 2021
	Vegetation Survey	2021	
Year 7 Monitoring	Stream Survey	2022	November 2022
	Vegetation Survey	2022	

[1]Seed and mulch is added as each section of construction is completed.

Table 3. Project Contact Table
Crooked Creek #2 Restoration Project Site
DMS Project No. 94687
Monitoring Year 3 - 2018

Designer Aaron Earley, PE, CFM	**Wildlands Engineering, Inc.** 1430 South Mint Street, Suite 104 Charlotte, NC 28203 704.332.7754
Construction Contractor	**North State Environmental, Inc.** 2889 Lowery Street Winston Salem, NC 27101
Planting Contractor	**Keller Environmental** 7921 Haymarket Lane Raleigh, NC 27615
Supplemental Planting Contractor & Invasive Species Maintenance	**Carolina Silvics** 908 Indian Trail Road Edenton, NC 27932
Seeding Contractor	**North State Environmental, Inc.** 2889 Lowery Street Winston Salem, NC 27101
Seed Mix Sources	**Green Resource, LLC**
Nursery Stock Suppliers **Bare Roots** **Live Stakes**	**Dykes & Son Nursery** 825 Maude Etter Rd. McMinnville, TN 37110
Monitoring Performers	**Wildlands Engineering, Inc.**
Monitoring, POC	Kirsten Gimbert 704.332.7754, ext. 110

Table 4. Project Information and Attributes
Crooked Creek #2 Restoration Project Site
DMS Project No. 94687
Monitoring Year 3 - 2018

Project Information	
Project Name	Crooked Creek #2 Restoration Project
County	Union County
Project Area (acres)	54.94
Project Coordinates (latitude and longitude)	34° 58' 54.78"N, 080° 31' 25.79"W

Project Watershed Summary Information	
Physiographic Province	Carolina Slate Belt of the Piedmont Physiographic Province
River Basin	Yadkin
USGS Hydrologic Unit 8-digit	03040105
USGS Hydrologic Unit 14-digit	03040105040010
DWR Sub-basin	03-07-12
Project Drainiage Area (acres)	24,619
Project Drainage Area Percentage of Impervious Area	28%
CGIA Land Use Classification	Agriculture 38%, Forested 29%, Developed 28%, Wetlands 3%, and Herbaceous Upland 2%

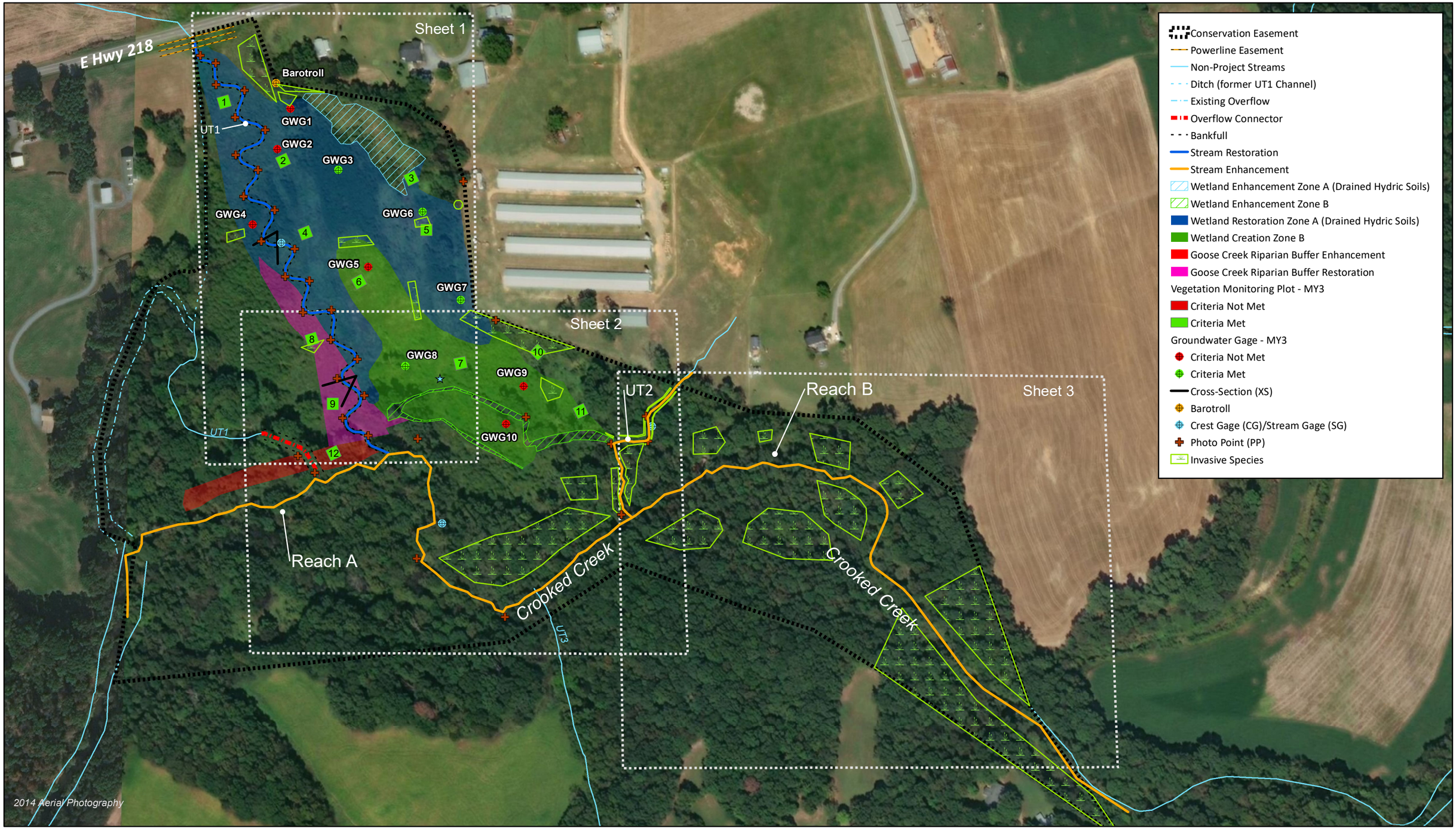
Reach Summary Information					
Parameters	**Crooked Creek Reach A**	**Crooked Creek Reach B**	**UT1**	**UT2**	
Length of reach (linear feet) - Post-Restoration	1,555	2,404	1,671	195	275
Drainage area (acres)	24,619		153	51	
NCDWR stream identification score	52		34.5	24.5	38
NCDWR Water Quality Classification	C				
Morphological Desription (stream type)	P	P	P	I	P
Evolutionary trend (Simon's Model) - Pre- Restoration	N/A	N/A	Stage III	Stage IV	
Underlying mapped soils	Chewacala silt loam 0-2% slopes (ChA)	Chewacala silt loam 0-2% slopes (ChA)	Chewacala silt loam 0-2% slopes (ChA)	Badin channery silt loam 8-15% slopes (BaC)	
Drainage class	Somewhat poorly drained	Somewhat poorly drained	Somewhat poorly drained	Well drained	
Soil hydric status	Type B (inclusions)	Type B (inclusions)	Type B (inclusions)	N/A	
Slope	0.0022		0.0047	0.0050	
FEMA classification	Zone AE	Zone AE	no regulated floodplain	no regulated floodplain	
Native vegetation community	Piedmont Bottomland forest				
Percent composition exotic invasive vegetation -Post-Restoration	5%	5%	60%	5%	

Regulatory Considerations			
Regulation	**Applicable?**	**Resolved?**	**Supporting Documentation**
Waters of the United States - Section 404	X	X	USACE Nationwide Permit No.27 and DWQ 401 Water Quality Certification No. 3885. Action ID # 2011-02201
Waters of the United States - Section 401	X	X	
Division of Land Quality (Erosion and Sediment Control)	X	X	NPDES Construction Stormwater General Permit NCG010000
Endangered Species Act	X	X	Crooked Creek #2 Mitigation Plan; Wildlands determined "no effect" on Union County listed endangered species. June 21, 2011 email correspondence from USFWS indicating no listed species occur on site.
Historic Preservation Act	X	X	No historic resources were found to be impacted (letter from SHPO dated 6/23/2011).
Coastal Zone Management Act (CZMA)/Coastal Area Management Act (CAMA)	N/A	N/A	N/A
FEMA Floodplain Compliance	X	X	Crooked Creek is a mapped Zone AE floodplain with defined base flood elevations. Base flood elevations have been defined and the floodway has been delineated; (FEMA Zone AE, FIRM panel 5540).
Essential Fisheries Habitat	N/A	N/A	N/A

Table 5. Monitoring Component Summary
Crooked Creek #2 Restoration Project Site
DMS Project No. 94687
Monitoring Year 3 - 2018

Parameter	Monitoring Feature	Quantity / Length by Reach					Frequency
		Crooked Creek Reach A	Crooked Creek Reach B	UT1	UT2	Wetlands	
Dimension	Riffle Cross-Section	N/A	N/A	2	N/A	N/A	Annual
	Pool Cross-Section	N/A	N/A	2	N/A	N/A	
Pattern	Pattern	N/A	N/A	N/A	N/A	N/A	N/A
Profile	Longitudinal Profile	N/A	N/A	N/A	N/A	N/A	Year 0
Substrate	Reach Wide (RW)/ Riffle 100 Pebble Count (RF)	N/A	N/A	1 RW / 2 RF	N/A	N/A	Annual
Hydrology	Crest Gage	1		1	1	N/A	Quarterly
Hydrology	Groundwater Gages	N/A	N/A	N/A	N/A	10	Quarterly
Vegetation	Vegetation Plots	12					Annual
Visual Assessment	All Streams	Y	Y	Y	Y	Y	Semi-Annual
Exotic and nuisance vegetation							Semi-Annual
Project Boundary							Semi-Annual
Reference Photos	Photo Points	34					Annual

