Morgan Creek
Stream Restoration Site

Year 3 Final Monitoring Report
Project ID Number: 16-D06027
EEP Project # 92527

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1.0 SUMMARY

This Annual Report details the monitoring activities conducted during 2011 (Year 3) on the Morgan Creek Mitigation Site. Construction of the site, including planting of trees, was completed in July 2008. Due to stream damage associated with several, consecutive tropical storm events in August 2008 stream repairs were implemented. Additionally, in April 2011 a second supplemental planting occurred for the repaired reaches as well as other areas noted with low stem densities. The 2011 data represent results from the third year of stream and vegetation monitoring.

The mitigation design plan for the Morgan Creek Site involved restoration, enhancement, and preservation associated with nine stream reaches. After construction, it was determined that the project generated 7,855 linear feet of stream restoration, 1,797 linear feet of stream enhancement level I, 1,629 linear feet of stream enhancement level II, and 7,491 linear feet of stream preservation amounting to 11,203 stream mitigation units (SMU's). Due to stream bank and bed damage from high flows in August 2008, repairs were deemed necessary for portions of the restored reaches. Repairs were completed in February 2010 and because of restoration pattern changes along Morgan Creek, Unnamed Tributary 4, and Unnamed Tributary 7, the footage of stream restoration was reduced to 7,804 linear feet. Based on the reconstructed pattern, the total combined assets at this point are 11,152 SMU's.

This Annual Report presents the data from 16 cross-sections, 3,230 linear feet of longitudinal profile, three crest gauges, eight vegetation monitoring plots, and 70 photographic reference locations; as specified in the approved Mitigation Plan (EBX, 2008).

The longitudinal profiles, cross-sections, substrate, and visual assessments indicate bed adjustments as compared to the As-built conditions. The Year 3 stream channel data indicates that the restored stream reaches are reaching the desired equilibrium that will provide the intended habitat and hydrologic function. The restored stream channel continues to receive significant sediment inputs from upstream sources which are likely driving the bed form changes observed between monitoring years. Since project completion at least four bankfull events have occurred within the project site; however no bankfull events were recorded during Year 3 monitoring.

Vegetation plot (VP) monitoring during Year 3 indicates survival rates between 364 and 890 stems per acre with an average of 642 planted stems per acre for the entire restoration site documenting that the site has achieved the interim vegetative success criteria of 320 stems per acre. The increase in survival rates since the Year 2 monitoring is the result of a supplemental planting effort in the spring of 2011. Overall, planted stems are surviving well at the project site with all plots on track to meet the final success criteria. When planted and natural stems are combined the average stem density for the entire restoration site is approximately 1,122 stems per acre, which is well above the interim success criterion of 320 stems per acre at the end of the Year 3 monitoring period. Additionally, an intensive exotic invasive plant control effort was initiated in the summer of 2011 with follow up treatments planned during subsequent monitoring years.

2.0 INTRODUCTION

2.1 Project Description

The Morgan Creek Stream Mitigation Site was identified and developed through the North Carolina Ecosystem Enhancement Program (NC EEP) full delivery process. The site is located in southern McDowell County approximately eight miles south of Marion, North Carolina **(Figure 1)**. The project streams lie within the Broad River Basin (Hydrologic Unit Code 03050105040040) and the North Carolina Division of Water Quality (NCDWQ) sub-basin 03-08-01.

The Mitigation Site consists of Morgan Creek and nine unnamed tributaries encompassing 18,772 linear feet. The nine distinct unnamed tributaries (UT) are identified as UT1, UT2, UT3, UT4, UT5, UT6, UT7, UT8, and UT9. Morgan Creek lies within a relatively flat valley with UT1, UT2, UT3, UT5, UT8, and UT9 originating within the property boundary in the mountainous area to the south of the Morgan Creek valley. UT4, UT6, and UT7 originate off the property north of the Morgan Creek valley and are included in the project easement area where they flow into the property. The USGS Sugar Hill topographic quadrangle **(Figure 2)** shows the project streams drain to the larger Cove Creek watershed. All reaches drain watersheds consisting of predominately forest and agricultural land. The site is defined by a conservation easement surrounding the streams and adjacent riparian buffers that total approximately 36.6 acres.

Channel restoration (improved pattern, dimension, and longitudinal profile) was completed on all of Morgan Creek and the downstream portions of UT1, UT2, UT3, UT4, UT5, UT6, and UT7 contiguous with Morgan Creek. An additional 163 feet of channel on UT8 was restored by stabilizing the downstream crossing through grading, boulder installation, and elimination of the backwater effect associated with a failed culvert. The middle section of UT1, upstream from the restoration reach was enhanced (enhancement level I) was enhanced by installing livestock exclusion fencing, a supplemental riparian buffer planting, and the stabilizing severely eroding logging roads. The middle sections of UT2, UT3, and UT5, located upstream of the restoration reaches, were enhanced (enhancement level II) by installation of livestock exclusion fencing. The stable headwater reaches and associated riparian buffers of UT1, UT2, UT3, UT5, UT8, and UT9 were protected under preservation criteria.

Prior to restoration, Morgan Creek and the sections of tributaries located within the valley were highly degraded due the presence of livestock, channelization, minimal riparian buffers, and failed culvert crossings. The enhancement reaches had been previously impacted by livestock access, limited riparian buffers, and adjacent eroding logging roads.

The 2011 monitoring season represents Year 3 of the monitoring period. Monitoring during 2011 included stream and vegetation monitoring stations **(Figure 3)** as approved in the Mitigation Plan (EBX, 2008).

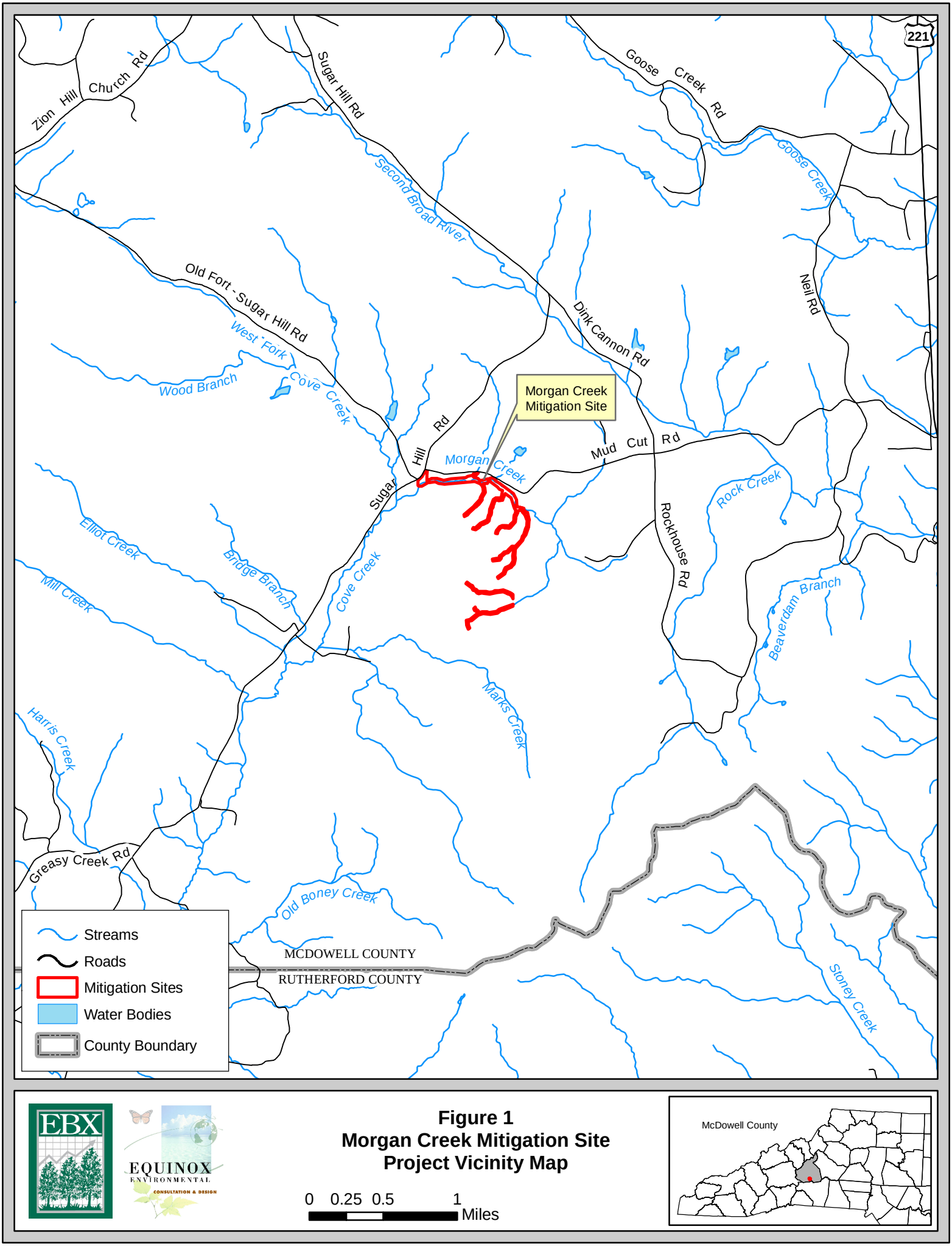


Figure 1
Morgan Creek Mitigation Site
Project Vicinity Map

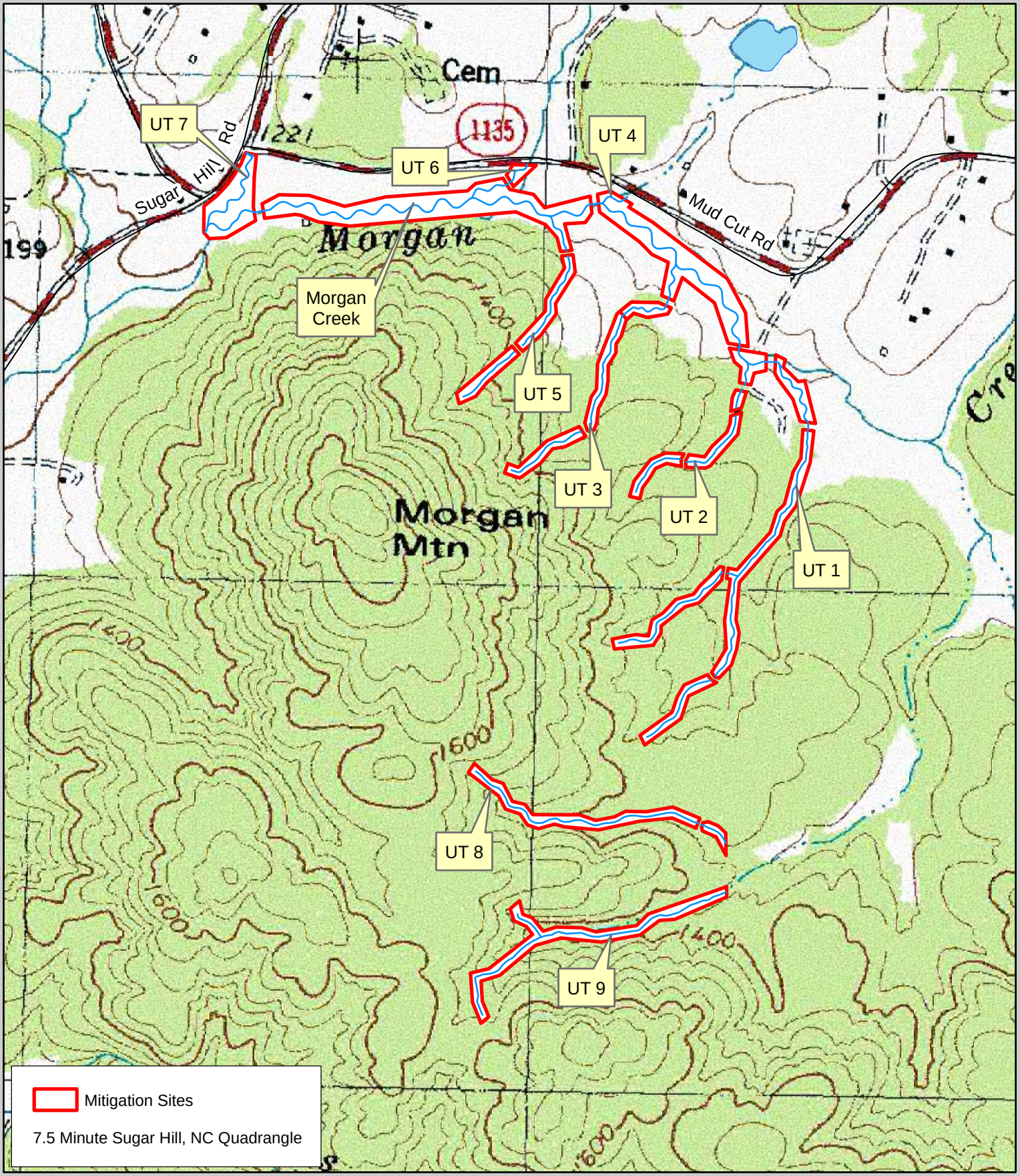
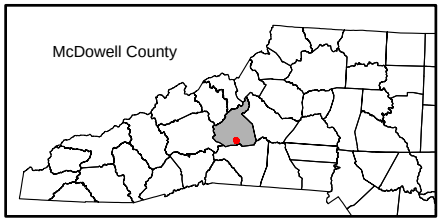
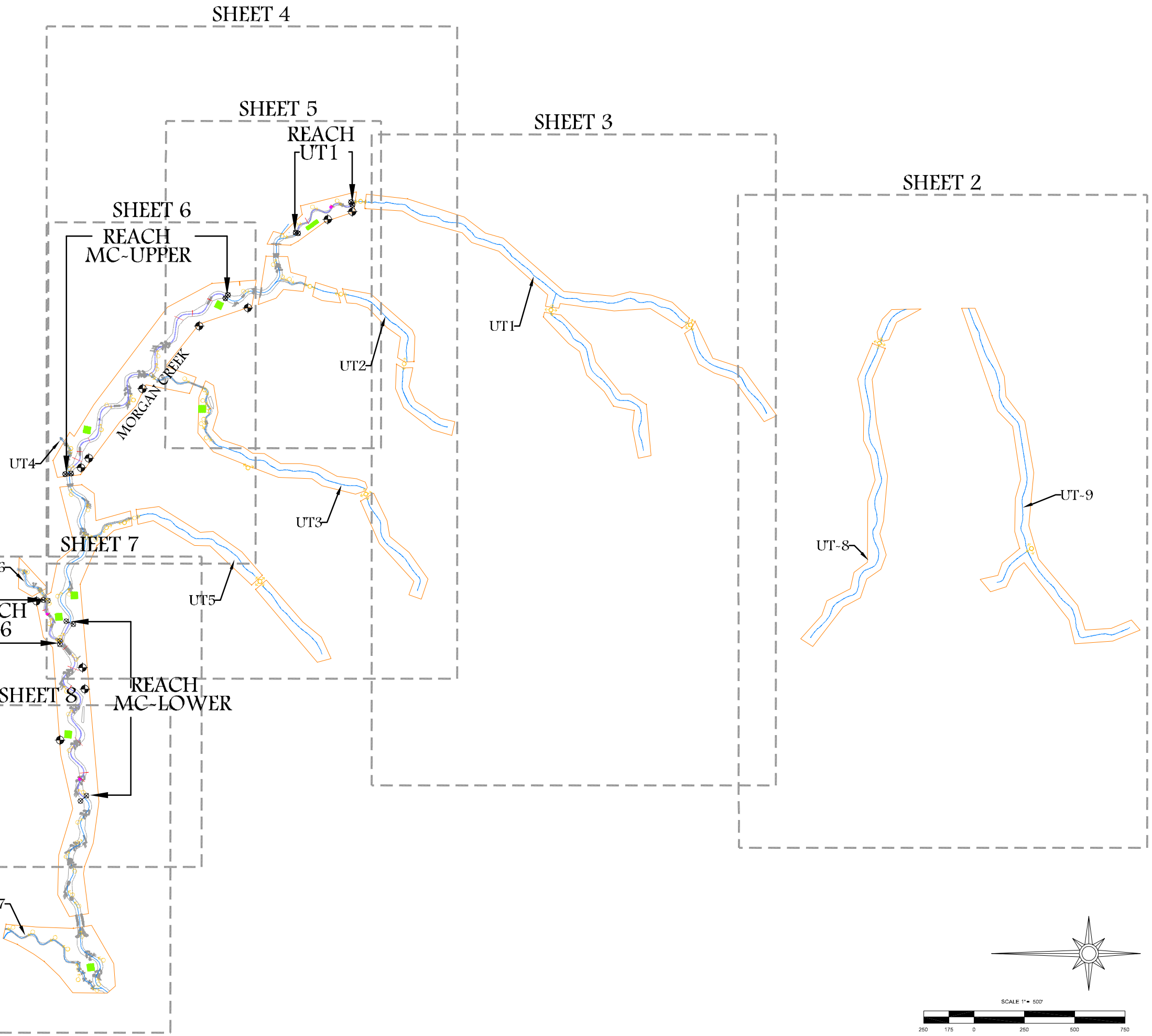


Figure 2
Morgan Creek Mitigation Site
USGS Map

0 500 1,000 2,000 Feet





LEGEND

- Vegetation Monitoring Plots
- Easement Boundary
- Stream
- Longitudinal Profile Reach
- Longitudinal Profile Begin/End
- Control Point
- Cross Section
- Crest Gauge
- Photo Point
- Constructed Riffle
- A-Vane
- Cross Vane
- J-Hook
- Log Sill
- Root Wad
- Rock Log Riffle
- Double Rock Drop Cross Vane
- Double Log Sill
- Rock Sill

SCALE 1" = 500'

250 175 0 250 500 750

Morgan Creek

McDowell County, NC

Monitoring Plan
Figure 3

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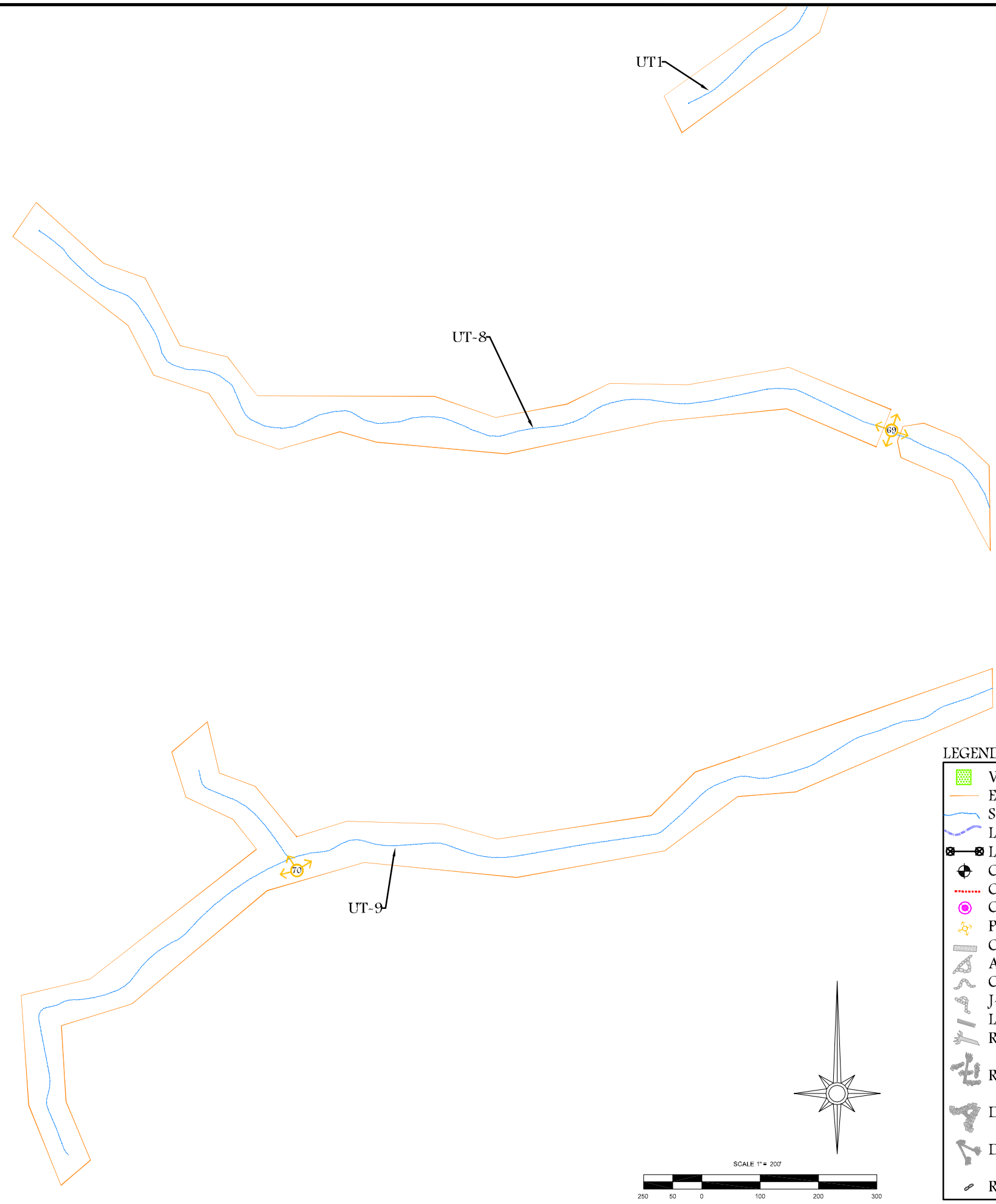

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McDowell County, NC

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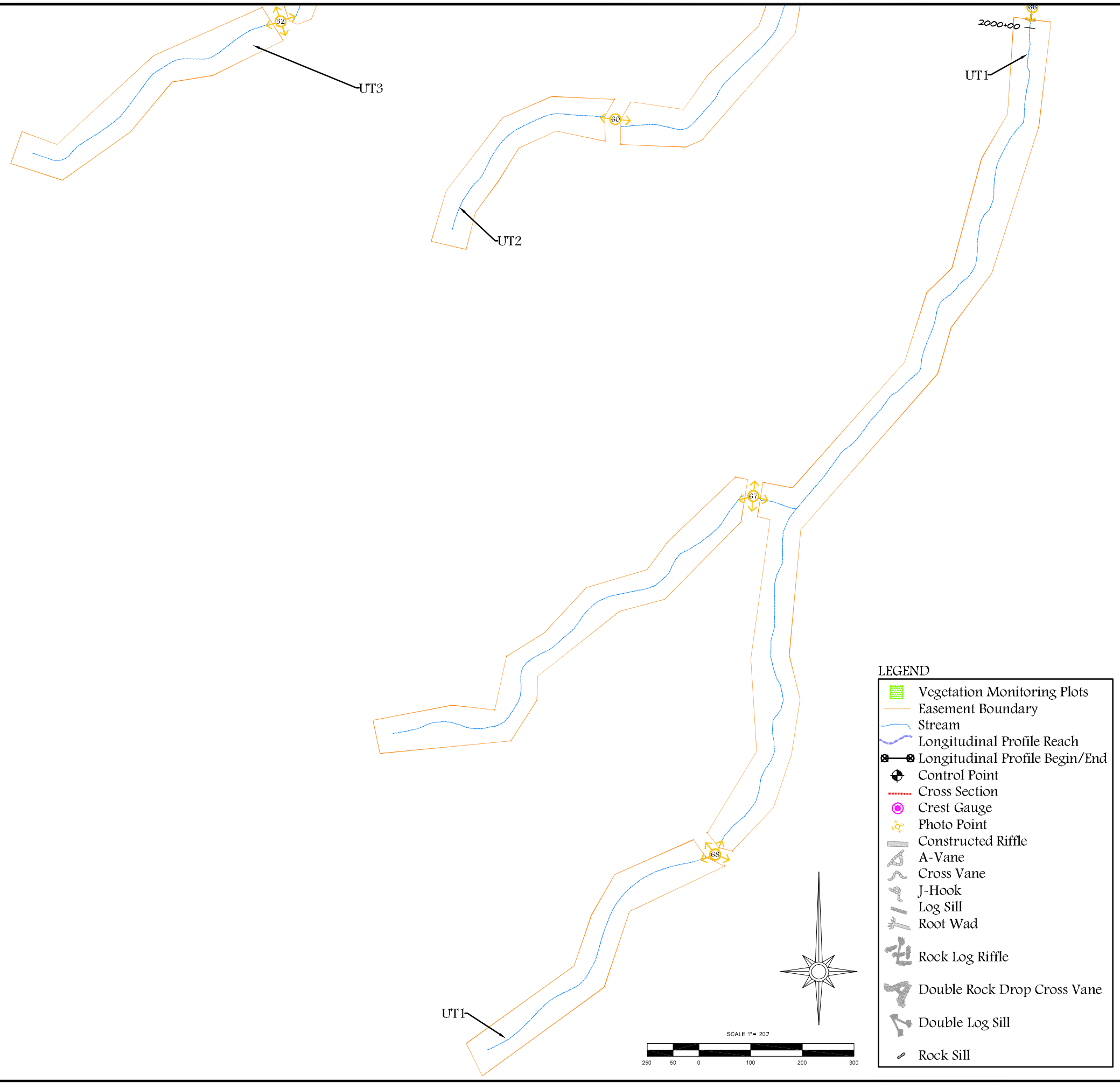

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McDowell County, NC

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McDowell County, NC

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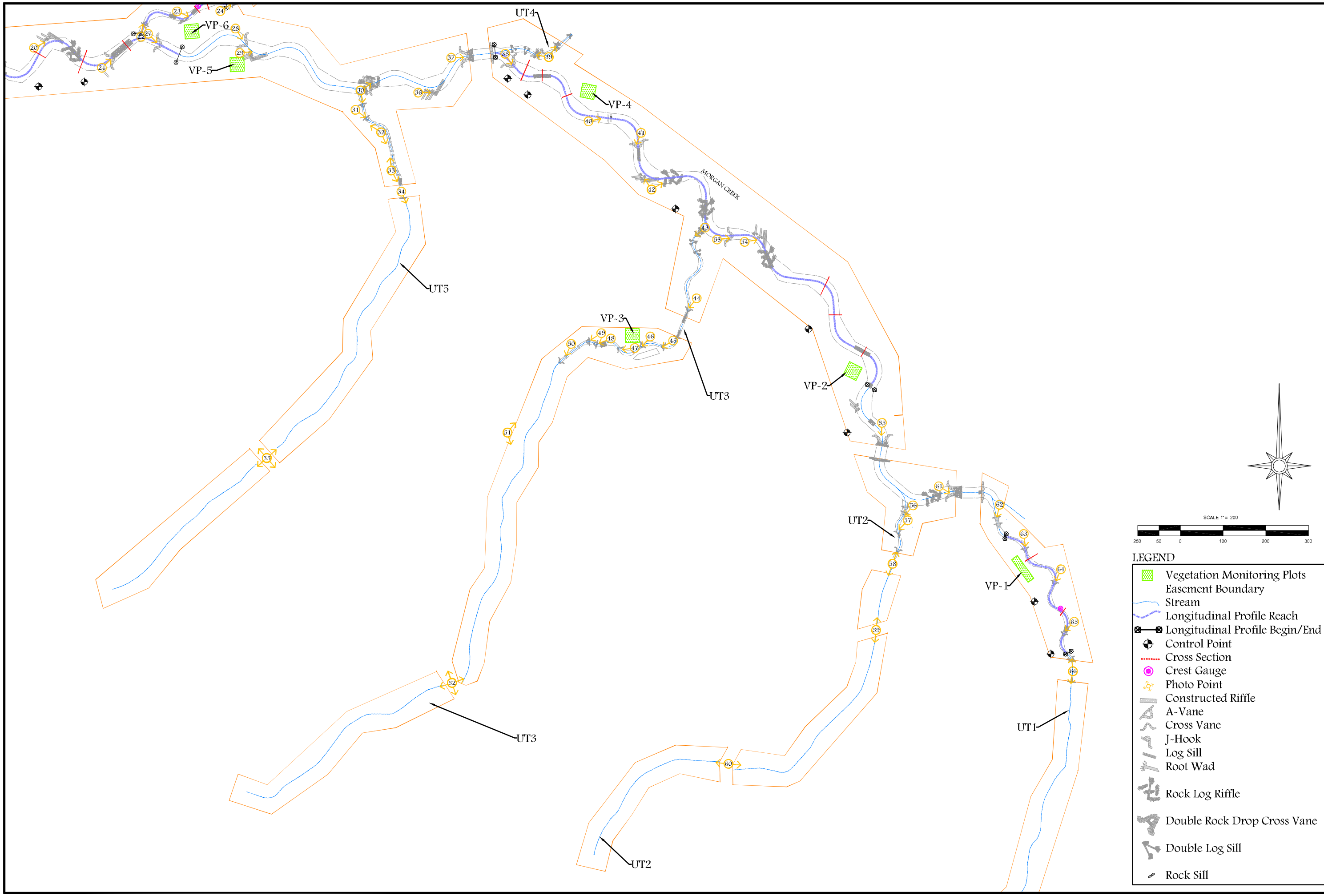

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MC Upper-P1
XS Station=1008+66.76

MC Upper-R1
XS Station=1006+56.98

MC Upper-R2
XS Station=1007+84.30

VP-3

VP-2

UT3

UT2

VP-1

UT1-P
XS Station=2003+77.15

UT1-R
XS Station=2001+95.47

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SCALE 1" = 100'

50 25 0 50 100 150

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Morgan Creek
McDowell County, NC

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SCALE 1" = 100'

50 25 0 50 100 150

UT4

UT5

UT3

MORGAN CREEK

MC Upper-R4
XS Station=1018+35.29

MC Upper-P2
XS Station=1018+80.45

MC Upper-R3
XS Station=1017+49.90

MC Upper-R2
XS Station=1007+84.30

MC Upper-P1
XS Station=1008+66.76

MC Upper-R1
XS Station=1006+56.98

VP-4

VP-3

VP-2

6002+78
6002+00
6001+00
6000+00
1022+00
1021+00
1020+00
5004+48
5003+00
5002+00
5001+00
5000+00
1019+00
1018+00
1017+00
1018+00
1015+00
1014+00
1013+00
4006+33
1012+00
4006+00
1011+00
4005+00
1010+00
1009+00
4004+00
1008+00
4003+00
1007+00
4002+00
1006+00
4001+00
1005+00
4000+00
1004+00

30 31 32 33 34 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 53 54 55

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UT6

UT6-P
XS Station=7002+81.15

UT6-R
XS Station=7003+09.20

MC Lower-R4
XS Station=1037+69.44

MC Lower-P2
XS Station=1037+36.08

VP-7

VP-6

VP-5

MC Lower-R3
XS Station=1035+34.24

MC Lower-R2
XS Station=1032+07.04

MC Lower-P1
XS Station=1030+71.42

MC Lower-R1
XS Station=1029+53.31

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SCALE 1"= 100'

50 25 0 50 100 150

Morgan Creek

McDowell County, NC

Monitoring Plan
Figure 3

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Morgan Creek

McDowell County, NC

UT7

VP-7

VP-8

8000+00
8001+00
8002+00
8003+00
8004+00
8005+00
8006+00
8006+90
1047+00
1049+46
1048+00
1049+00
1046+00
1045+00
1044+00
1043+00
1042+00
1041+00
1040+00
1038+01
1037+00
1036+00
1035+00
1034+00

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SCALE 1" = 100'

50 25 0 50 100 150

Monitoring Plan
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2.2 Project Purpose

The objective of the project was to provide 11,118 stream mitigation units (SMU's) for the NC EEP full delivery process in the Broad 03-08-01 Basin. In addition to providing mitigation credits; riparian habitat, aquatic habitat, and water quality improvements are expected to result from the restoration and enhancement of the stream channels at this site.

The Morgan Creek Mitigation Report (EBX, 2008) documented 7,855 linear feet of stream restoration, 1,797 linear feet of stream enhancement Level I, 1,629 linear feet of stream enhancement Level II, and 7,491 linear feet of stream preservation resulting in 11,203 SMU's **(Table 1)**. Due to alignment modifications associated with stream repairs made in 2010, the total linear feet of stream restoration was reduced to 7,804 linear feet. Based on the repair As-built conditions, a total of 11,152 SMU's were documented for the site **(Table 1)** as compared to the original mitigation units.

Table 1. Project Mitigation Structure and Approach

Reach Name	Stream Restoration (linear feet)	Stream Enhancement Level I (linear feet)	Stream Enhancement Level II (linear feet)	Stream Preservation (linear feet)	Total (linear feet)
Morgan Creek	4,794	-	-	-	4,794
UT1	507	1,797	-	1,569	3,873
UT2	162	-	120	928	1,210
UT3	583	-	807	559	1,949
UT4	171	-	-	-	171
UT5	275	-	702	454	1,431
UT6	460	-	-	-	460
UT7	689	-	-	-	689
UT8	163	-	-	1,693	1,856
UT9	-	-	-	2,288	2,288
Total Site Linear Feet	**7,804**	**1,797**	**1,629**	**7,491**	**18,721**
Total Site SMUs	**7,804**	**1,198**	**652**	**1,498**	**11,152**

Annual monitoring of the site is required to demonstrate successful mitigation based on criteria established in the Restoration Plan (EBX, 2007) and through a comparison to As-built and reference conditions. The success criteria components adhere to guidance provided by the United States Army Corps of Engineers (USACE) – Wilmington District (USACE, 2003) and recommendations from the NC EEP. Stream and vegetation monitoring are conducted annually for five years or until success criteria have been met. This Annual Monitoring Report details the results of the monitoring efforts for Year 3 at the Morgan Creek Stream Mitigation Site. Results from the Year 3 monitoring efforts are included within the following sections and **Appendix A**.

2.3 Project History and Schedule

The project was constructed in the spring and summer of 2008. Shortly after completion of the baseline data collection efforts, portions of the restored reaches were degraded due to significant

rainfall events. Stream repairs were delayed until early 2010, resulting in the postponement of the Year 1 monitoring efforts. An additional supplemental planting effort occurred in April 2011 within the repair areas and other areas previously noted with low stem densities. Additionally, a site wide exotic invasive plant control effort was initiated in June 2011. The Year 3 monitoring occurred as originally scheduled with the five year monitoring expected to be completed in the winter of 2013 **(Table 2)**. **Table 3** lists the project contacts.

