STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

PAT L. MCCRORY
GOVERNOR

ANTHONY J. TATA
SECRETARY

February 26, 2013

MEMORANDUM TO: Mr. Pat Ivey, PE
Division 9 Engineer

FROM: Philip S. Harris, III, P.E.
Natural Environment Section
Project Development and Environmental Analysis Unit

SUBJECT: Forsyth County; SR 3000 Extension from SR 2999 to US 158; Federal Aid Project No. STP-3000(a); W.B.S. No. 34845.1.1; **T.I.P. U-2707**

Attached are the U.S. Army Corps of Engineers Section 404 Individual Permit and the N.C. Division of Water Quality Section 401 Water Quality Certification for the above referenced project. All environmental permits have been received for the construction of this project.

A copy of this permit package will be posted on the NCDOT website at:
http://www.ncdot.gov/doh/preconstruct/pe/neu/permit.html

Cc:
Mr. Randy Garris, P.E. State Contract Officer
Mr. Kent Boyer, Division Environmental Officer
Mr. Majed Alghandour, P. E., Programming and TIP
Mr. Jay Bennett, P.E., Roadway Design Unit
Mr. Dewayne Sykes, P.E. Utilities Unit
Mr. Art McMillan, P.E., Hydraulics Unit
Mr. Tom Koch, P.E., Structure Design Unit
Mr. Mark Staley, Roadside Environmental Unit
Mr. Ron Hancock, P.E., State Roadway Construction Engineer
Mr. Mike Robinson, P.E., State Bridge Construction Engineer
Mr. Eric Midkiff, P.E., PDEA Central Region
Mr. Clarence Coleman, P.E., FHWA
Ms. Beth Harmon, EEP
Mr. Phillip Ayscue, Office of Inspector General

MAILING ADDRESS:
NC DEPARTMENT OF TRANSPORTATION
PROJECT DEVELOPMENT AND ENVIRONMENTAL ANALYSIS
1598 MAIL SERVICE CENTER
RALEIGH NC 27699-1598

TELEPHONE: 919-707-6100
FAX: 919-212-5785

WEBSITE: WWW.NCDOT.ORG

LOCATION:
1020 BIRCH RIDGE DRIVE
RALEIGH NC 27610-4328

PROJECT COMMITMENTS

TIP Project No. U-2707
SR 3000 (Idols Rd.) extension from SR 2999 (Hampton Road)
to US 158 (Clemmons Road)
Forsyth County
Federal Aid No. STP-3000(1)
State Project No. 8.2624101
WBS No. 34845.1.1

Commitments Developed through Project Development and Design

Current status, changes, or additions to the project commitments as shown in the environmental document for the project are printed in *italic* font.

Design Services/Division 9

- NCDOT will provide 4-ft paved shoulders to accommodate bicycle traffic along Idols Road Extension.

This commitment was addressed during design and will be implemented during construction.

- NCDOT will provide a left-turn lane for the access road to the historic property, Hanes Farm, if Alternative A is recommended and constructed.

Alternative B has been selected as the Preferred Alternative, so this commitment no longer applies.

- NCDOT will minimize tree removal between the railroad right of way and the edge of pavement on the new alignment in the area of the historic property, Hanes Farm, if Alternative B, C, or D is recommended and constructed.

This commitment was addressed during design and will be implemented during construction.

Roadside Environmental

- NCDOT will control erosion and sedimentation for the Muddy Creek crossing and the tributary culvert installation through the appropriate specification, installation, and maintenance of high quality erosion and sedimentation control measures.

The original commitment was based on Muddy Creek's 303(d) status at the time the Environmental Assessment was published (February 2002). Muddy Creek is currently included on the 2012 Final 303(d) list due to metals (copper and zinc), not sedimentation or turbidity. Therefore, NCDOT will utilize standard Best Management Practices for sedimentation and erosion control throughout construction of the project.

PDEA

- NCDOT will coordinate with the N.C. Division of Water Quality (DWQ) to fulfill the necessary requirements regarding stream mitigation. Compensatory mitigation with regard to stream mitigation is left to the discretion of DWQ. Pertinent details of the stream modifications will be outlined in the application for the 401 Water Quality Certification.

NCDOT coordinated with DWQ regarding the development of a compensatory stream mitigation plan. This commitment was addressed during the permitting process, via the inclusion of the compensatory stream mitigation plan in the permit application for the project. The 401 Permit was approved August 6, 2012.

The compensatory stream mitigation plan will be implemented prior to or during construction.

GeoEnvironmental

- One site exists within the project area that has the potential for Underground Storage Tank (UST) involvement. NCDOT will conduct further studies if the proposed project impacts the UST.

The parcel, former Ava Katrina Robertson property, at the intersection of Idols Road and Hampton Road was acquired by Right of Way. The GeoEnvironmental Section has conducted all necessary studies and preformed all necessary remediation at the site.

COMMITMENTS FROM PERMITTING

Natural Environment Section—Engineering Group

404 condition f
Compensatory mitigation for the unavoidable impacts to 892 (not including mitigation for 11 ft. of stream bank stabilization included in the requested 903 linear ft. of stream channel impacts) linear ft. of stream impact associated with the proposed project shall be provided by on-site stream restoration and enhancement to be performed by NCDOT at a 1:1 ratio. The on-site mitigation will be constructed and in compliance with the attached U-2707 Stream Mitigation Plan dated December 22, 2011 and identified as (Exhibit C).

401 condition 2
Compensatory mitigation for impacts to 831 linear ft. of streams at a replacement ratio of 1:1 is required. Compensatory mitigation for impacts to jurisdictional streams shall be provided by on-site stream relocation and restoration (1:1 ratio) of 1800 linear ft. of stream S-JH-A ('Reach 1') and by on-site enhancement (2:1) of 153 linear ft. of stream S-JH-B ('Reach 2'), generating 1876.5 stream mitigation credits. The on-site stream relocation shall be constructed in accordance with the design submitted in your May 10,

2012 application and additional information received electronically on June 25, 2012. All on-site mitigation sites shall be protected in perpetuity by a conservation easement or through NCDOT fee simple acquisition and recorded in the NCDOT Natural Environment Section mitigation geodatabase. Please be reminded that as-builts for the completed streams shall be submitted to the North Carolina Division of Water Quality 401 Wetlands Unit with the as-builts for the rest of the project. If the parameters of this condition are not met, then the permittee shall supply additional stream mitigation for the 831 linear ft. of impacts. All channel relocations will be constructed in a dry work area, will be completed and stabilized, and must be approved on-site by NCDWQ staff, prior to diverting water into the new channel. Whenever possible, channel relocations shall be allowed to stabilize for an entire growing season. All stream relocations shall have a 50-foot wide native wooded buffer planted on both sides of the stream unless otherwise authorized by this Certification. A transitional phase incorporating rolled erosion control product (RECP) and appropriate ground cover is allowable.

401 condition 3

The stream mitigation site shall be monitored annually for five years or until success criteria are satisfied. Monitoring protocols shall follow the Monitoring Level I outlined in the Stream Mitigation Guidelines, April 2003.

401 condition 4

Success of the mitigation site shall be determined by NCDWQ during an on-site visit at or near the end of the monitoring period.

DEPARTMENT OF THE ARMY PERMIT

Permittee: NCDOT SR 3000 (IDOLS ROAD) EXTENSION TIP U-27007
ATTN: DR. GREGORY J. THORPE, PH.D.

Permit No.: SAW-1998-20439

Issuing Office: USAED, WILMINGTON – CESAW-RG-R

NOTE: The term "you" and its derivatives, as used in this permit, means the permittee or any future transferee. The term "this office" refers to the appropriate district or division office of the Corps of Engineers having jurisdiction over the permitted activity or the appropriate official of that office acting under the authority of the commanding officer.

You are authorized to perform work in accordance with the terms and conditions specified below.

Project Description: The North Carolina Department of Transportation (NCDOT) has identified this project as TIP U-2707, which involves the construction of a 2.0 mile roadway on new location, as well as the replacement of bridge no. 109 over the Norfolk Southern Railroad and reconfiguration of the intersection of Idols and Hampton Roads. The cross section of the proposed new location facility consists of two 12 ft. travel lanes, 4 ft. paved shoulder to accommodate bicycles, and 4 ft. grass shoulders. The project would permanently impact 903 linear feet of the jurisdictional stream channels of Muddy Creek and two unnamed tributaries to Muddy Creek. In addition, impacts are proposed to 0.81 acre of jurisdictional wetlands adjacent to these tributaries. To mitigate for all unavoidable permanent impacts to jurisdictional features, the applicant proposes compensatory mitigation for 892 linear feet of permanent stream impacts (not including bank stabilization) and 0.81 acre of permanent riparian wetland impacts. On-site stream restoration and enhancement will be performed by NCDOT to compensate for all 892 linear feet of permanent stream impacts at a 1:1 ratio. The USACE is requiring all 892 feet of mitigation. The remaining compensatory mitigation for 0.81 acre of permanent riparian wetland impacts will be provided by North Carolina Ecosystem Enhancement Program (NCEEP) to satisfy the compensatory mitigation requirements associated with federal and state permits. In a letter dated March 6, 2010, NCEEP has agreed to provide the required wetland mitigation for this proposal if permitted.

Project Location: The project, known as TIP U-~~2702~~2707, is a 2.0 mile roadway on new location, as wetlands the replacement of bridge no. 109 over the Norfolk Southern Railroad and the reconfiguration of the intersection of Idols and Hampton Roads. The cross section of the proposed new location facility consists of two 12 ft. travel lanes, 4 ft. paved shoulders to accommodate bicycles, and 4 ft. grass shoulders. Impacts are proposed to Muddy Creek and two unnamed tributaries to Muddy Creek. In addition, impacts are proposed to 0.81 acre of jurisdictional wetlands adjacent to these tributaries. All project streams are tributaries to the Yadkin-Pee Dee River Basin in Forsyth County. (U.S. Geological Survey [USGS] Hydrologic Unit [HUC] 03040101). The approximate center of project is at 36.0124° N., -80.3586° W.

Permit Conditions:

General Conditions:

1. The time limit for completing the work authorized ends on December 31, 2019 If you find that you need more time to complete the authorized activity, submit your request for a time extension to this office for consideration at least one month before the above date is reached.

2. You must maintain the activity authorized by this permit in good condition and in conformance with the terms and conditions of this permit. You are not relieved of this requirement if you abandon the permitted activity, although you may make a good faith transfer to a third party in compliance with General Condition 4 below. Should you wish to cease to maintain the authorized activity or should you desire to abandon it without a good faith transfer, you must obtain a modification of this permit from this office, which may require restoration of the area.

3. If you discover any previously unknown historic or archeological remains while accomplishing the activity authorized by this permit, you must immediately notify this office of what you have found. We will initiate the Federal

and state coordination required to determine if the remains warrant a recovery effort or if the site is eligible for listing in the National Register of Historic Places.

4. If you sell the property associated with this permit, you must obtain the signature of the new owner in the space provided and forward a copy of the permit to this office to validate the transfer of this authorization.

5. If a conditioned water quality certification has been issued for your project, you must comply with the conditions specified in the certification as special conditions to this permit. For your convenience, a copy of the certification is attached if it contains such conditions.

6. You must allow representatives from this office to inspect the authorized activity at any time deemed necessary to ensure that it is being or has been accomplished in accordance with the terms and conditions of your permit,

Special Conditions:

SEE ATTACHED SPECIAL CONDITIONS

Further Information:

1. Congressional Authorities: You have been authorized to undertake the activity described above pursuant to:

( ) Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403).

(X) Section 404 of the Clean Water Act (33 U.S.C. 1344).

( ) Section 103 of the Marine Protection, Research and Sanctuaries Act of 1972 (33 U.S.C. 1413).

2. Limits of this authorization.

a. This permit does not obviate the need to obtain other Federal, state, or local authorizations required by law.

b. This permit does not grant any property rights or exclusive privileges.

c. This permit does not authorize any injury to the property or rights of others.

d. This permit does not authorize interference with any existing or proposed Federal project.

3. Limits of Federal Liability. In issuing this permit, the Federal Government does not assume any liability for the following:

a. Damages to the permitted project or uses thereof as a result of other permitted or unpermitted activities or from natural causes.

b. Damages to the permitted project or uses thereof as a result of current or future activities undertaken by or on behalf of the United States in the public interest.

c. Damages to persons, property, or to other permitted or unpermitted activities or structures caused by the activity authorized by this permit.

d. Design or construction deficiencies associated with the permitted work.

*U.S. GOVERNMENT PRINTING OFFICE: 1986-717-425

e. Damage claims associated with any future modification, suspension, or revocation of this permit.

4. Reliance on Applicant's Data: The determination of this office that issuance of this permit is not contrary to the public interest was made in reliance on the information you provided.

5. Reevaluation of Permit Decision. This office may reevaluate its decision on this permit at any time the circumstances warrant. Circumstances that could require a reevaluation include, but are not limited to, the following:

a. You fail to comply with the terms and conditions of this permit.

b. The information provided by you in support of your permit application proves to have been false, incomplete, or inaccurate (See 4 above).

c. Significant new information surfaces which this office did not consider in reaching the original public interest decision.

Such a reevaluation may result in a determination that it is appropriate to use the suspension, modification, and revocation procedures contained in 33 CFR 325.7 or enforcement procedures such as those contained in 33 CFR 326.4 and 326.5. The referenced enforcement procedures provide for the issuance of an administrative order requiring you to comply with the terms and conditions of your permit and for the initiation of legal action where appropriate. You will be required to pay for any corrective measures ordered by this office, and if you fail to comply with such directive, this office may in certain situations (such as those specified in 33 CFR 209.170) accomplish the corrective measures by contract or otherwise and bill you for the cost.

6. Extensions. General condition 1 establishes a time limit for the completion of the activity authorized by this permit, Unless there are circumstances requiring either a prompt completion of the authorized activity or a reevaluation of the public interest decision, the Corps will normally give favorable consideration to a request for an extension of this time limit.

*U.S. GOVERNMENT PRINTING OFFICE: 1986-717-425

Your signature below, as permittee, indicates that you accept and agree to comply with the terms and conditions of this permit.

E. L. Lusk for — Oct 31, 2012

(PERMITTEE) NCDOT SR 3000 (IDOLS ROAD) TIP U-2707 DR.GREGORY J. THORPE, PH.D. — *(DATE)*

This permit becomes effective when the Federal official, designated to act for the Secretary of the Army, has signed below.

FOR: — 11/06/12

(DISTRICT Engineer) STEVEN A. BAKER, COLONEL — *(DATE)*

When the structures or work authorized by this permit are still in existence at the time the property is transferred, the terms and conditions of this permit will continue to be binding on the new owner(s) of the property. To validate the transfer of this permit and the associated liabilities associated with compliance with its terms and conditions, have the transferee sign and date below.

(Transferee) — *(DATE)*

*U.S. GOVERNMENT PRINTING OFFICE: 1986 – 717-425

SPECIAL CONDITIONS: ACTION ID: SAW-1998-20439
NCDOT SR 3000 (Idols Road) TIP U-2707

Failure to institute and carry out the details of the following special conditions below (listed as a-w) will result in a directive to cease all ongoing and permitted work within waters of the United States, including wetlands, associated with the permitted project, or such other remedies and/or fines as the U.S. Army Corps of Engineers District Commander or his authorized representatives may seek.

a) The North Carolina Division of Water Quality (DWQ) permit/certification number WQC003938 was issued for this project on August 6, 2012. Special conditions were issued associated with this water quality permit/certification and a copy of these conditions is attached as (Exhibit A). These referenced conditions are hereby incorporated as special conditions of this permit.

b) All work authorized by this permit must be performed in strict compliance with the attached plans which were received on May 9, 2012. These plans are a part of this permit and identified as (Exhibit B). Any modification to these plans must be approved by the US Army Corps of Engineers (USACE) prior to implementation.

c) The permittee shall schedule a preconstruction meeting between its representatives, the contractor's representatives, and the Corps of Engineers, Raleigh Regulatory Field Office, NCDOT Regulatory Project Manager, prior to any work within jurisdictional waters and wetlands to ensure that there is a mutual understanding of all of the terms and conditions contained within this Department of the Army Permit. The permittee shall provide the USACE, Raleigh Regulatory Field Office, NCDOT Regulatory Project Manager, with a copy of the final plans at least two weeks prior to the preconstruction meeting along with a description of any changes that have been made to the project's design, construction methodology or construction timeframe. The permittee shall schedule the preconstruction meeting for a time when the USACE and North Carolina Division of Water Quality (NCDWQ) Project Managers can attend. The permittee shall invite the Corps and NCDWQ Project Managers a minimum of thirty (30) days in advance of the scheduled meeting in order to provide those individuals with ample opportunity to schedule and participate in the required meeting.

d) Except as authorized by this permit or any USACE approved modification to this permit, no excavation, fill or mechanized land-clearing activities shall take place at any time in the construction or maintenance of this project, within waters or wetlands. This permit does not authorize temporary placement or double handling of excavated or fill material within waters or wetlands outside the permitted area. This prohibition applies to all borrow and fill activities connected with this project.

e) Except as specified in the plans attached to this permit, no excavation, fill or mechanized land-clearing activities shall take place at any time in the construction or maintenance of this project, in such a manner as to impair normal flows and circulation patterns within waters or wetlands or to reduce the reach of waters or wetlands.

f) Compensatory mitigation for the unavoidable impacts to 892 (not including mitigation for 11 feet of stream bank stabilization included in the requested 903 linear feet of stream channel impacts) linear feet of stream impact associated with the proposed project shall be provided by on-site stream restoration and enhancement to be performed by NCDOT at a 1:1 ratio. The on-site mitigation will be constructed and in compliance with the attached U-2707 Stream Mitigation Plan dated December 22, 2012 and identified as (Exhibit C).

Compensatory mitigation for 0.81 acre of permanent Riparian-Nonriverine wetland impacts associated with the project will be provided by North Carolina Ecosystem Enhancement Program (NCEEP), as outlined in the letter dated March 6, 2012, from Michael Ellison, EEP Deputy Director. In order to compensate for this wetland impact associated with this permit, mitigation shall be provided in accordance with the provisions outlined on the most recent version of the attached Compensatory Mitigation Responsibility Transfer Form. The requirements of this form, including any special conditions listed on this form, are herby incorporated as special conditions of this permit authorization and identified as (Exhibit D).

g) All mechanized equipment will be regularly inspected and maintained to prevent contamination of waters and wetlands from fuels, lubricants, hydraulic fluids, or other toxic materials. In the event of a spill of petroleum products or any other hazardous waste, the permittee shall immediately report it to the N.C. Division of Water Quality at 1 (800) 858-0368 and provisions of the North Carolina Oil Pollution and Hazardous Substances Control Act will be followed.

h) The permittee shall advise the Corps in writing prior to beginning the work authorized by this permit and again upon completion of the work authorized by this permit.

i) Unless otherwise authorized by this permit, all fill material placed in waters or wetlands shall be generated from an upland source and will be clean and free of any pollutants except in trace quantities. Metal products, organic materials (including debris from land clearing activities), or unsightly debris will not be used.

j) The permittee shall require its contractors and/or agents to comply with the terms and conditions of this permit in the construction and maintenance of this project, and shall provide each of its contractors and/or agents associated with the construction or maintenance of this project with a copy of this permit. A copy of this permit, including all conditions, shall be available at the project site during construction and maintenance of this project

k) The permittee shall employ all sedimentation and erosion control measures necessary to prevent an increase in sedimentation or turbidity within waters and wetlands outside the permit area. This shall include, but is not limited to, the immediate installation of silt fencing or similar appropriate devices around all areas subject to soil disturbance or the movement of earthen fill, and the immediate stabilization of all disturbed areas. Additionally, the project must remain in full compliance with all aspects of the Sedimentation Pollution Control Act of 1973 (North Carolina General Statutes Chapter 113A Article 4).

l) The permittee shall remove all sediment and erosion control measures placed in wetlands or waters, and shall restore natural grades in those areas, prior to project completion.

m) During the clearing phase of the project, heavy equipment must not be operated in surface waters or stream channels. Temporary stream crossings will be used to access the opposite sides of stream channels. All temporary diversion channels and stream crossings will be constructed of non-erodible materials. Grubbing of riparian vegetation will not occur until immediately before construction begins on a given segment of stream channel.

n) No fill or excavation for the purposes of sedimentation and erosion control shall occur within jurisdictional waters, including wetlands, unless it is included on the plan drawings and specifically authorized by this permit.

o) The permittee, upon receipt of a notice of revocation of this permit or upon its expiration before completion of the work will, without expense to the United States and in such time and manner as the Secretary of the Army or his authorized representative may direct, restore the water or wetland to its pre-project condition.

p) Violations of these conditions or violations of Section 404 of the Clean Water Act or Section 10 of the Rivers and Harbors Act must be reported in writing to the Wilmington District U.S. Army Corps of Engineers within 24 hours of the permittee's discovery of the violation.

q) The permittee will ensure that the construction design plans for this project do not deviate from the permit plans attached to this authorization. Written verification shall be provided that the final construction drawings comply with the attached permit drawings prior to any active construction in waters of the United States, including wetlands. Any deviation in the construction design plans will be brought to the attention of the Corps of Engineers, Raleigh Regulatory Field Office prior to any active construction in waters or wetlands.

r) Prior to commencing construction within jurisdictional waters of the United States for any portion of the proposed project, the permittee shall forward the latest version of project construction drawings to the Corps of Engineers, Raleigh Regulatory Field Office NCDOT Regulatory Project Manager. Half-size drawings will be acceptable.

s) The permittee shall take measures to prevent live or fresh concrete from coming into contact with any surface waters until the concrete has hardened.

t) Measures will be included in the construction/installation that will promote the safe passage of fish and other aquatic organisms. The dimension, pattern, and profile of the stream above and below a pipe or culvert should not be modified by widening the stream channel or by reducing the depth of the stream in connection with the construction activity. The width, height, and gradient of a proposed opening should be such as to pass the average historical low flow and spring flow without adversely altering flow velocity. Spring flow should be determined from gauge data, if available. In the absence of such data, bankfull flow can be used as a comparable level.

u) Culverts greater than 48 inches in diameter will be buried at least one foot below the bed of the stream. Culverts 48 inches in diameter or less shall be buried or placed on the stream bed as practicable and appropriate to maintain aquatic passage, and every effort shall be made to maintain the existing channel slope. The bottom of the culvert must be placed at a depth below the natural stream bottom to provide for passage during drought or low flow conditions. Destabilizing the channel and head cutting upstream should be considered in the placement of the culvert. A waiver from the depth specifications in this condition may be requested in writing. The waiver will be issued if it can be demonstrated that the proposal would result in the least impacts to the aquatic environment.

v) To ensure that all borrow and waste activities occur on high ground and do not result in the degradation of adjacent wetlands and streams, except as authorized by this permit, the permittee shall require its contractors and/or agents to identify all areas to be used to borrow material, or to dispose of dredged, fill, or waste material. The permittee shall provide the USACE with appropriate maps indicating the locations of proposed borrow or waste sites as soon as the permittee has that information. The permittee will coordinate with the USACE before approving any borrow or waste sites that are within 400 feet of any streams or wetlands.

w) If the permittee discovers any previously unknown historic or archaeological sites while accomplishing the authorized work, he shall immediately stop work and notify the Corps of Engineers, Raleigh Regulatory Field Office NCDOT Regulatory Project Manager who will initiate the required State/Federal coordination.

U.S. ARMY CORPS OF ENGINEERS

EXHIBIT D

Wilmington District

Compensatory Mitigation Responsibility Transfer Form

Permittee: North Carolina Department of Transportation, Division of Highways **Action ID:** SAW- 199820439
Project Name: SR 3000 (Idols Road) extension TIP U-2707 **County:** Forsyth

Instructions to Permittee: The Permittee must provide a copy of this form to the Mitigation Sponsor, either an approved Mitigation Bank or the North Carolina Ecosystem Enhancement Program (NCEEP), who will then sign the form to verify the transfer of the mitigation responsibility. Once the Sponsor has signed this form, it is the Permittee's responsibility to ensure that to the U.S. Army Corps of Engineers (USACE) Project Manager identified on page two is in receipt of a signed copy of this form before conducting authorized impacts, unless otherwise specified below. If more than one mitigation Sponsor will be used to provide the mitigation associated with the permit, or if the impacts and/or the mitigation will occur in more than one 8-digit Hydrologic Unit Code (HUC), multiple forms will be attached to the permit, and the separate forms for each Sponsor and/or HUC must be provided to the appropriate mitigation Sponsors.

Instructions to Sponsor: The Sponsor must verify that the mitigation requirements shown below are available at the identified site. By signing below, the Sponsor is accepting full responsibility for the identified mitigation, regardless of whether or not they have received payment from the Permittee. Once the form is signed, the Sponsor must update the appropriate ledger and provide a copy of the signed form to the Permittee and to the USACE Bank/In-Lieu Fee Program Manager. The Sponsor must also comply with all reporting requirements established in their authorizing instrument.

Permitted Impacts and Compensatory Mitigation Requirements:

Permitted Impacts Requiring Mitigation* **8-digit HUC and Basin: 03040101, Upper Yadkin River Basin**

Stream Impacts (linear feet)			Wetland Impacts (acres)			
Warm	Cool	Cold	Riparian Riverine	Riparian Non-riverine	Non-Riparian	Coastal
				0.81		

*If more than one mitigation sponsor will be used for the permit, only include impacts to be mitigated by this sponsor.

Compensatory Mitigation Requirements: **8-digit HUC and Basin:** 03040101 Upper Yadkin River Basin

Stream Mitigation (credits)			Wetland Mitigation (credits)			
Warm	Cool	Cold	Riparian Riverine	Riparian Non-riverine	Non-Riparian	Coastal
				0.81		

Mitigation Site Debited: NCEEP
(List the name of the bank to be debited. For umbrella banks, also list the specific site. For NCEEP, list NCEEP. If the NCEEP acceptance letter identifies a specific site, also list the specific site to be debited).

Section to be completed by the Mitigation Sponsor

Statement of Mitigation Liability Acceptance: I, the undersigned, verify that I am authorized to approve mitigation transactions for the Mitigation Sponsor shown below, and I certify that the Sponsor agrees to accept full responsibility for providing the mitigation identified in this document (see the table above), associated with the USACE Permittee and Action ID number shown. I also verify that released credits (and/or advance credits for NCEEP), as approved by the USACE, are currently available at the mitigation site identified above. Further, I understand that if the Sponsor fails to provide the required compensatory mitigation, the USACE Wilmington District Engineer may pursue measures against the Sponsor to ensure compliance associated with the mitigation requirements.

Mitigation Sponsor Name: _____

Name of Sponsor's Authorized Representative: _____

_____ _____
Signature of Sponsor's Authorized Representative **Date of Signature**

USACE Wilmington District
Compensatory Mitigation Responsibility Transfer Form, Page 2

Conditions for Transfer of Compensatory Mitigation Credit:

- Once this document has been signed by the Mitigation Sponsor and the USACE is in receipt of the signed form, the Permittee is no longer responsible for providing the mitigation identified in this form, though the Permittee remains responsible for any other mitigation requirements stated in the permit conditions.
- Construction within jurisdictional areas authorized by the permit identified on page one of this form can begin only after the USACE is in receipt of a copy of this document signed by the Sponsor, confirming that the Sponsor has accepted responsibility for providing the mitigation requirements listed herein. For authorized impacts conducted by the North Carolina Department of Transportation (NCDOT), construction within jurisdictional areas may proceed upon permit issuance; however, a copy of this form signed by the Sponsor must be provided to the USACE within 30 days of permit issuance. NCDOT remains fully responsible for the mitigation until the USACE has received this form, confirming that the Sponsor has accepted responsibility for providing the mitigation requirements listed herein.
- Signed copies of this document must be retained by the Permittee, Mitigation Sponsor, and in the USACE administrative records for both the permit and the Bank/ILF Instrument. It is the Permittee's responsibility to ensure that the USACE Project Manager (address below) is provided with a signed copy of this form.
- If changes are proposed to the type, amount, or location of mitigation after this form has been signed and returned to the USACE, the Sponsor must obtain case-by-case approval from the USACE Project Manager and/or North Carolina Interagency Review Team (NCIRT). If approved, higher mitigation ratios may be applied, as per current District guidance and a new version of this form must be completed and included in the USACE administrative records for both the permit and the Bank/ILF Instrument.

Comments/Additional Conditions:

This form is not valid unless signed by the mitigation Sponsor and USACE Project Manager. For questions regarding this form or any of the conditions of the permit authorization, contact the Project Manager at the address below.

USACE Project Manager: **John Thomas**
USACE Field Office: **Raleigh Regulatory Field Office**
US Army Corps of Engineers
3331 Heritage Trade Drive, Suite 105
Wake Forest, North Carolina 27587
Email:

USACE Project Manager Signature

October 1, 2012
Date of Signature

Current Wilmington District mitigation guidance, including information on mitigation ratios, functional assessments, and mitigation bank location and availability, and credit classifications (including stream temperature and wetland groupings) is available at http://ribits.usace.army.mil.

NCDENR
North Carolina Department of Environment and Natural Resources
Division of Water Quality
Charles Wakild P.E
Director

Beverly Eaves Perdue
Governor

Dee Freeman
Secretary

August 6, 2012

Dr. Greg Thorpe, PhD., Manager
Project Development and Environmental Analysis
North Carolina Department of Transportation
1548 Mail Service Center
Raleigh, North Carolina, 27699-1548

Subject: 401 Water Quality Certification Pursuant to Section 401 of the Federal Clean Water Act with ADDITIONAL CONDITIONS for Proposed extension of SR 3000 (Idols Rd) from SR 2999 (Hampton Road) to US 158 (Clemmons Road) in Forsyth County, Federal Aid Project No. STP-3000 (1), State Project No. 8.2624101, TIP U-2707.
NCDWQ Project No. 2012-0470

Dear Dr. Thorpe:

Attached hereto is a copy of Certification No. 003938 issued to The North Carolina Department of Transportation (NCDOT) dated August 6, 2012.

If we can be of further assistance, do not hesitate to contact us.

Sincerely,

for Charles Wakild
Director

Attachments

cc: John Thomas, US Army Corps of Engineers, Raleigh Field Office (electronic copy only)
Kent Boyer, Division 9 Environmental Officer (electronic copy only)
Chris Militscher, Environmental Protection Agency (electronic copy only)
Marla Chambers, NC Wildlife Resources Commission
Jason Elliott, NCDOT, Roadside Environmental Unit (electronic copy only)
Beth Harmon, Ecosystem Enhancement Program (electronic copy only)
Wetlands/401 Transportation Unit
File Copy

Transportation and Permitting Unit
1650 Mail Service Center, Raleigh, North Carolina 27699-1650
Location: 512 N. Salisbury St. Raleigh, North Carolina 27604
Phone: 919-807-6300 \ FAX: 919-807-6492
Internet: www.ncwaterquality.org

401 Water Quality Certification Pursuant to Section 401 of the Federal Clean Water Act with ADDITIONAL CONDITIONS

THIS CERTIFICATION is issued in conformity with the requirements of Section 401 Public Laws 92-500 and 95-217 of the United States and subject to the North Carolina Division of Water Quality (NCDWQ) Regulations in 15 NCAC 2H .0500. This certification authorizes the NCDOT to impact 0.81acres of jurisdictional wetlands, and 903 linear feet of jurisdictional streams Forsyth County. The project shall be constructed pursuant to the application dated received May 10, 2012 with additional information dated received June 25, 2012 and July 17, 2012. The authorized impacts are as described below:

Stream Impacts in the Yadkin-Pee Dee River Basin

Site	Permanent Fill in Intermittent Stream (linear ft)	Temporary Fill in Intermittent Stream (linear ft)	Permanent Fill in Perennial Stream (linear ft)	Temporary Fill in Perennial Stream (linear ft)	Total Stream Impact (linear ft)	Stream Impacts Requiring Mitigation (linear ft)
2	61				61	
3			831		831	831
6			11		11	
Total	**61**		**842**		**903**	**831**

Total Stream Impact for Project: 903 linear feet

Wetland Impacts in the Yadkin River Basin (riverine)

Site	Fill (ac)	Fill (temporary) (ac)	Excavation (ac)	Mechanized Clearing (ac)	Hand Clearing (ac)	Area under Bridge (ac)	Total Wetland Impact (ac)
1				0.03			0.03
4	0.78						0.78
Total	**0.78**			**0.03**			**0.81**

Total Wetland Impact for Project: 0.81 acres.

The application provides adequate assurance that the discharge of fill material into the waters of the Yadkin-Pee Dee River Basin in conjunction with the proposed development will not result in a violation of applicable Water Quality Standards and discharge guidelines. Therefore, the State of North Carolina certifies that this activity will not violate the applicable portions of Sections 301, 302, 303, 306, 307 of PL 92-500 and PL 95-217 if conducted in accordance with the application and conditions hereinafter set forth.

This approval is only valid for the purpose and design that you submitted in your application dated received May 10, 2012 with additional information dated received June 25, 2012 and July 17, 2012. Should your project change, you are required to notify the NCDWQ and submit a new application. If the property is sold, the new owner must be given a copy of this Certification and approval letter, and is thereby responsible for complying with all the conditions. If any additional wetland impacts, or stream impacts, for this project (now or in the future) exceed one acre or 150 linear feet, respectively, additional compensatory mitigation may be required as described in 15A NCAC 2H .0506 (h) (6) and (7). For this approval to remain valid, you are required to comply with all the conditions listed below. In addition, you should obtain all other federal, state or local permits before proceeding with your project including (but not limited to) Sediment and Erosion control, Coastal Stormwater, Non-discharge and Water Supply watershed regulations. This Certification shall expire on the same day as the expiration date of the corresponding Corps of Engineers Permit.

Condition(s) of Certification:

1. The NCDOT Division Environmental Officer or Environmental Assistant will conduct a pre-construction meeting with all appropriate staff to ensure that the project supervisor and essential staff understand the potential issues with the stream mitigation site. NCDWQ staff shall be invited to the pre-construction meeting.
2. Compensatory mitigation for impacts to 831linear feet of streams at a replacement ratio of 1:1 is required. Compensatory mitigation for impacts to jurisdictional streams shall be provided by onsite stream relocation and

restoration (1:1 ratio) of 1800 linear feet of Stream S-JH-A ('Reach 1') and by on-site enhancement (2:1) of 153 linear feet of Stream S-JH-B ('Reach 2'), generating 1876.5 stream mitigation credits. The onsite stream relocation shall be constructed in accordance with the design submitted in your May 10, 2012 application and additional information dated received electronically on June 25, 2012. All on-site mitigation sites shall be protected in perpetuity by a conservation easement or through NCDOT fee simple acquisition and recorded in the NCDOT Natural Environment Unit mitigation geodatabase. Please be reminded that as-builts for the completed streams shall be submitted to the North Carolina Division of Water Quality 401 Wetlands Unit with the as-builts for the rest of the project. If the parameters of this condition are not met, then the permittee shall supply additional stream mitigation for the 831 linear feet of impacts. All channel relocations will be constructed in a dry work area, will be completed and stabilized, and must be approved on site by NCDWQ staff, prior to diverting water into the new channel. Whenever possible, channel relocations shall be allowed to stabilize for an entire growing season. All stream relocations shall have a 50-foot wide native wooded buffer planted on both sides of the stream unless otherwise authorized by this Certification. A transitional phase incorporating rolled erosion control product (RECP) and appropriate temporary ground cover is allowable.

3. The stream mitigation site shall be monitored annually for five years or until success criteria are satisfied. Monitoring protocols shall follow the Monitoring Level I outlined in the Stream Mitigation Guidelines, April 2003.
4. Success of the mitigation site shall be determined by NCDWQ during an on-site visit at or near the end of the monitoring period.
5. There are no temporary impacts permitted at this time. If temporary impacts are needed, a permit modification will be required.
6. Post-construction stormwater shall be designed as approved in the permit application. If any changes are made to the post-construction stormwater design, the Division of Water Quality shall be contacted for approval of the changes.
7. Two copies of the final construction drawings shall be furnished to NCDWQ Central Office prior to the pre-construction meeting. The permittee shall provide written verification that the final construction drawings comply with the permit drawings contained in the application dated received May 10, 2012 with additional information dated received June 25, 2012 and July 17, 2012. Any deviations from the approved drawings are not authorized unless approved by the NC Division of Water Quality.
8. All channel relocations will be constructed in a dry work area and stabilized before stream flows are diverted. Channel relocations will be completed and stabilized, and must be approved on site by NCDWQ staff, prior to diverting water into the new channel. Whenever possible, channel relocations shall be allowed to stabilize for an entire growing season. Vegetation used for bank stabilization shall be limited to native woody species, and should include establishment of a 30 foot wide wooded and an adjacent 20 foot wide vegetated buffer on both sides of the relocated channel to the maximum extent practical. All stream banks shall be matted with coir fiber matting. Also, rip-rap may be allowed if it is necessary to maintain the physical integrity of the stream, but the applicant must provide written justification and any calculations used to determine the extent of rip-rap coverage requested. Once the stream has been turned into the new channel, it may be necessary to relocate stranded fish to the new channel to prevent fish kills.
9. The post-construction removal of any temporary bridge structures must return the project site to its preconstruction contours and elevations. The impacted areas shall be revegetated with appropriate native species.
10. Strict adherence to the most recent version of NCDOT's Best Management Practices For Bridge Demolition and Removal approved by the US Army Corps of Engineers is a condition of the 401 Water Quality Certification.
11. Bridge deck drains shall not discharge directly into the stream. Stormwater shall be directed across the bridge and pre-treated through site-appropriate means (grassed swales, pre-formed scour holes, vegetated buffers, etc.) before entering the stream. Please refer to the most current version of *Stormwater Best Management Practices.*
12. There shall be no bents in the water. If the bridge design changes, this permit shall be modified.
13. No drill slurry or water that has been in contact with uncured concrete shall be allowed to enter surface waters. This water shall be captured, treated, and disposed of properly.
14. Riprap shall not be placed in the active thalweg channel or placed in the streambed in a manner that precludes aquatic life passage. Bioengineering boulders or structures should be properly designed, sized and installed.
15. The stream channel shall be excavated no deeper than the natural bed material of the stream, to the maximum extent practicable. Efforts must be made to minimize impacts to the stream banks, as well as to vegetation responsible for maintaining the stream bank stability. Any applicable riparian buffer impact for access to stream channel shall be temporary and be revegetated with native riparian species.
16. Unless otherwise approved in this certification, placement of culverts and other structures in open waters and streams shall be placed below the elevation of the streambed by one foot for all culverts with a diameter greater than 48 inches, and 20 percent of the culvert diameter for culverts having a diameter less than 48 inches, to allow low flow passage of water and aquatic life. Design and placement of culverts and other structures including temporary erosion control measures shall not be conducted in a manner that may result in dis-equilibrium of wetlands or streambeds or banks, adjacent to or upstream and down stream of the above structures. The applicant

is required to provide evidence that the equilibrium is being maintained if requested in writing by NCDWQ. If this condition is unable to be met due to bedrock or other limiting features encountered during construction, please contact NCDWQ for guidance on how to proceed and to determine whether or not a permit modification will be required.

17. During the construction of the project, no staging of equipment of any kind is permitted in waters of the U.S., or protected riparian buffers.
18. The dimension, pattern and profile of the stream above and below the crossing shall not be modified. Disturbed floodplains and streams shall be restored to natural geomorphic conditions.
19. The use of rip-rap above the Normal High Water Mark shall be minimized. Any rip-rap placed for stream stabilization shall be placed in stream channels in such a manner that it does not impede aquatic life passage.
20. The Permittee shall ensure that the final design drawings adhere to the permit and to the permit drawings submitted for approval.
21. All work in or adjacent to stream waters shall be conducted in a dry work area. Approved BMP measures from the most current version of NCDOT Construction and Maintenance Activities manual such as sandbags, rock berms, cofferdams and other diversion structures shall be used to prevent excavation in flowing water.
22. Heavy equipment shall be operated from the banks rather than in the stream channel in order to minimize sedimentation and reduce the introduction of other pollutants into the stream.
23. All mechanized equipment operated near surface waters must be regularly inspected and maintained to prevent contamination of stream waters from fuels, lubricants, hydraulic fluids, or other toxic materials.
24. No rock, sand or other materials shall be dredged from the stream channel except where authorized by this certification.
25. Discharging hydroseed mixtures and washing out hydroseeders and other equipment in or adjacent to surface waters is prohibited.
26. The permittee and its authorized agents shall conduct its activities in a manner consistent with State water quality standards (including any requirements resulting from compliance with §303(d) of the Clean Water Act) and any other appropriate requirements of State and Federal law. If NCDWQ determines that such standards or laws are not being met (including the failure to sustain a designated or achieved use) or that State or federal law is being violated, or that further conditions are necessary to assure compliance, NCDWQ may reevaluate and modify this certification.
27. All fill slopes located in jurisdictional wetlands shall be placed at slopes no flatter than 3:1, unless otherwise authorized by this certification.
28. A copy of this Water Quality Certification shall be maintained on the construction site at all times. In addition, the Water Quality Certification and all subsequent modifications, if any, shall be maintained with the Division Engineer and the on-site project manager.
29. The outside buffer, wetland or water boundary located within the construction corridor approved by this authorization shall be clearly marked by highly visible fencing prior to any land disturbing activities. Impacts to areas within the fencing are prohibited unless otherwise authorized by this certification.
30. The issuance of this certification does not exempt the Permittee from complying with any and all statutes, rules, regulations, or ordinances that may be imposed by other government agencies (i.e. local, state, and federal) having jurisdiction, including but not limited to applicable buffer rules, stormwater management rules, soil erosion and sedimentation control requirements, etc
31. The Permittee shall report any violations of this certification to the Division of Water Quality within 24 hours of discovery.
32. Upon completion of the project (including any impacts at associated borrow or waste sites), the NCDOT Division Engineer shall complete and return the enclosed "Certification of Completion Form" to notify NCDWQ when all work included in the 401 Certification has been completed.
33. Native riparian vegetation must be reestablished in the riparian areas within the construction limits of the project by the end of the growing season following completion of construction.
34. There shall be no excavation from, or waste disposal into, jurisdictional wetlands or waters associated with this permit without appropriate modification. Should waste or borrow sites, or access roads to waste or borrow sites, be located in wetlands or streams, compensatory mitigation will be required since that is a direct impact from road construction activities.
35. Erosion and sediment control practices must be in full compliance with all specifications governing the proper design, installation and operation and maintenance of such Best Management Practices in order to protect surface waters standards:

    a. The erosion and sediment control measures for the project must be designed, installed, operated, and maintained in accordance with the most recent version of the *North Carolina Sediment and Erosion Control Planning and Design Manual.*

b. The design, installation, operation, and maintenance of the sediment and erosion control measures must be such that they equal, or exceed, the requirements specified in the most recent version of the *North Carolina Sediment and Erosion Control Manual.* The devices shall be maintained on all construction sites, borrow sites, and waste pile (spoil) projects, including contractor-owned or leased borrow pits associated with the project.
c. For borrow pit sites, the erosion and sediment control measures must be designed, installed, operated, and maintained in accordance with the most recent version of the *North Carolina Surface Mining Manual.*
d. The reclamation measures and implementation must comply with the reclamation in accordance with the requirements of the Sedimentation Pollution Control Act.

36. Sediment and erosion control measures shall not be placed in wetlands or waters unless otherwise approved by this Certification.

Violations of any condition herein set forth may result in revocation of this Certification and may result in criminal and/or civil penalties. This Certification shall become null and void unless the above conditions are made conditions of the Federal 404 and/or Coastal Area Management Act Permit. This Certification shall expire upon the expiration of the 404 or CAMA permit.

If you wish to contest any statement in the attached Certification you must file a petition for an administrative hearing. You may obtain the petition form from the office of Administrative hearings. You must file the petition with the office of Administrative Hearings within sixty (60) days of receipt of this notice. A petition is considered filed when it is received in the office of Administrative Hearings during normal office hours. The Office of Administrative Hearings accepts filings Monday through Friday between the hours of 8:00am and 5:00pm, except for official state holidays. The original and one (1) copy of the petition must be filed with the Office of Administrative Hearings.

The petition may be faxed-provided the original and one copy of the document is received by the Office of Administrative Hearings within five (5) business days following the faxed transmission.
The mailing address for the Office of Administrative Hearings is:

Office of Administrative Hearings
6714 Mail Service Center
Raleigh, NC 27699-6714
Telephone: (919)-431-3000, Facsimile: (919)-431-3100

A copy of the petition must also be served on DENR as follows:

Mr. William Cary, General Counsel
Department of Environment and Natural Resources
1601 Mail Service Center

This the 6th day of August 2012

DIVISION OF WATER QUALITY

for Charles Wakild
Director

WQC No. 003938

North Carolina Department of Environment and Natural Resources
Division of Water Quality
Charles Wakild, P.E
Director

Beverly Eaves Perdue
Governor

Dee Freeman
Secretary

NCDWQ Project No.: _____ **County:** _____

Applicant: _____

Project Name: _____

Date of Issuance of 401 Water Quality Certification: _____

Certificate of Completion

Upon completion of all work approved within the 401 Water Quality Certification or applicable Buffer Rules, and any subsequent modifications, the applicant is required to return this certificate to the 401 Transportation Permitting Unit, North Carolina Division of Water Quality, 1650 Mail Service Center, Raleigh, NC, 27699-1650. This form may be returned to NCDWQ by the applicant, the applicant's authorized agent, **or** the project engineer. It is not necessary to send certificates from all of these.

Applicant's Certification

I, _____, hereby state that, to the best of my abilities, due care and diligence was used in the observation of the construction such that the construction was observed to be built within substantial compliance and intent of the 401 Water Quality Certification and Buffer Rules, the approved plans and specifications, and other supporting materials.

Signature: _____ Date: _____

Agent's Certification

I, _____, hereby state that, to the best of my abilities, due care and diligence was used in the observation of the construction such that the construction was observed to be built within substantial compliance and intent of the 401 Water Quality Certification and Buffer Rules, the approved plans and specifications, and other supporting materials.

