Restoration Plan for Stream Mitigation of Silver Creek and Tributary (Conway and Queen Site)

Silver Creek and Unnamed Tributary
Burke County, NC
SCO # D05016-1

Prepared for:
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Ecosystem Enhancement PROGRAM

APPENDIX A
Stream Restoration Plan

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EXECUTIVE SUMMARY

For this project, the restoration goal is to restore the physical and biological integrity beyond current stream conditions. Current conditions consist of modified or impaired stream channels. Restoration of the streams will provide the desired habitat and stability features necessary to improve the quality of the stream. Objectives to meet that goal of restoring these stream channels are listed below.

1. Provide a stable stream channel with features indicative of a biologically diverse environment.
2. Restore the connection between the bankfull width and floodprone width of the channels by restoring the floodplain area.
3. Stabilize eroding banks
4. Provide a functional, native riparian floodplain corridor where deficient, and preserve any existing forested corridor.
5. Improve the physical aquatic habitat features.
6. Minimize land development impacts to the stream.
7. Provide long-term protection of the stream corridor.

The restoration techniques proposed for the Unnamed Tributary stream will provide the attributes described above by incorporating a variety of features recognized to support the stability and biological diversity that are essential to ecosystem enhancement. Presently, these features are non-existent or diminished within Silver Creek and the associated Unnamed Tributary.

The restoration of the Silver Creek main stem includes assessing and predicting the morphological features that will become the foundation for the construction of a stable natural channel. Considerations that have been applied to the design of this project are listed below.

- A bankfull channel designed with the appropriate dimension and cross-sectional area to convey anticipated bankfull flows and to entrain bedload material.
- A stable channel pattern extrapolated from data collected from a stable reference reach within the Silver Creek watershed.
- Grade control and bank stabilization structures that enhance the environmental and ecological attributes of the stream channel though the use of natural materials and native plantings.
- In-stream habitat features, such as sand/gravel bars, pool/riffle complexes, rock vanes, cross-vanes, J-hook vanes, log vanes, root wad bank stabilization structures, step-pools and re-establishment of the appropriate substrate material.
- Reconnection of the stream channel to a functional floodplain by making improvements to the stream channel and riparian zone that restores dimension and profile based on reference reach conditions.
- Inclusion of indigenous instream and riparian plantings.

Proven natural stream geometry relationships, as described by Newbury, Leopold, Wolman, Miller, Rosgen and others, are the basis for designing a stable, self-maintaining channel. These empirical relationships between channel pattern, profile and dimension and stream flow form the foundation for the restoration of the physical and biological functions of the stream. The restoration work focuses on the main channel of Silver Creek and an associated Unnamed Tributary. Full-scale restoration is proposed for the Unnamed Tributary, as well as Silver Creek's main stem.

Approximately 2,959 linear feet of channel will be restored on the main stem, and approximately 1,533 feet on the Unnamed Tributary. The total stream length designated in the restoration plan is approximately 4,492 linear feet, which is consistent with the anticipated restoration length of 4,520 linear feet of stream from the original proposal.

The restoration site will be monitored for a period of five consecutive years or until the required success criteria has been met as determined by the North Carolina Department of Water Quality and the US Army Corps of Engineers. Parameters that will be included in the annual stream monitoring to ensure the success of the restoration activities will include stream channel surveys (longitudinal and cross-sectional profiles), pebble counts, photographs, and vegetation surveys along the riparian buffer.

1.0 PROJECT SITE IDENTIFICATION AND LOCATION

1.1 Directions to Project Site

The proposed project is located approximately 3,000 feet east of Dysartsville Road and approximately 2,500 feet south of Patton Road, west of the City of Morganton, Burke County, North Carolina as shown on Figure 1. The project spans properties owned separately by Mr. and Mrs. Frank Queen and Mr. and Mrs. Richard Conway (Seven Springs Farms, Inc.).

1.2 USGS Hydrologic Unit Code and NCDWQ River Basin Designations

The Silver Creek watershed is located within the Catawba River Basin. The project stream reaches are mapped on North Carolina Department of Transportation Light Detection and Ranging (LiDAR) coverage and are located within USGS Catalog Unit Number 03050101 and Local Watershed 14-digit basin 03050101050050, as shown on Figure 2. Silver Creek restoration project is located in a wide, Rosgen Valley Type VIII, approximately 8.25 miles upstream from the confluence of Silver Creek with the Catawba River.

1.3 Project Vicinity Map

Figure 1 presents the project Site Vicinity Map.

2.0 WATERSHED CHARACTERIZATION

2.1 Drainage Area

The drainage area tributary to the downstream limits of the project on the main stem of Silver Creek is 8.26 square miles or 5,287 acres. The associated Unnamed Tributary has a contribution drainage area of 0.08 square miles or 48 acres. These watershed areas are shown on Figure 2. Drainage areas for the project site are summarized in Table 1.

TABLE 1
Drainage Areas
Project Number D05016-1 (Silver Creek and Unnamed Tributary)

Reach	Drainage Area (Acres)
Reference Reach – Brindle Creek*	746
Silver Creek Main Stem	5,287
Unnamed Trib to Silver Creek*	48
Total	5,287

*The reference reach (Brindle Creek) and Unnamed Tributary drainage areas are included in the total drainage area for the Silver Creek Main Stem (See Figure 2).

2.2 Surface Water Classification/ Water Quality

Silver Creek is currently rated as fully supporting High Quality Water and is located within a watershed that was targeted based on resource features rather than degraded water quality. Along the portion of Silver Creek within the Queen/Conway properties, Silver Creek has undergone significant bank erosion and downcutting, resulting in a disconnection from the floodplain and deposition of sediment in the stream bed. This project will restore the connection between the bankfull width and floodprone width of the channel by restoring the floodplain area. Pattern, dimension and profile will be improved through a combination of meander restoration and stabilization, instream structures installed to stabilize the streambanks, the streambed and enhance aquatic and riparian habitat.

2.3 Physiography, Geology, and Soils

The Silver Creek watershed is located in the Eastern Blue Ridge Foothills on the boundary between the Southern Inner Piedmont and Blue Ridge Mountains Physiographic Province of Western North Carolina. Soils are developed over fault-emplaced metamorphic and intrusive igneous rocks associated with the Smith River Allochthon and Sauratown Mountains Anticlinorium, uplifted and displaced during tectonic continental plate collision during the Alleghenian Orogeny about 356 million years (my) ago (Fullager and Odom, 1973).

Metamorphic rocks that outcrop within the Silver Creek watershed include biotite gneiss and schist, amphibolite, megacrystic biotite gneiss, and inequigranular biotite gneiss. The plutonic igneous rock formation that underlies the stream restoration project along the main stem and the majority of the Unnamed Tributary is a migmatic granite gneiss (foliated to massive, granitic to quartz dioritic, biotite gneiss and amphibolite common). The spring that defines the top of the Unnamed Tributary emerges from an outcropping of metamorphosed plutonic granitic rock, radioactive dated to approximately 455-540 my. The exposed rock is equigranular to megacrystic, foliated to massive and includes the Toluca Granite (Fullager and Odom, 1973).

The soils along the main stem of Silver Creek that have been derived from and developed over these metamorphic and plutonic igneous rock formations include the Colvard Series consisting of loamy sediments ranging from 40 to 60 inches or more in thickness over deposits of sandy, loamy gravelly to cobbly sediments. Rock fragments range from 0 to 15 percent to a depth of 40 inches, and from 0 to 80 percent below 40 inches. Flakes of mica range from a few to common (USDA NRCS, 1/3/06).

Along the Unnamed Tributary the Rhodhiss Series is present and is residuum from the underlying felsic crystalline bedrock. The Rhodhiss sandy to sandy-clay loam is found on 25 to 40 percent hillside slopes with a depth to bedrock greater than 60 inches. The depth to the top of the argillaceous (clayey) horizon ranges from 2 to 20 inches. The depth to the base of the argillaceous horizon is 20 to 60 inches or more. The pedon contains 0 to 20 percent mica flakes throughout, with mica content ranging up to 35 percent below a depth of 40 inches when the C horizon is present. Soils mapping and taxonomic descriptions are from the NRCS Soil Survey of Burke County, North Carolina (USDA NRCS, 1/3/06), and were provided by the Burke County Soil & Water Conservation District. Figure 3 shows the boundaries of mapped soil units within the project site and vicinity.

Valley Type VIII (Rosgen, 1996) is most readily identified landform along the main stem corridor, with the presence of river terraces positioned laterally along the broad valley with gentle, down-valley elevation relief in the project vicinity. Alluvial terraces and floodplains are the predominant depositional features and produce a high sediment supply.

First-order, Rosgen Type I v-shaped valleys and Type II narrow colluvial valleys, with their associated A and B type stream channels, respectively, dominate the upper reaches of the watershed. Second- and third-order streams within the watershed are attributed to alluvial riverine depositional processes where Rosgen Type VIII valleys with classic C3 to C5 channel types are the natural endpoints of landform evolution. Elevations within the watershed range from 2,818 feet above mean sea level (MSL) at Silver Creek Knob at the headwaters at the Burke County/Rutherford County line to below 1,120 feet MSL at the downstream limits of the stream restoration project. The resulting relief is 1,698 feet, from the headwaters to the downstream limits of the project, located approximately 5.3 miles downstream (north) from the watershed divide.

2.4 Historical Land Use and Development Trends

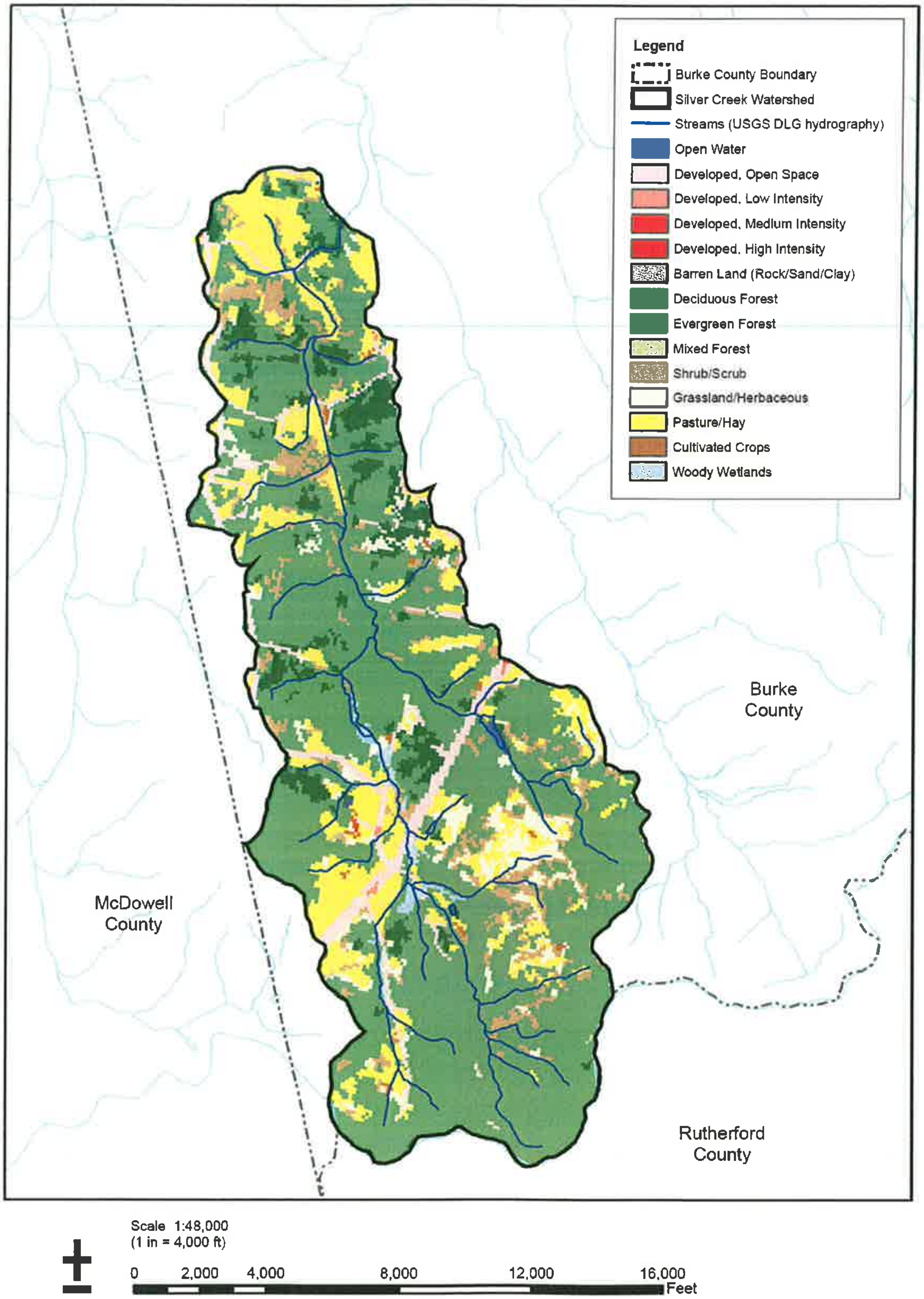
Within the watershed boundaries of the project, land use is predominantly agricultural, including row crop production and pasture/hay land with wooded and cleared hillsides. Land use in the vicinity of the project is not expected to change in the foreseeable future. Table 2 presents a breakdown of land use with the local watershed based upon USGS National Land Cover Data (NLCD, 2001).

TABLE 2
Silver Creek Watershed Land Use Summary
Project Number D05016-1 (Silver Creek and Unnamed Tributary)

Description	Count	Sq Meters	Acres	Sq Mi	Percent
Open water	33	29700	7.34	0.011	0.1%
Developed, open space	1222	1099800	271.77	0.425	5.4%
Developed, low intensity	25	22500	5.56	0.009	0.1%
Developed, medium intensity	7	6300	1.56	0.002	0.0%
Barren land (rock/sand/clay)	27	24300	6.00	0.009	0.1%
Deciduous Forest	13871	12483900	3084.84	4.822	60.7%
Evergreen Forest	1566	1409400	348.27	0.544	6.9%
Mixed Forest	5	4500	1.11	0.002	0.0%
Shrub/Scrub	1334	1200600	296.67	0.464	5.8%
Grassland/Herbaceous	1117	1005300	248.41	0.388	4.9%
Pasture/Hay	3360	3024000	747.25	1.168	14.7%
Cultivated Crops	79	71100	17.57	0.027	0.3%
Woody Wetlands	187	168300	41.59	0.065	0.8%
	Totals	**20,549,700**	**5,287**	**8.26**	**100.0%**

The following map identifies the distribution of land uses within the local watershed.

Silver Creek Watershed - USGS National Land Cover Dataset (NLCD) 2001



2.5 Endangered/ Threatened Species

Table 3 presents the Federally-listed Threatened or Endangered Species in Burke County, NC according to the US Fish and Wildlife Service website (http://nc-es.fws.gov/es/countyfr.html; last update 3/7/2002).

TABLE 3
Federal Threatened and Endangered Species in Burke County
Project Number D05016-1 (Silver Creek and Unnamed Tributary)

Common Name	Scientific Name	Federal Status	Known Occurrences
Bald Eagle	*Halieeatus leucocephalus*	Threatened	Current
Bog Turtle	*Clemmys muhlenbergii*	Threatened	Current
Dwarf-flowered Heartleaf	*Hexastylis naniflora*	Threatened	Current
Heller's Blazing Star	*Liatris helleri*	Threatened	Current
Mountain Golden Heather	*Hudsonia montana*	Threatened	Current
Small-whorled pogonia	*Isotria medeoloides*	Threatened	Current
Spreading Avens	*Geum radiatum*	Endangered	Historical

The "Known Occurrences" column refers to the last time the species was observed in a particular county, according to the species distribution maps from the North Carolina Natural Heritage Program dataset. "Current" means that the species was seen in the county within the last 20 years, and "Historical" means that the species was last observed in the county more than 20 years ago.

Species accounts for each of these Threatened and Endangered species were obtained from the US Fish and Wildlife Service website to determine whether suitable habitat exists within the project area. A request for a site-specific search of the North Carolina Natural Heritage Program Database was made to the North Carolina Department of Environment and Natural Resources (NCDENR). The search revealed no records of any rare species, significant natural communities, or priority areas within the Silver Creek project area, nor within a mile of the site.

Based on a review of all available information, including a site visit, no habitat for any of the listed species is present on the site. Due to a lack of available habitat, the Silver Creek project is not likely to have an adverse effect on any federally-listed threatened or endangered species. This information was presented in the Categorical Exclusion report submitted to and accepted by the Federal Highway Administration and State of North Carolina.

2.6 Cultural Resources

A literature review was prepared by EMH&T and submitted to the North Carolina Department of Cultural Resources, State Historic Preservation Office (SHPO) for review. In correspondence dated August 9, 2005, the SHPO recommended that the project area be surveyed for the presence of prehistoric and historic archaeological sites. Phase I Cultural Resources Management investigations were conducted by the Archaeological Division of EMH&T, Inc. for the project area during the month of August, 2005 (ER-05-1636). No historic buildings or structures were identified in the area of potential effect, and documentation of the survey methods and findings were provided to SHPO for review. EMH&T recommended no further archaeological investigation be conducted for the project site. In correspondence dated November 15, 2005, Mr. Peter Sandbeck, the SHPO Administrator, concurred with this determination.

2.7 Potential Constraints

There are no constraints that have potential to adversely impact or limit improvements associated with the Restoration Plan for Silver Creek and the associated Unnamed Tributary.

2.7.1 Property Ownership History and Boundary

The project site lies entirely within two tracts of land. The first tract is owned by Frank H. Queen and Sarah M. Queen (Map: 89 Page: 38, Blk. Lot: 4 7U, Deed Reference: Book 222 Page 654) containing approximately 156.25 acres; the second tract is owned by Seven Springs Farms, Inc., Richard P. Conway, President, Elizabeth B. Conway, Secretary, (Map: 89 Page: 38, Blk. Lot: 4 10U, Deed Reference: Book 1083 Page 924) containing approximately 324.37 acres. Both tracts are located in Silver Creek Township, Burke County, North Carolina.

2.7.2 Site Access

Access to the site is provided from Dysartsville Road across Seven Springs Lane as shown on Figure 1.

2.7.3 Utilities

To the best of our knowledge, there is only one utility located within the project corridor. An overhead electric line owned by Rutherford Electric Membership Corporation is present along the Unnamed Tributary to Silver Creek. The project will not disturb this existing utility, nor will the electric line hinder the construction of the project. The location and designation of that utility are shown on the Restoration Plan design sheets contained in Appendix 1.

3.0 PROJECT SITE STREAMS

3.1 Channel Classification

Silver Creek Main Stem

The North Carolina DWQ Stream Classification Form was completed for the Silver Creek reach and is included in Appendix 2. The stable, natural channel form for the main stem of Silver Creek is a Rosgen C4 stream type, based on detailed, quantitative analysis of a stable reference reach located approximately 2.4 miles upstream from the top of the altered reach within the Silver Creek watershed. Agricultural land use and channel incision have altered the channel throughout the project reach, resulting in its present unstable F4 type. The incised nature of the cannel is attributed to channelization and isolated areas of cattle intrusion, which resulted in vegetative denuding and bank destabilization from hoof shear.

The restoration plan for Silver Creek utilizes proven geomorphological approaches developed by understanding and implementing stable channel dimension, pattern and profile, based on data extrapolated from reference reach boundary conditions and superimposing stable dimension, pattern and profile on the unstable form. The approach will incorporate re-establishing a floodplain with appropriate elevation, width and valley slope, emulated from stable attributes measured, quantified and extrapolated from the reference reach boundary conditions.

Unnamed Tributary to Silver Creek

The North Carolina DWQ Stream Classification Form was completed for the Unnamed Tributary to Silver Creek and is included in Appendix 2. At the top of the Unnamed Tributary the stream emerges from a granite bedrock spring at altered profile survey station 15+10. From profile station 15+10 to station 5+00, the channel form is a classic Type I valley-confined, A1-A2 stream type with some bedrock control. In-stream boulders and flood-placed woody debris from leaning or fallen trees are present along the reach. The banks are unstable and steep to undercut. The vegetated riparian corridor along the Unnamed Tributary is visibly impaired. Cattle intrusion has adversely impacted the entire tributary as evidenced by vegetative denuding and bank failure attributed to hoof shear. Agricultural land use (pastureland) adjacent to the stream corridor and uncontrolled cattle access to the stream for drinking water and shade has resulted in unstable, steep to undercut stream banks, accelerated down-slope movement of colluvium into the stream channel and severe to extreme streambank erosion. The denuded, unstable streambanks are contributing large volumes of sediment and suspended solids to the larger Silver Creek watershed.

The Unnamed Tributary, in its natural form, is a Rosgen A1-A2, transitioning to a B4-B5 stream type with bed materials ranging in size from silt and sand to large cobbles and boulders from the bottom to the top of the stream reach. The transition from a v-shaped, Type I Valley confined "A" channel to a Type II colluvial valley "B4-B5" stream type occurs at approximate altered profile station 5+00 along the lower one-third of the impaired reach. Along this final 500 linear feet stream segment, the thalweg profile gradient flattens to less than four percent (0.04 ft/ft) and the floodplain widens enough to allow small meanders to form across the width of the stream's narrow floodplain. Since the terrain is less rugged along this stream segment, it is the preferred watering location for cattle grazing in the adjacent pastureland within the small, 48-acre watershed. An abandoned terrace exists adjacent to and along the right bank from altered profile station 2+00 to the bottom of the reach at altered profile station 0+00, where the stream emerges onto Silver Creek's Valley Type VIII floodplain, upstream from its confluence with another Unnamed Tributary. Approximately 250 feet downstream from the confluence of the two unnamed tributaries is the confluence point with the main stem of Silver Creek.

3.2 Discharge

Silver Creek Main Stem

For Silver Creek, bankfull discharge was determined through quantitative analysis of stable reference reach boundary conditions and comparison of predicted bankfull discharge through a stable riffle section located approximately 2.4 miles upstream from the impaired reach (project area). The reference reach is a stable, Rosgen C4 stream type with excellent connection to its healthy, deciduous hardwood forest floodplain. Calculated discharge for the reference reach riffle section was compared to stratified C-type streams data from *Bankfull Regional Curves for North Carolina Mountain Streams* data set, as included in the appendices of the multi-agency *Stream Mitigation Guidelines* document (USACE Wilmington District et al., 4/03). The calculated discharge using quantified reference reach data provided a very close match to the stratified data set. Bankfull characteristics for the altered main stem reach were extrapolated from the stratified dataset. Bankfull discharge at the top of the impaired reach, with a drainage area of 8.01 square miles and interpolated from the regional curve data set, is 460 cubic feet per second (cfs). Independent HEC-RAS modeling predicted the same flow for this position in the watershed, verifying the bankfull discharge for a 1.7-year return interval flow, extrapolated from the stratified dataset.

Unnamed Tributary

Bankfull discharge for the Unnamed Tributary was interpreted directly from regression equations published with the *Bankfull Regional Curves for North Carolina Mountain Streams*. The mountain streams regional curves data sets do not include data for A and B stream types with drainage areas less than one square mile. Therefore the regression equations developed from the regional curves data sets were used to extrapolate beyond the lower limits of verified bankfull dimensions, discharge and drainage area relationships. The area of a surveyed riffle cross-section near the bottom of the Unnamed Tributary reach, however, very closely matches the empirical relationship between drainage area and bankfull cross-sectional area extrapolated from the published regional curve data for North Carolina mountain streams. The predicted bankfull discharge for the Unnamed Tributary is 14.4 cfs.

3.3 Channel Morphology

As previously noted, existing morphology along the Silver Creek main stem altered reach is Rosgen Valley Type VIII. The pre-restoration channel is an unstable F4 stream type. The restoration goal is to re-establish pattern, profile and dimension consistent with the stable C4 reference reach boundary conditions. Table 4 summarizes the morphological data for Silver Creek and the reference reach.

TABLE 4
Morphological Data For Silver Creek and Reference Reach
Project Number D05016-1 (Silver Creek and Unnamed Tributary)

Item	Existing Conditions	Designed Conditions	Designed Conditions	Reference Reach
LOCATION	Silver Creek Main Stem	Silver Creek Main Stem	Unnamed Tributary	Brindle Creek, Trib to Silver Ck
STREAMS TYPE	F4	C4	A1-A2 to B4-B5	C4
DRAINAGE AREA, Ac-Sq Mi	5127.15 Ac – 8.01 Sq Mi	5127.15 Ac – 8.01 Sq Mi	48 Ac -0.08 Sq Mi	745.75 Ac – 1.16 Sq Mi
BANKFULL WIDTH (W_{bkf}), ft	30.0 ft	30.0 ft	8.0 ft	24.0 ft
BANKFULL MEAN DEPTH (d_{bkf}), ft	7-9 ft	3.0 ft	0.5	1.28 ft
WIDTH/DEPTH RATIO (W_{bkf}/d_{bkf})	3.3 – 4.3	9.0	16	18.77
BANKFULL X-SECTION AREA (A_{bkf}), ft^2	210-270 ft^2	90 ft^2	3.5 ft^2	30.77 ft^2
BANKFULL MEAN VELOCITY, fps	1.7-2.2 fps	5.1 fps	4.2 fps	3.19 fps
BANKFULL DISCHARGE, cfs	2300 cfs*	460 cfs	14.7 cfs	98.16 cfs
BANKFULL MAX DEPTH (d_{max}), ft	9 ft	4.2 ft	~~.5~~ 1.0	1.86 ft
WIDTH Flood-Prone Area (W_{fpa}), ft	40 ft	80 - 145 ft	Valley Confined to 15 ft	232 ft
ENTRENCHMENT RATIO (ER)	1.3	2.7 - 4.8	1.0 – 1.9	9.66
MEANDER LENGTH (Lm), ft	0 – 550	180 - 190	0 - 80	90 – 120

*Flow rate representative of the 5-year return interval event based on HEC-RAS analysis. Based on existing conditions, the 5-year peak discharge storm event will fill the existing channel (i.e., bankfull discharge) and flow out onto the existing floodplain.

The Unnamed Tributary is a Rosgen A1-A2, transitioning to a B4-B5 stream type in the lower third of the reach and has been impaired by agricultural impacts (mainly clearing of native deciduous hardwood forest to create pastureland and impacts associated with cattle intrusion, as previously noted).

3.4 Channel Stability Assessment

Silver Creek Main Stem

In its present state, the stream channel's unstable width to depth ratio (3.3 – 4.3), entrenchment ratio (flood prone width/bankfull width = 1.3), relatively flat profile slope (0.0027 ft/ft) and poorly defined active streambed has resulted in a deeply incised channel disconnected from its floodplain. Mid-channel, lateral, and transverse sand and gravel bar deposits are present at locations throughout the entire reach, demonstrating the stream lacks stable pattern, profile and dimension to entrain its bedload. The locations of these depositional features in the near bank region deflects flows from the center of the channel toward the incised vertical banks, accelerating streambank erosion. Near bank stress at a critical riffle cross-section, located at altered reach profile station 12+52.50, is approximately 2.24 lbs/square foot, based on design calculations. The near vertical, denuded 8-feet streambanks at this location are typical of the existing impaired stream reach within the main stem project corridor. Utilizing the near bank stress method algorithm included in RiverMorph® v.4.0, it is estimated 5,570 cubic yards per year (or 6,980 tons per year) of sediment is being eroded from the unstable stream banks along the main stem. Bank Erosion Hazard Index (BEHI) and sediment export estimates are included with the information in Appendix 3.

Silver Creek is a vertically contained stream that has abandoned its floodplain due to a lowering of base level and is characterized by 7 to 9 feet high, near vertical stream banks. The consequence of channelization, cattle intrusion, confinement (lateral containment), major floods, changes in sediment regime and loss of riparian vegetation are attributed causes and effects for existing conditions along the altered reach. The effects of these anthropogenic changes are accelerated streambank erosion, land loss, aquatic habitat loss, lowering of the water table, land productivity reduction and in-stream and downstream sedimentation.

Unnamed Tributary to Silver Creek

The Unnamed Tributary channel is a classic Type I valley confined, A1-A2 stream type transitioning to a Type II colluvial valley, B4-B5 stream type in the lower third of the altered reach. The upper two-thirds of the reach exhibits some bedrock control, in-stream boulders together with flood placed woody debris from leaning or fallen trees along the unstable, steep to undercut streambanks. The impaired riparian vegetative communities exacerbate streambank erosion rates and down-slope movement of colluvium. Cattle intrusion has adversely impacted the entire tributary as evidenced by vegetative denuding and bank failure attributed to hoof shear. Agricultural land use (pastureland) adjacent to the stream corridor and uncontrolled cattle access to the stream for drinking water and shade has resulted in unstable, steep to undercut streambanks, and accelerated severe to extreme streambank erosion. The unstable streambanks are contributing large volumes of suspended sediment and bedload material to the larger Silver Creek watershed. Utilizing the near bank stress method, adjusted for channel pattern and depositional features algorithm included in RiverMorph® v.4.0, it is estimated 290 cubic yards per year (or 375 tons per year) of sediment is being eroded from the unstable stream banks along the Unnamed Tributary. BEHI and sediment export estimates are presented in Appendix 3. Representative photographs of the Unnamed Tributary are presented in Appendix 4.

3.5 Bankfull Verification

Silver Creek Main Stem

As noted in Section 3.2, for Silver Creek main stem, bankfull discharge was determined through quantitative analysis of stable reference reach data and comparison of predicted bankfull discharge through a stable riffle section located approximately 2.4 miles upstream from the impaired reach (project area). Drainage area discharge relationships for the reference reach riffle section were compared to stratified C-type streams data from *Bankfull Regional Curves for North Carolina Mountain Streams* data set. The calculated discharge using quantified reference reach data provided a very close match to the discharge extrapolated from the stratified data set. Bankfull discharge at the top of the impaired reach, with a drainage area of 8.01 square miles was extrapolated from the from stable reference reach boundary conditions, with adjusted drainage area tributary to the altered reach (8.01 mi^2) with a calculated bankfull discharge of 461 cubic feet per second (cfs). Independent HEC-RAS modeling predicted the same flow for this position in the watershed, verifying the bankfull discharge for a 1.7-year return interval flow.

Unnamed Tributary

Bankfull characteristics for the Unnamed Tributary were interpreted directly from regression equations published with the *Bankfull Regional Curves for North Carolina Mountain Streams*. The mountain streams regional curves data sets do not include data for A and B stream types with drainage areas less than one square mile. Therefore the regression equations developed from the regional curves data sets were used to extrapolate beyond the lower limits of verified bankfull discharge, dimension and drainage area empirical relationships. The area of a surveyed riffle cross-section at altered profile station 1+15 near the bottom of the Unnamed Tributary reach, however, very closely matches the empirical relationship between drainage area and bankfull cross-sectional area extrapolated from the regression equations published regional curve data for North Carolina mountain streams. The surveyed bankfull cross-sectional area (A_{BKF}) is 3.9 ft^2. The A_{BKF} derived from the published power function regression equation, $A_{BKF} = 22.1A_w^{0.67}$, where A_w is the watershed area in square miles (for the Unnamed Tributary, the drainage area is 0.08 square miles). This equation yields a bankfull cross-sectional area of 3.7 ft^2. The survey verification of the required cross-sectional area needed to carry the estimated bankfull discharge of 14.4 cfs from the contribution drainage area, with a predicted return interval of 1.25 years, has therefore been carried forward into the design for the impaired Unnamed Tributary reach.

3.6 Vegetation

The existing riparian corridor along Silver Creek varies from wide to denuded within the project area. The wide portion consists of a mature forested corridor, while narrow and denuded areas are the result of a pine beetle infestation. A narrow forested corridor is present along the majority of the Unnamed Tributary. Typical species observed along the streams and adjancent forested areas include *Pinus taeda* (loblolly pine), *Platanus occidentalis* (sycamore) and *Ilex opaca* (American holly). Active cattle pasture land is present outside of the riparian corridors along both streams. Photographs of the Silver Creek corridor are included within Appendix 3, and Appendix 4 presents photographs of the Unnamed Tributary.

4.0 REFERENCE STREAMS

4.1 Watershed Characterization

A stable reference reach was selected using recent aerial photography (February 2005) and NCDOT LiDAR contour data coverages for the drainage area tributary to the restoration project in the Silver Creek watershed. Two complete meander wavelengths along the reference reach were evaluated using accepted stream classification techniques and procedures (D.L. Rosgen, 1994).

The location of the reference reach in relation to the project is shown on Figure 2. The top of the reference reach begins at 35°37'07" North Latitude and 81°48'58" West Longitude (NAD 83, UTM Zone 17 Coordinates 691,930.8729 N, 1,163,198.3476 E GPS Reference Point). The drainage area tributary to the reference reach is 1.16 square miles.

Dimension, pattern, profile and substrate data were collected along the reference reach and quantitatively evaluated using RiverMorph® v.3.1 software application. Reference reach geomorphologic summary reports, dimensionless ratios, longitudinal profile, cross-sections, including photos taken at stable riffle and pool cross-section locations, are included in Appendix 5. Figure 4 presents the pattern summary for the reference reach.

4.2 Channel Classification

The reference reach is a stable, Rosgen C4 stream type with excellent connection to its healthy, deciduous hardwood forest floodplain. Calculated discharge for a stable reference reach riffle cross-section was compared to stratified C Type streams data from *Bankfull Regional Curves for North Carolina Mountain Streams* data set. The calculated discharge using quantified reference reach data is a very close match to the stratified data's empirical relationships.

4.3 Discharge

The calculated bankfull discharge, using quantified and verified reference reach data collected at a stable riffle cross-section is 96.1 cfs. The calculations are included in the information within Appendix 5.

4.4 Channel Morphology

The reference reach channel morphology summary report is presented in Appendix 5. Stream channel morphology data for the reference reach, the Silver Creek main steam, and the Unnamed Tributary is presented in tabular format on Table 4.

4.5 Channel Stability Assessment

As shown on the photographs in Appendix 5, the plant community exists over the streambanks into the active channel along the reference reach. High root densities and depths were observed at both stable riffle and pool locations throughout the reference reach, with healthy communities of canopy, shrub and herbaceous species present. Best-fit trend lines drawn through the bankfull indicator points, water surface and thalweg points, respectively, on the longitudinal profile are essentially parallel. There is no indication of head cutting, downcutting, aggradation or degradation. The reference reach is an extremely stable, second-order C4 stream channel, with a large gravel to small cobble streambed substrate, based on quantitative analysis of reference reach boundary conditions measured in the field.

4.6 Bankfull Verification

See Section 4.2 for reference reach bankfull verification details.

4.7 Vegetation

The reference reach exists within a second-growth, forested floodplain containing mature trees, saplings, and some shrubs. Tree species observed along the reference reach include *Pinus taeda*, *Platanus occidentalis*, *Quercus rubra* (red oak), and *Fagus grandifolia* (American beech). Scattered *Symplocos tinctoria* (common sweetleaf) shrubs were also present. Vegetative cover along the reference reach is much more dense and intact than that along Silver Creek and the Unnamed Tributary. The reference reach flows through a wide forested area, rather than a narrow riparian corridor. Vegetation along the reference reach is undisturbed, and tree roots along the channel are providing stability along the reach. Photographs of the reference reach are provided within Appendix 5.

5.0 PROJECT SITE RESTORATION PLAN

5.1 Restoration Project Goals and Objectives

Silver Creek Main Stem

The ultimate goal and objective for the restoration project is to restore stable pattern, profile and dimension along the main stem of Silver Creek. This will be accomplished by raising the streambed using grade control structures (cross-vanes) to reduce critical shear stress in the near bank region while maintaining flow velocities required to entrain large gravel, based upon streambed particle size distributions collected from both the stable reference reach and the altered main stem reach. To establish the bankfull channel dimension, a floodprone bench will be constructed with appropriate elevation, width and slope, thereby restoring the floodplain area.

A combination of cross-vanes, J-hook vanes and rock vane deflector weirs will be constructed at appropriate locations throughout the reach to alleviate near bank stress and associated streambank erosion. Streambed structures, constructed using strategically placed boulder dual winged jetties, root wad bank stabilization structures, and log vanes will be utilized, where needed, to achieve entrainment velocities required to move silt and sand size particles through the system during normal and low-flow conditions. The streambed structures have the added benefit of creating aquatic habitat and preventing the development of deleterious depositional sand and gravel bars features within the active channel. The plan sheets detailing the design for the Silver Creek main stem (RP-3/19 through RP-8/19) are included in Appendix 1.

Unnamed Tributary to Silver Creek

The fundamental goal to stabilize the Unnamed Tributary within its valley confined stream channel is to stabilize steep to undercut banks with heavy coir fabric jute matting, combined with implementing an aggressive native revetment plan and excluding cattle from the riparian corridor. Step-pools will be constructed at appropriate spacing to dissipate energy during bankfull discharge events along stream segments in the upper two-thirds of the reach. The plan sheets presenting the design for the Unnamed Tributary stream (RP-9/19 through RP-11/19) are included in Appendix 1. Design details are provided in sheets RP-12/19 through RP-14/19 in Appendix 1.

5.1.1 Designed Channel Classification

The designed main stem channel is a stable C4 channel, with restored pattern, profile and dimension to entrain its bedload. The designed Unnamed Tributary stream will be restored to a stable A1-A2 stream, transitioning to a stable B4-B5 stream. Table 5 summarizes the restoration structure and objectives for Silver Creek and the Unnamed Tributary.

TABLE 5
Project Restoration Structure and Objectives
Project Number D05016-1 (Silver Creek and Unnamed Tributary)

Restoration Segment / Reach ID	Station Range	Restoration Type	Priority Approach	Existing Linear Footage	Designed Linear Footage	Comment
Reach I: Silver Creek Main Stem	00+00 – 29+59.12	Restoration	P1 PII	3,039 lf	2,959 lf	Reach I includes restoration of stable pattern, profile, dimension, substrate and floodprone area
Reach II: Unnamed Tributary to Silver Creek	0+00 – 15+32.70	Restoration	P1 PII	1,510 lf	1,533 lf	Reach II consist of restoration of stable profile, pattern, dimension and substrate

5.1.2 Target Buffer Communities

The target buffer community for both the Silver Creek main stem and the Unnamed Tributary is of the Piedmont/Low Mountian Alluvial Forest community type, as described in *Classification of the Natural Communities of North Carolina* (Schafale and Weakley, 1990). According to the Schafale and Weakley publication, hydrology of these areas is palustrine, seasonally or intermittently flooded on various alluvial soils. Important characteristices regarding the Piedmont/Low Mountain Alluvial forest Community according to Schafale and Weakley, 1990 include the following:

- *Flood carried sediment provides nutrient input to these communities, as well as serving as a natural disturbance factor.*

- *Variation is probably most related to frequency and recentness of destructive flooding. Sites may vary due to different alluvial material and its effect on soil fertility but almost all alluvial sites are more fertile than surrounding uplands.*

- *Piedmont/Low Mountain alluvial forests may be distinguished from mesic communities by location in a floodplain and by the presence of alluvial species such as Platanus occidentalis, Betula nigra, and Acer negundo.*

- *Piedmont Alluvial Forests may be distinguished from Montane Alluvial Forests by the presence of low elevation alluvial species such as Liquidambar styraciflua, Acer negundo, Fraxinus pennsylvanica, Ulmus americana, and Ulmus alata...*

5.2 Sediment Transport Analysis

5.2.1 Methodology

The modified Shields Equation was used to calculate the largest entrainable particle size, based on site-specific stable and altered boundary conditions for the Silver Creek main stem and the Unnamed Tributary. (Rosgen, 1994; Williams and Rosgen, 1989; Andrews, 1984).

5.2.2 Calculations and Discussion

Shields (1936) described shear stress as:

$\tau = \gamma RS$

where:

τ = shear stress (lbs/sq. ft.)
γ = specific weight of water (62.4 lbs/cu. ft.)
R = hydraulic radius (ft.), and
S = channel slope (ft./ft.).

To test the relationship between shear stress and mean stream velocity at multiple flow levels, Rosgen (1994) used an aggregate data set for six stream types. By plotting discharge (cfs) vs. bedload (lbs/sec) it was demonstrated a significant relationship was not found for the aggregate data set. Rosgen found, however, there is a significant empirical relationship when the same data set was stratified by stream type and shear stress (lbs/sq. ft.) was plotted vs. mean velocity (ft/sec) on a log-log scale.

The magnitude of shear stress required to entrain the design particle diameter (31 mm) is 0.524 lbs/sq. ft. with a required hydraulic radius of 2.35 feet, bankfull mean depth of 2.67 feet, and a mean bankfull velocity of 4.5 ft/sec.

The associated critical dimensionless shear stress (τ_{ci}*) was calculated based on the D50 particle distribution at altered main stem riffle section 12+52.5 and composite D50 particle distribution from the reference reach is 0.0098. When a composite particle distribution has been assembled for stable reference reach boundary conditions, the need for a bar sample particle distribution is negated (Wolman, 1954). Therefore the reference reach composite D50 particle size was used in the computation of τ_{ci}*).

The critical dimensionless shear stress, returned from RiverMorph®, is calculated using the following equation (Williams & Rosgen, 1989):

$\tau_{ci}{*} = 0.0834(D50_{BED}/D50_{BAR})^{-0.872}$

The following equation is used to predict the depth and slope needed to move the largest size of sediment available to the channel:

$$d = \frac{(\tau_{ci}^{*})\,(\gamma_S)\,(D50_{BAR})}{S}$$

Where:

γ_S = submerged specific weight of sediment
$D50_{BAR}$ = median diameter of bar sample
d = mean depth
S = mean water surface slope at bankfull

The required bankfull water surface slope, based on boundary conditions as noted, is 0.0037 ft./ft. The design thalweg average slope is 0.0027 ft/ft. To maintain stable geomorphic geometry relationships, streambed structures, constructed using strategically placed dual-winged boulder jetties, root wad bank stabilization structures, and log vanes will be utilized, where needed, to constrict flow and increase entrainment velocities needed to move silt and sand size particles through the system during normal and low-flow conditions and ensure critical entrainment velocity required to move the D50 design particle through the system at bankfull discharge is maintained. The streambed structures have the added benefit of creating additional aquatic habitat and will prevent the development of deleterious depositional sand and gravel bars features within the active streambed. Entrainment calculations are included in the RiverMorph design summary reports in Appendix 3.

