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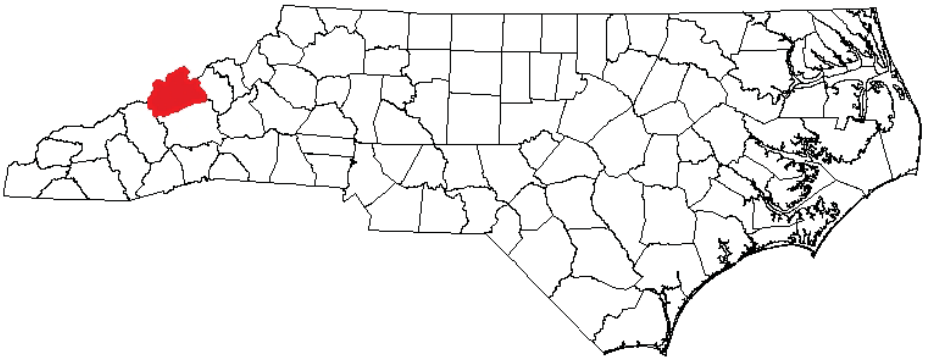
ANNUAL REPORT FOR 2003



Little Ivy Creek Stream Mitigation Site (Barnhill Site)
Madison County
WBS Element 32573.4.1
TIP No. A-10WM

Prepared By:
Office of Natural Environment & Roadside Environmental Unit
North Carolina Department of Transportation
December 2003

Summary

The following report summarizes the stream monitoring activities that have occurred during the Year 2003 at the Barnhill Site in Madison County. This site was designed and constructed during 2000 by the North Carolina Wildlife Resources Commission (NCWRC). This report provides the monitoring results for the first documented year of monitoring (Year 2003). The Barnhill Site will be monitored again in 2004. The actual timeline for formal monitoring will be decided by the Mitigation Review Team.

Based on the overall conclusions of monitoring along Little Ivy Creek, the Barnhill Site has met the required monitoring protocols for the first year of monitoring. Localized areas of active bank scour and erosion exist; however, immediate stabilization is not required at this time. These areas and all other areas will continue to be monitored during 2004.

Based on information obtained from the USGS, the Barnhill Site has met the required hydrologic monitoring protocols. The vegetative success criteria have also been met for the first year of monitoring. No biological sampling has been conducted to-date. It is unknown whether or not this sampling will be conducted as part of overall monitoring activities.

NCDOT will continue stream and vegetation monitoring at the site for 2004.

1.0 INTRODUCTION

1.1 Project Description

The following report summarizes the stream monitoring activities that have occurred during the Year 2003 at the Barnhill Site. The site is situated immediately south and adjacent to Beech Glen Road (SR 1540) in the southeastern portion of Madison County (Figure 1). It is approximately 2.0 miles (3.2 kilometers) southeast of Mars Hill and nearly 12 miles (19.2 kilometers) north of Asheville. The Barnhill Site was constructed as one of four projects to provide mitigation for stream impacts associated with Transportation Improvement Program (TIP) number A-10 in Madison County.

The mitigation project covers approximately 1,200 linear feet of Little Ivy Creek. Design and construction was implemented during 2000 by the North Carolina Wildlife Resources Commission (NCWRC). Stream restoration involved the installation of j-hook vanes and sloping the adjacent streambanks to reduce overall erosion.

1.2 Purpose

According to the as-built report (NCWRC, 2000), the objectives at this mitigation site were to improve water quality, fisheries habitat, riparian quality, and the overall stability of Little Ivy Creek. The following specific objectives were proposed:

- Protection of Little Ivy Creek's channel and riparian zone via a conservation easement;
- Install j-hook vanes along the large meander bend to reduce erosion and increase available fisheries habitat;
- Stabilize the eroding, vertical streambanks on the site by constructing floodplain benches along the toes of the slopes;
- Planting of native trees, shrubs, and ground cover that will help to stabilize the stream banks, establish shade, and provide wildlife cover and food.

Successful stream mitigation is demonstrated by a stable channel that does not aggrade or degrade over time. It is also demonstrated by reduced erosion rates, the permanent establishment of native vegetation, and bed features consistent with the design stream type. Vegetation survival is based on federal guidelines denoting success criteria for wetland mitigation. Results of stream monitoring conducted during the 2003 growing season at the Barnhill Site are included in this report.

Activities in 2003 reflect the first formal year of monitoring following the restoration efforts; however, this is the third year following construction at the site. Included in this report are analyses on stability (primarily the longitudinal profile and cross sections), vegetative monitoring results, and site photographs.

1.3 Project History

The effort to provide stream mitigation for TIP No. A-10 began in 1996 with a Memorandum of Agreement (MOA) between the North Carolina Department of Transportation (NCDOT) with the NCWRC. The MOA was to provide 25,000 feet of mitigation for 9,990 feet of jurisdictional stream impacts. Subsequent amendments to the MOA were made to provide mitigation for additional stream impacts from TIP No. A-10. These amendments resulted in a total mitigation of over 26,000 feet.

The NCDOT worked with representatives from the NCWRC, U.S. Army Corps of Engineers, North Carolina Division of Water Quality, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, Natural Resources Conservation Service and Madison County Soil and Water Conservation District on a Mitigation Review Team. The purpose of the team was to develop criteria and policies for selecting stream reaches for mitigation.

The Barnhill Site was one of the sites selected by the Mitigation Review Team to provide compensatory mitigation for TIP No. A-10. The mitigation plan for this mitigation site was developed during 1998 and approved by the team. The NCWRC implemented the project in 1999.

June 2000	Construction Completed.
June 2000	Site Planted with Native Perennial Seed Mix
December 2001	NCWRC Planted Additional Live Stakes and Bare Rooted Trees
March – July 2003	Stream Channel Monitoring (1 yr.)
March – July 2003	Vegetation Monitoring (1 yr.)

1.4 Debit Ledger

The entire Barnhill Site was used for TIP No. A-10 to compensate for unavoidable stream impacts related with roadway construction. This project generated 1,200 linear feet of stream credits.

2.0 STREAM ASSESSMENT

2.1 Success Criteria

The success criterion, as defined by the Mitigation Site Monitoring Protocol for the NCWRC/NCDOT Mitigation Program (2003), evaluates channel stability and improvements to fish habitat. Specifically, this evaluation includes all or a combination of the following parameters: channel stability, erosion control, seeding, woody vegetation, and overall response of fish and invertebrate populations for stream mitigation projects. This is to be accomplished using photo reference sites, stream dimension and profile, survival of planted vegetation, and direct sampling of important populations. The chart provided below further details the criteria used to evaluate success or failure at these mitigation sites.

NCWRC/ NCDOT Mitigation Monitoring Criteria

Measurement	Success (requires no action)	Failure	Action
Photo Reference Sites			
Longitudinal Photos Lateral Photos	No significant* aggradation, degradation, or erosion	Significant* aggradation, degradation, or erosion	When significant* aggradation, degradation or erosion occurs, remedial actions will be undertaken.
Channel Stability			
Cross-Sections Longitudinal Profiles Pebble Counts	Minimal evidence of instability (down-cutting, deposition, erosion, decrease in particle size)	Significant* evidence of instability	When significant* evidence of instability occurs, remedial actions will be undertaken.
Plant Survival			
Survival Plots	≥75% coverage in Photo Plots	<75% coverage in Photo Plots	Areas of less than 75% coverage will be re-seeded and/or fertilized, live stakes and bare-rooted trees will be replanted to achieve >80% survival.
Stake Counts	≥80% survival of stakes, 4/m2	<80% survival of stakes, 4/m2	
Tree Counts	≥80% survival of bare-rooted trees	<80% survival of bare-rooted trees	
Biological Indicators (only used for projects with potential to make watershed level changes)			
Invertebrate Pop. Fish Populations	Population measures remain to same or improve	Population measures indicate a negative trend	Reasons for failure will be evaluted and remedial action plans developed and implemented.
Overall success or failure will be based on success of 3 of the 4 criteria.			

*Significance or subjective determinations of success will be determined by a majority decision of the Mitigation Review Team

Federal guidelines for stream mitigation are relatively consistent with those protocols established by the NCWRC and NCDOT. These guidelines include the following main parameters: no less than two bankfull events for the five-year monitoring period, reference photos, plant survivability analyses, channel stability analyses, and biological data if specifically required by permit conditions (USACE, 2003). This report addresses all of the above mentioned parameters for both the NCWRC/NCDOT protocols and federal guidelines aside from shading and biological data, which was not required at this site.

Natural streams are dynamic systems that are in a constant state of change. Longitudinal profile and cross section surveys will differ from year to year based on changes in the watershed. Natural channel stability is achieved by allowing the stream to develop a proper dimension, pattern, and profile such that, over time, channel features are maintained and the stream system neither aggrades nor degrades. A stable stream consistently transports its sediment load, both in size and type, associated with local deposition and scour. Channel instability occurs when the scouring process leads to degradation, or excessive sediment deposition results in aggradation (Rosgen, 1996). The following surveys were conducted in support of the monitoring assessment:

- Longitudinal Profile Survey. This survey addressed the overall slope of the reach, as well as slopes between bed features. The bed features are secondary delineative criteria describing channel configuration in terms of riffle/pools, rapids, step/pools, cascades and convergence/divergence features which are inferred from channel plan form and

gradient. The surveys are compared on a yearly basis to note and/or compare aggradation, degradation, head cuts, and areas of mass wasting. The longitudinal profile is expected to change from year to year. Significant changes may require additional monitoring.

- Cross Section Surveys. These surveys addressed the following characteristics at various locations along the reach: entrenchment ratio, width/depth ratio, and dominant channel materials. The entrenchment ratio is a computed index value used to describe the degree of vertical containment. The width/depth ratio is an index value which indicates the shape of the channel cross section. The dominant channel materials refer to a selected size index value, the D_{50}, representing the most prevalent of one of six channel material types or size categories, as determined from a channel material size distribution index.

2.2 Stream Description

2.2.1 Pre-Construction Conditions

Little Ivy Creek was classified as a B3c stream type according to the Rosgen Classification of Natural Rivers. The channel at the Barnhill Site is confined by a narrow valley which descends approximately eight feet over the 1,200-foot reach. The entrenchment ratio was approximately 2.0 and the width/depth ratio was around 18.1. Small cobble (72 mm) was the D_{50} of the bed material throughout the project reach. The water surface slope along the reach averaged 0.0085 (NCWRC, 2000).

Pool habitat at this site was limited, with only one large pool present in the upper third of the reach. The remaining pools were small scour pools of limited length and depth. The D_{50} of the bed material remained small cobble; however, the distribution of the bed material sampled during pebble counts indicated a bimodal distribution (NCWRC, 2000).

2.2.2. Post-Construction Conditions

Three j-hook vanes were installed along the right bank and through the upper bend at this site. Floodplain benches were created along the right bank of the main channel at the lower end of the project and along the left bank of the cutoff channel. Large boulders were used to construct the benches. The adjacent streambanks were also extensively re-graded at the site (NCWRC, 2000).

2.2.3 Monitoring Conditions

Little Ivy Creek was initially classified as a C3b stream type according to the Rosgen Classification of Natural Rivers. A total of three cross sections were surveyed in addition to the longitudinal profile. A comparison of channel morphology is presented in Table 1. Channel stationing is provided on Figure 2.

Table 1. Abbreviated Morphological Summary (Barnhill Site)

Variable		Little Ivy Creek (Cross Section #3)						
		Pre-Const.*	As-Built*	Year 1	Year 2	Year 3**	Year 4**	Year 5**
Drainage Area (mi^2)		46.5	46.5	46.5	46.5	46.5	46.5	46.5
Bankfull Width (ft)	Mean	-	-	42.0				
Bankfull Mean Depth (ft)	Mean	-	-	2.2				
Width/Depth Ratio	Mean	18.1	-	19.0				
Bankfull Cross Sectional Area (ft^2)	Mean	-	-	94.5				
Maximum Bankfull Depth (ft)	Mean	-	-	3.5				
Width of Floodprone Area (ft)	Mean	-	-	200				
Entrenchment Ratio	Mean	2.0	-	4.8				
Slope		0.0085	-	0.009				
Particle Sizes								
D_{16} (mm)		-	-	0.5				
D_{35} (mm)		-	-	16.0				
D_{50} (mm)		72.0	-	45.0				
D_{84} (mm)		-	-	10.1				
D_{95} (mm)		-	-	2048.0				

* According to the NCWRC, comparisons of pre-construction, as-built, and monitoring data are not valid due to intangible factors. Monitoring data for subsequent years should be used as the basis of comparison.
** Year 3 through Year 5 Formal Monitoring has not been defined and may not be required.