Table 2. Project Activity and Reporting History

Month / Year	Activity
August 2007	Restoration Plan
June 2008	Construction Completed
July 2008	Planting Completed
September 2008	Mitigation Plan / As-Built Report
December 2008	Supplemental Planting
February 2010	Repairs Completed
February - April 2010	Year 1 Morphological Data Collection
May 2010	Year 1 Annual Monitoring Report
October 2010	Year 2 Morphological Data Collection
December 2010	Year 2 Annual Monitoring Report
April 2011	Supplemental Planting
April 2011	Year 3 Morphological Data Collection
June - July 2011	Exotic Invasive Plant Control
December 2011	Year 3 Annual Monitoring Report
December 2012	Year 4 Annual Monitoring Report (Scheduled)
December 2013	Year 5 Annual Monitoring Report (Scheduled)

Table 3. Project Contacts

Contact	Provider Information
Full Delivery Service Contractor Norton Webster	Environmental Banc & Exchange 909 Capability Drive Suite 3100 Raleigh, North Carolina 27606 (919) 829-9909
Designer William Wilhelm	Kimley-Horn and Associates, Inc. 4651 Charlotte Park Drive, Suite 300 Charlotte, North Carolina 28217 (704) 333-5131
Construction/Seeding Contractor Robert Grady	RFG Construction Inc. 1907 Cambridge Drive Kinston, North Carolina 28504 (252) 523-2405
Planting Contractor Robert Cato	Superior Wildlife Services 2105 Sparre Drive Kinston, North Carolina 28504 (252) 939-0465
Repair Designer David Bidelspach	Stantec Consulting Inc. 801 Jones Frankline Road Raleigh, North Carolina 27606 (919) 851-6866
Repair Construction Contractor Darrell Westmoreland	North State Environmental 2889 Lowery Street Winston-Salem, North Carolina 27101 336-725-2010
Monitoring Contractor Steve Melton	Equinox Environmental Consultation & Design, Inc. 37 Haywood Street, Suite 100 Asheville, North Carolina 28801 (828) 253-6856

3.0 STREAM MONITORING

3.1 Stream Success Criteria

As stated in the Mitigation Plan (EBX, 2008), the stream geometry will be considered successful if the cross-section geometry, longitudinal profile, and channel sinuosity are stable or reach a dynamic equilibrium within the 5-year monitoring period. While the channels may not adhere to the design or reference ratios of stream geometry, the streams will be considered stable if the following key indicators are present:

- *Stream Type*: Maintenance of the design stream type or progression toward or conversion to a stable stream type such as B, C, or E will indicate stability.
- *Bank Height Ratio*: Bank height ratio between 1.0 and 1.2 will indicate that flood flows have access to the active floodplain and that higher flows do not apply excessive stresses to stream banks.

A minimum of two bankfull events is required during the 5-year monitoring period. If two bankfull events do not occur, the monitoring period may be extended at the discretion of the USACE.

3.2 Stream Morphology Monitoring Plan

The stream monitoring program will document trends and progress in achieving the channel success criteria. Monitoring will occur annually for five years or until the final success criteria are met, whichever is longer. The locations of the individual stream monitoring components are shown in **Figure 3**.

3.2.1 Cross-Sections

A total of 16 cross-sections were established as part of the As-built monitoring efforts. Cross-sections for Morgan Creek include four riffles and two pools for each of the two monitored reaches, Morgan Creek Upper (MC-Upper) and Morgan Creek Lower (MC-Lower). Due to stream and bank repairs within MC-Lower, cross-section locations had to be re-established prior to the Year 1 monitoring efforts. Additionally, the floodplain bench at MC-Upper Riffle 4 / Cross-Section 5 was impacted resulting in a change in bankfull elevation between monitoring years. The Monitoring Plan View **(Figure 3)** has been updated to reflect these changes in cross-sectional monitoring stations. The UT1 and UT6 restoration reaches each include one riffle and one pool cross-section. Each cross-section was marked on both banks with permanent iron pins to establish known elevations and stationing for comparisons between annual data collection efforts. Annual cross-sectional survey points include all present breaks in slope; including top of bank, bankfull, inner berm, and thalweg. Photos are taken annually at each cross-section to visually document left and right bank conditions.

3.2.2 Longitudinal Profile

Four permanent longitudinal profile reaches were established during the As-built monitoring efforts. Morgan Creek includes an upper (MC-Upper) and lower reach (MC-Lower), whereas UT1 and UT6 include a portion of the restored reaches. The beginning and end of each longitudinal profile reach were marked on both banks with permanent iron pins to establish benchmarks for annual data comparison and analyses. Longitudinal profile measurements include thalweg, water surface, bankfull, and top of low bank elevations. Thalweg and water surface elevation measurements also are collected annually at the head and tail of each bedform type.

3.2.3 Substrate

Bed substrate assessment sites were established at each permanent cross-section. Annual pebble counts are collected utilizing methods adapted from Harrelson et al. (1994). A minimum of 100 particles are selected and measured from each channel feature type sampled. Sampled materials are placed into size classes using the traditional Wentworth scale classes subdivided based on phi scale. These classes are grouped into broader sediment size categories (e.g. sand, gravel or cobble) and are utilized to compare substrate progression from As-built conditions.

3.2.4 Hydrology

Crest gauges installed at the lower end of Morgan Creek, UT1, and UT6 are utilized to document bankfull events during the monitoring period. Crest gauges are checked during each site visit to document the highest flow between visits. Gauge height readings are recorded and digital images of floodplain debris lines and sediment deposition are collected to document annual bankfull events.

3.2.5 Photo Reference Stations

A total of 70 representative photo stations were established throughout the site to subjectively evaluate overall trends in project progression and general site conditions over the duration of the monitoring effort. Additionally, the entire site is visually assessed to document any identified areas of concern. Representative photos are collected to document areas of concern identified during the visual site assessment.

3.3 Stream Morphology Monitoring Results

The Year 3 annual stream morphology data were collected between April and November 2011. Reference station photos were collected in January 2011 prior to leaf out to document the general conditions of the site. The Year 3 cross-section, longitudinal profile, and substrate data collection efforts occurred in April 2011. Visual assessments and bankfull documentation were noted during each site visit of the annual monitoring effort. A final quantitative site assessment and data collection effort occurred in November 2011.

3.3.1 Cross-Sections

The MC-Upper, MC-Lower, UT1, and UT6 cross-sectional data collected during the Year 3 monitoring effort have been compared with previous data sets **(Appendices B & C)**. Due to stream and bank repairs that resulted in the loss of cross-sectional stations within the MC-Lower reach, data for the As-built conditions are not depicted within the cross-sectional profiles in **Appendix B**. Furthermore, stream and bank repairs impacted bankfull elevation at MC-Upper Riffle 4 / Cross-Section 5 and data comparisons between As-built and subsequent monitoring years are only reported in the tables for reference and not for analysis. Lastly, bankfull elevations for the UT6 cross-sections were set at a higher elevation during Year 1 to reflect the floodplain aggradation that occurred between monitoring years.

Overall, the riffle cross-sectional data for MC-Upper indicated narrowing channels with inner berm feature development along the banks between As-built and Year 1 monitoring. Additionally, the two constructed riffles within the MC-Upper reach maintained similar maximum depths between As-built and Year 1 whereas maximum depths for the two non-constructed riffles significantly increased. Based on the two pools monitored within the MC-Upper reach, cross-sectional area decreased significantly between the As-built and Year 1 data collection efforts. However, the Year 3 data for MC-Upper reach continue to indicate that the cross-sectional dimensions are stable as compared to the Year 1 and 2 data sets.

Due to the loss of cross-sectional stations within the MC-Lower reach, data comparisons with the As-built conditions are not representative. However, the Year 3 cross-sectional data for MC-Lower indicates minimal changes since the repair As-built data (Year 1) were collected. The primary change noted in Year 3 is an increase in cross-sectional area and depth for riffle 1 and 2.

Compared to the UT1 As-built data, the Year 3 channel cross-sectional data shows minimal differences between years, indicating that the overall UT1 stream dimensions have remained stable. The riffle cross-section for this reach indicates similar inner berm feature development as seen within the MC-Upper reach.

Stream dimensions for UT6 were impacted from sediment deposition both within the channel and along the floodplain between As-built and Year 1 monitoring. The Year 3 cross-sectional data for UT6 continues to indicate that stream dimensions have stabilized since the Year 1 monitoring effort.

3.3.2 Longitudinal Profile

Longitudinal profile surveys were conducted along four separate reaches of the restoration project, totaling approximately 3,230 linear feet. The surveys included reach MC-Upper from STA 1005+15 to STA 1019+47 (1,432 linear feet), MC-Lower from STA 1028+20 to STA 1039+27 (1,107 linear feet), UT1 from STA 2000+85 to STA 2004+67 (382 linear feet), and reach UT6 from STA 7002+34 to STA 7004+81 (247 linear feet). Due to design changes resulting from repairs made within the MC-Lower reach, the original As-built data are only reported in the tables for reference and not for analysis. Additionally, data for the MC-Lower As-built conditions are not depicted within the longitudinal profiles in **Appendix B**. The

longitudinal profiles document bed elevations, stream features, and in-stream grade control structures and compare them with the As-built profiles **(Appendices B & C)**.

While the project site continues to experience some changes in morphology, the Year 3 stream profiles and visual observations indicate that the majority of the project has reached a state of equilibrium and is therefore providing the intended habitat and hydrologic function. UT6 continues to indicate an evolving system with an overall trend back towards the designed profile. The restored stream channel continues to receive significant sediment inputs from upstream sources which are likely driving the bed form changes observed between monitoring years.

3.3.3 Substrate

Overall, pebble count data for MC-Upper indicate minimal change in substrate size composition between years for both riffles and pools. The MC-Upper pebble count data collected during Year 3 primarily indicate silt/clay and fine sand particles within the pool habitat types and coarser materials within the riffles. As compared to the MC-Upper reach pebble counts collected for the MC-Lower reach indicated an overall coarser composition within both the pool and riffle habitat types, with pools primarily consisting of sand and gravel and riffles primarily comprised of gravel. The UT1 pebble count data collected during Year 3 continues to indicate finer substrate material within both pool and riffle habitats, with substrate composition comprised of silt/clay and sand particles. The Year 3 substrate composition within the UT6 riffle habitat was primarily comprised of sand particles. However, due to changes in bed profiles the pool substrate composition has coarsened and was comprised of both sand and gravel substrate. The pebble count data summary plots are included in **Appendix B**.

3.3.4 Hydrology

Since project completion at least four bankfull events have occurred within the project site. An initial bankfull event occurred in August 2008, shortly after project completion, which registered 0.15 feet above bankfull on Morgan Creek and 0.02 feet above bankfull on UT6. Owing to damaged crest gauges from this initial event, bankfull events in May 2009 and January 2010 were documented with photos. During the Year 2 monitoring bankfull events were documented with crest gauges located on the UT1, UT6, and Morgan Creek mainstem restoration reaches **(Table 4)**. No bankfull events occurred during the Year 3 monitoring period.

Table 4. Crest Gauge Data

Month / Year Recorded	Morgan Creek (ft)	UT1 (ft)	UT6 (ft)
August 2008	0.15	0.00	0.02
November 2010	0.56	0.02	0.57

3.3.5 Photo Reference Stations

The Year 3 reference station photos are included in **Appendix D**. Stream problem areas (SPA) identified through the morphological monitoring and visual assessments include isolated areas of stream bed aggradation and degradation, stream bank erosion, and grade control degradation

(Table 5). Representative photos of these areas taken during the Year 3 monitoring are included in **Appendix D**.

Table 5. Stream Areas Requiring Observation

SPA	Feature	Reach	STA	Description	Recommendation
1	Pool	UT1	2001+10	Reduced pool depth due to aggradation	Continue to monitor
2	Pool	UT1	2001+75	Reduced pool depth due to aggradation	Continue to monitor
3	Pool	UT1	2002+40	Reduced pool depth due to aggradation	Continue to monitor
4	Pool	Morgan Creek	1002+25	Reduced pool depth due to aggradation	Continue to monitor
5	Pool/Riffle	UT2	3000+50	Reduced pool depth and riffle fining due to aggradation	Continue to monitor
6	Pool	Morgan Creek	1003+25	Reduced pool depth due to aggradation	Continue to monitor
7	Pool	Morgan Creek	1004+20	Reduced pool depth due to aggradation	Continue to monitor
8	Pool	Morgan Creek	1005+00	Reduced pool depth due to aggradation	Continue to monitor
9	Pool	Morgan Creek	1006+00	Reduced pool depth due to aggradation	Continue to monitor
10	Riffle	Morgan Creek	1007+75	Riffle down cutting	Continue to monitor
11	Riffle	Morgan Creek	1008+75	Riffle down cutting	Continue to monitor
12	Pool	UT3	4000+10	Reduced pool depth due to aggradation	Continue to monitor
13	Pool	UT3	4001+90	Reduced pool depth due to aggradation	Continue to monitor
14	Stream Bank	Morgan Creek	1012+25	Bank erosion	Continue to monitor
15	Pool	UT4	5000+90	Reduced pool depth due to aggradation	Continue to monitor
16	Pool/Riffle	UT4	5001+50	Reduced pool depth and riffle fining due to aggradation	Continue to monitor
17	Riffle	Morgan Creek	1020+75	Riffle down cutting	Continue to monitor
18	Pool/Riffle	UT5	6000+50	Reduced pool depth and riffle fining due to aggradation	Continue to monitor
19	Stream Channel	Morgan Creek	1025+50	Beaver dam	Beaver management program
20	Riffle	Morgan Creek	1028+85	Transverse riffle directing thalweg at bank	Continue to monitor
21	Stream Bank	Morgan Creek	1029+40	Bank erosion due to thalweg directed at bank	Continue to monitor
22	Pool	Morgan Creek	1033+80	Reduced pool depth due to aggradation	Continue to monitor
23	Riffle	Morgan Creek	1038+50	Mid channel bar	Continue to monitor
24	Pool	Morgan Creek	1047+00	Reduced pool depth due to aggradation	Continue to monitor
25	Pool/Riffle	UT7	8000+40	Reduced pool depth and riffle fining due to aggradation	Continue to monitor
26	Pool/Riffle	UT7	8006+00	Reduced pool depth and riffle fining due to aggradation	Continue to monitor

3.4 Stream Conclusions

The Year 3 morphological monitoring and visual assessments continue to indicate an evolving system in which the restoration areas continue to evolve towards stability. Areas of concern identified during Year 3 were primarily associated with pool aggradation and riffle degradation. Upstream sediment sources, in conjunction with on-site riffle down-cutting, appear to be the primary influences associated with bed profile changes between years. These observations will be monitored during subsequent years to document profile stabilization over time and recommendations will be made, if necessary, to ensure project success. **Table 6** summarizes the riffle morphologic parameters since the As-built conditions; details of the morphologic parameters are provided in **Appendices B & C**. The MC-Lower As-built and Year 1 parameters in **Table 6** are presented for the purpose of comparing the original As-built conditions to conditions following completion of the repairs.

Table 6. Summary of Morphologic Monitoring Parameters

Morgan Creek – Upper Reach				
Parameter	**As-Built**	**Year 1**	**Year 2**	**Year 3**
Average Bankfull Cross-Section Area Abkf (sq ft)	28.4	25.0	24.9	24.2
Average Bankfull Width Wbkf (ft)	20.8	19.7	19.8	18.8
Average Bankfull Width / Depth Ratio	15.5	15.6	16.0	14.8
Average Bankfull Mean Depth Dbkf (ft)	1.4	1.3	1.3	1.3
Average Bankfull Max Depth Dmax (ft)	2.4	3.0	3.0	3.1

Morgan Creek – Lower Reach				
Parameter	**As-Built***	**Year 1**	**Year 2**	**Year 3**
Average Bankfull Cross-Section Area Abkf (sq ft)	28.2	42.2	43.1	45.8
Average Bankfull Width Wbkf (ft)	22.4	24.3	24.3	25.2
Average Bankfull Width / Depth Ratio	17.8	14.1	14.0	14.5
Average Bankfull Mean Depth Dbkf (ft)	1.3	1.7	1.8	1.8
Average Bankfull Max Depth Dmax (ft)	2.4	3.2	3.4	3.6

*Morgan Creek Lower As-built data are presented for the purpose of comparing the original to those of the repair As- built conditions (Year 1) and not for morphological analysis.

Table 6 Continued. Summary of Morphologic Monitoring Parameters

Morgan Creek – UT1				
Parameter	**As-Built**	**Year 1**	**Year 2**	**Year 3**
Bankfull Cross-Section Area Abkf (sq ft)	4.1	4.2	4.2	4.2
Bankfull Width Wbkf (ft)	9.1	9.0	9.7	9.2
Bankfull Width / Depth Ratio	19.9	19.4	22.7	20.2
Bankfull Mean Depth Dbkf (ft)	0.5	0.5	0.4	0.5
Bankfull Max Depth Dmax (ft)	1.2	1.3	1.3	1.4

Morgan Creek – UT6				
Parameter	**As-Built**	**Year 1**	**Year 2**	**Year 3**
Bankfull Cross-Section Area Abkf (sq ft)	11.1	10.3	9.7	8.7
Bankfull Width Wbkf (ft)	13.4	11.7	11.7	10.0
Bankfull Width / Depth Ratio	16.2	13.2	14.1	11.5
Bankfull Mean Depth Dbkf (ft)	0.8	0.9	0.8	0.9
Bankfull Max Depth Dmax (ft)	1.7	1.7	1.6	1.7

4.0 VEGETATION

4.1 Vegetation Success Criteria

Successful establishment of vegetation for the Morgan Creek Stream Restoration Project should be the survival of 320 planted stems per acre by the end of Year 3 such that the site will achieve the final requirement of 260 planted stems per acre by Year 5.

4.2 Description of Species and Vegetation Monitoring

Eight vegetation plots (VP), or approximately 1% of the restoration site, were established within the project easement area: seven standard (10m x 10m) plots and one non-standard (5m x 20m) plot **(Figure 3)**. These plots were established in accordance with the CVS-EEP Level II monitoring protocol (Lee et al., 2008) within the planted restoration areas. Approximately 0.025-acre in size, vegetation plots were monitored to determine the success of planted vegetation and the overall trajectory of woody plant restoration and natural plant regeneration at the project site. Plots were placed within the applicable planting zones to capture the heterogeneity of the restored vegetative communities. However, given that several planting zones were too narrow to accommodate the standard or non-standard plots, all vegetation plots were placed within riparian and upland planting zones. Due to the stream repairs completed in early 2010, VP8 had to be re-established and replanted prior to the Year 2 monitoring efforts. An additional supplemental planting effort occurred in April 2011 within the repair areas and other areas previously noted with low stem densities. A total of 11 tree species were planted on the site **(Table 7)**. Taxonomic nomenclature follows Weakley (2008).

Table 7. Planted Tree Species

Common Name	Scientific Name
Willow Oak	*Quercus phellos*
Water Oak	*Quercus nigra*
Swamp Chestnut Oak	*Quercus michauxii*
Black Willow	*Salix nigra*
River Birch	*Betula nigra*
Yellow Poplar	*Liriodendron tulipifera var. tulipifera*
American Sycamore	*Platanus occidentalis var. occidentalis*
Green Ash	*Fraxinus pennsylvanica*
Buttonbush	*Cepalanthus occidentalis*
Black Willow	*Salix nigra*
Silky Dogwood	*Cornus amomum*

4.3 Results of Vegetation Monitoring

Planted stem counts for each of the eight vegetation monitoring plots were recorded by species **(Table 8)**. Low stem densities reported for the As-built conditions resulted in a supplemental planting that occurred in December 2008. Additionally, in April 2011 a follow up supplemental planting occurred within the repaired areas and other areas noted with low stem densities.

Results from the Year 3 vegetation monitoring documented survivability ranging from 364 to 890 planted stems per acre **(Table 9)** with an average planted stem density of 642 planted stems planted stems per acre for the entire restoration site. This increase between years is primarily the result of the recent supplemental planting effort.

Table 8. Results of Monitoring Year 3 Vegetation Monitoring by Plot

Species	Plot ID							
	VP1	VP2	VP3	VP4	VP5	VP6	VP7	VP8
Betula nigra	2	1	2	3		12	8	1
Cephalanthus occidentalis	1						6	2
Fraxinus pennsylvanica	4	4	6		12	4	2	5
Liriodendron tulipifera var. tulipifera	1			3			5	
Platanus occidentalis var. occidentalis	1	2		4	1	1		
Quercus michauxii		2			3		1	5
Quercus nigra					2			
Quercus phellos	2	1		2	3			
Quercus species	1		1		1			
Salix nigra		1		1		5		1

Table 9. Summary of Vegetation Monitoring Results

Plot ID	Stems Planted (Original Baseline Conditions)	Baseline Stems + Initial Supplemental Planting Stems (Revised Baseline Conditions)	2011 Stems*	Percent Survival as Compared to Revised Baseline Conditions	Stems per Acre					
					Stems Planted (Original Baseline)	2009 Year 1** (Revised Baseline)	2010 Year 2	2011 Year 3*	2012 Year 4	2013 Year 5
VP1	7	10	12	120%	283	405	405	486		
VP2	3	5	11	220%	122	162	283	445		
VP3	5	7	9	129%	202	283	283	364		
VP4	7	10	13	130%	283	405	445	526		
VP5	10	17	22	129%	405	688	728	890		
VP6	14	23	22	96%	567	931	850	890		
VP7	16	22	22	100%	648	891	809	890		
VP8	9	21	14	N/A	364	850	486	567		

Average stems per acre: 642
Range of stems per acre: 364 – 890
*Increases since revised baseline conditions are the result of an additional supplemental planting effort in April 2011.
**Includes supplemental planting data
N/A – Plot re-established in Year 2 and percent survival is not applicable between monitoring years.

A visual estimate of herbaceous vegetation cover within the monitoring plots is provided to assess the overall stability of the restoration site **(Table 10)**. On average, herbaceous vegetation coverage is 90% within the plots ranging from 80% to 100%. While woody stem densities in VP5 are adequate, the herbaceous coverage was low as compared to other plots. Observations of herbaceous cover throughout the project area were noted during the visual assessment and are documented in **Appendix A**; representative photos are included in **Appendix D**. Herbaceous cover typically consists of dogfennel (*Eupatorium capillifolium*), hollow-stem Joe-pye weed (*Eutrochium fistulosum*), narrow-leaved sunflower (*Helianthus angustifolius*), goldenrod (*Solidago sp.*), rice cutgrass (*Leersia oryzoides*), horsenettle (*Solanum carolinensis*), and blackberry (*Rubus sp.*). Overall, herbaceous cover has increased between years and is expected to continue as a result of natural recruitment from adjacent vegetated areas and due to previous remedial actions undertaken by EBX to improve vegetative cover in the bare areas.

Table 10. Estimated Herbaceous Total Percent Cover

Plot ID	Estimated Herbaceous Cover (%)
VP1	100%
VP2	90%
VP3	100%
VP4	85%
VP5	80%
VP6	95%
VP7	85%
VP8	85%

Commonly encountered woody volunteer or natural species are also documented throughout the five-year monitoring period **(Table 11)**. A large number of the volunteer species documented within the vegetation monitoring plots in Year 2 were of the same species planted at the site. However, due to the small height classes and lack of being previously recorded within the plots these stems were classified as recruits and were not included in the stems per acre summations in **Table 9.** As a result of natural recruitment and classifying these additional planted trees as volunteers, recruitment between Year 1 and Year 2 increased significantly (299%) across the restoration site resulting in approximately 197 volunteer stems per acre. Likewise, recruitment between Year 2 and Year 3 increased significantly (236%) across the restoration site resulting in approximately 663 volunteer stems per acre.

Table 11. Volunteer Tree Species

Common Name	Scientific Name
American Persimmon	*Diospyros virginiana*
American Hornbeam	*Carpinus caroliniana*
Black Willow	*Salix nigra*
Tag Alder	*Alnus serrulata*
Buttonbush*	*Cepalanthus occidentalis*
Willow Oak*	*Quercus phellos*
Green Ash*	*Fraxinus pennsylvanica*
American Sycamore*	*Platanus occidentalis var. occidentalis*
Swamp Chestnut Oak*	*Quercus michauxii*
River Birch*	*Betula nigra*
Red Maple	*Acer rubrum*
Black Cherry	*Prunus serotina*
Shortleaf Pine	*Pinus echinata*
Smooth Sumac	*Rhus glabra*
Silky Dogwood	*Cornus amomum*

*Likely planted during the earlier repair efforts.

4.4 Vegetation Observations and Conclusions

Overall, planted stems are surviving well at the Morgan Creek Stream Restoration Site. Only 4% of planted stems were found to be dead or missing during Year 3 monitoring. Planted stem mortality was highest at VP6 and VP7 although the majority (85%) of planted stems observed in Year 3 had good or excellent vigor scores.

All vegetation monitoring plots meet the interim success criterion of 320 stems per acre. Additionally, with the significant increase in volunteer stems in Year 3, the average stem density across the whole site for planted and volunteers combined is approximately 1,122 stems per acre, which is well above the interim success criterion of 320 stems per acre at the end of Year 3. Additionally, the herbaceous vegetation coverage increased between years and is relatively high in the majority of the vegetation monitoring plots. Due to low herbaceous coverage within VP5 this area was depicted as a bare bench within Appendix A.

Invasive exotic plants such as multiflora rose (*Rosa multiflora*), Japanese stiltgrass (*Microstegium vimineum*), Japanese honeysuckle (*Lonicera japonica*), and privet (*Ligustrum sp*.) were generally abundant throughout the easement area. Japanese knotweed (*Reynoutria japonica*), tree of heaven (*Ailanthus altissima*), princess tree (*Paulownia tomentosa*), Oriental bittersweet (*Celastrus orbiculatus*), kudzu (*Pueraria montana var. lobata*), Japanese barberry (*Berberis thunbergii*), and olive species (*Elaeagnus sp.*) were also documented in dense isolated patches within the easement boundary**.** Control of the kudzu, knotweed, and other high-priority species began prior to Year 3 monitoring and appears to have eliminated the Japanese knotweed from the site. Additional intensive control efforts were initiated in Year 3 with follow up treatments scheduled throughout the remainder of the monitoring period. **Appendix A** depicts those areas treated for invasive exotic plants during Year 3. **Appendix E** contains the baseline

report which provides a summary of the invasive exotic management activities conducted during this period.

5.0 CONCLUSIONS AND RECOMMENDATIONS

- The morphological data and observations of stream conditions indicate the restored reaches are reaching the desired equilibrium. Areas of concern identified during Year 3 monitoring were primarily associated with pool aggradation and riffle degradation caused by upstream sediment sources.

- Vegetation monitoring efforts have documented the average number of planted stems per acre for the entire restoration site to be 642 stems per acre for the 2011 monitoring year. Due to the additional supplemental planting in April 2011, the majority of the monitoring plots indicate an increase in survivability between years. Additionally, all vegetation plots are currently meeting the interim success criterion of 320 stems per acre. Likewise, individuals classified as volunteer species significantly increased between years. Lastly, the invasive exotic plant control efforts will be monitored with follow up control efforts planned during subsequent monitoring years.

- Stream and vegetation monitoring are scheduled through 2013.

6.0 REFERENCES

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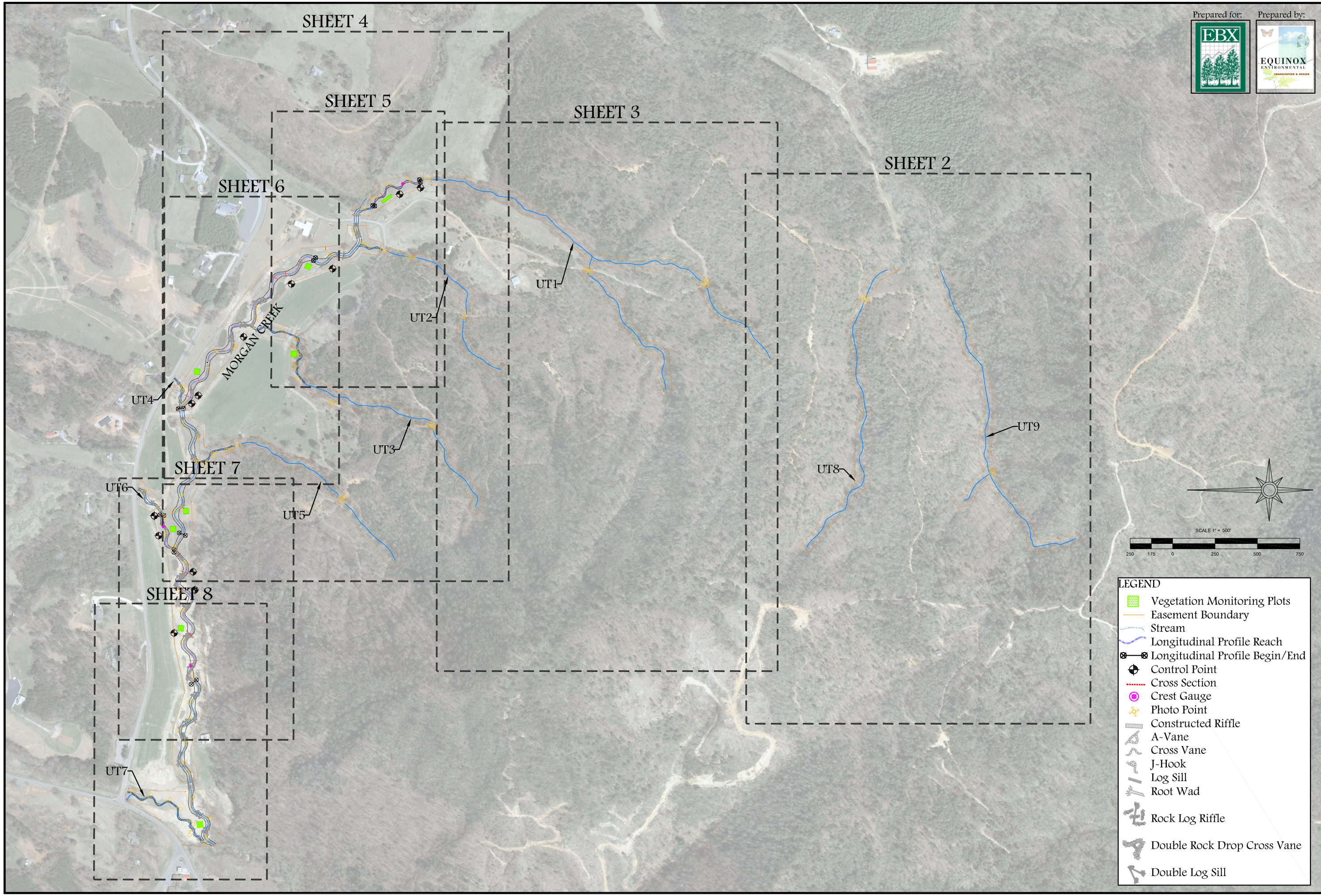
Weakley, A.S. 2008. Flora of the Carolinas, Virginia, Georgia, northern Florida, and surrounding areas. Working draft of 7 April 2008. University of North Carolina Herbarium (NCU). North Carolina Botanical Garden. University of North Carolina at Chapel Hill. Chapel Hill, North Carolina.

APPENDIX A

Monitoring Year 3
Current Condition Plan View



Prepared for: EBX

Prepared by: EQUINOX ENVIRONMENTAL CONSULTATION & DESIGN

Notes:
1. Coordinate System is State Plane Feet NAD 83.
2. Base map information provided by Kinley Horn & Stantec.Dwg title(s): ACAD-018336000-BASE.dwg & 171300323_ASBUILT_BASE_corrected.dwg respectively.
3. Aerial photography is NC One Map 2010.