Signature: _____ Date:_____

Engineer's Certification

_____ Partial _____ Final

I, _____, as a duly registered Professional Engineer in the State of North Carolina, having been authorized to observe (periodically, weekly, full time) the construction of the project,for the Permittee hereby state that, to the best of my abilities, due care and diligence was used in the observation of the construction such that the construction was observed to be built within substantial compliance and intent of the 401 Water Quality Certification and Buffer Rules, the approved plans and specifications, and other supporting materials.

Signature _____ Registration No. _____

Date _____

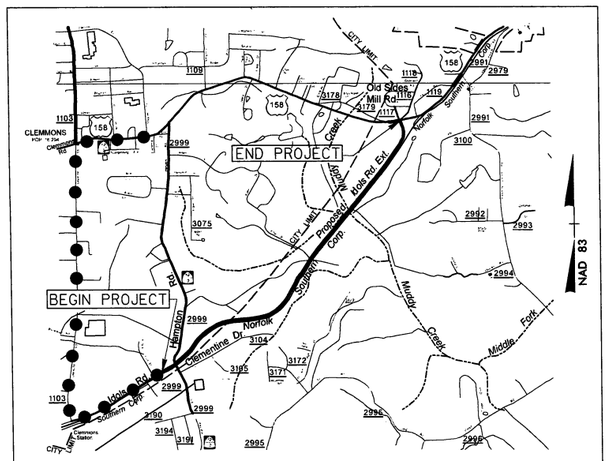
Transportation and Permitting Unit
1650 Mail Service Center Raleigh, North Carolina 27699-1650
Location: 512 N Salisbury St Raleigh, North Carolina 27604
Phone 919-807-6300 \ FAX 919-807-6492
Internet: www.ncwaterquality.org

7/01/99

TIP PROJECT: U-2707

CONTRACT:

See Sheet 1-A For Index of Sheets
See Sheet 1-B For Conventional Symbols



VICINITY MAP
FORSYTH COUNTY, NC

OFF SITE DETOUR ROUTE

STATE OF NORTH CAROLINA
DIVISION OF HIGHWAYS

FORSYTH COUNTY

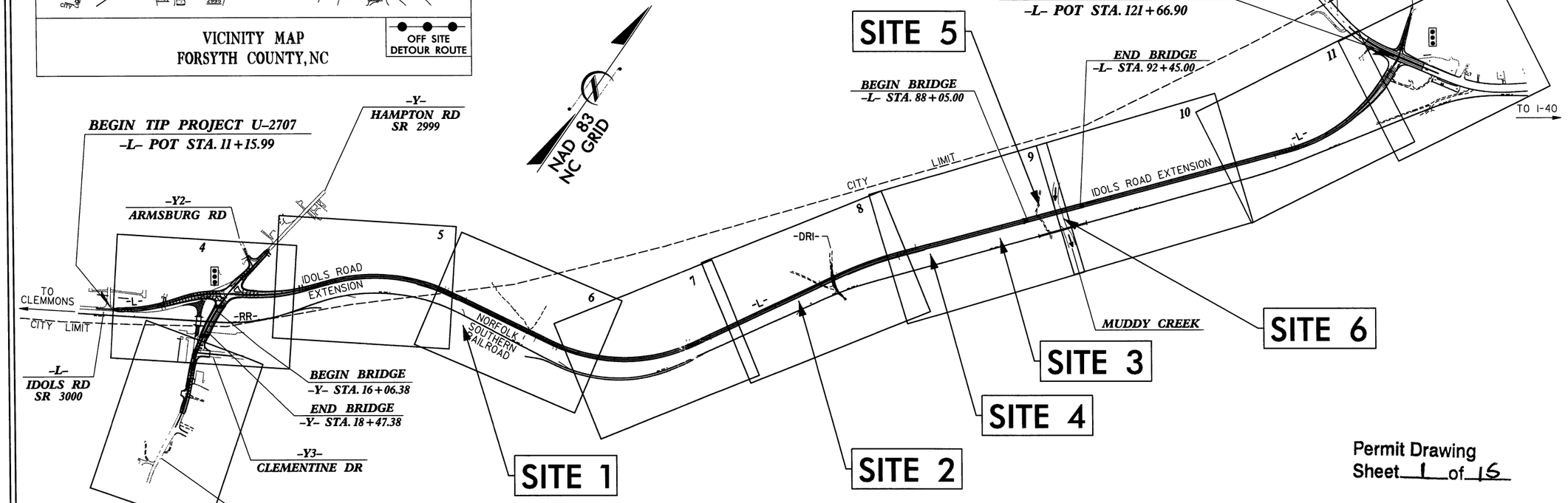
STATE	STATE PROJECT REFERENCE NO.	SHEET NO.	TOTAL SHEETS
N.C.	U-2707	1	

WBS NO.	F. A. PROJ. NO.	DESCRIPTION
34845.1.1	STP-3000(1)	P.E.
34845.2.1	STP-3000(1)	R/W & UTIL.
34845.2.2		

LOCATION: CLEMMONS – SR 3000 (IDOLS ROAD), FROM SR 2999 (HAMPTON ROAD) TO US 158 (CLEMMONS ROAD)

TYPE OF WORK: GRADING, DRAINAGE, PAVING, STRUCTURES, SIGNING, AND SIGNALS

WETLAND & STREAM IMPACTS



Permit Drawing
Sheet 1 of 15

CLEARING ON THIS PROJECT SHALL BE PERFORMED TO THE LIMITS ESTABLISHED BY METHOD III

A PORTION OF THIS PROJECT IS WITHIN THE MUNICIPAL BOUNDARIES OF CLEMMONS.

PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

GRAPHIC SCALES

PLANS: 50 25 0 50 100

PROFILE (HORIZONTAL): 50 25 0 50 100

PROFILE (VERTICAL): 10 5 0 10 20

DESIGN DATA

ADT 2006 = 7800
ADT 2026 = 14467
DHV = 12 %
D = 60 %
T = 4 % *
V = 50 MPH

* TTST 1 % DUAL 3 %

PROJECT LENGTH

LENGTH ROADWAY TIP PROJECT U-2707 = 2.093 MILE

LENGTH STRUCTURE TIP PROJECT U-2707 = 0.083 MILE

TOTAL LENGTH TIP PROJECT U-2707 = 2.010 MILE

NOTE: PROJECT LENGTH FOR U-2707 DETERMINED BY USING -L-

Prepared in the Office of:
SEPI ENGINEERING GROUP
2300 Rexwoods Drive
Suite 370
Raleigh, NC 27607
Tel:919-789-9977 Fax:789-9591

2002 STANDARD SPECIFICATIONS

RIGHT OF WAY DATE: FEBRUARY 18, 2005

LETTING DATE: NOVEMBER 21, 2006

NCDOT CONTACT

BRIAN D. SPEIGHT, PE
PROJECT ENGINEER

BRYON M. PALMER, PE
PROJECT DESIGN ENGINEER

CATHY S. HOUSER, PE
PROJECT ENGINEER
ENGINEERING COORDINATION

HYDRAULICS ENGINEER

SIGNATURE: *P.E.*

ROADWAY DESIGN ENGINEER

SIGNATURE: *P.E.*

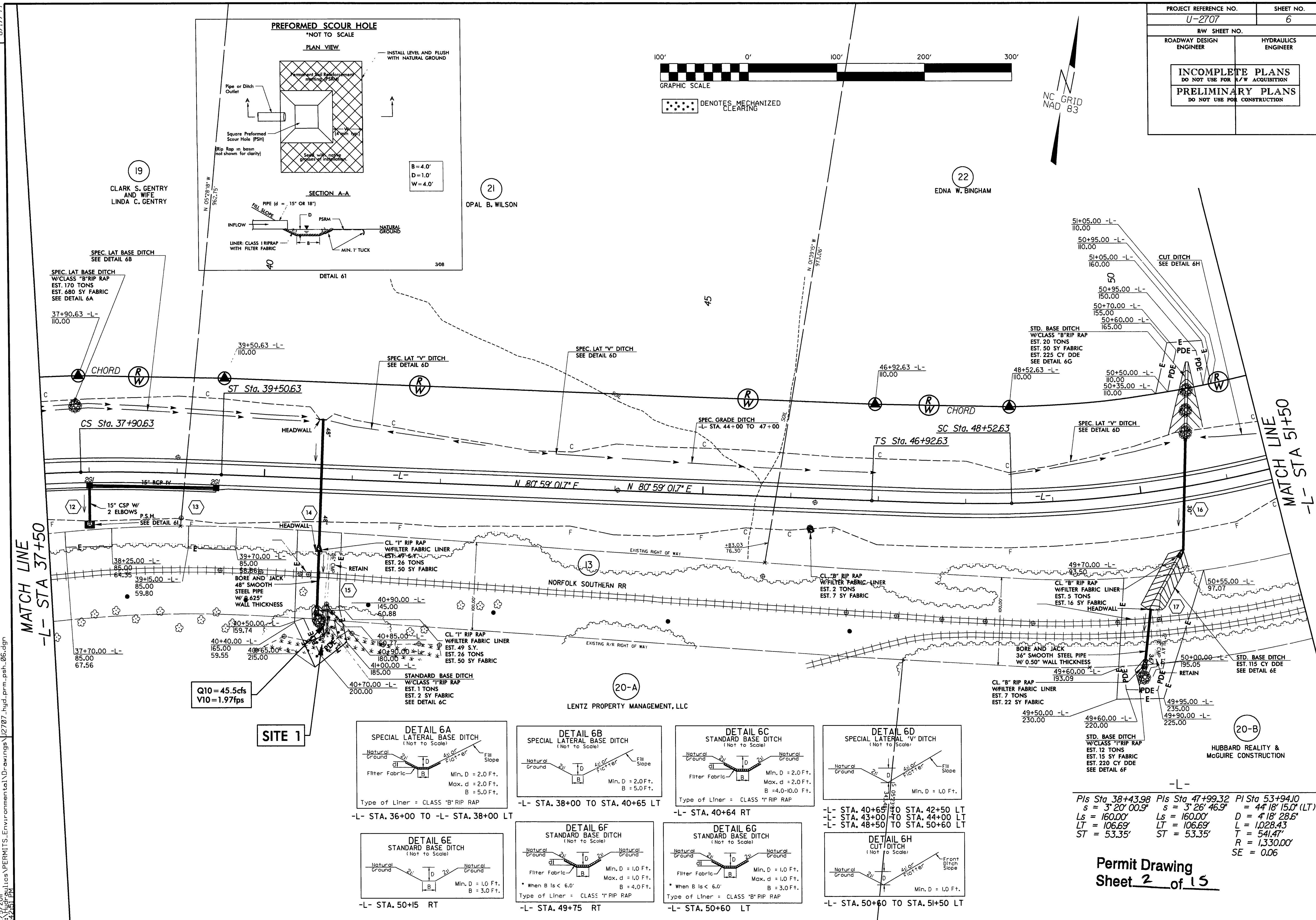
DIVISION OF HIGHWAYS
STATE OF NORTH CAROLINA

STATE DESIGN ENGINEER *P.E.*

DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

APPROVED
DIVISION ADMINISTRATOR *DATE*

12/5/2011
12/5/2011
12:23:30 PM
H:\Highways\Projects\PERMITS_Environmental\Drawings\U2707_hyd_prm_tsh.dgn



PROJECT REFERENCE NO. U-2707 | SHEET NO. 6

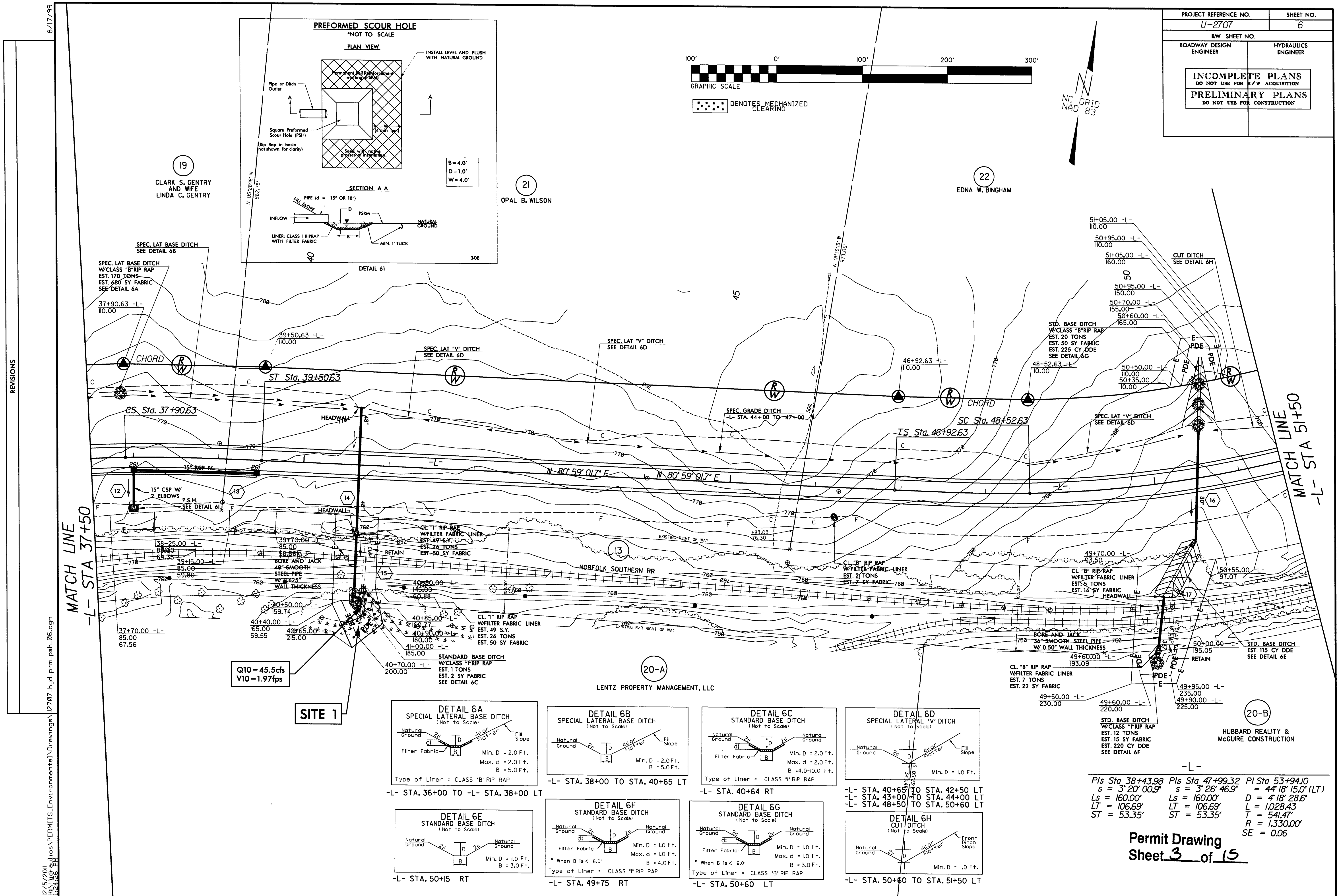
RW SHEET NO.

ROADWAY DESIGN ENGINEER | HYDRAULICS ENGINEER

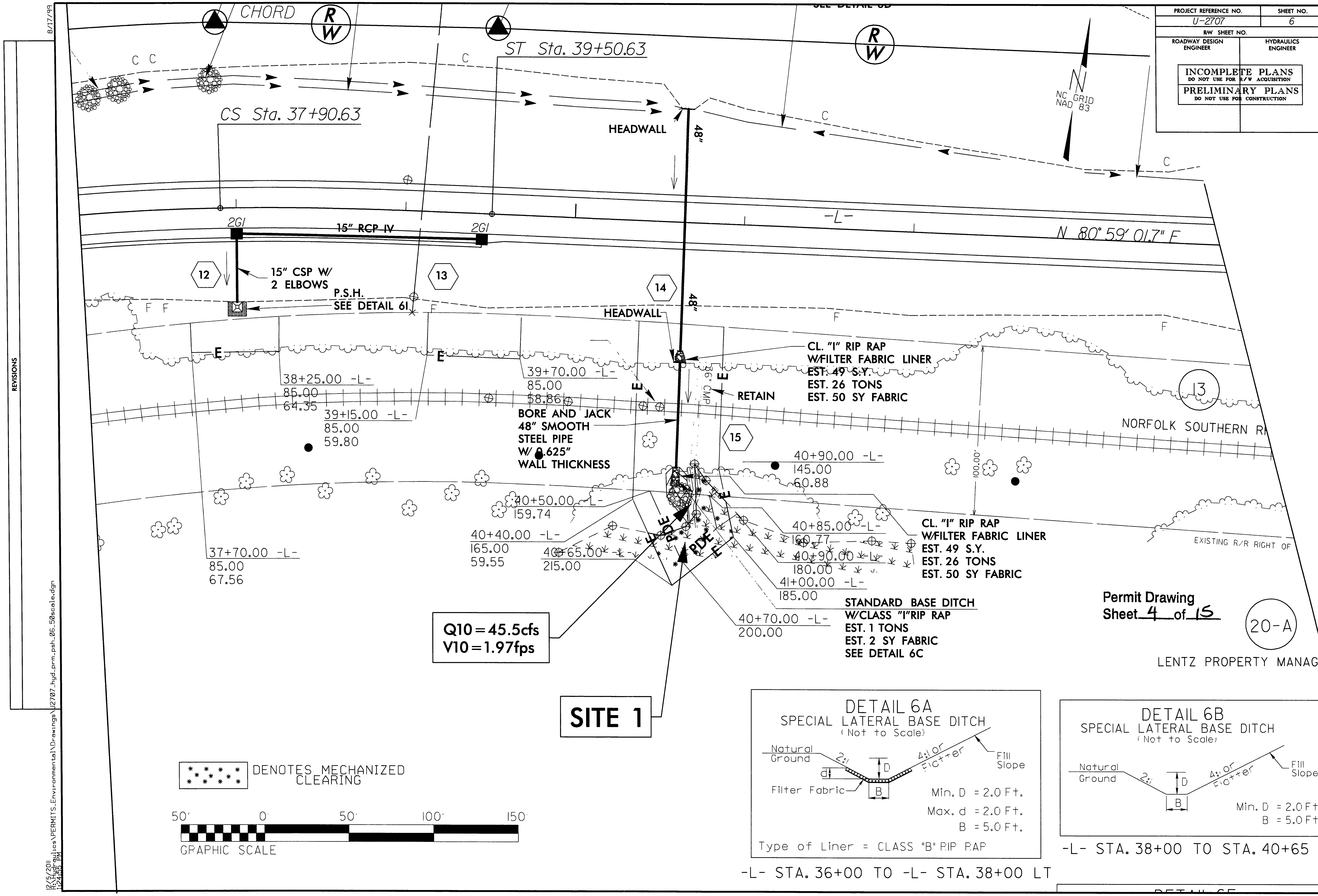
INCOMPLETE PLANS DO NOT USE FOR R/W ACQUISITION

PRELIMINARY PLANS DO NOT USE FOR CONSTRUCTION

Permit Drawing
Sheet 2 of 15



PROJECT REFERENCE NO.
U-2707
SHEET NO.
6
R/W SHEET NO.
ROADWAY DESIGN ENGINEER
HYDRAULICS ENGINEER
INCOMPLETE PLANS
DO NOT USE FOR R/W ACQUISITION
PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION
GRAPHIC SCALE
100' 0' 100' 200' 300'
DENOTES MECHANIZED CLEARING
NC GRID NAD 83
PREFORMED SCOUR HOLE
*NOT TO SCALE
PLAN VIEW
INSTALL LEVEL AND FLUSH WITH NATURAL GROUND
Pipe or Ditch Outlet
Square Preformed Scour Hole (PSH)
SECTION A-A
B=4.0'
D=1.0'
W=4.0'
INFLOW
LINER: CLASS I RIPRAP WITH FILTER FABRIC
MIN. 1' TUCK
NATURAL GROUND
DETAIL 61
19
CLARK S. GENTRY AND WIFE LINDA C. GENTRY
21
OPAL B. WILSON
22
EDNA W. BINGHAM
13
NORFOLK SOUTHERN RR
20-A
LENTZ PROPERTY MANAGEMENT, LLC
20-B
HUBBARD REALITY & McGUIRE CONSTRUCTION
MATCH LINE -L- STA 37+50
MATCH LINE -L- STA 51+50
SPEC. LAT BASE DITCH SEE DETAIL 6B
SPEC. LAT BASE DITCH W/CLASS "B" RIP RAP EST. 170 TONS EST. 680 SY FABRIC SEE DETAIL 6A
37+90.63 -L- 110.00
39+50.63 -L- 110.00
CHORD
ST Sta. 39+50.63
CS Sta. 37+90.63
SPEC. LAT "V" DITCH SEE DETAIL 6D
SPEC. LAT "V" DITCH SEE DETAIL 6D
SPEC. GRADE DITCH -L- STA. 44+00 TO 47+00
TS Sta. 46+92.63
SC Sta. 48+52.63
46+92.63 -L- 110.00
48+52.63 -L- 110.00
N 80° 59' 01.7" E
15" CSP W/ 2 ELBOWS
P.S.H. SEE DETAIL 61
HEADWALL
48"
BORE AND JACK 48" SMOOTH STEEL PIPE W/ 0.625" WALL THICKNESS
CL. "I" RIP RAP W/FILTER FABRIC LINER EST. 49 S.Y. EST. 26 TONS EST. 50 SY FABRIC
RETAIN
CL. "B" RIP RAP W/FILTER FABRIC LINER EST. 2 TONS EST. 7 SY FABRIC
STANDARD BASE DITCH W/CLASS "I" RIP RAP EST. 1 TONS EST. 2 SY FABRIC SEE DETAIL 6C
Q10=45.5cfs
V10=1.97fps
SITE 1
STD. BASE DITCH W/CLASS "B" RIP RAP EST. 20 TONS EST. 50 SY FABRIC EST. 225 CY DDE SEE DETAIL 6G
CUT DITCH SEE DETAIL 6H
CL. "B" RIP RAP W/FILTER FABRIC LINER EST. 5 TONS EST. 16 SY FABRIC
BORE AND JACK 36" SMOOTH STEEL PIPE W/ 0.50" WALL THICKNESS
STD. BASE DITCH EST. 115 CY DDE SEE DETAIL 6E
CL. "B" RIP RAP W/FILTER FABRIC LINER EST. 7 TONS EST. 22 SY FABRIC
STD. BASE DITCH W/CLASS "I" RIP RAP EST. 12 TONS EST. 15 SY FABRIC EST. 220 CY DDE SEE DETAIL 6F
DETAIL 6A SPECIAL LATERAL BASE DITCH (Not to Scale) Min. D = 2.0 Ft. Max. d = 2.0 Ft. B = 5.0 Ft. Type of Liner = CLASS "B" RIP RAP
-L- STA. 36+00 TO -L- STA. 38+00 LT
DETAIL 6B SPECIAL LATERAL BASE DITCH (Not to Scale) Min. D = 2.0 Ft. B = 5.0 Ft.
-L- STA. 38+00 TO STA. 40+65 LT
DETAIL 6C STANDARD BASE DITCH (Not to Scale) Min. D = 2.0 Ft. Max. d = 2.0 Ft. B = 4.0-10.0 Ft. Type of Liner = CLASS "I" RIP RAP
-L- STA. 40+64 RT
DETAIL 6D SPECIAL LATERAL 'V' DITCH (Not to Scale) Min. D = 1.0 Ft.
-L- STA. 40+65 TO STA. 42+50 LT
-L- STA. 43+00 TO STA. 44+00 LT
-L- STA. 48+50 TO STA. 50+60 LT
DETAIL 6E STANDARD BASE DITCH (Not to Scale) Min. D = 1.0 Ft. B = 3.0 Ft.
-L- STA. 50+15 RT
DETAIL 6F STANDARD BASE DITCH (Not to Scale) Min. D = 1.0 Ft. Max. d = 1.0 Ft. B = 4.0 Ft. Type of Liner = CLASS "I" RIP RAP
-L- STA. 49+75 RT
DETAIL 6G STANDARD BASE DITCH (Not to Scale) Min. D = 1.0 Ft. Max. d = 1.0 Ft. B = 3.0 Ft. Type of Liner = CLASS "B" RIP RAP
-L- STA. 50+60 LT
DETAIL 6H CUT DITCH (Not to Scale) Min. D = 1.0 Ft.
-L- STA. 50+60 TO STA. 51+50 LT
-L-
PIs Sta 38+43.98 s = 3° 20' 00.9" Ls = 160.00' LT = 106.69' ST = 53.35'
PIs Sta 47+99.32 s = 3° 26' 46.9" Ls = 160.00' LT = 106.69' ST = 53.35'
PI Sta 53+94.10 = 44° 18' 15.0" (LT) D = 4° 18' 28.6" L = 1,028.43 T = 541.47' R = 1,330.00' SE = 0.06
Permit Drawing Sheet 3 of 15
REVISIONS
8/17/99


PROJECT REFERENCE NO.
U-2707
SHEET NO.
6
R/W SHEET NO.
ROADWAY DESIGN ENGINEER
HYDRAULICS ENGINEER
INCOMPLETE PLANS
DO NOT USE FOR R/W ACQUISITION
PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION
NC GRID NAD 83
REVISIONS
8/17/99
CHORD
ST Sta. 39+50.63
CS Sta. 37+90.63
HEADWALL
48"
-L-
N 80° 59' 01.7" E
2GI
15" RCP IV
2GI
12
15" CSP W/ 2 ELBOWS
13
P.S.H. SEE DETAIL 6I
14
HEADWALL
CL. "I" RIP RAP W/FILTER FABRIC LINER EST. 49 S.Y. EST. 26 TONS EST. 50 SY FABRIC
38+25.00 -L- 85.00 64.35
39+70.00 -L- 85.00 58.86
36" CMP
RETAIN
39+15.00 -L- 85.00 59.80
BORE AND JACK 48" SMOOTH STEEL PIPE W/ 0.625" WALL THICKNESS
NORFOLK SOUTHERN R
15
40+90.00 -L- 145.00 60.88
100.00'
40+50.00 -L- 159.74
40+85.00 -L- 160.77
40+40.00 -L- 165.00 59.55
40+65.00 -L- 215.00
40+90.00 -L- 180.00
41+00.00 -L- 185.00
37+70.00 -L- 85.00 67.56
PDE
CL. "I" RIP RAP W/FILTER FABRIC LINER EST. 49 S.Y. EST. 26 TONS EST. 50 SY FABRIC
EXISTING R/R RIGHT OF
STANDARD BASE DITCH W/CLASS "I" RIP RAP EST. 1 TONS EST. 2 SY FABRIC SEE DETAIL 6C
40+70.00 -L- 200.00
Q10 = 45.5cfs
V10 = 1.97fps
SITE 1
Permit Drawing Sheet 4 of 15
20-A
LENTZ PROPERTY MANAGE
13
DENOTES MECHANIZED CLEARING
50' 0 50' 100' 150
GRAPHIC SCALE
DETAIL 6A
SPECIAL LATERAL BASE DITCH
(Not to Scale)
Natural Ground
2:1
4:1 or Flatter
Fill Slope
Filter Fabric
D
d
B
Min. D = 2.0 Ft.
Max. d = 2.0 Ft.
B = 5.0 Ft.
Type of Liner = CLASS "B" RIP RAP
-L- STA. 36+00 TO -L- STA. 38+00 LT
DETAIL 6B
SPECIAL LATERAL BASE DITCH
(Not to Scale)
Natural Ground
2:1
4:1 or Flatter
Fill Slope
D
B
Min. D = 2.0 Ft.
B = 5.0 Ft.
-L- STA. 38+00 TO STA. 40+65 L
12/5/2011
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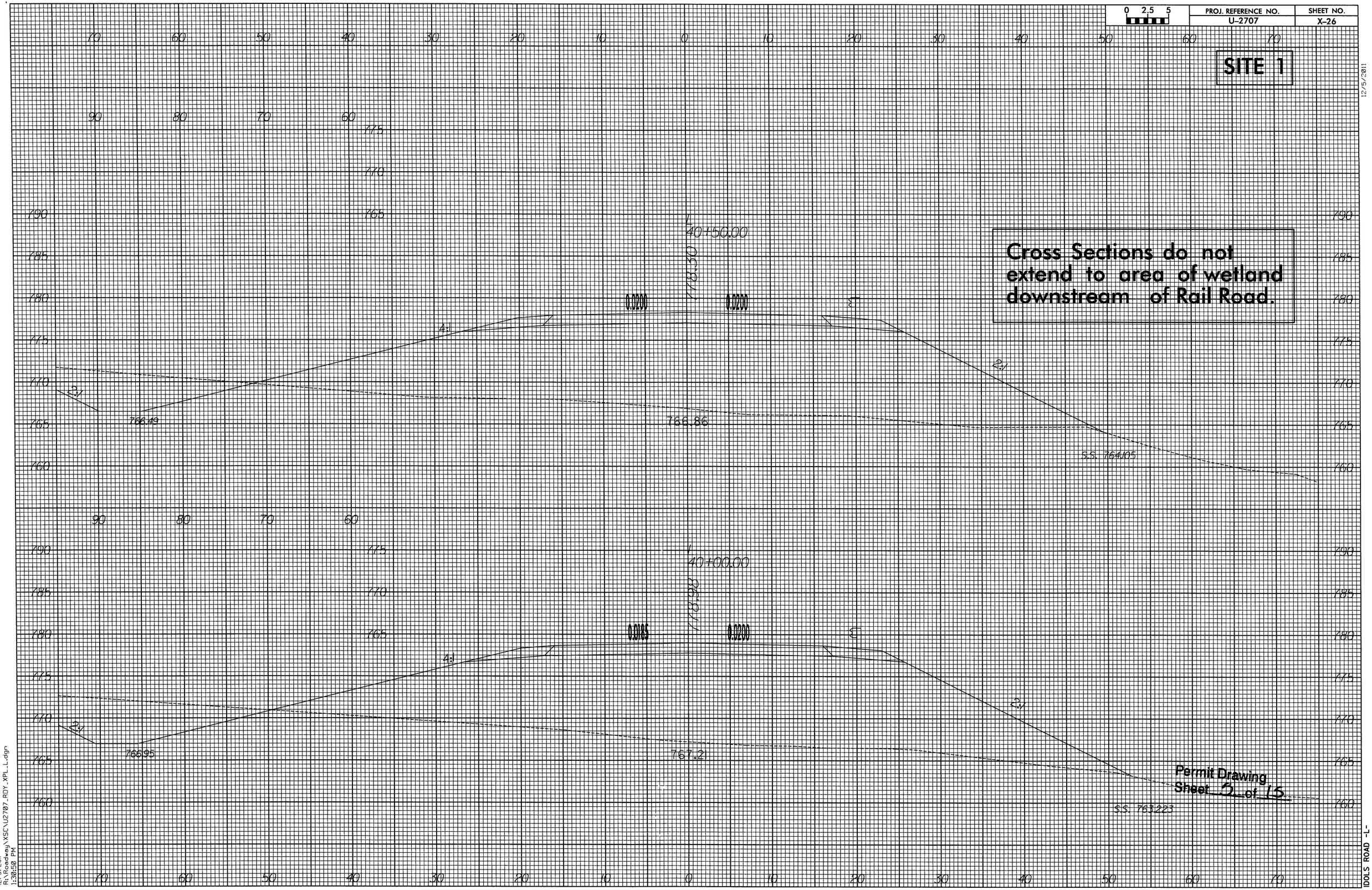
0 2.5 5	PROJ. REFERENCE NO.	SHEET NO.
	U-2707	X-26

SITE 1

Cross Sections do not extend to area of wetland downstream of Rail Road.



Permit Drawing
Sheet 5 of 15

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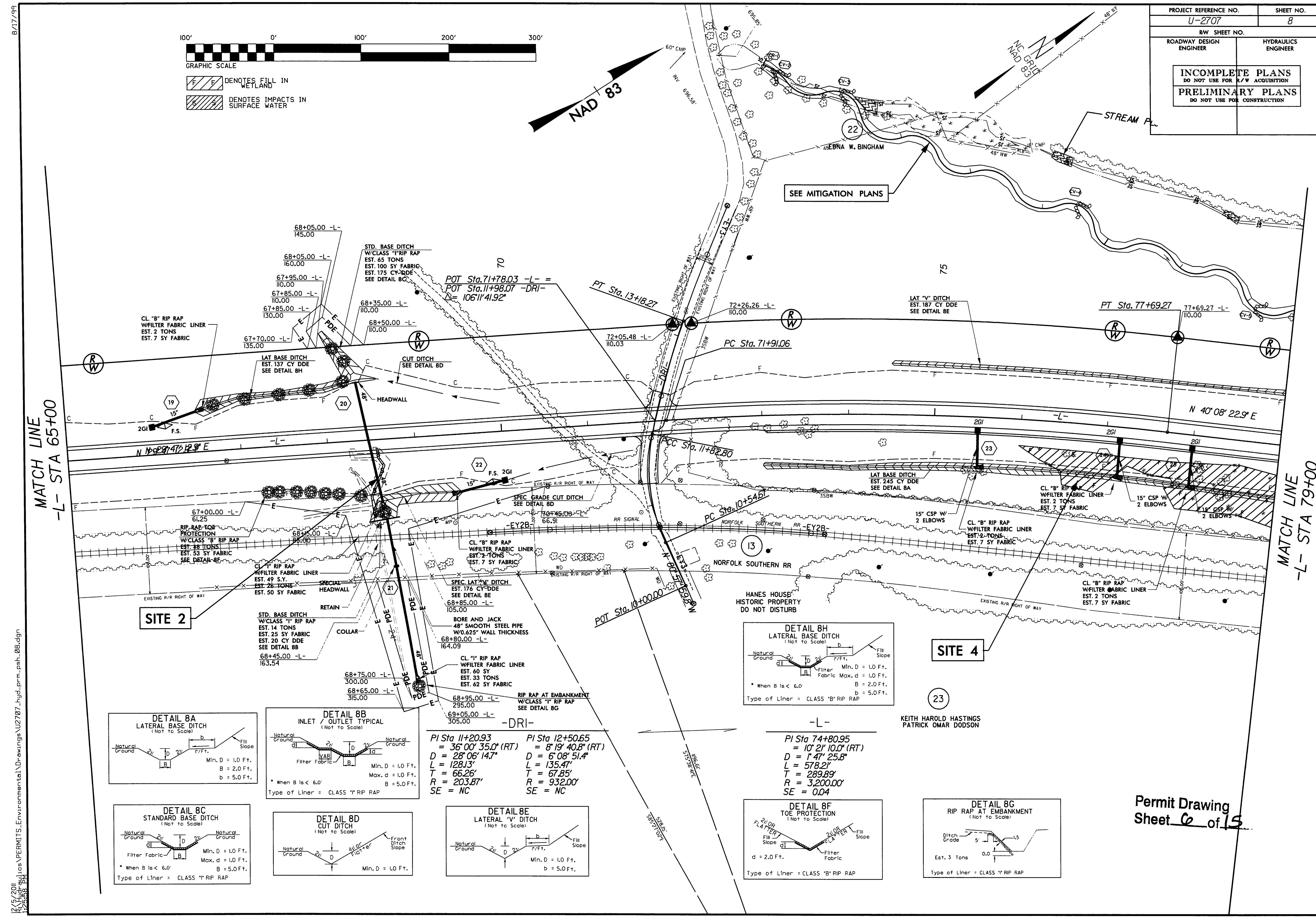
IDOLS ROAD -L-


PROJECT REFERENCE NO.
U-2707
SHEET NO.
8
RW SHEET NO.
ROADWAY DESIGN ENGINEER
HYDRAULICS ENGINEER
INCOMPLETE PLANS
DO NOT USE FOR R/W ACQUISITION
PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION
GRAPHIC SCALE
100' 0' 100' 200' 300'
DENOTES FILL IN WETLAND
DENOTES IMPACTS IN SURFACE WATER
NAD 83
NC GRID NAD 83
MATCH LINE -L- STA 65+00
MATCH LINE -L- STA 79+00
SEE MITIGATION PLANS
STREAM PL
EDNA W. BINGHAM
POT Sta. 71+78.03 -L- =
POT Sta. 11+98.07 -DRI-
Δ = 106°11'41.92"
PT Sta. 13+18.27
PC Sta. 71+91.06
PT Sta. 77+69.27
PCC Sta. 11+82.80
PC Sta. 10+54.61
POT Sta. 10+00.00
N 40°08'22.9" E
NORFOLK SOUTHERN RR
HANES HOUSE HISTORIC PROPERTY DO NOT DISTURB
SITE 2
SITE 4
KEITH HAROLD HASTINGS
PATRICK OMAR DODSON
STD. BASE DITCH W/CLASS "I" RIP RAP EST. 65 TONS EST. 100 SY FABRIC EST. 175 CY DDE SEE DETAIL 8C
CL. "B" RIP RAP W/FILTER FABRIC LINER EST. 2 TONS EST. 7 SY FABRIC
LAT BASE DITCH EST. 137 CY DDE SEE DETAIL 8H
CUT DITCH SEE DETAIL 8D
HEADWALL
LAT "V" DITCH EST. 187 CY DDE SEE DETAIL 8E
LAT BASE DITCH EST. 245 CY DDE SEE DETAIL 8A
SPEC. GRADE CUT DITCH SEE DETAIL 8D
RIP RAP TOE PROTECTION W/CLASS "B" RIP RAP EST. 48 TONS EST. 53 SY FABRIC SEE DETAIL 8F
CL. "I" RIP RAP W/FILTER FABRIC LINER EST. 49 S.Y. EST. 26 TONS EST. 50 SY FABRIC
SPECIAL HEADWALL
SPEC. LAT "V" DITCH EST. 176 CY DDE SEE DETAIL 8E
STD. BASE DITCH W/CLASS "I" RIP RAP EST. 14 TONS EST. 25 SY FABRIC EST. 20 CY DDE SEE DETAIL 8B
BORE AND JACK 48" SMOOTH STEEL PIPE W/0.625" WALL THICKNESS
CL. "I" RIP RAP W/FILTER FABRIC LINER EST. 60 SY EST. 33 TONS EST. 62 SY FABRIC
RIP RAP AT EMBANKMENT W/CLASS "I" RIP RAP SEE DETAIL 8G
15" CSP W/ 2 ELBOWS
-DRI-
PI Sta 11+20.93 Δ = 36°00'35.0" (RT) D = 28°06'14.7" L = 128.13' T = 66.26' R = 203.87' SE = NC
PI Sta 12+50.65 Δ = 8°19'40.8" (RT) D = 6°08'51.4" L = 135.47' T = 67.85' R = 932.00' SE = NC
-L-
PI Sta 74+80.95 Δ = 10°21'10.0" (RT) D = 1°47'25.8" L = 578.21' T = 289.89' R = 3,200.00' SE = 0.04
DETAIL 8A LATERAL BASE DITCH (Not to Scale)
DETAIL 8B INLET / OUTLET TYPICAL (Not to Scale)
DETAIL 8C STANDARD BASE DITCH (Not to Scale)
DETAIL 8D CUT DITCH (Not to Scale)
DETAIL 8E LATERAL 'V' DITCH (Not to Scale)
DETAIL 8F TOE PROTECTION (Not to Scale)
DETAIL 8G RIP RAP AT EMBANKMENT (Not to Scale)
DETAIL 8H LATERAL BASE DITCH (Not to Scale)
Type of Liner = CLASS "I" RIP RAP
Type of Liner = CLASS "B" RIP RAP
Permit Drawing
Sheet 6 of 15
8/17/99
12/5/2011
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8/17/99

PROJECT REFERENCE NO.	SHEET NO.
U-2707	8
R/W SHEET NO.	
ROADWAY DESIGN ENGINEER	HYDRAULICS ENGINEER

INCOMPLETE PLANS
DO NOT USE FOR R/W ACQUISITION

PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

100' 0' 100' 200' 300'
GRAPHIC SCALE

DENOTES FILL IN WETLAND

DENOTES IMPACTS IN SURFACE WATER

NAD 83

NC GRID NAD 83

60" CMP INV 696.58'

STREAM PI...

22 EDNA W. BINGHAM

SEE MITIGATION PLANS

MATCH LINE -L- STA 65+00

68+05.00 -L- 145.00
68+05.00 -L- 160.00
67+95.00 -L- 110.00
67+85.00 -L- 110.00
67+85.00 -L- 130.00
67+70.00 -L- 135.00

STD. BASE DITCH W/CLASS "I" RIP RAP
EST. 65 TONS
EST. 100 SY FABRIC
EST. 175 CY DDE
SEE DETAIL 8C

CL "B" RIP RAP W/FILTER FABRIC LINER
EST. 2 TONS
EST. 7 SY FABRIC

LAT BASE DITCH
EST. 137 CY DDE
SEE DETAIL 8H

POT Sta.71+78.03 -L- =
POT Sta.11+98.07 -DRI-
N 06°11'41.92" E

PT Sta. 13+18.27

68+35.00 -L- 110.00
68+80.00 -L- 110.00

CUT DITCH
SEE DETAIL 8D

72+26.26 -L- 110.00
72+05.48 -L- 110.03

PC Sta. 71+91.06

LAT "V" DITCH
EST. 187 CY DDE
SEE DETAIL 8E

PT Sta. 77+69.27
77+69.27 -L- 110.00

N 40° 08' 22.9" E

N 49° 47' 12.8" E

19 15" 2GI F.S.

20 48" HEADWALL

21

22 F.S. 2GI 15"

EXISTING R/R RIGHT OF WAY

SPEC GRADE CUT DITCH
SEE DETAIL 8D

PC Sta. 42+80

67+00.00 -L- 61.25

RIP RAP FOR PROTECTION
W/CLASS "B" RIP RAP
EST. 88 TONS
EST. 53 SY FABRIC
SEE DETAIL 8F

68+95.00 -L- 66.91

FY2B-

CL "B" RIP RAP W/FILTER FABRIC LINER
EST. 2 TONS
EST. 7 SY FABRIC

CL "I" RIP RAP W/FILTER FABRIC LINER
EST. 49 S.Y.
EST. 28 TONS
EST. 50 SY FABRIC

SPECIAL HEADWALL

RETAIN

COLLAR

SITE 2

STD. BASE DITCH
W/CLASS "I" RIP RAP
EST. 14 TONS
EST. 25 SY FABRIC
EST. 20 CY DDE
SEE DETAIL 8B

68+45.00 -L- 163.54

SPEC. LAT "V" DITCH
EST. 176 CY-DDE
SEE DETAIL 8E

68+85.00 -L- 105.00

BORE AND JACK
48" SMOOTH STEEL PIPE
W/0.625" WALL THICKNESS

68+80.00 -L- 164.09

CL "I" RIP RAP W/FILTER FABRIC LINER
EST. 60 SY
EST. 33 TONS
EST. 62 SY FABRIC

68+75.00 -L- 300.00
68+65.00 -L- 315.00
68+95.00 -L- 295.00
69+05.00 -L- 305.00

RIP RAP AT EMBANKMENT
W/CLASS "I" RIP RAP
SEE DETAIL 8G

POT Sta. 10+00.00

N 87° 37' 59.2" E

NORFOLK SOUTHERN RR

HANES HOUSE
HISTORIC PROPERTY
DO NOT DISTURB

SITE 4

23 KEITH HAROLD HASTINGS
PATRICK OMAR DODSON

LAT BASE DITCH
EST. 245 CY DDE
SEE DETAIL 8A

CL "B" RIP RAP W/FILTER FABRIC LINER
EST. 2 TONS
EST. 7 SY FABRIC

15" CSP W/ 2 ELBOWS

CL "B" RIP RAP W/FILTER FABRIC LINER
EST. 2 TONS
EST. 7 SY FABRIC

MATCH LINE -L- STA 79+00

-DRI-

PI Sta 11+20.93
= 36° 00' 35.0" (RT)
D = 28° 06' 14.7"
L = 128.13'
T = 66.26'
R = 203.87'
SE = NC

PI Sta 12+50.65
= 8° 19' 40.8" (RT)
D = 6° 08' 51.4"
L = 135.47'
T = 67.85'
R = 932.00'
SE = NC

-L-

PI Sta 74+80.95
= 10° 21' 10.0" (RT)
D = 1° 47' 25.8"
L = 578.21'
T = 289.89'
R = 3,200.00'
SE = 0.04

DETAIL 8A
LATERAL BASE DITCH
(Not to Scale)

Natural Ground, 2%, D, 2%, b, 1':1Ft., Fill Slope, B
Min. D = 1.0 Ft.
B = 2.0 Ft.
b = 5.0 Ft.

DETAIL 8B
INLET / OUTLET TYPICAL
(Not to Scale)

Natural Ground, d, 2%, D, 2%, Natural Ground, VAR, Filter Fabric, B
Min. D = 1.0 Ft.
Max. d = 1.0 Ft.
B = 5.0 Ft.
* When B Is < 6.0'
Type of Liner = CLASS "I" RIP RAP

DETAIL 8C
STANDARD BASE DITCH
(Not to Scale)

Natural Ground, 2%, d, D, 2%, Natural Ground, Filter Fabric, B
Min. D = 1.0 Ft.
Max. d = 1.0 Ft.
B = 5.0 Ft.
* When B Is < 6.0'
Type of Liner = CLASS "I" RIP RAP

DETAIL 8D
CUT DITCH
(Not to Scale)

Natural Ground, 2%, D, 4:1 Or Flatter, Front Ditch Slope
Min. D = 1.0 Ft.

DETAIL 8E
LATERAL 'V' DITCH
(Not to Scale)

Natural Ground, 2%, D, 2%, b, 1':1Ft., Fill Slope
Min. D = 1.0 Ft.
b = 5.0 Ft.

