

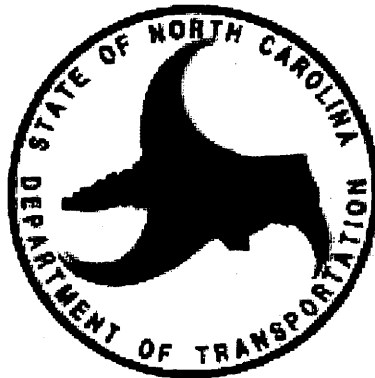
STREAM MITIGATION PLAN

US19, R-2518A
ON-SITE MITIGATION
MADISON COUNTY, NORTH CAROLINA

STATE PROJECT NUMBER: 6.869006T
TIP NUMBER: R-2518WM

Prepared for:

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
PROJECT DEVELOPMENT AND ENVIRONMENTAL
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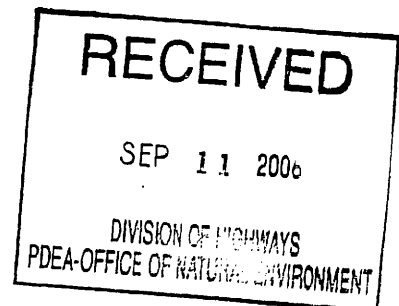


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1.0 INTRODUCTION

The North Carolina Department of Transportation (NCDOT) plans to use on-site stream mitigation to offset unavoidable impacts to existing streams from the construction that will occur due to the widening and relocation of US 19 (R-2518A). The NCDOT requested that Hayes, Seay, Mattem & Mattem, Inc. (HSMM) develop on-site mitigation plans for R-2518A. The project corridor is located in Madison County, NC near Radford Gap.

The mitigation components planned for the R-2518A on-site mitigation sites consist of restoring the natural pattern, dimension, and profile of the streams and restoring the natural functions provided by the streams. Alteration of existing land use will consist of reforestation of the riparian buffer and establishing a permanent conservation easement. The R-2518A mitigation sites will provide approximately 1,323 linear meters (4,341 linear feet) of stream restoration/relocation potential, 195 linear meters (640 linear feet) of stream enhancement potential, and 4,674 linear meters (15,335 linear feet) of stream preservation potential. The total on-site mitigation potential for R-2518A will provide approximately 6,192 linear meters (20,315 feet).

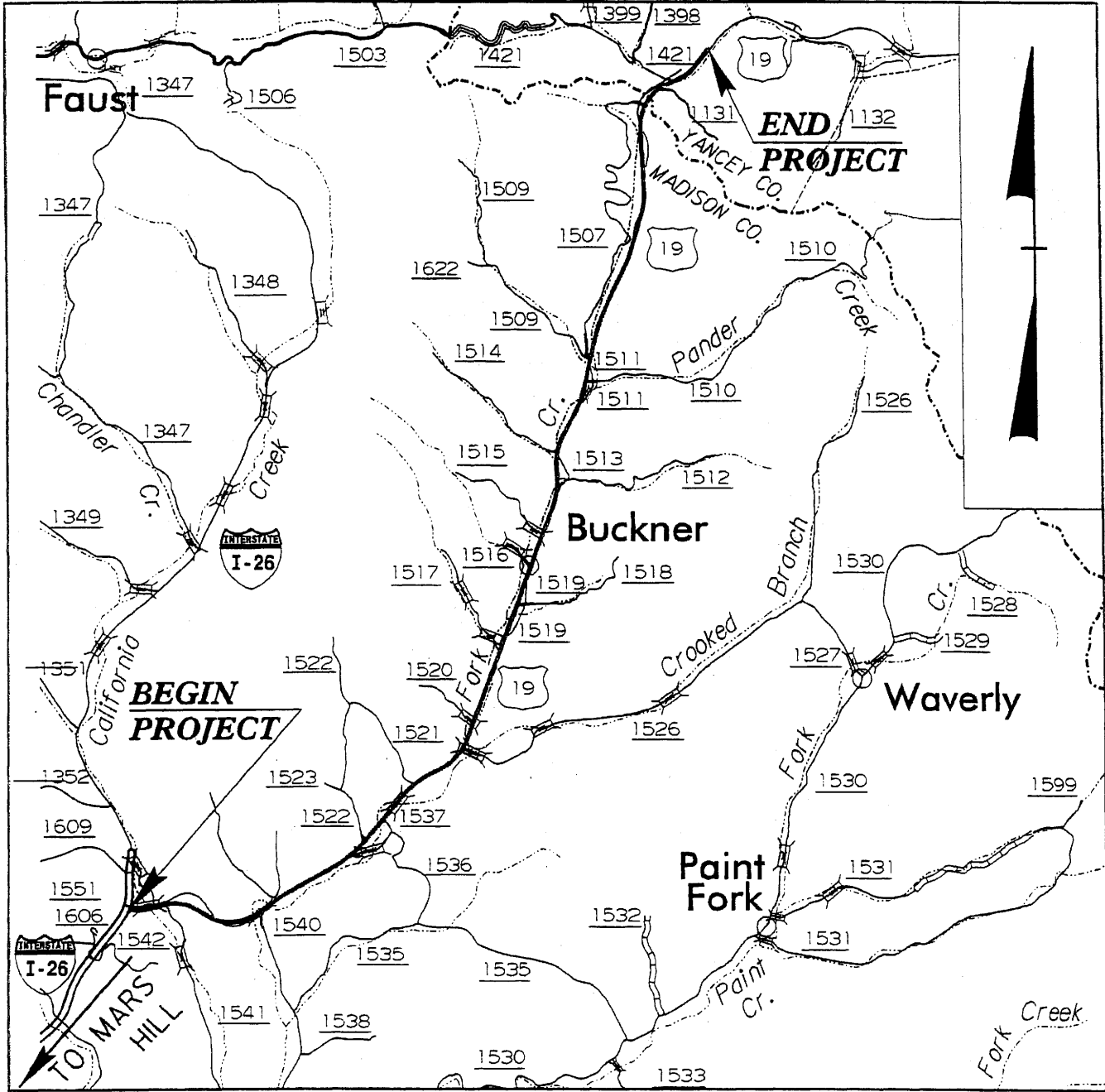
2.0 GOALS AND OBJECTIVES

The goal of this project is to restore, enhance, and preserve approximately 6,192 meters of stream and its riparian areas. The objective is a stable stream system that adequately conveys water and sediment as well as providing good quality aquatic and terrestrial habitat. The reaches to be restored were previously channelized and in some instances relocated. This project will improve bank stability by correcting channel dimension and pattern, and enhance in-stream habitat with placement of structures that improve bed-form and diversity.

3.0 LOCATION INFORMATION

The R-2518A on-site mitigation sites are located along US 19 in Madison County, between Radford Gap north to Ivy Gap (Figures 1 and 2). Table 1 provides the location information for each site.

River Basin – French Broad
USGS 8-Digit Catalog Number - 06010105
County – Madison County
Nearest town – Mars Hill



VICINITY MAP

SCALE: 1" = 260m'



TIP R-2518A US 19
 ON-SITE MITIGATION PLAN
 MADISON COUNTY, NORTH CAROLINA

FIGURE 1

TABLE 1: SITE LOCATION INFORMATION

Site Name	Station	Stream Name	Stream Classification	Stream Index Number	Proposed Methods
A	19+80 Rt; 19+80 to 21+40 Lt; 21+40 Rt	Middle Fork Creek	WS-II; HQW	6-96-10-1	Restoration/Enhancement/Preservation
B	21+35 to 21+90 Lt	UT to Middle Fork Creek	WS-II; HQW	-	Restoration
C	27+40 Rt	UT to Middle Fork Creek	WS-II; HQW	6-96-10-1-9	Restoration
D	31+20 Rt; 31+60 Lt	Bailey Branch	WS-II; HQW	-	Restoration/Relocation
E	33+80 Rt; 33+80 to 38+00 Lt	Middle Fork Creek	WS-II; HQW	6-96-10-1	Restoration/Preservation
F	37+80 to 38+40 Lt	UT to Middle Fork Creek	WS-II; HQW	-	Relocation
G	38+00 to 41+40 Rt	Middle Fork Creek	WS-II; HQW	6-96-10-1	Preservation
H	47+50 to 51+60 Lt	Middle Fork Creek	WS-II; HQW	6-96-10-1	Preservation
I	51+70 to 53+90 Lt	Middle Fork Creek	WS-II; HQW	6-96-10-1	Restoration
J	56+20 to 57+70 Rt	Turkey Branch	WS-II; HQW	6-96-10-1-6	Relocation
K	65+40 to 77+20 Lt	Middle Fork Creek	WS-II; HQW	6-96-10-1	Preservation
L	70+20 Rt	Polly Branch	WS-II; HQW	6-96-10-1-5	Preservation
M	81+80 to 82+20 Lt; 81+30 Rt	Holland Creek	WS-II; HQW	6-96-10-1-2	Restoration
N	82+20 to 82+50 Rt; 82+80 to 84+20 Lt	Ivy Gap Branch	WS-II; HQW	6-96-10-1-1	Preservation/Relocation
O	85+20 to 90+95 Lt	Ivy Gap Branch	WS-II; HQW	6-96-10-1-1	Enhancement/Preservation
	90+85 to 92+00 Lt	UT to Ivy Gap Branch	WS-II; HQW	-	Preservation
P	88+40 Rt	UT to Ivy Gap Branch	WS-II; HQW	-	Preservation
Q	97+70 to 105+00 Lt	Ivy Gap Branch	WS-II; HQW	6-96-10-1-1	Preservation
R	109+20 Lt; 109+40 to 114+40 Rt	Bald Creek	C	7-3-22	Preservation

4.0 GENERAL WATERSHED INFORMATION

Table 2. Drainage Area

SITE	STREAM	DRAINAGE AREA (mi ²)
A	Middle Fork Creek	12.8
B	UT to Middle Fork Creek	0.16
C	UT to Middle Fork Creek	0.08
D	Bailey Branch	0.95
E	Middle Fork Creek	10.4
F	UT to Middle Fork Creek	0.22
I	Middle Fork Creek	7.08
J	Turkey Branch	0.37
M	Holland Creek	1.3
N	Ivy Gap Branch	1.14

Dominant Land Use – Rural, low density residential, and agriculture

Relative Distribution of Land Use - <15% residential and commercial development; other land uses include agriculture and forest

Estimation of future land use change – estimated very little changes in land use over the next 10+ yrs; possible changes may include increased residential and commercial areas and highway improvements

5.0 EXISTING CONDITIONS

Site	Existing Condition		Proposed Avlt Buffer
	Stream	Buffer	
Site A Stream: Middle Fork Creek Location: 19+80 Rt; 19+80 - 21+40 Lt; 21+40 Rt	Classification: B and G Bed Material: Gravel/Silt Description: Some vertical banks, with bank failure and erosion, over-widened at bridge Instream Habitat: riffle-pool habitat present, gravel bed with significant fines	Left: Little to no buffer Right: Little to no buffer Vegetation: Disturbed/Successional	R: 73 m (239 ft) E: 145 m (476 ft) P: 146 m (479 ft)
Site B Stream: UT to Middle Fork Creek Location: 21+35 - 21+90 Lt	Classification: Piped stream Bed Material: NA Description: Small piped channel Instream Habitat: None due to piping	Left: No Buffer, piped Right: No Buffer Vegetation: None	R: 56 m (184 ft)
Site C Stream: UT to Middle Fork Creek Location: 27+40 Rt	Classification: G Bed Material: Gravel/Silt Description: Small dredged and entrenched channel Instream Habitat: limited, thalweg choked with vegetation	Left: No Buffer, Ag field Right: No Buffer Vegetation: Early Successional	R: 79 m (259 ft)
Site D Stream: Bailey Branch Location: 31+20 Rt; 31+60 Lt	Classification: G Bed Material: Gravel/silt Description: Entrenched Instream Habitat: Riffle-pool sequence	Left: No Buffer Right: No Buffer Vegetation: Open, grass early successional	R: 80 m (262 ft)
Site E Stream: Middle Fork Creek Location: 33+80 Rt Location: 33+80 - 38+00 Lt	Classification: B Bed Material: Gravel/Silt/Cobble Description: Fairly stable Instream Habitat: Riffle-pool habitat present	Left: Narrow buffer Right: >10 m Vegetation: Ag field on Lt; Disturbed, successional on Rt	P: 250 m (820 ft)
Site F Stream: UT to Middle Fork Creek Location: 37+80 - 38+40 Lt	Classification: B Bed Material: Gravel/Silt/Cobble Description: Channel to be impacted by roadway fill Instream Habitat: Riffle-pool habitat	Left: No buffer Right: No buffer Vegetation: Early successional	R: 69 m (226 ft)
Site G Stream: Middle Fork Creek Location: 38+00 - 41+40 Rt	Classification: B Bed Material: Gravel/Silt/Cobble Description: Stable, good condition Instream Habitat: Riffle-pool seq. present	Left: Narrow buffer Right: Narrow buffer Vegetation: Early successional	P: 325 m (1,066 ft)
Site H Stream: Middle Fork Creek Location: 47+50 - 51+60 Lt	Classification: B Bed Material: Gravel/Silt/Cobble Description: Stable, good condition Instream Habitat: Riffle-pool sequence	Left: Narrow buffer, limited by road Right: Narrow buffer, adjacent Ag fields Vegetation: Successional, Hardwoods	P: 415 m (1,362 ft)
Site I Stream: Middle Fork Creek Location: 51+70 - 53+90 Lt	Classification: G Bed Material: Gravel/ Silt/Cobble Description: Entrenched, some evidence to bank erosion Instream Habitat: Some riffle habitat, mostly run, narrow channel, choked with vegetation	Left: No buffer Right: No buffer Vegetation: Grassed, scattered trees mostly open, very limited	R: 240 m (787 ft)
Site J Stream: Turkey Branch Location: 56+20 - 57+70 Rt	Classification: G Bed Material: Description: Impacted by roadway fill Instream Habitat: Limited	Left: Narrow buffer, adjacent Ag field Right: Narrow buffer, limited by road Vegetation: Herbaceous Vegetation	R: 211 m (692 ft)
Site K Stream: Middle Fork Creek Location: 65+40 - 71+00 Lt Location: 71+00 - 73+00 Lt Location: 73+20 - 75+10 Lt Location: 75+10 - 77+20 Lt	Classification: B Bed Material: Gravel, Cobble Description: (65+40 - 71+00 Lt) Good condition, stable. Adjacent to road Instream Habitat: Riffle-pool sequence	Left: Narrow buffer Right: Narrow buffer Vegetation: Mostly early successional	P: 530 m (1,739 ft)
	Classification: B Description: Good condition, stable, Adjacent to road, attacking bank in few spots Instream Habitat: Riffle-pool sequence	Left: Established Right: Established Vegetation: mature buffer	P: 280 m (919 ft)
	Classification: B Bed Material: Gravel, Cobble Description: Good condition, pipe blew out at 75+20, 100' D/s has been reworked Instream Habitat: Riffle-pool sequence	Left: Established Right: Established Vegetation: mature buffer	P: 230 m (755 ft)
	Classification: B and C Bed Material: Gravel/Silt/Cobb/Boulder Description: Fairly good condition, close to commercial buildings Instream Habitat: Riffle-pool sequence	Left: Narrow Right: Established Vegetation: Mature buffer on Rt., disturbed veg on Lt	P: 260 m (853 ft)

