December 29, 2000

Michael Buckley, Director
Flood Hazard Mapping Technical Services Division
Federal Emergency Management Agency
500 C Street SW
Washington, DC 20472

Dear Director Buckley,

I have attached additional information relating to the flood insurance study and Base Flood Elevations for Richland and Lexington Counties contained in the September 26, 2000 Preliminary Revised FIRM. The additional information includes

- Gauge data and historical flood stages
- A critique of FEMA's and USGS's hydrological modeling methods
- BFE's for Lexington County

I will continue to provide assistance in your investigation; please feel free to contact me with any questions.

Sincerely,

[redacted]

cc: Dr. Paul Sandifer, SC DNR
[redacted] SELC

Additional Information on FEMA's 9/26/00 Appeal Resolution for Congaree River in Richland and Lexington Counties, South Carolina

December 29, 2000

1 Introduction

This document is a supplement to the appeal of the new Base Flood Elevations for Richland and Lexington Counties and includes information and issues not discussed in my October 26, 2000 supplement. I am particularly concerned that neither FEMA nor the USGS has taken to heart the numerous warnings in Bulletin 17B to account for multiple sources of flooding in their analysis of a 100-year flood estimate for the Congaree River at Columbia. Their analysis devoted absolutely no effort to separate modeling of flooding caused by tropical storms; as a direct result, the current 100-year flood estimate is considerably lower than a careful review of the historical record would produce.

In my earlier supplement, I had pointed out that Lexington BFE's had been computed under an impossible scenario: levees were assumed not to be either over-topped or breached at 292,000 cfs. The correct analysis should compare earlier conditions (levees intact at a lower flow) against later conditions (levees breached and overtopped at 292,000 cfs) and select the analysis that produces higher BFE's. In today's submission, I use FEMA's own HEC-2 models to show the fallacy of FEMA's statements that the peak flood on the Lexington side would occur earlier than the peak flood on the Richland side.

We will first review historical data, then provide corrected BFE's for Lexington County, and provide a critique of the hydrology analysis conducted by FEMA and USGS.

2 Historical Data

2.1 1840 Flood

I have obtained additional information on the May 1840 flood. The account of this flood in an August 26, 1908 newspaper article suggested it was only modestly smaller in magnitude than the August 1852 flood. Contemporary accounts from 1852, however, suggest that the 1852 flood was much greater in magnitude (several feet higher at the Gervais Street Bridge) than the 1840 flood. Newspaper accounts from 1840 (see Attachment 1) confirm the latter version. The May 1840 flood was actually typical of other large "spring freshets" such as occured in May 1886, April 1912, and April 1936.

> At the Columbia bridge the water was within 15 inches of the floor. *Carolina Planter, June 3, 1840*

Remembering that the floor of the Gervais Street bridge was 31' in 1840 (see October 26, 2000 supplement), this suggests that the stage for the 1840 flood was 29.9' (or 33.9' when calibrated to the current gauge). Nevertheless, the 1840 flood seems to have been much larger than any flood in the previous 40 years and equivalent in magnitude to the 1796 flood.

> The height of the freshet is estimated variously. Some of our older inhabitants think it as high as that of 1796 which was the most extraordinary in the annals of our country–and others think it somewhat lower. A gentleman of our town who remembers the inundation of 96, and has data upon which to estimate the height of the present one, has promised us the result of his examination. *Carolina Planter, June 3, 1840*

> We understand that at the Columbia bridge the river was four feet higher than in 1833. *Carolina Planter, June 3, 1840*

> From the best authorities we learn that at the Columbia Bridge the height of the river was equal to that of 1796–the great Yazoo Fresh, as it was called–a few miles below Columbia the water was lower by two feet–in many places there was a great variation. *Carolina Planter, June 17, 1840*

Inspite of the smaller size of the 1840 flood, however, it caused considerable damage in the floodplains below Columbia, apparently breaching agricultural levees constructed by Wade Hampton.

> The plantations below Columbia for miles were under water–the immense dams at Col. Hampton's and Col. Singleton's were broken, and their whole plantations inundated. All of the Swamp and Creek plantations have been under water–thousands of acres of cotton, corn and oats will be lost. Mr. B.F. Taylor's and Col. Peay's plantations have suffered severely from the current. *Carolina Planter, June 3, 1840*

2.2 Broad River at Blairs

In my October 26, 2000 supplement, some annual peak stages for the Broad River at Blairs were reported incorrectly. Comparisons with peak stages for the Congaree River at Columbia and the Broad River at Blairs produced the corrections included in Attachment 2. The revised table confirms that the peaks for the gauge at Blairs almost always coincide with the peaks for the gauge at Columbia. Note that the source material for these peaks was included in the October 26, 2000 supplement and can be used to verify the table in Attachment 2.

