FINAL
YEAR 1 (2016) ANNUAL MONITORING REPORT

BOBS CREEK
STREAM MITIGATION SITE

NCDMS Project No. 92879
Contract No. D09023S
USACE Action ID No. SAW-2009-917 & NCDWR Project No. 10-0122
SCO No. 08-07308-01
McDowell County, North Carolina

Data Collection: May-November 2016
Submission: January 2017

PREPARED FOR:

N.C. DEPARTMENT OF ENVIRONMENTAL QUALITY
DIVISION OF MITIGATION SERVICES
1601 MAIL SERVICE CENTER
RALEIGH, NORTH CAROLINA 27699-1601

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PREPARED BY:

AXIOM ENVIRONMENTAL, INC.
218 SNOW AVENUE
RALEIGH, NORTH CAROLINA 27603

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APPENDICES

1.0 PROJECT SUMMARY

The North Carolina Division of Mitigation Services (NCDMS) has established the Bobs Creek Stream Mitigation Site (Site). The primary goals of the project focused on improving water quality by reducing nutrient loading from the on-site buffalo and horse operation, reducing excess sedimentation input from site channel banks and hill slopes, increasing the attenuation of floodwater flows, and restoring and enhancing aquatic and riparian habitat. These goals were accomplished through the following objectives.

- Reduce point (i.e. buffalo directly accessing the channel) and non-point source (i.e. stormwater runoff through pastures) pollution associated with an on-site buffalo and horse operation by exclusionary fencing from the stream and riparian buffer, and by providing a vegetative buffer on stream banks and adjacent floodplains to treat nutrient enriched surface runoff from adjacent pastureland.
- Stabilize degraded portions of on-site streams, to reduce sediment inputs. Stabilization methods will include the following.
    1. Restoring a stable dimension, pattern, and profile to selected sections of channels to ensure the channel will transport and attenuate watershed flows and sediment loads without aggrading or degrading.
    2. Stabilize selected channel banks by excavating bankfull benches, placing stream structures to reduce shearing forces on outside meander bends, and planting native vegetative species to provide soil stability.
    3. Stabilize selected channel banks by matting and planting native vegetative species to establish root masses along channel and valley side slopes.
- Improve aquatic habitat by enhancing stream bed variability, providing shading/cover areas within the stream channel, and introducing woody debris in the form of rootwads, log vanes, and log sills.
- Diversify aquatic habitat by creating floodplain oxbows that will be breeding grounds for amphibians and also store overbank flows from adjacent stream channels.
- Enhance fish passage within Bobs Creek and UT 8 Bobs Creek. This is accomplished by removing livestock fencing that has become clogged with debris on Bobs Creek, and restoring UT 8 Bobs Creek and replacing an existing perched culvert to allow fish passage upstream.
- Enhance riparian wildlife habitat by fencing livestock out of existing and restored riparian buffers as well as installing alternative watering devices that will ensure livestock have sufficient watering areas. This is detailed further in the Farm Management Plans completed for the site by NCDMS.
- Enhance wildlife habitat by vegetating existing denuded riparian buffers with native trees, shrubs, herbs, and grasses. Forest vegetation species were selected by studying a Reference Forest Ecosystem located on-site and reviewing Montane Alluvial Forest species listed in *Classification of the Natural Communities of North Carolina: Third Approximation* (Schafale and Weakley 1990).
- Create wildlife corridors through agricultural lands which have significantly dissected the landscape. The corridors will provide connectivity to a diversity of habitats including mature forest, early successional forest, stream-side forest, riparian wetlands, and uplands.

Stream Success Criteria: Success criteria for stream restoration will include 1) successful classification of the reach as a functioning stream system (Rosgen 1996) and 2) channel variables indicative of a stable stream system.

Collected data will be utilized to determine the success in restoring stream channel stability. Specifically, the width-to-depth ratio and bank-height ratios should be indicative of a stable or moderately unstable channel with minimal changes in cross-sectional area, channel width, and/or bank erosion along the

monitoring reach. In addition, channel abandonment and/or shoot cutoffs must not occur and sinuosity values must remain relatively constant. Visual assessment of instream structures will be conducted to determine if failure has occurred. Failure of a structure may be indicated by collapse of the structure, undermining of the structure, abandonment of the channel around the structure, and/or stream flow beneath the structure.

Stream Dimension: General maintenance of a stable cross-section and hydrologic access to the floodplain features over the course of the monitoring period will generally represent success in dimensional stability. Some changes in dimension (such as lowering of bankfull width) should be expected. Riffle cross-sections should generally maintain a bank-height ratio approaching 1.0, with some variation in this ratio naturally occurring. Pool cross-sections naturally adjust based on recent flows and time between flows, therefore more leeway on pool cross-section geometry is expected.

Stream Pattern and Profile: The profile should not demonstrate significant trends towards degradation or aggradation over a significant portion of a reach. Additionally, bed form variables should remain noticeably intact and consistent with original design parameters that were based off of reference conditions. Pattern features should show little adjustment over the standard 5-year monitoring period and will be monitored to ensure adjustment is minor prior to close out.

Substrate: Substrate measurements should indicate the progression towards or the maintenance of the known distributions from the design phase.

Sediment Transport: There should be an absence of any significant trend in the aggradational or depositional potential of the channel.

Hydraulics: A minimum of two bankfull events must be documented within the standard 5-year monitoring period. The two bankfull events shall occur within separate years.

Vegetation Success Criteria: Success criteria have been established to verify that the vegetation component supports community elements necessary for forest development. Success criteria are dependent upon the density and growth of characteristic forest species. An average density of 320 stems per acre of planted stems must be surviving in the first three monitoring years. Subsequently, 290 planted stems per acre must be surviving in year 4 and 260 planted stems per acre in year 5.

The Bobs Site is located approximately five miles southeast of the town of Marion (Figure 1, Appendix B). The Site is situated due southwest of the intersection of Marlowe Road and Fat Wall Road in McDowell County, North Carolina and is located within the United States Geological Survey (USGS) Hydrologic Unit and Targeted Local Watershed 03050101040010 (North Carolina Division of Water Quality Subbasin 03-08-30) of the Catawba River Basin and will service USGS 8-digit Cataloging Unit 03050101.

The contributing watersheds are characterized primarily by forest land (approximately 87 percent of the total area) with pasture at the lower elevations (approximately 10 percent of the total area) and low-density residential development scattered along the outer fringes of the pasture/agricultural land. Impervious surfaces appear to account for approximately one percent of the watershed land surface. Prior to Site construction, riparian vegetation had been removed, stream channels were manipulated, and hoof shear from livestock on stream banks and floodplain soils was responsible for degraded water quality and unstable channel characteristics (stream entrenchment, erosion, and bank collapse) within Site streams.

Project mitigation efforts resulted in the following.

- Restore 929 linear feet of stream
- Enhance (Level I) 238 linear feet of stream
- Enhance (Level II) 402 linear feet of stream
- Preserve 6794 linear feet of stream
- Preserve 0.35 acres of riparian wetland

The Muddy Creek Restoration Partnership (Partnership) was formed in 1998 to address impacts to the Muddy Creek Watershed. The Partnership completed the *Muddy Creek Watershed Restoration Initiative Feasibility Report and Restoration Plan* (Watershed Plan) for the Muddy Creek Watershed in December of 2003 (MCRP 2003). Since 2004 NCDMS has informally participated in the Partnership by implementing priority projects named by the partnership and adopted the 2003 report as part of its Local Watershed Plan (LWP). The NCDMS's *Upper Catawba River Basin Restoration Priorities* (2009) identifies North Muddy Creek as a Targeted Local Watershed (TLW). The Site is located within the North Muddy Creek Watershed. In 2008 NCDMS contracted with a consulting firm to conduct outreach programs with landowners and identify additional project sites in the Muddy Creek Watershed.

The primary goals identified by the Partnership's Watershed Plan include the following.

1. Restore the Watershed to its Full Intended Use
2. Restore Riparian Buffers
3. Enhance Open Space Preservation
4. Improve Water Quality
5. Restore Physical Habitat
6. Establish a Trout Fishery

The Watershed Plan listed the following components of watershed restoration to be expected.

1. Natural Channel Design Stream Restoration
2. Riparian Reforestation
3. Livestock Exclusion
4. Riparian Forest Preservation

These four components were included within the *Bobs Creek Site's Mitigation Plan* (NCEEP 2009). The project restored the watershed to its full intended use by restoring a stream, floodplain, and riparian wetland ecosystem through stream and wetland restoration, enhancement and preservation. The project restored riparian buffers through revegetation of buffer zones with native riparian and wetland species along all Site streams. The project enhanced open space preservation by placing Site streams, wetlands, and their buffers into a permanent conservation easement. The overall Site helps improve water quality by reducing sedimentation in on-Site streams and planted a vegetated riparian buffer that filters nutrients from adjacent pasturelands. Additionally, exclusionary fencing and alternate watering devices removed livestock from accessing on-site channels and riparian buffers. The project restored and enhanced physical habitat for both aquatic and terrestrial species by planting native vegetation along stream banks and riparian buffers, creating wildlife corridors through a dissected landscape, and restoring bedform variability to Site streams. The stabilization of streams and buffers in the project area enhanced water quality in downstream receiving waters, which should help in the re-establishment of the watershed's ability to host trout and enhance their ability to propagate.

Site design was completed in April 2014. Site construction was completed in December 2015 and Site planting was completed in December 2015. Completed project activities, reporting history, completion dates, project contacts, and project attributes are summarized in Tables 1-4 (Appendix A).

2.0 METHODS

Monitoring of restoration efforts will be performed for five years or until success criteria are fulfilled. Monitoring is proposed for the stream channel and vegetation. In general, the restoration success criteria, and required remediation actions, are based on the *Stream Mitigation Guidelines* (USACE et al. 2003). Monitoring features are described below and are depicted on Figures 2A-B (Appendix B).

Streams

The restored stream reaches are proposed to be monitored for geometric activity as follows.

- 850 linear feet of stream profile
- 4 riffle cross-sections
- 1 pool cross-section

The data will be presented in graphic and tabular format. Data to be presented will include 1) cross-sectional area, 2) bankfull width, 3) average depth, 4) maximum depth, 5) width-to-depth ratio, 6) meander wavelength, 7) belt-width, 8) water surface slope, and 9) sinuosity. The stream will subsequently be classified according to stream geometry and substrate (Rosgen 1996). Significant changes in channel morphology will be tracked and reported by comparing data in each successive monitoring year. Pebble counts will be completed at the 4 riffle cross-sections to be used for substrate analysis (Appendix D). Annual photographs will include 27 fixed station photographs (Appendix B). In addition, the Site contains two stream crest gauges to assist with documentation of bankfull events. One bankfull event has been documented to date during monitoring year 1 (2016) (Table 12, Appendix E).

Early in Year 1 (2016), several structures were damaged and surrounding streambanks were eroded by significant storm events that occurred shortly after Site construction. Warranty repair work was completed in October 2016 to address these issues. The repaired structures and banks currently appear stable. They will be monitored throughout the remainder of the monitoring period to determine if the repair work sufficiently resolved the issues and if any additional repairs will be required. Currently, stream measurements are meeting success criteria.

Vegetation

Restoration monitoring procedures for vegetation will monitor plant survival and species diversity. The Site planting area consists of 1.8 acres. After planting was completed, three vegetation plots were installed and monitored at the Site; results can be found in Appendix C. Annual measurements of vegetation will consist of the following.

- 2 plant warranty inspection plots (only monitoring years 1-3)
- 3 CVS vegetation plots

A photographic record of plant growth should be included in each annual monitoring report; baseline photographs are included in Appendix B. During the first year, vegetation will receive a cursory, visual evaluation on a periodic basis to ascertain the degree of overtopping of planted elements by nuisance species. Subsequently, quantitative sampling of vegetation will be performed as outlined in the *CVS-EEP Protocol for Recording Vegetation, Version 4.2* (Lee et al. 2008) in September of the first monitoring year and annually between June 1 and September 30 for the remainder of the monitoring period until vegetation success criteria are achieved.

Year 1 stem count measurements indicate planted stem densities are well above the required 320 stems per acre based on permanent CVS and temporary warranty plots combined. Planted stem densities for permanent CVS plots is 432 planted stems per acre (Table 9, Appendix C). Planted stem densities of warranty plots is 445 planted stems per acre (Table 8, Appendix C). Total planted stem density based on warranty and CVS plots is 437 planted stems per acre across the Site. In addition, all three individual CVS plots and both warranty plots met success criteria based on planted stems alone (Table 7, Appendix C). Therefore, the Site is currently meeting vegetation success criteria.

3.0 REFERENCES

Lee, M.T., R.K. Peet, S.D. Roberts, and T.R. Wentworth. 2008. CVS-EEP Protocol for Recording Vegetation. Version 4.2. North Carolina Department of Environment and Natural Resources, Ecosystem Enhancement Program. Raleigh, North Carolina.

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Rosgen D. 1996. Applied River Morphology. Wildland Hydrology. Pagosa Springs, Colorado.

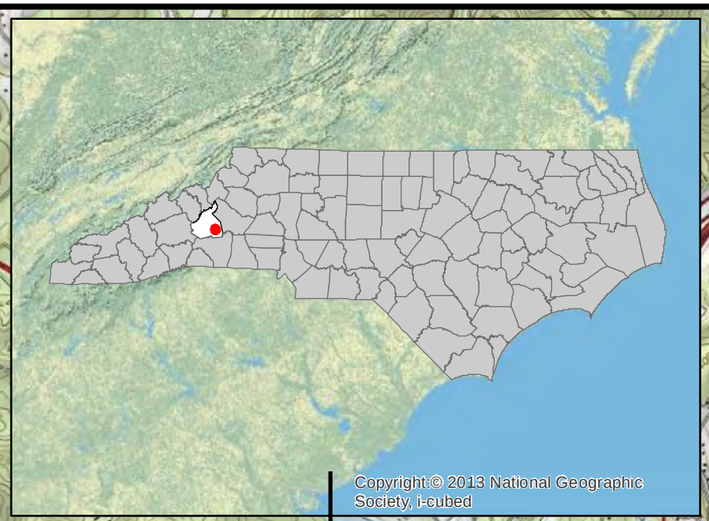
Schafale, M.P. and A.S. Weakley. 1990. Classification of the Natural Communities of North Carolina: Third Approximation. North Carolina Natural Heritage Program, Division of Parks and Recreation, North Ccarolina Department of Environment, Health, and Natural Resources. Raleigh, North Carolina.

