ATTACHMENT 7C

AGRICULTURAL RISK AND UNCERTAINTY ANALYSES
YAZOO BACKWATER AREA, MISSISSIPPI

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AGRICULTURAL RISK AND UNCERTAINTY ANALYSES

GENERAL

1. Risk and uncertainty are intrinsic values in water resources planning and design. These values arise from measurement errors and from the inherent variability of complex physical, social, and economic situations. Agricultural analyses of proposed water resources projects contain unique risks and uncertainties that arise from numerous variables and complex independent and dependent relationships. Determining the "true" values of all the variables and relationships to derive a single mean value (average value) is an ambitious, if not impossible, undertaking. By incorporating risk and uncertainty into the agricultural analyses, a complete display of all possible outcomes can be derived along with the expected mean or average value. The results reflect a range of values (variation) with the relative likelihood of occurrence.

2. The economic evaluation of the Yazoo Backwater Area was conducted utilizing the risk analyses procedures described in Engineer Circular 1105-2-100, "Planning Guidance Notebook" (22 April 2000), and Engineer Regulation 1105-2-101, "Risk Analysis for Flood Damage Reduction Studies" (22 April 2000). These procedures, along with traditional methodologies, were chosen as the most effective means of evaluating the uncertainty in agricultural analyses. To grasp the incorporation of agricultural risk and uncertainty, it is meaningful to first understand the traditional agricultural analyses procedures and relationships involved. The following section is an overview of traditional agricultural analyses.

TRADITIONAL AGRICULTURAL ANALYSES

3. The traditional analyses involve gathering pertinent data, applying an agricultural flood damage model, determining average annual acres flooded, projecting damages, and comparing without- and with-project conditions, as also described in previous paragraphs. The following tasks and evaluations are essential to assess existing conditions and estimate conditions with the installation of proposed water resources improvements.

a. Determine present and future without- and with-project cropping patterns, crop distributions, farming practices, yields, and gross and net returns per crop. These data are derived from surveys of area farmers, extension agents, agronomists, soil scientists, Federal Crop Reporting Service personnel, and other local, state, and Federal agricultural personnel.

b. Develop area-specific crop budgets for without- and with-project conditions. Current State of Mississippi extension crop budgets are adjusted by the area-specific data described in the Economic Analysis Appendix.

c. Derive daily routings data (historical period-of-record hydrologic data and flooded acres on a daily basis) for without- and with-project conditions. The entire flood history is applied, which, in this analysis, records 55 years of daily historical stages. Time of year (i.e., seasonality) of flooding is critical to more accurately estimate crop damages.

d. Calculate per-acre flood damages for without- and with-project conditions. A computer model developed jointly by the Department of Agricultural Economics, Mississippi State University, and the U.S. Army Corps of Engineers, Vicksburg District, to quantify agricultural crop flood losses was employed. The Computerized Agricultural Crop Flood Damage Assessment System (CACFDAS) utilizes historical daily flood routing data, current budget data, present cropping patterns and production techniques including replanting and substitution, as well as other relevant data to assess damages to crops. Output from the CACFDAS program includes acres flooded for the historical period, total damage by crop, and damage per-acre flooded. (Refer to the Economic Analysis Appendix for a description of the CACFDAS program for a more detailed explanation of program output.)

e. Determine the average annual cleared acres flooded for without- (existing) and with-project conditions. Average annual acres flooded are determined through integration of elevation-area (stage-area) flooded and partial duration elevation-frequency (stage-frequency) curves and computation of the area contained by the resulting area flooded-frequency curve.

f. Compute agricultural benefits from a proposed water resources plan of improvement. Two categories of agricultural benefits exist: flood damage prevented (inundation reduction) benefits derived from the reduction in flood damages, and intensification benefits that occur when a plan enables improved utilization of the land and increases net income. Numerous acreage and other adjustments are made during the computation of agricultural benefits. Some of these adjustments include adjustments to appropriately account for farmed wetland acreage, low-lying cleared acreage, and other land removed from production; adjustment to exclude land in the Conservation Reserve Program; the Wetlands Reserve Program; and adjustments to net returns per acre.