5.3 HEC-RAS Analysis

An analysis of the floodplain of the project reach of both streams was undertaken to determine the elevations and extents of the existing floodprone areas of the channel valleys. Peak discharge values for both Silver Creek and its Unnamed Tributary were calculated using regional equations contained within *Estimating the Magnitude and Frequency of Floods in Rural Basins of North Carolina-Revised*, published by the U.S. Geological Survey (U.S.G.S.) as Report 01-4207 in 2001. This publication contains equations to calculate peak discharge rates for multiple storm events as summarized in Table 6.

TABLE 6
Peak Discharge Rates
Project Number D05016-1 (Silver Creek and Unnamed Tributary)

Storm Event	Unnamed Tributary (cfs)	Silver Creek	
		Upstream Project Limits (cfs)	Downstream Project Limits (cfs)
2-year	23	578	594
5-year	44	983	1010
10-year	63	1315	1351
25-year	93	1810	1858
50-year	121	2245	2301
100-year	154	2718	2788
500-year	252	4060	4161

The peak discharge values summarized above were plotted on semi-log paper to extrapolate a 1.7-year flow event to confirm the bankfull discharge calculated independently. This plot can be found in Appendix 6 and verifies that the bankfull discharge at the upstream project limits on Silver Creek main stem is 460 cfs.

The peak discharge values summarized above were entered into the U.S. Army Corps of Engineers Hydrologic Engineering Centers River Analysis System (HEC-RAS) computer program to determine the elevations of each of the various flood events. Topographic information used within the HEC-RAS analysis was taken from both aerial orthophotography and field survey information of the two project areas. The results of this analysis were utilized to confirm the extent of the floodplain for the two project areas and are included in Appendix 6. Along Silver Creek it was determined that a storm greater than a 5-year event would leave the channel and enter the floodplain. Based on the results of the HEC-RAS analysis of the Unnamed Tributary to Silver Creek, the channel is capable of conveying events larger than the 25-year event, with several locations conveying the 100-year event.

The project area is shown on the Flood Insurance Rate Map (FIRM) for Burke County, Number 370034, panel 0200C, dated June 17, 1991. The FIRM depicts no special flood hazard areas along Silver Creek or the Unnamed Tributary within the project area.

The proposed project increases the flood carrying capacity of Silver Creek by providing an excavated floodprone bench. A hydraulic backwater analysis has been performed using the U.S. Army Corps of Engineers HEC-RAS computer model and verifies that the proposed project will not increase the flood hazard potential of Silver Creek on adjoining properties. Regarding the improvements to the Unnamed Tributary, the entire watercourse is contained to the property owners participating in the project, who understand and accept the nature of the improvements. Furthermore, the watercourse and any associated flooding are also contained within a narrow and deep valley on these properties.

5.4 Stormwater Best Management Practices

5.4.1 Site-Specific Stormwater Concerns

Silver Creek Main Stem

The watershed area for Silver Creek within the project corridor is more than 8 square miles. As such, conventional methods for channel de-watering during construction of in-stream features are not practical for use on this project. All stormwater best management practices (BMP's) will be confined to areas outside and adjacent to the stream channel, reducing the possibility of sediment from denuded lands getting into the channel.

Unnamed Tributary to Silver Creek

Due to the small watershed area for this channel, stormwater BMP's will be applied that intercept and treat all stormwater flows from the watershed prior to their release to the downstream receiving channel.

5.4.2 BMP Device Description and Application

Design sheets RP-15/19 and RP-16/19 contained in Appendix 1 of this document detail the various BMP applications and provide an indication of their location along the project corridor, for both the main stem of Silver Creek and the Unnamed Tributary. The design sheets also includes notes and references for the installation and maintenance of these features. There are also notes specific to construction sequence, intended to reduce the impact of sedimentation within the project corridor. Further discussion of the two different scenarios is provided below.

Silver Creek Main Stem

As described previously, all BMP applications will be outside of the channel. Essentially, it is proposed that sediment barrier fencing or straw waddles be applied as a buffer between the stream channel and adjoining denuded areas. Where there are areas of concentrated flow coming to the stream channel from the adjoining areas, then a method will be applied to convey that flow directly to the stream channel without passing through the denuded areas. This may include temporary culverts, or rock or fabric lined drainage swales. The determination of these locations and the appropriate application will be coordinated with the contractor prior to and during construction.

Unnamed Tributary to Silver Creek

As described previously, the approach to stormwater BMP along this watercourse is to capture and treat sediment laden flows prior to reaching the downstream channel. That can be accomplished using a sediment trap at the downstream end of the project corridor. Maintenance of that feature will be important to ensure that it provides the required storage volume for the capture of sediment for the duration of the project. Furthermore, the contractor may choose to use conventional de-watering practices to facilitate construction of the many in-stream features included along the project corridor.

5.5 Natural Plant Community Restoration

5.5.1 Plant Community Restoration Plan

The proposed riparian planting plan was developed by integrating the native plant species observed on site along with selected species known to inhabit the Piedmont/Low Mountain alluvial forest community type as described in *Classification of the Natural Communities of North Carolina* (Schafale and Weakley, 1990) to institute species diversity. According to the Schafale and Weakley publication, hydrology of these areas is palustrine, seasonally or intermittently flooded on various alluvial soils. Important characteristices regarding the Piedmont/Low Mountain alluvial forest community according to Schafale and Weakley, 1990 include the following:

- *Flood carried sediment provides nutrient input to these communities, as well as serving as a natural disturbance factor.*
- *Variation is probably most related to frequency and recentness of destructive flooding. Sites may vary due to different alluvial material and its effect on soil fertility but almost all alluvial sites are more fertile than surrounding uplands.*

- _Piedmont/Low Mountain alluvial forests may be distinguished from mesic communities by location in a floodplain and by the presence of alluvial species such as Platanus occidentalis, Betula nigra, and Acer negundo._

- _Piedmont Alluvial Forests may be distinguished from Montane Alluvial Forests by the presence of low elevation alluvial species such as Liquidambar styraciflua, Acer negundo, Fraxinus pennsylvanica, Ulmus americana, and Ulmus alata..._

Silver Creek Mainstem

Along the mainstem of Silver Creek, the majority of the restored riparian zone will be located within the created bankfull bench and toe slope areas. The restored streams will be fully replanted with the appropriate native species in the form of live stakes or bare-root material, along with some larger specimens (1 gallon container size). Planting zones have been designated for Silver Creek as described in the tables below. The bare root seedlings will be planted during the fall or early spring seasons, as soon as possible after the completion of the earthwork associated with constructing the new stream channels. During the following fall, supplemental shrub and tree species will be planted if survival rates of previously planted seedlings are below target densities as determined in late summer (August-September). Final species selection will be based upon availability. In addition to planting described below, temporary and permanent seeding will occur in Zones 2, 3 & 4. The planting plan is presented in the schematic engineering drawings, included on design sheet RP-17/19 in Appendix 1.

Proposed Silver Creek Plantings

- Zone 1 – Outside Meander bends
  Live branches, 2x2' centers

Common Name	Scientific Name
Silky dogwood	_Cornus amomum_
Southern arrowwood viburnum	_Viburnum dentatum_
Elderberry	_Sambucus canadensis_
Black willow	_Salix nigra_

- Zone 2 – Streamside Shrubs and Trees

Shrubs - 4x4' centers

Common Name	Scientific Name
Painted buckeye	_Aesculus sylvatica_
Silky dogwood	_Cornus amomum_
Tag alder	_Alnus serrulata_
Black willow	_Salix nigra_
Elderberry	_Sambucus canadensis_
Southern arrowwood viburnum	_Viburnum dentatum_
American hazelnut	_Corylus americana_

- Zone 2 – Streamside Shrubs and Trees (cont.)

Trees – 100 foot spacing (1 gallon container size)

Common Name	Scientific Name
Box elder	*Acer negundo*
River birch	*Betula nigra*
Sycamore	*Platanus occidentalis*
Sweet gum	*Liquidambar styraciflua*
Green ash	*Fraxinus pennsylvanica*
Tulip poplar	*Liriodendron tulipifera*
American elm	*Ulmus americana*
Bitternut hickory	*Carya cordiformis*

- Zone 3 – Floodplain
  8x8' centers

Common Name	Scientific Name
Box elder	*Acer negundo*
River birch	*Betula nigra*
Sycamore	*Platanus occidentalis*
Sweet gum	*Liquidambar styraciflua*
Green ash	*Fraxinus pennsylvanica*
Tulip poplar	*Liriodendron tulipifera*
American elm	*Ulmus americana*
Bitternut hickory	*Carya cordiformis*

- Zone 4 – 30' Riparian Buffer
  10x10' centers

Common Name	Scientific Name
White ash	*Fraxinus alba*
Black walnut	*Juglans nigra*
Tulip poplar	*Liriodendron tulipifera*
Black gum	*Nyssa sylvatica*
Black cherry	*Prunus serotina*
White oak	*Quercus alba*

Unnamed Tributary to Silver Creek

Along the majority of the Unnamed Tributary to Silver Creek, a narrow riparian corridor is present. The existing riparian vegetation will be preserved to the extent possible and will be enhanced through the installation of supplemental plantings as indicated on design sheets RP-18/19 through RP-19/19 in Appendix 1. A mixture of bare-root tree material including *Fraxinus alba, Juglans nigra, Liriodendron tulipifera, Nyssa sylvatica, Prunus serotina*, and *Quercus alba* will be planted on 10' by 10' centers. Some additional larger caliper trees will also be incorporated into the plantings. In areas where cattle intrusion has caused the most damage to the corridor, bare-root material will be installed on 8' by 8' centers in addition to some larger caliper container trees. A full replanting of the riparian corridor will be performed for areas along the stream that are cleared for restoration construction, including the excavated floodplain bench and construction access points. This full replanting will follow the 'zone' methodology prescribed for the mainstem of Silver Creek.

5.5.2 On-Site Invasive Species Management

This project proposes to treat and eradicate exotic woody vegetation by appropriate means. This will help meet one of the overall goals of the restoration project by enhancing buffers and creating habitat for birds and animals. By eradicating non-native vegetation, native vegetation will be allowed to colonize and provide a better food source for the local fauna.

Before treatment, a vegetation assessment would be performed to determine extent of invasive vegetation. The most appropriate treatment options will be determined after the assessment. Possible treatments for invasive exotic vegetation include application of appropriate herbicides either through stem cut and spray or spraying of the actively photosynthesizing leaves. This work would most likely be done in the fall or winter, during the dormant season of most native vegetation. The initial treatment would likely take a week to complete. Follow up and maintenance is critical in order to eradicate any root sprouts that may occur in the following seasons.

6.0 PERFORMANCE CRITERIA

6.1 Streams

As discussed in the original proposal, the restoration goal for the stream is to restore the physical and biological integrity beyond current stream conditions. Current conditions consist of modified or impaired stream channels. Objectives to meet that goal of restoring these stream channels include the following:

1. Provide a stable stream channel with features indicative of a biologically diverse environment.
2. Restore the connection between the bankfull width and floodprone width of the channels by restoring the floodplain area.
3. Stabilize eroding banks.
4. Provide a functional, native riparian floodplain corridor where deficient, and preserve any existing forested corridor.
5. Improve the physical aquatic habitat features.
6. Minimize land development impacts to the stream.
7. Provide long-term protection of the stream corridor.

Restoration of the streams will provide all the desired habitat and stability features necessary to improve the quality of the stream. There are many long-term benefits derived from the efforts to restore the streams, such as:

- reversing the effects of channel incision
- stabilizing eroding channel banks
- development of instream habitat features
- re-vegetation of the riparian corridor with native, wildlife friendly plants
- construction of a floodplain with the accompanying benefits of sediment and nutrient storage

The restoration techniques proposed for the Unnamed Tributary stream will provide the attributes described above by incorporating a variety of features recognized to support the stability and biological diversity that are essential to ecosystem enhancement. Presently, these features are non-existent or diminished within Sliver Creek and the associated Unnamed Tributary.

The restoration of the stream includes assessing and predicting the morphological features that will become the foundation for the construction of a stable natural channel. Considerations that have been applied to the design of this project are listed below.

- A bankfull channel designed with the appropriate dimension and cross-sectional area to convey anticipated bankfull flows and to entrain bedload material.
- A stable channel pattern (sinuosity) extrapolated from data collected from a stable reference reach within the Silver Creek watershed.
- Grade control and bank stabilization structures that enhance the environmental and ecological attributes of the stream channel though the use of natural materials and native plantings.

- In-stream habitat features, such as sand/gravel bars, pool/riffle complexes, rock vanes, cross-vanes, J-hook vanes, log vanes, root wad bank stabilization structures, step-pools (where appropriate) and re-establishment of the appropriate substrate material.
- Reconnection of the stream channel to a functional floodplain, to be accomplished using a combination of Priority 1 (raising the stream channel) and Priority 2 (lowering the floodplain) restoration.
- Inclusion of extensive instream and riparian plantings.

Proven natural stream geometry relationships as described by Newbury, Leopold, Wolman, Miller, Rosgen and others, is the basis for designing a stable, self-maintaining channel. These empirical relationships between channel pattern, profile and dimension and stream flow form the foundation for the restoration of the physical and biological functions of the stream.

6.2 Stormwater Management Devices

Properly installed and well maintained BMP applications should adequately mitigate the impact of sediment laden stormwater flows within the project corridor. Stormwater BMP's for the project are discussed in Section 5.4. All BMP applications will be inspected and maintained throughout the construction process and until the site is stabilized.

6.3 Vegetation

The target density for the riparian buffer is to establish a minimum of 320 stems per acre after 3 years, with a minimum of 260 stems per acre at the end of the 5-year monitoring period. This would represent a minimum survival rate of 80% of the plantings.

6.4 Monitoring Schedule and Reporting

The restoration site will be monitored for five consecutive years or until the required success criteria has been met as determined by the EEP, NC DWQ, and USACE. Monitoring activities will begin immediately following completion of the stream construction in order to alleviate any potential problems as they occur. Planting will occur during the fall of 2006 and possibly spring of 2007; therefore, the riparian buffer restoration will be monitored the following growing season projected to be summer of 2007. Monitoring activities will follow the guidelines presented in the request for proposal for this project.

Parameters that will be included in the annual stream monitoring to ensure the success of the restoration activities will include stream channel surveys (longitudinal and cross-sectional profiles), pebble counts, photographs, and vegetation surveys.

Following the submittal of the monitoring reports to the appropriate agency representatives, the recipients of the report will be contacted for the purpose of discussing the monitoring data, required success criteria and whether or not the site is functioning as expected. If the site is not functioning as expected, a site visit will be scheduled with the review agencies so that consideration can be given to whether a remediation plan should be created and implemented. The remediation plans, if required, will directly reflect the requested alterations as discussed with the regulatory agencies, if it is determined that such alterations will correct any identified deficiencies.

Stream Channels

Stream channel stability will be physically monitored by establishing permanent cross-sections located approximately every 500 feet along the restored channels (or no more than 2 per thousand feet). Each cross-section will be monumented for future identity and survey. All of these cross-sectional surveys will also be utilized as photographic points. Cross-section locations to be monitored will be established immediately following construction during the completion of the "as-built" survey. A longitudinal profile survey will be conducted along the entire restoration reach of the Silver Creek main stem as well as the entire Unnamed Tributary. The "as-built" report will include the constructed stream channel dimension, pattern, and longitudinal profile. This data will be utilized as baseline to compare future monitoring surveys and subsequently to determine channel stability and transition. Other data collected will include at least six pebble counts for the project, stream pattern data, and stream side plant conditions. Annual inspection of in-stream structures will also occur to verify proper function and channel stability. Stream channel monitoring surveys will be completed annually for five consecutive years, starting on Year 1 after completion of the project.

Riparian Buffers

Vegetation within the restored riparian buffer will be monitored for five consecutive years. Ten by ten meter square plots will be permanently established following completion of the planting phase and at least two opposing corners will be permanently installed and surveyed for future use. Approximately 5% of the project area will be monitored. A stem count of planted species will be performed within each monitoring plot. The species, density, survival rates, and the cause of mortality if identifiable will be reported for each planted species in each plot. Vegetation plots will be sampled annually and reported every year along with the data collected during the physical monitoring of the channel. The primary focus of the vegetative monitoring will be on the planted individuals in the tree and shrub strata, although herbaceous species encountered may also be recorded. Vegetation monitoring will occur between August and October.

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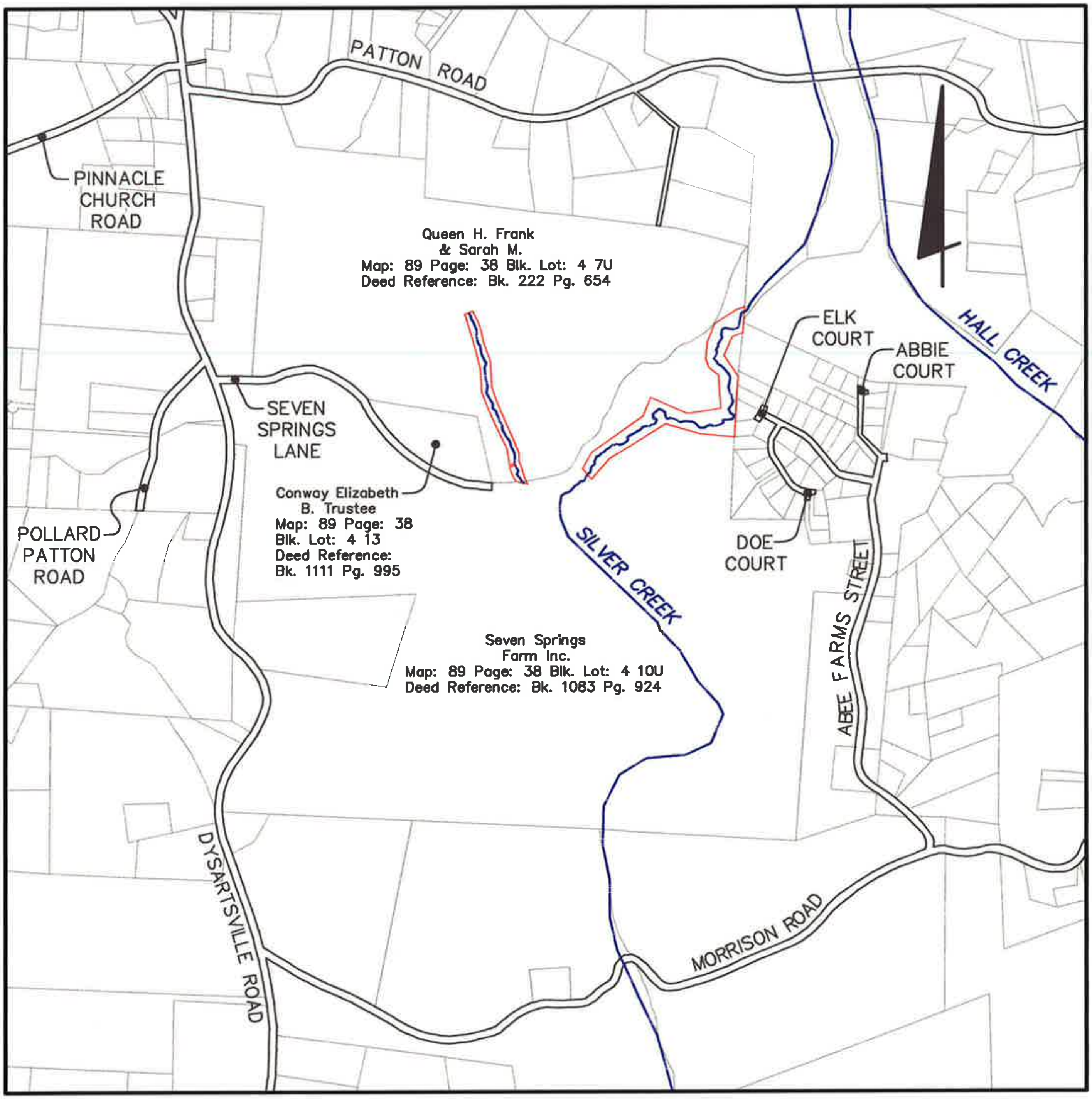


EMH&T
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists

BURKE COUNTY, NORTH CAROLINA

SILVER CREEK RESTORATION

FIGURE 1: SITE VICINITY MAP

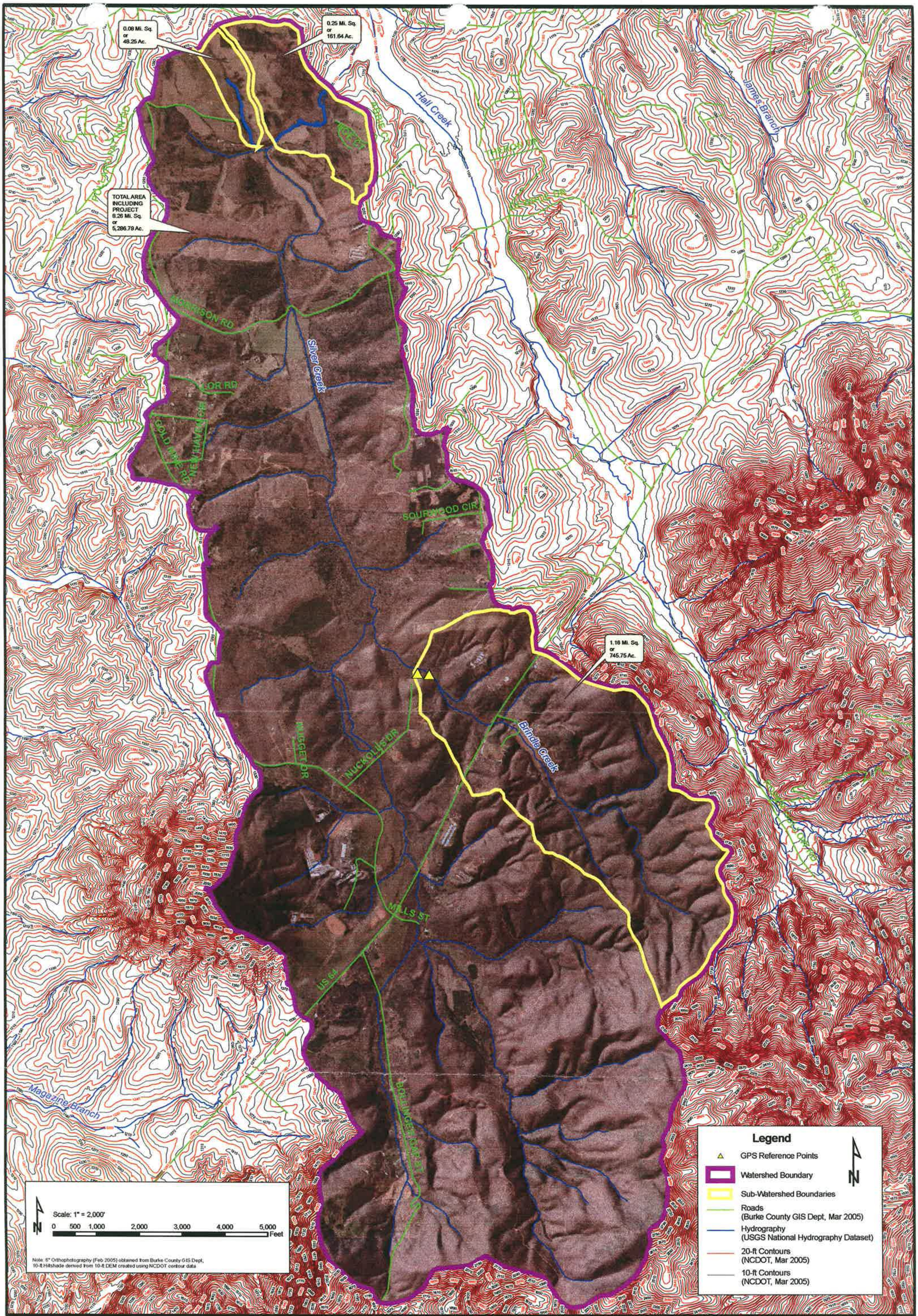
N.C. ECOSYSTEM ENHANCEMENT PROGRAM

Date: May, 2006

Not To Scale

Ecosystem Enhancement PROGRAM

\\CMHDATA2\ENVI... ROJECT\20051446\DWG\EXHIBITS\FIGURE 1- VICINITY MAP.DWG<LAYOUT1> - NO XREFS - LAST SA... Y JCRAMER [5/18/2006 12:13:58 PM] - PLOTTED BY JCRAMER [5/19/2006 12:53:33 PM]



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BURKE COUNTY, NORTH CAROLINA

SILVER CREEK WATERSHEDS
6" Orthophotography (Feb 2005) over 10-ft Hillshade
FIGURE 2

Date: May, 2006

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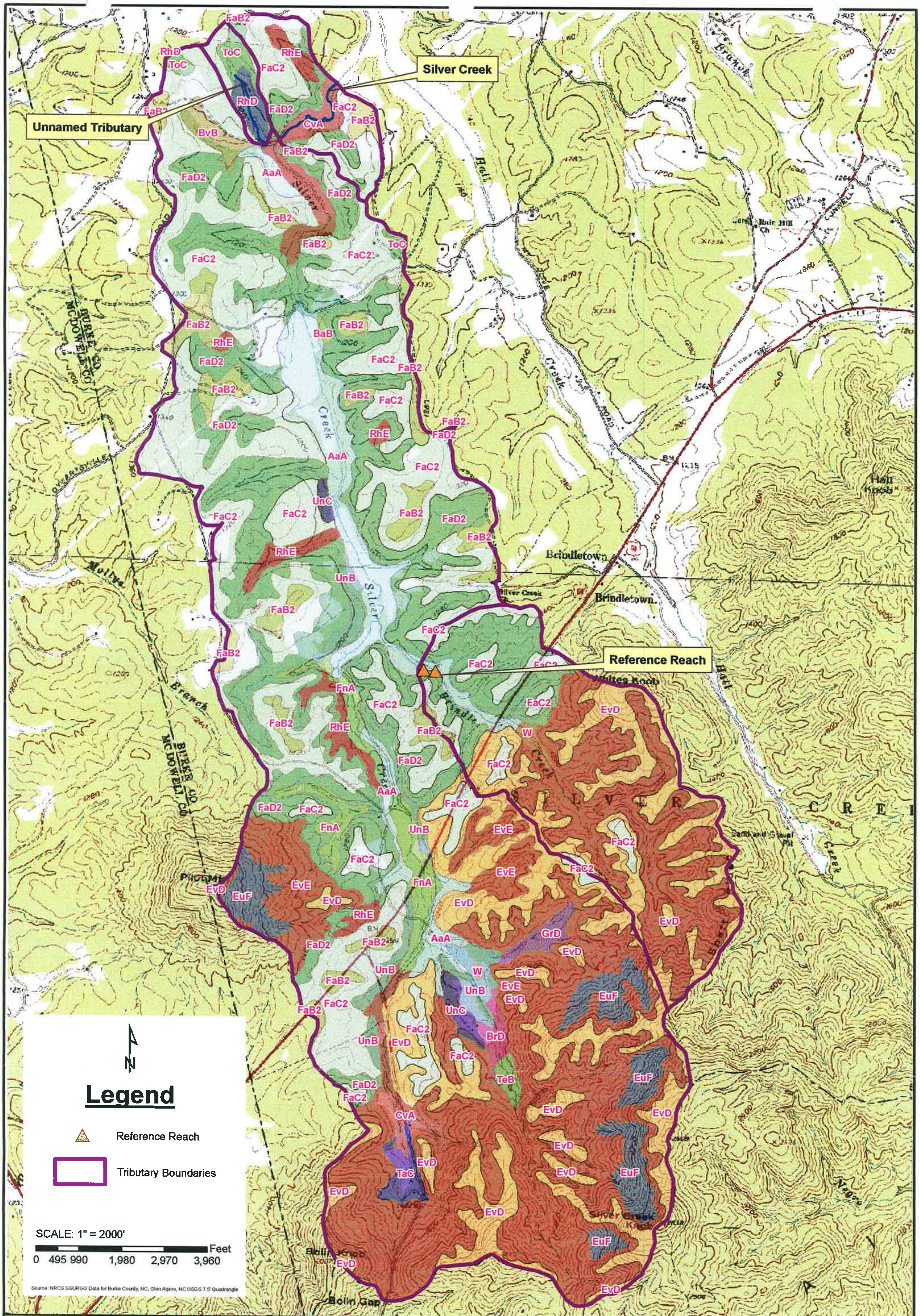

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SILVER CREEK RESTORATION

SOILS DATA

FIGURE 3

Date: May, 2006

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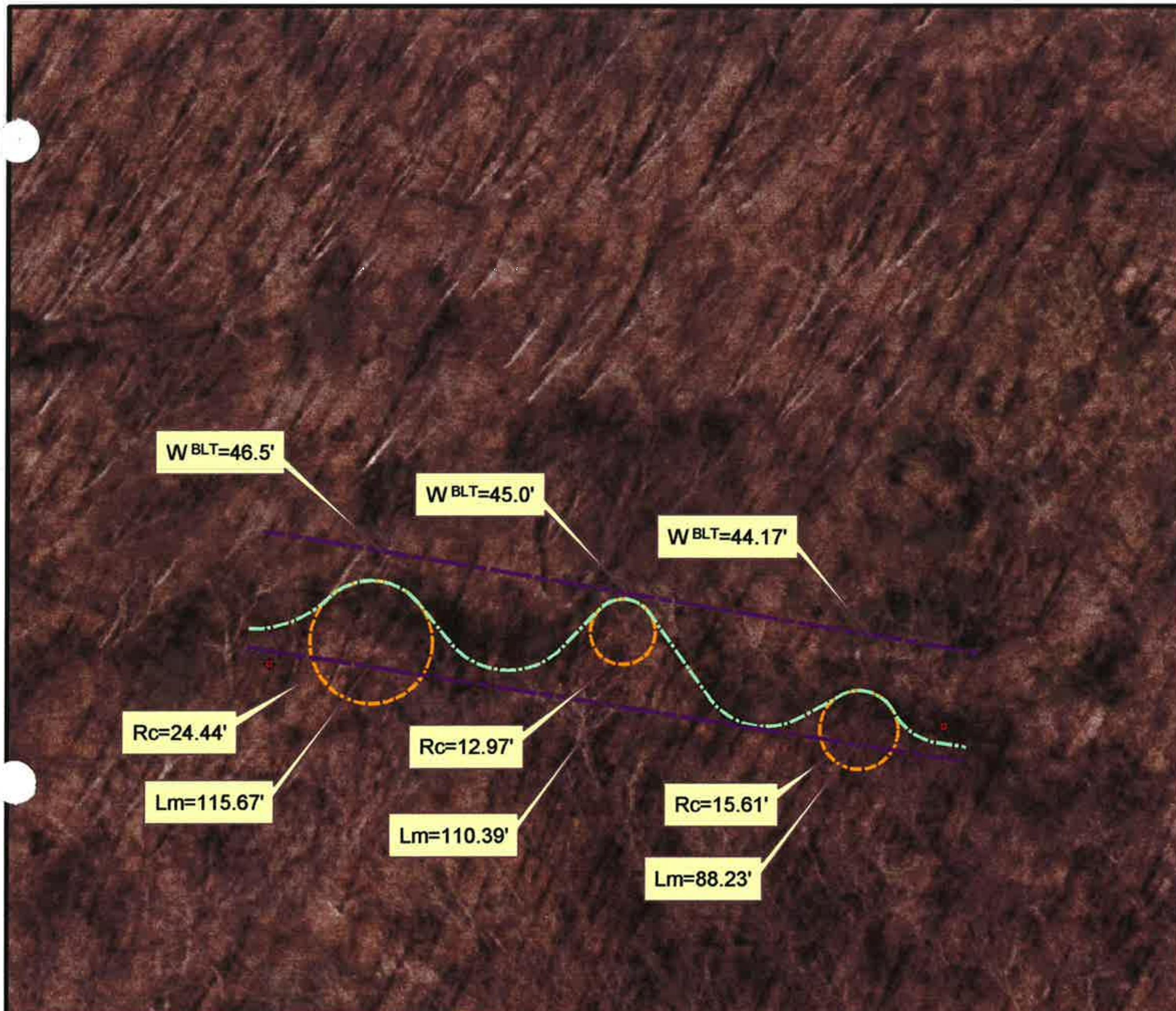

Legend

N

◆ Silver Creek Reference Reach

Mean Beltwidth = W BLT=45.22'
Mean Radius of Curvature = Rc=17.67'
Mean Meander Length = Lm=104.76'
Sinuosity = K=1.2

SCALE: 1" = 60'

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SILVER CREEK RESTORATION
REFERENCE REACH - PATTERN SUMMARY
FIGURE 4

Date: May, 2006

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APPENDIX 1

Restoration Plan Design Sheets

BURKE COUNTY, NORTH CAROLINA

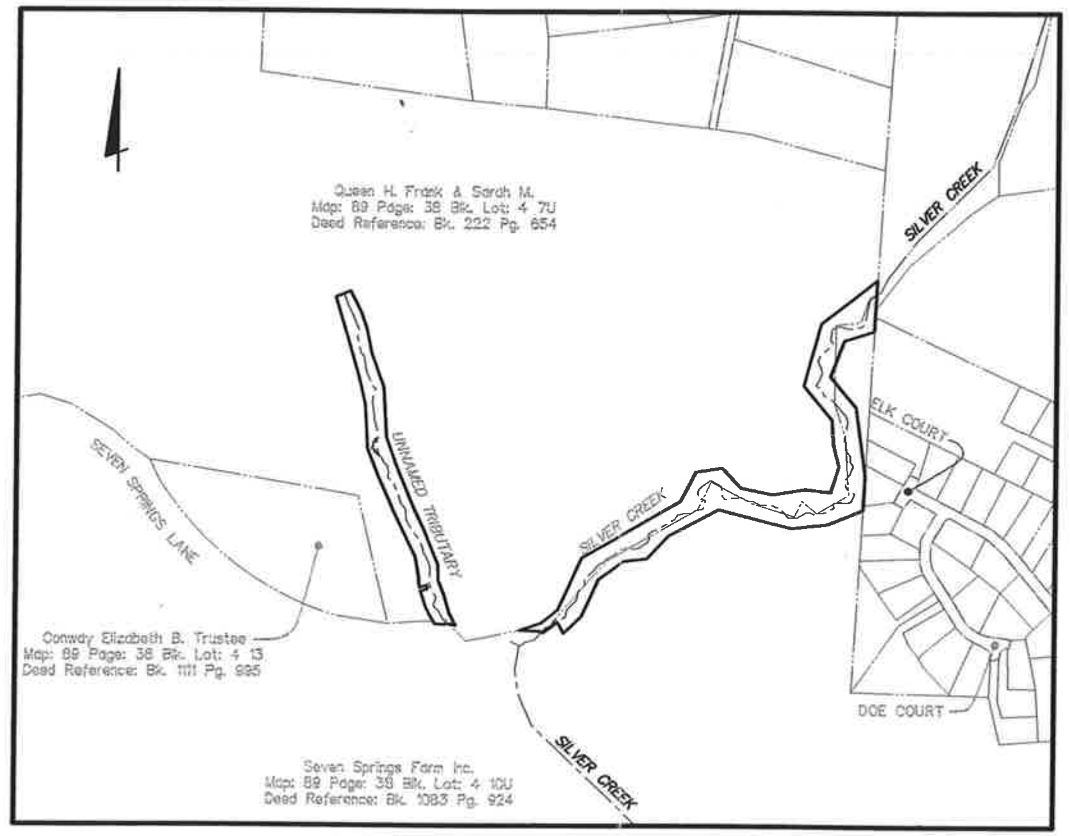
STREAM RESTORATION PLAN

FOR

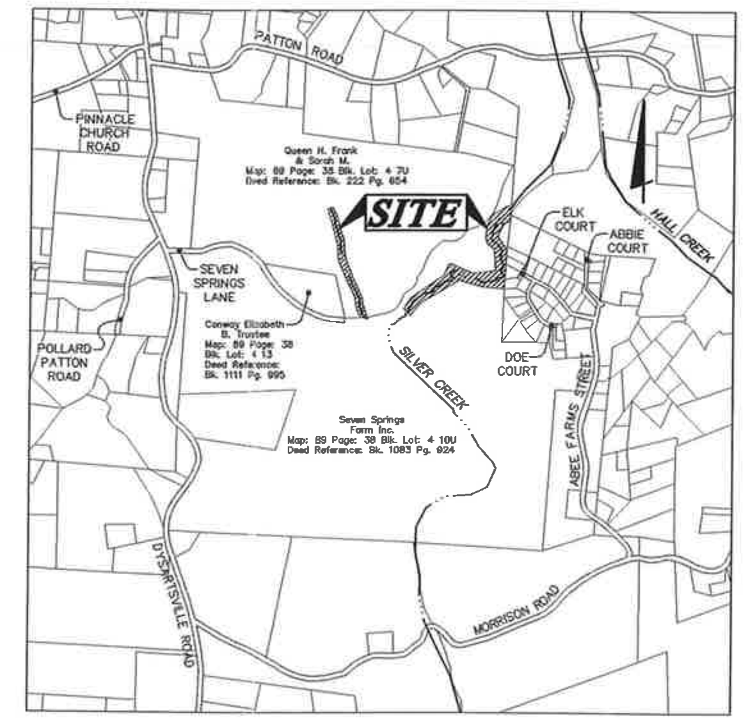
SILVER CREEK AND UNNAMED TRIBUTARY

2006

INDEX OF SHEETS



LOCATION MAP
Scale: 1"=400'



VICINITY MAP
Not To Scale

PRELIMINARY
NOT FOR CONSTRUCTION

Job No. 2005-1446
Sheet RP-1/19
Date May, 2006 Rev. June 2006
Scale As Noted

BURKE COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
SILVER CREEK AND UNNAMED TRIBUTARY
STREAM RESTORATION PROJECT
TITLE SHEET

Ecosystem Enhancement PROGRAM

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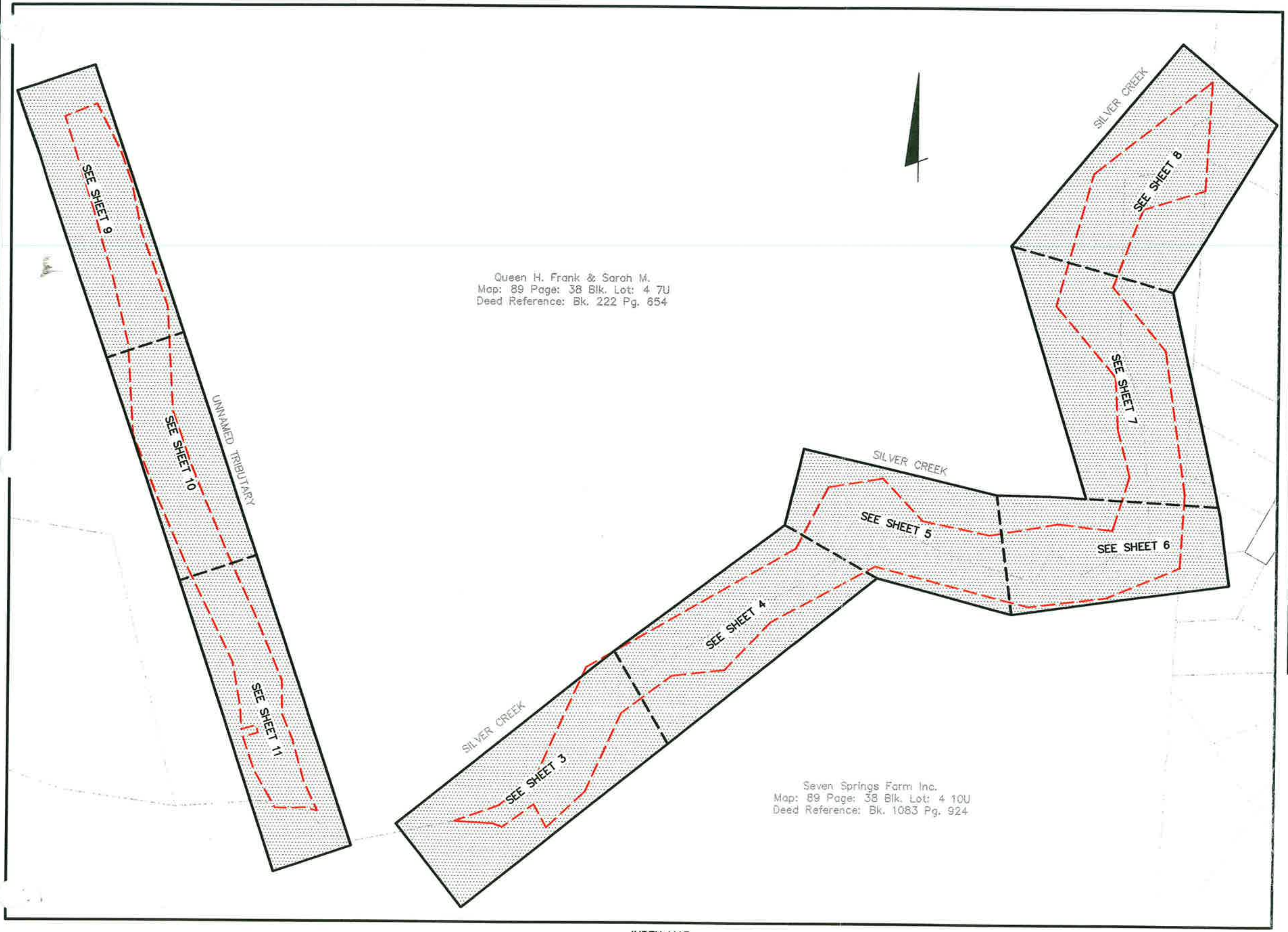
REVISIONS
MARK | DATE | DESCRIPTION



INDEX MAP
Scale: 1" = 100'

LEGEND

- EX. POWER POLE
- EX. GUY WIRE
- EX. HARDWOOD TREE
- EX. PINE TREE
- EX. DEBRIS AREA
- EX. SAND BAR
- EX. POOLS
- EX. ROCKS
- EX. ROOT WAD
- LOG — EX. LOG
- SILL — EX. SILL
- EX. TREE LINE
- EX. 1 FOOT CONTOURS
- EX. 5 FOOT CONTOURS
- EX. THALWEG
- EX. FENCE
- PROPERTY LINE
- PROP. THALWEG
- PROP. BANKFULL
- PROP. BELTWIDTH
- PROP. CONSERVATION EASEMENT
- PROP. CONSTRUCTED POINT BAR
- PROP. BANK FILL
- PROP. LOG
- PROP. RIFFLE
- PROP. CROSS VANE
- PROP. J-HOOK
- PROP. ROCK VANE
- PROP. ROOT WAD
- PROP. STEP LOG

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BURKE COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
SILVER CREEK AND UNNAMED TRIBUTARY
INDEX SHEET

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Job No.	2005-1446
Sheet	RP-2/19
Date	May, 2006 Rev. June 2006
Scale	As Noted

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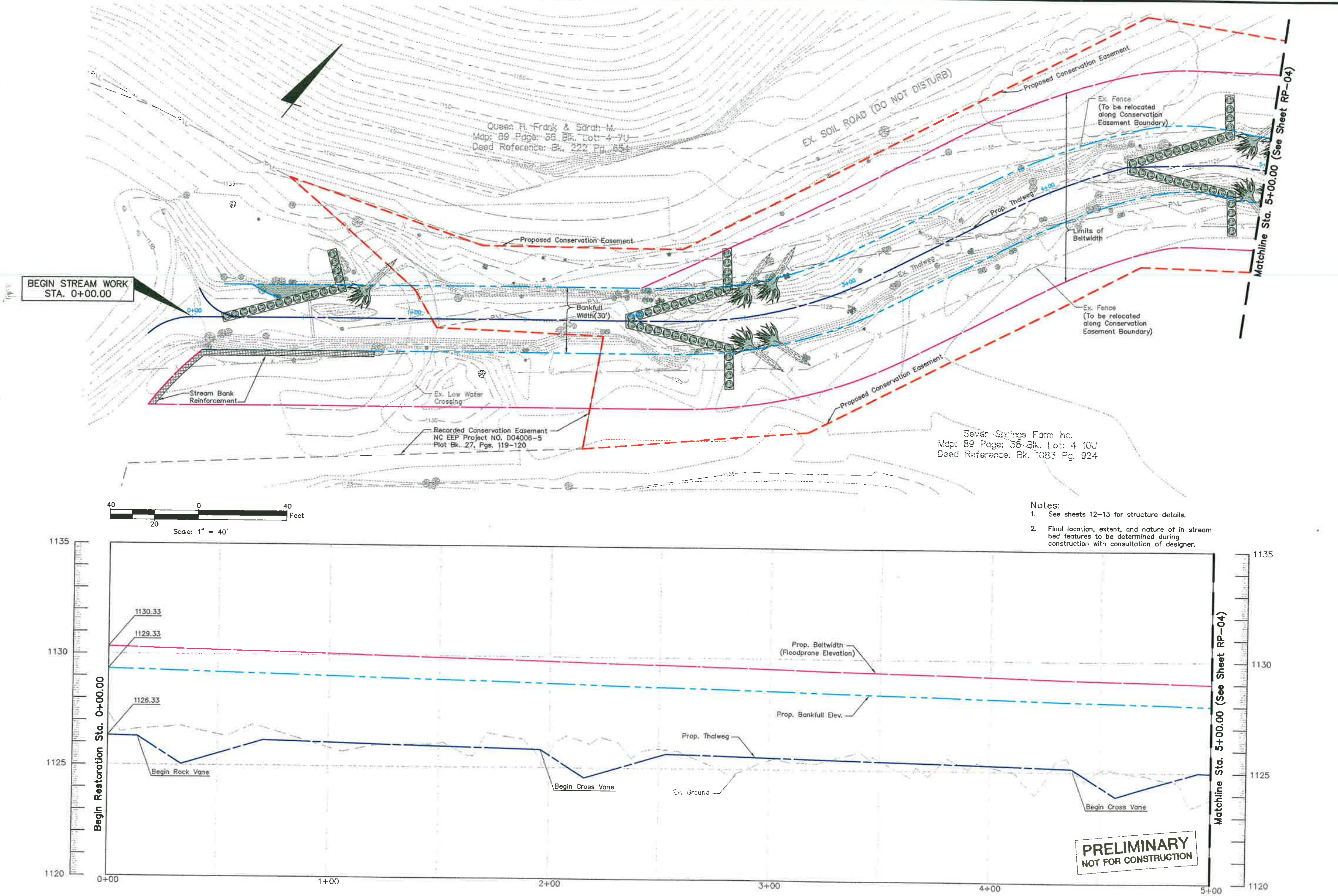

Notes:
1. See sheets 12–13 for structure details.
2. Final location, extent, and nature of in stream bed features to be determined during construction with consultation of designer.

