Appeal of Technical Information from FEMA presented 26 September 2000

26 October 2000

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SCHEDULE

■ Preparation Time

- FEMA changed the method of analysis from entirely HEC-2 based to RMA-2 and HEC-2 combination. The RMA-2 is a specialized model that requires significant review time. We have not had opportunity to thoroughly review and comment on the RMA-2 models in a 30-day period

- HEC-2 models and resulting mapping are completely different; therefore, extended review is required. Also the HEC-2 models were significantly revised by FEMA on 18 October 2000 We have not had opportunity to thoroughly review and comment in a 7-day period.

FLOODWAY DETERMINATION

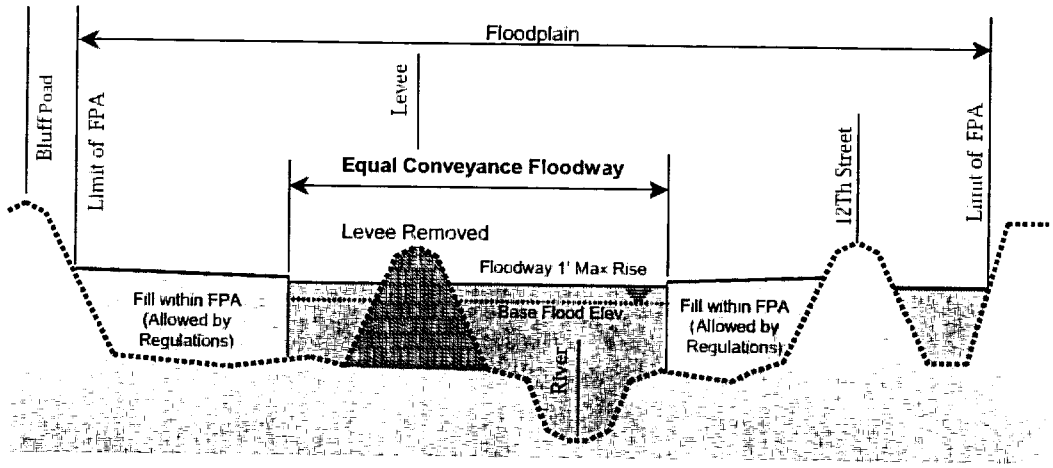
■ FEMA Floodway

- By using the Richland County HEC-2 model (levee out) for floodway determination increases the risk of flooding.

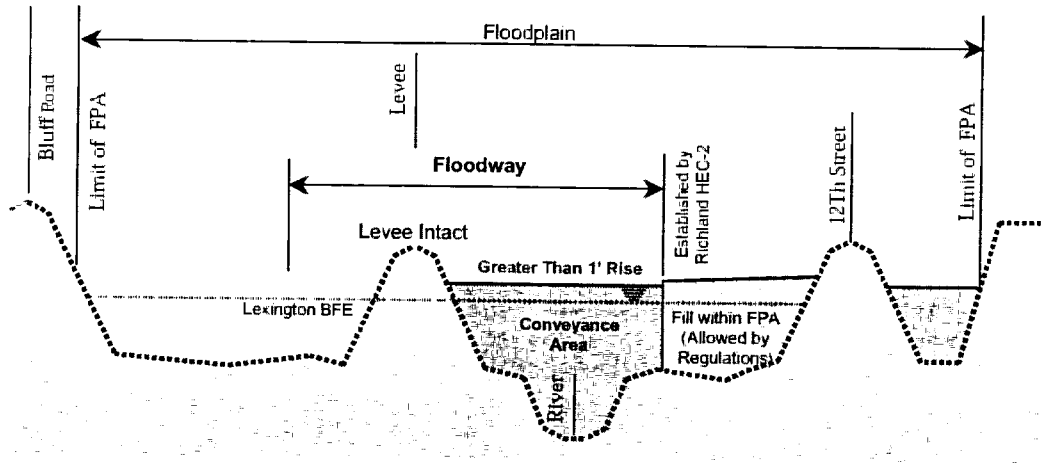
- FEMA's currently proposed floodway assumes a condition that may not occur, as described below

  - Flow conveyance occurs for full width of floodway.
  - Levee is removed as a barrier or impediment to flow by the floodway.
  - Richland and Lexington Counties are developed (new construction) to floodway limit.