Site	Existing Condition		Proposed Mitigation
	Stream	Buffer	
Site L Stream: Polly Branch Location: 70+20 Rt	Classification: E Bed Material: Gravel Description: Small naturalized channel, good condition Instream Habitat: Riffle-pool habitat	Left: Established Right: Established Vegetation: mature buffer	P: 160 m (525 ft)
Site M Stream: Holland Creek Location: 81+80 - 82+20 Lt; 81+30 Rt	Classification: B Bed Material: Gravel/Silt/Cobble Description: Banks impacted by cattle grazing Instream Habitat: Riffle-pool habitat	Left: No Buffer Right: No Buffer Vegetation: Early successional canopy/shrub sap stratum absent	R: 84 m (276 ft)
Site N Stream: Ivy Gap Branch Location: 82+20 - 82+50 Rt Location: 82+80 - 84+20Lt	Classification: B Bed Material: Gravel/Silt/Cobble Description: Stable, good condition Instream Habitat: Riffle-pool sequence	Left: Narrow Right: Narrow Vegetation: Herbaceous vegetation	P: 45 m (148 ft)
	Classification: B Bed Material: Gravel/Silt/Cobble Description: Channel to be impacted by roadway fill Instream Habitat: Riffle-pool sequence	Left: NA Right: NA Vegetation: NA	R: 177 m (581 ft)
Site O Stream: Ivy Gap Branch Location: 85+20 - 87+70 Lt Location: 87+70 - 90+95 Lt Stream: UT to Ivy Gap Br Location: 90+85 - 92+00 Lt	Classification: G Bed Material: Gravel/Silt/Cobble Description: Entrenched, banks eroding, debris in channel Instream Habitat: Woody material; riffle pool habitat	Left: Varies Right: Varies Vegetation: Ag field and mature woods along stream	E: 50 m (164 ft)
	Classification: E and G Bed Material: Gravel/Silt/Cobble Description: Narrow but fairly stable, local erosion Instream Habitat: Riffle-pool sequence	Left: Varies Right: Varies Vegetation: Early successional, scarce canopy/shrub/sapling	P: 600 m (1,968 ft)
	Classification: G Bed Material: Gravel/Silt/Cobble Description: Small channelized stream Instream Habitat: Variable substrate	Left: No Buffer Right: No Buffer Vegetation: Successional/herbaceous	P: 125 m (410 ft)
Site P Stream: UT to Ivy Gap Br Location: 88+40 Rt	Classification: G Bed Material: Gravel/Silt/Cobble Description: Small channelized stream Instream Habitat: Variable substrate; riffle-pool habitat	Left: Irregularly maintained with partial canopy Right: Irregularly maintained with partial canopy Vegetation: Successional	P: 50 m (164 ft)
Site Q Stream: Ivy Gap Br Location: 97+70 - 105+00 Lt	Classification: E Bed Material: Gravel/Silt Description: Low width:depth ratio; localized bank failures Instream Habitat: Riffle-pool sequence	Left: Varies Right: Varies Vegetation: Varies; early successional, herbaceous	P: 700 m (2,297 ft)
Site R Stream: Bald Creek Location: 109+20 Lt; 109+40 - 114+40 Rt	Classification: B Bed Material: Gravel/Cobble Description: Stable Instream Habitat: Riffle-pool sequence	Left: Narrow buffer Right: Moderate buffer Vegetation: Some mature canopy species, shrub/herbaceous layer	P: 558 m (1,831 ft)

R: Restoration/Relocation
 E: Enhancement
 P: Preservation

Site N Rt - 15 ft
 say P but
 plans show R
 ?

6.0 FEDERALLY PROTECTED SPECIES

There are three federally threatened or endangered species listed for Madison County, North Carolina. As of April 2005, the Natural Heritage Programs database of threatened and endangered species (NHP) reported no individuals or populations of any federally protected species within 1.0 mile of the site. Table 1 includes all federally protected species listed for Madison County.

Table 1. Federally Protected Species for Madison County

Scientific Name	Common Name	Status
<i>Myotis grisescens</i>	Gray bat	Endangered
<i>Hybopsis monacha</i>	Spotfin chub	Threatened
<i>Epioblasma capsaeformis</i>	Oyster mussel	Endangered

Habitat for the spotfin chub and oyster mussel do exist in the form of clear water over coarse sand, gravel, boulder, and bedrock substrate with moderate current on these sites. Consequently, before in-stream work is conducted, surveys for these species should be performed.

7.0 STREAM REFERENCE RESTORATION STUDIES

The reference reach analysis provides the foundation for developing the hydraulic geometry of the design channel. A reference reach is a stream segment that represents a stable channel within a particular valley morphology. A stable stream is defined as a stream, which over time and in the present climate transports the flows and sediment produced by its watershed in such a manner that the dimension, pattern, and profile are maintained without either aggrading or degrading (Rosgen, 1996, 1998).

The methodology used for the reference reach analysis consisted of the following tasks: (1) determine the appropriate properties of a reference reach based on information acquired during the site investigation, (2) conduct a search for suitable reference reaches, (3) survey and classify the stream morphology, and (4) develop dimensionless ratios for the reference reach. The search for a suitable reference reach consisted of investigating the stream reaches upstream and downstream of the project site. The advantage of having a reference reach located upstream or downstream of the project site is that it provides a closer relationship between the channel properties and the discharges produced (flow and sediment) by the watershed.

This project is located in a low rainfall hydrologic region within the mountain physiographic province of western North Carolina. The North Carolina Stream Restoration Institute's (SRI) regional curve for the mountain physiographic province contain three sites that are also located within this sub-region. However, the majority of the sites used to develop the curve are located

outside of the sub-region of the proposed project. HSMM used the three SRI sites along with on-site reference data, and USGS data to develop a localized regional curve (Appendix A). This curve was then utilized to predict cross sectional area and bankfull discharge of the proposed mitigation sites.

Three on-site reference reaches were surveyed to aid in the design of the streams to be restored and relocated and used as well to assist in the development of a localized curve mentioned above. Two of the references are located along Middle Fork Creek (Reference 1 and 2) and one on Polly Branch (Reference 3). Polly Branch was solely used to develop the localized curve. The morphological data and photos for these reference reaches are located in Appendix A. Appendix B contains the morphological characteristics of each stream that is proposed to be restored or relocated, along with the corresponding data for each reference reach.

Shear stress was calculated for the reference reaches as well as for the proposed restoration sites to determine the particle size that will be mobilized by the stream. These calculations assist in the determining if the design channel will be stable after it is constructed (Appendix C).

8.0 STREAM RESTORATION PLAN

The stream restoration plan for R-2518A is included in Appendix D of this report. The plan includes the following information:

- Scaled plan view of site showing existing channel location, proposed channel location, proposed in-stream structure locations, and the adjacent buffer areas;
- Longitudinal profile for proposed channel; and
- Typical cross sections for proposed channel.

The design sections were evaluated for their competency to transport the sediment supplied by the watershed. Shear stress was calculated for each of the design sections to confirm that it matched the reference reaches (see Appendix C). Also a riparian planting plan with specifications is located in Appendix E.

9.0 STREAM PERFORMANCE CRITERIA AND MONITORING PLAN

An As-Built will be submitted within sixty (60) days of completion of the project. The As-built will document the dimension, pattern, profile, vegetation plantings, and structures of the constructed channel.

The following components of Level 1 monitoring will be performed each year of the 5-year monitoring period: Reference photos, plant survival (i.e., identify specific problems areas

(missing, stressed, damaged or dead plantings), estimated causes and proposed/required remedial action); visual inspection of channel stability. Physical measurements of channel stability/morphology will not be performed. A monitoring report will be submitted within sixty (60) days after completing the monitoring.

10.0 MITIGATION SUMMARY

NCDOT has made an effort to restore/relocate, enhance and preserve approximately 6192 meters of streams adjacent to the US 19 corridor to meet our mitigation requirements. The streams are being purchased as right of way for the roadway project. These sites will have controlled access to ensure they are protected from local landowner encroachment. Also, placing these streams and riparian buffers into right of way guarantees that no future impacts will occur directly to these channels due to commercial or residential development along the corridor.

Several of these enhancement and restoration areas will be located upstream or downstream of several of the preservation sites. They include:

Site A: Enhancement and restoration of site is linked to the upstream preservation site

Site E: Restoration site links the preservation sites upstream and downstream

Site I: Restoration site is linked to a downstream preservation site

Site N: Relocation site is linked to a preservation site

By connecting these sites we have protected extensive portions of the stream system from any future development. Based on the efforts to enhance the water quality adjacent to the roadway, NCDOT proposes the following credit ratios:

Restoration/Relocation	1:1
Enhancement	2:1
Preservation	3:1

Using these ratios would yield the following:

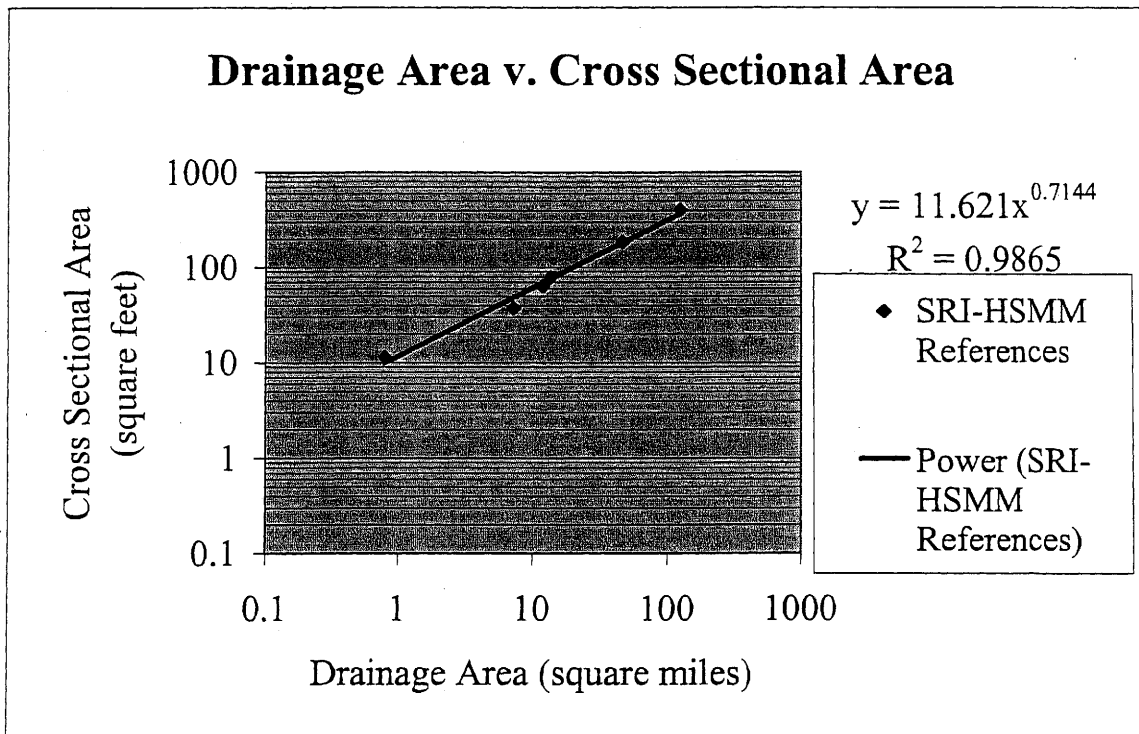
Table 5. Mitigation Summary

APPROACH	CREDIT RATIO	PROPOSED LENGTH	PROPOSED CREDITS
Restoration	1	1323 meters	1323 meters
Enhancement	2	195 meters	97.5 meters
Preservation	3	4674 meters	1558 meters
TOTAL			2978.5 meters (9772 feet)

