

# World Environmental and Water Resources Congress 2017



The Yolo Bypass in Sacramento Valley  
Photo by Carson Jeffres

## Groundwater, Sustainability, and Hydro-Climate/Climate Change

Selected Papers from the Proceedings of the  
World Environmental and Water Resources Congress 2017  
Sacramento, California ■ May 21-25, 2017



EDITED BY  
Christopher N. Dunn, P.E., D.WRE



ENVIRONMENTAL &  
WATER RESOURCES  
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# WORLD ENVIRONMENTAL AND WATER RESOURCES CONGRESS 2017

*GROUNDWATER, SUSTAINABILITY, AND  
HYDRO-CLIMATE/CLIMATE CHANGE*

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SELECTED PAPERS FROM THE WORLD ENVIRONMENTAL AND  
WATER RESOURCES CONGRESS 2017

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May 21–25, 2017  
Sacramento, California

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Environmental and Water Resources Institute (EWRI)  
of the American Society of Civil Engineers

EDITED BY  
Christopher N. Dunn, P.E., D.WRE  
Brian Van Weele, P.E., D.WRE



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**Front cover:** Carson Jeffres

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## Preface

We are excited to offer an engaging and challenging array of technical sessions, posters, and accompanying published papers at our Environmental and Water Resources Institute's (EWRI) 17<sup>th</sup> annual Congress in Sacramento, California. This meeting is a leading venue for professional interaction among engineers and scientists, covering disciplines relating to the needs of critical infrastructure in water and environment. As is pointed out in the American Society of Civil Engineers' Report Card for America's Infrastructure, an investment of over \$3.6 trillion is needed to return the nation's infrastructure to a state of good repair. This Congress contributes in many ways to innovative solutions to this critical problem. We proudly host the meeting under the auspices of the American Society of Civil Engineers (ASCE).

Within the five (5) volumes of the proceedings of the Congress you will find nearly 300 written technical papers from more than 700 oral and poster presentations dealing with the subject areas of the EWRI Councils; a list of subject area tracks is included in the acknowledgements below. Our profession advances through presentations in special state-of-knowledge tracks represented at the Congress. We hope these proceedings serve to enhance your knowledge in these areas and encourage you to follow up with more detailed publications by the same authors, typically found in ASCE technical journals.

*World Environmental and Water Resources Congress 2017: Groundwater, Sustainability, and Hydro-climate/Climate Change* contains papers organized by the following EWRI Councils, Committees and conference Symposia:

- **Environmental Council** whose purpose is to establish a focal point and provide a forum for civil engineers and scientists to participate and exchange ideas on the full range of innovative and emerging environmental engineering topics.
- **Symposium: Groundwater (Council)** whose purpose is the dissemination of knowledge on many aspects of groundwater including groundwater hydrology, ground water planning and management, and groundwater quality.
- **Sustainability Committee (Interdisciplinary Council)** whose purpose is to promote sustainability as a central discipline of EWRI by helping coordinate and optimize sustainability initiatives throughout EWRI, and with external organizations seeking to promote a more sustainable built environment.
- **Symposium: Hydro-Climate/Climate Change (Committee)** whose purpose is to provide a formal organizational structure within ASCE/EWRI for addressing the various engineering problems that are created by hydroclimate phenomena and climate change, fostering their science-based engineering solutions.

## Acknowledgments

Preparation and planning for this Congress strongly depends on the dedication of those who plan track subjects, solicit abstracts and papers, oversee reviews of all this material and then “encourage” all authors to provide their material in a timely manner! We are deeply grateful to all who have provided this considerable effort, especially the track chairs listed below:

