APPENDIX

**Request for Corps of Engineers Jurisdictional Determination (JD)
and/or Delineation Review**

Georgia DNR Application for 25-Foot Vegetative Buffer Encroachment

Soil Survey

**Georgia Department of Transportation
Bridge Inspection Report**

Bridge Foundation Investigation Report

Bridge Hydraulic Analysis

US Army Corps
of Engineers
Savannah District

SAS APPENDIX 1: Request for Corps of Engineers Jurisdictional Determination (JD) and/or Delineation Review

I. Reason for request: (check as many as applicable)

☐ I intend to construct/develop a project or perform activities on this parcel which would be designed to avoid all aquatic resources.

☐ I intend to construct/develop a project or perform activities on this parcel which would be designed to avoid all jurisdictional aquatic resources under Corps authority.

☑ I intend to construct/develop a project or perform activities on this parcel which may require authorization from the Corps, and the JD would be used to avoid and minimize impacts to jurisdictional aquatic resources and as an initial step in a future permitting process.

☐ I intend to construct/develop a project or perform activities on this parcel which may require authorization from the Corps; this request is accompanied by my permit application and the JD is to be used in the permitting process.

☐ I intend to construct/develop a project or perform activities in a navigable water of the U.S. which is included on the district Section 1O list and/or is subject to the ebb and flow of the tide.

☐ A Corps JD is required in order to obtain my local/state authorization.

☐ I intend to contest jurisdiction over a particular aquatic resource and request the Corps confirm that jurisdiction does/does not exist over the aquatic resource on the parcel.

☐ I believe that the site may be comprised entirely of dry land.

☐ Other:_____

II. I am requesting that the U.S. Army Corps of Engineers, Savannah District, provide me with the following:

☑ **Delineation Review of Aquatic Resources** - Concurrence with an aquatic resource delineation is a written notification from the Corps concurring, not concurring, or commenting on the aquatic resource boundaries, or limits, delineated on a property.

☐ **Preliminary Jurisdictional Determination** - (PJD). A PJD is defined in Corps regulations at 33 CFR 331.2, as "written indications that there may be waters of the United States on a parcel". When the Corps provides a PJD, the Corps is making no legally binding determination of any type regarding whether jurisdiction exists over the particular aquatic resource in question.

☐ **Approved Jurisdictional Determination** - (AJD) An AJD is defined in Corps regulations at 33 CFR 331.2. A definitive, official determination that there are, or that there are not, jurisdictional aquatic resources on a parcel.

☐ I am unclear as to what I would like to request and require additional information to inform my decision.

III. Property/Owner Information. Please complete **ALL** of the following information for the property under review:

SECTION 1

Parcel Number of Property: N/A

Lat. 33.99260 **Long.** - 84.38655 (in decimal degrees)

Parcel Address: N/A

Parcel City : N/A Parcel County: Cobb and Fulton Zip: N/A

Size of Review Area: 6.33 Acre(s) 830 Linear feet

SECTION 2

LANDOWNER NAME	AUTHORIZED AGENT'S NAME
First: Rustavius	First: James
Last: Ford	Last: Barnett
Company: Cobb County	Company: Edwards-Pitman Environmental, Inc.
Email Address: rustavius.ford@cobbcounty.org	Email Address: jbarnett@edwards-pitman.com
Address: 1890 County Services Parkway	Address: 2700 Cumberland Parkway, Suite 300
City: Marietta	City: Atlanta
State: GA Zip: 30008	State: GA Zip: 30339
Phone: 770-420-6659	Phone: 770-333-9484

PROPERTY ACCESS PERMISSION, AKNOWLEDGEMENT OF 18 U.S.C. SECTION 10001 AND STATEMENT OF AGENT AUTHORIZATION

Initial ONLY One:

By signing below, I certify that I am the owner of record of the property referenced in III, Section 1 above, and I hereby authorize representatives of the U.S. Army Corps of Engineers, Savannah District, to enter the property for purposes of conducting on-site inspections, and issuing an aquatic resource delineation concurrence and/or a jurisdictional determination. My signature shall also be an affirmation that I possess the requisite property rights to request a delineation review and/or a jurisdictional determination on the property referenced in III - Section 1. Further, I authorize the agent in III - Section 2, to act on my behalf in the processing of this request and to furnish supplemental information in support of this request.

X By signing below, I certify that I am acting as the duly authorized agent of the owner of record of the property referenced in III, Section 1 above, and have been given the authority to: 1) request a delineation review and/or a jurisdictional determination (JD) on the property referenced in III - Section 1, and 2) authorize representatives of the U.S. Army Corps of Engineers, Savannah District, to enter the property for purposes of conducting on-site inspections, and issuing an aquatic resource delineation concurrence and/or a jurisdictional determination. I understand that I may be required to provide documentary evidence of my authority to request a delineation review and/or JD, and/or to grant Corps of Engineers personnel access to the property.

Please Print Name Legibly: Rustavius Ford

Signature Rustavius Ford Digitally signed by Rustavius Ford Date: 2020.07.10 09:13:46 -04'00' Date: 7/10/2020

✱ Authorities: Rivers and Harbors Act, Section 10, 33 USC 403; Clean Water Act, Section 404, 33 USC 1344; Marine Protection, Research, and Sanctuaries Act, Section 103, 33 USC 1413; Regulatory Program of the U.S. Army Corps of Engineers; Final Rule for 33 CFR Parts 320-332.
Principal Purpose: The information that you provide will be used in evaluating your request to determine whether there are any aquatic resources within the project area subject to federal jurisdiction under the regulatory authorities referenced above.
Routine Uses: This information may be shared with the Department of Justice and other federal, state, and local government agencies, and the public, and may be made available as part of a public notice as required by federal law. Your name and property location where federal jurisdiction is to be determined will be included in the approved jurisdictional determination (AJD), which will be made available to the public on the District's website and on the Headquarters USACE website.
Disclosure: Submission of requested information is voluntary; however, if information is not provided, the request for an AJD cannot be evaluated nor can an AJD be issued.

GEORGIA DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION

REVISED MAY 2016

APPLICATION FOR A 25-FOOT VEGETATIVE BUFFER ENCROACHMENT ON DESIGNATED WARM WATERS OF THE STATE

(Required prior to conducting land disturbing activities within the State-mandated 25-foot buffer in accordance with the Erosion and Sedimentation Act of 1975, as amended, O.C.G.A. 12-7-6(b)(15))

Property Owner's Name *(Person)*: Rustavius Ford, P.E.

Company Name *(if applicable)*: Cobb County

Current Mailing Address: 1890 County Services Parkway, Marietta, GA 30008

Telephone: 770-420-6659 E-Mail: rustavius.ford@cobbcounty.org

Contact Person's Name and Address: James Barnett, Ecologist
2700 Cumberland Parkway, Suite 300, Atlanta, GA 30339

Contact Person's Telephone: 770-333-9484 E-Mail: jbarnett@edwards-pitman.com

Contact Person's Company Name *(if applicable)*: Edwards-Pitman Environmental, Inc.

Project Name: Willeo Road over Willeo Creek

Total Project Disturbed Acreage: 1.45 acres

Type of Project: Bridge Replacement

Buffer Variance Criteria *(391-3-7.05(2)(a) – (k))*: 2(a) and 2(h)

Location of Buffer Impacts:

City *(list only if the buffer impacts are located within jurisdictional boundaries of the municipality)*: Roswell

County *(list only if the buffer impacts are located within jurisdictional boundaries of the county)*: _____

GPS Coordinates *(decimal degrees)*: Latitude: 33.992056 Longitude: -84.386690

Watershed Name and 8-digit HUC *(Hydrologic Unit Code)*: Upper Chattahoochee River (HUC 03130001)

Detailed Directions to Project *(attach location map and USGS quad sheet)*: See attached sheet with directions following this application.

Name of State water(s) Impacted: Open Water (OW) 7 flowing into the Chattahoochee River
(if unnamed, indicate the first named waterbody that this State water flows into)

Total Area of Buffer Disturbance *(square feet)*: 9,159

Total Length of Buffer Disturbance *(linear feet)*: 387

Signature: Rustavius Ford Digitally signed by Rustavius Ford Date: 2020.07.10 09:03:40 -04'00' **Date:** 7/10/20

-

SOIL SURVEY SUMMARY

COBB NO. X2122

WILLEO ROAD BRIDGE

ROSWELL/MARIETTA, FULTON/COBB COUNTY, GEORGIA

G20ATK01

February 18, 2020

Prepared For:

Atkins
1600 Riveredge Parkway
Suite 700
Atlanta, Georgia 30328

1955 Vaughn Road, Suite 101 • Kennesaw, Georgia 30144 • (770) 794-0266 • fax (770) 794-9483
www.contoureng.com

SOIL SURVEY SUMMARY
For
Willeo Road Bridge
Roswell/Marietta, Fulton/Cobb County, Georgia
Cobb No. X2122
February 18, 2020

1. Location / Description	This project is for the bridge replacement of the existing Willeo Road Bridge. The project begins at Station 10+00 on Willeo Road and continues north to Station 19+00. The project lies within the city limits of Roswell/Marietta in Fulton/Cobb County.
2. Geology	The project will be geologically sited in the Mica Schist / Gneiss / Amphibolite Formation of the Georgia Piedmont Region.
3. Rock	None encountered.
4. Removal	No material requiring removal was encountered. This work should be done at the direction of the Engineer, and may be eliminated if the subgrade soils are dry and stable at the time of construction.
5. Waste	None of the materials found on this project will require wasting.
6. Subgrade Materials	No additional subgrade material will be required for this project.
7. Pavement Design Values	We recommend the following values for use in the pavement design calculations for this project: **Soil Support Value =** 3.0 Graded aggregate base is the only base material recommended for use on this project.
8. Ditch Lining	We recommend the following values for use in the ditch lining calculations for this project: **Plasticity Index, PI =** NP **D75 (mm) =** 0.230 **Unified Soils Classification System (USCS) =** SM

Sample HA-7 at Station 11+28 37' LT was used for ditch lining evaluation.

9. Slopes

Maximum 2:1 slopes will be safe for this project.

10. Groundwater

The project crosses low wet areas and swamps which may be inundated at the time of construction. Because of the relatively flat terrain on this project, it does not appear that these areas may be drainable. The soils in the low areas listed below consist primarily of loose sands, which will not require removal. However, we recommend that one layer of low-strength filter fabric per Special Provision 881 be placed on top of the existing ground prior to placing the fills in accordance to Standard Specifications 455 as shown on the attached detail, to provide stability over the loose sands. The low wet areas where this fabric will be required are as follows:

Station to Station	Location
10+00 to 15+50	Left and Right

However, if these areas are dry and stable at the time of construction, the fabric may be eliminated, as directed by the Engineer.

If it is not feasible to drain these areas / this area during construction, a mat of rock embankment should be placed to a height of 18 inches above the water level prior to placing normal fills. Separate the rock embankment from normal fills with a layer of woven plastic filter fabric per Standard Specifications 881.

11. Shrinkage

We recommend an average shrinkage factor of 25% for use in the earthwork calculations for this project.

12. Culverts

We recommend that a 36-inch blanket of Type II Foundation Backfill material be placed under the barrel of all culverts and 48-inch diameter and larger cross-drains on this project.

13. Corrosion

Reference should be made to the attached "Pipe Culvert Material Alternates" chart for materials allowable by the Laboratory corrosion test.

14. Bench Detail

Where new fills are to be placed on existing slopes steeper than 3:1, the existing slope should be benched in accordance with the attached detail.

15. Serrated Slopes

Serrated slopes will not be required on this project.

16. Special Problems

The stream/reservoir at the following locations will require siltation control during construction. We also recommend pre- and post-construction cross-sections be performed at this location, as per the construction manual to protect the Department against claims.

Station to Station	Location
10+00 to 15+00	Left
10+00 to 19+00	Right

We recommend that all bridge approach slabs on this project be constructed in accordance with the notched detail on Georgia Standard 9017-R.

If inundated areas are dry at the time of construction, the toes of the proposed 2:1 slopes should be stabilized by placement of layers of geofabric and rock embankment per the provided In-place Stabilization along Toes of Slopes Detail located in Appendix A of this report.

Prepared By: William M. Hesterlee, E.I.T.

Approved By Name: James E. Gough, P.E.

Approved By Signature:

GEORGIA REGISTERED No. PE036335 PROFESSIONAL ENGINEER JAMES E. GOUGH
02-18-2020

Revised 06/16/06

GEORGIA DEPARTMENT OF TRANSPORTATION

STATE OF GEORGIA

SPECIAL PROVISION

G20ATK01, Fulton/Cobb County

Cobb No. X2122

Section 881- Fabrics

Add the following to Subsection 881.2.08:

881.2.08 Filter Fabric for Embankment Stabilization

A. Requirements

1. Use woven filter fabric for embankment stabilization.
2. Sew fabric with a lock stitch using high strength polypropylene or nylon thread.
3. Obtain approval of the stitch and sewing method from the Engineer prior to use.
4. Use fabric that meets the following minimum tensile strength requirements:

Fabric Type	Tensile Strengths in lbs/in (kN/m) width			
	Warp Direction		Fill Direction	
	5% Strain	Ultimate	5% Strain	Ultimate
Polyester	100 (17.5 kN/m)	250 (43.8 kN/m)	100 (17.5 kN/m)	250 (43.8 kN/m)
Polypropylene	100 (17.5 kN/m)	400 (70 kN/m)	100 (17.5 kN/m)	400 (70 kN/m)

Minimum Seam Strength = 100 lbs/in (17.5 kN/m) width

a. Tensile strengths at 5% strain are based on reduction factors from the ultimate strengths of 0.4 for polyester and 0.25 for polypropylene fabrics.

b. Use of reduction factors other than those shown are allowed only if verified by laboratory tests acceptable to the Department.

5. Submit a certification from the manufacturer that shows the physical properties of the material used and how it meets this Specification. Submit the certificate according to Subsection 106.05, “Materials Certification.”

8.2.16

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

Test according to the following:

Test	Method
Tensile strength, elongation	ASTM D 4595 Wide Strip Test
Seam Strength	ASTM D 4884 Wide Strip Test

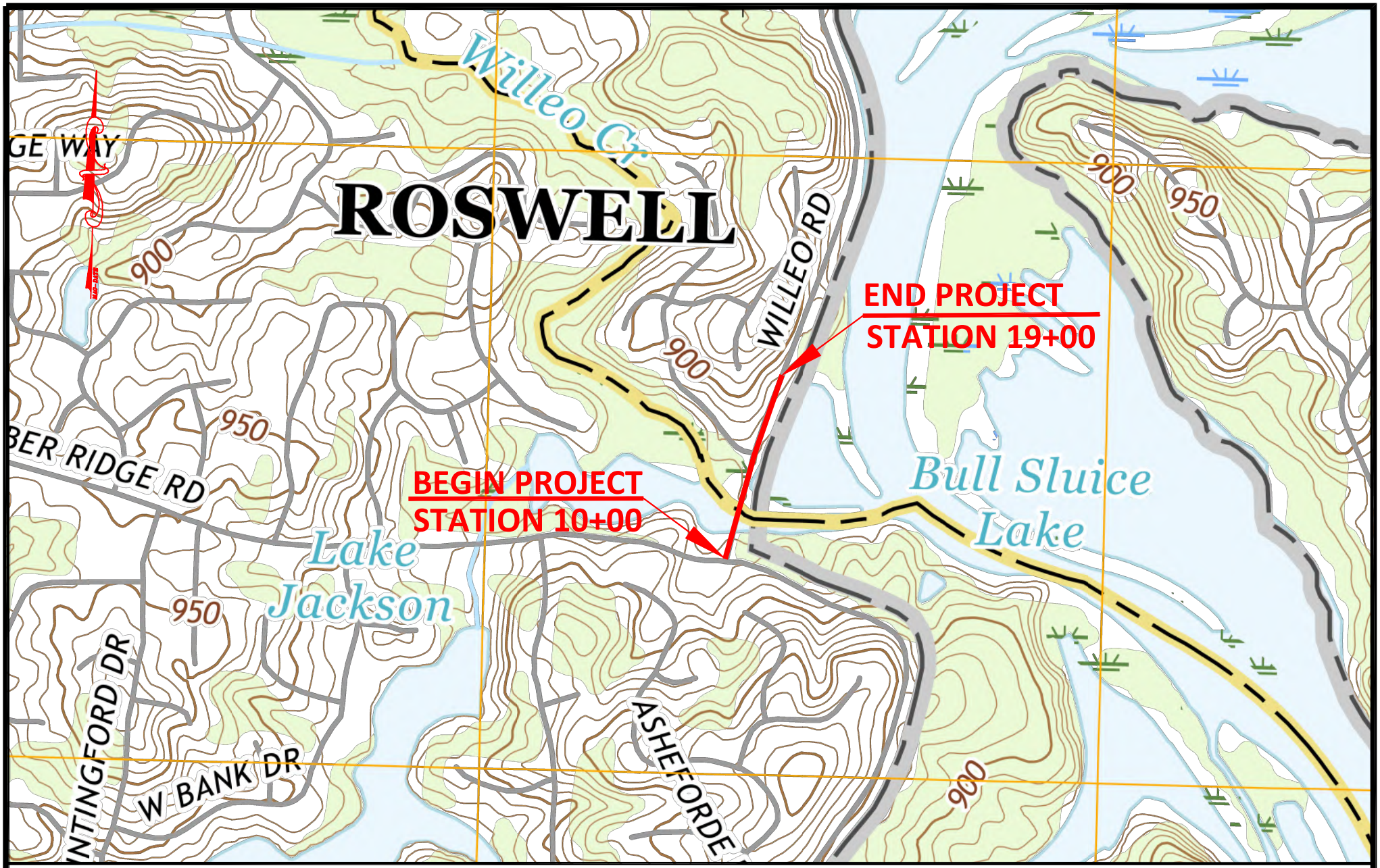
1. Run the tests at a strain rate of 10% per minute.
2. Use a pre tensioning load of 10 lbs/in (1.75 kN/m) or 3%, whichever is less.

D. Materials Warranty

General Provisions 101 through 150.

FIGURES:

Site Vicinity Map
Aerial Boring Location Plan
Boring Location Plan (1)
Boring Location Plan (2)



SITE VICINITY MAP

CONTOUR ENGINEERING

LEGEND

Source: USGS Topographic Map - Sandy Springs, GA Quadrangle

Scale: Not to Scale

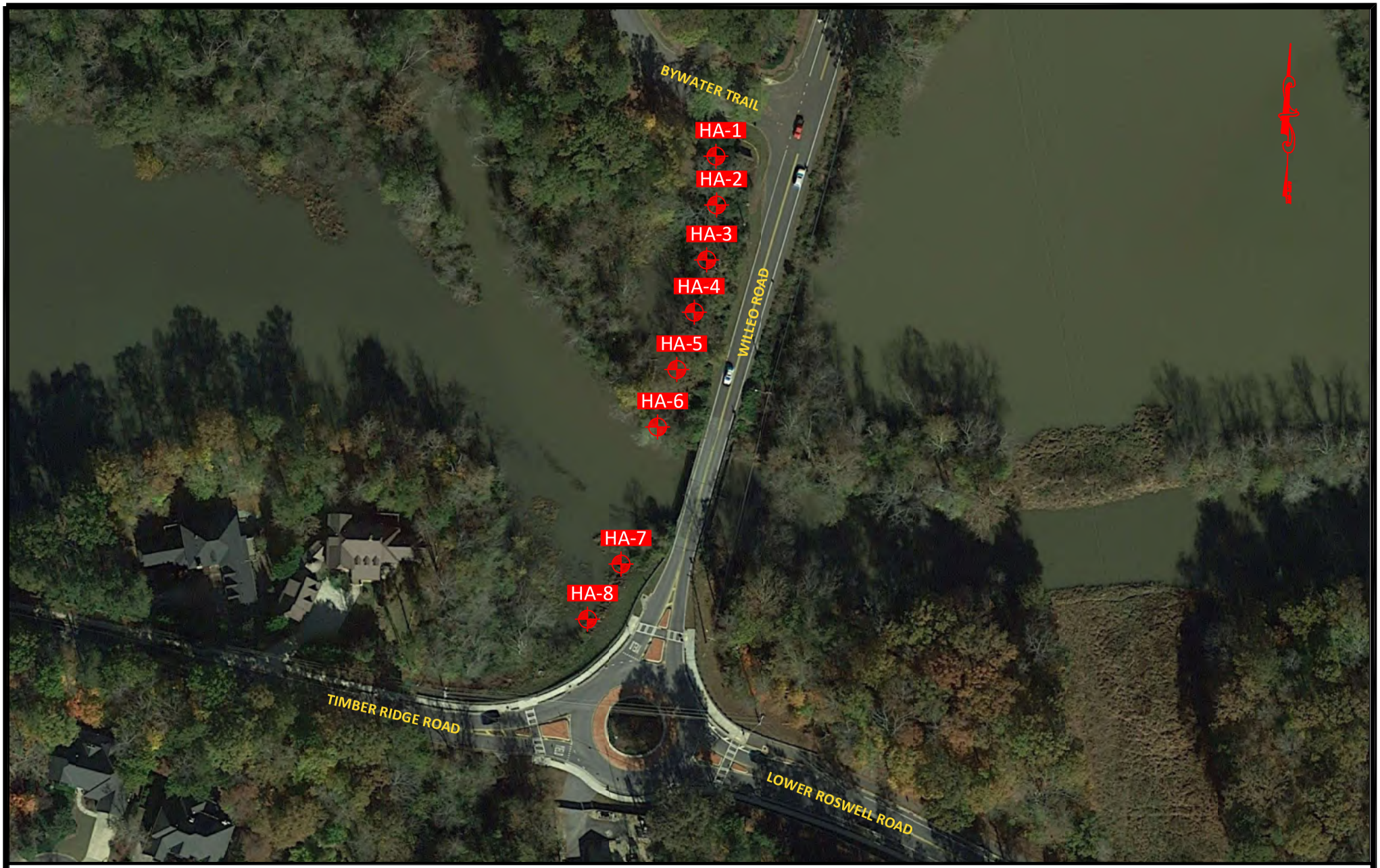
PROJECT

Soil Survey

Willeo Road Bridge

Roswell/Marietta, Fulton/Cobb County, Georgia

Cobb No.: X2122



AERIAL BORING LOCATION PLAN

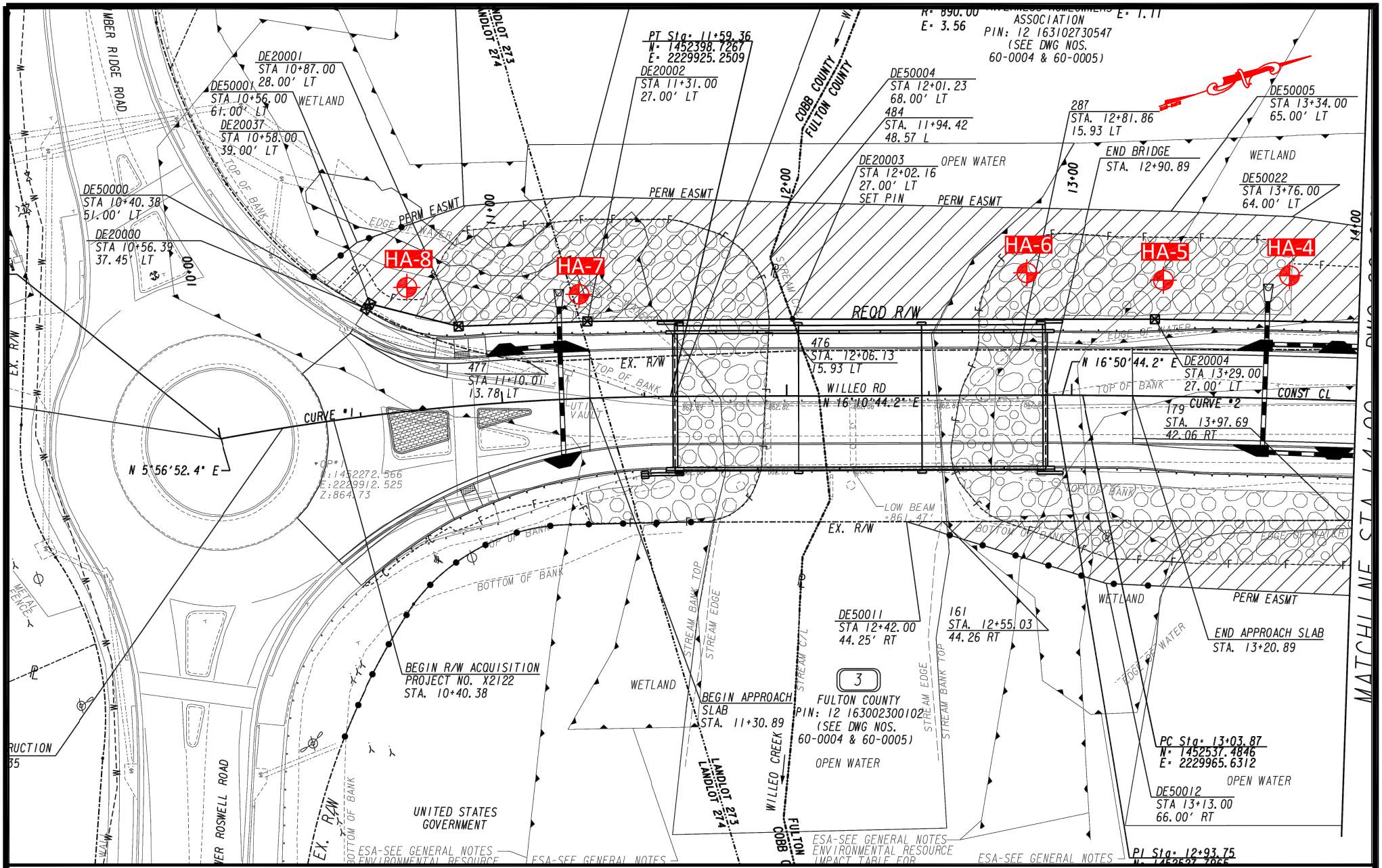
CONTOUR ENGINEERING

LEGEND

HA-1 - Approximate Boring Location

Scale: Not to Scale

PROJECT
Soil Survey
Willeo Road Bridge
Roswell/Marietta, Fulton/Cobb County, Georgia
Cobb No.: X2122



BORING LOCATION PLAN (1)

CONTOUR ENGINEERING

LEGEND

HA-1

- Approximate Boring Location

Scale: Not to Scale

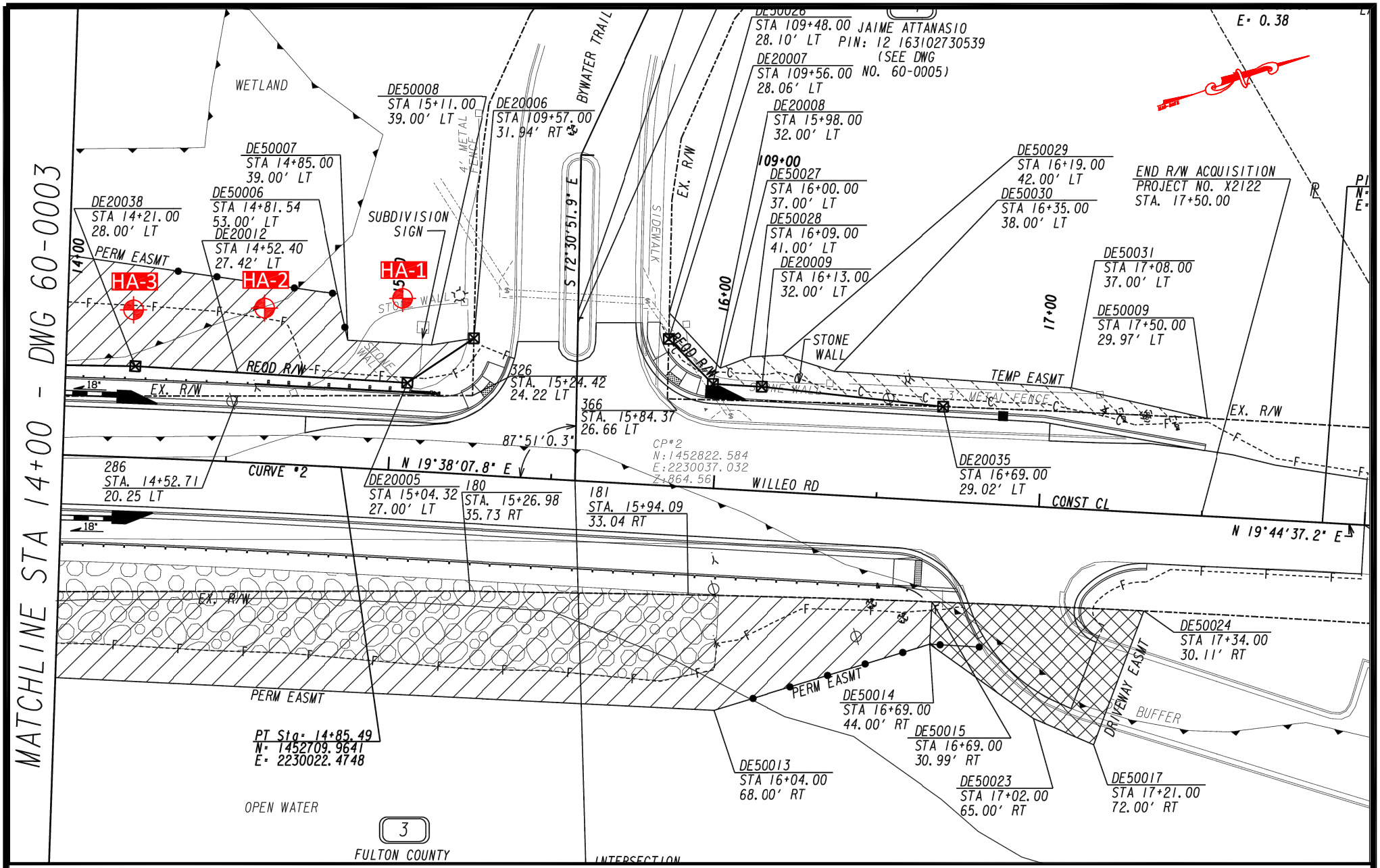
PROJECT

Soil Survey

Willeo Road Bridge

Roswell/Marietta, Fulton/Cobb County, Georgia

Cobb No.: X2122



BORING LOCATION PLAN (2)

CONTOUR ENGINEERING

LEGEND

HA-1 - Approximate Boring Location

Scale: Not to Scale

PROJECT

Soil Survey

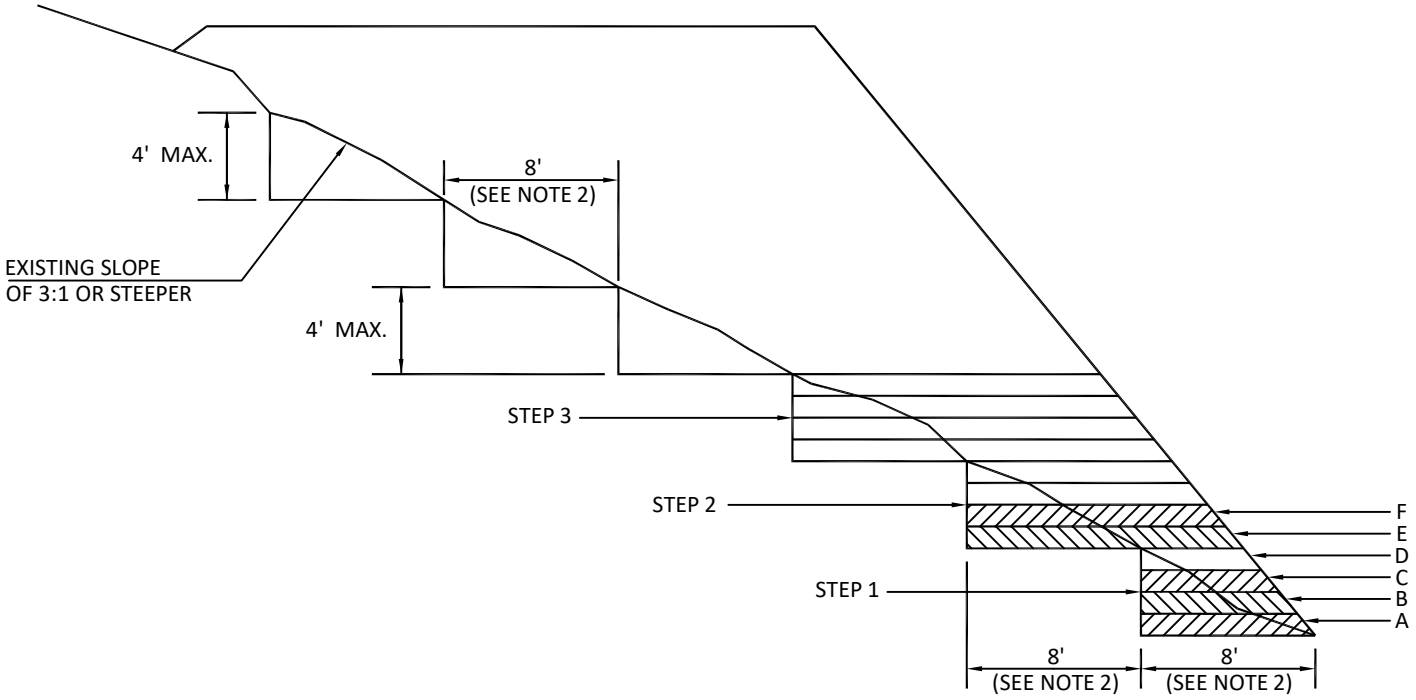
Willeo Road Bridge

Roswell/Marietta, Fulton/Cobb County, Georgia

Cobb No.: X2122

APPENDIX A:

Typical Benching Detail
Typical Filter Fabric & Embankment Detail
Typical In-place Stabilization along Toe of Slopes Detail
Pipe Culvert Material Alternates



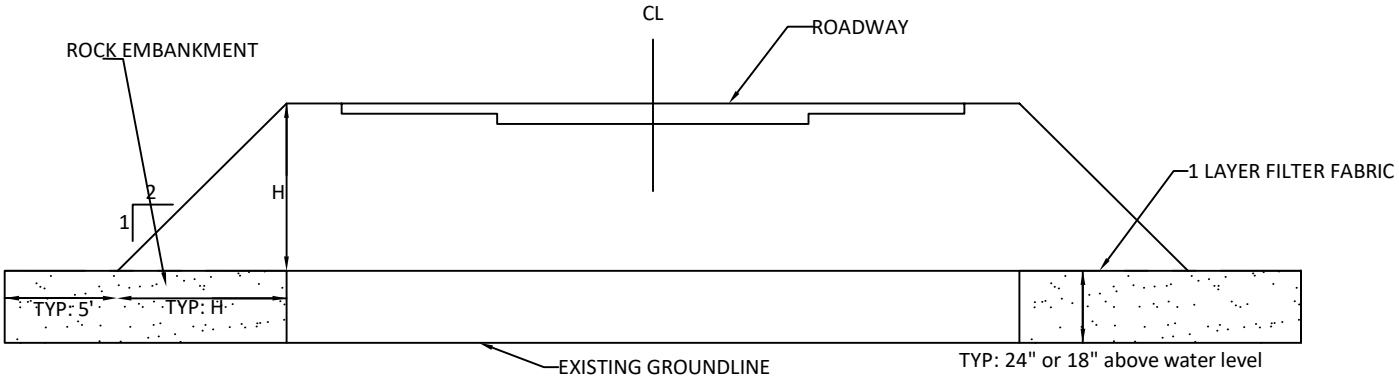
NOTES :

1. WHERE THE EMBANKMENT IS TO BE PLACED ON A HILLSIDE OR ANOTHER EXISTING EMBANKMENT HAVING A SLOPE OF 3 TO 1 OR STEEPER, THE FOUNDATION MUST BE BENCHED WHILE THE EMBANKENT IS BEING MADE. (SEE DIAGRAM ABOVE)

2. THE DIAGRAM SHOWS THAT BEFORE LAYER "A" IS PLACED THE FIRST STEP (1) IS CUT INTO THE SLOPE A MAXIMUM DISTANCE OF ABOUT 8 FEET (ABOUT 3/4 THE WIDTH OF THE TYPICAL D-8 BULLDOZER BLADE). SUCCESSIVE LAYERS B, C, AND D ARE THEN PLACED BEFORE LAYER "E" IS PLACED. THE SECOND STEP IS CUT 8 FEET INTO THE SLOPE AND SUCCESSIVE LAYERS ARE AGAIN PLACED. IF IT IS ANTICIPATED THAT THE VERTICAL PART OF THE STEP WILL EXCEED 4 FEET WHEN A 8 FOOT HORIZONTAL CUT IS MADE, THEN THE ACTUAL CUT STOPS WHEN THE VERTICAL PART REACHES A MAXIMUM OF 4 FEET ALLOWING THE HORIZONTAL DISTANCE TO VARY.

3. THE PROCESS OF BENCHING IS CONSIDERED INCIDENTAL TO THE ITEM OF UNCLASSIFIED EXCAVATION AND BORROW IN CONSTRUCTION OF THE EMBANKMENT AND NO ADDITIONAL MEASUREMENT OF QUANTITY OR PAYMENT WILL BE MADE FOR BENCHING.

CONTOUR ENGINEERING	**LEGEND** Typical Benching Detail Scale: Not to Scale	**PROJECT** **Willeo Road Bridge Soil Survey** Roswell/Marietta, Fulton/Cobb County, Georgia Cobb No.: X2122



NOTES :

1. PLACEMENT OF FABRIC PER SECTION 455 OF STANDARD SPECIFICATION AND IN ACCORDANCE WITH SPECIAL PROVISION 881.

2. THE PLASTIC FILTER FABRIC SHOULD BE ELIMINATED WHERE CONFLICTS WITH PILE DRIVING EXIST.

APPLIES TO STATION TO STATION	LOCATION
10+00 to 15+50	Left
10+00 to 16+75	Right

CONTOUR ENGINEERING

LEGEND

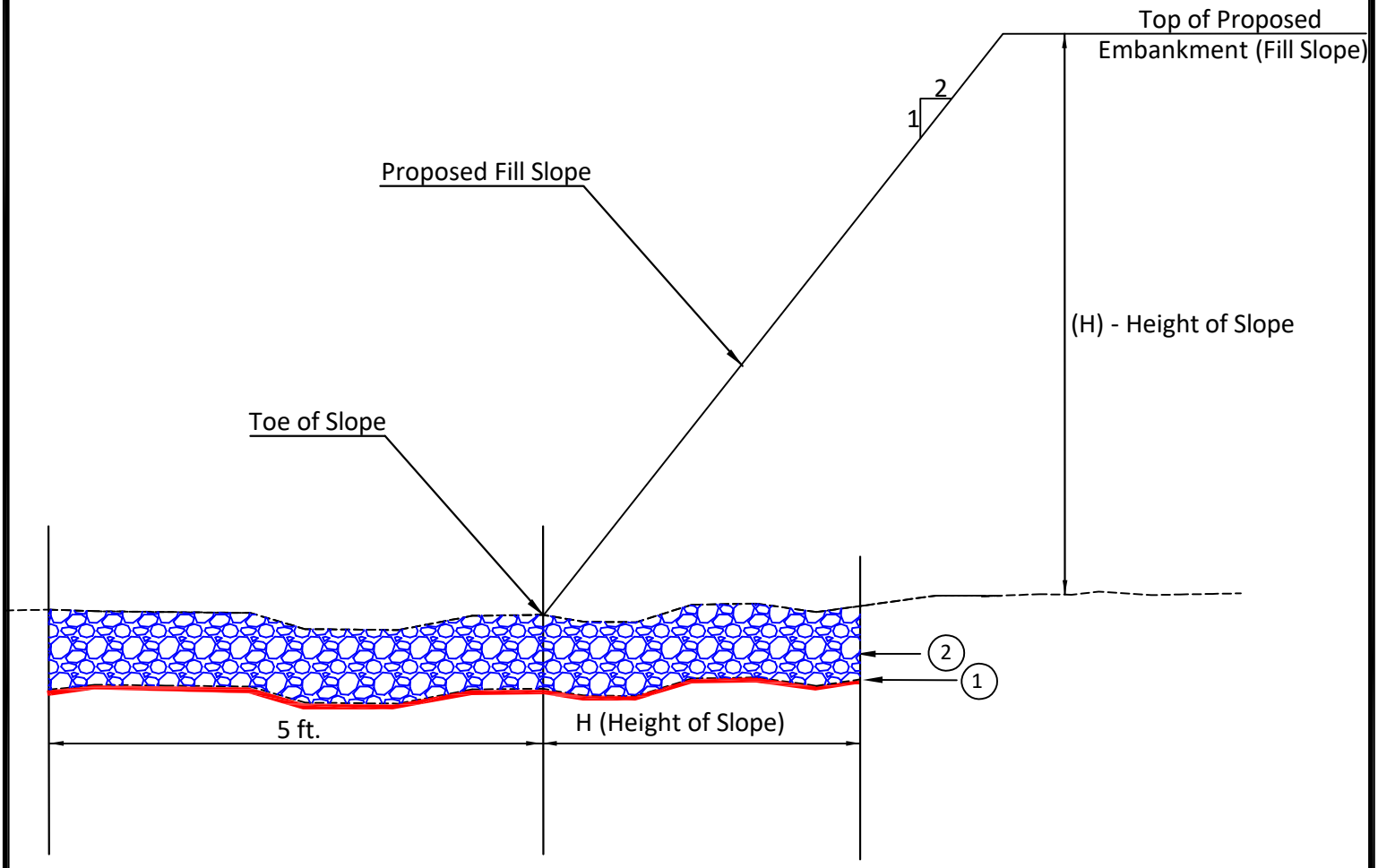
Typical Filter Fabric and Embankment Detail

Scale: Not to Scale

PROJECT

Willeo Road Bridge Soil Survey
Fulton/Cobb County, Georgia
Cobb No.: X2122

TYPICAL IN-PLACE STABILIZATION ALONG TOE OF SLOPES



1 MIRAFI 600X (OR EQUIVALENT) GEOGRID

2 24-INCHES ROCK EMBANKMENT

CONTOUR ENGINEERING

LEGEND

Typical In-place Stabilization along Toe of Slopes (Prior to Fill Placement)

Scale: Not to Scale

PROJECT

Willeo Road Bridge Soil Survey
Fulton/Cobb County, Georgia
Cobb No.: X2122

pH	6.1
Resistivity	10001

County: Fulton/Cobb

Cobb No. X2122

Pipe Culvert Material Alternates

TYPE OF INSTALLATION				PIPE TYPE									
				CONCRETE	STEEL			ALLUMINUM	THERMOPLASTIC				
				REINFORCED CONCRETE AASHTO M-170	CORRUGATED STEEL ALUMINUM COATED (TYPE 2) AASHTO M-36	CORRUGATED STEEL PLAIN ZINC COATED AASHTO M-36	POLYMER COATED STEEL AASHTO M-245	CORRUGATED ALUMINUM AASHTO M-196	CORRUGATED HDPE AASHTO M-252	CORRUGATED SMOOTHED LINED HDPE TYPE "S" AASHTO M-294	CORRUGATED SMOOTH LINED POLYPROPYLENE AASHTO M 330	PVC CORRUGATED SMOOTH INTERIOR ASTM F-949	PVC Profile Wall Drain Pipe AASHTO M-304
STORM DRAIN	NON-TRAVEL BEARING (OUTSIDE ROADBED)		INTERSTATE	X									
STORM DRAIN	NON-TRAVEL BEARING (OUTSIDE ROADBED)		NON INTERSTATE	X	X		X	X		X	X	X	X
STORM DRAIN	TRAVEL BEARING (INSIDE ROADBED)	GRADE ≤ 10%	ADT < 1,500	X	X		X	X		X	X	X	X
STORM DRAIN	TRAVEL BEARING (INSIDE ROADBED)	GRADE ≤ 10%	1,500 < ADT < 5,000	X	X		X	X		X	X	X	X
STORM DRAIN	TRAVEL BEARING (INSIDE ROADBED)	GRADE ≤ 10%	5,000 < ADT < 15,000	X						X	X	X	X
STORM DRAIN	TRAVEL BEARING (INSIDE ROADBED)	GRADE ≤ 10%	ADT > 15,000 & INTERSTATES	X									
STORM DRAIN	TRAVEL BEARING (INSIDE ROADBED)	GRADE > 10%					X			X	X	X	X
SIDE DRAIN				X	X	X	X	X		X	X	X	X
PERMANENT SLOPE DRAIN					X	X	X	X		X	X	X	X
PERFORATED UNDERDRAIN					X	X		X	X	X	X	X	X

NOTES:

1 Allowable materials are indicated by an "X".

2 Structural, installation, fill height and backfill requirements of storm drain pipe will be in accordance with Georgia Standard 1030-D or 1030-P and the Standard Specifications

3 The Contractor shall provide additional storm sewer capacity calculations if a pipe material other than concrete is selected.

4 Pipe used under mechanically stabilized earth (MSE) walls, within MSE wall backfill, or within five feet of an MSE wall face shall be Class V Concrete Pipe.

Rev. 1-12-16

APPENDIX B:

Field Boring Logs
Field Notes
Photo Documentation

CONTOUR ENGINEERING

Field Boring Logs

Willeo Road Bridge Soil Survey

Cobb No. X2122

Fulton/Cobb County

BORING	LOCATION	DEPTH	DESCRIPTION	CLASS	SAMPLE	NOTES/COMMENTS
HA-1	15+00 53' LT	0 - 2'	Brown, silty SAND (SM), moist			**DCP Values:** 0' - 2 4' - 2
		2 - 6'	Dark brown, silty SAND (SM), wet	IIB4	HA -1 Bulk	2' - 3 6' - 3
						GW @ 1.5'
HA-2	14+58 47' LT	0 - 3'	Brown, sandy SILT (ML), wet			**DCP Values:** 0' - 0 3' - 1
		3 - 4'	Dark brown-gray, silty SAND (SM), wet (gravelly sample)	IIB4	HA -1 Bulk	2' - 0 5' - 1
		4 - 5'	Dark brown, silty SAND (SM), wet			GW @ 0.5'
HA-3	14+18 45' LT	0 - 3+'	Brown-gray, silty GRAVEL (GM), with sand, wet			did not run DCP due to high water level and
			GW @ surface	IIB4	HA-5 Bulk	very loose sandy soils, area was inundated
						on second site vist (2/14)
HA-4	13+77 43' LT	0 - 3+'	Brown-gray, silty GRAVEL (GM), with sand, wet			did not run DCP due to high water level and
			GW @ surface	IIB4	HA-5 Bulk	very loose sandy soils, area was inundated
						on second site vist (2/14)
HA-5	13+32 41' LT	0 - 3+'	Brown-gray, silty GRAVEL (GM), with sand, wet			did not run DCP due to high water level and
			GW @ surface	IIB4	HA-5 Bulk	very loose sandy soils, area was inundated
						on second site vist (2/14)
HA-6	12+84 43' LT	0 - 3+'	Brown, poorly graded SAND (SP), wet			did not run DCP due to high water level and
			GW @ surface	IIB3	HA-6 Bulk	very loose sandy soils, area was inundated
			(this area is usually underwater, dry stream bed)			on second site vist (2/14)
HA-7	11+28 37' LT	0 - 3+'	Brown-gray, silty GRAVEL (GM), with sand, wet			did not run DCP due to high water level and
			GW @ surface	IIB4	HA-7 Bulk	very loose sandy soils, area was inundated
						on second site vist (2/14)
HA-8	10+70 44' LT	0 - 3+'	Brown-gray, silty GRAVEL (GM), with sand, wet			did not run DCP due to high water level and
			GW @ surface	IIB4	HA-7 Bulk	very loose sandy soils, area was inundated
						on second site vist (2/14)

Note:
LT - Left of Centerline
RT - Right of Centerline

CONTOUR ENGINEERING

Field Notes

Willeo Road Bridge Soil Survey

Cobb No. X2122

Fulton/Cobb County

LOCATION	Offset	DESCRIPTION	NOTES/COMMENTS
11+75 to 12+75	LT and RT	Perennial stream	Willeo Creek runs under the existing bridge that is planned to be replaced
10+50	LT	Existing drainage features	Observed two concrete drainage features routing surface runoff under Timber Ridge Road toward Willeo Creek
15+25	LT	Existing drainage feature	Observered drainage feature routing surface runoff under Bywater Trail toward Willeo Creek
10+00 to 14+00	LT	Inundated area	Observed existing wetland area of loose, wet sand where we took most of our samples on 1/28/20, on second site visit on 2/14/20 the whole area was completely inundated
10+00 to 18+00	RT	Inundated area	Existing body of water located in between Willeo Road and the Chattahoochee River, whole area is inundated besides a narrow strip of land near station 13+00
11+00 to 14+00	LT	Soil mixed with organics near stream	Closer you get to Willeo Creek, more organics were observed mixed in with loose, wet sandy material in wetland area, when the stream is high, these areas are the creek bottom

Note:
LT - Left of Centerline
RT - Right of Centerline

PHOTOGRAPH 1
View of drainage feature north of bridge passing under Bywater Trail near station 15+25 on day of sampling 1/28/20

PHOTOGRAPH 2
View of drainage features south of bridge passing under Timber Ridge Road near station 10+50 on day of sampling 1/28/20

CONTOUR ENGINEERING

PROJECT
Willeo Road Soil Survey
Photographic Documentation
Fulton/Cobb County, Georgia
Cobb No.: X2122

PHOTOGRAPH 1
View of wetland area north of bridge on day of sampling
1/28/20

PHOTOGRAPH 2
View of wetland area north of bridge on day of sampling
1/28/20

CONTOUR
ENGINEERING

PROJECT
Willeo Road Soil Survey
Photographic Documentation
Fulton/Cobb County, Georgia
Cobb No.: X2122

PHOTOGRAPH 1
View of wetland area south of bridge on day of sampling
1/28/20

PHOTOGRAPH 2
View of wetland area south of bridge on day of sampling
1/28/20

CONTOUR
ENGINEERING

PROJECT
Willeo Road Soil Survey
Photographic Documentation
Fulton/Cobb County, Georgia
Cobb No.: X2122

PHOTOGRAPH 1
View of existing bridge foundations on day of sampling
1/28/20

PHOTOGRAPH 2
View existing bridge foundations on day of sampling
1/28/20

CONTOUR
ENGINEERING

PROJECT
Willeo Road Soil Survey
Photographic Documentation
Fulton/Cobb County, Georgia
Cobb No.: X2122

PHOTOGRAPH 1
View of completed HA-1 on day of sampling 1/28/20

PHOTOGRAPH 2
View of completed HA- 2 on day of sampling 1/28/20

CONTOUR
ENGINEERING

PROJECT
Willeo Road Soil Survey
Photographic Documentation
Fulton/Cobb County, Georgia
Cobb No.: X2122

PHOTOGRAPH 1
View of dry creek bed where sample from location HA-6 was taken on 1/28/20

PHOTOGRAPH 2
View of creek level on day of sampling 1/28/20

CONTOUR ENGINEERING

PROJECT
Willeo Road Soil Survey
Photographic Documentation
Fulton/Cobb County, Georgia
Cobb No.: X2122

PHOTOGRAPH 1
View of full creek level on day of second site visit on 2/14/20

PHOTOGRAPH 2
View of full creek level on day of second site visit 2/14/20

CONTOUR
ENGINEERING

PROJECT
Willeo Road Soil Survey
Photographic Documentation
Fulton/Cobb County, Georgia
Cobb No.: X2122

PHOTOGRAPH 1
View of wetland area north of the bridge (where samples were taken) on day of second site visit on 2/14/20

PHOTOGRAPH 2
View of wetland area south of the bridge (where samples were taken) on day of second site visit on 2/14/20

CONTOUR
ENGINEERING

PROJECT
Willeo Road Soil Survey
Photographic Documentation
Fulton/Cobb County, Georgia
Cobb No.: X2122

APPENDIX C:

Soils Report (Lab Summary)
D75 Calculation
Complete Lab Results

Contour Engineering, LLC
Willeo Road Bridge Soil Survey
Roswell/Marietta, GA
Laboratory Testing

County: Fulton/Cobb

Cobb No.: X2122
Submitted By: W. Hesterlee
Examined For: 810.02, Moisture

Project/Lab No.:	Cobb No. X2122	Cobb No. X2123	Cobb No. X2124	Cobb No. X2125				
Sample No.:	HA-1 Bulk	HA-5 Bulk	HA-6 Bulk	HA-7 Bulk				
Station	15+00 53' LT	13+32 41' LT	12+84 43' LT	11+28 37' LT				
Location	HA-1	HA-5	HA-6	HA-7				
Description	Willeo Road LT	Willeo Road LT	Willeo Road LT	Willeo Road LT				
PHYSICAL TESTS								
2 1/2" Sieve	100.0	100.0	100.0	100.0				
1 1/2" Sieve	100.0	100.0	100.0	100.0				
#10 Sieve	97.9	45.4	67.9	93.3				
#40 Sieve	81.0	35.8	22.4	82.9				
#60 Sieve	71.6	34.4	6.5	79.4				
#200 Sieve	49.6	26.7	2.3	40.3				
% Clay	22.60	8.63	0.10	15.22				
T Vol Chg	5.78	4.67	6.45	6.41				
% Swell	5.38	4.13	6.06	6.06				
% Shrinkage	0.40	0.54	0.39	0.35				
Max. Dry Den	96.4	99.2	100.9	103.2				
%Opt Moist.	21.7	19.9	18.9	19				
Liquid Limit (LL)	NV	NV	NV	NV				
Plastic Index (PI)	NP	NP	NP	NP				
Erosion Index	7.5	7.5	7.5	7.5				
Resistivity								
CBR - SSV		2.3 (3.3)		3.0 (3.8)				
Ph								
Organic								
Natural Moisture	42.4	46.9	24.4	33.1				
CLASSIFICATION								
Class	IIB4	IIB4	IIB4	IIB4				
USCS	SM	GM	SP	SM				
AASHTO	A-4(0)	A-2-4(0)	A-1-b	A-4(0)				
TESTING DATES								
Date Sampled	1/28/2020	1/28/2020	1/28/2020	1/28/2020				
Date Received	1/28/2020	1/28/2020	1/28/2020	1/28/2020				
Date Completed	2/7/2020	2/7/2020	2/7/2020	2/7/2020				

Contour Engineering, LLC
Willeo Road Bridge Soil Survey
Roswell/Marietta, GA
Laboratory Testing

County: Fulton/Cobb

Cobb No.: X2122
Submitted By: W. Hesterlee
Examined For: PSD, Moisture

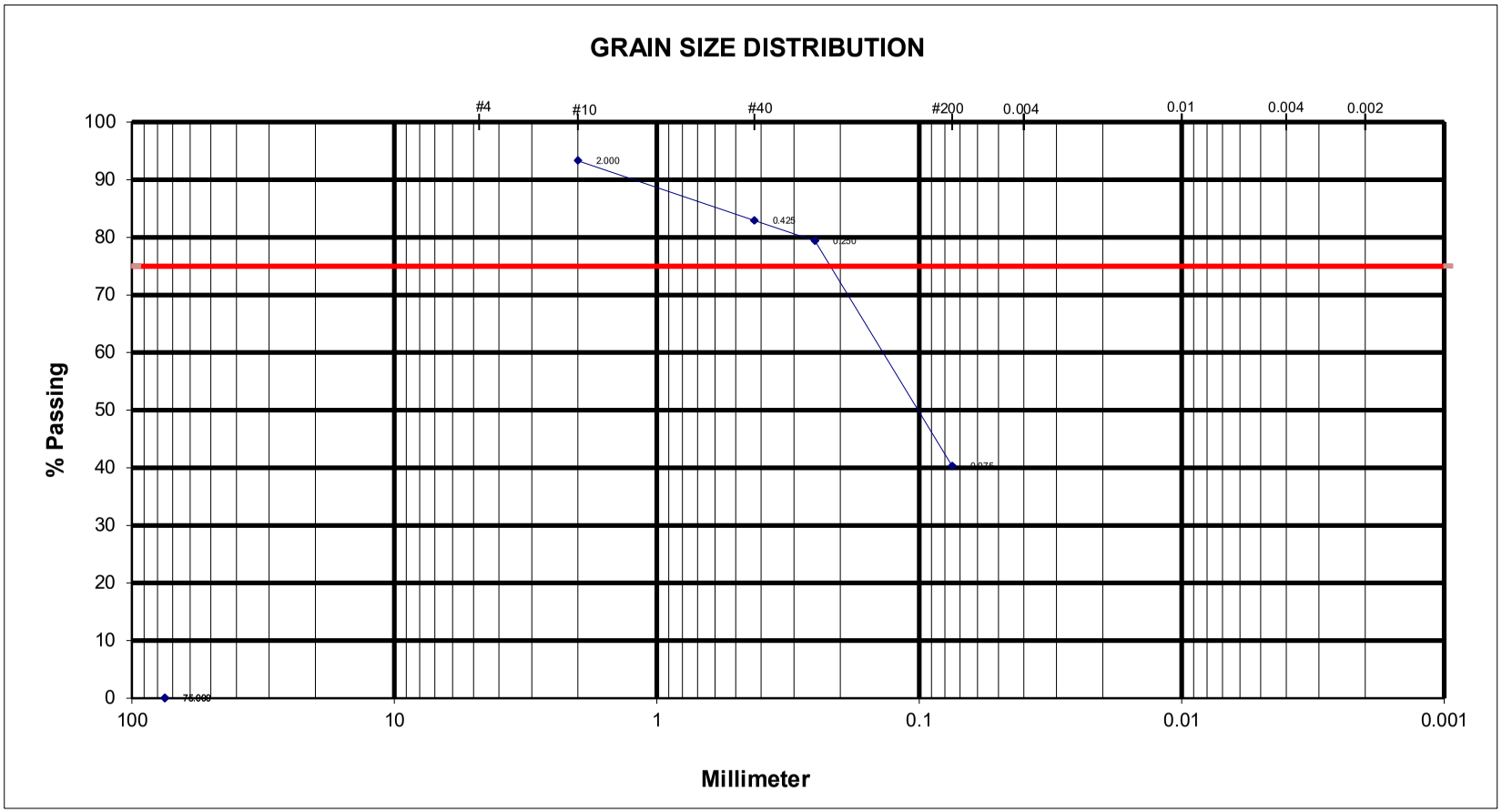
Project/Lab No.:	Cobb No. X2126	Cobb No. X2127	Cobb No. X2128	Cobb No. X2129				
Sample No.:	HA-1 (0-2')	HA-1 (4-5')	HA-2 (0-2')	HA-2 (3-4')				
Station	15+00 53' LT	15+00 53' LT	14+58 47' LT	14+58 47' LT				
Location	HA-1	HA-1	HA-2	HA-2				
Description	Willeo Road LT	Willeo Road LT	Willeo Road LT	Willeo Road LT				
PHYSICAL TESTS								
2 1/2" Sieve	100.0	100.0	100.0	100.0				
1 1/2" Sieve	100.0	100.0	100.0	100.0				
#8 Sieve	98.8	96.9	97.5	73.2				
#30 Sieve	88.8	81.4	91.1	58.2				
#50 Sieve	80.7	71.0	84.7	47.1				
#200 Sieve	47.0	47.4	56.9	12.2				
% Clay								
T Vol Chg								
% Swell								
% Shrinkage								
Max. Dry Den								
%Opt Moist.								
Liquid Limit (LL)	NV	NV	NV	NV				
Plastic Index (PI)	NP	NP	NP	NP				
Erosion Index	7.5	7.5	7.5	7.5				
Resistivity								
CBR - SSV								
Ph								
Organic								
Natural Moisture								
CLASSIFICATION								
Class								
USCS	SM	SM	ML	SM				
AASHTO								
TESTING DATES								
Date Sampled	1/28/2020	1/28/2020	1/28/2020	1/28/2020				
Date Received	1/28/2020	1/28/2020	1/28/2020	1/28/2020				
Date Completed	2/7/2020	2/7/2020	2/7/2020	2/7/2020				

Contour Engineering, LLC
Willeo Road Bridge SS
Roswell/Marietta, GA
D75 for boring HA-7

Contour Project No.: G20ATK01
Cobb No.: X2122

Sieve #	Millimeter	% Passing
# 10	2.00	93.3
# 40	0.425	82.9
# 60	0.250	79.4
#200	0.075	40.3

	mm	%	D75
size > 75%	0.250	79.4	**0.230**
size < 75%	0.075	40.3	



PROCTOR TEST REPORT

Curve No.: HA-1

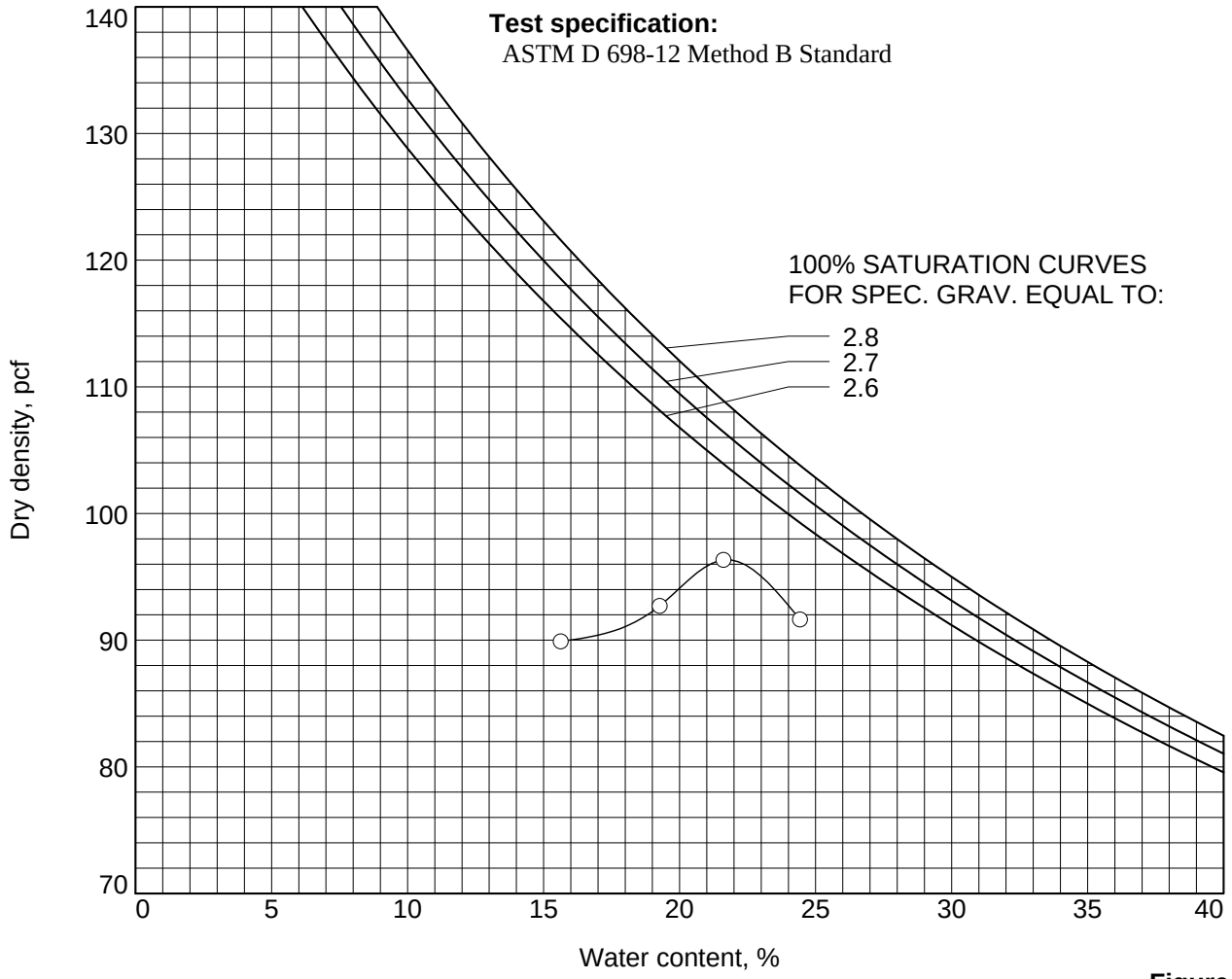
Project No.: G20ATK01 **Date:** 1-28-20
Project: Willeo Road Bridge Soil Survey
Client: Atkins
Location: Hand Auger #1
Sample Number: HA-1 **Depth:** 0-5'
Volume Change: 5.78%

MATERIAL DESCRIPTION

Description: Brown to dark brown silty SAND (SM)

Classifications - **USCS:** SM GDOT: IIB4 **AASHTO:** A-4(0)
Nat. Moist. = 42.4 % **Clay % = 22.6**
Liquid Limit = NV **Plasticity Index =** NP
%<No.10 = 97.9 % **%<No.40 =** 81.0 %
%<No.60 = 71.6 % **%<No.200 =** 49.6 %

TEST RESULTS
Maximum dry density = 96.4 pcf
Optimum moisture = 21.7 %



Figure

Contour Engineering, LLC

PROCTOR TEST REPORT

Curve No.: HA-5

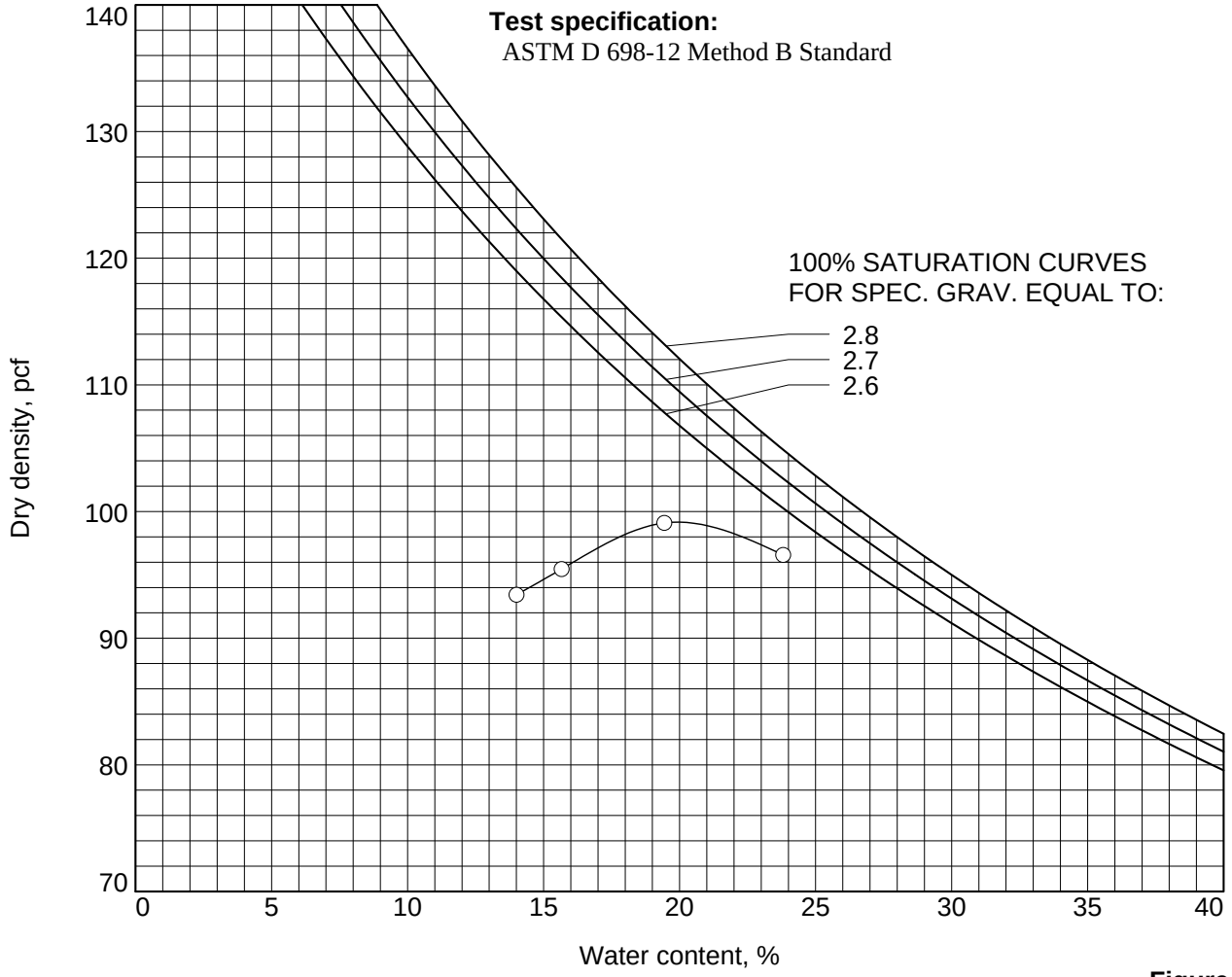
Project No.: G20ATK01 **Date:** 1-28-20
Project: Willeo Road Bridge Soil Survey
Client: Atkins
Location: Hand Auger #5
Sample Number: HA-5 **Depth:** 0-3'
Volume Change: 4.67%

