

36th Annual USSD Conference 2016

**Celebrating the Value of Dams and
Levees – Yesterday, Today and Tomorrow**

**Denver, Colorado, USA
11 - 15 April 2016**

Volume 1 of 2

ISBN: 978-1-5108-2942-8

Printed from e-media with permission by:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571



Some format issues inherent in the e-media version may also appear in this print version.

Copyright© (2016) by United States Society on Dams (USSD)
All rights reserved.

Printed by Curran Associates, Inc. (2016)

For permission requests, please contact United States Society on Dams (USSD)
at the address below.

United States Society on Dams (USSD)
1616 Seventeenth Street #483
Denver, CO 80202
USA

Phone: 303-628-5430
Fax: 303-628-5431

gene@ussdams.org

Additional copies of this publication are available from:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571 USA
Phone: 845-758-0400
Fax: 845-758-2633
Email: curran@proceedings.com
Web: www.proceedings.com

CONTENTS

Conference Theme

<i>Is This Community Worth Saving?</i>	1
Robert Beduhn , HDR	
<i>Unintended Consequences of Dam Removal</i>	11
Melinda Dirdal, Greg Paxson and Dave Campbell , Schnabel Engineering	
<i>The Kentucky River: Managing 19th Century Infrastructure to Meet 21st Century Needs</i>	29
Daniel A. Gilbert, Jeffrey S. Dingrando and April L. Welshans , hO I UStantec Consulting Services, Inc.; and David Hamilton , Kentucky River Authority	
<i>Historical Perspective — Dams, Hydro, and Multi-Purpose Projects</i>	45
David Kleiner , MWH	

Hydraulics

<i>Use of Labyrinth Piano Key Weir (PKW) Spillway to Improve Dam Safety for a Large Set of Dams</i>	61
Frédéric Laugier, Julien Vermeulen and Thomas Pinchard , EDF-CIH	
<i>Ensuring Water Supply Reliability with Innovative PK Weir Spillway Design</i>	79
G. Robblee, S. Kees and B.M. Crookston , Schnabel Engineering; and K. Keel , Town of Hillsborough	
<i>Importance of Site Considerations for Labyrinth Spillway Hydraulic Design — Upper Brushy Creek Dam 7 Modernization</i>	97
Tina Stanard and Victor Vasquez , Freese and Nichols, Inc.; Ruth Haberman , Upper Brushy Creek Water Control and Improvement District; Blake Tullis , Utah State University; and Bruce Savage , Idaho State University	
<i>Automated Incremental Hazard and Sensitivity Analysis of a Hypothetical Dam Breach Model</i>	107
Mikell Warms, Dan Christensen and Christopher Goodell , WEST Consultants, Inc.; and Cynthia Oestreich , Aista Utilities	
<i>GSSA Modeling for Analysis of Flood Design Features at the Picayune Strand Restoration Project</i>	123
Charles W. Downer, Jaime A. Graulau-Santiago, Brian E. Skahill, David M. Weston, Nawa Raj Pradhan and Aaron R. Byrd , Corps of Engineers	

