AEG News

Program with Abstracts – 2016

UA HĀNAU KA MOKU

AEG

KONA 2016

ENVIRONMENTAL AND ENGINEERING GEOLOGY IN THE NEW LAND

AEG News

2016 Annual Meeting – Program with Abstracts

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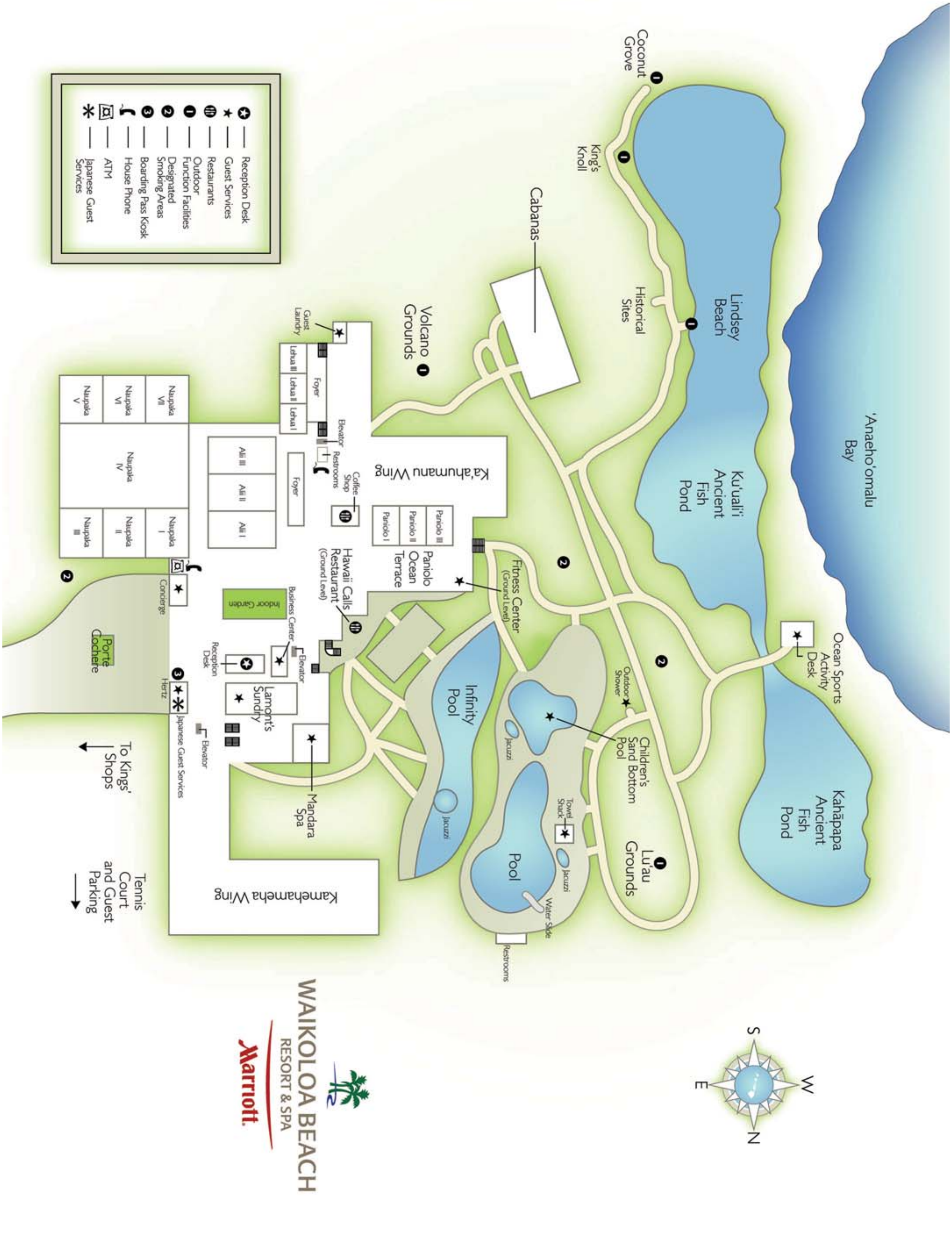

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Boarding Pass Kiosk
House Phone
ATM
Japanese Guest Services
Coconut Grove
King's Knoll
Cabanas
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Ku'uali'i Ancient Fish Pond
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To Kings' Shops
Tennis Court and Guest Parking
S
W
N
E
WAIKOLOA BEACH
RESORT & SPA
Marriott.

Schedule of Events

This schedule is subject to change.
Daily schedules will be provided at the Annual Meeting and will be available at registration.

EVENT	PLACE	TIME
SUNDAY–MONDAY, SEPTEMBER 18–19		
Field Trip #1: The Big Island: Volcanoes, Geohazards & Active Structural Geology	Departs from Hotel Lobby	8:00am
MONDAY, SEPTEMBER 19		
Registration Desk	Naupaka Ballroom Foyer	8:00am–5:00pm
Field Trip #2: Mauna Kea Stargazing	Departs from Hotel Lobby	4:00pm–11:00pm
TUESDAY, SEPTEMBER 20		
Registration Desk	Naupaka Ballroom Foyer	7:00am–5:00pm
AEG Executive Council Meeting	Paniolo 3	8:00am–5:00pm
AEG Foundation Board Meeting	Paniolo 2	8:00am–5:00pm
Field Trip #3: Green Sand Beach and South Point	Departs from Hotel Lobby	8:00am–4:00pm
Field Trip #4: Kona Coast Landslides	Departs from Hotel Lobby	6:30am–5:00pm
Guest Tour #1: Volcanoes National Park & South Island Tour	Departs from Hotel Lobby	8:30am–5:00pm
Student/Professional Networking Reception	Paniolo Terrace	5:15pm–6:15pm
Ice Breaker Reception and Exhibitor Opening	Naupaka I-IV	6:30pm–8:30pm
WEDNESDAY, SEPTEMBER 21		
Registration Desk	Naupaka Ballroom Foyer	7:00am–5:00pm
Committee Rooms	Paniolo 3	7:00am–5:00pm
Speaker Preparation Room	Keiki Club Room	7:00am–5:00pm
Speakers'/Moderators' Breakfast	Paniolo Terrace	7:00am–8:00am
Poster Session Presentations	Naupaka Foyer	8:00am–5:00pm
Exhibitors	Naupaka I-IV	8:00am–5:00pm
Opening Session Welcome (Paul Santi, Ken Neal and Stephen Evans)	Naupaka V-VII	8:00am–8:10am
AEG Foundation Awards (Briget Doyle)	Naupaka V-VII	8:10am–8:30am
Keynote Speaker: Gary Kitkowski, U.S. Army Corps of Engineers, Pacific Ocean Division	Naupaka V-VII	8:30am–9:15am
Keynote Speaker: Christina Neal, USGS Hawaiian Volcano Observatory	Naupaka V-VII	9:15am–10:00am
Mid-Morning Break	Exhibit Hall	10:00am–10:20am
OEEG Project Award: The US-89 Bitter Springs Landslide Repair (Mark Higley, James Lemmon and Bill McCormick)	Naupaka V-VII	10:20am–11:00am
2015–16 Jahns Lecturer: Jerome DeGraff	Naupaka V-VII	11:00am–11:30am
Introduction of the 2016–17 Jahns Lecturer	Naupaka V-VII	11:30am–12:00pm
Exhibitors' Luncheon	Exhibit Hall	12:00pm–1:30pm
Dams Technical Working Group Meeting	Paniolo 3	12:15pm–1:15pm
AEG Volunteer Recognition Event	Paniolo 2	1:00pm–2:30pm
Advocacy Workshop	Paniolo 2	2:30pm–3:30pm
Technical Session #1: Dam and Dam Foundation Design, Repair and Rehabilitation Symposium - Part 1	Naupaka V	2:00pm–5:00pm
Technical Session #2: Archeology and Engineering Geology Symposium	Naupaka VI	2:00pm–3:20pm
Technical Session #3: Volcanic and Seismic Hazards of the Circum-Pacific Region	Naupaka VI	3:40pm–5:00pm

