Little Sugar Creek and Briar Creek Subbasin, Mecklenburg County, NC

Hydraulic Analyses - HEC-RAS Models

Submitted by

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1.0 Introduction

Dewberry & Davis, Inc. (herein referred to as 'Dewberry') was selected by Charlotte-Mecklenburg County Storm Water Services (herein referred to as 'The County'), to update the land uses and floodplain maps/models for nine (9) streams within the highly urbanized Little Sugar Creek and Briar Creek (LSCBC) subbasin. The area identified for the Hydrologic and Hydraulic (H&H) analysis is the drainage basin as defined by a point located at approximately 3 miles downstream of NC-51 at the southern boundary of Mecklenburg County on Little Sugar Creek. The drainage basin is approximately 51 square miles in area and is urban with densely populated residential areas (Figure 1).

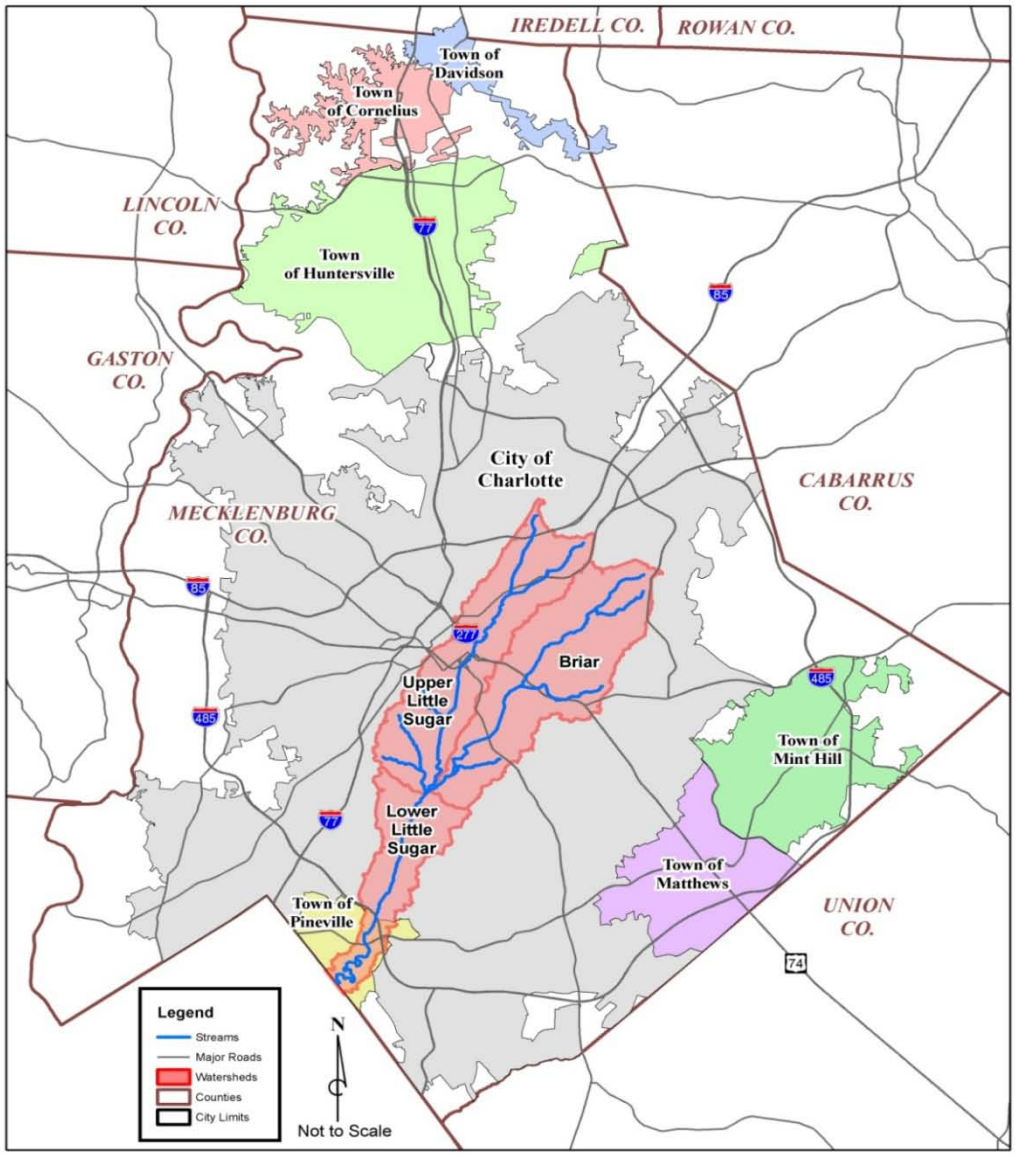

Figure 1. Little Sugar Creek and Briar Creek Subbasin Location map

A hydrologic analysis was conducted to calculate peak surface runoff flows and to assess the general hydrologic response of the watershed for a range of rainfall events for existing and future land use conditions. The analysis was conducted for the 50%, 20%, 10%, 4%, 2%, 1%, and 0.2 % annual chance (2-, 5-, 10-, 25-, 50-, 100-, and 500-year recurrence interval storms, respectively), 24 hour duration events for existing and future land use conditions, using Soil Conservation Services (SCS) Technical Release 55 (TR-55, 1986) methodology within the Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS version 3.3) rainfall-runoff model. The HEC-HMS model was calibrated using August 2008 storm event. The discharge from calibrated HEC-HMS model were used in the open channel hydraulics modeling for all nine (9) study streams within the basin, using the Hydrologic Engineering Center's River Analysis System (HEC-RAS version 4.0). Table 1 below provides a list of streams modeled within LSCBC subbasin. A map of studied streams is also attached as Appendix B.

Table 1. Modeled Streams and Study Extents

Stream Name	Downstream Limit	Upstream Limit	Length (miles)
Briar Creek Watershed			
Briar Creek	Confluence with Little Sugar Creek	Approximately 171 feet upstream of St. Johns church Road	10.8
Briar Creek Tributary 1	Confluence with Briar Creek	Approximately 352 feet upstream of Shoreham Road	1.8
Briar Creek Tributary 2	Confluence with Briar Creek	Approximately 251 feet upstream of Karenstone Drive	2.1
Edwards Branch	Confluence with Briar Creek	Approximately 1,272 feet upstream of Driftwood Drive	3.0
Little Sugar Creek Watershed			
Dairy Branch	Confluence with Little Sugar Creek	Approximately 421 feet upstream of Dilworth Mews Ct.	1.5
Derita Branch	Confluence with Little Sugar Creek	Approximately 956 feet upstream of Princess Street	2.9
Little Hope Creek	Confluence with Little Sugar Creek	Approximately 200 feet upstream of Belton Street	3.0
Little Hope Creek Tributary	Confluence with Little Hope Creek	Approximately 440 feet upstream of Baylor Drive	1.3
Little Sugar Creek	Lancaster County, South Carolina State Line	Approximately 198 feet upstream of Elgywood Ln.	20.3
		Total Length	**46.7 miles**

The HEC-RAS models were calibrated using the High Water Marks (HWMs) from August 2008 event. The storage discharge relationships for channel routing were updated in HEC-HMS model from the calibrated HEC-RAS models. The discharges in HEC-RAS models were then updated using the final calibrated HEC-HMS model.

Following the hydraulic analyses, the existing and future conditions floodplains were created for all study streams. This submittal provides the updated HEC-HMS model, calibrated HEC-RAS models, and

preliminary floodplain boundaries for review by the County and independent Quality Assurance/Quality Check (QA/QC) reviewer (Michael Baker Inc.).

2.0 Hydrologic Analysis

Hydrologic analysis was conducted using a detailed rainfall runoff HEC-HMS model to generate peak flows for use in the hydraulic models. The HEC-HMS was calibrated and model was provided to the County and independent QA/QC reviewer in a submittal dated 07/15/2009. A detailed description of the methodology used during hydrologic analysis and calibration was provided in the report attached with submittal mentioned above.

During HEC-RAS model calibration process, the calibrated HEC-HMS model previously provided to the County was revised with updated storage discharge relationships for channel routing. These changes caused differences in the discharges obtained from HEC-HMS model. Appendix A contains the tables with the discharges from updated HEC-HMS model and comparisons with effective model. The updated HEC-HMS model is being provided in a DVD as Appendix D.

3.0 Hydraulic Analyses

A steady state one-dimensional hydraulic analysis was conducted on the study streams to generate water surface elevations (WSELs) for all recurrence interval storm events, using techniques consistent with Federal Emergency Management Agency (FEMA) Guidelines and Specifications' (G&S) and County's 'Floodplain Analysis and Mapping Standards Guidance Document' (Standards Document). A FEMA accepted open channel hydraulics model, HEC-RAS 4.0 was used to develop the open channel hydraulics for all nine (9) streams within LSCBC. The results of the hydraulic modeling and profile development were enhanced by using automated floodplain mapping programs in Geographic Information System (GIS) to visualize the flooding extents. Following sections provide a discussion of the methodology used during hydraulic analyses.