2.3 Results of the Stream Assessment

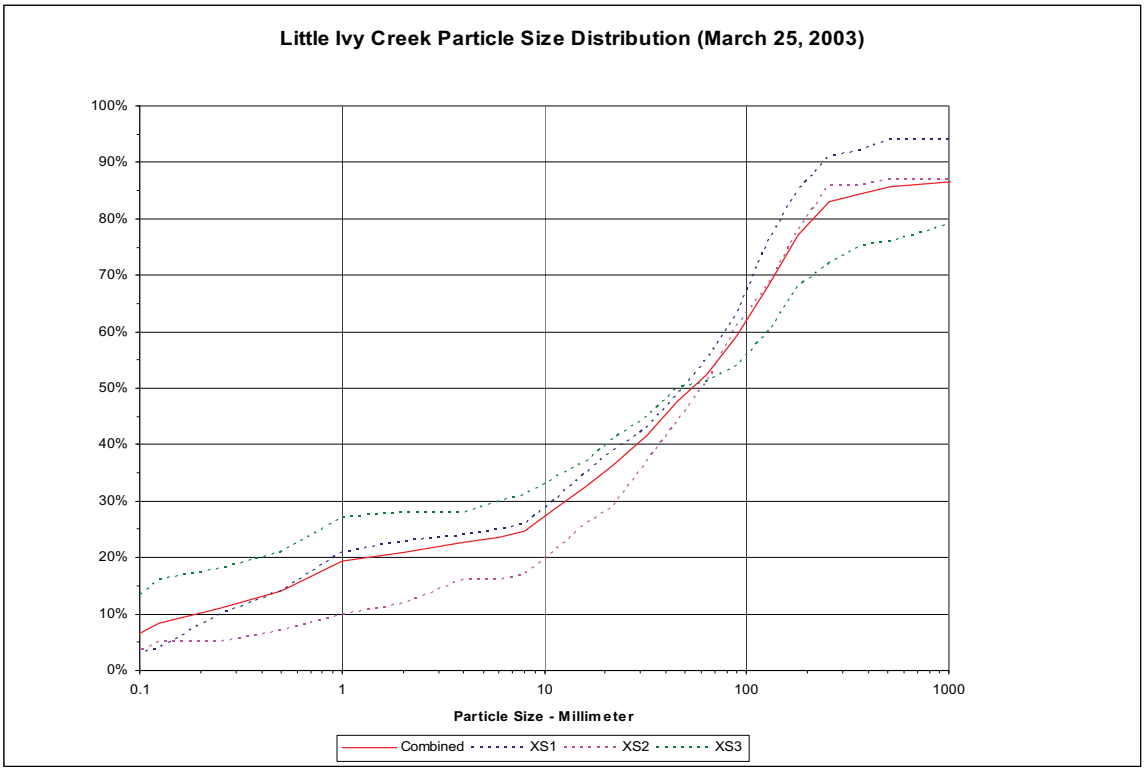
2.3.1 Site Data

The assessment included the re-survey of three cross sections and the longitudinal profile of Little Ivy Creek established by the NCWRC after construction. The length of the profile along Little Ivy Creek was approximately 700 linear feet. Cross section locations were subsequently based on the stationing of the longitudinal profile and are presented below. The locations of the cross sections and longitudinal profiles are shown in Appendix A.

- Cross Section #1. Little Ivy Creek, Station 1+56, midpoint of glide
- Cross Section #2. Little Ivy Creek, Station 3+00, midpoint of pool
- Cross Section #3. Little Ivy Creek, Station 5+04, midpoint of riffle

All three of the cross sections have remained intact based on comparisons with the as-built data and visual observations. Several benchmarks associated with the as-built surveys were not found; therefore exact data comparisons were not feasible. The Year 2003 data will be used for future comparisons. Based on the comparison of cross section survey results with the as-built sections, all three of the cross sections remain stable. These cross sections will be monitored during the next several years to determine the actual extent of aggradation or degradation. All of the cross sections appeared stable with little or no active bank erosion. Survey data will also vary depending on actual location of rod placement and alignment; however, this information should remain similar in overall appearance. The cross section comparison is presented in Appendix B.

Pebble counts were taken at each cross section as a means to determine the extent of change in bed material during the monitoring period. Existing data was available Little Ivy Creek. A comparison of pre-construction, as-built surveys, and first year monitoring was not feasible based on the fact that pre-construction and as-built pebble counts were taken throughout the reach rather than at the intended cross sections. Pebble counts taken during the monitoring assessment were restricted to Cross Sections #1 through #3. These pebble counts are skewed due to the presence of boulders associated with the j-hook vanes. The boulders were treated as bedrock. A chart depicting the particle size distributions for Little Ivy Creek is presented below. Comparisons will be made between 2003 data and future monitoring efforts.



Longitudinal profile surveys were conducted along a 700 linear foot segment of this reach. Bank stability was assessed during the longitudinal profile survey. One area of active scouring was observed. Descriptions relating to this area as well as several other notables are listed below:

<u>Little Ivy Creek</u>

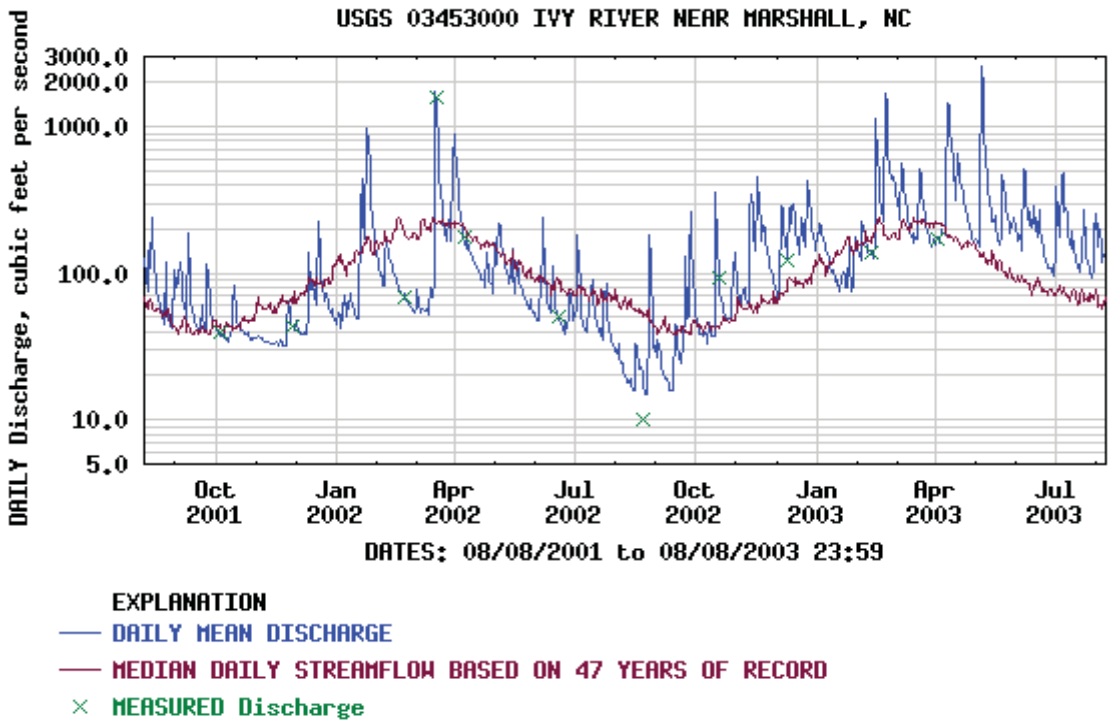
- A large amount of debris was noted along the project during the survey. This debris had been deposited during the abnormally wet spring months of 2003.
- Stations 0+00 to 1+50. The high bank associated with the cut-off channel continues to erode. Boulders were installed along the toe of this bank for added protection; however active erosion is still occurring above the elevation of these rocks. This area should be assessed during the next monitoring period to determine remedial actions, if necessary.

- Station 1+10. One boulder associated with the third j-hook vane has fallen into the pool immediately downstream of the structure. The structure remains intact and should be assessed during the next monitoring period to determine remedial actions, if necessary.

2.3.2 Climatic Data

Monitoring requirements state that at least two bankfull events must be documented through the five-year monitoring period. No surface water gages exist on Little Ivy Creek or its tributaries. A review of known U.S. Geological Survey (USGS) surface water gages identified two gages within 8 miles (12.8 kilometers) of the mitigation site: one along the French Broad River approximately one mile downstream of Marshall and one along Ivy Creek (referred to as "Ivy River" by the USGS) at the US 25/70 crossing between Marshall and Weaverville, immediately northwest of the Madison and Buncombe County boundary.

The Ivy River gage was utilized for this report since it is downstream of Barnhill Site and the smaller of the two gages (158 square-mile drainage area as compared to the 1,332 square-mile drainage area associated with the French Broad). It more accurately reflects hydrology and precipitation in the project area. The Ivy River gage is situated in USGS Hydrologic Unit 06010105. Datum of the gage is 1,700.41 feet above sea level NGVD29. Based on the drainage area associated with the gage, the correlated bankfull discharge according to the NC Rural Mountain Regional Curves (USACE, 2003) is between 450 and 500 cubic feet per second (cfs). A review of peak flows was conducted for the period between August 2001 and August 2003. According to the graph, there were 14 bankfull events occurring during this period, with seven of the events happening in 2003. Approximately five of these events over the two year period exceeded 1,000 cfs, well above the bankfull discharge. The USGS graph depicting these peak flows is presented below.



2.4 Conclusions

Little Ivy Creek remains stable. The left bank associated with the cut-off channel and the third j-hook vane should be closely monitored to determine if remedial actions are necessary. In addition, the sediment load should also be closely monitored to determine the overall change in bed particle size. Monitoring associated with the three cross sections and longitudinal profile will continue through 2004.

Based on information obtained from the USGS, the Barnhill Site has met the required monitoring protocols for hydrology. No supplemental work is proposed at this time.

3.0 VEGETATION

3.1 Success Criteria

The NCDOT will monitor the Little Ivy Creek Site for five years or until success criteria is met. A 320 stems per acre survival criterion for planted seedlings will be used to determine success for the first three years. The required survival criterion will decrease by 10 percent per year after the third year of vegetation monitoring (i.e., for an expected 290 stems per acre for year 4, and 260 stems per acre for year 5). The number of plants of one species will not exceed 20 percent of the total number of plants of all species planted.

3.2 Description of Species

According to the As-Built Report for the Barnhill Mitigation Site, Little Ivy Creek, Madison County (2000), the following species were planted along the streambanks:

Live Stakes

Black willow (*Salix nigra*)
Silky willow (*Salix sericea*)
Silky dogwood (*Cornus amomum*)

Bare Rooted Trees

Black willow (*Salix nigra*)
Red-osier dogwood (*Cornus stonoifera*)
Persimmon (*Diospyros virginiana*)
River birch (*Betula nigra*)
Sycamore (*Platanus occidentalis*)
Red maple (*Acer rubrum*)
Green ash (*Fraxinus pennsylvanica*)

Permanent Seeding Mix

Sensitive fern (*Onoclea sensibilis*)
Joe pye weed (*Eupatorium fistulosa*)
Swamp milkweed (*Asclepias incarnata*)
Eastern gamagrass (*Tripascum dactyloides*)
Creeping spikerush (*Eleocharis palustris*)
Green bulrush (*Scirpus atrovirens*)
Hop sedge (*Carex lupilina*)
Rice cut grass (*Leersia oryzoides*)
Soft rush (*Juncus effusus*)
Softstem bulrush (*Scirpus validus*)
Three square spikerush (*Scirpus americanus*)
Virginia wild rye (*Elymus virginicus*)
Woolgrass (*Scirpus cyperinus*)
Deertongue (*Panicum clandestinum*)
Button bush (*Cephalanthus occidentalis*)
Elderberry (*Sambucus canadensis*)
Red chokeberry (*Aronia arbutifolia*)
Silky dogwood (*Cornus amomum*)
Winterberry (*Ilex verticillata*)
Blackgum (*Nyssa sylvatica*)
Green ash (*Fraxinus pennsylvanica*)
Red maple (*Acer rubrum*)
Pin oak (*Quercus palustris*)
Black cherry (*Prunus serotina*)
Silver maple (*Acer saccharium*)

3.3 Plot Descriptions

Several vegetation plots were installed by the NCWRC during and immediately after construction. Since these plots were not staked and information regarding species was not available, eight new plots were randomly established along both streambanks within the project area. These eight plots included two large 1,000 square-foot areas along the right bank of Little Ivy Creek; Tree Plot A near Station 0+00 and Tree Plot B immediately upstream of Mr. Barnhill's driveway crossing. The remaining six plots were one-meter square plots (12.1 square feet). Stakes were placed at all four edges of the 1,000 square-foot plots and at the two opposing edges of the 12.1 square-foot plots. These stakes were flagged and labeled for future identification. Vegetation (trees) within the two 1,000 square-foot plots were flagged, tagged, and numbered. The vegetation associated with the 12.1 square-foot plots were only flagged. Due to the narrow riparian area and ease of access, the locations of these plots were not surveyed. As per conversations with Mr. Barnhill after the surveys, he had removed all representative flagging associated with the vegetation plots and cross section stakes.