APPENDIX A
REFERENCE REACH STREAM DATA

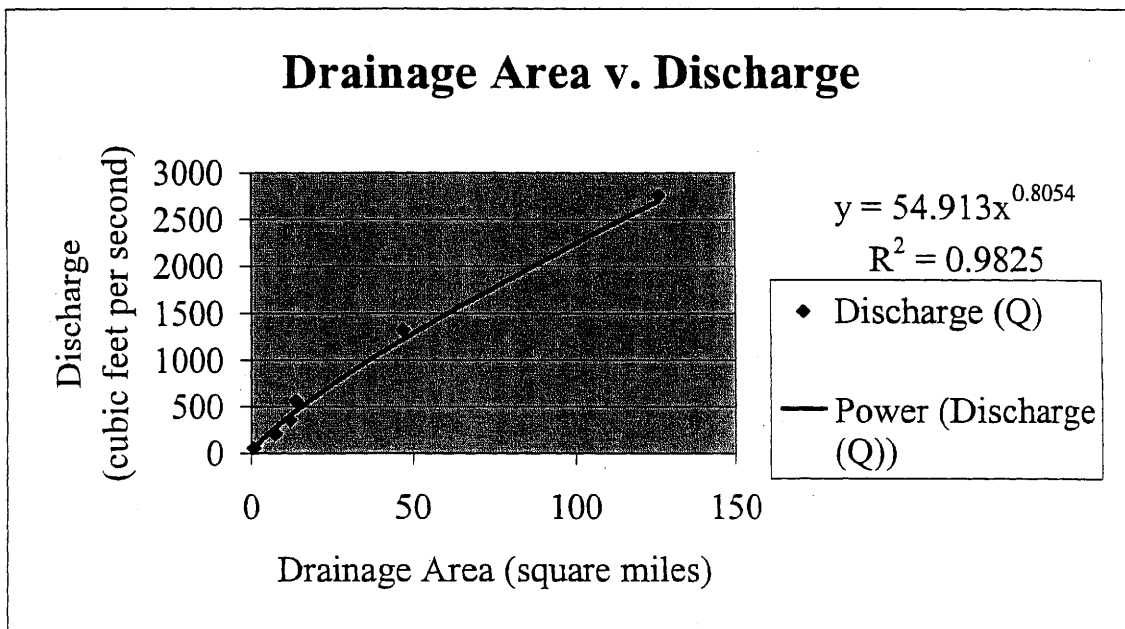
Stream Name	DA (SQ MI)	XSA (SF)
Big Laurel	126	406
Caldwell Fork	13.8	79.3
Cataloochee	46.9	186.9
Reference 1*	7.3	37.3
Reference 2*	12	64.1
Reference 3	0.8	11.5
A	12.8	71.82
B	0.16	3.14
C	0.077	1.86
D	0.95	11.20
E	10.4	61.92
E	10.4	61.92
F	0.22	3.94
I	7.08	47.04
J	0.37	5.71
M	1.3	14.02
N	1.14	12.76

* Middle Fork Creek (used as reference in design)



Stream Name	DA (SQ. MI)	Discharge (Q) (CFS)
Big Laurel	126	2763
Caldwell Fork	13.8	560
Cataloochee	46.9	1320
Reference 1*	7.3	203
Reference 2*	12	352
Reference 3	0.8	52

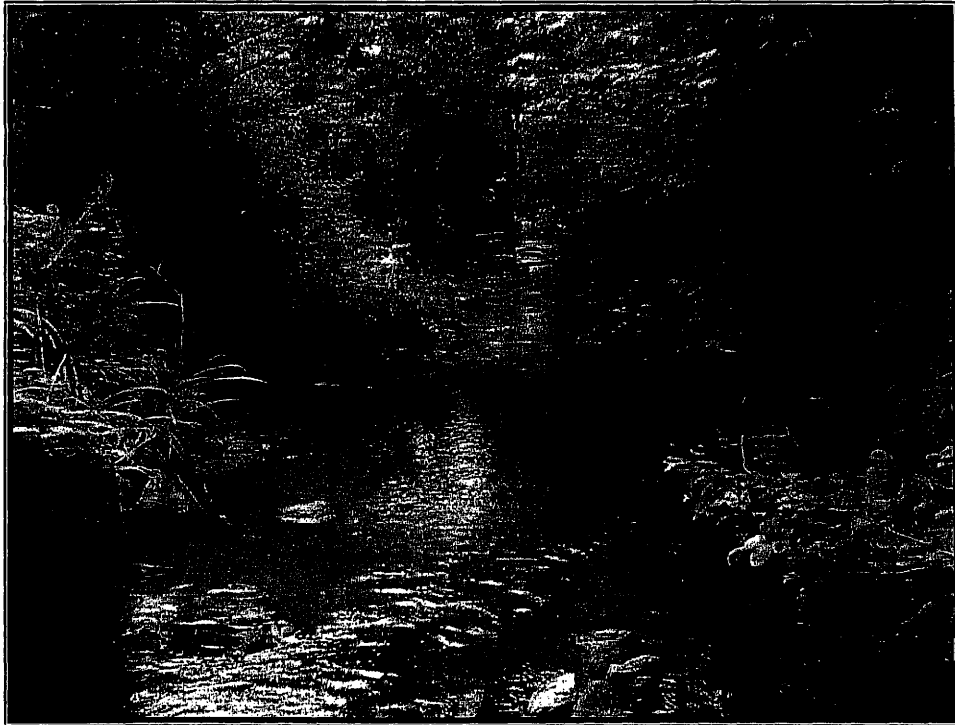
* Middle Fork Creek (used as reference in design)



Morphological Characteristics of the Reference Reaches

Variables	Reference 1 Middle Fork Creek	Reference 2 Middle Fork Creek
1. Stream Type	B4c	B4c
2. Drainage Area (mi. ²)	7.3	12
3. Bankfull Width (Wb _{kf})	19.4-20.1	25.5-28.6
4. Bankfull Mean Depth (D _{b_{kf}})	1.9-2.0	2.24
5. Width/Depth Ratio	9.5-10.8	10.7-12.8
6. Max Riffle Depth Ratio (D _{max} /D _{b_{kf}})	1.3-1.5	1.2-1.4
7. Bankfull Cross-Sectional Area (A _{b_{kf}})	37.3-39.7	60.5-64.1
8. Bankfull Mean Velocity (V _{b_{kf}})	4.9-5.2	5.5
9. Bankfull Discharge (Q _{b_{kf}})	195	352
10. Bankfull Maximum Depth (D _{max})	2.3-3.0	2.7-3.1
11. Width of Floodprone Area (W _{f_{pa}})	25.5-27.0	34-90
12. Entrenchment Ratio (W _{f_{pa}} /W _{b_{kf}})	1.3-1.4	1.2-3.5
13. Meander Length (L _m)	-	-
14. Meander Length Ratio (L _m /W _{b_{kf}})	-	-
15. Radius of Curvature (R _c)	23.5-51.8	30-122
16. Radius of Curvature Ratio (R _c /W _{b_{kf}})	1.2-2.7	1.1-4.8
17. Belt Width (W _{b_{lt}})	-	-
18. Meander Width Ratio (W _{b_{lt}} /W _{b_{kf}})	-	-
19. Sinuosity (K)	1.04	1.0
20. Valley Slope	0.011	0.007
21. Average Slope (S _{avg})	0.0093-0.0108	0.007
22. Pool Slope (S _{pool})	0-0.001	0-0.004
23. Pool Slope Ratio (S _{pool} /S _{avg})	0.093-0.11	0-0.6
24. Max. Pool Depth (D _{pool})	3.1-3.3	3.1-4.9
25. Pool Depth Ratio (D _{pool} /D _{b_{kf}})	1.7-1.8	1.4-2.2
26. Pool Area Ratio (A _{pool} /A _{b_{kf}})	1.1	0.9
27. Pool Length Ratio (L _{pool} /W _{b_{kf}})	0.5-1.1	0.9-2.2
28. Pool Width (W _{pool})	16.4-17.8	23.4-25.8
29. Pool Width Ratio (W _{pool} /W _{b_{kf}})	0.8-0.9	0.8-0.9
30. Pool-Pool Spacing (p-p)	38-107	65-190
31. Pool Spacing Ratio (p-p/W _{b_{kf}})	1.9-5.3	2.3-7.5
Materials:		
1. Particle Size Distribution		
d ₁₆	9.42	1.4
d ₃₅	40.39	7.3
d ₅₀	57.8	15.2
d ₈₄	123	92
d ₉₅	170	155

REFERENCE 1 PHOTOGRAPHS



Reference 1: Facing upstream



Reference 1: Facing downstream

REFERENCE 2 PHOTOGRAPHS



Reference 2: Facing upstream



Reference 2: Facing downstream

APPENDIX B
MORPHOLOGICAL CHARACTERISTICS
PROPOSED STREAMS

Morphological Characteristics of the Proposed Reach and Reference Reach

Variables	Proposed Site A Middle Fork Creek	Reference 1 Middle Fork Creek	Reference 2 Middle Fork Creek
1. Stream Type	B4c	B4c	B4c
2. Drainage Area (mi. ²)	12.8	7.3	12
3. Bankfull Width (Wb _{kf})	29.4	19.4-20.1	25.5-28.6
4. Bankfull Mean Depth (D _{b_{kf}})	2.45	1.9-2.0	2.24
5. Width/Depth Ratio	12	9.5-10.8	10.7-12.8
6. Max Riffle Depth Ratio (D _{max} /D _{b_{kf}})	1.3	1.3-1.5	1.2-1.4
7. Bankfull Cross-Sectional Area (A _{b_{kf}})	72	37.3-39.7	60.5-64.1
8. Bankfull Mean Velocity (V _{b_{kf}})	5.9	4.9-5.2	5.5
9. Bankfull Discharge (Q _{b_{kf}})	428	195	352
10. Bankfull Maximum Depth (D _{max})	2.9-3.7	2.3-3.0	2.7-3.1
11. Width of Floodprone Area (W _{f_{pa}})	50	25.5-27.0	34-90
12. Entrenchment Ratio (W _{f_{pa}} /W _{b_{kf}})	1.7	1.3-1.4	1.2-3.5
13. Meander Length (L _m)	290-410	-	-
14. Meander Length Ratio (L _m /W _{b_{kf}})	10-14	-	-
15. Radius of Curvature (R _c)	59-88	23.5-51.8	30-122
16. Radius of Curvature Ratio (R _c /W _{b_{kf}})	2.0-3.0	1.2-2.7	1.1-4.8
17. Belt Width (W _{b_{lt}})	36	-	-
18. Meander Width Ratio (W _{b_{lt}} /W _{b_{kf}})	1.24	-	-
19. Sinuosity (K)	1.08	1.04	1.0
20. Valley Slope	0.0092	0.011	0.007
21. Average Slope (S _{avg})	0.0085	0.0093-0.0108	0.007
22. Pool Slope (S _{pool})	0	0-0.001	0-0.004
23. Pool Slope Ratio (S _{pool} /S _{avg})	0	0.093-0.11	0-0.6
24. Max. Pool Depth (D _{pool})	4.2	3.1-3.3	3.1-4.9
25. Pool Depth Ratio (D _{pool} /D _{b_{kf}})	1.8	1.7-1.8	1.4-2.2
26. Pool Area Ratio (A _{pool} /A _{b_{kf}})	0.9-1.1	1.1	0.9
27. Pool Length Ratio (L _{pool} /W _{b_{kf}})	0.5-2.2	0.5-1.1	0.9-2.2
28. Pool Width (W _{pool})	23.5-26.5	16.4-17.8	23.4-25.8
29. Pool Width Ratio (W _{pool} /W _{b_{kf}})	0.8-0.9	0.8-0.9	0.8-0.9
30. Pool-Pool Spacing (p-p)	118-147	38-107	65-190
31. Pool Spacing Ratio (p-p/W _{b_{kf}})	4-5	1.9-5.3	2.3-7.5
Materials:			
1. Particle Size Distribution			
d16	15	9.42	1.4
d35	30	40.39	7.3
d50	50	57.8	15.2
d84	100	123	92
d95	150	170	155

Morphological Characteristics of the Proposed Reach and Reference Reach

Variables	Proposed Site B UT to Middle Fork Creek	Reference 1 Middle Fork Creek	Reference 2 Middle Fork Creek
1. Stream Type	B4c	B4c	B4c
2. Drainage Area (mi. ²)	0.16	7.3	12
3. Bankfull Width (Wbkf)	6.1	19.4-20.1	25.5-28.6
4. Bankfull Mean Depth (Dbkf)	0.51	1.9-2.0	2.24
5. Width/Depth Ratio	12	9.5-10.8	10.7-12.8
6. Max Riffle Depth Ratio (Dmax/Dbkf)	1.3	1.3-1.5	1.2-1.4
7. Bankfull Cross-Sectional Area (Abkf)	3.14	37.3-39.7	60.5-64.1
8. Bankfull Mean Velocity (Vbkf)	4.1	4.9-5.2	5.5
9. Bankfull Discharge (Qbkf)	12.6	195	352
10. Bankfull Maximum Depth (Dmax)	0.58-0.72	2.3-2.8	2.7-3.1
11. Width of Floodprone Area (Wfpa)	10.4	25.5-27.0	34-90
12. Entrenchment Ratio (Wfpa/Wbkf)	1.7	1.3-1.4	1.2-3.5
13. Meander Length (Lm)	61-85	-	-
14. Meander Length Ratio (Lm/Wbkf)	10-14	-	-
15. Radius of Curvature (Rc)	11.6-17.4	23.5-51.8	30-122
16. Radius of Curvature Ratio (Rc/Wbkf)	2.0-3.0	1.2-2.7	1.1-4.8
17. Belt Width (Wblt)	13.8-17.7	-	-
18. Meander Width Ratio (Wblt/Wbkf)	2.3-2.9	-	-
19. Sinuosity (K)	1.09	1.04	1.0
20. Valley Slope	0.0375	0.011	0.007
21. Average Slope (Savg)	0.0344	0.0093-0.0108	0.007
22. Pool Slope (Spool)	0	0-0.001	0-0.004
23. Pool Slope Ratio (Spool/Savg)	0-0.6	0.093-0.11	0-0.6
24. Max. Pool Depth (Dpool)	0.92	3.1-3.3	3.1-4.9
25. Pool Depth Ratio (Dpool/Dbkf)	1.8	1.7-1.8	1.4-2.2
26. Pool Area Ratio (Apool/Abkf)	0.9-1.1	1.1	0.9
27. Pool Length Ratio (Lpool/Wbkf)	0.5-2.2	0.5-1.1	0.9-2.2
28. Pool Width (Wpool)	4.8-5.5	16.4-17.8	23.4-25.8
29. Pool Width Ratio (Wpool/Wbkf)	0.8-0.9	0.8-0.9	0.8-0.9
30. Pool-Pool Spacing (p-p)	23-29	38-107	65-190
31. Pool Spacing Ratio (p-p/Wbkf)	4-5	1.9-5.3	2.3-7.5
Materials:			
1. Particle Size Distribution			
d16	15	9.42	1.4
d35	30	40.39	7.3
d50	50	57.8	15.2
d84	100	123	92
d95	150	170	155