EVENT	PLACE	TIME
WEDNESDAY, SEPTEMBER 21		
Technical Session #4: Rock Engineering-Rock Mechanics Symposium	Naupaka VII	2:00pm–5:00pm
Technical Session #5: Reaching the Last Mile: Our Responsibility to Effectively Communicate to Those in Harms Way What Geohazards They Face and Implement Disaster Mitigation Strategies Symposium	Paniolo 1	2:00pm–5:00pm
Mid-Afternoon Break	Exhibit Hall	3:20pm–3:40pm
Special Event: Traditional Hawaiian Luau	Hotel Luau Grounds	6:00pm–10:00pm
THURSDAY, SEPTEMBER 22		
Registration Desk	Naupaka Ballroom Foyer	7:00am–5:00pm
Committee Room	Paniolo 3	7:00am–5:00pm
Speaker Preparation Room	Keiki Club Room	7:00am–5:00pm
Speakers'/Moderators' Breakfast	Paniolo Terrace	7:00am–8:00am
Poster Session Presentations	Naupaka Foyer	8:00am–5:00pm
Exhibitors	Naupaka I-IV	8:00am–5:00pm
Technical Session #6: Dam and Dam Foundation Design, Repair and Rehabilitation - Part 2	Naupaka V	8:00am–12:00pm
Technical Session #7: Landslides and Society: Economics, Social Impacts, and Emergency Management Symposium - Part 1	Naupaka VI	8:00am–12:00pm
Technical Session #8: Coastal and Harbor Projects Symposium	Naupaka VII	8:00am–12:00pm
Technical Session #9: Engineering Geology for Tunnels and Underground Construction Symposium	Paniolo 1	8:00am–12:00pm
Guest Tour #3: Macadamia Nut Co & Parker Ranch	Departs from Hotel Lobby	9:30am–3:00pm
Mid-Morning Break	Exhibit Hall	10:00am–10:20am
AEG Awards Luncheon & Corporate Business Meeting	Paniolo 2 & 3	12:15pm–1:45pm
Technical Session #10: Dam and Dam Foundation Design, Repair and Rehabilitation - Part 3	Naupaka V	2:00pm–5:00pm
Technical Session #11: Landslides and Society: Economics, Social Impacts, and Emergency Management Symposium - Part 2	Naupaka VI	2:00pm–5:00pm
Technical Session #12: Application of Geophysics to Geotechnical Investigations	Naupaka VII	2:00pm–3:20pm
Technical Session #13: Geophysics and Remote Sensing in Engineering Geology: Case Studies and Advances Using Geophysics, Drones and Satellites	Naupaka VII	3:40pm–5:00pm
Technical Session #14: Groundwater and Hydrogeologic Projects	Paniolo 1	2:00pm–5:00pm
Mid-Afternoon Break	Exhibit Hall	3:20pm–3:40pm
Poster Presentations and Awards Reception	Naupaka Foyer	6:00pm–7:00pm
Annual Banquet	Naupaka VI & VII	7:00pm–10:00pm
FRIDAY, SEPTEMBER 23		
Registration Desk	Naupaka Ballroom Foyer	7:00am–5:00pm
Committee Room	Paniolo 3	7:00am–2:00pm
Speaker Preparation Room	Keiki Club Room	7:00am–2:00pm
Speakers'/Moderators' Breakfast	Paniolo Terrace	7:00am–8:00am
Women in AEG/AWG Breakfast	Paniolo 2	7:30am–8:30am
Poster Session Presentations	Naupaka Ballroom Foyer	8:00am–11:30am
Exhibitors	Naupaka I-IV	8:00am–11:30am
Technical Session #15: Dam and Dam Foundation Design, Repair and Rehabilitation - Part 4	Naupaka V	8:30am–10:00am
Guest Tour #4: Downtown Kona Historic Walking Tour	Departs from Hotel Lobby	9:00am -2:30pm
Technical Session #16: Naturally Occurring Geohazards	Naupaka V	10:20am–12:00pm

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EVENT	PLACE	TIME
FRIDAY, SEPTEMBER 23		
Technical Session #17: Transportation and Infrastructure Project: Rebuilding our Pipelines, Tunnels, Bridges, Highways and Railways	Naupaka VI	9:00am–12:00pm
Technical Session #18: Geologic Hazards, Communication and Mitigation of Volcanic, Seismic, Liquefaction and Tsunami Hazards	Naupaka VII	9:00am–12:00pm
Technical Session #19: Environmental Remediation Projects	Paniolo 1	9:00am–12:00pm
Mid-Morning Break	Exhibit Hall	10:00am–10:20am
Past Presidents' Luncheon (invitation only)	Paniolo 2	12:00pm–1:45pm
Board of Directors' Orientation Meeting	Paniolo 3	1:00pm–2:00pm
AEG Board of Directors' Meeting	Naupaka VI & VII	2:00pm–6:00pm
Technical Session #20: Challenges for the Geotechnical Practice	Naupaka V	2:00pm–3:20pm
Technical Session #21: Climate Change and Engineering Geology: Coast Line effects and Mitigation Projects	Naupaka VI	3:40pm–5:00pm
Technical Session #22: Slope Movements: Landslides and Rockfall Hazard Remediation and Mitigation Projects	Naupaka VII	2:00pm–5:00pm
Technical Session #23: Subsidence/Sinkhole Hazards in Karst and other Terrains	Paniolo 1	2:00pm–3:20pm
Technical Session #24: Unique Engineering Geology Projects	Paniolo 1	3:40pm–5:00pm
Mid-Afternoon Break	Naupaka Ballroom Foyer	3:20pm–3:40pm
SATURDAY, SEPTEMBER 24		
Field Trip #5: Tsunami and Landslide Hazards of the Northern Portion of the Big Island and H‘m‘kua Coast	Departs from Hotel Lobby	7:30am–7:00pm
Field Trip #6: Hawai‘i Volcanoes National Park	Departs from Hotel Lobby	7:30am–7:30pm
Short Course #2: Geotechnical Site Characterization for Engineering Geologists	Paniolo 1	8:00am–5:00pm
AEG Board of Directors' Meeting	Naupaka VI & VII	8:00am–5:00pm

Women in AEG/AWG Breakfast

Friday, September 23 – 7:30-8:30am

Join speaker Madeline German for what has become an AEG Annual Meeting tradition.

Throughout history women scientists have blazed trails to new and unique discoveries. At this year's Women in AEG/AWG Breakfast we will discuss a few notable women in geology and their contributions. Then we will brainstorm and discuss the women who are leading the field today to generate takeaways we could all use to be better geologists.

Technical Session Numbers and Names

See page 21 for full Technical Session listings.

SESSION	TIME
WEDNESDAY MORNING, SEPTEMBER 21	
Opening Session Welcome (Paul Santi, Ken Neal and Stephen Evans)	8:00am–8:10am
AEG Foundation Awards (Briget Doyle)	8:10am–8:30am
Keynote Speaker: Gary Kitkowski, U.S. Army Corps of Engineers, Pacific Ocean Division	8:30am–9:15am
Keynote Speaker: Christina Neal, USGS Hawaiian Volcano Observatory	9:15am–10:00am
Mid-Morning Break	10:00am–10:20am
OEEG Project Award: The US-89 Bitter Springs Landslide Repair (Mark Higley, James Lemmon and Bill McCormick)	10:20am–11:00am
2015–16 Jahns Lecturer: Jerome DeGraff	11:00am–11:30am
Introduction of the 2016–17 Jahns Lecturer	11:30am–12:00pm
WEDNESDAY AFTERNOON, SEPTEMBER 21	
Technical Session #1: Dam and Dam Foundation Design, Repair and Rehabilitation Symposium - Part 1	2:00pm–5:00pm
Technical Session #2: Archeology and Engineering Geology Symposium	2:00pm–3:20pm
Technical Session #3: Volcanic and Seismic Hazards of the Circum-Pacific Region	3:40pm–5:00pm
Technical Session #4: Rock Engineering-Rock Mechanics Symposium	2:00pm–5:00pm
Technical Session #5: Reaching the Last Mile: Our Responsibility to Effectively Communicate to Those in Harms Way What Geohazards They Face and Implement Disaster Mitigation Strategies Symposium	2:00pm–5:00pm
THURSDAY MORNING, SEPTEMBER 22	
Technical Session #6: Dam and Dam Foundation Design, Repair and Rehabilitation - Part 2	8:00am–12:00pm
Technical Session #7: Landslides and Society: Economics, Social Impacts, and Emergency Management Symposium - Part 1	8:00am–12:00pm
Technical Session #8: Coastal and Harbor Projects Symposium	8:00am–12:00pm
Technical Session #9: Engineering Geology for Tunnels and Underground Construction Symposium	8:00am–12:00pm
THURSDAY AFTERNOON, SEPTEMBER 22	
Technical Session #10: Dam and Dam Foundation Design, Repair and Rehabilitation - Part 3	2:00pm–5:00pm
Technical Session #11: Landslides and Society: Economics, Social Impacts, and Emergency Management Symposium - Part 2	2:00pm–5:00pm
Technical Session #12: Application of Geophysics to Geotechnical Investigations	2:00pm–3:20pm
Technical Session #13: Geophysics and Remote Sensing in Engineering Geology: Case Studies and Advances Using Geophysics, Drones and Satellites	3:40pm–5:00pm
Technical Session #14: Groundwater and Hydrogeologic Projects	2:00pm–5:00pm
FRIDAY MORNING, SEPTEMBER 23	
Technical Session #15: Dam and Dam Foundation Design, Repair and Rehabilitation - Part 4	9:00am–10:00am
Technical Session #16: Naturally Occurring Geohazards	10:20am–12:00pm
Technical Session #17: Transportation and Infrastructure Project: Rebuilding Our Pipelines, Tunnels, Bridges, Highways and Railways	9:00am–12:00pm
Technical Session #18: Geologic Hazards, Communication and Mitigation of Volcanic, Seismic, Liquefaction and Tsunami Hazards	9:00am–12:00pm
Technical Session #19: Environmental Remediation Projects	9:00am–12:00pm

SESSION	TIME
FRIDAY AFTERNOON, SEPTEMBER 23	
Technical Session #20: Challenges for the Geotechnical Practice	2:00pm–3:20pm
Technical Session #21: Climate Change and Engineering Geology: Coast Line Effects and Mitigation Projects	3:40pm–5:00pm
Technical Session #22: Slope Movements: Landslides and Rockfall Hazard Remediation and Mitigation Projects	2:00pm–5:00pm
Technical Session #23: Subsidence/Sinkhole Hazards in Karst and other Terrains	2:00pm–3:20pm
Technical Session #24: Unique Engineering Geology Projects	3:40pm–5:00pm

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USACE

Yogi Kwong Engineers, LLC

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Kim Bishop (Field Trip Leader)

Chuck T. Blay (Field Trip Leader)

Denise Brosie (Customer Service, Offinger Management Co.)