APPENDIX 2. Visual Assessment Data

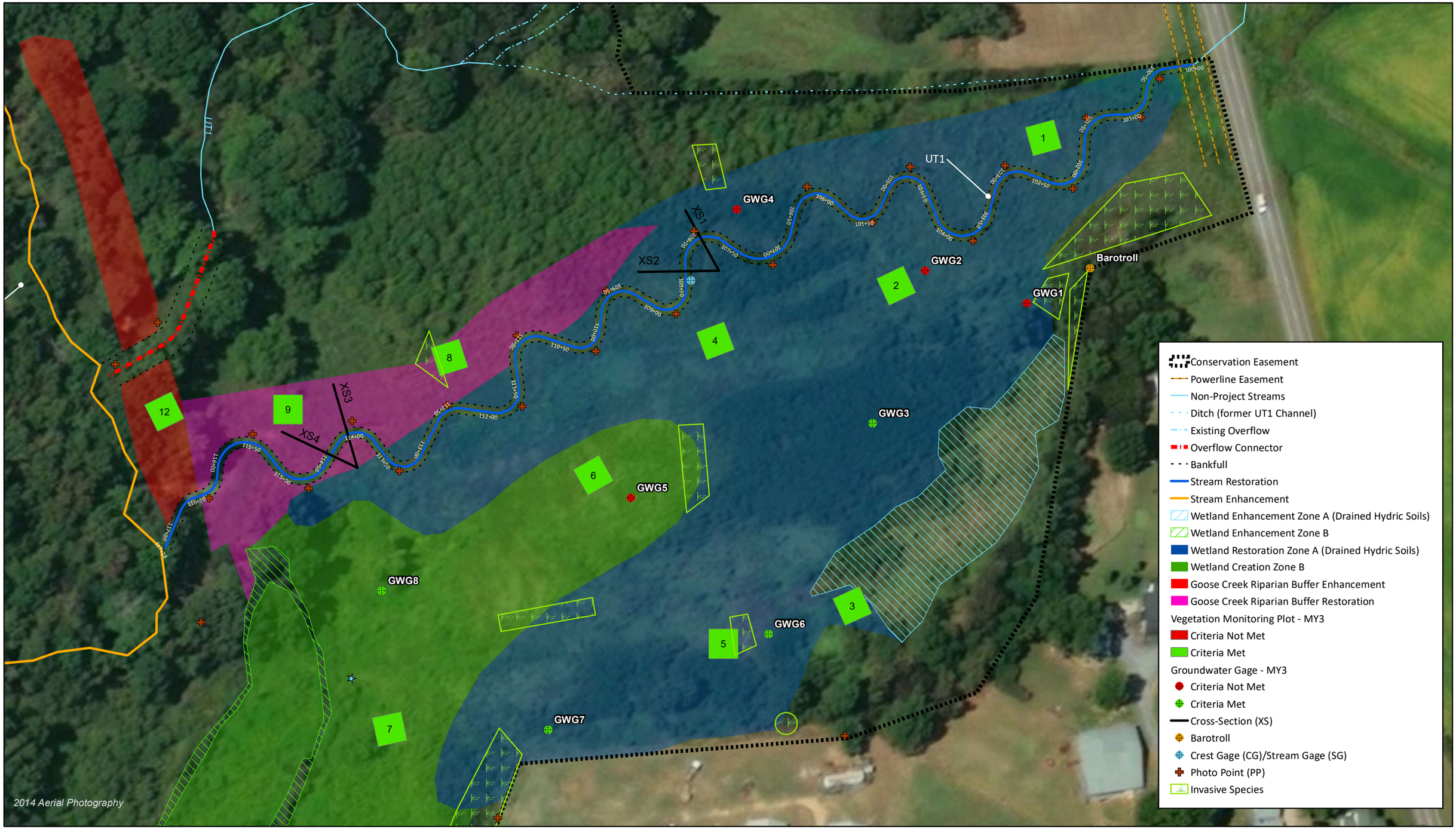


WILDLANDS ENGINEERING

0 125 250 500 Feet

N

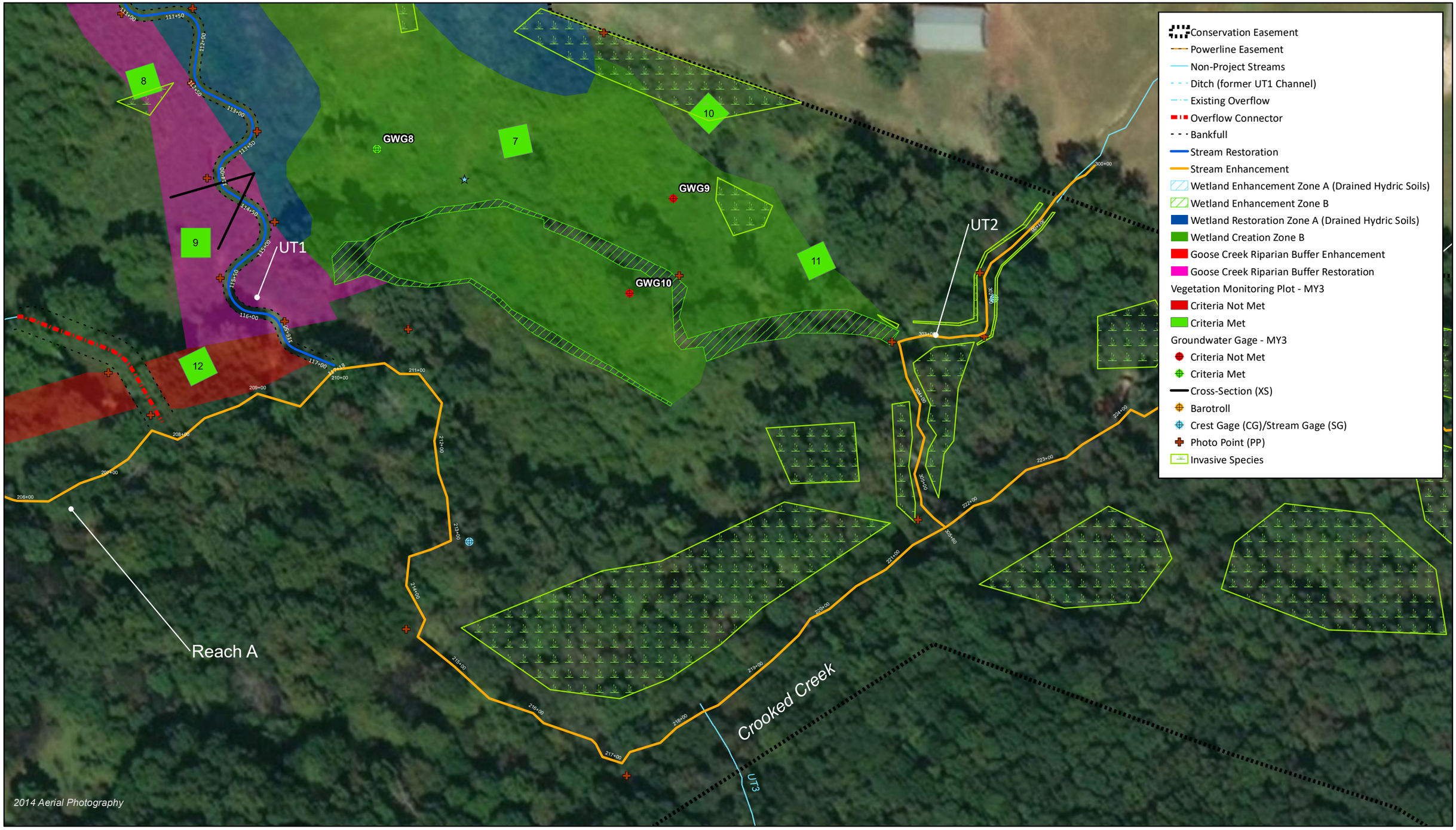
Figure 3.0 Integrated Current Condition Plan View
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 3 - 2018
Union County, NC



WILDLANDS ENGINEERING

0 50 100 200 Feet

Figure 3.1 Integrated Current Condition Plan View
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 3 - 2018
Union County, NC



WILDLANDS ENGINEERING

0 50 100 200 Feet

N

Figure 3.2 Integrated Current Condition Plan View
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 3 - 2018
Union County, NC

WILDLANDS ENGINEERING

0 50 100 200 Feet

N

Figure 3.3 Integrated Current Condition Plan View
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 3 - 2018
Union County, NC

Table 6. Visual Stream Morphology Stability Assessment Table
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 3 - 2018

UT1 (1,671 LF)

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. Meander Pool Condition	Depth Sufficient	20	20			100%			
		Length Appropriate	20	20			100%			
	4. Thalweg Position	Thalweg centering at upstream of meander bend (Run)	20	20			100%			
		Thalweg centering at downstream of meander bend (Glide)	20	20			100%			
2. Bank	1. Scoured/Eroded	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	n/a	n/a	n/a
	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%	n/a	n/a	n/a
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	n/a	n/a	n/a
				Totals	0	0	100%	n/a	n/a	n/a
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	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%.	9	9			100%			
	4. Habitat	Pool forming structures maintaining ~Max Pool Depth : Bankfull Depth ≥ 1.6 Rootwads/logs providing some cover at baseflow.	20	20			100%			

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

Table 7. Vegetation Condition Assessment Table

Crooked Creek #2 Restoration Site

DMS Project No. 94687

Monitoring Year 3 - 2018

Planted Acreage **15.0**

Vegetation Category	Definitions	Mapping Threshold	Number of Polygons	Combined Acreage[1]	% of Planted Acreage
Bare Areas	Very limited cover of both woody and herbaceous material	0.1 ac	0	0.0	0%
Low Stem Density Areas[1]	Woody stem densities clearly below target levels based on MY3, 4, 5, or 7 stem count criteria.	0.1 ac	10	0.25	1.6%
		Total	**10**	**0.25**	**1.6%**
Areas of Poor Growth Rates or Vigor	Areas with woody stems of a size class that are obviously small given the monitoring year.	0.25	0	0.00	0.0%
		Cumulative Total	**10**	**0.25**	**1.6%**

Easement Acreage **54.9**

Vegetation Category	Definitions	Mapping Threshold	Number of Polygons	Combined Acreage[2]	% of Easement Acreage
Invasive Areas of Concern[2]	Areas or points (if too small to render as polygons at map scale).	1000 SF	27	6.3	11%
Easement Encroachment Areas	Areas or points (if too small to render as polygons at map scale).	none	0	0	0%

[1]Acreage calculated from annual vegetation monitoring plots and plant warranty inspection plots.
[2]Acreage of each polygon modified by estimated percent cover of invasive population

Vegetation Photographs

Vegetation Plot 1 – (08/13/2018)

Vegetation Plot 2 – (08/13/2018)

Vegetation Plot 3 – (08/14/2018)

Vegetation Plot 4 – (08/13/2018)

Vegetation Plot 5 – (08/14/2018)

Vegetation Plot 6 – (08/13/2018)

Vegetation Plot 7 – (08/14/2018)

Vegetation Plot 8 – (08/13/2018)

Vegetation Plot 9 – (08/13/2018)

Vegetation Plot 10 – (08/14/2018)

Vegetation Plot 11 – (08/14/2018)

Vegetation Plot 12 – (08/13/2018)

Stream Photographs

	
Photo Point 1 – UT1 looking upstream (8/15/2018)	**Photo Point 1** – UT1 looking downstream (8/15/2018)
	
Photo Point 2 – UT1 looking upstream (8/15/2018)	**Photo Point 2** – UT1 looking downstream (8/15/2018)
	
Photo Point 3 – UT1 looking upstream (8/15/2018)	**Photo Point 3** – UT1 looking downstream (8/15/2018)

	
Photo Point 4 – UT1 looking upstream (8/15/2018)	**Photo Point 4** – UT1 looking downstream (8/15/2018)
	
Photo Point 5 – UT1 looking upstream (8/15/2018)	**Photo Point 5** – UT1 looking downstream (8/15/2018)
	
Photo Point 6 – UT1 looking upstream (8/15/2018)	**Photo Point 6** – UT1 looking downstream (8/15/2018)

	
Photo Point 7 – UT1 looking upstream (8/15/2018)	**Photo Point 7** – UT1 looking downstream (8/15/2018)
	
Photo Point 8 – UT1 looking upstream (8/15/2018)	**Photo Point 8** – UT1 looking downstream (8/15/2018)
	
Photo Point 9 – UT1 looking upstream (8/15/2018)	**Photo Point 9** – UT1 looking downstream (8/15/2018)

	
Photo Point 10 – UT1 looking upstream (8/15/2018)	**Photo Point 10** – UT1 looking downstream (8/15/2018)
	
Photo Point 11 – UT1 looking upstream (8/15/2018)	**Photo Point 11** – UT1 looking downstream (8/15/2018)
	
Photo Point 12 – UT1 looking upstream (8/15/2018)	**Photo Point 12** – UT1 looking downstream (8/15/2018)

	
Photo Point 13 – UT1 looking upstream (8/15/2018)	**Photo Point 13** – UT1 looking downstream (8/15/2018)
	
Photo Point 14 – UT1 looking upstream (8/15/2018)	**Photo Point 14** – UT1 looking downstream (8/15/2018)
	
Photo Point 15 – UT1 looking upstream (8/15/2018)	**Photo Point 15** – UT1 looking downstream (8/15/2018)

	
Photo Point 16 – UT1 looking upstream (8/15/2018)	**Photo Point 16** – UT1 looking downstream (8/15/2018)
	
Photo Point 17 – UT1 looking upstream (8/15/2018)	**Photo Point 17** – UT1 looking downstream (8/15/2018)
	
Photo Point 18 – UT1 looking upstream (8/15/2018)	**Photo Point 18** – UT1 looking downstream (8/15/2018)

	
Photo Point 19 – UT1 looking upstream (8/15/2018)	**Photo Point 19** – UT1 looking downstream (8/15/2018)
	
Photo Point 20 – UT1 looking upstream (8/15/2018)	**Photo Point 20** – UT1 looking downstream (8/15/2018)
	
Photo Point 21 – UT1 looking upstream (8/15/2018)	**Photo Point 21** – UT1 looking downstream (8/15/2018)

	
Photo Point 22 – UT1 looking upstream (8/15/2018)	**Photo Point 22** – UT1 looking downstream (8/15/2018)
	
Photo Point 23 – UT1 looking upstream (8/15/2018)	**Photo Point 23** – UT1 looking downstream (8/15/2018)
	
Photo Point 24 – Crooked Creek looking upstream (8/15/2018)	**Photo Point 24** – Crooked Creek looking downstream (8/15/2018)

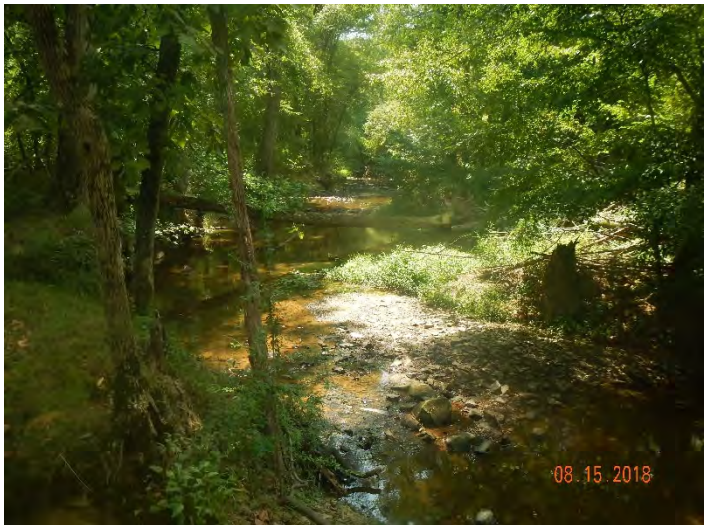
	
Photo Point 25 – Crooked Creek looking upstream (8/15/2018)	**Photo Point 25** – Crooked Creek looking downstream (8/15/2018)
	
Photo Point 26 – Crooked Creek looking upstream (8/15/2018)	**Photo Point 26** – Crooked Creek looking downstream (8/15/2018)
	
Photo Point 27 – Crooked Creek looking upstream (8/15/2018)	**Photo Point 27** – Crooked Creek looking downstream (8/15/2018)

Photo Point 28 – UT2 looking upstream (8/15/2018)

Photo Point 28 – UT2 looking downstream (8/15/2018)

Photo Point 29 – UT2 looking upstream (8/15/2018)

Photo Point 29 – UT2 looking downstream (8/15/2018)

Photo Point 30 – UT2 looking downstream to UT2 (8/15/2018)

Photo Point 31 – UT2 looking upstream Crooked Creek

Photo Point 31 – UT2 looking downstream (8/15/2018)

Photo Point 31 – UT2 looking upstream UT2 (8/15/2018)

Wetland Photographs

Photo Point 30 –Wetland CC outlet facing W (8/15/2018)

Photo Point 30 –Wetland CC outlet facing E (8/15/2018)

Photo Point 32 –Wetland AA facing W (8/15/2018)

Photo Point 32 – Wetland Zone A facing S (8/15/2018)

Photo Point 33 – Wetland Zone A & B facing W (8/15/2018)

Photo Point 33 - Wetland B facing S (8/15/2018)

	
Photo Point 34 –Wetland CC facing NW (8/15/2018)	**Photo Point 34** –Wetland CC facing S (8/15/2018)

APPENDIX 3. Vegetation Plot Data

Table 8. Vegetation Plot Criteria Attainment

Crooked Creek #2 Restoration Project Site

DMS Project No. 94687

Monitoring Year 3 - 2018

Plot	MY2 Success Criteria Met (Y/N)	Tract Mean
1	Y	100%
2	Y	
3	Y	
4	Y	
5	Y	
6	Y	
7	Y	
8	Y	
9	Y	
10	Y	
11	Y	
12	Y	

