



# MONITORING YEAR 1 ANNUAL REPORT

Final

## CROOKED CREEK #2 RESTORATION PROJECT

Union County, NC
NCDEQ Contract D09126S
DMS Project Number 94687

Data Collection Period: Aug. 2016 – Sept. 2016
Draft Submission Date: November 18, 2016
Final Submission Date: December 12, 2016

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**PREPARED FOR:**

**NC Department of Environment 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

## 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 6,147 linear feet (LF) of perennial streams, enhance 1.0 acre of existing wetlands, restore and create 10.6 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 3,489.6 stream mitigation units (SMUs), 8.6 wetland mitigation units (WMUs), and 1.3 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 1 (MY1) assessments were completed during August and September, 2016 to assess the conditions of the site. The average stem density for the Site is 320 stems per acre and is therefore on track to meet the interim Year 3 requirement of 320 stems per acres. The floodplain has dense herbaceous cover. Cross section dimensions appear stable and functioning as designed. Hydrologic success criteria were achieved in two of the 10 groundwater monitoring wells, and at least one bankfull event occurred on all monitored reaches.

**CROOKED CREEK #2 STREAM AND WETLAND MITIGATION SITE**
Monitoring Year 1 Annual Report

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## APPENDICES

# 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 pre-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 1 Data Assessment

Annual monitoring was conducted during MY1 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 (Wildlands, 2013).

### 1.2.1 Vegetation Assessment

Planted woody vegetation is being monitored in accordance with the guidelines and procedures developed by the Carolina Vegetation Survey-EEP Level 2 Protocol (Lee et al., 2008). 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 MY1 vegetative survey was completed in September 2016, resulting in an average stem density of 320 stems per acre. Although the site has met the interim requirement of 320 stems/acre, only 6 of the 12 plots (50%) individually met this requirement. The planted stem mortality was approximately 39% from the baseline density recorded in February 2016 at MY0 of 526 stems/acre. There is an average of 8 stems per plot as compared to 13 stems per plot in MY0. Approximately 60% of the planted stems scored a vigor of 2 or less, indicating that they are unlikely to survive. This low vigor rating is due to the dry soil conditions and the suffocation of the surrounding herbaceous material. 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

While significant efforts were implemented during construction to control the invasive species within the Site, visual assessments in MY1 revealed areas in which follow up treatments may be warranted. Non-native invasive identified include Chinaberry (*Melia* azedarach), Chinese privet (*Ligustrum sinense*), Johnson grass (*Sorghum halepense*), and morning glory (*Ipomoea sp.*). The native invasive cattail (*Typha latifolia*) has colonized into Vegetation Plot 5, which may impact planted woody stem survival.

The majority of the floodplain contains dense, native herbaceous cover; however, the competition for water could potentially impact the planted stems in drought conditions. Morning glory vines, and other invasive plants are impacting planted stems near photo point 33, which is located at the center, northern border of the easement. Despite herbicide treatment along the fence line, the vines have intruded further into the easement. The treated areas of Chinese privet on Crooked Creek Reach A and Reach B are showing increasing dominance of this species once again. Refer to Appendix 2 for the vegetation condition assessment table, Integrated Current Condition Plan View (CCPV), and reference photographs.

### 1.2.3 Stream Assessment

MY1 Morphological surveys for were conducted in August 2016. 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 fell within the parameters defined for channels of the appropriate Rosgen stream type (Rosgen, 1996). In general, substrate materials in the restoration reaches indicated maintenance of coarser materials in the riffle reaches and finer particles in the pools. The particle size distribution for MY1 riffle cross section 4 are similar or slightly larger than the as-built conditions, however pebble count data for riffle cross section 2 indicates increased deposition of fine sediment. This area will be watched in future monitoring years for embeddedness. Refer to Appendix 2 for the visual stability assessment table, CCPV map, and reference photographs. Refer to Appendix 4 for the morphological summary data and plots.

### 1.2.4 Stream Areas of Concern

No stream areas of concern were identified during MY1.

### 1.2.5 Hydrology Assessment

At least one bankfull event occurred on all reaches during the MY1 data collection, which was recorded on crest gages and by visual indicators. Two bankfull flow events must be documented on the restoration reaches within the seven-year monitoring period. The two bankfull events must occur in separate years. Therefore, the performance criteria have been partially met in MY1. 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. Only two of the ten gages (GWG 6 and GWG7) met the performance criteria for MY1. GWG 6 met criteria for 26 consecutive days (15.5%) and GWG 7 recorded 18 consecutive days (8.0%). Both gages meeting success criteria are in the Wetland Restoration Zone A. According to onsite rain gage data and climate

data from a nearby USGS station, the site received less than typical amount of rain in 2016. The monthly rainfall in Feb-April and June fell below the 30% percentile for the area (USGS 2016). Refer to Appendix 5 for the groundwater hydrology data and plots.

## 1.3 Monitoring Year 1 Summary

All restored streams within the Site appear stable and functioning as designed. The average stem density (320 stems per acre) for the Site is currently on track to meeting the MY7 success criteria; however only 50% of the vegetation plots individually meet the interim success criteria as noted in CCPV. Two of the 10 groundwater gages met the performance criteria in MY1. The bankfull performance criteria has been partially met in MY1.

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


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

North Carolina Ecosystem Enhancement Program (NCEEP), 2009. Lower Yadkin Pee-Dee River Basin Restoration Priorities. Retrieved from: http://deq.nc.gov/document/yadkin-pee-dee-rbrp-2009-final

North Carolina Ecosystem Enhancement Program (NCEEP), Tetra Tech, CCoG, 2012. Goose Creek and Crooked Creek Local Watershed Plan. Retrieved from: http://www.gooseandcrooked.org/documents/GooseandCrookedLWP-WMP_Final_7-2012.pdf

Rosgen, D.L. 1996. Applied River Morphology. Pagosa Springs, CO: Wildland Hydrology Books.

United States Army Corps of Engineers (USACE), 2003. Stream Mitigation Guidelines. USACE, NCDENR-DWQ, USEPA, NCWRC.

United States Geological Survey (USGS), 1998. North Carolina Geology. Retrieved from: http://www.geology.enr.state.nc.us/usgs/coastalp.htm

United States Geological Survey (USGS), 2016. Real Time Water Data for North Carolina. Retrieved from: http://nc.water.usgs.gov/realtime/real_time_yadkin_peedee.html

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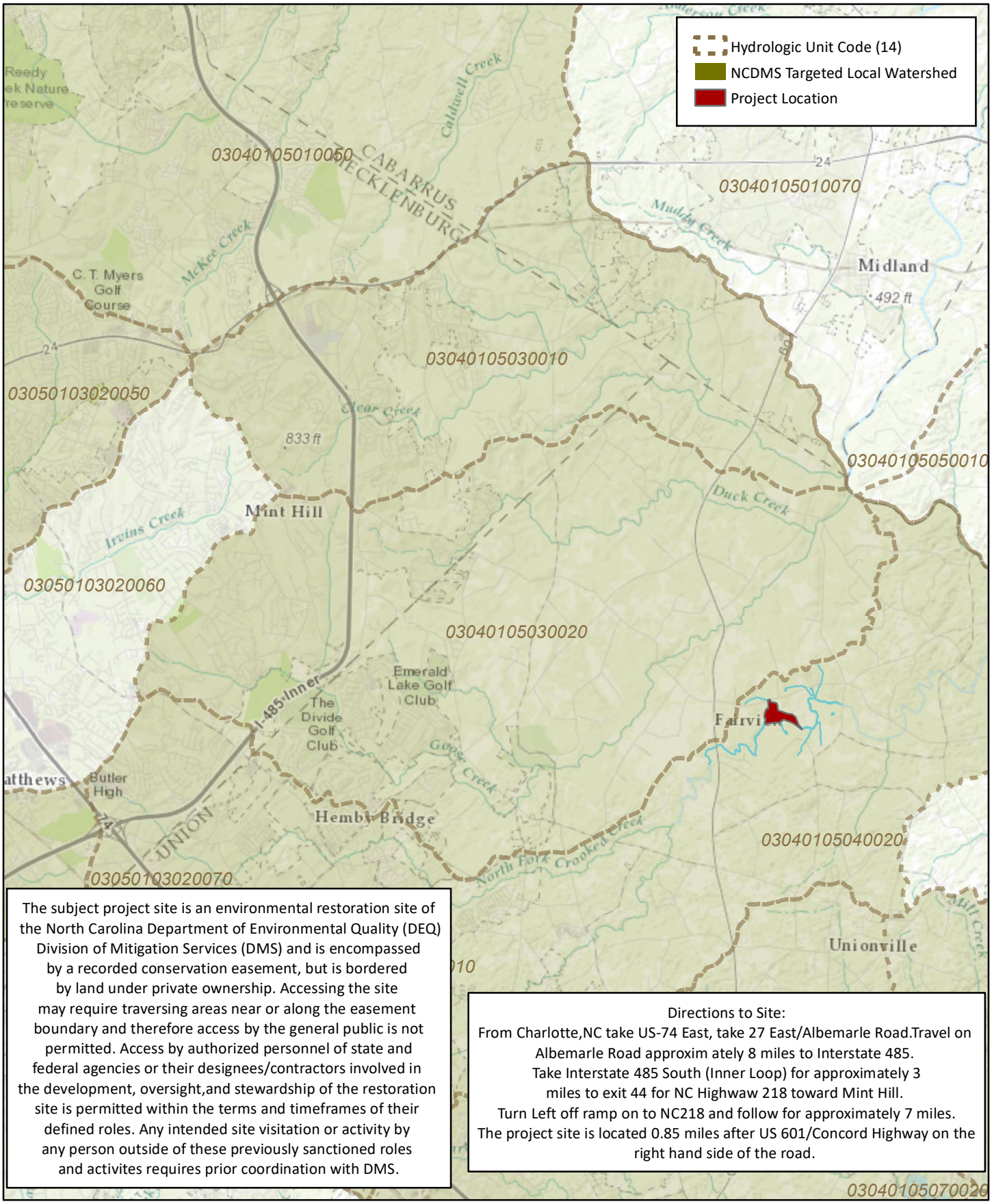
# APPENDIX 1. General Tables and Figures




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 within the terms and timeframes of their defined roles. Any intended site visitation or activity by any person outside of these previously sanctioned roles and activites requires prior coordination with DMS.

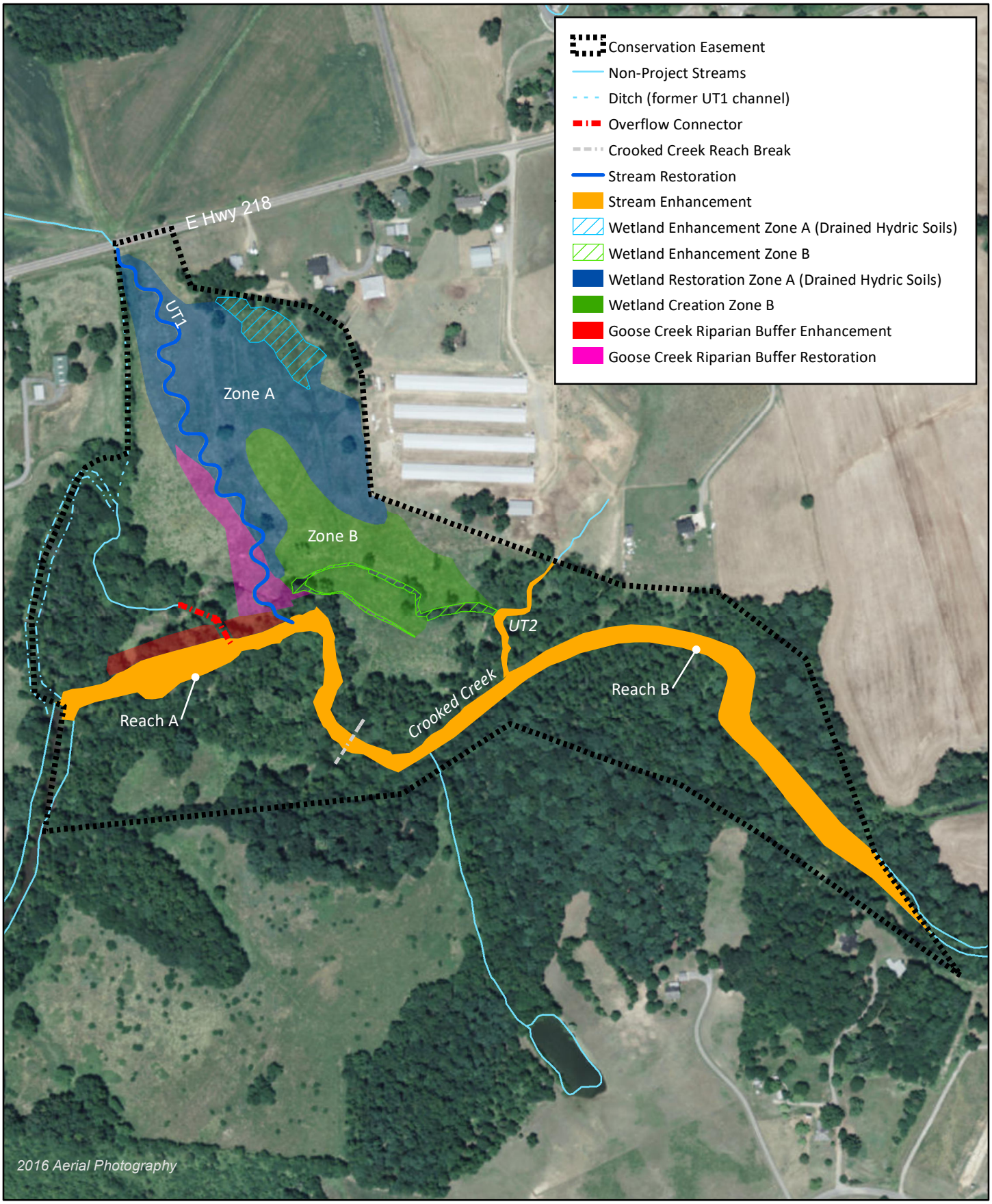
Directions to Site:
From Charlotte,NC take US-74 East, take 27 East/Albemarle Road.Travel on Albemarle Road approxim ately 8 miles to Interstate 485.
Take Interstate 485 South (Inner Loop) for approximately 3 miles to exit 44 for NC Highwaw 218 toward Mint Hill.
Turn Left off ramp on to NC218 and follow for approximately 7 miles.
The project site is located 0.85 miles after US 601/Concord Highway on the right hand side of the road.