AGRICULTURAL RISK AND UNCERTAINTY ANALYSES

4. It is evident from the data presented above that numerous variables and complicated relationships are involved in the procedures necessary to quantify existing agricultural crop flood losses and proposed plan improvement benefits. Although detailed and thorough area-specific

data enumerations were conducted, state-of-the-art computer models applied, and utilization of knowledge of scores of agricultural experts, uncertainties remain. (Perfect knowledge is never obtainable.) The application of risk analyses in the evaluation of agricultural benefits is not only the acknowledgement of these uncertainties, but the willingness to quantify these uncertainties.

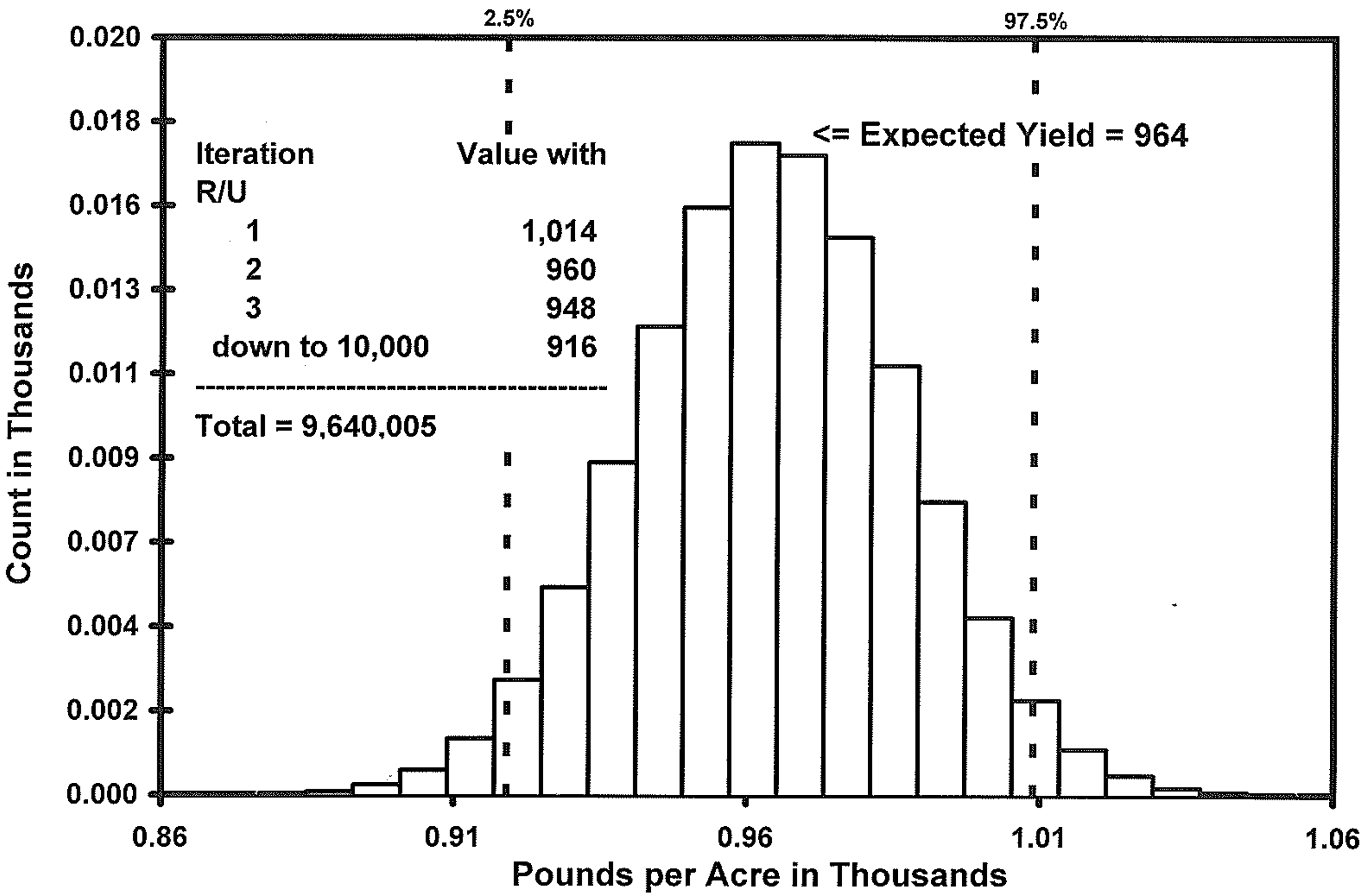
5. With new technology, including the computer software program @Risk, economists along with hydrological experts can deal statistically with the risk and uncertainty that was previously not attempted in traditional agricultural flood damage analyses. Risk-based analyses incorporate risk and uncertainty into the calculation of agricultural damages by using a simulation technique in which multiple iterations select from the full range of possible values for selected key variables utilized in the computation of proposed plan benefits. The resulting mean (average) value and probability distributions provide the decision maker (customer) with a more complete analogy of possible results.

