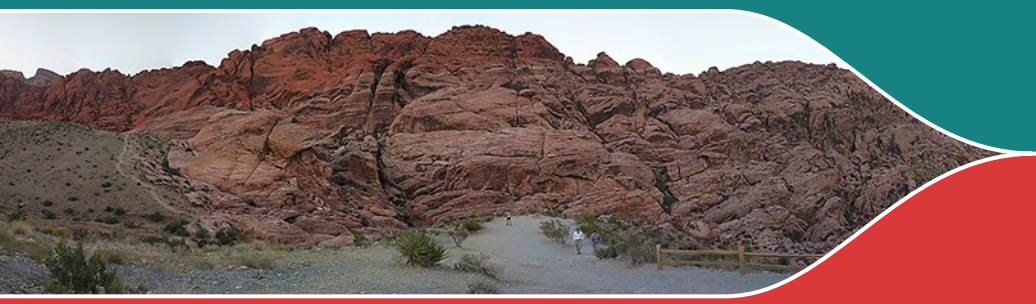
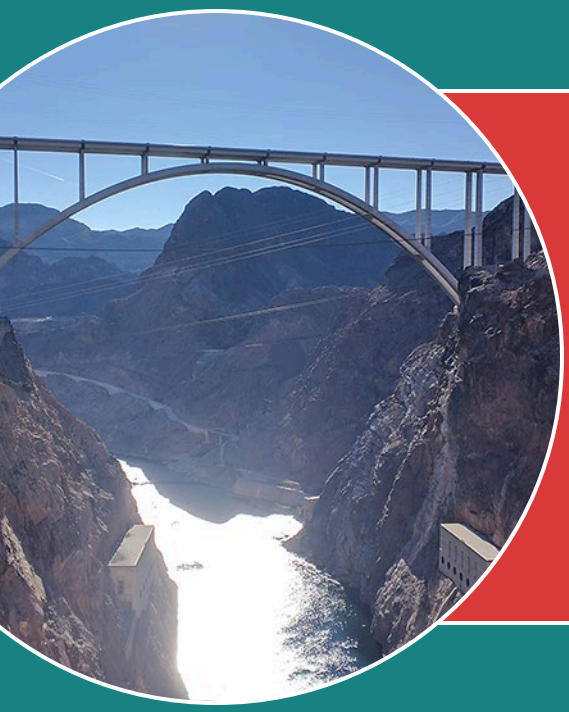


World Environmental and Water Resources Congress 2020



Hydraulics, Waterways, and Water Distribution Systems Analysis

Selected Papers from the Proceedings of the World Environmental and Water Resources Congress 2020

Henderson, Nevada • May 17–21, 2020

EDITED BY

Sajjad Ahmad, Ph.D.

ASCE

EWRI ASCE ENVIRONMENTAL & WATER RESOURCES INSTITUTE

WORLD ENVIRONMENTAL AND WATER RESOURCES CONGRESS 2020

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Preface

Welcome to the proceedings of the 2020 World Environmental and Water Resources Congress! These proceedings contain technical papers associated with the diverse set of talks, posters, and workshops presented at the American Society of Engineers' (ASCE) Environmental and Water Resources Institute's (EWRI) 20th Annual Congress, held in Henderson, NV, May 17-21, 2020. Engineers and scientists from around the world gather at the EWRI Congress to discuss the latest innovative research, case studies, and developing best practices in water resources and the environment.

The theme of this year's conference is, "Be Smart and Sustainable: Don't Gamble with your Infrastructure." Across the globe, infrastructure is in urgent need of investment and careful attention. ASCE's 2017 Infrastructure Report Card found the national grade for infrastructure remains near the bottom of the scale at a "D+" and estimates that an investment of over $4.5 trillion is needed to return the nation's infrastructure to a state of good repair. The ASCE Failure to Act study notes that "deteriorating infrastructure, long known to be a public safety issue, has a cascading impact on our nation's economy, impacting business productivity, gross domestic product (GDP), employment, personal income, and international competitiveness". If this investment gap is not addressed throughout the nation's infrastructure sectors by 2025, the economy is expected to lose almost $4 trillion in GDP.