See the following illustrations



- The highest potential for flooding exist when:
  - The levee remains intact as barrier to flow.
  - Lexington is fully developed (new construction) to the floodway limit.
  - Flow does not occur for the full width of the floodway.



- In order to maintain 1' maximum surcharge Lexington floodway should be set with levee intact. Use the Lexington HEC-2 model (levee in) for Lexington County Floodway.

HYDROLOGY

■ General

- The Lake Murray 100-year discharge flow rate of 22000 to 25000 cfs presented from Mr. Neville Lorick of SCANA was not included into FEMA's calculation for the 100-year flow rate.

- Use the soon to be provided (by SCANA) Lake Murray routing in the computations of the 100-year flow rate on the Congaree River at Gervais Street.

GEOTECHNICAL EVALUATION

■ General

- Refer to the geotechnical evaluation prepared by S&ME that indicates the probability of levee failure.

- The probability of levee failure is low based on US Army Corps of Engineers technical procedures.

- The probability of a double breach scenario is unlikely.

2-D MODEL (RMA-2)

■ General

- The FEMA RMA-2 model is run as a steady state model, and the results indicate a "snap shot" in time. This particular method does not account for breach or failure occurring over time, hydrograph (inflow) duration, and constantly varied quantity of water filling the area. The RMA-2 model must be run as a time varied model to obtain accurate results.

- 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 (refin geo and refin129.sol) at 292,000 cfs.

- Velocities greater than 1 fps are only located at the FEMA imposed breach locations and the I-77 bridges.
- Velocities that are greater than 1 fps are generally perpendicular to the Congaree River at the south breach.
- Areas approaching the I-77 bridges in Richland County have velocities less than 1 foot per second. Velocities only exceed 1 foot per second passing through the bridges.
- Richland County downstream of I-77 has velocity less than 1 foot per second. See Figure 2.

- The steady state model indicates a double breach scenario. Refer to the S&ME prepared geotechnical evaluation that indicates that this occurrence is highly unlikely

Geometry

- The geometry mesh should extend upstream from the point of interest (levee) including left and right overbanks. Expand the mesh to include topographic information from the high ground north of the boat ramp and existing levees along both quarries. The lack of mesh in this area impacts the model results at the most northern portion of the levee. The geometry mesh must be expanded a sufficient distance to prevent boundary conditions from influencing the results near the levee. Please refer to the previously submitted Lockwood Greene aerial photograph.

- Gills Creek is not modeled correctly in the mesh geometry Please refer to the previously submitted Lockwood Greene topographic information.

- The existing levee circling north and south of Gills Creek is missing from the mesh geometry. Please refer to the previously submitted Lockwood Greene topographic information.

- The existing levee separating levee section 1 from levee section 2 is missing in the mesh geometry. Please refer to the previously submitted Lockwood Greene topographic information

- The area surrounding the City of Columbia WWT facility (noted as Area 1 on Figure 1) is indicated as a wet/dry boundary, but this may not be appropriate since grade at the wastewater treatment plan varies from 127 – 140 feet in elevation. Figure 1 taken from the FEMA provided double piping breach scenario (refin.geo and refin129.sol) files indicate that the water level is approximately 131 to 133 feet; therefore, portions of the area should be excluded from the wet/dry boundary.