6. The analyses are accomplished by considering the range of possible values (maximum and minimum values for each selected input variable in the flood damage calculation) and distribution of the occurrence of outcomes over the specified range. The @Risk program uses Monte Carlo simulation to derive the possible occurrences. Monte Carlo simulation utilizes randomly generated numbers to simulate the occurrences of selected variables from established ranges and distributions. In a normal distribution, 68 percent of the occurrences of a specified result would be within one standard deviation (on either side) of the mean or expected value, 95 percent within two standard deviations (on either side) of the mean, and 99.7 percent within three standard deviations (on either side) of the mean.

7. The computerized Latin Hypercube sampling technique is utilized to sample from within the range of values. With each sample or iteration, a value is selected from the random number generator system contained within the computer. For example, if mean cotton yield of 964 pounds is allowed to vary, the first sample may be 1,014 pounds, the second sample 960 pounds, etc. (Figure 7C-1). The range of potential values varied from a minimum of 876 pounds to a maximum of 1,053 pounds, with each specific iterative value determined by the random number generator system. Each value is utilized through the total computational process to derive the proposed project benefits. The sum of all sampled values divided by the number of samples yields the expected mean value. This routine is accomplished simultaneously for each of the variables evaluated for its inherent uncertainty.

8. The risk and uncertainty analysis includes not only the mean estimate that is the expected result (or the most likely occurrence of a variable), but also the range of potential outcomes for that variable and the distribution of potential outcomes over that range. The results reflect the magnitude of rare and unlikely combinations of possible values that affect project formulation.

Figure 7C-1
Cotton Yield Uncertainty
Yazoo Backwater Area, Mississippi



9. Some of the key variables in agricultural flood damage reduction evaluations include crop yields, production cost, crop distributions, seasonality of flooding, plant yield loss due to flooding, crop prices, and crop acres flooded. Crop yields and the damage per acre flooded value from the CACFDAS program were selected to evaluate the risks and uncertainties within this agricultural evaluation. These two variables capture a large portion of the uncertainty in quantifying agricultural damages and benefits. The variability of yields for both without- and with-project conditions is a key component in calculating crop damages and benefits. The damage per acre flooded value generated by the CACFDAS program encompasses crop distributions, crop budgets, substitution of alternative crops, damage-duration data, daily historical hydrologic data, and other physical and economic relationships.

10. Figure 7C-1 displays a schematic diagram of the results of risk and uncertainty modeling from calculating per acre cotton yield. A normal distribution is depicted with a sample mean value (survey value) of 964 pounds, standard deviation of 22.9 pounds. Assuming a 95 percent confidence level exists in this sample, the true mean is within plus or minus 5 percent of the sample mean. This example produces a standard deviation for per-acre cotton yield of 22.9 pounds (44.9/1.96). The uncertainty of the flood damage per acre value from the CACFDAS program is also evaluated and integrated with the other variables to determine total damages and benefits and their corresponding uncertainty, assuming the uncertainty of all the variables.

11. Figure 7C-2 displays an example of the results of benefits derived from incorporating the uncertainties of crop yields and the flood damage per acre values from the CACFDAS program for initial array Plan 5. A normal distribution results with a sample mean value of $6,534,000, and a standard deviation of $2,163,000. Also, the benefit probability distribution of the National Economic Development Plan implies 95 percent confidence that the expected annual benefit for the structural component, agricultural sector, would be within the range of $675,000 and $12,433,000.

FINAL ANALYSIS

RECOMMENDED PLAN

12. The final analysis of agricultural flood benefits used the same methodology applied to the traditional agricultural analysis to determine the risk and uncertainty associated with both structural and nonstructural segments of the recommended plan. The results yielded a mean value of $11,448,000 and a standard deviation of $4,274,000 (Figure 7C-3). In addition, the benefit probability distribution of the recommended plan implies 95 percent confidence that the expected annual benefit would be within the range of $2,734,000 and $19,575,000. This same type of analysis would be applicable to each of the other final alternatives.

