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Flood Study

Kalas Falls Subdivision

Rolesville Road

Rolesville, North Carolina

Prepared For

Mitchell Mill Road Investors LLC
100 Weston Estates Way
Cary, NC 27513

June 26, 2017

Kalas Falls Subdivision

Stormwater Management Report

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HEC-RAS Report

Kalas Falls Subdivision

General

This project is located in Rolesville, North Carolina at Rolesville Road. It drains to tributaries of Harris Branch which is part of the Falls of Neuse River basin. There are three culverts that need designed as part of the development for the 200 lot subdivision. This study will explain the rational used to run the HEC RAS computer model to determine 100 year floodplain elevations at two of the three culverts.

Existing and Proposed Conditions

A copy of the Rolesville quadrangle in the appendix shows the 144 acre parcel. The property has one stream running through from the south to the north. The drainage boundary begins around Mitchell Mill Road and just to the east of Rolesville Road.

The Stormwater Management Report explains the existing and proposed conditions for the three crossing locations. These locations are labeled Crossing A, Crossing C and Crossing D. To design the culvert crossings, the post development condition was used to determine the flows.

Crossing A contains a drainage basin of 61 acres. The crossing is at the upstream side of the existing farm pond (identified as B on the hydrologic model). After passing through the farm pond, there is approximately 1,300 feet of stream to reach Crossing C. The total drainage area for Crossing C is 120 acres.

Crossing D drainage area is 280 acres. The stream from Crossing C is combined with an unnamed tributary to the east. There are existing water fall features downstream of Crossing D that will be protected as much as possible.

Flood Study

The project is outside any FEMA floodplain. Therefore the HEC RAS computer model is being used to determine the 100 year elevations.

Due to the size of the drainage basins, we performed two additional methods to determine a 100 year flow value. The first method was StreamStats 4.0 from the USGS website. For crossing A, we modified the upstream drainage area to 30 percent impervious. A 100 year flow value of 125 cfs is projected.

The second method was using NCDOT Hydrologic Design Charts, which are a series of nomographs used to determine the 100 year flow value. The rural runoff method calculated 70 cfs and the urban method projected 150 cfs. The SCS method estimated a value of 192 cfs for the 100 year storm. Comparing the three methods, it was concluded that a value of 150 cfs was realistic for Crossing A.

The Crossing C drainage area is 120 acres. StreamStats 4.0 had an average flow of 208 cfs, with a lower / upper range between 110 and 394 cfs.

The NCDOT Hydrologic Design Charts calculated the rural runoff method calculated 130 cfs. The urban charts did not extend beyond 100 acres. The SCS method estimated a value of 351 cfs for the 100 year storm. Comparing the three methods, it was concluded that a value of 316 cfs was realistic for Crossing C.

The Crossing D area is 280 acres. StreamStats 4.0 had an average flow of 459 cfs, with a lower / upper range between 243 and 867 cfs. The SCS method estimated a value of 938 cfs for the 100 year storm. These values show a significant variation between the two methods. It was concluded to use a value of 867 cfs for the design of Crossing D.

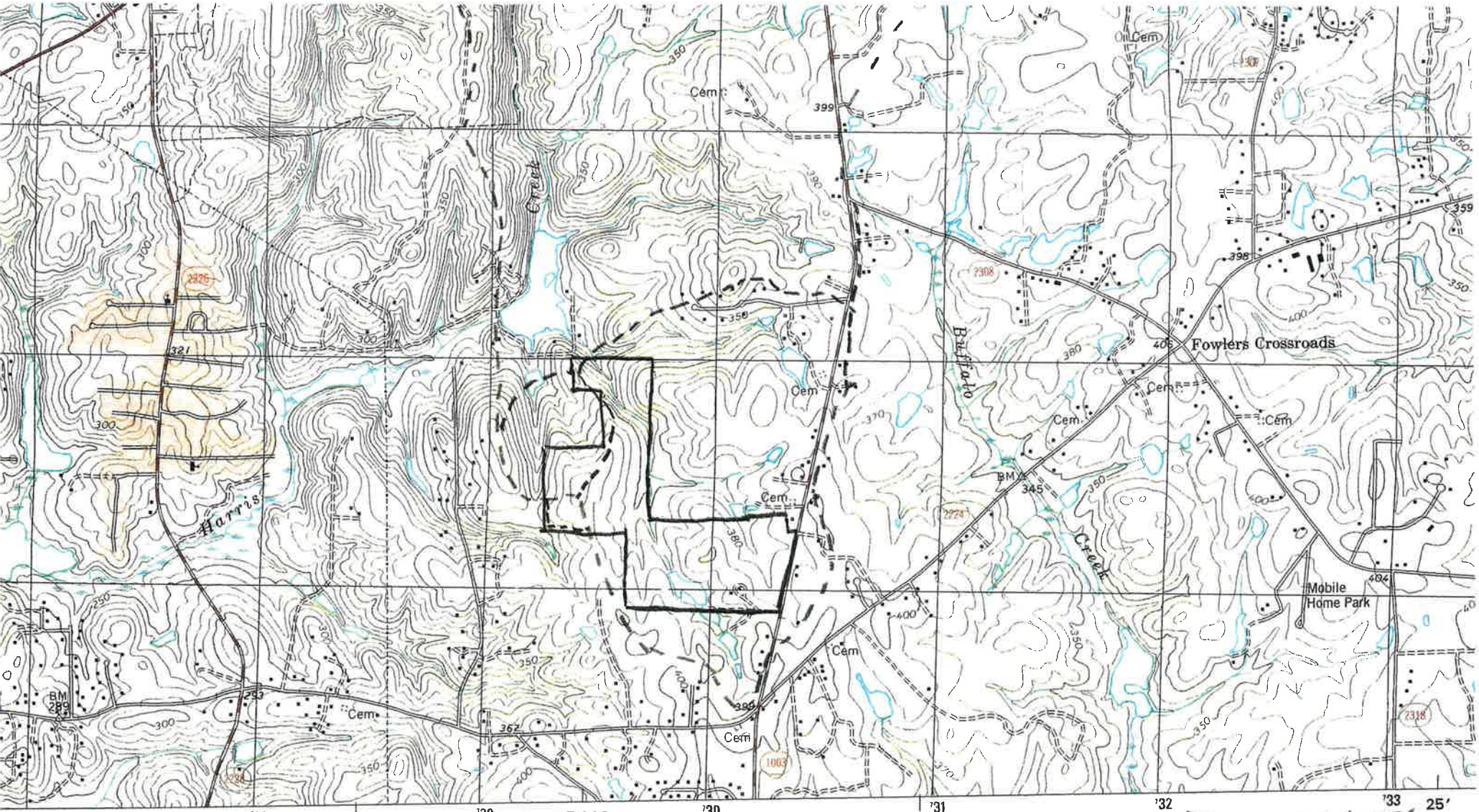
Culvert Sizing / 100 year elevations

With the Crossing A pipe being influenced by Pond B, a simple culvert design was performed for the crossing. Dual 48" pipes are proposed. The west pipe has two catch basins dropping into the pipe. The east pipe is continuous for its entire length. The 100 year flow of 150 cfs was used, and a HW/D value of 1.03 is obtained. We feel that this would be a conservative design for this crossing.

The HEC RAS summary report is included in the Appendix. Dual culverts are proposed at the other culvert crossings as well. At Crossing C (station 25+22), the model has a 60" culvert with 6" of being blocked and a 54" culvert with no blockage (pages 8 and 9). The 100 year flood elevation is 352.93' (page 25). The crown of the pipe is 351.50'

Crossing D (station 10+96). the model has a 84" culvert with 12" of being blocked and a 84" culvert with no blockage (pages 18 and 19). The 100 year flood elevation is 341.18' (page 25). The crown of the pipe is 339.00'. With the water falls downstream of this crossing, aquatic wildlife cannot pass from downstream to upstream. However, we have designed the culvert with riprap baffles on the low flow pipe to minimize scour from the crossing.

Appendix



SCALE 1:24 000

PROJECT 144 ALPES
WATERSHED 1600 ACRES

Geological Survey
Carolina Department
sources

y derived from imagery
control current as of 1967

83). Projection and
Mercator, zone 17S
rdinate System of 1983
27) is shown by dashed
tween NAD 83 and
e obtainable from
oftware
er Labeled Buildings 1967

MN
GN
9°
160 MILS
1° 30'
27 MILS

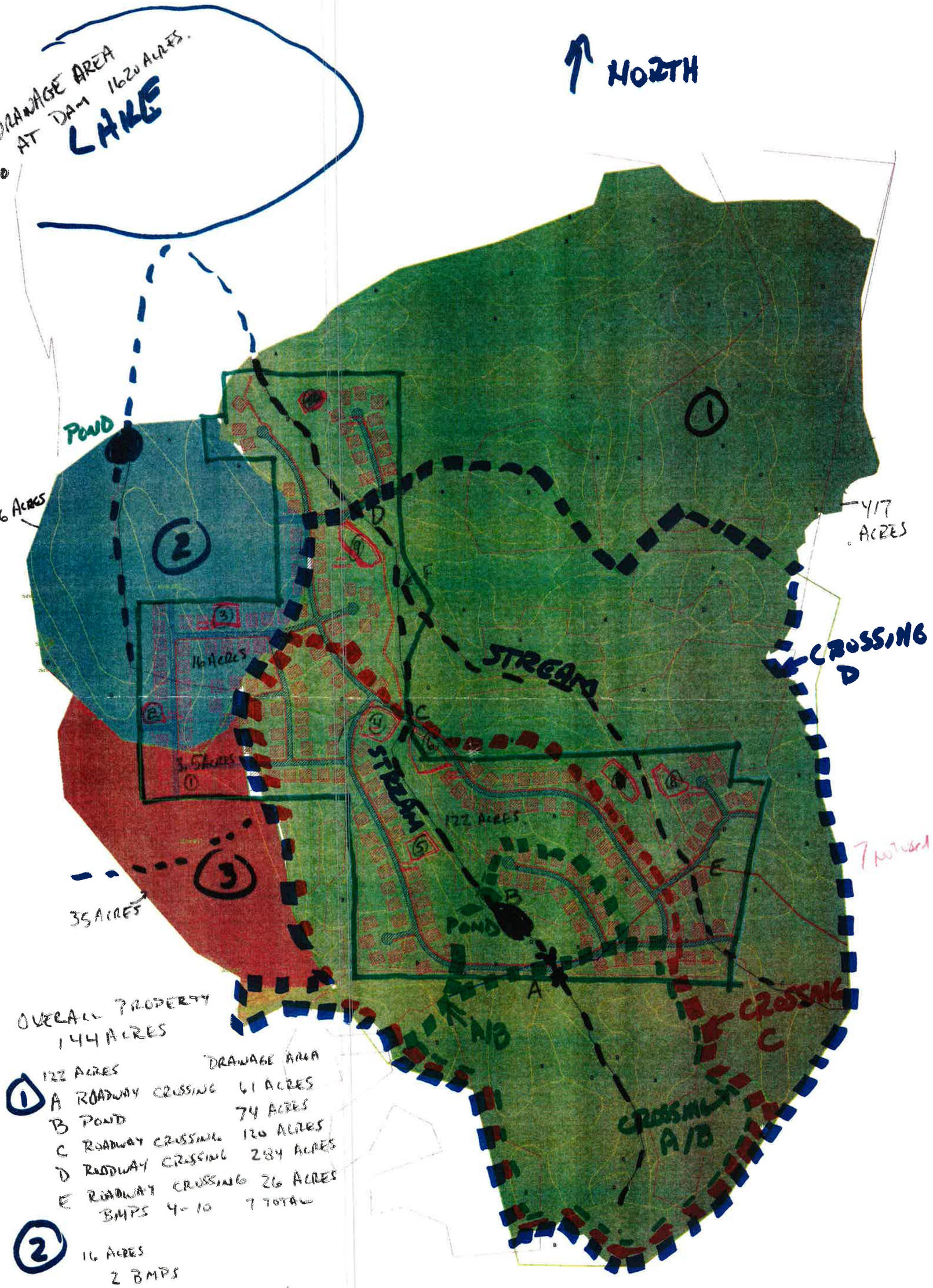
UTM GRID AND 2003 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET

U.S. National Grid
100,000-m Square ID
QV

1 0.5 0 KILOMETERS 1
1000 0 METERS 1000 2000
1 0.5 0 1
MILES
1000 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000
FEET

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
(TO CONVERT ELEVATIONS TO THE NORTH AMERICAN VERTICAL DATUM OF 1988, SUBTRACT 1FOOT)
TO CONVERT FROM FEET TO METERS, MULTIPLY BY 0.3048

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U.S. GEOLOGICAL SURVEY, P.O. BOX 25286, DENVER, COLORADO 80225



DRAINAGE BASINS

Appendix

StreamStats Report and Rural Runoff Charts

StreamStats Report -Kalas Falls

Region ID:
NC
Workspace ID:
NC20170515140822077000
Clicked Point (Latitude, Longitude):
35.88279, -78.45243
Time:
2017-05-15 16:08:47 -0400

assume upstream impervious area of 30 percent

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	0.0875	square miles
LC06IMP	Average percentage of impervious area determined from NLCD 2006 impervious dataset	30	percent

General Disclaimers

Parameter values have been edited, computed flows may not apply.

Urban-Flow Statistics Parameters [100 Percent (0.0878 square miles) Region 1 Urban under 3 sqmi 2014 5030]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.0875	square miles	0.1	3
LC06IMP	Percent Impervious NLCD2006	30	percent	0	47.9

Urban-Flow Statistics Disclaimers [100 Percent (0.0878 square miles) Region 1 Urban under 3 sqmi 2014 5030]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Urban-Flow Statistics Flow Report [100 Percent (0.0878 square miles) Region 1 Urban under 3 sqmi 2014 5030]

Statistic	Value	Unit
Urban 2 Year Peak Flood	72.6	ft^3/s
Urban 5 Year Peak Flood	92	ft^3/s
Urban 10 Year Peak Flood	103	ft^3/s

Statistic	Value	Unit
Urban 25 Year Peak Flood	113	ft^3/s
Urban 50 Year Peak Flood	119	ft^3/s
Urban 100 Year Peak Flood	125	ft^3/s
Urban 200 Year Peak Flood	130	ft^3/s
Urban 500 Year Peak Flood	143	ft^3/s

Urban-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/)

Use Hc = 5.5

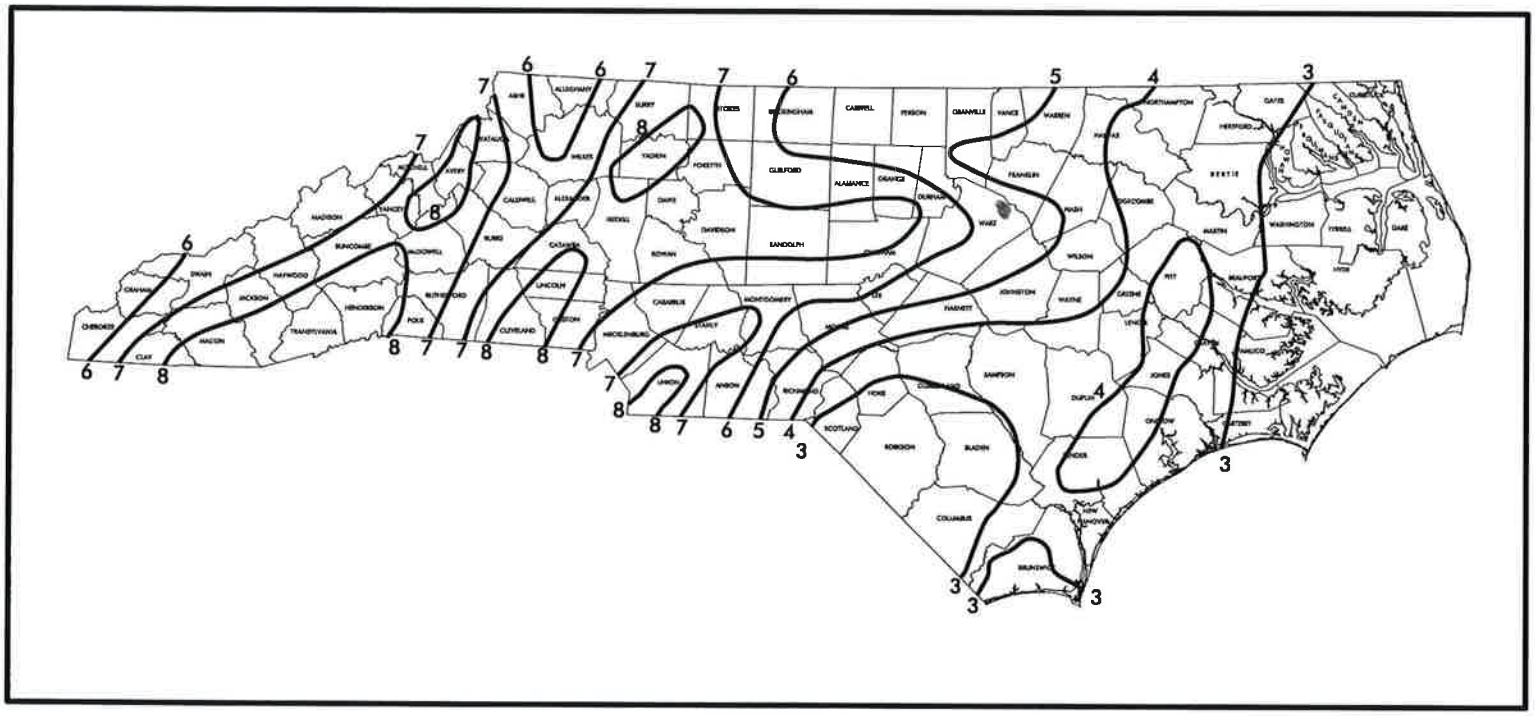
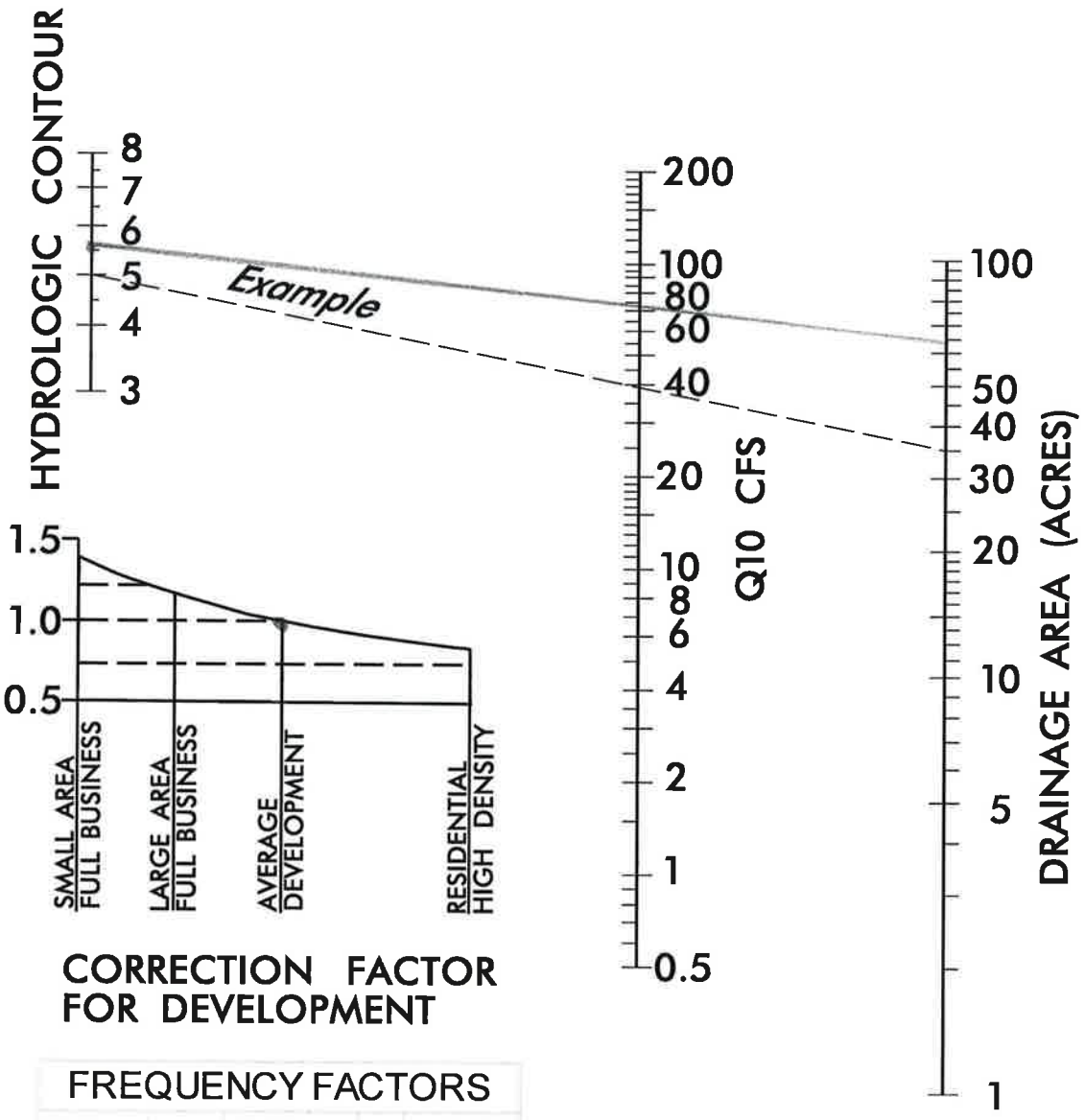


Chart C200.1 NC Hydrologic Contours

Example:
Hydrologic Contour 5.0
Drainage Area 35 ac
Small Area – Full Business
Q10 = 39x1.4 = 55 cfs