Track	Chairs
Hydro-Climate/Climate Change Symposium	Dr. M. Levent Kavvas – Volume 3
14th Urban Watersheds Management Symposium	Shirley Clark – Volume 5
Groundwater Symposium	Dr. Amy Chan Hilton – Volume 3
Water Distribution Systems Analysis Symposium	Juan Saldarriaga – Volume 4
Education	Colleen Bronner – Volume 1
Emerging Technologies	David Hill – Volume 1
Environmental	Wendy Cohen, Lisa Hayes – Volume 3
History and Heritage	Lawrence Magura, J. David Rogers – Volume 1
Hydraulics and Waterways	Christina Tsai – Volume 4
International	Ali Mirchi, Dr. Erfan Goharian – Volume 1
Irrigation and Drainage	Thomas W. Ley – Volume 2
Municipal Water Infrastructure Symposium	Ruth Hocker – Volume 5
Planning and Management	Kaveh Madani, Mashor Housh – Volume 2
New Professionals/Professional Development	Cidney Jones – Volume 1
Standards	Dr. Kathlie Jeng-Bulloch – Volume 1
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Sustainability	Joseph Threadcraft – Volume 3
Smart Water Symposium	Sudhir Kshirsagar
Water, Wastewater, and Stormwater	Sri Kamojjala, Bridget Wadzuk – Volume 5
Watersheds	Dr. M. Levent Kavvas, Don Frevert – Volume 2

We also acknowledge the Congress Organizing Committee members, without whose time and efforts the event would not be possible. We also thank others not mentioned here.

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Finally, we acknowledge and thank the staff of the EWRI of ASCE who, in the end, makes it all happen. Most particularly, we thank Gabrielle Dunkley, EWRI's Manager, whose patience, perseverance, good humor, and great organizational talent ensure yet another successful EWRI Congress!

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# Contents

## *Environmental*

<b>The Evaluation of Risk for Exposure to Groundwater during Construction/Trench Work .....</b>	<b>1</b>
Meng Ling, Jeff Heglie, Michael Acton, Jim Twiford, and Barbara Mickelson	

<b>Lack of Correlation in Two Bacteria Indicator Species in Near-Shore Marine Waters, Sarasota County, Florida .....</b>	<b>8</b>
L. Donald Duke and Jennifer E. Clemente	

<b>Daylighting Harbor Brook for the New Meriden Green .....</b>	<b>17</b>
James G. MacBroom, Jeanine Armstrong Gouin, and Mark Arigoni	

## *Groundwater Symposium*

<b>Comparison of Statistical and Geostatistical Methods in Zoning the Groundwater Table: Case Study; Zayandehroudd Basin, Isfahan Province, Iran .....</b>	<b>25</b>
R. Masoudi, Gh. Zehtabian, A. Malekian, H. A. Loáiciga, M. Jafari, and M. H. Seyyed Seraji	

<b>Estimate Dilution Factor with SEAWAT Modeling to Calculate Groundwater Cleanup Goals .....</b>	<b>36</b>
Meng Ling, Jeff Heglie, Michael Acton, Jim Twiford, and Barbara Mickelson	

<b>SWAT and MODFLOW Modeling of Spatio-Temporal Runoff and Groundwater Recharge Distribution .....</b>	<b>51</b>
Aksara Putthividhya and Jeerapong Laonamsai	

<b>Influence of Coastal Flooding on Seawater Intrusion in Coastal Aquifers .....</b>	<b>66</b>
Davood Mahmoodzadeh and Mohammad Karamouz	

<b>Recognizing Climate Signals in Groundwater .....</b>	<b>80</b>
M. Lee Davisson	

<b>Aquifer Compartmentalization at a Transitional Mountain Front: Implications for Basin Assessment and Numerical Modeling .....</b>	<b>90</b>
Barry J. Hibbs	