<i>Using the Variable Infiltration Capacity Model in a Semi-Stochastic Format for Hydrologic Hazard Estimates for Dam Safety Risk Analysis</i>	139
Frank Dworak , Bureau of Reclamation	
<i>Dynamic Desert Floods at a Dry Dam</i>	149
Robert A. Eichinger, Zachary Whitten and Michael Gerlach , Stantec Consulting Services, Inc.	
<i>Cultivating Ingenuity and Safety In Alabama: The Taming of Lake Ogleetree Reservoir</i>	165
James R. Crowder, Brian M. Crookston, Bradley T. Boyer and J. Tyler Coats , Schnabel Engineering	
<i>Replacing Ruby Dam Outlet Uses Computational Fluid Dynamics to Model Energy Dissipation</i>	179
Frank Lan, Robert Waddell and Michael Zusi , AECOM; and Brian Grant , Montana DNRC	
<i>Reducing Scour with Flow Splitters, Extension Fins and Computational Fluid Dynamics.....</i>	199
Duane McClelland and Daniel Morse , CH2M; and Nathan M. Gullo and Jason A. Eichler , LCRA	
<i>Sediment Transport Analysis in Support of Prado Basin Sediment Management Project.....</i>	221
Craig P. Baxter , Golder Associates Inc.; Nathan Scheevel , Scheevel Engineering, LLC; and George W. Annandale , Golder Associates Inc.	
<i>Verification of Sediment Yield Calculations in the Arid Southwest.....</i>	237
Brian Wahlin and Jesse Piotrowski , WEST Consultants, Inc.; and Chuck Davis , Beaver Creek Hydrology	
<i>Post-Removal Reservoir Erosion: Elwha Dam and Glines Canyon Dam Removals, Washington</i>	251
Jennifer A. Bountry , Bureau of Reclamation; Andy Ritchie , National Park Service; and Timothy J. Randle , Bureau of Reclamation	
<i>Unit Hydrograph Peaking Factors and their Application to PMF Simulations.....</i>	269
Michael Bartles and Matthew Fleming , Corps of Engineers	
<i>Areal Reduction Factors — Colorado Front Range and Analysis of the 2013 Storm</i>	287
Doug Hultstrand and Bill Kappel , Applied Weather Associates, LLC	
<i>Evaluating Effort Levels of Inflow Design Flood Study Methods for Dams.....</i>	303
S. Samuel Lin , Federal Energy Regulatory Commission; and Jason E. Hedien , MWH Americas, Inc.	

Monitoring

<i>2015 USACE Instrumentation and Monitoring Program: Internal Peer Review Results</i>	315
Georgette Hlepas and Travis Tutka , Corps of Engineers	
<i>The Hydrogeological Model of Boone Dam</i>	335
Scottie Barrentine, Andrew Dodson and Lindsay McMichen , Tennessee Valley Authority	
<i>Relearning How to Look at Piezometric Data for Seepage Evaluation</i>	351
Richard S. Olsen and Isaac J. Stephens , Corps of Engineers	
<i>Evaluation and Monitoring Response to Upstream Slope Failure at an Embankment Dam</i>	379
Jay N. Stateler and Jeff Wormer , Bureau of Reclamation	
<i>On Calero Pond: Evaluation of Downstream Wetland and Potential Dam Seepage</i>	395
Matthew Powers , GEI Consultants Inc.; Bal Ganjoo , Santa Clara Valley Water District; and Mark Freitas , GEI Consultants Inc.	
<i>Maintaining Performance — Rehabilitation of Critical Drains at Crab Orchard Dam</i>	415
David Snyder and Robert Saber , Gannett Fleming, Inc.; and David Hibbs , U.S. Fish and Wildlife Service	
<i>Foundation Protection during Post Tensioned Anchor Construction</i>	435
William B. Stiller and Y. Erwin Supranata , HDR; and Stephen J. Mockler , Brookfield Renewable Energy Group	

Environment

<i>Buchanan Dam — Keeping Current for Eight Decades</i>	445
Victor M. Vasquez , Freese and Nichols, Inc.; Doug Witkowski , Lower Colorado River Authority; M. Leslie Boyd , Freese and Nichols, Inc.; Monica Masters , Lower Colorado River Authority; and Layne Bukhair , Freese and Nichols, Inc.	
<i>Risk Management for Dam Construction Projects — An Owner's Perspective</i>	469
Susan S. Hou, Tedman Lee, Alan Johanson , and Daniel L. Wade , San Francisco Public Utilities Commission	

Seismic

<i>Clover and Junction Dams: Risk-Based Seismic Evaluation of Two Slab and Buttress Dams</i>	485
Scott Jones, Steve O'Brien and David Hughes , AECOM	
<i>Nonlinear Seismic Evaluation and Acceptance Criteria for Arch Dams</i>	497
Yusof Ghanaat , Quest Structures, Inc.	
<i>Developing Time Histories with Acceptable Record Parameters for Dillon Dam</i>	515
Dina Bourliea Hunt , MWH Global; Justin Beutel , Pacific Gas and Electric Company; and Christine Weber , MWH Global	
<i>Seismic Deformation Analyses of Embankment Dams: A Reviewer's Checklist</i>	535
Ross W. Boulanger , University of California, Davis; and Michael H. Beaty , Beaty Engineering LLC	
<i>Lessons from Earthquake Lake in Preparing for Seismically Induced Landslides</i>	547
Roger L. Kay , Corps of Engineers	