MATERIAL DESCRIPTION

Description: Brown gray silty SAND (SM)

Classifications - **USCS:** GM GDOT: IIB4 **AASHTO:** A-2-4(0)
Nat. Moist. = 46.9 % **Clay % = 8.63**
Liquid Limit = NV **Plasticity Index =** NP
%<No.10 = 45.4 % **%<No.40 =** 35.8 %
%<No.60 = 34.4 % **%<No.200 =** 26.7 %

TEST RESULTS
Maximum dry density = 99.2 pcf
Optimum moisture = 19.9 %



Figure

Contour Engineering, LLC

PROCTOR TEST REPORT

Curve No.: HA-6

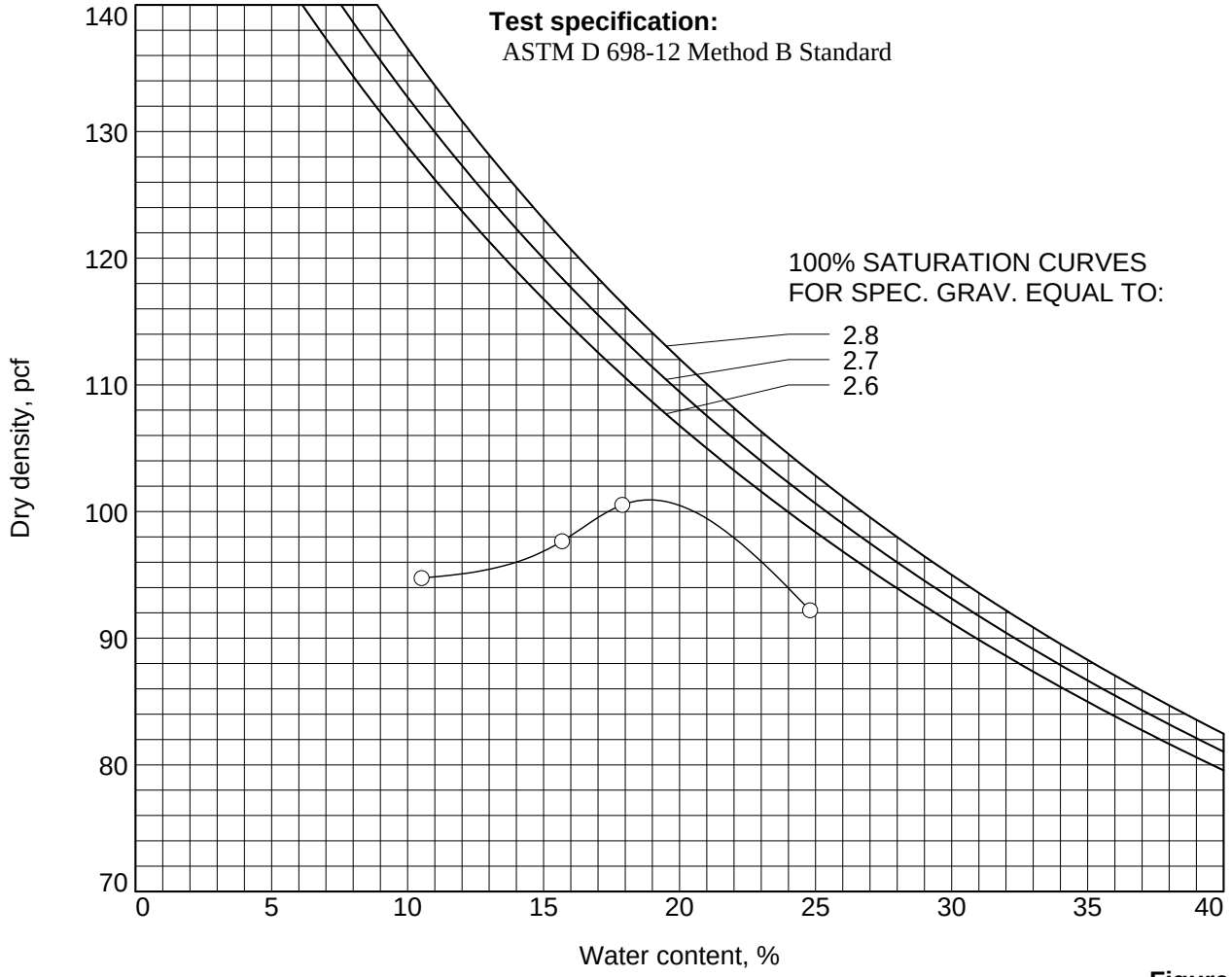
Project No.: G20ATK01 **Date:** 1-28-20
Project: Willeo Road Bridge Soil Survey
Client: Atkins
Location: Hand Auger #6
Sample Number: HA-6 **Depth:** 0-3'
Volue Change: 6.45%

MATERIAL DESCRIPTION

Description: Brown silty SAND (SM)

Classifications - **USCS:** SP GDOT: IIB4 **AASHTO:** A-1-b
Nat. Moist. = 24.4 % **Clay % = .1**
Liquid Limit = NV **Plasticity Index =** NP
%<No.10 = 67.9 % **%<No.40 =** 22.4 %
%<No.60 = 6.5 % **%<No.200 =** 2.3 %

TEST RESULTS
Maximum dry density = 100.9 pcf
Optimum moisture = 18.9 %



Figure

Contour Engineering, LLC

PROCTOR TEST REPORT

Curve No.: HA-7

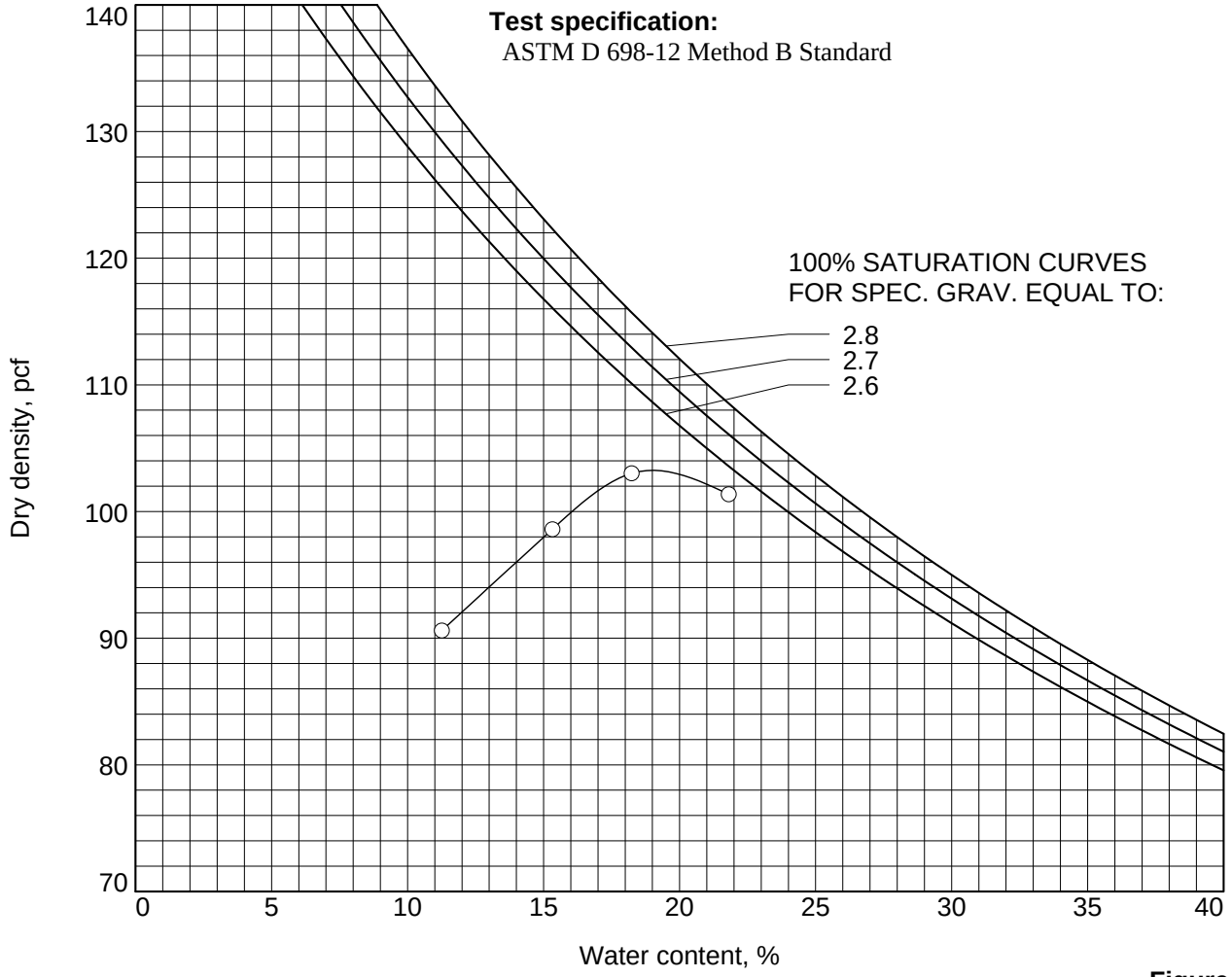
Project No.: G20ATK01 **Date:** 1-28-20
Project: Willeo Road Bridge Soil Survey
Client: Atkins
Location: Hand Auger #7
Sample Number: HA-7 **Depth:** 0-2'
Volume Change: 6.41%

MATERIAL DESCRIPTION

Description: Brown silty SAND (SM)

Classifications - **USCS:** SM GDOT: IIB4 **AASHTO:** A-4(0)
Nat. Moist. = 33.1 % **Clay % = 15.22**
Liquid Limit = NV **Plasticity Index =** NP
%<No.10 = 93.3 % **%<No.40 =** 82.9 %
%<No.60 = 79.4 % **%<No.200 =** 40.3 %

TEST RESULTS
Maximum dry density = 103.2 pcf
Optimum moisture = 19.0 %



Figure

Contour Engineering, LLC

CALIFORNIA BEARING RATIO

ASTM D-1883

Willeo Road Bridge Soil Survey

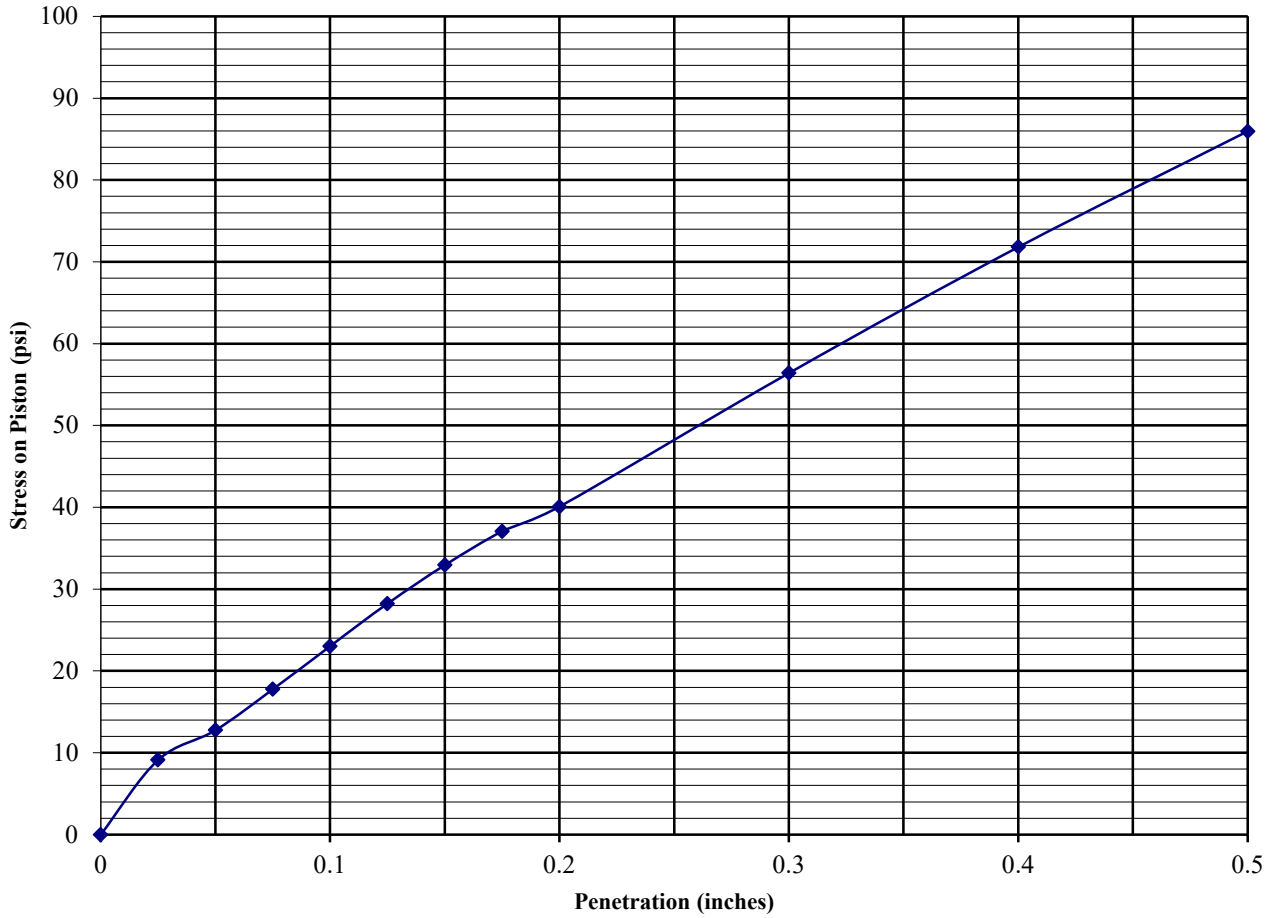
Roswell, Georgia

G20ATK01

Sampled No.: HA-5 Sample Description: Brown gray silty SAND (SM)

Date: 2/7/2020

Surcharge Load	10
Condition of Sample	Soaked
Dry Density Before Soaking (pcf)	96.9
Moisture Content Before Soaking (%)	20.9
Dry Density After Soaking (pcf)	94.6
Moisture Content After Soaking (%)	26.5
Swell (in)	0.084
Bearing Ratio as tested at 0.100	2.3
Bearing Ratio as tested at 0.200	2.7



CONTOUR ENGINEERING

CALIFORNIA BEARING RATIO

ASTM D-1883

Willeo Road Bridge Soil Survey

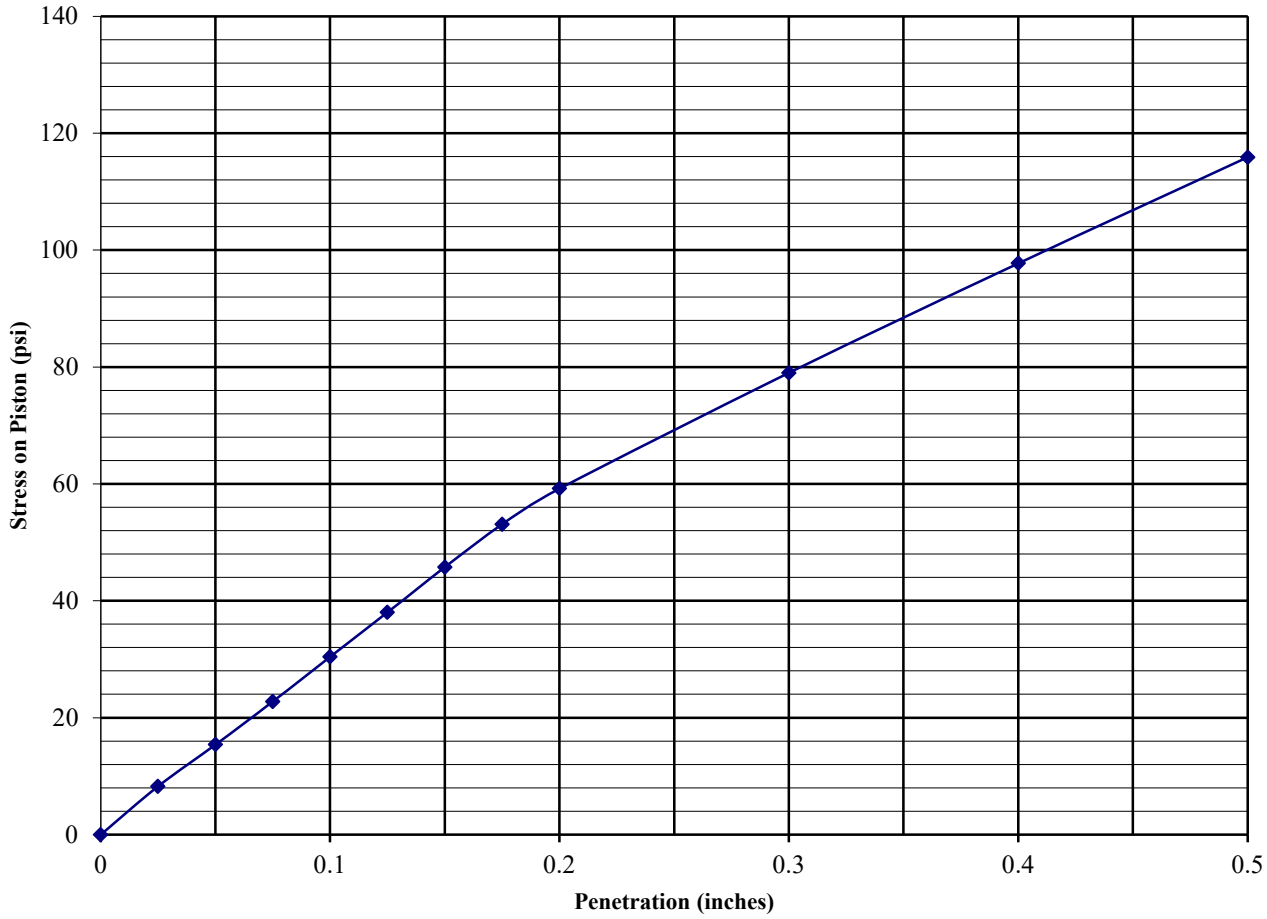
Roswell, Georgia

G20ATK01

Sampled No.: HA-7 Sample Description: Brown silty SAND (SM)

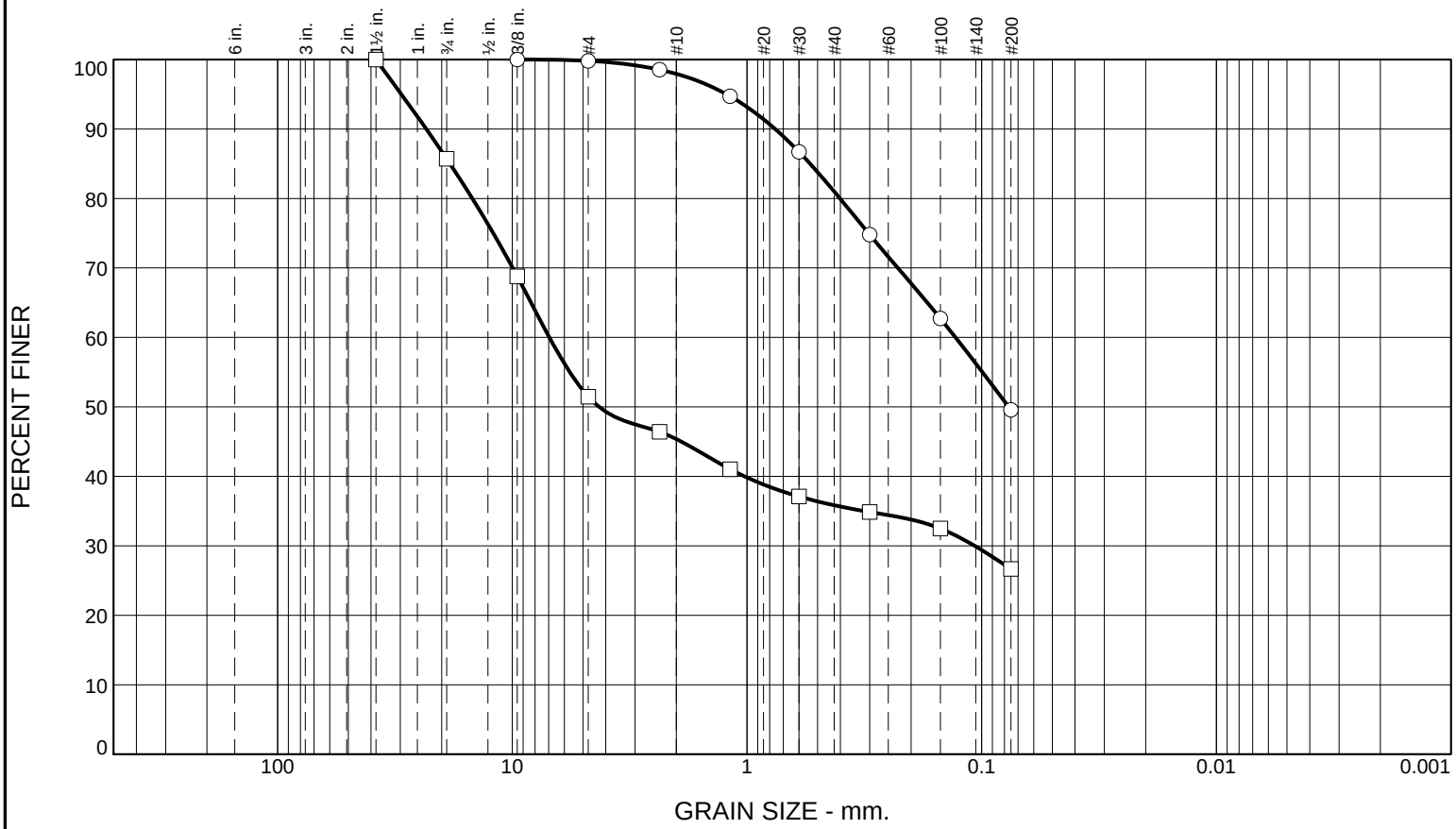
Date: 2/7/2020

Surcharge Load	10
Condition of Sample	Soaked
Dry Density Before Soaking (pcf)	100.8
Moisture Content Before Soaking (%)	21.1
Dry Density After Soaking (pcf)	80.9
Moisture Content After Soaking (%)	34.5
Swell (in)	0.042
Bearing Ratio as tested at 0.100	3.0
Bearing Ratio as tested at 0.200	3.9



CONTOUR ENGINEERING

Particle Size Distribution Report



	+3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○	0.0	0.2	50.2	49.6		SM	A-4(0)	NP	NV
□	0.0	48.5	24.8	26.7		GM	A-2-4(0)	NP	NV

SIEVE inches size	PERCENT FINER ○	PERCENT FINER □	
1.5		100.0	
.75		85.7	
.375	100.0	68.8	
	GRAIN SIZE		
D_{60}	0.1293	6.9500	
D_{30}		0.1071	
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○	PERCENT FINER □	
#4	99.8	51.5	
#8	98.5	46.4	
#16	94.7	41.0	
#30	86.7	37.1	
#50	74.8	34.9	
#100	62.7	32.5	
#200	49.6	26.7	

Material Description

○ Brown to dark brown silty SAND (SM)

□ Brown gray silty SAND (SM)

REMARKS:

○

□

○ Location: Hand Auger #1 Depth: 0-5' Sample Number: HA-1

□ Location: Hand Auger #5 Depth: 0-3' Sample Number: HA-5

CONTOUR ENGINEERING

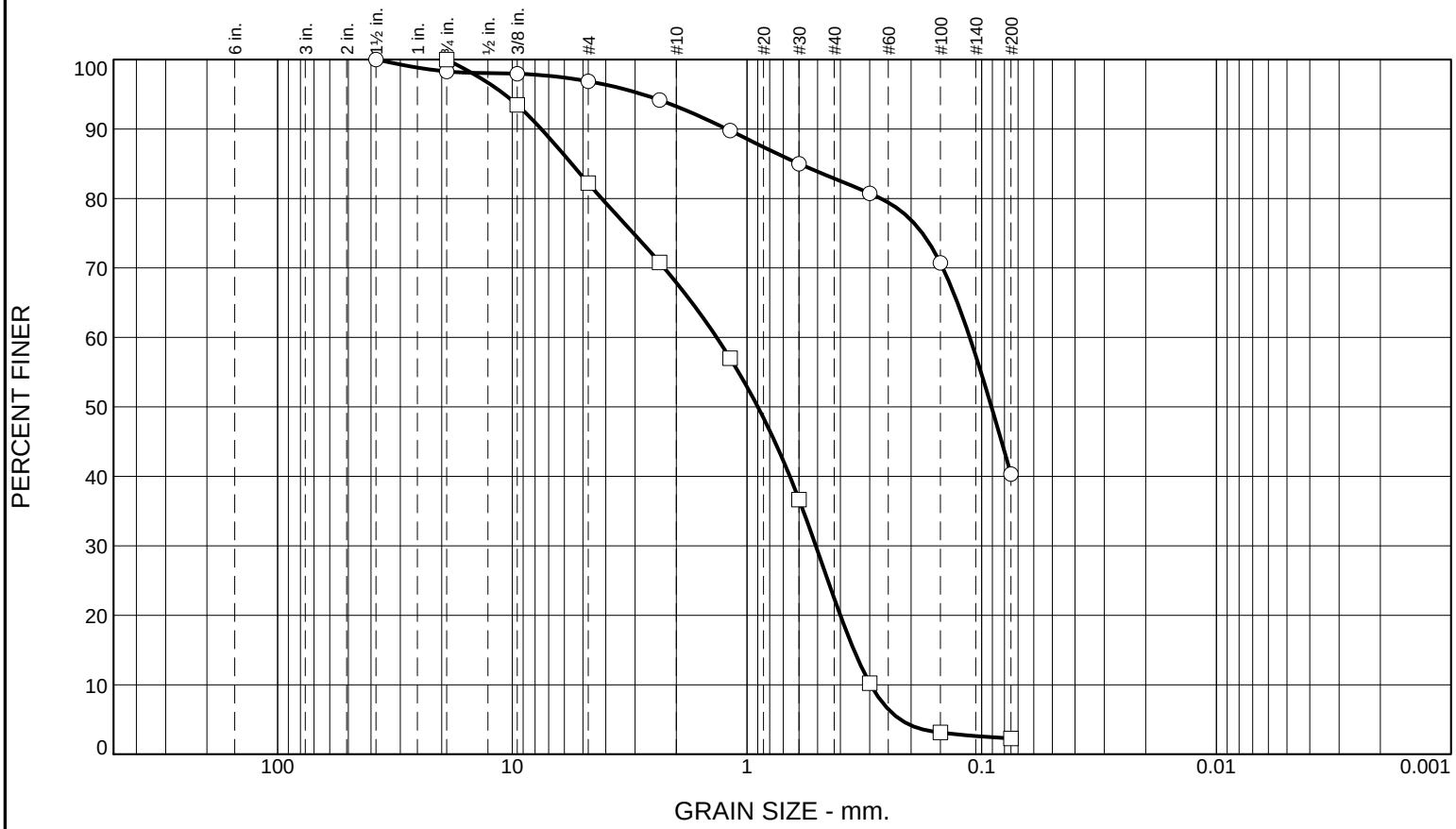
Client: Atkins

Project: Willeo Road Bridge Soil Survey

Project No.: G20ATK01

Figure

Particle Size Distribution Report



	+3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○	0.0	3.1	56.6	40.3		SM	A-4(0)	NP	NV
□	0.0	17.8	79.9	2.3		SP	A-1-b	NP	NV

SIEVE inches size	PERCENT FINER ○	PERCENT FINER □
1.5	100.0	
.75	98.3	100.0
.375	98.0	93.5
GRAIN SIZE		
D_{60}	0.1124	1.3464
D_{30}		0.5093
D_{10}		0.2975
COEFFICIENTS		
C_c		0.65
C_u		4.53

SIEVE number size	PERCENT FINER ○	PERCENT FINER □
#4	96.9	82.2
#8	94.2	70.8
#16	89.8	57.0
#30	85.0	36.7
#50	80.7	10.2
#100	70.7	3.1
#200	40.3	2.3

Material Description

○ Brown silty SAND (SM)

□ Brown silty SAND (SM)

REMARKS:

○

□

○ Location: Hand Auger #7 Depth: 0-2' Sample Number: HA-7

□ Location: Hand Auger #6 Depth: 0-3' Sample Number: HA-6

CONTOUR ENGINEERING

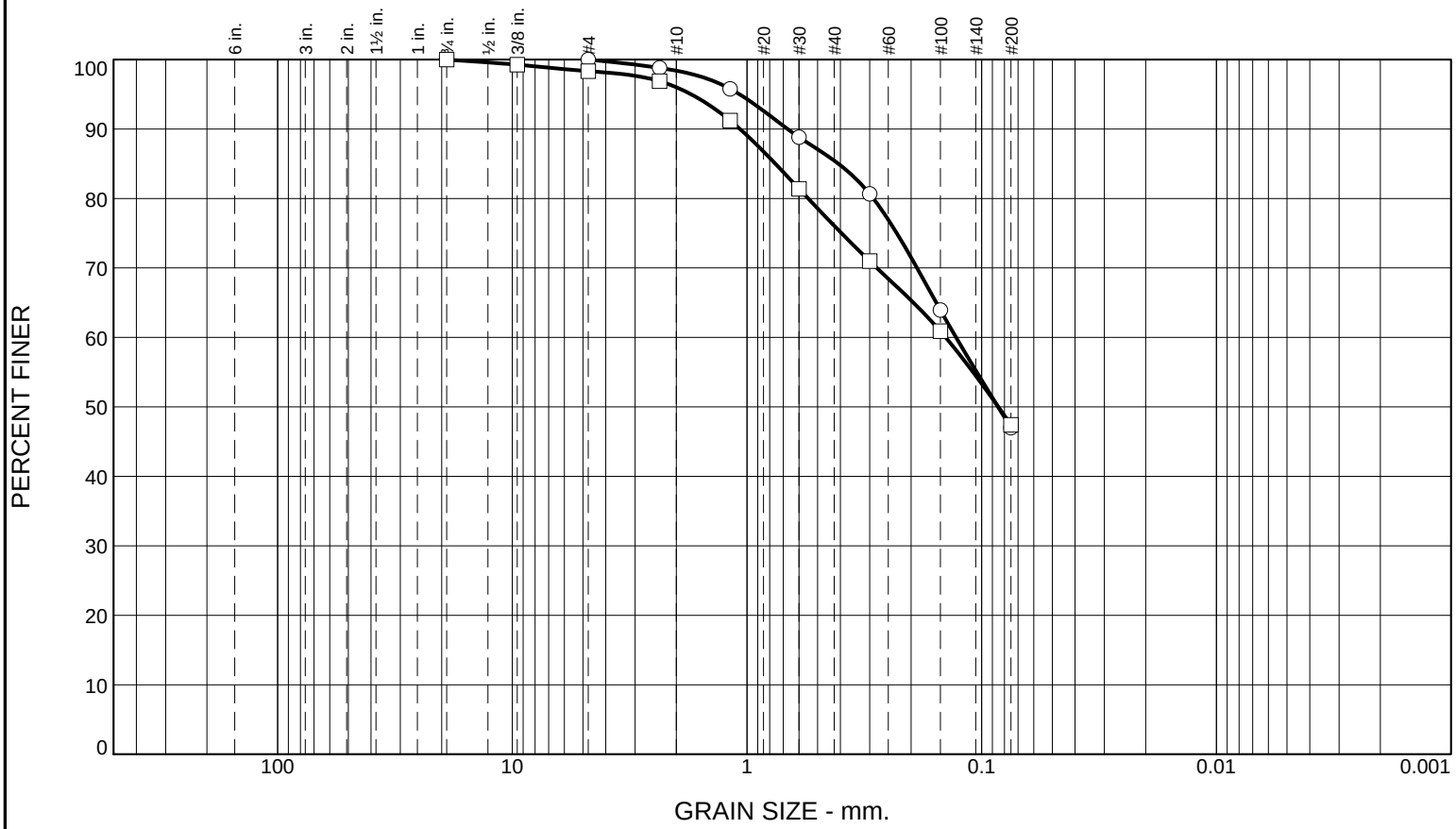
Client: Atkins

Project: Willeo Road Bridge Soil Survey

Project No.: G20ATK01

Figure

Particle Size Distribution Report



	+3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○	0.0	0.0	53.0	47.0		SM	A-4(0)	NP	NV
□	0.0	1.7	50.9	47.4		SM	A-4(0)	NP	NV

SIEVE inches size	PERCENT FINER ○	PERCENT FINER □	
.75		100.0	
.375		99.2	
	GRAIN SIZE		
D_{60}	0.1286	0.1424	
D_{30}			
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○	PERCENT FINER □	
#4	100.0	98.3	
#8	98.8	96.9	
#16	95.8	91.2	
#30	88.8	81.4	
#50	80.7	71.0	
#100	63.9	60.9	
#200	47.0	47.4	

Material Description

○ Brown silty SAND (SM)

□ Dark brown silty SAND (SM)

REMARKS:

○

□

○ Location: HA-1 Depth: 0-2'

□ Location: HA-1 Depth: 4-5'

CONTOUR ENGINEERING

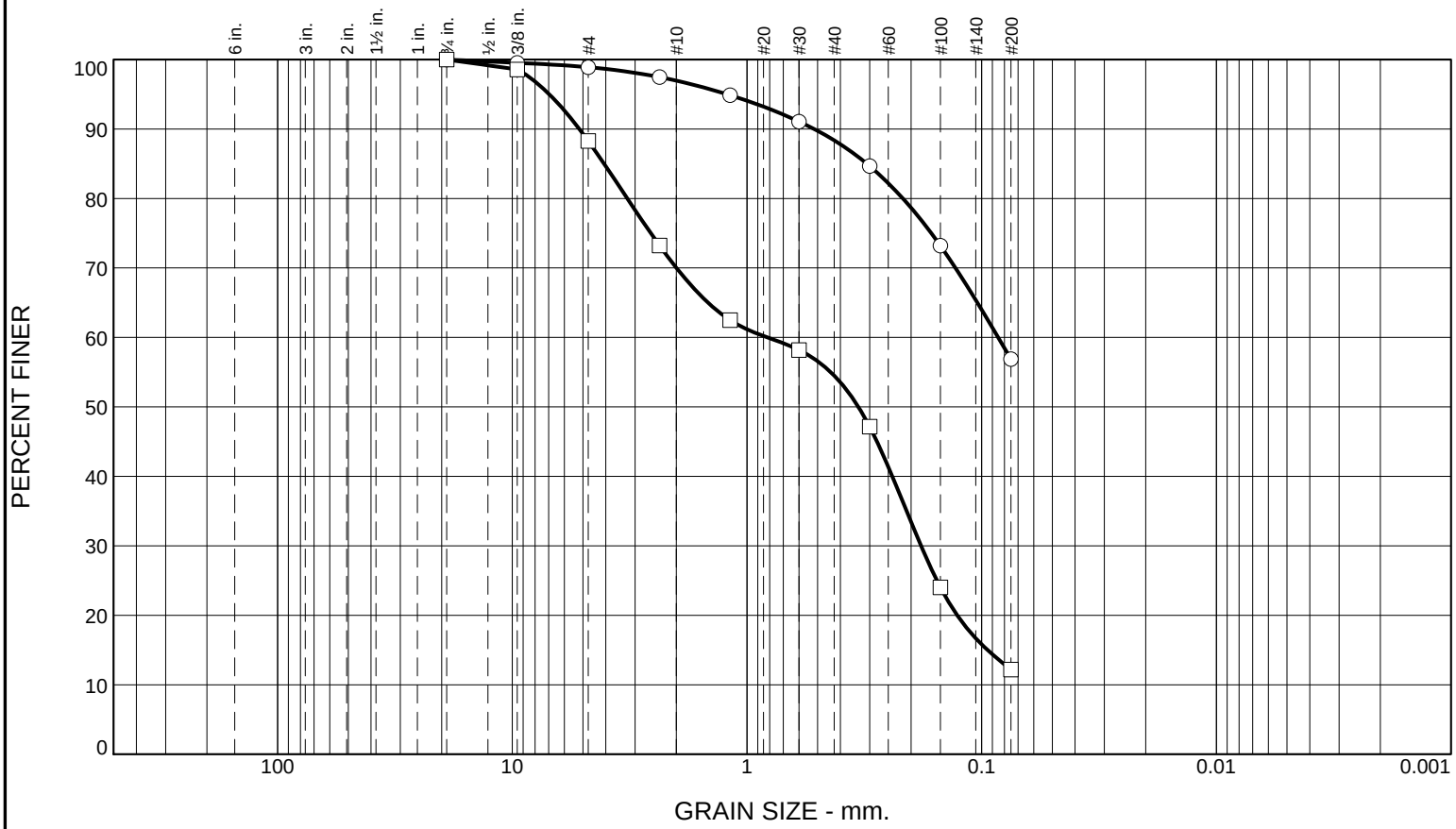
Client: Atkins

Project: Willeo Road Bridge Soil Survey

Project No.: G20ATK01

Figure

Particle Size Distribution Report



	+3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○	0.0	1.1	42.0	56.9		ML	A-4(0)	NP	NV
□	0.0	11.7	76.1	12.2		SM	A-2-4(0)	NP	NV

SIEVE inches size	PERCENT FINER ○	PERCENT FINER □	
.75	100.0	100.0	
.375	99.5	98.6	
	GRAIN SIZE		
D_{60}	0.0850	0.8170	
D_{30}		0.1814	
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○	PERCENT FINER □	
#4	98.9	88.3	
#8	97.5	73.2	
#16	94.9	62.5	
#30	91.1	58.2	
#50	84.7	47.1	
#100	73.2	24.0	
#200	56.9	12.2	

Material Description

○ Brown red sandy SILT (ML)

□ Brown gray silty SAND (SM)

REMARKS:

○

□

○ Location: HA-2 Depth: 0-2'

□ Location: HA-2 Depth: 3-4'

CONTOUR ENGINEERING

Client: Atkins

Project: Willeo Road Bridge Soil Survey

Project No.: G20ATK01

Figure

CONTOUR ENGINEERING

Volume Change

Project Name: Willeo Road Bridge SS
Project No.: G20ATK01

Lab Tech: CL
Date: 2/4/2020

HA-1	Swell	Shrinkage	Final Volume Change
Original Dial Reading	0.11	0.110	
Final Dial Reading	0.163	0.095	
Diameter Reading	NA	4/3.98	
Volume Change	5.38071066	0.400	5.78
Sample No.	HA-5		
Original Dial Reading	0.118	0.110	
Final Dial Reading	0.159	0.093	
Diameter Reading	NA	4/3.99	
Volume Change	4.128902316	0.540	4.67

Sample No.	HA-6		
Original Dial Reading	0.115	0.109	
Final Dial Reading	0.175	0.091	
Diameter Reading	NA	4/3.98	
Volume Change	6.060606061	0.388	6.45

Sample No.	HA-7		
Original Dial Reading	0.115	0.099	
Final Dial Reading	0.175	0.090	
Diameter Reading	NA	4/3.99	
Volume Change	6.060606061	0.350	6.41

Georgia Department of Transportation

Bridge Inspection Report

District: 4841700000 - D7 District Seven **Inspection Area:** 12 **County:** Fulton
Location ID: 121-01350X-003.05W **Over:** WILLEO CREEK
Structure ID: 121-5158-0 **Road Name:** WILLEO ROAD
Bridge Information: 7-Initial inventory

Georgia Department of Transportation

National Bridge Inventory - Structure Inventory and Appraisal (SI&A)

IDENTIFICATION	
(1) State Name	134 - Georgia
(8) Structure Number	12151580
(5) Inventory Route	ON: 41013500
(2) Highway Agency District	7
(3) County Code	121 - Fulton
(4) Place Code	67284
(6) Features Intersected	WILLEO CREEK
(7) Facility Carried	WILLEO ROAD
(9) Location	.01 MI N OF COBB CO LINE
(11) Kilometer Point	4.91 km
(12) Base Highway Network	Yes
(13) LRS Inventory Route & Subroute	12133679170
(16) Latitude	33° 59' 33.49"
(17) Longitude	084° 23' 11.40"
(98) Border Bridge State Code	% Share %
(99) Border Bridge Structure No.	
STRUCTURE TYPE AND MATERIAL	
(43) Main Structure Type	122
Material	1-Concrete
Type	22- Channel Beam
(44) Approach Structure Type	000
Material	0- Other
Type	0- Other
(45) Number of Spans in Main Unit	4
(46) Number of Approach Spans	0
(107) Deck Structure Type	2 - Precast Concrete Plank
(108) Wearing Surface/Protective System	
Type of Wearing Surface	6. Bituminous
Type of Membrane	0. None
Type of Deck Protection	0. None
AGE AND SERVICE	
(27) Year Built	1960
(106) Year Reconstructed	0
(42) Type of Service	15
On	1-Highway
Under	5-Waterway
(28) Lane	
On	2
Under	0
(29) Average Daily Traffic	1940
(30) Year of ADT	2011
(109) Truck ADT	1 %
(19) Bypass, Detour Length	8 km
GEOMETRIC DATA	
(48) Length of Maximum Span	9.1 m
(49) Structure Length	36.6 m
(50) Curb or Sidewalk Width	
Left	0.2 m
Right	0.2 m
(51) Bridge Roadway Width Curb to Curb	6.9 m
(52) Deck Width Out to Out	7.4 m
(32) Approach Roadway Width (W/Shoulders)	7 m
(33) Bridge Median	0-None
(34) Skew	0 Deg
(35) Structure Flared	No
(10) Inventory Route Min Vert Clear	99.99 m
(47) Inventory Route Total Horiz Clear	6.9 m
(53) Min Vert Clear Over Bridge Rdwy	99.99 m
(54) Min Vert Underclear	
Ref:N- Feature not a highway or railroad.	0 m
(55) Min Lat Underclear RT	
Ref:N- Feature not a highway or railroad.	0 m
(56) Min Lat Underclear LT	0 m
NAVIGATION DATA	
(38) Navigation Control	0- Navigation is not controlled by an Agency
(111) Pier Protection	
(39) Navigation Vertical Clearance	0 m
(116) Vert-Lift Bridge Nav Min Vert Clear	0 m
(40) Navigation Horizontal Clearance	0 m

SUFFICIENCY RATING	62.8
STATUS (SD/FO/None)	Functionally Obsolete
CLASSIFICATION	
(112) NBIS Bridge Length	Y
(104) Highway System	0- Inventory Route is not on the NHS
(26) Functional Class	19- Urban - Local
(100) Defense Highway	0- The Feature is not a STRAHNET route.
(101) Parallel Structure	N. No parallel structure exists
(102) Direction of Traffic	2- Two Way
(103) Temporary Structure	NOT Temporary Structure
(105) Federal Lands Highways	0. Not applicable
(110) Designated National Network	0- NOT part of Network
(20) Toll	3- On a Free Road or Non-Highway
(21) Maintain	02-County Highway Agency.
(22) Owner	02-County Highway Agency.
(37) Historical Significance	5 - Not eligible
CONDITION	
(58) Deck	6
(59) Superstructure	6
(60) Substructure	6
(61) Channel & Channel Protection	7
(62) Culverts	N
LOAD RATING AND POSTING	
(31) Design Load	2- H 15
(63) Operating Rating Method	2-Allowable Stress (AS)
(64) Operating Rating	
Type	2 - HS loading.
Rating	33.3 metric tons
(65) Inventory Rating Method	2-Allowable Stress (AS)
(66) Inventory Rating	
Type	2 - HS loading.
Rating	20.7 metric tons
(70) Bridge Posting	5. Equal to or above legal loads
(41) Structure Open/Posted/Closed	A. Open, no restriction
APPRAISAL	
(67) Structural Evaluation	5
(68) Deck Geometry	3
(69) Clearances, Vertical/Horizontal	N
(71) Waterway Adequacy	7
(72) Approach Roadway Alignment	6
(36) Traffic Safety Features	0000
A) Bridge Railings	0-Not meet standard or None provided
B) Transitions	0-Not meet standard or None provided
C) Approach Guardrail	0-Not meet standard or None provided
D) Approach Guardrail Ends	0-Not meet standard or None provided
(113) Scour Critical Bridges	U
PROPOSED IMPROVEMENTS	
(75) Type of Work	34- Widening with deck rehabilitation or replacement
(76) Length of Structure Improvement	438.9 m
(94) Bridge Improvement Cost	$ 469,000
(95) Roadway Improvement Cost	$ 47,000
(96) Total Project Cost	$ 703,000
(97) Year of Improvement Cost Estimate	2013
(114) Future ADT	2910
(115) Year of Future ADT	2031

INSPECTIONS

(90) Inspection Date			10/18/2017
(91) Frequency			24 Months
(92) Critical Feature Inspection	Done	Freq.	Date
A: Fracture Critical Detail	No		02/01/2001
B: Underwater Inspection	Yes	60 Month	12/02/2014
C: Other Special Inspection	No		02/01/2001

Evaluation

Topside Inspection Team **Inspection Type:** General **Inspection Date:** 10/18/2017

Team Leader: Jason T. Edwards

Assistants: Michael Banks and Robert Davis

Deck

NBIS Condition 6 - Satisfactory Condition **Material:** O. Concrete

Deck Wearing Surface Type: 6. Bituminous

Pre-cast 4 inch thick top flange of channel beams with 1.5" asphalt overlay (waffle type 8-panels per span).

Asphalt overlay is spalled throughout.
All joints are leaking.
Panel 1, 2, 7 and 8 are not bolted in span 1.
Minor cracking and spalls with some exposed steel on the bottom.

Superstructure

NBIS Condition 6 - Satisfactory Condition **Material:** O. Concrete **Year Painted:** 0000

Paint Type : 0- Not Applicable **Temperature (F):**

4-span pre-cast concrete channel beams (waffle type 8-panels per span).
Panel stems measure 12.5" high X 6" wide.
All panels are bolted at mid-span.

Panel 1, 2, 7 and 8 are not bolted in span 1.
Minor cracking and spalls with some exposed steel on the bottom.

Substructure

NBIS Condition 6 - Satisfactory Condition **Material:** N. Steel-Concrete **Year Painted:** 1990

Paint Type : 2- Non-Lead Oil Alkyd System (System IV)

Concrete caps at both abutments.
Minor erosion at abutment 1.
Bents 2, 3 and 4 have concrete caps on 4-10" concrete filled steel tube piles with concrete encasements.
Old masonry abutment left in place as retaining wall at abutment 5.

All piles have been painted but were not cleaned.
All caps have minor cracks and spalls.
Abutment 1 has minor settlement.
The cap at bent 3 rear has two spalls with exposed steel over pile 1 and 2.
Bent 3 pile 1 has cap spalls at the pile connection.
Bent 3 and 4 piles have moderate abrasion with some aggregate loss.

General

This Bridge:

Built in 1960, project - unknown.

Willeo Road.

Span 4 right guardrail has impact damage.

District: 4841700000 - D7 District Seven **Inspection Area:** 12 **County:** Fulton
Location ID: 121-01350X-003.05W **Over:** WILLEO CREEK
Structure ID: 121-5158-0 **Road Name:** WILLEO ROAD

Load Rating and Posting

Truck Type	Gross/H-Modified	HSModified	Tandem	3-S-2	Log	Piggy
Calculated Posting	16	25	21	30	27	00
Posting Required	No	No	No	No	No	No
Existing Posting	00	00	00	00	00	00

Item 103 Temporarily Shored : No **Posting Required:** No
Item 41 - Structure Open, Posted or Closed: A. Open, no restriction

Element Data

Element	Parent Element	Measurement Unit	Env*	Quantity	State 1	State 2	State 3	State 4
16-Reinforced Concrete Top Flange		SQUARE FEET	2	2904	2904			
510-Wearing Surfaces (16)	16-Reinforced Concrete Top Flange	SQUARE FEET	2	2904	1432	1452		20
110-Reinforced Conc Open Girder/Beam		Linear Foot	2	960	915	45		
215-Reinforced Conc Abutment		Linear Foot	2	48	40	8		
225-Steel Pile		Each	2	12	0	12		
515-Steel Protective Coating (225)	225-Steel Pile	SQUARE FEET	2	200	0		200	
234-Reinforced Conc Pier Cap		Linear Foot	2	72	64		8	
330-Metal Bridge Railing		Linear Foot	2	260	251		9	

Env* = Environment

Defects

Element	Defect	State 2	State 3	State 4
110-Reinforced Conc Open Girder/Beam	Damage	10		
110-Reinforced Conc Open Girder/Beam	Cracking (RC and Other)	35		
215-Reinforced Conc Abutment	Settlement	4		
215-Reinforced Conc Abutment	Delamination/Spall/Patched Area	4		
225-Steel Pile	Corrosion	12		
234-Reinforced Conc Pier Cap	Exposed Rebar		8	
330-Metal Bridge Railing	Damage		9	
510-Wearing Surfaces (16)	Delamination/Spall/Patched Area/Pothole	1452		20
515-Steel Protective Coating (225)	Effectiveness (Steel Protective Coatings)		200	

Maintenance Items

Activity	Work Quantity	Priority	Location	Inspection Date	Completion Date	Comments
615 - REPAIR/INSTALL GUARDRAIL (LINEAR FEET)		B	Span 4.	10/18/2017		Repair guardrail.
000 - BRIDGE PAINTING (Not performed by Highway Maintenance, used by Bridge Mntce) ()		B	All piles.	10/18/2017		clean and paint all piles.

District: 4841700000 - D7 District Seven **Inspection Area:** 12 **County:** Fulton
Location ID: 121-01350X-003.05W **Over:** WILLEO CREEK
Structure ID: 121-5158-0 **Road Name:** WILLEO ROAD

Activity	Work Quantity	Priority	Location	Inspection Date	Completion Date	Comments
845 - OTHER BRIDGE MAINT (PERSON HOURS)		B	Overlay	10/18/2017		Repair asphalt overlay.

Conditional Situations

Confined Space: No **Traffic Control Needed:** No

Equipment Used

Access Equipment: None **Topside Boat:** None
Waders: Hip boots **Special Imaging Device:** None

No Specialized Inspection performed on this bridge.

No Other Special Inspection performed on this bridge.

No Fracture Critical Inspection performed on this bridge.

Bridge Components

Superstructure Data

Span #	Beam Type	Beam Spacing	Length	# Beams	Remarks
1	Concrete Waffels	3	30	8	Waffle Panels
2	Concrete Waffels	3	30	8	Waffle Panels
3	Concrete Waffels	3	30	8	Waffle Panels
4	Concrete Waffels	3	30	8	Waffle Panels

Bearing Data

Span #	Rear Type Bearing	Forward Type Bearing	Remarks
1	08 - Beam on Cap	08 - Beam on Cap	Fair
2	08 - Beam on Cap	08 - Beam on Cap	Fair
3	08 - Beam on Cap	08 - Beam on Cap	Fair
4	08 - Beam on Cap	08 - Beam on Cap	Fair

This bridge has no intersected feature.

Underwater Report

Underwater Inspection Date : 12/02/2014

Underwater Inspection Team :

Team Leader : William S Reynolds

Dive Supervisor : Shon Reynolds

Diver : Paul Otte

Standby Diver :

Bents Inspected : Bents 3 and 4 **Boat Used :** None

Bent Construction : Steel shell pile, encased **Inspection Type:** Wading

Water Level Reference : Bridge height to cap is 6.4' at bent 4.

Maximum Water Depth (ft): 7

Bridge Inspection Procedure : 1. This bridge was inspected according to the procedures established in the Georgia Department of Transportation's Underwater Bridge Inspection Team Policy and Procedures Manual version 01/2011

Condition Ratings :

Substructure : 6 - Satisfactory Condition **Channel Protection :** 7 - Good Condition

Underwater : 7 - Good Condition **Waterway Adequacy :** 7 - Good Condition

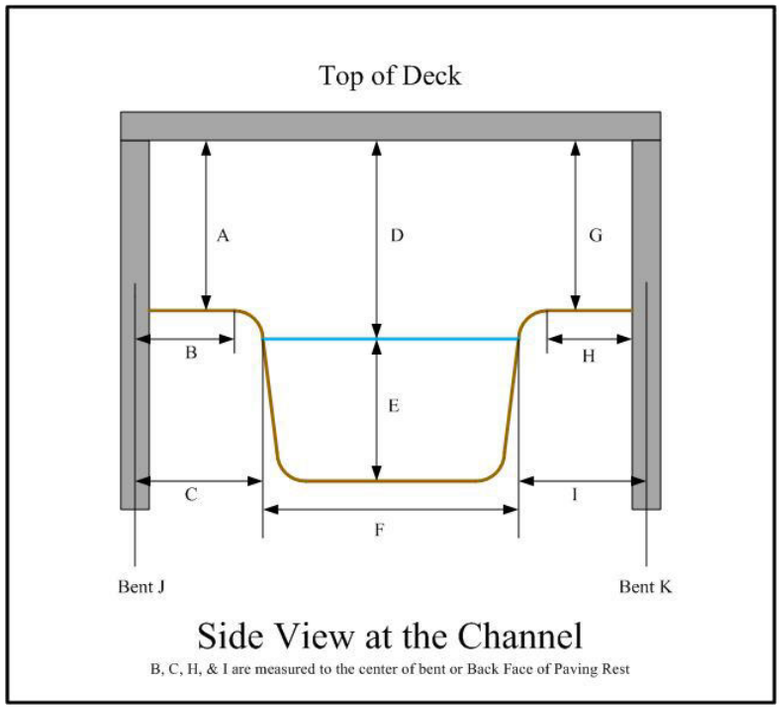
Scour : 6 - Satisfactory Condition

Detailed Inspection :

Protective coating above encasements is intact.
No exposure below encasements found.
Slight scour present at encasements.

District: 4841700000 - D7 District Seven **Inspection Area:** 12 **County:** Fulton
Location ID: 121-01350X-003.05W **Over:** WILLEO CREEK
Structure ID: 121-5158-0 **Road Name:** WILLEO ROAD

Waterway Information

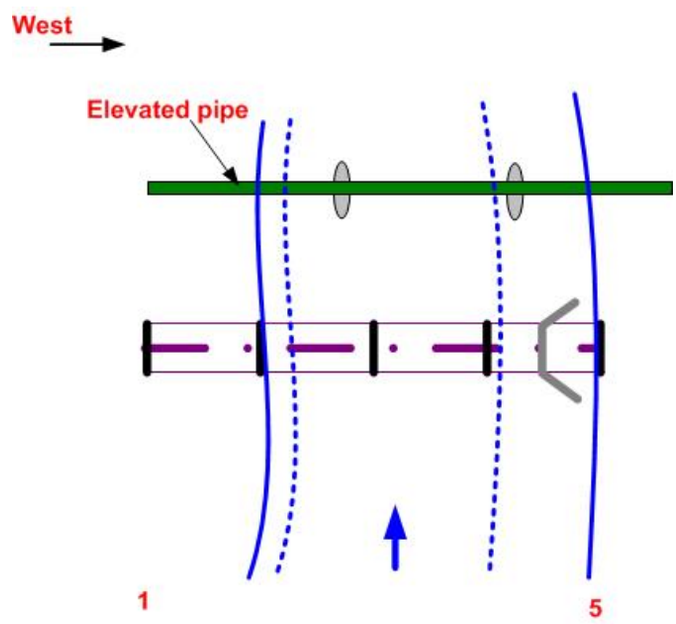


A : 9
B : 0
C : 30
D : 10.6
E : 7.2
F : 65
G : 8
H : 20
I : 25
J : 2
K : 5

Location of Bridge Height : 15.0' forward of bent 3.
Bridge Height Taken: DOWNSTREAM
Scour Condition : 6
Waterway Adequacy : 7
Channel Protection : 7

Comments :

Substructure Skew = 0 **Channel Skew =** 0 **Stream Angle =** 0



Collision Information

Beam Type :

Span # with Beam Damage :

Total # of Beams in Span :

# of Damaged Beams :

Minimum Vertical Clearance : ft - in

Actual Vertical Clearance at Point of Impact : ft - in

Posted Vertical Clearance : ft - in

Report Type :

Report Date :

Damage Location in Span :

Damage Type :
Damage Details :

Repairs Required : No **Repairs Made :** No
Repair Details :

Additional Comments :

Photographs

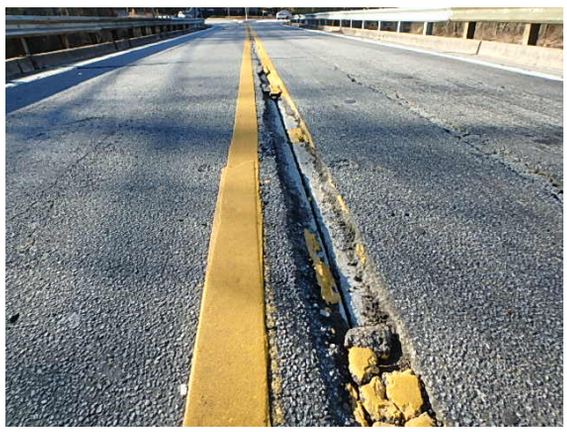
2017-10-18_Spall.JPG

Typical beam spalls in span 1.

2017-10-18_Guardrail.JPG

Typical beam spalls in span 4.

P1260015.JPG



Asphalt spall.

2017-10-18_Sideview.JPG

Required sideview, right side

2017-10-18_Roadway.JPG

Looking West.

2017-10-18_Typical.JPG

superstructure

Photographs

121-5158-0-3.JPG

Sewer Line = 8.5".

121-5158-0-4.JPG

Gas Line = 4.5".

121-5158-0-6.JPG

Water Line = 12".

P1260014.JPG

Spalls on cap at bent 3 rear.

121-5158-0-7.JPG

Spalls on cap at bent 3 rear.

Bridge Foundation Investigation Report

Willeo Road over Willeo Creek
Bridge Replacement
(Joint Project with the City of Roswell)
Cobb County and Fulton County, Georgia
Cobb County DOT Project No. X2122
Revision No. 1

Prepared For: Gresham Smith
1125 Sanctuary Parkway, Suite 350
Alpharetta, GA 30009

Prepared By: MC Squared, Inc.
1275 Shiloh Road NW, Suite 2620
Kennesaw, Georgia 30144

Project No.: A091603.099
Prepared: April 2020

MC²
GEOTECHNICAL • ENVIRONMENTAL
MATERIALS TESTING

April 29, 2020

Ms. Sarah Blackburn, P.E.
Project Manager
Gresham Smith
1125 Sanctuary Parkway, Suite 350
Alpharetta, GA 30009

Subject: Bridge Foundation Investigation Report – Revision No. 1
Willeo Road over Willeo Creek Bridge Replacement
(Joint Project with the City of Roswell)
Cobb County and Fulton County, Georgia
Cobb County DOT Project No. X2122
MC^2 Project Number: A091603.099

Dear Ms. Blackburn:

MC Squared, Inc. (MC^2) is pleased to present this Bridge Foundation Investigation (BFI) Report for the replacement of the Willeo Road over Willeo Creek bridge at the Cobb/ Fulton county line. The new bridge is 3-spans beginning at Station 11+60.89 and ending at Station 12+90.89. This BFI was performed in general accordance with Georgia DOT (GDOT) ASD BFI Guidelines and revised considering the third-party review comments by Contour Engineering, dated April 28, 2020 and a phone conference with Gresham Smith on April 29, 2020. Loads were not provided at the time of the writing of this report.

The report summarizes our findings, the subsurface conditions we encountered, and our conclusions and recommendations as they relate to bridge foundation design.

Thank you for giving us the opportunity to work with you. Please let us know if you have any comments or need additional information.

Respectfully submitted,
MC^2

Akli Hibouche, Ph.D.
Geotechnical Project Engineer

Lucas Caliari, Ph.D.
Geotechnical Project Engineer

Stephanie Grahl, P.E.
Geotechnical Project Manager
Georgia P.E. No. 041467

Prashanth Vaddu, P.E.
Principal, Vice President, Operations

Attachments:

Bridge Foundation Investigation Report	4 Pages
Special Provision 520 – Piling (Pilot Holes)	1 Page
Special Provision 154 – Construction Vibration Monitoring	4 Pages

Appendix I:

Project Location Map	Sheet 1
Boring Location Map	Sheet 2
Boring Location Plan/Bridge Layout	Sheet 3
Subsurface Boring Profile	Sheet 4
Legend	Sheet 5
Individual Soil Profiles (gINT Logs)	6 Pages

Appendix II:

Summary of Laboratory Results - USCS	1 Page
Atterberg Limits Results	1 Page
Grain Size Distribution Results	1 Page
Corrosion Test Results	1 Page
Rock Core Test Results Summary	1 Page
Rock Core Photographs	12 Pages
Rock Core Testing Photographs	4 Pages

Appendix III:

Important Information about This Geotechnical Engineering Report	2 Pages

BRIDGE FOUNDATION INVESTIGATION

PROJECT NUMBER Cobb County DOT X2122,

LOCATION (See Map) The project is the replacement and widening of the existing Willeo Road over Willeo Creek bridge at the Cobb/Fulton Countyline in Georgia. The three-span replacement bridge begins at Station 11+60.89 and ends at Station 12+90.89.

GENERAL INFORMATION

GEOLOGIC FORMATION This project is geologically located in the Mica Schist/ Gneiss/ Amphibolite Formation of the Georgia Piedmont Region.

SUBSURFACE FEATURES Subsurface soils generally consisted of very loose to medium dense SAND with variable amounts of silt (SM, SP-SM, and SW-SM). A layer of very soft CLAY (CL) and very loose clayey SAND (SC) was encountered from elevation 851 to 847-ft in borings B-1 and B-3. Underlying the upper soils, rock surface was encountered at elevations ranging from 828.5 to 835.5-ft. At the time of drilling, water in the creek was encountered at an elevation of approximately 855.5-ft, while groundwater was encountered at an elevation of approximately 849-ft. For additional information see the subsurface boring profile and individual logs in Appendix I.

MAXIMUM PILE DESIGN LOADS

END BEARING = 100 %
FRICTION = 0 %

Bents (1 through 4) (36 ksi loading)

HP 10 X 42 = 55 Tons
HP 12 X 53 = 70 Tons
HP 14 X 73 = 96 Tons
HP 14 X 89 = 117 Tons
HP 14 X 102 = 135 Tons
HP 14 X 117 = 155 Tons

Structural loads were not available at the time this report was prepared. Thus, we recommend selecting one of the H-pile types proposed in the list above for each bent.

Downdrag loads will likely be induced into the piles from potential settlement of the clayey layers due to construction of the approach fill on the widening side of the bridge. Unfactored downdrag loads of 25 kips may be included in pile design at bent 1 and bent 4 if no jackets nor permanent casings are used. If use of jackets is considered to protect the pile within the fill area, unfactored downdrag loads of 10 kips may be considered for pile design. The downdrag loads have been estimated based on HP 12 X 53 pile type.

FOUNDATION RECOMMENDATIONS

BENTS	DRILLED SHAFT (BEARING)	SPREAD FTG (BEARING)	PILE FOOTING (PILE TYPE)	PILE BENT (PILE TYPE)
Bent 1	-	-	-	Steel H-pile (36 ksi)
Bent 2	-	-	-	Steel H-pile (36 ksi)
Bent 3	-	-	-	Steel H-pile (36 ksi)
Bent 4	-	-	-	Steel H-pile (36 ksi)

ELEVATIONS

BENTS	MINIMUM TIP	ESTIMATED TIP*
1	820	820
2	825	825
3	822	822
4	822	822

*Estimated tip is based on a minimum 8 feet embedment into rock.

NOTES

Elevations All elevations are based on an Elevation of 864.73 feet, N=1452272.566 and E=2229912.525, taken at a benchmark Delta 1, located south of the southern end bent of the existing bridge. The benchmark is a ¾" rebar with cap located at Station 10+32.05, 14.03 feet LT; and was derived from the Preliminary Bridge Layout provided by Gresham Smith, dated August 2019. Horizontal datum is NAD83(94) and vertical datum is NAVD88. State Plane Zone is GA West.

Waiting Period None required if the downdrag loads are included in pile design or protection mentioned below is used.

Theoretical Scour The August 2019 Bridge Layout Plan identifies the theoretical scour line near or slightly below the top of rock. The Bridge Engineer should evaluate the elevation of the rock encountered during the subsurface investigation to determine if the scour lines should be modified in order to be at or above the top of rock. Rock was encountered at approximate elevations of 828 feet at B-1, 836 feet at B-2 and 830 feet at B-3.

Erosion We concur with the use of 24-inches of Type I riprap and filter fabric.

Vibration Monitoring

Due to the proximity of existing utilities and several properties located within and/or near the construction limits of the project, it is recommended that vibration monitoring be performed as various construction activities may have negative impact on vibration-sensitive utilities or may cause some concern with property owners. Existing utilities and structures should be surveyed before construction begins to determine the baseline condition of each utility or structure.

Vibration monitoring should be performed in accordance with Special Provision 154 – Construction Vibration Monitoring.

Pilot Holes

Due to the presence of vibration-sensitive utilities in the vicinity of the work area, pilot holes should be set up to socket the H-piles into the hard rock. The maximum pilot hole diameter should be slightly larger than the diameter of the selected pile, but no greater than 24". The holes should be filled with concrete at least to the top of the rock after the piles are seated per Special Provision 520-Piling (Pilot Holes). Pilot holes should be set up to the following elevations:

Bents	Elevation
1	820
2	825
3	822
4	822

Pile Protection

All exposed HP piles and steel sway bracing, if any, should be painted with a 2P epoxy coating as protection against corrosion.

The H-piles at intermediate bents 2 and 3 should be encased in concrete, as per standard GDOT Bridge Design Office specifications.

Permanent/ Temporary Casing

Permanent / Temporary casing will likely be required at all bents to prevent caving of the very loose/very soft soils during the preparation of the pilot holes and installing H-piles. Casing will be seated on top of rock.

Downdrag Protection

Piles at bents 1 and 4 may be protected from downdrag by using permanent casing in lieu of including downdrag loads in the design of piles. The casing used to install the H-piles as indicated in the "Permanent/Temporary Casing" section above can be left in place and used for this downdrag protection. The annular space between H-pile and casing may be filled with a granular type material.

To fully address downdrag in the piles, use permanent casing as indicated above. Alternatively, to reduce a percentage of downdrag as indicated in the Maximum Pile Design Load section above, jackets can be used.

Sway Bracing May be required to resist lateral and transverse loads if the unsupported pile lengths are too great or during peak flood conditions.

Special Problems Tip elevations and pilot hole elevations are based on conditions encountered at specific boring locations. Rock elevations may vary at unexplored locations along each proposed bent. As such, variations in pile lengths can be expected.

Stability of the approach fill in the widening side of the bridge should be evaluated by others.

As Built Foundation Information The as built foundation information should be forwarded to the Cobb County DOT upon completion of the foundation system.

Prepared By Akli Hibouche, Ph.D.