Morgan Creek

McDowell County, NC

Current Condition Plan View
Final
YEAR 3 Monitoring-2011
OVERVIEW

Sheet:
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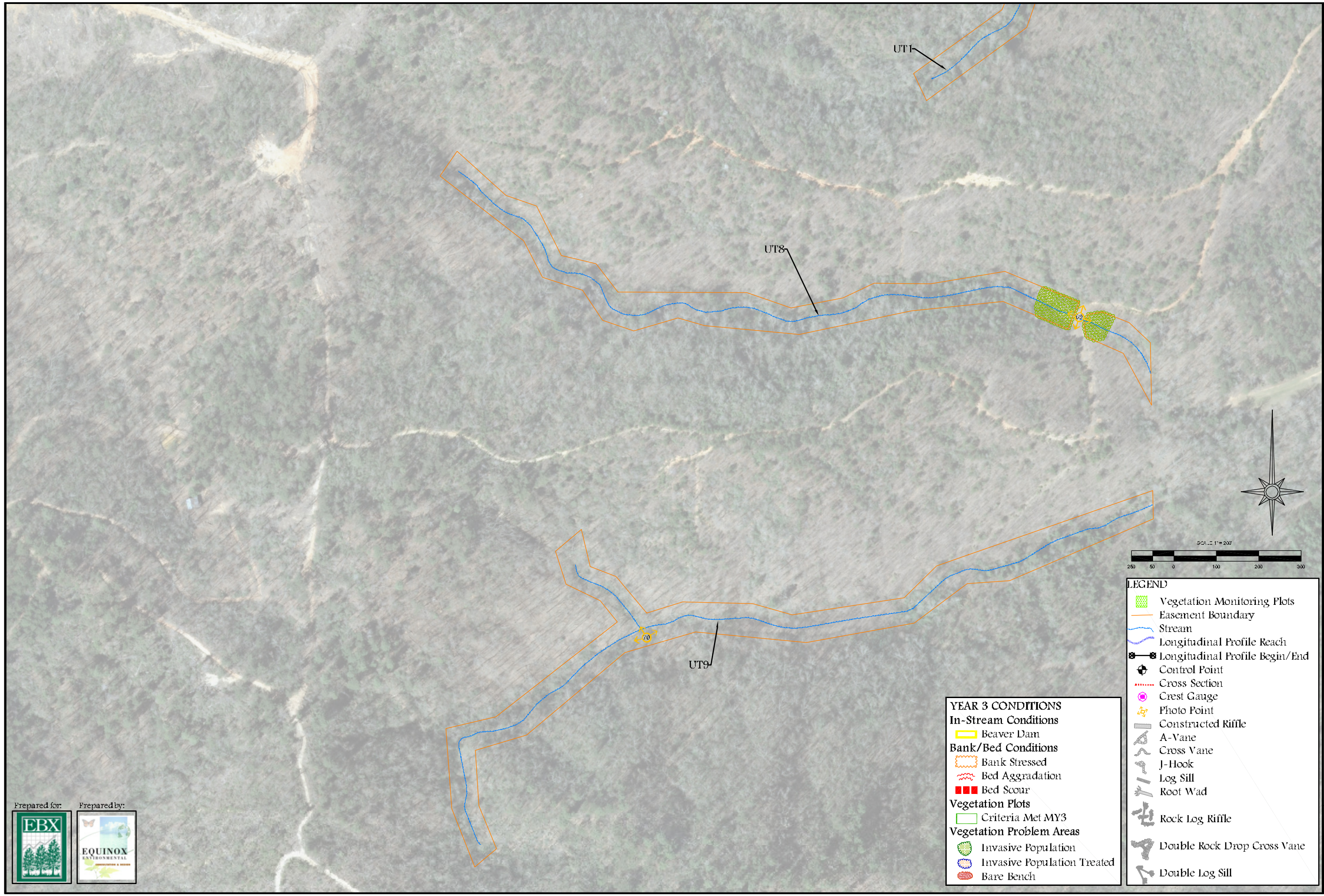
of 8

Date:
November, 2011



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Morgan Creek

McDowell County, NC

Current Condition Plan View
Final
YEAR 3 Monitoring-2011

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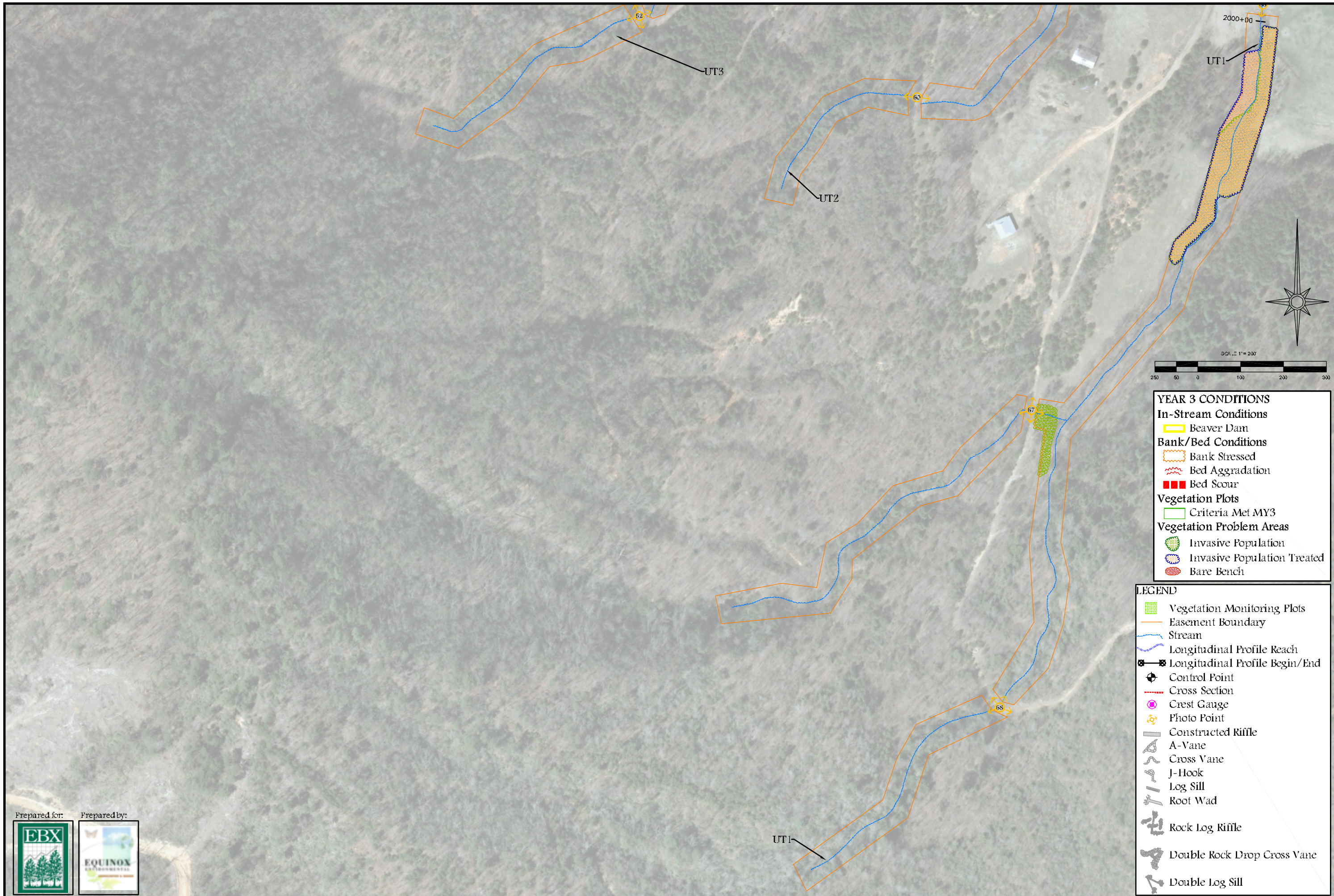
Date:
November, 2011

Prepared for: EBX

Prepared by: EQUINOX ENVIRONMENTAL



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3. Aerial photography is NC One Map 2010.

Morgan Creek

McDowell County, NC

Current Condition Plan View
Final
YEAR 3 Monitoring-2011

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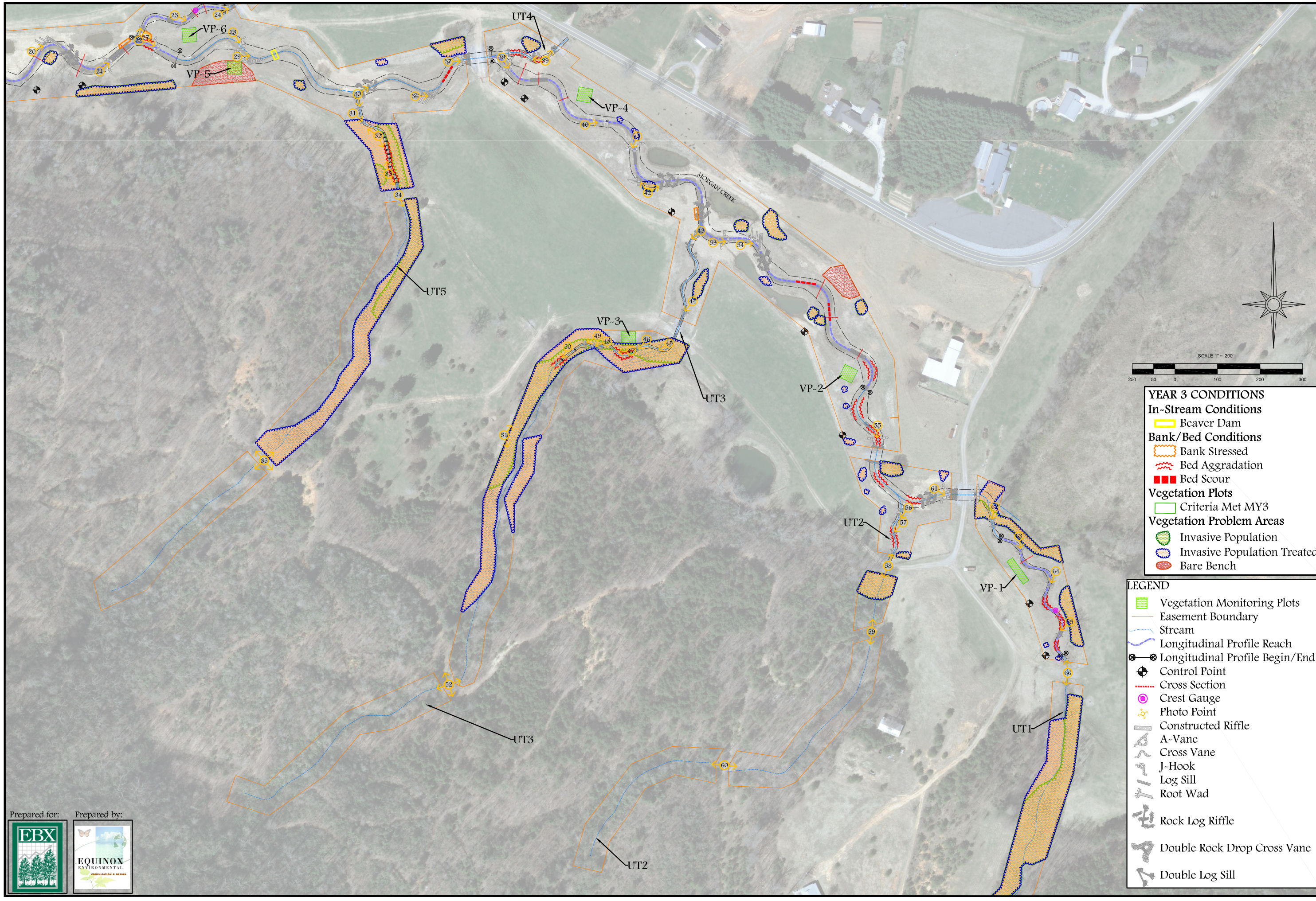
Date:
November, 2011

Prepared for: EBX

Prepared by: EQUINOX ENVIRONMENTAL



YEAR 3 CONDITIONS

In-Stream Conditions
- Beaver Dam

Bank/Bed Conditions
- Bank Stressed
- Bed Aggradation
- Bed Scour

Vegetation Plots
- Criteria Met MY3

Vegetation Problem Areas
- Invasive Population
- Invasive Population Treated
- Bare Bench

LEGEND
- Vegetation Monitoring Plots
- Easement Boundary
- Stream
- Longitudinal Profile Reach
- Longitudinal Profile Begin/End
- Control Point
- Cross Section
- Crest Gauge
- Photo Point
- Constructed Riffle
- A-Vane
- Cross Vane
- J-Hook
- Log Sill
- Root Wad
- Rock Log Riffle
- Double Rock Drop Cross Vane
- Double Log Sill

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3. Aerial photography is NC One Map 2010

Morgan Creek
McDowell County, NC

Current Condition Plan View
Final
YEAR 3 Monitoring-2011

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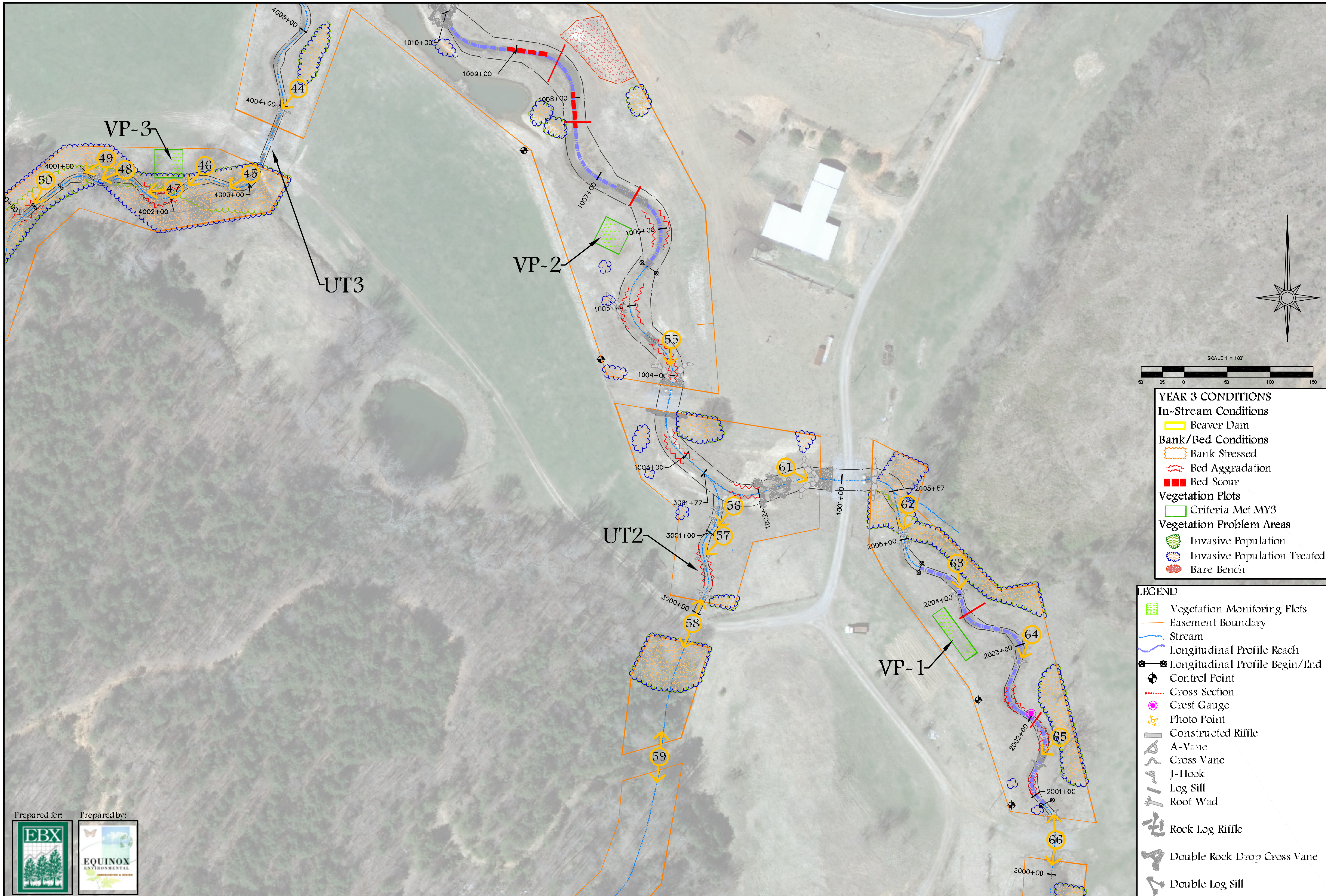
Date:
November, 2011

Prepared for: EBX

Prepared by: EQUINOX ENVIRONMENTAL CONSULTATION & DESIGN



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Morgan Creek

McDowell County, NC

Current Condition Plan View
Final
YEAR 3 Monitoring-2011

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Date: November, 2011

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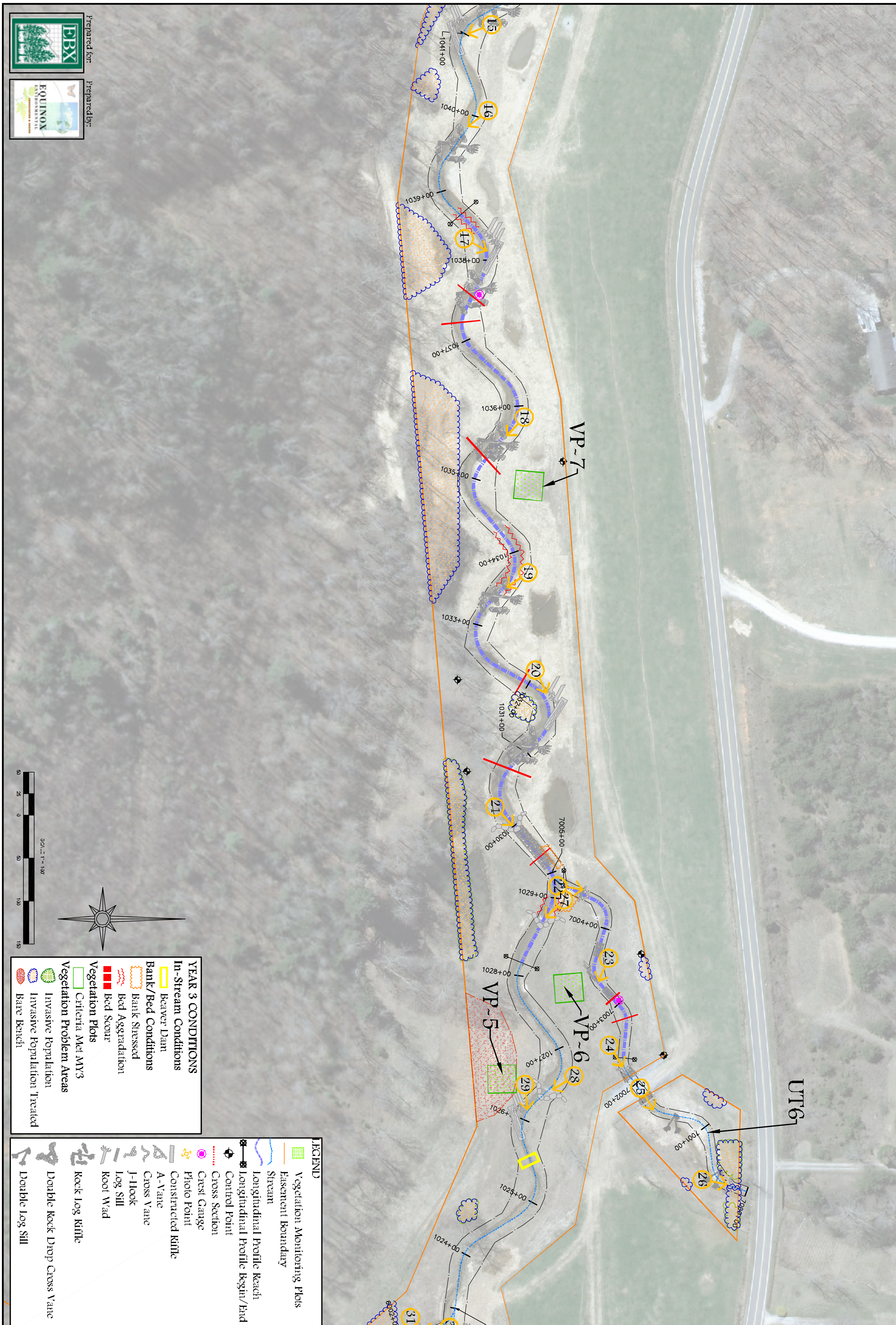
Morgan Creek

McDowell County, NC

Current Condition Plan View
Final
YEAR 3 Monitoring-2011

Sheet: 6 of 8

Date: November, 2011



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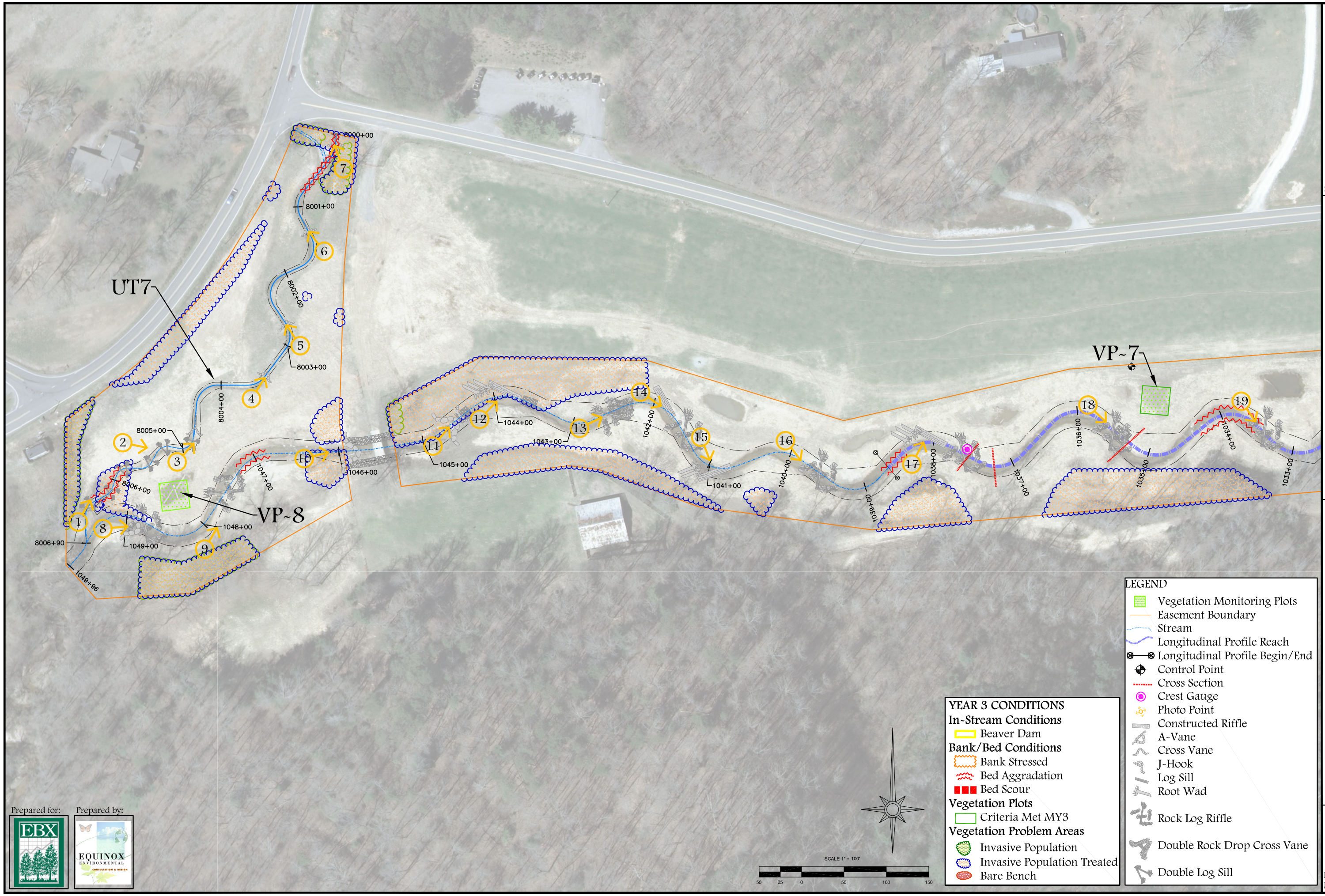
Morgan Creek

McDowell County, NC

Current Condition Plan View
Final
YEAR 3 Monitoring-2011

Sheet: 7 of 8

Date: November, 2011



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3. Aerial photography is NC One Map 2010

Morgan Creek

McDowell County, NC

Current Condition Plan View
Final
YEAR 3 Monitoring-2011

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Date:
November, 2011

YEAR 3 CONDITIONS
In-Stream Conditions
- Beaver Dam

Bank/Bed Conditions
- Bank Stressed
- Bed Aggradation
- Bed Scour

Vegetation Plots
- Criteria Met MY3

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- Constructed Riffle
- A-Vane
- Cross Vane
- J-Hook
- Log Sill
- Root Wad
- Rock Log Riffle
- Double Rock Drop Cross Vane
- Double Log Sill

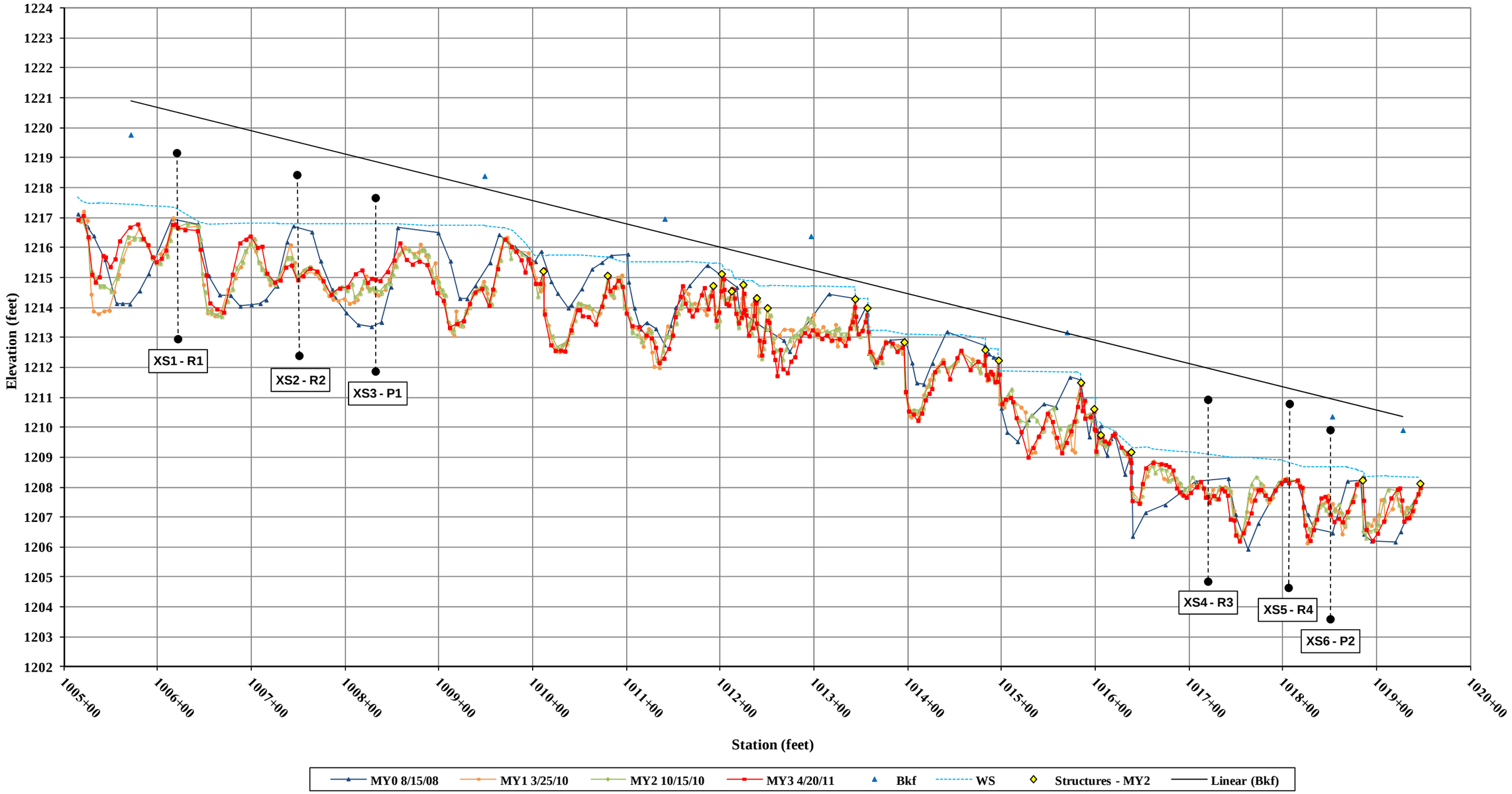
Prepared for: EBX

Prepared by: EQUINOX ENVIRONMENTAL CONSULTATION & DESIGN

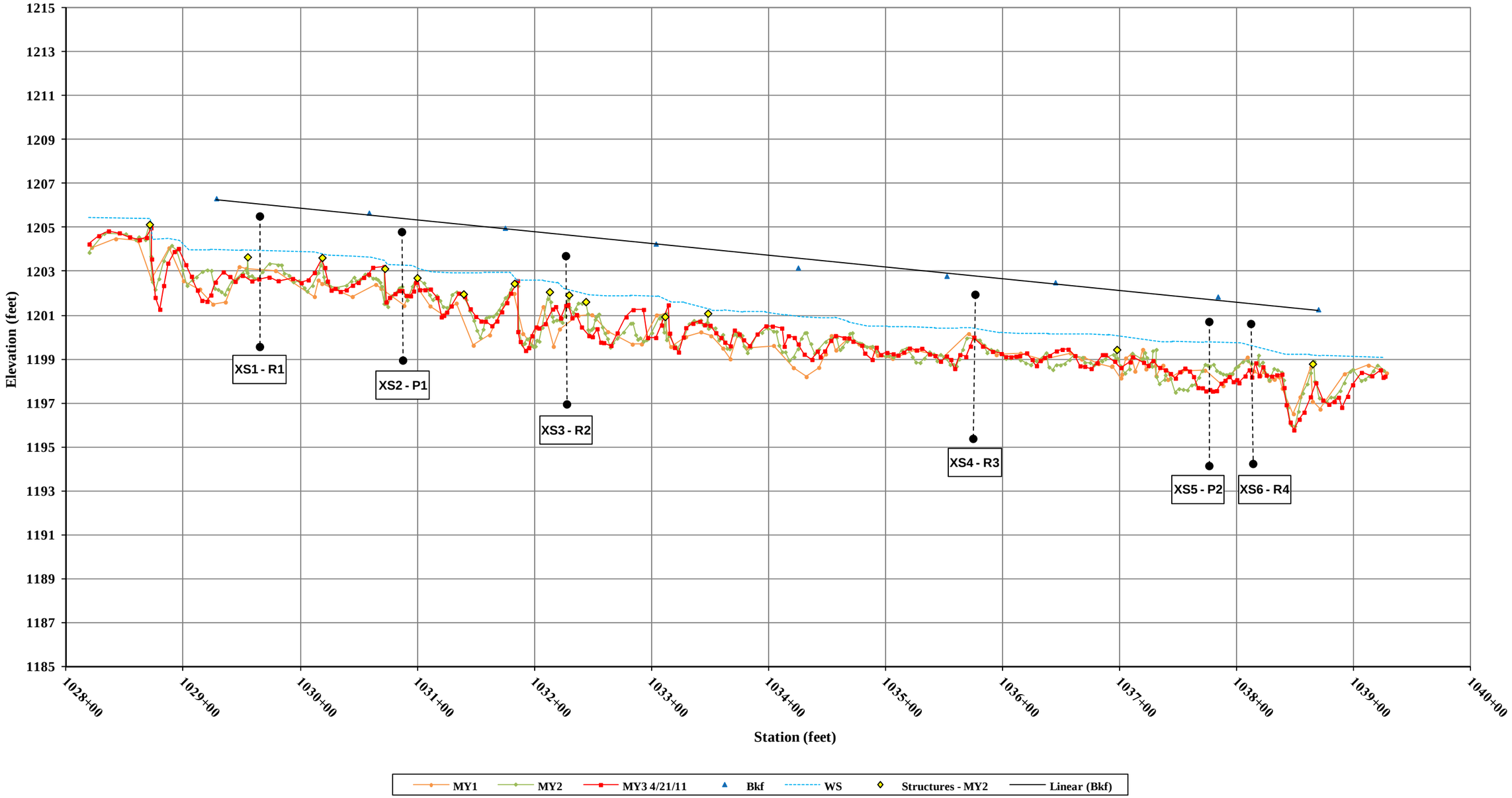
APPENDIX B

Monitoring Year 3
Profile, Cross-Section, and Substrate Data

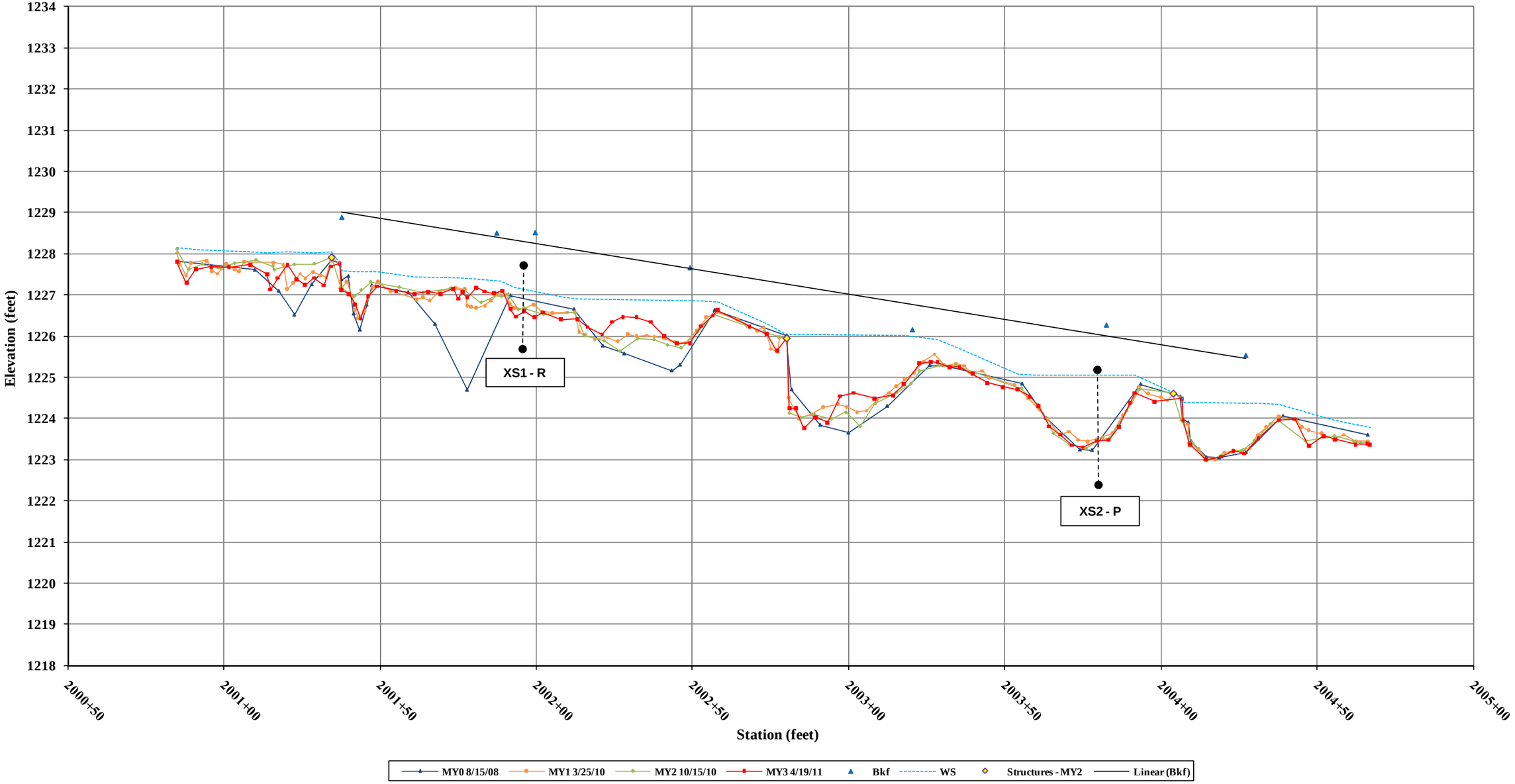
Morgan Creek - Upper
Longitudinal Profile



