Stream Stabilization and Enhancement Plan

Wild Site
Obids Creek, Ashe County

NCDOT/NCWRC Stream Mitigation Program

Prepared by
North Carolina Wildlife Resources Commission
Habitat Conservation Program

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Stream Stabilization/Enhancement Plan - Wild Site on Obids Creek, Ashe County

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Introduction

This plan is submitted as partial fulfillment of the off-site stream mitigation agreement between the North Carolina Department of Transportation (DOT) and North Carolina Wildlife Resources Commission (WRC) for the R-529 US 421 road improvement project in Watauga County. Under this agreement, a total of 14,814 linear feet of stream mitigation is required by the United States Army Corps of Engineers (COE) and 7,407 linear feet of mitigation for the North Carolina Division of Water Quality (DWQ). The purpose of this plan is to document those practices used for bank stabilization and habitat enhancement along 1805 linear feet of Obids Creek located on the Wild property, Ashe County.

Objectives

The objectives of the stream restoration project on Obids Creek on the Wild property are as follows:

1. Slope and vegetate the banks at selected locations to reestablish a bankfull bench to make the banks more resistant to erosion and flooding.
2. Install rootwads and/or rock vanes or rock weirs where appropriate to provide long-term bank stability, fish habitat, and to narrow and deepen the stream channel.
3. Plant native trees, shrubs and ground cover on all disturbed banks and along the channel to provide long term bank stability, stream shading, cover and food for wildlife.
4. Exclude livestock from the riparian zone through fencing and alternate water sources as specified in the plan developed by the Natural Resource Conservation Service. A 25-foot wide riparian buffer zone is recommended along each bank.
5. Treat multiflora rose (*Rosa multiflora*) with a one time herbicide application provided by this program with follow-up treatments by the landowner, as needed to eliminate or control this exotic plant.

Existing Conditions

Obids Creek is a tributary to the South Fork New River in the New River drainage, Ashe County. The watershed area of the proposed project is approximately 3.5 square miles. Land use consists of small rural farms containing pastures and forested wood lots. Most of the flatter valleys are used to raise crops and graze livestock. Some livestock grazing also occurs on steep slopes. Much of the forestland in the watershed has been converted to agricultural land, with a good portion used for Christmas tree farming. However, a significant portion of the watershed remains in secondary growth forest. There is some conversion of agricultural land to single family home sites. Obids Creek has suffered from past and ongoing land disturbing activities within the watershed. Streambank instability from poor riparian zone management in the watershed has continued for many years, causing adverse water quality impacts through increased sedimentation from eroding streambanks.

The stream flows through an alluvial valley (Valley Type VIII) with soils in the Toxaway series. Toxaway soils consist of poorly drained and very poorly drained soils on flood plains. These soils formed in loamy alluvium deposits. Slopes range from 0 to 0.2 percent. Toxaway soils have loamy horizons 40 to 60 inches thick and are strongly acidic or semiacidic, except where the surface layer has been limed.

At the Wild site (Figure 1) the riparian zone, though narrow (less than 10 feet, each bank), is fairly intact along many sections of the stream (Figure 2). Vegetation along this narrow riparian zone consists primarily of tag alder (*Alnus serrulata*) and multiflora rose (*Rosa multiflora*) along with some silky dogwood (*Cornus amomum*), red maple (*Acer rubrum*) and black cherry (*Prunus serotina*). Livestock grazing has caused bank erosion at numerous locations within the riparian zone. Severe bank erosion is occurring at several locations void of riparian vegetation (Figure 2). The instability of streambanks at several locations is causing adverse water quality impacts through increased sedimentation. Fish cover is limited to a few undercut banks, deep pools, and a limited amount of small woody debris. The combination of these factors provides fair habitat for aquatic species.

A major tributary is located at station 2+77 and smaller spring seeps are located at stations 4+16 and 6+69. There is an existing ford at station 16+13 to 16+28 which is used for farm equipment access to pastures on the west side of Obids Creek. An abandoned stream channel is located from station 12+00 to 14+19. This abandoned channel is the result of an old beaver dam or past channelization project.

Eroding stream banks are in need of bank stabilization/enhancement work to restore the stream corridor to a more state condition. The following major bank erosion areas were noted during the survey:

Station #	Site condition
3+12 - 3+42	eroding left bank
3+91 - 4+26	eroding left bank/debris jam
5+60 - 6+00	eroding right bank
6+30 - 6+65	eroding right bank
7+75 - 8+50	eroding left bank
8+65 - 9+60	eroding right bank

10+64 - 11+30	eroding left bank
11+94 - 14+06	eroding left bank
14+20 - 14+30	eroding right bank

In addition to the above sites, there are many small bank erosion locations that are the result of cattle access. Excluding livestock from the stream riparian zone would allow for these areas to heal naturally.

Figure 3 summarizes the longitudinal profile. On the Wild property the stream is composed of 79% riffles and 21% pools. Bankfull was determined using field-identified indicators, primarily a scour line and point bar height, and evaluated using regional curve information (NCSU-Stream Restoration Institute). Bankfull was difficult to determine at most locations because livestock had destroyed most indicators. Cross-section dimension data is summarized in Figures 4 - 7. Pebble count, subpavement and pavement samples are summarized in Figures 8 - 12. Course to very course gravel is the bed material in the reach (D50 = 30 mm, Figure 8) and cross-section (D50 = 45mm, Figure 9). The weighted D50 and D 84 is 35 mm and 103 mm, respectively (Figure 10). Pavement and subpavement analysis is summarized in Figures 11 and 12. The subpavement is probably more representative of the particle sizes to be moved during a bankfull event. Stream reach data is summarized in Table 1. Sinuosity is 1.33, water surface slope 0.011 ft, valley slope 0.0135 ft, entrenchment ratios of 4.3 -5.7 and width/depth ratios of 14.2 - 25.2. Based on sinuosity, entrenchment ratio, width/depth ratio, water surface slope and streambed materials, the stream is classified as a C4 stream type.

Site Recommendations

Stream Restoration/enhancement

Table 2 summarizes the location of in-stream structures and bank stabilization improvements planned for this site. Figure 13 shows the plan view of the proposed bank stabilization and habitat enhancement structures. At selected locations (Table 2) we propose to construct rock weirs, rock vanes, log vanes, and root wad structures to improve in-stream aquatic habitat and provide long term bank stability and to reshape streambanks on a 2:1 or 3:1 grade to create a bankfull or floodplain bench (Figure 14). The purpose of this activity is to reduce streambank erosion and create an area for bank re-vegetation. Disturbed banks will be revegetated and planted with riparian shrubs and trees.

Rock/log vanes (Figure 15), rock weirs (Figure 16) and root wads (Figure 17) will be used to reduce the near bank water velocity and stress (Figures 14 - 16). Rock for vanes and weirs will be hauled from a local quarry or hauled to the site from US 421 waste areas. Root wads and logs will be hauled to the site from stockpiles along the new section of US 421. Structures will be built by a track-hoe working from the top of the bank or from within the channel if necessary. Vanes and weirs will be off-set from the bank 20-30 degrees and will be sloped from a bankfull or inner berm elevation upstream and into the bed of the stream on a 8 - 15% slope. Footer rocks will be placed approximately 2 feet below the normal stream bottom. Rock size will vary from approximately 250 pounds (2 cu feet) up to 1250 pounds (9 cu feet). Root wads will be used to protect the outside of meanders and provide in-stream cover. These structures will raise the water level in the near bank region and cause it to fall toward mid-channel, moving the thalwag to the center of the channel to create a deeper pool or run and reduce near-bank stress.

Design parameters are given in Table 3. Reference reach data was collected from 1682 linear feet of Meadow Fork in Alleghany County, South Fork New River watershed (Figure 18). Reference reach cross-section and pebble count data are given in Figures 19 and 20, respectively. Dimensionless ratios of measurements taken from the reference reach were compared with information taken onsite. This information was also compared with the NC Mountain Regional Curve data. All of this information was used in the design of this Priority 2 and 3 bank stabilization and habitat enhancement project. No change in pattern is planned. Figures 21 - 23 compare the existing condition and design dimensions for three cross-sections.

In general, the degraded stream bank and habitat conditions at this site are not the result of sediment transport problems. Unnatural aggradation is not present in that there are no unusual bars forming in the channel. The degradation that has occurred was due to mechanical modifications in the past and continued impacts from livestock grazing. However, we have evaluated the competency of the proposed bank stabilization activities to ensure that problems will not be created by this project. The proposed bank stabilization activities are competent and the channel will be able to move its bed load (Table 4, Figures 5 and 7).

Riparian Improvements

The current riparian zone provides stream shading in many locations necessary to maintain cold water temperatures during the summer months necessary for cold water aquatic species (trout). The rooting depth of existing vegetation is deep enough to provide long-term bank stability. However, at many locations a lack of riparian vegetation contributes to streambank failure and increased sedimentation.

We propose to improve the riparian zone at this site with a number of practices. "Riparian Seeding and Planting Guidelines for the WRC Mitigation Program" is located in Appendix 1. Streambanks at selected sites will

be sloped to approximately a 2:1 or 3:1 slope (Figure 14). Sloping should reduce undercutting, improve the ability of vegetation growth to cover the slope and increase the stability of the bank. This will allow the water to rise along the sloped surface rather than eroding a vertical bank. After the riverbank has been sloped it will be vegetated with sod mats removed from the existing bank or covered with erosion control matting. Disturbed areas will be reseeded with brown top millet or winter wheat/rye and with a native all-purpose grass/wildflower seed mix (Appendix 1). Woody vegetation, including live stakes and bare root vegetation will be used in all areas within the Conservation Easement boundaries. We will plant short understory growing native woody species such as tag alder (*Alnus serrulata*), silky willow (*Salix sericea*), and silky dogwood (*Cornus amomum*) along the riparian zone. On the upper banks we will plant native trees that provide shade, bank stability and cover and food for wildlife. Woody plantings will be at the rate of 320 per acre as per DWQ guidelines.

Livestock Exclusion

An important part of the stream mitigation plan is exclusion of livestock from the riparian buffer of the stream within the conservation easement boundaries (Figure 24). In a large part, livestock management will determine the success of the other practices. The Natural Resource Conservation Service (NRCS) has developed these livestock exclusion proposals (Appendix 2). The livestock plan details recommended treatments and the costs by treatment. The NRCS will administer all phases of this part of the mitigation plan.

Conservation Easement

A permit condition for a landowner participation in the stream mitigation program requires that the proposed stream restoration and riparian corridor be placed in a conservation easement (CE). The CE boundary line is determined based on the size of the stream, the amount of land needed to provide a significant vegetative cover for the stream and desires of the landowner. DOT Location and Survey has developed the CE for this site (Figure 27). The Wild CE average width is approximately 66 feet (50 to 85 feet) and encompasses 2.6 acres plus a temporary construction access. Right-of-way access to the easement by WRC personnel will be from SR 1003 Idlewild Road at the southern end of the project. The CE agreement will be between the landowner and the WRC and the CE document will be held by the WRC. A copy of the signed CE will be submitted to DWQ with the as- built survey report once the project is completed.

Erosion Control

Before any work begins on the stream, two stabilized stream crossings will be built to NRCS specifications to allow for equipment access across the stream. Crossing locations are shown on the NRCS Conservation Plan. Once the stream restoration project is completed and fenced, these crossings will remain in place as stable livestock crossing sites.

During construction, equipment will only access the stream when absolutely necessary. For this project, it is anticipated that all track hoe work can be accomplished from the top of the bank. All construction materials including rock, root wads, logs, and erosion control materials will be stockpiled at a central location at the site. To limit disturbance of soils, all equipment will travel along identified travel corridors.

Disturbance of soils will be limited to only what work can be accomplished and stabilized on a daily basis. As a structure is completed, the site will be sloped. Stockpiled soils or disturbed areas on steep slopes will have erosion control fencing installed as needed. Once the banks are sloped, they will be hand seeded with a 'native all-purpose seed mix" (10 lbs. per acre) that was prepared for this region (see attached planting guidelines) and browntop millet or winter wheat/rye grain (1 lb. per 1,000 sq. ft). The surface of the sloped bank will be covered with sod mats salvaged from the site or with excelsior erosion control matting. These materials will be anchored in place with stakes and landscape staples. We will also plant low growing woody species such as tag alder, willow and silky dogwood as dormant cuttings along the stream banks. Medium to large shrub/tree species will be planted throughout the CE area as bare-root materials during the dormant season.

Spill Containment

All equipment supplied by the contractor must be in good working order and should not be leaking any fluids that could contaminate the stream or property. In case of an accidental spill of hazardous materials (hydraulic fluids, gas, oil) two Attack Pac emergency spill kits will be on site during construction. Any spills of hazardous materials will be cleaned up immediately with contaminated soils disposed of according to state regulations.

Monitoring

Environmental components monitored at this site will be those that allow an evaluation of channel stability and improvements to fish habitat. The monitoring plan is based on the WRC Mitigation Site Monitoring Protocol for the NCWRC/NCDOT Mitigation Program. Specifically we will evaluate the success of channel modification, erosion control, shading, seeding, and woody vegetation plantings (Table 3). Biological monitoring is not required at this

site since the project is not a Priority I restoration. However, Mr. Dave Penrose, DWQ, may decide to collect samples for his own interest.

Photo Reference Sites

Photographs used to evaluate reference sites will be made before, during, and post-construction. Reference sites should be photographed at least once a year for 5 years following construction. Reference photos should be taken at approximately the same date and under similar weather conditions. After construction has taken place, reference sites should be permanently marked with stakes, above the bankfull elevation. Detailed notes and a map describing the location of reference points should be made.

The stream will be photographed longitudinally beginning at one end of the site and moving to the other end with photographs taken at delineated locations. Reference photo locations should be marked and described for future reference. Points should be close enough together to get an over all view of the reach. The angle of the shot will depend on what angle provides the best view and should be noted and continued in future shots. Reference points should not be changed unless absolutely necessary. When reference photos have to be moved the new position should be as close as possible to the old with changes noted. The new position should be used in all future photos.

Lateral Reference photo transects should be established based on criteria which is described in the initial monitoring data summary and followed in subsequent data collections. Most often these may be the reference cross-sections. Permanent photo points should be demarcated using wooden stakes and duplicated each year. Photographs will be taken of both banks at each transect. The transect line will be centered in the photographs of the bank. Photographers should make an effort to consistently maintain the same area in each photo over time. Photos of areas that have been treated differently should also be included; for example two different types of erosion control material used. This will allow for future comparisons.

Photographs will be used to subjectively evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation and effectiveness of erosion control measures. Longitudinal photos should indicate the absences of developing bars within the channel or an excessive increase in channel depth. Lateral photos should not indicate excessive erosion or continuing degradation of the bank over time. A series of photos over time should indicate successional maturation of riparian vegetation. Vegetative succession should include initial herbaceous growth, followed by increasing densities of woody vegetation and then ultimately a mature overstory with herbaceous understory.

Cross-sections

Permanent cross-sections will be established in minimum of four riffles and two pools. These cross-sections may be at the same location as those taken to develop construction plans or they may be different. New cross-sections should be developed to monitor structures or features that may have an increased risk of failure. Each cross-section should be marked on both banks to establish the exact transect location. A common benchmark should be used for cross-sections and consistently used to facilitate easy comparison of year to year data. The annual cross section survey should include points measured at all breaks in slope, including top-of-bank, bankfull, inner berm, edge of water, and thalwag. Riffle cross-sections should be classified using the Rosgen stream classification system. Data should be taken at a scale that allows the evaluation of bank and channel changes. Photos of each cross-section should be made. Data should be collected once a year for the first 3 years and then again on the 5th year to evaluate stability of the bank and channel.

There should be little or no change in as built cross-sections. If changes do take place they should be evaluated to determine if they represent a movement toward a more unstable condition (down-cutting, erosion) or are minor changes that represent an increase in stability (settling, vegetative changes, deposition along the banks, decrease in width/depth ratio). Unstable conditions that require remediation will indicate failure of restoration activities.

Longitudinal Profiles

A longitudinal profile will be developed for each site prior to construction. This profile will be duplicated on the 1st, 3rd and 5th years after construction for data comparison. The beginning and end of each profile should be well demarcated and the length should be at least 20 bankfull widths.

The as-built longitudinal profile should show that the bedform features are remaining stable, e.g. they are not aggrading or degrading. The pools should remain deep with flat-water surface slopes and the riffles should remain steep and shallow. There should be little change in the as-built longitudinal profile. Unstable conditions that require remediation will indicate failure of restoration activities.

Pebble Counts

Two types of pebble counts should be collected in each reach including 1) 100 counts reach wide stratified by the percentage of riffles and pools, and 2) 100 counts from each permanent cross section. The Wolman pebble count procedure will be used. Plots will be made showing the cumulative frequency curve and histogram for each

cross-section and reach wide. The pebble counts should be completed at the same time as the cross-sections and longitudinal surveys. The pebble count data should show a coarsening of the entire frequency distribution in the reach and a coarsening of the pools over time.

Vegetative Cover

One objective of the mitigation program is to increase the quantity of shade, through vegetative cover of the stream. This will be accomplished by planting herbaceous and woody vegetation along the riparian zone. As this vegetation grows and matures the stream should become more and more shaded, the air temperature along the stream corridor should become more stable and water temperatures should not rise in the affected reach.

The ability of planted vegetation to thermally stabilize mitigation site riparian zones will be evaluated by monitoring both water temperature and air temperature. Temperature will be sampled using StowAway® XTI recording thermometers made by Onset Computer Corporation. These thermometers will be placed upstream and downstream of the site reach and will record water temperature every hour. They will be deployed by the 1st of August each year to record the water temperature during August and September. Streams in Western North Carolina usually are the warmest during these months and begin to cool by the end of September. Water temperature will be recorded prior to construction and each year during the 5-year monitoring period. As vegetation matures, water temperature should decrease, or at least be constant, as it moves through the mitigation site for the 5 year monitoring period.