Internationally, water infrastructure is critically important to the public's health, safety and security. The ASCE Report Card rated components of water infrastructure separately, assigning America's drinking water, inland waters and dams a "D," wastewater a D+, and bridges a "C+". The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. Sustainable Development Goal (SDG) 6 focuses on ensuring availability and sustainable management of water infrastructure and sanitation for all. Compounding the state of water infrastructure are the variability and uncertainty of future changes in climate. A systems approach is needed to address these complex challenges that cross the boundaries of water, energy, health, environment and the economy. Professionals in the water and environmental fields are in the best position to find creative and practical solutions to build resilience and sustainability into the world's water infrastructure.

The 2020 EWRI Congress covers a wide range of topic areas related to drinking water, groundwater, wastewater, stormwater, waterways, and irrigation and drainage infrastructure. Many overarching themes such as sustainability, smart water, security, systems analysis, and innovative technologies will also be addressed.

Within the six (6) volumes of the proceedings, more than 160 written scientific and technical papers from nearly 850 oral and poster presentations focusing on the subject areas of various EWRI Councils are included. A list of the subject area technical tracks is included in the acknowledgements below. We hope these proceedings enhance your knowledge base and inspire you to read other publications by the same authors or on similar topics that can be found in ASCE technical journals and publications.

The collection of papers in this volume of the Proceedings of the *World Environmental and Water Resources Congress, 2020, Be Smart and Sustainable: Don't Gamble With Your Infrastructure* contains papers organized by the following EWRI Councils:

- **Hydraulics and Waterways Council** whose purpose is to represent EWRI in technical matters pertaining to all aspects of hydraulic engineering of natural and man-made environmental systems. The Council promotes responsible water resources management and protection to foster sustainability and enhancement of the environment through the development, collection and dissemination of information and technology regarding the advancements and application of hydraulic engineering.
- **WDSA (Committee):** Water distribution systems analysis (WDSA) involves the quantitative planning, design, operations, management, modeling, and monitoring of hydraulics and water quality of water distribution systems. The purpose of the committee is to provide coordination for all activities within EWRI related to the field of water distribution systems analysis.

Acknowledgments

The EWRI Congress depends on the dedication of volunteers who plan technical session topic areas, solicit abstracts and papers, oversee reviews of submitted abstracts and papers, identify moderators, and ensure the overall success of the program. We appreciate the efforts of everyone involved, especially the track chairs listed below:

Cyber Physical Security of Urban Water Infrastructure	Mohsen Aghashahi, Ph.D.
Desalination Symposium	Berrin Tansel, Ph.D., P.E., D.WRE, F.EWRI, F.ASCE
Education	William Gonwa, Ph.D., P.E., M.ASCE
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Groundwater Symposium	Paul Mathisen, P.E., M.ASCE
History & Heritage (Nevada & California Water History Symposium)	Larry Magura, P.E., D.WRE(Ret.), F.ASCE
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Professional Practice	Kristin White
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Stormwater Symposium	Sarah Waickowski, E.I. Ryan Winston, Ph.D., P.E., M.ASCE
Student Competition	Wes Lauer, Ph.D., P.E., M.ASCE
Sustainability	Joshua Peschel, Ph.D., A.M.ASCE Kelly Sanders, Aff.M.ASCE

Water Distribution Systems Analysis Symposium	Mohsen Aghashahi, Ph.D.
Water, Wastewater and Stormwater	Arnold Strasser, P.E., M.ASCE Bridget Wadzuk, Ph.D.
Watershed	Levent Kavvas, Ph.D., Dist.M.ASCE Don Frevert, Ph.D., P.E., D.WRE(Ret.), F.ASCE
Watershed Management Conference (co-located with the EWRI Congress)	Rosanna LaPlante, P.E., F.ASCE

We also acknowledge the members of the Congress Organizing Committee; without whose time and efforts the event would not be possible.

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Finally, we acknowledge and thank EWRI staff who make this conference possible.

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