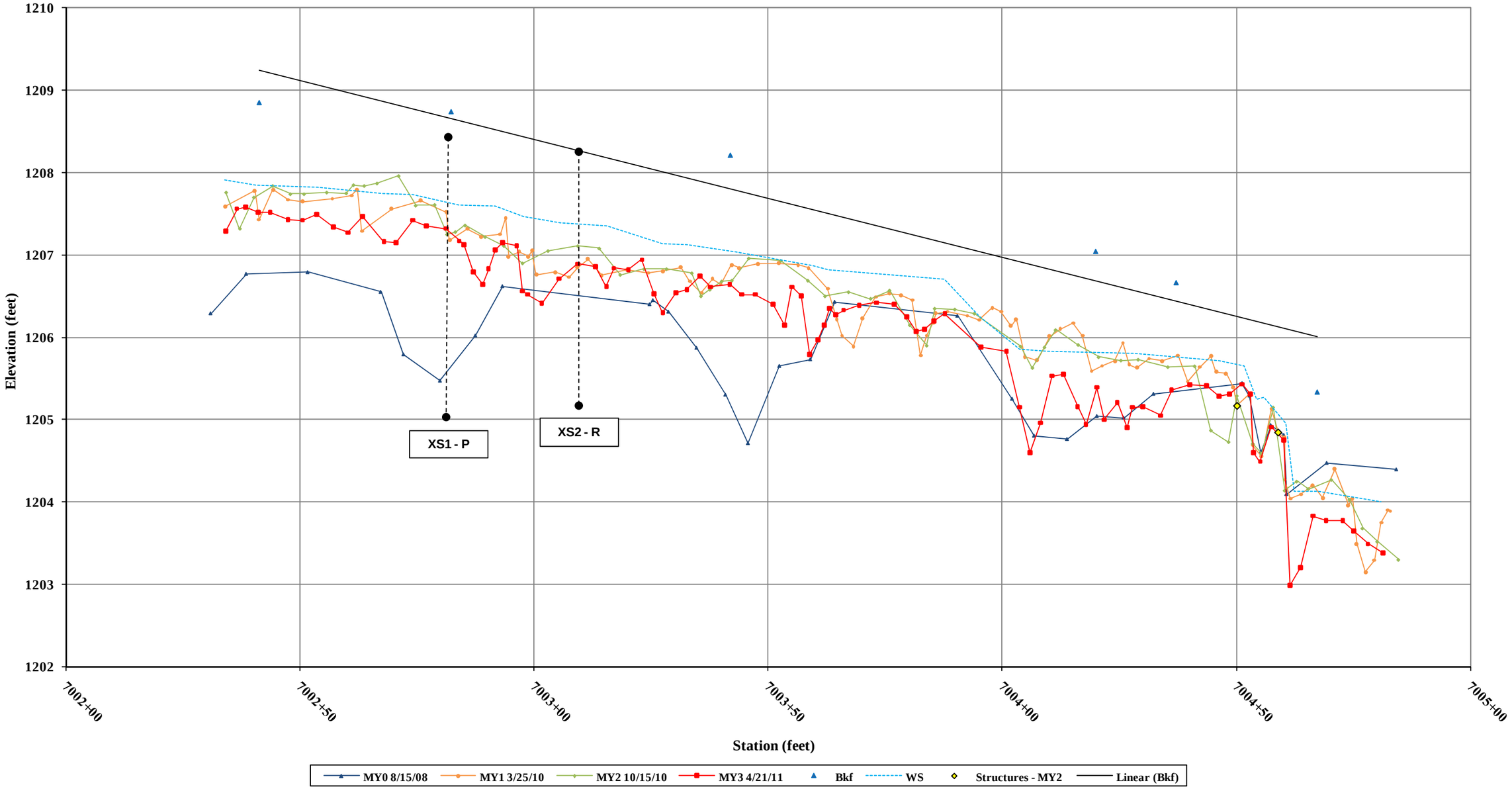
Morgan Creek - Lower
Longitudinal Profile



Morgan Creek - Unnamed Tributary 1
Longitudinal Profile



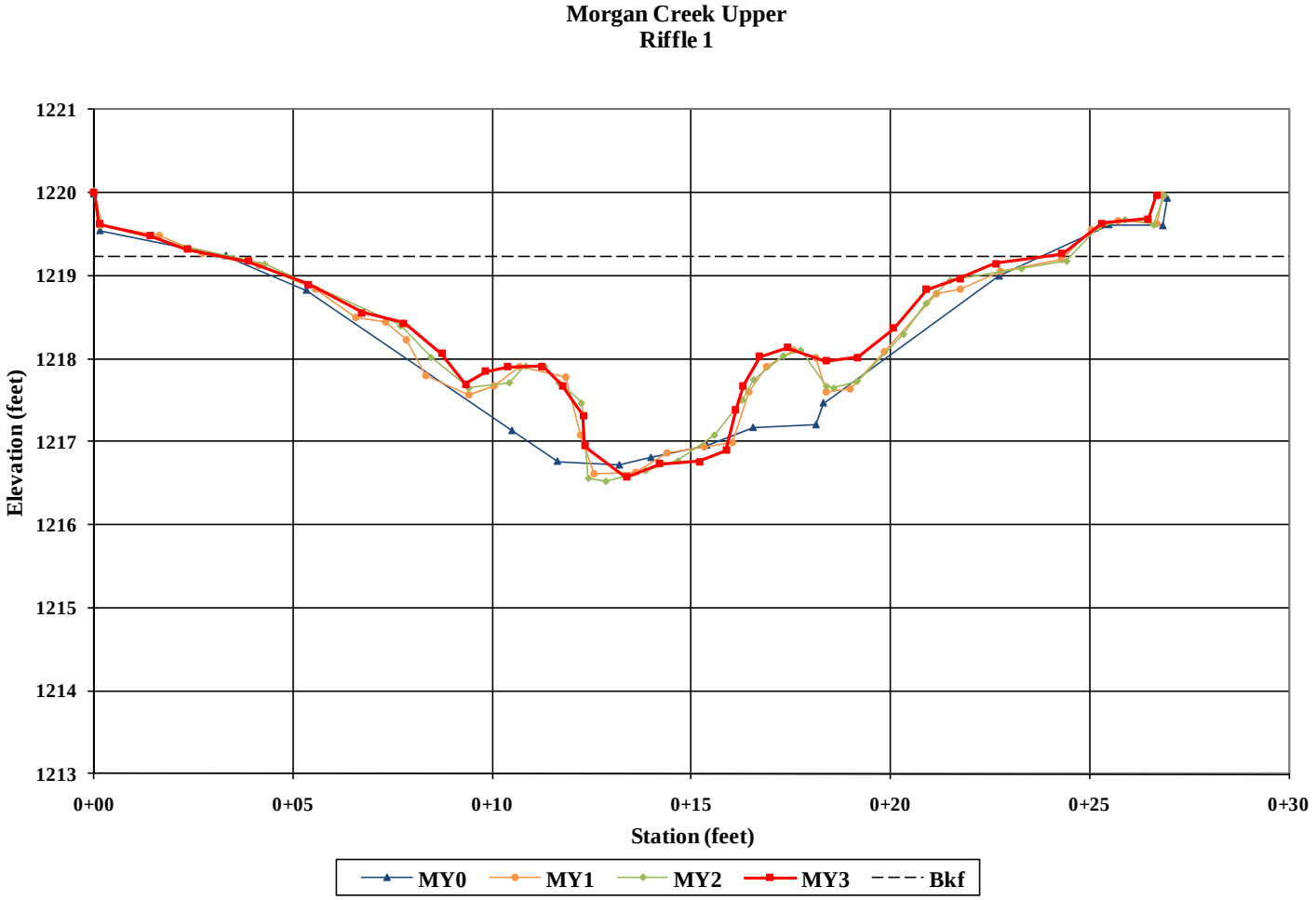
Morgan Creek - Unnamed Tributary 6
Longitudinal Profile