Plant Survival

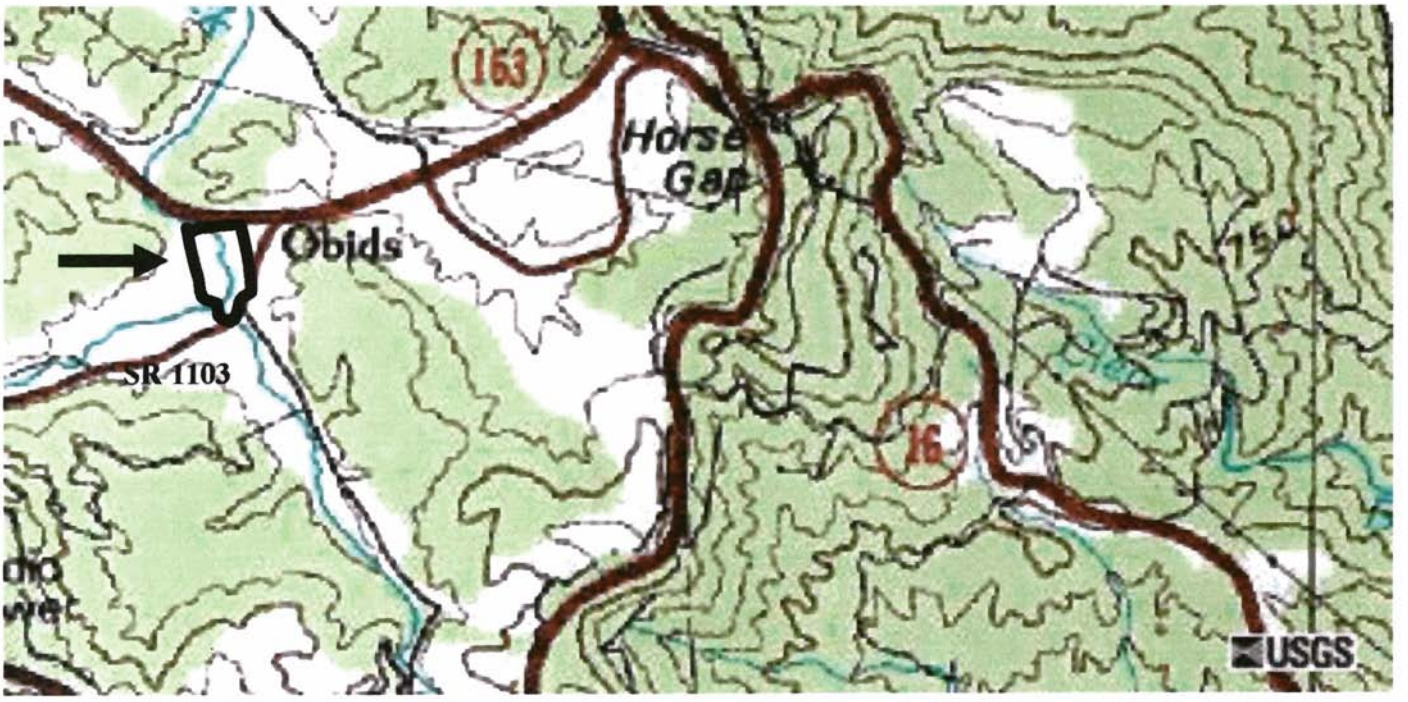
Survival of vegetation will be evaluated by visual observations and/or direct counts of planted trees and/or live stakes. Coverage by the cover crop will be evaluated at regular intervals the first 2 months following construction. Seeded areas will be subjectively evaluated using photographs. Survival of live stakes and rooted stock will be evaluated by direct counts taken the first, 3rd and 5th years after construction.

When seeded vegetation does not show satisfactory germination and plant density, plans should be made to either sow more seed, fertilize the site or both. Successful growth of seeded vegetation will be based on 75% coverage of any seeded site. Success of live stake plantings will require an 80% survival rate. Success of bare root trees will require an 80% survival rate, based on examination of all planted trees. An attempt will be made to replace all dead bare root trees. The goal is to have 320 trees per acre inside the CE boundary.

Conclusion

Past disturbances have impacted aquatic and riparian habitat along Obids Creek. Through streambank stabilization/in-stream habitat enhancement, riparian corridor enhancement and livestock exclusion the stream can be improved to resemble a more natural stream environment. Water quality will be improved through reduced sedimentation and aquatic and wildlife habitat will be improved with the return of a functioning riparian corridor.

FIGURE 1. Wild Site on Obids Creek, Ashe County



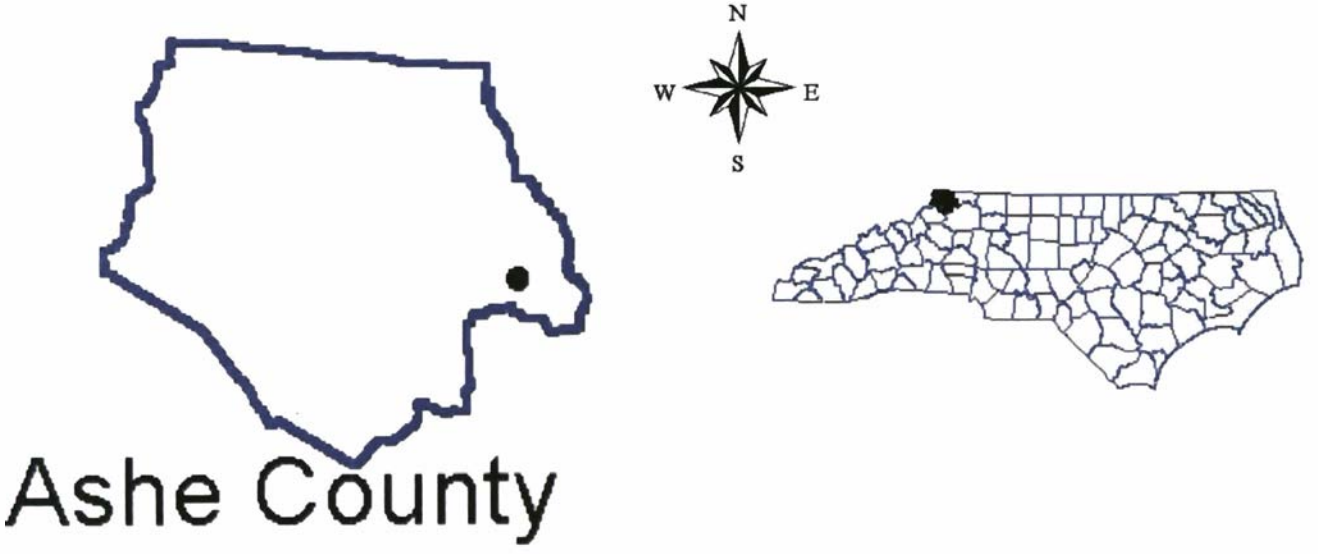
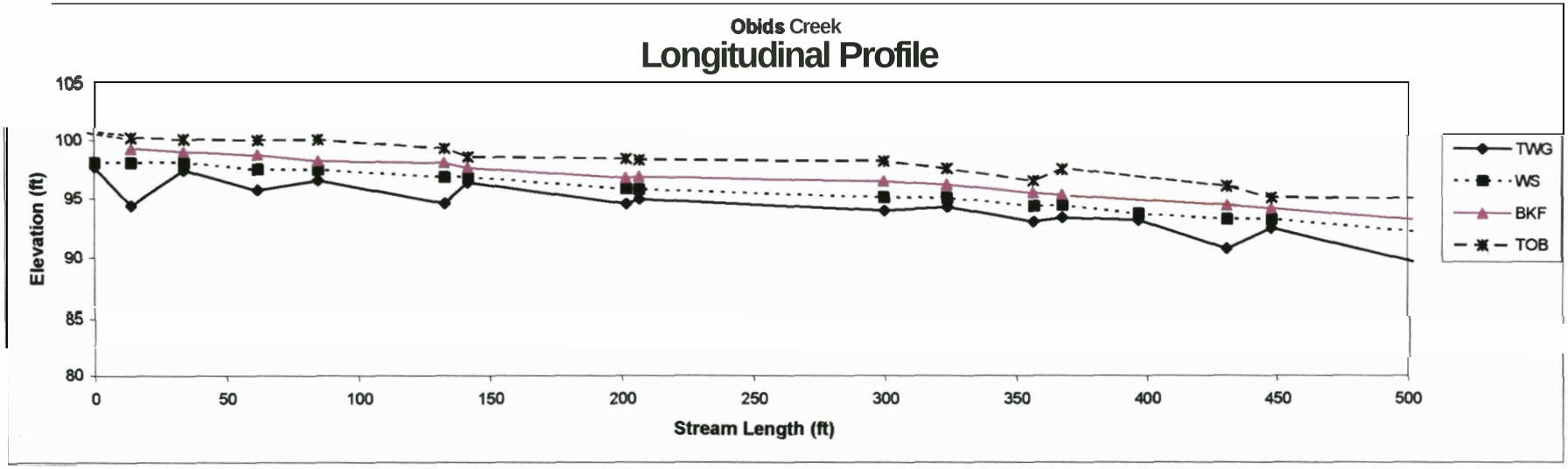


FIGURE 2: Pictures **of Obids** Creek on the Wild site, **Ashe** County, May **3,2000.**

The first three **pictures are** areas of the stream that **are** priority bank **stabilization** sections. **These are** major sites of sedimentation resulting in poor habitat and loss of riparian vegetation. Rock vanes, rock weirs, and root wads will be installed at these locations to prevent further bank erosion. Banks will be sloped and revegetated. Livestock will be **fenced** from the riparian zone for long **term protection.**

These two pictures show examples of a stable stream section. The **banks *are*** vegetated with alders and other **trees** which help prevent bank erosion, provide for stream shading and nutrient input..

FIGURE 3. Longitudinal profile of Obids Creek through the Wild property, Ashe County, May 3,2000.



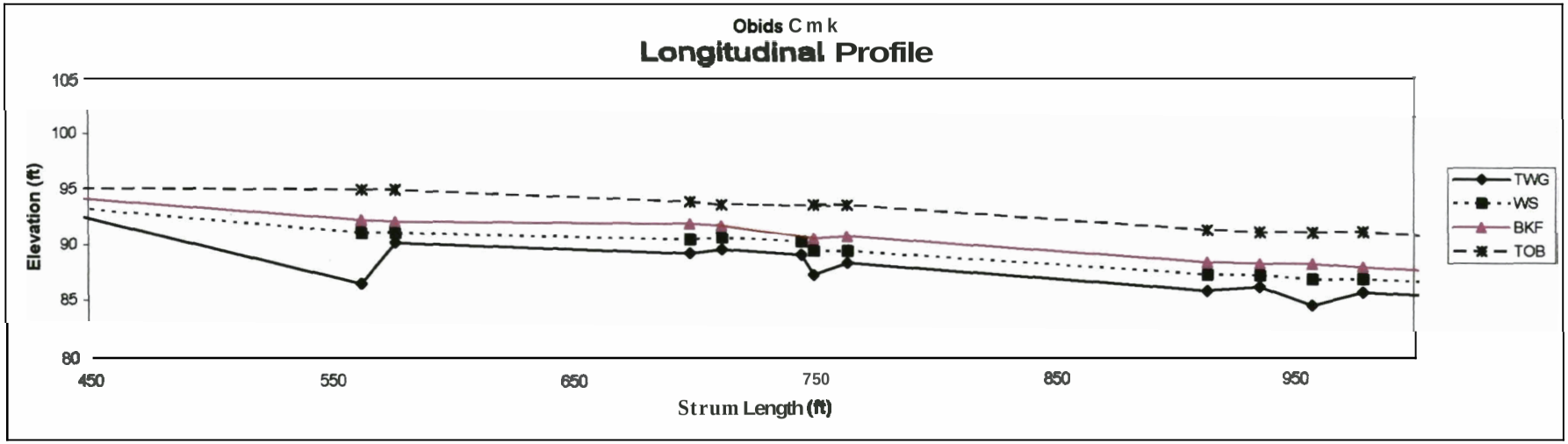


FIGURE 3. Continued.

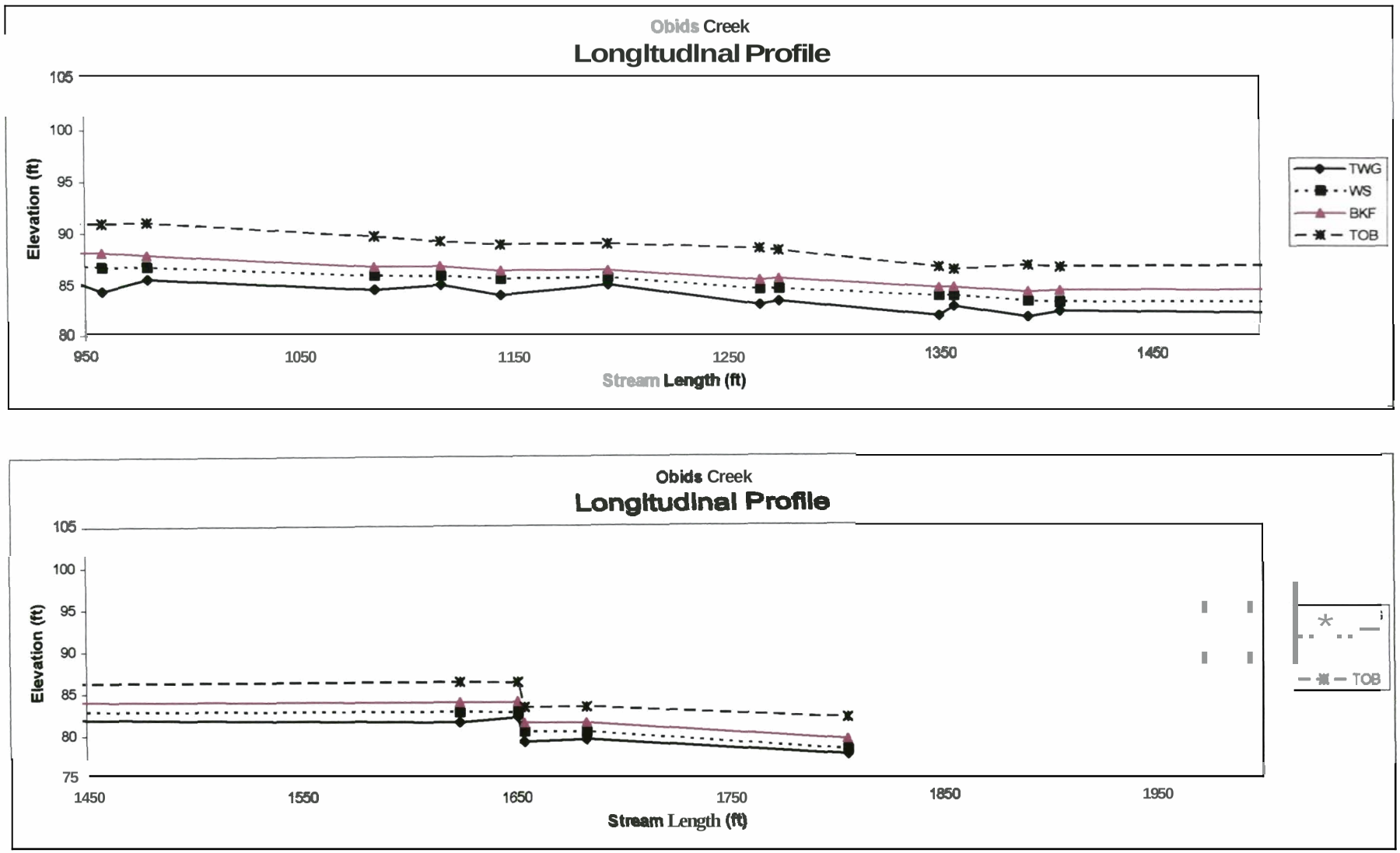
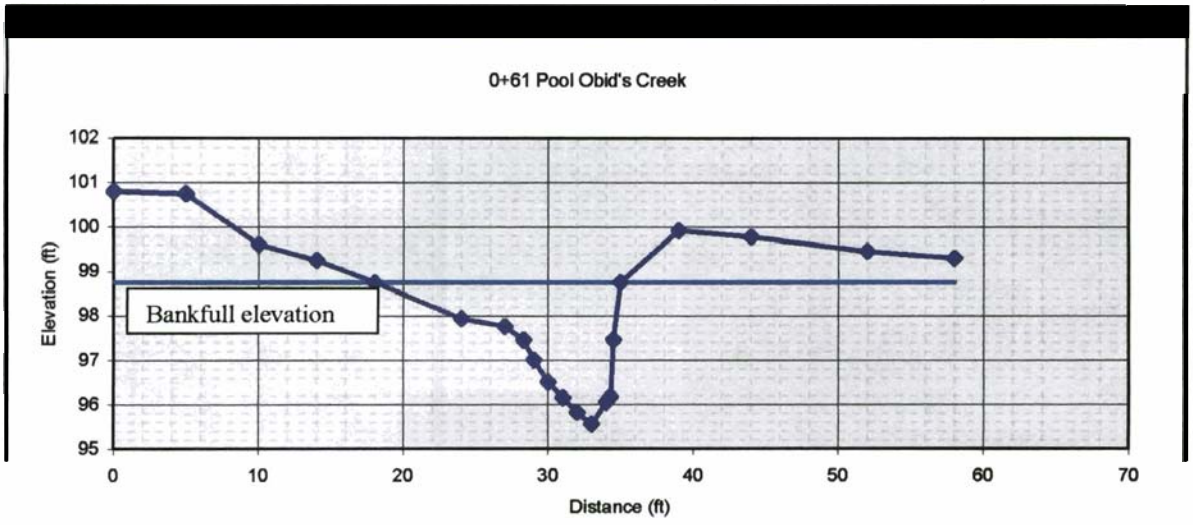


FIGURE 4. Pool cross-section 0+61 on Obids Creek, Wild site, Ashe County, May 3, 2000.