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Tim Shevlin (Field Trip Committee and Leader)

Rachel Teasdale (Field Trip Leader)

Alan Troup (Technical Session Moderator)

Rex Upp (Technical Session Moderator)

Coralie Wilhite (Symposia Committee)

Special Message from Governor David Y. Ige

Presented to

The Association of Environmental & Engineering Geologists

59th Annual Meeting

September 24, 2016

It is my pleasure to send my *aloha* and welcome to all attendees and guests of the 59th Annual Meeting of the Association of Environmental & Engineering Geologists (AEG) in Kona at the Waikoloa Beach Marriott.

Our unique locale and culture provides an ideal backdrop for this year's theme, "Engineering and Environmental Geology in the New Land." The island of Hawai'i is truly "the new land" as it is formed from some of the youngest rock on Earth and is still growing. The spectacular volcanic landscape is beautiful and awe-inspiring, and Native Hawaiians have a spiritual connection to this land and consider it sacred ground.

I would like to commend the meeting coordinators for planning an event that allows professionals to come together to support AEG's mission of providing leadership, advocacy and applied research in environmental and engineering geology.

My best wishes for a successful meeting, and I wish you a rich and unique experience during your stay. Once again, welcome and enjoy your visit to the island of Hawai'i.

With warmest regards,

DAVID Y. IGE
Governor, State of Hawai'i

Experience the Magic!

The 59th Annual Meeting– Kona, Hawai'i

Welcome to our first meeting in our youngest state! Literally. Our theme, Environmental and Engineering Geology in the New Land reflects the declaration on the meeting logo, "Ua Hanau Ka Moku" or "The Land was Born." Everywhere you look there are young rocks, active processes, recent deposits, and young-feeling people. See the smoldering volcanoes, the green sand, the dramatic landslides, and the work of the relentless crashing waves. Learn about regional volcanic and seismic hazards, coastal and harbor projects, dams and dam foundations, tunnels, slope movements, and a dozen other critical things AEG members do for our society.

You've undoubtedly experienced the envy of your workmates as you headed to this unique place, but Hawai'i is well-suited to the study of engineering and environmental geology and you will return with a storehouse of experiences and observations that will make you a better professional. I urge you to take advantage of the fantastic program put together by our organizing committee as you enjoy the tranquil surroundings.

"Our meetings are always known for networking, and this location is particularly amenable to interacting with colleagues."

Our meetings are always known for networking, and this location is particularly amenable to interacting with colleagues. Please include our newer members, students, and first-time attendees in your plans for socializing, touring, and relaxing. We all recall that lost feeling as we settled into AEG, and we were grateful for those people who made us feel welcome.

Enjoy your stay in Waikoloa and the Kona area and get all you can out of the meeting. Feel free to stop me to chat about whatever is on your mind. And remember to welcome and congratulate our 2016–17 Executive Council, Regional Directors, and Chapter Officers. Our volunteers are the backbone of the Association, so don't forget to thank members of our Kona Organizing Committee, the operating and technical committee chairs and members, and the many people who step up to make this organization what it is.

Paul M. Santi
AEG 2015–16 President

Welcome to the 59th AEG Annual Meeting

On behalf of the 2016 Annual Meeting Planning Committee, we welcome you to the beautiful Island of Hawai'i. Our committee has worked hard to bring you "environmental and engineering geology in the new land."

We invite you to participate in the many spectacular activities this meeting offers in this unique location. This program provides information for the icebreaker reception, lunch and dinner meetings, special event, student activities, and our amazing sponsors and exhibitors. It lists our distinguished lecturers, as well as our awards and awardees. Please also take advantage of our meeting app. Just download the free "Guidebook" app on your mobile device at http://guidebook.com/g/aeg2016, then search for "AEG" from within the app to get this year's guide. You'll be able to plan your day with a personalized schedule, browse exhibitors, use interactive maps, connect with meeting attendees, and much more. Use the AEG meeting app and leave the paper behind!

Hawai'i Island is the youngest of the Hawai'ian Island chain—truly the "new land." "Old" rocks on Hawai'i Island erupted hundreds of thousands of years ago. Lava flows located just north of the Kona Airport are from an 1801–02 eruption. Eruptions at Kilauea have continued intermittently over at least the past three centuries, and the current eruption has continued since January 1983. Mauna Loa, located northwest of Kilauea, is considered the most dangerous volcano in Hawai'i. Flows have threatened Hilo on seven occasions, the most recent in 1984. This ongoing volcanic activity is increasing the areal extent of the island

Large landslides have occurred in numerous locations around the periphery of the island. Frequent seismic activity has triggered slope movements. The island is also susceptible to tsunamis from local earthquakes, as well as from seismic activities around the Pacific Basin, Hilo has experienced the brunt of the impacts from tsunamis.

The Kona area is on the "dry" side of Hawai'i Island, and is a popular tourist destination. Activities include horseback riding, surfing, sail boarding, snorkeling, touring the many local shops, and just lying on the beach. For those wanting to explore and seeking more excitement, several companies offer ziplining.

Please join the members of our committee in celebrating the first ever AEG Annual Meeting in Hawai'i. We are certain you will be delighted with the location, enlightened by the outstanding symposia and technical sessions, and excited by the many networking opportunities and unique social events.

Thank you for attending. Enjoy your stay. Let us know if we can help make your meeting experience even better.

Ken Neal
General
Co-Chair

Stephen
Evans
General
Co-Chair

AEG 2016 Awardees

Honorary Member

Dr. Richard E. Goodman

AEG confers an honor of such high esteem that the distinction is recognized as a membership class: Honorary Member. This recognition is given to those persons whose careers have exemplified the ideals of AEG.

Karl and Ruth Terzaghi Mentor Award

Dr. J. David Rogers

This award, established in 2008, recognizes outstanding individuals for their achievements as Mentors throughout their career. The recipient should be an individual who has made lifelong efforts in providing professional, ethical, and technical mentoring for environmental and engineering geologists.

Floyd T. Johnston Service Award

Honoring Service to the Association

Duane Kreuger

This award is presented to a Member for outstanding active and faithful service to AEG over a minimum period of nine years to coincide with Floyd T. Johnston's tenure as Executive Director.

Schuster Medal

D. Jean Hutchinson

A joint award from AEG and the Canadian Geotechnical Society that recognizes excellence in geohazards research in North America. Nominees must be residents of North America and meet at least two of the following criteria: professional excellence in geohazards research with relevance to North America; significant contribution to public education regarding geohazards; international recognition for a professional career in geohazards; influential geohazards research or development of methods or techniques; or teacher of geohazards students.

No Photo Available

Claire P. Holdredge Award

Jeff Keaton

The Association's highest publication award, the Claire P. Holdredge Award, is presented to an AEG Member who has produced a publication within the past five years that is adjudged to be an outstanding contribution to the Environmental and Engineering Geology Profession.

Richard H. Jahns Distinguished Lecturer in Engineering Geology

Scott A. Anderson

A joint committee of AEG and the Engineering Geology Division of the Geological Society of America selects the Richard H. Jahns Distinguished Lecturer. The Lecturer presents an annual series of lectures at academic institutions in order to increase awareness of students about careers in Engineering Geology.

NOMINATE a Deserving AEG MEMBER for One of Our 2017 AWARDS

These are just a few of the AEG awards that recognize the contributions our members make to the Association and to the profession. It is our members that make the effort each day to provide public safety and protect property. For a complete list of the awards and requirements for each, visit the awards page on our website: http://www.aegweb.org/?page=Awards

AEG Foundation 2016 Scholars

Beardsley-Kuper Field Camp Scholarship

Tyler Craig Gilkerson *No Photo Available*

University of North Carolina at Charlotte – Dept. of Geography and Earth Sciences

Matthew Kyle Seigler

Clemson University

Ariel Marie Ellison

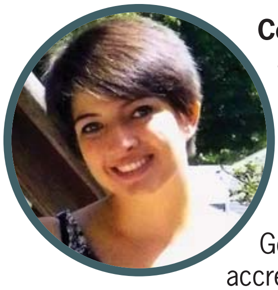
No Photo Available

University of Alaska Fairbanks – Dept. of Mining and Geological Engineering

The Beardsley-Kuper Field Camp Scholarship Fund is proud to announce its sixth annual awards. Funds are intended to support geology field camp expenses with applied environmental and engineering geology that will be useful to the students' future profession as an environmental or engineer geologist.