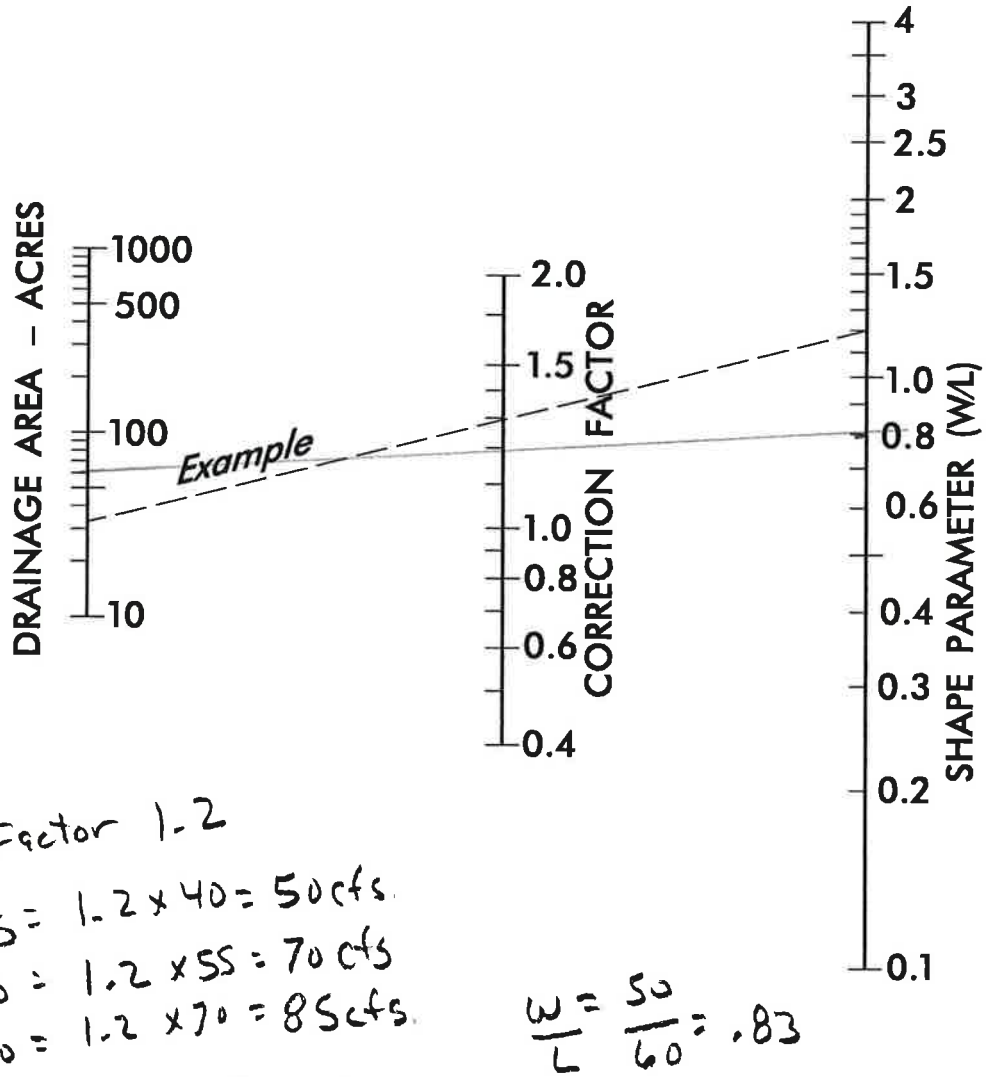
CORRECTION FACTOR FOR DEVELOPMENT

FREQUENCY FACTORS				
Q2	=	Q10	x	0.50
Q5	=	Q10	x	0.75
Q25	=	Q10	x	1.35
Q50	=	Q10	x	1.85
Q100	=	Q10	x	2.15
Q500	=	Q10	x	3.10

70 x 1.35 = 95 cfs - 25yr
70 x 2.15 = 150 cfs - 100yr

USE FOR CULVERT CROSSING A

C200.3 URBAN RUNOFF CHART (REVISED)



Factor 1.2

$Q_{25} = 1.2 \times 40 = 50$ cfs

$Q_{50} = 1.2 \times 55 = 70$ cfs

$Q_{100} = 1.2 \times 70 = 85$ cfs

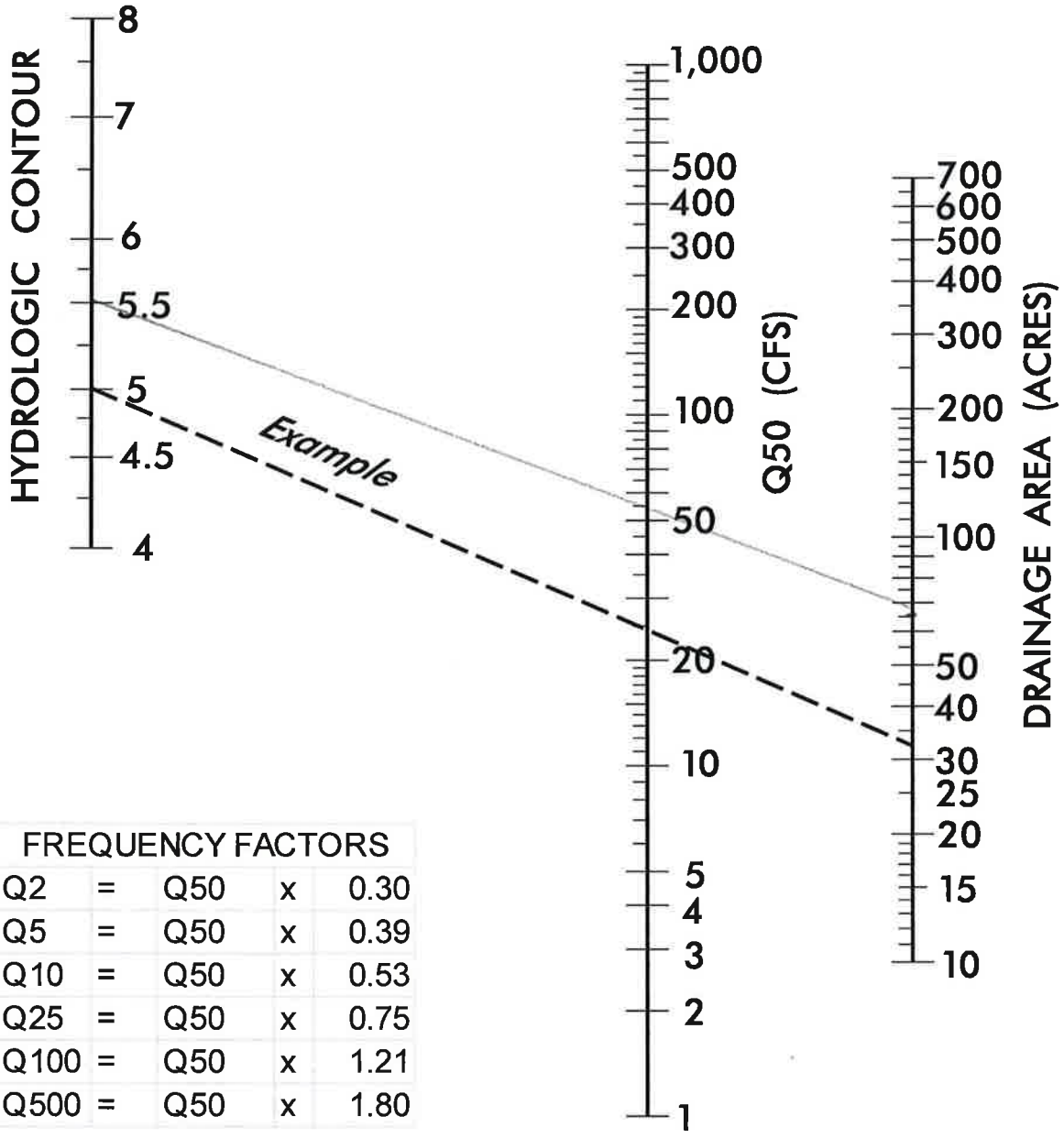
$\frac{W}{L} = \frac{50}{60} = .83$

Example:
Drainage Area 32 ac
W/L = 1.2
Q50 = 25 cfs (from Chart C200.2)
Corrected Q50 = 25x1.3 = 33 cfs

DRAINAGE AREA SHAPE PARAMETER CORRECTION FACTORS

C200.4

Example:
Hydrologic Contour = 5.0
Drainage Area = 32 acres
Read Q50 = 24 cfs



FREQUENCY FACTORS				
Q2	=	Q50	x	0.30
Q5	=	Q50	x	0.39
Q10	=	Q50	x	0.53
Q25	=	Q50	x	0.75
Q100	=	Q50	x	1.21
Q500	=	Q50	x	1.80

$Q_{50} = 55$ cfs

$Q_{25} = 0.75 \times 55 = 40$ cfs

$Q_{100} = 1.21 \times 55 = 70$ cfs

C200.2 RURAL RUNOFF CHART (REVISED)

StreamStats Report Kalas Falls

Region ID:
NC
Workspace ID:
NC20170515141324064000
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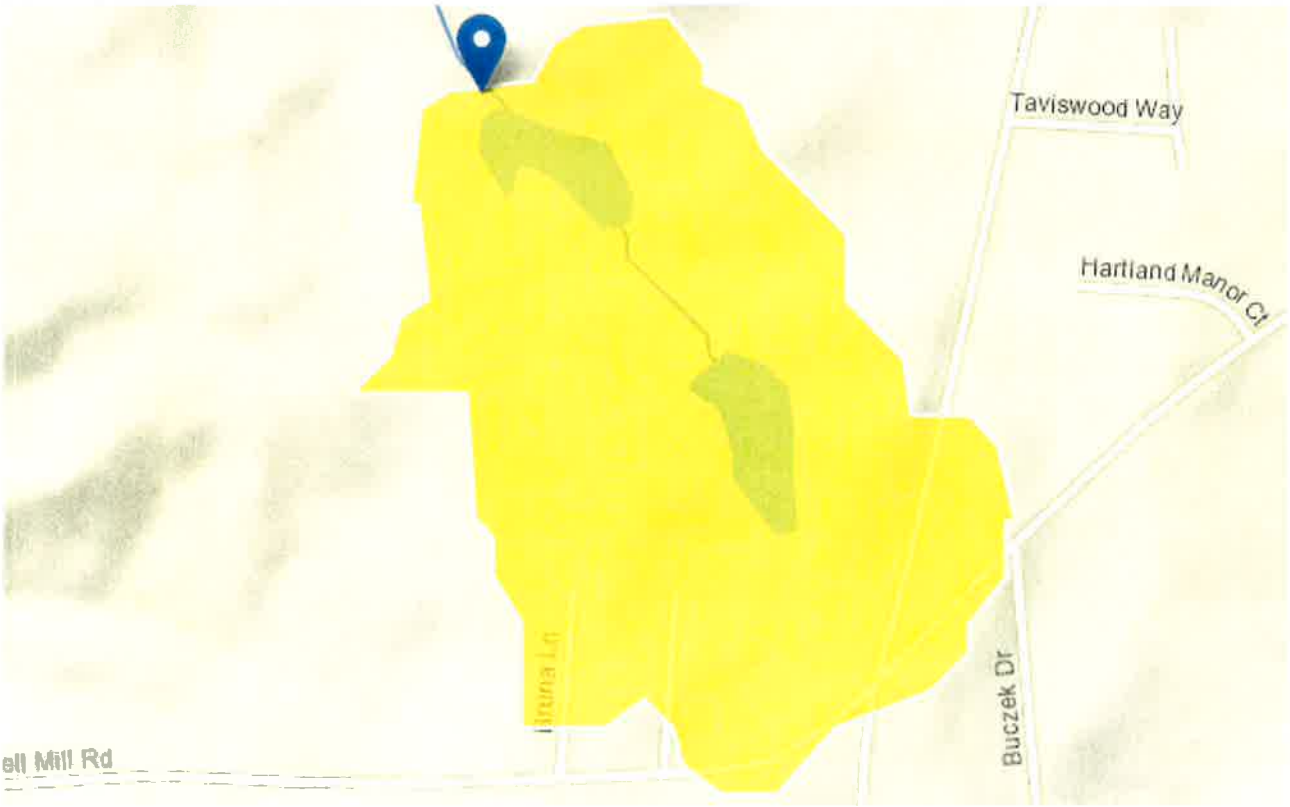
35.88385, -78.45382
Time:
2017-05-15 16:13:52 -0400



Outfall of pond B

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	0.11	square miles
PCTREG1	Percentage of drainage area located in Region 1	100	percent

Parameter Code	Parameter Description	Value	Unit
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
PCTREG5	Percentage of drainage area located in Region 5	0	percent
LC06IMP	Average percentage of impervious area determined from NLCD 2006 impervious dataset	1.78	percent
SSURGOA	Percentage of area of Hydrologic Soil Type A from SSURGO	0	percent
SSURGOB	Percentage of area of Hydrologic Soil Type B from SSURGO	86.2	percent
SSURGOC	Percentage of area of Hydrologic Soil Type C from SSURGO	3.94	percent
SSURGOD	Percentage of area of Hydrologic Soil Type D from SSURGO	7.61	percent

Peak-Flow Statistics Parameters [100 Percent (0.109 square miles) Region 1 rural under 1 sqmi 2014 5030]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.11	square miles	0.1	1
LC06IMP	Percent Impervious NLCD2006	1.78	percent	0	47.9

Peak-Flow Statistics Flow Report [100 Percent (0.109 square miles) Region 1 rural under 1 sqmi 2014 5030]

Statistic	Value	Unit	Average standard error of prediction	Lower Prediction Interval	Upper Prediction Interval
2 Year Peak Flood	36	ft^3/s	31.9	18.9	68.4
5 Year Peak Flood	58.3	ft^3/s	25.4	34.6	98.2

Statistic	Value	Unit	Average standard error of prediction	Lower Prediction Interval	Upper Prediction Interval
10 Year Peak Flood	74.5	ft^3/s	25	45	123
25 Year Peak Flood	95.6	ft^3/s	27	55.1	166
50 Year Peak Flood	112	ft^3/s	29.3	61.8	204
100 Year Peak Flood	129	ft^3/s	32.1	67	248
200 Year Peak Flood	146	ft^3/s	35.1	71.7	297
500 Year Peak Flood	173	ft^3/s	37.5	81.3	366

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/)

StreamStats Report Kalas Falls

Region ID:
NC
Workspace ID:
NC20170515141906458000
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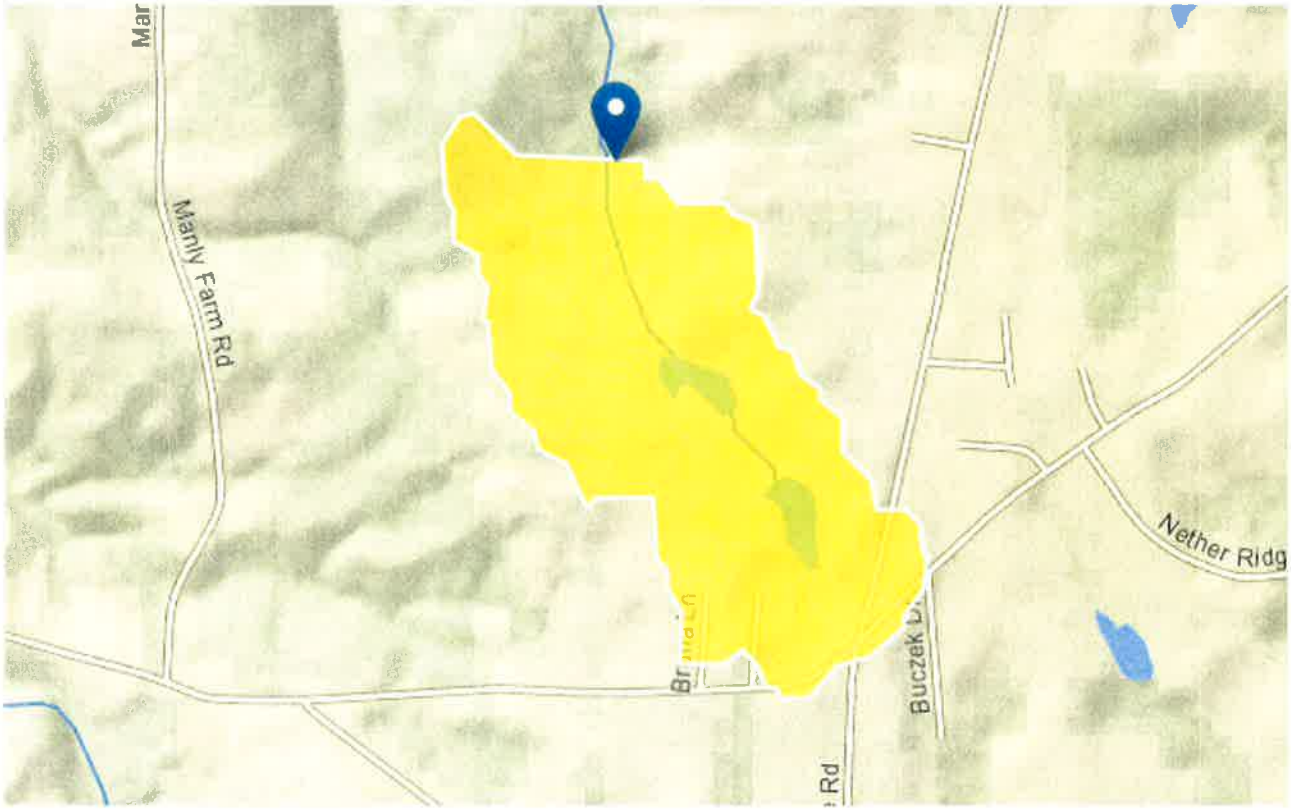
35.88705, -78.45496
Time:
2017-05-15 16:19:34 -0400



Crossing C

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	0.2	square miles
PCTREG1	Percentage of drainage area located in Region 1	100	percent

Parameter Code	Parameter Description	Value	Unit
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
PCTREG5	Percentage of drainage area located in Region 5	0	percent
LC06IMP	Average percentage of impervious area determined from NLCD 2006 impervious dataset	0.96	percent
SSURGOA	Percentage of area of Hydrologic Soil Type A from SSURGO	0	percent
SSURGOB	Percentage of area of Hydrologic Soil Type B from SSURGO	86.2	percent
SSURGOC	Percentage of area of Hydrologic Soil Type C from SSURGO	2.87	percent
SSURGOD	Percentage of area of Hydrologic Soil Type D from SSURGO	9.78	percent

Peak-Flow Statistics Parameters [100 Percent (0.2 square miles) Region 1 rural under 1 sqmi 2014 5030]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.2	square miles	0.1	1
LC06IMP	Percent Impervious NLCD2006	0.96	percent	0	47.9

Peak-Flow Statistics Flow Report [100 Percent (0.2 square miles) Region 1 rural under 1 sqmi 2014 5030]

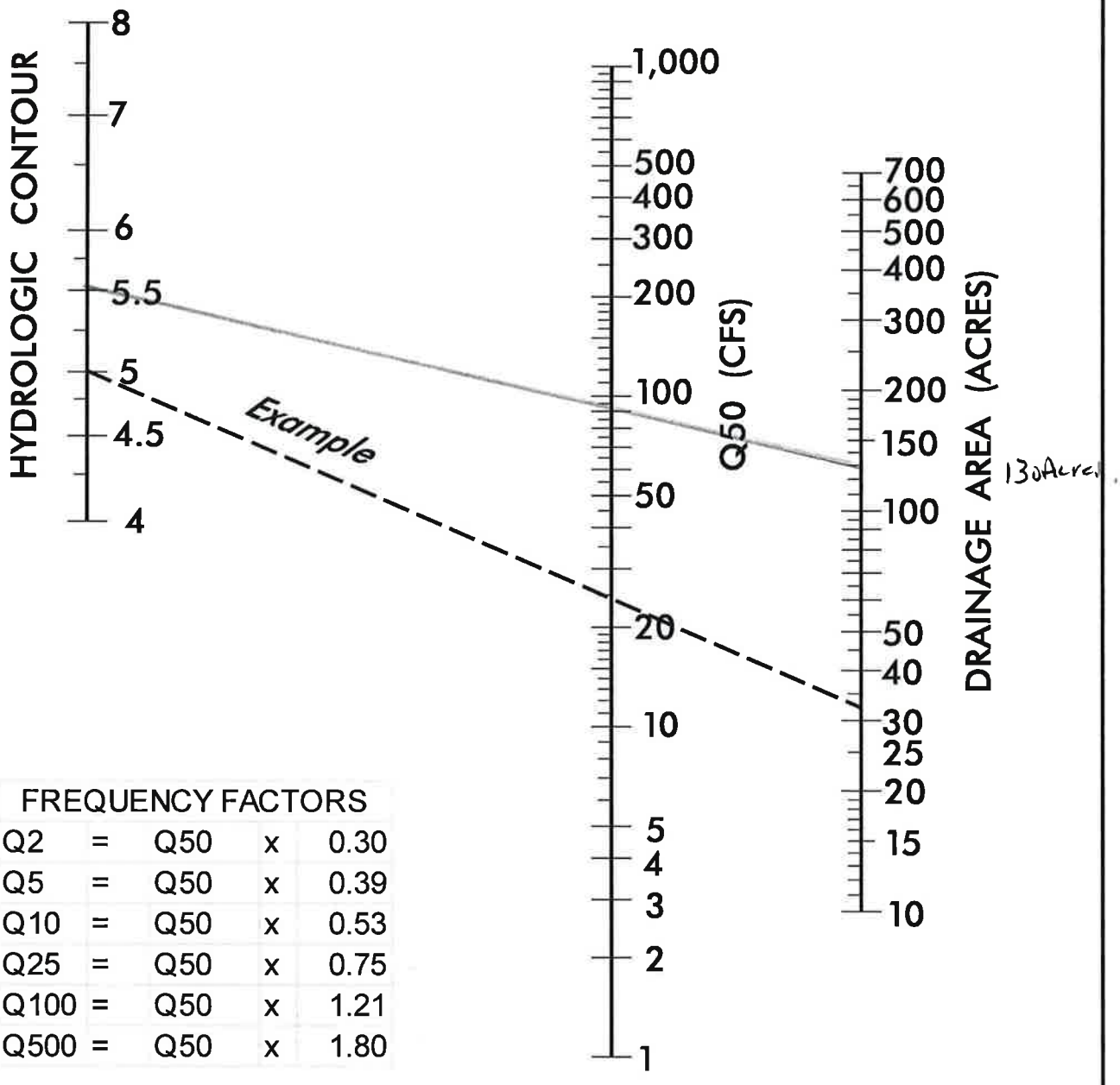
Statistic	Value	Unit	Average standard error of prediction	Lower Prediction Interval	Upper Prediction Interval
2 Year Peak Flood	53.6	ft^3/s	31.9	28.6	101
5 Year Peak Flood	88.9	ft^3/s	25.4	53.3	148

