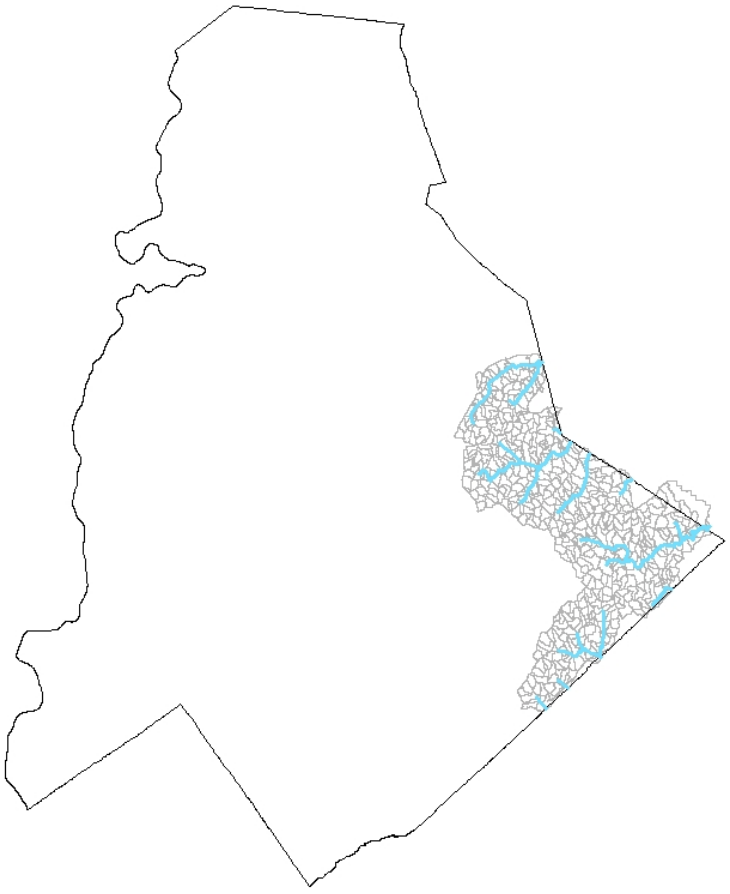
PRELIMINARY

MECKLENBURG COUNTY FLOODPLAIN MAPPING 2008

Yadkin Sub-Basin Hydraulics Report



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Introduction

The purpose of this study is to quantify the magnitude and extent of flooding during storms of selected recurrence intervals within the Yadkin watershed of Mecklenburg County, North Carolina. Accomplishing this task required the development / capture of detailed hydrologic and hydraulic data. This report will outline the various parameters and procedures used to perform the detailed *hydraulic* modeling in the Yadkin watershed, with the detailed hydrologic modeling being described and outlined separately in the "*Mecklenburg County Floodplain Mapping 2008: Yadkin Sub-Basin Hydrology Report*".

Scope of Study

The intent of the Charlotte-Mecklenburg Storm Water Services Floodplain Mapping Project is to provide accurate and up-to-date floodplain maps for the entirety of Mecklenburg County. This involves the restudying and remapping of all streams in the county that have been studied in previous FEMA flood studies. The initiative, which began most recently in 2007, is being carried out through a strategy that sub-divides the county into major watersheds, with each watershed being studied individually (though consistency between the various studies is ensured through adherence to the county's "Floodplain Analysis and Mapping Standards Guidance Document"). Since then, the Charlotte-Mecklenburg Storm Water Services (CMSWS) has conducted restudy efforts in a number of watersheds in conjunction with various study contractors, with AECOM being one of them.