Carolinas Scholarship

Ashleigh Nicole Kirker



College of Charleston – Dept. of Geology & Environmental Geosciences

Established in 2015 with initial funds for the gift from Carolinas Section, this scholarship supports geologic studies by undergraduate students enrolled in a Geology or Geoscience Program at an accredited university in North or South Carolina. 2016 is the first time this scholarship has been awarded.

Christopher C. Mathewson Scholarship

Eric Bergersen

University of Texas at El Paso – Dept. of Geological Sciences

Graduate Division

Sean Michael Czarnecki

Angelo State University – Dept. of Physics and Geosciences and Dept. of Mathematics

Undergraduate Division

The Christopher C. Mathewson Scholarship was established in 2007 as the Texas Section Scholarship to support undergraduate and graduate students studying in Texas. The Fund was renamed at the request of the Texas Section of the AEG in 2011 to honor Dr. Chris Mathewson of Texas A&M University.

Shlemon Quaternary Engineering Geology Scholarship

Elaine Kathleen Young

University of California, Davis – Dept. of Earth and Planetary Science

The Shlemon Quaternary Engineering Geology Scholarship supports graduate geology students conducting Quaternary engineering geology research. Initial funding for the Scholarship was provided by a gift from Roy J. Shlemon, Honorary Member of the AEG. The 2016 award is the first Shlemon Quaternary Engineering Geology Scholarship.

Stout Scholarship

David William LaPorte

Colorado School of Mines – Geology and Geological Engineering Dept.

Graduate Division 1st Place

Priscilla Efua Addison

Michigan Technological University – Dept. of Geological and Mining Engineering & Sciences

Graduate Division 2nd Place

Randall Jones *No Photo Available*

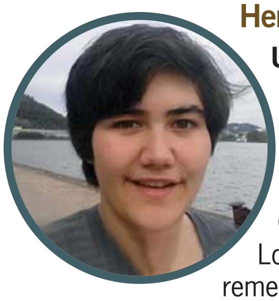
UNC-Chapel Hill

Undergraduate Division 1st Place

Danielle Terhaar

Boise State University

Undergraduate Division 2nd Place



Heni Barnes

University of Alaska Fairbanks

Undergraduate Division 3rd Place

Dr. Martin L. Stout was Professor of Geology at California State University, Los Angeles from 1960 to 1990. He is remembered by all of his students for his passionate and insightful instruction in engineering geology. Dr. Stout was well known for his expertise on mega landslides, his worldly travels, his good humor, and his gracious manner. This scholarship supports his legacy.

Norman R. Tilford Field Study Scholarships

Matthew Thomas Dorsey

San Diego State University – Dept. Geological Sciences MC-1020

Graduate Masters Division

Emily Penelope Anderson-Merritt

University of California Davis – Earth and Planetary Sciences

Undergraduate Division

Anna Katharina Schuh

University of Arizona

Undergraduate Division

The scholarships are awarded for the summer field season and were established in memory of Norman R. Tilford, who was a leader in engineering geology and a professor of engineering geology at Texas A&M University. Norm died in late 1997 while flying his small aircraft to meet a student field trip. Norm was dedicated to teaching geology in the field and these scholarships will support his legacy.

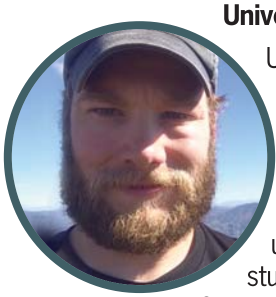
West-Gray Scholarship

Victoria Leffel

Purdue University – Health & Human Sciences

Graduate Division

Christopher Lee Orr



University of NC at Charlotte

Undergraduate Division

Established in 2014 with initial funding provided as a gift from AEG Past Presidents Terry R. West and Richard E. Gray, this fund supports undergraduate and graduate geology students in the eastern half of the United States through scholarship grants.

Exhibitors

Our exhibitors offer an excellent platform to interact one-on-one with you and your company. Your active interest and participation during the exhibit hours will help to ensure that vendor support will remain strong during the years to come. Remember, without these exhibitors, AEG would not be able to offer the special touches that make our 2016 Annual Meeting a “step above the rest.”

Be sure to:

- Visit each and every booth
- Express your needs
- Ask questions and get answers
- Learn about new products and services

Exhibit Hours:

Tuesday	**September 20**	**6:30pm–8:30pm**
Wednesday	**September 21**	**8:00am–5:00pm**
Thursday	**September 22**	**8:00am–5:00pm**
Friday	**September 23**	**8:00am–11:30am**

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www.adamtech.com.au
Contact: Kevin Ha, adam@adamtech.com.au

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Association of Environmental & Engineering Geologists

1100-H Brandywine Blvd., Zanesville, OH 43701
740-452-4541 x3229, Fax 740-452-2552
www.aegweb.org
Contact: aeg@aegweb.org

AEG welcomes you to Hawai'i! We hope your stay is filled with informative technical sessions, great meals, and of course lots of networking. Stop by our booth to see some of the latest publications and merchandise available. We will also have information on the various committees and what each has been working on to advance the AEG and the profession.

Association of Environmental & Engineering Geologists 2017 Annual Meeting

Contact: Contact: David Bieber,
David.Bieber@martinmarietta.com and Julie Frazier,
geojulia@gmail.com, Annual Meeting Co-Chairs.

AEG is pleased to host the 2017 Annual meeting in Colorado Springs, Colorado. Stop by our booth to get all of the details.

AEG Foundation Booth and Silent Auction

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312-403-0846
www.aegfoundation.org, staff@aegfoundation.org

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www.bucksgeophysical.com
Contact: Matthew J. McMillen, bucksgeo@bucksgeo.com

Bucks Geophysical Corporation is a full service geophysical consulting firm specializing in near-surface geophysical and borehole logging investigations. Our capabilities include EM, GPR, MAG, Seismic, Resistivity, VF, Utility Locating, and Geophysical Borehole Logging.

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Curtis and Tompkins is the leading California provider of a wide array of analyses for Organic, Metals, General Chemistry, and Radiochemistry constituents to all sectors of the industry. From commercial to federal, C&T has a long history of supporting Department of Defense, USEPA Superfund, and other programs. Curtis and Tompkins specializes in client oriented approach to project and data management, whether it be more focused on fast turn around time, comprehensive reporting or unique logistic needs.

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www.hitechrockfall.com
Contact: Dane Wagner, dane@hitechrockfall.com

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Contact: William Kane, wkane@kanegeotech.com

KANE GeoTech, Inc., is a civil engineering firm specializing in difficult geotechnical problems such as landslides, rockfall mitigation, instrumentation and rock mechanics. We also provide services such as foundation and other geotechnical investigations.

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Matrix Construction Products, LLC (Matrix) provides high quality polymer and bentonite products and additives to the construction drilling industries. Our products, technical service and equipment are used in a wide variety of applications for contractors in the construction of deep earth excavations such as foundation drilled shafts, diaphragm slurry walls, tunneling, soil mixing and micropiles. Our products and technology also extend to other heavy civil construction industries.

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ASBOG® serves as a connective link among the individual state geologic registration licensing boards for the planning and preparation of uniform procedures and the coordination of geologic protective measures for the general public. One of ASBOG's principal services is to develop standardized written examinations for determining qualifications of applicants seeking licensure as professional geologists. State boards of registration are provided with uniform examinations that are valid measures of competency related to the practice of the profession. Examination candidates are provided with a copy of the Professional Geologist Candidate Handbook, which delineates the format and outline for the exam.

