Morgan Creek
Stream Restoration Site

Year 4 Final Monitoring Report
Project ID Number: 16-D06027
EEP Project # 92527

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1.0 SUMMARY

This Annual Monitoring Report details the activities conducted during 2012 (Year 4) 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 required. Additionally, in April 2011 a second supplemental planting of trees occurred within the repaired reaches as well as other areas noted with low stem densities. The 2012 data represent results from the fourth 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 included 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 generating 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 are 11,152 SMU's.

This Annual Report presents the data from 16 cross-sections, 3,163 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 have occurred when compared to the as-built conditions. The Year 4 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 that are likely driving the bed form changes observed between monitoring years. Since project completion at least five bankfull events have occurred at the project site.

Vegetation plot (VP) monitoring during Year 4 indicates planted stem densities ranged between 324 and 890 stems per acre with an average of 613 planted stems per acre for the entire restoration site. This is a strong indicator that the site is on target to meet the final vegetative success criterion of 260 stems per acre. The increase in percent survival of planted stems since the Year 2 monitoring is the result of a supplemental planting effort that occurred in spring 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 1,098 stems per acre. Additionally, an intensive exotic invasive plant control effort was initiated in the summer of 2011 with follow up treatments administered in 2012 and planned for 2013.

2.0 INTRODUCTION

2.1 Project Description

The Morgan Creek Stream Mitigation Site was identified and developed through the North Carolina Ecosystem Enhancement Program (NCEEP) 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 includes portions 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 while UT1, UT2, UT3, UT5, UT8, and UT9 originate within the property boundary in the more mountainous area to the south of the Morgan Creek valley. Tributaries UT4, UT6, and UT7 originate off the project property north of Morgan Creek; portions of them on the project property are included in the project easement area. The USGS Sugar Hill topographic quadrangle **(Figure 2)** shows the project streams draining to the larger Cove Creek watershed. All reaches drain watersheds consisting of predominately forested 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) by installing livestock exclusion fencing, a supplemental riparian buffer planting, and 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 buffer vegetation, and failed culvert crossings. The enhancement reaches had been previously impacted by livestock access, limited riparian buffer vegetation, and adjacent eroding logging roads.

The 2012 monitoring season represents Year 4 of the monitoring period. Monitoring during 2012 included stream and vegetation monitoring stations **(Figure 3, Sheets 1-8)** as approved in the Mitigation Plan (EBX 2008).

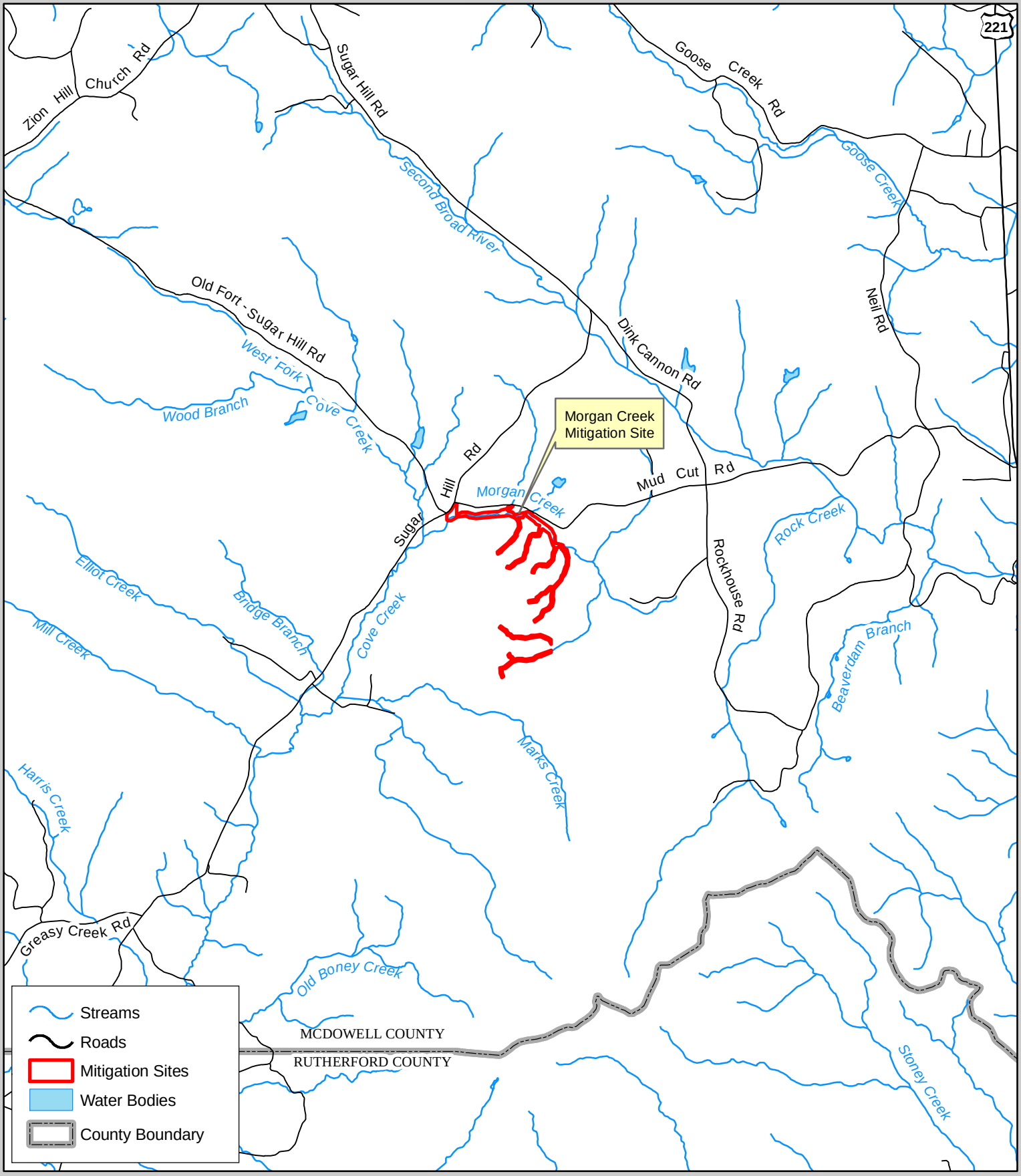
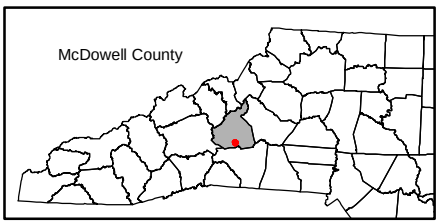
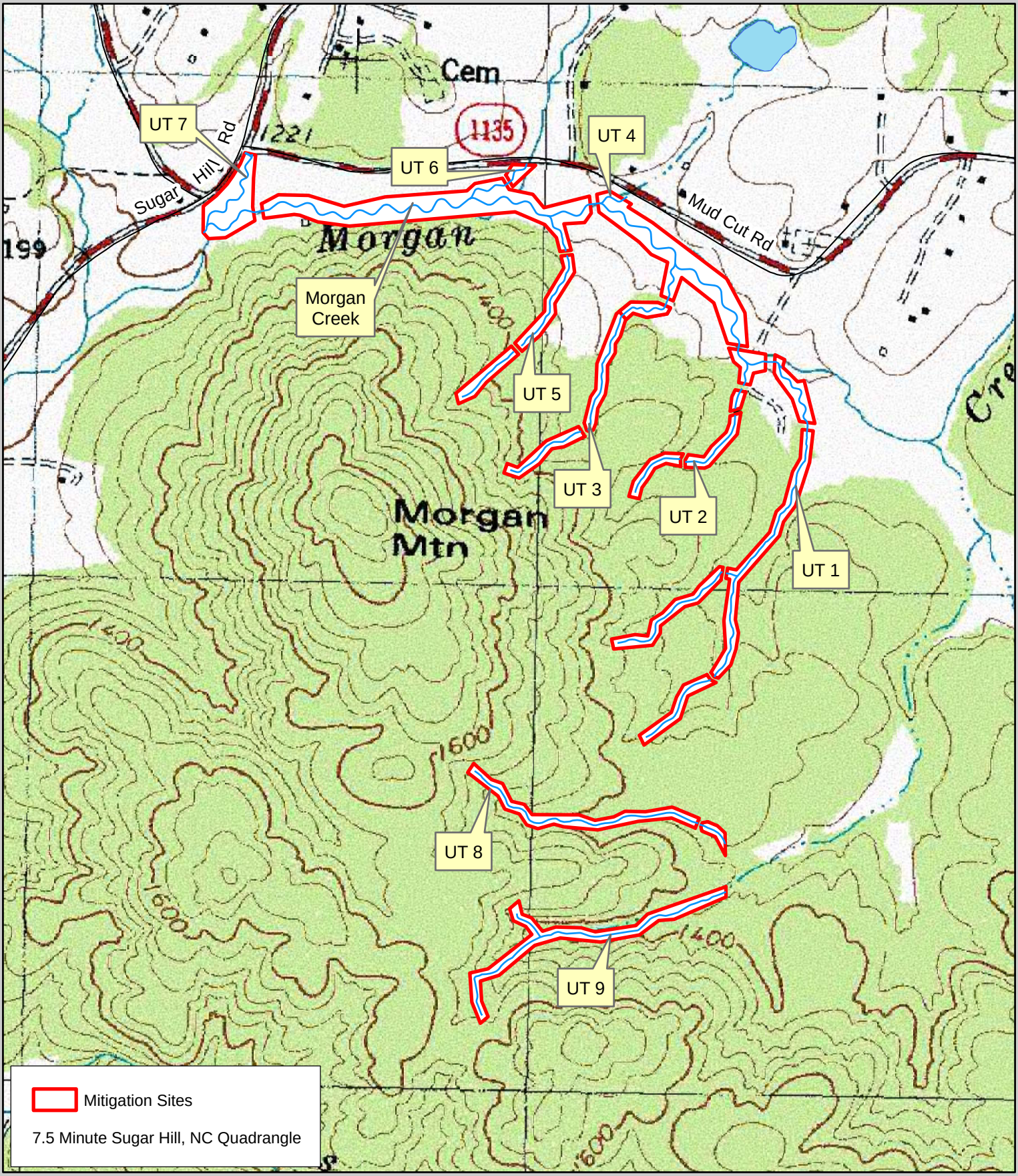


Figure 1
Morgan Creek Mitigation Site
Project Vicinity Map

0 0.25 0.5 1 Miles



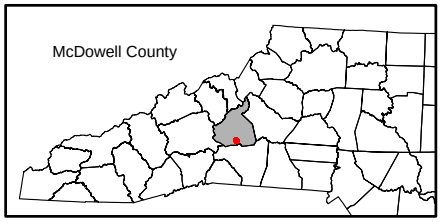


EBX

EQUINOX ENVIRONMENTAL CONSULTATION & DESIGN

Figure 2
Morgan Creek Mitigation Site
USGS Map

0 500 1,000 2,000 Feet



SHEET 4

SHEET 5

SHEET 3

SHEET 2

SHEET 6

REACH
UT 1

REACH
MC-UPPER

UT-1

UT-2

MORGAN CREEK

UT-4

UT-3

UT-8

UT-9

SHEET 7

UT-6

UT-5

REACH
UT-6

SHEET 8

REACH
MC-LOWER

UT-7

LEGEND

- Vegetation Monitoring Plots
- Easement Boundary
- Stream
- Longitudinal Profile Reach
- Longitudinal Profile Begin/End
- 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

SCALE 1" = 500'

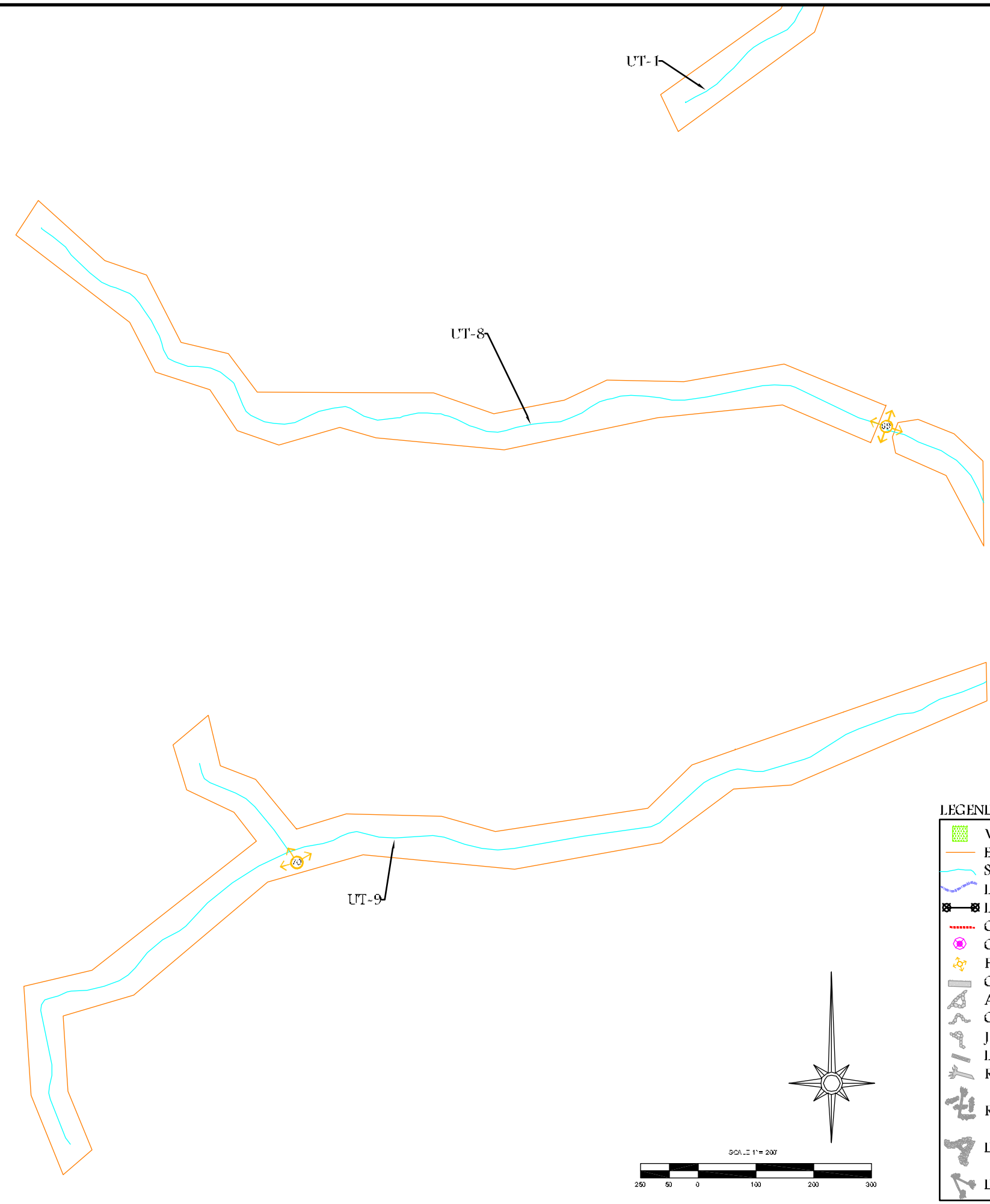
250 175 0 250 500 750

Morgan Creek

McDowell County, NC

Monitoring Plan
Figure 3

Sheet:
1
of 8



Morgan Creek

McDowell County, NC

Monitoring Plan
Figure 3

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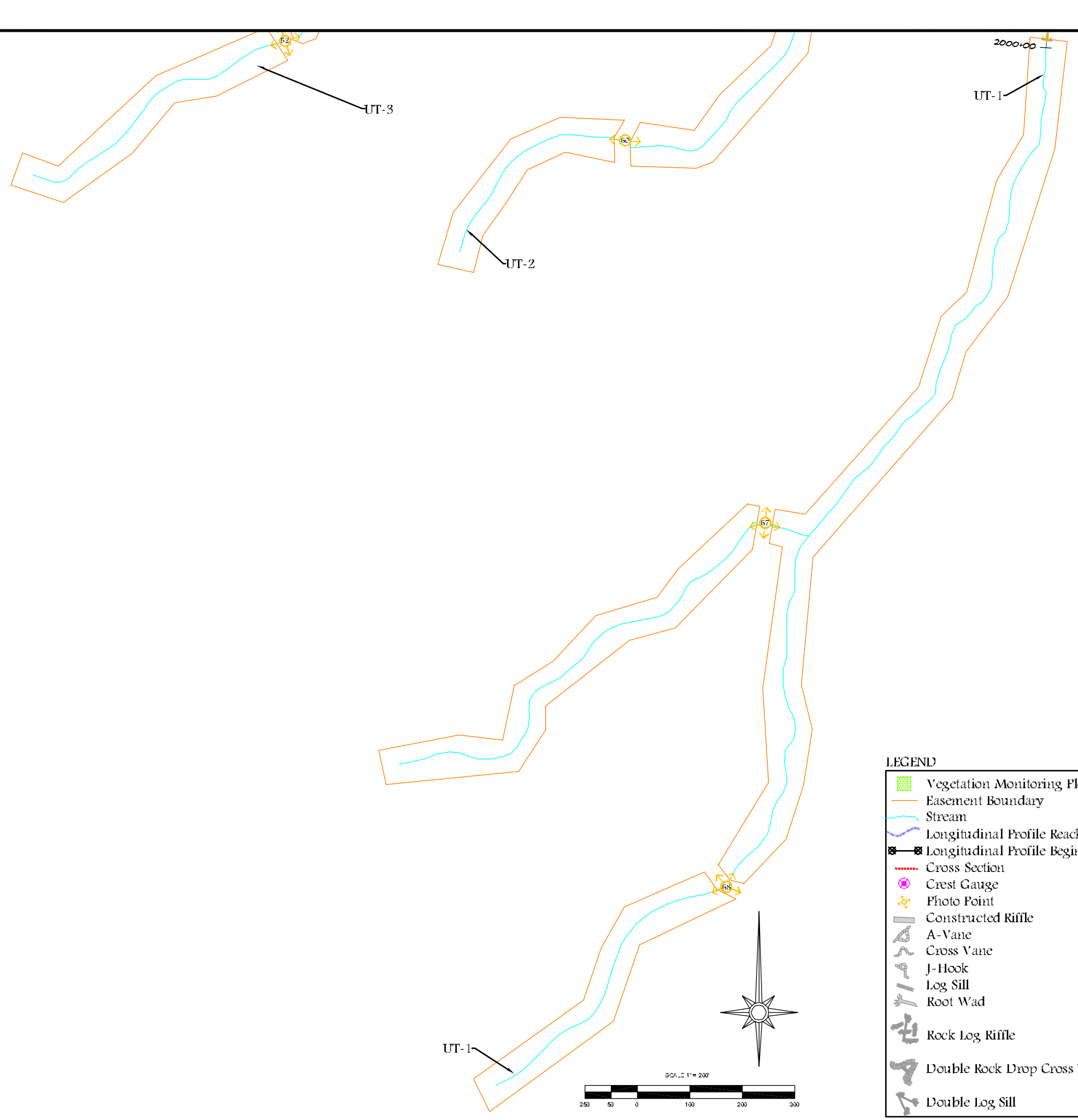

Morgan Creek

McDowell County, NC

Monitoring Plan
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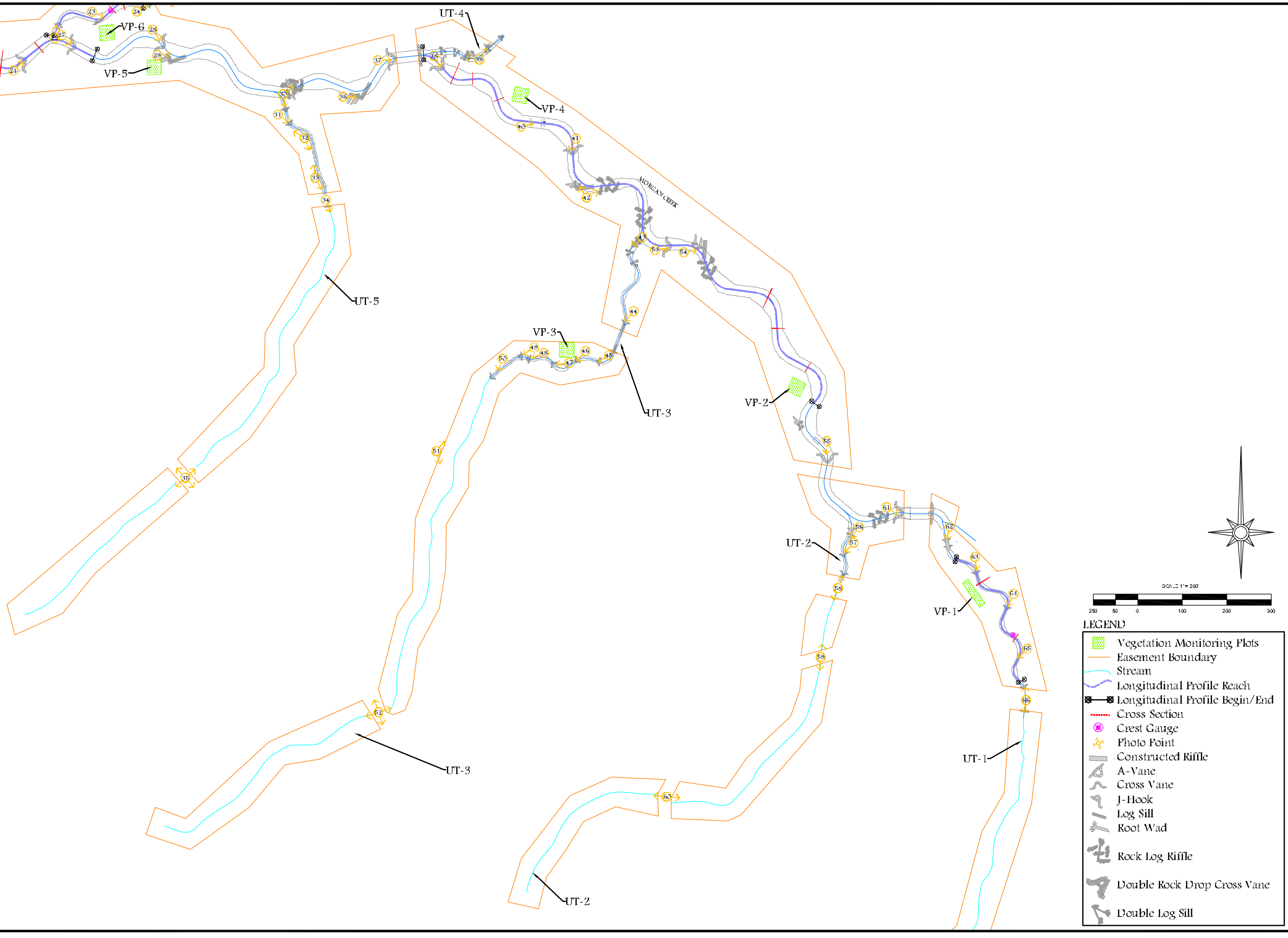
Morgan Creek

McDowell County, NC



Monitoring Plan
Figure 3

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LEGEND

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SCALE 1" = 100'

50 25 0 50 100 150

VP-3

UT-3

MC Upper-R2
XS Station=1007+84.30

MC Upper-R1
XS Station=1006+56.98

VP-2

UT-2

UT1-P
XS Station=2003+77.15

VP-1

UT1-R
XS Station=2001+95.47

Morgan Creek

McDowell County, NC

Monitoring Plan
Figure 3

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UT-4

MC Upper-R4
XS Station=1018+35.29

VP-4

MC Upper-P2
XS Station=1018+80.45

MC Upper-R3
XS Station=1017+49.90

MC Upper-P1
XS Station=1008+66.76

MORGAN CREEK

UT-5

VP-3

UT-3

MC Upper-R2
XS Station=1007+84.30

MC Upper-R1
XS Station=1006+56.98

VP-2

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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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UT-6

UT6-P
XS Station=7002+81.15

UT6-R
XS Station=7003+09.20

MC Lower-R4
XS Station=1037+65.72

MC Lower-P2
XS Station=1037+31.23

VP-7

VP-6

VP-5

MC Lower-R3
XS Station=1035+55.54

MC Lower-R2
XS Station=1032+07.04

MC Lower-P1
XS Station=1030+53.19

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

UT~7

VP~7

VP~8

8000+00
8001+00
8002+00
8003+00
8004+00
8005+00
8006+00
8006+90
1041+00
1042+00
1043+00
1044+00
1045+00
1046+00
1047+00
1048+00
1049+00
1054+96
1035+00
1036+00
1037+00
1038+00
1039+00
1040+00

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SCALE 1" = 100'

50 25 0 50 100 150

Monitoring Plan
Figure 3

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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 NCEEP full delivery process in the Broad River 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. 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 **(Table 1)**. Based on the repair as-built conditions, a total of 11,152 SMU's were documented for the site.

Table 1. Project Approach, Mitigation Structure, and SMUs by Stream Reach

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 NCEEP. Stream and vegetation monitoring are conducted annually for five years or until success criteria have been met. The following sections and Appendix A detail the results of the monitoring efforts for Year 4 at the Morgan Creek Stream Mitigation Site.

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. Repairs to the damaged areas were delayed until early 2010, resulting in the

postponement of the Year 1 monitoring efforts. In addition, a supplemental planting occurred in April 2011 not only within the repaired areas, but also in other areas previously noted to have low stem densities. A site wide exotic invasive plant control effort also was initiated in June 2011 with follow up treatments occurring in 2012. The Year 4 monitoring was completed as originally scheduled, with the fifth year of monitoring expected to be finished in the winter of 2013 (**Table 2**). Project service providers and contacts are listed in **Table 3**.

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
February and June 2012	Exotic Invasive Plant Control
December 2012	Year 4 Annual Monitoring Report
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 restoration 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.
- *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 must occur in separate years during the 5-year monitoring period. If two bankfull events do not occur, additional monitoring may be required by the USACE.

3.2 Stream Morphology Monitoring Plan

The stream monitoring program is intended to document trends and progress in achieving the channel success criteria. Monitoring is to 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 at the time the as-built conditions were measured. Cross-sections on Morgan Creek include four riffles and two pools within 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 by the repairs, resulting in a change in the apparent 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. All cross-sections were marked on both banks with permanent iron pins to establish known elevations and stationing for comparisons between annual data collection efforts. 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. Pebble counts are collected annually 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 changes 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 4 annual stream morphology data were collected between March and November 2012. Reference station photos were collected in January 2012 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 March and April 2012. 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 on November 14, 2012.

3.3.1 Cross-Sections

The MC-Upper, MC-Lower, UT1, and UT6 cross-sectional data collected during the Year 4 monitoring effort have been compared with previous data sets **(Appendices B and C)**. Due to stream and bank repairs in 2010 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 condition and Year 1 monitoring. Additionally, the two constructed riffles (Cross-Sections 1 and 5) within the MC-Upper reach maintained similar maximum depths between the as-built and Year 1 whereas maximum depths for the two non-constructed riffles (Cross-Sections 2 and 4) 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 4 data for MC-Upper reach continue to indicate that the cross-sectional dimensions are stable when compared to the Year 1 and 2 data sets (Table 6).

