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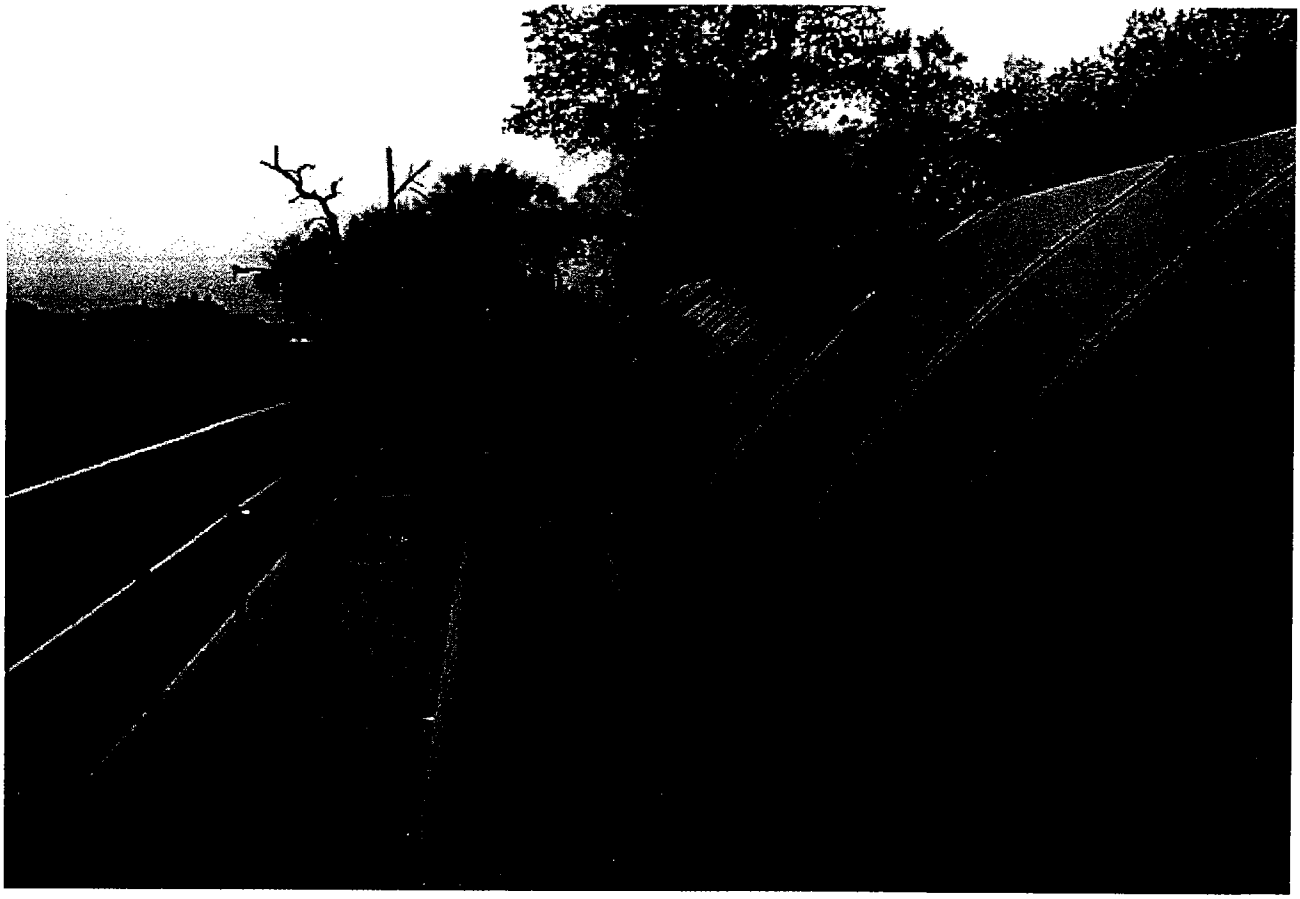

Photo: Kelsey Creek Detention Structure, Lake County, California. *Floodplain Management Association*

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Diffusion Hydrodynamic Model: Using DHM Rainfall-Runoff Output To Estimate Urban Watershed Existing Condition Hydrology

Abstract

A proposed flood insurance study submittal to the Federal Emergency Management Agency (FEMA) for a large urban alluvial fan watershed in Orange County, California, required defensible, existing condition, one-percent event hydrology for peak discharges and runoff hydrographs. A regionally calibrated Orange County Flood Control District ("Agency") hydrology model, a FEMA detailed method hydrology study, and an enhanced 2-dimensional Diffusion Hydrodynamic Model study provided some, but not all, of the information needed for the submittal to FEMA. All three models shared one common concentration point. Both the FEMA and DHM model of existing condition peak discharges agreed closely, and both discharges were about half the future fully urbanized peak discharge from the regionally calibrated Agency model. Adjusted Agency model peak discharges at other concentration points and DHM discharges and hydrographs for these and other points can provide all the information for the FEMA submittal.

Introduction

A fully-urbanized 73 square km (28 square mile) alluvial fan watershed in central Orange County, California had been hydrologically studied three times, once with a regionally-calibrated county Agency hydrology model, once with a Federal Emergency Management Agency (FEMA) detailed method, and once with an enhanced U.S. Geological Survey (USGS) two-dimensional Diffusion Hydrodynamic Model (DHM Version 21.1). A proposed submittal to FEMA for a flood insurance study (FIS) required defensible, existing condition, one percent event hydrology for peak discharges, and runoff hydrographs over the entire watershed including major tributaries and a retarding

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basin. Each of the three models provided some, but not all, of the information needed for the FEMA FIS.

