Morgan Creek
Stream Restoration Site

Year 1 Final Monitoring Report
Project ID Number: 16-D06027

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1.0 SUMMARY

This Annual Report details the monitoring activities during 2009 and 2010 (Year 1) 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, the majority of the Year 1 monitoring efforts were postponed until repairs were completed in February 2010. The 2009 and 2010 data represent results from the first year of stream and vegetation monitoring.

The stream design 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, 3,106 linear feet of longitudinal profile, three crest gauges, eight vegetation monitoring plots, and photographic reference locations; as specified in the approved Mitigation Plan (EBX, 2008).

The Year 1 stream channel data indicates that the restored stream is still in a state of development towards providing the intended habitat and hydrologic functions. The longitudinal profiles, cross sections, substrate, and visual assessments indicate bed adjustments as compared to the As-built conditions. Stream hydrology monitoring recorded multiple bankfull events since the initial completion of construction in July 2008. The restored stream channel appears to have received significant sediment inputs from upstream sources during these events and likely resulted in bed form changes observed between monitoring years.

Vegetation plot monitoring during Year 1 indicates survival rates between 162 and 931 stems per acre with an average of 546 planted stems per acre for the entire restoration site. Generally speaking, planted stems are surviving at the project site. Only two plots failed to meet the interim success criterion (VP2 and VP3), but planted stems were also low for VP1. While natural recruitment of woody volunteers was low across the site, when planted and natural stems are combined the average stem density for the entire restoration site is approximately 556 stems, which is well above the interim success criterion of 320 stems per acre at the end of the Year 3 monitoring period. Natural recruits are expected to increase over time as volunteer seeds become established.

2.0 INTRODUCTION

2.1 Project Description

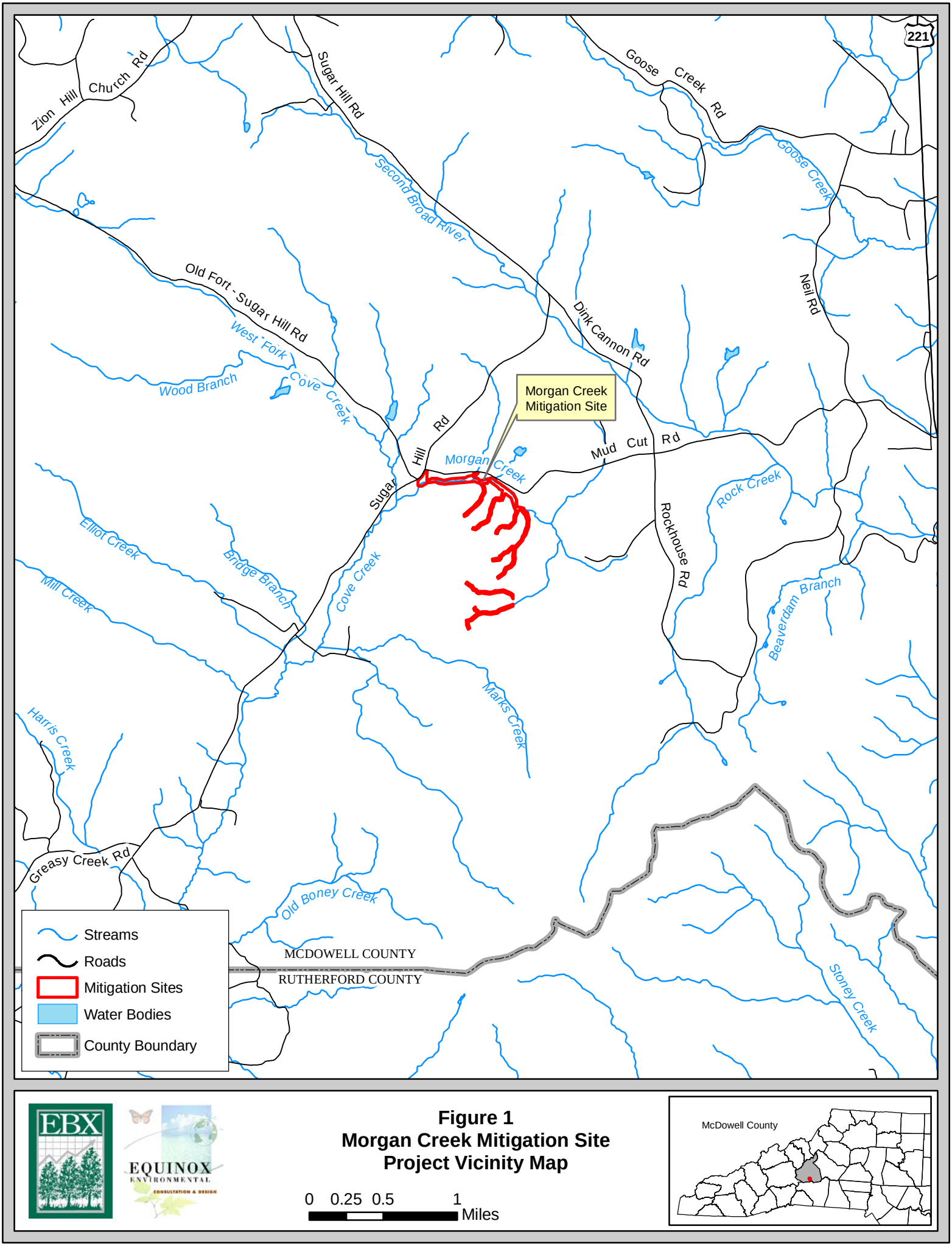
The Morgan Creek Stream Mitigation Site was identified and developed through the North Carolina Ecosystem Enhancement Program (NC EEP) full delivery process. The site is located in southern McDowell County approximately eight miles south of Marion, North Carolina **(Figure 1)**. The project streams lie 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 totaling 18,772 linear feet. The nine distinct unnamed tributaries (UT) are identified as UT1, UT2, 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-site 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 conservation easements 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 sections of UT1, UT2, UT3, UT4, UT5, UT6, and UT7 located in the valley of Morgan Creek. Additionally, a 163-linear foot section of 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) through livestock exclusion fencing, supplemental riparian buffer plantings, and the stabilization of severely eroding logging roads. The middle sections of UT2, UT3, and UT5 upstream from the restoration reaches were enhanced (enhancement level II) through 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 2009/2010 monitoring season represents Year 1 of the monitoring period. Monitoring during 2009/2010 included stream and vegetation monitoring stations **(Figure 3)** as approved in the Mitigation Plan (EBX, 2008).


Zion Hill Church Rd
Sugar Hill Rd
Goose Creek Rd
221
Second Broad River
Goose Creek
Old Fort - Sugar Hill Rd
Dink Cannon Rd
Neil Rd
West Fork
Wood Branch
Cove Creek
Morgan Creek Mitigation Site
Sugar Hill Rd
Morgan Creek
Mud Cut Rd
Rock Creek
Rockhouse Rd
Elliot Creek
Bridge Branch
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Marks Creek
Harris Creek
Greasy Creek Rd
Old Boney Creek
MCDOWELL COUNTY
RUTHERFORD COUNTY
Stoney Creek
Streams
Roads
Mitigation Sites
Water Bodies
County Boundary
EBX
EQUINOX ENVIRONMENTAL
CONSULTATION & DESIGN
Figure 1
Morgan Creek Mitigation Site
Project Vicinity Map
0 0.25 0.5 1
Miles
McDowell County

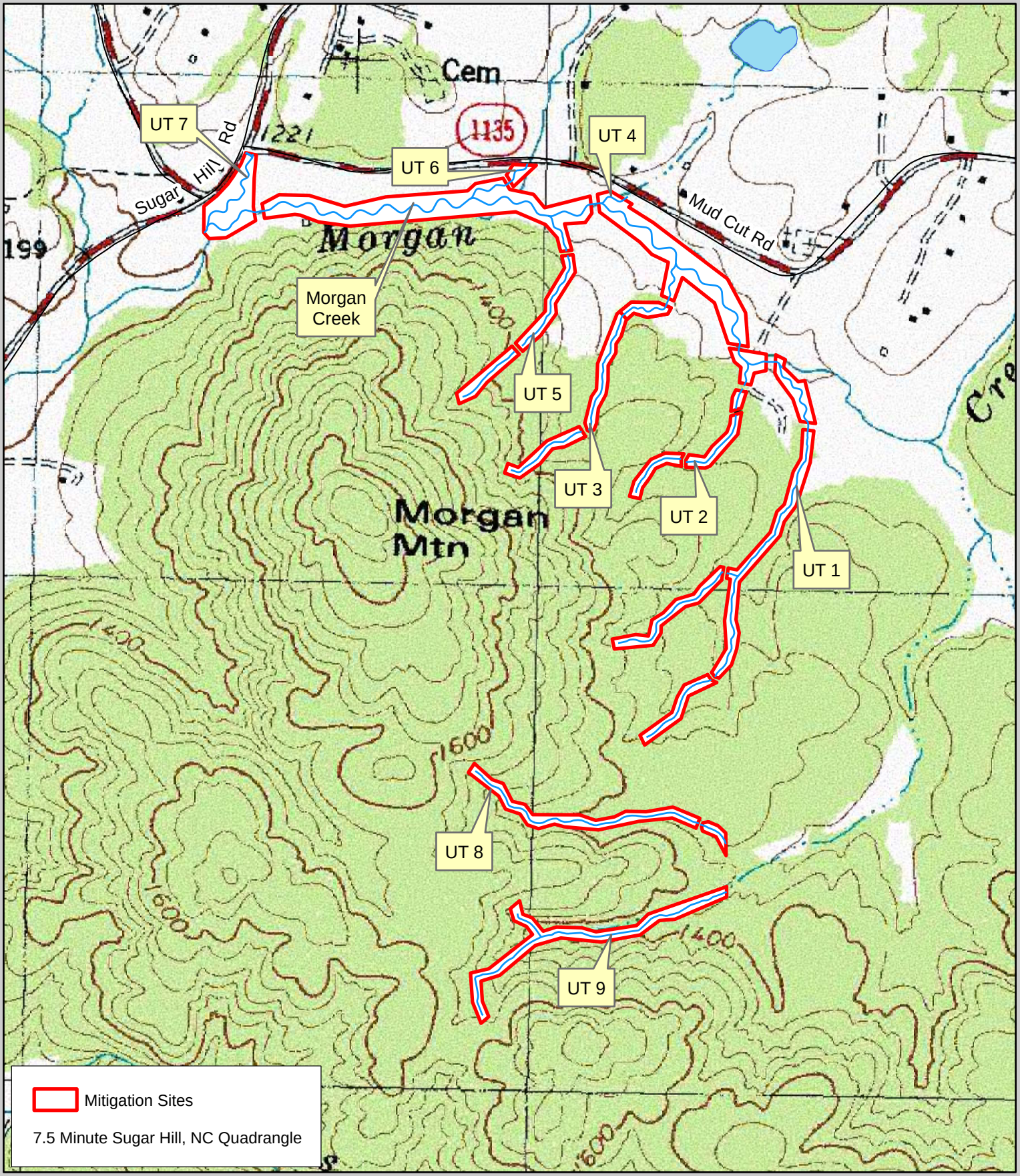
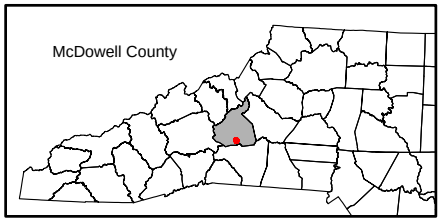
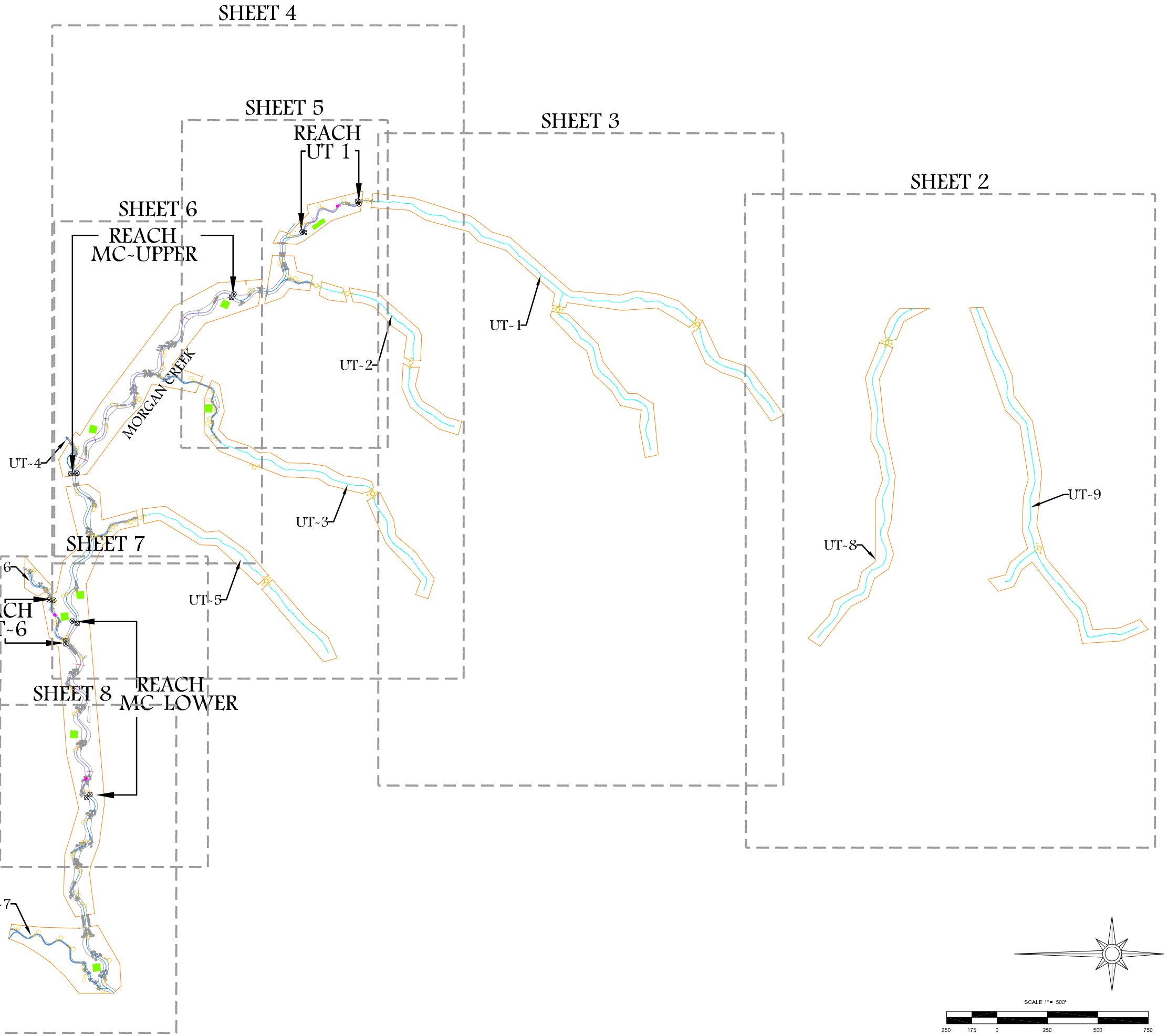


Figure 2
Morgan Creek Mitigation Site
USGS Map

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

Morgan Creek

McDowell County, NC

Monitoring Plan
Figure 3

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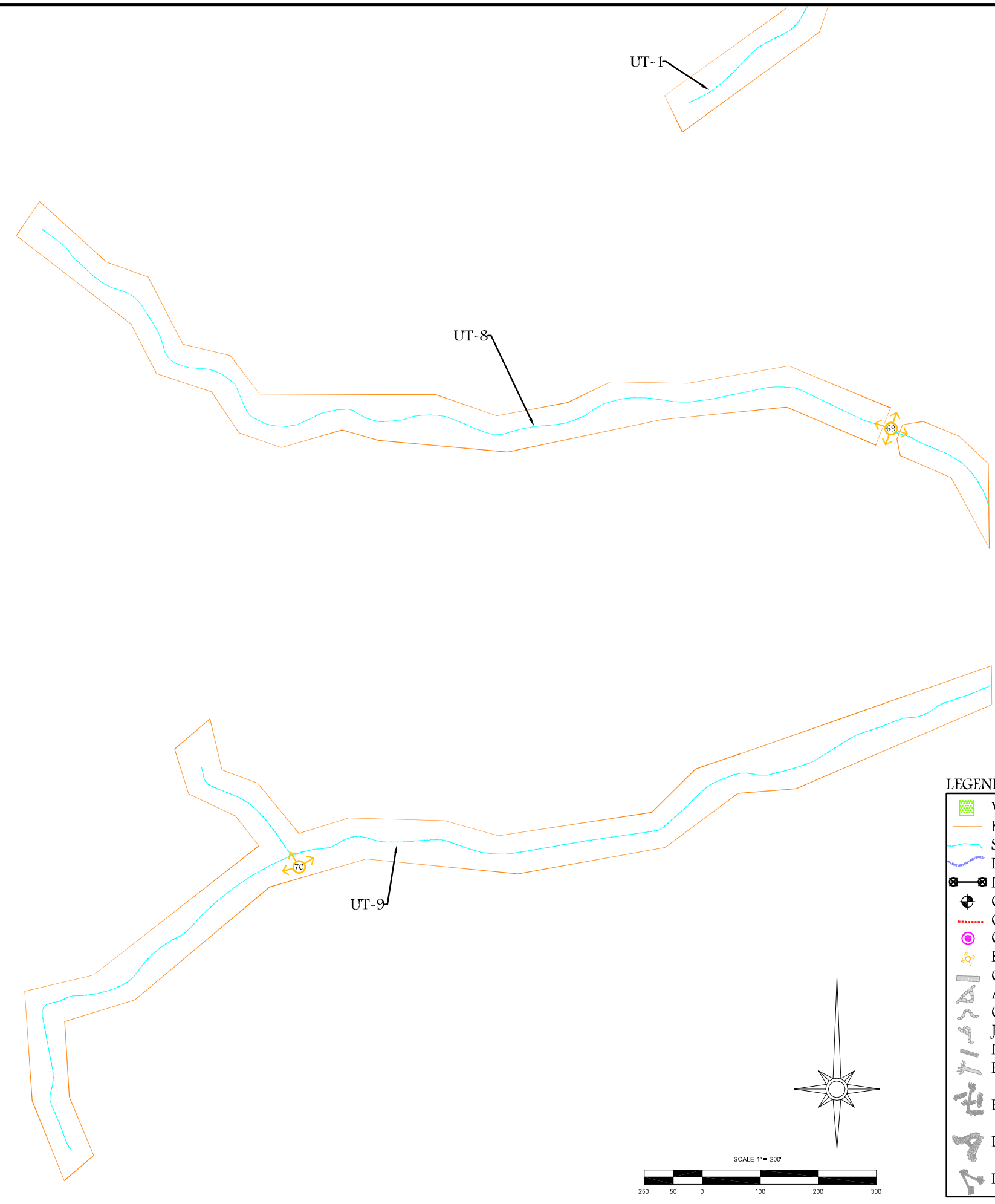

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McDowell County, NC

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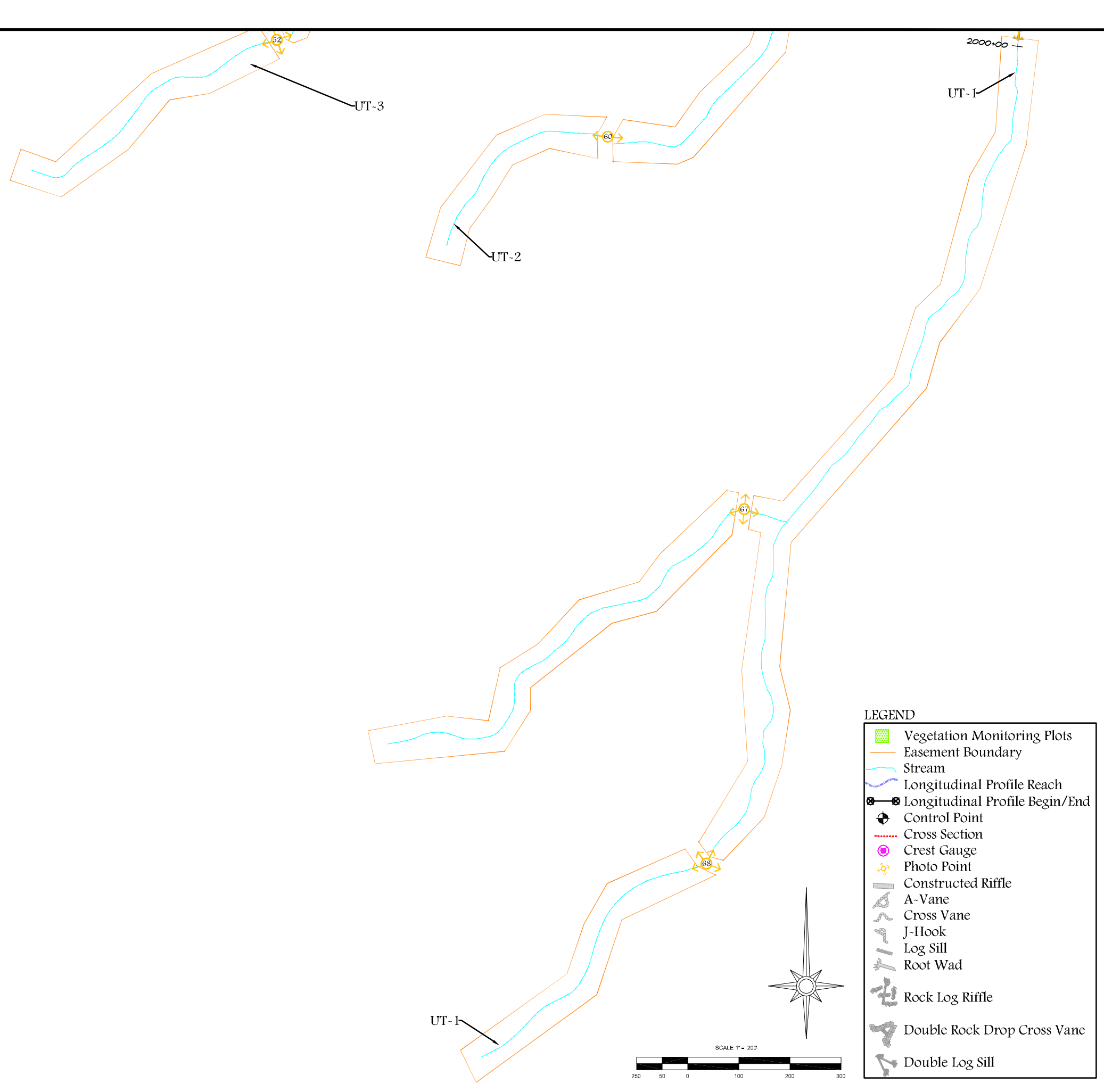

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McDowell County, NC

Monitoring Plan
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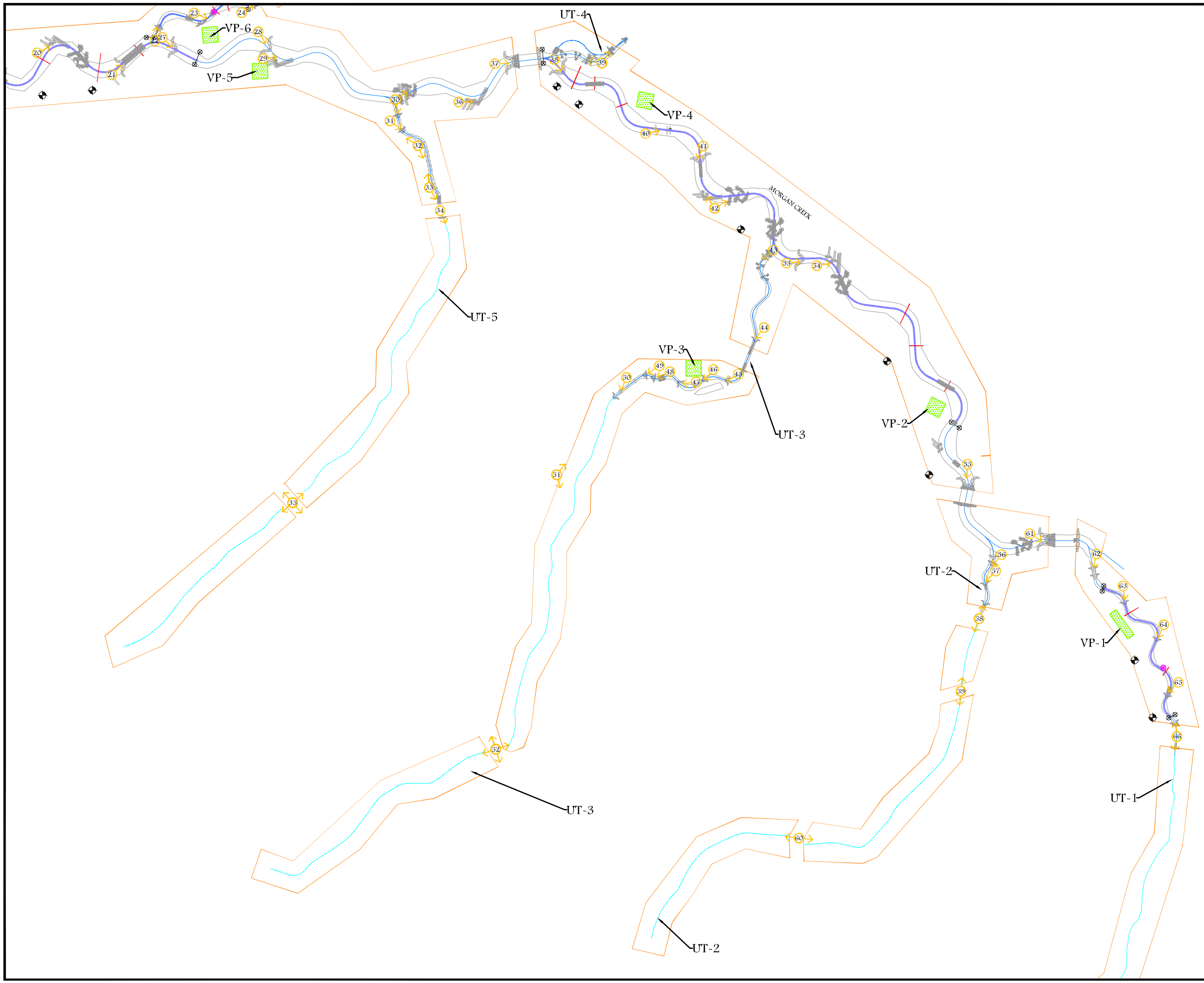
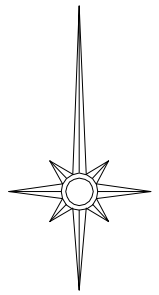
Morgan Creek

McDowell County, NC

Monitoring Plan
Figure 3





SCALE 1" = 200'

250 50 0 100 200 300

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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

VP-1

UTI-P
XS Station=2003+77.15

UTI-R
XS Station=2001+95.47

Morgan Creek

McDowell County, NC

Monitoring Plan
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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-P1
XS Station=1008+66.76

MC Upper-R3
XS Station=1017+49.90

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
1047+00
1046+00
1045+00
1044+00
1043+00
1042+00
1041+00
1040+00
1039+00
1038+00
1037+00
1036+00
1035+00
1034+00
1048+00
1049+00
1049+46

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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 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 as a result of the ecological restoration and enhancement practices.

