STILLHOUSE CREEK
RESTORATION PLAN
NCWRP
JUNE 2002

PROPOSED STILLHOUSE CREEK STREAM RESTORATION PROJECT

INTRODUCTION

Project Description and Location

The North Carolina Wetlands Restoration Program (NCWRP) is working in conjunction with the Orange County Soil and Water Conservation District, Natural Resources Conservation Service (NRCS) and Orange County to restore Stillhouse Creek, a tributary to the Eno River. Stillhouse Creek is approximately 1,200 linear feet in length. The site is located in historic downtown Hillsborough at the Orange County Park and the adjacent to a replica Oconechee Indian village. The banks along the entire reach are unstable and are experiencing significant erosion. Downcutting of the streambed has occurred in some of the reach. The foundation of one municipal building is threatened from the stream erosion.

Project Goals:

- Reduce stream bank erosion and prevent downcutting by restoring degraded, incised stream to stable, referenced condition.
- Prevent stream erosion from continuing to threaten existing building foundation located near the head of the stream by implementing natural stream design restoration.
- Improve retention of nutrients by restoring woody vegetation to riparian buffer.
- Increase environmental education opportunities within a park setting.
- Improve wildlife habitat within the conservation easement area and in-stream.
- Enhance habitat for wetland dependent plants and animals by use of shallow wetland habitat areas in the floodplain.
- Improve water quality by providing temporary stormwater storage in shallow wetland habitat areas in the floodplain.
- Improve aesthetics of stream corridor.

Protected Species

A review of the US Fish and Wildlife Orange County Endangered Species, Threatened Species, and Federal Species of Concern list (2/25/03) and the North Carolina Natural Heritage Program Element Occurrence database of rare species and unique habitats (as of December 2002) was completed to determine the potential presence of protected species. Additionally, a field based visual examination of the proposed Stillhouse Creek was by conducted by the NCWRP staff for evidence of mollusks. No mollusks were identified in Stillhouse Creek during the field walk through by NCWRP staff.

The USFWS lists three vertebrates, seven invertebrates, seven vascular plants, and one nonvascular plant as either federally endangered, federally threatened, or federal species of concern as being located in Orange County.

The Natural Heritage Program database was used to determine whether any state or federal listed species occurred within 3000 feet and 5 miles of the proposed project.

Species Located Within 3000 linear Feet

According to the Natural Heritage Program database, there are two data points with four element occurrences of state or federally listed species within 3000 feet. The four occurrences had digital points located in the Eno River approximately at the outlet of the proposed Stillhouse Creek project. These four occurrences included one amphibian and three mollusks. None of the species are listed as federally endangered or threatened:

Scientific Name	Common Name	State Protection	Federal Protection	Precision
NECTURUS LEWISI	NEUSE RIVER WATERDOG	SC	None	+/-5 miles
ALASMIDONTA UNDULATA	TRIANGLE FLOATER	T	None	+/-5 miles
FUSCONAIA MASONI	ATLANTIC PIGTOE	T	SC	+/-1 mile
LAMPSILIS CARIOSA	YELLOW LAMPMUSSEL	T	SC	+/-5 miles

The Atlantic Pigtoe occurrence was known to be destroyed and was last seen in 1951. The Neuse River Waterdog occurrence is a historic occurrence meaning that the evidence is old (1979) but no evidence exists that the species has been destroyed. Of the three species thought to still be in existence in the Eno River, only the Yellow Lampmussel is listed by the USFWS as a species of concern. Species listed federally as "Species of Concern" are not subject to Section 7 consultation requirements. Also of significance during the investigation was the precision of data. The Natural Heritage Element Occurrence point data has varying degrees of precision for each of its element occurrences. The data is labeled as "G" (General, actual location is within 500 feet of mapped location), "M" (Minutes, actual location is within 1 mile of mapped location), or "S" (Seconds, actual location is within 5 miles of mapped location). The existing element occurrences located within 3000 linear feet of the proposed project each had precision levels of "Seconds" or the actual location is within 5 miles of mapped location. Because the level of precision is coarse, NCWRP identified the element occurrences located within 5 miles of the proposed Stillhouse Creek stream restoration project.

Species Located Within 5 miles

The Natural Heritage Program database shows eleven occurrences of federally listed species located within five miles of the project site. Two of these are listed as federally listed endangered or threatened species: Michaux's Sumac (federally endangered) and Small Whorled Pogonia (federally threatened). Both of these species are plants. The Michaux's Sumac is approximately 3.9 miles away +/- 0.2 miles. The Small Whorled Pogonia is located approximately 4 miles away +/- 1 mile. Neither of these plant species will be affected or impacted by the implementation of the proposed Stillhouse Creek stream restoration project.

The other nine element occurrences are listed as Federal Species of Concern - which is a species that may or may not be listed in the future (formerly C2 candidate species or species under consideration for listing for which there is insufficient information to support listing). Of the nine, at least 4 are located more than 1 mile away and 5 are located within +/- 5miles (with 1 of the 4 being known to have been destroyed).

There are twenty-three additional element occurrences listed as state threatened, endangered, and rare plants and animals located within 5 miles.

Summary

There are no federally endangered or threatened species located within 3.5 miles of the proposed Stillhouse Creek project. There are eleven Federal Species of Concern known to exist within 5 miles of the project site. There are twenty-three species of state listed endangered, threatened or species of concern within 5 miles. The proposed Stillhouse Creek stream restoration project will have no negative effect on federally endangered or federally threatened species. Stillhouse Creek has no evidence of state or federal listed species being present in the stream. The proposed project, with the implementation of proper sedimentation and erosion controls, should have no negative effect on species located downstream. Conversely, the implementation of the stream restoration project may benefit downstream species by reducing long-term sedimentation. A complete listing of the Natural Heritage Program Element Occurrences located within five miles of the proposed Stillhouse Creek stream restoration project is listed in the table below:

Complete Listing of Natural Heritage Element Occurrences Located Within 5 Miles of Propose Stillhouse Creek Stream Restoration Site

ELEMOC_	ELEMOC	LAT	LONG	SNAME	SCOMNAME	ELCLASS	MG_DISP	PR	ION	EORANK	EOSTAT	LASTOBS	DATASENS	1	SPROT	USESA	SRANK	GRANK	AC	TIC	ELEMENT_ID
130	130	360500N	0790030W	ROCKY BAR AND SHORE		C	Natural Community	M			E	1988-07	N				S5	G5	N		43271
649	649	360345N	0790855W	PIEDMONT/LOW MOUNTAIN ALLUVIAL FOREST		C	Natural Community	M		A	E	1988-08-07	N				S5	G5	N		112400
650	650	360435N	0790820W	PIEDMONT/LOW MOUNTAIN ALLUVIAL FOREST		C	Natural Community	M		B	E	1988-07-07	N				S5	G5	N		122400
651	651	360445N	0790410W	PIEDMONT/LOW MOUNTAIN ALLUVIAL FOREST		C	Natural Community	M		B?	E	1988-06-15	N				S5	G5	N		132400
652	652	360500N	0790030W	PIEDMONT/LOW MOUNTAIN ALLUVIAL FOREST		C	Natural Community	M			E	1988-07	N				S5	G5	N		142400
921	921	360420N	0790210W	UPLAND DEPRESSION SWAMP FOREST		C	Natural Community	M		C	E	1988-07-13	N				S2	G3	N		172741
981	981	360430N	0790410W	LOW ELEVATION SEEP		C	Natural Community	M			E	1988-06-15	N				S3	G4?	N		13238
982	982	360155N	0790350W	LOW ELEVATION SEEP		C	Natural Community	M		A?	E	1988-09-15	N				S3	G4?	N		23238
2871	2871	360445N	0790830W	MESIC MIXED HARDWOOD FOREST (PIEDMONT SUBTYPE)		C	Natural Community	M		B	E	1988-07-07	N				S4	G5T5	N		181550
2872	2872	360455N	0790120W	MESIC MIXED HARDWOOD FOREST (PIEDMONT SUBTYPE)		C	Natural Community	M			E	1988-07	N				S4	G5T5	N		191550
3053	3053	360345N	0790850W	BASIC MESIC FOREST (PIEDMONT SUBTYPE)		C	Natural Community	M		A?	E	1988-08-07	N				S2	G5T3	N		71926
3205	3205	360345N	0790715W	PINE--OAK/HEATH		C	Natural Community	M		A?	E	1988-08-29	N				S4	G5	N		261129
3373	3373	360345N	0790715W	PIEDMONT MONADNOCK FOREST		C	Natural Community	M		A	E	1988-08-29	N				S4	G5	N		121231
3540	3540	360350N	0790700W	DRY OAK--HICKORY FOREST		C	Natural Community	M		B?	E	1987-05-17	N				S4	G5	N		191126
3541	3541	360435N	0790145W	DRY OAK--HICKORY FOREST		C	Natural Community	M			E	1988-07-13	N				S4	G5	N		201126
3631	3631	360447N	0790832W	DRY-MESIC OAK--HICKORY FOREST		C	Natural Community	M		B	E	1988-07-07	N				S5	G5	N		261128
3632	3632	360520N	0790050W	DRY-MESIC OAK--HICKORY FOREST		C	Natural Community	M			E	1988-07	N				S5	G5	N		271128
3633	3633	360430N	0790125W	DRY-MESIC OAK--HICKORY FOREST		C	Natural Community	M			E	1988-07-13	N				S5	G5	N		281128
3721	3721	360040N	0790455W	BASIC OAK--HICKORY FOREST		C	Natural Community	M			E	1988-08-20	N				S3	G4	N		121127
3722	3722	360035N	0790605W	BASIC OAK--HICKORY FOREST		C	Natural Community	M		BC?	E	1988-06-26	N				S3	G4	N		131127
3764	3764	360206N	0790632W	BASIC OAK--HICKORY FOREST		C	Natural Community	S		A	E	1993-09-30	N				S3	G4	N		531127
3843	3843	360213N	0790620W	XERIC HARDPAN FOREST		C	Natural Community	S		C?	E	1993-09-30	N				S3	G3G4	N		391481
4120	4120	360350N	0790725W	PIEDMONT/COASTAL PLAIN ACIDIC CLIFF		C	Natural Community	M		A	E	1988-08-29	N				S2?	G4	N		82012
4121	4121	360515N	0790105W	PIEDMONT/COASTAL PLAIN ACIDIC CLIFF		C	Natural Community	M			E	1988-07-13	N				S2?	G4	N		92012

4141	4141360430N 0790415W	PIEDMONT/COASTAL PLAIN HEATH BLUFF		C	Natural Community	M		E	1988-06-15	N			S3	G4?	N	72013
5385	360200N 0790355W	HEMIDACTYLIUM SCUTATUM	FOUR-TOED SALAMANDER	A	Amphibian	S		E	1988-03	Y	SC		S3	G5	N	462955
5433	5433360505N 0790340W	NECTURUS LEWISI	NEUSE RIVER WATERDOG	A	Amphibian	S		H	1968-01-01	N	SC		S3	G3	Y	62136
5445	5445360445N 0790030W	NECTURUS LEWISI	NEUSE RIVER WATERDOG	A	Amphibian	S		E	1995-12-14	N	SC		S3	G3	Y	222136
5450	5450360417N 0790555W	NECTURUS LEWISI	NEUSE RIVER WATERDOG	A	Amphibian	S		H	1979	N	SC		S3	G3	Y	282136
5959	5959360510N 0790120W	ACCIPITER STRIATUS	SHARP-SHINNED HAWK	A	Bird	G		E	1981-05	N	SR		S2B,S4N	G5	N	102079
8434	8434360435N 0790412W	LYTHRURUS MATUTINUS	PINEWOODS SHINER	A	Fish	S		A	E	1998-08-03	N	SR	FSC	S3	G3	Y	273413
8441	8441360815N 0790415W	LYTHRURUS MATUTINUS	PINEWOODS SHINER	A	Fish	M		O	E		N	SR	FSC	S3	G3	Y	333413
8621	8621360500N 0790040W	AMBLOPLITES CAVIFRONS	ROANOKE BASS	A	Fish	M		E	E	1977	N	SR		S3	G3	Y	92067
8698	8698360440N 0790820W	ETHEOSTOMA COLLIS POP 2	CAROLINA DARTER - EASTERN PIEDMONT POPULATION	A	Fish	M		H	H	1949	N	SC	FSC	S2	G3T3Q	Y	43427
10724	10724360340N 0790715W	FIXSENIA FAVONIUS ONTARIO	NORTHERN OAK HAIRSTREAK	I	Insect	S		E	E	1999-06-18	N	SR		S3?	G4T4	N	132479
11195	11195360415N 0790546W	ALASMIDONTA UNDULATA	TRIANGLE FLOATER	I	Mollusk	S		E	E	1992-11-18	N	T		S2	G4	Y	323132
11196	11196360418N 0790048W	ALASMIDONTA UNDULATA	TRIANGLE FLOATER	I	Mollusk	S		E	E	1992-11-18	N	T		S2	G4	Y	333132
11220	11220360722N 0790918W	ALASMIDONTA VARICOSA	BROOK FLOATER	I	Mollusk	S		E	E	1995-07-07	N	T	FSC	S1	G3	Y	172014
11376	11376360417N 0790555W	FUSCONAIA MASONI	ATLANTIC PIGTOE	I	Mollusk	M		X?	X	1951	N	T	FSC	S1	G2	Y	72546
11491	11491360415N 0790546W	LAMPSILIS CARIOSA	YELLOW LAMPMUSSEL	I	Mollusk	S		E	E	1992-11-18	N	T	FSC	S1	G3G4	Y	252092
11545	11545360411N 0790824W	LAMPSILIS RADIATA RADIATA	EASTERN LAMPMUSSEL	I	Mollusk	S		E	E	1992-11-18	N	SC		S1S2	G5T5	Y	202099
11578	11578360411N 0790824W	LASMIGONA SUBVIRIDIS	GREEN FLOATER	I	Mollusk	S		E	E	1992-11-18	Y	E	FSC	S1	G3	Y	123229
11659	11659360455N 0790824W	STROPHITUS UNDULATUS	SQUAWFOOT	I	Mollusk	S		E	E	1995-10-11	N	T		S2S3	G5	Y	283160
11660	11660360400N 0790830W	STROPHITUS UNDULATUS	SQUAWFOOT	I	Mollusk	S		E	E	1995-10-11	N	T		S2S3	G5	Y	283160
11661	11661360725N 0790918W	STROPHITUS UNDULATUS	SQUAWFOOT	I	Mollusk	S		E	E	1995-10-11	N	T		S2S3	G5	Y	283160
11695	11695360455N 0790824W	VILLOSA CONSTRICTA	NOTCHED RAINBOW	I	Mollusk	S		E	E	1992-11-18	N	SR		S3	G3	Y	82898
12661	12661360515N 0790952W	RHUS MICHAUXII	MICHAUX'S SUMAC	P	Vascular Plant	G		X	X	1964-10	Y	E-SC	LE	S2	G2	N	21893
14379	14379360355N 0791003W	BERBERIS CANADENSIS	AMERICAN BARBERRY	P	Vascular Plant	M		H	H	1960-04-29	N	SR-T		S2	G3	N	161163
16613	16613360345N 0790715W	FOTHERGILLA MAJOR	LARGE WITCH-ALDER	P	Vascular Plant	S		B	E	1990-04-07	N	SR-T		S2	G3	N	42482
16869	16869360309N 0790159W	TRICHOSTEMA BRACHIATUM	GLADE BLUECURLS	P	Vascular Plant	M		H	H	1973-10-15	N	SR-P		S1	G4G5	N	41392
17240	17240360345N 0790715W	MONOTROPSIS ODORATA	SWEET PINESAP	P	Vascular Plant	M		H	H		N	SR-T	FSC	S3	G3	N	12809
17241	17241360158N 0790430W	MONOTROPSIS ODORATA	SWEET PINESAP	P	Vascular Plant	M		H	H	1976-05	N	SR-T	FSC	S3	G3	N	22809
18507	18507360510N 0791003W	BUCHNERA AMERICANA	AMERICAN BLUEHEARTS	P	Vascular Plant	M		H	H	1960-06-28	N	SR-P		SH	G5?	N	12746

20492	20492	360035N	0790605W	HEXALECTRIS SPICATA	CRESTED CORALROOT	P	Vascular Plant	S	E	E	1988-06-26	N	SR-P		S2	G5	N	341404
20513	2	55958N	0790549W	ISOTRIA MEDEOLOIDES	SMALL WHORLED POGONIA	P	Vascular Plant	M	H	H	1973	Y	E	LT	S1	G2	N	111715
20600	20600	360345N	0790715W	PLATANTHERA PERAMOENA	PURPLE FRINGELESS ORCHID	P	Vascular Plant	M	O	E	1977-01	N	SR-P		S1	G5	N	21145
20601	20601	360350N	0790855W	PLATANTHERA PERAMOENA	PURPLE FRINGELESS ORCHID	P	Vascular Plant	S	E	E	1988	N	SR-P		S1	G5	N	31145
20844	20844	360213N	0790212W	PANICUM FLEXILE	WIRY PANIC GRASS	P	Vascular Plant	M	X?	X		N	SR-P		S1	G5	N	93264
21226	21226	360350N	0790720W	ASPLENIUM BRADLEYI	BRADLEY'S SPLEENWORT	P	Vascular Plant	S	C	E	1994-02-06	N	SR-P		S1	G4	N	21487

MORPHOLOGICAL CHARACTERISTICS OF THE EXISTING AND PROPOSED CHANNEL WITH GAGE STATION AND REFERENCE REACH DATA

(After Rosgen, 1996)

Restoration Site (Name of stream & location): **Stillhouse Creek, Hillsborough, NC**

Reference Reach (Name of stream & location): **UT to Caraway Creek, Camp Caraway, Randolph County, NC**

Reference Reach (Name of stream & location): **UT to North Fork New River, Ashe County, NC**

VARIABLES	EXISTING CHANNEL Stillhouse Creek	PROPOSED REACH Stillhouse Creek	REFERENCE REACH UT to Caraway Creek	REFERENCE REACH (UT to N Fork New River)
1. Stream type	E4 (Incision, lat. migration)	E4 (Upper Reach)	E4/5 (Confined valley)	E4/5 (Confined valley)
2. Drainage area (sq. mi.)	0.14	0.14	0.17	0.25
3. Bankfull width (w_{bkf}) – ft.	Mean: 7.0 Range: 6.0-7.6	Mean: 8.5 Range: 7.5 – 9.5	Mean: 9.7 Range: 7.3 – 12.4	Mean: 7.2 Range: 6.0 – 9.0
4. Bankfull mean depth (d_{bkf}) – ft.	Mean: 1.0 Range: 0.8-1.4	Mean: 1.06 Range: 0.95 – 1.2	Mean: 1.1 Range: 0.9 – 1.3	Mean: 0.8 Range 0.6 – 1.0
5. Width/depth ratio (w_{bkf}/d_{bkf})	Mean: 7.1 Range: 4.4-9.3	Mean: 8.0 Range: 6.0 – 10.0	Mean: 9.3 Range: 7.3 – 14	Mean: 10.1 Range: 6.0 – 15.0
6. Bankfull cross-sectional area (A_{bkf}) – sq. ft.	Mean: 7.3 Range: 5.6-8.1	Mean: 9.0 Range:	Mean: 10.35 Range: 7.3 – 13.2	Mean: 5.4 Range: 4.4 – 6.1
7. Bankfull mean velocity (v_{bkf}) – f/s	Mean: 5.0 Range: 4.4-6.4	Mean: 3.8 Range: 3.6 - 4.1	Mean: 3.2 Range: 2.5 – 4.5	Mean: 6.1 Range: 5.4 – 7.5
8. Bankfull discharge, cfs (Q_{bkf})	36	36	33 (Note: Soil hydrologic group C)	33 (Note: Dry side of eastern mountains)
9. Bankfull Maximum depth (d_{max}) – ft.	Mean: 1.7 Range: 1.2-2.0	Mean: 1.8 Range: 1.3 – 2.4	Mean: 1.8 Range: 1.6 – 2.0	Mean: 1.5 Range: 1.4 – 1.6
10. Max d_{riff}/d_{bkf} ratio	Mean: 1.6 Range: 1.2-2.0	Mean: 1.7 Range:1.2 – 2.3	Mean: 1.6 Range: 1.2 – 2.2	Mean: 1.9 Range: 1.6 – 2.3
11. Low bank height to max. d_{bkf} ratio	Mean: 1.13 Range: 1.0-1.4	Mean: 1.0 Range:	Mean: 1.06 Range: 1.0 – 1.25	Mean: 1.0 Range:
12. Width of flood prone area (w_{fpa}) – ft.	Mean: 35.1 Range: 17.1-47.0	Mean: 104 Range:23 – 176	Mean: 49.6 Range: 27.0 – 74.0	Mean: 135.5 Range: 122 – 149
13. Entrenchment ratio (w_{fpa}/w_{bkf})	Mean: 5.1 Range: 2.3-6.3	Mean: 12.2 Range:2.7 – 20.7	Mean: 5.6 Range: 2.7 – 10.1	Mean: 18.8 Range: 16.9 – 20.7
14. Meander length (L_m) – ft.	Mean: 63 Range: 29-116	Mean: 27.2 Range:12.8 – 39.1	Mean: 34.7 Range: 21.2 – 57.0	Mean: 20 Range: 13.5 – 26
15. Ratio of meander length to bankfull width (L_m/w_{bkf})	Mean: 9 Range: 4.1-16.6	Mean: 3.6 Range:2.2 – 6.0	Mean: 3.6 Range: 2.2 – 5.9	Mean: 2.8 Range: 1.9 - 3.6

VARIABLES	EXISTING CHANNEL	PROPOSED REACH	REFERENCE REACH (UT to Caraway Crk)	REFERENCE REACH (UT to N Fork New River)
51. Ratio of glide length to bankfull width (L_{glide}/W_{bkf})	Mean: Range:	Mean: 0.55 Range: 0.2 – 2.0	Mean: 0.55 Range: 0.2 – 2.0	Mean: 0.4 Range:0.14 – 0.8
52. Riffle thalweg slope ($S_{riff\ TW}$) – ft/ft	Mean: Range:	Mean: Range:	Mean: 0.0415 Range:0.02-0.073	Mean: Range:
53. Run thalweg slope ($S_{run\ TW}$) – ft/ft [Note: Run reach that goes into pool]	Mean: Range:	Mean: Range:	Mean: 0.1165 Range:0.011-0.222	Mean: Range:
54. Glide thalweg slope ($S_{glide\ TW}$)-ft/ft	Mean: Range:	Mean: Range:	Mean: -0.0604 Range: - 0.0192 to -0.1067	Mean: Range:
55. Pool entrance thalweg slope ($S_{pool\ TW\ entrance}$)-ft/ft	Mean: Range:	Mean: Range:	Mean: 0.059 Range:0.024 to 0.17	Mean: Range:
56. Pool exit thalweg slope ($S_{pool\ TW\ exit}$) – ft/ft	Mean: Range:	Mean: Range:	Mean: -0.071 Range:-0.0084 to –0.12	Mean: Range:

- **Data in Item Nos. 59 through 63 are for use with a CAD system.**

MATERIALS:				
1. Particle Size Distribution of Channel Material				
D_{16}	<0.062 mm		< 0.062 mm	<0.062 mm
D_{35}	0.8		0.09	0.08
D_{50}	5		0.4	0.12
D_{84}	27		21	8
D_{95}	70		70	15
2. Particle Size Distribution of Bar Material	Particle Size Distribution of Subpavement Material		Particle Size Distribution of Subpavement Material	
D_{16}	1.2		0.6 mm	
D_{35}	5.1		3.7	
D_{50}	13		9.9	
D_{84}	50		45	
D_{95}	80		55	
Largest size particle in sub-pavement sample	63		70	

VARIABLES	EXISTING CHANNEL	PROPOSED REACH	REFERENCE REACH (UT to Caraway Crk)	REFERENCE REACH (UT to N Fork New River)

SEDIMENT TRANSPORT VALIDATION (BASED ON BANKFULL SHEAR STRESS)	Existing Condition	Proposed Condition	Reference Condition (UT to Caraway Crk)
Bankfull shear stress - Calculated value (lb/ft^2)	0.63	0.46	0.41
Predicted Critical shear stress to initiate movement (Adjusted curve with field data used)	0.28	0.30	0.32
OR Grain Diameter from Shields Diagram (mm) (Relation adjusted to include field data)	150	100	90
Critical dimensionless shear stress	0.016	0.016	0.026
Minimum mean d_{bkf} calculated using critical dimensionless shear stress equations (ft)	0.43	0.65	1.0
Manning's "n"	0.033	0.03	0.03

Remarks: _____

These values and ratios were calculated and proposed by:

Name: Angela G. Jessup **Location:** Yadkinville TSO

Title: Civil Engineer **Date:** 2-24-02 & 5-14-02

MORPHOLOGICAL CHARACTERISTICS OF THE EXISTING AND PROPOSED CHANNEL WITH GAGE STATION AND REFERENCE REACH DATA

(After Rosgen, 1996)

Restoration Site (Name of stream & location): **Stillhouse Creek, Hillsborough, NC- Lower Reach**

Reference Reach (Name of stream & location): **Silas Creek near Silas Crk Pkwy and Reynolda Rd, Winston-Salem, NC**

