Watershed Management 2020

A Clear Vision of Watershed Management

Proceedings of the Watershed Management Conference 2020
Henderson, Nevada
May 20–21, 2020

Edited by
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SELECTED PAPERS FROM THE WATERSHED MANAGEMENT CONFERENCE 2020

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Preface

Watershed management practice and research has been rapidly advancing for at least 6 decades if not longer. The quinquennial ASCE-EWRI Watershed Management Conference, held since 1965, serves as a vital forum to present, discuss, and document these essential advances in applied research and practice at an early stage. Seminal early advances presented and documented at these conferences include: the adoption of the watershed as a fundamental unit in managing nonpoint source pollution and water resources in general; a better understanding of the use of the curve number relationship between rainfall and runoff; the assessment and revision of current practices of analysis and modeling in Total Maximum Daily Load (TMDL) development and implementation; and the use of remote sensing in water resources management, to name a few. From this 2020 and future quinquennial conferences we anticipate remarkable progress in the use of drones and wireless communication to accelerate simplifications of synoptic data collection necessary to develop, calibrate and verify watershed and receiving water quality models necessary to link point and nonpoint source pollution, and to finally restore and protect the beneficial use of all U.S. waters. Better data collection should spur the evolution in research and application of water movement and water quality processes to evaluate the necessary models and better understand how to forecast the total TMDLs necessary to clean up all impaired U.S. waters.

The interdisciplinary ASCE-EWRI Watershed Management Conference remains vital in bringing together engineers, hydrologists, soil scientists, foresters, environmental scientists, and a variety of other disciplines, along with regulators and resource managers, for quality international technical presentations and discussions of the practice of watershed management. The 2020 Conference, held on May 20-21 and co-located with the 2020 EWRI Environmental and Water Resources Congress in Henderson, Nevada gave presenters and attendees a *clear vision of watershed management* by focusing on practice and research.

The subsequent proceedings from the ASCE 2020 Watershed Management Conference contain 24 papers from authors who presented in two tracks on watershed modeling, advances in curve number hydrology, aerial and satellite remote sensing, ecological systems, emerging and innovative technologies, sediment and nutrient TMDL development and implementation, and stream restoration. A minimum of two reviewers evaluated each technical paper and case study during two rounds of review. Technical papers are 7 to 10 pages and present findings that are of significant interest to the watershed management community. Case study papers are 10 to 15 pages and provide more extensive project details, photographs, and results.

Papers submitted to the Watershed Track of the Congress are also included in these proceedings.

On behalf of the Watershed Management Technical Committee and the conference organizers, we are pleased to acknowledge all of the session chairs and reviewers for making this a successful conference and for contributing to the publication of these

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Contents

Random Generation of Excess Rainfall Time Series for Probabilistic Flood Evaluation

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ABSTRACT

This study offers a practical method for generating random time series of excess rainfall. The uncertainties in rainfall depth, rainfall temporal distribution, and hydrological losses are accounted for. First, the point rainfall or spatially distributed rainfall depth grids are obtained from NOAA Atlas 14. In random selection of rainfall depth, the probability of each recurrence interval as well as the probability distribution of rainfall between the lower and upper confidence limits are considered. Random selection of temporal distribution considers probability of each of the available empirical curves. The curve number (CN) for each grid (or lumped area) is randomly selected from a statistical distribution fit to CN ranging from dry to wet conditions. The selected CN value is then adjusted for rainfall durations shorter than 24 h. The process of excess rainfall time series generation is repeated hundreds of times for to provide a full range of runoff possibilities. A unique property of the proposed method is that all generated excess rainfall time series are equally valid and probable.

INTRODUCTION

Probabilistic Flood Evaluation (PFE) is a flood modeling approach which considers the uncertainties associated with rainfall, hydrological losses and flow routing. An important application of PFE is probabilistic floodplain mapping for both pluvial and fluvial flood inundation modeling. Potential uses of the results from PFE include benefit-cost analysis of flood mitigation project and flood insurance rate assessment. Unlike the traditional floodplain analysis, PFE considers a wide range of reasonable input parameter values and provides a full range of possible flooding depths and velocities for a given location. The results could be used to evaluate average annual flood depth and annualized average flood losses for each location. The probabilistic flood modeling requires an ensemble of time series of excess rainfall at each location. The objective of this study is to develop and describe a practical and objective method for generating random time series of excess rainfall reflecting the uncertainties in rainfall depth and temporal distribution and hydrological losses.