Statistic	Value	Unit	Average standard error of prediction	Lower Prediction Interval	Upper Prediction Interval
10 Year Peak Flood	115	ft^3/s	25	70.5	188
25 Year Peak Flood	151	ft^3/s	27	87.9	258
50 Year Peak Flood	179	ft^3/s	29.3	99.9	319
100 Year Peak Flood	208	ft^3/s	32.1	110	394
200 Year Peak Flood	238	ft^3/s	35.1	119	475
500 Year Peak Flood	281	ft^3/s	37.5	135	585

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/)

Example:
Hydrologic Contour = 5.0
Drainage Area = 32 acres
Read Q50 = 24 cfs



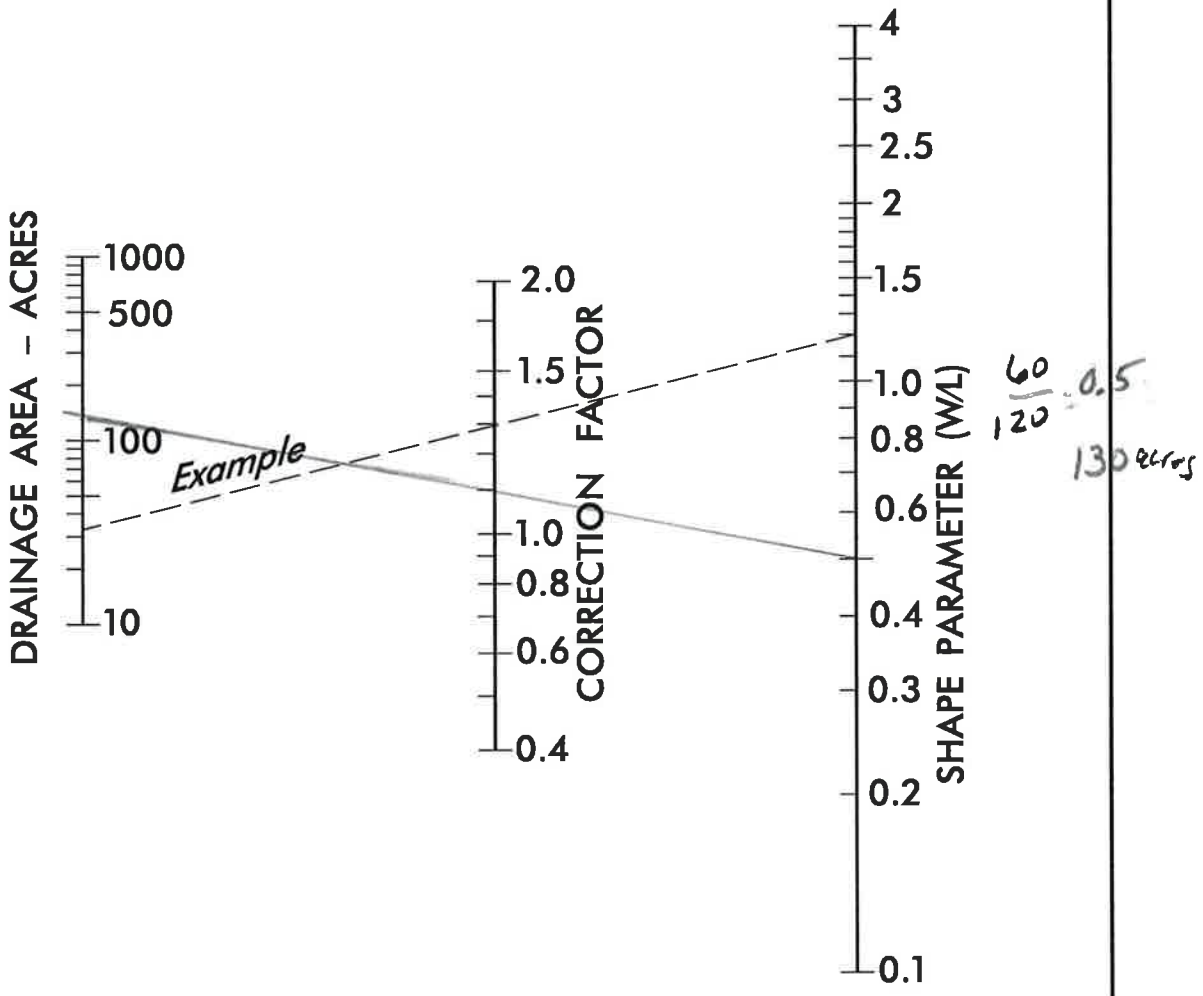
FREQUENCY FACTORS				
Q2	=	Q50	x	0.30
Q5	=	Q50	x	0.39
Q10	=	Q50	x	0.53
Q25	=	Q50	x	0.75
Q100	=	Q50	x	1.21
Q500	=	Q50	x	1.80

$Q_{50} = 95$ cfs.

$Q_{25} = 0.75 \times 95 = 70$ cfs

$Q_{100} = 1.21 \times 95 = 115$ cfs

C200.2 RURAL RUNOFF CHART (REVISED)



60/120 = 0.5

130 acres

W/L 0.50 CF = 1.1

Example:
Drainage Area 32 ac
W/L = 1.2
Q50 = 25 cfs (from Chart C200.2)
Corrected Q50 = 25x1.3 = 33 cfs

130 CFS Q_{100} (1.21)

95 x 1.1 = 105 CFS Q_{50}

80 CFS Q_{25} (.75)

DRAINAGE AREA SHAPE PARAMETER CORRECTION FACTORS

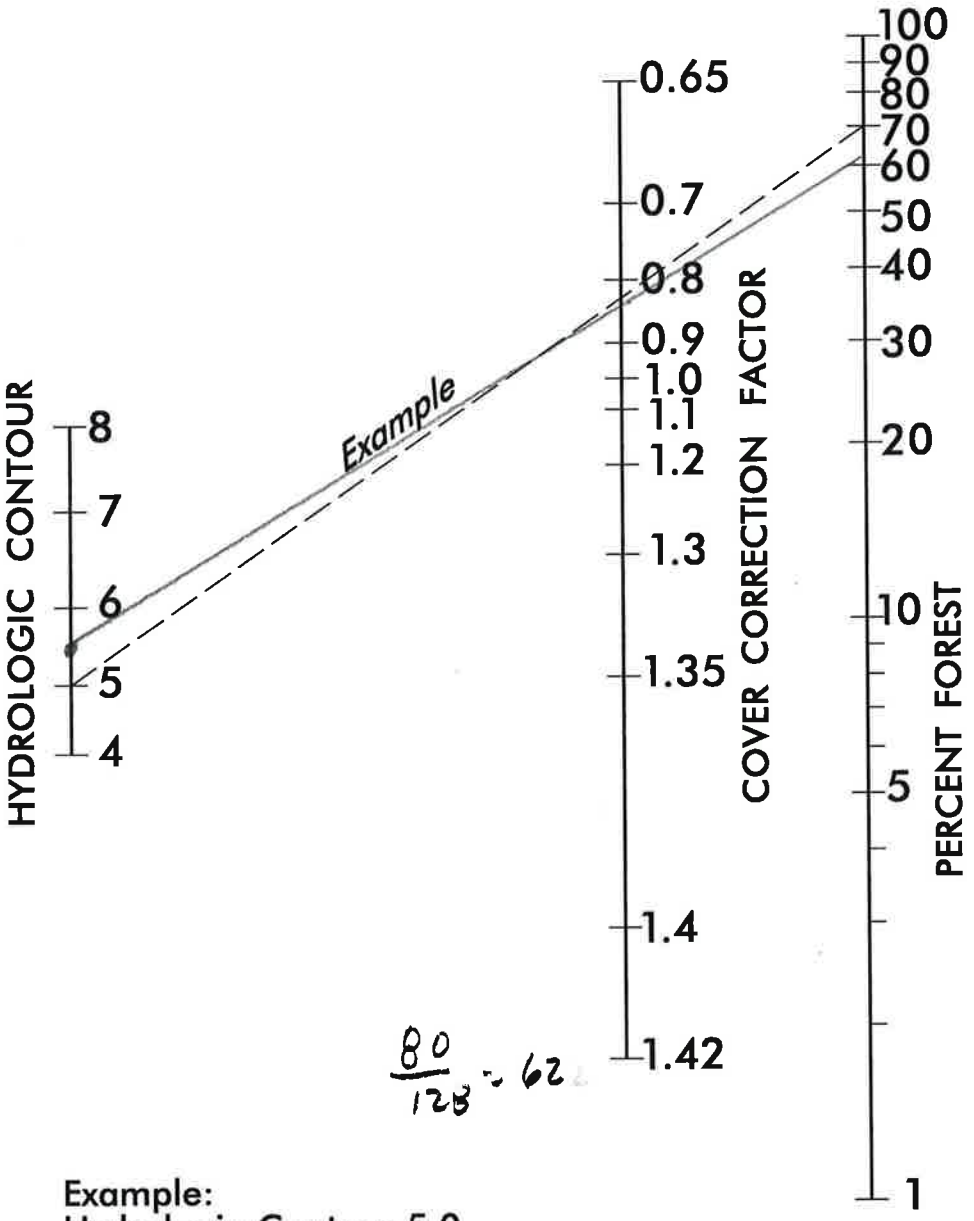
CULVERT C

SAME AS CULVERT A

C200.4

USE Q_{25} = 95 CFS

Q_{100} = 150 CFS



80/128 = 62

Example:
Hydrologic Contour 5.0
Drainage Area 35 ac
70% forest cover
Q50 = 25 cfs (from C200.2)
Corrected Q50 = 25x0.84 = 21 cfs

Corrected Factor = 0.83 → DON'T USE FACTOR

DRAINAGE AREA COVER PARAMETER CORRECTION FACTORS

C200.5

StreamStats Report Kalas Falls

Region ID:
NC
Workspace ID:
NC20170515142413820000
Clicked Point (Latitude, Longitude):
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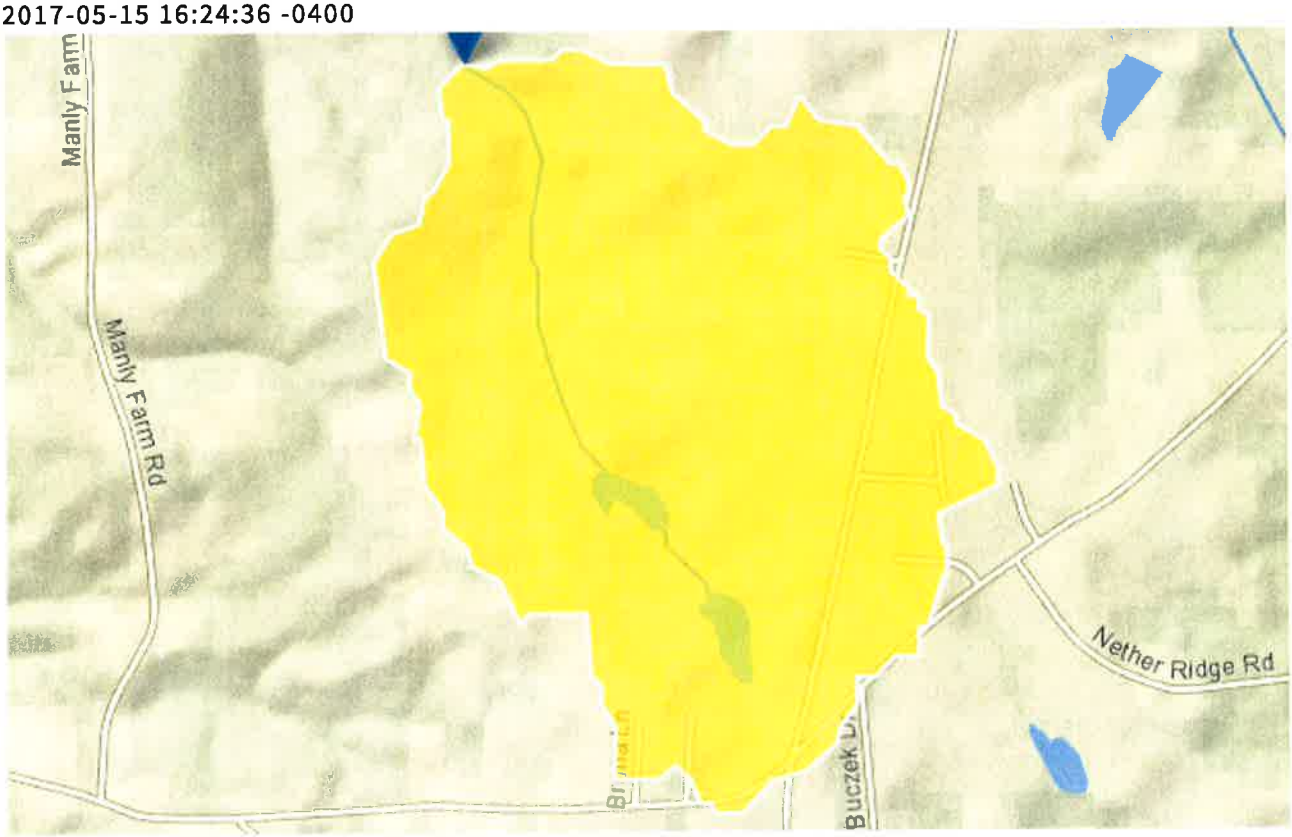
Time:
2017-05-15 16:24:36 -0400



Crossing D impervious area 30 percent

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
SSURGOA	Percentage of area of Hydrologic Soil Type A from SSURGO	0	percent
SSURGOB	Percentage of area of Hydrologic Soil Type B from SSURGO	81.8	percent

Parameter Code	Parameter Description	Value	Unit
SSURGOC	Percentage of area of Hydrologic Soil Type C from SSURGO	4.46	percent
SSURGOD	Percentage of area of Hydrologic Soil Type D from SSURGO	12.9	percent
DRNAREA	Area that drains to a point on a stream	0.44	square miles
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
PCTREG5	Percentage of drainage area located in Region 5	0	percent
LC06IMP	Average percentage of impervious area determined from NLCD 2006 impervious dataset	30	percent

General Disclaimers

Parameter values have been edited, computed flows may not apply.

Peak-Flow Statistics Parameters [100 Percent (0.44 square miles) Region 1 rural under 1 sqmi 2014 5030]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.44	square miles	0.1	1
LC06IMP	Percent Impervious NLCD2006	30	percent	0	47.9

Peak-Flow Statistics Flow Report [100 Percent (0.44 square miles) Region 1 rural under 1 sqmi 2014 5030]

Statistic	Value	Unit	Average standard error of prediction	Lower Prediction Interval	Upper Prediction Interval

Statistic	Value	Unit	Average standard error of prediction	Lower Prediction Interval	Upper Prediction Interval
2 Year Peak Flood	228	ft^3/s	31.9	122	428
5 Year Peak Flood	301	ft^3/s	25.4	181	501
10 Year Peak Flood	347	ft^3/s	25	213	565
25 Year Peak Flood	395	ft^3/s	27	232	675
50 Year Peak Flood	427	ft^3/s	29.3	239	760
100 Year Peak Flood	459	ft^3/s	32.1	243	867
200 Year Peak Flood	487	ft^3/s	35.1	245	970
500 Year Peak Flood	535	ft^3/s	37.5	261	1090

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-Flow Statistics Parameters [100 Percent (0.44 square miles) Region 1 Urban under 3 sqmi 2014 5030]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.44	square miles	0.1	3
LC06IMP	Percent Impervious NLCD2006	30	percent	0	47.9

Urban-Flow Statistics Flow Report [100 Percent (0.44 square miles) Region 1 Urban under 3 sqmi 2014 5030]

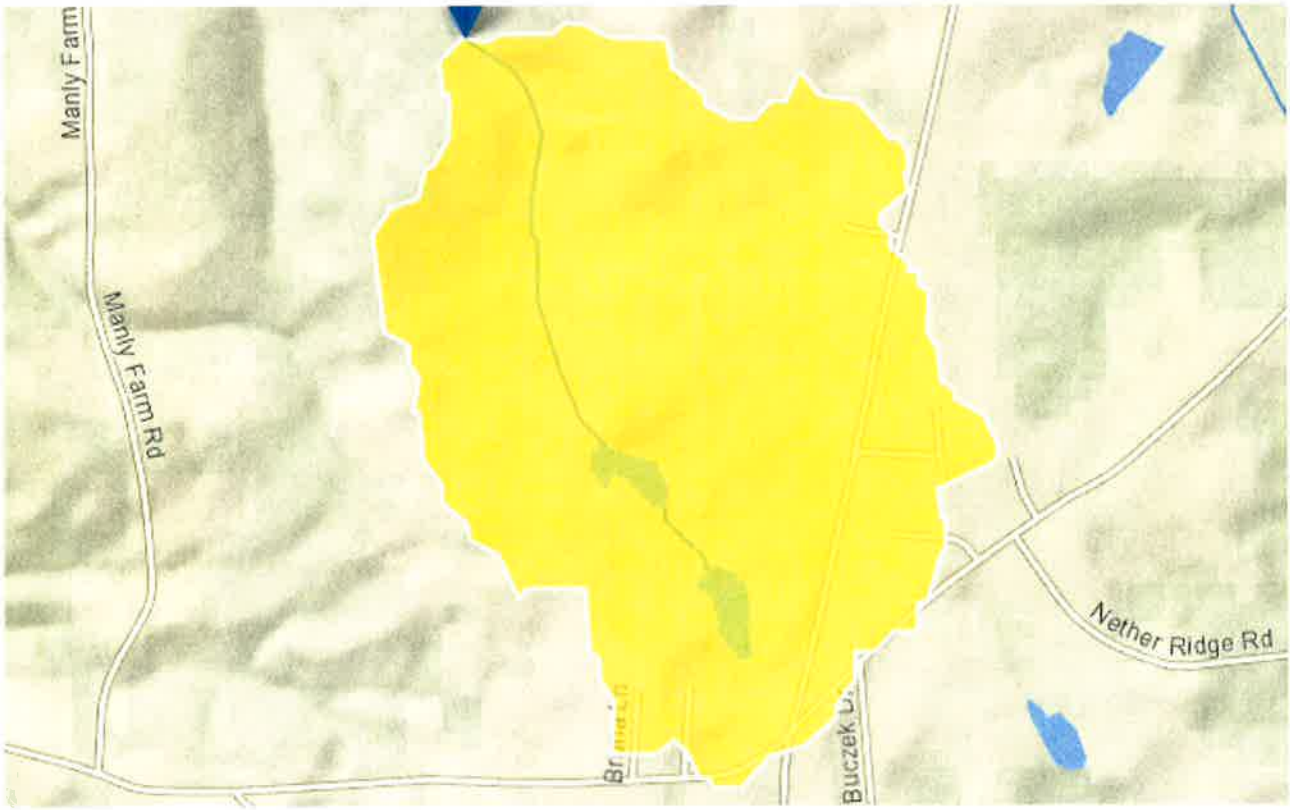
Statistic	Value	Unit	Average standard error of prediction	Lower Prediction Interval	Upper Prediction Interval
Urban 2 Year Peak Flood	228	ft^3/s	31.9	122	428
Urban 5 Year Peak Flood	301	ft^3/s	25.4	181	501
Urban 10 Year Peak Flood	347	ft^3/s	25	213	565
Urban 25 Year Peak Flood	395	ft^3/s	27	232	675
Urban 50 Year Peak Flood	427	ft^3/s	29.3	239	760
Urban 100 Year Peak Flood	459	ft^3/s	32.1	243	867
Urban 200 Year Peak Flood	487	ft^3/s	35.1	245	970
Urban 500 Year Peak Flood	535	ft^3/s	37.5	261	1090

Urban-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/)

StreamStats Report Kalas Falls

Region ID:
NC
Workspace ID:
NC20170515142413820000
Clicked Point (Latitude, Longitude):
35.89075, -78.45652
Time:
2017-05-15 16:24:36 -0400



Crossing D Regression

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
SSURGOA	Percentage of area of Hydrologic Soil Type A from SSURGO	0	percent
SSURGOB	Percentage of area of Hydrologic Soil Type B from SSURGO	81.8	percent

Parameter Code	Parameter Description	Value	Unit
SSURGOC	Percentage of area of Hydrologic Soil Type C from SSURGO	4.46	percent
SSURGOD	Percentage of area of Hydrologic Soil Type D from SSURGO	12.9	percent
DRNAREA	Area that drains to a point on a stream	0.44	square miles
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
PCTREG5	Percentage of drainage area located in Region 5	0	percent
LC06IMP	Average percentage of impervious area determined from NLCD 2006 impervious dataset	2.37	percent

Peak-Flow Statistics Parameters [100 Percent (0.44 square miles) Region 1 rural under 1 sqmi 2014 5030]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.44	square miles	0.1	1
LC06IMP	Percent Impervious NLCD2006	2.37	percent	0	47.9

Peak-Flow Statistics Flow Report [100 Percent (0.44 square miles) Region 1 rural under 1 sqmi 2014 5030]

Statistic	Value	Unit	Average standard error of prediction	Lower Prediction Interval	Upper Prediction Interval
2 Year Peak Flood	97.9	ft^3/s	31.9	52.9	181
5 Year Peak Flood	164	ft^3/s	25.4	99.3	270
10 Year Peak Flood	214	ft^3/s	25	133	345

Statistic	Value	Unit	Average standard error of prediction	Lower Prediction Interval	Upper Prediction Interval
25 Year Peak Flood	282	ft^3/s	27	167	477
50 Year Peak Flood	337	ft^3/s	29.3	191	594
100 Year Peak Flood	394	ft^3/s	32.1	211	736
200 Year Peak Flood	454	ft^3/s	35.1	231	893
500 Year Peak Flood	535	ft^3/s	37.5	261	1090

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-Flow Statistics Parameters [100 Percent (0.44 square miles) Region 1 Urban under 3 sqmi 2014 5030]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.44	square miles	0.1	3
LC06IMP	Percent Impervious NLCD2006	2.37	percent	0	47.9

Urban-Flow Statistics Flow Report [100 Percent (0.44 square miles) Region 1 Urban under 3 sqmi 2014 5030]