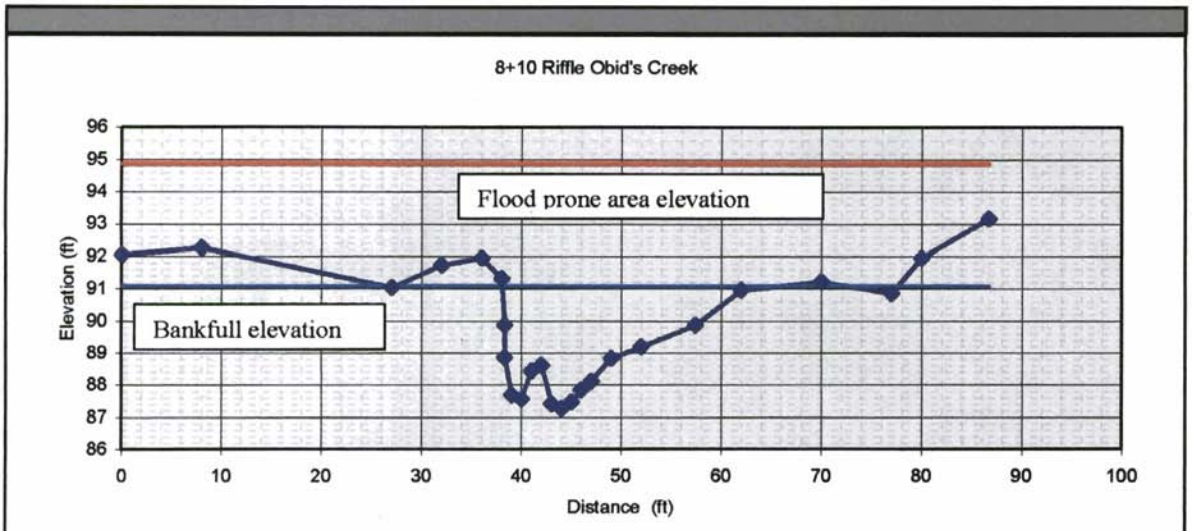
			section:	0+61					
				Pool Obid's Creek South Fork New River					
			description:						
			height of instrument (ft):	103.31					
notes	omit pt.	distance (ft)	FS (ft)	elevation		FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
PIN/TOB	☐	0	2.5	100.81		4.55	3.35			
	☐	5	2.55	100.76		98.76	99.96			
	☐	10	3.7	99.61						
	☐	14	4.05	99.26						
LBKF	☐	18	4.55	98.76						
	☐	24	5.37	97.94						
	☐	27	5.55	97.76						
WS	☐	28.3	5.85	97.46						
	☐	29	6.3	97.01						
	☐	30	6.8	96.51						
	☐	31	7.15	96.16						
	☐	32	7.47	95.84						
TWG	☐	33	7.75	95.56						
	☐	34	7.25	96.06						
	☐	34.3	7.12	96.19						
WS	☐	34.5	5.85	97.46						
RBKF	☐	35	4.55	98.76						
TOB	☐	39	3.38	99.93						
	☐	44	3.53	99.78						
	☐	52	3.85	99.46						
PIN	☐	58	4	99.31						
	☐									
	☐									
	☐									
	☐									

dimensions			
22.5	x-section area	1.3	d mean
17.0	width	19.6	wet P
3.2	d max	1.1	hyd radi
4.4	bank ht	12.9	w/d ratio
0.0	W flood prone area	0.0	ent ratio

hydraulics	
0.0	velocity (ft/sec)
0.0	discharge rate, Q (cfs)
0.00	shear stress ((lbs/ft sq)
0.00	shear velocity (ft/sec)
0.000	unit stream power (lbs/ft/sec)
0.00	Froude number
0.0	friction factor u/u*
0.0	threshold grain size (mm)

check from channel material			
156	measured D84 (mm)		
2.6	relative roughness	5.2	fric. factor
0.000	Manning's n from channel material		

FIGURE 5. riffle cross-section 8+10 on Obids Creek, Wild site, Ashe County, May 3,2000.



section:	8+10
	Riffle
	Obid's Creek
	South Fork New River
description:	
height of instrument (ft):	97.28

notes	omit pt.	distance (ft)	FS (ft)	elevation
PIN	☐	0	5.21	92.07
	☐	8	5	92.28
	☐	27	6.23	91.05
	☐	32	5.53	91.75
TOB	☐	36	5.32	91.96
LBKF	☐	38	5.95	91.33
	☐	38.3	7.4	89.88
WS/WE	☐	38.3	8.4	88.88
	☐	39	9.58	87.7
	☐	40	9.7	87.58
	☐	41	8.83	88.45
	☐	42	8.65	88.63
	☐	43	9.85	87.43
	☐	44	10	87.28
	☐	45	9.8	87.48
	☐	46	9.42	87.86
	☐	47	9.15	88.13
WS/WE	☐	49	8.43	88.85
	☐	52	8.07	89.21
	☐	57.4	7.4	89.88
RBKF	☐	62	6.3	90.98
	☐	70	6.05	91.23
	☐	77	6.4	90.88
	☐	80	5.32	91.96
PIN	☐	86.7	4.1	93.18

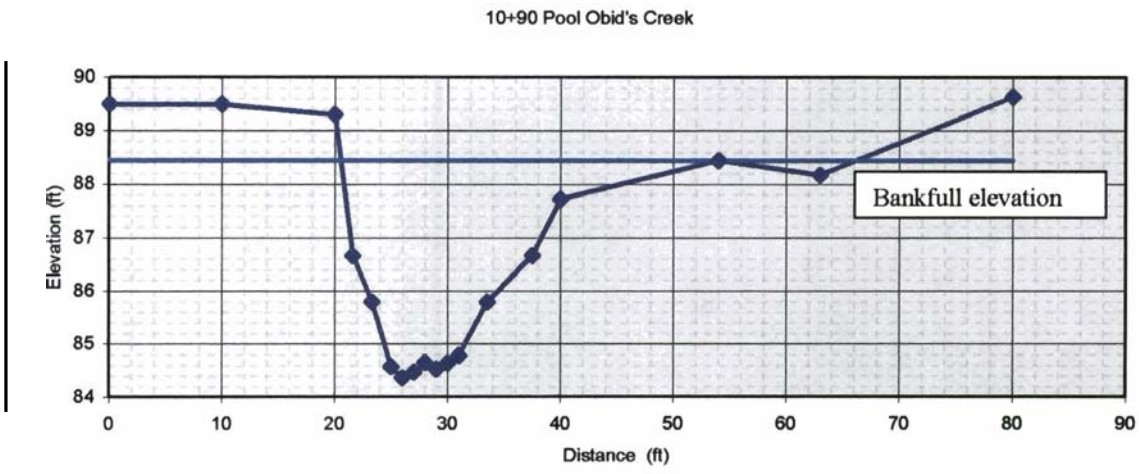
FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
6.2	5.32	100.0		
91.08	91.96			

dimensions			
51.4	x-section area	1.6	d mean
32.4	width	36.4	wet P
3.8	d max	1.4	hyd radi
4.7	bank ht	20.4	w/d ratio
100.0	W flood prone area	3.1	ent ratio

hydraulics	
0.0	velocity (ft/sec)
0.0	discharge rate, Q (cfs)
0.00	shear stress ((lbs/ft sq)
0.00	shear velocity (ft/sec)
0.000	unit stream power (lbs/ft/sec)
0.00	Froude number
0.0	friction factor u/u*
0.0	threshold grain size (mm)

check from channel material			
156	measured D84 (mm)		
3.1	relative roughness	5.6	fric. factor
0.000	Manning's n from channel material		

FIGURE 6. Pool cross-section 10+90 Obids Creek, Wild site, Ashe County, May 3, 2000.



section:	10+90
	Pool
	Obid's Creek
	South Fork New River
description:	
height of instrument (ft):	96.47

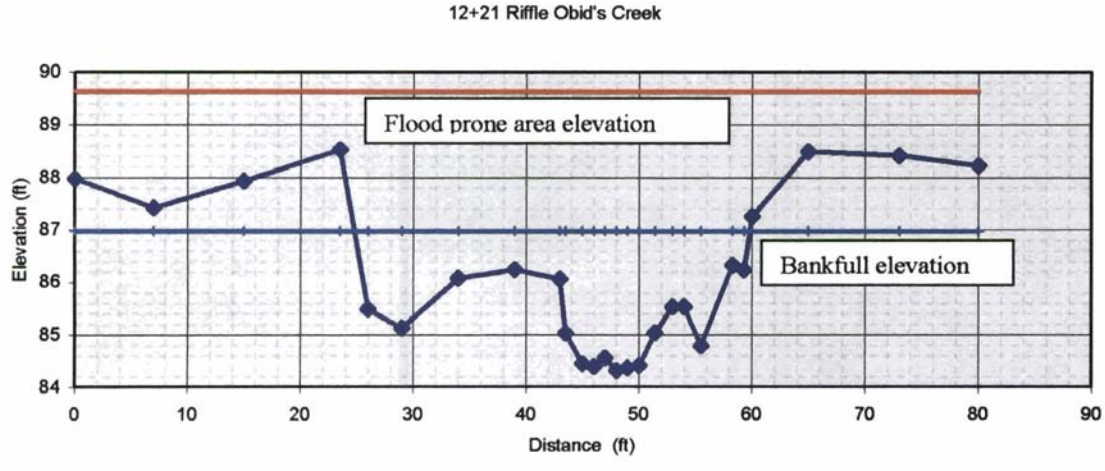
notes	omit pt.	distance (ft)	FS (ft)	elevation
PIN	☐	0	6.97	89.5
TOB	☐	10	6.97	89.5
LBKF	☐	20	7.16	89.31
	☐	21.6	9.8	86.67
WE/WS	☐	23.3	10.67	85.8
	☐	25	11.88	84.59
TWG	☐	26	12.1	84.37
	☐	27	11.99	84.48
	☐	28	11.81	84.66
	☐	29	11.93	84.54
	☐	30	11.82	84.65
	☐	31	11.68	84.79
WE/WS	☐	33.5	10.67	85.8
	☐	37.5	9.8	86.67
	☐	40	8.74	87.73
RBKF	☐	54	8.02	88.45
	☐	63	8.3	88.17
PIN	☐	80	6.83	89.64
	☐			

FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
8.02	6.97			
88.45	89.5			

dimensions			
60.2	x-section area	1.3	d mean
45.7	width	47.9	wet P
4.1	d max	1.3	hyd radi
5.1	bank ht	34.7	w/d ratio
0.0	W flood prone area	0.0	ent ratio

hydraulics	
0.0	velocity (ft/sec)
0.0	discharge rate, Q (cfs)
0.00	shear stress ((lbs/ft sq)
0.00	shear velocity (ft/sec)
0.000	unit stream power (lbs/ft/sec)
0.00	Froude number
0.0	friction factor u/u*
0.0	threshold grain size (mm)

FIGURE 7. Riffle cross-section 12+21 on Obids Creek, Wild site, Ashe County, May 3, 2000.



section:	12+21
	Riffle
	Obid's Creek
	South Fork New River
description:	
height of instrument (ft):	94.68

notes	omit pt.	distance (ft)	FS (ft)	elevation
PIN		0	6.7	87.98
		7	7.25	87.43
TOB		15	6.74	87.94
LBKF		23.5	6.15	88.53
		26	9.19	85.49
		29	9.54	85.14
		34	8.6	86.08
		39	8.43	86.25
		43	8.61	86.07
WS/WE		43.5	9.6d	85.04
		45	10.23	84.45
		46	10.28	84.4
		47	10.12	84.56
TWG		48	10.36	84.32
		49	10.31	84.37
		50	10.26	84.42
WS/WE		51.4	9.6d	85.04
		53	9.14	85.54
		54	9.14	85.54
		55.5	9.88	84.8
		58.3	8.35	86.33
		59.3	8.43	86.25
RBKF		60	7.42	87.26
		65	6.19	88.49
		73	6.26	88.42
PIN		80	6.45	88.23

FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
7.7	6.74	100.0		
86.98	87.94			

dimensions			
51.8	x-section area	1.5	d mean
35.0	width	37.8	wet P
2.7	d max	1.4	hyd radi
3.6	bank ht	23.7	w/d ratio
100.0	W flood prone area	2.9	ent ratio

hydraulics	
0.0	velocity (ft/sec)
0.0	discharge rate, Q (cfs)
0.00	shear stress ((lbs/ft sq)
0.00	shear velocity (ft/sec)
0.000	unit stream power (lbs/ft/sec)
0.00	Froude number
0.0	friction factor u/u*
0.0	threshold grain size (mm)

check from channel material			
156	measured D84 (mm)		
2.9	relative roughness	5.5	fric. factor
0.000	Manning's n from channel material		

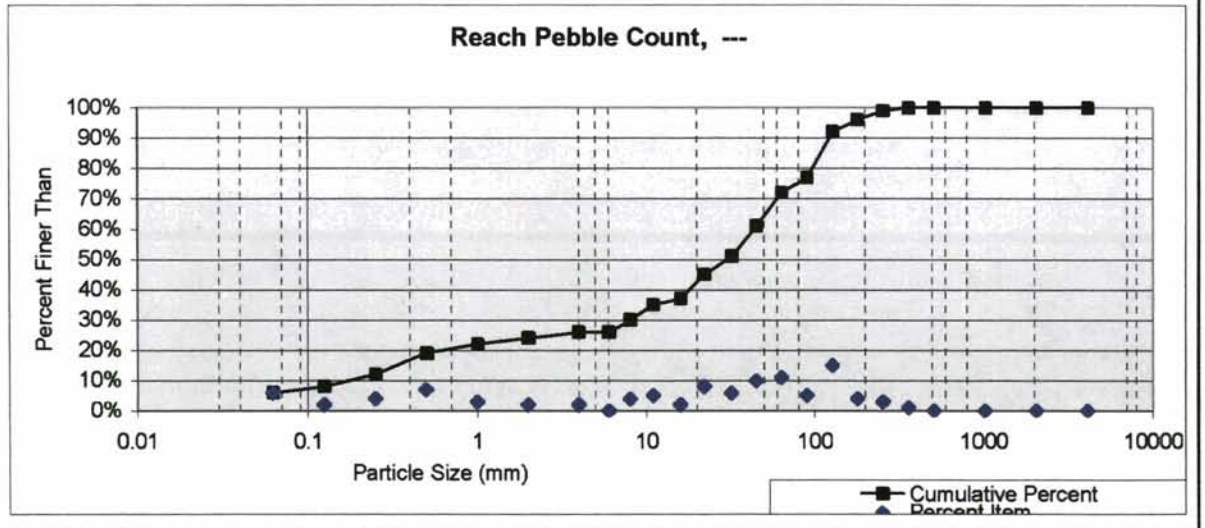
FIGURE 8. Reach pebble count summary, Obids Creek, Wild site, May 3, 2000.

Reach Pebble Count

Pool Pebble Count,

Obid's Creek
South Fork New River
Wild Site
Note:

Material	Size Range (mm)		Count
silt/clay	0	0.062	**6**
very fine sand	0.062	0.13	**2**
fine sand	0.13	0.25	**4**
medium sand	0.25	0.5	**7**
coarse sand	0.5	1	**3**
very coarse sand	1	2	**2**
very fine gravel	2	4	**2**
fine gravel	4	6	
fine gravel	6	8	**4**
medium gravel	8	11	**5**
medium gravel	11	16	**2**
coarse gravel	16	22	**8**
coarse gravel	22	32	**6**
very coarse gravel	32	45	**10**
very coarse gravel	45	64	**11**
small cobble	64	90	**5**
medium cobble	90	128	**15**
large cobble	128	180	**4**
very large cobble	180	256	**3**
small boulder	256	362	**1**
small boulder	362	512	
medium boulder	512	1024	
large boulder	1024	2048	
very large boulder	2048	4096	
bedrock			
Total Particle Count:			100



Size percent less than (mm)				
D16	D35	D50	D84	D95
0.371	11.00	30.1	106	165

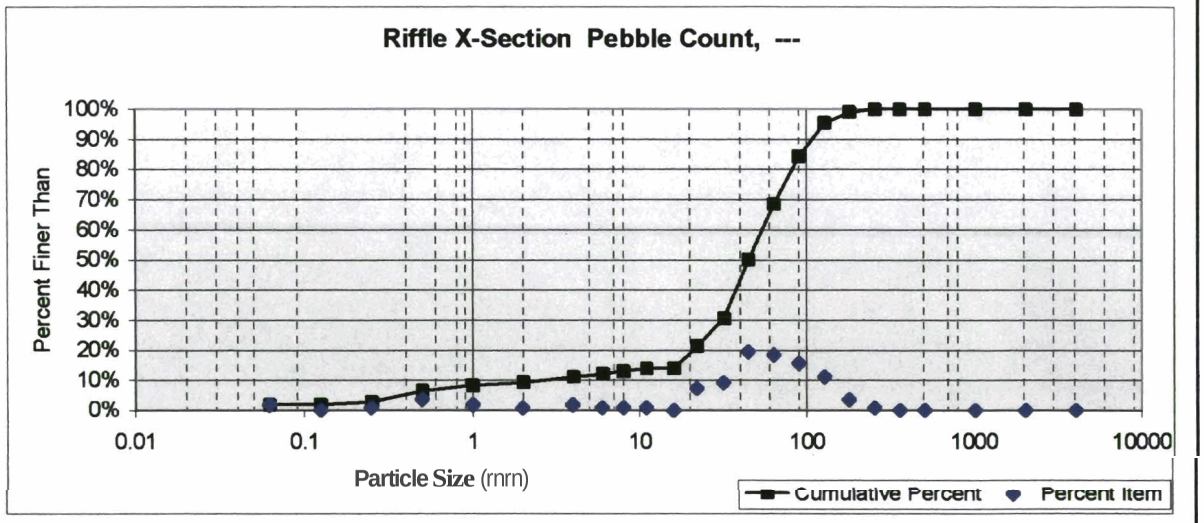
Percent by substrate type					
silt/clay	sand	gravel	cobble	boulder	bedrock
6%	18%	48%	27%	1%	0%

FIGURE 9. Riffle cross-section pebble count, Obids Creek, Wild site, Ashe County, May 3,2000.