DETAIL 8H
LATERAL BASE DITCH
(Not to Scale)

Natural Ground, 2%, d, D, 2%, b, 1':1Ft., Fill Slope, Filter Fabric, B
Min. D = 1.0 Ft.
Max. d = 1.0 Ft.
B = 2.0 Ft.
b = 5.0 Ft.
* When B Is < 6.0'
Type of Liner = CLASS "B" RIP RAP

DETAIL 8F
TOE PROTECTION
(Not to Scale)

2:1.00 FLATTER Fill Slope, d, 2:1.00 FLATTER Fill Slope, Filter Fabric
d = 2.0 Ft.
Type of Liner = CLASS "B" RIP RAP

DETAIL 8G
RIP RAP AT EMBANKMENT
(Not to Scale)

Ditch Grade, 5', 1.5, 0.0, Est. 3 Tons
Type of Liner = CLASS "I" RIP RAP

Permit Drawing
Sheet 7 of 15

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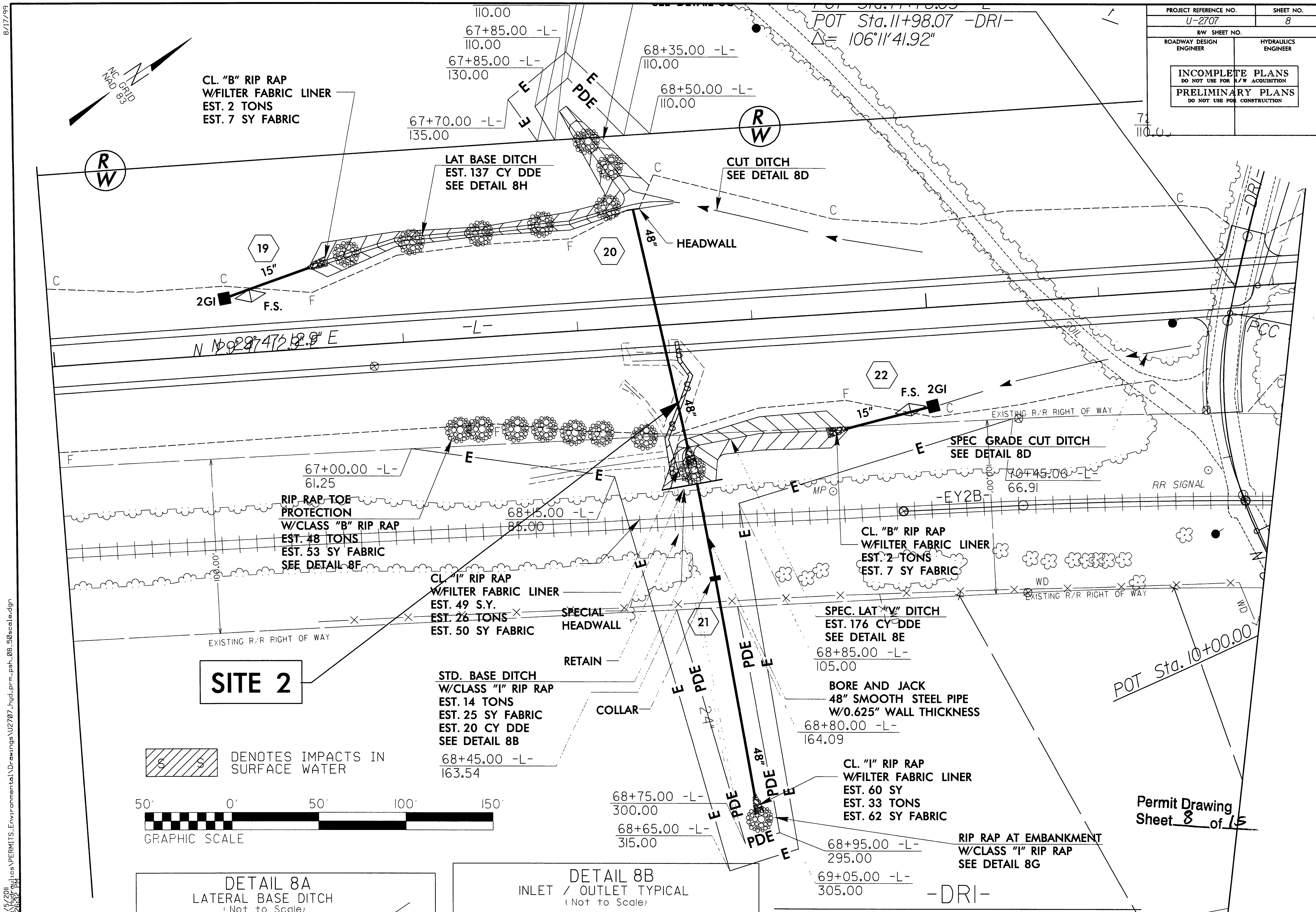
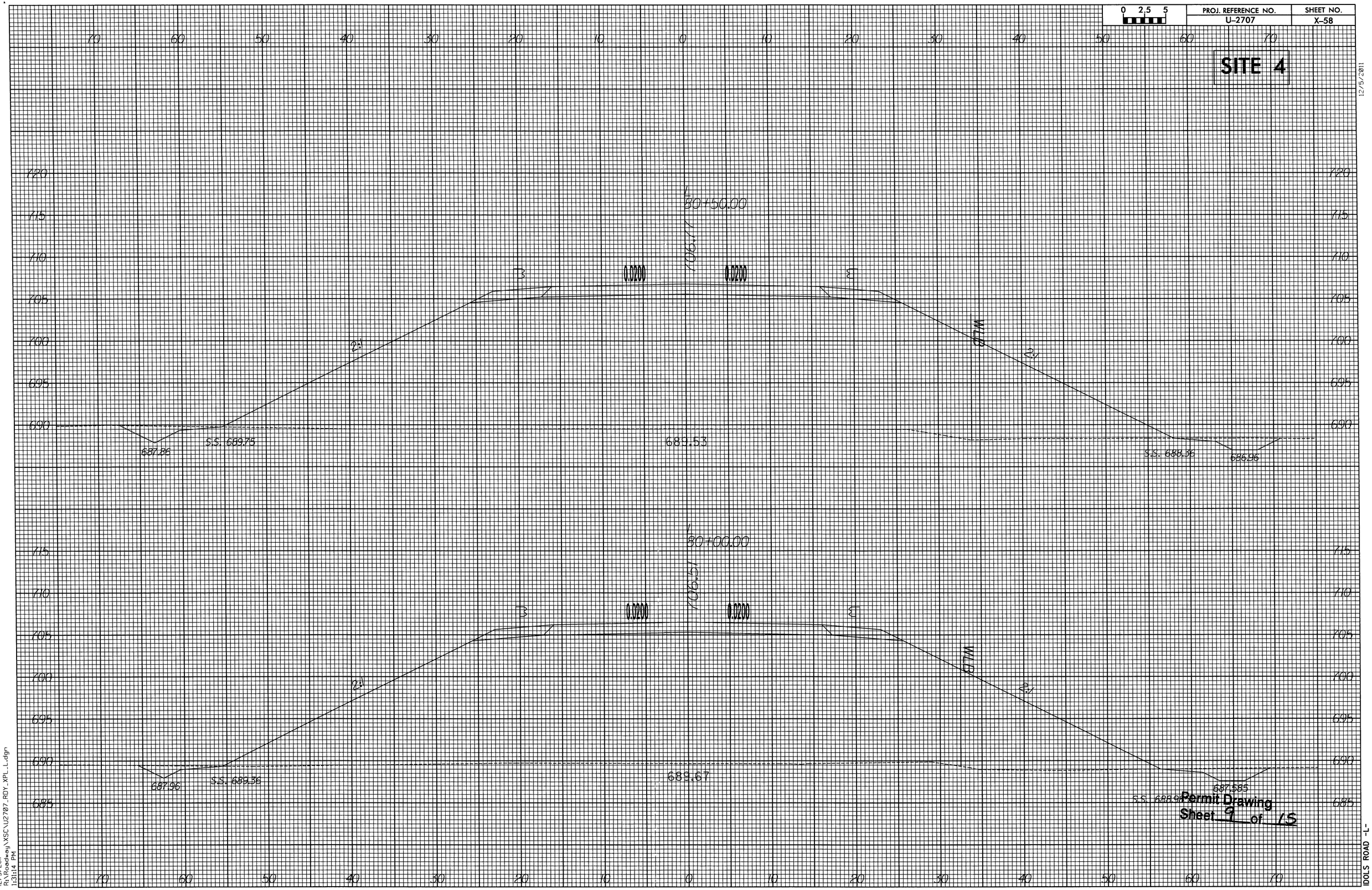


PROJECT REFERENCE NO. U-2707
SHEET NO. 8
R/W SHEET NO.
ROADWAY DESIGN ENGINEER
HYDRAULICS ENGINEER
INCOMPLETE PLANS DO NOT USE FOR R/W ACQUISITION
PRELIMINARY PLANS DO NOT USE FOR CONSTRUCTION
8/17/99
NC GRID NAD 83
POT Sta. 11+98.07 -DRI-
Δ= 106°11'41.92"
110.00
67+85.00 -L-
110.00
67+85.00 -L-
130.00
67+70.00 -L-
135.00
68+35.00 -L-
110.00
68+50.00 -L-
110.00
CL. "B" RIP RAP
W/FILTER FABRIC LINER
EST. 2 TONS
EST. 7 SY FABRIC
LAT BASE DITCH
EST. 137 CY DDE
SEE DETAIL 8H
CUT DITCH
SEE DETAIL 8D
HEADWALL
48"
15"
2GI
F.S.
-L-
N 29°47'12.9" E
22
F.S. 2GI
15"
EXISTING R/R RIGHT OF WAY
SPEC GRADE CUT DITCH
SEE DETAIL 8D
70+45.00 -L-
66.91
RR SIGNAL
-EY2B-
MP
67+00.00 -L-
61.25
RIP RAP TOE PROTECTION
W/CLASS "B" RIP RAP
EST. 48 TONS
EST. 53 SY FABRIC
SEE DETAIL 8F
68+15.00 -L-
85.00
CL. "B" RIP RAP
W/FILTER FABRIC LINER
EST. 2 TONS
EST. 7 SY FABRIC
CL. "I" RIP RAP
W/FILTER FABRIC LINER
EST. 49 S.Y.
EST. 26 TONS
EST. 50 SY FABRIC
SPECIAL HEADWALL
21
SPEC. LAT "V" DITCH
EST. 176 CY DDE
SEE DETAIL 8E
68+85.00 -L-
105.00
EXISTING R/R RIGHT OF WAY
WD
POT Sta. 10+00.00
SITE 2
RETAIN
STD. BASE DITCH
W/CLASS "I" RIP RAP
EST. 14 TONS
EST. 25 SY FABRIC
EST. 20 CY DDE
SEE DETAIL 8B
COLLAR
BORE AND JACK
48" SMOOTH STEEL PIPE
W/0.625" WALL THICKNESS
68+80.00 -L-
164.09
68+45.00 -L-
163.54
DENOTES IMPACTS IN SURFACE WATER
CL. "I" RIP RAP
W/FILTER FABRIC LINER
EST. 60 SY
EST. 33 TONS
EST. 62 SY FABRIC
Permit Drawing Sheet 8 of 15
50' 0' 50' 100' 150'
GRAPHIC SCALE
68+75.00 -L-
300.00
68+65.00 -L-
315.00
68+95.00 -L-
295.00
RIP RAP AT EMBANKMENT
W/CLASS "I" RIP RAP
SEE DETAIL 8G
69+05.00 -L-
305.00
-DRI-
DETAIL 8A
LATERAL BASE DITCH
(Not to Scale)
DETAIL 8B
INLET / OUTLET TYPICAL
(Not to Scale)
12/5/2011

0 2.5 5	PROJ. REFERENCE NO.	SHEET NO.
	U-2707	X-58

SITE 4

12/5/2011



Permit Drawing
Sheet 9 of 15

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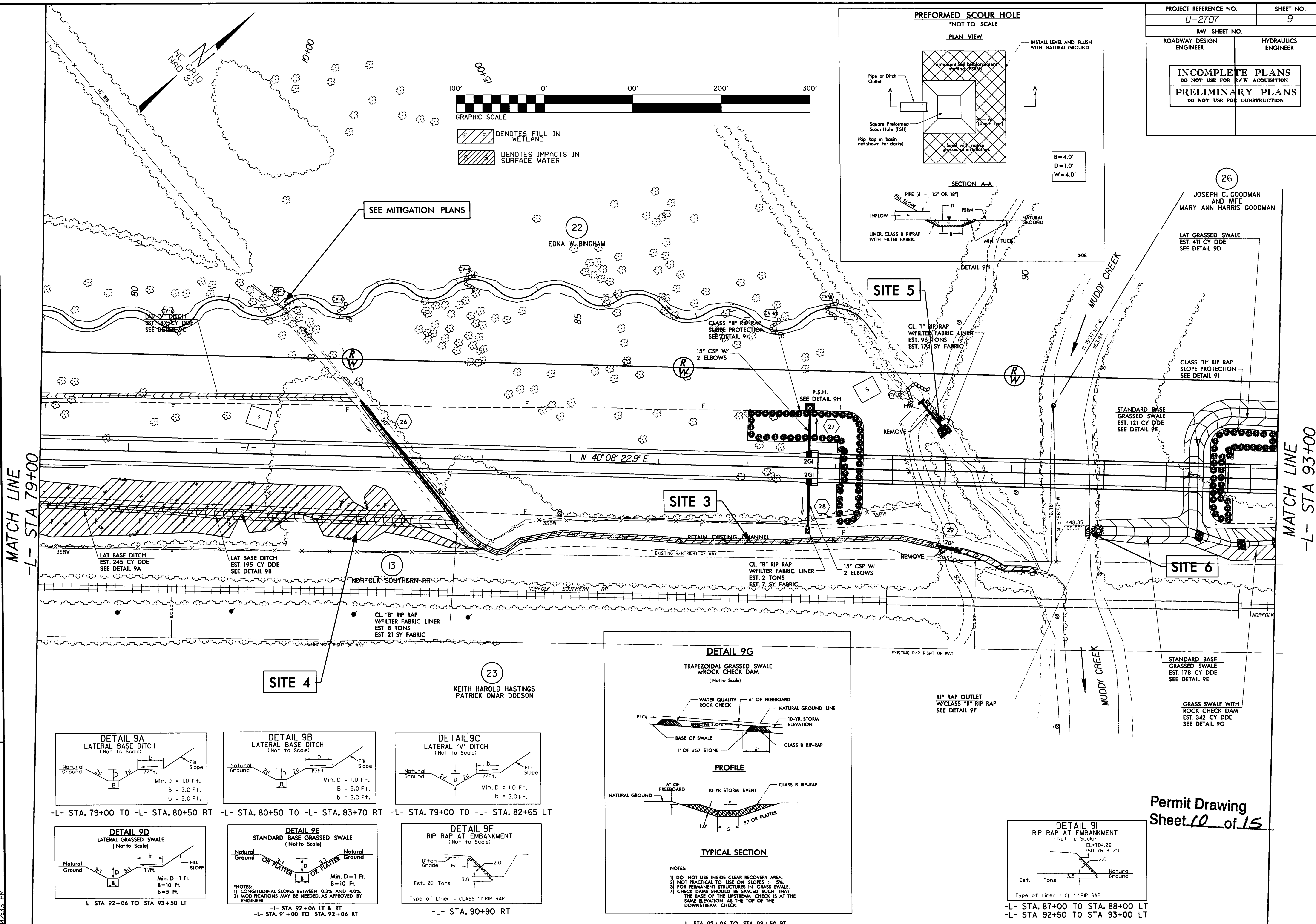
IDOLS ROAD -L-

PROJECT REFERENCE NO.	SHEET NO.
U-2707	9
R/W SHEET NO.	
ROADWAY DESIGN ENGINEER	HYDRAULICS ENGINEER

INCOMPLETE PLANS
DO NOT USE FOR R/W ACQUISITION

PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION



Permit Drawing
Sheet 10 of 15

PROJECT REFERENCE NO.	SHEET NO.
U-2707	9
R/W SHEET NO.	
ROADWAY DESIGN ENGINEER	HYDRAULICS ENGINEER

INCOMPLETE PLANS
DO NOT USE FOR R/W ACQUISITION

PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

REVISIONS

8/17/99

N.C. GRID NAD 83

10+00

15+00

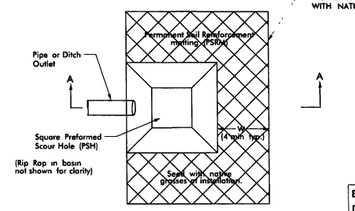
GRAPHIC SCALE 100' 0' 100' 200' 300'

F F DENOTES FILL IN WETLAND

S S DENOTES IMPACTS IN SURFACE WATER

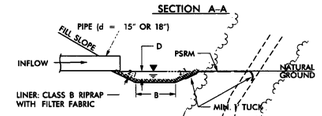
PREFORMED SCOUR HOLE
*NOT TO SCALE

PLAN VIEW



B = 4.0'
D = 1.0'
W = 4.0'

SECTION A-A



308

SEE MITIGATION PLANS

22
EDNA W. BINGHAM

DETAIL 9H

SITE 5

CLASS "II" RIP-RAP SLOPE PROTECTION SEE DETAIL 9I

15" CSP W/ 2 ELBOWS

069 CL. "I" RIP RAP W/FILTER FABRIC LINER EST. 96 TONS EST. 174 SY FABRIC

P.S.H. SEE DETAIL 9H

REMOVE

MUDDY CREEK

N 15°51'57" W 183.54'

26
JOSEPH C. GOODMAN AND WIFE MARY ANN HARRIS GOODMAN

LAT GRASSED SWALE EST. 411 CY DDE SEE DETAIL 9D

CLASS "II" RIP-RAP SLOPE PROTECTION SEE DETAIL 9I

STANDARD BASE GRASSED SWALE EST. 121 CY DDE SEE DETAIL 9E

N 40°08'22.9" E

2GI

SITE 3

RETAIN EXISTING CHANNEL

EXISTING R/R RIGHT OF WAY

CL "B" RIP RAP W/FILTER FABRIC LINER 00L EST. 2 TONS EST. 7 SY FABRIC

15" CSP W/ 2 ELBOWS

REMOVE

SITE 6

S 15°56'57" W +48.85 99.52'

MUDDY CREEK

NORFOLK SOUTHERN RR

LAT BASE DITCH EST. 245 CY DDE SEE DETAIL 9A

LAT BASE DITCH EST. 195 CY DDE SEE DETAIL 9B

13

Cl "B" RIP RAP W/FILTER FABRIC LINER EST. 8 TONS EST. 21 SY FABRIC

EXISTING R/R RIGHT OF WAY

RIP RAP OUTLET W/CLASS "II" RIP RAP SEE DETAIL 9F

STANDARD BASE GRASSED SWALE EST. 178 CY DDE SEE DETAIL 9E

GRASS SWALE WITH ROCK CHECK DAM EST. 342 CY DDE SEE DETAIL 9G

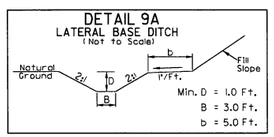
SITE 4

23
KEITH HAROLD HASTINGS
PATRICK OMAR DODSON

MATCH LINE -L- STA 79+00

MATCH LINE -L- STA 93+00

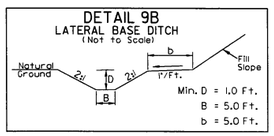
DETAIL 9A
LATERAL BASE DITCH
(Not to Scale)



Min. D = 1.0 Ft.
B = 3.0 Ft.
b = 5.0 Ft.

-L- STA. 79+00 TO -L- STA. 80+50 RT

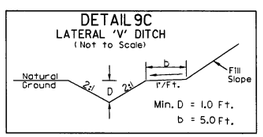
DETAIL 9B
LATERAL BASE DITCH
(Not to Scale)



Min. D = 1.0 Ft.
B = 5.0 Ft.
b = 5.0 Ft.

-L- STA. 80+50 TO -L- STA. 83+70 RT

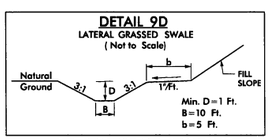
DETAIL 9C
LATERAL 'V' DITCH
(Not to Scale)



Min. D = 1.0 Ft.
b = 5.0 Ft.

-L- STA. 79+00 TO -L- STA. 82+65 LT

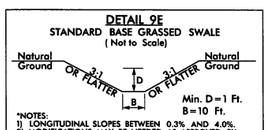
DETAIL 9D
LATERAL GRASSED SWALE
(Not to Scale)



Min. D=1 Ft.
B=10 Ft.
b=5 Ft.

-L- STA 92+06 TO STA 93+50 LT

DETAIL 9E
STANDARD BASE GRASSED SWALE
(Not to Scale)

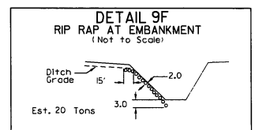


Min. D=1 Ft.
B=10 Ft.

*NOTES:
1) LONGITUDINAL SLOPES BETWEEN 0.3% AND 4.0%.
2) MODIFICATIONS MAY BE NEEDED, AS APPROVED BY ENGINEER.

-L- STA. 92+06 LT & RT
-L- STA. 91+00 TO STA. 92+06 RT

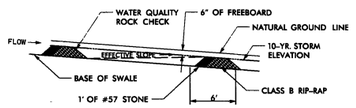
DETAIL 9F
RIP RAP AT EMBANKMENT
(Not to Scale)



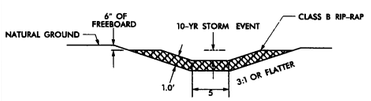
Type of Liner = CLASS "II" RIP RAP

-L- STA. 90+90 RT

DETAIL 9G
TRAPEZOIDAL GRASSED SWALE wROCK CHECK DAM
(Not to Scale)



PROFILE

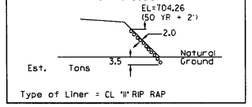


TYPICAL SECTION

NOTES:
1) DO NOT USE INSIDE CLEAR RECOVERY AREA.
2) NOT PRACTICAL TO USE ON SLOPES > 5%.
3) FOR PERMANENT STRUCTURES IN GRASS SWALE
4) CHECK DAMS SHOULD BE SPACED SUCH THAT THE BASE OF THE UPSTREAM CHECK IS AT THE SAME ELEVATION AS THE TOP OF THE DOWNSTREAM CHECK.

-L- STA. 92+06 TO STA. 93+50 RT

DETAIL 9I
RIP RAP AT EMBANKMENT
(Not to Scale)



Type of Liner = CL "II" RIP RAP

-L- STA. 87+00 TO STA. 88+00 LT
-L- STA 92+50 TO STA 93+00 LT

Permit Drawing
Sheet 11 of 15

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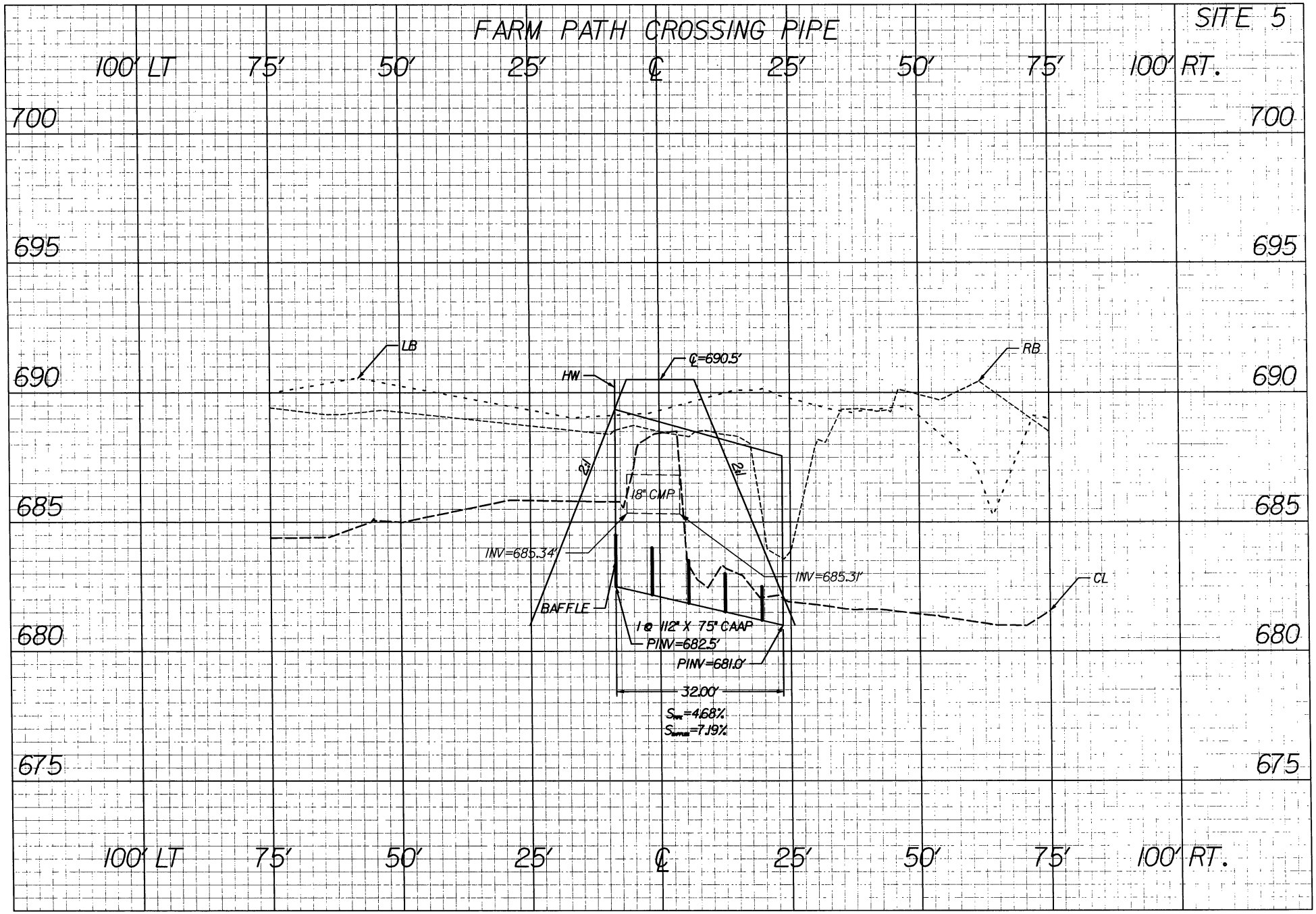
FARM PATH CROSSING PIPE
SITE 5
100' LT
75'
50'
25'
℄
25'
50'
75'
100' RT.
700
695
690
685
680
675
LB
RB
℄=690.5'
HW
2:1
2:1
18" CMP
INV=685.34'
INV=685.31'
BAFFLE
CL
1 @ 112" X 75" CAAP
PINV=682.5'
PINV=681.0'
32.00'
S_{min}=4.68%
S_{max}=7.19%

5/28/99

SEPI ENGINEERING GROUP	PROJECT REFERENCE NO.	SHEET NO.
2300 REXWOODS DRIVE SUITE 370 RALEIGH, NC 27607 TEL: 919-789-9977 FAX: 789-9591	U-2707	16
ROADWAY DESIGN ENGINEER	HYDRAULICS ENGINEER	

PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

-L-

SPECIAL GRADE DITCH
-L- STA.68+45 TO 70+00 LT

STA= 66+50.00
EL= 728.00

(-) 8.86%

SPECIAL GRADE DITCH
-L- STA.66+50 TO 68+45 LT

STA= 67+50.00
EL= 719.14

(-) 5.60%

(+) 4.00%

STA= 68+45.00
EL= 715.82

STA= 68+45.00
EL= 705.75

(+) 0.83%

STA= 69+50.00
EL= 706.22

STA= 70+00.00
EL= 715.87

STA= 70+00.00
EL= 720.00

(+) 0.50%

STA= 71+50.00
EL= 714.62

VPC= 72+00.22
EL= 715.65

SPECIAL GRADE DITCH
-L- STA.70+00 TO 71+50 RT

SPECIAL GRADE DITCH
-L- STA.68+45 TO 69+50 RT

PI= 75+25.22
EL= 704.00'
K = 168
VC = 650'

STA= 74+40.00
EL= 693.08

(-) 3.583%

(+) 0.528%

VPT= 79+56.22
EL= 705.72

SPECIAL GRADE DITCH
-L- STA.74+50 TO 82+65 LT

(-) 1.478%

(-) 0.92%

(-) 1.00%

(-) 0.77%

(-) 1.046%

STA= 73+60.00
EL= 696.35

STA= 74+00.00
EL= 693.76

SPECIAL GRADE DITCH
-L- STA.73+00 TO 79+00 RT

STA= 79+50.00
EL= 696.32

STA= 79+00.00
EL= 696.08

PIPE HYDRAULIC DATA
DRAINAGE STRUCTURE NO. 20

DRAINAGE AREA	= 26.53	AC
DESIGN FREQUENCY	= 50	YRS
DESIGN DISCHARGE	= 96.2	CFS
DESIGN HW ELEVATION	= 718.26	FT
100 YEAR DISCHARGE	= 111.8	CFS
100 YEAR HW ELEVATION	= 719.5	FT
OVERTOPPING FREQUENCY	= >100	YRS
OVERTOPPING DISCHARGE	= >100	CFS
OVERTOPPING ELEVATION	= 728.55	FT

SEE SHEET 8 FOR -L- PLAN

BM #6 ELEV=715.26 R/R SPIKE IN BASE OF 44" OAK -L- STA. 75+58.48 (614.79' LT)

-L-

SITE 6

PIPE HYDRAULIC DATA
DRAINAGE STRUCTURE NO. 26

DRAINAGE AREA	= 6.73	AC
DESIGN FREQUENCY	= 50	YRS
DESIGN DISCHARGE	= 19.97	CFS
DESIGN HW ELEVATION	= 689.13	FT
100 YEAR DISCHARGE	= 21.58	CFS
100 YEAR HW ELEVATION	= 689.28	FT
OVERTOPPING FREQUENCY	= >500	YRS
OVERTOPPING DISCHARGE	= >500	CFS
OVERTOPPING ELEVATION	= 710.74	FT

VPC= 92+99.23
EL= 715.34

(+) 4.46%

(+) 2.00%

(-) 0.92%

(-) 0.20%

(-) 0.9%

STA= 80+00.00
EL= 687.96

STA= 80+45.00
EL= 686.96

SPECIAL GRADE DITCH
-L- STA.80+50 TO 83+70 RT

STA= 82+65.00
EL= 687.43

STA= 83+47.00
EL= 686.35

STA= 92+45.00
EL= 695.30

STA= 92+16.00
EL= 693.15

STA= 91+00.00
EL= 688.08

SPECIAL GRADE DITCH
-L- STA.92+15 TO 100+50 RT

SPECIAL GRADE DITCH
-L- STA.91+00 TO 92+15 RT

BRIDGE HYDRAULIC DATA

DESIGN DISCHARGE	= 18000	CFS
DESIGN FREQUENCY	= 50	YRS
DESIGN HW ELEVATION	= 702.2	FT
BASE DISCHARGE	= 19000	CFS
BASE FREQUENCY	= 100	YRS
BASE HW ELEVATION	= 702.6	FT
OVERTOPPING DISCHARGE	= 26000	CFS
OVERTOPPING FREQUENCY	= 100+	YRS
OVERTOPPING ELEVATION	= 704.8	FT
DATE OF SURVEY	= 10-2-03	
W.S. ELEVATION AT DATE OF SURVEY	= 679.9	FT

SEE SHEET 9 FOR -L- PLAN

BM #7 ELEV=693.90 R/R SPIKE IN BASE OF 18" ELM -L- STA. 92+06.11 (228.64' LT)

Permit Drawing
Sheet 12 of 15

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WETLAND PERMIT IMPACT SUMMARY

			WETLAND IMPACTS					SURFACE WATER IMPACTS				
Site No.	Station (From/To)	Structure Size / Type	Permanent Fill In Wetlands (ac)	Temp. Fill In Wetlands (ac)	Excavation in Wetlands (ac)	Mechanized Clearing in Wetlands (ac)	Hand Clearing in Wetlands (ac)	Permanent SW impacts (ac)	Temp. SW impacts (ac)	Existing Channel Impacts Permanent (ft)	Existing Channel Impacts Temp. (ft)	Natural Stream Design (ft)
1	-L- 40+80	48"				0.03						
2	-L- 68+50	48"						<0.01		61		
3	-L- 73+09 to 90+31	Roadway Fill						0.10		831		1876.5
4	-L- 75+98 to 84.02 Rt	Roadway Fill	0.78									
5*	-L- 89.00 Lt	1@96" CAAP										
6	-L- 90+85 Rt	Bank Stabilization						<0.01		11		
TOTALS:			0.78			0.03		0.10		903		1876.5

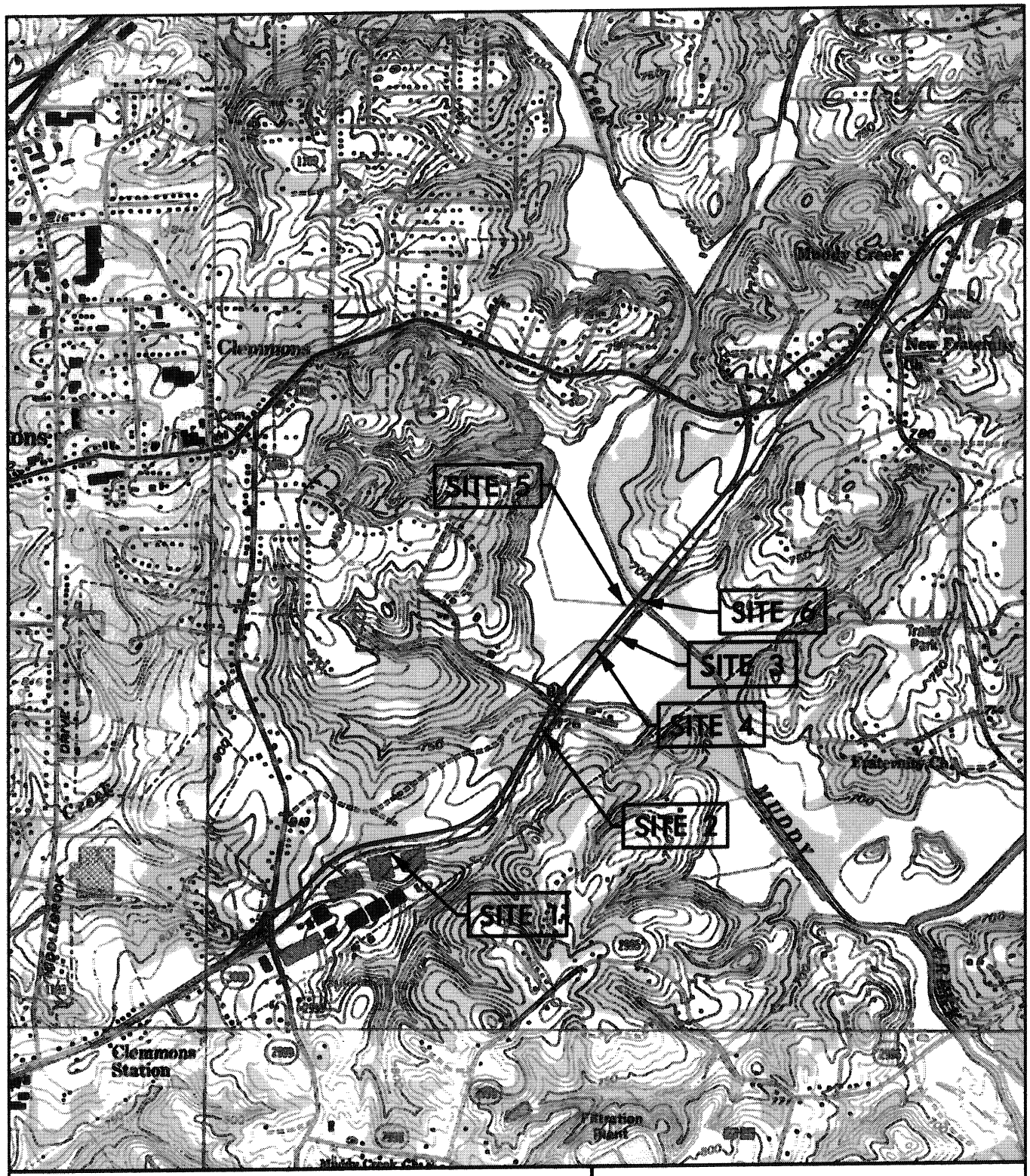
* The proposed 96" CAAP is considered an enhancement due to the reconnection of the fish passage and hydrology, therefore no impacts will be calculated here.

NC DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS

FORSYTH COUNTY
WBS - 34845.1.1 (U-2707)

SHEET 15 of 15 12/07/11

ATN Revised 3/31/05



TOPO MAP

SCALE: 1" = 2000'

NCDOT

DIVISION OF HIGHWAYS

FORSYTH COUNTY

PROJECT: U-2707

SR 3000 (IDOLS ROAD), FROM SR 2999 (HAMPTON ROAD) TO US 158 (CLEMMONS ROAD)

PROPERTY OWNERS

NAMES AND ADDRESSES

REFERENCE NO.	NAMES	ADDRESSES
20-A	LENTZ PROPERTY MANAGEMENT, LLC	PO BOX 989 CLEMMONS, NC 27012
22	EDNA BINGHAM	PO BOX 5 CLEMMONS, NC 27012
13	NORFOLK SOUTHERN RR	THREE COMMERCIAL PLACE NORFOLK, VA 23510
26	JOSEPH C. GOODMAN MARY ANN HARRIS GOODMAN	3049 S. STRATFORD ROAD WINSTON SALEM, NC 27103

NCDOT

DIVISION OF HIGHWAYS

FORSYTH COUNTY

PROJECT: U-2707

SR 3000 (IDOLS ROAD), FROM
SR 2999 (HAMPTON ROAD)
TO US 158 (CLEMMONS ROAD)

WETLAND PERMIT IMPACT SUMMARY

Site No.	Station (From/To)	Structure Size / Type	WETLAND IMPACTS					SURFACE WATER IMPACTS				
			Permanent Fill In Wetlands (ac)	Temp. Fill In Wetlands (ac)	Excavation in Wetlands (ac)	Mechanized Clearing in Wetlands (ac)	Hand Clearing in Wetlands (ac)	Permanent SW impacts (ac)	Temp. SW impacts (ac)	Existing Channel Impacts Permanent (ft)	Existing Channel Impacts Temp. (ft)	Natural Stream Design (ft)
1	-L- 40+80	48"				0.03						
2	-L- 68+50	48"						<0.01		61		
3	-L- 73+09 to 90+31	Roadway Fill						0.10		831		1876.5
4	-L- 75+98 to 84.02 Rt	Roadway Fill	0.78									
5*	-L- 89.00 Lt	1@96" CAAP										
6	-L- 90+85 Rt	Bank Stabilization						<0.01		11		
TOTALS:			0.78			0.03		0.10		903		1876.5

* The proposed 96" CAAP is considered an enhancement due to the reconnection of the fish passage and hydrology, therefore no impacts will be calculated here.

NC DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS

FORSYTH COUNTY
WBS - 34845.1.1 (U-2707)

SHEET 15 of 15 12/07/11

ATN Revised 3/31/05

EXHIBIT C

U-2707 STREAM MITIGATION PLAN

FORSYTH COUNTY, NORTH CAROLINA

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

DECEMBER 22, 2011

U-2707 Stream Mitigation Plan

Forsyth County, North Carolina

December 5, 2011

Prepared For:
North Carolina Department of Transportation

MULKEY
ENGINEERS & CONSULTANTS

Report Prepared by Mulkey, Inc.:

Emmett Perdue, P.E.
Design Engineer – Natural Resources

Wendee Smith
Project Manager – Natural Resources Group Manager

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U-2707 STREAM MITIGATION PLAN

FORSYTH COUNTY

WBS NO.: 34845.1.1

DECEMBER 22, 2011

1.0 BASELINE INFORMATION

1.1 Introduction

This U-2707 stream mitigation plan proposes improvements to be implemented by the North Carolina Department of Transportation (NCDOT) along two unnamed tributaries (UT's) to Muddy Creek. The plan is being completed to provide on-site mitigation for unavoidable stream impacts associated with the construction of Transportation Improvement Project (TIP) number U-2707, or the Idols Road Extension (SR 3000) in Forsyth County, North Carolina near the town of Clemmons. The project location is within the floodplain of Muddy Creek and consists of approximately 1,800 linear feet of restoration along Reach 1 (R1) coupled with the enhancement of bank conditions and reconnection of hydrology associated with the replacement of a culvert along Reach 2 (R2) (Figure 1).

1.2 General Watershed Information

The two unnamed tributaries are situated within the Yadkin-Pee Dee River Basin within the US Geological Survey (USGS) hydrological unit code (HUC) 03040101 and the NC Division of Water Quality (NCDWQ) sub-basin 03-07-04. R1 has an existing drainage area of 0.42 square miles (271 acres) at the culvert under Clouds Harbor Trail, the upstream limit of the project, increasing to 0.49 square miles (316 acres) at the point where the road alignment will fill the stream. R2 has an existing drainage area of 0.62 square miles (410 acres) at the culvert inlet. Both of these drainage areas are predominantly woodland/pasture areas with residential and commercial intermixed.

1.3 Project Site Description

1.3.1 Topography, Physiographic Providence, and Soils

The project site is situated entirely within the southwest portion of the Muddy Creek floodplain. A railway embankment and the future SR 3000 (Idols Road) form the southeastern boundary of the project site. The floodplain of Muddy Creek is relatively flat with minimal elevation change. There is a large levee on the western bank of Muddy Creek that separates it from R2. Elevation ranges on the project site from 700 feet above mean sea level (msl) along Clouds Harbor Trail to 679 feet msl at the confluence with Muddy Creek. The U-2707 mitigation site is within the Piedmont physiographic province: specifically, the Southern Outer Piedmont Ecoregion (Griffith et al., 2002). According to the Forsyth County Soil Survey, Chewacla soils dominate the project area.

1.3.2 Jurisdictional Wetlands

Jurisdictional wetland determinations were performed using the three-parameter approach as prescribed in the 1987 *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory, 1987). NCDOT personnel performed wetland delineations between December 1998 and November 2001 and reconfirmed any changes in June 2011. Four small wetlands occur within the entire U-2707 project area. Three of these areas were found to be non-jurisdictional due to a lack of hydric soils and are not within the work limits of the mitigation site. The fourth is contained within the stream banks of R1 approximately 165 feet downstream of Clouds Harbor Trail. This fourth wetland was deemed to be unimportant and non-mitigable because it was created by horses accessing the stream. The banks in this location are severely degraded and almost nonexistent therefore creating an inline channel pool/wetland area (NCDOT, 2002).

1.3.3 Existing Plant Communities

The vegetative communities found within the project area can be characterized by two major groupings. These groupings include pastureland (predominantly fescue) and the riparian fringe. The riparian fringe is a narrow band of vegetation found along each unnamed tributary. Common herbaceous species found include poison ivy (*Toxicondendron radicans*), jewelweed (*Impatiens capensis*), common violet (*Viola* sp.), common greenbrier (*Smilax roundifolia*), Japanese honeysuckle (*Lonicera japonica*), multiflora rose (*Rosa multiflora*), and giant cane (*Arundinaria gigantea*). Woody species located in the subcanopy primarily consist of silky dogwood (*Cornus amomum*), Chinese privet (*Ligustrum sinense*), river birch (*Betula nigra*), black willow (*Salix nigra*), and black cherry (*Prunus serotina*). Common tree species occupying the canopy of the riparian fringe include boxelder (*Acer negundo*), green ash (Fraxinus pennsylvanica), and tulip poplar (*Liriodendron tulipifera*).

1.3.4 Threatened and Endangered Species

According to the US Fish and Wildlife Service (USFWS), two endangered and one threatened species are known to occur in Forsyth County. The threatened species (bog turtle) is listed by similarity of appearance (S/A), but is neither biologically threatened nor endangered. Therefore, the bog turtle is not subject to Section 7 consultation (Endangered Species Act). Information regarding these federally listed species can be found in Table 1.

Table 1. Federally Listed Species for Forsyth County

Common Name	Scientific Name	Federal Status	Preferred Habitat	Habitat Availability	Biological Conclusion
Red-cockaded woodpecker	*Picoides borealis*	Endangered	Open park-like pine stands (live) w/ little undergrowth	No	No Effect
Small-anthered bittercress	*Cardamine micranthera*	Endangered [A]	Near seeps and wet rock crevices, moist woods near small streams, full to partial sun	No	No Effect
Bog Turtle	*Clemmys muhlenbergii*	Threatened (S/A) [B]	Shallow spring-fed fens, open and sunny muddy-bottomed streams	No	Not Applicable

[A] Denotes no specimen from Forsyth County found in the past twenty years.

[B] Threatened due to similarity of appearance (S/A) denotes a species that is threatened due to similarity of appearance with other rare species and is listed for its protection. These species are not biologically endangered or threatened and are not subject to Section 7 consultation.

2.0 SITE SELECTION

Both R1 and R2 were selected because of their proximity to the impact that they will offset and due to their degraded condition. As a part of the U-2707 right-of-way, these unnamed tributaries are part of the system being impacted by the construction of the Idols Road Extension. After analyzing all the impacted systems affected by the U-2707 project. R1 and R2 were identified as highly degraded systems offering the most potential ecological uplift. Therefore. the proximity to the impact being offset and the degraded nature of the streams offer an exemplary mitigation site.

2.1 Reach 1 (R1) Existing Conditions

The headwaters of R1 originate in a residential neighborhood approximately 0.3 miles south of the intersection of existing SR 3000 (Hampton Road) and US 158. The tributary flows in a southerly direction for approximately 0.3 miles before turning to the east/northeast and eventually connecting with R2 just upstream of Muddy Creek. The drainage area associated with R1 is 316 acres (0.49 mi^2) and is predominantly woodland/pasture with residential intermixed (Figure 2). The current location of the R1 stream channel (along the northeast toe of the Norfolk Southern railroad embankment) is a product of agricultural operations and railroad construction. Agriculture practices over the last century have played a major role in the destabilization of R1 by relocating, straightening, and channelizing the stream to provide for more active and accessible pastureland. In addition, vegetation removal throughout what should be the riparian buffer coupled with livestock access to the stream for watering purposes have created unstable banks contributing more sediment to the system. In addition to bank instability, Muddy Creek being actively dredged has increased the rate at which lower sections of R1 have become incised and entrenched. To combat this incision and the instability along the railroad, large boulders and concrete have been placed throughout the downstream section effectively removing any aquatic passage or hydrologic connection to Muddy Creek.