Concrete

<i>Non-Destructive Testing of Post-Tensioned Anchorages at JT Myers and Markland Dams</i>	563
Robert F. Lindyberg and Afshin Karshenas , FDH Velocitel; Jeff Lillycrop , Charles E. Wiggins , Larry L. Dalton II and Matthew Watts , Corps of Engineers; and Brandon Compton , FDH Velocitel	
<i>USACE Portland District Spillway Gate Rehabilitation Program</i>	581
Matthew Craig , Laurie Ebner , William Fortuny , David Hamernik , Matt Hess and Mark Sawka , Corps of Engineers	
<i>Lessons Learned from the Spillway Gate Failure at Folsom Dam</i>	599
Jerzy Salamon , Bureau of Reclamation	
<i>A Finite Element Approach to Predict the Stability of Gravity Dams Laying on Rough Rock Interfaces</i>	611
Sylvain Renaud and Najib Bouaanani , Polytechnique Montréal; and Benjamin Miquel , Hydro-Québec	
<i>Applications of FLOW-3D for Stability Analyses of Concrete Spillways at FERC Projects</i>	627
Elise Dombeck , Federal Energy Regulatory Commission	

<i>The Stability of Masonry Walls and Dams: A Review of the Historical Design of Concrete Dams</i>	643
Kevin Griebenow , Federal Energy Regulatory Commission	
<i>A New and Advanced Dam Performance and Response Integration Program</i>	657
Ziyad Duron , Harvey Mudd College; and John Yen , Southern California Edison	
<i>Practical Analysis and Assessment of AAR-Affected Dams and Hydroelectric Plants</i>	675
Dan D. Curtis , Lingmim (Frank) Feng , Gurinderbir S. Sooch and Jiqin (Tom) Zheng , Hatch, Ltd; and John Fletcher , NB Power	
<i>Using the Trial Load Method to Optimize Feasibility Design of Watana Dam</i>	695
Aled Hughes , Glenn Tarbox and Brian Sadden , MWH Americas, Inc.; and Bryan Carey , Alaska Energy Authority	
<i>Linear and Nonlinear Seismic Analysis for the Post Tensioning System Design of the Wanapum Dam Spillway Monoliths</i>	711
Bashar S. Sudah , Juan E. Quiroz , Bryan J. Brumley , David P. Thompson and Richard E. Barrie , MWH	
<i>Static and Dynamic Mass Concrete Material Properties of a Concrete Gravity Dam</i>	727
Soheil Razavi Darbar , David Queen and Chris Hatton , BC Hydro; Timothy Dolen , Dolen and Associates LLC; and Katie Bartojay , Bureau of Reclamation	
<u>Levees</u>	
<i>Using Risk Assessment to Inform Levee System Evaluation Decisions for the National Flood Insurance Program</i>	749
David A. Margo , Lea G. Adams , Scott E. Shewbridge and Richard Varuso , Corps of Engineers	
<i>Using Tolerable Risk Guidelines in the California Delta</i>	765
Lawrence H. Roth and Jessica Ludy , Arcadis U.S.	
<i>Geotechnical Evaluation of the Levees in the Central Valley, California</i>	781
Richard Millet , AECOM; Steve Mahnke , California Department of Water Resources; Mary Perlea , Corps of Engineers; and Ray Costa , Geotechnical Consultant	
<i>Phased Investigation Approach for a Partial Slope Failure on the Rio Grande</i>	799
Isaac J. Stephens , Lucas A. Walshire and Joseph B. Dunbar , Corps of Engineers	