Reviewed By Stephanie Grahl, P.E.
Lucas Caliari, Ph.D.

Revised January 24, 2008

DEPARTMENT OF TRANSPORTATION
STATE OF GEORGIA

SPECIAL PROVISION

Cobb County and Fulton County, Georgia
Cobb County DOT Project NO. X2122

SECTION 520—PILING (PILOT HOLES)

Delete Sub-Section 520.3.05.B and substitute the following:

520.3.05.B. Drill Pilot Holes
When pilot holes are required, drill them to the diameter and approximate depth specified on the Plans.

Backfill voids and holes with Class A or better concrete. Furnishing and placing backfill concrete is an incidental part of the work.

The following are not considered pilot holes:

- Holes created by spudding (punching)
- Holes dug to drive piling that is too long to fit leads
- Holes dug to replace a template (if permitted)

Where pilot holes are required in granular material and the material cannot be sealed off using "mudding" drilling methods, drill the pilot hole as follows:

1. Place a casing pipe with a large enough diameter around the boring device.
2. Hold the casing in position until the pilot hole is completed and the pile driving progresses deep enough into the hard material to keep loose material out of the pilot hole.

The use of casing is incidental to the work.

Office of Materials and Testing

Revised 07/23/2014

DEPARTMENT OF TRANSPORTATION
STATE OF GEORGIA

SPECIAL PROVISION

Cobb County and Fulton County, Georgia
Cobb County DOT Project NO. X2122

Section 154 — Construction Vibration Monitoring

Add the following:

154.1 General Description

This Work consists of performing preconstruction crack surveys, seismograph and other monitoring of construction vibrations, and post construction crack surveys of the buildings located at the Willeo Creek Pump Station and all utilities remaining in service within and adjacent to the proposed project construction on Willeo Road by procuring the services of a prequalified subcontractor specializing in this work.

154.1.01 Definitions

General Provisions 101 through 150.

154.1.02 Related References

A. Standard Specifications

General Provisions 101 through 150.

B. Referenced Documents

General Provisions 101 through 150.

154.1.03 Submittals

A. Prequalification of Subcontractor

Submit the following documentation for the Engineer's review and approval a minimum of thirty days prior to beginning construction activities on the project:

Evidence of the subcontractor's successful completion of at least five projects similar in concept and scope to the proposed crack survey and vibration monitoring. Include names, addresses and telephone numbers of the owners' representatives for verification.

Résumés of employees performing this work. Provide evidence showing each employee possesses experience and knowledge similar in concept and scope of this work for performing crack surveys and installing and reading seismographs. Provide evidence that the reports will be reviewed and signed by a Georgia Licensed Professional Engineer or Georgia Licensed Professional Geologist. The Department will be sole judge of determining if employees are qualified to perform the work on this project.

A detailed survey plan, monitoring plan, and sequence of work that describes all materials, methods and equipment to be used to complete the crack survey and vibration monitoring.

B. Construction Monitoring

Submit the following documentation during construction monitoring:

Preconstruction Crack Survey Report documenting existing conditions of buildings and utilities remaining in service prior to construction activities in accordance with subsection 154.3.03.B.

Monthly Seismograph Data and Data Summary Report and Activity Log of all construction activities within 500 feet (152 meters) of the seismograph in accordance with subsection 154.3.03.A.1.

Reports of building conditions regarding cracks or any other damage potentially caused by construction activities as complaints are received in accordance with subsection 154.3.03.C.

C. Post Construction

Submit a Post Construction Crack Survey Report in accordance with subsection 154.3.03.D documenting post construction condition of cracks or damage identified in the pre-construction survey and cracks or any other damage potentially caused by construction activities.

154.2 Materials

General Provision 101 through 150.

154.3 Construction Requirements

154.3.01 Personnel

Ensure all employees performing this work have been approved by the Engineer in accordance with subsection 154.1.03.A.

154.3.02 Equipment

A. Seismograph

Use a seismograph(s) that is weather proof and capable of continuously recording particle velocity in three perpendicular components with a flat response of 2-250 HZ over a range of at least 0.01 to 5.0 inches per second (0.254 to 127 mm per second). Provide a seismograph(s) that employs an internal dynamic calibration during each recording sequence and that has been shake table tested within the previous 24 months verifying an accuracy of +/- 5% over the frequency range of 4 to 125 Hertz. Provide a recorder/ software system that is capable of digitally storing and reproducing vibration levels in tabular or histogram (bar graph) form at no greater than six minute intervals.

B. Crack Gauges

Use crack gauges specifically designed for use on this type of work. Utilize a minimum of 15 crack gauges and a maximum of 25 to monitor significant cracks on the interior or exterior of buildings located closest to the construction activities. Submit the proposed locations of crack gauges to the Engineer for review and approval prior to installation. Use crack gauges that do not damage or stain existing surfaces. Replace missing or damaged gauges at no additional cost to the Department. Repair and restore surfaces back to the pre- installation state.

154.3.03 Construction

Obtain Engineer's written approval of the Prequalification documents submitted in accordance with Subsection 154.1.03.A prior to beginning this work.

Perform the preconstruction crack survey prior to starting construction activities on the project.

Install and begin seismograph monitoring prior to starting excavation, pile installation, shoring and backfilling construction activities on the project.

Maintain seismograph and crack monitoring until excavation, pile installation, shoring and backfilling, compaction of subgrade, base and pavement construction activities on the project are complete.

A. Seismograph Installation and Monitoring

Monitor vibrations at buildings and vibration-sensitive utilities using seismographs when construction activities including, but not limited to, excavation, pile installation, shoring installation, backfilling, and compaction of subgrade, base and pavement are within 75 feet (23 meters) of the buildings, or otherwise have the potential to result in vibrations that may cause damage or complaints. Relocate seismographs as needed. Protect the seismograph from weather and vandalism. Replace missing or damaged equipment at no cost to the Department. Document the following information at the time that the seismograph is installed:

Date and time of installation
Coordinates of installed instrument or Station and offset
Method of transducer attachment
Name and affiliation of the person installing the instrument

1. Monthly Seismograph Data and Data Summary Report and Activity Log:

Compile a Monthly Seismograph Data and Data Summary Report containing the data from the seismograph and a summarization of the data showing time and magnitude of the maximum vibration that has occurred each day.

Maintain an activity log of all construction activities within 500 feet (152 meters) of the seismograph. Include the following data in each log:

Location of construction activity
Type of construction activity
Types and number of construction equipment being used, including model, manufacture and weight.
Date and times construction equipment was used.

Submit Monthly Seismograph Data Summary Report and Activity Log to the Engineer on a monthly basis.

B. Preconstruction Crack Survey

Complete a preconstruction crack survey on the outside and inside of all buildings located at the Willeo Road Pump Station. Document building conditions by taking photographs and detailed notes citing location, length and width of cracks. Compile documentation into a Preconstruction Crack Survey Report and submit to the Engineer.

C. Building Monitoring

Monitor buildings during construction for any new cracks and or elongation or widening of existing cracks. Provide a report of building conditions to the Engineer regarding cracks or any other damage potentially caused by construction activities as complaints are received.

D. Post Construction Crack Survey

Complete a post construction crack survey on the outside and inside of all buildings located at the Willeo Road Pump Station. Document building conditions by taking photographs and detailed notes citing condition of cracks or damage identified in the pre-construction survey; also, location, length and width of cracks or any other damage potentially caused by construction activities.

154.4 Measurement

The Work under this Contract Item is not measured separately for payment.

154.5 Payment

This Contract Item completed and accepted will be paid for at the Lump Sum Price bid. Payment will be full compensation for furnishing and installing the seismographs and crack gauges, for monitoring and reporting vibration data recorded on the seismographs and crack gauges, and completing crack survey and documenting building conditions and providing copies of all data to the Engineer in accordance with this specification. Seismographs, crack gauges and all other measuring equipment and devices will remain property of the Contractor.

Payment will be made under:

Item No. 154	Construction Vibration Monitoring	Per Lump Sum

Office of Materials and Testing

APPENDIX I

Project Location Map – Sheet 1

Boring Location Map – Sheet 2

Boring Location Plan/Bridge Layout – Sheet 3

Subsurface Boring Profile – Sheet 4

Legend – Sheet 5

Individual Soil Profiles (gINT Logs) – 6 Pages

LEGEND:

★ Project Location

Source: Google Earth
Image Date: 11/2/2019

0′ 500′ 1000′

Graphic Scale (feet)

Cobb County DOT Project No. X2122

DATE	NAME	REVISION	APPROVED BY:

MC² Geotechnical • Environmental Materials Testing

MC SQUARED, INC.
Geotechnical Consultants
1275 Shiloh Road NW
Suite 2620
Kennesaw, GA 30144
Ph:770-650-0873 Fax:770-650-7825

GEORGIA ENGINEERING CERTIFICATE OF AUTHORIZATION No. PEF004822
Stephanie Grahl, P.E.
GEORGIA LICENSE No. 041467

	NAME	DATE
DESIGNED BY:	DP	3/12/2020
DRAWN BY:	DP	3/12/2020
CHECKED BY:	AH	3/12/2020
SUPERVISED BY:	SG	

Project Location Map

Willeo Road over Willeo Creek Bridge Replacement
Cobb County and Fulton County, GA

MC² PROJ. NO.: A091603.099

SHEET NO.: 1

LEGEND:

Approximate Boring Location

Source: Google Earth
Image Date: 11/2/2019

0′ 50′ 100′
Graphic Scale (feet)

Cobb County DOT Project No. X2122

DATE	NAME	REVISION	APPROVED BY:

MC SQUARED, INC.
Geotechnical Consultants
1275 Shiloh Road NW
Suite 2620
Kennesaw, GA 30144
Ph:770-650-0873 Fax:770-650-7825

GEOTECHNICAL • ENVIRONMENTAL MATERIALS TESTING

GEORGIA ENGINEERING CERTIFICATE OF AUTHORIZATION No. PEF004822
Stephanie Grahl, P.E.
GEORGIA LICENSE No. 041467

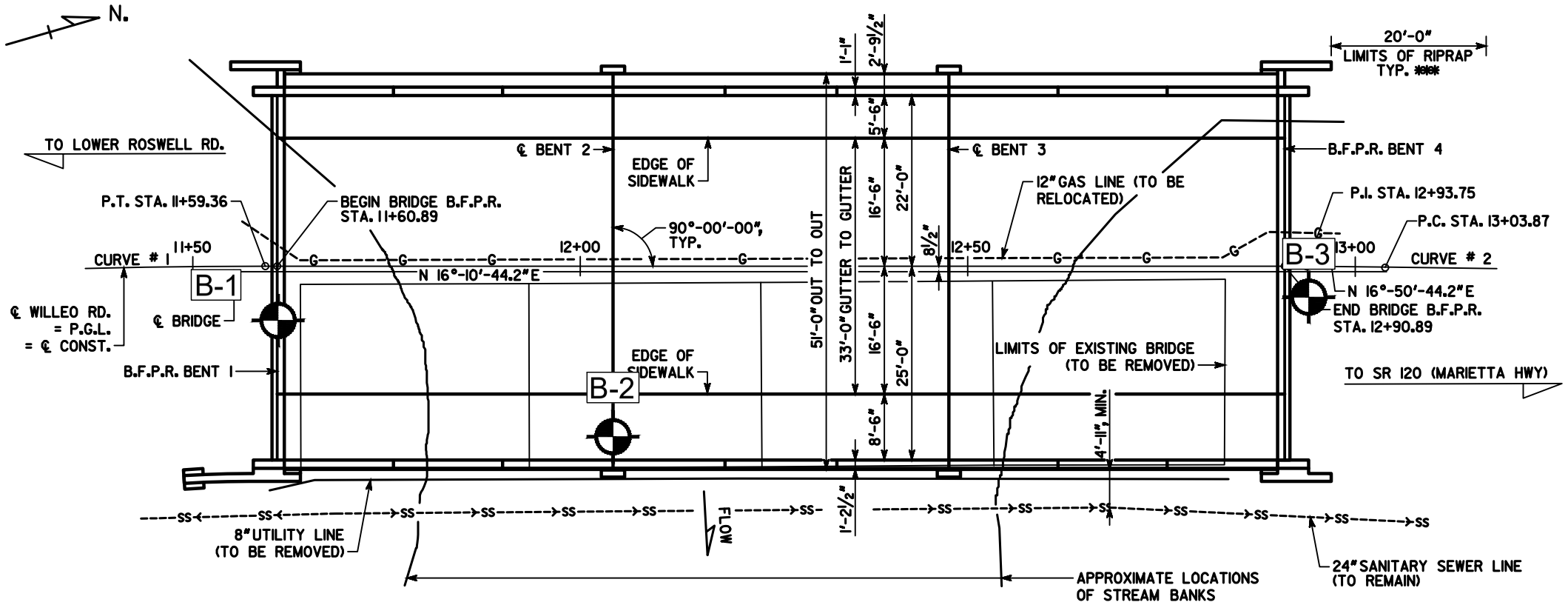
	NAME	DATE
DESIGNED BY:	DP	3/12/2020
DRAWN BY:	DP	3/12/2020
CHECKED BY:	AH	3/12/2020
SUPERVISED BY:	SG	

Boring Location Map

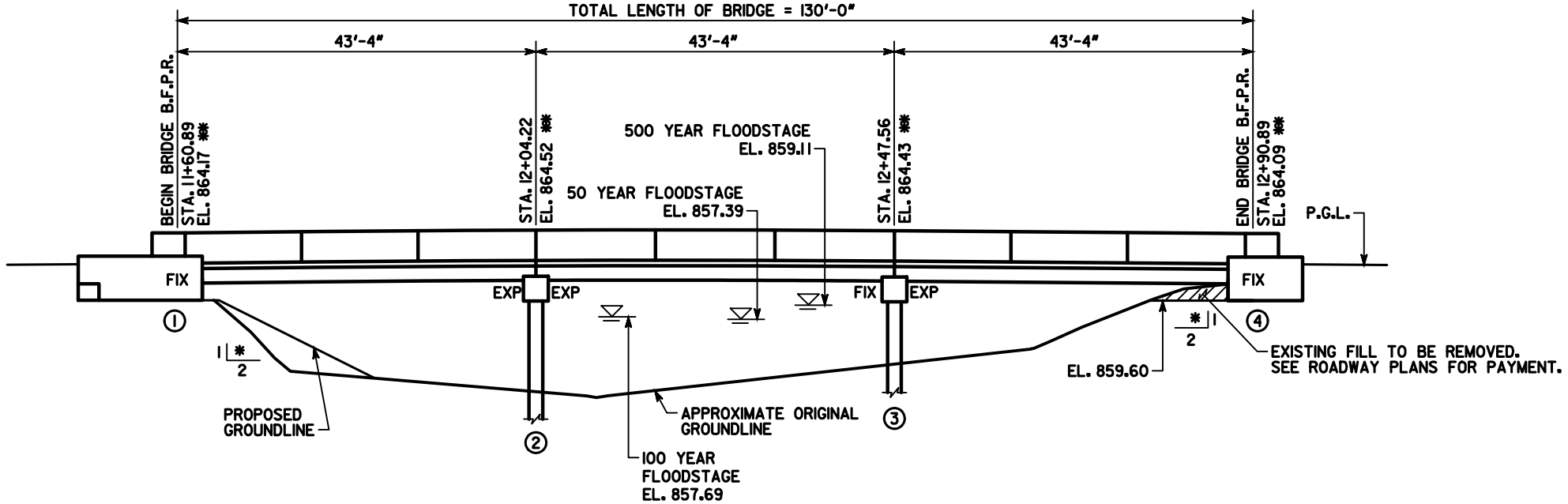
Willeo Road over Willeo Creek Bridge Replacement
Cobb County, and Fulton County GA

MC² PROJ. NO.: A091603.099

SHEET NO.: 2



PLAN



ELEVATION

LEGEND:

Approximate Boring Location

Plans Provided By: Gresham Smith
DRAWING NO. 35-0001

Cobb County DOT Project No. X2122

DATE	NAME	REVISION	APPROVED BY:

MC² GEOTECHNICAL • ENVIRONMENTAL MATERIALS TESTING

MC SQUARED, INC.
Geotechnical Consultants
1275 Shiloh Road NW
Suite 2620
Kennesaw, GA 30144
Ph:770-650-0873 Fax:770-650-7825

GEORGIA ENGINEERING CERTIFICATE OF AUTHORIZATION No. PEF004822
Stephanie Grahl, P.E.
GEORGIA LICENSE No. 041467

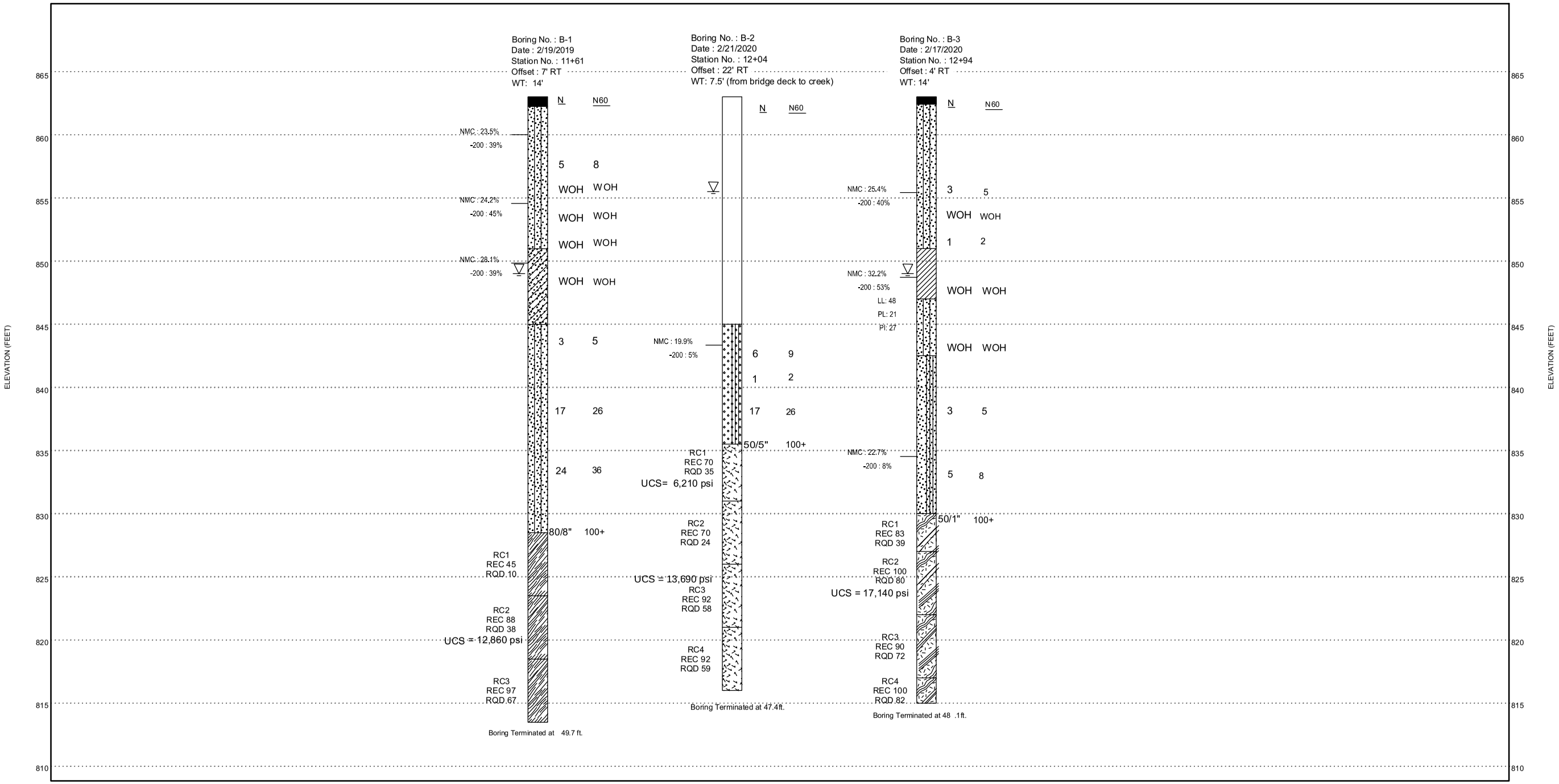
	NAME	DATE
DESIGNED BY:	DP	3/12/2020
DRAWN BY:	DP	3/12/2020
CHECKED BY:	AH	3/12/2020
SUPERVISED BY:	SG	

Boring Location Plan and Bridge Layout

Willeo Road over Willeo Creek Bridge Replacement
Cobb County and Fulton County, GA

MC² PROJ. NO.: A091603.099

SHEET NO.: 3



**N60 Values Based on Hammer Efficiency of 91%.

Cobb County DOT Project No. X2122

DATE	NAME	REVISION	APPROVED BY:

MC² GEOTECHNICAL • ENVIRONMENTAL MATERIALS TESTING

MC SQUARED, INC.
Geotechnical Consultants
1275 Shiloh Road NW
Suite 2620
Kennesaw, GA 30144
Ph:770-650-0873 Fax:770-650-7825

GEORGIA ENGINEERING CERTIFICATE OF AUTHORIZATION No. PEF004822
Stephanie Grahl, P.E.
GEORGIA LICENSE No. 041467

	NAME	DATE
DESIGNED BY:	DP	3/12/2020
DRAWN BY:	DP	3/12/2020
CHECKED BY:	AH	3/12/2020
SUPERVISED BY:	SG	

Subsurface Boring Profile

Willeo Road over Willeo Creek Bridge Replacement
Cobb County and Fulton County, GA

MC² PROJ. NO.: A091603.099

SHEET NO.: 4

LEGEND

- Top Soil
- Asphalt
- Concrete
- (GAB) Graded Aggregate Base
- Limerock Base
- No. 57 Stone
- Soil Cement
- (SP) Poorly Graded Sand
- (SP-SM) Poorly Graded Sand With Silt
- (SP-SC) Poorly Graded Sand With Clay
- (SM) Silty Sand
- (SC) Clayey Sand
- (MH) Elastic Silt
- (ML) Silt
- (CL-ML) Silty Clay
- (CH) Fat Clay
- (CL) Lean Clay
- (OH) Organic Clay
- (OL) Organic Silt
- Peat
- Fill
- Bedrock
- Limestone
- (WLS) Weathered Limestone
- (PWR) Partially Weathered Rock
- Granite
- Gneiss
- Schist

NOTES:

▽	Water Table At Time Of Drilling
▼	Water Table After 24 Hours
GNE	Groundwater Not Encountered
GNA	Groundwater Not Apparent
GNM	Groundwater Not Measured
CL	Center Line
RT	Right Of Center Line
LT	Left of Center Line
BGS	Below Ground Surface
HA	Hand Auger
PA	Power Auger
NMC	Natural Moisture Content (%)
-200	Fines Passing A No. 200 Sieve (%)
PI	Plasticity Index
NP	Non Plastic
LL	Liquid Limit
OC	Organic Content (%)
N	SPT N-Value
WOH	Weight-Of-Hammer
WOR	Weight-Of-Rod
CPT	Cone Penetrometer Test
SPT	Standard Penetration Test
DT	Dilatometer Test
LOC	Loss Of Circulation
ROC	Regain Of Circulation
REC	Rock Core Recovery(%)
RQD	Rock Quality Designation
ST	Shelby Tube Sample
q_u	Unconfined Compressive Strength From Pocket Penetrometer In tsf
T	Casing

GRANULAR MATERIALS- RELATIVE DENSITY	SPT (BLOWS/FT)
VERY LOOSE	≤ 4
LOOSE	5-10
MEDIUM	11-30
DENSE	31-50
VERY DENSE	GREATER THAN 50
SILTS AND CLAYS CONSISTENCY	**SPT (BLOWS/FT)**
VERY SOFT	≤ 2
SOFT	3-4
FIRM	5-8
STIFF	9-15
VERY STIFF	16-30
HARD	30-50
VERY HARD	GREATER THAN 50

SPT Spoon Inside Diameter 1 3/8"
SPT Spoon Outside Diameter 2"

ASTM Standard Drop Safety Hammer
Average Hammer Drop Height 30"
Hammer Weight 140 lbs

Cobb County DOT Project No. X2122

DATE	NAME	REVISION	APPROVED BY:

MC SQUARED, INC.
Geotechnical Consultants
1275 Shiloh Road NW
Suite 2620
Kennesaw, GA 30144
Ph:770-650-0873 Fax:770-650-7825
GEOTECHNICAL • ENVIRONMENTAL MATERIALS TESTING

GEORGIA ENGINEERING CERTIFICATE OF AUTHORIZATION No. PEF004822
Stephanie Grohl, P.E.
GEORGIA LICENSE No. 041467

	NAME	DATE
DESIGNED BY:	DP	3/12/2020
DRAWN BY:	DP	3/12/2020
CHECKED BY:	AH	3/12/2020
SUPERVISED BY:	SG	

Legend

Willeo Road over Willeo Creek Bridge Replacement
Cobb County and Fulton County, GA

MC² PROJ. NO.: A091603.099

SHEET NO.: 5

Soil Profile

BORING ID: B-1

MC² Geotechnical • Environmental Materials Testing

CLIENT Gresham Smith
PROJECT NAME Willeo Road over Willeo Creek Bridge Replacement
PROJECT NUMBER A091603.099
PROJECT LOCATION Cobb County and Fulton County, GA
DATE STARTED 2/19/19 **COMPLETED** 2/19/19
GROUND ELEVATION 863 ft **HOLE SIZE** 4 inches
DRILLING CONTRACTOR Geo Lab Drilling
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger, NQ Rock Coring
AT TIME OF DRILLING 14.0 ft / Elev 849.0 ft
LOGGED BY AH **CHECKED BY** SG
AT END OF DRILLING ---
NOTES 11+61, 7' RT
AFTER DRILLING ---

DEPTH (ft)	ELEV. (ft)	USCS Group Symbol	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)
0			9" Asphalt		
	862	SM	Very loose to loose, reddish brown, brown, gray, moist, silty SAND	HA	
	860				
5	858			SS 1	2-2-3-3 (5)
	856		WOH (6.5'-8')	SS 2	1-0-0-0 (0)
	854		WOH (8.5'-10')	SS 3	1-0-0-0 (0)
10	852		WOH (10'-12')	SS 4	0-0-0-0 (0)
	850	SC	Very loose, gray, wet, clayey SAND		
15	848		WOH (13.5'-15')	SS 5	0-0-0 (0)
	846		ST No Recovery (16'-18')	ST 1	
	844	SM	Very loose to medium dense, gray, moist to wet, silty SAND	SS 6	1-1-2-4 (3)
20	842				
	840				
25	838			SS 7	4-7-10-20 (17)

RECOVERY % (RQD)

● SPT N VALUE ●
⊕ ORGANIC CONTENT % ⊕
PL MC LL
□ FINES CONTENT (%) □
20 40 60 80

MC2 REPORT W ELEV. A16.099.GPJ MC2.GDT 3/26/20

(Continued Next Page)

Soil Profile

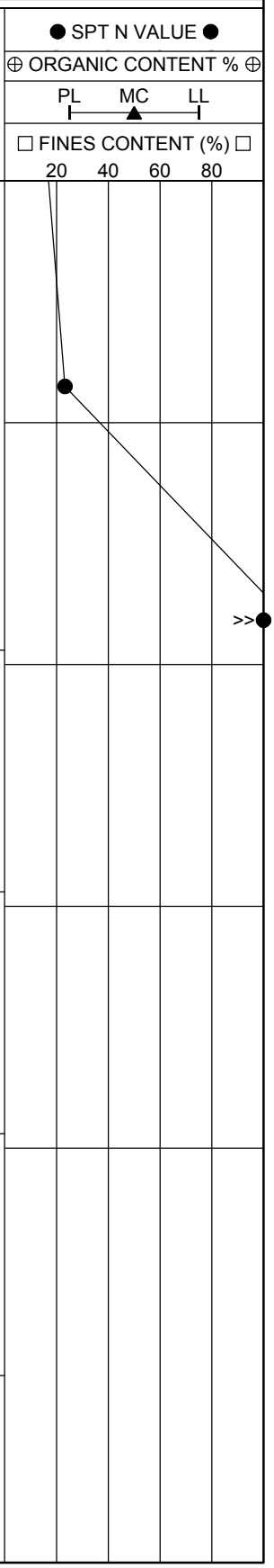
BORING ID: B-1

MC2 Geotechnical • Environmental Materials Testing

CLIENT Gresham Smith **PROJECT NAME** Willeo Road over Willeo Creek Bridge Replacement

PROJECT NUMBER A091603.099 **PROJECT LOCATION** Cobb County and Fulton County, GA

DEPTH (ft)	ELEV. (ft)	GRAPHIC LOG	USCS Group Symbol	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	RECOVERY % (RQD)
25				Very loose to medium dense, gray, moist to wet, silty SAND			
	836						
	834				SS 8	3-4-20 (24)	
30			SM				
	832						
	830						
					SS 9	5-30-50/2"	
35	828			(34.5'-39.7') SCHIST (feldspar, biotite, quartz), white, gray, black, moderately hard to hard, slightly to moderately weathered, non-foliated to 20 degrees foliation, medium to coarse grained, intensely fractured, planar to non-planar, FeOx staining present throughout.			
	826				RC 1		45 (10)
	824						
40				(39.7'-44.7') SCHIST (feldspar, biotite, quartz), white, gray, black, moderately hard to hard, slightly to moderately weathered, 20 degrees foliation, medium to coarse grained, moderately fractured, planar to non-planar, some FeOx staining observed.			
	822						
	820				RC 2		88 (38)
45	818			(44.'-49.7') SCHIST (feldspar, biotite, quartz), white, gray, black, hard to very hard, slightly weathered to fresh, non-foliated to 15 degrees foliation, medium to coarse grained, moderately fractured, planar to non-planar, some FeOx staining present.			
	816				RC 3		97 (67)
	814						
				Bottom of hole at 49.7 feet.			
	812						
	810						



Soil Profile

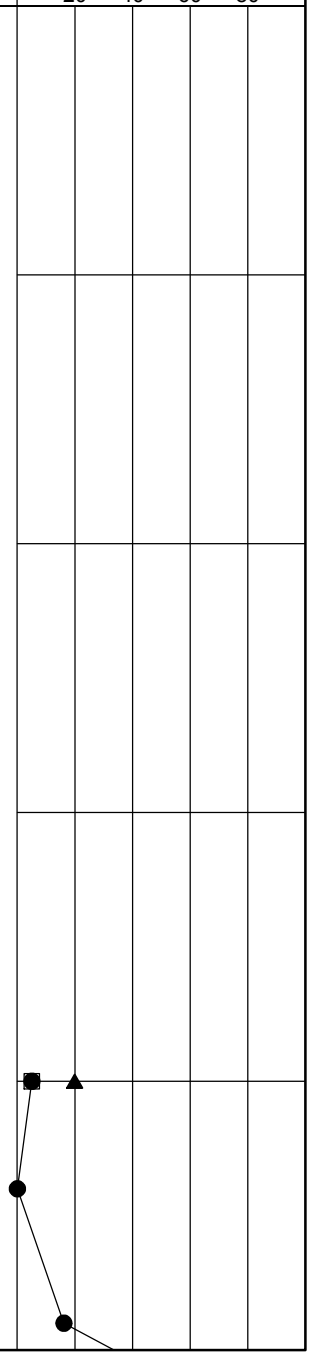
BORING ID: B-2

MC2 Geotechnical • Environmental Materials Testing

CLIENT Gresham Smith
PROJECT NAME Willeo Road over Willeo Creek Bridge Replacement
PROJECT NUMBER A091603.099
PROJECT LOCATION Cobb County and Fulton County, GA
DATE STARTED 2/21/20 **COMPLETED** 2/21/20
GROUND ELEVATION 863 ft **HOLE SIZE** 4 inches
DRILLING CONTRACTOR Geo Lab Drilling
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger, NQ Rock Coring
AT TIME OF DRILLING 7.5 ft / Elev 855.5 ft
LOGGED BY AH **CHECKED BY** SG
AT END OF DRILLING ---
NOTES 12+04, 22' RT
AFTER DRILLING ---

DEPTH (ft)	ELEV. (ft)	GRAPHIC LOG	USCS Group Symbol	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	RECOVERY % (RQD)
0				Bridge Deck			
	862						
	860						
5	858						
	856						
	854						
10							
	852						
	850						
15	848						
	846						
	844		SW-SM	Very loose to medium dense, gray, wet, well-graded SAND with silt			
20				Rock fragments (19'-21')	SS 1	3-5-1-4 (6)	
	842						
	840			WOH (22'-22.5')	SS 2	25-1-0-8 (1)	
25	838				SS 3	4-13-4-3 (17)	

● SPT N VALUE ●
⊕ ORGANIC CONTENT % ⊕
PL MC LL
☐ FINES CONTENT (%) ☐
20 40 60 80



(Continued Next Page)

Soil Profile

BORING ID: B-2

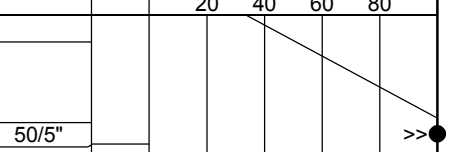
MC2 Geotechnical • Environmental Materials Testing

CLIENT Gresham Smith **PROJECT NAME** Willeo Road over Willeo Creek Bridge Replacement

PROJECT NUMBER A091603.099 **PROJECT LOCATION** Cobb County and Fulton County, GA

DEPTH (ft)	ELEV. (ft)	USCS Group Symbol	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	RECOVERY % (RQD)
25		SW-SM	Very loose to medium dense, gray, wet, well-graded SAND with silt			
	836		Auger Refusal at 27 fbgs			
			(27'-32.4') GRANITIC GNEISS (feldspar, biotite, quartz), white, gray, black, moderately hard to hard, slightly to moderately weathered, non-foliated to 20 degrees foliation, medium to coarse grained, intensely fractured, planar to non-planar, FeOx staining throughout.	SS 4	50/5"	
	834					
30				RC 1		70 (35)
	832					
	830		(32.4'-37.4') GRANITIC GNEISS (feldspar, biotite, quartz), white, gray, black, moderately hard to hard, slightly to moderately weathered, non-foliated to 20 degrees foliation, medium to coarse grained, intensely to moderately fractured, planar to non-planar, FeOx staining throughout.			
35	828			RC 2		70 (24)
	826					
			(37.4'-42.4') GRANITIC GNEISS (feldspar, biotite, quartz), white, gray, black, moderately hard to hard, moderately weathered to fresh, non-foliated to 20 degrees foliation, medium to coarse grained, moderately fractured, planar to non-planar, FeOx staining throughout			
	824					
40				RC 3		92 (58)
	822					
	820		(42.4'-47.4') GRANITIC GNEISS (feldspar, biotite, quartz), white, gray, black, moderately hard to hard, moderately weathered to fresh, non-foliated to 20 degrees foliation, medium to coarse grained, moderately fractured, planar to non-planar, FeOx staining throughout			
45	818			RC 4		92 (59)
	816					
			Bottom of hole at 47.4 feet.			
	814					
	812					
	810					

● SPT N VALUE ●
⊕ ORGANIC CONTENT % ⊕
PL MC LL
☐ FINES CONTENT (%) ☐
20 40 60 80



Soil Profile

BORING ID: B-3

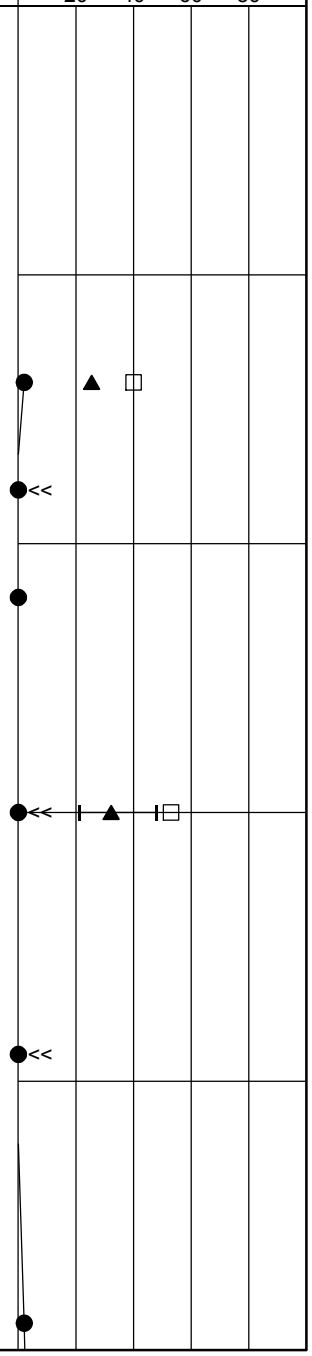
MC² Geotechnical • Environmental Materials Testing

CLIENT Gresham Smith
PROJECT NAME Willeo Road over Willeo Creek Bridge Replacement
PROJECT NUMBER A091603.099
PROJECT LOCATION Cobb County and Fulton County, GA
DATE STARTED 2/17/20 **COMPLETED** 2/17/20
GROUND ELEVATION 863 ft **HOLE SIZE** 4 inches
DRILLING CONTRACTOR Geo Lab Drilling
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger, NQ Rock Coring
AT TIME OF DRILLING 14.0 ft / Elev 849.0 ft
LOGGED BY AH **CHECKED BY** SG
AT END OF DRILLING ---
NOTES 12+94, 4' RT
AFTER DRILLING ---

DEPTH (ft)	ELEV. (ft)	USCS Group Symbol	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)
0			7" Asphalt		
	862	SM	Very loose, brown to reddish brown, gray, moist, silty SAND	HA	
	860				
5	858		4'-6' : Sample attempted. No recovery due to impedence of caved-in pavement.		
	856			SS 1	3-2-1-1 (3)
	854		WOH (8.5'-10')	SS 2	1-0-0-0 (0)
10			WOH (10'-10.5')		
	852		WOH (11'-12'), Clay in tip of spoon	SS 3	0-1-0-0 (1)
	850	CL	Very soft, brown to gray, moist, sandy lean CLAY ST No Recovery (12'-14')	ST 1	
15	848		WOH (14'-15.5')	SS 4	0-0-0-1 (0)
	846	SM	Very loose, gray, wet, silty SAND	ST 2	
	844		WOH (18.5'-20')	SS 5	0-0-0-1 (0)
20					
	842	SP-SM	Very loose to loose, gray to light brown, wet, poorly-graded SAND with silt		
	840				
25	838		WOH (24.5'-25')	SS 6	3-3-0-1 (3)

RECOVERY % (RQD)

● SPT N VALUE ●
⊕ ORGANIC CONTENT % ⊕
PL MC LL
□ FINES CONTENT (%) □
20 40 60 80



MC2 REPORT W ELEV. A16.099.GPJ MC2.GDT 3/27/20

(Continued Next Page)

Soil Profile

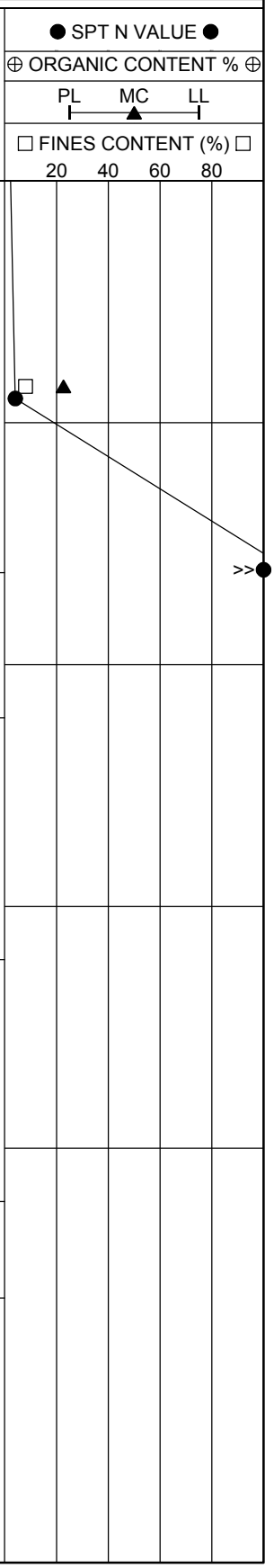
BORING ID: B-3

MC2 Geotechnical • Environmental Materials Testing

CLIENT Gresham Smith **PROJECT NAME** Willeo Road over Willeo Creek Bridge Replacement

PROJECT NUMBER A091603.099 **PROJECT LOCATION** Cobb County and Fulton County, GA

DEPTH (ft)	ELEV. (ft)	USCS Group Symbol	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	RECOVERY % (RQD)
25			Very loose to loose, gray to light brown, wet, poorly-graded SAND with silt			
	836					
	834	SP-SM		SS 7	3-3-2-1 (5)	
30						
	832					
	830		Auger Refusal at 33 fbgs			
			(33'-36.1') GNEISS (feldspar, biotite, quartz), white, gray, black, hard to very hard, slightly weathered to fresh, non-foliated to 35 degree foliation, medium to coarse grained, moderately fractured, non-planar, some FeOx staining present	SS 8	50/1"	
35	828			RC 1		83 (39)
			(36.1'-41.1') GNEISS (feldspar, biotite, quartz), white, gray, black, hard to very hard, slightly weathered to fresh, non-foliated to 35 degree foliation, medium to coarse grained, slightly to very slightly fractured, non-planar, some FeOx staining present in fracture			
	826					
	824			RC 2		100 (82)
40						
	822					
			(41.1'-46.1') GNEISS (feldspar, biotite, quartz), white, gray, black, hard to very hard, slightly weathered to fresh, non-foliated to 35 degree foliation, medium to coarse grained, slightly to very slightly fractured, non-planar, some FeOx staining present in fracture			
	820			RC 3		90 (72)
45	818					
			(46.1'-48.1') GNEISS (feldspar, biotite, quartz), white, gray, black, hard to very hard, slightly weathered to fresh, non-foliated to 35 degree foliation, medium to coarse grained, slightly to very slightly fractured, non-planar, some FeOx staining present in fracture			
	816			RC 4		100 (82)
			Bottom of hole at 48.1 feet.			
	814					
	812					
	810					



APPENDIX II

Summary of Laboratory Results – USCS - 1 Page

Atterberg Limits Results - 1 Page

Grain Size Distribution Results - 1 Pages

Corrosion Test Results - 1 Page

Rock Core Test Results Summary - 1 Page

Rock Core Photographs - 12 Pages

Rock Core Testing Photographs - 4 Pages

SUMMARY OF LABORATORY RESULTS-USCS

MC Squared, Inc.
1275 Shiloh Road, Suite 2620
Kennesaw, GA 30144

CLIENT Gresham Smith

PROJECT NAME Willeo Road Over Willeo Creek Bridge Replacement

PROJECT NUMBER A091603.99

PROJECT LOCATION Cobb County and Fulton County, GA

Sample No.	Station/ Offset (C/L)	Soil Description	USCS Class.	%< Finer Sieve								NMC (%)	pH	Resistivity (ohm-cm)	LL %	PL %	PI %
				3/4"	#4	#10	#20	#40	#60	#100	#200						
B-1 (3 to 4 ft)	11+61, 7' R	Reddish Brown Silty SAND	SM								39	23.5					
B-1 (8 to 10 ft)	11+61, 7' R	Reddish Brown Silty SAND	SM								45	24.2					
B-1 (13.5 to 15 ft)	11+61, 7' R	Brown Clayey SAND	SC								39	28.1					
B-1 (28.5 to 30 ft)	11+61, 7' R	Brown Silty SAND	SM										5.3	19000			
B-2 (19 to 21 ft)	12+04, 22' R	Dark Brown Well Graded SAND with Silt	SW-SM		85	69	41	21	13	8	5	19.9					
B-3 (6 to 8 ft)	12+94, 4' R	Reddish Brown Silty SAND	SM								40	25.4					
B-3 (14 to 16 ft)	12+94, 4' R	Reddish Brown Sandy Lean CLAY	CL								53	32.2			48	21	27
B-3 (23.5 to 25 ft)	12+94, 4' R	Brown Poorly Graded SAND with Silt	SP-SM										4.9	61000			
B-3 (28.5 to 30 ft)	12+94, 4' R	Reddish Brown Poorly Graded SAND with Silt	SP-SM		100	98	86	59	30	15	8	22.7					
Water Sample													5.4	7000			

ATTERBERG LIMITS RESULTS

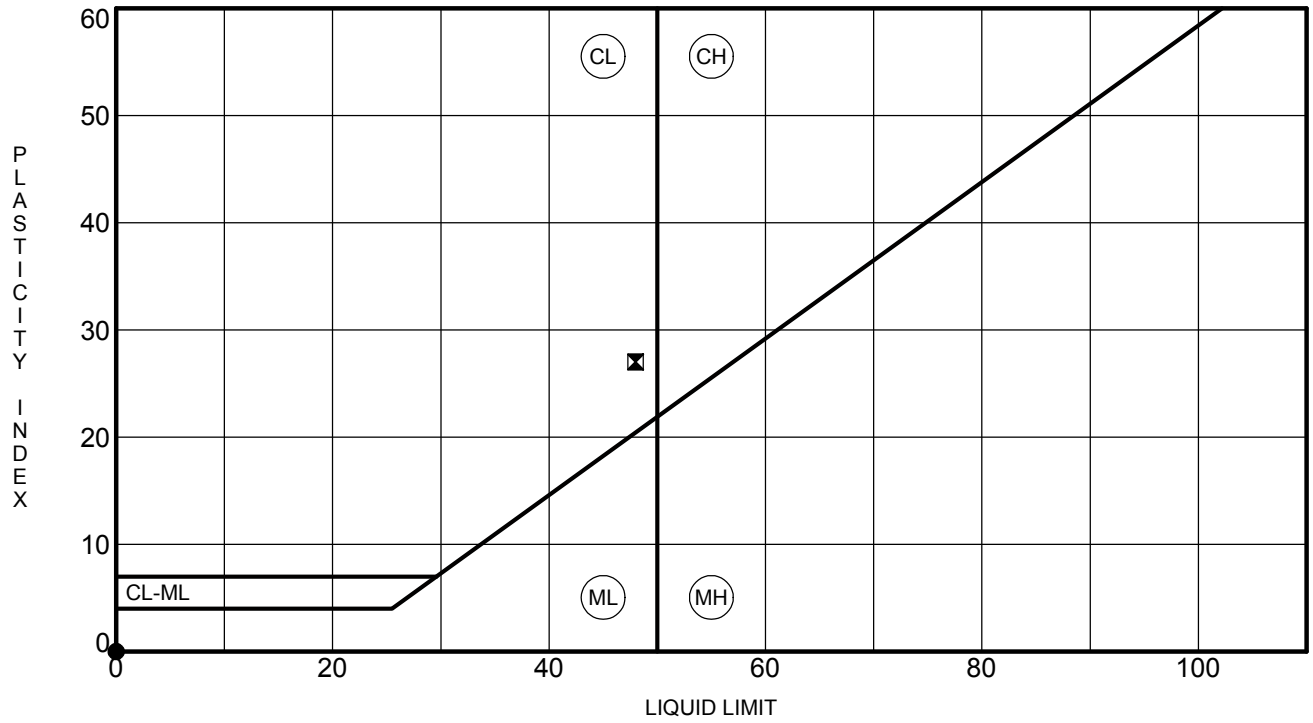
MC Squared, Inc.
1275 Shiloh Road,Suite 2620
Kennesaw, GA 30144

CLIENT Gresham Smith

PROJECT NAME Willeo Road Over Willeo Creek Bridge Replacement

PROJECT NUMBER A091603.99

PROJECT LOCATION Cobb County and Fulton County, GA



	Specimen Identification	LL	PL	PI	Fines	Classification
⧗	**B-3 (14 to 16 ft)**	**48**	**21**	**27**	**53**	**Reddish Brown Sandy Lean CLAY**

GRAIN SIZE DISTRIBUTION

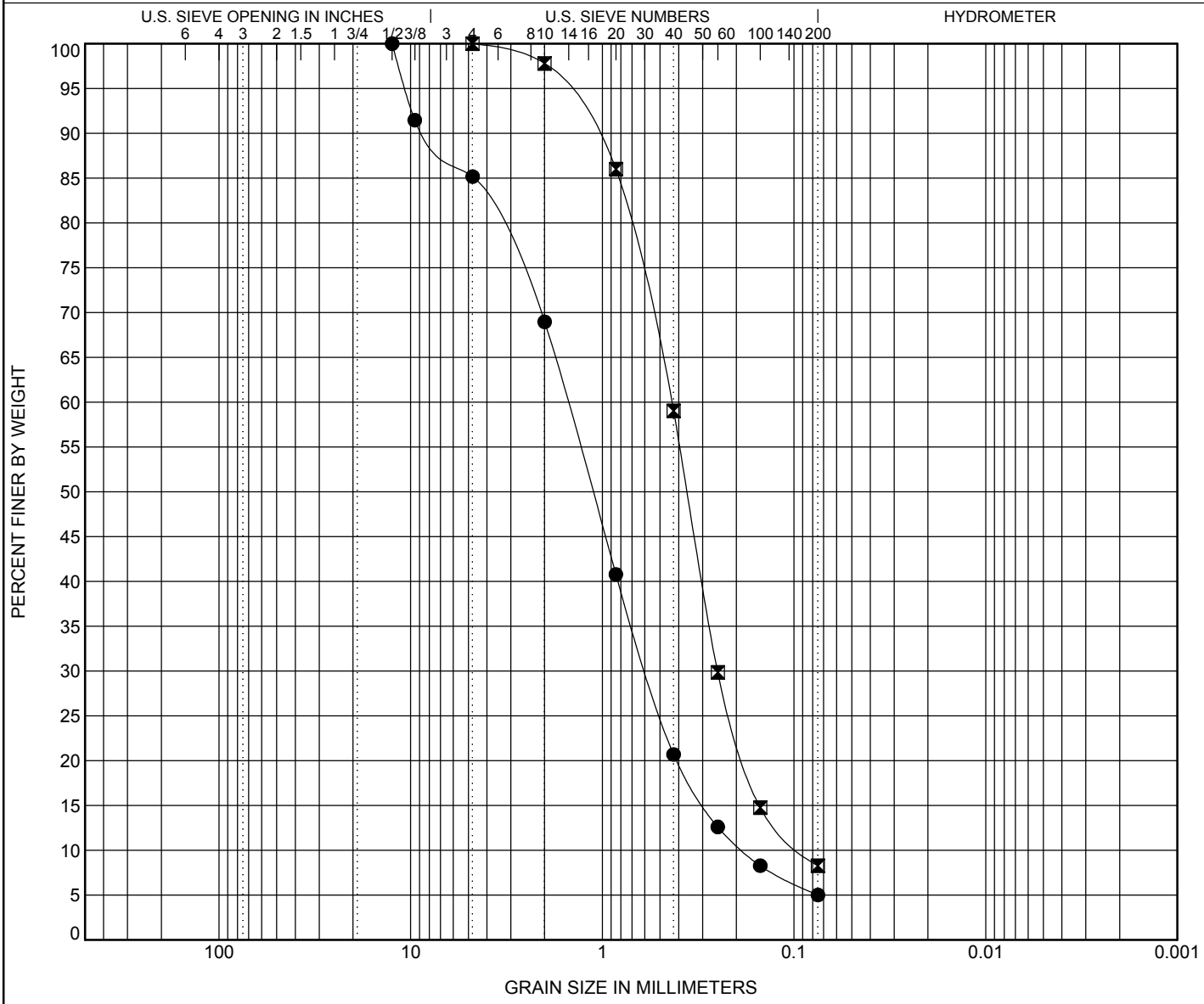
MC Squared Inc.
1275 Shiloh Road,Suite 2620
Kennesaw, GA 30144

CLIENT Gresham Smith

PROJECT NAME Willeo Road Over Willeo Creek Bridge Replacement

PROJECT NUMBER A091603.99

PROJECT LOCATION Cobb County and Fulton County, GA



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification	Classification	LL	PL	PI	Cc	Cu
●	**B-2 (19 to 21 ft)**	**Dark Brown Well Graded SAND with Silt**				**1.23**	**8.29**
⊠	**B-3 (28.5 to 30 ft)**	**Reddish Brown Poorly Graded SAND with Silt**				**1.60**	**4.82**

	Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-2 (19 to 21 ft)**	**12.5**	**1.523**	**0.586**	**0.184**	**14.8**	**80.2**	**5.0**	
⊠	**B-3 (28.5 to 30 ft)**	**4.75**	**0.436**	**0.251**	**0.09**		**91.7**	**8.3**	

Note-Sample soaked for 16 hrs (+/- 10 min)

Willeo Road over Willeo Creek
Bridge Replacement
Cobb County and Fulton County, Georgia
Cobb County DOT Project No. X2122
MC^2 Project No. A091603.099

Summary of Corrosion Test Results							
Boring No. / Depth (ft)	**Station/ Offset**	**USCS**	**pH**	**Resistivity (ohm-cm)**	**Chloride Content (ppm)**	**Sulfate Content (ppm)**	**Env. Classification***
B-1 (28.5–30)	11+61, 7′ RT	SM	5.3	19,000	BRL**	14	Potentially Corrosive
B-3 (23.5–25.5)	12+94, 4′ RT	SP-SM	4.9	61,000	BRL**	BRL**	Potentially Corrosive
Creek Water Sample	N/A	N/A	5.4	7,000	4.9	3.0	Potentially Corrosive

Notes:
*As per AASHTO LRFD 2014 Bridge Design Specification (version 2014) Section 10.7.5.
**Any Reading represented as “BRL” is below reporting limits.
pH – tested in accordance with ASTM D4972.
Resistivity – tested in accordance with ASTM G57.
Sulfates – content determined by EPA SW9056A test method.
Chlorides – content determined by EPA SW9056A test method.

MC2
GEOTECHNICAL • ENVIRONMENTAL
MATERIALS TESTING

Rock Core Test Results Summary
Unconfined Compressive Strength
Willeo Road over Willeo Creek
Bridge Replacement
Cobb County and Fulton County, Georgia
MC^2 Project No. A091603.099

Boring No.	Run No.	Approx. Sample Depth (ft, *bgs)	Approx. Elevation (ft, *bgs)	Bulk Density (pcf)	Unconfined Compressive Strength (psi)
B-1	2	40.0 – 40.3	823.0 – 822.7	181.2	12,860
B-2	1	31.5 – 31.8	835.8 – 835.5	166.0	6,210
B-2	3	37.5 – 35.8	825.5 – 825.2	167.5	13,690
B-3	2	37.0 – 37.3	828.0 – 827.7	171.6	17,140

*bgs: below ground surface

DRY
Boring No. B-01 (Sta. 11+61, 7' R) Runs 1 and 2
Run 1: 34.7ft. – 39.7 ft., REC = 45%, RQD = 10%
Run 2: 39.7 ft. – 44.7 ft., REC = 88%, RQD = 38%

MC² Geotechnical • Environmental Materials Testing	**Bridge Foundation Investigation (BFI) Report** **Willeo Road Over Willeo Creek Bridge Replacement** **Cobb County and Fulton County Georgia**	**Prepared For:** Gresham Smith **MC² Project No.** A091603.099
	ROCK CORE PHOTOGRAPHS	**Date:** 3/12/20

WET
Boring No. B-01 (Sta. 11+61, 7' R) Runs 1 and 2
Run 1: 34.7 ft. – 39.7 ft., REC = 45%, RQD = 10%
Run 2: 39.7 ft. – 44.7 ft., REC = 88%, RQD = 38%

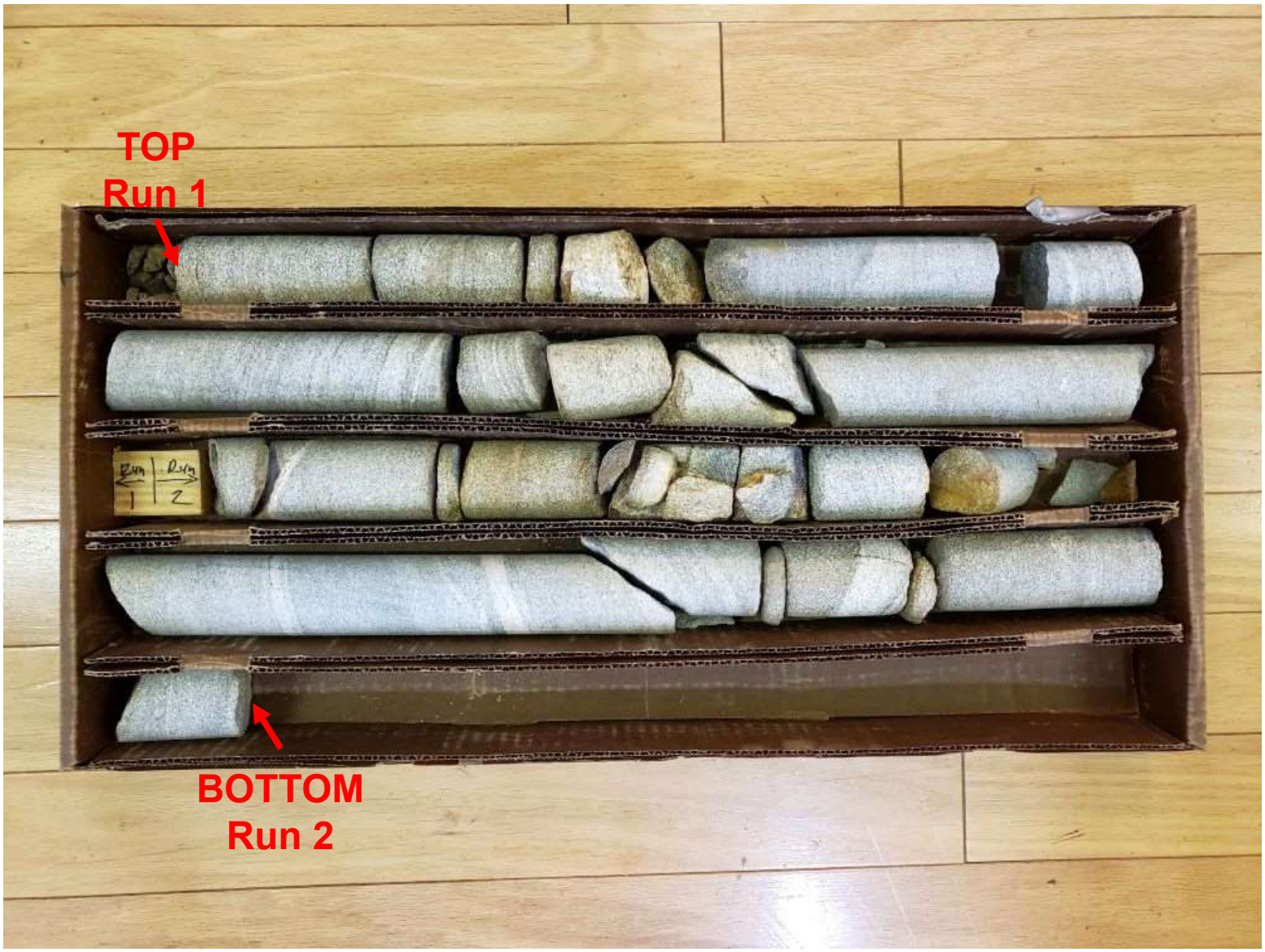
MC² Geotechnical • Environmental Materials Testing	**Bridge Foundation Investigation (BFI) Report** **Willeo Road Over Willeo Creek Bridge Replacement** **Cobb County and Fulton County Georgia**	**Prepared For:** Gresham Smith
		MC² Project No. A091603.099
	ROCK CORE PHOTOGRAPHS	**Date:** 3/12/20

DRY
Boring No. B-01 (Sta. 11+61, 7' R) Run 3
Run 3: 44.7 ft. – 49.7 ft., REC = 97%, RQD = 67%

MC² Geotechnical • Environmental Materials Testing	**Bridge Foundation Investigation (BFI) Report** **Willeo Road Over Willeo Creek Bridge Replacement** **Cobb County and Fulton County Georgia**	**Prepared For:** Gresham Smith **MC² Project No.** A091603.099
	ROCK CORE PHOTOGRAPHS	**Date:** 3/12/20

WET
Boring No. B-01 (Sta. 11+61, 7' R) Run 3
Run 3: 44.7 ft. – 49.7 ft., REC = 97%, RQD = 67%

MC² Geotechnical • Environmental Materials Testing	**Bridge Foundation Investigation (BFI) Report** **Willeo Road Over Willeo Creek Bridge Replacement** **Cobb County and Fulton County Georgia**	**Prepared For:** Gresham Smith **MC² Project No.** A091603.099
	ROCK CORE PHOTOGRAPHS	**Date:** 3/12/20



DRY
Boring No. B-02 (Sta. 12+04, 22' R) Runs 1 and 2
Run 1: 27.4 ft. – 32.4 ft., REC = 70%, RQD = 35%
Run 2: 32.4 ft. – 37.4 ft., REC = 70%, RQD = 24%

MC² Geotechnical • Environmental Materials Testing	**Bridge Foundation Investigation (BFI) Report** **Willeo Road Over Willeo Creek Bridge Replacement** **Cobb County and Fulton County Georgia**	**Prepared For:** Gresham Smith **MC² Project No.** A091603.099
	ROCK CORE PHOTOGRAPHS	**Date:** 3/12/20

WET
Boring No. B-02 (Sta. 12+04, 22' R) Runs 1 and 2
Run 1: 27.4 ft. – 32.4 ft., REC = 70%, RQD = 35%
Run 2: 32.4 ft. – 37.4 ft., REC = 70%, RQD = 24%

MC² Geotechnical • Environmental Materials Testing	**Bridge Foundation Investigation (BFI) Report** **Willeo Road Over Willeo Creek Bridge Replacement** **Cobb County and Fulton County Georgia**	**Prepared For:** Gresham Smith **MC² Project No.** A091603.099
	ROCK CORE PHOTOGRAPHS	**Date:** 3/12/20

DRY
Boring No. B-02 (Sta. 12+04, 22' R) Runs 3 and 4
Run 3: 37.4 ft. – 42.4 ft., REC = 92%, RQD = 58%
Run 4: 42.4 ft. – 47.4 ft., REC = 92%, RQD = 59%

MC² Geotechnical • Environmental Materials Testing	**Bridge Foundation Investigation (BFI) Report** **Willeo Road Over Willeo Creek Bridge Replacement** **Cobb County and Fulton County Georgia**	**Prepared For:** Gresham Smith **MC² Project No.** A091603.099
	ROCK CORE PHOTOGRAPHS	**Date:** 3/12/20

WET
Boring No. B-02 (Sta. 12+04, 22' R) Runs 3 and 4
Run 3: 37.4 ft. – 42.4 ft., REC = 92%, RQD = 58%
Run 4: 42.4 ft. – 47.4 ft., REC = 92%, RQD = 59%

MC² Geotechnical • Environmental Materials Testing	**Bridge Foundation Investigation (BFI) Report** **Willeo Road Over Willeo Creek Bridge Replacement** **Cobb County and Fulton County Georgia**	**Prepared For:** Gresham Smith
		MC² Project No. A091603.099
	ROCK CORE PHOTOGRAPHS	**Date:** 3/12/20

DRY
Boring No. B-03 (Sta. 12+94, 4' R) Runs 1 and 2
Run 1: 33.1 ft. – 36.1 ft., REC = 83%, RQD = 39%
Run 2: 36.1 ft. – 41.1 ft., REC = 100%, RQD = 82%

MC² Geotechnical • Environmental Materials Testing	**Bridge Foundation Investigation (BFI) Report** **Willeo Road Over Willeo Creek Bridge Replacement** **Cobb County and Fulton County Georgia**	**Prepared For:** Gresham Smith **MC² Project No.** A091603.099
	ROCK CORE PHOTOGRAPHS	**Date:** 3/12/20

WET
Boring No. B-03 (Sta. 12+94, 4' R) Runs 1 and 2
Run 1: 33.1 ft. – 36.1 ft., REC = 83%, RQD = 39%
Run 2: 36.1 ft. – 41.1 ft., REC = 100%, RQD = 82%

MC² Geotechnical • Environmental Materials Testing	**Bridge Foundation Investigation (BFI) Report** **Willeo Road Over Willeo Creek Bridge Replacement** **Cobb County and Fulton County Georgia**	**Prepared For:** Gresham Smith **MC² Project No.** A091603.099
	ROCK CORE PHOTOGRAPHS	**Date:** 3/12/20

DRY
Boring No. B-03 (Sta. 12+94, 4' R) Runs 3 and 4
Run 3: 41.1 ft. – 46.1 ft., REC = 90%, RQD = 72%
Run 4: 46.1 ft. – 48.1 ft., REC = 100%, RQD = 82%

MC² Geotechnical • Environmental Materials Testing	**Bridge Foundation Investigation (BFI) Report** **Willeo Road Over Willeo Creek Bridge Replacement** **Cobb County and Fulton County Georgia**	**Prepared For:** Gresham Smith
		MC² Project No. A091603.099
	ROCK CORE PHOTOGRAPHS	**Date:** 3/12/20

WET
Boring No. B-03 (Sta. 12+94, 4' R) Runs 3 and 4
Run 3: 41.1 ft. – 46.1 ft., REC = 90%, RQD = 72%
Run 4: 46.1 ft. – 48.1 ft., REC = 100%, RQD = 82%

MC² Geotechnical • Environmental Materials Testing	**Bridge Foundation Investigation (BFI) Report** **Willeo Road Over Willeo Creek Bridge Replacement** **Cobb County and Fulton County Georgia**	**Prepared For:** Gresham Smith
		MC² Project No. A091603.099
	ROCK CORE PHOTOGRAPHS	**Date:** 3/12/20

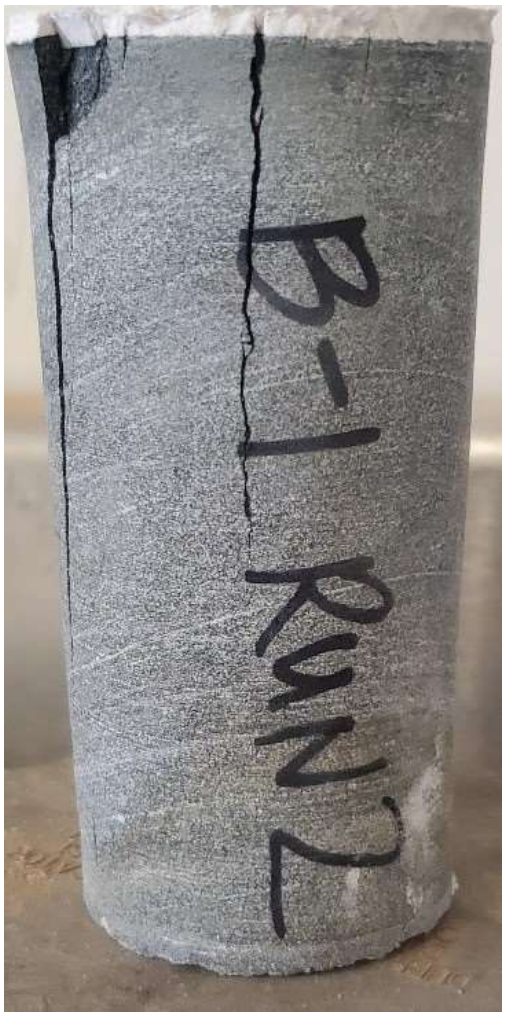
Unconfined Compressive Test Sample

Boring No. B-1, Run 2

40.0 ft. – 40.3 ft.