Table 9. CVS Vegetation Plot Metadata

Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 3 - 2018

Report Prepared By	Ruby Davis
Date Prepared	11/15/2018 15:37
Database Name	cvs-eep-entrytool-v2.3.0_Crooked Creek_MY3.mdb
Database Location	Q:\ActiveProjects\005-02156 Crooked Creek Monitoring\Monitoring\Monitoring Year 3 (2018)\Vegetation Assessment
Computer Name	RUBY
File Size	45125632
DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT----------	
Metadata	Description of database file, the report worksheets, and a summary of project(s) and project data.
Project planted	Each project is listed with its PLANTED stems per acre, for each year. This excludes live stakes.
Project 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	94687
Project Name	Crooked Creek #2 Restoration Project
Description	Crooked Creek #2 Restoration Project
Required Plots (calculated)	12
Sampled Plots	12

Table 10. Planted and Total Stem Counts

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 3 - 2018

			Current Plot Data (MY3 2018)																				
			94687-WEI-0001			94687-WEI-0002			94687-WEI-0003			94687-WEI-0004			94687-WEI-0005			94687-WEI-0006			94687-WEI-0007		
Scientific Name	Common Name	Species Type	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T
Acer negundo	Box Elder	Tree			3																		5
Acer rubrum	Red Maple	Tree	1	1	1							2	2	2									
Betula nigra	River Birch	Tree				1	1	1	1	1	1	1	1	1	1	1	1	6	6	6			
Carpinus caroliniana	Ironwood	Shrub Tree																					
Celtis laevigata	Sugarberry	Shrub Tree	2	2	2				1	1	1							2	2	2	1	1	1
Cornus florida	Flowering Dogwood	Shrub Tree																					
Diospyros virginiana	American Persimmon	Tree	2	2	5	1	1	1	1	1	1												
Fraxinus pennsylvanica	Green Ash	Tree			20						9			1									5
Juglans nigra	Black Walnut	Tree																					
Liquidambar styraciflua	Sweet Gum	Tree			1																		3
Liriodendron tulipifera	Tulip Poplar	Tree																					
Nyssa sylvatica	Black Gum	Tree			1																1	1	1
Platanus occidentalis	Sycamore	Tree	6	6	6	5	5	5	1	1	1	3	3	3	1	1	1	4	4	25	2	2	2
Quercus	Oak sp.	Shrub Tree										1	1	1				1	1	1			
Quercus lyrata	Overcup Oak	Tree	1	1	1	1	1	1															
Quercus nigra	Water Oak	Tree																			3	3	3
Quercus phellos	Willow Oak	Tree				1	1	1				1	1	1				1	1	1	2	2	2
Salix nigra	Black Willow	Tree			2																		
Taxodium distichum	Bald-cypress	Tree	4	4	4	4	4	4	7	7	7	4	4	4	9	9	9	2	2	2	1	1	1
Ulmus alata	Winged Elm	Tree																2	2	4	4	4	6
Ulmus americana	American Elm	Tree																					
Stem count			16	16	46	13	13	13	11	11	20	12	12	13	11	11	11	18	18	41	14	14	29
size (ares)			1			1			1			1			1			1			1		
size (ACRES)			0.02			0.02			0.02			0.02			0.02			0.02			0.02		
Species count			6	6	11	6	6	6	5	5	6	6	6	7	3	3	3	7	7	7	7	7	10
Stems per ACRE			647	647	1862	526	526	526	445	445	809	486	486	526	445	445	445	728	728	1659	567	567	1174

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%

PnoLS: Number of planted stems excluding live stakes

P-all: Number of planted stems including live stakes

T: Total stems

Table 10. Planted and Total Stem Counts

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 3 - 2018

			Current Plot Data (MY3 2018)															Annual Means											
			94687-WEI-0008			94687-WEI-0009			94687-WEI-0010			94687-WEI-0011			94687-WEI-0012			MY3 (8/2018)			MY2 (8/2017)			MY1 (9/2016)			MY0 (2/2016)		
Scientific Name	Common Name	Species Type	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T
Acer negundo	Box Elder	Tree			8			7						7			19			49			43			18			17
Acer rubrum	Red Maple	Tree	3	3	4	7	7	7										13	13	14	11	11	11	13	13	13	14	14	14
Betula nigra	River Birch	Tree	2	2	2	4	4	4	2	2	2	4	4	4	4	4	4	26	26	26	12	12	14	14	14	15	18	18	18
Carpinus caroliniana	Ironwood	Shrub Tree																											2
Celtis laevigata	Sugarberry	Shrub Tree	1	1	1			2	2	2	4						1	9	9	14			4			1			
Cornus florida	Flowering Dogwood	Shrub Tree													2	2	2	2	2	2	2	2	2	2	2	2	6	6	6
Diospyros virginiana	American Persimmon	Tree	5	5	5	3	3	3							1	1	1	13	13	16	7	7	7	10	10	13	27	27	27
Fraxinus pennsylvanica	Green Ash	Tree						2			3			1						41			25			26			45
Juglans nigra	Black Walnut	Tree															3			3			4						1
Liquidambar styraciflua	Sweet Gum	Tree												1			1			6			7			7			4
Liriodendron tulipifera	Tulip Poplar	Tree																					1			1			2
Nyssa sylvatica	Black Gum	Tree							1	1	1							2	2	3	2	2	2	3	3	3	7	7	7
Platanus occidentalis	Sycamore	Tree	3	3	3	1	1	2	1	1	1				1	1	1	28	28	50	12	12	44	13	13	26	15	15	16
Quercus	Oak sp.	Shrub Tree																2	2	2	1	1	1	13	13	13	53	53	53
Quercus lyrata	Overcup Oak	Tree							1	1	1	3	3	3	2	2	2	8	8	8	8	8	8	7	7	7			
Quercus nigra	Water Oak	Tree	1	1	1				1	1	1	6	6	6	1	1	1	12	12	12	11	11	11	4	4	4			
Quercus phellos	Willow Oak	Tree							1	1	1							6	6	6	6	6	6	3	3	3			
Salix nigra	Black Willow	Tree																		2									
Taxodium distichum	Bald-cypress	Tree	1	1	1	1	1	1	4	4	4				4	4	4	41	41	41	12	12	12	13	13	13	16	16	16
Ulmus alata	Winged Elm	Tree									1						1	6	6	12			5						1
Ulmus americana	American Elm	Tree																								7			
Stem count			16	16	25	16	16	28	13	13	19	13	13	22	15	15	40	168	168	307	84	84	207	95	95	172	156	156	229
size (ares)			1			1			1			1			1			12			12			12			12		
size (ACRES)			0.02			0.02			0.02			0.02			0.02			0.30			0.30			0.30			0.30		
Species count			7	7	8	5	5	8	8	8	10	3	3	6	7	7	12	13	13	18	11	11	18	11	11	17	8	8	15
Stems per ACRE			647	647	1012	647	647	1133	526	526	769	526	526	890	607	607	1619	567	567	1035	283	283	698	320	320	580	526	526	772

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%

PnoLS: Number of planted stems excluding live stakes

P-all: Number of planted stems including live stakes

T: Total stems

APPENDIX 4. Morphological Summary Data and Plots

Table 11. Baseline Stream Data Summary
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 3 - 2018

UT1

Parameter	Gage	Pre-Restoration Condition				Reference Reach Data				Design		As-Built/Baseline	
		UT1 Reach 1		UT1 Reach 2		UT to Lyle Creek		Spencer Creek 1		UT1		UT1	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Shallow													
Bankfull Width (ft)	N/A	17.7		10.9		7.0	8.6	8.7		12.0		11.7	12.6
Floodprone Width (ft)		500		539		45	49	229		44+		200+	
Bankfull Mean Depth		0.5		0.7		0.5		1.2		0.7		0.6	
Bankfull Max Depth		1.3		1.0		1.0	1.1	1.9		1.0		1.1	
Bankfull Cross-sectional Area (ft^2)		8.6		7.8		3.5	4.1	10.6		8.7		7.3	7.5
Width/Depth Ratio		36.4		15.3		14.9	18.3	7.3		16.6		18.9	21.1
Entrenchment Ratio		28.2		49.3		5.7	6.4	26.3		2.2+		2.2+	
Bank Height Ratio		1.4		2.9		0.6	0.9	1.0		1.0		1.0	
D50 (mm)		3.1		---								0.3	35.9
Riffle Length (ft)	N/A					---		---		---		12	50
Riffle Slope (ft/ft)		*		*		0.0055	0.0597	0.0100	0.0670	0.0045	0.0080	0.0004	0.0193
Pool Length (ft)						---		---		---		17.8	65.4
Pool Max Depth (ft)		0.76	1.27	0.76	1.27	1.3		2.5		1.5	2.1	1.1	3.0
Pool Spacing (ft)		20	74	20	74	15	28	13	47	42	84	36	99
Pool Volume (ft^3)													
Pattern													
Channel Beltwidth (ft)	N/A	---		115	543	21		24	52	30	72	30	72
Radius of Curvature (ft)		61.2	170.6	61.2	170.6	19	32	5	22	22	48	22	48
Rc:Bankfull Width (ft/ft)		3.5	9.6	3.5	9.6	2.7	3.7	0.6	2.5	1.8	4.0	1.8	4.0
Meander Length (ft)		---		163	400	39	44	54	196	72	132	102	135
Meander Width Ratio		---		10.5	49.7	2.4	3	2.8	6.0	2.5	6.0	2.5	6.0
Substrate, Bed and Transport Parameters													
Ri%/Ru%/P%/G%/S%	N/A												
SC%/Sa%/G%/C%/B%/Be%													
d16/d35/d50/d84/d95/d100		-/-/3.1/8.6/11.0/16.0		---		-/0.1/0.2/0.5/4.0/8.0		0.1/3.0/8.8/77/180/-				SC/SC/0.1/19/90/256	
Reach Shear Stress (Competency) lb/ft^2		---		---						0.012		0.11	0.12
Max part size (mm) mobilized at bankfull													
Stream Power (Capacity) W/m^2													
Additional Reach Parameters													
Drainage Area (SM)	N/A	0.24		N/A		0.25		0.50		0.24		0.24	
Watershed Impervious Cover Estimate (%)		<1%		<1%		---		---		<1%		<1%	
Rosgen Classification		N/A[1]		N/A[1]		C5/6		E4/C4		C4		C4	
Bankfull Velocity (fps)		3.5		4.1		4.7		---		3.4		2.2	
Bankfull Discharge (cfs)		30		N/A[2]		18		---		30		16	
Q-NFF regression (2-yr)		50		N/A[2]									
Q-USGS extrapolation (1.2-yr)		17	40	N/A[2]									
Q-Mannings		24		N/A[2]									
Valley Length (ft)		---		---		---		---		1,353		1,353	
Channel Thalweg Length (ft)		1,789				---		---		1,718		1,718	
Sinuosity		1.0		1.5		1.1		1.1		1.3		1.3	
Water Surface Slope $(ft/ft)^2$		0.0071		0.0034		0.004		0.0132		0.0032		0.0034	
Bankfull Slope (ft/ft)		0.0066		0.0058		0.009		0.0139		0.0041		0.0036	

SC: Silt/Clay <0.062 mm diameter particles
(---): Data was not provided
N/A: Not Applicable
N/A[1]: The rosgen classification system is for natural streams. These channels have been heavily manipulated by man and therefore the Rosgen classification system is not applicable
N/A[2]: Donstream of the confluence with overflow channel, hydraulic regime not applied
*: Channel was dry during survey, slope was calculated using channel thalweg

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

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 3 - 2018

	Cross-Section 1, UT1 (Pool)						Cross-Section 2, UT1 (Riffle)						Cross-Section 3, UT1 (Pool)						Cross-Section 4, UT1 (Riffle)					
Dimension and Substrate[1]	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
Bankfull elevation	541.8	541.9	541.8	541.8			542.1	542.0	542.1	542.1			539.7	539.7	539.7	539.6			539.8	539.8	539.8	539.7		
Low Bank Elevation	541.8	541.9	541.8	541.8			542.1	542.0	542.1	542.1			539.7	539.7	539.7	539.6			539.8	539.8	539.8	539.7		
Bankfull Width (ft)	13.3	12.7	13.6	13.3			11.7	11.1	11.4	14.6			12.6	12.3	12.2	15.4			12.6	11.9	12.0	13.0		
Floodprone Width (ft)	---	---	---	---			200+	200+	200+	200+			---	---	---	---			200+	200+	200+	200+		
Bankfull Mean Depth (ft)	0.7	0.7	0.6	0.7			0.6	0.5	0.6	0.5			1.0	0.9	1.0	0.8			0.6	0.7	0.6	0.6		
Bankfull Max Depth (ft)	1.5	1.4	1.4	1.5			1.1	0.9	1.0	1.1			2.4	2.2	2.1	2.2			1.1	1.0	1.2	1.1		
Bankfull Cross-Sectional Area (ft^2)	8.7	8.5	8.3	8.7			7.3	5.9	6.5	7.3			12.6	11.4	12.3	12.6			7.5	7.8	7.6	7.5		
Bankfull Width/Depth Ratio	20.4	18.9	22.4	20.4			18.9	20.8	20.1	29.1			12.7	13.4	12.1	18.9			21.1	18.0	18.9	22.6		
Bankfull Entrenchment Ratio	---	---	---	---			2.2+	2.2+	2.2+	2.2+			---	---	---	---			2.2+	2.2+	2.2+	2.2+		
Bankfull Bank Height Ratio	---	---	---	---			1.0	1.0	1.0	1.0			---	---	---	---			1.0	1.0	1.0	1.0		

[1] Prior to MY3, bankfull dimensions were calculated using a fixed bankfull elevation. For MY3 through MY7, bankfull elevation is calculating using a fixed Abkf as described in the Standard Measurement of the BHR Monitoring Parameter documented provided by NCIRT and NCDMS (9/2018).