Due to the loss of the original cross-sectional stations within the MC-Lower reach, data comparisons with the as-built data are not appropriate. However, the Year 4 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 4 is an increase in cross-sectional area and depth for riffle 1 and 2 (Table 6).

Compared to the UT1 as-built data, the Year 4 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 conditions and Year 1 monitoring. The Year 4 cross-sectional data for UT6 continues to indicate that stream dimensions have stabilized since the Year 1 monitoring effort. The pool cross-section for this reach indicates an increase in bankfull maximum depth between the Year 3 and 4 data sets trending back toward the as-built conditions.

3.3.2 Longitudinal Profile

Longitudinal profile surveys were conducted along four separate reaches of the restoration project, totaling approximately 3,163 linear feet. The surveys included reach MC-Upper from STA 1005+15 to STA 1019+46 (1,431 linear feet), MC-Lower from STA 1028+20 to STA 1039+25 (1,105 linear feet), UT1 from STA 2000+85 to STA 2004+67 (382 linear feet), and reach UT6 from STA 7002+34 to STA 7004+79 (245 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 and C)**.

While the project site continues to experience some changes in morphology, the Year 4 stream profiles and visual observations indicate that the majority of the project has reached a state of equilibrium and is providing the intended habitat and hydrologic function. Tributary UT6 continues to indicate an evolving stream system with an overall trend back towards the designed profile. The restored stream channel continues to receive significant sediment inputs from upstream sources that 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 (Appendix B). The MC-Upper pebble count data collected during Year 4 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 indicate an overall coarser composition within both the pool and riffle habitat types, with pools primarily containing sand and gravel and riffles primarily comprised of gravel. The UT1 pebble count data collected during Year 4 continues to indicate finer substrate material within both pool and riffle habitats, with substrate composition comprised of silt/clay and sand particles. The Year 4 substrate composition within the UT6 riffle habitat has coarsened since the previous year and was primarily comprised of a wide range of sand and gravel particles. The UT6 pool substrate composition has remained unchanged and was primarily comprised of coarse sand and fine gravel substrate. The pebble count data summary plots are included in **Appendix B**.

3.3.4 Hydrology

Since the Morgan Creek project was completed at least five bankfull events have occurred at 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 (MY1) and January 2010 (MY2) 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)**. One bankfull event occurred during the Year 4 monitoring period.

Table 4. Crest Gauge Data, Height above Bankfull

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
May 2012	0.66	0.41	0.76

3.3.5 Photo Reference Stations

The Year 4 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 4 monitoring are included in **Appendix D**.

Table 5. Stream Problem 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 4 morphological monitoring and visual assessments continue to indicate an evolving stream system in which the restoration areas continue to progress towards stability. Areas of concern identified during Year 4 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 the final year 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 were measured. Details of the morphologic parameters are provided in **Appendices B and 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**	**Year 4**
Average Bankfull Cross-Section Area Abkf (sq ft)	28.4	25.0	24.9	24.2	24.0
Average Bankfull Width Wbkf (ft)	20.8	19.7	19.8	18.8	18.5
Average Bankfull Width/Depth Ratio	15.5	15.6	16.0	14.8	14.6
Average Bankfull Mean Depth Dbkf (ft)	1.4	1.3	1.3	1.3	1.3
Average Bankfull Max Depth Dmax (ft)	2.4	3.0	3.0	3.1	3.1

Morgan Creek – Lower Reach					
Parameter	**As-Built***	**Year 1**	**Year 2**	**Year 3**	**Year 4**
Average Bankfull Cross-Section Area Abkf (sq ft)	28.2	42.2	43.1	45.8	46.3
Average Bankfull Width Wbkf (ft)	22.4	24.3	24.3	25.2	24.7
Average Bankfull Width/Depth Ratio	17.8	14.1	14.0	14.5	13.8
Average Bankfull Mean Depth Dbkf (ft)	1.3	1.7	1.8	1.8	1.9
Average Bankfull Max Depth Dmax (ft)	2.4	3.2	3.4	3.6	3.7

*Morgan Creek - Lower as-built data are presented for the purpose of comparing the original measures 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**	**Year 4**
Average Bankfull Cross-Section Area Abkf (sq ft)	4.1	4.2	4.2	4.2	4.3
Average Bankfull Width Wbkf (ft)	9.1	9.0	9.7	9.2	9.0
Average Bankfull Width/Depth Ratio	19.9	19.4	22.7	20.2	18.9
Average Bankfull Mean Depth Dbkf (ft)	0.5	0.5	0.4	0.5	0.5
Average Bankfull Max Depth Dmax (ft)	1.2	1.3	1.3	1.4	1.4

Morgan Creek – UT6					
Parameter	**As-Built**	**Year 1**	**Year 2**	**Year 3**	**Year 4**
Average Bankfull Cross-Section Area Abkf (sq ft)	11.1	10.3	9.7	8.7	9.0
Average Bankfull Width Wbkf (ft)	13.4	11.7	11.7	10.0	10.0
Average Bankfull Width/Depth Ratio	16.2	13.2	14.1	11.5	11.1
Average Bankfull Mean Depth Dbkf (ft)	0.8	0.9	0.8	0.9	0.9
Average Bankfull Max Depth Dmax (ft)	1.7	1.7	1.6	1.7	1.9

4.0 VEGETATION

4.1 Vegetation Success Criteria

Successful establishment of vegetation for the Morgan Creek Stream Restoration Project should be an average of 320 planted stems per acre by the end of Year 3 such that the site will meet 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 (10 m x 10 m) plots and one non-standard (5 m x 20 m) 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 to include 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 4 vegetation monitoring documented planted stem densities ranging from 324 to 890 stems per acre **(Table 9)** with an average planted stem density of 613 planted stems per acre for the entire restoration site.

Table 8. Results of Monitoring Year 4 Vegetation Monitoring by Plot

Species	Plot ID							
	VP1	VP2	VP3	VP4	VP5	VP6	VP7	VP8
Betula nigra	2	1	2	3		12	8	2
Cephalanthus occidentalis	1						5	1
Fraxinus pennsylvanica	4	4	6		11	4	2	5
Liriodendron tulipifera var. tulipifera	1			3			5	
Platanus occidentalis var. occidentalis	1	2		4	1	1		
Quercus michauxii		1			3		1	3
Quercus nigra					2			
Quercus phellos	2	1		2	3			
Quercus species	1							
Salix nigra		1		1		5		1
Totals	12	10	8	13	20	22	21	12

Table 9. Summary of Vegetation Monitoring Results

Plot ID	Stems Planted (Original Baseline Conditions)	Baseline Stems + Initial Supplemental Planting Stems (Revised Baseline Conditions)	2012 Planted 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	486	
VP2	3	5	10	200%	122	162	283	445	405	
VP3	5	7	8	114%	202	283	283	364	324	
VP4	7	10	13	130%	283	405	445	526	526	
VP5	10	17	20	118%	405	688	728	890	809	
VP6	14	23	22	96%	567	931	850	890	890	
VP7	16	22	21	95%	648	891	809	890	850	
VP8	9	21	12	N/A	364	850	486	567	486	
				Mean	359	576	536	632	597	

Average stems per acre: 613
Range of stems per acre: 324 – 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 94% within the plots ranging from 85% to 100%. 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*), soft rush (*Juncus effusus*), daisy fleabane (*Erigeron annuus*), Queen Anne's lace (*Daucus carota*), arrowleaf tearthumb (*Polygonum sagittatum*) 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	95
VP3	100
VP4	85
VP5	85
VP6	100
VP7	85
VP8	100
Mean	94

Commonly encountered woody volunteer or natural species also have been documented throughout the five-year monitoring period **(Table 11)**. Recruitment mean densities of volunteer stems remained at approximately 597 stems per acre between Year 3 and Year 4.

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*
Elderberry	*Sambucus canadensis*

*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 6% of planted stems were found to be dead or missing during Year 4 monitoring. Planted stem mortality was highest at VP7 and VP8 although the majority (87%) of planted stems observed in Year 4 had good or excellent vigor scores.

All vegetation monitoring plots are on target to meet the final success criterion of 260 stems per acre. The average stem density across the whole site for planted and volunteers combined is approximately 1,098 stems per acre, which is well above the final success criterion of 260 stems per acre at the end of Year 5. Additionally, the herbaceous vegetation coverage increased between years and is relatively high in the majority of the vegetation monitoring plots.

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 4 monitoring and appears to have eliminated the Japanese knotweed from the site. Additional intensive control efforts were administered in Year 4 with follow up treatments scheduled throughout the remainder of the monitoring period. The current condition plan views (CCPV) in **Appendix A** depict those areas treated for invasive exotic plants during Year 4. **Appendix E** contains the baseline report and contains 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 4 monitoring were primarily associated with pool aggradation and riffle degradation caused by upstream sediment sources. No remedial action is recommended at this time and this will be addressed upon further inspection throughout the 2013 monitoring year. Beaver activity has also been observed on Morgan Creek and current trapping is ongoing through the Animal and Plant Health Inspection Service.

- Vegetation monitoring efforts have documented the average density planted stems to be 613 stems per acre for the 2012 monitoring year. All vegetation plots are on target to meet the final success criterion of 260 stems per acre. Likewise, individuals classified as volunteer species were similar between years. Lastly, the invasive exotic plant control efforts will be monitored with follow up control efforts planned during the final year of monitoring. No remedial action is recommended at this time.

- Stream and vegetation monitoring are scheduled through 2013.

6.0 REFERENCES

EBX (Environmental Banc & Exchange). 2007. Restoration Plan – Morgan Creek Creek Site. McDowell County, North Carolina. Project ID No. 16-D06027.

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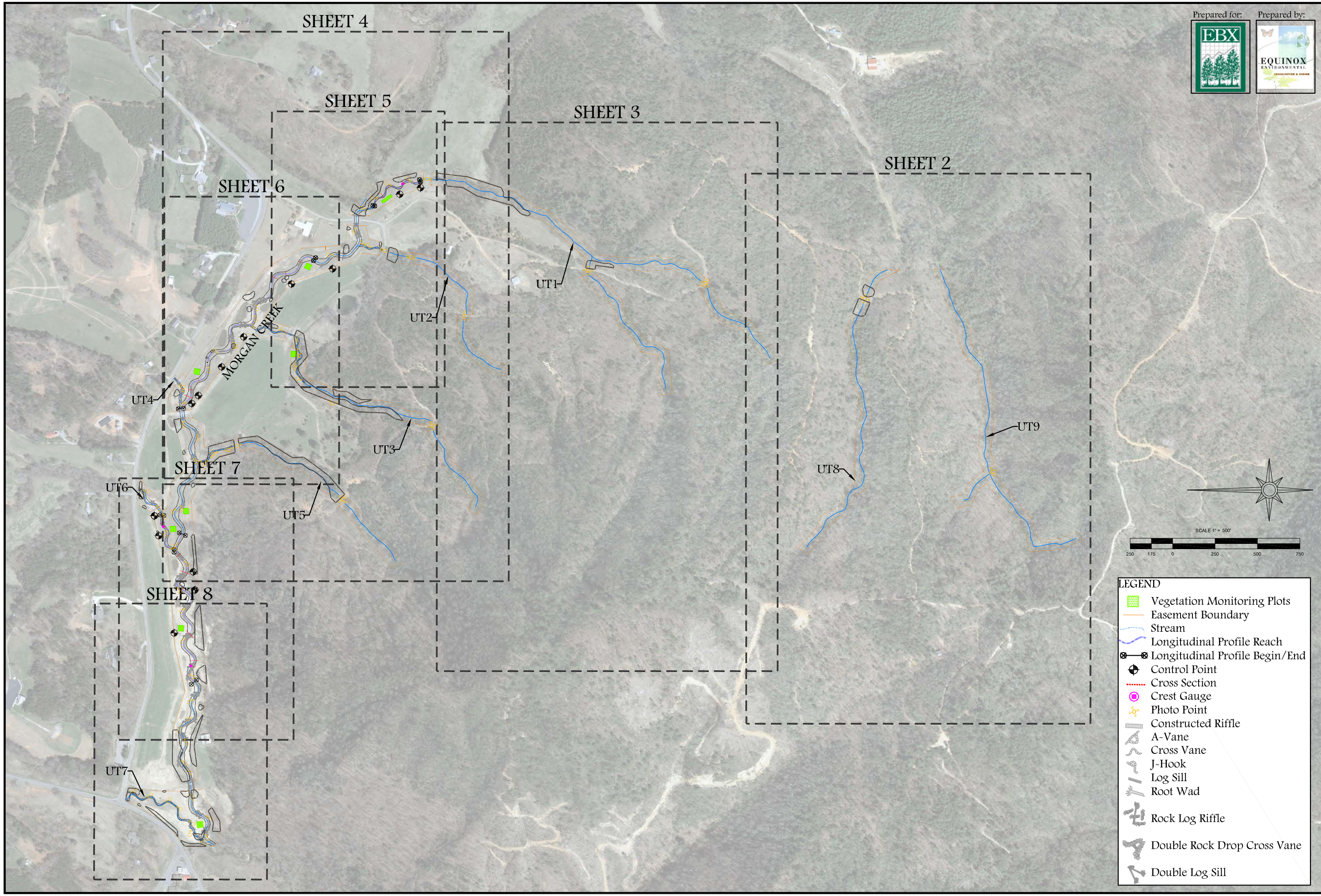
Weakley, A.S. 2008. Flora of the Carolinas, Virginia, Georgia, northern Florida, and surrounding areas. Working draft of 7 April 2008. University of North Carolina Herbarium (NCU). North Carolina Botanical Garden. University of North Carolina at Chapel Hill. Chapel Hill, North Carolina.

APPENDIX A

Monitoring Year 4
Current Condition Plan View



Prepared for: EBX

Prepared by: EQUINOX ENVIRONMENTAL

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

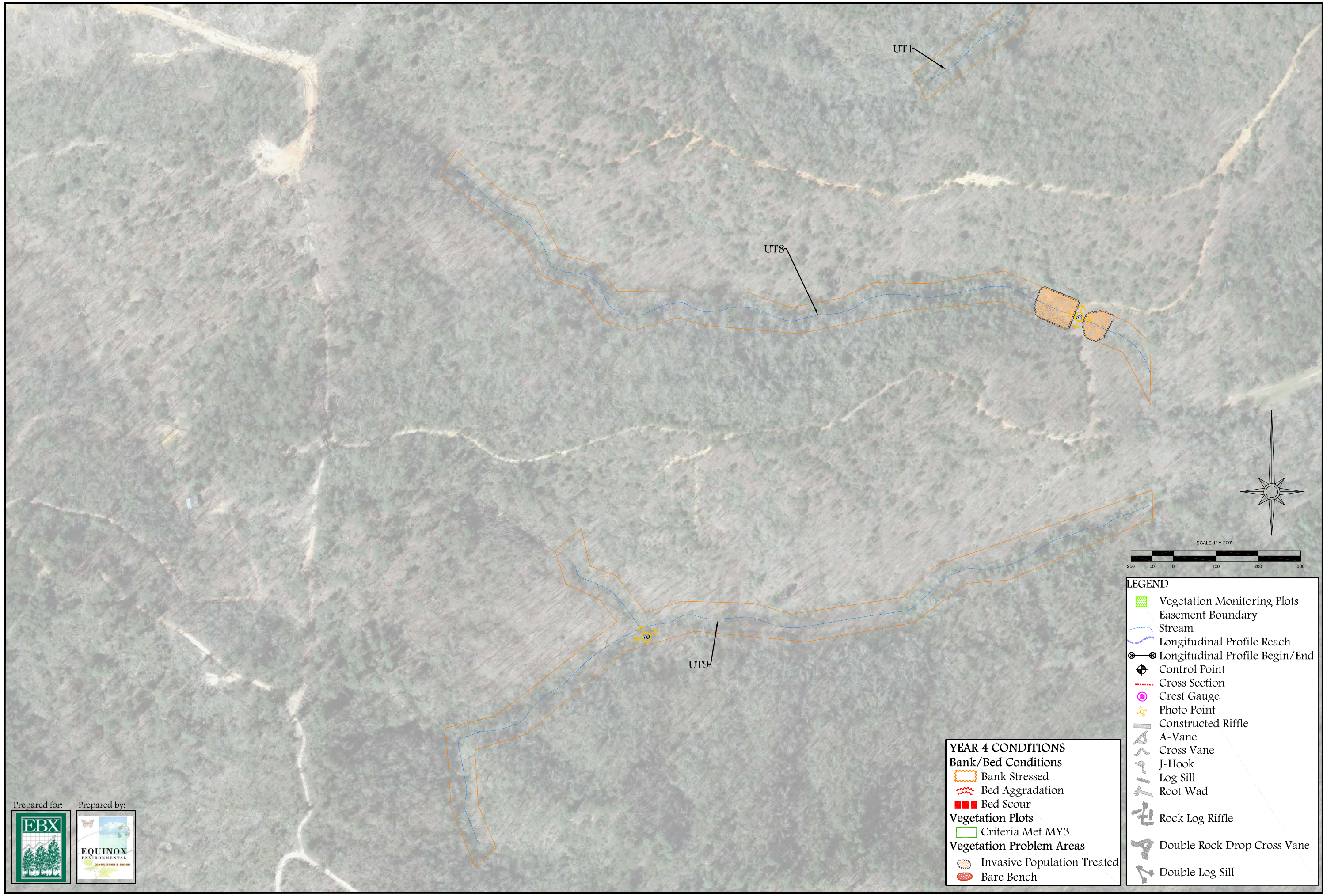
Current Condition Plan View
Final
Year 4 Monitoring-2012
OVERVIEW

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

Sheet: 1 of 8

Date: November 2012



Prepared for: EBX

Prepared by: EQUINOX ENVIRONMENTAL CONSULTATION & DESIGN

Notes:
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2. Base map information provided by Kimley 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 4 Monitoring-2012

Sheet:
2
of 8

Date:
November 2012

Notes:
1. Coordinate System is State Plane Feet NAD 83.
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3. Aerial photography is NC One Map 2010.

Morgan Creek

McDowell County, NC

Current Condition Plan View
Final
Year 4 Monitoring-2012

Sheet:
3
of 8

Date:
November 2012

Prepared for: EBX

Prepared by: EQUINOX ENVIRONMENTAL CONSULTATION & DESIGN

Notes:
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3. Aerial photography is NC One Map 2010.

Morgan Creek

McDowell County, NC

Current Condition Plan View
Final
Year 4 Monitoring-2012

SCALE 1" = 200'

250 50 0 100 200 300

YEAR 4 CONDITIONS

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

Vegetation Plots
- Criteria Met MY3

Vegetation Problem Areas
- 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
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- J-Hook
- Log Sill
- Root Wad
- Rock Log Riffle
- Double Rock Drop Cross Vane
- Double Log Sill

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Sheet: 4 of 8

Date: November 2012

Notes:
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3. Aerial photography is NC One Map 2010

Morgan Creek

McDowell County, NC

Current Condition Plan View
Final
Year 4 Monitoring-2012

Sheet:
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of 8

Date:
November 2012

SCALE 1" = 100'

50 25 0 50 100 150

YEAR 4 CONDITIONS

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

Vegetation Plots
- Criteria Met MY3

Vegetation Problem Areas
- Invasive Population Treated
- Bare Bench

LEGEND
- Vegetation Monitoring Plots
- Easement Boundary
- Stream
- Longitudinal Profile Reach
- Longitudinal Profile Begin/End
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- Double Rock Drop Cross Vane
- Double Log Sill

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Notes:
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3. Aerial photography is NC One Map 2010

Morgan Creek

McDowell County, NC

Current Condition Plan View
Final
Year 4 Monitoring-2012

Sheet:
6
of 8

Date:
November 2012

SCALE 1" = 100'
50 25 0 50 100 150

YEAR 4 CONDITIONS
Bank/Bed Conditions
- Bank Stressed
- Bed Aggradation
- Bed Scour

Vegetation Plots
- Criteria Met MY3

Vegetation Problem Areas
- Invasive Population Treated
- Bare Bench

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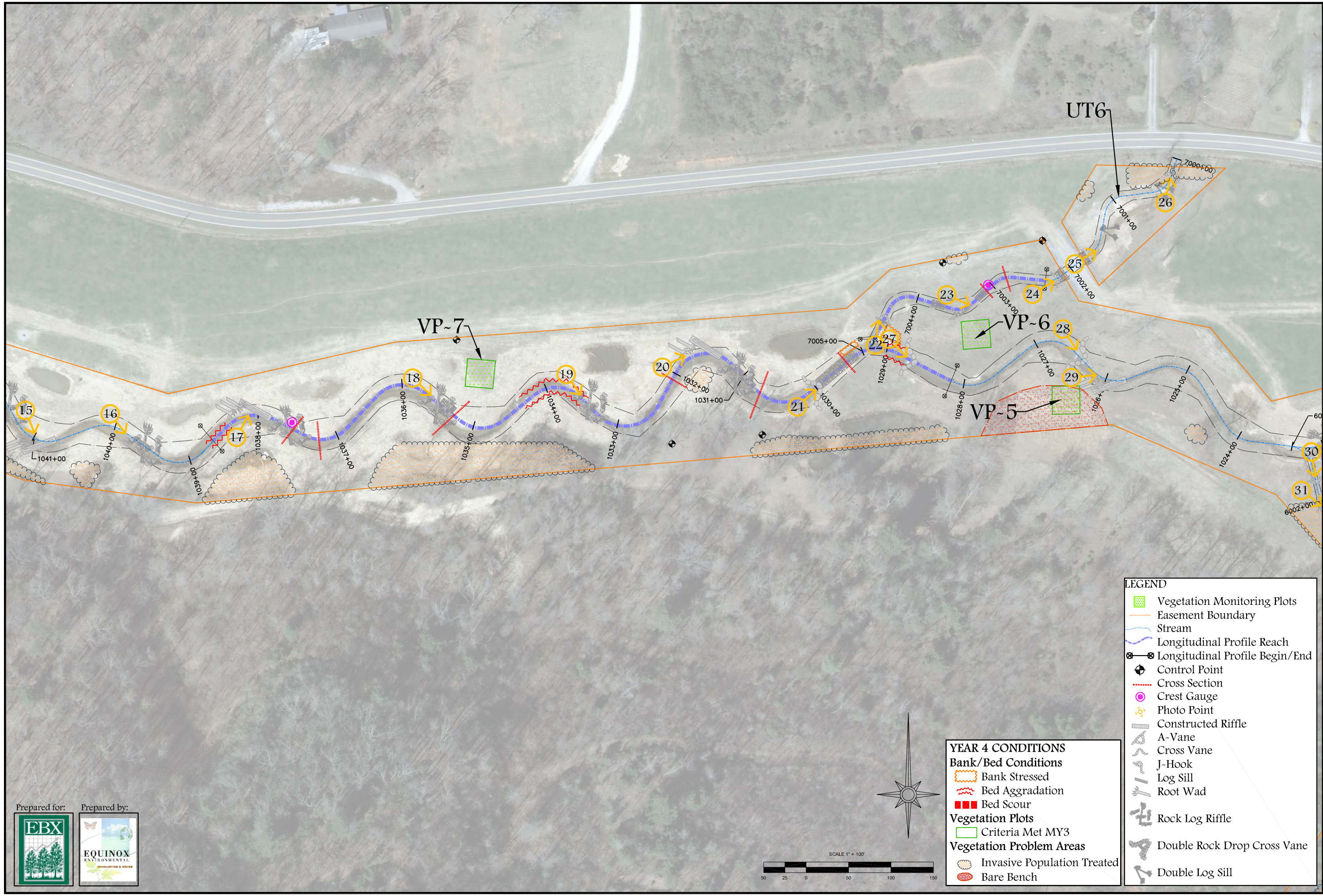
- Constructed Riffle
- A-Vane
- Cross Vane
- J-Hook
- Log Sill
- Root Wad
- Rock Log Riffle
- Double Rock Drop Cross Vane
- Double Log Sill

UT4
UT5
UT3
VP-4
VP-3
VP-2
MORGAN CREEK
Vernal Pool Inlet Scour

Prepared for: EBX

Prepared by: EQUINOX ENVIRONMENTAL CONSULTATION & DESIGN



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3. Aerial photography is NC One Map 2010

Morgan Creek

McDowell County, NC

Current Condition Plan View
Final
Year 4 Monitoring-2012

Sheet:
7
of 8

Date:
November 2012

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

YEAR 4 CONDITIONS
Bank/Bed Conditions
- Bank Stressed
- Bed Aggradation
- Bed Scour

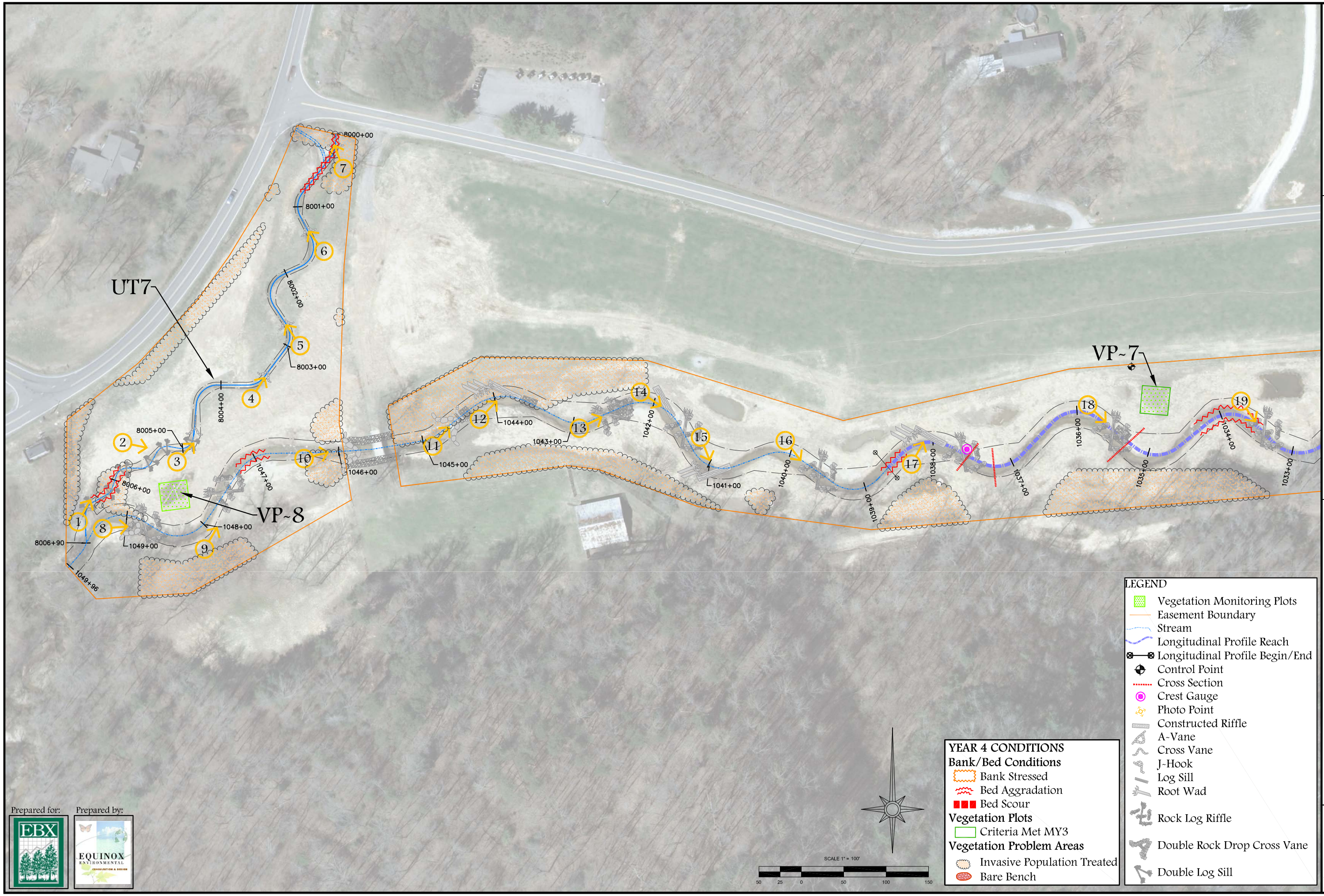
Vegetation Plots
- Criteria Met MY3

Vegetation Problem Areas
- Invasive Population Treated
- Bare Bench

SCALE 1" = 100'
50 25 0 50 100 150

Prepared for: EBX

Prepared by: EQUINOX ENVIRONMENTAL CONSULTATION & DESIGN



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3. Aerial photography is NC One Map 2010.