Unconfined Compressive Strength = 12,860 psi

Before Test



After Test

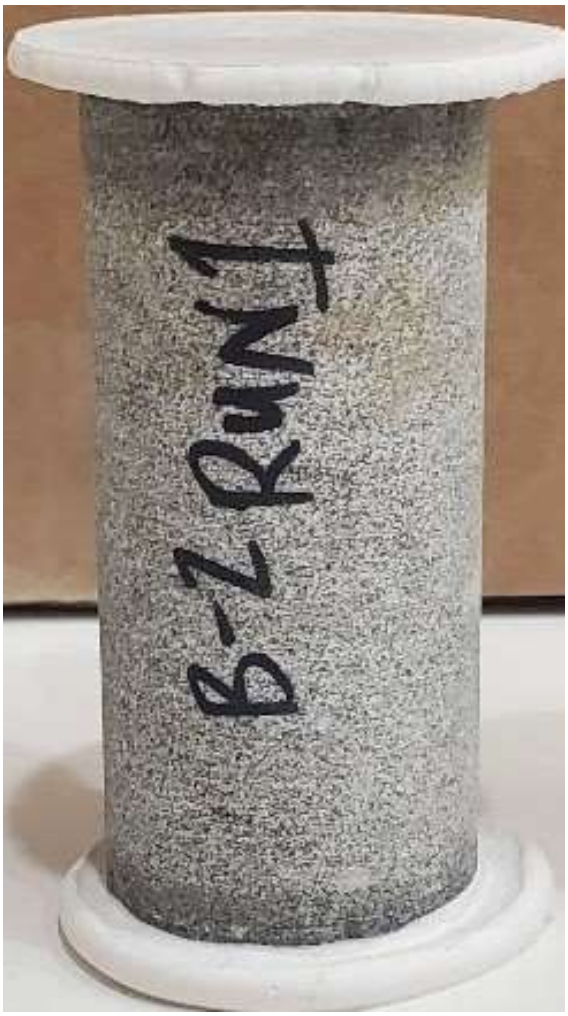
MC² Geotechnical • Environmental Materials Testing	**Bridge Foundation Investigation** **Willeo Road Over Willeo Creek Bridge Replacement** **Cobb County and Fulton County, Georgia**	**Prepared For:** Gresham Smith
		MC² Project No. A091603.099
	ROCK CORE TESTING PHOTOGRAPHS	**Date:** 3/26/20

Unconfined Compressive Test Sample

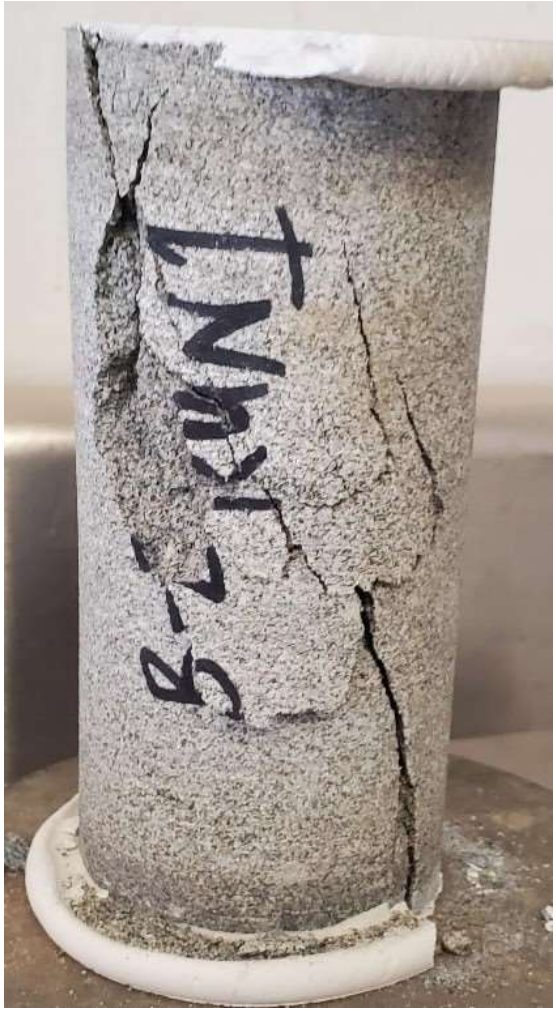
Boring No. B-2, Run 1

31.5 ft. – 31.8 ft.

Unconfined Compressive Strength = 6,210 psi



Before Test



After Test

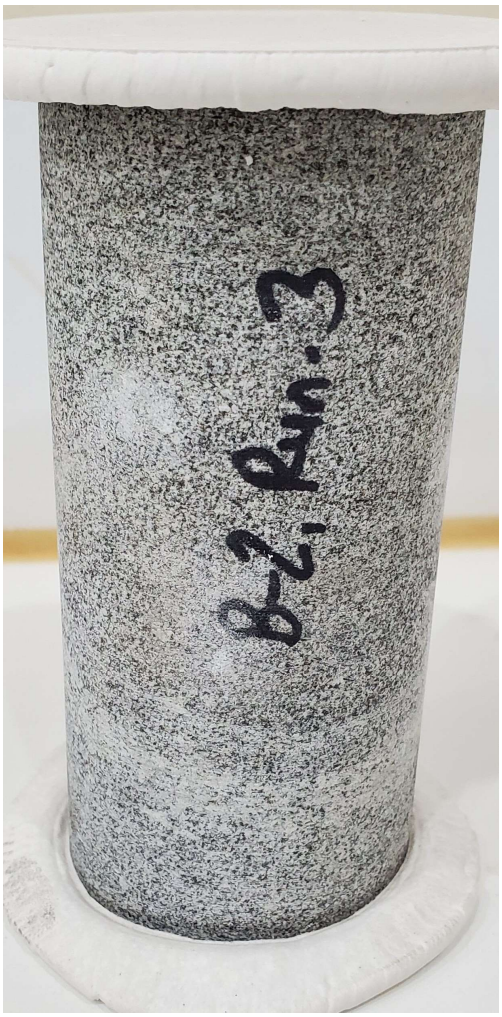
MC² Geotechnical • Environmental Materials Testing	**Bridge Foundation Investigation** **Willeo Road Over Willeo Creek Bridge Replacement** **Cobb County and Fulton County, Georgia**	**Prepared For:** Gresham Smith **MC² Project No.** A091603.099
	ROCK CORE TESTING PHOTOGRAPHS	**Date:** 3/26/20

Unconfined Compressive Test Sample

Boring No. B-2, Run 3

37.5 ft. – 37.8 ft.

Unconfined Compressive Strength = 13,690 psi



Before Test

After Test

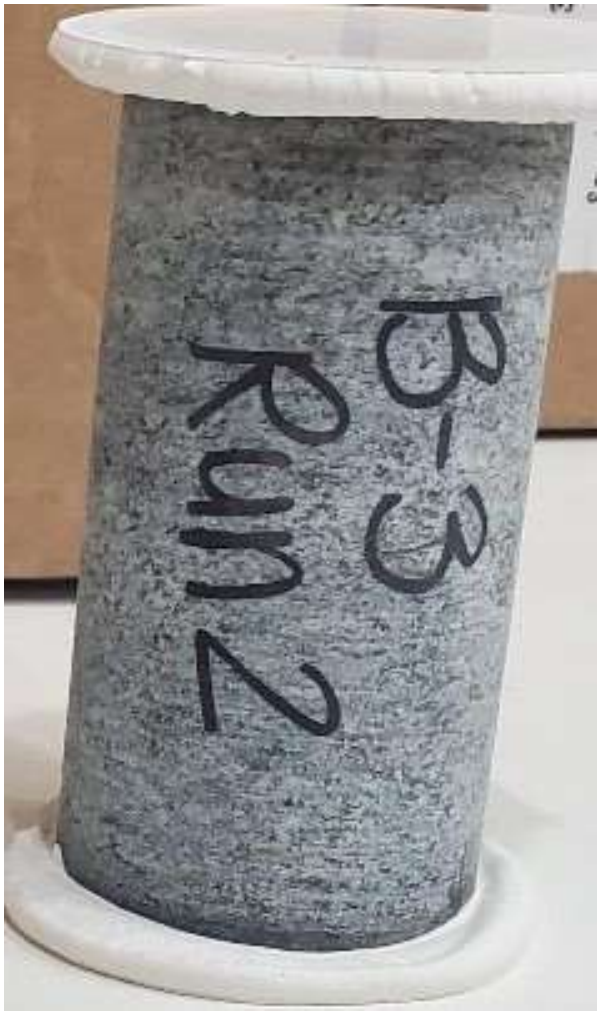
MC² Geotechnical • Environmental Materials Testing	**Bridge Foundation Investigation** **Willeo Road Over Willeo Creek Bridge Replacement** **Cobb County and Fulton County, Georgia**	**Prepared For:** Gresham Smith **MC² Project No.** A091603.099
	ROCK CORE TESTING PHOTOGRAPHS	**Date:** 3/26/20

Unconfined Compressive Test Sample

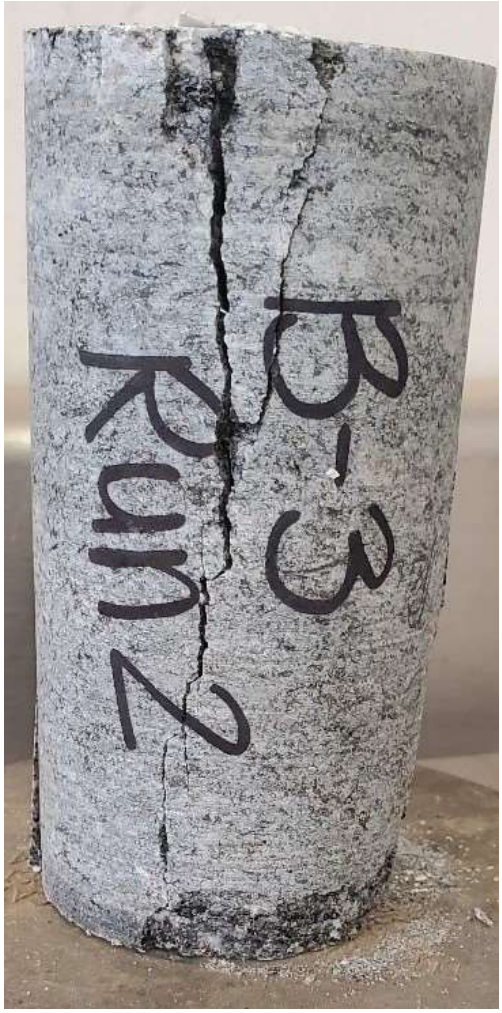
Boring No. B-3, Run 1

37.0 ft. – 37.3 ft.

Unconfined Compressive Strength = 17,140 psi



Before Test



After Test

MC² Geotechnical • Environmental Materials Testing	**Bridge Foundation Investigation** **Willeo Road Over Willeo Creek Bridge Replacement** **Cobb County and Fulton County, Georgia**	**Prepared For:** Gresham Smith **MC² Project No.** A091603.099
	ROCK CORE TESTING PHOTOGRAPHS	**Date:** 3/26/20

APPENDIX III

Important Information about This Geotechnical Engineering Report

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, clients can benefit from a lowered exposure to the subsurface problems that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed below, contact your GBA-member geotechnical engineer. Active involvement in the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Geotechnical-Engineering Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. *Those who rely on a geotechnical-engineering report prepared for a different client can be seriously misled*. No one except authorized client representatives should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one – not even you – should apply this report for any purpose or project except the one originally contemplated.*

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read it *in its entirety*. Do not rely on an executive summary. Do not read selected elements only. *Read this report in full.*

You Need to Inform Your Geotechnical Engineer about Change

Your geotechnical engineer considered unique, project-specific factors when designing the study behind this report and developing the confirmation-dependent recommendations the report conveys. A few typical factors include:

- the client's goals, objectives, budget, schedule, and risk-management preferences;
- the general nature of the structure involved, its size, configuration, and performance criteria;
- the structure's location and orientation on the site; and
- other planned or existing site improvements, such as retaining walls, access roads, parking lots, and underground utilities.

Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.*

This Report May Not Be Reliable

Do not rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, that it could be unwise to rely on a geotechnical-engineering report whose reliability may have been affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If your geotechnical engineer has not indicated an "apply-by" date on the report, ask what it should be*, and, in general, *if you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying it. A minor amount of additional testing or analysis – if any is required at all – could prevent major problems.

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface through various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing were performed*. The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgment to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team from project start to project finish, so the individual can provide informed guidance quickly, whenever needed.

This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, *they are not final*, because the geotechnical engineer who developed them relied heavily on judgment and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* revealed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation*.

This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a full-time member of the design team, to:

- confer with other design-team members,
- help develop specifications,
- review pertinent elements of other design professionals' plans and specifications, and
- be on hand quickly whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction observation.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for informational purposes only*. To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report, but they may rely on the factual data relative to the specific times, locations, and depths/elevations referenced. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely*. Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures*. If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. As a general rule, *do not rely on an environmental report prepared for a different client, site, or project, or that is more than six months old.*

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, none of the engineer's services were designed, conducted, or intended to prevent uncontrolled migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration.*** Confront the risk of moisture infiltration by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are not building-envelope or mold specialists.***

GEOPROFESSIONAL BUSINESS ASSOCIATION

Telephone: 301/565-2733
e-mail: info@geoprofessional.org www.geoprofessional.org

Copyright 2016 by Geoprofessional Business Association (GBA). Duplication, reproduction, or copying of this document, in whole or in part, by any means whatsoever, is strictly prohibited, except with GBA's specific written permission. Excerpting, quoting, or otherwise extracting wording from this document is permitted only with the express written permission of GBA, and only for purposes of scholarly research or book review. Only members of GBA may use this document or its wording as a complement to or as an element of a report of any kind. Any other firm, individual, or other entity that so uses this document without being a GBA member could be committing negligent

Bridge Hydraulic Analysis

Gresham Smith Project No. 42086.04

Cobb County Project No. X2122

Bridge Replacement – Willeo Road Over Willeo Creek

Cobb County & Fulton County, Georgia

Prepared by:

Gresham Smith

Genuine Ingenuity

1125 Sanctuary Parkway, Suite 350

Alpharetta, GA, 30009

EXAMINED AND APPROVED:

February 18, 2020
DATE

Allen Shariett, PE

GEORGIA REGISTERED No. PE36828 PROFESSIONAL ENGINEER C. ALLEN SHARIETT, IV 2/18/20

____ FEMA and Community Coordination Required
_X_ Community Coordination Only Required
____ No FEMA or Community Coordination Required

Executive Summary

The project, a joint effort between Cobb County and the City of Roswell, proposes to replace the existing functionally obsolete bridge at Willeo Road over Willeo Creek. The existing bridge over Willeo Creek is a 2-lane, four span structure with a total bridge length of 120 feet. The existing bridge is approximately 22 feet wide with substandard guardrail attachments that attach directly to the bridge deck. The bridge was constructed in 1960 and has a sufficiency rating of 62.8 out of 100. Given the age of the structure, low sufficiency rating, and narrow bridge width, the decision to replace the bridge is justified. The following study was performed to establish a hydraulic bridge recommendation for the replacement of the existing bridge.

Willeo Creek is designated by the Federal Emergency Management Agency (FEMA) as a Zone AE area on the Flood Insurance Rate Map (FIRM Panel 13067C0132J), effective March 04, 2013. Therefore, in accordance with the Georgia Department of Transportation (GDOT) Drainage Manual, community coordination is required regarding the FIRM.

The drainage area for this bridge is 19.70 square miles as determined from the USGS StreamStats online tool, as well as the FEMA Flood Insurance Study (FIS). The design speed for Willeo Road is 35 MPH, but there is no traffic data available to determine the design storm. However, the ADT was assumed to be over 1,500 VPD, the criteria for roads not designated as state routes, therefore the design storm will be the 50-year storm event.

The proposed bridge is 130 ft long comprised of three 43 ft-4 inch spans and is 31 ft wide, gutter to gutter. The proposed bridge superstructure is a 21-inch cored slab. The proposed bridge deck is to be built on a 2.0% normal crown and the typical section consists of 11 ft travel lanes, 4 ft bicycle lanes, 1.5 ft gutter, a 5.5 ft sidewalk on the west side and an 8.5 ft sidewalk on the east side. The lane width meets the criteria outlined in the GDOT Design Policy Manual (for an ADT less than 2,000, AASHTO criteria is utilized) and exceeds the 10 ft. minimum per guidance from Design Policy and Support for Low Impact Bridges. The shoulder width exceeds the criteria outlined in the GDOT Bridge and Structures Policy manual section 2.9.2 for off-system bridges for an ADT less than or equal to 2000 VPD.

A hydraulic analysis using HEC-RAS version 5.0.6 was performed in accordance with the GDOT Drainage Manual and in conjunction with the preparation of the preliminary layout for the Design-Bid-Build contract.

A comparison of the modeling results of the existing and proposed conditions demonstrates that the proposed bridge replacement will not significantly alter the upstream or downstream conditions for all modeled storm events as compared to existing conditions.

GDOT hydraulic design criteria for Simulation 1 is detailed in the Technical Memo, which is included as an appendix in this report.

- The existing and proposed conditions produce 3.09 ft. and 2.15 ft. of backwater, respectively, during the 100-year storm event at the approach section when compared to natural conditions. It was determined that the bridge would need to be lengthened more than 100 additional feet than what is currently proposed to achieve less than one foot of backwater. The proposed design should be satisfactory because it is decreasing the existing backwater.
- The proposed bridge replacement will provide 4.21 ft. of clearance above the design (50-year) storm event at the downstream bounding cross section, which exceeds GDOT guidelines for minimum clearance of 2 ft. Further, 3.90 ft. of clearance above the 100-year storm event will be provided, which exceeds GDOT guidelines for desired clearance of 1 ft.
- The project is designated as a FEMA Zone AE with a regulatory floodway, so an encroachment analysis is required, and community coordination should be documented.
- The results of the encroachment analysis suggest that floodway widths and elevations will not be increased as compared to existing conditions. A summary table is included at the end of Appendix A.
- Deck drainage will not be necessary, as shown in calculations provided in Appendix B.4.
- Combined contraction and pier scour for the proposed conditions at the storm events are:
    - 12.51 ft at bent 2 and 12.36 at bent 3 for 100-year.
    - 15.14 ft at bent 2 and 15.03 at bent 3 for 500-year.

Based on the results from the hydraulic analysis, the proposed bridge replacement will not result in any negative hydraulic impact. A no-rise certification is included in Appendix A.

Table of Contents

Executive Summary 2
List of Tables 4
List of Figures 5
List of Appendices 5
Introduction 6
1.1 Purpose of Study 6
1.2 Coordination and Site Reconnaissance 6
1.3 Study Area 6
1.4 FEMA Considerations 9
Engineering Methods 10
2.1 Hydrologic Analysis 10
2.1.1 Flow Data 10
2.1.2 Cross Sections 10
2.1.3 Land Use and Roughness Coefficients 11
2.1.4 Contraction and Expansion Coefficients 11
2.1.5 Reach Boundary Conditions 11
Hydraulic Recommendations 11
3.1 Preliminary Hydraulic Bridge Recommendations 11
3.2 Summary of Results 13
3.3 Design Calculations 14

List of Tables

Table 1 – Discharge and Stage Values (Ref. Table 2 of FIS Report) 10
Table 2 – Flow Distributions 10
Table 3 – Manning's Roughness Coefficients 11
Table 4 – Bridge Clearance Table 13
Table 5 – Summary Hydraulic Table 13
Table 6 – Scour Summary 14

List of Figures

Table of Contents....4
Figure 1 – Aerial Photo of Proposed Site (Ref. Google Earth)....7
Figure 2 – Contributing Drainage Area Map....8
Figure 3 – Flood Insurance Rate Map (FIRM)....9
Figure 4 – Roadway (looking south)....36
Figure 5 – Roadway (looking north)....36
Figure 6 – Floodstream Approach....37
Figure 7 – Floodstream Departure....37
Figure 8 – Upstream Face....38
Figure 9 – Downstream Face....38
Figure 10 – Upstream Overbank....39
Figure 11 – Downstream Overbank....39
Figure 12 – Utility Marker (Southwest corner of bridge)....40
Figure 13 – Utility Marker (Northwest corner of bridge)....40

List of Appendices

Appendix A – Site Data & Flood Insurance Study
Appendix B – Design Calculations
Appendix B.1 – Scour Calculations
Appendix B.2 – Riprap Calculations
Appendix B.3 – Guide Bank Calculations
Appendix B.4 – Gutter Spread Calculations
Appendix C – Plan and Profile Sheets
Appendix D – Risk Assessment Sheet
Appendix E – Photos
Appendix F – HEC-RAS Models
Appendix F.1 – Natural Conditions HEC-RAS Models
Appendix F.2 – Existing Conditions HEC-RAS Models
Appendix F.3 – Proposed Conditions HEC-RAS Models

Introduction

1.1 Purpose of Study

Cobb County and the City of Roswell have contracted with Gresham Smith to design the replacement structure of Willeo Road over Willeo Creek. This study provides the hydraulic recommendations and bridge plans for the bridge replacement. In addition to detailing the hydraulic study, this report assists in the documentation of relevant issues associated with the work assignment.

1.2 Coordination and Site Reconnaissance

A site reconnaissance was performed by Gresham Smith on October 24th, 2016 to inspect site conditions. At the site visit, flow conditions appeared to be normal based on observed vegetation established on the overbank areas. There was minimal scour at the abutments, and small deposits of debris were found on the banks, but not at the bent locations. The stream had moderate velocities, with a channel depth of 5-10 feet. The embankments were very shallow upstream and downstream of the bridge and had a steeper approximate slope of 2:1 up to the roadway and bridge. The floodplain was observed to have very little slope, and contained winding, slow sections of flow, with wooded and residential areas outside the floodway. The existing concrete bridge was placed on concrete end bents. The main channel of 65-100 feet was completely spanned by the bridge. Overhead utilities were found to run parallel to the bridge and roadway on the east side. Additional information regarding existing conditions can be found in Appendix A, E, F, and G. All descriptions and variables were either developed or confirmed by the site reconnaissance and field visit. Photos from the site reconnaissance are included in Appendix G.

1.3 Study Area

The existing bridge is located approximately 2.58 miles southwest of Roswell, GA. The crossing has a drainage area of 19.70-square miles with a terrain primarily consisting of small hills and a dense underbrush, including a significant residential area. The limits of study extend approximately 0.1-miles both downstream and upstream of the hydraulic crossing.

Willeo Road is classified as a local road and has a two-lane roadway width of approximately 22 ft, measured gutter to gutter. The existing structure is 120 ft long and consists of four 30 ft spans. Details of the existing structure were taken from the survey and were confirmed by a previous study and a site visit. The existing structure is composed of concrete precast panels on steel piles. The structure is aligned with the channel with no skew. According to the survey, the existing minimum roadway elevation at the structure is 862.84.

A neighboring bridge of Willeo Road is approximately 1.10 miles upstream at Roswell Road, and no crossings are in the immediate downstream. This structure does not appear to constrain the floodway of Willeo Creek. The Roswell Road Crossing consists of 3 spans (30, 40, 30) and is 100 ft long and 73 ft wide, measured gutter to gutter. Backwater from the Chattahoochee River is causing an abnormal flood stage event at the Willeo Road crossing over Willeo Creek. These flood elevations are mapped in the FIS and included in Appendix A.

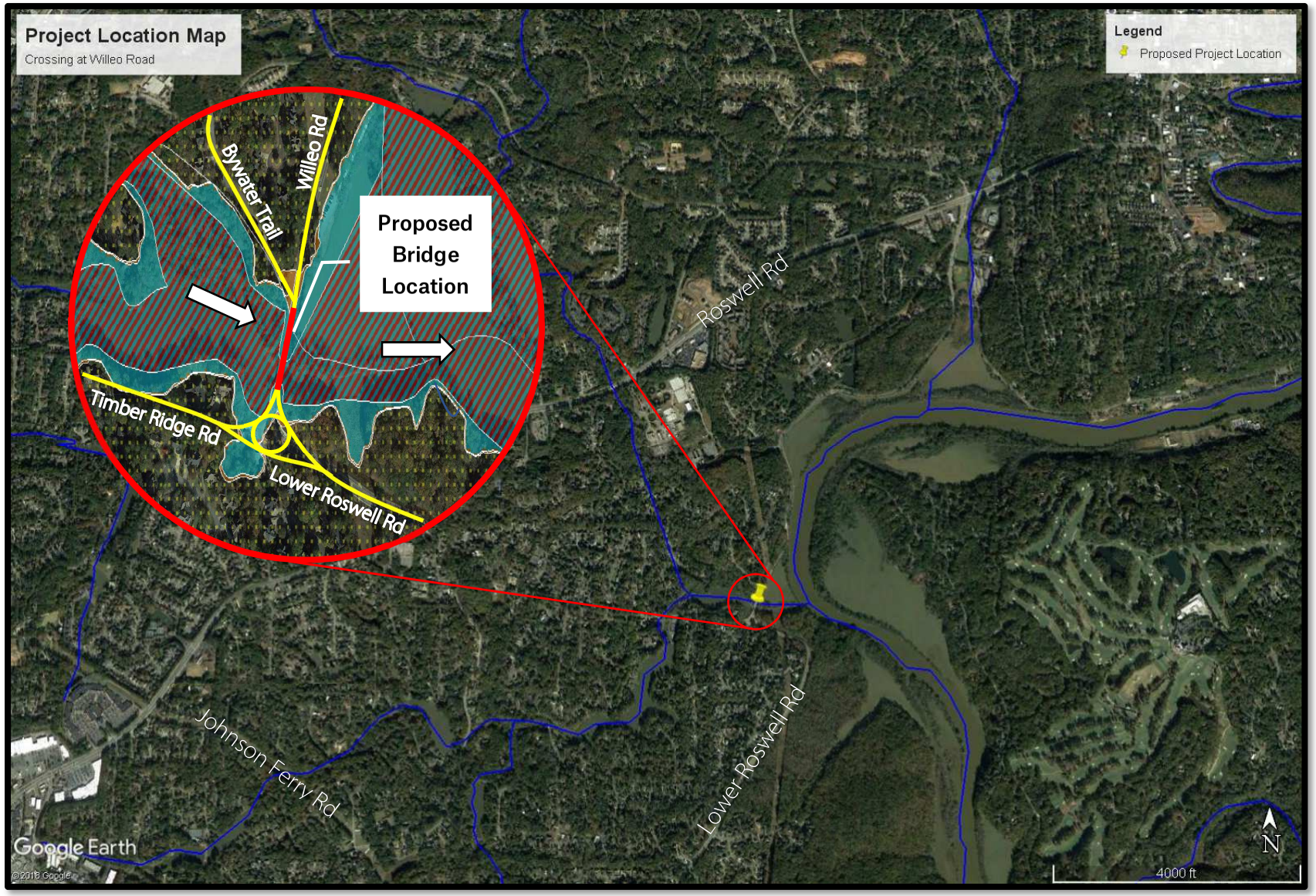


Figure 1 – Aerial Photo of Proposed Site (Ref. Google Earth)

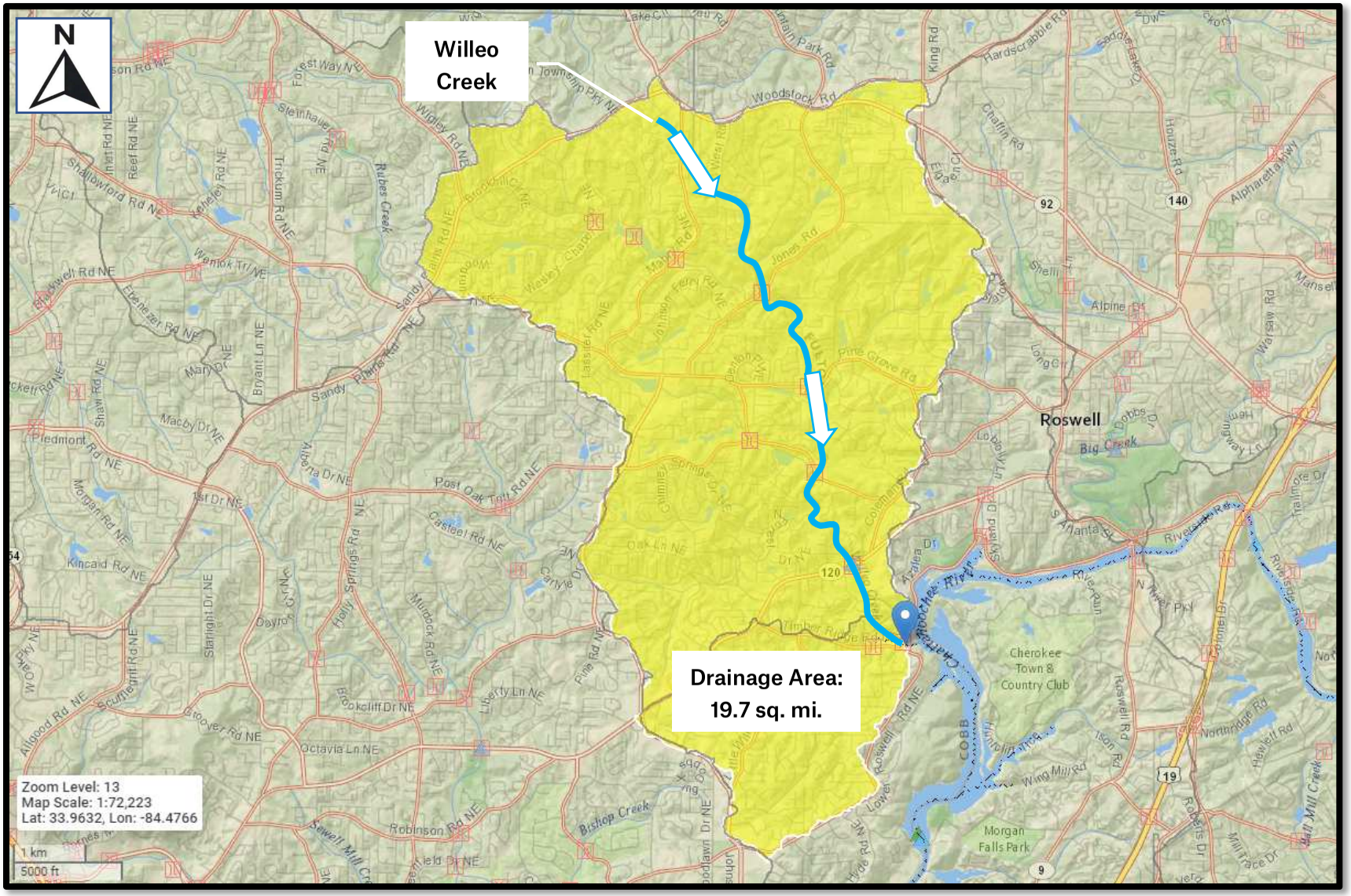


Figure 2 – Contributing Drainage Area Map

1.4 FEMA Considerations

The hydraulic crossing over Willeo Creek is located within a detailed studied stream with a regulatory floodway. The Flood Insurance Rate Map (FIRM), panel 13067C0132J, referenced in Figure 3 below illustrates that the area of interest is designated as a Zone AE, which in accordance with the GDOT Drainage Manual, a floodway encroachment analysis is required. The FIRM representation, revised in 2010, has established base elevations for the site.

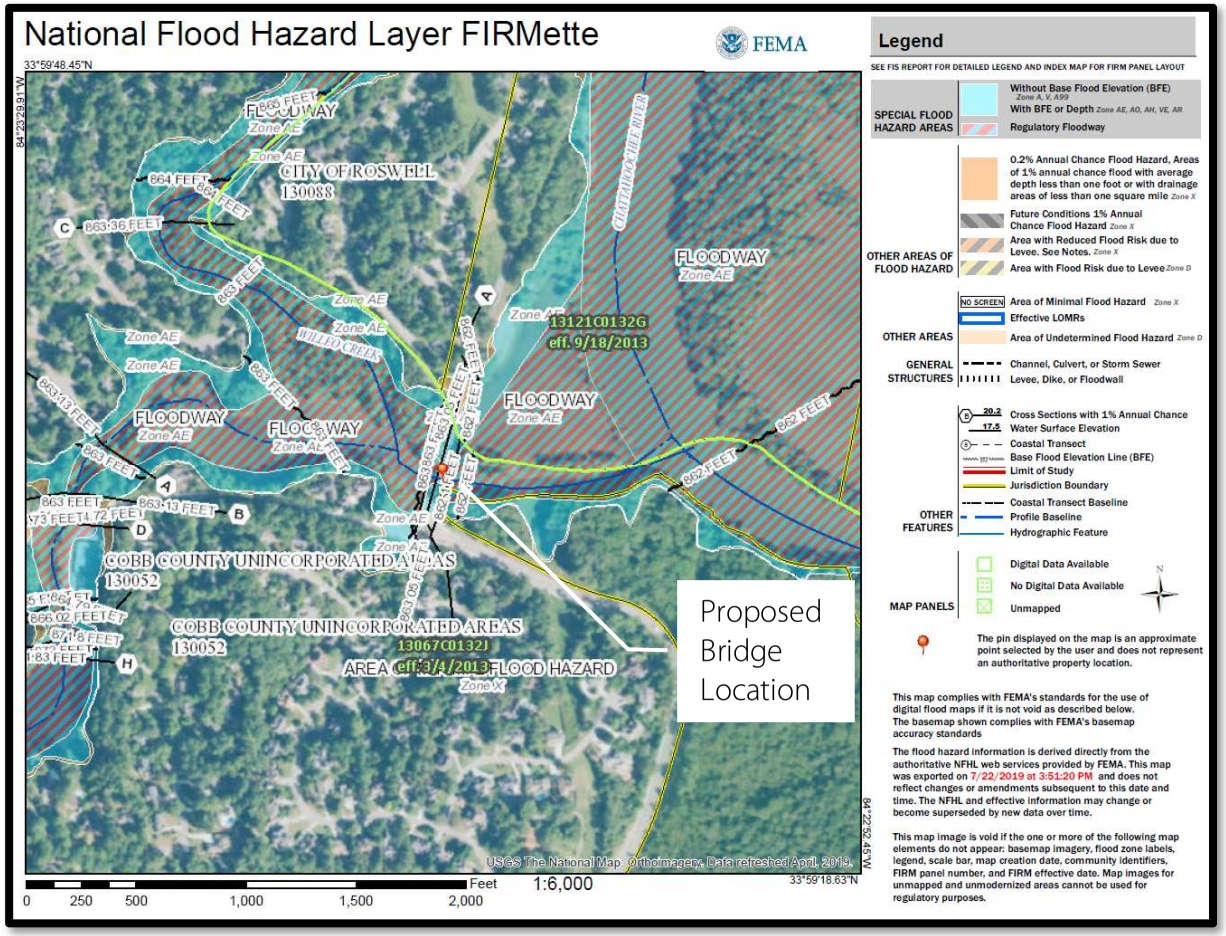


Figure 3 – Flood Insurance Rate Map (FIRM)

Engineering Methods

2.1 Hydrologic Analysis

A hydraulic analysis was performed to estimate water surface elevations and flow velocities within the study area for various scenarios.

To perform the hydraulic analysis, Gresham Smith used HEC-RAS v. 5.0.6. A HEC-RAS model was provided by Cobb County dated November 2010. Input data was evaluated as to its accuracy at Squirrel Town Creek, and a revised model was created for the proposed bridge replacement. The following sections describe the various input variables for the model.

2.1.1 Flow Data

The primary flooding source for the subject crossing is Willeo Creek. Discharge data from the FIS can be found in Table 1 below.

The discharge flow data for flood events corresponding to the 2-year, 10-year, 50-year, 100-year, and 500-year recurrence intervals. This data represents conditions at the downstream face of the existing structure.

Table 1 – Discharge and Stage Values (Ref. Table 2 of FIS Report)

Recurrence Interval	Discharge (cfs)
2-year	1,738.5
10-year	4,145
50-year	7,057
100-year	7,699
500-year	11,092

The flow distribution across the cross-section is provided in Table 2. This data represents proposed conditions at the upstream bounding cross-section (1034.509 8).

Table 2 – Flow Distributions

Recurrence Interval	Upstream Bounding Flow Distribution (cfs)		
	Left Overbank	Main Channel	Right Overbank
50-year	498.64	6414.30	144.05
100-year	578.70	6951.74	168.56

2.1.2 Cross Sections

The existing hydraulic model provided by Cobb County included nineteen cross sections, sixteen upstream of the proposed bridge and three downstream. These cross sections were determined to

be sufficient, as they spanned the width of the floodplain and elevations were consistent with data from both the survey and from USGS topo maps. The bridge is located at station 999.1037.

2.1.3 Land Use and Roughness Coefficients

The area surrounding the hydraulic crossing is primarily a forested region, containing several residential and open areas. The main channel and overbank regions appeared to remain consistent and showed a relatively clean, winding channel, with substantial growth along the banks prior to reaching the Chattahoochee River. Therefore, only two Manning's roughness coefficients were used, which can be seen in Table 3 below.

Table 3 – Manning's Roughness Coefficients

Description	n
Main Channel – Clean, straight, but contains stones	0.040
Dense weeds, high as flow depth	0.080

2.1.4 Contraction and Expansion Coefficients

Contraction and expansion coefficients were used to evaluate the amount of energy loss that is experienced by the contraction and expansion of flow through the hydraulic opening. Values of 0.3 and 0.5 were used between the approach (1220.68) and the downstream bounding cross sections, including the bridge. Standard values of 0.1 and 0.3 were used at all other cross sections. Ineffective flow areas were also incorporated into the model to accurately depict the flow patterns normally found in the approach and downstream sections of a stream flowing through a hydraulic opening. Ineffective flow areas contract upstream of the opening in a H:V 1:1 ratio and expand downstream of the opening with a H:V ratio of 1:2.

2.1.5 Reach Boundary Conditions

For the design of the Willeo Rd over Willeo Creek bridge, a normal depth slope was used for the reach boundary conditions. A slope of 0.0007786 which was used in the model provided by Cobb County was maintained for comparison and used for this report.
An abnormal flood stage condition is present due to the bridge's proximity to the Chattahoochee River. Backwater values were modeled to determine the effect on the proposed bridge. Water surface elevations appear to decrease from existing conditions.

Hydraulic Recommendations

3.1 Preliminary Hydraulic Bridge Recommendations

Willeo Road likely has an ADT over 1500, which gives the bridge a minimum design storm of 50-year according to section 12.1.1. of the GDOT Drainage Design Manual. The minimum design requirement for roads not designated as state routes, but consist of a design traffic frequency over 1500, require a freeboard elevation 2 ft. above the 50-year event. The design storm additionally has a desirable freeboard of 0.50 ft. above the 100-year event. Gresham Smith recommends placing a bridge over Willeo Creek with a three-span arrangement of 43 ft.-4 in. – 43 ft.-4 in. – 43 ft.-4 in. The

low chord elevation for the proposed bridge is 861.67. The low chord was determined by the following formula; where the PGL is 864.09, the beam depth is 21", and the asphalt overlay is 8".

$$\text{Low Chord} = \text{PGL} - \text{beam depth} - \text{overlay}$$
$$861.67\text{ft} = 864.09\text{ft} - 1.75\text{ft} - 0.667\text{ft}$$

The proposed bridge length and span arrangement was chosen to meet freeboard and backwater requirements, while improving existing conditions for water surface elevation, floodplain width and stream velocities. Backwater under proposed conditions is lower than existing conditions, and under the allowable limit. Water surface elevations at the downstream face and at the downstream bounding cross section show a slight decrease, freeboard requirements are met, and channel velocities are lowered, which results in a decreased risk of scour issues. A shorter bridge length would not maintain the hydraulic opening from existing conditions and would result in an increase in channel velocities. A culvert was not considered for the bridge replacement because of the large required hydraulic opening, and due to the nature of the design build contract, which called for a bridge replacement. Refer to the plan layout in Appendix C for the span arrangement and bridge details.

Table 4 – Bridge Clearance Table

Water Surface Elevation Downstream Bounding Freeboard = Low Chord (861.67) - WSEL		
Storm Event	Proposed WSEL	Freeboard
50-yr	857.39	4.28
100-yr	857.69	3.98
500-yr	859.11	2.56

3.2 Summary of Results

The following tables show hydraulic values for existing and proposed conditions at the bridge crossing. As shown below, the channel velocity through the bridge is lowered for the proposed conditions as compared to the existing conditions. The existing conditions model and the proposed model show a smooth profile as the flow travels through the reach of the study. Refer to Appendix F for the HEC-RAS reports, and relevant tables, profiles and cross sections.

Table 5 – Summary Hydraulic Table

		Storm Event			
	Conditions	2-yr	50-yr	100-yr	500-yr
Water Surface Elevation Bridge Downstream Face	Existing	854.28	858.05	858.37	860.03
	Proposed	854.21	857.55	857.76	859.82
Discharge (ft^3/s) Through Bridge Opening	Existing	1,738.5	7,057	7,699	11,092
	Proposed	1,738.5	7,057	7,699	11,092
Discharge (ft^3/s) Over Road	Existing	0	0	0	0
	Proposed	0	0	0	0
Area Under Opening (ft^2) Through Bridge Opening	Existing	255	549	581	762
	Proposed	269	559	580	803
Mean Velocity (ft/s) Through Bridge Opening	Existing	6.82	12.86	13.24	14.56
	Proposed	6.46	12.62	13.27	13.81
Channel Velocity (ft/s) Through Bridge Opening	Existing	6.86	13.36	13.76	15.17
	Proposed	6.54	13.72	14.48	15.63
	Natural	7.04	11.16	11.40	11.40
Backwater (ft) Approach Section	Existing	0.15	2.82	3.09	4.54
	Proposed	0.11	1.88	2.15	3.45
Water Surface Elevation Approach Section River Station 1220.68	Natural	855.41	858.93	859.18	860.33
	Existing	855.56	861.75	862.27	864.87
	Proposed	855.52	860.81	861.33	863.78

3.3 Design Calculations

The proposed bridge was designed to include protection based on scour, riprap, and guide bank calculations. Scour calculations were performed in HEC-RAS, utilizing the same model which was used for the remainder of the hydraulic report. A soil analysis was conducted by a geotechnical subcontractor which confirmed the D50 of 0.138 mm to be used for the scour calculations. Calculated scour values can be seen summarized in Table 6 below.

Table 6 – Scour Summary

	Contraction Scour (ft)			Pier Scour (ft)	
Storm Event	Left	Channel	Right	Bent 2	Bent 3
100-yr	1.90	6.77	3.38	5.74	5.59
500-yr	4.37	9.00	6.15	6.24	6.11

Guide bank calculations were performed to determine the necessary length of guide banks. Per Section 12.1.8 from the GDOT Drainage Design Manual, no Guide bank is required because the calculated length was less than 150ft.

Riprap calculations were performed to determine the recommended amount of riprap to be added for the bridge abutment protection. Guidelines provided in Section 12.1.7 from the GDOT Drainage Design Manual were followed in calculating the bridge abutment protection. It was determined that a riprap apron of 8 ft. with a depth of 2 ft. of Type 1 riprap should be used for abutment protection.

Gutter Spread was calculated to be less than the 6' - 6" available gutter, so no deck drainage is required. Additionally, per contract, use of deck drains are not permitted directly above areas designated as Waters of the US and associated vegetative buffers.

For detailed scour calculations, guide bank calculations, riprap calculations, and gutter spread calculations, see Appendix B.

FLOODWAY "NO-RISE / NO-IMPACT" CERTIFICATION

This document is to certify that I am duly qualified engineer licensed to practice in the State of

Georgia (State). It is to further certify that the attached technical data supports

the fact that proposed Willeo Road Bridge over Willeo Creek (Name of Development) will not impact the base flood

elevations, floodway elevations, and floodway widths on Willeo Creek (Name of Stream) at published

cross sections in the Flood Insurance Study for, Cobb County, GA (Name of community), dated March 4, 2013 (Date)

and will not impact the base flood elevations, floodway elevations, and floodway widths at the

unpublished cross-sections in the area of the proposed development.

GEORGIA REGISTERED No. PE36828 PROFESSIONAL ENGINEER C. ALLEN SHARIETT, IV 2/18/20

SEAL, SIGNATURE AND DATE

Allen Shariett, P.E., CFM, CPESC
Senior Drainage Engineer

D: 678.518.3953
M: 678.357.9726

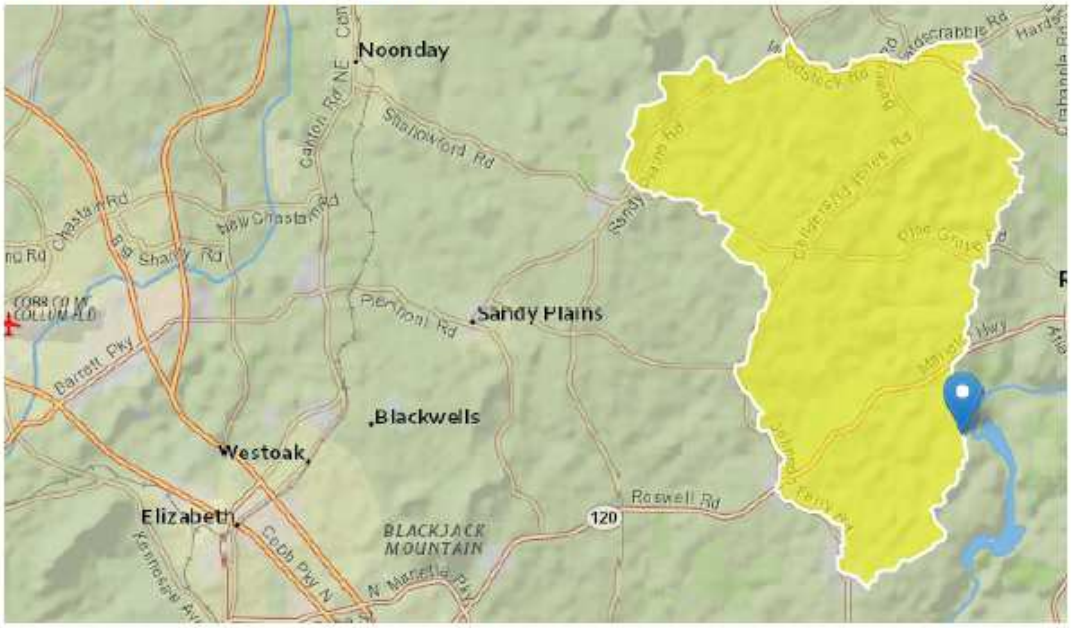
Gresham Smith
1125 Sanctuary Pkwy., Suite 350
Alpharetta, GA 30009

FOR COMMUNITY USE ONLY:		
Community Approval ☐ Approved ☐ Disapproved		
Community Official's Name	Community Official's Signature	Title

FEMA, MT
DTD.09/2004

StreamStats Report

Region ID: GA
Workspace ID: GA20190722195315448000
Clicked Point (Latitude, Longitude): 33.99253, -84.38622
Time: 2019-07-22 15:53:35 -0400



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	19.7	square miles
PRECPRIS00	Basin average mean annual precipitation for 1971 to 2000 from PRISM	53.8	inches
PCTREG1	Percentage of drainage area located in Region 1	100	percent
PCTREG2	Percentage of drainage area located in Region 2	0	percent
PCTREG3	Percentage of drainage area located in Region 3	0	percent
PCTREG4	Percentage of drainage area located in Region 4	0	percent

Parameter Code	Parameter Description	Value	Unit
PCTREG5	Percentage of drainage area located in Region 5	0	percent
LC06IMP	Percentage of impervious area determined from NLCD 2006 impervious dataset	14.44	percent

General Disclaimers

The delineation point is in an exclusion area. undefined

Annual Flow Statistics Parameters[N Georgia mean flow 2017 5001]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	19.7	square miles	1.67	576
PRECPRIS00	Mean Annual Precip PRISM 1971 2000	53.8	inches	47.6	81.6

Annual Flow Statistics Flow Report[N Georgia mean flow 2017 5001]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PIl	PIu
Mean Annual Flow	24.5	ft^3/s	19.5	30.9

Annual Flow Statistics Citations

Gotvald, A.J.,2017, Methods for estimating selected low-flow frequency statistics and mean annual flow for ungaged locations on streams in North Georgia: U.S. Geological Survey Scientific Investigations Report 2017–5001, 25 p. (https://doi.org/10.3133/sir20175001)

Peak-Flow Statistics Parameters[Peak Southeast US over 1 sqmi 2009 5043]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	19.7	square miles	1	9000
PCTREG1	Percent Area in Region 1	100	percent	0	100
PCTREG2	Percent Area in Region 2	0	percent	0	100
PCTREG3	Percent Area in Region 3	0	percent	0	100
PCTREG4	Percent Area in Region 4	0	percent	0	100
PCTREG5	Percent Area in Region 5	0	percent	0	100

Peak-Flow Statistics Flow Report[Peak Southeast US over 1 sqmi 2009 5043]

PIl: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PIl	Plu	SEp
2 Year Peak Flood	1100	ft^3/s	632	1900	34.5
5 Year Peak Flood	1910	ft^3/s	1110	3290	34
10 Year Peak Flood	2500	ft^3/s	1430	4380	35.1
25 Year Peak Flood	3270	ft^3/s	1800	5930	37.5
50 Year Peak Flood	3950	ft^3/s	2110	7390	39.6
100 Year Peak Flood	4560	ft^3/s	2360	8820	41.9
200 Year Peak Flood	5160	ft^3/s	2600	10200	44.3
500 Year Peak Flood	6090	ft^3/s	2900	12800	47.7

Peak-Flow Statistics Citations

Gotvald, A.J., Feaster, T.D., and Weaver, J.C.,2009, Magnitude and Frequency of Rural Floods in the Southeastern United States, 2006: Volume 1, Georgia: U.S. Geological Survey Scientific Investigations Report 2009-5043, 120 p. (http://pubs.usgs.gov/sir/2009/5043/)

Rural Peak-Flow Statistics Parameters[Region 1 Urban over 3 sqmi 2014 5030]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	19.7	square miles	3	436
LC06IMP	Percent Impervious NLCD2006	14.44	percent	0	47.9

Rural Peak-Flow Statistics Flow Report[Region 1 Urban over 3 sqmi 2014 5030]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PIl	PIu	SEp
Urban 2 Year Peak Flood	1530	ft^3/s	801	2930	34.4
Urban 5 Year Peak Flood	2440	ft^3/s	1340	4440	31.4
Urban 10 Year Peak Flood	3080	ft^3/s	1720	5510	30.7
Urban 25 Year Peak Flood	3910	ft^3/s	2140	7130	31.4
Urban 50 Year Peak Flood	4530	ft^3/s	2440	8410	32.4
Urban 100 Year Peak Flood	5140	ft^3/s	2680	9880	34.2
Urban 200 Year Peak Flood	5790	ft^3/s	2920	11500	35.8
Urban 500 Year Peak Flood	6650	ft^3/s	3210	13800	38.7

Rural Peak-Flow Statistics Citations

Feaster, T.D., Gotvald, A.J., and Weaver, J.C.,2014, Methods for estimating the magnitude and frequency of floods for urban and small, rural streams in Georgia, South Carolina, and North Carolina, 2011 (ver. 1.1, March 2014): U.S. Geological Survey Scientific Investigations Report 2014–5030, 104 p. (http://pubs.usgs.gov/sir/2014/5030/)

Urban Peak-Flow Statistics Parameters[Region 1 Urban under 3 sqmi 2014 5030]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	19.7	square miles	0.1	3
LC06IMP	Percent Impervious NLCD2006	14.44	percent	0	47.9

Urban Peak-Flow Statistics Flow Report[Region 1 Urban under 3 sqmi 2014 5030]

Statistic	Value	Unit

Urban Peak-Flow Statistics Citations

USGS Data Disclaimer: Unless otherwise stated, all data, metadata and related materials are considered to satisfy the quality standards relative to the purpose for which the data were collected. Although these data and associated metadata have been reviewed for accuracy and completeness and approved for release by the U.S. Geological Survey (USGS), no warranty expressed or implied is made regarding the display or utility of the data for other purposes, nor on all computer systems, nor shall the act of distribution constitute any such warranty.

USGS Software Disclaimer: This software has been approved for release by the U.S. Geological Survey (USGS). Although the software has been subjected to rigorous review, the USGS reserves the right to update the software as needed pursuant to further analysis and review. No warranty, expressed or implied, is made by the USGS or the U.S. Government as to the functionality of the software and related material nor shall the fact of release constitute any such warranty. Furthermore, the software is released on condition that neither the USGS nor the U.S. Government shall be held liable for any damages resulting from its authorized or unauthorized use.

USGS Product Names Disclaimer: Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Application Version: 4.3.8

FLOOD INSURANCE STUDY

VOLUME 1 OF 5

Cobb County

COBB COUNTY, GEORGIA

AND INCORPORATED AREAS

COMMUNITY NAME	COMMUNITY NUMBER
ACWORTH, CITY OF	130053
AUSTELL, CITY OF	130054
COBB COUNTY (UNINCORPORATED AREAS)	130052
KENNESAW, CITY OF	130055
MARIETTA, CITY OF	130226
POWDER SPRINGS, CITY OF	130056
SMYRNA, CITY OF	130057

REVISED:
October 5, 2018

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER
13067CV001E

TABLE 2 - SUMMARY OF DISCHARGES (continued)

Flooding Source and Location	Drainage Area (square miles)	Peak Discharges (cubic feet per second) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance Existing	1-Percent-Annual-Chance Future	0.2-Percent-Annual-Chance
VININGS BRANCH(Continued)						
At Kirkpatrick Drive Southwest	1.70	1,070	1,702	1,962	2,121	2,470
WARD CREEK						
At confluence with Noses Creek	8.10	2,130	3,360	3,739	4,122	5,059
At John Ward Road Southwest	7.20	2,066	3,242	3,620	3,993	4,873
At Cheatham Hill Road Southwest	5.80	2,149	3,408	3,894	4,260	5,123
At Kirkpatrick Drive Southwest	1.70	1,070	1,702	1,962	2,121	2,470
WESTSIDE BRANCH						
At confluence with Ward Creek	0.87	1,020	1,700	2,000	*	2,880
WILDHORSE CREEK						
At confluence with Noses Creek	4.30	1,755	2,881	3,134	*	4,209
At Macedonia Road Southwest	2.40	1,012	1,800	1,987	*	2,747
Approximately 1967 Feet upstream of old Villarica road	1.40	983	1,694	1,864	*	2561
At Lost Mountain Road	0.69	571	996	1,089	*	1,474
WILDWOOD BRANCH						
Approximately 1,670 feet upstream of North Marietta Parkway	0.67	1,239	1,839	2,102	2,281	2,764
At Amanda Lane	0.33	884	1,282	1,456	1,607	1,892
WILLEO CREEK						
At confluence with Chattahoochee River	19.70	4,145	7,057	7,699	*	11,092
Approximately 367 feet Upstream of Lower Roswell Road	19.62	4,159	7,071	7,707	*	11,123
At Roswell Road	16.14	4,024	6,856	7,482	*	10,931
Approximately 111 feet Downstream of Post Oak Tritt Drive	12.55	3,443	5,527	5,958	*	8,556
At Chiders Road	7.28	1,573	3,449	3,847	*	6,391

* Data not available

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Willeo Creek								
A	948[1]	182\182[2]	774	10.0	862.1	857.4[3]	857.4	0.0
B	1,035[1]	395\394[2]	3,349	2.3	863.1	863.1	863.1	0.0
C	2,563[1]	157\157[2]	1,086	6.0	863.4	863.4	863.4	0.0
D	7,154[1]	97\45[2]	758	9.9	868.3	868.3	869.0	0.7
E	7,308[1]	105\34[2]	1,049	7.1	873.0	873.0	873.1	0.1
F	9,759[1]	365\50[2]	3,570	2.1	876.1	876.1	876.4	0.3
G	12,753[1]	78\26[2]	917	6.5	877.6	877.6	878.3	0.7
H	13,334[1]	72\72[2]	583	10.3	889.1	889.1	889.8	0.7
I	14,910[1]	69\29[2]	494	10.5	898.3	898.3	898.7	0.4
J	15,041[1]	83\42[2]	835	6.2	903.0	903.0	903.1	0.1
K	17,263[1]	131\52[2]	672	7.7	904.1	904.1	904.8	0.7
L	17,373[1]	179\81[2]	1,322	3.9	906.6	906.6	906.9	0.3
M	19,148[1]	116\93[2]	834	4.9	908.9	908.9	909.9	1.0
N	20,745[1]	67\55[2]	629	6.4	912.4	912.4	912.9	0.5
O	20,868[1]	109\36[2]	886	4.5	913.2	913.2	913.6	0.4
P	23,986[1]	214\111[2]	1,281	3.1	920.8	920.8	921.1	0.3
Q	24,448[1]	112\58[2]	548	7.3	920.9	920.9	921.3	0.4
R	27,255[1]	43\43[2]	346	11.2	929.7	929.7	929.9	0.2
S	28,164[1]	66\0[2]*	664	5.8	938.8	938.8	939.6	0.8
R	28,526[1]	48\48[2]	486	7.9	939.4	939.4	940.1	0.7
U	29,256[1]	39\39[2]	269	6.8	941.6	941.6	942.2	0.6

[1]Feet above confluence with Chattahoochee River
[2]Total width/width within county
[3]Elevation computed without consideration of backwater effects from Chattahoochee River
*Floodway lies entirely outside of Cobb County

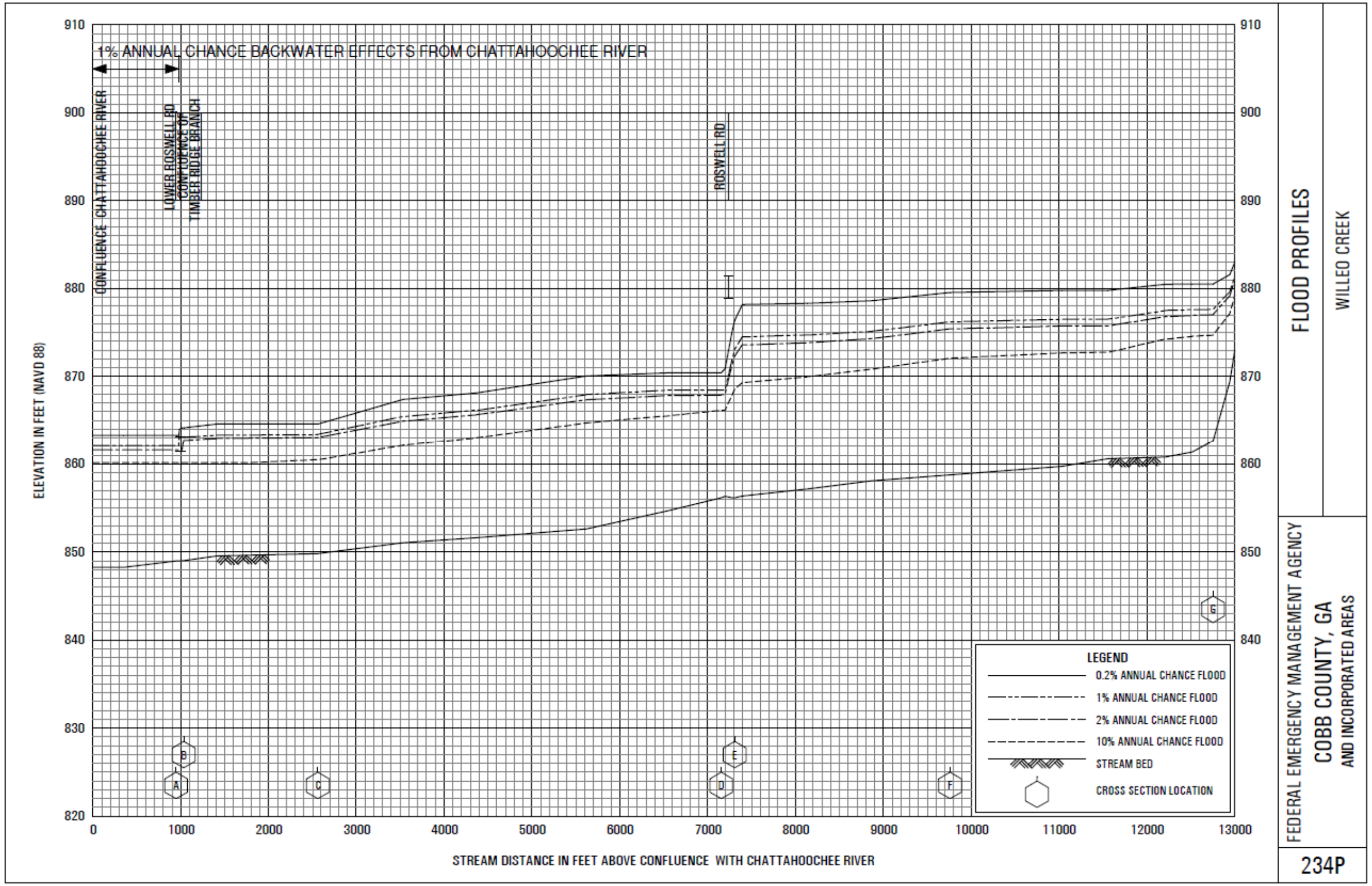
TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY

COBB COUNTY, GA AND INCORPORATED AREAS

FLOODWAY DATA

WILLEO CREEK


1% ANNUAL CHANCE BACKWATER EFFECTS FROM CHATTAHOOCHEE RIVER
CONFLUENCE CHATTAHOOCHEE RIVER
LOWER ROSWELL RD
CONFLUENCE OF TIMBER RIDGE BRANCH
ROSWELL RD
ELEVATION IN FEET (NAVD 88)
STREAM DISTANCE IN FEET ABOVE CONFLUENCE WITH CHATTAHOOCHEE RIVER
LEGEND
0.2% ANNUAL CHANCE FLOOD
1% ANNUAL CHANCE FLOOD
2% ANNUAL CHANCE FLOOD
10% ANNUAL CHANCE FLOOD
STREAM BED
CROSS SECTION LOCATION
FLOOD PROFILES
WILLEO CREEK
FEDERAL EMERGENCY MANAGEMENT AGENCY
COBB COUNTY, GA
AND INCORPORATED AREAS
234P

COBB CO PROJECT NO. X2122
WILLEO RD OVER WILLEO CREEK
FLOODWAY DATA FOR WILLEO CREEK, COBB CO, GEORGIA

PUBLISHED FIS VALUES					DUPLICATE EFFECTIVE MODEL (HEC-RAS)					CORRECTED EFFECTIVE MODEL (HEC-RAS)					EXISTING CONDITION MODEL (HEC-RAS) "A"					PROPOSED CONDITION MODEL (HEC-RAS) "B"					
SECTION	WIDTH (FT)	WITH FLDWAY	WITHOUT FLDWAY	INCREASE (FT)	SECTION	WIDTH (FT)	WITH FLDWAY	WITHOUT FLDWAY	INCREASE (FT)	SECTION	WIDTH (FT)	WITH FLDWAY	WITHOUT FLDWAY	INCREASE (FT)	SECTION	WIDTH (FT)	WITH FLDWAY	WITHOUT FLDWAY	INCREASE (FT)	SECTION	WIDTH (FT)	WITH FLDWAY	WITHOUT FLDWAY	INCREASE (FT)	DELTA F/W ELEV B-A (FT)
-	-	-	-	-	342.5338 1381	642.38	856.04	855.73	0.31	342.5338 1381	642.38	856.04	855.72	0.32	342.5338 1381	642.38	856.04	855.72	0.32	342.5338 1381	642.38	856.04	855.72	0.32	0.00
-	-	-	-	-	-	-	-	-	-	682.81	542.2	856.58	856.28	0.30	682.81	542.2	856.57	856.28	0.29	682.81	542.2	856.57	856.28	0.29	0.00
A	182	857.4	857.4	0.0	947.9219 869	182.24	857.44	857.44	0.00	947.9219 869	182.24	857.33	857.36	-0.03	947.9219 869	172.24	857.69	857.69	0.00	947.9219 869	172.24	857.69	857.69	0.00	0.00
B	395	863.1	863.1	0.0	1034.509 868	394.52	863.07	863.05	0.02	1034.509 868	394.52	861.36	861.36	0.00	1034.509 868	394.52	861.62	861.62	0.00	1034.509 868	394.52	859.8	859.8	0.00	-1.82
-	-	-	-	-	-	-	-	-	-	1220.68	258.06	862.05	862.05	0.00	1220.68	258.93	862.27	862.27	0.00	1220.68	255.12	861.33	861.33	0.00	-0.94
-	-	-	-	-	1410.406 538	567.61	863.31	863.29	0.02	1410.406 538	567.61	862.29	862.30	-0.01	1410.406 538	567.61	862.50	862.5	0.00	1410.406 538	567.61	861.61	861.62	-0.01	-0.89
C	157	863.4	863.4	0.0	2562.879 1382	156.78	863.42	863.36	0.06	2562.879 1382	156.78	862.75	862.70	0.05	2562.879 1382	156.78	862.88	862.82	0.06	2562.879 1382	156.78	862.44	862.39	0.05	-0.44
-	-	-	-	-	3532.729 1384	227.61	865.41	865.37	0.04	3532.729 1384	227.61	865.90	865.85	0.05	3532.729 1384	227.61	865.92	865.87	0.05	3532.729 1384	227.61	865.86	865.81	0.05	-0.06
-	-	-	-	-	4364.004 1385	166.32	866.24	866.10	0.14	4364.004 1385	166.32	866.85	866.67	0.18	4364.004 1385	166.32	866.87	866.69	0.18	4364.004 1385	166.32	866.82	866.64	0.18	-0.05
-	-	-	-	-	5618.333 3990	346.49	868.14	867.86	0.28	5618.333 3990	346.49	868.88	868.53	0.35	5618.333 3990	346.49	868.89	868.54	0.35	5618.333 3990	346.49	868.87	868.52	0.35	-0.02
-	-	-	-	-	6563.108 1881	420.34	868.86	868.36	0.50	6563.108 1881	420.34	869.44	868.90	0.54	6563.108 1881	420.34	869.44	868.91	0.53	6563.108 1881	420.34	869.43	868.89	0.54	-0.01
D	97	869.0	868.3	0.7	7153.706 865	97.40	868.97	868.29	0.68	7153.706 865	97.40	869.43	868.76	0.67	7153.706 865	97.40	869.44	868.76	0.68	7153.706 865	97.40	869.43	868.75	0.68	-0.01
E	105	873.1	873.0	0.1	7308.132 864	94.23	871.07	871.05	0.02	7308.132 864	94.23	871.07	871.05	0.02	7308.132 864	94.23	871.07	871.05	0.02	7308.132 864	94.23	871.07	871.05	0.02	0.00
-	-	-	-	-	7394.653 1327	347.40	872.94	872.98	-0.04	7394.653 1327	347.40	873.05	873.06	-0.01	7394.653 1327	347.40	873.05	873.06	-0.01	7394.653 1327	347.40	873.05	873.06	-0.01	0.00
-	-	-	-	-	8133.710 532	198.82	873.40	873.37	0.03	8133.710 532	198.82	873.31	873.29	0.02	8133.710 532	198.82	873.31	873.29	0.02	8133.710 532	198.82	873.31	873.29	0.02	0.00
-	-	-	-	-	8872.189 1882	152.14	874.16	874.05	0.11	8872.189 1882	152.14	873.79	873.72	0.07	8872.189 1882	152.14	873.79	873.72	0.07	8872.189 1882	152.14	873.79	873.72	0.07	0.00
F	365	876.4	876.1	0.3	9759.109 1907	365.31	875.72	875.45	0.27	9759.109 1907	365.31	874.89	874.70	0.19	9759.109 1907	365.31	874.89	874.70	0.19	9759.109 1907	365.31	874.89	874.70	0.19	0.00

Appendix B – Design Calculations

Appendix B.1 – Scour Calculations

100-yr

Contraction Scour

		Left	Channel	Right
Input Data				
	Average Depth (ft):	5.67	9.04	0.75
	Approach Velocity (ft/s):	1.72	4.77	0.46
	Br Average Depth (ft):	3.10	9.04	3.65
	BR Opening Flow (cfs):	278.29	7235.49	185.22
	BR Top WD (ft):	27.93	75.10	14.58
	Grain Size D50 (mm):	0.37	0.37	0.37
	Approach Flow (cfs):	654.99	7043.56	8.45
	Approach Top WD (ft):	67.33	163.29	24.50
	K1 Coefficient:	0.690	0.690	0.640
Results				
	Scour Depth Ys (ft):	1.90	6.77	3.38
	Critical Velocity (ft/s):	1.60	1.72	1.14
	Equation:	Live	Live	Clear

Pier Scour

Pier: #1 (CL = 423.14)

Input Data		
	Pier Shape:	Square nose
	Pier Width (ft):	1.67
	Grain Size D50 (mm):	0.37000
	Depth Upstream (ft):	8.18
	Velocity Upstream (ft/s):	9.48
	K1 Nose Shape:	1.10
	Pier Angle:	0.00
	Pier Length (ft):	51.00
	K2 Angle Coef:	1.00
	K3 Bed Cond Coef:	1.10
	Grain Size D90 (mm):	0.46000
	K4 Armouring Coef:	1.00
Results		
	Scour Depth Ys (ft):	5.59
	Froude #:	0.58
	Equation:	CSU equation

Pier: #2 (CL = 466.45)

Input Data		
	Pier Shape:	Square nose
	Pier Width (ft):	1.67
	Grain Size D50 (mm):	0.37000
	Depth Upstream (ft):	9.91
	Velocity Upstream (ft/s):	9.48
	K1 Nose Shape:	1.10
	Pier Angle:	0.00
	Pier Length (ft):	51.00
	K2 Angle Coef:	1.00
	K3 Bed Cond Coef:	1.10
	Grain Size D90 (mm):	0.46000
	K4 Armouring Coef:	1.00
Results		
	Scour Depth Ys (ft):	5.74
	Froude #:	0.53
	Equation:	CSU equation

500-yr

Contraction Scour

		Left	Channel	Right
Input Data				
	Average Depth (ft):	7.80	11.50	2.78
	Approach Velocity (ft/s):	2.00	5.29	1.03
	Br Average Depth (ft):	5.10	11.37	4.91
	BR Opening Flow (cfs):	653.07	10058.06	380.86
	BR Top WD (ft):	27.89	72.43	17.67
	Grain Size D50 (mm):	0.37	0.37	0.37
	Approach Flow (cfs):	1099.44	9934.45	89.11
	Approach Top WD (ft):	70.60	163.29	31.18
	K1 Coefficient:	0.690	0.690	0.640
Results				
	Scour Depth Ys (ft):	4.37	9.00	6.15
	Critical Velocity (ft/s):	1.68	1.80	1.42
	Equation:	Live	Live	Clear

Pier Scour

Pier: #1 (CL = 423.14)

Input Data		
	Pier Shape:	Square nose
	Pier Width (ft):	1.67
	Grain Size D50 (mm):	0.37000
	Depth Upstream (ft):	10.29
	Velocity Upstream (ft/s):	10.82
	K1 Nose Shape:	1.10
	Pier Angle:	0.00
	Pier Length (ft):	51.00
	K2 Angle Coef:	1.00
	K3 Bed Cond Coef:	1.10
	Grain Size D90 (mm):	0.46860
	K4 Armouring Coef:	1.00
Results		
	Scour Depth Ys (ft):	6.11
	Froude #:	0.59
	Equation:	CSU equation

Pier: #2 (CL = 466.45)

Input Data		
	Pier Shape:	Square nose
	Pier Width (ft):	1.67
	Grain Size D50 (mm):	0.37000
	Depth Upstream (ft):	12.02
	Velocity Upstream (ft/s):	10.82
	K1 Nose Shape:	1.10
	Pier Angle:	0.00
	Pier Length (ft):	51.00
	K2 Angle Coef:	1.00
	K3 Bed Cond Coef:	1.10
	Grain Size D90 (mm):	0.46890
	K4 Armouring Coef:	1.00
Results		
	Scour Depth Ys (ft):	6.24
	Froude #:	0.55
	Equation:	CSU equation

Appendix B.2 – Riprap Calculations

References:
HEC 23: DESIGN GUIDELINE 14 ROCK RIPRAP AT BRIDGE ABUTMENTS

Design flood event	50-yr	
Design high water (ft)	859.35	At u.s. bounding cross-section 1034.509 868
Design discharge (cfs)	7056.99	
Left abutment setback (ft)	20.4	near edge of main channel to toe of abutment
Right abutment setback (ft)	1	
Abutment type	Spill-through	
Abutment spill-through slope	2:1	
Specific gravity of rip-rap	2.65	

Output parameters from HEC-RAS:

Location: RS 999.1037 U	Depth (ft)	Discharge (cfs)	Velocity (fps)	Flow Area (sq ft)
Left overbank	2.88	228.11	3.05	74.89
Main channel	8.62	6672.65	10.30	647.56
Right overbank	3.44	156.24	3.31	47.20

Step 1: Compute set back ratio (SBR)
SBR=set back length/average depth
if SBR<5 then V=Q(total)/A
if SBR>5 then V=Q(overbank)/A

SBR left= 4.10
SBR right = 0.20

Step 2: Determine average velocity

V_{left}= 9.17
V_{right}= 9.17

Step 3: Check SBR velocity against channel velocity
Since $V_{channel} > V_{SBR}$, use V_{SBR}

$V_{channel}$= 10.30

Step 4: Determine Froude number
$F_r=V/(gy)^{0.5}$

F_r left = 0.9521
F_r right = 0.8712

$V/(32.2*y)^{0.5}$

Step 5: Determine the D_{50} of the riprap required on the abutment (in feet)
if $F_r < 0.8$ use eq. 14.1
$D_{50}/y=K/(S-1)(V^2/gy)$
K=0.61 for spill-through
K=0.69 for vertical wall
if $F_r > 0.8$ use eq. 14.2
$D_{50}/y=K/(S-1)((V^2/gy))^{.014}$
K=0.61 for spill-through
K=0.69 for vertical wall

$D_{50(left)}$= 0.9653
$D_{50(right)}$= 0.9653

Lagasse et al. (2001)

Step 6: Determine riprap extent and layout (in feet)
Riprap extent from toe = 2 x flow depth or 25 ft whichever is shorter length

$Apron_{left}$ = 5.76
$Apron_{right}$ = 6.88

Use X = 8 ft *Riprap apron should use 2x depth of flow, or 8 ft minimum

Riprap extends to design high water + 2-ft freeboard
Top of riprap E = 861.35

Mattress thickness in feet
$T = 1.5D_{50}$ or D_{100}
T = 1.4479 (But > D_{100})

Y= 25 ft *Downstream face should be protected a distance 2X flow or 25ft, whichever is greater

After a preliminary review, it was determined that the minimum apron width could not be met because it would encroach on the stream bank. An apron with the largest width practicable will be placed at the abutments as a scour countermeasure.