3.1 *Modeling Approach*

HEC-RAS version 4.0 was used as the hydraulic model for the analyses, since it is a FEMA accepted model for flood studies on open channels. Input parameters used in the hydraulic models were based on FEMA G&S and the County's Standards Documents; include boundary conditions, Manning's n values, expansion/contraction coefficients, ineffective flow areas, etc. Debris blockage of structures can have a significant impact on upstream flooding, but is typically not included in flood hazard assessments due to the lack of historical documentation. The hydraulic analyses contained in this study were based on unobstructed flow. HEC-RAS model required a number of input parameters compute flood profiles, including but not limited to:

- Peak discharges
- Downstream boundary conditions
- Cross section survey data
- Manning's roughness coefficients for friction losses
- Bridge and culvert crossing data - geometry and dimensions of the openings, top-of-road profile, and entrance characteristics

- Other hydraulic characteristics such as expansion and contraction loss coefficients and ineffective flow areas

3.1.1 Peak Discharges

The peak discharges used in the HEC-RAS model were obtained from the results of the detailed hydrologic analyses identified in the section 2.0. The peak discharges from the updated HEC-HMS model are provided in the Appendix A as Table 11.

3.1.2 Boundary Conditions

For all the streams, normal depth was used as boundary condition for the all recurrence interval storms. Although Little Sugar Creek discharges into a FEMA studied Zone A within South Carolina, no associated WSELs were identified. Normal depth was as downstream boundary conditions.

3.1.3 Cross Sections

Channel cross sections (XSs) in the HEC-RAS model are typically based on field surveys. According to the Standards Document, a portion of the XS data was to be collected using 'full survey-grade' channel survey using detailed methods and 'relative' GPS channel survey methods. For this study, a total of 155 cross-sections (78 by detailed methods and 77 by GPS method) were collected by Dewberry. While the HEC-RAS XS at the surveyed locations were modeled using survey data, remaining XSs were modeled using interpolation and extrapolation from the survey data. The overbank elevation data was extracted from the digital terrain model created from North Carolina Floodplain Mapping Program's (NCFMP) Light Detection And Ranging (LiDAR) data.

HEC-RAS XSs were located perpendicular to flow along the channel as well as upstream and downstream of road crossings and confluences, and at major changes in stream valley characteristics such as channel slope, roughness, or geometry. Once the locations of the XSs were established, automated routines were used to extract ground profiles (station-elevation data) along the XSs. The data was converted to a HEC-RAS compatible format by utilizing an Environmental Systems Research Institute (ESRI) Geographic Information System (GIS) software ArcMap extension, HEC-GeoRAS and Dewberry's Terrain Extension from GeoFIRM suite.

3.1.4 Manning's n Values

The hydraulic roughness coefficients (Manning's n-values) are a measure of the stream valley's resistance to flow, or in other words, the friction losses. Channel overbanks with high roughness coefficients, for example channels with large boulders and densely forested overbanks, tend to slow the flow and result in higher flood elevations, while relatively smooth areas, like mowed grass provide little resistance to flow and result in higher velocities and lower flood elevations. Typical factors that influence the resistance to flow, or friction losses include:

- Degree of channel meander and irregularity
- Type and density of vegetation along the channel and floodplain
- The size and shape of the channel and floodplain
- Number of obstructions in the channel and floodplain

- Flood elevation and discharge
- Depth of flow

Table 2 summarizes the range of Manning's n-values used for each stream. Manning's n-values were estimated based on best engineering judgment and field observations of the channels and floodplain areas.

Table 2. Manning's n Range

Stream	Channel 'n'	Overbank 'n'
Briar Creek	0.03-0.065	0.012-0.12
Briar Creek Tributary 1	0.055	0.025-0.12
Briar Creek Tributary 2	0.055	0.025-0.12
Dairy Branch	0.035-0.04	0.025-0.12
Derita Branch	0.05-0.055	0.025-0.12
Edwards Branch	0.045-0.055	0.025-0.12
Little Hope Creek	0.035-0.055	0.025-0.12
Little Hope Creek Tributary	0.047-0.055	0.025-0.075
Little Sugar Creek	0.03-0.055	0.025-0.12

3.1.5 Stream Crossings

Bridge and culvert crossings can often be the cause of flooding due to inadequate capacity. Therefore, it is important to properly model bridges and culverts so that the effects of these structures on flood elevations can be accurately determined. The bridge and culvert data required for HEC-RAS modeling includes:

- Opening geometry including abutment side slopes, low-chord elevations, pier shape and size, number of spans, and width of bridge deck
- Top-of-road profile along the highest point on the road
- Contraction and expansion characteristics
- Culvert type, material, shape, length, number of barrels, and dimensions
- Upstream and downstream invert elevations

Detailed field survey data was collected by Dewberry at specified crossings, which included top of road, opening information and upstream downstream channel XSs. The dimensions for remaining crossings were obtained either from the previous effective model or field verification.

3.1.6 Ineffective Flow Areas

Low velocity areas of the floodplain that were generally stagnant and did not contribute to the flood conveyance were designated as ineffective flow areas. Ineffective flow areas were designated in the HEC-RAS model where natural areas of high ground or ridges along the overbanks tend to constrict flow or prevent flow on the landward side of the ridge. Ineffective flow areas were also defined upstream and downstream of bridge and culvert crossings based generally on a 1:1 contraction and expansion ratios.

3.1.7 Expansion and Contraction Coefficients

Expansion and contraction loss coefficients are used to approximate the energy loss between XSs and through bridge and culvert crossings. Typically, the greatest expansion loss occurs downstream of a bridge or culvert, as flow expands from the relatively narrow width of the bridge or culvert to the full width of the floodplain. Similarly, the greatest contraction loss occurs upstream of a bridge or culvert, as flow contracts from the full width of the floodplain to the narrower bridge or culvert opening. At sections '2', '3', and '4' for any structure as defined by HEC-RAS, Hydraulic Reference Manual (USACE, 2002), contraction and expansion loss coefficients were defined to be 0.3 and 0.5, respectively. These values were chosen to be consistent with the Standards Document and procedures outlined in HEC-RAS, Hydraulic Reference Manual (USACE, 2002).

3.1.8 Blocked Obstructions

Blocked obstructions are obstructions to the flow, causing the flow to constrict and raise the water surface elevations. The blocked obstructions were modeled based on Mecklenburg County planimetric data depicting raised structures. In accordance with the guidance provided in the Standards Document, large buildings within the floodplain were designated as blocked obstruction while smaller clusters of buildings were represented with high Manning's n values.

3.2 *Hydraulic Model Calibration*

As a part of modeling process, models are typically 'calibrated' to accurately simulate a response from a known real life event. During calibration of hydraulic models, the HWMs from August 2008 storm event were used to compare with WSELs from HEC-RAS models. Similar to the guidance provided in the Standards Document, input parameters (such as ineffective area, roughness coefficients, and contraction/expansion coefficients) were adjusted to mimic the response from August 2008. HWMs were available at several locations along three (3) streams; Little Sugar Creek, Briar Creek, and Little Hope Creek. Input parameters were revised on these models to achieve calibration with 0.5 ft of the HWMs where possible. The Standards Document indicates that peak flow and total volume should match within 10% and time to peak should be within 30 minutes. There are some locations where one of more of these criteria were not met due to unique challenges discussed in next sections. In such area, the tolerances are revised to achieve calibration after discussion with the County and other stakeholders (i.e. QA/QC Contractors). Once the calibration on these three (3) streams was achieved, input parameters were revised within same range for remaining six (6) streams. The lag time of 1.8*Tc and initial abstraction value of 0.7' were used to achieve calibration. The initial abstraction value of 0.7' was used based on the fact that the overall curve numbers for the subbasin was approximately 80 and 83 for existing and future conditions, respectively. Following sections discusses the calibration approach, revisions, and results for the three streams. In the end, a summary of the input parameters is identified for remaining six (6) streams which do not have known HWMs.

3.2.1 Little Sugar Creek

The flows used in the calibration model were based on the United States Geological Survey (USGS) gage flow data and the flows from the hydrologic model (HEC-HMS) for August 2008 event. The HEC-HMS flows were adjusted using USGS gage flow data as shown in Figure 2.

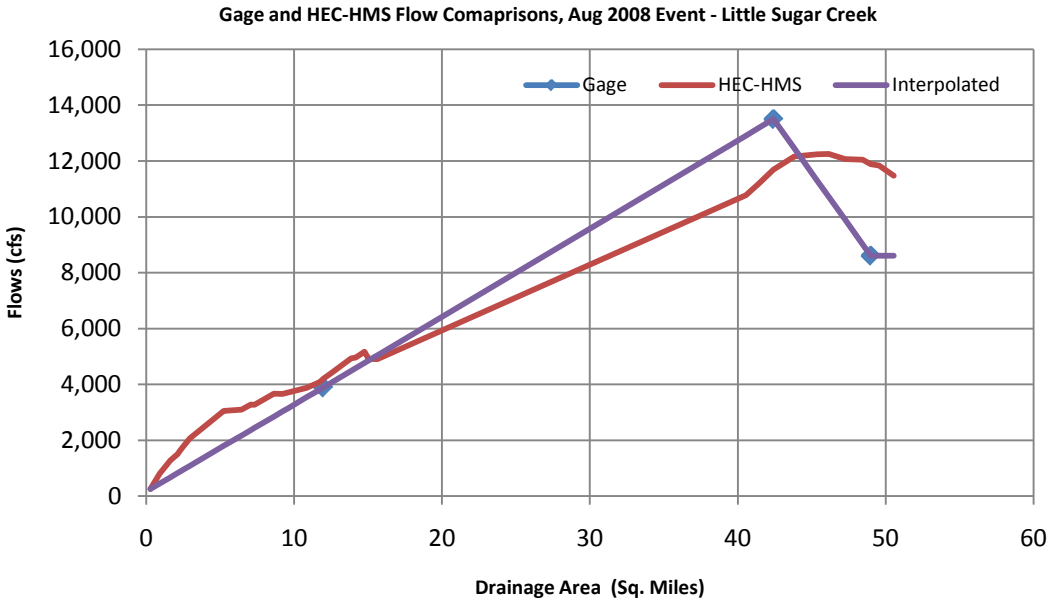

Figure 2. Adjusted Flows based on Gage Data and HEC-HMS Output- Little Sugar Creek

The 'adjusted' flows were used in the HEC-RAS model and the model outputs were compared with HWMs. Table 3 shows the comparisons of August 2008 event WSELs with HWMs, without making any adjustments to the model parameters. The table also indicates the type, quality and locations of HWMs. It is to be noted that at few locations multiple HWMs were observed in the field therefore two columns were included in the table to show multiple HWMs observed within close proximity. Out of five (5) USGS gage sites, three (3) sites have HWM and discharge data and two gages have only HWM data. The results indicate that the difference in HWMs and original model peak stage ranged within 0.0- 5.5 feet. The target stage range specified per the Standards Document is 0.5 feet for streams with historical stage gage data, where possible.