Morgan Creek
McDowell County, NC

Current Condition Plan View
Final
Year 4 Monitoring-2012

Sheet:
8
of 8
Date:
November 2012

Prepared for: EBX

Prepared by: EQUINOX ENVIRONMENTAL CONSULTATION & DESIGN

SCALE 1" = 100'
50 25 0 50 100 150

YEAR 4 CONDITIONS
Bank/Bed Conditions
- Bank Stressed
- Bed Aggradation
- Bed Scour

Vegetation Plots
- Criteria Met MY3

Vegetation Problem Areas
- Invasive Population Treated
- Bare Bench

LEGEND
- Vegetation Monitoring Plots
- Easement Boundary
- Stream
- Longitudinal Profile Reach
- Longitudinal Profile Begin/End
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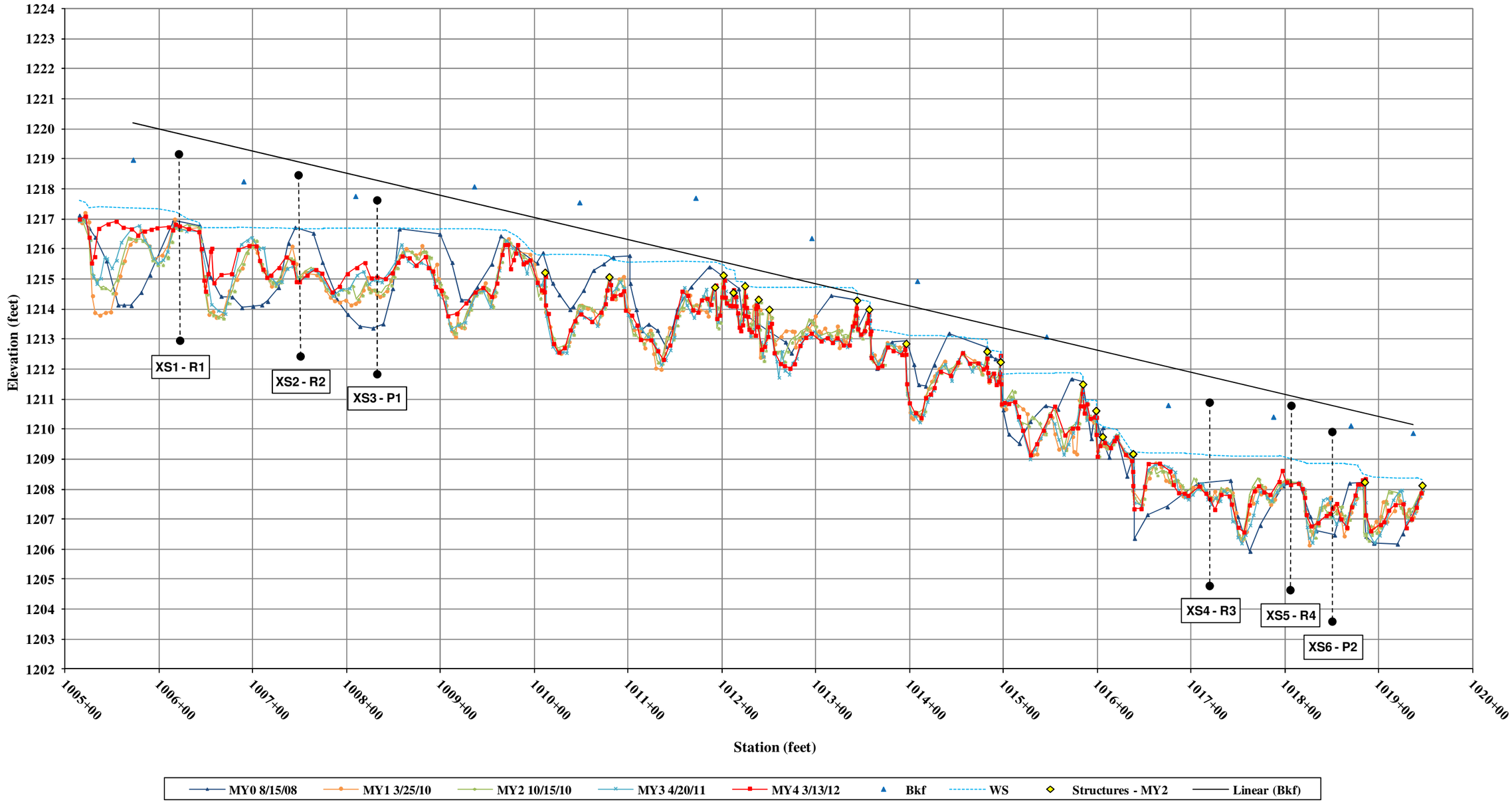
- Rock Log Riffle
- Double Rock Drop Cross Vane
- Double Log Sill

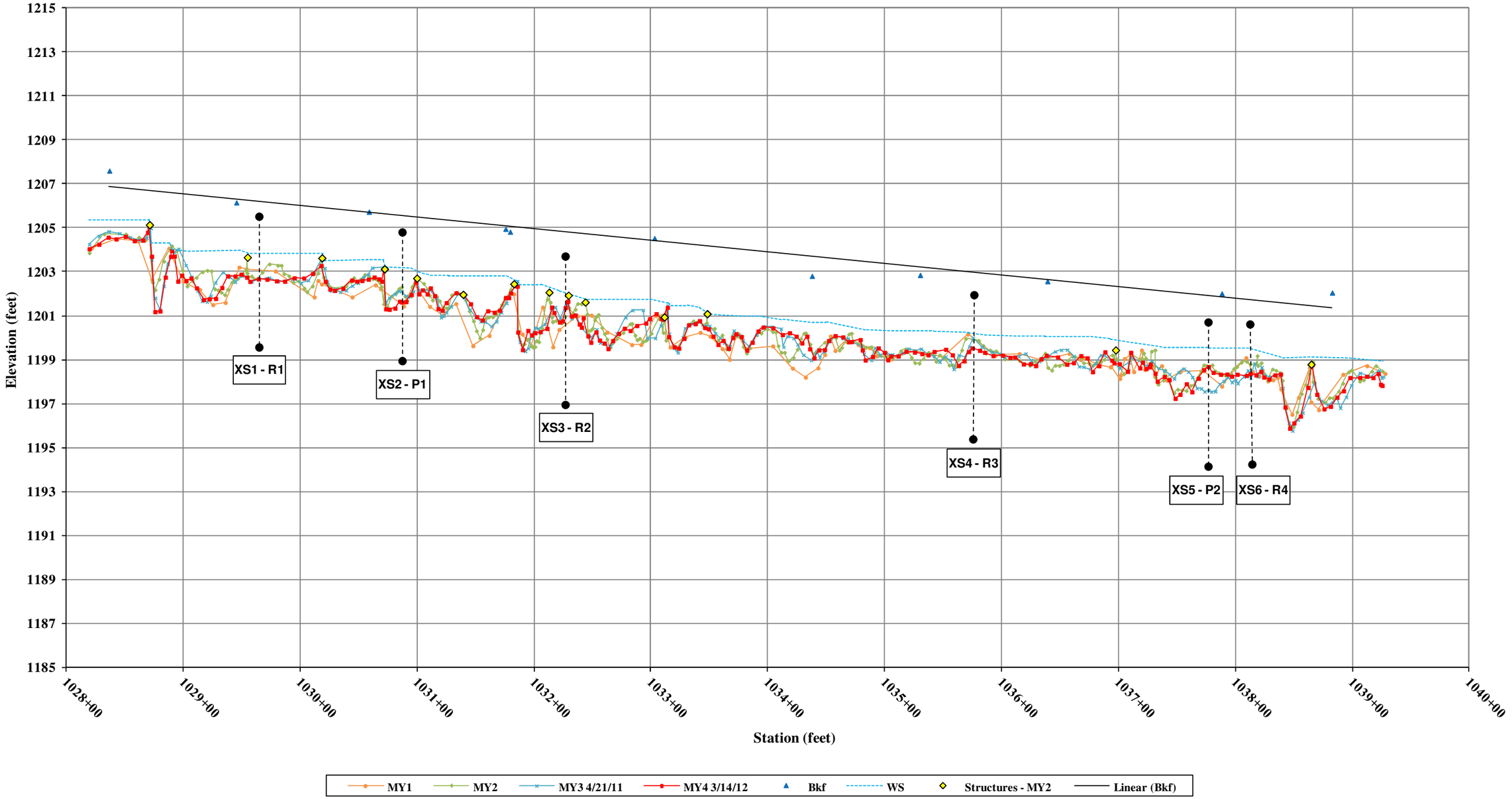
APPENDIX B

Monitoring Year 4
Longitudinal Profile, Cross-Section, and Substrate Data

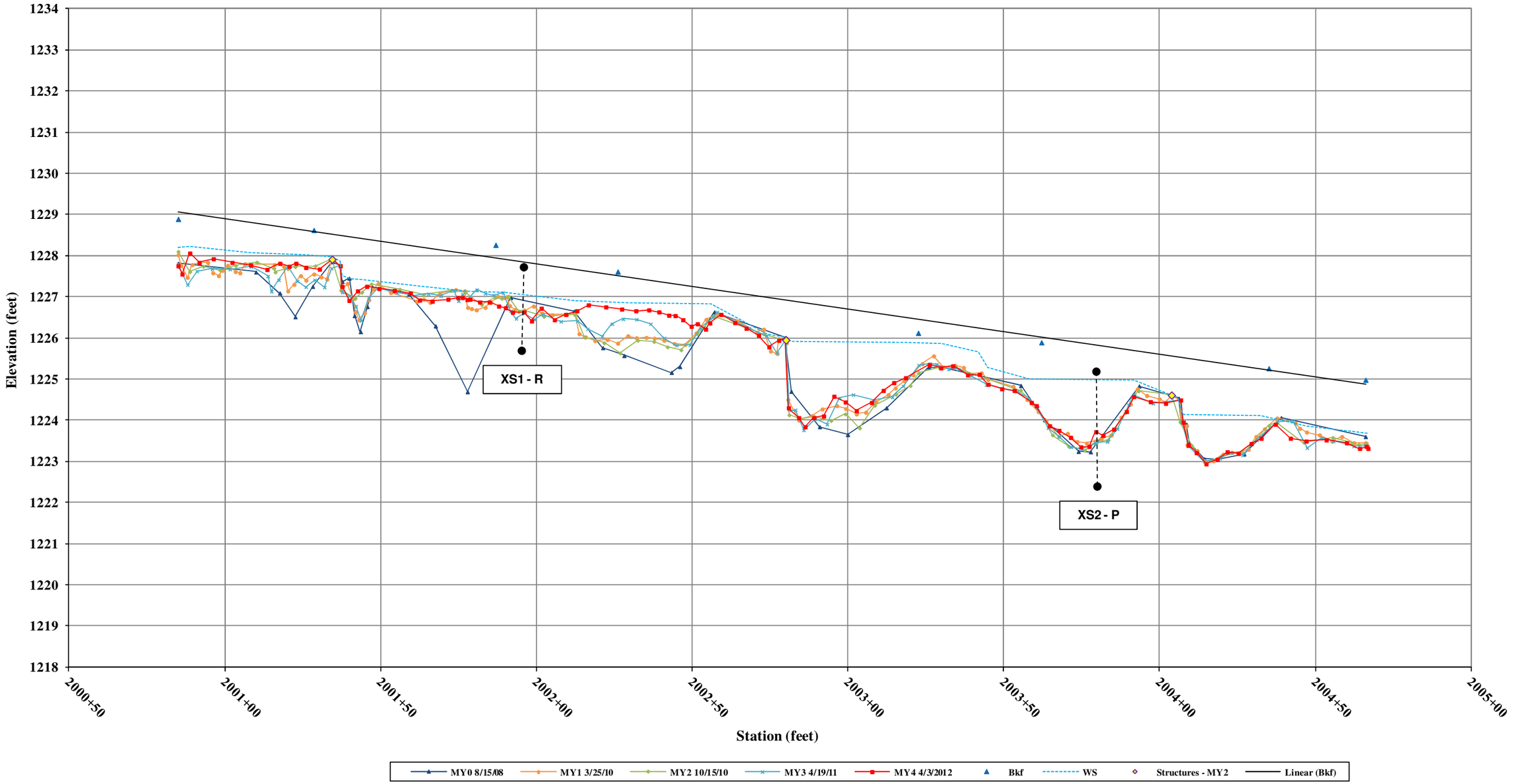
Morgan Creek - Upper
Longitudinal Profile



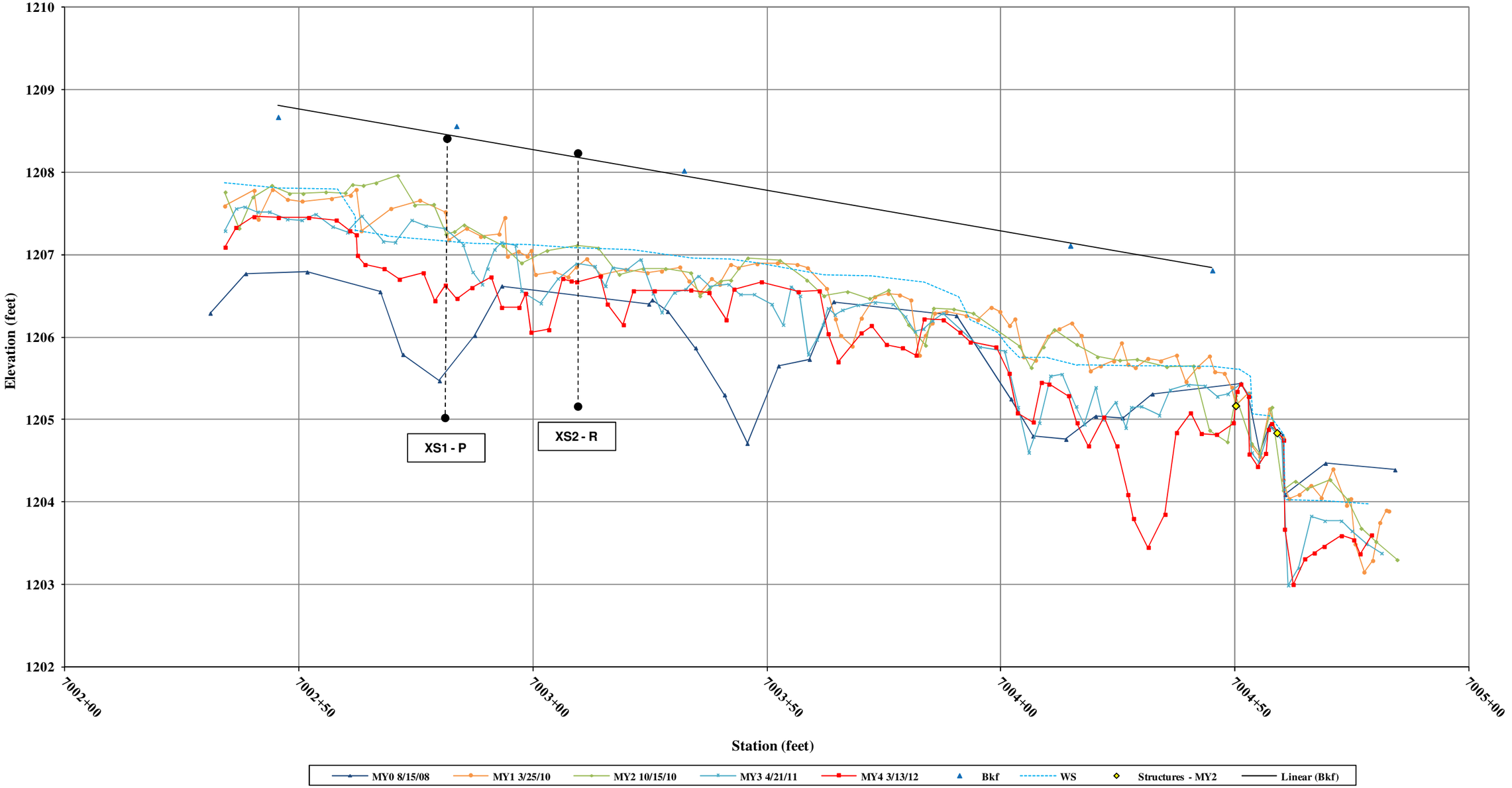
Morgan Creek - Lower
Longitudinal Profile



Morgan Creek - Unnamed Tributary 1
Longitudinal Profile



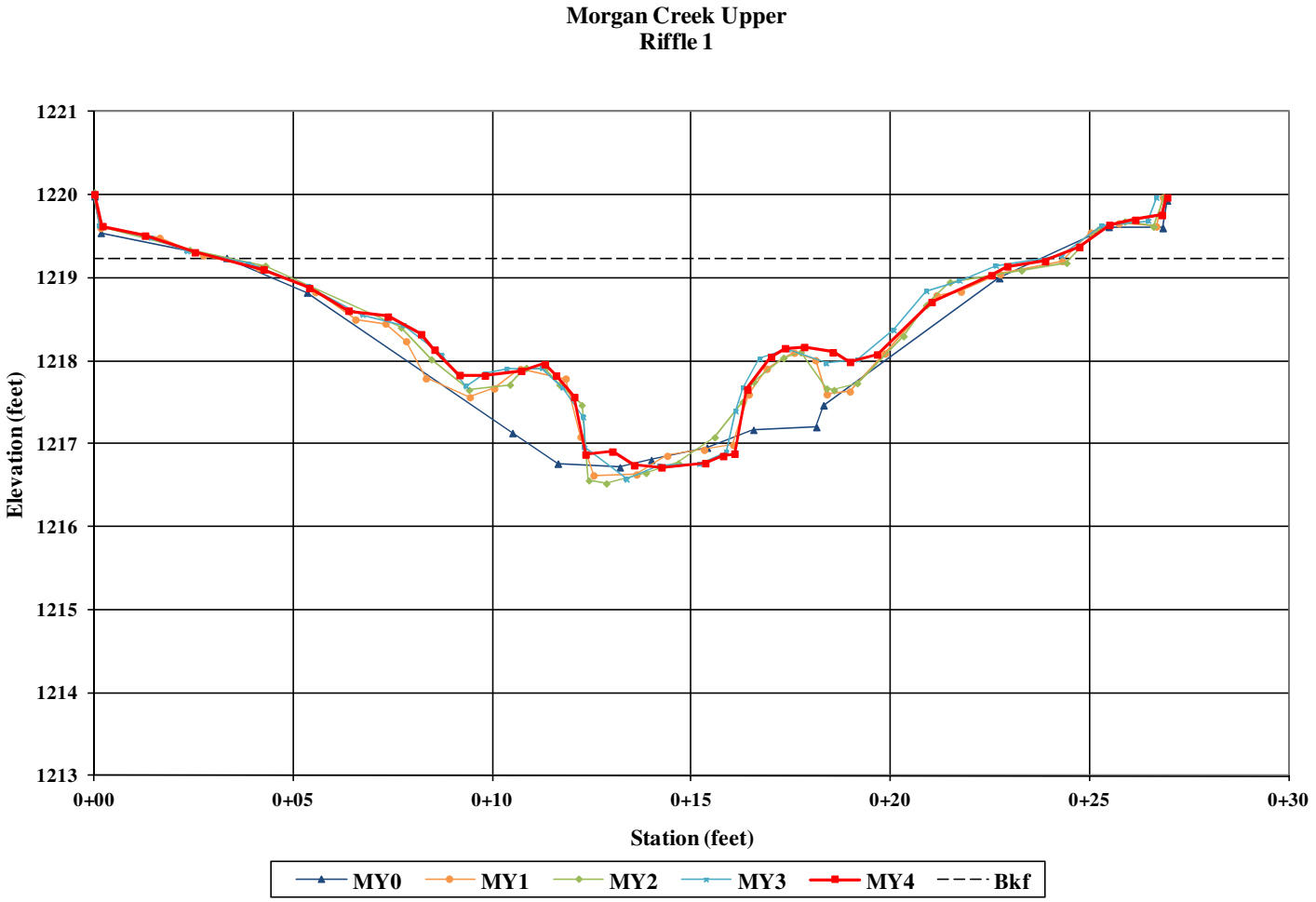
Morgan Creek - Unnamed Tributary 6
Longitudinal Profile



