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(TECBU2)

## TECHNICAL BULLETIN

TO: All Benefit-Cost Analysts  
FROM: Gary Sepulvado, Cliff Oliver, Ken Goettel, and Jerry Horner  
SUBJECT: The Mathematics of Aggregating Benefit-Cost Ratios

This fulfills our promise to commit to paper the procedures of aggregating benefit-cost ratios (BCRs) when a large number of residential structures are under consideration in flood hazard areas. In several communities flooded during the Midwest Flood of 1993, for example, the number of structures coupled with the urgency of resolving BCR questions overwhelmed the expertise of the few staff analyst that were available at the time. It was therefore appropriate to ask the question whether there is an acceptable mathematical solution that will produce results expeditiously and accurately. This bulletin shows how to calculate the BCR of projects, groups and subgroups of residential structures expeditiously and accurately.

Two things are considered in this bulletin: (1) how benefit-cost results are correctly aggregated, and (2) when it makes sense to use benefit-cost results that are aggregated. The following examples demonstrate the procedure to be used in aggregating benefit-cost results.

### 1. Aggregating Benefit-Cost Results

When confronted with a group of residential structures at different elevations, they may be grouped by elevation "bands" or contours, and for each group at the same elevation a benefit-cost analysis may be performed.

(This assumes all other things about the structures are fairly equal as to vulnerability, such as building type, contents, age, etc.)

The proper way of calculating an aggregate BCR for any such group of structures is to add up all the costs and all the benefits, thus producing the total costs and total benefits for the structures involved in any one group, and then calculate the BCR by dividing the total benefit by the total cost. Note that it would be mathematically wrong to average the BCR of any two structures, groups, and subgroups however. Directly averaging BCRs gives erroneous results. Therefore, BCRs must never be averaged.

**Example of Aggregating Benefits and Costs**

	1	2	3	4
Project		Cost	Benefits	BC Ratio
Group A		\$10,000	\$25,000	2.5
Group B		\$1,000,000	\$500,000	0.5
Aggregate		\$1,010,000 (A + B)	\$525,000 (A + B)	0.52 (Cols. 3/2)

Note: “Averaging” the BC ratios in the example above gives wrong results ( $2.5 + 0.5$  divided by 2 = 1.5, compared to the correct BCR of 0.52. Averaging BCRs does not recognize the weighted difference among projects. In this example, the Group B project has 100 times the weight of the Group A project (one million vs. ten thousand). Therefore, averaging would produce a false BCR of 1.5, in this example.

2. When Aggregating Benefit-Cost Results Makes Sense

Aggregating benefit-cost results makes sense if and only if the projects and the groups within them are sensibly related. For example, when a whole neighborhood or subdivision is being considered for a “buyout,” it makes sense to aggregate benefit-cost ratios. Another example is buying out structures with benefit-cost ratios of less than one to avoid a pattern of “checkerboarding.” Aggregation to prevent checkerboarding makes sense because it facilitates the conversion of land areas to open space by removing structures where a majority of structures have BCRs greater than one. If an aggregate of the whole project has a BCR greater than one, then it meets hazard mitigation regulatory requirements under the Stafford Act.

Keep in mind, however, that “averaging” several distinct projects does not make sense. Also, a project or group in one neighborhood or city cannot be combined logically with a project in another neighborhood or city to demonstrate that the combined project has a BCR greater than one. Each project must have a BCR greater than one to satisfy regulatory and statutory requirements under the Stafford Act.