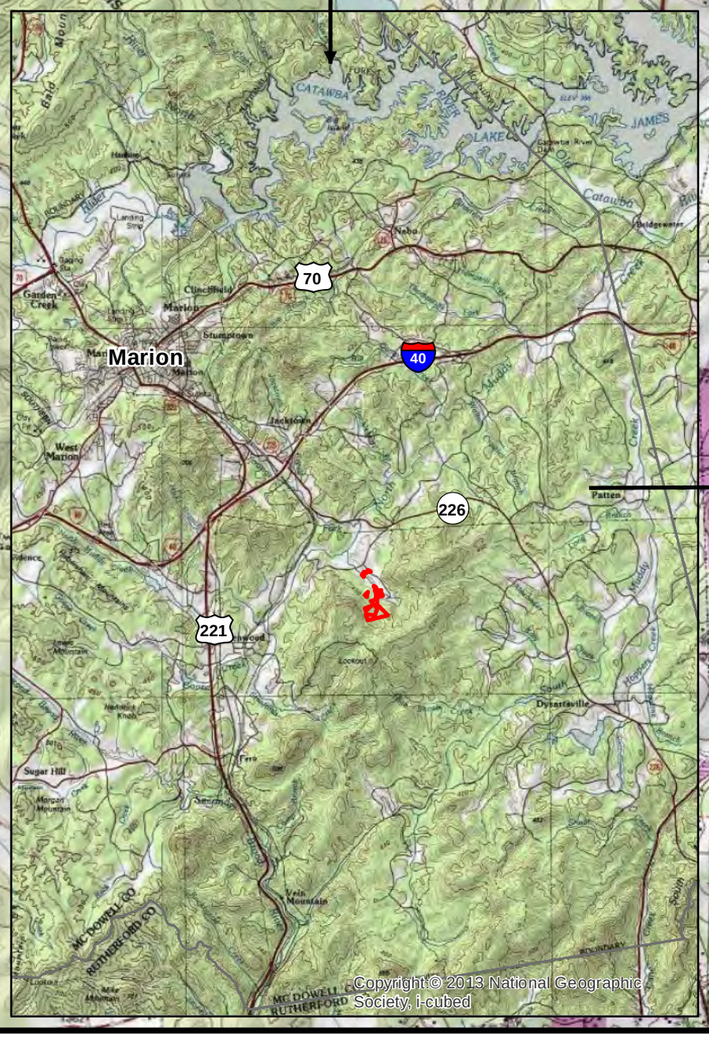
United States Army Corps of Engineers (USACE), United States Environmental Protection Agency (USEPA), North Carolina Wildlife Resources Commission (NCWRC), Natural Resources Conservation Service (NRCS), and North Carolina Division of Water Quality (NCDWQ). 2003. Stream Mitigation Guidelines. State of North Carolina.

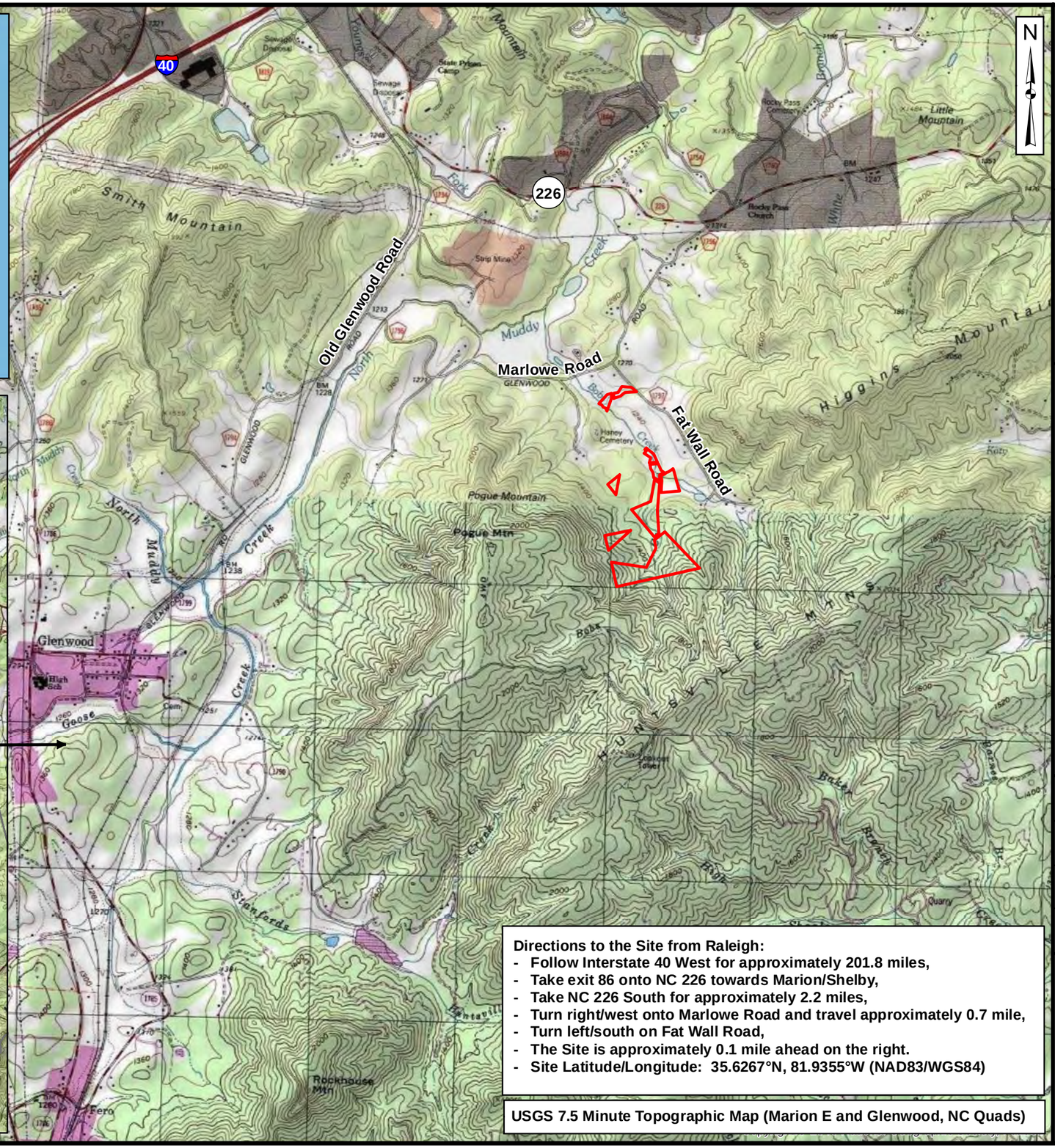
Weather Underground. 2016. Station KFQD at Bostic, North Carolina (online). Available: www.wunderground.com/history/airport/KFQD/ [December 7, 2016]. Weather Underground.

Appendix A.
Site Location Map and Background Tables

Figure 1. Site Location
Table 1. Project Mitigation Components
Table 2. Project Activity and Reporting History
Table 3. Project Contacts Table
Table 4. Project Attributes Table







Directions to the Site from Raleigh:
- **Follow Interstate 40 West for approximately 201.8 miles,**
- **Take exit 86 onto NC 226 towards Marion/Shelby,**
- **Take NC 226 South for approximately 2.2 miles,**
- **Turn right/west onto Marlowe Road and travel approximately 0.7 mile,**
- **Turn left/south on Fat Wall Road,**
- **The Site is approximately 0.1 mile ahead on the right.**
- **Site Latitude/Longitude: 35.6267°N, 81.9355°W (NAD83/WGS84)**

USGS 7.5 Minute Topographic Map (Marion E and Glenwood, NC Quads)

Axiom Environmental, Inc.

Prepared for:

NC Department of Environmental Quality

Division of Mitigation Services

Project:

BOBS CREEK

McDowell County, NC

Title:

SITE LOCATION

Drawn by: KRJ

Date: APR 2016

Scale: 1:30000

Project No.: 12-004.21

FIGURE

1

Table 1. Project Components and Mitigation Credits

Bobs Creek Mitigation Site/ DMS Number 92879

Mitigation Credit Summations					
Stream	**Riparian Wetland**	**Nonriparian Wetland**	**Buffer**	**Nitrogen Offset**	**Phosphorous Offset**
2607	**0.07**	**---**	**---**	**---**	**---**

Projects Components							
Project Component –or-Reach ID	**Stationing**	**Existing Footage or Acreage**	**Restoration Footage or Acreage**	**Restoration Level/Equivalent**	**Mitigation Ratio**	**Mitigation Credits**	**Comment**
Bobs Creek Bob Creek As-built Plan Stationing	39+86 – 43+21 (09+90 – 13+25)	3315	335 335	Restoration (PI)	1:1	335	Channel moved away from terrace and around existing mature vegetation.
Bobs Creek	36+74 – 37+21 37+89 – 38+67 39+14 – 39+50		161	Enhance I	1.5:1	107	Bankfull bench excavation, channel structures, and vegetative plantings on degraded banks.
Bobs Creek	37+21 – 37+89 38+67 – 39+14 39+50 – 39+86		151	Enhance II	2.5:1	60	Exclusionary fencing and permanent conservation easement. The easement break at 39+86 has been removed from credit summation.
Bobs Creek	10+00 – 36+74		2674	Preservation	5:1	535	Two easement breaks have been removed from credit summation.
UT 1 Bobs Creek	10+00 – 20+60	1060	1060	Preservation	5:1	212	---
UT 2 Bobs Creek	10+00 – 15+90	590	590	Preservation	5:1	118	---
UT 3 Bobs Creek	10+00 – 15+30	530	530	Preservation	5:1	106	The easement break has been removed from credit summation.
UT 4 Bobs Creek	10+00 – 16+51 10+00 - 10+75	726	726	Preservation	5:1	145	
UT 5 Bobs Creek	10+00 – 12+24	224	224	Preservation	5:1	45	---
UT 6 Bobs Creek	10+17 – 10+37 10+73 – 10+78 12+50 – 12+76	369	51	Enhance II	2.5:1	20	Vegetative plantings on degraded meanders and matting.
UT 6 Bobs Creek	10+00 – 10+17 10+37 – 10+73 10+78 – 12+50 12+76 – 13+37		286	Preservation	5:1	57	---
UT 7 Bobs Creek	15+23 – 15+48	682	25	Enhance I	1.5:1	17	Bankfull bench excavation, channel structures, and vegetative plantings on degraded banks.
UT 7 Bobs Creek	10+00 – 15+23 15+48 – 16+36		611	Preservation	5:1	122	The easement break at the crossing has been removed from credit summation.

UT 8 Bobs Creek Bob Creek As-built Plan Stationing	11+58 – 13+35 (10+00 – 11+77) 15+22 – 16+95 (10+00 – 11+73) 17+85 – 19+39 (13+16 - 14+70)	985	504	Restoration (PI)	1:1	504	Channel moved away from valley side slope, and around mature vegetation in Upstream Reach. New channel location in new valley in Downstream Reach. The easement break at the crossing in the downstream reach has been removed from credit summation.
UT 8 Bobs Creek Bob Creek As-built Plan Stationing	16+95 – 17+85 (12+26 – 13+16)		90	Restoration (PII)	1:1	90	Channel moved approximately 100 feet to the west of existing location to historic valley.
UT 8 Bobs Creek	10+93 – 11+25 14+45 – 14+65		52	Enhance I	1.5:1	35	Bankfull bench excavation, channel structure, and vegetative plantings on degraded banks.
UT 8 Bobs Creek	11+25 – 11+58 13+35 – 14+45 14+65 – 15+22		200	Enhance II	2.5:1	80	Vegetative plantings on degraded meanders and matting.
UT 8 Bobs Creek	10+00 – 10+93		93	Preservation	5:1	19	---
Wetlands	---	0.35	0.35	Preservation	5:1	0.07	---

Length and Area Summations

Restoration Level	Stream (linear footage)	Riparian Wetland (acreage)		Nonriparian Wetland (acreage)	Buffer (square feet)	Upland (acres)
		Riverine	Non-Riverine			
Restoration	929	--		--		
Enhancement (Level I)	238	--		--		
Enhancement (Level II)	402	--		--		
Preservation	6,794	**0.35**		--		
Totals	**8,363**	**0.35**		--		
Mitigation Units	**2,607 SMUs**	**0.07 Riparian WMUs**		**0.00 Nonriparian WMUs**		

BMP Elements

Element	Location	Purpose/Function	Notes

Table 2. Project Activity and Reporting History
Bobs Creek Mitigation Site/ DMS Number 92879

Activity or Deliverable	Data Collection Complete	Completion or Delivery
Project Institution		
Mitigation Plan	April 2009	December 2009
Permits Issued		
Final Design – Construction Plans		April 2014
Construction	--	December 2015
Temporary S&E Mix applied to Entire Project Site	--	December 2015
Permanent Seed Mix applied to the Entire Project Site	--	December 2015
Bare Root; Containerized; and B&B Plantings for the Entire Project Site	--	December 2015
Baseline Monitoring Document (Year 0 Monitoring Baseline)	April 2016	July 2016
Repair	--	October 2016
Year 1 Monitoring	November 2016	December 2016
Year 2 Monitoring		
Year 3 Monitoring		
Year 4 Monitoring		
Year 5 Monitoring		

Table 3. Project Contact Table
Bobs Creek Mitigation Site/ DMS Number 92879

Designer	Florence & Hutcheson Engineering (Now HDR) 5121 Kingdom Way, Suite 100 Raleigh, NC 27607 Kevin Williams (919) 851-6066
Construction Plans and Sediment and Erosion Control Plans	Florence & Hutcheson Engineering (Now HDR) 5121 Kingdom Way, Suite 100 Raleigh, NC 27607 Kevin Williams (919) 851-6066
Construction Contractor	Carolina Environmental Contracting, Inc. Mount Airy, NC (336) 320-3849
Planting Contractor	Keller Environmental 7291 Haymarket Lane Raleigh, NC 27615 Jay Keller (919) 749-8259
As-built Surveyor	Turner Land Surveying. PLLC 3719 Benson Drive Raleigh, NC 27609 Elisabeth Turner (919) 827-0745
Baseline Data Collection	Axiom Environmental, Inc. 218 Snow Avenue Raleigh, NC 27603 Grant Lewis (919) 215-1693