Morgan Creek Upper – Riffle 1
Cross-Section 1

Looking at Left Bank

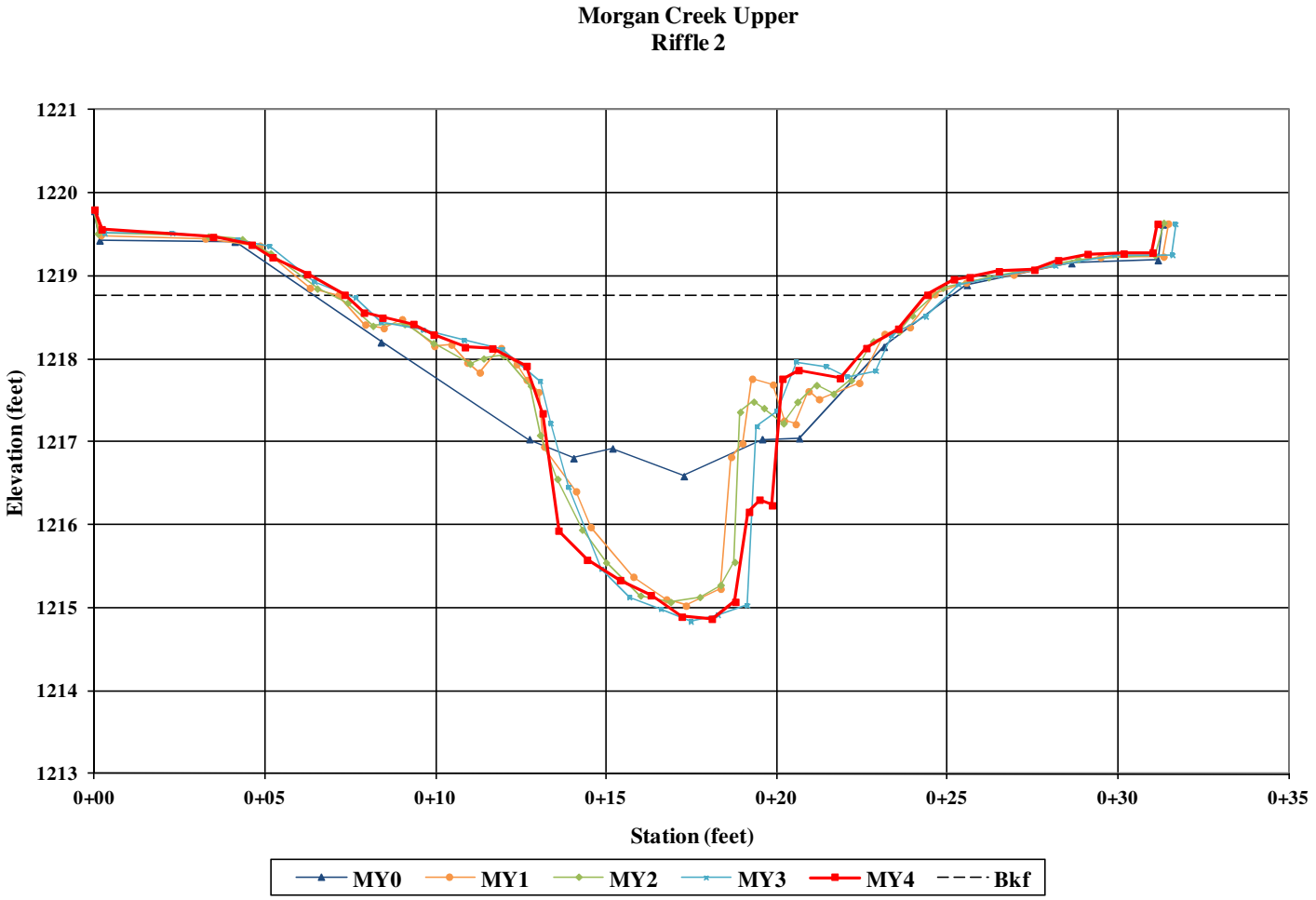
Looking at Right Bank



Morgan Creek Upper – Riffle 2
Cross-Section 2

Looking at Left Bank

Looking at Right Bank



Morgan Creek Upper – Pool 1
Cross-Section 3

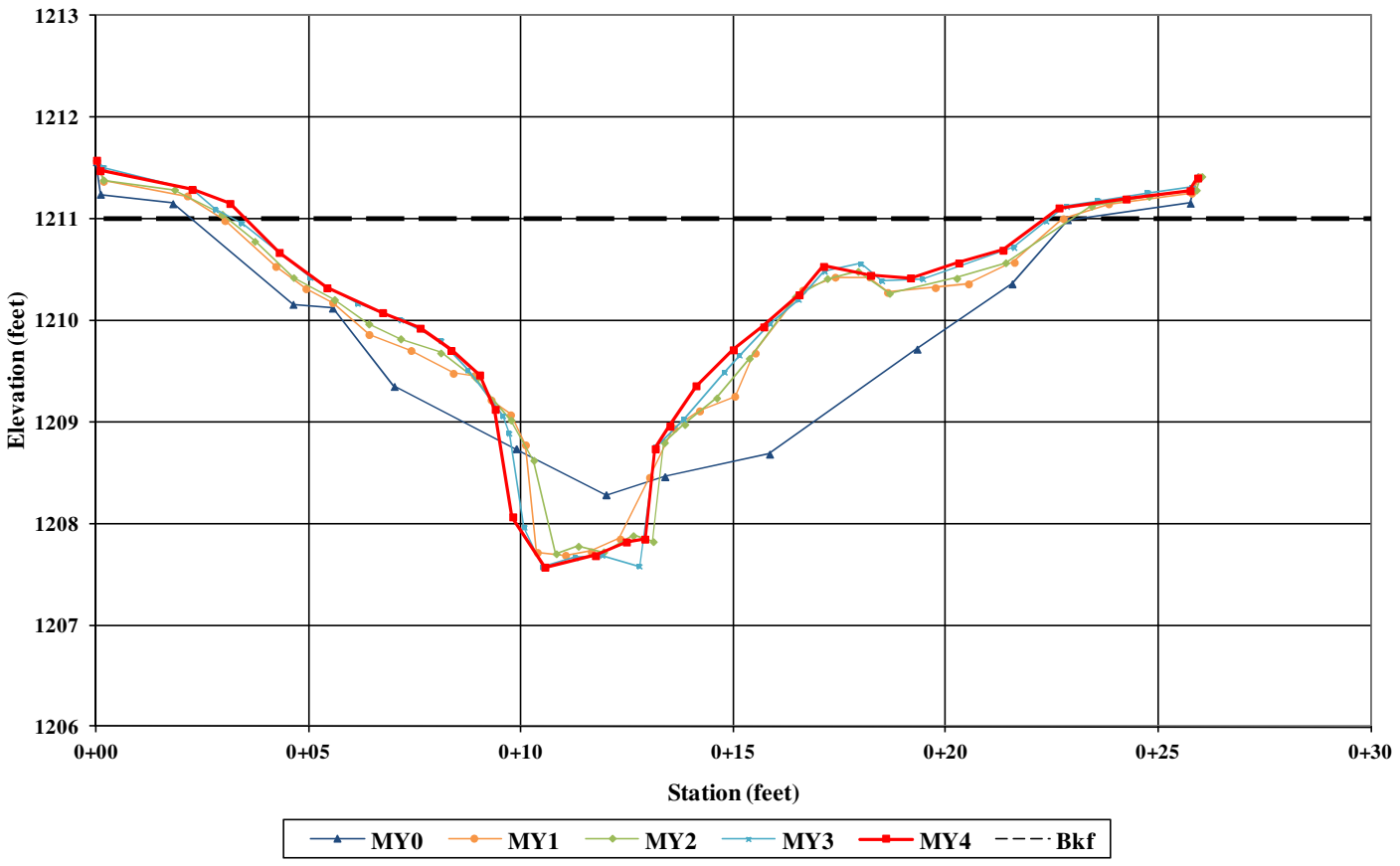
Looking at Left Bank

Looking at Right Bank

Morgan Creek Upper – Riffle 3
Cross-Section 4

Looking at Left Bank

Looking at Right Bank

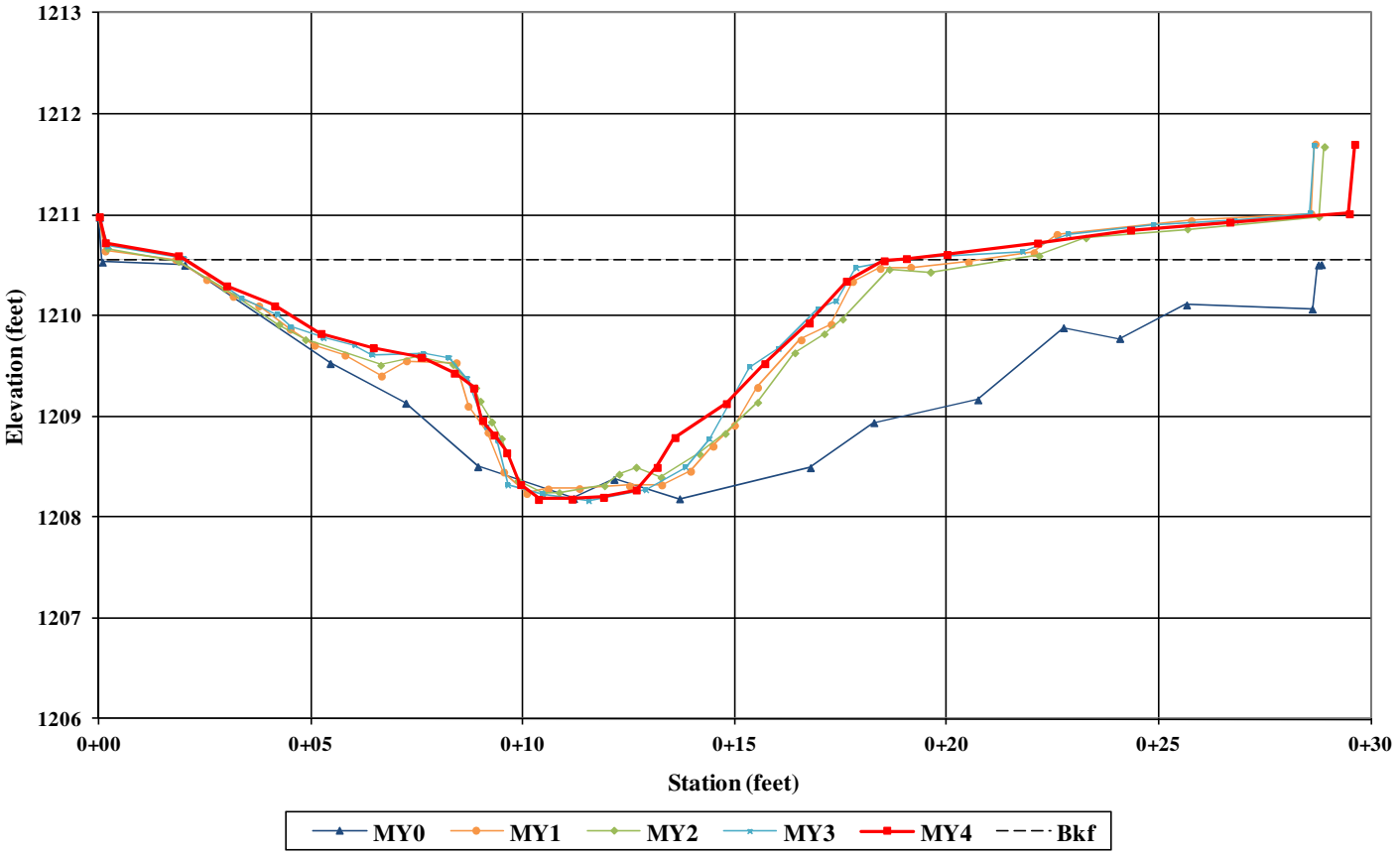


Morgan Creek Upper – Riffle 4
Cross-Section 5

Looking at Left Bank

Looking at Right Bank

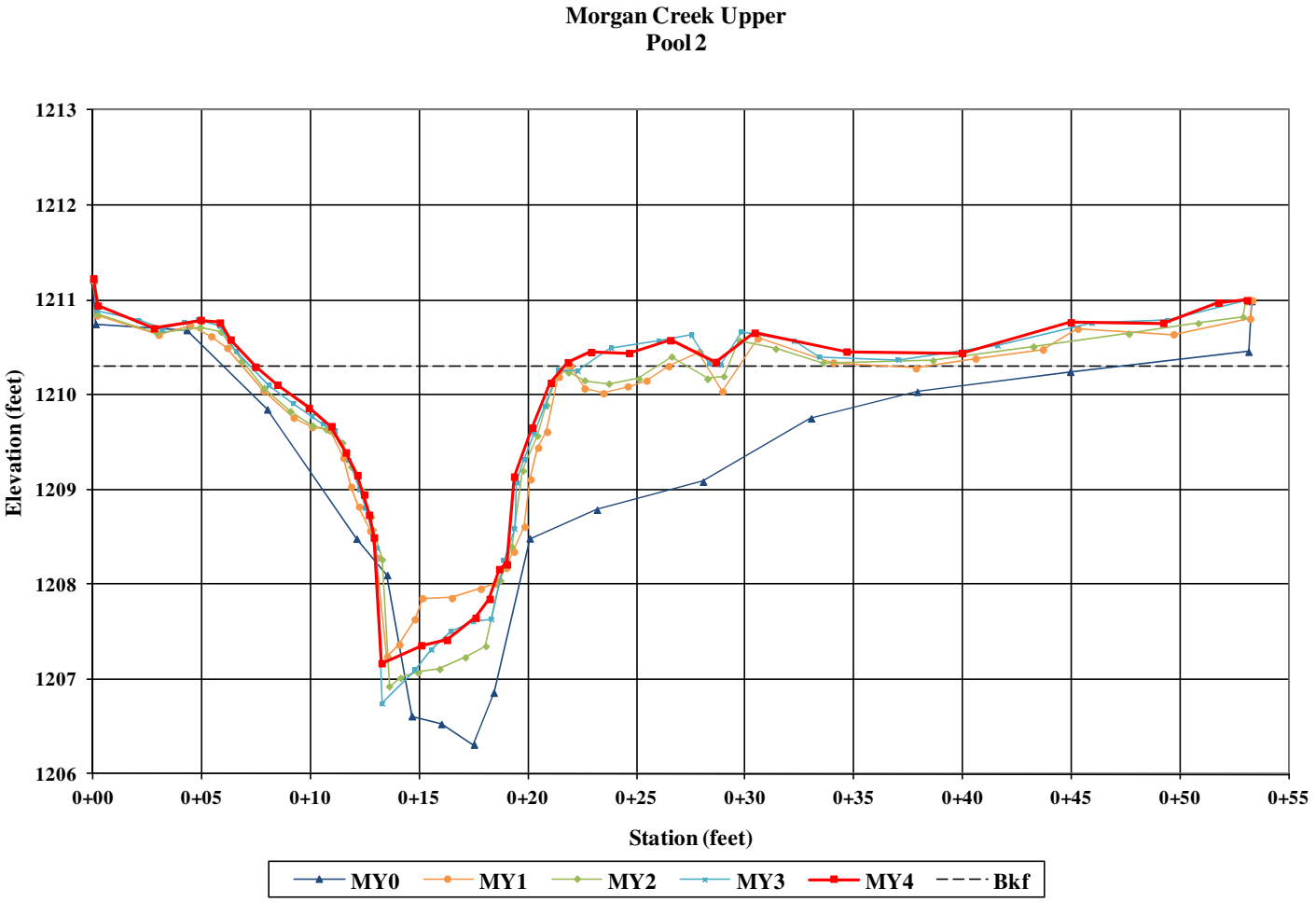
Morgan Creek Upper
Riffle 4



Morgan Creek Upper – Pool 2
Cross-Section 6

Looking at Left Bank

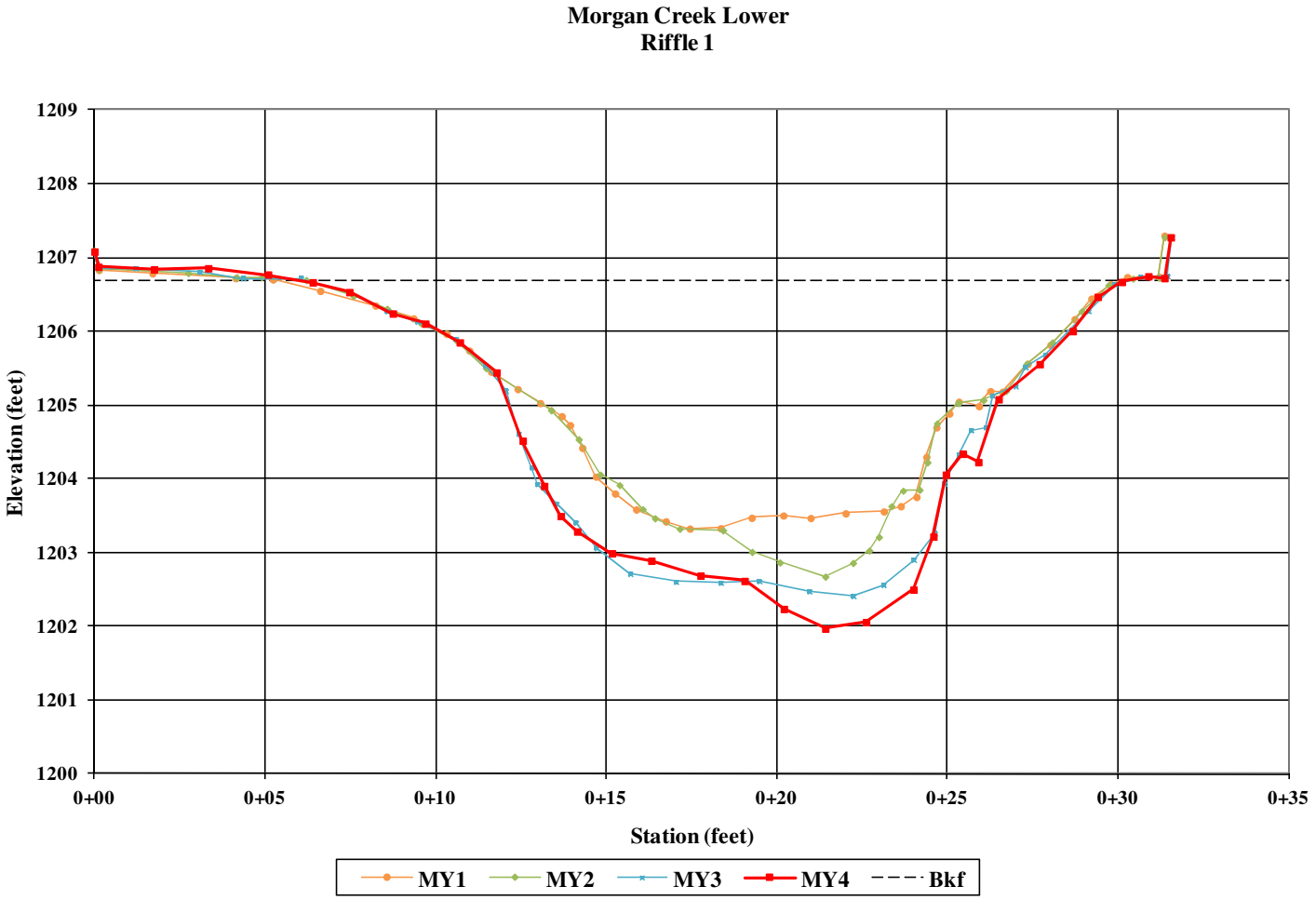
Looking at Right Bank



Morgan Creek Lower – Riffle 1
Cross-Section 1

Looking at Left Bank

Looking at Right Bank

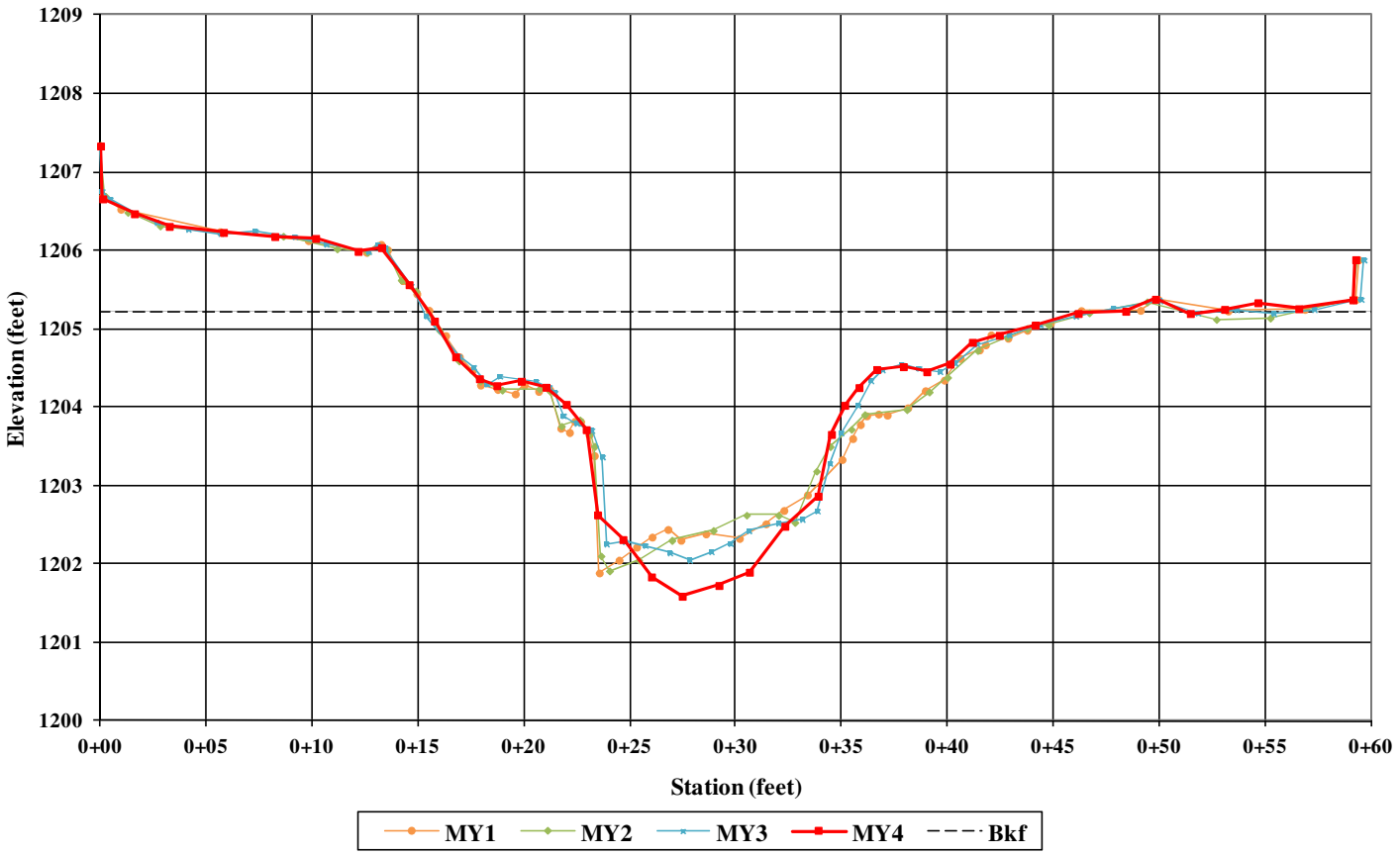


Morgan Creek Lower – Pool 1
Cross-Section 2

Looking at Left Bank

Looking at Right Bank

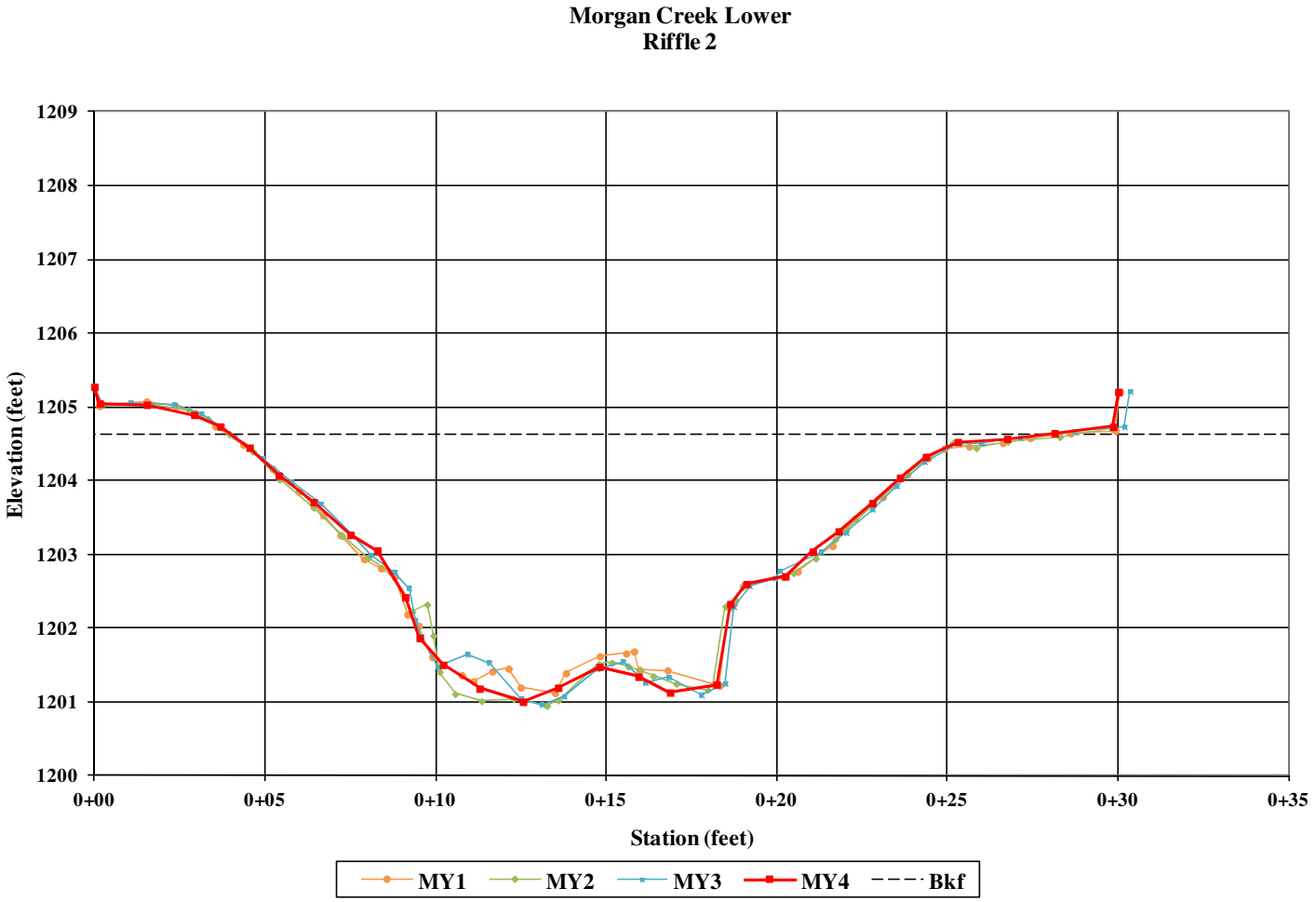
Morgan Creek Lower
Pool 1