- The wet/dry boundary located north of Heathwood Hall (noted as Area 2 on Figure 1) is not appropriate since elevation in that area is approximately 130 feet based on the USGS map (topographic survey is not available) Figure 1 taken from the FEMA provided double piping breach scenario (refin.geo and refin129.sol) files indicate that the water level is approximately 137 to 134 feet, therefore, the area should be excluded from the wet/dry boundary The removal of this wet/dry boundary will reduce the velocity in the northern area of the levee interior.

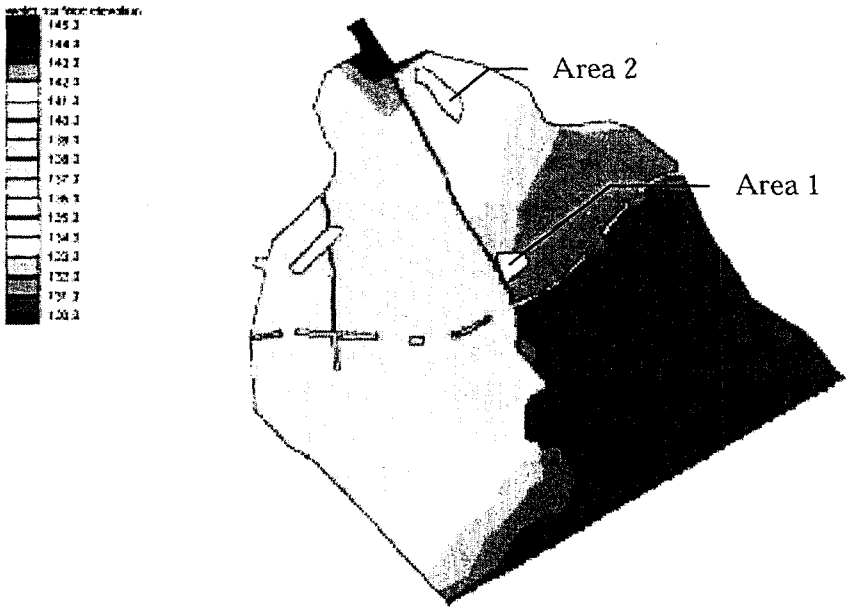


Figure 1 – FEMA Hydraulic Grade Elevation

- The FEMA prescribed breach on the northern most levee is blocked by an existing cellular or looped levee. The interior levee forms a cell around the breach. The top of this existing interior levee ranges from elevation 136 (in one narrow location) to elevation 141 in most locations. Please refer to the previously submitted Lockwood Greene topographic information.

Velocity and Effective Flow

- On page 19 of the "Appeal Resolution for Congaree River in Richland and Lexington Counties, South Carolina" document, effective flow behind the levee is defined as water velocity greater than 1.0 foot per second. Figures 2 and 3 taken from the FEMA provided double piping breach scenario (refin.geo and refin129.sol with Q=292,000) files indicate that the water velocity is less than 1 foot per second south of I-77; therefore, portions of the area should be defined as ineffective flow. In fact the areas north of I-77 cannot be considered effective flow when it does not pass through the downstream portion of the property as effective flow.