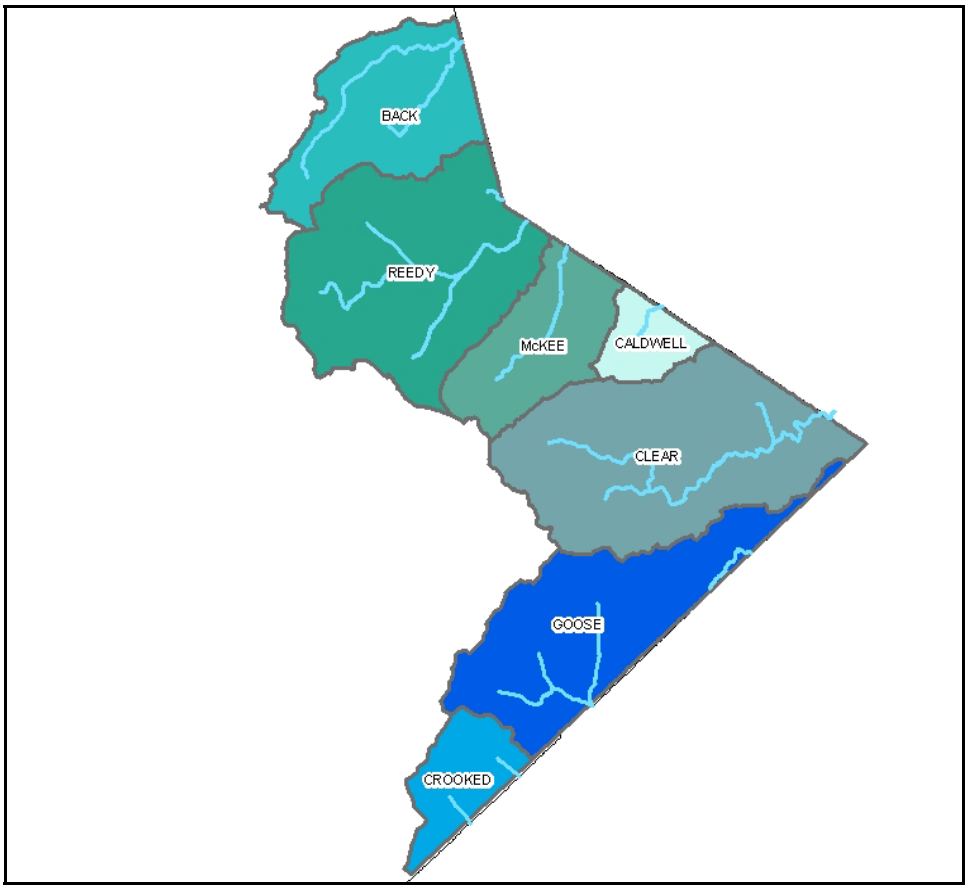

Figure 1 – Yadkin (Goose / Reedy Basin) Sub-Watersheds

The Yadkin watershed (referred to in the Mapping Activity Statement as the “Reedy / Goose Basin”) consists of approximately 36.7 miles of detailed riverine mapping. A list of the study limits for streams studied by detailed methods can be found in table 1 below:

Table 1. Stream Reaches Studied by Detailed Methods in Mecklenburg County

Stream Name	Downstream Limit	Upstream Limit	Length (mi)
Back Creek	The Mecklenburg/ Cabarrus County Line	Approximately 2,600 feet upstream of Back Creek Drive	4.6
Back Creek Tributary	The confluence with Back Creek	Approximately 360 feet upstream of Back Creek Church Road	2.3
Caldwell Creek	The Mecklenburg/ Cabarrus County Line	Approximately 1.0 miles upstream of Cabarrus County Line	1.0
Clear Creek	The Mecklenburg/ Cabarrus County Line	Approximately 1,660 feet upstream of Interstate 485	6.3
Clear Creek Tributary	The confluence with Clear Creek	Approximately 1,665 feet upstream of Truelight Church Road	2.8
Duck Creek	The Mecklenburg/ Union County Line	Approximately 1.4 miles upstream of Union County Line	1.1
Goose Creek	The Mecklenburg/ Union County Line	Approximately 1.2 miles upstream of Lawyers Road	2.0
McKee Creek	The Mecklenburg/ Cabarrus County Line	Approximately 1,410 feet upstream of Eastlake Road	3.2
North Fork Crooked Creek	The Mecklenburg/ Union County Line	Approximately 2,390 feet upstream of County Line	0.5
North Fork Crooked Creek Tributary	The Mecklenburg/ Union County Line	Approximately 630 feet upstream of Stallings Road	0.4
Reedy Creek	The Mecklenburg/ Cabarrus County Line	Approximately 0.7 miles upstream of Plaza Road Extension	3.9
Reedy Creek Tributary 1	The Mecklenburg/ Cabarrus County Line	Approximately 430 feet upstream of Interstate 485	0.4
Reedy Creek Tributary 2	The confluence with Reedy Creek	Approximately 1.2 miles upstream of Robinson Church Road	1.9
Reedy Creek Tributary 3	The confluence with Reedy Creek	Approximately 118 feet upstream of Chapparal Lane	2.7
Sherman Branch	The confluence with Clear Creek	Approximately 0.6 miles upstream of Cabarrus Road	0.8
Stevens Creek	The confluence with Goose Creek	Approximately 0.5 miles upstream of Thompson Road	2.1
Stevens Creek Tributary	The confluence with Stevens Creek	Approximately 0.5 miles upstream of Thompson Road	0.7

Hydraulic Approach

Water-surface elevations of floods of the selected annual chance of exceedance discharges were computed through use of the Army Corps of Engineers' HEC-RAS step-backwater computer program version 4.1. These computer models were calibrated using historic high water data collected during field investigations.