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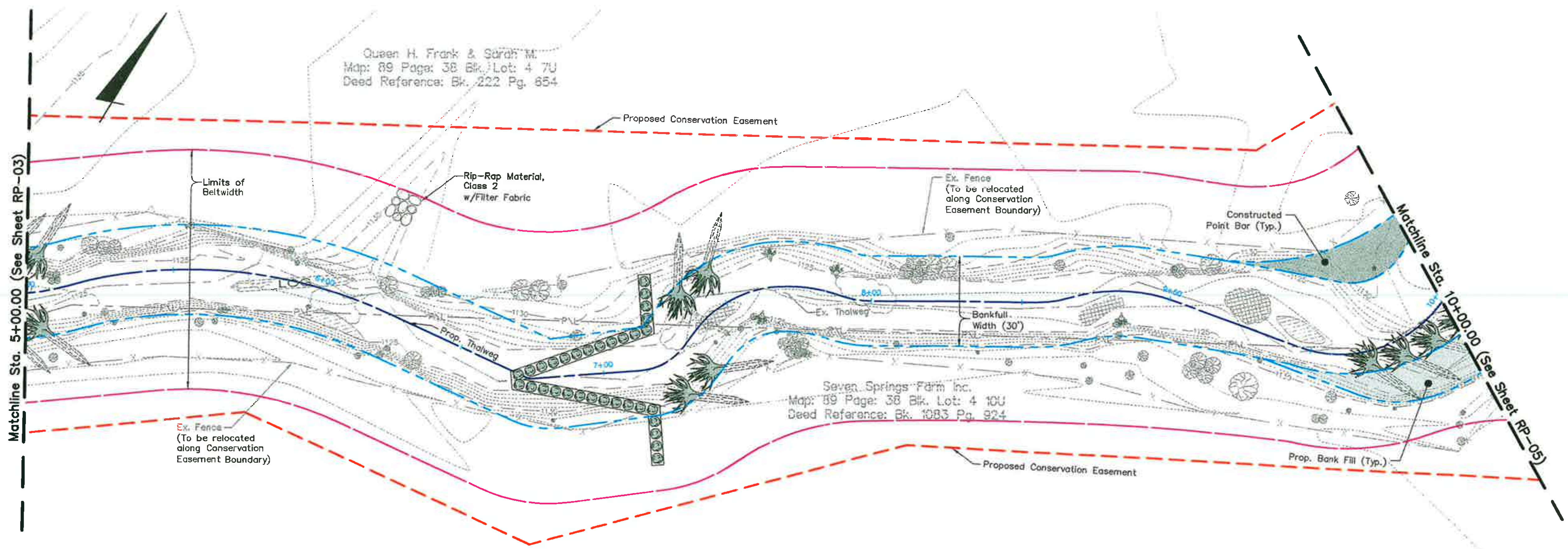
BURKE COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
SILVER CREEK AND UNNAMED TRIBUTARY
SILVER CREEK
PLAN & PROFILE

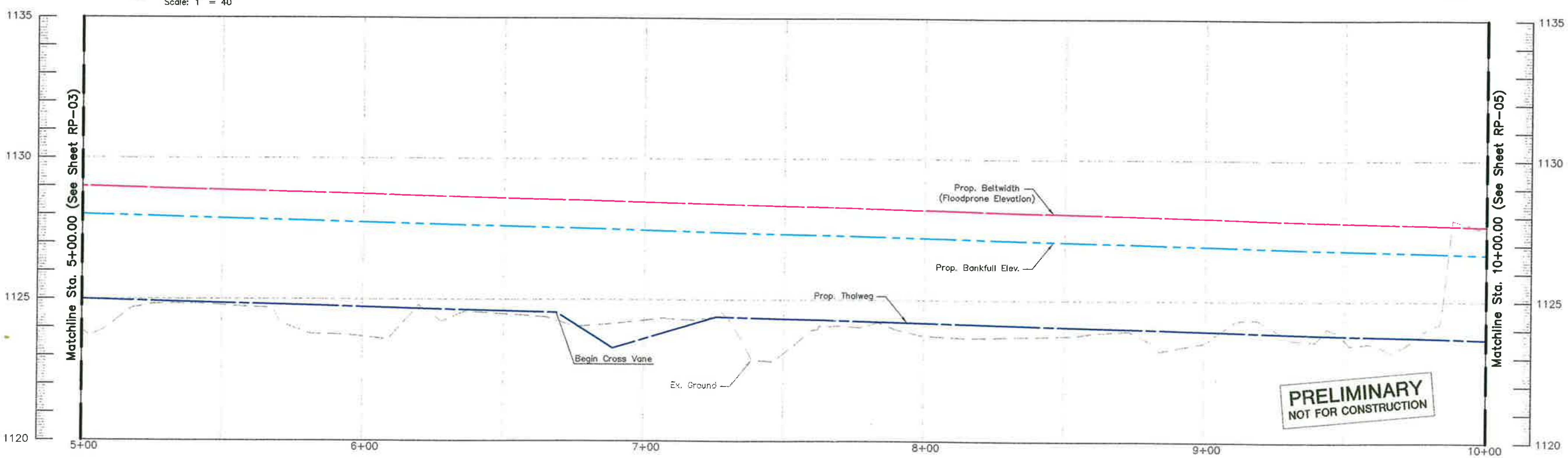
Date	Job No.
May, 2006 Rev. June 2006	2005-1446
Scale	Sheet
Hor: 1" = 40' Ver: 1" = 4'	RP-03/19

REVISIONS
MARK | DATE | DESCRIPTION



40 0 40 Feet
20
Scale: 1" = 40'

Notes:
1. See sheet 12–13 for structure details.
2. Final location, extent, and nature of in stream bed features to be determined during construction with consultation of designer.



PRELIMINARY
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BURKE COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
SILVER CREEK AND UNNAMED TRIBUTARY
SILVER CREEK
PLAN & PROFILE

Date: May, 2006 Rev. June 2006	Job No. 2005-1446
Scale: Hor: 1" = 40' Ver: 1" = 4'	Sheet RP-04/19

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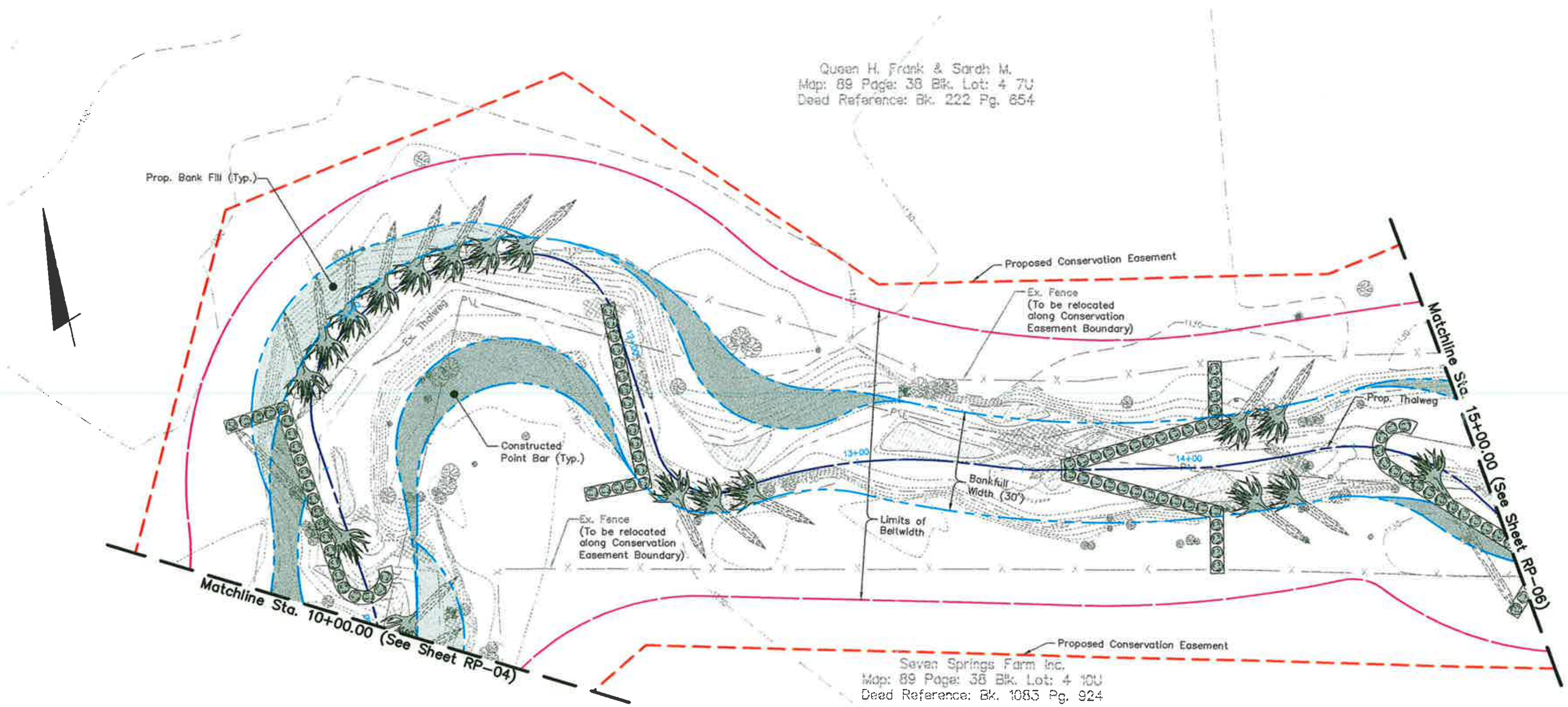
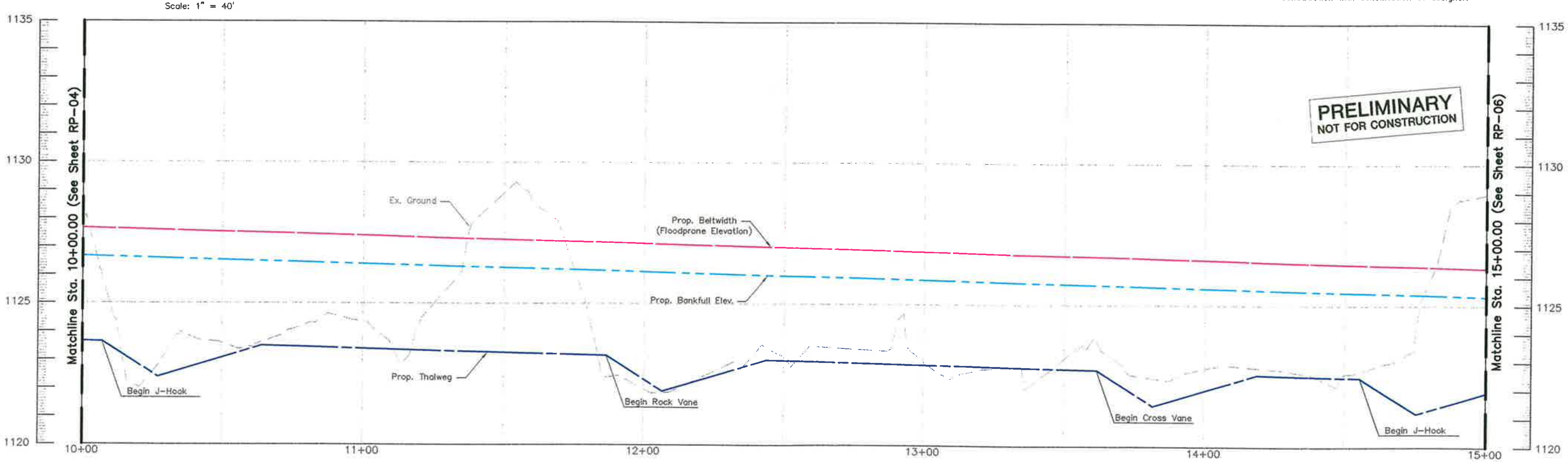


Notes:
1. See sheet 12–13 for structure details.
2. Final location, extent, and nature of in stream bed features to be determined during construction with consultation of designer.



Job No. 2005-1446
Sheet RP-05/19
Date May, 2006 Rev. June 2006
Scale Hor: 1" = 40' Ver: 1" = 4'

BURKE COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
SILVER CREEK AND UNNAMED TRIBUTARY
SILVER CREEK
PLAN & PROFILE

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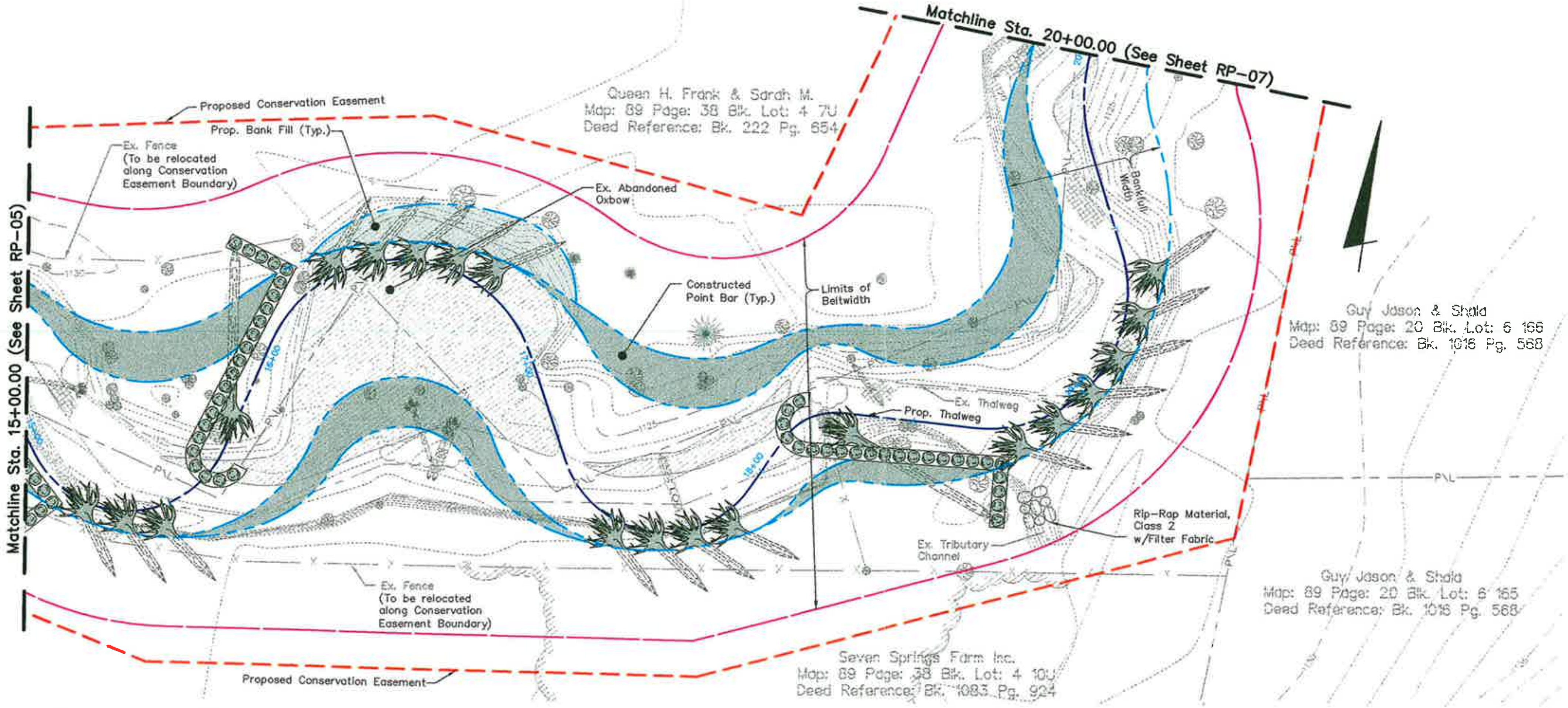
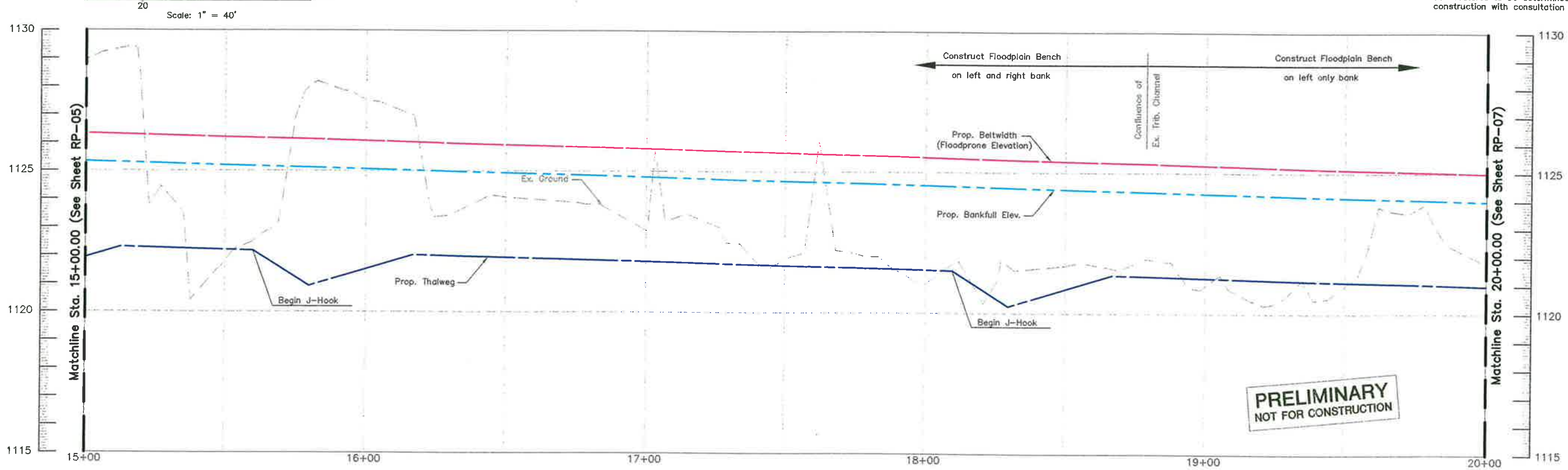


Notes:
1. See sheet 12–13 for structure details.
2. Final location, extent, and nature of in stream bed features to be determined during construction with consultation of designer.



PRELIMINARY
NOT FOR CONSTRUCTION

Job No. 2005-1446
Sheet RP-06/19
Date May, 2006 Rev. June 2006
Scale Hor: 1" = 40' Ver: 1" = 4'

BURKE COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
SILVER CREEK AND UNNAMED TRIBUTARY
SILVER CREEK
PLAN & PROFILE

Ecosystem Enhancement PROGRAM

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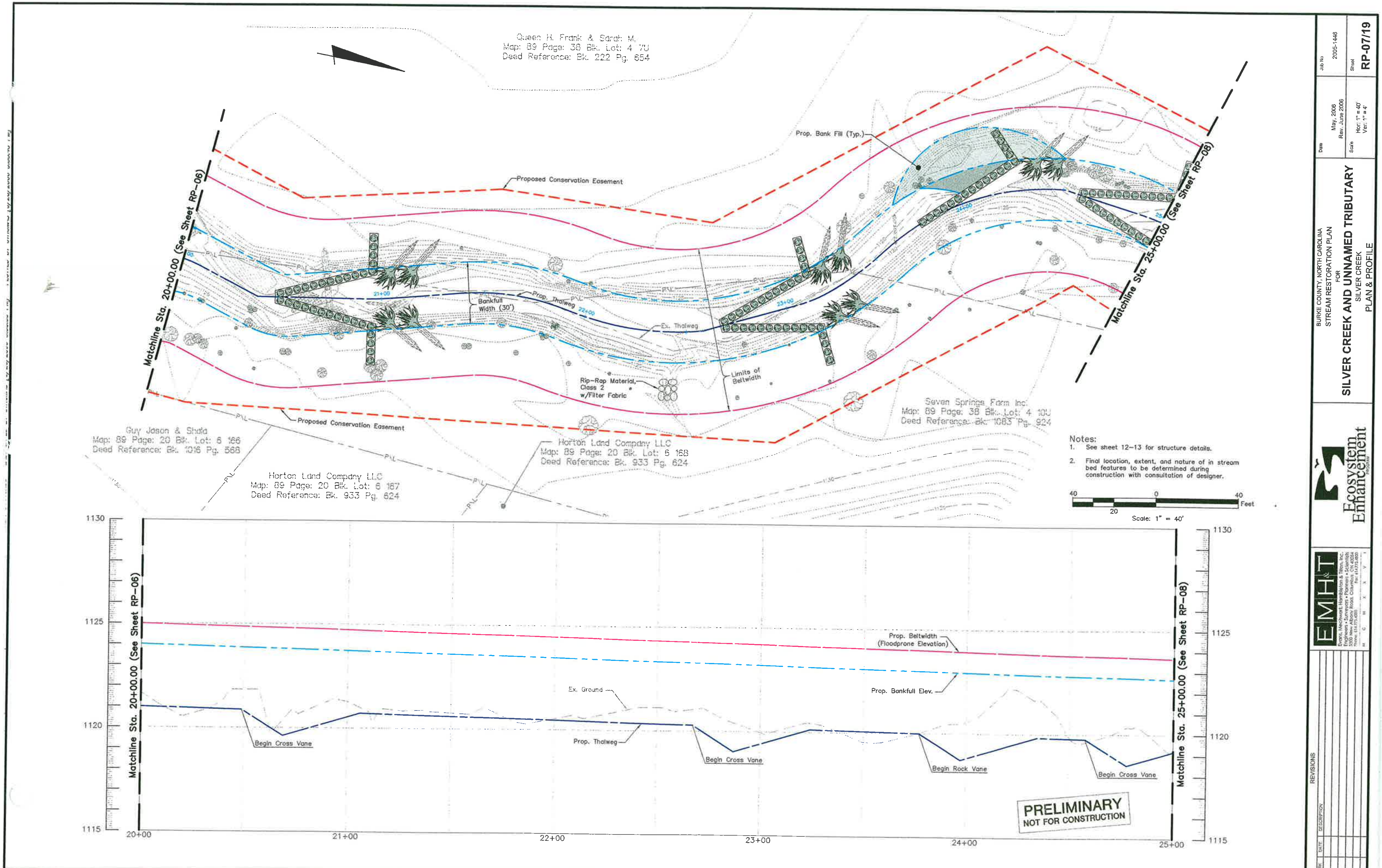
MARK | DATE | DESCRIPTION



Queen H. Frank & Sarah M.
Map: 89 Page: 38 Blk. Lot: 4 7U
Deed Reference: Bk. 222 Pg. 654
Proposed Conservation Easement
Prop. Bank Fill (Typ.)
Matchline Sta. 20+00.00 (See Sheet RP-06)
Matchline Sta. 25+00.00 (See Sheet RP-08)
Bankfull Width (30')
Prop. Thalweg
Ex. Thalweg
Limits of Beltwidth
Rip-Rap Material, Class 2 w/Filter Fabric
Seven Springs Farm Inc.
Map: 89 Page: 38 Blk. Lot: 4 10U
Deed Reference: Bk. 1083 Pg. 924
Guy Jason & Shdia
Map: 89 Page: 20 Blk. Lot: 6 166
Deed Reference: Bk. 1016 Pg. 568
Horton Land Company LLC
Map: 89 Page: 20 Blk. Lot: 6 168
Deed Reference: Bk. 933 Pg. 624
Horton Land Company LLC
Map: 89 Page: 20 Blk. Lot: 6 167
Deed Reference: Bk. 933 Pg. 624
Notes:
1. See sheet 12-13 for structure details.
2. Final location, extent, and nature of in stream bed features to be determined during construction with consultation of designer.
40 20 0 40 Feet
Scale: 1" = 40'
Prop. Beltwidth (Floodprone Elevation)
Prop. Bankfull Elev.
Ex. Ground
Prop. Thalweg
Begin Cross Vane
Begin Rock Vane
1130
1125
1120
1115
20+00
21+00
22+00
23+00
24+00
25+00
PRELIMINARY
NOT FOR CONSTRUCTION
BURKE COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
SILVER CREEK AND UNNAMED TRIBUTARY
SILVER CREEK
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Date May, 2006 Rev. June 2006
Scale Hor: 1" = 40' Ver: 1" = 4'
Job No 2005-1446
Sheet RP-07/19
Ecosystem Enhancement
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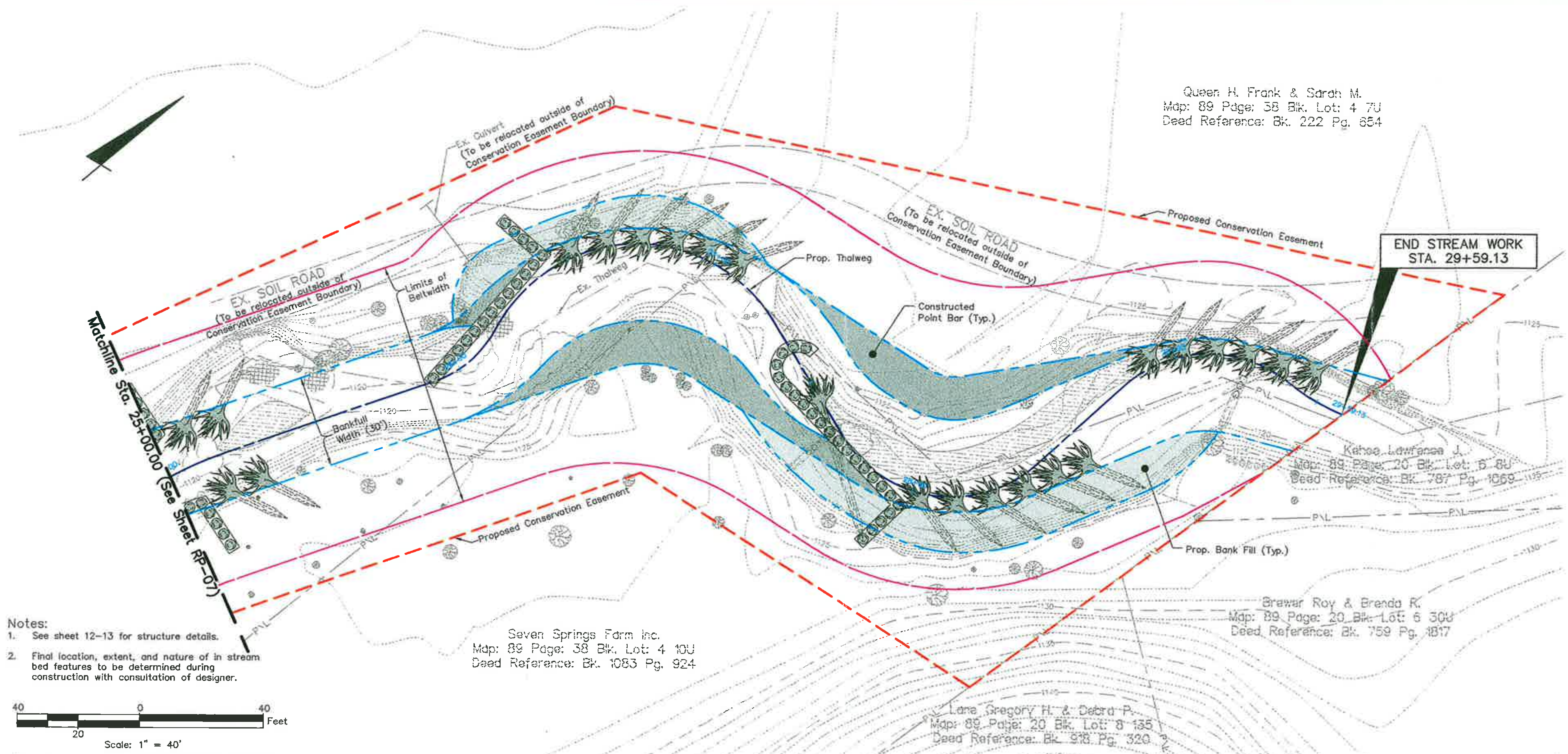
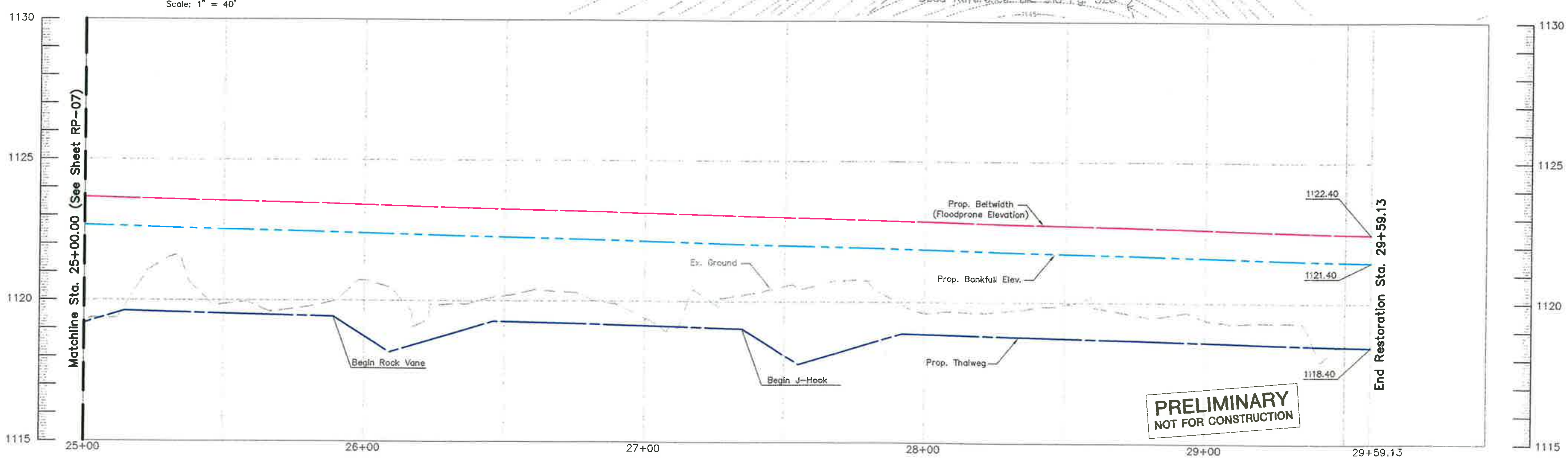


Notes:
1. See sheet 12–13 for structure details.
2. Final location, extent, and nature of in stream bed features to be determined during construction with consultation of designer.

40 20 0 40 Feet
Scale: 1" = 40'



Job No. 2005-1446
Sheet RP-08/19
Date May, 2006 Rev. June 2006
Scale Hor: 1" = 40' Ver: 1" = 4'

BURKE COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
SILVER CREEK AND UNNAMED TRIBUTARY
SILVER CREEK
PLAN & PROFILE

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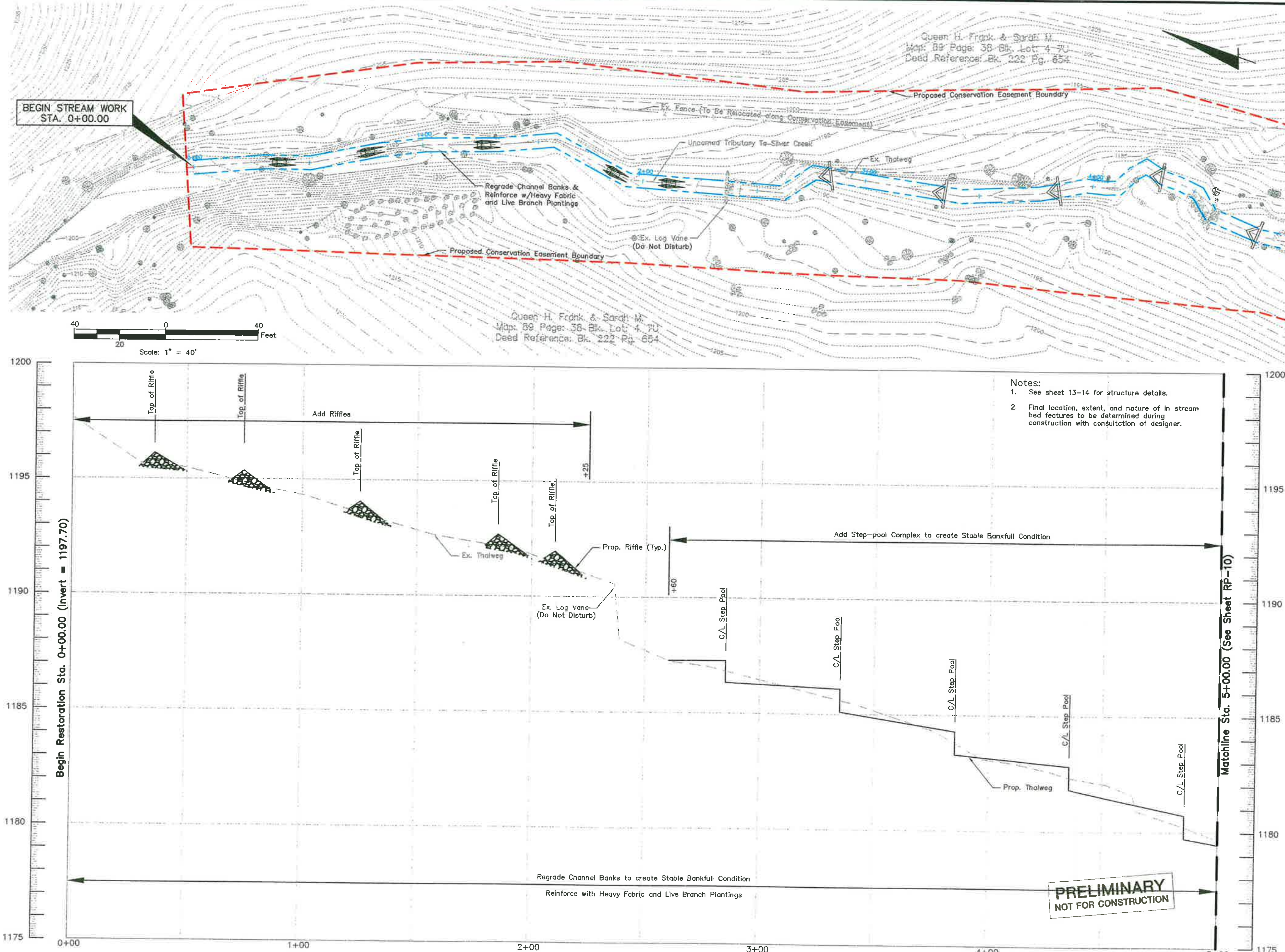

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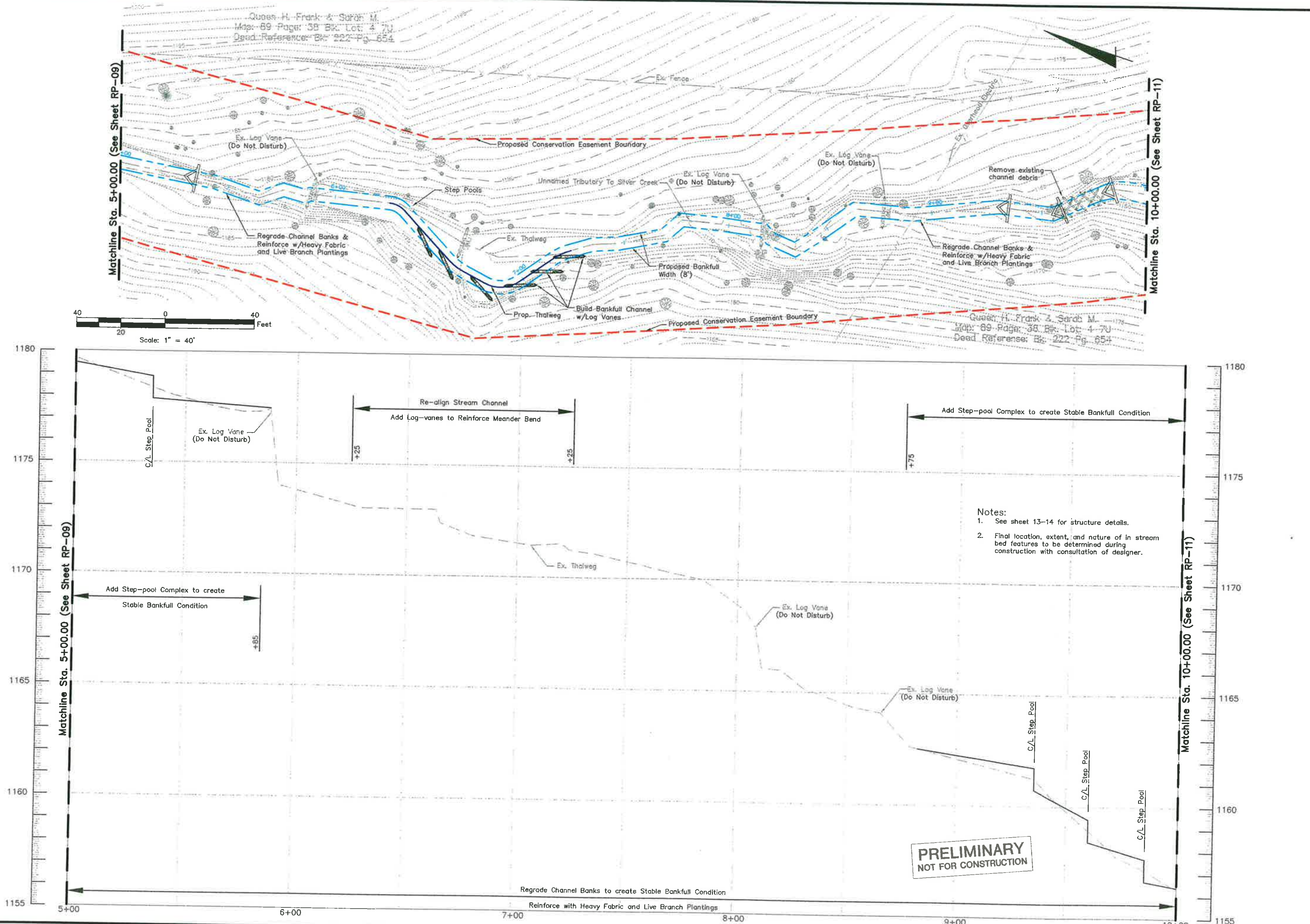
BURKE COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
UNNAMED TRIBUTARY TO SILVER CREEK
UNNAMED TRIBUTARY
PLAN & PROFILE