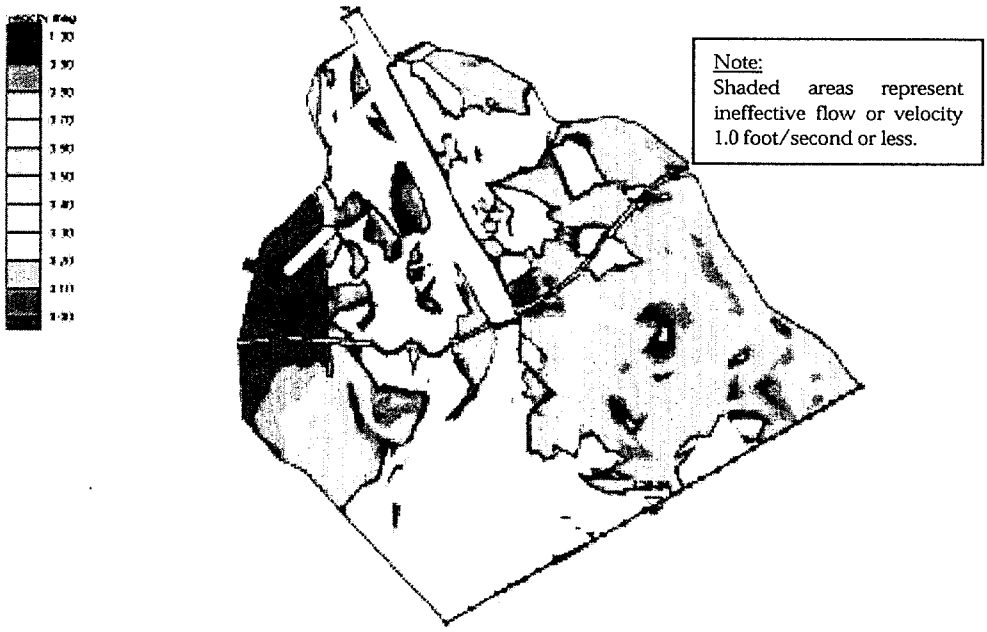


Figure 2 - Velocity Less Than 1 Foot per Second at Q = 292,000 cfs

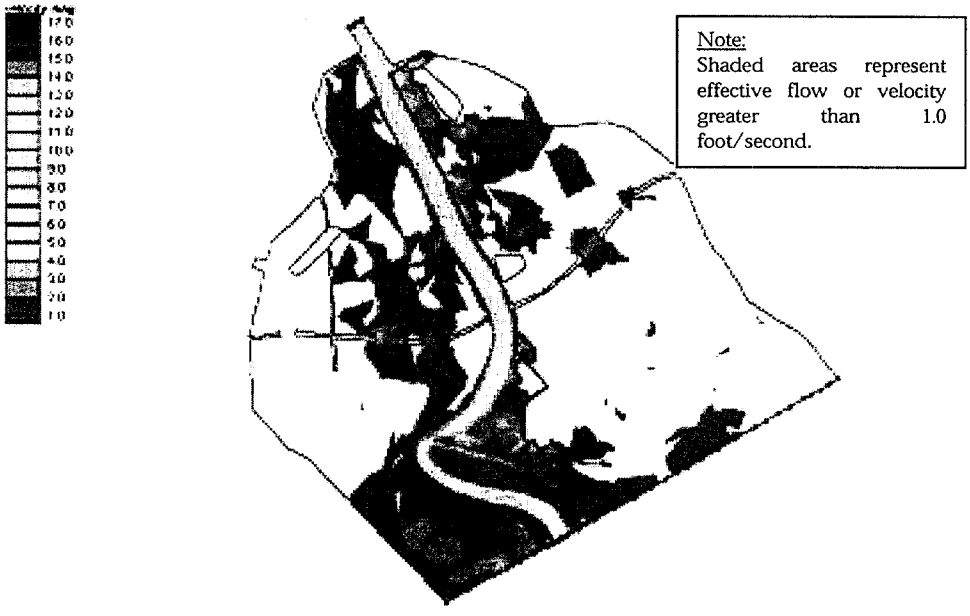


Figure 3 - Effective Flow, Velocity Greater Than 1.0 Foot per Second at Q= 292,000 cfs

■ Boundary Conditions

- Boundary flows are not present for Gills Creek or Congaree Creek. Omitting this information may change RMA-2 model results. Evaluations of the flow additions are difficult to predict since the points of addition are on the fringe of the floodplain and controlled by backwater from the Congaree River.