Riffle X-Section Pebble Count

Material	Size Range (mm)		Count
silt/clay	0	0.062	2
very fine sand	0.062	0.13	
fine sand	0.13	0.25	1
medium sand	0.25	0.5	4
coarse sand	0.5	1	2
very coarse sand	1	2	1
very fine gravel	2	4	2
fine gravel	4	6	1
fine gravel	6	8	1
medium gravel	8	11	1
medium gravel	11	16	
coarse gravel	16	22	8
coarse gravel	22	32	10
very coarse gravel	32	45	21
very coarse gravel	45	64	20
small cobble	64	90	17
medium cobble	90	128	12
large cobble	128	180	4
very large cobble	180	256	1
small boulder	256	362	
small boulder	362	512	
medium boulder	512	1024	
large boulder	1024	2048	
very large boulder	2048	4096	
bedrock			
	Total Particle Count:		108

Riffle Pebble Count,
Obid's Creek
South Fork New River
Wild Site
Note:



Size percent less than (mm)				
D16	D35	D50	D84	D95
17.520	34.59	45.0	89	127

Percent by substrate type					
silt/clay	sand	gravel	cobble	boulder	bedrock
2%	7%	59%	31%	0%	0%

FIGURE 10. Weighted pebble count, Obids Creek, Wild site, Ashe County, May 3,2000.

Weighted Pebble Count

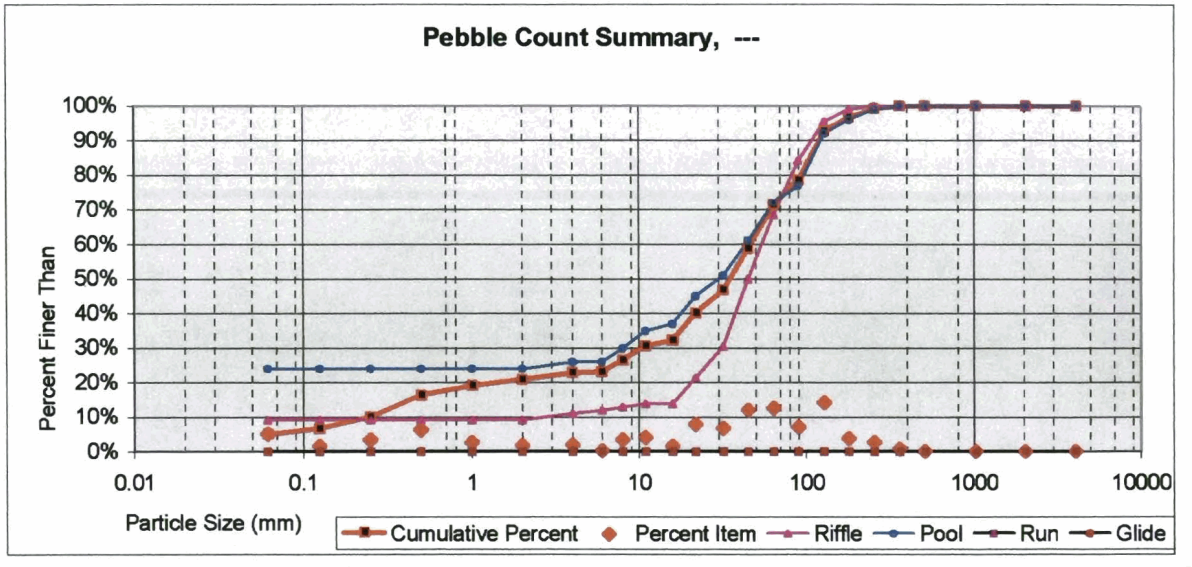
Percent Riffle:	79	Percent Run:	
Percent Pool:	21	Percent Glide:	

Pebble Count,

Obid's Creek
South Fork New River
Wild Site

Note:

Material	Size Range (mm)		Total #	
silt/clay	0	0.062	5.1	# #
very fine sand	0.062	0.13	1.6	# #
fine sand	0.13	0.25	3.4	# #
medium sand	0.25	0.5	6.3	# #
coarse sand	0.5	1	2.7	# #
very coarse sand	1	2	1.8	# #
very fine gravel	2	4	2.0	# #
fine gravel	4	6	0.2	# #
fine gravel	6	8	3.4	# #
medium gravel	8	11	4.1	# #
medium gravel	11	16	1.6	# #
coarse gravel	16	22	7.9	# #
coarse gravel	22	32	6.7	# #
very coarse gravel	32	45	12.0	# #
very coarse gravel	45	64	12.6	# #
small cobble	64	90	7.2	# #
medium cobble	90	128	14.2	# #
large cobble	128	180	3.8	# #
very large cobble	180	256	2.6	# #
small boulder	256	362	0.8	# #
small boulder	362	512	0.0	# #
medium boulder	512	1024	0.0	# #
large boulder	1024	2048	0.0	# #
very large boulder	2048	4096	0.0	# #
bedrock			0.0	#
		Weighted Count:	100	
		True Total Particle Count:	208	



Size percent less than (mm)				
D16	D35	D50	D84	D95
0.478	17.91	35.0	103	156

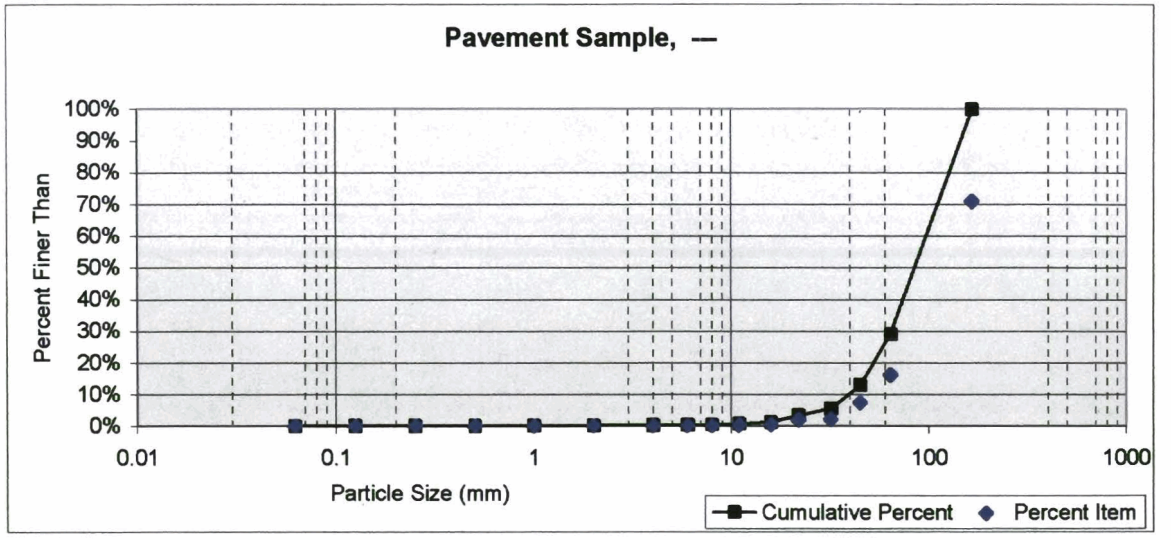
Percent by substrate type					
silt/clay	sand	gravel	cobble	boulder	bedrock
5%	16%	51%	28%	1%	0%

FIGURE 11. **Pavement pebble count, Obids Creek, Wild site, Ashe County, May 3,2000.**

Pavement Sample

Material	Size Range (mm)		Count		
silt/clay	0	0.062	**0.7**	#	0%
very fine sand	0.062	0.13	**0.5**	#	0%
fine sand	0.13	0.25	**1**	#	0%
medium sand	0.25	0.5	**1**	#	0%
coarse sand	0.5	1	**2**	#	0%
very coarse sand	1	2	**3**	#	0%
very fine gravel	2	4	**5**	#	0%
fine gravel	4	6	**4**	#	0%
fine gravel	6	8	**7**	#	0%
medium gravel	8	11	**17**	#	1%
medium gravel	11	16	**26**	#	1%
coarse gravel	16	22	**110**	#	3%
coarse gravel	22	32	**120**	#	6%
very coarse gravel	32	45	**395**	#	13%
very coarse gravel	45	64	**866**	#	29%
small cobble	64	90		#	29%
medium cobble	90	128		#	29%
large cobble	128	*165*	**3799**	#	###
very large cobble	180	256		#	###
small boulder	256	362		#	###
small boulder	362	512		#	###
medium boulder	512	1024		#	###
large boulder	1024	2048		#	###
very large boulder	2048	4096		#	###
bedrock				#	
	Total Particle Count:		5357.2		

Pebble Count,
Obid's Creek
South Fork New River
Wild Site
Note: **Largest Particle:165**



Size percent less than (mm)				
D16	D35	D50	D84	D95
48.123	130.74	138.0	156	162

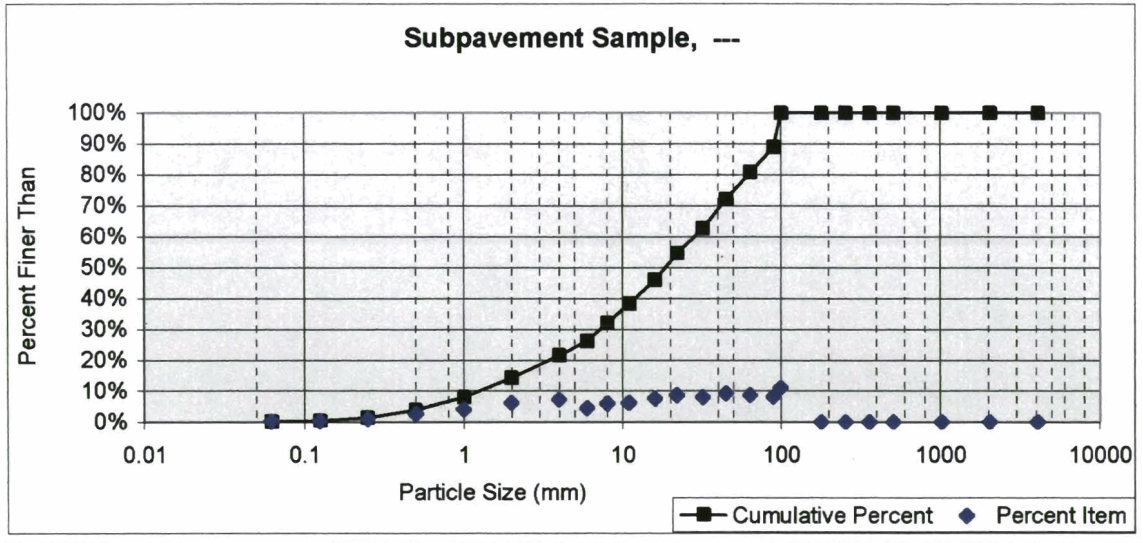
Percent by substrate type					
silt/clay	sand	gravel	cobble	boulder	bedrock
0%	0%	29%	71%	0%	0%

FIGURE 12. **Sub-pavement pebble count, Obids Creek, Wild site, Ashe County, May 3,2000.**

Sub-Pavement Sample

Material	Size Range (mm)		Count
silt/clay	0	0.062	**15**
very fine sand	0.062	0.13	**59**
fine sand	0.13	0.25	**184**
medium sand	0.25	0.5	**499**
coarse sand	0.5	1	**784**
very coarse sand	1	2	**1207**
very fine gravel	2	4	**1406**
fine gravel	4	6	**882**
fine gravel	6	8	**1139**
medium gravel	8	11	**1207**
medium gravel	11	16	**1472**
coarse gravel	16	22	**1681**
coarse gravel	22	32	**1552**
very coarse gravel	32	45	**1796**
very coarse gravel	45	64	**1686**
small cobble	64	90	**1578**
medium cobble	90	*100*	**2135**
large cobble	128	180	
very large cobble	180	256	
small boulder	256	362	
small boulder	362	512	
medium boulder	512	1024	
large boulder	1024	2048	
very large boulder	2048	4096	
	Total Particle Count:		19282

Bar Sample,
Obid's Creek
South Fork New River
Wild Site
Note: **Largest particle: 100**



Size percent less than (mm)					Percent by substrate type				
D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder
2.362	9.31	18.6	73	95	0%	14%	66%	19%	0%

FIGURE 13. Obids Creek plan view, Wild site, Ashe County.

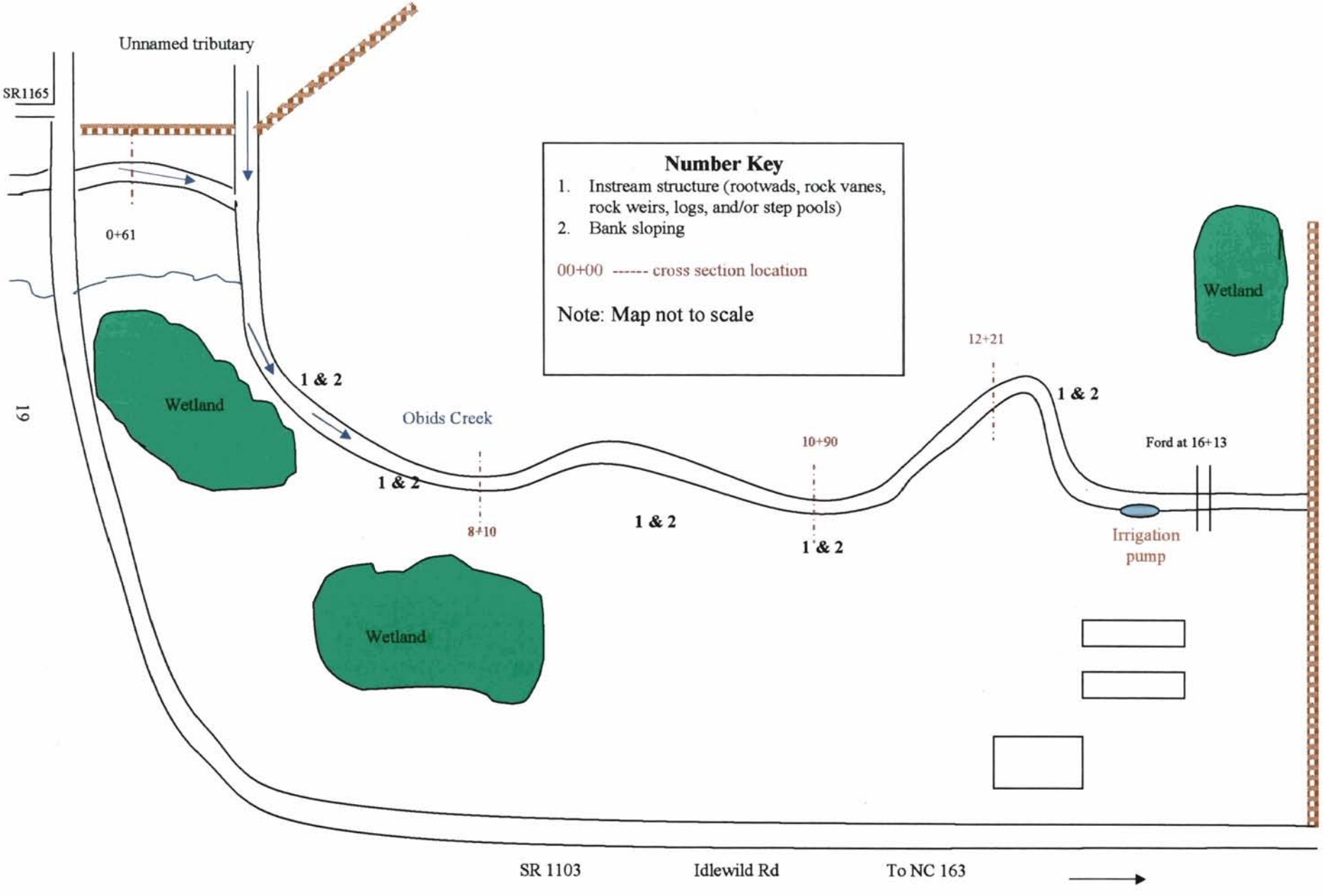


FIGURE 14. Typical bank grading and revegetation plan for low stress areas.