Table 13. Monitoring Data - Stream Reach Data Summary
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 3 - 2018

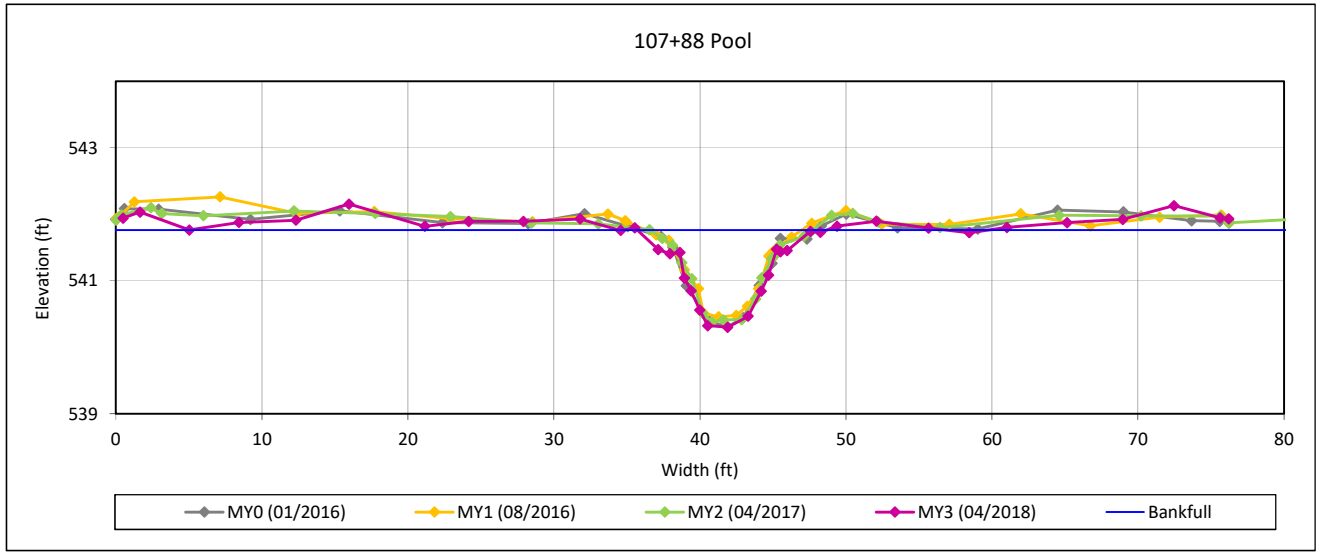
UT1

Parameter	As-Built/Baseline		MY-1		MY-2		MY-3		MY-4		MY-5	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Riffle												
Bankfull Width (ft)	11.7	12.6	11.1	11.9	11.4	12.0	13.0	14.6				
Floodprone Width (ft)	200+		200+		200+		200+					
Bankfull Mean Depth	0.6		0.5	0.7	0.6		0.5	0.6				
Bankfull Max Depth	1.1		0.9	1.0	1.0	1.2	1.1					
Bankfull Cross-sectional Area (ft^2)	7.3	7.5	5.9	7.8	6.5	7.6	7.3	7.5				
Width/Depth Ratio	18.9	21.1	18.0	20.8	18.9	20.1	22.6	29.1				
Entrenchment Ratio	2.2+		2.2+		2.2+		2.2+					
Bank Height Ratio	1.0		1.0		1.0		1.0	1.1				
D50 (mm)	0.3	35.9	SC	65.6	SC	66.2	SC	52.8				
Profile												
Riffle Length (ft)	12	50										
Riffle Slope (ft/ft)	0.0004	0.0193										
Pool Length (ft)	18	65										
Pool Max Depth (ft)	1.1	3.0										
Pool Spacing (ft)	36	99										
Pool Volume (ft^3)												
Pattern												
Channel Beltwidth (ft)	30	72										
Radius of Curvature (ft)	22	48										
Rc:Bankfull Width (ft/ft)	1.8	4.0										
Meander Wave Length (ft)	102	135										
Meander Width Ratio	2.5	6.0										
Additional Reach Parameters												
Rosgen Classification	C4											
Channel Thalweg Length (ft)	1,718											
Sinuosity (ft)	1.3											
Water Surface Slope (ft/ft)	0.0034											
Bankfull Slope (ft/ft)	0.004											
Ri%/Ru%/P%/G%/S%												
SC%/Sa%/G%/C%/B%/Be%												
d16/d35/d50/d84/d95/d100	SC/SC/0.1/19/90/256											
% of Reach with Eroding Banks												

Cross-Section Plots

Crooked Creek #2 Stream and Wetland Mitigation Site
DMS Project No. 94687
Monitoring Year 3 - 2018

Cross-Section 1-UT1



Bankfull Dimensions

8.7	x-section area (ft.sq.)
13.3	width (ft)
0.7	mean depth (ft)
1.5	max depth (ft)
14.0	wetted perimeter (ft)
0.6	hydraulic radius (ft)
20.4	width-depth ratio

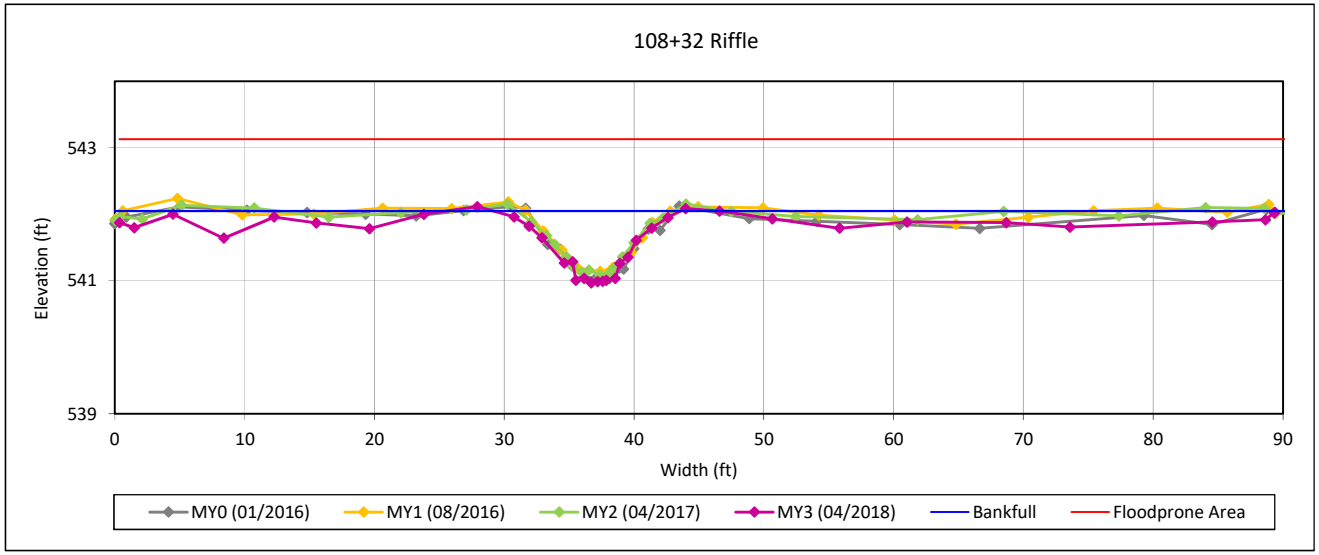
Survey Date: 04/2018
Field Crew: Wildlands Engineering

View Downstream

Cross-Section Plots

Crooked Creek #2 Stream and Wetland Mitigation Site
DMS Project No. 94687
Monitoring Year 3 - 2018

Cross-Section 2-UT1



Bankfull Dimensions

7.3	x-section area (ft.sq.)
14.6	width (ft)
0.5	mean depth (ft)
1.1	max depth (ft)
14.9	wetted perimeter (ft)
0.5	hydraulic radius (ft)
29.1	width-depth ratio
150.0	W flood prone area (ft)
10.3	entrenchment ratio
1.0	low bank height ratio

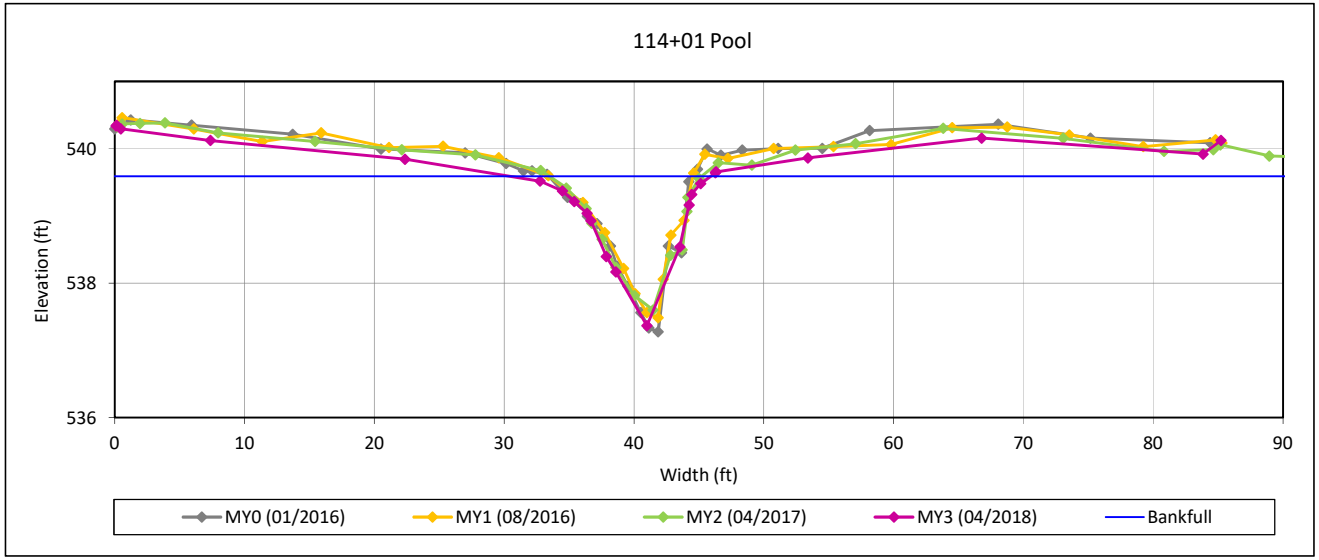
Survey Date: 04/2018
Field Crew: Wildlands Engineering

View Downstream

Cross-Section Plots

Crooked Creek #2 Stream and Wetland Mitigation Site
DMS Project No. 94687
Monitoring Year 3 - 2018

Cross-Section 3-UT1



Bankfull Dimensions

12.6	x-section area (ft.sq.)
15.4	width (ft)
0.8	mean depth (ft)
2.2	max depth (ft)
16.3	wetted perimeter (ft)
0.8	hydraulic radius (ft)
18.9	width-depth ratio

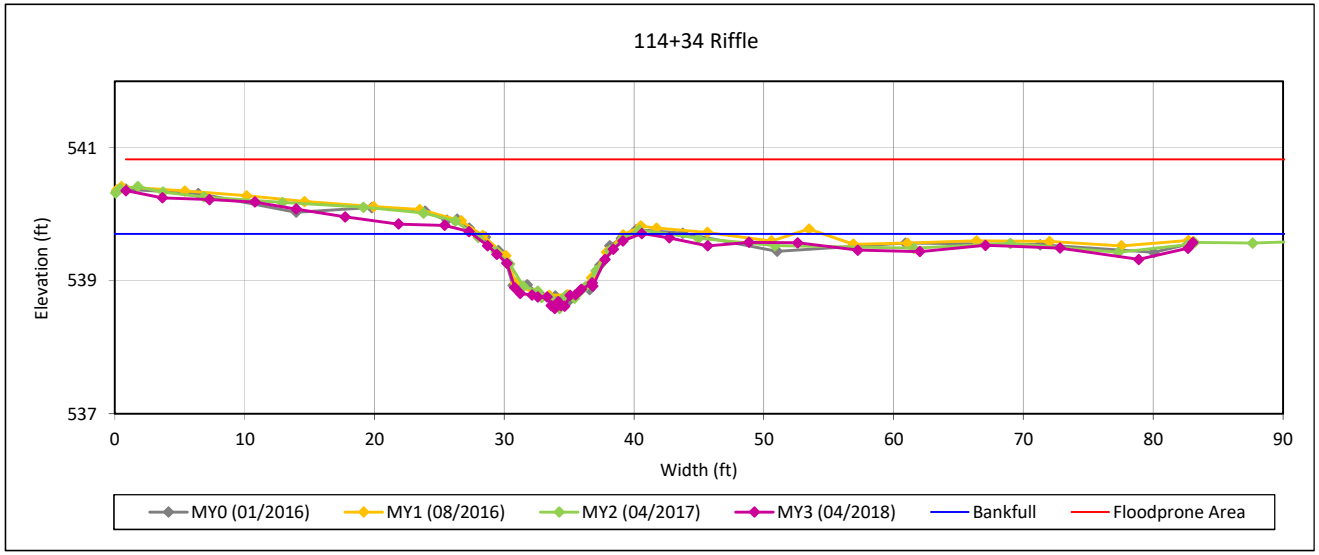
Survey Date: 04/2018
Field Crew: Wildlands Engineering

View Downstream

Cross-Section Plots

Crooked Creek #2 Stream and Wetland Mitigation Site
DMS Project No. 94687
Monitoring Year 3 - 2018

Cross-Section 4-UT1



Bankfull Dimensions

7.5	x-section area (ft.sq.)
13.0	width (ft)
0.6	mean depth (ft)
1.1	max depth (ft)
13.4	wetted perimeter (ft)
0.6	hydraulic radius (ft)
22.6	width-depth ratio
150.0	W flood prone area (ft)
11.5	entrenchment ratio
1.0	low bank height ratio