WILDLANDS ENGINEERING

0 0.5 1 Mile

N

Figure 1 Project Vicinity Map
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 1 - 2016
*Union County, NC*




WILDLANDS ENGINEERING

0 200 400 Feet

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Figure 2 Project Component/Asset Map
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 1 - 2016
*Union County, NC*

**Table 1. Project Components and Mitigation Credits**
Crooked Creek #2 Restoration Project Site
DMS Project No. 94687
**Monitoring Year 1 - 2016**

| Mitigation Credits | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Stream | | Riparian Wetland | | Non-Riparian Wetland | | Buffer | Nitrogen Nutrient | Phosphorous Nutrient Offset |
| Type | R | RE | R | RE | R | RE | | | |
| Totals | 3,489.6 | N/A | 8.0 | 0.6 | N/A | N/A | 1.3 | N/A | |

| Project Components | | | | | | | |
|---|---|---|---|---|---|---|---|
| Reach ID | As-Built Stationing/ Location | Existing Footage/ Acreage | Approach | Restoration or Restoration Equivalent | Restoration Footage/ Acreage | Mitigation Ratio | Credits (SMU/ WMU) |
| **STREAMS** | | | | | | | |
| Crooked Creek Reach A | 200+00-228+29 | 1,555 LF | N/A | Enhancement II | 1,555 | 2.5:1 | 622.0 |
| Crooked Creek Reach B | | 2,404 LF | N/A | Enhancement II | 2,404 | 2.5:1 | 961.6 |
| UT1 | 100+00-117+18 | 1,762 LF | P1 | Restoration | 1,718 | 1:1 | 1,718.0 |
| UT2 | 300+00-305+60 | 470 LF | N/A | Enhancement II | 470 | 2.5:1 | 188.0 |
| **WETLANDS** | | | | | | | |
| Zone A (Drained Hydric Soils) | N/A | 0.7 AC | | Enhancement | 0.7 | 2:1 | 0.4 |
| Zone A (Drained Hydric Soils) | N/A | N/A | | Restoration | 6.7 | 1:1 | 6.7 |
| Zone B | N/A | 0.3 AC | | Enhancement | 0.3 | 2:1 | 0.2 |
| Zone B | N/A | N/A | | Creation | 3.9 | 3:1 | 1.3 |
| **BUFFER** | | | | | | | |
| Goose Creek Buffer | N/A | 0.6 AC | | Enhancement | 0.6 | 3:1 | 0.2 |
| Goose Creek Buffer | N/A | N/A | | Restoration | 1.1 | 1:1 | 1.1 |

| Component Summation | | | | | | |
|---|---|---|---|---|---|---|
| Restoration Level | Stream (LF) | Riparian Wetland (acres) | | Non-Riparian (acres) | Buffer (square feet) | Upland (acres) |
| | | Riverine | Non-Riverine | | | |
| Restoration | 1,718 | 6.7 | | | 45,735 | |
| Enhancement | | 1.0 | | | 25,201 | |
| Enhancement I | | | | | | |
| Enhancement II | 4,429 | | | | | |
| Creation | | 3.9 | | | | |

**Table 2. Project Activity and Reporting History**
Crooked Creek #2 Restoration Project Site
DMS Project No. 94687
**Monitoring Year 1 - 2016**

| 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 | August-September 2016 | November 2016 |
| Year 2 Monitoring | 2017 | November 2017 |
| Year 3 Monitoring | 2018 | November 2018 |
| Year 4 Monitoring | 2019 | November 2019 |
| Year 5 Monitoring | 2020 | November 2020 |
| Year 6 Monitoring | 2021 | November 2021 |
| Year 7 Monitoring | 2022 | November 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 1 - 2016**

| | |
|---|---|
| **Designer**<br>Aaron Early, PE, CFM | **Wildlands Engineering, Inc.**<br>1430 South Mint Street, Suite 104<br>Charlotte, NC 28203<br>704.332.7754 |
| **Construction Contractor** | **North State Environmental, Inc.**<br>2889 Lowery Street<br>Winston Salem, NC 27101 |
| **Planting Contractor** | **Keller Environmental**<br>7921 Haymarket Lane<br>Raleigh, NC 27615 |
| **Seeding Contractor** | **North State Environmental, Inc.**<br>2889 Lowery Street<br>Winston Salem, NC 27101 |
| **Seed Mix Sources** | **Green Resource, LLC** |
| **Nursery Stock Suppliers**<br>**Bare Roots**<br>**Live Stakes** | **Dykes & Son Nursery**<br>825 Maude Etter Rd.<br>McMinnville, TN 37110 |
| **Monitoring Performers** | **Wildlands Engineering, Inc.** |
| Monitoring, POC | Kirsten Gimbert<br>704.332.7754, ext. 110 |

**Table 4. Project Information and Attributes**
Crooked Creek #2 Restoration Project Site
DMS Project No. 94687
**Monitoring Year 1 - 2016**

| 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% |

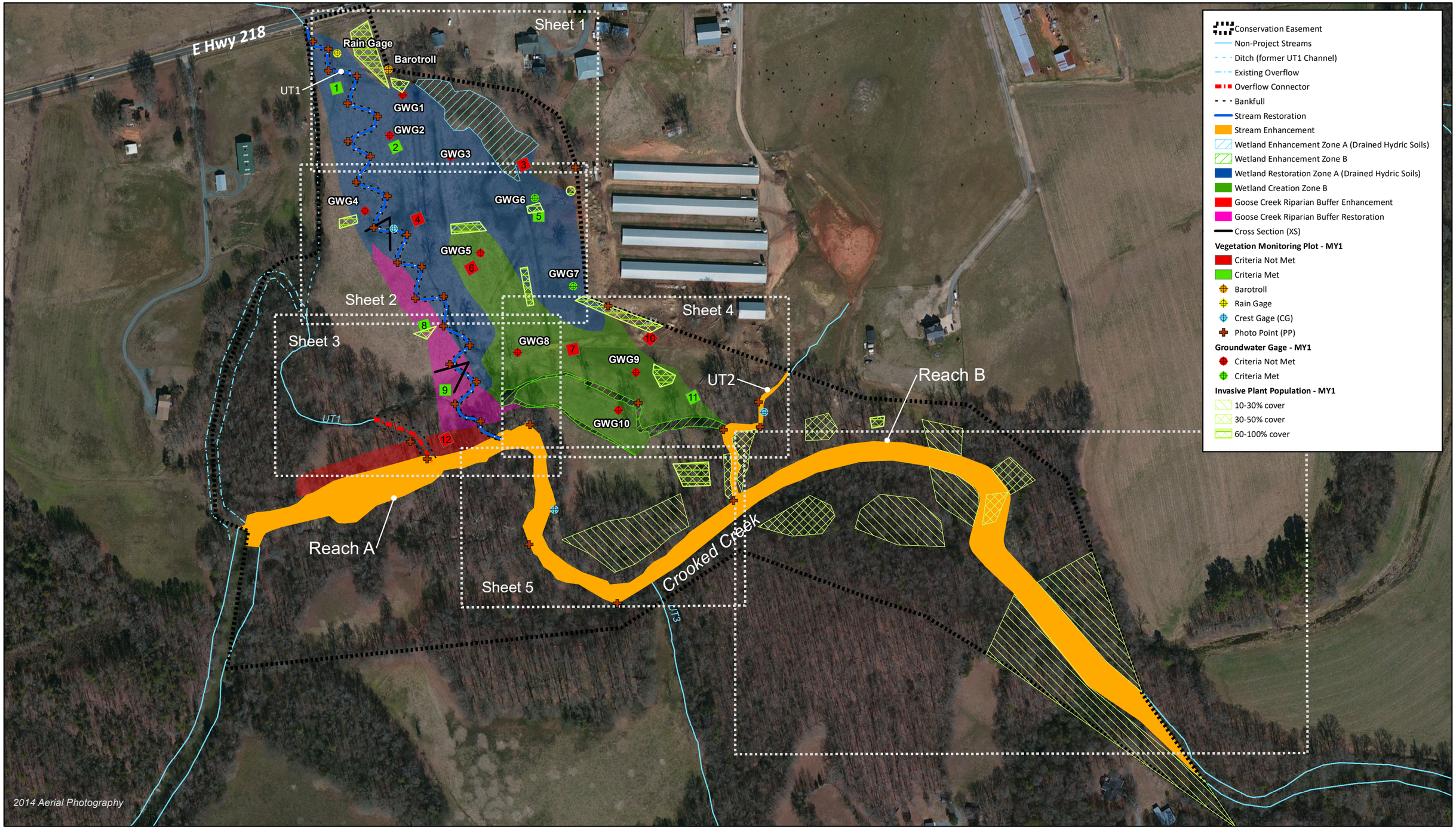
| Reach Summary Information | | | | | |
|---|---|---|---|---|---|
| **Parameters** | **Crooked Creek Reach A** | **Crooked Creek Reach B** | **UT1** | **UT2** | |
| Length of reach (linear feet) - Post-Restoration | 1,555 | 2,404 | 1,718 | 195 | 275 |
| Drainage area (acres) | 24,619 | | 153 | 51 | |
| 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 1 - 2016**

| 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 1 - 2016
*Union County, NC*

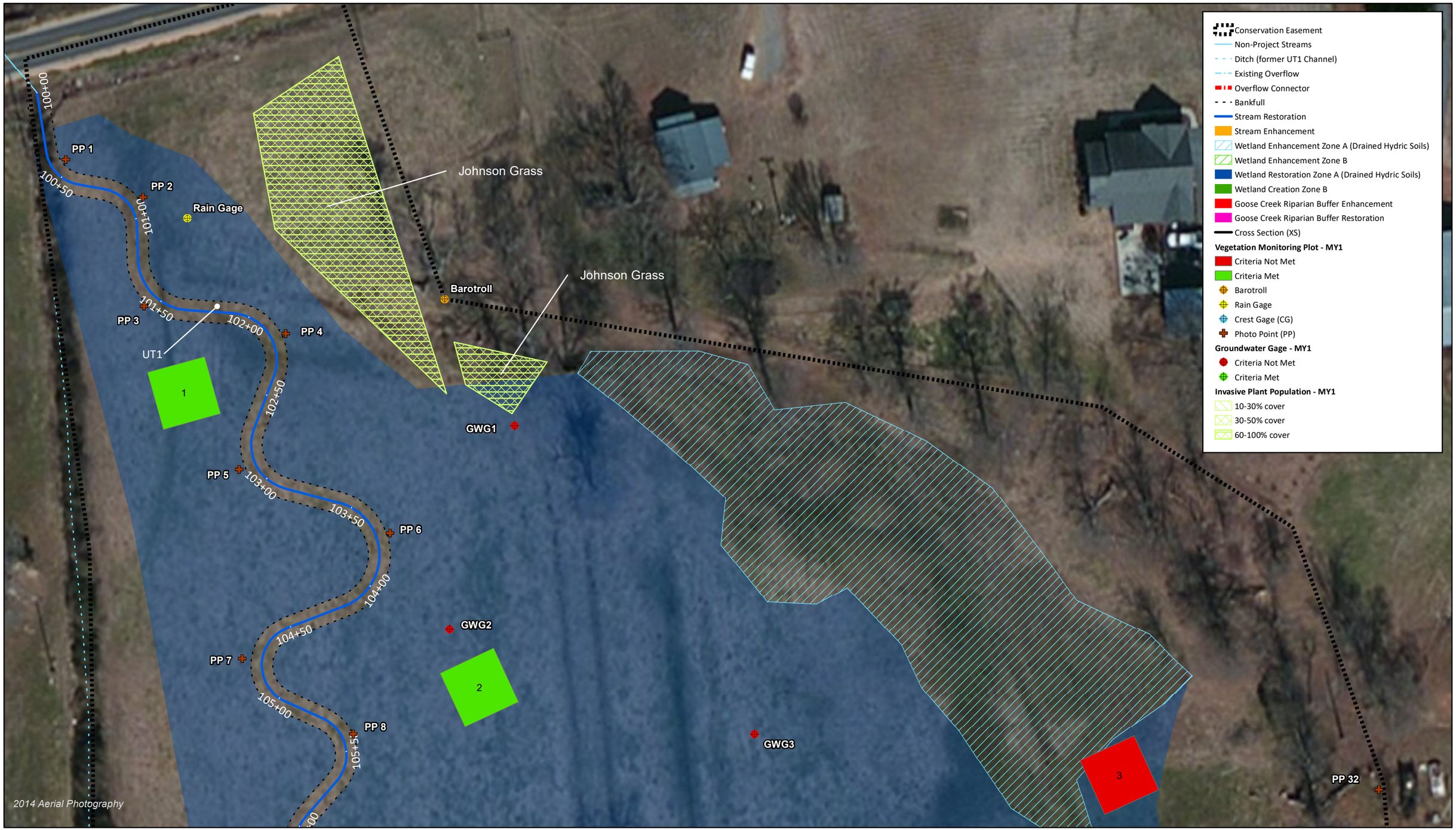
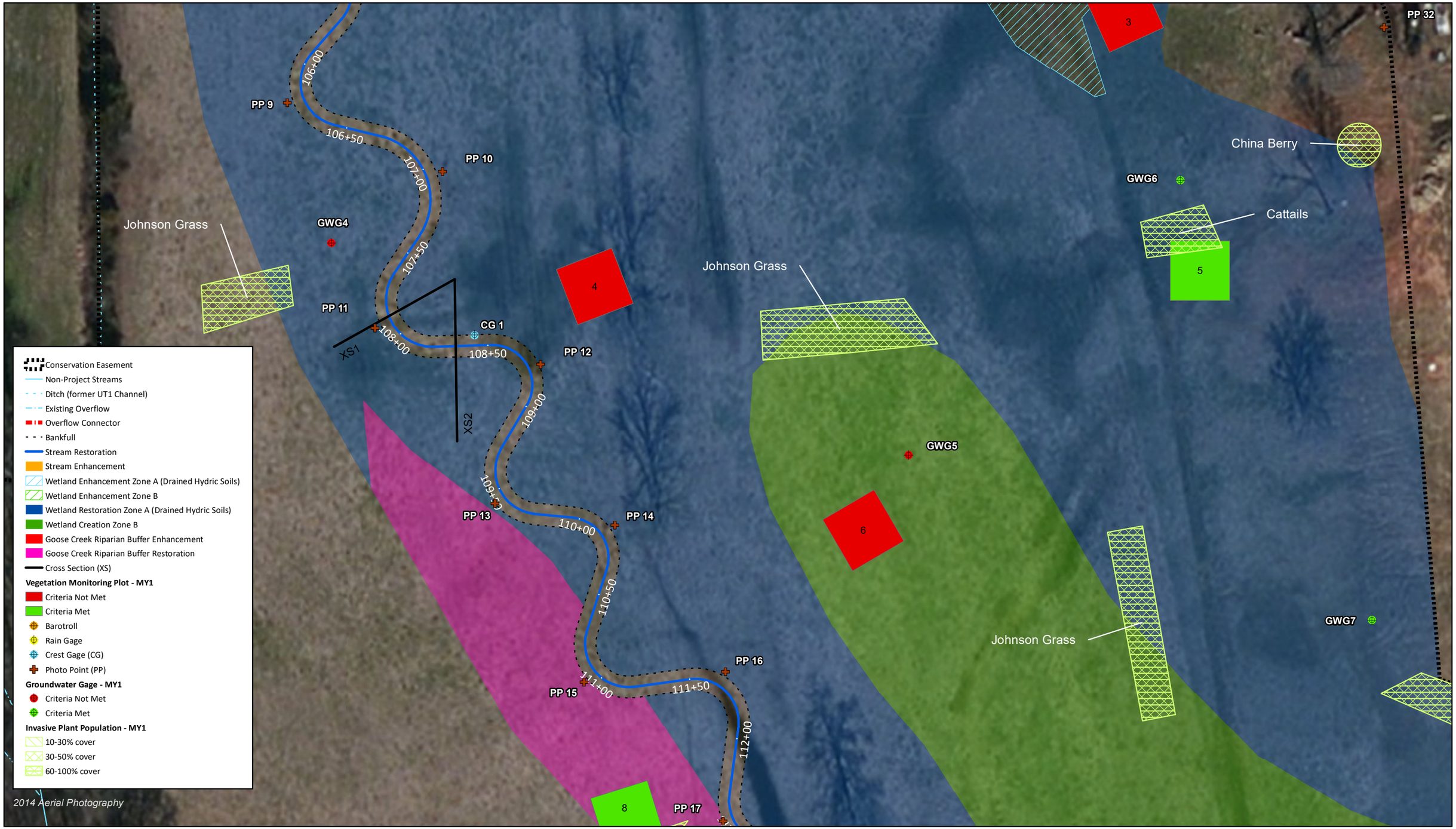



Figure 3.1 Integrated Current Condition Plan View (Sheet 1)
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 1 - 2016
*Union County, NC*

