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Application of a Computer Model to a Desert Watershed

*by J. H. Kitchen & J. L. Thames**

Only about five per cent of the total precipitation which falls on the warm dry deserts of Arizona is retained for our use. Efficient watershed management could increase this percentage. However, a first requirement for efficient management and utilization of our water resources requires methods of accurately predicting runoff from real or hypothetical storms that might occur on our watersheds. Computer technology is rapidly expanding these methods. Old methods have been streamlined and new ones greatly increased in scope have been made possible.

Watershed modeling using computers is the most promising of the newer methods. The models are computer programs which reproduce a mathematical representation of the hydrologic system operating within a watershed. Separate processes of the hydrologic cycle, believed to have the greatest influence on streamflow, are expressed in mathematical terms and then combined into a complete system. Such models are used to predict outflow from a watershed for a given rainfall and measurements or estimates or certain watershed characteristics.

The hydrologic modeling approach has important implications to Arizona's water users. It presents a means of estimating the individual and composite effect of many changing activities on the quantity, quality, and timing of water yields. Land managers, for example, may be able to estimate how stream flow from a watershed will react to a given land management practice such as range conversion, forest cutting, or burning. Hydrologic models provide a method for estimating streamflow from watersheds for which records are not available. They could be used on flood control projects to predict the effects of unusual storms, or to estimate peak flows, and could be of great value in the design and management of water storage and diversion structures.

The goal in using computer models is not to develop a complete synthesis of the hydrologic cycle but to establish workable relationships between measurements of selected components to solve practical technological problems. The innumerable processes operating on the hydrology of a watershed necessitates selecting only those processes to be included in the model which are believed to exert the greatest influence on runoff. It has been pointed out that although the selection is necessary, it may also infringe upon both accuracy and uniqueness. In other words, strict accuracy must be sacrificed to practical limitations. Useful results which give us the answers we seek within the precisions we need is the purpose of hydrologic models.

For this study we employed a mathematical watershed model developed at Purdue University. The model was chosen because it was developed for small watersheds and has the ability to account for spacial variations within the watershed. The purpose was not to judge the theoretical basis of the model, but to test its usefulness as a tool for watershed management practices in Arizona, a region completely different from the cultivated fields in Indiana for which it was devised.

The model was applied without modification to a small desert watershed located in the Tucson Basin to see how well runoff from summer rainstorms might be predicted. Vegetation on the watershed is sparse scattered desert shrubs and grasses, consisting mostly of creosotebush (*Larrea tridentata*) and desert mesquite (*Prosopis juliaflora*), with some cacti and scattered herbaceous vegetation. The watershed is situated on the side of a ridge which is the remnant of an old alluvial fan. The relief is simple and the slopes are gentle, on the order of three per cent. The soils are sandy to gravelly loams with lime accumulations from one to several feet deep.

Many of the summer rainstorms that fall on the Tucson Basin are of short duration and high intensity. The runoff hydrographs resulting from two such storms were simulated with the "Purdue Model" and compared with the actual hydrographs. The hydro-