Morgan Creek Upper – Riffle 1
Cross-Section 1

Looking at Left Bank

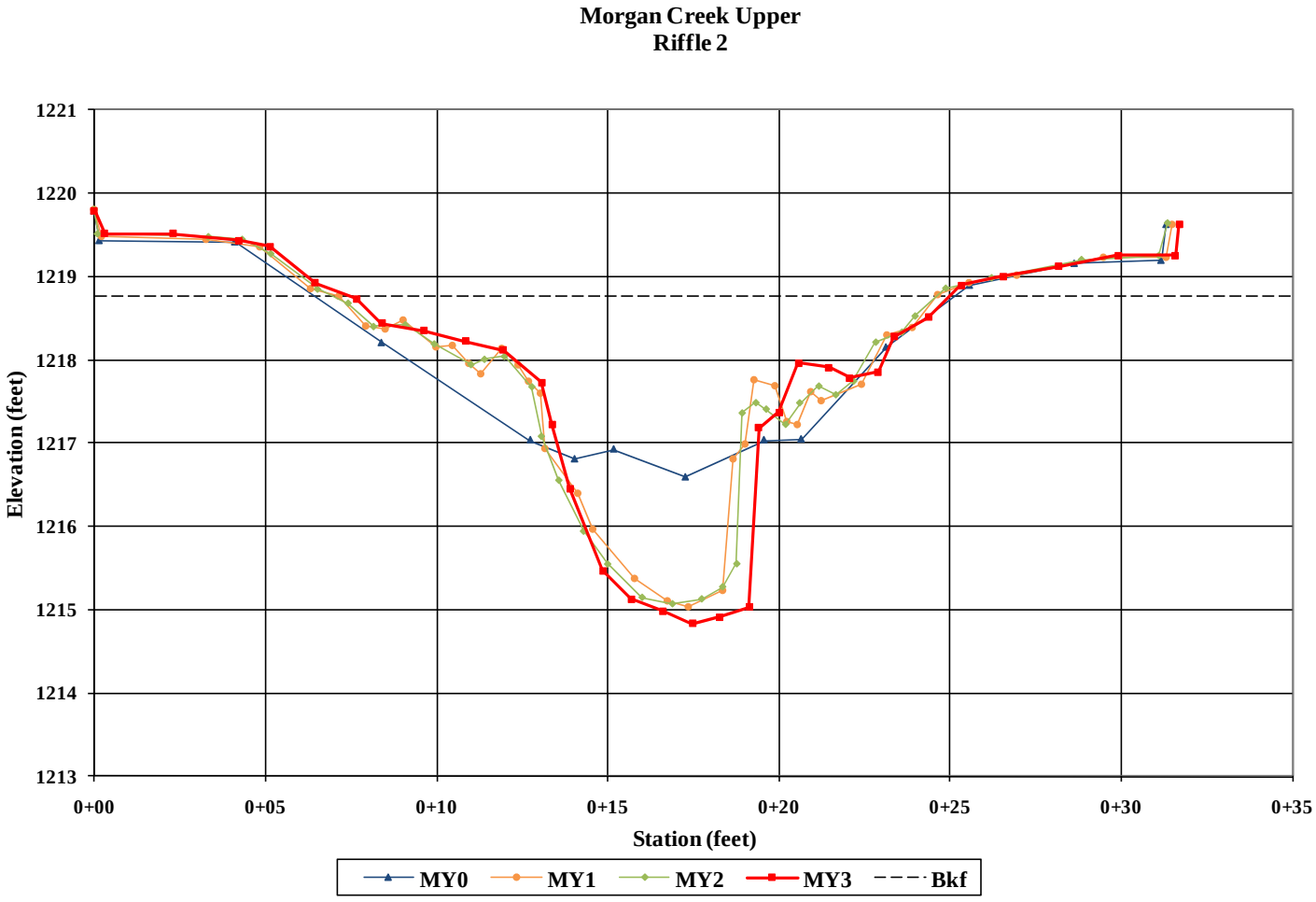
Looking at Right Bank



Morgan Creek Upper – Riffle 2
Cross-Section 2

Looking at Left Bank

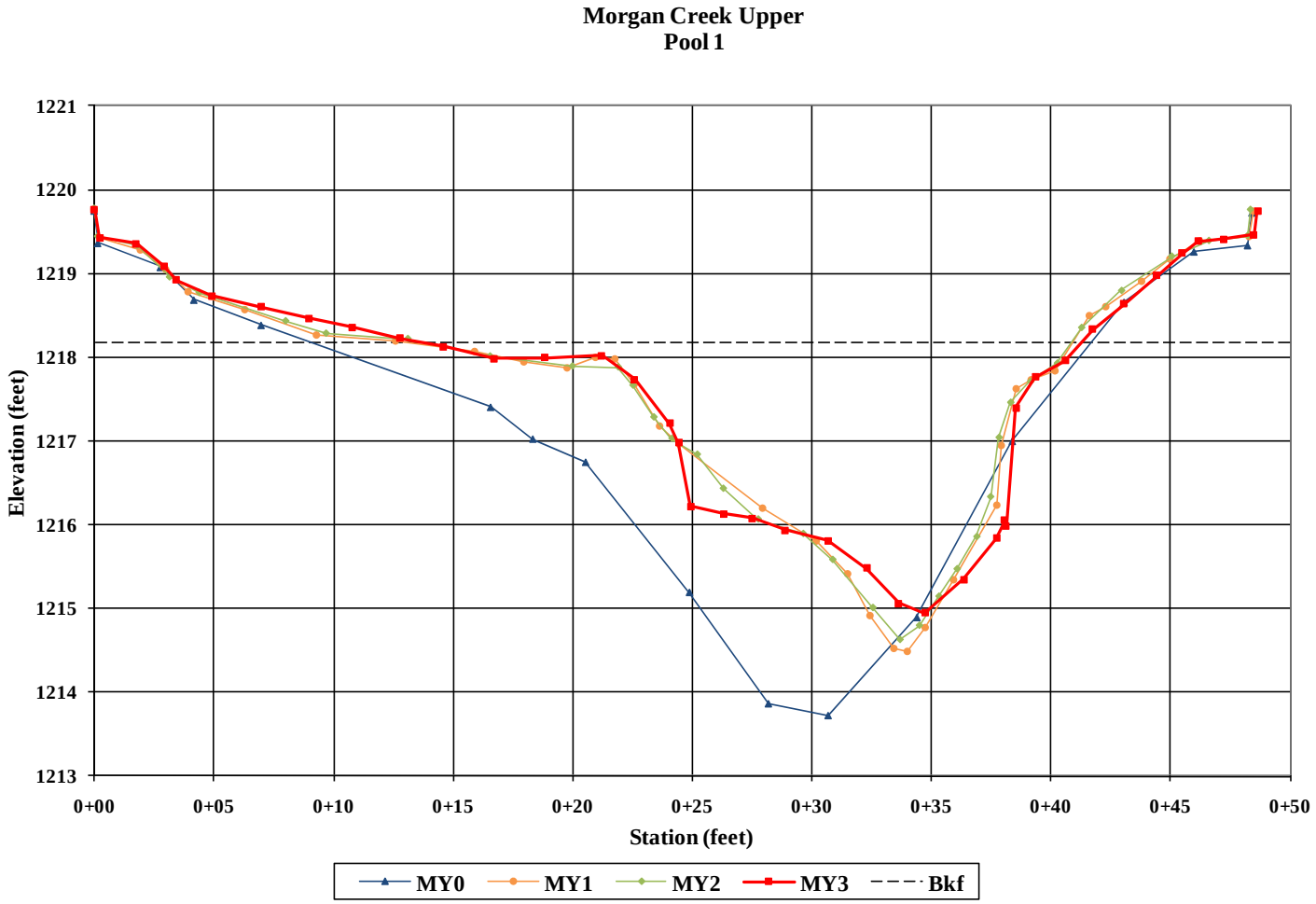
Looking at Right Bank



Morgan Creek Upper – Pool 1
Cross-Section 3

Looking at Left Bank

Looking at Right Bank

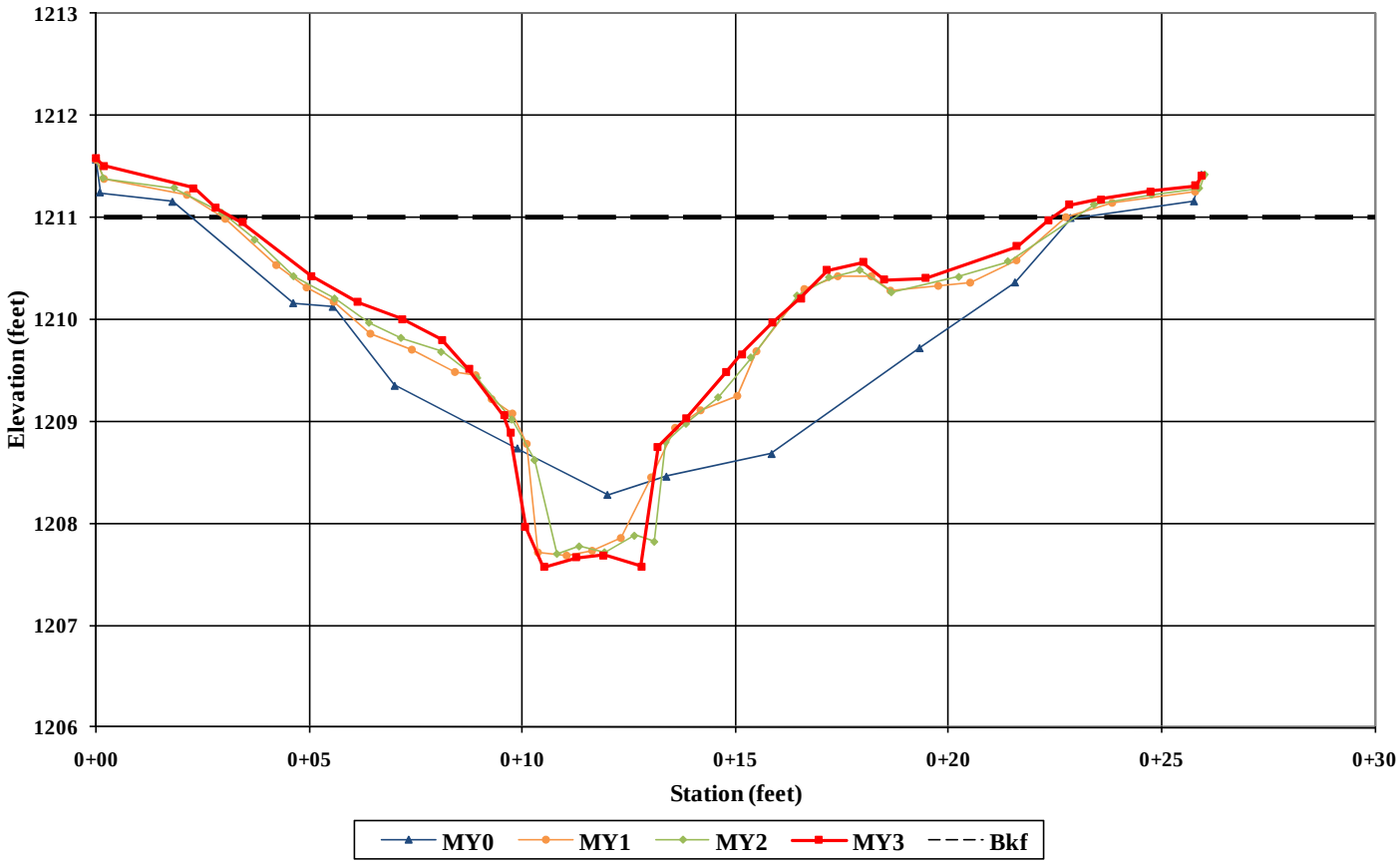


Morgan Creek Upper – Riffle 3
Cross-Section 4

Looking at Left Bank

Looking at Right Bank

Moragn Creek Upper
Riffle 3

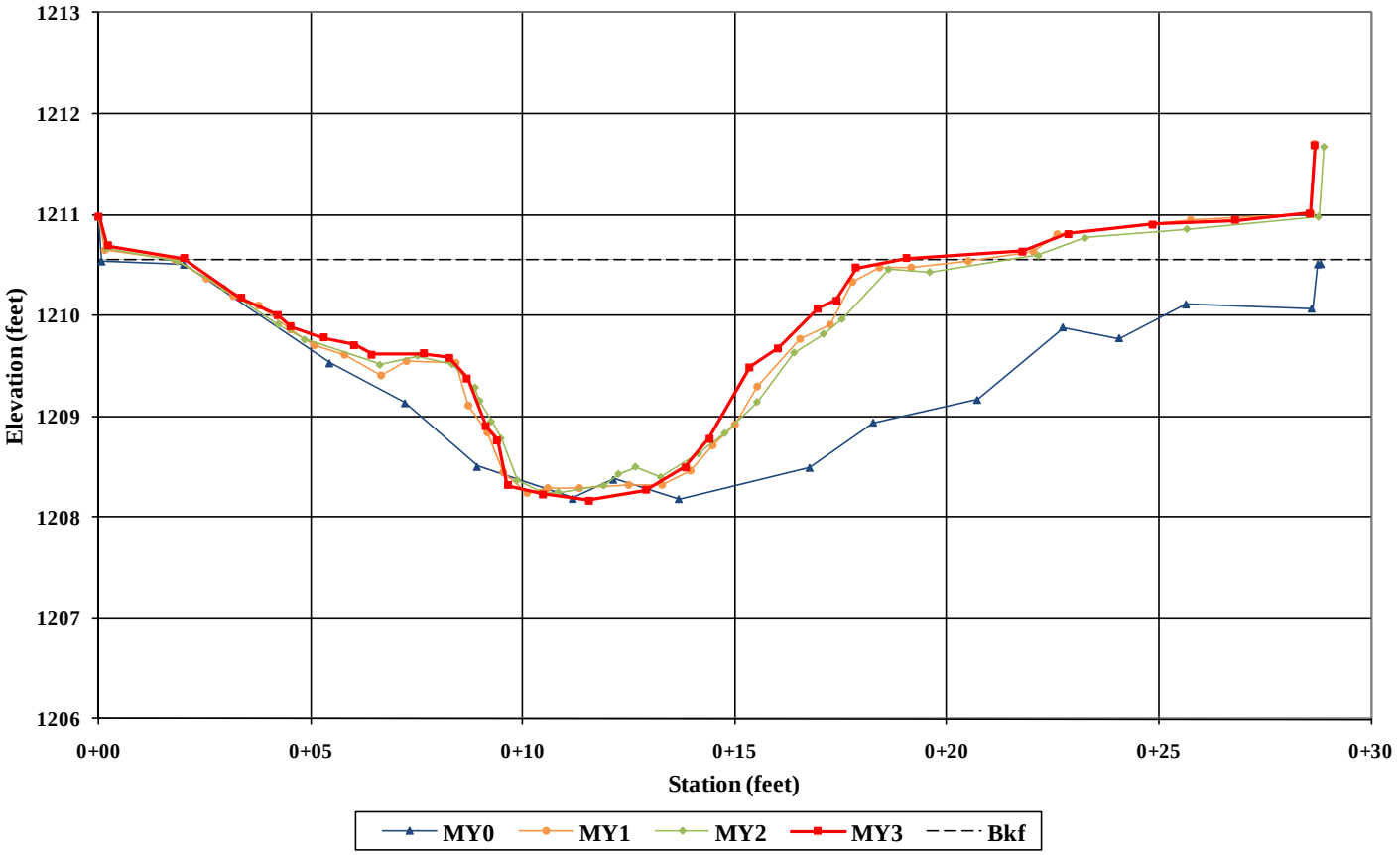


Morgan Creek Upper – Riffle 4
Cross-Section 5

Looking at Left Bank

Looking at Right Bank

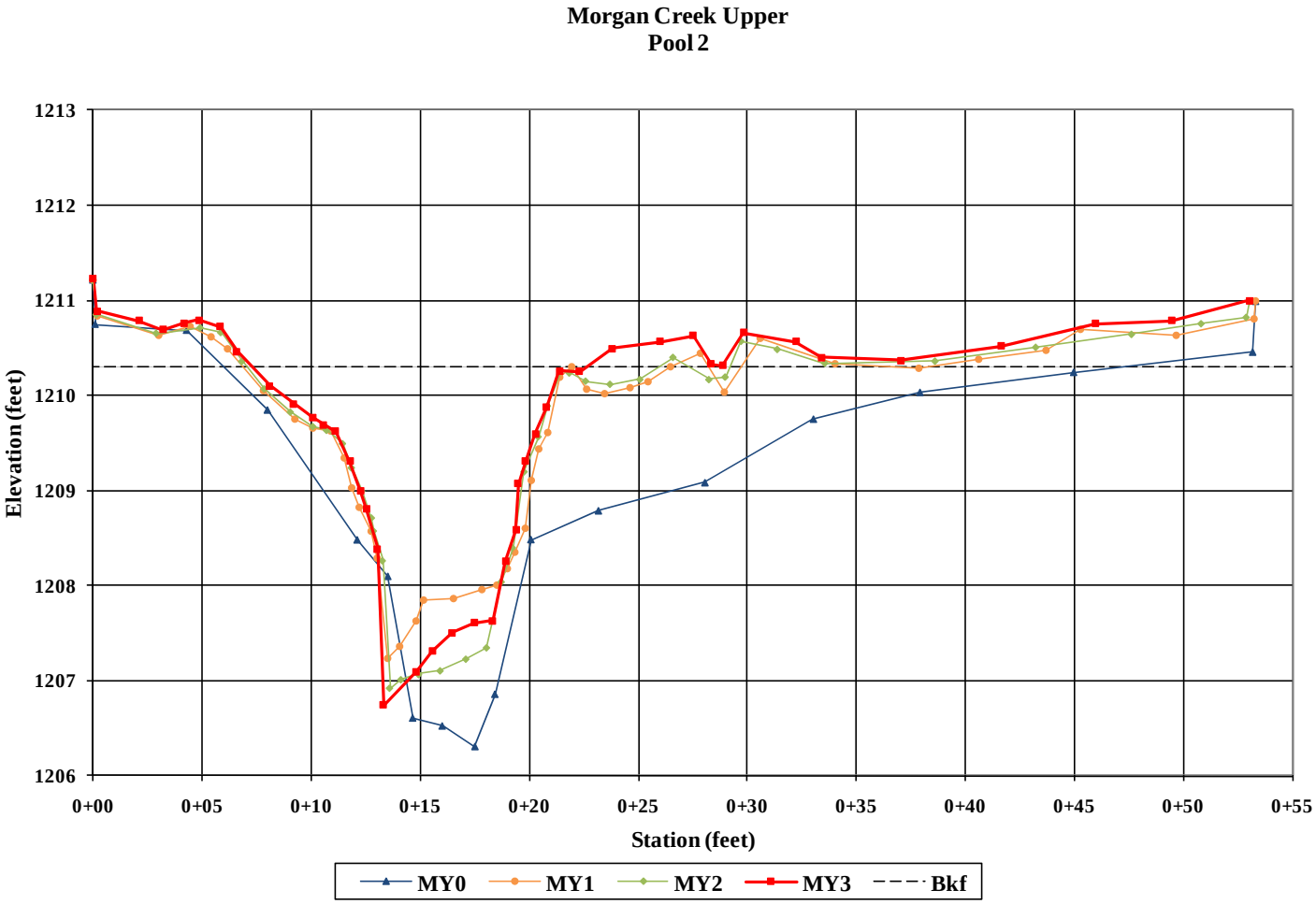
Morgan Creek Upper
Riffle 4



Morgan Creek Upper – Pool 2
Cross-Section 6

Looking at Left Bank

Looking at Right Bank

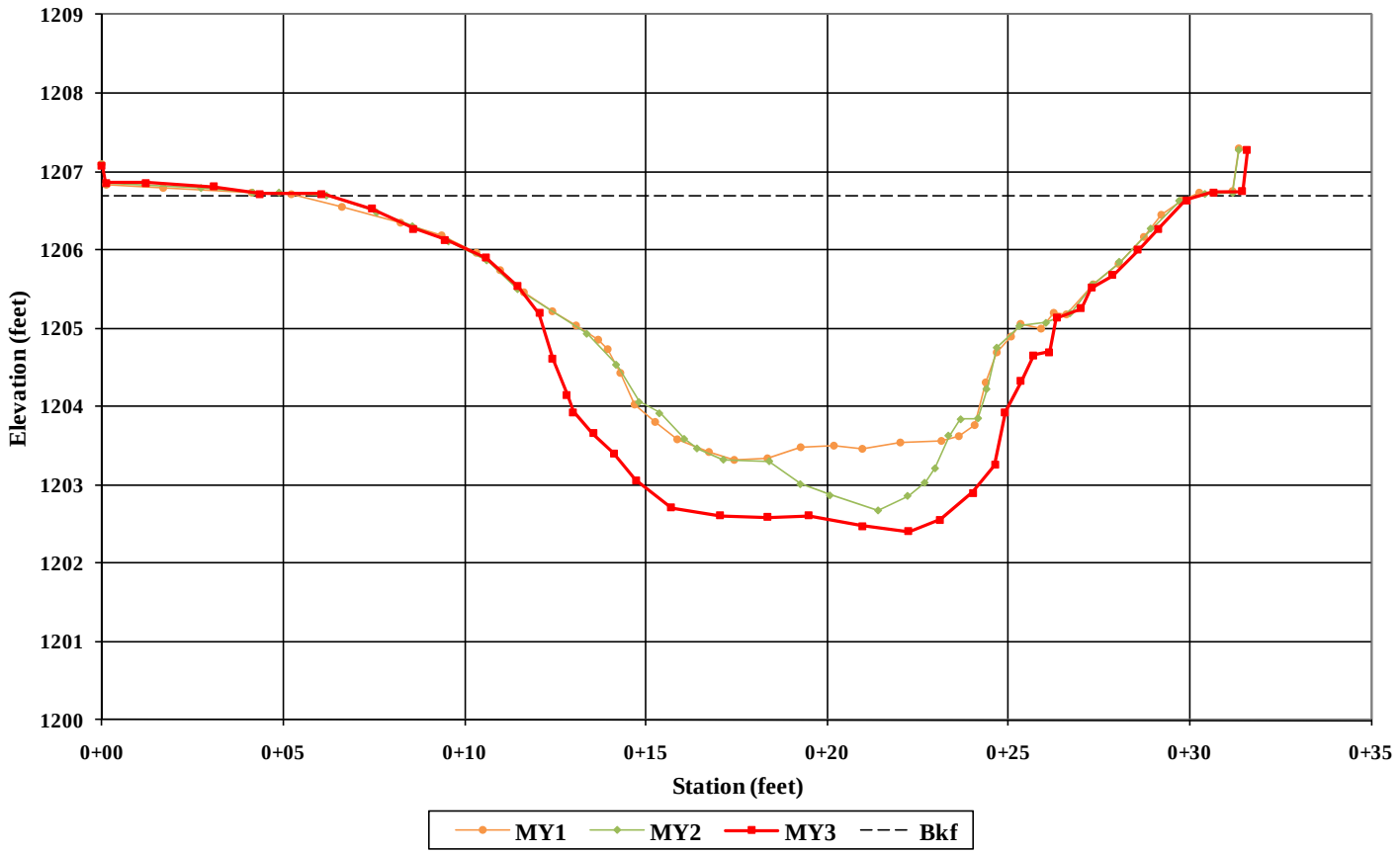


Morgan Creek Lower – Riffle 1
Cross-Section 1

Looking at Left Bank

Looking at Right Bank

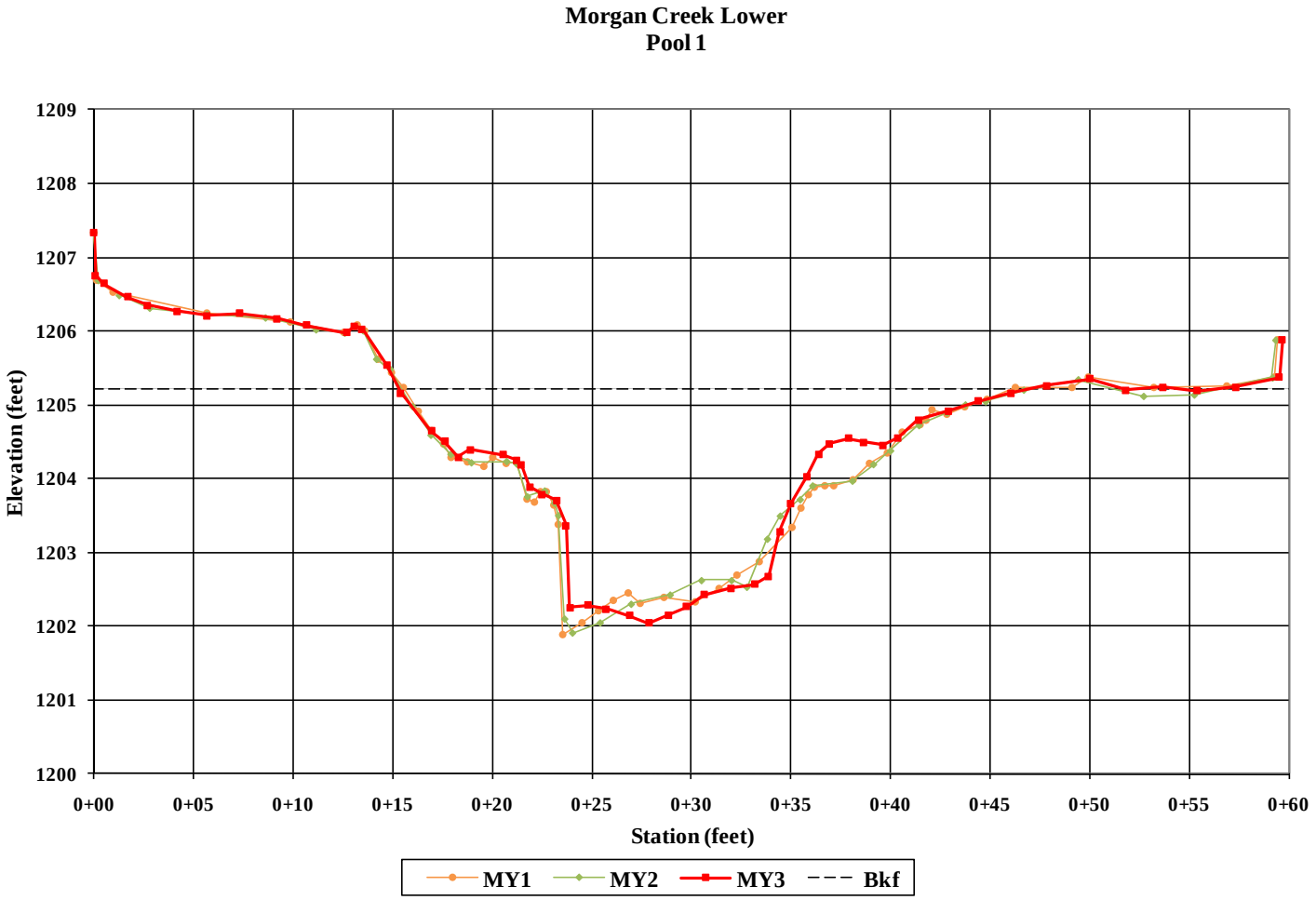
Morgan Creek Lower
Riffle 1



Morgan Creek Lower – Pool 1
Cross-Section 2

Looking at Left Bank

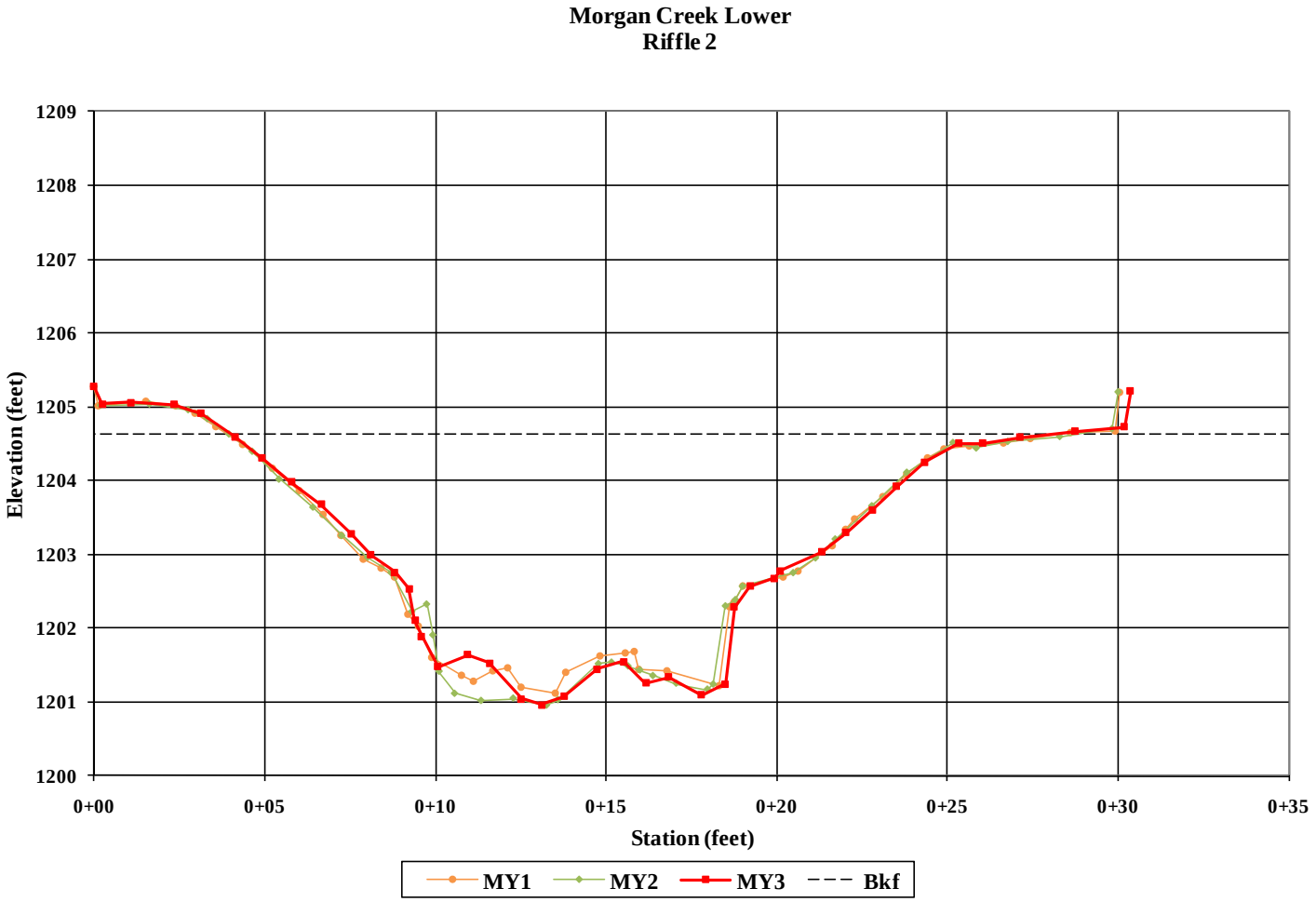
Looking at Right Bank



Morgan Creek Lower – Riffle 2
Cross-Section 3

Looking at Left Bank

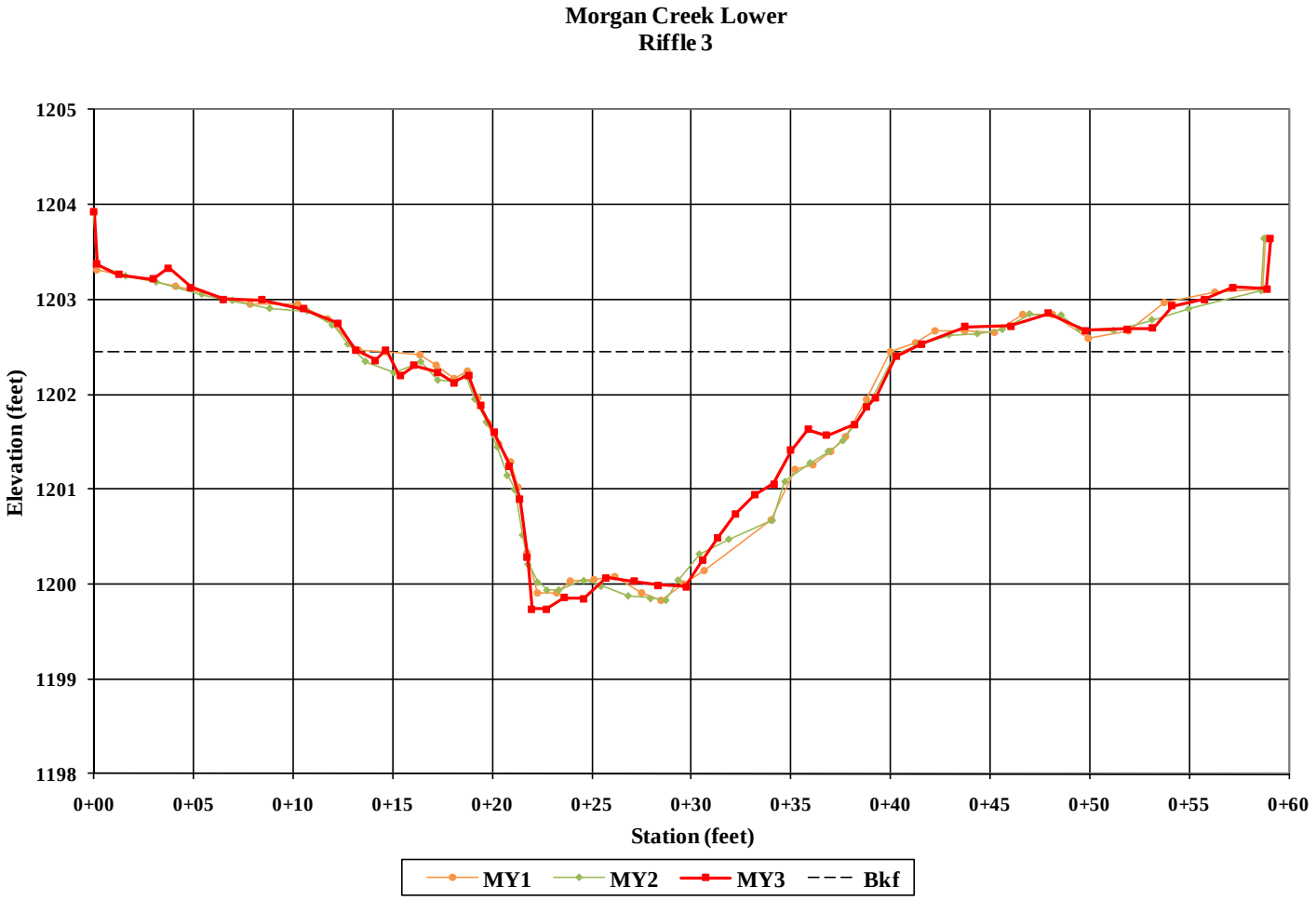
Looking at Right Bank



Morgan Creek Lower – Riffle 3
Cross-Section 4

Looking at Left Bank

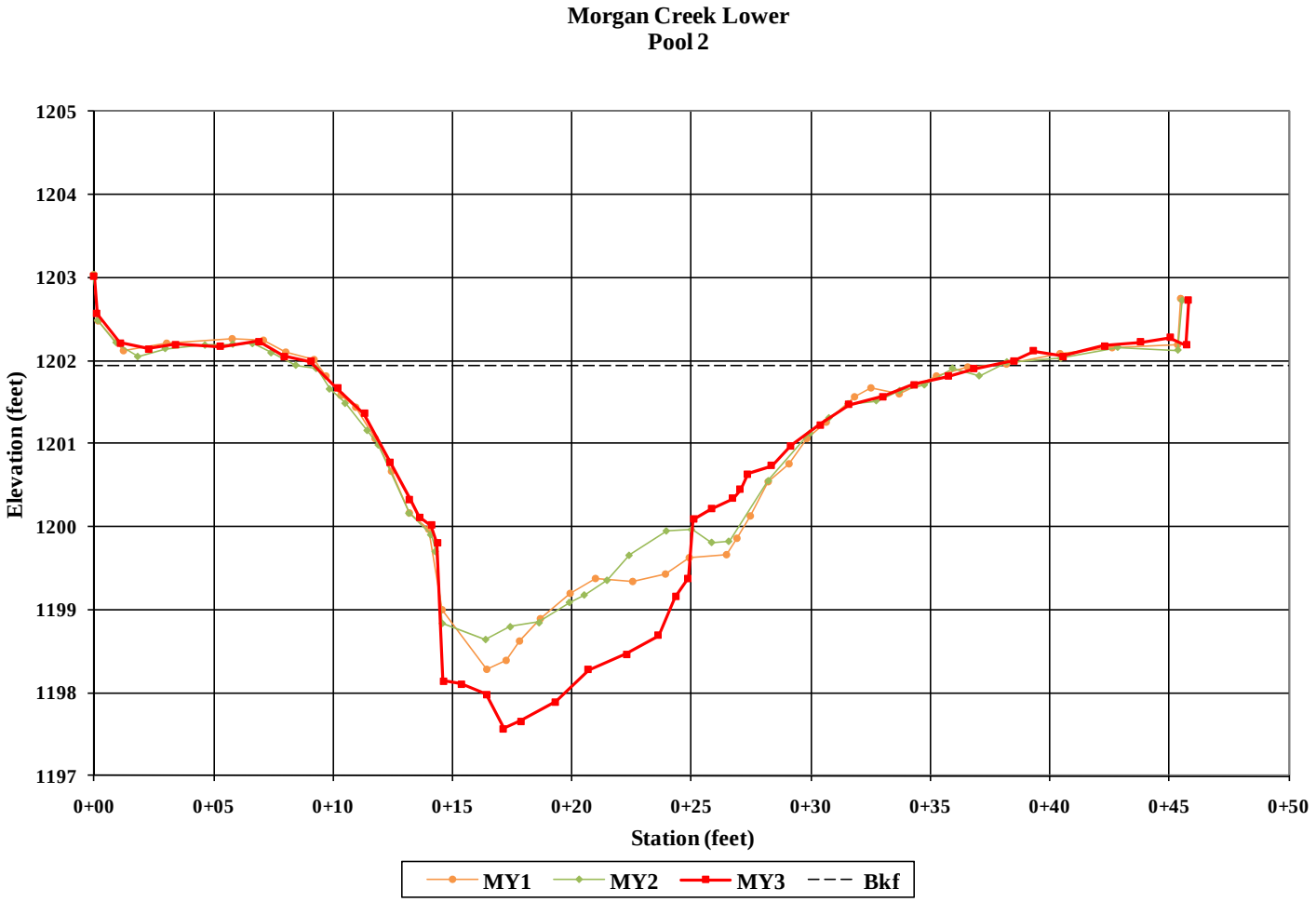
Looking at Right Bank



Morgan Creek Lower – Pool 2
Cross-Section 5

Looking at Left Bank