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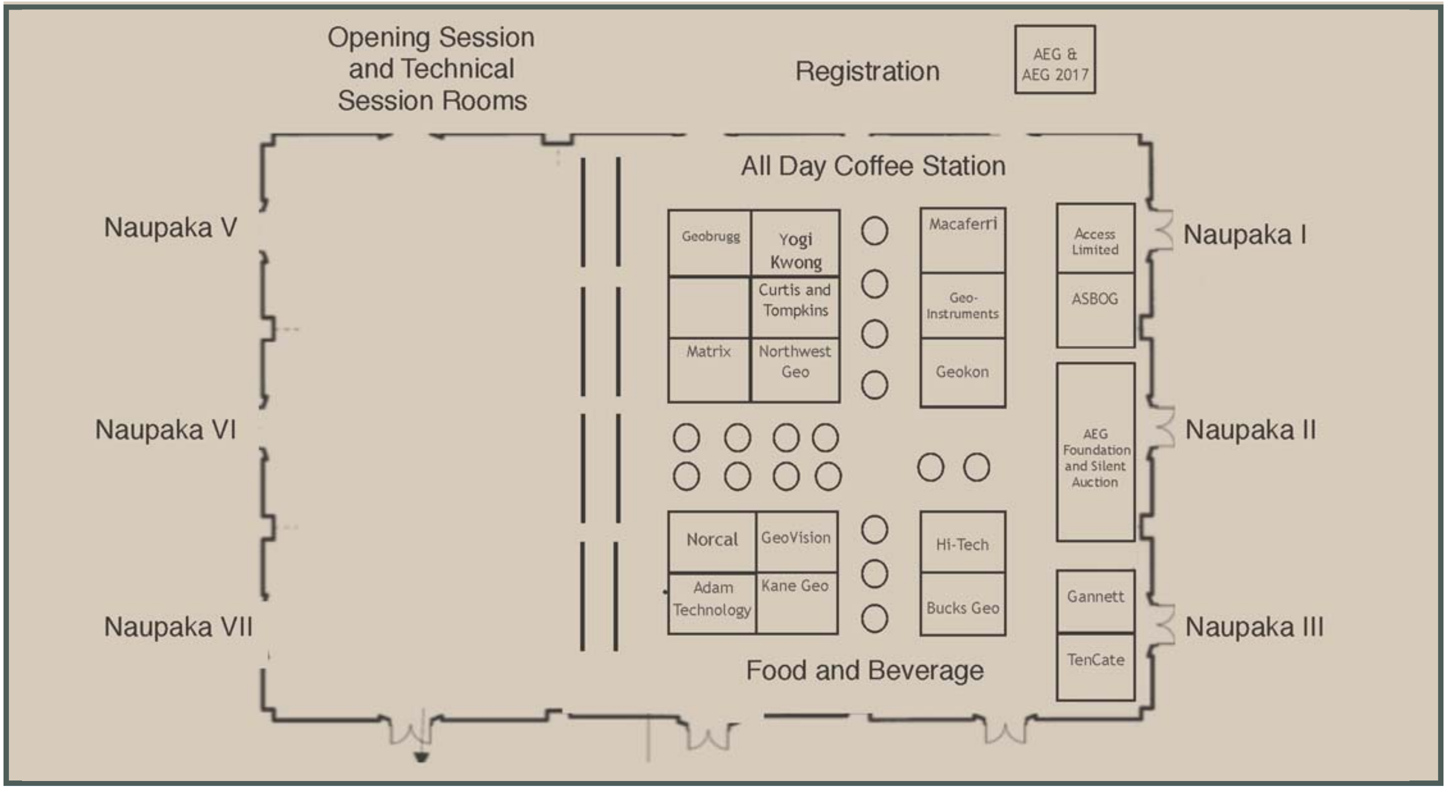
The Exhibitors' Luncheon

Free for All Full Meeting Registrants!

Wednesday, September 21
Exhibit Hall, Noon–1:30pm

Exhibit Hall – Naupaka Ballroom



The Association of Environmental & Engineering Geologists (AEG), as part of its Annual Meeting, provides an exhibit area with special events. The sole purpose of this exhibition is to provide the attendees of the meeting with an opportunity to view current and relevant products and services that may be of interest to working engineering geologists, environmental geologists, and hydrogeologists. AEG makes no claims or representations with respect to the quality, performance, or fitness for any purpose, of any given product or service that an exhibitor(s) may offer at the conference. AEG makes no endorsement of any product or service. AEG makes no warranty either expressed or implied with respect to any product or service offered at the conference. The quality, performance and/or warranty of any product or service offered at the conference is the exclusive, sole and complete responsibility of the exhibitor(s). AEG shall assume no responsibility for or liability resulting from the representations made by any exhibitor(s) for any product or service offered at the conference.

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TECHNICAL SESSIONS BREAKS

Wednesday

AEG Oregon Chapter

www.aegoregon.org
Adam Reese, Chair, AReese@apexcos.com

TECHNICAL SESSION 1:

Dam and Dam Foundation Design, Repair and Rehabilitation Symposium - Part 1

AEG Carolinas Chapter

www.aegcarolinas.org
Contact: Madeline German, madeline@smithgardnerinc.com

TECHNICAL SESSION 4:

Rock Engineering/Rock Mechanics Symposium

AEG Puget Sound Chapter

www.aegwashington.org
Contact: Kristina Sumner, kksumner@uw.edu

TECHNICAL SESSION 6:

Dam and Dam Foundation Design, Repair and Rehabilitation Symposium - Part 2

Schnabel Engineering

11-A Oak Branch Dr., Greensboro, NC 27407
336-274-9456
www.schnabel-eng.com
Contact: Gary Rogers, grogers@schnabel-eng.com

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SHORT COURSE 2:

Geotechnical Site Characterization

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Contact: Gary Rogers, grogers@schnabel-eng.com

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ALL DAY COFFEE STATIONS

Wednesday

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www.schnabel-eng.com
Contact: Gary Rogers, grogers@schnabel-eng.com

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www.hitechrockfall.com
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Friday

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POSTER PRESENTATIONS AND AWARDS RECEPTION

AEG Bay Area Chapter

Elizabeth Beckman, mbeckman@kleinfelder.com
AEG's San Francisco Bay Area Chapter is proud to sponsor this year's poster session. Our thriving chapter holds monthly meetings in Oakland/Berkeley. Find out more at www.aegsf.org!

WOMEN IN AEG/AWG BREAKFAST

AEG Carolinas Chapter

www.aegcarolinas.org
Contact: Madeline German, madeline@smithgardnerinc.com

and

Steele and Associates

2390 Forest St, Denver, CO 80207
303-333-6071
Contact: Susan Steele Weir and Bob Weir, steeleweir@aol.com

AWARD LUNCHEON & CORPORATE BUSINESS MEETING

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Contact: Dale Andrews, dale.andrews@carmeusena.com

STUDENT/PROFESSIONAL RECEPTION

LaManna Geosciences Inc.

Contact: John LaManna, johnl@lamannageosciences.com

and

Paul Santi

psanti629@gmail.com

and

Nate Saraceno

nrsaraceno@gmail.com

STUDENT MINI GRANT PROGRAM

Gill Editing Online

Contact: Jane Gill-Shaler, janehgillshaler@gmail.com

FIELD TRIP 1:

The Big Island: Volcanoes, Geohazards & Active Structural Geology

Greater Pittsburgh Chapter

http://www.aegweb.org/group/AO
Contact: Heather Krivos, hkrivos@gmail.com

FIELD TRIP 2:

Mauna Kea Stargazing

Celtic Earth Consulting

Contact: Stephen Evans, sevans@pangeoinc.com

FIELD TRIP 4:

Kona Coast Landslides

Kansas City-Omaha Chapter

http://www.aegweb.org/group/KCO
Contact: Theresa Ferguson, theresa.ferguson@atcassociates.com

FIELD TRIP 5:

Tsunami and Landslide Hazards of the Northern Portion of the Big Island and Hāmākua Coast

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www.pangeoinc.com
Contact: Paul Grant, pgrant@pangeoinc.com

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FIELD TRIP 6:

Hawai'i Volcano National Park

AEG Texas Chapter

Contact: Benson Chow, benson.chow@nacoal.com

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STUDENT MINI-GRANT

The Association of GeoHazard Professionals

561-768-9487
www.GeohazardAssociation.org
Contact: Becky Slaybaugh, BSlaybaugh@geohazardassociation.org

The Association of Geohazard Professionals (AGHP) was created in 2013 to support the development of standards, specifications, and best practices concerning the design and implementation of geohazard-related technologies and products; and to support and provide education to the geohazard community and those it serves. The Association aims to create a stable of resources that will support the purpose of the organization and the promotion of best practices in the geohazards field. The Association leadership is formulating high-altitude goals based on the needs of both the geohazard community and the communities influenced by and benefiting from geohazard technologies. In the first full year of formation, the Association will develop, through its leaders and membership, a more precise list of goals and related deliverables.

2016 Technical Program

The 2016 Technical Program will focus on a variety of topics including two full days of both Dam Symposium and Landslides and Society: Eco-nomics, Social Impacts, and Emergency Management Symposium. Other titles include: Archeology and Engineering Geology Symposium; Volcanic and Seismic Hazards of the Circum-Pacific Region; Rock Engineering-Rock Mechanics Symposium; Reaching the Last Mile: Our Responsibility to Effectively Communicate to Those in Harms Way What Geohazards They Face and Implement Disaster Mitigation Strategies Symposium; Coastal and Harbor Projects Symposium; Engineering Geology for Tunnels and Underground Construction Symposium; Application of Geophysics to Geotechnical Investigations; Geophysics and Remote Sensing in Engineering Geology: Case Studies and Advances Using Geophysics, Drones and Satellites; Groundwater and Hydrogeologic Projects; Naturally Occurring Geohazards; Transportation and Infrastructure Project: Rebuilding our Pipelines, Tunnels, Bridges, Highways and Railways Symposium; Geologic Hazards, Communication and Mitigation of Volcanic, Seismic, Liquefaction and Tsunami Hazards; Environmental Remediation Projects; Challenges for the Geotechnical Practice; Climate Change and Engineering Geology: Coast Line Effects and Mitigation Projects; Slope Movements: Landslides and Rockfall Hazard Remediation and Mitigation Projects; Subsidence/Sinkhole Hazards in Karst and Other Terrains and Unique Engineering Geology Projects.