3 Hydraulics

The September 26, 2000 BFEs assume that floods will peak on the Lexington floodway before peaking in Richland County because the peak in Lexington before the levees break will be greater than the peak after the levees break. Thus the Lexington County BFE's were computed as though the levees were intact (though mistakenly at the full height of the 100-year flood–an impossible scenario). In my October 26 appeal supplement, I had pointed out that

a likely flow at which the levees would break would be 140,000 cfs. In in its September 26, 2000 Appeal Resolution, FEMA stated:

> it is evident that the maximum flood elevations for the Congaree River floodplain in Lexington County will occur prior to the breach of Manning's dike. In order to simulate this scenario, the existing conditions model for Lexington County considered no conveyance behind the Manning's dike in Richland County.

Actually, it is *not at all evident* that the maximum flood elevations for the floodplain in Lexington County will occur prior to the breach. FEMA's statement is simple to disprove. In their HEC-2 run for Lexington County (CONGLC2K.OUT), we can look at the flood elevations for a flow very close to the flow at which the levees break–151,300 cfs–to estimate the Lexington County flood elevations immediately prior to the breach. The levee break would occur well before the peak of a 100-year flood ans so we refer to these flood elevations as the First Peak flood elevations. These are compared to the Richland County BFE's at the 100-year flood in Table 1, which should be identical to the Lexington County flood elevations at the 100-year flood (298,400 cfs). These flood elevations occur at the peak flow of a 100-year flood (well after the levee breach) and we refer to them as the Second Peak flood elevations. The conclusion could not be more obvious: the Second Peak flood elevations are consistently more than 3.5' greater than the First Peak flood elevations and FEMA's claim that the First Peak flood elevations would be higher is disproved.

Based on this analysis, there is no need to develop separate BFE's for Richland and Lexington; I recommend that the Richland County analysis can be used to set BFE's for both Lexington and Richland Counties.

4 Hydrology

4.1 Adjustments

In both the FEMA September 26, 2000 analysis and the USGS July 30, 2000 critique, methods are examined for adjusting large historical floods in defiance of FEMA guidelines for applying historical adjustments to watersheds

Table 1: Comparison of Flood Elevations at the Second Peak (levees breached) vs. the First Peak (levees intact) at Study Cross Sections

Cross Section	CONGRC2K.OUT (298,400 cfs)	CONGLX2K.OUT (151,300 cfs)	Height of Second Peak Above First Peak
234100	133.71	130.16	3.55
238900	134.99	131.13	3.86
239800	135.18	131.35	3.83
241500	135.61	131.69	3.92
247000	137.37	133.92	3.45
249300	138.06	134.52	3.54
249590	138.03	134.60	3.43
250770	138.22	134.64	3.58

with no specifically dedicated flood storage capacity. It is reasonable to conjecture that there might be incidental storage and to develop methods for estimating the effect of storage on historical floods. However, if these methods are demonstrably ineffective, then they should not be used and FEMA guidelines should be followed instead.

During the regulated period (1930-1998), there have been four spillway events (1936, 1964, 1965 and 1969), excepting 1930 because of the peculiar circumstances associated with that event. These events allow us to study the effectiveness of historical flood adjustments, since the historical floods (assuming Lake Murray is anywhere near full pool) would also be spillway events.

When we study these events, we see the deficiency of proposed adjustment FEMA Methods (1) and (2) and USGS MOVE.1. Our four spillway events since 1930 are consistently underestimated (and badly underestimated) by all of these adjustment methods (see Table 2).

Both FEMA and USGS are concerned that adjusted flows prior to 1925 (obtained using Methods 3A and 3B) "may be too high". An examination of the 1936 flood shows that these methods are much more reasonable than the other methods proposed, but still over-adjust the unregulated floods. If we invert FEMA Equation (4) to estimate the unregulated flow on the

Table 2: Comparison of measured Congaree River (Columbia) mean daily flows vs. adjusted flows for spillway releases from Lake Murray.

Date	Broad at Richtex (cfs)	Actual Congaree	Adjusted Congaree FEMA (1)	Adjusted Congaree FEMA (2)	Adjusted Congaree USGS MOVE.1
4/8/36	157,000	231,000	196,079	204,360	218,879
4/10/64	99,500	142,000	120,791	123,224	131,989
6/16/65	29,800	68,400	33,563	32,363	34,662
4/19/69	52,700	94,200	61,497	60,902	63,935

Congaree during the 1936 flood for instance, we obtain a value of 245,227 cfs. The unregulated flow, computed by removing the effects of Lake Murray Dam (see my December 14, 1999 appeal) is 239, 819. Thus, the adjustment should have been only 8,819 cfs instead of 14,227 cfs; the input adjusted flow for Methods 3A and 3B over-estimated the adjustment by 61%.

