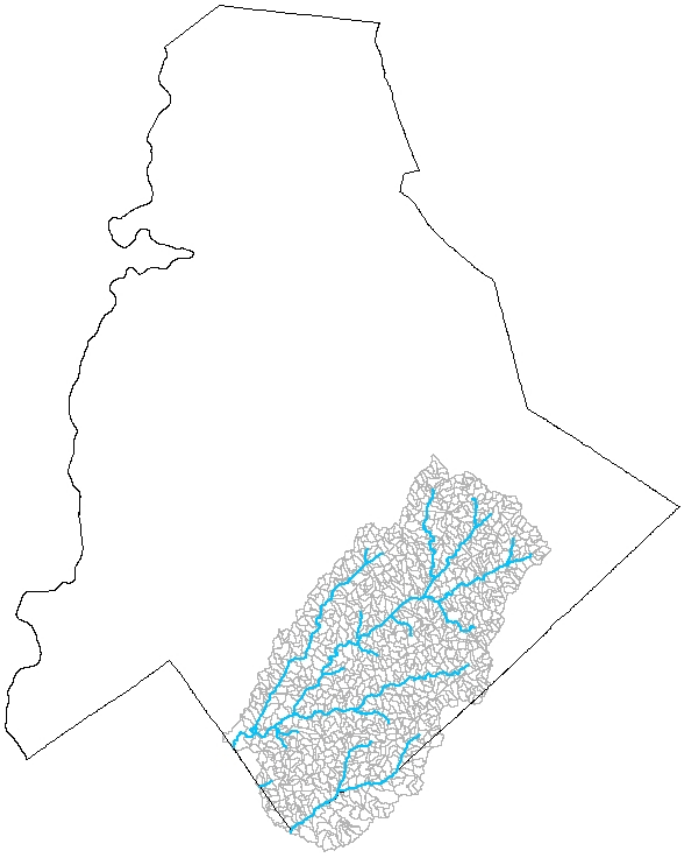
PRELIMINARY

MECKLENBURG COUNTY FLOODPLAIN MAPPING 2008

Catawba Sub-Basin Hydraulics Report



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AECOM
6201 Fairview Road, Suite 400, Charlotte, North Carolina 28210
T 704.553.6150 F 704.553.6151 www.aecom.com

Introduction

The purpose of this study is to quantify the magnitude and extent of flooding during storms of selected recurrence intervals within the Catawba 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 Catawba watershed, with the detailed hydrologic modeling being described and outlined separately in the "*Mecklenburg County Floodplain Mapping 2008: Catawba 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.