BACKGROUND AND PREVIOUS STUDIES

Probabilistic flood evaluation and hazard assessment has recently gained more attention as a viable method to incorporate the effect of uncertainties in flood damage prediction and flood control. The Federal Emergency Management Agency (FEMA) has recently started to explore flood risk analysis techniques that incorporate uncertainty with the goal of quantifying risk from multiple flood hazards down to a structure level to reshape the rate structure of the National Flood Insurance Program (NFIP). Central to this effort is the Probabilistic Flood Risk Analysis (PFRA) Study. The starting point for the research presented in this paper was the author's work in the early stages of the PFRA. The proposed approach was later further refined and applied to several example cases to provide a clear picture of the results one could expect.

It is well recognized that the hazard risk to a given locality or facility may not be limited to flooding or one source of flooding. While some relevant studies such as Ben Daoued et al. (2016) consider multiple sources of flooding (rain, tidal impacts, etc.), this study focuses on the direct runoff generation from rainfall.

Unlike the traditional flood calculation, probabilistic flood modeling considers the uncertainties inherent in the input parameters. Winter et al. (2018) summarizes the previous work by several investigators that resulted in distinguishing between aleatoric and epistemic uncertainty, whereas aleatoric uncertainty refers to an inherent or natural variability over space and time, epistemic uncertainty is the result of incomplete knowledge about the process, system or object under study. Beven et al. (2015) identified and examined a full range of epistemic uncertainties in natural hazard risk assessment. Ambiguity and issues would arise if one tries to quantify the impact of uncertainties such as non-stationarity, errors in measurements and reporting of data, age of data, and impact of sedimentation, wildfire or snowmelt. It would be unclear how one might factor in any of these uncertainties with a proper weight in a random selection process. The approach in this study only includes runoff generation factors for which each alternative can be objectively weighted in. The idea is to have a random generation process resulting in equally probable realizations of excess rainfall time series.

While the event-based flood calculations usually use a design rainfall temporal distribution, the PFE should use a range of observed (empirical) temporal distributions. Wright (2013) recognized the importance of using realistic spatial and temporal distribution of rain rather than applying a fixed design rainfall uniformly.

The probabilistic generation of rainfall and excess rainfall events makes up only the first stage for probabilistic flood risk assessment. Torres et al. (2013) describe how this stage could be followed by hydrologic and hydraulic evaluations and generation of flood scenarios of known probability.

RANDOM GENERATION METHOD AND CALCULATION TOOL

This section describes the method to generate random time series of excess rainfall and a tool for performing the calculations. The calculation steps are explained through a sample application to an urban watershed in Baltimore County, Maryland. The outlet for the drainage area of 2.13 square miles is at the location of the USGS Station 01585200 West Branch Herring Run at Idlewylde, MD. The 6-hour rainfall is used for this analysis. First, the rainfall depths for 50%, lower 10% and upper 90% for recurrence intervals of 2- to 1000-years are obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14. Either the point rainfall for the centroid of the watershed or the spatially distributed rainfall depth grids averaged over the watershed area can be used. Similar information must be secured from alternative sources where NOAA Atlas 14 is not available. To randomly select a rainfall depth, the proposed method considers exceedance probability of each recurrence interval as well as the probability distribution of rainfall between the lower and upper confidence limits. The original statistical distributions that NOAA used to establish the lower and upper limits are unavailable. In this study, a statistical distribution is back fit to the three available values for each recurrence interval. The resulting distribution parameters are used for random generation of rainfall depths consistent with NOAA Atlas 14. Figure 1 shows five hundred randomly generated 6-hour rainfall depths compared to the 50% values of the 2- and 100-year rainfall. Each generated rainfall depth is equally likely to happen. Therefore, there are more points close to the 2-year level than the 100-year level.