VARIABLES	EXISTING CHANNEL Stillhouse Creek	PROPOSED REACH Stillhouse Creek	REFERENCE REACH (Silas Creek)
1. Stream type	G4c/1	B4/1	B4c/1
2. Drainage area (sq. mi.)	3.3	3.3	3.3
3. Bankfull width (w_{bkf}) – ft.	Mean: 11.8 Range: 9.8-14.6	Mean: 17.4 Range: 14.9-19.5	Mean: 25.6 Range: 23.1-28.0
4. Bankfull mean depth (d_{bkf}) – ft.	Mean: 1.9 Range: 1.7-2.0	Mean: 1.15 Range: 1.1-1.2	Mean: 1.7 Range: 1.5-1.9
5. Width/depth ratio (w_{bkf}/d_{bkf})	Mean: 6.2 Range:4.9-8.6	Mean: 15.2 Range: 12.4-17.2	Mean: 15.2 Range: 12.4-17.2
6. Bankfull cross-sectional area (A_{bkf}) – sq. ft.	Mean: 21.7 Range: 19.2-24.7	Mean: 20 Range: 18-22	Mean: 43.5 Range: 38.5-48.9
7. Bankfull mean velocity (v_{bkf}) – f/s	Mean: 4.2 Range: 3.7-4.8	Mean: 4.5 Range: 4.2-5.1	Mean: 4.4 Range: 3.6-4.9
8. Bankfull discharge, cfs (Q_{bkf})	92	92	199
9. Bankfull Maximum depth (d_{max}) – ft.	Mean: 2.7 Range: 2.6-2.8	Mean: 1.8 Range: 1.7-1.9	Mean: 2.7 Range: 2.4-2.9
10. Max d_{riff}/d_{bkf} ratio	Mean: 1.45 Range: 1.4-1.5	Mean: 1.6 Range: 1.5-1.6	Mean: 1.6 Range: 1.5-1.6
11. Riffle length (L_{riff}) - ft.		Mean: 12.2 Range: 6.0-19.5	Mean: 18.4 Range: 9.5-29.0
12. Ratio of riffle length to bkf width (L_{riff}/w_{bkf})		Mean: 0.7 Range: 0.4-1.0	Mean: 0.7 Range: 0.4-1.0
13. Low bank height to max. d_{bkf} ratio	Mean: 2.6 Range: 2.5-2.9	Mean: 1.0 Range:	Mean: 1.0 Range: 1.0-1.0
14. Width of flood prone area (w_{fpa}) – ft.	Mean: 19.3 Range: 15.5-26.8	Mean: 26.1 Range: 17.9-35.1	Mean: 33.7 Range: 33.0-35.0
13. Entrenchment ratio (w_{fpa}/w_{bkf})	Mean: 1.6 Range: 1.4-1.8	Mean: 1.5 Range: 1.2-1.8	Mean: 1.3 Range: 1.2-1.4

VARIABLES	EXISTING CHANNEL	PROPOSED REACH	REFERENCE REACH Silas Creek
14. Meander length (L_m) – ft.	Mean: Range:	Mean: 115 Range: 39-94	Mean: 168 Range: 130-245
15. Ratio of meander length to bankfull width (L_m/w_{bkf})	Mean: Range:	Mean: 6.6 Range: 5.1-9.6	Mean: 6.6 Range: 5.1-9.6
16. Radius of curvature (R_c) – ft.	Mean: Range:	Mean: 34.8 Range: 29.8-39.0	Mean: 41.25 Range: 19.5-54.0
17. Ratio of radius of curvature to bankfull width (R_c/w_{bkf})	Mean: Range:	Mean: 2.0 Range:	Mean: 1.6 Range: 0.8-2.1
18. Belt width (w_{blt}) - ft.	Mean: Range:	Mean: 29.6 Range: 23.8-39.0	Mean: 43.7 Range: 40-51
19. Meander width ratio (w_{blt}/w_{bkf})	Mean: Range:	Mean: 1.7 Range: 1.6-2.0	Mean: 1.7 Range: 1.6-2.0
20. Sinuosity = k (Stream Length$_{thalweg}$/ valley distance)	$\frac{314}{282} = 1.1$	1.1	$\frac{348}{325} = 1.07$
21. Valley slope (ft/ft)	0.0185	0.0185	Not measured
22. Average water surface slope-ft/ft (s_{avg}) = (s_{valley}/k)	0.0168	0.023	0.00819
23. Pool slope (s_{pool}) – ft/ft	Mean: Range:	Mean: 0.0017 Range: 0.00-0.0035	Mean: 0.0000376 Range: -0.001316 to 0.00122
24. Ratio of pool slope to average slope (s_{pool}/s_{bkf})	Mean: Range:	Mean: 0.075 Range: 0.00-0.15	Mean: 0.00459 Range: -0.1607 to 0.149
25. Maximum pool depth ($d_{max\ pool}$) – ft.	Mean: Range:	Mean: 3.0 Range: 2.5-3.5	Mean: 4.5 Range: 4.0-5.0
26. Ratio of pool depth to average bankfull depth ($d_{max\ pool}/d_{bkf}$)	Mean: Range:	Mean: 2.6 Range: 2.3-2.9	Mean: 2.6 Range: 2.3-2.9
27. Pool width (w_{pool}) – ft.	Mean: Range:	Mean: 17.4 Range: 13.4-21.5	Mean: 26.0 Range: 22.6-28.0
28. Ratio of pool width to bankfull width (w_{pool}/w_{bkf})	Mean: Range:	Mean: 1.0 Range: 0.9-1.1	Mean: 1.0 Range: 0.9-1.1

VARIABLES	EXISTING CHANNEL	PROPOSED REACH	REFERENCE REACH Silas Creek
29. Pool Area – sq ft (A_{pool})	Mean: Range:	Mean: 32 Range: 25-40	Mean: 70.3 Range: 59.9-79.8
30. Ratio of Pool Area to Bankfull Area (A_{pool}/A_{bkf})	Mean: Range:	Mean: 1.6 Range: 1.4-1.8	Mean: 1.6 Range: 1.4-1.8
31. Pool to pool spacing (p-p) – ft.	Mean: Range:	Mean: 57 Range: 39-94	Mean: 62.4 Range: 27.2-126.0
32. Ratio of p-p spacing to bankfull width ($p\text{-}p/w_{bkf}$)	Mean: Range:	Mean: 3.3 Range: 2.6-4.8	Mean: 2.4 Range: 1.1-4.9
33. Pool length (L_{pool}) – ft.	Mean: Range:	Mean: 21 Range: 5-53	Mean: 31.2 Range: 8.2 – 68.0
34. Ratio of Pool length to bankfull width (L_{pool}/w_{bkf})	Mean: Range:	Mean: 1.2 Range: 0.3-2.7	Mean: 1.2 Range: 0.3-2.7
35. Avg. riffle slope (s_{riff}) - ft./ft.	Mean: Range:	Mean: 0.055 Range: 0.023-0.198	Mean: 0.01942 Range: 0.000581 to 0.0705
36. Ratio of riffle slope to avg. slope (s_{riff}/s_{avg})	Mean: Range:	Mean: 2.4 Range: 1.0-8.6	Mean: 2.4 Range: 0.07-8.6
37. Avg. run slope ft/ft	Mean: Range:	Mean: 0.03 Range:0.023-0.037	Mean: 0.0048 Range: -0.0025 to 0.01324
38. Ratio of run slope to avg slope (s_{run}/s_{avg})	Mean: Range:	Mean: 1.3 Range: 1.0-1.6	Mean: 0.6 Range: -0.3 to 1.6
39. Avg. step slope-ft/ft	Mean: Range:	Mean: 0.23 Range: 0.018-0.49	Mean: 0.0817 Range: 0.00667 to 0.1733
40. Ratio of step slope to avg slope (s_{step}/s_{avg})	Mean: Range:	Mean: 10.0 Range: 0.8-21.2	Mean: 10.0 Range: 0.8-21.2
41. Avg. glide slope ft/ft	Mean: Range:	Mean: 0.014 Range: 0.00-0.04	Mean: 0.004948 Range: 0.00-0.014
42. Ratio of glide slope to avg slope (s_{glide}/s_{avg})	Mean: Range:	Mean: 0.6 Range: 0.00-1.7	Mean: 0.6 Range: 0.0-1.7
43. Max run depth ($d_{max\ run}$) – ft.	Mean: Range:	Mean: 2.2 Range: 2.1-2.3	Mean: 3.3 Range: 3.3-3.3
44. Ratio of max. run depth to mean bkf depth ($d_{max\ run}/d_{bkf}$)	Mean: Range:	Mean: 1.9 Range:	Mean: 1.9 Range:
45. Run width (w_{run}) – ft.	Mean: Range:	Mean: 17.4 Range: 13.4-21.5	Mean: 26.5 Range: 24.0-29.0

VARIABLES	EXISTING CHANNEL	PROPOSED REACH	REFERENCE REACH Silas Creek
46. Run width to bankfull width ratio (w_{run}/w_{bkf})	Mean: Range:	Mean: 1.0 Range: 0.9-1.1	Mean: 1.0 Range: 0.9-1.1
47. Mean run depth (d_{run}) ft.	Mean: Range:	Mean: 1.6 Range: 1.5-1.8	Mean: 2.4 Range: 2.2-2.6
48. Ratio mean run depth to mean bkf depth (d_{run}/d_{bkf})	Mean: Range:	Mean: 1.4 Range: 1.4-1.5	Mean: 1.4 Range: 1.4-1.5
49. Run w/d ratio (w_{run}/d_{run})	Mean: Range:	Mean: 13.7 Range: 12.4-15.5	Mean: 11.4 Range: 9.4-13.4
50. Ratio of run w/d to riffle w/d	Mean: Range:	Mean: 0.9 Range:	Mean: 0.75 Range: 0.6-0.9
51. Run length (L_{run}) – ft.	Mean: Range:	Mean: 5.9 Range: 1.5-11.7	Mean: 8.8 Range: 3.2-16.0
52. Ratio of run length to bankfull width (L_{run}/w_{bkf})	Mean: Range:	Mean: 0.34 Range: 0.1-0.6	Mean: 0.34 Range: 0.1-0.6
53. Max step depth ($d_{max\ step}$) - ft	Mean: Range:	Mean: 2.0 Range: 1.9-2.2	Mean: 2.95 Range: 2.9-3.0
54. Ratio of max step depth to mean bkf depth ($d_{max\ step}/d_{bkf}$)	Mean: Range:	Mean: 1.7 Range: 1.7-1.8	Mean: 1.7 Range: 1.7-1.8
55. Step width (w_{step}) - ft	Mean: Range:	Mean: 17.4 Range:13.4-21.5	Mean: 25.65 Range: 23.0-28.3
56. Step width to bankfull width ratio (w_{step}/w_{bkf})	Mean: Range:	Mean: 1.0 Range: 0.9-1.1	Mean: 1.0 Range: 0.9-1.1
57. Step area (A_{step}) – sq ft	Mean: Range:	Mean: 20 Range: 16.2-24.2	Mean: 44.1 Range: 42.6-45.6
58. A_{step}/A_{bkf} ratio	Mean: Range:	Mean: 1.0 Range: 0.9-1.1	Mean: 1.0 Range: 0.9-1.1
59. Mean step depth (d_{step}) - ft	Mean: Range:	Mean: 1.15 Range: 1.1-1.3	Mean: 1.75 Range: 1.6-1.9
60. d_{step}/d_{bkf} ratio	Mean: Range:	Mean: 1.0 Range: 1.0-1.1	Mean: 1.0 Range: 1.0-1.1
61. Step w/d ratio	Mean: Range:	Mean: 14.7 Range: 12.0-18.9	Mean: 14.7 Range: 13.1-16.2
62. Ratio of step w/d to bkf w/d	Mean: Range:	Mean: 0.97 Range: 0.9-1.1	Mean: 0.97 Range: 0.9-1.1
63. Step length (L_{step}) – ft	Mean: Range:	Mean: 2.2 Range: 1.0-4.1	Mean: 3.2 Range: 1.5-5.8
64. L_{step}/w_{bkf} ratio	Mean: Range:	Mean: 0.125 Range: 0.065-0.21	Mean: 0.125 Range: 0.065-0.21
65. Max. glide depth ($d_{max\ glide}$) – ft.	Mean: Range:	Mean: 2.3 Range: 1.9-2.5	Mean: 3.25 Range: 2.9-3.6

VARIABLES	EXISTING CHANNEL	PROPOSED REACH	REFERENCE REACH Silas Creek
66. Ratio of max. glide depth to mean bkf depth ($d_{max\ glide}/d_{bkf}$)	Mean: Range:	Mean: 2.0 Range: 1.7-2.1	Mean: 1.9 Range: 1.7-2.1
67. Glide width (w_{glide}) – ft.	Mean: Range:	Mean: 17.4 Range: 14.2-20.3	Mean: 25.5 Range: 24.3-26.7
68. Ratio of glide width to bankfull width (w_{glide}/w_{bkf})	Mean: Range:	Mean: 1.0 Range: 0.95-1.04	Mean: 1.0 Range: 0.95-1.04
69. Glide mean depth (d_{glide}) – ft.	Mean: Range:	Mean: 1.3 Range: 1.2-1.6	Mean: 1.95 Range: 1.9-2.0
70. d_{glide}/d_{bkf} ratio		Mean: 1.15 Range: 1.1-1.3	Mean: 1.15 Range: 1.1-1.3
71. Glide w/d ratio (w_{glide}/d_{glide})	Mean: Range:	Mean: 13.7 Range: 12-15.5	Mean: 13.1 Range: 12.5-13.7
72. Ratio of glide w/d to riffle w/d	Mean: Range:	Mean: 0.9 Range: 0.8-0.9	Mean: 0.9 Range: 0.8-0.9
73. Glide length (L_{glide}) – ft.	Mean: Range:	Mean: 7.0 Range: 3.0-15.6	Mean: 9.8 Range: 5.0-22.0
74. Ratio of glide length to bankfull width (L_{glide}/w_{bkf})	Mean: Range:	Mean: 0.4 Range: 0.2-0.8	Mean: 0.4 Range: 0.2-0.8
75. Riffle thalweg slope ($s_{riff\ TW}$) – ft/ft	Mean: Range:	Mean: 0.12 Range: 0.025-0.35	Mean: 0.0423 Range: 0.0093-0.1263
76. $s_{riff\ TW}/s_{bkf}$ ratio	Mean: Range:	Mean: 5.2 Range: 1.1-15.4	Mean: 5.2 Range: 1.1-15.4
77. Step thalweg slope ($s_{step\ TW}$) – ft/ft	Mean: Range:	Mean: 0.4 Range: 0.28-0.56	Mean: 0.1429 Range: 0.10-0.20
78. $s_{step\ TW}/s_{bkf}$ ratio	Mean: Range:	Mean: 17.45 Range: 12.2-24.4	Mean: 17.45 Range: 12.2-24.4
79. Run thalweg slope ($s_{run\ TW}$) – ft/ft [Note: Run reach that goes into pool]	Mean: Range:	Mean: 0.34 Range: 0.11-0.79	Mean: 0.1227 Range: 0.04-0.28125
80. $s_{run\ TW}/s_{bkf}$ ratio	Mean: Range:	Mean: 14.98 Range: 4.88-34.34	Mean: 14.98 Range: 4.88-34.34
81. Glide thalweg slope ($s_{glide\ TW}$) – ft/ft	Mean: Range:	Mean: -0.39 Range:-0.78 to –0.14	Mean: -0.14022 Range: -0.2778 to –0.05
82. $s_{glide\ TW}/s_{bkf}$ ratio	Mean: Range:	Mean: -17.12 Range:-33.9 to –6.1	Mean: -17.12 Range:-33.9 to –6.1
83. Pool entrance thalweg slope ($s_{pool\ TW\ entrance}$) – ft/ft	Mean: Range:	Mean: 0.1 Range: 0.00 to 0.35	Mean: 0.0356 Range: 0.00 to 0.123
84. $s_{pool\ TW\ entrance}/s_{bkf}$ ratio	Mean: Range:	Mean: 4.3 Range: 0.00 to 15.0	Mean: 4.3 Range: 0.00 to 15.0

VARIABLES	EXISTING CHANNEL	PROPOSED REACH	REFERENCE REACH Silas Creek
85. Pool exit thalweg slope ($s_{pool\ TW\ exit}$) – ft/ft	Mean: Range:	Mean: -0.27 Range: -0.94 to 0.0	Mean: -0.09492 Range: -0.333 to 0.0
86. $s_{pool\ TW\ exit}/s_{bkf}$ ratio	Mean: Range:	Mean: -11.6 Range: -40.7 to 0.0	Mean: -11.6 Range: -40.7 to 0.0

*** Data in Item Nos. 59 through 63 are for use with a CAD system.**

MATERIALS:			
1. Particle Size Distribution of Channel Material			
D_{16}	0.062		0.29 mm
D_{35}	8.43		0.9
D_{50}	16		22.6
D_{84}	128		200
D_{95}	259		Bedrock (>2048 mm)
2. Particle Size Distribution of Bar Material	Particle Size Distribution of Subpavement Material		Particle Size Distribution of Bar Material
D_{16}	2.8		1.8 mm
D_{35}	9.5		15.3
D_{50}	22		31.9
D_{84}	60		96
D_{95}	75		117
Largest size particle at the toe (lower third) of bar	90 mm		90 mm

VARIABLES	EXISTING CHANNEL	PROPOSED REACH	REFERENCE REACH Silas Creek

SEDIMENT TRANSPORT VALIDATION (BASED ON BANKFULL SHEAR STRESS)	Existing Condition	Proposed Condition	Reference Condition
Bankfull shear stress - Calculated value (lb/ft^2)	1.47	1.0	0.869
Predicted Critical shear stress to initiate movement (Adjusted curve with field data used)	0.42	0.42	0.69
OR Grain Diameter from Shields Diagram (mm) (Relation adjusted to include field data)	350	200	55
Critical dimensionless shear stress	0.0204	0.0204	0.023
Minimum mean d_{bkf} calculated using critical dimensionless shear stress equations (ft)	0.59	0.6	1.4
Manning's "n"	0.043	0.043	0.045

Remarks: _____

These values and ratios were calculated and proposed by:

Name: Angela G. Jessup, P.E. **Location:** Yadkinville, NC

Title: Civil Engineer **Date:** June 7, 2002

CONSTRUCTION SPECIFICATION - BIOENGINEERING

GENERAL

The work shall consist of furnishing all labor, materials, and equipment including the harvesting of materials for the construction of a bioengineering installation as required by the drawings and specifications. The installation may include a combination of the following bioengineering practices: contour brushlayering, fascines, brushmattress, live stakes and transplanted live plant materials.

MATERIALS

All cut materials shall be freshly obtained from live plants during the dormant season. The woody plants or vegetation to be transplanted shall have vigorous root systems. All plants shall have normal, well-developed branches. When possible, plant materials should be selected from locally available native species. The fresh dormant cuttings of willows, silky dogwood or other specified materials shall be harvested from within the work limits or from a nearby-designated source. The materials shall be harvested within one (1) week of installation. The collected materials shall conform to the American Association of Nurserymen Standards for collected material. The cut and transplanted materials shall be stored in a cool, moist condition until installed. All plant materials shall be installed or planted above the normal water line with the buds planted in the direction of growth (usually up).

Cuttings - The fresh cuttings and branches shall be at least 25% longer than the width needed for installation. The plant material should be ½ to 2 inches in diameter unless being used for live stakes. Materials for live stakes shall be 1 to 3 inches in diameter and 18 to 36 inches in length. The basal end should be cut at an angle or point. The bark should be left intact. Live stakes should be driven in the ground to a minimum depth of 3 inches above the ground (or to refusal) with a wooden or rubber mallet.

Bare Root Transplanted - Bare root materials to be transplanted shall be dug so that the major portion of the root system and attached soil, including fibrous roots, remain intact. Any roots that are broken or which must be cut shall be cleanly cut. The roots shall be protected at all times to prevent injury or drying caused by heat, sun, wind and freezing temperatures.

EXCAVATION

This work shall consist of the excavation of the existing channel to restore the channel dimensions or add a bankfull bench and to grade the channel bank to a positive slope for the bioengineering installation. The work shall be completed as shown on the drawings, as described in this specification and as staked by the Engineer. Excavation shall bottom on bedrock when it lies above the lines and grades shown on the drawings. Excavation into bedrock is not required or allowed.

Suitable earthfill material from the required excavation shall be used in the bioengineering installation. Excavated material suitable for use, as earthfill, will be stockpiled adjacent to the work area. The Contractor shall remove and dispose of all debris encountered, including but not limited to, trash, stumps, and concrete rubble. The Contractor shall dispose of all unsuitable or excess material at sites of his own choosing away from the work site.

Any accumulation of sediment in the channel shall be cleaned as needed during construction and at the end of construction. No separate payment will be made for this clean-up work. Known utility locations are shown on the drawings but may not be all-inclusive. The Contractor shall be responsible for verifying the location of all utilities prior to excavation. The Contractor shall be responsible for repairing any damage to existing structures or utilities.

EARTHFILL

This work shall consist of the placement and compaction of the earthfill or earth backfill to complete the bioengineering installation as required by the drawings and specifications. Fill materials shall contain no frozen soil, sod, brush, roots, rocks over six (6) inches in diameter, or other objectionable materials. The placing and spreading of fill shall be started at the lowest point of the foundation and shall be brought up in approximately horizontal layers.

Sloughed areas in the slope shall be corrected by shaping the slope to provide a uniform subgrade for the bioengineering installation. The source of earthfill shall be the required shaping of the slope unless otherwise approved by the Engineer.

The moisture content of the fill material shall be maintained as high as attainable within the limits required to:

- Prevent bulking or dilatance of the material under the action of the hauling or compacting equipment;
- Prevent the adherence of the fill material to the treads and tracks of the equipment;
- Ensure the crushing and blending of the soil clods and aggregations into a reasonable homogeneous mass. Fill shall not be placed which is so dry that a sample will not remain formed after squeezing in the hand.

The maximum thickness of a layer before compaction for hand placed and compacted material shall be 4 inches and for machine placed and compacted material shall be 9 inches. Each layer of earthfill shall be compacted to a density equivalent to that of the surrounding in-place materials. Compaction shall be accomplished by means of manually directed power tampers, walk-behind or self-propelled rollers, or by tamping with the bucket of a hydraulic excavator with a minimum operating weight of 42,000 lbs. and a minimum bucket force of 25,000 lbs. unless otherwise approved by the Engineer.

CONTOUR BRUSHLAYERING

This item shall consist of all work, including harvesting and transporting materials, necessary to install contour brushlayering as shown on the drawings or described below for the purpose of restoring the streambank with a bioengineering installation. Contour brushlayering consists of embedding cut live branches of tree or shrub species on successive horizontal contours or benches (in lifts) on the face of the streambank.

The foundation for the contour brushlayering shall be stripped to remove any unsuitable materials or shall be excavated as specified. The foundation surface shall sloped toward the bank on a 5 to 10% grade. The foundation shall be inspected and approved by the Engineer prior to the installation of the contour brushlayering. A minimum twelve(12) inch layer of compacted backfill shall be placed above the fascine prior to installation of the first brushlayer. The backfill shall be placed as specified above in Earthfill.

Brush layer cuttings shall be placed on the foundation or backfill layer with the butt ends stuck into the undisturbed bank material. The butt ends should be angled slightly down. The branches should be spaced no more than 8 to 12 inches apart. The branches should be layered to a thickness of 3 to 6 inches. The branch placements should result in some crisscrossing of the stems.

A thin layer of earthfill shall be placed over the brush layer and firmly hand-tamped to fill the voids between the branch stems. Water packing of the soil in the voids may used with the approval of the Engineer. After filling the voids in the brush layer, a layer of compacted earthfill shall be placed in accordance with the above requirements for Earthfill. Earthfill shall be obtained as specified above in Excavation and Earthfill.

Successive alternate layers of brush and compacted earthfill shall be placed as shown on the drawing or directed by the Engineer. The installation should be completed with a layer of compacted earthfill and transplanted willows with attached root mat.

FASCINES

This item shall consist of all work, including harvesting and transporting materials, necessary to construct and install fascines as shown on the drawings or described below for the purpose of restoring the streambank with a bioengineering installation. Fascines are made by packing live material cuttings into continuous thick round bundles and fastening them with bailing twine or wire. Fascines are typically made from willow cuttings.

Cut materials should be long, straight, and flexible. The minimum length of materials is 3 feet, but 6 or 7 feet is preferred. The completed fascine should be a minimum of one (1) foot longer than the longest whip (branch) in the bundle. Whip butt ends should be randomly alternated. Bundles should be tied every 10 to 15 inches with bailing twine. Every third tie should also be secured with 12 gauge galvanized wire. The compressed and tied bundle shall average eight (8) inches in diameter.

The completed fascine should be placed in a freshly prepared trench. The trench shall be ten (10) inches wide and six (6) inches deep. Fascines should be keep cool and moist until placed in the trench. Fascines shall be placed in the trench with ends overlapping to provide a uniform thickness along the length of the installation. Dead stout stakes 2 ½ feet long shall be driven through the bundle to secure the fascine in place. The stakes shall be placed every three (3) feet. The overlapping ends shall be staked between the last ties. The **dead stout stakes** shall be fabricated by sawing a 2"x4" lumber (Southern yellow pine or equivalent) on the diagonal to produce two dead stout stakes. The fascine and staking shall be inspected and approved by the Engineer prior to placement of fill over the installation.

Fascines shall be covered with soil and hand tamped to fill the voids in the bundle. The process of covering the fascine with soil should leave 10 to 20 percent of the top and/or front of the fascine exposed and visible. Additional dead stout stakes shall be placed below the fascine for added protection during high storm flows. The stakes shall be placed every 5 feet.

BRUSHMATTRESS

This item shall consist of all work, including harvesting and transporting materials, necessary to install a brushmattress as shown on the drawings or described below for the purpose of protecting the streambank with a bioengineering installation. A brushmattress shall consist of placing a thick mat of cut live branches of tree or shrub species on the face of the streambank. The mat shall be staked and wired to hold the branches in place, then the mat shall be partially covered with soil. Dead stout stakes as described in the section on Fascines, shall be used to anchor the brushmattress. Tie wire shall be single strand, galvanized 12-gauge wire, or larger. A fascine shall be installed at the base of the brushmattress to anchor the base of the branches in place. The fascine shall be placed in accordance with the above requirements for Fascines.

A brushmattress shall be constructed when the plant species are dormant. An 8- to 12-inch trench shall be dug just at or below the water line and flush with the plane of the slope. The brush shall be placed butt down in the trench with stems laid perpendicular to the trench and against the bank. The slope to be treated shall be covered from the top to the bottom of the slope with the brush layer. Enough brush shall be placed to ensure that the layer will be 4- to 6-inches thick when compressed. When species with good rooting ability are in short supply, other species can be substituted for up to 50 percent of the materials. A single row of fascines shall be placed in the dug trench to form the base of the brushmattress and anchor the butt ends of the brush.

Stout dead stakes shall be driven into the brushmattress every 2 to 4 feet on center, beginning a foot beyond each horizontal side of the mattress. The stakes shall be placed 1 foot inside the mattress at the top and bottom. The stakes shall be driven to within 6 or 8 inches of the soil surface before tying down the mattress. The brushmattress shall be tied down with wire in horizontal runs and then diagonal runs between each horizontal row of stakes. The wire shall be wrapped around the stakes in such a manner that if the wire between

two stakes breaks; the integrity of the remaining wiring will remain intact. After tying, the stakes shall be driven into the soil to compress the brushmattress and to place tension on the wire. The staking and wiring shall be inspected and approved by the Engineer prior to final driving of the stakes and the placement of fill over the installation.

After the brush is placed, staked, tied and compressed, soil shall be placed to cover the mattress. The soil shall be worked into voids in the mattress to aid in the rooting process. If the soil is dry, water should be used to help pack the soil in the brushmattress.