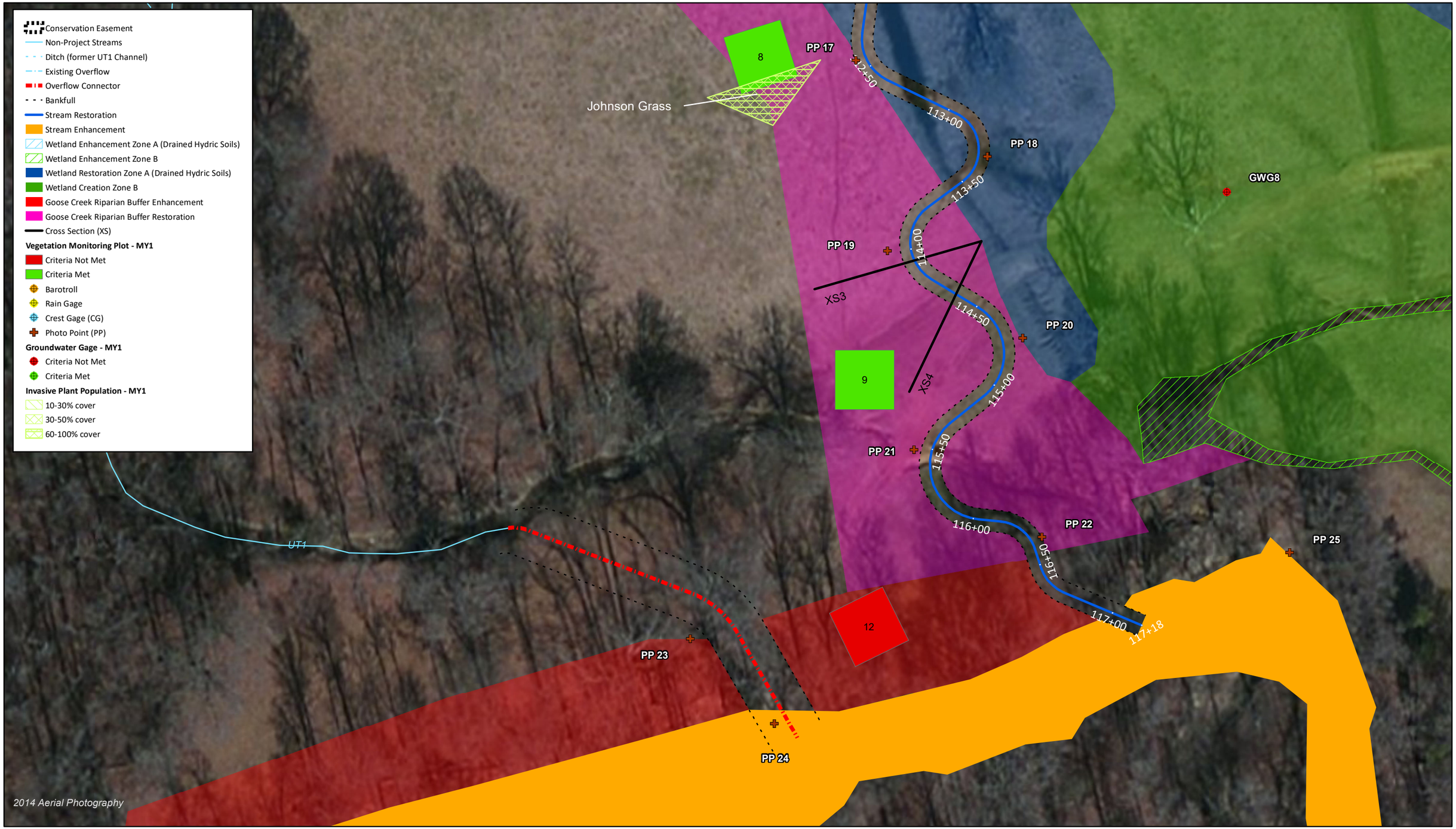



WILDLANDS ENGINEERING

0 25 50 100 Feet

N

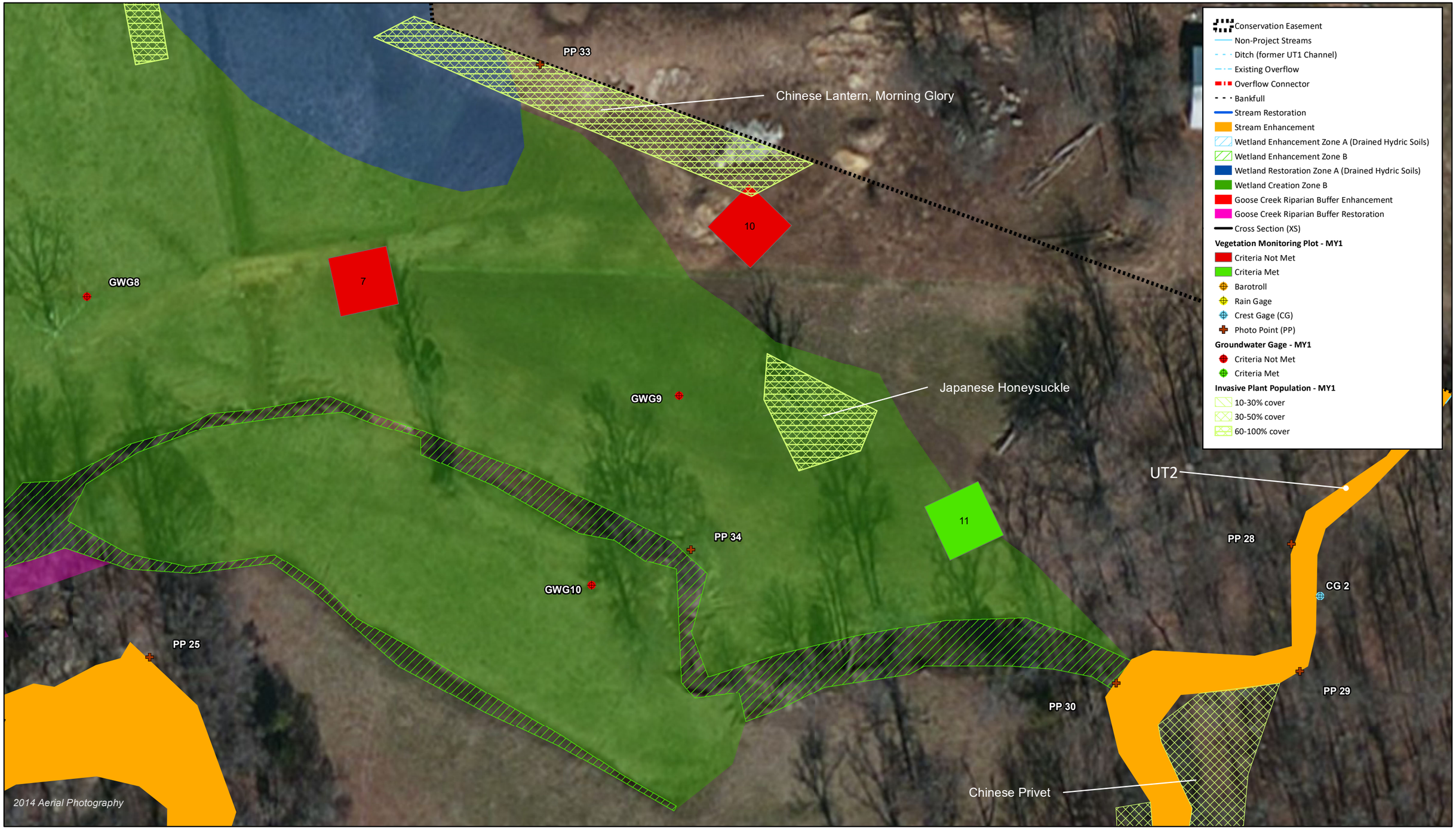
Figure 3.2 Integrated Current Condition Plan View (Sheet 2)
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 1 - 2016
*Union County, NC*




0 25 50 100 Feet

WILDLANDS ENGINEERING

Figure 3.3 Integrated Current Condition Plan View (Sheet 3)
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 1 - 2016
*Union County, NC*




WILDLANDS ENGINEERING

0 25 50 100 Feet

N

Figure 3.4 Integrated Current Condition Plan View (Sheet 4)
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 1 - 2016
*Union County, NC*


Figure 3.5 Integrated Current Condition Plan View (Sheet 5)
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 1 - 2016
*Union County, NC*


WILDLANDS ENGINEERING

Figure 3.6 Integrated Current Condition Plan View (Sheet 6)
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 1 - 2016
*Union County, NC*

**Table 6. Visual Stream Morphology Stability Assessment Table**
Crooked Creek #2 Restoration Project
DMS Project No. 94687
**Monitoring Year 1 -2016**

**UT1 (1,718 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 | 23 | 23 | | | 100% | | | |
| | 3. Meander Pool Condition | Depth Sufficient | 23 | 23 | | | 100% | | | |
| | | Length Appropriate | 23 | 23 | | | 100% | | | |
| | 4. Thalweg Position | Thalweg centering at upstream of meander bend (Run) | 23 | 23 | | | 100% | | | |
| | | Thalweg centering at downstream of meander bend (Glide) | 23 | 23 | | | 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. | 15 | 15 | | | 100% | | | |
| | 2. Grade Control | Grade control structures exhibiting maintenance of grade across the sill | 15 | 15 | | | 100% | | | |
| | 2a. Piping | Structures lacking any substantial flow underneath sills or arms. | 15 | 15 | | | 100% | | | |
| | 3. Bank Protection | Bank erosion within the structures extent of influence does not exceed 15%. | 15 | 15 | | | 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]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 1 -2016**

**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 | 23 | 0.55 | 4% |
| | | **Total** | **23** | **0.6** | **4%** |
| **Areas of Poor Growth Rates or Vigor[1]** | Areas with woody stems of a size class that are obviously small given the monitoring year. | 0.25 | 23 | 0.55 | 60% |
| | | **Cumulative Total** | **23** | **0.6** | **64%** |

**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 | 24 | 1.9 | 3% |
| | | | | | |
| **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

Stream Photographs

| | |
|---|---|
|  |  |
| **Photo Point 1** – UT1 looking upstream (08/18/2016) | **Photo Point 1** – UT1 looking downstream (08/18/2016) |
|  |  |
| **Photo Point 2** – UT1 looking upstream (08/18/2016) | **Photo Point 2** – UT1 looking downstream (08/18/2016) |
|  |  |
| **Photo Point 3** – UT1 looking upstream (08/18/2016) | **Photo Point 3** – UT1 looking downstream (08/18/2016) |

| | |
|---|---|
|  |  |
| **Photo Point 4** – UT1 looking upstream (08/18/2016) | **Photo Point 4** – UT1 looking downstream (08/18/2016) |
|  |  |
| **Photo Point 5** – UT1 looking upstream (08/18/2016) | **Photo Point 5** – UT1 looking downstream (08/18/2016) |
|  |  |
| **Photo Point 6** – UT1 looking upstream (08/18/2016) | **Photo Point 6** – UT1 looking downstream (08/18/2016) |

| | |
|---|---|
|  |  |
| **Photo Point 7** – UT1 looking upstream (08/18/2016) | **Photo Point 7** – UT1 looking downstream (08/18/2016) |
|  |  |
| **Photo Point 8** – UT1 looking upstream (08/18/2016) | **Photo Point 8** – UT1 looking downstream (08/18/2016) |
|  |  |
| **Photo Point 9** – UT1 looking upstream (08/18/2016) | **Photo Point 9** – UT1 looking downstream (08/18/2016) |

| | |
|---|---|
|  |  |
| **Photo Point 10** – UT1 looking upstream (08/18/2016) | **Photo Point 10** – UT1 looking downstream (08/18/2016) |
|  |  |
| **Photo Point 11** – UT1 looking upstream (08/18/2016) | **Photo Point 11** – UT1 looking downstream (08/18/2016) |
|  |  |
| **Photo Point 12** – UT1 looking upstream (08/18/2016) | **Photo Point 12** – UT1 looking downstream (08/18/2016) |

| | |
|---|---|
|  |  |
| **Photo Point 13** – UT1 looking upstream (08/18/2016) | **Photo Point 13** – UT1 looking downstream (08/18/2016) |
|  |  |
| **Photo Point 14** – UT1 looking upstream (08/18/2016) | **Photo Point 14** – UT1 looking downstream (08/18/2016) |
|  |  |
| **Photo Point 15** – UT1 looking upstream (08/18/2016) | **Photo Point 15** – UT1 looking downstream (08/18/2016) |

| | |
|---|---|
|  |  |
| **Photo Point 16** – UT1 looking upstream (08/18/2016) | **Photo Point 16** – UT1 looking downstream (08/18/2016) |
|  |  |
| **Photo Point 17** – UT1 looking upstream (08/18/2016) | **Photo Point 17** – UT1 looking downstream (08/18/2016) |
|  |  |
| **Photo Point 18** – UT1 looking upstream (08/18/2016) | **Photo Point 18** – UT1 looking downstream (08/18/2016) |

| | |
|---|---|
|  |  |
| **Photo Point 19** – UT1 looking upstream (08/18/2016) | **Photo Point 19** – UT1 looking downstream (08/18/2016) |
|  |  |
| **Photo Point 20** – UT1 looking upstream (08/18/2016) | **Photo Point 20** – UT1 looking downstream (08/18/2016) |
|  |  |
| **Photo Point 21** – UT1 looking upstream (08/18/2016) | **Photo Point 21** – UT1 looking downstream (08/18/2016) |

| | |
|---|---|
|  |  |
| **Photo Point 22** – UT1 looking upstream (08/18/2016) | **Photo Point 22** – UT1 looking downstream (08/18/2016) |
|  |  |
| **Photo Point 23** – UT1 looking upstream (08/18/2016) | **Photo Point 23** – UT1 looking downstream (08/18/2016) |
|  |  |
| **Photo Point 24** – Crooked Creek looking upstream (08/18/2016) | **Photo Point 24** – Crooked Creek looking downstream (08/18/2016) |

| | |
|---|---|
|  |  |
| **Photo Point 25** – Crooked Creek looking upstream (08/18/2016) | **Photo Point 25** – Crooked Creek looking downstream (08/18/2016) |
|  |  |
| **Photo Point 26** – Crooked Creek looking upstream (08/18/2016) | **Photo Point 26** – Crooked Creek looking downstream (08/18/2016) |
|  |  |
| **Photo Point 27** – Crooked Creek looking upstream (08/18/2016) | **Photo Point 27** – Crooked Creek looking downstream (08/18/2016) |

**Photo Point 28** – UT2 looking upstream (08/18/2016)

**Photo Point 28** – UT2 looking downstream (08/18/2016)

**Photo Point 29** – UT2 looking upstream (08/18/2016)

**Photo Point 29** – UT2 looking downstream (08/18/2016)

**Photo Point 30** – UT2 looking downstream to UT2 (08/18/2016)

**Photo Point 31** – UT2 looking upstream Crooked Creek

**Photo Point 31** – UT2 looking downstream (08/18/2016)

**Photo Point 31** – UT2 looking upstream UT2 (08/18/2016)

Vegetation Photographs

| | |
|---|---|
|  |  |
| **Vegetation Plot 1** – (09/07/2016) | **Vegetation Plot 2** – (09/07/2016) |
|  |  |
| **Vegetation Plot 3** – (09/07/2016) | **Vegetation Plot 4** – (09/07/2016) |
|  |  |
| **Vegetation Plot 5** – (09/07/2016) | **Vegetation Plot 6** – (09/07/2016) |

| | |
|---|---|
|  |  |
| **Vegetation Plot 7** – (09/07/2016) | **Vegetation Plot 8** – (09/08/2016) |
|  |  |
| **Vegetation Plot 9** – (09/08/2016) | **Vegetation Plot 10** – (09/07/2016) |
|  |  |
| **Vegetation Plot 11** – (09/07/2016) | **Vegetation Plot 12** – (09/08/2016) |

Wetland Photographs

| | |
|---|---|
|  |  |
| **Photo Point 30** –Wetland CC outlet facing W (08/18/2016) | **Photo Point 30** –Wetland CC outlet facing E (08/18/2016) |
|  |  |
| **Photo Point 32** –Wetland AA facing W (08/18/2016) | **Photo Point 32** – Wetland Zone A facing S(08/18/2016) |
|  |  |
| **Photo Point 33** – Wetland Zone A & B facing W (08/18/2016) | **Photo Point 33** - Wetland B facing S (08/18/2016) |

| | |
|---|---|
|  |  |
| **Photo Point 34** –Wetland CC facing NW (08/18/2016) | **Photo Point 34** –Wetland CC facing S (08/18/2016) |