Morgan Creek Lower – Riffle 2
Cross-Section 3

Looking at Left Bank

Looking at Right Bank

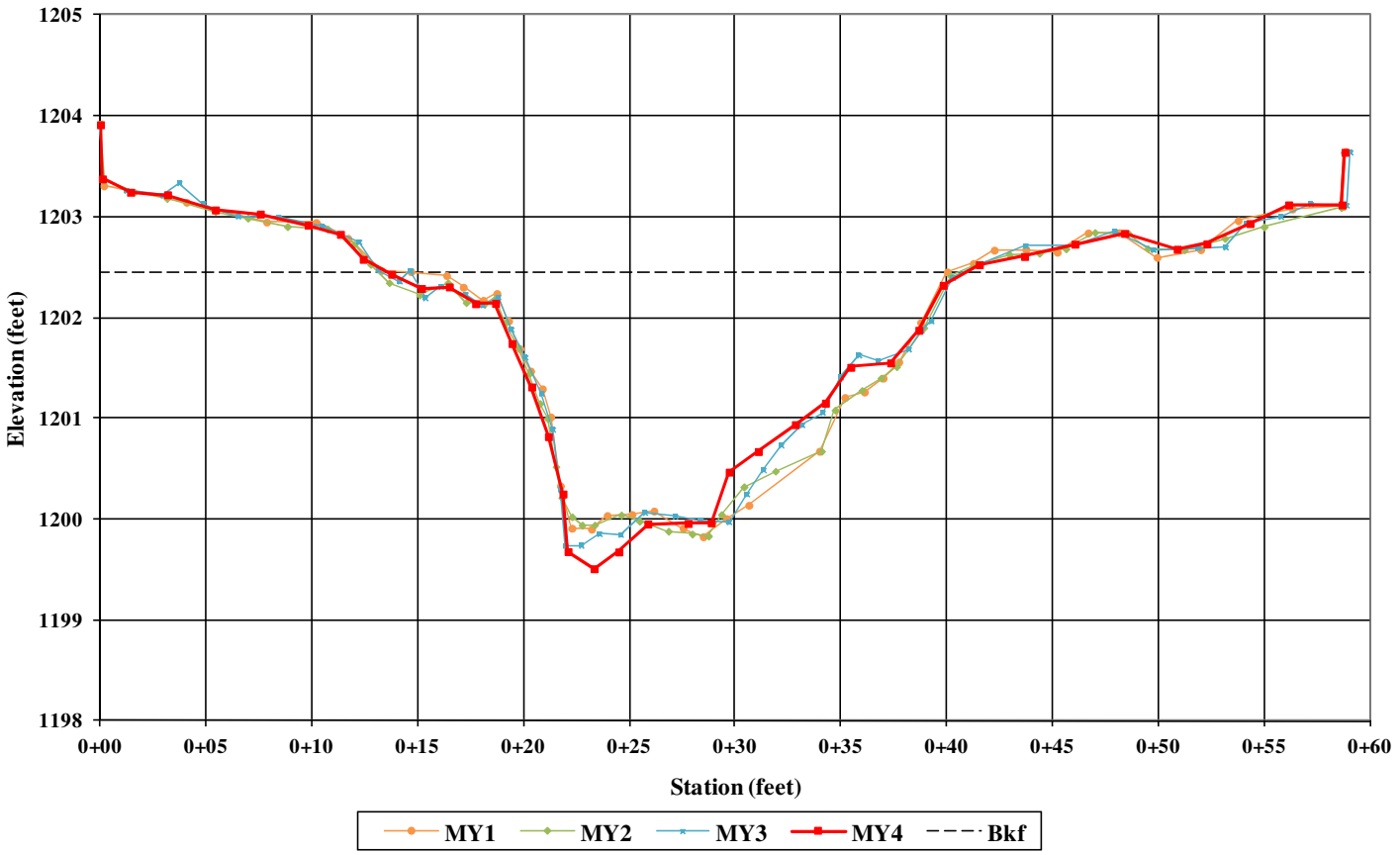


Morgan Creek Lower – Riffle 3
Cross-Section 4

Looking at Left Bank

Looking at Right Bank

Morgan Creek Lower
Riffle 3

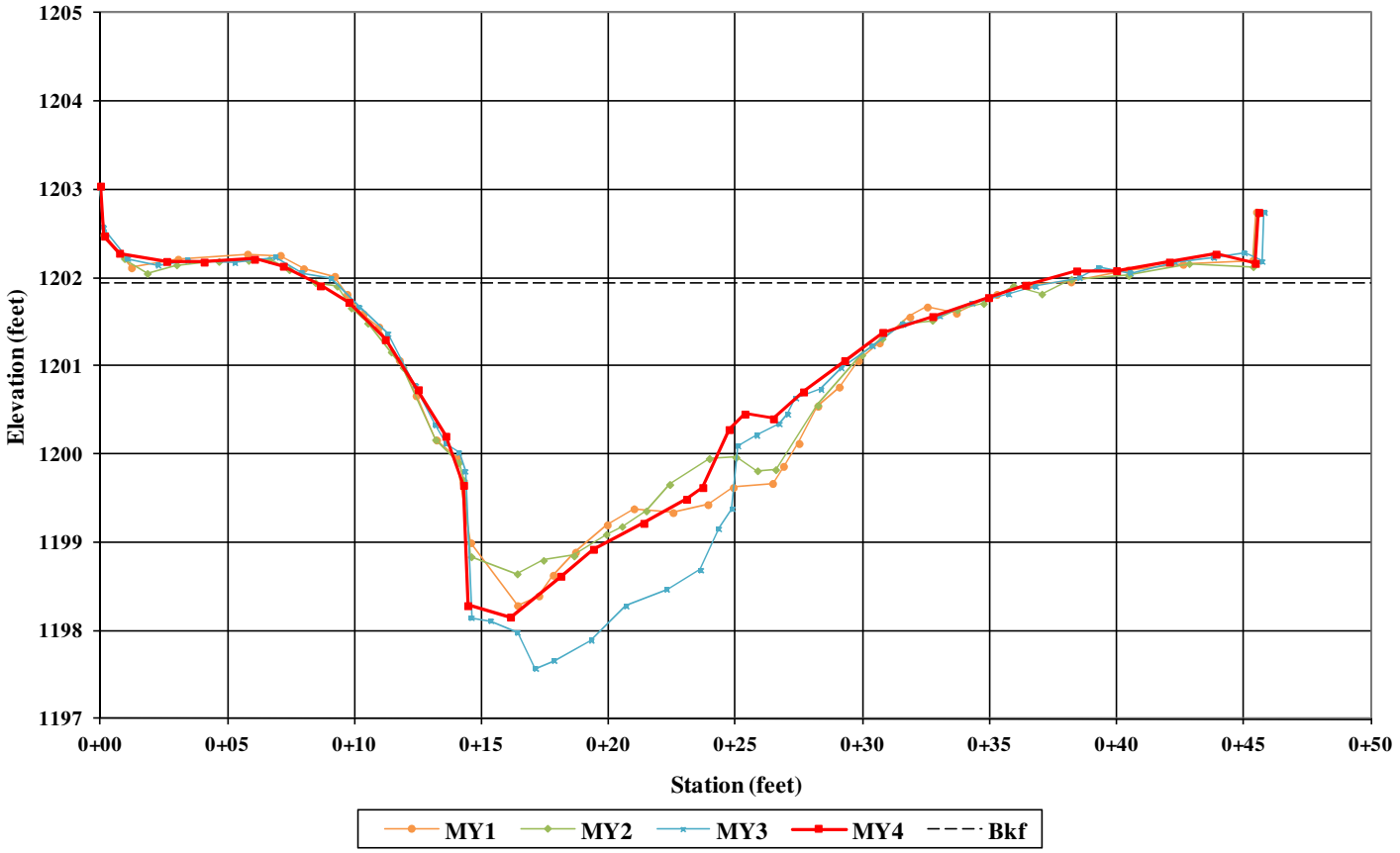


Morgan Creek Lower – Pool 2
Cross-Section 5

Looking at Left Bank

Looking at Right Bank

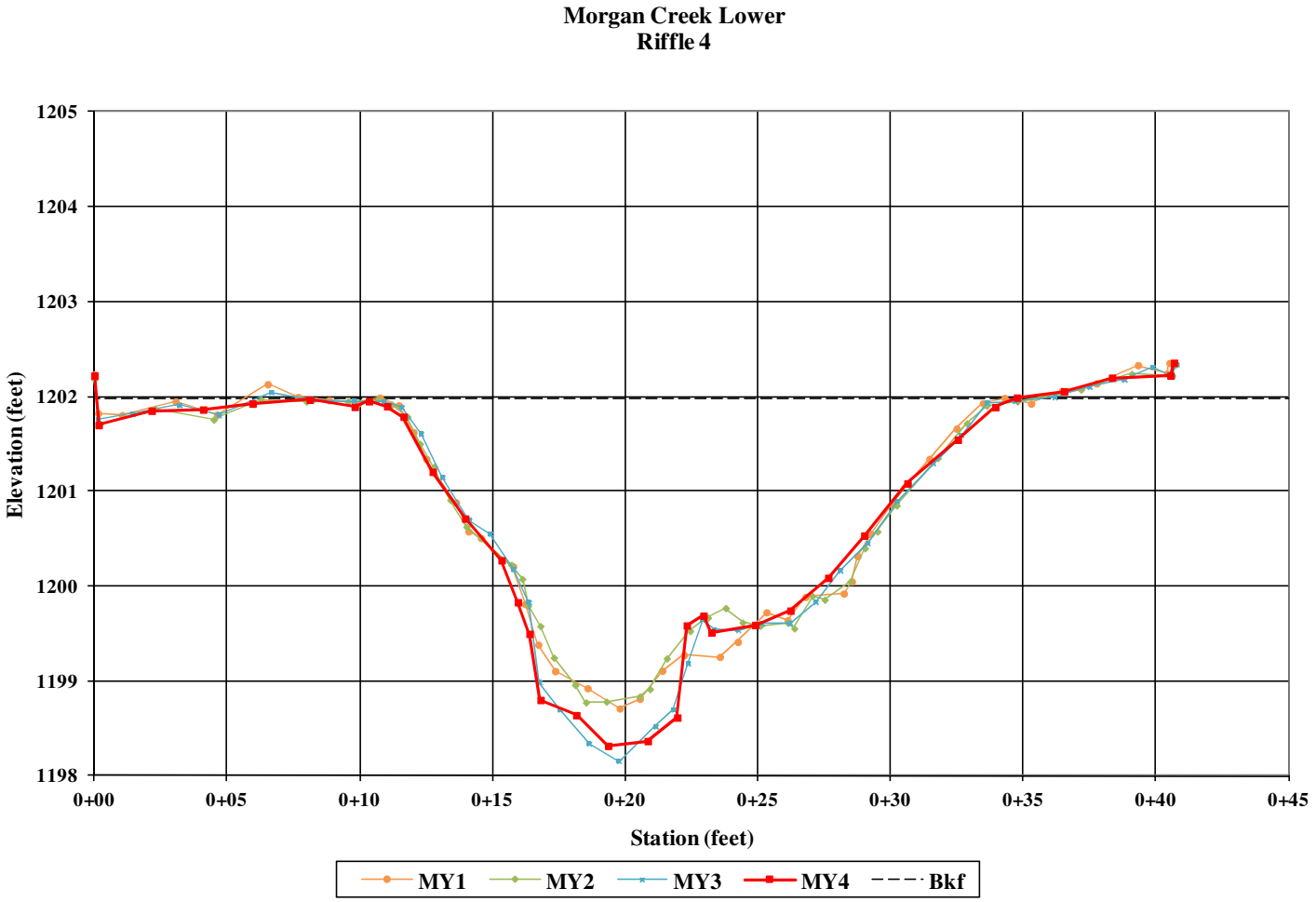
Morgan Creek Lower
Pool 2



Morgan Creek Lower – Riffle 4
Cross-Section 6

Looking at Left Bank

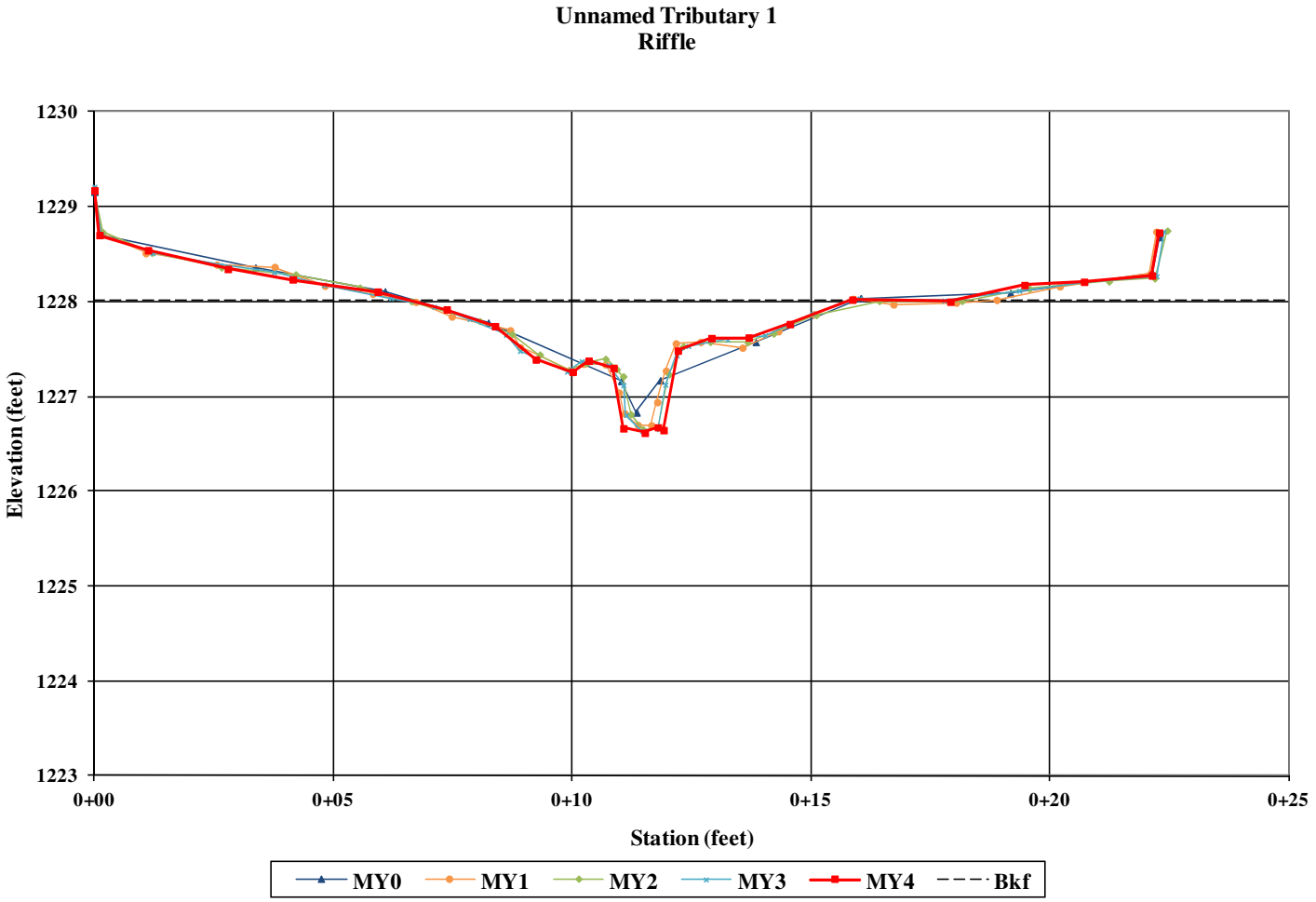
Looking at Right Bank



Unnamed Tributary 1 – Riffle
Cross-Section 1

Looking at Left Bank

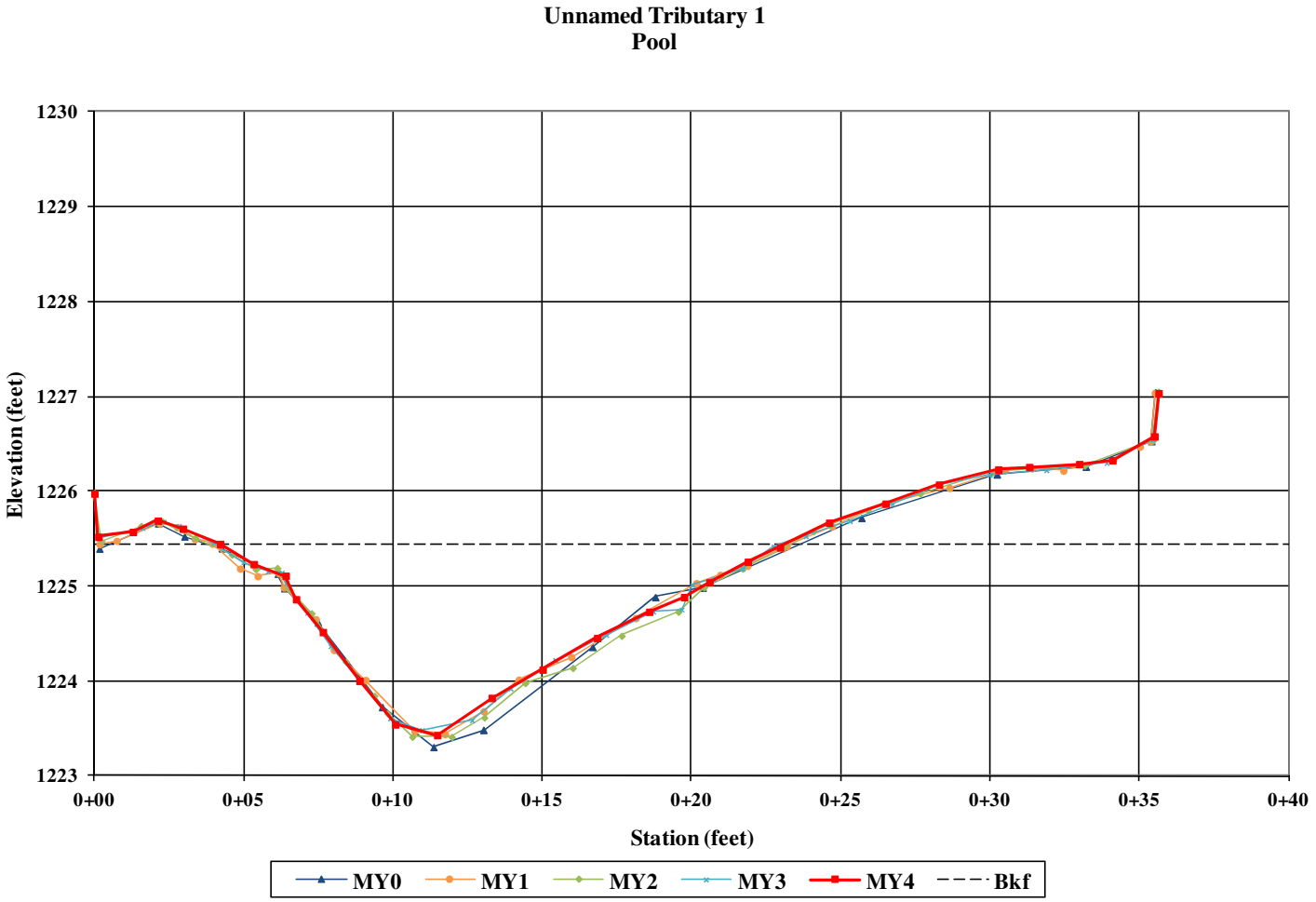
Looking at Right Bank



Unnamed Tributary 1 – Pool
Cross-Section 2

Looking at Left Bank

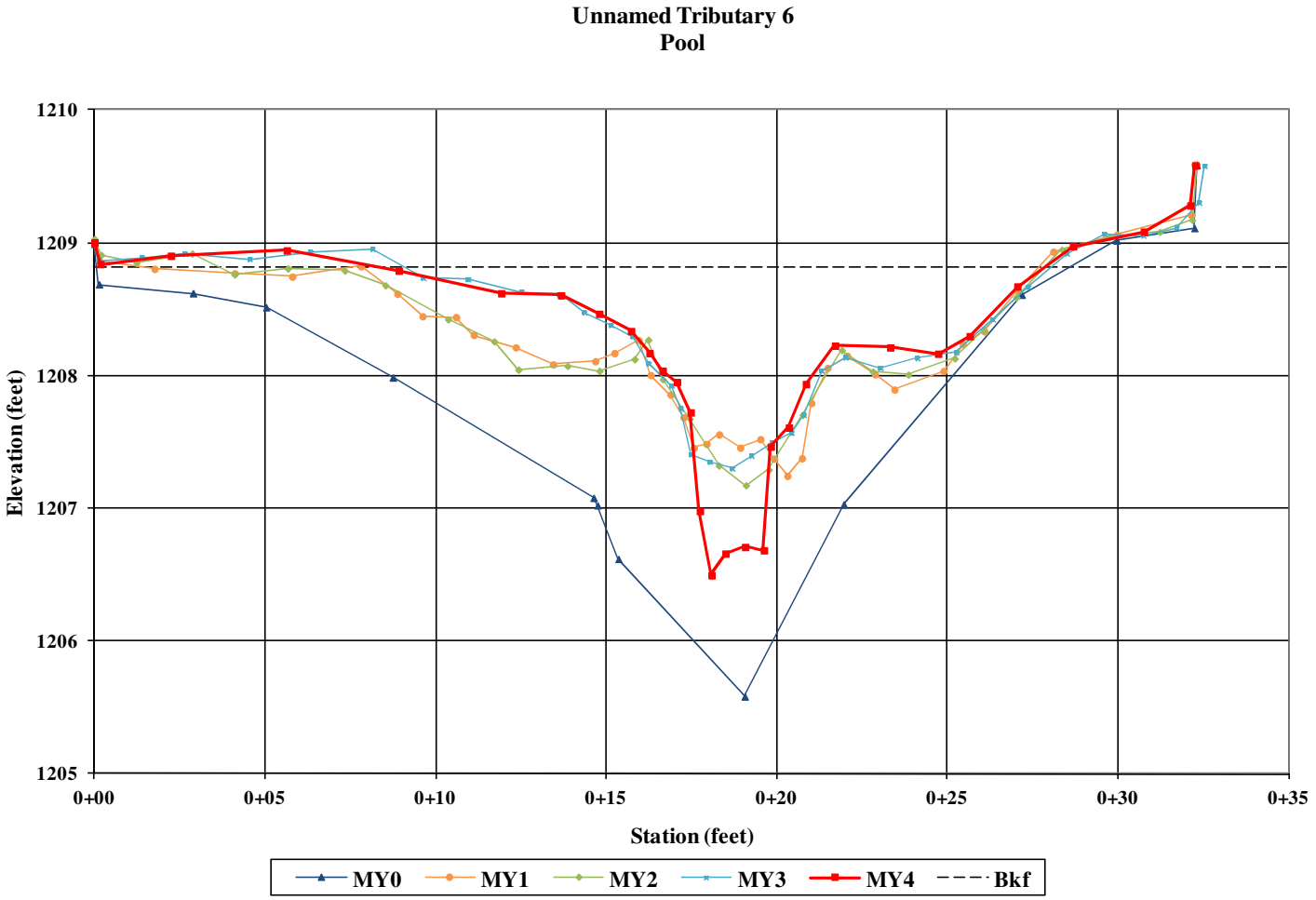
Looking at Right Bank



Unnamed Tributary 6 – Pool
Cross-Section 1

Looking at Left Bank

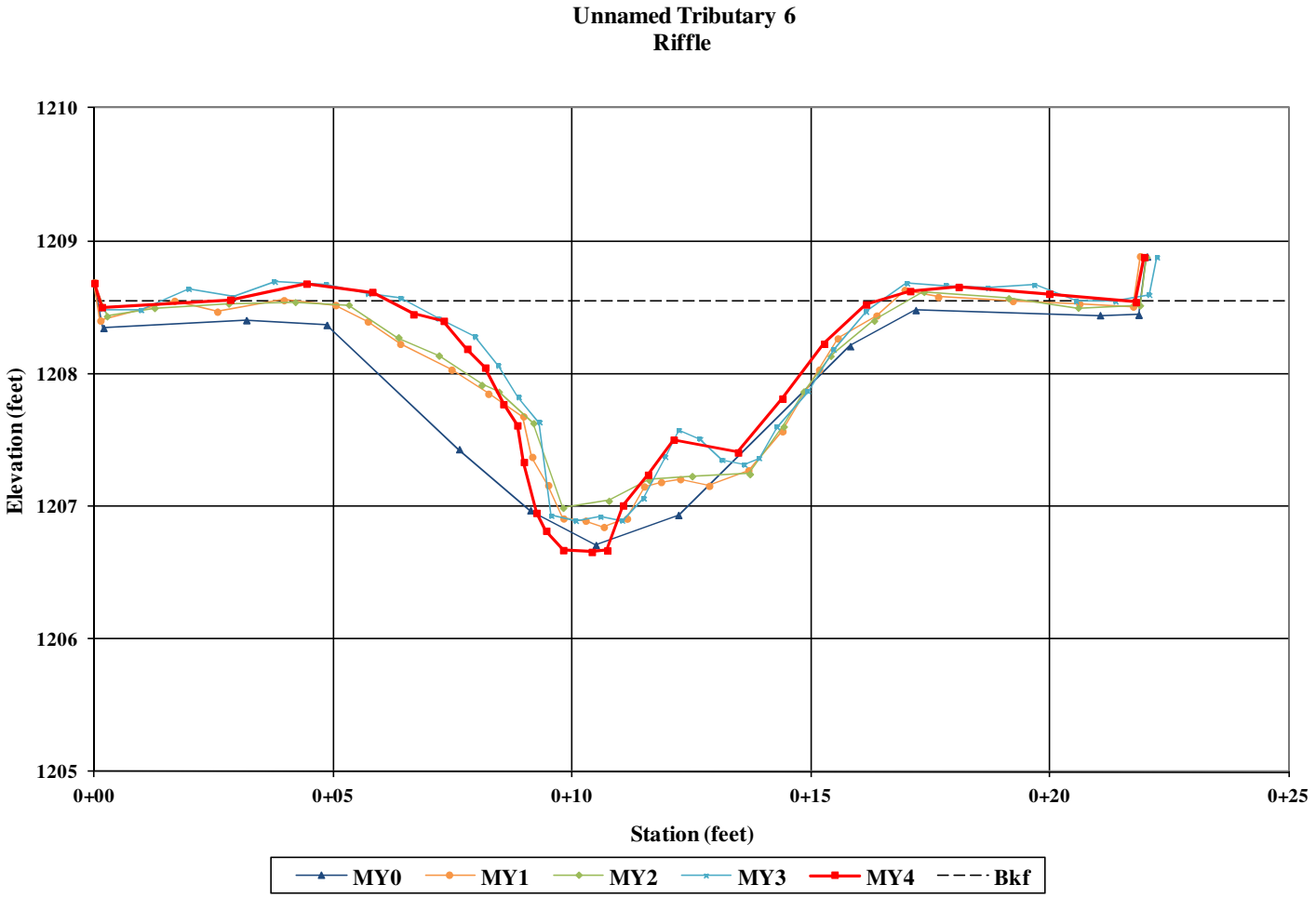
Looking at Right Bank



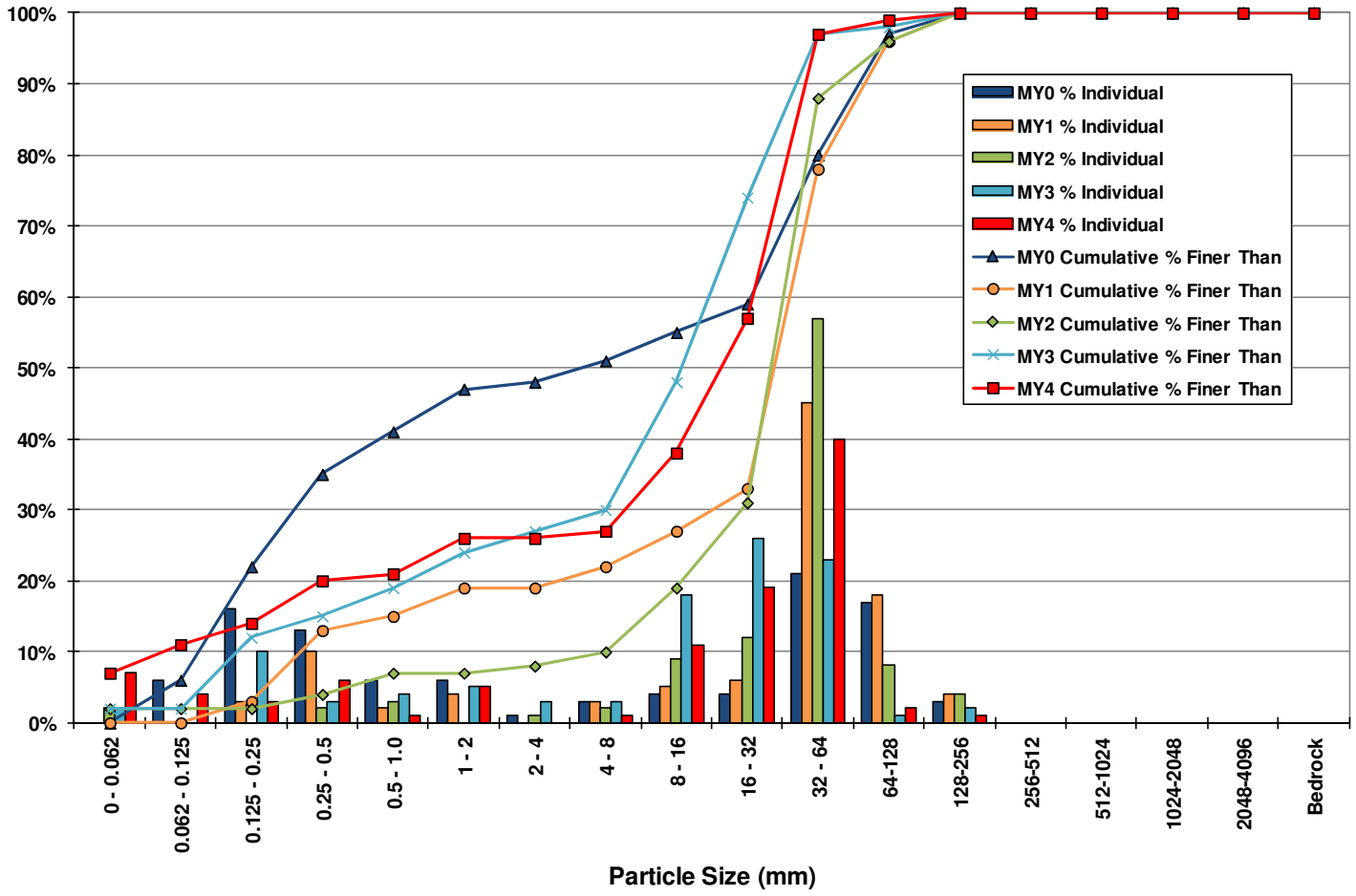
Unnamed Tributary 6 – Riffle
Cross-Section 2