Embankment Dams

<i>Reducing Uncertainties when Assessing the Stability of Rockfill Dams: Characterizing Analysis Parameters</i>	813
Daniel B. Rogers, Kyle R. Blakley and Jeffrey S. Dingrando , Stantec Consulting Services Inc.; and Jeff W. Munsey , Tennessee Valley Authority	
<i>Don't Judge a Rockfill Dam by its Name Alone</i>	829
Brian Benson and Peter Amos , Damwatch Engineering Ltd	
<i>Shear Strength of Compacted Beaumont Clay for Consolidated-Undrained Conditions</i>	849
Mark J. Thompson and David J. Bentler , CH2M; Thomas L. Brandon , Virginia Polytechnic Institute and State University; and Daniel R. VandenBerge , Tennessee Technological University	
<i>Estimating the Peak Friction Angle of Sandy Soils In Situ with State-Based Overburden Normalized CPT Tip Resistance</i>	865
Robert A. Jaeger , GEI Consultants, Inc.; and Ian P. Maki , California Department of Water Resources	
<i>Decades of Foundation Deterioration Threatening Public Safety</i>	883
George L. Sills , George Sills Geotechnical Engineering Consultant, LLC; and Leslie F. Harder , HDR	
<i>An Empirical Model for Estimating Internal Erosion Critical Gradients for Inclined Exit Face Conditions</i>	909
Richard A. Keizer , GEI Consultants, Inc., John D. Rice , Utah State University; and Robert A. Jaeger , GEI Consultants, Inc.	
<i>Laboratory Measurements of Critical Gradients of Cohesionless Soils</i>	927
Bryant A. Robbins, Axel Montalvo-Bartolomei, Jamie López-Soto and Isaac J. Stephens , Corps of Engineers	
<i>Reliability Slope Stability Analysis for Rapid Drawdown</i>	939
Mark J. Thompson and David J. Bentler , CH2M; and Thomas L. Brandon , Virginia Polytechnic Institute and State University	
<i>Embankment Dam Analysis Parameters Estimated from 100 Years of Laboratory Tests</i>	955
David W. Harris , David Harris Engineering and Assistance, LLC/Allegiance Consulting, LLC; and Garrett Sutley , Bureau of Reclamation	
<i>Calaveras Dam Replacement Project — Providing a Seismically-Reliable Water Source</i>	969
John Roadifer and Michael Forrest , AECOM; and Daniel Wade, Susan Hou, Tedman Lee and Carman Ng , San Francisco Public Utilities Commission	

Dam Decommissioning

Non-Linear Modeling of Sediment Retention Structures for Dam Removal Project.....985
Kristen M. Martin and Erik J. Malwick, California Department of Water Resources

Recent Progress Towards Removal of Matilija Dam1001
Seth Gentzler and John Roadifer, AECOM; **Derek Booth and Yantao Cui**, Stillwater Sciences; and **Peter Sheydayi**, Ventura County Water Protection District

Dam Safety

Risk Analysis Work for Dams — “Big Picture” Considerations.....1017
Jay N. Stateler, Bureau of Reclamation; **Kim de Rubertis**, Consulting Engineer; and **Doug Boyer**, Federal Energy Regulatory Commission

Implementing a Risk-Informed Approach to Dam Safety in a Regulatory Environment.....1035
Douglas D. Boyer and William Allerton, Federal Energy Regulatory Commission

Use of Quantitative Risk Results to Inform Dam Safety Governance: Practical Cases in Europe1053
Ignacio Escuder-Bueno, Universitat Politècnica de València; **Adrián Morales-Torres**, iPresas; and **Jesica Tamara Castillo-Rodríguez**, Universitat Politècnica de València

The Role of Risk Assessment in the Bureau of Reclamation’s Dam Safety Program1069
William R. Fiedler and William Engemoen, Bureau of Reclamation

Semi-Quantitative Portfolio Risk Assessment for Prioritizing Dam Safety Activities.....1083
John Yen, Matthew Muto and Nicolas Von Gersdorff, Southern California Edison Company; and **Gregg A. Scott**, Scott Consulting, LLC

Bureau of Reclamation Risk-Informed Approach to Selecting the Inflow Design Flood.....1097
William R. Fiedler, Bureau of Reclamation; and **John H. LaBoon**, Consulting Civil Engineer