Date: May, 2006, Rev. June 2006
Scale: Hor: 1" = 40', Ver: 1" = 4'
Job No. 2005-1446
Sheet **RP-09/19**



BURKE COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
UNNAMED TRIBUTARY TO SILVER CREEK
UNNAMED TRIBUTARY
PLAN & PROFILE

Date: May, 2006 Rev. June 2006
Scale: Hor: 1" = 40' Ver: 1" = 4'
Job No. 2005-1446
Sheet RP-10/19

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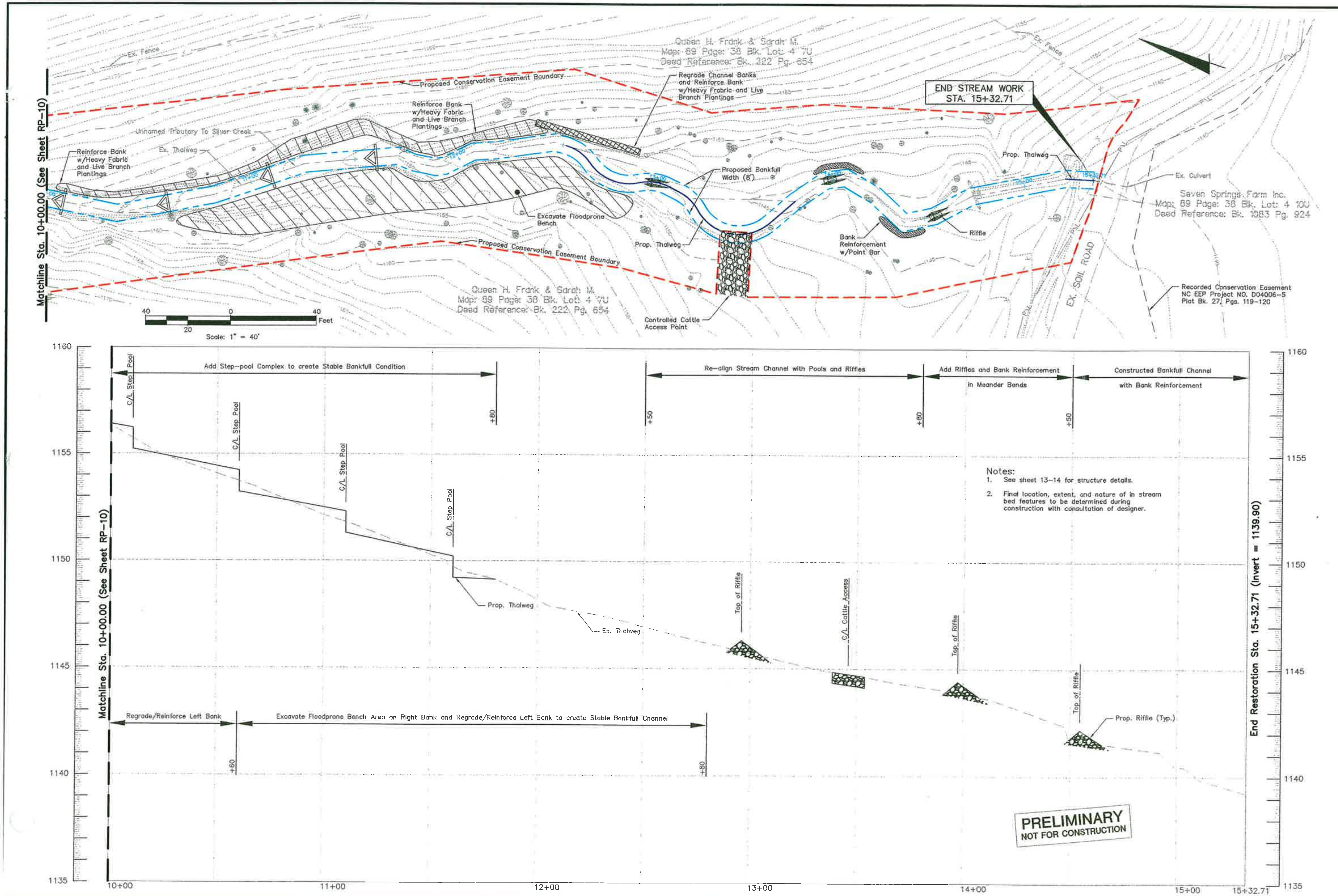

Job No. 2005-1446

Sheet RP-11/19

Date May, 2006
Rev. June 2006

Scale Hor: 1" = 40'
Ver: 1" = 4'

BURKE COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
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UNNAMED TRIBUTARY
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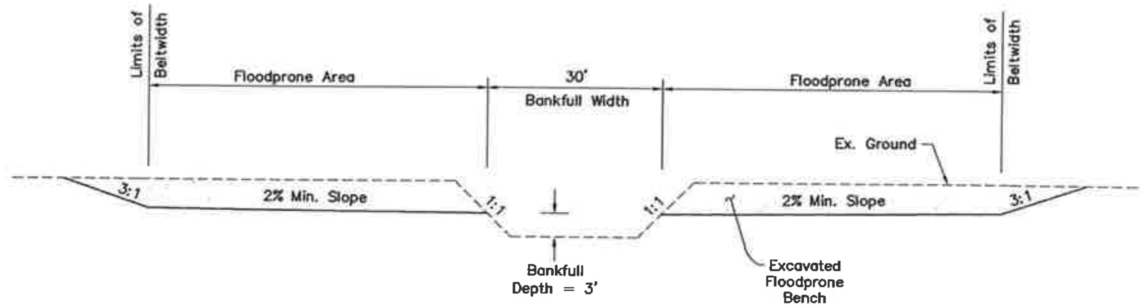
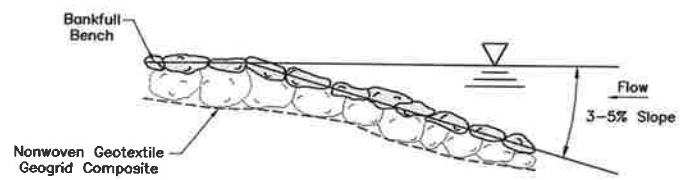
Notes:

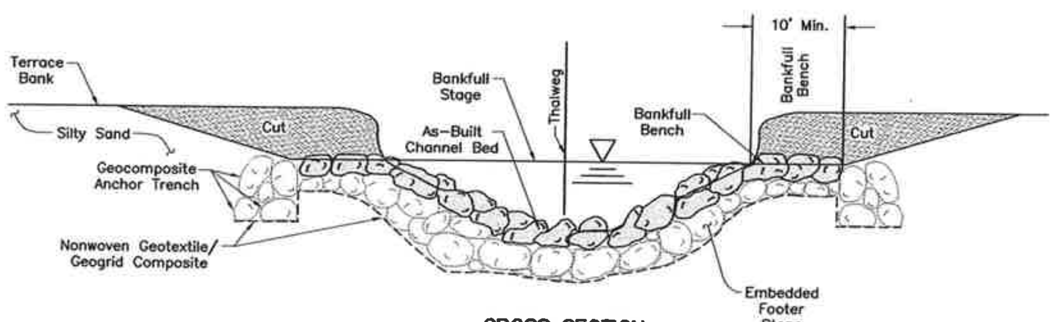
1. Final location, extent, and nature of in stream bed features to be determined during construction with consultation of designer.
2. All embedded footer stone and crest boulders should have a minimum diameter of 2.6 feet.
3. Final placement of rocks in J-Hook Vane, Cross-Vane, Submerged Cover Log and Root Wad Structures to be determined by stream restoration specialist in the field.
4. A Nonwoven Geotextile/Geogrid Composite with a tensile strength ≥ 560 lbs./in. (across width & length) & elongation break < 5% (test method ASTM D 4595) will be placed as shown on plan details where structures will be constructed in sand or silt clay channel beds.



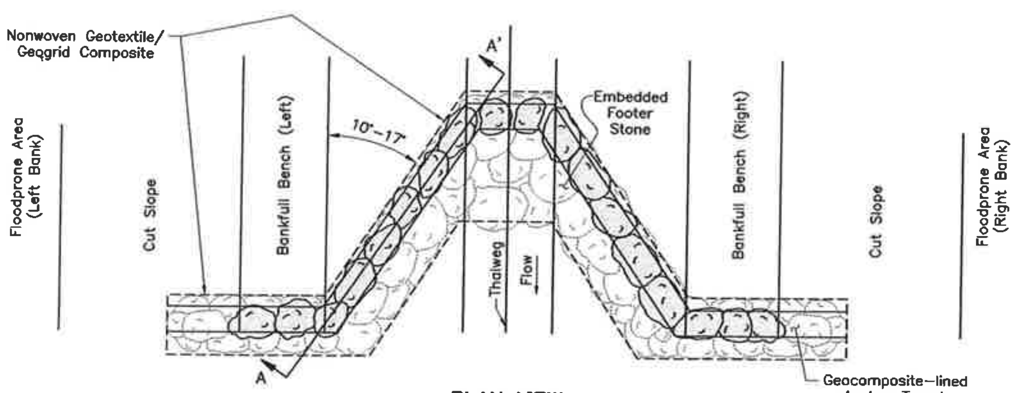
SILVER CREEK MAIN STEM TYPICAL SECTION
Not to Scale



SECTION A–A
Not to Scale

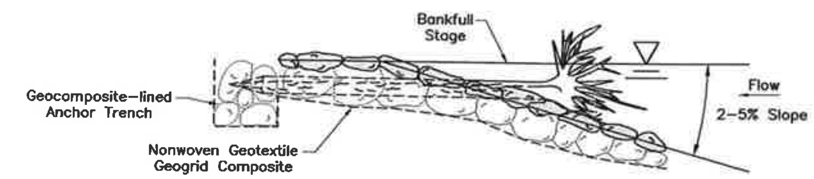


CROSS SECTION
Not to Scale

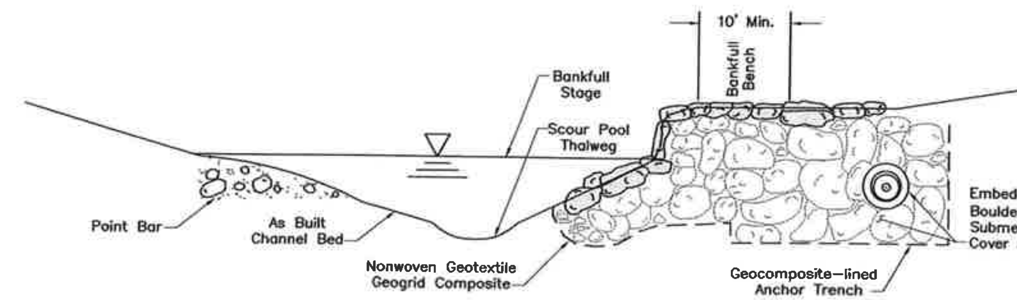


PLAN VIEW
Not to Scale

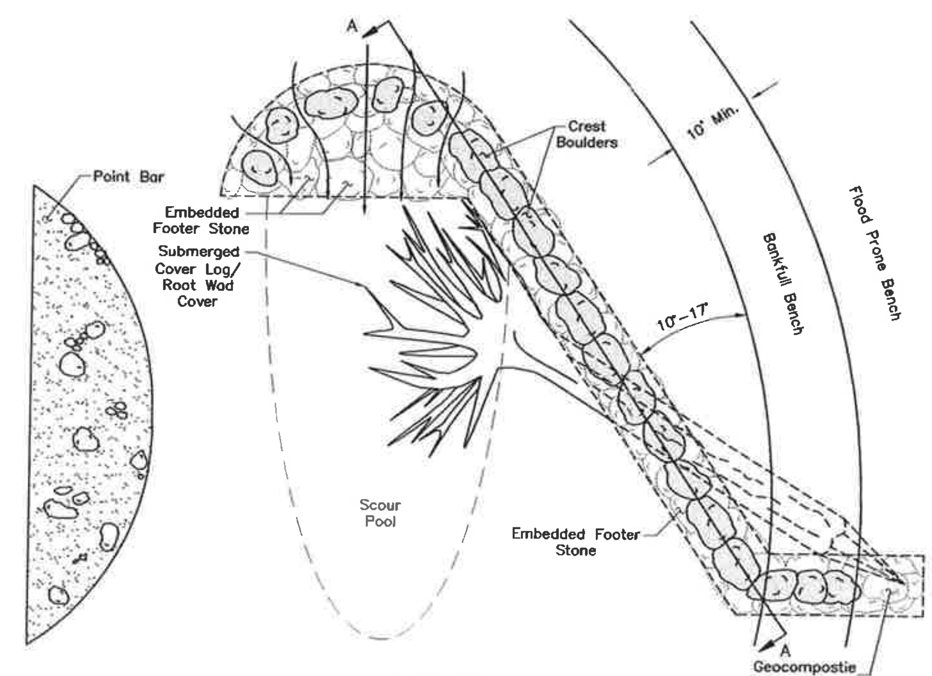
CROSS VANE DETAIL
Not to Scale



SECTION A–A
Not to Scale



CROSS SECTION
Not to Scale



PLAN VIEW
Not to Scale

J-HOOK/ROOT WAD DETAIL
Not to Scale

PRELIMINARY
NOT FOR CONSTRUCTION

Job No.	2005-1446
Sheet	RP-12/19
Date	May, 2006 Rev. June 2006
Scale	As Noted

BURKE COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
SILVER CREEK AND UNNAMED TRIBUTARY
SILVER CREEK
DETAILS

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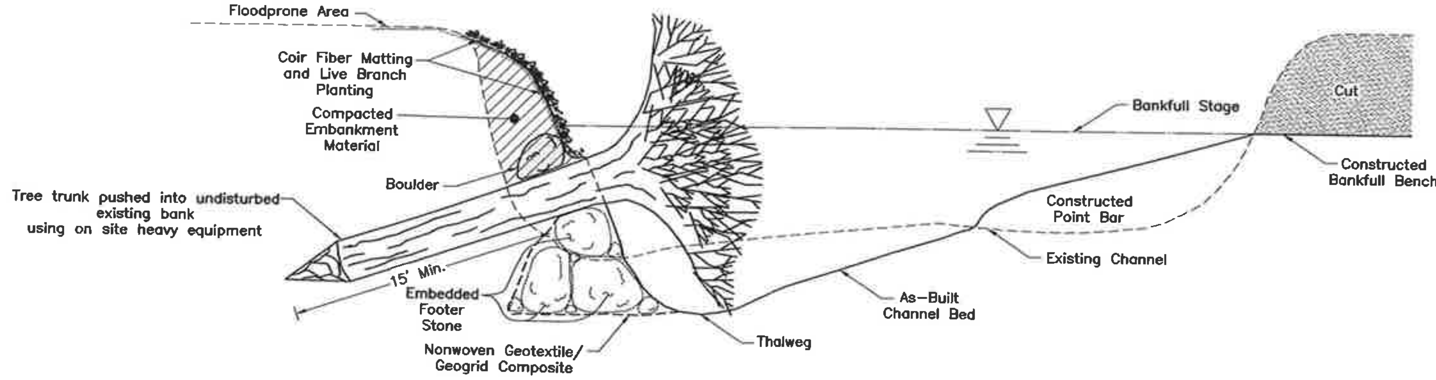
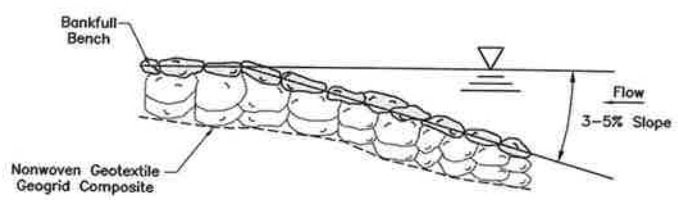


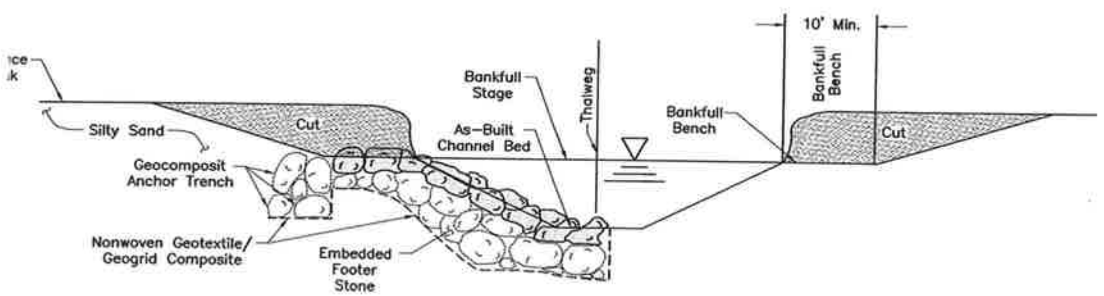
SECTION B-B
Not to Scale

Notes:

1. Final location, extent, and nature of in stream bed features to be determined during construction with consultation of designer.
2. All embedded footer stone and crest boulders should have a minimum diameter of 2.6 feet.
3. Final placement of rocks in J-Hook Vane, Cross-Vane, Submerged Cover Log and Root Wad Structures to be determined by stream restoration specialist in the field.
4. A Nonwoven Geotextile/Geogrid Composite with a tensile strength ≥ 560 lbs./in. (across width & length) & elongation break < 5% (test method ASTM D 4595) will be placed as shown on plan details where structures will be constructed in sand or silt clay channel beds.



SECTION A-A
Not to Scale



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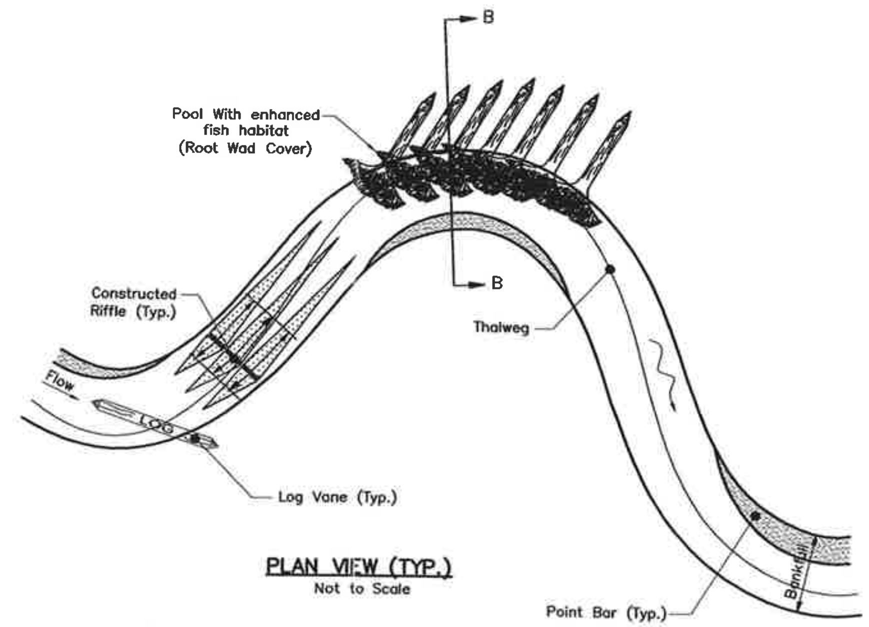
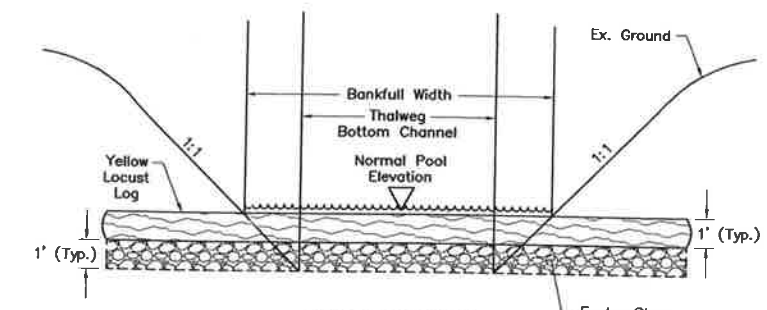


PLAN VIEW (TYP.)
Not to Scale

ROOT WAD BANK STABILIZATION DETAIL
Not to Scale



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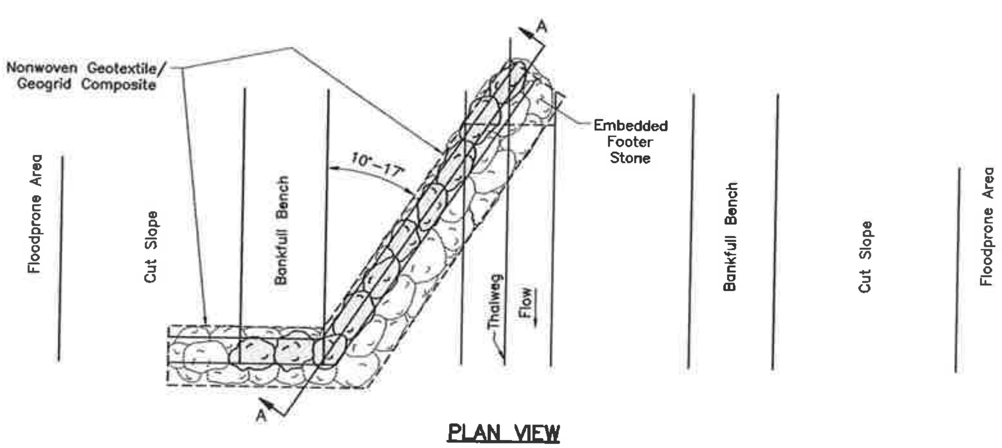
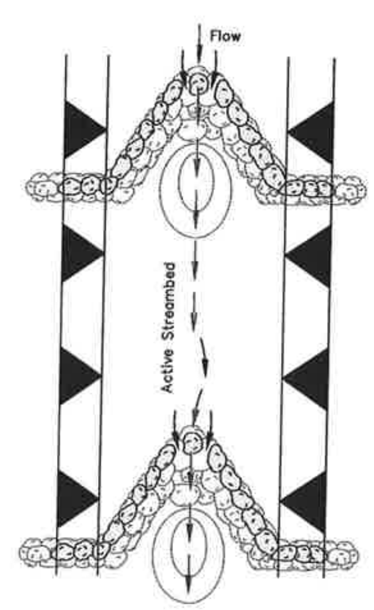


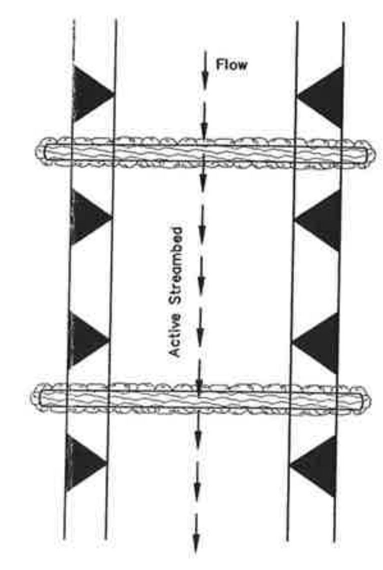
PLAN VIEW
Not to Scale

ROCK VANE DETAIL
Not to Scale



STEP-POOL DETAIL
Not to Scale

Refer to cross vane detail for additional schematic information related to step-pool construction.



PLAN VIEW
Not to Scale

LOG STEP POOL DETAIL
Not to Scale

PRELIMINARY
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Ecosystem Enhancement PROGRAM

BURKE COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
SILVER CREEK AND UNNAMED TRIBUTARY
SILVER CREEK AND UNNAMED TRIBUTARY
DETAILS

Date: May, 2006 Rev. June 2006
Scale: As Noted
Job No. 2005-1446
Sheet RP-13/19

ROCK RIFFLES:
1.0 CREST STONE
The crest height is determined in the field by measuring the elevation of the toe of the proceeding upstream riffle. The crest elevation must pool water back to the base of the upstream riffle/run.

Installation:
The crest height must be determined and the center weir stone installed first. Trench into the stream bed approximately 1.0 feet and place the stone(s) so that the center weir stone reaches the crest elevation. Trench and install the remaining crest stones across the stream, elevating them into the banks the specified distance.

2.0 SUPPORT STONE
Installation:
Support stone must be placed tightly on both sides of the crest stone paying close attention to fit on the downstream side. Proper elevation of the support stone must be maintained and must be as high as the crest stone. Four (4) feet downstream of the crest stone the support stone will be laid more loosely to create turbulence of flow across the riffle. At this point, the stone should start to become trenched into the streambed. At the end of the riffle, the support stone will be trenched fully into the stream bed to a depth of approximately 1.0 feet. Finished elevations of the support stone must concentrate flows across the riffle and create non-laminar (turbulent) flow. Support stones will continue up the banks to the final elevation. Support stone will be trenched into the banks to support the crest stone.

3.0 FILL STONE
Installation:
After the installation of the larger crest and support stones, fill all voids with fill stone materials and compact with an excavator bucket. Final grading and transition with the upper bank area can be accomplished using this stone size.

BOULDER TOE:
1.0 Material:
The boulder toe material may consist of quarried material (no construction rubble is permissible). The Contractor shall review samples of this material with the Engineer for approval prior to installation.

2.0 Installation:
The boulder toe material shall be imbedded into the channel bottom and channel bank to the minimum depths shown on Channel Reinforcement Detail, This Sheet. Filter fabric material per NCDOT Item 1056, Type 2, shall be included in the construction of the boulder toe reinforcement, as demonstrated on Channel Reinforcement Detail, This Sheet. Over-excavation of the channel bank to install the boulder toe reinforcement shall be back-filled with compactable material that is placed in lifts and graded to conform to the designed channel bank, and reinforced with the geotextile material specified by this plan.

STOCKPILE SUBSTRATE MATERIAL:
Remove and stockpile any available stream bed material through the reach of the existing stream channel to be excavated/relocated. Stockpiled material shall be replaced within excavated /relocated stream bed upon completion. Cost of this work to be included in the price bid for the various related items. Also, see "Cobble" note, this sheet.

GEOTEXTILES:
The specified geotextile shall meet the specifications identified on this plan, unless otherwise approved by the Engineer.

Geotextile shall be placed in accordance with manufacturer's recommendations.

The geotextile Rolls shall be furnished with suitable wrapping for protection against moisture and extended ultraviolet exposure prior to placement. Each Roll shall be labeled or tagged to provide product identification sufficient for field inventory and quality control purposes. Rolls shall be stored in a manner which provides identification, as well as protection from the elements. If stored outdoors, the Rolls shall be elevated and protected with a waterproof cover.

COIR ROLL:
1.0 Material:
Rolls shall consist of biodegradable material with a density of 7 lbs./cu.ft. The coir roll outer netting shall consist of a biodegradable twine 0.24 inches in diameter with the breaking strength of 80 lbs. Hardwood stakes to anchor the coir rolls shall be 2"x2"x36" in size. The specified length is a minimum and may need to be adjusted to allow for sufficient anchoring.

2.0 Installation:
Refer to Typical Plan View of Riffle-Run-Bend/Pool Complex for a schematic of the location of the coir roll material along the channel and Channel Reinforcement Detail, This Sheet for a schematic of the location of the coir rolls with respect to the other bank reinforcement materials.

The coir rolls shall be installed after the boulder toe material is in place. The upstream and downstream ends of the coir roll installation shall be bent back into the channel bank to prevent stream flow from cutting behind the rolls. The ends of abutting coir rolls shall be tied together with twine. Hardwood stakes shall be driven into the undisturbed native soil behind the rolls. The rolls shall be tied to the stakes with twine. Stakes shall be placed at the beginning and end of each roll and on at a maximum spacing of 2 feet.

LIVE BRANCHES:
1.0 Material:
Live branch material shall be dormant and gathered locally (within or in proximity to the project site) or purchased from a reputable commercial supplier. This material shall be planted only during its natural dormancy period, extending from late fall through early spring.

Branches shall be 1/2 to 2-inches in diameter, 3 to 4 feet in length, and living based on the presence of young buds and green bark. Prior to installation, the branches shall be cut so that they are angled on the bottom and flush on the top. See Planting Plan for list of required material.

All harvested or purchased live branch material shall be preserved in a cool, moist environment until installation. Plant material that has been allowed to dry out or is not preserved in a dormant state prior to installation shall be discarded.

2.0 Installation:
Refer to Typical Plan View of Riffle-Run-Bend/Pool Complex for a schematic of the location of the live branches along the channel and Channel Reinforcement Detail, This Sheet for a schematic of the location of the live branches with respect to the other bank reinforcement materials.

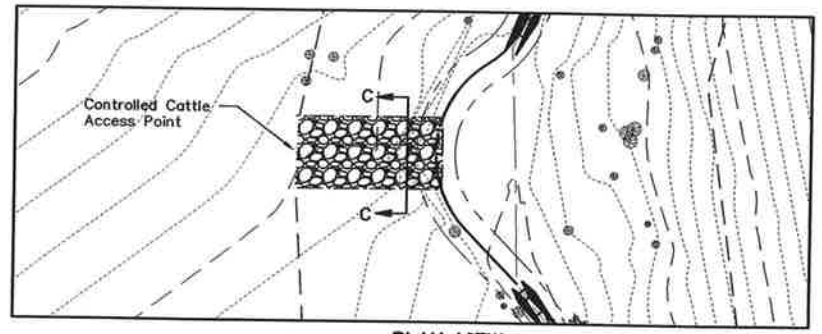
Live branches shall be installed at 1/2-foot spacing and two-thirds of the stake is to be imbedded within the channel bank. The angle of the imbedded stake to the channel bank shall be between 45 and 90 degrees. When installed, at least two (2) buds should remain above the ground surface and those buds shall be oriented upwards.

Live branches that split or become bent or broken during installation shall be removed from the channel bank and discarded.

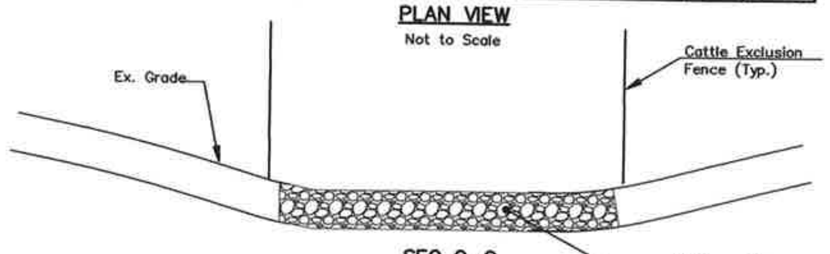
3.0 Payment:
The cost of all labor and materials associated with the installation of live branches shall be included in the price bid for Item, Spec., Live Branches, as per plan.

Installation Sequence for Channel Reinforcement Materials:

- Over-excavation of the channel bank may be necessary to accomplish the installation of the rock toe protection. The rock toe protection shall be imbedded into the bottom of the channel to the depth specified on this detail.
- The live branches shall be placed on top of the imbedded boulder toe material, protruding into the native, undisturbed soil of the channel bank.
- Soil material, including the specified topsoil, shall be placed to backfill the over-excavated channel bank.
- The specified seeding shall be applied to the disturbed/restored soil material.
- The first (lowest) row of the geotextile material shall be anchored to the restored soil material.
- The coir roll material shall be installed and secured with the hardwood stakes protruding into the native, undisturbed soil of the channel bank.
- Any remaining rows of geotextile material shall be installed and anchored to the channel bank, with the last (highest) row "trenched" into the bank.



PLAN VIEW
Not to Scale



SEC C-C
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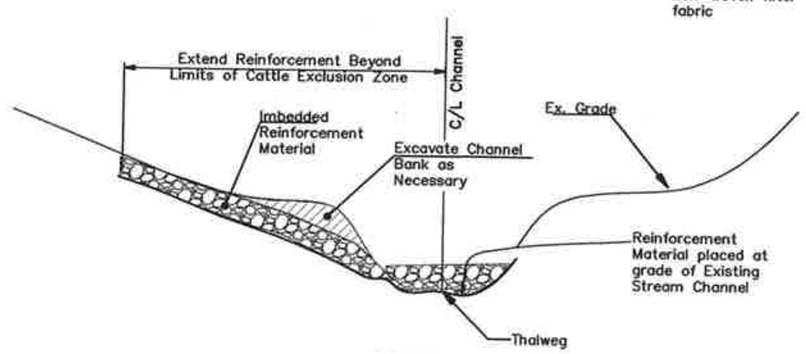
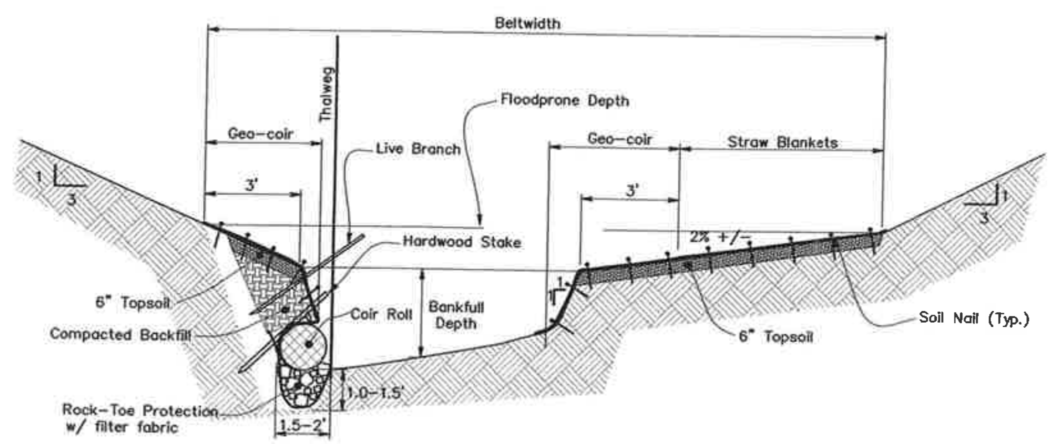


CROSS-SECTION
CATTLE ACCESS DETAIL
Not to Scale



CHANNEL REINFORCEMENT DETAIL - SEC. B-B
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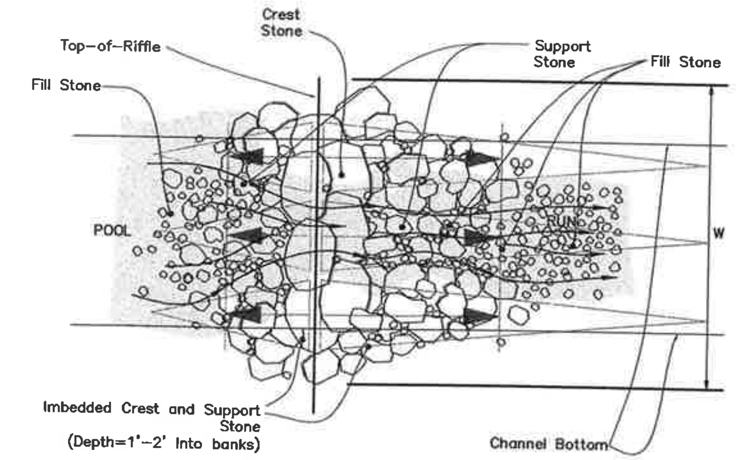
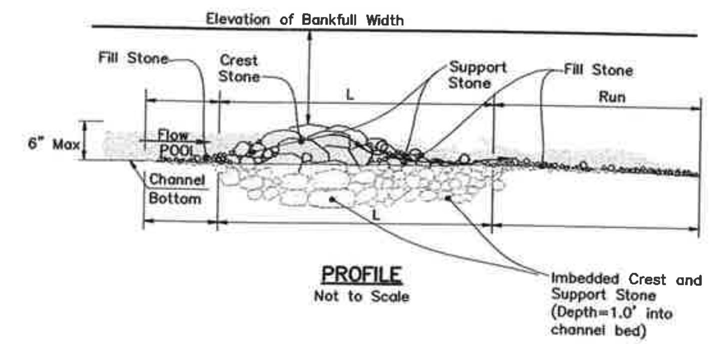
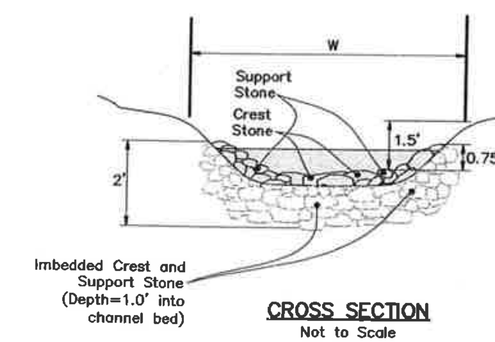


PLAN VIEW
Not to Scale



PROFILE
Not to Scale



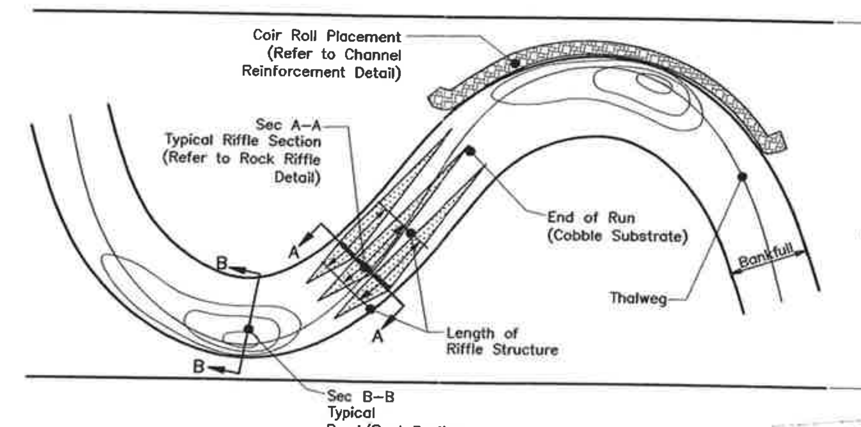
CROSS SECTION
Not to Scale

H= Crest Height (varies per field conditions). Refer to notes on this sheet and stream profile, sheets 4-5.

W= Bankfull Width= width of channel from bank to bank.

L= Length of Riffle; adjusted per field conditions to allow for energy dissipation in flow. Refer to stream profile.

ROCK RIFFLE DETAIL - SEC. A-A
Not to Scale



TYPICAL PLAN VIEW OF RIFFLE-RUN-BEND/POOL COMPLEX
Not to Scale

PRELIMINARY
NOT FOR CONSTRUCTION

MARK	DATE	DESCRIPTION
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Ecosystem Enhancement PROGRAM

BURKE COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
SILVER CREEK AND UNNAMED TRIBUTARY
UNNAMED TRIBUTARY
DETAILS

Date: May, 2006 Rev. June 2006
Scale: As Noted
Job No. 2005-1446
Sheet RP-14/19

SEQUENCE OF EROSION & SEDIMENT CONTROL IMPLEMENTATION

Silver Creek

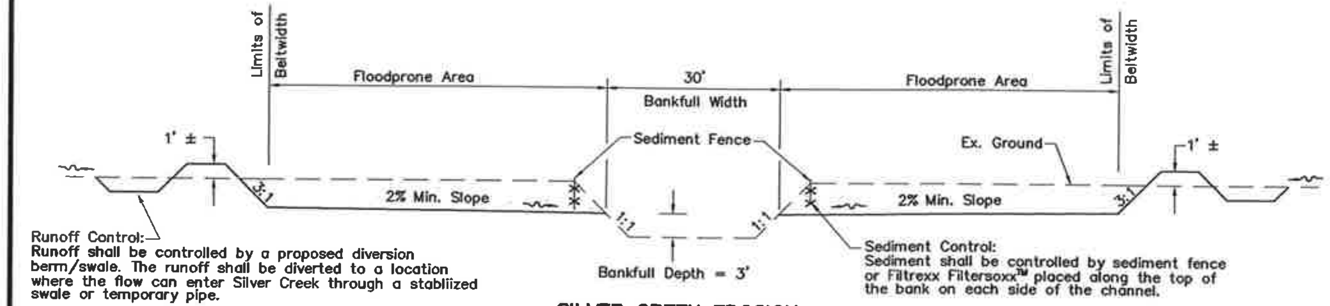
1. Install runoff control features as shown on the detail. (this sheet)
2. Excavate for the floodprone area.
3. As the floodprone area is excavated, sediment control features should be installed along the bankfull channel, (see detail, this sheet)
Stabilize the floodprone area.
Construct the in stream control structures such as cross vanes, root wads, etc.
Stabilize any excavated or disturbed areas.
Remove the runoff control features and stablize the area.

Unnamed Tributary

1. Construct the temporary sediment trap as shown on the detail. (this sheet)
2. Plug the existing stream with an "earthen plug" and begin diverting water to the temporary sediment trap.
3. Construct stream restoration improvements.
4. Install the stabilized cattle access.
5. Stabilize any excavated or disturbed areas.
6. Remove the earthen plug.
7. Fill in and stabilize the temporary sediment trap.