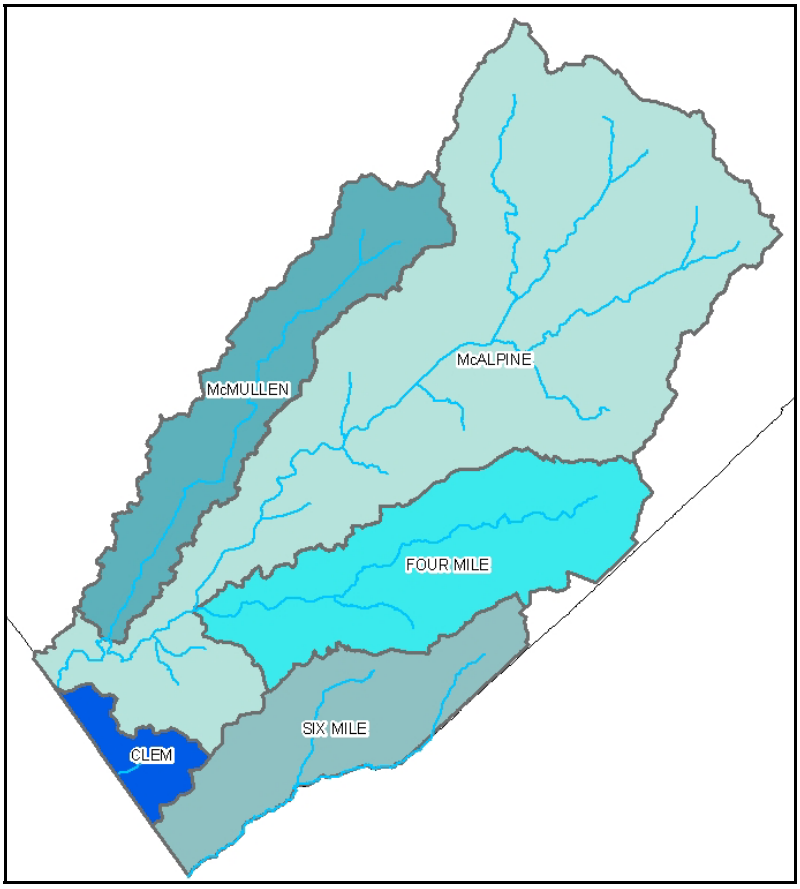

Figure 1 – Catawba (McAlpine / Six Mile Basin) Sub-Watersheds

The Catawba watershed (referred to in the Mapping Activity Statement as the McAlpine / Six Mile Basin) consists of approximately 79.9 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.)
Campbell Creek	Confluence with McAlpine Creek	Approx. 750 feet upstream of Barcliff Drive	5.3
Clems Branch	Mecklenburg / Lancaster (SC) County Line	Approx. 190 feet upstream of Lancaster Highway	0.7
Flat Branch	Confluence with Six Mile Creek	Approx. 0.9 miles upstream of Tom Short Rd	3.1
Four Mile Creek	Confluence with McAlpine Creek	Approx. 190 feet upstream of E. John St.	9.6
Irvins Creek	Confluence with McAlpine Creek	Approx. 375 feet upstream of Lawyers Road	6.2
Irvins Creek Trib 1	Confluence with Irvins Creek	Approx. 2400 feet upstream of Independence Blvd.	2.7
Irvins Creek Trib 2	Confluence with Irvins Creek	Approx. 0.6 miles upstream of Lawyers Road	1.3
McAlpine Creek	Mecklenburg / Lancaster (SC) County Line	Approx. 500 feet upstream of Albemarle Rd.	21.7
McAlpine Creek Trib 1	Confluence with McAlpine Creek	Approx. 0.7 miles upstream of Hwy 521	1.3
McAlpine Creek Trib 1A	Confluence with McAlpine Creek Trib 1	Approx. 485 feet upstream of Ballantyne Commons Pky	1.1
McAlpine Creek Trib 3	Confluence with McAlpine Creek	Approx. 600 feet upstream of Providence Rd.	1.2
McAlpine Creek Trib 6	Confluence with McAlpine Creek	Approx. 1.1 miles upstream of confluence	1.1
McMullen Creek	Confluence with McAlpine Creek	Approx. 0.8 miles upstream of Addison Road	10.9
McMullen Creek Trib	Confluence with McMullen Creek	Approx. 300 feet upstream of Sharon Amity Rd.	0.7
Rea Branch	Confluence with McAlpine Creek	Approx. 210 feet upstream of Sequoia Red Ln.	1.0
Rocky Branch	Confluence with Four Mile Creek	Approx. 0.5 mile upstream of Providence Road	2.0
Sardis Branch	Confluence with McAlpine Creek	Approx. 800 feet upstream of Sardis Road	1.6
Six Mile Creek	Mecklenburg / Lancaster (SC) County Line	Approx. 0.5 miles upstream of Tilley Morris Road	8.8
Swan Run Branch	Confluence with McAlpine Creek	Approx. 1 mile upstream of Sharon View Road	1.4

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 stream gage data and 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. Most 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	0.150
2	OPEN SPACE, GREATER THAN 2 ACRES RESIDENTIAL	0.055	0.095
3	GREATER THAN 0.5 TO 2 ACRES RESIDENTIAL	0.075	0.115
4	0.25 TO 0.5 ACRE RESIDENTIAL	0.075	0.125
5	LESS THAN 0.25 ACRE RESIDENTIAL/APTS./MULTIFAM	0.095	0.135
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)	0.055	0.075
11	WATER BODIES/PONDS	0.040	0.040
12	TRANSPORTATION, MULTILANE ROADS, INTERSTATES	0.060	0.060

Channel n-values varied from 0.035 to 0.053. 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 and survey data. Known water surface elevations were not used as a boundary condition anywhere in the Catawba watershed hydraulic analysis. McAlpine Creek and Sixmile Creek flow from Mecklenburg County into Lancaster County, SC, where McAlpine Creek is studied by approximate methods and Sixmile Creek has an effective detailed study. However, due to the age of the effective Sixmile Creek analysis in Lancaster County, SC, as well as the significantly decreased discharge values that are yielded by the updated hydrologic analysis, a known WSEL boundary condition was not used for Sixmile Creek.