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 1 at the Morgan Creek Stream Mitigation Site. Results from the Year 1 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 morphology monitoring efforts. Vegetation plot monitoring occurred on schedule in September 2009 and is included in this report with the morphological data collected during March and April 2010. In order to complete the five-year monitoring requirements in 2013 as originally proposed, the Year 2 vegetation monitoring efforts will occur in the summer of 2010 followed by the Year 2 stream monitoring efforts in the fall of 2010 **(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 (Scheduled)
December 2010	Year 2 Annual Monitoring Report (Scheduled)
December 2011	Year 3 Annual Monitoring Report (Scheduled)
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 Contractor Robert Grady	RFG Construction Inc. 1907 Cambridge Drive Kinston, North Carolina 28504 (252) 523-2405
Planting/Seeding Contractor Robert Cato	Superior Wildlife Services 2105 Sparre Drive Kinston, North Carolina 28504 (252) 939-0465
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, profile, and sinuosity are stable or reach a dynamic equilibrium. 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 annual system development and progress in achieving the 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 installed during 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, one cross section within the MC-Upper reach (MC-Upper Riffle 4 / Cross Section 5) was impacted resulting in a change in bankfull elevation between 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 include one riffle and one pool cross-section. Each cross-section was marked on both banks with permanent iron pins to establish known annual transects. A common benchmark was established to facilitate 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. Cross-sectional photos are collected annually 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). 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 analysis. Longitudinal profile measurements include thalweg, water surface, bankfull, and top of low bank. Annual thalweg and water surface measurements are collected at the head and tail of each bedform type.

3.2.3 Substrate

Bed substrate assessment sites were established at each permanent cross-section location. 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 form As-built conditions.

3.2.4 Hydrology

Crest gauges installed at the lower end of Morgan Creek, UT1, and UT6 will be utilized to document bankfull events during the monitoring period. Crest gauges will be checked during each site visit to document the highest flow between visits. Gauge height readings will be recorded and digital images of floodplain debris lines and sediment deposition will be 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 stream project reach will be visually assessed to document any identified areas of concern. Representative photos will be collected to document areas of concern identified during the visual site assessment.

3.3 Stream Morphology Monitoring Results

The Year 1 annual stream morphology data were collected between February and April 2010. Reference station photos were collected in February 2010 prior to the onset of vegetation emergence to document the general conditions of the site. The Year 1 cross-section, longitudinal profile, and substrate data collection efforts occurred in March and April 2010. 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 April 2010.

3.3.1 Cross Sections

The MC-Upper, UT1, and UT6 cross-sectional data collected during the Year 1 monitoring effort have been compared with the As-built data **(Appendix B & C)**. Due to stream and bank repairs that resulted in the loss of cross-sectional stations within the MC-Lower reach, data for this tributary are not available for the Year 1 monitoring period and are not discussed below. Furthermore, stream and bank repairs impacted bankfull elevation at one cross section location on the MC-Upper reach (MC-Upper Riffle 4 / Cross Section 5) and data comparisons between 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. The Year 1 data for these cross-sections are presented in **Appendix B & C** and will be utilized for comparison during subsequent monitoring years.

Overall, the riffle cross-sectional data for MC-Upper indicate narrowing channels with inner berm feature development along the banks. The two constructed riffles within the MC-Upper reach have maintained similar max depths between years while max depths for the two non-constructed riffles have significantly increased. Based on the two monitored pools within the MC-Upper reach, cross-sectional area has decreased significantly between years.

Compared to the UT1 As-built data, the Year 1 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 dimension for UT6 has been impacted from sediment deposition both within the channel and along the floodplain. While the UT6 bed elevation is similar between years, mid-channel bar development has occurred due to deposition. Deposition within the pool cross-section has significantly reduced the cross-sectional area as well as depth.

3.3.2 Longitudinal Profile

Longitudinal profile surveys were conducted along four separate reaches of the restoration project, totaling approximately 3,106 linear feet. The surveys conducted included reach MC-Upper from STA 1005+51 to STA 1019+75 (1,424 linear feet), MC-Lower from STA 1028+16 to STA 1038+67 (1,051 linear feet), UT1 from STA 2000+85 to STA 2004+63 (378 linear feet), and reach UT6 from STA 7002+31 to STA 7004+84 (253 linear feet). Due to design changes resulting from repairs made within the MC-Lower reach, data comparisons between years are only reported in the tables for reference and not for analysis. The longitudinal profiles documented bed elevations, stream features, and in-stream grade control structures as compared to the As-built profiles **(Appendix B & C)**.

Based on stream profiles and visual observations, the project site has experienced some changes in morphology as compared to the original As-built conditions. While bed conditions within the project site are stable within areas, stream bed profiles and visual observations indicate an

overall trend of filling pools and down cutting riffles. Areas requiring observation identified through the profile surveys and visual assessments are included in **Table 5** and **Appendix A.**

3.3.3 Substrate

In general, pebble count data for MC-Upper indicate little change in substrate size composition between years for both riffles and pools. The MC-Upper pebble count data collected during Year 1 primarily indicate silt/clay and fine sand particles within the pool habitat types and coarser materials within the riffles. Although pebble counts collected for the MC-Lower reach are not directly comparable due to changes in locations between years, there appears to be a general trend towards a coarser composition within both riffle and pool habitat types. The UT1 pebble count data collected during Year 1 suggest a general trend of fining within both the riffle and pool, with substrate composition primarily comprised of sand within the riffle and silt/clay within the pool habitat types. Substrate composition within the UT6 stream channel indicates the riffle is fining with sand deposition while the pool is trending towards a coarser sand composition. The As-built and Year 1 pebble count data summary plots are included in **Appendix B**.

3.3.4 Hydrology

Since project completion at least three 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 for Morgan Creek and 0.02 feet above bankfull for UT6 **(Table 4)**. Owing to damaged crest gauges from this initial event, subsequent bankfull events in May 2009 and January 2010 were documented with photos **(Appendix D)**.

Table 4. Crest Gauge Data

Month / Year Recorded	Morgan Creek (ft)	UT1 (ft)	UT6 (ft)
August / 2008	0.15	---	0.02

3.3.5 Photo Reference Stations

The Year 1 reference station photos are included in **Appendix D**. Stream areas of concern (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 during the Year 1 monitoring effort are included in **Appendix D**.

Table 5. Stream Areas Requiring Observation

SPA	Feature	Reach	STA	Description
1	Pool	UT1	2001+10	Insufficient pool depth due to aggradation
2	Rock Vane	UT1	2001+50	Grade control structure piping
3	Pool	UT1	2001+75	Insufficient pool depth due to aggradation
4	Pool	Morgan Creek	1001+50	Insufficient pool depth due to aggradation
5	Pool / Riffle	UT2	3000+50	Insufficient pool depth and riffle fining due to aggradation
6	Pool	Morgan Creek	1004+20	Insufficient pool depth due to aggradation
7	Pool	Morgan Creek	1005+05	Insufficient pool depth due to aggradation
8	Riffle	Morgan Creek	1005+50	Riffle down cutting
9	Riffle	Morgan Creek	1007+75	Riffle down cutting
10	Riffle	Morgan Creek	1009+10	Riffle down cutting
11	Pool	UT3	4000+10	Insufficient pool depth due to aggradation
12	Pool	UT3	4001+90	Insufficient pool depth due to aggradation
13	Stream Bank	Morgan Creek	1014+50	Bank erosion due to piping behind root wad
14	Pool / Riffle	UT4	5001+50	Insufficient pool depth and riffle fining due to aggradation
15	Stream Bank	Morgan Creek	1021+25	Bank erosion due to piping behind root wad
16	Pool / Riffle	UT6	7001+00	Insufficient pool depth and riffle fining due to aggradation
17	Pool / Riffle	UT6	7003+00	Insufficient pool depth and riffle fining due to aggradation
18	Pool	UT6	7004+10	Insufficient pool depth due to aggradation
19	Pool / Riffle	UT7	8000+40	Insufficient pool depth and riffle fining due to aggradation
20	Pool / Riffle	UT7	8006+00	Insufficient pool depth and riffle fining due to aggradation

3.4 Stream Conclusions

The Year 1 morphological monitoring and visual assessments indicate a developing system. Areas of concern identified during Year 1 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** and **Table 7** summarize the riffle morphologic parameters between the As-built conditions and Year 1; more detailed morphologic parameters are provided in **Appendix B & C**. The MC-Lower As-built and Year 1 parameters in Table 6 and Table 7 below are presented for the purpose of comparing the original As-built conditions to those of the repair As-built conditions. Subsequent annual monitoring reports will utilize the repair As-built conditions to monitor annual riffle morphological parameters within the MC-Lower reach.

Table 6. Summary of Morphologic Monitoring Parameters – As-Built

Parameter	As-Built Morgan Creek Upper	As-Built Morgan Creek Lower*	As-Built UT1	As-Built UT6
Average Bankfull Cross Section Area Abkf (sq ft)	28.4	28.2	4.1	11.1
Average Bankfull Width Wbkf (ft)	20.8	22.4	9.1	13.4
Bankfull Width / Depth Ratio	15.5	17.8	19.9	16.2
Bankfull Mean Depth Dbkf (ft)	1.4	1.3	0.5	0.8
Bankfull Max Depth Dmax (ft)	2.4	2.4	1.2	1.7

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

Table 7. Summary of Morphologic Monitoring Parameters – Year 1

Parameter	Year 1 Morgan Creek Upper	Year 1 Morgan Creek Lower*	Year 1 UT1	Year 1 UT6
Average Bankfull Cross Section Area Abkf (sq ft)	25.0	42.4	4.2	10.3
Average Bankfull Width Wbkf (ft)	19.7	24.4	9.0	11.7
Bankfull Width / Depth Ratio	15.6	14.2	19.4	13.2
Bankfull Mean Depth Dbkf (ft)	1.3	1.7	0.5	0.9
Bankfull Max Depth Dmax (ft)	3.0	3.2	1.3	1.7

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

4.0 VEGETATION

4.1 Vegetation Success Criteria

Successful establishment of vegetation for the Morgan Creek Stream Restoration Project will be the survival of 260 stems at the end of Year 5 monitoring. The site must also meet the interim success criterion of the minimum survival of 320 planted stems per acre at the end of the Year 3 monitoring period.

4.2 Description of Species and Vegetation Monitoring

Eight plots, 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 regeneration at the project site. Plots were placed within the applicable planting zones to capture the heterogeneity of the designed 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. A total of nine tree species were planted on the site **(Table 8)**. Taxonomic nomenclature follows Weakley (2008).

Table 8. 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

Stem counts for each of the eight vegetation monitoring plots were recorded by species **(Table 9)**. Low stem densities reported in the 2008 baseline monitoring report resulted in a supplemental planting that occurred in December 2008. These stems were monitored in Year 1. Results from Year 1 vegetation monitoring documented a wide survivability range of 162 to 931 planted stems per acre across all vegetation plots. The average stem density for the entire restoration site is 546 planted stems per acre **(Table 10)**, up approximately 52% from 2008.

However, one vegetation plot (VP8) was lost as a result of construction repairs that occurred after the Year 1 vegetation monitoring. This plot will be reestablished and monitored in Year 2.

Table 9. Results of 2009 Vegetation Monitoring by Plot

Species	Plot ID							
	VP1	VP2	VP3	VP4	VP5	VP6	VP7	VP8
Betula nigra	2	1	2	3		12	9	8
Cephalanthus occidentalis						1	6	
Fraxinus pennsylvanica	3		5		9	3		11
Liriodendron tulipifera var. tulipifera	1			3			5	
Platanus occidentalis var. occidentalis	1	1		3		1		
Quercus michauxii								2
Quercus nigra					2		1	
Quercus phellos	1	1			2		1	
Salix nigra		1		1		6		

Table 10. Summary of Vegetation Monitoring Results

Plot ID	Stems Planted (baseline)	Supplemental Planting	2009 Stems	Percent Survival	Stems per Acre					
					Stems Planted (baseline)	2009 Year 1*	2010 Year 2	2011 Year 3	2012 Year 4	2013 Year 5
VP1	7	8	8	100%	283	324				
VP2	3	4	4	100%	122	162				
VP3	5	7	7	100%	202	283				
VP4	7	10	10	100%	283	405				
VP5	10	13	13	100%	405	526				
VP6	14	23	23	100%	567	931				
VP7	16	22	22	100%	648	891				
VP8	9	21	21	100%	364	850				

Average stems per acre: 546
Range of stems per acre: 162 - 931
*Includes supplemental planting data

A visual estimate of herbaceous vegetation cover within the monitoring plots is provided to assess the overall stability of the restoration site **(Table 11)**. On average, herbaceous vegetation coverage is 76% within the plots. Observations of herbaceous cover throughout the project area were noted during the visual assessment and are documented within **Appendix A** and 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.*), and rice cutgrass (*Leersia oryzoides*). Herbaceous cover in bare areas is expected to increase as a result of natural recruitment from adjacent wooded areas and EBX has taken remedial action to improve vegetative cover in these bare areas.

Table 11. Estimated Herbaceous Total Percent Cover

Plot ID	Estimated Herbaceous Cover (%)
VP1	95%
VP2	100%
VP3	75%
VP4	75%
VP5	40%
VP6	100%
VP7	50%
VP8	70%

Commonly encountered woody volunteer or natural species are also monitored throughout the five-year monitoring period **(Table 12)**. Recruitment was low across the restoration site, most likely due to frequent disturbance, and longer distances from mature seed sources, but natural recruits are expected to increase over time as volunteer seeds become established.

Table 12. Volunteer Tree Species

Common Name	Scientific Name
American Persimmon	*Diospyros virginiana*
American Hornbeam	*Carpinus caroliniana*

4.4 Vegetation Observations and Conclusions

Overall, planted stems are surviving at the Morgan Creek Stream Restoration Site. Only 7% of planted stems were dead and 3% were missing during Year 1 monitoring, respectively. However, over 40% of planted stems in Year 1 monitoring for the entire restoration site had fair, unlikely to survive, or dead vigor scores. In particular, planted stem mortality was highest at VP7 and VP8. Of these, buttonbush had the highest mortality rate and green ash and river birch were among the most damaged species.

Invasive exotic plants such as multiflora rose (*Rosa multiflora*), Japanese stiltgrass (*Microstegium vimineum*), Japanese honeysuckle (*Lonicera japonica*), and privet (*Ligustrum sp*.) were observed in VP1 and VP3, and 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*), and thorny olive (*Elaeagnus pungens*) were also documented in dense isolated patches outside of the vegetation monitoring plots but within the easement boundary **(Appendix A).** EBX has begun controlling the kudzu, knotweed, and other high-priority species with subsequent control efforts planned throughout the monitoring period. Representative photos of these areas during the Year 1 monitoring effort are included in **Appendix D**.

Vegetation plots 2 and 3 did not meet the interim success criteria, and VP1 only had 324 planted stems per acre. Stem loss in the 2009 monitoring period may be partly due to flooding events that occurred in 2008 and 2009. In addition, vegetation plots were established in riparian and

upland planting zones, and the number of stems recorded in these plots was extrapolated across the entire restoration area. Therefore, it is assumed that these zones are representative of the full restoration area. While this may largely be true, it is likely that other, smaller planting zones are underrepresented. For example, if the vegetation plots had captured stream bank vegetation, which is planted at higher densities with live stake plant material, planted stem survivability might be much greater.

Excluding VP2 and VP3, all vegetation monitoring plots meet success criteria. Herbaceous vegetation cover was relatively high although VP5 and VP7 had 50% or less vegetative cover **(Appendix A)**. Planted stems were also low for VP1 with 324 stems per acre. Only two volunteer stems occurred for the entire restoration site. When planted and volunteer stems are combined, the average stem density for the site is approximately 556 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.

5.0 CONCLUSIONS AND RECOMENDATIONS

- Morphological data and observations of stream conditions at the site primarily indicate a developing system with areas of concern identified during the Year 1 monitoring that are principally associated with pool aggradation and riffle degradation. The restored stream reaches will continue to be monitored during subsequent monitoring years and recommendations will be made if profile changes indicate that the criteria specified in the Restoration Plan (EBX, 2007) will not be met.

- Vegetation monitoring efforts have documented the average number of planted stems per acre for the entire restoration site to be 546 stems per acre for the 2009 monitoring year, which represents an increase of 52% from 2008. Native, woody volunteer recruitment was low and the increase in stem density was primarily the result of a supplemental planting that occurred in December 2008. In general, most planted stems are surviving at the project site, but VP2 and VP3 failed to meet the target success criteria. Planted stems were also low for VP1 with 324 stems per acre. An additional supplemental planting will be considered to ensure that deficient areas meet success criteria during future monitoring events. Lastly, expansion of invasive exotic plant populations should continue to be monitored and controlled as warranted both within the vegetation plots in which they occur and within the larger restoration area.

- Stream and vegetation monitoring will continue through 2013.

6.0 REFERENCES

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APPENDIX A

2010 Current Condition Plan View

Prepared for: EBX

Prepared by: EQUINOX ENVIRONMENTAL

SHEET 4

SHEET 5

SHEET 3

SHEET 2

SHEET 6

SHEET 7

SHEET 8

UT-1

UT-2

UT-3

UT-4

UT-5

UT-6

UT-7

UT-8

UT-9

MORGAN CREEK

SCALE 1" = 500'

250 175 0 250 500 750

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

Notes:

1. Coordinate System is State Plane Feet NAD 83
2. Base map information provided by Kimley Horn & Stantec. Dwg titles 0: ACAD-01835600-BASE.dwg & 1713003123_ASBUILT_BASE_corrected.dwg respectively
3. Aerial photography is McDowell County 2005

Morgan Creek

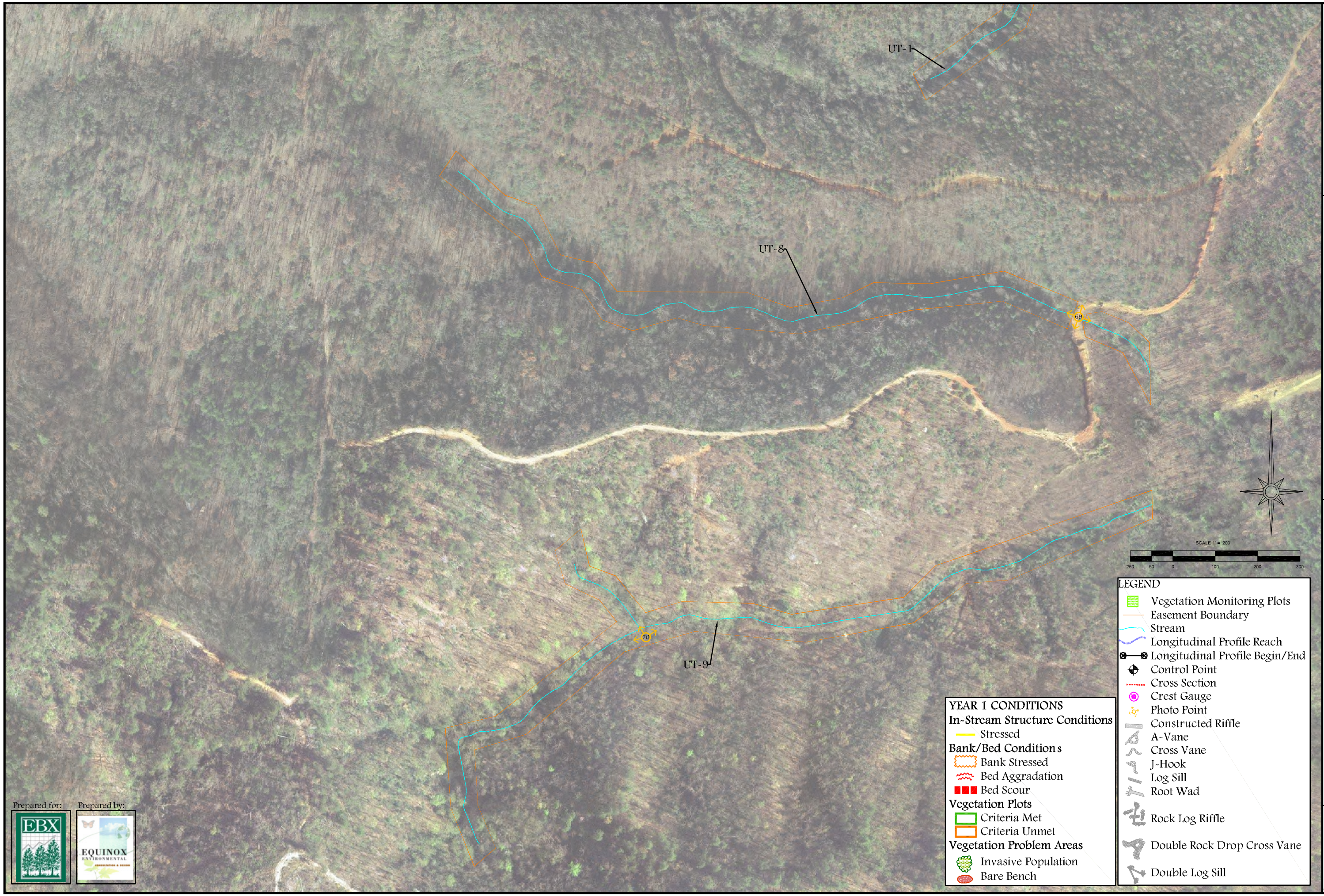
McDowell County, NC

Integrated Current Condition Plan View
Final
YEAR 1 Monitoring-2010
OVERVIEW

Sheet:

1
of 8

Date:
June, 2010



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3. Aerial photography is McDowell County 2005

Morgan Creek

McDowell County, NC

YEAR 1 CONDITIONS

In-Stream Structure Conditions
- Stressed

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

Vegetation Plots
- Criteria Met
- Criteria Unmet

Vegetation Problem Areas
- Invasive Population
- 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

Prepared for: EBX

Prepared by: EQUINOX ENVIRONMENTAL

Integrated Current Condition Plan View
Final
YEAR 1 Monitoring-2010

Sheet: 2 of 8

Date: June, 2010

YEAR 1 CONDITIONS

In-Stream Structure Conditions
- Stressed

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

Vegetation Plots
- Criteria Met
- Criteria Unmet

Vegetation Problem Areas
- Invasive Population
- Bare Bench

LEGEND
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- Stream
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- 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 McDowell County 2005

Morgan Creek

McDowell County, NC

Integrated Current Condition Plan View
Final
YEAR 1 Monitoring-2010

Sheet:
3
of 8

Date:
June, 2010

Prepared for: EBX

Prepared by: EQUINOX ENVIRONMENTAL

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3. Aerial photography is McDowell County 2005

Morgan Creek

McDowell County, NC

Integrated Current Condition Plan View
Final
YEAR 1 Monitoring-2010

Sheet:
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Date:
June, 2010

SCALE 1" = 200'

250 50 0 100 200 300

YEAR 1 CONDITIONS
In-Stream Structure Conditions
- Stressed

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

Vegetation Plots
- Criteria Met
- Criteria Unmet

Vegetation Problem Areas
- Invasive Population
- Bare Bench

LEGEND
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- Longitudinal Profile Begin/End
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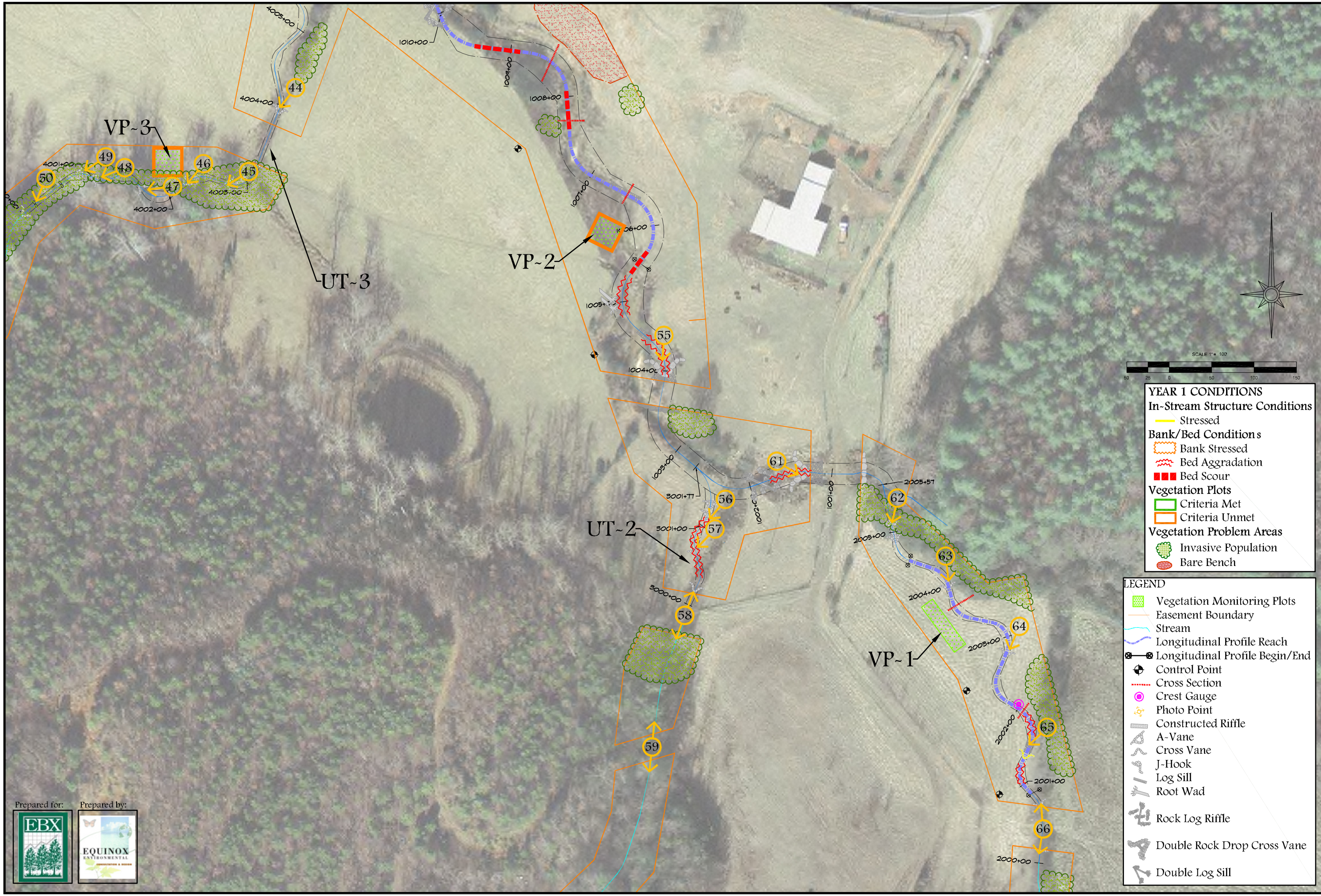
- Root Wad
- Rock Log Riffle
- Double Rock Drop Cross Vane
- Double Log Sill

Prepared for: EBX

Prepared by: EQUINOX ENVIRONMENTAL



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3. Aerial photography is McDowell County 2005