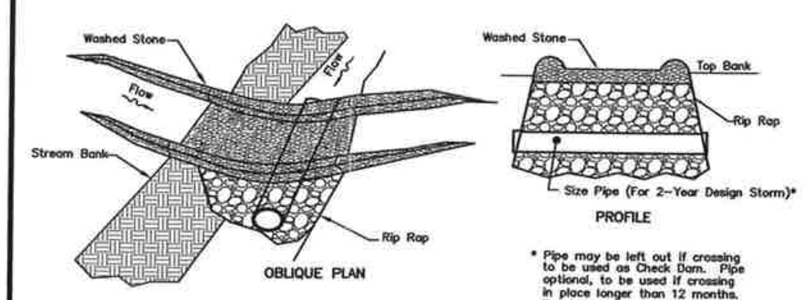
Temporary & Permanent Seeding — See Table

TYPE	APPLICATION RATES	APPLICATION DATES
TEMPORARY SEED: Winter Rye (*Secale cereale*)	40 lbs/acre	June–August
PERMANENT SEED: Big Bluestem (*Andropogon gerardii*) Broomsedge (*Andropogon virginicus*) Deertongue (*Panicum clandestinum*) Little Bluestem (*Schizachyrium scoparium*) Indiangrass (*Sorghastrum nutans*)	15 lbs/acre of mixture	September – May
OVERSEED: Pearl Millet (*Pennisetum glaucum*)	15 lbs/acre	June–August



SILVER CREEK EROSION CONTROL DETAIL

Not to Scale



* Pipe may be left out if crossing to be used as Check Dam. Pipe optional, to be used if crossing in place longer than 12 months. To be sized by Engineer.

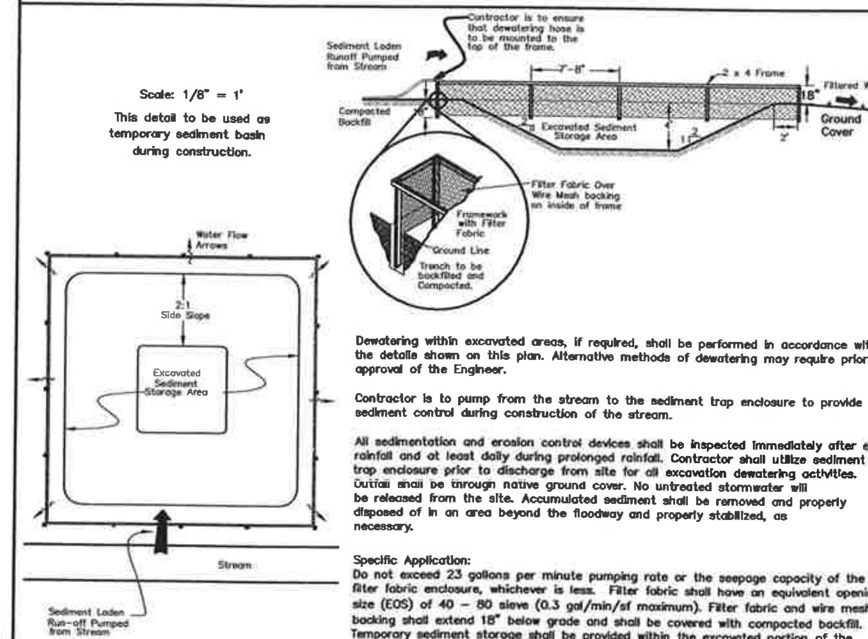
TEMPORARY STREAM CROSSING

(No Scale)

TEMPORARY SEDIMENT TRAP ENCLOSURE DETAILS

Scale: 1/8" = 1'

This detail to be used as temporary sediment basin during construction.

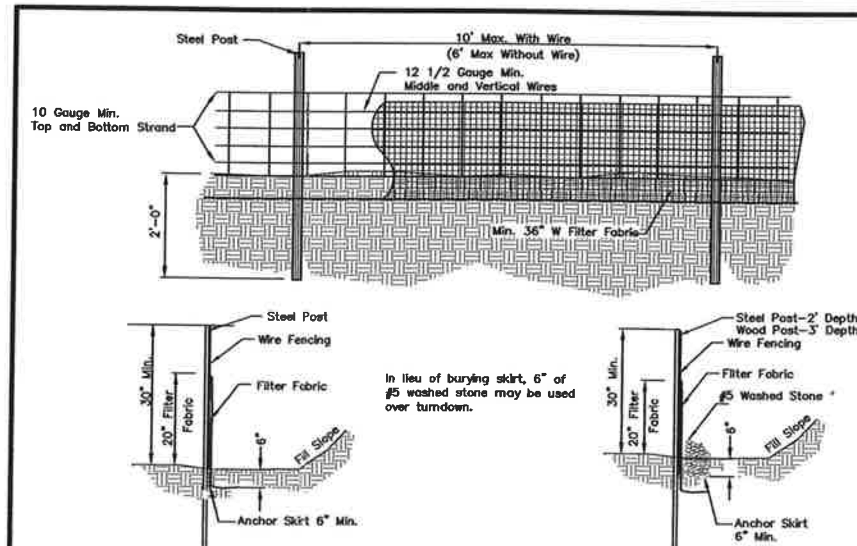


Dewatering within excavated areas, if required, shall be performed in accordance with the details shown on this plan. Alternative methods of dewatering may require prior approval of the Engineer.

Contractor is to pump from the stream to the sediment trap enclosure to provide sediment control during construction of the stream.

All sedimentation and erosion control devices shall be inspected immediately after each rainfall and at least daily during prolonged rainfall. Contractor shall utilize sediment trap enclosure prior to discharge from site for all excavation dewatering activities. Outfall shall be through native ground cover. No untreated stormwater will be released from the site. Accumulated sediment shall be removed and properly disposed of in an area beyond the floodway and properly stabilized, as necessary.

Specific Application:
Do not exceed 23 gallons per minute pumping rate or the seepage capacity of the filter fabric enclosure, whichever is less. Filter fabric shall have an equivalent opening size (EOS) of 40 – 80 sieve (0.3 gal/min/sf maximum). Filter fabric and wire mesh backing shall extend 18" below grade and shall be covered with compacted backfill. Temporary sediment storage shall be provided within the excavated portion of the sediment trap. Excavated side slopes shall not be steeper than 2 horiz :1 vert. Depth of excavation shall be 4–feet below natural grade. Sediment trap shall be re–excavated when the holding area becomes half–full of sediment.



GENERAL NOTES

1. Filter fabric fence shall be a minimum of 36" in width and shall be fastened adequately as directed by the Engineer.
2. Woven filter fabric be used where silt fence is to remain for a period of more than 30 days.
3. Steel posts shall be 5'–0" in height and be of the self–fastener angle steel type. Wood posts shall be 6' long and 3" in diameter.
4. Wire fencing shall be at least #10 gauge with a minimum of 6 line wires with 12" stay spacing.
5. Turn silt fence up slope at ends.
6. Wire mesh shall be min. 13 gauge with maximum 12" openings.
7. Wire and washed stone will be required and noted on plans when:
a. At toe of slopes greater than 10 feet vertical (2:1 slope)
b. At denuded limits where an undisturbed buffer is 50 feet or less away
8. Orange safety fence is required at back of silt fence(within 5 ft.) when grading is adjacent to swim buffers (refer to swim buffer guidelines).

MAINTENANCE NOTES

1. Filter barriers shall be inspected by the financially responsible party or his agent immediately after each rainfall and at least daily during prolonged rainfall. Any repairs needed shall be made immediately.
2. Should the fabric decompose or become ineffective prior to the end of the expected usable life and the barrier still is necessary, the fabric shall be replaced promptly. Sediment deposits should be removed when deposits reach approx. half the height of the barrier.
3. Any sediment deposits remaining in place after the silt fence is removed shall be dressed to conform to the existing grade, prepared and seeded.

TEMPORARY SILT FENCE

(No Scale)

PRELIMINARY
NOT FOR CONSTRUCTION

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Ecosystem Enhancement PROGRAM

BURKE COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
SILVER CREEK AND UNNAMED TRIBUTARY
SILVER CREEK AND UNNAMED TRIBUTARY
STORMWATER POLLUTION PREVENTION PLAN

Date: May, 2006 Rev. June 2006
Scale: As Noted
Job No. 2005-1446
Sheet RP-15/19

EROSION CONTROL NARRATIVE

PLAN DESIGNER:
Evans, Mechwart, Hambleton, & Tilton, Inc.
5500 New Albany Road
Columbus, Ohio 43054
Phone: (614)775-4500 Fax: (614)775-4800

SITE CONTACT
Bob Koone
(828) 432-7759

PROJECT OWNER:
Cal Miller
Wetlands Resource Center
3970 Bowen Rd
nal Winchester, OH 43110
4) 327-7034

PROJECT LOCATION:
The project is located within Burke County, south of Interstate 40.

PROJECT DESCRIPTION:
The project consists of the restoration and stabilization of stream channels, indicated as Silver Creek and unnamed tributary on the restoration plan. The existing eroded stream banks of the stream buffer corridors of the watercourse shall be planted with a variety of trees, shrubs and seedings as indicated on the planting plan.

AREA OF PROJECT SITE & AREAS OF DISTURBANCE:
Project Area: 11.2 Acres
Estimated Area of Disturbance: 6.7 Acres

EXISTING SITE CONDITIONS:
The Silver Creek corridor predominantly consists of a narrow riparian buffer with adjoining pasture lands. Some portions of the project corridor (near the downstream end) have a wider forested area, which will not be disturbed.

The unamed tributary is contained within a wooded ravine, also with adjoining pasture lands. Impact to existing wooded areas will be minimized.

ADJACENT AREAS:
The adjacent areas are predominately agricultural fields (Pasture).

DESCRIPTION OF SOILS:
SILVER CREEK
Colvard Series (CvA) Colvard soils are on flood plains of mountain valleys in the southern Appalachian Mountains. Slopes range from 0 to 4 percent. The soils consist of in loamy and sandy sediments.
Below 40 inches are sandy or loamy sediments contain 0 to 80 percent gravel to cobble size rock fragments.

UNNAMED TRIBUTARY
Rhodhiss sandy loam (RhD), 2 to 95 percent slopes

RECEIVING STREAM/SURFACE WATER:
Silver Creek

CONTRACTOR RESPONSIBILITIES

Details have been provided on this plan in an effort to help the Contractor provide erosion and sedimentation control. The details shown on the plan shall be considered a minimum. Erosion and sediment control features indicated on the relocation plan shall be installed per the State of North Carolina Department of Transportation details. The Contractor shall be solely responsibility for providing necessary and adequate measures for proper control of erosion and sediment runoff from the site along with proper maintenance and inspection in compliance with with the North Carolina Department of Environmental, and Natural Resources sion and sediment control regulations.

e Contractor shall provide a schedule of operations to the Owner. The schedule should include a sequence of the placement of the sedimentation and erosion control measures that provides for continual protection of the site throughout the earth moving activities.

Prior to Construction Operations in a particular area, all sedimentation and erosion control features shall be in place. Field adjustments with respect to locations and dimensions may be made by the Engineer.

It may become necessary to remove portions of sedimentation controls during construction to facilitate the grading operations in certain areas. However, the controls shall be replaced upon completion of grading or during any inclement weather.

The Contractor shall be responsible to have the current Erosion Control Plan immediately available or posted on site.

The Contractor shall be responsible to ensure that off-site tracking of sediments by vehicles and equipment is minimized. All such off-site sediment shall be cleaned up daily.

The Contractor shall be responsible to ensure that no solid or liquid waste is discharged into the stream tributaries. Untreated sediment-laden runoff shall not flow off of site without being directed through a sediment control practice.

INSPECTIONS

The Owner/Contractor holder provide qualified personnel to conduct site inspections ensuring proper functionality of the erosion and sedimentation controls. All erosion and sedimentation controls are to be inspected once every seven (7) calendar days or within 24 hours of a 1/2 inch storm event or greater. Records of the site inspections shall be kept and made available to jurisdictional agencies if requested.

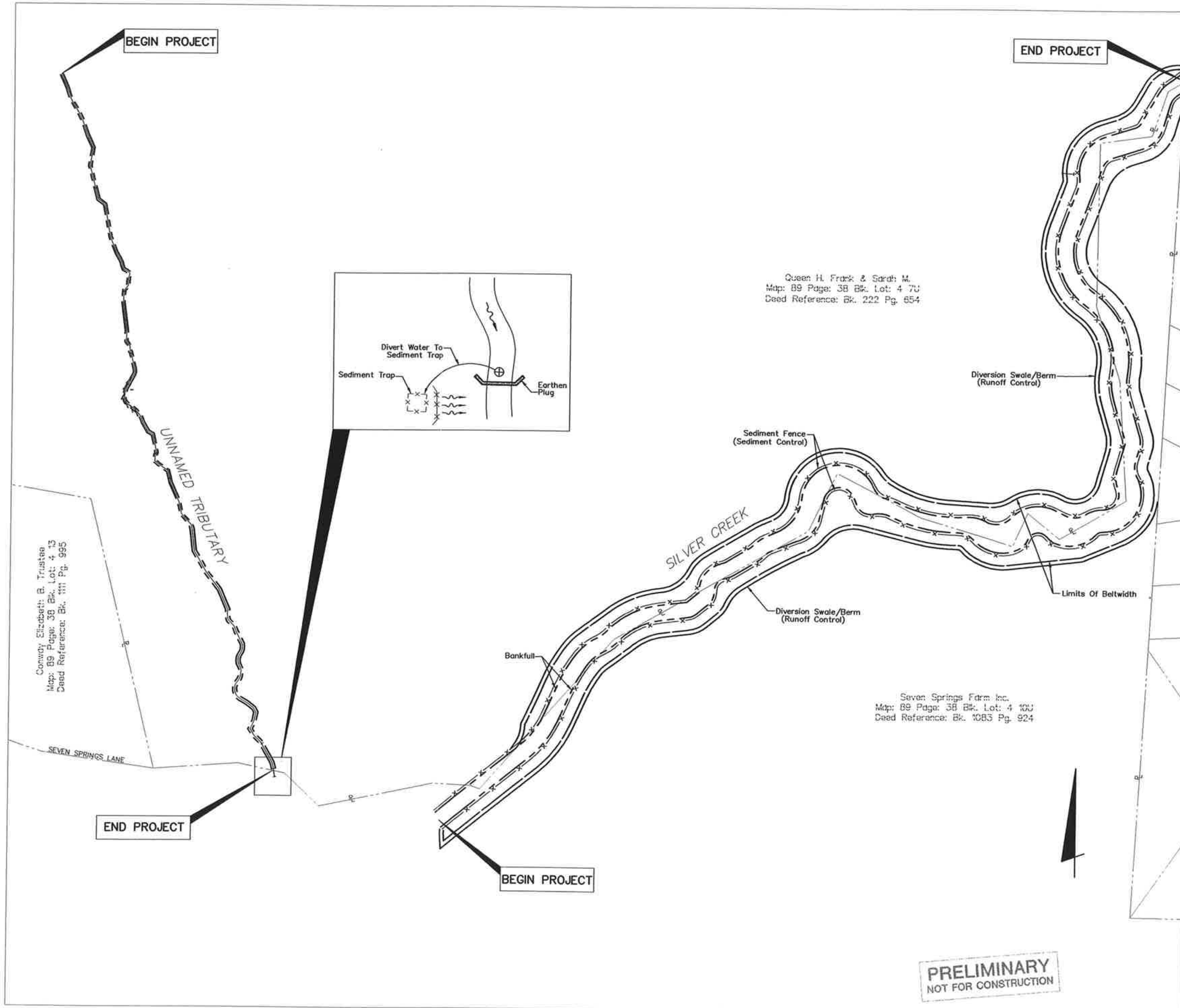
MAINTENANCE

It is the Contractor's responsibility to maintain the sedimentation and erosion control features on this project. Any sediment or debris that has reduced the efficiency of a control shall be removed immediately. Upon conducting an erosion control inspection, the Contractor shall repair or replace structures if it is determined that the structure is damaged and/or overwhelmed with sediment.

SOIL STABILIZATION

The Contractor shall stabilize disturbed slopes within 15 working days or 30 calendar days following completion of any phase of grading, permanent ground cover shall be established for all disturbed areas within 15 working days or 90 calendar days chever is shorter) following completion of construction or development.

sturbed slopes shall be stabilized per the stream channel bank stabilization details and the planting plan.



S.W.P.P.P. MAP
Scale: 1" = 100'

BURKE COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
SILVER CREEK AND UNNAMED TRIBUTARY
SILVER CREEK AND UNNAMED TRIBUTARY
STORMWATER POLLUTION PREVENTION PLAN

Ecosystem Enhancement PROGRAM

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Date	May, 2006 Rev. June 2006
Job No.	2005-1448
Scale	As Noted
Sheet	RP-16/19

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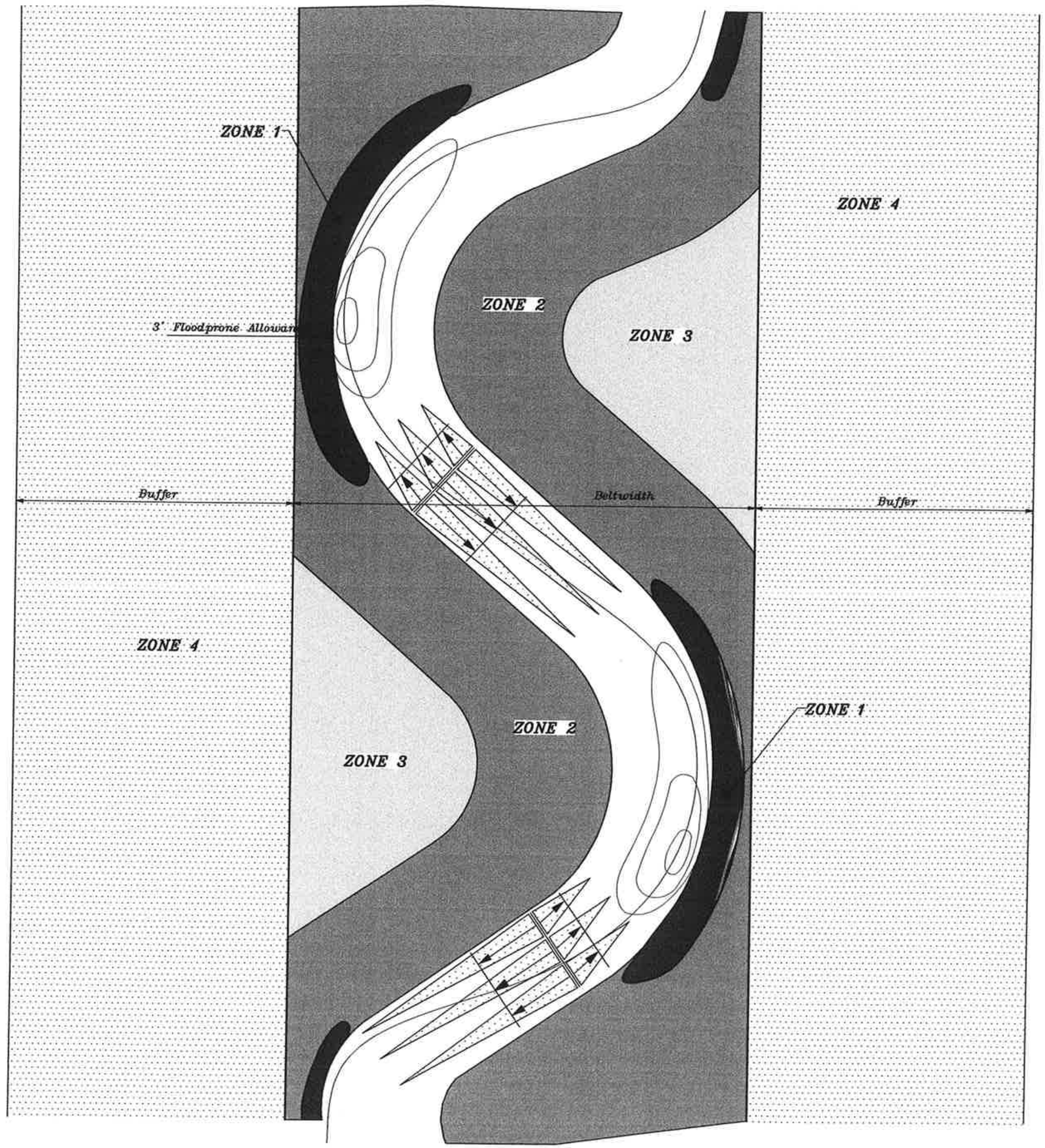

PLANTING ZONES – SILVER CREEK
Not to Scale

PLANTING ZONES – SILVER CREEK

– Zone 1 – Outside Meander
Live branches (See Channel Reinforcement Detail, Sheet RP-9)

Common Name	Scientific Name
Silky dogwood	*Cornus amomum*
Southern arrowwood viburnum	*Viburnum dentatum*
Elderberry	*Sambucus canadensis*
Black willow	*Salix nigra*

– Zone 2 – Streamside Shrubs & Trees

Shrubs

Common Name	Scientific Name
Painted buckeye	*Aesculus sylvatica*
Silky dogwood	*Cornus amomum*
Tag alder	*Alnus serrulata*
Black willow	*Salix nigra*
Elderberry	*Sambucus canadensis*
Southern arrowwood viburnum	*Viburnum dentatum*
American hazelnut	*Corylus americana*

Trees *

Common Name	Scientific Name
Box elder	*Acer negundo*
River birch	*Betula nigra*
Sycamore	*Platanus occidentalis*
Sweet gum	*Liquidambar styraciflua*
Green ash	*Fraxinus pennsylvanica*
Tulip poplar	*Liriodendron tulipifera*
American elm	*Ulmus americana*
Bitternut hickory	*Carya cordiformis*

* Trees should be 1 gallon pots on 100' spacing, unless otherwise indicated.

– Zone 3 – Floodprone Area

Common Name	Scientific Name
Box elder	*Acer negundo*
River birch	*Betula nigra*
Sycamore	*Platanus occidentalis*
Sweet gum	*Liquidambar styraciflua*
Green ash	*Fraxinus pennsylvanica*
Tulip poplar	*Liriodendron tulipifera*
American elm	*Ulmus americana*
Bitternut hickory	*Carya cordiformis*

– Zone 4 – Riparian Buffer

Common Name	Scientific Name
White ash	*Fraxinus alba*
Black walnut	*Juglans nigra*
Tulip poplar	*Liriodendron tulipifera*
Black gum	*Nyssa sylvatica*
Black cherry	*Prunus serotina*
White oak	*Quercus alba*

– Notes
- Final species selection will be based upon availability
- Planting densities:
  - Zone 1 – 2x2' centers
  - Zone 2 – 4x4' centers (Shrubs Only)
  - Zone 3 – 8x8' centers
  - Zone 4 – 10x10' centers
- Temporary and permanent seeding to occur in Zones 2, 3 & 4 – See Table

TYPE	APPLICATION RATES	APPLICATION DATES
TEMPORARY SEED: Winter Rye *(Secale cereale)*	40 lbs/acre	June–August
PERMANENT SEED: Big Bluestem *(Andropogon gerardii)* Broomsedge *(Andropogon virginicus)* Deertongue *(Panicum clandestinum)* Little Bluestem *(Schizachyrium scoparium)* Indiangrass *(Sorghastrum nutans)*	15 lbs/acre of mixture	September – May
OVERSEED: Pearl Millet *(Pennisetum glaucum)*	15 lbs/acre	June–August

PRELIMINARY
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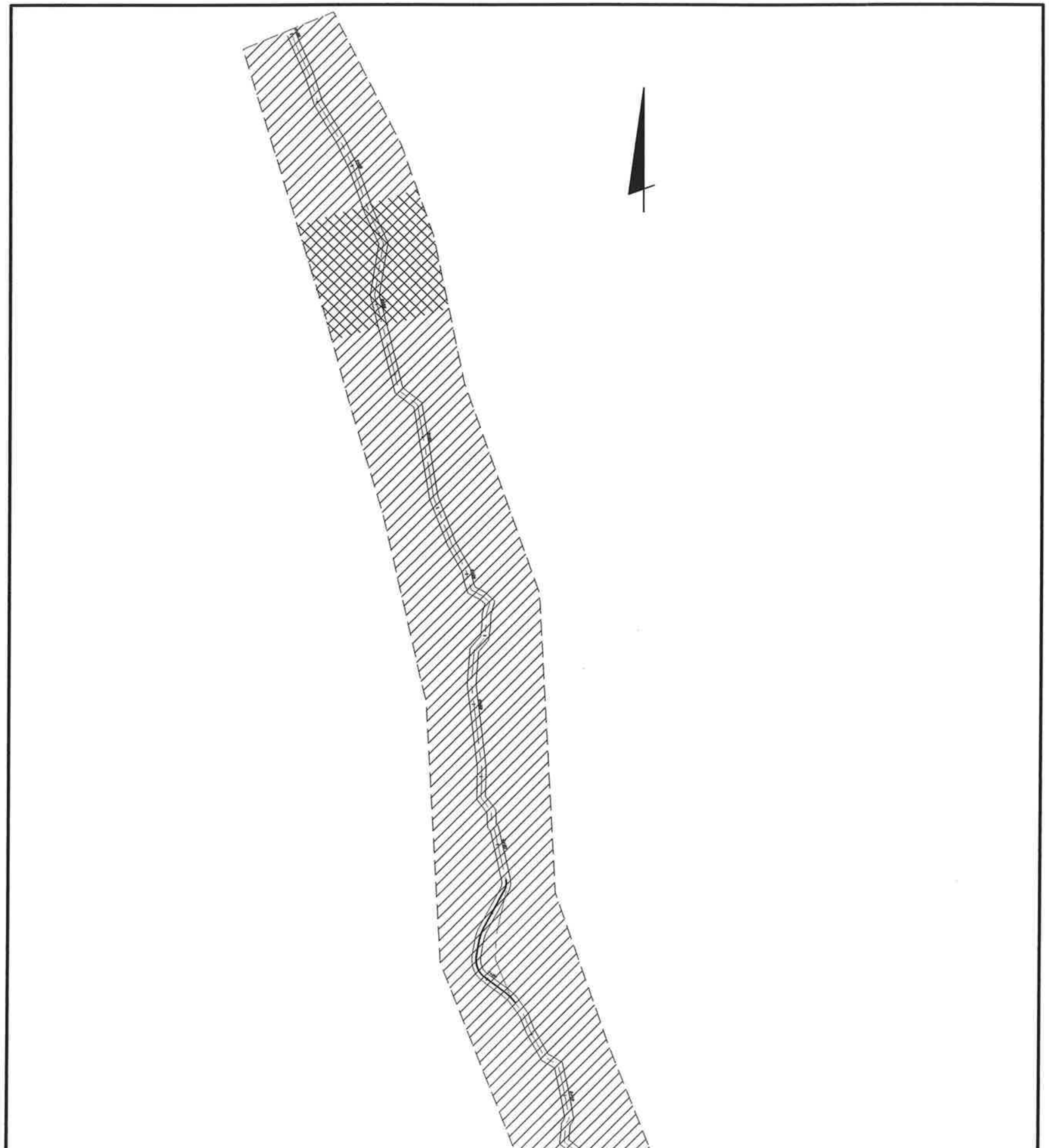
Ecosystem Enhancement PROGRAM

BURKE COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
SILVER CREEK AND UNNAMED TRIBUTARY
SILVER CREEK
PLANTING PLAN

Date: May, 2006 Rev. June 2006
Job No.: 2005-1446
Scale: As Noted
Sheet: RP-17/19



PLANTING ZONES – UNNAMED TRIBUTARY

– Zone 1 – Outside Meander (2'x2' centers)
Live branches (See Channel Reinforcement Detail, Sheet RP–9)

Common Name	Scientific Name
Silky dogwood	*Cornus amomum*
Southern arrowwood viburnum	*Viburnum dentatum*
Elderberry	*Sambucus canadensis*
Black willow	*Salix nigra*

– Zone 2 – Streamside Shrubs & Trees

Shrubs (4'x4' centers)

Common Name	Scientific Name
Painted buckeye	*Aesculus sylvatica*
Silky dogwood	*Cornus amomum*
Tag alder	*Alnus serrulata*
Black willow	*Salix nigra*
Elderberry	*Sambucus canadensis*
Southern arrowwood viburnum	*Viburnum dentatum*
American hazelnut	*Corylus americana*

Trees *

Common Name	Scientific Name
Box elder	*Acer negundo*
River birch	*Betula nigra*
Sycamore	*Platanus occidentalis*
Sweet gum	*Liquidambar styraciflua*
Green ash	*Fraxinus pennsylvanica*
Tulip poplar	*Liriodendran tulipirera*
American elm	*Ulmus americana*
Bitternut hickory	*Carya cordiformis*

* Trees should be 1 gallon pots on 100' spacing, unless otherwise indicated.

– Zone 3 – Floodprone Area (8'x8' centers)

Common Name	Scientific Name
Box elder	*Acer negundo*
River birch	*Betula nigra*
Sycamore	*Platanus accidentalis*
Sweet gum	*Liquidambar styraciflua*
Green ash	*Fraxinus pennsylvanica*
Tulip poplar	*Liriodendron tulipifera*
American elm	*Ulmus americana*
Bitternut hickory	*Carya cordiformis*

– Zone 4 – Riparian Buffer (10'x10' centers)

Common Name	Scientific Name
White ash	*Fraxinus alba*
Black walnut	*Juglans nigra*
Tulip poplar	*Liriodendron tulipifera*
Black gum	*Nyssa sylvatica*
Black cherry	*Prunus serotina*
White oak	*Quercus alba*

– Supplemental Plantings
Most existing vegetation will remain and will be supplemented by a mixture of bare–root and larger tree material to improve the riparian corridor.

Common Name	Scientific Name
White ash	*Fraxinus alba*
Black walnut	*Juglans nigra*
Tulip poplar	*Liriodendron tulipifera*
Black gum	*Nyssa sylvatica*
Black cherry	*Prunus serotina*
White oak	*Quercus alba*

– Cattle Intrusion Area
Current vegetation is sparse due to heavy cattle intrusion. Areas will be improved by planting of bare–root trees on 8' centers, in addition to same larger material.

Common Name	Scientific Name
White ash	*Fraxinus alba*
Black walnut	*Juglans nigra*
Tulip poplar	*Liriodendron tulipifera*
Black gum	*Nyssa sylvatica*
Black cherry	*Prunus serotina*
White oak	*Quercus alba*

– Notes
– Full planting (utilizing Zone 1–4 approach) will occur in areas cleared for construction access
– Final species selection will be based upon availability
– Temporary and permanent seeding to occur in Zones 2, 3 & 4 – See Table

TYPE		APPLICATION RATES	APPLICATION DATES
TEMPORARY SEED:			
Winter Rye	*(Secale cereale)*	40 lbs/acre	June–August
PERMANENT SEED:		15 lbs/acre of mixture	September – May
Big Bluestem	*(Andropogon gerardii)*		
Broomsedge	*(Andropogon virginicus)*		
Deertongue	*(Panicum clandestinum)*		
Little Bluestem	*(Schizachyrium scoparium)*		
Indiangrass	*(Sorghastrum nutans)*		
OVERSEED:			
Pearl Millet	*(Pennisetum glaucum)*	15 lbs/acre	June–August

PRELIMINARY
NOT FOR CONSTRUCTION

Job No. 2005-1446
Sheet RP-18/19
Date May, 2006 Rev. June 2006
Scale 1" = 40'

BURKE COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
SILVER CREEK AND UNNAMED TRIBUTARY
UNNAMED TRIBUTARY
PLANTING PLAN

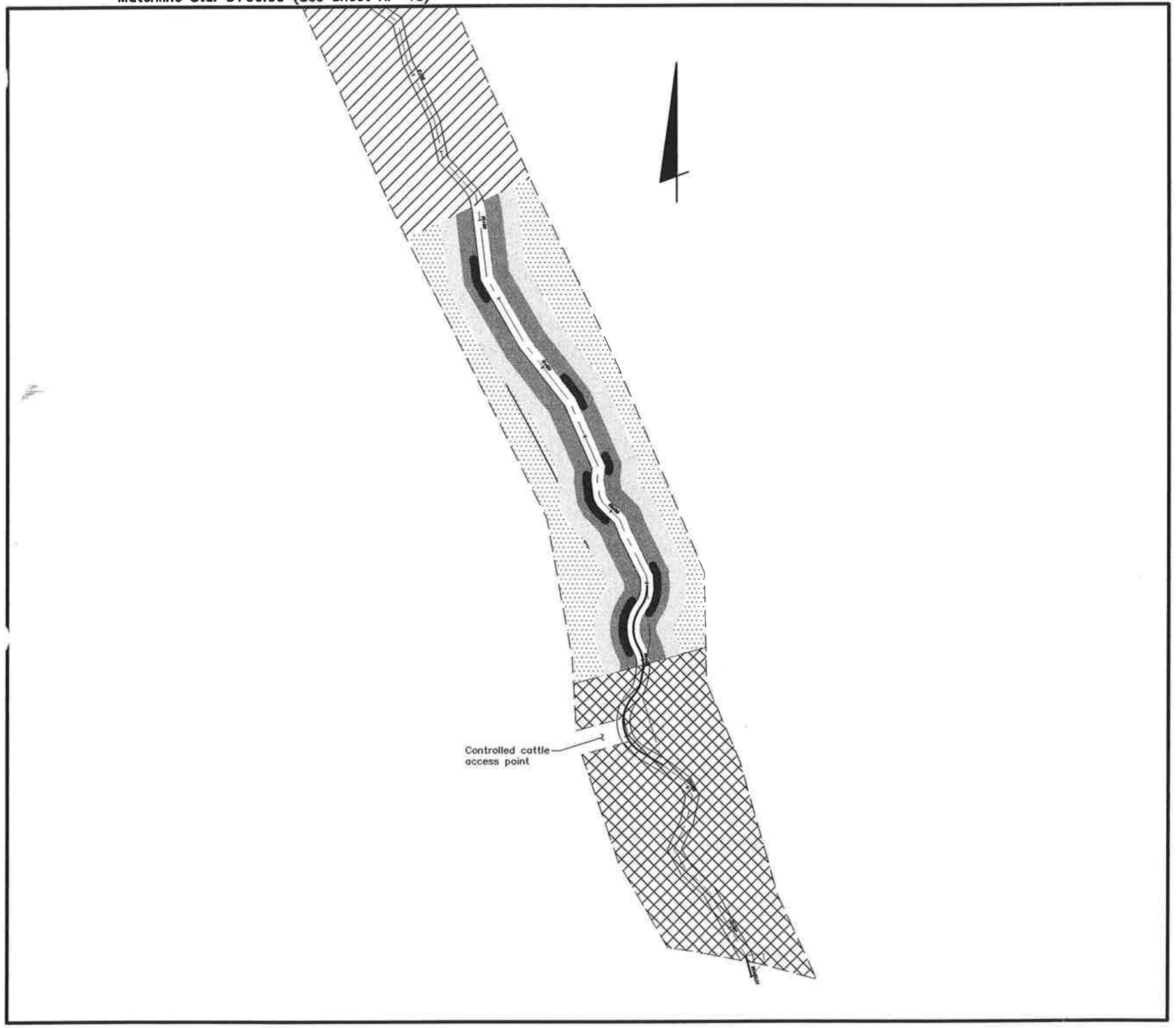
Ecosystem Enhancement PROGRAM

EMHT
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road, Columbus, OH 43054
Phone: 614.775.4500 Fax: 614.775.4800

MARK	DATE	DESCRIPTION

REVISIONS

Matchline Sta. 8+50.00 (See Sheet RP-18)



PLANTING ZONES – UNNAMED TRIBUTARY

– Zone 1 – Outside Meander (2'x2' centers)
Live branches (See Channel Reinforcement Detail, Sheet RP-9)

Common Name	Scientific Name
Silky dogwood	*Cornus amomum*
Southern arrowwood viburnum	*Viburnum dentatum*
Elderberry	*Sambucus canadensis*
Black willow	*Salix nigra*

– Zone 2 – Streamside Shrubs & Trees

Shrubs (4'x4' centers)

Common Name	Scientific Name
Painted buckeye	*Aesculus sylvatica*
Silky dogwood	*Cornus amomum*
Tag alder	*Alnus serrulata*
Black willow	*Salix nigra*
Elderberry	*Sambucus canadensis*
Southern arrowwood viburnum	*Viburnum dentatum*
American hazelnut	*Corylus americana*

Trees *

Common Name	Scientific Name
Box elder	*Acer negundo*
River birch	*Betula nigra*
Sycamore	*Platanus occidentalis*
Sweet gum	*Liquidambar styraciflua*
Green ash	*Fraxinus pennsylvanica*
Tulip poplar	*Liriodendran tulipirera*
American elm	*Ulmus americana*
Bitternut hickory	*Carya cordiformis*

* Trees should be 1 gallon pots on 100' spacing, unless otherwise indicated.

– Zone 3 – Floodprone Area (8'x8' centers)

Common Name	Scientific Name
Box elder	*Acer negundo*
River birch	*Betula nigra*
Sycamore	*Platanus accidentalis*
Sweet gum	*Liquidambar styraciflua*
Green ash	*Fraxinus pennsylvanica*
Tulip poplar	*Liriodendron tulipifera*
American elm	*Ulmus americana*
Bitternut hickory	*Carya cordiformis*

– Zone 4 – Riparian Buffer (10'x10' centers)

Common Name	Scientific Name
White ash	*Fraxinus alba*
Black walnut	*Juglans nigra*
Tulip poplar	*Liriodendron tulipifera*
Black gum	*Nyssa sylvatica*
Black cherry	*Prunus serotina*
White oak	*Quercus alba*

– Supplemental Plantings
Most existing vegetation will remain and will be supplemented by a mixture of bare-root and larger tree material to improve the riparian corridor.

Common Name	Scientific Name
White ash	*Fraxinus alba*
Black walnut	*Juglans nigra*
Tulip poplar	*Liriodendron tulipifera*
Black gum	*Nyssa sylvatica*
Black cherry	*Prunus serotina*
White oak	*Quercus alba*

– Cattle Intrusion Area
Current vegetation is sparse due to heavy cattle intrusion. Areas will be improved by planting of bare-root trees on 8' centers, in addition to some larger material.