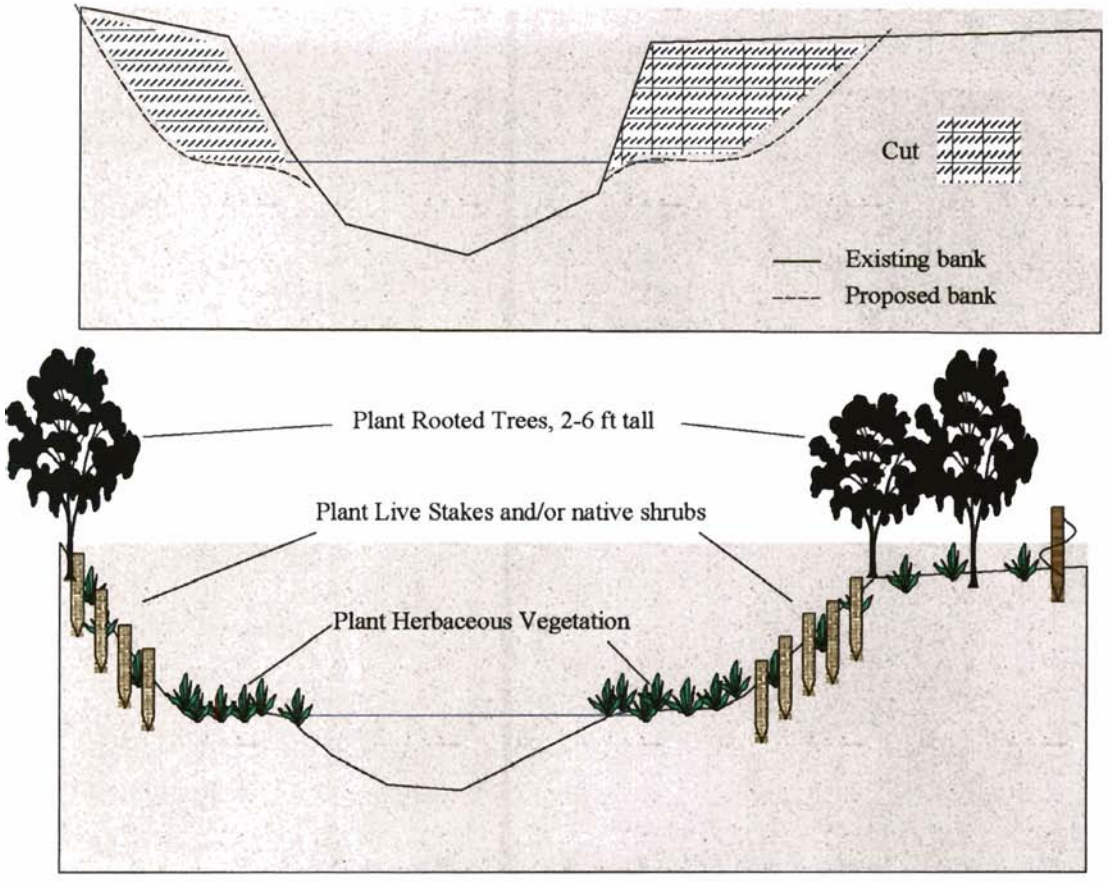
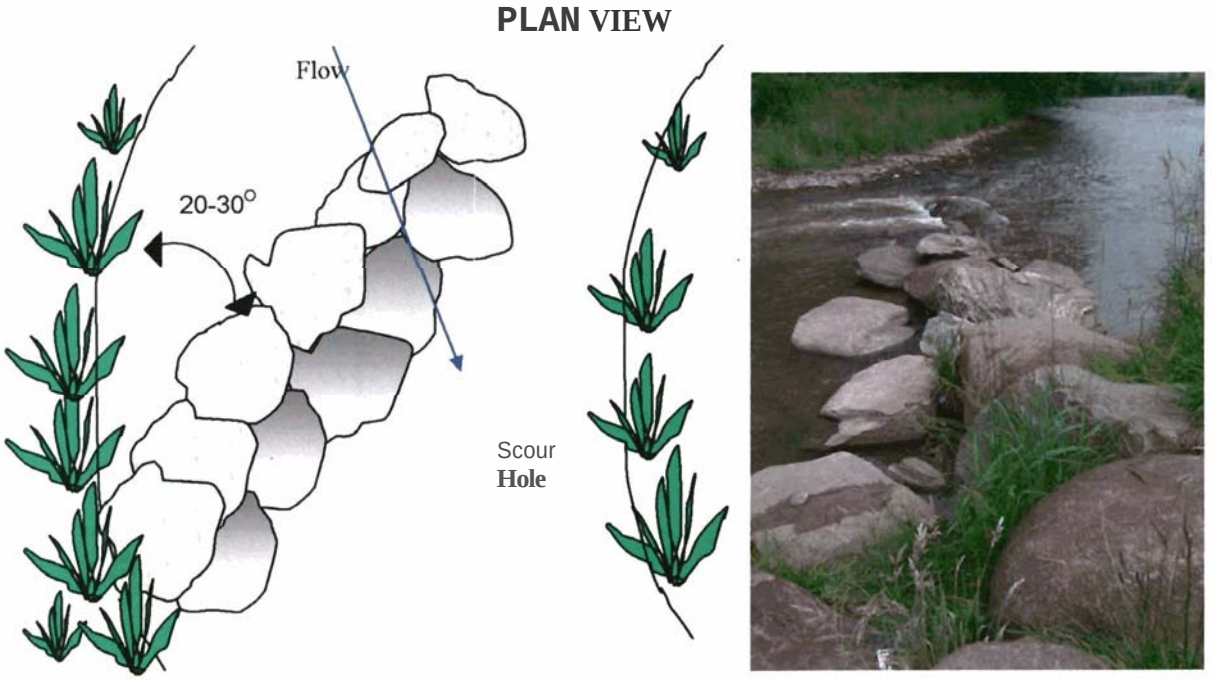


FIGURE 15. Typical rock vane structure showing plan and cross section views. **NOTE:** There should be no gaps between the rocks in the rock vane structure. The rock vane should have a 4 % to 12% slope from the top of bankfull or inner berm bench to streambed. Rock size should range from 4 cu ft. to 18 cu ft. Arm length will vary depending on size of stream.



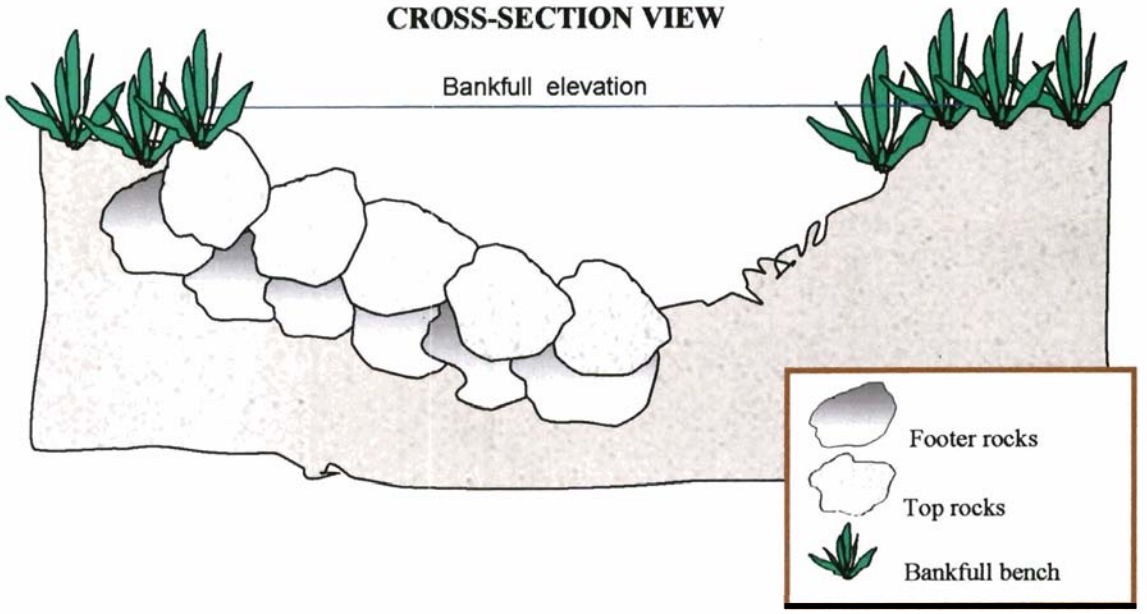


FIGURE 16. Typical cross-vane showing plan and cross-section views. NOTE: There should be no gaps between the rocks in the cross-vane. Rock size should range from 4 cu ft. to 18 cu ft.

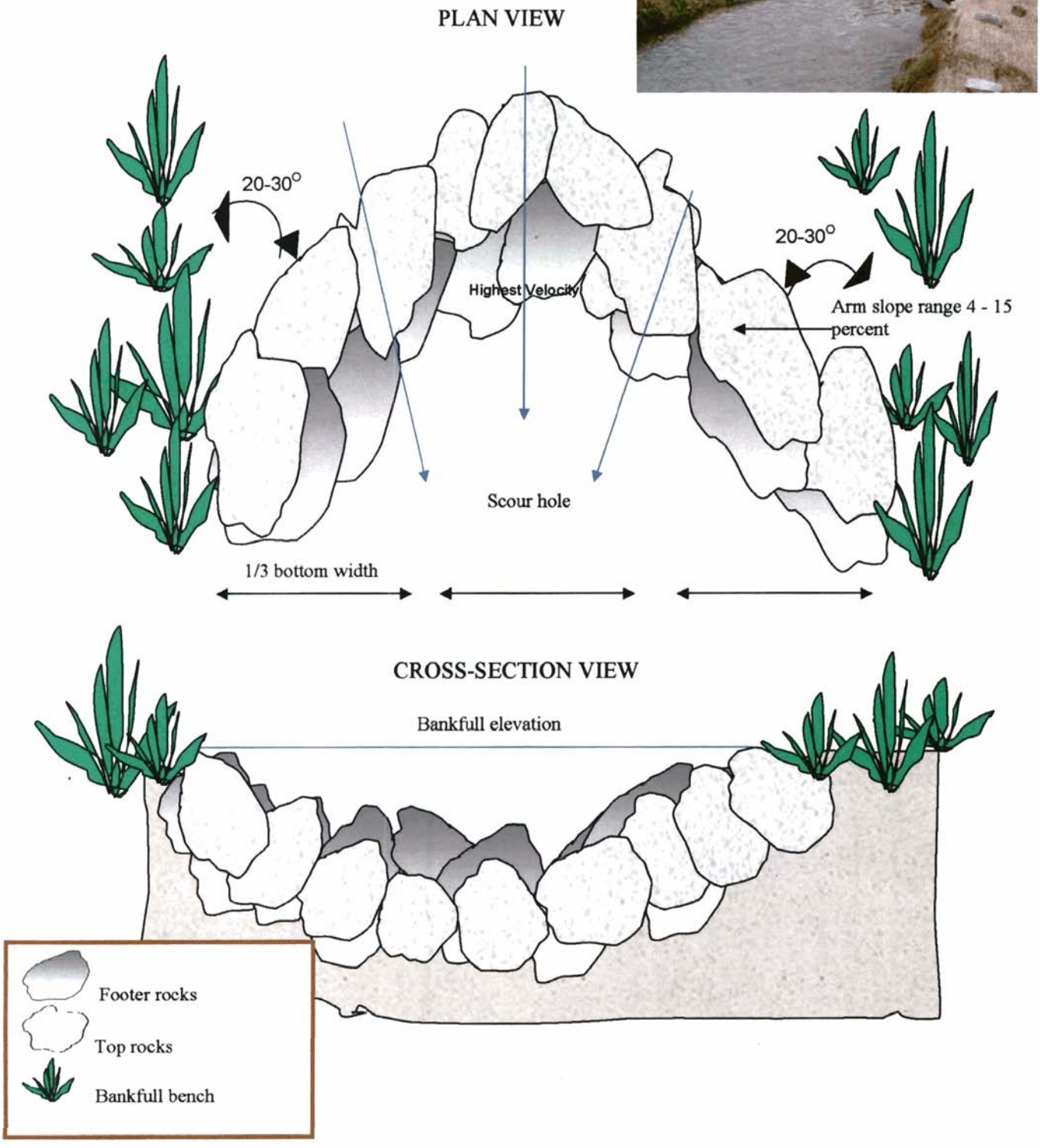
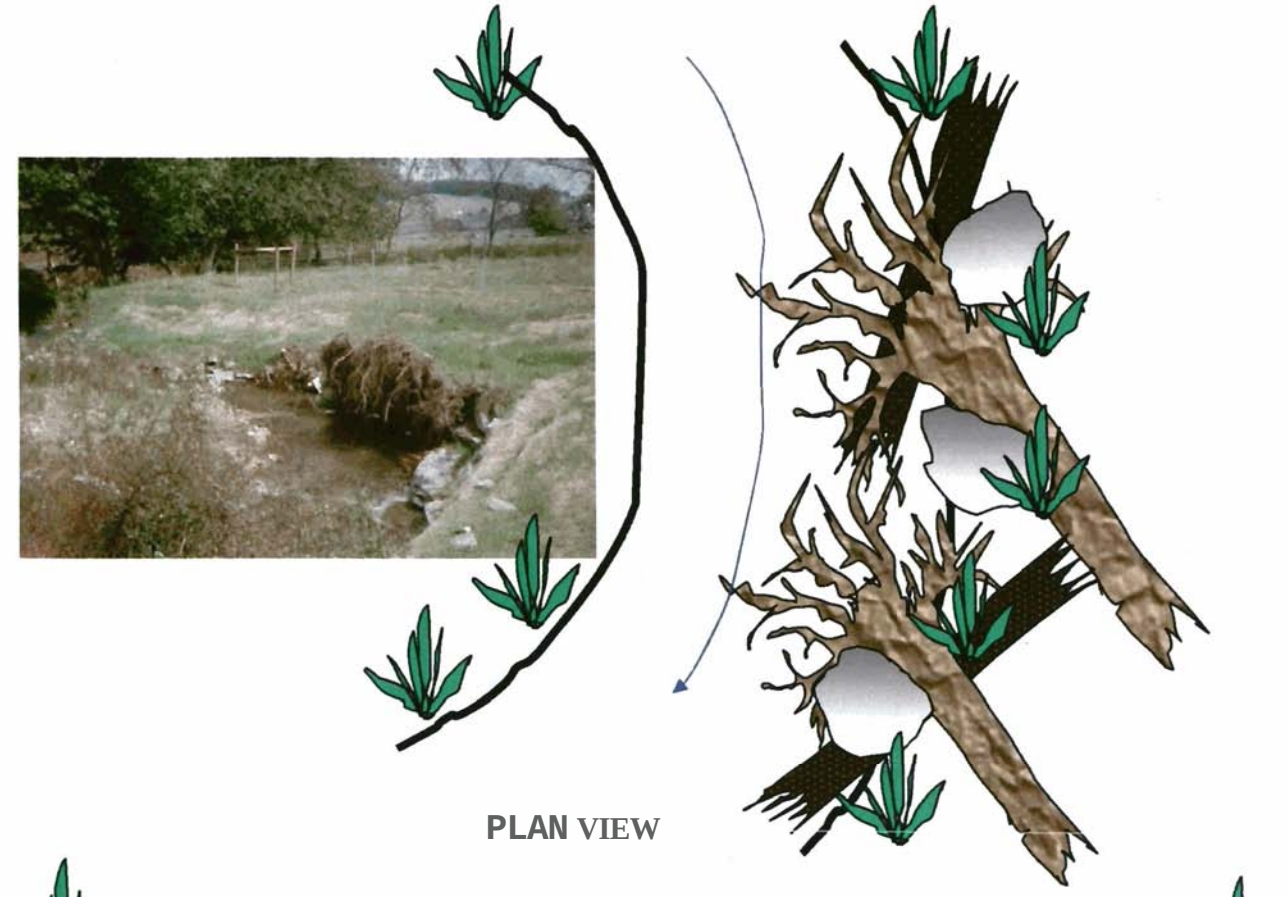
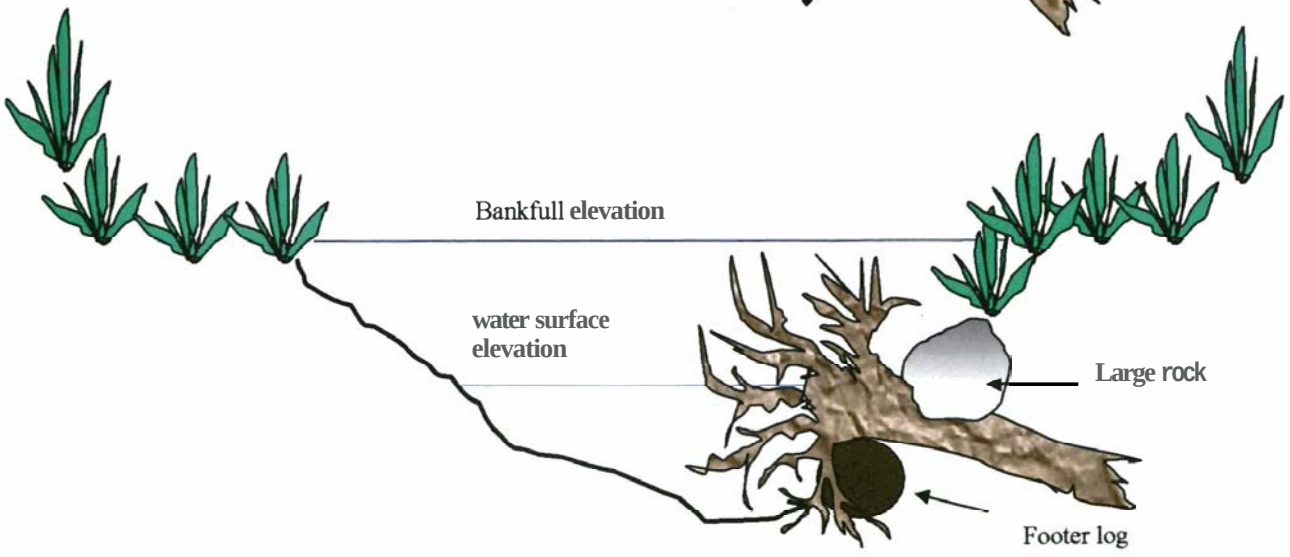


FIGURE 17. Typical root wad structure showing plan and cross section views. NOTE: Footer logs should be >8" diameter and installed below the streambed. Root wads should be 8-14 ft long and >10" diameter. Large boulders should be placed in gaps between root wads. Fill materials from the site should be placed behind the root wads and boulders, covered with an erosion control mat and seeded and trees planted on top of the bench.



PLAN VIEW



CROSSSECTION VIEW

FIGURE 1. Location of Meadow Fork reference reach, Laurel Springs, Alleghany County, May 2001. Map from US Geological Survey, Whitehead quadrangle.