■ RMA-2 Summary

- Model needs to have several corrections made, but calibrates fairly well with the Lexington HEC-2 model
- Corrections to RMA-2 model will improve calibration with Lexington HEC-2. See the following section.
- Flows in Richland County are ineffective south of I-77 and are ineffective in specific areas north of I-77

HEC-2 MODEL

■ Methodology

- Page 7-4 of FEMA 37 states that the equal conveyance reduction method is to be considered "if technically appropriate." This particular section for FEMA 37 appears to be written for small un-certified agricultural levees. The existing Manning levee exceeds the 100 BFE and in some locations exceeds the 500-year elevation. In this case the floodway in Lexington County should be established per the same method as the BFE, which uses the levee in-place.
- FEMA has ignored the existing levees along Gills Creek and the levee separating section 1 from 2. These levees cause water to be retained within the site producing ineffective flow interior to the existing levees. In this case FEMA has under estimated the BFE in Richland County since the water will pool to the same elevation as the outside of the levee The Richland County BFE will equal the Lexington County BFE once the levee area fills with water.

BFE Comparison

- BFE correlations between the RMA-2 and Richland HEC-2 model are poor. See the following BFE comparison table.

Table 1					
HEC-2 Station	Approximate 100 Yr WS Elevation				
	RMA-2		Richland HEC-2[1]	Difference	
	@ Levee	@ Bluff		@ Levee	@Bluff
253400 - E	137.0	133.5	140.0	3.0	6.5
249300 - D	135.0	132.0	138.0	3.0	6.0
246700 - C	133.0	132.0	137.5	4.5	5.5
234100 - B	130.5	130.5	134.5	4.0	4.0

The Richland HEC-2 model consistently yields a result 3.0 to 6.5 feet higher than the RMA-2 model for Richland County.

- BFE correlations between the RMA-2 and Lexington HEC-2 model are more consistent. See the following BFE comparison table:

Table 2			
HEC-2 Station	Approximate 100 Yr WS Elevation		
	RMA-2 @ Levee	Lexington HEC-2	Difference
253400 - E	142.5	142.0	0.5
249300 - D	140.0	141.5	1.5
246700 - C	138.5	140.0	1.5
234100 - B	135.0	135.5	0.5

- The Lexington HEC-2 model appears to approximate the RMA-2 model results, therefore, the Lexington HEC-2 model is the appropriate model to use for BFE and floodway computations.

- The RMA-2 model yields higher 100-year flood elevations on the Lexington side of the levee versus the Richland side. This indicates that the floodway is not split equally about the levee; therefore the floodway should not be computed per the equal conveyance method.

[1] From 26 September 2000 Richland County FIRM map.

Geometry

- The RMA-2 model prescribes a 2-breach scenario where water may enter (or exit) the levee interior. The Richland HEC-2 model does not use the levee to restrict the movement of water. In the unlikely event of a 2 breach scenario the remaining levee would affect water movement. The Richland HEC-2 model should follow the same assumptions as the RMA-2 model.

- Because the assumptions are not consistent between the two models the Richland HEC-2 model provides unrealistic output

  - The Richland HEC-2 model has an increase of flow on the left overbank (Richland County side) that does not correspond to the location of the breach. This is not physically possible based on the assumptions of the RMA-2 model. Also the Richland HEC-2 model has a decrease of flow on the left overbank just before the I-77 bridges that does not correspond to a breach location. See the following comparison

Table 3

HEC-2 Station		RMA-2 Breach Location	Richland HEC-2 Left Overbank[2] Flow (cfs)	Change
	254500	none	0	-
E	253400	120' Wide	42629	Increase
	250770	none	75515	Increase
	249590	none	99585	Increase
D	249300	none	95088	Increase
	248200	120' Wide	114418	Increase
	247200	none	114092	Increase
	247000	none	109637	Decrease
C	246700	none	179583[3]	Increase
	246000	none	141602	Decrease
	245800	none	136984	Decrease

[2] Left overbank represents the area outside the channel in Richland County per HEC-2 definitions.

[3] Left overbank flow rate exceeds quantity in channel (Congaree River).