Table 3. Comparison of HWMs and HEC-RAS model WSELs - Little Sugar Creek

Station	D/S Length	High Water Marks					Model WSEL (Feet)	Diff. WSEL (ft)	Comments
		Elevation1	Elevation 2	Location	Type	Quality			
99129	0	709.06		Vegetation	Debris Line	Poor	709.0	-0.1	
99043	0	708.15		Vegetation	Debris Line	Poor	709.0	0.8	
96215	155	703.19		Fence	Debris Line	Good	700.8	-2.4	
92886	271	689.17		Ground	Debris Line	Good	691.1	1.9	
91527	408	684.92		NA	NA	NA	690.4	5.5	USGS Gage (only HWM available)

82667	0	662.65		Ground	Debris Line	Good	664.4	1.7	
82427	0	662.49		Ground	Debris Line	Good	663.6	1.1	
69550 (Medical Center)	273	625.91		NA	NA	NA	629.0	3.0	USGS Gage
67000	81	623.46		Ground	Witness	Poor	624.1	0.6	
65764	198	620.31		Fence	Seed Line	Good	620.0	-0.3	
59134	382	607.69		NA	NA	NA	607.7	0.0	USGS Gage (only HWM available)
58723	56	605.78		Ground	Debris Line	Poor	606.7	0.9	
54500	175	594.57	594.45	Building	Stain Line	Good	596.3	1.7	
48000	0	585.36	585.33	Wall and Propane Tank	Mudline	Good	588.0	2.6	
45334 (Archdale)	70	578.68		NA	NA	NA	579.1	0.4	USGS Gage
43000	300	573.66		Building	Mud Line	Good	574.00	0.3	
39450	100	569.92		Building	Mud Line	Good	570.47	0.6	
35484	288	564.27		Fence	Mud Line	Good	564.50	0.2	
30446	218	561.83		Ground	Debris Line	Fair	560.37	-1.5	
26466	486	561.11		Fence	Mud Line	Good	558.88	-2.2	
22245	388	553.57	553.34	Car and Camper	Mud Line	Good	553.20	-0.4	
19345 (Pineville)	0	552.48		NA	NA	NA	552.65	0.2	USGS Gage
14268	0	548.44	548.62	Fence	Mud Line	Good	547.31	-1.1	
11984	0	546.1		Tree	Mud Line	Good	544.45	-1.6	

In order to achieve a better match between the model output and HWMs, the model parameters were adjusted. Table 4 shows the calibration results after making adjustments to the model parameters. Initially, the hydraulic model was calibrated to the USGS gage HWMs by adjusting Manning's n, discharges, contraction/expansion coefficients, and conveyance in the same order of priority. After calibrating the model to the five (5) USGS gage sites, minor adjustments were made wherever applicable to calibrate the model at other locations, where possible. As shown in the table, out of five USGS gages sites, four are calibrated within the target range of 0.5 foot. While it was not possible to achieve perfect

match due to variety of reasons (such as, 'poor' quality of HWM), the table also indicates the reason for some of the differences beyond the target of 0.5 ft.

Table 4. Comparison of HWMs and 'calibrated' HEC-RAS model WSELs - Little Sugar Creek

Stations	Downstream Distance	High Water Marks					Calibrated WSEL (ft)	Diff WSEL(ft)	100 yr EX WSEL (ft)	Comments
		Elevation1	Elevation2	Location	Type	Quality				
99129	0	709.06		Vegetation	Debris Line	Poor	707.6	-1.5	717.3	Quality of data is poor. The model calibrates to other HWMs in the close proximity.
99043	0	708.15		Vegetation	Debris Line	Poor	707.0	-1.1	717.3	
96215	155	703.19		Fence	Debris Line	Good	702.1	-1.1	703.0	
92886	271	689.17		Ground	Debris Line	Good	688.2	-1.0	692.6	
91527	408	684.92		NA	NA	NA	684.7	-0.2	691.9	USGS Gage (only HWM available)
82667	0	662.65		Ground	Debris Line	Good	662.7	0.1	664.1	
82427	0	662.49		Ground	Debris Line	Good	661.6	-0.9	663.5	
69550 (Medical Center)	273	625.91		NA	NA	NA	626.4	0.5	629.5	USGS Gage
67000	81	623.46		Ground	Witness	Poor	623.2	-0.3	625.7	
65764	198	620.31		Fence	Seed Line	Good	620.3	0.0	622.9	
59134	382	607.69		NA	NA	NA	607.0	-0.7	611.2	USGS Gage(only HWM available)
58723	56	605.78		Ground	Debris Line	Poor	606.4	0.6	611.0	

54500	175	594.57	594.45	Building	Stain Line	Good	595.0	0.4	597.1	
48000	0	585.36	585.33	Wall and Propane Tank	Mud Line	Good	587.7	2.3	588.2	
45334 (Archdale)	70	578.68		NA	NA	NA	578.2	-0.5	579.4	USGS Gage
43000	300	573.66		Building	Mud Line	Good	573.2	-0.5	575.0	
39450	100	569.92		Building	Mud Line	Good	569.9	0.0	572.6	
35484	288	564.27		Fence	Mud Line	Good	564.3	0.0	568.0	
30446	218	561.83		Ground	Debris Line	Fair	560.3	-1.5	564	
26466	486	561.11		Fence	Mud Line	Good	558.4	-2.7	562.5	Located in the recession limb of the interpolated gage discharge curve
22245	388	553.57	553.34	Car and Camper	Mud Line	Good	553.6	0.0	557.5	
19345 (Pineville)	0	552.48		NA	NA	NA	552.9	0.4	557.1	USGS Gage
14268	0	548.44	548.62	Fence	Mud Line	Good	548.0	-0.4	551.4	
11984	0	546.1		Tree	Mud Line	Good	545.7	-0.4	548.9	

As a result of calibration, out of five (5) USGS gages HWMs, four (4) USGS gage HWMs were matched within the specified target (i.e. 0.5 ft). The key parameter for the calibration was channel Manning's n except at the headwater where revisions to discharge and conveyance were performed.

3.2.2 Briar Creek

The flows used in the calibration model were based on the USGS gage flow data and the August 2008 flows from the hydrologic model (HEC-HMS). The HEC-HMS flows were adjusted using USGS gage flow data as shown in Figure 3.

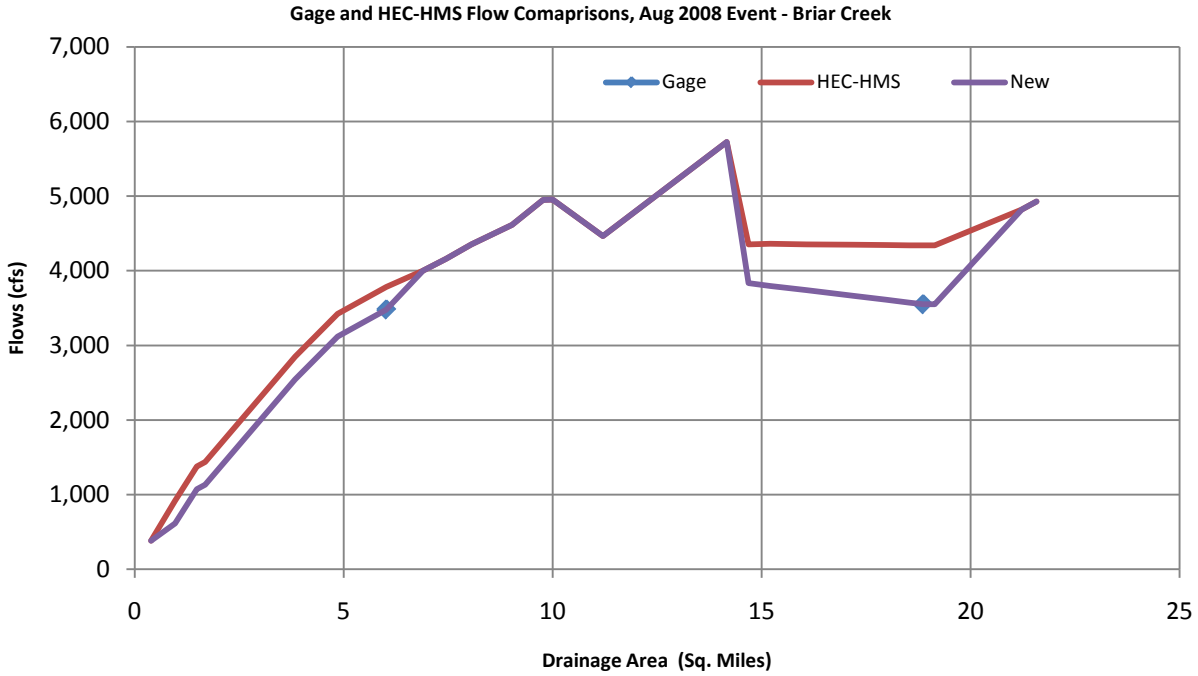

Figure 3. Adjusted Flows based on Gage Data and HEC-HMS Output – Briar Creek

The discharge based on linear interpolation between the gages, were used in the HEC-RAS model and the model outputs were compared with HWMs. The results from the original model (without any adjustments to the model parameters) are shown in Table 5.The WSELs differences were much higher (as high as -1.7 ft) at some HWM locations. The original model used lower flows between the gages, when compared to calibrate model.