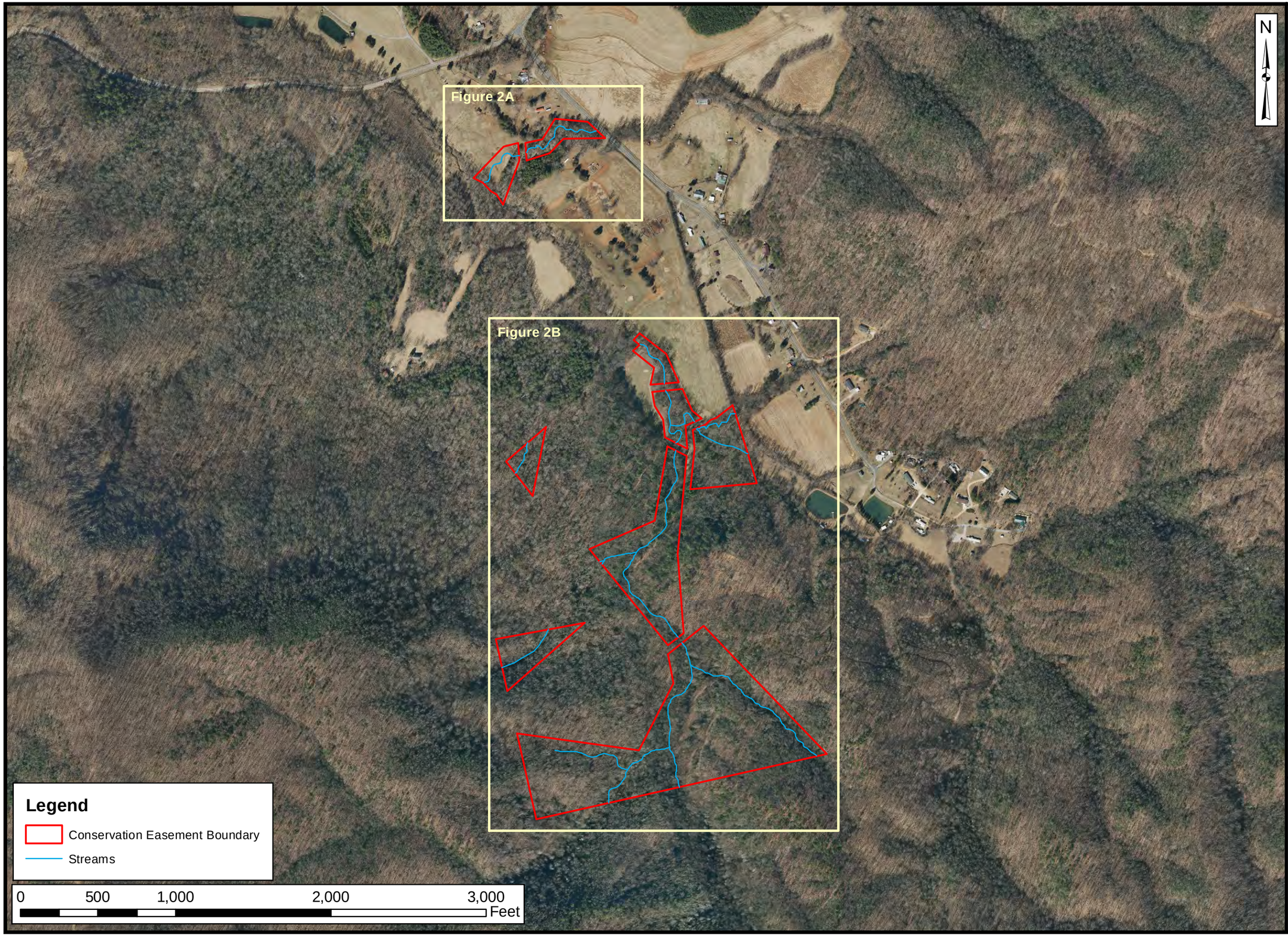
Table 4. Project Baseline Information and Attributes
Bobs Creek Mitigation Site/ DMS Number 92879

Project Information						
Project name	Bobs Creek Mitigation Site					
Project county	McDowell County, North Carolina					
Project area (Acres)	31.8					
Project coordinates (lat/long)	35.6567°N, 81.9355°W					
Project Watershed Summary Information						
Physiographic region	Blue Ridge					
Project river basin	Catawba River Basin					
USGS hydrologic unit (8 digit)	03050101					
NCDWQ Sub-basin	03-08-30					
Project drainage area (acres)	930					
% Drainage area impervious	1					
CGIA land use classification	----					
Reach Summary Information						
Parameters	**Bobs Creek**	**UT's to Bobs Creek**				
		UT 1	**UT 2/3**	**UT 4/5**	**UT 6/7**	**UT 8**
Length of reach (linear feet)	3321	1060	590/530	726/224	337/636	939
Valley classification	VIII	II	II	II	II & VII	II
Drainage area (acres)	930	1	20/120	20/40	440/45	60
NCDWQ stream identification score	46.5	24	39/24	27/34	27/41.5	33.5
NCDWQ water quality classification	C	C	C	C	C	C
Morphological description (stream type)	B & C & F4	B4	B4	E &C4 / A & B4	B4 / C4 & E4	B&C&G4
Design Rosgen stream type	C4	B4	B4	E &C4 / B4	B4 / C4 & E4	E & C4
Evolutionary trend						
Design approach (P1, P2, P3, E, etc.)	PI, EI, EII, & P	P	P	P	EI, EII, P	PI. PII, EI, EII, P
Underlying mapped soils	Tate/Chestnut/ Ashe	Tate	Tate/ Evard/ Cowee	Tate/ Evard	Iotla	Iotla
Drainage class	Well	Well	Well	Well	SW Poor	SW Poor
Soil hydric status	Nonhydric	Nonhydric	Nonhydric	Nonhydric	Nonhydric	Nonhydric
Slope	0.0173	0.191	0.258/ 0.286	0.086/ 0.255	0.039/ 0.047	0.0342
FEMA classification	Zone AE	Zone X	Zone X	Zone X	Zone X	Zone X
Native vegetation community	Forest/Pasture	Forest	Forest	Forest	Forest	Pasture
% Composition of exotic invasive spp.	<5	<5	<5	<5	<5	<5
Wetland Summary Information						
Parameters	**Wetland 1**					**Wetland 2**
Size of wetland (acres)	0.35					
Wetland type	Riparian Riverine					
Mapped soil series	Tate Loam (Wehadkee)					
Drainage class	Well (poorly)					
Soil hydric status	Nonhydric (hydric)					

Source of hydrology	Overbank and groundwater		
Hydrologic impairment	None		
Native vegetation community	Forested		
% Composition of exotic invasive spp.	<5		
Regulatory Considerations			
Regulation	**Applicable?**	**Resolved?**	**Supporting Documentation**
Waters of the US – Section 404	Yes	Yes	SAW-2009-917
Waters of the US – Section 401	Yes	Yes	SAW-2009-917
Endangered Species Act	Yes	Yes	No Effect – CE Document
Historic Preservation Act	Yes	Yes	CE Document
Coastal Zone Management Act (CZMA/CAMA)	No	NA	NA
FEMA Floodplain Compliance	Yes	Yes	No Rise
Essential Fisheries Habitat	No	NA	NA

Appendix B
Visual Assessment Data

Figures 2, 2A-2B. Current Conditions Plan View
Figures 3, 3A-3B. Project Assets
Tables 5A-5B. Visual Stream Morphology Stability Assessment
Table 6. Vegetation Condition Assessment
Stream Fixed Station Photo Points
Vegetation Plot Photos



Axiom Environmental, Inc.

Prepared for:

NC Department of Environmental Quality

Division of Mitigation Services

Project:

Bob's Creek Stream Restoration Project

DMS Project # 92879

McDowell County, NC

Title:

Current Conditions Plan View

Drawn by: KRJ

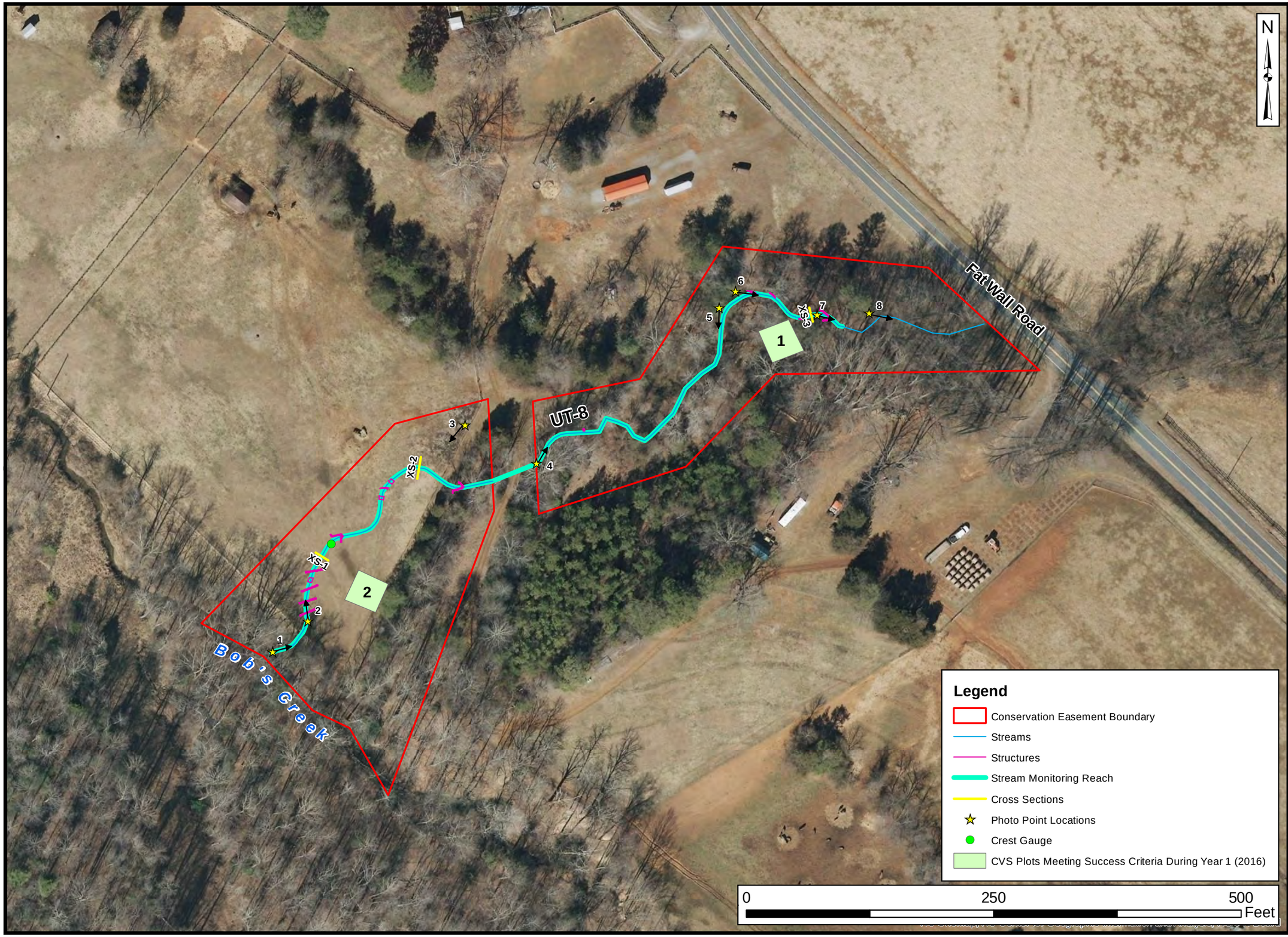
Date: DEC 2016

Scale: 1:7000

Project No.: 12-004.21

FIGURE

2



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DMS Project # 92879

McDowell County, NC

Title:

Current Conditions Plan View

Drawn by: KRJ

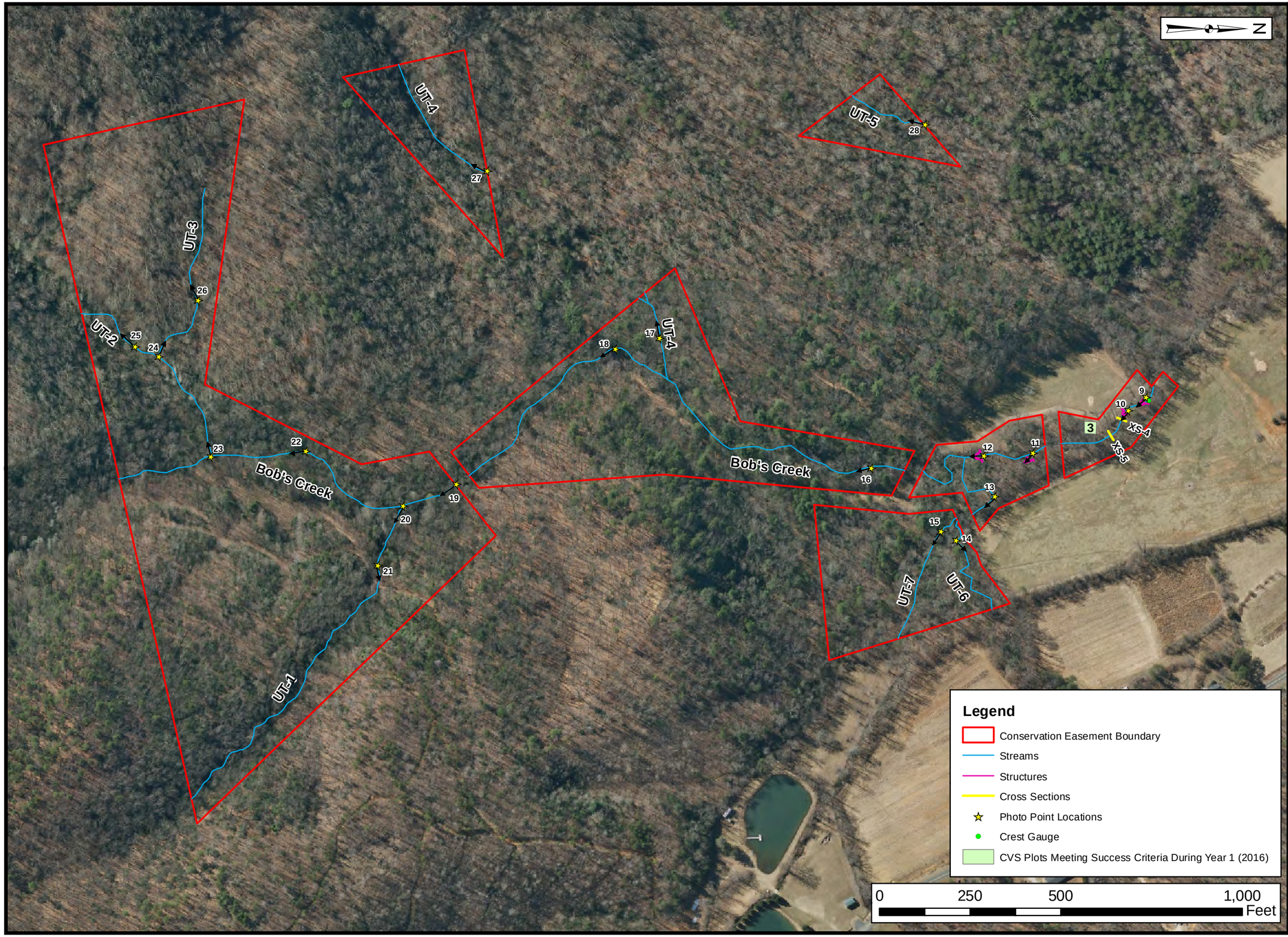
Date: DEC 2016

Scale: 1:1100

Project No.: 12-004.21

FIGURE

2A



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NC Department of Environmental Quality

Division of Mitigation Services

Project:

Bob's Creek Stream Restoration Project

DMS Project # 92879

McDowell County, NC

Title:

Current Conditions Plan View

Drawn by: KRJ

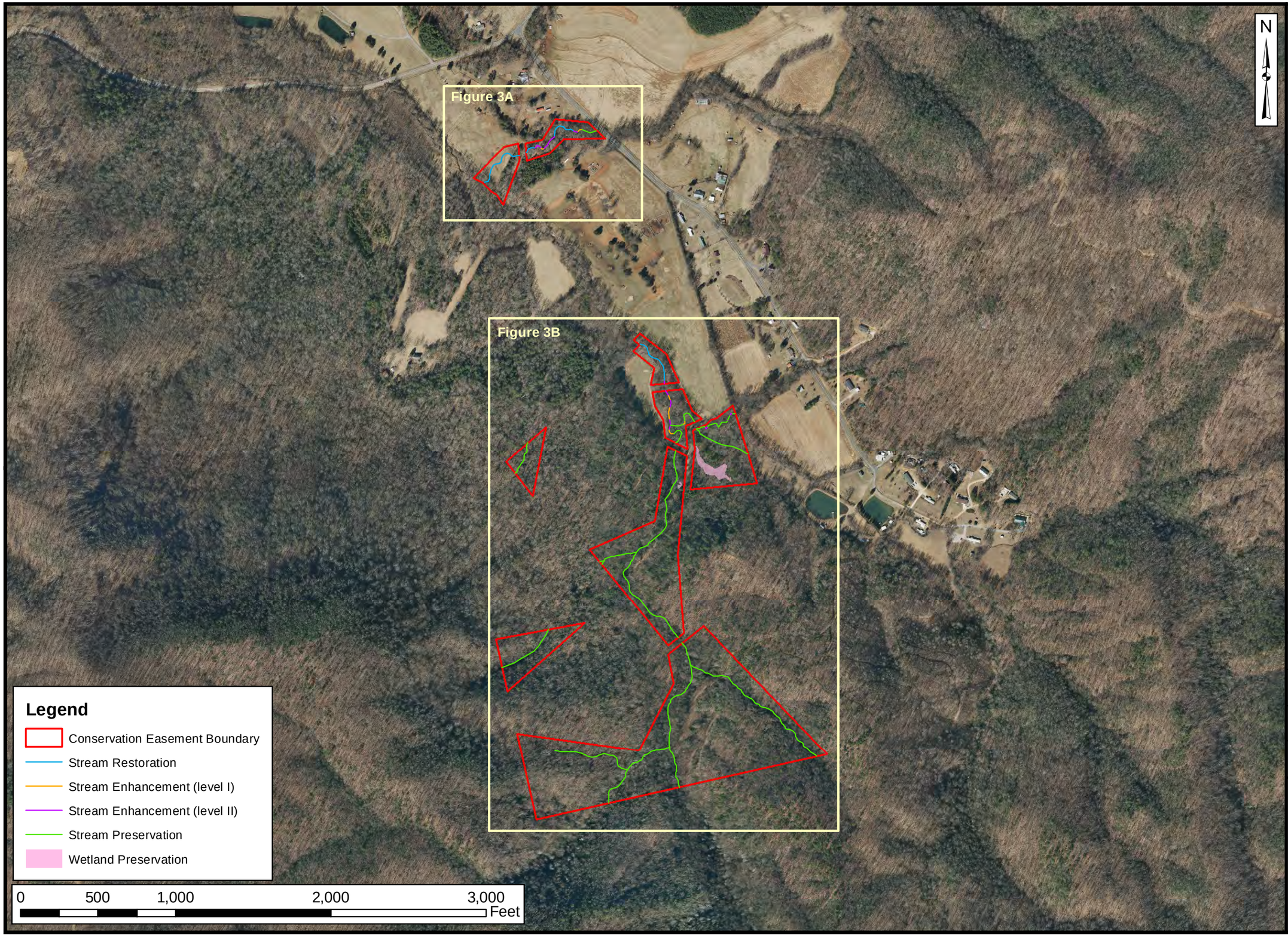
Date: DEC 2016

Scale: 1:3000

Project No.: 12-004.21

FIGURE

2B



Axiom Environmental, Inc.

Prepared for:

NC Department of Environmental Quality

Division of Mitigation Services

Project:

Bob's Creek Stream Restoration Project

DMS Project # 92879

McDowell County, NC

Title:

Project Assets

Drawn by: KRJ

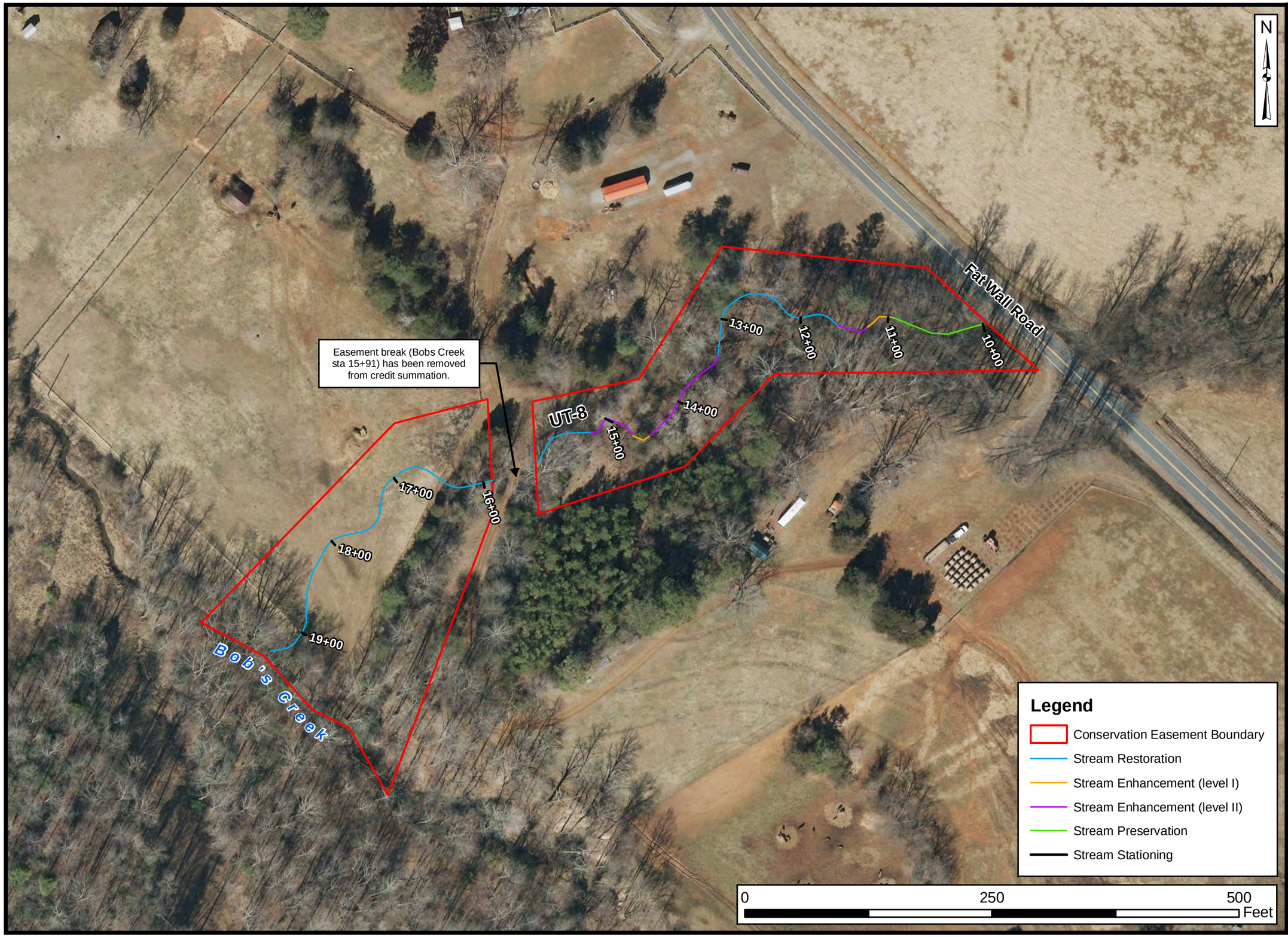
Date: JUN 2016

Scale: 1:7000

Project No.: 12-004.21

FIGURE

3



Axiom Environmental, Inc.

Prepared for:

NC Department of Environmental Quality

Division of Mitigation Services

Project:

Bob's Creek Stream Restoration Project

DMS Project # 92879

McDowell County, NC

Title:

Project Assets

Drawn by: KRJ

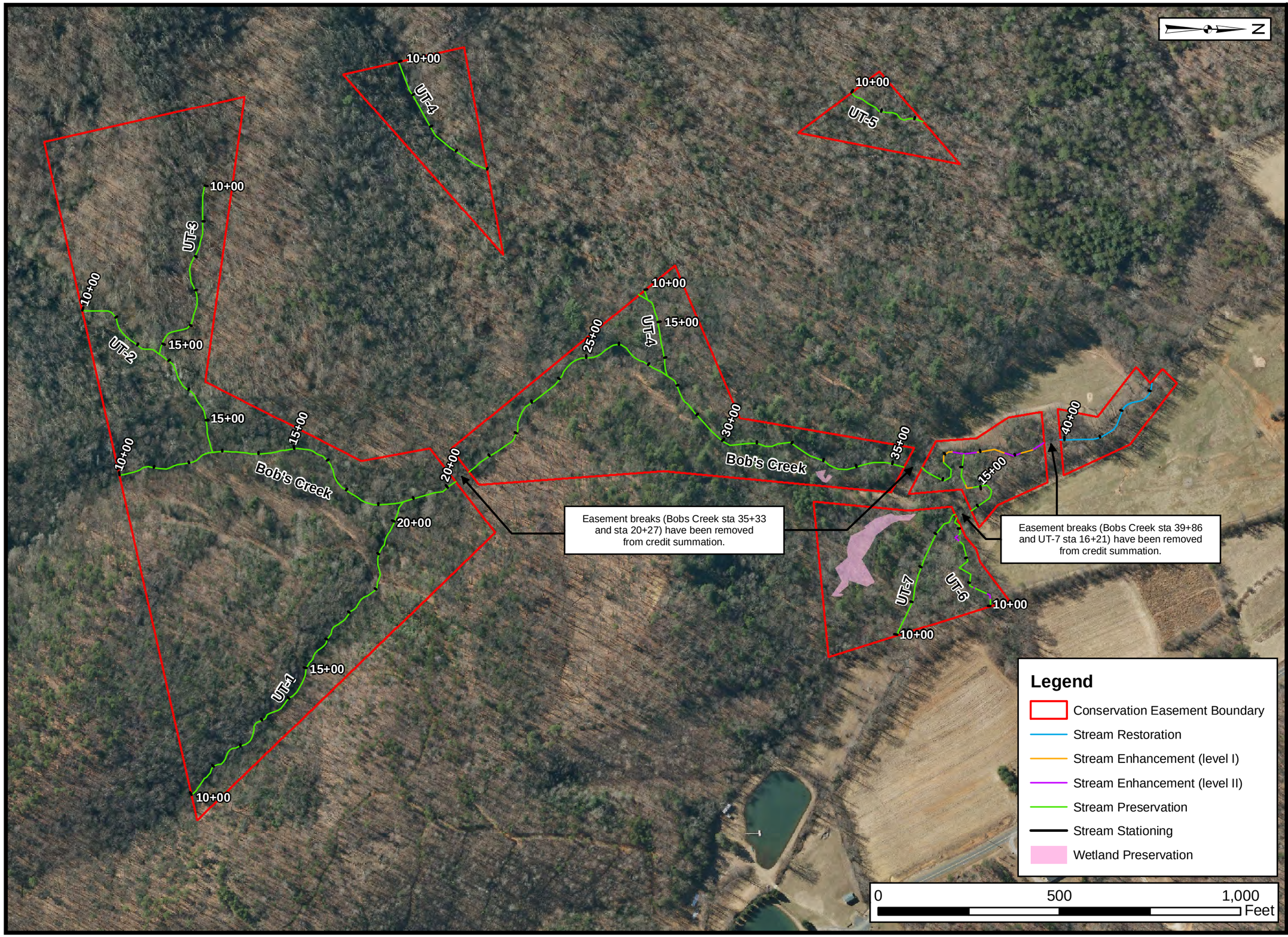
Date: JUN 2016

Scale: 1:1100

Project No.: 12-004.21

FIGURE

3A



Axiom Environmental, Inc.

Prepared for:

NC Department of Environmental Quality

Division of Mitigation Services

Project:

Bob's Creek Stream Restoration Project

DMS Project # 92879

McDowell County, NC

Title:

Project Assets

Drawn by: KRJ

Date: JUN 2016

Scale: 1:3000

Project No.: 12-004.21

FIGURE

3B

Table 5A **Visual Stream Morphology Stability Assessment**
Reach ID **Bobs Creek**
Assessed Length **647**

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	Adjusted % for Stabilizing Woody Vegetation
1. Bed	1. **Vertical Stability** (Riffle and Run units)	1. Aggradation - Bar formation/growth sufficient to significantly deflect flow laterally (not to include point bars)			0	0	100%			
		2. Degradation - Evidence of downcutting			0	0	100%			
	2. Riffle Condition	1. Texture/Substrate - Riffle maintains coarser substrate	7	7			100%			
	3. Meander Pool Condition	1. Depth Sufficient (Max Pool Depth : Mean Bankfull Depth ≥ 1.6)	6	6			100%			
		2. Length appropriate (>30% of centerline distance between tail of upstream riffle and head of downstrem riffle)	6	6			100%			
	4.**Thalweg Position**	1. Thalweg centering at upstream of meander bend (Run)	6	6			100%			
		2. Thalweg centering at downstream of meander (Glide)	6	6			100%			
2. Bank	**1. Scoured/Eroding**	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%			100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%			100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%			100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures	**1. Overall Integrity**	Structures physically intact with no dislodged boulders or logs.	7	7			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	7	7			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	7	7			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	7	7			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	7	7			100%			

Table 5B **Visual Stream Morphology Stability Assessment**
Reach ID **UT8 to Bobs Creek**
Assessed Length **939**

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	Adjusted % for Stabilizing Woody Vegetation
1. Bed	1. **Vertical Stability** (Riffle and Run units)	1. Aggradation - Bar formation/growth sufficient to significantly deflect flow laterally (not to include point bars)			0	0	100%			
		2. Degradation - Evidence of downcutting			0	0	100%			
	2. Riffle Condition	1. Texture/Substrate - Riffle maintains coarser substrate	26	26			100%			
	3. Meander Pool Condition	1. Depth Sufficient (Max Pool Depth : Mean Bankfull Depth ≥ 1.6)	25	25			100%			
		2. Length appropriate (>30% of centerline distance between tail of upstream riffle and head of downstrem riffle)	25	25			100%			
	4.**Thalweg Position**	1. Thalweg centering at upstream of meander bend (Run)	25	25			100%			
		2. Thalweg centering at downstream of meander (Glide)	25	25			100%			
2. Bank	**1. Scoured/Eroding**	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%			100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%			100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%			100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures	**1. Overall Integrity**	Structures physically intact with no dislodged boulders or logs.	22	22			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	22	22			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	22	22			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	22	22			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	22	22			100%			

Table 6 Vegetation Condition Assessment

Bobs Creek Mitigation Project

Planted Acreage[1] **2.1**

Vegetation Category	Definitions	Mapping Threshold	CCPV Depiction	Number of Polygons	Combined Acreage	% of Planted Acreage
1. Bare Areas	None	0.1 acres	none	0	0.00	0.0%
2. Low Stem Density Areas	None	0.1 acres	none	0	0.00	0.0%
2B. Low Planted Stem Density Areas	None	0.1 acres	none	0	0.00	0.0%
			Total	0	0.00	0.0%
3. Areas of Poor Growth Rates or Vigor	None	0.25 acres	N/A	0	0.00	0.0%
			Cumulative Total	0	0.00	0.0%

Easement Acreage[2] **42.7**

Vegetation Category	Definitions	Mapping Threshold	CCPV Depiction	Number of Polygons	Combined Acreage	% of Easement Acreage
4. Invasive Areas of Concern[4]	None	1000 SF	none	0	0.00	0.0%
5. Easement Encroachment Areas[3]	None	none	none	0	0.00	0.0%

1 = Enter the planted acreage within the easement. This number is calculated as the easement acreage minus any existing mature tree stands that were not subject to supplemental planting of the understory, the channel acreage, crossings or any other elements not directly planted as part of the project effort.