Successful use of DHM to estimate a watershed S-graph (Hromadka and Nestlinger, 1985) and favorable results using USGS DHM Version 21 (Hromadka and Yen, 1987) for an urban floodplain analysis in this watershed (Hromadka, Walker, Yen, and DeVries, 1989) prompted a closer look at the DHM Version 21.1 rainfall-runoff output to provide necessary information for the FEMA FIS. Peak discharge versus drainage area relationships for a concentration point (C.P. 40) common to all three models are sufficiently consistent to recommend that the adjusted Agency hydrology model or the unadjusted DHM Version 21.1 results can provide defensible existing-condition hydrology for this watershed.

The hydrology report (Ilkhanipour, 1990) for this watershed was prepared in accordance with the Agency hydrology manual (Orange County, 1986) which is regionally calibrated (Hromadka, 1985; U.S. Army Corps of Engineers, 1987). Lag times were 0.8 times the time of concentration (Tc), where Tc's were from detailed rational method hydrology per the Agency hydrology manual. Peak discharges were determined by the single area unit hydrograph method at each nodal point, including C.P. 40.

Regional calibration results in discharges from the design storm that will represent runoff from a fully urbanized watershed having sufficient open channel and underground conveyance to deliver calculated runoff to the regional flood control system. Peak discharges and runoff hydrographs in the Agency hydrology report, however, do not represent FEMA's existing condition requirement for runoff from a watershed with flooding, shallow ponding, and local drainage facility deficiencies. The Agency hydrology report 100-year expected value (50% confidence interval) peak discharge at C.P. 40 is 128 m^3 per second (4530 cfs) for a tributary area of 24.7 km^2 (6103 acres), or 5.2 $m^3/sec/km^2$ (0.74 cfs/acre).

FEMA Flood Insurance Study

A FEMA FIS (FEMA, 1993) had been most recently updated in 1993. Details of exact hydrologic methods used by FEMA in this watershed are not provided beyond a general statement that hydrology was "calculated by a variety of methods". Peak discharges are stated by FEMA to be based on peak discharge-drainage area relationships. Statistical details are not provided. Only two concentration points in the watershed are listed in the FEMA study, one of which is very near C.P. 40. The FEMA flood insurance study existing condition 100-year peak discharge near C.P. 40 is 45 m^3 per second (1600 cfs) for a tributary area of 2.6 km^2 (7 square miles or 4480 acres), or 2.5 $m^3/sec/km^2$ (0.36 cfs/acre). This discharge corresponds to about 48 percent of the future fully urbanized peak discharge.

DHM Rainfall-Runoff Model

A DHM inundation study (Hromadka, Yen, Bajak, and Lim, 1992) for this watershed was prepared in 1992 for delineation of flooding for a proposed benefit assessment district. The DHM Version 21.1 program is functionally equivalent to the USGS DHM Version 21 program (Hromadka and Yen, 1987) that has been approved by FEMA for flood

insurance studies. Although the DHM inundation study provides the extent and depth of flooding, only the DHM rainfall-runoff analysis is investigated here. The entire watershed is modeled with nearly one thousand 305 m by 305 m (1000 ft x 1000 ft) square elements. T-year storm events are centered at six locations, progressing from top to bottom of the watershed. The element representing C.P. 40 is located near the topographically lowest corner of the tributary area for the second storm centering. A detailed description of this DHM inundation study is reported elsewhere (Hromadka, Yen, Nestlinger, and Jordan, 1993).

T-year precipitation frequencies and corresponding antecedent moisture conditions were chosen using regional calibration to obtain 100-year expected value runoff estimates. The effective (net) rainfall for application to each of the storm centerings was obtained from the Agency hydrology report, and used in the DHM model as the effective rainfall mass curve. Effective rainfall was input because watershed loss mechanisms are not incorporated into the DHM. DHM rainfall-runoff model existing condition 100-year expected value peak discharge near C.P. 40 is 68 m^3 per second (2400 cfs) for a tributary area of 24.7 km^2 (6103 acre), or 2.8 $m^3/sec/km^2$ (0.39 cfs/acre). This corresponds to about 53 percent of the fully urbanized peak discharge.

Conclusions

Results of the three hydrology studies are summarized in Table 1 as peak discharge at or near C.P. 40 based on discharge per unit area in the Agency hydrology report. Both FEMA and DHM existing-condition peak discharges are close to half of the fully urbanized peak discharge from the regionally calibrated Agency hydrology. DHM tests have been shown to closely approximate Agency hydrology method results that use the Valley-Developed S-graph. Peak discharge versus drainage area relationships at a common concentration point are sufficiently close for both FEMA and DHM hydrology methods that Agency hydrology report peak discharges at all other concentration points can be factored by about 1/2 to obtain existing condition discharges. Alternatively, DHM rainfall-runoff results can be used as is or adjusted slightly to obtain peak discharges and runoff hydrographs at equivalent concentration points, at confluences with major tributaries, and at the retarding basin. The discharge versus drainage area relationships appear to meet FEMA defensibility requirements.

Table 1. Peak Discharge At Or Near Concentration Point 40 East Garden Grove-Wintersburg Channel At Euclid Street

Method	T-YR,	C.I.	Condition	Qp (cfs)	% Qp
Agency Hydrology	100y,	50%	Fully Urbanized	4530	
FEMA Study	100y,	*	Existing Condition	2180	48%
DHM Study	100y,	50%	Existing Condition	2400	53%

C.I. = Confidence Interval
* Not stated

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