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 stated in the Yadkin 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 3 below:

Table 3. Effective vs Updated 1-Percent-Annual-Chance Water Surface Elevations

	Effective Q (cfs)	Simulated Q (cfs)	Effective 1% WSEL	Simulated 1% WSEL	Difference (Feet)
Campbell Creek*					
at confluence w/ McAlpine	2571	2262	592.1	587.4	-4.7
At Idlewild Road**	2642	2146	674.9	672.1	-2.8
2100ft D/S of Exec Center Dr	2424	1856	687.95	688.1	0.1
50ft D/S of Exec Center dr	1900	1376	694.2	692.7	-1.5
400ft D/S of Barcliff Park	1505	836	711	710.5	-0.5
Clems Branch					
3100 feet DS of Lancaster Hwy	2030	2187	567.4	565.4	-2.0
2700 feet DS of Lancaster Hwy	1388	1460	568.9	569.3	0.4
40 feet DS of Lancaster Hwy	772	960	582.7	581.0	-1.7
Flat Branch*					
at confluence w/ Sixmile Creek	2863	1964	589.3	587.4	-1.9
1400 ft US of Threat Vail Ln	2358	1846	603.7	601.7	-2.0
2500 ft DS of Tom Short Rd	1995	1536	609.6	608.3	-1.3
2000 ft DS of Tom Short Rd	1756	1536	610.4	609.1	-1.3
1400 ft DS of Tom Short Rd	1283	1154	612.1	611.6	-0.5
3500 ft US of Tom Short Rd	1138	646	635.5	635.9	0.4
Four Mile Creek*					
at confluence w/ McAlpine Creek	4750	5061	540.6	540.1	-0.5
Gage below Elm Lane**	4750	5061	542.2	542.9	0.7
2200ft U/S of Providence Rd	4807	3906	577.7	580.4	2.7
5500ft U/S of Providence Rd	4510	3201	584.3	584.2	-0.1
100ft D/S of Retana Dr	4301	2859	599.1	598.7	-0.4
2800ft D/S of Trade St	3696	2492	608.5	608.5	0.0
2200ft U/S of Trade St	2755	1440	637.2	634.0	-3.2
5600ft U/S of Trade St	1048	462	653.5	650.5	-3.0
Irvins Creek*					
at confluence w/ McAlpine	3780	5322	583.5	582.2	-1.3

	Effective Q (cfs)	Simulated Q (cfs)	Effective 1% WSEL	Simulated 1% WSEL	Difference (Feet)
Irvins Creek* (cont)					
200ft D/S of Independence	3752	5222	593.7	594.8	1.1
3000ft U/S of Independence	3053	3611	609.2	609.7	0.5
At Sam Newell Rd**	3053	3728	627	627.3	0.3
100ft U/S of Lebanon Rd	2770	2462	658.1	658.3	0.2
D/S of Beaverdam Ln	2253	2015	667.7	668.0	0.3
U/S of Beaverdam Ln	1006	1156	669.8	670.2	0.4
700ft U/S of Apple Creek Dr	852	693	686.6	687.3	0.7
400ft U/S of Lawyers Rd	824	447	708.8	705.2	-3.6
Irvins Creek Tributary 1*					
at confluence w/ Irvins	1940	1852	586.6	589.3	2.7
2300ft D/S of Sam Newell***	1749	1786	626.2	621.0	-5.2
1500ft D/S of Independence	1717	1766	649.6	649.0	-0.6
800 ft US of Windsor Park	1500	1245	671.2	668.4	-2.9
Irvins Creek Tributary 2*					
at confluence w/ Irvins	1344	970	669.9	670.2	0.3
400ft U/S of Lawyers Rd	1559	915	681.6	680.5	-1.1
2300ft U/S of Lawyers Rd	971	1766	690.2	687.8	-2.4
McAlpine Creek					
5600ft D/S of Lancaster Hwy	11641	12613	526.35	524.2	-2.1
At Gage below McMullen**	11641	12907	534.3	534.0	-0.3
1700ft U/S of 485	10137	11794	538.7	537.6	-1.2
4600 ft D/S of Hwy 51	10073	11705	540.7	539.9	-0.8
600ft D/S of Carmel Country Club #3	9378	9740	548.9	547.5	-1.4
2300ft D/S of Old Providence Rd	9368	9860	560.4	561.2	0.8
U/S of Sardis Rd**	9216	9725	573	573.1	0.0
U/S of RR Bridge near Monroe rd	9039	10072	583.5	581.9	-1.6
U/S of Independence	5683	5039	591.7	587.8	-3.9
U/S of Idlewild**	3294	2549	631.8	623.2	-8.6
400ft U/S of Lawyers Rd	3099	1924	669.3	664.6	-4.7
500ft D/S of Marlwood Circle #1	1885	1030	674.2	673.1	-1.1
700ft U/S of Marlwood Circle #2	1380	780	683.8	683.1	-0.7
McAlpine Creek Tributary 1					
at confluence with McAlpine	2211	2679	538.8	537.6	-1.2
3800 ft US of US 521	1502	1198	554.7	554.7	0.0
McAlpine Creek Tributary 1A					
at confluence with McAlpine Trib 1	944	1049	538.8	537.6	-1.2
300 ft US of Ballantyne Commons Prkwy	977	837	568.2	567.3	-0.9
McAlpine Creek Tributary 3					
at confluence with McAlpine	1519	1466	560.6	561.2	0.6
700 ft DS of Rea Rd	1327	1433	566.5	566.5	0.0