A countywide LiDAR dataset flown in 2007 was used for terrain data. Hydraulic cross section geometries were obtained from a combination of terrain data and field survey. All bridges, dams, and culverts were field surveyed to obtain elevation data and structural geometry. Cross sections

were field surveyed at approximately 1500ft increments along the streams to determine channel geometries between bridges and culverts. Some of the overbank cross-section data for the backwater analyses were obtained from the LiDAR dataset.

Initial Manning's n-value assumptions were made based on values published in "Open-Channel Hydraulics" [Chow, 1959]. N-value change locations along each cross-section were set to coincide with the approved landuse polygons developed for the calculation of curve numbers in the hydrologic analysis. Refinements were made to these initial assumptions through a combination of field investigation and examination of Mecklenburg County 2009 color orthophotos for both channel and overbank areas, with additional adjustments made to account for the presence of buildings (as outlined in the county's *Floodplain Analysis and Mapping Standards Guidance Document*). A tabulation of the landuse descriptions and their associated range of assumed n-values can be found in Table 2 below:

Table 2. Assumed N-value Variation with Respect to Landuse

Landuse Code	Landuse Description	Minimum n-value	Maximum n-value
1	WOODS/BRUSH	0.110	0.160
2	OPEN SPACE, GREATER THAN 2 ACRES RESIDENTIAL	0.055	0.085
3	GREATER THAN 0.5 TO 2 ACRES RESIDENTIAL	0.075	0.135
4	0.25 TO 0.5 ACRE RESIDENTIAL	0.110	0.145
5	LESS THAN 0.25 ACRE RESIDENTIAL/APTS./MULTIFAM	0.110	0.160
6	INSTITUTIONAL; SCHOOLS, HOSPITALS, ETC.	0.070	0.070
7	INDUSTRIAL - LIGHT (WAREHOUSES, ETC.)	0.075	0.075
8	INDUSTRIAL - HEAVY	0.080	0.080
9	COMMERCIAL - LIGHT (OFFICE PARKS, HOTELS)	0.080	0.100
10	COMMERCIAL - HEAVY (CAR PARKS, MALLS)	0.075	0.080
11	WATER BODIES/PONDS	0.040	0.040
12	TRANSPORTATION, MULTILANE ROADS, INTERSTATES	0.060	0.060

Channel n-values varied from 0.04 to 0.05. Overbank reach lengths were calculated along the approximate centerline of the anticipated flowpath of the overbank flow during the 1-percent-annual-chance event. Overbank flow centerline locations were estimated from the topography, and refined once initial 1-percent-annual-chance runs were made. Starting conditions for the hydraulic models were set to normal depth using starting slopes calculated from channel invert values taken from the terrain data or, where applicable, derived from the water surface elevations of effective Flood Insurance Study water surface elevations in adjacent counties. The 100-yr tie-in elevations are shown in Table 3 below:

Table 3. Downstream Boundary Conditions & Tie-in Locations

	Boundary Condition	Tie-in Location	Modeled 100-yr WSEL (ft)	Known 100-yr WSEL (ft)
Back Creek	Normal Depth	Mecklenburg / Cabarrus County Line	613.7	613.6
Caldwell Creek	Normal Depth	Mecklenburg / Cabarrus County Line	622.6	623.2
Clear Creek	Normal Depth	Mecklenburg / Cabarrus County Line	526.6	529.8
Duck Creek	Normal Depth	Mecklenburg / Union County Line	573.2	574.5

	Boundary Condition	Tie-in Location	Modeled 100-yr WSEL (ft)	Known 100-yr WSEL (ft)
Goose Creek	Normal Depth	Mecklenburg / Union County Line	624.6	625.4
McKee Creek	Normal Depth	Mecklenburg / Cabarrus County Line	602.2	602.1
Reedy Creek	Normal Depth	Mecklenburg / Cabarrus County Line	607.9	607.6
Reedy Creek Trib 1*	Known WSEL	Mecklenburg / Cabarrus County Line	624.5	624.5
N. Fork Crooked Creek	Normal Depth	Mecklenburg / Union County Line	675.8	675.6
N. Fork Crooked Creek Trib	Normal Depth	Mecklenburg / Union County Line	657.7	658.0

* - Known water surface elevation includes backwater effects from bridge in the Cabarrus County model. This is the only model we tied into with a known water surface elevation.