Appendix B.3 – Guide Bank Calculations

References:
HEC 23: DESIGN GUIDELINE 15 GUIDE BANKS

Parameters from HEC-RAS output RS 1034.509 868 upstream bounding

Design Q	Q_{50} =	7071	cfs
Qleft	Q_L =	498.64	cfs
Qright	Q_R =	144.05	cfs
Depth left	Y_L =	4.68	ft
Depth right	Y_R =	4.43	ft
Velocity left	V_L =	3.09	ft/sec
Velocity right	V_R =	2.98	ft/sec
Abutment setback$_{left}$ (Bank-Abutment)	AS_L=	20.4	ft
Abutment setback$_{right}$ (Abutment-Bank)	AS_R=	1	ft
Flow area at bridge opening	A_{n2} =	558.99	from HEC-RAS Bridge output

Parameters from HEC-RAS output RS 1220.68 approach

Design Q	Q_{50} =	7070.99	cfs
Qleft	Q_L=	573.55	cfs
Qright	Q_R =	1.46	cfs
Depth left	Y_L =	5.21	ft
Depth right	Y_R =	0.27	ft
Velocity left	V_L =	1.65	ft/sec
Velocity right	V_R =	0.24	ft/sec
Abutment setback left	AS_L=	20.4	ft
Abutment setback right	AS_R=	1	ft

Determine Qf
(floodplain discharge intercepted by each approach embankment)

Q_F (left)	$Q_F=Q_L-(AS_L*Y_L*V_L)$ =	398	cfs
Q_F (right)	$Q_F=Q_R-(AS_R*Y_R*V_R)$ =	1	cfs

Determine Q_A
(overbank flow in the first 100 ft (30 m) of opening adjacent to the abutments)

Q_A left	$Q_A=(100*Y_L*V_L)$ =	1446	cfs
Q_A right	$Q_A=(100*Y_R*V_R)$ =	1320	cfs

Determine Q_F/Q_A

Q_F/Q_A left	Q_F/Q_A =	0.28
Q_F/Q_A right	Q_F/Q_A =	0.00

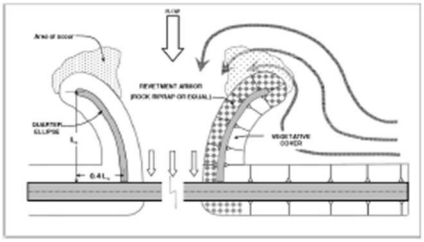
Determine the average channel velocity V_{n2} through the bridge opening by dividing the total discharge of the stream, Q, by the cross-sectional flow area at the bridge opening, A_{n2}

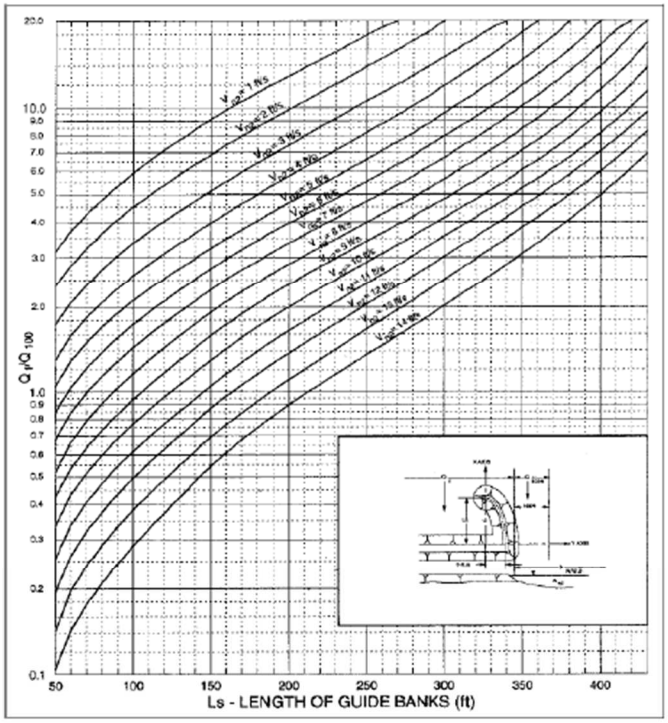
A_{n2} from HEC bridge output	A_{n2} =	558.99	sq ft
V_{n2}	V_{n2} = Q/A_{n2} =	12.65	ft/sec

Enter the nomograph with Q_F/Q_A and V_{n2} to determine guide bank length

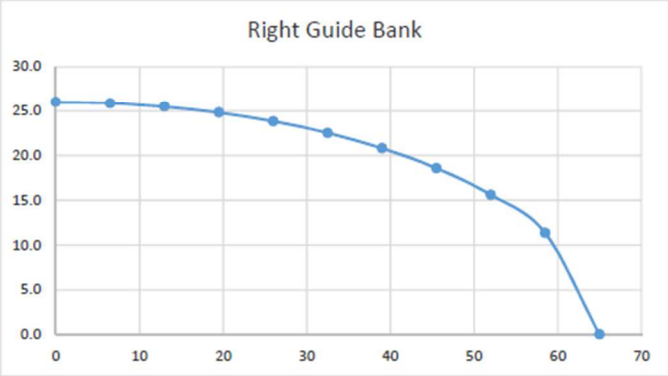
Length of guide bank left	L_L =	65	ft
Length of guide bank right	L_R =	N/A	ft

65-ft bank required on left. No guide bank required on right.





Coordinates for Guide Bank	
X (ft)	Y (ft)
0	26.0
6.5	25.9
13	25.5
19.5	24.8
26	23.8
32.5	22.5
39	20.8
45.5	18.6
52	15.6
58.5	11.3
65	0.0



Appendix B.4 – Gutter Spread Calculations

Willeo Rd over Willeo Creek

GDOT DECK DRAINAGE

Project No. X2122
Cobb County

Geometric Variables

FLAT GRADE | CONSTANT GRADE | **VERTICAL CURVE**

g1	=	1.0263	%	Grade 1, vertical grade before PVI
g2	=	-0.7951	%	Grade 2, vertical grade after PVI
LVC	=	70.00	ft	Length of vertical curve
PVI	=	12+13.38	-	Station at PVI
Beg	=	11+60.89	-	Station at beginning of bridge
L	=	130.00	ft	Length of bridge

Preliminary Data Analysis

Freq	=	10	year	Storm frequency -- 10 year per GDOT design manual
Speed	=	35	mph	Vehicle design speed
ID	=	121-5158-0	-	Existing Bridge Serial Number

Street Hydraulics

W_p	=	25.000	ft	Width being drained -- typically half of pavement
T	=	6.5000	ft	Design spread
S_x	=	2.0	%	Cross-slope of deck
n	=	0.016	-	Manning's coefficient -- typically, n = 0.016
C	=	0.90	-	Runoff -- typically, C = 0.9 for pavements

Inlet Specifications

CURB INLET | NEENAH | HEC-22 | **GDOT**

6 in. Scupper — Grate Details

L	=	0.50	ft	Inlet opening length
W	=	0.50	ft	Inlet opening width
H	=	n/a	ft	Inlet opening height
a	=	n/a	ft	Local Inlet depression

Capacity determined by information found in GDOT drainage manual, capacity in-sump determined by weir/orifice hydraulics.

Design Notes

- Design spread calculated from GDOT Drainage Manual section 12.2.2

Spread method from HEC-21 selected with 8 ft minimum spacing

NOAA Atlast 14 selected for rainfall information

CDOT coefficients selected for curb inlets

Willeo Rd over Willeo Creek

GDOT DECK DRAINAGE

Project No. X2122
Cobb County

Establishment of Rainfall Intensity

Closest station

Roswell

Station Information

Roswell, GA
ALPHARETTA 4 SSW
34.0661° LAT
-84.3233° LON
1138 ft

Station Location

IDF Calculations

t_o	=	0.79	min
t_g	=	2.27	min
t_c	=	3.06	min
t_t	=	5.00	min
i	=	7.99	in/hr
L_o	=	186	ft

Inlet requirement

NO INLETS NEEDED

Rainfall intensity is calculated using intensity-duration-frequency (IDF) curves and methods consistent with GDOT drainage manual. Point precipitation frequency estimates are taken from NOAA Atlas 14 Volume 9 for partial duration time series.

Inlet Spacing on Flat Bridge

P_{INLET}	=	1.57	ft	Inlet perimeter
P_{REQ}	=	3.43	ft	Required inlet perimeter
L_c	=	120	ft	Inlet spacing assuming 100% efficiency
Spacing	=	54	ft	Required inlet spacing

Inlet Spacing for Bridge on Grade

	Spacing (ft)	Gutter Flow (cfs)	Efficiency (%)	Bypass (cfs)	Spread (ft)
L_0					
L_1					
L_2					
L_3					
L_4					
L_n					

Flat bridge spacing should be considered for bridges with grades less than 0.03%.

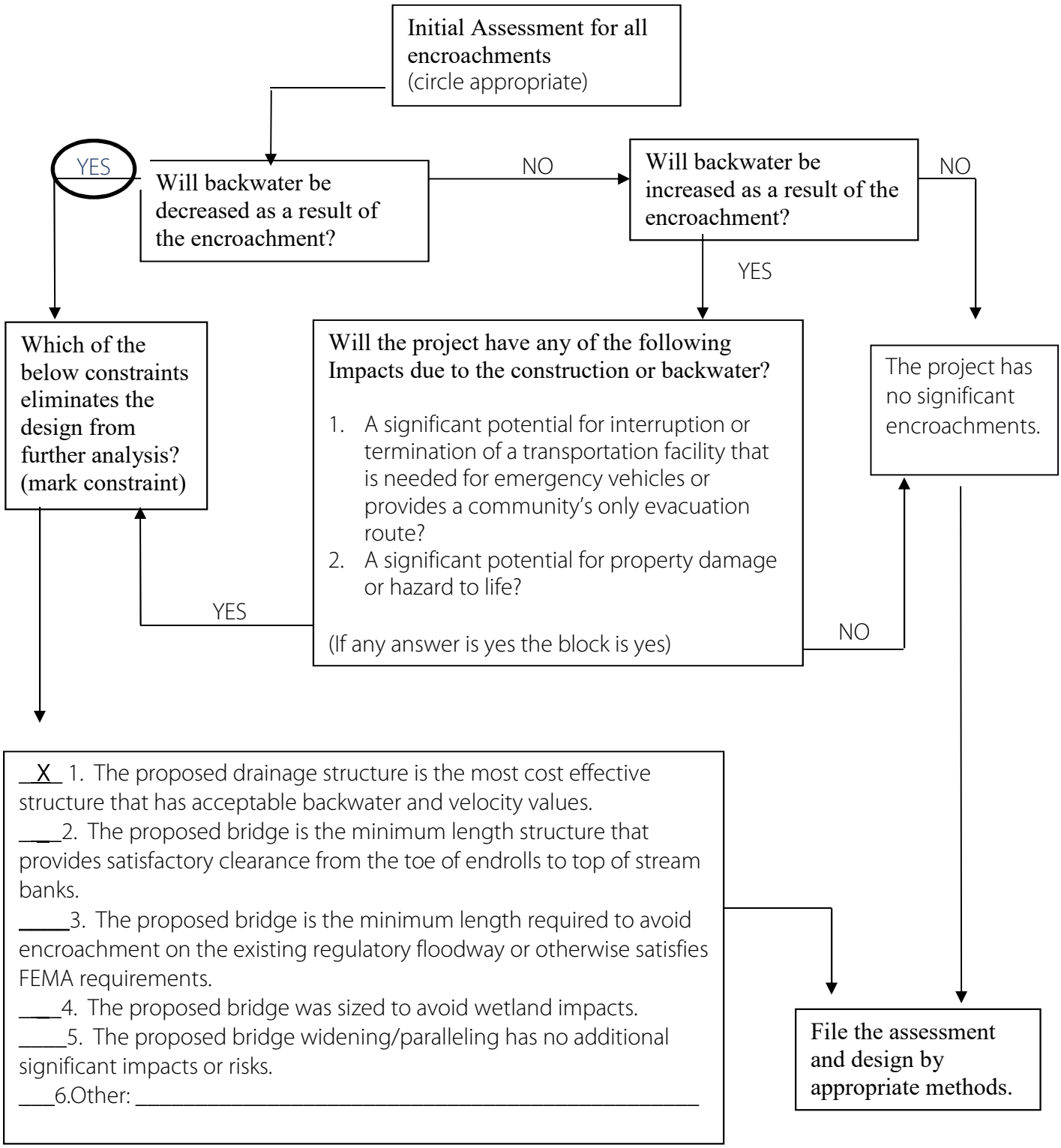
Hydroplaining and Visibility

Hydroplane Depth	=	0.113 in	Depth at which hydroplaning can occur
Hydroplain	=	At Risk	Risk of hydroplaning at rain intensity
Visibility	=	OK	Risk of impaired vision due to rain

Hydroplaning and visibility design procedures taken from methods in HEC-22. Methods shown are for constant-slope and flat bridges.

Appendix C – Plan and Profile Sheets

Appendix D – Risk Assessment Sheet



Appendix E – Photos

Figure 4 – Roadway (looking south)

Figure 5 – Roadway (looking north)

Figure 6 – Floodstream Approach

Figure 7 – Floodstream Departure

Figure 8 – Upstream Face

Figure 9 – Downstream Face

Figure 10 – Upstream Overbank

Figure 11 – Downstream Overbank

Figure 12 – Utility Marker (Southwest corner of bridge)

Figure 13 – Utility Marker (Northwest corner of bridge)

Appendix F – HEC-RAS Models

Appendix F.1 – Natural Conditions HEC-RAS Models

```
                    HEC-RAS HEC-RAS 5.0.7 March 2019
                      U.S. Army Corps of Engineers
                     Hydrologic Engineering Center
                           609 Second Street
                           Davis, California


          X     X  XXXXXX    XXXX        XXXX       XX      XXXX
          X     X  X        X    X       X   X     X  X    X
          X     X  X        X            X   X    X    X   X
          XXXXXXX  XXXX     X       XXX  XXXX     XXXXXX    XXXX
          X     X  X        X            X  X     X    X        X
          X     X  X        X    X       X   X    X    X        X
          X     X  XXXXXX    XXXX        X    X   X    X   XXXXX



PROJECT DATA
Project Title: WilleoCr
Project File : WilleoCr.prj
Run Date and Time: 8/30/2019 1:05:37 PM

Project in English units

Project Description:
Cobb County, Georgia, Willeo Creek Detailed Hydraulics Study, November, 2010,
submitted by Dewberry.



PLAN DATA

Plan Title: Unconstricted_Design
Plan File : g:\19180\Hydrology\Bridge Hydraulics\HEC-
RAS_Models\WilleoCreek\WilleoCr_HECRAS\WilleoCr.p15
```

```
           Geometry Title: Unconstricted
           Geometry File : g:\19180\Hydrology\Bridge Hydraulics\HEC-
RAS_Models\WilleoCreek\WilleoCr_HECRAS\WilleoCr.g06

           Flow Title    : Design
           Flow File     : g:\19180\Hydrology\Bridge Hydraulics\HEC-
RAS_Models\WilleoCreek\WilleoCr_HECRAS\WilleoCr.f06

Plan Summary Information:
Number of:  Cross Sections =   19    Multiple Openings  =    0
            Culverts       =    0    Inline Structures  =    0
            Bridges        =    1    Lateral Structures =    0

Computational Information
    Water surface calculation tolerance  =  0.01
    Critical depth calculation tolerance =  0.01
    Maximum number of iterations         =  20
    Maximum difference tolerance         =  0.3
    Flow tolerance factor                =  0.001

Computation Options
    Critical depth computed only where necessary
    Conveyance Calculation Method: At breaks in n values only
    Friction Slope Method:         Average Conveyance
    Computational Flow Regime:     Subcritical Flow

Encroachment Data
   Equal Conveyance = True
   Left Offset      =        0
   Right Offset     =        0

River = Willeo Creek     Reach = Willeo Creek
RS      Profile           Method  Value1  Value2
11553.1010Year                 0       0       0
11030.4310Year                 0       0       0
9759.10910Year                 0       0       0
8872.18910Year                 0       0       0
```

```
8133.71010Year                 0       0       0
7394.65310Year                 0       0       0
7308.13210Year                 0       0       0
7153.70610Year                 0       0       0
6563.10810Year                 0       0       0
5618.33310Year                 0       0       0
4364.00410Year                 0       0       0
3532.72910Year                 0       0       0
2562.87910Year                 0       0       0
1410.40610Year                 0       0       0
1220.68 10Year                 0       0       0
1034.50910Year                 0       0       0
947.921910Year                 0       0       0
682.81  10Year                 0       0       0
342.533810Year                 0       0       0

River = Willeo Creek     Reach = Willeo Creek
RS      Profile           Method  Value1  Value2
11553.1050Year                 0       0       0
11030.4350Year                 0       0       0
9759.10950Year                 0       0       0
8872.18950Year                 0       0       0
8133.71050Year                 0       0       0
7394.65350Year                 0       0       0
7308.13250Year                 0       0       0
7153.70650Year                 0       0       0
6563.10850Year                 0       0       0
5618.33350Year                 0       0       0
4364.00450Year                 0       0       0
3532.72950Year                 0       0       0
2562.87950Year                 0       0       0
1410.40650Year                 0       0       0
1220.68 50Year                 0       0       0
1034.50950Year                 0       0       0
947.921950Year                 0       0       0
682.81  50Year                 0       0       0
342.533850Year                 0       0       0
```

```
River = Willeo Creek     Reach = Willeo Creek
RS      Profile           Method  Value1  Value2
11553.10100Year                0       0       0
11030.43100Year                0       0       0
9759.109100Year                0       0       0
8872.189100Year                0       0       0
8133.710100Year                0       0       0
7394.653100Year                0       0       0
7308.132100Year                0       0       0
7153.706100Year                0       0       0
6563.108100Year                0       0       0
5618.333100Year                0       0       0
4364.004100Year                0       0       0
3532.729100Year                0       0       0
2562.879100Year                0       0       0
1410.406100Year                0       0       0
1220.68 100Year                0       0       0
1034.509100Year                0       0       0
947.9219100Year                0       0       0
682.81  100Year                0       0       0
342.5338100Year                0       0       0

River = Willeo Creek     Reach = Willeo Creek
RS      Profile           Method  Value1  Value2
11553.10500Year                0       0       0
11030.43500Year                0       0       0
9759.109500Year                0       0       0
8872.189500Year                0       0       0
8133.710500Year                0       0       0
7394.653500Year                0       0       0
7308.132500Year                0       0       0
7153.706500Year                0       0       0
6563.108500Year                0       0       0
5618.333500Year                0       0       0
4364.004500Year                0       0       0
3532.729500Year                0       0       0
2562.879500Year                0       0       0
1410.406500Year                0       0       0
```

```
1220.68 500Year                0       0       0
1034.509500Year                0       0       0
947.9219500Year                0       0       0
682.81  500Year                0       0       0
342.5338500Year                0       0       0
```

```
FLOW DATA

Flow Title: Design
Flow File : g:\19180\Hydrology\Bridge Hydraulics\HEC-
RAS_Models\WilleoCreek\WilleoCr_HECRAS\WilleoCr.f06

Flow Data (cfs)

  River           Reach           RS                  2Year          10Year          50Year
100Year         500Year
  Willeo Creek    Willeo Creek    11553.10           1836.7            3443            5527
5958            8556
  Willeo Creek    Willeo Creek    7308.132           1645.4            4024            6856
7482           10931
  Willeo Creek    Willeo Creek    4364.004           1267.2            4159            7071
7707           11123
  Willeo Creek    Willeo Creek    1034.509           1738.5            4145            7057
7699           11092


Boundary Conditions

  River           Reach           Profile                        Upstream                 Downstream

  Willeo Creek    Willeo Creek    2Year                                             Normal S = 0.0007786
  Willeo Creek    Willeo Creek    10Year                                            Normal S = 0.0007786
  Willeo Creek    Willeo Creek    50Year                                            Normal S = 0.0007786
  Willeo Creek    Willeo Creek    100Year                                           Normal S = 0.0007786
  Willeo Creek    Willeo Creek    500Year                                           Normal S = 0.0007786
```

GEOMETRY DATA

Geometry Title: Unconstricted
Geometry File : g:\19180\Hydrology\Bridge Hydraulics\HEC-RAS_Models\WilleoCreek\WilleoCr_HECRAS\WilleoCr.g06

CROSS SECTION

RIVER: Willeo Creek
REACH: Willeo Creek RS: 11553.10

INPUT
Description: Interpolated Channel
Station Elevation Data num= 75

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	883.72	4.95	883.04	9.9	882.29	14.84	881.46	19.79	880.58
24.74	879.69	29.69	878.79	34.64	877.93	39.59	877.22	44.53	876.75
49.48	876.53	54.43	876.23	59.38	875.5	64.33	874.59	69.28	873.61
74.22	872.66	79.17	872.06	84.12	872	96.63	871.97	108.63	871.97
118.76	871.93	123.71	871.84	128.66	871.76	133.6	871.67	138.55	871.6
143.5	871.56	148.45	871.53	153.4	871.5	158.35	871.47	163.29	871.43
168.24	871.38	173.19	871.32	181.49	870.68	194.32	869.44	197.17	867.97
210.4	861.79	224.45	860.59	237.88	862.08	247.45	868.98	275.58	870.81
288.8	871.33	308.21	871.91	325.26	872.02	338.53	872.18	350.53	872.35
358.93	872.36	363.88	873.67	368.84	874.99	373.79	876.26	378.74	877.58
383.7	878.94	388.65	879.93	393.6	880.34	398.56	880.67	403.51	881.03
408.47	881.39	413.42	881.72	418.37	882.08	423.33	882.52	428.28	883.06
433.24	883.69	438.19	884.62	443.14	885.97	448.1	887.29	453.05	888.74
458	890.02	462.96	890.69	467.91	891.35	472.87	892.04	477.82	892.7
482.77	893.34	487.73	893.99	492.68	894.54	497.64	894.97	502.59	895.33

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val

```
       0     .08  194.32     .04  247.45     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        194.32  247.45           374.92  522.66  721.63             .1       .3

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 11030.43

INPUT
Description: Interpolated Channel
Station Elevation Data    num=     135
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  895.69       5  894.88    9.99  893.42   14.99  891.64   19.99  889.69
   24.99  888.84   29.98  888.67   34.98   888.6   39.98  888.51   44.98  888.42
   49.97  888.33   54.97  888.23   59.97  888.15   64.97  888.04   69.96  887.96
   74.96  887.85   79.96  887.76   84.96  885.42   89.95  879.89   94.95  877.66
   99.95  875.41  104.94  873.18  109.94  871.71  114.94   871.1  119.94  870.74
  124.93  870.58  129.93  870.46  134.93  870.35  139.93  870.27  144.92  870.23
  149.92  870.21  159.92  870.19  164.91  870.18  174.91  870.16   179.9  870.15
   194.9  870.12  199.89  870.11  204.89   870.1  209.89  870.09  214.89  870.08
  219.88  870.07  229.88  870.05  239.87  870.07  244.87  870.11  249.87  870.15
  254.87  870.19  259.86  870.25  264.86  870.31  269.86  870.39  274.85  870.46
  279.85  870.53  284.85  870.61  289.85  870.68  294.84   870.7  325.98  869.96
   333.7  869.56  365.89  861.13  376.89  859.73  387.89  861.13  418.07  869.33
  425.79  869.58  432.34  869.36  437.29  869.31  442.24  869.27  447.19  869.22
  452.14  869.18  457.09  869.14  462.04  869.09  466.99  869.05  471.94  869.01
   476.9  868.97  481.85  868.92   486.8  868.85  491.75  868.77   496.7   868.7
  501.65  868.64   506.6  868.58  511.55  868.53   516.5  868.48   526.4   868.4
  531.35  868.35   536.3  868.31  541.26  868.29  546.21  868.32  551.16  868.36
  556.11   868.4  561.06  868.45  566.01  868.53  570.96  868.64  575.91  868.87
  580.86  869.33  585.81  869.79  590.76  870.24  595.71  870.61  600.66  870.56
  605.61  870.42  610.57  870.28  615.52  870.14  620.47     870  625.42  869.86
  630.37  869.54  635.32  868.64  640.27  867.97  645.22  868.22  650.17  868.83
  655.12  869.27  660.07   869.6  665.02  869.87  669.97  870.17  674.92  870.45
  679.88  870.83  684.83  872.19  689.78  873.52  694.73  874.88  699.68  876.21
```

```
  704.63  877.15  709.58  878.01  714.53   878.8  719.48  879.51  724.43  880.21
  729.38  881.04  734.33  881.97  739.28  883.31  744.24  885.33  749.19  887.97
  754.14  891.27  759.09  894.72  764.04  898.21  768.99  901.51  773.94  903.47
  778.89  904.62  783.84  905.73  788.79  906.86  793.74  907.96  798.69  909.44

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08   333.7     .04  418.07     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         333.7  418.07          1257.53 1271.33 1073.77             .1       .3
Ineffective Flow     num=       1
   Sta L   Sta R    Elev  Permanent
  610.53  798.69  870.38       F

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 9759.109

INPUT
Description: Interpolated Channel
Station Elevation Data    num=      97
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -38.01  887.23  -14.12   882.8    4.99  879.95    9.98  879.19   14.97  878.43
   19.96  877.76   24.95  877.11   29.94  876.47   34.93  875.81   39.92   875.2
   44.91  874.56    49.9  873.95   54.89  873.24   59.88  872.64   64.87  872.04
   69.86  871.58   74.85   871.2   79.84  870.87   84.83  870.53   89.82  870.21
   94.81  870.02    99.8     870  104.79  869.98  109.78  869.88  114.77  869.72
  119.76   869.6  124.75  869.55  129.75  869.31  134.74  868.63  139.73   868.1
  144.72  867.81  149.71  867.58   154.7  867.39  159.69  867.22  164.68  867.12
  169.67  867.02  174.66  866.92  179.65  866.91  184.64  867.05  189.63  867.23
  194.62  867.42  199.61   867.6   204.6  867.79  209.59  867.98  214.58  868.19
  219.57  868.51  224.56  868.84  229.55  868.67  234.54  867.69  239.53     867
   254.5  867.01  259.49  867.02  289.43  867.03   334.2  867.02  348.76  867.01
  358.46     867  367.56  867.94  376.89  860.93   394.2  858.77  411.49  860.93
  420.83  867.94  481.05  867.78  544.63  867.78  549.61  867.81   554.6  867.82
```

```
  559.58  867.85  564.56  867.86  569.55  867.84  579.51  867.77  584.49  867.73
  589.48   867.8  594.46  867.82  599.44  867.84  604.43  867.86  609.41  867.88
  614.39  867.89  619.38  867.91  624.36  867.94  629.34   868.1  634.33  868.58
  639.31  869.22  644.29  869.83  649.28  870.11  654.26  870.27  659.24  870.38
  664.23  870.48  669.21  871.55  674.19  873.52  679.18  875.83  684.16  878.16
  689.14  880.57  694.12  883.15  699.11  885.73  704.09  887.74  709.07  888.46
  714.06  889.38  719.04  890.48

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -38.01     .08  367.56     .04  420.83     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        367.56  420.83           845.18  886.92  691.75             .1       .3
Ineffective Flow     num=       1
   Sta L   Sta R    Elev  Permanent
  -38.01   227.4  868.74       F

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 8872.189

INPUT
Description: Survey Channel
Station Elevation Data    num=      89
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  885.31    4.89  882.64    9.77  882.25   14.66  881.96   19.55   881.8
   24.44  881.89   29.32  881.76   34.21   881.6    39.1  881.41   43.98  881.21
   48.87  881.13   53.76  881.39   58.65  881.81   63.53  882.15   68.42  882.43
   73.31  882.68   78.19  882.94   83.08  883.19   87.97  883.42   92.86  883.63
   97.71  883.85  102.55   884.1  112.25   884.6   117.1  884.83  121.95  884.51
   126.8   882.3  131.65  880.17   136.5   878.2  141.35  876.44   146.2  875.47
  151.05  875.05   155.9  874.57  160.75  874.14   165.6  873.77  170.45  873.58
   175.3  873.41  180.15  873.22     185  873.04  189.85  872.87   194.7  872.69
  199.55  872.52   204.4  872.34  209.25   872.2   214.1     872  218.94  870.86
  223.79  869.57  228.64  868.25   269.5  867.26   282.8  860.25  292.14  858.09
```

```
   303.7  858.49   314.8  858.66   317.4  859.22  322.74  866.68  354.39  867.83
  359.28     868  364.17  868.22  369.06  868.81  373.95  869.83  378.83  871.49
  383.72  873.55  388.61  875.55   393.5  877.39  398.39     879  403.28  880.38
  408.16  881.66  413.05  883.01  417.94  884.44  422.83  885.92  427.72  887.29
  432.61  888.48   437.5  889.56  442.38  890.68  447.27  891.83  452.16  893.05
  457.05  894.25  461.94  895.39  466.83  896.45  471.72  897.47   476.6  898.43
  481.49  899.45  486.38   900.4  491.27  901.29  496.16  902.18  501.05  903.05
  505.93  903.88  510.82  904.67  515.71  905.38   520.6  906.22

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08   269.5     .04  322.74     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         269.5  322.74           685.38  738.48  753.66             .1       .3

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 8133.710

INPUT
Description: Interpolated Channel
Station Elevation Data    num=      78
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  910.62    4.89  909.64    9.77  908.68   14.66  907.56   19.54  905.12
   24.43  900.87   29.32  896.53    34.2  892.29   39.09  888.08   43.97   883.8
   48.86  879.81   53.74  876.06   58.63  872.29   63.52  869.49    68.4  868.27
   73.29  867.47   78.17   866.9   83.06  866.56   87.95  866.33   97.29  859.32
  114.58  857.16  131.88  859.32  141.22  866.33  150.53  866.04  162.11  865.66
  170.04  865.29  179.58  865.21  184.34  865.17  189.11  865.13  193.87   865.1
  198.64  865.08  208.32  865.07  218.15  865.09  223.07  865.11  227.98  865.15
   232.9  865.18  237.82  865.21  242.73  865.24  247.65  865.27  252.57  865.29
  257.48   865.5   262.4   865.9  267.31  866.33  272.23  866.76  277.15  867.21
  282.06  867.78  286.98  868.47  291.89  869.01  296.81  869.35  301.73  869.64
  306.64  869.93  311.56  870.23  316.48  870.54  321.39  870.89  326.31  871.35
  331.22  871.97  336.14  872.67  341.06  873.41  345.97   874.2  350.89  874.98
```

```
   355.8  875.76  360.72  876.55  365.64  877.41  370.55  878.45  375.47   879.6
  380.39  880.83   385.3  882.06  390.22  883.29  395.13  884.53  400.05  885.78
  404.97  887.02  409.88  888.35   414.8  891.31  419.71  894.05  424.63  896.55
  429.55  897.02  434.46  897.05  439.38  897.21

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08   87.95     .04  141.22     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         87.95  141.22           722.72  739.06  722.47             .1       .3

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 7394.653

INPUT
Description: Interpolated Channel
Station Elevation Data    num=     126
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  882.25    4.91  881.86    9.81  881.74   14.72   881.7   19.63  881.86
   24.53  881.97   29.44  881.83   34.35  881.68   39.25  881.67   44.16  881.81
   49.06  881.87   53.97  882.16   58.88  882.53   63.78  881.87   68.69  881.26
    73.6  880.86    78.5  880.12   83.41   879.7   88.32  879.71   93.22  879.75
   98.13  879.38  103.04  879.02  107.94  878.72  112.85   878.5  117.75  878.23
  122.66  877.92  127.57  877.63  132.47  877.35  137.38  877.12  142.29  876.73
  147.25  876.04  152.21   875.2  157.17  874.35  162.12  873.54  167.08  872.72
  172.04  871.92     177  871.03  181.96  870.04  186.92  869.05  191.88  868.13
  196.84  867.39   201.8  866.88  206.76  866.55  211.72   866.4  266.28  866.36
  271.24  866.22  276.19  866.08  281.15  865.93  286.11  865.79  291.07  865.65
  300.99  865.37  310.91  865.42  315.87  865.48  320.83  865.53  325.79  865.59
  330.75  865.64  335.71   865.7  340.67  865.75  345.63  865.81  350.59   865.8
  355.55  865.74  360.51  865.63  365.47  865.52  370.43   865.4  375.39  865.29
  380.35  865.19   385.3  865.17  390.26  865.22  395.22  865.28  400.18  865.27
  405.14  865.32   410.1  865.38  415.06  865.42  420.02  865.46  424.98   865.5
  429.94  865.54  435.64  865.34  439.59  865.28  444.76  865.22  449.19  865.02
```

```
  453.63  864.67   455.6  864.35  463.33  858.53  480.64  856.37  497.93  858.53
  505.61  864.32  519.17  865.19  528.84   865.7  552.42   865.9  571.79   865.9
  579.77  866.27  586.25  866.42  591.17  867.14  596.08  867.98     601  868.82
  605.91  869.69  610.83  870.61  615.74  871.48  620.66  872.03  625.57  872.39
  630.48  872.82   635.4  873.26  640.31  873.67  645.23  874.05  650.14  874.32
  655.06  874.63  659.97  875.23  664.89  875.83   669.8  876.43  674.72  877.28
  679.63   878.2  684.54  880.14  689.46  882.31  694.37  884.71  699.29  887.21
   704.2  889.61  709.12  891.93  714.03  893.03  718.95   893.6  723.86  894.11
  728.78  894.48  733.69  894.94  738.61  895.43  743.52  895.91  748.43  896.25
  753.35  896.39

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08   455.6     .04  505.61     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         455.6  505.61          108.041  86.521  93.401             .3       .5

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 7308.132

INPUT
Description:
Station Elevation Data    num=     108
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  888.94    4.92  888.83    9.83  888.65   14.75  888.42   19.66  888.18
   24.58  887.96   29.49  887.75   34.41  887.35   39.32  887.12   44.24   887.1
   49.16  886.96   54.07  886.72   58.99  886.57    63.9  886.23   68.82  885.93
   73.73  885.62   78.65  885.26   83.56  885.03   88.48  884.85    93.4  884.79
   98.31  884.49  103.23   884.1  108.14  883.84  113.06   883.6  117.97  883.35
  122.89  883.14   127.8  882.93  132.72  882.63  137.64  882.38  142.55  881.47
  147.47   881.1  152.38   880.2   157.3  879.11  162.21  878.24  167.13  877.34
  172.04  876.74  176.96  876.15  181.88  875.33  186.79  874.03  191.71  871.96
  196.62  869.95  201.54  868.38  206.35  867.24  211.17  865.42  215.98  863.32
   220.8  861.34  225.61  859.52  229.22   857.8  230.43  857.22  235.25  856.23
```

```
  240.06  856.16   244.8  856.24  249.54  856.33  254.28  856.39  259.02  856.59
  263.76   858.3  268.45  862.93  273.13   865.4  277.82  867.41   282.5  869.21
  287.19  870.81  291.87  872.16  296.85   873.5  301.83  874.82   306.8  875.97
  311.78  876.57  316.76  876.34  321.74  876.11  326.72  875.85  331.69  875.92
  336.67  875.93  341.65     876  346.63  876.03   351.6  876.08  356.58  876.13
  361.56  876.16  366.54  876.23  371.51  876.24  376.49  876.31  381.47  876.32
  386.45  876.66  391.43  876.87   396.4  877.04  401.38     877  406.36  876.94
  411.34  876.89  416.31  876.83  421.29  876.77  426.27   876.7  431.25  876.64
  436.22  876.58   441.2  876.54  446.18  876.51  451.16  876.48  456.13  876.45
  461.11  876.43  466.09  876.41  471.07  876.39  476.05  876.38  481.02  876.36
     486   876.3  490.98  876.29  495.96   876.3  500.93  876.29  505.91  876.31
  510.89  876.29  515.87  876.28  520.84  876.26

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08  215.98     .04  268.45     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        215.98  268.45           144.84  154.43  146.12             .3       .5
Ineffective Flow     num=       2
   Sta L   Sta R    Elev  Permanent
       0     170     882       T
     320  520.84  877.33       T

BRIDGE


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 7241.553

INPUT
Description: Roswell Rd NE_ Marrietta  Hwy (94.5' Span Bridge)
Distance from Upstream XS =      24
Deck/Roadway Width        =      88
Weir Coefficient          =     2.6
Upstream  Deck/Roadway Coordinates
    num=      26
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
```

0	885.29		4.94	885.11		9.87	884.96		
14.81	884.8		19.75	884.63		24.68	884.5		
29.62	884.39		34.56	884.23		39.49	883.98		
44.43	883.92		49.37	883.88		54.25	883.8		
156	883.29		198.7	882.2		200	882.2		
200	882.2	879.7	227.5	881.6	879.7	227.5	881.6	878.35	
267	880.716	877.466	267	880.716	878.216	268.3	880.716	878.216	
294.5	880.716	878.216	294.5	880.716		395.62	876.44		
400.51	876.33		401.55	876.23					

Upstream Bridge Cross Section Data
Station Elevation Data num= 108

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	888.94	4.92	888.83	9.83	888.65	14.75	888.42	19.66	888.18
24.58	887.96	29.49	887.75	34.41	887.35	39.32	887.12	44.24	887.1
49.16	886.96	54.07	886.72	58.99	886.57	63.9	886.23	68.82	885.93
73.73	885.62	78.65	885.26	83.56	885.03	88.48	884.85	93.4	884.79
98.31	884.49	103.23	884.1	108.14	883.84	113.06	883.6	117.97	883.35
122.89	883.14	127.8	882.93	132.72	882.63	137.64	882.38	142.55	881.47
147.47	881.1	152.38	880.2	157.3	879.11	162.21	878.24	167.13	877.34
172.04	876.74	176.96	876.15	181.88	875.33	186.79	874.03	191.71	871.96
196.62	869.95	201.54	868.38	206.35	867.24	211.17	865.42	215.98	863.32
220.8	861.34	225.61	859.52	229.22	857.8	230.43	857.22	235.25	856.23
240.06	856.16	244.8	856.24	249.54	856.33	254.28	856.39	259.02	856.59
263.76	858.3	268.45	862.93	273.13	865.4	277.82	867.41	282.5	869.21
287.19	870.81	291.87	872.16	296.85	873.5	301.83	874.82	306.8	875.97
311.78	876.57	316.76	876.34	321.74	876.11	326.72	875.85	331.69	875.92
336.67	875.93	341.65	876	346.63	876.03	351.6	876.08	356.58	876.13
361.56	876.16	366.54	876.23	371.51	876.24	376.49	876.31	381.47	876.32
386.45	876.66	391.43	876.87	396.4	877.04	401.38	877	406.36	876.94
411.34	876.89	416.31	876.83	421.29	876.77	426.27	876.7	431.25	876.64
436.22	876.58	441.2	876.54	446.18	876.51	451.16	876.48	456.13	876.45
461.11	876.43	466.09	876.41	471.07	876.39	476.05	876.38	481.02	876.36
486	876.3	490.98	876.29	495.96	876.3	500.93	876.29	505.91	876.31
510.89	876.29	515.87	876.28	520.84	876.26				

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val

```
       0     .08  215.98    .035  268.45     .08

Bank Sta: Left   Right    Coeff Contr.   Expan.
        215.98  268.45             .3       .5
Ineffective Flow     num=       2
   Sta L   Sta R    Elev  Permanent
       0     170     882       T
     320  520.84  877.33       T

Downstream  Deck/Roadway Coordinates
    num=      26
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
       0  885.29            4.94  885.11            9.87  884.96
   14.81   884.8           19.75  884.63           24.68   884.5
   29.62  884.39           34.56  884.23           39.49  883.98
   44.43  883.92           49.37  883.88           54.25   883.8
     156  883.29           198.7   882.2             200   882.2
     200   882.2   879.7   227.5   881.6   879.7   227.5   881.6  878.35
     267 880.716 877.466     267 880.716 878.216   268.3 880.716 878.216
   294.5 880.716 878.216   294.5 880.716          395.62  876.44
  400.51  876.33          517.76  876.52

Downstream Bridge Cross Section Data
Station Elevation Data    num=     107
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     -80  890.68     -75   890.7  -70.01  890.41  -65.01  890.24  -60.02  890.01
  -55.02  889.69  -50.03  889.45  -45.03  889.25  -40.04  889.02  -35.04   888.8
  -30.05  888.59  -25.05  888.39  -20.05  888.17  -15.06  887.92  -10.06  887.73
   -5.07  887.52    -.07  887.24    4.92  886.75    9.92  886.06   14.91  885.82
   19.91  885.04   24.91  884.36    29.9  883.43    34.9  882.55   39.89  881.69
   44.89  880.84   49.88  879.99   54.88  879.15   59.87  878.33   64.87  877.51
   69.87  876.79   74.86  876.01   79.86  875.22   84.85  874.39   89.74  873.99
   94.63  873.58   99.52  873.15   104.4  872.63  109.29  871.97  114.18  871.24
  119.07  870.57  123.96   869.9  128.85  869.33  133.73  868.76  138.62  868.43
  143.51  868.03   148.4  867.38  158.09  867.07  165.04  866.83  170.93  866.66
  176.83  866.49  183.15  866.29  190.31  866.07  207.72  865.55  210.84  863.73
  219.72  856.99  222.44  856.15  236.74  856.47  246.34  856.37  250.94  857.11
  266.64  863.03  282.79  864.21  292.64  865.01  294.36  865.42  299.06  866.66
```

```
  303.03  867.89  307.77  868.86  312.77  869.34  317.77  869.71  322.77   870.1
  327.77  870.46  332.77  870.79  337.77  871.06  342.77  871.27  347.77  871.45
  352.77  871.63  357.77  871.81  362.77  871.99  367.77  872.17  372.77  872.35
  377.77   872.5  382.77  872.65  387.77  872.79  392.77  872.92  397.77  873.08
  402.77   873.2  407.77  873.29  412.77  873.54  417.76  873.84  422.76  874.07
  427.76  874.28  432.76  874.54  437.76  874.87  442.76  875.24  447.76  875.53
  452.76  875.79  457.76  875.98  462.76  876.16  467.76  876.52  472.76  876.66
  477.76  876.61  482.76   876.8  487.76     877  492.76  876.96  497.76  876.98
  502.76     877  552.76  876.98

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     -80     .08  210.84    .035  266.64     .08

Bank Sta: Left   Right    Coeff Contr.   Expan.
        210.84  266.64             .3       .5
Ineffective Flow     num=       2
   Sta L   Sta R    Elev  Permanent
     -80     140  876.33       F
     320  552.76  876.33       F

Upstream Embankment side slope              =       0 horiz. to 1.0 vertical
Downstream Embankment side slope            =       0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .98
Elevation at which weir flow begins         =
Energy head used in spillway design         =
Spillway height used in design              =
Weir crest shape                            = Broad Crested

Number of Abutments =  2

Abutment Data
Upstream     num=       2
     Sta    Elev     Sta    Elev
     200  875.28     230  858.54
Downstream     num=       2
     Sta    Elev     Sta    Elev
     200  875.28     230  858.54
```

```
Abutment Data
Upstream     num=       3
     Sta    Elev     Sta    Elev     Sta    Elev
   268.2  858.23   285.1   871.6   294.5   875.6
Downstream     num=       3
     Sta    Elev     Sta    Elev     Sta    Elev
   268.2  858.23   285.1   871.6   294.5   875.6

Number of Piers =  2

Pier Data
Pier Station     Upstream=     227    Downstream=     227
Upstream     num=       2
    Width   Elev    Width   Elev
     2.5     856     2.5   879.7
Downstream     num=       2
    Width   Elev    Width   Elev
     2.5     856     2.5   879.7

Pier Data
Pier Station     Upstream=     267    Downstream=     267
Upstream     num=       2
    Width   Elev    Width   Elev
     2.5     856     2.5  878.22
Downstream     num=       2
    Width   Elev    Width   Elev
     2.5     856     2.5  878.22

Number of Bridge Coefficient Sets =  1

Low Flow Methods and Data
       Energy
       Momentum               Cd   =     1.2
       Yarnell                KVal =      .9
Selected Low Flow Methods = Highest Energy Answer

High Flow Method
```

```
       Energy Only

Additional Bridge Parameters
       Add Friction component to Momentum
       Do not add Weight component to Momentum
       Class B flow critical depth computations use critical depth
           inside the bridge at the upstream end
       Criteria to check for pressure flow = Upstream energy grade line

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 7153.706

INPUT
Description: Survey Channel
Station Elevation Data    num=     100
```

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-80	890.68	-75	890.7	-70.01	890.41	-65.01	890.24	-60.02	890.01
-55.02	889.69	-50.03	889.45	-45.03	889.25	-40.04	889.02	-35.04	888.8
-30.05	888.59	-25.05	888.39	-20.05	888.17	-15.06	887.92	-10.06	887.73
-5.07	887.52	-.07	887.24	4.92	886.75	9.92	886.06	14.91	885.82
19.91	885.04	24.91	884.36	29.9	883.43	34.9	882.55	39.89	881.69
44.89	880.84	49.88	879.99	54.88	879.15	59.87	878.33	64.87	877.51
69.87	876.79	74.86	876.01	79.86	875.22	84.85	874.39	89.74	873.99
94.63	873.58	99.52	873.15	104.4	872.63	109.29	871.97	114.18	871.24
123.96	869.9	128.85	869.33	133.73	868.76	138.62	868.43	143.51	868.03
148.4	867.38	158.09	867.07	165.04	866.83	170.93	866.66	176.83	866.49
183.15	866.29	190.31	866.07	207.72	865.55	210.84	863.73	219.72	856.99
222.44	856.15	236.74	856.47	246.34	856.37	250.94	857.11	266.64	863.03
282.79	864.21	292.64	865.01	294.36	865.42	299.06	866.66	303.03	867.89
307.77	868.86	312.77	869.34	317.77	869.71	322.77	870.1	327.77	870.46
332.77	870.79	337.77	871.06	342.77	871.27	372.77	872.35	382.77	872.65
387.77	872.79	392.77	872.92	397.77	873.08	402.77	873.2	407.77	873.29
412.77	873.54	417.76	873.84	422.76	874.07	427.76	874.28	432.76	874.54
437.76	874.87	442.76	875.24	447.76	875.53	452.76	875.79	457.76	875.98
462.76	876.16	467.76	876.52	472.76	876.66	477.76	876.61	482.76	876.8

```
  487.76     877  492.76  876.96  497.76  876.98  502.76     877  552.76  876.98

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     -80     .08  210.84     .04  266.64     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        210.84  266.64           548.29   590.6  540.85             .3       .5
Ineffective Flow     num=       2
   Sta L   Sta R    Elev  Permanent
     -80     140  876.33       F
     320  552.76  876.33       F

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 6563.108

INPUT
Description: Survey Channel
Station Elevation Data    num=     161
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  876.24    9.94  876.23   14.91  876.21   19.88  876.19   24.85  876.18
   29.82  876.16   34.79  876.15   39.76  876.13   44.73  876.12   49.71   876.1
   54.68  876.08   59.65  876.05   64.62  876.02   69.59  875.99   74.56  875.82
   79.53  875.15    84.5  874.49   89.47  873.93   94.44  873.66   99.41   873.4
  104.38  873.14  109.35  872.91  114.32  872.77  119.29  872.66  124.26  872.55
  129.23  872.39   134.2  872.18  139.18   872.1  144.15  872.05  149.12  871.97
  159.06  871.75  164.03  871.65     169  871.54  183.91  871.21  188.88  871.11
  193.85  871.01  198.82  870.96  203.79  870.74  208.76  870.56  213.73  870.36
   218.7  870.08  223.67     870  258.47  869.86  263.44  869.77  268.41  869.75
  273.38  869.67  278.35  869.08  283.32     869  293.26  868.99  298.23  868.96
   303.2  868.88  308.17  868.76  313.14  868.63  318.11  868.51  323.09  868.37
  328.06  868.23  333.03  868.05     338     868  347.94  867.97  352.91  867.95
  362.85  867.97  367.82  867.98  372.79  867.87  377.76  867.28  382.73   867.1
   387.7  867.09  392.67  867.04  402.61  867.06  412.56  867.05  417.53  867.03
   422.5  867.02  427.47     867  432.44  867.04  437.41  867.16  447.35  867.42
```

```
  452.32  867.54  457.29  867.65  462.26  867.79  467.23  867.94   472.2     868
  482.14  868.05  487.11   868.1  502.03  868.09     507  868.01   511.8  867.83
  516.61  867.39  521.42  866.97     570  866.39  603.34  865.24  609.64  856.22
  621.84  855.61  634.34   855.1  638.14  854.71  653.84  855.68  664.14  859.33
  669.44  862.92  756.21  862.94  837.05  862.94  941.47  863.21 1012.21  863.34
 1079.58  863.48 1124.06  863.68 1129.05  863.88 1134.05  864.12 1139.04  864.44
 1144.03  864.78 1149.03   865.1 1154.02  865.42 1159.02  865.76 1164.01  866.14
 1169.01  866.72    1174  867.31 1178.99  867.92 1183.99  868.58 1188.98  869.25
 1193.98     870 1198.97  871.22 1203.97  872.57 1208.96  873.86 1213.96  875.03
 1218.95  875.46 1223.94  875.44 1228.94   875.5 1233.93  875.54 1238.93  875.57
 1243.92  875.59 1248.92   875.6 1253.91  875.61  1258.9  875.64  1263.9   875.7
 1268.89  875.79 1273.89   875.9 1278.88     876 1283.88  876.43 1288.87  877.06
 1293.86  877.74 1298.86  878.28 1303.85  878.85 1308.85     879 1328.83  879.21
 1333.82  879.72 1338.81  880.43 1343.81  881.23  1348.8  882.02  1353.8  882.75
 1358.79   883.5 1363.79  884.51 1368.78  886.15 1373.77  888.13 1378.77  890.28
 1383.76  892.27 1388.76  892.46 1393.75  892.51 1398.75  892.54 1403.74  892.49
 1408.74  892.37 1413.73  892.22 1418.72  892.23 1423.72  892.35 1428.71  892.49
 1433.71  892.63

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08  603.34     .04  669.44     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        603.34  669.44           625.09  944.78  683.16             .1       .3

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 5618.333

INPUT
Description: Interpolated Channel
Station Elevation Data    num=     174
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  875.18    4.97  875.01    9.95  874.81   14.92  874.61    19.9   874.4
   24.87   874.2   29.85  874.04   34.82     874   44.77  873.99   49.74  873.96
```

54.72	873.89	59.69	873.82	64.66	873.77	69.64	873.66	74.61	873.15
79.59	872.36	84.56	871.59	89.54	870.75	94.51	870.04	99.48	869.52
104.46	869.05	109.43	868.53	114.41	868.12	119.38	868	179.07	867.96
184.05	867.68	189.02	867.34	193.99	867.51	198.97	867.67	203.94	867.85
208.92	867.57	213.89	867.34	218.87	867.21	223.84	867.09	228.81	866.99
233.79	866.89	238.76	866.8	243.74	866.75	248.71	866.7	253.68	866.61
258.66	866.6	263.63	866.63	268.61	866.67	273.58	867.01	278.56	867.41
283.53	867.12	288.5	867.44	293.48	867.87	298.45	868.01	303.43	868.13
308.4	868.29	313.38	868	318.35	868.01	323.32	868	333.27	868.03
338.25	868.19	343.22	868.44	348.19	868.68	353.17	868.93	358.14	869.15
363.12	869.4	368.09	869.6	373.07	869.86	378.04	870.08	383.01	870.19
387.99	870.18	392.96	870.15	397.94	870.12	402.91	870.09	407.89	870.05
412.86	870.01	417.83	869.84	422.81	869.65	427.78	869.43	432.76	869.22
437.73	869.09	442.7	868.93	447.68	868.73	452.65	868.51	457.63	868.28
462.6	868.05	467.58	868	492.45	867.98	497.42	867.89	502.4	867.8
507.37	867.71	512.34	867.62	517.32	867.52	522.29	867.43	527.27	867.38
532.24	867.27	537.21	867.26	542.19	867.24	547.16	867.29	552.14	867.38
557.11	867.41	562.09	867.49	567.06	867.66	572.03	867.83	577.01	867.87
581.98	867.68	586.96	867.47	591.93	867.03	596.91	866.66	601.88	866.61
606.85	866.64	611.83	866.81	616.8	866.8	621.78	866.77	626.75	866.73
631.72	866.7	646.65	866.76	651.62	866.82	656.6	866.89	661.57	866.95
666.54	867.02	671.52	867.12	676.49	867.32	681.47	867.51	686.44	867.26
691.41	866.13	696.39	865.02	701.36	864	706.34	863.23	711.31	862.9
716.29	862.77	721.26	862.64	726.23	862.51	731.21	862.37	736.18	862.22
741.16	862.09	789.99	861.68	865.85	860.75	880.92	853.53	896.92	852.63
912.92	853.53	917.41	860.82	958.21	861.66	1015.58	862.13	1084.63	862.21
1165.47	862.25	1224.42	862.37	1249.62	862.45	1254.61	863.18	1259.59	864
1264.58	864.72	1269.56	864.59	1274.55	864.23	1279.53	864.03	1284.52	864
1299.48	864.03	1304.46	864.31	1309.45	864.84	1314.43	865.34	1319.42	865.82
1324.4	866.18	1329.39	866.46	1334.38	866.74	1339.36	867.11	1344.35	867.9
1349.33	868.98	1354.32	870.01	1359.3	871.06	1364.29	872.1	1369.27	873.14
1374.26	874.27	1379.25	874.73	1384.23	874.6	1389.22	874.63	1394.2	874.82
1399.19	875	1404.17	875.16	1409.16	875.23	1414.14	875.19		

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.08	865.85	.04	917.41	.08

```
Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        865.85  917.41          1062.51 1254.33 1205.75             .1       .3
Ineffective Flow     num=       1
   Sta L   Sta R    Elev  Permanent
       0  393.77  876.77       F

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 4364.004

INPUT
Description: Interpolated Channel
Station Elevation Data    num=      63
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  885.82    4.96  884.93    9.92  884.09   14.88  883.29   19.84  882.53
    24.8  881.81   29.76  881.09   34.72  880.38   39.68  879.68   44.64  879.02
    49.6  878.35   54.56  877.61   59.52  876.87   64.48  876.12   69.44  875.38
    74.4  874.58   79.36  873.74   84.32  873.03   89.28  872.25   94.24  871.33
    99.2  870.64  104.16  870.07  109.12  869.56  114.08  869.03  119.04  868.49
     124  867.66  128.95  866.81  133.91  866.06  138.87  865.38  143.83  864.72
  148.79  864.08  158.95  863.53  174.74  862.83  189.37  862.23  204.84  860.69
  211.53  859.33  225.05  852.53  241.05  851.63  257.05  852.53  270.42  859.37
  280.09  860.71  293.68  861.54  307.37  862.02  327.89  862.61  339.47  863.05
  346.97  863.95  352.39   864.7  357.36  866.14  362.33  867.15   367.3  867.87
  372.27  868.56  377.25   869.3  382.22  870.05  387.19  870.81  392.16  871.59
  397.13  872.36   402.1  873.15  407.07  873.95  412.04  874.79  417.01  875.71
  421.98  876.65  426.95  877.67  431.93  878.75

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08  211.53     .04  270.42     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        211.53  270.42           845.72  831.28  721.08             .1       .3

CROSS SECTION
```

```
RIVER: Willeo Creek
REACH: Willeo Creek       RS: 3532.729

INPUT
Description: Interpolated Channel
Station Elevation Data    num=      87
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0     883   29.54  882.85   34.46  882.51   39.38  882.13    44.3  881.67
   49.23  881.22   54.15  880.75   59.07  880.29   63.99  879.63   68.92  878.22
   73.84  876.84   78.76  875.52   83.69  874.29   88.61  873.25   93.53   872.6
   98.45  872.32  103.38  872.05   108.3  871.71  113.22  871.37  118.14  871.09
  123.07  870.57  127.99  868.78  132.91  867.04  137.83  865.44  142.76  864.05
  147.68  863.29   152.6  862.83  157.53   862.6  162.45  862.39  167.37  862.13
  172.29  861.59  177.22  860.99  181.43  860.31  184.65   859.9   205.3  858.63
  219.11  851.94  235.11  851.04  251.11  851.94  264.16  858.51  280.07   859.6
  290.56  859.99   295.5  859.95  300.44  859.91  305.39  859.87  310.33  859.83
  315.27  859.79  320.21  859.77  325.16  859.74   330.1  859.72  344.93  859.77
  349.87  859.83  354.81  859.86  359.75   859.2   364.7  858.05  369.64  856.88
  374.58  856.25  379.53   856.3  389.41  856.82  394.35  857.27   399.3  858.04
  404.24   858.8  409.18  859.86  414.12  860.97  419.07     862  424.01   862.4
  428.95  862.68  433.89  862.92  438.84  863.14  443.78  863.36  448.72  863.65
  453.67  864.27  458.61     865  463.55  865.78  468.49   866.6  473.44  867.41
  478.38  868.19  483.32  869.59  488.26  871.04  493.21  874.24  498.15  876.57
  503.09  877.49  508.03   878.5  512.98  879.55  517.92   880.6  522.86  881.67
  527.81  882.56  532.75     883

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08   205.3     .04  264.16     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         205.3  264.16           941.58  969.85  917.32             .1       .3
Ineffective Flow     num=       1
   Sta L   Sta R    Elev  Permanent
  352.27  532.75  859.74       F
```

CROSS SECTION

RIVER: Willeo Creek
REACH: Willeo Creek RS: 2562.879

INPUT
Description: Interpolated Channel
Station Elevation Data num= 101

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	874.79	4.97	874.11	9.94	873.38	14.91	872.55	19.88	871.8
24.86	871.09	29.83	870.32	34.8	869.57	39.77	868.85	44.74	868.18
49.71	867.57	54.68	867.05	59.66	866.51	64.63	866.09	69.6	865.75
74.57	865.67	79.54	865.6	84.51	865.58	89.48	865.66	94.45	865.73
104.4	865.66	109.37	865.56	114.34	865.51	119.31	865.52	124.28	865.54
129.25	865.55	134.22	865.44	139.19	864.96	144.17	864.38	149.14	863.75
154.11	863.1	159.08	862.27	164.05	861.41	171.8	860.84	182.54	860.16
195.97	859.81	209.4	859.49	221.72	858.17	255	856.86	260.05	854.87
267.76	850.73	283.76	849.83	299.76	850.73	308.05	854.97	312.47	856.97
317.13	860.71	319.85	861.37	325.83	862.19	330.68	863.53	335.53	864.67
340.38	865.29	345.23	866.02	350.09	866.7	354.94	867.24	359.79	868.19
364.64	868.96	369.64	869.38	374.63	869.89	379.63	870.28	384.62	870.52
389.62	870.95	394.61	871.74	399.61	872.17	404.6	872.58	409.6	872.83
414.59	872.95	419.59	873.12	424.58	873.31	429.58	873.53	434.58	874.03
439.57	874.43	444.57	874.59	449.56	874.96	454.56	875.63	459.55	875.87
464.55	876.19	469.54	876.61	474.54	876.98	479.53	877.17	484.53	877.29
489.52	877.47	494.52	877.77	499.51	878.18	504.51	878.37	509.5	878.6
514.5	879.28	519.5	879.97	524.49	880.32	529.49	880.67	534.48	881.05
539.48	881.38	544.47	881.78	549.47	882.41	554.46	883	559.46	883.49
564.45	883.98	569.45	884.46	574.44	884.63	579.44	884.53	584.43	884.33
589.43	884.2								

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.08	255	.04	312.47	.08

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.
255 312.47 1302.971152.4731152.473 .1 .3

CROSS SECTION

RIVER: Willeo Creek
REACH: Willeo Creek RS: 1410.406

INPUT
Description: Interpolated Channel
Station Elevation Data num= 106

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
19.93	872.84	24.92	872.42	29.9	871.98	34.88	871.54	39.86	871.04
44.85	870.4	49.83	869.8	54.81	869.19	59.8	868.53	64.78	867.7
69.76	867.12	74.75	866.37	79.73	865.59	84.71	865.01	89.69	863.99
94.68	863.39	99.66	862.91	104.64	862.08	109.63	861.28	114.61	860.29
117.19	859.54	120.53	858.79	147.13	856.1	166.13	850.49	190.5	849.55
210.92	850.77	221.13	856.16	227.36	859.49	232.37	859.65	234.04	859.76
239.25	859.59	244.24	859.32	249.22	858.57	254.2	857	259.18	855.49
264.17	855.2	283.86	855.23	288.76	856.18	293.66	856.97	298.56	856.87
303.46	856.78	308.36	856.65	313.26	856.51	318.16	856.42	323.06	856.23
327.96	855.79	332.86	855.21	337.76	855.2	367.16	855.21	372.06	855.39
376.96	855.71	381.86	855.86	386.76	855.58	391.65	855.2	445.55	855.59
450.45	856.64	455.35	857.16	460.25	857.18	470.09	857.2	479.98	857.12
484.92	856.76	489.87	855.97	494.81	855.29	499.76	855.2	504.7	855.21
509.64	855.91	514.59	857.13	519.53	855.99	524.48	855.61	529.42	855.2
534.36	855.68	539.31	856.8	544.25	857.17	549.19	857.2	648.07	857.24
653.02	857.45	657.96	857.69	662.91	857.93	667.85	858.12	672.79	858.3
677.74	858.48	682.68	858.71	687.62	858.89	692.57	858.94	697.51	858.92
702.46	858.9	707.4	858.88	712.34	858.89	717.29	858.93	722.23	858.98
727.18	859.03	732.12	859.07	737.06	859.13	742.01	859.52	746.95	860.46
751.9	861.38	756.84	862.32	761.78	863.21	766.73	864.2	771.67	865.21
776.62	866.32	781.56	867.33	786.5	868.13	791.45	868.53	796.39	868.92
801.33	869.17								