The Wanapum Spillway Monolith Cracking Incident Dam Safety Management Implications.....1119
Robin G. Charlwood, Robin Charlwood & Associates; **Adam N. Jones** and **Kevin Snyder**, HDR; **Kevin Marshall** and **David Mishalanie**, Grant County Public Utility District No. 2

<i>Panama Canal Borinquen Dams and Third Set of Locks Operations and Maintenance Strategy</i>	1133
Rachael V. Bisnett, Wonnie Kim and Donald J. Montgomery, MWH	
<i>Safety in Numbers?</i>	1145
Kim de Rubertis, Consulting Engineer	
<i>Public Safety and Security at Dams Are Not Mutually Exclusive</i>	1161
William F. Foos, Frank Calcagno and Paul G. Schweiger, Gannett Fleming, Inc.	
<i>Emergency Action Planning — Canadian Practice and Lessons Learned at Ontario Power Generation</i>	1173
Tali Serota and Tony Bennett, Ontario Power Generation	
<i>The Criticality of Engagement Before, During and After a Dam Safety Emergency.....</i>	1191
Bernie Auld, Benjamin Heath and Keil Neff, Tennessee Valley Authority	
<u>Construction</u>	
<i>Stagecoach Spillway Replacement and Performance at Electra Lake</i>	1201
Danielle Tripp Hannes and Stephen L. Jamieson, W. W. Wheeler and Associates, Inc.	
<i>High Capacity Anchors on Existing Concrete Dams — Application to Two TVA Dams</i>	1217
Husein Hasan and Aaron Nottis, Tennessee Valley Authority; Brian Krohmer, Barnard Construction Company; and Dennis Triplett and Boris Caro Vargas, Nicholson Construction Company	
<i>Lessons Learned on Post-Tensioned Trunnion Anchorage — Folsom Auxiliary Spillway.....</i>	1235
Cecily M. Nolan and Cheuk Y. Wan, Corps of Engineers	
<i>Uncovering and Addressing a History of Significant Incidents After an Annual Dam Safety Inspection</i>	1251
Steven Davidheiser and Robert A. Kline, Jr., Gannett Fleming, Inc.; and Amanda Lothes, Newport News Waterworks	
<i>Emergency Repairs to Prevent a Piping Failure in the Lake Manatee Dam</i>	1267
Jeffrey A. Beriswill and Nickolas J. Depin, Amec Foster Wheeler Environment & Infrastructure, Inc.; and Mark Simpson and Bruce MacLeod, Manatee County Utilities Department	
<i>Jet Grouting for Echo Dam Seismic Remediation</i>	1283
Tara Schenk-McFarland and Mark Bliss, Bureau of Reclamation	

<i>Improvements to Seepage Cutoff Wall Specifications Considering Lessons Learned from Construction</i>	1297
Michael Kynett , Corps of Engineers; Khaled Chowdhury and Richard Millet , AECOM; Mary Perlea , Corps of Engineers; and Francke Walberg , AECOM	

Foundations

<i>Levee Assessment Tool: Using Limited Data to Inspect/Evaluate Levees for Various Failure Modes Against Established Criteria</i>	1321
A. Wohletz and S. Wiesner , Kleinfelder	
<i>Fault Investigations During Borinquen Dam 1E Foundation Panama Canal Expansion.....</i>	1341
David Schug , Paul Salter , Dan Meier , Robert Urban , Chris Goetz , Lelio Mejia and James Toose , AECOM; and Derek Irving , Pastora Franceschi , Maximiliano De Puy , Jaime Arrocha and Roberto Miranda , Autoridad del Canal de Panamá	
<i>3D Modeling at Boundary Dam, WA: Visualizing a Geologically Complex Site.....</i>	1365
Robert Cannon and Frederic Snider , Schnabel Engineering; Kim Pate and Andre Ball , Seattle City Light; and Gary Rogers and J. Hawkins Gagnon , Schnabel Engineering	
<i>Underseepage and Heave Mitigation at Douglas Saddle Dam No. 1</i>	1379
Daniel A. Gilbert , Alan F. Rauch and Paul J. Cooper , Stantec; and Scottie L. Barrentine , Tennessee Valley Authority	
<i>A Deep Seepage Cutoff for the Thornton Composite Reservoir</i>	1395
Joseph R. Kovacich , MWH; Louis Storino , Metropolitan Water Reclamation District of Greater Chicago; Raymond J. Franz and Jonathon R. Bulger , Hayward Baker Inc.; and Brian J. Kazyak , MWH	
<i>Designing a Hybrid Dam on a Geologic Profile with Highly Variable Engineering Properties.....</i>	1419
Richard E. Riker and Jacob Esterhuizen , CH2M; Don Deere , Deere and Ault Consultants, Inc.; and Gabriel Fernandez-Delgado , University of Illinois	