Morphological Characteristics of the Proposed Reach and Reference Reach

Variables	Proposed Site C UT to Middle Fork Creek	Reference 1 Middle Fork Creek	Reference 2 Middle Fork Creek
1. Stream Type	B4c	B4c	B4c
2. Drainage Area (mi. ²)	0.08	7.3	12
3. Bankfull Width (Wbkf)	4.7	19.4-20.1	25.5-28.6
4. Bankfull Mean Depth (Dbkf)	0.39	1.9-2.0	2.24
5. Width/Depth Ratio	12	9.5-10.8	10.7-12.8
6. Max Riffle Depth Ratio (Dmax/Dbkf)	1.3	1.3-1.5	1.2-1.4
7. Bankfull Cross-Sectional Area (Abkf)	1.86	37.3-39.7	60.5-64.1
8. Bankfull Mean Velocity (Vbkf)	3.8	4.9-5.2	5.5
9. Bankfull Discharge (Qbkf)	7	195	352
10. Bankfull Maximum Depth (Dmax)	0.47-0.59	2.3-2.8	2.7-3.1
11. Width of Floodprone Area (Wfpa)	8	25.5-27.0	34-90
12. Entrenchment Ratio (Wfpa/Wbkf)	1.7	1.3-1.4	1.2-3.5
13. Meander Length (Lm)	47-66	-	-
14. Meander Length Ratio (Lm/Wbkf)	10-14	-	-
15. Radius of Curvature (Rc)	9.4-14.1	23.5-51.8	30-122
16. Radius of Curvature Ratio (Rc/Wbkf)	2.0-3.0	1.2-2.7	1.1-4.8
17. Belt Width (Wblt)	10.5-14.8	-	-
18. Meander Width Ratio (Wblt/Wbkf)	2.7	-	-
19. Sinuosity (K)	1.3	1.04	1.0
20. Valley Slope	0.0094	0.011	0.007
21. Average Slope (Savg)	0.007	0.0093-0.0108	0.007
22. Pool Slope (Spool)	0	0-0.001	0-0.004
23. Pool Slope Ratio (Spool/Savg)	0-0.06	0.093-0.11	0-0.6
24. Max. Pool Depth (Dpool)	0.70	3.1-3.3	3.1-4.9
25. Pool Depth Ratio (Dpool/Dbkf)	1.8	1.7-1.8	1.4-2.2
26. Pool Area Ratio (Apool/Abkf)	0.9-1.1	1.1	0.9
27. Pool Length Ratio (Lpool/Wbkf)	0.5-2.2	0.5-1.1	0.9-2.2
28. Pool Width (Wpool)	3.8-4.2	16.4-17.8	23.4-25.8
29. Pool Width Ratio (Wpool/Wbkf)	0.8-0.9	0.8-0.9	0.8-0.9
30. Pool-Pool Spacing (p-p)	19-24	38-107	65-190
31. Pool Spacing Ratio (p-p/Wbkf)	4-5	1.9-5.3	2.3-7.5
Materials:			
1. Particle Size Distribution			
d16	15	9.42	1.4
d35	30	40.39	7.3
d50	50	57.8	15.2
d84	100	123	92
d95	150	170	155

Morphological Characteristics of the Proposed Reach and Reference Reach

Variables	Proposed Site D1 Bailey Branch	Reference 1 Middle Fork Creek	Reference 2 Middle Fork Creek
1. Stream Type	B4	B4c	B4c
2. Drainage Area (mi. ²)	0.95	7.3	12
3. Bankfull Width (Wb _{kf})	11.6	19.4-20.1	25.5-28.6
4. Bankfull Mean Depth (D _{b_{kf}})	0.97	1.9-2.0	2.24
5. Width/Depth Ratio	12	9.5-10.8	10.7-12.8
6. Max Riffle Depth Ratio (D _{max} /D _{b_{kf}})	1.3	1.3-1.5	1.2-1.4
7. Bankfull Cross-Sectional Area (A _{b_{kf}})	11.2	37.3-39.7	60.5-64.1
8. Bankfull Mean Velocity (V _{b_{kf}})	4.7	4.9-5.2	5.5
9. Bankfull Discharge (Q _{b_{kf}})	53	195	352
10. Bankfull Maximum Depth (D _{max})	1.2-1.5	2.3-2.8	2.7-3.1
11. Width of Floodprone Area (W _{fpa})	19	25.5-27.0	34-90
12. Entrenchment Ratio (W _{fpa} /W _{b_{kf}})	1.7	1.3-1.4	1.2-3.5
13. Meander Length (L _m)	116-162	-	-
14. Meander Length Ratio (L _m /W _{b_{kf}})	10-14	-	-
15. Radius of Curvature (R _c)	23-35	23.5-51.8	30-122
16. Radius of Curvature Ratio (R _c /W _{b_{kf}})	2.0-3.0	1.2-2.7	1.1-4.8
17. Belt Width (W _{b_{lt}})	--	-	-
18. Meander Width Ratio (W _{b_{lt}} /W _{b_{kf}})	-	-	-
19. Sinuosity (K)	1.00	1.04	1.0
20. Valley Slope	0.0333	0.011	0.007
21. Average Slope (S _{avg})	0.0333	0.0093-0.0108	0.007
22. Pool Slope (S _{pool})	0	0-0.001	0-0.004
23. Pool Slope Ratio (S _{pool} /S _{avg})	0-0.6	0.093-0.11	0-0.6
24. Max. Pool Depth (D _{pool})	1.8	3.1-3.3	3.1-4.9
25. Pool Depth Ratio (D _{pool} /D _{b_{kf}})	1.8	1.7-1.8	1.4-2.2
26. Pool Area Ratio (A _{pool} /A _{b_{kf}})	0.9-1.1	1.1	0.9
27. Pool Length Ratio (L _{pool} /W _{b_{kf}})	0.5-2.2	0.5-1.1	0.9-2.2
28. Pool Width (W _{pool})	9.3-10.4	16.4-17.8	23.4-25.8
29. Pool Width Ratio (W _{pool} /W _{b_{kf}})	0.8-0.9	0.8-0.9	0.8-0.9
30. Pool-Pool Spacing (p-p)	46-58l	38-107	65-190
31. Pool Spacing Ratio (p-p/W _{b_{kf}})	4-5	1.9-5.3	2.3-7.5
Materials:			
1. Particle Size Distribution			
d16	20	9.42	1.4
d35	75	40.39	7.3
d50	130	57.8	15.2
d84	200	123	92
d95	300	170	155

Morphological Characteristics of the Proposed Reach and Reference Reach

Variables	Proposed Site D3 Bailey Branch	Reference 1 Middle Fork Creek	Reference 2 Middle Fork Creek
1. Stream Type	B4	B4c	B4c
2. Drainage Area (mi. ²)	0.95	7.3	12
3. Bankfull Width (Wbkf)	11.6	19.4-20.1	25.5-28.6
4. Bankfull Mean Depth (Dbkf)	0.97	1.9-2.0	2.24
5. Width/Depth Ratio	12	9.5-10.8	10.7-12.8
6. Max Riffle Depth Ratio (Dmax/Dbkf)	1.3	1.3-1.5	1.2-1.4
7. Bankfull Cross-Sectional Area (Abkf)	11.2	37.3-39.7	60.5-64.1
8. Bankfull Mean Velocity (Vbkf)	4.7	4.9-5.2	5.5
9. Bankfull Discharge (Qbkf)	53	195	352
10. Bankfull Maximum Depth (Dmax)	1.2-1.5	2.3-2.8	2.7-3.1
11. Width of Floodprone Area (Wfpa)	19	25.5-27.0	34-90
12. Entrenchment Ratio (Wfpa/Wbkf)	1.7	1.3-1.4	1.2-3.5
13. Meander Length (Lm)	116-162	-	-
14. Meander Length Ratio (Lm/Wbkf)	10-14	-	-
15. Radius of Curvature (Rc)	23-35	23.5-51.8	30-122
16. Radius of Curvature Ratio (Rc/Wbkf)	2.0-3.0	1.2-2.7	1.1-4.8
17. Belt Width (Wbit)	--	-	-
18. Meander Width Ratio (Wbit/Wbkf)	-	-	-
19. Sinuosity (K)	1.00	1.04	1.0
20. Valley Slope	0.0244	0.011	0.007
21. Average Slope (Savg)	0.0244	0.0093-0.0108	0.007
22. Pool Slope (Spool)	0	0-0.001	0-0.004
23. Pool Slope Ratio (Spool/Savg)	0-0.6	0.093-0.11	0-0.6
24. Max. Pool Depth (Dpool)	1.8	3.1-3.3	3.1-4.9
25. Pool Depth Ratio (Dpool/Dbkf)	1.8	1.7-1.8	1.4-2.2
26. Pool Area Ratio (Apool/Abkf)	0.9-1.1	1.1	0.9
27. Pool Length Ratio (Lpool/Wbkf)	0.5-2.2	0.5-1.1	0.9-2.2
28. Pool Width (Wpool)	9.3-10.4	16.4-17.8	23.4-25.8
29. Pool Width Ratio (Wpool/Wbkf)	0.8-0.9	0.8-0.9	0.8-0.9
30. Pool-Pool Spacing (p-p)	46-58l	38-107	65-190
31. Pool Spacing Ratio (p-p/Wbkf)	4-5	1.9-5.3	2.3-7.5
Materials:			
1. Particle Size Distribution			
d16	20	9.42	1.4
d35	75	40.39	7.3
d50	130	57.8	15.2
d84	200	123	92
d95	300	170	155

Morphological Characteristics of the Proposed Reach and Reference Reach

Variables	Proposed Site E Middle Fork Creek	Reference 1 Middle Fork Creek	Reference 2 Middle Fork Creek
1. Stream Type	B4c	B4c	B4c
2. Drainage Area (mi. ²)	10.4	7.3	12
3. Bankfull Width (Wbkf)	27.3	19.4-20.1	25.5-28.6
4. Bankfull Mean Depth (Dbkf)	2.27	1.9-2.0	2.24
5. Width/Depth Ratio	12	9.5-10.8	10.7-12.8
6. Max Riffle Depth Ratio (Dmax/Dbkf)	1.3	1.3-1.5	1.2-1.4
7. Bankfull Cross-Sectional Area (Abkf)	61.9	37.3-39.7	60.5-64.1
8. Bankfull Mean Velocity (Vbkf)	5.9	4.9-5.2	5.5
9. Bankfull Discharge (Qbkf)	362	195	352
10. Bankfull Maximum Depth (Dmax)	2.7-3.4	2.3-2.8	2.7-3.1
11. Width of Floodprone Area (Wfpa)	46	25.5-27.0	34-90
12. Entrenchment Ratio (Wfpa/Wbkf)	1.7	1.3-1.4	1.2-3.5
13. Meander Length (Lm)	273-382	-	-
14. Meander Length Ratio (Lm/Wbkf)	10-14	-	-
15. Radius of Curvature (Rc)	54.6-81.9	23.5-51.8	30-122
16. Radius of Curvature Ratio (Rc/Wbkf)	2.0-3.0	1.2-2.7	1.1-4.8
17. Belt Width (Wbtl)	43.3-58.4	-	-
18. Meander Width Ratio (Wbtl/Wbkf)	2.0	-	-
19. Sinuosity (K)	1.12	1.04	1.0
20. Valley Slope	0.0069	0.011	0.007
21. Average Slope (Savg)	0.0061	0.0093-0.0108	0.007
22. Pool Slope (Spool)	0	0-0.001	0-0.004
23. Pool Slope Ratio (Spool/Savg)	0-0.6	0.093-0.11	0-0.6
24. Max. Pool Depth (Dpool)	4.1	3.1-3.3	3.1-4.9
25. Pool Depth Ratio (Dpool/Dbkf)	1.8	1.7-1.8	1.4-2.2
26. Pool Area Ratio (Apool/Abkf)	0.9-1.1	1.1	0.9
27. Pool Length Ratio (Lpool/Wbkf)	0.5-2.2	0.5-1.1	0.9-2.2
28. Pool Width (Wpool)	21.8-24.6	16.4-17.8	23.4-25.8
29. Pool Width Ratio (Wpool/Wbkf)	0.8-0.9	0.8-0.9	0.8-0.9
30. Pool-Pool Spacing (p-p)	109-137	38-107	65-190
31. Pool Spacing Ratio (p-p/Wbkf)	4-5	1.9-5.3	2.3-7.5
Materials:			
1. Particle Size Distribution			
d16	15	9.42	1.4
d35	30	40.39	7.3
d50	50	57.8	15.2
d84	100	123	92
d95	150	170	155