Figure 7C-2
Expected Benefits
Structural Component - Agricultural Sector
Recommended Plan
Yazoo Backwater Area, Mississippi

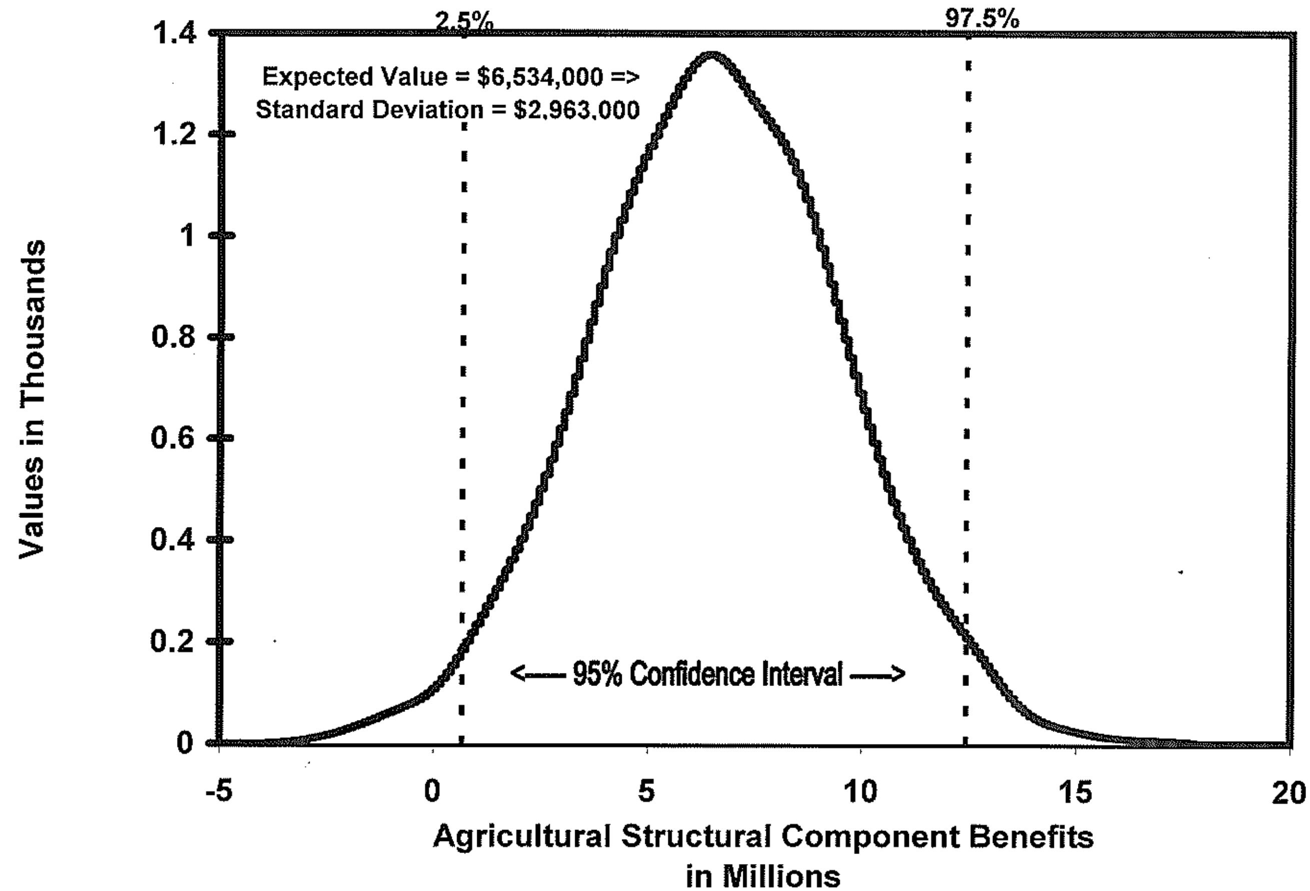
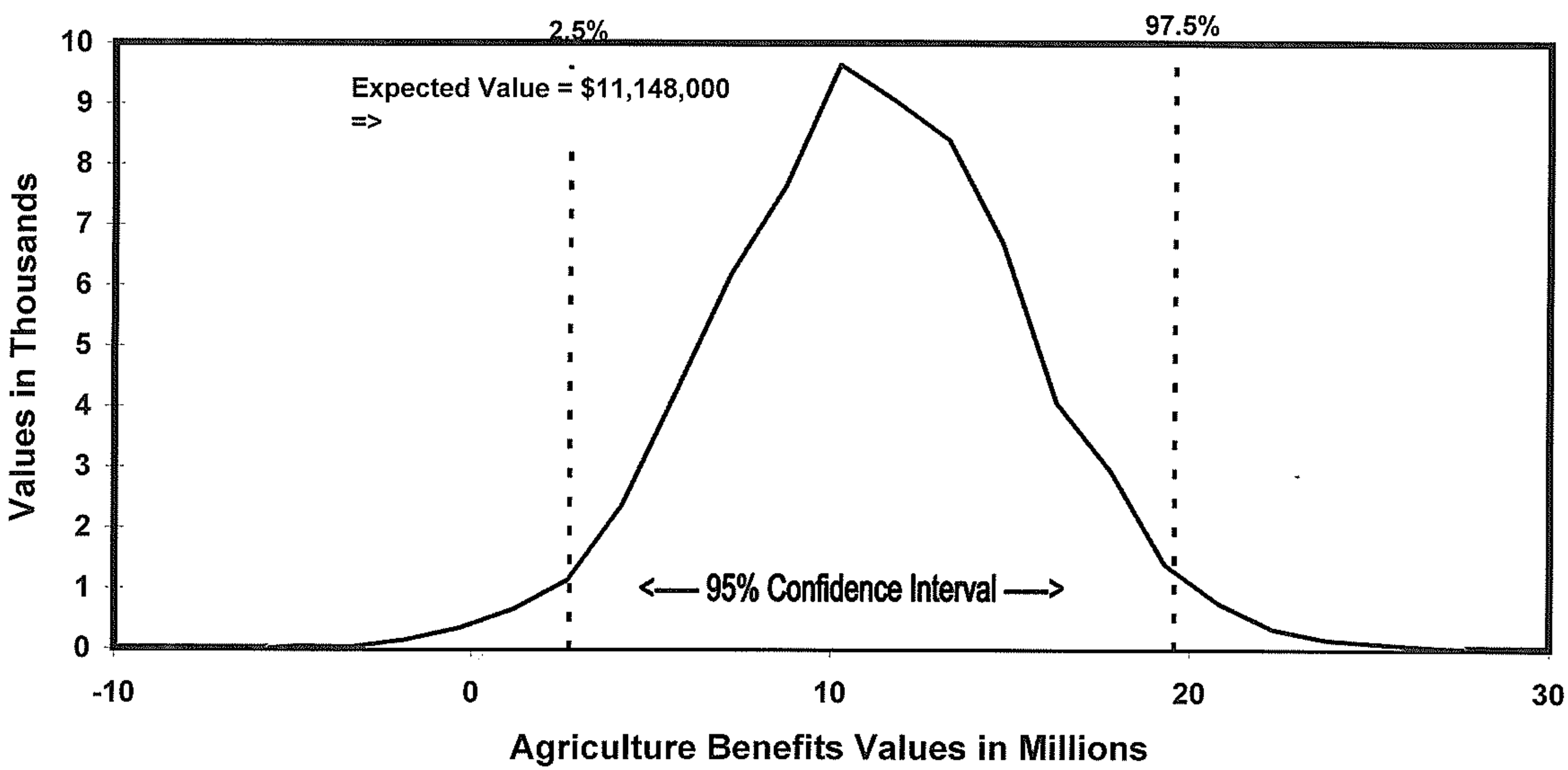


Figure 7C-3
Expected Benefits
Agricultural Sector
Recommended Plan
Yazoo Backwater Area, Mississippi



13. It should be emphasized that no technique, including the traditional methods and risk-based analysis procedures, can determine an absolutely accurate result or decision. These techniques are tools that are used to assist in making decisions and deriving solutions. Hindsight is as close to perfection as can be obtained when data are involved, which are not available at the time a decision needs to be made. However, with these well-researched and developed procedures, models, techniques, and the environmental considerations appropriately evaluated, the assumption can be made that the optimum plan has been selected, provided the information available and the reliability of the values utilized in the modeling.