Table 3				
HEC-2 Station		RMA-2 Breach Location	Richland HEC-2 Left Overbank[2] Flow (cfs)	Change
	243000	none	96998	Decrease
	242440	none	80480	Decrease
Bridges	I-77 Bridges 242241 thru 242049	none	33992	Decrease
	241850	none	59742	Increase
	241500	none	57205	Increase
	239800	none	73674	Increase
	239370	none	96109	Increase
	238900	none	101246	Increase
B	234100	none	66336	Decrease

Flow can only be added or removed from the levee interior at breach locations. In fact the quantity of flow at cross sections 246700, 246000, and 245800 exceed the flow in the main channel of the Congaree River. The I-77 bridges constrict flow down to a maximum flow rate of 33992 cfs.

- Conclusion: Flow can only enter or exit the levee interior at a breach location. According to the Richland HEC-2 model only 33992 cfs can pass through the I-77 bridge openings in Richland County. The Richland HEC-2 model is not representative of the breach assumptions.

Boundary Conditions

- Flow rates behind the levee from the two models are not consistent.
  - The Richland HEC-2 model indicates a flow rate behind the levee varying between 22894 cfs to 179583 cfs See the Table 3 above.
  - Lockwood Greene prepared independent calculations based on the geometry and head conditions of the FEMA RMA-2 northern breach (120' wide) that indicates a flow rate of 15900 cfs. The southern breach (120' wide) yielded a flow of 10400 cfs. The

combined total flow through the two breaches is 26300 cfs. See Figures 3 and 4 for rating tables of the breaches.

Table 4					
Breach Location	Width	Headwater Elevation (from RMA-2)	Tailwater Elevation (from RMA-2)	Breach Bottom Elevation (from RMA-2)	Flow (cfs)
North	120'	143	135	127.6	15900
South	120'	140	135	128.2	10400
Total					26300

- It appears that the HEC-2 maximum capacity (22894 cfs) of the I-77 bridges in Richland County approximately matches the breach assumptions (26300 cfs) on the RMA-2 model.