The 2016 Annual Meeting Planning Committee has planned a technical program and short courses that are sure to provide an outstanding educational experience for attendees. PDHs will be available for all technical sessions and short courses. The main meeting activities will begin at 8:00 am on Wednesday, September 21, 2016, with the Opening Welcome Session. The Opening Welcome Session will feature keynote speakers Gary Kitkowski of the Pacific Ocean Division, U.S. Army Corps of Engineers, and Christina Neal of the USGS Hawaiian Volcano Observatory. In addition, the session will feature the current and upcoming Jahns Lecturers and presentation of the AEG Foundation Awards and Outstanding Environmental & Engineering Geologic Project Award. A Speaker's Preparation Room will be open from September 21–23, 2016, from 7:00am to 5:00pm, Wednesday and Thursday, and 7:00am to 2:00pm on Friday. A computer and projector will be available for presenters to practice their presentations. AEG provides an open forum for the presentation of varying opinions and positions. However, opinions expressed by speakers do not necessarily represent the views or policies of AEG.

Registration Packet Giveaways

Sponsored by Northwest Geophysics (Registration Giveaway) and Beta Analytic (name badge lanyards).

Technical Program Sponsors

Opening Welcome Session: Gannet Fleming, Inc.

Technical Sessions & Symposia:

AEG Carolinas Section
AEG Washington Section
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OPENING SESSION

Keynote Speaker

Gary Kitkowski

Chief of Regional Business Directorate for the Pacific Ocean Division, U.S. Army Corps of Engineers

Gary Kitkowski is the Chief of Regional Business Directorate for the Pacific Ocean Division, U.S. Army Corps of Engineers. He provides leadership and direction for the Division and its four subordinate districts to operate as a Regional Business Center. He is responsible for executing strategic planning, corporate objectives and regionalization initiatives for a program exceeding $3.0 billion, which covers one-third of the earth's surface, including the Asia-Pacific region, and includes approximately 1,700 active duty military, U.S. civilians and foreign nationals. As a member of the National Management Board, Kitkowski also provides corporate leadership for the U.S. Army Corps of Engineers.

Kitkowski holds a Bachelor of Science degree in Civil Engineering from the University of Hawai'i. He is a registered Professional Engineer in California and a member of the Society of American Military Engineers and the American Society of Civil Engineers. He has received numerous awards in his career, including the Army Superior Civilian Service Award and the Bronze Order of the de Fleury Medal.

Building Strong Foundations — Geology, AEG, and the Corps

This keynote address will highlight the importance of geologists, both engineering and environmental, in meeting the Corps' multiple missions both nationally and internationally. Kitkowski will cover the Corps' Civil Works Program, Military Construction Program, Environmental Program, the Interagency & International Support for Others (IIS) Program, and the role played by geologists in carrying out the Corps' efforts for those programs. He will also stress the importance of partnering with the AEG to enhance the technical competency and professional development of Corps geologists and geotechnical engineers.

Keynote Speaker
Christina Neal

Scientist-in-Charge, USGS Hawai'ian Volcano Observatory

Born and raised in New England, after college and graduate school, Neal has lived primarily in the western U.S.

From 1983–89, she worked for the U.S. Geological Survey at the Hawaiian Volcano Observatory on the Big Island of Hawai'i. Her work included monitoring and study of the 1983–present east rift eruption of Kilauea and the 1984 eruption of Mauna Loa, and geologic mapping of the southwest rift zone and summit areas of Kilauea. While stationed in Hawai'i, she also participated in an ALVIN expedition to study a propagating submarine rift system on the ocean floor north of the Galapagos Islands.

In 1990, Neal moved to Anchorage for a position at the newly established Alaska Volcano Observatory of the USGS. There, she worked on eruptions in the Aleutian arc, including the 1989–90 and 2009 eruptions of Mt. Redoubt, the 1992 eruption of Mt. Spurr, and the 2005–06 eruption of Augustine, and the 2008 eruption of Okmok. During quiet times, she was involved in investigations of the eruption history and volcano hazards of several young volcanoes on the Alaska Peninsula and the eastern Aleutians including two young calderas: Aniakchak (on the Alaska Peninsula) and Okmok (on Umnak Island).

In 1998, Neal took a two-year temporary position as a USGS geoscience advisor to the Office of U.S. Foreign Disaster Assistance of the U.S. Agency of International Development in Washington DC. There, she was tasked with overseeing and initiating programs in geohazards mitigation, advising the office on responses to geologic disasters, acting as a liaison with other federal agencies and academics and NGOs working on natural hazard mitigation, and assisting the office in developing a global strategy to deal with natural hazards. "I was fortunate in this assignment to travel to many places outside the U.S. including Thailand, Nepal, Ecuador, Colombia, and Kazakhstan where I reviewed or worked on implementation of hazard mitigation programs," says Neal.

She returned to Alaska in June 2000, to resume duties as a staff geologist at the Alaska Volcano Observatory, where she continued geologic mapping, eruption response, and physical volcanology studies of active Alaskan volcanoes. She focused

on strengthening the Alaska-based interagency response system for volcanic eruptions with particular emphasis on reducing volcanic risk to aviation in the North Pacific. In summer 2014, Neal participated in an NSF funded multi-disciplinary study of the Islands of Four Mountains in the Aleutians. Working from a ship with a small helicopter, Neal and her team managed to install the first volcano monitoring equipment on long-active Cleveland volcano. From 20002015, she led coordination of AVO's eruption monitoring and crisis response work with Russian volcanology counterparts in Petropavlovsk-Kamchatsky and Yuzhno-Sakhalinksk. In 2009–2010 she completed two details to the USGS Western Regional Office as Chief of Staff and Deputy Regional Director.

In 2015 Neal returned to Hawai'i to be Scientist in Charge of the Hawaiian Volcano Observatory. "In my first year here, I have focused on staff support and preparing for the next Mauna Loa eruption," says Neal.

Neal has an ScB in Geological Sciences from Brown University (1980), an MS in Geological Sciences from Arizona State University (1986), and additional graduate study in Geology at UC Santa Barbara (1987–89).

Volcanic Activity in Hawai'i: Challenges in Hazard Communication and Engineering

This presentation will summarize current activity at Hawai'i's active volcanoes and discuss challenges faced by scientists and emergency officials in communicating hazard information to at-risk populations. It will also describe some novel engineering ideas tested on pahoehoe lava during the 2014–15 Puna lava flow crisis.

Advocate for Geoscience!

Wednesday, September 21 – 2:30pm–3:30pm – Paniolo 2

Phyllis Steckel, co-chair of the **AEG Advocacy Committee** will lead this workshop, which will provide ideas, insight, and tools to become advocates for the professions of environmental and engineering geology. There are many audiences that need to know about our profession, and each audience hears our message from different perspectives. **Please plan to attend this worthwhile workshop!**

The 2015–16 GSA/AEG Richard H. Jahns Distinguished Lecturer in Engineering Geology

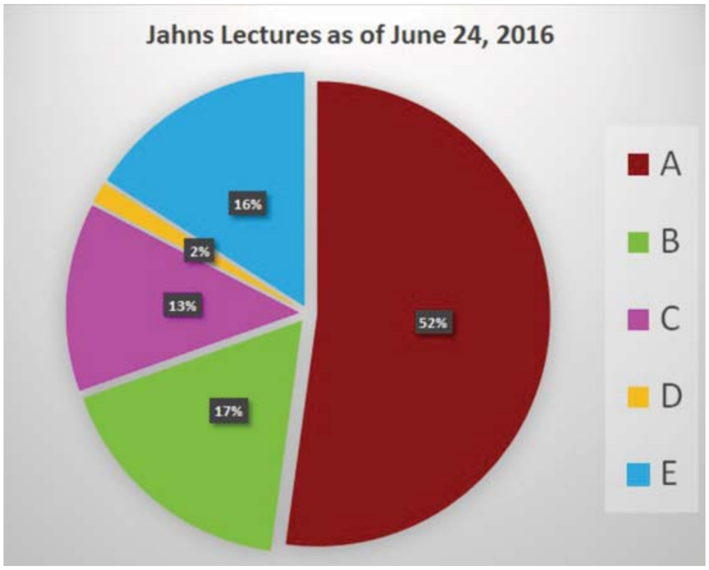
Jerome DeGraff

Eldon Gath (right) passes the "torch" to Jerry De Graff (left) at the October 2015 AEG San Joaquin Valley Chapter meeting in Fresno, CA.

Jerome De Graff is a native of the Finger Lakes Region of upstate New York. He graduated from SUNY Geneseo in 1967 with a BS in Education/Earth Science. Jerry counts himself lucky both for surviving a year teaching general science to eighth-graders and for then moving on to become an instructor at the newly opened Strasenburgh Planetarium (Rochester Museum & Science Center). His five years as a planetarium instructor and museum associate-in-geology resulted in his decision to pursue a Masters in Geology somewhere in the western United States. In 1976, Jerry received his master's degree in geology from Utah State University after completing a thesis mapping Quaternary geomorphic features over a 595-sq. mi. mountain range within a nearby National Forest. This started a chain of events resulting in Jerry having a 36-year career with the U.S. Forest Service as an environmental or engineering geologist on National Forests in Utah and California. During his last six years, he was a Forest Service On-Scene Coordinator for Superfund-type issues present at abandoned mines and closed landfills within National Forests scattered throughout the southern half of California.