# APPENDIX 3. Vegetation Plot Data

**Table 8. Vegetation Plot Criteria Attainment**
Crooked Creek #2 Restoration Project Site
DMS Project No. 94687
**Monitoring Year 1 - 2016**

| Plot | MY1 Success Criteria Met (Y/N) | Tract Mean |
|---|---|---|
| 1 | Y | 50% |
| 2 | Y | |
| 3 | N | |
| 4 | N | |
| 5 | Y | |
| 6 | N | |
| 7 | N | |
| 8 | Y | |
| 9 | Y | |
| 10 | N | |
| 11 | Y | |
| 12 | N | |

**Table 9. CVS Vegetation Plot Metadata**
Crooked Creek #2 Restoration Project
DMS Project No. 94687
**Monitoring Year 1 - 2016**

| | |
|---|---|
| **Report Prepared By** | Ruby Davis |
| **Date Prepared** | 9/9/2016 14:44 |
| **Database Name** | cvs-eep-entrytool-v2.5.0 Crooked Creek MY1.mdb |
| **Database Location** | Q:\ActiveProjects\005-02156 Crooked Creek Monitoring\Monitoring\Monitoring Year 1\Vegetation Assessment |
| **Computer Name** | RUBY |
| **File Size** | 73449472 |
| **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 |
| **River Basin** | |
| **Length(ft)** | |
| **Stream-to-edge Width (ft)** | |
| **Area (sq m)** | |
| **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 1 - 2016**

| | | | Current Plot Data (MY1 2016) | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 94687-WEI-0001 | | | 94687-WEI-0002 | | | 94687-WEI-0003 | | | 94687-WEI-0004 | | | 94687-WEI-0005 | | | 94687-WEI-0006 | | | 94687-WEI-0007 | | | 94687-WEI-0008 | | |
| **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** |
| *Acer negundo* | Box elder | Tree | | | 2 | | | | | | | | | | | | | | | | | | 4 | | | 4 |
| *Acer rubrum* | Red maple | Tree | | | | | | | | | | 3 | 3 | 3 | | | | | | | | | | 3 | 3 | 3 |
| *Betula nigra* | River birch | Tree | | | | 2 | 2 | 2 | | | | | | | | | | 3 | 3 | 4 | | | | 2 | 2 | 2 |
| *Carpinus caroliniana* | Ironwood | Shrub Tree | | | | | | | | | | | | | | | | | | | | | | | | |
| *Celtis laevigata* | Southern Hackberry, Sug | Shrub Tree | | | | | | | | | | | | | | | | | | | | | | | | |
| *Cornus florida* | Flowering dogwood | Shrub Tree | | | | | | | | | | | | | | | | | | | | | | | | |
| *Diospyros virginiana* | American persimmon | Tree | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | 5 | 5 | 5 |
| *Fraxinus pennsylvanica* | Green ash | Tree | | | | | | 1 | | | 5 | | | 3 | | | | | | | | | 7 | | | |
| *Juglans nigra* | Black walnut | Tree | | | | | | | | | | | | | | | | | | | | | | | | |
| *Liquidambar styraciflua* | Sweet gum | Tree | | | | | | 1 | | | 1 | | | | | | | | | | | | 3 | | | |
| *Liriodendron tulipifera* | Tulip poplar | Tree | | | | | | | | | | | | | | | | | | | | | | | | |
| *Nyssa sylvatica* | Black Gum | Tree | | | | | | | | | | | | | | | | | | | 2 | 2 | 2 | | | |
| *Platanus occidentalis* | Sycamore | Tree | 5 | 5 | 5 | 3 | 3 | 3 | | | | 1 | 1 | 1 | | | | 2 | 2 | 14 | | | | 2 | 2 | 2 |
| *Quercus sp.* | Oak | Shrub Tree | 1 | 1 | 1 | | | | | | | | | | | | | 1 | 1 | 1 | 4 | 4 | 4 | | | |
| *Quercus lyrata* | Overcup oak | Tree | 1 | 1 | 1 | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | |
| *Quercus nigra* | Water oak | Tree | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | 1 |
| *Quercus phellos* | Willow oak | Tree | | | | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | |
| *Taxodium distichum* | Bald-cypress | Tree | | | | | | | 4 | 4 | 4 | | | | 9 | 9 | 9 | | | | | | | | | |
| *Ulmus alata* | Winged elm | Tree | | | | | | | | | | | | | | | | | | | | | | | | |
| *Ulmus americana* | American elm | Tree | | | | | | | | | | | | | | | | | | | | | 1 | | | |
| | | **Stem count** | 8 | 8 | 10 | 8 | 8 | 10 | 4 | 4 | 10 | 4 | 4 | 7 | 9 | 9 | 9 | 6 | 6 | 19 | 6 | 6 | 21 | 13 | 13 | 17 |
| | | **size (ares)** | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | |
| | | **size (ACRES)** | 0.02 | | | 0.02 | | | 0.02 | | | 0.02 | | | 0.02 | | | 0.02 | | | 0.02 | | | 0.02 | | |
| | | **Species count** | 4 | 4 | 5 | 4 | 4 | 6 | 1 | 1 | 3 | 2 | 2 | 3 | 1 | 1 | 1 | 3 | 3 | 3 | 2 | 2 | 6 | 5 | 5 | 6 |
| | | **Stems per ACRE** | 324 | 324 | 405 | 324 | 324 | 405 | 162 | 162 | 405 | 162 | 162 | 283 | 364 | 364 | 364 | 243 | 243 | 769 | 243 | 243 | 850 | 526 | 526 | 688 |

**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% |

**Table 10. Planted and Total Stem Counts**
Crooked Creek #2 Restoration Project
DMS Project No. 94687
**Monitoring Year 1 - 2016**

| | | | Current Plot Data (MY1 2016) | | | | | | | | | | | | Annual Means | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 94687-WEI-0009 | | | 94687-WEI-0010 | | | 94687-WEI-0011 | | | 94687-WEI-0012 | | | MY1 (2016) | | | MY0 (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** |
| *Acer negundo* | Box elder | Tree | | | | | | | | | 2 | | | 6 | | | 18 | | | 17 |
| *Acer rubrum* | Red maple | Tree | 7 | 7 | 7 | | | | | | | | | | 13 | 13 | 13 | 14 | 14 | 14 |
| *Betula nigra* | River birch | Tree | | | | 2 | 2 | 2 | 5 | 5 | 5 | | | | 14 | 14 | 15 | 18 | 18 | 18 |
| *Carpinus caroliniana* | Ironwood | Shrub Tree | | | | | | | | | | | | | | | | | | 2 |
| *Celtis laevigata* | Southern Hackberry, Suga | Shrub Tree | | | 1 | | | | | | | | | | | | 1 | | | |
| *Cornus florida* | Flowering dogwood | Shrub Tree | | | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 6 | 6 |
| *Diospyros virginiana* | American persimmon | Tree | 4 | 4 | 4 | | | 1 | | | | | | 2 | 10 | 10 | 13 | 27 | 27 | 27 |
| *Fraxinus pennsylvanica* | Green ash | Tree | | | | | | 10 | | | | | | | | | 26 | | | 45 |
| *Juglans nigra* | Black walnut | Tree | | | | | | | | | | | | | | | | | | 1 |
| *Liquidambar styraciflua* | Sweet gum | Tree | | | | | | 1 | | | | | | 1 | | | 7 | | | 4 |
| *Liriodendron tulipifera* | Tulip poplar | Tree | | | | | | | | | | | | 1 | | | 1 | | | 2 |
| *Nyssa sylvatica* | Black Gum | Tree | | | | | | | | | | 1 | 1 | 1 | 3 | 3 | 3 | 7 | 7 | 7 |
| *Platanus occidentalis* | Sycamore | Tree | | | 1 | | | | | | | | | | 13 | 13 | 26 | 15 | 15 | 16 |
| *Quercus sp.* | Oak | Shrub Tree | | | | | | | 10 | 10 | 10 | | | | 16 | 16 | 16 | 53 | 53 | 53 |
| *Quercus lyrata* | Overcup oak | Tree | 1 | 1 | 1 | 1 | 1 | 1 | | | | 2 | 2 | 2 | 7 | 7 | 7 | | | |
| *Quercus nigra* | Water oak | Tree | | | | | | | | | | 1 | 1 | 1 | 2 | 2 | 2 | | | |
| *Quercus phellos* | Willow oak | Tree | 1 | 1 | 1 | | | | | | | | | | 2 | 2 | 2 | | | |
| *Taxodium distichum* | Bald-cypress | Tree | | | | | | | | | | | | | 13 | 13 | 13 | 16 | 16 | 16 |
| *Ulmus alata* | Winged elm | Tree | | | | | | | | | | | | | | | | | | 1 |
| *Ulmus americana* | American elm | Tree | | | | | | 2 | | | | | | 4 | | | 7 | | | |
| | | **Stem count** | 13 | 13 | 15 | 3 | 3 | 17 | 15 | 15 | 17 | 6 | 6 | 20 | 95 | 95 | 172 | 156 | 156 | 229 |
| | | **size (ares)** | 1 | | | 1 | | | 1 | | | 1 | | | 12 | | | 12 | | |
| | | **size (ACRES)** | 0.02 | | | 0.02 | | | 0.02 | | | 0.02 | | | 0.30 | | | 0.30 | | |
| | | **Species count** | 4 | 4 | 6 | 2 | 2 | 6 | 2 | 2 | 3 | 4 | 4 | 9 | 11 | 11 | 17 | 8 | 8 | 15 |
| | | **Stems per ACRE** | 526 | 526 | 607 | 121 | 121 | 688 | 607 | 607 | 688 | 243 | 243 | 809 | 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% |

# APPENDIX 4. Morphological Summary Data and Plots

**Table 11. Baseline Stream Data Summary**
Crooked Creek #2 Restoration Project
DMS Project No. 94687
**Monitoring Year 1 - 2016**

**UT1**

| | | Pre-Restoration Condition | | | | Reference Reach Data | | | | Design | | As-Built/Baseline | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **Gage** | **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 appliec
*: 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 1 - 2016**

| | Cross-Section 1, UT1 (Pool) | | | | | | Cross-Section 2, UT1 (Riffle) | | | | | | Cross-Section 3, UT1 (Pool) | | | | | | Cross-Section 4, UT1 (Riffle) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Dimension and Substrate** | **Base** | **MY1** | **MY2** | **MY3** | **MY4** | **MY5** | **Base** | **MY1** | **MY2** | **MY3** | **MY4** | **MY5** | **Base** | **MY1** | **MY2** | **MY3** | **MY4** | **MY5** | **Base** | **MY1** | **MY2** | **MY3** | **MY4** | **MY5** |
| *based on fixed bankfull elevation* | 541.8 | 541.9 | | | | | 542.1 | 542.0 | | | | | 539.7 | 539.7 | | | | | 539.8 | 539.8 | | | | |
| Bankfull Width (ft) | 13.3 | 12.7 | | | | | 11.7 | 11.1 | | | | | 12.6 | 12.3 | | | | | 12.6 | 11.9 | | | | |
| Floodprone Width (ft) | --- | --- | | | | | 200+ | 200+ | | | | | --- | --- | | | | | 200+ | 200+ | | | | |
| Bankfull Mean Depth (ft) | 0.7 | 0.7 | | | | | 0.6 | 0.5 | | | | | 1.0 | 0.9 | | | | | 0.6 | 0.7 | | | | |
| Bankfull Max Depth (ft) | 1.5 | 1.4 | | | | | 1.1 | 0.9 | | | | | 2.4 | 2.2 | | | | | 1.1 | 1.0 | | | | |
| Bankfull Cross-Sectional Area ($ft^2$) | 8.7 | 8.5 | | | | | 7.3 | 5.9 | | | | | 12.6 | 11.4 | | | | | 7.5 | 7.8 | | | | |
| Bankfull Width/Depth Ratio | 20.4 | 18.9 | | | | | 18.9 | 20.8 | | | | | 12.7 | 13.4 | | | | | 21.1 | 18.0 | | | | |
| Bankfull Entrenchment Ratio | --- | --- | | | | | 2.2+ | 2.2+ | | | | | --- | --- | | | | | 11.9 | 12.6 | | | | |
| Bankfull Bank Height Ratio | --- | --- | | | | | 1.0 | 1.0 | | | | | --- | --- | | | | | 1.0 | 1.0 | | | | |

**Table 13. Monitoring Data - Stream Reach Data Summary**
Crooked Creek #2 Restoration Project
DMS Project No. 94687
**Monitoring Year 1 - 2016**

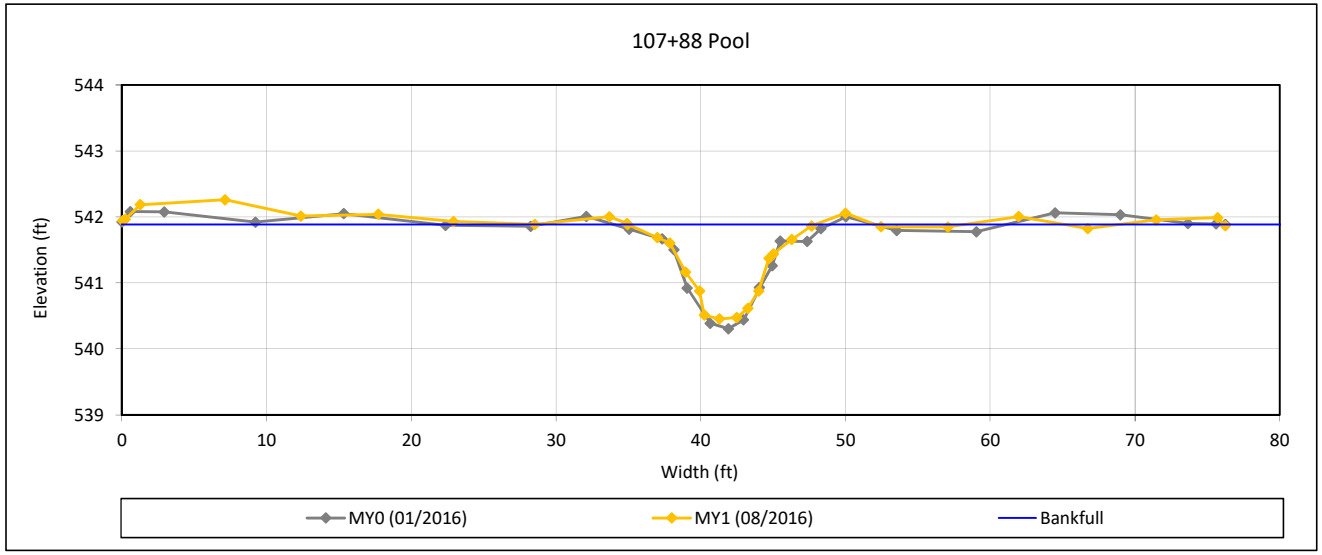
**UT1**

| 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 | | | | | | | | |
| Floodprone Width (ft) | 200+ | | 200+ | | | | | | | | | |
| Bankfull Mean Depth | 0.6 | | 0.5 | 0.7 | | | | | | | | |
| Bankfull Max Depth | 1.1 | | 0.9 | 1.0 | | | | | | | | |
| Bankfull Cross-sectional Area ($ft^2$) | 7.3 | 7.5 | 5.9 | 7.8 | | | | | | | | |
| Width/Depth Ratio | 18.9 | 21.1 | 18.0 | 20.8 | | | | | | | | |
| Entrenchment Ratio | 2.2+ | | 2.2+ | | | | | | | | | |
| Bank Height Ratio | 1.0 | | 1.0 | | | | | | | | | |
| D50 (mm) | 0.3 | 35.9 | SC | 65.6 | | | | | | | | |
| **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 1 - 2016**