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

YEAR 1 CONDITIONS
In-Stream Structure Conditions
- Stressed

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

Vegetation Plots
- Criteria Met
- Criteria Unmet

Vegetation Problem Areas
- Invasive Population
- Bare Bench

LEGEND
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- Double Log Sill

Morgan Creek
McDowell County, NC

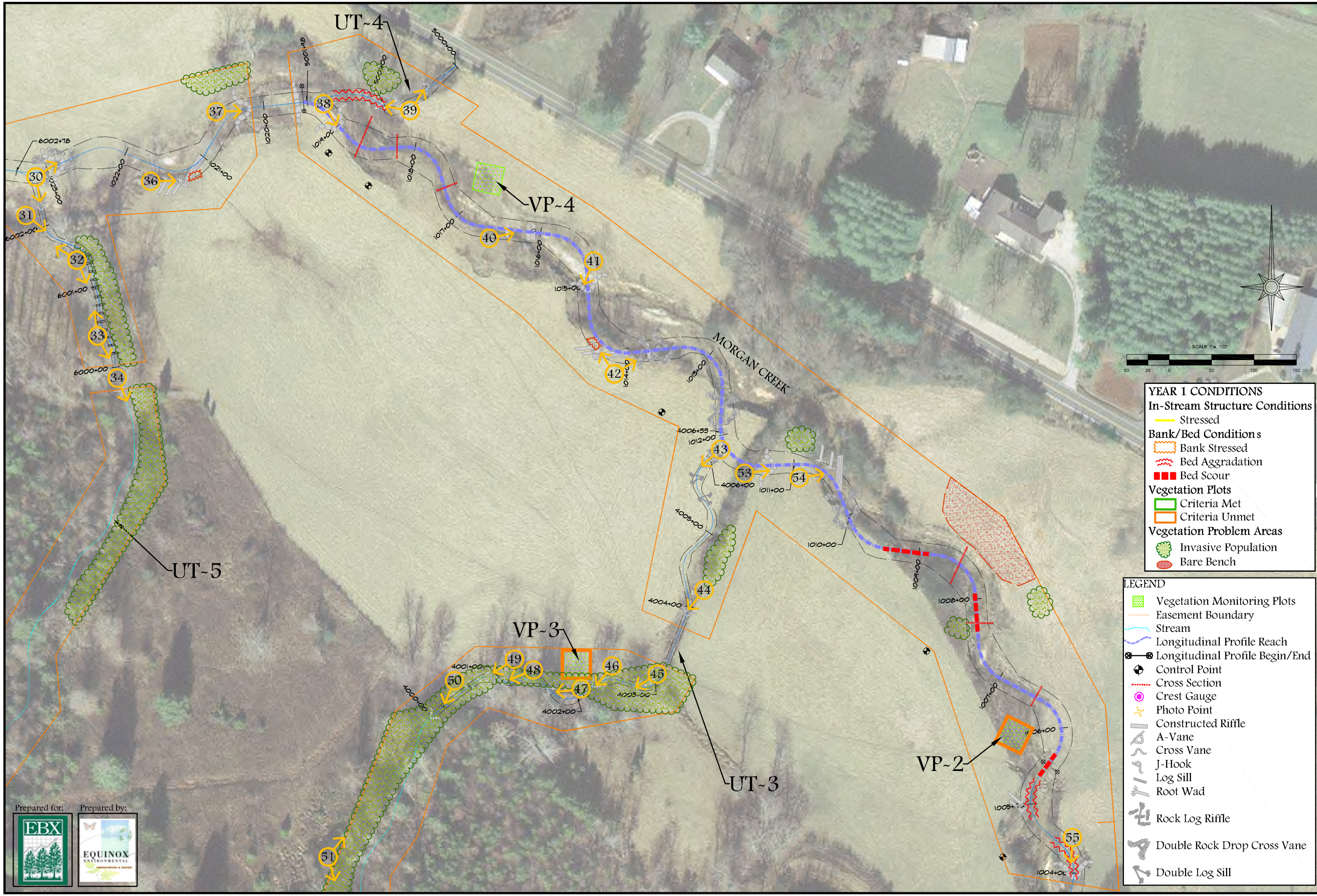
Integrated Current Condition Plan View
Final
YEAR 1 Monitoring-2010

Sheet:
5
of 8

Date:
June, 2010

Prepared for: EBX

Prepared by: EQUINOX ENVIRONMENTAL



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3. Aerial photography is McDowell County 2005

Morgan Creek
McDowell County, NC

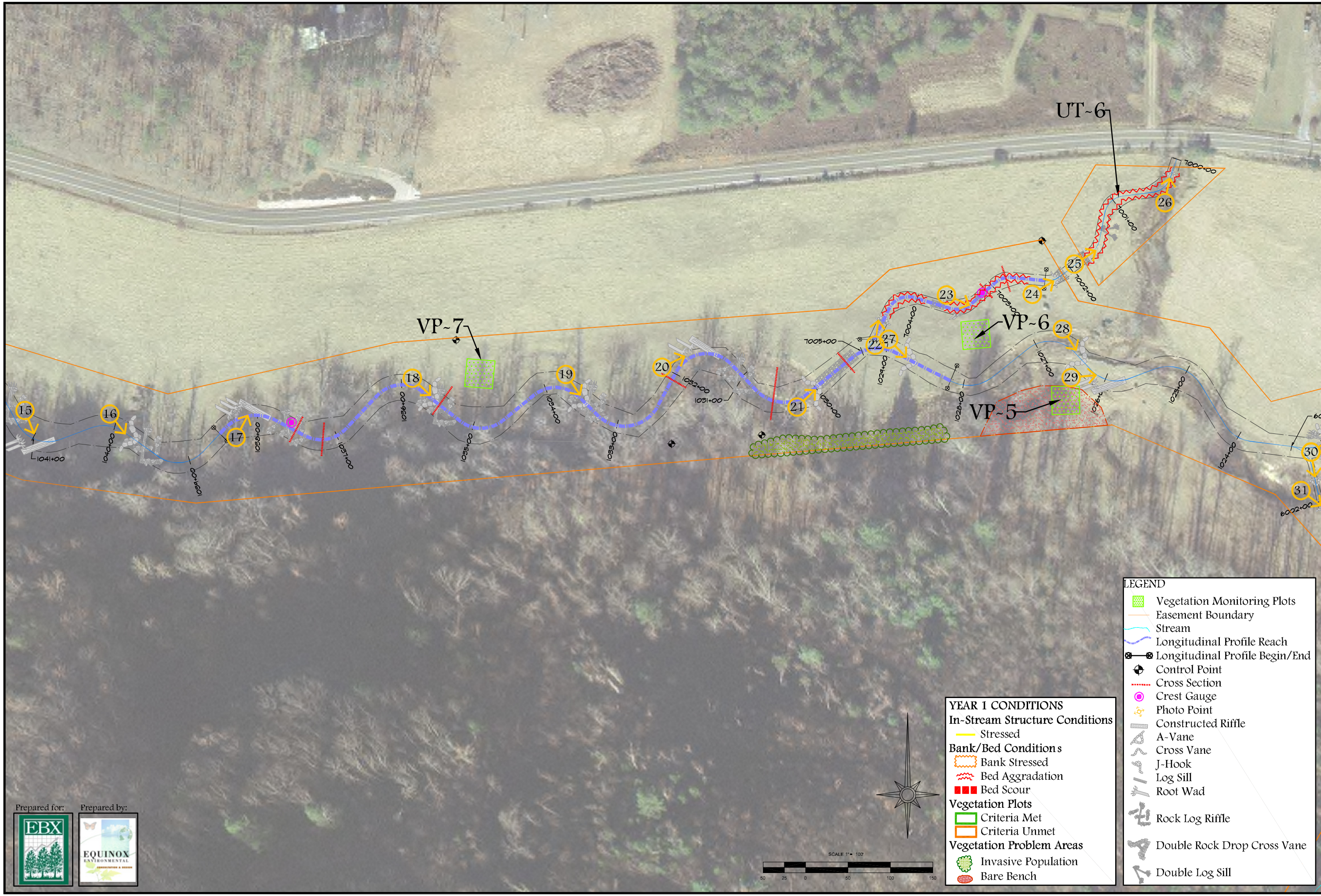
Integrated Current Condition Plan View
Final
YEAR 1 Monitoring~2010

Sheet:
6
of 8

Date:
June, 2010

Prepared for: EBX

Prepared by: EQUINOX ENVIRONMENTAL



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3. Aerial photography is McDowell County 2005

Morgan Creek

McDowell County, NC

Integrated Current Condition Plan View
Final
YEAR 1 Monitoring-2010

YEAR 1 CONDITIONS
In-Stream Structure Conditions
- Stressed

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

Vegetation Plots
- Criteria Met
- Criteria Unmet

Vegetation Problem Areas
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- Bare Bench

LEGEND
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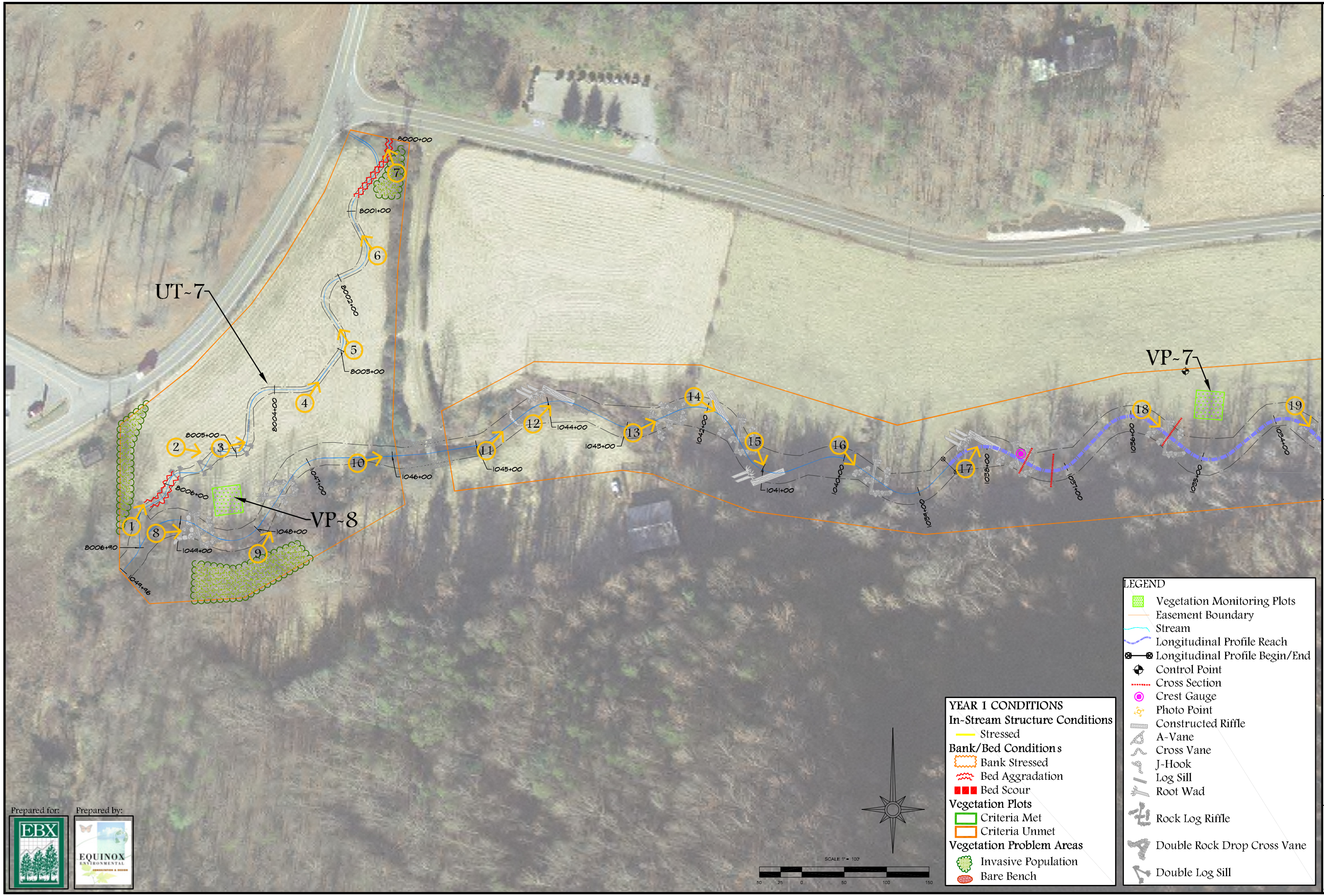
- Rock Log Riffle
- Double Rock Drop Cross Vane
- Double Log Sill

Prepared for: EBX

Prepared by: EQUINOX ENVIRONMENTAL CONSULTATION & DESIGN

Sheet: 7 of 8

Date: June, 2010



Prepared for: EBX

Prepared by: EQUINOX ENVIRONMENTAL

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3. Aerial photography is McDowell County 2005

Morgan Creek

McDowell County, NC

Integrated Current Condition Plan View
Final
YEAR 1 Monitoring-2010

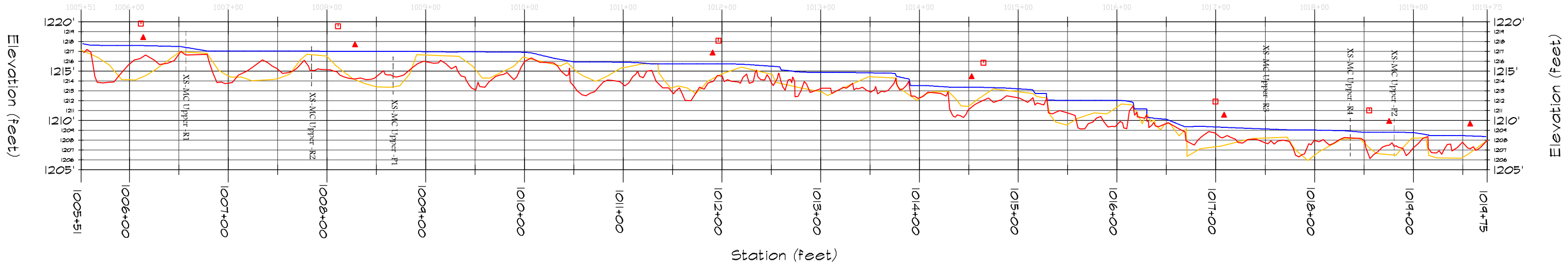
Sheet: 8 of 8

Date: June, 2010

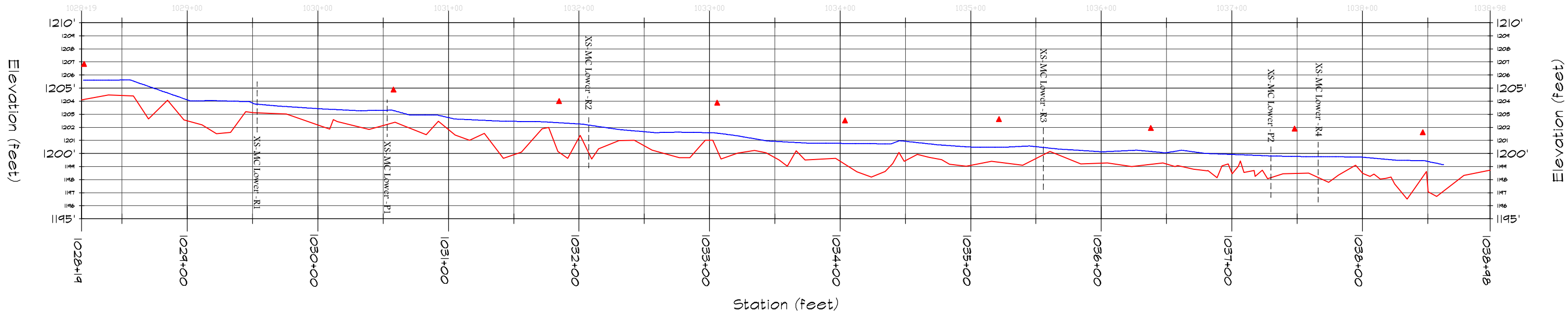
APPENDIX B

2010 Profile, Cross-Section, and Substrate Data

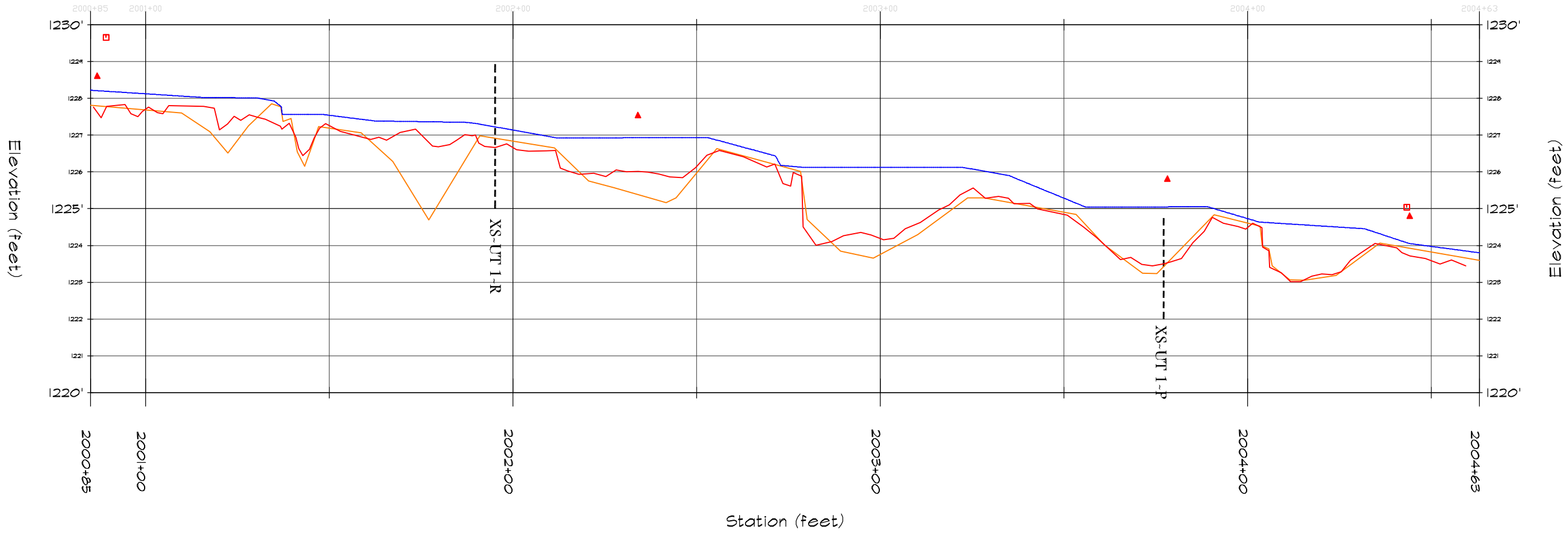
MORGAN CREEK ~ UPPER LONGITUDINAL PROFILE



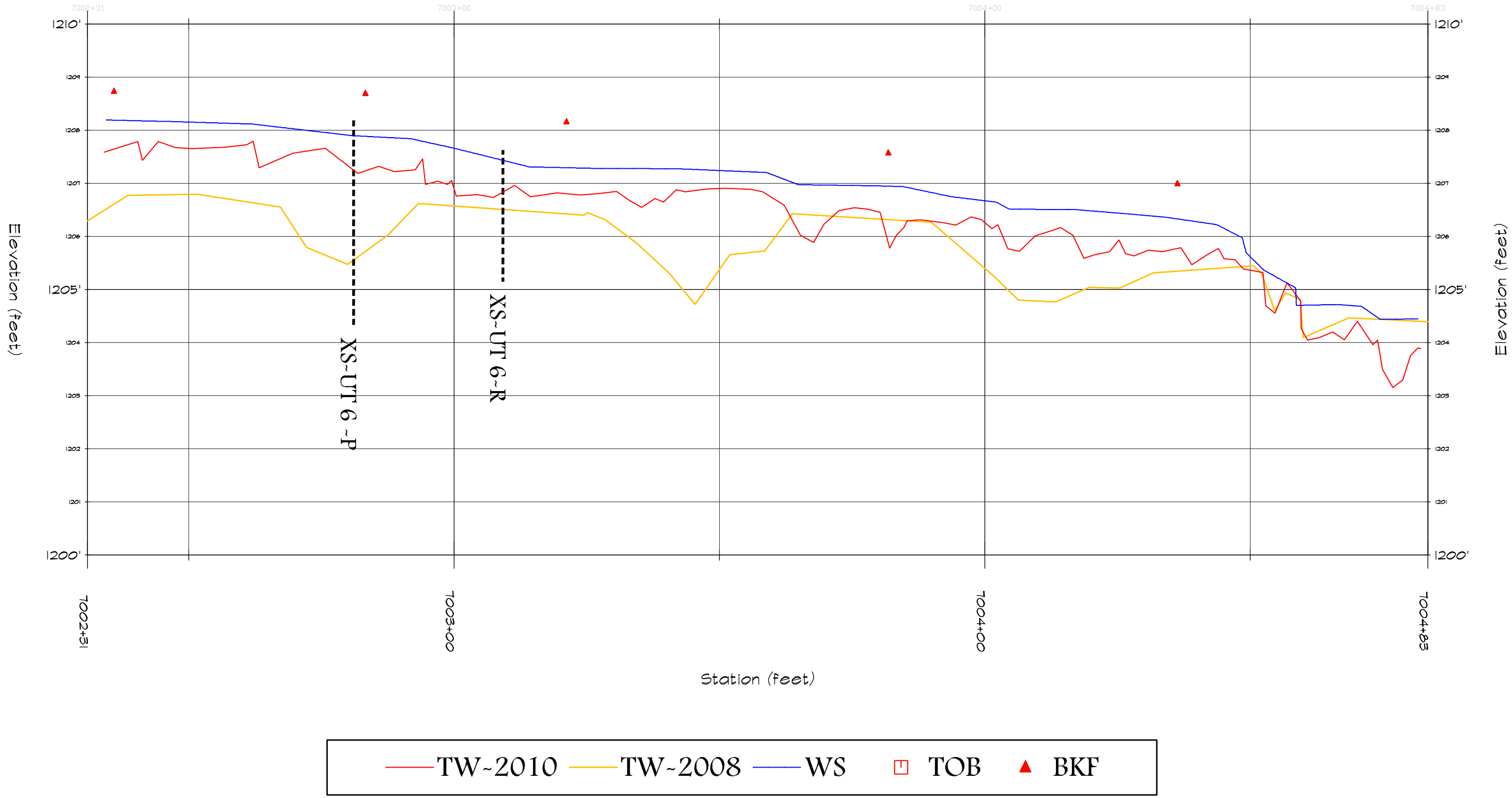
MORGAN CREEK ~ LOWER LONGITUDINAL PROFILE