Based on his professional experiences, he has authored or co-authored more than 70 contributions to books, proceedings, and peer-reviewed journals, including co-authoring a chapter in Landslides: Investigation and Mitigation Special Report 247 of the Transportation Research Board. In 2010, he received the Best Publication award from the Association of Environmental and Engineering Geologists for the paper, "The formation and persistence of the Matthieu landslide-dam Lake, Dominica, W.I." which was published in the journal, Environmental and Engineering Geoscience. So it is no surprise that since retiring from government service in 2014 Jerry continues to contribute to professional journals as a writer/reviewer/editor and remains active in professional organizations. He derives the most fun from teaching graduate courses for the Department of Earth & Environmental Science at California State University-Fresno (http://www.fresnostate.edu/csm/ees/facultystaff/degraff.html).

"I was very proud to have my inaugural lecture at my undergraduate alma mater, State University of New York at Geneseo, on the Friday after attending last year's AEG annual meeting. But one of the best parts of being the Jahns Lecturer is traveling to new places and making new friends. Of the 69 talks given to date (June 26, 2016), all but 13 were at universities. Almost all the non-university talks were at AEG Section meetings where students were often present. It is a great honor and privilege to generate interest in possible careers in applied geology.



A. *Fire, Earth & Rain: Emergency Response for Wildfire-induced Landslide Hazards*
B. *What Does It Take to Effectively Monitor for Environmental and Engineering Geology Projects?*
C. *The Challenges of Providing Landslide Information during an Emergency Response*
D. *Dealing with Hazardous Mine Openings-Blasting Is Not Always a Good Option*
E. *The Story of the Mattieu Landslide-Dam, Dominica, West Indies*

"Making arrangements posed logistical challenges with talks as far east as Wolfville, Nova Scotia, as far west as San Franciscoas, as far south as Hattiesburg, MS, and as far north as Vancouver, BC—and a lot of places in between! Many thanks to folks who have hosted and/or arranged for visits! I am almost fully booked for September and most of October which carries me to the end of my term. I wish to say, "Thanks to AEG and GSA for giving me such a fascinating once-in-a-career experience!"

INTRODUCING THE 2016–17 JAHNS DISTINGUISHED LECTURER

Scott Anderson, PhD, PE

For the past nine years Scott Anderson has been the Geotechnical Engineering Technical Services Team Manager for the

Federal Highway Administration's (FHWA) Resource Center. He leads a national team of geoprofessionals that assist state and local transportation agencies through technical assistance, training and the application of new technologies. He was initially drawn to FHWA through work he did with them in National Parks and he then worked six years as the Lead Geotechnical Engineer for the Federal Lands Divisions. This is the part of the agency that designs and constructs roads primarily to access our National Parks and Forests—some of the most beautiful and challenging project sites that can be imagined—and he has worked from Acadia National Park in Maine to Volcanoes National Park in Hawai'i. Prior to joining FHWA he advanced from Staff Geologist to Senior Consulting Engineer and Landslide Technology Leader for a major A/E design firm while working on landslides, dams, mines and transportation infrastructure, and he spent four years as an Assistant Professor of Civil Engineering at the University of Hawai'i. He earned his Bachelor's and Master's degrees in engineering geology from the University of Colorado at Boulder and Colorado State University, and Master's and Doctorate degrees in civil engineering from the University of California at Berkeley. His theses and much of his research address landslides, debris flows, soil and rock properties, and hillslope hydrology, and he has had a long interest in risk management that has landed him in a good place as an advocate for the risk-based asset and performance management needs for infrastructure. He is a licensed engineer and practicing engineering geologist with over 30 years of experience and approximately 100 publications and invited presentations. He has grown and lived in many places along a general path from Boston to Honolulu and now he makes his home in Colorado, where he enjoys all of the outdoor time he can get.

The 2016–17 Jahns Lectures Include:

- Natural hazards, risk, and the resilience of the built environment, especially highways
- How engineering geology relates to the needs of those owning and maintaining infrastructure
- Future opportunities for site and event characterization using remote sensing and crowd sourcing
- Lessons learned from the 2014 SR 530 (Oso) Landslide

How to Schedule a Jahns Lecture

AEG Members Kerry Cato, Greg Hempen, Loren Lasky, Alex Rutledge, and Darrel Schmitz collaborated to come up with with some helpful suggestions to get a Jahns Lecturer's visit in your area.

The individual Jahns Lecturer does almost all of their own scheduling and logistical coordination with the local Section and/or Chapter. In addition, the Lecturer is conducting talks in other areas. All while trying to perform their "real" day job back home."

Setting up a Jahns Lecturer takes patience and understanding on both ends, but the product is invaluable in its knowledge transfer, career guidance, and mentoring to students.

If your AEG Section or Chapter would like a Jahns Lecturer's visit to your area, check out the helpful tips on our website at: www.aegweb.org/?page=LecturerVisit

AEG's Outstanding Environmental and Engineering Geology Award – 2016

The US-89 Bitter Springs Landslide Repair

INTRODUCTION

US-89 is the main thoroughfare from the Flagstaff area to the recreational areas of the Grand and Marble Canyons and the Glen Canyon Dam/Lake Powell area in Northern Arizona. Renewed movement of an active landslide in the slopes of Echo Cliffs on February 20, 2013, resulted in large cracks and the collapse of over 500 feet of US 89 that required immediate closure of the road between the Bitter Springs community and the City of Page, Arizona. The highway was closed to all travel except emergency vehicles for two years, which had a major impact to the social and economic conditions and quality of life in Northern Arizona. The landslide-damaged highway traverses through environmentally and culturally sensitive lands of the Navajo Nation.

Kleinfelder's unique approach in this complex geologic setting included using a combination of techniques and tools to investigate the slide. Data from ground and helicopter based geologic mapping was used to model the geologic and recent past, as well as the present movement of the slides in the vicinity. Multiple subsurface exploration methods were employed to collect geotechnical properties including drilling with multiple truck, track, and portable drill rigs and instrumentation installations to monitor potential ongoing movement. The active slide that displaced the highway was a smaller feature at the base of a larger ancient slide, and the unique movement of the landslide was prompted by long-term erosion and subsequent creep-type movement of the toe, causing destabilization of the mass above the toe and ultimately reaching the roadway. The multidisciplinary approach combining geology and geotechnical engineering yielded a comprehensive model and ultimately a sustainable remedial design and fix. The mitigation took into account the environmentally and culturally sensitive location and focused on utilizing existing on-site resources to stabilize the landslide in the most economically feasible alternative for highway stabilization. The $25M mitigation included construction of the 1,000,000-cubic-yard gravity rock buttress solution to stabilize the slide, realignment of the roadway above the head scarp and completion of new cuts above the road.

PROJECT SIGNIFICANCE

Construction of US 89 through the Echo Cliffs area began in the late 1950s as part of the Glen Canyon Dam construction and since that time, has provided a scenic and time-efficient passage through Northern Arizona to the Lake Powell/Page recreational area and connection to Southern Utah. It also serves as a main arterial connection to the Glen Canyon Dam facility. US 89 serves as the community connector between Navajo Nation lands in the Bitter Springs area to the community of Page, AZ.

Loss of access along US 89 resulted in a sharp decline in tourism and a dramatic decline in the economic base of Northern Arizona communities. Detours as a result of the landslide damage created a 1.5–2-hour increased trip for commerce, tourists, as well as children who were bussed into the Page area for school.

Design and construction of the on-site buttress mitigation scheme restored the existing highway alignments and protected the Navajo lands at a savings to the State of Arizona ranging from several tens of million to possibly hundreds of millions of dollars, as compared to acquisition and construction of a new highway alignment bypassing the Echo Cliffs area.

PROJECT DESCRIPTION

The Bitter Springs landslide is a unique geologic feature present in the steep slopes of the Echo Cliffs, located approximately 20 miles south of Page, AZ. US Highway 89 at this location crosses over this and numerous other ancient landslide masses as it gradually climbs up the grade from the lower Kaibab plateau to the upper Kaibito Plateau and passes up and over the Echo Cliffs, which separates the two plateau levels. The Google 2013 image (left) shows the geographic features. The ancient landslide mass that slumped off the steep cliffs in the geologic past provided a bench topography that facilitated construction of a road up to the upper plateau. The traveling public, which includes local residents, tourists and commercial traffic, heavily rely upon use of US 89 to access Page and the Lake Powell area.

History of Project Need and Problem Definition

On February 20, 2013, a portion of an old landslide mass reactivated resulting in the development of a new head scarp across the road (right photo) that required closure of US89 and severely restricted the mobility of the traveling public in northern Arizona. This same general area experienced road cracking on the order of a couple inches in 1988, which was previously paved over.