Hydraulic Modeling Results

In comparison with the effective base flood elevations, the newly calculated 1-percent-annual-chance water surface elevations have generally decreased in most locations along the studied streams, with the most dramatic elevation decreases often occurring in the upper reaches of the studied streams. This is to be expected, given that – in conjunction with other factors – the discharges yielded by the accompanying updated hydrologic analysis have decreased in varying degrees relative to the effective discharges (with few exceptions). The reason for this phenomenon, as outlined in the hydrology report, is:

> *"Again, the general trend is, as you travel further upstream into the headwaters, our updated models display larger differences to the effective flows. And we believe that this is due to the more precise modeling of reservoirs in the headwater reaches that were not included in the effective study." – Yadkin Sub-Basin Hydrology Report*

Thus, as a result of the updated hydrologic analysis that was developed in conjunction with this hydraulic modeling, water surface elevations occurring during a 1-percent-annual-chance are predicted by this analysis to be lower than those yielded in the effective analysis. A comparison between the effective base flood elevations and the newly calculated 1-percent-annual-chance water surface elevations at select locations can be found in table 4 below:

Table 4. Effective vs Updated 1-Percent-Annual-Chance Water Surface Elevations

	Effective Q (cfs)	Simulated Q (cfs)	Effective 1% WSEL	Simulated 1% WSEL	Difference (Feet)
Back Creek					
@ county line	3397	3605	613.6	613.7	0.10
Immediately D/S of Back Creek Trib	3397	3605	616.1	616.2	0.10
780ft D/S of I-485	1971	2017	638	636.1	-1.90
320ft U/S of Back Creek Church Rd	1971	1829	656.7	656.1	-0.60
200ft D/S of WT Harris Blvd	1477	1016	692.2	692.0	-0.20
1190ft U/S of Back Creek Dr	1395	852	705.2	706.6	1.40

	Effective Q (cfs)	Simulated Q (cfs)	Effective 1% WSEL	Simulated 1% WSEL	Difference (Feet)
Back Creek Trib**					
at confluence w/ Back Creek	1779	1607	615.3	615.1	-0.20
360ft U/S of Back Creek Church Rd	1291	766	694.7	694.0	-0.70
Caldwell Creek					
county line	1352	1005	623.4	622.6	-0.80
4025ft U/S of county line	1841	648	657.5	656.3	-1.20
Clear Creek					
Near county line (Eff Sta 1485)	3874	3407	529.8	526.6	-3.20
460ft U/S of Ferguson Rd	3811	2992	572.6	571.0	-1.60
1400ft D/S of Arlington Church	3793	2832	604.5	602.9	-1.00
50ft U/S of Bartlett Rd	1470	2664	624.1	620.3	-3.80
700ft U/S of Bartlett Rd	1094	1004	624.9	623.5	-1.40
Clear Creek Trib**					
870ft U/S of confluence w/ Clear	3217	2358	624.1	623.4	-0.70
1500ft U/S of Bartlett Rd	2696	2358	625.3	624.5	-0.80
780ft U/S of Minnie Lemmond Ln	2981	1972	643.8	642.2	-1.60
Duck Creek					
county line	2045	1252	574.5	573.2	-1.30
800ft U/S of county line	1780	1164	579.5	578.2	-1.30
5580ft U/S of county line	1634	1051	606.6	602.4	-4.20
Goose Creek					
county line	4653	3822	625.4	624.6	-0.80
immediately D/S of I-485	2195	1828	626.5	627.6	1.10
1050ft U/S of Lawyers Rd	1244	1219	647.4	647.6	0.20
McKee Creek					
county line	2980	2660	602.3	602.2	0-.10
1780ft D/S of Camp Stewart	2300	2077	616.8	616.0	-0.80
930ft U/S of Camp Stewart	1999	1623	626	623.4	-2.60
940ft U/S of I-485	1750	1064	634	633.8	-0.20
310ft D/S of East Lake Rd	1559	846	650.7	650.0	-0.70
North Fork Crooked Creek*					
N/A	--	--	--	--	--
North Fork Crooked Creek Trib*					
N/A	--	--	--	--	--
Reedy Creek					
county line	5394	4674	607.6	607.9	0.30
3275ft U/S of I-485	5394	4326	618.5	617.8	-0.70
850ft D/S of Hood Rd	4576	3111	630.9	628.8	-2.10
3110ft U/S of Plaza Extension	1664	684	661.8	658.8	-3.00