LIVE STAKES

This item shall consist of harvesting and planting live stakes cut from species that readily root such as willow species. The stakes shall be 1 to 3 inches in diameter and 18 to 36 inches in length. Live stakes must be harvested and installed while dormant.

The tops of the stakes shall be cut flat and the base sharpened. The stakes shall be driven into the ground to a minimum depth of 3 inches above the ground (or to refusal) with a wooden or rubber mallet. The live stakes shall be planted on 2 x 2 feet spacing with a minimum of three staggered rows when placed at the toe of the streambank. The stakes should be placed slightly above the water line. All live stakes placed above the toe area may be placed on 2 x 4 feet spacing. When stakes are planted in a near vertical bank, the stakes should be angled into the bank rather than planted straight into the bank.

TREE/SHRUB PLANTING (INCLUDING TRANSPLANTS)

Tree and shrub seedlings shall be planted on the shaped streambank and in the riparian zone. Water-tolerant species shall be planted on the streambank. Species suitable for the soil and site conditions shall be planted in the riparian zone. Species shall be as specified on the drawings unless otherwise approved by the Engineer. Seedlings or transplanted trees and shrubs shall be placed on 4 x 6 feet spacing on the streambank. All plant materials in the work area that will be disturbed by the construction operations shall be salvaged and transplanted as directed by the Engineer.

CONSTRUCTION SPECIFICATION

400. EARTHWORK

1. SCOPE

This work shall consist of all excavation and earthfill (or earth backfill) necessary to restore the bankfull channel dimensions, construct a bankfull bench, and/or reshape/restore the channel bank. This work can include the earthwork necessary to support the installation of bioengineering practices and structures.

2. EXCAVATION

This work shall consist of the excavation of the existing channel to restore the bankfull channel dimensions and to grade the channel bank to a positive slope. The work shall be completed as shown on the drawings, as described in this specification, and as staked by the Engineer. Excavation shall bottom on bedrock when it lies above the lines and grades shown on the drawings. Excavation into bedrock is not required or allowed. The Engineer may adjust the excavation limits to improve channel conditions during construction.

Channel excavation shall start on the upstream end of the project reach and proceed in a downstream direction. Suitable earthfill material from the required excavation shall be used in the installation of the planned bioengineering practices or structures. Excavated material suitable for use, as earthfill will be stockpiled adjacent to the work area. When the channel excavation does not provide an adequate amount of soil fill suitable for supporting plant growth, the Engineer shall mark, on site, an alternate borrow source by means of stakes, flags, or other suitable methods.

The Contractor shall remove and dispose of all debris encountered, including but not limited to: trash, stumps and concrete rubble. The Contractor shall dispose of all unsuitable or excess materials at sites of his own choosing away from the work site. The Contractor may dispose of unsuitable or excess materials on-site with the concurrence of the Engineer only if the Contractor obtains permission for on-site disposal from the landowner in writing.

Any accumulation of excess sediment in the channel shall be cleaned as needed during construction and at the end of construction. No separate payment will be made for the clean-up work. Known utility locations are shown on the drawings but may not be all-inclusive. The Contractor shall be responsible for verifying the location of all utilities prior to excavation. The Contractor shall be responsible for repairing any damage to existing structures or utilities.

The volume excavated within the specified pay limits will be measured and computed to the nearest cubic yard by the method of average cross sectional end area. The pay limits shall be defined as follows:

> The upper limit shall be the original ground surface as it existed prior to the start of construction operations. The lower and lateral limits shall be the true surface of the completed excavation as shown on the drawings or as directed by the Engineer.

Payment for Excavation will be made at the contract unit price for excavation. Such payment will constitute full compensation for all labor, materials, equipment and other items necessary and incidental to the performance of the work.

3. EARTHFILL

This work shall consist of the placement and compaction of the earthfill or earth backfill to complete the installation of the bioengineering practices or structures and shaping of the channel slope as required by the plans and specifications. Fill materials shall contain no frozen soil, sod, brush, roots, rocks over six (6) inches in diameter, or other objectionable materials. The placing and spreading of fill shall be started at the lowest point of the foundation and shall be brought up in approximately horizontal layers.

Sloughed areas in the slope shall be corrected by shaping the slope to provide a uniform subgrade for the bioengineering installation. The source of earthfill shall be the required excavation and shaping of the channel slope unless otherwise approved by the Engineer.

The moisture content of the fill material shall be maintained as high as attainable within the limits required to:

- Prevent bulking or dilatance of the material under the action of the hauling or compacting equipment;
- Prevent the adherence of the fill material to the treads and tracks of the equipment;
- Ensure the crushing and blending of the soil clods and aggregations into a reasonable homogeneous mass. Fill shall not be place that is so dry that a sample will not remain formed after squeezing in the hand.

The maximum thickness of a layer before compaction for hand placed and compacted material shall be four (4) inches and for machine placed and

compacted material shall be nine (9) inches. Each layer of earthfill shall be compacted to a density equivalent to that of the surrounding in-place materials. Compaction shall be accomplished by means of manually directed power tampers, walk-behind or self-propelled rollers, or by tamping with the bucket of a hydraulic excavator with a minimum operating weight of 42,000 lbs. and a minimum bucket force of 25,000 lbs. unless otherwise approved by the Engineer.

No separate payment will be made for earthfill or earth backfill. Compensation for this item will be included in the payment for Pollution Control and Excavation.

CONSTRUCTION SPECIFICATION

404. EROSION CONTROL BLANKET

1. SCOPE

The work shall consist of the installation of an erosion control blanket on the channel side slopes and other areas disturbed by construction operations. The work shall consist of furnishing, transporting and installing the erosion control blanket in accordance with the plans and specifications.

2. MATERIALS

The erosion control blanket/channel lining shall be a machine-produced mat with a 100% coconut fiber matrix.

The blanket shall be of consistent thickness with the coconut fiber evenly distributed over the entire area of the mat. The blanket shall be covered on the top and bottom with heavyweight polypropylene netting having ultraviolet additives to delay breakdown and 3/8" to 5/8" mesh size. The blanket shall be sewn together on 1-1/2 to 2 inch centers with UV stable polypropylene thread.

The erosion control blanket shall be North American Green C125 Long-Term Erosion Control Blanket or equivalent.

3. SUBGRADE PREPARATION

The subgrade surfaces on which the blanket is to be placed shall be cut or filled and graded to the lines and grades shown on the drawings. Lime, fertilizer and seed shall be applied in accordance with Construction Specification-Streamside Seeding prior to installation of the blanket. The blanket shall not be placed until the prepared subgrade has been inspected and approved by the Engineer.

4. PLACEMENT

The top edge of the blanket shall be anchored in a 6-inch deep by 6-inch wide trench approximately 2 feet back from the top of the slope. The trench shall be backfilled and compacted after the blanket is fastened in the trench with staples or biodegradable fasteners (i.e., Eco-Stake, Bio-Stake). The blankets shall be placed with a minimum 4-inch overlap from one section of blanket to the next section. The blanket shall be overlapped with the upstream section overlapping the downstream section. All overlaps shall be secured with staples or stakes spaced 12 inches apart. The terminal end of the blanket must be anchored in a 6-inch deep by 6-inch wide trench. The trench shall be backfilled as noted above.

The blanket shall be fastened with staples or biodegradable fasteners such as Eco-Stakes or Bio-Stakes. The fasteners shall be installed in a staggered pattern on 3-ft. spacing along the row and 2-ft. spacing between rows. If specified in Section 8, live stakes may also be used in conjunction with the biodegradable fasteners to secure the blanket.

The edge of the blanket at or below normal water level shall be anchored in a 6-inch deep by 6-inch wide trench. The blanket shall be fastened in the trench with staples or stakes. The anchor trench shall be backfilled with stone or soil and compacted.

5. LIVE PLANTING THROUGH THE EROSION CONTROL BLANKET

An "X" shall be cut in the blanket using a utility knife or other sharp implement. The size of the opening should slightly exceed the limits of excavation for the size of the plant's root ball. If the plant's root ball is less than 3 inches in diameter, a single 6-inch cut in the blanket will provide enough room to insert the plant.

After placing the plants though the opening in the blanket and replacing and compacting the soil around the plant, the flaps of the blanket shall be folded back in place. Staples or stakes shall be installed to secure the blanket back in place. The staples or stakes shall be placed as close to the stem of the plant as possible without damaging the plant. Install staples or stakes on a 4-inch spacing around plant until the cut in the blanket is secured. If soil is left exposed due to mounding of earthfill around the installed root ball, extra pieces of the erosion control blanket may be required to cover the area.

6. MAINTENANCE AND RESTORATION

The Contractor shall maintain the areas treated with the erosion control blanket until all work under the contract has been completed and accepted. Maintenance shall consist of the repair of areas damaged by water erosion, wind, fire, or other causes. Such areas shall be repaired to reestablish the intended condition and to the design lines and grades required by the contract. The areas shall be treated with lime, fertilizer and seed in accordance with Construction Specification Streamside Seeding prior to the new or re-application of the erosion control blanket.

7. PAYMENT

For items of work for which specific unit prices are established in the contract, the quantity of erosion control blanket for each type placed within the specified limits will be determined to the nearest specified unit by computing the area of the actual roll size, or partial roll size installed. The computed area will include the amount required for overlap, seams, and anchorage as specified. Payment for the erosion control blanket and fasteners will be made at the contract unit price for Erosion Control Blanket. Such payment shall constitute full compensation for all labor,

equipment, materials, tools and other items necessary and incidental to the completion of the work.

CONSTRUCTION SPECIFICATION

408. MOBILIZATION AND DEMOBILIZATION

I. SCOPE

The work shall consist of the mobilization and demobilization of the Contractor's forces and equipment necessary for performing the work required under the contract.

This work shall not include mobilization and demobilization for specific items of work for which payment is provided elsewhere in the contract.

Mobilization will not be considered as work in fulfilling the contract requirement for commencement of work.

2. EQUIPMENT AND MATERIALS

Mobilization shall include all activities and costs for transportation of personnel, equipment, and operating supplies to the site; establishment of offices, buildings, and other necessary facilities for the Contractor's operations at the site; premiums paid for performance and payment bonds, including coinsurance and reinsurance agreements as applicable; and other items necessary for mobilization of the site.

Demobilization shall include all activities and costs for transportation of personnel, equipment, and supplies not included in the contract from the site; including the disassembly, removal and site clean up, of offices, buildings, and other facilities assembled on the site for this contract.

This work includes mobilization and demobilization required by the contract at the time of award. If additional mobilization and demobilization activities and costs are required during the performance of the contract as a result of changed, deleted, or added items of work for which the Contractor is entitled to an adjustment in contract price, compensation for such costs will be included in the price adjustment for the item or items of work changed or added.

3. PAYMENT

Payment for Mobilization will be made at the contract lump sum price. Payment will be made as the work proceeds, after presentation of invoices by the Contractor showing specific mobilization and demobilization costs and evidence of the charges of suppliers, subcontractors, and others. If the total of such payments is less than the lump sum contract price, the unpaid balance will be included in the final contract payment. Payment of the lump sum contract price for mobilization and demobilization will constitute full compensation for completion of the work.

Payment will not be made under this item for the purchase costs of materials having a residual value, the purchase costs of materials to be incorporated in the project, or the purchase costs of operating supplies.

CONSTRUCTION SPECIFICATION

405. PLANT MATERIALS

1. GENERAL

The work shall consist of furnishing and installing all herbaceous plantings, rooted cuttings, rooted seedlings, potted shrubs and trees of the kinds and sizes specified, at the locations shown on the drawings and as specified.

2. MATERIALS

Prior to bidding, the Contractor shall verify all sources of supply to insure that the size, species, variety and quality of plants specified can be supplied. At least one week prior to delivery, the Contractor shall notify the Contracting Officer of the source of the herbaceous plantings, rooted seedlings, potted shrubs and trees.

All plants shall be packed in a manner to insure adequate protection against climatic, seasonal or other injuries during transit. Special care shall be taken for prompt delivery and careful handling during delivery. Each shipment of plants to the site shall have a delivery ticket indicating source of supply, exact quantities, sizes and species delivered. A copy of all delivery tickets shall be provided to the Inspector.

Each plant type shall be properly identified by name and size on legible weatherproof labels securely attached to plants or labeled on (or in) the plant container. All plants shall be nursery grown, unless otherwise specified. All plants shall have normal, well-developed branches and vigorous root systems. They shall be sound, healthy, vigorous, free from defects, disfiguring knots, abrasions of the bark, sun scaled injuries, plant diseases, insect eggs, borers, and all other forms of infections. Final acceptance of all plant materials shall be given only after the materials are planted and after all requirements are met. Unacceptable plant materials shall be immediately removed from the job site at the contractor's expense.

3. PERMANENT HERBACEOUS PLANTINGS

The permanent herbaceous plantings shall be of the following species:

- Daylily *(Hemerocallis fulva)*

The herbaceous plantings shall have at least one year of growth. They shall be planted 1 ½ feet apart. Rows shall be planted in a staggered pattern on alternate rows. Adequate backfill shall be placed and hand-compacted around each planting.

4. ROOTED SEEDLINGS AND ROOTED CUTTINGS

The rooted seedlings shall be of the following species:

- Summersweet Clethra (*Clethra alnifolia*)
- Tag Alder *(Alnus serrulata)*

The rooted cuttings shall be of the following species:

- Virginia Willow *(Itea virginica)*
- Silky Dogwood *(Cornus ammomum)*
- Stiff Dogwood *(Cornus foemina)*

The rooted seedlings and rooted cuttings shall have at least 2 years of growth. The rooted seedlings and cuttings shall be planted 6 feet apart. The first row of rooted seedlings shall be planted at least 6 inches above the water line.

The rooted seedlings and rooted cuttings shall be planted in a staggered pattern in alternate rows. Adequate backfill shall be placed and hand-compacted around each planted cutting.

5. POTTED TREES OR SHRUBS

Preparation – Circular planting pits that are 1-1/3 times the diameter of the pot shall be dug with a level bottom to a depth that is 6 inches deeper than the necessary planting depth. The sides and bottom of the pit shall be well scarified. Before setting the plants, each pit shall be filled with 6 inches of backfill material, lightly tamped and watered. The mixture used for backfilling shall consist of topsoil that may be mixed with peat moss or potting soil. When the container is removed, the plant shall be placed in the center of the individual pit. Additional backfill material shall be added in 6-inch layers, lightly tamped, until the backfill is ¾ complete. When the backfill is ¾ complete, the plant pit shall be filled with water. After the pit has drained, it shall be filled with backfill material to 1 to 2 inches below average ground.

Riparian Zone - Potted trees/shrubs shall be planted at the top of the streambank in the riparian zone as shown on the plans. The plant species shall be as specified below unless otherwise approved by the Contracting Officer's Representative:

- Sycamore *(Platanus occidentalis)*
- Green Ash *(Fraxinus pennsylvanica)*
- River Birch *(Betula nigra)*

The potted trees/shrubs shall be approximately 24 inches in height and shall have at least 2 years growth. They shall be placed on a 10-foot spacing. The potted trees/shrubs shall be planted in a staggered pattern in alternate rows.

6. MEASUREMENT AND PAYMENT

Payment for Vegetation, herbaceous plants will be made at the contract unit price for each herbaceous plant that has been planted in accordance with the plans and specifications. The Contractor shall provide a copy of the invoice to the Inspector as documentation of the quantity of herbaceous plants. Each plant may be counted after successful placement when necessary to verify invoice quantities. Such payment will constitute full compensation for all labor, materials, equipment and other items necessary and incidental to the performance of the work.

Payment for Vegetation, rooted seedlings/rooted cuttings will be made at the contract unit price for each rooted woody seedling or rooted woody cutting that has been planted in accordance with the plans and specifications. The Contractor shall provide a copy of the invoice to the Inspector as documentation of the quantity of rooted seedlings/cuttings. Each plant may be counted after successful placement when necessary to verify invoice quantities. Such payment will constitute full compensation for all labor, materials, equipment and other items necessary and incidental to the performance of the work.

Payment for Vegetation, trees will be made at the contract unit price for each potted tree/shrub that has been installed in accordance with the plans and specifications. The Contractor shall provide a copy of the invoice to the Inspector as documentation of the quantity of herbaceous plants. Each plant may be counted after successful placement when necessary to verify invoice quantities. Such payment will constitute full compensation for all labor, materials, equipment and other items necessary and incidental to the performance of the work.

CONSTRUCTION SPECIFICATION

POLLUTION CONTROL

SCOPE

The work shall consist of installing measures or performing work to control erosion and minimize the production of sediment and other pollutants to water and air during construction operations.

EROSION AND SEDIMENT CONTROL MEASURES AND WORKS

The measures and works shall include, but are not limited to, the following:

Staging of Earthwork Activities - The excavation and moving of soil materials shall be scheduled so that the smallest possible areas will be unprotected from erosion for the shortest time feasible.

Seeding - Seeding to protect disturbed areas in accordance with the requirements of Construction Specification - Streamside Seeding.

Mulching - Mulching to provide temporary protection of soil surfaces from erosion in accordance with the requirements of Construction Specification - Streamside Seeding.

Diversions - Diversions to divert water away from work areas and to collect runoff from work areas for treatment and safe disposition. These works are temporary and shall be removed and the area restored to its original state when they are no longer needed or permanent measures are installed.

Stream Crossings - Culverts or bridges where equipment must cross streams. These works are temporary and shall be removed and the area restored to its original state when they are no longer needed or permanent measures are installed.

Sediment Filters - Straw bale filters or geotextile sediment fences to trap sediment from areas of limited runoff. Sediment filters shall be properly anchored to prevent erosion under them. These works are temporary and shall be removed and the area restored to its original state when they are no longer needed or permanent measures are installed.

Waterways - Waterways for the safe disposal of runoff from fields, diversions and other structures or measures. These

works are temporary and shall be removed and the area restored to its original state when they are no longer needed or permanent measures are installed.

Other - All work necessary to control soil erosion and minimize the introduction of sediment and other pollutants to water and air during construction. All work shall comply with the requirements of the **North Carolina Sedimentation Pollution Control Act and the National Pollutant Discharge Elimination Act.** Control of pollution shall apply to the construction site along the stream. Pollution control for any disposal site is the responsibility of the contractor unless the area is within the work limits of the stream protection project.

CHEMICAL POLLUTION

The Contractor shall provide watertight tanks or barrels or construct a sump sealed with plastic sheets to be used to dispose of chemical pollutants, such as drained lubricating or transmission oils, greases, soaps, concrete mixer wash water, asphalt, etc., produced as a by-product of the construction work. At the completion of the construction work, sumps shall be voided without causing pollution.

AIR POLLUTION

The burning of brush or slash or disposal of other materials shall adhere to local and state regulations. Fire prevention measures shall be taken to prevent the start or the spreading of wild fires that result from project work.

All public access or haul roads used by the contractor during construction of the project shall be sprinkled or otherwise treated to fully suppress dust. All dust control methods shall insure safe operations at all times. If chemical dust suppressants are used, the material shall be a commercially available product specifically designed for dust suppression and the application shall follow manufacturer's requirements and recommendations. A copy of the product data sheet and manufacturer's recommended application procedures shall be provided to the Engineer five working days before use.

MAINTENANCE, REMOVAL, AND RESTORATION

All pollution control measures and works shall be adequately maintained in a functional condition as long as needed during the construction operation. All temporary measures shall be removed and the site restored to as nearly original conditions as practical.

CONSTRUCTION SPECIFICATION

402. REMOVAL OF WATER

1. SCOPE

The work shall consist of the removal and/or control of surface, ground, and steam flow waters as necessary to perform the construction required by the contract in accordance with the specifications. It shall include: (1) constructing, installing, building, and maintaining all necessary temporary water containment facilities, channels, and diversions, (2) furnishing, installing, and operating all necessary pumps, piping, and other facilities and equipment, and (3) removing all such temporary works and equipment after their intended function is no longer required.

2. DIVERTING SURFACE WATER

The Contractor shall install, maintain and operate all cofferdams, channels, flumes, sumps, and all other temporary diversion and protective works needed to divert stream flow and other surface water through or around the construction site. Control of surface water shall be continuous during the period that damage to construction work could occur. Unless otherwise specified and/or approved, the diversion outlet shall be into the same drainage way that the water would have reached before being diverted.

The Contractor shall furnish the Contracting Officer, in writing, a proposed plan for diverting water before beginning any construction activities for which a diversion is required. Acceptance of this plan, or the waiving of the plan requirement, will not relieve the Contractor of the responsibilities related to this activity during the process of completing the work as specified.

3. DEWATERING THE CONSTRUCTION SITE

Foundations, cutoff trenches, and all other parts of the construction site shall be dewatered and kept free of standing water and muddy conditions as necessary for the proper execution of the work. The Contractor shall furnish, install, operate, and maintain all drains, sumps, pumps, and all other equipment required to properly dewater the site as specified. Dewatering systems that cause a loss of soil fines from the foundation areas will not be permitted.

The Contractor shall furnish the Contracting Officer, in writing, a proposed plan for dewatering before commencing with any construction activity for which dewatering may be required. Acceptance of this plan, or the waiving of the plan requirement, will not relieve the Contractor of responsibilities for completing the specified work.

4. EROSION AND POLLUTION CONTROL

Removal of water from the construction site, including the borrow areas, shall be accomplished in a manner that erosion and the transporting of sediment and other pollutants are minimized. Dewatering activities shall be accomplished in a manner that the water table water quality is not altered. Pollution control activities shall not conflict with the requirements of Construction Specification - Pollution Control.

5. REMOVAL OF TEMPORARY WORKS

When temporary works are no longer needed, the Contractor shall remove and return the area to a similar condition that existed prior to construction. Areas where temporary works were located shall be graded for sightly appearance with no obstruction to natural surface water flows or the proper functioning and access to the works of improvement installed. The Contractor shall exercise extreme care during the removal stages to minimize the loss of soil sediments and debris that was trapped during construction.

6. MEASUREMENT AND PAYMENT

This item shall consist of the removal and/or control of surface, ground, and stream flow waters as needed to perform the required construction in accordance with the drawings and specifications. Payment for Removal of Water will be made at the contract lump sum price. Payment will be made as the work proceeds and invoices presented by the Contractor that reflect actual costs will support payment. If the total of all progress payments is less than the lump sum contract price for this item, the balance remaining for this item will be included in the final contract payment. Payment will constitute full compensation for all labor, equipment, tools and all other items necessary and incidental to the completion of the work.

Compensation for any item of work described in the contract, but not listed in the bid schedule, will be included in the payment for the contract line item to which it is made subsidiary. Pollution control performed in conjunction with this item of work is subsidiary to the Pollution Control item of work.

CONSTRUCTION SPECIFICATION
ROCK STRUCTURES

The work shall consist of the construction of natural rock or rock riprap structures including rock vanes, J-hook vanes, rock cross vanes, cross vane rock weirs, and/or step-pool structures. The work shall consist of furnishing, transporting and installing materials to construct the rock structures in accordance with the plans and specifications.

Materials

Individual rocks shall be dense, sound and free from cracks, seams, and other defects. The rocks shall have a specific gravity of not less than 2.5. The size and grading of the rock shall be as shown on the drawings. The dimensions of the rock shall be 4 ft. long x 3 ft. wide x 2 ft. high. The dimensions may vary within +/- 1 foot. Flat rocks are preferred since they are more adapted for the intended use. The weight range of each rock should be between 1 and 3 tons. The source of rock shall be identified and approved by the Engineer prior to delivery to the site. It is anticipated that the rock will be a special order to obtain the specified sizes if the rock is to be obtained from a quarry.

Subgrade Preparation

The subgrade surfaces on which the rock is to be placed shall be cut or filled and graded to the lines and grades shown on the drawings. When fill is required, it shall consist of approved materials that have been placed according to the Construction Specification for Earthfill. The rock shall not be placed until the prepared subgrade has been inspected and approved by the Engineer.

Placement

The rock shall be placed by equipment on the surfaces and to the depths specified. The footer rock shall be placed first. If more than one footer rock layer is to be placed, placement shall begin with the bottom layer and proceed in sequence until all footer rock layers and the surface rock layer have been placed. A hydraulic excavator equipped with a hydraulic thumb shall accomplish placement of the rock in the structure unless otherwise approved by the Engineer.

The rock shall be placed in a manner to prevent damage to structures. Hand placing will be required to the extent necessary to prevent damage to any structure.

All rock structures are designed to be installed on a 20 degree angle from the channel bank toward the center of the stream. The grade, top and bottom, of the structure gradually tapers down from the channel bank toward the center of the stream. For the structure to work properly, the rock must be placed as shown on the drawings unless directed otherwise by the Engineer.

CONSTRUCTION SPECIFICATION
STREAMSIDE SEEDING

The work shall consist of preparing the area, furnishing and placing seed, sprigs, mulch, fertilizer, inoculate, soil amendments and anchoring mulch in the designated areas as specified; streambanks, access areas and other areas disturbed by construction activities.

Seedbed Preparation

On sites where equipment can be operated safely the seedbed shall be adequately loosened and smoothed. Disking or cultipacking or both may be necessary. On sites where equipment cannot operate safely, the seedbed shall be prepared by hand scarifying to provide a roughened surface so that seed will stay in place. If seeding is done immediately following construction, seedbed preparation may not be required except on compacted, polished or freshly cut areas.

Fertilizing

Evenly distribute lime and fertilizer over the area to be seeded. Uniformly mix lime and fertilizer into the top 3 inches of the soil. Where surface materials are predominately gravel and/or cobble, no incorporation is required. Apply lime and fertilizer according to soil test results or at the following rates.

	Per 1000 sq. ft.	Per Acre
Lime	50-100 lbs.	1-2 tons
10-10-10 Fertilizer	9-12 lbs.	400-500 lbs.

Seeding

Temporary Seeding - Use where needed for erosion and pollution 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.