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
19.93	.08	147.13	.04	221.13	.08

```
Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        147.13  221.13           73.739 189.731 180.653             .1       .3

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 1220.68

INPUT
Description: Surveyed Cross Section
Station Elevation Data    num=      60
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  242.65  865.06  242.97  865.06  243.32  865.05  243.37  865.05  243.46  865.06
  243.51  865.06  244.68  865.04  244.73  865.04  257.42  865.24  257.57  865.24
   271.6  865.21  271.86  865.21  272.13   865.2  272.54   865.2  272.81  865.19
  273.09  865.19  274.17  865.17  274.29  865.17  276.16  865.22  276.45  865.22
  276.56  865.23  276.88  865.25  277.06  865.24  277.13  865.25  277.33  865.24
  277.39  865.25  277.46  865.25  277.54  865.26  277.74  865.25  278.15  865.28
   278.2  865.29   278.3  865.29  278.35   865.3  282.35     865   282.9     865
  284.22  865.24  285.76  865.42  286.11  865.47  286.41  865.52  286.66  865.55
  286.87  865.59  291.71  866.21  292.75  866.32  310.31  853.16  347.66   856.4
  366.74  856.56  373.95   852.4  383.57  852.18  387.87  852.07  407.31  851.55
  437.66  850.61  452.54  850.25  469.53  850.87  485.41  851.12  495.34  853.35
   512.7  853.94  530.03  860.43  552.69  860.65  581.43  871.22  593.56  872.12

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  242.65     .08  366.74     .04  530.03     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        366.74  530.03           176.17  186.17  195.25             .1       .3

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 1034.509
```

```
INPUT
Description: Interpolated Channel
Station Elevation Data    num=      96
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  864.74    4.95  864.64     9.9  864.54   14.86  864.34   19.81  864.39
   24.76   864.4   29.71  864.25   34.66  864.35   39.61  864.43   44.57  864.28
   49.52  864.37   54.47   864.3   59.42  863.91   64.37  864.16   69.33  864.27
   74.28  864.25   79.23  864.08   84.18  863.93   89.13  863.82   94.08  863.74
   99.04  863.64  103.99  863.59  108.94  863.63  113.89  863.75  118.84  863.85
   123.8  863.95  128.75  864.02   133.7  864.06  138.65  864.03   143.6  863.88
  148.55  863.71  153.51  863.55  158.46  863.43  163.41  863.41  168.36  863.46
  173.31   863.5  178.27  863.42  183.22  863.01  188.17  862.36  193.12  861.44
  198.07  860.58  203.02  859.76  207.98  858.84  212.93  857.92  217.88  857.08
  222.83  856.62  227.78  856.22  244.63  856.01  266.74  855.74  292.53   855.5
  327.16  855.16  344.11  855.01  372.11  854.74  379.79   854.7  416.25  854.64
  420.68  853.22  422.89  852.15  429.64  850.54  456.55  849.02  483.45  850.54
  488.47  852.29  492.89  853.51  496.84  854.64  505.02   855.1  509.96  854.96
   514.9  855.17  519.83  855.25  524.77  855.14  529.71  854.85  539.59  854.94
  544.52  855.08  549.46  855.01   554.4  854.85  559.34  855.07  564.28  855.36
  569.21  855.54  574.15  855.94  579.09  856.53  584.03  857.05  588.97  857.67
   593.9  858.09  598.84   858.5  603.78  858.97  608.72  859.47  613.66   860.1
  618.59  861.05  623.53  862.25   630.8  862.92  633.41  863.13  638.35  863.35
  643.28   863.6  648.87  863.81  654.41  863.94  662.01  864.11  671.24  864.24
  693.21   864.6

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08  416.25     .04  496.84     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        416.25  496.84            85.25   86.59   74.13             .1       .3

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 947.9219
```

```
INPUT
Description: Survey Channel
Station Elevation Data    num=     121
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     -10  864.88   -5.03  864.81    -.06  864.95    4.91  864.81    9.89  864.53
   14.86  864.23   19.83  864.04    24.8  863.98   29.77  863.97   34.74  863.92
   39.72   863.9   44.69  863.87   49.66  863.68   54.63  863.48    59.6  863.39
   64.57  863.35   69.55  863.31   74.52  863.27   79.49  863.22   84.46  863.16
   89.43  863.11    94.4  863.02   99.38  862.89  104.35  862.97  109.32  862.89
  114.29  862.44  119.26  862.02  124.23     862  129.21  861.89  134.18  861.02
  139.15  860.56  144.12   860.2  149.09  859.92  154.06  859.34  159.04  858.82
  164.01  858.38  168.98  857.85  173.95  857.37  188.86  855.87  193.84  855.43
  198.81  855.16  203.78  854.89  208.75   854.5  213.72  854.07  218.69  853.91
  223.67  853.86  228.64   853.6  233.61  853.26  238.58  852.99  243.55  853.12
  248.52   853.1   253.5  853.03  258.47  852.93  263.44  852.88  268.41  853.11
  273.38  853.34  278.35  853.38  283.33  853.33   288.3  853.36  293.27  853.54
  298.24  853.74  303.21  853.79  308.18  853.84  313.16  853.92  318.13     854
   323.1  854.21  328.07  854.47  333.04  854.72  338.01  854.85  342.99  854.89
  347.96  854.95  352.93  854.94   357.9  854.98  362.87  854.96  367.84  854.85
  372.81  854.93  377.79  855.02  382.76     855     404  855.33     421  855.14
  424.75  852.62  435.35  851.75  448.55     849  469.45  849.68  489.15  850.52
  496.39   852.1  501.59   854.1  524.19  854.73  525.77  856.15  530.65  856.44
  535.54  856.72  540.43  857.06  545.31  857.33   550.2  857.65  555.09  858.56
  559.97  859.24  564.86  859.78  569.75  860.15  574.63  860.59  579.52   861.1
  584.41  861.58  589.29  862.05  594.18  862.72  599.07  863.03  603.95     863
  608.84  862.95  613.73   862.9  618.61  862.87   623.5  862.84  628.39  862.81
  633.27  862.78  638.16  862.82  643.05  862.92  647.93  863.06  652.82  863.25
  657.71  863.46  662.59  863.66  667.48  863.88  672.37  864.48  677.25  864.89
  682.14  865.34

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     -10     .08     421     .04  501.59     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
           421  501.59          239.821  255.14 271.224             .1       .3
Blocked Obstructions     num=       4
```

```
   Sta L   Sta R    Elev   Sta L   Sta R    Elev   Sta L   Sta R    Elev
  399.61  402.61  858.84  440.45  443.45   858.9   448.3   449.3  858.79
  487.07  490.07  859.01

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 682.81

INPUT
Description:
Station Elevation Data    num=      30
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     -52     865      -4     853       0  852.32   46.27  850.98   93.46  850.77
  136.75   850.4  158.34  850.46  191.97  850.56  246.71  850.66  303.56  851.36
  337.28  852.13  361.54  852.67  380.06  853.61  396.96  855.64  414.82  856.52
  431.72  855.86  435.68  852.81  467.95  848.78   508.4  852.98  509.61   854.7
  536.97  858.29  572.28  860.65  613.66  864.36  647.51  866.15  735.51  864.06
  747.59  864.86  789.84  863.76  857.65  886.47  877.68  883.79  959.45   900.8

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     -52     .08  431.72     .04  509.61     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        431.72  509.61           565.25  350.28  612.84             .1       .3

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 342.5338

INPUT
Description: Interpolated Channel
Station Elevation Data    num=     116
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
```

```
       0  865.76    4.99  865.66    9.98  865.34   14.97  864.89   19.96  864.41
   24.95  863.35   29.94  861.94   34.93  860.63   39.92  860.25   44.91   860.2
    49.9  860.11   54.89  860.01   59.88  859.96   64.87   859.9   69.86  859.86
   74.85  859.83   79.84  859.78   84.83  859.42   89.81  858.34    94.8   857.2
   99.79  856.15  104.78  855.19  109.77  854.31  114.76  853.51  119.75   852.2
  124.74  851.17  129.73   850.7  134.72  850.44  139.71  850.39   144.7  850.38
  154.68  850.37  164.66  850.35  169.65  850.34  174.64  850.33  184.62  850.32
   194.6   850.3  199.59  850.29  204.58  850.28  214.56  850.27  219.55  850.26
  224.54  850.25  234.52  850.23   244.5  850.22  249.49  850.21  254.48   850.2
  259.47  850.19  264.46  850.18  269.44  850.17  284.41  850.18  294.39  850.19
  304.37   850.2  314.35  850.21  324.33  850.22  334.31  850.23   339.3  850.24
  359.26  850.26  369.24  850.27  374.23  850.28  384.21  850.29  404.17  850.31
  414.15  850.32  419.14  850.33  429.12  850.34   439.1  850.35  449.08  850.36
  454.06  850.37  464.04  850.38  474.02  850.39     484   850.4  683.61  850.42
   688.6  851.78  693.49   853.3  698.51  853.46  703.54  853.27  708.26  852.43
  716.98  849.76  743.89  848.24  787.44  848.27  806.18  849.36  826.06  852.14
  839.06  853.46  845.57  854.57  848.48  855.34  853.48  856.78  858.48  858.25
  863.47  859.82  868.47  861.53  873.47  863.32  878.46   865.2  883.46  867.11
  888.45  869.12  893.45  871.23  898.45  872.42  903.44  873.23  908.44  873.89
  913.44  874.43  918.43  874.99  923.43  875.45  928.43  875.95  933.42  876.21
  938.42  876.39  943.41  876.62  948.41   876.9  953.41  877.23   958.4  877.32
   963.4  877.57   968.4  877.86  973.39  878.28  978.39   878.7  983.38  879.12
  988.38  879.46  993.38  879.81  998.37  880.16 1003.37  880.51 1008.37  880.82
 1013.36   881.2

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08  703.54     .04  839.06     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        703.54  839.06           123.65  342.53   84.21             .1       .3


SUMMARY OF MANNING'S N VALUES

River:Willeo Creek
```

Reach	River Sta.	n1	n2	n3
Willeo Creek	11553.10	.08	.04	.08
Willeo Creek	11030.43	.08	.04	.08
Willeo Creek	9759.109	.08	.04	.08
Willeo Creek	8872.189	.08	.04	.08
Willeo Creek	8133.710	.08	.04	.08
Willeo Creek	7394.653	.08	.04	.08
Willeo Creek	7308.132	.08	.04	.08
Willeo Creek	7241.553	Bridge		
Willeo Creek	7153.706	.08	.04	.08
Willeo Creek	6563.108	.08	.04	.08
Willeo Creek	5618.333	.08	.04	.08
Willeo Creek	4364.004	.08	.04	.08
Willeo Creek	3532.729	.08	.04	.08
Willeo Creek	2562.879	.08	.04	.08
Willeo Creek	1410.406	.08	.04	.08
Willeo Creek	1220.68	.08	.04	.08
Willeo Creek	1034.509	.08	.04	.08
Willeo Creek	947.9219	.08	.04	.08
Willeo Creek	682.81	.08	.04	.08
Willeo Creek	342.5338	.08	.04	.08

SUMMARY OF REACH LENGTHS

River: Willeo Creek

Reach	River Sta.	Left	Channel	Right
Willeo Creek	11553.10	374.92	522.66	721.63
Willeo Creek	11030.43	1257.53	1271.33	1073.77
Willeo Creek	9759.109	845.18	886.92	691.75
Willeo Creek	8872.189	685.38	738.48	753.66
Willeo Creek	8133.710	722.72	739.06	722.47
Willeo Creek	7394.653	108.041	86.521	93.401

Willeo Creek	7308.132	144.84	154.43	146.12
Willeo Creek	7241.553	Bridge		
Willeo Creek	7153.706	548.29	590.6	540.85
Willeo Creek	6563.108	625.09	944.78	683.16
Willeo Creek	5618.333	1062.51	1254.33	1205.75
Willeo Creek	4364.004	845.72	831.28	721.08
Willeo Creek	3532.729	941.58	969.85	917.32
Willeo Creek	2562.879	1302.97	1152.473	1152.473
Willeo Creek	1410.406	73.739	189.731	180.653
Willeo Creek	1220.68	176.17	186.17	195.25
Willeo Creek	1034.509	85.25	86.59	74.13
Willeo Creek	947.9219	239.821	255.14	271.224
Willeo Creek	682.81	565.25	350.28	612.84
Willeo Creek	342.5338	123.65	342.53	84.21

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: Willeo Creek

Reach	River Sta.	Contr.	Expan.
Willeo Creek	11553.10	.1	.3
Willeo Creek	11030.43	.1	.3
Willeo Creek	9759.109	.1	.3
Willeo Creek	8872.189	.1	.3
Willeo Creek	8133.710	.1	.3
Willeo Creek	7394.653	.3	.5
Willeo Creek	7308.132	.3	.5
Willeo Creek	7241.553	Bridge	
Willeo Creek	7153.706	.3	.5
Willeo Creek	6563.108	.1	.3
Willeo Creek	5618.333	.1	.3
Willeo Creek	4364.004	.1	.3
Willeo Creek	3532.729	.1	.3
Willeo Creek	2562.879	.1	.3

```
 Willeo Creek         1410.406        .1        .3
 Willeo Creek         1220.68         .1        .3
 Willeo Creek         1034.509        .1        .3
 Willeo Creek         947.9219        .1        .3
 Willeo Creek         682.81          .1        .3
 Willeo Creek         342.5338        .1        .3


Profile Output Table - Standard Table 1

  Reach          River Sta                   Profile   Q Total   Min Ch El   W.S. Elev   Crit W.S.
E.G. Elev   E.G. Slope   Vel Chnl   Flow Area   Top Width   Froude # Chl
                                                            (cfs)        (ft)        (ft)        (ft)
(ft)      (ft/ft)     (ft/s)     (sq ft)        (ft)

  Willeo Creek   11553.10 528                 2Year     1836.70      860.59      870.34
870.71     0.001434       4.90      391.02       83.41           0.33
  Willeo Creek   11553.10 528                 10Year    3443.00      860.59      872.07
872.84     0.002278       7.16      615.12      250.56           0.43

  Willeo Creek   11030.43 1905                2Year     1836.70      859.73      869.90      865.42
870.08     0.000870       3.50      675.03      301.01           0.25
  Willeo Creek   11030.43 1905                10Year    3443.00      859.73      871.87      867.29
872.04     0.000706       3.82     1726.93      574.24           0.24

  Willeo Creek   9759.109 1907                2Year     1836.70      858.77      868.70      864.23
868.92     0.000965       4.07      788.24      494.60           0.27
  Willeo Creek   9759.109 1907                10Year    3443.00      858.77      871.16      866.32
871.28     0.000519       3.63     2230.00      591.98           0.21

  Willeo Creek   8872.189 1882                2Year     1836.70      858.09      867.54
867.89     0.001390       4.80      393.28       88.20           0.32
  Willeo Creek   8872.189 1882                10Year    3443.00      858.09      869.95
870.51     0.001597       6.25      719.78      151.95           0.36

  Willeo Creek   8133.710 532                 2Year     1836.70      857.16      866.42
866.78     0.001632       4.96      480.56      182.29           0.34
```

```
  Willeo Creek   8133.710 532                10Year    3443.00      857.16      869.04
869.41     0.001269       5.47     1026.12      226.99           0.32

  Willeo Creek   7394.653 1327               2Year     1836.70      856.37      864.57
865.18     0.002935       6.23      295.53       55.34           0.45
  Willeo Creek   7394.653 1327               10Year    3443.00      856.37      868.21
868.52     0.001105       5.26     1325.26      405.92           0.30

  Willeo Creek   7308.132 864                2Year     1645.40      856.16      864.52      860.68
864.87     0.001462       4.77      348.65       58.24           0.33
  Willeo Creek   7308.132 864                10Year    4024.00      856.16      867.09      863.64
868.15     0.002844       8.29      513.40       70.34           0.48

  Willeo Creek   7241.553 354                            Bridge

  Willeo Creek   7153.706 865                2Year     1645.40      856.15      863.51      860.63
863.97     0.002405       5.43      304.73       62.10           0.41
  Willeo Creek   7153.706 865                10Year    4024.00      856.15      866.39      863.54
867.45     0.003302       8.41      546.77      117.97           0.51

  Willeo Creek   6563.108 1881               2Year     1645.40      854.71      862.61
862.88     0.001248       4.19      392.70       63.80           0.30
  Willeo Creek   6563.108 1881               10Year    4024.00      854.71      865.99
866.19     0.000791       4.34     1959.91      580.50           0.25

  Willeo Creek   5618.333 3990               2Year     1645.40      852.63      861.17      857.26
861.54     0.001616       4.87      347.45      102.48           0.34
  Willeo Creek   5618.333 3990               10Year    4024.00      852.63      865.47      860.32
865.62     0.000568       4.04     2387.47      621.37           0.22

  Willeo Creek   4364.004 1385               2Year     1267.20      851.63      859.61
859.83     0.001048       3.73      340.19       62.03           0.27
  Willeo Creek   4364.004 1385               10Year    4159.00      851.63      863.82
864.46     0.001598       6.64      825.26      192.30           0.37

  Willeo Creek   3532.729 1384               2Year     1267.20      851.04      858.61      854.97
858.86     0.001300       3.98      318.09      101.03           0.30
```

```
  Willeo Creek   3532.729 1384                10Year    4159.00      851.04      862.91      858.59
863.28     0.001145       5.52     1290.14      282.07           0.31

  Willeo Creek   2562.879 1382                2Year     1267.20      849.83      857.30
857.56     0.001376       4.09      311.88       69.06           0.31
  Willeo Creek   2562.879 1382                10Year    4159.00      849.83      860.83
861.68     0.002442       7.63      686.71      145.59           0.45

  Willeo Creek   1410.406 538                 2Year     1267.20      849.55      855.48
855.75     0.001821       4.13      331.80      201.58           0.35
  Willeo Creek   1410.406 538                 10Year    4159.00      849.55      857.70
858.35     0.003311       7.17     1065.86      498.84           0.50

  Willeo Creek   1220.68                      2Year     1267.20      850.25      855.41
855.49     0.000677       2.29      578.14      176.88           0.21
  Willeo Creek   1220.68                      10Year    4159.00      850.25      857.51
857.83     0.001594       4.62      999.79      217.75           0.35

  Willeo Creek   1034.509 868                 2Year     1738.50      849.02      854.75
855.19     0.003269       5.33      329.09      127.38           0.47
  Willeo Creek   1034.509 868                 10Year    4145.00      849.02      856.40      855.56
857.30     0.004712       8.05      776.69      352.49           0.59

  Willeo Creek   947.9219 869                 2Year     1738.50      849.02      853.95      853.31
854.69     0.010833       7.04      290.85      168.67           0.68
  Willeo Creek   947.9219 869                 10Year    4145.00      849.02      855.56      855.56
856.65     0.012943       9.30      680.51      322.75           0.75

  Willeo Creek   682.81                       2Year     1738.50      848.78      852.98
853.07     0.003508       3.62      855.72      444.30           0.44
  Willeo Creek   682.81                       10Year    4145.00      848.78      854.59
854.74     0.002791       4.55     1599.92      474.70           0.42

  Willeo Creek   342.5338 1381                2Year     1738.50      848.24      852.32      850.94
852.36     0.000779       2.22     1494.12      690.32           0.22
  Willeo Creek   342.5338 1381                10Year    4145.00      848.24      853.99      851.61
854.06     0.000779       2.76     2682.87      730.46           0.23
```

Profile Output Table - Standard Table 2

Reach	River Sta	Profile	E.G. Elev (ft)	W.S. Elev (ft)	Vel Head (ft)	Frctn Loss (ft)	C & E Loss (ft)	Q Left (cfs)	Q Channel (cfs)	Q Right (cfs)	Top Width (ft)
Willeo Creek	11553.10 528	2Year	870.71	870.34	0.37	0.58	0.06	1.74	1827.21	7.76	83.41
Willeo Creek	11553.10 528	10Year	872.84	872.07	0.77	0.63	0.18	39.71	3325.90	77.39	250.56
Willeo Creek	11030.43 1905	2Year	870.08	869.90	0.18	1.15	0.00	0.18	1735.15	101.37	301.01
Willeo Creek	11030.43 1905	10Year	872.04	871.87	0.17	0.74	0.02	236.92	2530.54	675.54	574.24
Willeo Creek	9759.109 1907	2Year	868.92	868.70	0.22	1.01	0.01	172.37	1569.67	94.66	494.60
Willeo Creek	9759.109 1907	10Year	871.28	871.16	0.12	0.72	0.04	904.57	1875.64	662.79	591.98
Willeo Creek	8872.189 1882	2Year	867.89	867.54	0.36	1.11	0.00	0.29	1832.44	3.97	88.20
Willeo Creek	8872.189 1882	10Year	870.51	869.95	0.56	1.05	0.06	112.28	3186.53	144.19	151.95
Willeo Creek	8133.710 532	2Year	866.78	866.42	0.36	1.58	0.02	0.01	1737.21	99.48	182.29
Willeo Creek	8133.710 532	10Year	869.41	869.04	0.37	0.87	0.02	38.33	2679.15	725.52	226.99
Willeo Creek	7394.653 1327	2Year	865.18	864.57	0.60	0.18	0.12	0.04	1836.54	0.13	55.34
Willeo Creek	7394.653 1327	10Year	868.52	868.21	0.32	0.15	0.22	702.81	2507.94	232.25	405.92

```
  Willeo Creek   7308.132 864                2Year        864.87      864.52       0.35          0.04
0.04      0.79     1643.26      1.35       58.24
  Willeo Creek   7308.132 864                10Year       868.15      867.09       1.06
23.55     3975.67     24.78       70.34

  Willeo Creek   7241.553 354                             Bridge

  Willeo Creek   7153.706 865                2Year        863.97      863.51       0.46          1.00
0.09               1644.84      0.56       62.10
  Willeo Creek   7153.706 865                10Year       867.45      866.39       1.06          0.83
0.43     12.26     3896.71    115.03      117.97

  Willeo Creek   6563.108 1881               2Year        862.88      862.61       0.27          1.34
0.01               1645.40                 63.80
  Willeo Creek   6563.108 1881               10Year       866.19      865.99       0.20          0.56
0.01      2.23     2661.58   1360.20      580.50

  Willeo Creek   5618.333 3990               2Year        861.54      861.17       0.37          1.66
0.05      1.87     1642.85      0.68      102.48
  Willeo Creek   5618.333 3990               10Year       865.62      865.47       0.15          1.11
0.05    632.75     2259.36   1131.90      621.37

  Willeo Creek   4364.004 1385               2Year        859.83      859.61       0.22          0.97
0.00      0.03     1267.14      0.03       62.03
  Willeo Creek   4364.004 1385               10Year       864.46      863.82       0.64          1.10
0.08     92.30     3898.83    167.88      192.30

  Willeo Creek   3532.729 1384               2Year        858.86      858.61       0.25          1.30
0.00               1267.19      0.01      101.03
  Willeo Creek   3532.729 1384               10Year       863.28      862.91       0.37          1.55
0.05    117.22     3156.19    885.59      282.07

  Willeo Creek   2562.879 1382               2Year        857.56      857.30       0.26          1.82
0.00      0.62     1266.57      0.01       69.06
  Willeo Creek   2562.879 1382               10Year       861.68      860.83       0.85          3.27
0.06    240.21     3907.95     10.84      145.59
```

```
  Willeo Creek   1410.406 538                2Year        855.75      855.48       0.26          0.20
0.05               1259.60      7.60      201.58
  Willeo Creek   1410.406 538                10Year       858.35      857.70       0.65          0.41
0.10     11.59     3354.43    792.97      498.84

  Willeo Creek   1220.68                    2Year        855.49      855.41       0.08          0.27
0.04     16.75     1250.45                176.88
  Willeo Creek   1220.68                    10Year       857.83      857.51       0.32          0.47
0.06    164.00     3995.00                217.75

  Willeo Creek   1034.509 868               2Year        855.19      854.75       0.44          0.47
0.03      0.53     1737.95      0.02      127.38
  Willeo Creek   1034.509 868               10Year       857.30      856.40       0.90          0.63
0.02    297.16     3695.87    151.98      352.49

  Willeo Creek   947.9219 869               2Year        854.69      853.95       0.74          1.42
0.19     70.67     1667.83                168.67
  Willeo Creek   947.9219 869               10Year       856.65      855.56       1.09          1.29
0.28    788.79     3297.02     59.19      322.75

  Willeo Creek   682.81                     2Year        853.07      852.98       0.10          0.69
0.02   1176.45      562.06                444.30
  Willeo Creek   682.81                     10Year       854.74      854.59       0.15          0.65
0.03   2893.32     1251.68                474.70

  Willeo Creek   342.5338 1381              2Year        852.36      852.32       0.04
908.85      829.65                690.32
  Willeo Creek   342.5338 1381              10Year       854.06      853.99       0.06
2510.27     1634.55      0.18      730.46


Profile Output Table - Six XS Bridge

  Reach          River Sta                        Profile   E.G. Elev   W.S. Elev   Crit W.S.   Frctn
Loss   C & E Loss   Top Width   Q Left   Q Channel   Q Right   Vel Chnl
                                                                (ft)        (ft)        (ft)
(ft)         (ft)        (ft)    (cfs)       (cfs)     (cfs)     (ft/s)
```

```
  Willeo Creek   7394.653 1327                    2Year        865.18      864.57
0.18         0.12       55.34     0.04     1836.54      0.13       6.23
  Willeo Creek   7394.653 1327                    10Year       868.52      868.21
0.15         0.22      405.92   702.81     2507.94    232.25       5.26

  Willeo Creek   7308.132 864                     2Year        864.87      864.52      860.68
0.04         0.04       58.24     0.79     1643.26      1.35       4.77
  Willeo Creek   7308.132 864                     10Year       868.15      867.09      863.64
70.34    23.55     3975.67     24.78       8.29

  Willeo Creek   7241.553 354             BR U   2Year        864.79      864.30      860.71
0.29         0.14       46.35              1644.30      1.10       5.64
  Willeo Creek   7241.553 354             BR U   10Year       868.05      866.40      864.04
54.56     0.00     4001.37     22.63      10.32

  Willeo Creek   7241.553 354             BR D   2Year        864.36      863.41      861.79
0.15         0.25       45.61              1645.24      0.16       7.82
  Willeo Creek   7241.553 354             BR D   10Year       868.15      865.15      865.15
53.80              3990.93     33.07      13.95

  Willeo Creek   7153.706 865                     2Year        863.97      863.51      860.63
1.00         0.09       62.10              1644.84      0.56       5.43
  Willeo Creek   7153.706 865                     10Year       867.45      866.39      863.54
0.83         0.43      117.97    12.26     3896.71    115.03       8.41

  Willeo Creek   6563.108 1881                    2Year        862.88      862.61
1.34         0.01       63.80              1645.40                 4.19
  Willeo Creek   6563.108 1881                    10Year       866.19      865.99
0.56         0.01      580.50     2.23     2661.58   1360.20       4.34


Profile Output Table - Bridge Only

  Reach          River Sta                    Profile   E.G. US.   Min El Prs   BR Open Area   Prs O WS
Q Total   Min El Weir Flow   Q Weir   Delta EG   BR Sluice Coef
                                                          (ft)         (ft)        (sq ft)        (ft)
(cfs)               (ft)    (cfs)       (ft)
```

```
  Willeo Creek   7241.553 354                2Year       864.87       879.70        1297.99
1645.40             877.34                0.91
  Willeo Creek   7241.553 354                10Year      868.15       879.70        1297.99
4024.00             877.34                0.70
```

Appendix F.2 – Existing Conditions HEC-RAS Models

```
                    HEC-RAS HEC-RAS 5.0.7 March 2019
                      U.S. Army Corps of Engineers
                     Hydrologic Engineering Center
                           609 Second Street
                           Davis, California


          X     X  XXXXXX    XXXX        XXXX       XX      XXXX
          X     X  X        X    X       X   X     X  X    X
          X     X  X        X            X   X    X    X   X
          XXXXXXX  XXXX     X       XXX  XXXX     XXXXXX    XXXX
          X     X  X        X            X  X     X    X        X
          X     X  X        X    X       X   X    X    X        X
          X     X  XXXXXX    XXXX        X    X   X    X   XXXXX



PROJECT DATA
Project Title: WilleoCr
Project File : WilleoCr.prj
Run Date and Time: 8/30/2019 1:01:06 PM

Project in English units

Project Description:
Cobb County, Georgia, Willeo Creek Detailed Hydraulics Study, November, 2010,
submitted by Dewberry.



PLAN DATA

Plan Title: FloodWay_Existing
Plan File : g:\19180\Hydrology\Bridge Hydraulics\HEC-
RAS_Models\WilleoCreek\WilleoCr_HECRAS\WilleoCr.p10
```

```
           Geometry Title: Existing
           Geometry File : g:\19180\Hydrology\Bridge Hydraulics\HEC-
RAS_Models\WilleoCreek\WilleoCr_HECRAS\WilleoCr.g04

           Flow Title    : Floodway_Truncated
           Flow File     : g:\19180\Hydrology\Bridge Hydraulics\HEC-
RAS_Models\WilleoCreek\WilleoCr_HECRAS\WilleoCr.f07

Plan Summary Information:
Number of:  Cross Sections =   19    Multiple Openings  =    0
            Culverts       =    0    Inline Structures  =    0
            Bridges        =    2    Lateral Structures =    0

Computational Information
    Water surface calculation tolerance  =  0.01
    Critical depth calculation tolerance =  0.01
    Maximum number of iterations         =  20
    Maximum difference tolerance         =  0.3
    Flow tolerance factor                =  0.001

Computation Options
    Critical depth computed only where necessary
    Conveyance Calculation Method: At breaks in n values only
    Friction Slope Method:         Average Conveyance
    Computational Flow Regime:     Subcritical Flow

Encroachment Data
   Equal Conveyance = True
   Left Offset      =        0
   Right Offset     =        0

River = Willeo Creek     Reach = Willeo Creek
RS      Profile           Method  Value1  Value2
11553.10Floodway               1  111.55  323.79
11030.43Floodway               1  215.65  524.94
9759.109Floodway               1  194.94  560.25
8872.189Floodway               1  204.53  356.67
```

```
8133.710Floodway                1   64.24  263.06
7394.653Floodway                1  246.91  594.31
7308.132Floodway                1   189.9  294.75
7153.706Floodway                1  177.82  275.22
6563.108Floodway                1  531.85  952.19
5618.333Floodway                1  720.13 1066.62
4364.004Floodway                1  164.81  331.13
3532.729Floodway                1  163.23  390.84
2562.879Floodway                1  166.43  323.21
1410.406Floodway                1  122.12  689.73
1220.68 Floodway                1  237.85  549.96
1034.509Floodway                1  207.98   602.5
947.9219Floodway                1  358.15  540.39
682.81  Floodway                1  349.44  493.47
342.5338Floodway                1  196.68  839.06
```

FLOW DATA

Flow Title: Floodway_Truncated
Flow File : g:\19180\Hydrology\Bridge Hydraulics\HEC-RAS_Models\WilleoCreek\WilleoCr_HECRAS\WilleoCr.f07

Flow Data (cfs)

River	Reach	RS	EX_100Year	Floodway
Willeo Creek	Willeo Creek	11553.10	5958	5958
Willeo Creek	Willeo Creek	7308.132	7482	7482
Willeo Creek	Willeo Creek	4364.004	7707	7707
Willeo Creek	Willeo Creek	1034.509	7699	7699

Boundary Conditions

River	Reach	Profile	Upstream	Downstream

```
  Willeo Creek    Willeo Creek    EX_100Year                                    Normal S = 0.0007786
  Willeo Creek    Willeo Creek    Floodway                                      Normal S = 0.0007786
```

GEOMETRY DATA

Geometry Title: Existing
Geometry File : g:\19180\Hydrology\Bridge Hydraulics\HEC-RAS_Models\WilleoCreek\WilleoCr_HECRAS\WilleoCr.g04

CROSS SECTION

RIVER: Willeo Creek
REACH: Willeo Creek RS: 11553.10

INPUT
Description: Interpolated Channel
Station Elevation Data num= 75

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	883.72	4.95	883.04	9.9	882.29	14.84	881.46	19.79	880.58
24.74	879.69	29.69	878.79	34.64	877.93	39.59	877.22	44.53	876.75
49.48	876.53	54.43	876.23	59.38	875.5	64.33	874.59	69.28	873.61
74.22	872.66	79.17	872.06	84.12	872	96.63	871.97	108.63	871.97
118.76	871.93	123.71	871.84	128.66	871.76	133.6	871.67	138.55	871.6
143.5	871.56	148.45	871.53	153.4	871.5	158.35	871.47	163.29	871.43
168.24	871.38	173.19	871.32	181.49	870.68	194.32	869.44	197.17	867.97
210.4	861.79	224.45	860.59	237.88	862.08	247.45	868.98	275.58	870.81
288.8	871.33	308.21	871.91	325.26	872.02	338.53	872.18	350.53	872.35
358.93	872.36	363.88	873.67	368.84	874.99	373.79	876.26	378.74	877.58
383.7	878.94	388.65	879.93	393.6	880.34	398.56	880.67	403.51	881.03
408.47	881.39	413.42	881.72	418.37	882.08	423.33	882.52	428.28	883.06
433.24	883.69	438.19	884.62	443.14	885.97	448.1	887.29	453.05	888.74
458	890.02	462.96	890.69	467.91	891.35	472.87	892.04	477.82	892.7
482.77	893.34	487.73	893.99	492.68	894.54	497.64	894.97	502.59	895.33

```
Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08  194.32     .04  247.45     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        194.32  247.45           374.92  522.66  721.63             .1       .3

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 11030.43

INPUT
Description: Interpolated Channel
Station Elevation Data    num=     135
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  895.69       5  894.88    9.99  893.42   14.99  891.64   19.99  889.69
   24.99  888.84   29.98  888.67   34.98   888.6   39.98  888.51   44.98  888.42
   49.97  888.33   54.97  888.23   59.97  888.15   64.97  888.04   69.96  887.96
   74.96  887.85   79.96  887.76   84.96  885.42   89.95  879.89   94.95  877.66
   99.95  875.41  104.94  873.18  109.94  871.71  114.94   871.1  119.94  870.74
  124.93  870.58  129.93  870.46  134.93  870.35  139.93  870.27  144.92  870.23
  149.92  870.21  159.92  870.19  164.91  870.18  174.91  870.16   179.9  870.15
   194.9  870.12  199.89  870.11  204.89   870.1  209.89  870.09  214.89  870.08
  219.88  870.07  229.88  870.05  239.87  870.07  244.87  870.11  249.87  870.15
  254.87  870.19  259.86  870.25  264.86  870.31  269.86  870.39  274.85  870.46
  279.85  870.53  284.85  870.61  289.85  870.68  294.84   870.7  325.98  869.96
   333.7  869.56  365.89  861.13  376.89  859.73  387.89  861.13  418.07  869.33
  425.79  869.58  432.34  869.36  437.29  869.31  442.24  869.27  447.19  869.22
  452.14  869.18  457.09  869.14  462.04  869.09  466.99  869.05  471.94  869.01
   476.9  868.97  481.85  868.92   486.8  868.85  491.75  868.77   496.7   868.7
  501.65  868.64   506.6  868.58  511.55  868.53   516.5  868.48   526.4   868.4
  531.35  868.35   536.3  868.31  541.26  868.29  546.21  868.32  551.16  868.36
  556.11   868.4  561.06  868.45  566.01  868.53  570.96  868.64  575.91  868.87
  580.86  869.33  585.81  869.79  590.76  870.24  595.71  870.61  600.66  870.56
  605.61  870.42  610.57  870.28  615.52  870.14  620.47     870  625.42  869.86
  630.37  869.54  635.32  868.64  640.27  867.97  645.22  868.22  650.17  868.83
```

```
  655.12  869.27  660.07   869.6  665.02  869.87  669.97  870.17  674.92  870.45
  679.88  870.83  684.83  872.19  689.78  873.52  694.73  874.88  699.68  876.21
  704.63  877.15  709.58  878.01  714.53   878.8  719.48  879.51  724.43  880.21
  729.38  881.04  734.33  881.97  739.28  883.31  744.24  885.33  749.19  887.97
  754.14  891.27  759.09  894.72  764.04  898.21  768.99  901.51  773.94  903.47
  778.89  904.62  783.84  905.73  788.79  906.86  793.74  907.96  798.69  909.44

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08   333.7     .04  418.07     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         333.7  418.07          1257.53 1271.33 1073.77             .1       .3
Ineffective Flow     num=       1
   Sta L   Sta R    Elev  Permanent
  610.53  798.69  870.38       F

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 9759.109

INPUT
Description: Interpolated Channel
Station Elevation Data    num=      97
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -38.01  887.23  -14.12   882.8    4.99  879.95    9.98  879.19   14.97  878.43
   19.96  877.76   24.95  877.11   29.94  876.47   34.93  875.81   39.92   875.2
   44.91  874.56    49.9  873.95   54.89  873.24   59.88  872.64   64.87  872.04
   69.86  871.58   74.85   871.2   79.84  870.87   84.83  870.53   89.82  870.21
   94.81  870.02    99.8     870  104.79  869.98  109.78  869.88  114.77  869.72
  119.76   869.6  124.75  869.55  129.75  869.31  134.74  868.63  139.73   868.1
  144.72  867.81  149.71  867.58   154.7  867.39  159.69  867.22  164.68  867.12
  169.67  867.02  174.66  866.92  179.65  866.91  184.64  867.05  189.63  867.23
  194.62  867.42  199.61   867.6   204.6  867.79  209.59  867.98  214.58  868.19
  219.57  868.51  224.56  868.84  229.55  868.67  234.54  867.69  239.53     867
   254.5  867.01  259.49  867.02  289.43  867.03   334.2  867.02  348.76  867.01
```

```
  358.46     867  367.56  867.94  376.89  860.93   394.2  858.77  411.49  860.93
  420.83  867.94  481.05  867.78  544.63  867.78  549.61  867.81   554.6  867.82
  559.58  867.85  564.56  867.86  569.55  867.84  579.51  867.77  584.49  867.73
  589.48   867.8  594.46  867.82  599.44  867.84  604.43  867.86  609.41  867.88
  614.39  867.89  619.38  867.91  624.36  867.94  629.34   868.1  634.33  868.58
  639.31  869.22  644.29  869.83  649.28  870.11  654.26  870.27  659.24  870.38
  664.23  870.48  669.21  871.55  674.19  873.52  679.18  875.83  684.16  878.16
  689.14  880.57  694.12  883.15  699.11  885.73  704.09  887.74  709.07  888.46
  714.06  889.38  719.04  890.48

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -38.01     .08  367.56     .04  420.83     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        367.56  420.83           845.18  886.92  691.75             .1       .3
Ineffective Flow     num=       1
   Sta L   Sta R    Elev  Permanent
  -38.01   227.4  868.74       F

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 8872.189

INPUT
Description: Survey Channel
Station Elevation Data    num=      89
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  885.31    4.89  882.64    9.77  882.25   14.66  881.96   19.55   881.8
   24.44  881.89   29.32  881.76   34.21   881.6    39.1  881.41   43.98  881.21
   48.87  881.13   53.76  881.39   58.65  881.81   63.53  882.15   68.42  882.43
   73.31  882.68   78.19  882.94   83.08  883.19   87.97  883.42   92.86  883.63
   97.71  883.85  102.55   884.1  112.25   884.6   117.1  884.83  121.95  884.51
   126.8   882.3  131.65  880.17   136.5   878.2  141.35  876.44   146.2  875.47
  151.05  875.05   155.9  874.57  160.75  874.14   165.6  873.77  170.45  873.58
   175.3  873.41  180.15  873.22     185  873.04  189.85  872.87   194.7  872.69
```

```
  199.55  872.52   204.4  872.34  209.25   872.2   214.1     872  218.94  870.86
  223.79  869.57  228.64  868.25   269.5  867.26   282.8  860.25  292.14  858.09
   303.7  858.49   314.8  858.66   317.4  859.22  322.74  866.68  354.39  867.83
  359.28     868  364.17  868.22  369.06  868.81  373.95  869.83  378.83  871.49
  383.72  873.55  388.61  875.55   393.5  877.39  398.39     879  403.28  880.38
  408.16  881.66  413.05  883.01  417.94  884.44  422.83  885.92  427.72  887.29
  432.61  888.48   437.5  889.56  442.38  890.68  447.27  891.83  452.16  893.05
  457.05  894.25  461.94  895.39  466.83  896.45  471.72  897.47   476.6  898.43
  481.49  899.45  486.38   900.4  491.27  901.29  496.16  902.18  501.05  903.05
  505.93  903.88  510.82  904.67  515.71  905.38   520.6  906.22

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08   269.5     .04  322.74     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         269.5  322.74           685.38  738.48  753.66             .1       .3

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 8133.710

INPUT
Description: Interpolated Channel
Station Elevation Data    num=      78
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  910.62    4.89  909.64    9.77  908.68   14.66  907.56   19.54  905.12
   24.43  900.87   29.32  896.53    34.2  892.29   39.09  888.08   43.97   883.8
   48.86  879.81   53.74  876.06   58.63  872.29   63.52  869.49    68.4  868.27
   73.29  867.47   78.17   866.9   83.06  866.56   87.95  866.33   97.29  859.32
  114.58  857.16  131.88  859.32  141.22  866.33  150.53  866.04  162.11  865.66
  170.04  865.29  179.58  865.21  184.34  865.17  189.11  865.13  193.87   865.1
  198.64  865.08  208.32  865.07  218.15  865.09  223.07  865.11  227.98  865.15
   232.9  865.18  237.82  865.21  242.73  865.24  247.65  865.27  252.57  865.29
  257.48   865.5   262.4   865.9  267.31  866.33  272.23  866.76  277.15  867.21
  282.06  867.78  286.98  868.47  291.89  869.01  296.81  869.35  301.73  869.64
```

```
  306.64  869.93  311.56  870.23  316.48  870.54  321.39  870.89  326.31  871.35
  331.22  871.97  336.14  872.67  341.06  873.41  345.97   874.2  350.89  874.98
   355.8  875.76  360.72  876.55  365.64  877.41  370.55  878.45  375.47   879.6
  380.39  880.83   385.3  882.06  390.22  883.29  395.13  884.53  400.05  885.78
  404.97  887.02  409.88  888.35   414.8  891.31  419.71  894.05  424.63  896.55
  429.55  897.02  434.46  897.05  439.38  897.21

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08   87.95     .04  141.22     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         87.95  141.22           722.72  739.06  722.47             .1       .3

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 7394.653

INPUT
Description: Interpolated Channel
Station Elevation Data    num=     126
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  882.25    4.91  881.86    9.81  881.74   14.72   881.7   19.63  881.86
   24.53  881.97   29.44  881.83   34.35  881.68   39.25  881.67   44.16  881.81
   49.06  881.87   53.97  882.16   58.88  882.53   63.78  881.87   68.69  881.26
    73.6  880.86    78.5  880.12   83.41   879.7   88.32  879.71   93.22  879.75
   98.13  879.38  103.04  879.02  107.94  878.72  112.85   878.5  117.75  878.23
  122.66  877.92  127.57  877.63  132.47  877.35  137.38  877.12  142.29  876.73
  147.25  876.04  152.21   875.2  157.17  874.35  162.12  873.54  167.08  872.72
  172.04  871.92     177  871.03  181.96  870.04  186.92  869.05  191.88  868.13
  196.84  867.39   201.8  866.88  206.76  866.55  211.72   866.4  266.28  866.36
  271.24  866.22  276.19  866.08  281.15  865.93  286.11  865.79  291.07  865.65
  300.99  865.37  310.91  865.42  315.87  865.48  320.83  865.53  325.79  865.59
  330.75  865.64  335.71   865.7  340.67  865.75  345.63  865.81  350.59   865.8
  355.55  865.74  360.51  865.63  365.47  865.52  370.43   865.4  375.39  865.29
  380.35  865.19   385.3  865.17  390.26  865.22  395.22  865.28  400.18  865.27
```

```
  405.14  865.32   410.1  865.38  415.06  865.42  420.02  865.46  424.98   865.5
  429.94  865.54  435.64  865.34  439.59  865.28  444.76  865.22  449.19  865.02
  453.63  864.67   455.6  864.35  463.33  858.53  480.64  856.37  497.93  858.53
  505.61  864.32  519.17  865.19  528.84   865.7  552.42   865.9  571.79   865.9
  579.77  866.27  586.25  866.42  591.17  867.14  596.08  867.98     601  868.82
  605.91  869.69  610.83  870.61  615.74  871.48  620.66  872.03  625.57  872.39
  630.48  872.82   635.4  873.26  640.31  873.67  645.23  874.05  650.14  874.32
  655.06  874.63  659.97  875.23  664.89  875.83   669.8  876.43  674.72  877.28
  679.63   878.2  684.54  880.14  689.46  882.31  694.37  884.71  699.29  887.21
   704.2  889.61  709.12  891.93  714.03  893.03  718.95   893.6  723.86  894.11
  728.78  894.48  733.69  894.94  738.61  895.43  743.52  895.91  748.43  896.25
  753.35  896.39

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08   455.6     .04  505.61     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         455.6  505.61          108.041  86.521  93.401             .3       .5

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 7308.132

INPUT
Description:
Station Elevation Data    num=     108
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  888.94    4.92  888.83    9.83  888.65   14.75  888.42   19.66  888.18
   24.58  887.96   29.49  887.75   34.41  887.35   39.32  887.12   44.24   887.1
   49.16  886.96   54.07  886.72   58.99  886.57    63.9  886.23   68.82  885.93
   73.73  885.62   78.65  885.26   83.56  885.03   88.48  884.85    93.4  884.79
   98.31  884.49  103.23   884.1  108.14  883.84  113.06   883.6  117.97  883.35
  122.89  883.14   127.8  882.93  132.72  882.63  137.64  882.38  142.55  881.47
  147.47   881.1  152.38   880.2   157.3  879.11  162.21  878.24  167.13  877.34
  172.04  876.74  176.96  876.15  181.88  875.33  186.79  874.03  191.71  871.96
```

```
  196.62  869.95  201.54  868.38  206.35  867.24  211.17  865.42  215.98  863.32
   220.8  861.34  225.61  859.52  229.22   857.8  230.43  857.22  235.25  856.23
  240.06  856.16   244.8  856.24  249.54  856.33  254.28  856.39  259.02  856.59
  263.76   858.3  268.45  862.93  273.13   865.4  277.82  867.41   282.5  869.21
  287.19  870.81  291.87  872.16  296.85   873.5  301.83  874.82   306.8  875.97
  311.78  876.57  316.76  876.34  321.74  876.11  326.72  875.85  331.69  875.92
  336.67  875.93  341.65     876  346.63  876.03   351.6  876.08  356.58  876.13
  361.56  876.16  366.54  876.23  371.51  876.24  376.49  876.31  381.47  876.32
  386.45  876.66  391.43  876.87   396.4  877.04  401.38     877  406.36  876.94
  411.34  876.89  416.31  876.83  421.29  876.77  426.27   876.7  431.25  876.64
  436.22  876.58   441.2  876.54  446.18  876.51  451.16  876.48  456.13  876.45
  461.11  876.43  466.09  876.41  471.07  876.39  476.05  876.38  481.02  876.36
     486   876.3  490.98  876.29  495.96   876.3  500.93  876.29  505.91  876.31
  510.89  876.29  515.87  876.28  520.84  876.26

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08  215.98     .04  268.45     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        215.98  268.45           144.84  154.43  146.12             .3       .5
Ineffective Flow     num=       2
   Sta L   Sta R    Elev  Permanent
       0     170     882       T
     320  520.84  877.33       T

BRIDGE


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 7241.553

INPUT
Description: Roswell Rd NE_ Marrietta  Hwy (94.5' Span Bridge)
Distance from Upstream XS =      24
Deck/Roadway Width        =      88
Weir Coefficient          =     2.6
Upstream  Deck/Roadway Coordinates
```

num= 26

Sta	Hi Cord	Lo Cord	Sta	Hi Cord	Lo Cord	Sta	Hi Cord	Lo Cord
0	885.29		4.94	885.11		9.87	884.96	
14.81	884.8		19.75	884.63		24.68	884.5	
29.62	884.39		34.56	884.23		39.49	883.98	
44.43	883.92		49.37	883.88		54.25	883.8	
156	883.29		198.7	882.2		200	882.2	
200	882.2	879.7	227.5	881.6	879.7	227.5	881.6	878.35
267	880.716	877.466	267	880.716	878.216	268.3	880.716	878.216
294.5	880.716	878.216	294.5	880.716		395.62	876.44	
400.51	876.33		401.55	876.23				

Upstream Bridge Cross Section Data
Station Elevation Data num= 108

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	888.94	4.92	888.83	9.83	888.65	14.75	888.42	19.66	888.18
24.58	887.96	29.49	887.75	34.41	887.35	39.32	887.12	44.24	887.1
49.16	886.96	54.07	886.72	58.99	886.57	63.9	886.23	68.82	885.93
73.73	885.62	78.65	885.26	83.56	885.03	88.48	884.85	93.4	884.79
98.31	884.49	103.23	884.1	108.14	883.84	113.06	883.6	117.97	883.35
122.89	883.14	127.8	882.93	132.72	882.63	137.64	882.38	142.55	881.47
147.47	881.1	152.38	880.2	157.3	879.11	162.21	878.24	167.13	877.34
172.04	876.74	176.96	876.15	181.88	875.33	186.79	874.03	191.71	871.96
196.62	869.95	201.54	868.38	206.35	867.24	211.17	865.42	215.98	863.32
220.8	861.34	225.61	859.52	229.22	857.8	230.43	857.22	235.25	856.23
240.06	856.16	244.8	856.24	249.54	856.33	254.28	856.39	259.02	856.59
263.76	858.3	268.45	862.93	273.13	865.4	277.82	867.41	282.5	869.21
287.19	870.81	291.87	872.16	296.85	873.5	301.83	874.82	306.8	875.97
311.78	876.57	316.76	876.34	321.74	876.11	326.72	875.85	331.69	875.92
336.67	875.93	341.65	876	346.63	876.03	351.6	876.08	356.58	876.13
361.56	876.16	366.54	876.23	371.51	876.24	376.49	876.31	381.47	876.32
386.45	876.66	391.43	876.87	396.4	877.04	401.38	877	406.36	876.94
411.34	876.89	416.31	876.83	421.29	876.77	426.27	876.7	431.25	876.64
436.22	876.58	441.2	876.54	446.18	876.51	451.16	876.48	456.13	876.45
461.11	876.43	466.09	876.41	471.07	876.39	476.05	876.38	481.02	876.36
486	876.3	490.98	876.29	495.96	876.3	500.93	876.29	505.91	876.31
510.89	876.29	515.87	876.28	520.84	876.26				

```
Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08  215.98    .035  268.45     .08

Bank Sta: Left   Right    Coeff Contr.   Expan.
        215.98  268.45             .3       .5
Ineffective Flow     num=       2
   Sta L   Sta R    Elev  Permanent
       0     170     882       T
     320  520.84  877.33       T

Downstream  Deck/Roadway Coordinates
    num=      26
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
       0  885.29            4.94  885.11            9.87  884.96
   14.81   884.8           19.75  884.63           24.68   884.5
   29.62  884.39           34.56  884.23           39.49  883.98
   44.43  883.92           49.37  883.88           54.25   883.8
     156  883.29           198.7   882.2             200   882.2
     200   882.2   879.7   227.5   881.6   879.7   227.5   881.6  878.35
     267 880.716 877.466     267 880.716 878.216   268.3 880.716 878.216
   294.5 880.716 878.216   294.5 880.716          395.62  876.44
  400.51  876.33          517.76  876.52

Downstream Bridge Cross Section Data
Station Elevation Data    num=     107
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     -80  890.68     -75   890.7  -70.01  890.41  -65.01  890.24  -60.02  890.01
  -55.02  889.69  -50.03  889.45  -45.03  889.25  -40.04  889.02  -35.04   888.8
  -30.05  888.59  -25.05  888.39  -20.05  888.17  -15.06  887.92  -10.06  887.73
   -5.07  887.52    -.07  887.24    4.92  886.75    9.92  886.06   14.91  885.82
   19.91  885.04   24.91  884.36    29.9  883.43    34.9  882.55   39.89  881.69
   44.89  880.84   49.88  879.99   54.88  879.15   59.87  878.33   64.87  877.51
   69.87  876.79   74.86  876.01   79.86  875.22   84.85  874.39   89.74  873.99
   94.63  873.58   99.52  873.15   104.4  872.63  109.29  871.97  114.18  871.24
  119.07  870.57  123.96   869.9  128.85  869.33  133.73  868.76  138.62  868.43
  143.51  868.03   148.4  867.38  158.09  867.07  165.04  866.83  170.93  866.66
  176.83  866.49  183.15  866.29  190.31  866.07  207.72  865.55  210.84  863.73
```

```
  219.72  856.99  222.44  856.15  236.74  856.47  246.34  856.37  250.94  857.11
  266.64  863.03  282.79  864.21  292.64  865.01  294.36  865.42  299.06  866.66
  303.03  867.89  307.77  868.86  312.77  869.34  317.77  869.71  322.77   870.1
  327.77  870.46  332.77  870.79  337.77  871.06  342.77  871.27  347.77  871.45
  352.77  871.63  357.77  871.81  362.77  871.99  367.77  872.17  372.77  872.35
  377.77   872.5  382.77  872.65  387.77  872.79  392.77  872.92  397.77  873.08
  402.77   873.2  407.77  873.29  412.77  873.54  417.76  873.84  422.76  874.07
  427.76  874.28  432.76  874.54  437.76  874.87  442.76  875.24  447.76  875.53
  452.76  875.79  457.76  875.98  462.76  876.16  467.76  876.52  472.76  876.66
  477.76  876.61  482.76   876.8  487.76     877  492.76  876.96  497.76  876.98
  502.76     877  552.76  876.98

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     -80     .08  210.84    .035  266.64     .08

Bank Sta: Left   Right    Coeff Contr.   Expan.
        210.84  266.64             .3       .5
Ineffective Flow     num=       2
   Sta L   Sta R    Elev  Permanent
     -80     140  876.33       F
     320  552.76  876.33       F

Upstream Embankment side slope              =       0 horiz. to 1.0 vertical
Downstream Embankment side slope            =       0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .98
Elevation at which weir flow begins         =
Energy head used in spillway design         =
Spillway height used in design              =
Weir crest shape                            = Broad Crested

Number of Abutments =  2

Abutment Data
Upstream     num=       2
     Sta    Elev     Sta    Elev
     200  875.28     230  858.54
Downstream     num=       2
```

```
     Sta    Elev     Sta    Elev
     200  875.28     230  858.54

Abutment Data
Upstream     num=       3
     Sta    Elev     Sta    Elev     Sta    Elev
   268.2  858.23   285.1   871.6   294.5   875.6
Downstream     num=       3
     Sta    Elev     Sta    Elev     Sta    Elev
   268.2  858.23   285.1   871.6   294.5   875.6

Number of Piers =  2

Pier Data
Pier Station     Upstream=     227    Downstream=     227
Upstream     num=       2
    Width   Elev    Width   Elev
     2.5     856     2.5   879.7
Downstream     num=       2
    Width   Elev    Width   Elev
     2.5     856     2.5   879.7

Pier Data
Pier Station     Upstream=     267    Downstream=     267
Upstream     num=       2
    Width   Elev    Width   Elev
     2.5     856     2.5  878.22
Downstream     num=       2
    Width   Elev    Width   Elev
     2.5     856     2.5  878.22

Number of Bridge Coefficient Sets =  1

Low Flow Methods and Data
       Energy
       Momentum               Cd   =     1.2
       Yarnell                KVal =      .9
Selected Low Flow Methods = Highest Energy Answer
```

```
High Flow Method
       Energy Only

Additional Bridge Parameters
       Add Friction component to Momentum
       Do not add Weight component to Momentum
       Class B flow critical depth computations use critical depth
           inside the bridge at the upstream end
       Criteria to check for pressure flow = Upstream energy grade line

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 7153.706

INPUT
Description: Survey Channel
Station Elevation Data    num=     100
```

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-80	890.68	-75	890.7	-70.01	890.41	-65.01	890.24	-60.02	890.01
-55.02	889.69	-50.03	889.45	-45.03	889.25	-40.04	889.02	-35.04	888.8
-30.05	888.59	-25.05	888.39	-20.05	888.17	-15.06	887.92	-10.06	887.73
-5.07	887.52	-.07	887.24	4.92	886.75	9.92	886.06	14.91	885.82
19.91	885.04	24.91	884.36	29.9	883.43	34.9	882.55	39.89	881.69
44.89	880.84	49.88	879.99	54.88	879.15	59.87	878.33	64.87	877.51
69.87	876.79	74.86	876.01	79.86	875.22	84.85	874.39	89.74	873.99
94.63	873.58	99.52	873.15	104.4	872.63	109.29	871.97	114.18	871.24
123.96	869.9	128.85	869.33	133.73	868.76	138.62	868.43	143.51	868.03
148.4	867.38	158.09	867.07	165.04	866.83	170.93	866.66	176.83	866.49
183.15	866.29	190.31	866.07	207.72	865.55	210.84	863.73	219.72	856.99
222.44	856.15	236.74	856.47	246.34	856.37	250.94	857.11	266.64	863.03
282.79	864.21	292.64	865.01	294.36	865.42	299.06	866.66	303.03	867.89
307.77	868.86	312.77	869.34	317.77	869.71	322.77	870.1	327.77	870.46
332.77	870.79	337.77	871.06	342.77	871.27	372.77	872.35	382.77	872.65
387.77	872.79	392.77	872.92	397.77	873.08	402.77	873.2	407.77	873.29
412.77	873.54	417.76	873.84	422.76	874.07	427.76	874.28	432.76	874.54

```
  437.76  874.87  442.76  875.24  447.76  875.53  452.76  875.79  457.76  875.98
  462.76  876.16  467.76  876.52  472.76  876.66  477.76  876.61  482.76   876.8
  487.76     877  492.76  876.96  497.76  876.98  502.76     877  552.76  876.98

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     -80     .08  210.84     .04  266.64     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        210.84  266.64           548.29   590.6  540.85             .3       .5
Ineffective Flow     num=       2
   Sta L   Sta R    Elev  Permanent
     -80     140  876.33       F
     320  552.76  876.33       F

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 6563.108

INPUT
Description: Survey Channel
Station Elevation Data    num=     161
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  876.24    9.94  876.23   14.91  876.21   19.88  876.19   24.85  876.18
   29.82  876.16   34.79  876.15   39.76  876.13   44.73  876.12   49.71   876.1
   54.68  876.08   59.65  876.05   64.62  876.02   69.59  875.99   74.56  875.82
   79.53  875.15    84.5  874.49   89.47  873.93   94.44  873.66   99.41   873.4
  104.38  873.14  109.35  872.91  114.32  872.77  119.29  872.66  124.26  872.55
  129.23  872.39   134.2  872.18  139.18   872.1  144.15  872.05  149.12  871.97
  159.06  871.75  164.03  871.65     169  871.54  183.91  871.21  188.88  871.11
  193.85  871.01  198.82  870.96  203.79  870.74  208.76  870.56  213.73  870.36
   218.7  870.08  223.67     870  258.47  869.86  263.44  869.77  268.41  869.75
  273.38  869.67  278.35  869.08  283.32     869  293.26  868.99  298.23  868.96
   303.2  868.88  308.17  868.76  313.14  868.63  318.11  868.51  323.09  868.37
  328.06  868.23  333.03  868.05     338     868  347.94  867.97  352.91  867.95
  362.85  867.97  367.82  867.98  372.79  867.87  377.76  867.28  382.73   867.1
```

```
   387.7  867.09  392.67  867.04  402.61  867.06  412.56  867.05  417.53  867.03
   422.5  867.02  427.47     867  432.44  867.04  437.41  867.16  447.35  867.42
  452.32  867.54  457.29  867.65  462.26  867.79  467.23  867.94   472.2     868
  482.14  868.05  487.11   868.1  502.03  868.09     507  868.01   511.8  867.83
  516.61  867.39  521.42  866.97     570  866.39  603.34  865.24  609.64  856.22
  621.84  855.61  634.34   855.1  638.14  854.71  653.84  855.68  664.14  859.33
  669.44  862.92  756.21  862.94  837.05  862.94  941.47  863.21 1012.21  863.34
 1079.58  863.48 1124.06  863.68 1129.05  863.88 1134.05  864.12 1139.04  864.44
 1144.03  864.78 1149.03   865.1 1154.02  865.42 1159.02  865.76 1164.01  866.14
 1169.01  866.72    1174  867.31 1178.99  867.92 1183.99  868.58 1188.98  869.25
 1193.98     870 1198.97  871.22 1203.97  872.57 1208.96  873.86 1213.96  875.03
 1218.95  875.46 1223.94  875.44 1228.94   875.5 1233.93  875.54 1238.93  875.57
 1243.92  875.59 1248.92   875.6 1253.91  875.61  1258.9  875.64  1263.9   875.7
 1268.89  875.79 1273.89   875.9 1278.88     876 1283.88  876.43 1288.87  877.06
 1293.86  877.74 1298.86  878.28 1303.85  878.85 1308.85     879 1328.83  879.21
 1333.82  879.72 1338.81  880.43 1343.81  881.23  1348.8  882.02  1353.8  882.75
 1358.79   883.5 1363.79  884.51 1368.78  886.15 1373.77  888.13 1378.77  890.28
 1383.76  892.27 1388.76  892.46 1393.75  892.51 1398.75  892.54 1403.74  892.49
 1408.74  892.37 1413.73  892.22 1418.72  892.23 1423.72  892.35 1428.71  892.49
 1433.71  892.63

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08  603.34     .04  669.44     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        603.34  669.44           625.09  944.78  683.16             .1       .3

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 5618.333

INPUT
Description: Interpolated Channel
Station Elevation Data    num=     174
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
```

0	875.18	4.97	875.01	9.95	874.81	14.92	874.61	19.9	874.4
24.87	874.2	29.85	874.04	34.82	874	44.77	873.99	49.74	873.96
54.72	873.89	59.69	873.82	64.66	873.77	69.64	873.66	74.61	873.15
79.59	872.36	84.56	871.59	89.54	870.75	94.51	870.04	99.48	869.52
104.46	869.05	109.43	868.53	114.41	868.12	119.38	868	179.07	867.96
184.05	867.68	189.02	867.34	193.99	867.51	198.97	867.67	203.94	867.85
208.92	867.57	213.89	867.34	218.87	867.21	223.84	867.09	228.81	866.99
233.79	866.89	238.76	866.8	243.74	866.75	248.71	866.7	253.68	866.61
258.66	866.6	263.63	866.63	268.61	866.67	273.58	867.01	278.56	867.41
283.53	867.12	288.5	867.44	293.48	867.87	298.45	868.01	303.43	868.13
308.4	868.29	313.38	868	318.35	868.01	323.32	868	333.27	868.03
338.25	868.19	343.22	868.44	348.19	868.68	353.17	868.93	358.14	869.15
363.12	869.4	368.09	869.6	373.07	869.86	378.04	870.08	383.01	870.19
387.99	870.18	392.96	870.15	397.94	870.12	402.91	870.09	407.89	870.05
412.86	870.01	417.83	869.84	422.81	869.65	427.78	869.43	432.76	869.22
437.73	869.09	442.7	868.93	447.68	868.73	452.65	868.51	457.63	868.28
462.6	868.05	467.58	868	492.45	867.98	497.42	867.89	502.4	867.8
507.37	867.71	512.34	867.62	517.32	867.52	522.29	867.43	527.27	867.38
532.24	867.27	537.21	867.26	542.19	867.24	547.16	867.29	552.14	867.38
557.11	867.41	562.09	867.49	567.06	867.66	572.03	867.83	577.01	867.87
581.98	867.68	586.96	867.47	591.93	867.03	596.91	866.66	601.88	866.61
606.85	866.64	611.83	866.81	616.8	866.8	621.78	866.77	626.75	866.73
631.72	866.7	646.65	866.76	651.62	866.82	656.6	866.89	661.57	866.95
666.54	867.02	671.52	867.12	676.49	867.32	681.47	867.51	686.44	867.26
691.41	866.13	696.39	865.02	701.36	864	706.34	863.23	711.31	862.9
716.29	862.77	721.26	862.64	726.23	862.51	731.21	862.37	736.18	862.22
741.16	862.09	789.99	861.68	865.85	860.75	880.92	853.53	896.92	852.63
912.92	853.53	917.41	860.82	958.21	861.66	1015.58	862.13	1084.63	862.21
1165.47	862.25	1224.42	862.37	1249.62	862.45	1254.61	863.18	1259.59	864
1264.58	864.72	1269.56	864.59	1274.55	864.23	1279.53	864.03	1284.52	864
1299.48	864.03	1304.46	864.31	1309.45	864.84	1314.43	865.34	1319.42	865.82
1324.4	866.18	1329.39	866.46	1334.38	866.74	1339.36	867.11	1344.35	867.9
1349.33	868.98	1354.32	870.01	1359.3	871.06	1364.29	872.1	1369.27	873.14
1374.26	874.27	1379.25	874.73	1384.23	874.6	1389.22	874.63	1394.2	874.82
1399.19	875	1404.17	875.16	1409.16	875.23	1414.14	875.19		

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val

```
       0     .08  865.85     .04  917.41     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        865.85  917.41          1062.51 1254.33 1205.75             .1       .3
Ineffective Flow     num=       1
   Sta L   Sta R    Elev  Permanent
       0  393.77  876.77       F

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 4364.004

INPUT
Description: Interpolated Channel
Station Elevation Data    num=      63
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  885.82    4.96  884.93    9.92  884.09   14.88  883.29   19.84  882.53
    24.8  881.81   29.76  881.09   34.72  880.38   39.68  879.68   44.64  879.02
    49.6  878.35   54.56  877.61   59.52  876.87   64.48  876.12   69.44  875.38
    74.4  874.58   79.36  873.74   84.32  873.03   89.28  872.25   94.24  871.33
    99.2  870.64  104.16  870.07  109.12  869.56  114.08  869.03  119.04  868.49
     124  867.66  128.95  866.81  133.91  866.06  138.87  865.38  143.83  864.72
  148.79  864.08  158.95  863.53  174.74  862.83  189.37  862.23  204.84  860.69
  211.53  859.33  225.05  852.53  241.05  851.63  257.05  852.53  270.42  859.37
  280.09  860.71  293.68  861.54  307.37  862.02  327.89  862.61  339.47  863.05
  346.97  863.95  352.39   864.7  357.36  866.14  362.33  867.15   367.3  867.87
  372.27  868.56  377.25   869.3  382.22  870.05  387.19  870.81  392.16  871.59
  397.13  872.36   402.1  873.15  407.07  873.95  412.04  874.79  417.01  875.71
  421.98  876.65  426.95  877.67  431.93  878.75

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08  211.53     .04  270.42     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        211.53  270.42          845.72  831.28  721.08             .1       .3
```