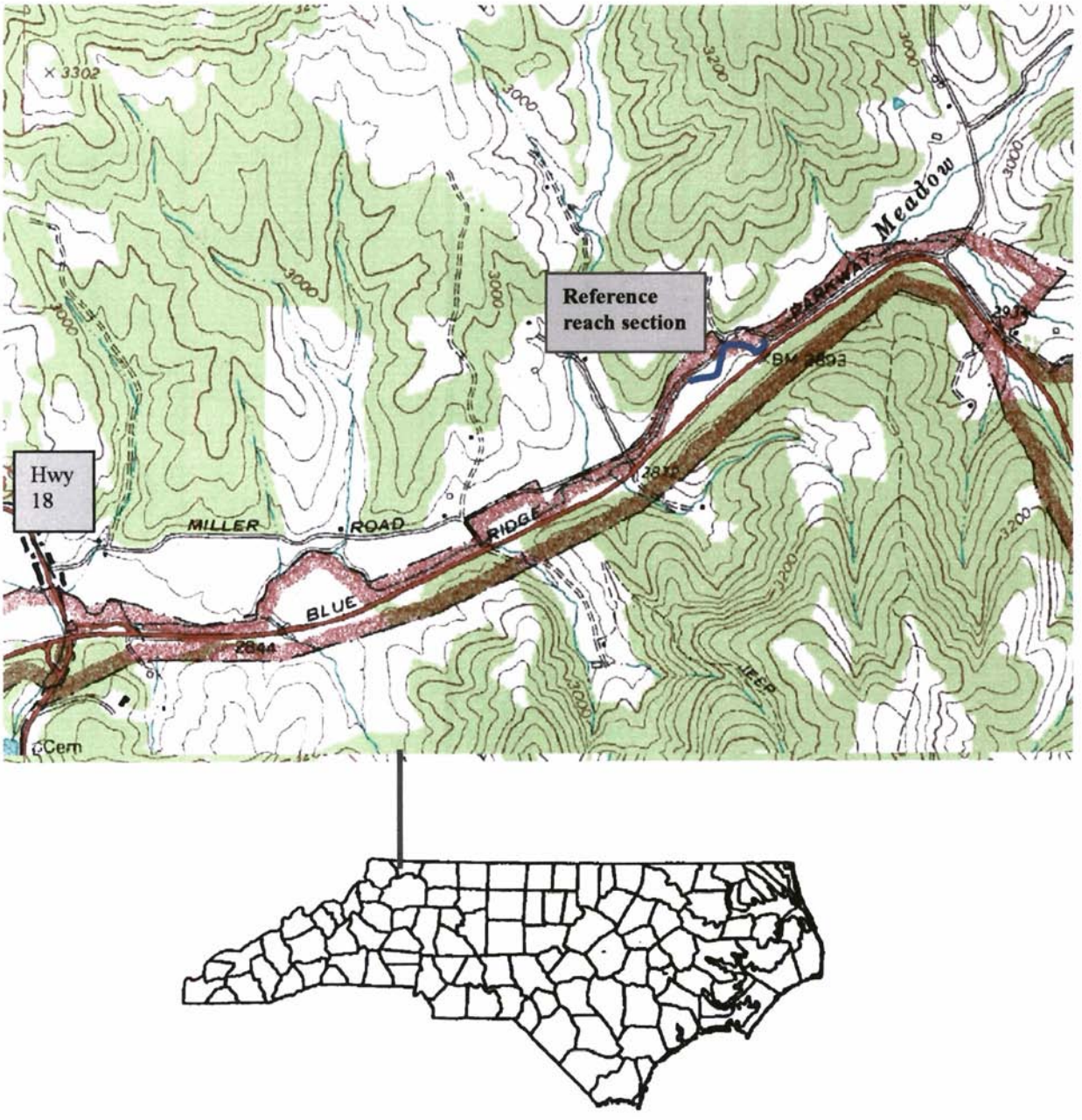
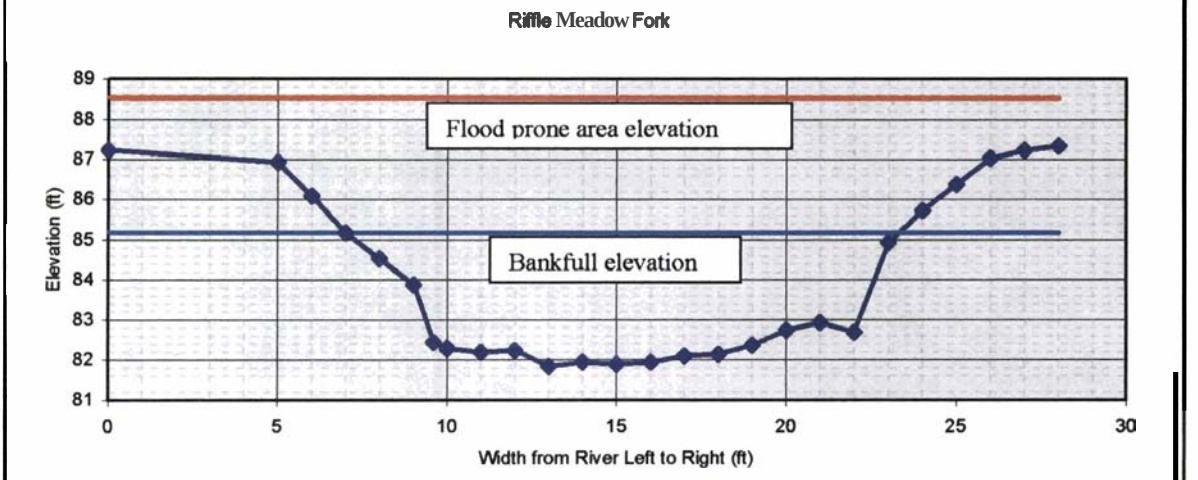


FIGURE 19. Meadow Fork Reference Reach x-section date, Alleghany County

Cross Section



section:	
	Riffle Meadow Fork New
description:	Reference riffle below long profile
height of instrument (ft):	93.24

notes	omit pt.	distance (ft)	FS (ft)	elevation
TOB	☐	0	6	87.24
	☐	5	6.3	86.94
	☐	6	7.15	86.09
BKF	☐	7	8.05	85.19
	☐	8	8.7	84.54
	☐	9	9.35	83.89
WE/WS	☐	9.6	10.8	82.44
	☐	10	10.95	82.29
	☐	11	11.05	82.19
	☐	12	11	82.24
TWG	☐	13	11.4	81.84
	☐	14	11.3	81.94
	☐	15	11.35	81.89
	☐	16	11.3	81.94
	☐	17	11.15	82.09
	☐	18	11.1	82.14
WE/WS	☐	19	10.87	82.37
gravel bar	☐	20	10.5	82.74
	☐	21	10.3	82.94
	☐	22	10.55	82.69
	☐	23	8.3	84.94
	☐	24	7.5	85.74
	☐	25	6.85	86.39
	☐	26	6.2	87.04
TOB	☐	27	6	87.24
	☐	28	5.9	87.34

FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
8.05	6	150.0	1	0.03
85.19	87.24			

dimensions			
40.5	x-section area	2.5	d mean
16.3	width	19.5	wet P
3.4	d max	2.1	hyd radi
5.4	bank ht	6.6	w/d ratio
150.0	W flood prone area	9.2	ent ratio

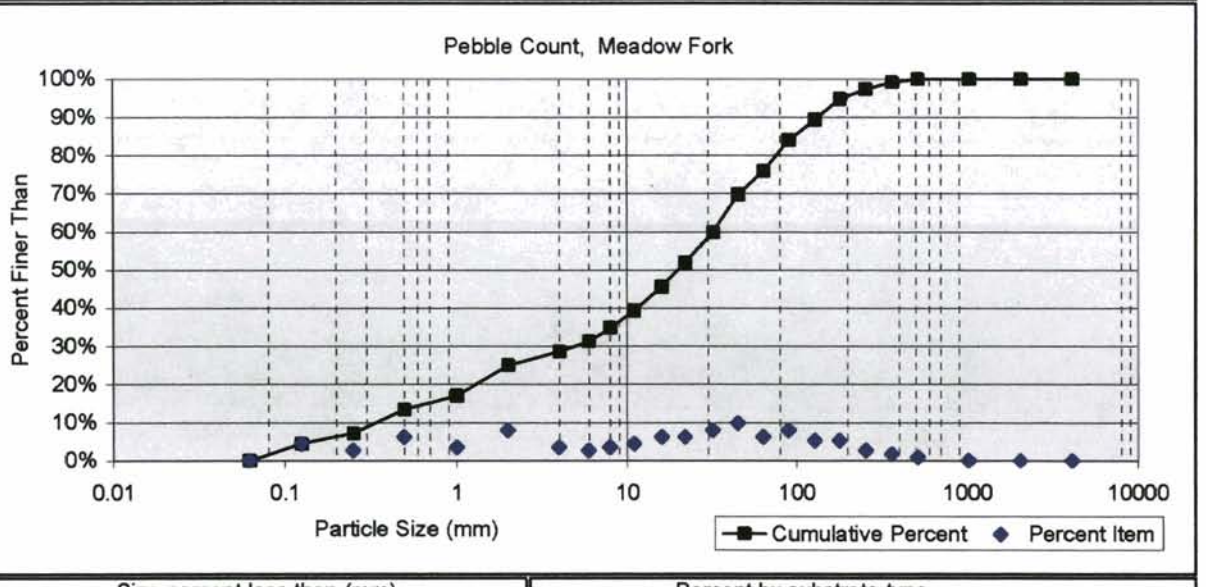
hydraulics	
8.1	velocity (ft/sec)
327.0	discharge rate, Q (cfs)
1.30	shear stress ((lbs/ft sq)
0.82	shear velocity (ft/sec)
12.509	unit stream power (lbs/ft/sec)
0.81	Froude number
9.9	friction factor u/u*
~~120.5~~	threshold grain size (mm)

check from channel material			
90	measured D84 (mm)		
8.4	relative roughness	8.1	fric. factor
0.037	Manning's n from channel material		

FIGURE 20. Meadow Fork reference reach pebble count summary data, Alleghany County.

Reach Pebble Count (75% riffle, run, glide and 25% pool)				
Material	Size Range (mm)		Count	
silt/clay	0	0.062		# #
very fine sand	0.062	0.13	5	# #
fine sand	0.13	0.25	3	# #
medium sand	0.25	0.5	7	# #
coarse sand	0.5	1	4	# #
very coarse sand	1	2	9	# #
very fine gravel	2	4	4	# #
fine gravel	4	6	3	# #
fine gravel	6	8	4	# #
medium gravel	8	11	5	# #
medium gravel	11	16	7	# #
coarse gravel	16	22	7	# #
coarse gravel	22	32	9	# #
very coarse gravel	32	45	11	# #
very coarse gravel	45	64	7	# #
small cobble	64	90	9	# #
medium cobble	90	128	6	# #
large cobble	128	180	6	# #
very large cobble	180	256	3	# #
small boulder	256	362	2	# #
small boulder	362	512	1	# #
medium boulder	512	1024		# #
large boulder	1024	2048		# #
very large boulder	2048	4096		# #
bedrock				#
	Total Particle Count:		112	

Pebble Count,
Meadow Fork
New
Along Blue Ridge Parkway
Note:



Size percent less than (mm)				
D16	D35	D50	D84	D95
0.829	8.10	20.1	90	189

Percent by substrate type					
silt/clay	sand	gravel	cobble	boulder	bedrock
0%	25%	51%	21%	3%	0%

FIGURE 21. Cross-section 8+10 existing condition and design comparisions, Obids Creek, Wild site, Ashe County.

8+10	Feature	Type	Wfpa	LBKF	RBKF	Elev bkf	Wbkf	Dbkf	W/D	Abkf	Dmax	ER
Existing	Riffle	C4	150			90.98	26.2	1.8	14.2	48.4	3.7	5.7
Design	Riffle	C4	150	30	62	90.29	32.0	1.6	20.6	49.6	3.01	4.7

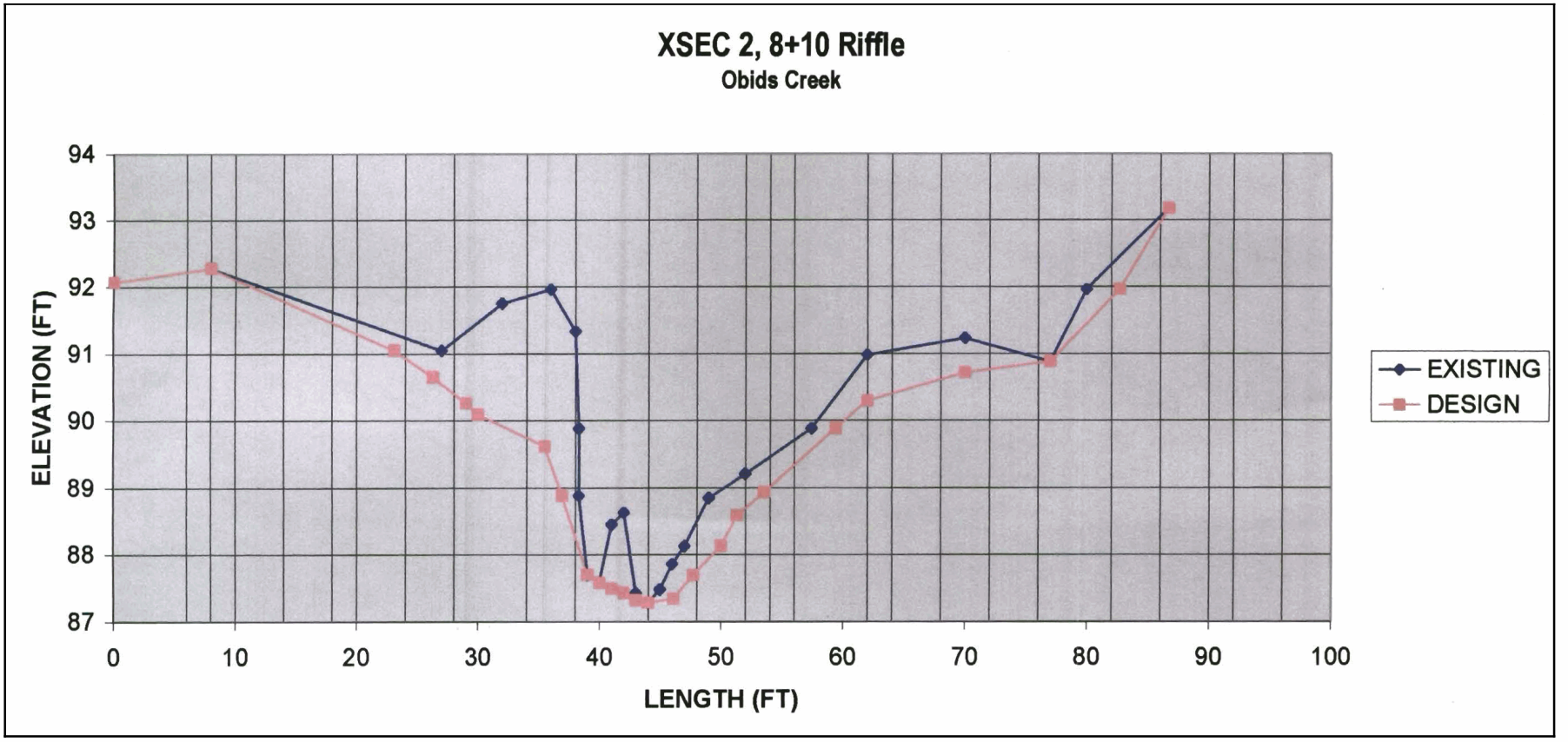


FIGURE 22. Cross-section 10+90 existing and design comparisons, Obids Creek, Wild site, Ashe County.

10+90	Feature	Type	Wfpa	LBKF	RBKF	Elev bkf	Wbkf	Dbkf	W/D	Abkf	Dmax	ER
Existing	Pool	C4				88.45	45.7	1.3		60.2	4.1	
Design	Pool	C4		10.7	57.1	87.49	46.4	1.2	39.7	54.2	3.12	0.0

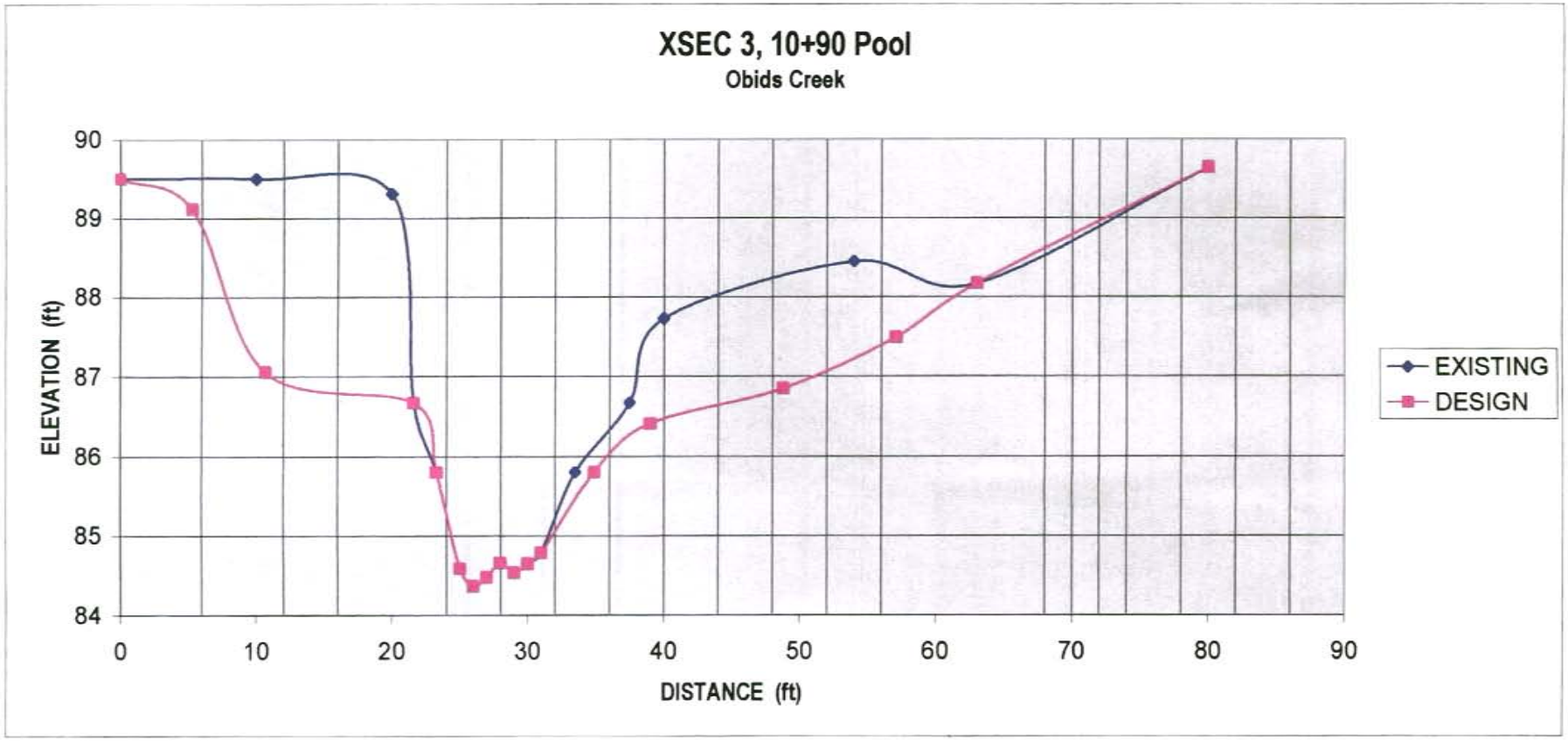


FIGURE 23. Cross-section 12+21 existing and design comparisons, Obids Creek, Wild site, Ashe County.