Given the results above, FEMA Methods (1) and (2) and USGS MOVE.1 should not be used further in the analysis. FEMA and USGS can be reassured that Methods 3A and 3B are much more reasonable estimators, though they still use over-adjusted unregulated flows.

4.2 Tropical Storms

Bulletin 17B explicitly states that floods resulting from multiple sources should be modeled separately and that the resulting estimators should then be combined to produce a credible 100-year flood estimate. I used such an approach in my October 26, 2000 report to account for tropical storms, which have generated the six largest documented floods observed on the Congaree River (1852, 188, 1908, 1916, 1928 and 1930). FEMA and USGS have never addressed this issue in their analyses and their estimates are accordingly too small.

One of the estimates (denoted Method 2) used in a weighted estimator endorsed by both USGS and FEMA generates a 100-year flood estimate of only 274,900 cfs. This estimate is smaller than 5 of 6 tropical storm-related

floods in the Congaree's 147-year history and essentially equivalent to the flow for the remaining tropical storm-related flood in 1916. Not only is it smaller than 5 of 6 tropical-storm related floods , but it is *significantly* smaller (25,000-90,000 cfs) than these storms.

It could not be more evident that tropical storms are a special cause of flooding on the Congaree River and any credible analysis must take account of them. Given Bulletin 17B's admonishments on multiple flood events, FEMA needs to develop an analyis in line with Bulletin 17B's guidelines. Failure to do so will result in signficantly underestimated 100-year flows and flood elevations.

4.3 Weighting Estimates

Weighting two 100-year flood estimates was meant to be used to average two reasonable alternatives, e.g., 100-year flood estimates using MOM and MLE on the entire data record, respectively. It was not meant to resuscitate an obviously poor estimate, such as the result of the Method 2 analysis (274,900 cfs). Since FEMA used the Method 2 100-year flood estimate, its resulting flood frequency curve is inconsistent with the historical record.

Though FEMA claims that the weighted frequency curve in Figure 1 (FEMA Report 8-10-00.doc) "is consistent with" the Weibull plotting positions of the flood data, it is obvious from the figure that the curve badly underestimates the six largest floods between 1892 and 1998 (1936, 1912, 1916, 1920, 1930, 1928 and 1908) *even after* floods prior to 1930 have been adjusted downwards. It is especially troubling here that even the large spring floods (in 1936 and 1912) are underestimated by the weighted frequency curve. If all large floods form a distinct population of events, these events should be modeled separately, using the method I outlined in my October 26, 2000 appeal supplement. In the absence of separate modeling, FEMA should discard Method 2 in computing its weighted frequency curve; a weighting of frequency curves computed using data from 1892-1998 and 1852-1998 would be preferable.

Attachment 1–Newspaper references

Attachment 1–The Carolina Planter, June 3, 1840

Carolina Planter.

COLUMBIA, WEDNESDAY, JUNE 8.

EXTRAORDINARY FRESHET.

A most unexpected, rapid and devastating rise in our river took place on Wednesday last—in less than 24 hours, the Congaree "rose 37 feet." On Thursday evening it got to its highest point.

At the Columbia bridge the water was within 16 inches of the floor, and great fears were entertained for its safety—but it has escaped. The Canal banks have been entirely submerged, and the Canal is entirely destroyed. Much Cotton in the ware-houses at the Canal was in danger of being lost, but by activity and energetic exertions, was floated out and saved. The brick yard belonging to the estate of Col. J. G. Brown is still covered with water, and a heavy loss is experienced there. The Mill dam at Cayce's near Granby was swimming—Haugabook swamp covered, the bridges carried away, and impassable, and the Charleston stage obliged to be stopped—the mail being carried on horse-back by way of Platt Springs.

The plantations below Columbia for miles were under water—the immense dams at Col. Hampton's and Col. Singletons were broken, and their whole plantations inundated. All of the Swamp and Creek plantations have been under water—thousands of acres of cotton, corn, and oats will be lost. The destruction of stock is immense, owing to the rapidity with which the fresh came on. Mr. B. F. Taylor's and Col. Peay's plantations have suffered severely from the current. At Col. Hampton's river place, the water covered the high bluff, and rose rapidly to the yard of the negro quarter—the negroes, removed to a high portion of land in time, to save themselves and their house-hold articles—the stock of cattle, sheep and mules were collected on a high dam and saved. His creek plantation as well as the river place was entirely covered, and most seriously injured, but no lives lost at either.