Survey Date: 04/2018
Field Crew: Wildlands Engineering

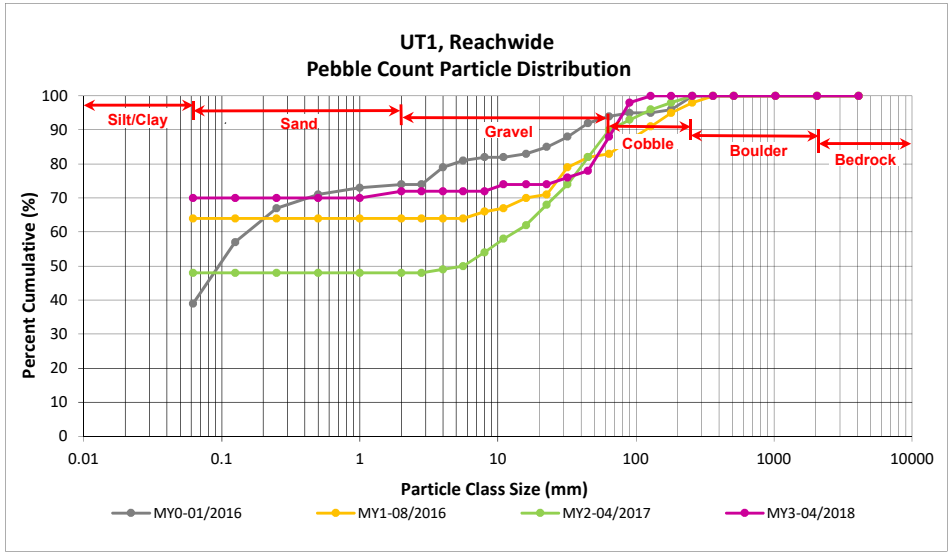
View Downstream

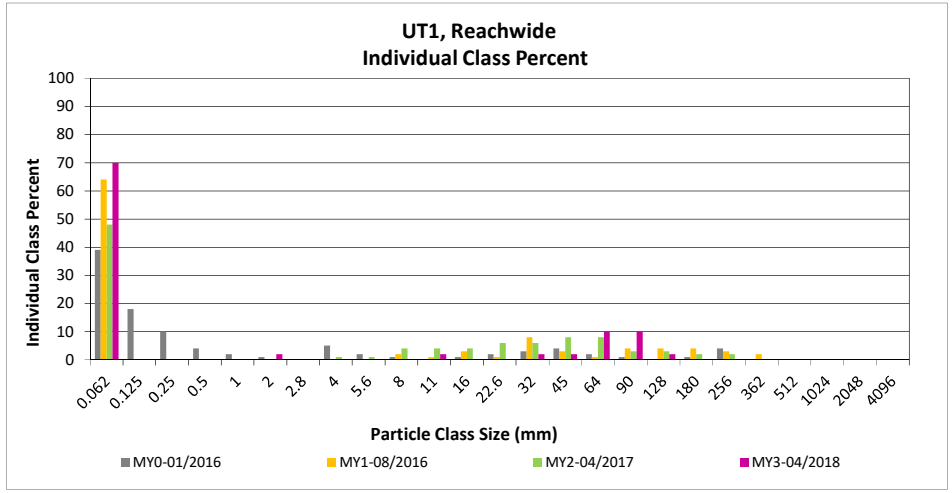
Reachwide and Cross-Section Pebble Count Plots

Crooked Creek #2 Stream and Wetland Mitigation Site
DMS Project No. 94687
Monitoring Year 3 - 2018.
UT1, Reachwide

Particle Class		Diameter (mm)		Particle Count			Reach Summary	
		min	max	Riffle	Pool	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062	30	40	70	70	70
SAND	Very fine	0.062	0.125					70
	Fine	0.125	0.250					70
	Medium	0.25	0.50					70
	Coarse	0.5	1.0					70
	Very Coarse	1.0	2.0	2		2	2	72
GRAVEL	Very Fine	2.0	2.8					72
	Very Fine	2.8	4.0					72
	Fine	4.0	5.6					72
	Fine	5.6	8.0					72
	Medium	8.0	11.0	2		2	2	74
	Medium	11.0	16.0					74
	Coarse	16.0	22.6					74
	Coarse	22.6	32	2		2	2	76
	Very Coarse	32	45	2		2	2	78
	Very Coarse	45	64	10		10	10	88
COBBLE	Small	64	90	10		10	10	98
	Small	90	128	2		2	2	100
	Large	128	180					100
	Large	180	256					100
BOULDER	Small	256	362					100
	Small	362	512					100
	Medium	512	1024					100
	Large/Very Large	1024	2048					100
BEDROCK	Bedrock	2048	>2048					100
			Total	**60**	**40**	**100**	**100**	**100**

Reachwide	
Channel materials (mm)	
D_{16} =	Silt/Clay
D_{35} =	Silt/Clay
D_{50} =	Silt/Clay
D_{84} =	55.6
D_{95} =	81.3
D_{100} =	128.0





Reachwide and Cross-Section Pebble Count Plots

Crooked Creek #2 Stream and Wetland Mitigation Site

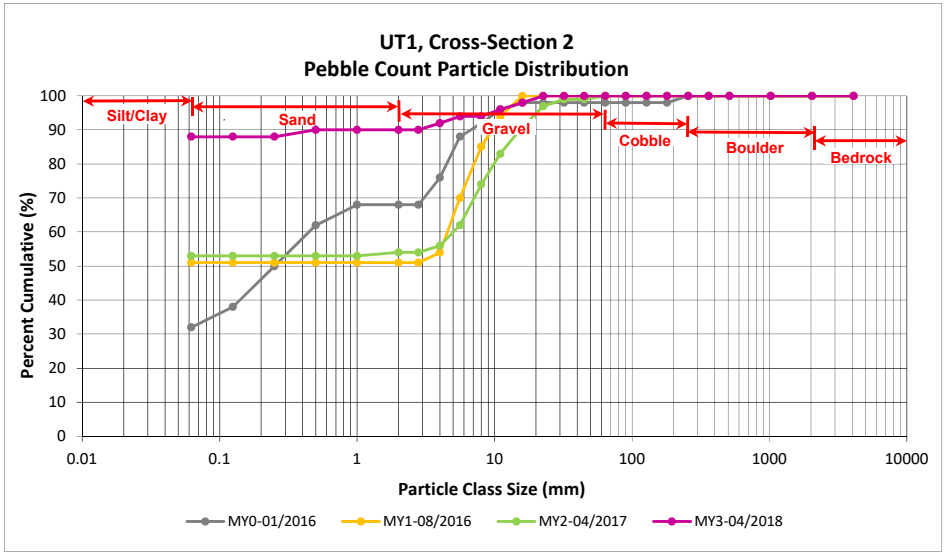
DMS Project No. 94687

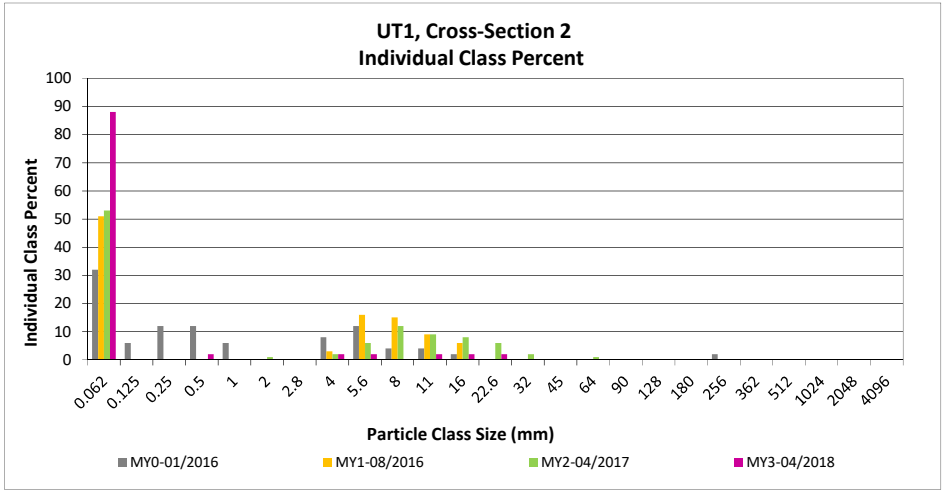
Monitoring Year 3 - 2018.

UT1, Cross-Section 2

Particle Class		Diameter (mm)		Riffle 100-Count	Summary	
		min	max		Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062	88	88	88
SAND	Very fine	0.062	0.125			88
	Fine	0.125	0.250			88
	Medium	0.25	0.50	2	2	90
	Coarse	0.5	1.0			90
	Very Coarse	1.0	2.0			90
GRAVEL	Very Fine	2.0	2.8			90
	Very Fine	2.8	4.0	2	2	92
	Fine	4.0	5.6	2	2	94
	Fine	5.6	8.0			94
	Medium	8.0	11.0	2	2	96
	Medium	11.0	16.0	2	2	98
	Coarse	16.0	22.6	2	2	100
	Coarse	22.6	32			100
	Very Coarse	32	45			100
	Very Coarse	45	64			100
COBBLE	Small	64	90			100
	Small	90	128			100
	Large	128	180			100
	Large	180	256			100
BOULDER	Small	256	362			100
	Small	362	512			100
	Medium	512	1024			100
	Large/Very Large	1024	2048			100
BEDROCK	Bedrock	2048	>2048			100
			Total	**100**	**100**	**100**

Cross-Section 2	
Channel materials (mm)	
D_{16} =	Silt/Clay
D_{35} =	Silt/Clay
D_{50} =	Silt/Clay
D_{84} =	#N/A
D_{95} =	9.4
D_{100} =	22.6





Reachwide and Cross-Section Pebble Count Plots

Crooked Creek #2 Stream and Wetland Mitigation Site

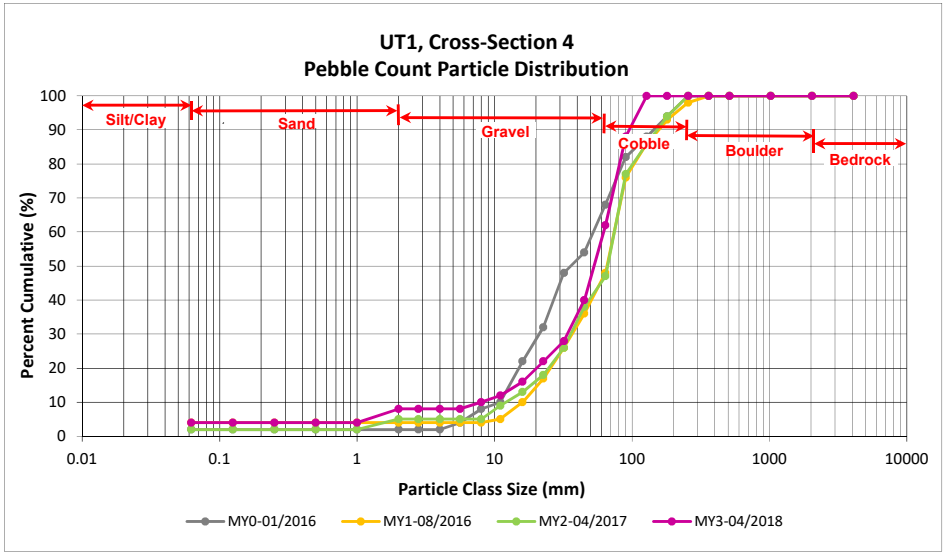
DMS Project No. 94687

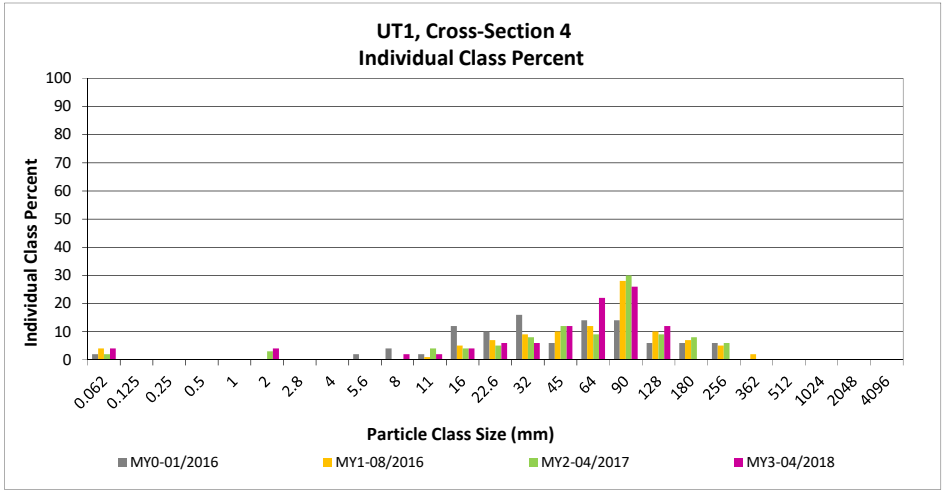
Monitoring Year 3 - 2018.