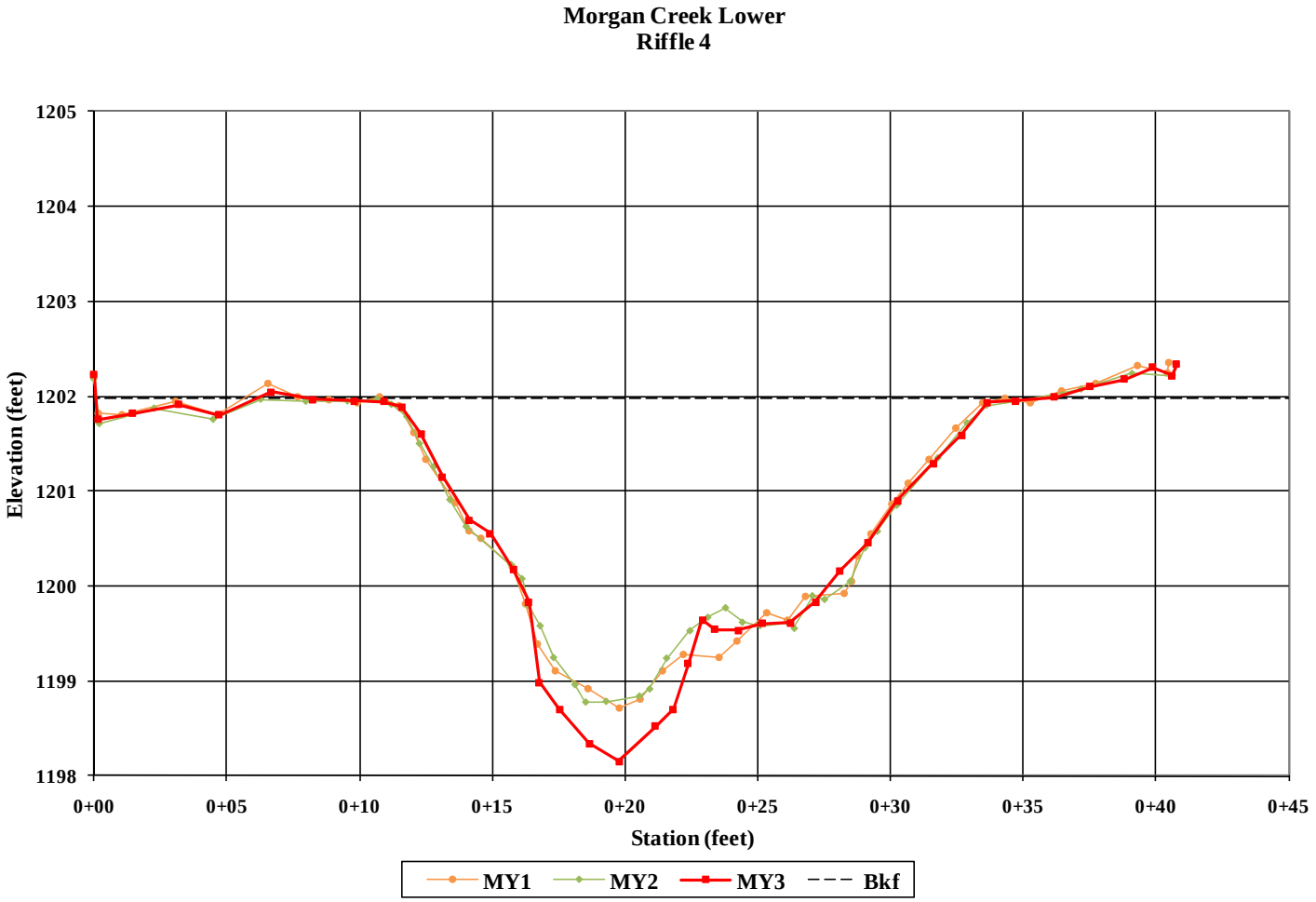
Looking at Right Bank



Morgan Creek Lower – Riffle 4
Cross-Section 6

Looking at Left Bank

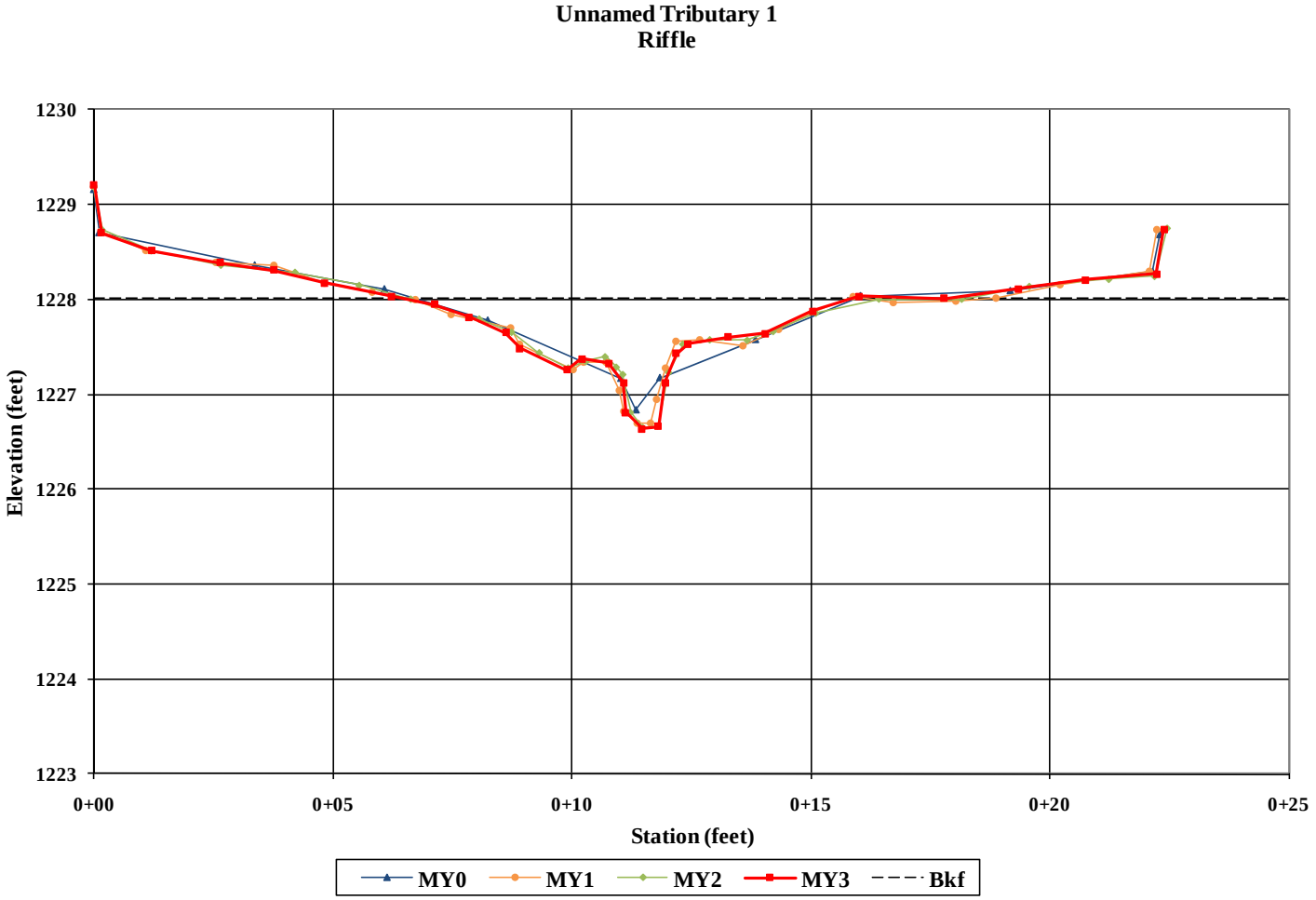
Looking at Right Bank



Unnamed Tributary 1 – Riffle
Cross-Section 1

Looking at Left Bank

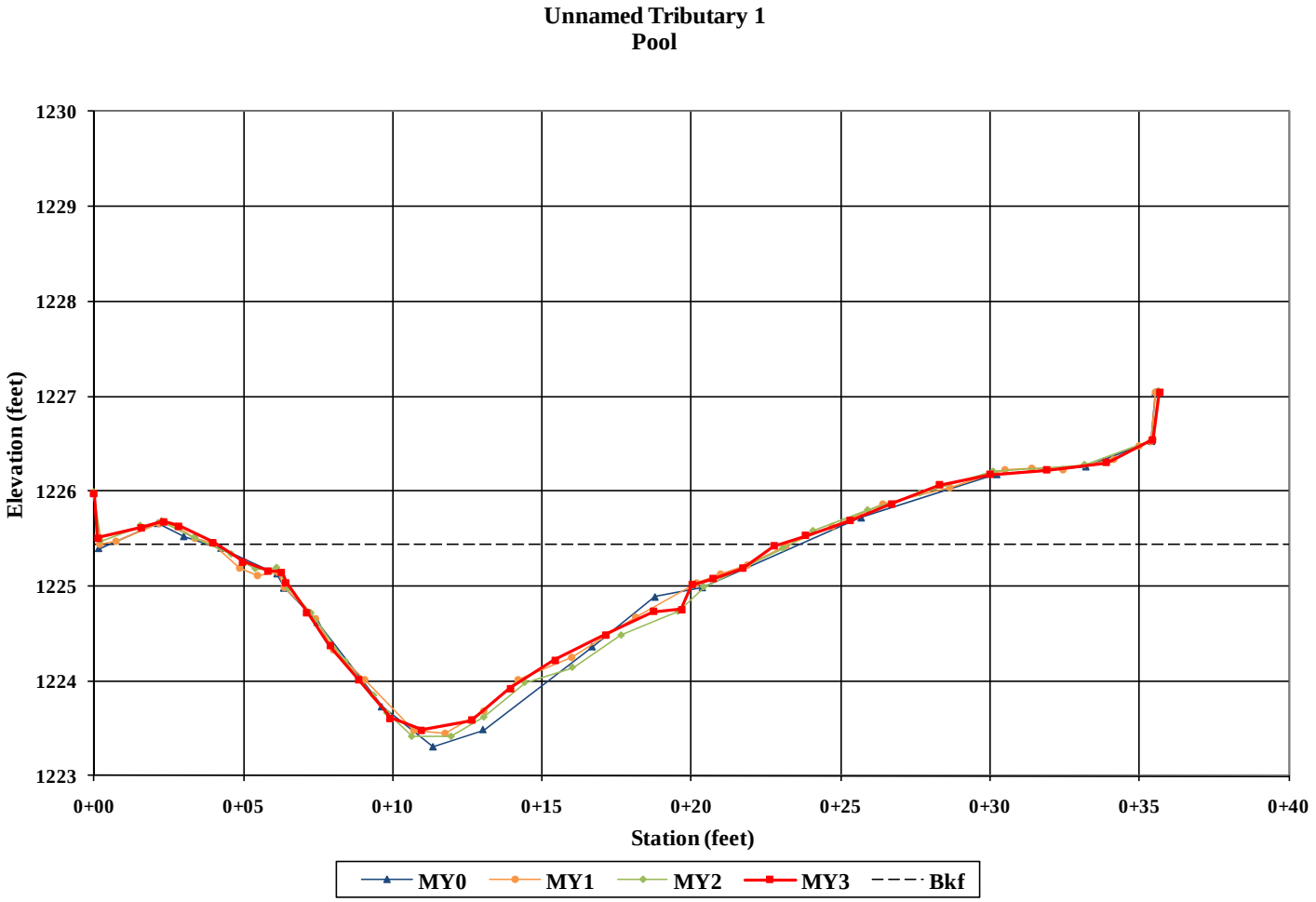
Looking at Right Bank



Unnamed Tributary 1 – Pool
Cross-Section 2

Looking at Left Bank

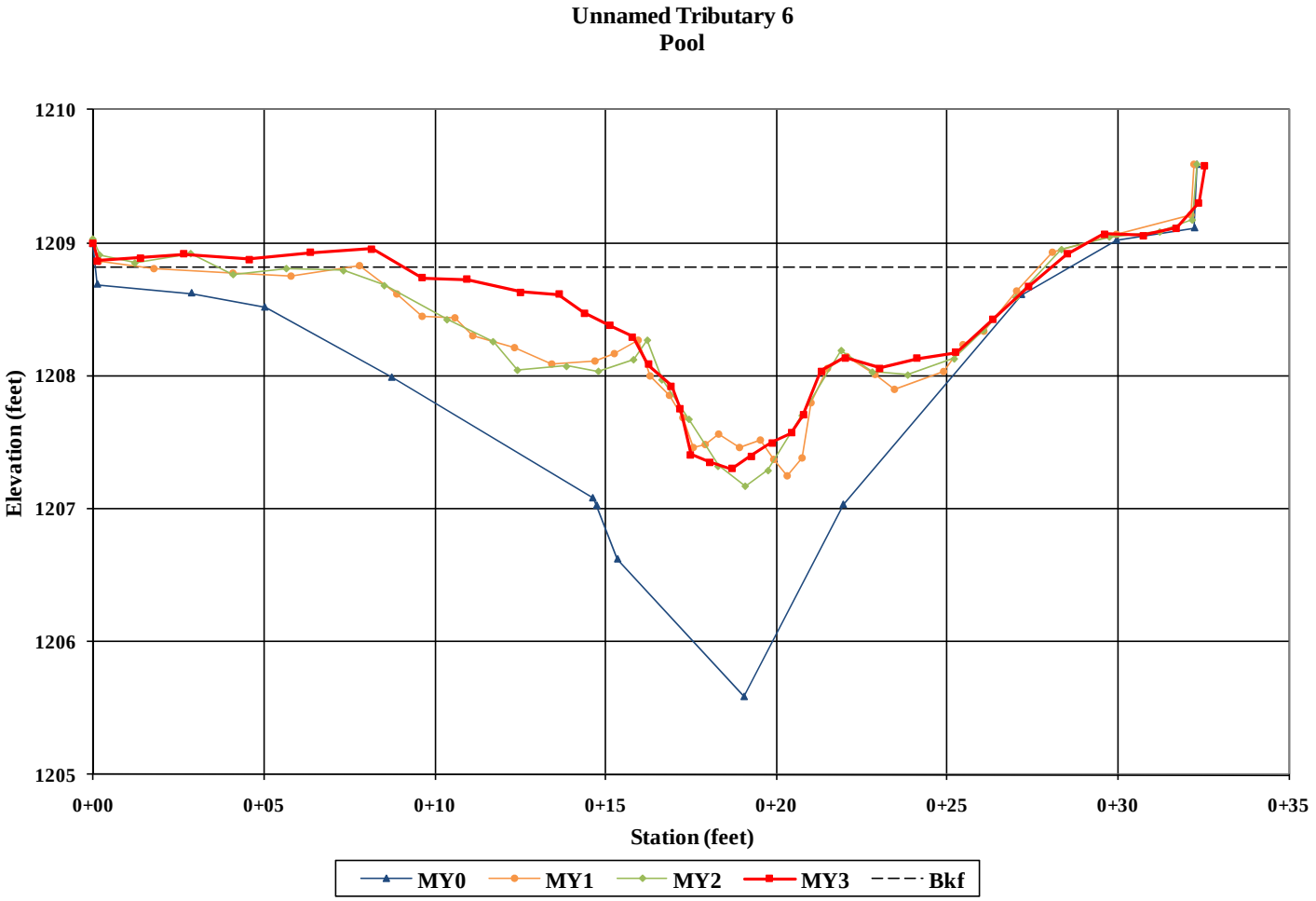
Looking at Right Bank



Unnamed Tributary 6 – Pool
Cross-Section 1

Looking at Left Bank

Looking at Right Bank

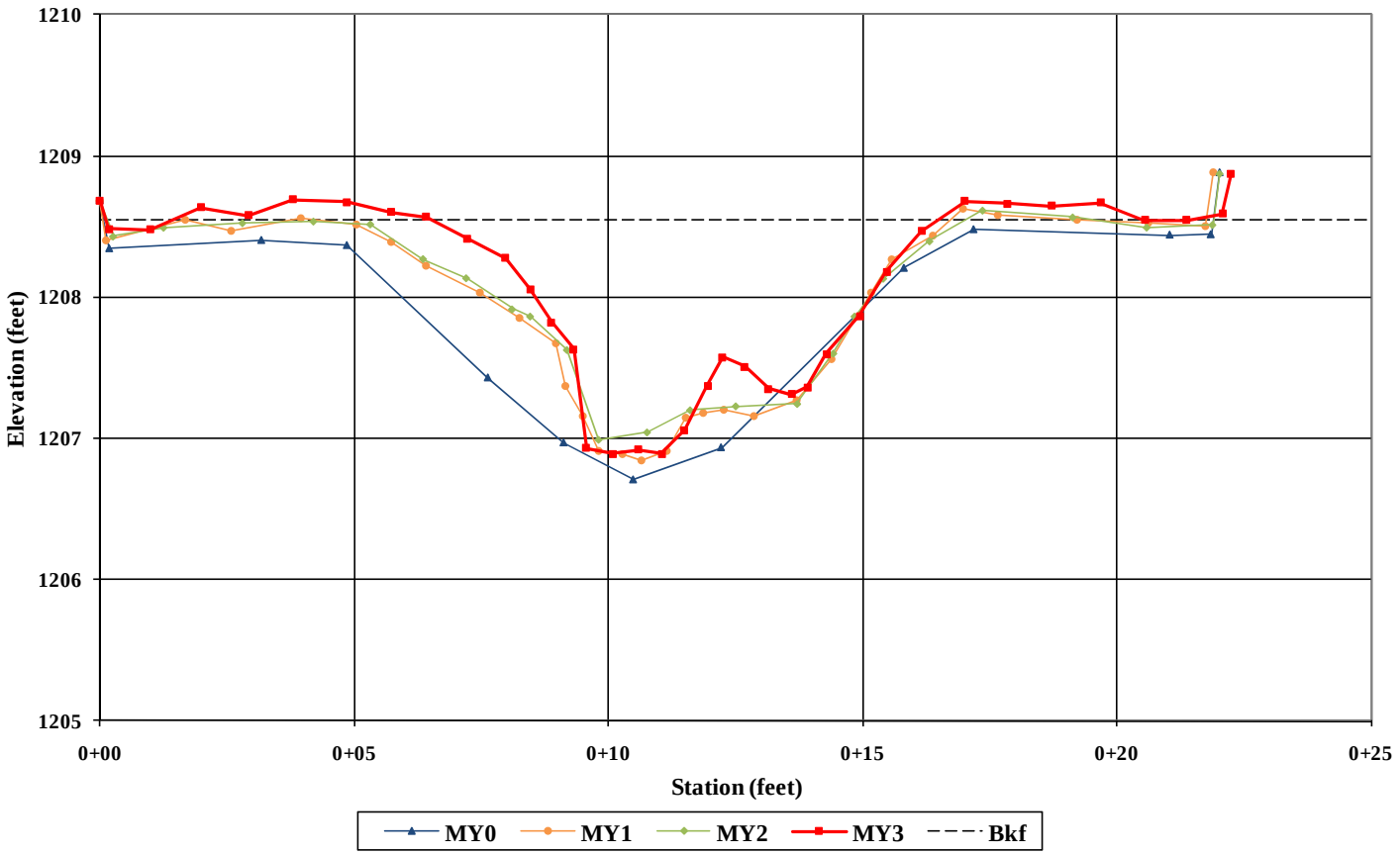


Unnamed Tributary 6 – Riffle
Cross-Section 2

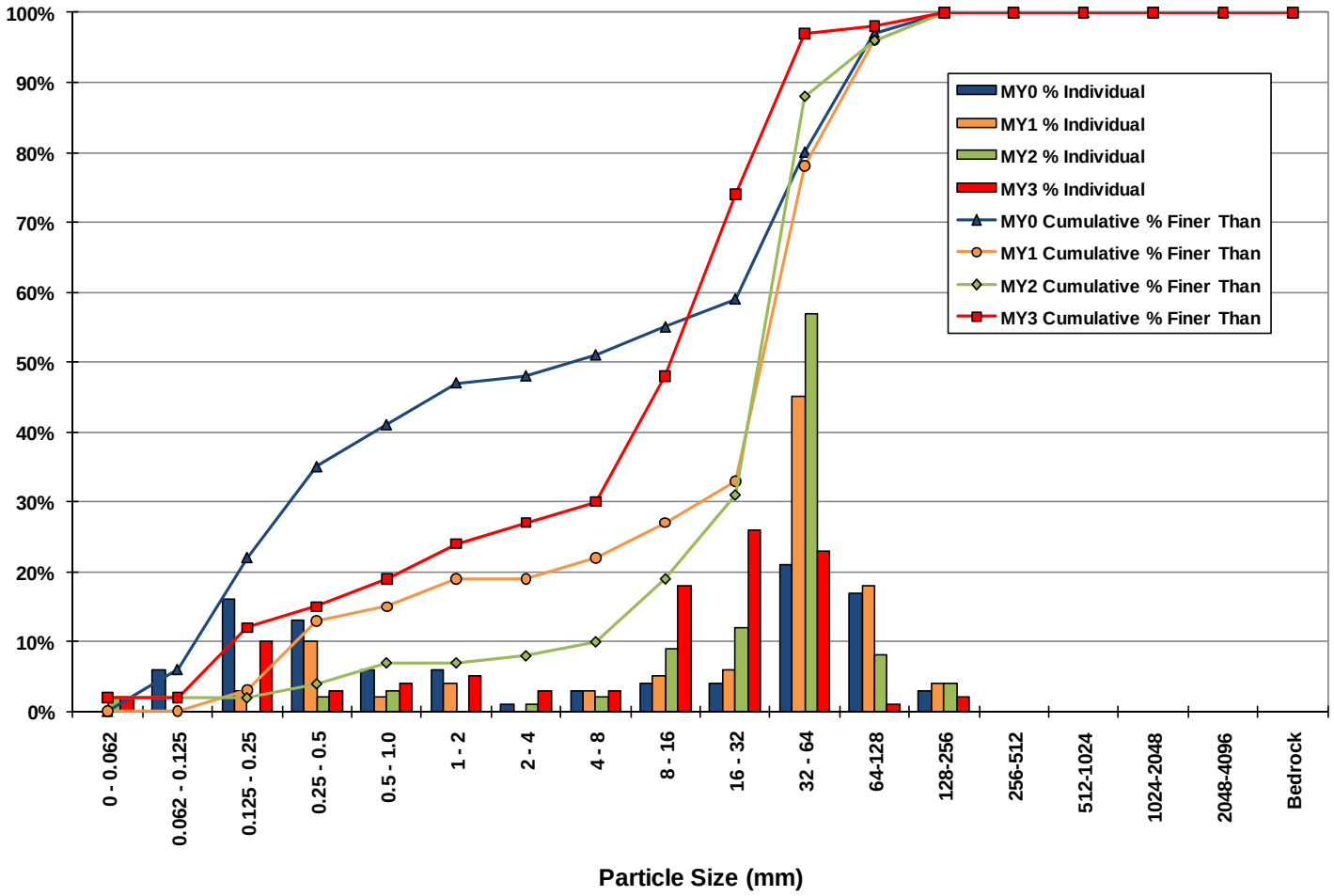
Looking at Left Bank

Looking at Right Bank

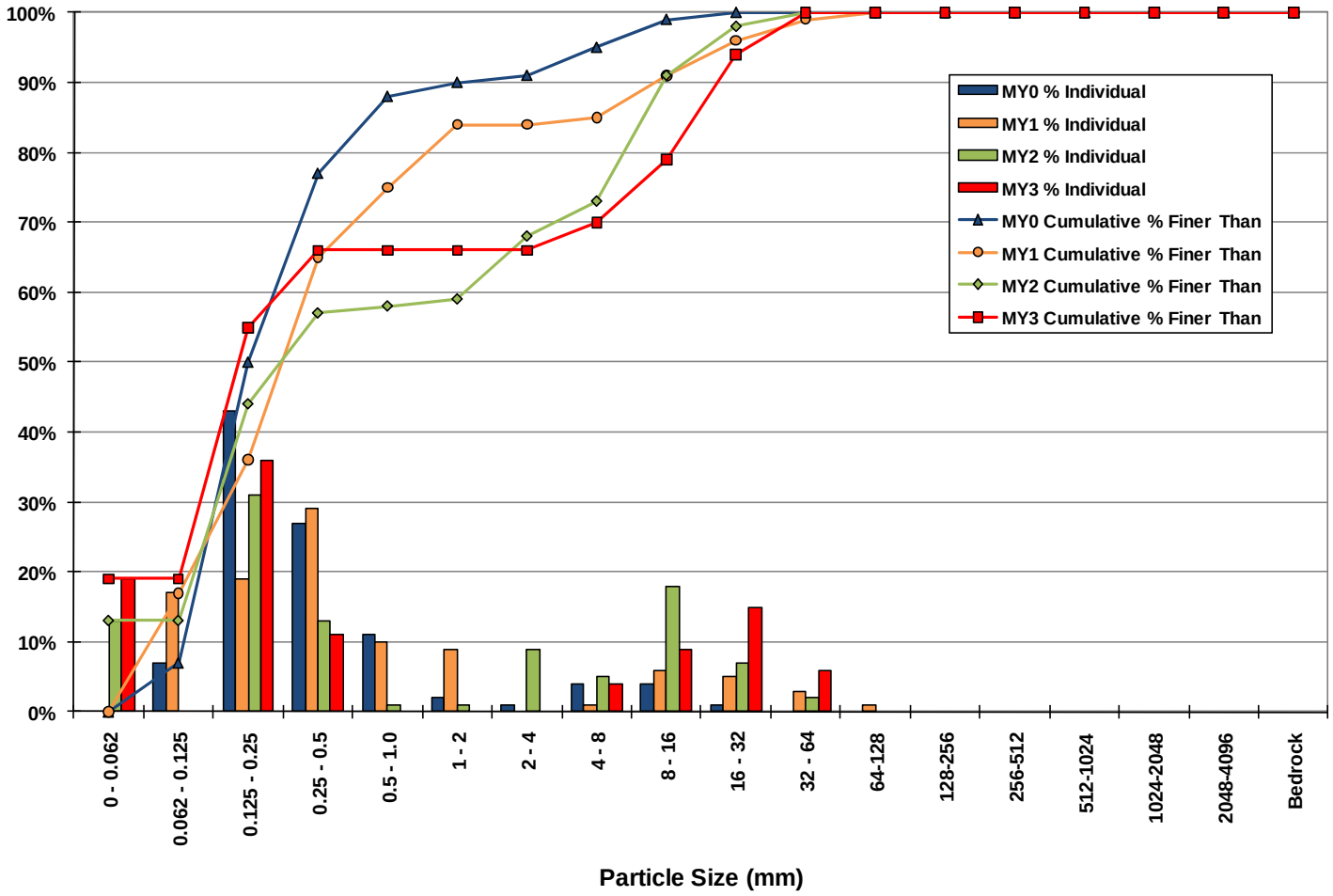
Unnamed Tributary 6
Riffle



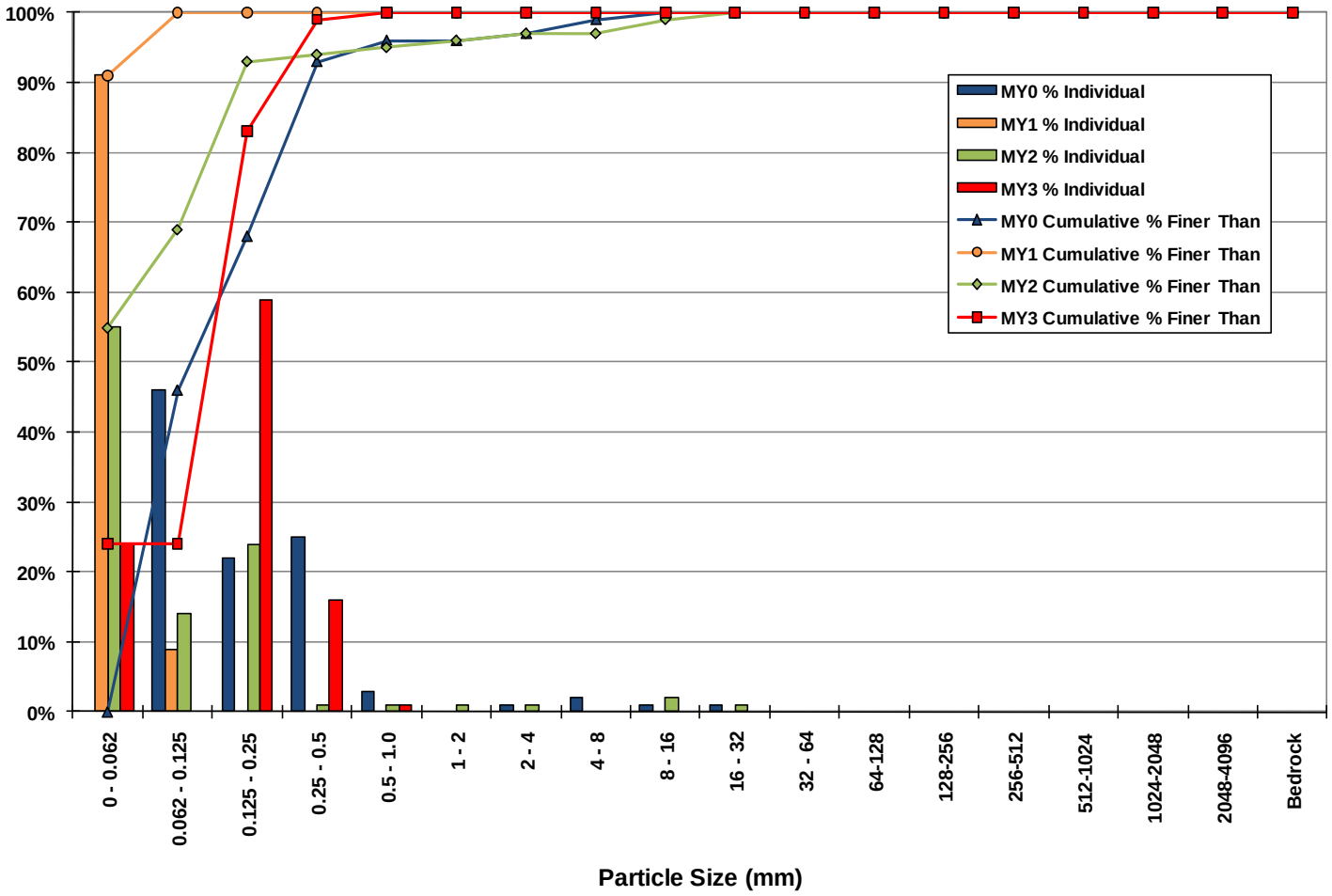
Morgan Creek Upper – Riffle 1
Pebble Count



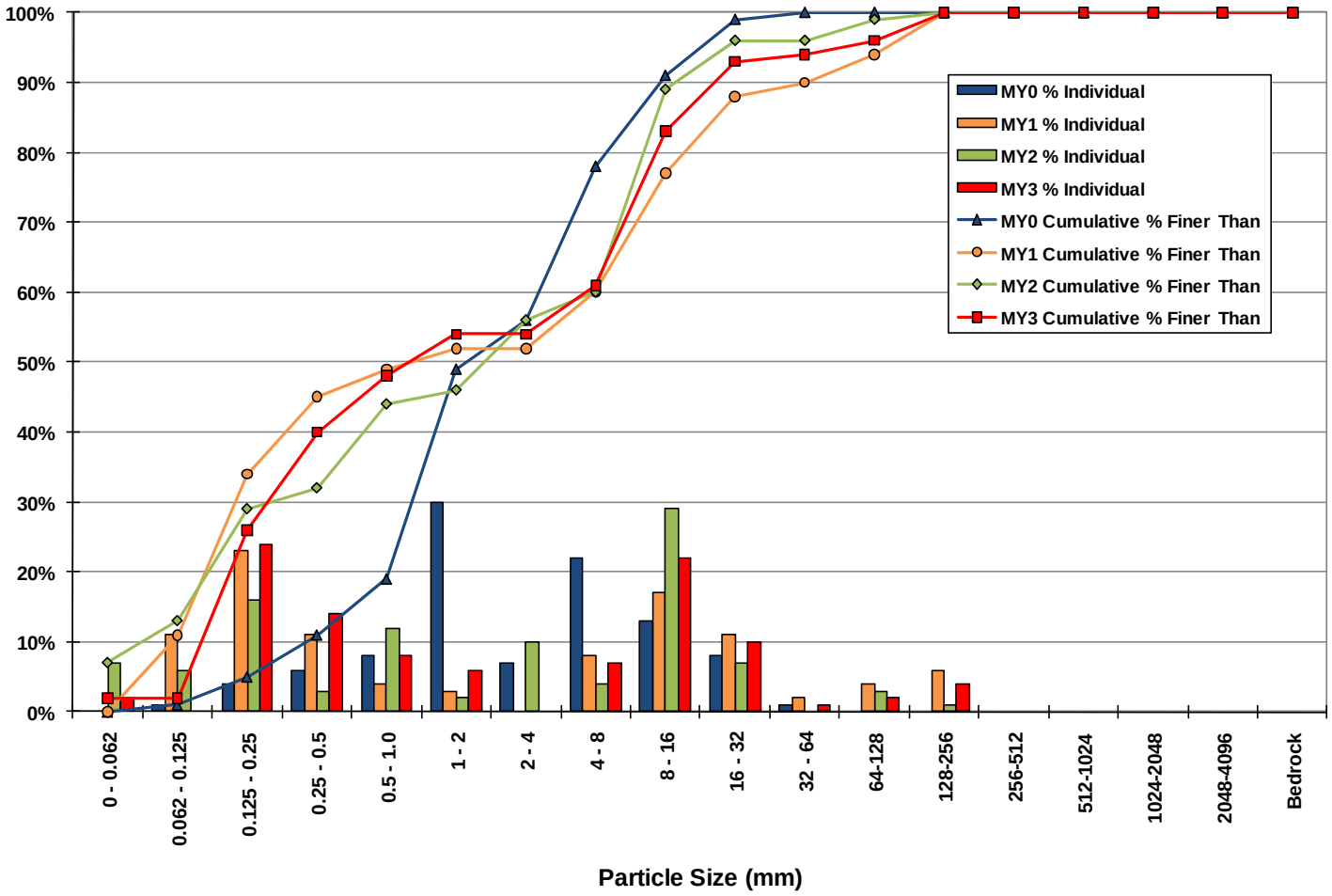
Morgan Creek Upper – Riffle 2
Pebble Count



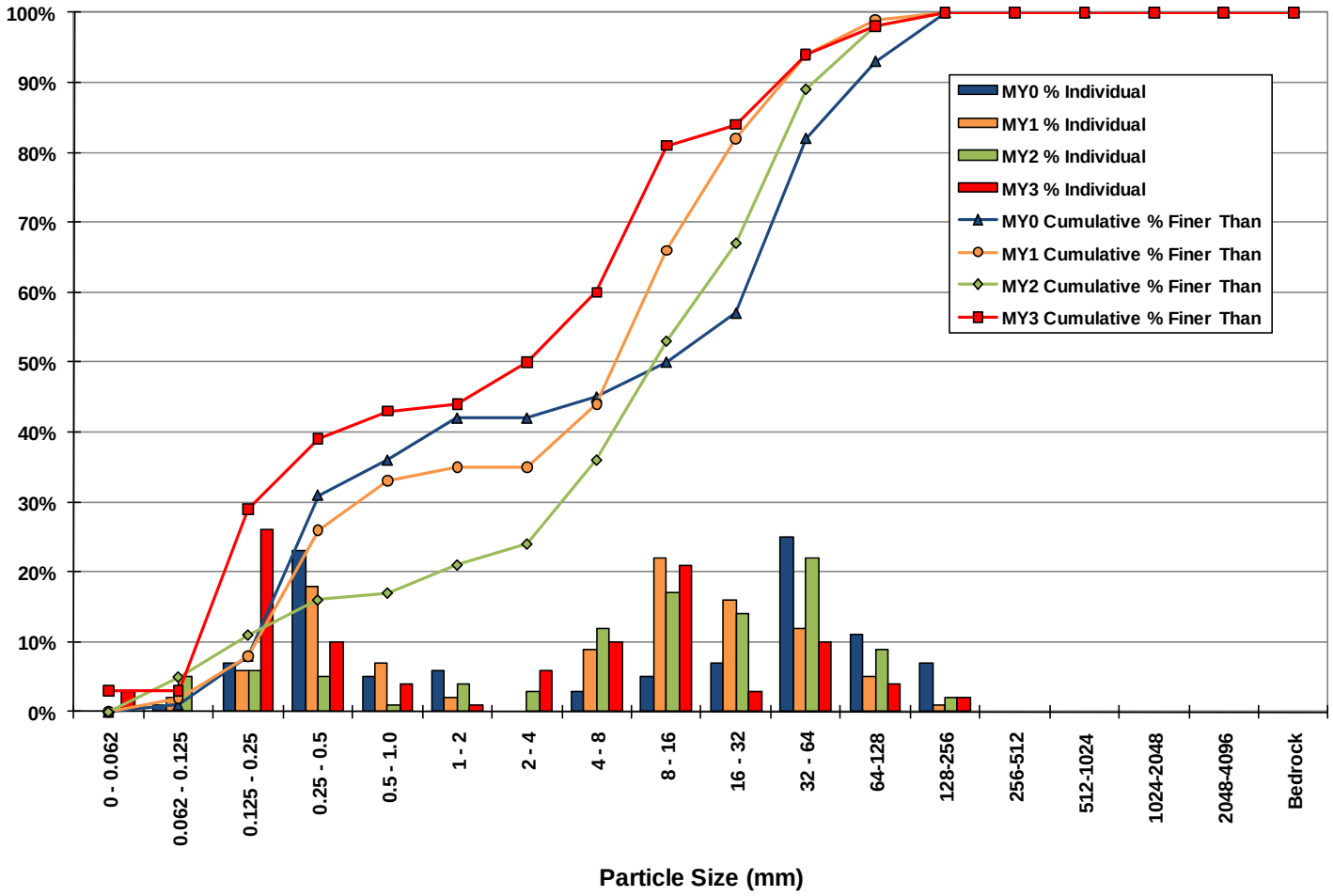
Morgan Creek Upper – Pool 1
Pebble Count



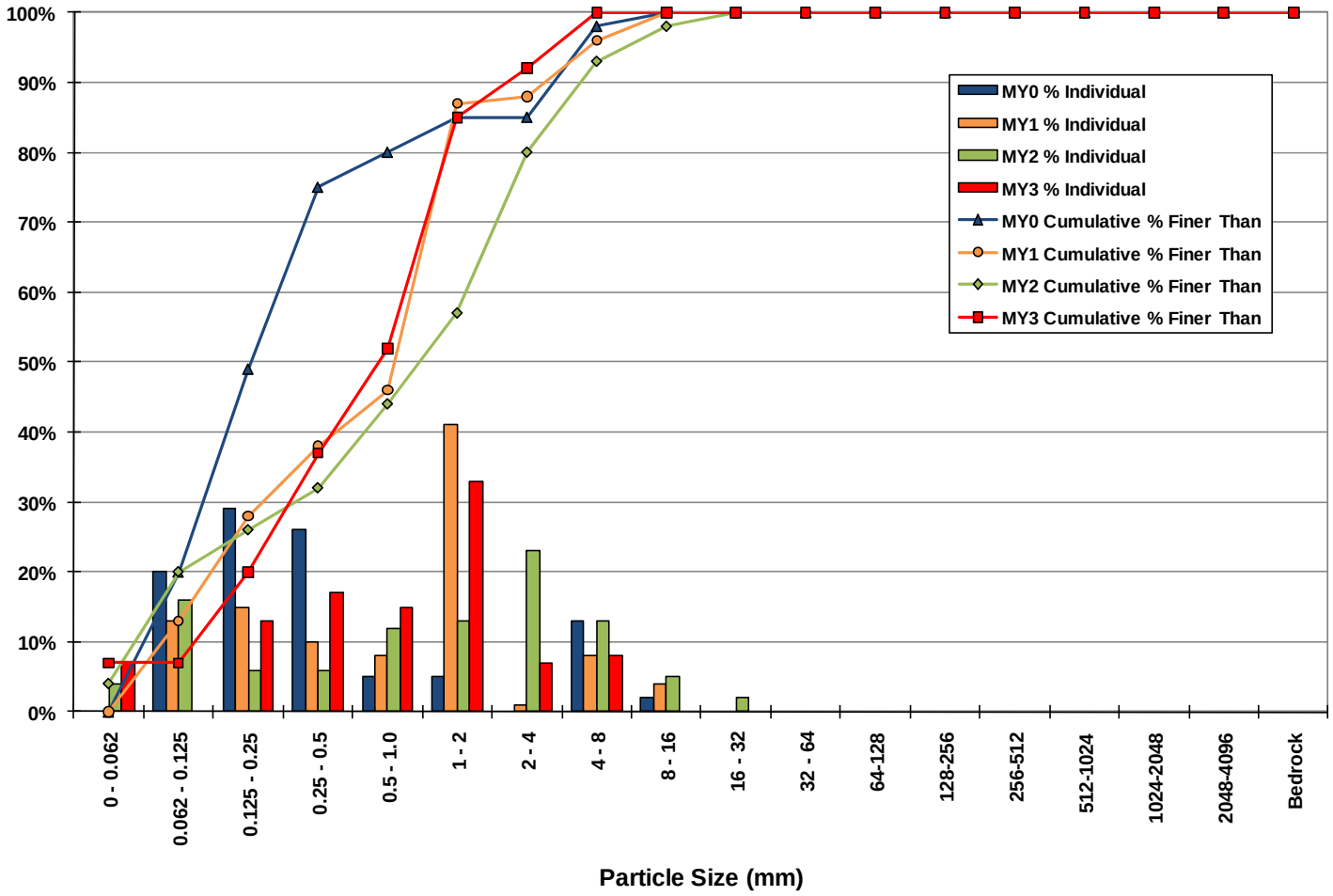
Morgan Creek Upper – Riffle 3
Pebble Count



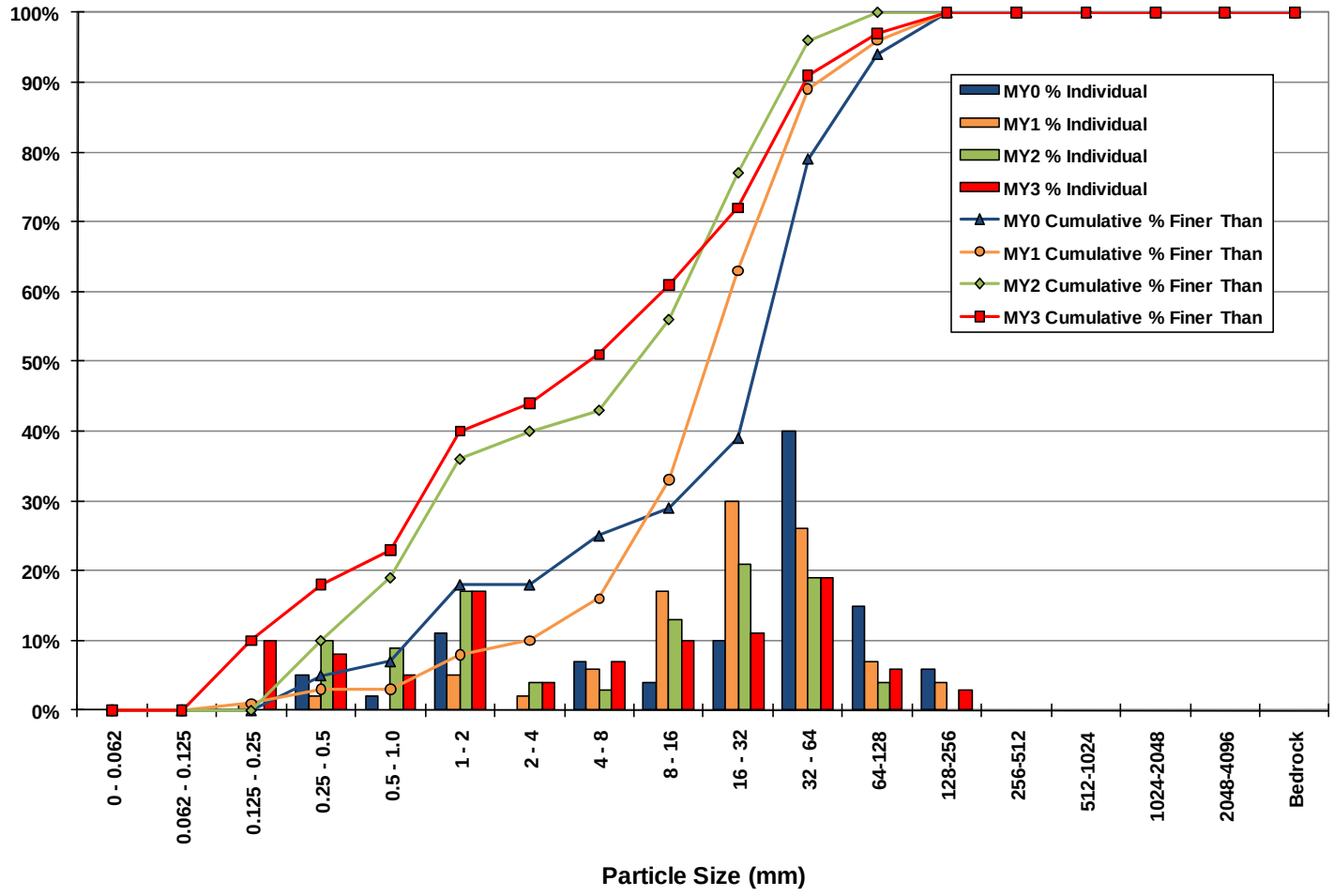
Morgan Creek Upper – Riffle 4
Pebble Count



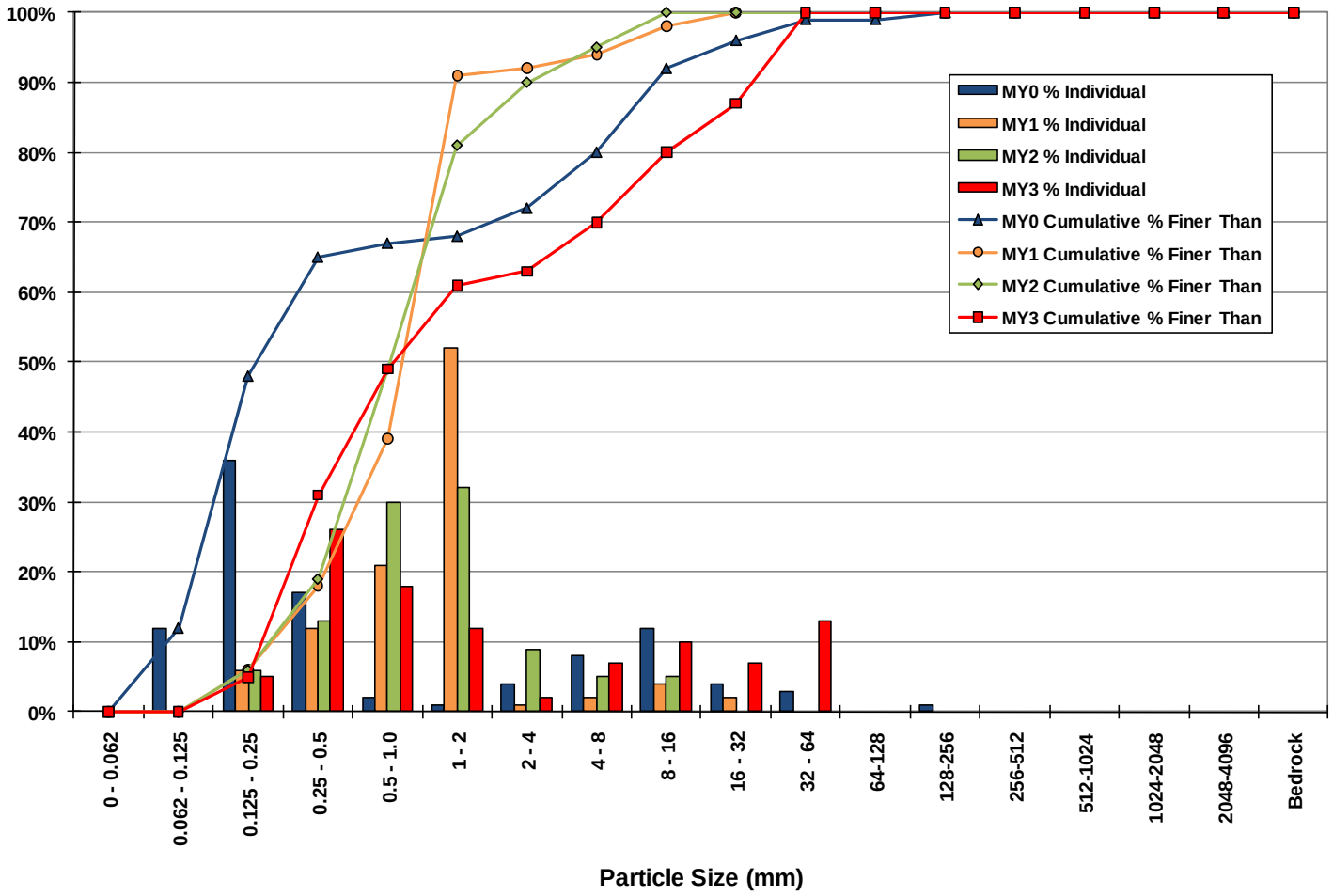
Morgan Creek Upper – Pool 2
Pebble Count



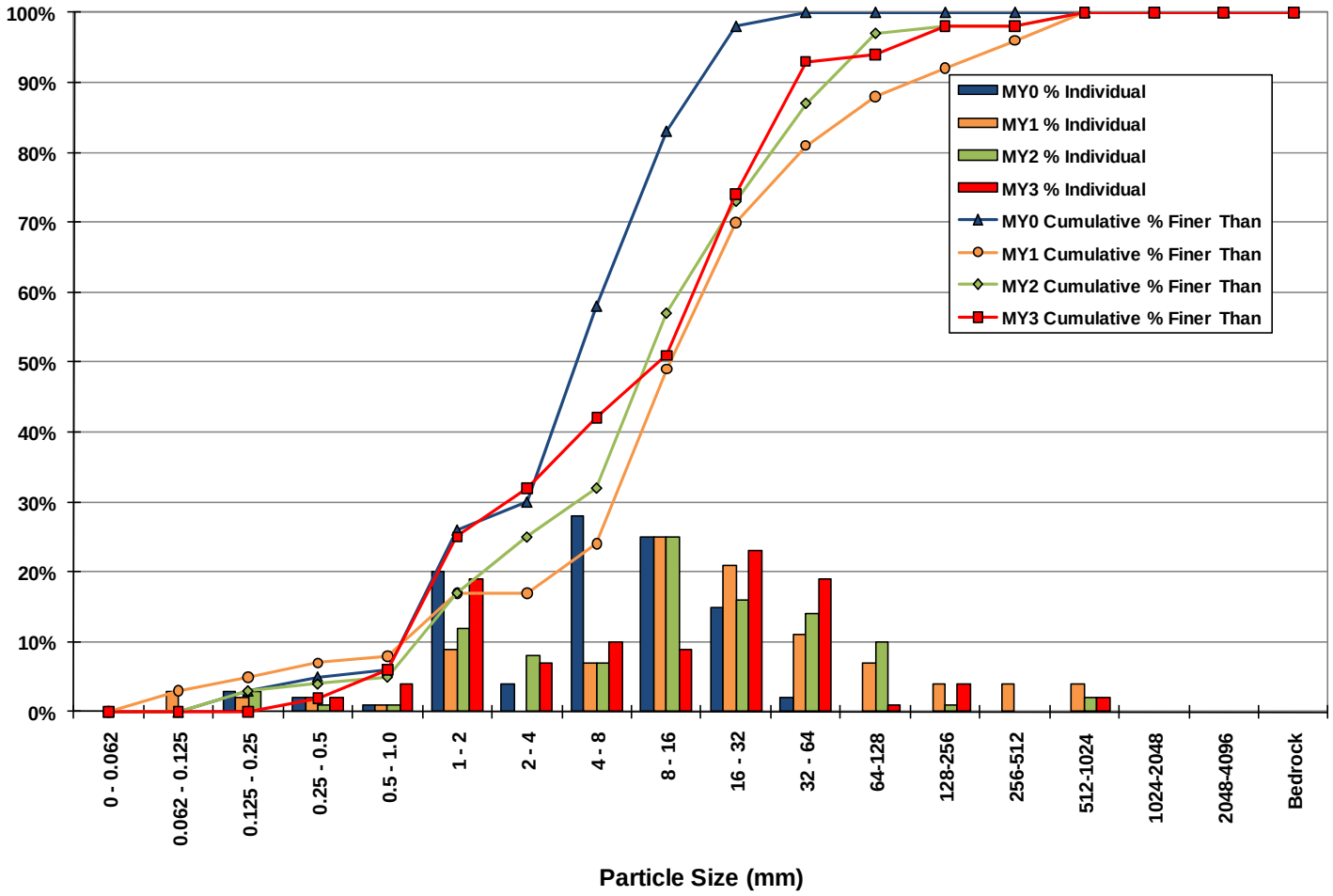
Morgan Creek Lower – Riffle 1
Pebble Count



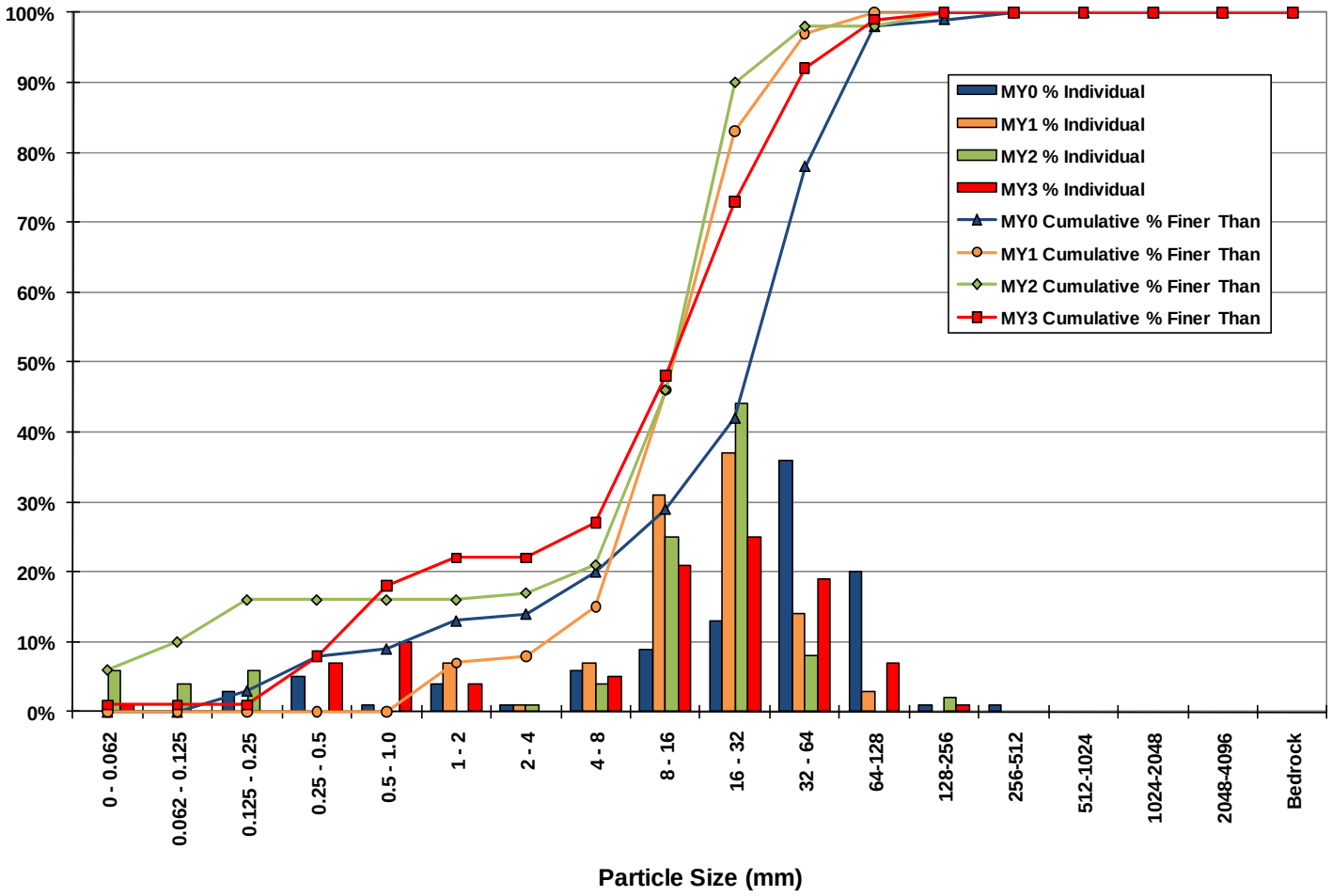
Morgan Creek Lower – Pool 1
Pebble Count