Table 5. Comparison of HWMs and HEC-RAS model WSELs - Briar Creek

Stations	D/S Length	High Water Marks				Model WSEL (ft)	Diff WSEL (ft)	Comments
		Elevation	Location	Quality	Type			
47672	0	692.57	Fence	Good	Wrack Line	693.47	0.9	
44824	245	684.9	Porch	Good	Mud Line	683.8	-1.1	
43188	45	681.4	NA	NA	NA	681.2	-0.2	USGS Gage

40948	25	676.9	Parking Lot	Fair	Wreck Line	675.6	-1.3	
33928	310	657.7	Fence	Fair	Wreck Line	656	-1.7	
26792	365	647.4	NA	NA	NA	647.6	0.2	USGS Gage (only HWM)
21862	286	629.3	Tree	Good	Mudline	628.5	-0.8	
18608	40	624.5	Tree	Good	Mudline	624.1	-0.4	
16373	112	622.9	NA	NA	NA	622.0	-0.9	USGS Gage (only HWM)
16196	28	622.0	Fence	Good	Mudline	621.7	-0.3	
13197	72	620.6	Fence	Good	Mud Line	620.8	0.2	
10941	50	614.1	NA	NA	NA	615.1	1.0	USGS Gage
4710	0	592.3	Tree	Good	Mud Line	591.3	-1.0	
3228	98	591.1	Tree	Fair	Wreck Line	588.8	-2.3	

The 'adjusted' flows shown in the Figure 3 above were used in the HEC-RAS model and the model outputs were compared with HWMs. The calibration results are shown in Table 6. As shown in the table, the WSELs are within 0.5 ft at some of the locations except upstream of the CSX Railroad near Cavalier Apartment at XS 26792, 33928, 18608, 16196, 13197, 10941, and 3228. A discussion regarding differences at Cavalier Apartment is provided later in the report.

Table 6. Comparison of HWMs and 'calibrated' HEC-RAS model WSELs - Briar Creek

Stations	D/S Length	High Water Marks				Calibrated WSEL (ft)	Diff WSEL (ft)	100 yr EX WSEL (ft)	Comments
		Elevation	Location	Quality	Type				
47672	0	692.6	Fence	Good	Wrack Line	693.0	0.4	694.4	
44824	245	684.9	Porch	Good	Mud Line	684.5	-0.4	685.4	
43188	45	681.4	NA	NA	NA	681.4	0	682.0	USGS Gage
40948	25	676.9	Parking Lot	Fair	Wreck Line	676.4	-0.5	677.7	
33928	310	657.7	Fence	Fair	Wrack Line	656.7	-1	657.1	

26792	365	647.4	NA	NA	NA	652.0	4.6	651.9	USGS Gage (only HWM)
21862	286	629.3	Tree	Good	Mudline	629.6	0.3	629.8	
18608	40	624.5	Tree	Good	Mudline	625.0	0.5	625.2	
16373	112	622.9	NA	NA	NA	622.3	-0.6	622.5	USGS Gage (only HWM)-located at structure
16196	28	622.0	Fence	Good	Mudline	622.3	0.3	622.5	
13197	72	620.6	Fence	Good	Mud Line	621.4	0.8	621.7	
10941	50	614.1	NA	NA	NA	614.9	0.8	615.1	USGS Gage
4710	0	592.3	Tree	Good	Mud Line	592.2	-0.1	592.0	
3228	98	591.1	Tree	Fair	Wreck Line	590.4	-0.7	590.3	

During hydraulic calibration on Briar Creek using August 2008 flood event, a difference between the HEC-RAS model results and HWM was observed near the Cavalier Apartments area. Figure 4 below shows the Cavalier Apartment area on Briar Creek. Due to its unique location between the CSX Railroad culvert downstream and confluence with the Edwards Branch upstream, the area has been subjected to intense flooding in the past. During recent August 2008 flood event, two (2) HWMs were recorded at WSEL of 647.17ft and 647.42 ft at Cavalier Apartment area.

Figure 4. Cavalier Apartment High Water Mark on Briar Creek

Table 7 below summarizes the differences in Water Surface Elevations (WSELs) observed during hydraulic calibration on Briar Creek near Cavalier Apartments area. The model yields a 4.5 ft higher WSEL compared to the HWM for August 2008. On the other hand, the 1% annual chance flood WSEL was 3.6 ft lower when compared to effective model WSEL.

Table 7. Water Surface Elevations at Cavalier Apartments on Briar Creek

Flood Event	Source	WSEL (NAVD88, ft)	Difference (ft)
August 2008 Event Flood	High Water Mark	647.4	+4.6
	HEC-RAS Model	652.0*	
1% Annual Chance Flood	Effective Model	655.5	-3.6
	HEC-RAS Model	651.9*	

*The water surface elevations are subject to change slightly, due to ongoing revisions.

There are two (2) USGS discharge gages on the Briar Creek upstream and downstream of the Cavalier Apartment area (refer to Figure 5 below). But, both of the USGS gages are located relatively distant from the Cavalier Apartments area. The upstream gage is located at Shamrock Drive and has a drainage area of 5.2 square miles. The downstream gage is located above Colony Road with drainage area of 19.0 square miles. Since the drainage area at the Cavalier Apartment is approximately 14.0 square miles, it is not possible to verify or refute the large discharges obtained from the HEC-HMS model at this specific location.

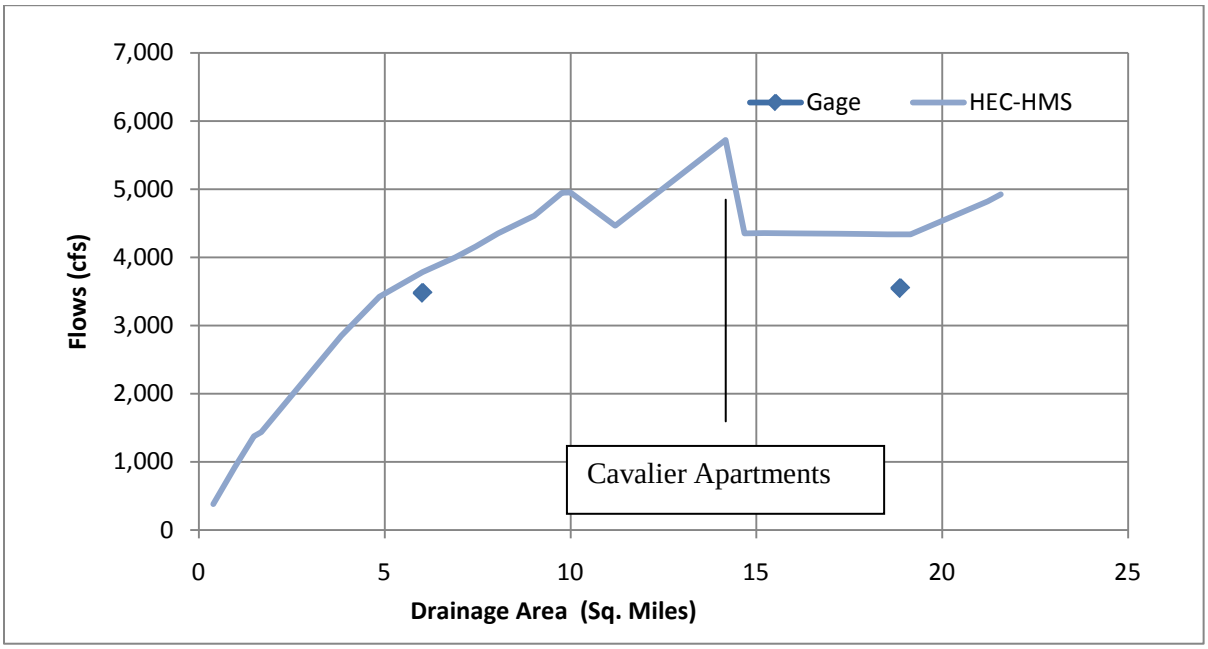

Figure 5. Briar Creek Discharges for August 2008 Flood Event

For hydraulic calibration of Briar Creek, the discharges from HEC-HMS were used in the hydraulic model while keeping the discharges at the neighboring gages unchanged. As shown in the Figure 5 above, a large peak was observed upstream of the Cavalier Apartment area due to the confluence with the Edwards Branch. To further attenuate the discharges, various revisions to the model parameters were evaluated:

- inclusion of additional storage areas on the Briar Creek and Edwards Branch to account for storage behind the road crossings
- change in storage discharge characteristics due to removal of ineffective areas in some areas
- decrease in lag times on Briar Creek and Edwards Branch

None of the above mentioned changes resulted in appreciable difference in the peak discharges for Briar Creek at Cavalier Apartment area. Table 8 below summarizes the changes in peak discharges due to the revisions.