	Effective Q (cfs)	Simulated Q (cfs)	Effective 1% WSEL	Simulated 1% WSEL	Difference (Feet)
McAlpine Creek Tributary 6					
at confluence with McAlpine	1258	1306	668.0	663.4	-4.6
2300 ft US of confluence with McAlpine	1251	1094	682.1	679.9	-2.2
5000 ft US of confluence with McAlpine	1299	1094	699.2	695.0	-4.2
McMullen Creek*					
at confluence w/ McAlpine	5902	5317	534.3	534.1	-0.2
4200ft U/S of Johnston Rd	5264	5087	547.8	545.4	-2.4
5200ft D/S of Quail Hollow Rd	4566	4681	557.5	555.0	-2.5
U/S of Mountainbrook Rd	4561	4517	595.4	593.9	-1.5
At gage below Sharon View Rd**	4561	4519	605.8	604.5	-1.3
1000ft D/S of Arborway Rd	4476	4240	628.5	627.2	-1.3
1300ft U/S of Arborway Rd	4358	3970	637.6	637.1	-0.5
300ft D/S of Lincrest Pl	2506	2068	666.9	665.3	-1.6
2200ft U/S of Lincrest Pl	2179	2005	674.2	673.7	-0.5
McMullen Creek Trib*					
at confluence w/ McMullen	1923	1870	666.9	665.3	-1.6
1200ft D/S of S Sharon Amity	1747	1645	674.3	673.7	-0.6
U/S of S Sharon Amity	1473	1411	686.9	686.8	-0.1
Rea Branch					
at confluence w/ McAlpine	2512	1168	546.5	545.7	-0.8
upstream of Parkview Dr	2458	959	556.4	552.6	-3.8
upstream of Sequoia Red Ln	2167	990	567.8	564.8	-3.0
Sardis Branch					
at confluence w/ McAlpine	2121	1593	573	573.1	0.1
200 ft upstream of North Sardis Rd	2272	1136	578.8	577.8	-1.0
1100 ft DS of Sardis Rd	1840	422	635.6	631.1	-4.5
Rocky Branch					
at confluence w/ Four Mile	1858	1337	557.1	557.6	0.5
1500 ft upstream of Four Mile Cr Rd	1237	1337	567.6	564.8	-2.8
900 ft US of Providence Rd	911	756	626.5	626.9	0.4
Six Mile Creek					
@ county line	6596	5296	575.2	570.5	-4.7
At gage below Marvin Rd**	6596	4961	577.1	573.3	-3.8
U/S of confluence with Flat Branch	3629	2814	589.6	587.7	-1.9
4100ft U/S of Tom Short	3242	2525	604.8	602.3	-2.5
400ft U/S of Providence Rd	2564	1792	621.8	619.6	-2.2
3100ft U/S of Providence Rd	2133	1549	626.6	624.8	-1.9
2500ft D/S of Tilley Morris	1783	1128	641.8	641.7	-0.1
Swan Run Branch*					
at confluence w/ McAlpine	2067	1513	561.4	562.1	0.7
5300ft U/S of Sharon View Rd	1687	1055	596.9	593.7	-3.2

**** - Elevations at confluences reported with consideration of backwater effects***

***** - USGS stream gage locations***

****** - Location is on a very steep decline, we have 3 new surveys in this area and feel our inverts are more accurate than the effective data***

The differences displayed in red text represent simulated BFE's that have decreased by more than 1 foot from the effective BFE's at the same location. The differences in blue text represent simulated BFE's that have increased by more than 1 foot from the effective BFE's, and black text represent a BFE change of less than 1 foot relative to the effective.

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 exist on the ground. 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: Catawba Sub-Basin Hydrology Report*"). A flow change spreadsheet was created for each model. The McAlpine Creek RAS model from the county line to just downstream of the confluence with Irvins Creek however did not use the flows calculated by the HEC_HMS model. The hydrology for this stream was based more on the Log-Pearson III gage analysis presented in the Catawba Hydrology Report. Therefore, the flows input into the HEC-RAS model for hydraulic calibration were taken directly from the stream gage at Sardis Road and the gage just below the confluence with McMullen Creek. This was done in order to clarify that we were calibrating the hydraulic aspect of the model only, with separation of the hydrology, which was already calibrated. 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 several USGS gages located along the creeks seen in Table 4, as well as from surveys of high water marks (HWMs) on Campbell Creek, Four Mile Creek, McAlpine Creek, McMullen Creek and Trib, and Swan Run that were conducted in the days subsequent to the 2008 event.