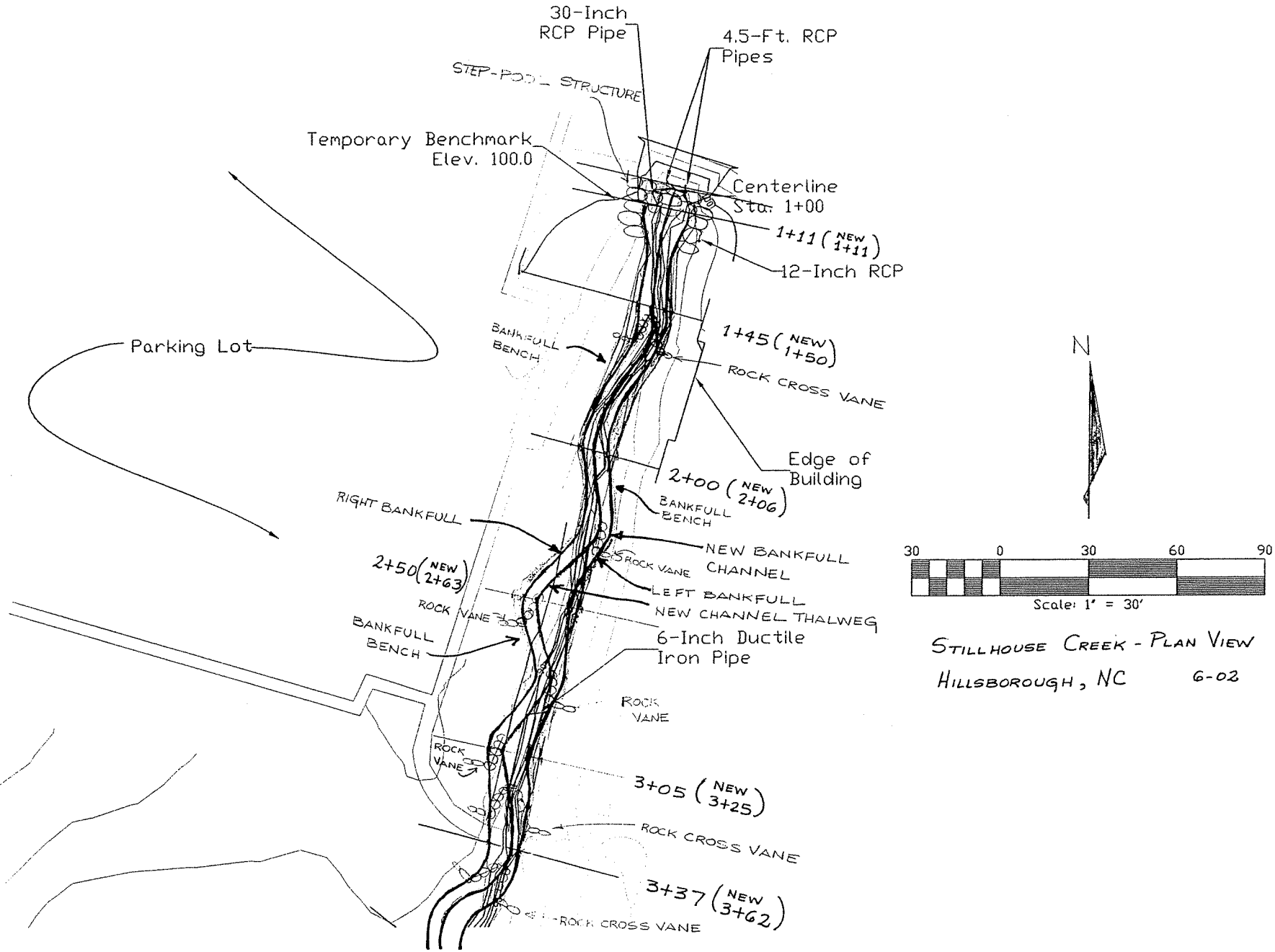
Fall, Winter, Spring Seeding	Per 1000 sq. ft.	Per Acre
Oats	2 lbs.	3 bu.
Rye	3 lbs.	2-3 bu.
Summer Seeding		
Sudangrass	1 lb.	35-45 lbs.
Browntop Millet	1 lb.	30-40 lbs.

Permanent Seeding – Use in combination with woody plantings on the upslope side of the riparian planting. Spring planting time is ideal for native perennial warm season grasses. These grasses should be used when enhancing wildlife habitat is a goal of the riparian planting. Spring planted seed should be treated with a cold wet chill process to maximize germination. Fall plantings should be planted with a lightly sowed cool season annual to hold the soil and the wet chill process is not required. Fertilizer may be omitted when establishing native grasses.

Fall, Spring Seeding	Per 1000 sq. ft.	Per Acre
Tall Fescue	1 lb.	50 lbs.
-Native warm season grasses-		
Big, Little or Broomsedge Bluestem	.2 lbs. PLS (pure live seed)	5 lbs. PLS
Eastern Gamma Grass or Switchgrass	½ lb. PLS	10 lbs. PLS

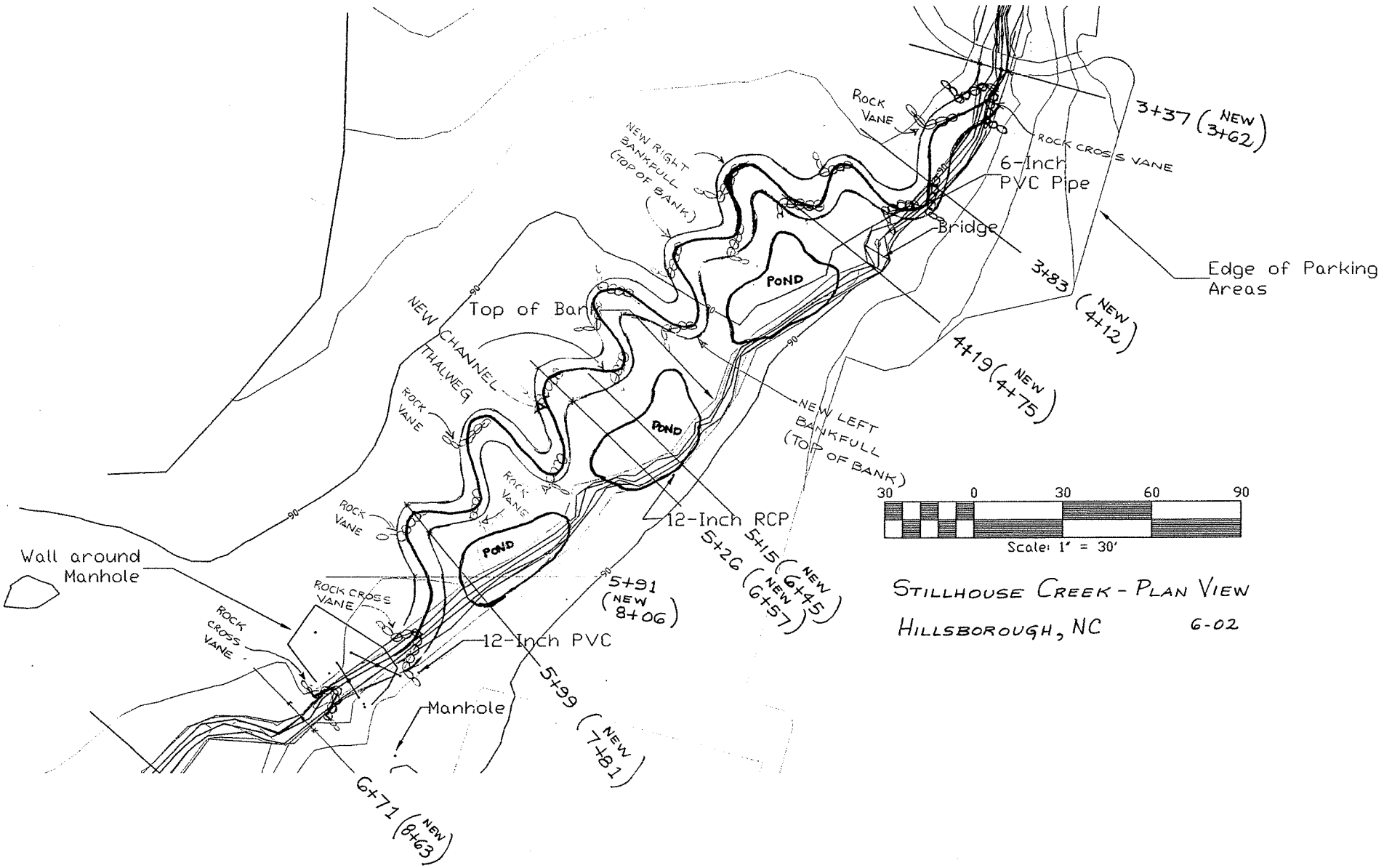
Mulching

Mulching should be performed within 48 hours of seeding. Grain straw mulch should be applied on seeded areas at a rate of 3 bales per 1000 square feet or 1.5 tons per acre. Apply mulch uniformly. Anchor mulch with a mulch crimper, asphalt tackifier or appropriate mulch netting.



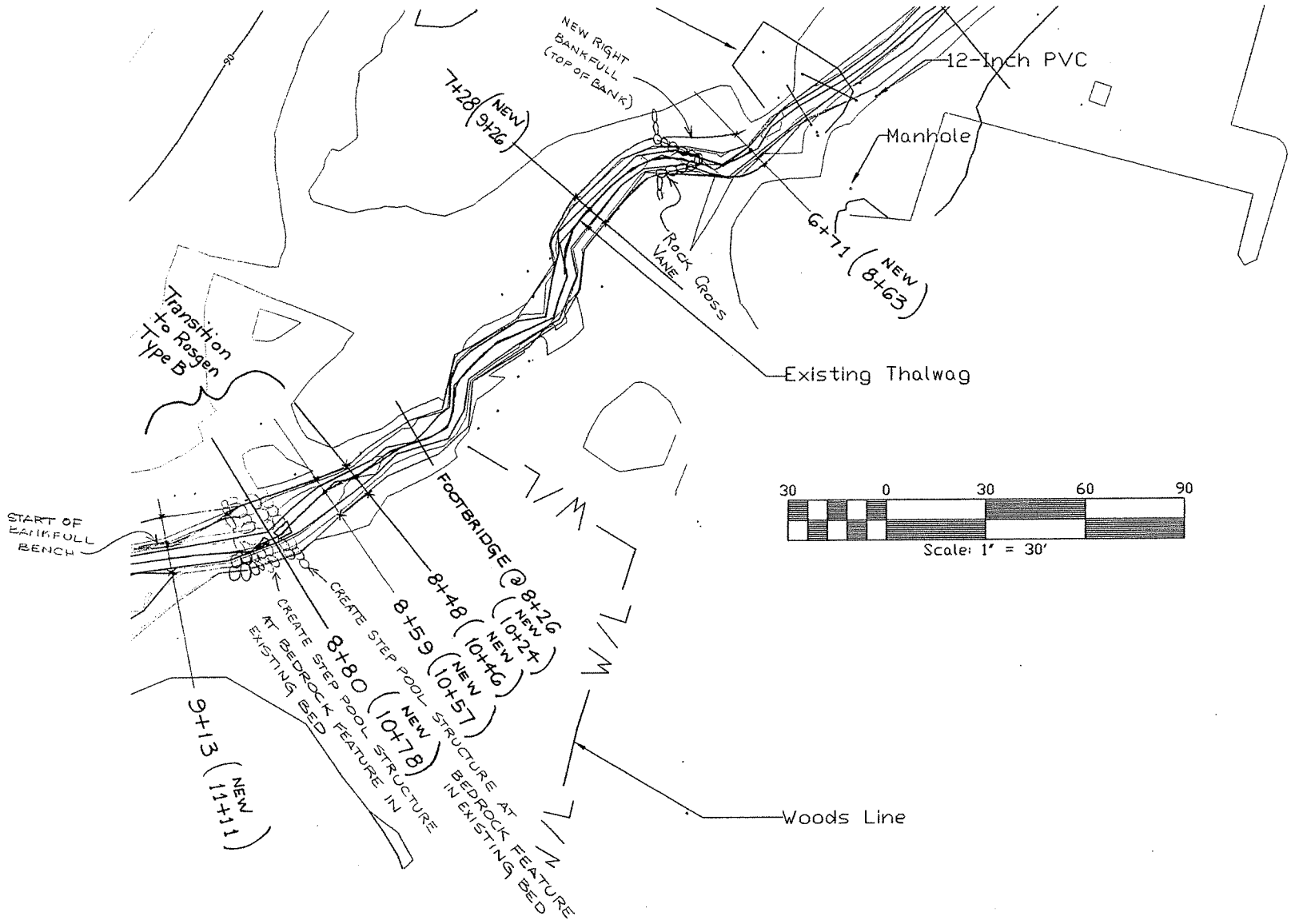
STILLHOUSE CREEK - PLAN VIEW

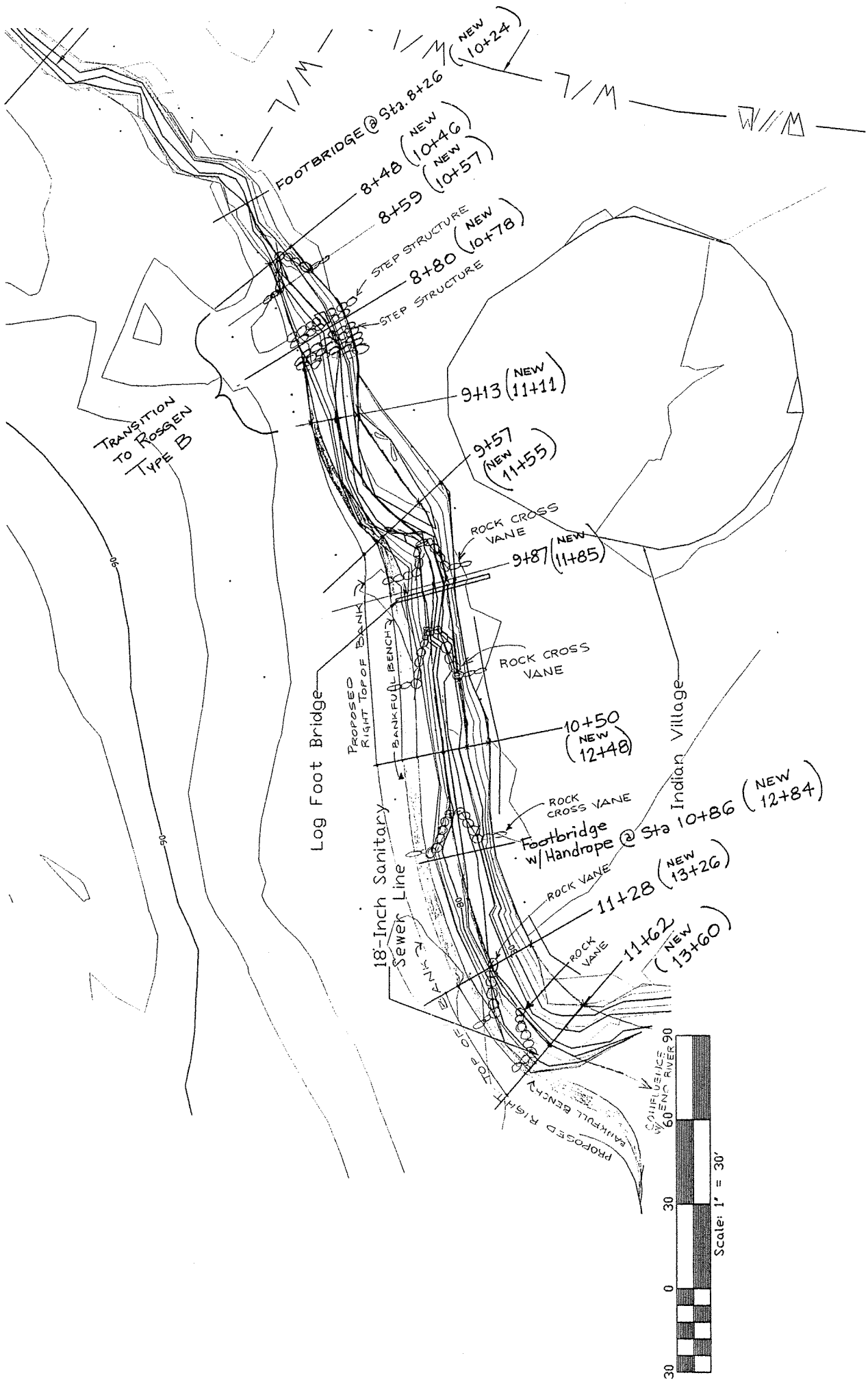
HILLSBOROUGH, NC 6-02

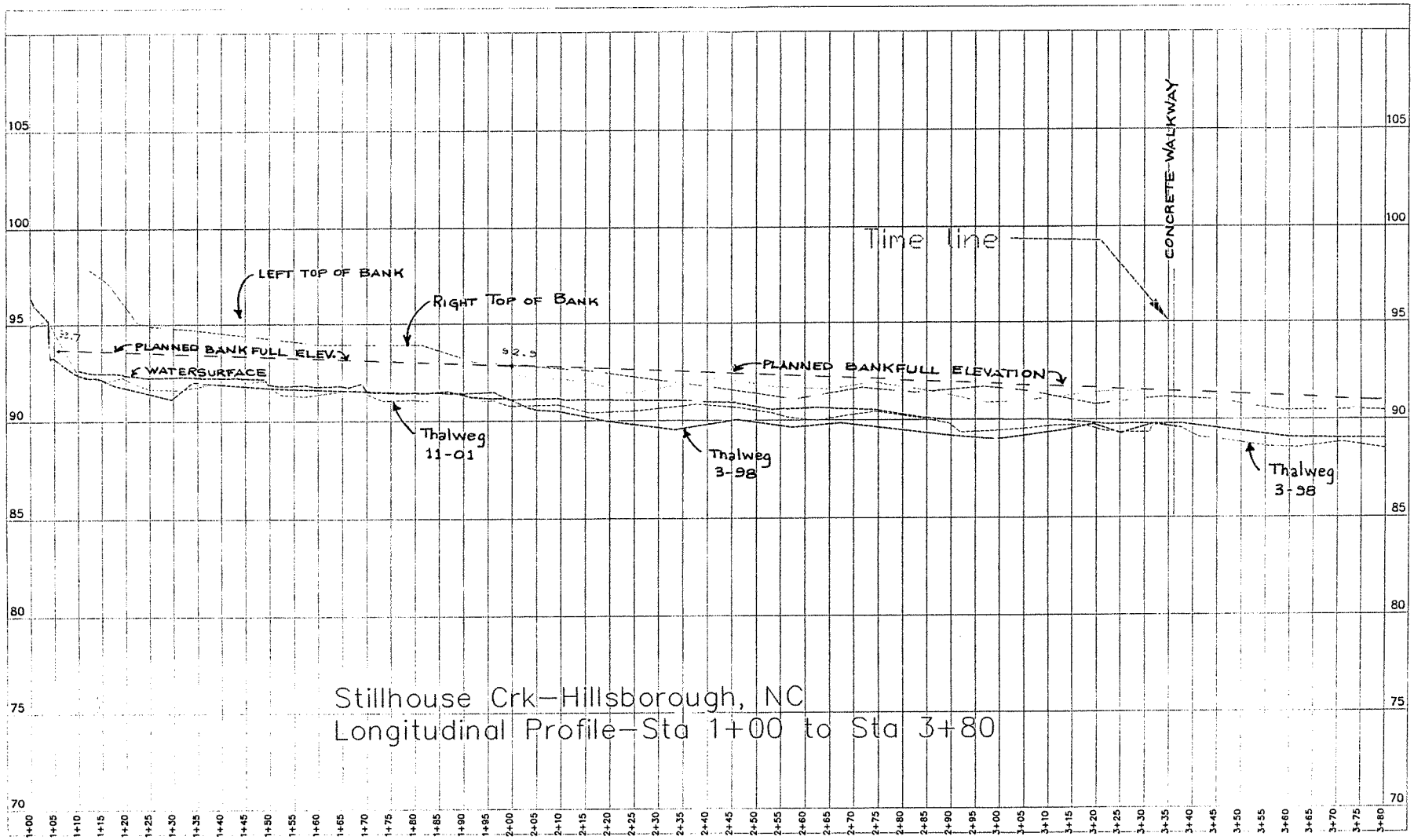


Stillhouse Creek - Plan View

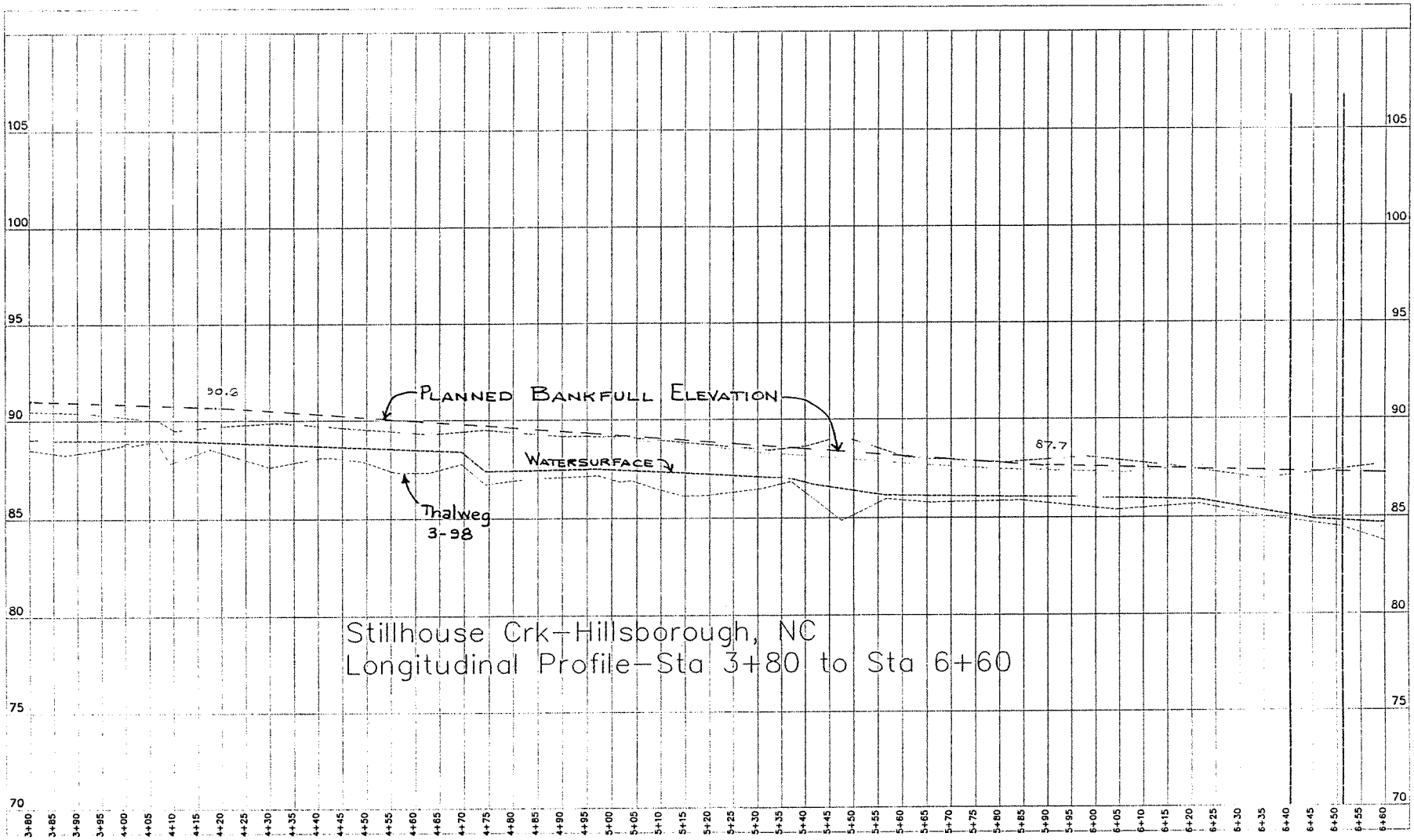
Hillsborough, NC 6-02


NEW RIGHT BANKFULL (TOP OF BANK)
12-Inch PVC
Manhole
7+28 (NEW 9+26)
6+71 (NEW 8+63)
Rock Cross Vane
Existing Thalwag
Transition to Rosgen Type B
START OF BANKFULL BENCH
FOOTBRIDGE @ 8+26 (NEW 10+24)
8+48 (NEW 10+46)
8+59 (NEW 10+57)
8+80 (NEW 10+78)
9+13 (NEW 11+11)
CREATE STEP POOL STRUCTURE AT BEDROCK FEATURE IN EXISTING BED
CREATE STEP POOL STRUCTURE AT BEDROCK FEATURE IN EXISTING BED
Woods Line
30 0 30 60 90
Scale: 1" = 30'