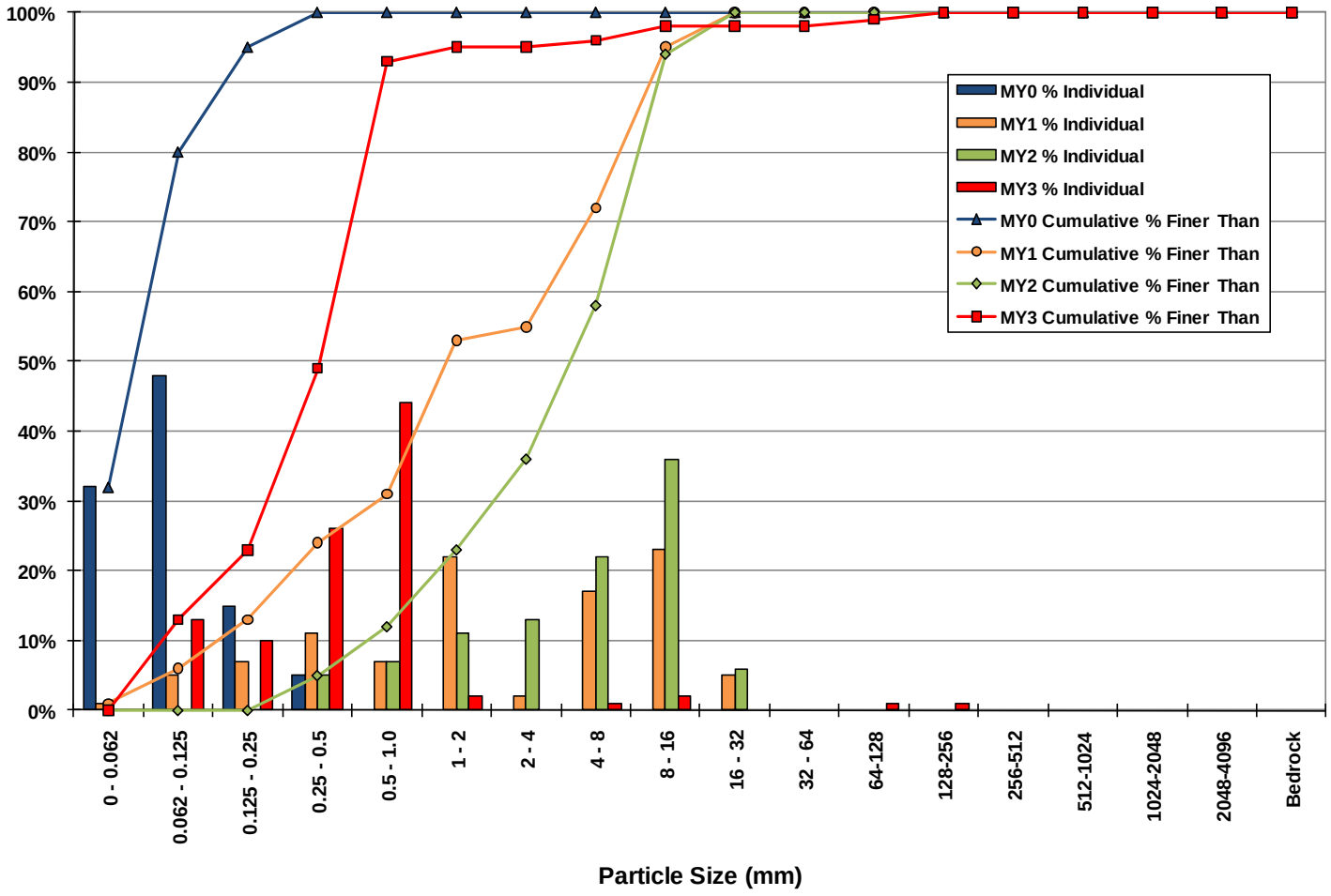
Morgan Creek Lower – Riffle 2
Pebble Count



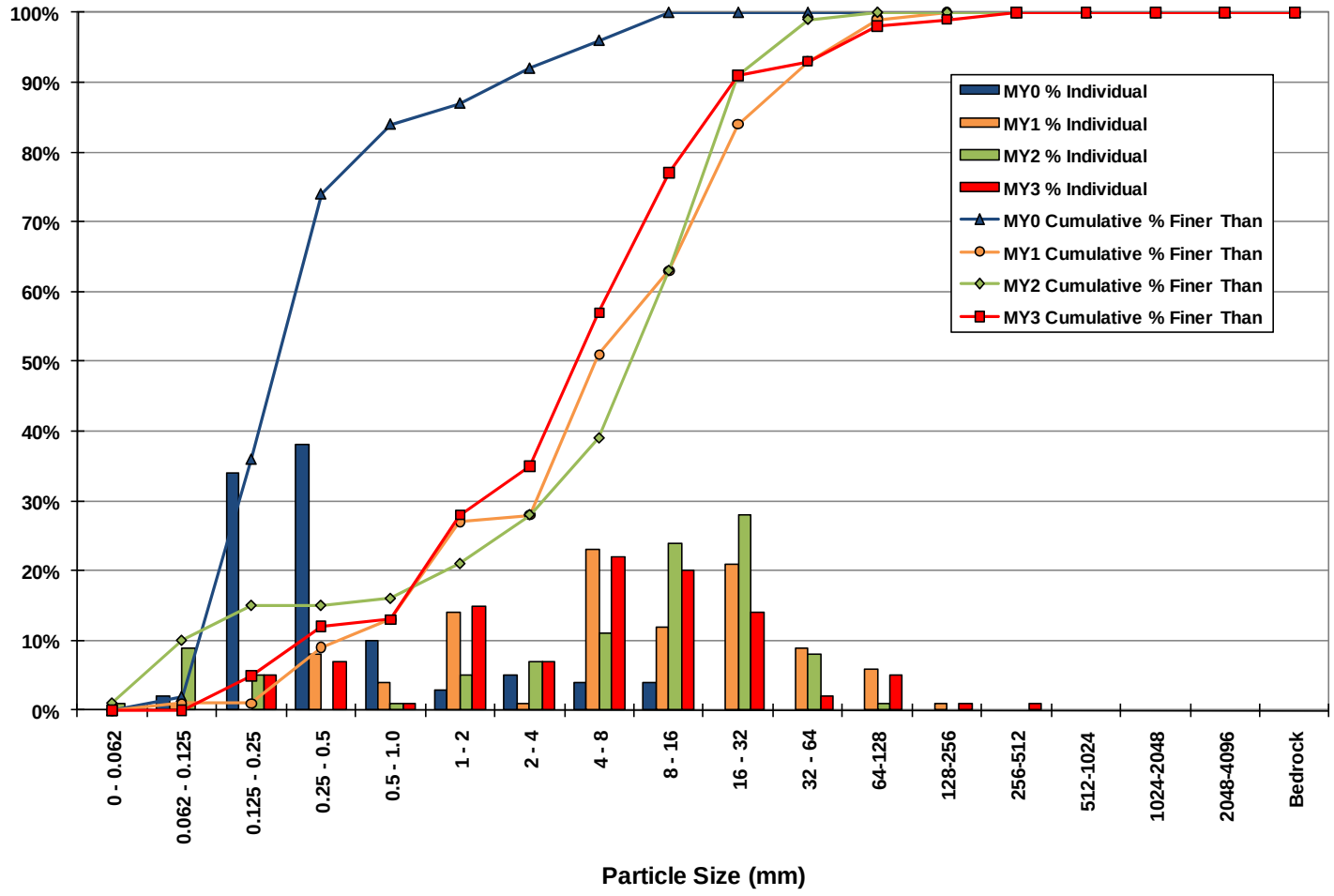
Morgan Creek Lower – Riffle 3
Pebble Count

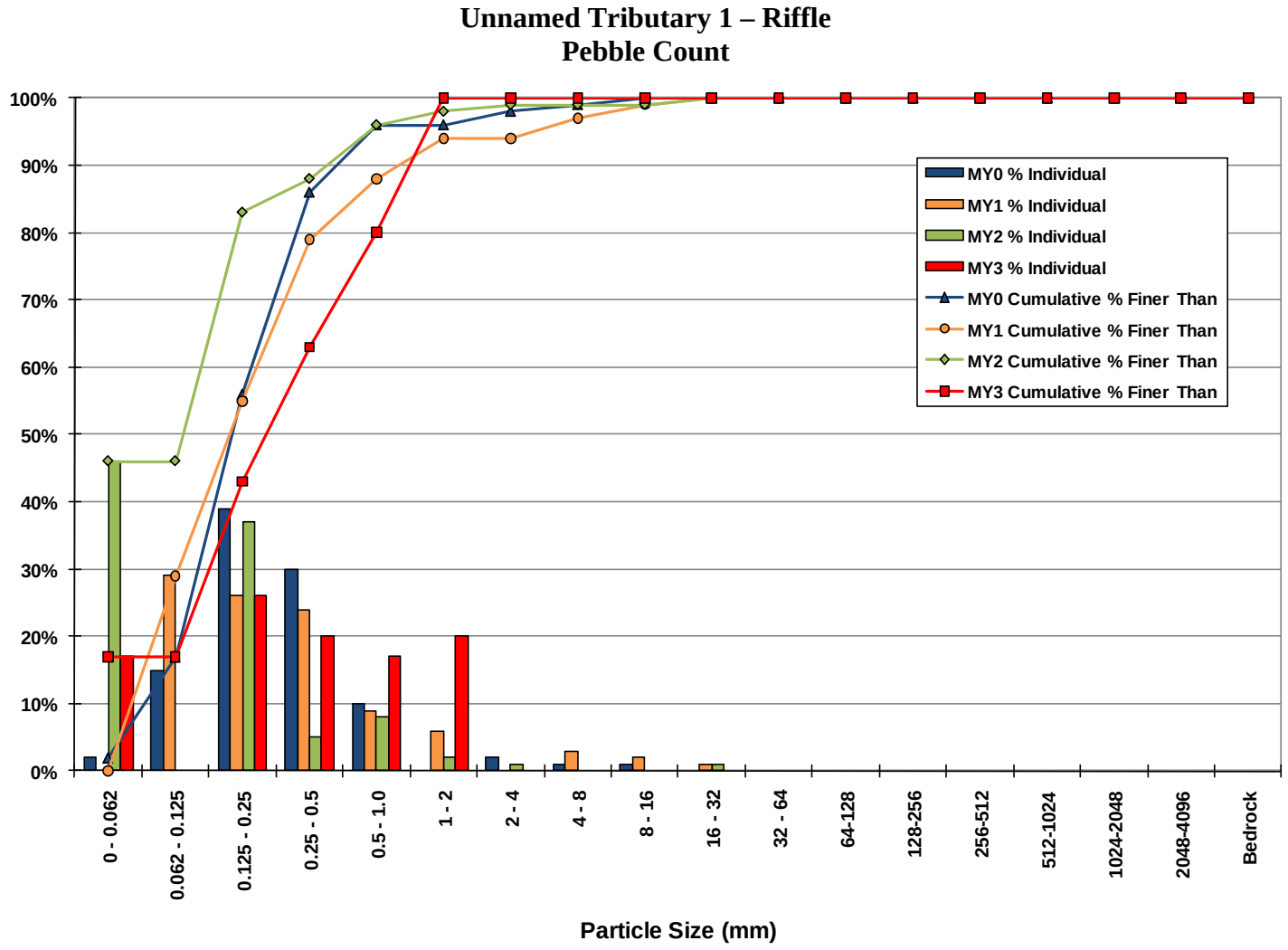


Morgan Creek Lower – Pool 2
Pebble Count

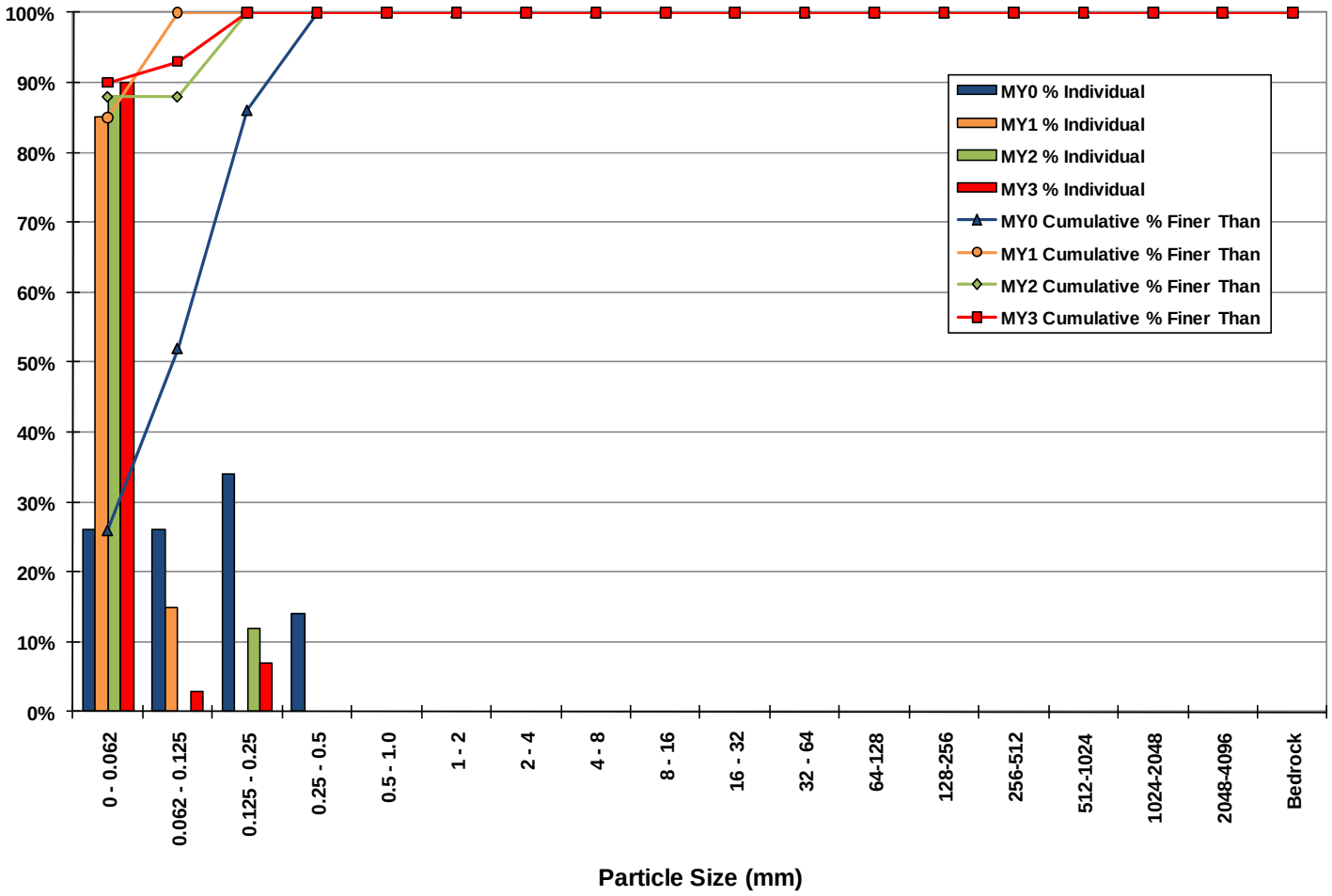


Morgan Creek Lower – Riffle 4
Pebble Count

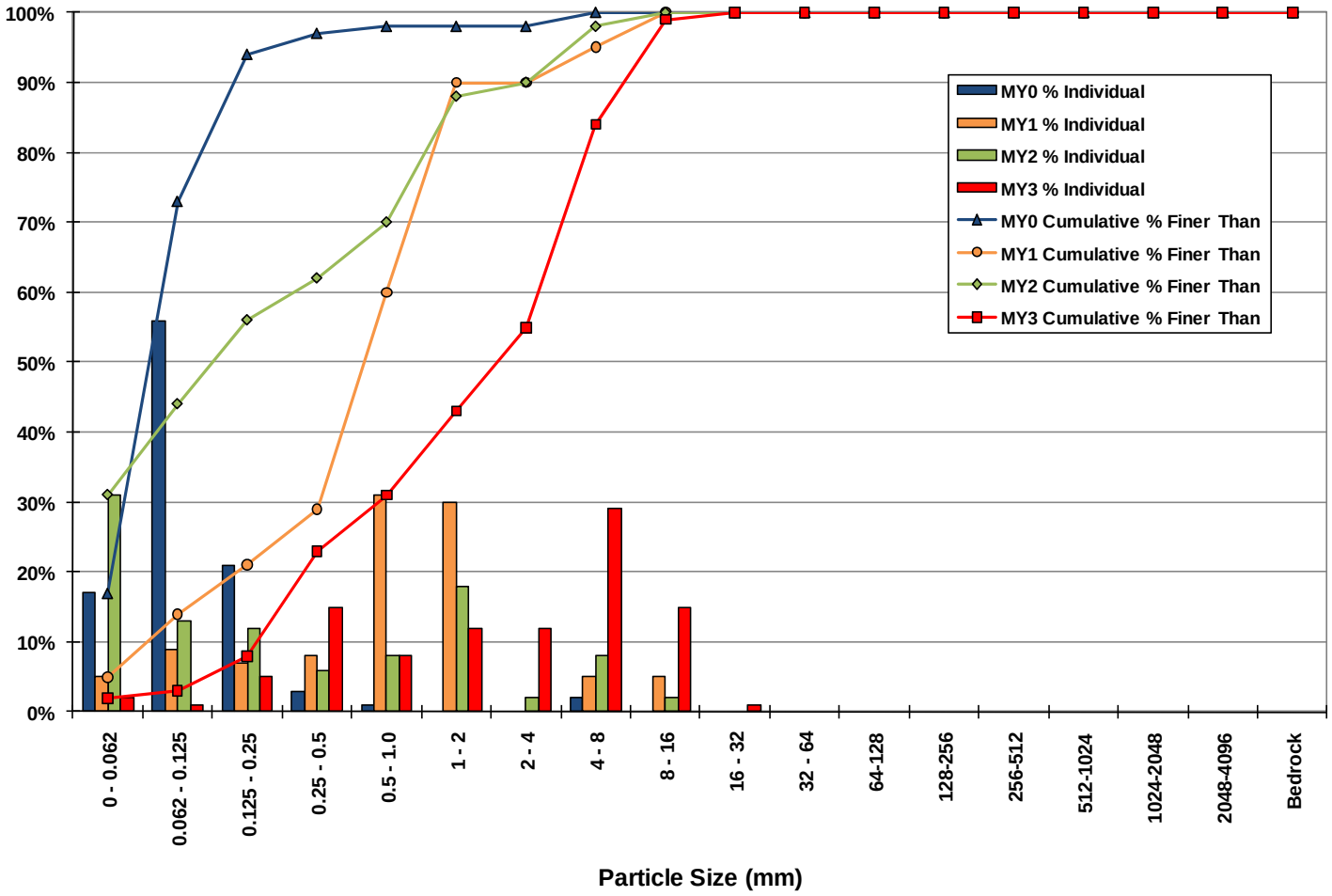


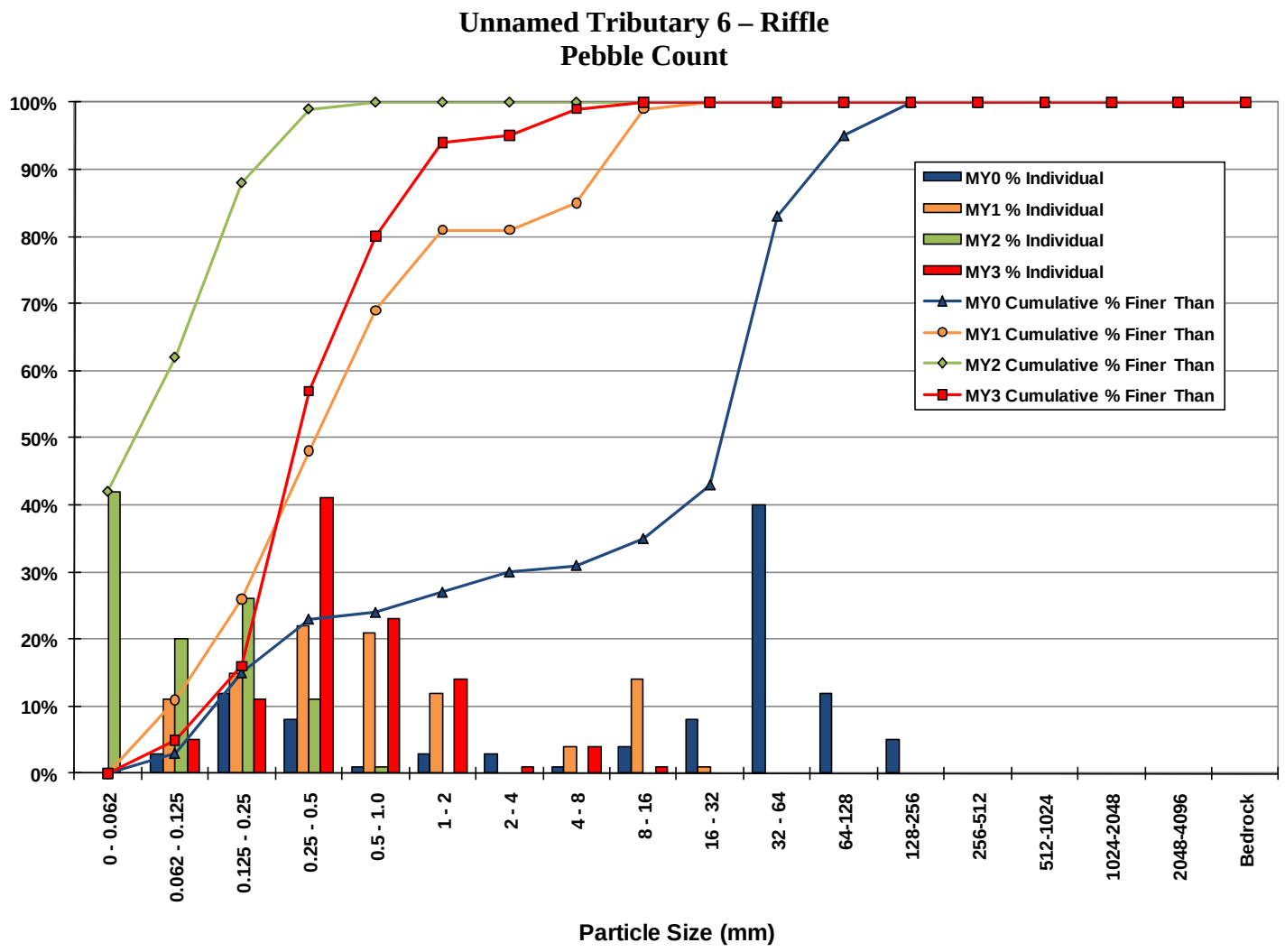

Unnamed Tributary 1 – Riffle
Pebble Count
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
MY0 % Individual
MY1 % Individual
MY2 % Individual
MY3 % Individual
MY0 Cumulative % Finer Than
MY1 Cumulative % Finer Than
MY2 Cumulative % Finer Than
MY3 Cumulative % Finer Than
0 - 0.062
0.062 - 0.125
0.125 - 0.25
0.25 - 0.5
0.5 - 1.0
1 - 2
2 - 4
4 - 8
8 - 16
16 - 32
32 - 64
64-128
128-256
256-512
512-1024
1024-2048
2048-4096
Bedrock
Particle Size (mm)

Unnamed Tributary 1 – Pool
Pebble Count



Unnamed Tributary 6 – Pool
Pebble Count




Unnamed Tributary 6 – Riffle
Pebble Count
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
MY0 % Individual
MY1 % Individual
MY2 % Individual
MY3 % Individual
MY0 Cumulative % Finer Than
MY1 Cumulative % Finer Than
MY2 Cumulative % Finer Than
MY3 Cumulative % Finer Than
0 - 0.062
0.062 - 0.125
0.125 - 0.25
0.25 - 0.5
0.5 - 1.0
1 - 2
2 - 4
4 - 8
8 - 16
16 - 32
32 - 64
64-128
128-256
256-512
512-1024
1024-2048
2048-4096
Bedrock
Particle Size (mm)

APPENDIX C

Monitoring Year 3
Morphologic Monitoring Parameters

Morgan Creek – Upper Reach																		
Parameter	**Cross-Section 1 Riffle 1**						**Cross-Section 2 Riffle 2**						**Cross-Section 3 Pool 1**					
Dimension	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
BF Width (ft)	20.5	21.4	21.2	20.8			19.6	18.8	18.4	18.3			32.9	28.3	27.3	27.8		
Floodprone Width (ft)	>100	>100	>100	>100			>100	>100	>100	>100			>100	>100	>100	>100		
BF Cross Sectional Area (ft^2)	29.4	25.2	24.4	23.1			26.6	28.1	29.1	29.7			65.7	38.3	38.0	38.9		
BF Mean Depth (ft)	1.4	1.2	1.2	1.1			1.4	1.5	1.6	1.6			2.0	1.4	1.4	1.4		
BF Max Depth (ft)	2.5	2.6	2.7	2.7			2.3	3.8	3.8	4.0			4.5	3.7	3.6	3.2		
Width/Depth Ratio	14.3	18.1	18.4	18.7			14.5	12.6	11.6	11.3			16.4	20.9	19.6	19.9		
Entrenchment Ratio	>4.9	>4.7	>4.7	>4.8			>5.1	>5.3	>5.4	>5.5			>3.0	>3.5	>3.7	>3.6		
Wetted Perimeter (ft)	21.3	23.4	23.1	22.5			20.3	22.9	21.8	22.2			34.4	30.2	29.0	30.0		
Hydraulic Radius (ft)	1.4	1.1	1.1	1.0			1.3	1.2	1.3	1.3			1.9	1.3	1.3	1.3		

Morgan Creek – Upper Reach																		
Parameter	**Cross-Section 4 Riffle 3**						**Cross-Section 5 Riffle 4**						**Cross-Section 6 Pool 2**					
Dimension	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
BF Width (ft)	20.6	19.7	19.8	19.1			22.3	18.7	19.6	16.8			39.0	22.7	20.6	15.4		
Floodprone Width (ft)	>100	>100	>100	>100			>100	>100	>100	>100			>100	>100	>100	>100		
BF Cross Sectional Area (ft^2)	32.7	25.7	25.1	24.4			24.7	21.0	20.9	19.7			49.2	23.4	24.8	23.3		
BF Mean Depth (ft)	1.6	1.3	1.3	1.3			1.1	1.1	1.1	1.2			1.3	1.0	1.2	1.5		
BF Max Depth (ft)	2.7	3.3	3.3	3.4			1.9	2.3	2.3	2.4			4.0	3.1	3.4	3.6		
Width/Depth Ratio	13.0	15.1	15.6	15.0			20.0	16.6	18.4	14.3			30.8	22.1	17.1	10.1		
Entrenchment Ratio	>4.9	>5.1	>5.0	>5.2			>4.5	>5.4	>5.1	>6.0			>2.6	>4.4	>4.9	>6.5		
Wetted Perimeter (ft)	21.4	21.9	22.0	21.6			22.8	19.9	20.6	18.0			40.9	25.0	23.3	18.4		
Hydraulic Radius (ft)	1.5	1.2	1.1	1.1			1.1	1.1	1.0	1.1			1.2	0.9	1.1	1.3		

Morgan Creek – Lower Reach*																		
Parameter	**Cross-Section 1 Riffle 1**						**Cross-Section 2 Pool 1**						**Cross-Section 3 Riffle 2**					
Dimension	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
BF Width (ft)	18.7	24.8	24.3	24.2			34.4	30.8	31.2	32.0			22.2	23.8	22.7	23.4		
Floodprone Width (ft)	>100	>100	>100	>100			>100	>100	>100	>100			>100	>100	>100	>100		
BF Cross Sectional Area (ft^2)	22.5	45.3	47.7	58.3			54.5	48.0	47.6	45.9			29.4	43.5	44.5	43.9		
BF Mean Depth (ft)	1.2	1.8	2.0	2.4			1.6	1.6	1.5	1.4			1.3	1.8	2.0	1.9		
BF Max Depth (ft)	2.3	3.4	4.0	4.3			3.4	3.3	3.3	3.2			2.3	3.5	3.6	3.6		
Width/Depth Ratio	15.5	13.6	12.3	10.0			21.7	19.7	20.5	22.4			16.7	13.0	11.6	12.5		
Entrenchment Ratio	>5.3	>4.0	>4.1	>4.1			>2.9	>3.3	>3.2	3.1			>4.5	>4.2	>4.4	>4.3		
Wetted Perimeter (ft)	19.3	26.5	26.2	26.9			35.3	33.1	33.3	34.0			22.8	26.3	25.3	25.9		
Hydraulic Radius (ft)	1.2	1.7	1.8	2.2			1.5	1.4	1.4	1.3			1.3	1.7	1.8	1.7		

*Morgan Creek Lower As-built data (Base) are presented for the purpose of comparing the original to those of the repair As-built conditions (MY1) and not for morphological analysis.

Morgan Creek – Lower Reach*																		
Parameter	**Cross-Section 4 Riffle 3**						**Cross-Section 5 Pool 2**						**Cross-Section 6 Riffle 4**					
Dimension	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
BF Width (ft)	24.9	25.1	27.4	27.3			26.4	28.6	29.5	28.4			23.9	23.4	22.9	26.0		
Floodprone Width (ft)	>100	>100	>100	>100			>100	>100	>100	>100			>100	>100	>100	>100		
BF Cross Sectional Area (ft^2)	31.0	37.7	38.5	36.7			41.3	47.2	45.4	53.5			30.0	42.2	41.6	44.4		
BF Mean Depth (ft)	1.2	1.5	1.4	1.3			1.6	1.6	1.5	1.9			1.3	1.8	1.8	1.7		
BF Max Depth (ft)	2.3	2.6	2.6	2.7			3.7	3.7	3.3	4.4			2.5	3.3	3.2	3.8		
Width/Depth Ratio	20.0	16.7	19.5	20.3			16.9	17.3	19.2	15.1			19.0	13.0	12.6	15.3		
Entrenchment Ratio	>4.0	>4.0	>3.6	>3.7			>3.8	>3.5	>3.4	>3.5			>4.2	>4.3	>4.4	>3.8		
Wetted Perimeter (ft)	25.6	26.3	28.6	28.9			27.8	30.3	31.2	31.5			24.6	24.8	24.3	28.0		
Hydraulic Radius (ft)	1.2	1.4	1.3	1.3			1.5	1.6	1.5	1.7			1.2	1.7	1.7	1.6		

*Morgan Creek Lower As-built data (Base) are presented for the purpose of comparing the original to those of the repair As-built conditions (MY1) and not for morphological analysis.