Statistic	Value	Unit	Average standard error of prediction	Lower Prediction Interval	Upper Prediction Interval
Urban 2 Year Peak Flood	97.9	ft^3/s	31.9	52.9	181
Urban 5 Year Peak Flood	164	ft^3/s	25.4	99.3	270

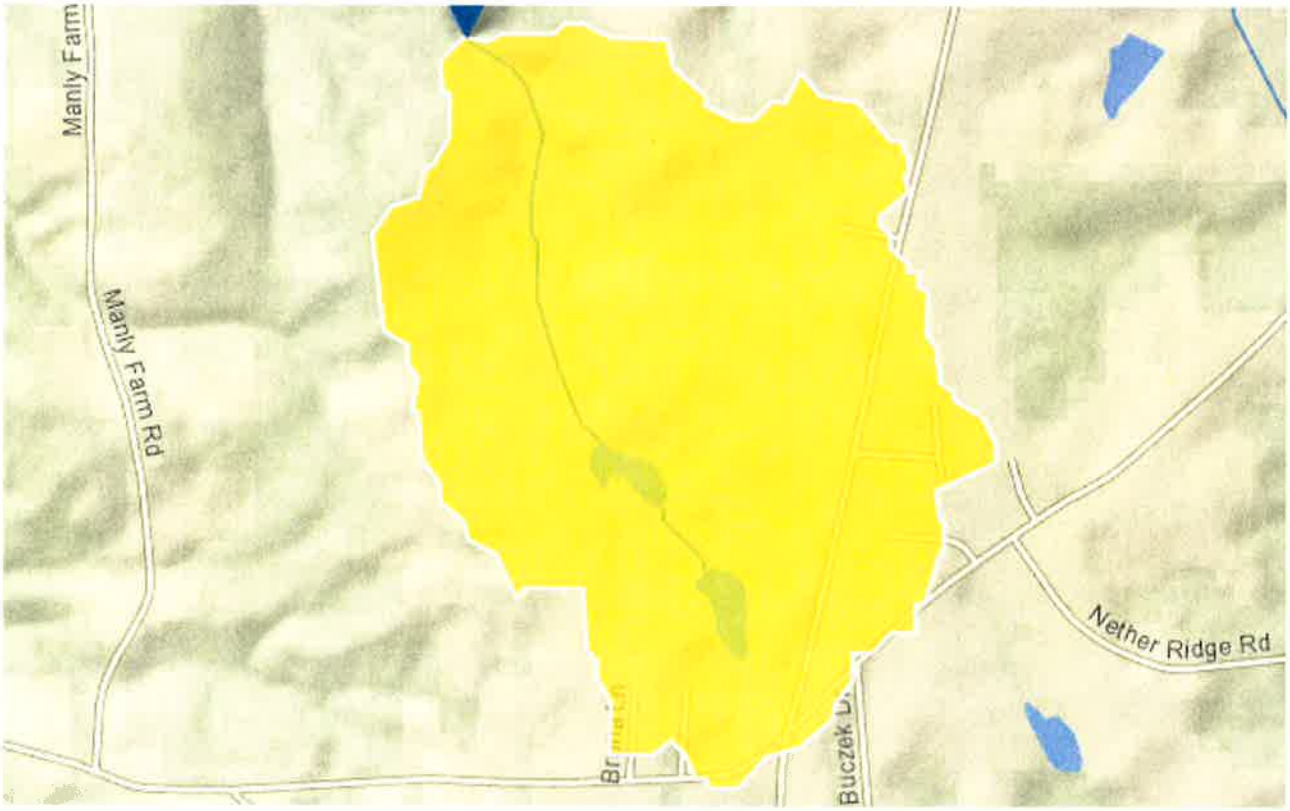
Statistic	Value	Unit	Average standard error of prediction	Lower Prediction Interval	Upper Prediction Interval
Urban 10 Year Peak Flood	214	ft^3/s	25	133	345
Urban 25 Year Peak Flood	282	ft^3/s	27	167	477
Urban 50 Year Peak Flood	337	ft^3/s	29.3	191	594
Urban 100 Year Peak Flood	394	ft^3/s	32.1	211	736
Urban 200 Year Peak Flood	454	ft^3/s	35.1	231	893
Urban 500 Year Peak Flood	535	ft^3/s	37.5	261	1090

Urban-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/)

StreamStats Report Kalas Falls

Region ID:
NC
Workspace ID:
NC20170515142413820000
Clicked Point (Latitude, Longitude):
35.89075, -78.45652
Time:
2017-05-15 16:24:36 -0400



Crossing D Peak Flow statistics

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
SSURGOA	Percentage of area of Hydrologic Soil Type A from SSURGO	0	percent
SSURGOB	Percentage of area of Hydrologic Soil Type B from SSURGO	81.8	percent

Parameter Code	Parameter Description	Value	Unit
SSURGOC	Percentage of area of Hydrologic Soil Type C from SSURGO	4.46	percent
SSURGOD	Percentage of area of Hydrologic Soil Type D from SSURGO	12.9	percent
DRNAREA	Area that drains to a point on a stream	0.44	square miles
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
PCTREG5	Percentage of drainage area located in Region 5	0	percent
LC06IMP	Average percentage of impervious area determined from NLCD 2006 impervious dataset	2.37	percent

Peak-Flow Statistics Parameters [100 Percent (0.44 square miles) Region 1 rural under 1 sqmi 2014 5030]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.44	square miles	0.1	1
LC06IMP	Percent Impervious NLCD2006	2.37	percent	0	47.9

Peak-Flow Statistics Flow Report [100 Percent (0.44 square miles) Region 1 rural under 1 sqmi 2014 5030]

Statistic	Value	Unit	Average standard error of prediction	Lower Prediction Interval	Upper Prediction Interval
2 Year Peak Flood	97.9	ft^3/s	31.9	52.9	181
5 Year Peak Flood	164	ft^3/s	25.4	99.3	270
10 Year Peak Flood	214	ft^3/s	25	133	345

Statistic	Value	Unit	Average standard error of prediction	Lower Prediction Interval	Upper Prediction Interval
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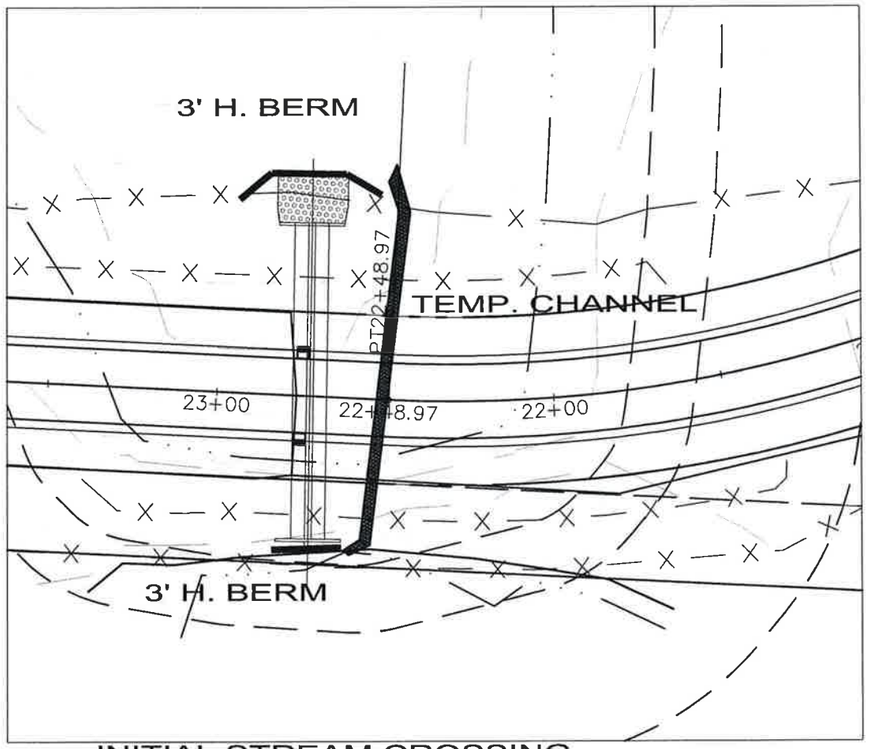
50 Year Peak Flood	337	ft^3/s	29.3	191	594
100 Year Peak Flood	394	ft^3/s	32.1	211	736
200 Year Peak Flood	454	ft^3/s	35.1	231	893
500 Year Peak Flood	535	ft^3/s	37.5	261	1090

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/)

Culvert Crossing Riprap Calculations / Crossing A Calculations



INITIAL STREAM CROSSING

SEQUENCE FOR 84" RCP CULVERT CROSSING

1. INSTALL TREE PROTECTION FENCING AND SILT FENCE AS SHOWN ON THE PLANS. WORK OUTSIDE THE FENCED AREA IS IN VIOLATION OF THE NCDENR PERMIT.

2. INSTALL TEMPORARY CHANNEL CROSSING AND BYPASS CHANNEL. SEE DETAIL.

3. UNDERCUT THE PROPOSED CULVERT AREA TO FIRM MATERIAL AS DIRECTED BY GEOTECH. UNDERCUT AREA OF ROADWAY FILL WEST OF CULVERT CONCURRENTLY. INSTALL 48" PIPE AS PER PLAN.

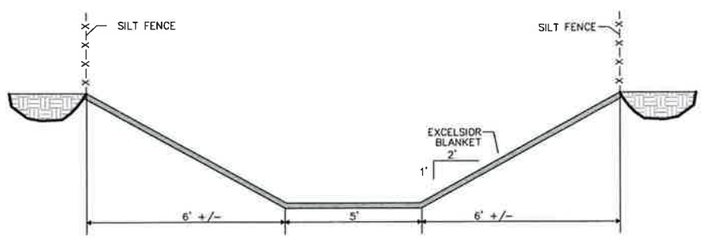
4. INSTALL ENDWALLS AND BACKFILL THE PIPE AS PER NCDOT SPECIFICATIONS. ENDWALLS SHALL BE NCDOT DETAIL 838.01.

5. REMOVE TEMPORARY STREAM CROSSING AND UNDERCUT ROADWAY FILL AREA EAST OF THE CULVERT CROSSING.

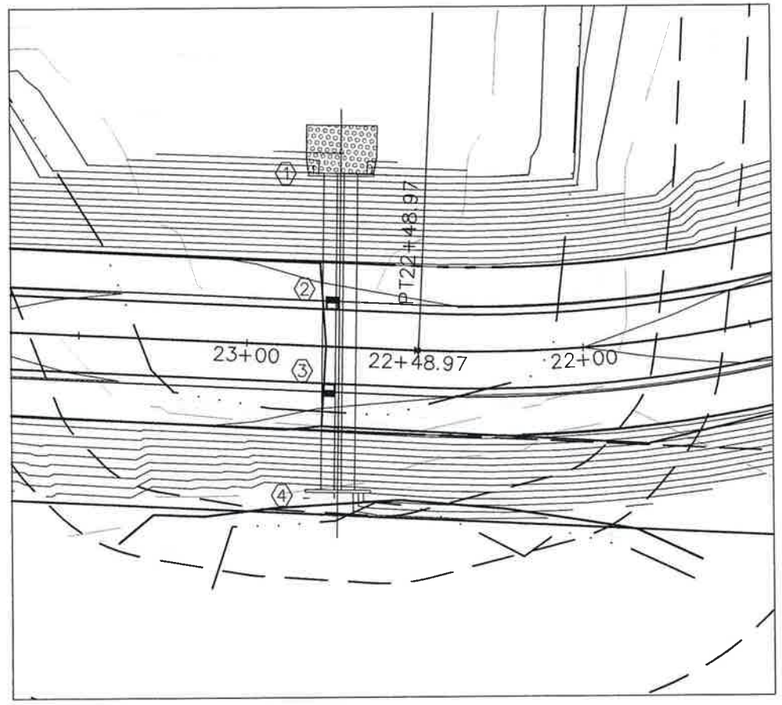
6. INSTALL THE RETAINING WALL AND GRADE THE SLOPES AS SHOWN ON THE PLAN.

7. STABILIZE THE SLOPES AS PER THE PLANS WITHIN 7 DAYS AFTER CONSTRUCTION.

8. PROVIDE SILT FENCE ON TOP OF FILL SLOPE UNTIL ROADWAY DRAINAGE IS INSTALLED.



TEMPORARY CHANNEL SECTION



FINAL GRADING PLAN CULVERT

GRAPHIC SCALE 1"=20'
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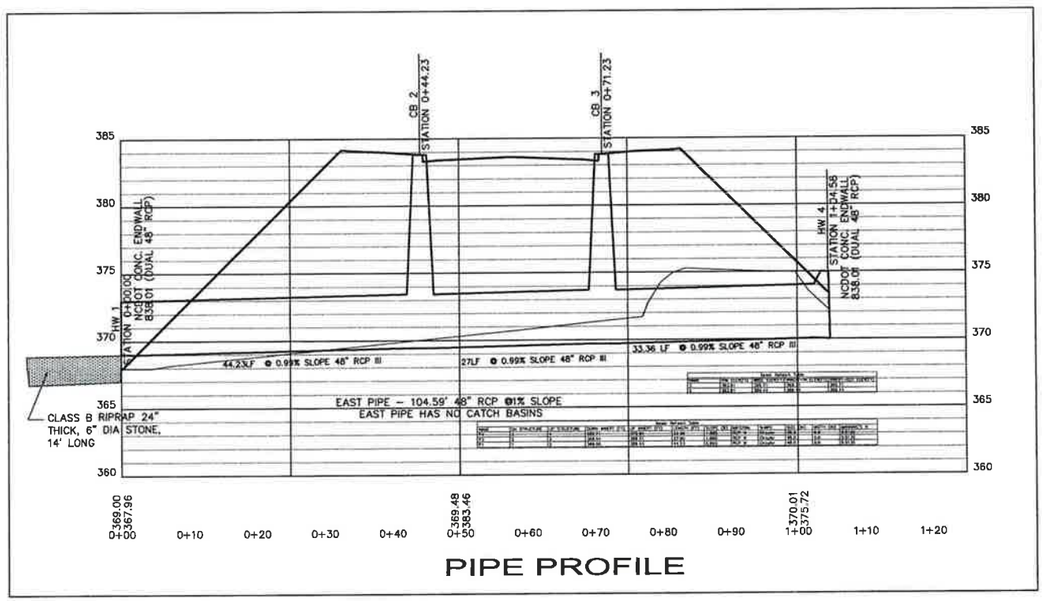


PIPE PROFILE

Hugh J. Gilleece and Associates
875 Walnut Street
Suite 360
Cary, NC 27511
BUSINESS LIC. # C-496
Phone: (919)469-1101
Fax: (919)460-7637

No.	DATE	REVISION	DWN/CHK

PRELIMINARY NOT FOR CONSTRUCTION

CULVERT A PLAN & PROFILE

FOR

KALAS FALLS

SITUATED AT

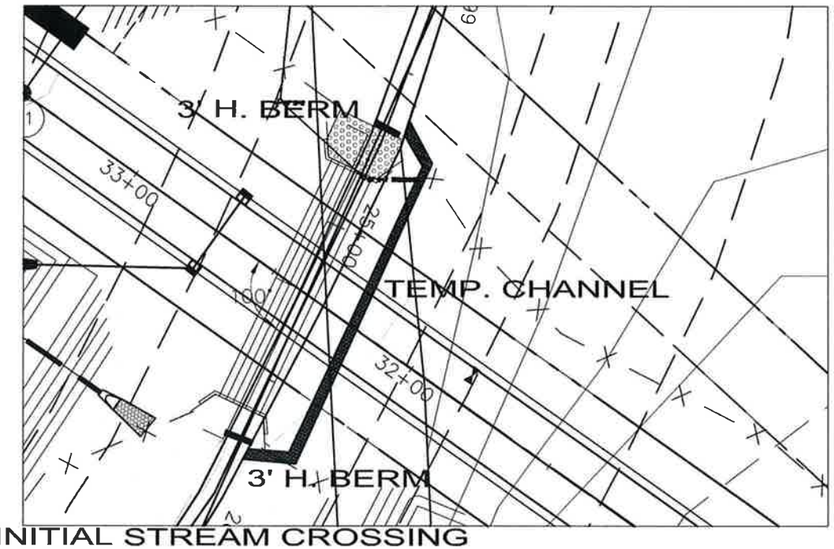
ROLESVILLE RD, ROLESVILLE

WAKE COUNTY, NORTH CAROLINA

JOB #	9900.50
DSN/CHK BY:	DS
DWN BY:	BH
DATE:	3/29/2017
HRZ SCALE:	1"=20'
VRT SCALE:	NONE

SHEET NO.

CULV A



INITIAL STREAM CROSSING

SEQUENCE FOR 84" RCP CULVERT CROSSING

1. INSTALL TREE PROTECTION FENCING AND SILT FENCE AS SHOWN ON THE PLANS. WORK OUTSIDE THE FENCED AREA IS IN VIOLATION OF THE NCDENR PERMIT.

2. INSTALL TEMPORARY CHANNEL CROSSING AND BYPASS CHANNEL. SEE DETAIL.

3. UNDERCUT THE PROPOSED CULVERT AREA TO FIRM MATERIAL AS DIRECTED BY GEOTECH. UNDERCUT AREA OF ROADWAY FILL WEST OF CULVERT CONCURRENTLY. INSTALL 60" AND 54" PIPE AS PER PLAN.

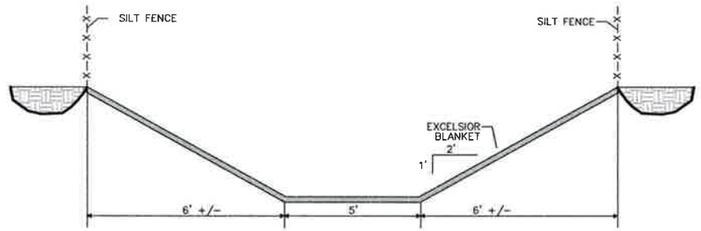
4. INSTALL ENDWALLS AND BACKFILL THE PIPE AS PER NCDOT SPECIFICATIONS. ENDWALLS SHALL BE NCDOT DETAIL 838.28 (USE 60" DETAIL).

5. REMOVE TEMPORARY STREAM CROSSING AND UNDERCUT ROADWAY FILL AREA EAST OF THE CULVERT CROSSING.

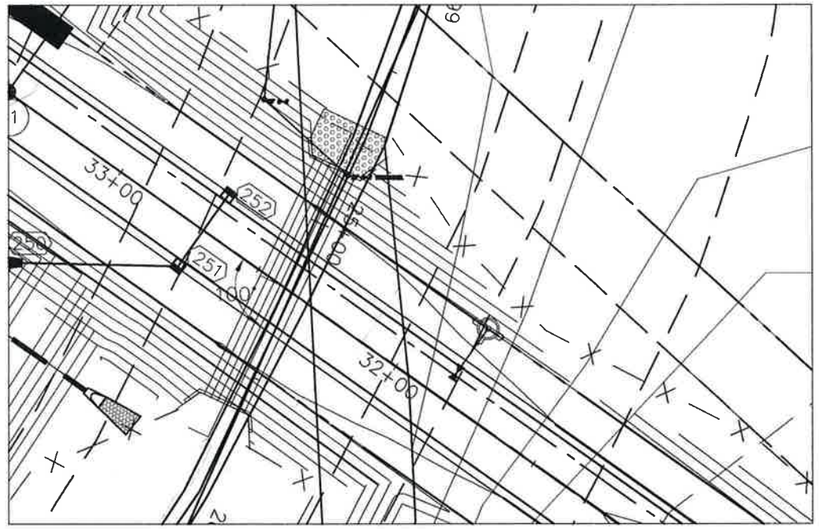
6. INSTALL THE RETAINING WALL AND GRADE THE SLOPES AS SHOWN ON THE PLAN.