**Cross Section 1-UT1**




| Bankfull Dimensions | |
|---|---|
| 8.5 | x-section area (ft.sq.) |
| 12.7 | width (ft) |
| 0.7 | mean depth (ft) |
| 1.4 | max depth (ft) |
| 13.3 | wetted perimeter (ft) |
| 0.6 | hydraulic radius (ft) |
| 18.9 | width-depth ratio |

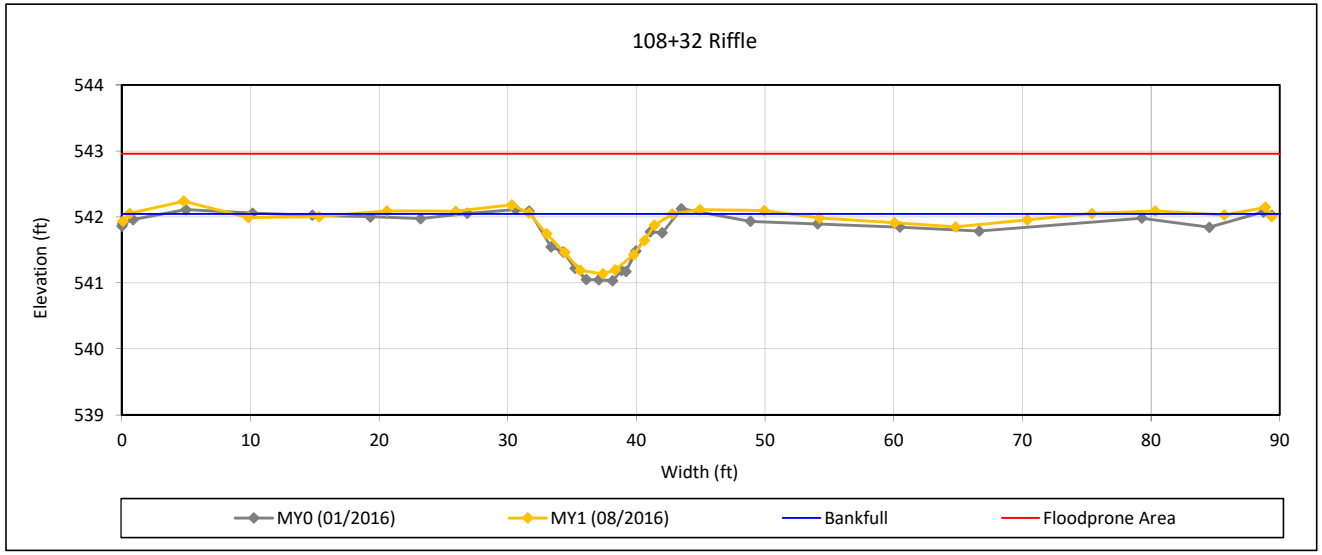
Survey Date: 08/2016
Field Crew: Wildlands Engineering

View Downstream

## Cross Section Plots

Crooked Creek #2 Stream and Wetland Mitigation Site
DMS Project No. 94687
**Monitoring Year 1 - 2016**

**Cross Section 2-UT1**




| Bankfull Dimensions | |
|---|---|
| 5.9 | x-section area (ft.sq.) |
| 11.1 | width (ft) |
| 0.5 | mean depth (ft) |
| 0.9 | max depth (ft) |
| 11.3 | wetted perimeter (ft) |
| 0.5 | hydraulic radius (ft) |
| 20.8 | width-depth ratio |
| 150.0 | W flood prone area (ft) |
| 13.5 | entrenchment ratio |
| 1.0 | low bank height ratio |

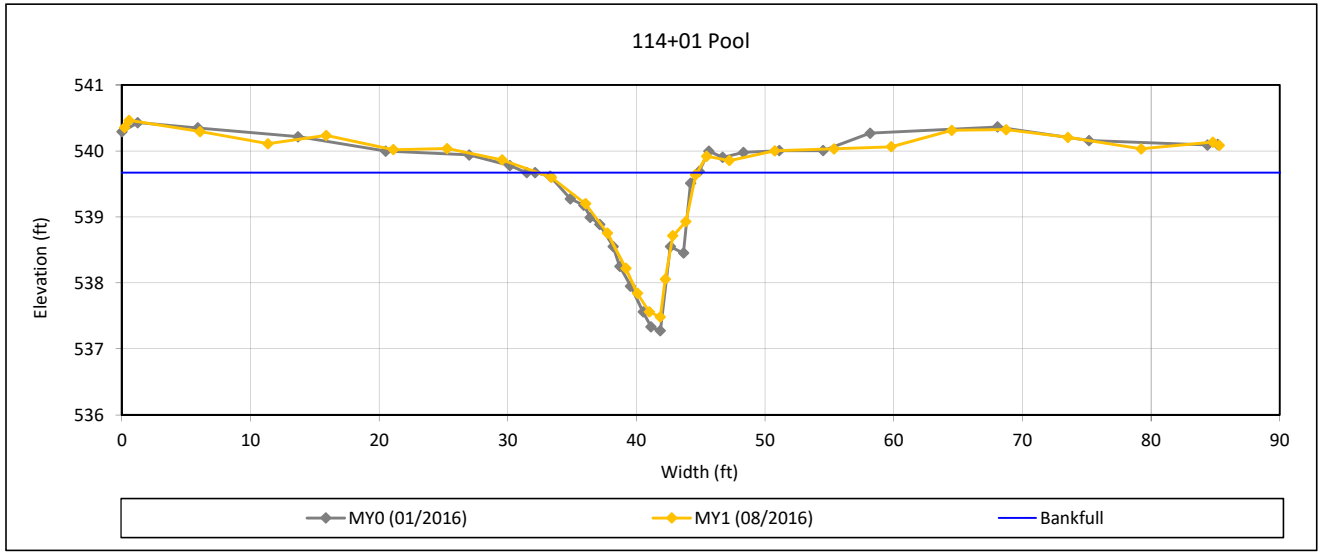
Survey Date: 08/2016
Field Crew: Wildlands Engineering

View Downstream

## Cross Section Plots

Crooked Creek #2 Stream and Wetland Mitigation Site
DMS Project No. 94687
**Monitoring Year 1 - 2016**

**Cross Section 3-UT1**




| Bankfull Dimensions | |
|---|---|
| 11.4 | x-section area (ft.sq.) |
| 12.3 | width (ft) |
| 0.9 | mean depth (ft) |
| 2.2 | max depth (ft) |
| 13.6 | wetted perimeter (ft) |
| 0.8 | hydraulic radius (ft) |
| 13.4 | width-depth ratio |

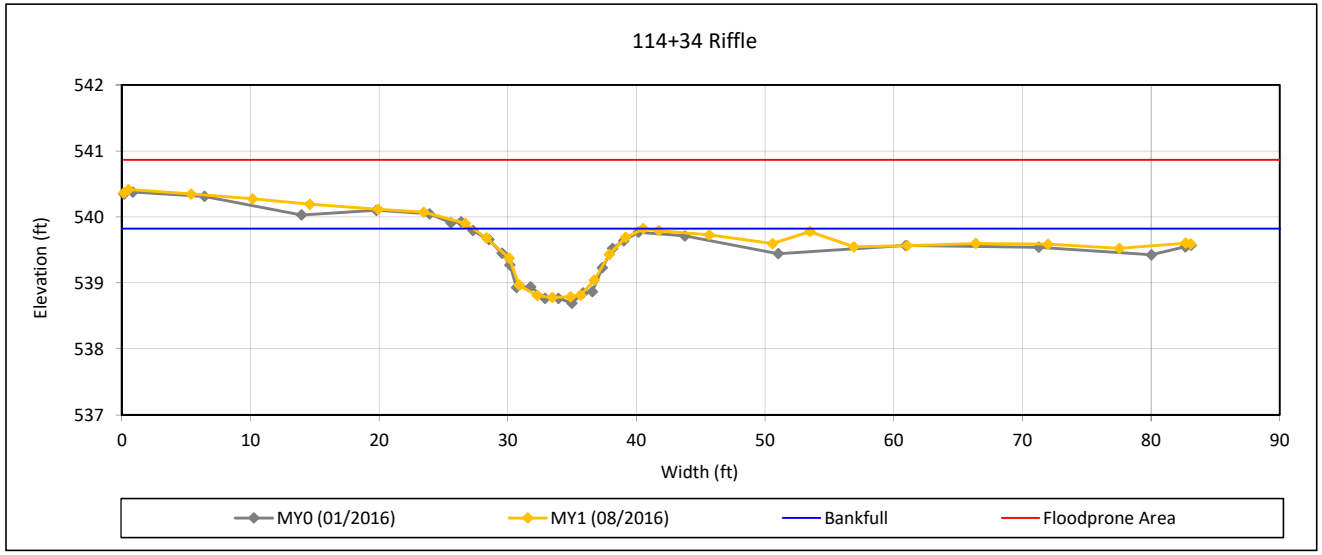
Survey Date: 08/2016
Field Crew: Wildlands Engineering

View Downstream

## Cross Section Plots

Crooked Creek #2 Stream and Wetland Mitigation Site
DMS Project No. 94687
**Monitoring Year 1 - 2016**

**Cross Section 4-UT1**




| Bankfull Dimensions | |
|---|---|
| 7.8 | x-section area (ft.sq.) |
| 11.9 | width (ft) |
| 0.7 | mean depth (ft) |
| 1.0 | max depth (ft) |
| 12.1 | wetted perimeter (ft) |
| 0.6 | hydraulic radius (ft) |
| 18.0 | width-depth ratio |
| 150.0 | W flood prone area (ft) |
| 12.6 | entrenchment ratio |
| 1.0 | low bank height ratio |

Survey Date: 08/2016
Field Crew: Wildlands Engineering

View Downstream

## Reachwide and Cross Section Pebble Count Plots

Crooked Creek #2 Stream and Wetland Mitigation Site

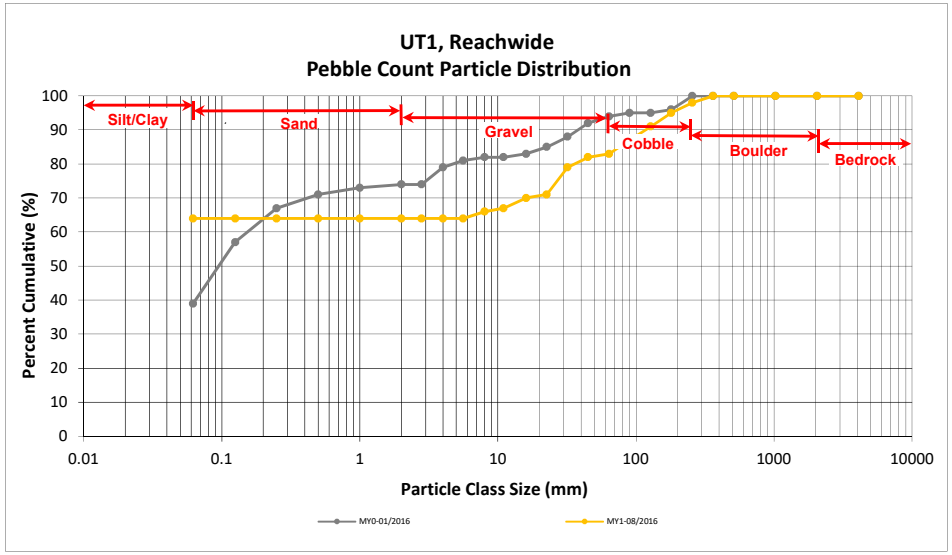
DMS Project No. 94687

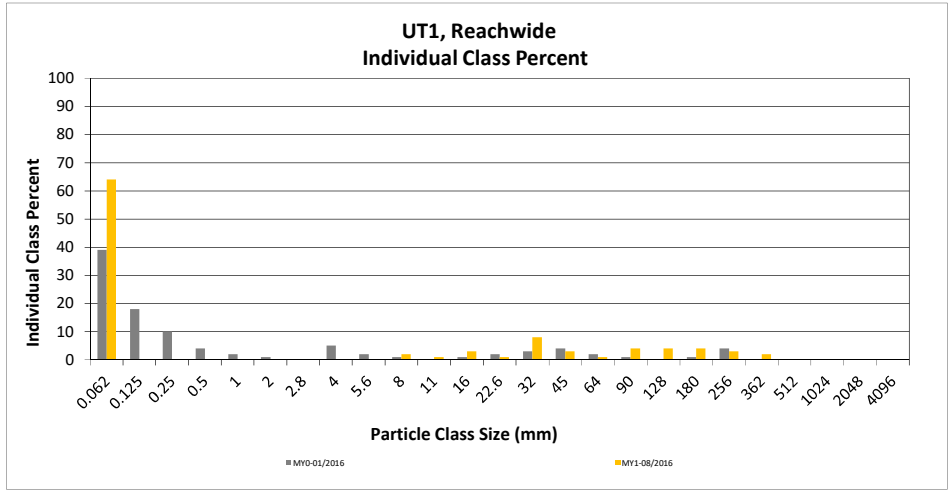
**Monitoring Year 1 - 2016**

**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 | 18 | 46 | 64 | 64 | 64 |
| *SAND* | Very fine | 0.062 | 0.125 | | | | | 64 |
| | Fine | 0.125 | 0.250 | | | | | 64 |
| | Medium | 0.25 | 0.50 | | | | | 64 |
| | Coarse | 0.5 | 1.0 | | | | | 64 |
| | Very Coarse | 1.0 | 2.0 | | | | | 64 |
| *GRAVEL* | Very Fine | 2.0 | 2.8 | | | | | 64 |
| | Very Fine | 2.8 | 4.0 | | | | | 64 |
| | Fine | 4.0 | 5.6 | | | | | 64 |
| | Fine | 5.6 | 8.0 | 2 | | 2 | 2 | 66 |
| | Medium | 8.0 | 11.0 | 1 | | 1 | 1 | 67 |
| | Medium | 11.0 | 16.0 | 3 | | 3 | 3 | 70 |
| | Coarse | 16.0 | 22.6 | 1 | | 1 | 1 | 71 |
| | Coarse | 22.6 | 32 | 4 | 4 | 8 | 8 | 79 |
| | Very Coarse | 32 | 45 | 3 | | 3 | 3 | 82 |
| | Very Coarse | 45 | 64 | 1 | | 1 | 1 | 83 |
| *COBBLE* | Small | 64 | 90 | 4 | | 4 | 4 | 87 |
| | Small | 90 | 128 | 4 | | 4 | 4 | 91 |
| | Large | 128 | 180 | 4 | | 4 | 4 | 95 |
| | Large | 180 | 256 | 3 | | 3 | 3 | 98 |
| *BOULDER* | Small | 256 | 362 | 2 | | 2 | 2 | 100 |
| | Small | 362 | 512 | | | | | 100 |
| | Medium | 512 | 1024 | | | | | 100 |
| | Large/Very Large | 1024 | 2048 | | | | | 100 |
| *BEDROCK* | Bedrock | 2048 | >2048 | | | | | 100 |
| | | | **Total** | **50** | **50** | **100** | **100** | **100** |

| Reachwide | |
|---|---|
| **Channel materials (mm)** | |
| $D_{16}$ = | Silt/Clay |
| $D_{35}$ = | Silt/Clay |
| $D_{50}$ = | Silt/Clay |
| $D_{84}$ = | 69.7 |
| $D_{95}$ = | 180.0 |
| $D_{100}$ = | 362.0 |