UNNAMED TRIBUTARY ~ 1 LONGITUDINAL PROFILE



UNNAMED TRIBUTARY ~ 6 LONGITUDINAL PROFILE

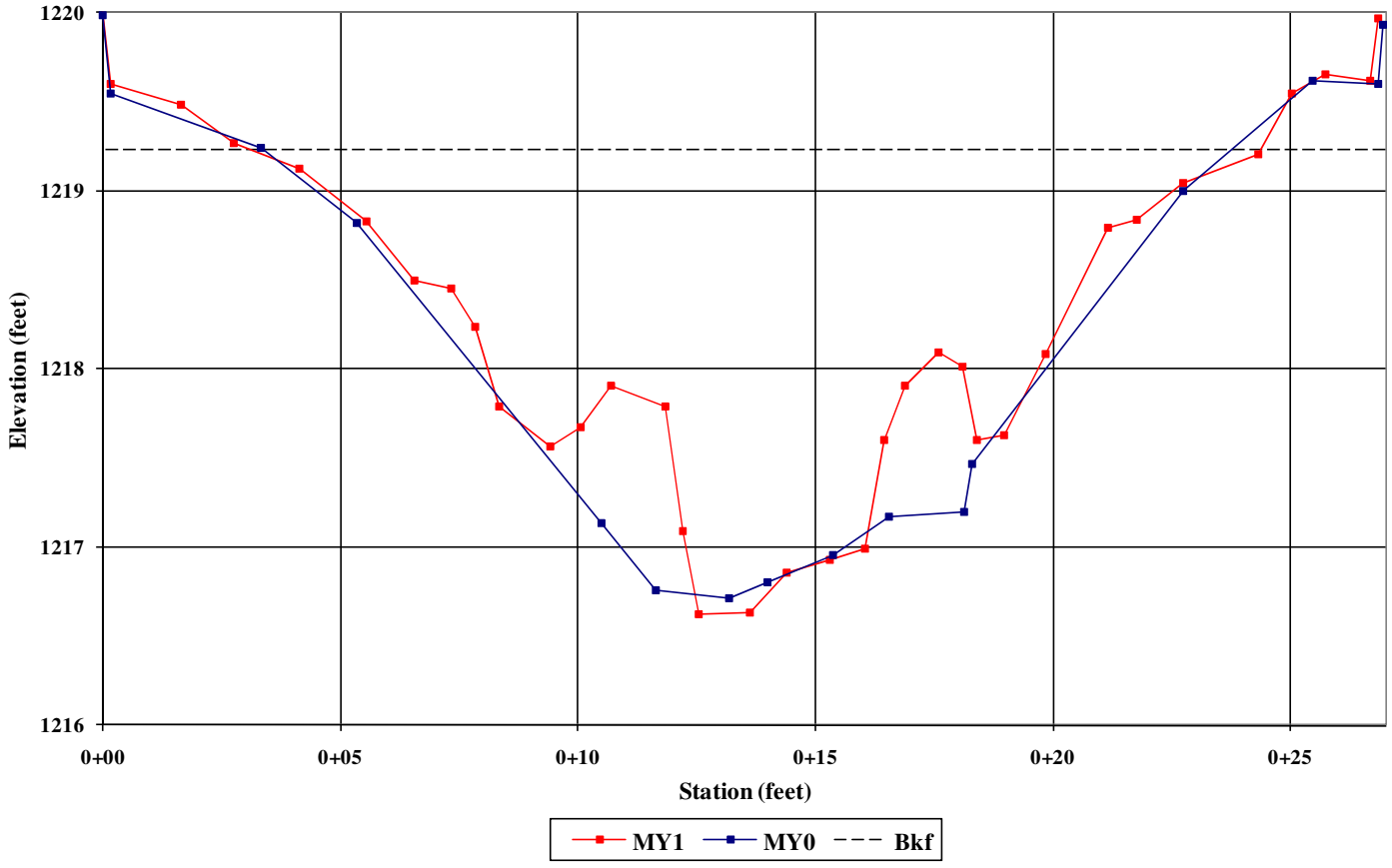


Morgan Creek Upper – Riffle 1
Cross-Section 1

Looking at Left Bank

Looking at Right Bank

Morgan Creek Upper
Riffle 1

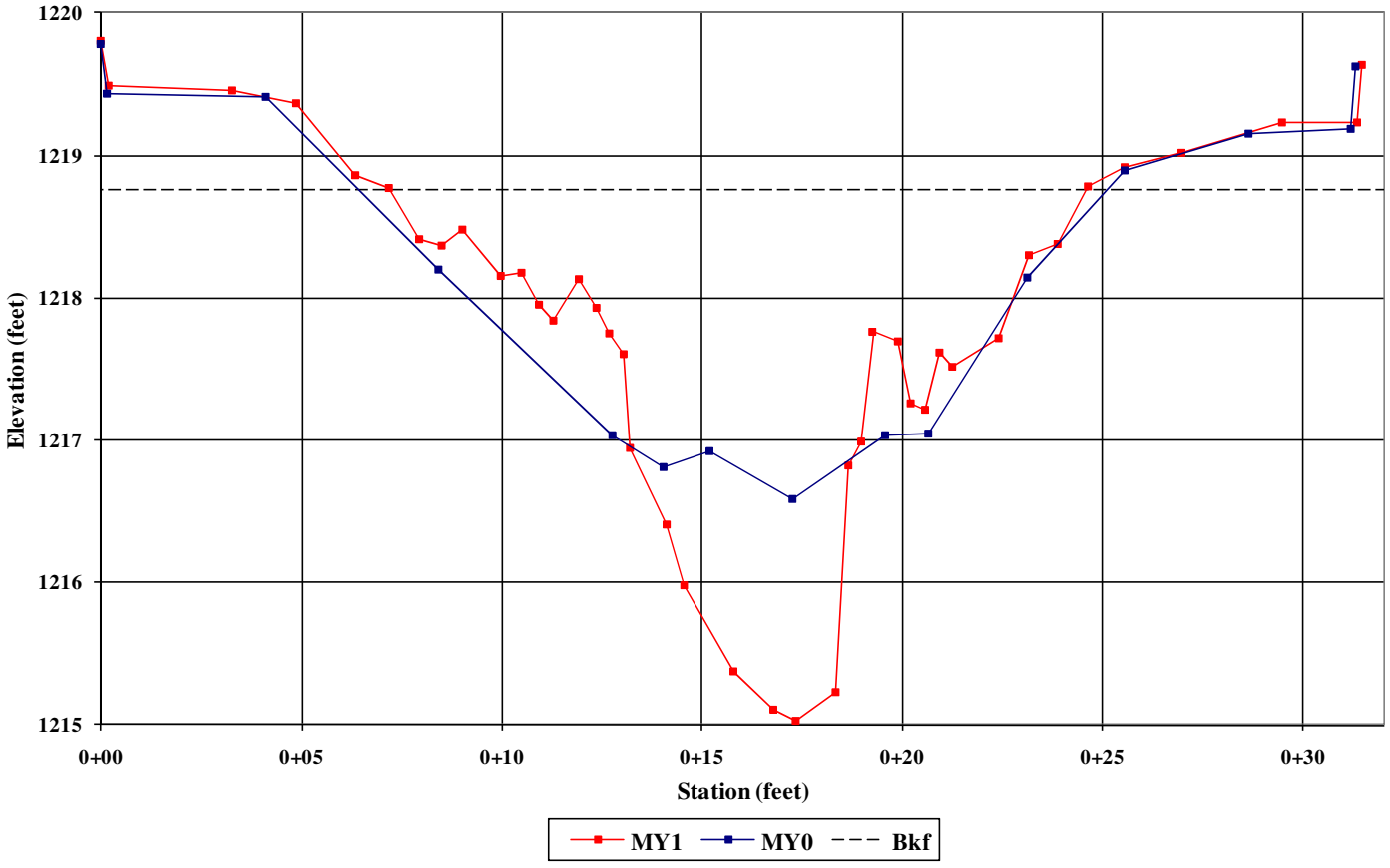


Morgan Creek Upper – Riffle 2
Cross-Section 2

Looking at Left Bank

Looking at Right Bank

Morgan Creek Upper
Riffle 2

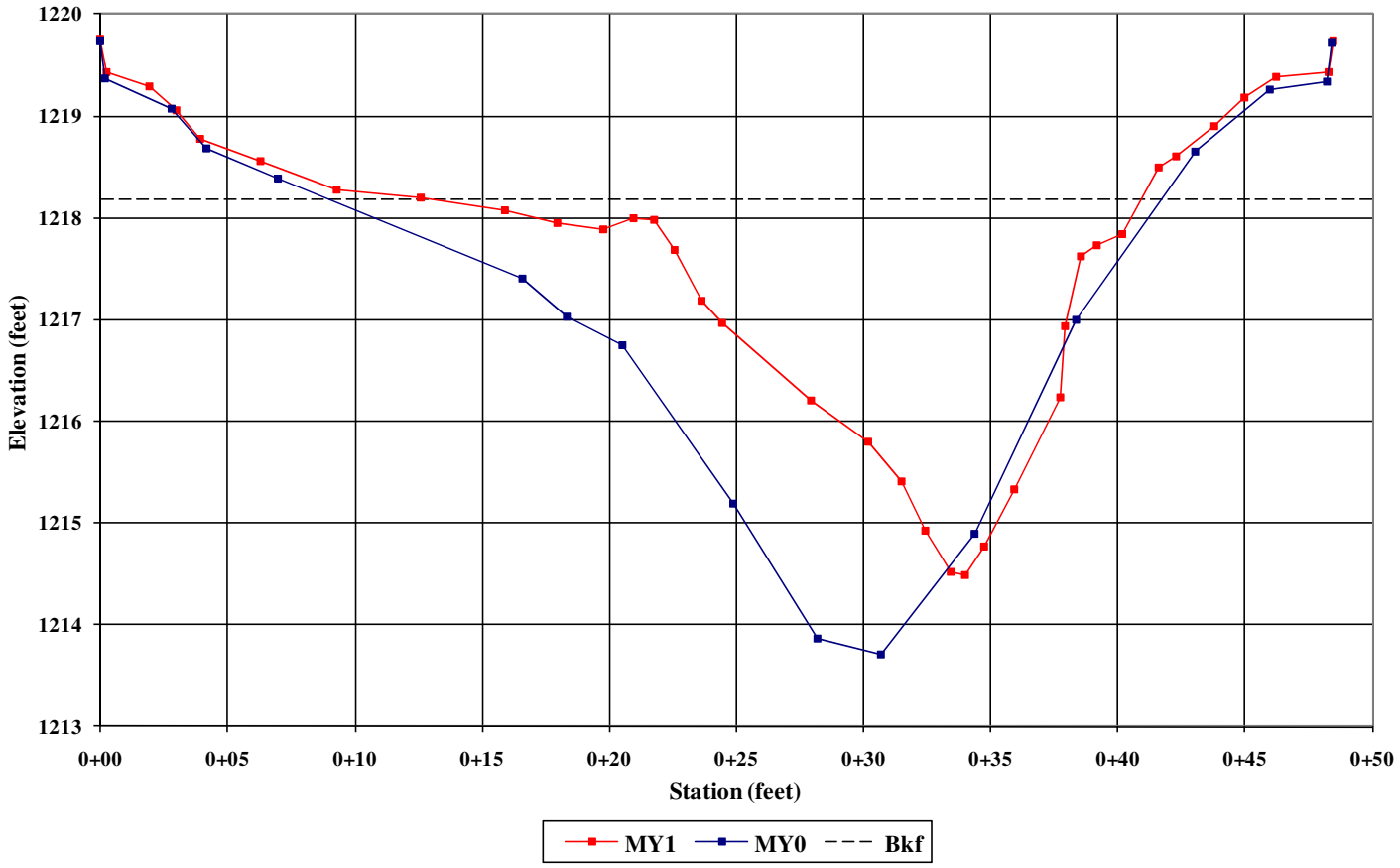


Morgan Creek Upper – Pool 1
Cross-Section 3

Looking at Left Bank

Looking at Right Bank

Morgan Creek Upper
Pool 1

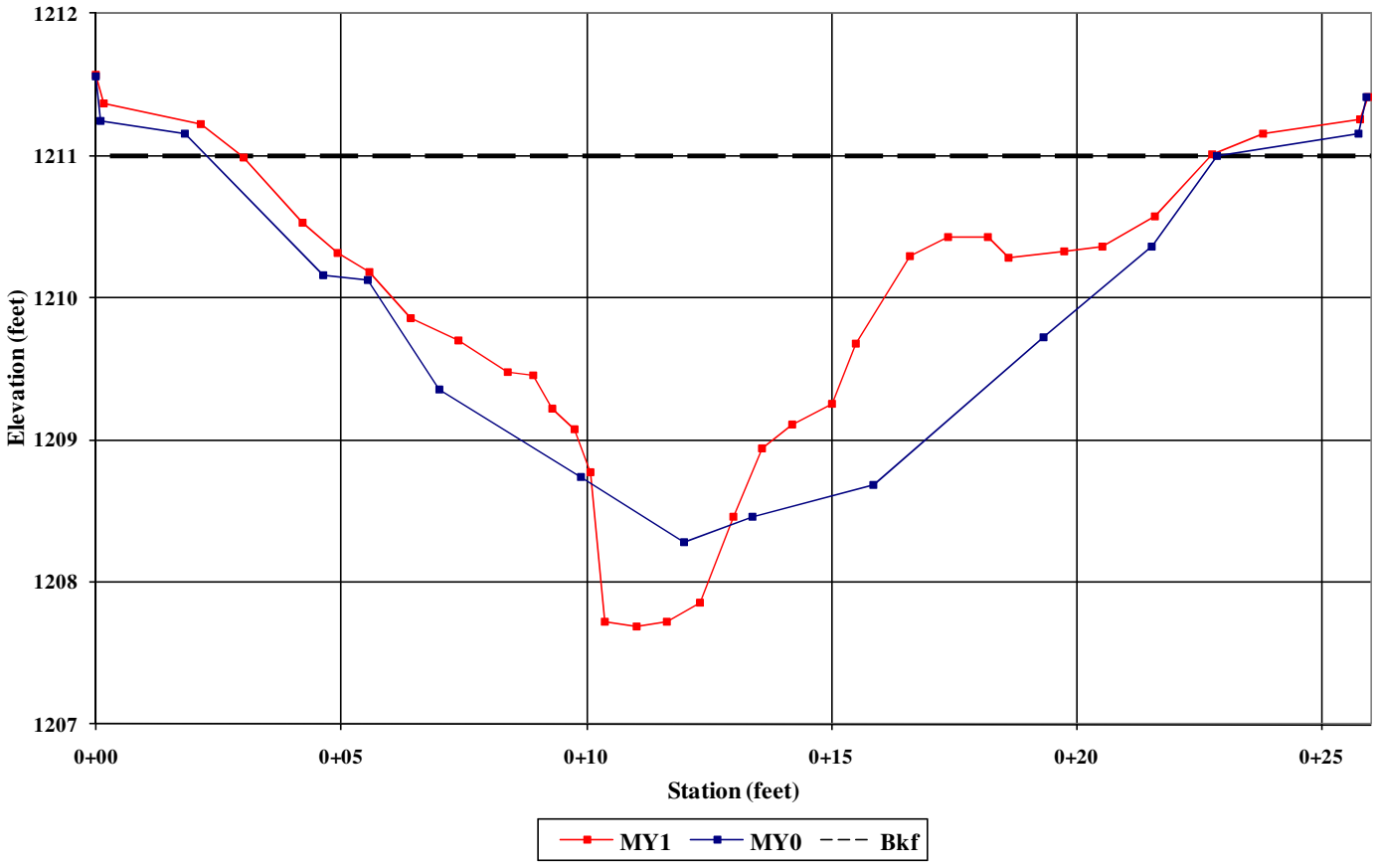


Morgan Creek Upper – Riffle 3
Cross-Section 4

Looking at Left Bank

Looking at Right Bank

Moragn Creek Upper
Riffle 3

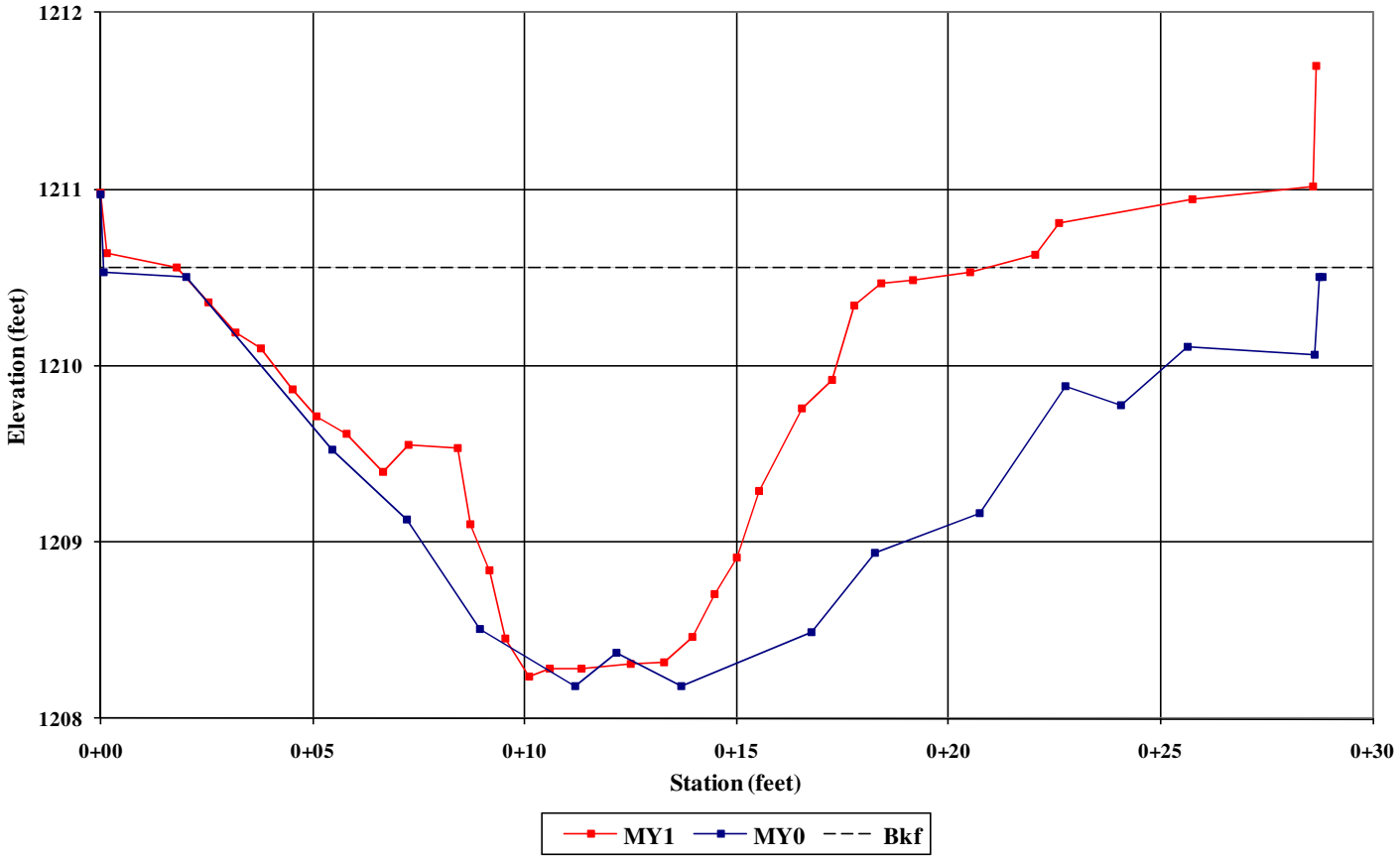


Morgan Creek Upper – Riffle 4
Cross-Section 5

Looking at Left Bank

Looking at Right Bank

Morgan Creek Upper
Riffle 4

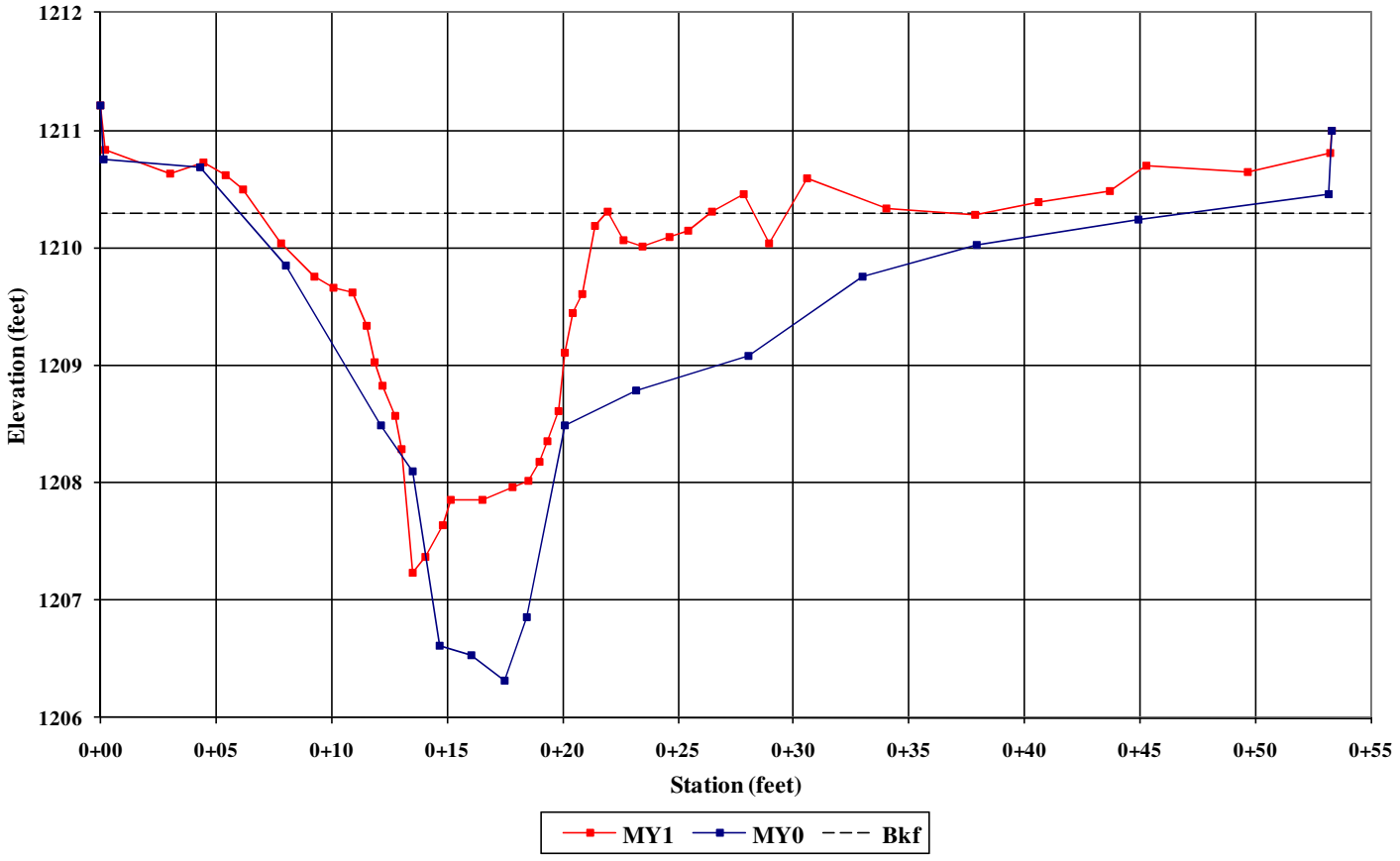


Morgan Creek Upper – Pool 2
Cross-Section 6

Looking at Left Bank

Looking at Right Bank