7. STABILIZE THE SLOPES AS PER THE PLANS WITHIN 7 DAYS AFTER CONSTRUCTION.

8. PROVIDE SILT FENCE ON TOP OF FILL SLOPE AND DIVERT WATER TO TST#4 AND 6 UNTIL ROADWAY DRAINAGE IS INSTALLED



TEMPORARY CHANNEL SECTION



GRAPHIC SCALE 1"=20'
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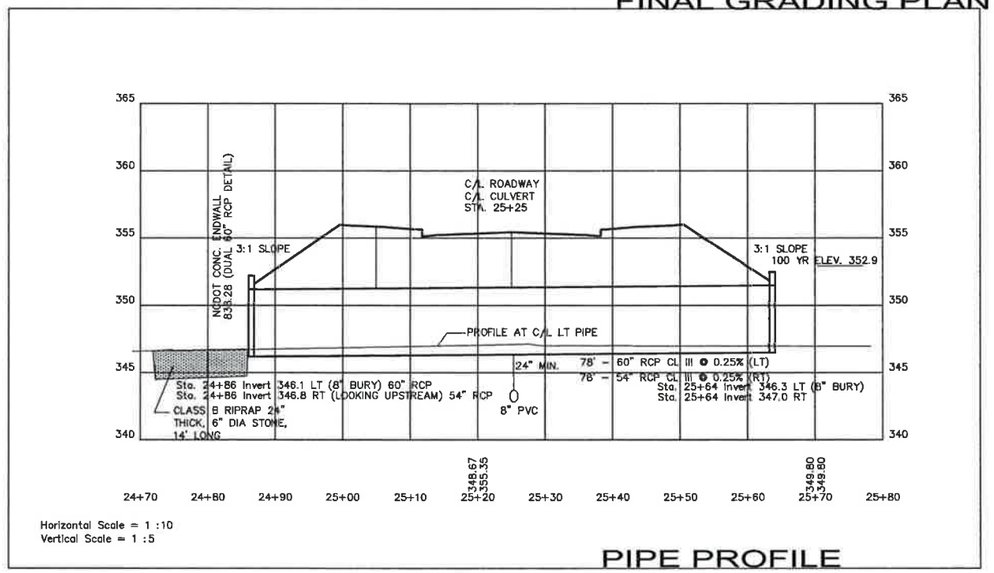
FINAL GRADING PLAN CULVERT



Horizontal Scale = 1 :10
Vertical Scale = 1 :5

PIPE PROFILE

Hugh J. Gilleece and Associates
875 Walnut Street
Suite 360
Cary, NC 27511
BUSINESS LIC. # C-496
Phone: (919)469-1101
Fax: (919)460-7637

No.	DATE	REVISION	DWN/CHK

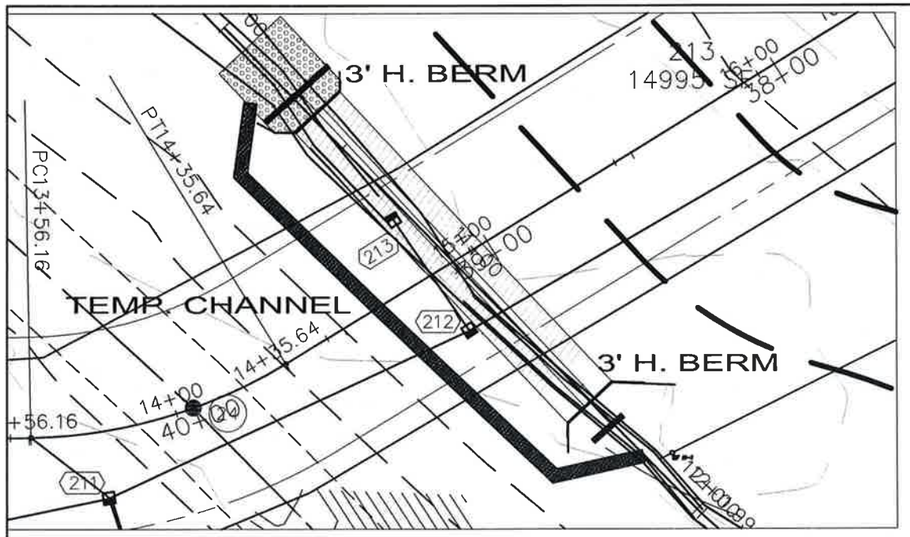
PRELIMINARY NOT FOR CONSTRUCTION

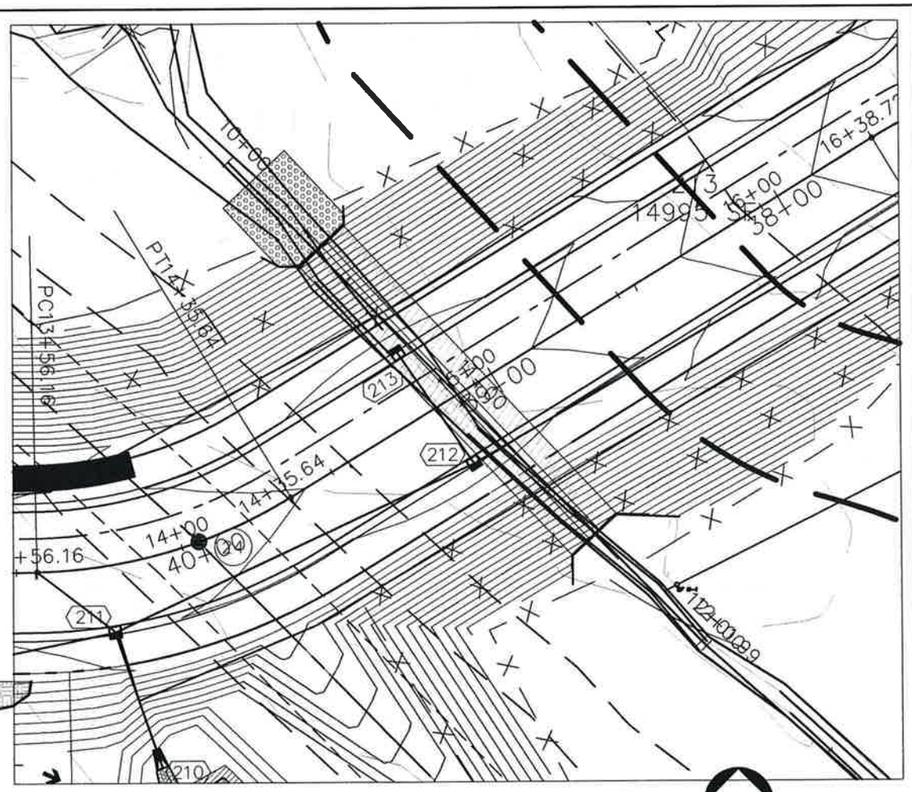
CULVERT C PLAN & PROFILE
FOR
KALAS FALLS
SITUATED AT
ROLESVILLE RD, ROLESVILLE
WAKE COUNTY, NORTH CAROLINA

JOB #	9900.50
DSN/CHK BY:	DS
DWN BY:	BH
DATE:	3/29/2017
HRZ SCALE:	1"=20'
VRT SCALE:	NONE

SHEET NO.

CULV C





GRAPHIC SCALE 1"=20'
0 20 40 60

FINAL GRADING PLAN CULVERT

INITIAL STREAM CROSSING

SEQUENCE FOR 84" RCP CULVERT CROSSING

1. INSTALL TREE PROTECTION FENCING AND SILT FENCE AS SHOWN ON THE PLANS. WORK OUTSIDE THE FENCED AREA IS IN VIOLATION OF THE NCDENR PERMIT.

2. INSTALL TEMPORARY CHANNEL CROSSING AND BYPASS CHANNEL, SEE DETAIL.

3. UNDERCUT THE PROPOSED CULVERT AREA TO FIRM MATERIAL AS DIRECTED BY GEOTECH. UNDERCUT AREA OF ROADWAY FILL WEST OF CULVERT CONCURRENTLY. INSTALL 84" PIPE AS PER PLAN.

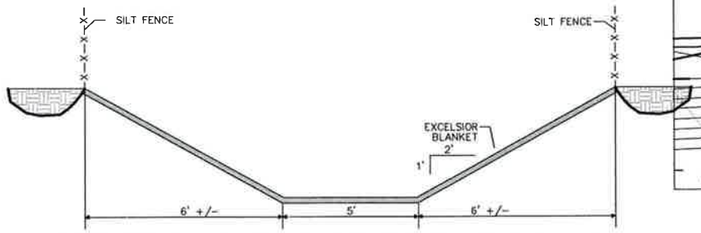
4. INSTALL ENDWALLS AND BACKFILL THE PIPE AS PER NCDOT SPECIFICATIONS. ENDWALLS SHALL BE NCDOT DETAIL 838.01.

5. REMOVE TEMPORARY STREAM CROSSING AND UNDERCUT ROADWAY FILL AREA EAST OF THE CULVERT CROSSING.

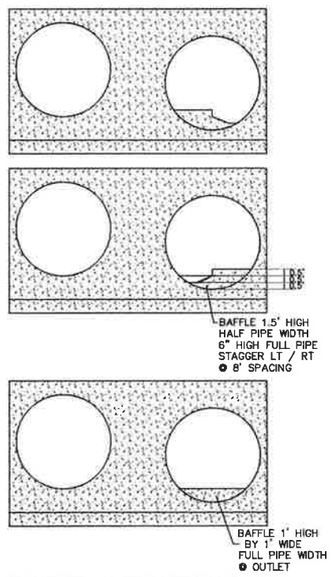
6. INSTALL THE RETAINING WALL AND GRADE THE SLOPES AS SHOWN ON THE PLAN.

7. STABILIZE THE SLOPES AS PER THE PLANS WITHIN 7 DAYS AFTER CONSTRUCTION.

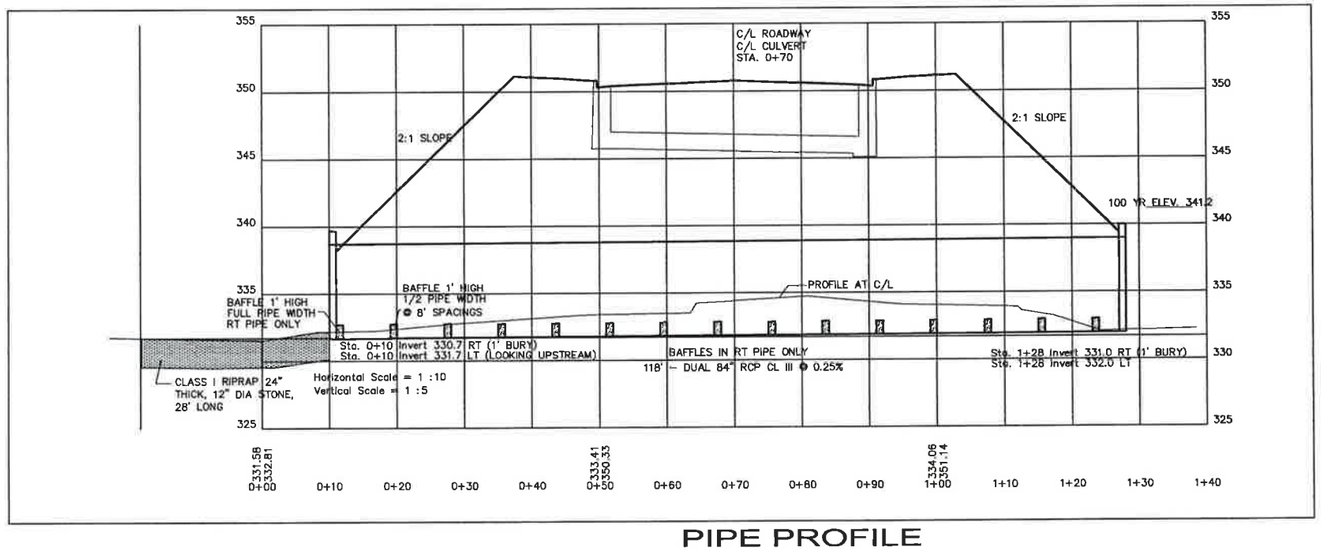
8. PROVIDE SILT FENCE ON TOP OF FILL SLOPE AND DIVERT WATER TO TST#9 UNTIL ROADWAY DRAINAGE IS INSTALLED.



TEMPORARY CHANNEL SECTION



PIPE SECTIONS



PIPE PROFILE

Hugh J. Gilleece and Associates
875 Walnut Street
Suite 360
Cary, NC 27511
BUSINESS LIC. # C-496
Phone: (919)469-1101
Fax: (919)460-7637

NO.	DATE	REVISION	DWN/CHK

PRELIMINARY NOT FOR CONSTRUCTION

CULVERT D PLAN & PROFILE

FOR

KALAS FALLS

SITUATED AT

ROLESVILLE RD, ROLESVILLE

WAKE COUNTY, NORTH CAROLINA

JOB #	9900.50
DSN/CHK BY:	DS
DWN BY:	BH
DATE:	3/29/2017
HRZ SCALE:	1"=20'
VRT SCALE:	NONE

SHEET NO.

CULV D

Culvert Report

100YR. FLOW

Hydraflow Express Extension for AutoCAD® Civil 3D® 2012 by Autodesk, Inc.

Tuesday, Apr 18 2017

Crossing A

Invert Elev Dn (ft)	= 371.00
Pipe Length (ft)	= 100.00
Slope (%)	= 0.50
Invert Elev Up (ft)	= 371.50
Rise (in)	= 48.0
Shape	= Cir
Span (in)	= 48.0
No. Barrels	= 2
n-Value	= 0.012
Inlet Edge	= Sq Edge
Coeff. K,M,c,Y,k	= 0.0098, 2, 0.0398, 0.67, 0.5

Embankment

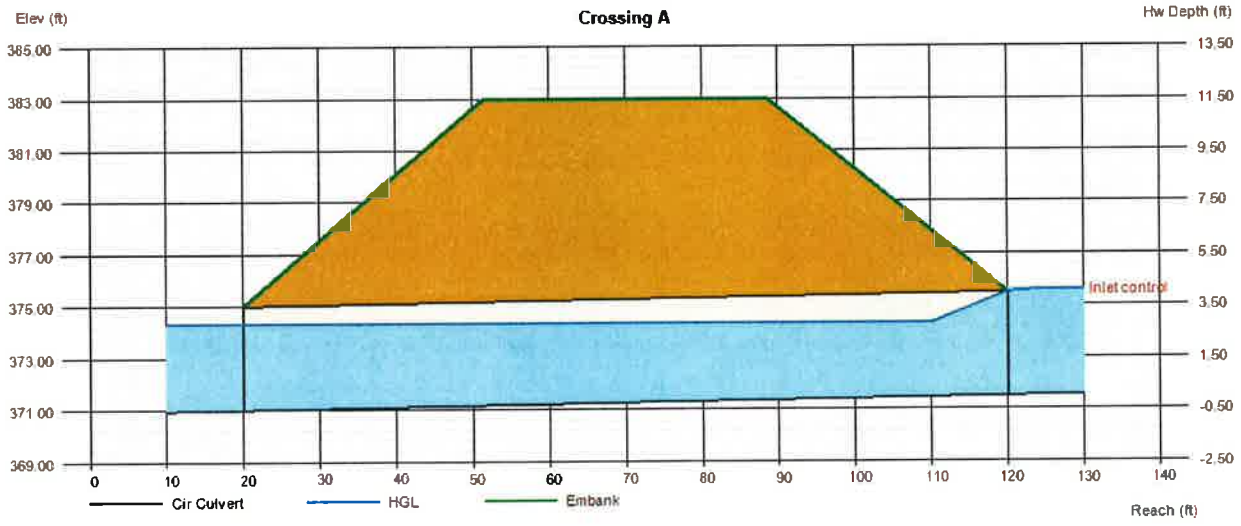
Top Elevation (ft)	= 383.00
Top Width (ft)	= 37.00
Crest Width (ft)	= 100.00

Calculations

Qmin (cfs)	= 150.00
Qmax (cfs)	= 150.00
Tailwater Elev (ft)	= (dc+D)/2

Highlighted

Qtotal (cfs)	= 150.00
Qpipe (cfs)	= 150.00
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 6.74
Veloc Up (ft/s)	= 7.91
HGL Dn (ft)	= 374.31
HGL Up (ft)	= 374.32
Hw Elev (ft)	= 375.62
Hw/D (ft)	= 1.03
Flow Regime	= Inlet Control



Culvert Report

10 Yr. FLOW

Hydraflow Express Extension for AutoCAD® Civil 3D® 2012 by Autodesk, Inc.

Thursday, May 18 2017

Crossing A

Invert Elev Dn (ft)	= 371.00
Pipe Length (ft)	= 70.00
Slope (%)	= 0.71
Invert Elev Up (ft)	= 371.50
Rise (in)	= 48.0
Shape	= Cir
Span (in)	= 48.0
No. Barrels	= 2
n-Value	= 0.012
Inlet Edge	= Beveled
Coeff. K,M,c,Y,k	= 0.0018, 2.5, 0.03, 0.74, 0.2

Embankment

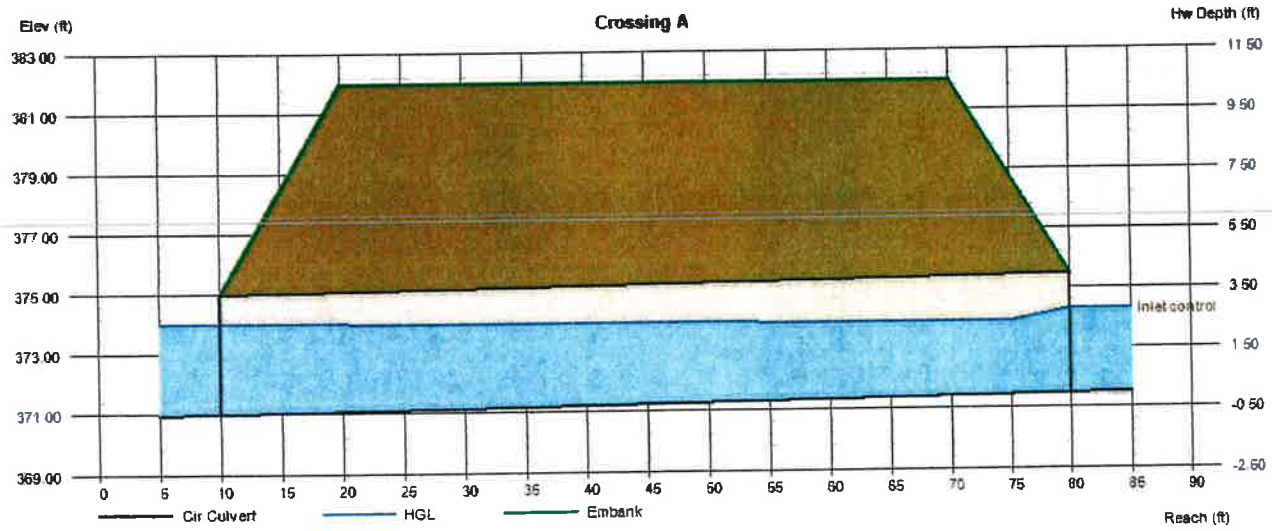
Top Elevation (ft)	= 382.00
Top Width (ft)	= 50.00
Crest Width (ft)	= 200.00

Calculations

Qmin (cfs)	= 90.00
Qmax (cfs)	= 90.00
Tailwater Elev (ft)	= (dc+D)/2

Highlighted

Qtotal (cfs)	= 90.00
Qpipe (cfs)	= 90.00
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 4.44
Veloc Up (ft/s)	= 5.67
HGL Dn (ft)	= 374.01
HGL Up (ft)	= 373.92
Hw Elev (ft)	= 374.33
Hw/D (ft)	= 0.71
Flow Regime	= Inlet Control



Culvert Report

10 YR. FLOW

Hydraflow Express Extension for AutoCAD® Civil 3D® 2012 by Autodesk, Inc. Thursday, May 18 2017

Crossing C

Invert Elev Dn (ft)	= 346.50
Pipe Length (ft)	= 100.00
Slope (%)	= 0.50
Invert Elev Up (ft)	= 347.00
Rise (in)	= 54.0
Shape	= Cir
Span (in)	= 54.0
No. Barrels	= 2
n-Value	= 0.012
Inlet Edge	= Beveled
Coeff. K,M,c,Y,k	= 0.0018, 2.5, 0.03, 0.74, 0.2

Embankment

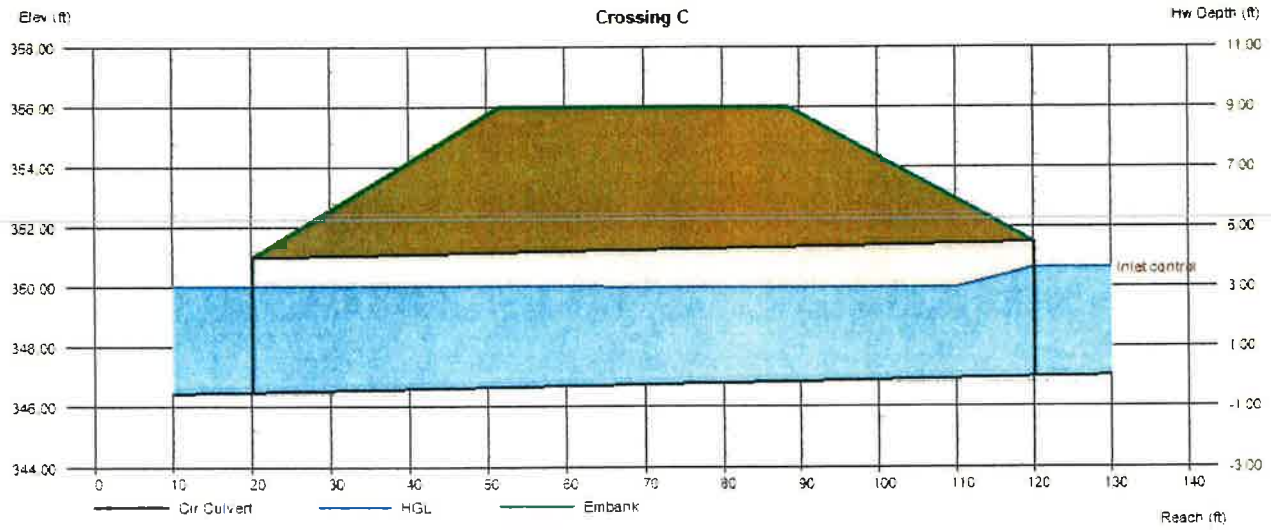
Top Elevation (ft)	= 356.00
Top Width (ft)	= 37.00
Crest Width (ft)	= 100.00

Calculations

Qmin (cfs)	= 152.00
Qmax (cfs)	= 152.00
Tailwater Elev (ft)	= (dc+D)/2

Highlighted

Qtotal (cfs)	= 152.00
Qpipe (cfs)	= 152.00
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 5.68
Veloc Up (ft/s)	= 6.75
HGL Dn (ft)	= 350.03
HGL Up (ft)	= 350.00
Hw Elev (ft)	= 350.65
Hw/D (ft)	= 0.81
Flow Regime	= Inlet Control



Culvert Report

10 YEAR FLOW

Hydraflow Express Extension for AutoCAD® Civil 3D® 2012 by Autodesk, Inc. Thursday, May 18 2017

Crossing D

Invert Elev Dn (ft)	= 331.70
Pipe Length (ft)	= 120.00
Slope (%)	= 0.25
Invert Elev Up (ft)	= 332.00
Rise (in)	= 84.0
Shape	= Cir
Span (in)	= 84.0
No. Barrels	= 2
n-Value	= 0.012
Inlet Edge	= Beveled
Coeff. K,M,c,Y,k	= 0.0018, 2.5, 0.03, 0.74, 0.2

Embankment

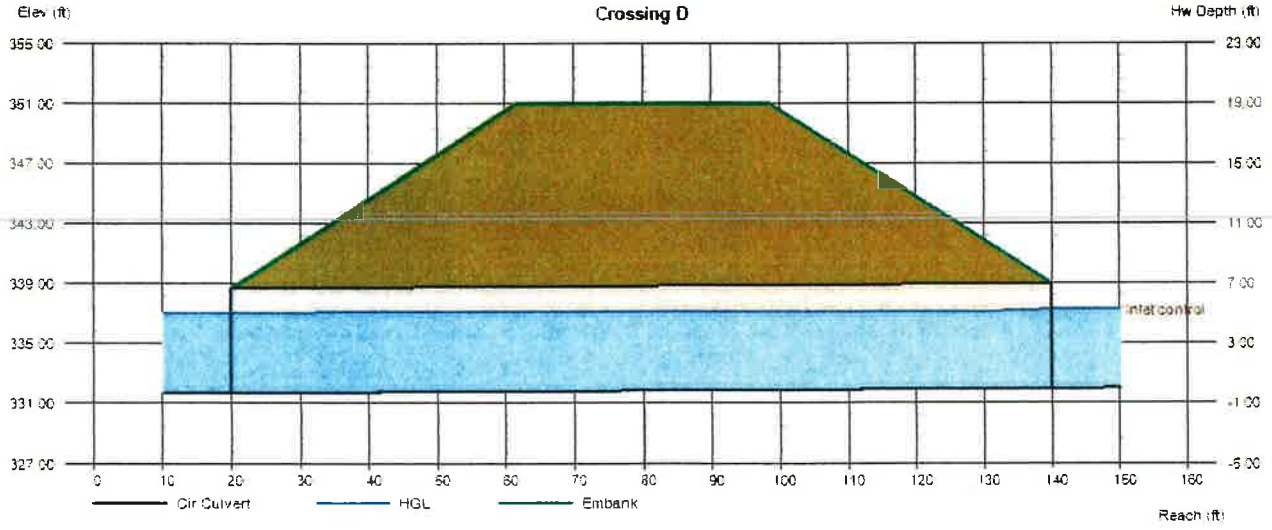
Top Elevation (ft)	= 351.00
Top Width (ft)	= 37.00
Crest Width (ft)	= 100.00

Calculations

Qmin (cfs)	= 407.00
Qmax (cfs)	= 407.00
Tailwater Elev (ft)	= (dc+D)/2

Highlighted

Qtotal (cfs)	= 407.00
Qpipe (cfs)	= 407.00
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 6.42
Veloc Up (ft/s)	= 6.73
HGL Dn (ft)	= 337.07
HGL Up (ft)	= 337.13
Hw Elev (ft)	= 337.28
Hw/D (ft)	= 0.75
Flow Regime	= Inlet Control



DESIGN OF RIPRAP OUTLET PROTECTION

New York DOT Dissipator Method For Use in Defined Channels

(Source: "Bank and channel lining procedures", New York Department of Transportation, Division of Design and Construction, 1971.)