UT1, Cross-Section 4

Particle Class		Diameter (mm)		Riffle 100-Count	Summary	
		min	max		Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062	4	4	4
SAND	Very fine	0.062	0.125			4
	Fine	0.125	0.250			4
	Medium	0.25	0.50			4
	Coarse	0.5	1.0			4
	Very Coarse	1.0	2.0	4	4	8
GRAVEL	Very Fine	2.0	2.8			8
	Very Fine	2.8	4.0			8
	Fine	4.0	5.6			8
	Fine	5.6	8.0	2	2	10
	Medium	8.0	11.0	2	2	12
	Medium	11.0	16.0	4	4	16
	Coarse	16.0	22.6	6	6	22
	Coarse	22.6	32	6	6	28
	Very Coarse	32	45	12	12	40
	Very Coarse	45	64	22	22	62
COBBLE	Small	64	90	26	26	88
	Small	90	128	12	12	100
	Large	128	180			100
	Large	180	256			100
BOULDER	Small	256	362			100
	Small	362	512			100
	Medium	512	1024			100
	Large/Very Large	1024	2048			100
BEDROCK	Bedrock	2048	>2048			100
			Total	**100**	**100**	**100**

Cross-Section 4	
Channel materials (mm)	
D_{16} =	16.00
D_{35} =	39.04
D_{50} =	52.8
D_{84} =	85.4
D_{95} =	110.5
D_{100} =	128.0





APPENDIX 5. Hydrology Summary Data and Plots

Table 14. Verification of Bankfull Events
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 3 - 2018

Reach	MY of Occurrence	Date of Occurrence	Method
UT1	MY1	7/11/2016	Crest Gage
	MY2	6/20/2017	Crest Gage/Stream Gage
	MY3	9/17/2018	Stream Gage
		10/12/2018	
		10/27/2018	
		11/5/2018	
UT2	MY1	7/11/2016	Crest Gage
		10/8/2016	
	MY2	6/20/2017	
	MY3	11/5/2018	Wrack Line
Crooked Creek	MY1	7/11/2016	Crest Gage
		10/8/2016	
	MY2	6/20/2017	Crest Gage
	MY3	11/5/2018	Wrack Line

Table 15. Wetland Gage Attainment Summary

Crooked Creek #2 Restoration Project

DMS Project No. 964687

Monitoring Year 3 - 2018

Summary of Groundwater Gage Results for Monitoring Years 1 through 7					
Gage	Success Criteria Achieved/Max Consecutive Days During Growing				
	Year 1 (2016)	Year 2 (2017)	Year 3 (2018)	Year 4 (2019)	Year 5 (2020)
1	No/0 Days (0%)	No/7 Days (3%)	No/12 Days (5%)		
2	No/2 Days (0.9%)	No/8 Days (4%)	No/13 Days (6%)		
3	No/1 Days (0.4%)	No/9 Days (4%)	Yes/29 Days (13%)		
4	No/0 Days (0%)	No/6 Days (3%)	No/10 Days (4%)		
5	No/1 Days (0.4%)	No/7 Days (3%)	No/12 Days (5%)		
6	Yes/26 Days (11.5%)	Yes/75 Days (33%)	Yes/88 Days (39%)		
7	yes/18 Days (8%)	Yes/47 Days (21%)	Yes/45 Days (20%)		
8	No/14 Days (6.2%)	Yes/31 Days (14%)	Yes/45 Days (20%)		
9	No/1 Days (0.4%)	No/7 Days (3%)	No/13 Days (6%)		
10	No/2 Days (0.9%)	No/11 Days (5%)	No/10 Days (4%)		

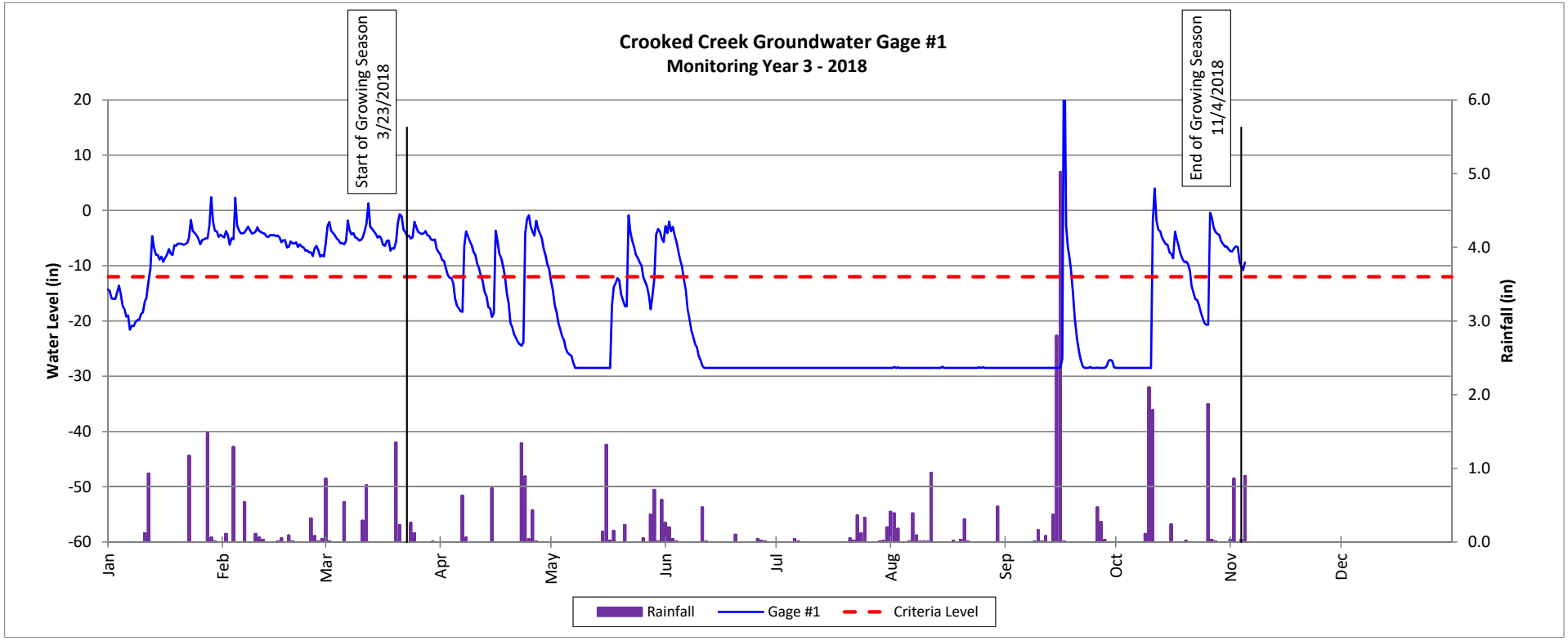
Growing season 3/23/2018- 11/4/2018

Success Criteria is 17 consecutive days

Gages meeting criteria: MY1 = 2/10, MY2 = 3/10, MY3 = 4/10.

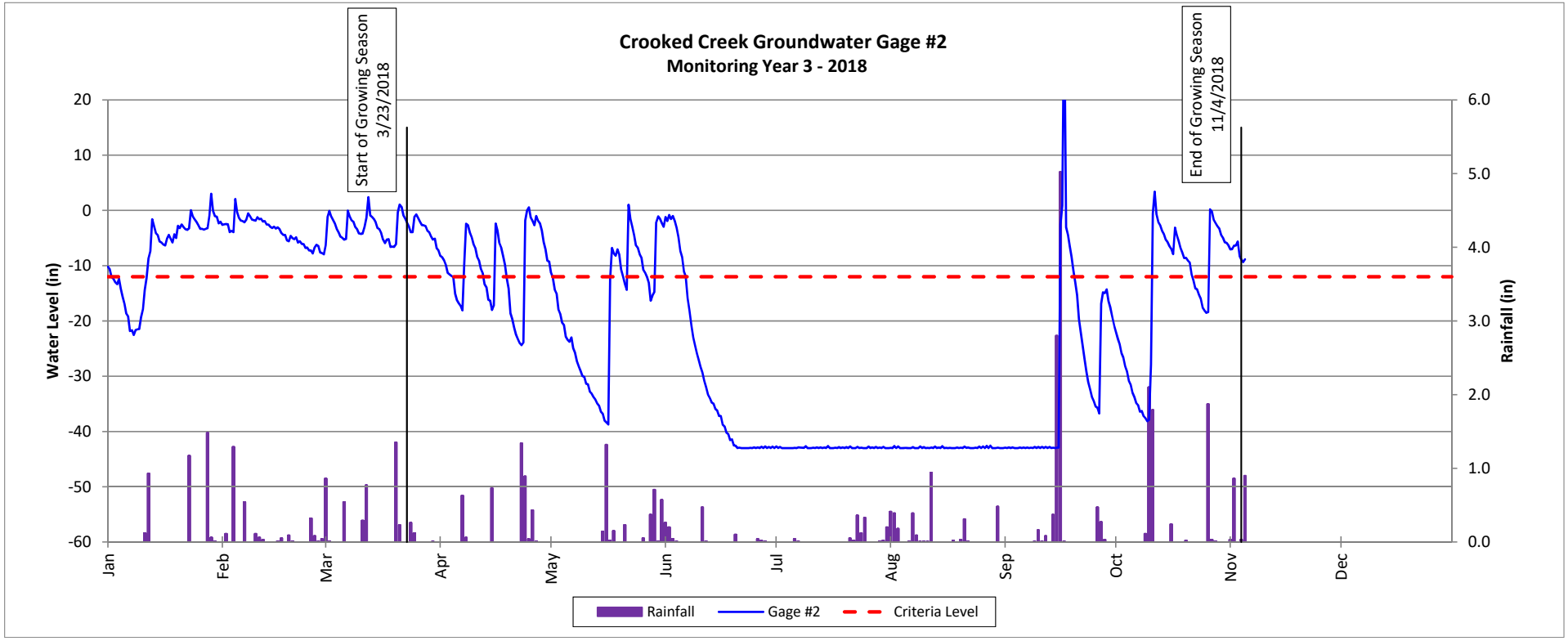
Groundwater Gage Plots

Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 3 - 2018
Wetland Restoration



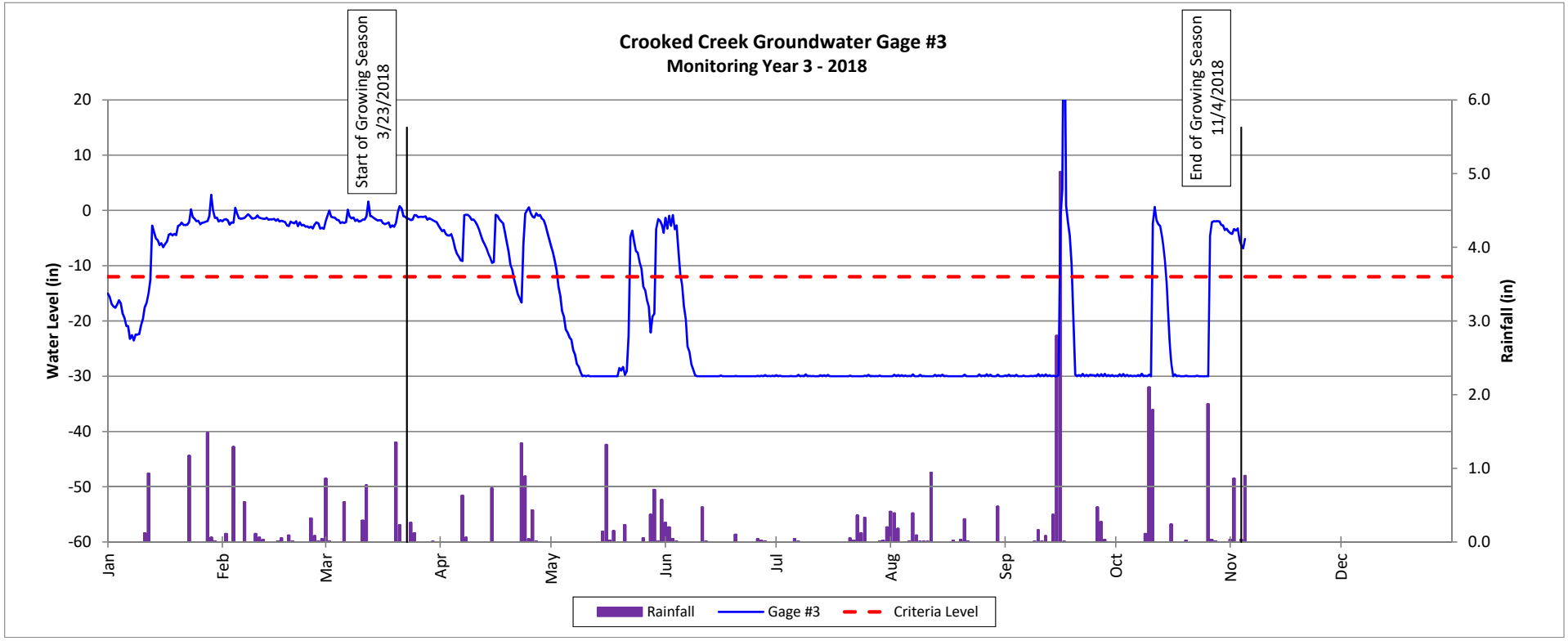
Groundwater Gage Plots

Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 3 - 2018
Wetland Restoration



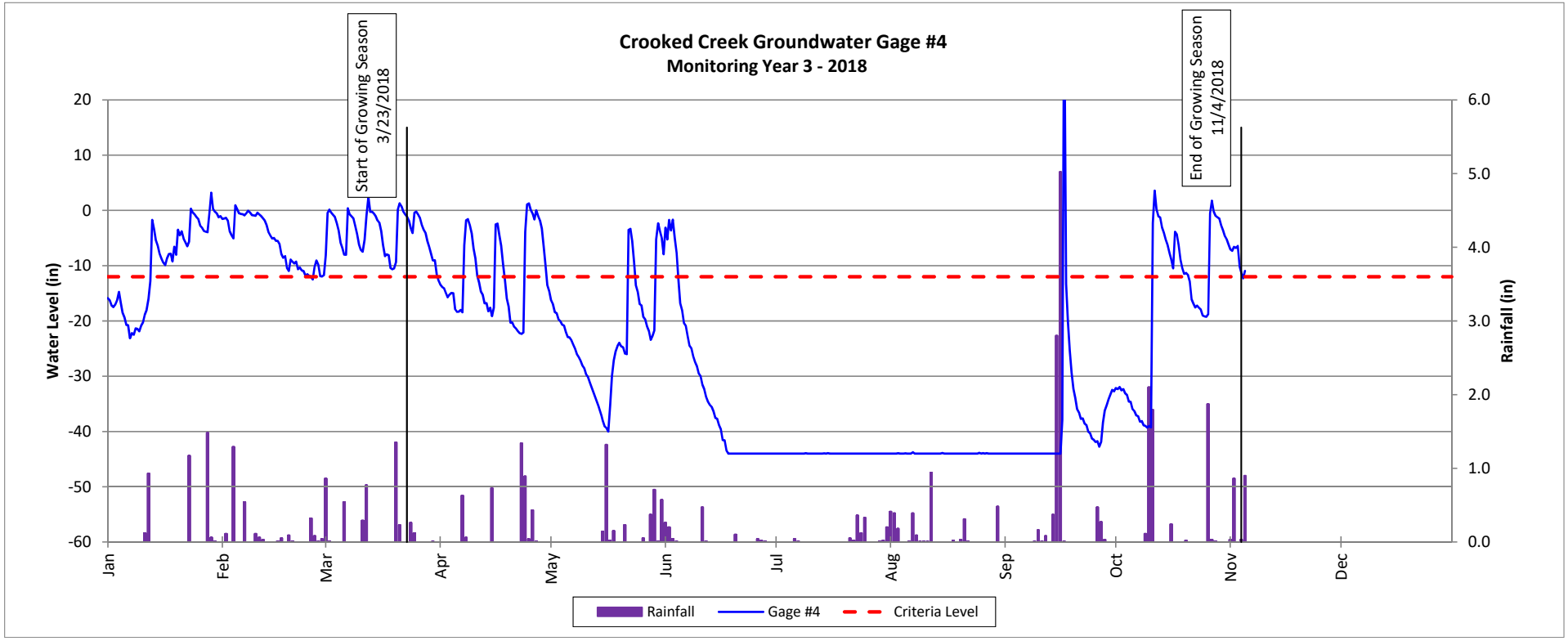
Groundwater Gage Plots

Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 3 - 2018
Wetland Restoration