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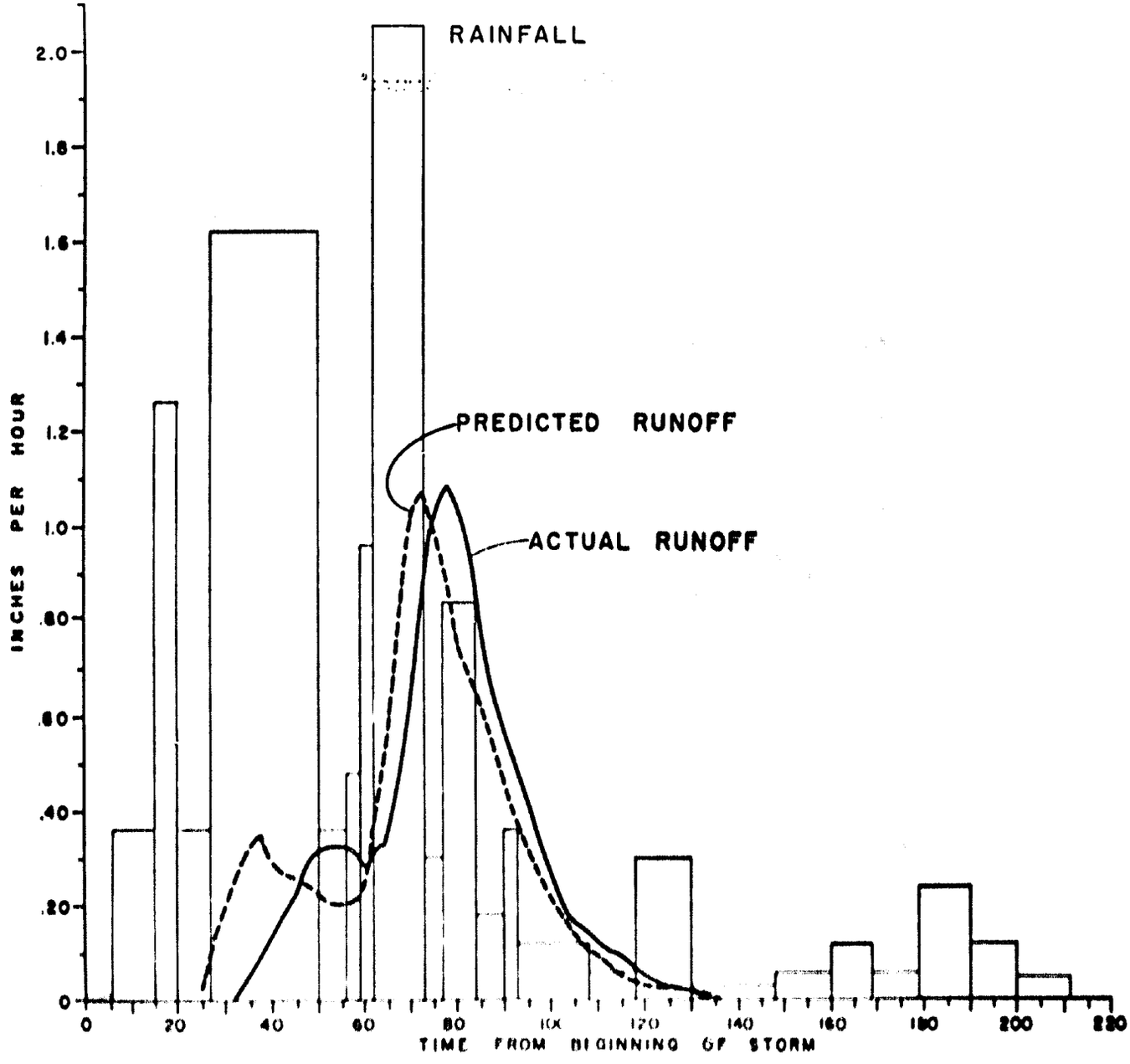
graphs obtained for one of these storms are shown in the figure.

A slight error in time of concentration of about five minutes exists between two hydrographs. The error may be inherent within the model, but is more likely due to instrumentation on the watershed. The hydrograph and rainfall recorders have separate clock systems which often differ by five minutes or more. Nevertheless, the close agreement in general shape and size of the predicted and actual hydrograph is remarkable.

The model predicts a total of 0.599 inches runoff from the 1.44 inches of rain that fell during the storm. The predicted runoff was 0.592, less than one per cent of the actual value. The greatest error occurred during a high intensity burst of rainfall at the beginning of the storm. Runoff predicted from the second storm also agreed with the actual hydrograph. There was also a difference in time of concentration. But the predicted runoff for the second storm was within 1.2 percent of the actual value.

The slight discrepancies between the predicted and actual hydrographs might be partially the result of the spotty rainfall distribution that is characteristic of summer storms. The model assumes an even rainfall distribution over the watershed. Improvements in modeling for the future will take into account the spacial variability of rainfall and other hydrologic parameters. This will also require that more attention be given to instrumentation of watersheds than is presently accorded.

The ability of a model which was developed in one region of the country to predict a hydrograph in a completely different area indicates that the development of practical working watershed models can be realized. Further research in the techniques of watershed modeling should lead to better understanding of the hydrologic processes operations on natural watersheds and provide a powerful tool for the watershed manager.