Guide to Color Key:	User Input Data	Calculated Value	Reference Data

Designed By:	DAS	**Date:**	5/17/2017
Checked By:		**Date:**	
Company:	GILLEECE & ASSOCIATES		
Project Name:	Kalas Falls		
Project No.:	9900		

Site Location (City/Town)	Rolesville
Culvert Id.	Crossing D

Estimation of Stone Size and Dimensions For Culvert Aprons

Step 1) Compute flow velocity V_o at culvert or paved channel outlet.

Step 2) For pipe culverts D_o is diameter.
For pipe arch, arch and box culverts, and paved channel outlets, $D_o = A_o$ where A_o = cross-sectional area of flow at outlet.

For multiple culverts, use $D_o = 1.25 \times D_o$ of single culvert.

Velocity (ft/s)	6.5
Opening type	Pipe Culvert
Single or multiple openings?	Single
Outlet pipe diameter, D_o (ft)	7

NOTE 1: If opening type is anything other than "Pipe Culvert", $D_o=A_o$ (Cross-sectional area of flow at outlet).

NOTE 2: If multiple openings, $D_o=1.25 \times D_o$ of single culvert.

Step 3) For apron grades of 10% or steeper, use recommendations for next higher zone. (Zones 1 through 6)

Zone	3	Figure 8.06c
Will apron have >/=10% grade?	No	

NOTE: For apron slopes equal to or greater than 10%, use next higher Zone in Figure 8.06d to determine apron length.

Apron length (ft)	28	Figure 8.06d

Determination of Stone Sizes For Dumped Stone Channel Linings and Revetments

Step 1. Use figure 8.06 e to determine maximum stone size (e.g. for 12 Fps = 20" or 550 lbs.

Max. stone size (in.)	8	Figure 8.06e

Step 2. Use figure 8.06 f to determine acceptable size range for stone (for 12 FPS it is 125-500 lbs. for 75% of stone, and the maximum and minimum range in weight should be 25-500 lbs.)

NOTE: In determining channel velocities for stone linings and revetment use the following coefficients of roughness:

	Diameter (inches)	Manning's "n"	Min. thickness of lining (Channels)	Min. thickness (inches) (Dissipators)
Fine	3	0.031	9	12
Light	6	0.035	12	18
Medium	13	0.040	18	24
Heavy	23	0.044	30	36

Min. & max range of stones (lbs)	25-150	Figure 8.05f
Weight range of 75% of stones (lbs)	50-150	Figure 8.05f

24" Depth

DESIGN OF RIPRAP OUTLET PROTECTION

New York DOT Dissipator Method For Use in Defined Channels

(Source: "Bank and channel lining procedures", New York Department of Transportation, Division of Design and Construction, 1971.)

Guide to Color Key:	User Input Data	Calculated Value	Reference Data

Designed By:	DAS	**Date:**	5/17/2017
Checked By:		**Date:**	
Company:	GILLEECE & ASSOCIATES		
Project Name:	Kalas Falls		
Project No.:	9900		

Site Location (City/Town)	Rolesville
Culvert Id.	Crossing C

Estimation of Stone Size and Dimensions For Culvert Aprons

Step 1) Compute flow velocity V_o at culvert or paved channel outlet.

Step 2) For pipe culverts D_o is diameter.
For pipe arch, arch and box culverts, and paved channel outlets,
$D_o = A_o$ where A_o = cross-sectional area of flow at outlet.

For multiple culverts, use $D_o = 1.25 \times D_o$ of single culvert.

Velocity (ft/s)	5.6
Opening type	Pipe Culvert
Single or multiple openings?	Single
Outlet pipe diameter, D_o (ft)	4.6

NOTE 1: If opening type is anything other than "Pipe Culvert", $D_o=A_o$ (Cross-sectional area of flow at outlet).

NOTE 2: If multiple openings, $D_o=1.25 \times D_o$ of single culvert.

Step 3) For apron grades of 10% or steeper, use recommendations for next higher zone. (Zones 1 through 6).

Zone	2	Figure 8.06c
Will apron have >/=10% grade?	No	

NOTE: For apron slopes equal to or greater than 10%, use next higher Zone in Figure 8.06d to determine apron length.

Apron length (ft)	14	Figure 8.06d

Determination of Stone Sizes For Dumped Stone Channel Linings and Revetments

Step 1. Use figure 8.06 [e] to determine maximum stone size (e.g. for 12 Fps = 20" or 550 lbs.)

Max. stone size (in.)	6	Figure 8.06e

Step 2. Use figure 8.06 [f] to determine acceptable size range for stone (for 12 FPS it is 125-500 lbs. for 75% of stone, and the maximum and minimum range in weight should be 25-500 lbs.)

NOTE: In determining channel velocities for stone linings and revetment, use the following coefficients of roughness:

	Diameter (inches)	Manning's n	Min. thickness of lining (Channels)	Min. thickness (inches) (Dissapators)
Fine	3	0.031	9	12
Light	6	0.035	12	18
Medium	13	0.040	18	24
Heavy	23	0.044	30	36

Min. & max range of stones (lbs)	25-150	Figure 8.05f
Weight range of 75% of stones (lbs)	50-150	Figure 8.05f

24" Depth

DESIGN OF RIPRAP OUTLET PROTECTION

New York DOT Dissipator Method For Use in Defined Channels

(Source: "Bank and channel lining procedures" New York Department of Transportation, Division of Design and Construction, 1971.)

Guide to Color Key:	User Input Data	Calculated Value	Reference Data

Designed By:	DAS	**Date:**	5/17/2017
Checked By:		**Date:**	
Company:	GILLEECE & ASSOCIATES		
Project Name:	Kalas Falls		
Project No.:	9900		

Site Location (City/Town)	Rolesville
Culvert Id.	Crossing A

Estimation of Stone Size and Dimensions For Culvert Aprons

Step 1) Compute flow velocity V_o at culvert or paved channel outlet.

Step 2) For pipe culverts D_o is diameter.
For pipe arch, arch and box culverts, and paved channel outlets, $D_o = A_o$ where A_o = cross-sectional area of flow at outlet.

For multiple culverts, use $D_o = 1.25 \times D_o$ of single culvert.

Velocity (ft/s)	4.4
Opening type	Pipe Culvert
Single or multiple openings?	Single
Outlet pipe diameter, D_o (ft)	4

NOTE 1: If opening type is anything other than "Pipe Culvert", $D_o=A_o$ (Cross-sectional area of flow at outlet).

NOTE 2: If multiple openings, $D_o=1.25 \times D_o$ of single culvert.

Step 3) For apron grades of 10% or steeper, use recommendations for next higher zone. (Zones 1 through 6)

Zone	2	Figure 8.06c
Will apron have >/=10% grade?	No	

NOTE: For apron slopes equal to or greater than 10%, use next higher Zone in Figure 8.06d to determine apron length.

Apron length (ft)	12	Figure 8.06d

Determination of Stone Sizes For Dumped Stone Channel Linings and Revetments

Step 1. Use figure 8.06 e to determine maximum stone size (e.g. for 12 Fps = 20" or 550 lbs.)

Max. stone size (in.)	6	Figure 8.06e

Step 2. Use figure 8.06 f to determine acceptable size range for stone (for 12 FPS it is 125-500 lbs. for 75% of stone, and the maximum and minimum range in weight should be 25-500 lbs.)

NOTE: In determining channel velocities for stone linings and revetment, use the following coefficients of roughness:

	Diameter (inches)	Manning's n	Min. thickness of lining (Channels)	Min. thickness (inches) (Dissipators)
Fine	3	0.031	9	12
Light	6	0.035	12	18
Medium	13	0.040	18	24
Heavy	23	0.044	30	36

Min. & max range of stones (lbs)	25-150	Figure 8.05f
Weight range of 75% of stones (lbs)	50-150	Figure 8.05f

24" Depth

Figure 8.06e: Maximum Stone Size for Riprap

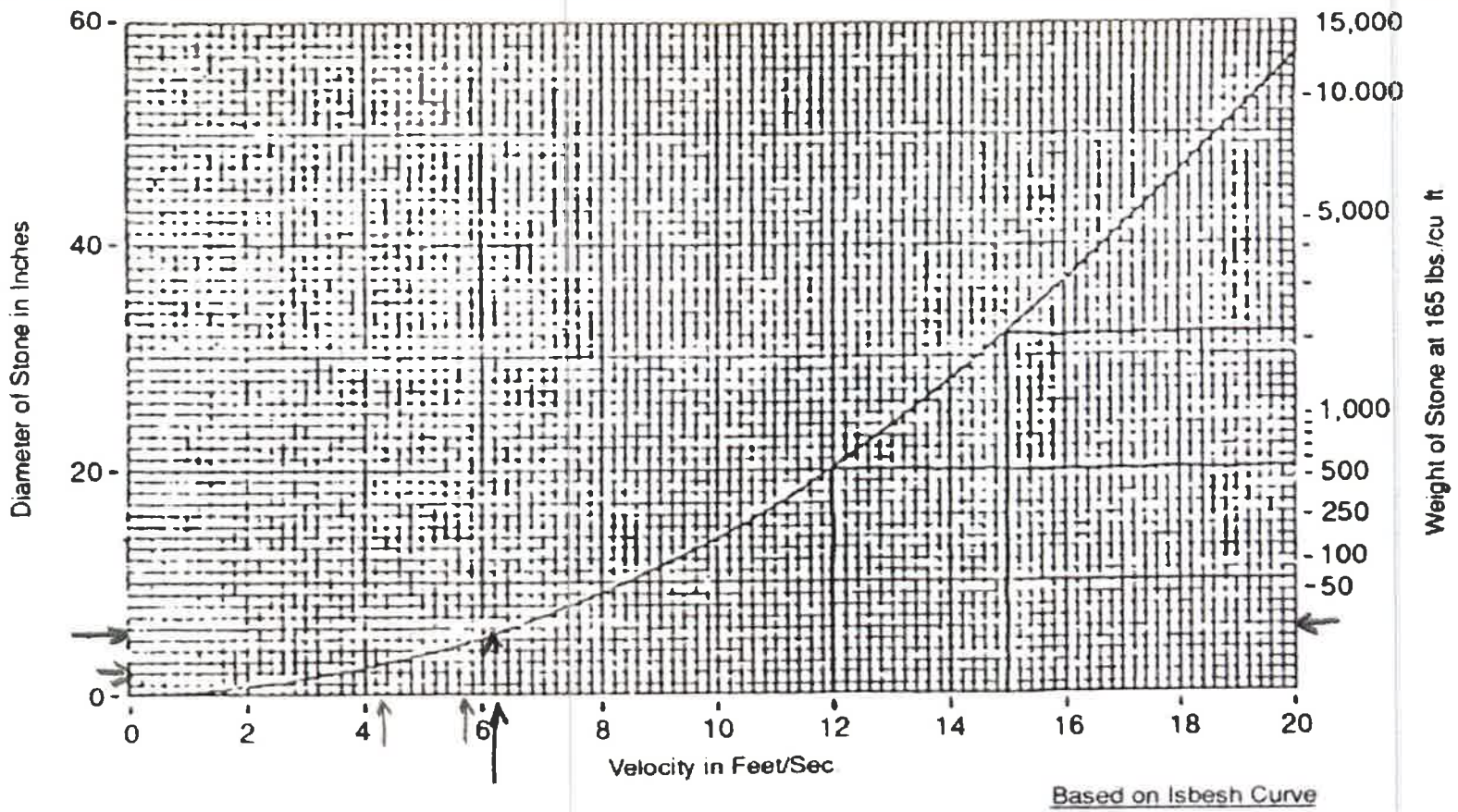


Figure 8.06e Maximum Stone Size for Riprap

Figure 8.06f: Gradation of Riprap

Maximum weight of stone required	Minimum and maximum range in weight of stones	Weight range of 75% of stones
(lbs)	(lbs.)	(lbs.)
150	25 - 150	50 - 150
200	25 - 200	50 - 200
250	25 - 250	50 - 250
400	25 - 400	100 - 400
600	25 - 600	150 - 600
800	25 - 800	200 - 800
1,000	50 - 1000	250 - 1000
1,300	50 - 1,300	325 - 1,300
1,600	50 - 1,600	400 - 1,600
2,000	75 - 2,000	600 - 2,000
2,700	100 - 2,700	800 - 2,700

Figure 8.06f Gradation of Riprap

Source: "Bank and channel lining procedures." New York Department of Transportation, Division of Design and Construction, 1971.

Figure 8.06d: Length of Apron

ZONE	APRON MATERIAL	LENGTH OF APRON	
		TO PROTECT CULVERT L1	TO PREVENT SCOUR HOLE USE L2 ALWAYS L2
1	STONE FILLING (FINE) CL. A	3 X D_o	4 x D_o
2	STONE FILLING (LIGHT) CL. B	3 X D_o	6 x D_o
3	STONE FILLING (MEDIUM) CL. 1	4 X D_o	8 x D_o
4	STONE FILLING (HEAVY) CL. 1	4 X D_o	8 x D_o
5	STONE FILLING (HEAVY) CL. 2	5 X D_o	10 x D_o
6	STONE FILLING (HEAVY) CL. 2	6 X D_o	10 x D_o
7	SPECIAL STUDY REQUIRED (ENERGY DISSIPATORS, STILLING BASIN OR LARGER SIZE STONE).		

Figure 8.06d

Width = 3 times pipe dia. (mm.)

NOTE: For apron slopes equal to or greater than 10%, use next higher Zone to determine Apron Length.

$3 \times 4.5 = 14'$

$\leftarrow 3 \times 4 = 12'$

$\leftarrow 4 \times 7 = 28'$

Figure 8.06c: Zone Determiniation for Apron Material

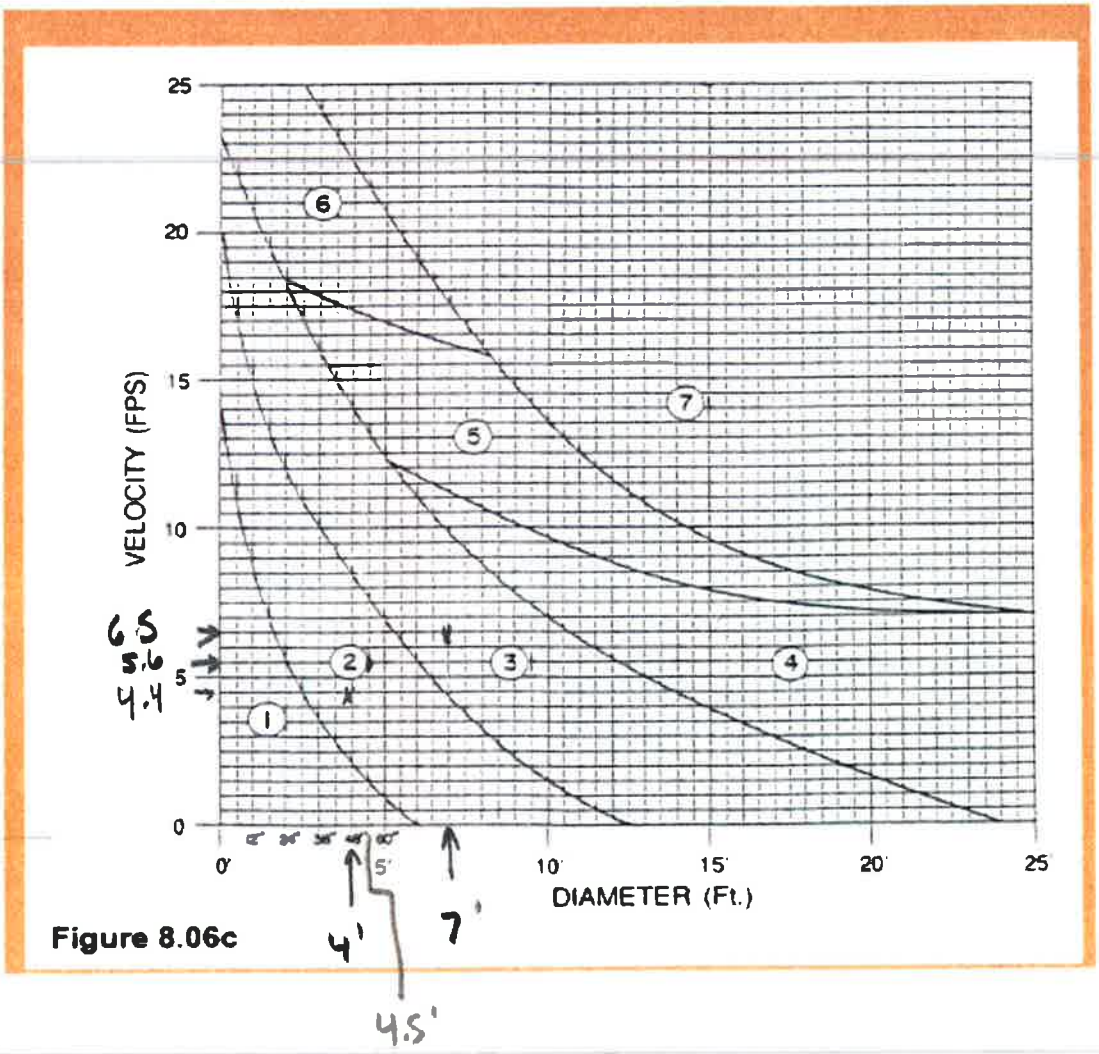


Figure 8.06c

HEC-RAS Report

kalas hec ras.rep.txt

HEC-RAS HEC-RAS 5.0.3 September 2016
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: kalas
Project File : kalas.prj
Run Date and Time: 5/17/2017 2:56:57 PM

Project in English units

PLAN DATA

Plan Title: Plan 01
Plan File : C:\Users\DSever\Documents\kalas.p01

Geometry Title: kalas
Geometry File : C:\Users\DSever\Documents\kalas.g02

Flow Title : kalas
Flow File : C:\Users\DSever\Documents\kalas.f01

Plan Summary Information:

Number of:	Cross Sections	= 10	Multiple Openings	=	0
	Culverts	= 2	Inline Structures	=	0
	Bridges	= 0	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

FLOW DATA

Flow Title: kalas
Flow File : C:\Users\DSever\Documents\kalas.f01

Flow Data (cfs)

River	Reach	RS	PF 1
1	1	3760.000	155
1	1	3000.000	316
1	1	1600.000	867

Boundary Conditions

River	Reach	Profile	Upstream	Downstream
1	1	PF 1		Critical

GEOMETRY DATA

Geometry Title: kalas
Geometry File : C:\Users\DSever\Documents\kalas.g02

CROSS SECTION

RIVER: 1

REACH: 1 RS: 3760.000

INPUT
Description:
Station Elevation Data num= 47

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	379.89	18.49	378.64	70.09	377.06	73.51	376.49	76.73	376.36
82.68	375.82	86.76	375.13	88.77	374.17	94.72	371.85	95.53	371.7
98.4	370.74	109.1	368.44	114.51	367.99	119.32	367.53	120	367.51
130	367.198	130.9	367.17	135.6	366.49	143.14	366.9	147.39	367.28
157.13	367.52	158.77	367.59	162.52	367.52	176.44	369.08	177.36	369.23
179.06	369.3	194.34	370.32	203.45	371.7	208.16	371.7	210.13	373.2
210.43	373.29	219.41	374.86	221.67	375.22	222.65	375.74	241.74	376.79
247.96	377.16	249.22	377.49	250.4	377.85	269.79	382.16	270.47	382.3
271.32	382.4	280	382.9	304.29	384.3	332.71	387.79	350.01	389.19
389.52	392.21	400	392.56						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.06	130	.035	147.39	.06

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
130	147.39	694.59	709.66 724.74	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

E.G. Elev (ft)	368.45	Element	Left OB	Channel
Right OB				
Vel Head (ft)	0.37	Wt. n-Val.	0.060	0.035
0.060				
W.S. Elev (ft)	368.08	Reach Len. (ft)	694.59	709.66
724.74				
Crit W.S. (ft)	368.05	Flow Area (sq ft)	9.16	21.26
10.77				
E.G. Slope (ft/ft)	0.013030	Area (sq ft)	9.16	21.26
10.77				
Q Total (cfs)	155.00	Flow (cfs)	17.46	117.47
20.07				
Top Width (ft)	54.01	Top Width (ft)	16.52	17.39
20.09				
Vel Total (ft/s)	3.76	Avg. Vel. (ft/s)	1.91	5.52
1.86				
Max Chl Dpth (ft)	1.59	Hydr. Depth (ft)	0.55	1.22
0.54				
Conv. Total (cfs)	1357.9	Conv. (cfs)	153.0	1029.1
175.8				
Length Wtd. (ft)	709.68	Wetted Per. (ft)	16.55	17.47

20.13				
Min Ch El (ft)	366.49	Shear (lb/sq ft)	0.45	0.99
0.44				
Alpha	1.69	Stream Power (lb/ft s)	0.86	5.47
0.81				
Frctn Loss (ft)	11.76	Cum Volume (acre-ft)	7.63	1.68
6.37				
C & E Loss (ft)	0.00	Cum SA (acres)	4.07	0.54
3.20				

Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.
Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate
the need for additional cross sections.