Tree Plot A is situated on the right streambank facing downstream near Station 5+00. It is oriented in a general north-south direction. The dominant woody species observed were willow oak, river birch, green ash, and red maple. Section 3.4 provides numerical counts for species found within Tree Plots A and B, as well as the six small plots.

Tree Plot B is located on the right streambank immediately upstream of the driveway crossing to Mr. Barnhill's residence over Little Ivy Creek. Dominant woody species were silky dogwood and green ash.

3.4 Results of Vegetation Monitoring

Vegetation Monitoring Statistics, by Plot																	
Plot No. (Type)	**Black Willow**	**Silky Willow**	**Silky Dogwood**	**Red-osier Dogwood**	**Willow Oak**	**River Birch**	**Sycamore**	**Persimmon**	**Green Ash**	**Red Maple**	**Total 2003 (Year 1)**	**Total 2004 (Year 2)**	**Total 2005 (Year 3)**	**Total 2006 (Year 4)**	**Total 2007 (Year 5)**	**Total (at planting)**	**Density (Trees/Acre)**
Plot A (50'x20')					2	3			3	2	10					10	435
Plot B (50'x20')			1						7		8					8	348
											AVERAGE DENSITY						**391**

Vegetation Monitoring Statistics, by Plot																	
Plot No. (Type)	**Black Willow**	**Silky Willow**	**Silky Dogwood**	**Red-osier Dogwood**	**Willow Oak**	**River Birch**	**Sycamore**	**Persimmon**	**Green Ash**	**Red Maple**	**Total 2003 (Year 1)**	**Total 2004 (Year 2)**	**Total 2005 (Year 3)**	**Total 2006 (Year 4)**	**Total 2007 (Year 5)**	**Total (at planting)**	**Density (Trees/Acre)**
Plot 1 (1 meter grid)											0					0	0
Plot 2 (1 meter grid)											0					0	0
Plot 3 (1 meter grid)											0					0	0
Plot 4 (1 meter grid)											0					0	0
Plot 5 (1 meter grid)			1								1					1	3,600
Plot 6 (1 meter grid)					1						1					1	3,600
											AVERAGE DENSITY						**1,200**

Site Notes:

Vegetation plots were established during the first year of monitoring. Several plots were installed during construction; however, these plots could not be located. Specific notes regarding each plot are presented below.

Tree Plot A. Japanese honeysuckle (*Lonicera japonica*), fescue (*Festuca* sp.), plantain (*Plantago* sp.), onion (*Allium* sp.), and henbit (*Lamium* sp.) were also observed in the plot.

Tree Plot B. Woody volunteers including blueberry (*Vaccinium* sp.), black walnut (*Juglans nigra*), and black cherry (*Prunus serotina*) were also observed in the plot. Herbaceous species included Japanese honeysuckle, goldenrod (*Solidago* sp.), aster (*Aster* sp.), onion, muscadine (*Vitis* sp.), greenbrier (*Smilax* sp.), multiflora rose (*Rosa multiflora*), and fescue.

Plot 1. Fescue was observed in and immediately adjacent to the vegetation plot. One stem of green ash was noted within five feet of the vegetation plot.

Plot 2. Japanese honeysuckle, rye grass (*Lolium* sp.), and several blueberry stems were observed in and immediately adjacent to the vegetation plot. One green ash was noted within five feet of the vegetation plot.

Plot 3. Rye grass was observed in and immediately adjacent to the vegetation plot. In addition, one green ash, one red maple, one sycamore, one willow oak, and one river birch were noted within five feet of the vegetation plot.

Plot 4. Rye grass, river oats (*Uniola* sp.), and chickweed (*Stellaria* sp.) were observed in and immediately adjacent to the plot. One river birch and one green ash were noted within five feet of the vegetation plot.

Plot 5. Fescue was observed in and immediately adjacent to the plot. In addition, six silky dogwoods, one green ash, and one sycamore were noted within five feet of the vegetation plot.

Plot 6. Japanese honeysuckle, goldenrod, and vetch (*Vicia* sp.) were observed in and immediately adjacent to the plot. In addition, one black cherry was noted within five feet of the vegetation plot.

3.5 Conclusions

The 2003 vegetation monitoring of the site represents an average density of more than 600 trees per acre, well above the minimum required by the success criteria.

4.0 BIOLOGICAL INDICATORS

Personnel with the Tennessee Valley Authority (TVA) were to conduct biological sampling along Little Ivy Creek. It is unknown at this time whether or not the sampling has been conducted at the mitigation site. If this information becomes available, it will be inserted into the report at a later time.

5.0 OVERALL CONCLUSIONS

The Barnhill Site has met the required monitoring protocols for the first year of monitoring. Localized areas of active bank scour and erosion exist; however, immediate stabilization is not required at this time. These areas and all other areas will continue to be monitored during 2004. If significant problems are noted during the next monitoring period, NCDOT may conduct supplemental corrective-action work. This work would primarily include structure rehabilitation, bank stabilization, and additional riparian vegetation planting.

Based on information obtained from the USGS, the Barnhill Site has met the required hydrologic monitoring protocols. The vegetative success criteria have also been met for the first year of monitoring. No biological sampling has been conducted to-date. It is unknown whether or not this sampling will be conducted as part of overall monitoring activities.

NCDOT will continue stream and vegetation monitoring at the site for 2004.

6.0 REFERENCES

North Carolina Wildlife Resources Commission (NCWRC), 2000. As-built Report for the Barnhill Mitigation Site, Little Ivy Creek, Madison County.

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

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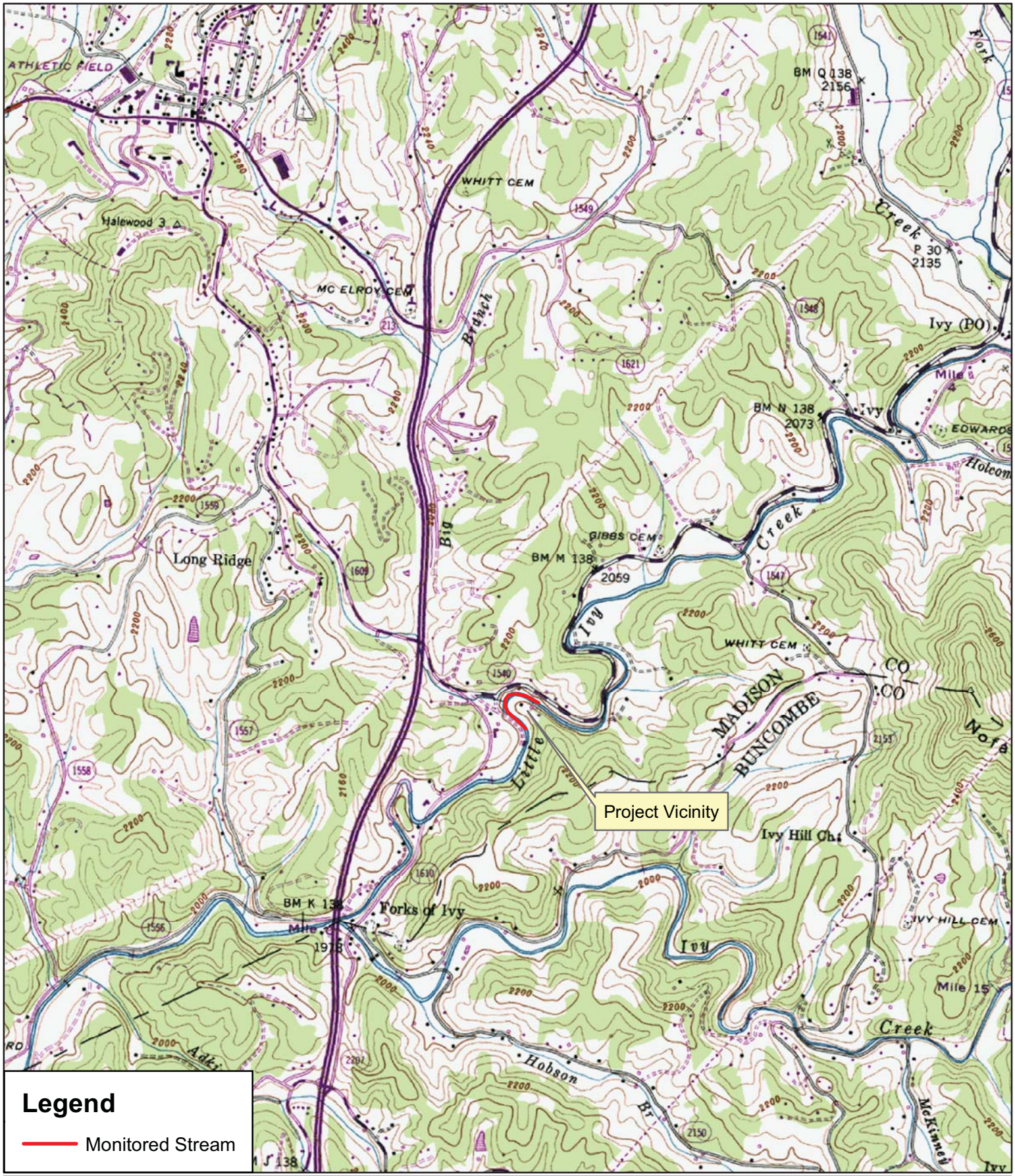
US Geological Survey (USGS), 2003. Real-time Data for USGS 03453000 Ivy River near Marshall, NC. http://waterdata.usgs.gov/nc/nwis.