	Effective Q (cfs)	Simulated Q (cfs)	Effective 1% WSEL	Simulated 1% WSEL	Difference (Feet)
Reedy Creek Trib 1					
county line	889	1259	624.5	624.5	0.00
Reedy Creek Trib 2**					
1170ft U/S of confluence w/ Reedy	2089	1074	624.3	622.1	-2.20
1210ft U/S of Robinson Church	1698	768	639.4	638.3	-1.10
3200ft U/S of Robinson Church	1335	768	648.1	645.0	-3.10
3900ft U/S of Robinson Church	1032	590	650.9	648.3	-2.60
6000ft U/S of Robinson Church	604	431	661.8	660.7	-1.10
Reedy Creek Trib 3**					
confluence w/ Reedy	2265	1773	637.2	637.2	0.00
946ft D/S of Plott Rd	1728	1277	675.9	676.3	0.40
1920ft U/S of Plott Rd	1106	563	688.1	687.4	-0.70
Sherman Branch**					
at confluence w/ Clear	1095	638	570.3	567.6	-2.70
Stevens Creek**					
330ft U/S of confluence w/ Goose	4653	2010	626.7	624.3	-2.40
3000ft U/S of 485	2533	2010	640.7	640.0	-0.70
300ft U/S of Thompson Rd	1919	805	667.9	666.1	-1.80
Stevens Creek Trib**					
at confluence w/ Stevens	1053	840	642.7	642.5	-0.20
2000ft U/S of Thompson Rd	764	811	661.6	658.9	-2.70

* ***No Effective Study Exists***

** ***Elevations at confluences reported without consideration of backwater effects***

As shown in table 4, the downstream limit of Reedy Creek Tributary 1 (RCT1) is at the county line, which coincides with the Plaza Road Extension crossing. Due to the existence of effective detailed study for RCT1 in Cabarrus County, the "known water surface elevation" option was used as the boundary condition for RCT1. This known elevation, 624.49 feet for the 1-percent-annual-chance event, has been taken from the Plaza Road Extension US face cross-section of the effective Cabarrus County RCT1 HEC-2 model (effective station 5769.5). However, the fact that the Plaza Road Extension crossing is already included in the Cabarrus County RCT1 model has made it necessary to add a mapping cross-section in order to facilitate the tie-in between the Mecklenburg and Cabarrus County floodplain boundaries. Elevations at the mapping cross-section were taken from station 5674.5 of the effective model.

Hydraulic Modeling Calibration

As specified in the county's *Floodplain Analysis and Mapping Standards Guidance Document*, calibration of the hydraulic models was conducted in order to ensure that the models accurately reflect the conditions as they actually exist. This was accomplished through comparison of observed water surface elevations from a known storm event (in this case, a storm occurring at the end of August 2008) with those yielded by the hydraulic models when using similar discharges. The simulated discharges that were used for this comparison were calculated using the recorded precipitation data from the event of interest in the hydrologic models that were developed in conjunction with this analysis (more detailed information about the development of these discharges

can be found in the "*Mecklenburg County Floodplain Mapping 2008: Yadkin Sub-Basin Hydrology Report"*). Various parameters of the hydraulic models were then revised as needed in an attempt to match the observed elevation values within +/- 0.5 feet.

The available observed water surface elevation data for the August 2008 storm were derived from 3 USGS gages, one each located along Reedy, Clear, and McKee Creeks (USGS site numbers 212430293, 212466000, and 212430653 respectively), as well as from surveys of high water marks (HWMs) on Back Creek, Reedy Creek Trib 1, Reedy Creek, Reedy Creek Trib 3, and McKee Creek that were conducted in the days subsequent to the 2008 event.

Calibration to Stream Gage Data

In accordance with the county's *Floodplain Analysis and Mapping Standards Guidance Document*, primary consideration during the hydraulic calibration phase was given to the observed WSELs recorded at the stream gage stations. Discharge and stage data were available from the USGS in 15-minute increments at each station, and peak flow values (and the corresponding stages) were used as the calibration values.

The gage on Reedy Creek (USGS site number 212430293) is located on the downstream face of the I-485 crossing. During the August 2008 event, the gage recorded a peak discharge value of **4500cfs** on August 27th at approximately 6:52 am. This corresponded to a recorded *stage* of 15.08 feet, which – when added to the gage datum elevation of 595.73 feet – yields a recorded water surface elevation of **610.8 feet** at the gage. Comparatively, the simulated August 2008 event in the hydrologic analysis predicted a peak flow of **4600cfs** at this location. The peak flow values from this simulation were used to make an "August08" event profile in the hydraulic model, which predicted a water surface elevation of **610.8 feet** at the downstream face of the I-485 crossing. This compares well with the observed elevation without any calibration.