## Reachwide and Cross Section Pebble Count Plots

Crooked Creek #2 Stream and Wetland Mitigation Site

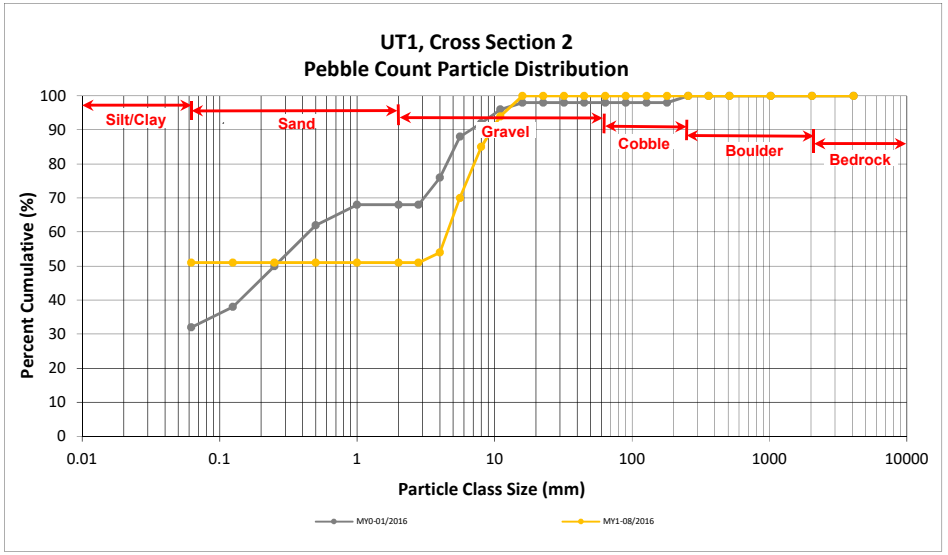
DMS Project No. 94687

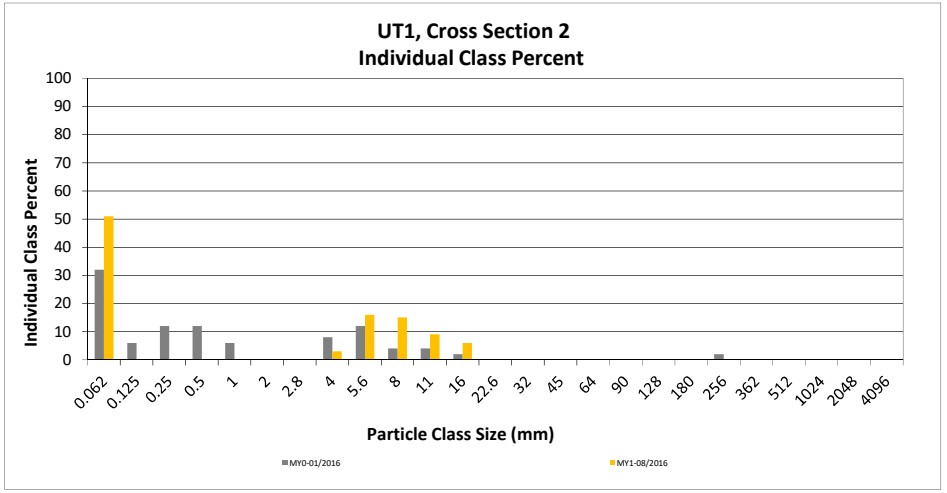
**Monitoring Year 1 - 2016**

**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 | 51 | 51 | 51 |
| *SAND* | Very fine | 0.062 | 0.125 | | | 51 |
| | Fine | 0.125 | 0.250 | | | 51 |
| | Medium | 0.25 | 0.50 | | | 51 |
| | Coarse | 0.5 | 1.0 | | | 51 |
| | Very Coarse | 1.0 | 2.0 | | | 51 |
| *GRAVEL* | Very Fine | 2.0 | 2.8 | | | 51 |
| | Very Fine | 2.8 | 4.0 | 3 | 3 | 54 |
| | Fine | 4.0 | 5.6 | 16 | 16 | 70 |
| | Fine | 5.6 | 8.0 | 15 | 15 | 85 |
| | Medium | 8.0 | 11.0 | 9 | 9 | 94 |
| | Medium | 11.0 | 16.0 | 6 | 6 | 100 |
| | Coarse | 16.0 | 22.6 | | | 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 |
| $D_{84}$ = | 7.8 |
| $D_{95}$ = | 11.7 |
| $D_{100}$ = | 16.0 |



## Reachwide and Cross Section Pebble Count Plots

Crooked Creek #2 Stream and Wetland Mitigation Site

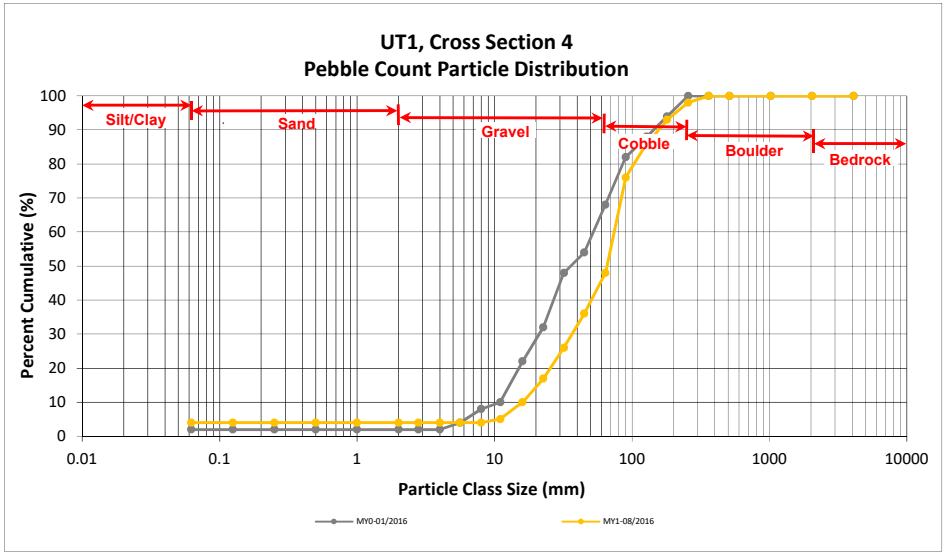
DMS Project No. 94687

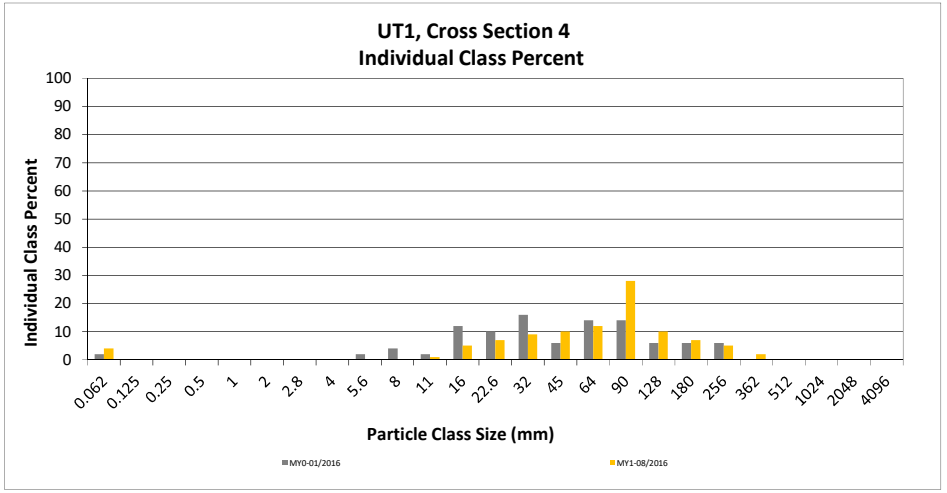
**Monitoring Year 1 - 2016**

**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 |
| ***GRAVEL*** | Very Fine | 2.0 | 2.8 | | | 4 |
| | Very Fine | 2.8 | 4.0 | | | 4 |
| | Fine | 4.0 | 5.6 | | | 4 |
| | Fine | 5.6 | 8.0 | | | 4 |
| | Medium | 8.0 | 11.0 | 1 | 1 | 5 |
| | Medium | 11.0 | 16.0 | 5 | 5 | 10 |
| | Coarse | 16.0 | 22.6 | 7 | 7 | 17 |
| | Coarse | 22.6 | 32 | 9 | 9 | 26 |
| | Very Coarse | 32 | 45 | 10 | 10 | 36 |
| | Very Coarse | 45 | 64 | 12 | 12 | 48 |
| ***COBBLE*** | Small | 64 | 90 | 28 | 28 | 76 |
| | Small | 90 | 128 | 10 | 10 | 86 |
| | Large | 128 | 180 | 7 | 7 | 93 |
| | Large | 180 | 256 | 5 | 5 | 98 |
| ***BOULDER*** | Small | 256 | 362 | 2 | 2 | 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) | |
| $D_{16}$ = | 21.51 |
| $D_{35}$ = | 43.49 |
| $D_{50}$ = | 65.6 |
| $D_{84}$ = | 119.3 |
| $D_{95}$ = | 207.2 |
| $D_{100}$ = | 362.0 |



# APPENDIX 5. Hydrology Summary Data and Plots

### Table 14. Verification of Bankfull Events

Crooked Creek #2 Restoration Project

DMS Project No. 94687

**Monitoring Year 1 - 2016**

**UT1, UT2, Crooked Creek**

| Reach | Date of Data Collection | Date of Occurrence | MY of Occurrence | Method |
|---|---|---|---|---|
| UT1 | 8/18/2016 | 7/11/2016 | 1 | Crest Gage |
| | 11/9/2016 | N/A | N/A | Crest Gage |
| UT2 | 8/18/2016 | 7/11/2016 | 1 | Crest Gage |
| | 11/9/2016 | 10/8/2016 | 1 | Crest Gage |
| Crooked Creek | 8/18/2016 | 7/11/2016 | 1 | Crest Gage |
| | 11/9/2016 | 10/8/2016 | 1 | Crest Gage |

N/A: Indicator below BKF elevation

### Table 15. Wetland Gage Attainment Summary

Crooked Creek #2 Restoration Project

DMS Project No. 94687

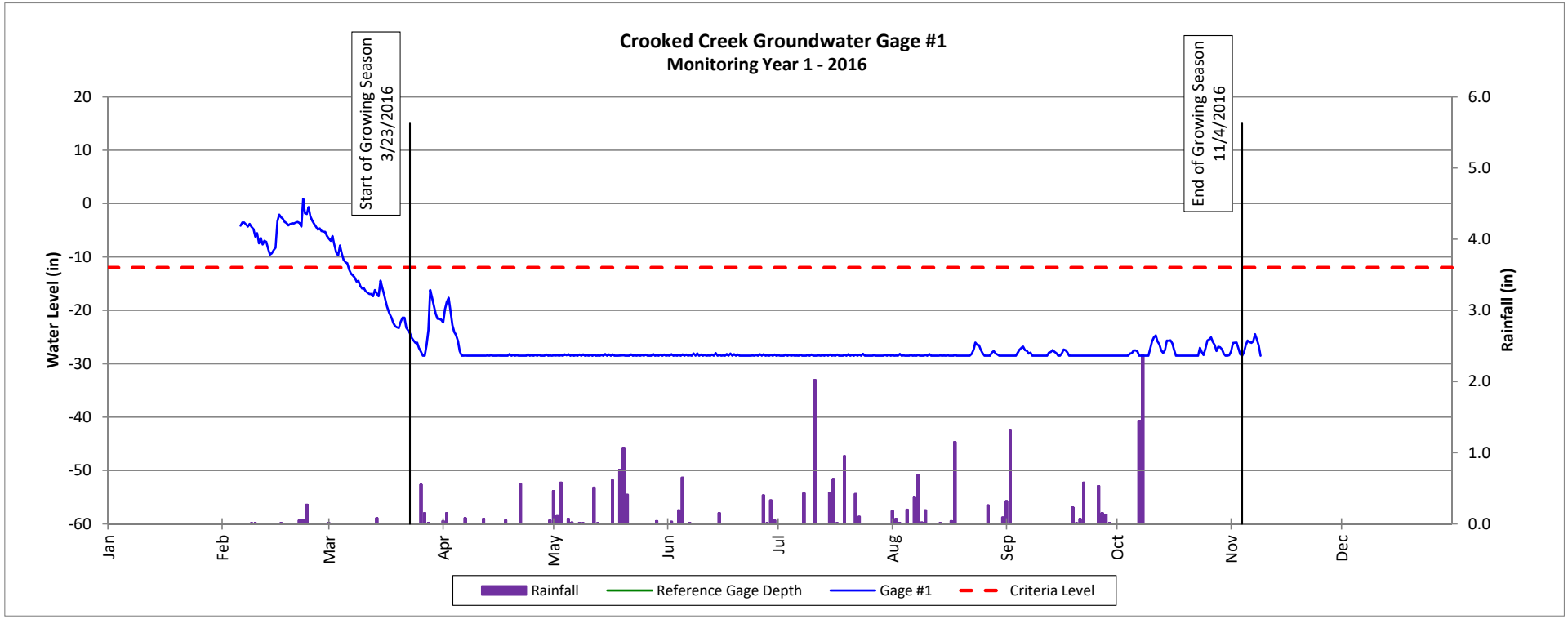
**Monitoring Year 1 - 2016**

| Summary of Groundwater Gage Results for MY1 | | | | | |
|---|---|---|---|---|---|
| Gage | Success Criteria Achieved/Max Consecutive Days During Growing Season (%) | | | | |
| | Year 1 (2016) | Year 2 (2017) | Year 3 (2018) | Year 4 (2019) | Year 5 (2020) |
| 1 | No/0 Days (0%) | | | | |
| 2 | No/2 Days (0.9%) | | | | |
| 3 | No/1 Day (0.4%) | | | | |
| 4 | No/0 Days (0%) | | | | |
| 5 | No/1 Day (0.4%) | | | | |
| 6 | Yes/26 Days (11.5%) | | | | |
| 7 | Yes/18 Days (8.0%) | | | | |
| 8 | No/14 Days (6.2%) | | | | |
| 9 | No/1 Day (0.4%) | | | | |
| 10 | No/2 Days (0.9%) | | | | |

Wetland success criteria is 7.5% of growing season (17 consecutive days).