Legend

Monitored Stream

MULKEY ENGINEERS & CONSULTANTS

0 1,000 2,000 3,000 4,000 Feet

0 200 400 600 800 1,000 Meters

1:24,000
USGS 7.5-Minute
Topographic Quadrangle:
Mars Hill, NC

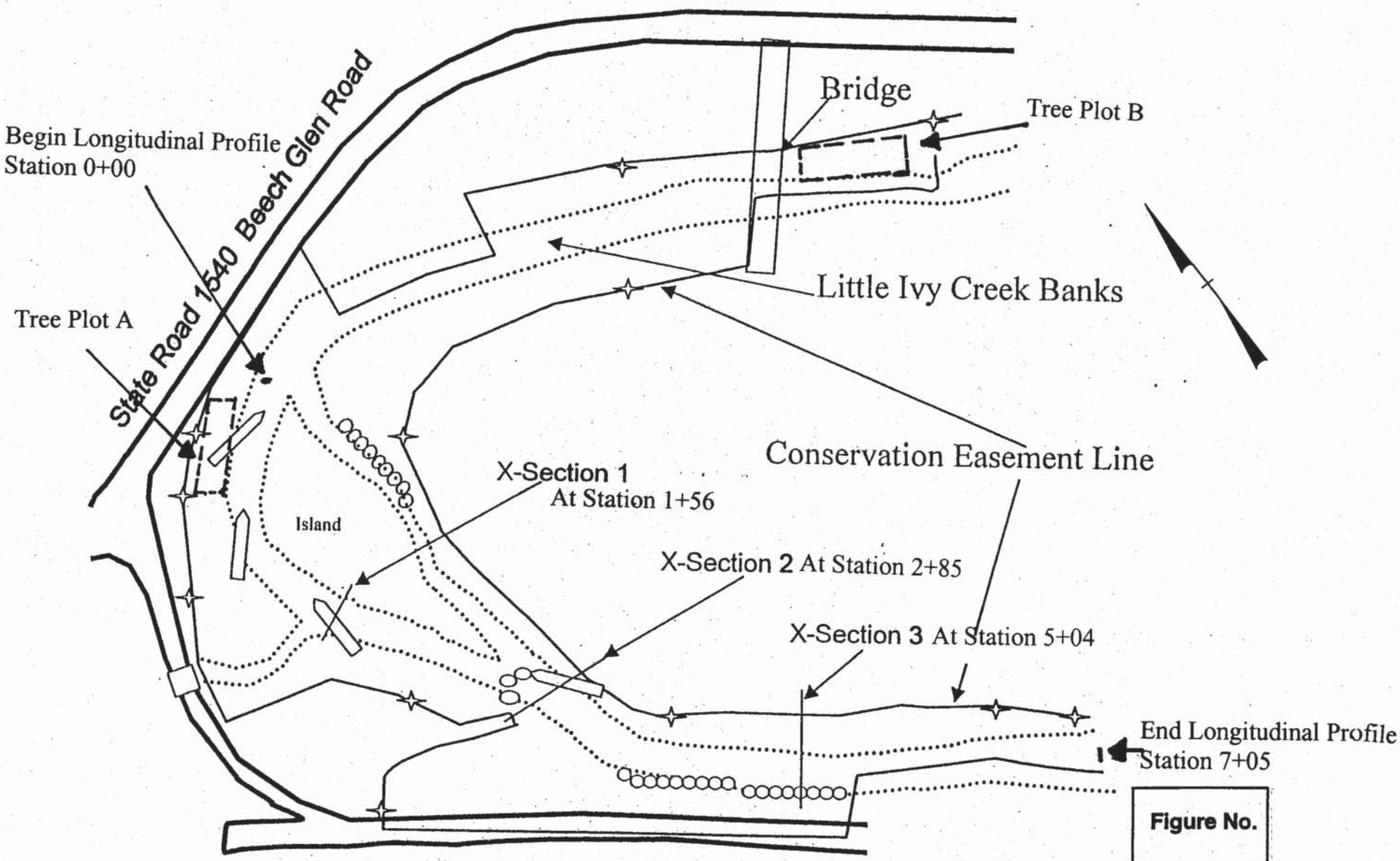
Figure No.

1

Prepared For:

PROJECT VICINITY
Barnhill Stream Mitigation Site
Little Ivy Creek
Madison County, North Carolina

Little Ivy Creek – Barnhill Site

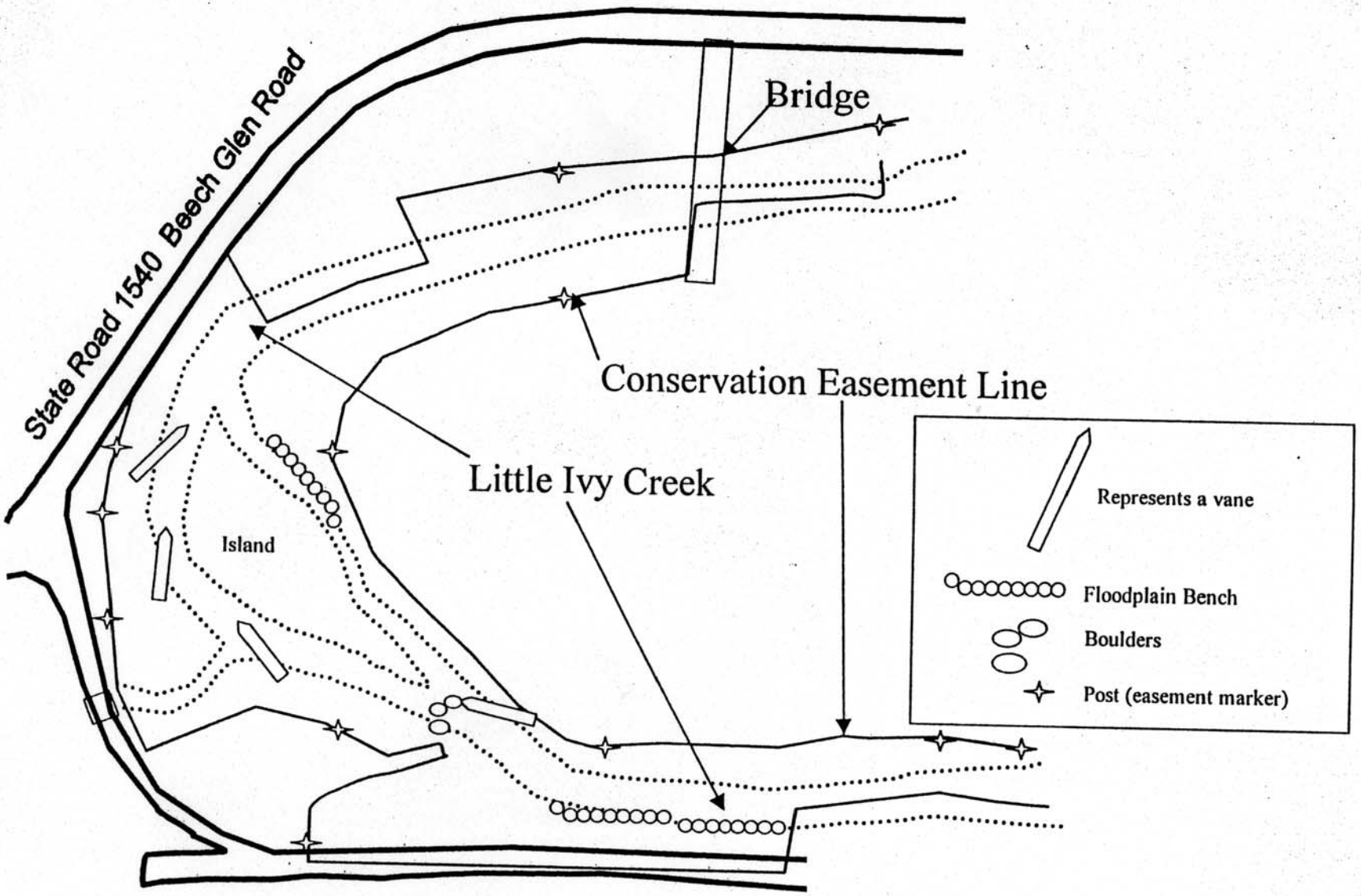


Location of cross-sections taken for monitoring postconstruction channel stability at the Barnhill Site.

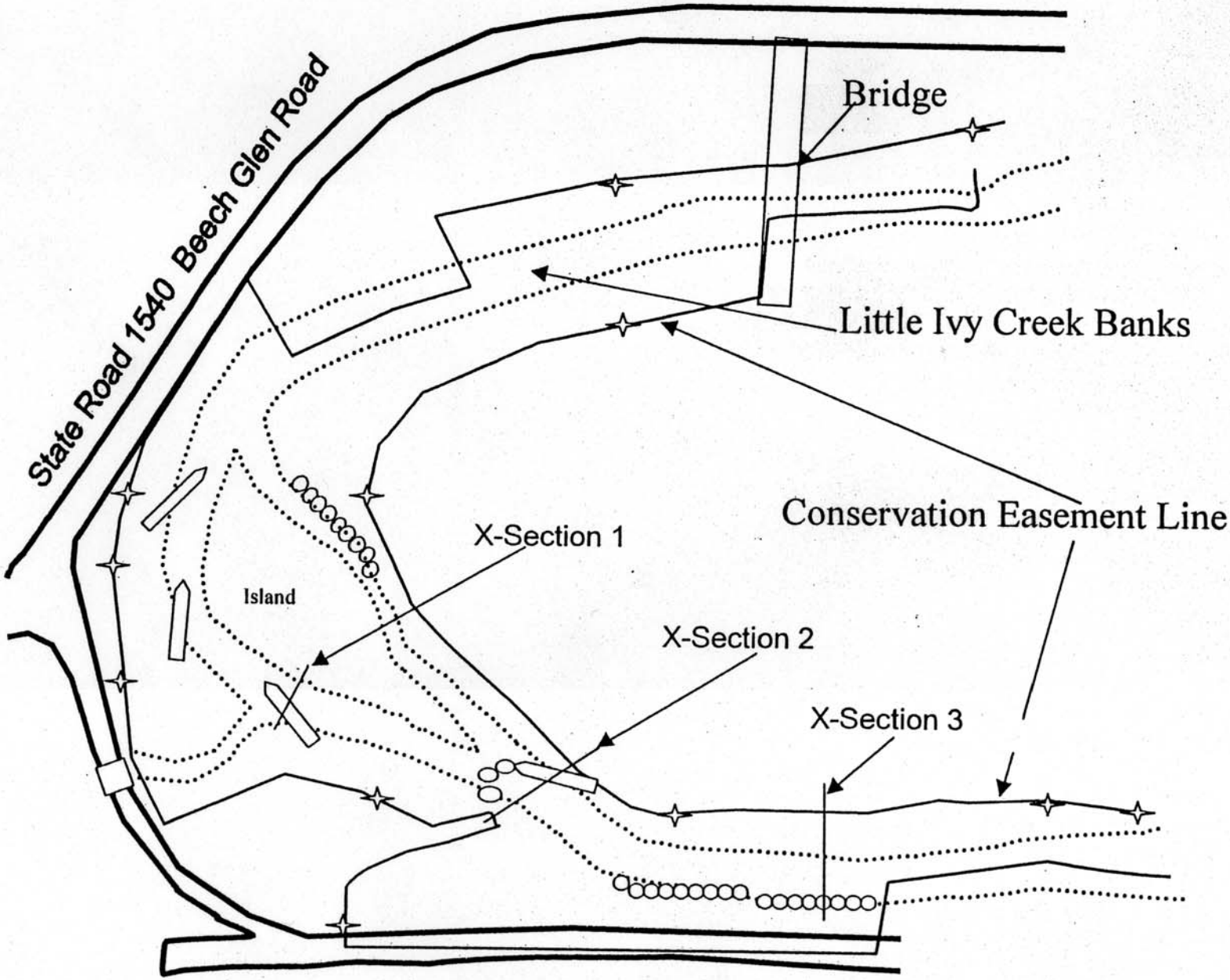
Figure No.