The vertical longitudinal profile of R1 indicates an altered system with fluctuating boundary conditions that is on the border of instability. Currently, the existing R1 channel flows approximately 2,000 linear feet within the limits of the U-2707 project area. The existing channel slope averages 0.00632 ft/ft over a representative 1100 feet of channel which is characteristic of E and C channels typical for this valley type. However, the upper 300 feet of the reach is characterized by a flat bed slope while the banks and bankfull channel are holding the average bankfull slope. This section of channel is actively being accessed by livestock and therefore the bed is being compressed into a uniform condition. The channel has also been straightened and channelized which is visible in the plan view of the channel and through the levees on both sides of the channel in cross sections 1 and 2. From station 300 to 600, the channel is not actively being accessed by livestock and maintains the best riparian buffer. This section of channel is the most stable with minimal incision occurring and consistent slope features across the banks, bankfull, water surface and bed. The lower 500 feet (station 600 to 1100). however, show the beginnings of incision as the channel bed deepens relative to the banks. This can be attributed to a downstream head cut moving through the channel as a result of the active dredging occurring in Muddy Creek. This corresponds to cross section 5 having a deep, narrow channel bottom as is the case with C streams moving towards G streams. These three scenarios depict a stream with instability on the upper and lower ends and altering

boundary conditions throughout. The tendency for streams in this situation is for the upper and lower conditions to migrate through the center and alter the channel conditions until equilibrium is reached. The complete data set for the existing profile information for R1 is presented in Appendix A.

Table 2. Summary of Existing Cross Sections –Reach 1 (R1)

Cross Section	Station No.	Morph. Feature	BKF Area (ft^2)	BKF Width (ft)	BKF Max Depth (ft)	W/D Ratio*	Ent. Ratio*	LBH Ratio*	Stream Class.*
1	88.5	Riffle	9.86	11.58	1.63	13.62	10.05	1.54	C5
2	136.5	Pool	18.73	14.22	2.47	10.77	9.46	--	--
3	465.5	Riffle	8.93	13.66	1.68	21.02	13.18	1.31	C5
4	538	Pool	16.55	17.87	2.08	19.22	8.95	--	--
5	1115	Riffle	14.00	8.86	2.37	5.61	14.66	1.33	E5
6	N/A	Riffle	13.35	14.82	1.41	16.47	3.29	1.73	C5

*Notes: Ent. Ratio is "Entrenchment Ratio"
W/D Ratio is "Width/Depth Ratio"
LB Ratio is "Low Bank Height Ratio"
Stream classification is only viable along riffle sections.

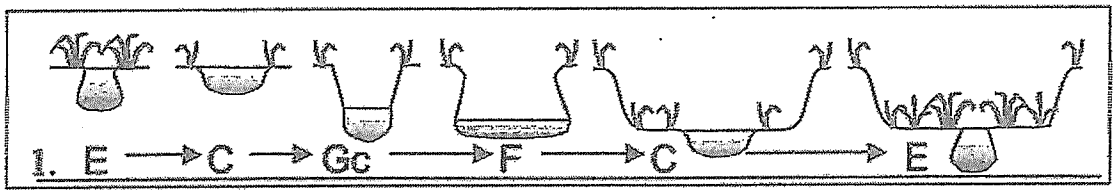
The cross section data is summarized in Table 2 above but graphs and the associated data can also be found in Appendix A. The cross section data suggests R1 is a stable C5 channel based on the Rosgen stream classification system (Rosgen. 1994). However, upon closer inspection of the riffle cross section graphs (pool cross sections are not used for evaluation). three trends toward instability can be spotted. The first, typical of most stream channels and not an indication of instability alone. is the bankfull area and width are both generally increasing as the riffle cross sections move downstream. The second is the degree of incision (Low Bank Height Ratio) remains consistent until cross section 6. where it increases slightly. And the third is the entrenchment ratio remains above 10 until the last cross section where it drops significantly to 3.29. These trends together indicate channel conditions that result in the floodplain being removed from the bankfull elevation as the bankfull elevation sinks lower into the stream channel on the downstream end. This situation is indicative of altered boundary conditions creating head cuts which travel upstream creating instability by producing steep, denuded, undercut banks; excessive in channel velocities; and overly widened channels.

A reach-wide modified Wolman Pebble Count was conducted to determine the average d_{50} (50% of the sampled population is equal to or finer than the representative particle diameter) to be approximately 0.13 mm for R1, which falls into the very fine sand size category. The wetted perimeter d_{50} was approximately 2.5mm. The bar sample was predominantly sand and therefore the d_{50} could not be determined. The particle size distribution data is presented in Appendix B. The results of the data suggest R1 is a sand dominated system with little grade control evidenced by the absence of a true pavement/subpavement stratum. These types of systems have a sensitive response to the alteration of boundary conditions since the channel is not well armored. Therefore these systems depend highly on bank vegetation and channel dimension, pattern and profile to maintain equilibrium.

The vertical longitudinal profile. corresponding cross sections, and material substrate of R1 exhibit conditions in which the channel is on the beginning path of instability. Taking into

account the typical stream types for this valley and the existing condition data, R1 is moving from a C to a Gc on a stream successional path of E→C→Gc→F→C→E (See Diagram 1 below). If allowed to fully develop, the channel's instability will lead to increased sediment supply through the mass wasting of banks, vertical instability, and channel widening.

Diagram 1. Stream Channel Succession



2.2 Reach 2 (R2) Existing Conditions

The R2 stream channel originates just north of the intersection of SR 3000 and US 158 and flows in an easterly direction for approximately 1.0 mile before turning south. R2 then flows south across the Muddy Creek floodplain for approximately 0.5 mile and eventually confluences with R1 just upstream of Muddy Creek. The existing drainage area associated with R2 is 0.64 square mile (410 acres.). R2 contains approximately 400 linear feet of existing channel within the project area and classifies as a G5 stream type. The average slope of this channel is 0.0023 ft/ft which is typical for streams in this valley type. The stream channel and banks associated with this tributary have been principally altered through channelization evidenced by the linear characteristics in the plan view (Figure 1 and 2). The stream section below the culvert has also seen increased entrenchment due to the dredging of Muddy Creek.

Agricultural access through the installation of a farm path and the associated stream crossing has exacerbated the degradation in R2. A high level analysis of R2 was not conducted because the farm path culvert was identified as the major obstacle inhibiting aquatic passage. R2 displays signs of stability upstream of the farm path culvert; however immediately downstream of the culvert the stream is severely entrenched and incised. Erosion around the culvert is causing the path to collapse into the stream channel. The severity in elevation drop from the inlet to the outlet of the culvert does not allow fish passage and minimizes any hydrologic connection of the upper part of R2 to Muddy Creek.

3.0 SITE PROTECTION INSTRUMENT

The Site will be located within the NCDOT right-of-way for the project and designated on the plan sheets as a mitigation area. The Site will be managed to prohibit all use inconsistent with its use as mitigation, including any activity that would materially alter the biological integrity or functional and educational value of the site, consistent with the mitigation plan. The Site will be recorded on the NEU mitigation geo-database (MGD). The MGD is distributed to the Divisions to designate the location and protected status of all onsite mitigation. After closeout, the Site will be placed in the NCDOT Stewardship Program for long term management and protection.

The Site will be managed according to the terms of this mitigation plan and the NCDOT Stewardship Process.

4.0 OBJECTIVES

The goal of the project is to improve water quality, to reduce bank erosion, to reestablish a floodplain along R1, and to improve the aquatic and terrestrial wildlife habitat. The functional restoration of the site will occur through a mixture of various treatments consistent with natural channel design techniques for 1800 linear feet of R1 and 153 linear feet of R2. Along R1, these techniques will include removing livestock from the stream through the implementation of a conservation easement; establishing a floodplain or reconnecting the stream back to its historic floodplain; increasing the amount of aquatic habitat through the addition of rock and wood structures; and reestablishing native plant communities throughout the conservation easement, whereby reintroducing shading, cover areas, and travel corridors. The restoration of R2 will be limited to the replacement of the existing culvert with a new arched pipe with baffles to allow functional fish passage, establish grade control, and minimize velocities therefore providing a more stable stream system.

5.0 MITIGATION WORK PLAN

The mitigation work plan will consist of construction activities associated with the implementation of the natural channel design set forth below.

5.1 Natural Channel Design

Natural channel design is the principle developed by Dave Rosgen of using stable reference reach streams to develop and project dimensionless variables onto unstable reaches with similar boundary conditions in order to superimpose a new stable system in low quality environments. The following section outlines the parameters necessary to undertake natural channel design and describes the fully developed mitigation plan.

5.1.1 Introduction

Based on existing condition data, the restoration of the U-2707 project was broken into two reaches, Reach 1 (R1) and Reach 2 (R2). R1 will undergo the most extensive restoration via priority I and II restoration techniques. Due to the nature of the valley and changing channel characteristics, explained further below, R1 was further divided into R1a (upstream 920ft) and R1b (downstream 880ft). R2 restoration is comprised of the removal and replacement of a nonfunctioning culvert and therefore some of the following analysis does not apply.

5.1.2 Reference Reach Analyses

One reference reach has been identified for use on the U-2707 stream restoration site. Spencer Creek was chosen as it represents a stable, rural, piedmont stream type and shares the same watershed size and characteristics as the project stream.

Spencer Creek is situated in Montgomery County, approximately 8.0 miles from Troy along the west side of SR 1134 (Figure 3). Spencer Creek is characterized as a second order stream and classifies as a rural E4/C4 stream type. Specific morphological data for this reference reach are given within the morphological table found in Appendix B. Its watershed is approximately 0.55 square mile (355 acres) and encompasses large tracts of undeveloped woodland within the Uwharrie National Forest. Common riparian species found along this stream corridor include

American holly (*Ilex opaca*), red maple (*Acer rubrum*) , sweet gum (*Liquidambar styraciflua*), mountain laurel (*Kalmia latifolia*), flowering dogwood (*Cornus florida*), water oak (*Quercus nigra*), willow oak (*Quercus phellos*), sourwood (*Oxydendrum arboreum*), and giant cane.

5.1.3 Sediment Transport Analysis

Sediment plays a major role in the influence of channel stability and morphology (Rosgen, 1996). A stable stream has the capacity to move its sediment load without aggrading or degrading.

The critical dimensionless shear stress (τ^*_{ci}) is the measure of force required to initiate general movement of particles in a bed of a given composition. Based on the d_i of 2.7 mm obtained from the active riffle sampling at cross section 3 and using a value of 0.1 mm for the bar sample d_{50} due to the composition of sand for R1, the critical dimensionless shear stress was calculated to be approximately 0.019 lbs/ft^2. Evaluating R1a and R1b with a consistent bankfull slopes, the differing channel geometries provide different bankfull shear stresses. R1a being classified a C5 channel has a smaller bankfull cross sectional area, but the geometry has a wider bankfull width and shallower depth resulting in a bankfull shear stress of 0.225 lbs/ft^2. R1b being classified an E5 channel has a larger bankfull area, but the smaller width and greater depth creates an environment where velocities are extremely high resulting in higher bankfull shear stress of 0.496 lbs/ft^2. These shear stresses result in the entrainment of particles a minimum of 16 mm in R1a and 38 mm in R1b. Entrainment and velocity calculation sheets used for this analysis are presented in Appendices C and D, respectively.

The bankfull shear stress for the proposed channel has to be sufficient to move the D_{84} of the bed material. The largest D_{84} particle determined within active riffles across the site was 4.87mm. Based on the entrainment calculations for the proposed R1a and R1b, the calculated bankfull shear stresses of 0.403 lbs/ft^2 and 0.284 lbs/ft^2 would move particles of 30 mm and 21 mm respectively. The proposed design provides the correct C5 channel geometry for both R1a and R1b, as seen in the design cross section overlays in Appendix E. However, due to valley conditions, R1a has an increased slope of 0.0080 ft/ft. This increase in slope increases velocities through the system with the same relative bankfull area and geometry which in turn creates a higher shear stress. Being further downstream and to match the existing conditions, R1b has a slightly larger bankfull cross sectional area than R1a but still retains the C5 channel geometry. This change in geometry coupled with the flattening of the slope through this section due to valley conditions allows the velocities and bankfull shear stress to be greatly reduced when compared to the existing conditions.

This analysis proves the system contains more than adequate bankfull shear stress to move the sediment through the system and raises concerns about degradation. The expected bankfull shear stress would move particles ranging from 21 mm to 30 mm. The largest particle found on depositional bars was 6 mm, while the D_{84} and D_{100} of the reach wide sampling of R1 was determined to be 8 mm and 32 mm, respectively. Therefore, the proposed design has sufficient shear stress to move the bedload associated with the project reach. However it will be extremely important that vegetation, grade control structures, and design plan form tolerances are strictly adhered to in construction as these will assist in maintaining the long term stability of the proposed channel, in particular in R1a.

5.1.4 Flood Analyses

The entire U-2707 mitigation site, including the channel of Muddy Creek and its immediate floodplain are located within the Federal Emergency Management Association's (FEMA) 100-year flood boundary, as depicted on Figure 4 (FEMA, 1991). These areas are inundated by the 100-year flood of Muddy Creek, where Base Flood Elevations (BFE) have been determined and a floodway established. However, the flood mapping only pertains to Muddy Creek proper. The unnamed tributaries are not a part of the flood study and are inundated by the floodwaters of Muddy Creek.

5.1.5 Proposed Design Reach 1 (R1)

The restoration of R1 has been divided into two sections, R1a and R1b, for design purposes. R1a, the upstream portion of R1 from Station 0+00 to 9+20, is characterized by a steeper valley slope and smaller bankfull channel. This area has been severely impacted by the agricultural practices of channelization and through livestock access. The stream channel has been straightened and deepened in locations while the banks have consistent levees on both sides of the channel except for where livestock is actively accessing the stream as a water supply. In the current condition, the channel classifies as a C5 stream, however as mentioned in Section 2 above, the system appears to be trending through the E→C→Gc→F→C→E stream succession. Therefore the design approach for R1a is to halt the succession at the first stage. E→C, through the design of a stable C channel: then reverse the trend, effectively jumping to the C→E stage, through the implementation of a vigorous vegetation plan.

R1a, being in the upstream steep valley scenario, will undergo Priority I restoration. This consists of raising the bed elevation such that the corresponding bankfull elevation matches the natural ground of the historic floodplain. In the case of R1a, performing this while keeping within the design ranges of the horizontal plan form variables of sinuosity, meander length, belt width, pool to pool spacing, and radius of curvature, the resulting bankfull slope was 0.0080 ft/ft (See Appendix F). The bankfull cross section was designed based on a cross sectional area of 10.0 ft^2 which matches the existing conditions and the NC Piedmont Regional Curve Data for a drainage area of 0.46 mi^2. The channel was then shaped based on a stable C5 dimension with a width to depth ratio of 14.4. This results in a bankfull width of 12.0 feet and a maximum bankfull depth of 1.37 feet. As depicted in the design overlays of cross section 1 and 3 in Appendix E, this geometry closely matches the existing conditions geometry at the bankfull stage therefore indicating a correct sizing. With the design of a stable C5 channel, the implementation of structures will provide vertical stability. Then a vigorous planting of the stream banks will facilitate bank stabilization and encourage a tightening of the bankfull width through sedimentation to form a stable E channel. This process will stabilize the system without moving through the complete E→C→Gc→F→C→E stream succession minimizing mass wasting of banks and down cutting of the channel.

R1b, the downstream section of R1, is characterized by a flatter valley slope, larger bankfull area and has the downstream elevation boundary condition at the confluence with R2. This channel encompasses the 863 feet of R1 being relocated due to the construction of SR3000. The current channel condition has been impacted by channelization and the creation of levees, but has also experienced inappropriate stabilization techniques along the section that abuts the railroad

alignment. In this area, concrete and large boulders have been introduced to the stream channel as vertical grade control. However, this technique has removed any hydrologic or aquatic connection to Muddy Creek by hardening large drops throughout the lower 300 feet. The disconnection to Muddy Creek coupled with the constraints imposed by the construction of SR3000 required R1b to be diverted to connect with R2 prior to connecting with Muddy Creek. This diversion resulted in a net loss of 185 linear feet of channel along R1 as R2 now makes the 185 foot connection to Muddy Creek.

Given the downstream elevation constraint imposed by the confluence with R2, R1b will undergo Priority II restoration. This type of restoration involves allowing the channel to drop through the natural valley ground level in an effort to meet other constraints. However, to ensure proper stability and flood capacity, a bankfull bench is excavated at the bankfull elevation to create the necessary floodplain. To achieve the required floodplain for a C5 channel, the entrenchment ratio (ratio of floodprone width to bankfull width) has to be greater than 2.2. Based on the NC Piedmont Regional Curve Data for a drainage area of 0.49 mi^2, the appropriate bankfull cross sectional area is 15.0 ft^2. Using a width to depth ratio of 13.0 provided a bankfull width of 14.0 feet and a maximum depth of 1.6 feet. Similar to R1a, design overlays of cross sections 5 and 6 in Appendix E confirm this geometry is suitable in comparison to the bankfull stage associated with the existing conditions. Using the entrenchment ratio of 2.2 and a bankfull width of 14.0 feet, the minimum floodprone width was calculated to be 30.8 feet. The design incorporates a 35.0 feet floodprone width to ensure this minimum is achieved. Adhering to the design variable ranges associated with sinuosity, meander length, belt width, pool to pool spacing, and radius of curvature (See Appendix F) while meeting the elevation constraints imposed by connecting R1a to R2; the design bankfull slope for R1b was determined to be 0.0044 ft/ft. These channel modifications in slope and geometry significantly lower the shear stress and velocities in this section creating a more stable system. As with R1a, the implementation of structures for grade control and vegetation for bank stability and channel tightening will significantly improve the long term stability of the channel. However, R1b was closer to the second stage of the E→C→Gc→F→C→E stream succession as indicated by the incision in cross section 5 and the entrenchment in cross section 6. The degradation processes in the lower portion of the reach were most likely tied to the dredging operation in Muddy Creek. Therefore, the decision to divert the channel to R2 now requires measures be taken to stabilize R2 as it now provides the hydrologic and aquatic connection to Muddy Creek.

5.1.6 Proposed Design Reach 2 (R2)

The work along R2 will consist of the replacement of a degraded culvert causing restrictive water passage effectively removing any hydrologic and aquatic connection to Muddy Creek while increasing erosive forces immediately downstream of the crossing. The existing pipe is an 18 inch corrugated metal pipe (CMP) with a buried inlet and a perched outlet approximately 3 feet above bed elevation. The downstream section of R2 is extremely incised and entrenched as a result of the perched pipe and active dredging occurring in Muddy Creek. Simply removing the degraded culvert would remove agricultural access and create an unstable transition in elevation which would result in a severe head cut moving upstream. Therefore the design must maintain agricultural access, provide vertical stability, and reconnect the aquatic passage of the upstream reach to Muddy Creek.

A 112 inch by 75 inch corrugated aluminum arch pipe (CAAP) was selected based on stream channel size and because this type of pipe can be easily modified to incorporate a baffling system. The baffling system is installed in such a manner as to create a sinuous low flow path through the pipe that encourages fish passage. The 75 inch height of the pipe coupled with a 1.15 foot headwall matches the existing grades of the surrounding banks allowing for easy path construction. The original drainage area of the culvert was 0.64 mi^2 before diverting R1 into R2 upstream of the culvert. Including R1, the new drainage area for the culvert is 1.13 mi^2 which based on an ungauged station analysis of that size produces a 2 year design discharge of 172 cfs and a 5 year design discharge of 319 cfs. Taking into account the baffling system, the flow path of this pipe is reduced to an equivalent pipe size of an 87 inch by 63 inch CAAP. The baffling system also effectively raised the invert elevation of the pipe to the invert of the first baffle. Accounting for these hydraulic changes, an analysis of the pipe determined the 5 year return interval caused the water to overtop the farm path by 2.41 feet whereas the 2 year return interval placed the water 1.5 feet below the road. As the pipe is installed to provide agricultural access, to allow for fish passage, and is completely contained within NCDOTs right of way; these hydraulic conditions were deemed acceptable for the purpose. The baffled pipe system will provide for the aquatic and hydrologic connection now missing throughout R1 and R2. Specific details of the pipe design can be found in Appendix G and in Appendix H within the details of the construction plans.

5.1.7 Stream Riparian Planting Plan

A protected riparian buffer will be established as part of the on-site mitigation and the entire conservation easement will be fenced to restrict access to the restored areas and the SR 3000 right-of-way. The planting plan for the riparian and upland buffers of the U-2707 site will provide post-construction erosion control and riparian habitat enhancement. The planting plan will also attempt to blend existing vegetative communities into recently restored areas. Plantings in the buffer areas will include native species appropriate for the Piedmont physiographic province. Plants within the floodplain will be flood tolerant species, which can accommodate periodic flooding events throughout the year. A variety of trees will be planted to provide cover and habitat for wildlife as well as soil stabilization. NCDOT Roadside Environmental Unit will develop the specific details and plant lists to be utilized on the U-2707 restoration site.

Trees with extensive, deep rooting systems will assist in stabilizing the banks in the long term. Colonization of local herbaceous vegetation will inevitably occur, which will provide additional soil stability. Tree species will be planted as bare root stock on random 8-foot centers at a frequency of 680 stems per acre. Planting stock will be culled to remove inferior specimens, so only healthy, viable stock will be planted at the U-2707 restoration site. Planting of species will utilize dormant plant stock and will be performed to the extent practicable between December 1st and March 15th.

A complete Plan and Profile (Sheets MIT-03 and MIT-04) of the design described above along with the Planting Plan (Sheets PLT-03 and PLT-04) can be found in Appendix I. Specific details regarding construction and typicals of the stream can be found in Appendix H.

5.2 Construction Implementation

Construction activities associated with the implementation of the natural channel design outlined above will include excavation, structure installation, pipe removal and replacement, utility marking, and vegetation installation. Prior to any work, the permittee will be responsible for the knowledge and implementation of appropriate erosion control practices that meet all local, county, and state regulations. The use of a pump around system will be incorporated and where possible work will be conducted offline to minimize sediment input. Work will continue in a fashion that allows for any land disturbance to be adequately treated by the end of each day. Prior to any work beginning, the permittee will be responsible for marking all utilities on-site and to confirm the elevations and locations shown on the plans. Excavation will be performed by qualified personnel using equipment suitable for the conditions. Excavation will include cutting the channel, bankfull bench, and any work necessary to remove the existing culvert. To stabilize the banks, seed and straw will be immediately applied to the newly cut channel and covered with coir fiber matting. Structure installation will include the installation of rock (or log if deemed acceptable on site) cross vanes and constructed riffles. These structures are installed to provide grade control and offer bank protection so it is important qualified personnel use equipment outfitted for stream restoration. Similar to the structure installation, the pipe removal and replacement will require specialized equipment and personnel familiar with the installation of CAAPs and baffling systems. The last phase of construction will consist of planting the conservation easement. As the vegetation is as important as the channel construction and structure installation, the vegetation should be installed by a qualified landscaper or person of similar background. This site will require the installation of bare root stock and live stake material, each of which requires particular handling and installation for manual installation.

6.0 PERFORMANCE STANDARDS

The NCDOT shall monitor stream channel stability and buffer vegetation survival on the site. Post-restoration monitoring will be conducted for a minimum of five years or until the success criteria are met following the completion of construction to document project success. Monitoring approaches follow those recommended by the Stream Mitigation Guidelines (USACE and NCDWQ 2003). These approaches are described below in Section 7.0.

7.0 MONITORING REQUIREMENTS

The stream mitigation site will be monitored for five years or until success criteria is satisfied. Monitoring protocols shall follow the Monitoring Level 1 outlined in the Stream Mitigation Guidelines, April 2003. NCDOT will evaluate the success of the stream restoration project based on guidance provided by the Stream Mitigation Guidelines disseminated by the United States Army Corps of Engineers- Wilmington District. The survey of the channel dimension will consist of permanent cross sections placed at equal number of pools and riffles. Annual photographs showing both banks and upstream and downstream views will be taken from permanent, mapped photo points. The survey of the longitudinal profile will represent distinct areas of the stream and cover a cumulative total of approximately 1,800 linear feet LF of channel. The entire restored length of stream will be investigated for channel stability and in-stream structure functionality. Any evidence of channel instability will be identified, mapped and photographed.

8.0 OTHER INFORMATION

No other information is available.

9.0 DETERMINATION OF CREDITS

Restoration						
Stream	Station	Priority Level	Type	Existing Length of Channel (lf)	Proposed Length of Channel (lf)	Stream Mitigation Units (SMU)
Reach 1	0+00 to 9+20	I	Perennial	920	920	920
Reach 1	9+20 to 11+22	II	Perennial	202	202	202
Relocation						
Stream	Station	Priority Level	Type	Existing Length of Channel (lf)	Proposed Length of Channel (lf)	Stream Mitigation Units (SMU)
Reach 1	11+22 to 18+00	II	Perennial	863	678	678
Enhancement						
Stream	Station	Priority Level	Type	Existing Length of Channel (lf)	Proposed Length of Channel (lf)	Stream Mitigation Units (SMU)
Reach 2	0+00 to 1+53	II	Perennial	153	153	76.5
			Total	2138	1953	1876.5

The site will be debited at the following ratios: 1:1 for stream restoration and 2:1 for stream enhancement to mitigate for the 903 linear feet of stream impacts associated with U-2707. An as-built report will be submitted within 60 days of completion of the project to verify final feet of mitigation. The success of the mitigation areas and determination of final credits will be based upon successful completion of the monitoring.

No wetland credit is currently proposed. However, there is potential for wetland restoration within the floodplain of Reach 1. Any wetland restoration will be documented during the monitoring phase and addressed with the agencies at a future time.

9.1 Credit Release Schedule

NCDOT proposes immediate, full release of the stream restoration and enhancement and the wetland restoration as on-site mitigation for the impacts associated with U-2707. Any mitigation not debited for U-2707 will be placed on the NCDOT debit ledger for future use on other projects.

10.0 GEOGRAPHIC SERVICE AREA

The U-2707 Mitigation Plan has been developed to provide on-site mitigation for unavoidable stream impacts associated with the construction of Transportation Improvement Project (TIP) number U-2707, or the Idols Road Extension (SR 3000) in Forsyth County, North Carolina near the town of Clemmons. The Site is situated within the Yadkin-Pee Dee River Basin within the US Geological Survey (USGS) hydrological unit code (HUC) 03040101 and the NC Division of Water Quality (NCDWQ) sub-basin 03-07-04. All stream and wetland mitigation assets not

compensate for impacts beyond the GSA may be considered by the Corps or the permitting agency on a case-by-case basis.

11.0 MAINTENANCE PLAN

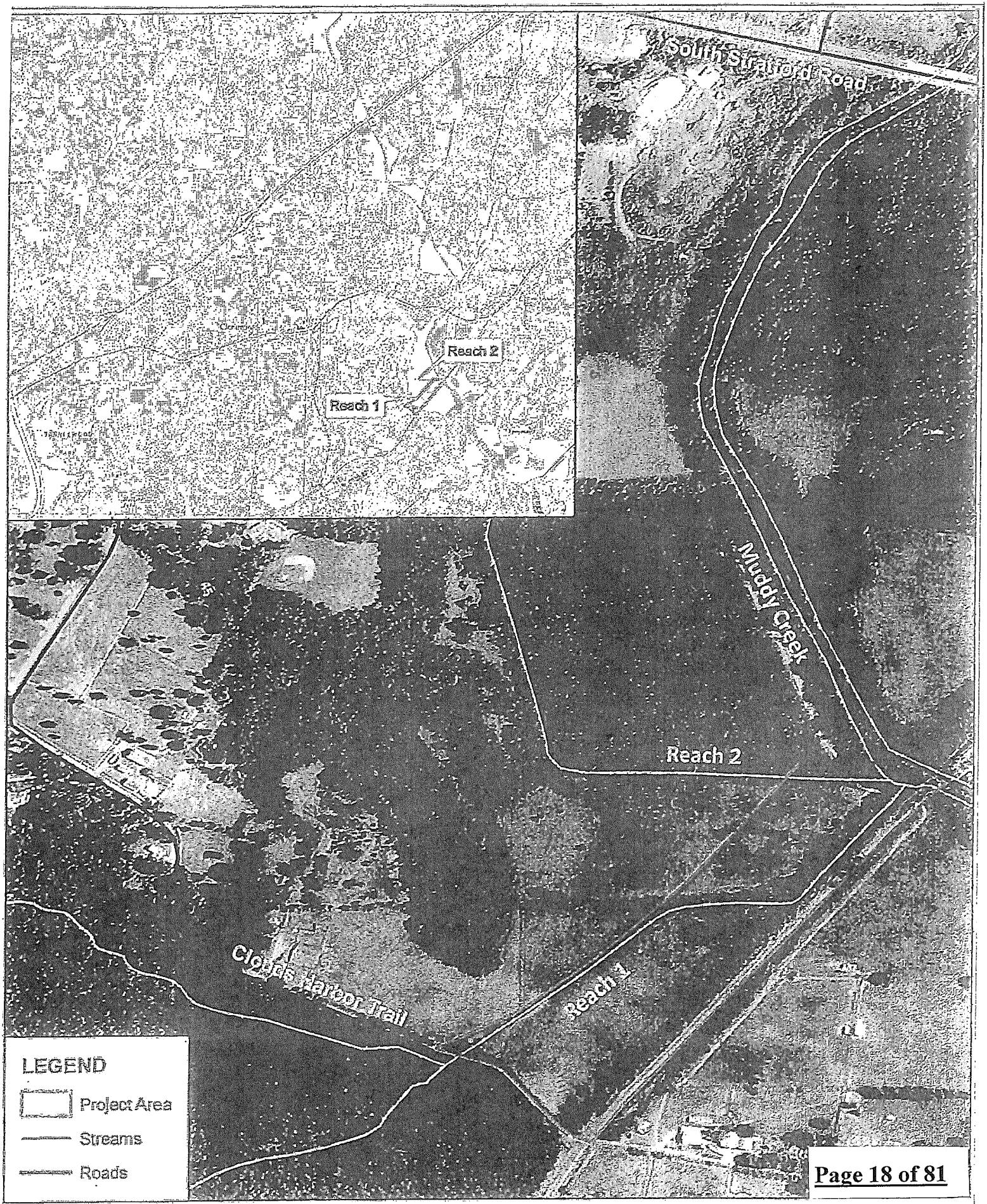
The Site will be held by NCDOT and placed on the NEU mitigation geodatabase. If an appropriate third party recipient is identified in the future, then the transfer of the property will include a conservation easement or other measure to protect the natural features and mitigation value of the site in perpetuity.

12.0 LONG TERM ADAPTIVE MANAGEMENT PLAN

The Site will be managed by the NCDOT according to the site plans. In the event that unforeseen issues arise that affect the management of the site, any remediation will be addressed by NCDOT in coordination with the Interagency Review Team.

13.0 FINANCIAL ASSURANCES

The Site is will be managed by NCDOT with its own distinct cost center number within the NCDOT budgeting and financial tracking system. Therefore, all accounting for revenues, contract encumbrances, fund transfers, and expenses will be performed and reported independent from other capital budget or operating budget accounting.



PREPARED FOR:

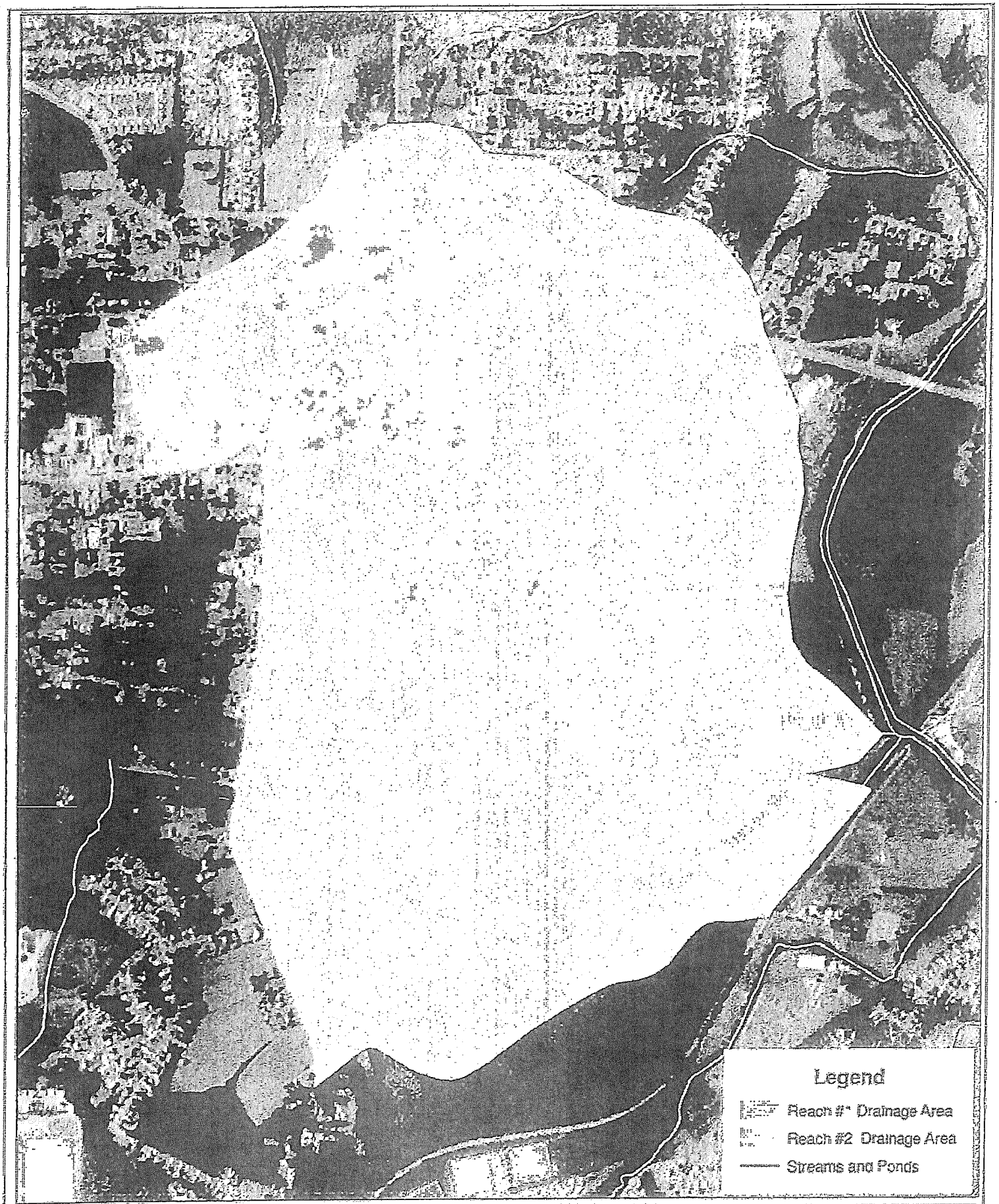
VICINITY MAP

L2397 STREAM RESTORATION

GRAPHIC SCALE

0 0.25 0.5 0.75 1 Miles

FIGURE



PREPARED FOR:

DRAINAGE AREA MAP

U-2707 STREAM RESTORATION

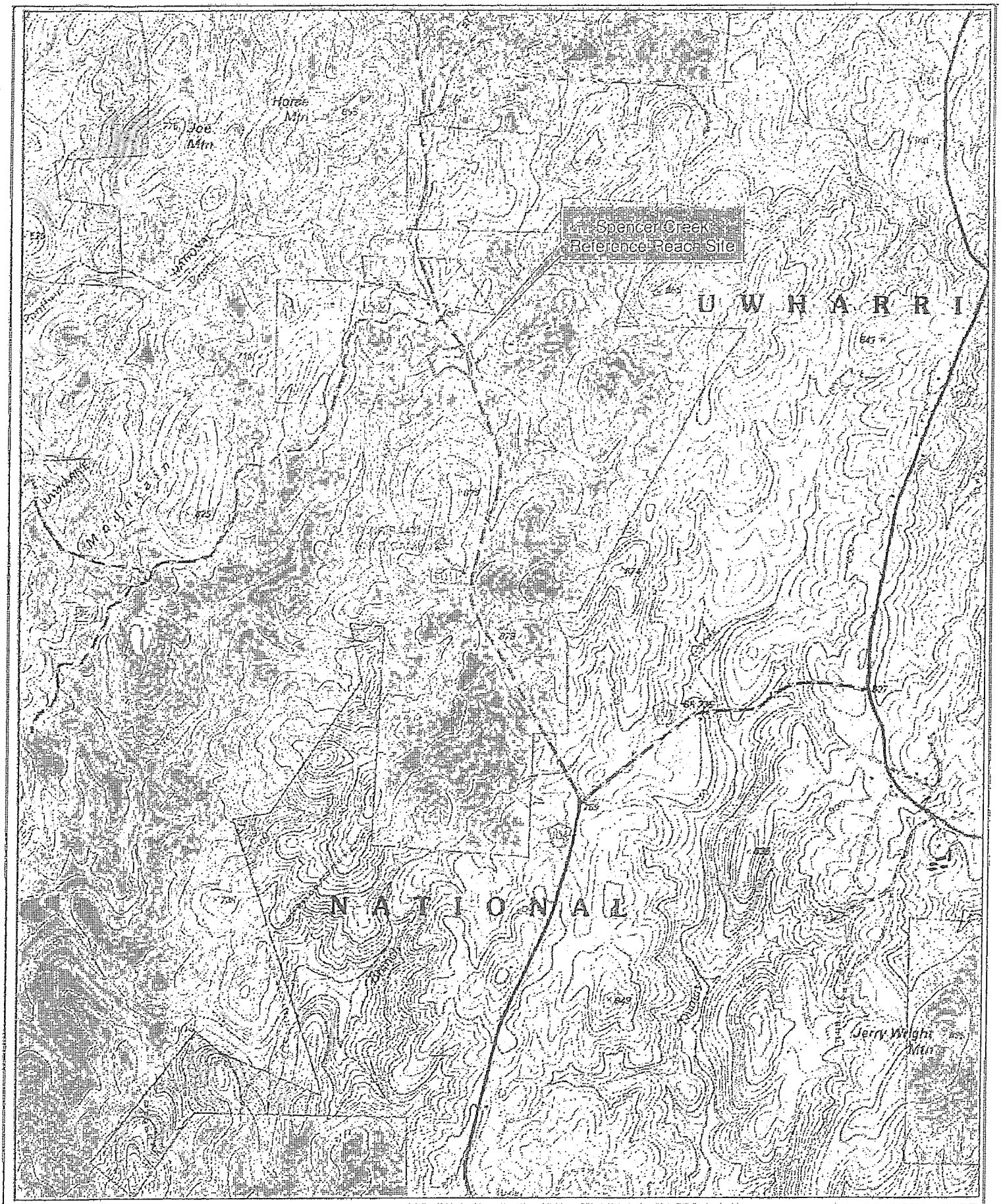
FORSYTH COUNTY, NORTH CAROLINA

1 inch = 1,000 feet

GRAPHIC SCALE

0 250 500 1,000 Feet

FIGURE 2



PREPARED FOR:

REFERENCE REACH VICINITY MAP

SPENCER CREEK

MONTGOMERY COUNTY NORTH CAROLINA

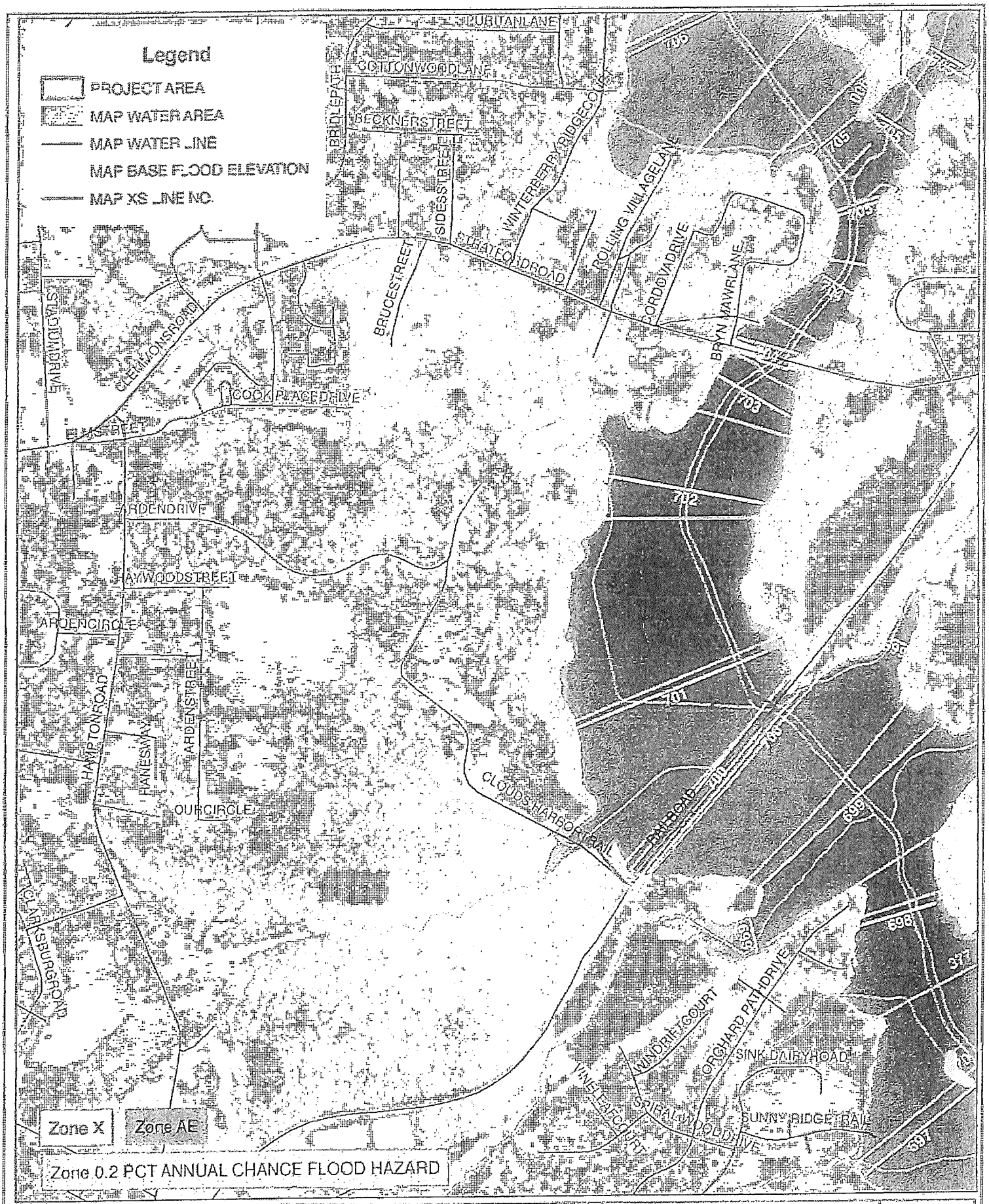
1 inch = 2,000 feet

GRAPHIC SCALE

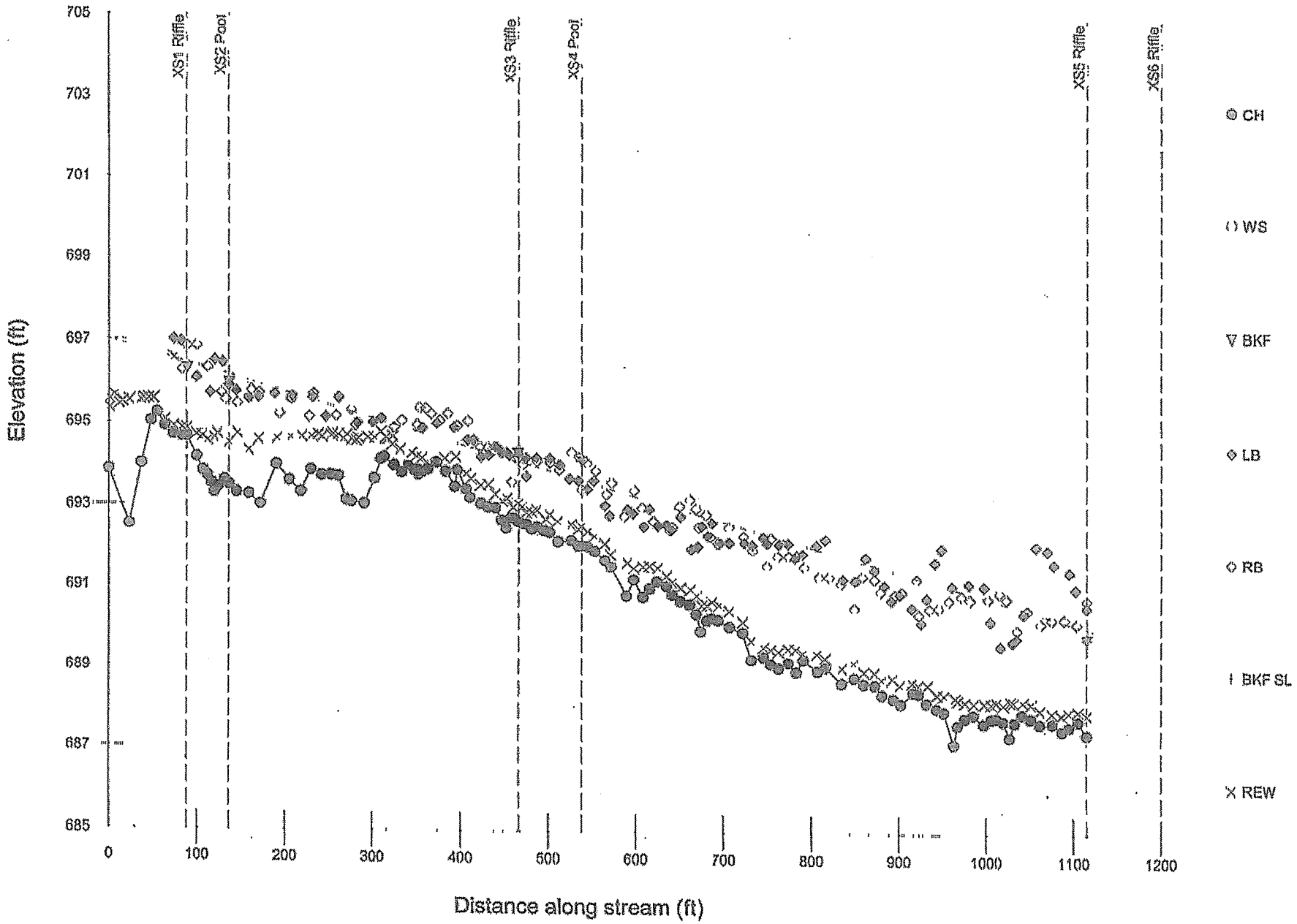
0 500 1,000 2,000 Feet

FIGURE

3


Legend
PROJECT AREA
MAP WATER AREA
MAP WATER LINE
MAP BASE FLOOD ELEVATION
MAP XS LINE NO.
PURITAN LANE
COTTONWOOD LANE
BECKNER STREET
SIDES STREET
BRIDLE PATH
WINTERBERRY RIDGE COURT
ROLLING VILLAGE LANE
CORDOVA DRIVE
BRYN MAWR LANE
STRATFORD ROAD
BRUCE STREET
STADIUM DRIVE
CHERRYMON ROAD
COOK PLACE DRIVE
ELM STREET
ARDEN DRIVE
HAYWOOD STREET
ARDEN CIRCLE
HAMPTON ROAD
HANES WAY
ARDEN STREET
OUR CIRCLE
CLOUDS HARBOR TRAIL
RAILROAD
CLARKSBURG ROAD
WINDRIFT COURT
ORCHARD PATH DRIVE
SINK DAIRY ROAD
PINE LEAF COURT
SPIGAL WOOD DRIVE
SUNNY RIDGE TRAIL
705
703
702
701
699
698
697
Zone X
Zone AE
Zone 0.2 PCT ANNUAL CHANCE FLOOD HAZARD
PREPARED FOR:
FEMA FLOOD MAP
J-270: STREAM RESTORATION
FORSYTH COUNTY, NORTH CAROLINA
GRAPHIC SCALE
0 250 500 1,000 Feet
FIGURE
4