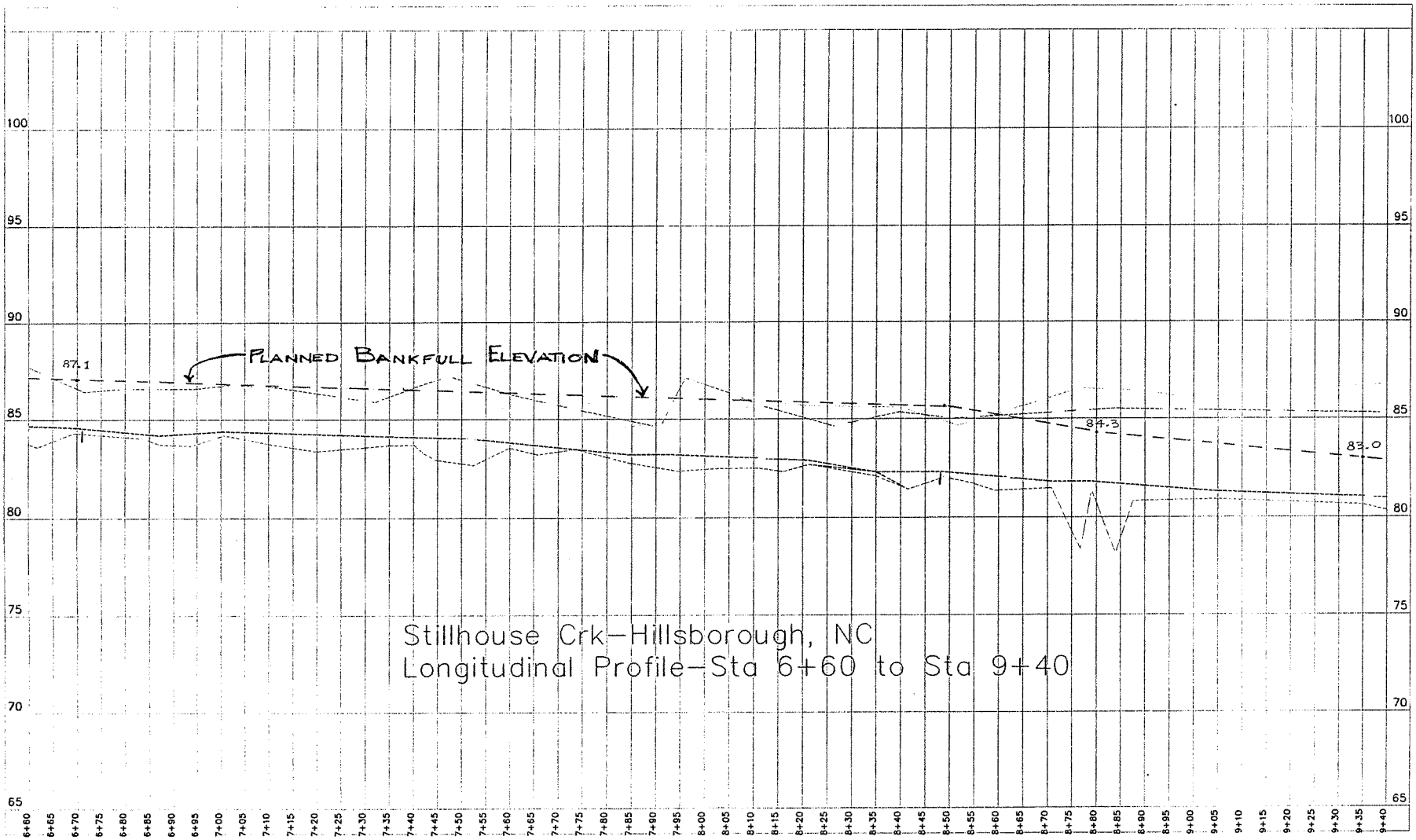

FOOTBRIDGE @ Sta. 8+26
8+48 (NEW 10+46)
8+59 (NEW 10+57)
STEP STRUCTURE
8+80 (NEW 10+78)
STEP STRUCTURE
(NEW 10+24)
9+13 (NEW 11+11)
9+57 (NEW 11+55)
ROCK CROSS VANE
9+87 (NEW 11+85)
ROCK CROSS VANE
10+50 (NEW 12+48)
ROCK CROSS VANE
Footbridge w/Handrope @ Sta 10+86 (NEW 12+84)
ROCK VANE
11+28 (NEW 13+26)
ROCK VANE
11+62 (NEW 13+60)
TRANSITION TO ROSGEN TYPE B
Log Foot Bridge
PROPOSED RIGHT TOP OF BANK
BANKFULL BENCH
18-Inch Sanitary Sewer Line
Indian Village
PROPOSED RIGHT TOP OF BANK
BANKFULL BENCH
CONFLUENCE WITH ENO RIVER
90
60
30
0
30
Scale: 1" = 30'



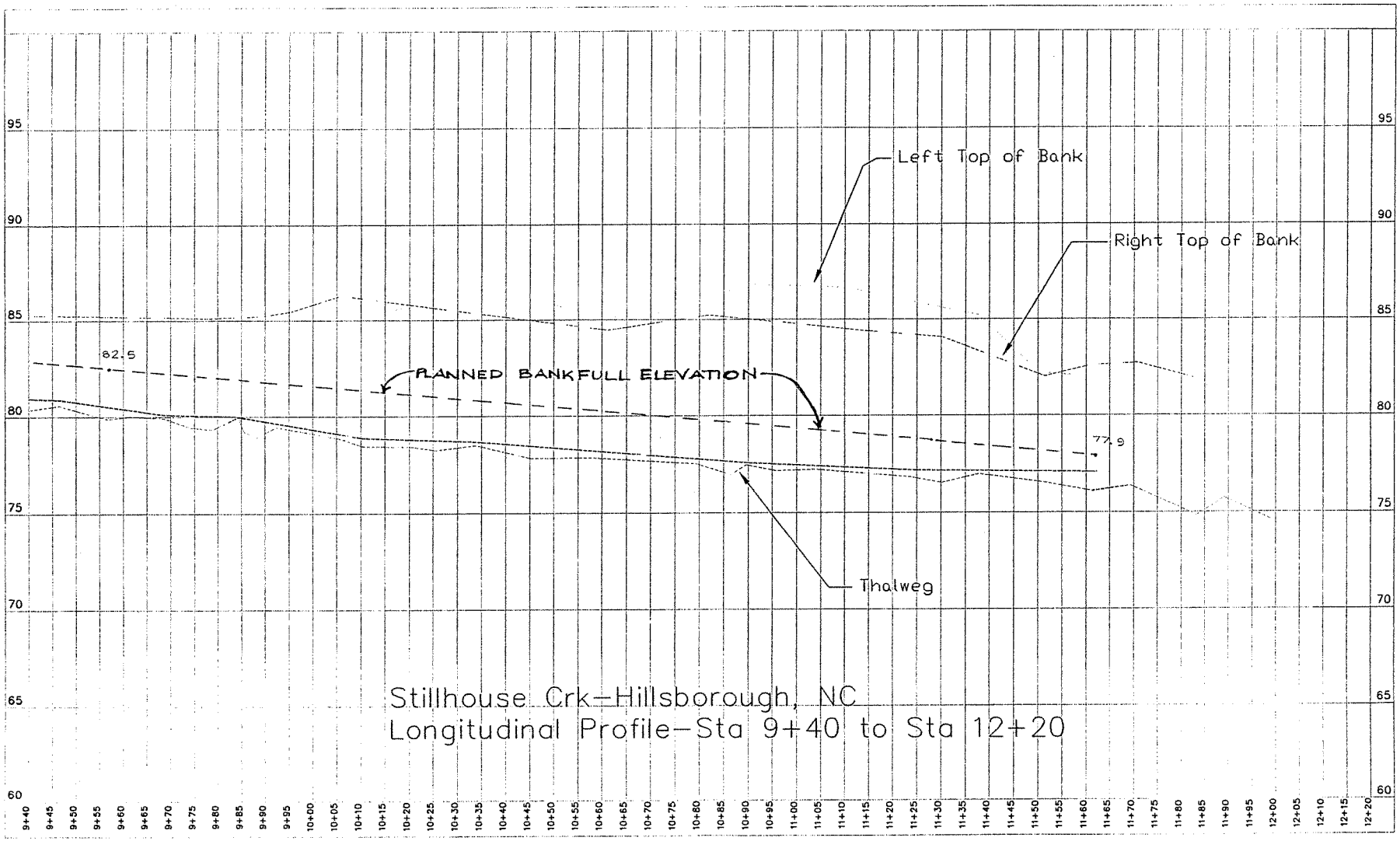
Stillhouse Crk—Hillsborough, NC
Longitudinal Profile—Sta 1+00 to Sta 3+80

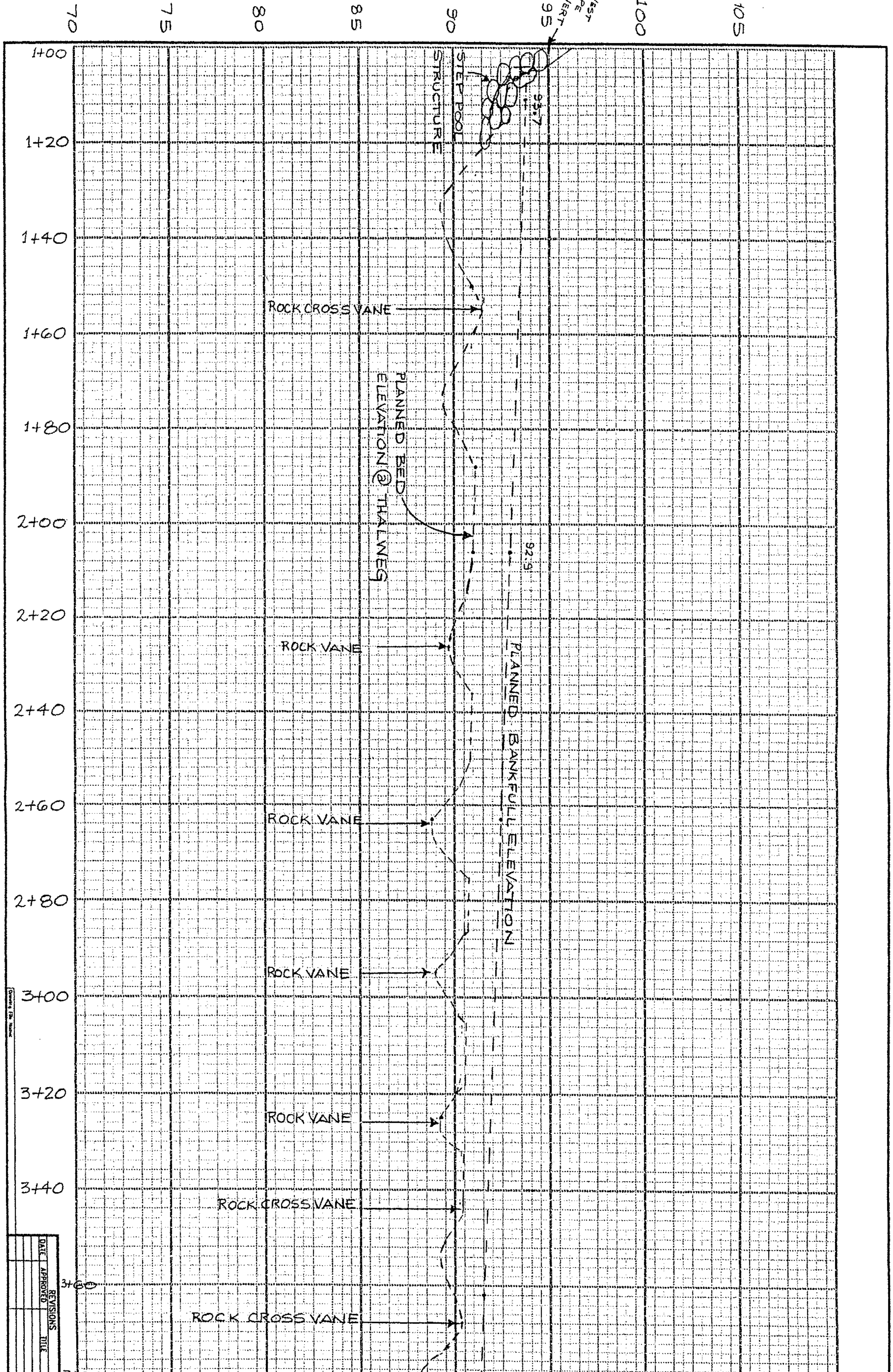


Stillhouse Crk–Hillsborough, NC
Longitudinal Profile–Sta 3+80 to Sta 6+60



Stillhouse Crk–Hillsborough, NC
Longitudinal Profile–Sta 6+60 to Sta 9+40

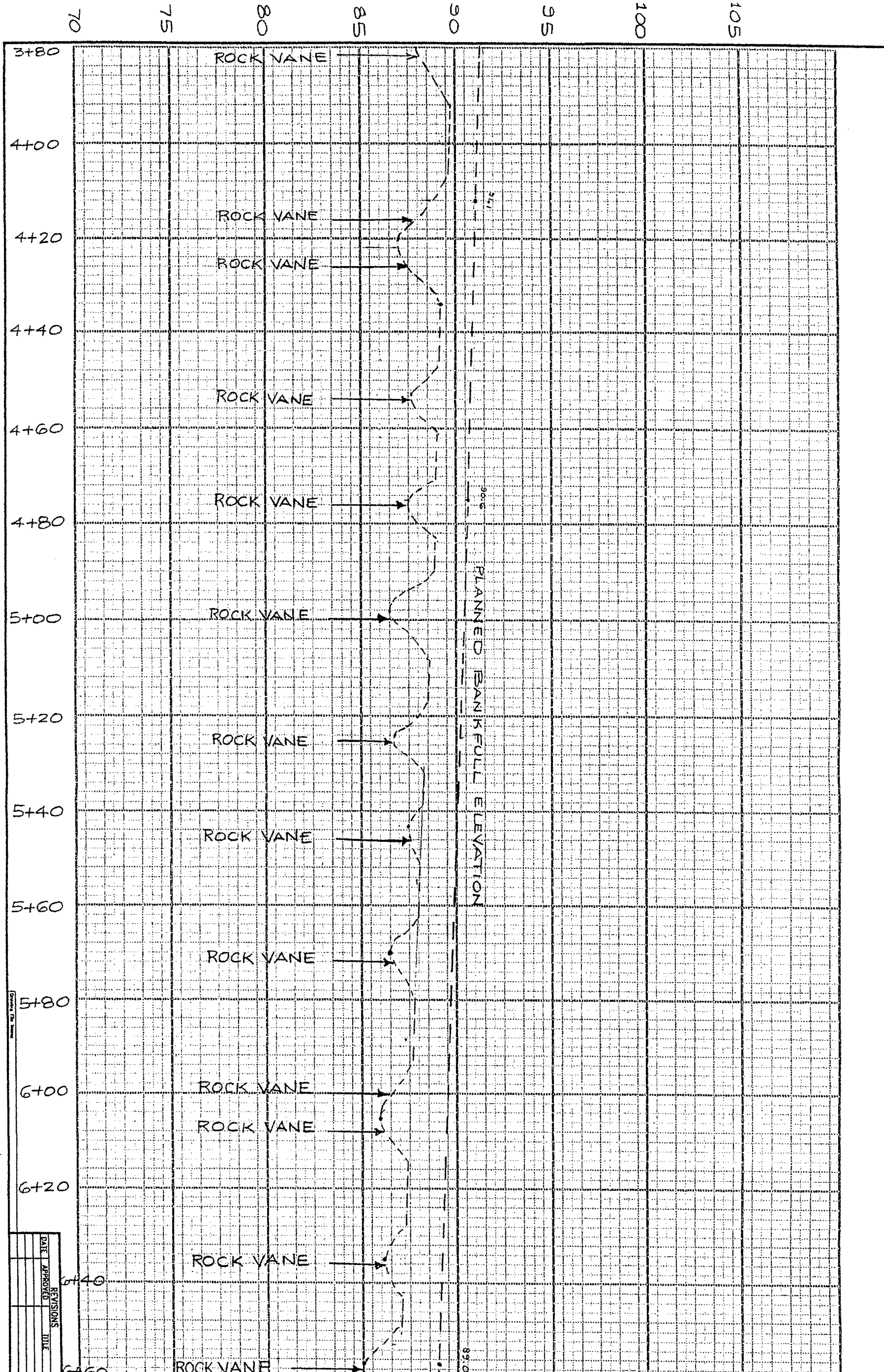

Left Top of Bank
Right Top of Bank
82.5
PLANNED BANKFULL ELEVATION
77.9
Thalweg
Stillhouse Crk–Hillsborough, NC
Longitudinal Profile–Sta 9+40 to Sta 12+20
95
90
85
80
75
70
65
60
9+40
9+45
9+50
9+55
9+60
9+65
9+70
9+75
9+80
9+85
9+90
9+95
10+00
10+05
10+10
10+15
10+20
10+25
10+30
10+35
10+40
10+45
10+50
10+55
10+60
10+65
10+70
10+75
10+80
10+85
10+90
10+95
11+00
11+05
11+10
11+15
11+20
11+25
11+30
11+35
11+40
11+45
11+50
11+55
11+60
11+65
11+70
11+75
11+80
11+85
11+90
11+95
12+00
12+05
12+10
12+15
12+20



STILLHOUSE CRK- HILLSBOROUGH, NC
PROPOSED LONGITUDINAL PROFILE 1+00→3+80

U.S. DEPARTMENT OF AGRICULTURE NATURAL RESOURCES CONSERVATION SERVICE

Designed AG JESSUP 6/02
Drawn AG JESSUP 6/02
Traced
Checked
Approved By
Title
Title