2

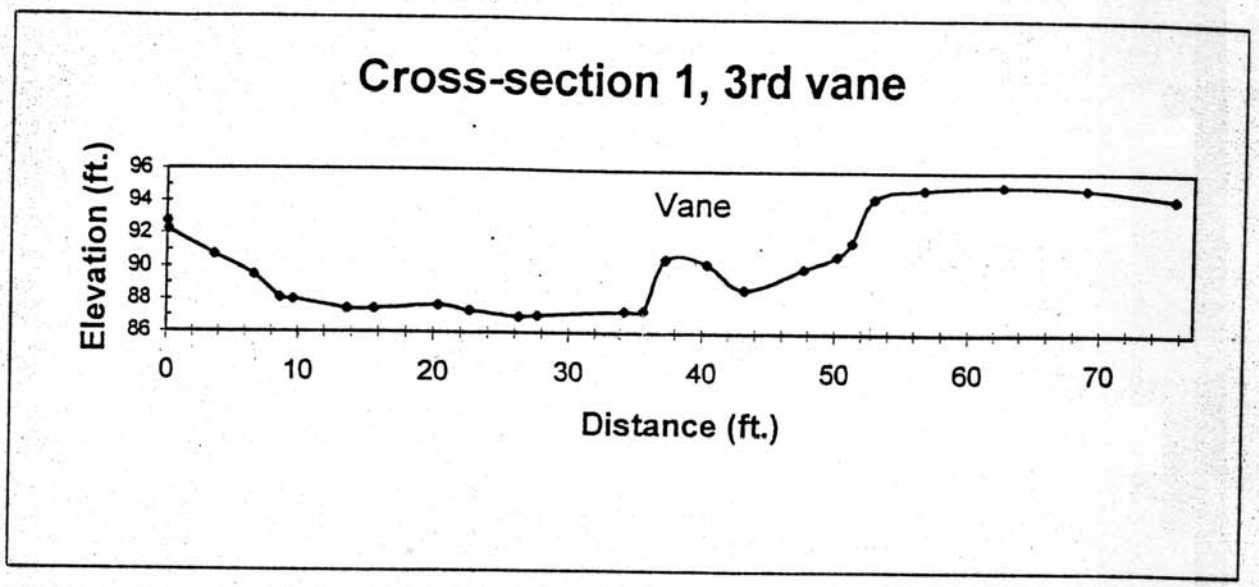
APPENDIX A
AS-BUILT DATA

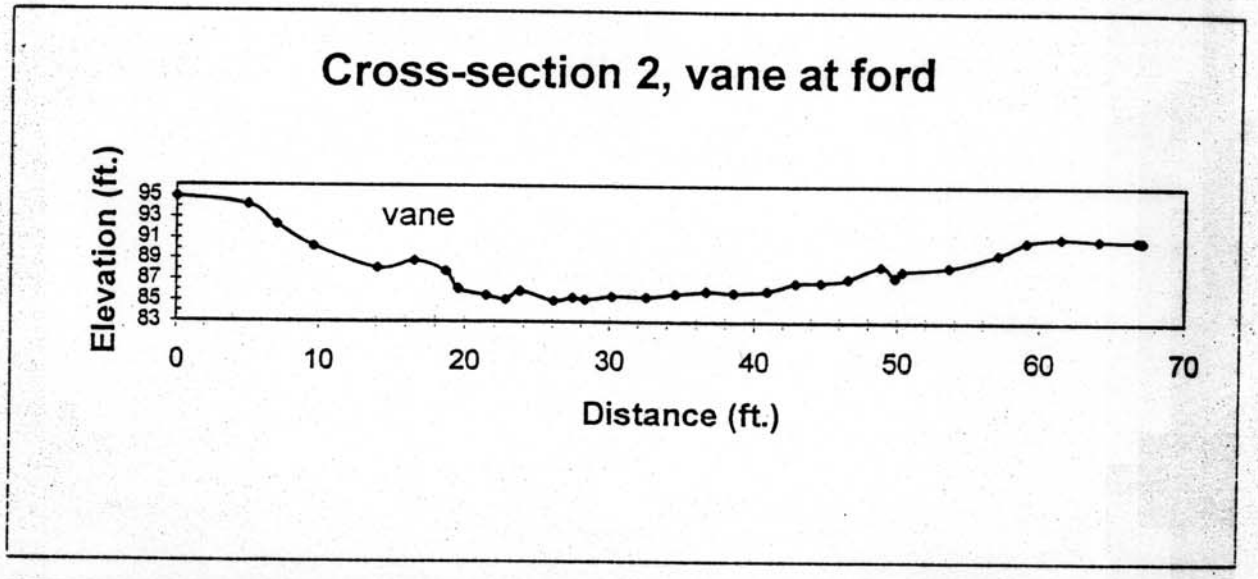


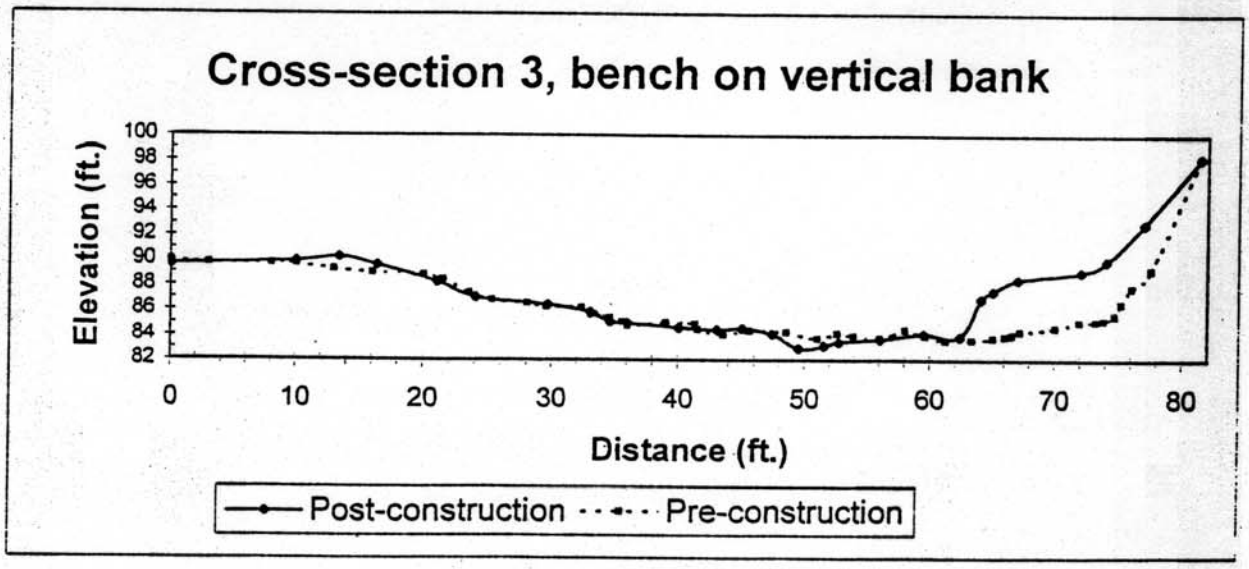
Location of vanes, boulders, floodplain benches and conservation easement markers at the Barnhill Site.

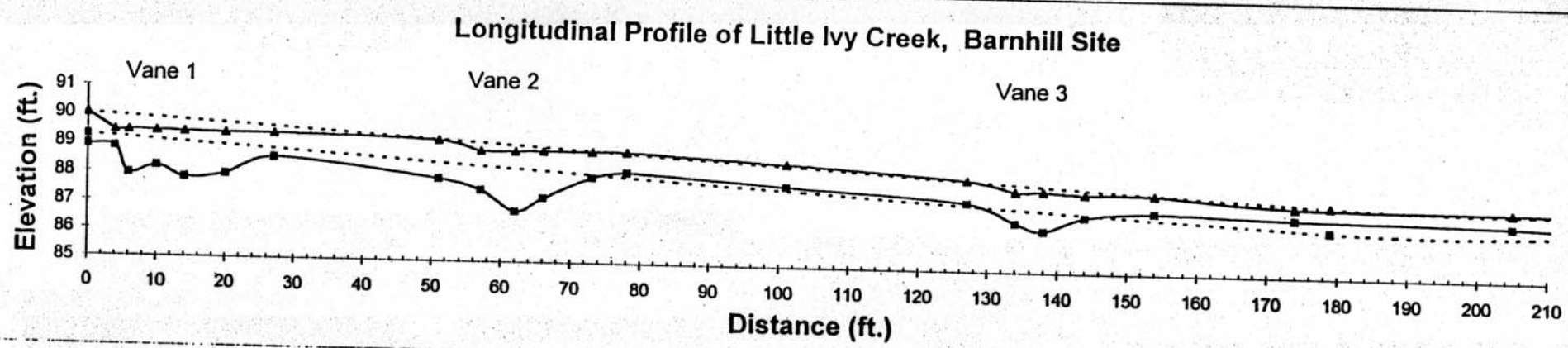


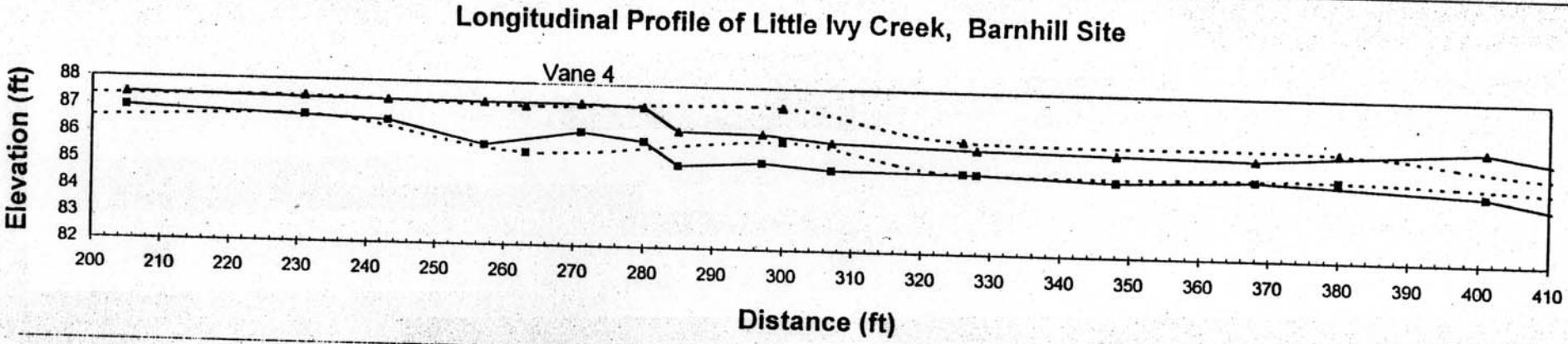
Location of cross-sections taken for monitoring postconstruction channel stability at the Barnhill Site.

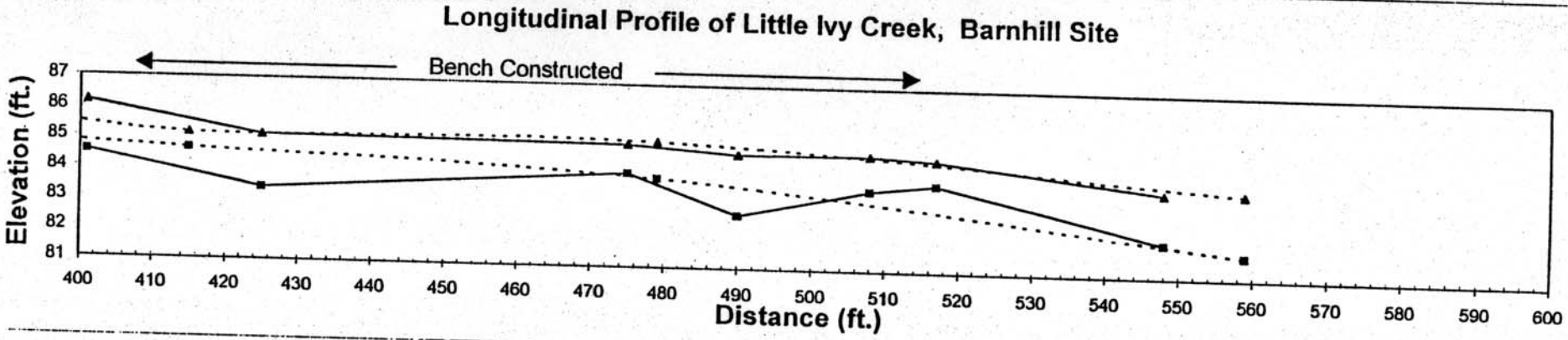

Cross-section 1, 3rd vane
Elevation (ft.)
96
94
92
90
88
86
Vane
0
10
20
30
40
50
60
70
Distance (ft.)


Cross-section 2, vane at ford
Elevation (ft.)
95
93
91
89
87
85
83
vane
0
10
20
30
40
50
60
70
Distance (ft.)


Cross-section 3, bench on vertical bank
Elevation (ft.)
100
98
96
94
92
90
88
86
84
82
0
10
20
30
40
50
60
70
80
Distance (ft.)
Post-construction
Pre-construction