12+21	Feature	Type	Wfpa	LBKF	RBKF	Elev bkf	Wbkf	Dbkf	W/D	Abkf	Dmax	ER
Existing	RIFFLE	C4	150			87.26	34.9	1.4	25.2	48.3	2.6	4.3
Design	RIFFLE	C4	150	19.8	72.5	86.6	52.7	1.0	52.7	52.7	2.35	2.8

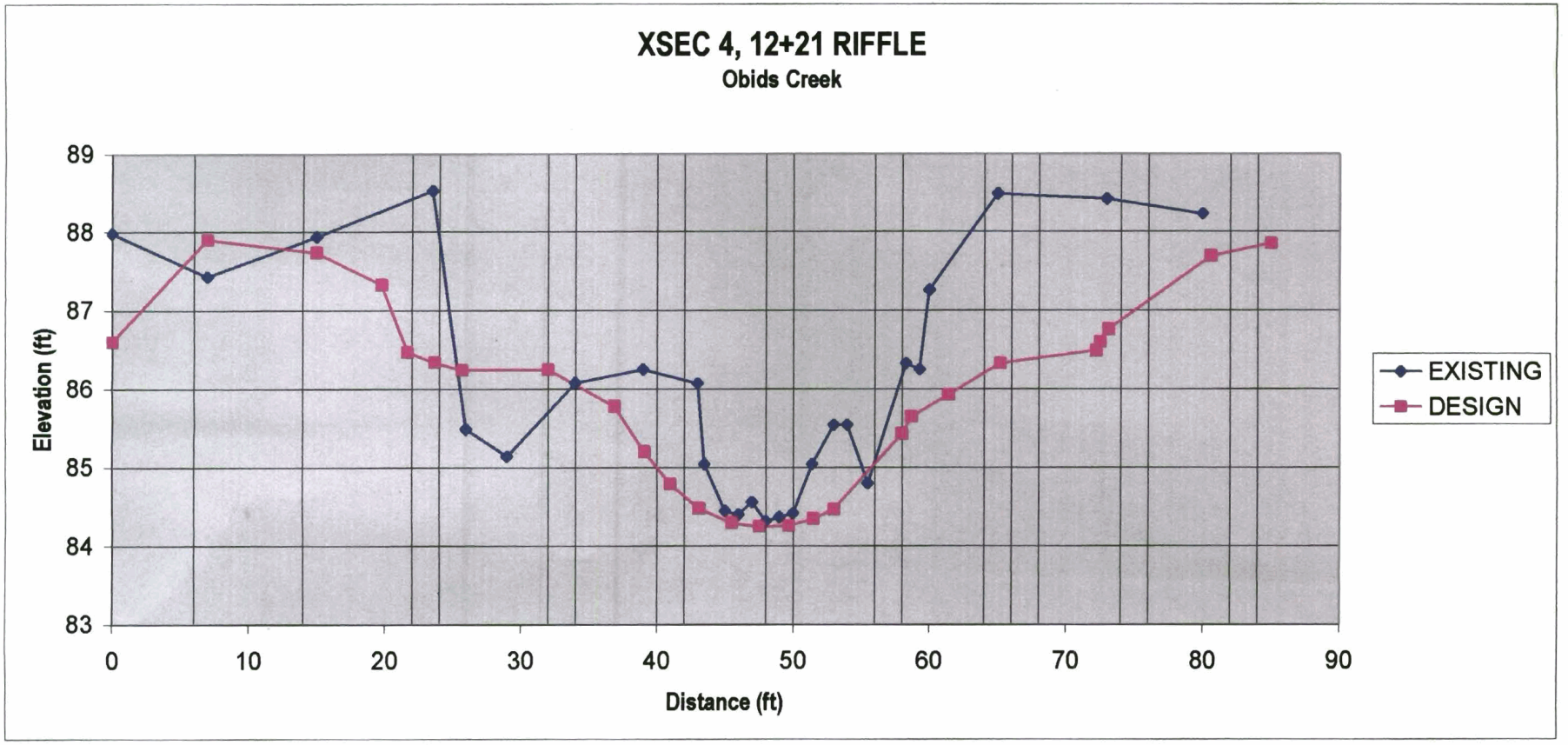


FIGURE 24. Conservation easement plan view, Wild site on Obids Creek, Ashe County, January 31, 2001.

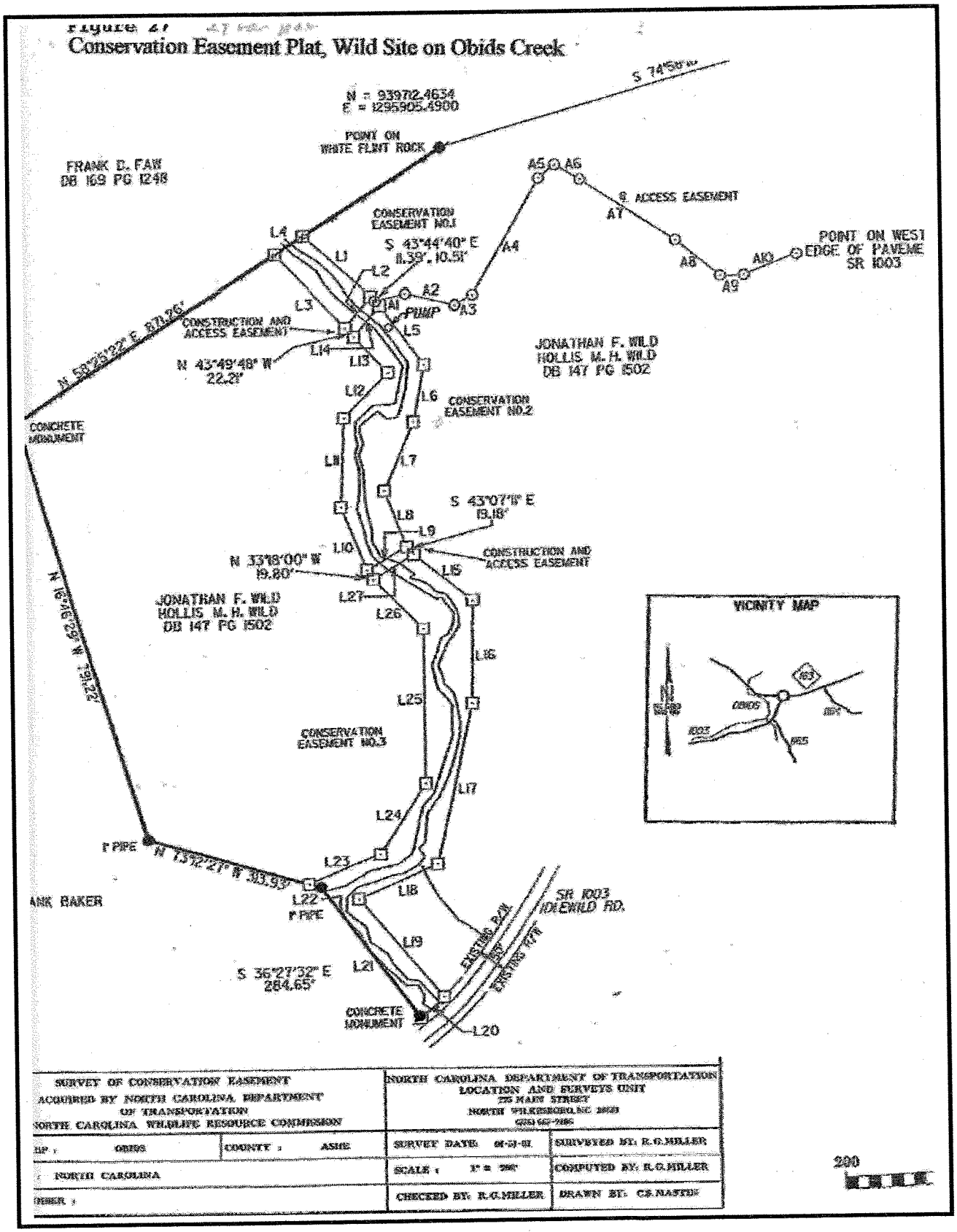


TABLE 1. Obids Creek stream reach data from the Wild site, Ashe County. May 3, 2000.

Stream Name: Obids Creek Date: 6/7/2001

Basin Name: NEW Drainage AREA: 2250 Ac. 3.5 MI^2

Location: Wild 421 Mitigation Site, off Idlewild Road, Ashe County

Observers: J. Mickey, M. Martinez, S. Scott, NCWRC -Stream Mitigation Program

	X-Section 8+10	X-Section 12+21	Design	Reference Reach (MF*)	Regional Curve data
Bankfull WIDTH (W_{bkf}):	26.2	34.9	25-35	16.3	33
Mean DEPTH (D_{bkf}):	1.8	1.40	1.5-2.5	2.5	1.6
Bankfull X-sectional AREA (A_{bkf}):	48.4	48.3	40-50	40.5	47-50
Width / Depth RATIO (W_{bkf}/d_{bkf}):	14.2	25.2	15-25	6.6	
Maximum DEPTH (d_{mbkf}):	3.7	2.60	3.5	3.4	
WIDTH of Flood -Prone Area (W_{fpa}):	150	150	100	150	
Entrenchment Ratio (ER):	5.7	4.3	3.0 - 5.0	9.2	
Channel Materials D50 (mm):	45	30	32-64	20.1	
Water Surface SLOPE (S):	0.011	0.011	0.11	0.06	
Channel SINUOSITY (K):	1.33	1.33	1.33	1.3	
STREAM TYPE:	C4	C4	C4	C4e	

***Reference reach stream is Meadow Fork, Alleghany County. DA 4.4 sq miles. Stream length surveyed was 1682 feet at two sites (1210' and 472').**

Table 2. Location of in-stream structures and bank stabilization improvements, Wild site on Obids Creek, Ashe County.

Location (Stn. #)	Existing in-stream feature	Proposed Improvements	Remarks
3+12 - 3+42	run/shallow pool/glide	2 rock vanes/bank sloping and revegetation	channel is wide due to past gravel removal/livestock access and bank is eroding.
3+50	end of riffle/head of small pool	rock weir	channel is overwide, better pool habitat is needed
3+91 - 4+26	mid channel bar and pool	rock vane/bank sloping revegetation	remove in-stream vegetated bar by placing in back into the bank, install a rock vane and slope eroding banks
5+48	Log jam	Rock weir	Replace log jam with rock weir to maintain drop pool and prevent future stream headcutting
5+60 - 6+00	outside of meander containing an unstable riffle/pool/glide complex	2 rock vanes/bank sloping bank log/revegetation	stabilize eroding right bank and provide in-stream habitat
6+30 - 6+65	head of Run Pool	rock weir/2 rock vanes/cover log/bank sloping/revegetation	eroding right bank needs sloping and in-stream stabilization and habitat structures
7+50	Step pool created by old beaver dam	rock weir	Replace old dam with rock weir to maintain drop pool and prevent future stream headcutting
7+75 - 8+50	riffle	rock weir/rock vane/cover log/ bank sloping/revegetation	eroding right bank needs sloping and revegetation. Rock weir used to hold grade, rock vane and log for in-stream habitat

TABLE 2. Continued.

Location (Stn. #)	Existing in-stream feature	Proposed Improvements	Remarks
8+65 - 9+60	riffle/run/pool/glide complex	rock weir/2 rock vanes/bank bank log/revegetation	eroding right bank needs sloping and revegetation. Rock weir used to hold grade, rock vane and log for in-stream habitat
10+64 - 11+30	run/pool/riffle complex	rock weir/rock vanecover log/ bank sloping/revegetation	eroding left bank needs sloping and revegetation. Rock weir used to hold grade, rock vane and log for in-stream habitat
11+80	shallow riffle/run	rock weir and livestock crossing	install stable livestock crossing at this location per NRCS specifications and rock weir to hold grade
11+94 - 14+06	long riffle with short pool complex	rock weir/rock vane/bank log/ bank sloping/revegetation	eroding left bank needs sloping and revegetation. Rock weir used to hold grade, rock vane and log for in-stream habitat
14+20 -14+30	riffle	rock vane/bank sloping	eroding right bank needs sloping and revegetation. Rock vane used for bank stabilization and in-stream habitat
16+13 - 16+28	riffle and existing livestock and farm equipment crossing	livestock crossing/rock weir	install stable livestock crossing at this location per NRCS specifications and rock weir to hold grade

*Note that all structures are approximate locations since stream conditions could have chaneged by time of construciton.
**Structure type could change due to adjustments made to stream conditions at time of construction.

TABLE 3. Monitoring criteria for mitigation sites.

Criteria used to evaluate the success or failure of activities at mitigation sites and actions that will be taken when failure occurs.

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.
Vegetative Cover Shading Water Temperature Temperature Stability	Water and air temperature should decrease and shading should increase over time	No change in air, water, or shade measurements.	Reasons for failure will be evaluated and remedial action plans developed and implemented.
Plant Survival Survival Plots Stake Counts Tree Counts	≥75% coverage in photo plots ≥80% survival of stakes, 4/m^2 ≥80% survival of bare rooted trees	<75% coverage in photo plots <80% survival of stakes, 4/m^2 <80% survival of trees	Areas of less than 75% coverage will be reseeded and or fertilized, live stakes and bare rooted trees will be replanted to achieve ≥80% survival.
Biological Indicators (only used for projects with potential to make watershed level changes) Invertebrate Populations Fish Populations	Population measures remain the same or improve.	Population measures indicate a negative trend.	Reasons for failure will be evaluated and remedial action plans developed and implemented

Overall success or failure will be based on success in 3 of the 5 criteria or 3 of the 4 criteria when biological indicators are not used.

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

TABLE 4. Sediment transport calculations, Wild site on Obids Creek, Ashe County.

Hydraulic Radius R	Existing X-S 8+10	Design XS 8+10
Average Bankfull Depth=	1.8	1.5
Average Bankfull Channel Width	26.2	33.2
Wetted Perimeter P =	29.8	36.2
Bankfull Cross-sectional Area =	48.4	50.1
Hydraulic Radius R =	1.6	1.4
Critical dimensionless shear stress T*ci		
di=d_{50} of riffle bed surface from pebble count =	45	45
d_{50} =subsurface d_{50} or bar d_{50} =	18.6	18.6
τ^*c_i=	0.039	0.039
Required water depth to move largest bar particle		
τ^*c_i=	0.039	0.039
Specific Gravity of Sediment (g/c^3) =	2.65	2.65
Density of Water (g/c^3) =	1.0	1.0
D_i largest particle found in the bar sample or pavement =	130	130
s average riffle slope =	0.01	0.01
d =	2.7	2.7
Shear Stress at Riffle		
γ =specific gravity of water (lb/ft^3) =	62.4	62.4
Hydraulic Radius R =	1.6	1.4
s average riffle slope =	0.01	0.01
τ =γRs (lb/ft^2) =	1.0	0.9
At this τ Shield's Curve predicts the stream can move a D84 of =	72.8mm	61.4mm

Flow Resistance		n is known	V is known
Manning's Equation	mean cross-section velocity=$V=k/nR^{2/3}S^{1/2}$		
	k =	1.486	1.486
	Manning's roughness coefficient n=	0.0	
	hydraulic radius R=	1.6	1.4
	Energy slope(water surface slope) S=	0.0	0.0

APPENDIX 1

Riparian seeding and planting guidelines for the North Carolina Wildlife Resources Mitigation Program

Vegetating of the riparian zone at mitigation sites should be done as work proceeds. Stream banks should be planted with native vegetation that represents both woody (trees and shrubs) and herbaceous species. Species selection can be based on a survey of the vegetation from the reference reach, from less degraded sections of the stream being restored or from reference literature that details native species. The result should be an appropriate vegetative community for the site. Live staking, with such species as willow or dogwood, or the application of other bioengineering methods is recommended to provide bank stability and shade quickly following project completion.

Herbaceous vegetation should be established through plantings of existing plants, by relocating sod mats or by seeding with a native riparian seed mix. An annual cover crop should be sowed to stabilize the banks until the other vegetation can become established. A cover crop should be selected whose germination season matches the time of application. Evaluations of the cover crop and perennial herbaceous vegetation should be made regularly to insure good germination and establishment of the herbaceous community

These guidelines will provide the methods to be used for reestablishing riparian vegetation at NCWRC mitigation sites. They will include seedbed preparation, nutrient enhancement, temporary seeding, permanent seeding, and erosion control. Methodology for planting sod mats, live stakes, and trees will also be presented.

Herbaceous Vegetation

Sod mats: Prior to sloping stream banks within easement areas the sod on these banks will be removed. Mats should be deep enough to contain a majority of the roots. These mats should be stockpiled for later use. After banks are sloped the mats should be placed from the bankfull elevation down to the normal water line or onto the interberm feature. Mats should be laid as close to one another as possible and pushed into the under laying soil. Openings between mats should be filled with soil and seeded with temporary seed mix. Mats should be fertilized at a rate of 25 lbs. per 1000 sq. ft. and watered using a pump or by dipping water out of the creek with a clean track-hoe bucket

Seed

Seedbed Preparation: On sites where equipment can be operated safely the seedbed shall be adequately loosened and smoothed. This may require disking and dragging. On sites where equipment cannot operate safely, the seedbed shall be prepared by hand scarifying the soil surface to roughen it so that seed will stay in place. If seeding is done immediately following construction, seedbed preparation may be required only on areas where heavy equipment has caused compaction of the ground.

Fertilizing: Evenly distribute lime and fertilizer over the area to be seeded using a tractor mounted fertilizer spreader or a hand held fertilizer spreader. Uniformly mix lime and fertilizer into the top 3 inches of the soil using a drag or hand rake. Where surface materials are predominately gravel and/or cobble, no incorporation is required.