Table 8. Changes in Peak Discharges due to revision of model parameters – Briar Creek

Change	Increase in peak discharge	Reduction in peak discharge
Addition of Storage Area on Edwards Branch	2%	-
Addition of Storage Areas on Briar Creek	2%	-
Change in Ineffective areas	No significant change	No significant change
Change in Lag times	-	5%

During further investigation of the hydrologic and hydraulic models, it was observed that the WSELs in the hydraulic model were different from the WSELs obtained from the hydrologic model upstream of the CSX Railroad. This discrepancy was attributed to the different discharges in the two models at this location. Based on discussions with subject matter experts at Dewberry and CDM, it was determined that the attenuated flows should be applied upstream of the CSX Railroad Bridge structure. The rationale is that water ponds behind the Railroad and acts as a storage area, only the attenuated discharges were observed at the structure. The WSELs reported in the Table 3 were obtained using this methodology.

A meeting was organized by Dewberry with the County, Baker, and CDM to discuss the difference in the HWM elevation and WSEL at the Cavalier Apartments. Although differences remain between the HWM and WSEL obtained from hydraulic model at Cavalier Apartments, all parties agreed that proposed calibration approach and results are reasonable and ultimately result in a conservative BFE. Such approach also results in a significant decrease in the BFE at the Cavalier Apartment areas when compared to effective model. All parties agreed that such results for 1% annual chance flood elevations would be accepted for final calibrated model.

3.2.3 Little Hope Creek

The flows used in the calibration model were based on the USGS gage flow data and the calibration flows from the hydrologic model (HEC-HMS). The HEC-HMS discharges were adjusted using one (1) USGS gage discharge data as shown in Figure 6.

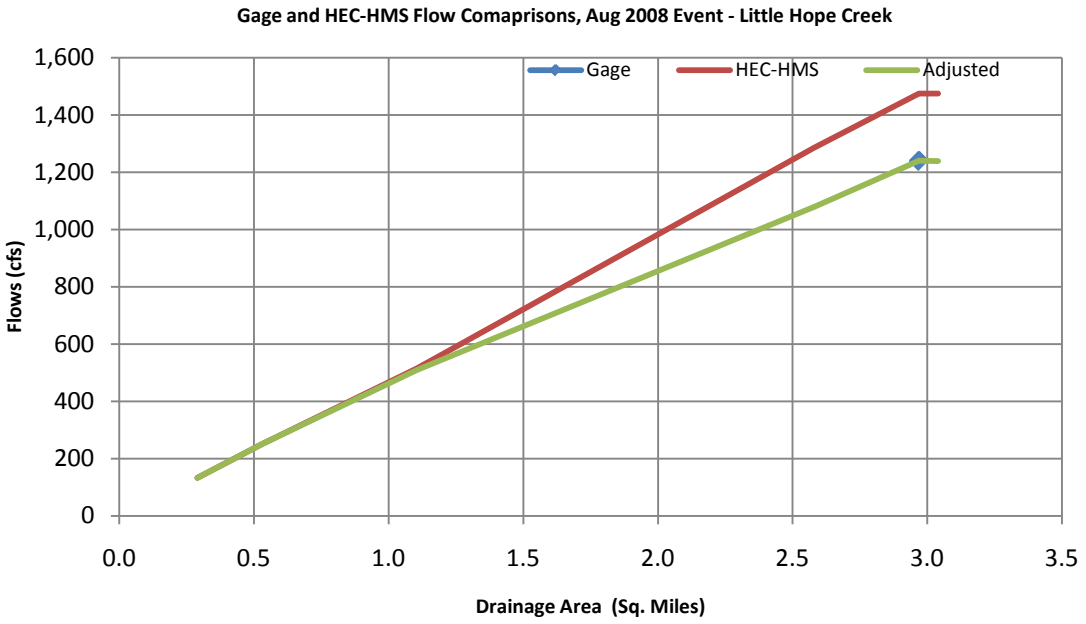

Figure 6. Adjusted Flows based on Gage Data and HEC-HMS Output – Little Hope Creek

The results from the original model (without any adjustments to the calibration parameters) are shown in Table 9.The difference in water surface elevations was 1.2 feet at the USGS gage.

Table 9.Comparison of HWMs and HEC-RAS model WSELs – Little Hope Creek

Stations	D/S Length	High Water Marks				Original WSEL (ft)	Diff WSEL (ft)	Comments
		Elevation	Location	Quality	Type			
3759	60	605.0	NA	NA	NA	606.2	1.2	USGS gage

In order to achieve a better match between the model output and HWMs, the model parameters (such as Manning's n, ineffective area, contraction/expansion coefficients etc.) were changed. As shown in Table 10, the simulated elevations were within ± 0.5-ft at the USGS gage.

Table 10. Comparison of HWMs and 'calibrated' HEC-RAS model WSELs – Little Hope Creek

Stations	D/S Length	High Water Marks				Original WSEL (ft)	Diff WSEL (ft)	100 yr EX WSEL (ft)	Comments
		Elevation	Location	Quality	Type				

3759	60	605.0	NA	NA	NA	605.5	0.5	608.40	USGS gage

3.2.4 Remaining Streams (without HWM)

From the calibration efforts for three major streams where the HWMs were available, it was observed that the channel Manning's n were most critical model parameter. For the smaller drainage area streams, the Manning's n values ranged from 0.04 – 0.055. Similar ranges of values were used for other models based on the field observation. The contraction/expansion coefficients can be used as specified in the Standards Document (0.3/0.5 for sections '2' and '3' of the structure and 0.1/0.3 for natural channel sections).

In additions, the ineffective areas were placed based on the contraction/expansion ratios of 1:1. The ineffective areas at the natural channel cross-sections (XSs) should be placed per effective areas based on the transition of flow between XSs at ratio of 1:1.

3.3 *Summary of Hydraulic Results*

Following the calibration, the calibrated HEC-RAS models were executed for recurrence interval storms. After the HEC-RAS run, an internal QA/QC of hydraulic models was performed to verify the modeling approaches. The 1% annual chance WSELs were compared with effective studies upstream of the structures and points of interest. Table 13 in Appendix C provides a comparison of WSELs in proposed model with the effective model and Letters of Map Revisions (LOMRs) at such locations. As shown in the table, the WSELs increase and decrease for all the streams. The increases and decreases are as high as 5.4 and 5.6 ft, respectively. At most of the location, the current studies resulted in significant decreases compared to the effective study.

The County and Dewberry are coordinating with FEMA regarding the use of a 'modified' discharge (a discharge based on loss of available storage area resulting from future encroachments) for community and FEMA floodway analyses. The floodways will be created and provided to the County once the guidance is received from FEMA.

4.0 Floodplain Mapping

The WSELs obtained from the HEC-RAS model were mapped on digital terrain model created from NCFMP LiDAR) data using ESRI's GIS software ArcMap. The floodway boundaries will be created and provided to the County once the guidance is received from FEMA. The floodplain boundaries were created for 50%, 20%, 10%, 4%, 2%, 1%, and 0.2 % annual chance events for existing conditions and 1% annual chance events for future conditions.

Appendix A: Discharges from Updated HEC-HMS Model

Table 11. Summary of Discharges from Updated HEC-HMS Model

Stream	Drainage Area	Existing Conditions Peak Flow (cfs)							Future Conditions Peak Flows (cfs)						
	Sq. Miles	2 Yr	5 Yr	10 Yr	25 yr	50 Yr	100 Yr	500 Yr	2 Yr	5 Yr	10 Yr	25 yr	50 Yr	100 Yr	500 Yr
Briar Creek	0.4	118	213	284	382	461	543	748	134	237	313	415	495	579	787
	1.0	293	525	699	936	1125	1322	1815	357	614	799	1046	1239	1440	1935
	1.5	431	773	1029	1378	1656	1947	2672	518	893	1165	1529	1813	2108	2827
	1.7	428	768	1024	1374	1653	1945	2749	509	882	1154	1519	1805	2102	2932
	3.8	810	1460	1949	2630	3179	3751	5209	949	1658	2177	2893	3454	4039	5529
	4.9	968	1738	2320	3158	3818	4506	6242	1175	2032	2677	3551	4231	4937	6712
	6.0	1032	1861	2479	3337	4007	4790	6716	1261	2176	2845	3736	4449	5289	7311
	6.9	1096	1973	2589	3477	4182	5114	7250	1334	2277	2960	3887	4728	5664	7889
	7.4	1130	2032	2637	3524	4299	5282	7630	1373	2327	3005	3938	4876	5882	8274
	8.1	1175	2116	2739	3657	4458	5496	7997	1426	2419	3118	4087	5069	6140	8722
	9.0	1248	2241	2888	3848	4711	5838	8569	1506	2548	3274	4300	5362	6523	9314
	9.8	1269	2266	2930	3889	4757	5856	7770	1526	2579	3307	4351	5379	6374	8306
	10.0	1272	2245	2907	3851	4688	5722	7214	1527	2556	3276	4302	5265	6165	7628
	11.2	1272	2173	2710	3524	4129	4630	5985	1513	2399	3009	3870	4383	4942	6166
	11.2	1272	2173	2710	3524	4129	4630	5985	1513	2399	3009	3870	4383	4942	6166
	14.2	1455	2499	3311	4393	4991	5638	7389	1719	2749	3686	4657	5290	6010	7800
	14.5	1464	2432	2924	3612	4078	4466	5379	1702	2619	3150	3881	4241	4680	5543
	14.7	1472	2444	2936	3626	4094	4482	5399	1711	2631	3162	3896	4257	4697	5562
	15.2	1495	2476	2969	3662	4138	4529	5455	1736	2662	3194	3931	4301	4745	5619
	16.1	1543	2521	3021	3710	4182	4564	5503	1780	2711	3238	3974	4344	4779	5665
	17.2	1644	2567	3083	3764	4234	4604	5548	1860	2762	3289	4014	4392	4810	5708
	18.0	1705	2591	3115	3796	4271	4641	5587	1926	2788	3319	4040	4428	4841	5747
	18.5	1691	2586	3112	3791	4296	4666	5616	1911	2782	3316	4038	4453	4865	5777
	18.9	1705	2597	3125	3806	4314	4686	5639	1925	2793	3328	4053	4471	4883	5800