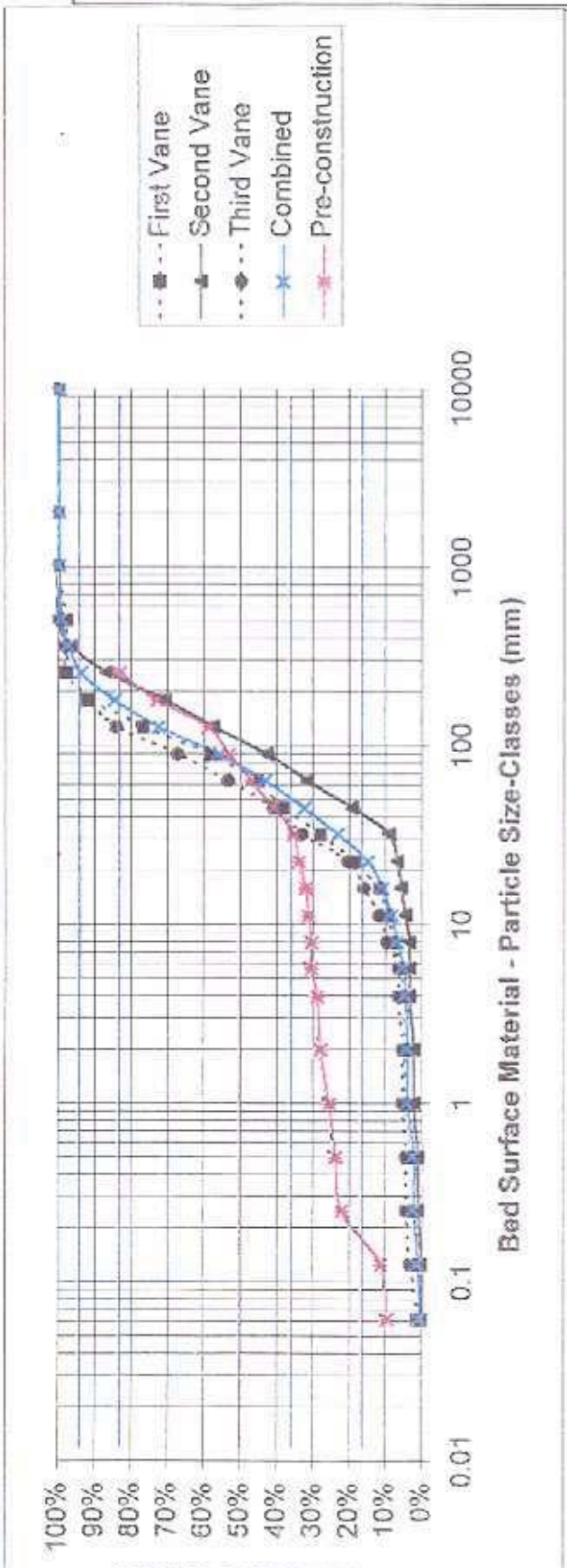


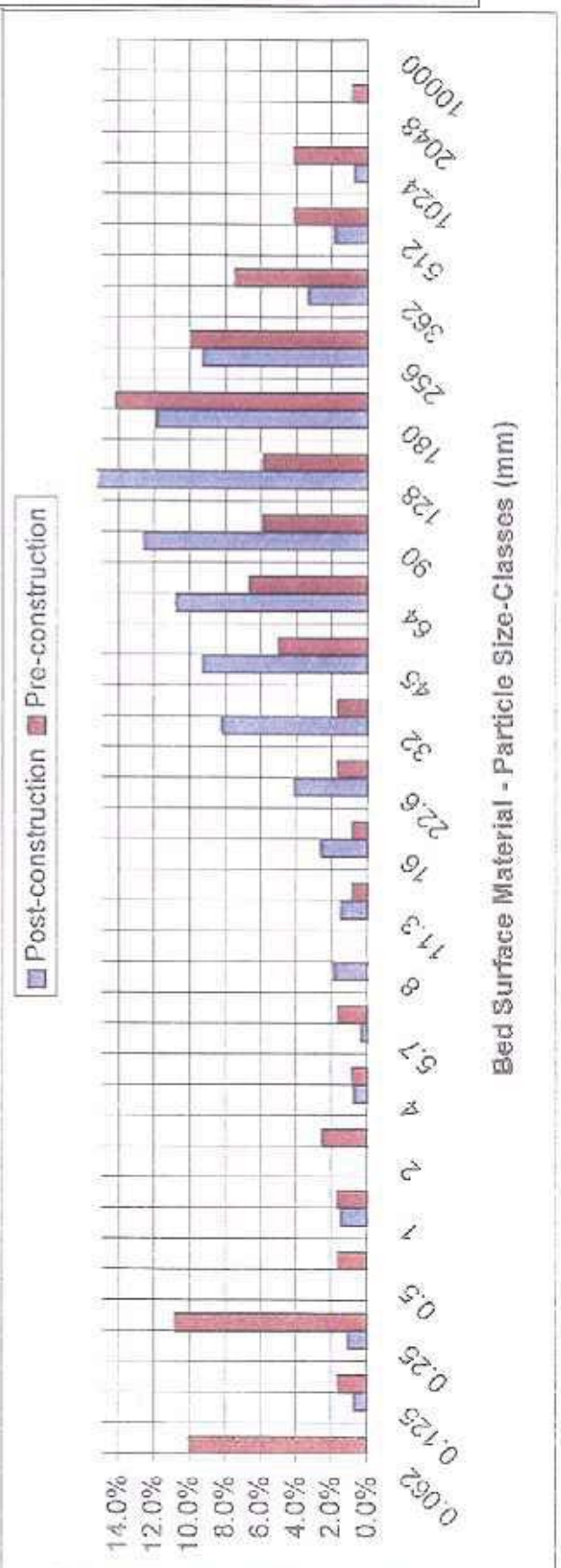


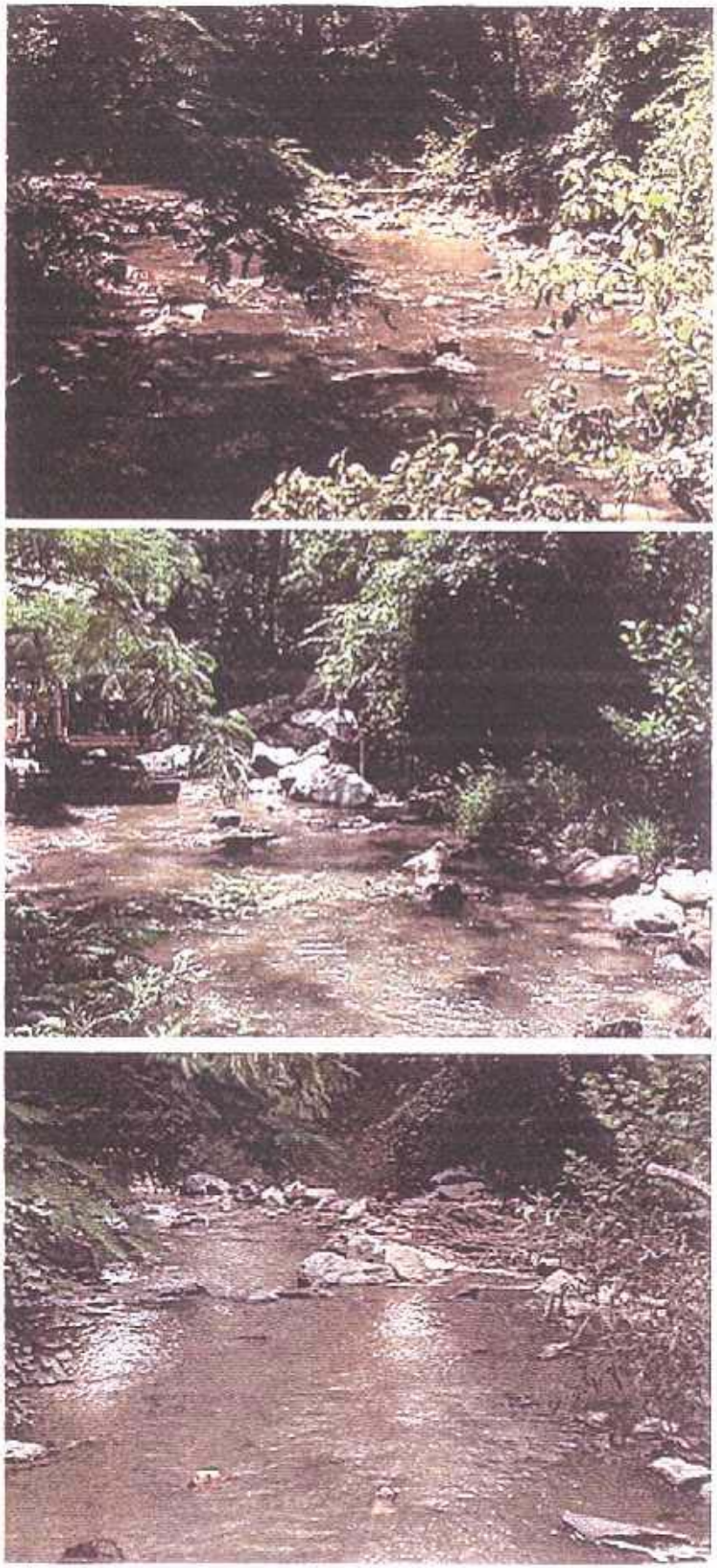


Thalwag Elevation
Preconstruction Thalwag Elevation
Bankfull Elevation
Preconstruction Bankfull Elevation

PEBBLE COUNT INFORMATION







Site of the second vane, taken from the first vane downstream. Top photo shows site before construction, middle photo is the site during construction and bottom photo is three months after construction.

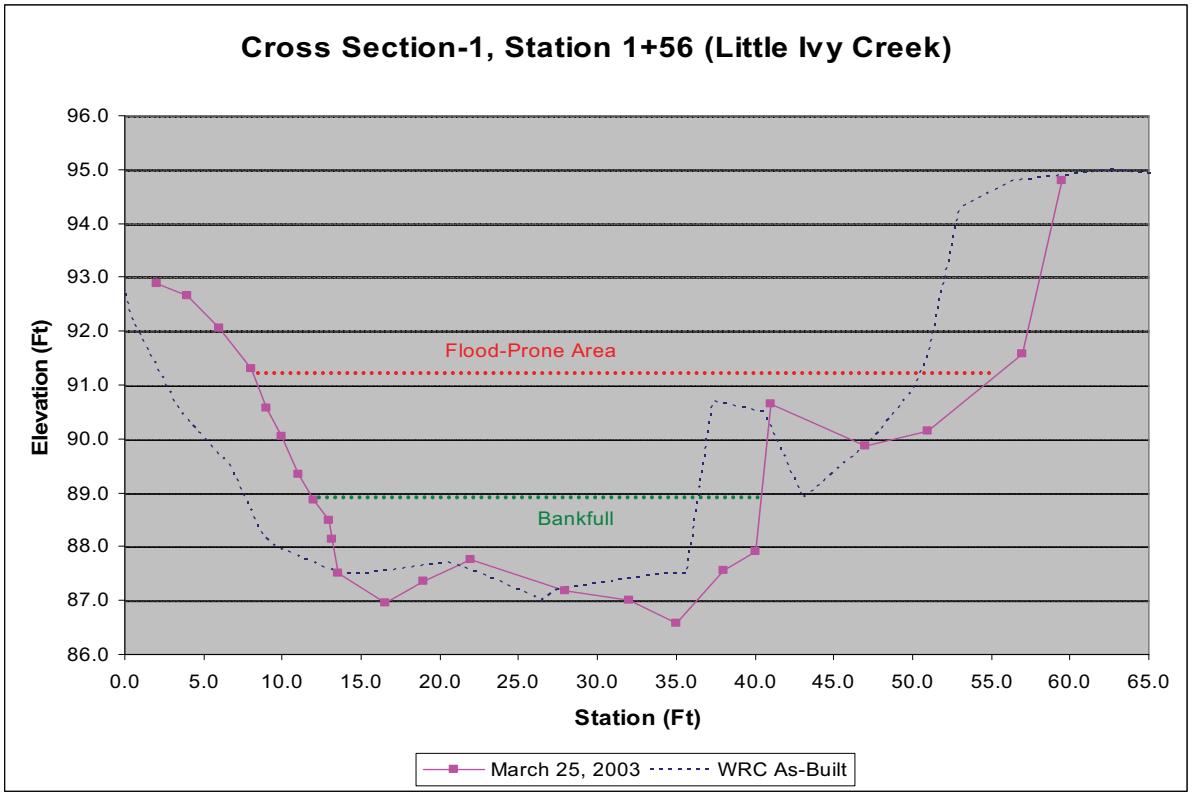
Site of second vane, taken from the third vane upstream. Top photo shows the area before construction and bottom photo shows the same area after construction, with scour hole developed.

Upper photo - the third vane after construction showing high water pooling upstream of the vane and falling toward mid-channel. Bottom photo - shows the same vane with sediment deposited above the vane as water slows and the sloped, vegetated bank.