Apply lime and fertilizer according to soil test or at the following rates.

	Per 1000 sq. ft.	Per Acre
Lime	50 lbs.	1 ton
18-46-00 Fertilizer*	12 lbs.	500 lbs.

*(half of fertilizer will be applied in fall at planting and other half in spring)

Temporary seeding – Use as needed for erosion control, when permanent vegetation cannot be established due to planting season and where temporary ground cover is needed to allow native or woody vegetation to become established. Apply the following vegetation at the listed rates.

Fall, Winter, and Spring Seeding

	Per 1000 sq. ft.	Per Acre
Millet	½ lb.	20 lbs.
Winter Wheat	1 lbs.	40 lbs.
Winter Rye	1 lbs.	40 lbs.

Summer Seeding

	Per 1000 sq. ft.	Per Acre
Sudangrass	1 lb.	40 lbs.
Browntop Millet	1 lb.	40 lbs.

Permanent Seeding – Use in combination with woody plantings from the easement line down to the bankfull elevation. This mixture can be planted at any time but will do best in spring or late fall. Spring planted seed should be treated with a cold wet chill process to maximize germination. Fall plantings should be planted with a lightly sown cool season annual to hold soil. Fall planting does not need to be chilled. Seeding should be done evenly over the area using a mechanical or hand seeder. A drag should be used to cover the seed with no more than ½ inch of soil. Where a drag can not safely be utilized the seed should be covered by hand raking.

The following listed seed mix or a similar mix, will be used at all mitigation sites to establish native flora. Given limited knowledge of which species will do best at each mitigation site we are taking the approach of planting a diverse mix and letting those that do best at each site respond. In affect we are trying to replace a seed bank. This mix will be seeded at the following rate: .5 lb. per 1000 sq. ft. and 20 lbs. per Acre. While nutrient enhancement may encourage competitors to this mix, we feel that native biomass is our goal and successful bank stabilization will be accomplished by establishing either this mix or volunteer species.

Native Riparian Mix

%	Common Name	Botanical Name
4.0	Big bluestem	Andropogon gerardii
3.0	Black-eyed susan	Rudbeckia hirta
15.0	Switchgrass	Panicum virgatum
4.0	Bur-marigold	Bidens aristosa
4.0	Evening primrose	Oenothera biennis
5.0	Indian grass	Sorghastrum nutans
6.0	Lance-leaved coreopsis	Coreopsis lanceolata
9.0	Little bluestem	Andropogon scoparium
11.0	Partridge pea	Chamaecrista fasciculata
6.0	Pennsylvania smartweed	Polygonum pennsylvanicum
4.0	River oats	Chasmanthium latifolium
6.0	Slender smartweed	Polygonum lapathifolium
5.0	Smooth panic grass	Panicum dichotomiflorum
3.0	Ashy sunflower	Helianthus mollis
5.0	Virginia wild rye	Elymus virginicus
3.0	Button Bush	Cephalanthus occidentalis
3.0	Silky Dogwood	Cornus amomiun
4.0	Southern Arrowwood	Viburnum dentatum

Erosion Control: All seeded areas, areas disturbed by heavy equipment, or other areas disturbed by mitigation activities should be protected from erosion by installation of erosion control blankets, matting or mulching with straw or other mulch material. An area at least 6 feet above the bankfull elevation should be stabilized using either a coir fiber mat or coir/straw blanket. A 4 ft. wide jute blanket should be installed up-slope of the 6.5 ft. strip. All of these materials should be installed and stapled according to the attached diagram and instruction. Staples should be installed on a 2 ft. spacing. Mulch should cover the seeded area to a depth that will allow for moisture retention and protect seed.

Woody Vegetation

A mix of shrub and tree species native to Western North Carolina will be planted at mitigation sites as either live stakes, potted stock, balled stock or bare root stock. These plantings will take place in the winter or early spring. Spacing suggestions should be used as guidelines, but can be varied depending on species requirements and landscape objectives. For example species that are commonly found growing in clumped distributions should be planted that way. It is desirable for the final distribution of trees and shrubs to have a more natural, random appearance. In order to accomplish this, exact spacing should be avoided and mixing of various species should be done. However, if competition from non-natives or an undesirable

species is a problem, trees should be planted in rows for easy herbicide application to the undesirable species.

Live stakes (unrooted material)

Live stake material should be dormant and gathered locally or purchased from a reputable commercial supplier. Stakes should be ½ to 3 inches in diameter and living based on the presence of young buds and green bark. Stakes should be kept cool and moist to improve survival and to maintain dormancy. Stakes should be driven into the ground using a rubber hammer, dead-blow hammer or by creating a hole and slipping the stake into it. The ground around the stake should be firmed against the stake after planting. Stakes should be placed so that 75% of the stake is below the ground and 2 or 3 buds are above ground. Stakes should be planted on a 5 to 10 foot spacing and at a density of 5 – 15 stakes per 1000 sq. ft.

Bare rooted or potted stock

Care and handling: Desirable trees and shrubs on the construction site should be dug and stored. These plants should be stored in a cool moist environment or heeled in. Roots of bareroot stock should be kept moist during planting operations. Bareroot material should only be planted during Winter and early Spring. Container or potted stock shall be kept moist at all times. Do not let roots freeze or dry out prior to planting.

Site Preparation: The soil in the area of tree planting should be loosened to a depth of at least 1 foot. This is only necessary on hard compacted soil.

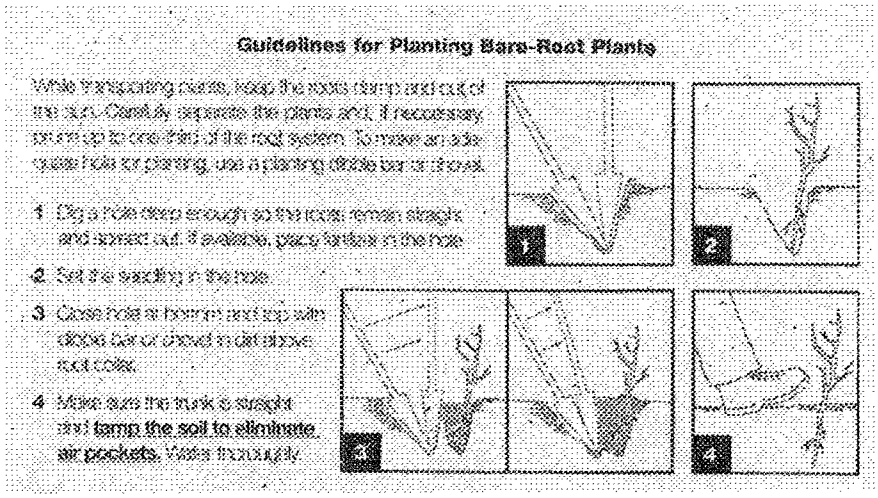
Planting:

On site material - Transplants should be replanted to the same depth they were originally growing.

Potted stock - Planting should be done mechanically or by hand using a shovel. The planting trench or hole must be deep enough and wide enough to permit roots to spread out and down without J-rooting. Potted stock should be planted in a hole 2-3 times the diameter of the root ball and at the same depth as the root ball. When setting plants, be certain to plant them high. Locate the root ball on solid soil and not loose backfill. Wire baskets do not need to be completely removed from large field grown trees. Be sure to remove plastic liners or synthetic burlap materials. Construct an earthen dam 4-6 inches high around the drip zone area of the plant after planting. This will allow for self watering and runoff will be minimized.

Bare rooted stock - Bare rooted material can be planted using a hoedad or a dibble bar (see diagram below). Planting slits for bare rooted material should be 6-8 inches in diameter and should be at least 8-12 inches deep. Damaged roots should be trimmed. Plants should be placed with the root collar slightly below the soil surface.

Holes and slits should be closed completely, including and especially at the bottom of the hole.



Spacing of rooted Woody Vegetation – the following guidelines should be used for spacing rooted woody vegetation.

Type	spacing	# per 1000 sq. ft.
Shrubs, less than 10 ft. in height	3 – 6 ft.	5 - 15
Shrubs and Trees, 10 -25 ft. in height	6 – 8 ft.	5 - 10
Trees greater than 25 ft. in height	8 – 15 ft.	1 - 3

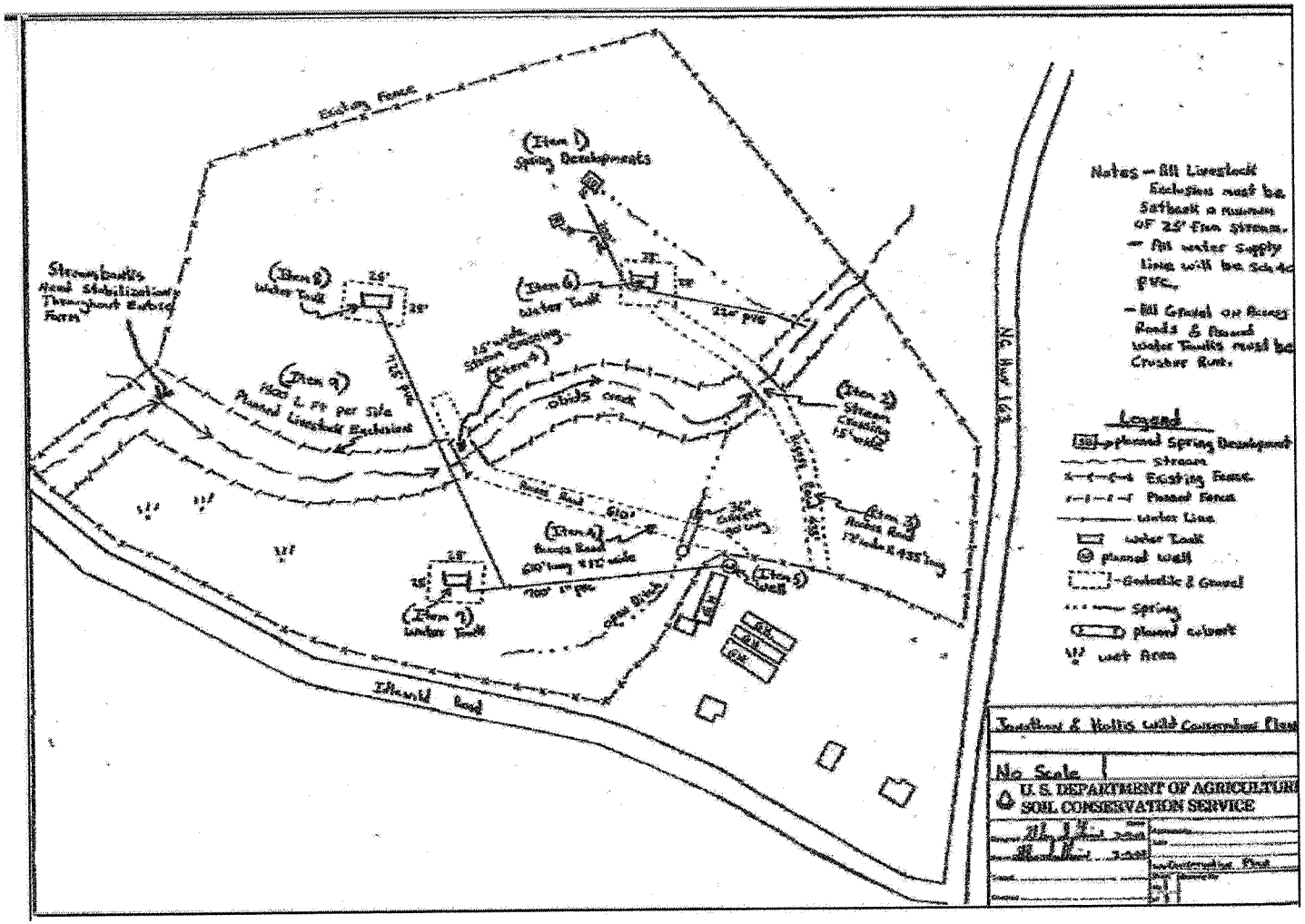
Survival of woody species planted at mitigation sites should be at least 320 stems/acre through year three. A ten percent mortality rate will be accepted in year four (288 stems/acre) and another ten percent in year five resulting in a required survival rate of 260 trees/acre through year five. This is consistent with Wilmington District (1993) guidance for wetland mitigation and the joint "Stream Mitigation Guidelines" that DWQ, WRC, USACOE and other agencies have agreed to. In some cases, it may be appropriate to include naturally recruited, desirable native species in the stem count. It is recognized these may not be the best plant density guidelines for all riparian systems. As more information becomes available it should be incorporated into these procedures.

ALL-PURPOSE SEED MIX				COMMENTS: List revised 2/15/01
COMMON NAME	BOTANICAL NAME	PERCENTAGE	SUN/SHADE	
Big bluestem	Andropogon gerardii	3	full sun	tall grass with bluish blades
Black-eyed susan	Rudbeckia hirta	5	full sun - shade	yellow flowers with brown centers (May - July)
Bur-marigold	Bidens aristosa	7	full sun	yellow flowers (Sept. - Oct.)
Deertongue 'Tioga'	Dichanthelium clandestinum	9	part shade	short bunch grass with strong fibrous root system
Evening primrose	Oenothera biennis	3	full sun	yellow flowers (June - Oct.)
Indian grass	Sorghastrum nutans	10	full sun	tall grass with yellow flowers
Lance-leaved coreopsis	Coreopsis lanceolata	5	full sun	yellow flowers (April - June)
Little bluestem	Schizachyrium scoparium	10	full sun - part shade	medium grass with bluish stems/reddish brown after frost
Partridge Pea	Chamaecrista fasciculata	5	full sun - part shade	legume with yellow flowers (June - Sept.)
Pennsylvania smartweed	Polygonum pennsylvanicum	5	part shade	deep pink flowers (July - frost)
Slender smartweed	Polygonum lapathifolium	5	full sun - part shade	pale pink - white flowers (Aug. - frost)
Smooth panic grass	Panicum dichotomiflorum	5	full sun - part shade	medium grass ; excellent wildlife food for birds
Swamp sunflower	Helianthus angustifolius	5	full sun - part shade	yellow flowers with dark red centers (July - frost)
Switchgrass	Panicum virgatum	6	full sun	medium-tall grass with stiff stems; excellent wildlife cover
Virginia wild rye	Elymus virginicus	5	part shade	short - medium grass; good wildlife food/cover
Elderberry	Sambucus canadensis	3	full sun	shrub
Red chokeberry	Aronia arbutifolia	2	full sun-part shade	shrub
Silky dogwood	Cornus amomum	3	full sun	shrub-small tree
Winterberry	Ilex verticillata	2	full sun-part shade	shrub
Spicebush	Lindera benzoin	2	part shade	shrub-small tree
This seed mix is comprised of a diverse assortment of native species that tolerate a broad range of growing conditions and should be suitable along stream corridors.				

APPENDIX 2

Livestock exclusion plan developed by Glen Sullivan, Cost Share Technician, Ashe County Soil and Water Conservation District, February 2, 2001.

Plan view of the Wild livestock exclusion plan on Obids Creek, Ashe County



North Carolina Agriculture, Cost Share Program, Conservation Plan of Operation, Ashe County

Name: Jay & Hollis Wild

Address: 204 Idlewild Rd.
West Jefferson, NC 28694

BMP Item Number	Planned Treatments	Est. Amounts (units)	Average Cost $	Total
1	**Spring Developments**			
	Excavation	15 hours	50/hour	$ 750.00
	Gravel - washed stone	30 tons	14.40/ton	$ 432.00
	4" Drain tube	180 LF	1.80/foot	$ 324.00
	4" Schedule 40 PVC	30 LF	2.65/foot	$ 79.50
	Junction Box	1	40/each	$ 40.00
	Geotextiles	50 yd^2	2/yd^2	$ 100.00
	Vegetation	.2 acre	216/acre	$ 43.20
2	**Stream Crossing**			
	Grading - moderate	80 LF	600/foot	$ 600.00
	Geotextiles	83 yd^2	2/yd^2	$ 166.00
	Anchor Pins	20	2/each	$ 40.00
	Gravel - crusher run	30 tons	14.40/ton	$ 432.00
	Vegetation	.1 acre	216/acre	$ 21.60
3	**Access Road**			
	Grading	435 LF	.50/foot	$ 217.50
	Gravel - crusher run	230 tons	14.40/ton	$ 3,312.00
	Geotextiles	575 yd^2	2/yd^2	$ 1,150.00
4	**Access Road & Stream Crossing**			
	Grading	610 LF	.50/foot	$ 305.00
	Gravel - crusher run	290 tons	14.40/ton	$ 4,176.00
	36" CSP Culvert	40 feet	26.51/foot	$ 1,060.40
	Geotextiles	813 yd^2	2/yd^2	$ 1,626.00
5	**Well Construction**	1	2000/each	$ 2,000.00
	Pump	1	450/eaach	$ 450.00
	Well Head Protection	1	500/each	$ 500.00

6	**Water Tank**			
	Prefab Concrete Tank	1	500/each	$ 500.00
	Gravel - crusher run	27 tons	14.40/ton	$ 388.80
	1.5" Schedule 40 PVC	520 LF	1.50/foot	$ 780.00
	Schedule 40 PVC fittings	4	3/each	$ 12.00
7	**Water Tank**			
	Pressure Fed Tank	1	533/each	$ 533.00
	Concrete	1.5 yd^3	100/yd^3	$ 150.00
	Gravel - crusher run	27 tons	14.40/ton	$ 388.80
	Geotextiles	80 yd^2	2/yd^2	$ 160.00
	1" Schedule 40 PVC	700 LF	1.50/ foot	$ 1,050.00
8	**Water Tank**			
	Pressure Fed Tank	1	533/each	$ 533.00
	Concrete	1.5 yd^3	100/yd^3	$ 150.00
	Gravel - crusher run	27 tons	14.40/ton	$ 388.80
	Geotextiles	80 yd^2	2/yd^2	$ 160.00
	1" Schedule 40 PVC	725 LF	1.50/ foot	$ 1,087.50
9	**Livestock Exclusion**	3600 LF	1.50/Foot	$ 5,400.00