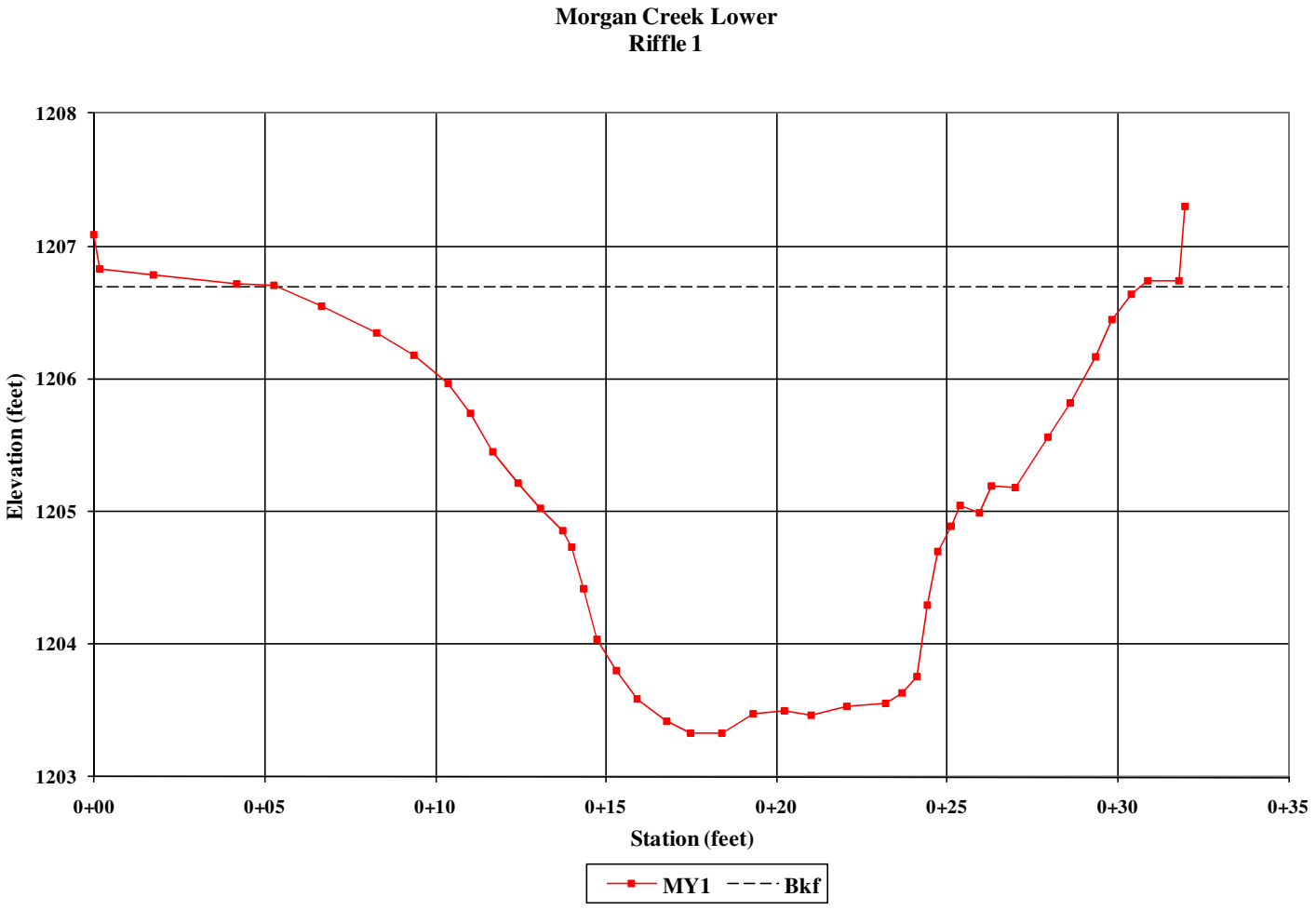
Morgan Creek Upper
Pool 2



Morgan Creek Lower – Riffle 1
Cross-Section 1

Looking at Left Bank

Looking at Right Bank

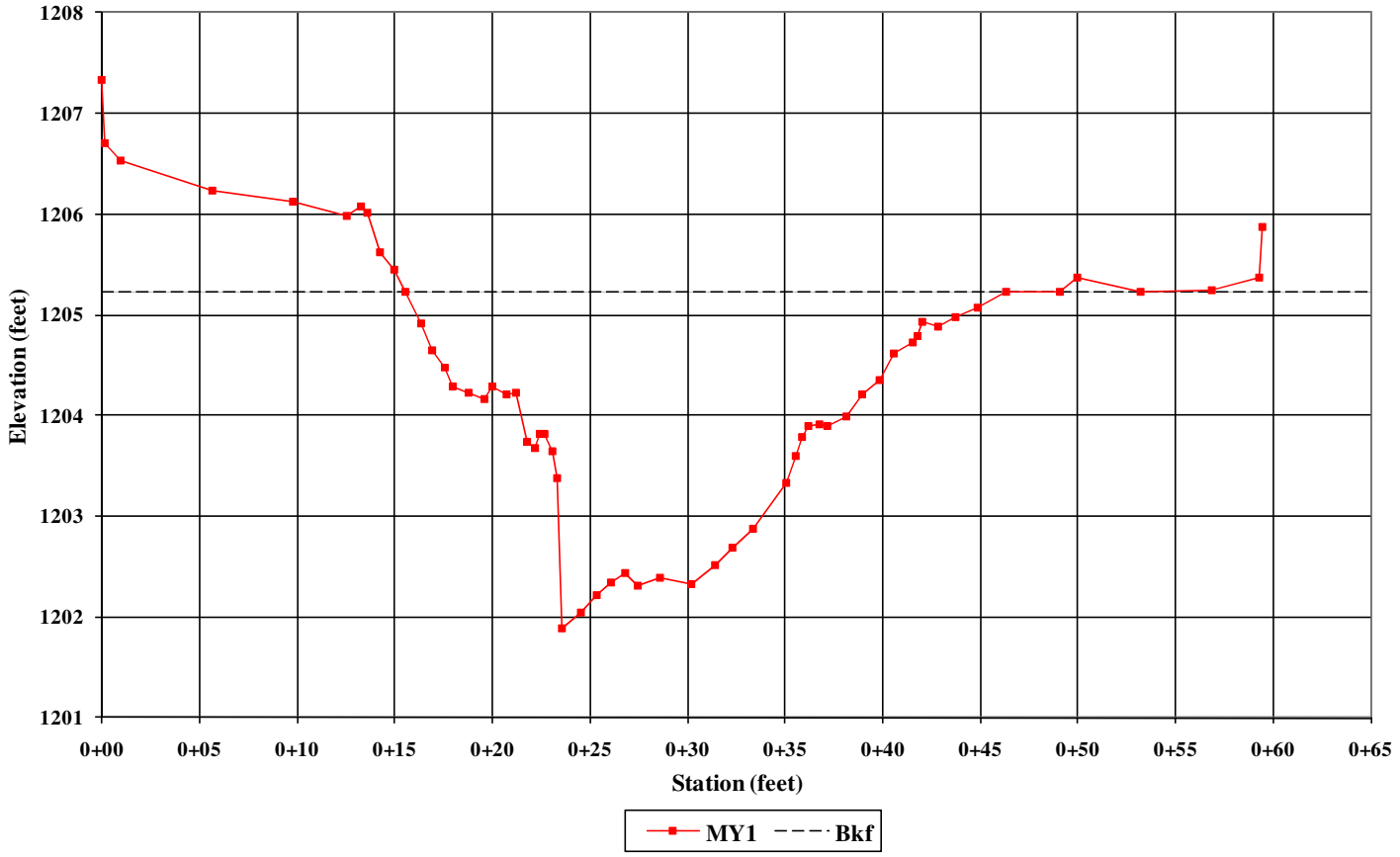


Morgan Creek Lower – Pool 1
Cross-Section 2

Looking at Left Bank

Looking at Right Bank

Morgan Creek Lower
Pool 1

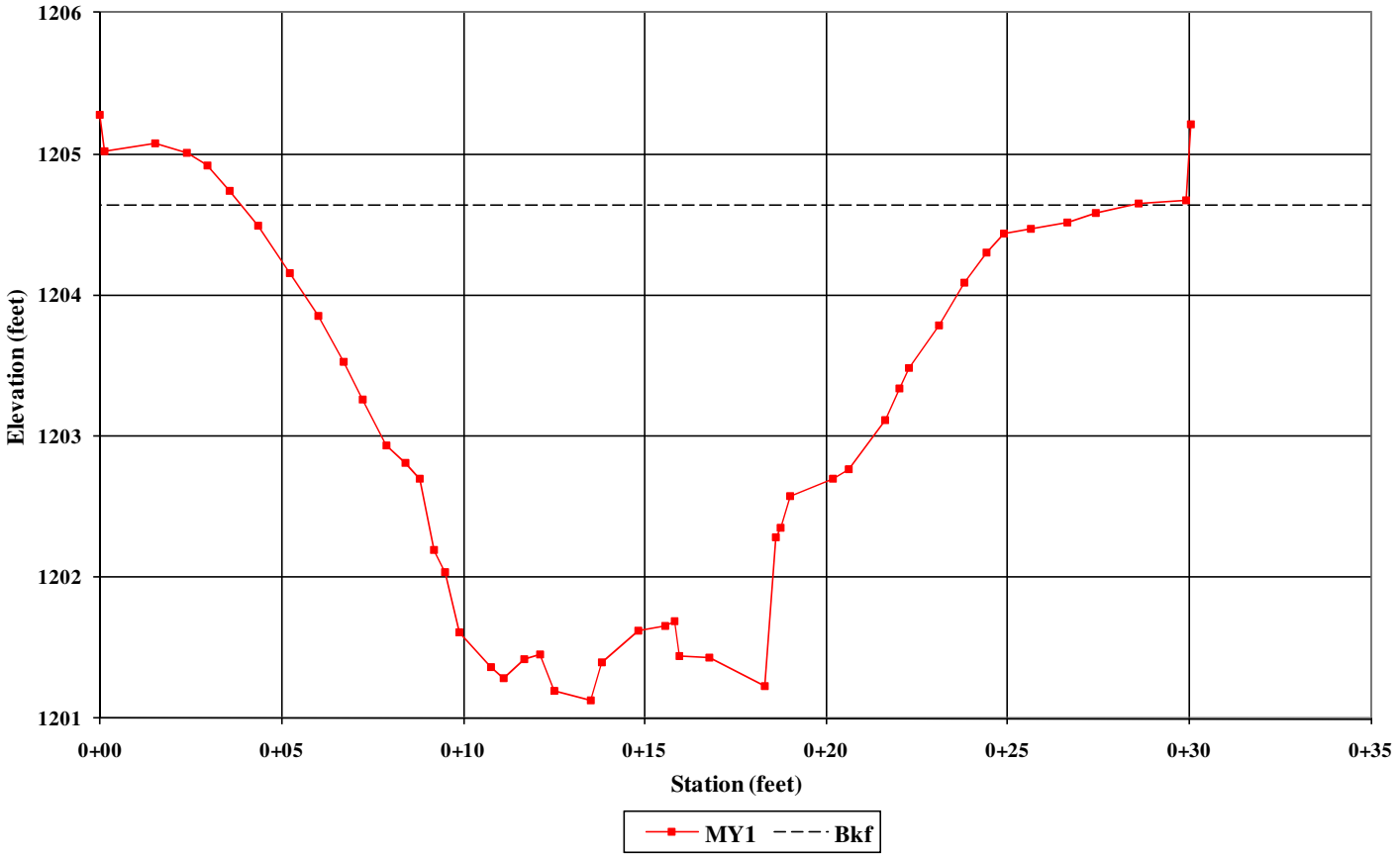


Morgan Creek Lower – Riffle 2
Cross-Section 3

Looking at Left Bank

Looking at Right Bank

Morgan Creek Lower
Riffle 2

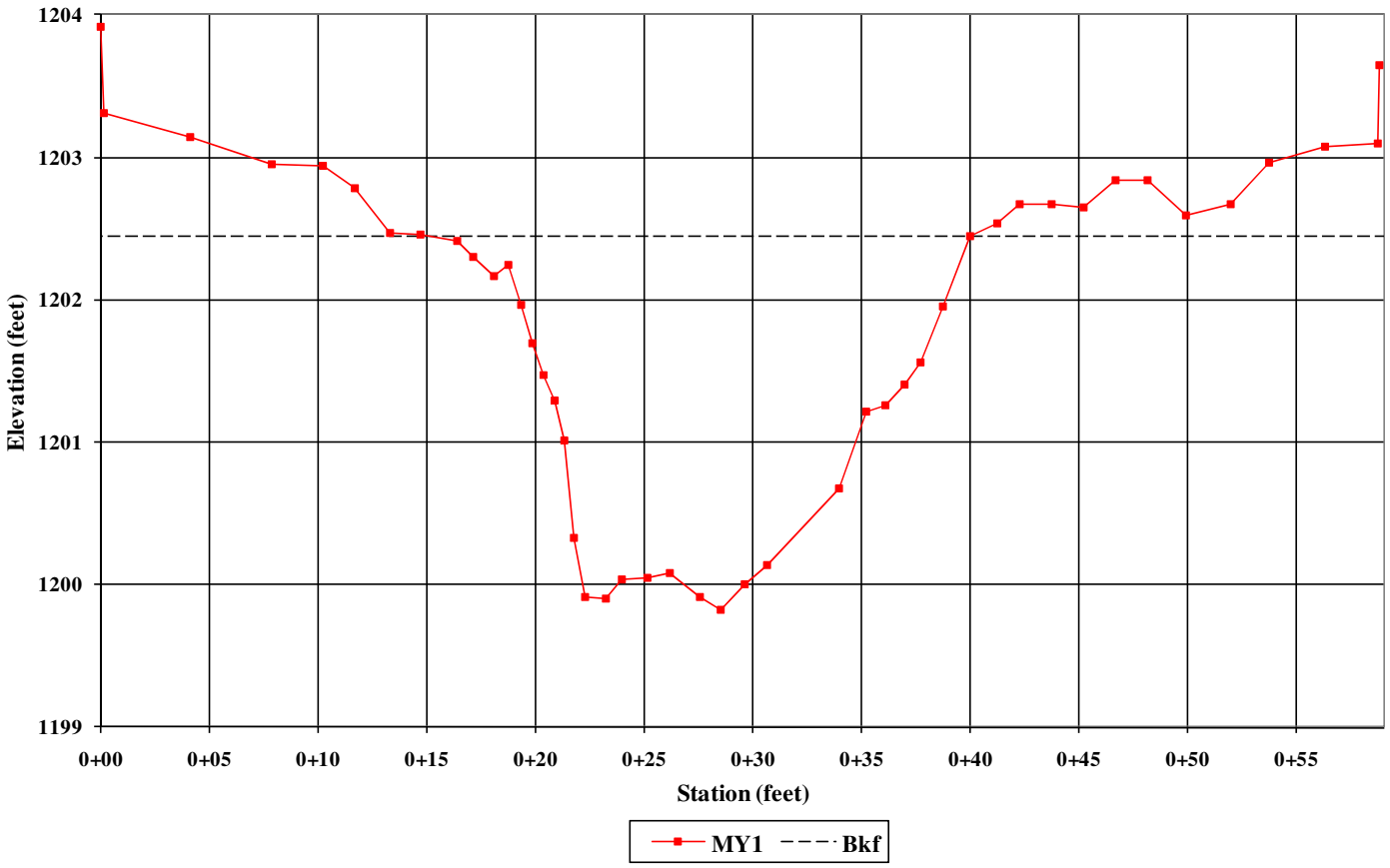


Morgan Creek Lower – Riffle 3
Cross-Section 4

Looking at Left Bank

Looking at Right Bank

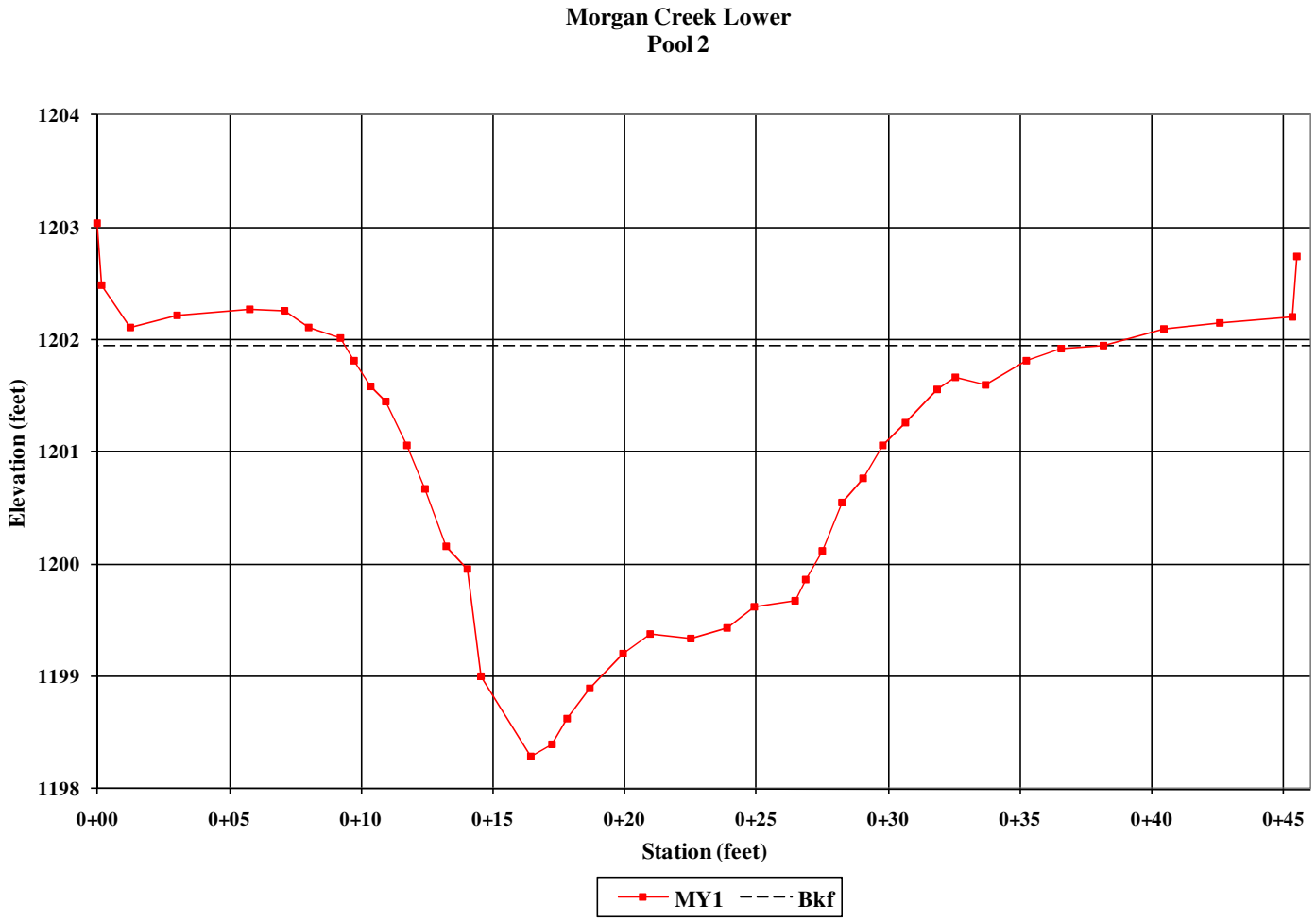
Morgan Creek Lower
Riffle 3



Morgan Creek Lower – Pool 2
Cross-Section 5

Looking at Left Bank

Looking at Right Bank

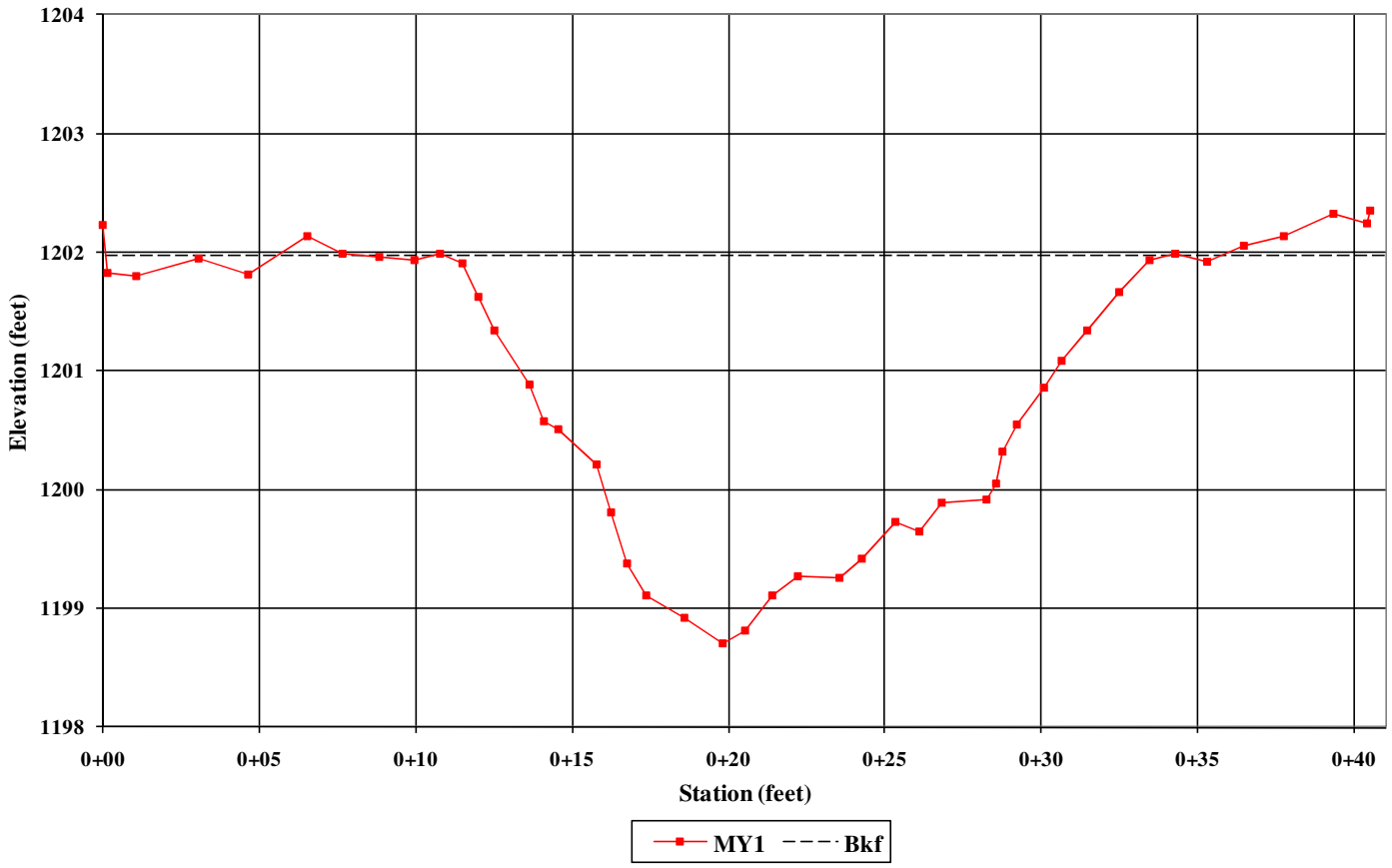


Morgan Creek Lower – Riffle 4
Cross-Section 6

Looking at Left Bank

Looking at Right Bank

Morgan Creek Lower
Riffle 4

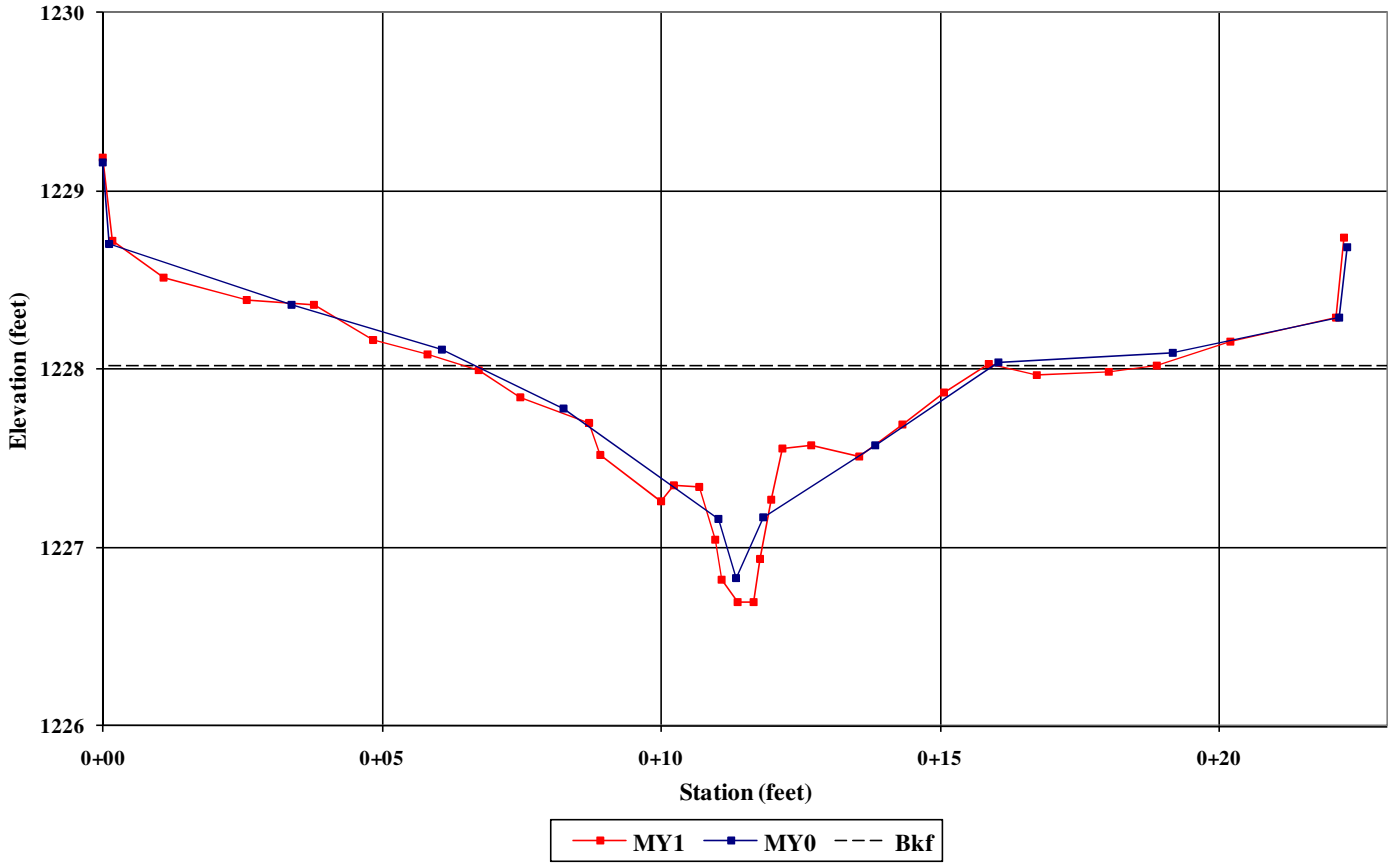


Unnamed Tributary 1 – Riffle
Cross-Section 1

Looking at Left Bank