Looking at Left Bank

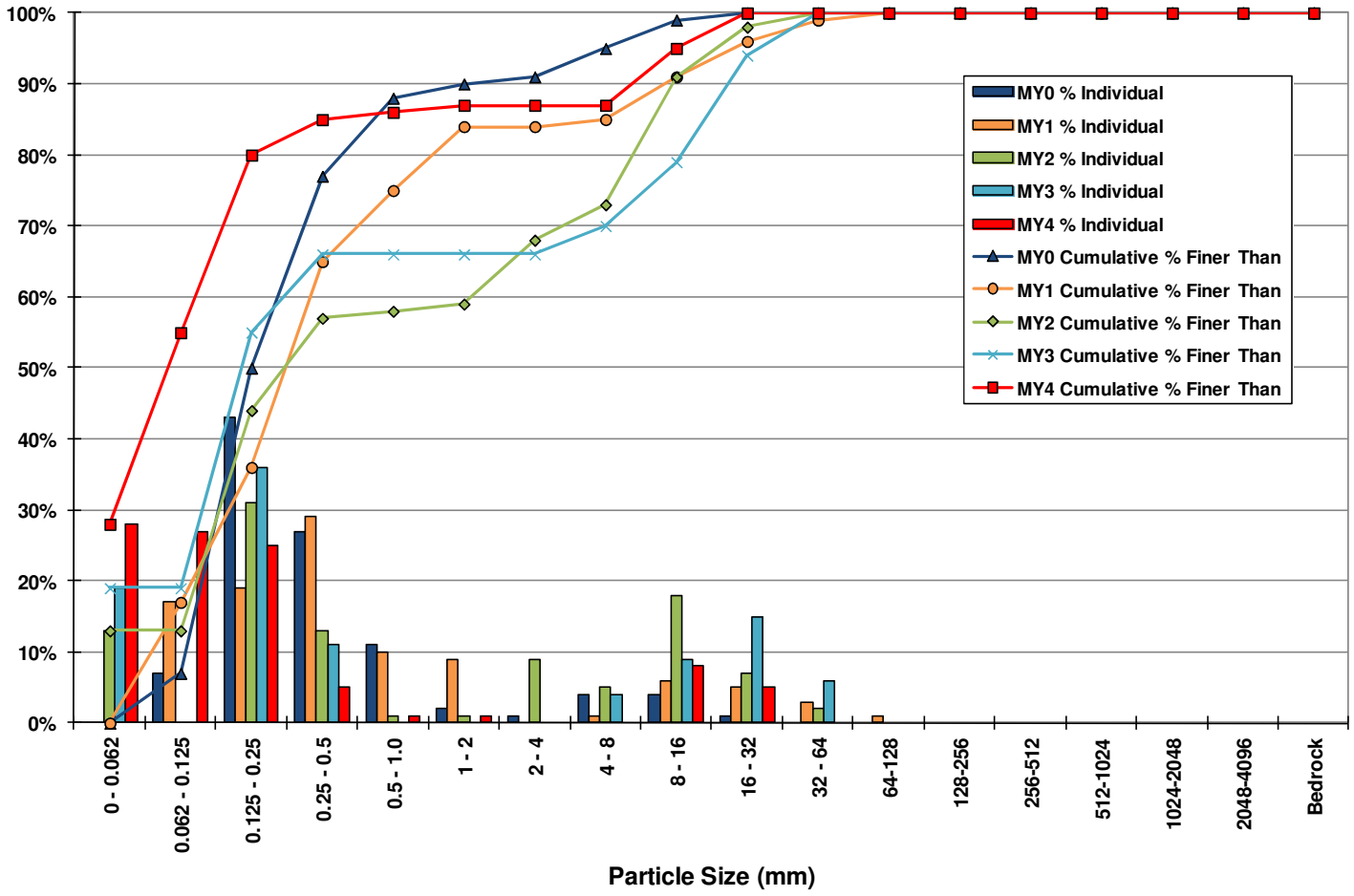
Looking at Right Bank



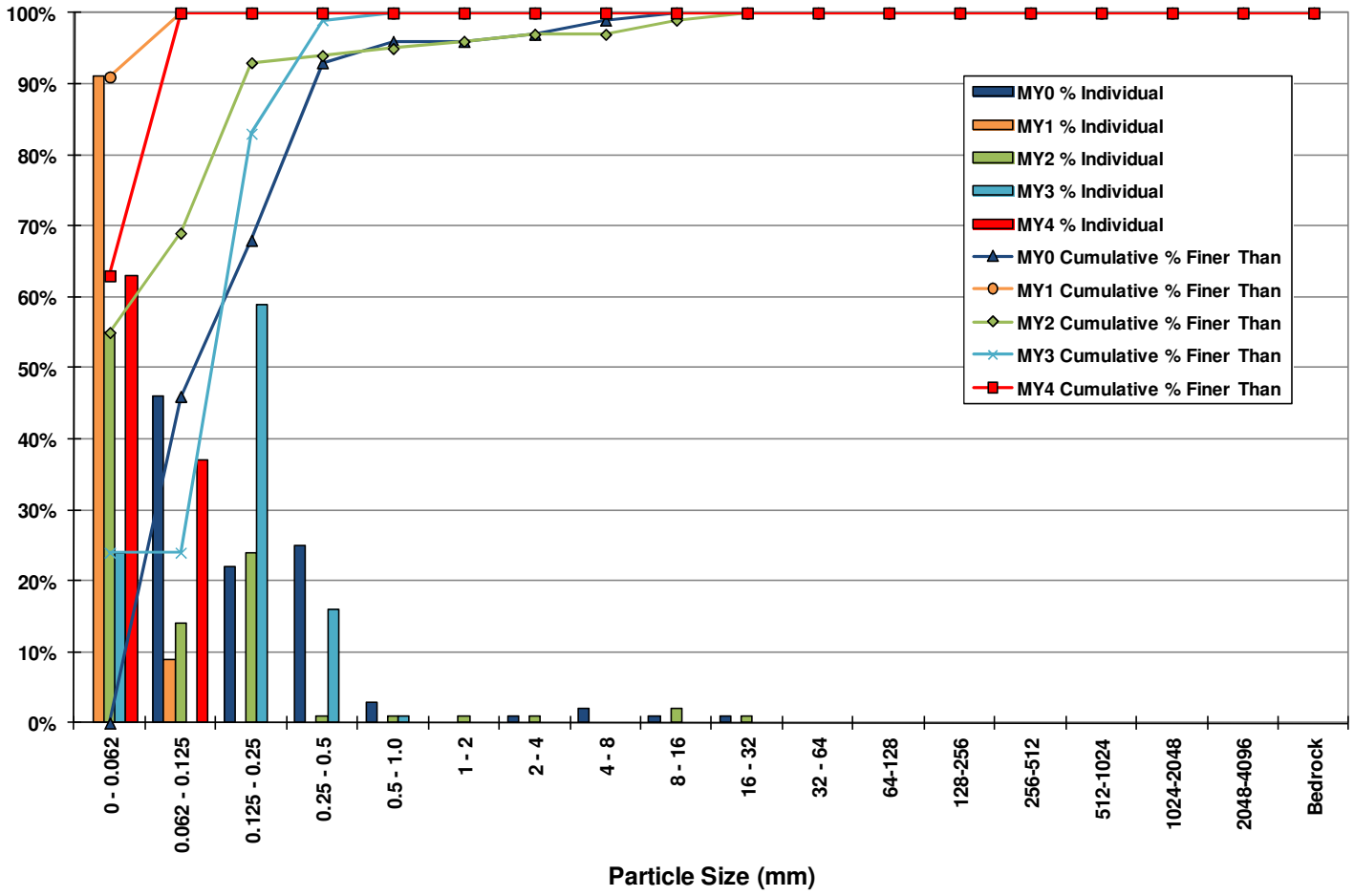
Morgan Creek Upper – Riffle 1
Pebble Count



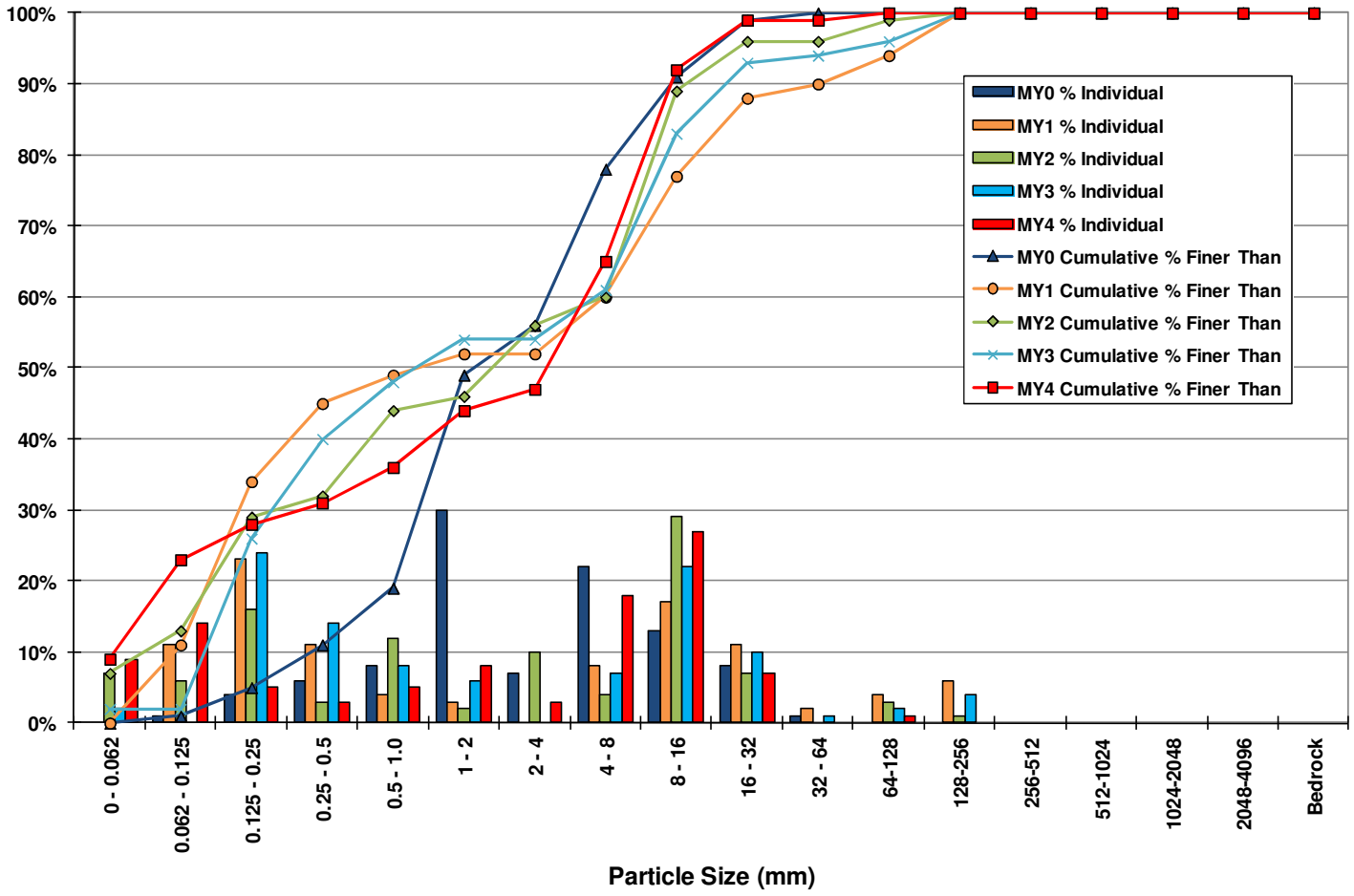
Morgan Creek Upper – Riffle 2
Pebble Count



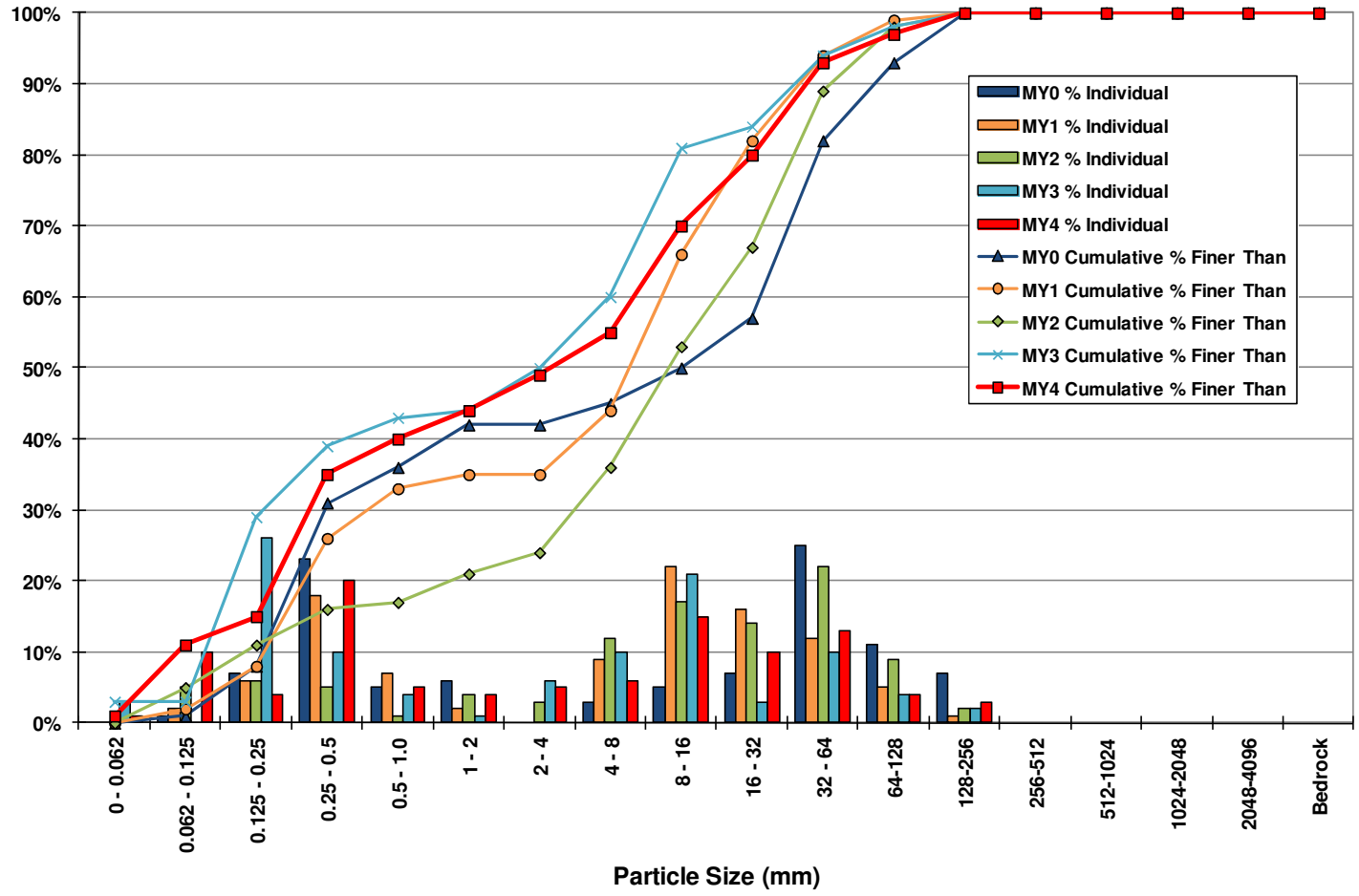
Morgan Creek Upper – Pool 1
Pebble Count



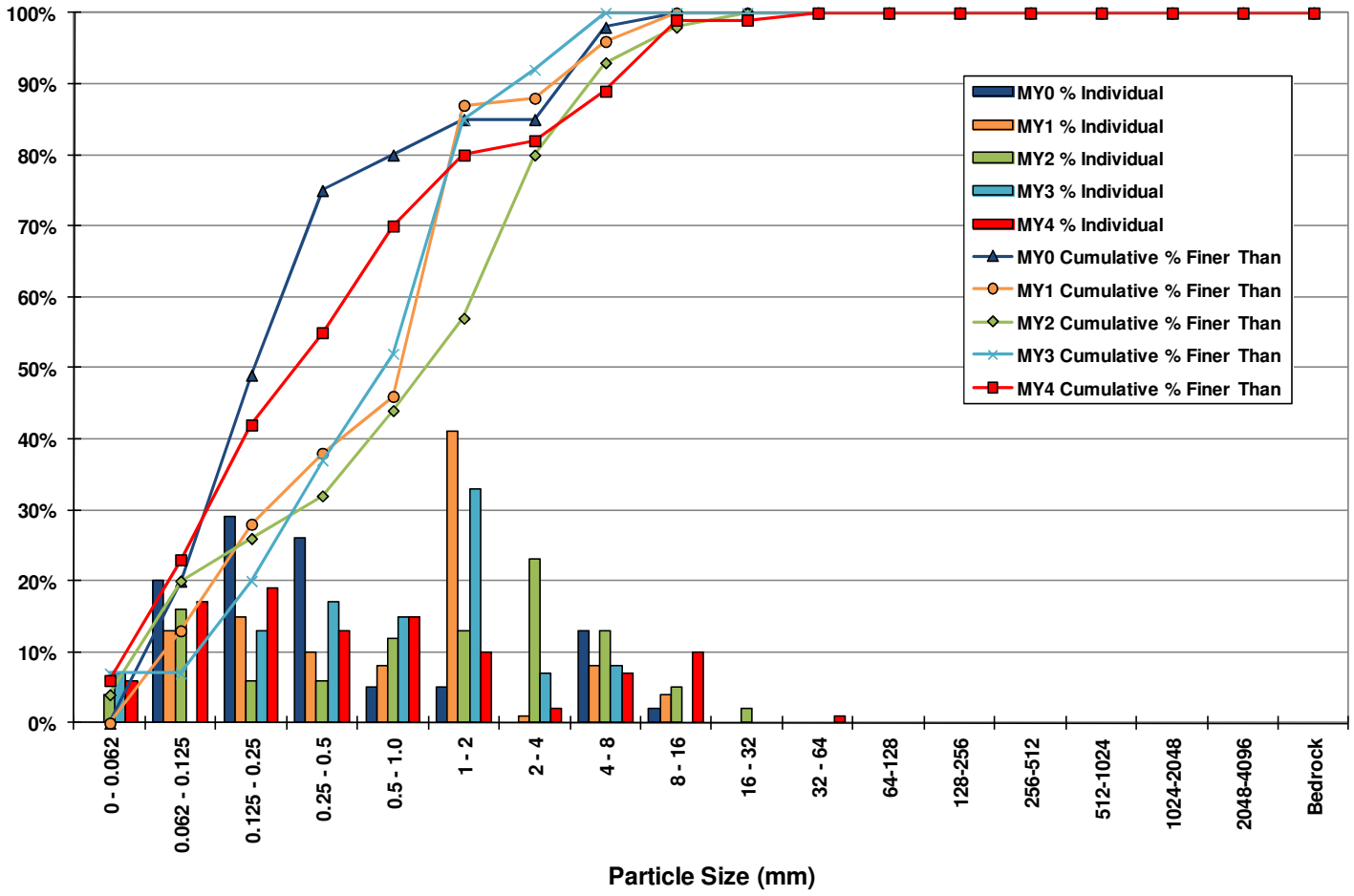
Morgan Creek Upper – Riffle 3
Pebble Count



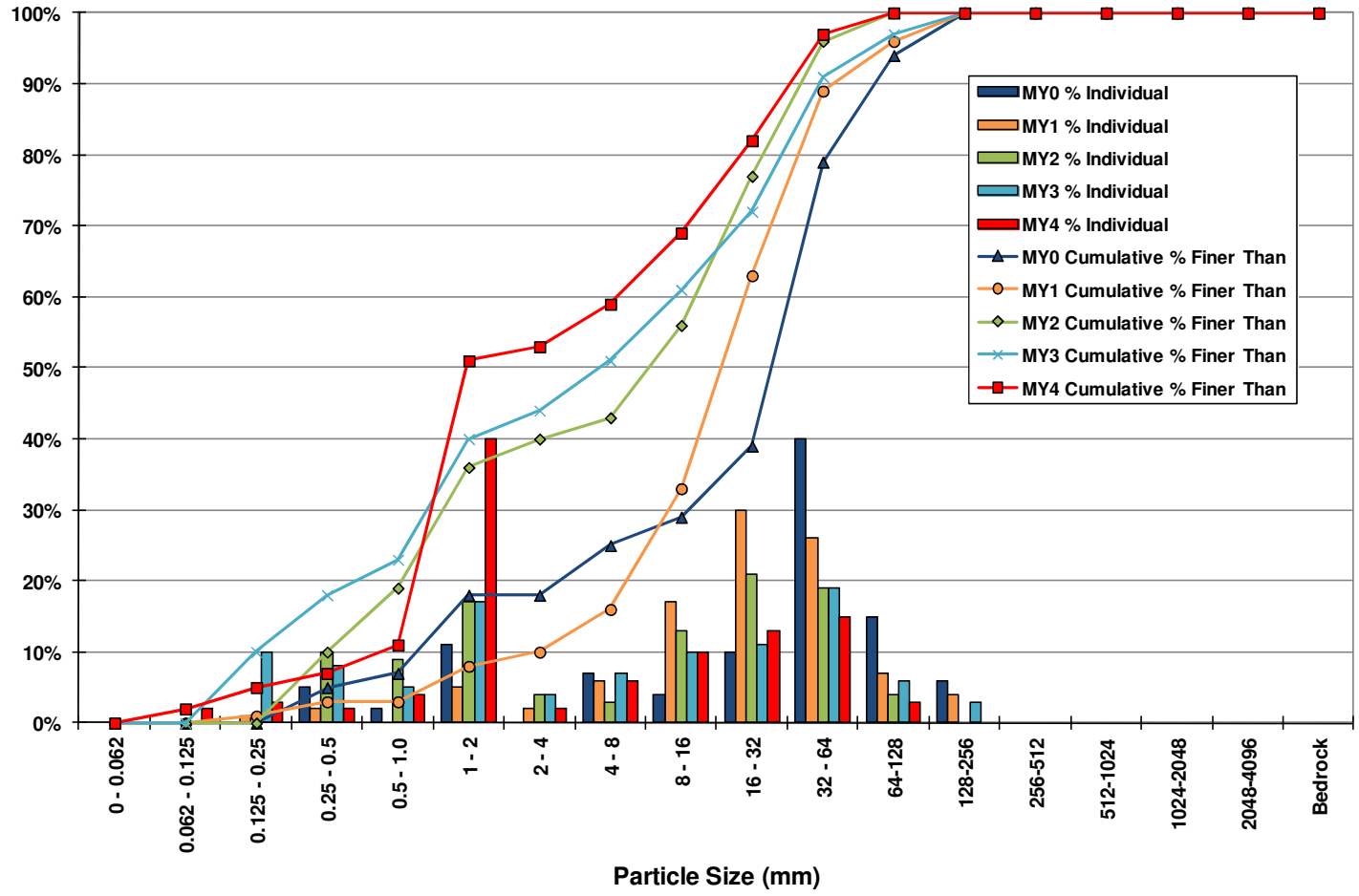
Morgan Creek Upper – Riffle 4
Pebble Count



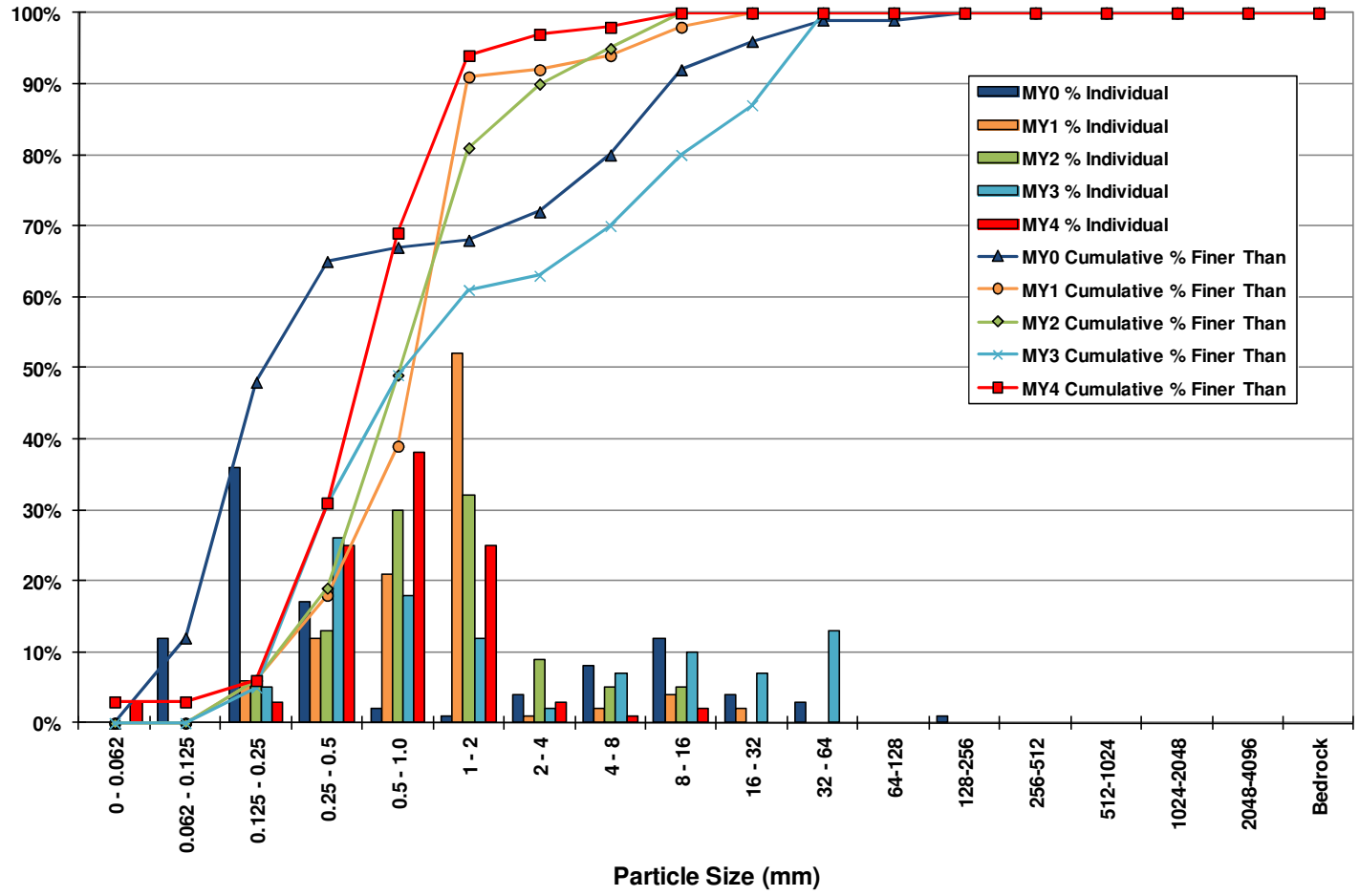
Morgan Creek Upper – Pool 2
Pebble Count



