[redacted]

15 February 2001

Doug Bellomo
Flood Hazard Mapping Technical Services Division
Federal Emergency Management Agency
500 C Street SW
Washington, DC 20472

Dear Mr. Bellomo:

Attached are additional comments forwarded as part of the citizens appeal of the Flood Insurance Rate Maps and Flood Insurance Studies for Richland and Lexington Counties, South Carolina. This material was prepared by [redacted] of the University of South Carolina.

With regards,

[redacted]

University of South Carolina
Columbia, SC 29208

CC: [redacted], SELC

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

February 15, 2001

1 Introduction

This document contains comments on material submitted to FEMA by interested parties between September 26, 2000 and January 2, 2001. FEMA's basic approach is sound and should not be substantially modified on the basis of the new submissions. The analysis conducted by Lockwood Greene and S & ME strays from FEMA's approach and contains serious technical errors.

2 Hydrology

Little additional information on hydrology has been submitted by Columbia Venture since September 26, 2000. Efforts were made to contact SCANA for insights, but SCANA withdrew its assistance and stands by a 100-year flood estimate of 105,000 cfs for the Saluda River at Lake Murray Dam. This would suggest that FEMA's current 100-year flood estimate of 292,000 cfs for the Congaree River at Columbia is too low since the 100-year flood estimate for the Broad River at Richtex is 225,000 cfs. Indeed, the estimate for the Broad River is low since it includes no information from floods before 1926 and has not been adjusted for the smaller watershed at Richtex as opposed to the watershed at the confluence of the Broad River and Congaree River.

The National Weather Service has prepared a draft revision of the E-19 report for the Congaree River at Columbia gauge. They have undertaken this effort given the inconsistencies between the current E-19 report and historic NWS publications. The draft report reaffirms the stage height for the August 1852 flood as 34.4', which makes it the second largest flood on record. I request that FEMA conduct further analyses using this information which is dependable and obviously relevant to determing Congaree Base Flood Elevations.

The report also confirms that NWS used a pre-existing gauge until 1898 and that the pre-existing gauge had the same zero as the 1898 gauge. Given the proximity in time of the 1886 and 1888 floods to 1891, and the other information on those floods I provided on October 26, 2000, the stages for those floods are consistent with the 1852 stages and flood stages since 1891. Alternative analyses using the 1886 and 1888 floods in addition to the 1852 flood should be strongly considered.

3 Hydraulics

3.1 Historical accounts of conveyance

In the October 3, 2000 meeting in Washington, DC, it was suggested by Lexington County council member John Carrigg that levees had been in place since the turn of the century and had not failed prior to 1976. That is incorrect. FEMA has videotape of a 1964 failure and we have previously provided information that levees existed at least since 1840 and that news reports on floods prior to 1891 either refer directly to levee failure or strongly suggest levee failure for all large historical floods.

While we have submitted newspaper articles on 20th century floods that gnerally cast doubt on Councilman Carrigg's claim, I would like to draw your attention to some specific passages from these articles to clarify that substantial and dangeour conveyance below Columbia on the Richland County side is not only possible, it is historically documented fact. In addition to suggesting levee failure, they also support FEMA's contention that conveyance behind the levees in a large flood is substantial.

> Among the largest losses that have been reported are those of Mr. M.R. Spigener and Mr. F.W. Seegers. The land of Mr. Spigener,

which is situated seven miles out of Columbia, is flooded and the loss is said to be in the neighborhood of $10,000...Both the Morris quarry, near Olympia, and the Ross quarry, at Cayce, will sustain serious damage. The Morris quarry is one vast lake. The dams and dykes have been obliterated, tools and machinery are under water and the power house has caved into the water...The dikes at the Ross quarry have held so far but they are giving way now and will go under the increased stage of water that is due. *The State, August 27, 1908*

The swamps of Congaree river below Columbia yesterday resembled a swiftly flowing lake several miles in width, or like an immense river bespecked with trees, houses, tops of corn stalks and broadly beaming unbroken expanses of hurtling muddy water–in short it was like Congaree river on flood...the raging waters, which in many places, though traveling through miles of trees, travel at such rapid speed that progress in a rowboat, with auxiliary paddles, coud not be nengotiated without superhuman effort. *The State, August 18, 1928*

Entering the water at Big lake, about 14 miles below Columbia, on the submerged Bluff road, Doctor Gasque piloted the frail craft approxiamtely 11 miles through woods, swamps and fields–all flooded under water from 20 feet to a few inches deep...Afterward, battling a swirling current that at times threatened to carry them away from their objective...Eaves of houses in the section were lapped by the waters, with more water to come from Colubmia and above. Live stock, farm animals, hogs and chickens, with innumerable rabbits thrown in for wildness sake, were reported floating along helpless or drowned...the loss among livestock will be large and all crops are ruined. *The State, October 4, 1929.*

3.2 Effective Flow

Though FEMA considers specific failure scenarios to support their decision to move the floodway off the Manning levees, it wisely uses modelling approaches that are not tied to specific failure scenarios when determining an

area of effective flow. While FEMA looked at RMA-2 models with hypothetical failures, the map of effective flow areas (Figure 6 in their September 26, 2000 Appeal Resolution) is based on an RMA-2 model with levees removed. This assumption is mandated by FEMA's regulations on uncertified levees. The practice of modeling the floodway based on an equal conveyance approach is, as a matter of flood management policy, far more responsible than encouraging floodway encroachments based on conjecture as to how, when and why a "system" of uncertified and improperly maintained agricultural dikes will fail. And these levees will fail–even Columbia Venture has now conceded this point (which it earlier did not). Given the certainty of failure, it would be irresponsible and instiutionally reckless to encourage risk of property and life by artificially narrowing the floodway boundaries on optimistic assumptions of precisely how the levees will wash away. The approach FEMA used in the September 26 appeals resolution, in addition to being mandatory and consistent with FEMA's governing statutes, represents sound public policy that must not lightly be abandoned.