Common Name	Scientific Name
White ash	*Fraxinus alba*
Black walnut	*Juglans nigra*
Tulip poplar	*Liriodendron tulipifera*
Black gum	*Nyssa sylvatica*
Black cherry	*Prunus serotina*
White oak	*Quercus alba*

– Notes
- Full planting (utilizing Zone 1–4 approach) will occur in areas cleared for construction access
- Final species selection will be based upon availability
- Temporary and permanent seeding to occur in Zones 2, 3 & 4 – See Table

TYPE		APPLICATION RATES	APPLICATION DATES
TEMPORARY SEED: Winter Rye	*(Secale cereale)*	40 lbs/acre	June–August
PERMANENT SEED: Big Bluestem Broomsedge Deertongue Little Bluestem Indiangrass	*(Andropogon gerardii)* *(Andropogon virginicus)* *(Panicum clandestinum)* *(Schizachyrium scoparium)* *(Sorghastrum nutans)*	15 lbs/acre of mixture	September – May
OVERSEED: Pearl Millet	*(Pennisetum glaucum)*	15 lbs/acre	June–August

PRELIMINARY
NOT FOR CONSTRUCTION

REVISIONS

MARK	DATE	DESCRIPTION

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Ecosystem Enhancement PROGRAM

BURKE COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
SILVER CREEK AND UNNAMED TRIBUTARY
UNNAMED TRIBUTARY
PLANTING PLAN

Date: May, 2006 Rev. June 2006
Scale: 1" = 40'
Job No. 2006-1446
Sheet: RP-19/19

APPENDIX 2

Project Site NCDWQ Stream Classification Forms

NCDWQ Stream Classification Form

Project Name: River Basin: County: Evaluator: d'ver

DWQ Project Number: Nearest Named Stream: Latitude: Signature:

Date: USGS QUAD: Longitude: Location/Directions:

*PLEASE NOTE: *If evaluator and landowner agree that the feature is a man-made ditch, then use of this form is not necessary. Also, if in the best professional judgement of the evaluator, the feature is a man-made ditch and not a modified natural stream—this rating system should not be used****

Primary Field Indicators: *(Circle One Number Per Line)*

I. Geomorphology	Absent	Weak	Moderate	Strong
1) Is There A Riffle-Pool Sequence?	0	1	2	3
2) Is The USDA Texture In Streambed Different From Surrounding Terrain?	0	1	2	3
3) Are Natural Levees Present?	0	1	2	3
4) Is The Channel Sinuous?	0	1	2	3
5) Is There An Active (Or Relic) Floodplain Present?	0	1	2	3
6) Is The Channel Braided?	0	1	2	3
7) Are Recent Alluvial Deposits Present?	0	1	2	3
8) Is There A Bankfull Bench Present?	0	1	2	3
9) Is A Continuous Bed & Bank Present?	0	1	2	3

NOTE: If Bed & Bank Caused By Ditching And WITHOUT Sinuosity Then Score=0

10) Is A 2nd Order Or Greater Channel (As Indicated On Topo Map *And/Or* In Field) Present? *Yes=3* *No=0*

PRIMARY GEOMORPHOLOGY INDICATOR POINTS: 19

II. Hydrology	Absent	Weak	Moderate	Strong
1) Is There A Groundwater Flow/Discharge Present?	0	1	2	3

PRIMARY HYDROLOGY INDICATOR POINTS: 1

III. Biology	Absent	Weak	Moderate	Strong
1) Are Fibrous Roots Present In Streambed?	3	2	1	0
2) Are Rooted Plants Present In Streambed?	3	2	1	0
3) Is Periphyton Present?	0	1	2	3
4) Are Bivalves Present?	0	1	2	3

PRIMARY BIOLOGY INDICATOR POINTS: 8

Secondary Field Indicators: *(Circle One Number Per Line)*

I. Geomorphology	Absent	Weak	Moderate	Strong
1) Is There A Head Cut Present In Channel?	0	.5	1	1.5
2) Is There A Grade Control Point In Channel?	0	.5	1	1.5
3) Does Topography Indicate A Natural Drainage Way?	0	.5	1	1.5

SECONDARY GEOMORPHOLOGY INDICATOR POINTS: 3

II. Hydrology	Absent	Weak	Moderate	Strong
1) Is This Year's (Or Last's) Leaflitter Present In Streambed?	1.5	1	.5	0
2) Is Sediment On Plants (Or Debris) Present?	0	.5	1	1.5
3) Are Wrack Lines Present?	0	.5	1	1.5
4) Is Water In Channel *And* >48 Hrs. Since ***Known*** Rain? *(*NOTE: If Ditch Indicated In #9 Above Skip This Step And #5 Below*)*	0	.5	1	1.5
5) Is There Water In Channel During Dry Conditions *Or* In Growing Season)?	0	.5	1	1.5
6) Are Hydric Soils Present In Sides Of Channel (Or In Headcut)?		*Yes=1.5*	*No=0*	

SECONDARY HYDROLOGY INDICATOR POINTS: 7

III. Biology	Absent	Weak	Moderate	Strong
1) Are Fish Present?	0	.5	1	1.5
2) Are Amphibians Present?	0	.5	1	1.5
3) Are AquaticTurtles Present?	0	.5	1	1.5
4) Are Crayfish Present?	0	.5	1	1.5
5) Are Macrobenthos Present?	0	.5	1	1.5
6) Are Iron Oxidizing Bacteria/Fungus Present?	0	.5	1	1.5
7) Is Filamentous Algae Present?	0	.5	1	1.5

8) Are Wetland Plants In Streambed?	SAV	Mostly OBL	Mostly FACW	Mostly FAC	Mostly FACU	Mostly UPL
*(*NOTE: If Total Absence Of All Plants In Streambed As Noted Above Skip This Step UNLESS SAV Present*).*	2	1	.75	.5	0	0

SECONDARY BIOLOGY INDICATOR POINTS: 2.5

TOTAL POINTS *(Primary + Secondary)* = 39.5 *(If Greater Than Or Equal To 19 Points The Stream Is At Least Intermittent)*

NCDWQ Stream Classification Form

Silver Cr. Trib

Project Name:	River Basin:	County:	Evaluator:
DWQ Project Number:	Nearest Named Stream:	Latitude:	Signature:
Date:	USGS QUAD:	Longitude:	Location/Directions:

PLEASE NOTE: *If evaluator and landowner agree that the feature is a man-made ditch, then use of this form is not necessary. Also, if in the best professional judgement of the evaluator, the feature is a man-made ditch and not a modified natural stream—this rating system should not be used**

Primary Field Indicators: *(Circle One Number Per Line)*

I. Geomorphology	Absent	Weak	Moderate	Strong
1) Is There A Riffle-Pool Sequence?	0	1	2	3
2) Is The USDA Texture In Streambed Different From Surrounding Terrain?	0	1	2	3
3) Are Natural Levees Present?	0	1	2	3
4) Is The Channel Sinuous?	0	1	2	3
5) Is There An Active (Or Relic) Floodplain Present?	0	1	2	3
6) Is The Channel Braided?	0	1	2	3
7) Are Recent Alluvial Deposits Present?	0	1	2	3
8) Is There A Bankfull Bench Present?	0	1	2	3
9) Is A Continuous Bed & Bank Present?	0	1	2	3
*(*NOTE: If Bed & Bank Caused By Ditching And WITHOUT Sinuosity Then Score=0*)*				
10) Is A 2^{nd} Order Or Greater Channel (As Indicated On Topo Map *And/Or* In Field) Present?	*Yes=3*		*No=0*	

PRIMARY GEOMORPHOLOGY INDICATOR POINTS: 14

II. Hydrology	Absent	Weak	Moderate	Strong
1) Is There A Groundwater Flow/Discharge Present?	0	1	2	3

PRIMARY HYDROLOGY INDICATOR POINTS: 3

III. Biology	Absent	Weak	Moderate	Strong
1) Are Fibrous Roots Present In Streambed?	3	2	1	0
2) Are Rooted Plants Present In Streambed?	3	2	1	0
3) Is Periphyton Present?	0	1	2	3
4) Are Bivalves Present?	0	1	2	3

PRIMARY BIOLOGY INDICATOR POINTS: 6

Secondary Field Indicators: *(Circle One Number Per Line)*

I. Geomorphology	Absent	Weak	Moderate	Strong
1) Is There A Head Cut Present In Channel?	0	.5	1	1.5
2) Is There A Grade Control Point In Channel?	0	.5	1	1.5
3) Does Topography Indicate A Natural Drainage Way?	0	.5	1	1.5

SECONDARY GEOMORPHOLOGY INDICATOR POINTS: 3.5

II. Hydrology	Absent	Weak	Moderate	Strong
1) Is This Year's (Or Last's) Leaflitter Present In Streambed?	1.5	1	.5	0
2) Is Sediment On Plants (Or Debris) Present?	0	.5	1	1.5
3) Are Wrack Lines Present?	0	.5	1	1.5
4) Is Water In Channel *And* >48 Hrs. Since Known Rain? *(*NOTE: If Ditch Indicated In #9 Above Skip This Step And #5 Below*)*	0	.5	1	1.5
5) Is There Water In Channel During Dry Conditions *Or* In Growing Season)?	0	.5	1	1.5
6) Are Hydric Soils Present In Sides Of Channel (Or In Headcut)?		*Yes=1.5*	*No=0*	

SECONDARY HYDROLOGY INDICATOR POINTS: 5.5

III. Biology	Absent	Weak	Moderate	Strong
1) Are Fish Present?	0	.5	1	1.5
2) Are Amphibians Present?	0	.5	1	1.5
3) Are AquaticTurtles Present?	0	.5	1	1.5
4) Are Crayfish Present?	0	.5	1	1.5
5) Are Macrobenthos Present?	0	.5	1	1.5
6) Are Iron Oxidizing Bacteria/Fungus Present?	0	.5	1	1.5
7) Is Filamentous Algae Present?	0	.5	1	1.5

	SAV	Mostly OBL	Mostly FACW	Mostly FAC	Mostly FACU	Mostly UPL
8) Are Wetland Plants In Streambed? *(*NOTE: If Total Absence Of All Plants In Streambed As Noted Above Skip This Step UNLESS SAV Present*)*	2	1	.75	.5	0	0

SECONDARY BIOLOGY INDICATOR POINTS: 4

TOTAL POINTS *(Primary + Secondary)*=37 *(If Greater Than Or Equal To 19 Points The Stream Is At Least Intermittent)*

APPENDIX 3

Project Site Design Calculations, Plots, Photographs and Summary Reports

Stream Classification Form

Stream Channel Classification (Level II) ...

Stream NAME: Silver Creek & Trib Restoration, Reach - Reach 2 (Abandoned Oxbow)

Basin NAME: CATAWBA RIVER Drainage AREA: 5126.4 acre 8.01 mi^2

Location: RIFFLE XS STA 12+52.5, SILVER CREEK, BURKE CO., NC

Twp: ______ Rge: ______ Sec: ______ Qtr: ______ Lat: 0 Long: 0

Observers: WARREN E. KNOTTS, PG Date: 2/8/2006

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel, at bankfull stage elevation, in a riffle section.	**122.5** Feet
Mean DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section. ($d_{bkf}=A_{bkf}/W_{bkf}$)	**2.56** Feet
Bankfull Cross Section Area (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**315.9** $Feet^2$
WIDTH / DEPTH RATIO (W_{bkf}/d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**47.85** Ft/Ft
Maximum DEPTH (d_{mrif}) Maximum depth of the bankfull channel cross-section, or elevation between the bankfull stage and thalweg in a riffle section.	**8.31** Feet
Flood-Prone Area WIDTH (W_{fpa}) The stage/elevation at which flood-prone area WIDTH is determined in a riffle section at twice maximum DEPTH, or (2 x d_{mrif})	**123.4** Feet
Entrenchment RATIO (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa}/W_{bkf}) in a riffle section.	**1.01** Ft/Ft
Channel Materials (Particle Size Index) D50 The 50th percentile, or less than, from a pebble count frequency distribution of channel particles representing the median or dominant particle size.	**38.5** mm
Water Surface SLOPE (S) Average water surface slope as measured between the same position of bed features in the profile over two meander wave lengths. This is similar to average bankfull slope.	**0.00218** Ft/Ft
Channel SINUOSITY (K) Sinuosity: an index of channel pattern, determined from stream length / valley length, i.e. (SL/VL); or estimated from a ratio of valley slope divided by channel slope (VS/ S).	**1**

Stream Type → **F 4** ← *For Reference, see page 5-5, 5-6: Rosgen, 1996. Applied River Morphology.*

Altered Reach Summary Data Form

Silver Creek Abandoned Oxbow Riffle Section

... and Altered Reach Summary Data

Channel Dimension

Mean Riffle Depth (d_{bkf})	1.83	feet	Mean Riffle Width (W_{bkf})	123.4	feet	Mean Riffle Area (A_{bkf})	225.5	feet^2
Mean Pool Depth (d_{bkfp})	0	feet	Mean Pool Width (W_{bkfp})	0	feet	Mean Pool Area (A_{bkfp})	0	feet^2
Ratio Mean Pool Depth/Mean Riffle Depth	0.000	d_{bkfp}/ d_{bkf}	Ratio Pool Width/Riffle Width	0.000	W_{bkfp}/ W_{bkf}	Ratio Pool Area/ Riffle Area	0.000	A_{bkfp}/ A_{bkf}
Max Riffle Depth (d_{mrif})	7.58	feet	Max Pool Depth (d_{mpool})	0	feet	Max riffle depth/Mean riffle depth	4.142	
Max pool depth/Mean riffle depth	0					Point Bar Slope	0	
Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	1.46	ft/s				Estimation Method		
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	461	cfs				Drainage Area	8.01	mi^2

Channel Pattern

Geometry	Ave	Min	Max		Dimensionless Geometry Ratios	Ave	Min	Max
Meander Length (Lm)	0	0	0	feet	Meander Length Ratio (Lm/W_{bkf})	0.000	0.000	0.000
Radius of Curvature (Rc)	0	0	0	feet	Radius of Curvature/Riffle Width (Rc/W_{bkf})	0.000	0.000	0.000
Belt Width (W_{blt})	0	0	0	feet	Meander Width Ratio (W_{blt}/W_{bkf})	0.000	0.000	0.000
Individual Pool Length	31.95	25.75	36.05	feet	Pool Length/Riffle Width	0.259	0.209	0.292
Pool to Pool Spacing	119.1	101.1	137.2	feet	Pool to Pool Spacing/Riffle Width	0.965	0.819	1.112

Channel Profile

Valley Slope (VS)	0.0051	ft/ft	Average Water Surface Slope (S)	0.00218	ft/ft	Sinuosity (VS/S)	1	
Stream Length (SL)	0	feet	Valley Length (VL)	0	feet	Sinuosity (SL/VL)	#####	
Low Bank Height (LBH)	start 0	feet	Max Riffle Depth	start 0	feet	Bank Height Ratio (LBH/Max Riffle Depth)	start	#####
	end 0	feet		end 0	feet		end	#####

Facet Slopes	Ave	Min	Max		Dimensionless Slope Ratios	Ave	Min	Max
Riffle Slope (S_{rif})	0.0028	0.0028	0.0028	ft/ft	Riffle Slope/Average Water Surface Slope (S_{rif}/S)	1.303	1.303	1.303
Run Slope (S_{run})	0.0014	0.0006	0.0025	ft/ft	Run Slope/Average Water Surface Slope (S_{run}/S)	0.619	0.257	1.138
Pool Slope (S_p)	0.0026	0.0004	0.0080	ft/ft	Pool Slope/Average Water Surface Slope (S_p/S)	1.170	0.202	3.683
Glide Slope (S_g)	0.0119	0.0000	0.0320	ft/ft	Glide Slope/Average Water Surface Slope (S_g/S)	5.440	0.000	14.661

Feature Midpoint[a]	Ave	Min	Max		Dimensionless Depth Ratios	Ave	Min	Max
Riffle Depth (d_{mrif})	7.580	7.580	7.580	feet	Riffle Max Depth/Riffle Mean Depth (d_{mrif}/d_{bkf})	4.142	4.142	4.142
Run Depth (d_{mrun})	4.940	4.940	4.940	feet	Run Max Depth/Riffle Mean Depth (d_{mrun}/d_{bkf})	2.699	2.699	2.699
Pool Depth (d_{mp})	0.000	0.000	0.000	feet	Pool Max Depth/Riffle Mean Depth (d_{mp}/d_{bkf})	0.000	0.000	0.000
Glide Depth (d_{mg})	0.000	0.000	0.000	feet	Glide Max Depth/Riffle Mean Depth (d_{mg}/d_{bkf})	0.000	0.000	0.000

Channel Materials

Catagories	Reach[b]	Riffle[c]	Bar
% Silt/Clay		0	
% Sand		0	
% Gravel		90	
% Cobble		10	
% Boulder		0	
% Bedrock		0	

Indices	Reach[b]	Riffle[c]	Bar	
D16		20.0		mm
D35		29.7		mm
D50		38.5		mm
D84		60.2		mm
D95		77		mm
D100		90		mm

a. The range of "feature" mid-point maximum bankfull depths, including the minimum, maximum and average values. (Pool depths are obtained from the deepest portion of the feature.)

b. A composite sample of materials from riffle and pool featutes taken within the designated reach.

c. Sample obtained within the "active" bed of a riffle feature at the location of the cross section.

Silver Creek Main Stem NCD Report

RIVERMORPH NATURAL CHANNEL DESIGN REPORT

River Name: Silver Creek
Reach Name: Main Stem

--Reference Reach--

Silver Creek & Trib Restoration; Reach 1 (Reference Reach) (C 4)

--Boundary Conditions--

Drainage Area:	8.01 sq mi
Valley Slope:	.0051 ft/ft
Bankfull Discharge:	461 cfs
Bankfull Cross Sectional Area:	103 sq ft
Mean Depth Calculation Tolerance:	0.2 ft

--Sediment Data--

Riffle Bed Material ID:	
Riffle Bed Material D84:	60.2 mm
Riffle Bed Material D50:	38.5 mm
Bar Sample ID:	
Bar Sample Dmax:	180 mm
Bar Sample D50:	27.3 mm

--Entrainment Options--

Shields Entrainment Function

---------------NCD Results---------------

--Alignment--

Meander Wavelength:	191.8 ft
Channel Length:	264.03 ft
Sinuosity:	1.38
Radius of Curvature:	32.3 ft
Bankfull Slope:	0.0037
Meander Belt Width:	82.8 ft
Meander Width Ratio:	2.06
Deflection Angle:	0 rad

--Riffle Cross Sectional Properties--

Width to Depth Ratio:	15.67
Entrenchment Ratio:	9.66
Floodprone Width:	388.04 ft
Bankfull Width:	40.17 ft
Bankfull Mean Depth:	2.56 ft
Bankfull Velocity:	4.48 ft/s
Bankfull Hydraulic Radius:	2.27 ft
Bankfull Shear Stress:	0.524 lbs/sq ft
Required Roughness (n):	0.0349 ft^(1/6)
Entrainable Particle Size:	30.6 mm

--Rosgen Stream Classification--

Reference Reach :	C 4
Proposed Reach :	C 4
Existing Reach :	F 4

--Sediment Transport Competency--

Ratio - Riffle Slope / Bankfull Slope:	2.14
Ratio - D50bed / D50bar:	1.410
Critical Dimensionless Shear Stress (1):	0.0618
Required Mean Depth (1):	16.27 ft
Ratio - Di bar / D50bed:	4.675
Critical Dimensionless Shear Stress (2):	0.0098
Required Mean Depth (2):	2.57 ft

Minimum Required Mean Depth: 2.57 ft

Cross-Vane Design Summary
RIVERMORPH VANE DESIGN REPORT

River Name: Silver Creek
Reach Name: Main Stem
Vane Name: Cross-Vane

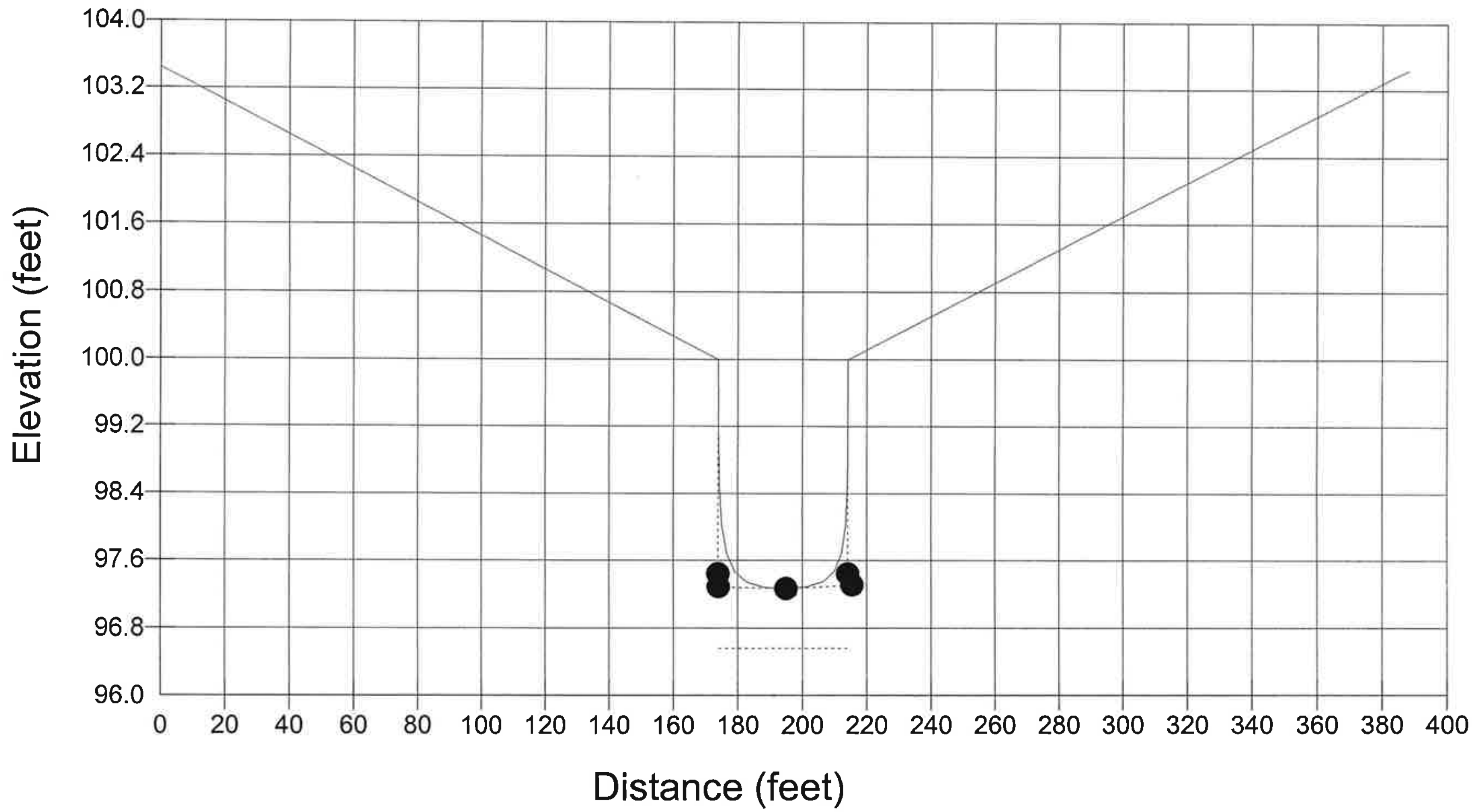
Input Data

Bank Height:	7.0	ft
Bankfull Height:	3.0	ft
Shear Stress:	0.55	lbs/sq ft
Near Bank Stress:	2.24	lbs/sq ft
Bankfull Slope:	0.0027	ft/ft
Bankfull Width:	30.0	ft
Radius of Curvature:	30.0	ft
Plan View Vane Angle:	10-17	deg

Results

Ratio - Rc/Wbkf:		
Vane Spacing:	1.00	ft
Vane Length:	250	ft
Minimum Rock Size (Diameter):	2.6	ft
Protrusion Height:	0.25	ft
Footing Depth:	4.75	ft
Layers of Footing Stones:	2	
Vane Slope:	5.0	%

Silver Creek Main Stem - Riffle Section Geometry

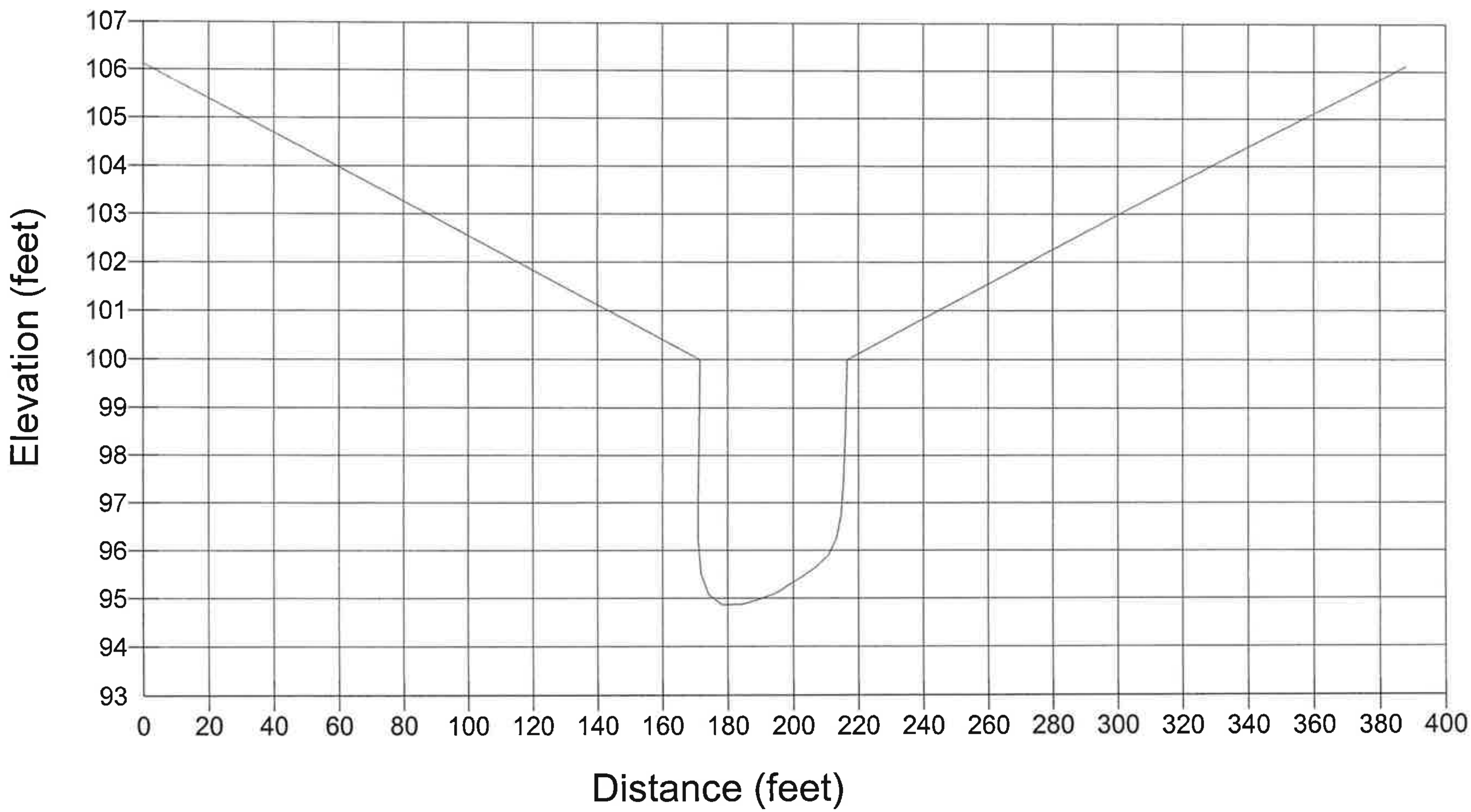


RIVERMorph Cross Section Detail
- Riffle -

Bankfull Elevation:	100.00	ft
Cross Sectional Area:	103.04	sq ft
Wetted Perimeter:	43.22	ft
Bankfull Width:	40.17	ft
Floodprone Width:	388.04	ft
Bankfull Mean Depth:	2.57	ft
Bankfull Max Depth:	2.74	ft
Lt. Bank Tangent Slope:	-	ft/ft
Rt. Bank Tangent Slope:	-	ft/ft

X-Coord	Y-Coord
0	103.44
173.93	100
173.98	99.15
174.28	98.5
175.07	98.02
176.59	97.68
179.11	97.46
182.84	97.34
188.05	97.28
194.96	97.26
201.66	97.29
206.59	97.35
210.02	97.47
212.21	97.69
213.45	98.02
213.99	98.5
214.12	99.15
214.1	100
388.04	103.44

Silver Creek Main Stem - Pool Section Geometry

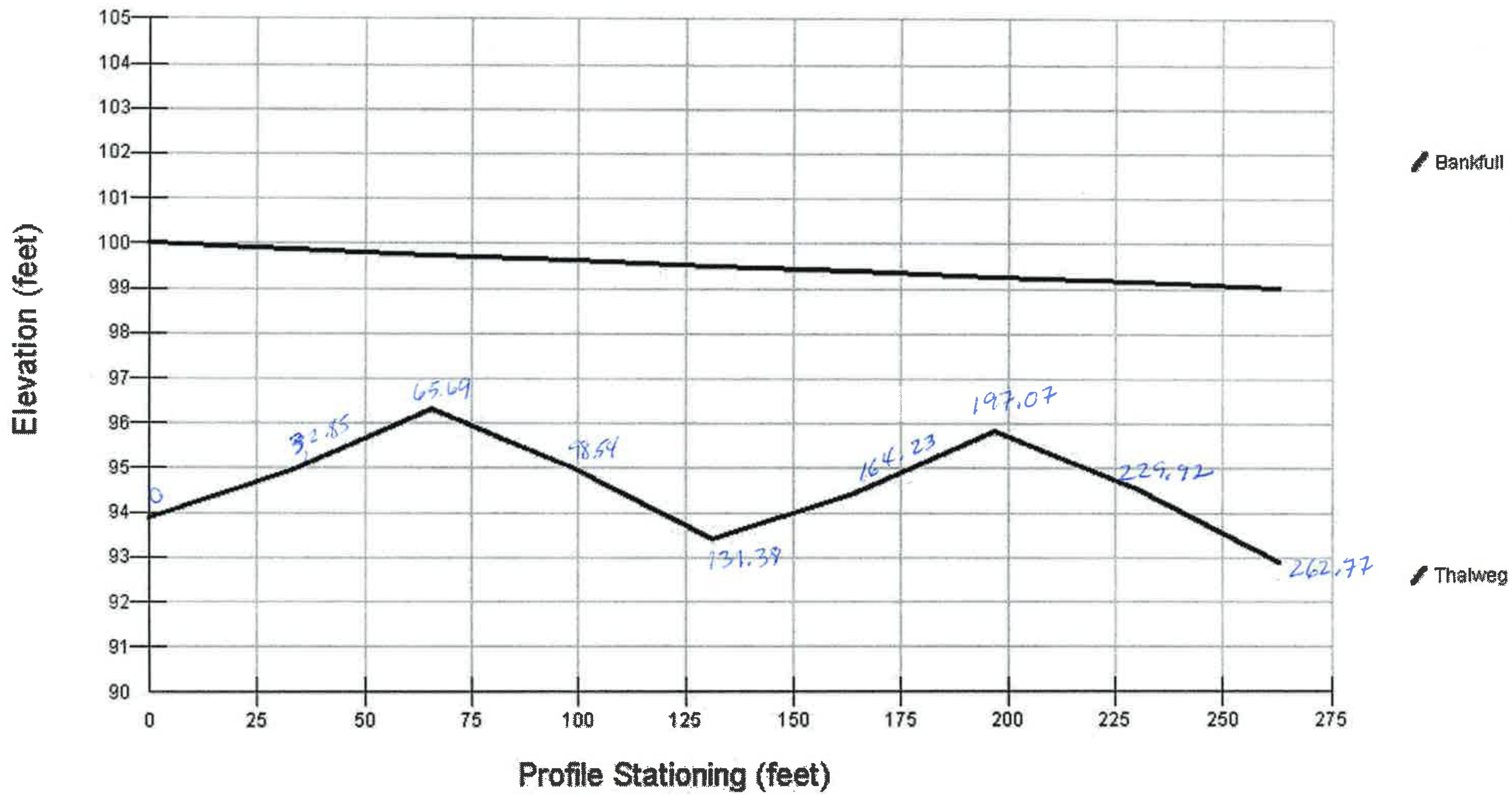


RIVERMorph Cross Section Detail
- Pool -

Bankfull Elevation:	100.00	ft
Cross Sectional Area:	209.03	sq ft
Wetted Perimeter:	51.86	ft
Bankfull Width:	45.1	ft
Floodprone Width:	388.04	ft
Bankfull Mean Depth:	4.63	ft
Bankfull Max Depth:	6.12	ft
Lt. Bank Tangent Slope:	-	ft/ft
Rt. Bank Tangent Slope:	-	ft/ft

X-Coord	Y-Coord
0	106.12
171.47	100
171.24	98.42
170.89	97.16
170.91	96.19
171.81	95.5
174.09	95.07
178.24	94.87
184.76	94.88
194.15	95.08
201.68	95.4
207.14	95.65
210.88	95.91
213.27	96.26
214.67	96.76
215.45	97.5
215.96	98.55
216.57	100
388.04	106.12

Design Profile BKF Geometry - Silver Creek Main Stem

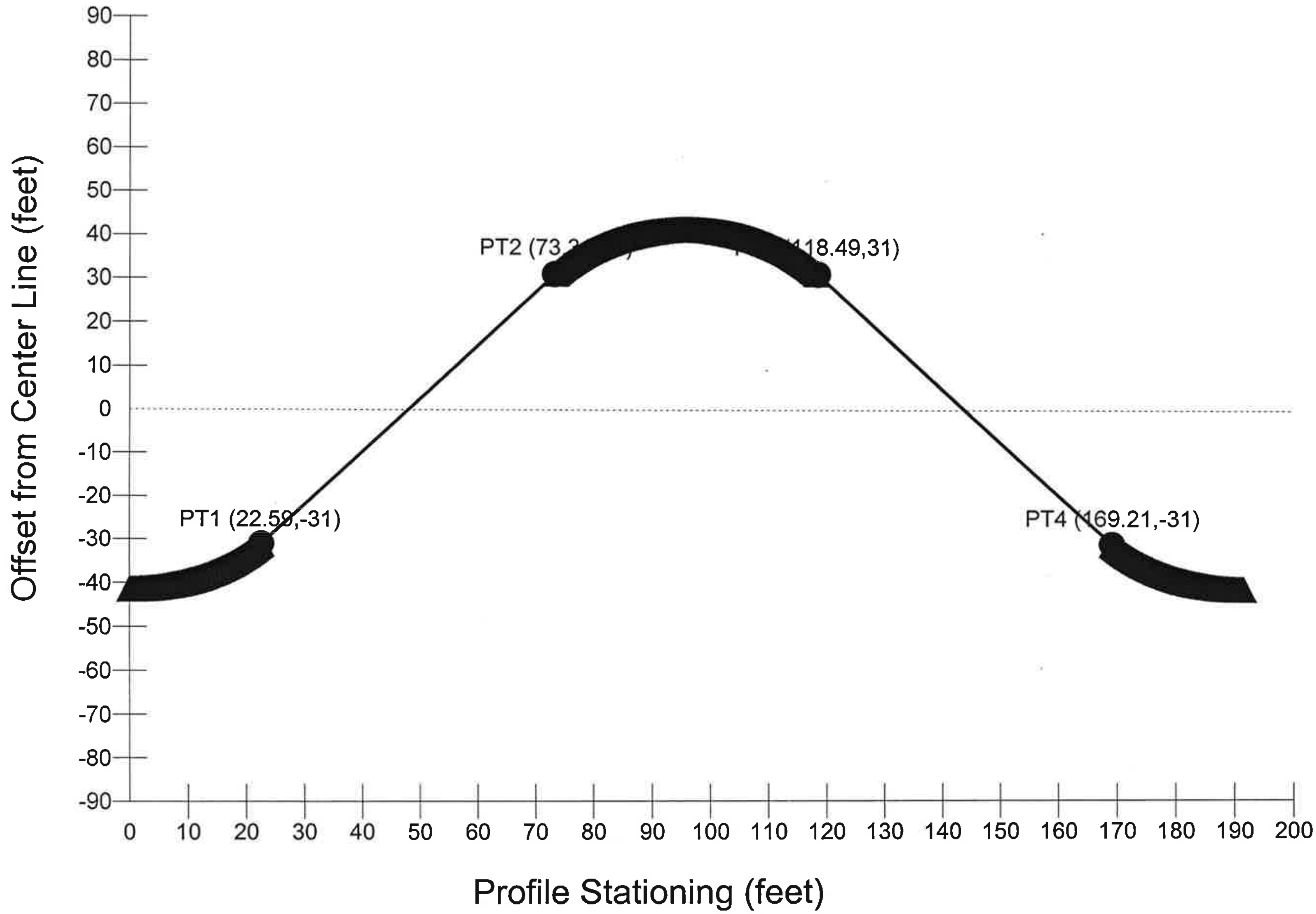


NCD PROFILE - ONE MEANDER WAVELENGTH

River: Silver Creek & Trib Restoration
Reach: Reach 1 (Reference Reach)

X-Coord	Y-Coord
0.00	93.88
32.85	94.94
65.69	96.32
98.54	95.03
131.38	93.39
164.23	94.45
197.07	95.83
229.92	94.54
262.77	92.90

Silver Creek Altered Reach Meander Geometry - Plan View



MEANDER WAVELENGTH

River:	Silver Creek & Trib Restoration
Reach:	Reach 1 (Reference Reach)
Sinuosity:	1.37
Meander Wavelength:	191.8 ft
Channel Length:	262.83 ft
Meander Belt Width:	82.8 ft
Radius of Curvature:	29.73 ft

Circular Curve Option Selected

Tangent Coordinates:

Pt. No.	X-Coord	Y-Coord
1	22.59	-31.00
2	73.31	31.00
3	118.49	31.00
4	169.21	-31.00

Thalweg Coordinates:

Pt. No.	X-Coord	Y-Coord
1	0.00	-41.40
2	0.26	-41.40
3	0.51	-41.40
4	0.77	-41.39
5	1.03	-41.38
6	1.28	-41.37
7	1.54	-41.36
8	1.80	-41.35
9	2.05	-41.33
10	2.31	-41.31
11	2.56	-41.29
12	2.82	-41.27
13	3.07	-41.24
14	3.33	-41.21
15	3.58	-41.18
16	3.84	-41.15
17	4.09	-41.12
18	4.35	-41.08
19	4.60	-41.04
20	4.85	-41.00
21	5.11	-40.96
22	5.36	-40.91
23	5.61	-40.87
24	5.86	-40.82
25	6.11	-40.76
26	6.37	-40.71
27	6.62	-40.65
28	6.87	-40.60
29	7.11	-40.54
30	7.36	-40.47
31	7.61	-40.41
32	7.86	-40.34
33	8.11	-40.27
34	8.35	-40.20
35	8.60	-40.13

36	8.84	-40.05
37	9.09	-39.98
38	9.33	-39.90
39	9.58	-39.82
40	9.82	-39.73
41	10.06	-39.65
42	10.30	-39.56
43	10.54	-39.47
44	10.78	-39.38
45	11.02	-39.28
46	11.26	-39.19
47	11.50	-39.09
48	11.73	-38.99
49	11.97	-38.88
50	12.20	-38.78
51	12.44	-38.67
52	12.67	-38.57
53	12.90	-38.46
54	13.13	-38.34
55	13.36	-38.23
56	13.59	-38.11
57	13.82	-37.99
58	14.04	-37.87
59	14.27	-37.75
60	14.49	-37.63
61	14.72	-37.50
62	14.94	-37.37
63	15.16	-37.24
64	15.38	-37.11
65	15.60	-36.98
66	15.82	-36.84
67	16.03	-36.70
68	16.25	-36.57
69	16.46	-36.42
70	16.68	-36.28
71	16.89	-36.14
72	17.10	-35.99
73	17.31	-35.84
74	17.52	-35.69
75	17.72	-35.54
76	17.93	-35.38
77	18.13	-35.23
78	18.33	-35.07
79	18.54	-34.91
80	18.74	-34.75
81	18.93	-34.59
82	19.13	-34.43
83	19.33	-34.26
84	19.52	-34.09
85	19.71	-33.92
86	19.91	-33.75
87	20.10	-33.58
88	20.28	-33.40
89	20.47	-33.23
90	20.66	-33.05
91	20.84	-32.87
92	21.02	-32.69
93	21.20	-32.51
94	21.38	-32.32
95	21.56	-32.14
96	21.73	-31.95
97	21.91	-31.76
98	22.08	-31.57
99	22.25	-31.38

100	22.42	-31.19
101	22.59	-31.00
102	73.48	31.19
103	73.65	31.38
104	73.82	31.57
105	73.99	31.76
106	74.17	31.95
107	74.34	32.14
108	74.52	32.32
109	74.70	32.51
110	74.88	32.69
111	75.06	32.87
112	75.24	33.05
113	75.43	33.23
114	75.62	33.40
115	75.80	33.58
116	75.99	33.75
117	76.19	33.92
118	76.38	34.09
119	76.57	34.26
120	76.77	34.43
121	76.97	34.59
122	77.16	34.75
123	77.36	34.91
124	77.57	35.07
125	77.77	35.23
126	77.97	35.38
127	78.18	35.54
128	78.38	35.69
129	78.59	35.84
130	78.80	35.99
131	79.01	36.14
132	79.22	36.28
133	79.44	36.42
134	79.65	36.57
135	79.87	36.70
136	80.08	36.84
137	80.30	36.98
138	80.52	37.11
139	80.74	37.24
140	80.96	37.37
141	81.18	37.50
142	81.41	37.63
143	81.63	37.75
144	81.86	37.87
145	82.08	37.99
146	82.31	38.11
147	82.54	38.23
148	82.77	38.34
149	83.00	38.46
150	83.23	38.57
151	83.46	38.67
152	83.70	38.78
153	83.93	38.88
154	84.17	38.99
155	84.40	39.09
156	84.64	39.19
157	84.88	39.28
158	85.12	39.38
159	85.36	39.47
160	85.60	39.56
161	85.84	39.65
162	86.08	39.73
163	86.32	39.82

164	86.57	39.90
165	86.81	39.98
166	87.06	40.05
167	87.30	40.13
168	87.55	40.20
169	87.79	40.27
170	88.04	40.34
171	88.29	40.41
172	88.54	40.47
173	88.79	40.54
174	89.03	40.60
175	89.28	40.65
176	89.53	40.71
177	89.79	40.76
178	90.04	40.82
179	90.29	40.87
180	90.54	40.91
181	90.79	40.96
182	91.05	41.00
183	91.30	41.04
184	91.55	41.08
185	91.81	41.12
186	92.06	41.15
187	92.32	41.18
188	92.57	41.21
189	92.83	41.24
190	93.08	41.27
191	93.34	41.29
192	93.59	41.31
193	93.85	41.33
194	94.10	41.35
195	94.36	41.36
196	94.62	41.37
197	94.87	41.38
198	95.13	41.39
199	95.39	41.40
200	95.64	41.40
201	95.90	41.40
202	96.16	41.40
203	96.41	41.40
204	96.67	41.39
205	96.93	41.38
206	97.18	41.37
207	97.44	41.36
208	97.70	41.35
209	97.95	41.33
210	98.21	41.31
211	98.46	41.29
212	98.72	41.27
213	98.97	41.24
214	99.23	41.21
215	99.48	41.18
216	99.74	41.15
217	99.99	41.12
218	100.25	41.08
219	100.50	41.04
220	100.75	41.00
221	101.01	40.96
222	101.26	40.91
223	101.51	40.87
224	101.76	40.82
225	102.01	40.76
226	102.27	40.71
227	102.52	40.65

228	102.77	40.60
229	103.02	40.54
230	103.26	40.47
231	103.51	40.41
232	103.76	40.34
233	104.01	40.27
234	104.25	40.20
235	104.50	40.13
236	104.74	40.05
237	104.99	39.98
238	105.23	39.90
239	105.48	39.82
240	105.72	39.73
241	105.96	39.65
242	106.20	39.56
243	106.44	39.47
244	106.68	39.38
245	106.92	39.28
246	107.16	39.19
247	107.40	39.09
248	107.63	38.99
249	107.87	38.88
250	108.10	38.78
251	108.34	38.67
252	108.57	38.57
253	108.80	38.46
254	109.03	38.34
255	109.26	38.23
256	109.49	38.11
257	109.72	37.99
258	109.94	37.87
259	110.17	37.75
260	110.39	37.63
261	110.62	37.50
262	110.84	37.37
263	111.06	37.24
264	111.28	37.11
265	111.50	36.98
266	111.72	36.84
267	111.93	36.70
268	112.15	36.57
269	112.36	36.42
270	112.58	36.28
271	112.79	36.14
272	113.00	35.99
273	113.21	35.84
274	113.42	35.69
275	113.62	35.54
276	113.83	35.38
277	114.03	35.23
278	114.23	35.07
279	114.44	34.91
280	114.64	34.75
281	114.83	34.59
282	115.03	34.43
283	115.23	34.26
284	115.42	34.09
285	115.61	33.92
286	115.81	33.75
287	116.00	33.58
288	116.18	33.40
289	116.37	33.23
290	116.56	33.05
291	116.74	32.87