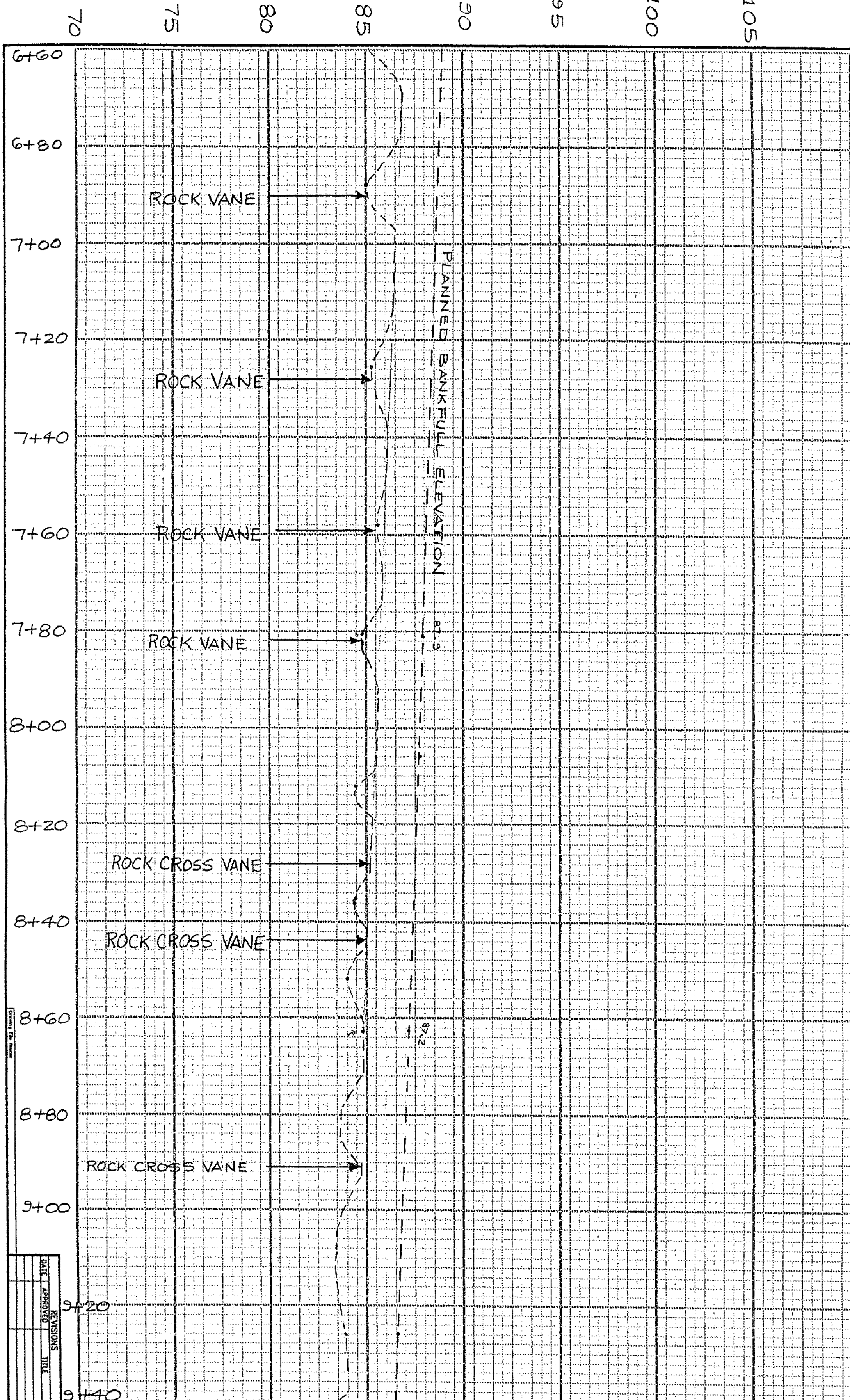


STILLHOUSE CRK - HILLSBOROUGH, NC
PROPOSED LONGITUDINAL PROFILE 3+80→6+60

U.S. DEPARTMENT OF AGRICULTURE NATURAL RESOURCES CONSERVATION SERVICE

Designed	AGJessup	6/02
Drawn	AGJessup	6/02
Traced		
Checked		

Approved By	Date
Title	
Title	



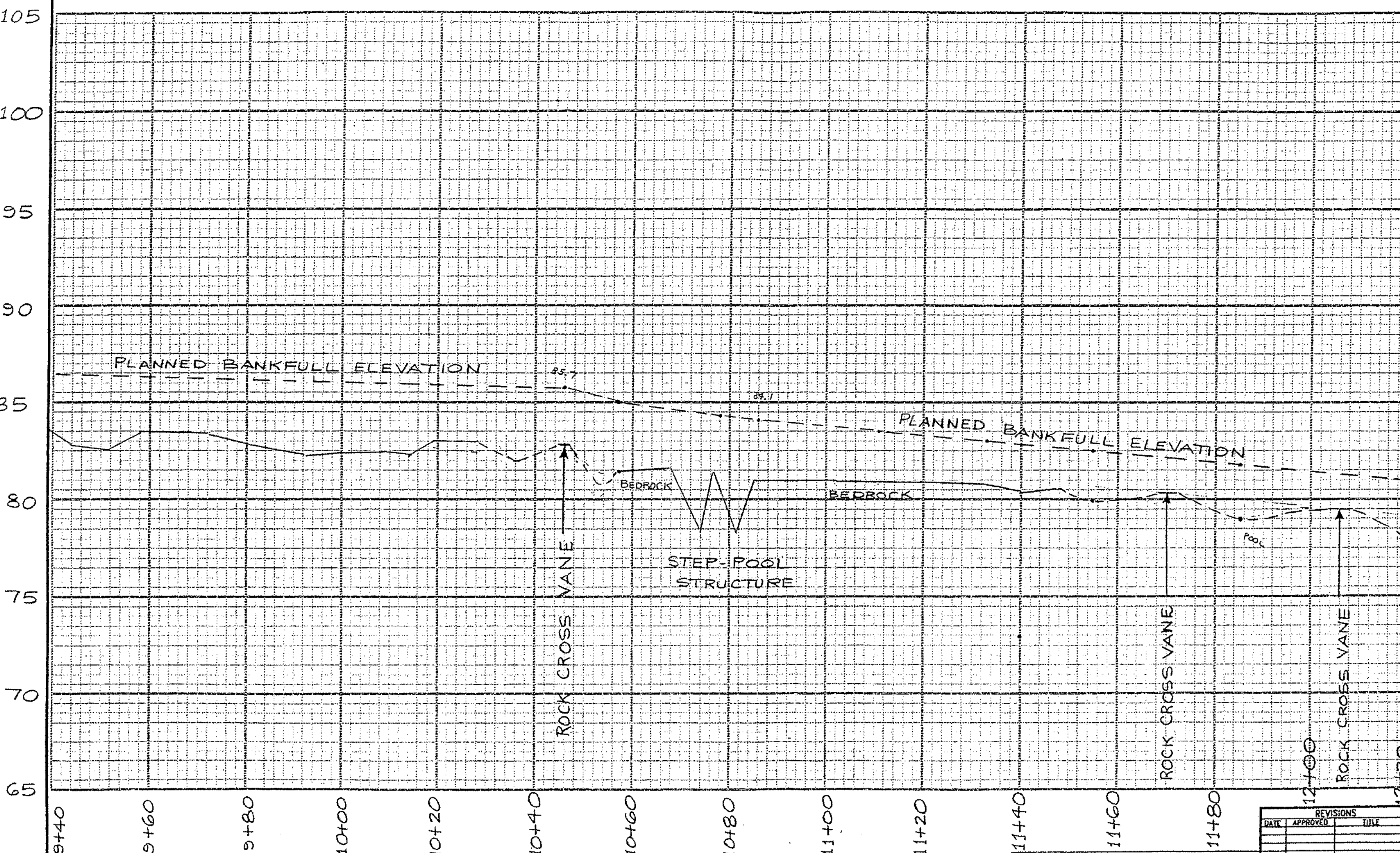
STILLHOUSE CRK - HILLSBOROUGH, NC

PROPOSED LONGITUDINAL PROFILE 6+60 → 9+40

U.S. DEPARTMENT OF AGRICULTURE NATURAL RESOURCES CONSERVATION SERVICE

Designed AG JESSUP 6-02

Drawn AG JESSUP 6-02

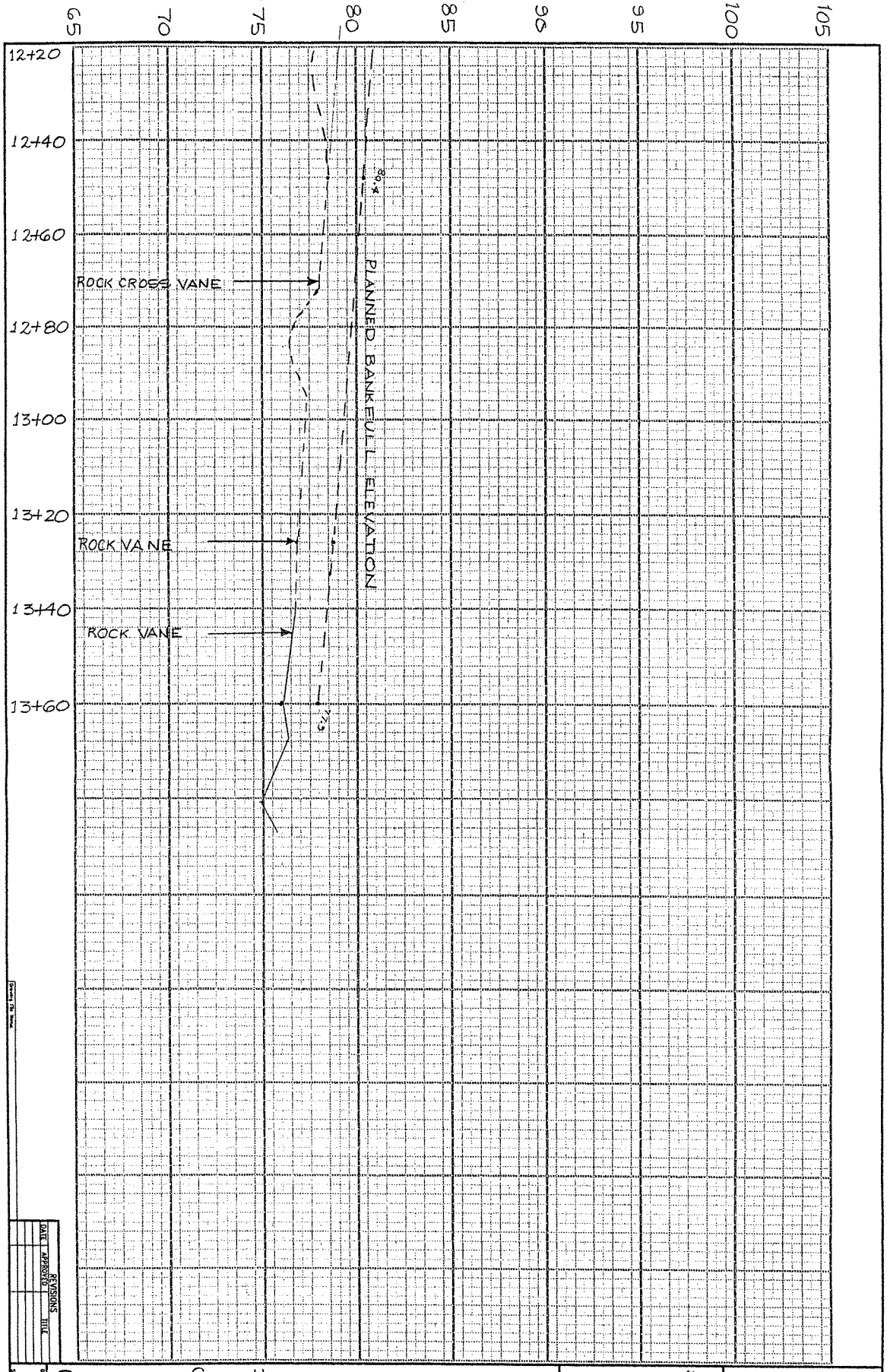


STILLHOUSE CRK - HILLSBOROUGH, NC
PROPOSED LONGITUDINAL PROFILE 9+40 → 12+20

U.S. DEPARTMENT OF AGRICULTURE NATURAL RESOURCES CONSERVATION SERVICE

Designed AGJessup 6-02
Drawn AGJessup 6-02

REVISIONS		
DATE	APPROVED	TITLE



REVISIONS			
	TITLE	APPROVED	DATE

STILLHOUSE CRK - HILLSBOROUGH, NC

PROPOSED LONGITUDINAL PROFILE - 12+20 → 13+60

U.S. DEPARTMENT OF AGRICULTURE NATURAL RESOURCES CONSERVATION SERVICE

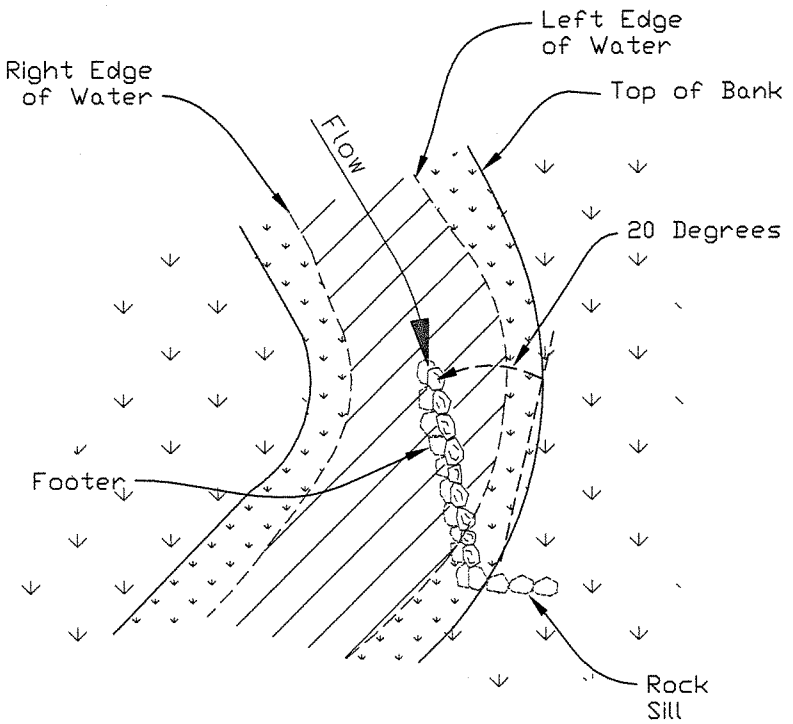
Designed AGJESSUP 6/02

Drawn AGJESSUP 6/02

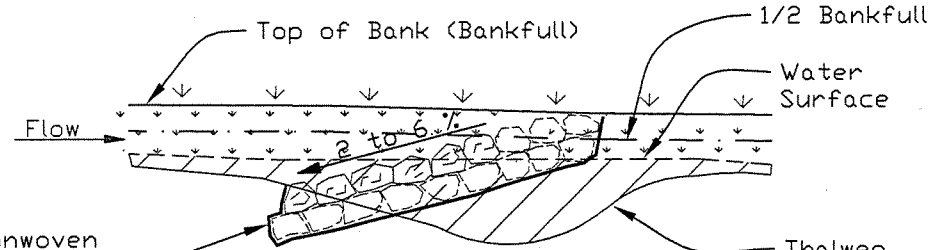
Traced

Checked

ROCK VANE

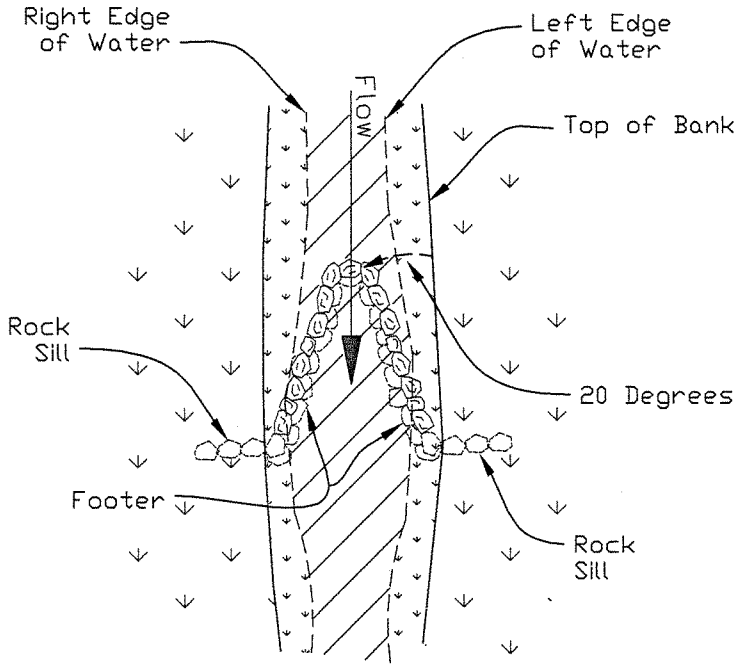


PLAN VIEW

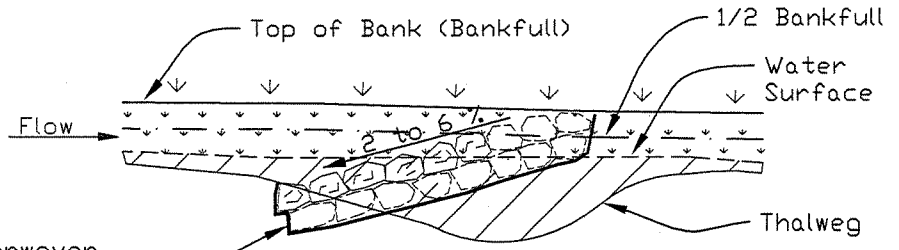


PROFILE VIEW

ROCK CROSS VANE



PLAN VIEW



PROFILE VIEW

REVISIONS		
DATE	APPROVED	TITLE

Drawing File Name:

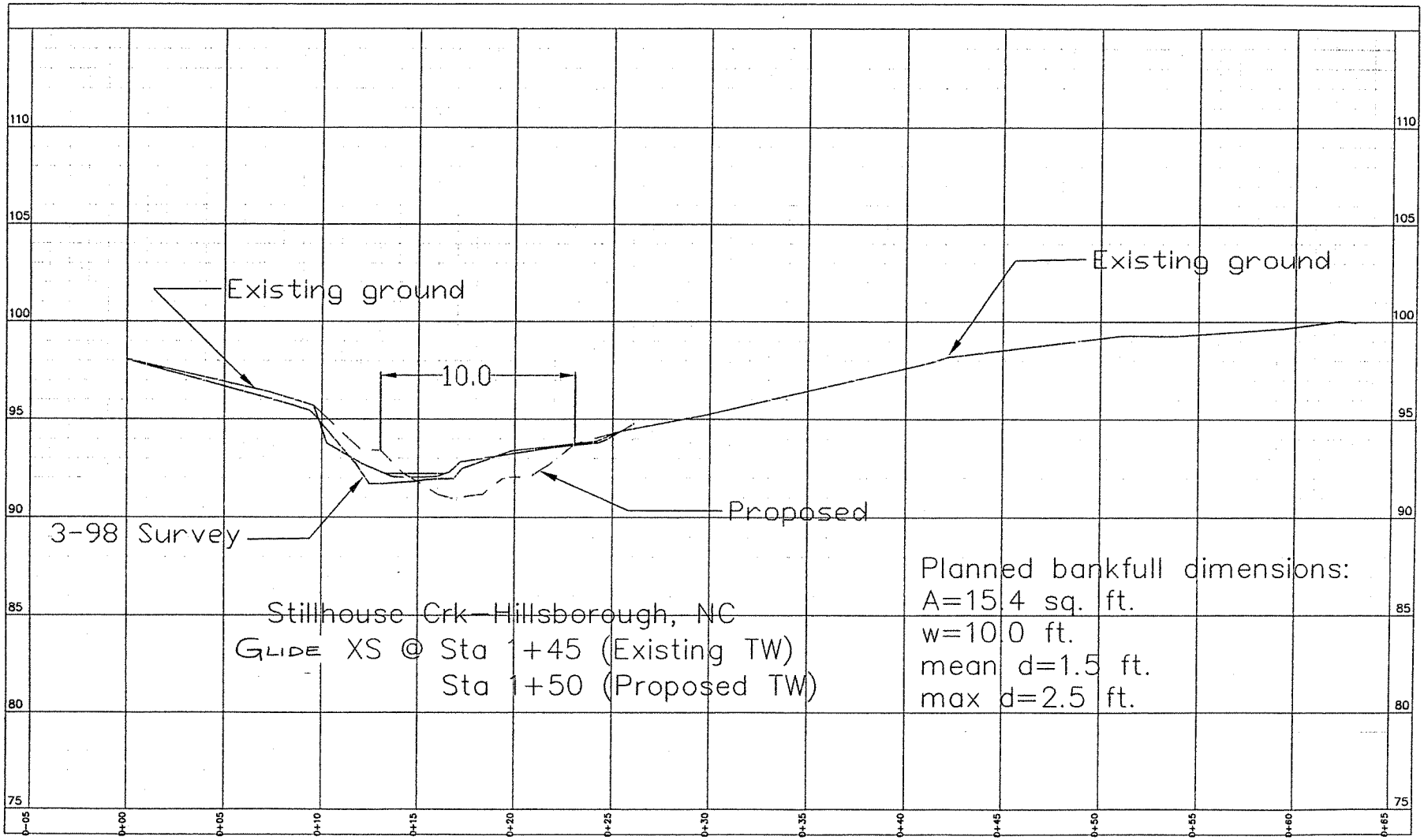
Date
Approved By:
File:

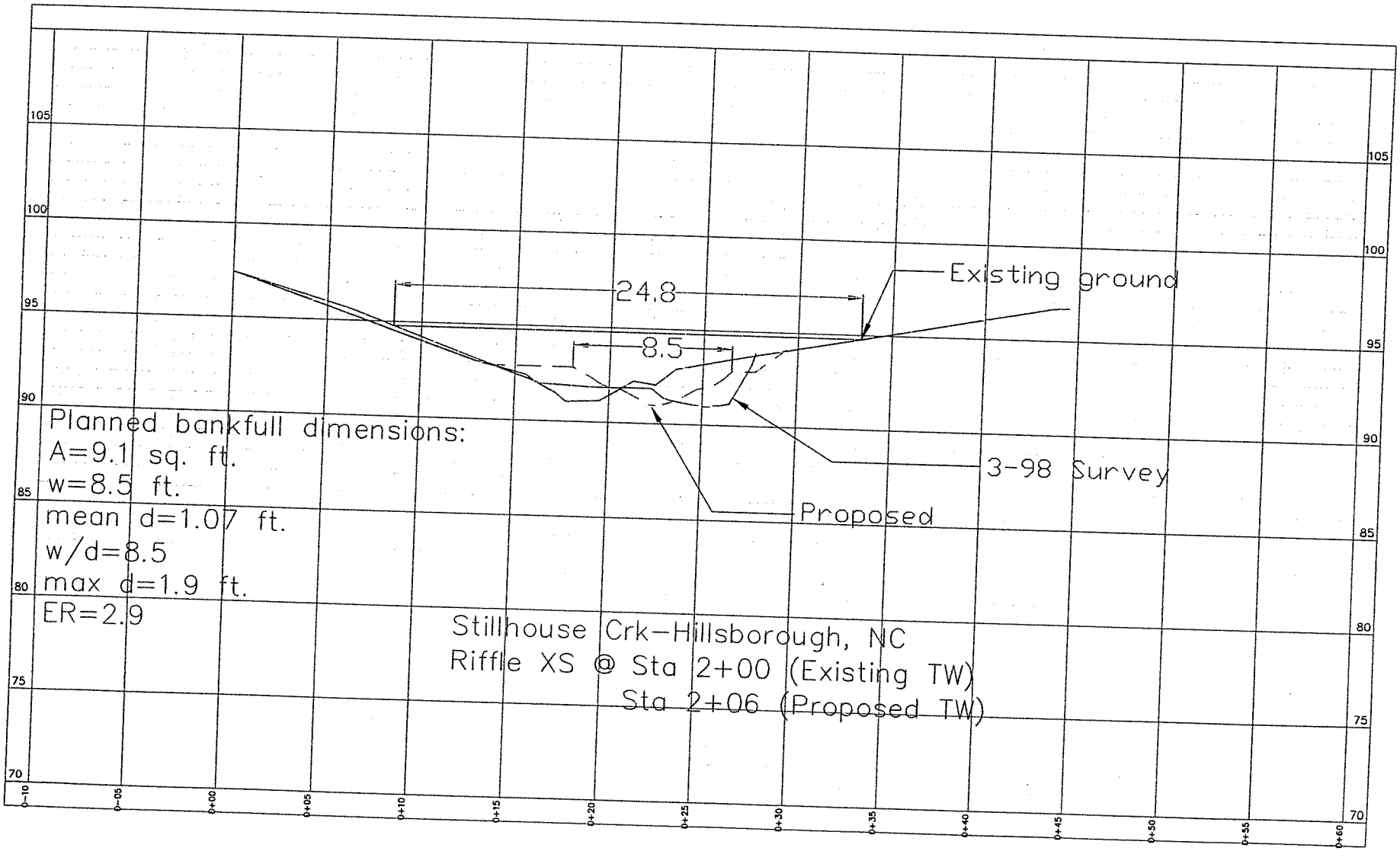
Date 02/03
Designed: ASchnepp
Drawn: T. Burchette
Traced:
Checked:

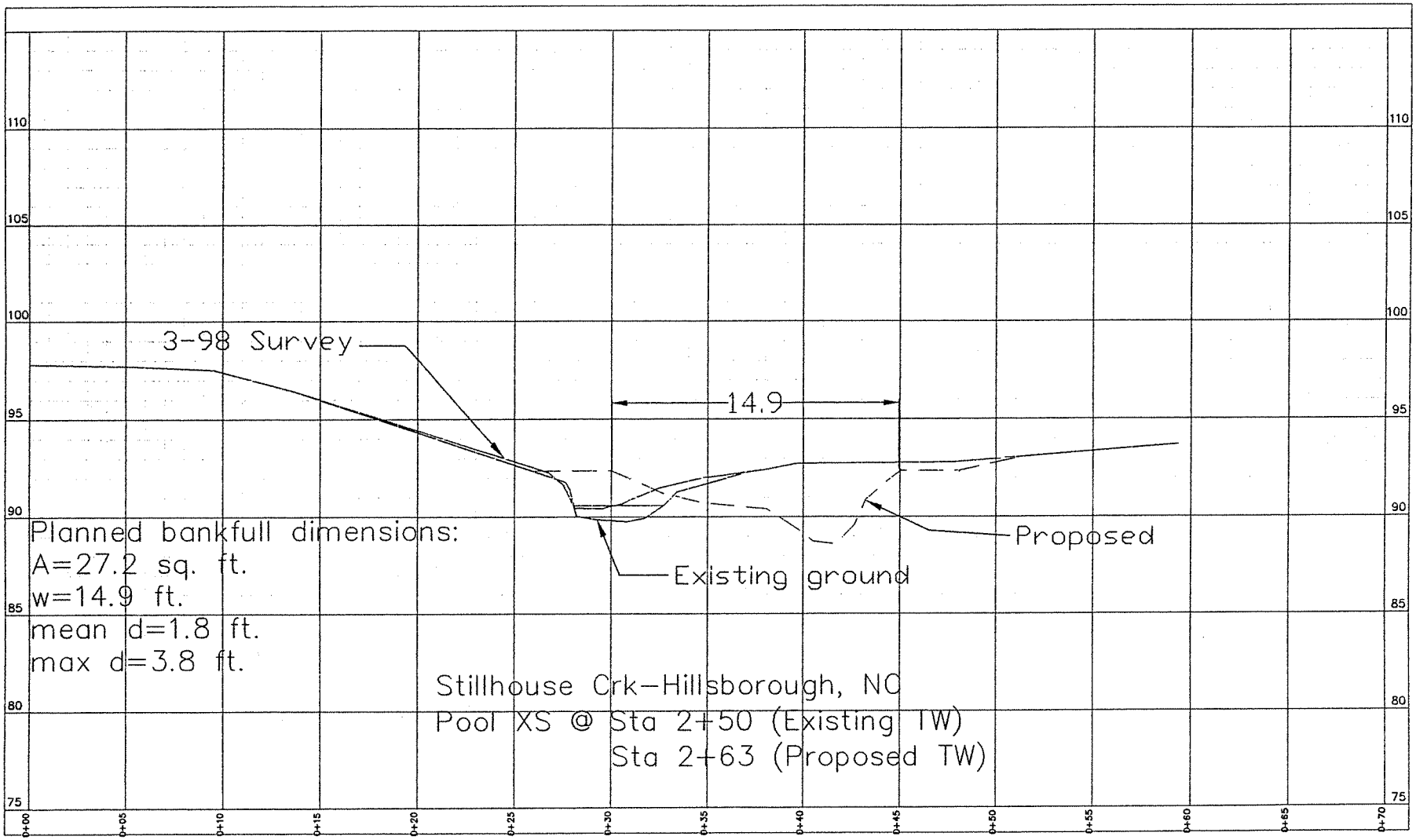
STILLHOUSE CREEK RESTORATION PROJECT
ORANGE COUNTY, NORTH CAROLINA
TYPICAL ROCK STRUCTURE DETAIL
ROCK VANE / CROSS VANE

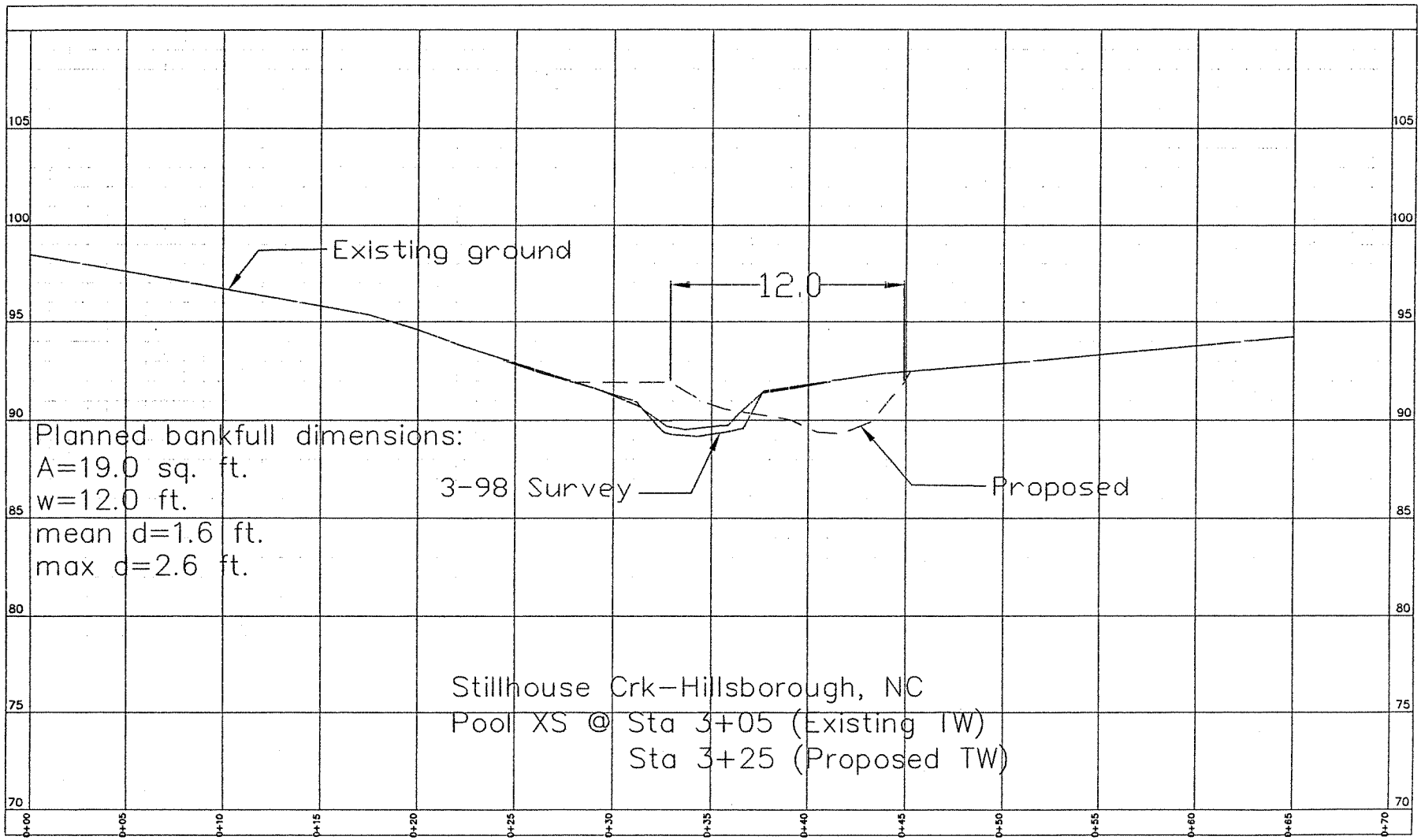
Drawing Number:

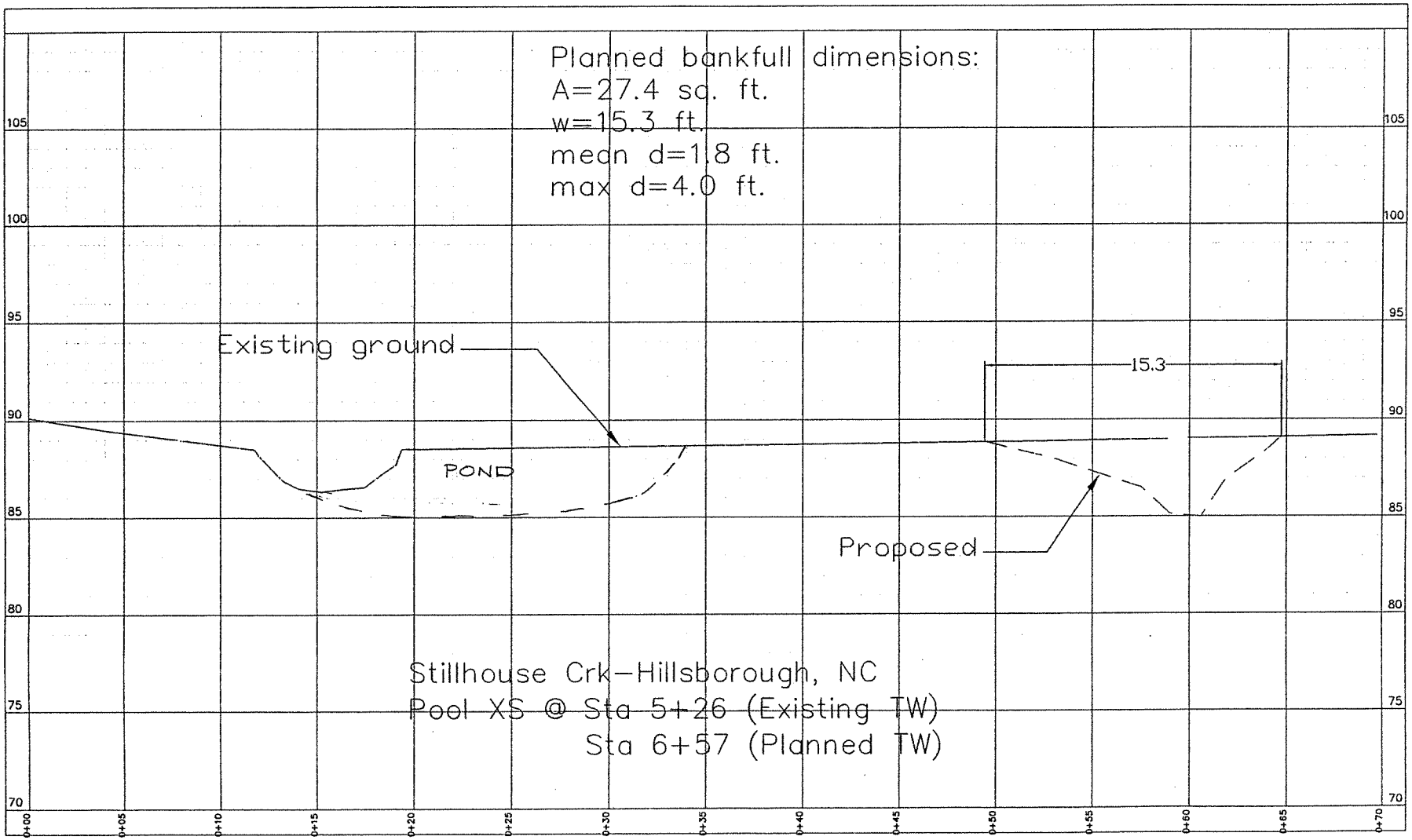
Sheet No. of

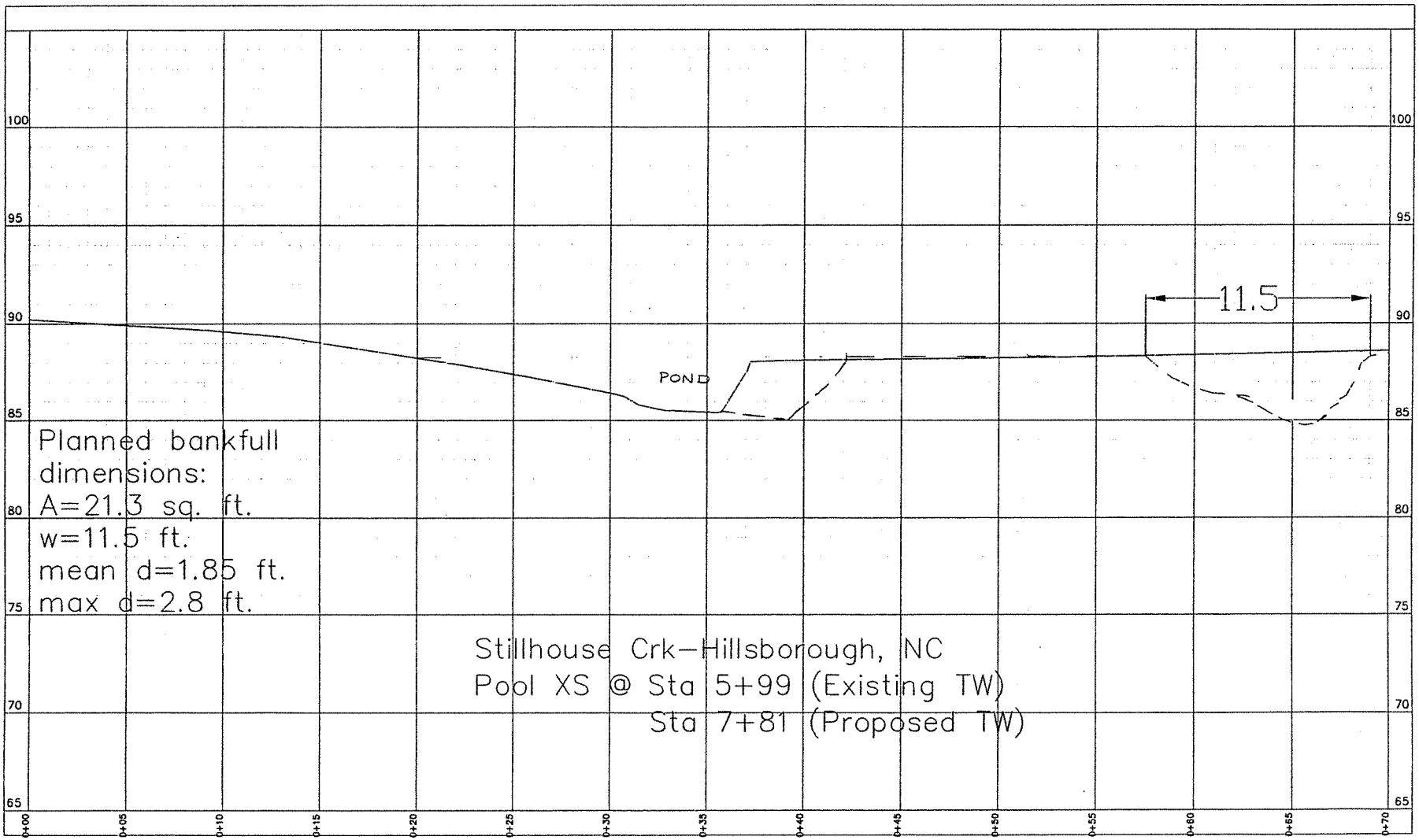

110
105
100
95
90
85
80
75
0+05
0+00
0+05
0+10
0+15
0+20
0+25
0+30
0+35
0+40
0+45
0+50
0+55
0+60
0+65
Existing ground
Existing ground
10.0
Proposed
3-98 Survey
Stillhouse Crk-Hillsborough, NC
Glide XS @ Sta 1+45 (Existing TW)
Sta 1+50 (Proposed TW)
Planned bankfull dimensions:
A=15.4 sq. ft.
w=10.0 ft.
mean d=1.5 ft.
max d=2.5 ft.