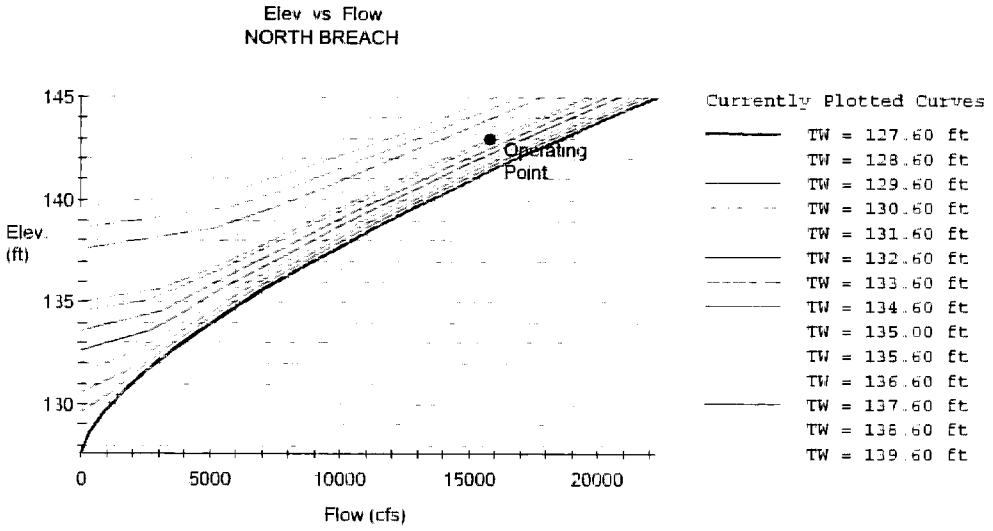


Figure 4 - North Breach Rating Curve

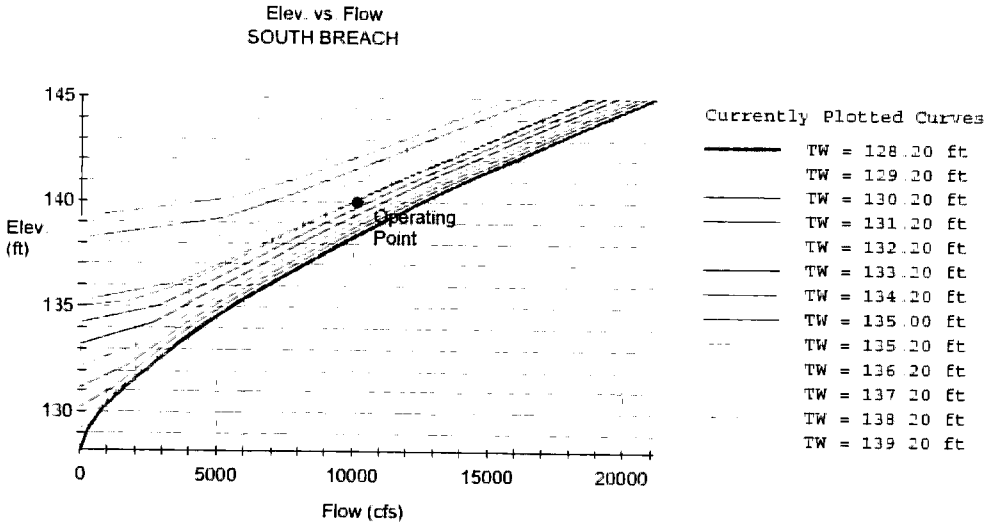


Figure 5 - South Breach Rating Curve

HEC-2 Summary

- FEMA should use consistent assumptions and input between the RMA-2 (2D) and HEC-2 (1D) models Flow can only enter or exit the existing levee interior at breach locations In the unlikely event of a double breach scenario the remaining levee will affect flow.

- Equal conveyance reduction for floodway determination is not appropriate based on RMA-2 results. The presence of the levee (even if a breach occurs) and physical constraints of the existing I-77 bridges makes equal conveyance inappropriate.

- Flow entering the levee interior is limited by two breaches and the quantity that can pass through the I-77 bridges.

- The Lexington (levee in-place) HEC-2 BFE model is the most appropriate model to establish floodway in Lexington County.

SUMMARY

- FEMA hydrology computations do not include the information provided by SCANA concerning Lake Murray and the forthcoming Lake Murray routing computations should be included in FEMA's evaluation.

- The S&ME prepared geotechnical evaluation indicates low probability of levee failure. The probability of a double breach levee failure is unlikely.

- The FEMA RMA-2 model is run as a steady state model, but the model should be run as a time varied model to obtain accurate results.

- When wet/dry boundaries are set properly ineffective flow area will increase in Richland County and calibration will become better with Lexington HEC-2 model.

- The levees around Gills Creek and the levee separating levee section 1 from 2 are missing in the RMA-2 model If these existing levees were added it would help calibration with the Lexington (levee in scenario) HEC-2 model.

- When a flow rate of 292,000 cfs is used most of Richland County becomes ineffective flow area based on the RMA-2 model. This forces the BFE for Richland and Lexington to be equal.

Evaluation of the impact of the above on the HEC-2 model has not been made because of time constraints impose for review of the information. It is anticipate that consideration for the above items will have significant effect on the HEC-2 modeling. The effect of the above comments has been ignored in the evaluation of the HEC-2 models as present in this report and summarized below

- Assuming the 2 breach scenario flows used in the Richland County HEC-2 model do not provide an accurate representation of the actual flows.

- Equal conveyance reduction is not technically appropriate for determination of the floodway because it ignores the obstruction provided by the remaining levee.

- Lexington HEC-2 model is most appropriate to use for floodplain and floodway modeling in Lexington County.

Evaluation of the HEC-2 model is continuing and a revised Richland County model will be provided when complete.