U-2707 Existing Conditions Longitudinal Profile Reach 1



RIVERMORPH PROFILE SUMMARY

River Name: UT to Muddy Creek
Reach Name: Existing Conditions
Profile Name: Longitudinal Profile
Survey Date: 06/29/2011

Survey Data

DIST	CH	WS	BKF	LB	RB	BKF SL	REW
0	693.86						
0.625							695.585
0.795							695.353
6.222							695.661
11.832							695.451
15.196							695.501
15.91							695.508
23.074	692.516						
23.074							695.545
35.993							695.56
36.912	694.001						
39.507							695.59
44.881							695.587
47.663	695.034						
50.396							695.575
50.837							695.603
54.722	695.233						
63.645	694.927						
63.749							695.075
73.117							694.928
73.2	694.716						
73.794							696.585
74.078				697.024			
81.249				696.974			
82.706							694.882
82.877	694.668						
83.024					696.285		
88.5	694.665		696.299		696.869		694.87
99.124				696.086			
99.525							694.727
99.892	694.174						
99.892					696.881		
106.129							694.688
106.979	693.842						
111.923	693.713						
111.923							694.588
111.923					696.35		
114.753				695.735			
116.742	693.546						
120.095							694.643
120.095	693.327						
120.095				696.526			
123.141							694.746
124.212	693.447						
127.768					695.745		
128.083				696.468			

331.674
333.534
333.534 693.833
341.028 693.983
344.937
347.63 693.888
350.418
350.989
351.841 693.909
352.811 693.785
353.7
356.197
356.197 693.848
356.197
360.804
363.215 693.916
366.921
373.203 694.087
373.203
376.582
382.241
383.637 693.86
385.519
392.281
394.032 693.489
394.708
396.542 693.895
396.542
406.39 693.427
406.39
407.997
408.593
411.161 693.223
412.037
414.26
421.844
423.082
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423.112 693.091
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431.771
431.95
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439.792
440.087 692.974
440.898
447.108 692.673
447.108
447.599
447.965
451.908 692.477
453.145
453.145
455.345
457.389 692.731
458.313
460.023
461.541 692.719
461.805
465.5 692.641

694.404
695.1
694.318
694.232
694.992
695.413
694.921
694.193
695.4
695.264
695.039
695.1
694.189
695.283
694.947
694.231
694.983
693.818
694.636
695.107
693.689
694.637
694.472
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694.27
694.468
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693.155
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693.216
694.274
693.628
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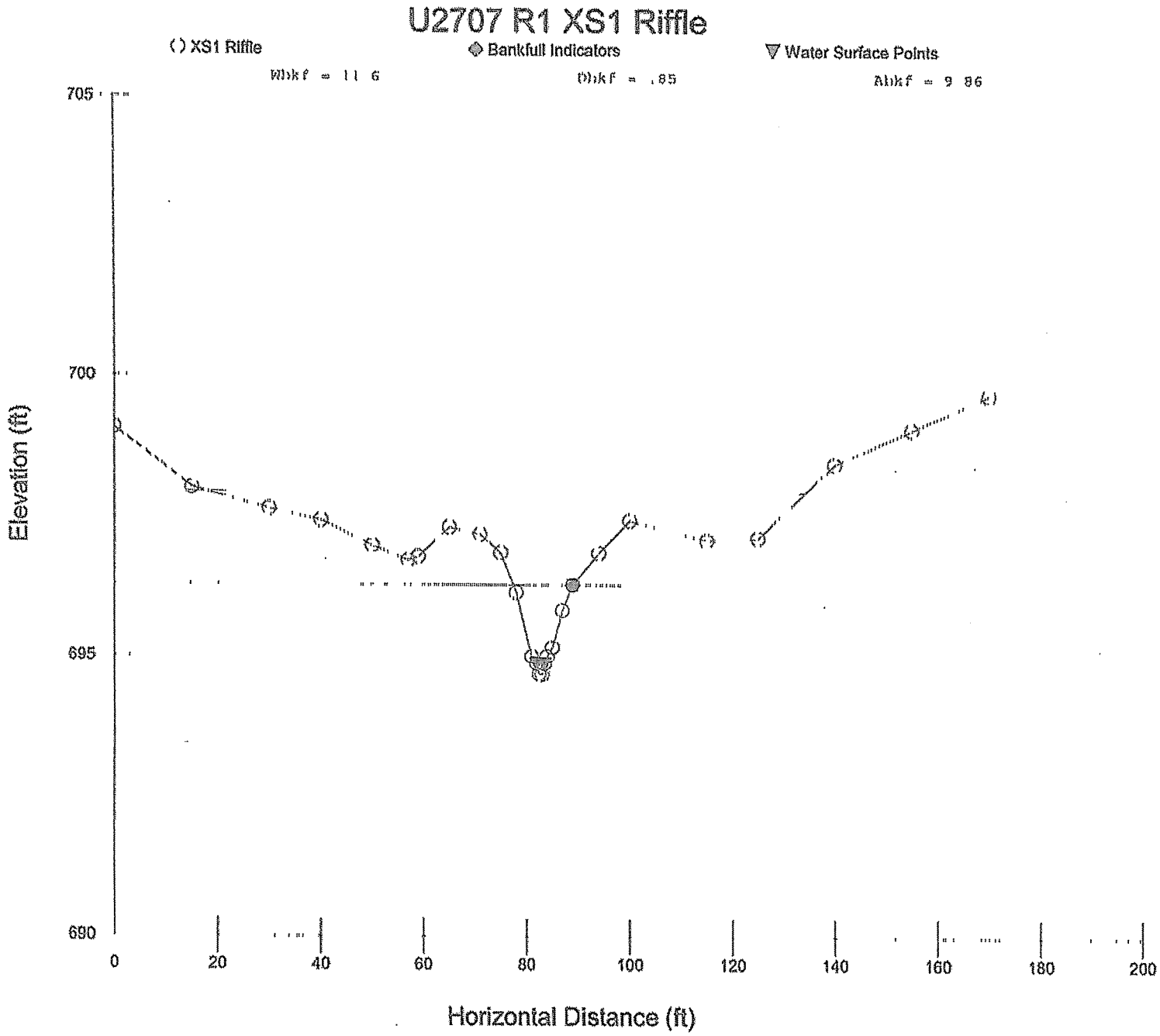
694.318 694.318 694.21 694.318 693.093

625.309
635.241
635.241
635.241 691.053
639.735
640.767
641.297
641.691 690.848
641.736
650.351
650.769 690.701
650.95
651.129
661.495
661.495 690.612
662.436
663.46
668.731
669.118 690.381
669.382
671.086
671.777
674.104 689.955
674.957
675.335
680.051
680.753 690.225
681.12
682.151
685.566
686.997
686.997 690.274
686.997
693.424
693.924 690.233
695.323
695.537
705.96
706.456
706.756
707.13 690.071
722.031 689.925
722.184
722.943
723.709
731.686
731.904 689.253
732.747
733.164
745.342
745.836 689.319
745.836
749.539
749.97
753.833
754.193 689.151
754.193
762.004
762.787
763.028 689.046
763.028

692.564
692.584
692.456
692.468
692.528
693.056
692.803
693.23
691.985
693.003
692.052
692.542
692.563
692.856
692.329
692.309
692.646
692.137
692.141
692.541
692.155
692.317
692.153
692.102
691.973
692.299
691.573
692.149
692.271
691.827
692.123

691.314
691.153
691.021
690.982
690.833
690.586
690.595
690.676
690.603
690.457
690.19
689.726
689.559
689.499
689.452

957.256			690.742			
960.778		691.1				
962.98	687.184					
964.518					688.335	
967.327	687.656					
967.836					688.282	
971.514			690.857			
975.646	687.834					
975.995					688.236	
980.071		691.151				
981.588			690.764			
985.416	687.921					
985.997					688.206	
997.44		691.088				
997.44	687.703					
998.031					688.206	
1001.877			690.787			
1005.131		690.245				
1006.051					688.196	
1006.249	687.822					
1011.827					688.239	
1011.827	687.846					
1015.221			690.939			
1016.241		689.619				
1019.807	687.764					
1019.807					688.177	
1023.383			690.792			
1026.997	687.379					
1027.94					688.254	
1030.424		689.739				
1031.593					688.248	
1032.83	687.738					
1035.472		689.825				
1035.601			690.031			
1041.331	687.937					
1042.459					688.245	
1043.257		690.429				
1047.057			690.508			
1051.403	687.839					
1051.518					688.201	
1056.684		692.099				
1061.414	687.705					
1061.725					688.05	
1062.482			690.197			
1069.657		691.999				
1075.188			690.292			
1075.529					687.982	
1076.185	687.725					
1077.718		691.654				
1086.712					687.934	
1087.274	687.538					
1089.763			690.297			
1094.75					687.992	
1094.998	687.641					
1095.412		691.461				
1102.243		691.038				
1103.956			690.189			
1105.034					688.029	
1105.204	687.774					
1115	687.445	689.806	690.588	690.765	689.806	687.945


U2707 R1 XS1 Riffle
() XS1 Riffle
Bankfull Indicators
Water Surface Points
Wbkf = 11 6
Dbkf = .85
Abkf = 9 86
705
700
695
690
Elevation (ft)
0
20
40
60
80
100
120
140
160
180
200
Horizontal Distance (ft)

RIVERMORPH CROSS SECTION SUMMARY

River Name: UT to Muddy Creek
Reach Name: Existing Conditions
Cross Section Name: XS1 Riffle
Survey Date: 06/14/2011

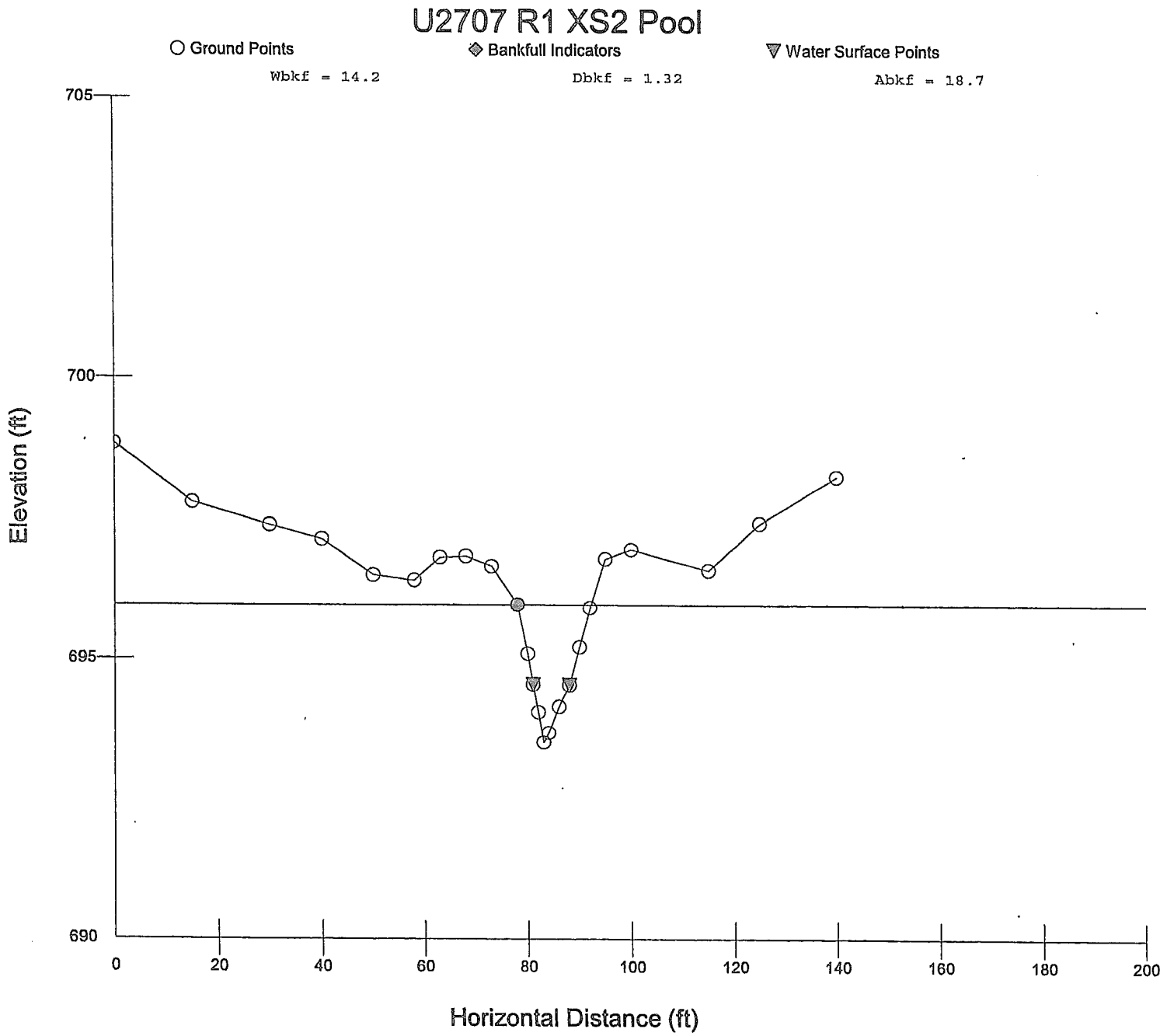
Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	699.0642	GS
15	0	698.0063	GS
30	0	697.6342	GS
40	0	697.4325	GS
50	0	696.9929	GS
57	0	696.7344	GS
59	0	696.7981	GS
65	0	697.3121	GS
71	0	697.1896	LB
75	0	696.8689	GS
78	0	696.1681	GS
81	0	694.9963	GS
82	0	694.8701	LEW
82.5	0	694.6763	TW
83	0	694.665	SB
83.5	0	694.8619	REW
84	0	694.9972	GS
85	0	695.1601	GS
87	0	695.8468	GS
89	0	696.2988	BKF
94	0	696.8665	GS
100	0	697.4391	RB
115	0	697.0983	GS
125	0	697.1365	GS
140	0	698.434	GS
155	0	699.0594	GS
170	0	699.6787	GS

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	697.94	697.94	697.94
Bankfull Elevation (ft)	696.3	696.3	696.3
Floodprone Width (ft)	116.36	-----	-----
Bankfull Width (ft)	11.58	5.35	6.22
Entrenchment Ratio	10.05	-----	-----
Mean Depth (ft)	0.85	0.9	0.81
Maximum Depth (ft)	1.63	1.63	1.63
Width/Depth Ratio	13.62	5.94	7.68
Bankfull Area (sq ft)	9.86	4.79	5.07
Wetted Perimeter (ft)	12.00	7.27	8.08


U2707 R1 XS2 Pool
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 14.2
Dbkf = 1.32
Abkf = 18.7
705
700
695
690
Elevation (ft)
0
20
40
60
80
100
120
140
160
180
200
Horizontal Distance (ft)

RIVERMORPH CROSS SECTION SUMMARY

River Name: UT to Muddy Creek
Reach Name: Existing Conditions
Cross Section Name: XS2 Pool
Survey Date: 06/14/2011

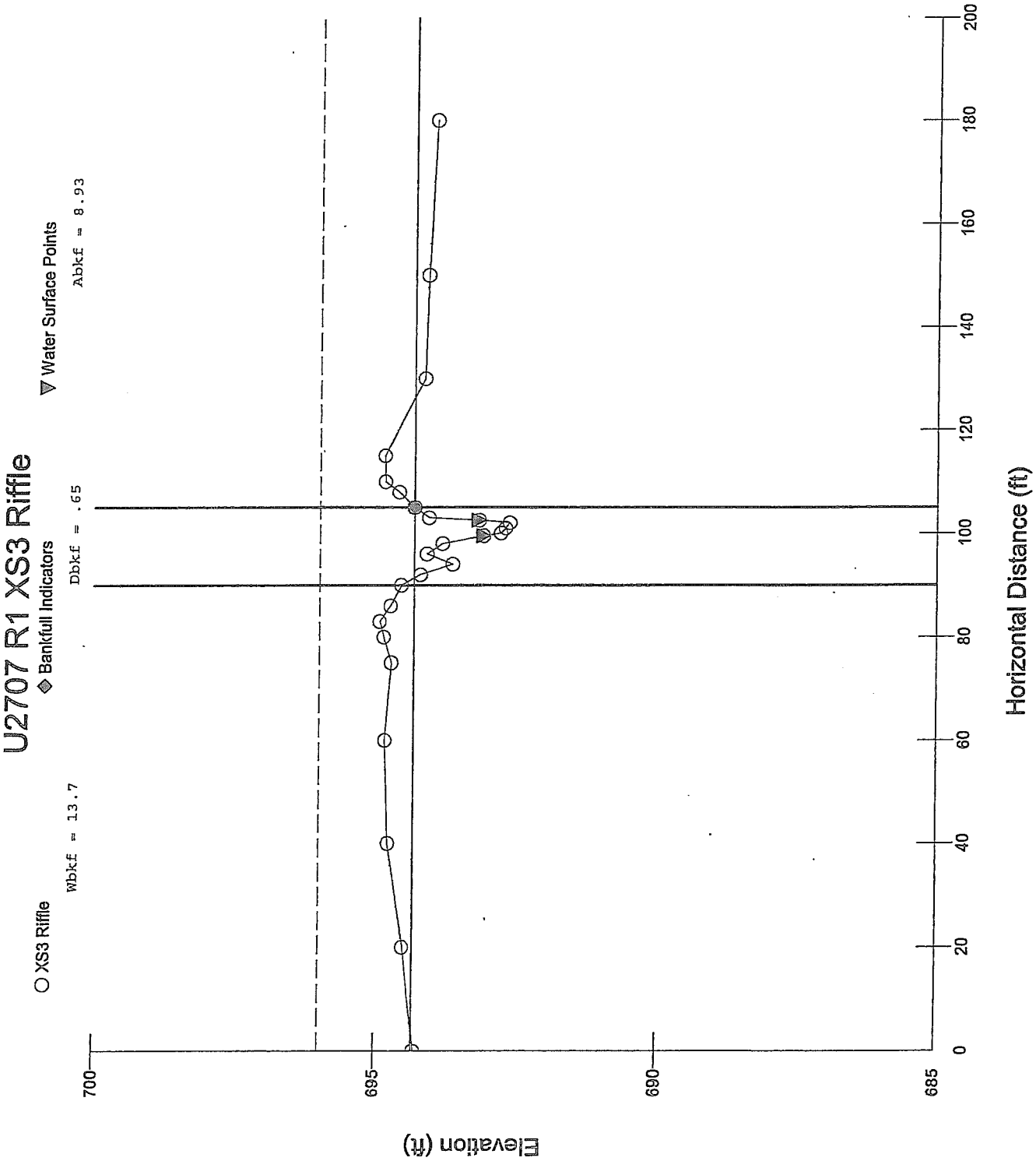
Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	698.8197	GS
15	0	697.7803	GS
30	0	697.3835	GS
40	0	697.1321	GS
50	0	696.4967	GS
58	0	696.4032	GS
63	0	696.8045	GS
68	0	696.83	GS
73	0	696.6516	GS
78	0	695.9671	BKF
80	0	695.0878	GS
81	0	694.5389	LEW
82	0	694.0439	SB
83	0	693.5011	TW
84	0	693.6753	SB
86	0	694.1423	SB
88	0	694.5287	REW
90	0	695.2058	GS
92	0	695.9111	RB
95	0	696.7802	GS
100	0	696.951	GS
115	0	696.5771	GS
125	0	697.406	GS
140	0	698.2313	GS

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	698.44	698.44	698.44
Bankfull Elevation (ft)	695.97	695.97	695.97
Floodprone Width (ft)	134.5	-----	-----
Bankfull Width (ft)	14.22	7.11	7.11
Entrenchment Ratio	9.46	-----	-----
Mean Depth (ft)	1.32	1.5	1.13
Maximum Depth (ft)	2.47	2.47	2.04
Width/Depth Ratio	10.77	4.74	6.29
Bankfull Area (sq ft)	18.73	10.66	8.06
Wetted Perimeter (ft)	15.15	9.78	9.45
Hydraulic Radius (ft)	1.24	1.09	0.85
Begin BKF Station	77.98	77.98	85.09
End BKF Station	92.2	85.09	92.2


U2707 R1 XS3 Riffle
XS3 Riffle
Bankfull Indicators
Water Surface Points
Wbkf = 13.7
Dbkf = .65
Abkf = 8.93
Elevation (ft)
Horizontal Distance (ft)
700
695
690
685
0
20
40
60
80
100
120
140
160
180
200

RIVERMORPH CROSS SECTION SUMMARY

River Name: UT to Muddy Creek
Reach Name: Existing Conditions
Cross Section Name: XS3 Riffle
Survey Date: 06/14/2011

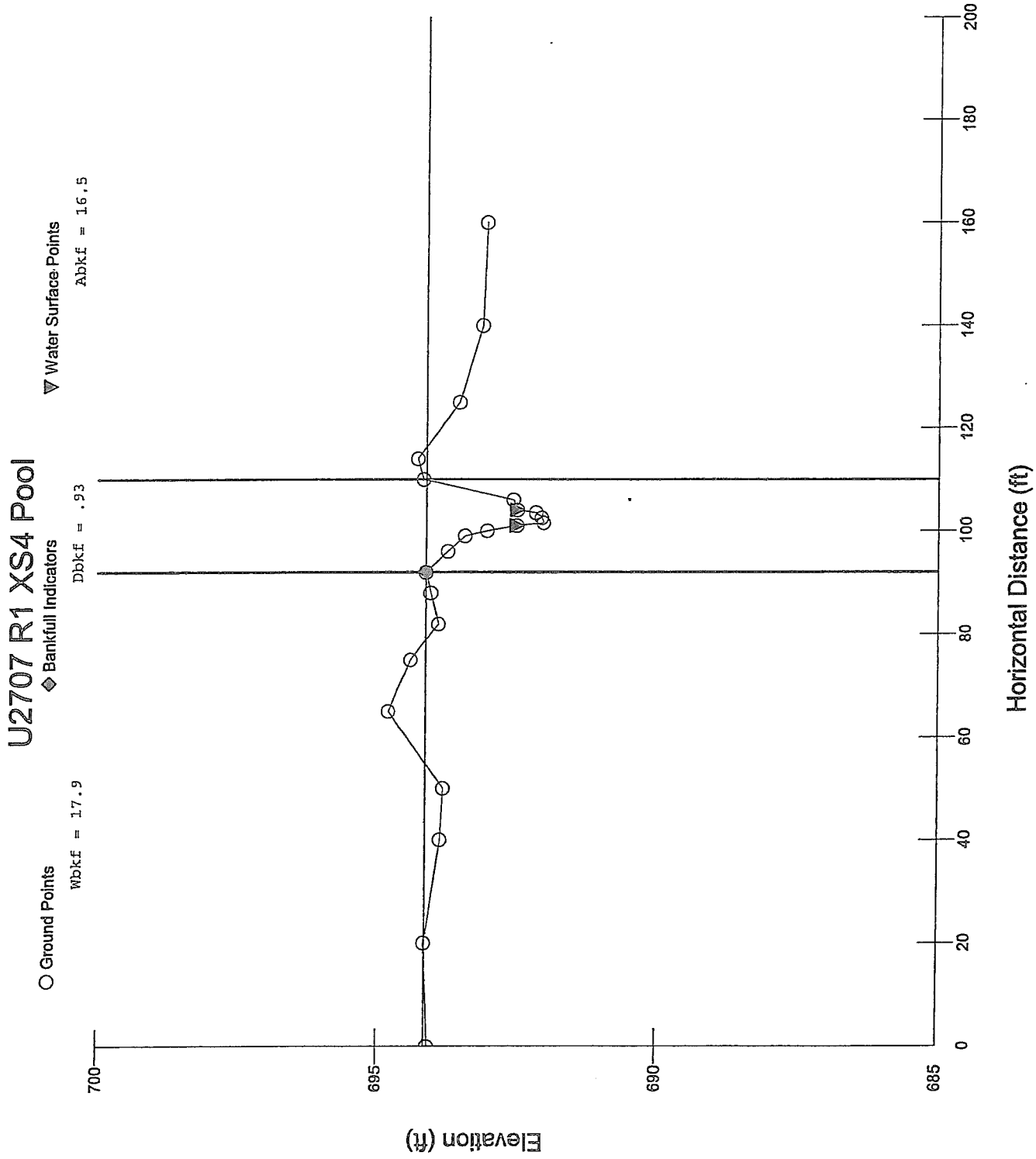
Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	694.281	GS
20	0	694.4926	GS
40	0	694.768	GS
60	0	694.8287	GS
75	0	694.7147	GS
80	0	694.8549	GS
83	0	694.9303	LB
86	0	694.7372	GS
90	0	694.5439	GS
92	0	694.2099	GS
94	0	693.6444	GS
96	0	694.098	GS
98	0	693.8268	GS
99.5	0	693.0932	LEW
100	0	692.7944	SB
101	0	692.7124	SB
102	0	692.6413	TW
102.5	0	693.1772	REW
103	0	694.0695	GS
105	0	694.318	BKF
108	0	694.5922	GS
110	0	694.843	RB
115	0	694.8506	GS
130	0	694.1478	GS
150	0	694.0967	GS
180	0	693.961	GS

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	696	696	696
Bankfull Elevation (ft)	694.32	694.32	694.32
Floodprone Width (ft)	180	-----	-----
Bankfull Width (ft)	13.66	9.09	4.57
Entrenchment Ratio	13.18	-----	-----
Mean Depth (ft)	0.65	0.56	0.84
Maximum Depth (ft)	1.68	1.56	1.68
Width/Depth Ratio	21.02	16.23	5.44
Bankfull Area (sq ft)	8.93	5.08	3.85
Wetted Perimeter (ft)	14.85	11.06	6.91
Hydraulic Radius (ft)	0.6	0.46	0.56


U2707 R1 XS4 Pool
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 17.9
Dbkf = .93
Abkf = 16.5
Elevation (ft)
Horizontal Distance (ft)
700
695
690
685
0
20
40
60
80
100
120
140
160
180
200

RIVERMORPH CROSS SECTION SUMMARY

River Name: UT to Muddy Creek
Reach Name: Existing Conditions
Cross Section Name: XS4 Pool
Survey Date: 06/14/2011

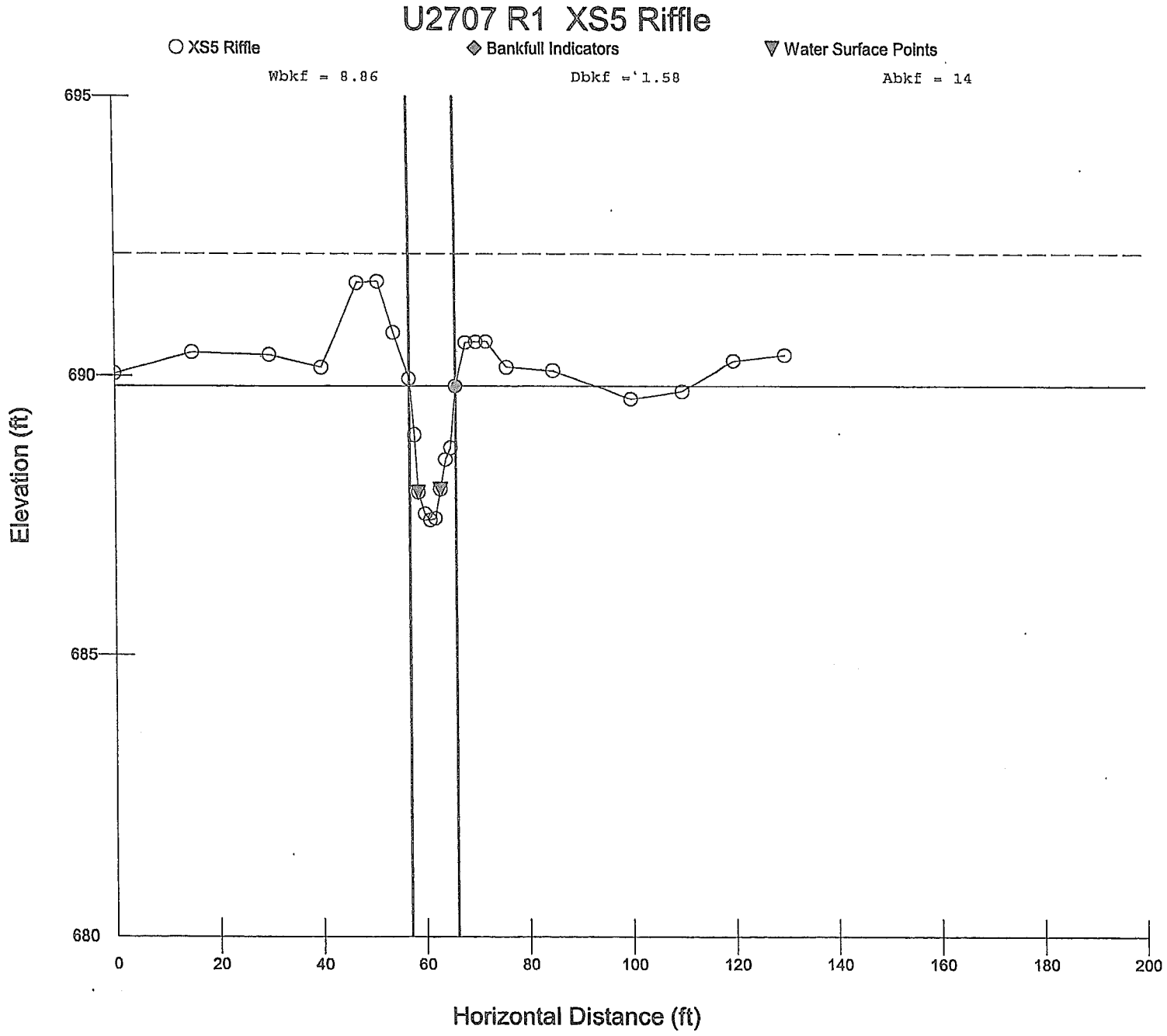
Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	694.0738	GS
20	0	694.1469	GS
40	0	693.8737	GS
50	0	693.8238	GS
65	0	694.796	GS
75	0	694.4041	GS
82	0	693.9102	GS
88	0	694.0461	GS
92	0	694.1282	BKF
96	0	693.7505	GS
99	0	693.4465	GS
100	0	693.057	GS
101	0	692.5303	LEW
101.5	0	692.0527	TW
102.5	0	692.086	SB
103.5	0	692.191	SB
104	0	692.522	REW
106	0	692.5926	GS
110	0	694.18253	RB
114	0	694.283555	GS
125	0	693.552789	GS
140	0	693.149204	GS
160	0	693.080396	GS

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	696.21	696.21	696.21
Bankfull Elevation (ft)	694.13	694.13	694.13
Floodprone Width (ft)	160	-----	-----
Bankfull Width (ft)	17.87	11.58	6.29
Entrenchment Ratio	8.95	-----	-----
Mean Depth (ft)	0.93	0.84	1.09
Maximum Depth (ft)	2.08	2.08	1.89
Width/Depth Ratio	19.22	13.79	5.77
Bankfull Area (sq ft)	16.55	9.7	6.85
Wetted Perimeter (ft)	18.7	13.92	8.55
Hydraulic Radius (ft)	0.88	0.7	0.8
Begin BKF Station	92	92	103.58
End BKF Station	109.87	103.58	109.87


U2707 R1 XS5 Riffle
XS5 Riffle
Bankfull Indicators
Water Surface Points
Wbkf = 8.86
Dbkf = 1.58
Abkf = 14
695
690
685
680
Elevation (ft)
0
20
40
60
80
100
120
140
160
180
200
Horizontal Distance (ft)

RIVERMORPH CROSS SECTION SUMMARY

River Name: UT to Muddy Creek
Reach Name: Existing Conditions
Cross Section Name: XS5 Riffle
Survey Date: 06/14/2011

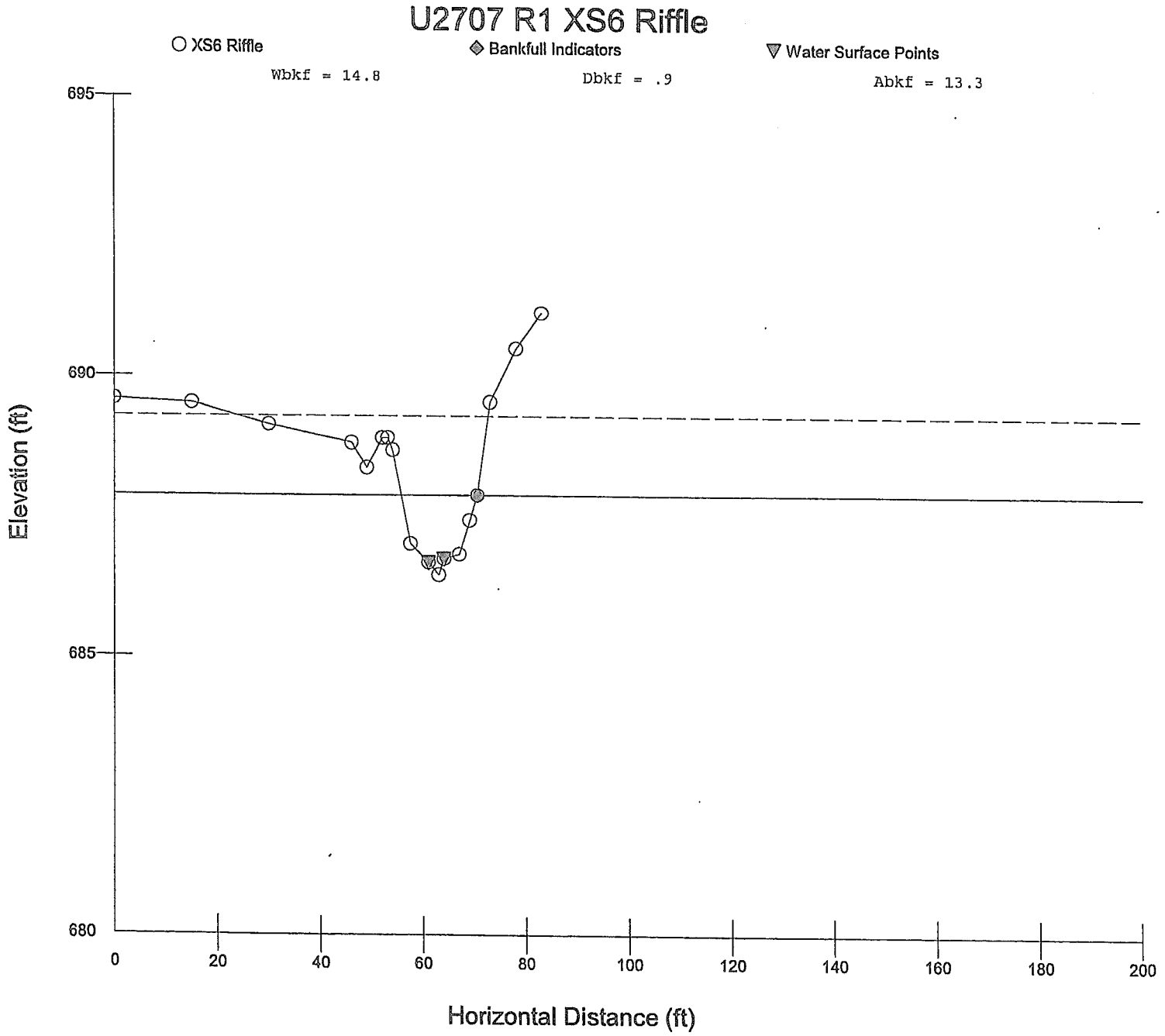
Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	690.032	GS
15	0	690.4106	GS
30	0	690.3663	GS
40	0	690.1402	GS
47	0	691.6543	GS
51	0	691.681	LB
54	0	690.765	GS
57	0	689.9441	GS
58	0	688.9531	GS
58.7	0	687.9453	LEW
60	0	687.5588	SB
61	0	687.4447	TW
62	0	687.4768	SB
63	0	687.9997	REW
64	0	688.5247	GS
65	0	688.7279	GS
66	0	689.8061	BKF
68	0	690.5877	RB
70	0	690.5979	GS
72	0	690.606	GS
76	0	690.1461	GS
85	0	690.0836	GS
100	0	689.5855	GS
110	0	689.7192	GS
120	0	690.2572	GS
130	0	690.3618	GS

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	692.18	692.18	692.18
Bankfull Elevation (ft)	689.81	689.81	689.81
Floodprone Width (ft)	130	-----	-----
Bankfull Width (ft)	8.86	1.93	6.93
Entrenchment Ratio	14.66	-----	-----
Mean Depth (ft)	1.58	1.05	1.73
Maximum Depth (ft)	2.37	1.97	2.37
Width/Depth Ratio	5.61	1.84	4.01
Bankfull Area (sq ft)	14	2.03	11.97
Wetted Perimeter (ft)	10.56	4.81	9.7
Hydraulic Radius (ft)	1.33	0.42	1.23


U2707 R1 XS6 Riffle
XS6 Riffle
Bankfull Indicators
Water Surface Points
Wbkf = 14.8
Dbkf = .9
Abkf = 13.3
695
690
685
680
Elevation (ft)
0
20
40
60
80
100
120
140
160
180
200
Horizontal Distance (ft)

RIVERMORPH CROSS SECTION SUMMARY

River Name: UT to Muddy Creek
Reach Name: Existing Conditions
Cross Section Name: XS6 Riffle
Survey Date: 06/14/2011

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

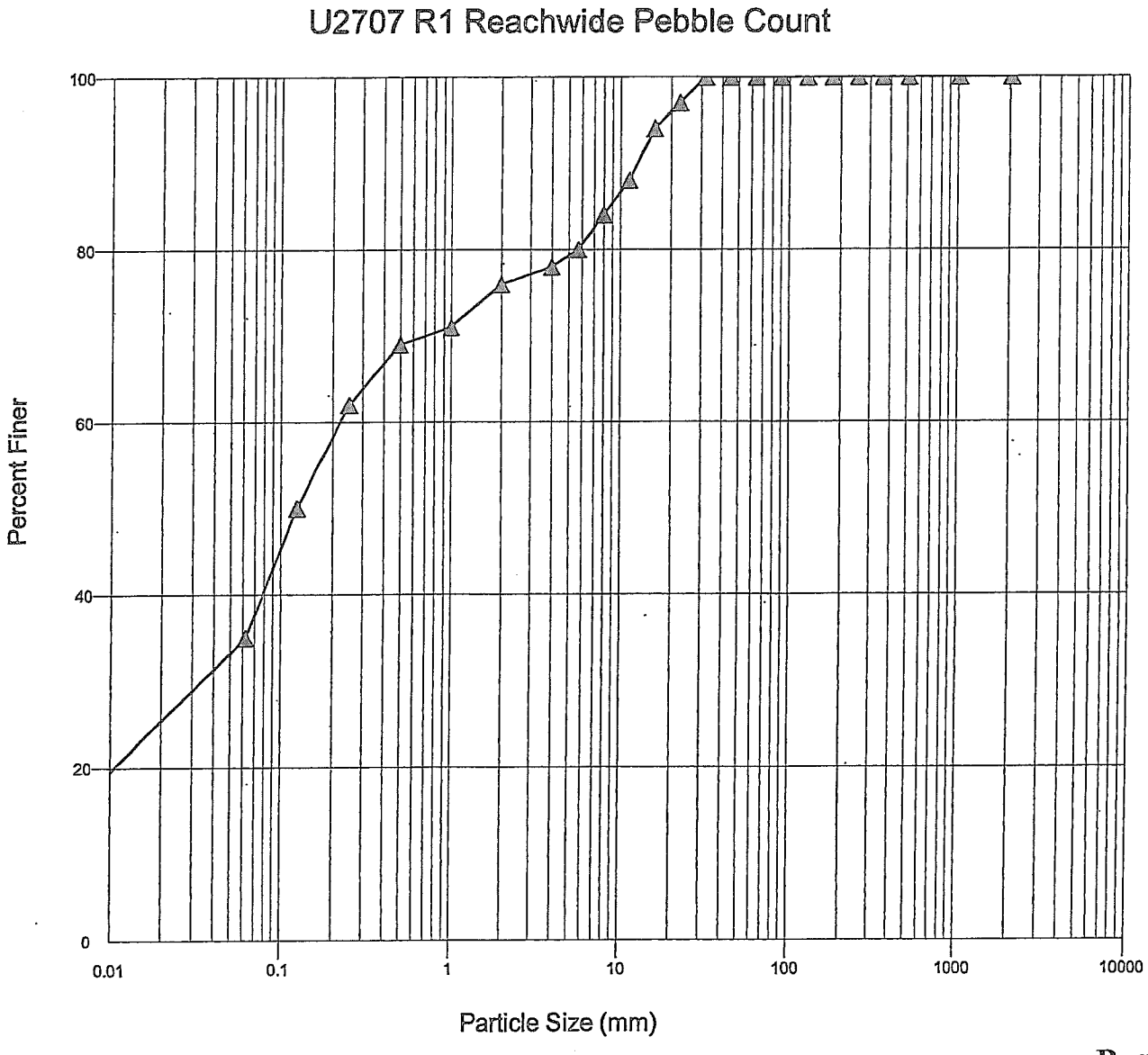
TAPE	FS	ELEV	NOTE
0	0	689.5793	GS
15	0	689.5134	GS
30	0	689.1252	GS
46	0	688.8049	GS
49	0	688.3591	GS
52	0	688.8873	GS
53	0	688.8949	LB
54	0	688.6721	GS
57.5	0	687.0096	GS
61	0	686.678	LEW
63	0	686.4578	TW
64	0	686.7395	REW
67	0	686.8219	GS
69	0	687.4243	GS
70.5	0	687.866	BKF
73	0	689.537	GS
78	0	690.4895	GS
83	0	691.1334	GS

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	689.28	689.28	689.28
Bankfull Elevation (ft)	687.87	687.87	687.87
Floodprone Width (ft)	48.69	-----	-----
Bankfull Width (ft)	14.82	7.12	7.7
Entrenchment Ratio	3.29	-----	-----
Mean Depth (ft)	0.9	0.94	0.86
Maximum Depth (ft)	1.41	1.39	1.41
Width/Depth Ratio	16.47	7.57	8.95
Bankfull Area (sq ft)	13.35	6.71	6.64
Wetted Perimeter (ft)	15.23	8.73	9.28
Hydraulic Radius (ft)	0.88	0.77	0.71
Begin BKF Station	55.69	55.69	62.81
End BKF Station	70.51	62.81	70.51

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve


U2707 R1 Reachwide Pebble Count
Percent Finer
100
80
60
40
20
0
0.01
0.1
1
10
100
1000
10000
Particle Size (mm)

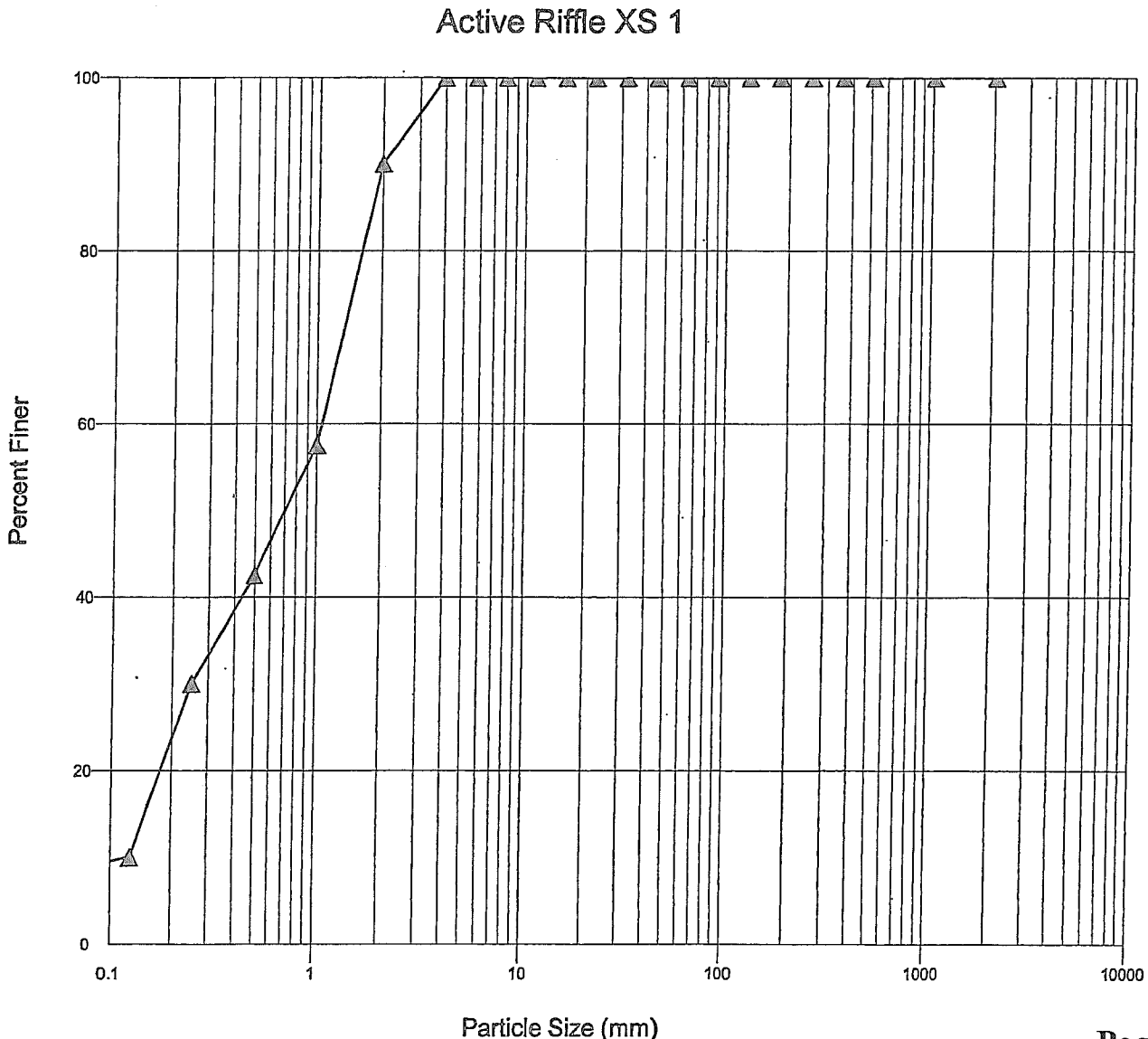
RIVERMORPH PARTICLE SUMMARY

River Name: UT to Muddy Creek
Reach Name: Existing Conditions
Sample Name: U2707 R1 Reachwide
Survey Date: 06/14/2011

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	35	35.00	35.00
0.062 - 0.125	15	15.00	50.00
0.125 - 0.25	12	12.00	62.00
0.25 - 0.50	7	7.00	69.00
0.50 - 1.0	2	2.00	71.00
1.0 - 2.0	5	5.00	76.00
2.0 - 4.0	2	2.00	78.00
4.0 - 5.7	2	2.00	80.00
5.7 - 8.0	4	4.00	84.00
8.0 - 11.3	4	4.00	88.00
11.3 - 16.0	6	6.00	94.00
16.0 - 22.6	3	3.00	97.00
22.6 - 32.0	3	3.00	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)	0.03
D35 (mm)	0.06
D50 (mm)	0.13
D84 (mm)	8
D95 (mm)	18.2
D100 (mm)	32
Silt/Clay (%)	35
Sand (%)	41
Gravel (%)	24
Cobble (%)	0
Boulder (%)	0
Bedrock (%)	0

Total Particles = 100.