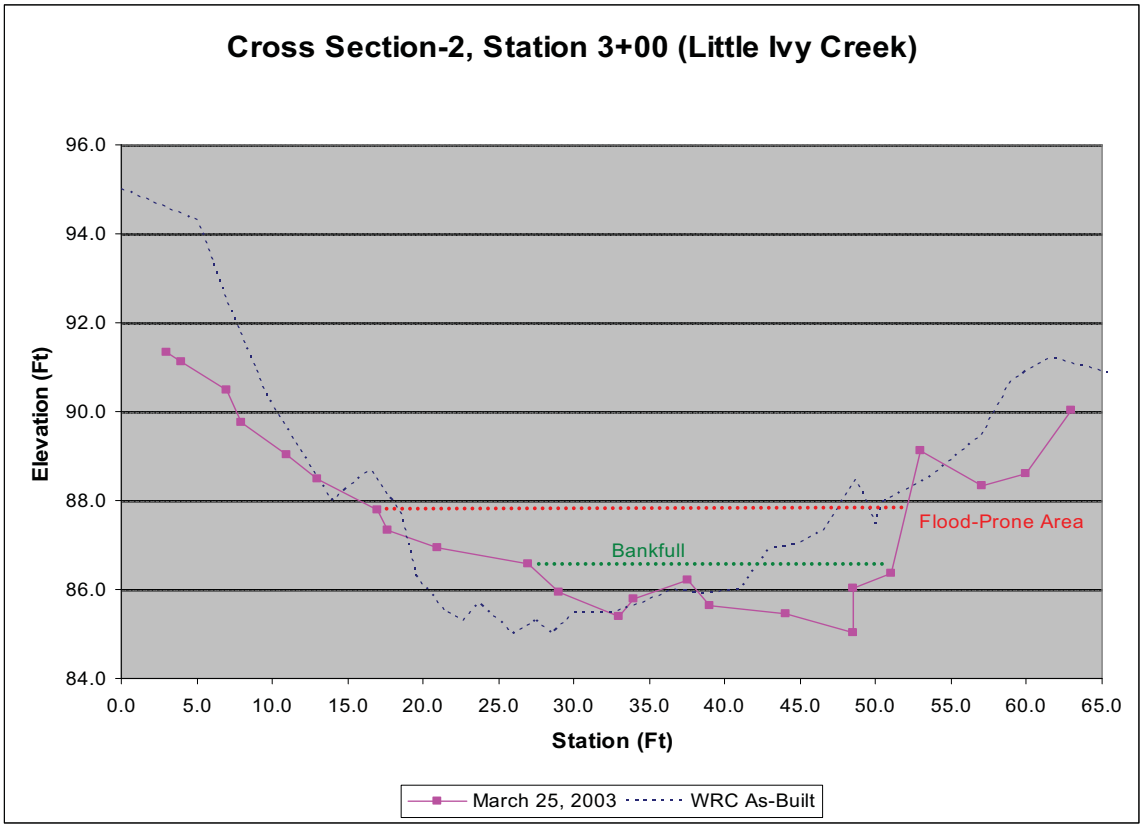
Bench construction at the lower end of the reach. Top photo shows the condition of the high vertical bank before construction. Middle photo shows construction and bottom photo shows site three months after construction.

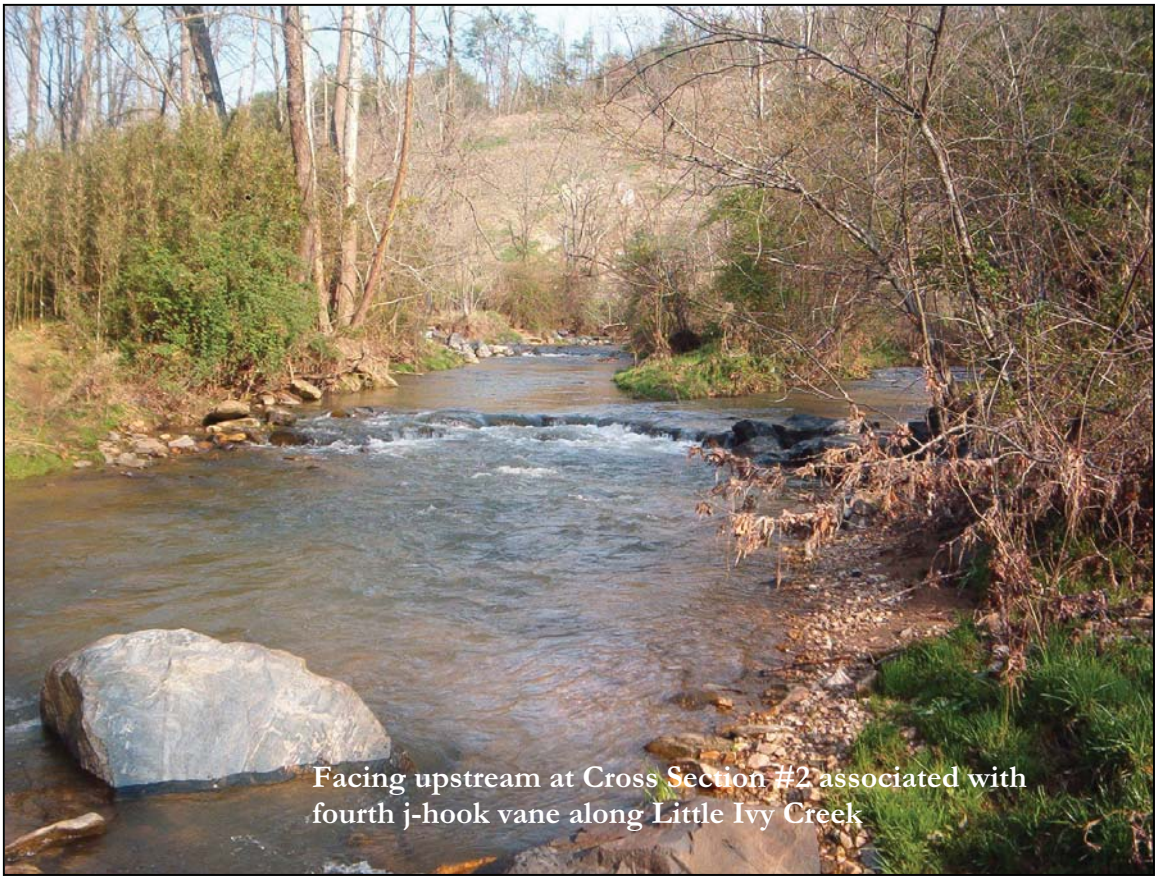
APPENDIX B

CROSS SECTIONS AND THE LONGITUDINAL PROFILE COMPARISON

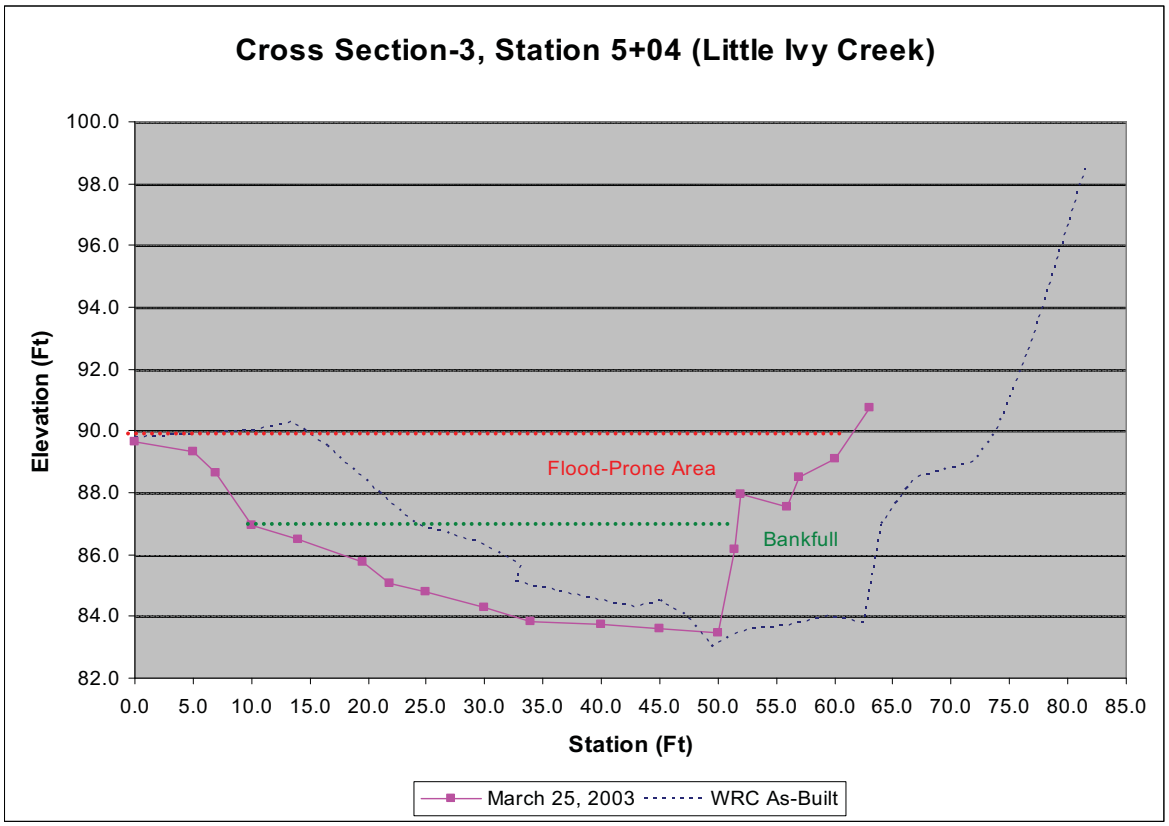


Cross Section #1 across third j-hook vane at Station 1+56 along Little Ivy Creek

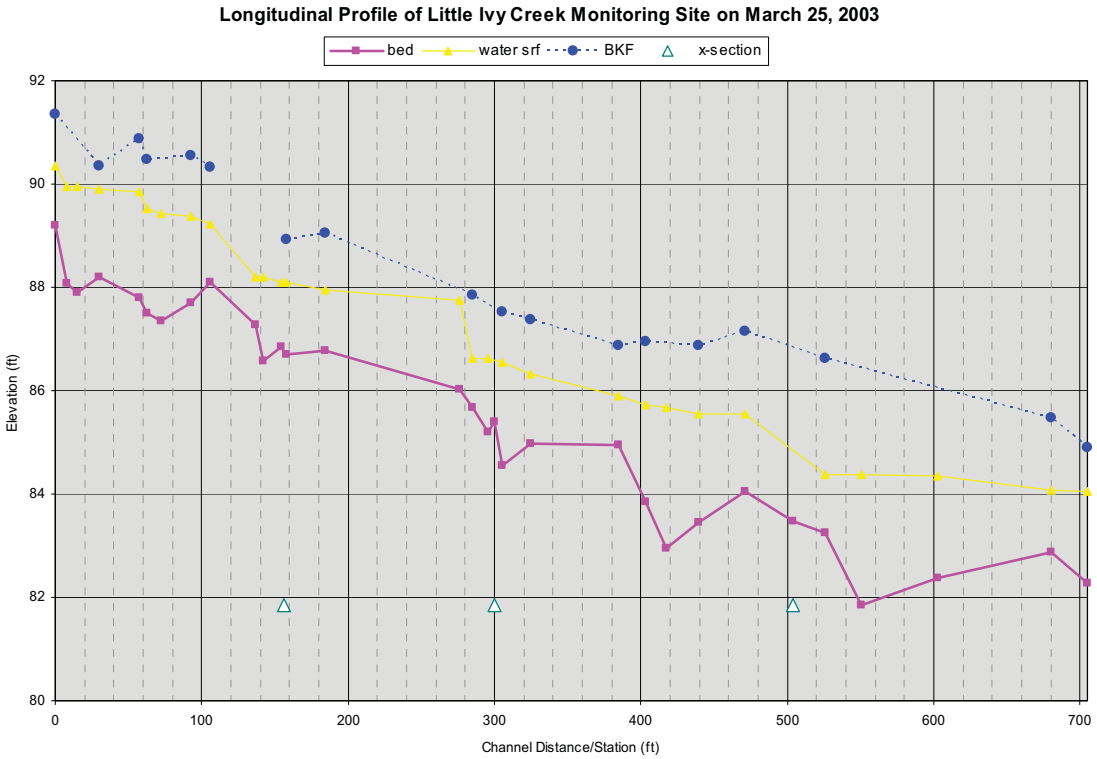




Facing upstream at Cross Section #2 associated with fourth j-hook vane along Little Ivy Creek


Cross Section-3, Station 5+04 (Little Ivy Creek)
Elevation (Ft)
100.0
98.0
96.0
94.0
92.0
90.0
88.0
86.0
84.0
82.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
55.0
60.0
65.0
70.0
75.0
80.0
85.0
Station (Ft)
Flood-Prone Area
Bankfull
March 25, 2003
WRC As-Built

Cross Section #3 at Station 5+04. The existing boulder revetment is below top of near bank


Longitudinal Profile of Little Ivy Creek Monitoring Site on March 25, 2003
bed
water srf
BKF
x-section
Elevation (ft)
Channel Distance/Station (ft)
92
90
88
86
84
82
80
0
100
200
300
400
500
600
700