From Mr. Singleton's plantations below, we have had no positive accounts—much of his stock is said to be lost.

The plantations on the opposite side of the river below Granby are seriously injured. Mrs. Taylor had about 300 acres of cotton under water. Gen. Arthur's and Dr. Percival's plantations were entirely submerged.

At Granby on the Columbia side, the boats were on the high bluff which overlooks the river.

We regret to state that a negro belonging to Mrs. Myers of Columbia, was drowned in an attempt to get out a boat from the Canal into the river.

The current at the Broad River bridge passed over the flooring, and some damage was sustained by it; one of the piers being carried away. The Saluda bridge was in great danger, but has not materially suffered.

A large part of the dam of the Saluda Factory was washed away, and the water rose four feet into the [illegible] injuring some of the machinery and

The height of this freshet is estimated variously. Some of our oldest inhabitants think it as high as that of 1795 which was the most extraordinary in the annals of our country—and others think it somewhat lower. A gentleman of our town who remembers the inundation of 96, and has data upon which to estimate the height of the present one, has promised us the result of his examination, as soon as he is able to visit his plantation.

We understand that at the Columbia bridge the river was four feet higher than in 1833.

We have had no particular accounts from above nor below. We fear most disastrous accounts from the Santee plantations.

The Wateree has been very high.

We publish from the Charleston Courier distressing accounts from Hamburg and Augusta.

Attachment 1–The Carolina Planter, June 17, 1840

Carolina Planter.

COLUMBIA, WEDNESDAY, JUNE 17.

FINE MERINO WOOL.

The samples of wool from W. S. Gibbes Esq. of Chester, mentioned in his letter which we publish, are of beautiful staple—the finest and softest we have ever seen. They may be seen at the office of this paper.—

THE FRESHET.

From the best authorities we learn that at the Columbia Bridge the height of the river was equal to that of 1796—the great Yamoo Freeb, as it was called—a few miles belw Columbia the water was lower by twq feet—in many places there was a great variation.

PROSPECT OF FRUIT.

We have a remarkable show of fruit in our gardens. The trees are breaking down with their loads even at this early period.—

OATS CROP.

In our neighborhood the Chinch Bugs and the Freshet have destroyed the entire crops of many planters.—

Attachment 2–Peak Stages for the Broad River at Blairs

Water Year	Date	Peak Stage (ft)	Water Year	Date	Peak Stage (ft)
1905	August 12	10.1	1943	January 30	22.0
1906	January 5	15.6	1944	March 20	25.5
1907	June 2	9.5	1945	September 19	28.8
1908	August 27	31.1	1946	January 9	23.0
1909	June 5	19.9	1947	January 21	22.2
1910	March 2	15.0	1948	February 14	20.5
1911	October 9	10.8	1949	November 30	29.0
1912	March 16	32.4	1950	October 9	21.8
1913	March 16	19.9	1951	December 9	17.3
1914	April 16	11.9	1952	March 5	26.6
1915	January 8	17.4	1953	February 23	20.0
1916	July 16	36.9	1954	January 24	24.0
1917	March 6	18.1	1955	April 15	19.6
1918	January 31	12.9	1956	March 18	20.0
1919	Octobe 27	22.4	1957	April 7	17.6
1920	August 28	22.6	1958	November 21	22.8
1921	February 11	22.2	1959	December 30	18.0
1922	February 16	20.3	1960	February 7	23.2
1923	March 18	20.5	1961	February 25	21.6
1924	January 18	18.4	1962	January 7	23.3
1925	October 1	24.0	1963	March 8	27.5
1926	January 19	17.6	1964	April 9	30.3
1927	February 25	15.4	1965	October 18	31.0
1928	August 17	40.0	1966	March 5	25.0
1929	September 28	25.0	1967	August 25	26.7
1930	October 3	40.0	1968	January 11	20.7
1931	May 22	11.8	1969	April 20	22.5
1932	January 10	19.8	1970	August 12	21.9
1933	October 18	27.8	1971	March 4	23.9
1934	March 5	17.4	1972	June 23	25.5
1935	October 12	26.5	1973	February 3	27.4
1936	April 8	33.8	1974	April 6	22.7
1937	October 18	24.0	1975	March 15	30.4
1938	October 21	21.2	1976	NA	NA
1939	March 1	20.0	1977	October 10	37.0
1940	August 15	31.6	1978	January 27	24.0
1941	July 18	20.0	1979	February 26	24.7
1942	February 19	21.5	1980	March 20	23.3