24.8
8.5
Existing ground
3-98 Survey
Proposed
Planned bankfull dimensions:
A=9.1 sq. ft.
w=8.5 ft.
mean d=1.07 ft.
w/d=8.5
max d=1.9 ft.
ER=2.9
Stillhouse Crk-Hillsborough, NC
Riffle XS @ Sta 2+00 (Existing TW)
Sta 2+06 (Proposed TW)
105
100
95
90
85
80
75
70
0-10
0-05
0+00
0+05
0+10
0+15
0+20
0+25
0+30
0+35
0+40
0+45
0+50
0+55
0+60


110
105
100
95
90
85
80
75
0+00
0+05
0+10
0+15
0+20
0+25
0+30
0+35
0+40
0+45
0+50
0+55
0+60
0+65
0+70
3-98 Survey
14.9
Proposed
Existing ground
Planned bankfull dimensions:
A=27.2 sq. ft.
w=14.9 ft.
mean d=1.8 ft.
max d=3.8 ft.
Stillhouse Crk-Hillsborough, NC
Pool XS @ Sta 2+50 (Existing TW)
Sta 2+63 (Proposed TW)

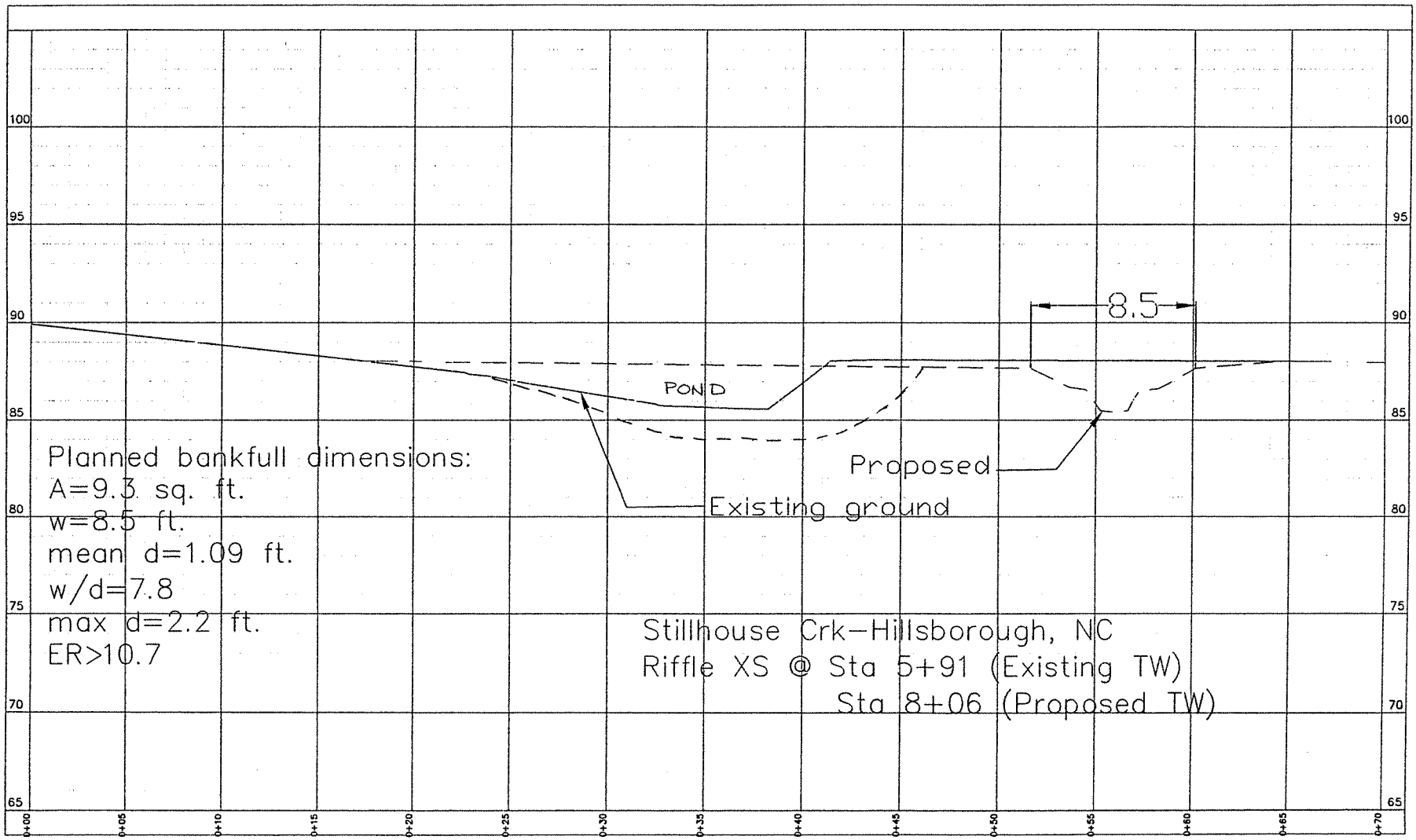

105
100
95
90
85
80
75
70
0+00
0+05
0+10
0+15
0+20
0+25
0+30
0+35
0+40
0+45
0+50
0+55
0+60
0+65
0+70
Existing ground
12.0
Planned bankfull dimensions:
A=19.0 sq. ft.
w=12.0 ft.
mean d=1.6 ft.
max d=2.6 ft.
3-98 Survey
Proposed
Stillhouse Crk-Hillsborough, NC
Pool XS @ Sta 3+05 (Existing TW)
Sta 3+25 (Proposed TW)

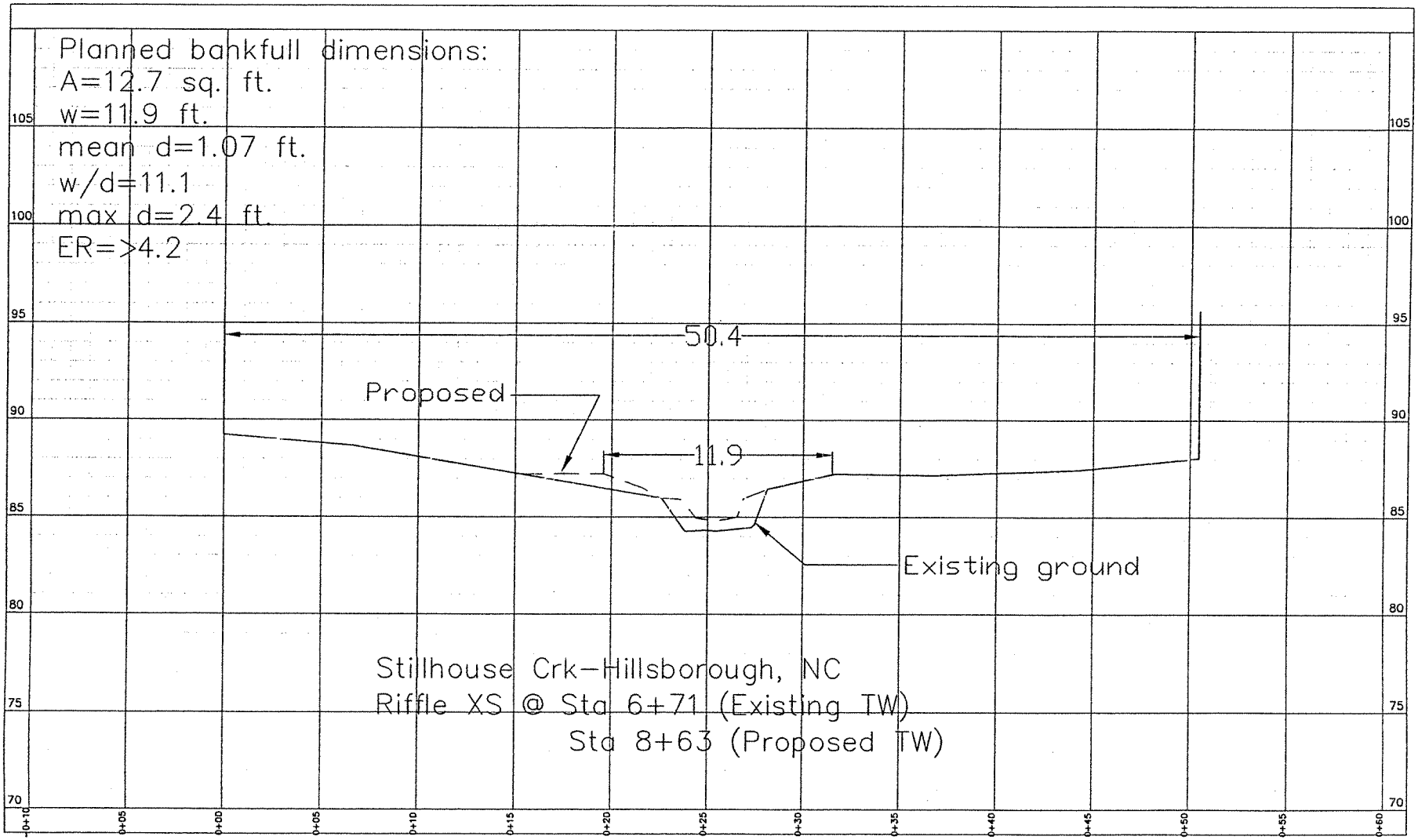

Planned bankfull dimensions:
A=27.4 sq. ft.
w=15.3 ft.
mean d=1.8 ft.
max d=4.0 ft.
Existing ground
POND
15.3
Proposed
Stillhouse Crk–Hillsborough, NC
Pool XS @ Sta 5+26 (Existing TW)
Sta 6+57 (Planned TW)
105
100
95
90
85
80
75
70
0+00
0+05
0+10
0+15
0+20
0+25
0+30
0+35
0+40
0+45
0+50
0+55
0+60
0+65
0+70

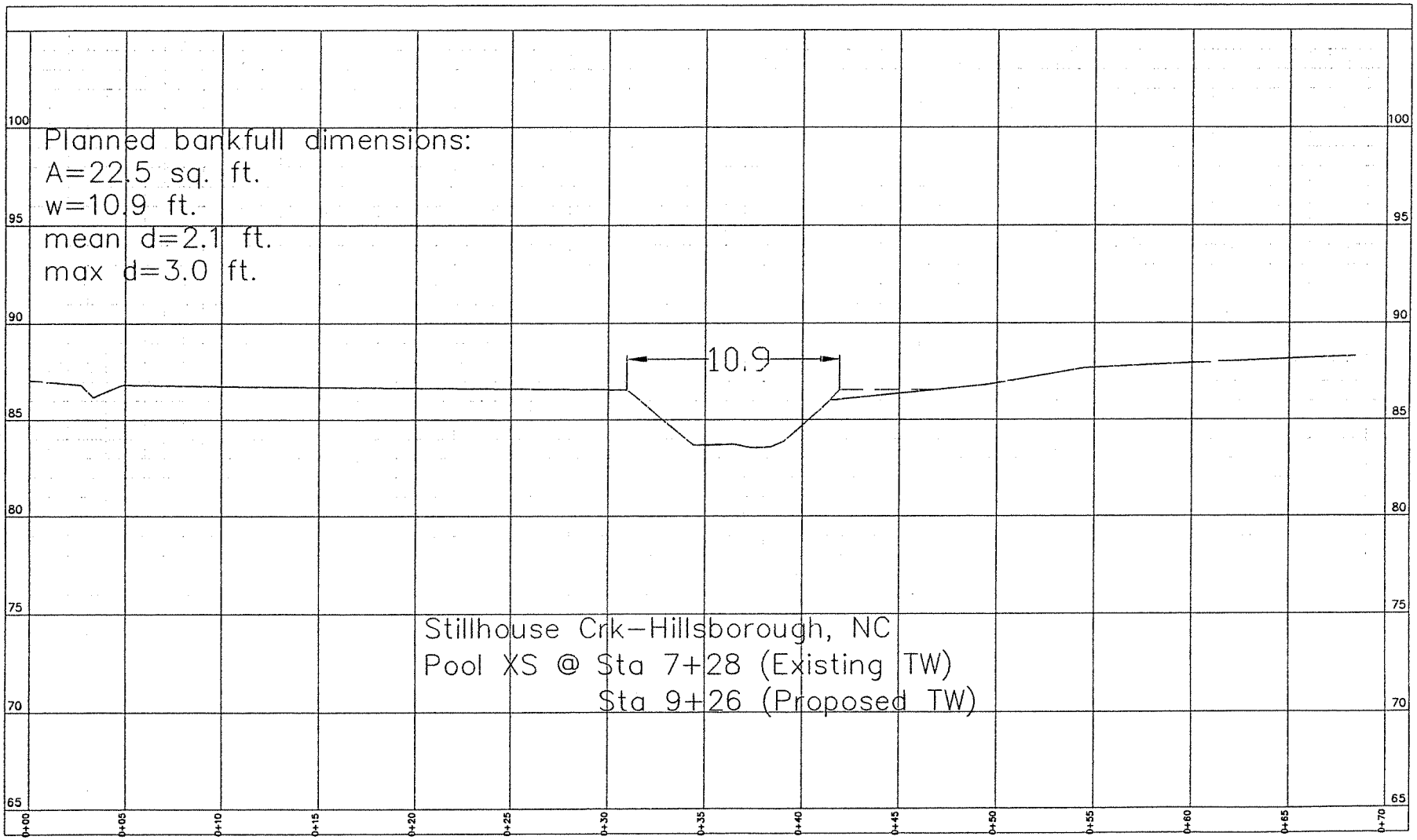


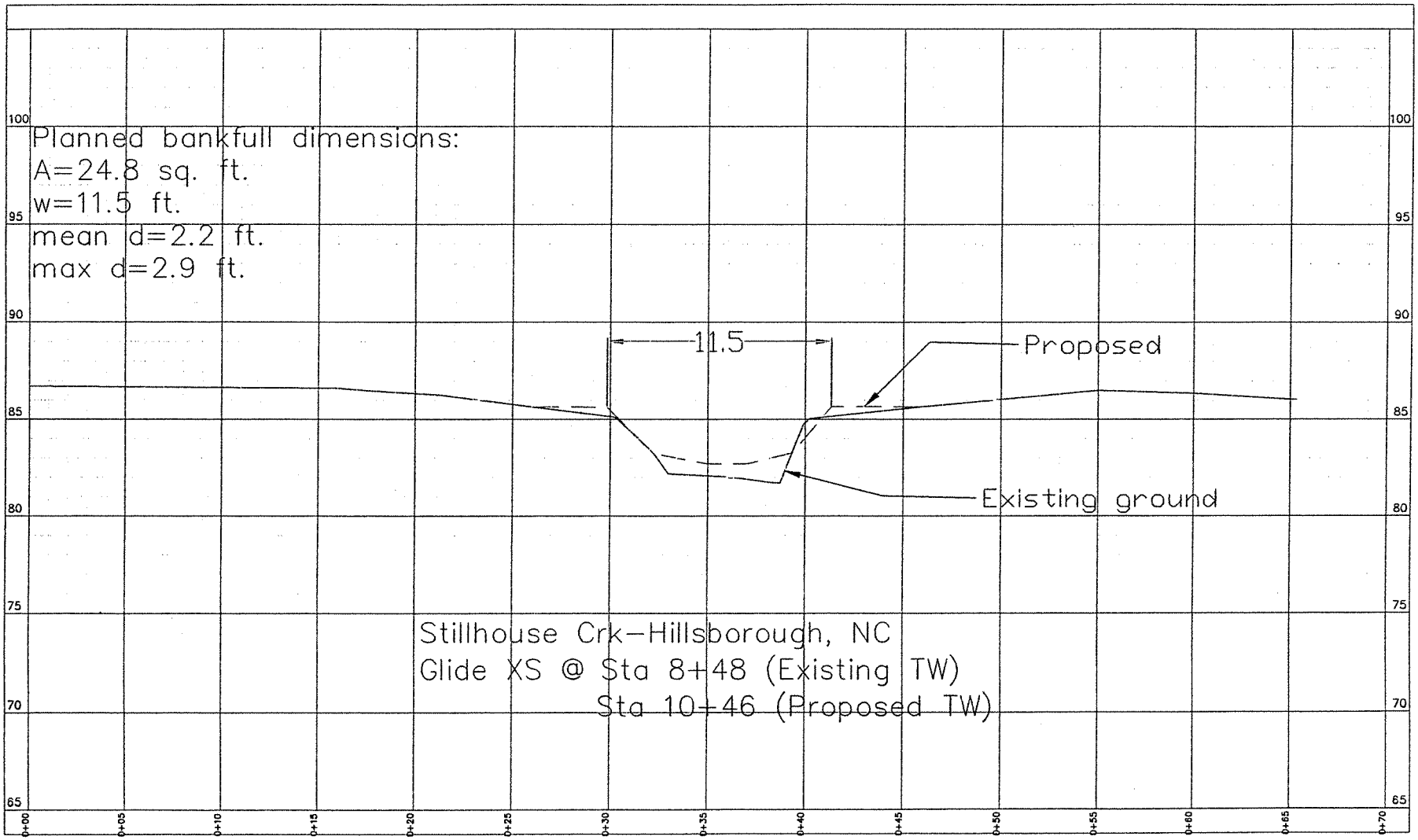
Planned bankfull dimensions:
A=21.3 sq. ft.
w=11.5 ft.
mean d=1.85 ft.
max d=2.8 ft.

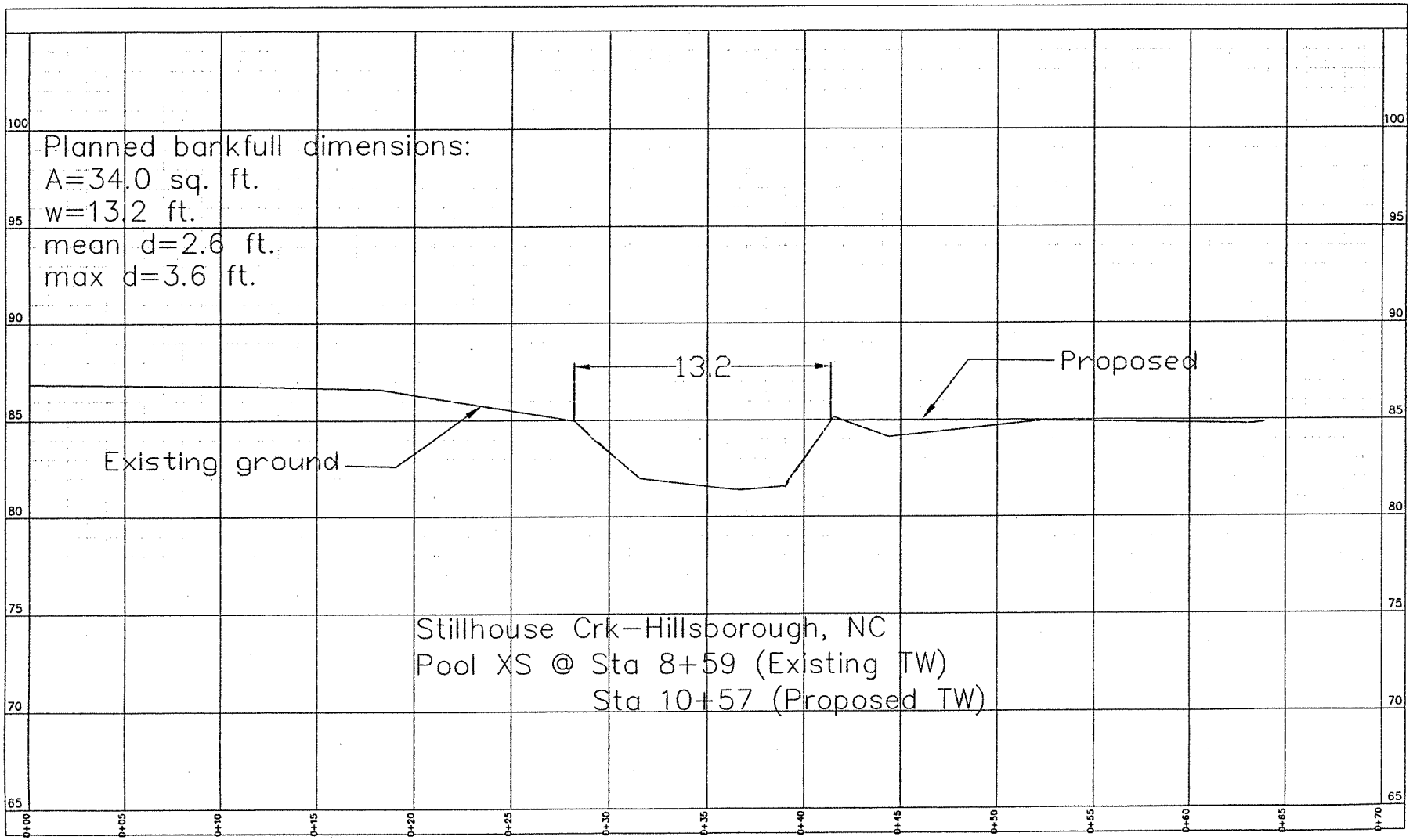
Stillhouse Crk–Hillsborough, NC
Pool XS @ Sta 5+99 (Existing TW)
Sta 7+81 (Proposed TW)