Stream	Drainage Area	Existing Conditions Peak Flow (cfs)							Future Conditions Peak Flows (cfs)						
	Sq. Miles	2 Yr	5 Yr	10 Yr	25 yr	50 Yr	100 Yr	500 Yr	2 Yr	5 Yr	10 Yr	25 yr	50 Yr	100 Yr	500 Yr
	18.9	1707	2599	3128	3809	4317	4689	5643	1927	2794	3330	4055	4474	4886	5803
	19.1	1714	2606	3136	3818	4328	4701	5658	1934	2802	3339	4063	4485	4898	5818
	21.2	1826	2693	3233	3927	4452	4829	6038	2052	2886	3433	4169	4605	5023	6290
	21.6	1834	2705	3247	3943	4470	4849	6149	2061	2898	3447	4181	4624	5041	6433
	21.6	1834	2705	3247	3943	4469	4849	6143	2061	2898	3447	4181	4624	5041	6424
Briar Creek Trib 1	0.7	183	336	452	615	745	883	1233	205	369	492	662	796	937	1293
	1.2	302	546	670	856	1011	1195	1793	330	575	705	899	1059	1274	1882
	1.2	298	538	665	849	1002	1175	1737	326	570	699	891	1047	1249	1822
Briar Creek Trib 2	0.4	93	167	222	298	358	421	579	106	185	244	322	384	448	608
	0.9	231	414	550	736	884	1039	1401	264	462	605	799	951	1108	1472
	1.7	381	681	906	1214	1458	1714	2369	444	771	1008	1328	1578	1846	2498
	1.7	340	608	810	1092	1321	1558	2187	396	687	901	1199	1432	1673	2320
Dairy Branch	0.2	92	163	216	289	347	407	557	118	199	256	332	391	452	603
	0.7	223	399	531	711	853	1002	1375	266	460	599	787	933	1085	1458
	0.9	268	480	636	846	1014	1190	1650	315	546	707	927	1100	1286	1741
	1.1	317	569	756	1007	1209	1410	1930	370	643	838	1100	1301	1514	2027
	1.1	314	566	753	1003	1203	1404	1928	366	640	834	1095	1295	1509	2019
Derita Branch	0.2	25	44	59	80	96	113	157	39	64	81	104	121	139	184
	0.4	88	160	215	292	353	417	579	135	226	290	375	441	508	675
	0.9	191	342	456	612	736	864	1187	274	456	584	752	881	1015	1343
	0.9	199	358	476	642	773	909	1250	283	473	609	787	923	1064	1411
	1.2	262	468	622	830	998	1174	1603	348	586	753	978	1153	1331	1765
	1.7	379	662	870	1145	1364	1590	2151	467	783	1002	1293	1518	1750	2332
	2.1	434	684	852	1091	1461	1772	2512	523	765	951	1337	1656	1973	2708
	2.1	432	683	851	1091	1460	1771	2508	522	765	951	1336	1655	1972	2707
Edward Branch	0.2	72	125	163	213	253	294	394	80	135	174	226	265	306	407

Stream	Drainage Area	Existing Conditions Peak Flow (cfs)							Future Conditions Peak Flows (cfs)						
	Sq. Miles	2 Yr	5 Yr	10 Yr	25 yr	50 Yr	100 Yr	500 Yr	2 Yr	5 Yr	10 Yr	25 yr	50 Yr	100 Yr	500 Yr
	0.6	175	313	415	554	664	779	1067	203	352	460	605	719	836	1126
	1.0	270	485	648	871	1049	1236	1706	318	558	733	971	1157	1351	1833
	1.2	301	544	729	984	1183	1301	1673	357	629	830	1103	1251	1392	1785
	1.9	483	874	1158	1507	1774	2012	2612	573	1008	1283	1654	1911	2153	2776
	2.1	542	981	1308	1694	1977	2252	2930	651	1143	1456	1856	2146	2414	3128
	2.4	563	1029	1351	1708	1991	2246	2991	685	1182	1519	1880	2153	2408	3301
	2.6	598	1098	1434	1798	2086	2338	3103	723	1250	1603	1966	2237	2499	3437
	2.6	598	1098	1434	1798	2086	2338	3103	723	1250	1603	1966	2237	2499	3437
Little Hope Creek	0.3	78	135	178	235	280	327	443	92	155	200	259	305	352	468
	0.5	132	237	315	422	508	597	820	151	263	345	455	542	633	858
	1.1	257	468	628	850	1027	1214	1692	295	525	695	927	1110	1302	1785
	2.6	693	1231	1632	2159	2583	3008	4117	772	1344	1763	2303	2726	3165	4286
	3.0	743	1331	1772	2353	2808	3279	4490	830	1458	1919	2512	2975	3458	4646
	3.0	738	1321	1759	2337	2787	3214	4300	825	1449	1907	2495	2955	3378	4463
	3.0	737	1321	1759	2337	2787	3214	4299	825	1449	1907	2495	2955	3378	4463
Little Hope Creek Trib 1	0.3	108	180	232	299	352	406	539	120	196	248	316	369	423	555
	0.4	146	254	332	437	520	607	819	164	277	357	465	549	636	847
	1.2	410	720	949	1259	1502	1753	2383	451	776	1012	1328	1573	1828	2460
	1.2	402	706	930	1202	1427	1663	2264	442	761	992	1266	1495	1733	2338
Little Sugar Creek	0.3	102	170	219	284	334	386	515	111	182	231	296	347	399	527
	0.9	254	447	591	786	941	1104	1511	305	518	671	876	1037	1203	1614
	1.6	374	670	893	1200	1416	1556	1986	464	799	1042	1368	1511	1676	2127
	2.1	428	760	1011	1336	1468	1594	1926	523	897	1168	1420	1547	1679	2024
	2.3	459	815	1082	1440	1606	1752	2118	560	959	1253	1546	1694	1842	2218
	2.5	501	888	1175	1570	1782	1970	2398	617	1051	1368	1714	1905	2092	2509
	2.9	579	1022	1366	1829	2110	2366	2935	705	1209	1578	2007	2265	2506	3066

Stream	Drainage Area	Existing Conditions Peak Flow (cfs)							Future Conditions Peak Flows (cfs)						
	Sq. Miles	2 Yr	5 Yr	10 Yr	25 yr	50 Yr	100 Yr	500 Yr	2 Yr	5 Yr	10 Yr	25 yr	50 Yr	100 Yr	500 Yr
	5.2	1041	1756	2245	2953	3583	3993	5006	1257	1992	2550	3364	3829	4246	5260
	6.4	1203	1764	2193	2621	2967	3289	3971	1319	1962	2361	2804	3150	3442	4127
	7.1	1287	1865	2299	2766	3123	3477	4320	1407	2051	2476	2944	3299	3642	4484
	7.3	1295	1883	2310	2786	3150	3508	4335	1420	2061	2487	2965	3325	3673	4497
	8.6	1498	2238	2710	3271	3733	4145	5221	1647	2402	2841	3442	3890	4308	5383
	9.2	1537	2298	2793	3361	3827	4224	5228	1687	2464	2935	3527	3985	4373	5374
	9.6	1592	2403	2947	3545	4030	4462	5460	1745	2572	3091	3701	4193	4570	5581
	10.8	1709	2600	3220	3830	4415	5060	6607	1877	2781	3344	3991	4644	5246	6944
	11.7	1792	2763	3451	4208	4989	5739	7973	1967	2950	3622	4478	5269	6020	8344
	12.0	1813	2806	3511	4413	5270	6059	8395	1988	2994	3696	4712	5546	6350	8777
	12.5	1859	2903	3644	4717	5589	6394	8773	2039	3096	3847	5027	5863	6695	9149
	13.8	1981	3262	4272	5573	6565	7545	10213	2171	3576	4603	5931	6927	7920	10666
	14.2	2002	3330	4308	5557	6497	7453	10038	2202	3623	4618	5887	6842	7834	10539
	14.8	2060	3517	4558	5865	6863	7880	10616	2269	3829	4885	6213	7227	8279	11083
	15.0	2065	3475	4411	5580	6457	7399	9794	2276	3751	4696	5875	6779	7755	10176
	15.3	2086	3527	4454	5575	6427	7357	9676	2302	3806	4736	5858	6744	7699	10032
	15.4	2094	3542	4471	5593	6446	7379	9703	2311	3822	4753	5876	6764	7721	10053
	15.6	2109	3578	4510	5629	6482	7415	9742	2327	3856	4789	5909	6798	7756	10100
	40.5	4010	6393	8167	10173	11642	13183	17281	4429	6895	8681	10654	12165	13817	17958
	41.4	4065	6552	8429	10574	12179	13830	17985	4494	7114	8980	11136	12776	14515	18724
	42.4	4160	6765	8750	11057	12773	14536	18829	4597	7350	9322	11649	13399	15247	19600
	43.8	4244	7013	9078	11521	13345	15220	19748	4695	7629	9694	12174	14039	16013	20571
	45.4	4312	7194	9314	11745	13584	15528	20372	4769	7818	9949	12396	14292	16372	21211
	46.2	4376	7302	9435	11794	13593	15522	20549	4837	7921	10074	12419	14283	16347	21415
	47.3	4310	7070	8988	11317	12994	14782	19256	4773	7603	9575	11886	13627	15421	20004
	48.5	4291	7007	8871	11212	12879	14653	19155	4753	7525	9442	11778	13502	15314	19898