Unnamed Tributary 1												
Parameter	**Cross-Section 1 Riffle**						**Cross-Section 2 Pool**					
Dimension	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
BF Width (ft)	9.1	9.0	9.7	9.2			19.1	18.9	19.0	18.4		
Floodprone Width (ft)	>50.0	>50.0	>50.0	>50.0			>50.0	>50.0	>50.0	>50.0		
BF Cross Sectional Area (ft^2)	4.1	4.2	4.2	4.2			18.6	17.8	18.8	17.9		
BF Mean Depth (ft)	0.5	0.5	0.4	0.5			1.0	0.9	1.0	1.0		
BF Max Depth (ft)	1.2	1.3	1.3	1.4			2.1	2.0	2.0	1.9		
Width/Depth Ratio	19.9	19.4	22.7	20.2			19.6	20.1	19.1	18.9		
Entrenchment Ratio	>5.5	>5.6	>5.2	>5.4			>2.6	>2.6	>2.6	>2.7		
Wetted Perimeter (ft)	9.5	10.0	10.7	10.3			19.7	19.5	19.5	19.0		
Hydraulic Radius (ft)	0.4	0.4	0.4	0.4			0.9	0.9	1.0	0.9		

Unnamed Tributary 6												
Parameter	**Cross-Section 1 Pool**						**Cross-Section 2 Riffle**					
Dimension	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
BF Width (ft)	24.3	19.9	22.2	19.0			13.4	11.7	11.7	10.0		
Floodprone Width (ft)	>50.0	>50.0	>50.0	>50.0			>50.0	>50.0	>50.0	>50.0		
BF Cross Sectional Area (ft^2)	29.4	14.6	14.8	11.7			11.1	10.3	9.7	8.7		
BF Mean Depth (ft)	1.2	0.7	0.7	0.6			0.8	0.9	0.8	0.9		
BF Max Depth (ft)	3.0	1.6	1.6	1.5			1.7	1.7	1.6	1.7		
Width/Depth Ratio	20.2	27.1	33.2	30.9			16.2	13.2	14.1	11.5		
Entrenchment Ratio	>2.1	>2.5	>2.3	>2.6			>3.7	>4.3	>4.3	>5.0		
Wetted Perimeter (ft)	25.3	20.7	22.8	19.5			13.9	12.5	12.4	11.2		
Hydraulic Radius (ft)	1.2	0.7	0.7	0.6			0.8	0.8	0.8	0.8		

Morgan Creek – Upper Reach																		
Parameter	**Baseline**			**MY1**			**MY2**			**MY3**			**MY4**			**MY5**		
Pattern	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Channel Beltwidth (ft)	60.0	92.7	81.2	62.5	95.48	87.6	62.5	95.48	87.6	62.5	95.48	87.6						
Radius of Curvature (ft)	42.3	55.6	49.7	34.6	56.6	48.9	34.6	56.6	48.9	34.6	56.6	48.9						
Meander Wavelength (ft)	141.4	215.2	200.3	153.7	219.3	199.6	153.7	219.3	199.6	153.7	219.3	199.6						
Meander Width Ratio	3.68	3.87	3.70	4.28	4.87	4.65	4.13	4.76	4.42	4.13	4.76	4.42						
Profile																		
Riffle Length (ft)	16.93	43.38	26.51	14.13	68.47	27.23	8.82	87.11	22.83	10.50	54.40	23.26						
Riffle Slope (ft/ft)	0.0024	0.0197	0.0035	0.0018	0.0209	0.0079	0.0010	0.0320	0.0074	0.0007	0.0487	0.0074						
Pool Length (ft)	13.27	80.84	44.42	15.25	68.17	33.69	10.12	80.00	34.90	10.82	75.70	31.60						
Pool Spacing (ft)	51.77	138.88	102.18	58.30	170.24	106.81	19.12	162.26	85.29	19.25	154.72	80.40						
Additional Reach Parameters																		
Valley Length (ft)	1181.5			1181.5			1181.5			1181.5								
Channel Length (ft)	1424.7			1465.5			1463.0			1461.9								
Sinuosity	1.21			1.24			1.24			1.24								
Water Surface Slope (ft/ft)	0.007			0.007			0.007			0.007								
BF Slope (ft/ft)	0.009			0.008			0.007			0.007								
Rosgen Classification	C4			C4			C4			C4								

Morgan Creek – Lower Reach*																		
Parameter	**Baseline**			**MY1**			**MY2**			**MY3**			**MY4**			**MY5**		
Pattern	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Channel Beltwidth (ft)	57.5	84.9	70.4	62.5	85.5	70.2	58.7	85.1	73.7	58.7	85.1	73.7						
Radius of Curvature (ft)	30.7	53.7	34.1	30.2	55.8	36.8	24.5	54.6	33.8	24.5	54.6	33.8						
Meander Wavelength (ft)	170.2	200.3	181.2	172.1	203.9	180.3	175.6	200.9	181.5	175.6	200.9	181.5						
Meander Width Ratio	2.83	3.76	3.17	2.76	2.95	2.80	2.69	3.25	3.03	2.69	3.25	3.03						
Profile																		
Riffle Length (ft)	14.76	53.25	44.15	30.46	91.11	47.28	12.73	116.57	33.82	10.06	118.89	37.92						
Riffle Slope (ft/ft)	0.0016	0.0201	0.0076	0.0037	0.0206	0.0103	0.0017	0.0310	0.0113	0.0025	0.0464	0.0148						
Pool Length (ft)	38.51	80.98	60.72	15.40	38.70	30.03	8.09	47.56	23.88	13.51	43.05	23.38						
Pool Spacing (ft)	92.14	157.68	109.52	40.56	234.10	109.20	19.21	242.08	58.75	29.19	275.41	67.51						
Additional Reach Parameters																		
Valley Length (ft)	865			865			865			865								
Channel Length (ft)	1054.4			1083.7			1116.5			1125.8								
Sinuosity	1.22			1.25			1.29			1.30								
Water Surface Slope (ft/ft)	0.006			0.006			0.005			0.005								
BF Slope (ft/ft)	0.007			0.005			0.005			0.005								
Rosgen Classification	C4			C4			C4			C4								

*Morgan Creek Lower As-built data (Baseline) are presented for the purpose of comparing the original to those of the repair As-built conditions (MY1) and not for morphological analysis.

Unnamed Tributary 1																		
Parameter	**Baseline**			**MY1**			**MY2**			**MY3**			**MY4**			**MY5**		
Pattern	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Channel Beltwidth (ft)	36.6	65.0	39.6	32.0	65.4	44.1	32.0	65.4	44.1	32.0	65.4	44.1						
Radius of Curvature (ft)	22.1	29.9	26.7	13.3	25.9	23.1	13.3	25.9	23.1	13.3	25.9	23.1						
Meander Wavelength (ft)	95.6	109.3	101.4	94.6	103.4	103.0	94.6	103.4	103.0	94.6	103.4	103.0						
Meander Width Ratio		4.35			4.89			4.54			4.54							
Profile																		
Riffle Length (ft)	13.18	25.73	23.34	9.24	29.68	17.52	11.18	26.08	18.06	11.20	28.48	23.71						
Riffle Slope (ft/ft)	0.0084	0.0467	0.0222	0.0062	0.0324	0.0155	0.0036	0.0365	0.0222	0.0033	0.0359	0.0187						
Pool Length (ft)	4.34	30.99	20.78	4.12	38.54	21.86	6.51	35.32	15.21	8.13	39.35	25.69						
Pool Spacing (ft)	17.63	77.03	36.48	22.69	91.52	37.28	25.89	77.14	40.92	28.90	101.63	40.51						
Additional Reach Parameters																		
Valley Length (ft)		310.3			310.3			310.3			310.3							
Channel Length (ft)		378.1			386.4			384.3			386.4							
Sinuosity		1.22			1.25			1.24			1.25							
Water Surface Slope (ft/ft)		0.011			0.012			0.012			0.011							
BF Slope (ft/ft)		0.013			0.013			0.013			0.012							
Rosgen Classification		C5			C5			C5			C5							

Unnamed Tributary 6																		
Parameter	**Baseline**			**MY1**			**MY2**			**MY3**			**MY4**			**MY5**		
Pattern	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Channel Beltwidth (ft)	28.7	43.5	42.3	29.6	45.4	45.0	28.6	46.2	42.6	28.6	46.2	42.6						
Radius of Curvature (ft)	27.7	31.7	30.2	21.7	32.1	22.5	22.1	27.4	24.5	22.1	27.4	24.5						
Meander Wavelength (ft)	114.0	123.1	120.1	100.9	120.3	119.5	101.2	121.3	117.6	101.2	121.3	117.6						
Meander Width Ratio		3.16			3.85			3.64			3.64							
Profile																		
Riffle Length (ft)	14.86	30.95	28.19	7.28	25.67	16.29	7.94	44.39	25.23	14.31	44.76	31.76						
Riffle Slope (ft/ft)	0.0013	0.0110	0.0042	0.0014	0.0237	0.0108	0.0104	0.0432	0.0269	0.0046	0.0098	0.0078						
Pool Length (ft)	2.38	18.09	14.64	4.02	15.59	8.70	2.16	5.20	3.56	3.59	6.92	5.52						
Pool Spacing (ft)	5.90	66.37	54.03	14.52	54.28	28.32	4.99	71.09	24.79	7.01	78.77	43.72						
Additional Reach Parameters																		
Valley Length (ft)		222.5			222.5			222.5			222.5							
Channel Length (ft)		252.4			258.9			254.5			255.1							
Sinuosity		1.13			1.16			1.14			1.15							
Water Surface Slope (ft/ft)		0.008			0.010			0.017			0.016							
BF Slope (ft/ft)		0.014			0.010			0.013			0.016							
Rosgen Classification		C4			C5			C5			C5							

APPENDIX D

Monitoring Year 3
Site Photos

Permanent Photo Point 1 – Unnamed Tributary 7
Looking Upstream
January 19, 2011

Permanent Photo Point 2 – Unnamed Tributary 7
Looking Upstream
January 19, 2011

Permanent Photo Point 3 – Unnamed Tributary 7
Looking Upstream
January 19, 2011

Permanent Photo Point 4 – Unnamed Tributary 7
Looking Upstream
January 19, 2011

Permanent Photo Point 5 – Unnamed Tributary 7
Looking Upstream
January 19, 2011

Permanent Photo Point 6 – Unnamed Tributary 7
Looking Upstream
January 19, 2011

Permanent Photo Point 7 – Unnamed Tributary 7
Looking Upstream
January 19, 2011

Permanent Photo Point 8 – Morgan Creek
Looking Upstream
January 19, 2011

Permanent Photo Point 9 – Morgan Creek
Looking Upstream
January 19, 2011

Permanent Photo Point 10 – Morgan Creek
Looking Upstream
January 19, 2011

Permanent Photo Point 11 – Morgan Creek
Looking Upstream
January 19, 2011

Permanent Photo Point 12 – Morgan Creek
Looking Upstream
January 19, 2011

Permanent Photo Point 13 – Morgan Creek
Looking Upstream
January 19, 2011

Permanent Photo Point 14 – Morgan Creek
Looking Upstream
January 20, 2011

Permanent Photo Point 15 – Morgan Creek
Looking Upstream
January 20, 2011

Permanent Photo Point 16 – Morgan Creek
Looking Upstream
January 20, 2011

Permanent Photo Point 17 – Morgan Creek
Looking Upstream
January 20, 2011

Permanent Photo Point 18 – Morgan Creek
Looking Upstream
January 20, 2011

Permanent Photo Point 19 – Morgan Creek
Looking Upstream
January 20, 2011

Permanent Photo Point 20 – Morgan Creek
Looking Upstream
January 20, 2011

Permanent Photo Point 21 – Morgan Creek
Looking Upstream
January 20, 2011

Permanent Photo Point 22 – Unnamed Tributary 6
Looking Upstream
January 20, 2011

Permanent Photo Point 23 – Unnamed Tributary 6
Looking Upstream
January 20, 2011

Permanent Photo Point 24 – Unnamed Tributary 6
Looking Upstream
January 20, 2011

Permanent Photo Point 25 – Unnamed Tributary 6
Looking Upstream
January 20, 2011

Permanent Photo Point 26 – Unnamed Tributary 6
Looking Upstream
January 20, 2011

Permanent Photo Point 27 – Morgan Creek
Looking Upstream
January 20, 2011

Permanent Photo Point 28 – Morgan Creek
Looking Upstream
January 20, 2011

Permanent Photo Point 29 – Morgan Creek
Looking Upstream
January 20, 2011

Permanent Photo Point 30 – Morgan Creek
Looking Upstream
January 20, 2011

Permanent Photo Point 30 – Unnamed Tributary 5
Looking Upstream
January 20, 2011

Permanent Photo Point 31 – Unnamed Tributary 5
Looking Upstream
January 20, 2011

Permanent Photo Point 32 – Unnamed Tributary 5
Looking Downstream
January 20, 2011

Permanent Photo Point 32 – Unnamed Tributary 5
Looking Upstream
January 20, 2011

Permanent Photo Point 33 – Unnamed Tributary 5
Looking Downstream
January 20, 2011

Permanent Photo Point 33 – Unnamed Tributary 5
Looking Upstream
January 20, 2011

Permanent Photo Point 34 – Unnamed Tributary 5
Looking Upstream
January 20, 2011

Permanent Photo Point 35 – Unnamed Tributary 5
Looking Downstream
January 20, 2011

Permanent Photo Point 35 – Unnamed Tributary 5
Looking 115 Degrees
January 20, 2011

Permanent Photo Point 35 – Unnamed Tributary 5
Looking Upstream
January 20, 2011

Permanent Photo Point 35 – Unnamed Tributary 5
Looking 358 Degrees
January 20, 2011

Permanent Photo Point 36 – Morgan Creek
Looking Upstream
January 20, 2011

Permanent Photo Point 37 – Morgan Creek
Looking Upstream
January 20, 2011

Permanent Photo Point 38 – Morgan Creek
Looking Upstream
January 20, 2011

Permanent Photo Point 39 – Unnamed Tributary 4
Looking Downstream
January 20, 2011

Permanent Photo Point 39 – Unnamed Tributary 4
Looking Upstream
January 20, 2011

Permanent Photo Point 40 – Morgan Creek
Looking Upstream
January 20, 2011

Permanent Photo Point 41 – Morgan Creek
Looking Upstream
January 20, 2011

Permanent Photo Point 42 – Morgan Creek
Looking Downstream
January 20, 2011

Permanent Photo Point 42 – Morgan Creek
Looking Upstream
January 20, 2011

Permanent Photo Point 43 – Unnamed Tributary 3
Looking Upstream
January 20, 2011

Permanent Photo Point 44 – Unnamed Tributary 3
Looking Upstream
January 20, 2011

Permanent Photo Point 45 – Unnamed Tributary 3
Looking Upstream
January 20, 2011

Permanent Photo Point 46 – Unnamed Tributary 3
Looking Upstream
January 20, 2011

Permanent Photo Point 47 – Unnamed Tributary 3
Looking Upstream
January 20, 2011

Permanent Photo Point 48 – Unnamed Tributary 3
Looking Upstream
January 20, 2011

Permanent Photo Point 49 – Unnamed Tributary 3
Looking Upstream
January 20, 2011

Permanent Photo Point 50 – Unnamed Tributary 3
Looking Upstream
January 20, 2011

Permanent Photo Point 51 – Unnamed Tributary 3
Looking Downstream
January 20, 2011

Permanent Photo Point 51 – Unnamed Tributary 3
Looking Upstream
January 20, 2011

Permanent Photo Point 52 – Unnamed Tributary 3
Looking Downstream
January 20, 2011

Permanent Photo Point 52 – Unnamed Tributary 3
Looking 110 Degrees
January 20, 2011

Permanent Photo Point 52 – Unnamed Tributary 3
Looking Upstream
January 20, 2011

Permanent Photo Point 52 – Unnamed Tributary 3
Looking 355 Degrees
January 20, 2011

Permanent Photo Point 53 – Morgan Creek
Looking Upstream
January 20, 2011

Permanent Photo Point 54 – Morgan Creek
Looking Upstream
January 20, 2011

Permanent Photo Point 55 – Morgan Creek
Looking Upstream
January 20, 2011

Permanent Photo Point 56 – Unnamed Tributary 2
Looking Upstream
January 20, 2011

Permanent Photo Point 57 – Unnamed Tributary 2
Looking Upstream
January 20, 2011

Permanent Photo Point 58 – Unnamed Tributary 2
Looking Downstream
January 20, 2011

Permanent Photo Point 58 – Unnamed Tributary 2
Looking Upstream
January 20, 2011

Permanent Photo Point 59 – Unnamed Tributary 2
Looking Downstream
January 20, 2011

Permanent Photo Point 59 – Unnamed Tributary 2
Looking Upstream
January 20, 2011

Permanent Photo Point 60 – Unnamed Tributary 2
Looking Downstream
January 20, 2011

Permanent Photo Point 60 – Unnamed Tributary 2
Looking Upstream
January 20, 2011

Permanent Photo Point 61 – Morgan Creek
Looking Upstream
January 20, 2011

Permanent Photo Point 62 – Unnamed Tributary 1
Looking Upstream
January 20, 2011

Permanent Photo Point 63 – Unnamed Tributary 1
Looking Upstream
January 20, 2011

Permanent Photo Point 64 – Unnamed Tributary 1
Looking Upstream
January 20, 2011

Permanent Photo Point 65 – Unnamed Tributary 1
Looking Upstream
January 20, 2011

Permanent Photo Point 66 – Unnamed Tributary 1
Looking Downstream
January 20, 2011

Permanent Photo Point 66 – Unnamed Tributary 1
Looking Upstream
January 20, 2011

Permanent Photo Point 67 – Unnamed Tributary 1
Looking Downstream
January 20, 2011

Permanent Photo Point 67 – Unnamed Tributary 1
Looking 185 Degrees
January 20, 2011

Permanent Photo Point 67 – Unnamed Tributary 1
Looking Upstream
January 20, 2011

Permanent Photo Point 67 – Unnamed Tributary 1
Looking 360 Degrees
January 20, 2011

Permanent Photo Point 68 – Unnamed Tributary 1
Looking Downstream
January 20, 2011

Permanent Photo Point 68 – Unnamed Tributary 1
Looking 94 Degrees
January 20, 2011

Permanent Photo Point 68 – Unnamed Tributary 1
Looking Upstream
January 20, 2011

Permanent Photo Point 68 – Unnamed Tributary 1
Looking 327 Degrees
January 20, 2011

Permanent Photo Point 69 – Unnamed Tributary 8
Looking Downstream
January 20, 2011

Permanent Photo Point 69 – Unnamed Tributary 8
Looking 168 Degrees
January 20, 2011

Permanent Photo Point 69 – Unnamed Tributary 8
Looking Upstream
January 20, 2011

Permanent Photo Point 69 – Unnamed Tributary 8
Looking 53 Degrees
January 20, 2011

Permanent Photo Point 70 – Unnamed Tributary 9
Looking Downstream
January 20, 2011

Permanent Photo Point 70 – Unnamed Tributary 9
Looking Upstream 196 Degrees
January 20, 2011

Permanent Photo Point 70 – Unnamed Tributary 9
Looking Upstream 248 Degrees
January 20, 2011

Vegetation Plot 1

Vegetation Plot 2

Vegetation Plot 3

Vegetation Plot 4

Vegetation Plot 5

Vegetation Plot 6

Vegetation Plot 7

Vegetation Plot 8

Morgan Creek Representative Photos of Stream Areas Requiring Observation

SPA 4 Morgan Creek Sta. 1002+25 – Reduced pool depth due to aggradation

SPA 21 Morgan Creek Sta. 1029+40 – Bank erosion due to thalweg not centering

Morgan Creek Representative Photos of Stream Areas Requiring Observation

SPA 23 Morgan Creek Sta. 1038+50 – Riffle aggradation due to mid-channel bar formation

SPA 24 Morgan Creek Sta. 1047+00 – Reduced pool depth due to aggradation

Unnamed Tributary 1 Representative Photos of Stream Areas Requiring Observation

SPA 2 UT1 Sta. 2001+75 – Reduced pool depth due to aggradation

Unnamed Tributary 2 Representative Photo of Stream Areas Requiring Observation

SPA 5 UT2 Sta. 3000+50 – Reduced pool depth and riffle fining due to aggradation

Unnamed Tributary 3 Representative Photo of Stream Areas Requiring Observation

SPA 13 UT3 Sta. 4001+90 – Reduced pool depth due to aggradation

Unnamed Tributary 4 Representative Photo of Stream Areas Requiring Observation

SPA 16 UT4 Sta. 5001+50 – Reduced pool depth and riffle fining due to aggradation

Unnamed Tributary 7 Representative Photos of Stream Areas Requiring Observation

SPA 25 UT7 Sta. 8000+40 – Reduced pool depth and riffle fining due to aggradation

APPENDIX E

Invasive Exotic Vegetation Control at Morgan Creek and North Muddy Creek Stream Restoration Sites Baseline Report

Invasive Exotic Vegetation Control at Morgan Creek and North Muddy Creek Stream Restoration Sites
Year 3, August 2011
Baseline Report

Purpose

Several occurrences of invasive exotic plant infestations were observed at the Morgan Creek and North Muddy Creek Stream Restorations Sites following construction and riparian area planting. In an effort to eliminate competition and prevent the establishment and further invasion of non-native plants within easement areas, control activities were conducted from June 1 – July 22, 2011. This Baseline Report provides a summary of management activities conducted during this period.

Baseline Conditions

Prior to management activities, invasive exotic plant infestations at Morgan Creek was 4.5 acres and 3.0 acres occurred at the North Muddy Creek Site. Target species include:

- Privet *(Ligustrum sinense)*
- Multiflora Rose *(Rosa multiflora)*
- Japanese Honeysuckle *(Lonicera japonica)*
- Oriental Bittersweet *(Celastrus orbiculatus)*
- Autumn Olive *(Elaeagnus umbellata)*
- Kudzu *(Pueraria Montana)*
- Tree of Heaven *(Ailanthus altissima)*
- Princess Tree *(Paulownia tomentosa)*
- Shrubby Lespedeza *(Lespedeza bicolor)*

Summary of Control Activities

Seven days were spent treating invasive exotic plants at Morgan Creek and tributaries while three days were spent at the North Muddy Creek site (Figure 1 & Figure 2). In general, foliar herbicide application was used on reaches where vegetation was less than 8 feet high. Vegetation too high to safely spray with backpack sprayers was treated with cut stump applications using hand clippers. Cut stump applications were also made on trees with large diameters (greater than 2 inches) using a chainsaw. All herbicide applications were applied and/or supervised by certified NCDA&CS Pesticide Applicators, License #026-26135 and #026-29539.

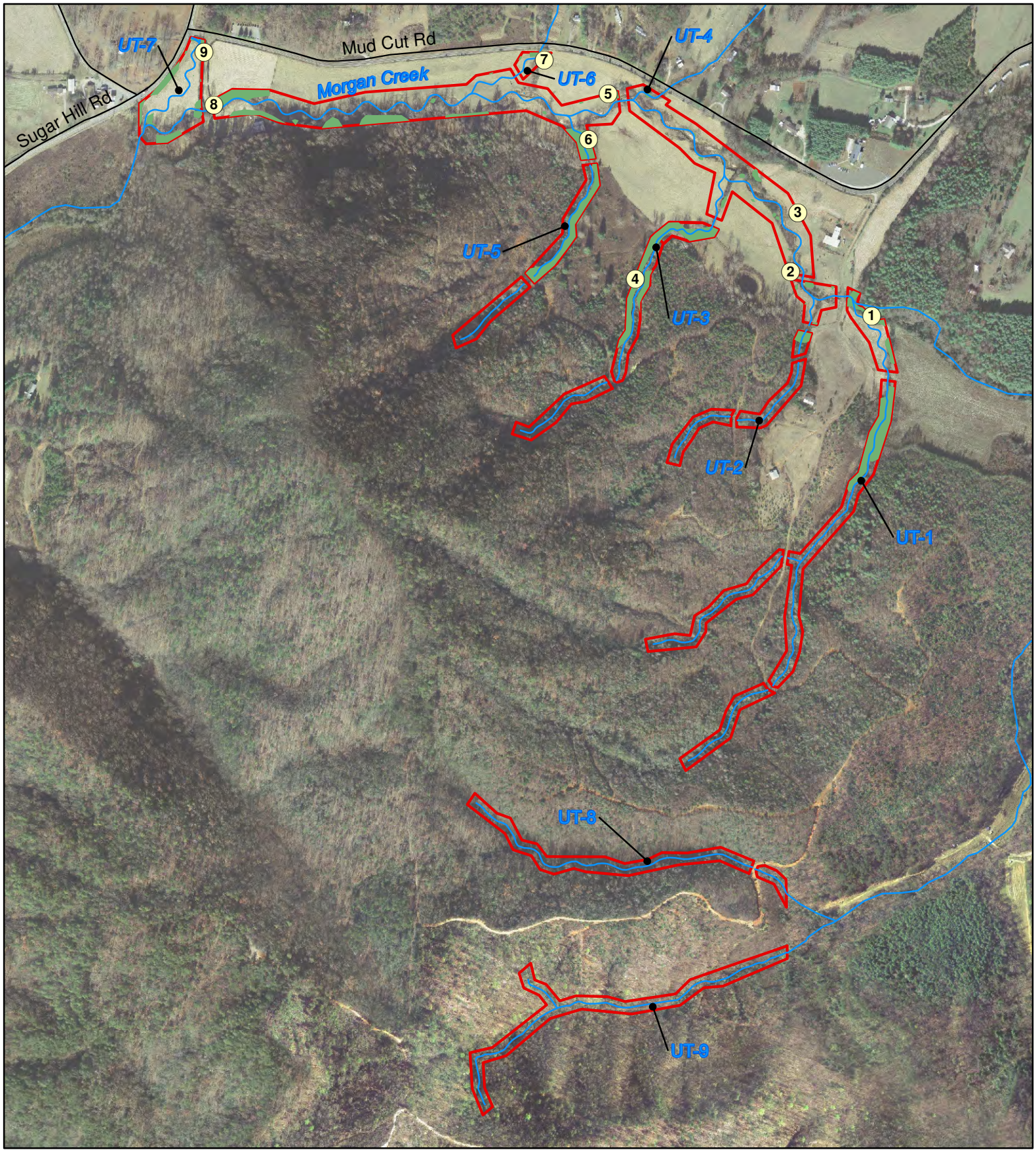
Follow-up re-treatment is necessary at all reaches. In some instances, invasive exotic vegetation was so dense that the entire area could not be treated and re-treatment is required on plants that were not accessible. In other instances, target species intertwined and growing adjacent to non-target vegetation were not treated. In these situations, semi-evergreen and early emergent target plants will need to be treated in early spring 2012 before non-target plants leaf out. Although invasive exotic plants were treated prior to the production of viable seeds, seed banking, root propagation, recruitment, and other means of reproduction may occur for which re-treatment will also be necessary. Table 1 summarizes the reaches treated, application method employed, herbicide volume used, herbicide concentrations used, and other relevant information.

It should be noted that some herbicide unintentionally came in contact with non-target vegetation in some areas, but did not appear to be a detriment to native plant succession. Utmost care was taken to prevent damage to non-target species, but herbicide drift and dripping is unavoidable where non-native vines are climbing up trees or are intertwined with native vegetation. These areas will be monitored to ensure proper revegetation of native plants occurs overtime.

Table 1: Treatment Records

Date	Site	Reaches	Target Species	Application Method	Herbicide	Herbicide Mixture Used (gal)	Concentration (%)	Volume Herbicide Used (oz)	Weather	Temp (°F)	Wind Speed (mph)	Notes
6/1/2011	Morgan Creek	UT-1, Morgan Ck	Privet, Multiflora Rose, Japanese Honeysuckle, Oriental Bittersweet	foliar	Garlon 3A	25	3%	100	Sunny	95	4	Large (>3" DBH) Privet and climbing Honeysuckle need retreatment at UT-1
6/8/2011	North Muddy Creek	UT-5, UT-4, UT-2	Shrubby Lespedeza, Privet, Multiflora Rose, Japanese Honeysuckle, Oriental Bittersweet	foliar	Garlon 3A	10	3%	40	Sunny, then T-storms	91	1	T-storm downpour 30 minutes after treating UT-2
6/14/2011	Morgan Creek	UT-2, Morgan Ck	Privet, Multiflora Rose, Japanese Honeysuckle, Kudzu, Autumn Olive	foliar	Garlon 3A	20	3%	80	Sunny morning, cloudy afternoon	81	5	Honeysuckle needs retreatment at UT-2
6/21/2011	Morgan Creek	UT-3	Paulownia, Tree of Heaven, Privet, Multiflora Rose, Japanese Honeysuckle	cut stump	Garlon 3A	0.3	25%	8	Sunny	89	2	Chainsaw cut stump on dozens of Paulownia and Tree of Heaven >12" DBH
6/24/2011	Morgan Creek	UT-6, Morgan Creek	Privet, Multiflora Rose, Japanese Honeysuckle, Oriental Bittersweet, Kudzu, Tree of Heaven	foliar	Garlon 3A	19	3%	76	Sunny, partly cloudy	89	10	Extensive Bittersweet along forest edge of Morgan Ck needs follow up
6/29/2011	North Muddy Creek	UT-6	Privet, Japanese Honeysuckle, Multiflora Rose	foliar	Garlon 3A	12.5	3%	50	Sunny, then T-storms	86	2	Cut 100's of 1" diam Honeysuckle vines, Privet & Honeysuckle need retreatment
7/7/2011	Morgan Creek	UT-5	Tree of Heaven, Privet, Japanese Honeysuckle, Multiflora Rose	cut stump	Garlon 3A	0.3	25%	8	Sunny	87	1	Chainsaw cut stump on dozens of Tree of Heaven >12" DBH and large Privet
7/14/2011	Morgan Creek	Morgan Ck, UT-5, UT-3	Multiflora Rose, Privet, Japanese Honeysuckle, Kudzu, Oriental Bittersweet	foliar	Garlon 3A	15	3%	56	Sunny	82	8	
7/14/2011	Morgan Creek	Morgan Ck, UT-5, UT-3	Tree of Heaven, Multiflora Rose, Privet, Japanese Honeysuckle	cut stump	Garlon 3A	0.06	25%	2	Sunny	82	8	Cut stump smaller diameter vegetation with hand clippers
7/22/2011	North Muddy Creek	UT-1	Kudzu, Privet, Multiflora Rose, Japanese Honeysuckle	foliar	Garlon 3A	18	3%	72	Sunny, then T-storms	93	1	Dense kudzu on the furthest upstream reach needs retreatment

Figure 1: Morgan Creek Stream Restoration Site



Morgan Creek
Photos of Invasive Plant Control

UT-1, Photo 1, looking west
November 12, 2010

UT-1, Photo 1, looking west
August 3, 2011

Morgan Creek, Photo 2, looking east
May 24, 2011

Morgan Creek, Photo 2, looking east
August 3, 2011

Morgan Creek, Photo 3, looking west
April 16, 2010

Morgan Creek, Photo 3, looking west
August 3, 2011

UT-3, Photo 4, looking northeast
August 8, 2008

UT-3, Photo 4, looking northeast
August 3, 2011

Morgan Creek, Photo 5, looking east
April 16, 2010

Morgan Creek, Photo 5, looking east
August 3, 2010

UT-5, Photo 6, looking northwest
April 16, 2010

UT-5, Photo 6, looking northwest
August 3, 2011

UT-6, Photo 7, looking north
November 19, 2010

UT-6, Photo 7, looking north
August 3, 2011

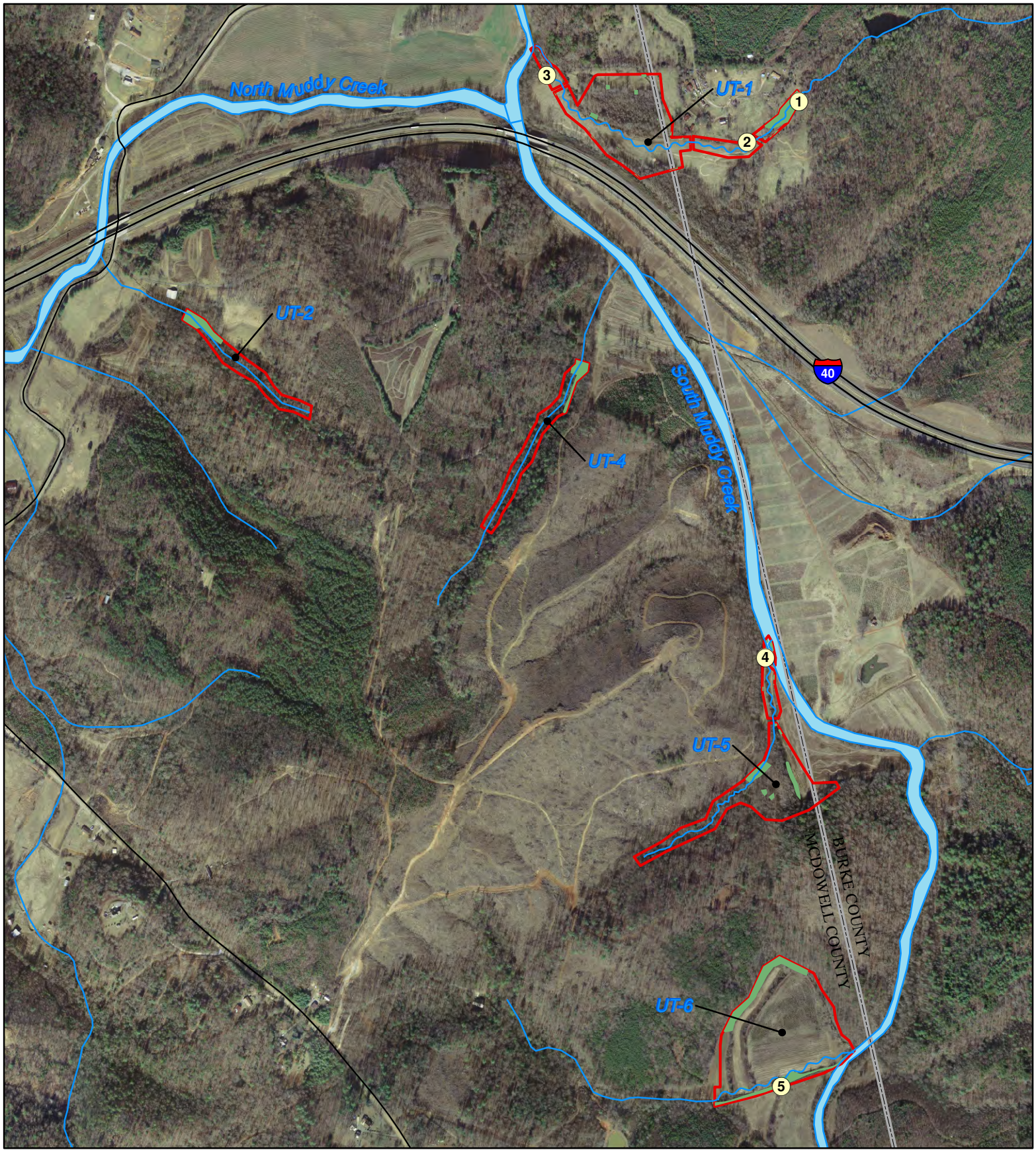
Morgan Creek, Photo 8, looking south
November 12, 2010

Morgan Creek, Photo 8, looking south
August 3, 2011

UT-7, Photo 9, looking north
April 16, 2010

UT-7, Photo 9, looking north
August 3, 2011

Figure 2: North Muddy Creek Stream Restoration Site



North Muddy Creek
Photos of Invasive Plant Control

UT-1, Photo 1, looking northeast
April 26, 2010

UT-1, Photo 1, looking northeast
August 3, 2011

UT-1, Photo 1, looking south
August 3, 2011

UT-1, Photo 1, looking southwest
August 3, 2011

UT-1, Photo 2, looking southwest
April 26, 2010

UT-1, Photo 2, looking southwest
August 3, 2011

UT-1, Photo 3, looking northwest
November 19, 2009

UT-1, Photo 3, looking northwest
August 3, 2011

UT-5, Photo 4, looking north
April 26, 2010

UT-5, Photo 4, looking north
August 3, 2011

UT-6, Photo 5, looking south
February 9, 2009

UT-6, Photo 5, looking south
August 3, 2011