Looking at Right Bank

Unnamed Tributary 1
Riffle

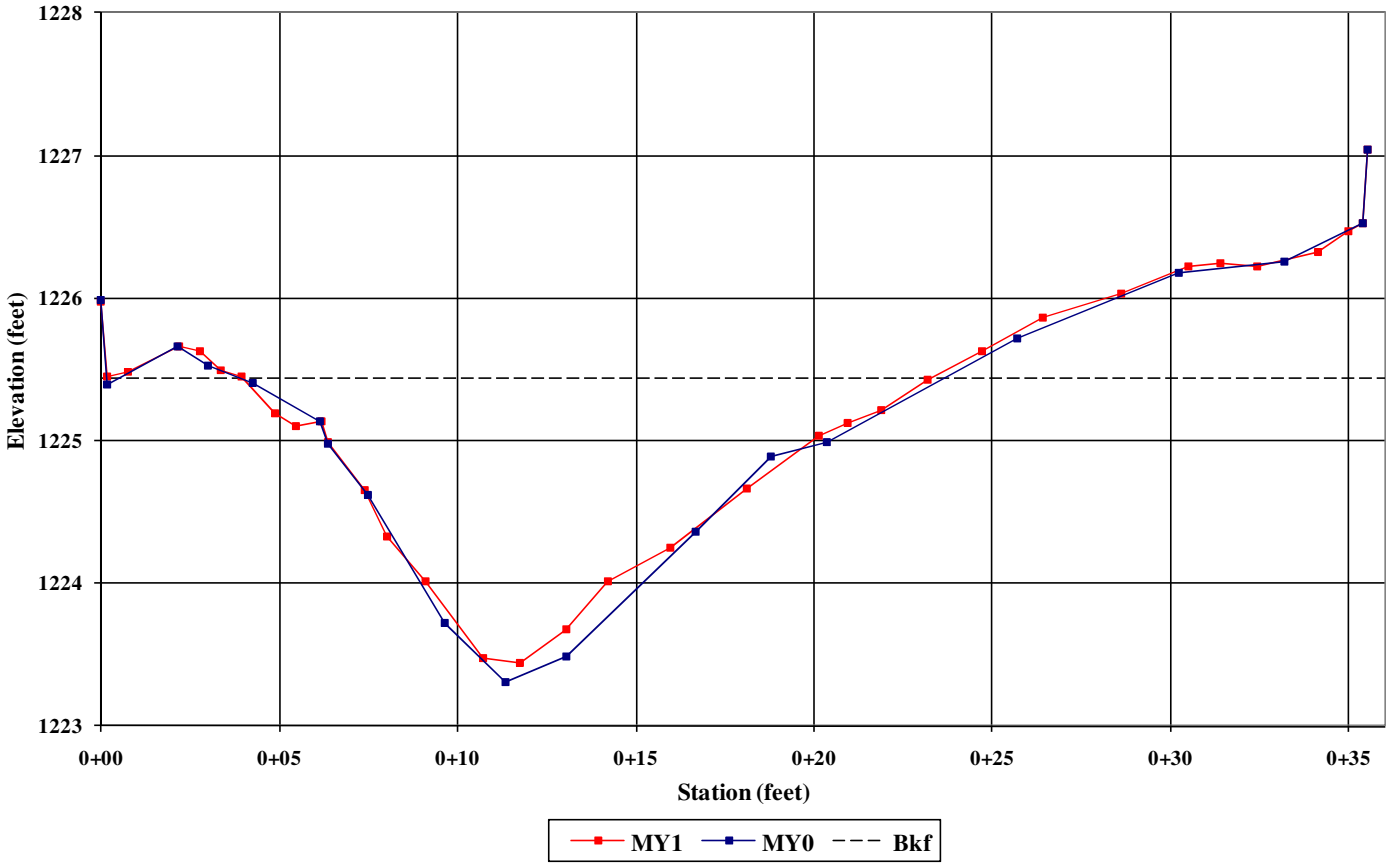


Unnamed Tributary 1 – Pool
Cross-Section 2

Looking at Left Bank

Looking at Right Bank

Unnamed Tributary 1
Pool

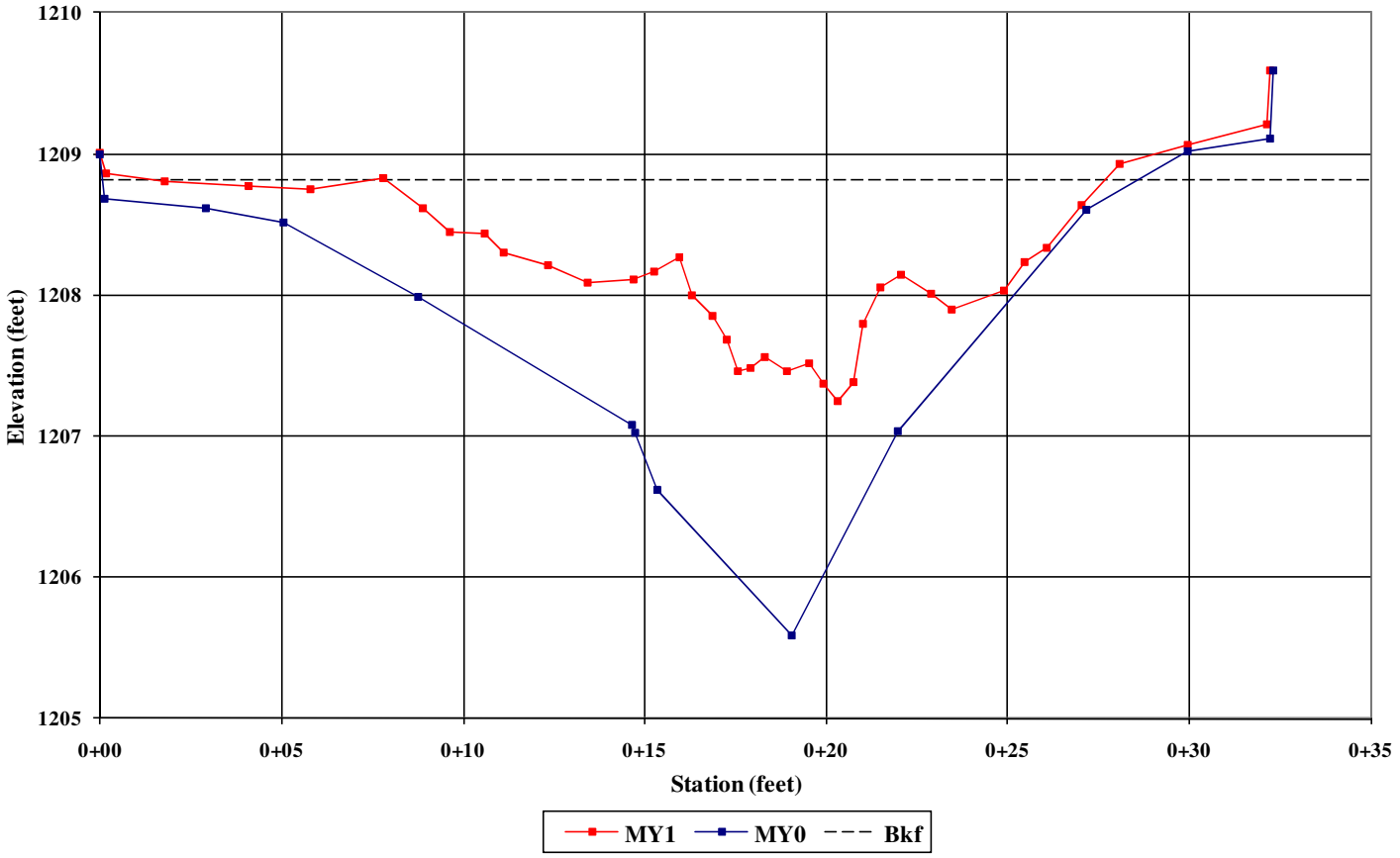


Unnamed Tributary 6 – Pool
Cross-Section 1

Looking at Left Bank

Looking at Right Bank

Unnamed Tributary 6
Pool

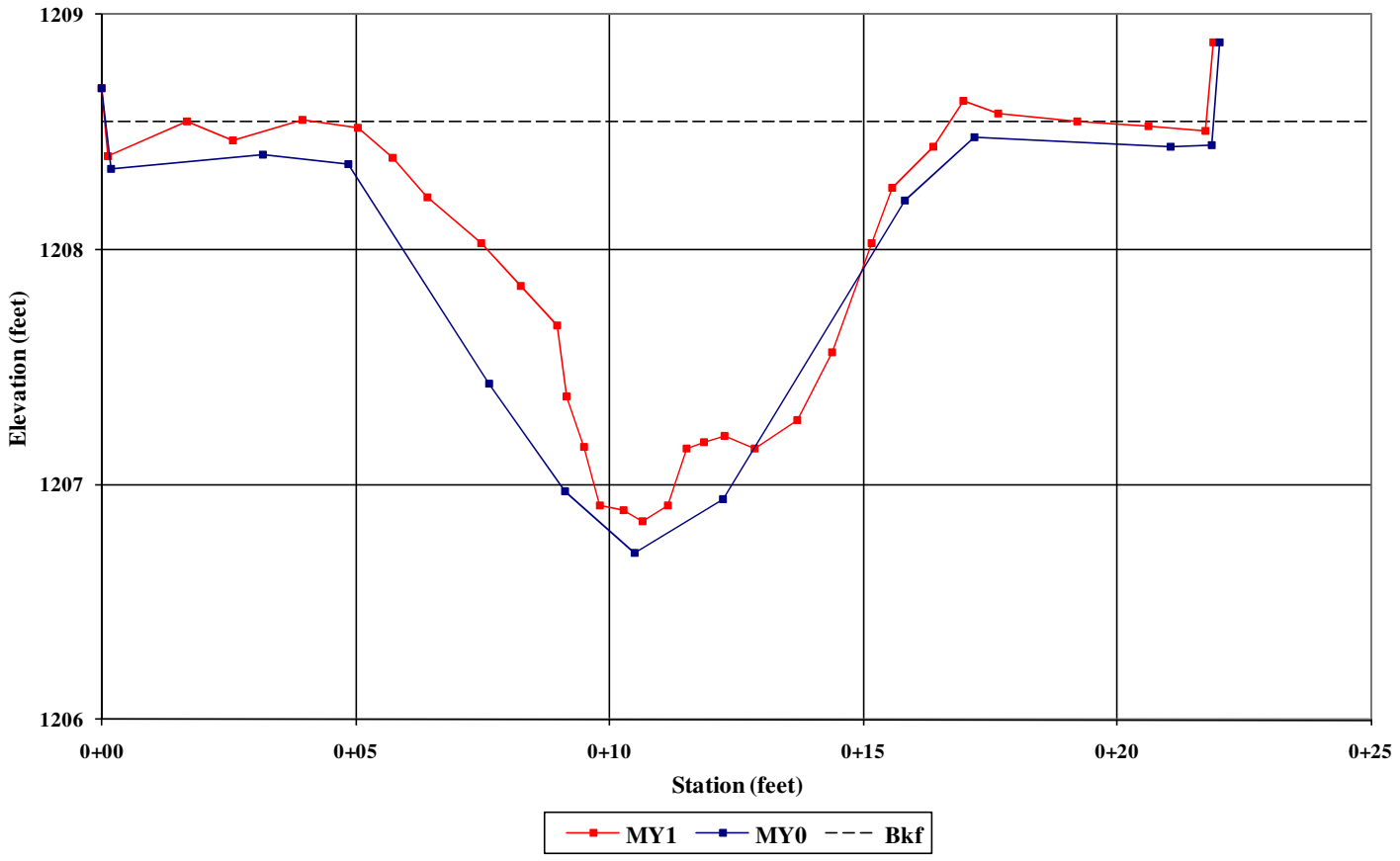


Unnamed Tributary 6 – Riffle
Cross-Section 2

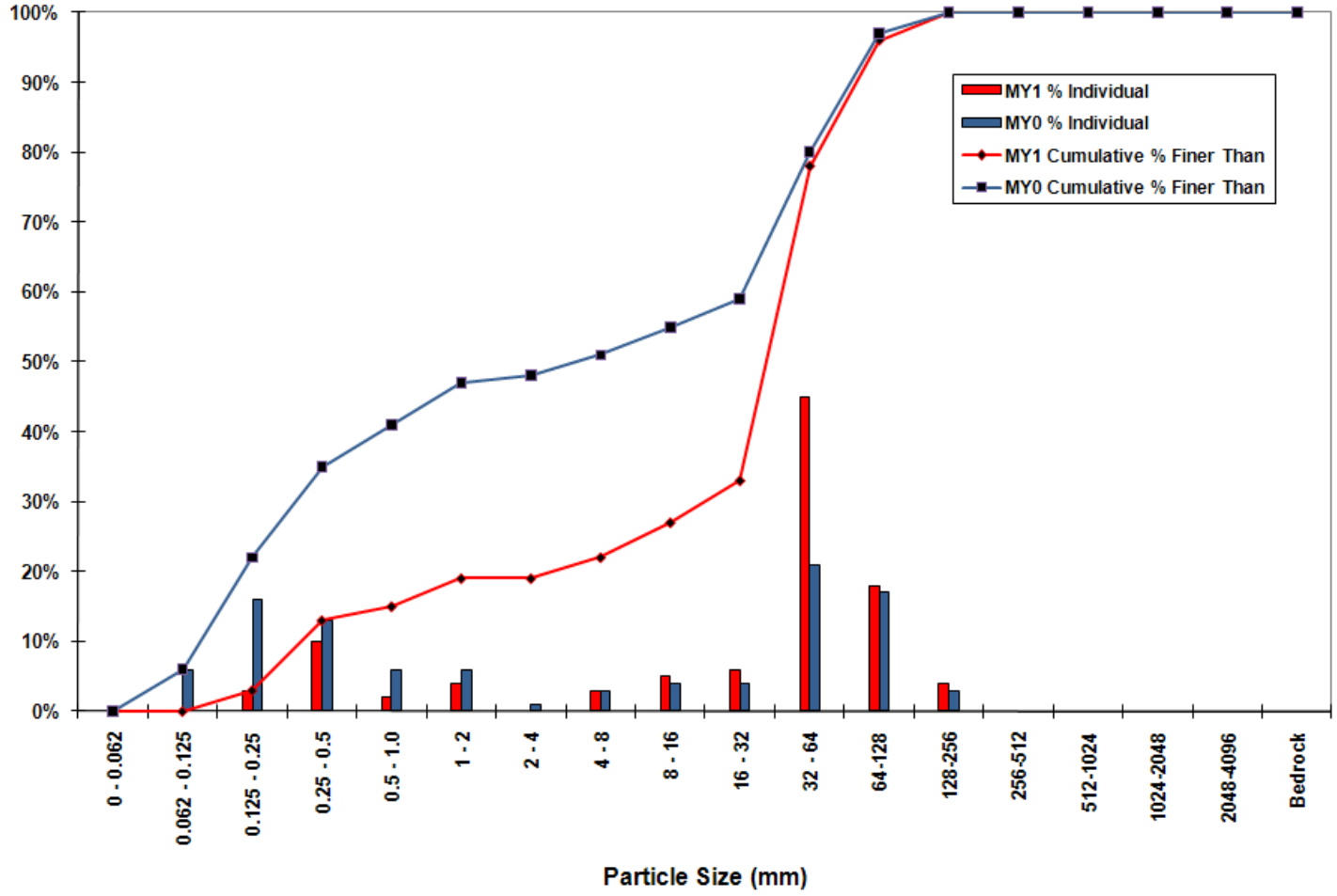
Looking at Left Bank

Looking at Right Bank

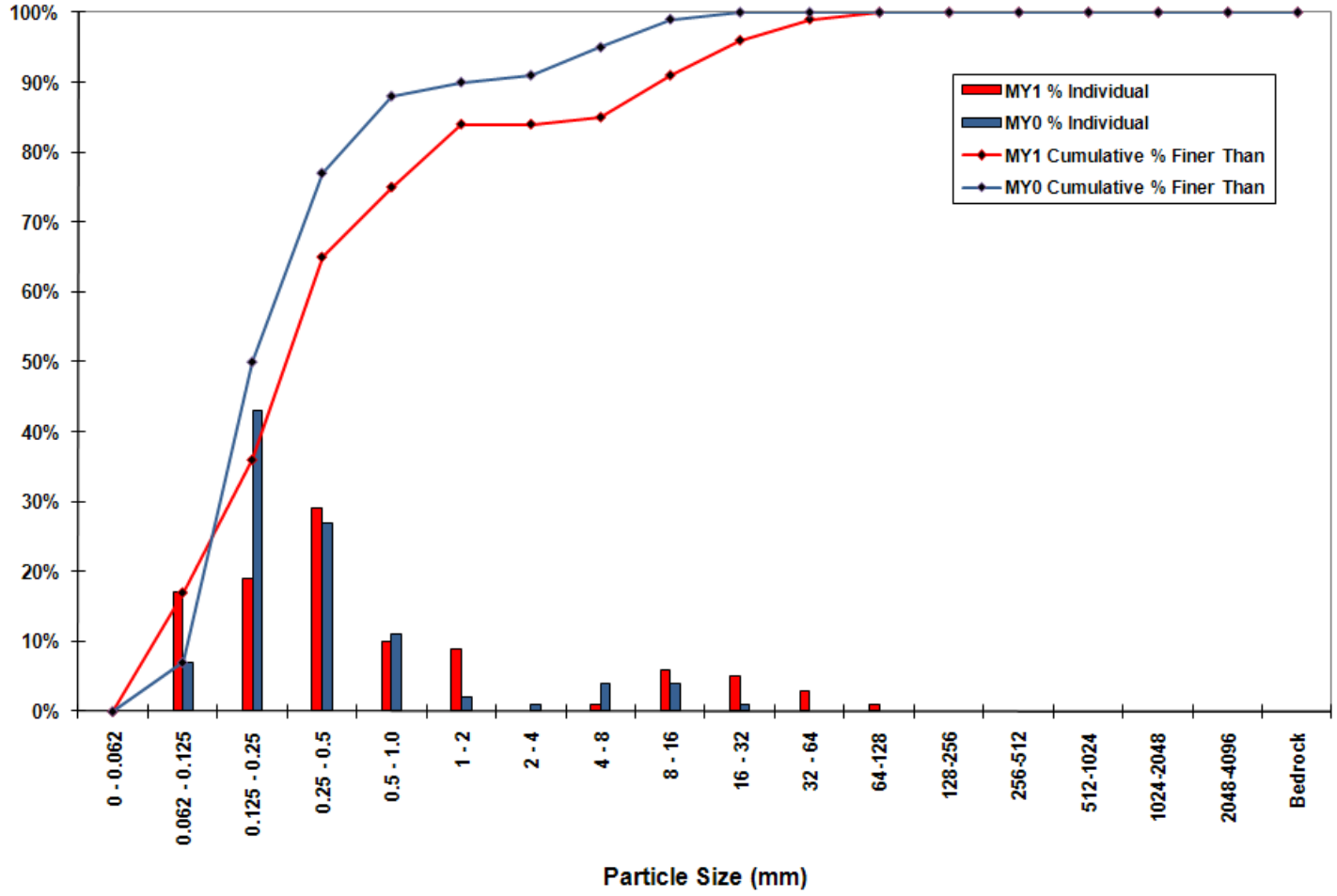
Unnamed Tributary 6
Riffle



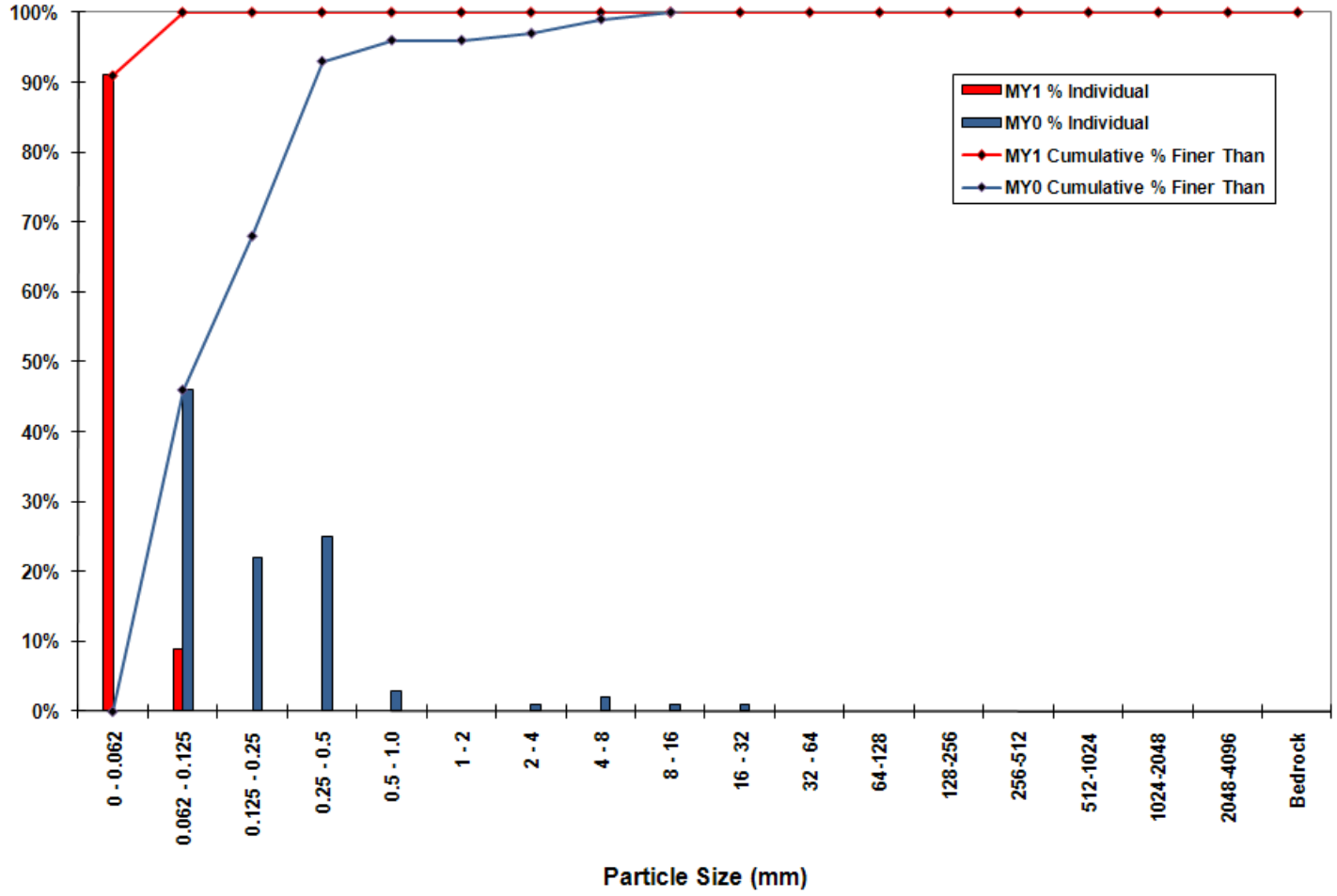
Morgan Creek Upper – Riffle 1
Pebble Count



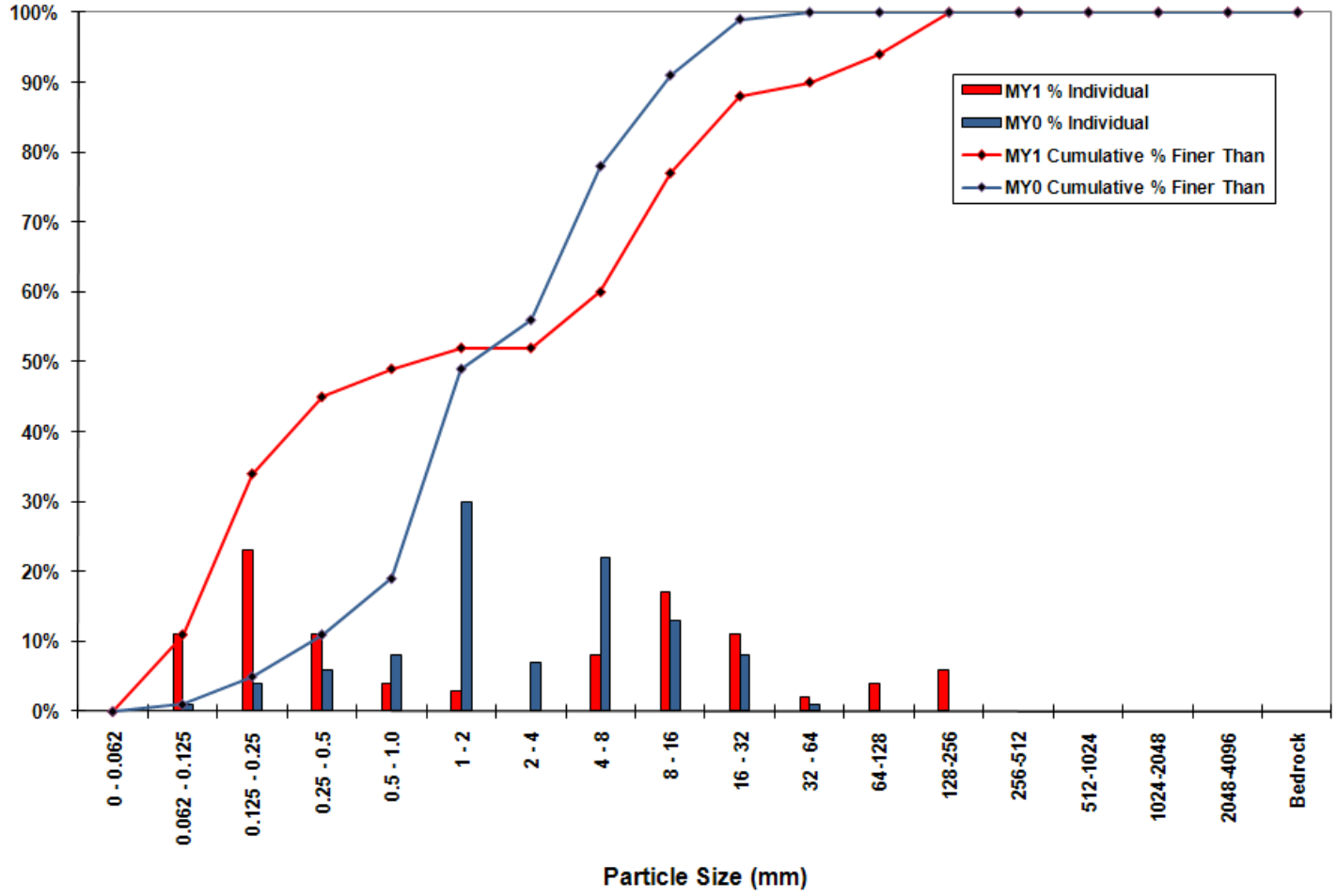
Morgan Creek Upper – Riffle 2
Pebble Count



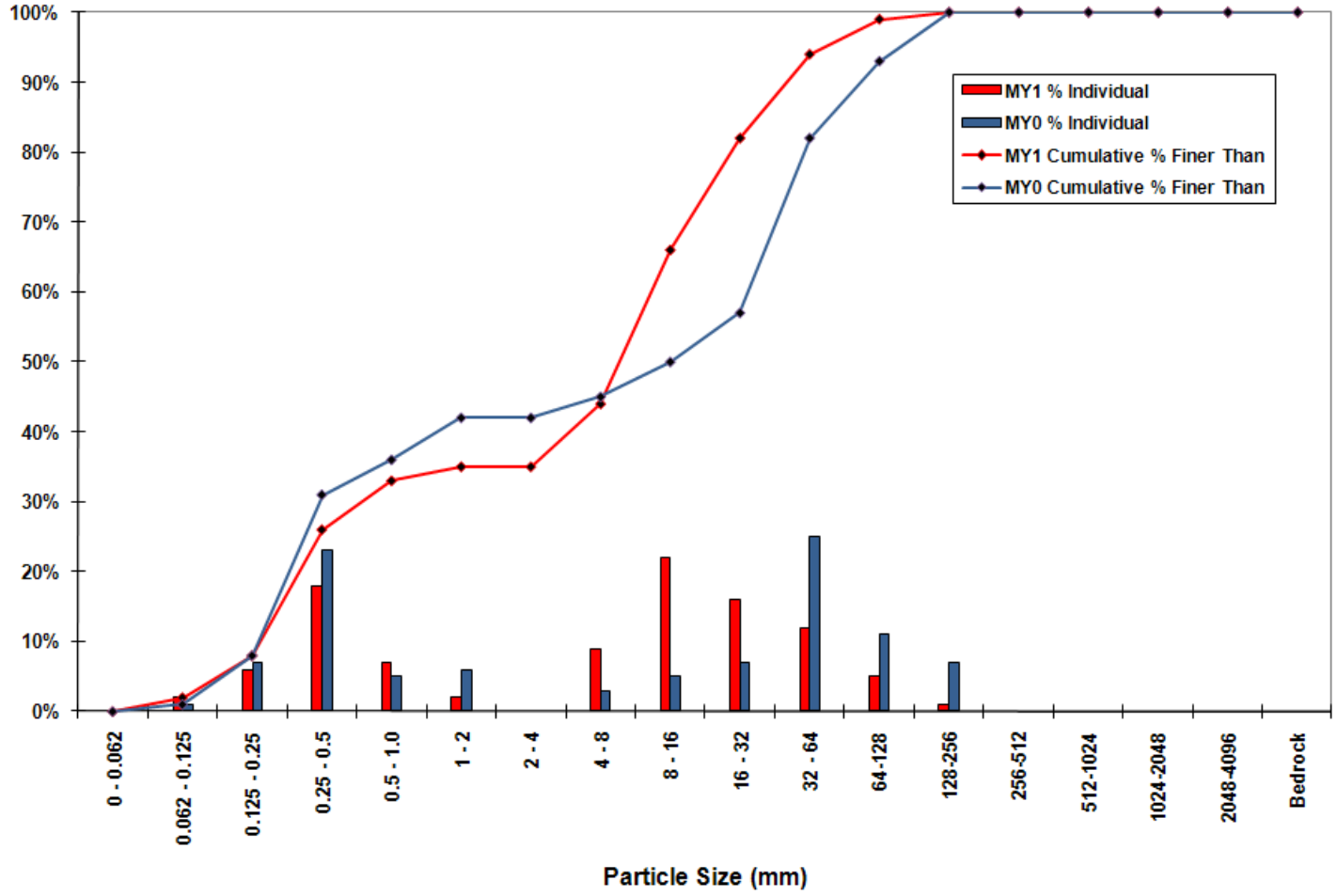
Morgan Creek Upper – Pool 1
Pebble Count



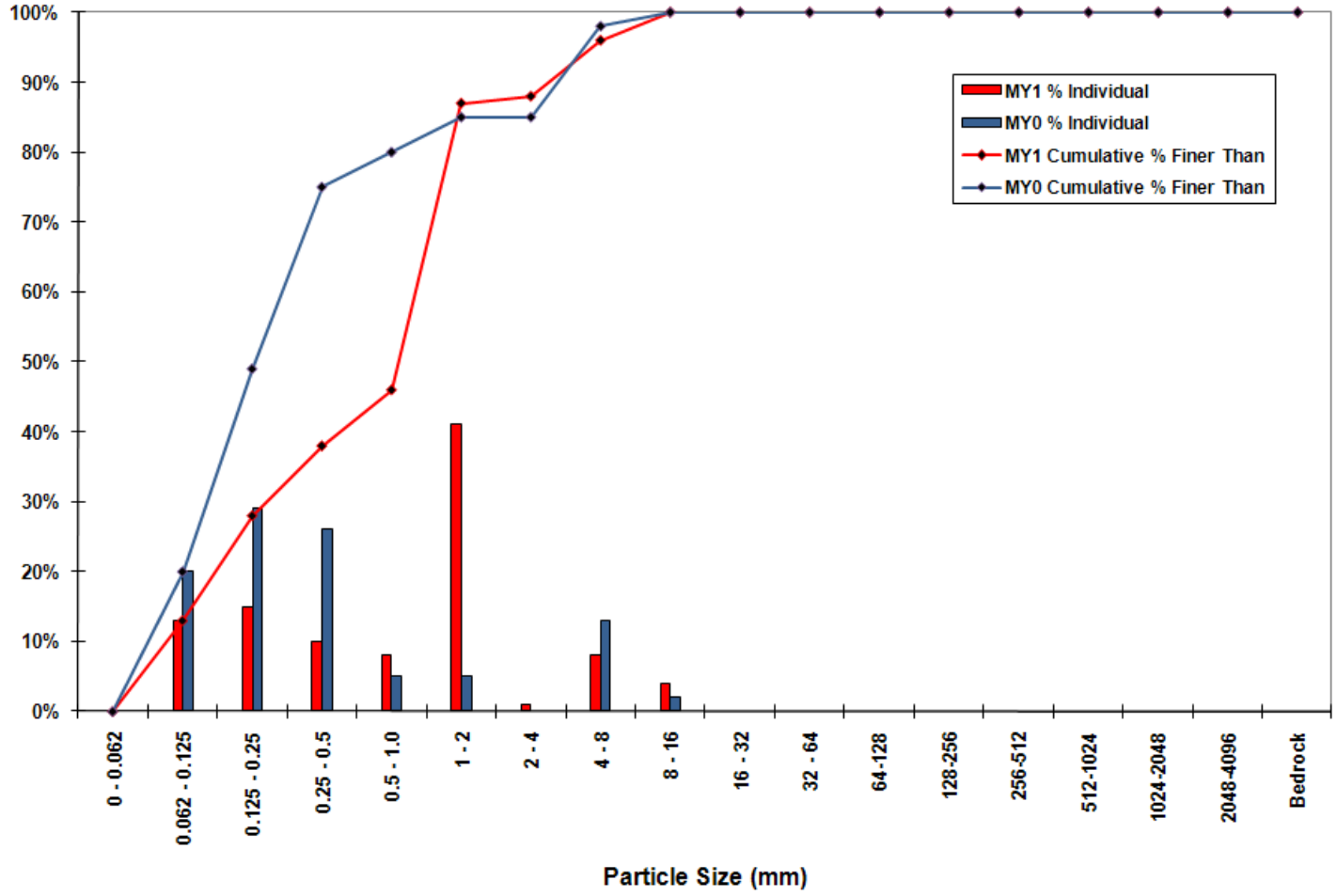
Morgan Creek Upper – Riffle 3
Pebble Count



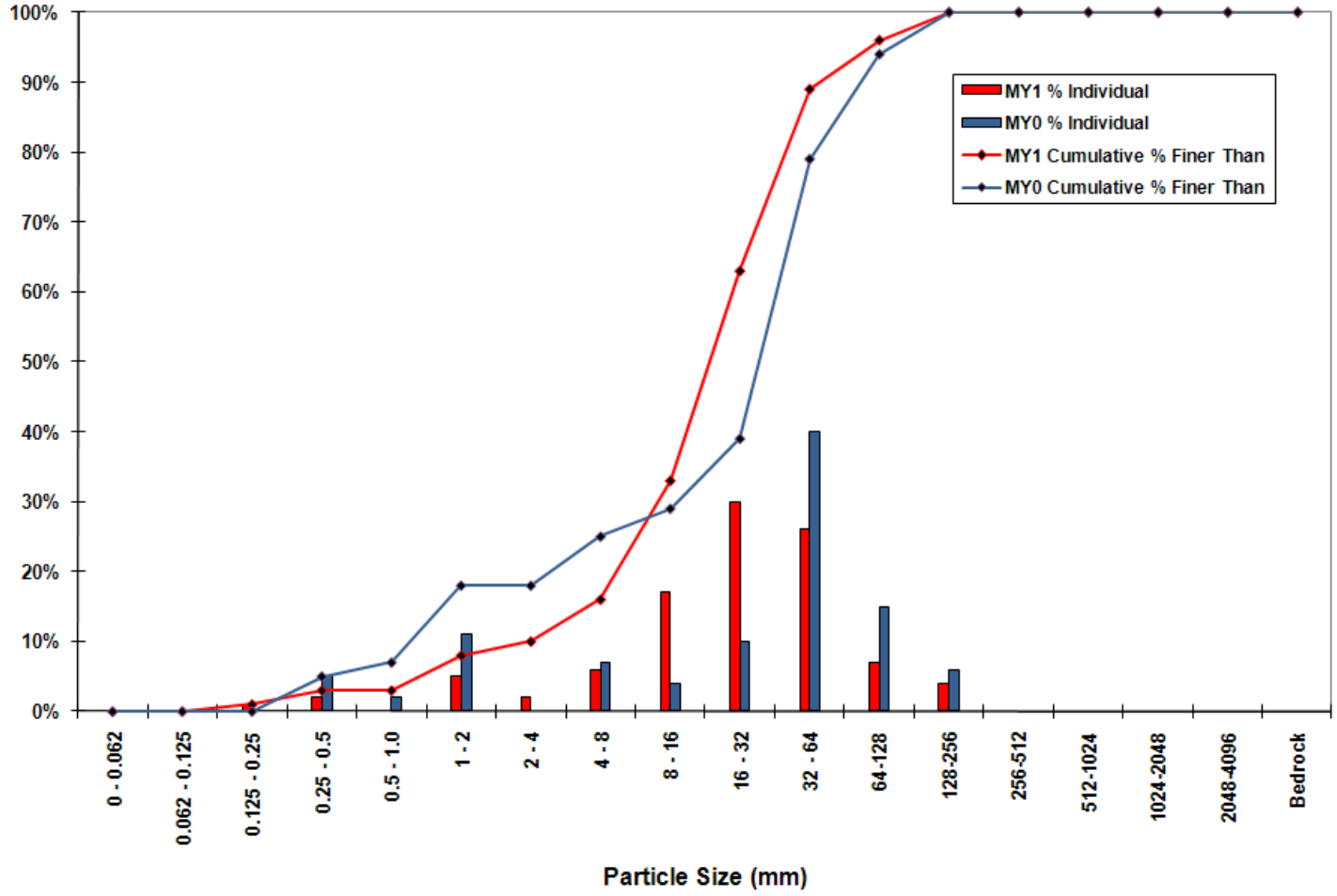
Morgan Creek Upper – Riffle 4
Pebble Count