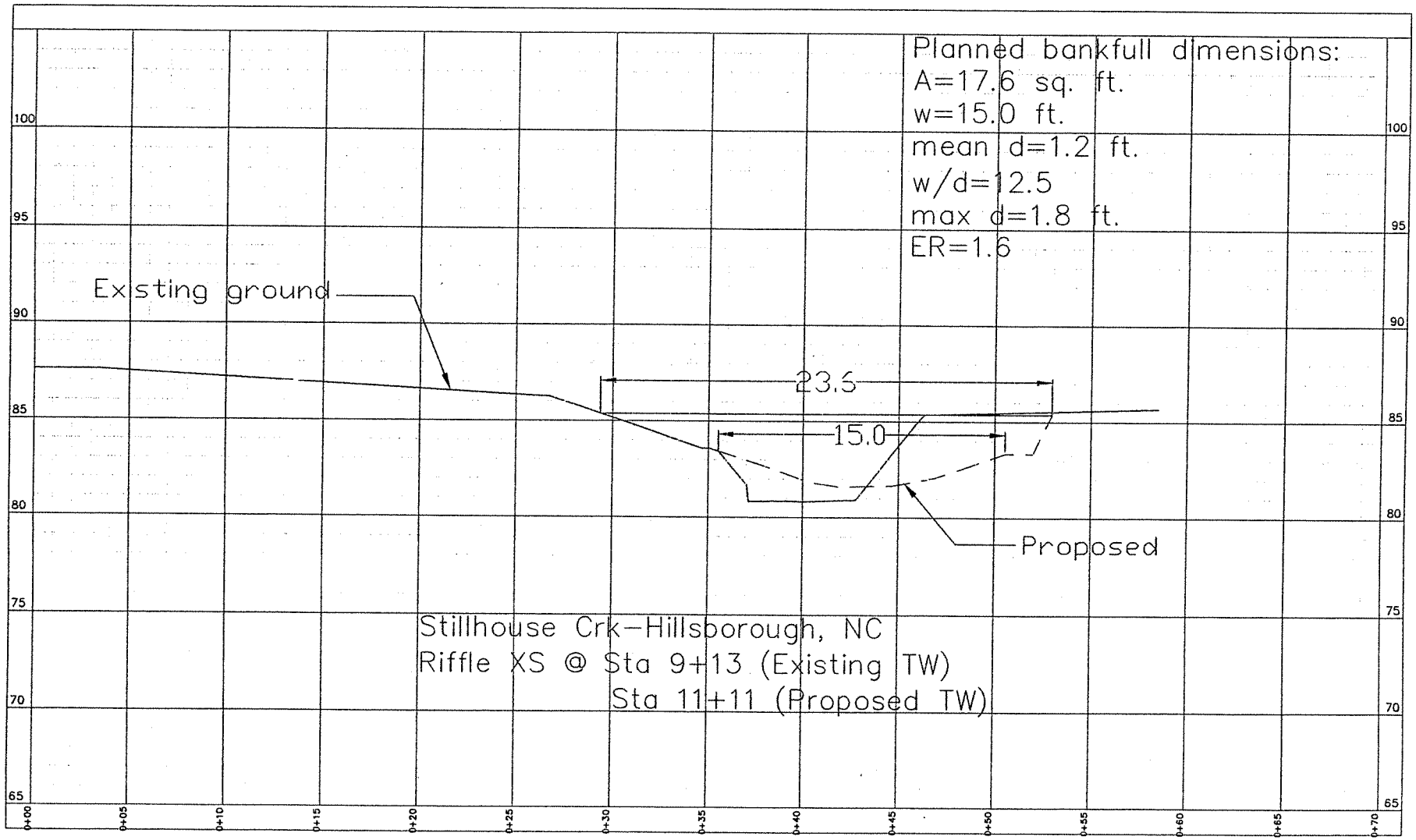

100
95
90
85
80
75
70
65
0+00
0+05
0+10
0+15
0+20
0+25
0+30
0+35
0+40
0+45
0+50
0+55
0+60
0+65
0+70
8.5
POND
Proposed
Existing ground
Planned bankfull dimensions:
A=9.3 sq. ft.
w=8.5 ft.
mean d=1.09 ft.
w/d=7.8
max d=2.2 ft.
ER>10.7
Stillhouse Crk–Hillsborough, NC
Riffle XS @ Sta 5+91 (Existing TW)
Sta 8+06 (Proposed TW)

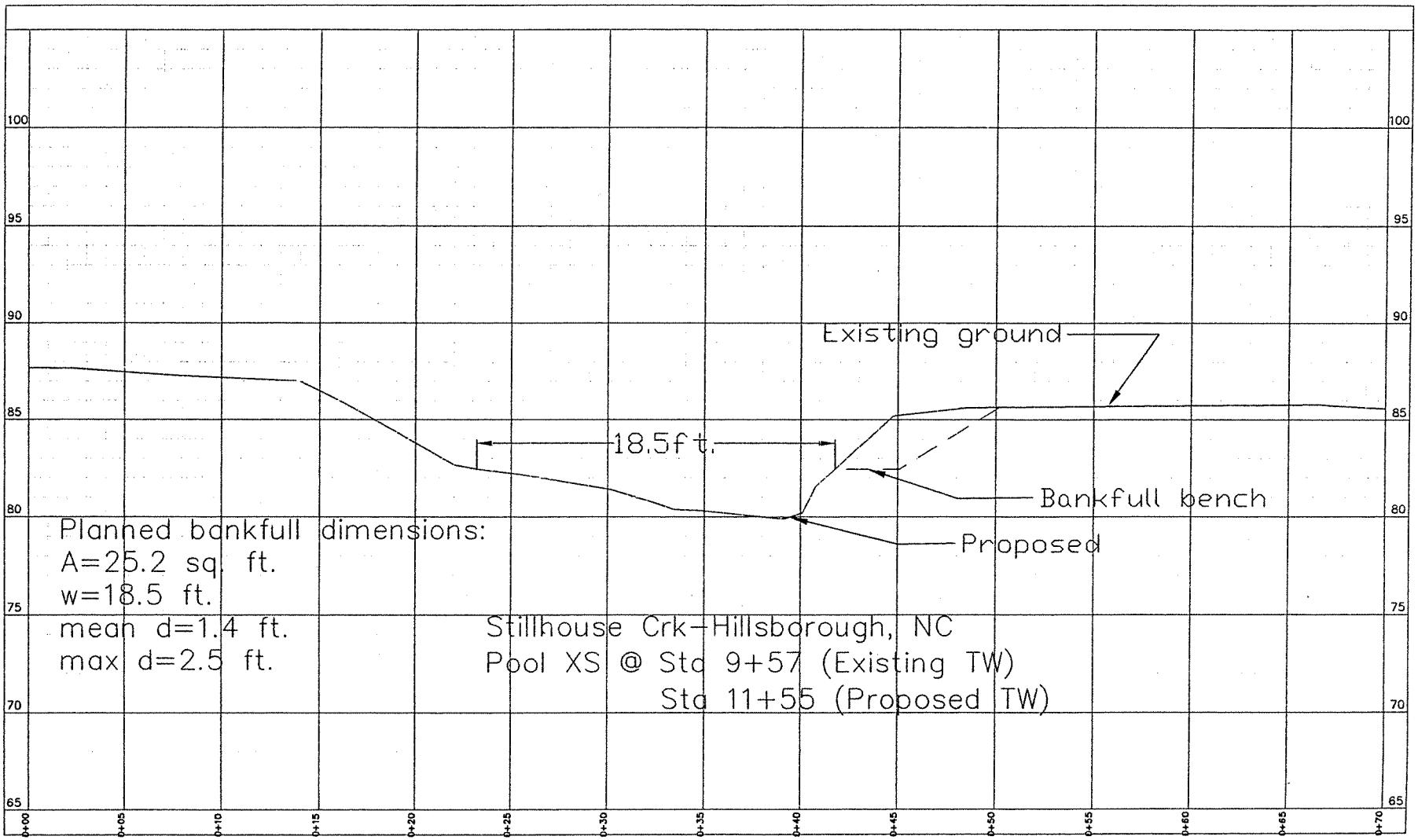

Planned bankfull dimensions:
A=12.7 sq. ft.
w=11.9 ft.
mean d=1.07 ft.
w/d=11.1
max d=2.4 ft.
ER=>4.2
50.4
Proposed
11.9
Existing ground
Stillhouse Crk–Hillsborough, NC
Riffle XS @ Sta 6+71 (Existing TW)
Sta 8+63 (Proposed TW)
105
100
95
90
85
80
75
70
-0+10
0+05
0+00
0+05
0+10
0+15
0+20
0+25
0+30
0+35
0+40
0+45
0+50
0+55
0+60

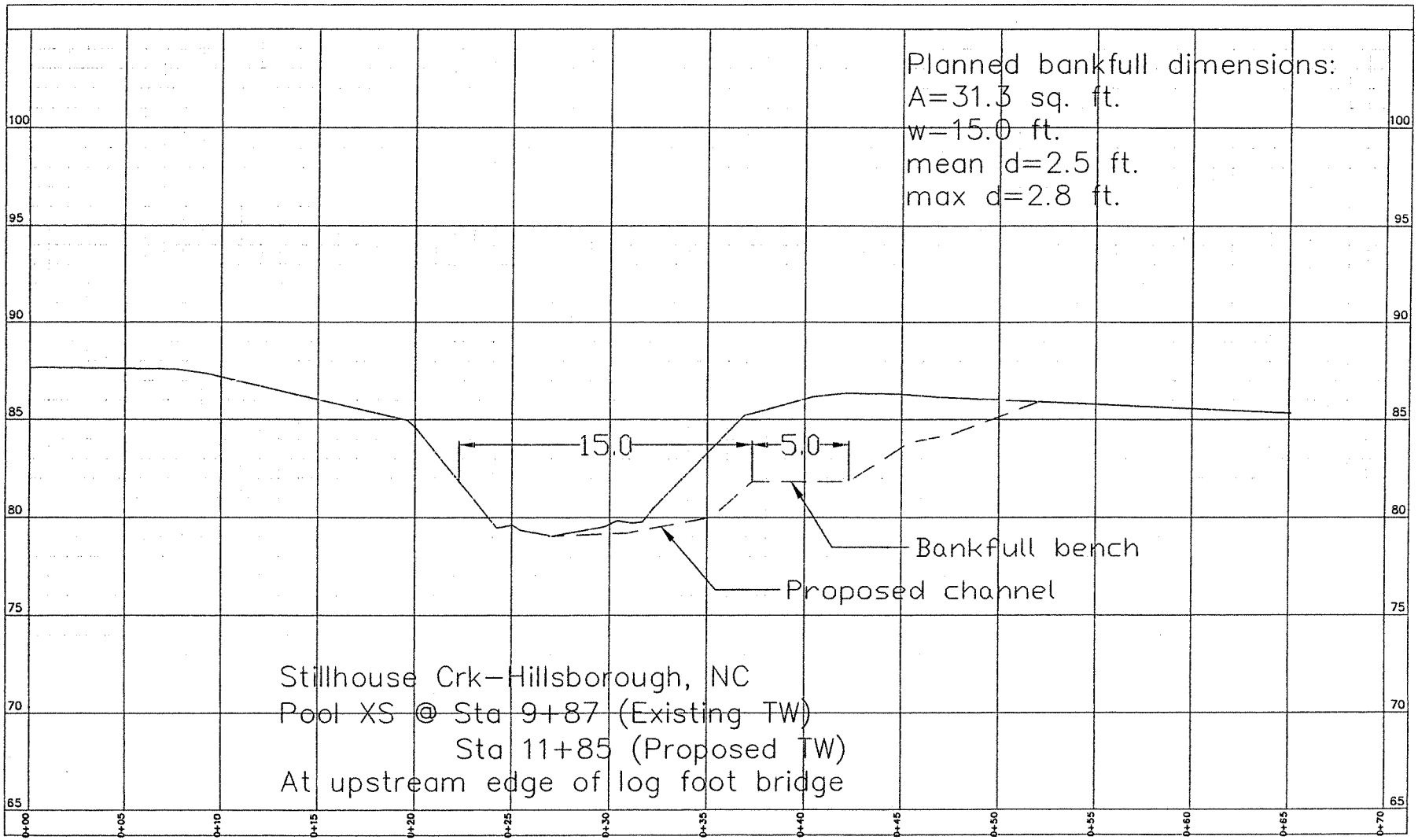

Planned bankfull dimensions:
A=22.5 sq. ft.
w=10.9 ft.
mean d=2.1 ft.
max d=3.0 ft.
10.9
Stillhouse Crk-Hillsborough, NC
Pool XS @ Sta 7+28 (Existing TW)
Sta 9+26 (Proposed TW)
100
95
90
85
80
75
70
65
0+00
0+05
0+10
0+15
0+20
0+25
0+30
0+35
0+40
0+45
0+50
0+55
0+60
0+65
0+70

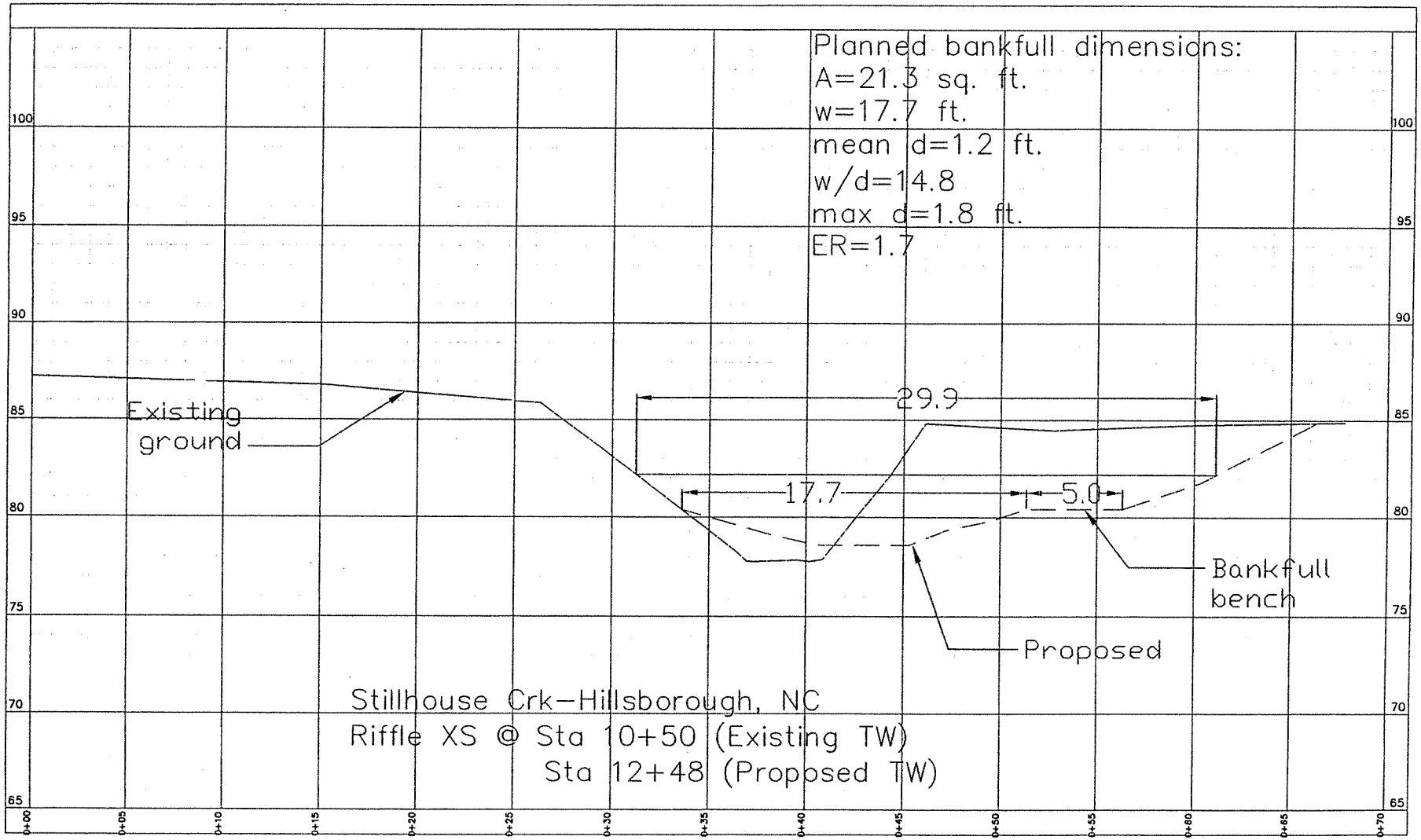

Planned bankfull dimensions:
A=24.8 sq. ft.
w=11.5 ft.
mean d=2.2 ft.
max d=2.9 ft.
11.5
Proposed
Existing ground
Stillhouse Crk-Hillsborough, NC
Glide XS @ Sta 8+48 (Existing TW)
Sta 10+46 (Proposed TW)
100
95
90
85
80
75
70
65
0+00
0+05
0+10
0+15
0+20
0+25
0+30
0+35
0+40
0+45
0+50
0+55
0+60
0+65
0+70

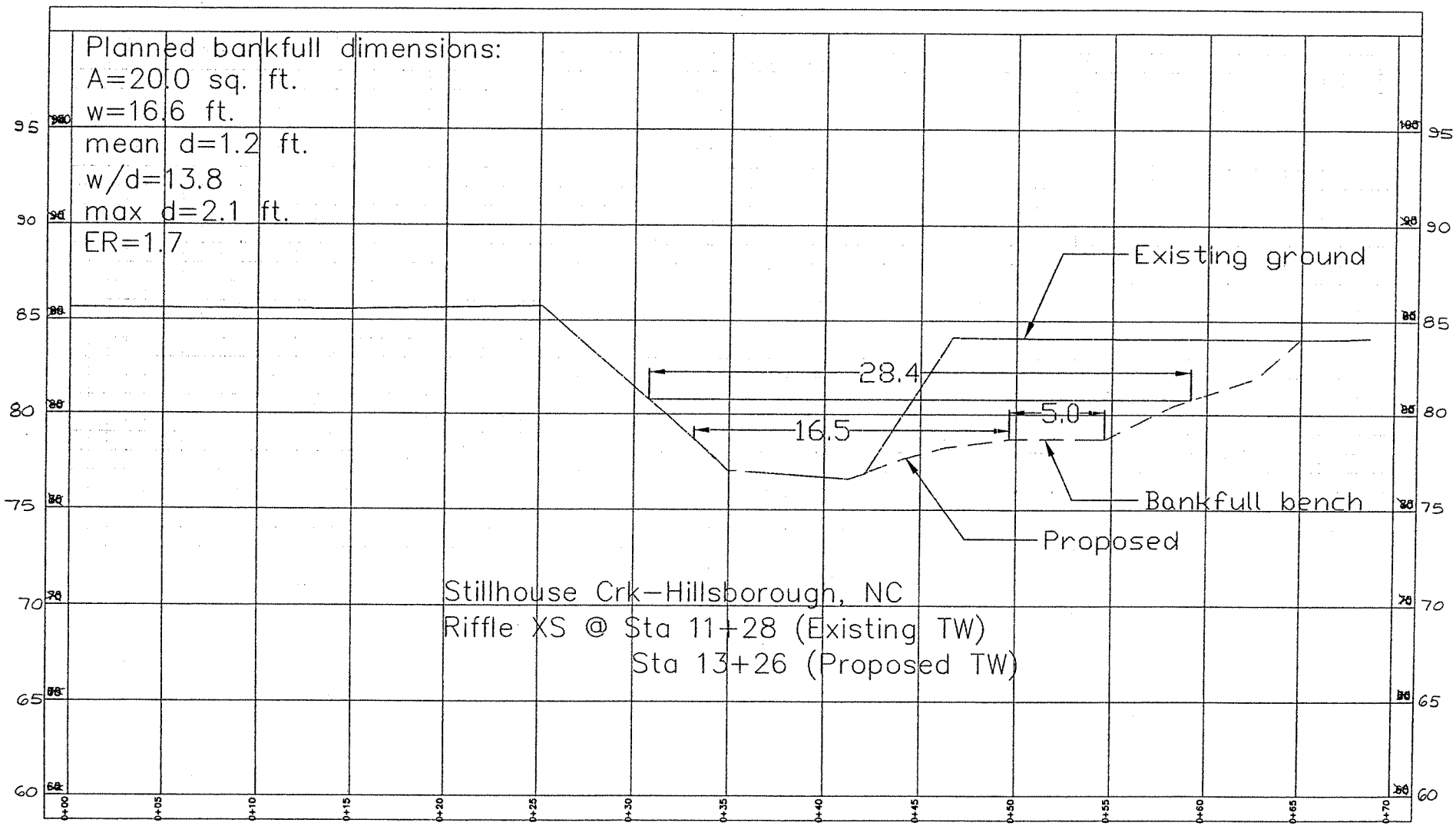

Planned bankfull dimensions:
A=34.0 sq. ft.
w=13.2 ft.
mean d=2.6 ft.
max d=3.6 ft.
13.2
Proposed
Existing ground
Stillhouse Crk-Hillsborough, NC
Pool XS @ Sta 8+59 (Existing TW)
Sta 10+57 (Proposed TW)
100
95
90
85
80
75
70
65
0+00
0+05
0+10
0+15
0+20
0+25
0+30
0+35
0+40
0+45
0+50
0+55
0+60
0+65
0+70

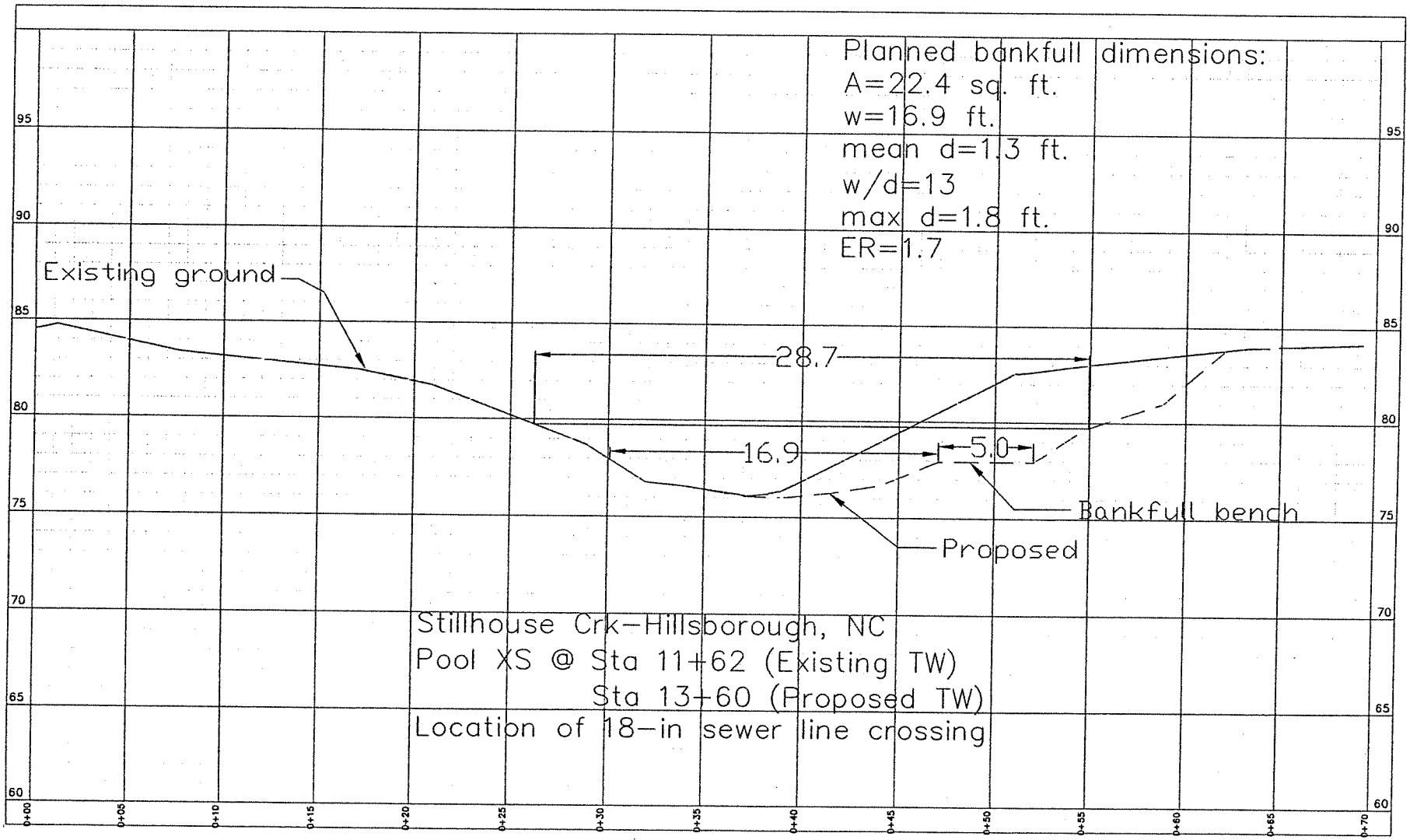

Planned bankfull dimensions:
A=17.6 sq. ft.
w=15.0 ft.
mean d=1.2 ft.
w/d=12.5
max d=1.8 ft.
ER=1.6
Existing ground
23.6
15.0
Proposed
Stillhouse Crk–Hillsborough, NC
Riffle XS @ Sta 9+13 (Existing TW)
Sta 11+11 (Proposed TW)
100
95
90
85
80
75
70
65
0+00
0+05
0+10
0+15
0+20
0+25
0+30
0+35
0+40
0+45
0+50
0+55
0+60
0+65
0+70


100
95
90
85
80
75
70
65
0+00
0+05
0+10
0+15
0+20
0+25
0+30
0+35
0+40
0+45
0+50
0+55
0+60
0+65
0+70
Existing ground
18.5ft.
Bankfull bench
Proposed
Planned bankfull dimensions:
A=25.2 sq. ft.
w=18.5 ft.
mean d=1.4 ft.
max d=2.5 ft.
Stillhouse Crk-Hillsborough, NC
Pool XS @ Sta 9+57 (Existing TW)
Sta 11+55 (Proposed TW)


Planned bankfull dimensions:
A=31.3 sq. ft.
w=15.0 ft.
mean d=2.5 ft.
max d=2.8 ft.
15.0
5.0
Bankfull bench
Proposed channel
Stillhouse Crk–Hillsborough, NC
Pool XS @ Sta 9+87 (Existing TW)
Sta 11+85 (Proposed TW)
At upstream edge of log foot bridge
100
95
90
85
80
75
70
65
0+00
0+05
0+10
0+15
0+20
0+25
0+30
0+35
0+40
0+45
0+50
0+55
0+60
0+65
0+70


Planned bankfull dimensions:
A=21.3 sq. ft.
w=17.7 ft.
mean d=1.2 ft.
w/d=14.8
max d=1.8 ft.
ER=1.7
100
95
90
85
80
75
70
65
Existing ground
29.9
17.7
5.0
Bankfull bench
Proposed
Stillhouse Crk-Hillsborough, NC
Riffle XS @ Sta 10+50 (Existing TW)
Sta 12+48 (Proposed TW)
0+00
0+05
0+10
0+15
0+20
0+25
0+30
0+35
0+40
0+45
0+50
0+55
0+60
0+65
0+70


Planned bankfull dimensions:
A=20.0 sq. ft.
w=16.6 ft.
mean d=1.2 ft.
w/d=13.8
max d=2.1 ft.
ER=1.7
Existing ground
28.4
16.5
5.0
Bankfull bench
Proposed
Stillhouse Crk–Hillsborough, NC
Riffle XS @ Sta 11+28 (Existing TW)
Sta 13+26 (Proposed TW)
95
90
85
80
75
70
65
60
0+00
0+05
0+10
0+15
0+20
0+25
0+30
0+35
0+40
0+45
0+50
0+55
0+60
0+65
0+70


Planned bankfull dimensions:
A=22.4 sq. ft.
w=16.9 ft.
mean d=1.3 ft.
w/d=13
max d=1.8 ft.
ER=1.7
Existing ground
28.7
16.9
5.0
Bankfull bench
Proposed
Stillhouse Crk–Hillsborough, NC
Pool XS @ Sta 11+62 (Existing TW)
Sta 13+60 (Proposed TW)
Location of 18–in sewer line crossing
95
90
85
80
75
70
65
60
0+00
0+05
0+10
0+15
0+20
0+25
0+30
0+35
0+40
0+45
0+50
0+55
0+60
0+65
0+70