Morphological Characteristics of the Proposed Reach and Reference Reach

Variables	Proposed Site F UT to Middle Fork Creek	Reference 1 Middle Fork Creek	Reference 2 Middle Fork Creek
1. Stream Type	B4c	B4c	B4c
2. Drainage Area (mi. ²)	0.22	7.3	12
3. Bankfull Width (Wbkf)	6.9	19.4-20.1	25.5-28.6
4. Bankfull Mean Depth (Dbkf)	0.57	1.9-2.0	2.24
5. Width/Depth Ratio	12	9.5-10.8	10.7-12.8
6. Max Riffle Depth Ratio (Dmax/Dbkf)	1.3	1.3-1.5	1.2-1.4
7. Bankfull Cross-Sectional Area (Abkf)	3.94	37.3-39.7	60.5-64.1
8. Bankfull Mean Velocity (Vbkf)	4.1	4.9-5.2	5.5
9. Bankfull Discharge (Qbkf)	16	195	352
10. Bankfull Maximum Depth (Dmax)	0.68-0.86	2.3-2.8	2.7-3.1
11. Width of Floodprone Area (Wfpa)	11.7	25.5-27.0	34-90
12. Entrenchment Ratio (Wfpa/Wbkf)	1.7	1.3-1.4	1.2-3.5
13. Meander Length (Lm)	69-96.6	-	-
14. Meander Length Ratio (Lm/Wbkf)	10-14	-	-
15. Radius of Curvature (Rc)	13.8-20.7	23.5-51.8	30-122
16. Radius of Curvature Ratio (Rc/Wbkf)	2.0-3.0	1.2-2.7	1.1-4.8
17. Belt Width (Wbtl)	13.4-21	-	-
18. Meander Width Ratio (Wbtl/Wbkf)	2.5	-	-
19. Sinuosity (K)	1.15	1.04	1.0
20. Valley Slope	0.0174	0.011	0.007
21. Average Slope (Savg)	0.0152	0.0093-0.0108	0.007
22. Pool Slope (Spool)	0	0-0.001	0-0.004
23. Pool Slope Ratio (Spool/Savg)	0-0.6	0.093-0.11	0-0.6
24. Max. Pool Depth (Dpool)	1.0	3.1-3.3	3.1-4.9
25. Pool Depth Ratio (Dpool/Dbkf)	1.8	1.7-1.8	1.4-2.2
26. Pool Area Ratio (Apool/Abkf)	0.9-1.1	1.1	0.9
27. Pool Length Ratio (Lpool/Wbkf)	0.5-2.2	0.5-1.1	0.9-2.2
28. Pool Width (Wpool)	5.5-6.2	16.4-17.8	23.4-25.8
29. Pool Width Ratio (Wpool/Wbkf)	0.8-0.9	0.8-0.9	0.8-0.9
30. Pool-Pool Spacing (p-p)	28-35	38-107	65-190
31. Pool Spacing Ratio (p-p/Wbkf)	4-5	1.9-5.3	2.3-7.5
Materials:			
1. Particle Size Distribution			
d16	15	9.42	1.4
d35	30	40.39	7.3
d50	50	57.8	15.2
d84	100	123	92
d95	150	170	155

Morphological Characteristics of the Proposed Reach and Reference Reach

Variables	Proposed Site I1 UT to Middle Fork Creek	Reference 1 Middle Fork Creek	Reference 2 Middle Fork Creek
1. Stream Type	B4c	B4c	B4c
2. Drainage Area (mi. ²)	7.08	7.3	12
3. Bankfull Width (Wbkf)	23.8	19.4-20.1	25.5-28.6
4. Bankfull Mean Depth (Dbkf)	1.98	1.9-2.0	2.24
5. Width/Depth Ratio	12	9.5-10.8	10.7-12.8
6. Max Riffle Depth Ratio (Dmax/Dbkf)	1.3	1.3-1.5	1.2-1.4
7. Bankfull Cross-Sectional Area (Abkf)	47.04	37.3-39.7	60.5-64.1
8. Bankfull Mean Velocity (Vbkf)	5.7	4.9-5.2	5.5
9. Bankfull Discharge (Qbkf)	266	195	352
10. Bankfull Maximum Depth (Dmax)	2.38-2.97	2.3-2.8	2.7-3.1
11. Width of Floodprone Area (Wfpa)	40.5	25.5-27.0	34-90
12. Entrenchment Ratio (Wfpa/Wbkf)	1.7	1.3-1.4	1.2-3.5
13. Meander Length (Lm)	238-333	-	-
14. Meander Length Ratio (Lm/Wbkf)	10-14	-	-
15. Radius of Curvature (Rc)	47.6-71.4	23.5-51.8	30-122
16. Radius of Curvature Ratio (Rc/Wbkf)	2.0-3.0	1.2-2.7	1.1-4.8
17. Belt Width (Wblt)	60.7-70.2	-	-
18. Meander Width Ratio (Wblt/Wbkf)	2.8	-	-
19. Sinuosity (K)	1.1	1.04	1.0
20. Valley Slope	0.0102	0.011	0.007
21. Average Slope (Savg)	0.0093	0.0093-0.0108	0.007
22. Pool Slope (Spool)	0	0-0.001	0-0.004
23. Pool Slope Ratio (Spool/Savg)	0-0.6	0.093-0.11	0-0.6
24. Max. Pool Depth (Dpool)	3.6	3.1-3.3	3.1-4.9
25. Pool Depth Ratio (Dpool/Dbkf)	1.8	1.7-1.8	1.4-2.2
26. Pool Area Ratio (Apool/Abkf)	0.9-1.1	1.1	0.9
27. Pool Length Ratio (Lpool/Wbkf)	0.5-2.2	0.5-1.1	0.9-2.2
28. Pool Width (Wpool)	19.0-21.4	16.4-17.8	23.4-25.8
29. Pool Width Ratio (Wpool/Wbkf)	0.8-0.9	0.8-0.9	0.8-0.9
30. Pool-Pool Spacing (p-p)	95-119	38-107	65-190
31. Pool Spacing Ratio (p-p/Wbkf)	4-5	1.9-5.3	2.3-7.5
Materials:			
1. Particle Size Distribution			
d16	20	9.42	1.4
d35	75	40.39	7.3
d50	130	57.8	15.2
d84	200	123	92
d95	300	170	155

Morphological Characteristics of the Proposed Reach and Reference Reach

Variables	Proposed Site I2 UT to Middle Fork Creek	Reference 1 Middle Fork Creek	Reference 2 Middle Fork Creek
1. Stream Type	B4c	B4c	B4c
2. Drainage Area (mi. ²)	7.08	7.3	12
3. Bankfull Width (Wb _{kf})	23.8	19.4-20.1	25.5-28.6
4. Bankfull Mean Depth (D _{b_{kf}})	1.98	1.9-2.0	2.24
5. Width/Depth Ratio	12	9.5-10.8	10.7-12.8
6. Max Riffle Depth Ratio (D _{max} /D _{b_{kf}})	1.3	1.3-1.5	1.2-1.4
7. Bankfull Cross-Sectional Area (A _{b_{kf}})	47.04	37.3-39.7	60.5-64.1
8. Bankfull Mean Velocity (V _{b_{kf}})	5.7	4.9-5.2	5.5
9. Bankfull Discharge (Q _{b_{kf}})	266	195	352
10. Bankfull Maximum Depth (D _{max})	2.38-2.97	2.3-2.8	2.7-3.1
11. Width of Floodprone Area (W _{f_{pa}})	40.5	25.5-27.0	34-90
12. Entrenchment Ratio (W _{f_{pa}} /W _{b_{kf}})	1.7	1.3-1.4	1.2-3.5
13. Meander Length (L _m)	238-333	-	-
14. Meander Length Ratio (L _m /W _{b_{kf}})	10-14	-	-
15. Radius of Curvature (R _c)	47.6-71.4	23.5-51.8	30-122
16. Radius of Curvature Ratio (R _c /W _{b_{kf}})	2.0-3.0	1.2-2.7	1.1-4.8
17. Belt Width (W _{b_{lt}})	61.3-66.6	-	-
18. Meander Width Ratio (W _{b_{lt}} /W _{b_{kf}})	2.7	-	-
19. Sinuosity (K)	1.1	1.04	1.0
20. Valley Slope	0.0166	0.011	0.007
21. Average Slope (S _{avg})	0.0151	0.0093-0.0108	0.007
22. Pool Slope (S _{pool})	0	0-0.001	0-0.004
23. Pool Slope Ratio (S _{pool} /S _{avg})	0-0.6	0.093-0.11	0-0.6
24. Max. Pool Depth (D _{pool})	3.6	3.1-3.3	3.1-4.9
25. Pool Depth Ratio (D _{pool} /D _{b_{kf}})	1.8	1.7-1.8	1.4-2.2
26. Pool Area Ratio (A _{pool} /A _{b_{kf}})	0.9-1.1	1.1	0.9
27. Pool Length Ratio (L _{pool} /W _{b_{kf}})	0.5-2.2	0.5-1.1	0.9-2.2
28. Pool Width (W _{pool})	19.0-21.4	16.4-17.8	23.4-25.8
29. Pool Width Ratio (W _{pool} /W _{b_{kf}})	0.8-0.9	0.8-0.9	0.8-0.9
30. Pool-Pool Spacing (p-p)	95-119	38-107	65-190
31. Pool Spacing Ratio (p-p/W _{b_{kf}})	4-5	1.9-5.3	2.3-7.5
Materials:			
1. Particle Size Distribution			
d16	20	9.42	1.4
d35	75	40.39	7.3
d50	130	57.8	15.2
d84	200	123	92
d95	300	170	155

Morphological Characteristics of the Proposed Reach and Reference Reach

Variables	Proposed Site J1 Turkey Branch	Reference 1 Middle Fork Creek	Reference 2 Middle Fork Creek
1. Stream Type	B4c	B4c	B4c
2. Drainage Area (mi. ²)	0.37	7.3	12
3. Bankfull Width (Wbkf)	8.3	19.4-20.1	25.5-28.6
4. Bankfull Mean Depth (Dbkf)	0.69	1.9-2.0	2.24
5. Width/Depth Ratio	12	9.5-10.8	10.7-12.8
6. Max Riffle Depth Ratio (Dmax/Dbkf)	1.3	1.3-1.5	1.2-1.4
7. Bankfull Cross-Sectional Area (Abkf)	5.71	37.3-39.7	60.5-64.1
8. Bankfull Mean Velocity (Vbkf)	4.4	4.9-5.2	5.5
9. Bankfull Discharge (Qbkf)	25	195	352
10. Bankfull Maximum Depth (Dmax)	0.83-1.04	2.3-2.8	2.7-3.1
11. Width of Floodprone Area (Wfpa)	14	25.5-27.0	34-90
12. Entrenchment Ratio (Wfpa/Wbkf)	1.7	1.3-1.4	1.2-3.5
13. Meander Length (Lm)	83-116	-	-
14. Meander Length Ratio (Lm/Wbkf)	10-14	-	-
15. Radius of Curvature (Rc)	16.6-24.9	23.5-51.8	30-122
16. Radius of Curvature Ratio (Rc/Wbkf)	2.0-3.0	1.2-2.7	1.1-4.8
17. Belt Width (Wblt)	12.5-22	-	-
18. Meander Width Ratio (Wblt/Wbkf)	2.07	-	-
19. Sinuosity (K)	1.07	1.04	1.0
20. Valley Slope	0.0145	0.011	0.007
21. Average Slope (Savg)	0.0136	0.0093-0.0108	0.007
22. Pool Slope (Spool)	0	0-0.001	0-0.004
23. Pool Slope Ratio (Spool/Savg)	0-0.6	0.093-0.11	0-0.6
24. Max. Pool Depth (Dpool)	1.2	3.1-3.3	3.1-4.9
25. Pool Depth Ratio (Dpool/Dbkf)	1.8	1.7-1.8	1.4-2.2
26. Pool Area Ratio (Apool/Abkf)	0.9-1.1	1.1	0.9
27. Pool Length Ratio (Lpool/Wbkf)	0.5-2.2	0.5-1.1	0.9-2.2
28. Pool Width (Wpool)	6.6-7.5	16.4-17.8	23.4-25.8
29. Pool Width Ratio (Wpool/Wbkf)	0.8-0.9	0.8-0.9	0.8-0.9
30. Pool-Pool Spacing (p-p)	33-42	38-107	65-190
31. Pool Spacing Ratio (p-p/Wbkf)	4-5	1.9-5.3	2.3-7.5
Materials:			
1. Particle Size Distribution			
d16	-	9.42	1.4
d35	-	40.39	7.3
d50	13	57.8	15.2
d84	35	123	92
d95	-	170	155

Morphological Characteristics of the Proposed Reach and Reference Reach

Variables	Proposed Site J2 Turkey Branch	Reference 1 Middle Fork Creek	Reference 2 Middle Fork Creek
1. Stream Type	B4c	B4c	B4c
2. Drainage Area (mi. ²)	0.37	7.3	12
3. Bankfull Width (Wbkf)	8.3	19.4-20.1	25.5-28.6
4. Bankfull Mean Depth (Dbkf)	0.69	1.9-2.0	2.24
5. Width/Depth Ratio	12	9.5-10.8	10.7-12.8
6. Max Riffle Depth Ratio (Dmax/Dbkf)	1.3	1.3-1.5	1.2-1.4
7. Bankfull Cross-Sectional Area (Abkf)	5.71	37.3-39.7	60.5-64.1
8. Bankfull Mean Velocity (Vbkf)	4.4	4.9-5.2	5.5
9. Bankfull Discharge (Qbkf)	25	195	352
10. Bankfull Maximum Depth (Dmax)	0.83-1.04	2.3-2.8	2.7-3.1
11. Width of Floodprone Area (Wfpa)	14	25.5-27.0	34-90
12. Entrenchment Ratio (Wfpa/Wbkf)	1.7	1.3-1.4	1.2-3.5
13. Meander Length (Lm)	83-116	-	-
14. Meander Length Ratio (Lm/Wbkf)	10-14	-	-
15. Radius of Curvature (Rc)	16.6-24.9	23.5-51.8	30-122
16. Radius of Curvature Ratio (Rc/Wbkf)	2.0-3.0	1.2-2.7	1.1-4.8
17. Belt Width (Wbtl)	-	-	-
18. Meander Width Ratio (Wbtl/Wbkf)	-	-	-
19. Sinuosity (K)	1.07	1.04	1.0
20. Valley Slope	0.0065	0.011	0.007
21. Average Slope (Savg)	0.0061	0.0093-0.0108	0.007
22. Pool Slope (Spool)	0	0-0.001	0-0.004
23. Pool Slope Ratio (Spool/Savg)	0-0.6	0.093-0.11	0-0.6
24. Max. Pool Depth (Dpool)	1.2	3.1-3.3	3.1-4.9
25. Pool Depth Ratio (Dpool/Dbkf)	1.8	1.7-1.8	1.4-2.2
26. Pool Area Ratio (Apool/Abkf)	0.9-1.1	1.1	0.9
27. Pool Length Ratio (Lpool/Wbkf)	0.5-2.2	0.5-1.1	0.9-2.2
28. Pool Width (Wpool)	6.6-7.5	16.4-17.8	23.4-25.8
29. Pool Width Ratio (Wpool/Wbkf)	0.8-0.9	0.8-0.9	0.8-0.9
30. Pool-Pool Spacing (p-p)	33-42	38-107	65-190
31. Pool Spacing Ratio (p-p/Wbkf)	4-5	1.9-5.3	2.3-7.5
Materials:			
1. Particle Size Distribution			
d16	15	9.42	1.4
d35	30	40.39	7.3
d50	50	57.8	15.2
d84	100	123	92
d95	150	170	155

