



February 13, 2001

[REDACTED]
Lockwood Greene Engineers
Post Office Box 491
Spartanburg, SC 29304

Re: Relative Probability of Failure of Levees given in Cases 1, 2 and 3
in Exponent, Inc. Report
Green Diamond Development, Columbia, SC
S&ME Project No. 1611-00-937

Dear [REDACTED]

As requested by [REDACTED] in your office, we have reviewed a copy of a report prepared by Exponent, Inc., titled "EXPANDED TWO DIMENSIONAL FLOW ANALYSIS AND DETERMINATION OF NO FLOODWAY FOR THE CONGAREE RIVER FLOODPLAIN IN RICHLAND COUNTY, SOUTH CAROLINA", dated February 12, 2001. We have compared the scenarios used for breaching in this report to those identified in our October 25, 2000 report which addressed the relative reliability at different points along the levee against a piping type failure at the 100 year Base Flood Elevation (BFE). BFE elevations differ from the ones we used in October since the new analyses use the RMA-2 model.

Exponent has analyzed flood velocities within the protected areas of the current levees using five scenarios of breaching of the levees for a flood having a flow of 292,000 cfs. Cases 4 and 5 of the Exponent scenarios are variations of the other three, and thus the five scenarios resolve into only three:

- Case 1 – breaches are located at positions "A", "C" and "D"
- Case 2 – breaches are located at positions "B", "C" and "D"
- Case 3 – breaches are located at positions "A", "B", "C" and "D"

Breach position "A" used by Exponent corresponds roughly to Cross Sections 1A through 6 we used in our letter of October 25, 2000; however, their BFE elevation is higher than we used in our report. From a review of our previous computations, the probability of the seepage gradient exceeding the critical value of 1.0 is approximately 28 percent at this elevation at Cross Section 3, thus the "worst case" reliability (non failure) of any of these sections for a flood at 144 feet is 72 percent.

Breach position "B" by Exponent corresponds to anywhere between cross sections 11 through 17 in our October 25, 2000 report. Since Cross Section 11 provided the lowest reliability against piping in this reach, we have assumed that section to represent Position "B". The BFE used is approximately the same, 142 feet. At this elevation Cross Section 11 has a probability of failure (via piping) of 32 percent, or a reliability of 68 percent.

One of the conveyance formulations presented by Exponent was based on formation of two breaches simultaneously at positions "A" and "B" in the portion of Levee Section 1 north of the wastewater treatment plant. To evaluate the probability of breaches occurring in both locations simultaneously during a single flood, we first defined the reliability of the levee reach defined by cross sections 1A through 6, and the reach defined by cross sections 11 through the WWTP, to be the lowest reliability value obtained

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for any of the individual reliabilities of the 3 to 4 cross sections analyzed for seepage gradient in each reach at the 100 year BFE. Reliability is defined as unity minus the probability of failure. The probability of at least one breach occurring at any location, in both reaches at the same flood stage, is thus $\{1 - (1 - P_{rA})\}$ times $\{1 - (1 - P_{rB})\}$. A probability of failure of 28 percent at "A" times 32 percent at "B" results in a combined probability of failure of approximately 9 percent for the RMA-2 100-year BFE.

The probability of one or the other of the sections failing, but not both, during a single flood event is the product of the reliabilities of the two sections, or $\{1 - P_{rA}\}$ times $\{1 - P_{rB}\}$. Considering Breach "A" (reliability 72 percent) and Breach "B" (68 percent) the joint reliability (non failure) is 0.72×0.68 equals 50 percent.

The 9 percent probability of two breaches occurring does not take into account the reduced potential for piping occurrence in the event that a tailwater condition exists landward of the levee once a breach has occurred. Reduction in net head across the levee due to ponding on the landside would greatly reduce the exit gradient and potential for formation of seepage erosion channels. If a breach formed on the levee near the wastewater plant and water were to pond behind levee cross sections 1A through 6 to a depth of 3 to 5 feet (to elevation 130), for example, the probability of a second breach forming at the north end of the protected area would be reduced to about 2 percent

Ranking the three cases by Exponent in terms of their relative probability of piping failure is as follows:

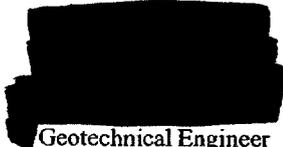
CASE 2 only	32 percent chance
CASE 1 only	28 percent chance
CASE 3 (Both Case 1 and 2)	9 percent chance

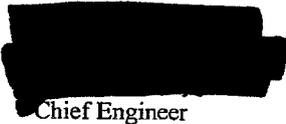
The reliability analysis above suggests a the probability of two widely separated breaches forming in the Manning Levee where it fronts the Congaree River during the 100 year BFE is about five times less than formation of only one breach at one or the other locations. While two breaches were observed in the City of Columbia levee in 1976, we feel that the second breach, which formed at a penetration, was due to poor backfilling around the conduit when the treatment plant was built about 1970.

Please call if you have any questions.

Very Truly Yours,

S&ME, Inc.


Geotechnical Engineer


Chief Engineer