International Low Impact Development Conference China 2016

Applications in Sponge City Construction

Proceedings of the International
Low Impact Development Conference China 2016

Beijing, China
June 26–29, 2016

ASCE

EDITED BY

Haifeng Jia, Ph.D., P.E., D.WRE; Shaw L. Yu, Ph.D.;
Robert Traver, Ph.D., P.E., D.WRE; Huapeng Qin, Ph.D.

EWRI ASCE ENVIRONMENTAL & WATER RESOURCES INSTITUTE

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LID APPLICATIONS IN SPONGE CITY PROJECTS

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Chinese Academy of Engineering—Division of Civil, Hydraulic, and Architecture Engineering

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Preface

The 2016 International Low Impact Development (LID) Conference was successfully held at the China National Conference Center in Beijing, China during June 26-29, 2016. The conference brought together experts and scholars from more than 23 countries and regions to Beijing, China. A total of nearly 800 papers were submitted, of which 576, through rounds of peer reviews, were selected and presented at the conference. There were 6 topical tracks, 4 special sessions and 4 keynote presentations. The major theme of the conference was theory and practice of LID and green infrastructure (GI) application, which provided timely and valuable information for the implementation of the "Sponge City" projects, a major urban water management initiative, in China.

The conference papers were reviewed by members of the program committee and selected authors were invited to submit their papers for possible publication in the ASCE Proceedings. Manuscripts submitted were reviewed by proceeding editors listed below:

Haifeng Jia, Tsinghua University

Shaw L. Yu, University of Virginia

Robert Traver, Villanova University

Huapeng Qin, Peking University Shenzhen Graduate School

Junqi Li, Beijing University of Civil Engineering and Architecture

Mike Clar, Ecosite Inc.

The papers approved for inclusion in the Proceedings are grouped into the following major tracks:

- LID and Urban Planning & Design
- LID/GI Research & Development
- Urban Water Infrastructure System Design & Optimization
- LID/GI Practices – Case Studies and Recent Advances

Acknowledgements

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Contents

Urban Hydrology and Water Systems

Urban Runoff Simulation and Analysis

Temporal and Spatial Variations of Extreme Precipitation and Flood Thresholds in Qinghe Basin in Beijing, China

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ABSTRACT

Extreme weather frequently causes torrential rains and flooding in modern cities, e.g., Beijing, which are much sensitive and fragile to flooding disasters because of high population density. In this study, we aimed to quantify the temporal and spatial distribution of extreme precipitation in Qinghe Basin in Beijing and to develop optimal flood management thresholds by using precipitation records from 1986 to 2014 in two sites of the region. The time that maximum precipitation occurs in a year differed temporally and spatially and mainly concentrated in July and August. Extreme precipitation amount covered 41.7% of total precipitation in a month during flood season. Rain days of rainstorms were on average 1.7 d and 87% of them concentrated in July and August and were more in upstream than that in downstream. Precipitation intensity (SDII) during flood season was on average 11.7 mm d^{-1} and highest (15.1 mm d^{-1}) in July. SDII during critical flood control period increased in upstream during recent 30 years and implied a high flood risk in the future. The spatial distribution of precipitation intensity was significantly different. Our results at basin level would help city authorities designing optimal flood control constructions, drainage facilities, and warning systems.

KEY WORDS: climate variation; flood control; precipitation intensity; rain events; urban area

INTRODUCTION

Meteorological and secondary disasters happened frequently due to the extreme weather under climate change in the world especially during 21 century. Under climate change, the maximum of total precipitation and extreme rain events from 1950 to 2014 occurred in 1990s and 2000s, and the extreme rain events would continuously increase according to the report of Intergovernmental Panel on Climate Change (IPCC) (2014). Since meteorological disasters cause significant social and economic losses, governments, civil societies, organizations and the public therefore pay great concern to the managements of the disasters for the alleviation of the negative influences of climate changes.

Extreme weathers frequently cause torrential rains and flooding in modern cities, e.g. Beijing

and Shanghai, which are more sensitive and fragile to flooding disasters because of high population density. The average annual cost of natural disasters was 200 to 400 billion Yuans from 1949 to 1989 and gradually increased due to the climate changes. The safety of big cities, including managements, lives and properties, is greatly threatened by seeping in streets, rainwater intrusion into underground facilities and other damages caused by extreme precipitation events. "Metropolis Disease" due to extreme precipitations were frequently reported by public media. For example, a heavy rain of 170 mm in one day, with a maximum precipitation of 541 mm in Hebeizhen in Fangshan District, attacked Beijing on July 21, 2012, which broke a historical record of single rain station in Beijing. Nearly 600 million m^3 rainwater concentrated in a 2000 km^2 area in Fangshan District during 10 hours, which equaled that the Kunming Lake in Summer Palace was poured down once every 3 minutes. The highest rainstorm warning grade with "Orange Degree" and "Level II" of Flood Control Emergency were announced. The direct economic losses were as high as 11.8 billion Yuan, and 119.28 million populations were greatly affected. Total 9.48 million people were transferred to safe regions in emergency, and 79 people were died during this terrible event. More than 10 thousands of houses collapsed, 940 enterprises were discontinued, and 361 kilometers embankments were damaged. The huge losses from this extreme precipitation event were partially due to the limitation knowledge on the relationship between extreme rain and flood occurrence in a big city. Temporal and spatial distribution of precipitation intensity in relation to the land use types and population density would significantly affect the alarm threshold. However, such important studies are lagged.

Average annual rainstorm days in China showed a slight but not significant increasing trend in the past half century (Zhi et al., 2006; Min and Qian, 2008; Feng et al., 2008; Zou et al., 2009; Chen et al., 2010). The frequency and intensity of extreme precipitation over total rainfall events increased in most of China, while the rainfall days tended to be decreasing, and annual rainstorm days slightly increased with high differences in temporal and spatial distribution (Zhai et al., 2005; Wang and Zhai, 2008). Heavy rainfall in summer reduced in the north of China (Wang and Yan, 2009). The frequency and intensity of extreme precipitation events decreased in North China (Alexander et al., 2006; Wang et al., 2012). The frequency of precipitations during 1954 to 2006 reduced in North China; however, that of heavy rain did not too (Tu et al., 2010). The extreme precipitation intensity and frequency of big cities in north of China were increased more than in surrounding agricultural areas (Wang and Zhai, 2009). Although the extreme precipitation amount, days and intensity in Beijing showed a downward trend from 1981 to 2010 (You et al. (2009), the highest precipitation intensity occurred in 2012. That implies increased variations of precipitations in Beijing, thus, it is necessary to explore the temporal and spatial variations of precipitations in relation to flood control based on the capability of flood discharges at a basin level.

The objectives of this study therefore were to (a) quantify the temporal and spatial distribution of extreme precipitations with frequency, amount and intensity in the basin of Qinghe River in north of Beijing city, where is one of four rivers in the capital urban center with a drainage area of 175 km^2, a length of 28.7 km, an elevation range from 24.4 m to 500.3 m, and a stream length of 23.7 km; and (b) develop an extreme precipitation threshold (index) for the flood control of Beijing city in relation to the real basin situation, in which the hydraulic structures and embankment of Qinghe River are 20 years of flood recurrence period. Considering natural and social factors, the study would help to design an optimal construction of Sponge Cities and provide scientific support to emergency warning and response activities.