Morphological Characteristics of the Proposed Reach and Reference Reach

Variables	Proposed Site M Holland Creek	Reference 1 Middle Fork Creek	Reference 2 Middle Fork Creek
1. Stream Type	B4c	B4c	B4c
2. Drainage Area (mi. ²)	1.3	7.3	12
3. Bankfull Width (Wb _{kf})	13.0	19.4-20.1	25.5-28.6
4. Bankfull Mean Depth (D _{b_{kf}})	1.08	1.9-2.0	2.24
5. Width/Depth Ratio	12	9.5-10.8	10.7-12.8
6. Max Riffle Depth Ratio (D _{max} /D _{b_{kf}})	1.3	1.3-1.5	1.2-1.4
7. Bankfull Cross-Sectional Area (A _{b_{kf}})	14.02	37.3-39.7	60.5-64.1
8. Bankfull Mean Velocity (V _{b_{kf}})	4.9	4.9-5.2	5.5
9. Bankfull Discharge (Q _{b_{kf}})	68	195	352
10. Bankfull Maximum Depth (D _{max})	1.3-1.6	2.3-2.8	2.7-3.1
11. Width of Floodprone Area (W _{fpa})	22	25.5-27.0	34-90
12. Entrenchment Ratio (W _{fpa} /W _{b_{kf}})	1.7	1.3-1.4	1.2-3.5
13. Meander Length (L _m)	130-182	-	-
14. Meander Length Ratio (L _m /W _{b_{kf}})	10-14	-	-
15. Radius of Curvature (R _c)	26-39	23.5-51.8	30-122
16. Radius of Curvature Ratio (R _c /W _{b_{kf}})	2.0-3.0	1.2-2.7	1.1-4.8
17. Belt Width (W _{b_{lt}})	22.3-33.1	-	-
18. Meander Width Ratio (W _{b_{lt}} /W _{b_{kf}})	2.1	-	-
19. Sinuosity (K)	1.04	1.04	1.0
20. Valley Slope	0.0375	0.011	0.007
21. Average Slope (S _{avg})	0.0361	0.0093-0.0108	0.007
22. Pool Slope (S _{pool})	0	0-0.001	0-0.004
23. Pool Slope Ratio (S _{pool} /S _{avg})	0-0.6	0.093-0.11	0-0.6
24. Max. Pool Depth (D _{pool})	1.8	3.1-3.3	3.1-4.9
25. Pool Depth Ratio (D _{pool} /D _{b_{kf}})	1.7	1.7-1.8	1.4-2.2
26. Pool Area Ratio (A _{pool} /A _{b_{kf}})	0.9-1.1	1.1	0.9
27. Pool Length Ratio (L _{pool} /W _{b_{kf}})	0.5-2.2	0.5-1.1	0.9-2.2
28. Pool Width (W _{pool})	10.4-11.7	16.4-17.8	23.4-25.8
29. Pool Width Ratio (W _{pool} /W _{b_{kf}})	0.8-0.9	0.8-0.9	0.8-0.9
30. Pool-Pool Spacing (p-p)	52-65	38-107	65-190
31. Pool Spacing Ratio (p-p/W _{b_{kf}})	4-5	1.9-5.3	2.3-7.5
Materials:			
1. Particle Size Distribution			
d16	20	9.42	1.4
d35	75	40.39	7.3
d50	130	57.8	15.2
d84	200	123	92
d95	300	170	155

Morphological Characteristics of the Proposed Reach and Reference Reach

Variables	Proposed Site N1 Ivy Gap Branch	Reference 1 Middle Fork Creek	Reference 2 Middle Fork Creek
1. Stream Type	B4c	B4c	B4c
2. Drainage Area (mi. ²)	1.14	7.3	12
3. Bankfull Width (Wbkf)	12.4	19.4-20.1	25.5-28.6
4. Bankfull Mean Depth (Dbkf)	1.03	1.9-2.0	2.24
5. Width/Depth Ratio	12	9.5-10.8	10.7-12.8
6. Max Riffle Depth Ratio (Dmax/Dbkf)	1.34	1.3-1.5	1.2-1.4
7. Bankfull Cross-Sectional Area (Abkf)	12.8	37.3-39.7	60.5-64.1
8. Bankfull Mean Velocity (Vbkf)	19.7	4.9-5.2	5.5
9. Bankfull Discharge (Qbkf)	61	195	352
10. Bankfull Maximum Depth (Dmax)	1.3	2.3-2.8	2.7-3.1
11. Width of Floodprone Area (Wfpa)	10	25.5-27.0	34-90
12. Entrenchment Ratio (Wfpa/Wbkf)	1.7	1.3-1.4	1.2-3.5
13. Meander Length (Lm)	58-81	-	-
14. Meander Length Ratio (Lm/Wbkf)	10-14	-	-
15. Radius of Curvature (Rc)	23-35	23.5-51.8	30-122
16. Radius of Curvature Ratio (Rc/Wbkf)	2.0-3.0	1.2-2.7	1.1-4.8
17. Belt Width (Wblt)	20.7-25.6	-	-
18. Meander Width Ratio (Wblt/Wbkf)	1.86	-	-
19. Sinuosity (K)	1.05	1.04	1.0
20. Valley Slope	0.0258	0.011	0.007
21. Average Slope (Savg)	0.0245	0.0093-0.0108	0.007
22. Pool Slope (Spool)	0	0-0.001	0-0.004
23. Pool Slope Ratio (Spool/Savg)	0	0.093-0.11	0-0.6
24. Max. Pool Depth (Dpool)	1.85	3.1-3.3	3.1-4.9
25. Pool Depth Ratio (Dpool/Dbkf)	1.8	1.7-1.8	1.4-2.2
26. Pool Area Ratio (Apool/Abkf)	0.9-1.1	1.1	0.9
27. Pool Length Ratio (Lpool/Wbkf)	0.5-2.2	0.5-1.1	0.9-2.2
28. Pool Width (Wpool)	4.6-5.2	16.4-17.8	23.4-25.8
29. Pool Width Ratio (Wpool/Wbkf)	0.8-0.9	0.8-0.9	0.8-0.9
30. Pool-Pool Spacing (p-p)	47-59	38-107	65-190
31. Pool Spacing Ratio (p-p/Wbkf)	4-5	1.9-5.3	2.3-7.5
Materials:			
1. Particle Size Distribution			
d16	20	9.42	1.4
d35	75	40.39	7.3
d50	130	57.8	15.2
d84	200	123	92
d95	300	170	155

Morphological Characteristics of the Proposed Reach and Reference Reach

Variables	Proposed Site N2 Ivy Gap Branch	Reference 1 Middle Fork Creek	Reference 2 Middle Fork Creek
1. Stream Type	B4c	B4c	B4c
2. Drainage Area (mi. ²)	1.14	7.3	12
3. Bankfull Width (Wbkf)	12.4	19.4-20.1	25.5-28.6
4. Bankfull Mean Depth (Dbkf)	1.03	1.9-2.0	2.24
5. Width/Depth Ratio	12	9.5-10.8	10.7-12.8
6. Max Riffle Depth Ratio (Dmax/Dbkf)	1.34	1.3-1.5	1.2-1.4
7. Bankfull Cross-Sectional Area (Abkf)	12.8	37.3-39.7	60.5-64.1
8. Bankfull Mean Velocity (Vbkf)	19.7	4.9-5.2	5.5
9. Bankfull Discharge (Qbkf)	61	195	352
10. Bankfull Maximum Depth (Dmax)	1.3	2.3-2.8	2.7-3.1
11. Width of Floodprone Area (Wfpa)	10	25.5-27.0	34-90
12. Entrenchment Ratio (Wfpa/Wbkf)	1.7	1.3-1.4	1.2-3.5
13. Meander Length (Lm)	58-81	-	-
14. Meander Length Ratio (Lm/Wbkf)	10-14	-	-
15. Radius of Curvature (Rc)	23-35	23.5-51.8	30-122
16. Radius of Curvature Ratio (Rc/Wbkf)	2.0-3.0	1.2-2.7	1.1-4.8
17. Belt Width (Wbtl)	-	-	-
18. Meander Width Ratio (Wbtl/Wbkf)	-	-	-
19. Sinuosity (K)	1.00	1.04	1.0
20. Valley Slope	0.025	0.011	0.007
21. Average Slope (Savg)	0.025	0.0093-0.0108	0.007
22. Pool Slope (Spool)	0	0-0.001	0-0.004
23. Pool Slope Ratio (Spool/Savg)	0	0.093-0.11	0-0.6
24. Max. Pool Depth (Dpool)	1.85	3.1-3.3	3.1-4.9
25. Pool Depth Ratio (Dpool/Dbkf)	1.8	1.7-1.8	1.4-2.2
26. Pool Area Ratio (Apool/Abkf)	0.9-1.1	1.1	0.9
27. Pool Length Ratio (Lpool/Wbkf)	0.5-2.2	0.5-1.1	0.9-2.2
28. Pool Width (Wpool)	4.6-5.2	16.4-17.8	23.4-25.8
29. Pool Width Ratio (Wpool/Wbkf)	0.8-0.9	0.8-0.9	0.8-0.9
30. Pool-Pool Spacing (p-p)	47-59	38-107	65-190
31. Pool Spacing Ratio (p-p/Wbkf)	4-5	1.9-5.3	2.3-7.5
Materials:			
1. Particle Size Distribution			
d16	-	9.42	1.4
d35	-	40.39	7.3
d50	52	57.8	15.2
d84	140	123	92
d95	-	170	155

APPENDIX C

SEDIMENT TRANSPORT CALCULATIONS

SEDIMENT TRANSPORT CALCULATIONS

SITE	STREAM NAME	SHEAR STRESS (τ_0)	STREAM POWER
A	Middle Fork Creek	1.17 lb/ft ²	7.77 lb/ft-s
B	UT to Middle Fork Creek	0.98 lb/ft ²	4.58 lb/ft-s
C	UT to Middle Fork Creek	0.18 lb/ft ²	0.35 lb/ft-s
D1	Bailey Branch	1.67 lb/ft ²	10.35 lb/ft-s
D3	Bailey Branch	1.30 lb/ft ²	7.17 lb/ft-s
E	Middle Fork Creek	0.87 lb/ft ²	4.62 lb/ft-s
F	UT to Middle Fork Creek	0.55 lb/ft ²	1.95 lb/ft-s
I1	Middle Fork Creek	1.09 lb/ft ²	6.23 lb/ft-s
I2	Middle Fork Creek	1.61 lb/ft ²	11.05 lb/ft-s
J1	Turkey Branch	0.60 lb/ft ²	2.27 lb/ft-s
J2	Turkey Branch	0.31 lb/ft ²	0.87 lb/ft-s
M	Holland Creek	2.27 lb/ft ²	11.73 lb/ft-s
N1	Ivy Gap Branch	1.47 lb/ft ²	7.38 lb/ft-s
N2	Ivy Gap Branch	1.98 lb/ft ²	11.42 lb/ft-s
Reference 1	Middle Fork Creek	1.17 lb/ft ²	6.41 lb/ft-s
Reference 2	Middle Fork Creek	1.00 lb/ft ²	5.66 lb/ft-s

Sediment Transport Validation

Project: R-2518A
Stream: Site A - Middle Fork Creek
Date: 09/05/2006
Reach: 20+10 Rt - 21+00 Lt

Q_{Bkf} : 428 cfs
 W/D_{Design} : 12
Side Slopes : 3
Manning's n : 0.035
 S_{valley} = 0.0092 ft./ft.
Sinuosity = 1.08

$S_{WS} = S_{valley}/Sin.$ = 0.0085 ft./ft.
 V = 6.6 fps
 $A_{X-Sect} = Q/V$ = 64.4 sq. ft.
 $W_{Bkf} = (A*W/D)^{1/2}$ = 27.8 ft.
 $D_{Mean} = A/W$ = 2.32 ft.
 $D_{Avg. Bot.}$ = 4.63 ft.
 P = 29.30 ft.
 $R = A/P$ = 2.198 ft.

$\tau_c = \gamma S_{WS} R$ = 1.17 lb/ft²
Particle Range = 54 - 324 mm
Stream Power = 7.77 lb/ft-s

Sediment Transport Validation

Project: R-2518A
Stream: Site B - UT to Middle Fork Creek
Date: 09/05/2006
Reach: 21+35 Rt - 21+90 Rt

Q_{Bkf} : 13 cfs
 W/D_{Design} : 12
Side Slopes : 3
Manning's n : 0.035
 S_{valley} = 0.0375 ft./ft.
Sinuosity = 1.09

$S_{WS} = S_{valley}/Sin.$ = 0.0344 ft./ft.
 V = 4.7 fps
 $A_{X-Sect} = Q/V$ = 2.8 sq. ft.
 $W_{Bkf} = (A*W/D)^{1/2}$ = 5.8 ft.
 $D_{Mean} = A/W$ = 0.48 ft.
 $D_{Avg. Bot.}$ = 0.96 ft.
 P = 6.09 ft.
 $R = A/P$ = 0.456 ft.

