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Thunderstorm Runoff in Southeastern Arizona[a]

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The writers greatly appreciate the discussion by Cristofferson. The discusser's questions point up the complexities involved in analyzing thunderstorm rainfall. In answering, several points should be emphasized.

1. Only storms that produced major peak discharges, not a full spectrum of events, were used in these analyses. These were less than 10% of all runoff events.
2. The largest air-mass thunderstorm runoff events are relatively insensitive to storm orientation and watershed location.
3. Because of this relative insensitivity and because most of the rainfall occurs in about 30 min, 30-min rainfall volumes correlate well with peak discharge for large events.
4. The 30-min rainfall volume is an artificial accumulation of the maximum 30-min volumes over the watershed, regardless of time. Again, because of the nature of thunderstorm rainfall and the restricted size of the watersheds, this simplification of runoff producing rainfall is a useful variable in a prediction equation for major runoff events.
5. Runoff volumes for large events are somewhat more sensitive to storm orientation and location than peak discharges, but still are correlated strongly with peak discharge and, therefore, maximum 30-min rainfall.
6. Smaller runoff volumes and peaks are very sensitive to storm orientation and location.
7. Simplified equations have been developed for predicting all runoff events very accurately for small watersheds (12), but these equations become either very complex or unacceptably inaccurate for larger (over 1 sq mile) watersheds.

Point depth-duration mass curves for three air-mass and one frontal-convective event on Walnut Gulch are shown in Fig. 9. Two points are plotted for September 10, 1967, to illustrate that point intensities are not uniform over the watershed. Also, storm orientation for air-mass thunderstorms can be quite complex due to random cell propagation. The curves for September 10, 1967, August 17, 1957, and July 22, 1964, are quite similar, differing primarily in when the intense rain ceased. These three storms are typical air-mass events and all three would plot above the discusser's design curve (Fig. 8) for up to 1 hr and below afterward. The August 25, 1968, storm on Walnut Gulch was a rare major runoff-producing frontal-convective storm. Intensities were generally less than usual for a longer

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duration. Point rainfalls plot below the writer's design curve up to 1 hr and above it afterward. Peak discharge on August 25, 1968, was less than usual for pure air-mass thunderstorms with similar volumes of rainfall and higher intensities.

Storms similar to that of August 25, 1968, are much more common on the Alamgordo Creek watershed in eastern New Mexico than on Walnut Gulch in southeastern Arizona. For design flood peaks and volumes, such storms on Walnut Gulch can be ignored, whereas they cannot be ignored on Alamgordo Creek. The writers suggest adding four additional references pertinent to the

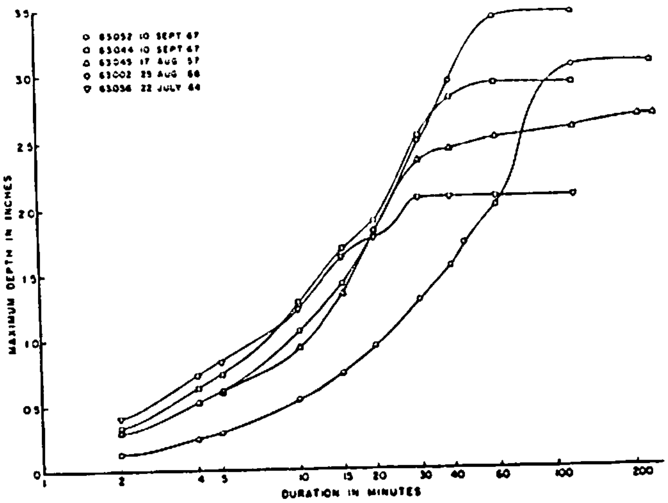

FIG. 9.—Depth-Duration Rainfall Curves for Selected Points for four Major Thunderstorms on Walnut Gulch.

subject of thunderstorm runoff in southeastern Arizona (24,25,26,27), especially Figs. 2 and 3 in Ref. 25 (average depth-area curves for Walnut Gulch) and Fig. 14 in Ref. 27 (maximum point depth-area curves for two selected events on Walnut Gulch). These references should aid the reader in more fully understanding the complexities of thunderstorm runoff in the Southwest.

Appendix.—References

24. Lane, L. J., and Osborn, H. B., "Hypotheses on the Seasonal Distribution of Thunderstorm Rainfall in Southeastern Arizona," *Proceedings*, Second International Symposium in Hydrology, Fort Collins, Colo., 1972.
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27. Osborn, H. B., and Renard, K. G., "Analysis of Two Runoff-Producing Southwest Thunderstorms," *Journal of Hydrology*, Vol. 8, No. 3, 1969, pp. 282-302.