Table 4: Stream Gages used for Catawba River sub-basin Model Parameter Calibration

Gage Station ID	Gaged Stream and Location	Drainage Area (square miles)
02146562	Campbell Creek near Charlotte, NC	5.6
0214657975	Irvins Creek at SR 3168 near Charlotte, NC	8.4
02146700	McMullen Creek at Sharon View near Charlotte, NC	7.0
0214655255	McAlpine Creek at SR 3150 near Idlewild, NC	7.5
02146600	McAlpine Creek at Sardis Rd near Charlotte, NC	39.6
02146750	McAlpine Creek below McMullen Cr near Pineville, NC	92.4
0214685800	Six Mile Creek near Pineville, NC	20.3

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 gaging 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. A comparison of the simulated and observed water surface elevations for the August 2008 event at each USGS gage location can be found in table 5.

The gage on Campbell Creek is located on the upstream face of the Idlewild Road crossing. During the August 2008 event, the gage recorded a peak discharge value of **2000cfs** on August 27th at approximately 6:30 am. This corresponded to a recorded *stage* of 7.34 feet, which – when added to the gage datum elevation of 595.73 feet – yields a recorded water surface elevation of **671.26 feet** at the gage. Comparatively, the simulated August 2008 event in the hydrologic analysis predicted a peak flow of **2234cfs** at this location. The peak flow values from this simulation were used to make an "August08" event profile in the hydraulic model, which originally predicted a water surface elevation of **672.6 feet** at the upstream face of the Idlewild Road crossing. While this is about 1.3 feet higher than the observed elevation, our efforts lower the water surface elevations were not very successful. From just upstream of the gage the woods/brush n-value was lowered from 0.15 to 0.125 and the open space n-value was lowered from 0.11 to between 0.055 and 0.075. These adjustments lowered the simulated water surface elevation at the gage to **672.2 feet**, which is 0.9 feet higher than the observed elevation.

Table 5: Stream Gage versus Simulated Water Surface Elevations

Stream	Gage ID	Model XS Station	Time of Q(peak)	Gage Stage @ Q(peak) (ft)	Gage Datum (ft)	Gage WSEL(ft) (Datum+Stage)	Pre-Cal XS Elevation (ft)	pre-cal diff (ft)	Post-Cal XS Elevation (ft)	post-cal diff (ft)
Campbell Creek	2146562	13625	8/27/08 @ 6:30	7.34	663.92	671.26	672.6	0.64	672.2	0.94
Irvins Creek	214657975	12998	8/27/08 @ 6:00	9.44	612.56	622.00	622.47	0.47	621.94	-0.06
Four Mile Creek	2146770	6700	N/A	11.4	528.69	540.09	540.51	0.42	539.85	-0.24
McMullen Creek	2146700	36030	8/27/08 @ 6:45	11.44	592.31	603.75	604.68	0.93	604.34	0.59
McAlpine Creek	214655255	99020	8/27/08 @ 6:15	10.57	613.19	623.76	624.87	1.11	624.26	0.5
McAlpine Creek	2146600	75660	8/27/08 @ 6:30	16.34	552.36	568.70	570.83	2.13	569.01	0.31
McAlpine Creek	At Colony Road	59570	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
McAlpine Creek	2146750	23100	8/27/08 @ 11:30	15.41	515.51	530.92	533.84	2.92	530.43	-0.49
Sixmile Creek	214685800	5546	8/27/08 @ 7:15	8.6	560.33	568.93	566.26	-2.67	566.79	-2.14

The gage on Irvins Creek is located at the upstream face of Sam Newell Road. During the August 2008 event the gage recorded a peak discharge of **2090 cfs** on August 27th at approximately 6:00 am. The corresponding stage recorded during this time interval was 9.44 feet, which yields a recorded elevation of **622.00 feet** at the gage when the gage datum of 612.56 is included. Comparatively, the August 2008 event simulation in the hydrologic analysis for Irvins Creek predicted a peak flow of **2123cfs** 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 **622.47 feet** at the gage location. Although this elevation is within the accepted elevation range, the general global n-value adjustments that were suggested in the Yadkin HEC-RAS review were still applied here as well. This consisted of lowering the open space overbank n-value from 0.11 to 0.075 and adjusting the n-values near structures to not reflect the transportation

layer. These revisions lowered the overall water surface elevation to **621.94**, still well within the desired limits.