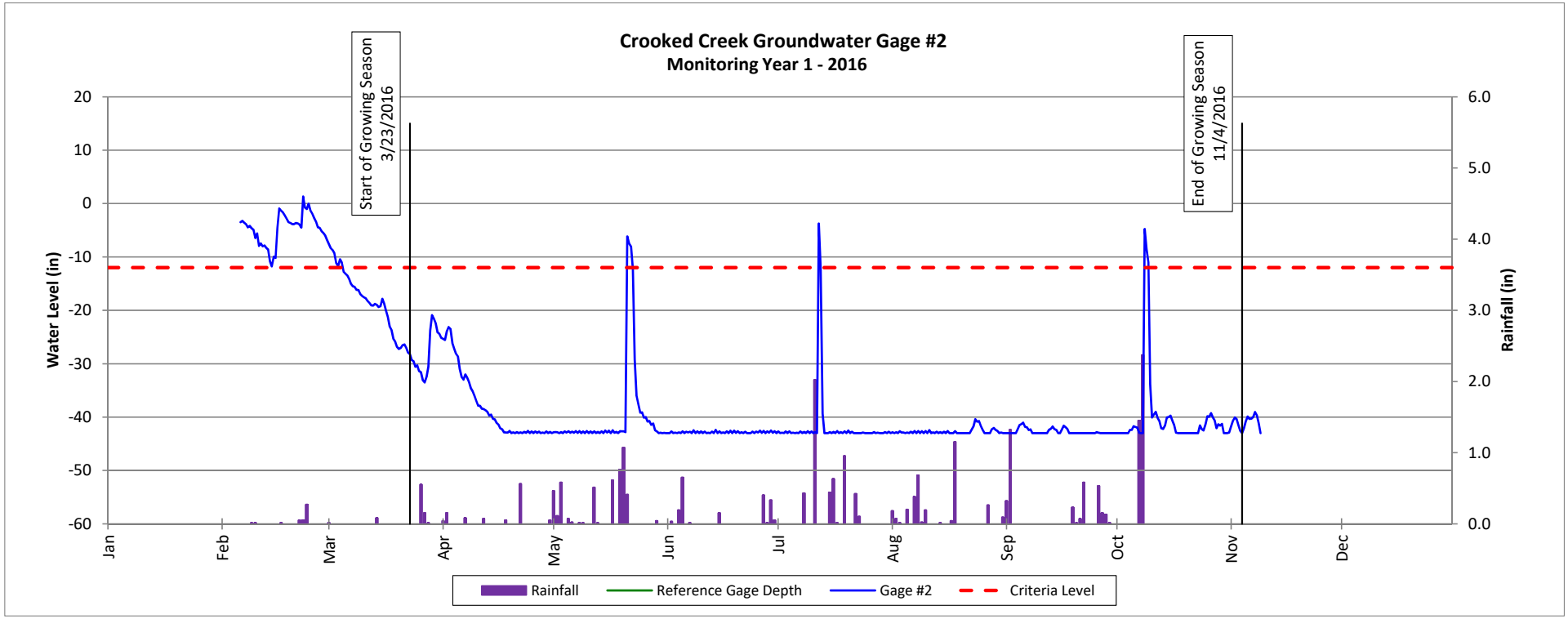
## Groundwater Gage Plots

Crooked Creek #2 Restoration Project
DMS Project No. 94687
**Monitoring Year 1 - 2016**
Wetland Wetland Restoration



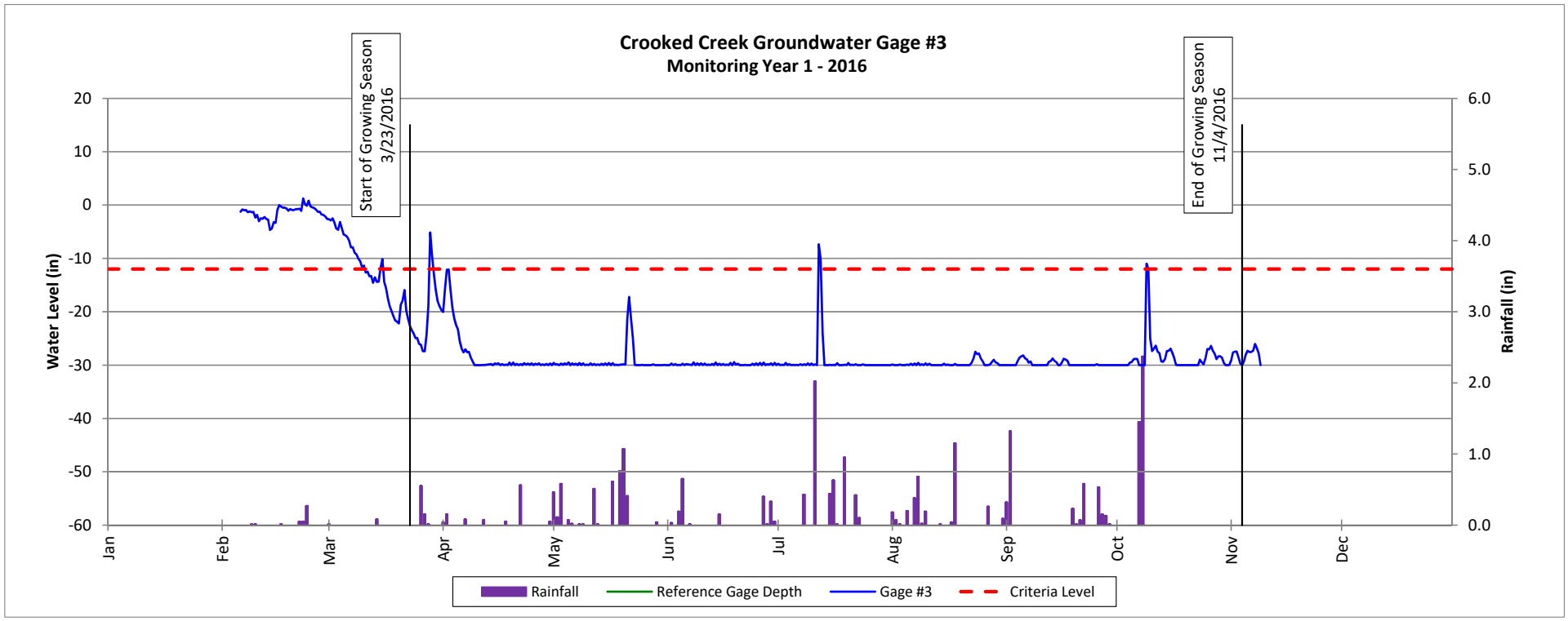
## Groundwater Gage Plots

Crooked Creek #2 Restoration Project
DMS Project No. 94687
**Monitoring Year 1 - 2016**
Wetland Wetland Restoration



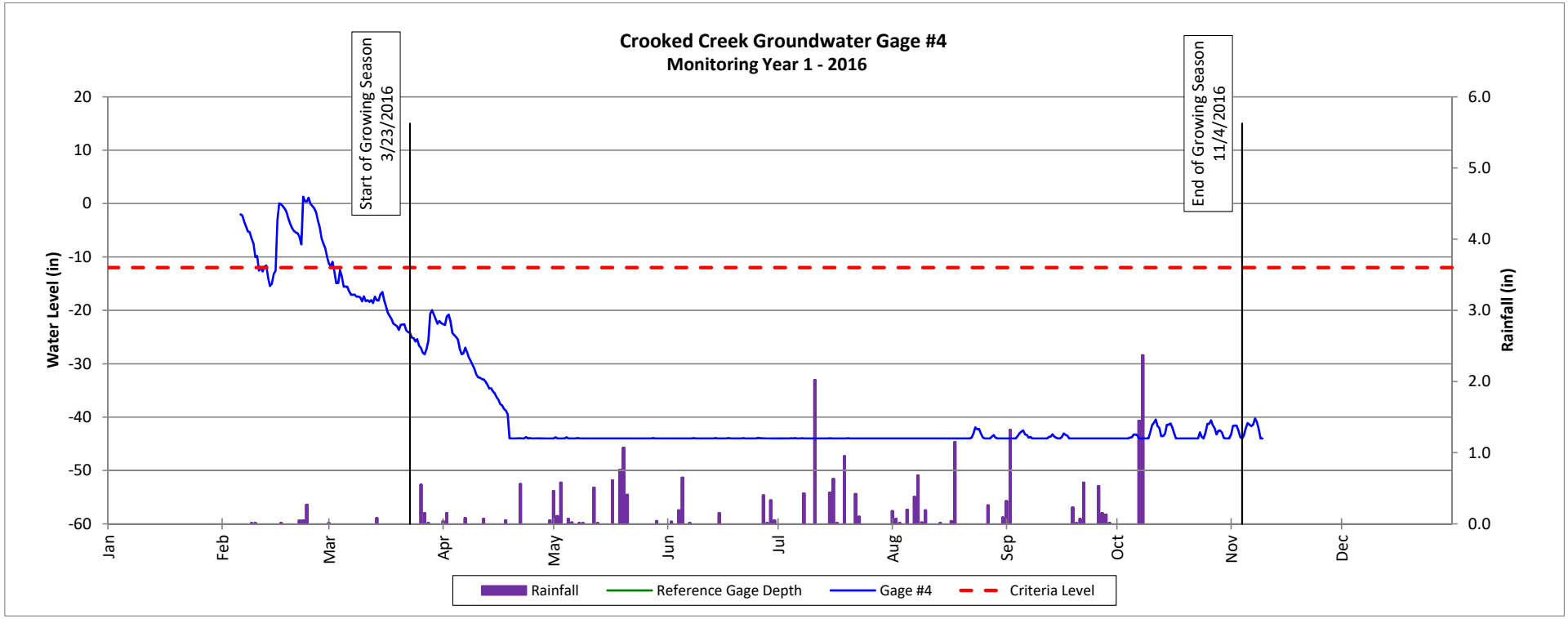
## Groundwater Gage Plots

Crooked Creek #2 Restoration Project
DMS Project No. 94687
**Monitoring Year 1 - 2016**
Wetland Wetland Restoration



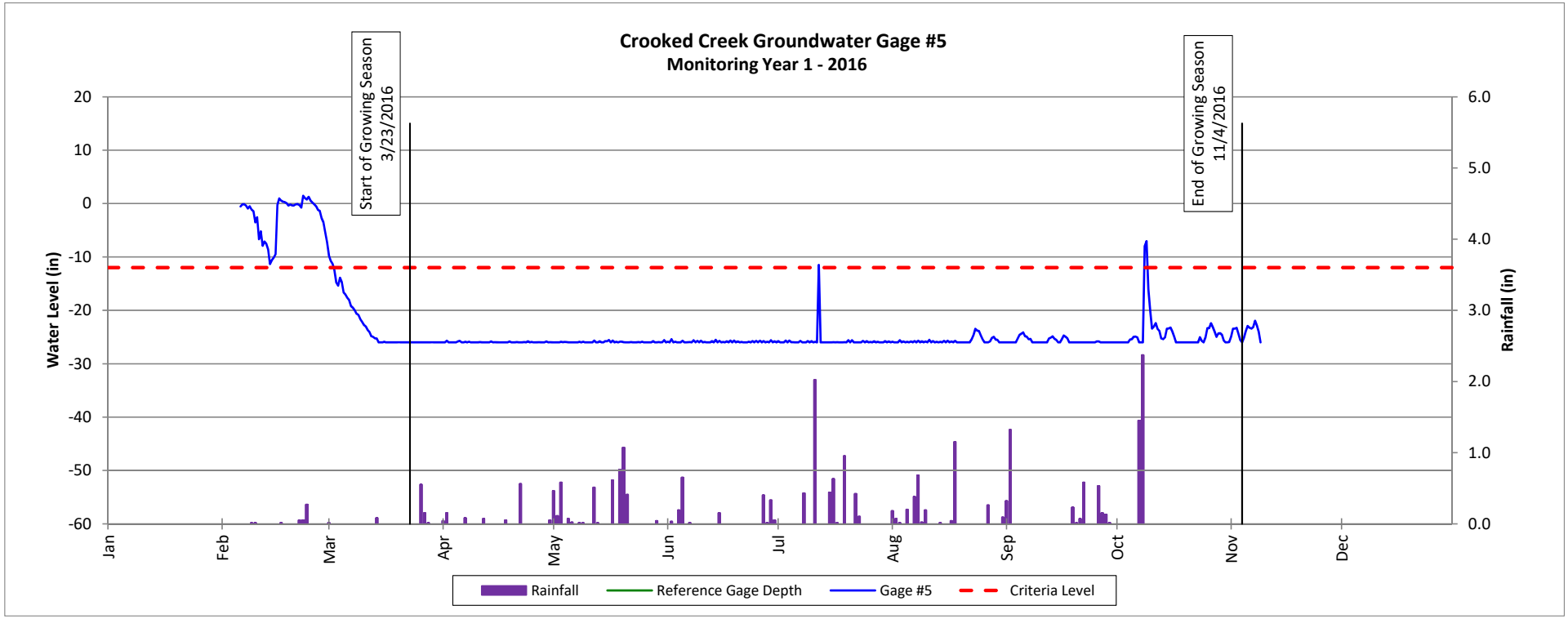
## Groundwater Gage Plots

Crooked Creek #2 Restoration Project
DMS Project No. 94687
**Monitoring Year 1 - 2016**
Wetland Wetland Restoration



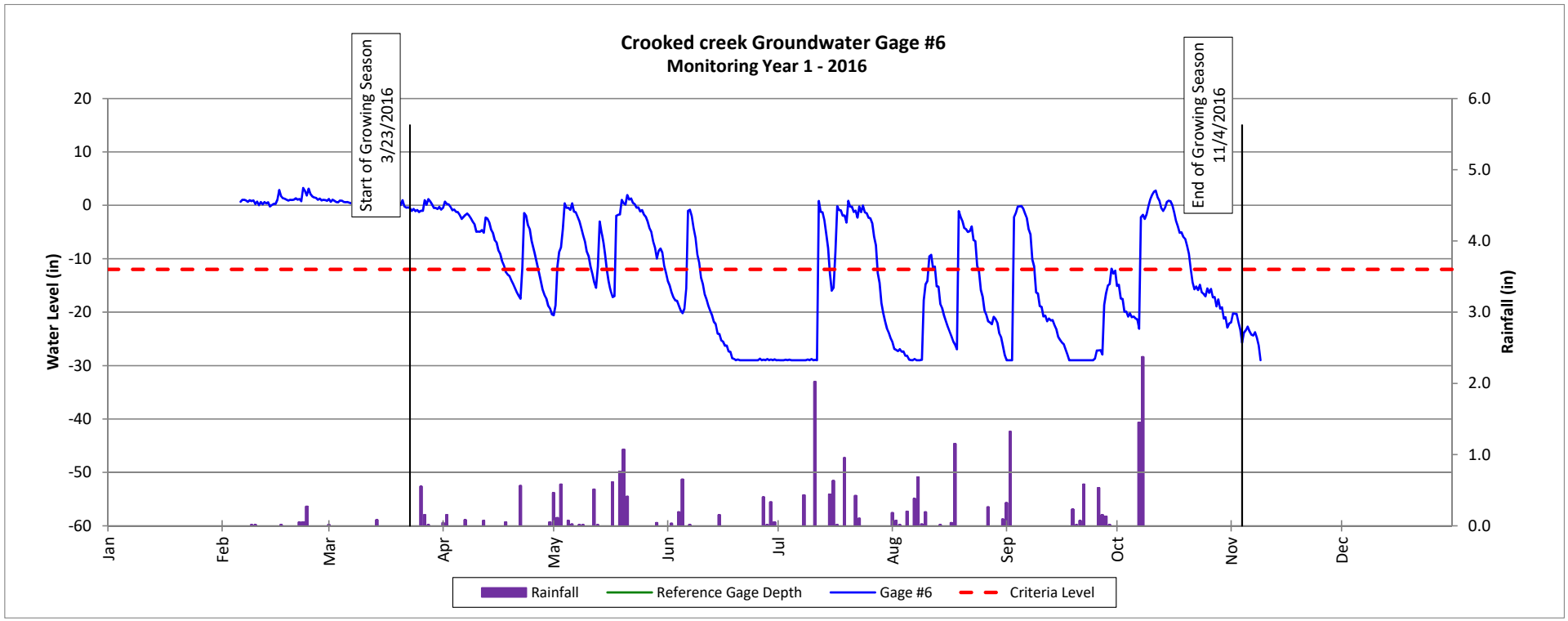
## Groundwater Gage Plots

Crooked Creek #2 Restoration Project
DMS Project No. 94687
**Monitoring Year 1 - 2016**
Wetland Wetland Creation