2 = The acreage within the easement boundaries.

3 = Encroachment may occur within or outside of planted areas and will therefore be calculated against the overall easement acreage. In the event a polygon is cataloged into items 1, 2 or 3 in the table and is the result of encroachment, the associated acreage should be tallied in the relevant item (i.e., item 1,2 or 3) as well as a parallel tally in item 5.

4 = Invasives may occur in or out of planted areas, but still within the easement and will therefore be calculated against the overall easement acreage. Invasives of concern/interest are listed below. The list of high concern spcies are those with the potential to directly outcompete native, young, woody stems in the short-term (e.g. monitoring period or shortly thereafter) or affect the community structure for existing, more established tree/shrub stands over timeframes that are slightly longer (e.g. 1-2 decades). The low/moderate concern group are those species that generally do not have this capacity over the timeframes discussed and therefore are not expected to be mapped with regularity, but can be mapped, if in the judgement of the observer their coverage, density or distribution is suppressing the viability, density, or growth of planted woody stems. Decisions as to whether remediation will be needed are based on the integration of risk factors by DMS such as species present, their coverage, distribution relative to native biomass, and the practicality of treatment. For example, even modest amounts of Kudzu or Japanese Knotweed early in the projects history will warrant control, but potentially large coverages of Microstegium in the herb layer will not likley trigger control because of the limited capacities to impact tree/shrub layers within the timeframes discussed and the potential impacts of treating extensive amounts of ground cover. Those species with the "watch list" designator in gray shade are of interest as well, but have yet to be observed across the state with any frequency. Those in *red italics* are of particular interest given their extreme risk/threat level for mapping as points where isolated specimens are found, particularly ealry in a projects monitoring history. However, areas of discreet, dense patches will of course be mapped as polygons. The symbology scheme below was one that was found to be helpful for symbolzing invasives polygons, particulalry for situations where the conditon for an area is somewhere between isolated specimens and dense, discreet patches. In any case, the point or polygon/area feature can be symbolized to describe things like high or low concern and species can be listed as a map inset, in legend items if the number of species are limited or in the narrative section of the executive summary.

Bobs Creek
Fixed Station Photographs
Taken August 2016

Photo Point 1 – UT-8

Photo Point 2 – UT-8

Photo Point 3 – UT-8

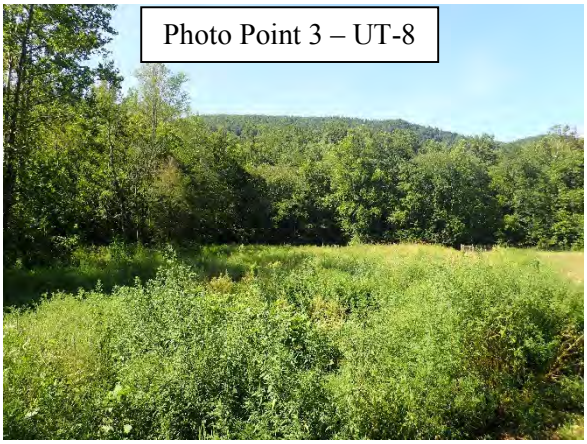
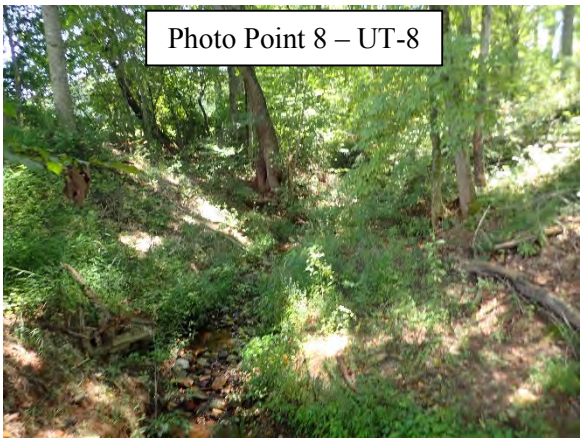


Photo Point 4 – UT-8

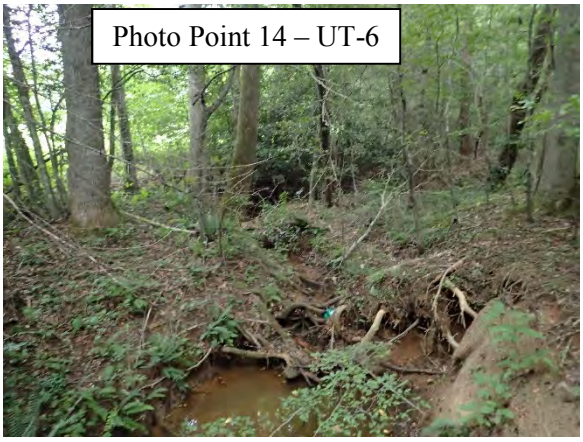
Photo Point 5 – UT-8

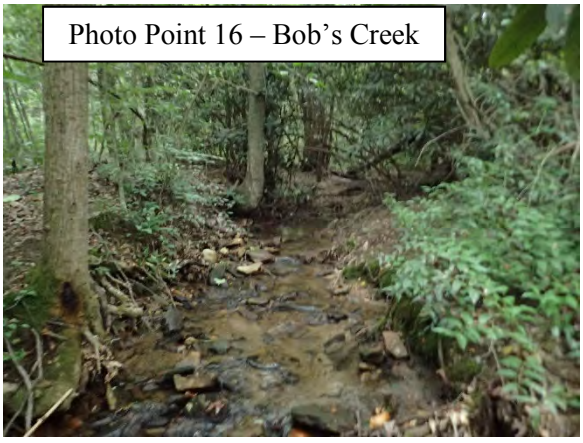
Photo Point 6 – UT-8

Bobs Creek
Fixed Station Photographs (continued)
Taken August 2016



Bobs Creek
Fixed Station Photographs (continued)
Taken August 2016





Bobs Creek
Fixed Station Photographs (continued)
Taken August 2016

Bobs Creek
Fixed Station Photographs (continued)
Taken August 2016

Photo Point 25 – UT-2

Photo Point 26 – UT-3

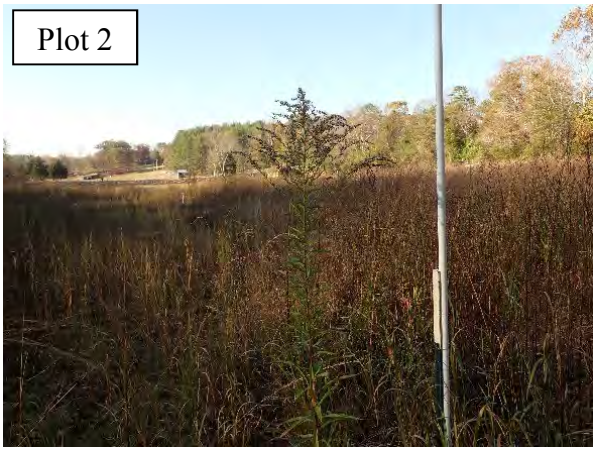
Photo Point 27 – UT-4

Photo Point 28

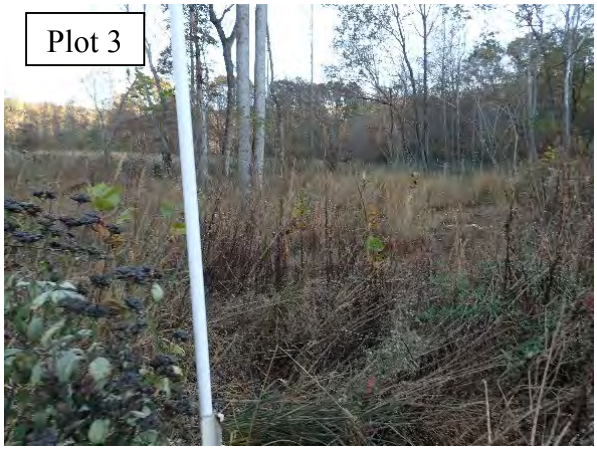
Bobs Creek
Vegetation Monitoring Photographs
Taken August 2016

Plot 1

Plot 2



Plot 3



Appendix C.
Vegetation Plot Data

Table 7. Vegetation Plot Success Summary
Table 8. CVS Vegetation Plot Metadata
Table 9. Total Planted Stems by Plot and Species

Table 7. Vegetation Plot Success Summary

Vegetation Plot ID	Vegetation Survival Threshold Met?	Tract Mean
1	Yes	100%
2	Yes	
3	Yes	

Table 8. CVS Vegetation Plot Metadata

Report Prepared By	Phillip Perkinson
Date Prepared	11/8/2016 8:53
database name	Axiom-BobsCreek-2016-A-v2.3.1.mdb
database location	S:\Business\Projects\12\12-004 EEP Monitoring\12-004.21 Neighbors Bob\Bobs Creek\MY-01\CVS
computer name	PHILLIP-PC
file size	58728448
DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT----------	
Metadata	Description of database file, the report worksheets, and a summary of project(s) and project data.
Proj, planted	Each project is listed with its PLANTED stems per acre, for each year. This excludes live stakes.
Proj, total stems	Each project is listed with its TOTAL stems per acre, for each year. This includes live stakes, all planted stems, and all natural/volunteer stems.
Plots	List of plots surveyed with location and summary data (live stems, dead stems, missing, etc.).
Vigor	Frequency distribution of vigor classes for stems for all plots.
Vigor by Spp	Frequency distribution of vigor classes listed by species.
Damage	List of most frequent damage classes with number of occurrences and percent of total stems impacted by each.
Damage by Spp	Damage values tallied by type for each species.
Damage by Plot	Damage values tallied by type for each plot.
Planted Stems by Plot and Spp	A matrix of the count of PLANTED living stems of each species for each plot; dead and missing stems are excluded.
ALL Stems by Plot and spp	A matrix of the count of total living stems of each species (planted and natural volunteers combined) for each plot; dead and missing stems are excluded.
PROJECT SUMMARY----------	
Project Code	92879
project Name	Bobs Creek
River Basin	Catawba
length(ft)	
stream-to-edge width (ft)	
Required Plots (calculated)	
Sampled Plots	3

Table 9. Total and Planted Stems by Plot and Species
DMS Project Code 92879. Project Name: Bobs Creek

			Current Plot Data (MY1 2016)									Annual Means					
			92879-01-0001			92879-01-0002			92879-01-0003			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
Acer rubrum	red maple	Tree				1	1	1			5	1	1	6	2	2	25
Diospyros virginiana	common persimmon	Tree	1	1	1	1	1	1				2	2	2	4	4	4
Fraxinus pennsylvanica	green ash	Tree	1	1	1							1	1	1	1	1	1
Liriodendron tulipifera	tuliptree	Tree			3									3			
Nyssa	tupelo	Tree	1	1	1							1	1	1			
Nyssa sylvatica	blackgum	Tree	4	4	4	5	5	5				9	9	9	11	11	11
Platanus occidentalis	American sycamore	Tree	3	3	3	1	1	1	4	4	12	8	8	16	10	10	10
Quercus nigra	water oak	Tree	1	1	1	1	1	1	2	2	2	4	4	4	5	5	5
Quercus phellos	willow oak	Tree	2	2	2	2	2	2	2	2	2	6	6	6	5	5	5
		Stem count	13	13	16	11	11	11	8	8	21	32	32	48	38	38	61
		size (ares)	1			1			1			3			3		
		size (ACRES)	0.02			0.02			0.02			0.07			0.07		
		Species count	7	7	8	6	6	6	3	3	4	8	8	9	7	7	7
		Stems per ACRE	526.1	526.1	647.5	445.2	445.2	445.2	323.7	323.7	849.8	431.7	431.7	647.5	512.6	512.6	822.9

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%

P-all = Planting including livestakes
T = All planted and natural recruits including livestakes
T includes natural recruits

Appendix D.
Stream Measurements and Geomorphology Data

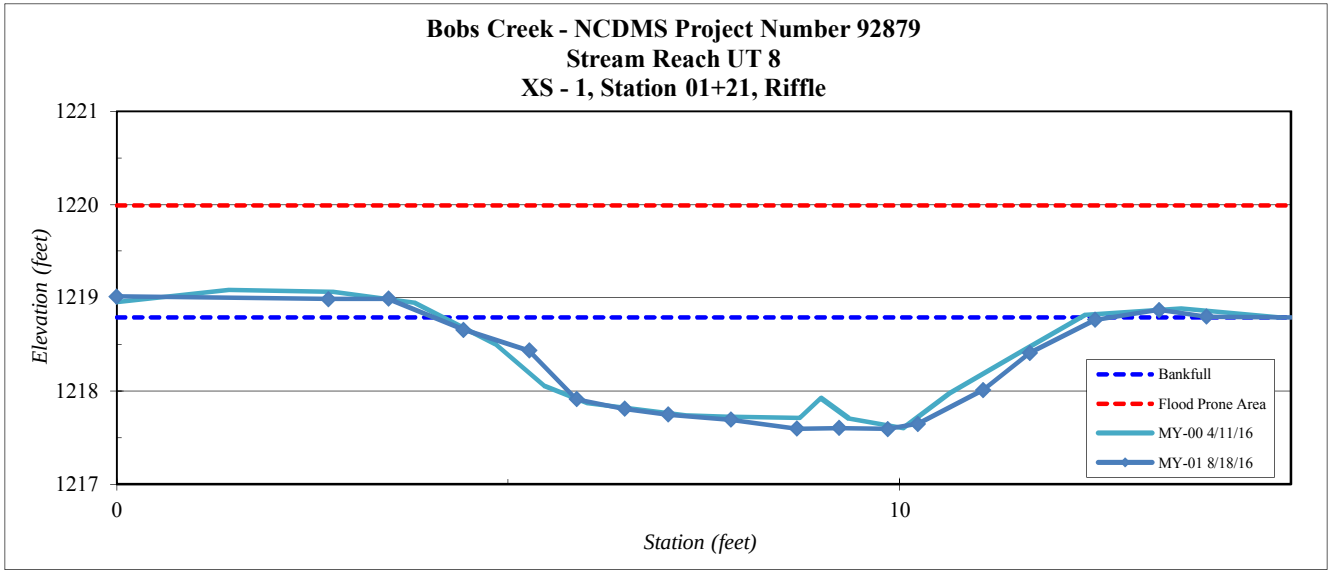
Cross Section Plots
Longitudinal Profile Plots
Substrate Plots
Tables 10A-10B. Baseline Stream Data Summary
Tables 11A-11B. Monitoring Data-Dimensional Data Summary

Site	Bobs Creek - UT 8
Project Number:	92879
XS ID	XS - 1, Riffle
Reach	UT 8
Date:	8/18/2016
Field Crew:	Perkinson, Jernigan

Station	Elevation
0.00	1219.01
2.70	1218.99
3.47	1218.99
4.43	1218.66
5.27	1218.43
5.88	1217.91
6.49	1217.81
7.04	1217.75
7.84	1217.69
8.69	1217.60
9.23	1217.60
9.85	1217.59
10.24	1217.65
11.07	1218.01
11.67	1218.41
12.5	1218.76
13.3	1218.87
13.9	1218.80
15.0	1218.79