Active Riffle XS 1
Percent Finer
100
80
60
40
20
0
0.1
1
10
100
1000
10000
Particle Size (mm)

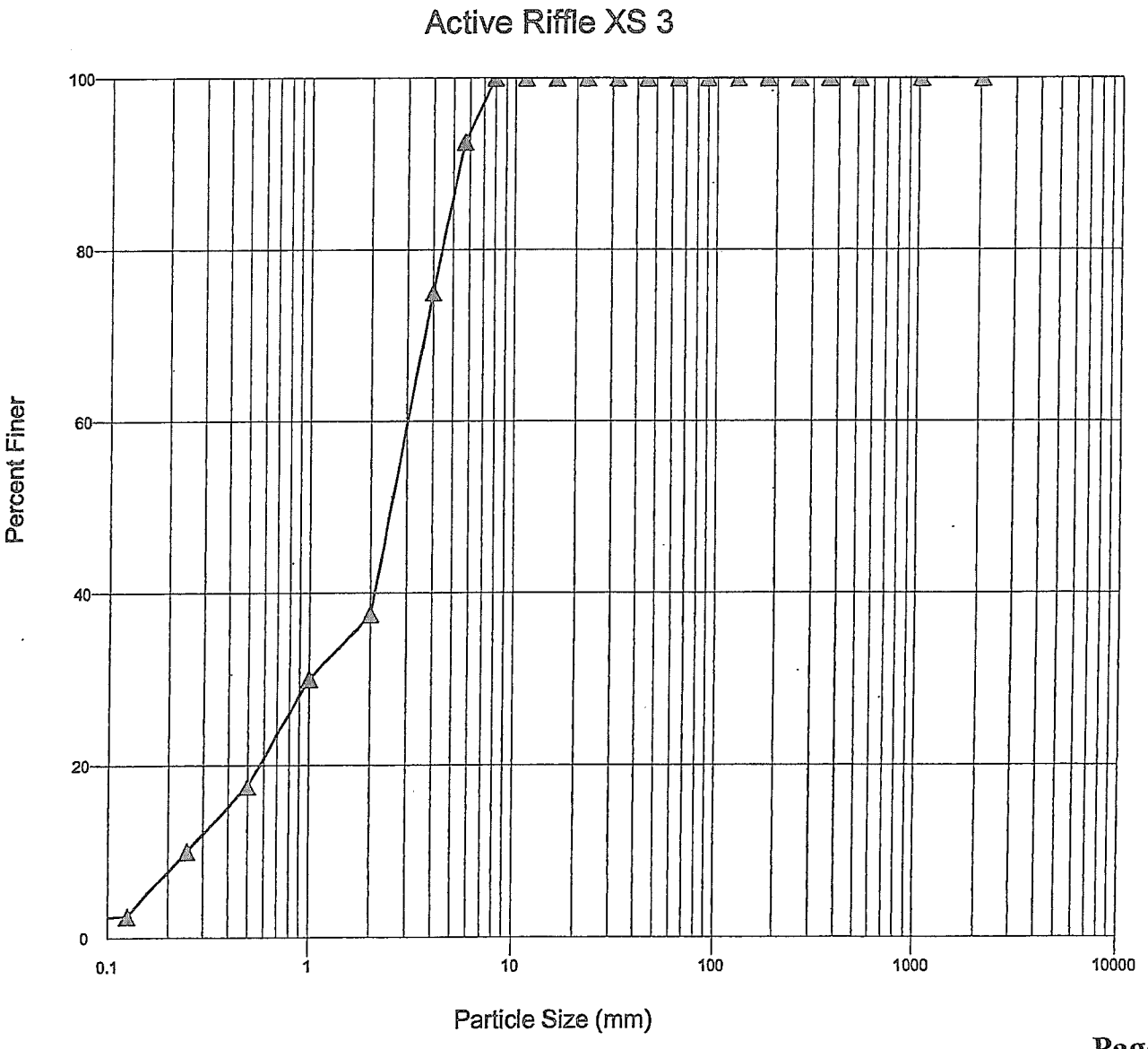
RIVERMORPH PARTICLE SUMMARY

River Name: UT to Muddy Creek
Reach Name: Existing Conditions
Sample Name: Active Riffle XS 1
Survey Date: 11/30/2011

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	0	0.00	0.00
0.062 - 0.125	4	10.00	10.00
0.125 - 0.25	8	20.00	30.00
0.25 - 0.50	5	12.50	42.50
0.50 - 1.0	6	15.00	57.50
1.0 - 2.0	13	32.50	90.00
2.0 - 4.0	4	10.00	100.00
4.0 - 5.7	0	0.00	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)	0.16
D35 (mm)	0.35
D50 (mm)	0.75
D84 (mm)	1.82
D95 (mm)	3
D100 (mm)	4
Silt/Clay (%)	0
Sand (%)	90
Gravel (%)	10
Cobble (%)	0
Boulder (%)	0
Bedrock (%)	0

Total Particles = 40 (need at least 60).


Active Riffle XS 3
Percent Finer
100
80
60
40
20
0
0.1
1
10
100
1000
10000
Particle Size (mm)

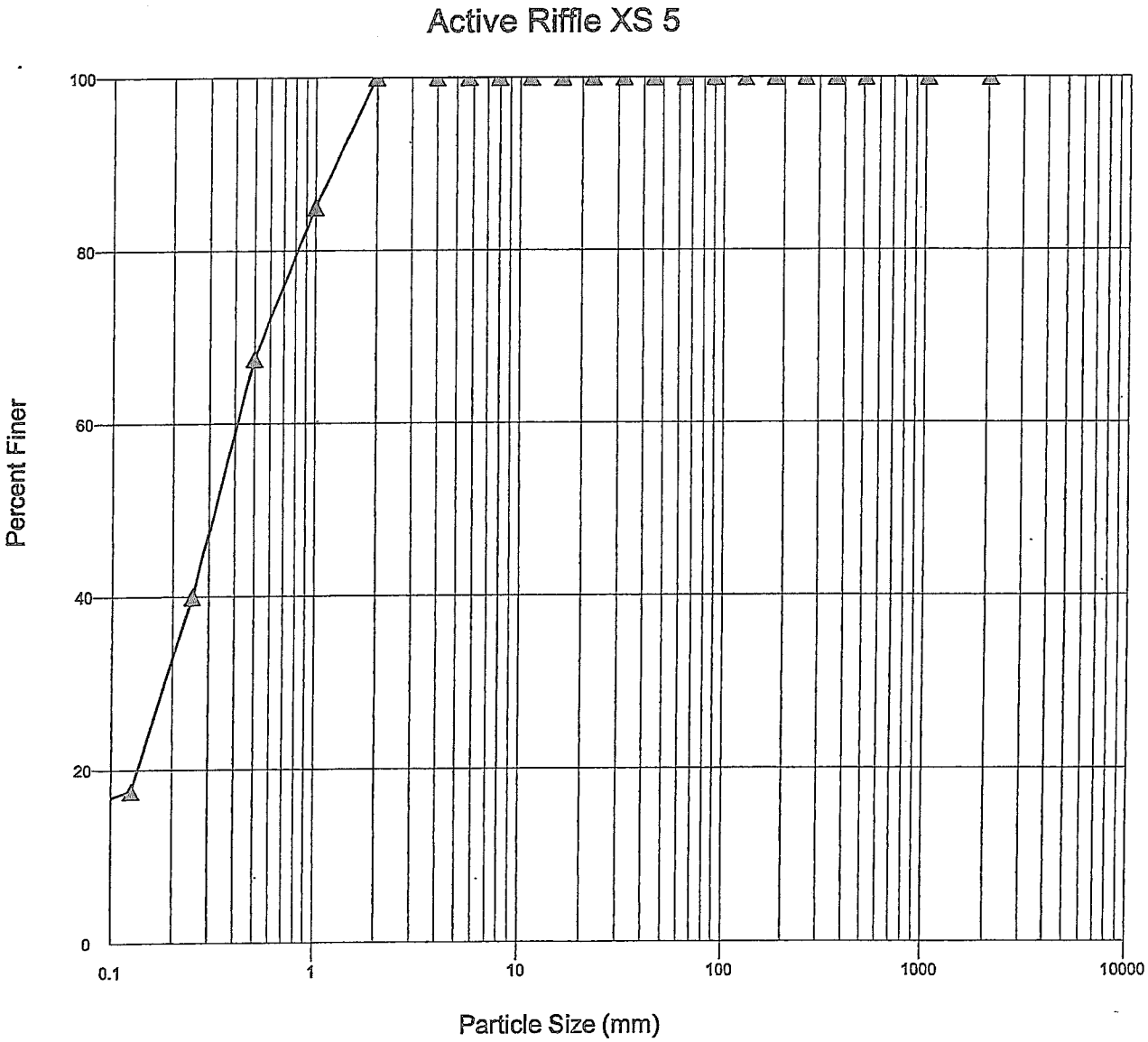
RIVERMORPH PARTICLE SUMMARY

River Name: UT to Muddy Creek
Reach Name: Existing Conditions
Sample Name: Active Riffle XS 3
Survey Date: 11/30/2011

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	0	0.00	0.00
0.062 - 0.125	1	2.50	2.50
0.125 - 0.25	3	7.50	10.00
0.25 - 0.50	3	7.50	17.50
0.50 - 1.0	5	12.50	30.00
1.0 - 2.0	3	7.50	37.50
2.0 - 4.0	15	37.50	75.00
4.0 - 5.7	7	17.50	92.50
5.7 - 8.0	3	7.50	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)	0.45
D35 (mm)	1.67
D50 (mm)	2.67
D84 (mm)	4.87
D95 (mm)	6.47
D100 (mm)	8
Silt/Clay (%)	0
Sand (%)	37.5
Gravel (%)	62.5
Cobble (%)	0
Boulder (%)	0
Bedrock (%)	0

Total Particles = 40 (need at least 60).


Active Riffle XS 5
Percent Finer
100
80
60
40
20
0
0.1
1
10
100
1000
10000
Particle Size (mm)

RIVERMORPH PARTICLE SUMMARY

River Name: UT to Muddy Creek
Reach Name: Existing Conditions
Sample Name: Active Riffle XS 5
Survey Date: 11/30/2011

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	0	0.00	0.00
0.062 - 0.125	7	17.50	17.50
0.125 - 0.25	9	22.50	40.00
0.25 - 0.50	11	27.50	67.50
0.50 - 1.0	7	17.50	85.00
1.0 - 2.0	6	15.00	100.00
2.0 - 4.0	0	0.00	100.00
4.0 - 5.7	0	0.00	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)	0.12
D35 (mm)	0.22
D50 (mm)	0.34
D84 (mm)	0.97
D95 (mm)	1.67
D100 (mm)	2
Silt/Clay (%)	0
Sand (%)	100
Gravel (%)	0
Cobble (%)	0
Boulder (%)	0
Bedrock (%)	0

Total Particles = 40 (need at least 60).

Entrainment Calculation Form

Status:	Existing Conditions	Location:	Forsythe Co.
Project:	U-270	Reach:	Rla, XS 3, Pebble Count Riffle 3
Date:	7/22/2011	Observers:	EMP

Value	Variable	Definition		
Required Information for Entrainment Analysis				
2.7	D_{50} (mm)	D_{50} from Riffle (1) or Pavement (2)	Riffle	Select Sample Type
0.1	D^*_{50} (mm)	D_{50} from Bar Sample (1) or Subpavement (2)	Bar Sample	
6	D_i (mm)	Largest Particle from Bar Sample (1) or Pavement (2)	Bar Sample	
0.020	D_i (ft)	D_i (mm) ÷ 304.8 (mm/ft)		
0.006	S (ft/ft)	Bankfull Water Surface Slope		
0.65	d (ft)	Bankfull Mean Depth		
8.93	A (ft^2)	Bankfull Cross Sectional Area		
14.85	W_p (ft)	Wetted Perimeter		
1.65	γ_s	Submerged Specific Weight of Sediment (1.65)		
62.4	γ (lbs/ft^3)	Density of Water (62.4)		
Calculation of Critical Dimensionless Shear Stress				
27.00	D_{50}/D^*_{50}	Range 3-7	Use Equation 1: $\tau^*_c = 0.0834(D_{50}/D^*_{50})^{-0.872}$	
2.22	D_i/D_{50}	Range 1.3-3.0	Use Equation 2: $\tau^*_c = 0.0384(D_i/D^*_{50})^{-0.887}$	
0.019	τ^*_c	Critical Dimensionless Shear Stress	Equation Used:	2
Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle				
0.102	d_c	Required Bankfull Mean Depth (ft)	$d_c = \frac{\tau^*_c \gamma_s D_i}{S}$	
6.349	d/d_c	Stability:	Degrading	
Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle				
0.001	S_c	Required Bankfull Water Surface Slope (ft/ft)	$S_c = \frac{\tau^*_c \gamma_s D_i}{d}$	
6.349	S/S_c	Stability:	Degrading	
Sediment Transport Validation - Bankfull Shear Stress				
0.60	R	Hydraulic Radius (ft)	$R = A/W_p$	
0.225	τ_c	Bankfull Shear Stress (lb/ft^2)	$\tau_c = \gamma RS$	
Y	Y or N	Is the Bed Material Homogeneous?		

Determine from reach wide pebble count distribution (Use your best judgement).
If homogeneous use "Leopold et. al" Curve Data, if heterogeneous use "Colorado" Curve Data.

16	mm	Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline.
0.085	lb/ft^2	Predicted Shear Stress (lbs/ft^2) Required To Move D_i predicted by the Leopold, Wolman, & Miller 1964 Power-trendline.
N/A	mm	Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline.
N/A	lb/ft^2	Predicted Shear Stress (lbs/ft^2) Required To Move D_i predicted by the Colorado Data Power-trendline.

Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

Entrainment Calculation Form

Status: Proposed, iteration 1
Project: U-270
Date: 7/22/2011

Location: Forsythe Co.
Reach: R1a, XS 3, Pebble Count Riffle 3
Observers: EMP

Value	Variable	Definition		
Required Information for Entrainment Analysis				
2.7	D_{50} (mm)	D_{50} from Riffle (1) or Pavement (2)	Riffle	Select Sample Type
0.1	D^*_{50} (mm)	D_{50} from Bar Sample (1) or Subpavement (2)	Bar Sample	
6	D_i (mm)	Largest Particle from Bar Sample (1) or Pavement (2)	Bar Sample	
0.020	D_i (ft)	D_i (mm) / 304.8 (mm/ft)		
0.008	S (ft/ft)	Bankfull Water Surface Slope		
0.84	d (ft)	Bankfull Mean Depth		
10	A (ft^2)	Bankfull Cross Sectional Area		
12.39	W_p (ft)	Wetted Perimeter		
1.65	γ_s	Submerged Specific Weight of Sediment (1.65)		
62.4	γ (lbs/ft^3)	Density of Water (62.4)		
Calculation of Critical Dimensionless Shear Stress				
27.00	D_{50}/D^*_{50}	Range 3-?	Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/D^*_{50})^{-0.872}$	
2.22	D_i/D_{50}	Range 1.3-3.0	Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/D^*_{50})^{-0.887}$	
0.019	τ^*_{ci}	Critical Dimensionless Shear Stress	Equation Used:	2
Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle				
0.077	d_c	Required Bankfull Mean Depth (ft) $d_c = \frac{\tau^*_{ci}\gamma_s D_i}{S}$		
10.940	d/d_c	Stability:	Degrading	
Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle				
0.001	S_c	Required Bankfull Water Surface Slope (ft/ft) $S_c = \frac{\tau^*_{ci}\gamma_s D_i}{d}$		
10.940	S/S_c	Stability:	Degrading	
Sediment Transport Validation - Bankfull Shear Stress				
0.81	R	Hydraulic Radius (ft) $R = A/W_p$		
0.403	τ_c	Bankfull Shear Stress (lb/ft^2) $\tau_c = \gamma RS$		
Y	Y or N	Is the Bed Material Homogeneous? **Determine from reach wide pebble count distribution (Use your best judgement).** If homogeneous use "Leopold et. al" Curve Data, if heterogeneous use "Colorado" Curve Data.		
30	mm	Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline.		
0.085	lb/ft^2	Predicted Shear Stress (lbs/ft^2) Required To Move D_i predicted by the Leopold, Wolman, & Miller 1964 Power-trendline.		
N/A	mm	Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline.		
N/A	lb/ft^2	Predicted Shear Stress (lbs/ft^2) Required To Move D_i predicted by the Colorado Data Power-trendline.		

*Taken from *The Reference Reach Field Book*. 2005 by Rosgen and Silvey

Entrainment Calculation Form

Status: Existing Conditions
Project: U-270
Date: 7/22/2011

Location: Forsythe Co.
Reach: R1b, XS 5, Pebble Count Riffle 3
Observers: EMP

Value	Variable	Definition		
Required Information for Entrainment Analysis				
2.7	D_{50} (mm)	D_{50} from Riffle (1) or Pavement (2)	Riffle	Select Sample Type
0.1	D^*_{50} (mm)	D_{50} from Bar Sample (1) or Subpavement (2)	Bar Sample	
6	D_i (mm)	Largest Particle from Bar Sample (1) or Pavement (2)	Bar Sample	
0.020	D_i (ft)	D_i (mm) / 304.8 (mm/ft)		
0.006	S (ft/ft)	Bankfull Water Surface Slope		
1.58	d (ft)	Bankfull Mean Depth		
14	A (ft^2)	Bankfull Cross Sectional Area		
10.56	W_p (ft)	Wetted Perimeter		
1.65	γ_s	Submerged Specific Weight of Sediment (1.65)		
62.4	γ (lbs/ft^3)	Density of Water (62.4)		
Calculation of Critical Dimensionless Shear Stress				
27.00	D_{50}/D^*_{50}	Range 3-7	Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/D^*_{50})^{-0.872}$	
2.22	D_i/D_{50}	Range 1.3-3.0	Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/D^*_{50})^{-0.887}$	
0.019	τ^*_{ci}	Critical Dimensionless Shear Stress	Equation Used:	2
Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle				
0.102	d_c	Required Bankfull Mean Depth (ft) $d_c = \frac{\tau^*_{ci}\gamma_s D_i}{S}$		
15.433	d/d_c	Stability:	Degrading	
Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle				
0.000	S_c	Required Bankfull Water Surface Slope (ft/ft) $S_c = \frac{\tau^*_{ci}\gamma_s D_i}{d}$		
15.433	S/S_c	Stability:	Degrading	
Sediment Transport Validation - Bankfull Shear Stress				
1.33	R	Hydraulic Radius (ft) $R = A/W_p$		
0.496	τ_c	Bankfull Shear Stress (lb/ft^2) $\tau_c = \gamma RS$		
Y	Y or N	Is the Bed Material Homogeneous?		
		Determine from reach wide pebble count distribution (Use your best judgement). If homogeneous use "Leopold et. al" Curve Data, if heterogeneous use "Colorado" Curve Data.		
38	mm	Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline.		
0.085	lb/ft^2	Predicted Shear Stress (lbs/ft^2) Required To Move D_i predicted by the Leopold, Wolman, & Miller 1964 Power-trendline.		
N/A	mm	Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline.		
N/A	lb/ft^2	Predicted Shear Stress (lbs/ft^2) Required To Move D_i predicted by the Colorado Data Power-trendline.		

Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

Entrainment Calculation Form

Status: Proposed, iteration 1
Project: U-2707
Date: 7/22/2011

Location: Forsythe Co.
Reach: R1b, XS 5, Pebble Count Riffle 3
Observers: EMP

Value	Variable	Definition
Required Information for Entrainment Analysis		
2.7	D_{50} (mm)	D_{50} from Riffle (1) or Pavement (2) — Riffle — Select Sample Type
0.1	D^*_{50} (mm)	D_{50} from Bar Sample (1) or Subpavement (2) — Bar Sample
6	D_i (mm)	Largest Particle from Bar Sample (1) or Pavement (2) — Bar Sample
0.020	D_i (ft)	Di (mm) / 304.8 (mm/ft)
0.0044	S (ft/ft)	Bankfull Water Surface Slope
1.07	d (ft)	Bankfull Mean Depth
15	A (ft^2)	Bankfull Cross Sectional Area
14.52	W_p (ft)	Wetted Perimeter
1.65	γ_s	Submerged Specific Weight of Sediment (1.65)
62.4	γ (lbs/ft^3)	Density of Water (62.4)
Calculation of Critical Dimensionless Shear Stress		
27.00	D_{50}/D^*_{50}	Range 3- Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/D^*_{50})^{-0.872}$
2.22	D_i/D_{50}	Range 1.3-3.0 Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/D^*_{50})^{-0.887}$
0.019	τ^*_{ci}	Critical Dimensionless Shear Stress — Equation Used: 2
Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle		
0.140	d_c	Required Bankfull Mean Depth (ft): $d_c = \frac{\tau^*_{ci}\gamma_s D_i}{S}$
7.665	d/d_c	Stability: Degrading
Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle		
0.001	S_c	Required Bankfull Water Surface Slope (ft/ft): $S_c = \frac{\tau^*_{ci}\gamma_s D_i}{d}$
7.665	S/S_c	Stability: Degrading
Sediment Transport Validation - Bankfull Shear Stress		
1.03	R	Hydraulic Radius (ft): $R = A_f/W_p$
0.284	τ_c	Bankfull Shear Stress (lb/ft^2): $\tau_c = \gamma RS$
Y	Y or N	Is the Bed Material Homogeneous? **Determine from reach wide pebble count distribution (Use your best judgement).** If homogeneous use "Leopold et. al" Curve Data, if heterogeneous use "Colorado" Curve Data.
21	mm	Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline.
0.085	lb/ft^2	Predicted Shear Stress (lbs/ft^2) Required To Move D_i predicted by the Leopold, Wolman, & Miller 1964 Power-trendline.
N/A	mm	Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline.
N/A	lb/ft^2	Predicted Shear Stress (lbs/ft^2) Required To Move D_i predicted by the Colorado Data Power-trendline.

*Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

Velocity Comparison Form

Project:	U-2707	Location:	Forsyth County, NC
Stream:	UT to Muddy Creek	Reach:	R1 Existing XS1
Date:	8/16/2011	Observers:	Mulkey

Input Variables		Output Variables	
Bankfull X-Sec Area (Abkf)	9.86 sq ft	Bankfull Mean Depth (Dbkf)	0.85 ft
Bankfull Width (Wbkf)	11.58 ft	Wetted Perimeter (WP)	13.28 ft
D84 (Riffle or pavement)	1.82 mm	D84 (mm/304.8)	0.01 ft
Bankfull Slope (S)	0.0063 ft/ft	Hydraulic Radius (R)	0.74 ft
Gravitational Accleration (g)	32.2 ft/sq sec	Dbkf/D84 (use D84 in ft)	142.35 ft/ft
Bankfull Maximum Depth	1.63 ft	R/D84 (use D84 in ft)	124.34 ft/ft

Dbkf/D84, u/u*, Mannings n		
u/u*	(Using Dbkf/D84 Red Book: p188; Blue p233)	13.5 ft/s/ft/s
Mannings n	(Red Book: p189; Blue :p236)	0.024
Velocity	(From Mannings' equation: u=1.4865 * (R^2/3)(S^1/2)/n)	4.04 ft/s

u/u*=2.83+5.7logR/D84		
u*	u* = (gRS)^.5	0.39 ft/s
Velocity:	u = u*(2.83+5.7log(R/D84))	5.74 ft/s

Mannings n by Stream Type		
Stream type		C5
Mannings n	(Red Book: p187; Blue :p237)	0.036
Velocity	(From Mannings' equation: u=1.4865 * (R^2/3)(S^1/2)/n)	2.77 ft/s

Continuity Equation		
Qbkf	(cfs) original curve or stream gage hydraulic geometry	53 cfs
Velocity	(u=Q/A) or from stream gage hydraulic geometry	5.38 ft/s

Sandbed stream

Dr. Richard Hey Method		
Coefficient a	a = 11(R/dmax)^-0.314	14.2
Friction Factor - f	1/f^1/2 = 2.03 log (aR/3.5D84)	0.033
Velocity	(From D'Arcy Weisbach equation: u=(8*g*R S/f)^1/2)	6.03 ft/s

Velocity Comparison Form

Project:	U-2707	Location:	Forsyth County, NC
Stream:	UT to Muddy Creek	Reach:	R1 Existing XS3
Date:	8/16/2011	Observers:	Mulkey

Input Variables		Output Variables	
Bankfull X-Sec Area (Abkf)	8.93 sq ft	Bankfull Mean Depth (Dbkf)	0.65 ft
Bankfull Width (Wbkf)	13.66 ft	Wetted Perimeter (WP)	14.96 ft
D84 (Riffle or pavement)	4.867 mm	D84 (mm/304.8)	0.02 ft
Bankfull Slope (S)	0.0063 ft/ft	Hydraulic Radius (R)	0.60 ft
Gravitational Accleration (g)	32.2 ft/sq sec	Dbkf/D84 (use D84 in ft)	40.54 ft/ft
Bankfull Maximum Depth	1.68 ft	R/D84 (use D84 in ft)	37.23 ft/ft

Dbkf/D84, u/u*, Mannings n		
u/u*	(Using Dbkf/D84 Red Book: p188; Blue p233)	11.2 ft/s/ft/s
Mannings n	(Red Book: p189; Blue :p236)	0.026
Velocity	(From Mannings' equation: u=1.4865 * (R^2/3)(S^1/2)/n)	3.22 ft/s

u/u*=2.83+5.7logR/D84		
u*	u* = (gRS)^.5	0.35 ft/s
Velocity:	u = u*(2.83+5.7log(R/D84))	4.11 ft/s

Mannings n by StreamType		
Stream type		C5
Mannings n	(Red Book: p187; Blue :p237)	0.035
Velocity	(From Mannings' equation: u=1.4865 * (R^2/3)(S^1/2)/n)	2.39 ft/s

Continuity Equation		
Qbkf	(cfs) original curve or stream gage hydraulic geometry	53 cfs
Velocity	(u=Q/A) or from stream gage hydraulic geometry	5.94 ft/s

Sandbed stream

Dr. Richard Hey Method		
Coefficient a	a = 11(R/dmax)^-0.314	15.4
Friction Factor - f	1/f^1/2 = 2.03 log (aR/3.5D84)	0.050
Velocity	(From D'Arcy Weisbach equation: u=(8*g*R S/f)^1/2)	4.43 ft/s

Velocity Comparison Form

Project:	U-2707	Location:	Forsyth County, NC
Stream:	UT to Muddy Creek	Reach:	R1 Existing XS5
Date:	8/16/2011	Observers:	Mulkey

Input Variables		Output Variables	
Bankfull X-Sec Area (Abkf)	14 sq ft	Bankfull Mean Depth (Dbkf)	1.58 ft
Bankfull Width (Wbkf)	8.86 ft	Wetted Perimeter (WP)	12.02 ft
D84 (Riffle or pavement)	0.97 mm	D84 (mm/304.8)	0.00 ft
Bankfull Slope (S)	0.0063 ft/ft	Hydraulic Radius (R)	1.16 ft
Gravitational Accleration (g)	32.2 ft/sq sec	Dbkf/D84 (use D84 in ft)	496.48 ft/ft
Bankfull Maximum Depth	2.37 ft	R/D84 (use D84 in ft)	365.99 ft/ft

Dbkf/D84, u/u*, Mannings n		
u/u*	(Using Dbkf/D84 Red Book: p188; Blue :p233)	ft/s/ft/s
Mannings n	(Red Book: p189; Blue :p236)	
Velocity	(From Mannings' equation: u=1.4865 * (R^2/3)(S^1/2)/n)	#DIV/0! ft/s

UNABLE TO CALCULATE DUE TO LOW D84

u/u*=2.83+5.7logR/D84		
u*	u* = (gRS)^.5	0.49 ft/s
Velocity:	u = u*(2.83+5.7log(R/D84))	8.49 ft/s

Mannings n by Stream Type		
Stream type		C5
Mannings n	(Red Book: p187; Blue :p237)	0.035
Velocity	(From Mannings' equation: u=1.4865 * (R^2/3)(S^1/2)/n)	3.74 ft/s

Continuity Equation		
Qbkf	(cfs) original curve or stream gage hydraulic geometry	53 cfs
Velocity	(u=Q/A) or from stream gage hydraulic geometry	3.79 ft/s

Sandbed stream

Dr. Richard Hey Method		
Coefficient a	a = 11(R/dmax)^-0.314	13.9
Friction Factor - f	1/f^1/2 = 2.03 log (aR/3.5D84)	0.024
Velocity	(From D'Arcy Weisbach equation: u=(8*g*R S/f)^1/2)	8.84 ft/s

Velocity Comparison Form

Project:	U-2707	Location:	Forsyth County, NC
Stream:	UT to Muddy Creek	Reach:	Proposed R1a
Date:	8/16/2011	Observers:	Mulkey

Based on Characteristics of Riffle Number 3

Input Variables		Output Variables	
Bankfull X-Sec Area (Abkf)	10 sq ft	Bankfull Mean Depth (Dbkf)	0.84 ft
Bankfull Width (Wbkf)	12 ft	Wetted Perimeter (WP)	13.68 ft
D84 (Riffle or pavement)	4.87 mm	D84 (mm/304.8)	0.02 ft
Bankfull Slope (S)	0.0075 ft/ft	Hydraulic Radius (R)	0.73 ft
Gravitational Accleration (g)	32.2 ft/sq sec	Dbkf/D84 (use D84 in ft)	52.57 ft/ft
Bankfull Maximum Depth	1.4 ft	R/D84 (use D84 in ft)	45.75 ft/ft

Dbkf/D84, u/u*, Mannings n		
u/u*	(Using Dbkf/D84 Red Book: p188; Blue p233)	12 ft/s/ft/s
Mannings n	(Red Book: p189; Blue :p236)	0.025
Velocity	(From Mannings' equation: u=1.4865 * (R^2/3)(S^1/2)/n)	4.18 ft/s

u/u*=2.83+5.7logR/D84		
u*	u* = (gRS)^.5	0.42 ft/s
Velocity:	u = u*(2.83+5.7log(R/D84))	5.17 ft/s

Mannings n by StreamType		
Stream type		C5
Mannings n	(Red Book: p187; Blue :p237)	0.035
Velocity	(From Mannings' equation: u=1.4865 * (R^2/3)(S^1/2)/n)	2.98 ft/s

Continuity Equation		
Qbkf	(cfs) original curve or stream gage hydraulic geometry	53 cfs
Velocity	(u=Q/A) or from stream gage hydraulic geometry	5.30 ft/s

Sandbed stream

Dr. Richard Hey Method		
Coefficient a	a = 11(R/dmax)^-0.314	13.6
Friction Factor - f	1/f^1/2 = 2.03 log (aR/3.5D84)	0.048
Velocity	(From D'Arcy Weisbach equation: u=(8*g*R S/f)^1/2)	5.43 ft/s

Velocity Comparison Form

Project:	U-2707	Location:	Forsyth County, NC
Stream:	UT to Muddy Creek	Reach:	Proposed R1b
Date:	8/16/2011	Observers:	Mulkey

Based on Characteristics of Riffle Number 5

Input Variables		Output Variables	
Bankfull X-Sec Area (Abkf)	15 sq ft	Bankfull Mean Depth (Dbkf)	1.07 ft
Bankfull Width (Wbkf)	14 ft	Wetted Perimeter (WP)	16.14 ft
D84 (Riffle or pavement)	0.97 mm	D84 (mm/304.8)	0.00 ft
Bankfull Slope (S)	0.0044 ft/ft	Hydraulic Radius (R)	0.93 ft
Gravitational Acceleration (g)	32.2 ft/sq sec	Dbkf/D84 (use D84 in ft)	336.22 ft/ft
Bankfull Maximum Depth	1.76 ft	R/D84 (use D84 in ft)	292.03 ft/ft

Dbkf/D84, u/u*, Mannings n		
u/u*	(Using Dbkf/D84 Red Book: p188; Blue p233)	ft/s/ft/s
Mannings n	(Red Book: p189; Blue :p236)	
Velocity	(From Mannings' equation: u=1.4865 * (R^2/3)(S^1/2)/n)	#DIV/0! ft/s

UNABLE TO CALCULATE DUE TO LOW D84

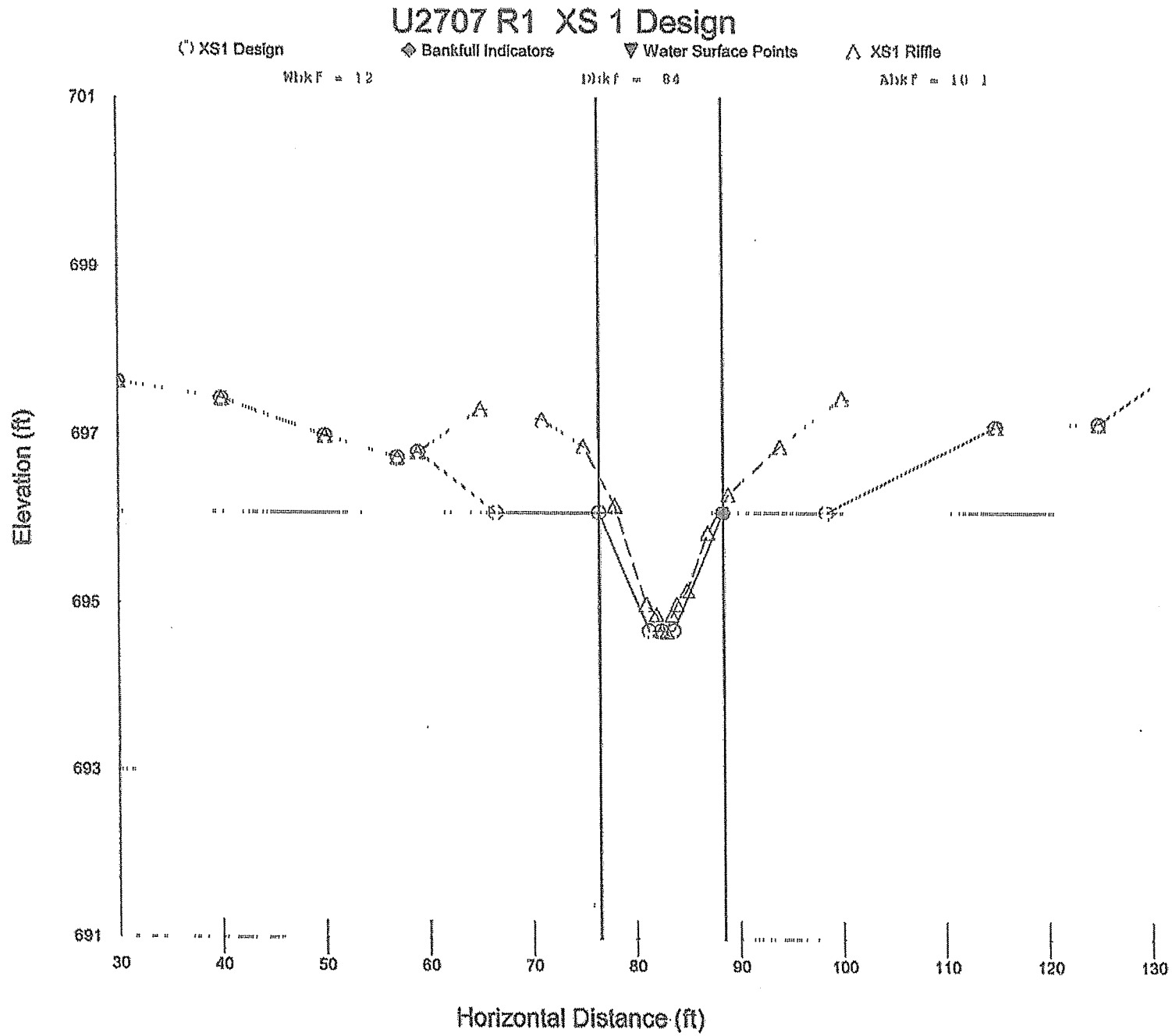
u/u*=2.83+5.7logR/D84		
u*	u* = (gRS)^.5	0.36 ft/s
Velocity:	u = u*(2.83+5.7log(R/D84))	6.13 ft/s

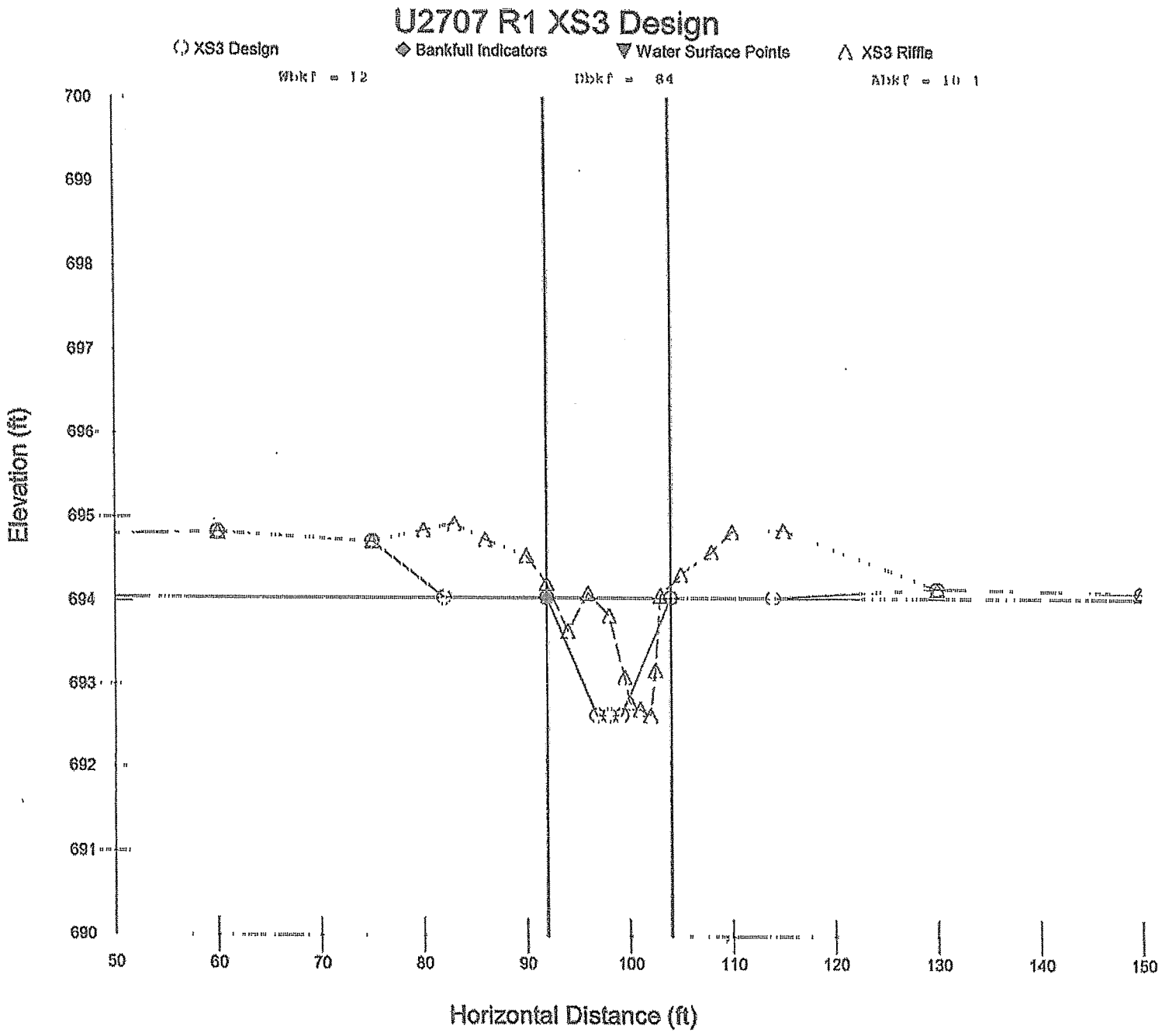
Mannings n by StreamType	
Stream type	C5
Mannings n (Red Book: p187; Blue :p237)	0.035
Velocity (From Mannings' equation: u=1.4865 * (R^2/3)(S^1/2)/n)	2.68 ft/s

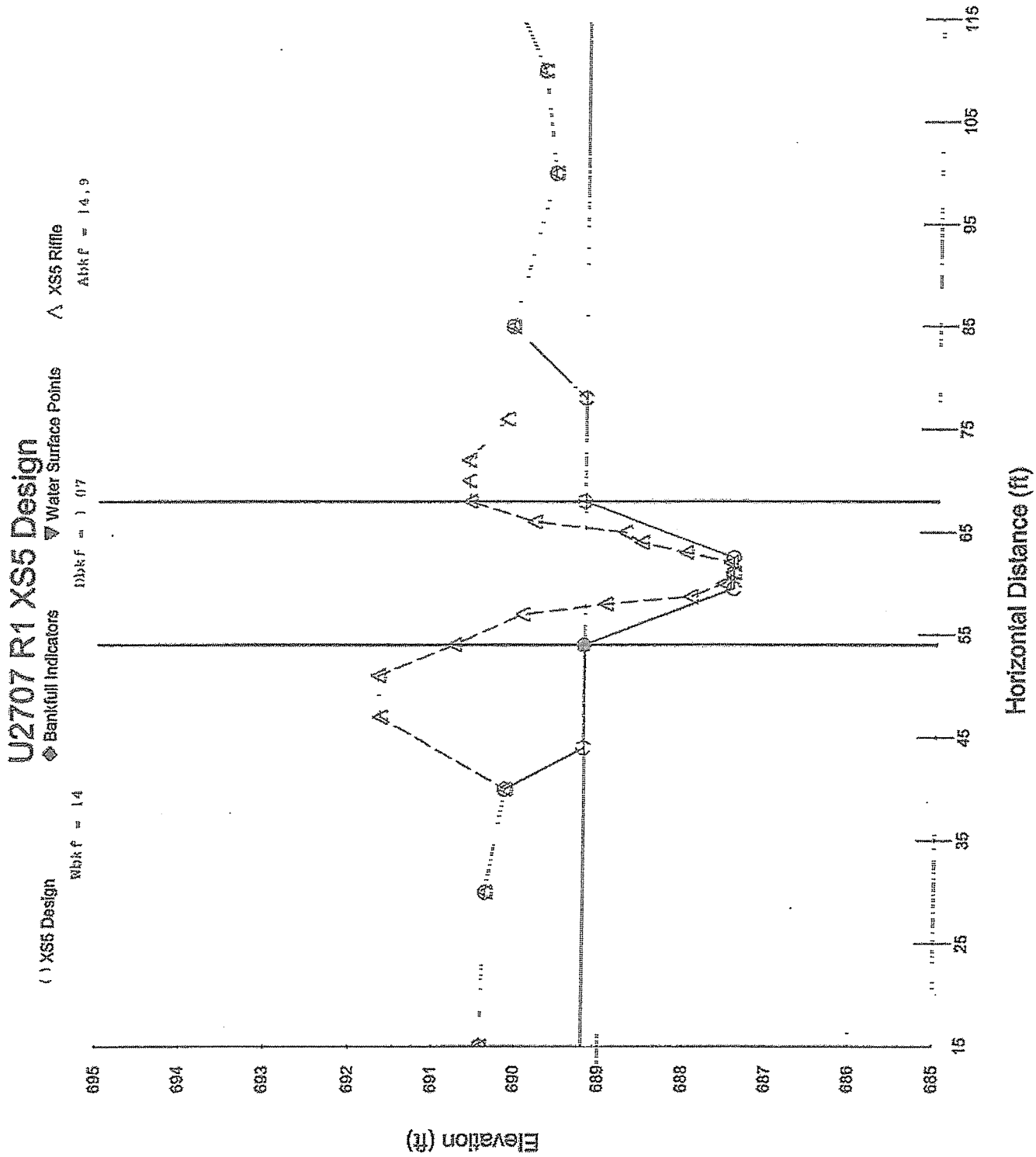
Continuity Equation	
Qbkf (cfs) original curve or stream gage hydraulic geometry	53 cfs
Velocity (u=Q/A) or from stream gage hydraulic geometry	3.53 ft/s