<b>Naturally-Occurring Chaotic Advection in Groundwater and Surface-Water Systems .....</b>	<b>102</b>
Colter Ritsch, Roseanna M. Neupauer, and David C. Mays	
<b>Engineered Injection and Extraction for Remediation of Uranium-Contaminated Groundwater.....</b>	<b>111</b>
John A. Greene, Roseanna M. Neupauer, Ming Ye, Joseph R. Kasprzyk, David C. Mays, and Gary P. Curtis	
<b>Effects of Dead-End Pores on Solute Transport Processes.....</b>	<b>119</b>
Sami Maalouf	
<b>The Use of Inverse Distance Weighted Interpolation to Calibrate the Vertical Hydraulic Conductivity below an Estuary .....</b>	<b>126</b>
Wissam Al-Taliby, Ashok Pandit, Antonio Berber, and Howell Heck	
<b>Groundwater Recharge from Dams in United Arab Emirates .....</b>	<b>139</b>
Mohsen Sherif, AbdelAzim Ebraheem, and Ampar Shetty	
<b>Arsenic Removal Potential Using Naturally Occurring Iron in Groundwater: A Geo-Spatial Assessment of Household Potable Drinking Water in Bangladesh .....</b>	<b>147</b>
T. Tarannum, N. Mirza, and T. Ahmed	
<b>Contribution of Drinking Water to Dietary Intakes of Nutrient Minerals in Bangladesh.....</b>	<b>161</b>
N. Mirza, T. Tarannum, and T. Ahmed	
<b>Modeling the River-Aquifer Flow-Interaction Using a Coupled hsB-VPMM Approach .....</b>	<b>172</b>
Bhabagrahi Sahoo, Soumyaranjan Sahoo, and Ratnakar Swain	
<b>Monitoring Organochlorine Pesticides, Polychlorinated Biphenyls, and Polyaromatic Hydrocarbons in Wastewater and Groundwater .....</b>	<b>183</b>
Jim Nguyen, Crissini M. Sison, Varenka Lorenzi, Pitiporn Asvapathanagul, and Nhut M. Pham	
<b>Methodology and Applications in Developing Salt Balances in Groundwater Basins.....</b>	<b>193</b>
Barry J. Hibbs and Godina Ying	

*Sustainability*

<b>Implementing SGMA—An Update on California’s Foray into Groundwater Regulation .....</b>	<b>206</b>
Leslie Dumas	
<b>Evaluation of Soil Mixes in Shallow Bioretention Systems.....</b>	<b>212</b>
Cara J. Poor and Daniel M. Wagner	
<b>The Importance of Changings in Brazilian Law to Introduce the Use of Environmental Criteria in Public Buildings.....</b>	<b>223</b>
Luis Felipe Bismarchi, Teresa Villac, and Maria Cecília Loschiavo dos Santos	
<b>On the Coastal Topography and Storm Surge for Infrastructure Risk Assessment and Adaptation .....</b>	<b>232</b>
Marissa S. Liang and Susan Julius	
<b>Use of GCM Wind Projections in Risk Assessment and Adaptation Planning and Design .....</b>	<b>241</b>
Marissa S. Liang and Susan Julius	
<b>Evaluating the Feasibility of Photovoltaic-Based Plant for Potable Water Treatment .....</b>	<b>256</b>
Saria Bukhary, Jacimaria Batista, and Sajjad Ahmad	
<b>Using Distributed Solar for Treatment of Drinking Water in Developing Countries .....</b>	<b>264</b>
Saria Bukhary, Jennifer Weidhaas, Kamran Ansari, Rasool Bux Mahar, Christine Pomeroy, James A. VanDerslice, Steve Burian, and Sajjad Ahmad	
<b>Green Infrastructure in Urbanized Areas and Roadway Projects .....</b>	<b>277</b>
Hamed Hakimelahi, Ann McKinney, and Adam Lee	
<b>More Pop per Drop: Functional Environmental Flows to Meet Ecosystem Needs and Human Demands.....</b>	<b>284</b>
Joshua H. Viers, Jenny Ta, and Daniel M. Nover	

*Hydro-Climate/Climate Change Symposium*

<b>Future 100-Year Sea Level Trend near Miami, Florida .....</b>	<b>296</b>
C. K. Turan, Y. P. Kinfu, and K. Y. Ng	
<b>A Statistical Approach to Multisite Downscaling of Daily Precipitation Processes in the Context of Climate Change.....</b>	<b>306</b>
Malika Khalili and Van-Thanh-Van Nguyen	