Lunch Presentation and Poster Session

<i>Things You Wanted to Know About Individual Consulting, but Were Afraid to Ask.....</i>	1447
Larry K. Nuss , Nuss Engineering; and Kenneth D. Hansen , Consulting Engineer	

<i>Construction of La Romaine Complex in Northern Quebec, Canada: Behaviour of Asphalt Core Rockfill Dams</i>	1463
Vlad Alicescu, Jean Pierre Tournier, Redha Kara and Dan Rosculet , Hydro-Québec	
<i>Selecting an Intensity Measure for Fragility Curves Derived from Performance-Based Testing</i>	1483
Spenser Anderson, Kunal Menda, Mo Zhao and Ziyad Duron , Harvey Mudd College	
<i>Retrofit and Closure of CCR Impoundments to Meet New Regulations</i>	1497
Matt Bishop, Brian Owens and Luke Williams , Amec Foster Wheeler	
<i>Antecedent Snow Covered Area Analysis for Inflow Design Floods</i>	1507
Steven F. Daly and Angela Duren , Corps of Engineers	
<i>Evaluation of New Storage with Optimal Hydropower: Weiser-River Basin, Idaho</i>	1521
Jeremy Giovando , Corps of Engineers	
<i>Field Tests of Placed Riprap as Erosion Protection Against Accidental Overtopping and Leakage</i>	1531
Priska Helene Hiller, Fredrikke Kjosavik, Leif Lia and Jochen Aberle , Norwegian University of Science and Technology	
<i>Design-Build Construction of the Panama Canal Borinquen Dams 1W, 2W, and 2E</i>	1541
Gabriel Martinez, Wonnie Kim and Carlos Zambrano , MWH	
<i>A Performance-Based Approach to Developing Fragility Curves for Structures Subject to Seismic Loading Conditions</i>	1559
Kunal Menda, Mo Zhao, Spenser Anderson and Ziyad Duron , Harvey Mudd College	
<i>Implementing Lessons Learned from Wheeler Lock Collapse on New Lock Construction Projects</i>	1575
Michael A. Morrison , Tennessee Valley Authority; and Bernard Schulte , Corps of Engineers	
<i>Assessing and Evaluating the Operation of Pressure Cells in Embankment Dams: A Case Study of Five Iranian Embankment Dams</i>	1591
Bahareh Shoghli , University of North Dakota; Ali Asghar Mirghasemi , University of Tehran; and Yeo Howe Lim , University of North Dakota	
<i>Stability of Slopes in Embankment Dams</i>	1603
Gopi Siddappa and Santhosh G. Gowda , P.E.S. College of Engineering	

<i>Ritschard Dam Monitoring: Awareness Leads to Learning which Leads to Action</i>	1621
Ray D. Tenney and Don B. Meyer , Colorado River Water Conservation District; and Michael R. May , AECOM	
<i>Boundary Dam Spillway No. 2 Modifications</i>	1639
John Werner and James H. Rutherford , Hatch Associates Consultants Inc.; Kim Pate and Daniel Kirschbaum , Seattle City Light; Joe Groeneveld , Hatch Associates Consultants Inc.; Keith Moen , HDR; and Justin Arnold , Alden Laboratories Inc.	
<i>Selecting A Damage Measure for Fragility Curves Derived from Performance-Based Testing.....</i>	1655
Mo Zhao, Spenser Anderson, Kunal Menda and Ziyad Duron , Harvey Mudd College	