SUMMARY DATA	
Bankfull Elevation:	1218.8
Bankfull Cross-Sectional Area:	6.7
Bankfull Width:	8.7
Flood Prone Area Elevation:	1220.0
Flood Prone Width:	100.0
Max Depth at Bankfull:	1.2
Mean Depth at Bankfull:	0.8
W / D Ratio:	11.3
Entrenchment Ratio:	11.5
Bank Height Ratio:	1.0

Stream Type	E

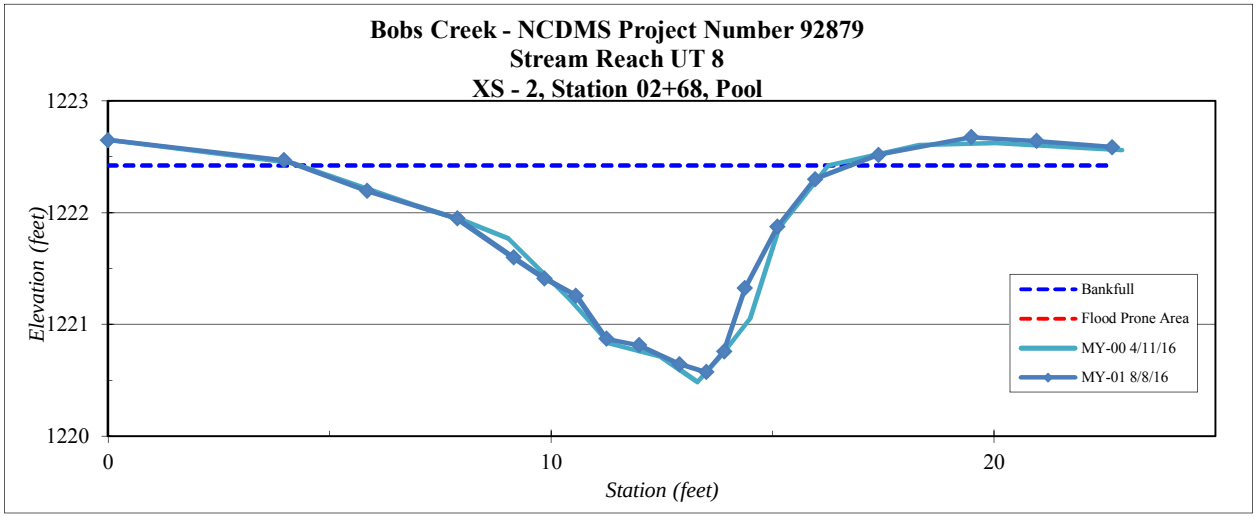


Site	Bobs Creek - UT 8
Project Number:	92879
XS ID	XS - 2, Pool
Reach	UT 8
Date:	8/18/2016
Field Crew:	Perkinson, Jernigan

Station	Elevation
0.0	1222.7
4.0	1222.5
5.9	1222.2
7.9	1221.9
9.2	1221.6
9.8	1221.4
10.6	1221.3
11.2	1220.9
12.0	1220.8
12.9	1220.6
13.5	1220.6
13.9	1220.8
14.4	1221.3
15.1	1221.9
16.0	1222.3
17.4	1222.5
19.5	1222.7
21.0	1222.6
22.7	1222.6

SUMMARY DATA	
Bankfull Elevation:	1222.4
Bankfull Cross-Sectional Area:	10.1
Bankfull Width:	12.4
Flood Prone Area Elevation:	NA
Flood Prone Width:	NA
Max Depth at Bankfull:	1.8
Mean Depth at Bankfull:	0.8
W / D Ratio:	NA
Entrenchment Ratio:	NA
Bank Height Ratio:	1.0

Stream Type	E

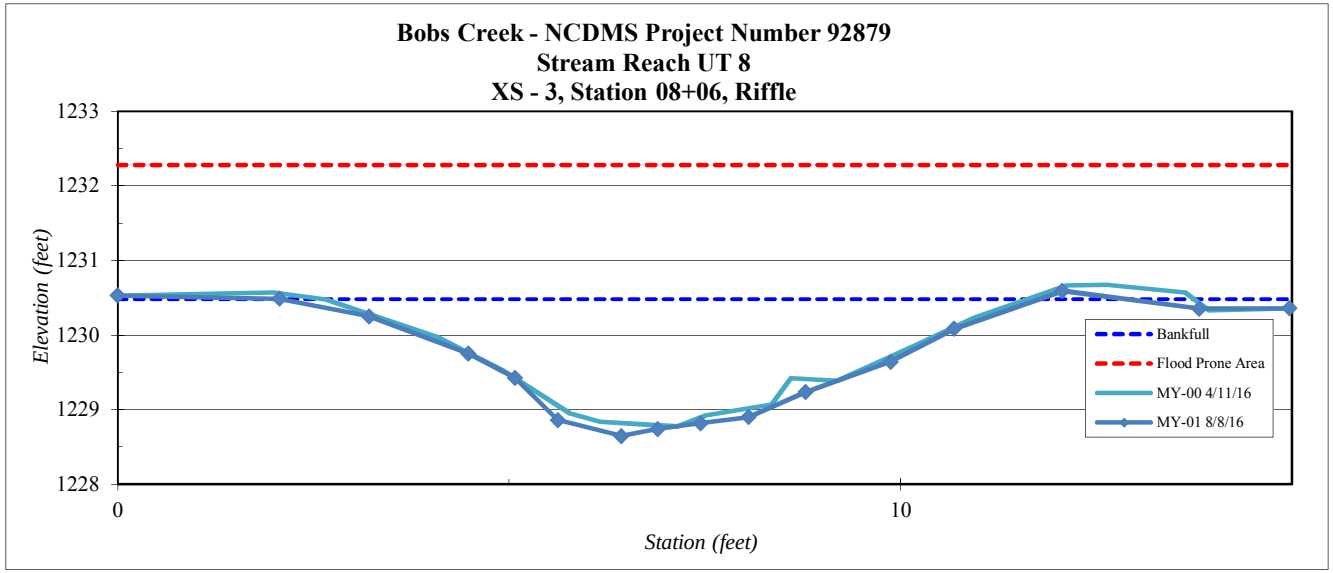


Site	Bobs Creek - UT 8
Project Number:	92879
XS ID	XS - 3, Riffle
Reach	UT 8
Date:	8/18/2016
Field Crew:	Perkinson, Jernigan

Station	Elevation
0.00	1230.53
2.06	1230.49
3.21	1230.25
4.47	1229.75
5.07	1229.43
5.62	1228.86
6.43	1228.65
6.90	1228.74
7.45	1228.82
8.06	1228.90
8.78	1229.23
9.87	1229.64
10.69	1230.09
12.07	1230.59
13.81	1230.36
15.0	1230.36

SUMMARY DATA	
Bankfull Elevation:	1230.5
Bankfull Cross-Sectional Area:	9.0
Bankfull Width:	9.7
Flood Prone Area Elevation:	1232.3
Flood Prone Width:	100.0
Max Depth at Bankfull:	1.8
Mean Depth at Bankfull:	0.9
W / D Ratio:	10.5
Entrenchment Ratio:	10.3
Bank Height Ratio:	1.0

Stream Type	E

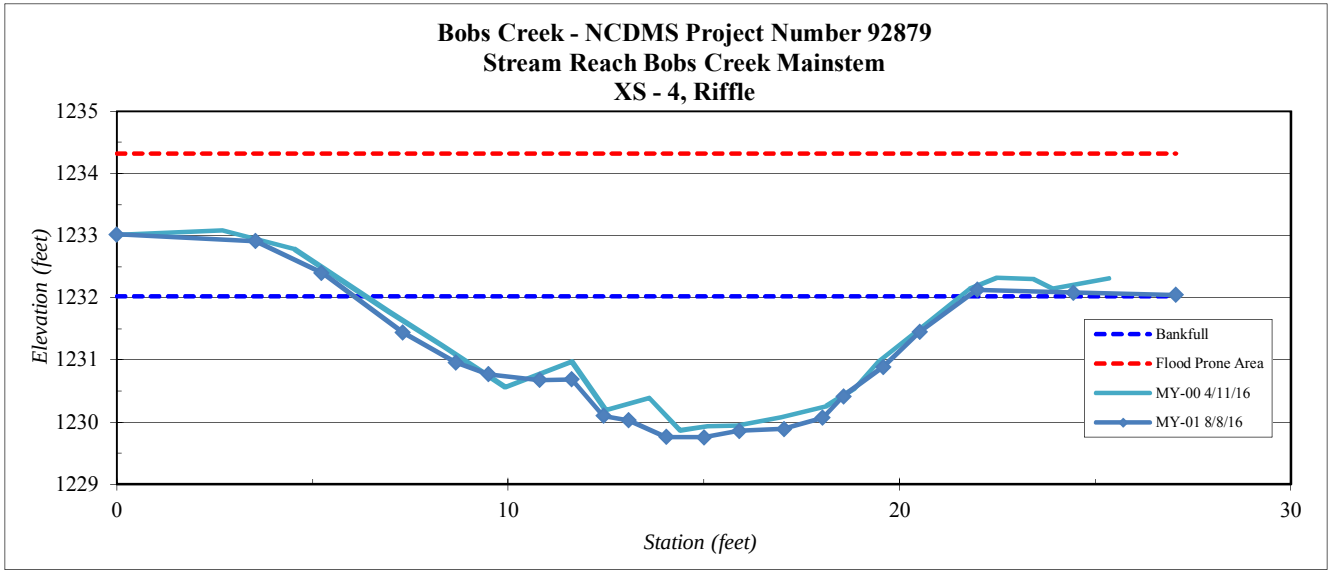


Site	Bobs Creek
Project Number:	92879
XS ID	XS - 4, Riffle
Reach	Bobs Creek
Date:	8/18/2016
Field Crew:	Perkinson, Jernigan

Station	Elevation
0.00	1233.02
3.55	1232.91
5.23	1232.40
7.31	1231.44
8.66	1230.96
9.50	1230.77
10.80	1230.68
11.62	1230.69
12.43	1230.10
13.08	1230.03
14.04	1229.76
15.01	1229.76
15.90	1229.86
17.05	1229.89
18.04	1230.07
18.6	1230.41
19.6	1230.89
20.5	1231.45
22.0	1232.13
24.4	1232.08
27.1	1232.05

SUMMARY DATA	
Bankfull Elevation:	1232.0
Bankfull Cross-Sectional Area:	22.0
Bankfull Width:	15.7
Flood Prone Area Elevation:	1234.3
Flood Prone Width:	150.0
Max Depth at Bankfull:	2.3
Mean Depth at Bankfull:	1.4
W / D Ratio:	11.2
Entrenchment Ratio:	9.6
Bank Height Ratio:	1.0

Stream Type	E

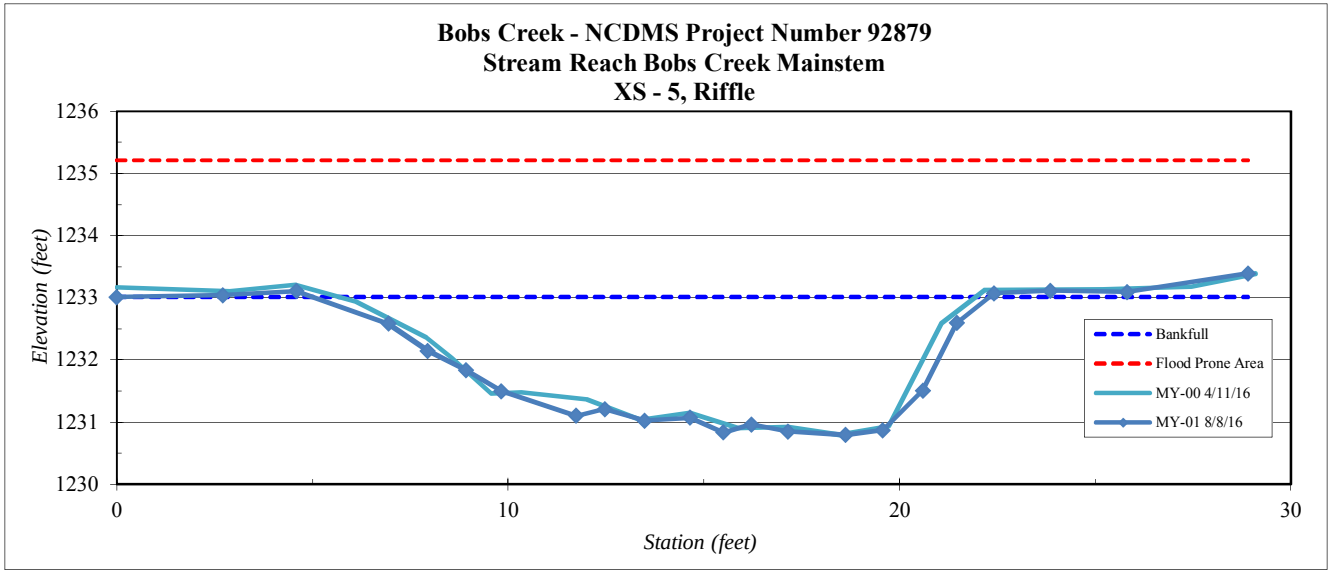


Site	Bobs Creek
Project Number:	92879
XS ID	XS - 5, Riffle
Reach	Bobs Creek
Date:	8/18/2016
Field Crew:	Perkinson, Jernigan

Station	Elevation
0.00	1233.01
2.71	1233.04
4.58	1233.11
6.94	1232.59
7.95	1232.15
8.92	1231.84
9.83	1231.50
11.74	1231.10
12.47	1231.21
13.49	1231.03
14.65	1231.07
15.50	1230.83
16.21	1230.96
17.14	1230.85
18.61	1230.80
19.6	1230.87
20.6	1231.51
21.5	1232.59
22.4	1233.07
23.9	1233.12
25.8	1233.09
28.9	1233.39

SUMMARY DATA	
Bankfull Elevation:	1233.0
Bankfull Cross-Sectional Area:	25.5
Bankfull Width:	17.3
Flood Prone Area Elevation:	1235.2
Flood Prone Width:	150.0
Max Depth at Bankfull:	2.2
Mean Depth at Bankfull:	1.5
W / D Ratio:	11.7
Entrenchment Ratio:	8.7
Bank Height Ratio:	1.0