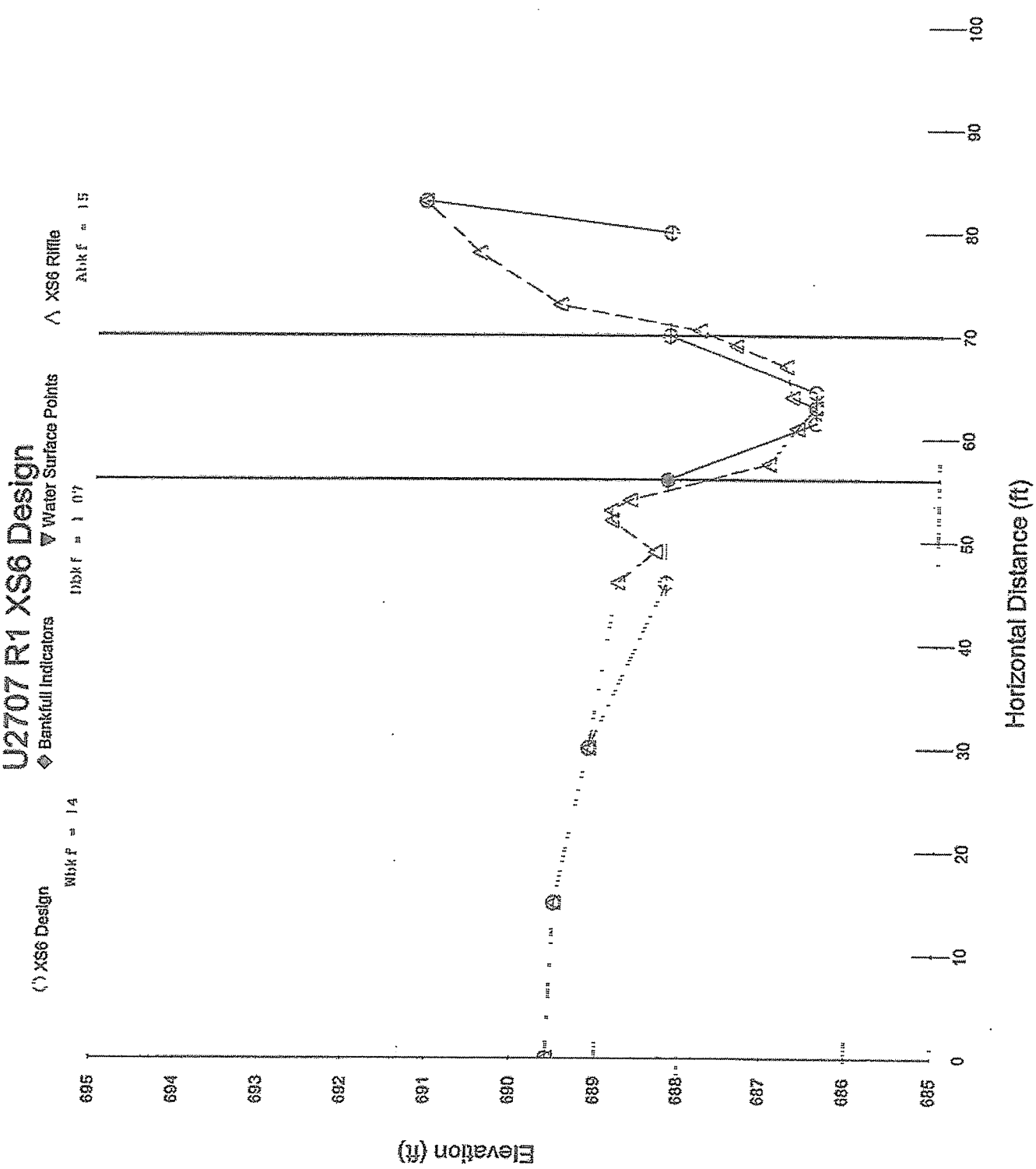
Sandbed stream

Dr. Richard Hey Method		
Coefficient a	a = 11(R/dmax)^-0.314	13.6
Friction Factor - f	1/f^1/2 = 2.03 log (aR/3.5D84)	0.026
Velocity	(From D'Arcy Weisbach equation: u=(8*g*R S/f)^1/2)	6.36 ft/s


U2707 R1 XS 1 Design
XS1 Design
Bankfull Indicators
Water Surface Points
XS1 Riffle
Elevation (ft)
701
699
697
695
693
691
30
40
50
60
70
80
90
100
110
120
130
Horizontal Distance (ft)


U2707 R1 XS3 Design
XS3 Design
Bankfull Indicators
Water Surface Points
XS3 Riffle
Wbkf = 12
Dbkf = 84
Abkf = 10.1
Elevation (ft)
700
699
698
697
696
695
694
693
692
691
690
50
60
70
80
90
100
110
120
130
140
150
Horizontal Distance (ft)


U2707 R1 XS5 Design
Bankfull Indicators
Water Surface Points
XS5 Riffle
XS5 Design
Wbkf = 14
Wbkf = 1 017
Abkf = 14.9
Elevation (ft)
Horizontal Distance (ft)
695
694
693
692
691
690
689
688
687
686
685
15
25
35
45
55
65
75
85
95
105
115


U2707 R1 XS6 Design
XS6 Design
Bankfull Indicators
Water Surface Points
XS6 Riffle
Elevation (ft)
Horizontal Distance (ft)
695
694
693
692
691
690
689
688
687
686
685
0
10
20
30
40
50
60
70
80
90
100

ROADWAY DESIGN ENGINEER | HYDRAULICS ENGINEER

INCOMPLETE PLANS — DO NOT USE FOR R/W ACQUISITION

PRELIMINARY PLANS — DO NOT USE FOR CONSTRUCTION

MORPHOLOGICAL MEASUREMENTS TABLE

UT TO MUDDY CREEK

-RI- Sta. 0+00.00 to Sta. 9+20.00

Variables	Existing Channel	Proposed Reach	USGS Station	Reference Reach
1. Stream type	C/E5	C5	--	E 4/1
2. Drainage area	0.49 SQ MI (316 ACRES)	0.45 SQ MI (288 ACRES)	------	0.55 SQ MI (355 ACRES)
3. Bankfull width	Mean: 11.36 Range: 8.86-14.80	Mean: 12.00 Range: ------	------	Mean: 15.48 Range: 11.90-17.70
4. Bankfull mean depth	Mean: 0.72 Range: 0.58-0.85	Mean: 0.83 Range: ------	------	Mean: 1.29 Range: 1.23-1.41
5. Width/depth ratio	Mean: 15.56 Range: 5.65-17.48	Mean: 14.4 Range: ------	------	Mean: 12.97 Range: 11.42-14.37
6. Bankfull cross-sectional area	Mean: 10.77 Range: 5.93-14.00	Mean: 10.00 Range: ------	------	Mean: 21.33 Range: 20.00-22.70
7. Bankfull mean velocity	Mean: 5.38 Range: ------	Mean: 5.30 Range: ------	------	Mean: 2.90 Range: ------
8. Bankfull discharge, cfs	Mean: 53 Range: ------	Mean: 53 Range: ------	------	Mean: 58 Range: ------
9. Bankfull max depth	Mean: 1.60 Range: 0.96-2.37	Mean: 1.40 Range: 1.40-1.40	------	Mean: 1.94 Range: 1.60-2.12
10. Width of floodprone area	Mean: 118.67 Range: 48.69-180.00	Mean: >100.00 Range: ------	------	Mean: 171.25 Range: 162.00-186.00
11. Entrenchment ratio	Mean: 11.41 Range: 3.29-17.68	Mean: >2.2 Range: ------	------	Mean: 11.30 Range: 10.06-14.45
12. Meander length	Mean: 50.92 Range: 31.09-73.07	Mean: 95.10 Range: 80.10-102.00	------	Mean: 80.30 Range: 64.32-114.00
13. Ratio of meander length to bankfull width	Mean: 4.48 Range: 2.47-6.43	Mean: 7.93 Range: 6.68-8.50	------	Mean: 5.19 Range: 4.16-7.37
14. Radius of curvature	Mean: 22.22 Range: 10.01-32.89	Mean: 33.47 Range: 28.00-49.00	------	Mean: 18.44 Range: 11.73-25.30
15. Ratio of radius of curvature to bankfull width	Mean: 1.96 Range: 0.88-2.90	Mean: 2.79 Range: 2.33-4.08	------	Mean: 1.19 Range: 0.76-1.63
16. Belt width	Mean: 6.38 Range: 1.28-14.48	Mean: 21.91 Range: 11.52-41.14	------	Mean: 31.92 Range: 12.54-54.25
17. Meander width ratio	Mean: 0.56 Range: 0.11-1.27	Mean: 1.83 Range: 0.96-3.43	------	Mean: 2.06 Range: 0.81-3.51
18. Sinuosity (stream length/valley length)	Mean: 1.06 Range: ------	Mean: 1.12 Range: ------	------	Mean: 1.41 Range: ------
19. Valley slope	Mean: 0.00670 Range: ------	Mean: 0.00899 Range: ------	------	Mean: 0.01230 Range: ------
20. Average slope	Mean: 0.00632 Range: ------	Mean: 0.0080 Range: 0.0080-0.0080	------	Mean: 0.00872 Range: ------
21. Pool slope	Mean: 0.00606 Range: 0.00081-0.01136	Mean: 0.00194 Range: 0.00120-0.00200	------	Mean: 0.00221 Range: 0.00175-0.00267
22. Ratio of pool slope to average slope	Mean: 0.96 Range: 0.13-1.80	Mean: 0.24 Range: 0.15-0.25	------	Mean: 0.25 Range: 0.20-0.31
23. Maximum pool depth	Mean: 1.94 Range: 1.40-2.47	Mean: 1.83 Range: 1.83-1.83	------	Mean: 2.87 Range: 2.85-2.89
24. Ratio of pool depth to average bankfull depth	Mean: 2.71 Range: 1.95-3.45	Mean: 2.20 Range: 2.20-2.20	------	Mean: 2.22 Range: 2.21-2.23
25. Pool width	Mean: 11.69 Range: 9.16-14.22	Mean: 12.00 Range: ------	------	Mean: 16.30 Range: 12.60-20.00
26. Ratio of pool width to bankfull width	Mean: 1.03 Range: 0.81-1.25	Mean: 1.0 Range: ------	------	Mean: 1.05 Range: 0.81-1.29
27. Pool to pool spacing	Mean: 61.22 Range: 29.34-78.63	Mean: 53.50 Range: 39.00-62.00	------	Mean: 51.98 Range: 35.73-68.22
28. Ratio of pool to pool spacing to bankfull width	Mean: 5.39 Range: 2.58-6.92	Mean: 4.46 Range: 3.25-5.17	------	Mean: 3.36 Range: 2.31-4.41
29. Ratio of lowest bank height to bankfull height (or max bankfull depth)	Mean: N/A Range: N/A	Mean: 1.0 Range: ------	------	Mean: 1.06 Range: 1.0-1.15

REVISIONS

INCOMPLETE PLANS
DO NOT USE FOR R/W ACQUISITION
PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

MORPHOLOGICAL MEASUREMENTS TABLE

UT TO MUDDY CREEK
-R1- Sta. 9+20.00 to Sta. 18+00.00

Variables	Existing Channel	Proposed Reach	USGS Station	Reference Reach
1. Stream type	C/E5	C5	------	CE 4/1
2. Drainage area	0.49 SQ MI (316 ACRES)	0.49 SQ MI (316 ACRES)		0.55 SQ MI (355 ACRES)
3. Bankfull width	Mean: 11.36 Range: 8.86-14.80	Mean: 13.96 Range: ------	------	Mean: 15.48 Range: 11.90-17.70
4. Bankfull mean depth	Mean: 0.72 Range: 0.58-0.85	Mean: 1.07 Range: ------	------	Mean: 1.29 Range: 1.23-1.41
5. Width/depth ratio	Mean: 15.56 Range: 13.65-17.48	Mean: 13.00 Range: ------	------	Mean: 12.97 Range: 11.42-14.37
6. Bankfull cross-sectional area	Mean: 10.77 Range: 5.93-14.00	Mean: 15.00 Range: ------	------	Mean: 21.33 Range: 20.00-22.70
7. Bankfull mean velocity	Mean: 5.38 Range: ------	Mean: 3.53 Range: ------	------	Mean: 2.90 Range: ------
8. Bankfull discharge, cfs	Mean: 53 Range: ------	Mean: 53 Range: ------	------	Mean: 58 Range: ------
9. Bankfull max depth	Mean: 1.60 Range: 0.96-2.37	Mean: 1.75 Range: 1.61-1.76	------	Mean: 1.94 Range: 1.60-2.12
10. Width of floodprone area	Mean: 118.67 Range: 48.69-180.00	Mean: >100.00 Range: ------	------	Mean: 171.25 Range: 162.00-186.00
11. Entrenchment ratio	Mean: 11.41 Range: 3.29-17.68	Mean: >2.2 Range: ------	------	Mean: 11.30 Range: 10.06-14.45
12. Meander length	Mean: 50.92 Range: 31.09-73.07	Mean: 97.48 Range: 91.07-120.51	------	Mean: 80.30 Range: 64.32-114.00
13. Ratio of meander length to bankfull width	Mean: 4.48 Range: 2.47-6.43	Mean: 6.96 Range: 6.51-8.61	------	Mean: 5.19 Range: 4.16-7.37
14. Radius of curvature	Mean: 22.22 Range: 10.01-32.89	Mean: 33.88 Range: 28.00-49.00	------	Mean: 18.44 Range: 11.73-25.36
15. Ratio of radius of curvature to bankfull width	Mean: 1.96 Range: 0.88-2.90	Mean: 2.42 Range: 2.0-3.5	------	Mean: 1.19 Range: 0.76-1.63
16. Belt width	Mean: 6.38 Range: 1.28-14.48	Mean: 23.20 Range: 12.00-44.00	------	Mean: 31.92 Range: 12.54-54.25
17. Meander width ratio	Mean: 0.56 Range: 0.11-1.27	Mean: 1.66 Range: 0.86-3.14	------	Mean: 2.06 Range: 0.81-3.51
18. Sinuosity (stream length/valley length)	Mean: 1.06 Range: ------	Mean: 1.13 Range: ------	------	Mean: 1.41 Range: ------
19. Valley slope	Mean: 0.00670 Range: ------	Mean: 0.00498 Range: ------	------	Mean: 0.01230 Range: ------
20. Average slope	Mean: 0.00632 Range: ------	Mean: 0.0044 Range: 0.0044-0.0044	------	Mean: 0.00872 Range: ------
21. Pool slope	Mean: 0.00606 Range: 0.00081-0.01136	Mean: 0.00117 Range: 0.00110-0.00130	------	Mean: 0.00221 Range: 0.00175-0.00267
22. Ratio of pool slope to average slope	Mean: 0.96 Range: 0.13-1.80	Mean: 0.27 Range: 0.25-0.30	------	Mean: 0.25 Range: 0.20-0.31
23. Maximum pool depth	Mean: 1.94 Range: 1.40-2.47	Mean: 2.40 Range: 2.40-2.40	------	Mean: 2.87 Range: 2.85-2.89
24. Ratio of pool depth to average bankfull depth	Mean: 2.71 Range: 1.95-3.45	Mean: 2.40 Range: 2.40-2.40	------	Mean: 2.22 Range: 2.21-2.23
25. Pool width	Mean: 11.69 Range: 9.16-14.22	Mean: 14.00 Range: ------	------	Mean: 16.30 Range: 12.60-20.00
26. Ratio of pool width to bankfull width	Mean: 1.03 Range: 0.81-1.25	Mean: 1.0 Range: ------	------	Mean: 1.05 Range: 0.81-1.29
27. Pool to pool spacing	Mean: 61.22 Range: 29.34-78.63	Mean: 56.20 Range: 50.00-71.00	------	Mean: 51.98 Range: 35.73-68.22
28. Ratio of pool to pool spacing to bankfull width	Mean: 5.39 Range: 2.58-6.92	Mean: 4.01 Range: 3.57-5.07	------	Mean: 3.36 Range: 2.31-4.41
29. Ratio of lowest bank height to bankfull height (or max bankfull depth)	Mean: N/A Range: N/A	Mean: 1.0 Range: ------	------	Mean: 1.06 Range: 1.0-1.15

REVISIONS

5/28

12/5/2011 ... \Design\U2787 mt morph2.dgn

FARM PATH CROSSING PIPE
100' LT
75'
50'
25'
℄
25'
50'
75'
100' RT
700
695
690
685
680
675

PIPE DATA SHEET

Date: 12/1/2011 | Project Number: 20031772.01 | I.D. No. U-2707 | County: Forsyth | Designed By: EMP | Sheet 1 of 5 | Checked By: JKS

Station:	N/A	Shoulder Elev.:	690.5 ft
Skew:	90°		
Size/Type Pipe:	1 @ 112x75 CAAP		
Type Entrance:	headwall		
Direction of Flow:	L-R		
Hydrological Method:	USGS	Invert Elev.:	684.5 ft
H.W. Control Elevation:	689.5	L=	32 ft

CL Elev.: 690.5 ft

H.W. / LS$_a$ / H / T.W / So= 7.19%

Outlet Inv. Elev. 682.00 ft

Plan Summary Data

Drainage Area:	1.13 sq. mi.
Design Freq.:	2 YR
Design Disch.:	172 cfs
Design H.W Elev.:	688.98
Bankfull Disch.:	N/A
Bankfull H.W. Elev.:	N/A
Overtopping Freq.'	N/A
Overtopping Disch.:	N/A
Overtopping Elev.:	N/A

PIPE CULVERT ANALYSIS (English)

rcp=.012, cmp=.024 n= 0.024

Channel Specs. Slope: 0.00 Lt. Side Slope 0
Base= 0.0 n= 0.00 Rt. Side Slope 0

Size & Type		TW*	Q	Nat	Allow	Inlet Control			Outlet Control						HW	Vs	Remarks
SIZE	#	FREQ	ft	H.W	ft/s	H.W	HW/D	HW (ft)	Ke	de	(de+D)/2	he	H	Ts-So	HW	ELEV	
Pipes																	
67.25	1	5 YR	2.9	8.9		5.00	1.5	8.41	0.2	5.25	5.43	5.43	4.025	2.30	7.15	692.91	INLET CONTROL
67.25	1	2 YR	2.1	7.2		5.00	0.9	4.48	0.2	3.65	4.63	4.63	1.170	2.30	3.50	688.98	INLET CONTROL

**"Pipe will be buried 2.5 feet at inlet end 1.2 feet at outlet, minimum 1 foot buried for fish passage
**Hydraulics takes into acount pipe is 112X75 CAAP with baffles reducing pipe size to an equivalent 87X63 CAAP
**Inlet Invert Elevation based on invert of first baffle, outlet invert elevation based on 1.2 foot buried
**HW Control Elevation equals 1 foot below shoulder
**Discharges based on USGS Rural Regression Equation with a drainage area of 1.13 sq mi

U-2707 FARM PATH
12/1/11

This spreadsheet computes the 50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent chance exceedance flows for an ungaged site in Georgia, South Carolina, and North Carolina. The spreasheet also includes the 95-percent prediction intervals, the minus and plus standard error of prediction intervals, and the average standard error of prediction. To use the spreadsheet, enter requested information in the yellow cells below.

Enter a site-description name: Test site anywhere in GA, SC, or NC

Enter the explanatory variables:

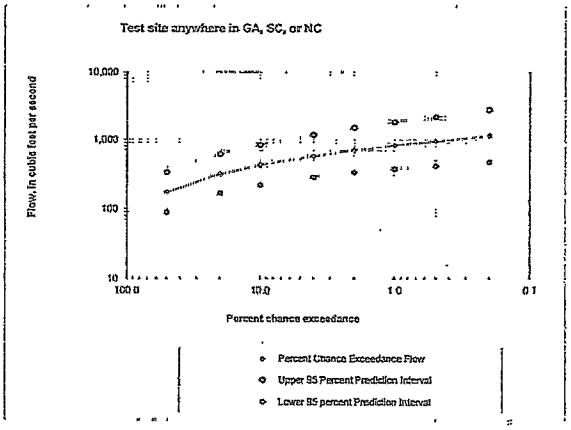
Drainage area, in square miles	[illegible]113
Percent of basin in Hydrologic Region 1	[illegible]300
Percent of basin in Hydrologic Region 2	[illegible]0
Percent of basin in Hydrologic Region 3	[illegible]0
Percent of basin in Hydrologic Region 4	[illegible]0
Percent of basin in Hydrologic Region 5	[illegible]0

Applicable range of drainage area is 1 to 9,000 square miles
Hydrologic Region 1 corresponds to the USEPA Level III Ridge and Valley and Piedmont ecoregions
Hydrologic Region 2 corresponds to the USEPA Level III Blue Ridge ecoregion
Hydrologic Region 3 corresponds to the USEPA Level IV Sand Hills ecoregion
Hydrologic Region 4 corresponds to the USEPA Level III Southeastern, Middle Atlantic Coastal, and Southern Coastal Plain ecoregions
Hydrologic Region 5 corresponds to the lower portion of the USEPA Level IV Tifton Uplands ecoregion

Sum of region percentages	100

Drainage area check
DRAINAGE AREA WITHIN APPLICABLE LIMITS

Percent chance exceedance	Percent chance exceedance flow, in ft³/s	Lower 95 percent prediction interval flow, in ft³/s	Upper 95 percent prediction interval flow, in ft³/s	$-S_{Pd}$ (percent)	$+S_{Pd}$ (percent)	Average S_{Pd} (percent)
50	[illegible]	[illegible]	[illegible]	-28.6	40.0	34.6
20	[illegible]	[illegible]	[illegible]	-28.1	39.4	34.2
10	[illegible]	[illegible]	[illegible]	-29.0	40.8	35.3
4	[illegible]	[illegible]	[illegible]	-30.5	43.9	37.6
2	[illegible]	[illegible]	[illegible]	-31.8	46.7	39.8
1	[illegible]	[illegible]	[illegible]	-33.2	49.8	42.1
0.5	[illegible]	[illegible]	[illegible]	-34.6	53.0	44.5
0.2	[illegible]	[illegible]	[illegible]	-36.5	57.6	47.9



12/1/11

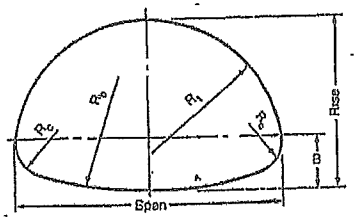


*Table 2.10 Sizes and Layout Details—CSP Pipe Arch. 2⅔ x ½ in. Corrugation

Equiv. Diameter, in.	Span, in.	Rise, in.	Waterway Area, ft²	Layout Dimensions B in.	R_c in.	R_1 in.	R_b in.
15	17	13	1.1	4⅛	3½	8⅝	25⅝
18	21	15	1.6	4⅞	4⅛	10⅝	33⅛
21	24	18	2.2	5⅝	4⅞	11⅞	34⅝
24	28	20	2.9	6½	5⅛	14	42¼
30	35	24	4.5	8⅛	6⅞	17⅞	55⅛
36	42	29	6.5	9⅞	8¼	21½	66⅛
42	49	33	8.9	11⅜	9⅝	25⅛	77¼
48	57	38	11.6	13	11	29⅝	88¼
54	64	43	14.7	14⅝	12⅜	32¼	99⅛
60	71	47	18.1	16¼	13¾	35⅝	110⅛
66	77	52	21.9	17⅞	15⅛	39⅜	121¼
72	83	57	26.0	19½	16½	43	132¼

*Table 2.10 Sizes and Layout Details—CSP Pipe-Arch 3 x 1 or 5 x 1 in. Corrugation

Equiv. Diameter, in.	Nominal Size, in.	Design Span, in.	Design Rise, in.	Waterway Area, ft²	Layout Dimensions B in.	R_c in.	R_1 in.	R_b in.
48	53 x 41	53	41	11.7	15¼	10¹⁵⁄₁₆	28¹⁵⁄₁₆	73¹⁵⁄₁₆
54	60 x 46	59½	46½	15.0	20½	10¾	26⅜	51½
60	66 x 51	65	54	19.0	22¾	20⅛	32⅜	58¼
66	73 x 55	72½	58½	23.2	25⅛	22⅜	36½	63¾
72	81 x 59	78	62½	27.4	23¾	20⅝	39½	82⅝
78	87 x 63	86½	67¼	32.1	25⅜	22⅛	43⅛	92¼
84	95 x 67	93½	71¾	37.0	27⅜	24⅛	47	100¼
90	103 x 71	101⅛	76	42.4	28⅜	26⅛	51⅛	111⅛
96	112 x 75	109½	80⅛	48.0	31⅝	27⅞	54¼	120¼
102	117 x 79	116½	84¼	54.2	33⅝	29½	58½	131¼
108	125 x 83	123½	89¼	60.5	35⅝	31¼	63½	139¾
114	132 x 87	131	93½	67.4	37⅝	33	67⅝	149½
120	142 x 91	139½	98	74.5	39½	34¾	71½	162⅜
126	150 x 98	146	102	81	41	36	70	172
132	157 x 101	153	107	89	43	38	80	180
138	164 x 105	159	113	98	45	40	82	184
144	171 x 110	165	110½	107	47	41	85	190

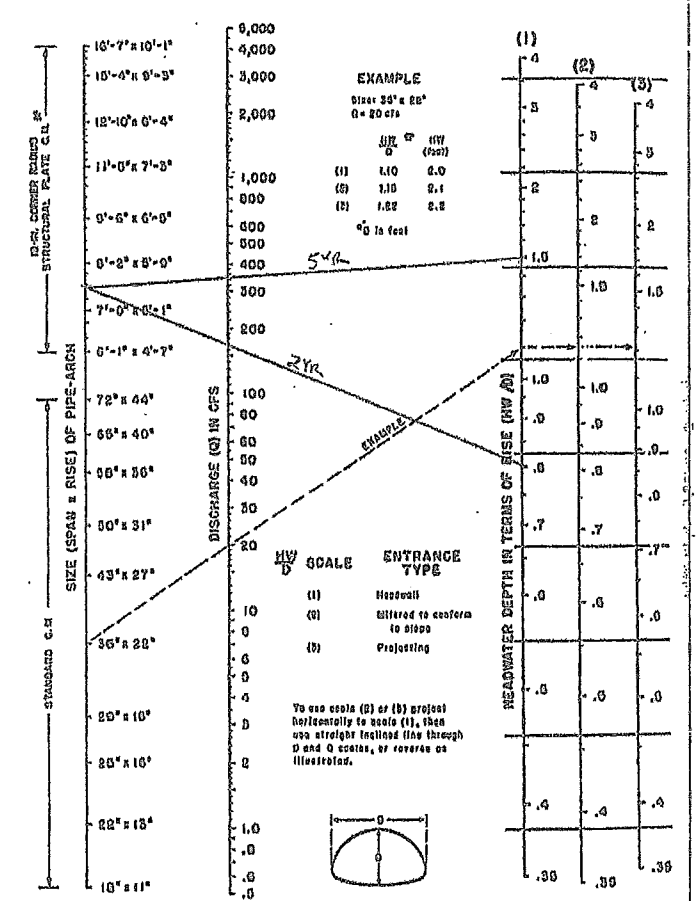
*Dimensions shown not for specification purposes, subject to manufacturing tolerances.

EQUIVALENT SIZE WITH BAFFLES IN PIPE

PIPE SIZE IN STEAM CHANNEL

U-2707 FARM PATH
12/1/11

CHART 34B



*ADDITIONAL SIZES NOT DIMENSIONED ARE LISTED IN FABRICATOR'S CATALOG

BUREAU OF PUBLIC ROADS JAN 1963

HEADWATER DEPTH FOR C. M. PIPE-ARCH CULVERTS WITH INLET CONTROL

ROADWAY DESIGN ENGINEER | HYDRAULICS ENGINEER

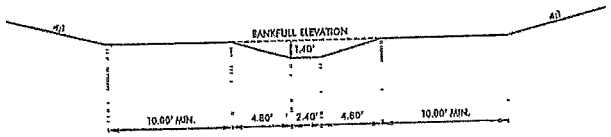
INCOMPLETE PLANS
DO NOT USE FOR R/W ACQUISITION

PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

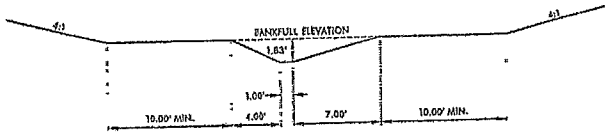
REVISIONS

R1
Sta. 0+00.00 to 9+20.00

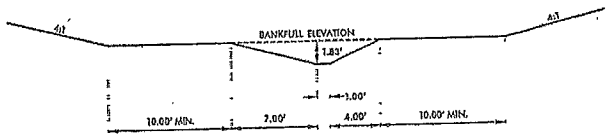
TYPICAL SECTION RIFFLE
BANKFULL AREA 10.0 SQ FT



TYPICAL SECTION POOL LEFT
BANKFULL AREA 11.9 SQ FT

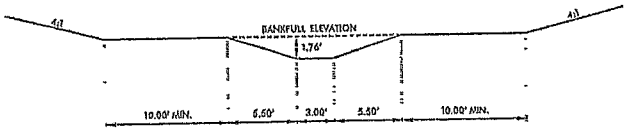


TYPICAL SECTION POOL RIGHT
BANKFULL AREA 11.9 SQ FT

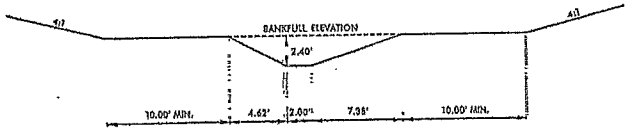


R1
Sta. 9+20.00 to 18+00.00

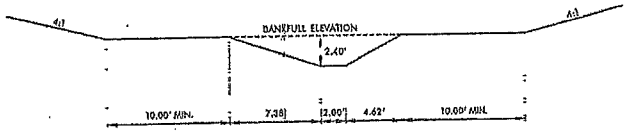
TYPICAL SECTION RIFFLE
BANKFULL AREA 15.0 SQ FT



TYPICAL SECTION POOL LEFT
BANKFULL AREA 19.2 SQ FT



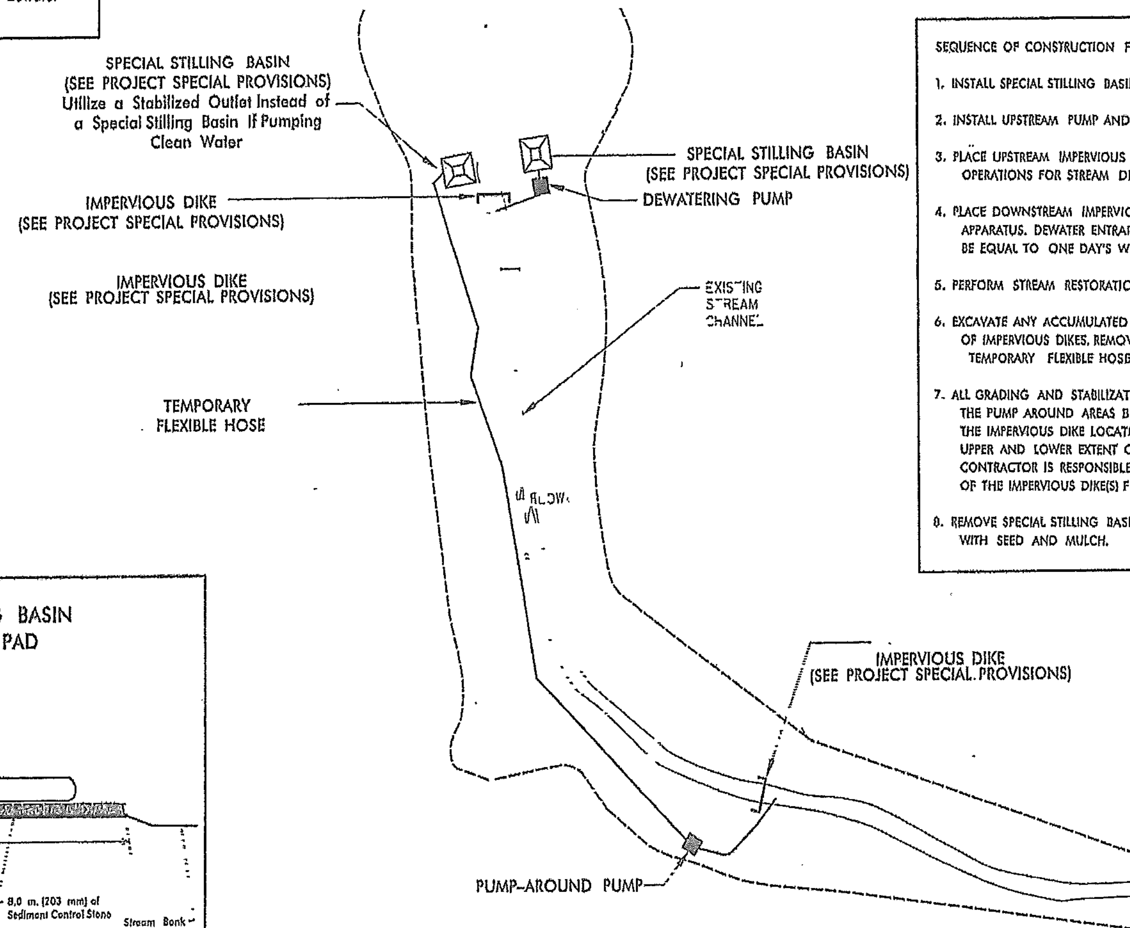
TYPICAL SECTION POOL RIGHT
BANKFULL AREA 19.2 SQ FT



ROADWAY DESIGN ENGINEER	HYDRAULICS ENGINEER
INCOMPLETE PLANS DO NOT USE FOR R/W ACQUISITION	
PRELIMINARY PLANS DO NOT USE FOR CONSTRUCTION	

NOTES:
1) All excavation shall be performed in only dry or isolated sections of channel.
2) Impervious dikes are to be used to isolate work from stream flow when necessary.
3) All graded areas shall be stabilized within 24 hours.
4) Maintenance of stream flow operations shall be incidental to the work. This includes polyethylene sheeting, diversion pipes, pumps and hoses.
5) Pumps and hoses shall be of sufficient size to dewater the work area.

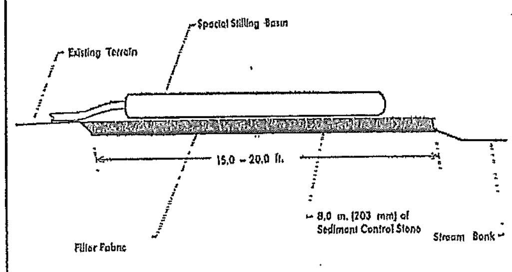
EXAMPLE OF PUMP-AROUND OPERATION



SEQUENCE OF CONSTRUCTION FOR TYPICAL WORK AREA

1. INSTALL SPECIAL STILLING BASIN(S).
2. INSTALL UPSTREAM PUMP AND TEMPORARY FLEXIBLE HOSE.
3. PLACE UPSTREAM IMPERVIOUS DIKE AND BEGIN PUMPING OPERATIONS FOR STREAM DIVERSION.
4. PLACE DOWNSTREAM IMPERVIOUS DIKE AND PUMPING APPARATUS. DEWATER ENTRAPPED AREA. AREA TO BE DEWATERED SHALL BE EQUAL TO ONE DAY'S WORK.
5. PERFORM STREAM RESTORATION WORK IN ACCORDANCE WITH THE PLANS.
6. EXCAVATE ANY ACCUMULATED SILT AND DEWATER BEFORE REMOVAL OF IMPERVIOUS DIKES. REMOVE IMPERVIOUS DIKES, PUMPS, AND TEMPORARY FLEXIBLE HOSE. (DOWNSTREAM IMPERVIOUS DIKES FIRST).
7. ALL GRADING AND STABILIZATION MUST BE COMPLETED IN ONE DAY WITHIN THE PUMP AROUND AREAS BETWEEN THE IMPERVIOUS DIKES. THE IMPERVIOUS DIKE LOCATIONS AS SHOWN ON THIS SHEET ONLY SHOW THE UPPER AND LOWER EXTENT OF WORK FOR EACH STREAM SEGMENT. THE CONTRACTOR IS RESPONSIBLE FOR DETERMINING THE LOCATION OF THE IMPERVIOUS DIKE(S) FOR EACH DAY'S WORK.
8. REMOVE SPECIAL STILLING BASIN(S) AND BACKFILL. STABILIZE DISTURBED AREA WITH SEED AND MULCH.

SPECIAL STILLING BASIN WITH ROCK PAD



Not To Scale

Note: Provide Stabilized Outlet to Streambank

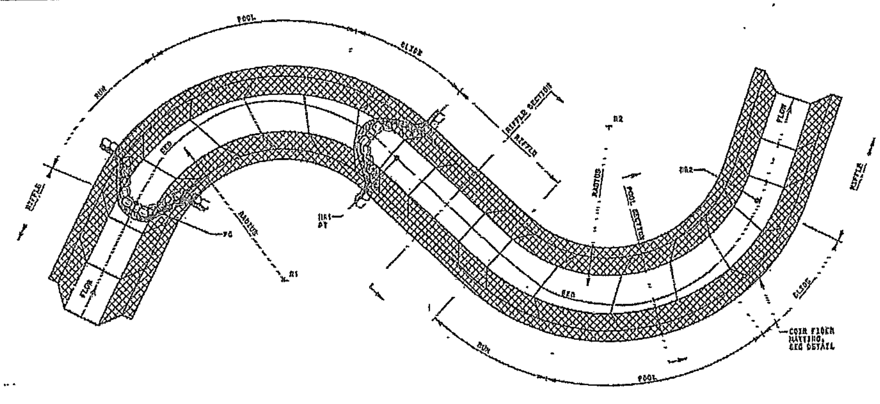
REVISIONS

5/28

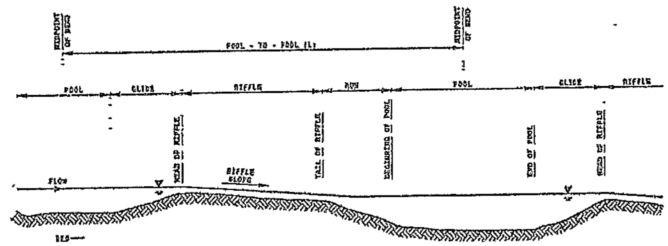
ROADWAY DESIGN ENGINEER	HYDRAULICS ENGINEER

INCOMPLETE PLANS
DO NOT USE FOR R/W ACQUISITION

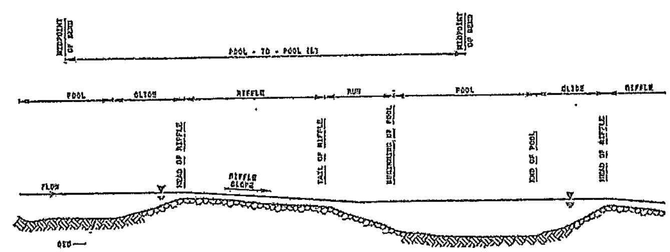
PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION



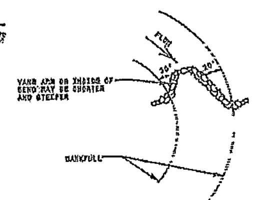
TYPICAL PLAN



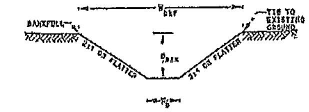
TYPICAL PROFILE



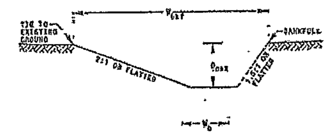
TYPICAL PROFILE FOR ARMORED RIFFLE SECTION



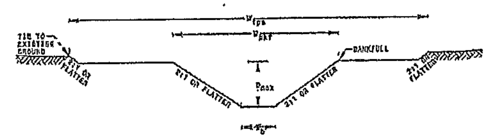
CROSS VANE CONSTRUCTION
IN MEANDER-BEND
PLAN VIEW



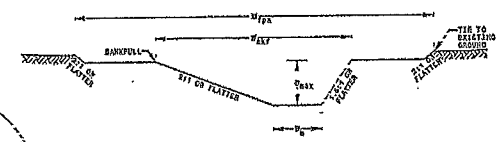
TYPICAL RIFFLE



TYPICAL POOL



TYPICAL RIFFLE WITH
BANKFULL BENCH



TYPICAL POOL WITH
BANKFULL BENCH

W_{bkf} = BANKFULL WIDTH
D_{max} = MAXIMUM DEPTH
W_b = BOTTOM WIDTH
W_{fpa} = FLOOD PRONE AREA WIDTH

CROSS-SECTION DIMENSIONS

REACH R1	RIFFLE W_{bkf}	RIFFLE D_{max}	RIFFLE W_b	RIFFLE W_{fpa}	POOL W_{bkf}	POOL D_{max}	POOL W_b	POOL W_{fpa}	Width/Depth Ratio
Sta. 0+00 - Sta. 8+20	12.0	1.10	2.40	>33	12.0	1.83	1.00	>35	14.4
Sta. 8+20 - Sta. 18+00	14.0	1.70	3.00	>33	14.0	2.40	2.00	>33	13.0

REACH R2	RIFFLE W_{bkf}	RIFFLE D_{max}	RIFFLE W_b	RIFFLE W_{fpa}	POOL W_{bkf}	POOL D_{max}	POOL W_b	POOL W_{fpa}	Width/Depth Ratio
	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

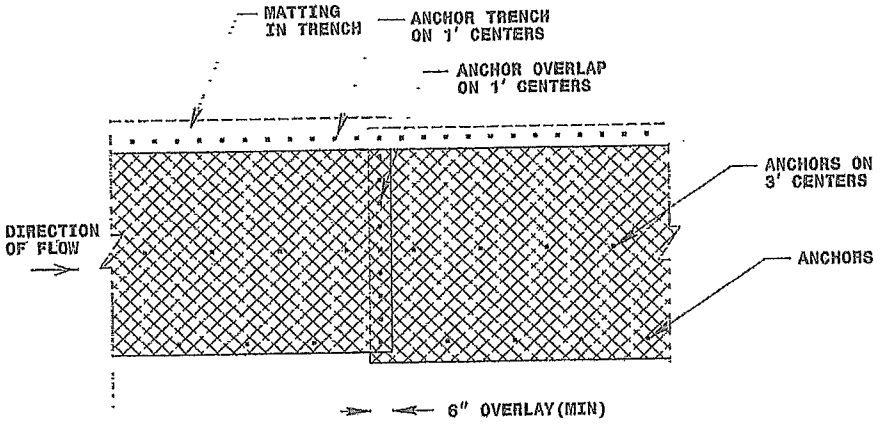
NOTES:
1. THE COORDINATES FOR EACH CENTER OF RADIUS (EX. "R1","R2") AND EACH HEAD OF RIFFLE (EX. "HR1", "HR2") ARE INDICATED ON THE PLAN SHEETS.

CHANNEL TYPICAL DETAIL
NOT TO SCALE

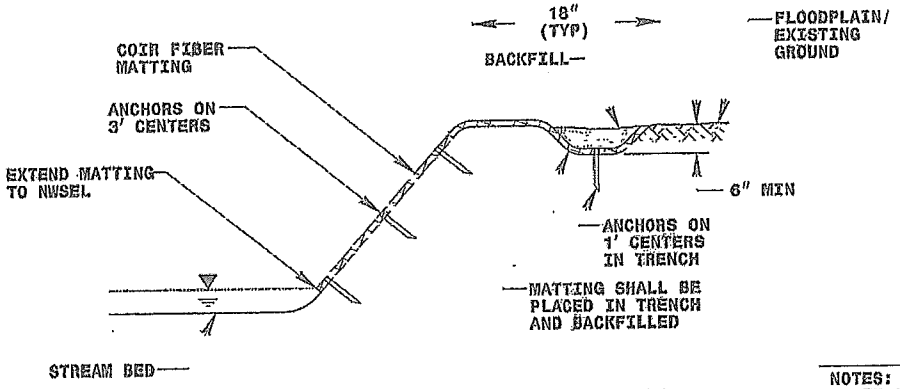
REVISIONS

12/4/2011

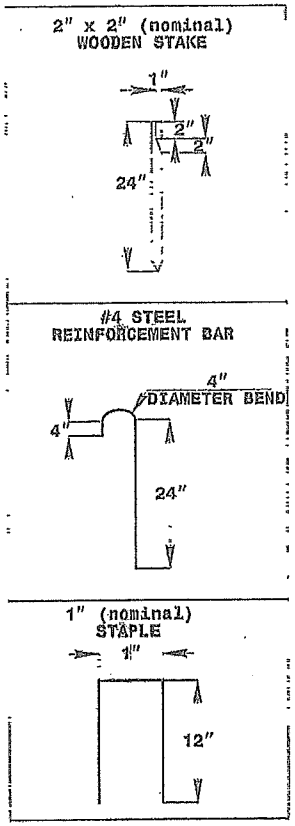
5/28



PLAN VIEW



TYPICAL CROSS SECTION



ANCHOR OPTIONS

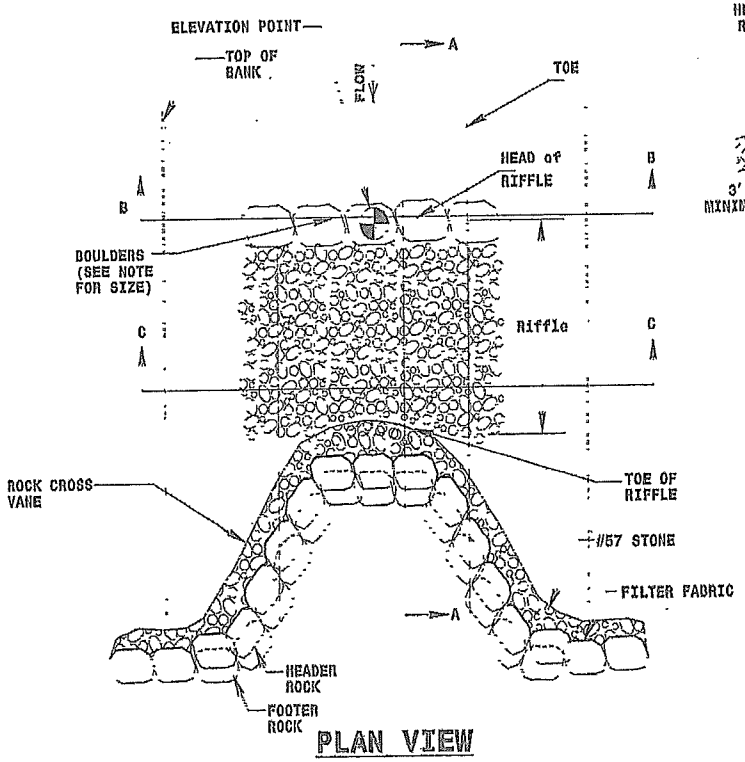
NOTES:
1. IN AREAS TO BE MATTED, ALL SEEDING, SOIL AMENDMENTS, AND SOIL PREPARATION MUST BE COMPLETED IN ACCORDANCE WITH THE PROJECT SPECIFICATIONS PRIOR TO PLACEMENT OF COIR FIBER MATTING.
2. REBAR OR STAPLES MAY BE USED IN PLACE OF WOODEN STAKES AS DIRECTED BY THE ENGINEER.