The gage on Four Mile Creek is located just downstream of the Elm Lane crossing. Because this gage is a "stage only" gage, no discharges were recorded at this location during the August 2008 event. The peak stage at the gage was recorded as 11.4 feet at an unknown time on August 27, 2008. Combined with the gage datum of 528.69 feet, a peak observed water surface elevation of **540.09 feet** is calculated. The peak flow values from the HMS simulation were used to make an "August 08" event profile in the hydraulic model, which predicted an initial water surface elevation of **540.51 feet** at the downstream face of Elm Lane. Although this initial elevation is within the accepted elevation range according to the gage data, the global adjustments concerning open space and upstream / downstream face cross section n-values were still applied to the Four Mile Creek model. Also, this gage location is unique in that surveyed high water marks are present at here in addition to the peak stage observed by the USGS gage. The raw elevation of the high water mark on the downstream side of the crossing should be close to the gage elevation. The high water mark near the gage was surveyed at **539.76 feet**, a difference of 0.33 feet from the observed gage elevation. A comparison of the simulated August 2008 water surface elevations to the high water marks will be presented later in this report. When the global adjustments were made to the model the water surface elevation at the downstream face of Elm Lane was calculated to be **540.21 feet**, 0.12 feet higher than the gage.

The gage on McMullen Creek is located just downstream of the Sharon View Road crossing and it recorded a peak discharge of **4020 cfs** on August 27th at approximately 6:45 am. The corresponding stage recorded at this time was 11.44 feet, which, when added to the gage datum of 592.31, results in a recorded peak water surface elevation of **603.75 feet** during the August 2008 event. Comparatively, the simulated hydrologic analysis at this gage for the August 2008 storm event predicted a peak flow of **4010 cfs**. This peak flow was input into the "August08" event profile in the hydraulic model and resulted in a peak water surface elevation of **604.68 feet** at the gage location. The hydraulic simulation therefore originally calculated an elevation that was 0.93 feet higher than what was actually recorded. We applied the global land use n-value adjustments for open space and transportation as mentioned above. The updated simulated water surface elevation is now **604.34 feet**, which is 0.59 feet higher than the gage elevation.

McAlpine Creek contains three functioning gages for the August 2008 storm event. From upstream to downstream, they are as follows:

Gage Station ID	Gaged Stream and Location	Drainage Area (square miles)
0214655255	McAlpine Creek at SR 3150 near Idlewild, NC	7.5
02146600	McAlpine Creek at Sardis Rd near Charlotte, NC	39.6
02146750	McAlpine Creek below McMullen Cr near Pineville, NC	92.4

The gage at Idlewild Road, located just upstream of the crossing, recorded a peak discharge of **3100 cfs** during the August 2008 storm event at approximately 5:15 am. The corresponding stage recorded at this time was 10.57 feet and when added to the gage datum of 613.19 feet, resulted in a peak water surface elevation of **623.76 feet** during the August 2008 storm event. Comparatively, the simulated hydrologic analysis at this gage for the August 2008 event predicted a peak flow of **3029 cfs**. This peak flow was input into the "August08" event profile in the hydraulic model and resulted in a peak water surface elevation of **624.87 feet** at the gage location. The simulation initially over-predicted the elevation by 1.11 feet. In order to correct this, the global land use n-value adjustments for open space and transportation mentioned above were applied throughout the model. Following these revisions, the simulated water surface elevation was then 624.85 feet. Further calibration of the model using more elaborate methods was needed. The culvert

calculations were manually set to be performed under inlet control, which lowered the simulated storm elevation to **624.26 feet**, within the allowable range. The justification to use inlet control is the steep slope of the culverts, which is at 1.0%, the highest slope of any culvert in this model.

The next gage on McAlpine Creek is just upstream of Sardis Road and, apparently, just upstream of the confluence with Sardis Branch. The gage recorded a peak discharge of **6330 cfs** during the August 2008 storm at approximately 9:00 am. The corresponding stage recorded at this time was 16.34 feet and when added to the gage datum of 552.36 feet, resulted in a peak water surface elevation of **568.70 feet** for the storm event. Comparatively, the simulated hydrologic analysis at this gage for the August 2008 event predicted a peak flow of **8134 cfs**. This peak flow was input into the "August08" event profile in the hydraulic model and resulted in a peak water surface elevation of **570.83 feet** at the gage location. Investigation into the source of this rather large discrepancy indicated that the over +2 feet of elevation difference is mainly due to the 28% difference in hydrology, which relied more on a Log-Pearson II analysis referenced in the Catawba Hydrology report. Therefore, in order to accurately calibrate only the hydraulic portion of the model, the actual observed gage flow was used to create the "August08 Actual" event profile which was used as the calibration profile downstream of the confluence with Irvins Creek. Use of the 6330 cfs peak flow resulted in a peak water surface elevation of 569.02 feet. The global n-value updates were then applied and this lowered the water surface by 0.01 feet to **569.01 feet**.