292	116.92	32.69
293	117.10	32.51
294	117.28	32.32
295	117.46	32.14
296	117.63	31.95
297	117.81	31.76
298	117.98	31.57
299	118.15	31.38
300	118.32	31.19
301	169.21	-31.00
302	169.38	-31.19
303	169.55	-31.38
304	169.72	-31.57
305	169.89	-31.76
306	170.07	-31.95
307	170.24	-32.14
308	170.42	-32.32
309	170.60	-32.51
310	170.78	-32.69
311	170.96	-32.87
312	171.14	-33.05
313	171.33	-33.23
314	171.52	-33.40
315	171.70	-33.58
316	171.89	-33.75
317	172.09	-33.92
318	172.28	-34.09
319	172.47	-34.26
320	172.67	-34.43
321	172.87	-34.59
322	173.06	-34.75
323	173.26	-34.91
324	173.47	-35.07
325	173.67	-35.23
326	173.87	-35.38
327	174.08	-35.54
328	174.28	-35.69
329	174.49	-35.84
330	174.70	-35.99
331	174.91	-36.14
332	175.12	-36.28
333	175.34	-36.42
334	175.55	-36.57
335	175.77	-36.70
336	175.98	-36.84
337	176.20	-36.98
338	176.42	-37.11
339	176.64	-37.24
340	176.86	-37.37
341	177.08	-37.50
342	177.31	-37.63
343	177.53	-37.75
344	177.76	-37.87
345	177.98	-37.99
346	178.21	-38.11
347	178.44	-38.23
348	178.67	-38.34
349	178.90	-38.46
350	179.13	-38.57
351	179.36	-38.67
352	179.60	-38.78
353	179.83	-38.88
354	180.07	-38.99
355	180.30	-39.09

356	180.54	-39.19
357	180.78	-39.28
358	181.02	-39.38
359	181.26	-39.47
360	181.50	-39.56
361	181.74	-39.65
362	181.98	-39.73
363	182.22	-39.82
364	182.47	-39.90
365	182.71	-39.98
366	182.96	-40.05
367	183.20	-40.13
368	183.45	-40.20
369	183.69	-40.27
370	183.94	-40.34
371	184.19	-40.41
372	184.44	-40.47
373	184.69	-40.54
374	184.93	-40.60
375	185.18	-40.65
376	185.43	-40.71
377	185.69	-40.76
378	185.94	-40.82
379	186.19	-40.87
380	186.44	-40.91
381	186.69	-40.96
382	186.95	-41.00
383	187.20	-41.04
384	187.45	-41.08
385	187.71	-41.12
386	187.96	-41.15
387	188.22	-41.18
388	188.47	-41.21
389	188.73	-41.24
390	188.98	-41.27
391	189.24	-41.29
392	189.49	-41.31
393	189.75	-41.33
394	190.00	-41.35
395	190.26	-41.36
396	190.52	-41.37
397	190.77	-41.38
398	191.03	-41.39
399	191.29	-41.40
400	191.54	-41.40

Silver Creek BEHI Summary Report
RIVERMORPH BANK EROSION HARZARD INDEX (BEHI)

River Name: Silver Creek Main Stem
Reach Name: Abondoned Oxbow - Altered Profile Station 12+00 - 15+00
BEHI Name: Riffle Section 12+52.5
Survey Date: 02/08/06

Bankfull Height: 3 ft
Bank Height: 7.9 ft
Root Depth: 1.5 ft
Root Density: 5 %
Bank Angle: 85 Degrees
Surface Protection: 0.1 %

Bank Material Adjustment: Sand 10

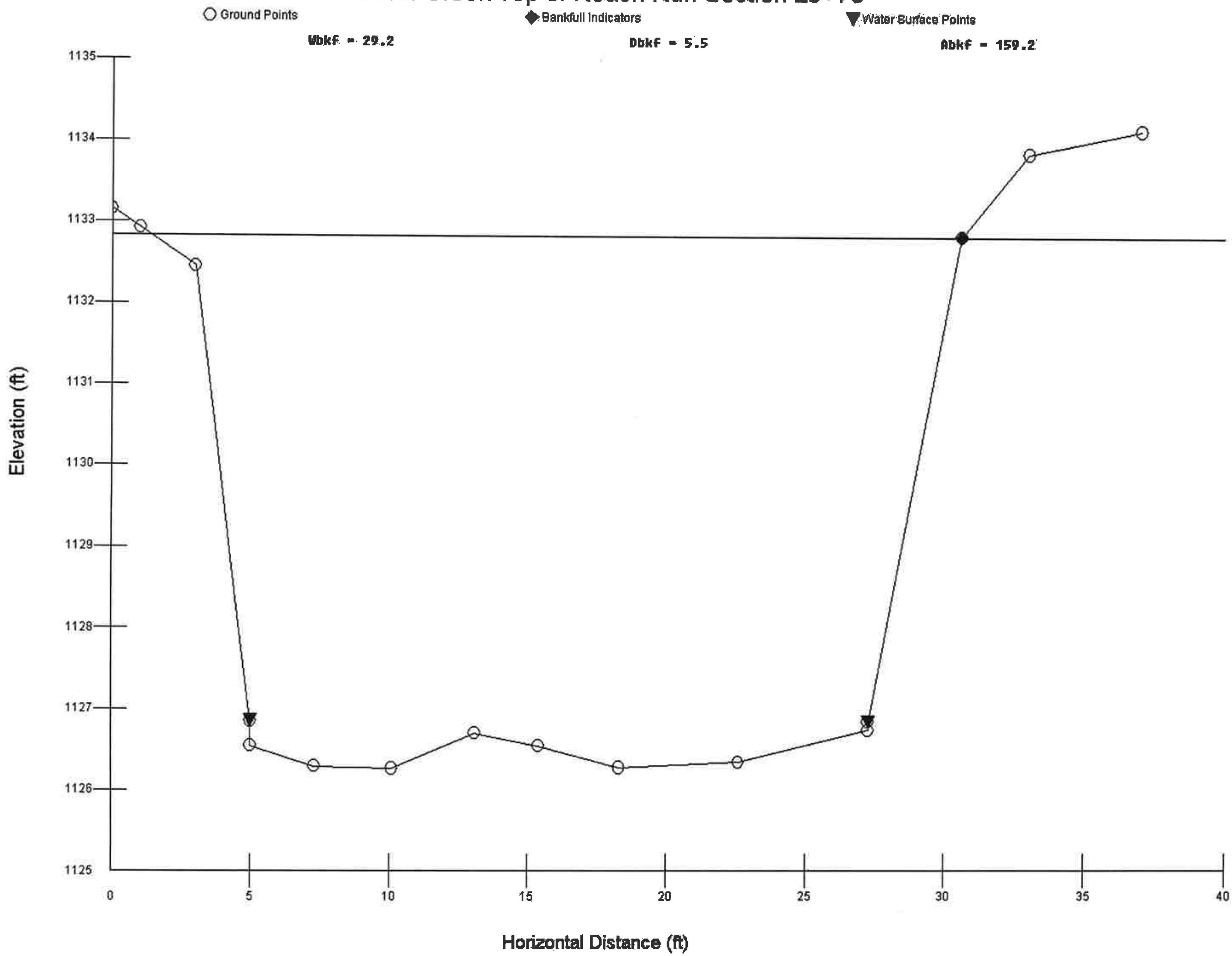
Bank Stratification Adjustment: Yes 2

Erosion Loss Curve: Colorado

NBS Method #1: Channel Pattern and/or Depositional Features for Adjustments in Near-Bank Stress
Rating: Very High

BEHI Numerical Rating: 55.0
BEHI Adjective Rating: Extreme
NBS Numerical Rating: 0
NBS Adjective Rating: Very High
Total Bank Length: 3059 ft
Estimated Sediment Loss: 5370.24 Cu Yds per Year
Estimated Sediment Loss: 6981.31 Tons per Year

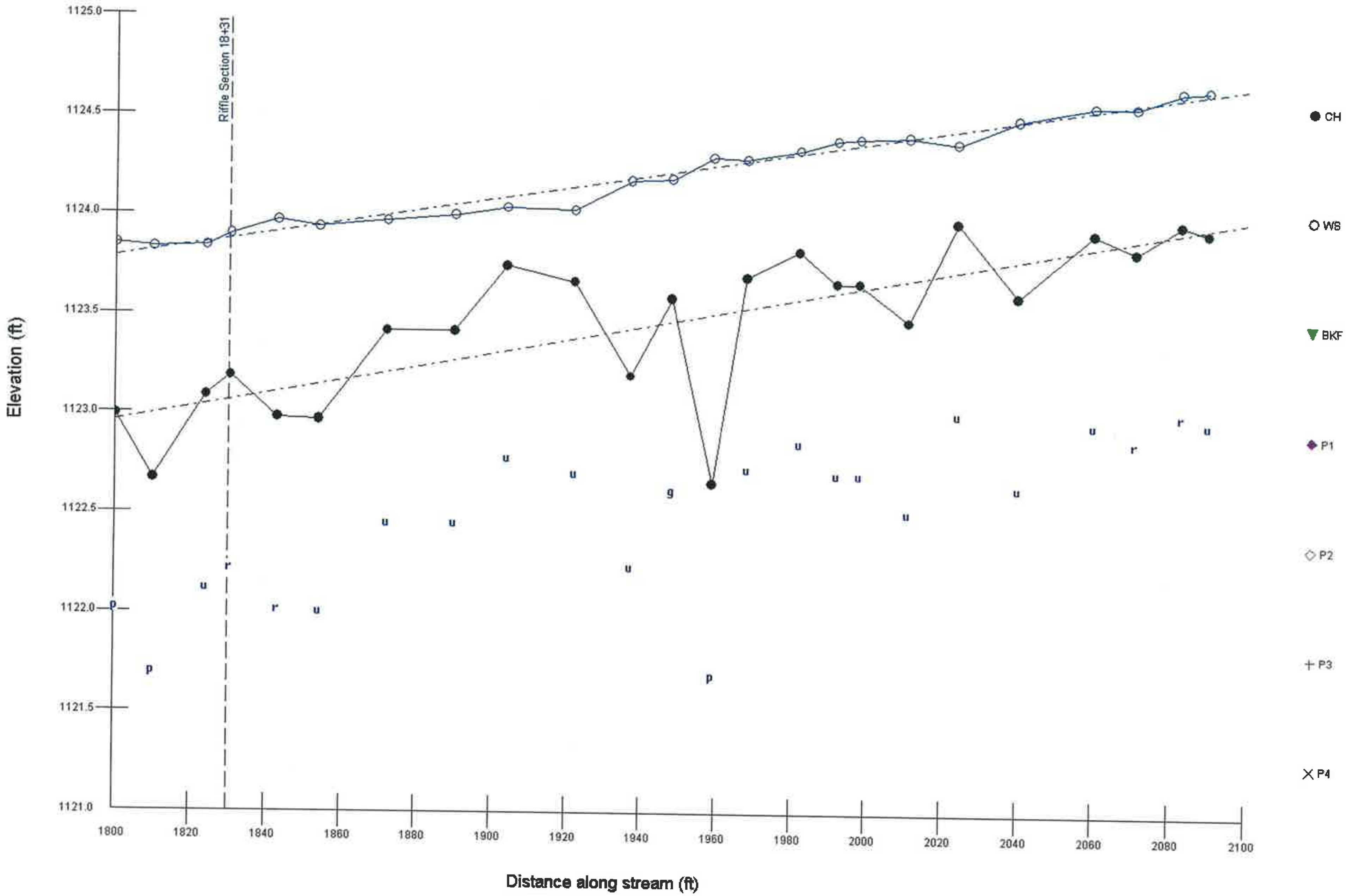
Silver Creek Top of Reacn Run Section 29+73

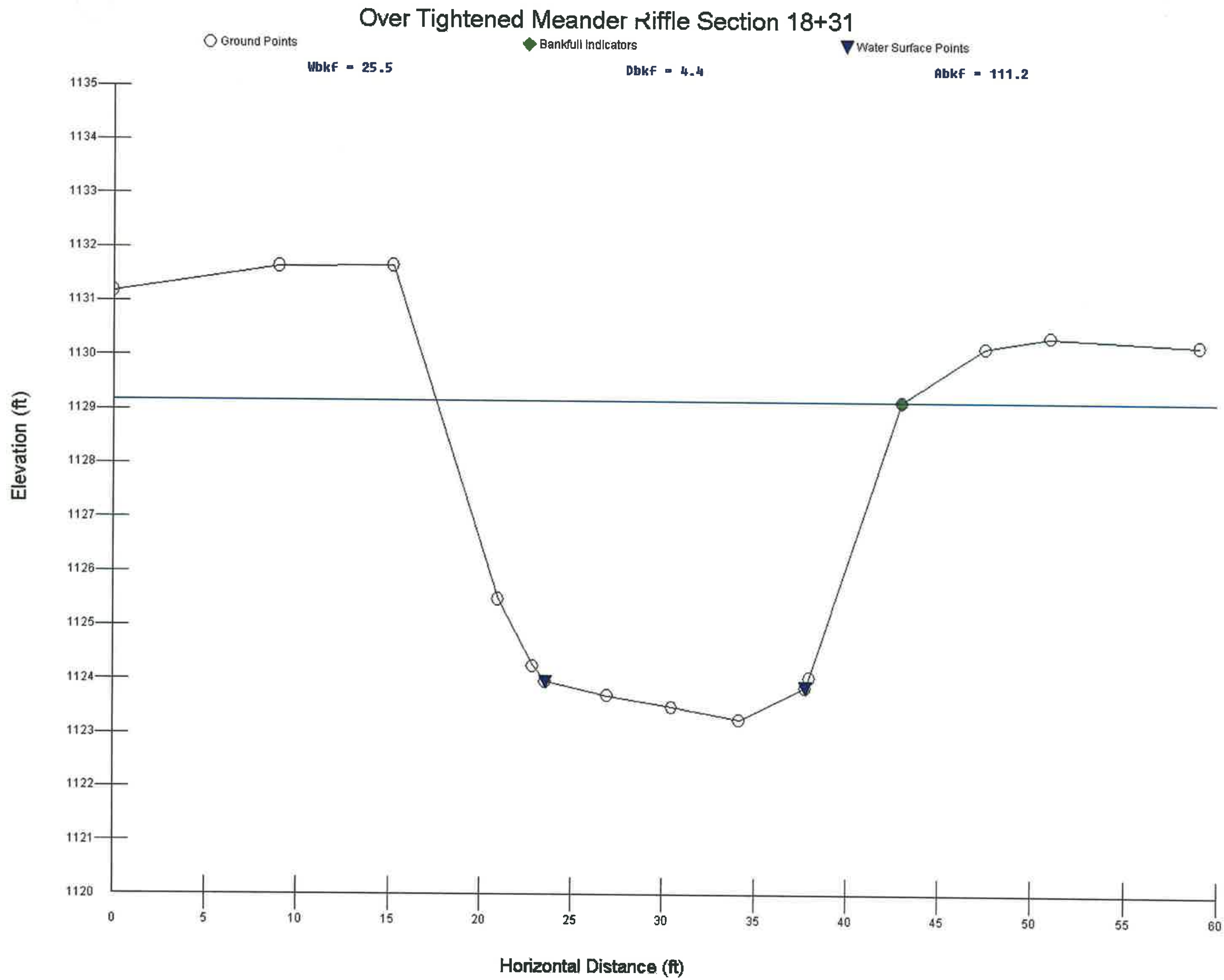


STA 29+73: Downstream View of Silver Creek at Run Cross-Section near Top of Main Stem Reach 02/09/2006

STA 29+73: Upstream View of Silver Creek at Run Cross-Section near Top of Main Stem Reach 02/09/2006

Silver Creek Over Tightened Meander Profile - Station 18+00 to 21+00





Over Tightened Meander Riffle Section 18+31
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 25.5
Dbkf = 4.4
Abkf = 111.2
Elevation (ft)
Horizontal Distance (ft)

RIVERMORPH PARTICLE SUMMARY

River Name: Silver Creek & Trib Restoration
Reach Name: Reach 3 (Over Tightened Meander)
Sample Name: Riffle X-S Sta. 18+31
Survey Date: 02/08/06

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	0	0.00	0.00
0.062 - 0.125	0	0.00	0.00
0.125 - 0.25	0	0.00	0.00
0.25 - 0.50	0	0.00	0.00
0.50 - 1.0	0	0.00	0.00
1.0 - 2.0	0	0.00	0.00
2.0 - 4.0	0	0.00	0.00
4.0 - 5.7	0	0.00	0.00
5.7 - 8.0	0	0.00	0.00
8.0 - 11.3	2	20.00	20.00
11.3 - 16.0	0	0.00	20.00
16.0 - 22.6	0	0.00	20.00
22.6 - 32.0	5	50.00	70.00
32 - 45	0	0.00	70.00
45 - 64	0	0.00	70.00
64 - 90	3	30.00	100.00
90 - 128	0	0.00	100.00
128 - 180	0	0.00	100.00
180 - 256	0	0.00	100.00
256 - 362	0	0.00	100.00
362 - 512	0	0.00	100.00
512 - 1024	0	0.00	100.00
1024 - 2048	0	0.00	100.00
Bedrock	0	0.00	100.00

D16 (mm)	10.64
D35 (mm)	25.42
D50 (mm)	28.24
D84 (mm)	76.13
D95 (mm)	85.67
D100 (mm)	90
Silt/Clay (%)	0
Sand (%)	0
Gravel (%)	70
Cobble (%)	30
Boulder (%)	0
Bedrock (%)	0

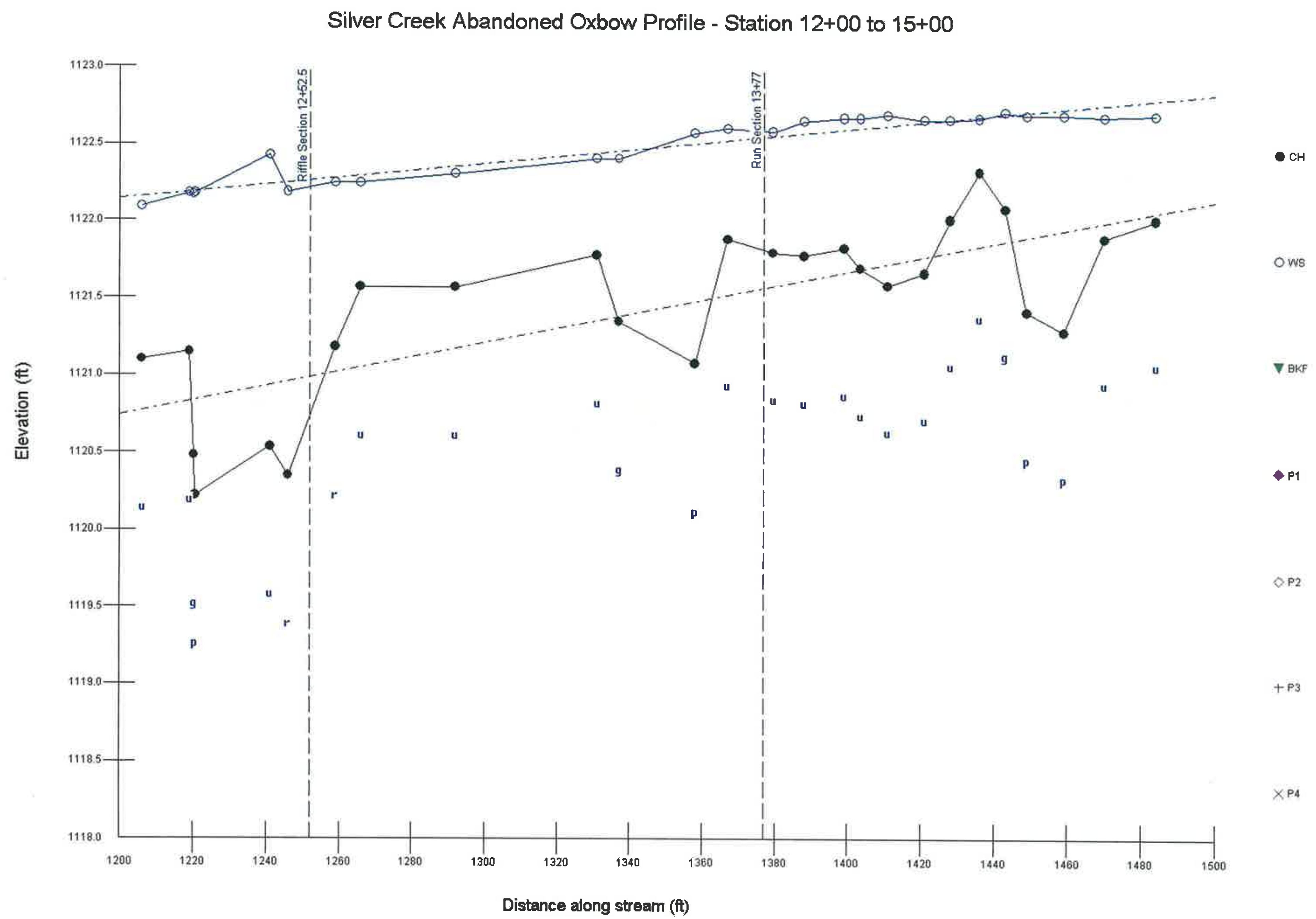
Total Particles = 10 (need at least 60).

STA 18+31: Across Channel View of Silver Creek at Riffle Cross-Section 02/09/2006

STA 18+31: Downstream View of Silver Creek
at Riffle Cross-Section at Over Tightened
Meander 02/09/2006

STA 18+31: Upstream View of Silver Creek at
Riffle Cross-Section at Over Tightened Meander
02/09/2006

STA 18+00 – 21+00: Panoramic View of Over Tightened Meander
02/09/2006



Silver Creek Abandoned Oxbow Profile - Station 12+00 to 15+00
Elevation (ft)
1123.0
1122.5
1122.0
1121.5
1121.0
1120.5
1120.0
1119.5
1119.0
1118.5
1118.0
Distance along stream (ft)
1200
1220
1240
1260
1280
1300
1320
1340
1360
1380
1400
1420
1440
1460
1480
1500
Riffle Section 12+52.5
Run Section 13+77
CH
WS
BKF
P1
P2
P3
P4

Abandoned Oxbow Profile 12+00-15+00 Summary Report
RIVERMORPH PROFILE SUMMARY

River Name: Silver Creek & Trib Restoration
Reach Name: Reach 2 (Abondoned Oxbow)
Profile Name: Silver Ck Altered Profile - Station 12+00 to 15+00
Survey Date: 02/08/06

Survey Data

DIST	CH	WS	BKF	P1	P2	P3	P4
1206	12.9	11.91					
1219	12.85	11.82					
1220.2	13.52	11.83					
1220.5	13.78	11.82					
1241	13.46	11.57					
1246	13.65	11.81					
1259	12.82	11.75					
1266	12.43	11.75					
1292	12.43	11.69					
1331	12.22	11.59					
1337	13.65	12.59					
1358	13.92	12.42					
1367	13.11	12.39					
1379.5	13.2	12.41					
1388	13.22	12.34					
1399	13.17	12.32					
1403.5	13.3	12.32					
1411	13.41	12.3					
1421	13.33	12.33					
1428	12.98	12.33					
1436	12.67	12.32					
1443	12.91	12.28					
1449	13.58	12.3					
1459	13.71	12.3					
1470	13.1	12.31					
1484	12.98	12.3					

Cross Section / Bank Profile Locations

Name	Type	Profile Station
Run Section 13+77	Run XS	1377
Riffle Section 12+52.5	Riffle XS	1252.5

Measurements from Graph

Bankfull Slope: 0.00218

Variable	Min	Avg	Max
S riffle	0.00284	0.00284	0.00284
S pool	0.00044	0.00255	0.00803
S run	0.00056	0.00135	0.00248
S glide	0.00000	0.01186	0.03196
P - P	101.07	119.13	137.19
P length	25.75	31.95	36.05

Abandoned Oxbow Profile 12+00-15+00 Summary Report

Dmax riffle	0.68	0.68	0.68
Dmax pool	1.41	1.63	1.97
Dmax run	0.74	0.91	1.11
Dmax glide	0.84	1.06	1.39
Low Bank Ht	0	0	0

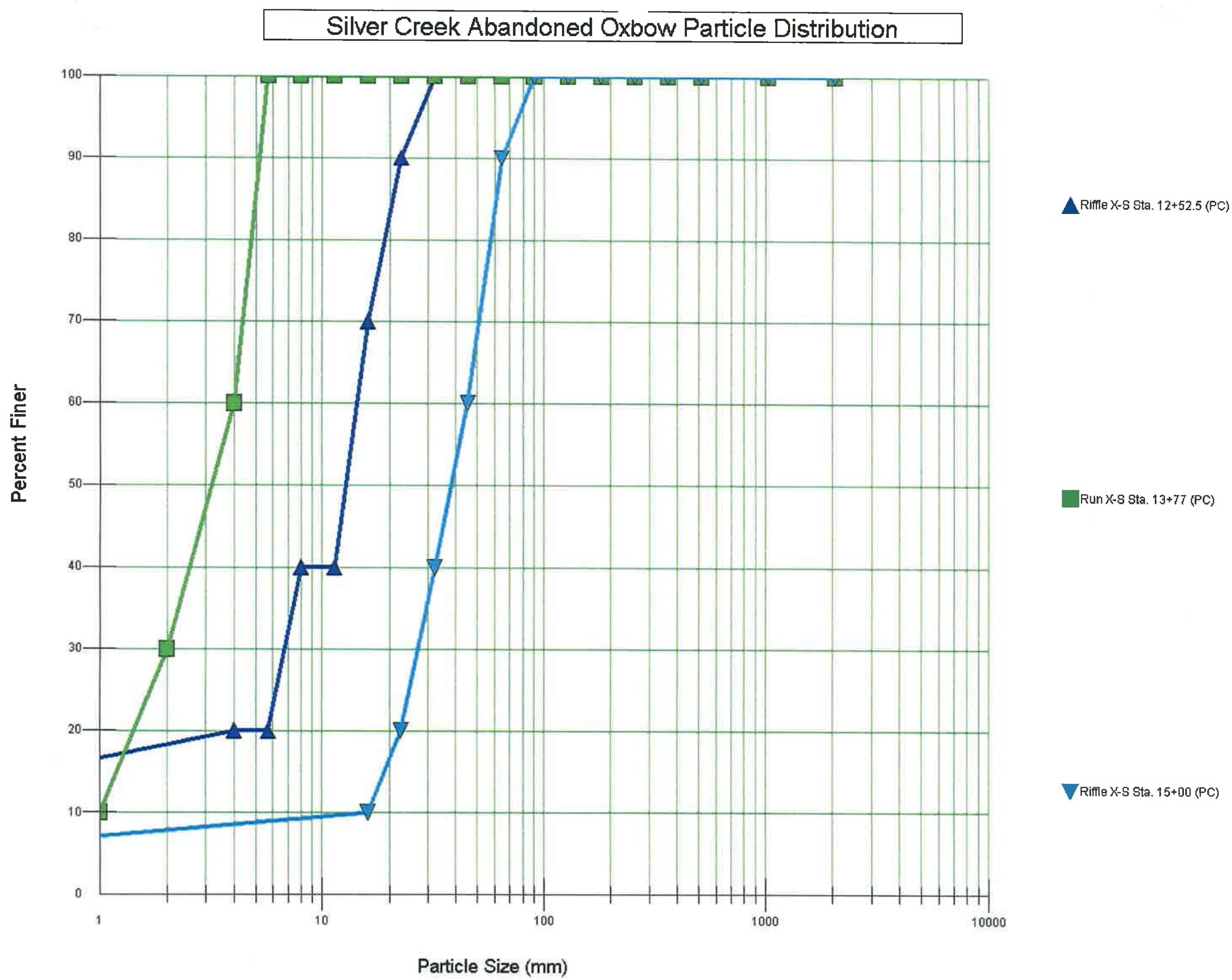
Length and depth measurements in feet, slopes in ft/ft.

RIVERMORPH PROFILE SUMMARY

Notes

River Name: Silver Creek & Trib Restoration
Reach Name: Reach 2 (Abondoned Oxbow)
Profile Name: Silver Ck Altered Profile - Station 12+00 to 15+0
Survey Date: 02/08/06

DIST	Note
1206	Run
1219	Run
1220.2	Glide
1220.5	Pool
1241	Run
1246	Riffle
1259	Riffle
1266	Run
1292	Run
1331	Run
1337	Glide Abandoned Oxbow
1358	Pool Immed. Upstream Debris-Log Jam
1367	Run
1379.5	Run
1388	Run
1399	Run
1403.5	Run
1411	Run
1421	Run
1428	Run
1436	Run Submerged Transverse Gravel Bar
1443	Glide
1449	Pool - Glide Transition
1459	Pool
1470	Run
1484	Run



Silver Creek Abandoned Oxbow Particle Distribution
Percent Finer
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
10000
Particle Size (mm)
Riffle X-S Sta. 12+52.5 (PC)
Run X-S Sta. 13+77 (PC)
Riffle X-S Sta. 15+00 (PC)

RIVERMORPH PARTICLE SUMMARY

River Name:	Silver Creek & Trib Restoration
Reach Name:	Reach 2 (Abondoned Oxbow)
Sample Name:	Riffle X-S Sta. 12+52.5
Survey Date:	02/09/06

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	0	0.00	0.00
0.062 - 0.125	0	0.00	0.00
0.125 - 0.25	0	0.00	0.00
0.25 - 0.50	0	0.00	0.00
0.50 - 1.0	0	0.00	0.00
1.0 - 2.0	0	0.00	0.00
2.0 - 4.0	2	20.00	20.00
4.0 - 5.7	0	0.00	20.00
5.7 - 8.0	2	20.00	40.00
8.0 - 11.3	0	0.00	40.00
11.3 - 16.0	3	30.00	70.00
16.0 - 22.6	2	20.00	90.00
22.6 - 32.0	1	10.00	100.00
32 - 45	0	0.00	100.00
45 - 64	0	0.00	100.00
64 - 90	0	0.00	100.00
90 - 128	0	0.00	100.00
128 - 180	0	0.00	100.00
180 - 256	0	0.00	100.00
256 - 362	0	0.00	100.00
362 - 512	0	0.00	100.00
512 - 1024	0	0.00	100.00
1024 - 2048	0	0.00	100.00
Bedrock	0	0.00	100.00

D16 (mm)	3.6
D35 (mm)	7.42
D50 (mm)	12.87
D84 (mm)	20.62
D95 (mm)	27.3
D100 (mm)	32
Silt/Clay (%)	0
Sand (%)	0
Gravel (%)	100
Cobble (%)	0
Boulder (%)	0
Bedrock (%)	0

Total Particles = 10 (need at least 60).

RIVERMORPH PARTICLE SUMMARY

River Name:	Silver Creek & Trib Restoration
Reach Name:	Reach 2 (Abondoned Oxbow)
Sample Name:	Run X-S Sta. 13+77
Survey Date:	02/09/06

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	0	0.00	0.00
0.062 - 0.125	0	0.00	0.00
0.125 - 0.25	0	0.00	0.00
0.25 - 0.50	0	0.00	0.00
0.50 - 1.0	1	10.00	10.00
1.0 - 2.0	2	20.00	30.00
2.0 - 4.0	3	30.00	60.00
4.0 - 5.7	4	40.00	100.00
5.7 - 8.0	0	0.00	100.00
8.0 - 11.3	0	0.00	100.00
11.3 - 16.0	0	0.00	100.00
16.0 - 22.6	0	0.00	100.00
22.6 - 32.0	0	0.00	100.00
32 - 45	0	0.00	100.00
45 - 64	0	0.00	100.00
64 - 90	0	0.00	100.00
90 - 128	0	0.00	100.00
128 - 180	0	0.00	100.00
180 - 256	0	0.00	100.00
256 - 362	0	0.00	100.00
362 - 512	0	0.00	100.00
512 - 1024	0	0.00	100.00
1024 - 2048	0	0.00	100.00
Bedrock	0	0.00	100.00

D16 (mm)	1.3
D35 (mm)	2.33
D50 (mm)	3.33
D84 (mm)	5.02
D95 (mm)	5.49
D100 (mm)	5.7
Silt/Clay (%)	0
Sand (%)	30
Gravel (%)	70
Cobble (%)	0
Boulder (%)	0
Bedrock (%)	0

Total Particles = 10 (need at least 60).

RIVERMORPH PARTICLE SUMMARY

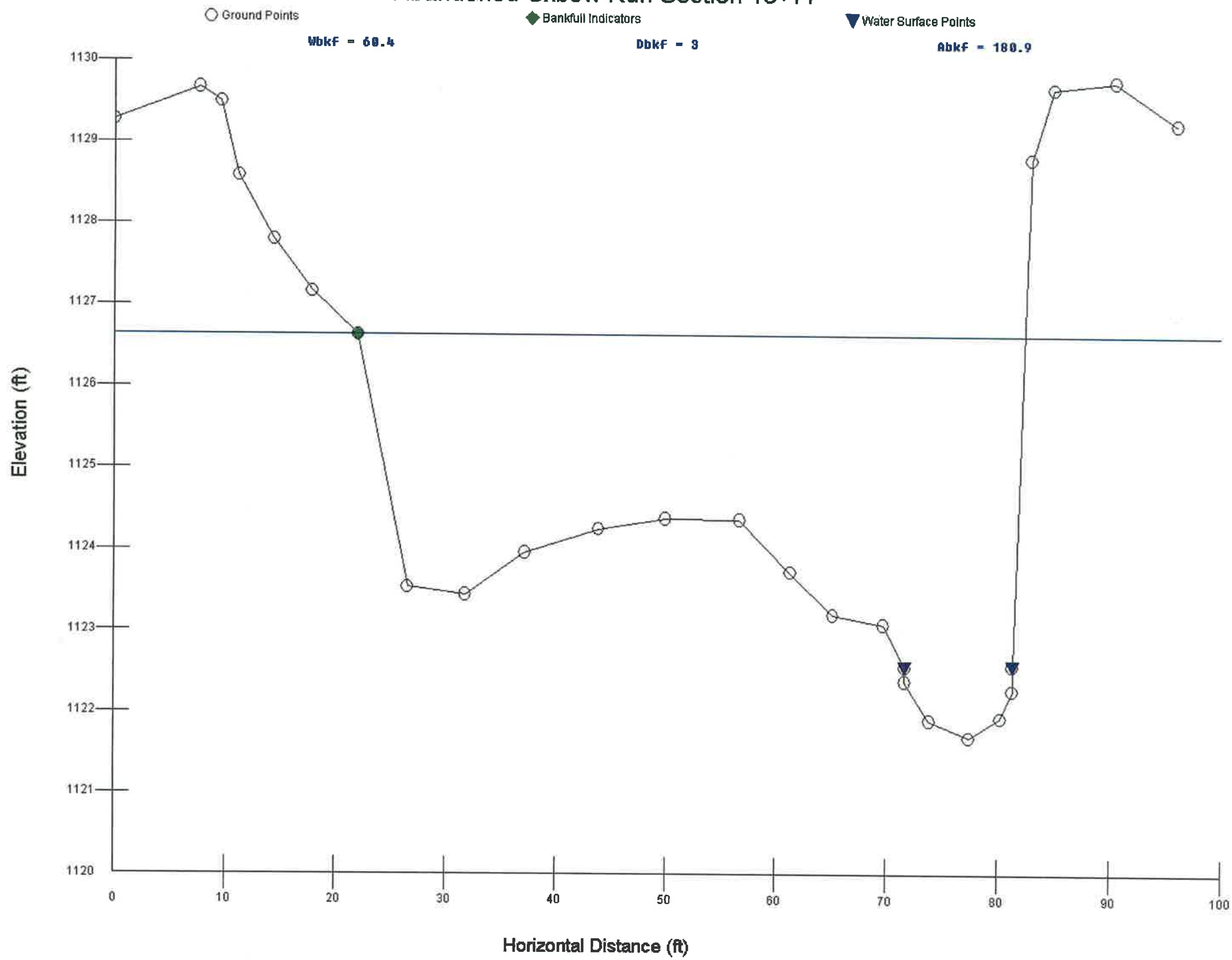
River Name: Silver Creek & Trib Restoration
Reach Name: Reach 2 (Abondoned Oxbow)
Sample Name: Riffle X-S Sta. 15+00
Survey Date: 02/09/06

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	0	0.00	0.00
0.062 - 0.125	0	0.00	0.00
0.125 - 0.25	0	0.00	0.00
0.25 - 0.50	0	0.00	0.00
0.50 - 1.0	0	0.00	0.00
1.0 - 2.0	0	0.00	0.00
2.0 - 4.0	0	0.00	0.00
4.0 - 5.7	0	0.00	0.00
5.7 - 8.0	0	0.00	0.00
8.0 - 11.3	0	0.00	0.00
11.3 - 16.0	1	10.00	10.00
16.0 - 22.6	1	10.00	20.00
22.6 - 32.0	2	20.00	40.00
32 - 45	2	20.00	60.00
45 - 64	3	30.00	90.00
64 - 90	1	10.00	100.00
90 - 128	0	0.00	100.00
128 - 180	0	0.00	100.00
180 - 256	0	0.00	100.00
256 - 362	0	0.00	100.00
362 - 512	0	0.00	100.00
512 - 1024	0	0.00	100.00
1024 - 2048	0	0.00	100.00
Bedrock	0	0.00	100.00

D16 (mm)	19.96
D35 (mm)	29.65
D50 (mm)	38.5
D84 (mm)	60.2
D95 (mm)	77
D100 (mm)	90
Silt/Clay (%)	0
Sand (%)	0
Gravel (%)	90
Cobble (%)	10
Boulder (%)	0
Bedrock (%)	0

Total Particles = 10 (need at least 60).