CROSS SECTION

RIVER: 1
REACH: 1 RS: 3000.000

INPUT
Description:
Station Elevation Data num= 33

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	363.44	4.67	363.58	8.15	363.57	54.36	361.51	61.43	361.06
67.6	360.57	90.61	358.65	97.12	358.44	120	356.8	135.15	355.7
151	355.14	154.24	355.15	167.57	355.08	167.96	355.02	172.68	354.33
172.73	354.34	175.96	354.9	198.83	355.79	206.25	355.64	207.54	354.98
209.53	354.48	210.87	355.1	212.42	355.48	233.07	357.45	243.05	358.29
267.74	359.58	280	360.24	292.91	360.93	297.01	360.46	323.9	360.58
356.83	360.03	375.32	360.24	400	360.57				

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.06	167.96	.035	175.96	.06

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
167.96	175.96	553.71	369.83	186.14	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

E.G. Elev (ft)	356.68	Element	Left OB	Channel

Right OB				
Vel Head (ft)	0.41	Wt. n-Val.	0.060	0.035
0.060				
W.S. Elev (ft)	356.26	Reach Len. (ft)	553.71	369.83
186.14				
Crit W.S. (ft)	356.26	Flow Area (sq ft)	34.97	12.90
36.06				
E.G. Slope (ft/ft)	0.018873	Area (sq ft)	34.97	12.90
36.06				
Q Total (cfs)	316.00	Flow (cfs)	107.68	102.66
105.66				
Top Width (ft)	93.25	Top Width (ft)	40.57	8.00
44.67				
Vel Total (ft/s)	3.76	Avg. Vel. (ft/s)	3.08	7.96
2.93				
Max Chl Dpth (ft)	1.93	Hydr. Depth (ft)	0.86	1.61
0.81				
Conv. Total (cfs)	2300.2	Conv. (cfs)	783.8	747.3
769.1				
Length Wtd. (ft)	438.19	Wetted Per. (ft)	40.61	8.10
45.13				
Min Ch El (ft)	354.33	Shear (lb/sq ft)	1.01	1.88
0.94				
Alpha	1.88	Stream Power (lb/ft s)	3.12	14.93
2.76				
Frctn Loss (ft)	0.12	Cum Volume (acre-ft)	7.28	1.40
5.98				
C & E Loss (ft)	0.12	Cum SA (acres)	3.62	0.33
2.66				

Warning: The energy equation could not be balanced within the specified number of iterations. The program used critical
depth for the water surface and continued on with the calculations.
Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.
Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate
the need for additional cross sections.
Warning: During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated
water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The
program defaulted to critical depth.

CROSS SECTION

RIVER: 1
REACH: 1 RS: 2565.000

INPUT
Description:
Station Elevation Data num= 31

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	350.12	1.84	350.11	48.14	350.76	73.97	351.73	89.05	351.21
118.1	349.8	120	349.71	133.44	349.11	135.47	349.1	149.76	348.31
170.17	347.53	174.28	347.73	195.83	349.85	198.52	348.74	199.47	348.1
201.18	349.04	203.16	349.64	203.63	349.69	216.88	350.4	258.92	352.77
262.11	353.7	265.9	354.87	270.12	356.21	280	357.11	288.89	357.92
289.88	358	290.1	358.02	290.75	358.04	326.8	360	389.57	360
400	360.09								

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.06	195.83	.035	203.63	.06

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
195.83	203.63	118.73	90	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

E.G. Elev (ft)	352.93	Element	Left OB	Channel
Right OB				
Vel Head (ft)	0.00	Wt. n-Val.	0.060	0.035
0.060				
W.S. Elev (ft)	352.93	Reach Len. (ft)	118.73	90.00
90.00				
Crit W.S. (ft)	349.28	Flow Area (sq ft)	590.74	30.13
94.62				
E.G. Slope (ft/ft)	0.000075	Area (sq ft)	590.74	30.13
94.62				
Q Total (cfs)	316.00	Flow (cfs)	261.58	25.64
28.78				
Top Width (ft)	259.46	Top Width (ft)	195.83	7.80
55.83				
Vel Total (ft/s)	0.44	Avg. Vel. (ft/s)	0.44	0.85
0.30				
Max Chl Dpth (ft)	5.40	Hydr. Depth (ft)	3.02	3.86
1.69				
Conv. Total (cfs)	36521.8	Conv. (cfs)	30231.9	2963.2
3326.8				
Length Wtd. (ft)	90.00	Wetted Per. (ft)	198.86	8.55

55.93

Min Ch El (ft)	348.10	Shear (lb/sq ft)	0.01	0.02
0.01				
Alpha	1.18	Stream Power (lb/ft s)	0.01	0.01
0.00				
Frctn Loss (ft)		Cum Volume (acre-ft)	3.30	1.22
5.70				
C & E Loss (ft)		Cum SA (acres)	2.11	0.26
2.45				

CULVERT

RIVER: 1
REACH: 1 RS: 2522

INPUT
Description: Crossing C
Distance from Upstream XS = 45
Deck/Roadway Width = 32
Weir Coefficient = 2.6
Upstream Deck/Roadway Coordinates
num= 4

Sta Hi Cord	Lo Cord	Sta Hi Cord	Lo Cord	Sta Hi Cord	Lo Cord
0	357	100	356	200	356
400	357				

Upstream Bridge Cross Section Data
Station Elevation Data num= 31

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	350.12	1.84	350.11	48.14	350.76	73.97	351.73	89.05	351.21
118.1	349.8	120	349.71	133.44	349.11	135.47	349.1	149.76	348.31
170.17	347.53	174.28	347.73	195.83	349.85	198.52	348.74	199.47	348.1
201.18	349.04	203.16	349.64	203.63	349.69	216.88	350.4	258.92	352.77
262.11	353.7	265.9	354.87	270.12	356.21	280	357.11	288.89	357.92
289.88	358	290.1	358.02	290.75	358.04	326.8	360	389.57	360
400	360.09								

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.06	195.83	.035	203.63	.06

Bank Sta: Left	Right	Coeff Contr.	Expan.
195.83	203.63	.1	.3

Downstream Deck/Roadway Coordinates

```
    num=       4
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
       0     357             100     356             200     356
     400     357

Downstream Bridge Cross Section Data
Station Elevation Data    num=      41
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  349.56   26.27  349.85   26.64  349.85   45.37  349.76   70.19  347.92
   71.53  347.91   73.86  347.89   87.94  347.31   93.09  347.24  108.55  346.87
  120.72  346.88  132.57  347.65  137.31  348.25   138.3 348.399  138.44  348.42
  138.48   348.3  141.91   347.3  142.07  347.33  142.35  347.41  147.92  348.51
  150.28  348.64  151.67   348.9  153.04   349.2  153.79  349.34  161.81  351.13
  177.04     352  191.74  353.21  204.72     354  207.78  354.17  219.33  354.84
   232.9     356  254.31  357.34  261.39     358  267.25   358.4  288.33  359.35
  299.64  359.62  323.64  359.82  325.67  359.89  327.48  359.92  332.67     360
  340.62     360

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .06   138.3    .035  147.92     .06

Bank Sta: Left   Right    Coeff Contr.   Expan.
         138.3  147.92            .1       .3

Upstream Embankment side slope              =       3 horiz. to 1.0 vertical
Downstream Embankment side slope            =       3 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 Culverts =  2

Culvert Name     Shape      Rise    Span
Culvert #2      Circular     4.5
FHWA Chart # 1 - Concrete Pipe Culvert
FHWA Scale # 2 - Groove end entrance with headwall
Solution Criteria = Highest U.S. EG
Culvert Upstrm Dist  Length    Top n  Bottom n  Depth Blocked  Entrance Loss Coef
Exit Loss Coef
                 5      85     .012     .012        0                    .2
      1
Upstream   Elevation =  347
           Centerline Station =  190
Downstream Elevation =  346.8
           Centerline Station =  130
```

← 54" Culvert

Culvert Name Shape Rise Span ← 60" Culvert
Culvert #1 Circular 5
FHWA Chart # 1 - Concrete Pipe Culvert
FHWA Scale # 2 - Groove end entrance with headwall
Solution Criteria = Highest U.S. EG

Culvert	Upstrm Dist	Length	Top n	Bottom n	Depth Blocked	Entrance Loss Coef	Exit Loss Coef
	5	85	.012	.035	.5	.2	1

Upstream Elevation = 346.5
Centerline Station = 200
Downstream Elevation = 346.2
Centerline Station = 140

CULVERT OUTPUT Profile #PF 1 Culv Group: Culvert #2

Q Culv Group (cfs)	149.09	Culv Full Len (ft)	
# Barrels	1	Culv Vel US (ft/s)	9.69
Q Barrel (cfs)	149.09	Culv Vel DS (ft/s)	10.98
E.G. US. (ft)	352.93	Culv Inv El Up (ft)	347.00
W.S. US. (ft)	352.93	Culv Inv El Dn (ft)	346.80
E.G. DS (ft)	348.91	Culv Frctn Ls (ft)	0.02
W.S. DS (ft)	348.79	Culv Exit Loss (ft)	3.35
Delta EG (ft)	4.02	Culv Entr Loss (ft)	0.29
Delta WS (ft)	4.14	Q Weir (cfs)	
E.G. IC (ft)	352.89	Weir Sta Lft (ft)	
E.G. OC (ft)	352.92	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	351.17	Weir Max Depth (ft)	
Culv WS Outlet (ft)	350.38	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	4.50	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	3.58	Min El Weir Flow (ft)	356.01

Note: The normal depth exceeds the height of the culvert. The program assumes that the normal depth is equal to the height of the culvert.

CULVERT OUTPUT Profile #PF 1 Culv Group: Culvert #1

Q Culv Group (cfs)	166.91	Culv Full Len (ft)	
# Barrels	1	Culv Vel US (ft/s)	9.00
Q Barrel (cfs)	166.91	Culv Vel DS (ft/s)	10.88
E.G. US. (ft)	352.93	Culv Inv El Up (ft)	346.50
W.S. US. (ft)	352.93	Culv Inv El Dn (ft)	346.20
E.G. DS (ft)	348.91	Culv Frctn Ls (ft)	0.19
W.S. DS (ft)	348.79	Culv Exit Loss (ft)	3.01

CROWN +5' 351.50

Delta EG (ft)	4.02	Culv Entr Loss (ft)	0.25
Delta WS (ft)	4.14	Q Weir (cfs)	
E.G. IC (ft)	352.67	Weir Sta Lft (ft)	
E.G. OC (ft)	352.94	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	351.43	Weir Max Depth (ft)	
Culv WS Outlet (ft)	350.08	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	4.50	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	3.38	Min El Weir Flow (ft)	356.01

Note: The normal depth exceeds the height of the culvert. The program assumes that the normal depth is equal to the height of the culvert.

CROSS SECTION

RIVER: 1
REACH: 1 RS: 2475.000

INPUT
Description:
Station Elevation Data num= 41

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	349.56	26.27	349.85	26.64	349.85	45.37	349.76	70.19	347.92
71.53	347.91	73.86	347.89	87.94	347.31	93.09	347.24	108.55	346.87
120.72	346.88	132.57	347.65	137.31	348.25	138.3	348.399	138.44	348.42
138.48	348.3	141.91	347.3	142.07	347.33	142.35	347.41	147.92	348.51
150.28	348.64	151.67	348.9	153.04	349.2	153.79	349.34	161.81	351.13
177.04	352	191.74	353.21	204.72	354	207.78	354.17	219.33	354.84
232.9	356	254.31	357.34	261.39	358	267.25	358.4	288.33	359.35
299.64	359.62	323.64	359.82	325.67	359.89	327.48	359.92	332.67	360
340.62	360								

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.06	138.3	.035	147.92	.06

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
138.3	147.92	20	73.28	172.65	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

E.G. Elev (ft)	348.91	Element	Left OB	Channel
Right OB				
Vel Head (ft)	0.12	Wt. n-Val.	0.060	0.035

0.060					
W.S. Elev (ft)	348.79	Reach Len. (ft)	20.00	73.28	172.65
Crit W.S. (ft)		Flow Area (sq ft)	105.40	8.70	0.56
E.G. Slope (ft/ft)	0.008244	Area (sq ft)	105.40	8.70	0.56
Q Total (cfs)	316.00	Flow (cfs)	284.96	30.65	0.40
Top Width (ft)	92.59	Top Width (ft)	79.82	9.62	3.15
Vel Total (ft/s)	2.76	Avg. Vel. (ft/s)	2.70	3.52	0.71
Max Chl Dpth (ft)	1.92	Hydr. Depth (ft)	1.32	0.90	0.18
Conv. Total (cfs)	3480.3	Conv. (cfs)	3138.4	337.5	4.4
Length Wtd. (ft)	78.48	Wetted Per. (ft)	79.94	9.97	3.17
Min Ch El (ft)	347.30	Shear (lb/sq ft)	0.68	0.45	0.09
Alpha	1.03	Stream Power (lb/ft s)	1.83	1.58	0.06
Frctn Loss (ft)	1.10	Cum Volume (acre-ft)	3.30	1.07	5.70
C & E Loss (ft)	0.04	Cum SA (acres)	1.74	0.25	2.39

Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.
Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate
the need for additional cross sections.

CROSS SECTION

RIVER: 1
REACH: 1 RS: 2400.000

INPUT
Description:
Station Elevation Data num= 27

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	349.56	25.66	349.51	55.28	348.87	67.81	348.5	73.48	348.11

80.65	347.7	86.09	347.38	108.34	345.99	111.09	345.84	114.05	345.86
141.91	346.35	144.11	345.82	146.39	345.18	148.4	345.8	150.13	346.68
156.7	349.96	160.22	351.73	165.03	352	205.88	353.4	218.05	353.73
220.92	353.82	226.91	354	252.27	354	272.57	353.71	294.56	354
316.06	354	350.67	354.54						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.06	108.34	.035	114.05	.06

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
108.34	114.05	806.88	771.88	739.55	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

E.G. Elev (ft)	347.77	Element	Left OB	Channel
Right OB				
Vel Head (ft)	0.52	Wt. n-Val.	0.060	0.035
0.060				
W.S. Elev (ft)	347.25	Reach Len. (ft)	806.88	771.88
739.55				
Crit W.S. (ft)	347.25	Flow Area (sq ft)	12.71	7.82
44.07				
E.G. Slope (ft/ft)	0.029231	Area (sq ft)	12.71	7.82
44.07				
Q Total (cfs)	316.00	Flow (cfs)	39.49	69.90
206.61				
Top Width (ft)	63.10	Top Width (ft)	20.17	5.71
37.22				
Vel Total (ft/s)	4.89	Avg. Vel. (ft/s)	3.11	8.94
4.69				
Max Chl Dpth (ft)	2.07	Hydr. Depth (ft)	0.63	1.37
1.18				
Conv. Total (cfs)	1848.3	Conv. (cfs)	231.0	408.9
1208.4				
Length Wtd. (ft)	771.67	Wetted Per. (ft)	20.21	5.71
37.82				
Min Ch El (ft)	345.84	Shear (lb/sq ft)	1.15	2.50
2.13				
Alpha	1.39	Stream Power (lb/ft s)	3.57	22.32
9.97				
Frctn Loss (ft)	4.25	Cum Volume (acre-ft)	3.27	1.05
5.61				
C & E Loss (ft)	0.10	Cum SA (acres)	1.71	0.23
2.31				

Warning: The energy equation could not be balanced within the specified number of iterations. The program used critical
depth for the water surface and continued on with the calculations.
Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.
Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate
the need for additional cross sections.
Warning: During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated
water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The
program defaulted to critical depth.

CROSS SECTION

RIVER: 1
REACH: 1 RS: 1600.000

INPUT
Description:
Station Elevation Data num= 42

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	353.74	14.72	351.44	32.27	349.04	64.97	345.88	75.64	344.55
77.86	344.61	115.31	341.28	120	340.91	120.44	340.88	161.22	338.33
171.13	338.18	191.2	338.36	191.27	338.36	191.28	336.45	200.3	338.3
200.38	338.19	201.42	336.29	201.58	336.31	204.97	337.5	208.24	338.31
208.3	338.41	210.01	338.46	223.95	338.97	225.5	338.98	236.65	339.58
266.55	341.17	271.86	341.3	280	341.58	289.89	341.92	295.68	342.2
305.87	342.85	316.32	343.58	328.51	344.47	332.63	346.38	335.82	347.77
338.95	349.12	346.62	350	364.38	351.75	367.34	352	370.96	352.39
388.57	354	400	354.94						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.06	191.2	.035	200.3	.06

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
191.2	200.3	135.31	311.61	488.7	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

E.G. Elev (ft)	341.45	Element	Left OB	Channel	Right OB

Vel Head (ft)	0.18	Wt. n-Val.	0.060	0.035
0.060				
W.S. Elev (ft)	341.27	Reach Len. (ft)	135.31	311.61
488.70				
Crit W.S. (ft)		Flow Area (sq ft)	158.76	35.35
124.18				
E.G. Slope (ft/ft)	0.003783	Area (sq ft)	158.76	35.35
124.18				
Q Total (cfs)	867.00	Flow (cfs)	395.78	198.75
272.46				
Top Width (ft)	155.05	Top Width (ft)	75.73	9.10
70.22				
Vel Total (ft/s)	2.72	Avg. Vel. (ft/s)	2.49	5.62
2.19				
Max Chl Dpth (ft)	4.98	Hydr. Depth (ft)	2.10	3.88
1.77				
Conv. Total (cfs)	14096.6	Conv. (cfs)	6435.1	3231.6
4430.0				
Length Wtd. (ft)	314.19	Wetted Per. (ft)	75.82	11.19
71.83				
Min Ch El (ft)	336.45	Shear (lb/sq ft)	0.49	0.75
0.41				
Alpha	1.56	Stream Power (lb/ft s)	1.23	4.20
0.90				
Frctn Loss (ft)	0.19	Cum Volume (acre-ft)	1.68	0.67
4.18				
C & E Loss (ft)	0.05	Cum SA (acres)	0.83	0.10
1.39				

Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.

CROSS SECTION

RIVER: 1
REACH: 1 RS: 1250.000

INPUT
Description:
Station Elevation Data num= 34

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	351.48	4.77	350.88	11.6	350.11	22.39	349.16	49.09	346.62
65.14	344.94	98.82	341.58	116.46	340.19	120	339.74	123.93	339.24
152.62	337.33	169.97	336.11	188.93	335.29	196.81	335.07	199.8	335.08

200.86	333.42	201.21	332.7	202.12	332.68	204.09	332.8	205.84	334.54
206.64	335.58	207.15	335.73	223.31	336.16	244.07	335.83	254.73	335.94
270.1	335.8	280	336.86	280.58	336.92	324.09	342.47	337.61	344.98
357.62	347.96	376.42	351.09	394.63	353.76	400	354.29		

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.06	199.8	.035	205.84	.06

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
199.8	205.84	100.91	87.95	75	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

E.G. Elev (ft)	341.21	Element	Left OB	Channel
Right OB				
Vel Head (ft)	0.02	Wt. n-Val.	0.060	0.035
0.060				
W.S. Elev (ft)	341.19	Reach Len. (ft)	100.91	87.95
75.00				
Crit W.S. (ft)		Flow Area (sq ft)	348.04	47.75
460.78				
E.G. Slope (ft/ft)	0.000234	Area (sq ft)	348.04	47.75
460.78				
Q Total (cfs)	867.00	Flow (cfs)	310.34	100.92
455.74				
Top Width (ft)	210.29	Top Width (ft)	96.04	6.04
108.22				
Vel Total (ft/s)	1.01	Avg. Vel. (ft/s)	0.89	2.11
0.99				
Max Chl Dpth (ft)	8.51	Hydr. Depth (ft)	3.62	7.90
4.26				
Conv. Total (cfs)	56723.8	Conv. (cfs)	20303.9	6602.7
29817.2				
Length Wtd. (ft)	84.82	Wetted Per. (ft)	96.26	8.12
109.09				
Min Ch El (ft)	332.68	Shear (lb/sq ft)	0.05	0.09
0.06				
Alpha	1.29	Stream Power (lb/ft s)	0.05	0.18
0.06				
Frctn Loss (ft)	0.02	Cum Volume (acre-ft)	0.90	0.37
0.90				
C & E Loss (ft)	0.00	Cum SA (acres)	0.56	0.05
0.39				

CROSS SECTION

RIVER: 1
REACH: 1 RS: 1162.000

INPUT
Description:
Station Elevation Data num= 32

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	350.16	50.44	344.88	54.13	344.31	83.37	341.86	84.56	341.74
120	339.28	129.93	338.59	131.64	338.52	132.73	338.44	137.33	338.18
181.6	335.14	192.81	334.86	194.44	334.3	196.68	333.94	196.98	333.18
197.55	332.22	199.17	332.27	200.86	332.08	201.56	332.97	201.96	334.06
203.34	334.49	205.55	334.82	228.28	334.99	242.88	334.09	259.44	333.77
272.13	335.34	280	336.79	310.33	342.38	346.76	348.82	356.81	350.58
395.14	354.58	400	355.07						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.06	196.68	.035	201.96	.06

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
196.68	201.96	132	132	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