The farthest downstream gage on McAlpine Creek is located just below McMullen Creek at cross section 23100 and it recorded a peak discharge of **7870 cfs** during the August 2008 storm at about 11:45 am. The corresponding stage recorded at this time was 15.41 feet and when added to the gage datum of 515.51 feet, resulted in a peak water surface elevation of **530.92 feet** during the August 2008 storm. Comparatively, the simulated hydrologic analysis at this gage for the August 2008 event predicted a peak flow of **11256 cfs**. This peak flow was input into the "August08" event profile in the hydraulic model and resulted in a peak water surface elevation of **533.84 feet** at the gage location. As with the previous gage, it appears that the almost three foot elevation difference is mainly due to the 40% difference in hydrology. Therefore, in order to accurately calibrate the hydraulic models, we input the actual gage flow into the "August08 Actual" event profile and ran the simulation. The **7870 cfs** peak flow resulted in a peak water surface elevation of 530.24 feet. The global n-value updates were then applied and this lowered the water surface by 0.01 feet to 530.23 feet. To raise the simulated water surface elevation to within 0.5 feet of the measured elevation, the woods/brush n-value was adjusted from 0.125 to 0.14 near the structure, ultimately resulting in a simulated elevation of **530.48 feet**.

With some calibration (mainly n-value adjustment) all of the simulated water surface elevations at the gages fall within the +/- 0.5 foot tolerance outlined in the Guides and Specs, except for Six Mile Creek which is explained below and Campbell Creek, which is explained above.

The gage on Six Mile Creek is located just downstream of the Marvin Road crossing and it recorded a peak discharge of **433 cfs** on August 27th at approximately 8:30 am. The corresponding stage recorded at this time was 8.6 feet, which, when added to the gage datum of 560.33, results in a recorded peak water surface elevation of **568.93 feet** during the August 2008 event. Comparatively, the simulated hydrologic analysis at this gage for the August 2008 storm event predicted a peak flow of **604 cfs**. This peak flow was input into the "August08" event profile in the hydraulic model and resulted in a peak water surface elevation of **566.26 feet** at the gage location. The simulated elevation is 2.67 feet lower than the measured gage elevation. Through discussions with the USGS about this gage it was discovered that they initially had the gage datum incorrect. That fact, along with the fact that the storm itself is below a 2-year event discharge, brings the gage elevation of 568.93 into question. Revisions were made to the orientation of the cross sections near the structure and this raised the elevation to 566.79 feet, but since the gage datum is in question no further calibration was performed on this model at this time.

Calibration to High Water Marks

A total of 51 HWM surveys were conducted in the McAlpine Creek watershed 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. A tabulation of calibration results at each HWM can be found in the Catawba High Water Mark Spreadsheet. Global edits were made to all of the models, adjusting the open space n-value from 0.1 – 0.11 to 0.055 – 0.075. Another global edit included adjusting the overbank n-values for the US and DS face cross sections at structures. These n-values were automatically calculated to be 0.06 because they mostly fell with the transportation feature in the land use shapefile. These n-values were adjusted to better represent the actual land use which was mostly a combination of woods/brush and open space. Values were generally set between 0.075 and 0.125.

Most of the HWMs were calibrated to either by re-drawing downstream cross sections, adjusting the n-values, or by adjusting how a downstream bridge or culvert was modeled. The adjustments were successful 75% of the time as there are only 15 HWMs that we could not get within +/- 0.5 feet tolerance. Of those 15 marks, the model calculates a significantly lower water surface elevation at only 3 locations. Of the 12 marks that are over-estimated, only 7 of those are over by 1 foot or more.

The simulated model elevation near cross section 94075 on McAlpine Creek is 0.66 feet lower than the HWM. The HWM is surveyed on the downstream side of a small footbridge. The simulated elevation on the upstream side of the bridge is 0.06 feet higher than the HWM. The bridge is modeled using the energy equation because of the minimal impact the bridge has to the hydraulic conductivity of water. Even though the upstream water surface in the August 2008 storm overtops the bridge by 2.5 feet, there is still a decrease in water surface from upstream of the bridge to downstream of 0.72 feet. If the simulated elevation is taken at the DS face of the structure in the model rather than the DS cross section, the model is still 0.55 lower than the mark.