The gage on Clear Creek (USGS site number 212466000) is located on the upstream face of Ferguson Road, immediately adjacent to the confluence with Sherman Branch. During the August 2008 event, the gage recorded a peak discharge of **1120cfs** on August 27th at approximately 5:22 am. The corresponding *stage* recorded during this time interval was 7.14 feet, which yields a recorded elevation of **565.4 feet** at the gage when the gage datum of 558.3 is included. Comparatively, the August 2008 event simulation in the hydrologic analysis for Clear Creek predicted a peak flow of **1243cfs** at this location. The peak flow values from this simulation were used to make an "August08" event profile in the hydraulic model, which predicted a water surface elevation of **567.3 feet** at the upstream face of the Ferguson Road crossing. With a difference of +1.9 feet, this is well outside of the +/- 0.5 foot tolerance relative to the observed water surface elevation. Thus, adjustments and refinements to some of the hydraulic parameters would appear to be justified.

In an effort to bring the Clear Creek hydraulic model results into agreement with the observed water surface elevations at the gage, several minor adjustments were made to the model in the vicinity of the gage. Moderate adjustments were made to the channel invert elevations at the 2 cross-sections downstream of Ferguson Road in order to normalize the slope of the stream in that area. Examination of the survey photos justified a reduction of channel n-values from 0.05 to 0.042 in the area between Ferguson Road and the private driveway, and from 0.048 to 0.042 from the downstream face of Ferguson Road to station 8789. Overbank n-values appeared to be reasonable, and were left unchanged. Additionally, the Yarnell equation was used for modeling the low-flow losses through the Ferguson Road crossing (the pier shape coefficient "K" was set to 1.25). The cumulative effect of these parameter adjustments was a reduction of 1.5 feet in the simulated "Aug08" water surface elevation at the gage, bringing the water surface elevation down to **565.8 feet**, with the difference in comparison to the observed water surface elevation reduced to +0.4 feet.

A comparison of the simulated and observed water surface elevations for the August 2008 event at the USGS gages located along Reedy Creek and McKee Creeks can be found in table 5 below. The simulated elevations at these particular gages did not need any calibration. The global adjustments of the open space land use n-value along with the adjustment of n-values at structures kept these simulated elevations within reason.

Since all of differences between the observed and the simulated water surface elevations for the August 2008 event are within the +/- 0.5 foot tolerance, it does not appear that further adjustments to the hydraulic parameters are needed at this time. In keeping with the approach specified in the county's guidance document, adjustments / refinements were made to the n-values, contraction / expansion coefficients, and ineffective flow area boundaries. Of these, the model seemed to be most sensitive to n-values adjustments (no changes resulted from reasonable adjustments to the ineffective area boundaries or contraction / expansion coefficients).

Table 5. Gage Data from USGS gages on Reedy Creek and Clear Creek

Stream	Nearest XS	Gage Q (cfs)	Gage WSEL	Simulated Q (cfs)	Pre-Cal XS WSEL	pre-cal diff (ft)	Post-cal XS WSEL	post-cal diff (ft)
Reedy Creek	Stream Gage DS of I-485 DS (RC) Sta 2340	4500	610.8	4600	610.8	0.0	--	**N/A**
Clear Creek	US face of Ferguson Rd (Sta 10620)	1120	565.4	1243	567.3	1.9	565.8	**0.4**
McKee Creek	DS side of Reedy Creek Rd (Sta 1679 DS)	NA	606.5	NA	606.4	-0.1	606.0	**-0.1**

Calibration to High Water Marks

As was previously stated, a total of six HWM surveys were conducted on Back Creek, Reedy Creek Trib 1, Reedy Creek, Reedy Creek Trib 3, and McKee Creek in the days following the August 2008 event. These surveyed HWMs were used in the calibration process as secondary targets due to their more variable nature relative to the gage measurements. In light of this, somewhat less rigorous efforts were made to bring the hydraulic models into agreement with the HWMs, with agreement being achieved with varying degrees of success. Simulated water surface elevations were within reasonable range of the surveyed HWMs at two locations. Simulated elevations were over 1.75 feet higher than surveyed marks at the other four locations. A simple reason for this could be the fact that these HWM elevations were taken mostly in the upper reaches of the streams where intricate hydrology and hydraulic parameters can have a big impact on the calculated discharges and water surface elevations. For example, the exact discharges at the HWM locations on these streams are unknown. The discharge estimates at these locations could be over-estimated. On the other hand, we have solid discharge and stage information at the gages and the pre-calibration comparisons at these gages are really close at two of the three locations and the third location required a specific bridge modeling method change to lower the simulated elevation to a reasonable estimate. Therefore, although the HWM comparison seems, at first glance, to be conservative, we believe that, when looked at together with the gage data comparison, the RAS models are accurate.