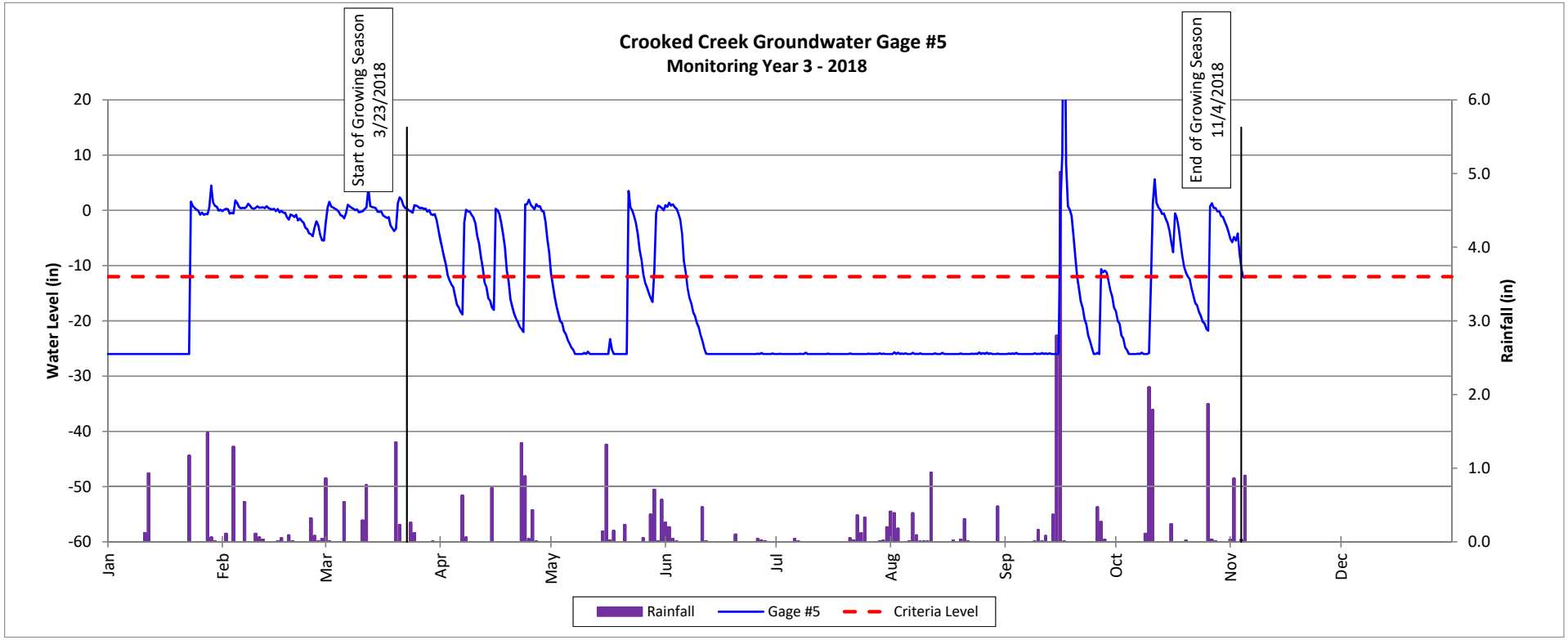
Groundwater Gage Plots

Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 3 - 2018
Wetland Restoration



Groundwater Gage Plots

Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 3 - 2018
Wetland Restoration