$\tau_c = \gamma S_{WS} R$ = 0.98 lb/ft²
Particle Range = 46 - 257 mm
Stream Power = 4.58 lb/ft-s

Sediment Transport Validation

Project: R-2518A
Stream: Site C - UT to Middle Fork Creek
Date: 06/29/2006
Reach: 27+00 Rt

Q_{Bkf} : _____ 4 cfs
 W/D_{Design} : _____ 12
Side Slopes : _____ 2
Manning's n : _____ 0.035
 S_{valley} = _____ 0.0094 ft./ft.
Sinuosity = _____ 1.3

$S_{WS} = S_{valley}/Sin.$ = _____ 0.0072 ft./ft.
 V = _____ 1.9 fps
 $A_{x-Sect} = Q/V$ = _____ 2.1 sq. ft.
 $W_{Bkf} = (A*W/D)^{1/2}$ = _____ 5.0 ft.
 $D_{Mean} = A/W$ = _____ 0.41 ft.
 $D_{Avg. Bot.}$ = _____ 0.52 ft.
 P = _____ 5.22 ft.
 $R = A/P$ = _____ 0.394 ft.

$\tau_c = \gamma S_{WS} R$ = _____ 0.18 lb/ft²
Particle Range = _____ 9 - 33 mm
Stream Power = _____ 0.35 lb/ft-s

Sediment Transport Validation

Project: R-2518A
Stream: Site D1 - Bailey Branch
Date: 06/29/2006
Reach: 31+75 Lt

Q_{Bkf} : 53 cfs
 W/D_{Design} : 12
Side Slopes : 2
Manning's n : 0.038
 S_{valley} = 0.0333 ft./ft.
Sinuosity = 1.00

$S_{WS} = S_{valley}/Sin.$ = 0.0333 ft./ft.
 V = 6.2 fps
 $A_{X-Sect} = Q/V$ = 8.6 sq. ft.
 $W_{Bkf} = (A*W/D)^{1/2}$ = 10.1 ft.
 $D_{Mean} = A/W$ = 0.84 ft.
 $D_{Avg. Bot.}$ = 1.07 ft.
 P = 10.64 ft.
 $R = A/P$ = 0.805 ft.

$\tau_c = \gamma S_{WS} R$ = 1.67 lb/ft²
Particle Range = 78 - 502 mm
Stream Power = 10.35 lb/ft-s

Sediment Transport Validation

Project: R-2518A
Stream: Site D3 - Bailey Branch
Date: 06/29/2006
Reach: 31+75 Rt

Q_{Bkf} : 53 cfs
 W/D_{Design} : 12
Side Slopes : 2
Manning's n : 0.038
 S_{valley} = 0.0244 ft./ft.
Sinuosity = 1

$S_{WS} = S_{valley}/Sin.$ = 0.0244 ft./ft.
 V = 5.5 fps
 $A_{X-Sect} = Q/V$ = 9.6 sq. ft.
 $W_{Bkf} = (A*W/D)^{1/2}$ = 10.7 ft.
 $D_{Mean} = A/W$ = 0.90 ft.
 $D_{Avg. Bot.}$ = 1.13 ft.
 P = 11.28 ft.
 $R = A/P$ = 0.853 ft.

$\tau_c = \gamma S_{WS} R$ = 1.30 lb/ft²
Particle Range = 61 - 370 mm
Stream Power = 7.17 lb/ft-s

Sediment Transport Validation

Project:	R-2518A
Stream:	Site E - Middle Fork Creek
Date:	09/05/2006
Reach:	<u>35+50 - 37+75 Lt</u>

Q_{Bkf} :	<u>362</u> cfs
W/D_{Design} :	<u>12</u>
Side Slopes :	<u>2</u>
Manning's n :	<u>0.038</u>
S_{valley} =	<u>0.0069</u> ft./ft.
Sinuosity =	<u>1.12</u>

$S_{WS} = S_{valley}/Sin.$ =	<u>0.0061</u> ft./ft.
V =	<u>5.3</u> fps
$A_{X-Sect} = Q/V$ =	<u>68.2</u> sq. ft.
$W_{Bkf} = (A*W/D)^{1/2}$ =	<u>28.6</u> ft.
$D_{Mean} = A/W$ =	<u>2.38</u> ft.
$D_{Avg. Bot.}$ =	<u>3.02</u> ft.
P =	<u>30.03</u> ft.
$R = A/P$ =	<u>2.271</u> ft.

$\tau_c = \gamma S_{WS} R$ =	<u>0.87</u> lb/ft ²
Particle Range =	<u>40 - 218</u> mm
Stream Power =	<u>4.62</u> lb/ft-s

Sediment Transport Validation

Project:	R-2518A
Stream:	Site F - UT to Middle Fork Creek
Date:	09/05/2006
Reach:	<u>37+80 - 38+40 Lt</u>

Q_{Bkf} :	<u>16</u> cfs
W/D_{Design} :	<u>12</u>
Side Slopes :	<u>3</u>
Manning's n :	<u>0.036</u>
S_{valley} =	<u>0.0174</u> ft./ft.
Sinuosity =	<u>1.15</u>

$S_{WS} = S_{valley}/Sin.$ =	<u>0.0152</u> ft./ft.
V =	<u>3.6</u> fps
$A_{X-Sect} = Q/V$ =	<u>4.5</u> sq. ft.
$W_{Bkf} = (A*W/D)^{1/2}$ =	<u>7.4</u> ft.
$D_{Mean} = A/W$ =	<u>0.61</u> ft.
$D_{Avg. Bot.}$ =	<u>1.22</u> ft.
P =	<u>7.75</u> ft.
$R = A/P$ =	<u>0.581</u> ft.

$\tau_c = \gamma S_{WS} R$ =	<u>0.55</u> lb/ft ²
Particle Range =	<u>25 - 104</u> mm
Stream Power =	<u>1.95</u> lb/ft-s

Sediment Transport Validation

Project: R-2518A
Stream: Site I1 - Middle Fork Creek
Date: 09/05/2006
Reach: 52+60 - 54+00 Lt

Q_{Bkf} : 266 cfs
 W/D_{Design} : 12
Side Slopes : 2
Manning's n : 0.038
 S_{valley} = 0.0102 ft./ft.
Sinuosity = 1.1

$S_{WS} = S_{valley}/Sin.$ = 0.0093 ft./ft.
 V = 5.7 fps
 $A_{X-Sect} = Q/V$ = 46.3 sq. ft.
 $W_{Bkf} = (A*W/D)^{1/2}$ = 23.6 ft.
 $D_{Mean} = A/W$ = 1.97 ft.
 $D_{Avg. Bot.}$ = 2.49 ft.
 P = 24.76 ft.
 $R = A/P$ = 1.872 ft.

$\tau_c = \gamma S_{WS} R$ = 1.09 lb/ft²
Particle Range = 50 - 294 mm
Stream Power = 6.23 lb/ft-s

Sediment Transport Validation

Project: R-2518A
Stream: Site 12 - Middle Fork Creek
Date: 09/05/2006
Reach: 51+80 - 52+60 Lt

Q_{Bkf} : 266 cfs
 W/D_{Design} : 12
Side Slopes : 2
Manning's n : 0.038
 S_{valley} = 0.0166 ft./ft.
Sinuosity = 1.1

$S_{WS} = S_{valley}/Sin.$ = 0.0151 ft./ft.
 V = 6.9 fps
 $A_{X-Sect} = Q/V$ = 38.7 sq. ft.
 $W_{Bkf} = (A*W/D)^{1/2}$ = 21.5 ft.
 $D_{Mean} = A/W$ = 1.80 ft.
 $D_{Avg. Bot.}$ = 2.28 ft.
 P = 22.62 ft.
 $R = A/P$ = 1.710 ft.

$\tau_c = \gamma S_{WS} R$ = 1.61 lb/ft²
Particle Range = 75 - 478 mm
Stream Power = 11.05 lb/ft-s

Sediment Transport Validation

Project: R-2518A
Stream: Site J1 - Turkey Branch
Date: 09/05/2006
Reach: 56+20 - 57+70 Rt

Q_{Bkf} : 25 cfs
 W/D_{Design} : 12
Side Slopes : 2
Manning's n : 0.036
 S_{valley} = 0.0145 ft./ft.
Sinuosity = 1.07

$S_{WS} = S_{valley}/Sin.$ = 0.0136 ft./ft.
 V = 3.8 fps
 $A_{X-Sect} = Q/V$ = 6.6 sq. ft.
 $W_{Bkf} = (A*W/D)^{1/2}$ = 8.9 ft.
 $D_{Mean} = A/W$ = 0.74 ft.
 $D_{Avg. Bot.}$ = 0.94 ft.
 P = 9.31 ft.
 $R = A/P$ = 0.704 ft.

$\tau_c = \gamma S_{WS} R$ = 0.60 lb/ft²
Particle Range = 28 - 120 mm
Stream Power = 2.27 lb/ft-s

Sediment Transport Validation

Project: R-2518A
Stream: Site J2 - Turkey Branch
Date: 09/05/2006
Reach: 56+20 - 57+70 Rt

Q_{Bkf} : 25 cfs
 W/D_{Design} : 12
Side Slopes : 2
Manning's n : 0.036
 S_{Valley} = 0.0065 ft./ft.
Sinuosity = 1.07

$S_{WS} = S_{valley}/Sin.$ = 0.0061 ft./ft.
 V = 2.8 fps
 $A_{X-Section} = Q/V$ = 8.9 sq. ft.
 $W_{Bkf} = (A*W/D)^{1/2}$ = 10.3 ft.
 $D_{Mean} = A/W$ = 0.86 ft.
 $D_{Avg. Bot.}$ = 1.09 ft.
 P = 10.83 ft.
 $R = A/P$ = 0.819 ft.

$\tau_c = \gamma S_{WS} R$ = 0.31 lb/ft²
Particle Range = 14 - 65 mm
Stream Power = 0.87 lb/ft-s

Sediment Transport Validation

Project: R-2518A
Stream: Site M - Holland Creek
Date: 09/05/2006
Reach: 81+80 Lt

Q_{Bkf} : 70 cfs
 W/D_{Design} : 12
Side Slopes : 3
Manning's n : 0.055
 S_{valley} = 0.0375 ft./ft.
Sinuosity = 1.04

$S_{WS} = S_{valley}/Sin.$ = 0.0361 ft./ft.
 V = 5.2 fps
 $A_{X-Sect} = Q/V$ = 13.5 sq. ft.
 $W_{Bkf} = (A*W/D)^{1/2}$ = 12.7 ft.
 $D_{Mean} = A/W$ = 1.06 ft.
 $D_{Avg. Bot.}$ = 2.12 ft.
 P = 13.43 ft.
 $R = A/P$ = 1.008 ft.

$\tau_c = \gamma S_{WS} R$ = 2.27 lb/ft²
Particle Range = 73 - 713 mm
Stream Power = 11.73 lb/ft-s

Sediment Transport Validation

Project: R-2518A
Stream: Site N1 - Ivy Gap Branch
Date: 09/05/2006
Reach: 83+00 - 84+00Lt

Q_{Bkf} : 61 cfs
 W/D_{Design} : 12
Side Slopes : 2
Manning's n : 0.045
 S_{valley} = 0.0258 ft./ft.
Sinuosity = 1.05

$S_{WS} = S_{valley}/Sin.$ = 0.0245 ft./ft.
 V = 5.0 fps
 $A_{X-Sect} = Q/V$ = 12.1 sq. ft.
 $W_{Bkf} = (A*W/D)^{1/2}$ = 12.1 ft.
 $D_{Mean} = A/W$ = 1.00 ft.
 $D_{Avg. Bot.}$ = 1.27 ft.
 P = 12.66 ft.
 $R = A/P$ = 0.957 ft.

$\tau_c = \gamma S_{WS} R$ = 1.47 lb/ft²
Particle Range = 68 - 429 mm
Stream Power = 7.38 lb/ft-s

Sediment Transport Validation

Project: R-2518A
Stream: Site N2 - Ivy Gap Branch
Date: 09/05/2006
Reach: 82+20 - 82+50Lt

Q_{Bkf} : 61 cfs
 W/D_{Design} : 12
Side Slopes : 2
Manning's n : 0.045
 S_{valley} = 0.0354 ft./ft.
Sinuosity = 1.00

$S_{WS} = S_{valley}/Sin.$ = 0.0354 ft./ft.
 V = 5.8 fps
 $A_{X-Sect} = Q/V$ = 10.6 sq. ft.
 $W_{Bkf} = (A*W/D)^{1/2}$ = 11.3 ft.
 $D_{Mean} = A/W$ = 0.94 ft.
 $D_{Avg. Bot.}$ = 1.19 ft.
 P = 11.81 ft.
 $R = A/P$ = 0.893 ft.

$\tau_c = \gamma S_{WS} R$ = 1.98 lb/ft²
Particle Range = 92 - 609 mm
Stream Power = 11.42 lb/ft-s

Sediment Transport Validation

Project: R-2518A
Stream: Middle Fork Creek
Date: 09/05/2006
Reach: Reference 1

Q_{Bkf} : 203 cfs
 W/D_{Design} : 11
Side Slopes : 2
Manning's n : 0.041
 S_{Valley} = 0.011232 ft./ft.
Sinuosity = 1.04

$S_{WS} = S_{valley}/Sin.$ = 0.0108 ft./ft.
 V = 5.5 fps
 $A_{X-Sect} = Q/V$ = 37.2 sq. ft.
 $W_{Bkf} = (A*W/D)^{1/2}$ = 20.2 ft.
 $D_{Mean} = A/W$ = 1.84 ft.
 $D_{Avg. Bot.}$ = 2.41 ft.
 P = 21.36 ft.
 $R = A/P$ = 1.740 ft.

$t_c = gS_{WS}R$ = 1.17 lb/ft²
Particle Range = 55 - 325 mm
Stream Power = 6.41 lb/ft-s

Sediment Transport Validation

Project: R-2518A
Stream: Middle Fork Creek
Date: 09/05/2006
Reach: Reference 2

Q_{Bkf} : 352 cfs
 W/D_{Design} : 12
Side Slopes : 2
Manning's n : 0.038
 S_{Valley} = 0.0074 ft./ft.
Sinuosity = 1

$S_{WS} = S_{valley}/Sin.$ = 0.0074 ft./ft.
 V = 5.7 fps
 $A_{X-Sect} = Q/V$ = 62.3 sq. ft.
 $W_{Bkf} = (A*W/D)^{1/2}$ = 27.3 ft.
 $D_{Mean} = A/W$ = 2.28 ft.
 $D_{Avg. Bot.}$ = 2.89 ft.
 P = 28.70 ft.
 $R = A/P$ = 2.170 ft.

