Recommendation for:
Precipitation Depth-Area Reduction in Harris County
(Revised 12/04/2002)

Goal: The current version of HEC-HMS (version 2.2.1) does not contain an option for performing depth-area reduction of rainfall for large watersheds (formerly implemented with HEC-1 using the JD record on watersheds greater than 10 square miles). In e-mail discussions with the HEC, it was noted that HEC will be incorporating this option into a future release of HEC-HMS (it is not clear whether this will be the next version or the following one). Therefore, several alternatives are to be evaluated to define a suitable resolution to this problem.

Recommended Procedure: No recommendation is made. However, four alternatives are offered for resolution.

1. Abandon the use of HEC-HMS and use only HEC-1.

2. Use only point rainfalls in HEC-HMS.

3. Develop a separate meteorologic model for each index storm, export the resulting index hydrographs from DSS into a spreadsheet and derive an interpolated hydrograph for the point of interest. The equation which would be used for interpolation of each hydrograph ordinate follows.

$$Q_i = Q_1\left[\frac{\log\left(\frac{A_2}{A_i}\right)}{\log\left(\frac{A_2}{A_1}\right)}\right] + Q_2\left[\frac{\log\left(\frac{A_i}{A_1}\right)}{\log\left(\frac{A_2}{A_1}\right)}\right]$$

   Where,

   Q_i = interpolated flow (cfs)
   Q_1 = flow for index hydrograph with nearest, but lesser drainage area than point of interest (cfs)
   Q_2 = flow for index hydrograph with nearest, but greater drainage area than point of interest (cfs)
   A_i = drainage area at point of interest (sq. mi.)
   A_1 = drainage area of index hydrograph corresponding to Q_1 (sq. mi.)
   A_2 = drainage area of index hydrograph corresponding to Q_2 (sq. mi.)

4. Develop a separate meteorologic model for each index storm. Once the index hydrographs have been created, a software utility program could be used to develop interpolated hydrographs at various points in the watershed system. This utility would have to be developed.

Assumptions: The primary assumption is that hypothetical rainfall events are better defined using the depth-area reduction option for large drainage areas.

Testing Procedure: No testing was done for these alternatives other than to verify that the problem does indeed exist.

Test Results: Although no testing was performed, an evaluation of the advantages and disadvantages of each alternative follow.

- Alternative #1: The advantage of returning back to HEC-1 is that many of the issues raised in these issue papers will become obsolete and old methods can be implemented simply because of familiarity with HEC-1 and Harris County hydrologic methods. The disadvantages are that HEC-1 is no longer supported by the HEC since all hydrologic model development focus is now being placed on HEC-HMS, and there may not

be another opportunity to make wholesale changes to Harris County hydrologic models for quite some time.

- Alternative #2: The advantage of not relying on depth-area reduction is the ease of modeling. It will be simple to model storm events in HEC-HMS as single storms rather than a series of index storms. Additionally, using HEC-HMS to model difficult situations such as modeling the effects of side-weir detention on downstream reaches will be less cumbersome. The disadvantage is that peak discharges are inclined to increase due to the fact that the single point rainfall will be distributed evenly across the entire watershed.

- Alternative #3: The advantage to performing an interpolation using this method would be that it would be possible to take advantage of the depth-area reduction option. The disadvantage is that it would be a tedious exercise to produce the desired results.

- Alternative #4: The advantage of using a utility program is (like Alternative #3) that it would be possible to incorporate depth-area reduction. However, (unlike Alternative #3) the process would be automated. The disadvantages are that the HEC-HMS user would be forced to rely on an external program to do the interpolation, and the program may contain flaws in its initial development which will have to be worked out.

Final Notes: Regarding Alternative #4, it may be possible to have the HEC develop this utility, but this idea needs further research.

Committee Resolution: Use point rainfall without depth-area reduction.

Additional Discussion: This additional discussion is included for clarity and insight into the problem.

An exhaustive investigation of how HEC-HMS handles the areal reductions in rainfall was conducted. As stated above, HEC-HMS cannot (at this time) create reductions based on a method similar to the old JD record in HEC-1 in which several index hydrographs are produced at each node and then an interpolated hydrograph is determined based on the drainage area at the node. In other words, if six areal distributions of rainfall are used (typical for Harris County HEC-1 models), six index hydrographs are created at each node. Each one is individually routed and combined with others so that the same index hydrographs are created at each node (for Harris County drainage areas of 0.01, 10, 25, 50, 100, and 300 square miles) and individually maintained throughout the model. If the drainage area at a combination point is 57 square miles, an interpolated hydrograph is found at that node by interpolating between the 50 and 100 square mile hydrographs for each ordinate in the hydrograph.

In HEC-HMS, the area of the storm may be inserted in the frequency-based storm option (this is similar to the PH record in HEC-1). However, if the user puts in 57 square miles for this storm area, then a subarea which has a drainage area of 1.85 square miles will use an areally reduced rainfall (based on 57 square miles) to define the rainfall amount. [As a side note, this reduction appears to be based on the equation for reduction in the HEC-1 User's Manual, which is similar to TP-40, but not identical.] Therefore, if the point rainfall is 12.5 inches, the reduced rainfall applied to the 1.85 square mile subarea will be 11.85 inches instead of the 12.47 inches which should be applied.

On the other hand, if the storm area field is left blank, HEC-HMS will reduce the rainfall based on the drainage area of each particular subarea (there is no indexing of hydrographs here). Unfortunately, it will not make adjustments at combination points. If this procedure is used, and a 3.21-square mile subarea is added to a 1.02-square mile subarea, the sum will produce a combined hydrograph which has a higher peak than would be expected from an interpolated hydrograph based on 4.23 square miles.

Neither method is adequate and, therefore, the committee opted to use point rainfalls (using 0.01 square miles in the storm area field) rather than create several indexed hydrographs based on several storm areas and then develop some method outside of HEC-HMS to compute interpolations from these indexed hydrographs.

Incidentally, if the HEC-1 PH method is compared with the HEC-HMS frequency-based storm method for various storm areas, the difference in discharges (assuming all else being the same--i.e., Green-Ampt losses, center-peaking storm hyetograph) is consistently off by about 0.4% to 0.5% and HEC-1 is usually lower.