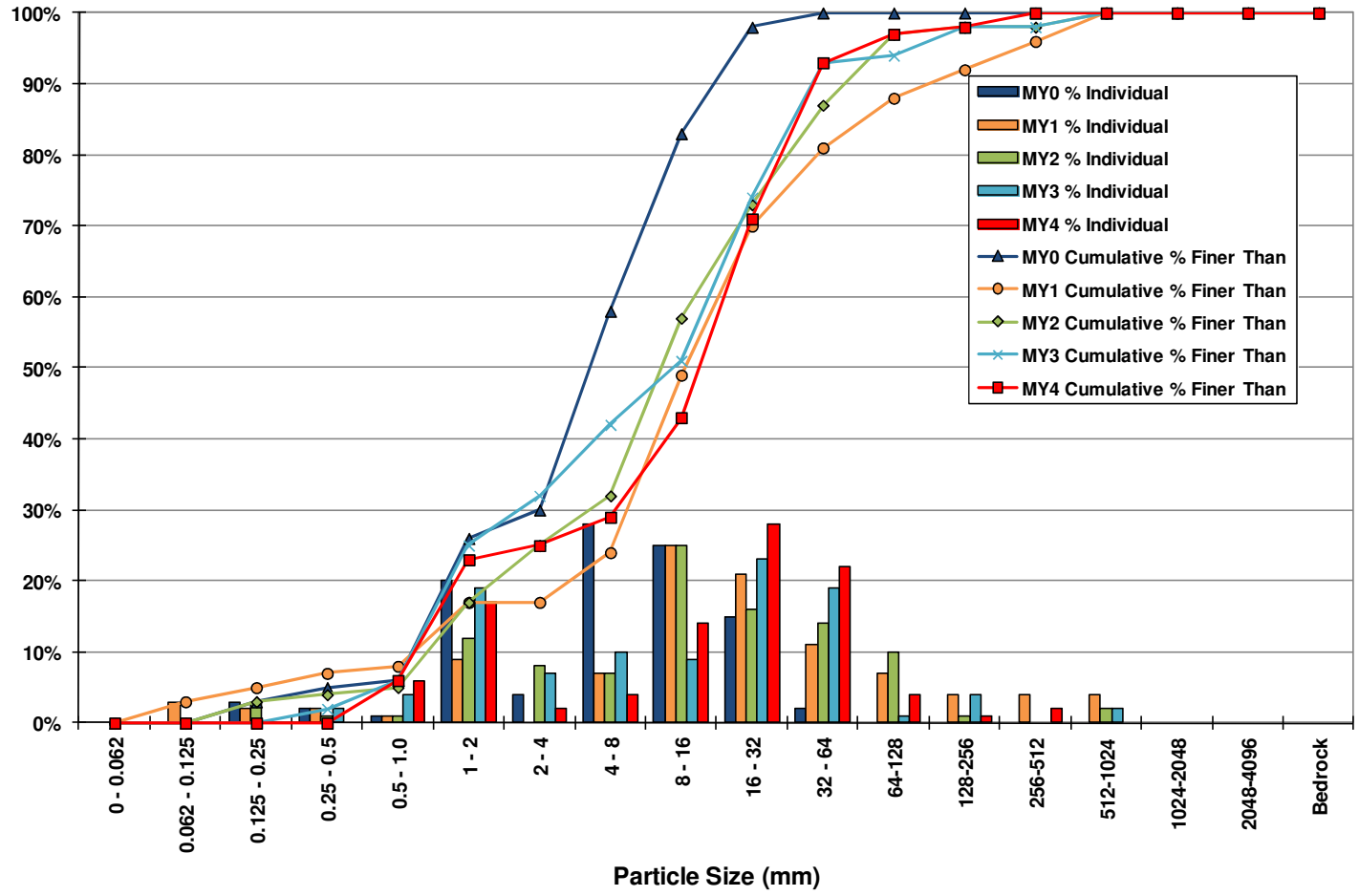
Morgan Creek Lower – Riffle 1
Pebble Count



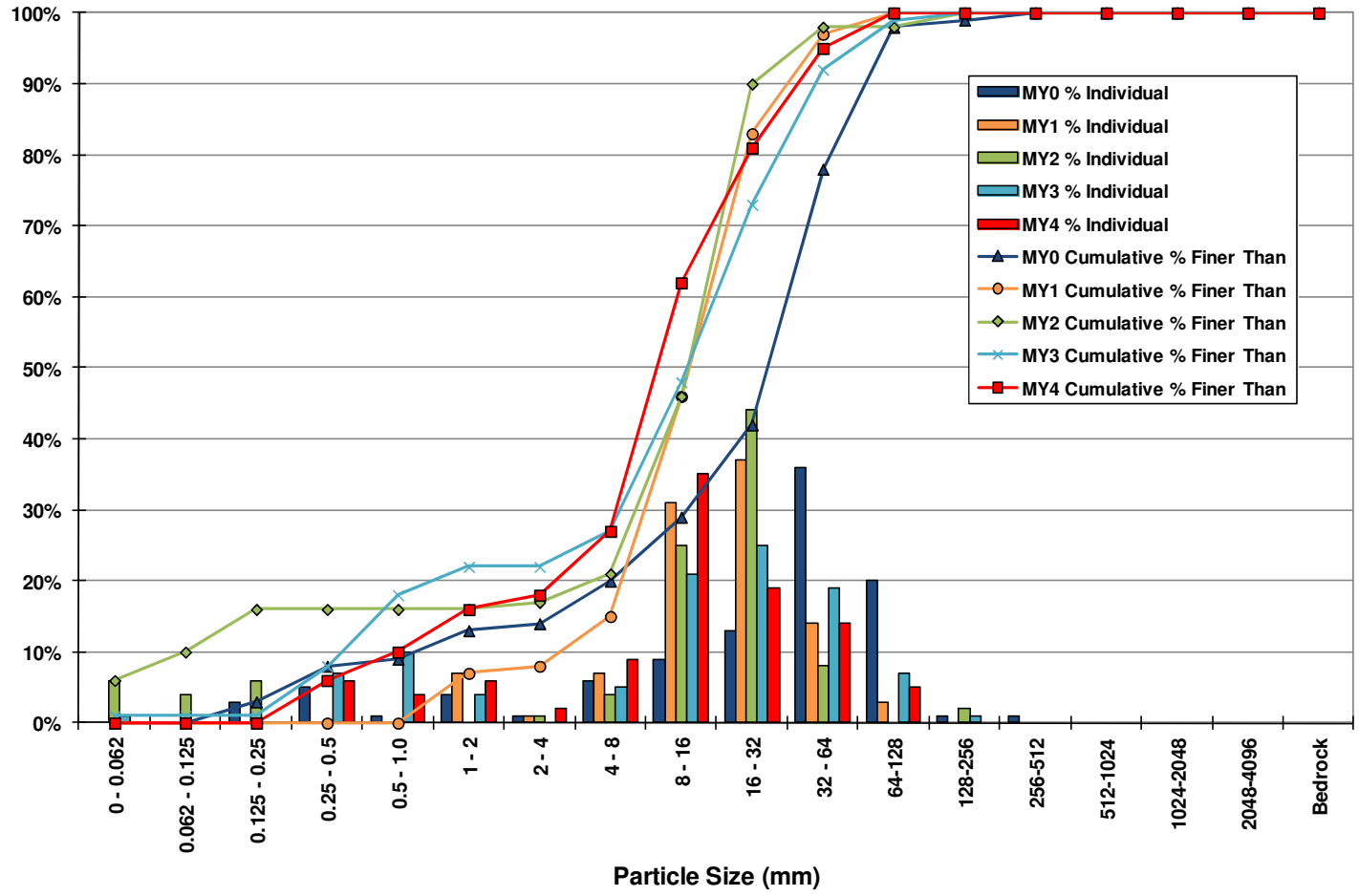
Morgan Creek Lower – Pool 1
Pebble Count



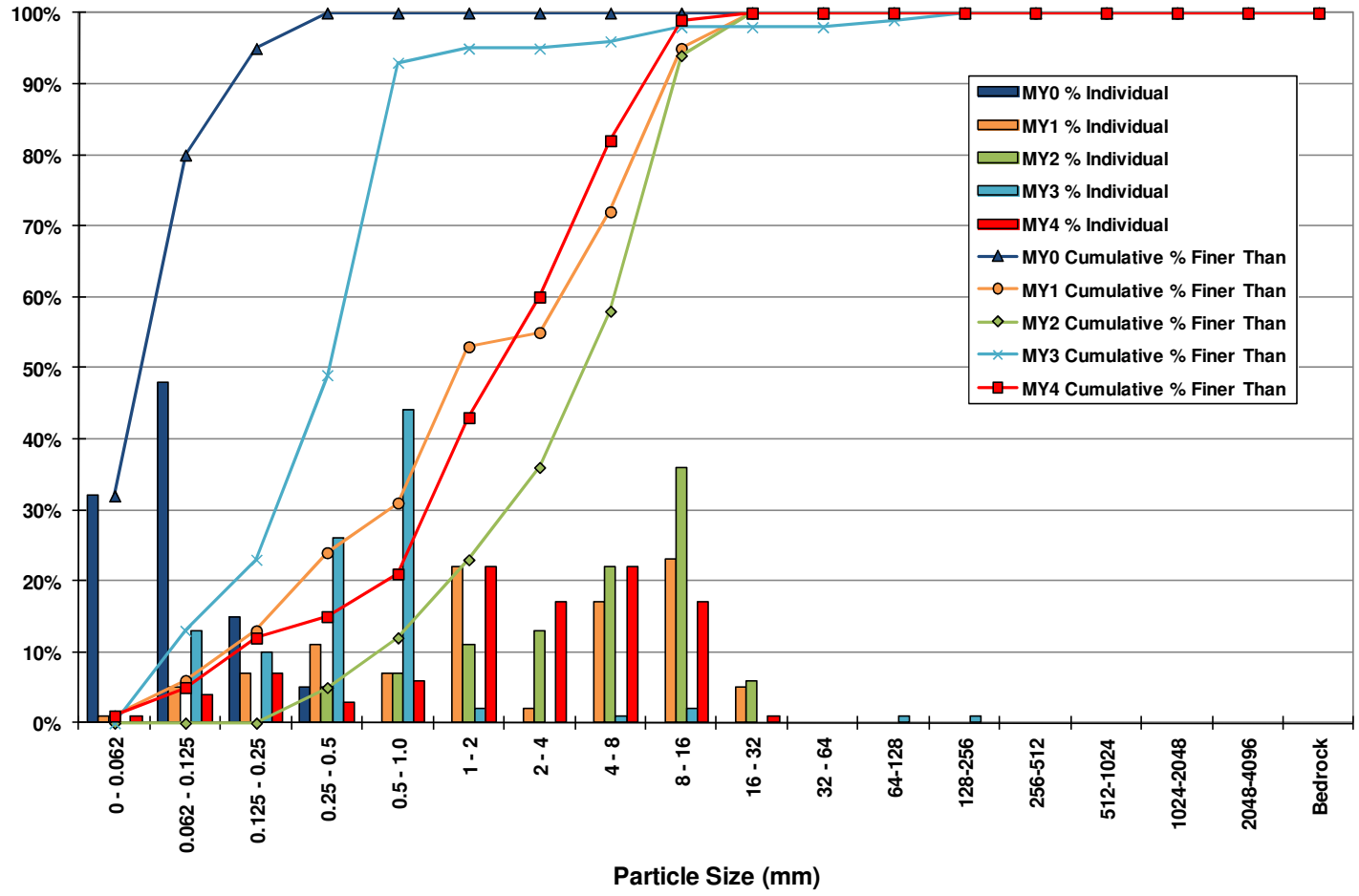
Morgan Creek Lower – Riffle 2
Pebble Count



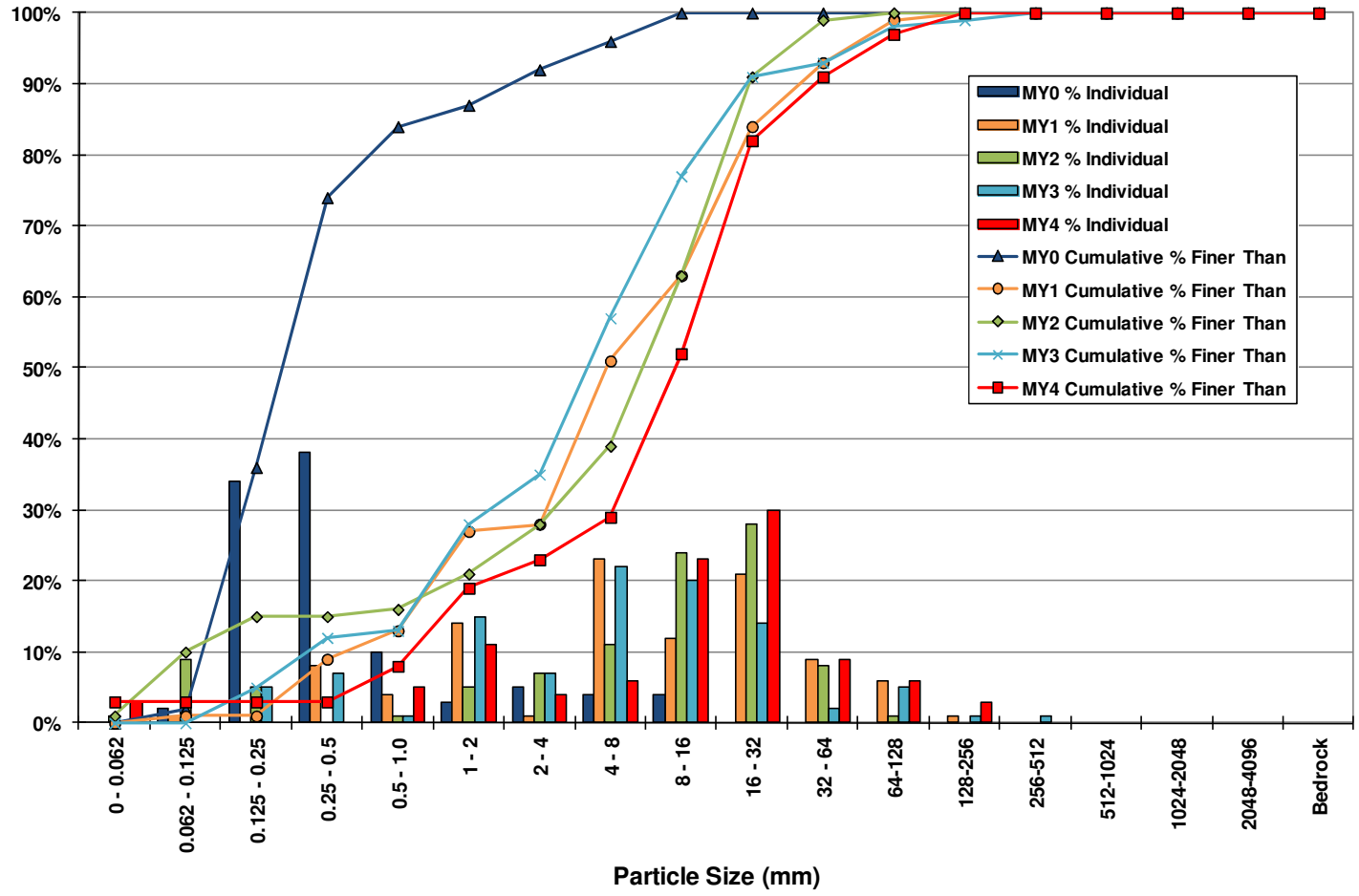
Morgan Creek Lower – Riffle 3
Pebble Count

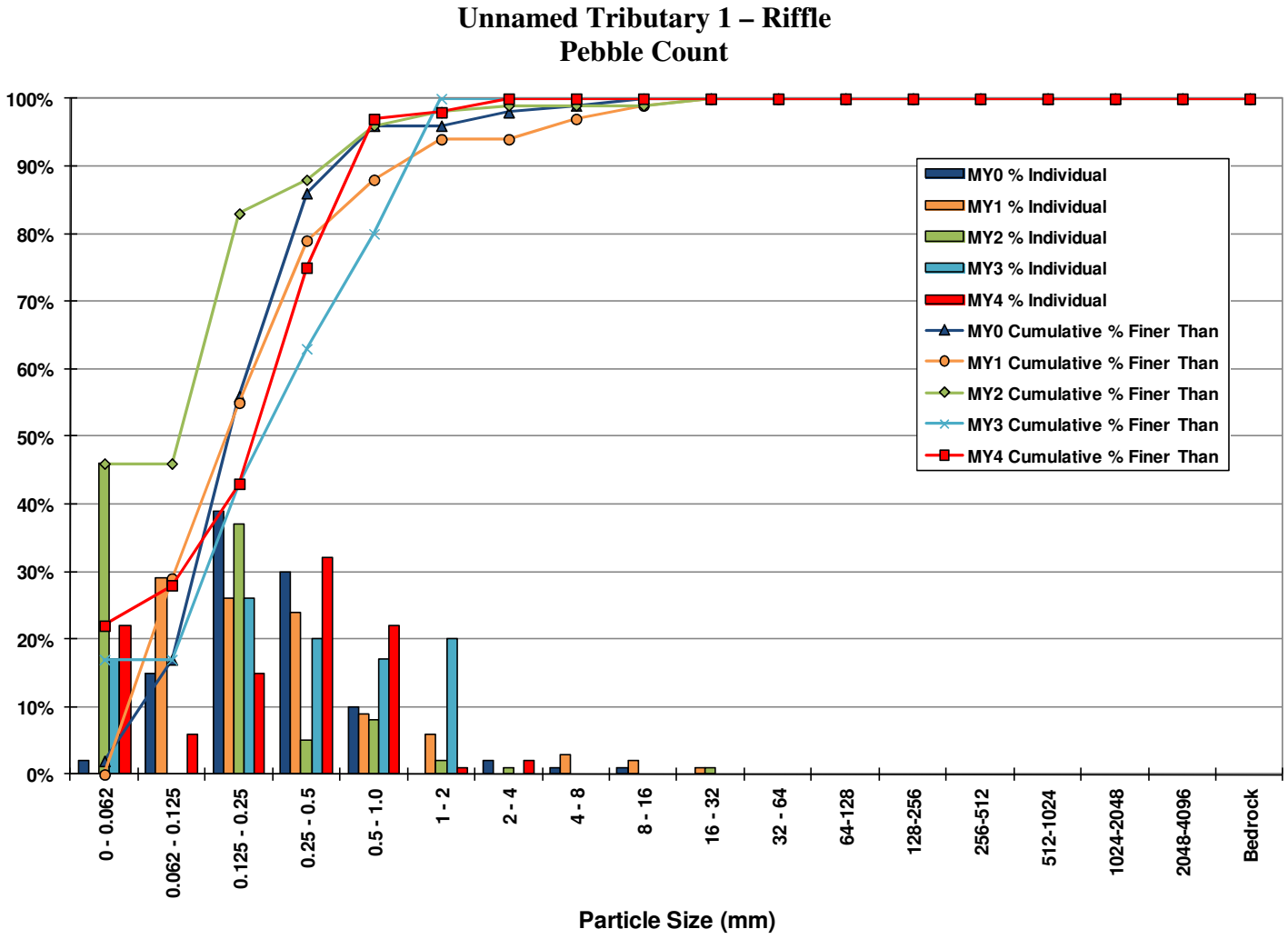


Morgan Creek Lower – Pool 2
Pebble Count

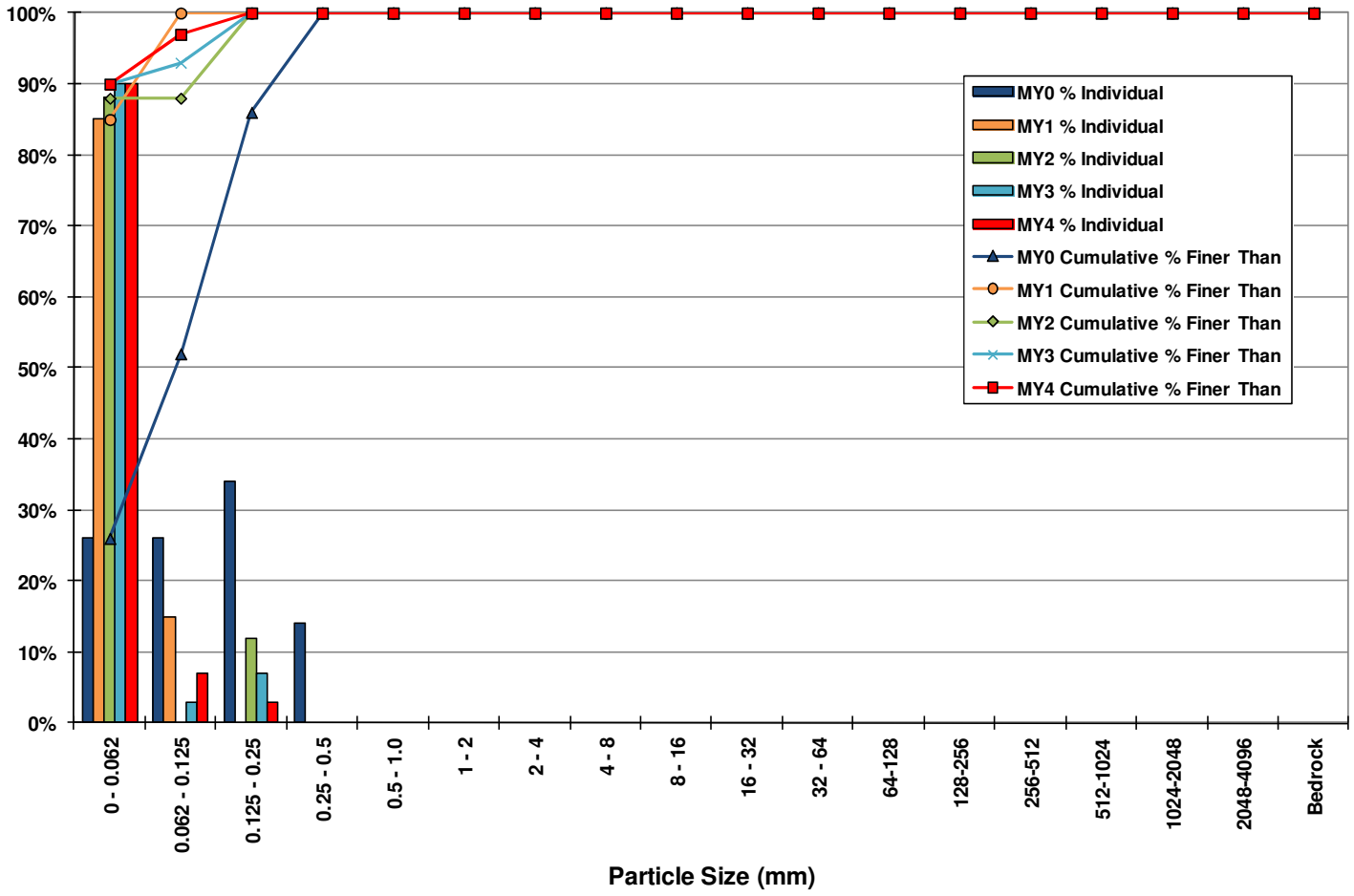


Morgan Creek Lower – Riffle 4
Pebble Count

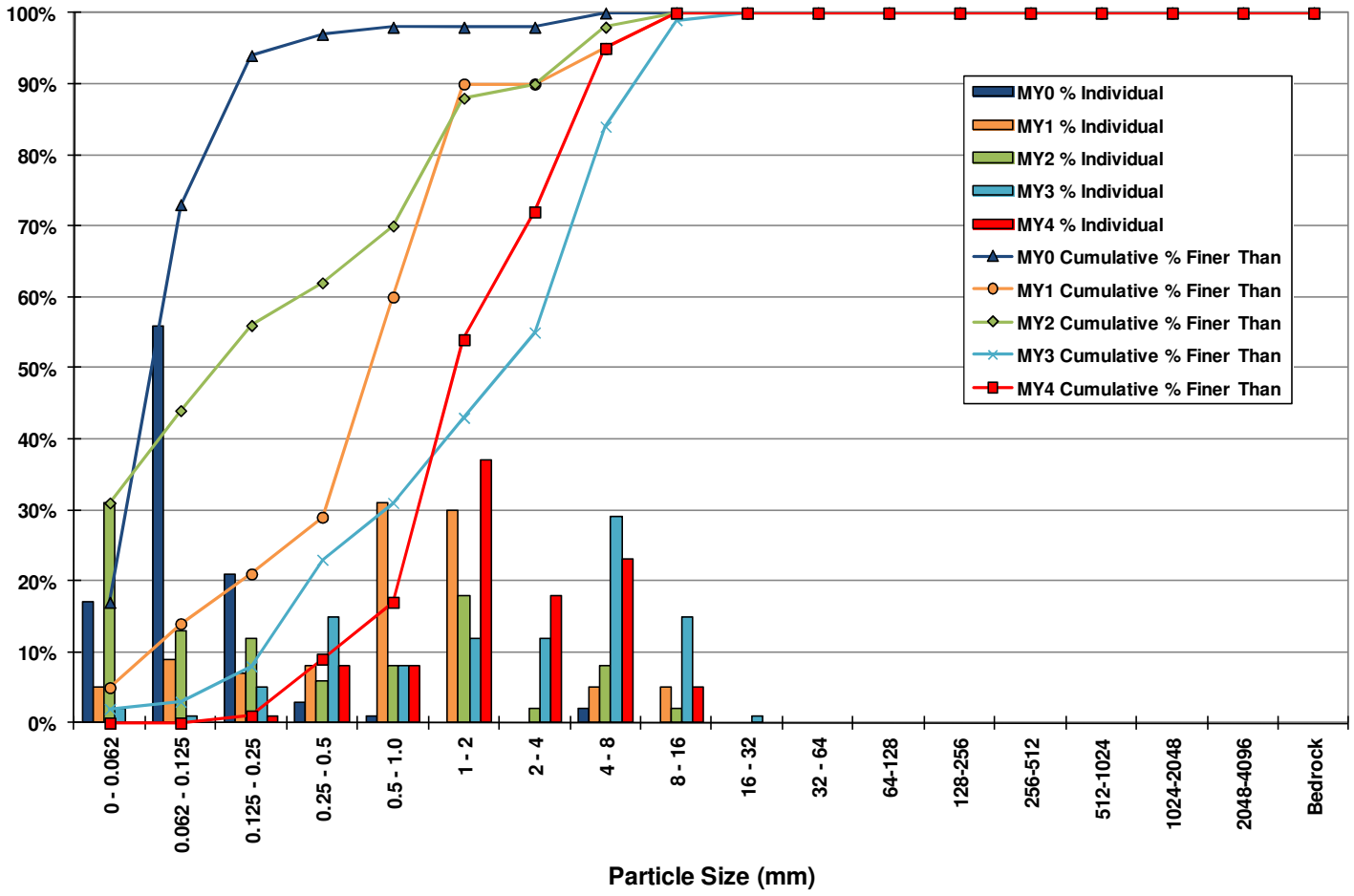



Unnamed Tributary 1 – Riffle
Pebble Count
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
MY0 % Individual
MY1 % Individual
MY2 % Individual
MY3 % Individual
MY4 % Individual
MY0 Cumulative % Finer Than
MY1 Cumulative % Finer Than
MY2 Cumulative % Finer Than
MY3 Cumulative % Finer Than
MY4 Cumulative % Finer 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)