FEMA's definition of area of effective flow is actually quite restrictive in this case. It is true that FEMA used a high flow (though 364,000 cfs is only modestly higher than the 330,000-340,000 cfs that would be a more typical point estimate of a 100-year flood), but this is out-weighed by the decisions to use 1 foot per second as a cut-off for effective flow and to use area of effective flow rather than the entire floodplain as the basis for setting floodway boundaries. Both of these decisions markedly decrease the size of the delineated floodway to an area smaller than that which will experience dangerous and destructive conveyances.

Columbia Venture consistently tries to tie decision-making to specific failure scenarios and this approach leads them astray in specific instances. On page 4 of Lockwood Greene's October 26 appeal information, they state that

> The steady state RMA-2 model results have been misinterpreted. FEMA interpreted the steady state model velocities greater than 1 foot per second north of I-77 as effective flow, but the model simply shows that the area is filling. This is confirmed by the following facts taken from the double piping breach scenario...

Lockwood Greene refers to the modeling used to develop Figures 7 and 8 in FEMA's September 26, 2000 report. In that report, however, FEMA

states quite clearly that the areas of effective flow were determined using the model that generated Figure 6. In Figure 6, the vast majority of the Richland County floodplain has velocities greater than 1 foot per second. FEMA *did not* misinterpret its own graph; Lockwood Greene referred to the wrong graph.

3.3 Levee Reliability

The two-failure scenario also leads S&ME astray when computing the reliability of the levees. Their reliability calculation takes into account only the six sections of the levees most recently tested and again relies on the two-breach scenario. Before examining their reliability calculation, I would first like to discuss the assumption that levee failures are independent.

There is evidence to suggest that levee failures are independent and evidence to suggest that levee failures are dependent. Both FEMA and Columbia Venture has mentioned that a failure in one area of the levee makes failures in other areas less likely because the water that fills in behind the levees helps to stabilize them. This suggests that levee failures are negatively correlated. The experience of 1976, in which the upstream levee break contributed to the downstream levee break, suggests that failures may be positively correlated. Finally, the geotechnical review dated July 12, 2000 provides an argument on the localized nature of levee behavior that supports independence. The reviewer states that

> Because of local variations in condition of the foundation and embankment soils, even within a single identified soil stratum, it is probable that failure would be rather localized, as in the 1976 failures, and would not extend over a great length of levee.

Regardless of the above discussion, we can take S&ME's assumptions at face value but apply them to the entire levee. The July 12, 2000 technical review by an independent experet contacted by FEMA identifies 10 questionable sections of the levee. S&ME's reliability curves are constructed for an idealized levee, but even so the chance of failure on the surveyed sections is typically 20%-30% for a 292,000 cfs flood. We can compute the probability of at least one failure and the probability of two or more failures assuming that failures for each of the 10 questionable sections are equally likely.

Table 1 contains these calculations assuming three different common failure probabilities of 20%, 25% and 30% for the 10 levee sections.

Table 1
Failure probabilities assuming a common failure rate for each of 10 questionable levee sections in a 100-year flood

	Common failure rate		
	20%	25%	30%
Probability of 1 or more failures	.89	.94	.97
Probability of 2 or more failures	.62	.76	.85

These failure probabilities are quite high and could be even higher if we included *all* levee sections and not just the most questionable sections. The failure probability S&ME associates with the levee section at the Waste Water Treatment Plant (80%) suggests that the failure probabilities in Table 1 could be higher still.

S&ME considers only the sections of the levees that FEMA included in its two-breach scenarios and made the additional assumption that exactly one failure would occur in the upper section and exactly one failure would occur at the lower section. There is no reason to consider only this single scenario when making reliability calculations; taking account of all the questionable levee sections, I would conclude that the probability of two or more failures is highly likely. In any event, the events of 1976 stand in flat contradiction to S&ME's notion that multiple breaches are unlikely.

4 Additional remarks

4.1 City and County resolutions

West Columbia, Cayce and Lexington passed resolutions that stated they were basically satisifed with the current floodway and supported the use of the Lexington BFE model to construct floodway boundaries provided it did not affect the current floodway lines. Since the current floodway was constructed using the Richland County BFE model (which assumes the levees *will* not stay intact), use of the Lexington BFE model (which assumes the levees *will* stay intact) would increase the size of the floodway considerably; it could well place structures currently outside the floodway *in* the floodway.

The resolutions can only be read to mean that these entities are satisfied with the floodway boundaries as drawn on the September 26, 2000 maps–not that they endorse a methodology that would change those boundaries (as incorrectly stated by Columbia Venture to FEMA). The resolutions quite clearly endorse a certain model only if that model produces the floodway boundaries shown on the September 26 maps.

4.2 Criteria for Model Selection

In a document submitted January 2, 2001 entitled "Most appropriate floodway HEC-2 model for Lexington County", Lockwood Greene states that since the Richland County HEC-2 and RMA-2 models do not calibrate with each other as well as the Lexington County HEC-2 and RMA-2 models, the Lexington County model should be used for BFE and floodway computations. The USGS, in its October 26, 2000 report, addequately explains the incongruities. Regardless, model choice should not be based solely on calibration agreement between HEC-2 and RMA-2 models. FEMA should select the floodway model that will accurately and safely map the regulatory floodway in Lexington County consistent with FEMA practice and policy.