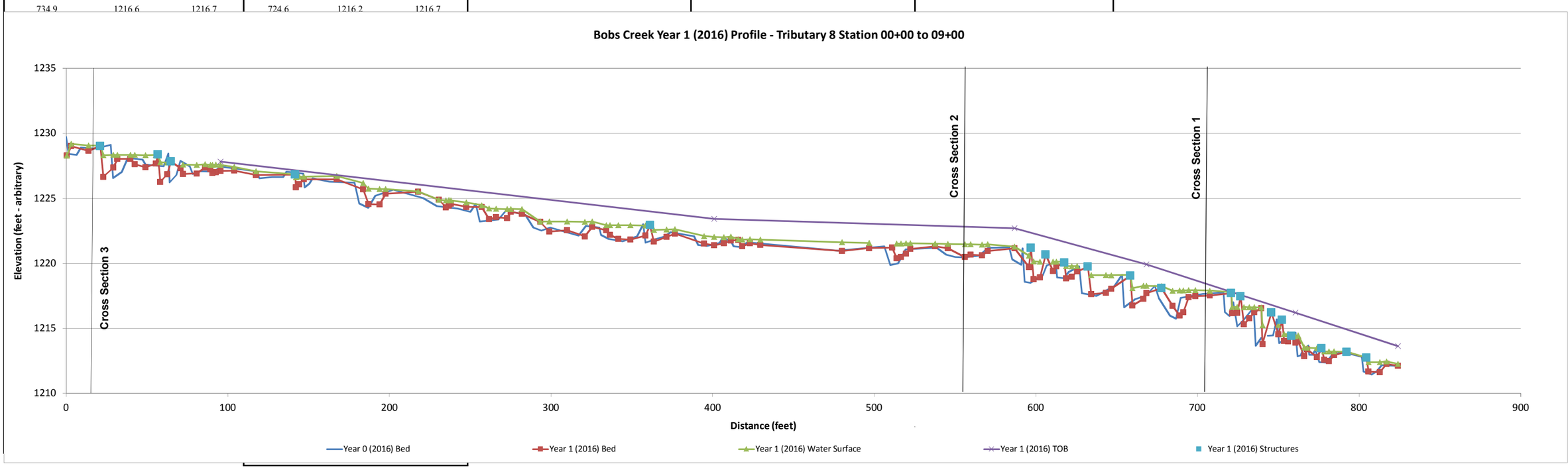
Stream Type	E



Project Name	Bobs Creek - Profile
Reach	UT 8 Station 00+00 - 09+00
Feature	Profile
Date	8/18/16
Crew	Perkinson, Jernigan

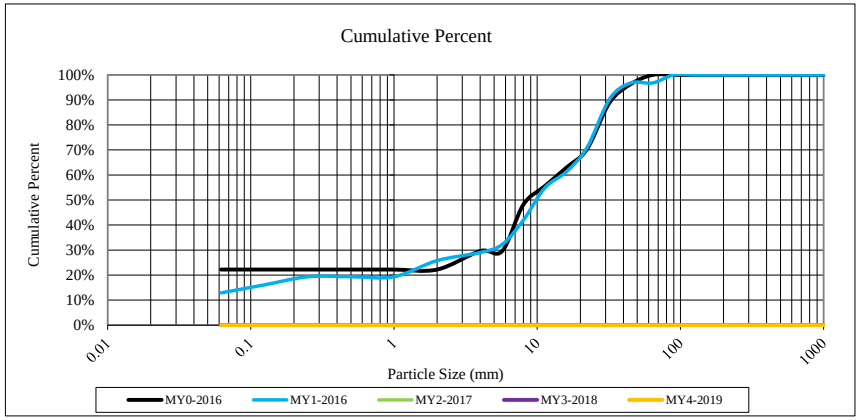
2016 Year 0 Monitoring \Survey			2016 Year 1 Monitoring \Survey			2017 Year 2 Monitoring \Survey			2018 Year 3 Monitoring \Survey			2019 Year 4 Monitoring \Survey		
Station	**Bed Elevation**	**Water Elevation**	**Station**	**Bed Elevation**	**Water Elevation**	**Station**	**Bed Elevation**	**Water Elevation**	**Station**	**Bed Elevation**	**Water Elevation**	**Station**	**Bed Elevation**	**Water Elevation**
824.0	1212.1	1212.4	824.0	1212.1	1212.3									
813.9	1212.2	1212.5	817.0	1212.3	1212.4									
811.2	1211.7	1212.5	812.8	1211.6	1212.4									
808.0	1211.5	1212.5	805.9	1211.7	1212.4									
802.8	1211.7	1212.5	804.7	1212.7	1212.8									
801.7	1212.8	1212.9	792.3	1213.2	1213.2									
789.2	1213.2	1213.3	784.4	1212.9	1213.2									
782.8	1212.9	1213.3	781.5	1212.5	1213.2									
779.3	1212.4	1213.3	778.4	1212.6	1213.2									
775.3	1212.4	1213.3	776.8	1213.4	1213.4									
772.9	1213.3	1213.5	774.0	1212.8	1213.5									
771.3	1213.0	1213.5	768.0	1213.4	1213.5									
769.2	1213.0	1213.5	766.1	1212.9	1213.5									
768.5	1213.7		762.4	1214.0	1214.5									
765.0	1213.3	1213.6	760.6	1213.9	1214.4									
763.8	1212.9	1213.6	758.2	1214.4										
762.0	1212.9	1213.6	756.0	1214.0	1214.6									
760.6	1214.6		753.6	1214.0	1214.6									
755.7	1214.2	1214.7	752.3	1215.6										
753.8	1214.1	1214.7	750.1	1214.5	1215.3									
750.6	1213.9	1214.7	745.8	1216.2										
749.0	1215.7		740.3	1213.8	1215.2									
746.8	1214.5	1215.6	739.5	1216.6	1216.6									
743.5	1214.4	1215.6	735.3	1216.2	1216.6									
742.0		1216.2	732.1	1215.8	1216.6									
739.5	1214.3	1215.7	728.8	1215.3	1216.6									
736.0	1213.6	1215.7	726.7	1217.5										
734.9	1216.6	1216.7	724.6	1216.2	1216.7									

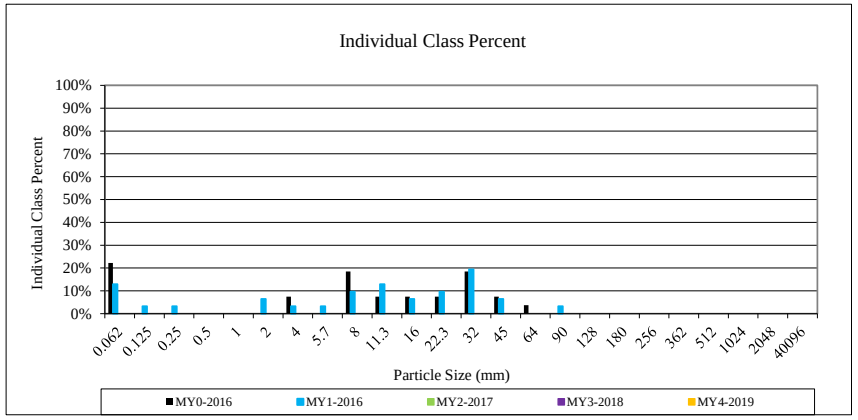
	2016	2016	2017	2018	2019
Avg. Water Surface Slope	0.0212	0.0210			
Riffle Length	17	20			
Avg. Riffle Slope	0.0172	0.0175			
Pool Length	15	13			
Pool to Pool Spacing	26	28			



Project Name: Bobs Creek - UT 8					
Cross-Section: 1					
Feature: Riffle					
			2016		
Description	Material	Size (mm)	Total #	Item %	Cum %
Silt/Clay	silt/clay	0.062	4	13%	36%
Sand	very fine sand	0.125	1	3%	44%
	fine sand	0.250	1	3%	48%
	medium sand	0.50	0	0%	48%
	coarse sand	1.00	0	0%	56%
	very coarse sand	2.0	2	6%	60%
Gravel	very fine gravel	4.0	1	3%	68%
	fine gravel	5.7	1	3%	72%
	fine gravel	8.0	3	10%	84%
	medium gravel	11.3	4	13%	92%
	medium gravel	16.0	2	6%	92%
	course gravel	22.3	3	10%	96%
	course gravel	32.0	6	19%	96%
	very coarse gravel	45	2	6%	96%
	very coarse gravel	64	0	0%	100%
Cobble	small cobble	90	1	3%	100%
	medium cobble	128	0	0%	100%
	large cobble	180	0	0%	100%
	very large cobble	256	0	0%	100%
Boulder	small boulder	362	0	0%	100%
	small boulder	512	0	0%	100%
	medium boulder	1024	0	0%	100%
	large boulder	2048	0	0%	100%
Bedrock	bedrock	40096	0	0%	100%
TOTAL % of whole count			31	100%	100%

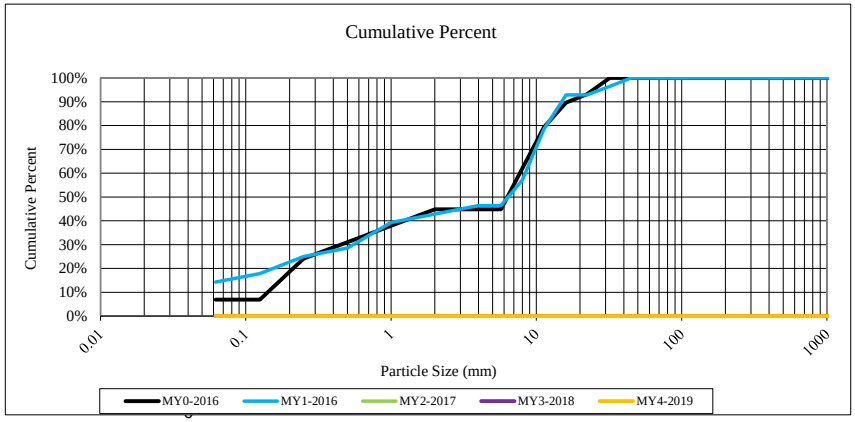
Summary Data	
D50	9.8
D84	28
D95	41





Project Name: Bobs Creek - UT 8					
Cross-Section: 3					
Feature: Riffle					
			2016		
Description	**Material**	**Size (mm)**	**Total #**	**Item %**	**Cum %**
Silt/Clay	silt/clay	0.062	4	14%	33%
Sand	very fine sand	0.125	1	4%	43%
	fine sand	0.250	2	7%	48%
	medium sand	0.50	1	4%	52%
	coarse sand	1.00	3	11%	62%
	very coarse sand	2.0	1	4%	67%
Gravel	very fine gravel	4.0	1	4%	67%
	fine gravel	5.7	0	0%	67%
	fine gravel	8.0	3	11%	71%
	medium gravel	11.3	6	21%	76%
	medium gravel	16.0	4	14%	86%
	course gravel	22.3	0	0%	90%
	course gravel	32.0	1	4%	95%
	very coarse gravel	45	1	4%	95%
	very coarse gravel	64	0	0%	95%
Cobble	small cobble	90	0	0%	100%
	medium cobble	128	0	0%	100%
	large cobble	180	0	0%	100%
	very large cobble	256	0	0%	100%
Boulder	small boulder	362	0	0%	100%
	small boulder	512	0	0%	100%
	medium boulder	1024	0	0%	100%
	large boulder	2048	0	0%	100%
Bedrock	bedrock	40096	0	0%	100%
TOTAL % of whole count			28	100%	100%

Summary Data	
D50	6.6
D84	13
D95	28



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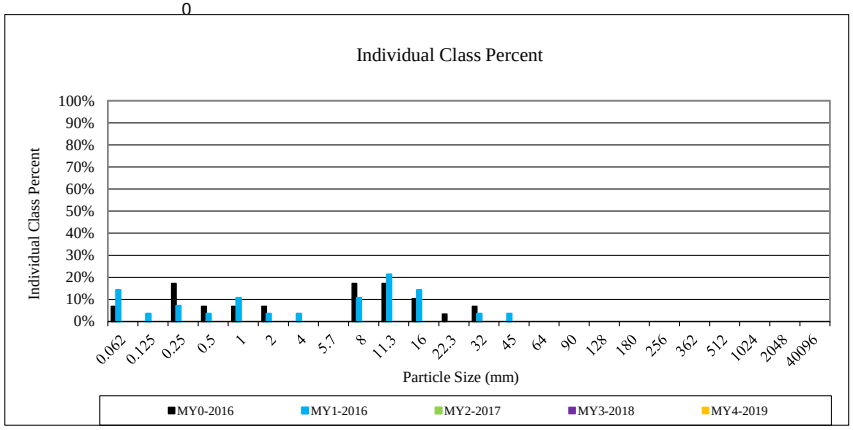
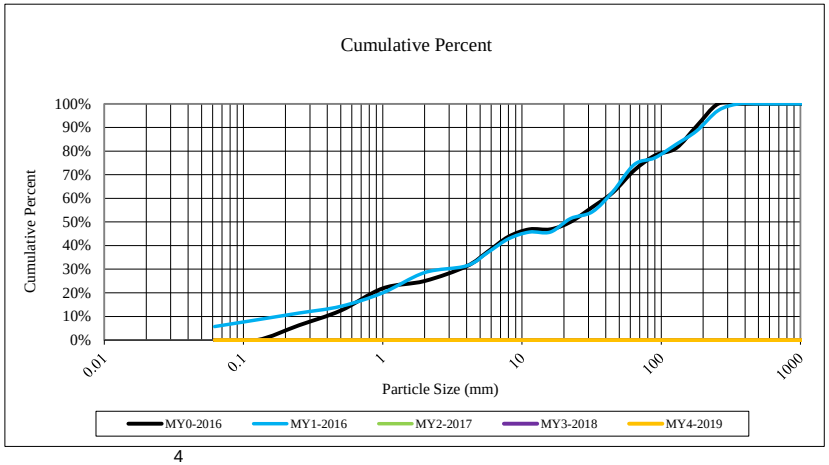


Project Name: Bobs Creek					
Cross-Section: 4					
Feature: Riffle					
			2016		
Description	Material	Size (mm)	Total #	Item %	Cum %
Silt/Clay	silt/clay	0.062	2	6%	24%
Sand	very fine sand	0.125	1	3%	32%
	fine sand	0.250	1	3%	44%
	medium sand	0.50	1	3%	48%
	coarse sand	1.00	2	6%	56%
	very coarse sand	2.0	3	9%	60%
Gravel	very fine gravel	4.0	1	3%	68%
	fine gravel	5.7	2	6%	72%
	fine gravel	8.0	2	6%	80%
	medium gravel	11.3	1	3%	80%
	medium gravel	16.0	0	0%	84%
	course gravel	22.3	2	6%	96%
	course gravel	32.0	1	3%	96%
	very coarse gravel	45	3	9%	96%
	very coarse gravel	64	4	11%	100%
Cobble	small cobble	90	1	3%	100%
	medium cobble	128	2	6%	100%
	large cobble	180	2	6%	100%
	very large cobble	256	3	9%	100%
Boulder	small boulder	362	1	3%	100%
	small boulder	512	0	0%	100%
	medium boulder	1024	0	0%	100%
	large boulder	2048	0	0%	100%
Bedrock	bedrock	40096	0	0%	100%
TOTAL % of whole count			35	100%	100%