$t_c = gS_{WS}R$ = 1.00 lb/ft²
Particle Range = 47 - 264 mm
Stream Power = 5.66 lb/ft-s

APPENDIX D

STREAM RESTORATION PLAN
(under separate cover)

APPENDIX E
RIPARIAN PLANTING PLAN AND SPECIFICATIONS

RIPARIAN PLANTING PLAN AND SPECIFICATIONS

The riparian buffer of the proposed stream restoration and enhancement sites along the US 19 corridor will include native species to the western region of North Carolina. Plants within the floodplain will be somewhat flood tolerant to accommodate for periodic flooding events throughout the year and in the long-term. A variety of shrubs and trees will be planted to provide cover and habitat for a variety of wildlife.

Trees with deep root systems will help stabilize the banks in the long term, while grasses and live stakes will be used at the site for short-term stabilization (Allen and Leech 1997). Vegetation will be planted in layers similar to layers found in a local reference site. Vegetative layers will include a shrubby edge layer adjacent to the stream and a forest canopy layer upslope of the shrub layer. Because of the shading effect of the associated forest layer, shrubs to be planted will be selected on the basis of their shade tolerance (FISRWG 1998). Local colonization of herbaceous vegetation will also occur.

Tree and shrub species to be planted these sites will be selected from the list of species found in the local references and surrounding wooded areas. The following species are suggested plantings depending on availability: white oak (*Quercus alba*), alder (*Alnus serrulata*), black walnut (*Juglan nigra*), tulip poplar (*Liriodendron tulipifera*), sycamore (*Platanus occidentalis*), black willow (*Salix nigra*), green ash (*Fraxinus pennsylvanica*), and elderberry (*Sambucus canadensis*).

The proposed will be stabilized with a grass mix and erosion control matting along the stream banks. Black willows (*Salix nigra*) will be live-staked on the channel banks on four-foot centers on the outside of the meander bends and on both banks of the riffle sections. Trees will be planted as bare root stock on eight-foot centers (680 stems per acre). Planting of species using dormant plant stock will be performed between November 15th and March 15th.

APPENDIX F
PHOTOGRAPHS



Site A: Roadway Station 19+80 DN



Site A: Roadway Station 19+80 DN



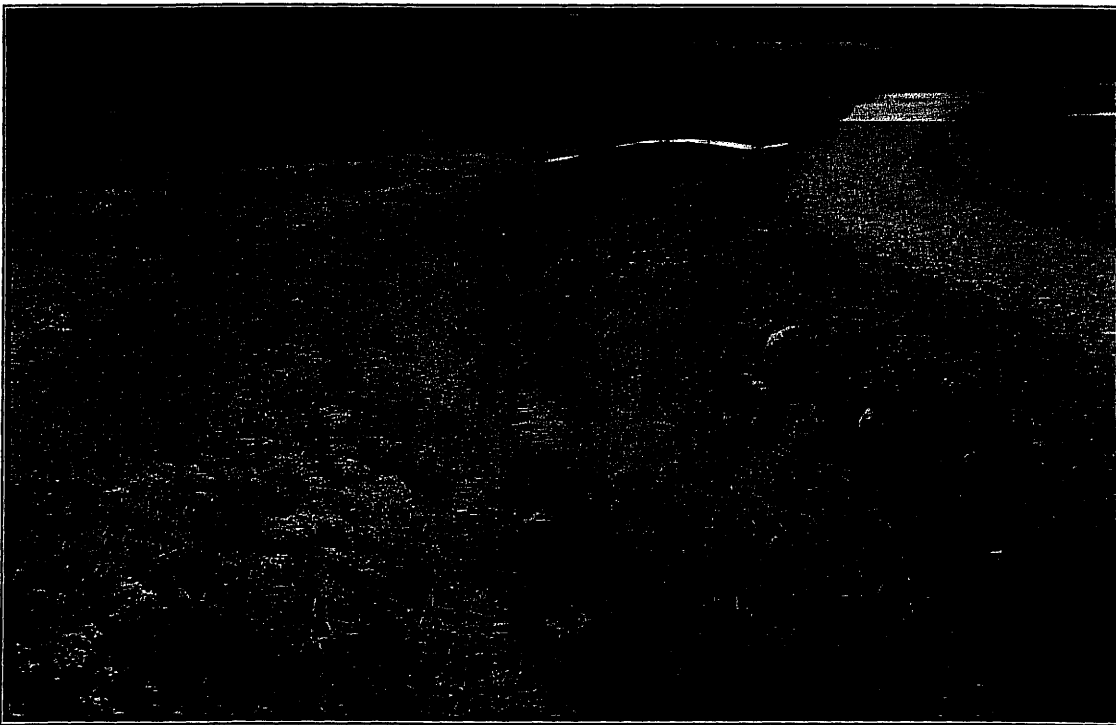
Site A: Roadway Station 19+80 UP



Site C: Roadway Station 27+20



Site D: Roadway Station 31+20 Trib. UP



Site D: Roadway Station 31+20 DN Trib.



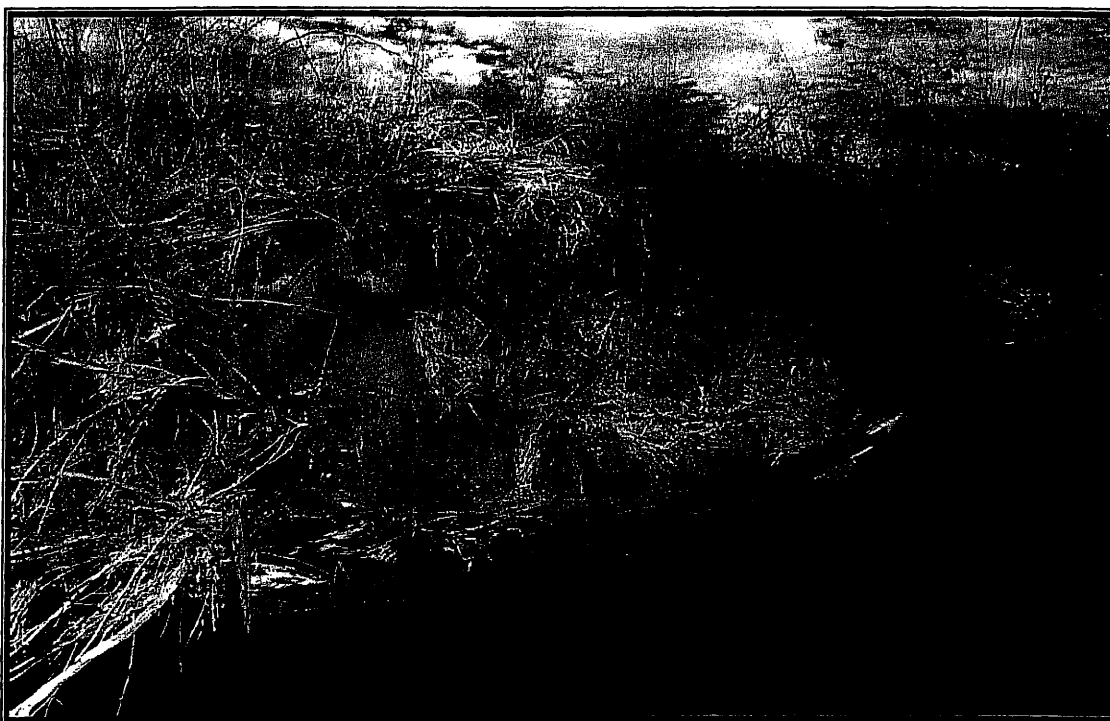
Site E: Roadway Station 35+60, DN



Site E: Roadway Station 35+60, Bank, DN



Site E: Roadway Station 35+60, Bank



Site E: Roadway Station 35+60, Bank



Site E: Roadway Station 35+60, Bank, DN



Site H: Roadway Station 51+60 DN



Site I: Roadway Station 51+60 UP



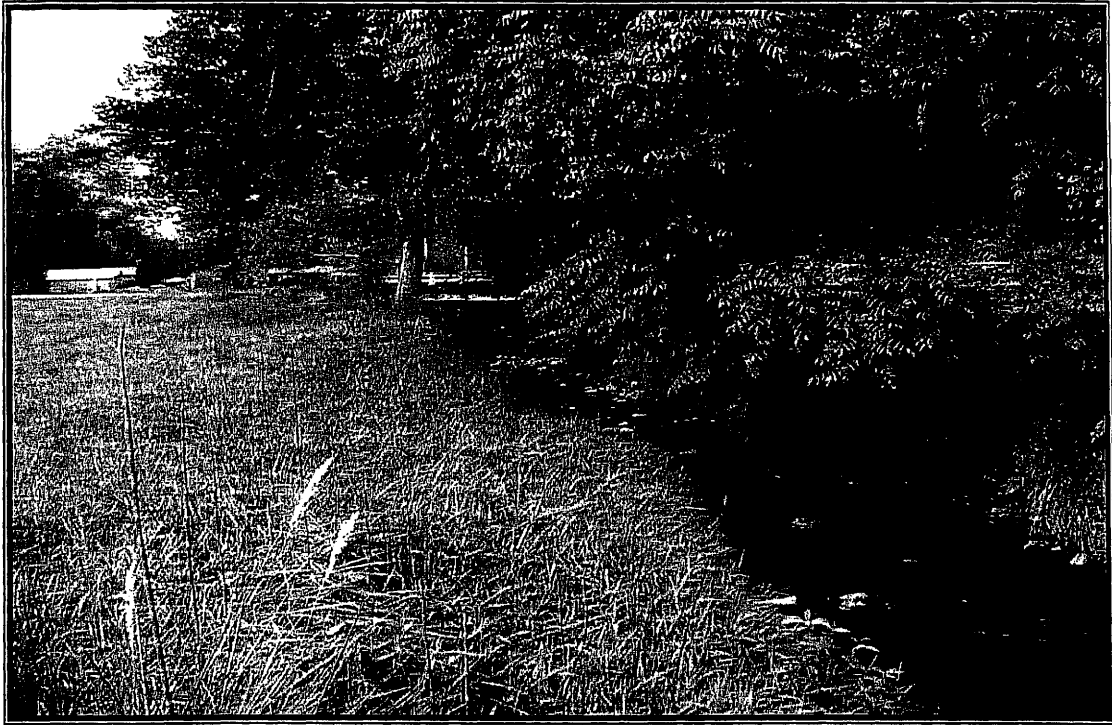
Site I: Roadway Station 52+00 DN



Site I: Roadway Station 52+00 UP



Site I: Roadway Station 53+50 DN



Site I: Roadway Station 53+50 UP



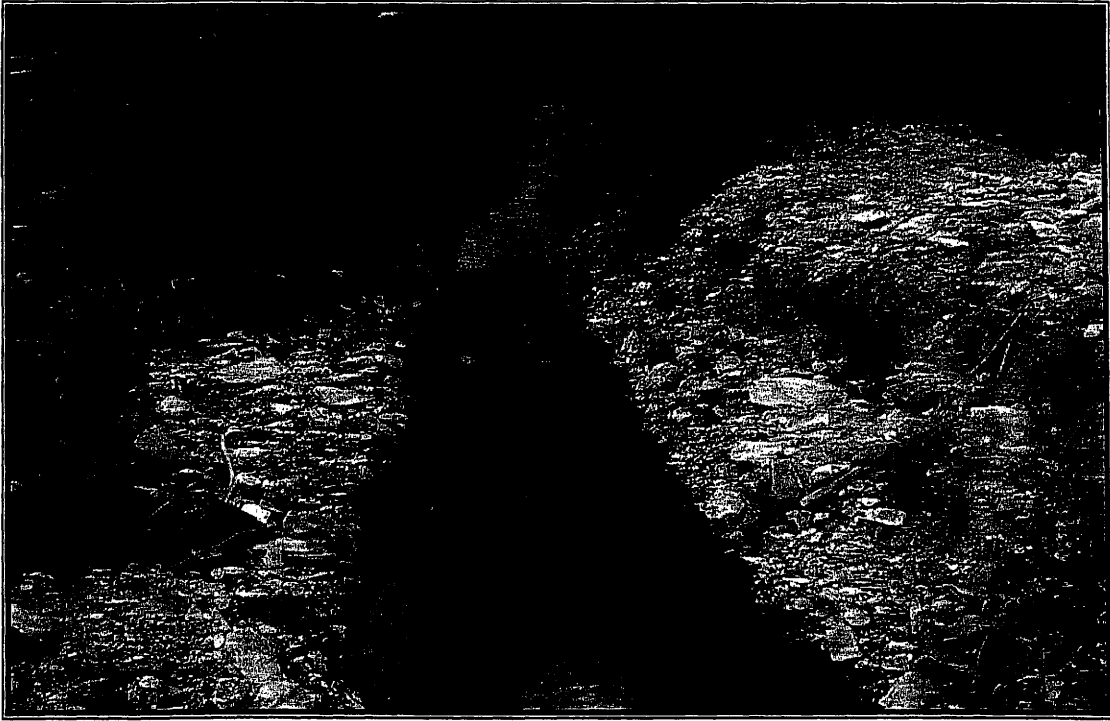
Site J: Roadway Station 56+50 UP



Site K: Roadway Station 73+00 DN



Site K: Roadway Station 73+00 UP



Site K: Roadway Station 75+16 DN



Site L: Roadway Station 77+00 DN



Site M: Roadway Station 82+00 DN, towards US19



Site M: Roadway Station 82+00 DN



Site M: Roadway Station 82+00 Bank, DN



Site M: Roadway Station 82+00, UP



Site O: Roadway Station 89+50 DN



Site O: Roadway Station 89+40



Site P: Roadway Station 91+20 LT



Site Q: Roadway Station 97+00 LT