E.G. Elev (ft)	341.19	Element	Left OB	Channel
Right OB				
Vel Head (ft)	0.02	Wt. n-Val.	0.060	0.035
0.060				
W.S. Elev (ft)	341.18	Reach Len. (ft)	132.00	132.00
132.00				
Crit W.S. (ft)	336.23	Flow Area (sq ft)	364.71	45.93
560.03				
E.G. Slope (ft/ft)	0.000152	Area (sq ft)	364.71	45.93
560.03				
Q Total (cfs)	867.00	Flow (cfs)	256.55	80.16
530.30				
Top Width (ft)	211.16	Top Width (ft)	104.03	5.28
101.85				
Vel Total (ft/s)	0.89	Avg. Vel. (ft/s)	0.70	1.75
0.95				
Max Chl Dpth (ft)	9.10	Hydr. Depth (ft)	3.51	8.70
5.50				
Conv. Total (cfs)	70294.7	Conv. (cfs)	20800.3	6498.8
42995.5				

Length Wtd. (ft)	132.00	Wetted Per. (ft)	104.36	7.55	102.60
Min Ch El (ft)	332.08	Shear (lb/sq ft)	0.03	0.06	0.05
Alpha	1.22	Stream Power (lb/ft s)	0.02	0.10	0.05
Frctn Loss (ft)		Cum Volume (acre-ft)	0.07	0.28	0.02
C & E Loss (ft)		Cum SA (acres)	0.33	0.04	0.21

CULVERT

RIVER: 1
REACH: 1 RS: 1096

INPUT
Description: Crossing D
Distance from Upstream XS = 45
Deck/Roadway Width = 36
Weir Coefficient = 2.6
Upstream Deck/Roadway Coordinates
num= 6

Sta	Hi Cord	Lo Cord	Sta	Hi Cord	Lo Cord	Sta	Hi Cord	Lo Cord
0	353		50	351.5		230	351.5	
280	352		330	353		400	355	

Upstream Bridge Cross Section Data
Station Elevation Data num= 32

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	350.16	50.44	344.88	54.13	344.31	83.37	341.86	84.56	341.74
120	339.28	129.93	338.59	131.64	338.52	132.73	338.44	137.33	338.18
181.6	335.14	192.81	334.86	194.44	334.3	196.68	333.94	196.98	333.18
197.55	332.22	199.17	332.27	200.86	332.08	201.56	332.97	201.96	334.06
203.34	334.49	205.55	334.82	228.28	334.99	242.88	334.09	259.44	333.77
272.13	335.34	280	336.79	310.33	342.38	346.76	348.82	356.81	350.58
395.14	354.58	400	355.07						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.06	196.68	.035	201.96	.06

Bank Sta: Left	Right	Coeff Contr.	Expan.
196.68	201.96	.1	.3

Downstream Deck/Roadway Coordinates
num= 6

Sta	Hi Cord	Lo Cord	Sta	Hi Cord	Lo Cord	Sta	Hi Cord	Lo Cord
0	353		50	351.5		230	351.5	
280	352		330	353		400	355	

Downstream Bridge Cross Section Data
Station Elevation Data num= 31

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	350.88	7.02	350.22	43.66	346.17	52.78	345.37	72.23	342.25
90.57	338.44	96.53	337.77	113.94	336.21	120	335.68	133.76	334.46
162.63	334.42	191.42	334.03	193.69	334.14	194.4	333.63	197.24	331.54
199.13	331.49	202.09	331.49	203.87	332.87	206.04	334.01	212.63	334.37
243.33	337.08	260.6	338.26	265.49	338.76	271	338.94	280	339.36
286.71	339.68	290.9	339.96	298.54	340.43	365.02	345.02	384.54	347.33
400	348.11								

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.06	194.4	.035	206.04	.06

Bank Sta: Left	Right	Coeff Contr.	Expan.
194.4	206.04	.1	.3

Upstream Embankment side slope = 2 horiz. to 1.0 vertical
Downstream Embankment side slope = 2 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 Culverts = 2

Culvert Name	Shape	Rise	Span
Culvert #2	Circular	7	

84"

FHWA Chart # 1 - Concrete Pipe Culvert
FHWA Scale # 2 - Groove end entrance with headwall
Solution Criteria = Highest U.S. EG

Culvert	Upstrm Dist	Length	Top n	Bottom n	Depth Blocked	Entrance Loss Coef	Exit Loss Coef
	2	120	.012	.012	0	.2	1

Upstream Elevation = 332
Centerline Station = 200
Downstream Elevation = 331.76
Centerline Station = 200

Culvert Name	Shape	Rise	Span
Culvert #1	Circular	7	

← 84"

FHWA Chart # 1 - Concrete Pipe Culvert
FHWA Scale # 2 - Groove end entrance with headwall
Solution Criteria = Highest U.S. EG

Culvert	Upstrm Dist	Length	Top n	Bottom n	Depth Blocked	Entrance Loss Coef	Exit Loss Coef
	2	120	.012	.035	1	.2	1

Upstream Elevation = 331
Centerline Station = 210
Downstream Elevation = 330.76
Centerline Station = 210

CULVERT OUTPUT Profile #PF 1 Culv Group: Culvert #2

Q Culv Group (cfs)	450.99	Culv Full Len (ft)	
# Barrels	1	Culv Vel US (ft/s)	12.22
Q Barrel (cfs)	450.99	Culv Vel DS (ft/s)	13.71
E.G. US. (ft)	341.19	Culv Inv El Up (ft)	332.00
W.S. US. (ft)	341.18	Culv Inv El Dn (ft)	331.76
E.G. DS (ft)	336.78	Culv Frctn Ls (ft)	0.02
W.S. DS (ft)	336.04	Culv Exit Loss (ft)	3.48
Delta EG (ft)	4.42	Culv Entr Loss (ft)	0.46
Delta WS (ft)	5.14	Q Weir (cfs)	
E.G. IC (ft)	341.18	Weir Sta Lft (ft)	
E.G. OC (ft)	341.19	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	338.40	Weir Max Depth (ft)	
Culv WS Outlet (ft)	337.34	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	7.00	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	5.58	Min El Weir Flow (ft)	351.51

+7' > 339' crown

Note: The normal depth exceeds the height of the culvert. The program assumes that the normal depth is equal to the height of the culvert.

CULVERT OUTPUT Profile #PF 1 Culv Group: Culvert #1

Q Culv Group (cfs)	416.01	Culv Full Len (ft)	62.69
# Barrels	1	Culv Vel US (ft/s)	11.85
Q Barrel (cfs)	416.01	Culv Vel DS (ft/s)	13.60
E.G. US. (ft)	341.19	Culv Inv El Up (ft)	331.00
W.S. US. (ft)	341.18	Culv Inv El Dn (ft)	330.76
E.G. DS (ft)	336.78	Culv Frctn Ls (ft)	0.71
W.S. DS (ft)	336.04	Culv Exit Loss (ft)	2.63
Delta EG (ft)	4.42	Culv Entr Loss (ft)	0.44

+7' = 338' crown

Delta WS (ft)	5.14	Q Weir (cfs)	
E.G. IC (ft)	340.53	Weir Sta Lft (ft)	
E.G. OC (ft)	341.20	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	338.00	Weir Max Depth (ft)	
Culv WS Outlet (ft)	336.53	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	6.00	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	4.77	Min El Weir Flow (ft)	351.51

Note: The normal depth exceeds the height of the culvert. The program assumes that the normal depth is equal to the height of the culvert.

CROSS SECTION

RIVER: 1
REACH: 1 RS: 1030.000

INPUT
Description:
Station Elevation Data num= 31

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	350.88	7.02	350.22	43.66	346.17	52.78	345.37	72.23	342.25
90.57	338.44	96.53	337.77	113.94	336.21	120	335.68	133.76	334.46
162.63	334.42	191.42	334.03	193.69	334.14	194.4	333.63	197.24	331.54
199.13	331.49	202.09	331.49	203.87	332.87	206.04	334.01	212.63	334.37
243.33	337.08	260.6	338.26	265.49	338.76	271	338.94	280	339.36
286.71	339.68	290.9	339.96	298.54	340.43	365.02	345.02	384.54	347.33
400	348.11								

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.06	194.4	.035	206.04	.06

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
194.4	206.04	30	30	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

E.G. Elev (ft)	336.78	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.74	Wt. n-Val.	0.060	0.035	0.060
W.S. Elev (ft)	336.04	Reach Len. (ft)	30.00	30.00	30.00

Crit W.S. (ft)	336.04	Flow Area (sq ft)	118.68	44.37 28.05
E.G. Slope (ft/ft)	0.009591	Area (sq ft)	118.68	44.37 28.05
Q Total (cfs)	867.00	Flow (cfs)	378.25	416.50 72.25
Top Width (ft)	115.72	Top Width (ft)	78.54	11.64 25.53
Vel Total (ft/s)	4.54	Avg. Vel. (ft/s)	3.19	9.39 2.58
Max Chl Dpth (ft)	4.55	Hydr. Depth (ft)	1.51	3.81 1.10
Conv. Total (cfs)	8853.2	Conv. (cfs)	3862.4	4253.0 737.8
Length Wtd. (ft)	30.00	Wetted Per. (ft)	78.78	13.08 25.62
Min Ch El (ft)	331.49	Shear (lb/sq ft)	0.90	2.03 0.66
Alpha	2.30	Stream Power (lb/ft s)	2.87	19.06 1.69
Frctn Loss (ft)	0.26	Cum Volume (acre-ft)	0.07	0.04 0.02
C & E Loss (ft)	0.00	Cum SA (acres)	0.05	0.01 0.02

Warning: The energy equation could not be balanced within the specified number of iterations. The program used critical
depth for the water surface and continued on with the calculations.
Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate
the need for additional cross sections.
Warning: During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated
water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The
program defaulted to critical depth.

CROSS SECTION

RIVER: 1
REACH: 1 RS: 1000.000

INPUT
Description:
Station Elevation Data num= 28

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	351.73	4.63	351.2	32.9	348.01	78.61	342.48	88.26	340.8
98.11	338.74	114.89	335.35	120	334.9	131.27	333.9	156.42	333.86
190.44	332.89	193.21	331.56	198.53	330.96	200.12	330.92	202.31	330.96
206.87	331.61	208.23	332.64	229.5	334.09	262.18	337.45	274.89	337.85
280	338.11	301.02	339.14	311.15	339.81	371.69	343.55	377.3	343.94
378.94	344.13	382.74	344.32	400	345.65				

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.06	190.44	.035	208.23	.06

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
190.44	208.23	1	1	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

E.G. Elev (ft)	335.73	Element	Left OB	Channel
Right OB				
Vel Head (ft)	0.76	Wt. n-Val.	0.060	0.035
0.060				
W.S. Elev (ft)	334.97	Reach Len. (ft)		
Crit W.S. (ft)	334.97	Flow Area (sq ft)	88.27	63.28
37.96				
E.G. Slope (ft/ft)	0.007963	Area (sq ft)	88.27	63.28
37.96				
Q Total (cfs)	867.00	Flow (cfs)	224.85	543.87
98.27				
Top Width (ft)	118.90	Top Width (ft)	71.26	17.79
29.85				
Vel Total (ft/s)	4.57	Avg. Vel. (ft/s)	2.55	8.59
2.59				
Max Chl Dpth (ft)	4.05	Hydr. Depth (ft)	1.24	3.56
1.27				
Conv. Total (cfs)	9716.1	Conv. (cfs)	2519.8	6095.0
1101.3				
Length Wtd. (ft)		Wetted Per. (ft)	71.32	18.52
29.94				
Min Ch El (ft)	330.92	Shear (lb/sq ft)	0.62	1.70
0.63				
Alpha	2.33	Stream Power (lb/ft s)	1.57	14.60
1.63				
Frctn Loss (ft)		Cum Volume (acre-ft)		
C & E Loss (ft)		Cum SA (acres)		

SUMMARY OF MANNING'S N VALUES

River:1

Reach	River Sta.	n1	n2	n3
1	3760.000	.06	.035	.06
1	3000.000	.06	.035	.06
1	2565.000	.06	.035	.06
1	2522	Culvert		
1	2475.000	.06	.035	.06
1	2400.000	.06	.035	.06
1	1600.000	.06	.035	.06
1	1250.000	.06	.035	.06
1	1162.000	.06	.035	.06
1	1096	Culvert		
1	1030.000	.06	.035	.06
1	1000.000	.06	.035	.06

SUMMARY OF REACH LENGTHS

River: 1

Reach	River Sta.	Left	Channel	Right
1	3760.000	694.59	709.66	724.74
1	3000.000	553.71	369.83	186.14
1	2565.000	118.73	90	90
1	2522	Culvert		
1	2475.000	20	73.28	172.65
1	2400.000	806.88	771.88	739.55
1	1600.000	135.31	311.61	488.7
1	1250.000	100.91	87.95	75
1	1162.000	132	132	132
1	1096	Culvert		
1	1030.000	30	30	30
1	1000.000	1	1	1

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: 1

Reach	River Sta.	Contr.	Expan.
1	3760.000	.1	.3
1	3000.000	.1	.3
1	2565.000	.1	.3
1	2522	Culvert	
1	2475.000	.1	.3
1	2400.000	.1	.3
1	1600.000	.1	.3
1	1250.000	.1	.3
1	1162.000	.1	.3
1	1096	Culvert	
1	1030.000	.1	.3
1	1000.000	.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/s)	(sq ft)	(ft)		
1	3760.000	PF 1	155.00	366.49	368.08	368.05
368.45	0.013030	5.52	41.20	54.01	0.88	
1	3000.000	PF 1	316.00	354.33	356.26	356.26
356.68	0.018873	7.96	83.94	93.25	1.10	
1	2565.000	PF 1	316.00	348.10	352.93	349.28
352.93	0.000075	0.85	715.49	259.46	0.08	
1	2522		Culvert			
1	2475.000	PF 1	316.00	347.30	348.79	
348.91	0.008244	3.52	114.66	92.59	0.65	
1	2400.000	PF 1	316.00	345.84	347.25	347.25
347.77	0.029231	8.94	64.59	63.10	1.35	
1	1600.000	PF 1	867.00	336.45	341.27	
341.45	0.003783	5.62	318.30	155.05	0.50	
1	1250.000	PF 1	867.00	332.68	341.19	
341.21	0.000234	2.11	856.56	210.29	0.13	
1	1162.000	PF 1	867.00	332.08	341.18	336.23
341.19	0.000152	1.75	970.67	211.16	0.10	

1	1096		Culvert			
1	1030.000	PF 1	867.00	331.49	336.04	336.04
336.78	0.009591	9.39	191.10	115.72	0.85	
1	1000.000	PF 1	867.00	330.92	334.97	334.97
335.73	0.007963	8.59	189.51	118.90	0.80	

Profile Output Table - Culvert Only

Reach	River Sta	Profile	E.G. US.	W.S. US.	E.G. IC	E.G. OC	Min El Weir Flow	Q Culv Group	Q Weir	Delta WS	Culv Vel US	Culv Vel DS
			(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(ft)	(ft/s)	(ft/s)
1	2522 Culvert #2	PF 1	352.93	352.93	352.89	352.92	356.01	149.09		4.14	9.69	10.98
1	2522 Culvert #1	PF 1	352.93	352.93	352.67	352.94	356.01	166.91		4.14	9.00	10.88
1	1096 Culvert #2	PF 1	341.19	341.18	341.18	341.19	351.51	450.99		5.14	12.22	13.71
1	1096 Culvert #1	PF 1	341.19	341.18	340.53	341.20	351.51	416.01		5.14	11.85	13.60

100 Yr Crossing C

100 Yr Crossing D

Subject: Re: Kalas Falls

From: Donald Sever (donald.sever@att.net)

To: bball@withersravenel.com;

Date: Wednesday, May 24, 2017 4:41 PM

Didn't know that I had some layers locked which is why they weren't included.

Don

Donald A. Sever, P.E.

Hugh J. Gilleece, III & Associates, P.A.
875 Walnut Street Suite 360
Cary, NC 27511

919 469-1101

From: Donald Sever <donald.sever@att.net>
To: "Ball, Blake" <bball@withersravenel.com>
Sent: Wednesday, May 24, 2017 4:04 PM
Subject: Re: Kalas Falls

Attached is the cad file that I have from Brad which is what I was basing my numbers on.

Lots 24 - 362
Lot 25 - 364
Lot 26 -365
Lot 27 - 367
Lot 64 - 385
Lot 65 - 390

This would give you all of the lots between the roadway crossing and the dam.

Thanks Don

Donald A. Sever, P.E.

Hugh J. Gilleece, III & Associates, P.A.
875 Walnut Street Suite 360
Cary, NC 27511

919 469-1101

From: "Ball, Blake" <bball@withersravenel.com>
To: Donald Sever <donald.sever@att.net>

Sent: Wednesday, May 24, 2017 3:34 PM
Subject: RE: Kalas Falls

On the map I have, 196, 197 (AND 26,27 & 28) are on the eastern side of the stream, and the line encroaches.

Could you estimate those too? I'll let you know how this looks with the SIMS analysis…

Thanks,

Blake

From: Donald Sever [mailto:donald.sever@att.net]
Sent: Wednesday, May 24, 2017 3:29 PM
To: Ball, Blake <bball@withersravenel.com>
Cc: Ravenel, Sam <SRavenel@withersravenel.com>
Subject: Re: Kalas Falls

The following FFE are based on the house being set 1' above the roadway grade.

Lot 90 - 373
Lot 91 - 370
BMP - 366 top of dam
Lot 92 - 368
Lot 93 - 367
Lot 94 - 366
Lot 95 - 364
Lot 96 - 362
Lot 97 - 365
Lot 163 - 360
Lot 165 - 366
BMP at 96 - 352 top of dam
BMP at 24 - 355 top of dam
Lot 167 - 367
Lot 168 - 366

not sure with your numbers 196 and 197, these are not next to the stream.

Don

Donald A. Sever, P.E.

Hugh J. Gilleece, III & Associates, P.A.
875 Walnut Street Suite 360
Cary, NC 27511

919 469-1101

From: "Ball, Blake" <bball@withersravenel.com>
To: Donald Sever <donald.sever@att.net>
Cc: "Ravenel, Sam" <SRavenel@withersravenel.com>
Sent: Wednesday, May 24, 2017 2:49 PM
Subject: RE: Kalas Falls

Don & Brad,

I have put together a SIMS inundation map for the proposed rehabilitated dam, and the breach wave encroaches on a few lots…

This is not to say that there is any threat to any future proposed structures, but without a full-blown breach analysis, it is what we have.

The potentially affected lots are 90, 91, the BMP between 91&92, 93, 94,95,96,97, the BMP adjacent to 97, 163, 165, 196, and 197.

Do you have any lot grading or minimum finished floor elevation on these lots yet? We may be asked to submit a Jurisdictional Determination / Hazard Classification Request to Dam Safety, and they will need that information to process the request.

Thanks,

Blake Ball

WithersRavenel
Our People. Your Success.
115 MacKenan Drive | Cary, NC 27511
Office: 919.469.3340 | Direct: 919.238.0376
bball@withersravenel.com

From: Donald Sever [mailto:donald.sever@att.net]
Sent: Monday, May 15, 2017 2:09 PM
To: Ball, Blake <bball@withersravenel.com>; bhaertling@bellsouth.net
Cc: Ravenel, Sam <SRavenel@withersravenel.com>
Subject: Re: Kalas Falls

Blake,

we have the following information downstream.

Crossing C - next crossing downstream

Dual 54", invert down 346.5, invert up 347.0 100' long @ 0.5% slope. Roadway elevation 356.0

Crossing D -

Dual 84" pipes, invert down 331.7, invert up 332.0 120' @0.25%. Roadway elevation 351.00.

Let us know if any other questions.

Thanks Don

Donald A. Sever, P.E.

Hugh J. Gilleece, III & Associates, P.A.
875 Walnut Street Suite 360
Cary, NC 27511

919 469-1101

From: "Ball, Blake" <bball@withersravenel.com>
To: "bhaertling@bellsouth.net" <bhaertling@bellsouth.net>; Donald Sever <donald.sever@att.net>
Cc: "Ravenel, Sam" <SRavenel@withersravenel.com>
Sent: Friday, May 12, 2017 10:44 AM
Subject: FW: Kalas Falls

Brad,

So you have it if you need it to analyze your culvert…

Based on a riser crest (Normal Pool) of 371.00 (lowered from 372.00), these are the calculated maximum water surface elevations for the impoundment.

10-year	371.83 (was 372.79)
25-year	372.14 (was 373.10)
100-year	372.78 (was 373.62)

This does reflect the existing contours sent back in February, but does not take any storage or attenuation provided by the crossing into account.

Please let me know if you have any questions.

From: Ball, Blake
Sent: Friday, May 12, 2017 9:47 AM
To: 'Brad Haertling' <bhaertling@bellsouth.net>
Subject: RE: Kalas Falls

What are you looking for exactly?
Brad,

I integrated the DTM you sent into our model. The topographic data is depicted.

If you are asking about the proposed road crossing, could you send that in a CAD drawing file?

Thanks.

Blake

From: Brad Haertling [mailto:bhaertling@bellsouth.net]
Sent: Friday, May 12, 2017 7:41 AM
To: Ball, Blake <bball@withersravenel.com>
Cc: Donald Sever <donald.sever@att.net>
Subject: FW: Kalas Falls

Blake,

After reviewing the plans that you sent over we noticed that the elevations that we had sent Jennifer were not accounted for. Can you also incorporate this change?

Thanks,
Brad Haertling
Hugh J. Gilleece, III, & Associates, P.A.
875 Walnut St. Ste. 360 Cary NC 27511
(P) 919-469-1101
(M) 919-605-5562

From: Brad Haertling [mailto:bhaertling@bellsouth.net]
Sent: Tuesday, February 14, 2017 1:37 PM
To: Diaz, Jennifer (jdiaz@withersravenel.com)
Cc: Donald Sever (donald.sever@att.net)
Subject: Kalas Falls

Jennifer,

Based on our conversation I have attached the base survey that we have. We would like to lower the NP elevation to 371.00. We are planning dual 48" pipes at the road crossing, at the location of the existing 18" CMP. The pipes will be 70' long with a DS El of 371 and an UP El of 371.50. We would need the backwater el for the 100 year analysis. Please let me know if you need anything else from us.

Would it be possible for you to give me your tentative schedule for submitting and when you think you might get your permit?

Thanks,
Brad Haertling
Hugh J. Gilleece, III, & Associates, P.A.
875 Walnut St. Ste. 360 Cary NC 27511
(P) 919-469-1101
(M) 919-605-5562

Attachments

- layout 5 24 2017 .dwg (3.90MB)