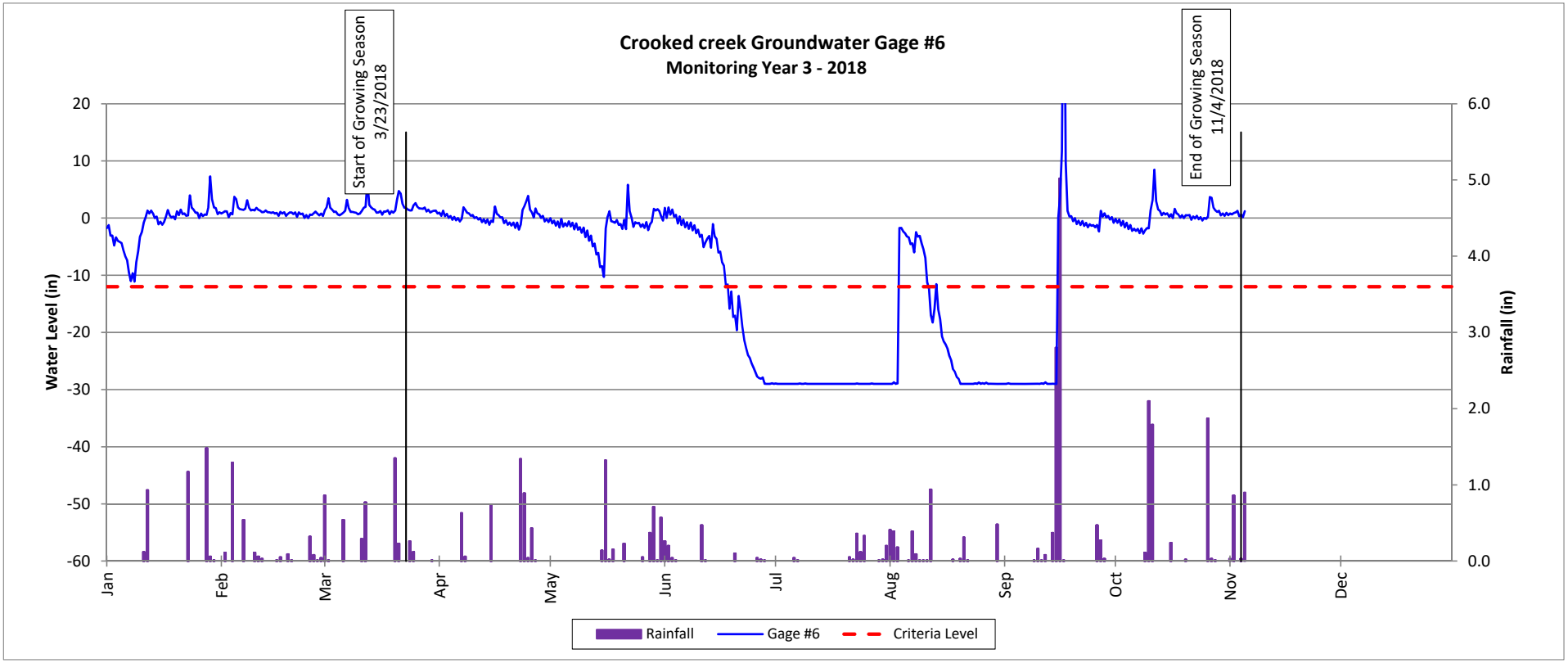
Groundwater Gage Plots

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 3 - 2018

Wetland Restoration



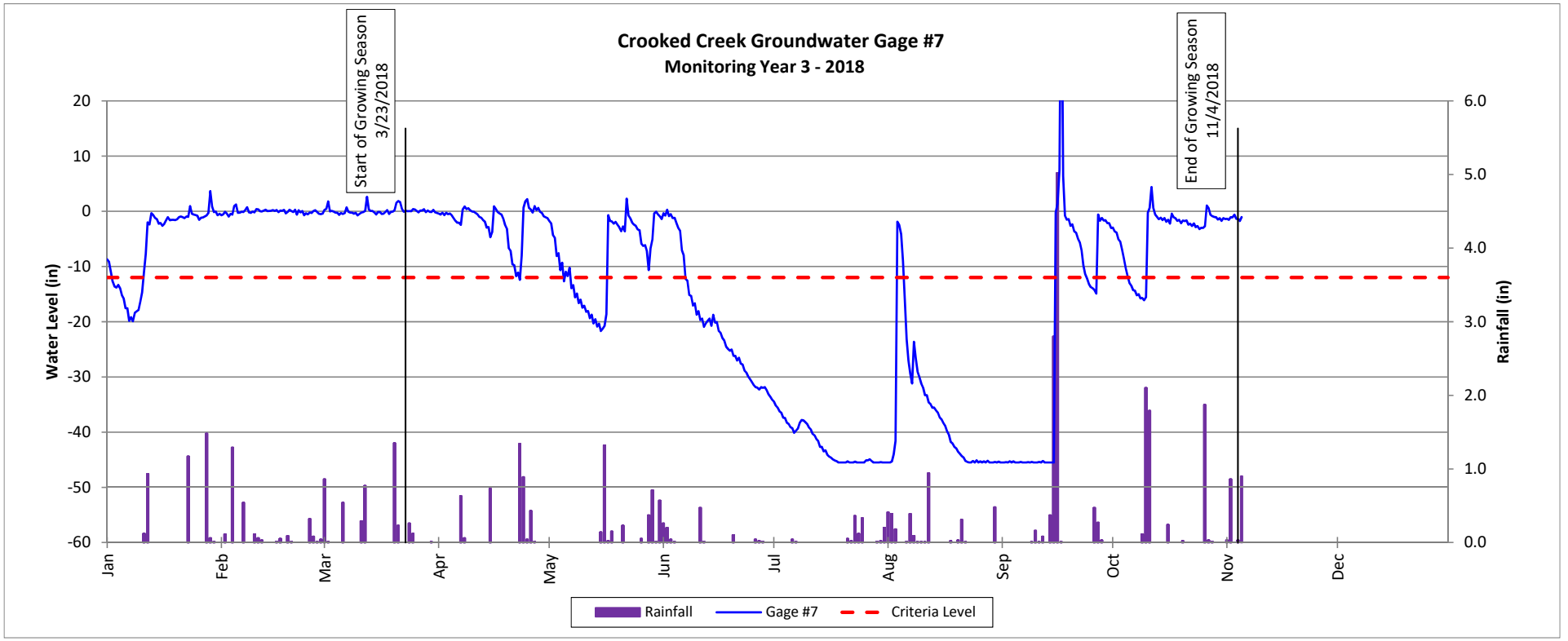
Groundwater Gage Plots

Crooked Creek #2 Restoration Project

DMS Project No. 94687

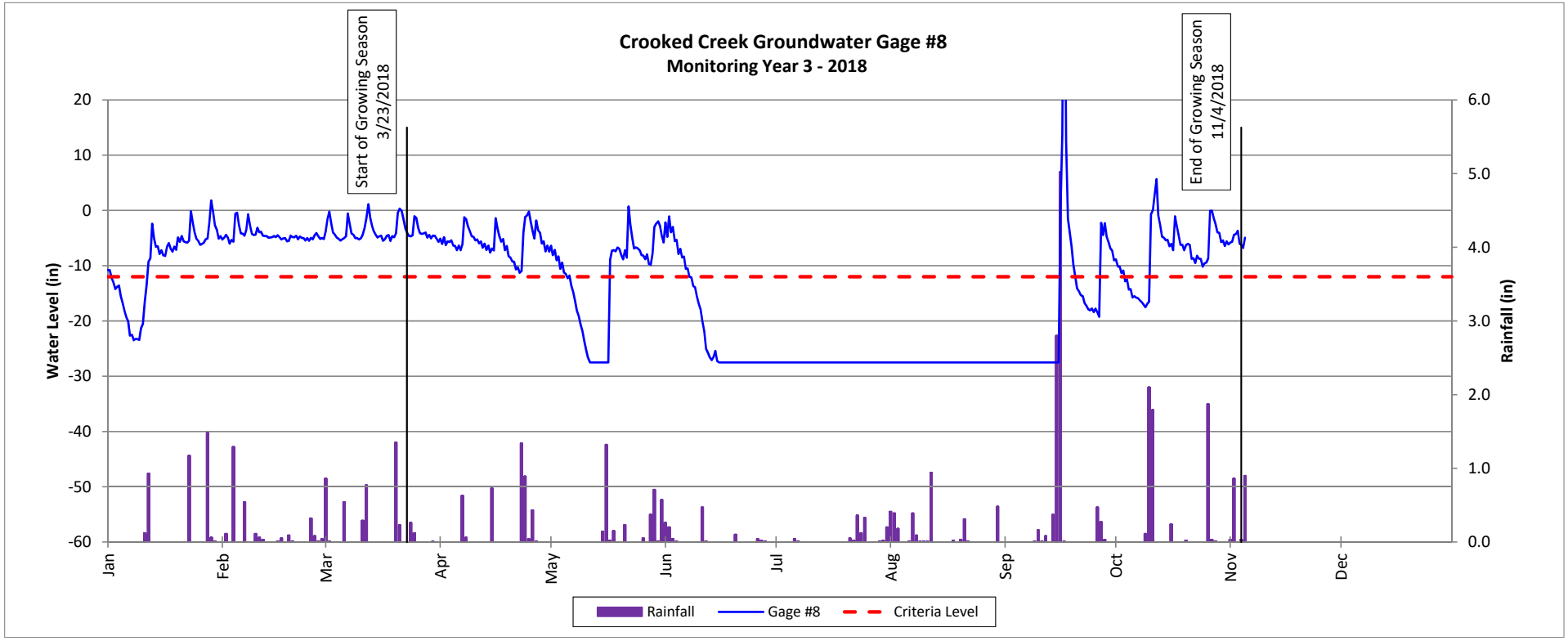
Monitoring Year 3 - 2018

Wetland Restoration



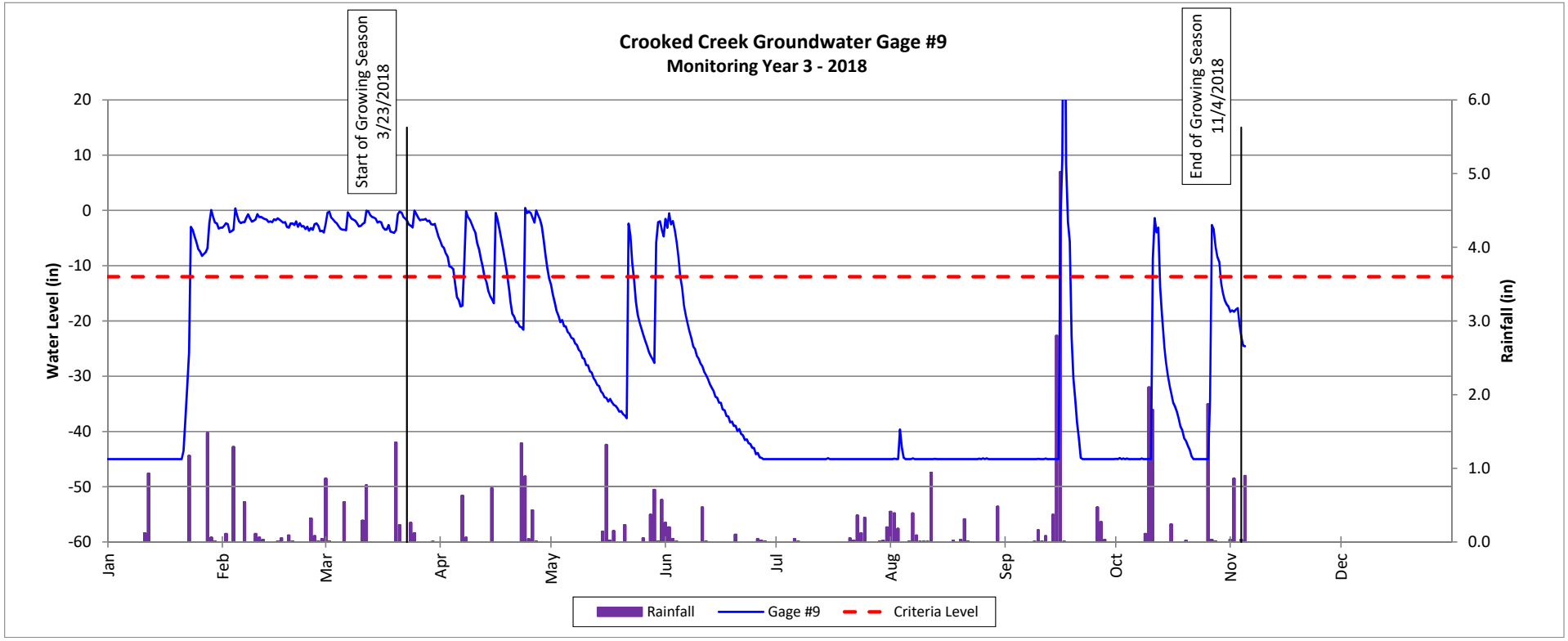
Groundwater Gage Plots

Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 3 - 2018
Wetland Restoration



Groundwater Gage Plots

Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 3 - 2018
Wetland Restoration



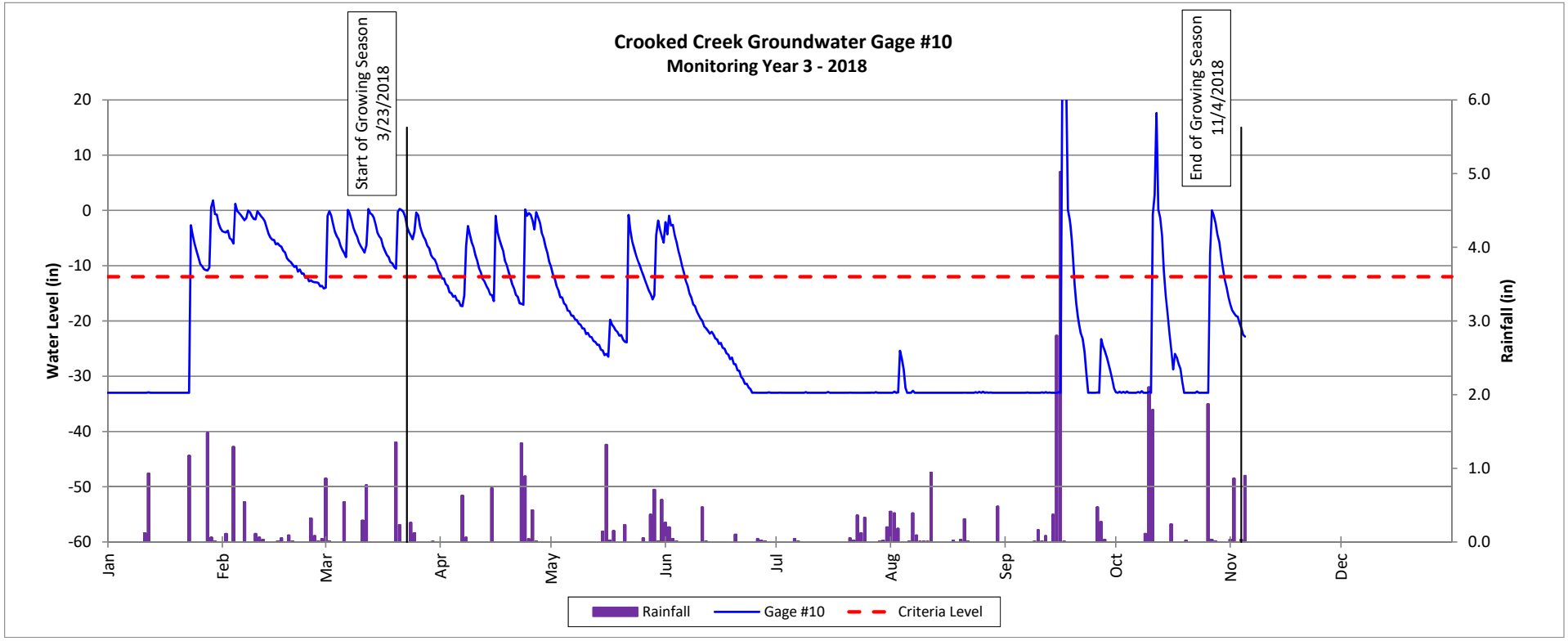
Groundwater Gage Plots

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 3 - 2018

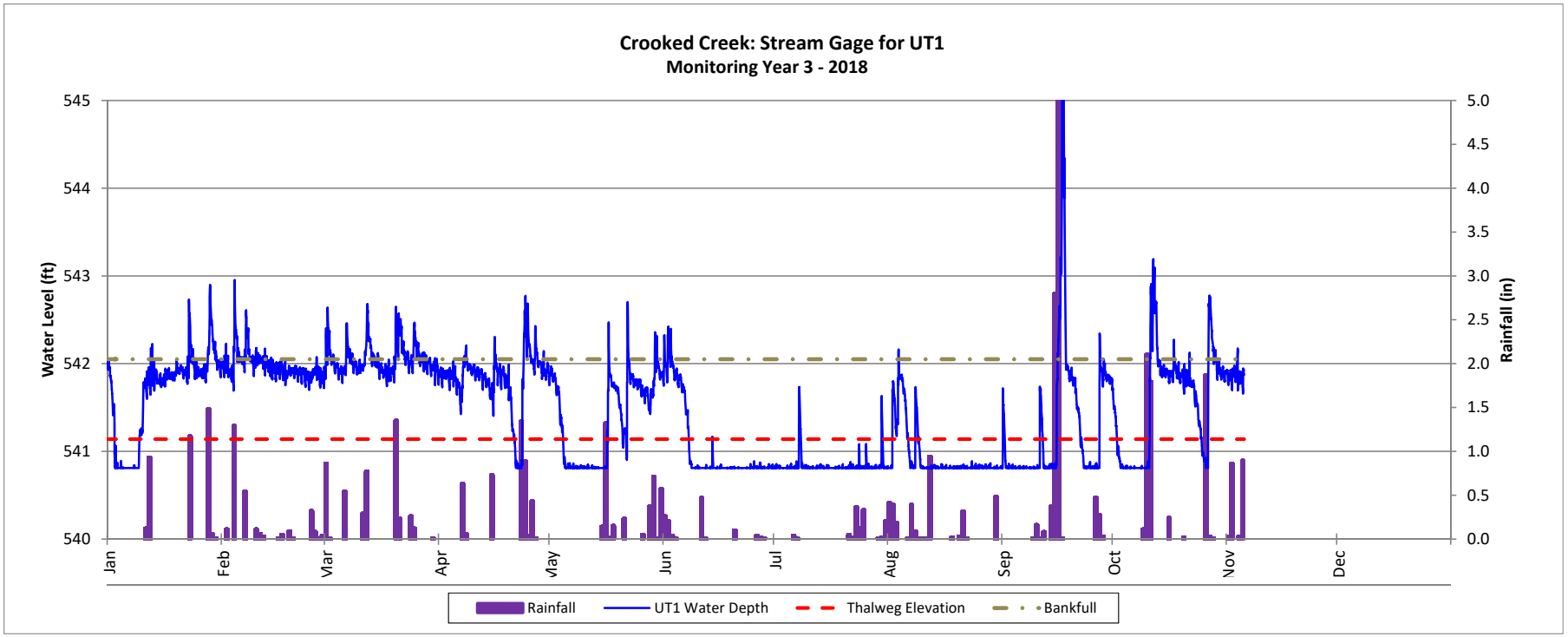
Wetland Restoration



Recorded Stream Gage Events

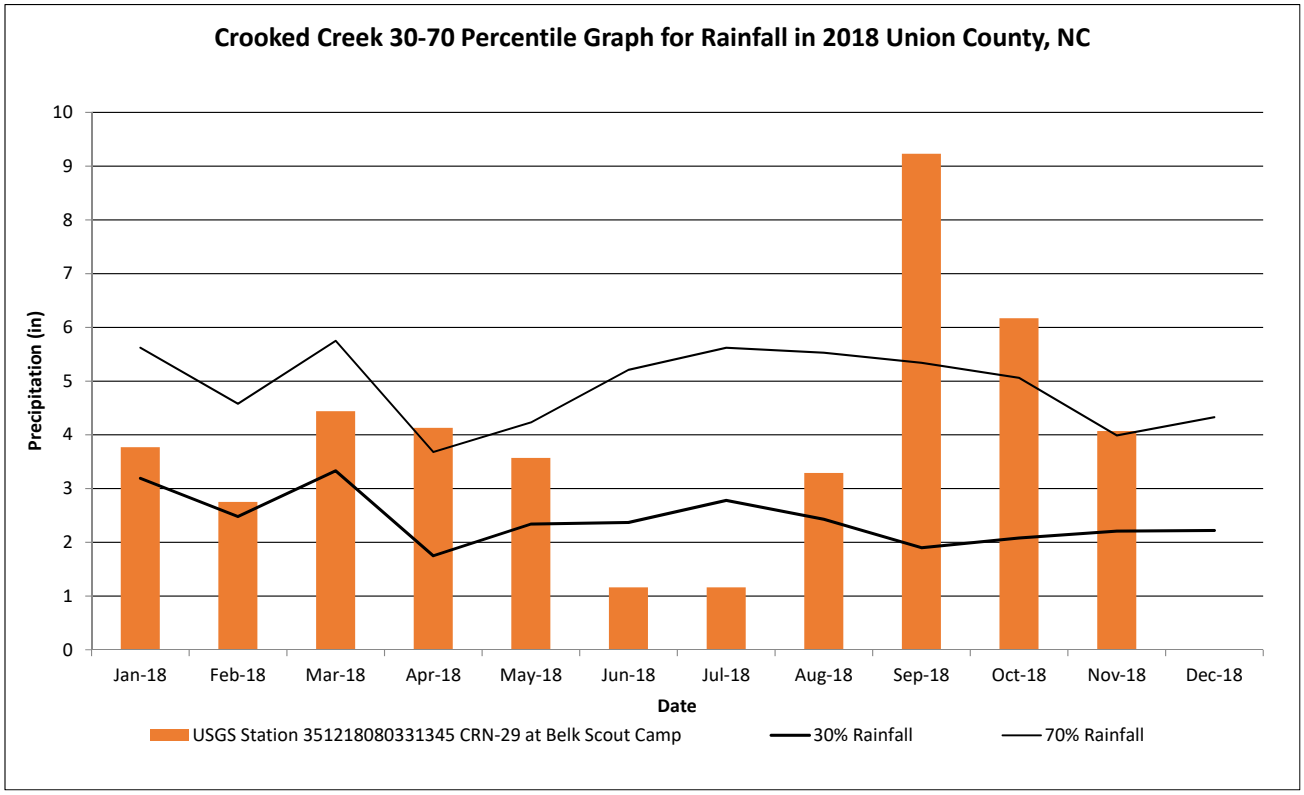
Crooked Creek #2 Restoration Project (DMS Project No. 94687)

Monitoring Year 3 - 2018



Monthly Rainfall Data

Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 3 - 2018



[1] 30th and 70th percentile rainfall data generated from WETS Table: Monroe, NC5771 (1971-2000). (USDA Field Office Climate Data, 2016)