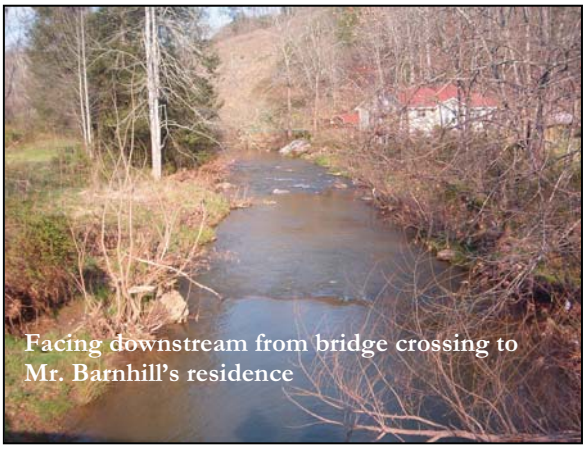
APPENDIX C

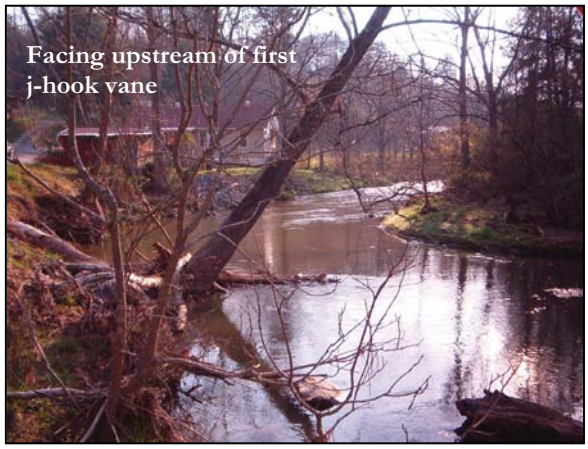
SITE PHOTOGRAPHS

Vegetation Plots

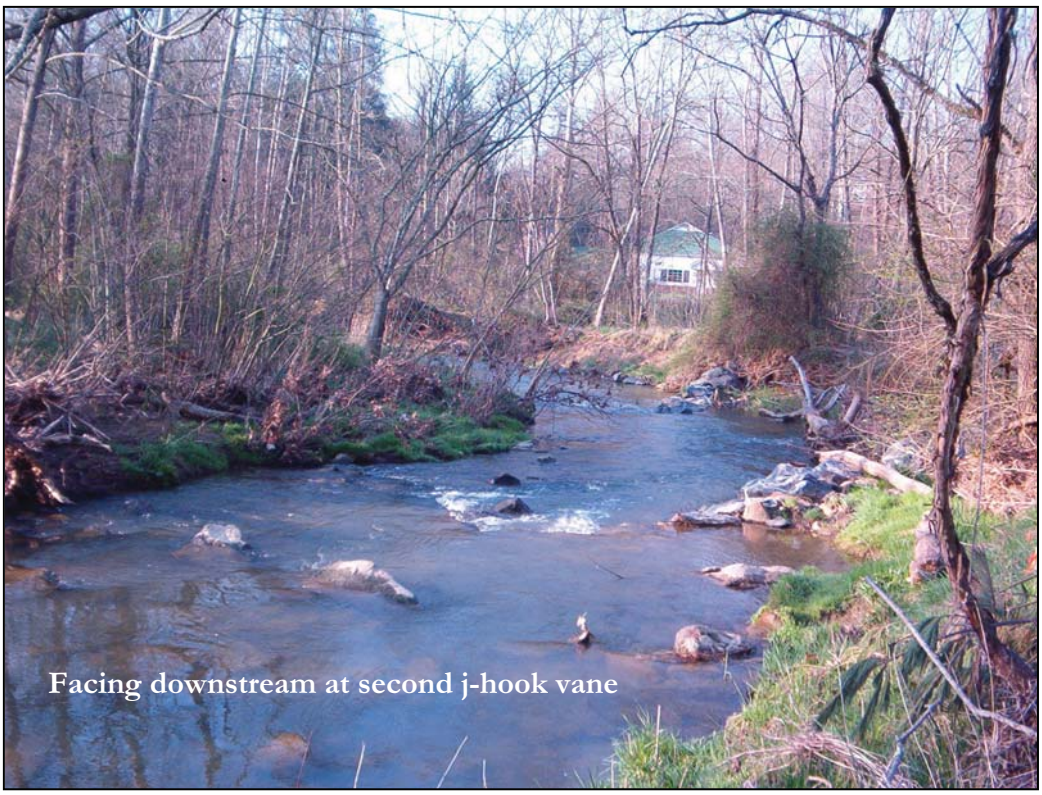
Vegetation Plots Continued

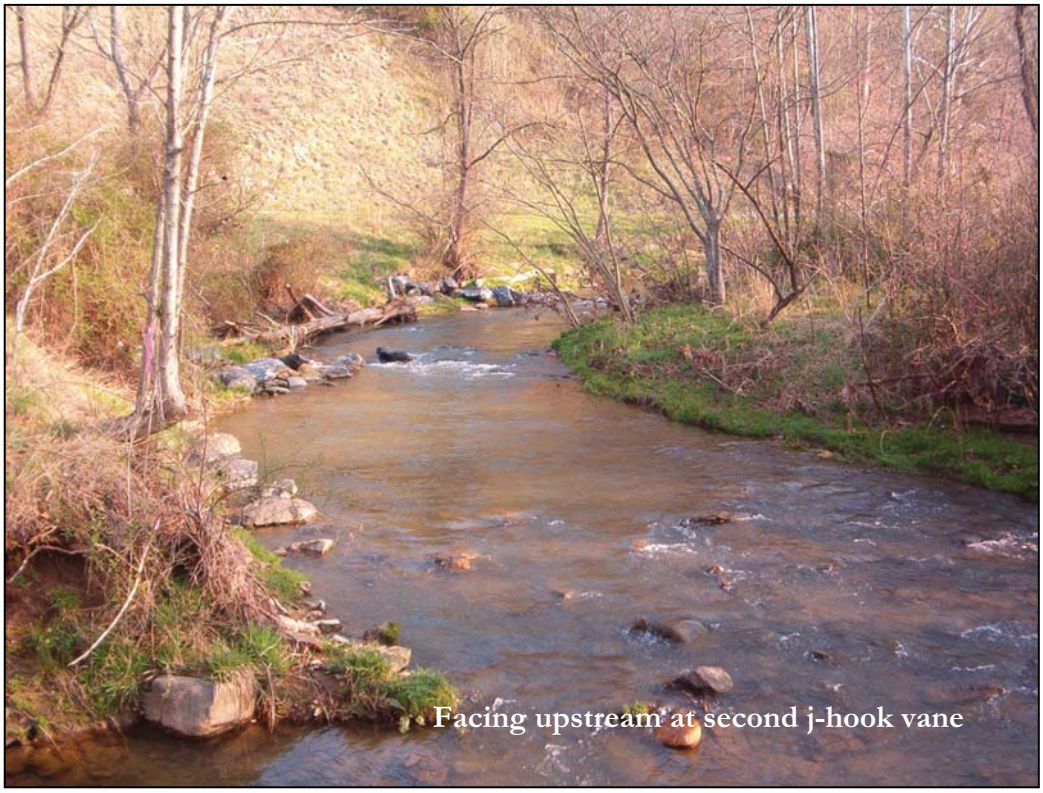
Little Ivy Creek

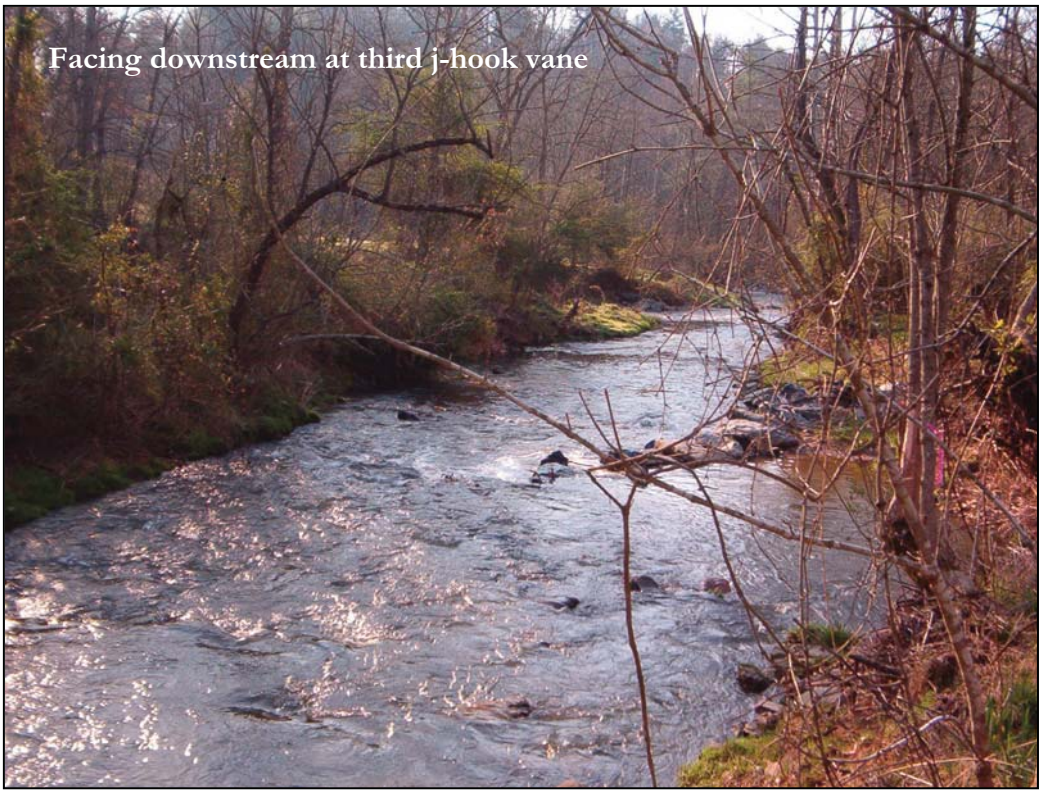


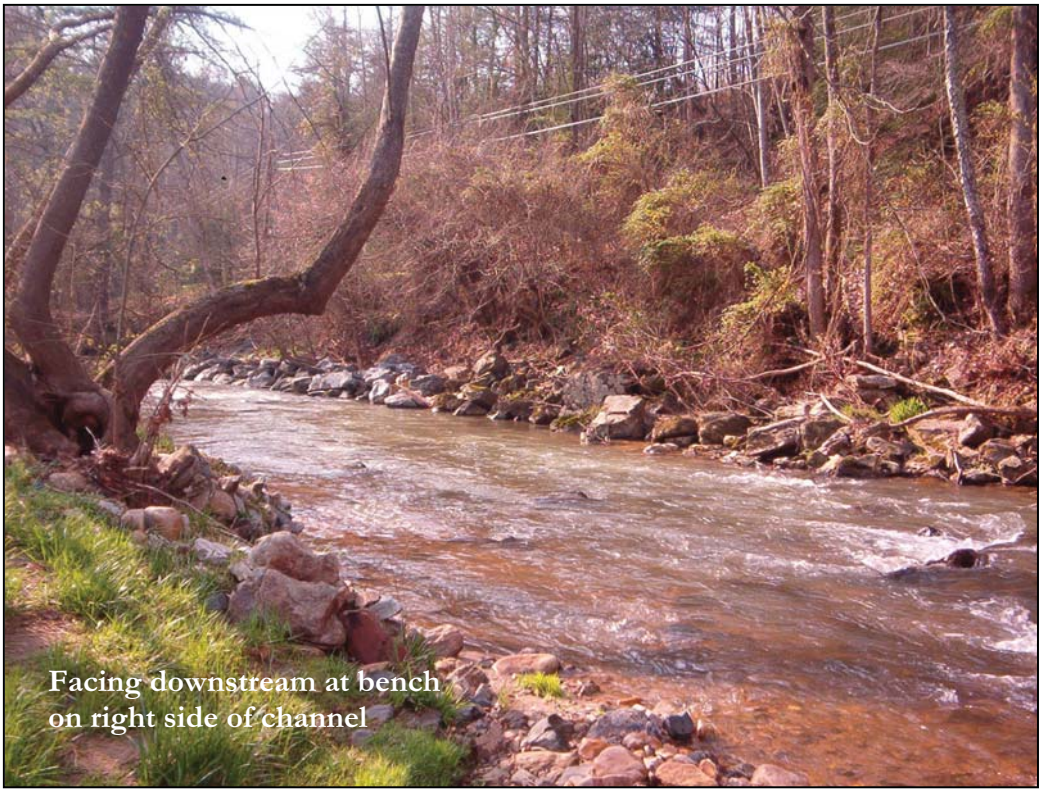


As-Built Comparisons






Facing downstream at third j-hook vane


Facing downstream at bench
on right side of channel