Back Creek – The location of the surveyed HWM on Back Creek is approximately 150 feet upstream of Katherine Kiker Road, in the left overbank area of the upstream expansion cross-section for this road crossing at station 16909 in the Back Creek hydraulic model. Although the surveyed HWM elevation of **679.4 feet** compared favorably with the simulated elevation of 678.5 feet at this location (a difference of -0.9 feet), minor adjustments were made in an attempt to further refine the simulated elevation. Channel n-values were increased slightly from 0.047 to 0.05 in the cross-sections between Katherine Kiker Road and McLean Road (station 19330). Additionally,

examination of the survey photos for the Katherine Kiker Road structure revealed that the bottom of the twin-barrel box culverts were buried, which justified increasing the "culvert bottom" n-value from the typical concrete culvert n-value of 0.012 to 0.052. These adjustments resulted in a cumulative increase in the simulated water surface elevation, raising it to **678.7 feet** (a difference of -0.7 feet relative to the surveyed HWM elevation).

Reedy Creek Trib 1 – The surveyed HWM on Reedy Creek Trib 1 is located in the vicinity of the I-485 downstream expansion cross-section at station 1336 in the Trib 1 model. The surveyed HWM elevation of **623.9 feet** differed dramatically from the simulated water surface elevation of **625.7 feet** at this location (a difference of +1.8 feet). Numerous attempts were made to lower the n-values for both the channel and the overbank areas in the vicinity of the HWM to achieve a favorable match between the simulated and HWM elevations, but even setting the n-values to unrealistically low values failed to bring the simulated water surface elevation into agreement with the surveyed HWM elevation. This could be due to the fact that the quality of the HWM is reported as "Poor" in the HWM shapefile. As a result, the surveyed HWM elevation may not be accurate, which may ultimately render this HWM inappropriate for calibration use but is shown for informational purposes only.

Reedy Creek – The surveyed HWM on Reedy Creek is located approximately 960 feet downstream of the Plaza Road Extension in the vicinity of the cross-section at station 15362. The surveyed HWM elevation of **639.7 feet** differed dramatically from the simulated water surface elevation of **642.5 feet** at this location (a difference of +2.8 feet). Attempts were made to lower the n-values for both the channel and the overbank areas in the vicinity of the HWM to achieve a favorable match between the simulated and HWM elevations. However, even setting the n-values to unrealistically low values failed to bring the simulated water surface elevation into complete agreement with the surveyed HWM elevation. Thus, channel n-values were lowered from 0.047 to 0.045 at all cross-sections between stations 15978 and 12391. Overbank n-values for wooded/brushy areas were reduced from 0.15 to 0.125 in the some locations. These adjustments resulted in a cumulative decrease in the simulated water surface elevation, lowering it to **642.0 feet** (a difference of +2.3 feet relative to the surveyed HWM elevation). Examination of the survey photos indicates that further n-value reductions would be unreasonable. This particular HWM lies downstream of Reedy Creek Park and as such this area may qualify for a slight reduction in the discharge values calculated by HEC-HMS. At this time however, we would like to report that we are 2.3 feet high as compared to the HWM and since we are accurate at the gage station we do not feel the need to calibrate this model further.

Reedy Creek Trib 3 - The surveyed HWM on Reedy Creek Trib 3 is located immediately upstream of Chapparal Lane in the vicinity of the cross-section at station 14022. Although the surveyed HWM elevation of **703.8** compared favorably with the simulated elevation of 704.8 feet at this location (a difference of +1 foot), minor adjustments to the entrance loss coefficient of the culverts at the Chapparal Lane crossing were made in an attempt to bring the simulated elevation at this location into agreement with the HWM surveyed elevation. Setting the entrance loss values for the twin-barrel concrete pipe to 0.2 resulted in a decrease to the simulated water surface elevation immediately upstream of the road. This resulted in lowering the elevation to **704.3 feet** (a difference of +0.5 feet relative to the surveyed HWM elevation).

McKee Creek – HWMs were surveyed on McKee Creek on the upstream and downstream faces of the Camp Stewart Road crossing. On the upstream face of Camp Stewart Road, the surveyed HWM elevation of **618 feet** differed drastically from the simulated elevation 622 feet (a difference of +4 feet). The difference between the surveyed HWM elevation and the simulated elevation at the DS face differed marginally less drastically, with the HWM elevation being **619 feet** and the simulated elevation being 621 feet (a difference of +2 feet). Numerous attempts were made to lower the n-values for both the channel and the overbank areas in the vicinity of the HWM to achieve a favorable match between the simulated and HWM elevations. However, even setting the n-values to

unrealistically low values failed to bring the simulated water surface elevation into complete agreement with the surveyed HWM elevation. In the end, the survey photos were re-examined, and the channel n-values were lowered from 0.045 to 0.042 at all cross-sections from station 7165 to 5346 (lowering overbank n-values didn't seem to have much effect). Also, the "momentum" method was used for modeling low-flow conditions at the bridge. Table 6 represents a comparison of the simulated and surveyed water surface elevations for the August 2008 event at the various HWMs.