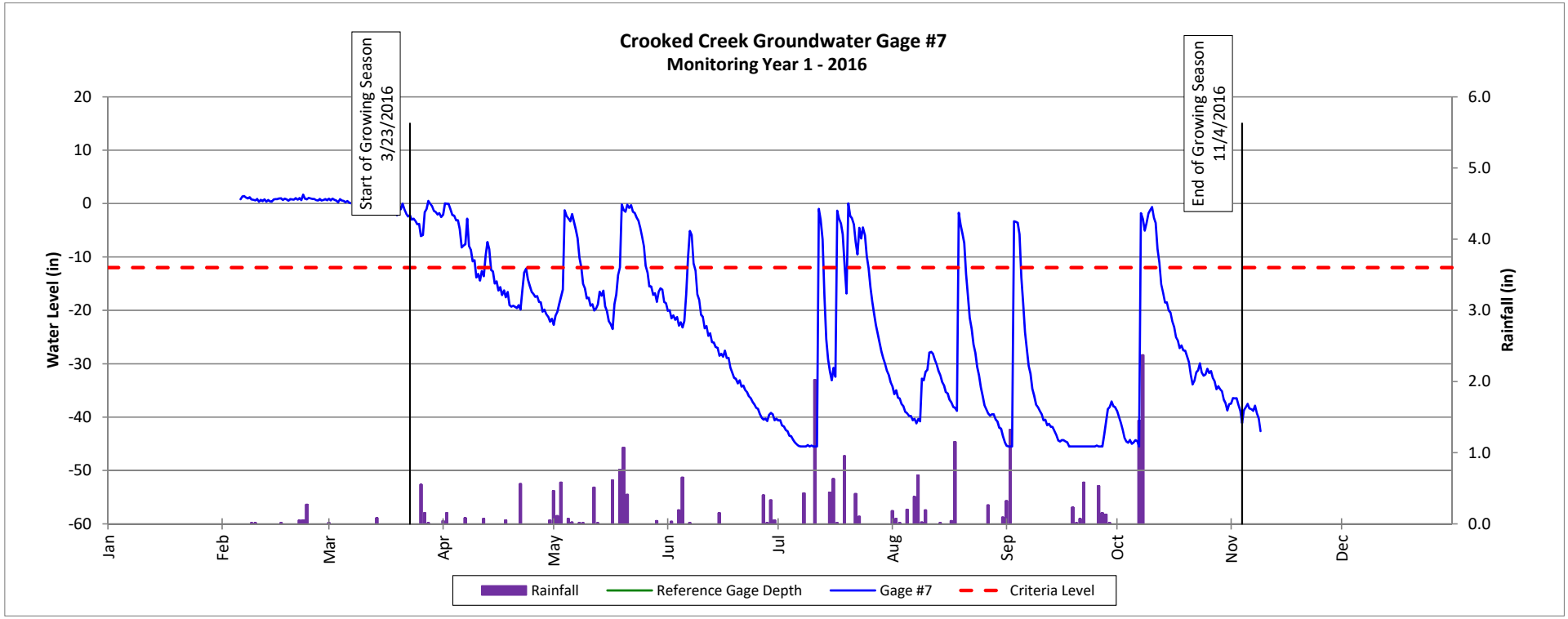
## Groundwater Gage Plots

Crooked Creek #2 Restoration Project
DMS Project No. 94687
**Monitoring Year 1 - 2016**
Wetland Wetland Restoration



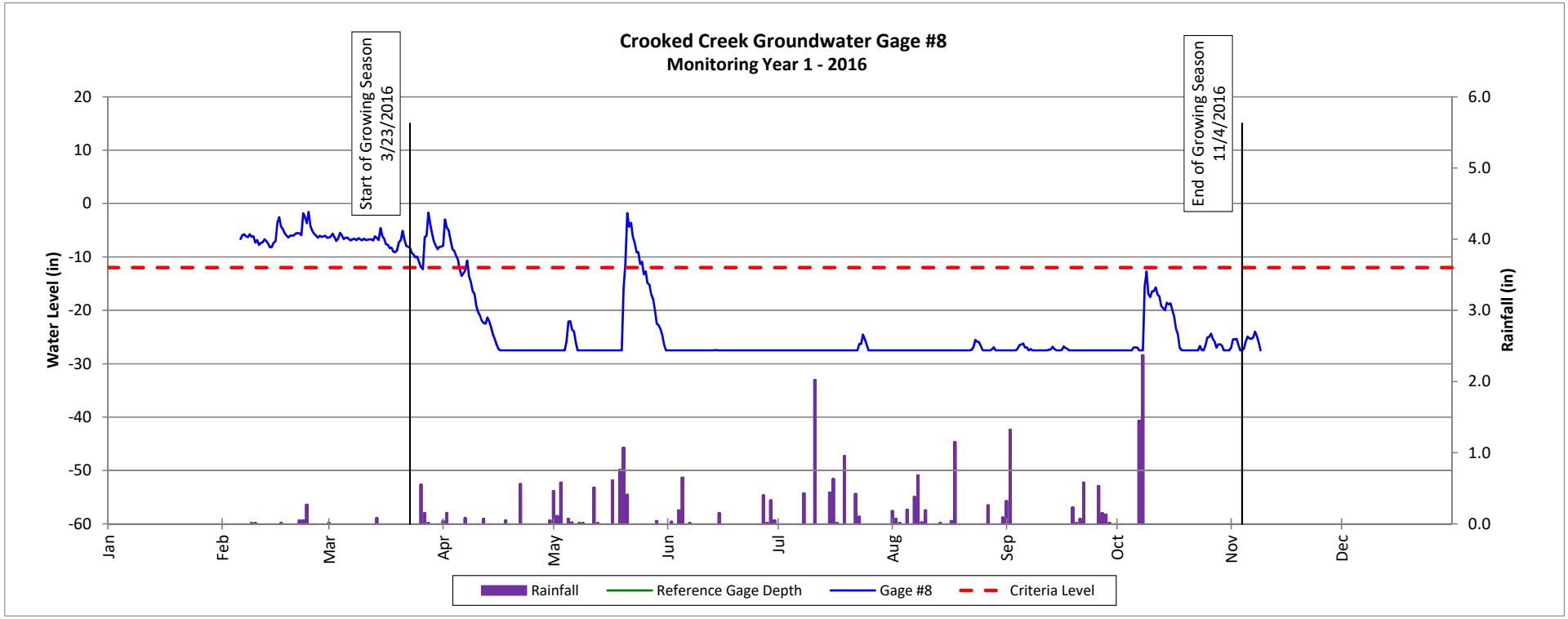
## Groundwater Gage Plots

Crooked Creek #2 Restoration Project
DMS Project No. 94687
**Monitoring Year 1 - 2016**
Wetland Wetland Restoration



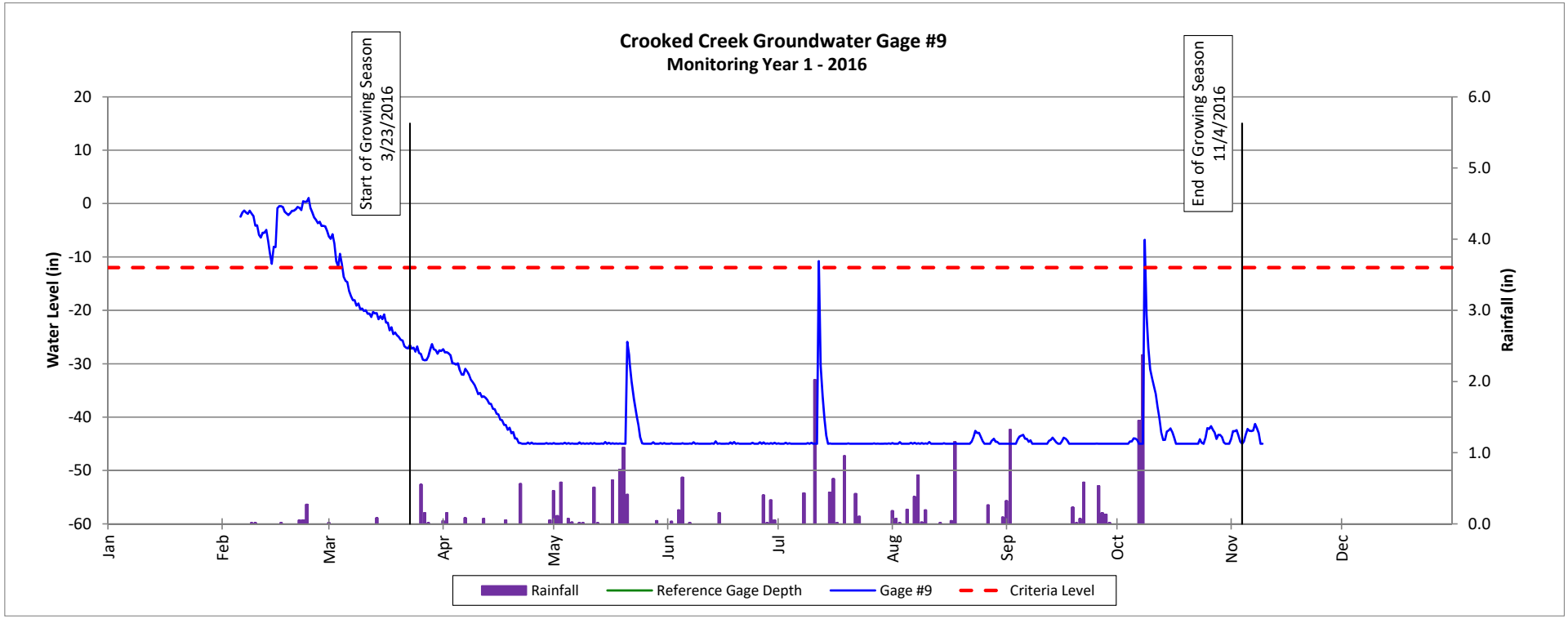
## Groundwater Gage Plots

Crooked Creek #2 Restoration Project
DMS Project No. 94687
**Monitoring Year 1 - 2016**
Wetland Wetland Creation



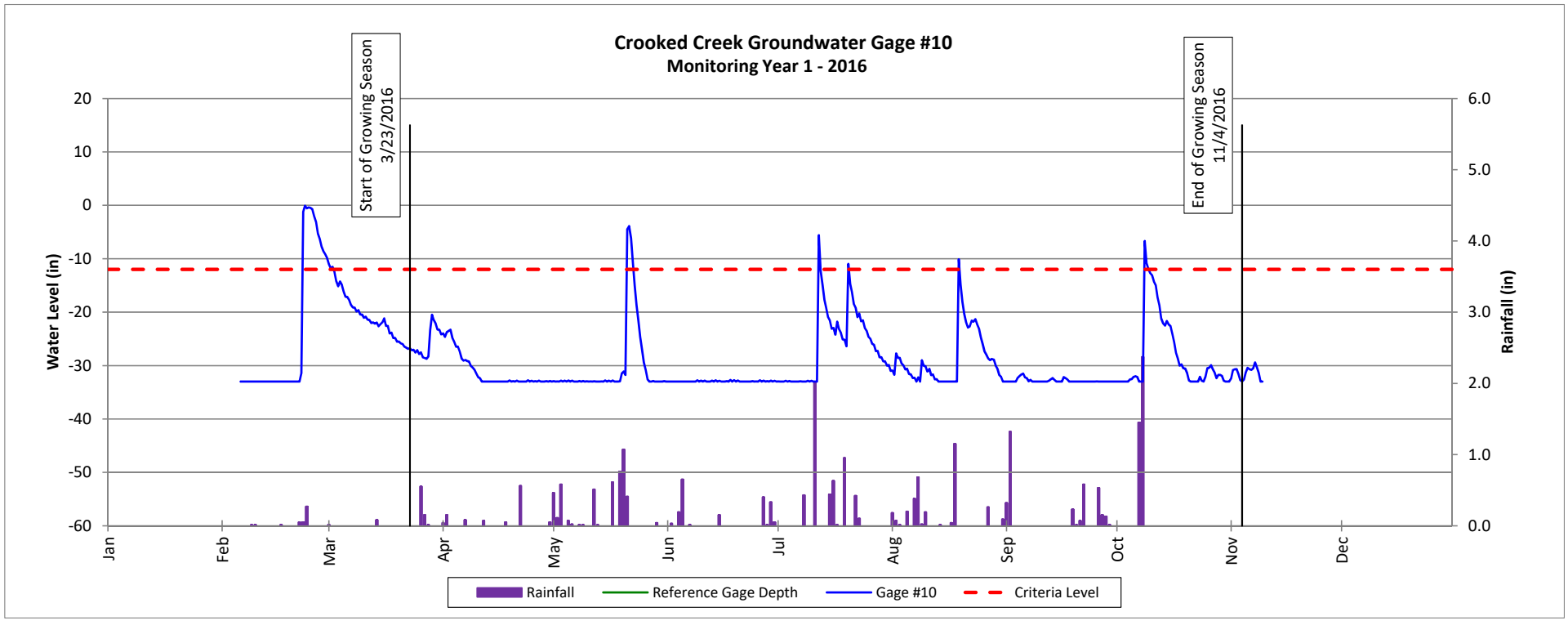
## Groundwater Gage Plots

Crooked Creek #2 Restoration Project
DMS Project No. 94687
**Monitoring Year 1 - 2016**
Wetland Wetland Creation



## Groundwater Gage Plots

Crooked Creek #2 Restoration Project
DMS Project No. 94687
**Monitoring Year 1 - 2016**
Wetland Wetland Creation

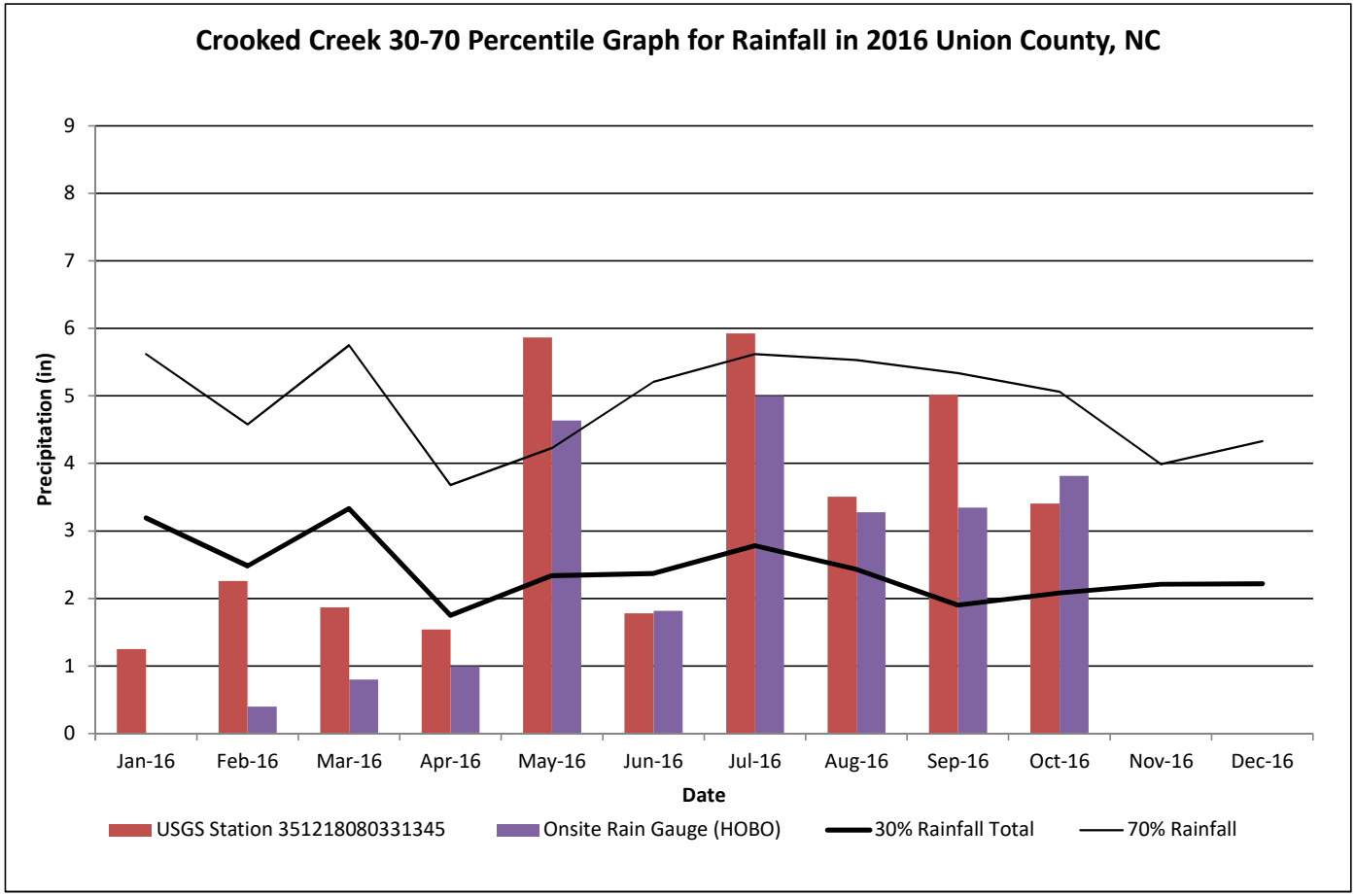


## Monthly Rainfall Data

Crooked Creek #2 Restoration Project

DMS Project No. 94687

**Monitoring Year 1 - 2016**




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

[2] On Site rain Gauge (HOBO) installed on 2/5/2016