COIR FIBER MATTING DETAIL

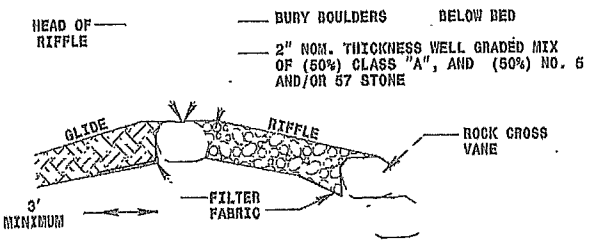
NOT TO SCALE

REVISIONS

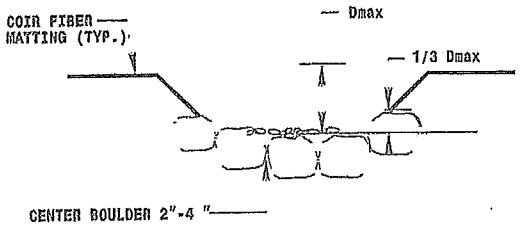
ROADWAY DESIGN ENGINEER	HYDRAULICS ENGINEER
INCOMPLETE PLANS DO NOT USE FOR R/W ACQUISITION	
PRELIMINARY PLANS DO NOT USE FOR CONSTRUCTION	



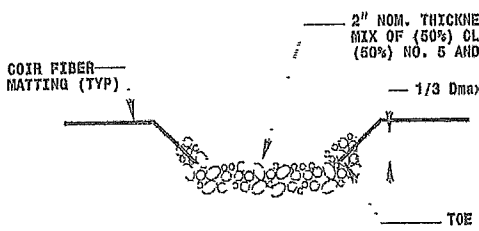
PLAN VIEW



SECTION A-A



SECTION B-B



SECTION C-C

REACH	R1
Wbkf (ft)	12.0
Dmax (ft)	1.40

REACH	R2
Wbkf (ft)	14.0
Dmax (ft)	1.76

NOTE:
1. BOULDERS SHOULD BE NATIVE STONES OR SHOT ROCK, ANGULAR AND OBLONG, WITH AN AXIS APPROXIMATELY
   Lx Wx D

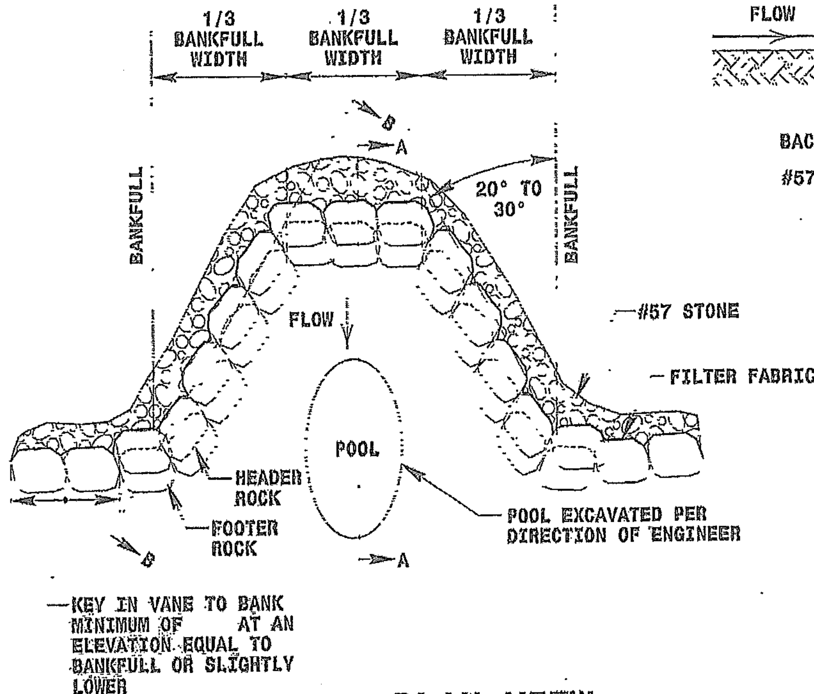
CONSTRUCTED RIFFLE DETAIL

NOT TO SCALE

ROADWAY DESIGN ENGINEER	HYDRAULICS ENGINEER

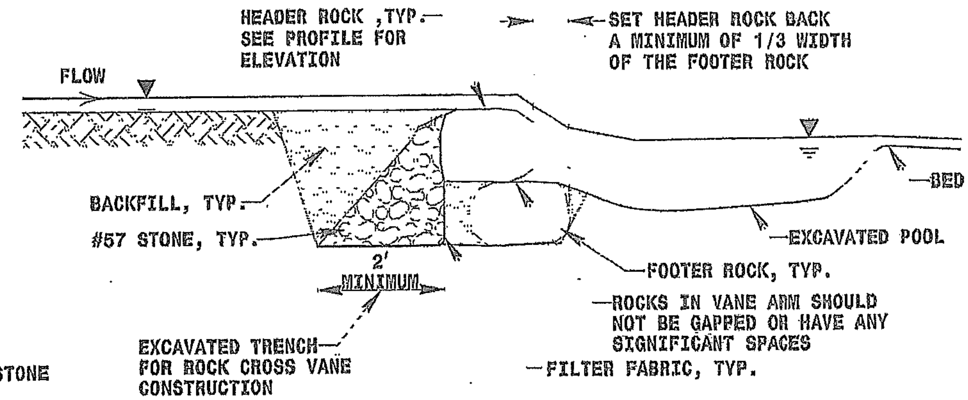
INCOMPLETE PLANS DO NOT USE FOR R/W ACQUISITION

PRELIMINARY PLANS DO NOT USE FOR CONSTRUCTION

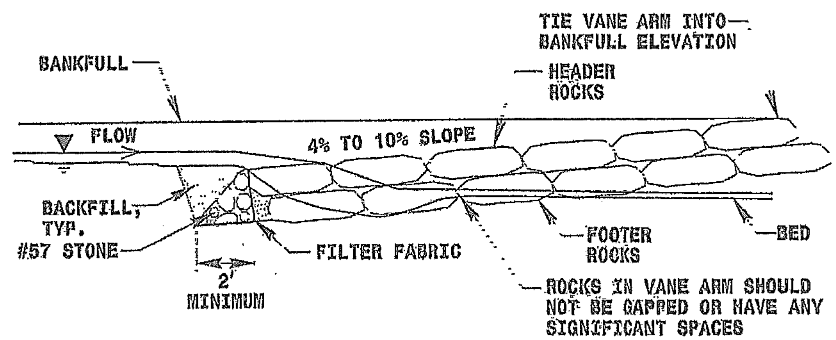


PLAN VIEW

BOULDER DIMENSIONS (FT)			
REACH	HEIGHT	LENGTH	WIDTH
R1	3	5	4
R2	3	5	4



SECTION A-A



SECTION B-B

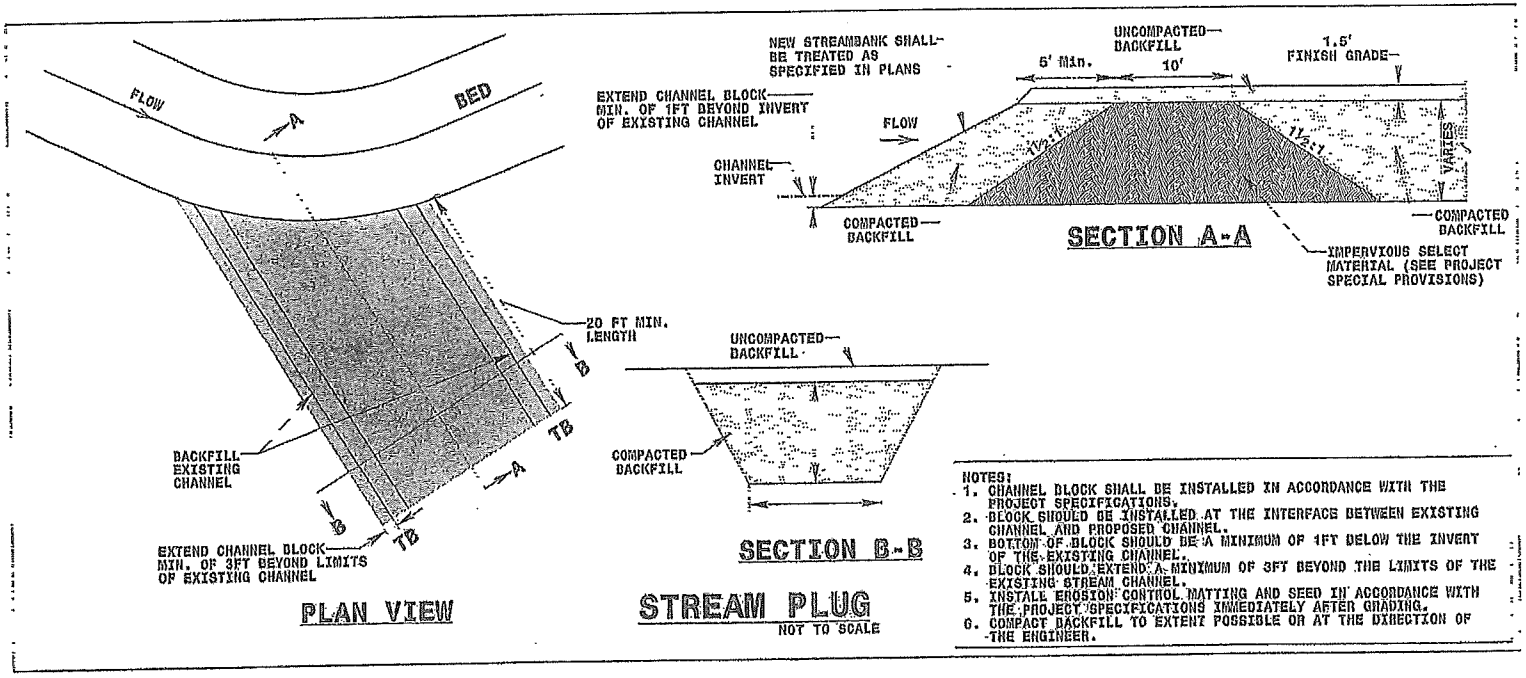
NOTES:
1. DEEPEST PART OF POOL TO BE IN LINE WITH WHERE VANE ARM TIES INTO BANKFULL.
2. DO NOT EXCAVATE POOL TOO CLOSE TO FOOTER BOULDERS.
3. CLASS "A" STONE CAN BE USED TO REDUCE VOIDS BETWEEN HEADERS AND FOOTERS.
4. COMPACT BACKFILL TO EXTENT POSSIBLE OR AT THE DIRECTION OF THE ENGINEER.
5. POOL DEPTH SHOULD BE 2 TO 3 TIMES BANKFULL DEPTH.

ROCK CROSS VANE DETAIL

NOT TO SCALE

REVISIONS

ROADWAY DESIGN ENGINEER	HYDRAULICS ENGINEER
INCOMPLETE PLANS DO NOT USE FOR R/W ACQUISITION	
PRELIMINARY PLANS DO NOT USE FOR CONSTRUCTION	



STREAM PLUG

NOT TO SCALE

NOTES:
1. CHANNEL BLOCK SHALL BE INSTALLED IN ACCORDANCE WITH THE PROJECT SPECIFICATIONS.
2. BLOCK SHOULD BE INSTALLED AT THE INTERFACE BETWEEN EXISTING CHANNEL AND PROPOSED CHANNEL.
3. BOTTOM OF BLOCK SHOULD BE A MINIMUM OF 1FT BELOW THE INVERT OF THE EXISTING CHANNEL.
4. BLOCK SHOULD EXTEND A MINIMUM OF 3FT BEYOND THE LIMITS OF THE EXISTING STREAM CHANNEL.
5. INSTALL EROSION CONTROL MATTING AND SEED IN ACCORDANCE WITH THE PROJECT SPECIFICATIONS IMMEDIATELY AFTER GRADING.
6. COMPACT BACKFILL TO EXTENT POSSIBLE OR AT THE DIRECTION OF THE ENGINEER.

RW SHEET NO.

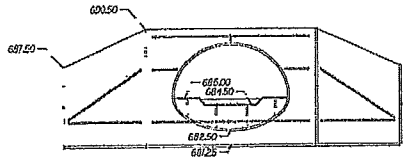
ROADWAY DESIGN ENGINEER	HYDRAULICS ENGINEER

INCOMPLETE PLANS
DO NOT USE FOR R/W ACQUISITION

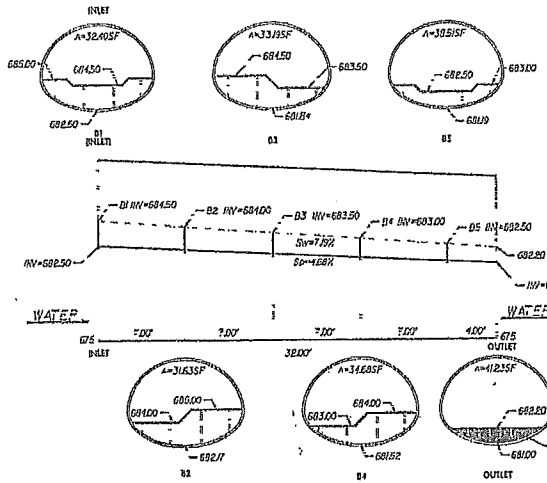
PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

REVISIONS

PIPE WITH BAFFLES
FARM PATH CROSSING
U-2707 CLEMMONS, NC

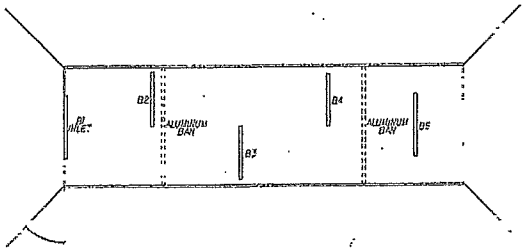


INLET WITH HEADWALL



PROFILE WITH CROSS SECTIONS AT BAFFELS

OUTLET WITH HEADWALL



PLAN VIEW

12/4/2018
H:\Projects\Documents\Design\U2707 mit design

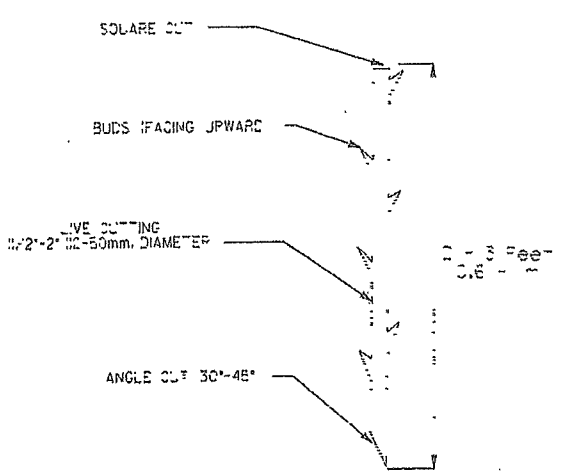
REVISIONS

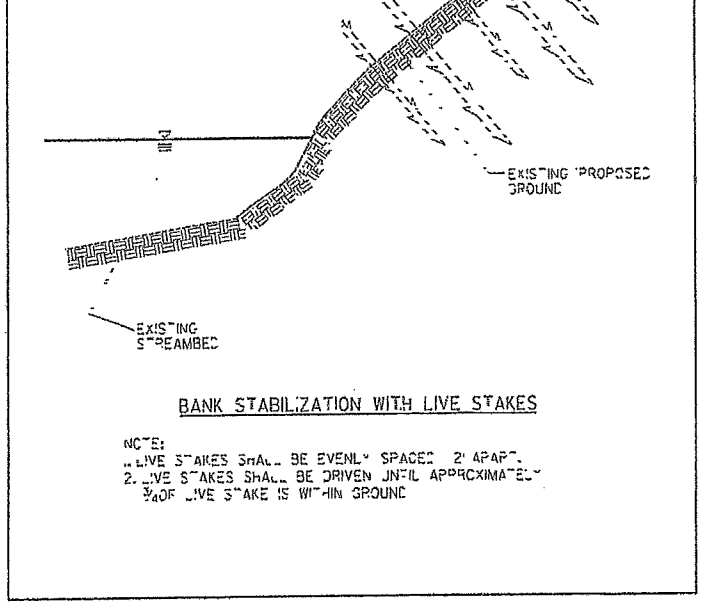
RW SHEET NO.

ROADWAY DESIGN ENGINEER	HYDRAULICS ENGINEER
INCOMPLETE PLANS DO NOT USE FOR R/W ACQUISITION	
PRELIMINARY PLANS DO NOT USE FOR CONSTRUCTION	

LIVE STAKE DETAIL

LIVE STAKE





BANK STABILIZATION WITH LIVE STAKES

NOTE:
1. LIVE STAKES SHALL BE EVENLY SPACED 2' APART.
2. LIVE STAKES SHALL BE DRIVEN UNTIL APPROXIMATELY 1/4 OF LIVE STAKE IS WITHIN GROUND

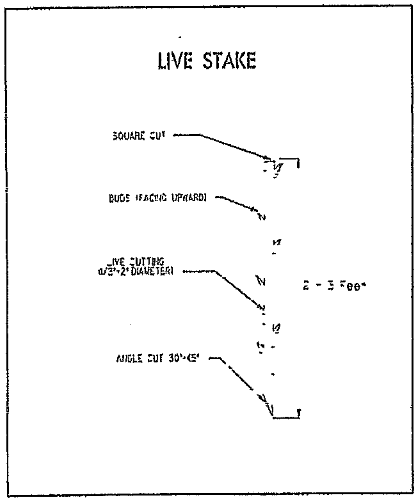
RW SHEET NO. | ROADWAY DESIGN ENGINEER | HYDRAULICS ENGINEER

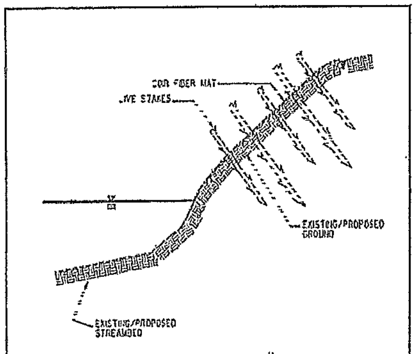
INCOMPLETE PLANS — DO NOT USE FOR R/W ACQUISITION

PRELIMINARY PLANS — DO NOT USE FOR CONSTRUCTION

PLANTING DETAILS

LIVE STAKES PLANTING DETAIL

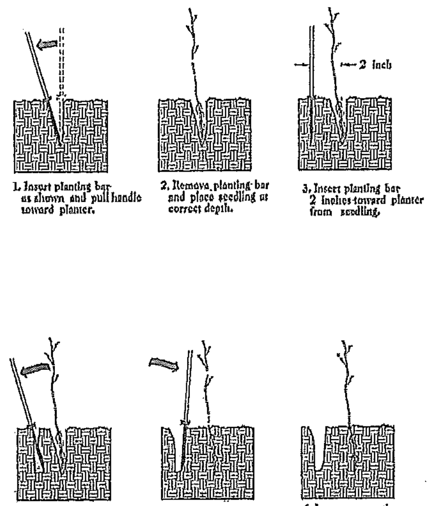




BANK STABILIZATION WITH LIVE STAKES

NOTE:
LIVE STAKES SHALL BE DRIVEN UNTIL APPROXIMATELY 3/4 OF LIVE STAKE IS WITHIN GROUND

BAREROOT PLANTING DETAIL
DIBBLE PLANTING METHOD
USING THE KBC PLANTING BAR



1. Insert planting bar as shown and pull handle toward planter.
2. Remove planting bar and place seedling at correct depth.
3. Insert planting bar 2 inches toward planter from seedling.
4. Pull handle of bar toward planter, firming soil at bottom.
5. Push handle forward firming soil at top.
6. Leave compaction hole open. Water thoroughly.

PLANTING NOTES:

PLANTING BAG
During planting, seedlings shall be kept in a moist canvas bag or similar container to prevent the root systems from drying.

KBC PLANTING BAR
Planting bar shall have a blade with a triangular cross section, and shall be 12 inches long, 4 inches wide and 1 inch thick at center.

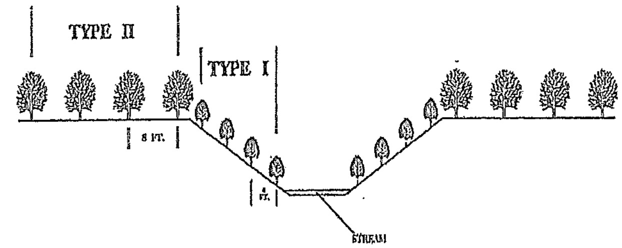
ROOT PRUNING
All seedlings shall be root pruned, if necessary, so that no roots extend more than 10 inches below the root collar.

[ ] TYPE 1 STREAMBANK REFORESTATION SHALL BE PLANTED 3 FT. TO 5 FT. ON CENTER, RANDOM SPACING, AVERAGING 4 FT. ON CENTER, APPROXIMATELY 2724 PLANTS PER ACRE.

[ ] TYPE 2 STREAMBANK REFORESTATION SHALL BE PLANTED 6 FT. TO 10 FT. ON CENTER, RANDOM SPACING, AVERAGING 8 FT. ON CENTER, APPROXIMATELY 680 PLANTS PER ACRE.

[ ] NOTE: TYPE 1 AND TYPE 2 STREAMBANK REFORESTATION SHALL BE PAID FOR AS "STREAMBANK REFORESTATION"

STREAMBANK REFORESTATION TYPICAL



STREAMBANK REFORESTATION

MIXTURE, TYPE, SIZE, AND FURNISH SHALL CONFORM TO THE FOLLOWING:

TYPE 1			
50%	SALIX NIGRA	BLACK WILLOW	2 ft - 3 ft LIVE STAKES
50%	CORNUS AMOMUM	SILKY DOGWOOD	2 ft - 3 ft LIVE STAKES
TYPE 2			
25%	FRAXINUS PENNSYLVANICA	GREEN ASH	12 in - 18 in BR
25%	QUERCUS PHELLOS	WILLOW OAK	12 in - 18 in BR
25%	QUERCUS MICHAUXII	SWAMPCHESTNUT OAK	12 in - 18 in BR
25%	BETULA NIGRA	RIVER BIRCH	12 in - 18 in BR

[ ] SEE PLAN SHEETS FOR AREAS TO BE PLANTED

STREAMBANK REFORESTATION DETAIL SHEET

N.C.D.O.T. - ROADSIDE ENVIRONMENTAL UNIT

REVISIONS

5/28

ALIGNMENT DATA
REACH 1

ROADWAY DESIGN ENGINEER	HYDRAULICS ENGINEER
INCOMPLETE PLANS DO NOT USE FOR R/W ACQUISITION	
PRELIMINARY PLANS DO NOT USE FOR CONSTRUCTION	

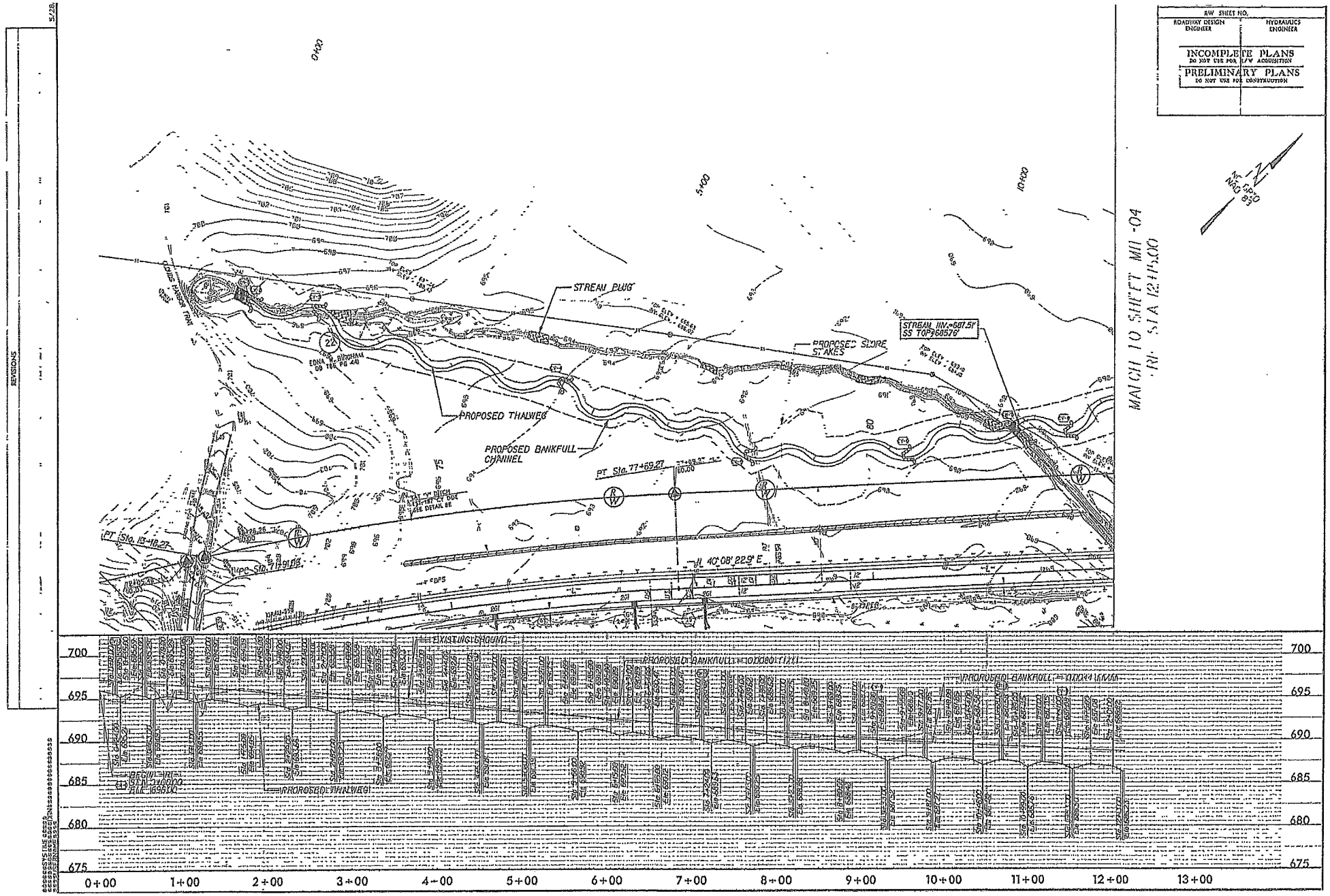
Beginning Point

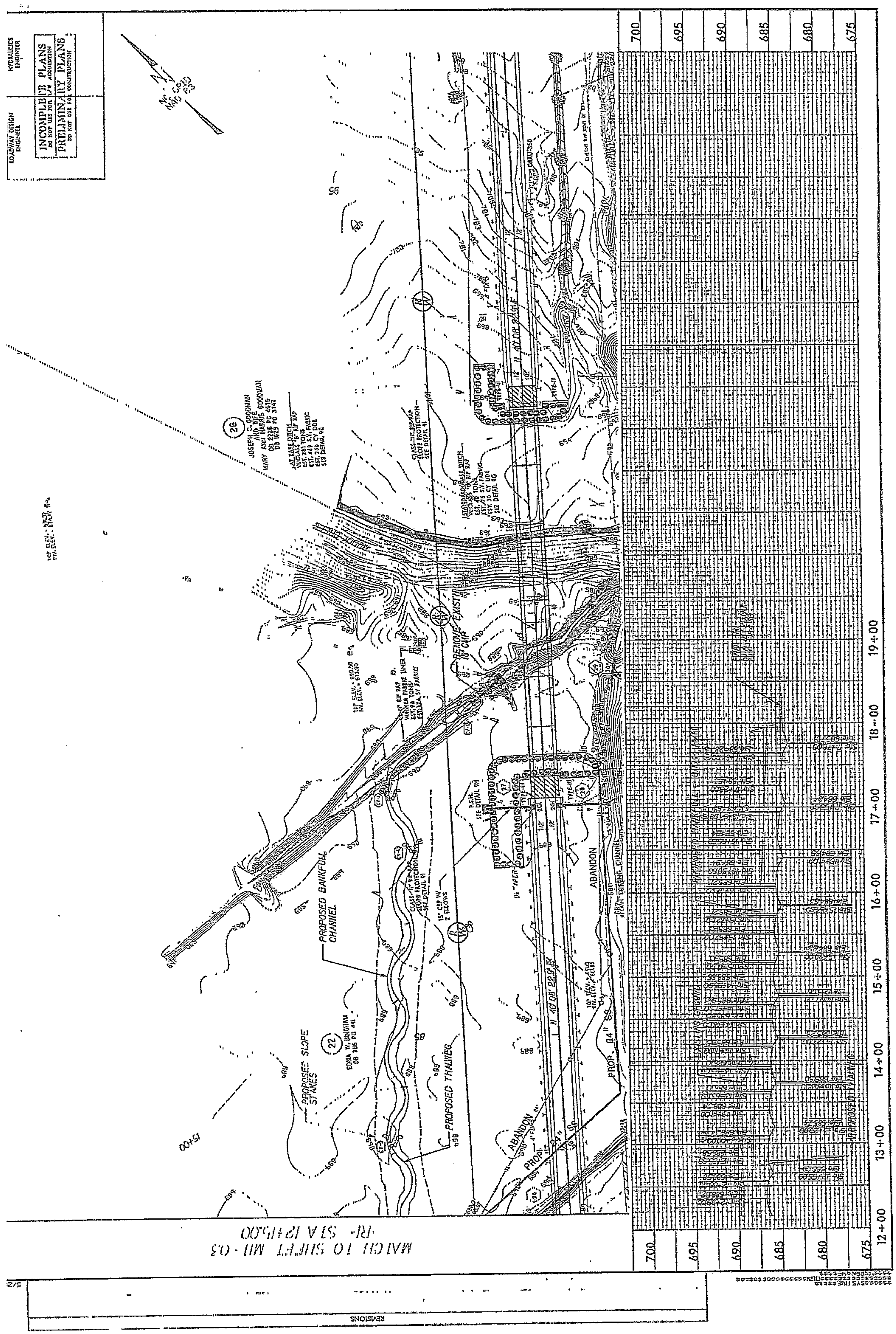
Station 00+00.00
Northing 826494.3736
Easting 1697077.6360

Station	Curve/Tangent Number	Curve/Tangent Length (ft)	Chord/Tangent Bearing	Chord Length (ft)	Delta Angle	Radius (ft)
0+00.00	Point 45000					
	Point 45000 to PC RI-1	10.48	N 61° 41' 44.10" E			
0+10.48	Curve RI-1	21.11	N 74° 02' 24.49" E	20.95	24° 41' 20.78" (RT)	49.00
	PTRI-1 to PC RI-2	3.84	N 86° 23' 04.88" E			
0+35.43	Curve RI-2	42.82	N 51° 20' 15.67" E	40.20	70° 05' 38.42" (LT)	35.00
	PTRI-2 to PC RI-3	5.61	N 16° 17' 26.46" E			
0+83.86	Curve RI-3	48.84	N 61° 25' 29.75" E	43.94	90° 16' 06.57" (RT)	31.00
	PTRI-3 to PC RI-4	9.73	S 73° 26' 26.92" E			
1+42.42	Curve RI-4	54.40	N 62° 01' 43.35" E	49.09	89° 03' 39.37" (LT)	35.00
	PTRI-4 to PC RI-5	7.49	N 17° 29' 53.66" E			
2+04.32	Curve RI-5	44.23	N 59° 44' 12.89" E	40.33	84° 28' 38.45" (RT)	30.00
	PTRI-5 to PC RI-6	5.23	S 78° 01' 27.88" E			
2+53.79	Curve RI-6	46.76	N 60° 06' 55.29" E	42.71	83° 43' 12.66" (LT)	32.00
	PTRI-6 to PC RI-7	7.03	N 18° 15' 19.46" E			
3+07.52	Curve RI-7	47.16	N 56° 51' 09.79" E	43.67	77° 11' 40.66" (RT)	35.00
	PTRI-7 to PC RI-8	7.41	S 849.32' 59.88" E			
3+62.14	Curve RI-8	52.42	N 54° 51' 46.39" E	48.14	81° 10' 27.46" (LT)	37.00
	PTRI-8 to PC RI-9	7.44	N 14° 16' 32.65" E			
4+22.00	Curve RI-9	50.33	N 63° 59' 44.48" E	44.25	99° 26' 23.64" (RT)	29.00
	PTRI-9 to PC RI-10	5.72	S 66° 12' 03.70" E			
4+78.05	Curve RI-10	49.84	N 62° 43' 03.65" E	43.52	101° 59' 45.29" (LT)	28.00
	PTRI-10 to PC RI-11	4.89	N 11° 43' 11.01" E			
5+32.78	Curve RI-11	52.74	N 50° 27' 47.72" E	48.82	97° 29' 13.42" (RT)	39.00
	PTRI-11 to PC RI-12	6.18	N 899° 12' 24.43" E			
5+91.70	Curve RI-12	39.46	N 51° 31' 45.40" E	36.67	75° 21' 18.07" (LT)	30.00
	PTRI-12 to PC RI-13	4.64	N 13° 51' 06.36" E			
6+35.80	Curve RI-13	47.52	N 60° 47' 33.87" E	42.38	93° 52' 55.01" (RT)	29.00
	PTRI-13 to PC RI-14	6.15	S 72° 15' 58.62" E			
6+89.48	Curve RI-14	59.25	N 60° 35' 07.59" E	52.78	94° 17' 47.57" (LT)	36.00
	PTRI-14 to PC RI-15	6.23	N 13° 26' 13.81" E			
7+54.95	Curve RI-15	34.19	N 48° 25' 14.01" E	32.11	69° 58' 00.40" (RT)	28.00
	PTRI-15 to PC RI-16	5.62	N 83° 24' 14.21" E			
7+94.77	Curve RI-16	45.15	N 41° 40' 42.92" E	41.26	83° 27' 02.58" (LT)	31.00
	PTRI-16 to PC RI-17	10.20	N 0° 02' 48.38" W			
8+50.12	Curve RI-17	49.30	N 40° 18' 30.95" E	45.33	80° 42' 38.65" (RT)	35.00
	PTRI-17 to PC RI-18	5.03	N 80° 39' 50.28" E			
9+04.46	Curve RI-18	51.70	N 31° 17' 40.66" E	45.54	98° 46' 19.23" (LT)	30.00
	PTRI-18 to PC RI-19	5.85	N 18° 04' 28.96" W			
9+62.01	Curve RI-19	49.02	N 30° 21' 01.43" E	43.39	96° 51' 00.73" (RT)	29.00
	PTRI-19 to PC RI-20	4.89	N 78° 46' 31.82" E			
10+15.92	Curve RI-20	53.31	N 38° 35' 21.06" E	49.04	80° 22' 21.52" (LT)	38.00
	PTRI-20 to PC RI-21	7.68	N 1° 35' 49.70" W			
10+76.91	Curve RI-21	39.93	N 39° 15' 33.94" E	36.63	81° 42' 47.28" (RT)	28.00
	PTRI-21 to PC RI-22	6.74	N 80° 06' 57.58" E			
11+23.58	Curve RI-22	52.12	N 28° 37' 28.08" E	45.39	102° 58' 59.00" (LT)	29.00
	PTRI-22 to PC RI-23	4.45	N 22° 52' 01.42" W			
11+80.16	Curve RI-23	56.65	N 27° 51' 09.41" E	49.54	101° 26' 21.65" (RT)	32.00
	PTRI-23 to PC RI-24	5.17	N 78° 34' 20.23" E			
12+41.98	Curve RI-24	43.64	N 56° 53' 51.67" E	39.89	83° 20' 57.13" (LT)	30.00
	PTRI-24 to PC RI-25	5.29	N 4° 46' 36.90" W			
12+90.92	Curve RI-25	51.80	N 36° 26' 53.31" E	47.45	82° 27' 00.41" (RT)	36.00
	PTRI-25 to PC RI-26	10.49	N 77° 40' 23.51" E			
13+53.21	Curve RI-26	39.24	N 41° 24' 49.79" E	36.67	72° 31' 07.44" (LT)	31.00

Station	Curve/Tangent Number	Curve/Tangent Length (ft)	Chord/Tangent Bearing	Chord Length (ft)	Delta Angle	Radius (ft)
	PTRI-26 to PC RI-27	8.81	N 5° 09' 16.07" E			
14+01.26	Curve RI-27	42.45	N 43° 59' 48.18" E	43.90	77° 41' 04.22" (RT)	35.00
	PTRI-27 to PC RI-28	9.08	N 82° 50' 20.29" E			
14+55.79	Curve RI-28	37.68	N 45° 37' 08.29" E	35.08	74° 26' 23.99" (LT)	29.00
	PTRI-28 to PC RI-29	8.64	N 8° 23' 56.30" E			
15+04.11	Curve RI-29	50.64	N 42° 36' 30.64" E	46.78	78° 25' 08.69" (RT)	37.00
	PTRI-29 to PC RI-30	6.20	N 86° 49' 04.99" E			
15+60.95	Curve RI-30	46.67	N 47° 29' 36.07" E	43.09	78° 38' 56.63" (LT)	34.00
	PTRI-30 to PC RI-31	7.87	N 8° 10' 08.36" E			
16+15.49	Curve RI-31	50.92	N 45° 34' 27.41" E	47.38	74° 48' 38.09" (RT)	39.00
	PTRI-31 to PC RI-32	8.06	N 82° 58' 46.45" E			
16+74.47	Curve RI-32	51.92	N 41° 39' 33.30" E	47.54	82° 38' 26.30" (LT)	36.00
	PTRI-32 to PC RI-33	11.29	N 0° 20' 20.15" E			
17+38.19	Curve RI-33	80.43	N 47° 21' 38.65" E	71.70	94° 02' 36.99" (RT)	49.00
	PC RI-33 to Point 45001	16.30	S 85° 37' 02.86" E			
18+34.91	Point 45001					

REVISIONS


RW SHEET NO.
ROADWAY DESIGN ENGINEER
HYDRAULICS ENGINEER
INCOMPLETE PLANS
DO NOT USE FOR R/W ACQUISITION
PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION
REVISIONS
STREAM PLUG
PROPOSED SLOPE STAKES
STREAM INV.=687.51'
SS TOP=686.76'
PROPOSED THALWEG
PROPOSED BANKFULL CHANNEL
PT Sta. 77+69.27
PT Sta. 113+18.27
PVC Sta. 77+91.18
N 40° 08' 22.9" E
MATCH TO SHEET MH-04
EXISTING GROUND
PROPOSED BANKFULL
PROPOSED THALWEG
0+00
1+00
2+00
3+00
4+00
5+00
6+00
7+00
8+00
9+00
10+00
11+00
12+00
13+00
700
695
690
685
680
675


INCOMPLETE PLANS
PRELIMINARY PLANS
PROPOSED BANKFULL CHANNEL
PROPOSED THALWEG
PROPOSED SLOPE STAKES
ABANDON
12+00
13+00
14+00
15+00
16+00
17+00
18+00
19+00
700
695
690
685
680
675
REVISIONS

INCOMPLETE PLANS
DO NOT USE FOR CONSTRUCTION
PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION
ROADWAY DESIGN ENGINEER
DRAINAGE ENGINEER
RW SHEET NOS.
NC SPC NAD 83
MATCH TO SHEET PLT-04
PLT-04 STA 12+15.00
STREAM INV=687.51'
SS TOP=695.18'
PROPOSED STAKES
TYPE II PLANTING ZONE
STREAM PLUG
PROPOSED THALWEG
PROPOSED BANKFULL CHANNEL
EXISTING GROUND
PROPOSED CHANNEL
LOUIS HARPER TRAIL
REVISIONS
0+00
1+00
2+00
3+00
4+00
5+00
6+00
7+00
8+00
9+00
10+00
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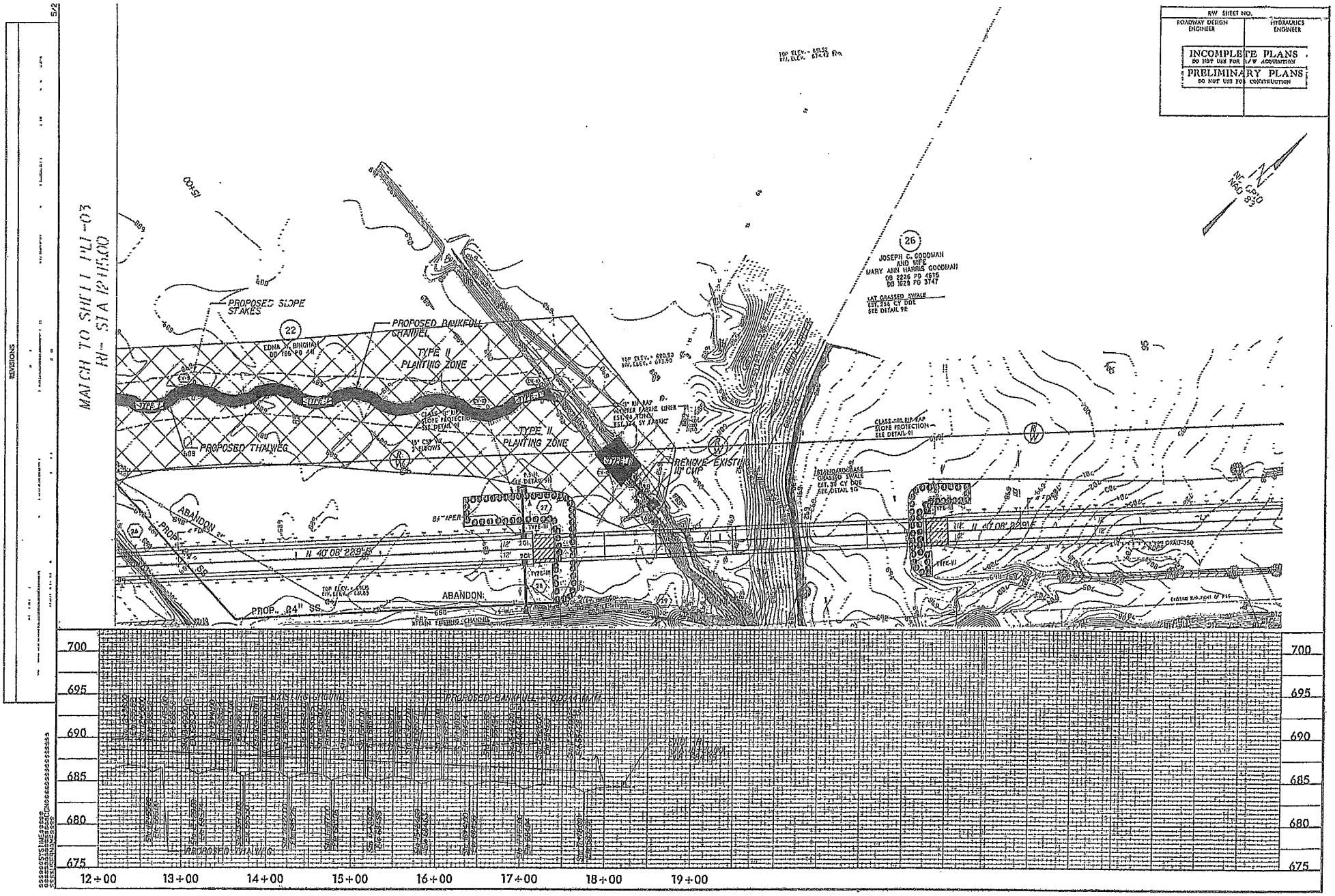
12+00
13+00
675
680
685
690
695
700


RW SHEET NO.
ROADWAY DESIGN ENGINEER
HYDRAULICS ENGINEER
INCOMPLETE PLANS
DO NOT USE FOR R/W ACQUISITION
PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION
REVISIONS
5/2
MATCH TO SHEET PLI-03
RW- STA 12+50.00
PROPOSED SLOPE STAKES
PROPOSED RANKFULL CHANNEL
TYPE II PLANTING ZONE
PROPOSED THALWEG
EDNA BINGHAM DB 166 PG 141
JOSEPH E. GOODMAN AND WIFE MARY ANN HARRIS GOODMAN DB 2226 PG 1915 DB 1629 PG 3747
CLASS VIII RIP-RAP SLOPE PROTECTION SEE DETAIL-91
REMOVE EXISTING 18" CMP
ABANDON
PROP. 84" SS
N 40°08'22"E
EXISTING GROUND
PROPOSED RANKFULL CHANNEL
PROPOSED THALWEG
700
695
690
685
680
675
12+00
13+00
14+00
15+00
16+00
17+00
18+00
19+00