Abandoned Oxbow Run Section 13+77

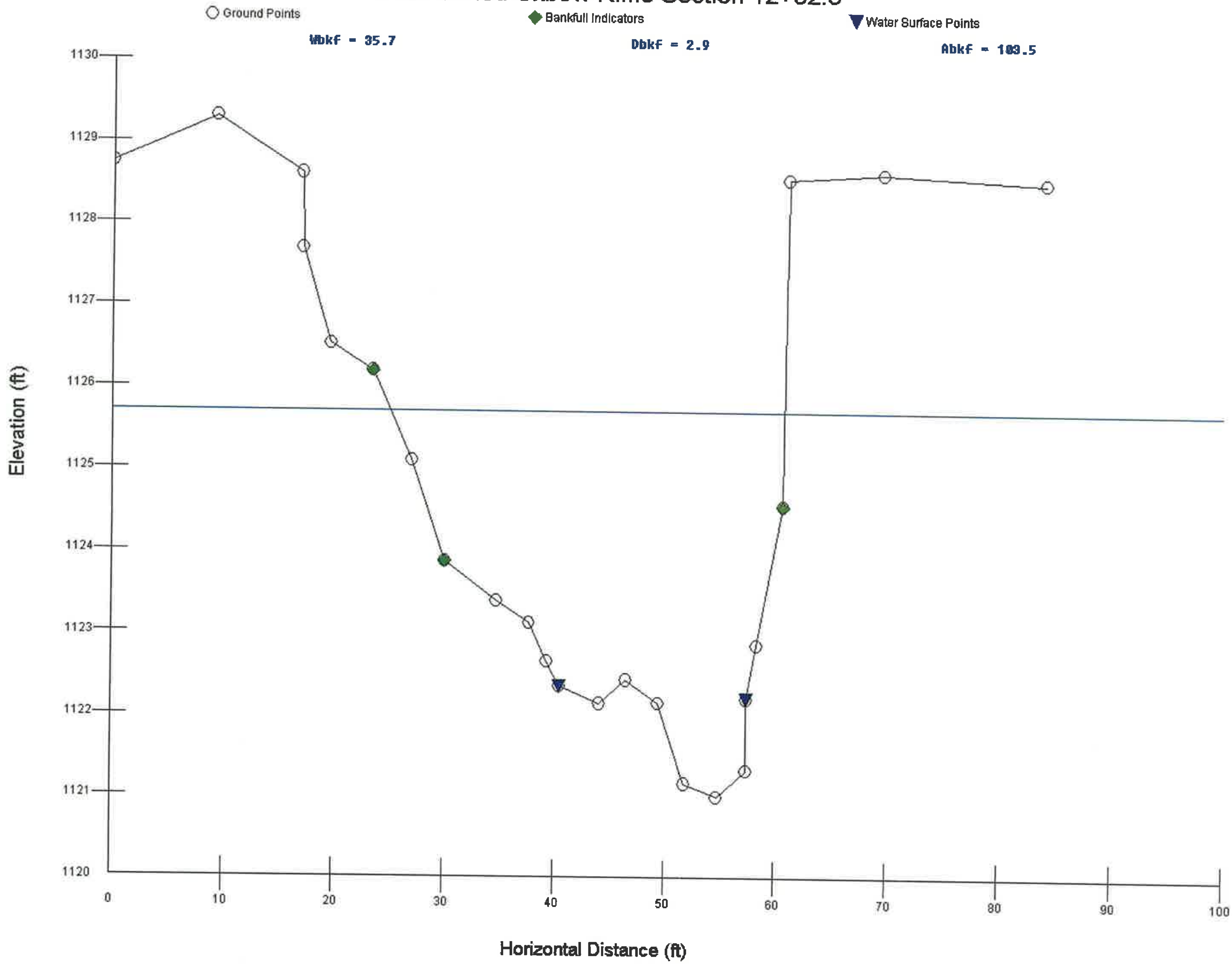


STA 13+77: Upstream View of Silver Creek at Abandoned Oxbow Run Cross-Section 02/09/2006

STA 13+77: Downstream View of Silver Creek at Abandoned Oxbow Run Cross-Section 02/09/2006

STA 13+77: Across Channel View of Silver Creek at Abandoned Oxbow Run Cross-Section
02/09/2006

Abandoned Oxbow Riffle Section 12+52.5



STA 12+52.5: Across Channel View of Silver Creek at Abandoned Oxbow Riffle Cross-Section 02/08/2006

STA 12+52.5: Upstream View of Silver Creek at Abandoned Oxbow Riffle Cross-Section
02/08/2006

STA 12+52.5: Downstream View of Silver Creek at Abandoned Oxbow Riffle Cross-Section 02/08/2006

RIVERMORPH BANK EROSION HARZARD INDEX (BEHI)

River Name: Silver Creek & Trib Restoration
Reach Name: Reach 5 (Unnamed Tributary)
BEHI Name: Unnamed Tributary
Survey Date: 01/14/06

Bankfull Height: 0.5 ft
Bank Height: 5 ft
Root Depth: 1.5 ft
Root Density: 5 %
Bank Angle: 85 Degrees
Surface Protection: 0 %

Bank Material Adjustment: Sand 10

Bank Stratification Adjustment: Yes 5

Erosion Loss Curve: Yellowstone

NBS Method #7: Vertical Velocity Near-Bank Shear Stress Method

Velocity at Surface: 4.2 fps
Depth: 0.5 ft
Bankfull Slope: .04
NB Shear Stress: 11.17 lb/sq/ft

Velocity at Bed: 3 fps
Hydraulic Radius: 0.18 ft
Shear Stress: 0.45 lb/sq/ft
Shear Ratio: 24.87

BEHI Numerical Rating: 57.7
BEHI Adjective Rating: Extreme
NBS Numerical Rating: 24.87
NBS Adjective Rating: Extreme
Total Bank Length: 1200 ft
Estimated Sediment Loss: 288.89 Cu Yds per Year
Estimated Sediment Loss: 375.56 Tons per Year

Silver Creek - Unnamed Tributary

Worksheet for Trapezoidal Channel - 1

Project Description		
Flow Element:	Trapezoidal Channel	
Friction Method:	Manning Formula	
Solve For:	Discharge	
Input Data		
Roughness Coefficient:	0.040	
Channel Slope:	0.04000	ft/ft
Normal Depth:	0.50	ft
Left Side Slope:	2.00	ft/ft (H:V)
Right Side Slope:	2.00	ft/ft (H:V)
Bottom Width:	6.00	ft
Results		
Discharge:	14.70	ft^3/s
Flow Area:	3.50	ft^2
Wetted Perimeter:	8.24	ft
Top Width:	8.00	ft
Critical Depth:	0.54	ft
Critical Slope:	0.03133	ft/ft
Velocity:	4.20	ft/s
Velocity Head:	0.27	ft
Specific Energy:	0.77	ft
Froude Number:	1.12	
Flow Type:	Supercritical	
GVF Input Data		
Downstream Depth:	0.50	ft
Length:	1210.00	ft
Number Of Steps:	24	
GVF Output Data		
Upstream Depth:	0.54	ft
Profile Description:	S2	
Headloss:	48.44	ft
Downstream Velocity:	4.20	ft/s
Upstream Velocity:	3.87	ft/s
Normal Depth:	0.50	ft
Critical Depth:	0.54	ft
Channel Slope:	0.04000	ft/ft

Worksheet for Trapezoidal Channel - 1

Critical Slope:	0.03133	ft/ft

Gradually Varied Flow Points for Trapezoidal Channel - 1

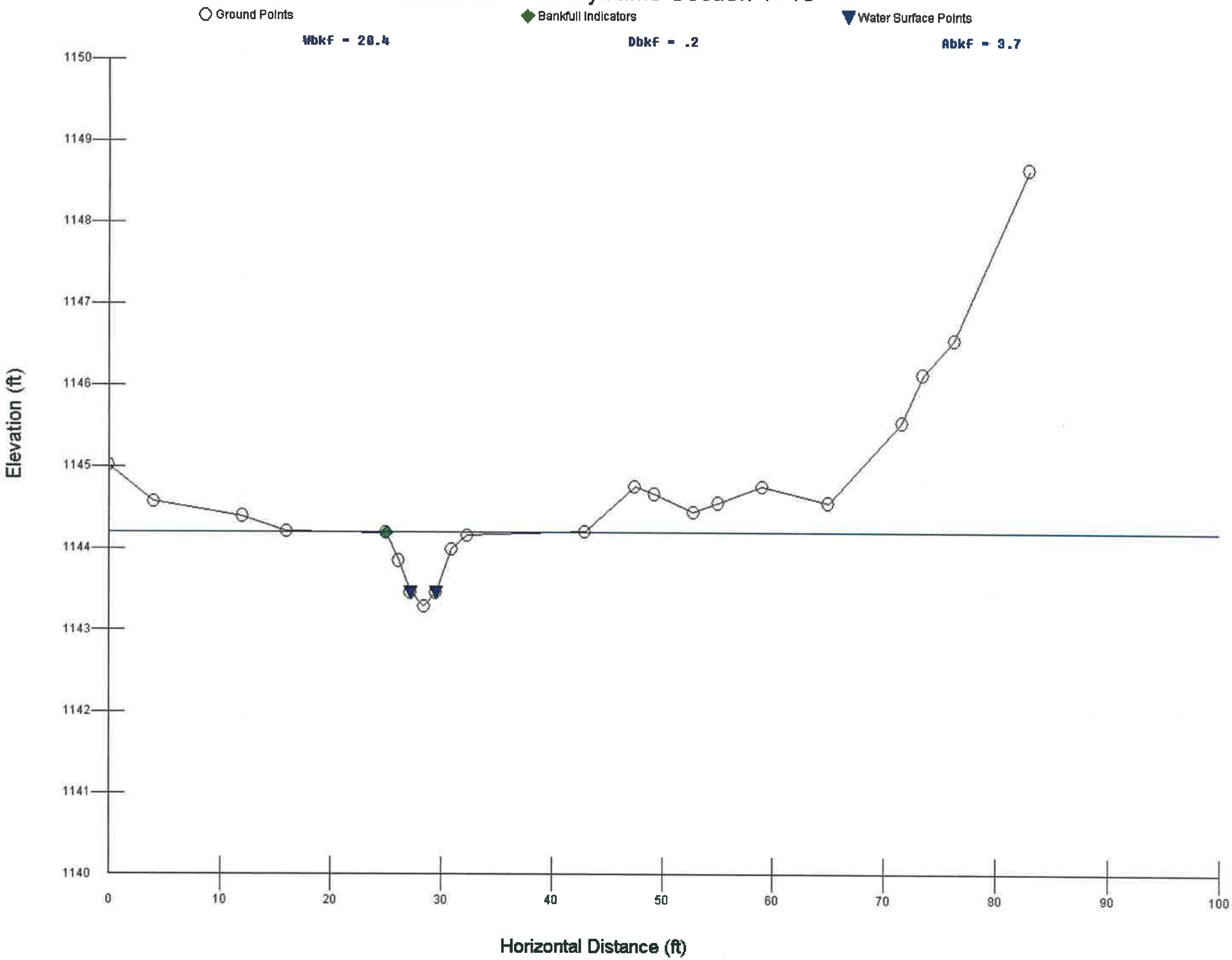
Project Description		
Flow Element:	Trapezoidal Channel	
Input Data		
Downstream Depth:	0.50	ft
Upstream Depth:	0.54	ft
Length:	1533.00	ft
Number Of Steps:	24	
Results		
Profile Description:	S2	
Headloss:	61.36	ft
Downstream Velocity:	4.20	ft/s
Upstream Velocity:	3.87	ft/s
Channel Slope:	0.04000	ft/ft
Discharge:	14.70	ft^3/s
Normal Depth:	0.50	ft
Critical Depth:	0.54	ft

Distance	Depth	Invert Elevation	Flow Area	Wetted Perimeter	Velocity	Specific Energy
0.00	0.50	0.00	3.50	8.24	4.20	0.77
1529.19	0.50	61.17	3.50	8.24	4.20	0.77
1530.99	0.50	61.24	3.51	8.24	4.18	0.77
1531.56	0.50	61.26	3.52	8.25	4.17	0.77
1531.89	0.50	61.28	3.54	8.26	4.16	0.77
1532.12	0.51	61.28	3.55	8.26	4.14	0.77
1532.28	0.51	61.29	3.56	8.27	4.13	0.77
1532.41	0.51	61.30	3.57	8.28	4.11	0.77
1532.52	0.51	61.30	3.59	8.28	4.10	0.77
1532.60	0.51	61.30	3.60	8.29	4.09	0.77
1532.67	0.51	61.31	3.61	8.30	4.07	0.77
1532.73	0.52	61.31	3.62	8.30	4.06	0.77
1532.78	0.52	61.31	3.63	8.31	4.04	0.77
1532.82	0.52	61.31	3.65	8.32	4.03	0.77
1532.86	0.52	61.31	3.66	8.32	4.02	0.77
1532.89	0.52	61.32	3.67	8.33	4.00	0.77
1532.91	0.52	61.32	3.68	8.34	3.99	0.77
1532.93	0.52	61.32	3.70	8.34	3.98	0.77
1532.95	0.53	61.32	3.71	8.35	3.96	0.77
1532.96	0.53	61.32	3.72	8.36	3.95	0.77
1532.98	0.53	61.32	3.73	8.37	3.94	0.77

Gradually Varied Flow Points for Trapezoidal Channel - 1

Distance	Depth	Invert Elevation	Flow Area	Wetted Perimeter	Velocity	Specific Energy
1532.98	0.53	61.32	3.75	8.37	3.92	0.77
1532.99	0.53	61.32	3.76	8.38	3.91	0.77
1533.00	0.53	61.32	3.77	8.39	3.90	0.77
1533.00	0.53	61.32	3.78	8.39	3.89	0.77
1533.00	0.54	61.32	3.51	8.24	4.18	0.81

Unnamed Tributary Riffle Section 1+15



RM Step-Pool Calcs

RIVERMORPH VANE DESIGN REPORT

River Name: Silver Creek
Reach Name: Reach 2 (Unnamed Tributary)
Vane Name: Cross-Vane Step-Pool Desiign

Input Data

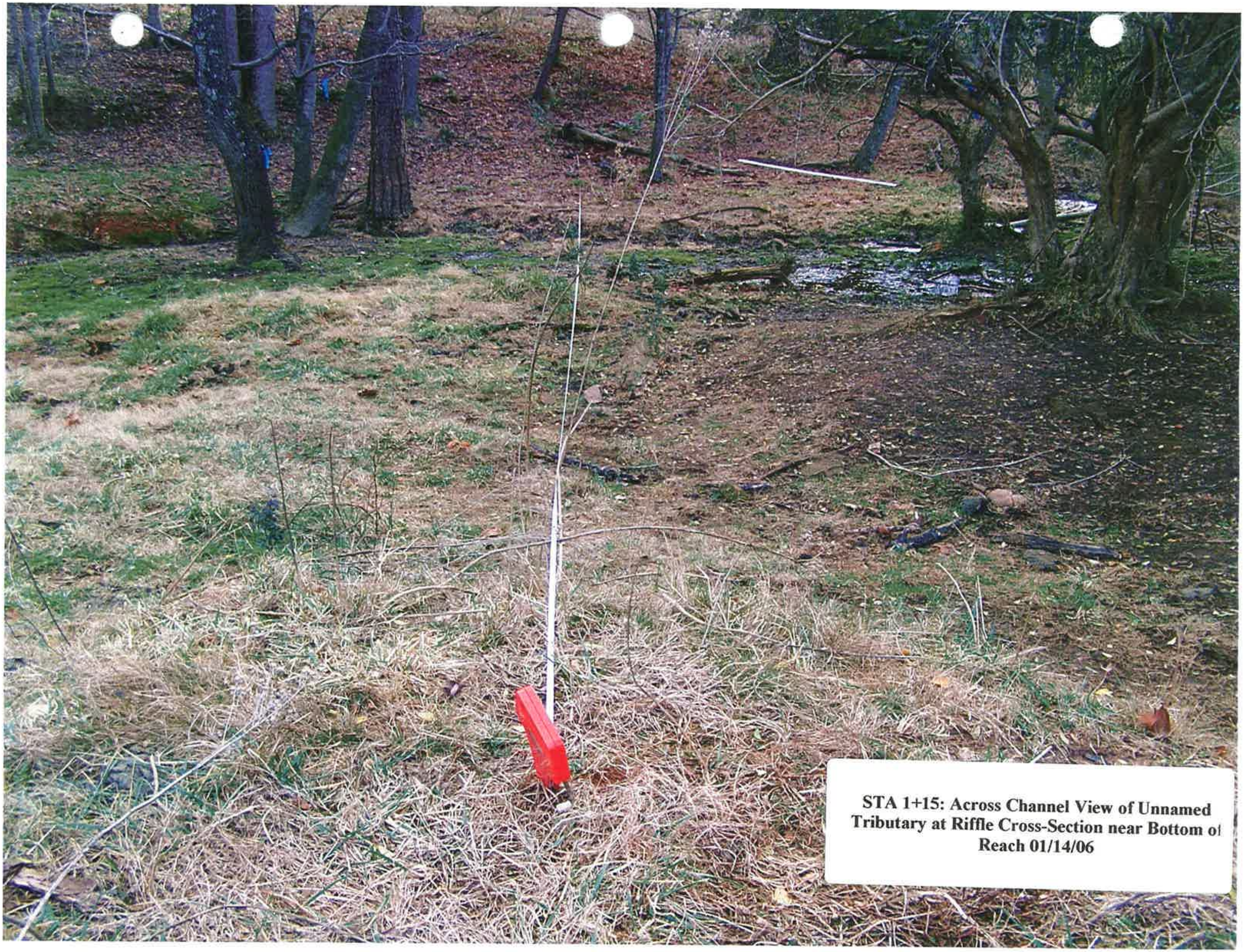
Bank Height:	0.5 ft
Bankfull Height:	0.5 ft
Shear Stress:	0.4 lbs/sq ft
Near Bank Stress:	1.5 lbs/sq ft
Bankfull Slope:	0.04 ft/ft
Bankfull Width:	8 ft
Radius of Curvature:	600 ft
Plan View Vane Angle:	20 deg

Results

Ratio - Rc/Wbkf:	75
Vane Spacing:	50.0 ft
Vane Length:	36.5 ft
Minimum Rock Size (Diameter):	2.0 ft
Protrusion Height:	0.05 ft
Footing Depth:	0.15 ft
Layers of Footing Stones:	1
Vane Slope:	1.4 %

STA 1+15: Upstream View of Unnamed Tributary at Riffle Cross-Section near Bottom of Reach 01/14/06

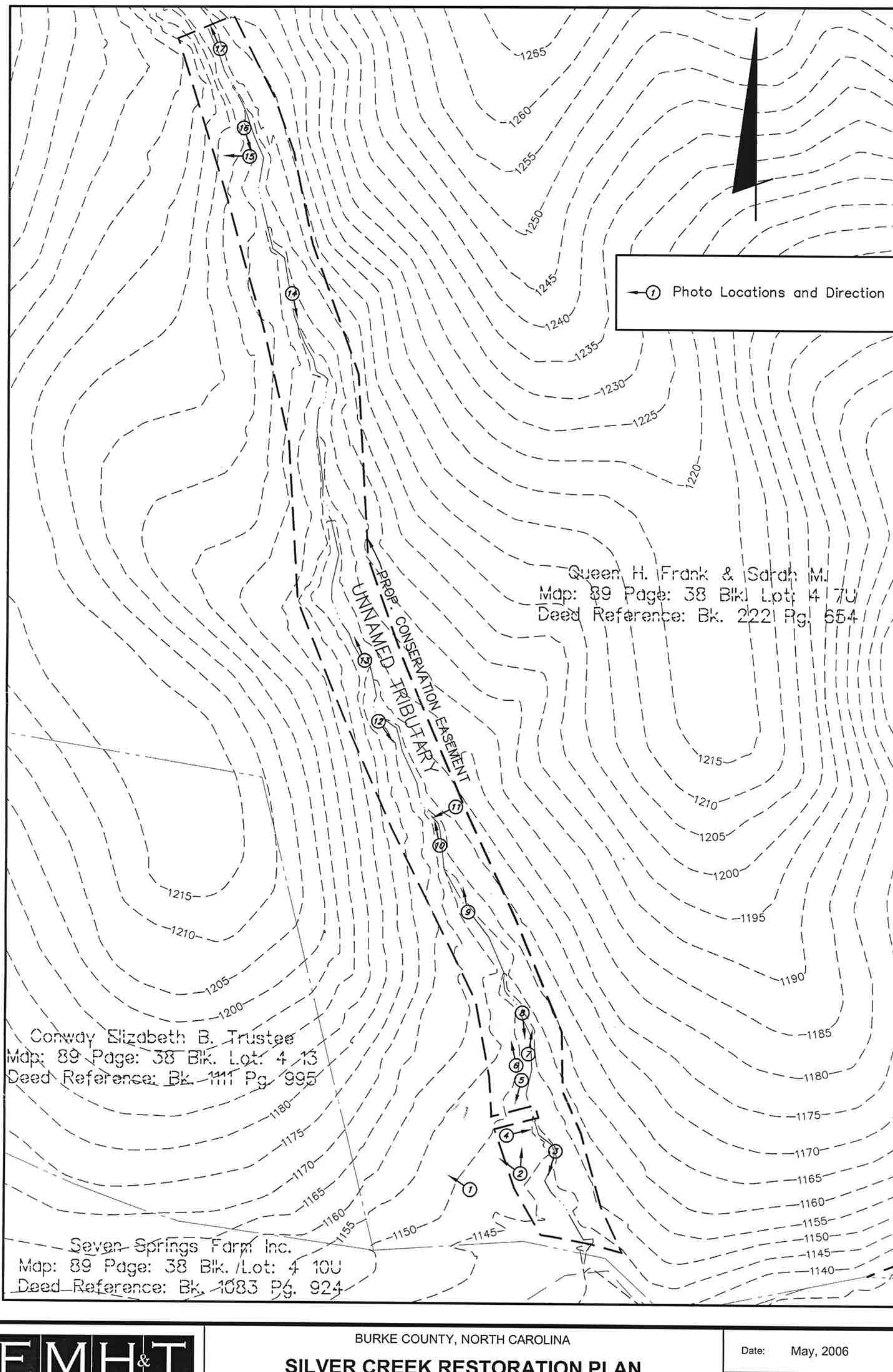
STA 1+15: Downstream View of Unnamed Tributary at Riffle Cross-Section near Bottom of Reach 01/14/06



STA 1+15: Across Channel View of Unnamed Tributary at Riffle Cross-Section near Bottom of Reach 01/14/06

APPENDIX 4

Unnamed Tributary to Silver Creek Photographs



EMH&T
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road, Columbus, OH 43054
Phone: 614.775.4500 Fax: 614.775.4800
M C M X X V I

BURKE COUNTY, NORTH CAROLINA

SILVER CREEK RESTORATION PLAN

APPENDIX 4

UNNAMED TRIBUTARY TO SILVER CREEK

PHOTO LOCATION MAP

Date:	May, 2006
Scale:	1" = 100'
Job No:	2005-1446

1. Adjacent pastureland on Queen property, along west side of Unnamed Tributary to Silver Creek.

2. Panoramic view of downstream portion of project corridor along Unnamed Tributary showing abandoned terrace feature on left side of photo.

3. Deficient riparian corridor along Unnamed Tributary to Silver Creek. Cattle intrusion is evident here.

4. Area of cattle intrusion and sparsely vegetated riparian corridor at downstream portion of Unnamed Tributray project corridor.

5. Evidence of extreme cattle intrusion and bank failure attributed to hoof shear along Unnamed Tributary at bottom of reach.

6. Pastureland is present to the west of the Unnamed Tributary, and a sparsely wooded corridor is present to the east (downstream portion of project corridor).

7. Undercut banks along east bank of Unnamed Tributary.

8. Undercutting of banks along Unnamed Tributary is resulting in loss of trees in some areas.

9. Unnamed Tributary, facing upstream.

10. Unnamed Tributary, facing upstream. The channel is laterally contained within a valley-confined ravine in this area.

11. Slumping bank along Unnamed Tributary attributed to hoof shear from cattle intrusion.

12. Unnamed Tributary, facing downstream at the approximate midpoint of the project corridor.

13. A dead cow was observed in the stream where denuded banks are steeper. This reinforces the need for cattle exclusion fencing along the stream to prevent damage to banks and channel, as well as loss of cattle.

14. Fallen tree within Unnamed Tributary.

15. Cattle intrusion was also noted along the upstream portion of the Unnamed Tributary in an area where the valley broadens, causing extreme degradation of the bed and banks and denuding of vegetation.

16. Cattle intrusion and eroding banks along upstream portion of Unnamed Tributary.

17. Upstream project terminus along Unnamed Tributary. Stream emerges from a granite bedrock spring within a steep ravine.

See Ap B
in Mitigation
Plan

APPENDIX 5

Reference Reach Classification, Photographs and Data Summary Reports

Stream Classification Form

Stream Channel Classification (Level II) ...

Stream NAME: Silver Creek & Trib Restoration, Reach - Reach 1 (Reference Reach)

Basin NAME: CATAWBA RIVER BASIN Drainage AREA: 742.4 acre 1.16 mi^2

Location: BRINDLE CREEK, TRIBUTARY TO SILVER CREEK, BURKE CO., NC

Twp: ____ Rge: ____ Sec: ____ Qtr: ____ Lat: 35.6186 Long: 81.817

Observers: MILES F. HEBERT, P.E & WARREN E. KNOTTS, P.G. Date: 1/13/2006

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel, at bankfull stage elevation, in a riffle section.	**24.02** Feet
Mean DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section. ($d_{bkf}=A_{bkf}/W_{bkf}$)	**1.28** Feet
Bankfull Cross Section Area (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**30.77** $Feet^2$
WIDTH / DEPTH RATIO (W_{bkf}/d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**18.77** Ft/Ft
Maximum DEPTH (d_{mrif}) Maximum depth of the bankfull channel cross-section, or elevation between the bankfull stage and thalweg in a riffle section.	**1.72** Feet
Flood-Prone Area WIDTH (W_{fpa}) The stage/elevation at which flood-prone area WIDTH is determined in a riffle section at twice maximum DEPTH, or (2 x d_{mrif})	**232** Feet
Entrenchment RATIO (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa}/W_{bkf}) in a riffle section.	**9.66** Ft/Ft
Channel Materials (Particle Size Index) D50 The 50th percentile, or less than, from a pebble count frequency distribution of channel particles representing the median or dominant particle size.	**38.5** mm
Water Surface SLOPE (S) Average water surface slope as measured between the same position of bed features in the profile over two meander wave lengths. This is similar to average bankfull slope.	**0.01149** Ft/Ft
Channel SINUOSITY (K) Sinuosity: an index of channel pattern, determined from stream length / valley length, i.e. (SL/VL); or estimated from a ratio of valley slope divided by channel slope (VS/ S).	**1.2**

Stream Type → **C 4** ← *For Reference, see page 5-5, 5-6: Rosgen, 1996. Applied River Morphology.*

Reference Reach Summary Data Form

... and Reference Reach Summary Data

Channel Dimension

Mean Riffle Depth (d_{bkf})	1.28	feet	Mean Riffle Width (W_{bkf})	24.02	feet	Mean Riffle Area (A_{bkf})	30.77	feet^2
Mean Pool Depth (d_{bkfp})	2.33	feet	Mean Pool Width (W_{bkfp})	26.97	feet	Mean Pool Area (A_{bkfp})	62.77	feet^2
Ratio Mean Pool Depth/Mean Riffle Depth	1.820	d_{bkfp}/ d_{bkf}	Ratio Pool Width/Riffle Width	1.123	W_{bkfp}/ W_{bkf}	Ratio Pool Area/ Riffle Area	2.040	A_{bkfp}/ A_{bkf}
Max Riffle Depth (d_{mrif})	2.41	feet	Max Pool Depth (d_{mpool})	3.76	feet	Max riffle depth/Mean riffle depth	1.883	
Max pool depth/Mean riffle depth	2.938					Point Bar Slope	0	
Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	3.19	ft/s				Estimation Method		
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	98.16	cfs				Drainage Area	1.16	mi^2

Channel Pattern

Geometry	Ave	Min	Max		Dimensionless Geometry Ratios	Ave	Min	Max
Meander Length (Lm)	104.8	88.23	115.7	feet	Meander Length Ratio (Lm/W_{bkf})	4.361	3.673	4.816
Radius of Curvature (Rc)	17.67	12.97	24.44	feet	Radius of Curvature/Riffle Width (Rc/W_{bkf})	0.736	0.540	1.017
Belt Width (W_{blt})	45.22	44.17	46.5	feet	Meander Width Ratio (W_{blt}/W_{bkf})	1.883	1.839	1.936
Individual Pool Length	17.42	11.01	31.56	feet	Pool Length/Riffle Width	0.725	0.458	1.314
Pool to Pool Spacing	71.36	67.6	77.5	feet	Pool to Pool Spacing/Riffle Width	2.971	2.814	3.226

Channel Profile

Valley Slope (VS)	0.0097	ft/ft	Average Water Surface Slope (S)	0.01149	ft/ft	Sinuosity (VS/S)	1.2
Stream Length (SL)	0	feet	Valley Length (VL)	0	feet	Sinuosity (SL/VL)	#####

Low Bank Height (LBH)	start	0 feet	Max Riffle Depth	start	0 feet	Bank Height Ratio (LBH/Max Riffle Depth)	start	#####
	end	0 feet		end	0 feet		end	#####

Facet Slopes	Ave	Min	Max		Dimensionless Slope Ratios	Ave	Min	Max
Riffle Slope (S_{rif})	0.0246	0.0172	0.0346	ft/ft	Riffle Slope/Average Water Surface Slope (S_{rif}/S)	2.144	1.500	3.008
Run Slope (S_{run})	0.0211	0.0125	0.0362	ft/ft	Run Slope/Average Water Surface Slope (S_{run}/S)	1.838	1.088	3.150
Pool Slope (S_p)	0.0043	0.0010	0.0095	ft/ft	Pool Slope/Average Water Surface Slope (S_p/S)	0.372	0.086	0.824
Glide Slope (S_g)	0.0053	0.0020	0.0075	ft/ft	Glide Slope/Average Water Surface Slope (S_g/S)	0.460	0.173	0.655

Feature Midpoint [a]	Ave	Min	Max		Dimensionless Depth Ratios	Ave	Min	Max
Riffle Depth (d_{mrif})	2.410	2.410	2.410	feet	Riffle Max Depth/Riffle Mean Depth (d_{mrif}/d_{bkf})	1.883	1.883	1.883
Run Depth (d_{mrun})	2.300	1.870	2.560	feet	Run Max Depth/Riffle Mean Depth (d_{mrun}/d_{bkf})	1.797	1.461	2.000
Pool Depth (d_{mp})	3.760	3.760	3.760	feet	Pool Max Depth/Riffle Mean Depth (d_{mp}/d_{bkf})	2.938	2.938	2.938
Glide Depth (d_{mg})	2.470	1.640	3.280	feet	Glide Max Depth/Riffle Mean Depth (d_{mg}/d_{bkf})	1.930	1.281	2.563

Channel Materials

Catagories	Reach[b]	Riffle[c]	Bar
% Silt/Clay	0	0	
% Sand	0	0	
% Gravel	0	0	
% Cobble	0	0	
% Boulder	0	0	
% Bedrock	0	0	

Indices	Reach[b]	Riffle[c]	Bar	
D16	0	0		mm
D35	0	0		mm
D50	27.73	38.5		mm
D84	58.3	60.2		mm
D95	0	0		mm
D100	0	0		mm

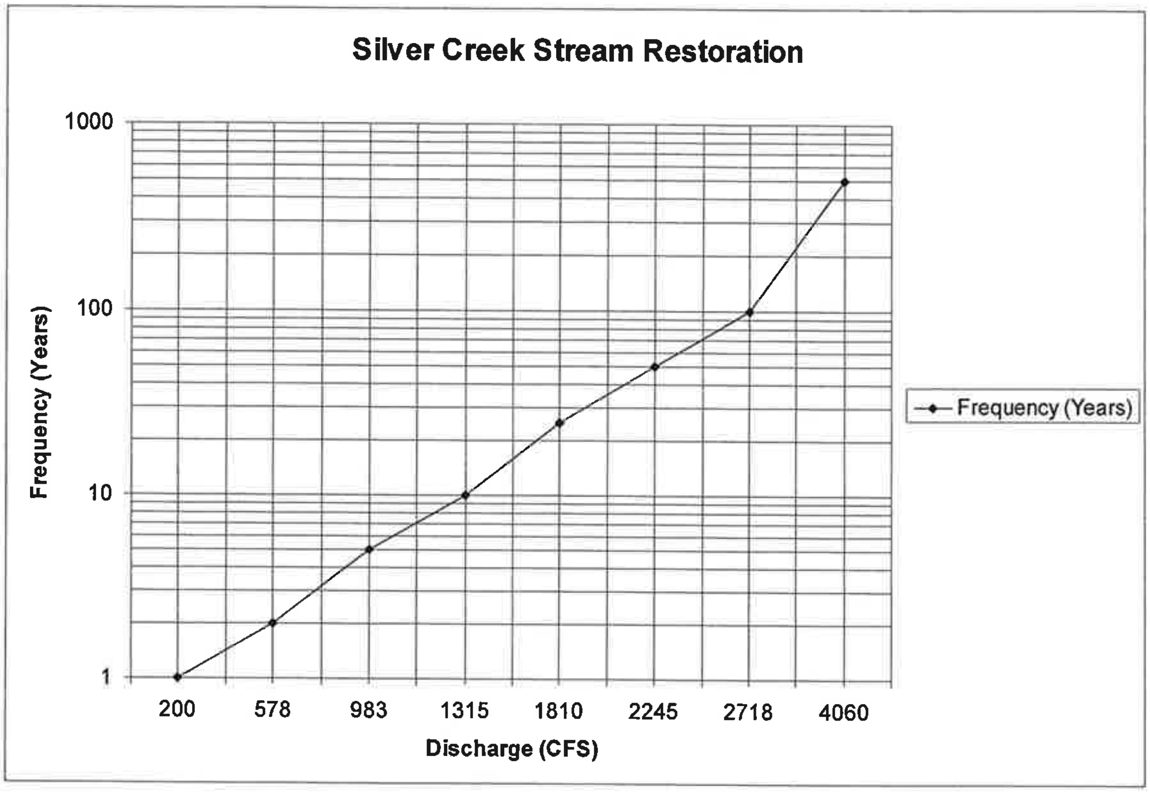
a. The range of "feature" mid-point maximum bankfull depths, including the minimum, maximum and average values. (Pool depths are obtained from the deepest portion of the feature.)

b. A composite sample of materials from riffle and pool featutes taken within the designated reach.

c. Sample obtained within the "active" bed of a riffle feature at the location of the cross section.

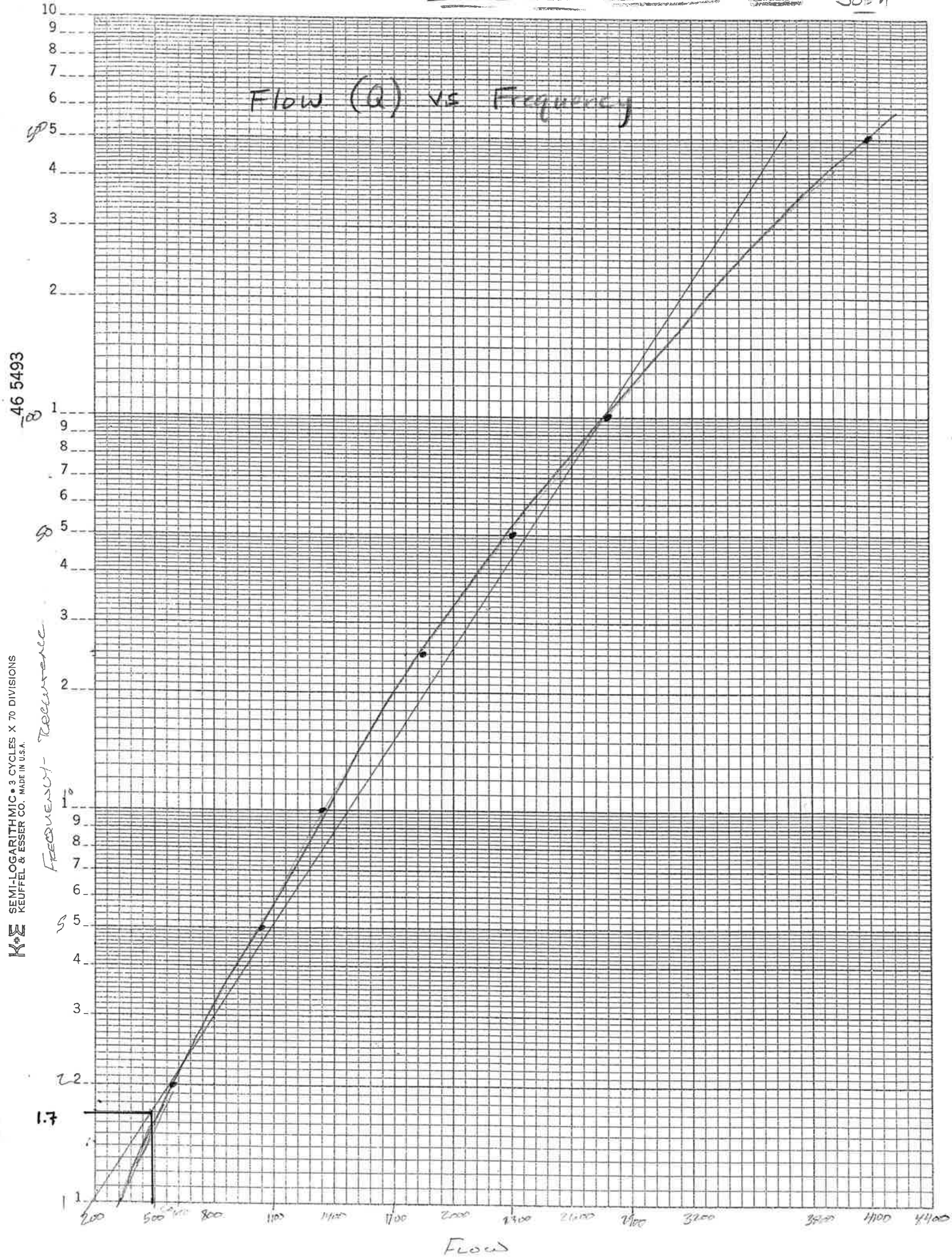
APPENDIX 6

HEC-RAS Analysis



Silver Creek Stream Restoration
1000
100
10
1
Frequency (Years)
200
578
983
1315
1810
2245
2718
4060
Discharge (CFS)
Frequency (Years)

SILVER CREEK DOWNSTREAM LIMITS Josh



HEC-RAS Output,

Flow

Elev

Width

[illegible] Creek

HEC-RAS Plan: existing River: Silver Creek Reach: Restoration

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Restoration	4451	2-year	578.00	1126.46	1131.96		1132.28	0.002543	4.53	127.71	29.29	0.38
Restoration	4451	5-year	983.00	1126.46	1133.81		1134.25	0.002535	5.31	185.65	→ 36.09	0.39
Restoration	4451	100-year	2718.00	1126.46	1136.86		1137.55	0.002876	7.46	545.91	153.19	0.45
Restoration	4103	2-year	578.00	1124.88	1130.99		1131.34	0.002802	4.79	120.66	27.10	0.40
Restoration	4103	5-year	983.00	1124.88	1132.78		1133.29	0.003007	5.70	172.51	30.72	0.42
Restoration	4103	100-year	2718.00	1124.88	1134.73	1134.73	1136.06	0.006287	9.98	418.69	196.97	0.64
Restoration	3763	2-year	578.00	1124.10	1130.24		1130.48	0.002127	3.97	145.62	37.89	0.36
Restoration	3763	5-year	983.00	1124.10	1131.96		1132.26	0.002686	4.33	226.84	→ 62.81	0.40
Restoration	3763	100-year	2718.00	1124.10	1134.01		1134.27	0.001919	4.89	993.76	467.21	0.36
Restoration	3555	2-year	578.00	1123.95	1129.72		1130.02	0.002321	4.35	132.97	31.49	0.37
Restoration	3555	5-year	983.00	1123.95	1131.31		1131.71	0.002431	5.18	221.12	130.26	0.39
Restoration	3555	100-year	2718.00	1123.95	1133.40		1133.80	0.002456	6.33	870.25	411.08	0.41
Restoration	3170	2-year	578.00	1122.70	1128.61		1128.94	0.003414	4.62	125.21	37.51	0.45
Restoration	3170	5-year	983.00	1122.70	1130.32		1130.64	0.003066	4.54	230.37	126.48	0.43
Restoration	3170	100-year	2718.00	1122.70	1132.30		1132.75	0.003042	6.12	727.67	348.57	0.46
Restoration	2975	2-year	578.00	1121.97	1127.93		1128.28	0.003330	4.77	121.17	33.67	0.44
Restoration	2975	5-year	983.00	1121.97	1129.56		1130.00	0.003314	5.34	184.23	→ 57.98	0.46
Restoration	2975	100-year	2718.00	1121.97	1131.91		1132.22	0.002090	5.62	945.47	410.28	0.39
Restoration	2690	2-year	594.00	1120.54	1127.46		1127.63	0.001435	3.36	176.96	43.92	0.29
Restoration	2690	5-year	1010.00	1120.54	1129.09		1129.33	0.001510	3.96	261.93	→ 114.09	0.31
Restoration	2690	100-year	2788.00	1120.54	1131.63		1131.79	0.000953	4.13	1361.63	531.50	0.27
Restoration	2460	2-year	594.00	1120.00	1127.09		1127.29	0.001500	3.65	163.81	49.16	0.31
Restoration	2460	5-year	1010.00	1120.00	1128.81		1129.03	0.001141	3.97	384.49	250.52	0.28
Restoration	2460	100-year	2788.00	1120.00	1131.45		1131.59	0.000743	4.08	1501.42	506.22	0.24
Restoration	2295	2-year	594.00	1120.02	1126.58		1126.93	0.003190	4.74	125.32	34.13	0.44
Restoration	2295	5-year	1010.00	1120.02	1128.37		1128.71	0.003362	4.68	222.96	107.47	0.45
Restoration	2295	100-year	2788.00	1120.02	1131.09		1131.39	0.001803	5.09	899.45	340.60	0.36
Restoration	1970	2-year	594.00	1119.80	1125.72		1126.02	0.002401	4.37	135.88	33.37	0.38
Restoration	1970	5-year	1010.00	1119.80	1127.36		1127.78	0.002456	5.17	205.80	83.17	0.40
Restoration	1970	100-year	2788.00	1119.80	1130.68		1130.90	0.001162	4.88	1071.40	318.42	0.30
Restoration	1500	2-year	594.00	1118.07	1122.05	1122.05	1123.45	0.019005	9.51	62.45	22.29	1.00
Restoration	1500	5-year	1010.00	1118.07	1123.31	1123.31	1125.17	0.018138	10.94	92.32	25.17	1.01
Restoration	1500	100-year	2788.00	1118.07	1127.67	1127.67	1129.54	0.009280	11.47	305.28	96.11	0.78

Josh,

Please do create a linear (x axis) log (y axis plot of Flow vs. Frequency as a check for my BKF Q @ a 1.7 yr R.I.

Thanks!

Warren.

TK-13

Q Elev. W.

HEC-RAS Plan: unname trib River: silver crk trib Reach: restoration

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
restoration	1430	2-yr	23.00	1194.30	1195.24	1195.24	1195.51	0.030675	4.20	5.48	10.32	1.02
restoration	1430	5-yr	44.00	1194.30	1195.54	1195.54	1195.93	0.027520	4.98	8.83	11.72	1.01
restoration	1430	100-yr	154.00	1194.30	1196.54	1196.54	1197.30	0.021808	7.05	22.08	15.20	1.00
restoration	1285	2-yr	23.00	1187.02	1188.71	1188.71	1189.15	0.032839	5.30	4.34	5.13	1.01
restoration	1285	5-yr	44.00	1187.02	1189.23	1189.23	1189.78	0.029672	5.96	7.38	6.80	1.01
restoration	1285	100-yr	154.00	1187.02	1190.67	1190.67	1191.50	0.021216	7.36	21.97	15.60	0.95
restoration	1110	2-yr	23.00	1182.19	1182.94	1182.94	1183.14	0.033284	3.52	6.53	17.37	1.01
restoration	1110	5-yr	44.00	1182.19	1183.17	1183.17	1183.42	0.030551	4.01	10.97	22.51	1.01
restoration	1110	100-yr	154.00	1182.19	1183.78	1183.78	1184.27	0.024345	5.61	27.54	29.31	1.01
restoration	895	2-yr	23.00	1173.00	1173.86	1173.86	1174.08	0.032061	3.76	6.12	14.27	1.01
restoration	895	5-yr	44.00	1173.00	1174.10	1174.10	1174.40	0.029329	4.41	9.98	17.06	1.02
restoration	895	100-yr	154.00	1173.00	1174.88	1174.88	1175.47	0.023275	6.19	24.90	21.32	1.01
restoration	560	2-yr	23.00	1157.36	1158.47	1158.47	1158.81	0.029451	4.70	4.90	7.30	1.01
restoration	560	5-yr	44.00	1157.36	1158.86	1158.86	1159.33	0.026878	5.48	8.03	8.75	1.01
restoration	560	100-yr	154.00	1157.36	1160.05	1160.05	1160.88	0.022972	7.31	21.07	13.30	1.01
restoration	340	2-yr	23.00	1148.46	1149.37	1149.30	1149.61	0.021812	3.97	5.79	8.93	0.87
restoration	340	5-yr	44.00	1148.46	1149.66	1149.63	1150.08	0.024654	5.17	8.52	9.47	0.96
restoration	340	100-yr	154.00	1148.46	1150.79	1150.79	1151.68	0.023623	7.58	20.31	11.54	1.01
restoration	100	2-yr	23.00	1142.39	1143.06	1143.06	1143.27	0.032606	3.65	6.30	15.63	1.01
restoration	100	5-yr	44.00	1142.39	1143.30	1143.30	1143.58	0.029446	4.27	10.31	18.70	1.01
restoration	100	100-yr	154.00	1142.39	1144.02	1144.02	1144.51	0.024443	5.67	27.18	28.31	1.01