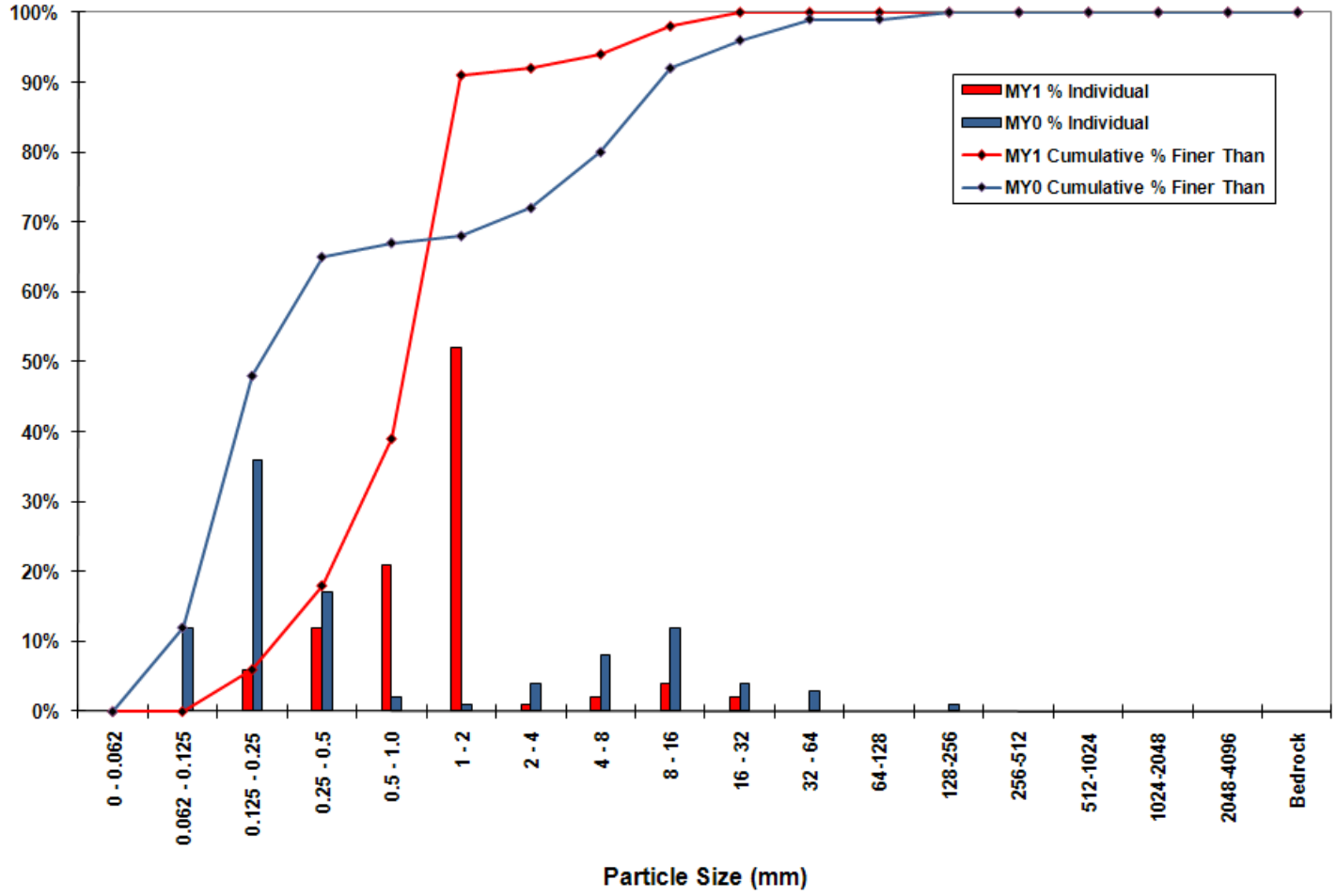
Morgan Creek Upper – Pool 2
Pebble Count



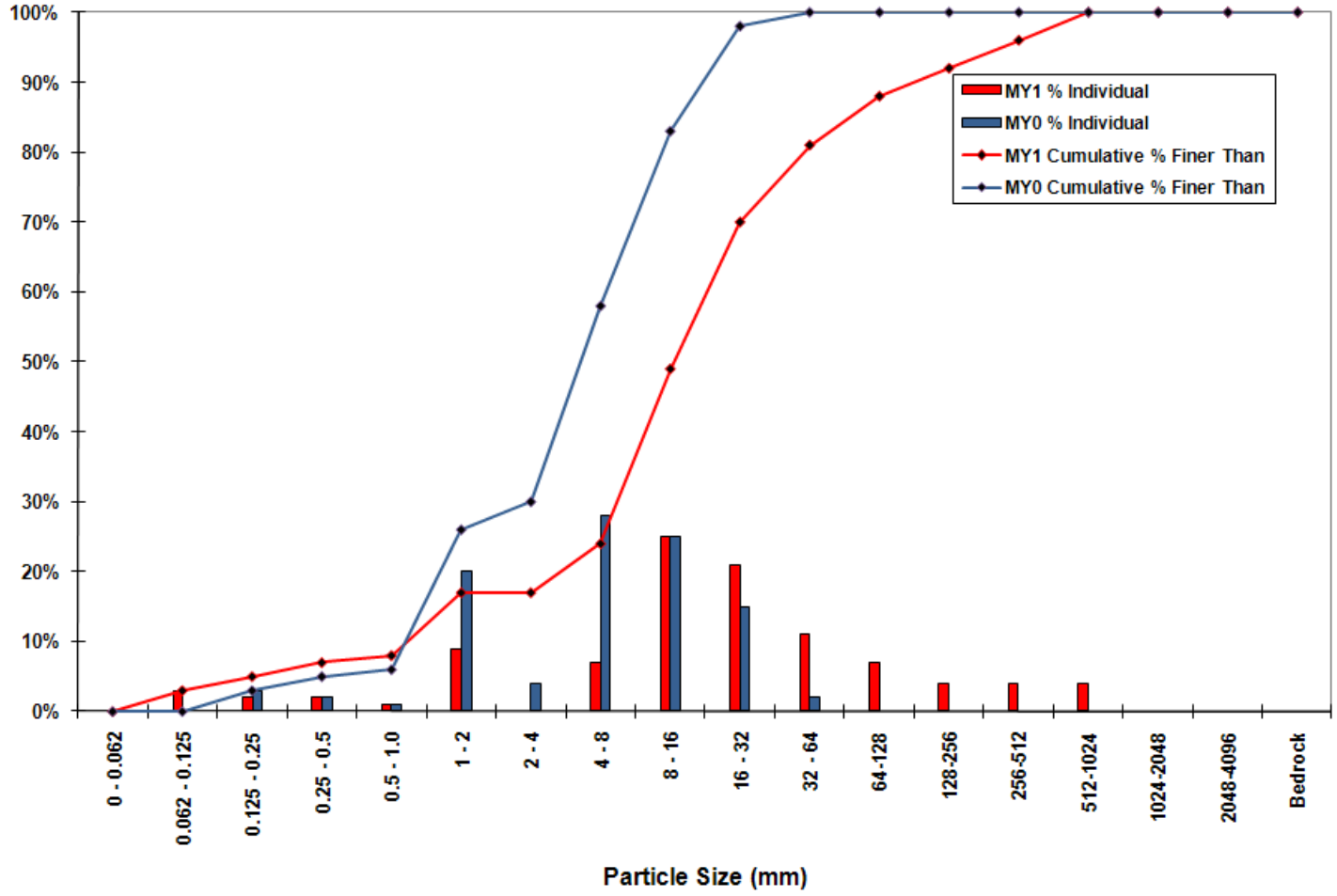
Morgan Creek Lower – Riffle 1
Pebble Count



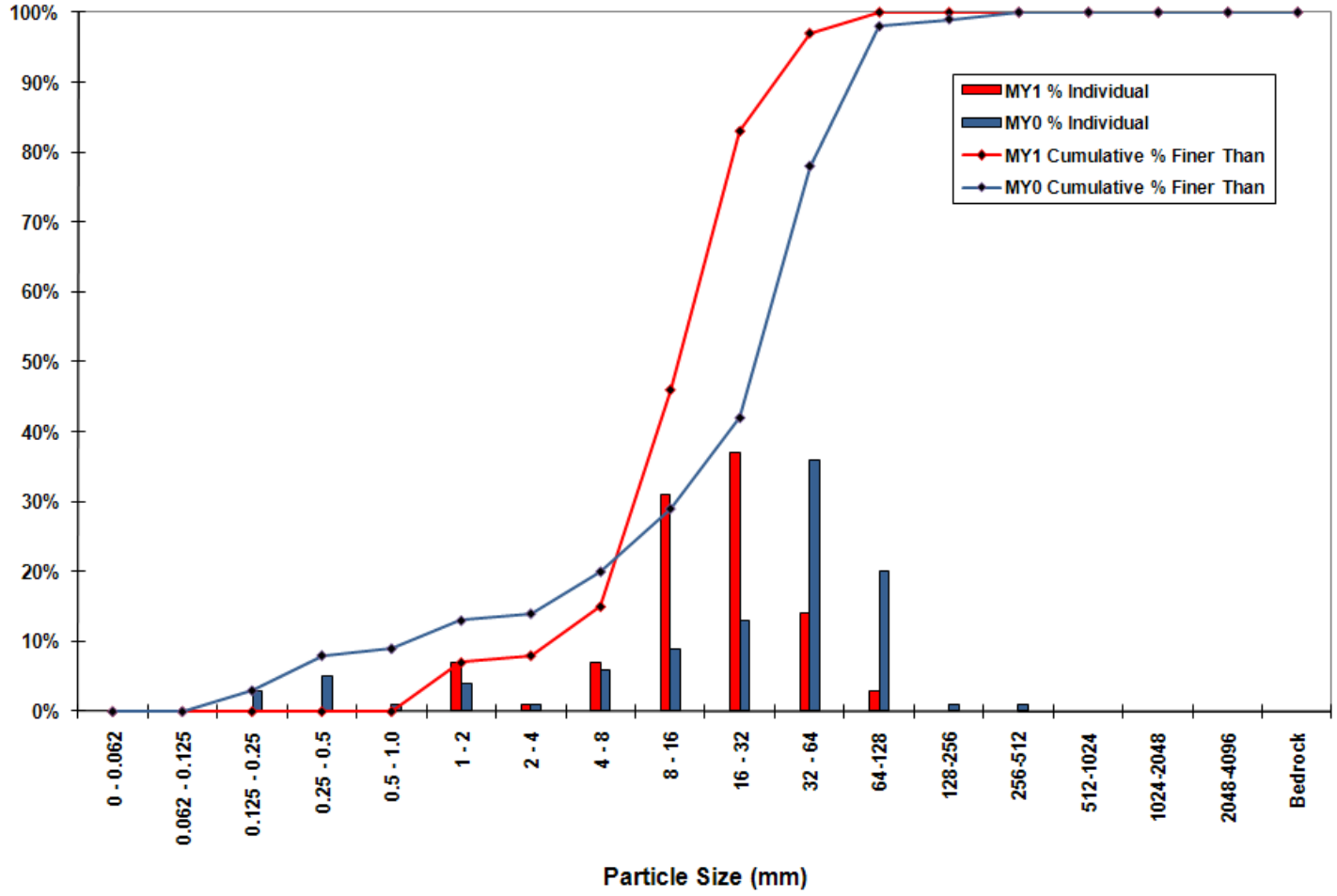
Morgan Creek Lower – Pool 1
Pebble Count



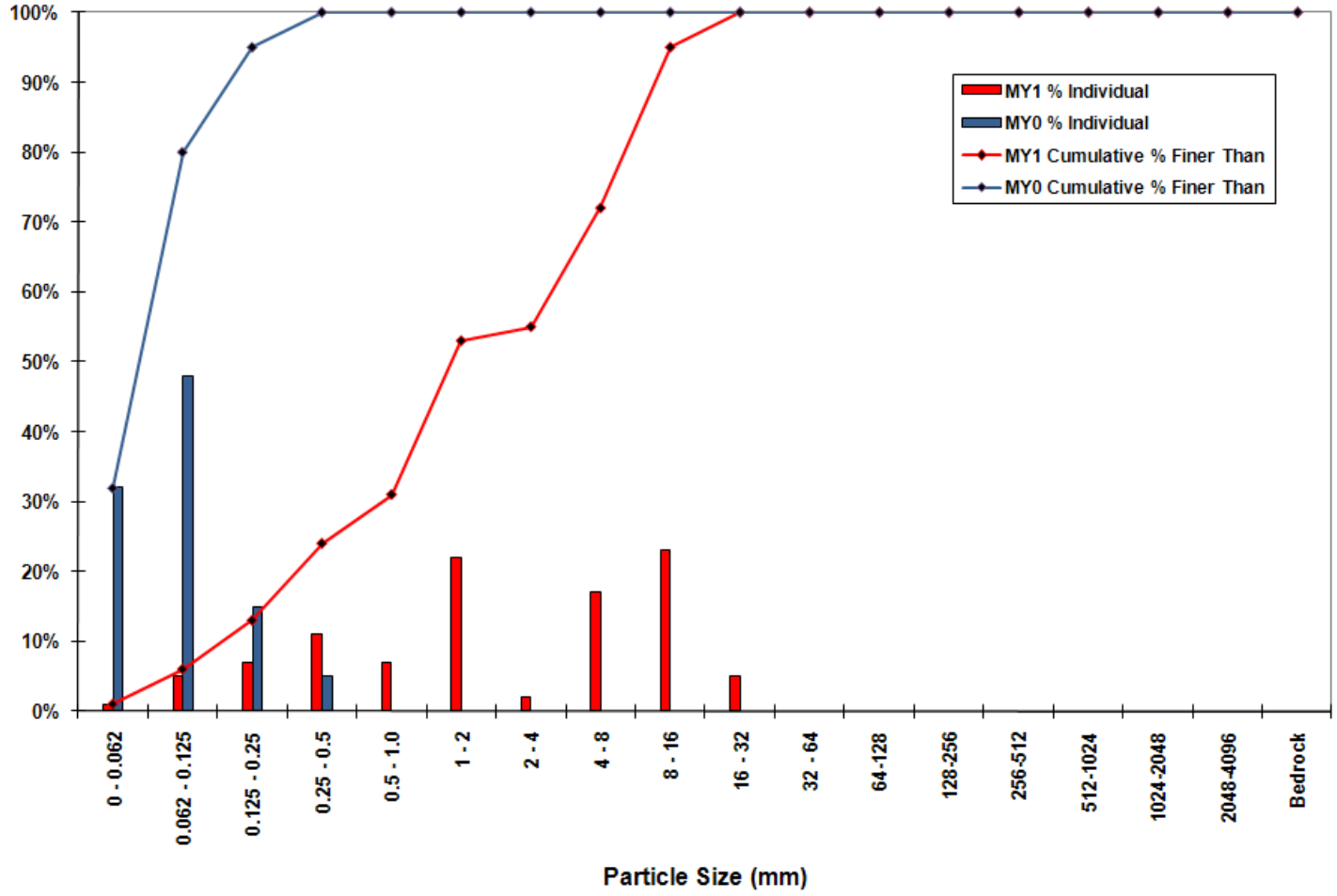
Morgan Creek Lower – Riffle 2
Pebble Count



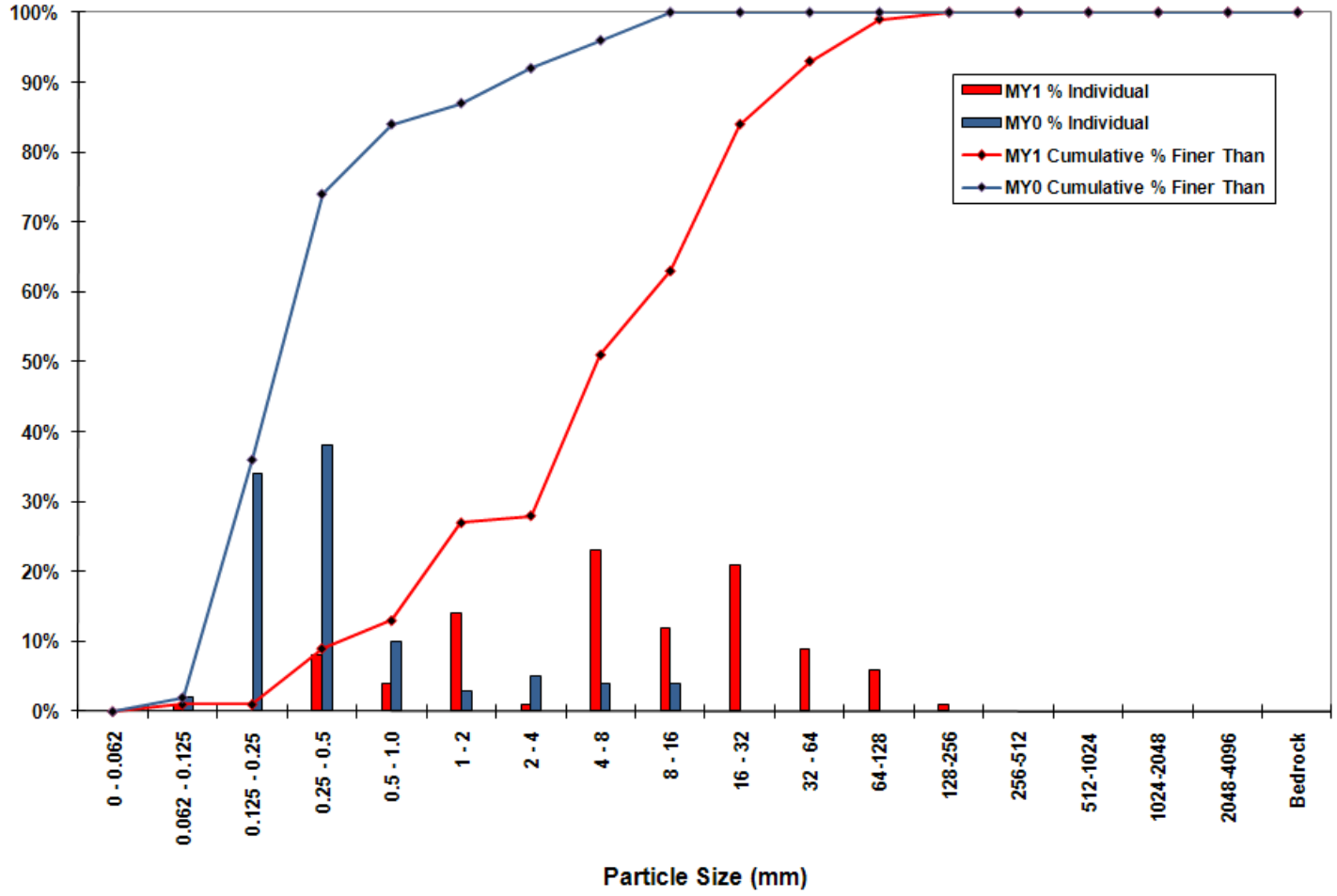
Morgan Creek Lower – Riffle 3
Pebble Count



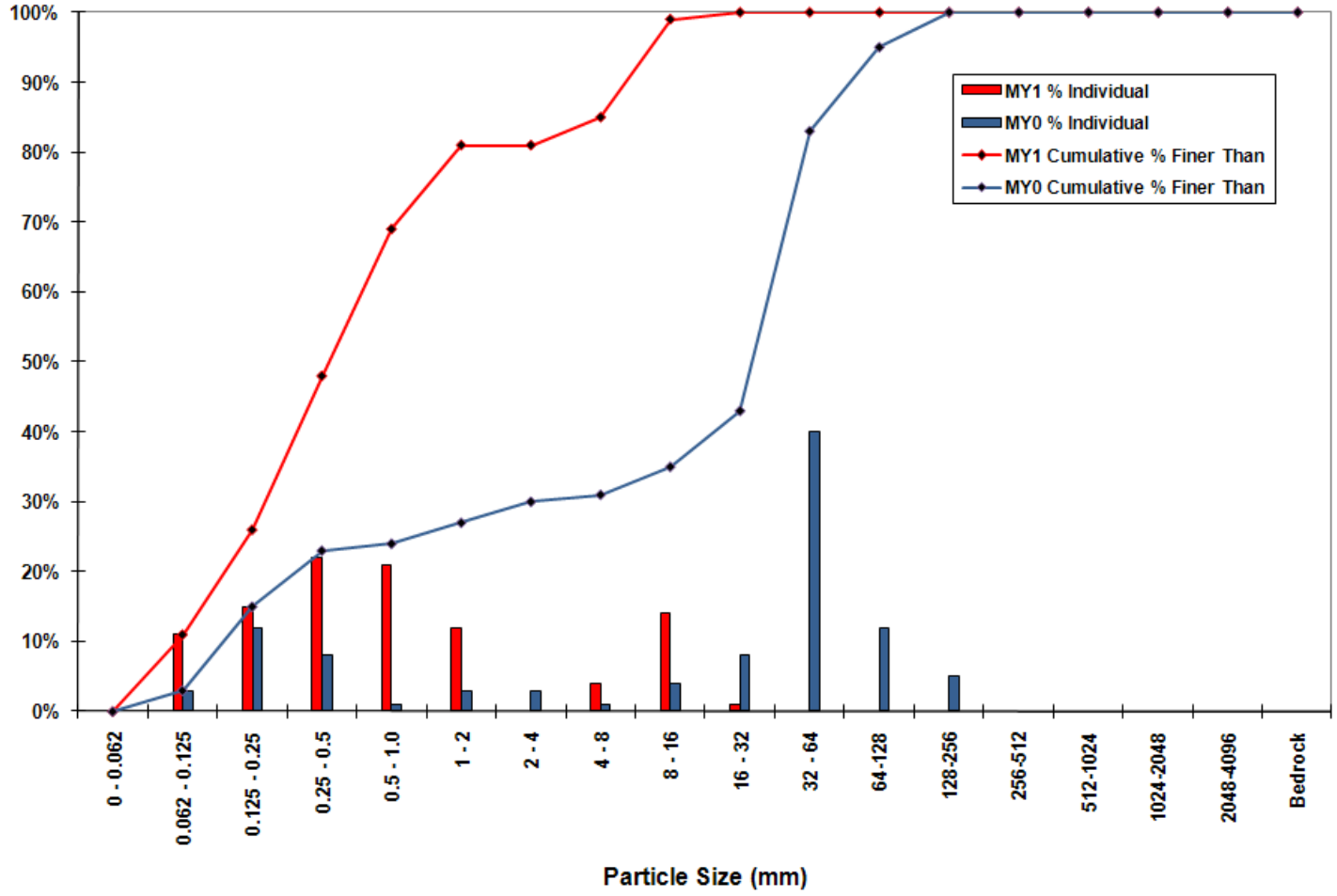
Morgan Creek Lower – Pool 2
Pebble Count



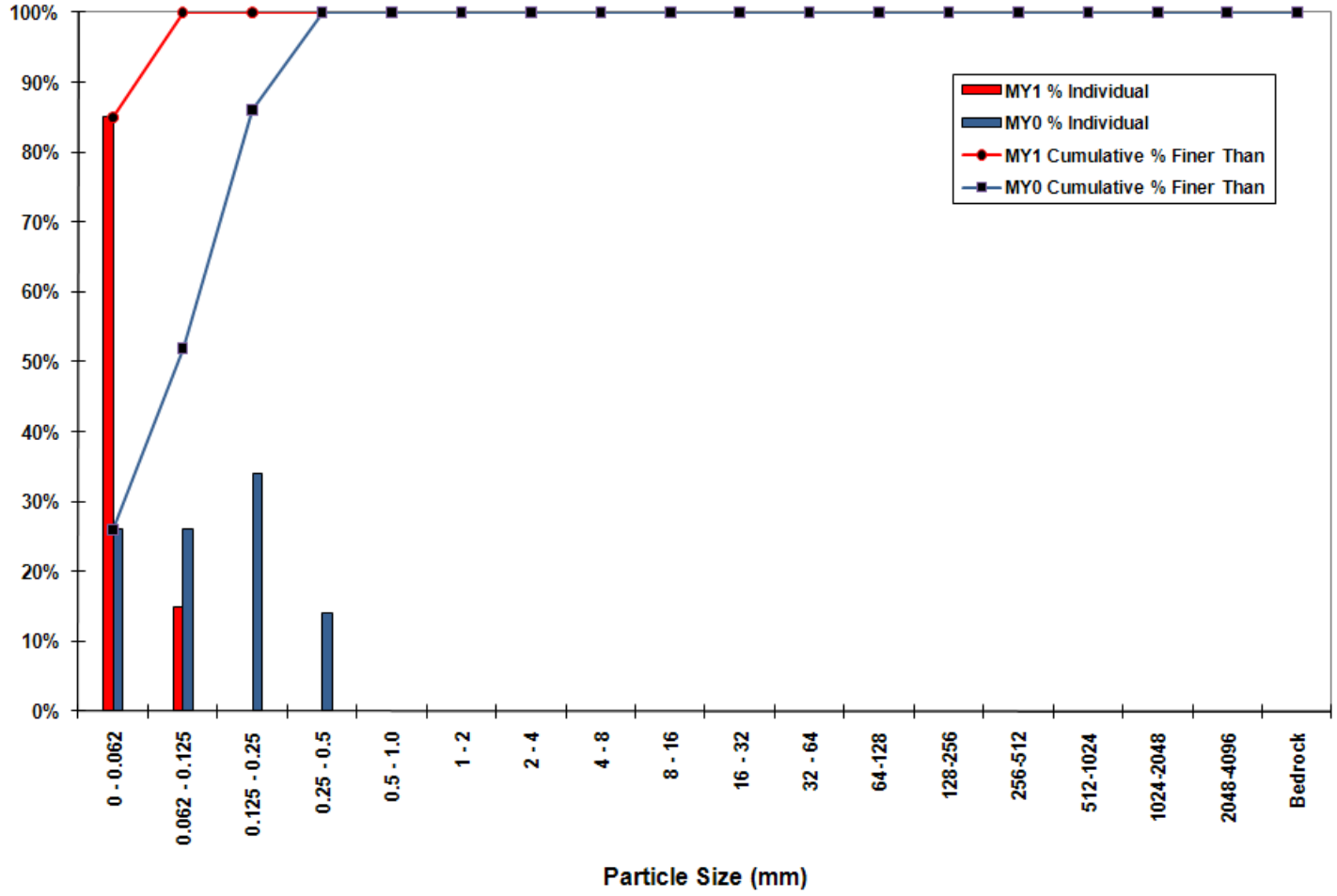
Morgan Creek Lower – Riffle 4
Pebble Count