Summary Data	
D50	20.3
D84	137
D95	234



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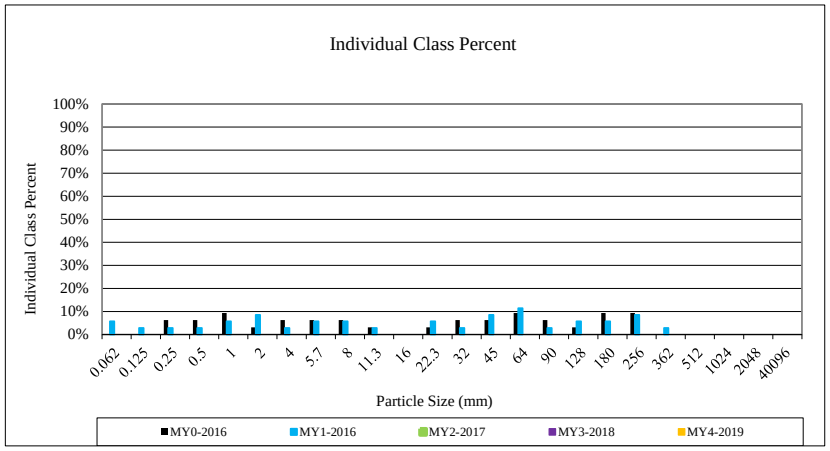
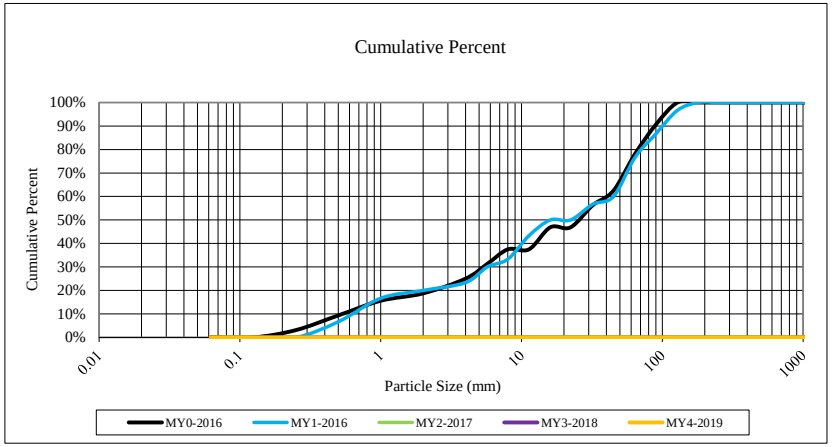


Project Name: Bobs Creek					
Cross-Section: 5					
Feature: Riffle					
			2016		
Description	Material	Size (mm)	Total #	Item %	Cum %
Silt/Clay	silt/clay	0.062	0	0%	68%
Sand	very fine sand	0.125	0	0%	72%
	fine sand	0.250	0	0%	84%
	medium sand	0.50	2	7%	84%
	coarse sand	1.00	3	10%	88%
	very coarse sand	2.0	1	3%	92%
Gravel	very fine gravel	4.0	1	3%	100%
	fine gravel	5.7	2	7%	100%
	fine gravel	8.0	1	3%	100%
	medium gravel	11.3	3	10%	100%
	medium gravel	16.0	2	7%	100%
	course gravel	22.3	0	0%	100%
	course gravel	32.0	2	7%	100%
	very coarse gravel	45	1	3%	100%
	very coarse gravel	64	5	17%	100%
Cobble	small cobble	90	3	10%	100%
	medium cobble	128	3	10%	100%
	large cobble	180	1	3%	100%
	very large cobble	256	0	0%	100%
Boulder	small boulder	362	0	0%	100%
	small boulder	512	0	0%	100%
	medium boulder	1024	0	0%	100%
	large boulder	2048	0	0%	100%
Bedrock	bedrock	40096	0	0%	100%
TOTAL % of whole count			30	100%	100%

Summary Data	
D50	22
D84	82
D95	121



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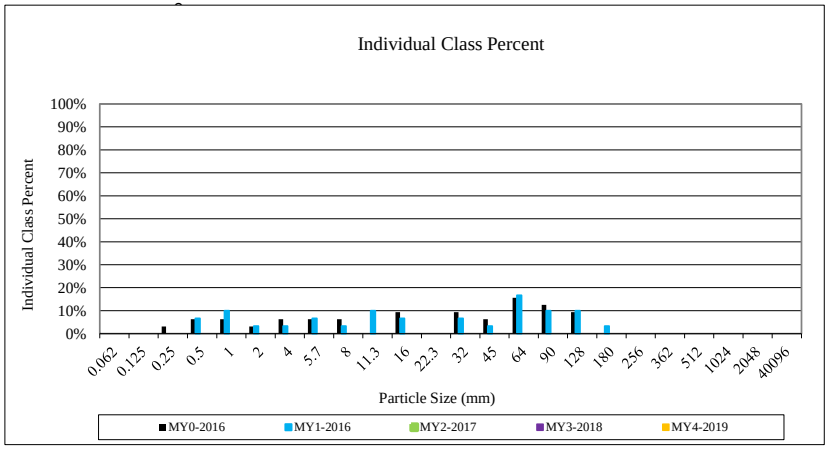

Table 10a. Baseline Stream Data Summary (Bob's Creek - UT 8)
Bob's Creek Mitigation Project - NCDMS Project Number 92633

Parameter	Gauge	Regional Curve			Pre-Existing Condition (UT 8)					Reference Reach(es) Data					Design (UT 8)			Monitoring Baseline (UT 8)					
Dimension and Substrate - Riffle Only		**LL**	**UL**	**Eq.**	**Min**	**Mean**	**Med**	**Max**	**SD**	**Min**	**Mean**	**Med**	**Max**	**SD**	**Min**	**Max**	**Med**	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**
BF Width (ft)					5.0			7.8			5.6						8.0	8.3		8.7	9		3
Floodprone Width (ft)					7.8			20.0			13				20	25				100			3
BF Mean Depth (ft)					0.6			0.9			0.5						0.8	0.8		0.9	0.9		3
BF Max Depth (ft)					0.9			1.2			0.7						1.0	1.2		1.5	1.7		3
BF Cross Sectional Area (ft^2)					3.7			4.7			3.0						5.9	6.6		7.5	8.3		3
Width/Depth Ratio					5.3			13.6			10.5						10.5	10.0		10.2	10.4		3
Entrenchment Ratio					1.6			2.6			2.3				2.5	3.1		11.1		11.6	12.0		3
Bank Height Ratio					1.1			7.3			1.0						1.0			1.0			3
Profile																							
Riffle length (ft)																		3.5	16.9	12	84.6	17.4	21
Riffle slope (ft/ft)					0.035			0.045			0.0480						0.0060	0.0119	0.0172	0.0155	0.0418	0.0117	19
Pool length (ft)																		4.4	14.7	12.8	37.5	8.6	32
Pool Max depth (ft)					1.5			2.6			0.9						1.9			1.9			1
Pool spacing (ft)					15.3			45.2		14.0			33.9		8.0	37.1		4.4	25.8	24.8	94.8	17.6	32
Pattern																							
Channel Beltwidth (ft)					23			33		17			25		24	48		24			48		2
Radius of Curvature (ft)					4			12		10			13		16	32		16			32		2
Rc:Bankfull width (ft/ft)					0.6			2.3		1.8			2.3		2	4		2			4		2
Meander Wavelength (ft)					32			65		31			38		40	80		40			80		2
Meander Width ratio					3			6.6		5.6			6.8		50	10		50			10		2
Transport parameters																							
Reach Shear Stress (competency) lbs/ft^2																							
Max part size (mm) mobilized at bankfull																							
Stream Power (transport capacity) W/m^2																							
Additional Reach Parameters																							
Rosgen Classification					B/C/G					E/C					E/C			E/C					
Bankfull Velocity (fps)					3.2-4.0																		
Bankfull Discharge (cfs)					15																		
Valley Length (ft)					----					----													
Channel Thalweg Length (ft)					----					----					----			824					
Sinuosity					1.11 - 1.18					1.28					1.11 - 1.17			1.11 - 1.17					
Water Surface Slope (ft/ft)					0.0148 - 0.0172					0.048					0.004			0.0212					
BF slope (ft/ft)					----					----					----			----					
Bankfull Floodplain Area (acres)					----					----					----			----					
% of Reach with Eroding Banks					----					----													
Channel Stability or Habitat Metric					----					----													
Biological or Other					----					----													

Table 10b. Baseline Stream Data Summary (Bob's Creek)
Bob's Creek Mitigation Project - NCDMS Project Number 92633

Parameter	Gauge	Regional Curve			Pre-Existing Condition (Bobs Cr)					Reference Reach(es) Data					Design (Bobs Cr)			Monitoring Baseline (Bobs Cr)					
Dimension and Substrate - Riffle Only		**LL**	**UL**	**Eq.**	**Min**	**Mean**	**Med**	**Max**	**SD**	**Min**	**Mean**	**Med**	**Max**	**SD**	**Min**	**Max**	**Med**	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**
BF Width (ft)					14.5			25.5			12.7						17.5	15.2			17		2
Floodprone Width (ft)					29.8			45.2			150						100			150			2
BF Mean Depth (ft)					1.1			1.2			0.9						1.3	1.3			1.5		2
BF Max Depth (ft)					1.4			2.0			1.2						1.7	2.2			2.3		2
BF Cross Sectional Area (ft^2)					17.4			29.0			11.4						22.3	19.9			25.2		2
Width/Depth Ratio					12.1			22.3			14.1						14.0	11.3			11.7		2
Entrenchment Ratio					1.2			3.1			11.8						5.7	8.8			9.9		2
Bank Height Ratio					1.2			1.8			1.0						1.0			1.0			2
Profile																							
Riffle length (ft)																		No profile measured in this reach.					
Riffle slope (ft/ft)							0.0239				0.0344						0.0105						
Pool length (ft)																							
Pool Max depth (ft)							3.3				2.2						3.3						
Pool spacing (ft)					43.8			171.6		38.8			64.7		53.7	89.4							
Pattern																							
Channel Beltwidth (ft)					36			55		30.5			32		43.8	105		43.8			105		2
Radius of Curvature (ft)					7			30		14.5			20		40.3	70		40.3			70		2
Rc:Bankfull width (ft/ft)					0.3			2.1		1.1			1.6		2.3	4		2.3			4		2
Meander Wavelength (ft)					100			145		95			98		87.5	175		87.5			175		2
Meander Width ratio					1.41			3.8		7.5			7.7		5	10		5			10		2
Transport parameters																							
Reach Shear Stress (competency) lbs/ft^2																							
Max part size (mm) mobilized at bankfull																							
Stream Power (transport capacity) W/m^2																							
Additional Reach Parameters																							
Rosgen Classification					B/C/F					C					C			E/C					
Bankfull Velocity (fps)					3.79-6.32																		
Bankfull Discharge (cfs)					110																		
Valley Length (ft)					----					----													
Channel Thalweg Length (ft)					----					----					----			371					
Sinuosity					1.17					1.22					1.13			1.13					
Water Surface Slope (ft/ft)					0.0149					0.0205					0.007								
BF slope (ft/ft)					----					----					----			----					
Bankfull Floodplain Area (acres)					----					----					----			----					
% of Reach with Eroding Banks					----					----													
Channel Stability or Habitat Metric					----					----													
Biological or Other					----					----													

Table 11a. Monitoring Data - Dimensional Morphology Summary (Dimensional Parameters - Cross Sections)
Bob's Creek Mitigation Project - NCDMS Project Number 92879

Parameter	Cross Section 1 (UT 8) Riffle							Cross Section 2 (UT 8) Pool							Cross Section 3 (UT 8) Riffle							Cross Section 4 (Bobs Creek) Riffle							Cross Section 5 (Bobs Creek) Riffle						
Dimension	MY0	MY1	MY2	MY3	MY4	MY5	MY5+	MY0	MY1	MY2	MY3	MY4	MY5	MY5+	MY0	MY1	MY2	MY3	MY4	MY5	MY5+	MY0	MY1	MY2	MY3	MY4	MY5	MY5+	MY0	MY1	MY2	MY3	MY4	MY5	MY5+
BF Width (ft)	8.3	8.7						11.9	12.4						9.0	9.7						15.2	15.7						17.0	17.3					
Floodprone Width (ft) (approx)	100.0	100.0						NA	NA						100.0	100.0						150.0	150.0						150.0	150.0					
BF Mean Depth (ft)	0.8	0.8						0.9	0.8						0.9	0.9						1.3	1.4						1.5	1.5					
BF Max Depth (ft)	1.2	1.2						1.9	1.8						1.7	1.8						2.2	2.3						2.3	2.2					
BF Cross Sectional Area (ft^2)	6.6	6.7						10.4	10.1						8.3	9.0						19.9	22.0						25.2	25.5					
Width/Depth Ratio	10.4	11.3						NA	NA						9.8	10.5						11.6	11.2						11.5	11.7					
Entrenchment Ratio	12.0	11.5						NA	NA						11.1	10.3						9.9	9.6						8.8	8.7					
Bank Height Ratio	1.0	1.0						1.0	1.0						1.0	1.0						1.0	1.0						1.0	1.0					
d50 (mm)	8.7	9.8						----	----						6.5	6.6						22.0	20.3						24.9	22.0					

Table 11b. Monitoring Data - Stream Reach Data Summary
Bob's Creek Mitigation Project - NCDMS Project Number 92879

Parameter	Baseline (UT 8)						MY-1 (UT 8)						MY-2 (UT 8)						MY-3 (UT 8)						MY-4 (UT 8)						MY-5 (UT 8)					
Dimension and Substrate - Riffle Only	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**
BF Width (ft)	8.3	8.7		9		2	8.7	9.2		9.7		2																								
Floodprone Width (ft)		100				2		100				2																								
BF Mean Depth (ft)	0.8	0.9		0.9		2	0.8	0.9		0.9		2																								
BF Max Depth (ft)	1.2	1.5		1.7		2	1.2	1.5		1.8		2																								
BF Cross Sectional Area (ft^2)	6.6	7.5		8.3		2	6.7	7.9		9.0		2																								
Width/Depth Ratio	10.0	10.2		10.4		2	10.8	10.8		10.9		2																								
Entrenchment Ratio	11.1	11.6		12.0		2	10.3	10.9		11.5		2																								
Bank Height Ratio		1.0				2		1.0				2																								
Profile																																				
Riffle length (ft)	3.5	16.9	12	84.6	17.4	21																														
Riffle slope (ft/ft)	0.0119	0.0172	0.0155	0.0418	0.0117	19																														
Pool length (ft)	4	15	13	38	9	32																														
Pool Max depth (ft)			1.9			1																														
Pool spacing (ft)	4	26	25	95	18	32																														
Pattern																																				
Channel Beltwidth (ft)	24			48		2																														
Radius of Curvature (ft)	16			32		2																														
Rc:Bankfull width (ft/ft)	2			4		2																														
Meander Wavelength (ft)	40			80		2																														
Meander Width ratio	50			10		2																														
Additional Reach Parameters																																				
Rosgen Classification	E/C-type						E/C-type																													
Channel Thalweg Length (ft)	824						861																													
Sinuosity	1.11 - 1.17						1.11 - 1.17																													
Water Surface Slope (Channel) (ft/ft)	0.0212						0.021																													
BF slope (ft/ft)	-----						-----																													
Ri%/RU%P%G%/S%																																				
SC%/SA%/G%/C%/B%BE%																																				
d16/d35/d50/d84/d95																																				
% of Reach with Eroding Banks	0						0																													
Channel Stability or Habitat Metric																																				
Biological or Other																																				

Appendix E
Hydrology Data

Table 12. Verification of Bankfull Events

Table 12. Verification of Bankfull Events
Bobs Creek Site (DMS Project Number 92879)

Date of Data Collection	Date of Occurrence	Method	Photo (if available)
August 17, 2016	July 4, 2016	Crest gauge data along with wrack observed on the TOB of UT8 indicate a bankfull event after approximately 1.88 inches of rain documented* in one day.	1

*Weather Underground 2016

Photo 1: Wrack on TOB of UT8