CROSS SECTION

RIVER: Willeo Creek
REACH: Willeo Creek RS: 3532.729

INPUT
Description: Interpolated Channel
Station Elevation Data num= 87

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	883	29.54	882.85	34.46	882.51	39.38	882.13	44.3	881.67
49.23	881.22	54.15	880.75	59.07	880.29	63.99	879.63	68.92	878.22
73.84	876.84	78.76	875.52	83.69	874.29	88.61	873.25	93.53	872.6
98.45	872.32	103.38	872.05	108.3	871.71	113.22	871.37	118.14	871.09
123.07	870.57	127.99	868.78	132.91	867.04	137.83	865.44	142.76	864.05
147.68	863.29	152.6	862.83	157.53	862.6	162.45	862.39	167.37	862.13
172.29	861.59	177.22	860.99	181.43	860.31	184.65	859.9	205.3	858.63
219.11	851.94	235.11	851.04	251.11	851.94	264.16	858.51	280.07	859.6
290.56	859.99	295.5	859.95	300.44	859.91	305.39	859.87	310.33	859.83
315.27	859.79	320.21	859.77	325.16	859.74	330.1	859.72	344.93	859.77
349.87	859.83	354.81	859.86	359.75	859.2	364.7	858.05	369.64	856.88
374.58	856.25	379.53	856.3	389.41	856.82	394.35	857.27	399.3	858.04
404.24	858.8	409.18	859.86	414.12	860.97	419.07	862	424.01	862.4
428.95	862.68	433.89	862.92	438.84	863.14	443.78	863.36	448.72	863.65
453.67	864.27	458.61	865	463.55	865.78	468.49	866.6	473.44	867.41
478.38	868.19	483.32	869.59	488.26	871.04	493.21	874.24	498.15	876.57
503.09	877.49	508.03	878.5	512.98	879.55	517.92	880.6	522.86	881.67
527.81	882.56	532.75	883						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.08	205.3	.04	264.16	.08

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
205.3	264.16	941.58	969.85	917.32	.1	.3

Ineffective Flow num= 1

Sta L	Sta R	Elev	Permanent

```
  352.27  532.75  859.74       F

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 2562.879

INPUT
Description: Interpolated Channel
Station Elevation Data    num=     101
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  874.79    4.97  874.11    9.94  873.38   14.91  872.55   19.88   871.8
   24.86  871.09   29.83  870.32    34.8  869.57   39.77  868.85   44.74  868.18
   49.71  867.57   54.68  867.05   59.66  866.51   64.63  866.09    69.6  865.75
   74.57  865.67   79.54   865.6   84.51  865.58   89.48  865.66   94.45  865.73
   104.4  865.66  109.37  865.56  114.34  865.51  119.31  865.52  124.28  865.54
  129.25  865.55  134.22  865.44  139.19  864.96  144.17  864.38  149.14  863.75
  154.11   863.1  159.08  862.27  164.05  861.41   171.8  860.84  182.54  860.16
  195.97  859.81   209.4  859.49  221.72  858.17     255  856.86  260.05  854.87
  267.76  850.73  283.76  849.83  299.76  850.73  308.05  854.97  312.47  856.97
  317.13  860.71  319.85  861.37  325.83  862.19  330.68  863.53  335.53  864.67
  340.38  865.29  345.23  866.02  350.09   866.7  354.94  867.24  359.79  868.19
  364.64  868.96  369.64  869.38  374.63  869.89  379.63  870.28  384.62  870.52
  389.62  870.95  394.61  871.74  399.61  872.17   404.6  872.58   409.6  872.83
  414.59  872.95  419.59  873.12  424.58  873.31  429.58  873.53  434.58  874.03
  439.57  874.43  444.57  874.59  449.56  874.96  454.56  875.63  459.55  875.87
  464.55  876.19  469.54  876.61  474.54  876.98  479.53  877.17  484.53  877.29
  489.52  877.47  494.52  877.77  499.51  878.18  504.51  878.37   509.5   878.6
   514.5  879.28   519.5  879.97  524.49  880.32  529.49  880.67  534.48  881.05
  539.48  881.38  544.47  881.78  549.47  882.41  554.46     883  559.46  883.49
  564.45  883.98  569.45  884.46  574.44  884.63  579.44  884.53  584.43  884.33
  589.43   884.2

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08     255     .04  312.47     .08
```

```
Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
           255  312.47          1302.971152.4731152.473             .1       .3

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 1410.406

INPUT
Description: Interpolated Channel
Station Elevation Data    num=     106
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
   19.93  872.84   24.92  872.42    29.9  871.98   34.88  871.54   39.86  871.04
   44.85   870.4   49.83   869.8   54.81  869.19    59.8  868.53   64.78   867.7
   69.76  867.12   74.75  866.37   79.73  865.59   84.71  865.01   89.69  863.99
   94.68  863.39   99.66  862.91  104.64  862.08  109.63  861.28  114.61  860.29
  117.19  859.54  120.53  858.79  147.13   856.1  166.13  850.49   190.5  849.55
  210.92  850.77  221.13  856.16  227.36  859.49  232.37  859.65  234.04  859.76
  239.25  859.59  244.24  859.32  249.22  858.57   254.2     857  259.18  855.49
  264.17   855.2  283.86  855.23  288.76  856.18  293.66  856.97  298.56  856.87
  303.46  856.78  308.36  856.65  313.26  856.51  318.16  856.42  323.06  856.23
  327.96  855.79  332.86  855.21  337.76   855.2  367.16  855.21  372.06  855.39
  376.96  855.71  381.86  855.86  386.76  855.58  391.65   855.2  445.55  855.59
  450.45  856.64  455.35  857.16  460.25  857.18  470.09   857.2  479.98  857.12
  484.92  856.76  489.87  855.97  494.81  855.29  499.76   855.2   504.7  855.21
  509.64  855.91  514.59  857.13  519.53  855.99  524.48  855.61  529.42   855.2
  534.36  855.68  539.31   856.8  544.25  857.17  549.19   857.2  648.07  857.24
  653.02  857.45  657.96  857.69  662.91  857.93  667.85  858.12  672.79   858.3
  677.74  858.48  682.68  858.71  687.62  858.89  692.57  858.94  697.51  858.92
  702.46   858.9   707.4  858.88  712.34  858.89  717.29  858.93  722.23  858.98
  727.18  859.03  732.12  859.07  737.06  859.13  742.01  859.52  746.95  860.46
   751.9  861.38  756.84  862.32  761.78  863.21  766.73   864.2  771.67  865.21
  776.62  866.32  781.56  867.33   786.5  868.13  791.45  868.53  796.39  868.92
  801.33  869.17

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
```

```
   19.93     .08  147.13     .04  221.13     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        147.13  221.13           73.739 189.731 180.653             .1       .3

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 1220.68

INPUT
Description: Surveyed Cross Section
Station Elevation Data    num=      60
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  242.65  865.06  242.97  865.06  243.32  865.05  243.37  865.05  243.46  865.06
  243.51  865.06  244.68  865.04  244.73  865.04  257.42  865.24  257.57  865.24
   271.6  865.21  271.86  865.21  272.13   865.2  272.54   865.2  272.81  865.19
  273.09  865.19  274.17  865.17  274.29  865.17  276.16  865.22  276.45  865.22
  276.56  865.23  276.88  865.25  277.06  865.24  277.13  865.25  277.33  865.24
  277.39  865.25  277.46  865.25  277.54  865.26  277.74  865.25  278.15  865.28
   278.2  865.29   278.3  865.29  278.35   865.3  282.35     865   282.9     865
  284.22  865.24  285.76  865.42  286.11  865.47  286.41  865.52  286.66  865.55
  286.87  865.59  291.71  866.21  292.75  866.32  310.31  853.16  347.66   856.4
  366.74  856.56  373.95   852.4  383.57  852.18  387.87  852.07  407.31  851.55
  437.66  850.61  452.54  850.25  469.53  850.87  485.41  851.12  495.34  853.35
   512.7  853.94  530.03  860.43  552.69  860.65  581.43  871.22  593.56  872.12

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  242.65     .08  366.74     .04  530.03     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        366.74  530.03           176.17  186.17  195.25             .3       .5

CROSS SECTION
```

```
RIVER: Willeo Creek
REACH: Willeo Creek       RS: 1034.509

INPUT
Description: Interpolated Channel
Station Elevation Data    num=      96
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  864.74    4.95  864.64     9.9  864.54   14.86  864.34   19.81  864.39
   24.76   864.4   29.71  864.25   34.66  864.35   39.61  864.43   44.57  864.28
   49.52  864.37   54.47   864.3   59.42  863.91   64.37  864.16   69.33  864.27
   74.28  864.25   79.23  864.08   84.18  863.93   89.13  863.82   94.08  863.74
   99.04  863.64  103.99  863.59  108.94  863.63  113.89  863.75  118.84  863.85
   123.8  863.95  128.75  864.02   133.7  864.06  138.65  864.03   143.6  863.88
  148.55  863.71  153.51  863.55  158.46  863.43  163.41  863.41  168.36  863.46
  173.31   863.5  178.27  863.42  183.22  863.01  188.17  862.36  193.12  861.44
  198.07  860.58  203.02  859.76  207.98  858.84  212.93  857.92  217.88  857.08
  222.83  856.62  227.78  856.22  244.63  856.01  266.74  855.74  292.53   855.5
  327.16  855.16  344.11  855.01  372.11  854.74  379.79   854.7  416.25  854.64
  420.68  853.22  422.89  852.15  429.64  850.54  456.55  849.02  483.45  850.54
  488.47  852.29  492.89  853.51  496.84  854.64  505.02   855.1  509.96  854.96
   514.9  855.17  519.83  855.25  524.77  855.14  529.71  854.85  539.59  854.94
  544.52  855.08  549.46  855.01   554.4  854.85  559.34  855.07  564.28  855.36
  569.21  855.54  574.15  855.94  579.09  856.53  584.03  857.05  588.97  857.67
   593.9  858.09  598.84   858.5  603.78  858.97  608.72  859.47  613.66   860.1
  618.59  861.05  623.53  862.25   630.8  862.92  633.41  863.13  638.35  863.35
  643.28   863.6  648.87  863.81  654.41  863.94  662.01  864.11  671.24  864.24
  693.21   864.6

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08  416.25     .04  496.84     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        416.25  496.84            85.25   86.59   74.13             .3       .5
Ineffective Flow     num=       2
   Sta L   Sta R    Elev  Permanent
       0   357.4   862.8       F
     527  693.21   862.8       F
```

```
BRIDGE


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 999.1037

INPUT
Description:
Distance from Upstream XS =      24
Deck/Roadway Width        =      25
Weir Coefficient          =     2.6
Upstream  Deck/Roadway Coordinates
    num=      28
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
       0  862.88           382.4  862.88  861.53   412.3  862.87  861.52
   442.2  862.86  861.51   472.1  862.82  861.47     502  862.89  861.54
  532.89  862.89          556.84     864          597.59     864
  621.48   864.5           634.2  864.84          636.98  864.93
  638.21  864.97          639.29     865          640.09  865.06
  640.49  865.09          647.47  865.62          648.06  865.66
  648.53   865.7          648.92  865.73          649.25  865.75
  650.92  865.85          651.78  865.91          653.19  865.98
  653.19  865.98           653.2  865.98           653.5     866
  689.47  865.68

Upstream Bridge Cross Section Data
Station Elevation Data    num=     131
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  864.74    4.95  864.64     9.9  864.54   14.86  864.34   19.81  864.39
   24.76   864.4   29.71  864.25   34.66  864.35   39.61  864.43   44.57  864.28
   49.52  864.37   54.47   864.3   59.42  863.91   64.37  864.16   69.33  864.27
   74.28  864.25   79.23  864.08   84.18  863.93   89.13  863.82   94.08  863.74
   99.04  863.64  103.99  863.59  108.94  863.63  113.89  863.75  118.84  863.85
   123.8  863.95  128.75  864.02   133.7  864.06  138.65  864.03   143.6  863.88
  148.55  863.71  153.51  863.55  158.46  863.43  163.41  863.41  168.36  863.46
  173.31   863.5  178.27  863.42  183.22  863.01  188.17  862.36  193.12  861.44
  198.07  860.58  203.02  859.76  207.98  858.84  212.93  857.92  217.88  857.08
```

```
  222.83  856.62  227.78  856.22  244.63  856.01  266.74  855.74  292.53   855.5
  327.16  855.16  344.11  855.01  372.11  854.74  379.79   854.7  406.25  854.64
  410.66     853  411.46  852.91  412.17  852.83  413.46  852.69   414.9  852.53
  419.71     852  423.46  851.58   425.6  851.35  428.76     851  430.58   850.8
  431.26  850.72  432.68  850.55  437.13     850  441.37  849.35  442.57  849.17
  443.08  849.09   443.1  849.09  443.37  849.05  443.74     849  444.08  848.95
  450.25     848  452.79     848  454.49     848  455.08     848   456.2  848.19
  460.91     849  465.66  849.79  466.48  849.89  467.36     850  468.51  850.14
  469.19  850.21  471.35  850.44  471.98   850.5  472.18  850.52  473.35  850.63
  473.38  850.63   477.8     851  485.77  851.67  487.12  851.79  488.95  851.98
  489.09     852  492.89  853.51  496.84  854.64  505.02   855.1  509.96  854.96
   514.9  855.17  519.83  855.25  524.77  855.14  529.71  854.85  539.59  854.94
  544.52  855.08  549.46  855.01   554.4  854.85  559.34  855.07  564.28  855.36
  569.21  855.54  574.15  855.94  579.09  856.53  584.03  857.05  588.97  857.67
   593.9  858.09  598.84   858.5  603.78  858.97  608.72  859.47  613.66   860.1
  618.59  861.05  623.53  862.25   630.8  862.92  633.41  863.13  638.35  863.35
  643.28   863.6  648.87  863.81  654.41  863.94  662.01  864.11  671.24  864.24
  693.21   864.6

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08  406.25     .04  489.09     .08

Bank Sta: Left   Right    Coeff Contr.   Expan.
        410.66  496.84             .3       .5
Ineffective Flow     num=       2
   Sta L   Sta R    Elev  Permanent
       0   357.4   862.8       F
     527  693.21   862.8       F

Downstream  Deck/Roadway Coordinates
    num=      28
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
       0  862.88           382.4  862.84  861.49   412.3   862.9  861.55
   442.2  862.82  861.47   472.1  862.83  861.48     502  862.88  861.53
  532.89  862.88          556.84     864          597.59     864
  621.48   864.5           634.2  864.84          636.98  864.93
  638.21  864.97          639.29     865          640.09  865.06
```

640.49	865.09	647.47	865.62	648.06	865.66
648.53	865.7	648.92	865.73	649.25	865.75
650.92	865.85	651.78	865.91	653.19	865.98
653.19	865.98	653.2	865.98	653.5	866
689.47	865.68				

Downstream Bridge Cross Section Data
Station Elevation Data num= 155

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-10	864.88	-5.03	864.81	-.06	864.95	4.91	864.81	9.89	864.53
14.86	864.23	19.83	864.04	24.8	863.98	29.77	863.97	34.74	863.92
39.72	863.9	44.69	863.87	49.66	863.68	54.63	863.48	59.6	863.39
64.57	863.35	69.55	863.31	74.52	863.27	79.49	863.22	84.46	863.16
89.43	863.11	94.4	863.02	99.38	862.89	104.35	862.97	109.32	862.89
114.29	862.44	119.26	862.02	124.23	862	129.21	861.89	134.18	861.02
139.15	860.56	144.12	860.2	149.09	859.92	154.06	859.34	159.04	858.82
164.01	858.38	168.98	857.85	173.95	857.37	188.86	855.87	193.84	855.43
198.81	855.16	203.78	854.89	208.75	854.5	213.72	854.07	218.69	853.91
223.67	853.86	228.64	853.6	233.61	853.26	238.58	852.99	243.55	853.12
248.52	853.1	253.5	853.03	258.47	852.93	263.44	852.88	268.41	853.11
273.38	853.34	278.35	853.38	283.33	853.33	288.3	853.36	293.27	853.54
298.24	853.74	303.21	853.79	308.18	853.84	313.16	853.92	318.13	854
323.1	854.21	328.07	854.47	333.04	854.72	338.01	854.85	342.99	854.89
347.96	854.95	352.93	854.94	357.9	854.98	362.87	854.96	367.84	854.85
372.81	854.93	377.79	855.02	382.76	855	404	855.33	410.66	853
411.46	852.91	412.17	852.83	413.46	852.69	414.9	852.53	419.71	852
423.46	851.58	425.6	851.35	428.76	851	430.58	850.8	431.26	850.72
432.68	850.55	437.13	850	441.37	849.35	442.57	849.17	443.08	849.09
443.1	849.09	443.37	849.05	443.74	849	444.08	848.95	450.25	848
452.79	848	454.49	848	455.08	848	456.2	848.19	460.91	849
465.66	849.79	466.48	849.89	467.36	850	468.51	850.14	469.19	850.21
471.35	850.44	471.98	850.5	472.18	850.52	473.35	850.63	473.38	850.63
477.8	851	485.77	851.67	487.12	851.79	488.95	851.98	489.09	852
501.59	854.1	524.19	854.73	525.77	856.15	530.65	856.44	535.54	856.72
540.43	857.06	545.31	857.33	550.2	857.65	555.09	858.56	559.97	859.24
564.86	859.78	569.75	860.15	574.63	860.59	579.52	861.1	584.41	861.58
589.29	862.05	594.18	862.72	599.07	863.03	603.95	863	608.84	862.95
613.73	862.9	618.61	862.87	623.5	862.84	628.39	862.81	633.27	862.78

```
  638.16  862.82  643.05  862.92  647.93  863.06  652.82  863.25  657.71  863.46
  662.59  863.66  667.48  863.88  672.37  864.48  677.25  864.89  682.14  865.34

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     -10     .08     404     .04  489.09     .08

Bank Sta: Left   Right    Coeff Contr.   Expan.
        410.66  501.59             .3       .5
Ineffective Flow     num=       2
   Sta L   Sta R    Elev  Permanent
     -10  363.61   862.8       F
   520.8  682.14   862.8       F
Blocked Obstructions     num=       4
   Sta L   Sta R    Elev   Sta L   Sta R    Elev   Sta L   Sta R    Elev
  399.61  402.61  858.84  440.45  443.45   858.9   448.3   449.3  858.79
  487.07  490.07  859.01

Upstream Embankment side slope              =       0 horiz. to 1.0 vertical
Downstream Embankment side slope            =       0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .98
Elevation at which weir flow begins         =
Energy head used in spillway design         =
Spillway height used in design              =
Weir crest shape                            = Broad Crested

Number of Abutments =  2

Abutment Data
Upstream     num=       3
     Sta    Elev     Sta    Elev     Sta    Elev
   382.4     854   382.4  861.53  397.46     854
Downstream     num=       3
     Sta    Elev     Sta    Elev     Sta    Elev
   382.4     854   382.4  861.49  397.38     854

Abutment Data
Upstream     num=       5
```

```
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
   479.9  855.98   481.8  857.76   483.6   857.9   495.5   857.9     502  857.91
Downstream     num=       5
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
   479.9  855.98   481.8  857.76   483.6   857.9   495.5   857.9     502  857.91

Number of Piers =  3

Pier Data
Pier Station     Upstream=   412.3    Downstream=   412.3
Upstream     num=       6
    Width   Elev    Width   Elev    Width   Elev    Width   Elev    Width   Elev
     1.7     852     1.7     856     .83     856     .83   859.4       2   859.4
       2   861.4
Downstream     num=       6
    Width   Elev    Width   Elev    Width   Elev    Width   Elev    Width   Elev
     1.7     852     1.7     856     .83     856     .83   859.4       2   859.4
       2   861.4

Pier Data
Pier Station     Upstream=   442.2    Downstream=   442.2
Upstream     num=       6
    Width   Elev    Width   Elev    Width   Elev    Width   Elev    Width   Elev
     1.7     852     1.7     856     .83     856     .83   859.4       2   859.4
       2   861.4
Downstream     num=       6
    Width   Elev    Width   Elev    Width   Elev    Width   Elev    Width   Elev
     1.7     852     1.7     856     .83     856     .83   859.4       2   859.4
       2   861.4

Pier Data
Pier Station     Upstream=   472.1    Downstream=   472.1
Upstream     num=       6
    Width   Elev    Width   Elev    Width   Elev    Width   Elev    Width   Elev
    1.67     852    1.67     856     .83     856     .83   859.4       2   859.4
       2   861.4
Downstream     num=       6
    Width   Elev    Width   Elev    Width   Elev    Width   Elev    Width   Elev
```

```
    1.67     852    1.67     856     .83     856     .83   859.4       2   859.4
       2   861.4

Number of Bridge Coefficient Sets =  1

Low Flow Methods and Data
       Energy
       Momentum               Cd   =     1.2
Selected Low Flow Methods = Energy

High Flow Method
       Energy Only

Additional Bridge Parameters
       Add Friction component to Momentum
       Do not add Weight component to Momentum
       Class B flow critical depth computations use critical depth
           inside the bridge at the upstream end
       Criteria to check for pressure flow = Upstream energy grade line

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 947.9219

INPUT
Description: Survey Channel
Station Elevation Data    num=     121
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     -10  864.88   -5.03  864.81    -.06  864.95    4.91  864.81    9.89  864.53
   14.86  864.23   19.83  864.04    24.8  863.98   29.77  863.97   34.74  863.92
   39.72   863.9   44.69  863.87   49.66  863.68   54.63  863.48    59.6  863.39
   64.57  863.35   69.55  863.31   74.52  863.27   79.49  863.22   84.46  863.16
   89.43  863.11    94.4  863.02   99.38  862.89  104.35  862.97  109.32  862.89
  114.29  862.44  119.26  862.02  124.23     862  129.21  861.89  134.18  861.02
  139.15  860.56  144.12   860.2  149.09  859.92  154.06  859.34  159.04  858.82
  164.01  858.38  168.98  857.85  173.95  857.37  188.86  855.87  193.84  855.43
```

```
  198.81  855.16  203.78  854.89  208.75   854.5  213.72  854.07  218.69  853.91
  223.67  853.86  228.64   853.6  233.61  853.26  238.58  852.99  243.55  853.12
  248.52   853.1   253.5  853.03  258.47  852.93  263.44  852.88  268.41  853.11
  273.38  853.34  278.35  853.38  283.33  853.33   288.3  853.36  293.27  853.54
  298.24  853.74  303.21  853.79  308.18  853.84  313.16  853.92  318.13     854
   323.1  854.21  328.07  854.47  333.04  854.72  338.01  854.85  342.99  854.89
  347.96  854.95  352.93  854.94   357.9  854.98  362.87  854.96  367.84  854.85
  372.81  854.93  377.79  855.02  382.76     855     404  855.33     421  855.14
  424.75  852.62  435.35  851.75  448.55     849  469.45  849.68  489.15  850.52
  496.39   852.1  501.59   854.1  524.19  854.73  525.77  856.15  530.65  856.44
  535.54  856.72  540.43  857.06  545.31  857.33   550.2  857.65  555.09  858.56
  559.97  859.24  564.86  859.78  569.75  860.15  574.63  860.59  579.52   861.1
  584.41  861.58  589.29  862.05  594.18  862.72  599.07  863.03  603.95     863
  608.84  862.95  613.73   862.9  618.61  862.87   623.5  862.84  628.39  862.81
  633.27  862.78  638.16  862.82  643.05  862.92  647.93  863.06  652.82  863.25
  657.71  863.46  662.59  863.66  667.48  863.88  672.37  864.48  677.25  864.89
  682.14  865.34

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     -10     .08     421     .04  501.59     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
           421  501.59          239.821  255.14 271.224             .3       .5
Ineffective Flow     num=       2
   Sta L   Sta R    Elev  Permanent
     -10  363.61   862.8       F
   520.8  682.14   862.8       F
Blocked Obstructions     num=       4
   Sta L   Sta R    Elev   Sta L   Sta R    Elev   Sta L   Sta R    Elev
  399.61  402.61  858.84  440.45  443.45   858.9   448.3   449.3  858.79
  487.07  490.07  859.01

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 682.81
```

```
INPUT
Description:
Station Elevation Data    num=      30
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     -52     865      -4     853       0  852.32   46.27  850.98   93.46  850.77
  136.75   850.4  158.34  850.46  191.97  850.56  246.71  850.66  303.56  851.36
  337.28  852.13  361.54  852.67  380.06  853.61  396.96  855.64  414.82  856.52
  431.72  855.86  435.68  852.81  467.95  848.78   508.4  852.98  509.61   854.7
  536.97  858.29  572.28  860.65  613.66  864.36  647.51  866.15  735.51  864.06
  747.59  864.86  789.84  863.76  857.65  886.47  877.68  883.79  959.45   900.8

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     -52     .08  431.72     .04  509.61     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        431.72  509.61           565.25  350.28  612.84             .1       .3

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 342.5338

INPUT
Description: Interpolated Channel
Station Elevation Data    num=     116
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  865.76    4.99  865.66    9.98  865.34   14.97  864.89   19.96  864.41
   24.95  863.35   29.94  861.94   34.93  860.63   39.92  860.25   44.91   860.2
    49.9  860.11   54.89  860.01   59.88  859.96   64.87   859.9   69.86  859.86
   74.85  859.83   79.84  859.78   84.83  859.42   89.81  858.34    94.8   857.2
   99.79  856.15  104.78  855.19  109.77  854.31  114.76  853.51  119.75   852.2
  124.74  851.17  129.73   850.7  134.72  850.44  139.71  850.39   144.7  850.38
  154.68  850.37  164.66  850.35  169.65  850.34  174.64  850.33  184.62  850.32
   194.6   850.3  199.59  850.29  204.58  850.28  214.56  850.27  219.55  850.26
  224.54  850.25  234.52  850.23   244.5  850.22  249.49  850.21  254.48   850.2
```

```
  259.47  850.19  264.46  850.18  269.44  850.17  284.41  850.18  294.39  850.19
  304.37   850.2  314.35  850.21  324.33  850.22  334.31  850.23   339.3  850.24
  359.26  850.26  369.24  850.27  374.23  850.28  384.21  850.29  404.17  850.31
  414.15  850.32  419.14  850.33  429.12  850.34   439.1  850.35  449.08  850.36
  454.06  850.37  464.04  850.38  474.02  850.39     484   850.4  683.61  850.42
   688.6  851.78  693.49   853.3  698.51  853.46  703.54  853.27  708.26  852.43
  716.98  849.76  743.89  848.24  787.44  848.27  806.18  849.36  826.06  852.14
  839.06  853.46  845.57  854.57  848.48  855.34  853.48  856.78  858.48  858.25
  863.47  859.82  868.47  861.53  873.47  863.32  878.46   865.2  883.46  867.11
  888.45  869.12  893.45  871.23  898.45  872.42  903.44  873.23  908.44  873.89
  913.44  874.43  918.43  874.99  923.43  875.45  928.43  875.95  933.42  876.21
  938.42  876.39  943.41  876.62  948.41   876.9  953.41  877.23   958.4  877.32
   963.4  877.57   968.4  877.86  973.39  878.28  978.39   878.7  983.38  879.12
  988.38  879.46  993.38  879.81  998.37  880.16 1003.37  880.51 1008.37  880.82
 1013.36   881.2

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08  703.54     .04  839.06     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        703.54  839.06           123.65  342.53   84.21             .1       .3


SUMMARY OF MANNING'S N VALUES

River:Willeo Creek

      Reach          River Sta.       n1        n2        n3

 Willeo Creek         11553.10          .08       .04       .08
 Willeo Creek         11030.43          .08       .04       .08
 Willeo Creek         9759.109          .08       .04       .08
 Willeo Creek         8872.189          .08       .04       .08
 Willeo Creek         8133.710          .08       .04       .08
 Willeo Creek         7394.653          .08       .04       .08
 Willeo Creek         7308.132          .08       .04       .08
```

Willeo Creek	7241.553	Bridge		
Willeo Creek	7153.706	.08	.04	.08
Willeo Creek	6563.108	.08	.04	.08
Willeo Creek	5618.333	.08	.04	.08
Willeo Creek	4364.004	.08	.04	.08
Willeo Creek	3532.729	.08	.04	.08
Willeo Creek	2562.879	.08	.04	.08
Willeo Creek	1410.406	.08	.04	.08
Willeo Creek	1220.68	.08	.04	.08
Willeo Creek	1034.509	.08	.04	.08
Willeo Creek	999.1037	Bridge		
Willeo Creek	947.9219	.08	.04	.08
Willeo Creek	682.81	.08	.04	.08
Willeo Creek	342.5338	.08	.04	.08

SUMMARY OF REACH LENGTHS

River: Willeo Creek

Reach	River Sta.	Left	Channel	Right
Willeo Creek	11553.10	374.92	522.66	721.63
Willeo Creek	11030.43	1257.53	1271.33	1073.77
Willeo Creek	9759.109	845.18	886.92	691.75
Willeo Creek	8872.189	685.38	738.48	753.66
Willeo Creek	8133.710	722.72	739.06	722.47
Willeo Creek	7394.653	108.041	86.521	93.401
Willeo Creek	7308.132	144.84	154.43	146.12
Willeo Creek	7241.553	Bridge		
Willeo Creek	7153.706	548.29	590.6	540.85
Willeo Creek	6563.108	625.09	944.78	683.16
Willeo Creek	5618.333	1062.51	1254.33	1205.75
Willeo Creek	4364.004	845.72	831.28	721.08
Willeo Creek	3532.729	941.58	969.85	917.32
Willeo Creek	2562.879	1302.97	1152.473	1152.473

Willeo Creek	1410.406	73.739	189.731	180.653
Willeo Creek	1220.68	176.17	186.17	195.25
Willeo Creek	1034.509	85.25	86.59	74.13
Willeo Creek	999.1037	Bridge		
Willeo Creek	947.9219	239.821	255.14	271.224
Willeo Creek	682.81	565.25	350.28	612.84
Willeo Creek	342.5338	123.65	342.53	84.21

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: Willeo Creek

Reach	River Sta.	Contr.	Expan.
Willeo Creek	11553.10	.1	.3
Willeo Creek	11030.43	.1	.3
Willeo Creek	9759.109	.1	.3
Willeo Creek	8872.189	.1	.3
Willeo Creek	8133.710	.1	.3
Willeo Creek	7394.653	.3	.5
Willeo Creek	7308.132	.3	.5
Willeo Creek	7241.553	Bridge	
Willeo Creek	7153.706	.3	.5
Willeo Creek	6563.108	.1	.3
Willeo Creek	5618.333	.1	.3
Willeo Creek	4364.004	.1	.3
Willeo Creek	3532.729	.1	.3
Willeo Creek	2562.879	.1	.3
Willeo Creek	1410.406	.1	.3
Willeo Creek	1220.68	.3	.5
Willeo Creek	1034.509	.3	.5
Willeo Creek	999.1037	Bridge	
Willeo Creek	947.9219	.3	.5
Willeo Creek	682.81	.1	.3
Willeo Creek	342.5338	.1	.3

Profile Output Table - Standard Table 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Willeo Creek	11553.10	528										
		EX_100Year	5958.00	860.59	875.01		875.66	0.001610	7.30	1473.70	306.91	0.38
Willeo Creek	11553.10	528										
		Floodway	5958.00	860.59	875.57		876.20	0.001454	7.16	1353.64	212.24	0.36
Willeo Creek	11030.43	1905										
		EX_100Year	5958.00	859.73	875.03	869.95	875.14	0.000356	3.41	3579.34	594.50	0.18
Willeo Creek	11030.43	1905										
		Floodway	5958.00	859.73	875.40	869.85	875.62	0.000558	4.36	2254.92	309.29	0.23
Willeo Creek	9759.109	1907										
		EX_100Year	5958.00	858.77	874.70	869.33	874.76	0.000254	3.12	4402.59	632.90	0.15
Willeo Creek	9759.109	1907										
		Floodway	5958.00	858.77	874.89	869.41	875.02	0.000400	3.96	3008.71	365.31	0.19
Willeo Creek	8872.189	1882										
		EX_100Year	5958.00	858.09	873.72		874.31	0.001219	6.80	1374.33	217.14	0.33
Willeo Creek	8872.189	1882										
		Floodway	5958.00	858.09	873.79		874.42	0.001241	6.89	1250.00	152.14	0.33
Willeo Creek	8133.710	532										
		EX_100Year	5958.00	857.16	873.29		873.56	0.000670	5.12	2132.72	282.94	0.25
Willeo Creek	8133.710	532										
		Floodway	5958.00	857.16	873.31		873.63	0.000741	5.40	1827.62	198.82	0.26
Willeo Creek	7394.653	1327										
		EX_100Year	5958.00	856.37	873.06		873.18	0.000336	3.82	3430.43	468.14	0.18
Willeo Creek	7394.653	1327										
		Floodway	5958.00	856.37	873.05		873.19	0.000393	4.13	2918.67	347.40	0.19

```
  Willeo Creek   7308.132 864                EX_100Year   7482.00      856.16      871.05      866.62
872.65     0.002770      10.40      839.86       94.07           0.51
  Willeo Creek   7308.132 864                Floodway     7482.00      856.16      871.07      866.62
872.67     0.002749      10.37      842.41       94.23           0.50

  Willeo Creek   7241.553 354                              Bridge

  Willeo Creek   7153.706 865                EX_100Year   7482.00      856.15      868.76      866.74
870.55     0.004259      11.29      903.75      173.56           0.61
  Willeo Creek   7153.706 865                Floodway     7482.00      856.15      869.51      866.62
871.30     0.003715      11.03      811.29       97.40           0.58

  Willeo Creek   6563.108 1881               EX_100Year   7482.00      854.71      868.91
869.06     0.000538       4.29     4091.44      885.05           0.22
  Willeo Creek   6563.108 1881               Floodway     7482.00      854.71      869.53
869.76     0.000667       4.94     2929.78      420.34           0.24

  Willeo Creek   5618.333 3990               EX_100Year   7482.00      852.63      868.54      864.02
868.66     0.000446       4.23     4645.02     1131.10           0.20
  Willeo Creek   5618.333 3990               Floodway     7482.00      852.63      869.00      864.01
869.23     0.000632       5.15     2891.27      346.49           0.24

  Willeo Creek   4364.004 1385               EX_100Year   7707.00      851.63      866.69
867.60     0.001826       8.39     1438.09      230.29           0.41
  Willeo Creek   4364.004 1385               Floodway     7707.00      851.63      867.07
867.97     0.001697       8.25     1352.85      166.32           0.40

  Willeo Creek   3532.729 1384               EX_100Year   7707.00      851.04      865.87      859.85
866.32     0.001124       6.54     2209.80      327.62           0.32
  Willeo Creek   3532.729 1384               Floodway     7707.00      851.04      866.22      861.64
866.72     0.001158       6.75     1927.86      227.61           0.33

  Willeo Creek   2562.879 1382               EX_100Year   7707.00      849.83      862.82
864.41     0.003706      10.76     1007.05      172.32           0.57
  Willeo Creek   2562.879 1382               Floodway     7707.00      849.83      863.91
865.08     0.002496       9.41     1165.62      156.78           0.48
```

```
  Willeo Creek   1410.406 538                EX_100Year   7707.00      849.55      862.50
862.65     0.000546       4.24     3970.73      655.77           0.22
  Willeo Creek   1410.406 538                Floodway     7707.00      849.55      863.83
863.93     0.000331       3.56     4480.26      567.61           0.18

  Willeo Creek   1220.68                     EX_100Year   7707.00      850.25      862.27
862.53     0.000631       4.28     2117.98      258.93           0.24
  Willeo Creek   1220.68                     Floodway     7707.00      850.25      863.66
863.85     0.000400       3.72     2461.94      253.66           0.19

  Willeo Creek   1034.509 868                EX_100Year   7699.00      849.02      861.62      857.33
862.25     0.001490       6.98     1484.95      428.81           0.37
  Willeo Creek   1034.509 868                Floodway     7699.00      849.02      863.61      857.33
863.76     0.000379       3.93     3572.59      394.52           0.19

  Willeo Creek   999.1037                                  Bridge

  Willeo Creek   947.9219 869                EX_100Year   7699.00      849.02      857.69      857.69
860.07     0.018385      13.14      715.09      369.71           0.88
  Willeo Creek   947.9219 869                Floodway     7699.00      849.02      862.05      857.69
862.65     0.002916       6.84     1388.53      182.24           0.37

  Willeo Creek   682.81                      EX_100Year   7699.00      848.78      856.28
856.50     0.002635       5.62     2435.16      527.52           0.43
  Willeo Creek   682.81                      Floodway     7699.00      848.78      858.16      858.16
860.74     0.011558      13.99      749.35      144.03           0.91

  Willeo Creek   342.5338 1381               EX_100Year   7699.00      848.24      855.72      852.26
855.81     0.000779       3.45     3960.78      747.79           0.25
  Willeo Creek   342.5338 1381               Floodway     7699.00      848.24      856.04      852.37
856.14     0.000779       3.52     3720.33      642.38           0.25


Profile Output Table - Standard Table 2

  Reach          River Sta                   Profile      E.G. Elev   W.S. Elev   Vel Head   Frctn
Loss   C & E Loss    Q Left   Q Channel   Q Right   Top Width
```

```
                                                                    (ft)        (ft)        (ft)
(ft)         (ft)     (cfs)       (cfs)     (cfs)        (ft)

  Willeo Creek   11553.10 528                EX_100Year      875.66      875.01       0.64
0.36         0.16    706.18     4534.09    717.72      306.91
  Willeo Creek   11553.10 528                Floodway        876.20      875.57       0.63
0.45         0.13    634.85     4654.25    668.90      212.24

  Willeo Creek   11030.43 1905               EX_100Year      875.14      875.03       0.10
0.36         0.01   1049.70     3163.08   1745.22      594.50
  Willeo Creek   11030.43 1905               Floodway        875.62      875.40       0.22
0.58         0.03    772.11     4187.34    998.55      309.29

  Willeo Creek   9759.109 1907               EX_100Year      874.76      874.70       0.07
0.40         0.05   2089.01     2201.74   1667.26      632.90
  Willeo Creek   9759.109 1907               Floodway        875.02      874.89       0.13
0.55         0.05   1820.99     2831.67   1305.33      365.31

  Willeo Creek   8872.189 1882               EX_100Year      874.31      873.72       0.59
0.65         0.10    478.41     4835.80    643.78      217.14
  Willeo Creek   8872.189 1882               Floodway        874.42      873.79       0.62
0.70         0.09    578.04     4928.49    451.47      152.14

  Willeo Creek   8133.710 532                EX_100Year      873.56      873.29       0.27
0.34         0.05    215.31     3670.07   2072.62      282.94
  Willeo Creek   8133.710 532                Floodway        873.63      873.31       0.31
0.39         0.05    210.01     3870.35   1877.64      198.82

  Willeo Creek   7394.653 1327               EX_100Year      873.18      873.06       0.12
0.08         0.45   2416.27     2745.29    796.44      468.14
  Willeo Creek   7394.653 1327               Floodway        873.19      873.05       0.15
0.08         0.44   2143.02     2964.23    850.75      347.40

  Willeo Creek   7308.132 864                EX_100Year      872.65      871.05       1.61
181.69     7142.33    157.97       94.07
  Willeo Creek   7308.132 864                Floodway        872.67      871.07       1.60
182.87     7140.28    158.84       94.23
```

```
  Willeo Creek   7241.553 354                                Bridge

  Willeo Creek   7153.706 865                EX_100Year      870.55      868.76       1.79
0.67         0.82    322.32     6726.76    432.92      173.56
  Willeo Creek   7153.706 865                Floodway        871.30      869.51       1.79
0.76         0.78    301.20     7038.41    142.39       97.40

  Willeo Creek   6563.108 1881               EX_100Year      869.06      868.91       0.15
0.39         0.01    273.83     3461.07   3747.10      885.05
  Willeo Creek   6563.108 1881               Floodway        869.76      869.53       0.23
0.53         0.00    243.10     4187.06   3051.84      420.34

  Willeo Creek   5618.333 3990               EX_100Year      868.66      868.54       0.13
0.98         0.08   1283.14     3035.19   3163.67     1131.10
  Willeo Creek   5618.333 3990               Floodway        869.23      869.00       0.23
1.19         0.07   1855.07     3814.21   1812.72      346.49

  Willeo Creek   4364.004 1385               EX_100Year      867.60      866.69       0.91
1.14         0.14    553.58     6348.61    804.81      230.29
  Willeo Creek   4364.004 1385               Floodway        867.97      867.07       0.90
1.13         0.12    519.15     6431.29    756.57      166.32

  Willeo Creek   3532.729 1384               EX_100Year      866.32      865.87       0.44
1.79         0.11    495.70     4872.63   2338.67      327.62
  Willeo Creek   3532.729 1384               Floodway        866.72      866.22       0.50
1.57         0.07    484.46     5173.72   2048.82      227.61

  Willeo Creek   2562.879 1382               EX_100Year      864.41      862.82       1.59
1.33         0.43    916.22     6740.70     50.08      172.32
  Willeo Creek   2562.879 1382               Floodway        865.08      863.91       1.17
0.83         0.32   1152.32     6483.30     71.38      156.78

  Willeo Creek   1410.406 538                EX_100Year      862.65      862.50       0.14
0.11         0.01    169.89     3493.41   4043.70      655.77
  Willeo Creek   1410.406 538                Floodway        863.93      863.83       0.10
0.07         0.01    166.86     3284.27   4255.86      567.61
```

```
  Willeo Creek   1220.68                    EX_100Year      862.53      862.27       0.26
0.17         0.11    701.91     6978.29     26.80      258.93
  Willeo Creek   1220.68                    Floodway        863.85      863.66       0.20
0.07         0.03    758.87     6902.97     45.15      253.66

  Willeo Creek   1034.509 868               EX_100Year      862.25      861.62       0.62
0.07         0.20   1058.00     6142.82    498.18      428.81
  Willeo Creek   1034.509 868               Floodway        863.76      863.61       0.14
0.03         0.29   2450.33     4093.21   1155.47      394.52

  Willeo Creek   999.1037                                   Bridge

  Willeo Creek   947.9219 869               EX_100Year      860.07      857.69       2.39
1.38         1.08    631.03     6710.95    357.02      369.71
  Willeo Creek   947.9219 869               Floodway        862.65      862.05       0.60
1.31         0.60   1283.64     5839.48    575.88      182.24

  Willeo Creek   682.81                     EX_100Year      856.50      856.28       0.22
0.65         0.04   5412.69     2278.66      7.65      527.52
  Willeo Creek   682.81                     Floodway        860.74      858.16       2.58
0.85         0.74   1288.16     6410.84                144.03

  Willeo Creek   342.5338 1381              EX_100Year      855.81      855.72       0.09
4843.31     2847.57      8.12      747.79
  Willeo Creek   342.5338 1381              Floodway        856.14      856.04       0.10
4637.01     3062.00                642.38


Profile Output Table - Six XS Bridge

  Reach          River Sta                       Profile      E.G. Elev   W.S. Elev   Crit W.S.
Frctn Loss   C & E Loss   Top Width    Q Left   Q Channel   Q Right   Vel Chnl
                                                                  (ft)        (ft)        (ft)
(ft)         (ft)        (ft)     (cfs)       (cfs)     (cfs)     (ft/s)

  Willeo Creek   7394.653 1327                  EX_100Year      873.18      873.06
0.08         0.45      468.14   2416.27     2745.29    796.44       3.82
```

```
  Willeo Creek   7394.653 1327                    Floodway        873.19      873.05
0.08         0.44      347.40   2143.02     2964.23    850.75       4.13

  Willeo Creek   7308.132 864                     EX_100Year      872.65      871.05      866.62
94.07    181.69     7142.33    157.97      10.40
  Willeo Creek   7308.132 864                     Floodway        872.67      871.07      866.62
94.23    182.87     7140.28    158.84      10.37

  Willeo Creek   7241.553 354             BR U   EX_100Year      872.61      870.10      867.53
68.92     28.49     7260.51    193.00      12.89
  Willeo Creek   7241.553 354             BR U   Floodway        872.63      870.14      867.53
69.04     29.13     7257.87    195.00      12.84

  Willeo Creek   7241.553 354             BR D   EX_100Year      872.51      868.45      868.45
63.87               7280.39    201.61      16.38
  Willeo Creek   7241.553 354             BR D   Floodway        872.58      868.39      868.39
57.87               7322.55    159.46      16.58

  Willeo Creek   7153.706 865                     EX_100Year      870.55      868.76      866.74
0.67         0.82      173.56    322.32     6726.76    432.92      11.29
  Willeo Creek   7153.706 865                     Floodway        871.30      869.51      866.62
0.76         0.78       97.40    301.20     7038.41    142.39      11.03

  Willeo Creek   6563.108 1881                    EX_100Year      869.06      868.91
0.39         0.01      885.05    273.83     3461.07   3747.10       4.29
  Willeo Creek   6563.108 1881                    Floodway        869.76      869.53
0.53         0.00      420.34    243.10     4187.06   3051.84       4.94


  Willeo Creek   1220.68                          EX_100Year      862.53      862.27
0.17         0.11      258.93    701.91     6978.29     26.80       4.28
  Willeo Creek   1220.68                          Floodway        863.85      863.66
0.07         0.03      253.66    758.87     6902.97     45.15       3.72

  Willeo Creek   1034.509 868                     EX_100Year      862.25      861.62      857.33
0.07         0.20      428.81   1058.00     6142.82    498.18       6.98
  Willeo Creek   1034.509 868                     Floodway        863.76      863.61      857.33
0.03         0.29      394.52   2450.33     4093.21   1155.47       3.93
```

```
  Willeo Creek   999.1037BR U                    EX_100Year      861.98      860.69      858.13
0.33         0.46      112.11    767.54     6906.21     25.25       9.41
  Willeo Creek   999.1037BR U                    Floodway        863.44      862.34      858.13
0.31         0.01                680.15     6982.76     36.09       8.74

  Willeo Creek   999.1037BR D                    EX_100Year      861.19      858.37      858.37
102.39    533.10     7165.63      0.27      13.76
  Willeo Creek   999.1037BR D                    Floodway        863.12      861.98      858.37
0.21         0.27                743.81     6953.95      1.25       8.84

  Willeo Creek   947.9219 869                    EX_100Year      860.07      857.69      857.69
1.38         1.08      369.71    631.03     6710.95    357.02      13.14
  Willeo Creek   947.9219 869                    Floodway        862.65      862.05      857.69
1.31         0.60      182.24   1283.64     5839.48    575.88       6.84

  Willeo Creek   682.81                          EX_100Year      856.50      856.28
0.65         0.04      527.52   5412.69     2278.66      7.65       5.62
  Willeo Creek   682.81                          Floodway        860.74      858.16      858.16
0.85         0.74      144.03   1288.16     6410.84                13.99


Profile Output Table - Bridge Only

  Reach          River Sta                    Profile      E.G. US.   Min El Prs   BR Open Area   Prs O
WS   Q Total   Min El Weir Flow   Q Weir   Delta EG   BR Sluice Coef
                                                                  (ft)         (ft)         (sq ft)
(ft)     (cfs)                (ft)    (cfs)       (ft)

  Willeo Creek   7241.553 354                EX_100Year     872.65       879.70        1297.99
7482.00             877.34                2.10
  Willeo Creek   7241.553 354                Floodway       872.67       879.70        1150.62
7482.00             880.73                1.37

  Willeo Creek   999.1037                    EX_100Year     862.25       861.54         927.29
7699.00             862.83                2.18
  Willeo Creek   999.1037                    Floodway       863.76       861.54         927.29
7699.00             862.83                1.11
```

Appendix F.3 – Proposed Conditions HEC-RAS Models

```
                    HEC-RAS HEC-RAS 5.0.7 March 2019
                      U.S. Army Corps of Engineers
                     Hydrologic Engineering Center
                           609 Second Street
                           Davis, California


          X     X  XXXXXX    XXXX        XXXX       XX      XXXX
          X     X  X        X    X       X   X     X  X    X
          X     X  X        X            X   X    X    X   X
          XXXXXXX  XXXX     X       XXX  XXXX     XXXXXX    XXXX
          X     X  X        X            X  X     X    X        X
          X     X  X        X    X       X   X    X    X        X
          X     X  XXXXXX    XXXX        X    X   X    X   XXXXX



PROJECT DATA
Project Title: WilleoCr
Project File : WilleoCr.prj
Run Date and Time: 8/30/2019 11:54:29 AM

Project in English units

Project Description:
Cobb County, Georgia, Willeo Creek Detailed Hydraulics Study, November, 2010,
submitted by Dewberry.



PLAN DATA

Plan Title: FloodWay_Proposed
Plan File : g:\19180\Hydrology\Bridge Hydraulics\HEC-
RAS_Models\WilleoCreek\WilleoCr_HECRAS\WilleoCr.p11
```

```
           Geometry Title: Proposed
           Geometry File : g:\19180\Hydrology\Bridge Hydraulics\HEC-
RAS_Models\WilleoCreek\WilleoCr_HECRAS\WilleoCr.g05

           Flow Title    : Floodway_Truncated
           Flow File     : g:\19180\Hydrology\Bridge Hydraulics\HEC-
RAS_Models\WilleoCreek\WilleoCr_HECRAS\WilleoCr.f07

Plan Summary Information:
Number of:  Cross Sections =   19    Multiple Openings  =    0
            Culverts       =    0    Inline Structures  =    0
            Bridges        =    2    Lateral Structures =    0

Computational Information
    Water surface calculation tolerance  =  0.01
    Critical depth calculation tolerance =  0.01
    Maximum number of iterations         =  20
    Maximum difference tolerance         =  0.3
    Flow tolerance factor                =  0.001

Computation Options
    Critical depth computed only where necessary
    Conveyance Calculation Method: At breaks in n values only
    Friction Slope Method:         Average Conveyance
    Computational Flow Regime:     Subcritical Flow

Encroachment Data
   Equal Conveyance = True
   Left Offset      =        0
   Right Offset     =        0

River = Willeo Creek     Reach = Willeo Creek
RS      Profile           Method  Value1  Value2
11553.10Floodway               1  111.55  323.79
11030.43Floodway               1  215.65  524.94
9759.109Floodway               1  194.94  560.25
8872.189Floodway               1  204.53  356.67
```

```
8133.710Floodway                1   64.24  263.06
7394.653Floodway                1  246.91  594.31
7308.132Floodway                1   189.9  294.75
7153.706Floodway                1  177.82  275.22
6563.108Floodway                1  531.85  952.19
5618.333Floodway                1  720.13 1066.62
4364.004Floodway                1  164.81  331.13
3532.729Floodway                1  163.23  390.84
2562.879Floodway                1  166.43  323.21
1410.406Floodway                1  122.12  689.73
1220.68 Floodway                1  237.85  549.96
1034.509Floodway                1  207.98   602.5
947.9219Floodway                1  358.15  540.39
682.81  Floodway                1  349.44  493.47
342.5338Floodway                1  196.68  839.06
```

FLOW DATA

Flow Title: Floodway_Truncated
Flow File : g:\19180\Hydrology\Bridge Hydraulics\HEC-RAS_Models\WilleoCreek\WilleoCr_HECRAS\WilleoCr.f07

Flow Data (cfs)

River	Reach	RS	EX_100Year	Floodway
Willeo Creek	Willeo Creek	11553.10	5958	5958
Willeo Creek	Willeo Creek	7308.132	7482	7482
Willeo Creek	Willeo Creek	4364.004	7707	7707
Willeo Creek	Willeo Creek	1034.509	7699	7699

Boundary Conditions

River	Reach	Profile	Upstream	Downstream

```
  Willeo Creek    Willeo Creek    EX_100Year                                    Normal S = 0.0007786
  Willeo Creek    Willeo Creek    Floodway                                      Normal S = 0.0007786
```

GEOMETRY DATA

Geometry Title: Proposed
Geometry File : g:\19180\Hydrology\Bridge Hydraulics\HEC-RAS_Models\WilleoCreek\WilleoCr_HECRAS\WilleoCr.g05

CROSS SECTION

RIVER: Willeo Creek
REACH: Willeo Creek RS: 11553.10

INPUT
Description: Interpolated Channel
Station Elevation Data num= 75

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	883.72	4.95	883.04	9.9	882.29	14.84	881.46	19.79	880.58
24.74	879.69	29.69	878.79	34.64	877.93	39.59	877.22	44.53	876.75
49.48	876.53	54.43	876.23	59.38	875.5	64.33	874.59	69.28	873.61
74.22	872.66	79.17	872.06	84.12	872	96.63	871.97	108.63	871.97
118.76	871.93	123.71	871.84	128.66	871.76	133.6	871.67	138.55	871.6
143.5	871.56	148.45	871.53	153.4	871.5	158.35	871.47	163.29	871.43
168.24	871.38	173.19	871.32	181.49	870.68	194.32	869.44	197.17	867.97
210.4	861.79	224.45	860.59	237.88	862.08	247.45	868.98	275.58	870.81
288.8	871.33	308.21	871.91	325.26	872.02	338.53	872.18	350.53	872.35
358.93	872.36	363.88	873.67	368.84	874.99	373.79	876.26	378.74	877.58
383.7	878.94	388.65	879.93	393.6	880.34	398.56	880.67	403.51	881.03
408.47	881.39	413.42	881.72	418.37	882.08	423.33	882.52	428.28	883.06
433.24	883.69	438.19	884.62	443.14	885.97	448.1	887.29	453.05	888.74
458	890.02	462.96	890.69	467.91	891.35	472.87	892.04	477.82	892.7
482.77	893.34	487.73	893.99	492.68	894.54	497.64	894.97	502.59	895.33

```
Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08  194.32     .04  247.45     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        194.32  247.45           374.92  522.66  721.63             .1       .3

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 11030.43

INPUT
Description: Interpolated Channel
Station Elevation Data    num=     135
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  895.69       5  894.88    9.99  893.42   14.99  891.64   19.99  889.69
   24.99  888.84   29.98  888.67   34.98   888.6   39.98  888.51   44.98  888.42
   49.97  888.33   54.97  888.23   59.97  888.15   64.97  888.04   69.96  887.96
   74.96  887.85   79.96  887.76   84.96  885.42   89.95  879.89   94.95  877.66
   99.95  875.41  104.94  873.18  109.94  871.71  114.94   871.1  119.94  870.74
  124.93  870.58  129.93  870.46  134.93  870.35  139.93  870.27  144.92  870.23
  149.92  870.21  159.92  870.19  164.91  870.18  174.91  870.16   179.9  870.15
   194.9  870.12  199.89  870.11  204.89   870.1  209.89  870.09  214.89  870.08
  219.88  870.07  229.88  870.05  239.87  870.07  244.87  870.11  249.87  870.15
  254.87  870.19  259.86  870.25  264.86  870.31  269.86  870.39  274.85  870.46
  279.85  870.53  284.85  870.61  289.85  870.68  294.84   870.7  325.98  869.96
   333.7  869.56  365.89  861.13  376.89  859.73  387.89  861.13  418.07  869.33
  425.79  869.58  432.34  869.36  437.29  869.31  442.24  869.27  447.19  869.22
  452.14  869.18  457.09  869.14  462.04  869.09  466.99  869.05  471.94  869.01
   476.9  868.97  481.85  868.92   486.8  868.85  491.75  868.77   496.7   868.7
  501.65  868.64   506.6  868.58  511.55  868.53   516.5  868.48   526.4   868.4
  531.35  868.35   536.3  868.31  541.26  868.29  546.21  868.32  551.16  868.36
  556.11   868.4  561.06  868.45  566.01  868.53  570.96  868.64  575.91  868.87
  580.86  869.33  585.81  869.79  590.76  870.24  595.71  870.61  600.66  870.56
  605.61  870.42  610.57  870.28  615.52  870.14  620.47     870  625.42  869.86
  630.37  869.54  635.32  868.64  640.27  867.97  645.22  868.22  650.17  868.83
```

```
  655.12  869.27  660.07   869.6  665.02  869.87  669.97  870.17  674.92  870.45
  679.88  870.83  684.83  872.19  689.78  873.52  694.73  874.88  699.68  876.21
  704.63  877.15  709.58  878.01  714.53   878.8  719.48  879.51  724.43  880.21
  729.38  881.04  734.33  881.97  739.28  883.31  744.24  885.33  749.19  887.97
  754.14  891.27  759.09  894.72  764.04  898.21  768.99  901.51  773.94  903.47
  778.89  904.62  783.84  905.73  788.79  906.86  793.74  907.96  798.69  909.44

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08   333.7     .04  418.07     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         333.7  418.07          1257.53 1271.33 1073.77             .1       .3
Ineffective Flow     num=       1
   Sta L   Sta R    Elev  Permanent
  610.53  798.69  870.38       F

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 9759.109

INPUT
Description: Interpolated Channel
Station Elevation Data    num=      97
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -38.01  887.23  -14.12   882.8    4.99  879.95    9.98  879.19   14.97  878.43
   19.96  877.76   24.95  877.11   29.94  876.47   34.93  875.81   39.92   875.2
   44.91  874.56    49.9  873.95   54.89  873.24   59.88  872.64   64.87  872.04
   69.86  871.58   74.85   871.2   79.84  870.87   84.83  870.53   89.82  870.21
   94.81  870.02    99.8     870  104.79  869.98  109.78  869.88  114.77  869.72
  119.76   869.6  124.75  869.55  129.75  869.31  134.74  868.63  139.73   868.1
  144.72  867.81  149.71  867.58   154.7  867.39  159.69  867.22  164.68  867.12
  169.67  867.02  174.66  866.92  179.65  866.91  184.64  867.05  189.63  867.23
  194.62  867.42  199.61   867.6   204.6  867.79  209.59  867.98  214.58  868.19
  219.57  868.51  224.56  868.84  229.55  868.67  234.54  867.69  239.53     867
   254.5  867.01  259.49  867.02  289.43  867.03   334.2  867.02  348.76  867.01
```

```
  358.46     867  367.56  867.94  376.89  860.93   394.2  858.77  411.49  860.93
  420.83  867.94  481.05  867.78  544.63  867.78  549.61  867.81   554.6  867.82
  559.58  867.85  564.56  867.86  569.55  867.84  579.51  867.77  584.49  867.73
  589.48   867.8  594.46  867.82  599.44  867.84  604.43  867.86  609.41  867.88
  614.39  867.89  619.38  867.91  624.36  867.94  629.34   868.1  634.33  868.58
  639.31  869.22  644.29  869.83  649.28  870.11  654.26  870.27  659.24  870.38
  664.23  870.48  669.21  871.55  674.19  873.52  679.18  875.83  684.16  878.16
  689.14  880.57  694.12  883.15  699.11  885.73  704.09  887.74  709.07  888.46
  714.06  889.38  719.04  890.48

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -38.01     .08  367.56     .04  420.83     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        367.56  420.83           845.18  886.92  691.75             .1       .3
Ineffective Flow     num=       1
   Sta L   Sta R    Elev  Permanent
  -38.01   227.4  868.74       F

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 8872.189

INPUT
Description: Survey Channel
Station Elevation Data    num=      89
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  885.31    4.89  882.64    9.77  882.25   14.66  881.96   19.55   881.8
   24.44  881.89   29.32  881.76   34.21   881.6    39.1  881.41   43.98  881.21
   48.87  881.13   53.76  881.39   58.65  881.81   63.53  882.15   68.42  882.43
   73.31  882.68   78.19  882.94   83.08  883.19   87.97  883.42   92.86  883.63
   97.71  883.85  102.55   884.1  112.25   884.6   117.1  884.83  121.95  884.51
   126.8   882.3  131.65  880.17   136.5   878.2  141.35  876.44   146.2  875.47
  151.05  875.05   155.9  874.57  160.75  874.14   165.6  873.77  170.45  873.58
   175.3  873.41  180.15  873.22     185  873.04  189.85  872.87   194.7  872.69
```

```
  199.55  872.52   204.4  872.34  209.25   872.2   214.1     872  218.94  870.86
  223.79  869.57  228.64  868.25   269.5  867.26   282.8  860.25  292.14  858.09
   303.7  858.49   314.8  858.66   317.4  859.22  322.74  866.68  354.39  867.83
  359.28     868  364.17  868.22  369.06  868.81  373.95  869.83  378.83  871.49
  383.72  873.55  388.61  875.55   393.5  877.39  398.39     879  403.28  880.38
  408.16  881.66  413.05  883.01  417.94  884.44  422.83  885.92  427.72  887.29
  432.61  888.48   437.5  889.56  442.38  890.68  447.27  891.83  452.16  893.05
  457.05  894.25  461.94  895.39  466.83  896.45  471.72  897.47   476.6  898.43
  481.49  899.45  486.38   900.4  491.27  901.29  496.16  902.18  501.05  903.05
  505.93  903.88  510.82  904.67  515.71  905.38   520.6  906.22

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08   269.5     .04  322.74     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         269.5  322.74           685.38  738.48  753.66             .1       .3

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 8133.710

INPUT
Description: Interpolated Channel
Station Elevation Data    num=      78
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  910.62    4.89  909.64    9.77  908.68   14.66  907.56   19.54  905.12
   24.43  900.87   29.32  896.53    34.2  892.29   39.09  888.08   43.97   883.8
   48.86  879.81   53.74  876.06   58.63  872.29   63.52  869.49    68.4  868.27
   73.29  867.47   78.17   866.9   83.06  866.56   87.95  866.33   97.29  859.32
  114.58  857.16  131.88  859.32  141.22  866.33  150.53  866.04  162.11  865.66
  170.04  865.29  179.58  865.21  184.34  865.17  189.11  865.13  193.87   865.1
  198.64  865.08  208.32  865.07  218.15  865.09  223.07  865.11  227.98  865.15
   232.9  865.18  237.82  865.21  242.73  865.24  247.65  865.27  252.57  865.29
  257.48   865.5   262.4   865.9  267.31  866.33  272.23  866.76  277.15  867.21
  282.06  867.78  286.98  868.47  291.89  869.01  296.81  869.35  301.73  869.64
```

```
  306.64  869.93  311.56  870.23  316.48  870.54  321.39  870.89  326.31  871.35
  331.22  871.97  336.14  872.67  341.06  873.41  345.97   874.2  350.89  874.98
   355.8  875.76  360.72  876.55  365.64  877.41  370.55  878.45  375.47   879.6
  380.39  880.83   385.3  882.06  390.22  883.29  395.13  884.53  400.05  885.78
  404.97  887.02  409.88  888.35   414.8  891.31  419.71  894.05  424.63  896.55
  429.55  897.02  434.46  897.05  439.38  897.21

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08   87.95     .04  141.22     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         87.95  141.22           722.72  739.06  722.47             .1       .3

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 7394.653

INPUT
Description: Interpolated Channel
Station Elevation Data    num=     126
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  882.25    4.91  881.86    9.81  881.74   14.72   881.7   19.63  881.86
   24.53  881.97   29.44  881.83   34.35  881.68   39.25  881.67   44.16  881.81
   49.06  881.87   53.97  882.16   58.88  882.53   63.78  881.87   68.69  881.26
    73.6  880.86    78.5  880.12   83.41   879.7   88.32  879.71   93.22  879.75
   98.13  879.38  103.04  879.02  107.94  878.72  112.85   878.5  117.75  878.23
  122.66  877.92  127.57  877.63  132.47  877.35  137.38  877.12  142.29  876.73
  147.25  876.04  152.21   875.2  157.17  874.35  162.12  873.54  167.08  872.72
  172.04  871.92     177  871.03  181.96  870.04  186.92  869.05  191.88  868.13
  196.84  867.39   201.8  866.88  206.76  866.55  211.72   866.4  266.28  866.36
  271.24  866.22  276.19  866.08  281.15  865.93  286.11  865.79  291.07  865.65
  300.99  865.37  310.91  865.42  315.87  865.48  320.83  865.53  325.79  865.59
  330.75  865.64  335.71   865.7  340.67  865.75  345.63  865.81  350.59   865.8
  355.55  865.74  360.51  865.63  365.47  865.52  370.43   865.4  375.39  865.29
  380.35  865.19   385.3  865.17  390.26  865.22  395.22  865.28  400.18  865.27
```

```
  405.14  865.32   410.1  865.38  415.06  865.42  420.02  865.46  424.98   865.5
  429.94  865.54  435.64  865.34  439.59  865.28  444.76  865.22  449.19  865.02
  453.63  864.67   455.6  864.35  463.33  858.53  480.64  856.37  497.93  858.53
  505.61  864.32  519.17  865.19  528.84   865.7  552.42   865.9  571.79   865.9
  579.77  866.27  586.25  866.42  591.17  867.14  596.08  867.98     601  868.82
  605.91  869.69  610.83  870.61  615.74  871.48  620.66  872.03  625.57  872.39
  630.48  872.82   635.4  873.26  640.31  873.67  645.23  874.05  650.14  874.32
  655.06  874.63  659.97  875.23  664.89  875.83   669.8  876.43  674.72  877.28
  679.63   878.2  684.54  880.14  689.46  882.31  694.37  884.71  699.29  887.21
   704.2  889.61  709.12  891.93  714.03  893.03  718.95   893.6  723.86  894.11
  728.78  894.48  733.69  894.94  738.61  895.43  743.52  895.91  748.43  896.25
  753.35  896.39

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08   455.6     .04  505.61     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         455.6  505.61          108.041  86.521  93.401             .3       .5

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 7308.132

INPUT
Description:
Station Elevation Data    num=     108
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  888.94    4.92  888.83    9.83  888.65   14.75  888.42   19.66  888.18
   24.58  887.96   29.49  887.75   34.41  887.35   39.32  887.12   44.24   887.1
   49.16  886.96   54.07  886.72   58.99  886.57    63.9  886.23   68.82  885.93
   73.73  885.62   78.65  885.26   83.56  885.03   88.48  884.85    93.4  884.79
   98.31  884.49  103.23   884.1  108.14  883.84  113.06   883.6  117.97  883.35
  122.89  883.14   127.8  882.93  132.72  882.63  137.64  882.38  142.55  881.47
  147.47   881.1  152.38   880.2   157.3  879.11  162.21  878.24  167.13  877.34
  172.04  876.74  176.96  876.15  181.88  875.33  186.79  874.03  191.71  871.96
```

```
  196.62  869.95  201.54  868.38  206.35  867.24  211.17  865.42  215.98  863.32
   220.8  861.34  225.61  859.52  229.22   857.8  230.43  857.22  235.25  856.23
  240.06  856.16   244.8  856.24  249.54  856.33  254.28  856.39  259.02  856.59
  263.76   858.3  268.45  862.93  273.13   865.4  277.82  867.41   282.5  869.21
  287.19  870.81  291.87  872.16  296.85   873.5  301.83  874.82   306.8  875.97
  311.78  876.57  316.76  876.34  321.74  876.11  326.72  875.85  331.69  875.92
  336.67  875.93  341.65     876  346.63  876.03   351.6  876.08  356.58  876.13
  361.56  876.16  366.54  876.23  371.51  876.24  376.49  876.31  381.47  876.32
  386.45  876.66  391.43  876.87   396.4  877.04  401.38     877  406.36  876.94
  411.34  876.89  416.31  876.83  421.29  876.77  426.27   876.7  431.25  876.64
  436.22  876.58   441.2  876.54  446.18  876.51  451.16  876.48  456.13  876.45
  461.11  876.43  466.09  876.41  471.07  876.39  476.05  876.38  481.02  876.36
     486   876.3  490.98  876.29  495.96   876.3  500.93  876.29  505.91  876.31
  510.89  876.29  515.87  876.28  520.84  876.26

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08  215.98     .04  268.45     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        215.98  268.45           144.84  154.43  146.12             .3       .5
Ineffective Flow     num=       2
   Sta L   Sta R    Elev  Permanent
       0     170     882       T
     320  520.84  877.33       T

BRIDGE


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 7241.553

INPUT
Description: Roswell Rd NE_ Marrietta  Hwy (94.5' Span Bridge)
Distance from Upstream XS =      24
Deck/Roadway Width        =      88
Weir Coefficient          =     2.6
Upstream  Deck/Roadway Coordinates
```

num= 26

Sta	Hi Cord	Lo Cord	Sta	Hi Cord	Lo Cord	Sta	Hi Cord	Lo Cord
0	885.29		4.94	885.11		9.87	884.96	
14.81	884.8		19.75	884.63		24.68	884.5	
29.62	884.39		34.56	884.23		39.49	883.98	
44.43	883.92		49.37	883.88		54.25	883.8	
156	883.29		198.7	882.2		200	882.2	
200	882.2	879.7	227.5	881.6	879.7	227.5	881.6	878.35
267	880.716	877.466	267	880.716	878.216	268.3	880.716	878.216
294.5	880.716	878.216	294.5	880.716		395.62	876.44	
400.51	876.33		401.55	876.23				