These adjustments resulted in a cumulative decrease in the simulated water surface elevation at both the upstream and downstream face of Camp Stewart Road, lowering the simulated elevation to **621.1 feet** at the upstream face and **620.9 feet** at the downstream face (a difference of +3.1 feet and +1.9 feet, respectively, relative to the surveyed HWM elevations). It is peculiar that the surveyed HWM elevation at the downstream face is greater than that at the upstream face. This fact calls the precision of the HWMs into question, and thus makes these HWMs practically unsuitable for use. To that end, no efforts were made to bring the simulated elevations into closer agreement with the surveyed HWM elevations.

Table 6. Surveyed HWM Elevations from the August 2008 event

Stream	Nearest XS	HWM elev (ft)	Pre-cal XS Elevation (ft)	pre-cal diff (ft)	Post-cal XS Elevation (ft)	post-cal diff (ft)
Back Creek	"Katherine Kiker Road - US Cont" (Sta 16909)	679.4	678.5	-0.9	678.7	**-0.7**
Reedy Creek Trib 1	DS of "I-485 - DS Exp (RCT1)" (Sta 1336)	623.9	625.9	2	625.7	**1.8**
Reedy Creek	1/2 way between XS 15362 and XS 15000	639.7	642.5	2.8	642.0	**2.3**
Reedy Creek Trib 3	"Chapparal Lane - US" (Sta 14022)	703.8	704.8	1	704.3	**0.5**
McKee Creek	"Camp Stewart Road - DS" (Sta 7078)	619	621	2	620.9	**1.9**
McKee Creek	"Camp Stewart Road - US" (Sta 7165)	618	622	4	621.1	**3.1**

Calibration along Streams with no Historic Flood Data

The remaining streams:

Back Creek Tributary,
Caldwell Creek,
Clear Creek Tributary 1,
Duck Creek,
Goose Creek,
North Fork Crooked Creek,
North Fork Crooked Creek Tributary,
Reedy Creek Tributary 2,

Sherman Branch,
Stevens Creek, and
Stevens Creek Tributary

were not calibrated at this time. We compared the 1% annual water surface elevations produced by the HEC-RAS models to effective elevations in Table 4 and found that the new elevations were consistently lower than effective in most every case except Goose Creek, where the elevation was 0.6 feet higher in the most extreme case. Reedy Creek Tributary 2 shows the biggest decrease as compared to effective elevations. The maximum 4.4 feet difference is mostly caused by the 65% reduction in flows noted in the Hydrology report at this location, which was apparently caused by the attenuation of flow by the many ponds at Charles T. Myers Golf Club, along with the wooded and open space land cover that dominates the upstream extents of this tributary.

At this time we feel that no calibration is warranted in these models because it will be difficult to justify specific calibration due to the lack of historical flood data. Also, considering the comparison to effective data, we do not feel that a further decrease to effective elevations is warranted.

Floodways and Community Encroachment Boundaries

The floodway represents the portion of the channel or other watercourse and the adjacent land area that should be reserved/maintained to carry the base flood without increasing flood elevations by more than a specified maximum tolerance. As specified in the county's *Floodplain Analysis and Mapping Standards Guidance Document*, two floodways were created for the Mecklenburg County FIRMs – the FEMA Floodway and the Community Encroachment Boundary.

FEMA Floodway

Encroachments for the FEMA floodway were initially set using method 4 in the encroachment routine in HEC-RAS version 4.1.0 using 0.5 feet as a target surcharge. The 1% annual chance existing conditions discharges were used in this process. Calculated surcharge values from the FEMA floodway analysis ranged from -0.04 to 0.54 feet and surcharges were optimized to be reasonably close to 0.5 ft. Floodway widths were also optimized to represent gradual changes from cross section to cross section in order to conform to the County's Guidance Document.

Community Encroachment Area

The community encroachment area (CEA) was determined using a 0.1 foot maximum surcharge using the ***modified*** 100-year existing conditions base flood discharges. The 100-year existing conditions discharge was modified to account for the future loss of storage due to the filling of the floodplain fringe to the FEMA floodway. The ***modified*** 100-year discharges were then used to re-compute the CEA Boundary Line optimizing the surcharge to be as close to 0.1 as possible. Calculated surcharge values from the Community Encroachment Area analysis ranged from -0.04 to 0.14 and all surcharges were optimized to be reasonably close to 0.1 ft. The widths were again optimized similarly to the FEMA floodways and in accordance with the Guidance Document.