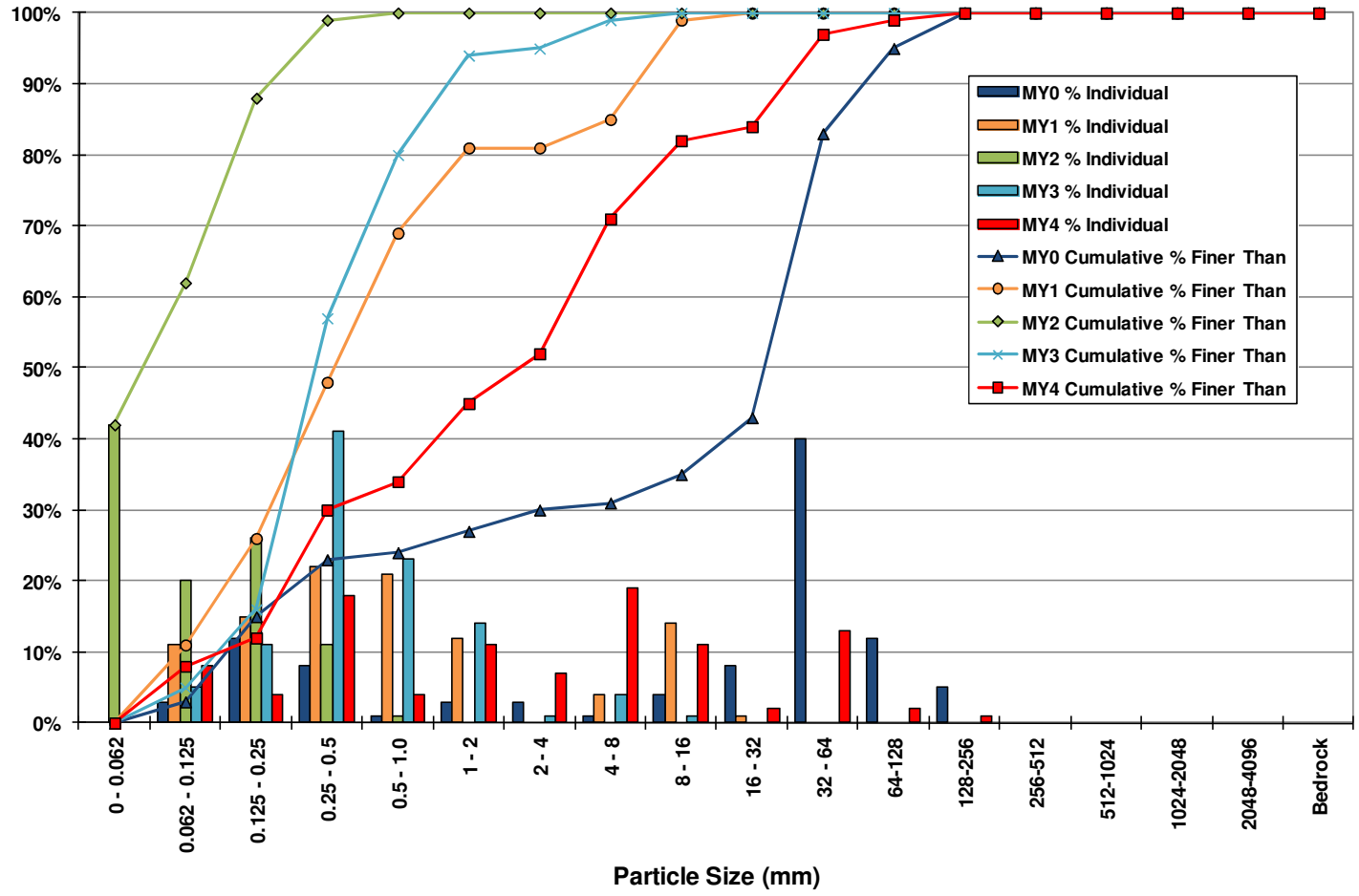
Unnamed Tributary 1 – Pool
Pebble Count



Unnamed Tributary 6 – Pool
Pebble Count



Unnamed Tributary 6 – Riffle
Pebble Count



APPENDIX C

Monitoring Year 4
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	20.7		19.6	18.8	18.4	18.3	17.8		32.9	28.3	27.3	27.8	27.9	
Floodprone Width (ft)	>100	>100	>100	>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	23.0		26.6	28.1	29.1	29.7	30.3		65.7	38.3	38.0	38.9	34.4	
BF Mean Depth (ft)	1.4	1.2	1.2	1.1	1.1		1.4	1.5	1.6	1.6	1.7		2.0	1.4	1.4	1.4	1.2	
BF Max Depth (ft)	2.5	2.6	2.7	2.7	2.5		2.3	3.8	3.8	4.0	4.0		4.5	3.7	3.6	3.2	3.1	
Width/Depth Ratio	14.3	18.1	18.4	18.7	18.7		14.5	12.6	11.6	11.3	10.5		16.4	20.9	19.6	19.9	22.7	
Entrenchment Ratio	>4.9	>4.7	>4.7	>4.8	>4.8		>5.1	>5.3	>5.4	>5.5	>5.6		>3.0	>3.5	>3.7	>3.6	>3.6	
Wetted Perimeter (ft)	21.3	23.4	23.1	22.5	22.5		20.3	22.9	21.8	22.2	21.7		34.4	30.2	29.0	30.0	29.8	
Hydraulic Radius (ft)	1.4	1.1	1.1	1.0	1.0		1.3	1.2	1.3	1.3	1.4		1.9	1.3	1.3	1.3	1.2	

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	18.7		22.3	18.7	19.6	16.8	16.6		39.0	22.7	20.6	15.4	14.2	
Floodprone Width (ft)	>100	>100	>100	>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	24.0		24.7	21.0	20.9	19.7	19.1		49.2	23.4	24.8	23.3	21.9	
BF Mean Depth (ft)	1.6	1.3	1.3	1.3	1.3		1.1	1.1	1.1	1.2	1.2		1.3	1.0	1.2	1.5	1.5	
BF Max Depth (ft)	2.7	3.3	3.3	3.4	3.4		1.9	2.3	2.3	2.4	2.4		4.0	3.1	3.4	3.6	3.1	
Width/Depth Ratio	13.0	15.1	15.6	15.0	14.6		20.0	16.6	18.4	14.3	14.4		30.8	22.1	17.1	10.1	9.3	
Entrenchment Ratio	>4.9	>5.1	>5.0	>5.2	>5.3		>4.5	>5.4	>5.1	>6.0	>6.0		>2.6	>4.4	>4.9	>6.5	>7.0	
Wetted Perimeter (ft)	21.4	21.9	22.0	21.6	21.1		22.8	19.9	20.6	18.0	17.6		40.9	25.0	23.3	18.4	16.8	
Hydraulic Radius (ft)	1.5	1.2	1.1	1.1	1.1		1.1	1.1	1.0	1.1	1.1		1.2	0.9	1.1	1.3	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	24.5		34.4	30.8	31.2	32.0	33.0		22.2	23.8	22.7	23.4	22.7	
Floodprone Width (ft)	>100	>100	>100	>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	59.8		54.5	48.0	47.6	45.9	48.2		29.4	43.5	44.5	43.9	43.9	
BF Mean Depth (ft)	1.2	1.8	2.0	2.4	2.4		1.6	1.6	1.5	1.4	1.5		1.3	1.8	2.0	1.9	1.9	
BF Max Depth (ft)	2.3	3.4	4.0	4.3	4.7		3.4	3.3	3.3	3.2	3.6		2.3	3.5	3.6	3.6	3.6	
Width/Depth Ratio	15.5	13.6	12.3	10.0	10.0		21.7	19.7	20.5	22.4	22.6		16.7	13.0	11.6	12.5	11.7	
Entrenchment Ratio	>5.3	>4.0	>4.1	>4.1	>4.1		>2.9	>3.3	>3.2	>3.1	>3.0		>4.5	>4.2	>4.4	>4.3	>4.4	
Wetted Perimeter (ft)	19.3	26.5	26.2	26.9	27.5		35.3	33.1	33.3	34.0	34.8		22.8	26.3	25.3	25.9	24.8	
Hydraulic Radius (ft)	1.2	1.7	1.8	2.2	2.2		1.5	1.4	1.4	1.3	1.4		1.3	1.7	1.8	1.7	1.8	

*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	27.3		26.4	28.6	29.5	28.4	28.4		23.9	23.4	22.9	26.0	24.4	
Floodprone Width (ft)	>100	>100	>100	>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	37.0		41.3	47.2	45.4	53.5	45.5		30.0	42.2	41.6	44.4	44.3	
BF Mean Depth (ft)	1.2	1.5	1.4	1.3	1.4		1.6	1.6	1.5	1.9	1.6		1.3	1.8	1.8	1.7	1.8	
BF Max Depth (ft)	2.3	2.6	2.6	2.7	2.9		3.7	3.7	3.3	4.4	3.8		2.5	3.3	3.2	3.8	3.7	
Width/Depth Ratio	20.0	16.7	19.5	20.3	20.2		16.9	17.3	19.2	15.1	17.8		19.0	13.0	12.6	15.3	13.4	
Entrenchment Ratio	>4.0	>4.0	>3.6	>3.7	>3.7		>3.8	>3.5	>3.4	>3.5	>3.5		>4.2	>4.3	>4.4	>3.8	>4.1	
Wetted Perimeter (ft)	25.6	26.3	28.6	28.9	28.7		27.8	30.3	31.2	31.5	30.7		24.6	24.8	24.3	28.0	26.4	
Hydraulic Radius (ft)	1.2	1.4	1.3	1.3	1.3		1.5	1.6	1.5	1.7	1.5		1.2	1.7	1.7	1.6	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.

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	9.0		19.1	18.9	19.0	18.4	18.4	
Floodprone Width (ft)	>50.0	>50.0	>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	4.3		18.6	17.8	18.8	17.9	17.7	
BF Mean Depth (ft)	0.5	0.5	0.4	0.5	0.5		1.0	0.9	1.0	1.0	1.0	
BF Max Depth (ft)	1.2	1.3	1.3	1.4	1.4		2.1	2.0	2.0	1.9	2.0	
Width/Depth Ratio	19.9	19.4	22.7	20.2	18.9		19.6	20.1	19.1	18.9	19.2	
Entrenchment Ratio	>5.5	>5.6	>5.2	>5.4	>5.5		>2.6	>2.6	>2.6	>2.7	>2.7	
Wetted Perimeter (ft)	9.5	10.0	10.7	10.3	10.3		19.7	19.5	19.5	19.0	19.0	
Hydraulic Radius (ft)	0.4	0.4	0.4	0.4	0.4		0.9	0.9	1.0	0.9	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	19.6		13.4	11.7	11.7	10.0	10.0	
Floodprone Width (ft)	>50.0	>50.0	>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	12.3		11.1	10.3	9.7	8.7	9.0	
BF Mean Depth (ft)	1.2	0.7	0.7	0.6	0.6		0.8	0.9	0.8	0.9	0.9	
BF Max Depth (ft)	3.0	1.6	1.6	1.5	2.3		1.7	1.7	1.6	1.7	1.9	
Width/Depth Ratio	20.2	27.1	33.2	30.9	31.2		16.2	13.2	14.1	11.5	11.1	
Entrenchment Ratio	>2.1	>2.5	>2.3	>2.6	>2.6		>3.7	>4.3	>4.3	>5.0	>5.0	
Wetted Perimeter (ft)	25.3	20.7	22.8	19.5	21.4		13.9	12.5	12.4	11.2	11.1	
Hydraulic Radius (ft)	1.2	0.7	0.7	0.6	0.6		0.8	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	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	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	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	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	11.38	63.86	21.66			
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	0.0009	0.0441	0.0097			
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	11.43	73.93	30.20			
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	17.63	134.54	92.51			
Additional Reach Parameters																		
Valley Length (ft)	1181.5			1181.5			1181.5			1181.5			1181.5					
Channel Length (ft)	1424.7			1465.5			1463.0			1461.9			1462.9					
Sinuosity	1.21			1.24			1.24			1.24			1.24					
Water Surface Slope (ft/ft)	0.007			0.007			0.007			0.007			0.007					
BF Slope (ft/ft)	0.009			0.008			0.007			0.007			0.007					
Rosgen Classification	C4			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	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	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	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	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	10.51	117.43	34.34			
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	0.0023	0.0325	0.0161			
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	11.99	41.17	21.58			
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	29.71	245.93	66.46			
Additional Reach Parameters																		
Valley Length (ft)	865			865			865			865			865					
Channel Length (ft)	1054.4			1083.7			1116.5			1125.8			1123.5					
Sinuosity	1.22			1.25			1.29			1.30			1.30					
Water Surface Slope (ft/ft)	0.006			0.006			0.005			0.005			0.005					
BF Slope (ft/ft)	0.007			0.005			0.005			0.005			0.005					
Rosgen Classification	C4			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	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	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	94.6	103.4	103.0			
Meander Width Ratio	4.35			4.89			4.54			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	13.91	29.89	21.64			
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	0.0056	0.0321	0.0105			
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	5.13	34.18	22.49			
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	32.10	113.64	63.87			
Additional Reach Parameters																		
Valley Length (ft)	310.3			310.3			310.3			310.3			310.3					
Channel Length (ft)	378.1			386.4			384.3			386.4			387.0					
Sinuosity	1.22			1.25			1.24			1.25			1.25					
Water Surface Slope (ft/ft)	0.011			0.012			0.012			0.011			0.012					
BF Slope (ft/ft)	0.013			0.013			0.013			0.012			0.011					
Rosgen Classification	C5			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	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	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	101.2	121.3	117.6			
Meander Width Ratio	3.16			3.85			3.64			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	6.30	47.58	15.94			
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	0.0041	0.0232	0.0119			
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	4.09	12.12	6.75			
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	7.93	65.36	24.59			
Additional Reach Parameters																		
Valley Length (ft)	222.5			222.5			222.5			222.5			222.5					
Channel Length (ft)	252.4			258.9			254.5			255.1			251.0					
Sinuosity	1.13			1.16			1.14			1.15			1.13					
Water Surface Slope (ft/ft)	0.008			0.010			0.017			0.016			0.016					
BF Slope (ft/ft)	0.014			0.010			0.013			0.016			0.010					
Rosgen Classification	C4			C5			C5			C5			C4					

APPENDIX D

Monitoring Year 4
Site Photos

Permanent Photo Point 1 – Unnamed Tributary 7
Looking Upstream
January 26, 2012

Permanent Photo Point 2 – Unnamed Tributary 7
Looking Upstream
January 26, 2012

Permanent Photo Point 3 – Unnamed Tributary 7
Looking Upstream
January 26, 2012

Permanent Photo Point 4 – Unnamed Tributary 7
Looking Upstream
January 26, 2012

Permanent Photo Point 5 – Unnamed Tributary 7
Looking Upstream
January 26, 2012

Permanent Photo Point 6 – Unnamed Tributary 7
Looking Upstream
January 26, 2012

Permanent Photo Point 7 – Unnamed Tributary 7
Looking Upstream
January 26, 2012

Permanent Photo Point 8 – Morgan Creek
Looking Upstream
January 26, 2012

Permanent Photo Point 9 – Morgan Creek
Looking Upstream
January 26, 2012

Permanent Photo Point 10 – Morgan Creek
Looking Upstream
January 26, 2012

Permanent Photo Point 11 – Morgan Creek
Looking Upstream
January 26, 2012

Permanent Photo Point 12 – Morgan Creek
Looking Upstream
January 26, 2012

Permanent Photo Point 13 – Morgan Creek
Looking Upstream
January 26, 2012

Permanent Photo Point 14 – Morgan Creek
Looking Upstream
January 26, 2012

Permanent Photo Point 15 – Morgan Creek
Looking Upstream
January 26, 2012

Permanent Photo Point 16 – Morgan Creek
Looking Upstream
January 26, 2012

Permanent Photo Point 17 – Morgan Creek
Looking Upstream
January 26, 2012

Permanent Photo Point 18 – Morgan Creek
Looking Upstream
January 26, 2012

Permanent Photo Point 19 – Morgan Creek
Looking Upstream
January 26, 2012

Permanent Photo Point 20 – Morgan Creek
Looking Upstream
January 26, 2012

Permanent Photo Point 21 – Morgan Creek
Looking Upstream
January 26, 2012

Permanent Photo Point 22 – Unnamed Tributary 6
Looking Upstream
January 26, 2012

Permanent Photo Point 23 – Unnamed Tributary 6
Looking Upstream
January 26, 2012

Permanent Photo Point 24 – Unnamed Tributary 6
Looking Upstream
January 26, 2012

Permanent Photo Point 25 – Unnamed Tributary 6
Looking Upstream
January 26, 2012

Permanent Photo Point 26 – Unnamed Tributary 6
Looking Upstream
January 26, 2012

Permanent Photo Point 27 – Morgan Creek
Looking Upstream
January 26, 2012

Permanent Photo Point 28 – Morgan Creek
Looking Upstream
January 26, 2012

Permanent Photo Point 29 – Morgan Creek
Looking Upstream
January 26, 2012

Permanent Photo Point 30 – Morgan Creek
Looking Upstream
January 26, 2012

Permanent Photo Point 30 – Unnamed Tributary 5
Looking Upstream
January 26, 2012

Permanent Photo Point 31 – Unnamed Tributary 5
Looking Upstream
January 26, 2012

Permanent Photo Point 32 – Unnamed Tributary 5
Looking Downstream
January 26, 2012

Permanent Photo Point 32 – Unnamed Tributary 5
Looking Upstream
January 26, 2012

Permanent Photo Point 33 – Unnamed Tributary 5
Looking Downstream
January 26, 2012

Permanent Photo Point 33 – Unnamed Tributary 5
Looking Upstream
January 26, 2012

Permanent Photo Point 34 – Unnamed Tributary 5
Looking Upstream
January 26, 2012

Permanent Photo Point 35 – Unnamed Tributary 5
Looking Downstream
January 26, 2012

Permanent Photo Point 35 – Unnamed Tributary 5
Looking 115 Degrees
January 26, 2012

Permanent Photo Point 35 – Unnamed Tributary 5
Looking Upstream
January 26, 2012

Permanent Photo Point 35 – Unnamed Tributary 5
Looking 358 Degrees
January 26, 2012

Permanent Photo Point 36 – Morgan Creek
Looking Upstream
January 26, 2012

Permanent Photo Point 37 – Morgan Creek
Looking Upstream
January 26, 2012

Permanent Photo Point 38 – Morgan Creek
Looking Upstream
January 26, 2012

Permanent Photo Point 39 – Unnamed Tributary 4
Looking Downstream
January 26, 2012

Permanent Photo Point 39 – Unnamed Tributary 4
Looking Upstream
January 26, 2012

Permanent Photo Point 40 – Morgan Creek
Looking Upstream
January 26, 2012

Permanent Photo Point 41 – Morgan Creek
Looking Upstream
January 26, 2012

Permanent Photo Point 42 – Morgan Creek
Looking Downstream
January 26, 2012

Permanent Photo Point 42 – Morgan Creek
Looking Upstream
January 26, 2012

Permanent Photo Point 43 – Unnamed Tributary 3
Looking Upstream
January 26, 2012

Permanent Photo Point 44 – Unnamed Tributary 3
Looking Upstream
January 26, 2012

Permanent Photo Point 45 – Unnamed Tributary 3
Looking Upstream
January 26, 2012

Permanent Photo Point 46 – Unnamed Tributary 3
Looking Upstream
January 26, 2012

Permanent Photo Point 47 – Unnamed Tributary 3
Looking Upstream
January 26, 2012

Permanent Photo Point 48 – Unnamed Tributary 3
Looking Upstream
January 26, 2012

Permanent Photo Point 49 – Unnamed Tributary 3
Looking Upstream
January 26, 2012

Permanent Photo Point 50 – Unnamed Tributary 3
Looking Upstream
January 26, 2012

Permanent Photo Point 51 – Unnamed Tributary 3
Looking Downstream
January 26, 2012

Permanent Photo Point 51 – Unnamed Tributary 3
Looking Upstream
January 26, 2012

Permanent Photo Point 52 – Unnamed Tributary 3
Looking Downstream
January 26, 2012

Permanent Photo Point 52 – Unnamed Tributary 3
Looking 110 Degrees
January 26, 2012

Permanent Photo Point 52 – Unnamed Tributary 3
Looking Upstream
January 26, 2012

Permanent Photo Point 52 – Unnamed Tributary 3
Looking 355 Degrees
January 26, 2012

Permanent Photo Point 53 – Morgan Creek
Looking Upstream
January 26, 2012

Permanent Photo Point 54 – Morgan Creek
Looking Upstream
January 26, 2012

Permanent Photo Point 55 – Morgan Creek
Looking Upstream
January 26, 2012

Permanent Photo Point 56 – Unnamed Tributary 2
Looking Upstream
January 26, 2012

Permanent Photo Point 57 – Unnamed Tributary 2
Looking Upstream
January 26, 2012

Permanent Photo Point 58 – Unnamed Tributary 2
Looking Downstream
January 26, 2012

Permanent Photo Point 58 – Unnamed Tributary 2
Looking Upstream
January 26, 2012

Permanent Photo Point 59 – Unnamed Tributary 2
Looking Downstream
January 26, 2012

Permanent Photo Point 59 – Unnamed Tributary 2
Looking Upstream
January 26, 2012

Permanent Photo Point 60 – Unnamed Tributary 2
Looking Downstream
January 26, 2012

Permanent Photo Point 60 – Unnamed Tributary 2
Looking Upstream
January 26, 2012

Permanent Photo Point 61 – Morgan Creek
Looking Upstream
January 26, 2012

Permanent Photo Point 62 – Unnamed Tributary 1
Looking Upstream
January 26, 2012

Permanent Photo Point 63 – Unnamed Tributary 1
Looking Upstream
January 26, 2012

Permanent Photo Point 64 – Unnamed Tributary 1
Looking Upstream
January 26, 2012

Permanent Photo Point 65 – Unnamed Tributary 1
Looking Upstream
January 26, 2012

Permanent Photo Point 66 – Unnamed Tributary 1
Looking Downstream
January 26, 2012

Permanent Photo Point 66 – Unnamed Tributary 1
Looking Upstream
January 26, 2012

Permanent Photo Point 67 – Unnamed Tributary 1
Looking Downstream
January 26, 2012

Permanent Photo Point 67 – Unnamed Tributary 1
Looking 185 Degrees
January 26, 2012

Permanent Photo Point 67 – Unnamed Tributary 1
Looking Upstream
January 26, 2012

Permanent Photo Point 67 – Unnamed Tributary 1
Looking 360 Degrees
January 26, 2012

Permanent Photo Point 68 – Unnamed Tributary 1
Looking Downstream
January 26, 2012

Permanent Photo Point 68 – Unnamed Tributary 1
Looking 94 Degrees
January 26, 2012

Permanent Photo Point 68 – Unnamed Tributary 1
Looking Upstream
January 26, 2012

Permanent Photo Point 68 – Unnamed Tributary 1
Looking 327 Degrees
January 26, 2012

Permanent Photo Point 69 – Unnamed Tributary 8
Looking Downstream
January 26, 2012

Permanent Photo Point 69 – Unnamed Tributary 8
Looking 168 Degrees
January 26, 2012

Permanent Photo Point 69 – Unnamed Tributary 8
Looking Upstream
January 26, 2012

Permanent Photo Point 69 – Unnamed Tributary 8
Looking 53 Degrees
January 26, 2012

Permanent Photo Point 70 – Unnamed Tributary 9
Looking Downstream
January 26, 2012

Permanent Photo Point 70 – Unnamed Tributary 9
Looking Upstream 196 Degrees
January 26, 2012

Permanent Photo Point 70 – Unnamed Tributary 9
Looking Upstream 248 Degrees
January 26, 2012

Morgan Creek Vegetation Plot Phots

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. 1003+25 – Reduced pool depth due to aggradation

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

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

SPA 24 Morgan Creek Sta. 1038+50 – 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

APPENDIX E

Invasive Exotic Vegetation Control at Morgan Creek Stream Restoration Site Progress Report

Invasive Exotic Vegetation Control at the Morgan Creek Stream Restoration Site
Year 4, June 2012
Progress Report

Purpose

The Morgan Creek Stream Restoration Site was treated for invasive exotic plants in the summer of 2011 to eliminate competition of non-native plants within riparian easement areas. Follow-up treatments were conducted in February and June 2012. This Progress Report provides a summary of management activities occurring in 2012 as well as the status of invasive exotic plant populations on-site.

Site Conditions

Approximately 4.5 acres of invasive exotic plant infestations were treated at Morgan Creek in 2011, which reduced these populations by 60%. In 2012, follow-up treatment occurred within the same areas and totaled 2.8 acres. Target species included:

- 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)*

Summary of Control Activities

Three days were spent on management activities at the Morgan Creek Stream Restoration Site. On February 24, 2012, foliar applications were applied to semi-evergreen species such as Privet and Japanese Honeysuckle prior to leaf-out of other non-target species. Several months later on June 7, 2012, one day was spent assessing previous management activities and monitoring all invasive exotic plant populations on-site. Treated and remnant infestations were observed while walking the entire perimeter of the easement area. These observations enabled adaptive management and allowed for more prepared and effective future treatments.

A final control event was held on June 13, 2012 to treat dense patches of large, mature shrubs. Privet and Autumn Olive larger than 2-5 inches in diameter were cut with a chainsaw and immediately applied with a 25% solution of herbicide. These patches were too tall to safely spray with backpack sprayers and too dense to effectively penetrate the population using foliar applications. The timing of the treatment occurred before seed production to prevent the spread of new infestations.

All herbicide applications were applied and/or supervised by certified NCDA&CS Pesticide Applicators, License #026-26135 and #026-29539. Table 1 summarizes the reaches treated, application method employed, herbicide volume used, herbicide concentrations used, and other relevant information occurring in 2012.

Seed banking, root propagation, recruitment, and other means of reproduction may occur even though treatment occurred prior to the production of viable seeds. Because of this, re-treatment will be necessary.

Table 1: Treatment Records

Date	Reaches	Target Species	Type of Treatment	Herbicide	Concentration (%)	Volume Herbicide Concentrate Used* (oz)	Volume Mixture Used (gal)	Weather	Temperature (°F)	Wind Speed (mph)	Notes
2/24/2012	Morgan Ck, UT-8, UT-1, UT-5, UT-6	Privet, Japanese Honeysuckle, Multiflora Rose	foliar	Element 3A	3%	116	20	Sunny, breezy at times	70	7	used adjuvant LI700
6/13/2012	UT-1, UT-2, UT-5	Privet, Autumn Olive, Japanese Honeysuckle	cut stump	Garlon 3A	25%	16	0.5	sunny	82	2	

Morgan Creek Stream Restoration Site
Photos of Invasive Plant Control
2012

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

UT-1, Photo Point 1, looking west
June 7, 2012

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

UT-3, Photo Point4, looking northeast
June 7, 2012

UT-8, Photo Point 10, looking north/northwest
June 7, 2012
April 16, 2010

UT-1 Photo Point 11, looking west June 7, 2012

Ut-1, Photo Point 12, looking west
June 7, 2012

UT-2, Photo Point 13, looking northwest
June 7, 2012