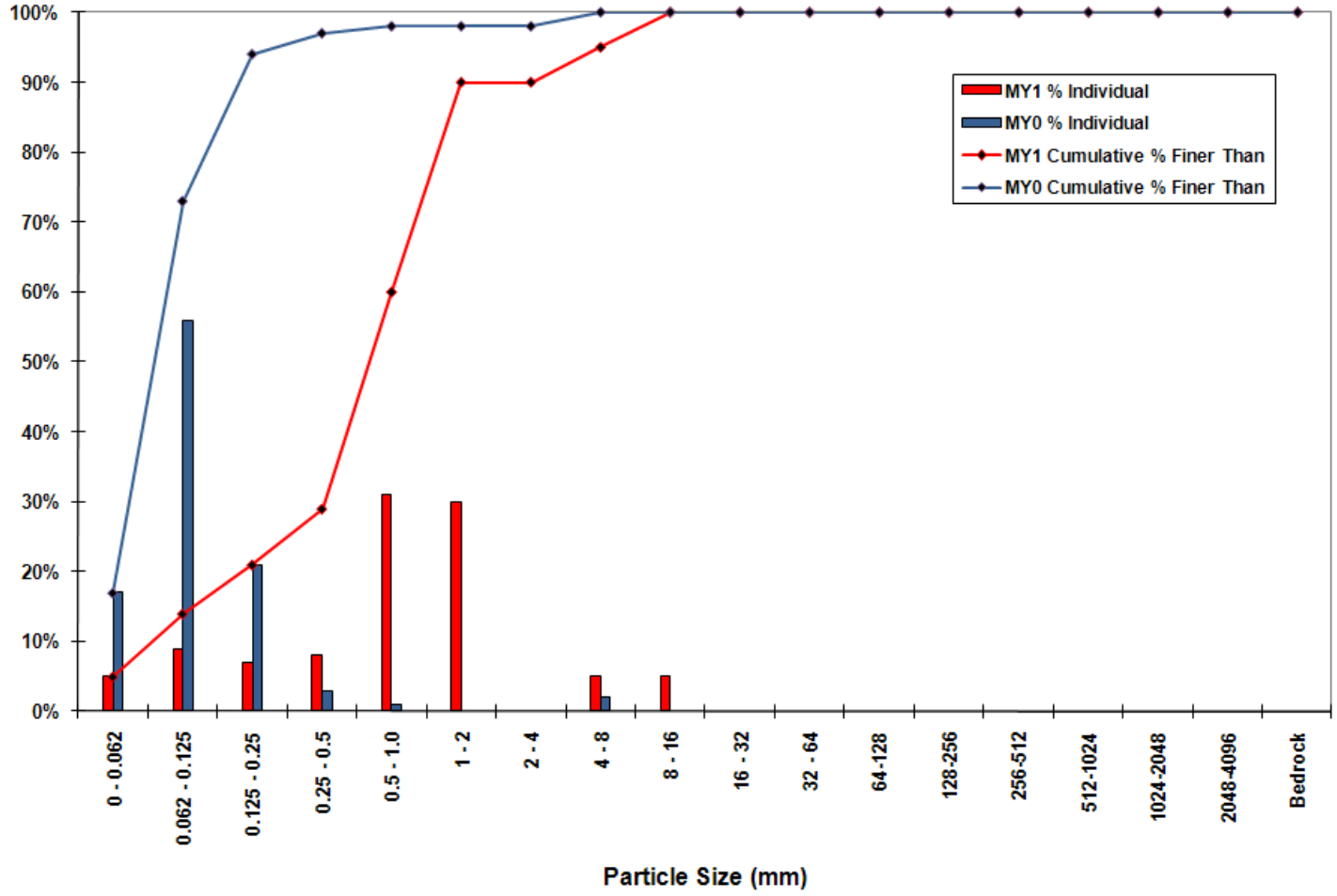
Unnamed Tributary 1 – Riffle
Pebble Count



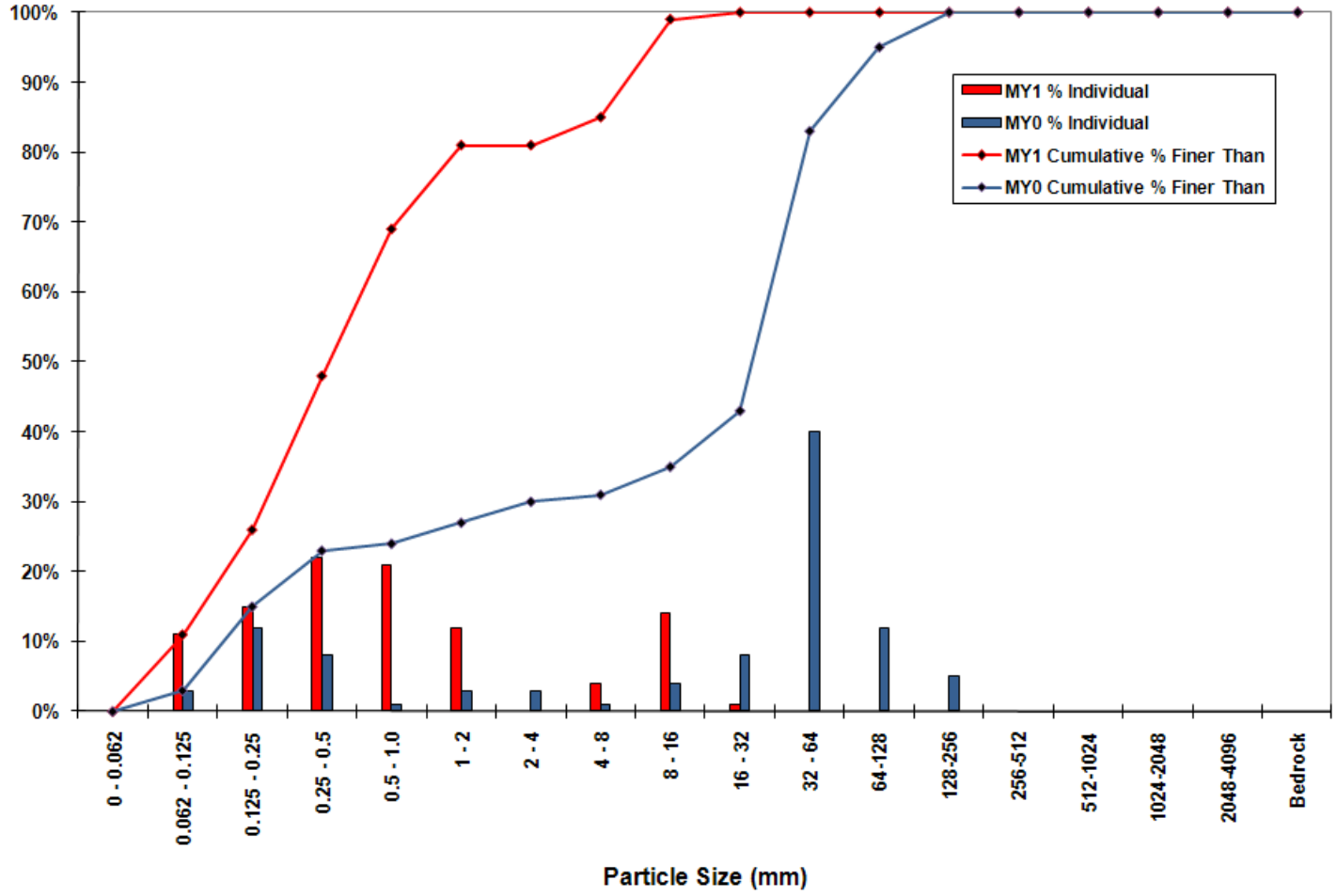
Unnamed Tributary 1 – Pool
Pebble Count



Unnamed Tributary 6 – Pool
Pebble Count



Unnamed Tributary 6 – Riffle
Pebble Count



APPENDIX C

2010 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					19.6	18.8					32.9	28.3				
Floodprone Width (ft)	>100	>100					>100	>100					>100	>100				
BF Cross Sectional Area (ft^2)	29.4	25.2					26.6	28.1					65.7	38.3				
BF Mean Depth (ft)	1.4	1.2					1.4	1.5					2.0	1.4				
BF Max Depth (ft)	2.5	2.6					2.3	3.8					4.5	3.7				
Width/Depth Ratio	14.3	18.1					14.5	12.6					16.4	20.9				
Entrenchment Ratio	4.9	4.7					5.1	5.3					3.0	3.5				
Wetted Perimeter (ft)	21.3	23.4					20.3	22.9					34.4	30.2				
Hydraulic Radius (ft)	1.4	1.1					1.3	1.2					1.9	1.3				

Morgan Creek – Upper Reach																		
Parameter	**Cross-Section 4 Riffle 3**						**Cross-Section5 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					22.3	18.7					39.0	22.7				
Floodprone Width (ft)	>100	>100					>100	>100					>100	>100				
BF Cross Sectional Area (ft^2)	32.7	25.7					24.7	21.0					49.2	23.4				
BF Mean Depth (ft)	1.6	1.3					1.1	1.1					1.3	1.0				
BF Max Depth (ft)	2.7	3.3					1.9	2.3					4.0	3.1				
Width/Depth Ratio	13.0	15.1					20.0	16.6					30.8	22.1				
Entrenchment Ratio	4.9	5.1					4.5	5.4					2.6	4.4				
Wetted Perimeter (ft)	21.4	21.9					22.8	19.9					40.9	25.0				
Hydraulic Radius (ft)	1.5	1.2					1.1	1.1					1.2	0.9				

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	25.4					34.4	30.8					22.2	23.8				
Floodprone Width (ft)	>100	>100					>100	>100					>100	>100				
BF Cross Sectional Area (ft^2)	22.5	46.2					54.5	48.0					29.4	43.5				
BF Mean Depth (ft)	1.2	1.8					1.6	1.6					1.3	1.8				
BF Max Depth (ft)	2.3	3.4					3.4	3.3					2.3	3.5				
Width/Depth Ratio	15.5	14.0					21.7	19.7					16.7	13.0				
Entrenchment Ratio	5.3	3.9					2.9	3.3					4.5	4.2				
Wetted Perimeter (ft)	19.3	27.1					35.3	33.1					22.8	26.3				
Hydraulic Radius (ft)	1.2	1.7					1.5	1.4					1.3	1.7				

*Morgan Creek Lower data presented for the purpose of comparing the original As-built conditions to those of the repair As-built conditions 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					26.4	28.6					23.9	23.4				
Floodprone Width (ft)	>100	>100					>100	>100					>100	>100				
BF Cross Sectional Area (ft^2)	31.0	37.7					41.3	47.2					30.0	42.2				
BF Mean Depth (ft)	1.2	1.5					1.6	1.6					1.3	1.8				
BF Max Depth (ft)	2.3	2.6					3.7	3.7					2.5	3.3				
Width/Depth Ratio	20.0	16.7					16.9	17.3					19.0	13.0				
Entrenchment Ratio	4.0	4.0					3.8	3.5					4.2	4.3				
Wetted Perimeter (ft)	25.6	26.3					27.8	30.3					24.6	24.8				
Hydraulic Radius (ft)	1.2	1.4					1.5	1.6					1.2	1.7				

*Morgan Creek Lower data presented for the purpose of comparing the original As-built conditions to those of the repair As-built conditions 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					19.1	18.9				
Floodprone Width (ft)	>50.0	>50.0					>50.0	>50.0				
BF Cross Sectional Area (ft^2)	4.1	4.2					18.6	17.8				
BF Mean Depth (ft)	0.5	0.5					1.0	0.9				
BF Max Depth (ft)	1.2	1.3					2.1	2.0				
Width/Depth Ratio	19.9	19.4					19.6	20.1				
Entrenchment Ratio	5.5	5.6					2.6	2.6				
Wetted Perimeter (ft)	9.5	10.0					19.7	19.5				
Hydraulic Radius (ft)	0.4	0.4					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					13.4	11.7				
Floodprone Width (ft)	>50.0	>50.0					>50.0	>50.0				
BF Cross Sectional Area (ft^2)	29.4	14.6					11.1	10.3				
BF Mean Depth (ft)	1.2	0.7					0.8	0.9				
BF Max Depth (ft)	3.0	1.6					1.7	1.7				
Width/Depth Ratio	20.2	27.1					16.2	13.2				
Entrenchment Ratio	2.1	2.5					3.7	4.3				
Wetted Perimeter (ft)	25.3	20.7					13.9	12.5				
Hydraulic Radius (ft)	1.2	0.7					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												
Radius of Curvature (ft)	42.3	55.6	49.7	34.6	56.6	48.9												
Meander Wavelength (ft)	141.4	215.2	200.3	153.7	219.3	199.6												
Meander Width Ratio	3.68	3.87	3.70	4.28	4.87	4.65												
Profile																		
Riffle Length (ft)	16.93	43.38	26.51	14.13	68.47	27.23												
Riffle Slope (ft/ft)	0.0024	0.0197	0.0035	0.0018	0.0209	0.0079												
Pool Length (ft)	13.27	80.84	44.42	15.25	68.17	33.69												
Pool Spacing (ft)	51.77	138.88	102.18	58.30	170.24	106.81												
Additional Reach Parameters																		
Valley Length (ft)	1181.5			1181.5														
Channel Length (ft)	1424.7			1465.5														
Sinuosity	1.21			1.24														
Water Surface Slope (ft/ft)	0.007			0.007														
BF Slope (ft/ft)	0.009			0.008														
Rosgen Classification	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												
Radius of Curvature (ft)	30.7	53.7	34.1	30.2	55.8	36.8												
Meander Wavelength (ft)	170.2	200.3	181.2	172.1	203.9	180.3												
Meander Width Ratio	2.83	3.76	3.17	2.76	2.95	2.80												
Profile																		
Riffle Length (ft)	14.76	53.25	44.15	30.46	91.11	47.28												
Riffle Slope (ft/ft)	0.0016	0.0201	0.0076	0.0037	0.0206	0.0103												
Pool Length (ft)	38.51	80.98	60.72	15.40	38.70	30.03												
Pool Spacing (ft)	92.14	157.68	109.52	40.56	234.10	109.20												
Additional Reach Parameters																		
Valley Length (ft)	865			865														
Channel Length (ft)	1054.4			1083.7														
Sinuosity	1.22			1.25														
Water Surface Slope (ft/ft)	0.006			0.006														
BF Slope (ft/ft)	0.007			0.005														
Rosgen Classification	C4			C4														

*Morgan Creek Lower data presented for the purpose of comparing the original As-built conditions to those of the repair As-built conditions 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												
Radius of Curvature (ft)	22.1	29.9	26.7	13.3	25.9	23.1												
Meander Wavelength (ft)	95.6	109.3	101.4	94.6	103.4	103.0												
Meander Width Ratio		4.35			4.89													
Profile																		
Riffle Length (ft)	13.18	25.73	23.34	9.24	29.68	17.52												
Riffle Slope (ft/ft)	0.0084	0.0467	0.0222	0.0062	0.0324	0.0155												
Pool Length (ft)	4.34	30.99	20.78	4.12	38.54	21.86												
Pool Spacing (ft)	17.63	77.03	36.48	22.69	91.52	37.28												
Additional Reach Parameters																		
Valley Length (ft)		310.3			310.3													
Channel Length (ft)		378.1			386.4													
Sinuosity		1.22			1.25													
Water Surface Slope (ft/ft)		0.011			0.012													
BF Slope (ft/ft)		0.013			0.013													
Rosgen Classification		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												
Radius of Curvature (ft)	27.7	31.7	30.2	21.7	32.1	22.5												
Meander Wavelength (ft)	114.0	123.1	120.1	100.9	120.3	119.5												
Meander Width Ratio		3.16			3.85													
Profile																		
Riffle Length (ft)	14.86	30.95	28.19	7.28	25.67	16.29												
Riffle Slope (ft/ft)	0.0013	0.0110	0.0042	0.0014	0.0237	0.0108												
Pool Length (ft)	2.38	18.09	14.64	4.02	15.59	8.70												
Pool Spacing (ft)	5.90	66.37	54.03	14.52	54.28	28.32												
Additional Reach Parameters																		
Valley Length (ft)		222.5			222.5													
Channel Length (ft)		252.4			258.9													
Sinuosity		1.13			1.16													
Water Surface Slope (ft/ft)		0.008			0.010													
BF Slope (ft/ft)		0.014			0.010													
Rosgen Classification		C4			C5													

APPENDIX D

2010 Site Photos

Permanent Photo Point #1 – Unnamed Tributary 7
Looking Upstream

Permanent Photo Point #2 – Unnamed Tributary 7
Looking Upstream

Permanent Photo Point #3 – Unnamed Tributary 7
Looking Upstream

Permanent Photo Point #4 – Unnamed Tributary 7
Looking Upstream

Permanent Photo Point #5 – Unnamed Tributary 7
Looking Upstream

Permanent Photo Point #6 – Unnamed Tributary 7
Looking Upstream

Permanent Photo Point #7 – Unnamed Tributary 7
Looking Upstream

Permanent Photo Point #8 – Morgan Creek
Looking Upstream

Permanent Photo Point #9 – Morgan Creek
Looking Upstream

Permanent Photo Point #10 – Morgan Creek
Looking Upstream

Permanent Photo Point #11 – Morgan Creek
Looking Upstream

Permanent Photo Point #12 – Morgan Creek
Looking Upstream

Permanent Photo Point #13 – Morgan Creek
Looking Upstream

Permanent Photo Point #14 – Morgan Creek
Looking Upstream

Permanent Photo Point #15 – Morgan Creek
Looking Upstream

Permanent Photo Point #16 – Morgan Creek
Looking Upstream

Permanent Photo Point #17 – Morgan Creek
Looking Upstream

Permanent Photo Point #18 – Morgan Creek
Looking Upstream

Permanent Photo Point #19 – Morgan Creek
Looking Upstream

Permanent Photo Point #20 – Morgan Creek
Looking Upstream

Permanent Photo Point #21 – Morgan Creek
Looking Upstream

Permanent Photo Point #22 – Unnamed Tributary 6
Looking Upstream

Permanent Photo Point #23 – Unnamed Tributary 6
Looking Upstream

Permanent Photo Point #24 – Unnamed Tributary 6
Looking Upstream

Permanent Photo Point #25 – Unnamed Tributary 6
Looking Upstream

Permanent Photo Point #26 – Unnamed Tributary 6
Looking Upstream

Permanent Photo Point #27 – Morgan Creek
Looking Upstream

Permanent Photo Point #28 – Morgan Creek
Looking Upstream

Permanent Photo Point #29 – Morgan Creek
Looking Upstream

Permanent Photo Point #30 – Morgan Creek
Looking Upstream

Permanent Photo Point #30 – Unnamed Tributary 5
Looking Upstream

Permanent Photo Point #31 – Unnamed Tributary 5
Looking Upstream

Permanent Photo Point #32 – Unnamed Tributary 5
Looking Downstream

Permanent Photo Point #32 – Unnamed Tributary 5
Looking Upstream

Permanent Photo Point #33 – Unnamed Tributary 5
Looking Downstream

Permanent Photo Point #33 – Unnamed Tributary 5
Looking Upstream

Permanent Photo Point #34 – Unnamed Tributary 5
Looking Upstream

Permanent Photo Point #35 – Unnamed Tributary 5
Looking Downstream

Permanent Photo Point #35 – Unnamed Tributary 5
Looking 115 Degrees

Permanent Photo Point #35 – Unnamed Tributary 5
Looking Upstream

Permanent Photo Point #35 – Unnamed Tributary 5
Looking 358 Degrees

Permanent Photo Point #36 – Morgan Creek
Looking Upstream

Permanent Photo Point #37 – Morgan Creek
Looking Upstream

Permanent Photo Point #38 – Morgan Creek
Looking Upstream

Permanent Photo Point #39 – Unnamed Tributary 4
Looking Downstream

Permanent Photo Point #39 – Unnamed Tributary 4
Looking Upstream

Permanent Photo Point #40 – Morgan Creek
Looking Upstream

Permanent Photo Point #41 – Morgan Creek
Looking Upstream

Permanent Photo Point #42 – Morgan Creek
Looking Downstream

Permanent Photo Point #42 – Morgan Creek
Looking Upstream

Permanent Photo Point #43 – Unnamed Tributary 3
Looking Upstream

Permanent Photo Point #44 – Unnamed Tributary 3
Looking Upstream

Permanent Photo Point #45 – Unnamed Tributary 3
Looking Upstream

Permanent Photo Point #46 – Unnamed Tributary 3
Looking Upstream

Permanent Photo Point #47 – Unnamed Tributary 3
Looking Upstream

Permanent Photo Point #48 – Unnamed Tributary 3
Looking Upstream

Permanent Photo Point #49 – Unnamed Tributary 3
Looking Upstream

Permanent Photo Point #50 – Unnamed Tributary 3
Looking Upstream

Permanent Photo Point #51 – Unnamed Tributary 3
Looking Downstream

Permanent Photo Point #51 – Unnamed Tributary 3
Looking Upstream

Permanent Photo Point #52 – Unnamed Tributary 3
Looking Downstream

Permanent Photo Point #52 – Unnamed Tributary 3
Looking 110 Degrees

Permanent Photo Point #52 – Unnamed Tributary 3
Looking Upstream

Permanent Photo Point #52 – Unnamed Tributary 3
Looking 355 Degrees

Permanent Photo Point #53 – Morgan Creek
Looking Upstream

Permanent Photo Point #54 – Morgan Creek
Looking Upstream

Permanent Photo Point #55 – Morgan Creek
Looking Upstream

Permanent Photo Point #56 – Unnamed Tributary 2
Looking Upstream

Permanent Photo Point #57 – Unnamed Tributary 2
Looking Upstream

Permanent Photo Point #58 – Unnamed Tributary 2
Looking Downstream

Permanent Photo Point #58 – Unnamed Tributary 2
Looking Upstream

Permanent Photo Point #59 – Unnamed Tributary 2
Looking Downstream

Permanent Photo Point #59 – Unnamed Tributary 2
Looking Upstream

Permanent Photo Point #60 – Unnamed Tributary 2
Looking Downstream

Permanent Photo Point #60 – Unnamed Tributary 2
Looking Upstream

Permanent Photo Point #61 – Morgan Creek
Looking Upstream

Permanent Photo Point #62 – Unnamed Tributary 1
Looking Upstream

Permanent Photo Point #63 – Unnamed Tributary 1
Looking Upstream

Permanent Photo Point #64 – Unnamed Tributary 1
Looking Upstream

Permanent Photo Point #65 – Unnamed Tributary 1
Looking Upstream

Permanent Photo Point #66 – Unnamed Tributary 1
Looking Downstream

Permanent Photo Point #66 – Unnamed Tributary 1
Looking Upstream

Permanent Photo Point #67 – Unnamed Tributary 1
Looking Downstream

Permanent Photo Point #67 – Unnamed Tributary 1
Looking 185 Degrees

Permanent Photo Point #67 – Unnamed Tributary 1
Looking Upstream

Permanent Photo Point #67 – Unnamed Tributary 1
Looking 360 Degrees

Permanent Photo Point #68 – Unnamed Tributary 1
Looking Downstream

Permanent Photo Point #68 – Unnamed Tributary 1
Looking 94 Degrees

Permanent Photo Point #68 – Unnamed Tributary 1
Looking Upstream

Permanent Photo Point #68 – Unnamed Tributary 1
Looking 327 Degrees

Permanent Photo Point #69 – Unnamed Tributary 8
Looking Downstream

Permanent Photo Point #69 – Unnamed Tributary 8
Looking 168 Degrees

Permanent Photo Point #69 – Unnamed Tributary 8
Looking Upstream

Permanent Photo Point #69 – Unnamed Tributary 8
Looking 53 Degrees

Permanent Photo Point #70 – Unnamed Tributary 9
Looking Downstream

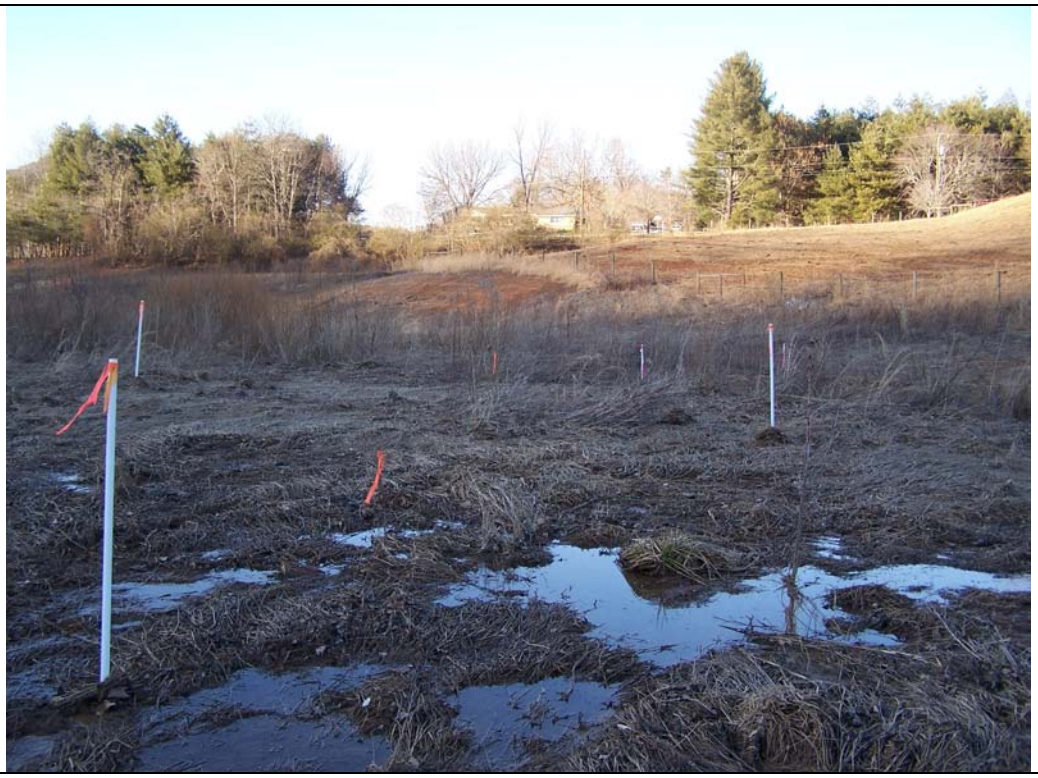
Permanent Photo Point #70 – Unnamed Tributary 9
Looking Upstream 196 Degrees

Permanent Photo Point #70 – Unnamed Tributary 9
Looking Upstream 248 Degrees

Wrack lines and deposition along Morgan Creek from bankfull event in May 2009

Wrack lines and deposition along Morgan Creek from bankfull event in May 2009

Wrack lines and deposition along Morgan Creek from bankfull event in January 2010



Wrack lines and deposition along Morgan Creek from bankfull event in January 2010

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 and Vegetation Areas Requiring Observation

SPA4 Morgan Creek Sta. 1001+50 – Pool Aggradation

SPA7 Morgan Creek Sta. 1005+05 – Pool Aggradation

Morgan Creek Representative Photos of Stream and Vegetation Areas Requiring Observation

SPA13 Morgan Creek Sta. 1014+50 – Stressed Bank

Morgan Creek – Bare Bench

Morgan Creek Representative Photos of Stream and Vegetation Areas Requiring Observation

Morgan Creek – Isolated Area of privet (*Ligustrum sp*.) and multiflora rose (*Rosa multiflora*)

Unnamed Tributary 1 Representative Photos of Stream and Vegetation Areas Requiring Observation

SPA2 UT1 Sta. 2001+50 – Grade Control Degradation

SPA3 UT1 Sta. 2001+75 – Pool Aggradation

Unnamed Tributary 1 Representative Photos of Stream and Vegetation Areas Requiring Observation

UT1 – Isolated Area of privet (*Ligustrum sp*.)

Unnamed Tributary 2 Representative Photo of Stream Areas Requiring Observation

SPA5 UT2 Sta. 3000+50 – Pool Aggradation

Unnamed Tributary 3 Representative Photo of Stream Areas Requiring Observation

SPA11 UT3 Sta. 4000+10 – Pool Aggradation

Unnamed Tributary 4 Representative Photo of Stream Areas Requiring Observation

SPA14 UT4 Sta. 5001+50 – Pool Aggradation

Unnamed Tributary 5 Representative Photo of Vegetation Areas Requiring Observation

UT5 – Isolated Area of privet (*Ligustrum sp*.), multiflora rose (*Rosa multiflora*), and Japanese honeysuckle (*Lonicera japonica*)

Unnamed Tributary 6 Representative Photos of Stream Areas Requiring Observation

SPA17 UT6 Sta. 7003+00 – Pool Aggradation

SPA17 UT6 Sta. 7003+00 – Riffle Aggradation

Unnamed Tributary 7 Representative Photos of Stream and Vegetation Areas Requiring Observation

SPA19 UT7 Sta. 8000+40 – Riffle Aggradation

UT7 – Isolated Area of privet (*Ligustrum sp*.) and Japanese honeysuckle (*Lonicera japonica*)