Stream	Drainage Area	Existing Conditions Peak Flow (cfs)							Future Conditions Peak Flows (cfs)						
	Sq. Miles	2 Yr	5 Yr	10 Yr	25 yr	50 Yr	100 Yr	500 Yr	2 Yr	5 Yr	10 Yr	25 yr	50 Yr	100 Yr	500 Yr
	49.0	4201	6836	8618	10832	12426	14111	18794	4661	7333	9165	11372	13010	14722	19539
	49.6	4186	6831	8607	10714	12271	13919	18624	4650	7327	9151	11236	12841	14519	19374
	50.6	3908	6286	7891	10106	11764	13312	17219	4338	6751	8391	10730	12301	13871	17907

Table 12. Comparison of Updated HEC-HMS Discharges with Effective Discharges

Stream	Flow Change Location	Drainage Area (sq. mi.)		Existing Peak Discharges (cfs)		New Peak Discharges (cfs)		Percent Difference		
		Effective Study	New Study	1%	1% Fut.	1%	1% Fut.	1%	1% Fut.	DA
Briar Creek	At Confluence with Little Sugar Creek	21.6	21.6	5326	8760	4849	5041	-9	-42	0
	Approx. 900 ft. upstream of Bramlet Rd.	11.5	14.2	4642	5807	5638	6010	21	4	24
	Approx. 400 ft. upstream of Commonwealth Avenue	9.9	11.2	5396	7212	4630	4942	-14	-31	13
	Approx. 2500 ft. downstream of Country Club Drive	8.1	9.0	6393	8060	5838	6523	-9	-19	11
	Approx. 1500 ft. downstream of Country Club Drive	7.5	8.1	6292	7918	5496	6140	-13	-22	8
	Approx. 100 ft. upstream of Eastway Drive	6.0	6.9	6270	7562	5114	5664	-18	-25	15
	Approx. 100 ft. upstream of Shamrock Drive	5.2	6.0	5810	6953	4790	5289	-18	-24	15
	Approx. 2500 ft. downstream of Shannonhouse Dr	3.8	4.9	4340	5155	4506	4937	4	-4	28
	Approx. 1400 ft. downstream of Shannonhouse Dr	1.9	3.8	2331	2636	3751	4039	61	53	103
	Approx. 200 ft. upstream of Plaza Road	1.1	1.5	1778	2023	1947	2108	9	4	35
Briar Creek Tributary 1	At Confluence with Briar Creek	1.3	1.2	1924	2077	1175	1249	-39	-40	-7
Briar Creek Tributary 2	At Confluence with Briar Creek	1.9	1.7	2761	3459	1558	1673	-44	-52	-9
	Approx. 200 ft. downstream of Galway Drive	0.7	1.7	1249	1447	1714	1846	37	28	151
Dairy Branch	At Confluence with Little Sugar Creek	1.1	1.1	2029	2099	1404	1509	-31	-28	-1
Derita Branch	At Confluence with Little Sugar Creek	2.2	2.1	2367	2658	1771	1972	-25	-26	-7
	Approx. 2200 ft. downstream of West Craighead Rd	1.7	1.7	1898	2163	1590	1750	-16	-19	-1
	Approx. 100 ft. downstream of West Craighead Rd	1.4	1.2	1635	1898	1174	1331	-28	-30	-12
	Approx. 900 ft. upstream of West Craighead Road	1.1	0.9	1340	1556	909	1064	-32	-32	-15
	Approx. 2400 ft. upstream of West Craighead Road	0.9	0.9	1150	1315	864	1015	-25	-23	-1
Edwards Branch	At Confluence with Briar Creek	2.8	2.6	2232	3107	2338	2499	5	-20	-7
	Approx. 500 ft. upstream of Eastway Road	1.9	1.9	2009	3030	2012	2153	0	-29	1
	Approx. 1800 ft. upstream of Eastway Road	1.2	1.2	1471	2522	1301	1392	-12	-45	-3
	Approx. 500 ft. downstream of Sheffield Drive	1.0	1.2	2213	--	1301	1392	-41	--	19

Stream	Flow Change Location	Drainage Area (sq. mi.)		Existing Peak Discharges (cfs)		New Peak Discharges (cfs)		Percent Difference		
		Effective Study	New Study	1%	1% Fut.	1%	1% Fut.	1%	1% Fut.	DA
Little Hope Creek	At Confluence with Little Sugar Creek	3.2	3.0	3929	4131	3214	3378	-18	-18	-5
	Approx. 1300 ft. downstream of Seneca Place	2.7	3.0	3712	3906	3279	3458	-12	-11	11
	Approx. 100 ft. downstream of Mockingbird Lane	1.2	2.6	1688	1865	3008	3165	78	70	108
Little Hope Creek Tributary	At Confluence with Little Hope Creek	1.4	1.2	2285	2348	1663	1733	-27	-26	-8
	Approx. 100 ft. downstream of Bradbury Drive	0.6	1.2	1138	1176	1753	1828	54	55	113
Little Sugar Creek	Approx. 16000 ft. downstream of South Polk Street	50.8	50.6	13208	14162	13312	13871	1	-2	-1
	Approx. 2000 ft. downstream of Princeton Avenue	14.2	15.0	7077	7609	7399	7755	5	2	6
	Approx. 100 ft. downstream of Access Road	11.2	11.7	6729	7023	5739	6020	-15	-14	5
	Approx. 300 ft. downstream of Independence Boulevard	9.6	9.2	5659	6063	4224	4373	-25	-28	-4
	Approx. 700 ft. downstream of Belmont Avenue	9.0	8.6	4950	5264	4145	4308	-16	-18	-4
	Approx. 850 ft. upstream of Brevard Street	6.8	7.1	2988	3100	3477	3642	16	17	4
	Approx. 1100 ft. downstream of E. 36th Street	5.7	5.2	2681	3077	3993	4246	49	38	-7
	Approx. 1200 ft. upstream of E. 36th Street	3.2	2.9	2044	2238	2366	2506	16	12	-9
	Approx. 850 ft. downstream of N. Tryon Street	2.4	2.1	2036	2242	1594	1679	-22	-25	-13
	Approx. 950 ft. upstream of N. Tryon Street	1.8	1.6	1664	1824	1556	1676	-7	-8	-13
	Approx. 3000 ft. upstream of N. Tryon Street	1.0	1.1	1131	1329	1260	1395	11	5	10

Appendix B: Study Streams Map

Appendix C: Comparison of HEC-RAS WSELs with Effective Study and LOMRs

Table 13. Comparison of HEC-RAS WSELs with Effective Study

Stream	Location	Old Effective Study			New Study			Difference
		Cross-section (ft)	Discharges (cfs)	1% Annual Chance WSEL (ft)	Cross-section (ft)	Discharges (cfs)	1% Annual Chance WSEL (ft)	1% Annual Chance WSEL (ft)
Briar Creek	Approx. 200 ft Upstream of Plaza Road	50,929	2,331	706.3	50,872	1,947	705.7	-0.5
	Approx. 100 ft upstream of Ruth Drive	49,639	2,331	700.5	49,561	1,945	700.3	-0.2
	Shannon House Road	48,524	2,331	696.4	48,463	1,945	695.8	-0.6
	Norfolk Southern Rail Road	45,567	5,810	688.8	45,526	4,506	688.3	-0.6
	Shamrock Road	42,667	6,270	682.9	42,714	4,790	681.9	-1.0
	East way Drive	41,632	6,292	681.6	41,726	5,114	681.0	-0.6
	Country Club Drive	38,742	6,292	674.6	38,832	5,282	673.4	-1.2
	Central Avenue	32,177	4,642	656.7	32,235	5,722	655.4	-1.4
	Commonwealth Avenue	29,546	4,642	656.2	29,664	4,630	653.5	-2.7
	Independence Blvd.	28,815	4,642	655.6	28,901	4,630	653.5	-2.2
	East of Bay St.	27,898	4,642	655.5	27,939	4,630	651.9	-3.6
	Bramlet Road	26,227	5,326	655.5	26,272	4,466	651.9	-3.6
	CSX Transportation Road	25,784	5,326	655.4	25,839	4,466	651.8	-3.6
	Monroe Road	25,296	5,326	638.1	25,378	4,482	638.2	0.0
	Bank of America Building	23,625	5,326	633.2	23,566	4,529	634.4	1.2
	Randolph Road	23,116	5,326	632.3	23,209	4,529	633.8	1.5
	Providence Road	16,327	5,326	625.3	16,373	4,641	623.2	-2.1
	Sharon Road	13,397	5,326	623.4	13,436	4,666	621.9	-1.5
	Colony Road	10,128	5,326	614.5	10,119	4,689	611.6	-2.9
	Runnymede Lane	7,259	5,326	598.1	7,285	4,701	598.1	0.0
	Michael Bake Place Road	6,610	5,326	596.1	6,609	4,701	596.4	0.2
	Southpark Senior Living, LLC Building	6,156	5,326	595.0	6,047	4,829	593.7	-1.3
	Park Road	1,091	5,326	588.2	1,142	4,849	586.3	-1.9
Briar Creek Trib 1	Colony Road	3,984	1,924	617.3	3,999	1,195	615.4	-1.9
	Selwyn Elem.School 2	1,553	1,924	602.9	1,542	1,195	598.8	-4.1