Upstream Bridge Cross Section Data
Station Elevation Data num= 108

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	888.94	4.92	888.83	9.83	888.65	14.75	888.42	19.66	888.18
24.58	887.96	29.49	887.75	34.41	887.35	39.32	887.12	44.24	887.1
49.16	886.96	54.07	886.72	58.99	886.57	63.9	886.23	68.82	885.93
73.73	885.62	78.65	885.26	83.56	885.03	88.48	884.85	93.4	884.79
98.31	884.49	103.23	884.1	108.14	883.84	113.06	883.6	117.97	883.35
122.89	883.14	127.8	882.93	132.72	882.63	137.64	882.38	142.55	881.47
147.47	881.1	152.38	880.2	157.3	879.11	162.21	878.24	167.13	877.34
172.04	876.74	176.96	876.15	181.88	875.33	186.79	874.03	191.71	871.96
196.62	869.95	201.54	868.38	206.35	867.24	211.17	865.42	215.98	863.32
220.8	861.34	225.61	859.52	229.22	857.8	230.43	857.22	235.25	856.23
240.06	856.16	244.8	856.24	249.54	856.33	254.28	856.39	259.02	856.59
263.76	858.3	268.45	862.93	273.13	865.4	277.82	867.41	282.5	869.21
287.19	870.81	291.87	872.16	296.85	873.5	301.83	874.82	306.8	875.97
311.78	876.57	316.76	876.34	321.74	876.11	326.72	875.85	331.69	875.92
336.67	875.93	341.65	876	346.63	876.03	351.6	876.08	356.58	876.13
361.56	876.16	366.54	876.23	371.51	876.24	376.49	876.31	381.47	876.32
386.45	876.66	391.43	876.87	396.4	877.04	401.38	877	406.36	876.94
411.34	876.89	416.31	876.83	421.29	876.77	426.27	876.7	431.25	876.64
436.22	876.58	441.2	876.54	446.18	876.51	451.16	876.48	456.13	876.45
461.11	876.43	466.09	876.41	471.07	876.39	476.05	876.38	481.02	876.36
486	876.3	490.98	876.29	495.96	876.3	500.93	876.29	505.91	876.31
510.89	876.29	515.87	876.28	520.84	876.26				

```
Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08  215.98    .035  268.45     .08

Bank Sta: Left   Right    Coeff Contr.   Expan.
        215.98  268.45             .3       .5
Ineffective Flow     num=       2
   Sta L   Sta R    Elev  Permanent
       0     170     882       T
     320  520.84  877.33       T

Downstream  Deck/Roadway Coordinates
    num=      26
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
       0  885.29            4.94  885.11            9.87  884.96
   14.81   884.8           19.75  884.63           24.68   884.5
   29.62  884.39           34.56  884.23           39.49  883.98
   44.43  883.92           49.37  883.88           54.25   883.8
     156  883.29           198.7   882.2             200   882.2
     200   882.2   879.7   227.5   881.6   879.7   227.5   881.6  878.35
     267 880.716 877.466     267 880.716 878.216   268.3 880.716 878.216
   294.5 880.716 878.216   294.5 880.716          395.62  876.44
  400.51  876.33          517.76  876.52

Downstream Bridge Cross Section Data
Station Elevation Data    num=     107
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     -80  890.68     -75   890.7  -70.01  890.41  -65.01  890.24  -60.02  890.01
  -55.02  889.69  -50.03  889.45  -45.03  889.25  -40.04  889.02  -35.04   888.8
  -30.05  888.59  -25.05  888.39  -20.05  888.17  -15.06  887.92  -10.06  887.73
   -5.07  887.52    -.07  887.24    4.92  886.75    9.92  886.06   14.91  885.82
   19.91  885.04   24.91  884.36    29.9  883.43    34.9  882.55   39.89  881.69
   44.89  880.84   49.88  879.99   54.88  879.15   59.87  878.33   64.87  877.51
   69.87  876.79   74.86  876.01   79.86  875.22   84.85  874.39   89.74  873.99
   94.63  873.58   99.52  873.15   104.4  872.63  109.29  871.97  114.18  871.24
  119.07  870.57  123.96   869.9  128.85  869.33  133.73  868.76  138.62  868.43
  143.51  868.03   148.4  867.38  158.09  867.07  165.04  866.83  170.93  866.66
  176.83  866.49  183.15  866.29  190.31  866.07  207.72  865.55  210.84  863.73
```

```
  219.72  856.99  222.44  856.15  236.74  856.47  246.34  856.37  250.94  857.11
  266.64  863.03  282.79  864.21  292.64  865.01  294.36  865.42  299.06  866.66
  303.03  867.89  307.77  868.86  312.77  869.34  317.77  869.71  322.77   870.1
  327.77  870.46  332.77  870.79  337.77  871.06  342.77  871.27  347.77  871.45
  352.77  871.63  357.77  871.81  362.77  871.99  367.77  872.17  372.77  872.35
  377.77   872.5  382.77  872.65  387.77  872.79  392.77  872.92  397.77  873.08
  402.77   873.2  407.77  873.29  412.77  873.54  417.76  873.84  422.76  874.07
  427.76  874.28  432.76  874.54  437.76  874.87  442.76  875.24  447.76  875.53
  452.76  875.79  457.76  875.98  462.76  876.16  467.76  876.52  472.76  876.66
  477.76  876.61  482.76   876.8  487.76     877  492.76  876.96  497.76  876.98
  502.76     877  552.76  876.98

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     -80     .08  210.84    .035  266.64     .08

Bank Sta: Left   Right    Coeff Contr.   Expan.
        210.84  266.64             .3       .5
Ineffective Flow     num=       2
   Sta L   Sta R    Elev  Permanent
     -80     140  876.33       F
     320  552.76  876.33       F

Upstream Embankment side slope              =       0 horiz. to 1.0 vertical
Downstream Embankment side slope            =       0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .98
Elevation at which weir flow begins         =
Energy head used in spillway design         =
Spillway height used in design              =
Weir crest shape                            = Broad Crested

Number of Abutments =  2

Abutment Data
Upstream     num=       2
     Sta    Elev     Sta    Elev
     200  875.28     230  858.54
Downstream     num=       2
```

```
     Sta    Elev     Sta    Elev
     200  875.28     230  858.54

Abutment Data
Upstream     num=       3
     Sta    Elev     Sta    Elev     Sta    Elev
   268.2  858.23   285.1   871.6   294.5   875.6
Downstream     num=       3
     Sta    Elev     Sta    Elev     Sta    Elev
   268.2  858.23   285.1   871.6   294.5   875.6

Number of Piers =  2

Pier Data
Pier Station     Upstream=     227    Downstream=     227
Upstream     num=       2
    Width   Elev    Width   Elev
     2.5     856     2.5   879.7
Downstream     num=       2
    Width   Elev    Width   Elev
     2.5     856     2.5   879.7

Pier Data
Pier Station     Upstream=     267    Downstream=     267
Upstream     num=       2
    Width   Elev    Width   Elev
     2.5     856     2.5  878.22
Downstream     num=       2
    Width   Elev    Width   Elev
     2.5     856     2.5  878.22

Number of Bridge Coefficient Sets =  1

Low Flow Methods and Data
       Energy
       Momentum               Cd   =     1.2
       Yarnell                KVal =      .9
Selected Low Flow Methods = Highest Energy Answer
```

```
High Flow Method
       Energy Only

Additional Bridge Parameters
       Add Friction component to Momentum
       Do not add Weight component to Momentum
       Class B flow critical depth computations use critical depth
           inside the bridge at the upstream end
       Criteria to check for pressure flow = Upstream energy grade line

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 7153.706

INPUT
Description: Survey Channel
Station Elevation Data    num=     100
```

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-80	890.68	-75	890.7	-70.01	890.41	-65.01	890.24	-60.02	890.01
-55.02	889.69	-50.03	889.45	-45.03	889.25	-40.04	889.02	-35.04	888.8
-30.05	888.59	-25.05	888.39	-20.05	888.17	-15.06	887.92	-10.06	887.73
-5.07	887.52	-.07	887.24	4.92	886.75	9.92	886.06	14.91	885.82
19.91	885.04	24.91	884.36	29.9	883.43	34.9	882.55	39.89	881.69
44.89	880.84	49.88	879.99	54.88	879.15	59.87	878.33	64.87	877.51
69.87	876.79	74.86	876.01	79.86	875.22	84.85	874.39	89.74	873.99
94.63	873.58	99.52	873.15	104.4	872.63	109.29	871.97	114.18	871.24
123.96	869.9	128.85	869.33	133.73	868.76	138.62	868.43	143.51	868.03
148.4	867.38	158.09	867.07	165.04	866.83	170.93	866.66	176.83	866.49
183.15	866.29	190.31	866.07	207.72	865.55	210.84	863.73	219.72	856.99
222.44	856.15	236.74	856.47	246.34	856.37	250.94	857.11	266.64	863.03
282.79	864.21	292.64	865.01	294.36	865.42	299.06	866.66	303.03	867.89
307.77	868.86	312.77	869.34	317.77	869.71	322.77	870.1	327.77	870.46
332.77	870.79	337.77	871.06	342.77	871.27	372.77	872.35	382.77	872.65
387.77	872.79	392.77	872.92	397.77	873.08	402.77	873.2	407.77	873.29
412.77	873.54	417.76	873.84	422.76	874.07	427.76	874.28	432.76	874.54

```
  437.76  874.87  442.76  875.24  447.76  875.53  452.76  875.79  457.76  875.98
  462.76  876.16  467.76  876.52  472.76  876.66  477.76  876.61  482.76   876.8
  487.76     877  492.76  876.96  497.76  876.98  502.76     877  552.76  876.98

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     -80     .08  210.84     .04  266.64     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        210.84  266.64           548.29   590.6  540.85             .3       .5
Ineffective Flow     num=       2
   Sta L   Sta R    Elev  Permanent
     -80     140  876.33       F
     320  552.76  876.33       F

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 6563.108

INPUT
Description: Survey Channel
Station Elevation Data    num=     161
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  876.24    9.94  876.23   14.91  876.21   19.88  876.19   24.85  876.18
   29.82  876.16   34.79  876.15   39.76  876.13   44.73  876.12   49.71   876.1
   54.68  876.08   59.65  876.05   64.62  876.02   69.59  875.99   74.56  875.82
   79.53  875.15    84.5  874.49   89.47  873.93   94.44  873.66   99.41   873.4
  104.38  873.14  109.35  872.91  114.32  872.77  119.29  872.66  124.26  872.55
  129.23  872.39   134.2  872.18  139.18   872.1  144.15  872.05  149.12  871.97
  159.06  871.75  164.03  871.65     169  871.54  183.91  871.21  188.88  871.11
  193.85  871.01  198.82  870.96  203.79  870.74  208.76  870.56  213.73  870.36
   218.7  870.08  223.67     870  258.47  869.86  263.44  869.77  268.41  869.75
  273.38  869.67  278.35  869.08  283.32     869  293.26  868.99  298.23  868.96
   303.2  868.88  308.17  868.76  313.14  868.63  318.11  868.51  323.09  868.37
  328.06  868.23  333.03  868.05     338     868  347.94  867.97  352.91  867.95
  362.85  867.97  367.82  867.98  372.79  867.87  377.76  867.28  382.73   867.1
```

```
   387.7  867.09  392.67  867.04  402.61  867.06  412.56  867.05  417.53  867.03
   422.5  867.02  427.47     867  432.44  867.04  437.41  867.16  447.35  867.42
  452.32  867.54  457.29  867.65  462.26  867.79  467.23  867.94   472.2     868
  482.14  868.05  487.11   868.1  502.03  868.09     507  868.01   511.8  867.83
  516.61  867.39  521.42  866.97     570  866.39  603.34  865.24  609.64  856.22
  621.84  855.61  634.34   855.1  638.14  854.71  653.84  855.68  664.14  859.33
  669.44  862.92  756.21  862.94  837.05  862.94  941.47  863.21 1012.21  863.34
 1079.58  863.48 1124.06  863.68 1129.05  863.88 1134.05  864.12 1139.04  864.44
 1144.03  864.78 1149.03   865.1 1154.02  865.42 1159.02  865.76 1164.01  866.14
 1169.01  866.72    1174  867.31 1178.99  867.92 1183.99  868.58 1188.98  869.25
 1193.98     870 1198.97  871.22 1203.97  872.57 1208.96  873.86 1213.96  875.03
 1218.95  875.46 1223.94  875.44 1228.94   875.5 1233.93  875.54 1238.93  875.57
 1243.92  875.59 1248.92   875.6 1253.91  875.61  1258.9  875.64  1263.9   875.7
 1268.89  875.79 1273.89   875.9 1278.88     876 1283.88  876.43 1288.87  877.06
 1293.86  877.74 1298.86  878.28 1303.85  878.85 1308.85     879 1328.83  879.21
 1333.82  879.72 1338.81  880.43 1343.81  881.23  1348.8  882.02  1353.8  882.75
 1358.79   883.5 1363.79  884.51 1368.78  886.15 1373.77  888.13 1378.77  890.28
 1383.76  892.27 1388.76  892.46 1393.75  892.51 1398.75  892.54 1403.74  892.49
 1408.74  892.37 1413.73  892.22 1418.72  892.23 1423.72  892.35 1428.71  892.49
 1433.71  892.63

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08  603.34     .04  669.44     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        603.34  669.44           625.09  944.78  683.16             .1       .3

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 5618.333

INPUT
Description: Interpolated Channel
Station Elevation Data    num=     174
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
```

0	875.18	4.97	875.01	9.95	874.81	14.92	874.61	19.9	874.4
24.87	874.2	29.85	874.04	34.82	874	44.77	873.99	49.74	873.96
54.72	873.89	59.69	873.82	64.66	873.77	69.64	873.66	74.61	873.15
79.59	872.36	84.56	871.59	89.54	870.75	94.51	870.04	99.48	869.52
104.46	869.05	109.43	868.53	114.41	868.12	119.38	868	179.07	867.96
184.05	867.68	189.02	867.34	193.99	867.51	198.97	867.67	203.94	867.85
208.92	867.57	213.89	867.34	218.87	867.21	223.84	867.09	228.81	866.99
233.79	866.89	238.76	866.8	243.74	866.75	248.71	866.7	253.68	866.61
258.66	866.6	263.63	866.63	268.61	866.67	273.58	867.01	278.56	867.41
283.53	867.12	288.5	867.44	293.48	867.87	298.45	868.01	303.43	868.13
308.4	868.29	313.38	868	318.35	868.01	323.32	868	333.27	868.03
338.25	868.19	343.22	868.44	348.19	868.68	353.17	868.93	358.14	869.15
363.12	869.4	368.09	869.6	373.07	869.86	378.04	870.08	383.01	870.19
387.99	870.18	392.96	870.15	397.94	870.12	402.91	870.09	407.89	870.05
412.86	870.01	417.83	869.84	422.81	869.65	427.78	869.43	432.76	869.22
437.73	869.09	442.7	868.93	447.68	868.73	452.65	868.51	457.63	868.28
462.6	868.05	467.58	868	492.45	867.98	497.42	867.89	502.4	867.8
507.37	867.71	512.34	867.62	517.32	867.52	522.29	867.43	527.27	867.38
532.24	867.27	537.21	867.26	542.19	867.24	547.16	867.29	552.14	867.38
557.11	867.41	562.09	867.49	567.06	867.66	572.03	867.83	577.01	867.87
581.98	867.68	586.96	867.47	591.93	867.03	596.91	866.66	601.88	866.61
606.85	866.64	611.83	866.81	616.8	866.8	621.78	866.77	626.75	866.73
631.72	866.7	646.65	866.76	651.62	866.82	656.6	866.89	661.57	866.95
666.54	867.02	671.52	867.12	676.49	867.32	681.47	867.51	686.44	867.26
691.41	866.13	696.39	865.02	701.36	864	706.34	863.23	711.31	862.9
716.29	862.77	721.26	862.64	726.23	862.51	731.21	862.37	736.18	862.22
741.16	862.09	789.99	861.68	865.85	860.75	880.92	853.53	896.92	852.63
912.92	853.53	917.41	860.82	958.21	861.66	1015.58	862.13	1084.63	862.21
1165.47	862.25	1224.42	862.37	1249.62	862.45	1254.61	863.18	1259.59	864
1264.58	864.72	1269.56	864.59	1274.55	864.23	1279.53	864.03	1284.52	864
1299.48	864.03	1304.46	864.31	1309.45	864.84	1314.43	865.34	1319.42	865.82
1324.4	866.18	1329.39	866.46	1334.38	866.74	1339.36	867.11	1344.35	867.9
1349.33	868.98	1354.32	870.01	1359.3	871.06	1364.29	872.1	1369.27	873.14
1374.26	874.27	1379.25	874.73	1384.23	874.6	1389.22	874.63	1394.2	874.82
1399.19	875	1404.17	875.16	1409.16	875.23	1414.14	875.19		

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val

```
       0     .08  865.85     .04  917.41     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        865.85  917.41          1062.51 1254.33 1205.75             .1       .3
Ineffective Flow     num=       1
   Sta L   Sta R    Elev  Permanent
       0  393.77  876.77       F

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 4364.004

INPUT
Description: Interpolated Channel
Station Elevation Data    num=      63
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  885.82    4.96  884.93    9.92  884.09   14.88  883.29   19.84  882.53
    24.8  881.81   29.76  881.09   34.72  880.38   39.68  879.68   44.64  879.02
    49.6  878.35   54.56  877.61   59.52  876.87   64.48  876.12   69.44  875.38
    74.4  874.58   79.36  873.74   84.32  873.03   89.28  872.25   94.24  871.33
    99.2  870.64  104.16  870.07  109.12  869.56  114.08  869.03  119.04  868.49
     124  867.66  128.95  866.81  133.91  866.06  138.87  865.38  143.83  864.72
  148.79  864.08  158.95  863.53  174.74  862.83  189.37  862.23  204.84  860.69
  211.53  859.33  225.05  852.53  241.05  851.63  257.05  852.53  270.42  859.37
  280.09  860.71  293.68  861.54  307.37  862.02  327.89  862.61  339.47  863.05
  346.97  863.95  352.39   864.7  357.36  866.14  362.33  867.15   367.3  867.87
  372.27  868.56  377.25   869.3  382.22  870.05  387.19  870.81  392.16  871.59
  397.13  872.36   402.1  873.15  407.07  873.95  412.04  874.79  417.01  875.71
  421.98  876.65  426.95  877.67  431.93  878.75

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08  211.53     .04  270.42     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        211.53  270.42          845.72  831.28  721.08             .1       .3
```

CROSS SECTION

RIVER: Willeo Creek
REACH: Willeo Creek RS: 3532.729

INPUT
Description: Interpolated Channel
Station Elevation Data num= 87

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	883	29.54	882.85	34.46	882.51	39.38	882.13	44.3	881.67
49.23	881.22	54.15	880.75	59.07	880.29	63.99	879.63	68.92	878.22
73.84	876.84	78.76	875.52	83.69	874.29	88.61	873.25	93.53	872.6
98.45	872.32	103.38	872.05	108.3	871.71	113.22	871.37	118.14	871.09
123.07	870.57	127.99	868.78	132.91	867.04	137.83	865.44	142.76	864.05
147.68	863.29	152.6	862.83	157.53	862.6	162.45	862.39	167.37	862.13
172.29	861.59	177.22	860.99	181.43	860.31	184.65	859.9	205.3	858.63
219.11	851.94	235.11	851.04	251.11	851.94	264.16	858.51	280.07	859.6
290.56	859.99	295.5	859.95	300.44	859.91	305.39	859.87	310.33	859.83
315.27	859.79	320.21	859.77	325.16	859.74	330.1	859.72	344.93	859.77
349.87	859.83	354.81	859.86	359.75	859.2	364.7	858.05	369.64	856.88
374.58	856.25	379.53	856.3	389.41	856.82	394.35	857.27	399.3	858.04
404.24	858.8	409.18	859.86	414.12	860.97	419.07	862	424.01	862.4
428.95	862.68	433.89	862.92	438.84	863.14	443.78	863.36	448.72	863.65
453.67	864.27	458.61	865	463.55	865.78	468.49	866.6	473.44	867.41
478.38	868.19	483.32	869.59	488.26	871.04	493.21	874.24	498.15	876.57
503.09	877.49	508.03	878.5	512.98	879.55	517.92	880.6	522.86	881.67
527.81	882.56	532.75	883						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.08	205.3	.04	264.16	.08

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
205.3	264.16	941.58	969.85	917.32	.1	.3

Ineffective Flow num= 1

Sta L	Sta R	Elev	Permanent

```
  352.27  532.75  859.74       F

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 2562.879

INPUT
Description: Interpolated Channel
Station Elevation Data    num=     101
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  874.79    4.97  874.11    9.94  873.38   14.91  872.55   19.88   871.8
   24.86  871.09   29.83  870.32    34.8  869.57   39.77  868.85   44.74  868.18
   49.71  867.57   54.68  867.05   59.66  866.51   64.63  866.09    69.6  865.75
   74.57  865.67   79.54   865.6   84.51  865.58   89.48  865.66   94.45  865.73
   104.4  865.66  109.37  865.56  114.34  865.51  119.31  865.52  124.28  865.54
  129.25  865.55  134.22  865.44  139.19  864.96  144.17  864.38  149.14  863.75
  154.11   863.1  159.08  862.27  164.05  861.41   171.8  860.84  182.54  860.16
  195.97  859.81   209.4  859.49  221.72  858.17     255  856.86  260.05  854.87
  267.76  850.73  283.76  849.83  299.76  850.73  308.05  854.97  312.47  856.97
  317.13  860.71  319.85  861.37  325.83  862.19  330.68  863.53  335.53  864.67
  340.38  865.29  345.23  866.02  350.09   866.7  354.94  867.24  359.79  868.19
  364.64  868.96  369.64  869.38  374.63  869.89  379.63  870.28  384.62  870.52
  389.62  870.95  394.61  871.74  399.61  872.17   404.6  872.58   409.6  872.83
  414.59  872.95  419.59  873.12  424.58  873.31  429.58  873.53  434.58  874.03
  439.57  874.43  444.57  874.59  449.56  874.96  454.56  875.63  459.55  875.87
  464.55  876.19  469.54  876.61  474.54  876.98  479.53  877.17  484.53  877.29
  489.52  877.47  494.52  877.77  499.51  878.18  504.51  878.37   509.5   878.6
   514.5  879.28   519.5  879.97  524.49  880.32  529.49  880.67  534.48  881.05
  539.48  881.38  544.47  881.78  549.47  882.41  554.46     883  559.46  883.49
  564.45  883.98  569.45  884.46  574.44  884.63  579.44  884.53  584.43  884.33
  589.43   884.2

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08     255     .04  312.47     .08
```

```
Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
           255  312.47          1302.971152.4731152.473             .1       .3

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 1410.406

INPUT
Description: Interpolated Channel
Station Elevation Data    num=     106
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
   19.93  872.84   24.92  872.42    29.9  871.98   34.88  871.54   39.86  871.04
   44.85   870.4   49.83   869.8   54.81  869.19    59.8  868.53   64.78   867.7
   69.76  867.12   74.75  866.37   79.73  865.59   84.71  865.01   89.69  863.99
   94.68  863.39   99.66  862.91  104.64  862.08  109.63  861.28  114.61  860.29
  117.19  859.54  120.53  858.79  147.13   856.1  166.13  850.49   190.5  849.55
  210.92  850.77  221.13  856.16  227.36  859.49  232.37  859.65  234.04  859.76
  239.25  859.59  244.24  859.32  249.22  858.57   254.2     857  259.18  855.49
  264.17   855.2  283.86  855.23  288.76  856.18  293.66  856.97  298.56  856.87
  303.46  856.78  308.36  856.65  313.26  856.51  318.16  856.42  323.06  856.23
  327.96  855.79  332.86  855.21  337.76   855.2  367.16  855.21  372.06  855.39
  376.96  855.71  381.86  855.86  386.76  855.58  391.65   855.2  445.55  855.59
  450.45  856.64  455.35  857.16  460.25  857.18  470.09   857.2  479.98  857.12
  484.92  856.76  489.87  855.97  494.81  855.29  499.76   855.2   504.7  855.21
  509.64  855.91  514.59  857.13  519.53  855.99  524.48  855.61  529.42   855.2
  534.36  855.68  539.31   856.8  544.25  857.17  549.19   857.2  648.07  857.24
  653.02  857.45  657.96  857.69  662.91  857.93  667.85  858.12  672.79   858.3
  677.74  858.48  682.68  858.71  687.62  858.89  692.57  858.94  697.51  858.92
  702.46   858.9   707.4  858.88  712.34  858.89  717.29  858.93  722.23  858.98
  727.18  859.03  732.12  859.07  737.06  859.13  742.01  859.52  746.95  860.46
   751.9  861.38  756.84  862.32  761.78  863.21  766.73   864.2  771.67  865.21
  776.62  866.32  781.56  867.33   786.5  868.13  791.45  868.53  796.39  868.92
  801.33  869.17

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
```

```
   19.93     .08  147.13     .04  221.13     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        147.13  221.13           73.739 189.731 180.653             .1       .3

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 1220.68

INPUT
Description: Surveyed Cross Section
Station Elevation Data    num=      60
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  242.65  865.06  242.97  865.06  243.32  865.05  243.37  865.05  243.46  865.06
  243.51  865.06  244.68  865.04  244.73  865.04  257.42  865.24  257.57  865.24
   271.6  865.21  271.86  865.21  272.13   865.2  272.54   865.2  272.81  865.19
  273.09  865.19  274.17  865.17  274.29  865.17  276.16  865.22  276.45  865.22
  276.56  865.23  276.88  865.25  277.06  865.24  277.13  865.25  277.33  865.24
  277.39  865.25  277.46  865.25  277.54  865.26  277.74  865.25  278.15  865.28
   278.2  865.29   278.3  865.29  278.35   865.3  282.35     865   282.9     865
  284.22  865.24  285.76  865.42  286.11  865.47  286.41  865.52  286.66  865.55
  286.87  865.59  291.71  866.21  292.75  866.32  310.31  853.16  347.66   856.4
  366.74  856.56  373.95   852.4  383.57  852.18  387.87  852.07  407.31  851.55
  437.66  850.61  452.54  850.25  469.53  850.87  485.41  851.12  495.34  853.35
   512.7  853.94  530.03  860.43  552.69  860.65  581.43  871.22  593.56  872.12

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  242.65     .08  366.74     .04  530.03     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        366.74  530.03           176.17  186.17  195.25             .3       .5

CROSS SECTION
```

```
RIVER: Willeo Creek
REACH: Willeo Creek       RS: 1034.509

INPUT
Description: Interpolated Channel
Station Elevation Data    num=      96
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  864.74    4.95  864.64     9.9  864.54   14.86  864.34   19.81  864.39
   24.76   864.4   29.71  864.25   34.66  864.35   39.61  864.43   44.57  864.28
   49.52  864.37   54.47   864.3   59.42  863.91   64.37  864.16   69.33  864.27
   74.28  864.25   79.23  864.08   84.18  863.93   89.13  863.82   94.08  863.74
   99.04  863.64  103.99  863.59  108.94  863.63  113.89  863.75  118.84  863.85
   123.8  863.95  128.75  864.02   133.7  864.06  138.65  864.03   143.6  863.88
  148.55  863.71  153.51  863.55  158.46  863.43  163.41  863.41  168.36  863.46
  173.31   863.5  178.27  863.42  183.22  863.01  188.17  862.36  193.12  861.44
  198.07  860.58  203.02  859.76  207.98  858.84  212.93  857.92  217.88  857.08
  222.83  856.62  227.78  856.22  244.63  856.01  266.74  855.74  292.53   855.5
  327.16  855.16  344.11  855.01  372.11  854.74  379.79   854.7  416.25  854.64
  420.68  853.22  422.89  852.15  429.64  850.54  456.55  849.02  483.45  850.54
  488.47  852.29  492.89  853.51  496.84  854.64  505.02   855.1  509.96  854.96
   514.9  855.17  519.83  855.25  524.77  855.14  529.71  854.85  539.59  854.94
  544.52  855.08  549.46  855.01   554.4  854.85  559.34  855.07  564.28  855.36
  569.21  855.54  574.15  855.94  579.09  856.53  584.03  857.05  588.97  857.67
   593.9  858.09  598.84   858.5  603.78  858.97  608.72  859.47  613.66   860.1
  618.59  861.05  623.53  862.25   630.8  862.92  633.41  863.13  638.35  863.35
  643.28   863.6  648.87  863.81  654.41  863.94  662.01  864.11  671.24  864.24
  693.21   864.6

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08  416.25     .04  496.84     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        416.25  496.84            85.25   86.59   74.13             .3       .5
Ineffective Flow     num=       2
   Sta L   Sta R    Elev  Permanent
       0  381.78     864       F
  507.76  693.21   864.1       F
```

BRIDGE

RIVER: Willeo Creek
REACH: Willeo Creek RS: 999.1037

INPUT
Description:
Distance from Upstream XS = 1
Deck/Roadway Width = 51
Weir Coefficient = 2.6
Upstream Deck/Roadway Coordinates
num= 71

Sta	Hi Cord	Lo Cord	Sta	Hi Cord	Lo Cord	Sta	Hi Cord	Lo Cord
10	865.25		14.98	865.18		19.95	865.08	
24.93	864.99		29.9	864.9		34.88	864.82	
39.85	864.72		44.83	864.67		49.8	864.66	
54.78	864.62		59.75	864.58		64.73	864.54	
69.7	864.49		74.68	864.39		79.65	864.25	
84.63	864.11		89.6	864.05		90.67	863.9	
100.67	863.83		110.67	863.74		120.67	863.69	
130.67	863.7		140.67	863.7		150.67	863.68	
160.67	863.63		170.67	863.58		180.67	863.54	
190.67	863.51		200.67	863.48		204.03	863.47	
207.83	863.46		218.55	863.43		224.98	863.42	
238.55	863.4		248.44	863.39		258.55	863.38	
258.7	863.38		278.55	863.41		285.94	863.43	
298.55	863.48		318.55	863.6		323.44	863.64	
338.55	863.76		382.78	864.11	861.69	421.64	864.42	862
422.29	864.43	862.02	438.55	864.52	862.1	452.85	864.55	862.13
457.29	864.54	862.13	458.55	864.54	862.13	478.55	864.46	862.04
498.55	864.28	861.86	506.76	864.2	861.78	518.55	864.08	
538.55	863.94		548.2	863.9		558.55	863.87	
568.73	863.86		578.55	863.87		585.7	863.88	
588.2	863.89		598.55	864.01		610.73	864.15	
621.3	864.26		636.18	864.58		641.13	864.62	
646.09	865.22		651.05	865.51		656	865.73	

```
  660.96   865.9             700   865.9

Upstream Bridge Cross Section Data
Station Elevation Data    num=     132
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  864.74    4.95  864.64     9.9  864.54   14.86  864.34   19.81  864.39
   24.76   864.4   29.71  864.25   34.66  864.35   39.61  864.43   44.57  864.28
   49.52  864.37   54.47   864.3   59.42  863.91   64.37  864.16   69.33  864.27
   74.28  864.25   79.23  864.08   84.18  863.93   89.13  863.82   94.08  863.74
   99.04  863.64  103.99  863.59  108.94  863.63  113.89  863.75  118.84  863.85
   123.8  863.95  128.75  864.02   133.7  864.06  138.65  864.03   143.6  863.88
  148.55  863.71  153.51  863.55  158.46  863.43  163.41  863.41  168.36  863.46
  173.31   863.5  178.27  863.42  183.22  863.01  188.17  862.36  193.12  861.44
  198.07  860.58  203.02  859.76  207.98  858.84  212.93  857.92  217.88  857.08
  222.83  856.62  227.78  856.22  244.63  856.01  266.74  855.74  292.53   855.5
  327.16  855.16  344.11  855.01  372.11  854.74  379.79   854.7  382.78     856
  406.25     856  410.66     853  411.46  852.91  412.17  852.83  413.46  852.69
   414.9  852.53  419.71     852  423.46  851.58   425.6  851.35  428.76     851
  430.58   850.8  431.26  850.72  432.68  850.55  437.13     850  441.37  849.35
  442.57  849.17  443.08  849.09   443.1  849.09  443.37  849.05  443.74     849
  444.08  848.95  450.25     848  452.79     848  454.49     848  455.08     848
   456.2  848.19  460.91     849  465.66  849.79  466.48  849.89  467.36     850
  468.51  850.14  469.19  850.21  471.35  850.44  471.98   850.5  472.18  850.52
  473.35  850.63  473.38  850.63   477.8     851  485.77  851.67  487.12  851.79
  488.95  851.98  489.09     852  492.89  853.51  496.84  854.64  505.02   855.1
  509.96  854.96   514.9  855.17  519.83  855.25  524.77  855.14  529.71  854.85
  539.59  854.94  544.52  855.08  549.46  855.01   554.4  854.85  559.34  855.07
  564.28  855.36  569.21  855.54  574.15  855.94  579.09  856.53  584.03  857.05
  588.97  857.67   593.9  858.09  598.84   858.5  603.78  858.97  608.72  859.47
  613.66   860.1  618.59  861.05  623.53  862.25   630.8  862.92  633.41  863.13
  638.35  863.35  643.28   863.6  648.87  863.81  654.41  863.94  662.01  864.11
  671.24  864.24  693.21   864.6

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08  410.66     .04  489.09     .08

Bank Sta: Left   Right    Coeff Contr.   Expan.
```

```
        410.66  489.09              .3       .5
Ineffective Flow     num=       2
   Sta L   Sta R    Elev  Permanent
       0  381.78     864       F
  507.76  693.21   864.1       F

Downstream  Deck/Roadway Coordinates
    num=      71
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
      10  865.25           14.98  865.18           19.95  865.08
   24.93  864.99            29.9   864.9           34.88  864.82
   39.85  864.72           44.83  864.67            49.8  864.66
   54.78  864.62           59.75  864.58           64.73  864.54
    69.7  864.49           74.68  864.39           79.65  864.25
   84.63  864.11            89.6  864.05           90.67   863.9
  100.67  863.83          110.67  863.74          120.67  863.69
  130.67   863.7          140.67   863.7          150.67  863.68
  160.67  863.63          170.67  863.58          180.67  863.54
  190.67  863.51          200.67  863.48          204.03  863.47
  207.83  863.46          218.55  863.43          224.98  863.42
  238.55   863.4          248.44  863.39          258.55  863.38
   258.7  863.38          278.55  863.41          285.94  863.43
  298.55  863.48          318.55   863.6          323.44  863.64
  338.55  863.76          382.78  864.11  861.69  421.64  864.42     862
  422.29  864.43  862.02  438.55  864.52   862.1  452.85  864.55  862.13
  457.29  864.54  862.13  458.55  864.54  862.13  478.55  864.46  862.04
  498.55  864.28  861.86  506.76   864.2  861.78  518.55  864.08
  538.55  863.94           548.2   863.9          558.55  863.87
  568.73  863.86          578.55  863.87           585.7  863.88
   588.2  863.89          598.55  864.01          610.73  864.15
   621.3  864.26          636.18  864.58          641.13  864.62
  646.09  865.22          651.05  865.51             656  865.73
  660.96   865.9             700   865.9

Downstream Bridge Cross Section Data
Station Elevation Data    num=     155
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     -10  864.88   -5.03  864.81    -.06  864.95    4.91  864.81    9.89  864.53
```

```
   14.86  864.23   19.83  864.04    24.8  863.98   29.77  863.97   34.74  863.92
   39.72   863.9   44.69  863.87   49.66  863.68   54.63  863.48    59.6  863.39
   64.57  863.35   69.55  863.31   74.52  863.27   79.49  863.22   84.46  863.16
   89.43  863.11    94.4  863.02   99.38  862.89  104.35  862.97  109.32  862.89
  114.29  862.44  119.26  862.02  124.23     862  129.21  861.89  134.18  861.02
  139.15  860.56  144.12   860.2  149.09  859.92  154.06  859.34  159.04  858.82
  164.01  858.38  168.98  857.85  173.95  857.37  188.86  855.87  193.84  855.43
  198.81  855.16  203.78  854.89  208.75   854.5  213.72  854.07  218.69  853.91
  223.67  853.86  228.64   853.6  233.61  853.26  238.58  852.99  243.55  853.12
  248.52   853.1   253.5  853.03  258.47  852.93  263.44  852.88  268.41  853.11
  273.38  853.34  278.35  853.38  283.33  853.33   288.3  853.36  293.27  853.54
  298.24  853.74  303.21  853.79  308.18  853.84  313.16  853.92  318.13     854
   323.1  854.21  328.07  854.47  333.04  854.72  338.01  854.85  342.99  854.89
  347.96  854.95  352.93  854.94   357.9  854.98  362.87  854.96  367.84  854.85
  372.81  854.93  377.79  855.02  382.78     856     404     856  410.66     853
  411.46  852.91  412.17  852.83  413.46  852.69   414.9  852.53  419.71     852
  423.46  851.58   425.6  851.35  428.76     851  430.58   850.8  431.26  850.72
  432.68  850.55  437.13     850  441.37  849.35  442.57  849.17  443.08  849.09
   443.1  849.09  443.37  849.05  443.74     849  444.08  848.95  450.25     848
  452.79     848  454.49     848  455.08     848   456.2  848.19  460.91     849
  465.66  849.79  466.48  849.89  467.36     850  468.51  850.14  469.19  850.21
  471.35  850.44  471.98   850.5  472.18  850.52  473.35  850.63  473.38  850.63
   477.8     851  485.77  851.67  487.12  851.79  488.95  851.98  489.09     852
  501.59   854.1  524.19  854.73  525.77  856.15  530.65  856.44  535.54  856.72
  540.43  857.06  545.31  857.33   550.2  857.65  555.09  858.56  559.97  859.24
  564.86  859.78  569.75  860.15  574.63  860.59  579.52   861.1  584.41  861.58
  589.29  862.05  594.18  862.72  599.07  863.03  603.95     863  608.84  862.95
  613.73   862.9  618.61  862.87   623.5  862.84  628.39  862.81  633.27  862.78
  638.16  862.82  643.05  862.92  647.93  863.06  652.82  863.25  657.71  863.46
  662.59  863.66  667.48  863.88  672.37  864.48  677.25  864.89  682.14  865.34

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     -10     .08  410.66     .04  489.09     .08

Bank Sta: Left   Right    Coeff Contr.   Expan.
        410.66  489.09             .3       .5
Ineffective Flow     num=       2
```

```
   Sta L   Sta R    Elev  Permanent
     -10  365.28     864       F
  524.26  682.14     864       F
Blocked Obstructions     num=       4
   Sta L   Sta R    Elev   Sta L   Sta R    Elev   Sta L   Sta R    Elev
  399.61  402.61  858.84  440.45  443.45   858.9   448.3   449.3  858.79
  487.07  490.07  859.01

Upstream Embankment side slope              =       0 horiz. to 1.0 vertical
Downstream Embankment side slope            =       0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .98
Elevation at which weir flow begins         =
Energy head used in spillway design         =
Spillway height used in design              =
Weir crest shape                            = Broad Crested

Number of Abutments =  2

Abutment Data
Upstream     num=       3
     Sta    Elev     Sta    Elev     Sta    Elev
   382.6     859   384.6     859   392.6     855
Downstream     num=       3
     Sta    Elev     Sta    Elev     Sta    Elev
   382.6     859   384.6     859   392.6     855

Abutment Data
Upstream     num=       3
     Sta    Elev     Sta    Elev     Sta    Elev
   480.9     848   504.9     860   506.9     860
Downstream     num=       3
     Sta    Elev     Sta    Elev     Sta    Elev
   480.9     848   504.9     860   506.9     860

Number of Piers =  2

Pier Data
Pier Station     Upstream=  423.14    Downstream=  423.14
```

```
Upstream     num=       4
    Width   Elev    Width   Elev    Width   Elev    Width   Elev
   1.667     845   1.667  859.52       3  859.52       3     862
Downstream     num=       4
    Width   Elev    Width   Elev    Width   Elev    Width   Elev
   1.667     845   1.667  859.52       3  859.52       3     862

Pier Data
Pier Station     Upstream=  466.45    Downstream=  466.45
Upstream     num=       4
    Width   Elev    Width   Elev    Width   Elev    Width   Elev
   1.667     845   1.667  859.52       3  859.52       3     862
Downstream     num=       4
    Width   Elev    Width   Elev    Width   Elev    Width   Elev
   1.667     845   1.667  859.52       3  859.52       3     862

Number of Bridge Coefficient Sets =  1

Low Flow Methods and Data
       Energy
       Momentum               Cd   =       2
Selected Low Flow Methods = Momentum

High Flow Method
       Energy Only

Additional Bridge Parameters
       Add Friction component to Momentum
       Do not add Weight component to Momentum
       Class B flow critical depth computations use critical depth
           inside the bridge at the upstream end
       Criteria to check for pressure flow = Upstream energy grade line

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 947.9219
```

```
INPUT
Description: Survey Channel
Station Elevation Data    num=     121
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     -10  864.88   -5.03  864.81    -.06  864.95    4.91  864.81    9.89  864.53
   14.86  864.23   19.83  864.04    24.8  863.98   29.77  863.97   34.74  863.92
   39.72   863.9   44.69  863.87   49.66  863.68   54.63  863.48    59.6  863.39
   64.57  863.35   69.55  863.31   74.52  863.27   79.49  863.22   84.46  863.16
   89.43  863.11    94.4  863.02   99.38  862.89  104.35  862.97  109.32  862.89
  114.29  862.44  119.26  862.02  124.23     862  129.21  861.89  134.18  861.02
  139.15  860.56  144.12   860.2  149.09  859.92  154.06  859.34  159.04  858.82
  164.01  858.38  168.98  857.85  173.95  857.37  188.86  855.87  193.84  855.43
  198.81  855.16  203.78  854.89  208.75   854.5  213.72  854.07  218.69  853.91
  223.67  853.86  228.64   853.6  233.61  853.26  238.58  852.99  243.55  853.12
  248.52   853.1   253.5  853.03  258.47  852.93  263.44  852.88  268.41  853.11
  273.38  853.34  278.35  853.38  283.33  853.33   288.3  853.36  293.27  853.54
  298.24  853.74  303.21  853.79  308.18  853.84  313.16  853.92  318.13     854
   323.1  854.21  328.07  854.47  333.04  854.72  338.01  854.85  342.99  854.89
  347.96  854.95  352.93  854.94   357.9  854.98  362.87  854.96  367.84  854.85
  372.81  854.93  377.79  855.02  382.76     855     404  855.33     421  855.14
  424.75  852.62  435.35  851.75  448.55     849  469.45  849.68  489.15  850.52
  496.39   852.1  501.59   854.1  524.19  854.73  525.77  856.15  530.65  856.44
  535.54  856.72  540.43  857.06  545.31  857.33   550.2  857.65  555.09  858.56
  559.97  859.24  564.86  859.78  569.75  860.15  574.63  860.59  579.52   861.1
  584.41  861.58  589.29  862.05  594.18  862.72  599.07  863.03  603.95     863
  608.84  862.95  613.73   862.9  618.61  862.87   623.5  862.84  628.39  862.81
  633.27  862.78  638.16  862.82  643.05  862.92  647.93  863.06  652.82  863.25
  657.71  863.46  662.59  863.66  667.48  863.88  672.37  864.48  677.25  864.89
  682.14  865.34

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     -10     .08     421     .04  501.59     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
           421  501.59          239.821  255.14 271.224             .3       .5
Ineffective Flow     num=       2
```

```
   Sta L   Sta R    Elev  Permanent
     -10  365.28     864       F
  524.26  682.14     864       F
Blocked Obstructions     num=       4
   Sta L   Sta R    Elev   Sta L   Sta R    Elev   Sta L   Sta R    Elev
  399.61  402.61  858.84  440.45  443.45   858.9   448.3   449.3  858.79
  487.07  490.07  859.01

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 682.81

INPUT
Description:
Station Elevation Data    num=      30
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     -52     865      -4     853       0  852.32   46.27  850.98   93.46  850.77
  136.75   850.4  158.34  850.46  191.97  850.56  246.71  850.66  303.56  851.36
  337.28  852.13  361.54  852.67  380.06  853.61  396.96  855.64  414.82  856.52
  431.72  855.86  435.68  852.81  467.95  848.78   508.4  852.98  509.61   854.7
  536.97  858.29  572.28  860.65  613.66  864.36  647.51  866.15  735.51  864.06
  747.59  864.86  789.84  863.76  857.65  886.47  877.68  883.79  959.45   900.8

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     -52     .08  431.72     .04  509.61     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        431.72  509.61           565.25  350.28  612.84             .1       .3

CROSS SECTION


RIVER: Willeo Creek
REACH: Willeo Creek       RS: 342.5338
```

```
INPUT
Description: Interpolated Channel
Station Elevation Data    num=     116
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  865.76    4.99  865.66    9.98  865.34   14.97  864.89   19.96  864.41
   24.95  863.35   29.94  861.94   34.93  860.63   39.92  860.25   44.91   860.2
    49.9  860.11   54.89  860.01   59.88  859.96   64.87   859.9   69.86  859.86
   74.85  859.83   79.84  859.78   84.83  859.42   89.81  858.34    94.8   857.2
   99.79  856.15  104.78  855.19  109.77  854.31  114.76  853.51  119.75   852.2
  124.74  851.17  129.73   850.7  134.72  850.44  139.71  850.39   144.7  850.38
  154.68  850.37  164.66  850.35  169.65  850.34  174.64  850.33  184.62  850.32
   194.6   850.3  199.59  850.29  204.58  850.28  214.56  850.27  219.55  850.26
  224.54  850.25  234.52  850.23   244.5  850.22  249.49  850.21  254.48   850.2
  259.47  850.19  264.46  850.18  269.44  850.17  284.41  850.18  294.39  850.19
  304.37   850.2  314.35  850.21  324.33  850.22  334.31  850.23   339.3  850.24
  359.26  850.26  369.24  850.27  374.23  850.28  384.21  850.29  404.17  850.31
  414.15  850.32  419.14  850.33  429.12  850.34   439.1  850.35  449.08  850.36
  454.06  850.37  464.04  850.38  474.02  850.39     484   850.4  683.61  850.42
   688.6  851.78  693.49   853.3  698.51  853.46  703.54  853.27  708.26  852.43
  716.98  849.76  743.89  848.24  787.44  848.27  806.18  849.36  826.06  852.14
  839.06  853.46  845.57  854.57  848.48  855.34  853.48  856.78  858.48  858.25
  863.47  859.82  868.47  861.53  873.47  863.32  878.46   865.2  883.46  867.11
  888.45  869.12  893.45  871.23  898.45  872.42  903.44  873.23  908.44  873.89
  913.44  874.43  918.43  874.99  923.43  875.45  928.43  875.95  933.42  876.21
  938.42  876.39  943.41  876.62  948.41   876.9  953.41  877.23   958.4  877.32
   963.4  877.57   968.4  877.86  973.39  878.28  978.39   878.7  983.38  879.12
  988.38  879.46  993.38  879.81  998.37  880.16 1003.37  880.51 1008.37  880.82
 1013.36   881.2

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .08  703.54     .04  839.06     .08

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        703.54  839.06           123.65  342.53   84.21             .1       .3
```

SUMMARY OF MANNING'S N VALUES

River:Willeo Creek

Reach	River Sta.	n1	n2	n3
Willeo Creek	11553.10	.08	.04	.08
Willeo Creek	11030.43	.08	.04	.08
Willeo Creek	9759.109	.08	.04	.08
Willeo Creek	8872.189	.08	.04	.08
Willeo Creek	8133.710	.08	.04	.08
Willeo Creek	7394.653	.08	.04	.08
Willeo Creek	7308.132	.08	.04	.08
Willeo Creek	7241.553	Bridge		
Willeo Creek	7153.706	.08	.04	.08
Willeo Creek	6563.108	.08	.04	.08
Willeo Creek	5618.333	.08	.04	.08
Willeo Creek	4364.004	.08	.04	.08
Willeo Creek	3532.729	.08	.04	.08
Willeo Creek	2562.879	.08	.04	.08
Willeo Creek	1410.406	.08	.04	.08
Willeo Creek	1220.68	.08	.04	.08
Willeo Creek	1034.509	.08	.04	.08
Willeo Creek	999.1037	Bridge		
Willeo Creek	947.9219	.08	.04	.08
Willeo Creek	682.81	.08	.04	.08
Willeo Creek	342.5338	.08	.04	.08

SUMMARY OF REACH LENGTHS

River: Willeo Creek

Reach	River Sta.	Left	Channel	Right
Willeo Creek	11553.10	374.92	522.66	721.63

Willeo Creek	11030.43	1257.53	1271.33	1073.77
Willeo Creek	9759.109	845.18	886.92	691.75
Willeo Creek	8872.189	685.38	738.48	753.66
Willeo Creek	8133.710	722.72	739.06	722.47
Willeo Creek	7394.653	108.041	86.521	93.401
Willeo Creek	7308.132	144.84	154.43	146.12
Willeo Creek	7241.553	Bridge		
Willeo Creek	7153.706	548.29	590.6	540.85
Willeo Creek	6563.108	625.09	944.78	683.16
Willeo Creek	5618.333	1062.51	1254.33	1205.75
Willeo Creek	4364.004	845.72	831.28	721.08
Willeo Creek	3532.729	941.58	969.85	917.32
Willeo Creek	2562.879	1302.97	1152.473	1152.473
Willeo Creek	1410.406	73.739	189.731	180.653
Willeo Creek	1220.68	176.17	186.17	195.25
Willeo Creek	1034.509	85.25	86.59	74.13
Willeo Creek	999.1037	Bridge		
Willeo Creek	947.9219	239.821	255.14	271.224
Willeo Creek	682.81	565.25	350.28	612.84
Willeo Creek	342.5338	123.65	342.53	84.21

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: Willeo Creek

Reach	River Sta.	Contr.	Expan.
Willeo Creek	11553.10	.1	.3
Willeo Creek	11030.43	.1	.3
Willeo Creek	9759.109	.1	.3
Willeo Creek	8872.189	.1	.3
Willeo Creek	8133.710	.1	.3
Willeo Creek	7394.653	.3	.5
Willeo Creek	7308.132	.3	.5
Willeo Creek	7241.553 Bridge		

```
 Willeo Creek         7153.706        .3        .5
 Willeo Creek         6563.108        .1        .3
 Willeo Creek         5618.333        .1        .3
 Willeo Creek         4364.004        .1        .3
 Willeo Creek         3532.729        .1        .3
 Willeo Creek         2562.879        .1        .3
 Willeo Creek         1410.406        .1        .3
 Willeo Creek         1220.68         .3        .5
 Willeo Creek         1034.509        .3        .5
 Willeo Creek         999.1037 Bridge
 Willeo Creek         947.9219        .3        .5
 Willeo Creek         682.81          .1        .3
 Willeo Creek         342.5338        .1        .3


Profile Output Table - Standard Table 1

  Reach          River Sta                   Profile      Q Total   Min Ch El   W.S. Elev   Crit W.S.
E.G. Elev   E.G. Slope   Vel Chnl   Flow Area   Top Width   Froude # Chl
                                                              (cfs)        (ft)        (ft)        (ft)
(ft)      (ft/ft)     (ft/s)     (sq ft)        (ft)

  Willeo Creek   11553.10 528                EX_100Year   5958.00      860.59      875.01
875.66     0.001610       7.30     1473.70      306.91           0.38
  Willeo Creek   11553.10 528                Floodway     5958.00      860.59      875.57
876.20     0.001454       7.16     1353.64      212.24           0.36

  Willeo Creek   11030.43 1905               EX_100Year   5958.00      859.73      875.03      869.95
875.14     0.000356       3.41     3579.34      594.50           0.18
  Willeo Creek   11030.43 1905               Floodway     5958.00      859.73      875.40      869.85
875.62     0.000558       4.36     2254.92      309.29           0.23

  Willeo Creek   9759.109 1907               EX_100Year   5958.00      858.77      874.70      869.33
874.76     0.000254       3.12     4402.59      632.90           0.15
  Willeo Creek   9759.109 1907               Floodway     5958.00      858.77      874.89      869.41
875.02     0.000400       3.96     3008.71      365.31           0.19
```

```
  Willeo Creek   8872.189 1882                EX_100Year   5958.00      858.09      873.72
874.31     0.001219       6.80     1374.33      217.14           0.33
  Willeo Creek   8872.189 1882                Floodway     5958.00      858.09      873.79
874.42     0.001241       6.89     1250.00      152.14           0.33

  Willeo Creek   8133.710 532                 EX_100Year   5958.00      857.16      873.29
873.56     0.000670       5.12     2132.72      282.94           0.25
  Willeo Creek   8133.710 532                 Floodway     5958.00      857.16      873.31
873.63     0.000741       5.40     1827.62      198.82           0.26

  Willeo Creek   7394.653 1327                EX_100Year   5958.00      856.37      873.06
873.18     0.000336       3.82     3430.43      468.14           0.18
  Willeo Creek   7394.653 1327                Floodway     5958.00      856.37      873.05
873.19     0.000393       4.13     2918.67      347.40           0.19

  Willeo Creek   7308.132 864                 EX_100Year   7482.00      856.16      871.05      866.62
872.65     0.002770      10.40      839.86       94.07           0.51
  Willeo Creek   7308.132 864                 Floodway     7482.00      856.16      871.07      866.62
872.67     0.002749      10.37      842.41       94.23           0.50

  Willeo Creek   7241.553 354                                Bridge

  Willeo Creek   7153.706 865                 EX_100Year   7482.00      856.15      868.75      866.74
870.54     0.004282      11.31      901.44      173.30           0.61
  Willeo Creek   7153.706 865                 Floodway     7482.00      856.15      869.51      866.62
871.30     0.003723      11.04      810.68       97.40           0.58

  Willeo Creek   6563.108 1881                EX_100Year   7482.00      854.71      868.89
869.04     0.000542       4.30     4077.78      883.97           0.22
  Willeo Creek   6563.108 1881                Floodway     7482.00      854.71      869.52
869.75     0.000669       4.94     2926.68      420.34           0.24

  Willeo Creek   5618.333 3990                EX_100Year   7482.00      852.63      868.52      864.02
868.64     0.000451       4.25     4628.08     1129.98           0.20
  Willeo Creek   5618.333 3990                Floodway     7482.00      852.63      868.99      864.01
869.22     0.000634       5.15     2888.16      346.49           0.24
```

```
  Willeo Creek   4364.004 1385                EX_100Year   7707.00      851.63      866.64
867.57     0.001853       8.44     1428.02      229.78           0.42
  Willeo Creek   4364.004 1385                Floodway     7707.00      851.63      867.06
867.96     0.001706       8.27     1350.02      166.32           0.40

  Willeo Creek   3532.729 1384                EX_100Year   7707.00      851.04      865.81      859.85
866.26     0.001152       6.59     2188.12      327.01           0.33
  Willeo Creek   3532.729 1384                Floodway     7707.00      851.04      866.20      861.64
866.70     0.001167       6.77     1922.31      227.61           0.33

  Willeo Creek   2562.879 1382                EX_100Year   7707.00      849.83      862.39
864.19     0.004377      11.38      933.80      168.19           0.62
  Willeo Creek   2562.879 1382                Floodway     7707.00      849.83      863.85
865.04     0.002551       9.48     1155.64      156.78           0.48

  Willeo Creek   1410.406 538                 EX_100Year   7707.00      849.55      861.62
861.82     0.000840       4.98     3393.51      645.62           0.27
  Willeo Creek   1410.406 538                 Floodway     7707.00      849.55      863.76
863.86     0.000341       3.60     4438.44      567.61           0.18

  Willeo Creek   1220.68                      EX_100Year   7707.00      850.25      861.33
861.65     0.000894       4.77     1876.30      255.12           0.28
  Willeo Creek   1220.68                      Floodway     7707.00      850.25      863.58
863.78     0.000409       3.74     2442.61      253.56           0.20

  Willeo Creek   1034.509 868                 EX_100Year   7699.00      849.02      859.80      857.32
861.08     0.003511       9.48      963.03      408.49           0.55
  Willeo Creek   1034.509 868                 Floodway     7699.00      849.02      862.87      857.32
863.52     0.001242       6.85     1350.52      394.52           0.35

  Willeo Creek   999.1037                                   Bridge

  Willeo Creek   947.9219 869                 EX_100Year   7699.00      849.02      857.69      857.69
860.04     0.018237      13.08      720.87      369.71           0.88
  Willeo Creek   947.9219 869                 Floodway     7699.00      849.02      862.05      857.69
862.64     0.002875       6.79     1402.46      182.24           0.37
```

```
  Willeo Creek   682.81                        EX_100Year   7699.00      848.78      856.28
856.50     0.002635       5.62     2435.16      527.52           0.43
  Willeo Creek   682.81                        Floodway     7699.00      848.78      858.16      858.16
860.74     0.011558      13.99      749.35      144.03           0.91

  Willeo Creek   342.5338 1381                 EX_100Year   7699.00      848.24      855.72      852.26
855.81     0.000779       3.45     3960.78      747.79           0.25
  Willeo Creek   342.5338 1381                 Floodway     7699.00      848.24      856.04      852.37
856.14     0.000779       3.52     3720.33      642.38           0.25


Profile Output Table - Standard Table 2

  Reach          River Sta                     Profile      E.G. Elev   W.S. Elev   Vel Head   Frctn
Loss   C & E Loss    Q Left   Q Channel   Q Right   Top Width
                                                                  (ft)        (ft)       (ft)
(ft)         (ft)     (cfs)       (cfs)     (cfs)        (ft)

  Willeo Creek   11553.10 528                  EX_100Year      875.66      875.01       0.64
0.36         0.16    706.18     4534.09    717.72      306.91
  Willeo Creek   11553.10 528                  Floodway        876.20      875.57       0.63
0.45         0.13    634.85     4654.25    668.90      212.24

  Willeo Creek   11030.43 1905                 EX_100Year      875.14      875.03       0.10
0.36         0.01   1049.70     3163.08   1745.22      594.50
  Willeo Creek   11030.43 1905                 Floodway        875.62      875.40       0.22
0.58         0.03    772.11     4187.34    998.55      309.29

  Willeo Creek   9759.109 1907                 EX_100Year      874.76      874.70       0.07
0.40         0.05   2089.01     2201.74   1667.26      632.90
  Willeo Creek   9759.109 1907                 Floodway        875.02      874.89       0.13
0.55         0.05   1820.99     2831.67   1305.33      365.31

  Willeo Creek   8872.189 1882                 EX_100Year      874.31      873.72       0.59
0.65         0.10    478.41     4835.80    643.78      217.14
  Willeo Creek   8872.189 1882                 Floodway        874.42      873.79       0.62
0.70         0.09    578.04     4928.49    451.47      152.14
```

```
  Willeo Creek   8133.710 532                EX_100Year      873.56      873.29       0.27
0.34         0.05    215.31     3670.07   2072.62      282.94
  Willeo Creek   8133.710 532                Floodway        873.63      873.31       0.31
0.39         0.05    210.01     3870.35   1877.64      198.82

  Willeo Creek   7394.653 1327               EX_100Year      873.18      873.06       0.12
0.08         0.45   2416.27     2745.29    796.44      468.14
  Willeo Creek   7394.653 1327               Floodway        873.19      873.05       0.15
0.08         0.44   2143.02     2964.23    850.75      347.40

  Willeo Creek   7308.132 864                EX_100Year      872.65      871.05       1.61
181.69     7142.33    157.97       94.07
  Willeo Creek   7308.132 864                Floodway        872.67      871.07       1.60
182.87     7140.28    158.84       94.23

  Willeo Creek   7241.553 354                                Bridge

  Willeo Creek   7153.706 865                EX_100Year      870.54      868.75       1.80
0.68         0.82    319.84     6730.29    431.87      173.30
  Willeo Creek   7153.706 865                Floodway        871.30      869.51       1.79
0.76         0.78    300.67     7039.00    142.33       97.40

  Willeo Creek   6563.108 1881               EX_100Year      869.04      868.89       0.15
0.39         0.01    270.94     3466.92   3744.14      883.97
  Willeo Creek   6563.108 1881               Floodway        869.75      869.52       0.23
0.53         0.00    242.55     4188.98   3050.47      420.34

  Willeo Creek   5618.333 3990               EX_100Year      868.64      868.52       0.13
1.00         0.08   1278.22     3042.30   3161.49     1129.98
  Willeo Creek   5618.333 3990               Floodway        869.22      868.99       0.23
1.20         0.07   1854.20     3816.03   1811.77      346.49

  Willeo Creek   4364.004 1385               EX_100Year      867.57      866.64       0.92
1.17         0.14    547.93     6360.55    798.52      229.78
  Willeo Creek   4364.004 1385               Floodway        867.96      867.06       0.90
1.14         0.12    517.77     6434.45    754.78      166.32
```

```
  Willeo Creek   3532.729 1384              EX_100Year      866.26      865.81       0.45
1.93         0.13    490.27     4890.45   2326.28      327.01
  Willeo Creek   3532.729 1384              Floodway        866.70      866.20       0.50
1.59         0.07    483.23     5178.12   2045.65      227.61

  Willeo Creek   2562.879 1382              EX_100Year      864.19      862.39       1.80
1.89         0.48    818.46     6849.37     39.17      168.19
  Willeo Creek   2562.879 1382              Floodway        865.04      863.85       1.19
0.85         0.33   1140.51     6496.21     70.28      156.78

  Willeo Creek   1410.406 538               EX_100Year      861.82      861.62       0.21
0.16         0.01    149.63     3774.70   3782.67      645.62
  Willeo Creek   1410.406 538               Floodway        863.86      863.76       0.10
0.07         0.01    166.27     3297.58   4243.15      567.61

  Willeo Creek   1220.68                    EX_100Year      861.65      861.33       0.33
0.29         0.29    654.99     7043.56      8.45      255.12
  Willeo Creek   1220.68                    Floodway        863.78      863.58       0.20
0.12         0.14    756.11     6906.94     43.95      253.56

  Willeo Creek   1034.509 868               EX_100Year      861.08      859.80       1.28
578.70     6951.74    168.56      408.49
  Willeo Creek   1034.509 868               Floodway        863.52      862.87       0.65
0.00         0.08    753.16     6719.40    226.43      394.52

  Willeo Creek   999.1037                                   Bridge

  Willeo Creek   947.9219 869               EX_100Year      860.04      857.69       2.36
1.38         1.07    605.86     6683.93    409.21      369.71
  Willeo Creek   947.9219 869               Floodway        862.64      862.05       0.59
1.30         0.60   1231.89     5799.59    667.51      182.24

  Willeo Creek   682.81                     EX_100Year      856.50      856.28       0.22
0.65         0.04   5412.69     2278.66      7.65      527.52
  Willeo Creek   682.81                     Floodway        860.74      858.16       2.58
0.85         0.74   1288.16     6410.84                144.03
```

```
  Willeo Creek   342.5338 1381                EX_100Year      855.81      855.72       0.09
4843.31     2847.57      8.12      747.79
  Willeo Creek   342.5338 1381                Floodway        856.14      856.04       0.10
4637.01     3062.00                747.38


Profile Output Table - Six XS Bridge

  Reach          River Sta                        Profile      E.G. Elev   W.S. Elev   Crit W.S.
Frctn Loss   C & E Loss   Top Width    Q Left   Q Channel   Q Right   Vel Chnl
                                                                  (ft)        (ft)        (ft)
(ft)         (ft)         (ft)     (cfs)       (cfs)     (cfs)     (ft/s)

  Willeo Creek   7394.653 1327                    EX_100Year      873.18      873.06
0.08         0.45      468.14   2416.27     2745.29    796.44       3.82
  Willeo Creek   7394.653 1327                    Floodway        873.19      873.05
0.08         0.44      347.40   2143.02     2964.23    850.75       4.13

  Willeo Creek   7308.132 864                     EX_100Year      872.65      871.05      866.62
94.07    181.69     7142.33    157.97      10.40
  Willeo Creek   7308.132 864                     Floodway        872.67      871.07      866.62
94.23    182.87     7140.28    158.84      10.37

  Willeo Creek   7241.553 354             BR U    EX_100Year      872.61      870.10      867.53
68.92     28.49     7260.51    193.00      12.89
  Willeo Creek   7241.553 354             BR U    Floodway        872.63      870.14      867.53
69.04     29.13     7257.87    195.00      12.84

  Willeo Creek   7241.553 354             BR D    EX_100Year      872.51      868.45      868.45
63.87               7280.39    201.61      16.38
  Willeo Creek   7241.553 354             BR D    Floodway        872.58      868.39      868.39
57.87               7322.55    159.46      16.58

  Willeo Creek   7153.706 865                     EX_100Year      870.54      868.75      866.74
0.68         0.82      173.30    319.84     6730.29    431.87      11.31
  Willeo Creek   7153.706 865                     Floodway        871.30      869.51      866.62
0.76         0.78       97.40    300.67     7039.00    142.33      11.04
```

```
  Willeo Creek   6563.108 1881                    EX_100Year      869.04      868.89
0.39         0.01      883.97    270.94     3466.92   3744.14       4.30
  Willeo Creek   6563.108 1881                    Floodway        869.75      869.52
0.53         0.00      420.34    242.55     4188.98   3050.47       4.94


  Willeo Creek   1220.68                          EX_100Year      861.65      861.33
0.29         0.29      255.12    654.99     7043.56      8.45       4.77
  Willeo Creek   1220.68                          Floodway        863.78      863.58
0.12         0.14      253.56    756.11     6906.94     43.95       3.74

  Willeo Creek   1034.509 868                     EX_100Year      861.08      859.80      857.32
408.49    578.70     6951.74    168.56       9.48
  Willeo Creek   1034.509 868                     Floodway        863.52      862.87      857.32
0.00         0.08      394.52    753.16     6719.40    226.43       6.85

  Willeo Creek   999.1037BR U                     EX_100Year      861.05      859.39      857.37
117.61    278.29     7235.49    185.22      10.65
  Willeo Creek   999.1037BR U                     Floodway        863.44      862.51      857.37
0.34         0.05                427.60     7014.21    257.20       8.03

  Willeo Creek   999.1037BR D                     EX_100Year      860.90      857.76      857.76
100.01    197.53     7389.63    111.84      14.48
  Willeo Creek   999.1037BR D                     Floodway        863.04      861.95      857.76
0.15         0.25       68.00    403.68     7076.56    218.77       8.73

  Willeo Creek   947.9219 869                     EX_100Year      860.04      857.69      857.69
1.38         1.07      369.71    605.86     6683.93    409.21      13.08
  Willeo Creek   947.9219 869                     Floodway        862.64      862.05      857.69
1.30         0.60      182.24   1231.89     5799.59    667.51       6.79

  Willeo Creek   682.81                           EX_100Year      856.50      856.28
0.65         0.04      527.52   5412.69     2278.66      7.65       5.62
  Willeo Creek   682.81                           Floodway        860.74      858.16      858.16
0.85         0.74      144.03   1288.16     6410.84                13.99


Profile Output Table - Bridge Only
```

```
  Reach          River Sta                    Profile      E.G. US.   Min El Prs   BR Open Area   Prs O
WS   Q Total   Min El Weir Flow   Q Weir   Delta EG   BR Sluice Coef
                                                                  (ft)         (ft)        (sq ft)
(ft)     (cfs)               (ft)    (cfs)       (ft)

  Willeo Creek   7241.553 354                EX_100Year     872.65       879.70        1297.99
7482.00             877.34                2.11
  Willeo Creek   7241.553 354                Floodway       872.67       879.70        1150.62
7482.00             880.73                1.38

  Willeo Creek   999.1037                    EX_100Year     861.08       862.13        1056.89
7699.00             864.01                1.03
  Willeo Creek   999.1037                    Floodway       863.52       862.13        1056.89
7699.00             864.01                0.89
```