The second location in which the model elevation is lower than a high water mark is at cross section 47473 on McMullen Creek. Here, a re-drawing the US and DS face structure cross sections, along with filling the culverts at Providence Road one foot raised the water surface by 1.6 feet. But that is still 1.6 feet lower than the measured HWM. Due to this abnormally high elevation at this location, it is reasonable to assume that the structure was blocked during the storm event and this is what caused the water surface elevation to be so high. Thus, since extraordinary measures would be required to approach this elevation, no rigorous efforts have been made to match this HWM.

The third location at which the simulated elevation is significantly lower than the HWM is between cross sections 23042 and 22759 on Campbell Creek. In an effort to match the HWM elevation of 702.23 feet, the orientations of the cross sections adjacent to this HWM were revised in order to more accurately represent the geometry of the overbanks. Additionally, n-values were increased in the channel from 0.048 to 0.052, and woods/brush overbank n-values were increased from 0.15 to 0.16 from cross section 23078 down to the US face of Albemarle Road. These revisions resulted in a simulated elevation of 701.25 feet, which is still 0.98 feet below the HWM elevation. Examination of the photos taken as part of the structure inventory that was conducted by Mecklenburg County in January 2009 revealed evidence of blockage of the Albemarle Road crossing that was still present 5 months after the August 2008 storm. Thus, it is reasonable to assume that this is the likely cause of the abnormally high HWM elevation at this location. Since extraordinary measures would be required to approach this elevation, no further efforts have been made to match this HWM.

The remaining 12 locations that fell outside of the recommended tolerance were higher than the measured high water mark. Model elevations ranged from 0.61 feet to 2.9 feet higher than measured marks.

One of the larger discrepancies between the simulated and reported HWM elevation occurs on McAlpine Creek at the upstream face of Independence Blvd, where the simulated elevation is 2.68 feet greater than the HWM elevation at that location. Upstream and downstream cross section orientations were adjusted to better reflect the geometry of the floodplain at this structure. Also, channel and overbank n-values in the vicinity of this structure were lowered in an effort to bring the simulated elevation into agreement with the HWM elevation. However, it would appear that a combination of factors – including the steepness of the channel, the confluence with Campbell Creek that occurs immediately upstream of this structure, and the transition from a narrow floodplain upstream of the structure to a wide floodplain downstream of it – prevent the simulated WSEL from being lowered to anywhere near the desired tolerance. Furthermore, the HWM at this location is designated as one of poor quality according to the attributes of the HWM shapefile. Thus, since it is possible that the recorded HWM elevation is inaccurate, no additional effort has been made to match the HWM elevation at this location.

The instance where the simulated elevation is 2.33 feet higher than the measured high water mark is intriguing. This high water mark, located at the downstream face of the Highway 51 crossing on McAlpine Creek, has a recorded elevation that is 0.6 feet lower than the adjacent high water mark that is 4500 feet downstream (on the upstream face of the Johnston Road crossing). This seems especially peculiar, and the abnormally low elevation reported at this location likely is the result of the "poor" quality of the HWM as noted in the attributes of the HWM shapefile. Therefore, due to the factors listed above, no additional calibration measures have been taken at this location.

The next two most egregious comparisons are on McMullen Creek at cross sections 13600 and 23530. It is interesting to note that other high water marks both upstream and downstream of these are slightly lower than measured marks. This may point to the need to adjust specific cross section locations or make some structure modeling routine edits. At cross section 13600 there is not much that could be done as far as cross section orientation revisions, as the channel is not sinuous and the overbanks are well defined. The flood profiles through this area are stable and dominated by the crossing at Johnston Road and the transition to a wide floodplain at cross section 16000. At cross section 23530, three cross sections downstream of the HWM were redrawn to try to better represent the overbank geometry, but it had little impact. Again, the flood profiles through this area are stable, as we are just downstream of the Quail Hollow Road crossing. No further calibration will be done at this time.

Calibration along streams with no Historic Flood Data

The remaining streams were not calibrated at this time:

- Clems Branch,
- Flat Branch,
- Irvins Creek Tributary 1,
- Irvins Creek Tributary 2,
- McAlpine Creek Tributary 1,
- McAlpine Creek Tributary 1A,
- McAlpine Creek Tributary 3,
- McAlpine Creek Tributary 6,
- Rea Branch,
- Rocky Branch, and
- Sardis Branch

Currently, no specific calibration is warranted on these models because it will be difficult to justify specific calibration measures due to the lack of historical flood data. However, the global n-value adjustments mentioned above were applied to these streams.