Stream	Location	Old Effective Study			New Study			Difference
		Cross-section (ft)	Discharges (cfs)	1% Annual Chance WSEL (ft)	Cross-section (ft)	Discharges (cfs)	1% Annual Chance WSEL (ft)	1% Annual Chance WSEL (ft)
	Runnymede Lane	1,081	1,924	602.7	1,093	1,195	598.6	-4.2
Briar Creek Trib 2	Galway Drive	2,967	1,249	706.3	3,015	1,714	706.3	0.0
	Grafton Drive	749	2,761	697.2	760	1,714	696.2	-1.1
Dairy Branch	Scott Ave	2,990	2,029	657.4	3,032	1,410	655.6	-1.8
	1st D\S Scott Av	2,744	2,029	644.9	2,748	1,410	643.3	-1.6
	Salem Village Apartments LLC, Building	2,442	2,029	637.1	2,400	1,410	634.9	-2.2
	Cumberland Ave	856	2,029	627.7	876	1,410	622.0	-5.7
	Ds Cumberland	254	2,029	622.0	215	1,410	620.5	-1.4
Derita Branch	W Craighead St	6,115	1,635	712.6	6,248	1,174	712.5	-0.1
	Access Road At 8114 New Town Rd	1,183	2,367	690.2	1,191	1,772	690.8	0.6
	N. Tryon St	900	2,367	689.3	983	1,772	689.0	-0.3
Edwards Branch	Sheffield Dr	11,945	2,213	698.2	11,909	1,236	694.9	-3.4
	Woodland Dr	10,151	1,471	692.5	10,348	1,301	692.8	0.3
	Service Rd	9,761	1,471	692.4	9,979	2,012	692.7	0.2
	Eastway @ Independen	7,411	2,232	675.6	7,517	2,252	675.6	0.1
	Off Commonwealth Ave	3,979	2,232	664.4	3,978	2,246	664.3	-0.1
	Independence Blvd	2,918	2,232	662.2	2,885	2,246	661.7	-0.5
	New Briar Creek Rd	2,407	2,232	657.4	2,405	2,338	654.3	-3.1
	Parking Driveway	2,306	2,232	655.6	2,300	2,338	653.5	-2.1
	Parking Deck Park Ministries Inc The	1,887	2,232	653.1	1,850	2,338	651.1	-2.0
	Old Briar Creek Rd.	1,230	2,232	648.4	1,245	2,338	645.7	-2.6
Little Hope Creek	Woodlawn Rd	6,934	1,688	627.2	6,971	1,214	626.2	-1.0
	Montford Dr	6,012	1,688	618.8	6,028	3,008	619.1	0.3
	Mockingbird Ln	4,888	1,688	615.8	4,888	3,008	613.8	-2.0
	Estates At Charlotte 1 LLC, Building	4,241	3,712	613.1	4,200	3,279	611.9	-1.2

Stream	Location	Old Effective Study			New Study			Difference
		Cross-section (ft)	Discharges (cfs)	1% Annual Chance WSEL (ft)	Cross-section (ft)	Discharges (cfs)	1% Annual Chance WSEL (ft)	1% Annual Chance WSEL (ft)
	Seneca Pl	3,738	3,712	610.2	3,759	3,279	610.1	-0.1
	Tyvola Rd	430	3,929	592.7	444	3,214	589.9	-2.8
Little Hope Creek Trib	Bradbury Dr	1,812	1,138	622.5	1,823	1,753	621.9	-0.6
Little Sugar Creek	Kentbrook Dr	99,711	1,131	718.22	100,695	1,556	718.85	0.63
	Wellingford St	98,159	1,131	709.42	99,129	1,556	717.1	7.68
	N. Tryon St	97,180	1,664	708.66	97,375	1,594	717.06	8.4
	E Sugar Creek Rd	96,011	2,036	703.39	96,215	1,752	702.94	-0.45
	W Craighead Rd	93,976	2,036	694.1	94,189	1,970	695.61	1.51
	E36Th St	91,470	2,044	690.33	91,630	3,993	691.82	1.49
	Norfolk Southern Rr	90,241	2,681	690.35	90,460	3,993	691.88	1.53
	E30Th St	88,867	2,681	689.53	89,073	3,289	691.69	2.16
	Norfolk Southern Rr	88,273	2,681	687.97	88,495	3,289	689.28	1.31
	Brevard St	87,001	2,988	678.43	87,223	3,477	679.14	0.71
	Davidson St	84,371	2,988	671.13	84,581	3,477	671.2	0.07
	Parkwood Ave	83,341	2,988	669.44	83,529	3,477	668.98	-0.46
	18Th St	82,599	2,988	666.68	82,794	3,508	667.36	0.68
	Belmont Ave	80,337	2,988	659.48	80,534	3,508	657.77	-1.71
	Csx Transportation Rr	79,581	2,988	658.19	79,790	4,145	655.78	-2.41
	12Th St	78,502	4,950	657.53	78,710	4,224	653.79	-3.74
	I-277 Ramp	76,903	4,950	656.92	77,052	4,224	649.35	-7.57
	I-277	76,379	4,950	654.07	76,581	4,224	647.52	-6.55
	Duke Power Building /Elizabeth Ave	75,475	5,659	647.36	75,706	4,462	644.34	-3.02
	4Th St	74,456	5,659	646.69	74,668	4,462	642.96	-3.73
	E 3Rd St	74,027	5,659	644.03	74,216	5,060	640.92	-3.11
	Independence Blvd	72,937	5,659	640.87	73,125	5,060	638.27	-2.6
	E Morehead St	69,880	6,729	634.4	70,113	5,739	634.24	-0.16

Stream	Location	Old Effective Study			New Study			Difference
		Cross-section (ft)	Discharges (cfs)	1% Annual Chance WSEL (ft)	Cross-section (ft)	Discharges (cfs)	1% Annual Chance WSEL (ft)	1% Annual Chance WSEL (ft)
	Charlotte Mecklenburg Hospital	68,498	6,729	629.79	68,700	6,059	628.3	-1.49
	East Blvd	66,414	6,729	626.86	66,618	6,394	624.24	-2.62
	Princeton Ave	62,227	7,077	616.95	62,169	7,453	616.7	-0.25
	Princeton Ave	59,422	7,077	612.55	59,335	7,399	612.36	-0.19
	Park Road Shopping Center Inc(350 Feet From Brandywine Road)	57,462	7,077	608.67	57,252	7,357	608.23	-0.44
	Brandywine Rd	57,144	7,077	607.84	56,985	7,357	607.3	-0.54
	E. Woodlawn Road	56,432	7,077	605.49	56,255	7,379	599.93	-5.56
	Park Rd	51,132	7,077	594.35	50,960	7,415	593.63	-0.72
	Tyvola Road	49,215	13,208	591.58	49,054	13,183	589.89	-1.69
	Treatment Plant Road	48,173	13,208	589.02	48,000	13,830	588.23	-0.79
	Archdale Road	45,490	13,208	580.98	45,334	14,536	580.64	-0.34
	Rockledge Dr	38,031	13,208	570.79	37,836	15,528	570.8	0.01
	Sharon Road West	33,382	13,208	566.99	33,171	15,522	567.41	0.42
	Department Store the Most Downstream Edge	26,797	13,208	563.29	26,466	14,653	562.78	-0.51
	I-485	25,376	13,208	561.47	25,188	14,653	561.92	0.45
	Pineville-Matthews Rd	19,523	13,208	557.68	19,345	14,111	557.09	-0.59
	S. Polk Street	16,050	13,208	555.67	15,854	13,919	554.41	-1.26

Stream	Location	LOMR (Case No.05-04-A580P)			New Study			Difference
		Cross-section (ft)	Discharges (cfs)	1% Annual Chance WSEL (ft)	Cross-section (ft)	Discharges (cfs)	1% Annual Chance WSEL (ft)	1% Annual Chance WSEL (ft)
	ACCESS ROAD	66662	6729	627.21	66859	6405	625.58	-1.63
	EAST BLVD	66413.5	6729	626.86	66618	6405	624.24	-2.62
	ACCESS ROAD	62698	7077	617.51	62957	7464	618.06	0.55
	PRINCETON AVE	62227	7077	616.77	62169	7464	616.7	-0.07
	HILLSIDE AVE	59422	7077	611.87	59335	7410	612.36	0.49
	NEW PEDESTRIAN BRIDGE	58823.83	7077	609.26	58723	7367	611.19	1.93
	BRANDYWINE RD	57144	7077	607.84	56985	7367	607.3	-0.54
	E. WOODLAWN ROAD	56432	7077	605.49	56255	7389	599.93	-5.56
	PARK RD	51132	7077	594.35	50960	7426	593.63	-0.72
Little Sugar Creek	TYVOLA ROAD	49215	13208	591.58	49054	13187	589.89	-1.69

Stream	Location	LOMR (Case No. 06-04-BP55P)			New Study			Difference
		Cross-section (ft)	Discharges (cfs)	1% Annual Chance WSEL (ft)	Cross-section (ft)	Discharges (cfs)	1% Annual Chance WSEL (ft)	1% Annual Chance WSEL (ft)
	SCOTT AVE	2990	2029	657.35	3032	1410	655.59	-1.76
	1ST D\S SCOTT AV	2744	2029	644.87	2748	1410	643.29	-1.58
	CUMBERLAND AVE	870	2029	626.6	876	1410	621.98	-4.62
Dairy Branch	DS CUMBERLAND	253.5	2029	621.95	215	1410	620.53	-1.42