With the limited mobility of travel in northern Arizona as a result of this slide and road closure, ADOT, supported by FHWA, contracted Kleinfelder on an emergency basis to develop an assessment of the cause of the landslide and to provide remedial engineering design solutions to repair the roadway and reopen to traffic as quickly as possible. The active landslide occurred along a 500-foot-long section of US 89 displacing all travel lanes with a vertical drop of about 4.5 feet. Within a couple of days, Kleinfelder recognized that this was a partial reactivation of a large ancient translational slide and developed an extensive exploration program to verify subsurface geologic conditions and landslide geometry.

Environmental and Engineering Geologic Principles Applied

The project was largely an engineering geology/geotechnical assessment of the landslide failure that required a solid understanding of the complex geologic conditions and subsurface geotechnical properties to establish a failure mechanism and effective sustainable remedial repairs.

Most of the ancient landslides in the steep cliffs of Northern Arizona are characterized by Pleistocene-age rotational failure. Detailed geologic and geomorphic mapping was the key to identifying this as a translational failure and for planning subsurface explorations, locating subsurface monitoring points and ultimately identifying and assessing the feasibility of various mitigation schemes. The project reinforced the importance of good old fashioned, "boots on the ground" field geology. The unique aspects and challenges associated with the project included using many different investigative methods to help understand the complex subsurface geology controlling the failure and utilizing iterative slope stability analyses with comprehensive geotechnical testing results.

Protection and Enhancement of the Environment

The highway alignment is bordered on both sides by Navajo Nation lands. In order to provide the required rock buttress mitigation, encroachment onto environmentally and culturally sensitive land was required. As such, both environmental and archeological studies were employed to identify sensitive areas. The buttress footprint and the uppermost rock back cut, which generated the rock fill material, were adjusted to avoid identified Navajo archeological sites on the ancient landslide.

The final stages of the project included safe construction of the remedial repairs on an active slide, particularly since the slide would not be stabilized until the primary movement-mitigating feature (gravity buttress) was completed. Kleinfelder provided continuous slope monitoring using a series of inclinometers and time domain reflectrometry (TDR) cables to detect possible slope movement and contribute to monitoring the safety of the work site.

Use of on-site rock materials cut from the upper roadway slope and placed as a buttress at the base of the slope significantly reduced the impact to the environment by limiting the removal and transport of import of fill materials from outside sources. Limiting the overall work area also acted to preserve native vegetation and wildlife.

BENEFIT TO THE PUBLIC

The project was executed in an emergency repair mode as a result of needing to restore the mobility to the Northern Arizona traveling public. The public was aware of the sense of urgency that ADOT and Kleinfelder placed on this project to execute a remedial design and safely reopen the highway as quickly as possible.

The value to the profession is showing that providing a unique approach and applying multiple investigative techniques for data collection results in an improved understanding and implementation of a lower risk solution. In this case understanding the landslide mass geometry and driving forces was crucial for a long-term repair solution.

The closure of the roadway resulted in significant costs to the public to reach their destination on much longer alternative routes. The local communities of Bitter Springs and Marble Canyon at the base of the Echo Cliffs could not reach Page in an efficient manner. According to a local resident, this restricted travel added two hours to each trip to Page and severely impacted the following services:

- School bus schedules
- Emergency vehicle service
- Local kiosks not able to operate
- Residents traveling to Page

Kleinfelder, ADOT, AECOM, and the FNF construction team worked together to design and construct a repair to the slide and reopen the roadway to the traveling public in as expedited manner as possible. Kleinfelder mobilized resources as necessary to assess the problem and develop a long-term stable solution. The roadway re-opened on March 27, 2015.

Advancement of the Public's Understanding of Environmental and Engineering Geology

Since the onset of the emergency closure to the re-opening of the highway in the same location two years later, ADOT conducted a progressive program of community outreach with a variety of public notices and a complete series of 26 web-accessible videos focused directly on this project. Kleinfelder participated in a number of videos describing preliminary geologic risk assessment, how geologic investigations are conducted, what are the purpose of these investigations, demonstration of drilling and sampling procedures, and how geotechnical design processes are conducted, ultimately leading to a mitigation design. Videos were also produced to show construction progress, including blasting of in-place rock and placement of that same rock as a stabilizing buttress fill. The public outreach for this project was un-paralleled and provided a start to finish tutorial on the geologic and geotechnical process. http://www.azdot.gov/media/blog (from February 2013 through November 2015)

UNIQUENESS & USE OF MULTIPLE EXPLORATION TECHNIQUES

The greatest challenge on this project was to understand the geology and the geometry of the landslide mass along with the driving forces that continued to result in movement of the active slide. The approach to the project was to collect surficial and subsurface data using multiple methods to understand the geology and geotechnical properties of the various deposits, inclusive of the ancient and active slide. Understanding the ancient landslide was important as the remedial design included earthmoving activities within the ancient slide and the team did not want to initiate movement of the larger ancient slide. The field methods listed below were uniquely applied to this project to gain a broader understanding of causes of the ancient slide and ascertain why only the lower portion of the old slide mass has continued to move since the beginning of construction of the roadway in 1957:

- Geologic mapping and helicopter reconnaissance;
- Subsurface drilling using truck, track and helicopter compatible portable drills to quickly access drill sites in the steep site topography without the need for road building;
- Geophysical surveys including refraction and ReMi;
- Installation of instrumentation to monitor surface and subsurface ground movement, including slope inclinometers and TDR, which can indicate shear depths based on electrical resistance and are capable of extending the life of the down-hole probe even after the inclinometer is no longer accessible if it begins to shear;
- Rock coring; and
- Laboratory testing of rock strengths.

In addition to the above field methods, a unique application included development of a geologic model to unfold an understanding of the development of the historic landslide mass on the slopes of the Echo Cliff and the geologic process driving the active failure, which represents a small portion of the larger historic slide in order to design a remedial repair that addressed and resisted the driving forces.

Complexity

One of the greatest challenges on this project was the complexity of the landslide mass. As noted in a previous section, a geologic model of the ancient slide was developed to understand the process of the larger landslide. This was important to understand since the remedial repair would require excavation of a part of the ancient landslide in order to produce local cost effective material to build the gravity buttress needed to stabilize the lower active slide. Understanding that the ancient landslide was deep seated allowed for a reasonable assumption that removal of portions of the larger slide would not destabilize and result in other areas of ground distress. The complexity was addressed during detailed geologic mapping and utilization

of borehole data from the various exploration points. (See Exhibits 9 and 10)

The unique feature of the active slide is that this landslide did not result from loading directly associated with the roadway construction. The larger ancient slide developed as a result of Echo Cliffs exposing a sedimentary rock sequence that included highly plastic clays of the Chinle Formation near the base of the slope. A translational slide occurred primarily along the Chinle clays resulting in a very large block sliding off from the cliff face. This larger ancient slide is estimated to be 300 feet thick and 1,200 feet long. The geometry of the active slide lies in the lower slopes (mostly below the roadway) and the toe area is located along a drainage that runs along the toe area and essentially has resulted in continued erosion of the soft Chinle clays exposed at the toe. As the toe material progressively gets removed during ongoing weathering and erosion the toe adjusts and creeps further away from the slope. (photo above.) Eventually, as the toe moves outward along the soft Chinle clays, the mass above slides in behind the shifting toe. The remedial design considered this condition and included stabilizing the toe with a gravity buttress to stop the creep-type movement and constrain the mass above the toe.

The Outstanding Environmental and Engineering Geologic Project Award was established in 1993 to recognize a project that meets the following criteria: • Displays national or international significance, • Demonstrates the application of the principles of environmental and engineering geology to the solution of a problem affecting the public, • Shows recognition of and respect for the environment and history and culture of the project area, and • Provides an opportunity for public education in: a. environmental and engineering geology, b. environmental issues, and c. culture and history of the area.
For information on award conditions and selection procedure, with AEG's webpage at http://www.aegweb.org/?page=OEEGProjectAward

Technical Program Schedule

Wednesday, September 21, 2016 – Afternoon

Technical Session #1
Dam and Dam Foundation Design, Repair and Rehabilitation Symposium - Part 1

Room: Naupaka 5 **Conveners: Brian Greene and Derek Morley**

The AEG Dams Technical Working Group has organized a three-day Dams Symposium for the Kona Annual Meeting that will be held on Wednesday, Thursday and Friday (September 21–23, 2016). There will be presentations on both national and international projects. The Dams Symposium will be led off with a series of presentations and a panel discussion on the evaluation of dams in Hawai'i with emphasis on the impact of the 2006 Kaloko Dam Failure and lessons learned from it. Our opening presentation will be by the U.S. Army Corps of Engineers, Honolulu District speaking on the topic of USACE Participation in High Hazard Dam Evaluations in Hawai'i following the 2006 Kaloko Dam Failure. In addition, there will be a Special Lecture on Dams by Dr. Richard Goodman, Consultant and Professor Emeritus from UC Berkeley. There are approximately 30 additional talks on topics that include: seepage and stability issues; risk evaluation of dams; site investigation; foundations, grouting and cutoff walls; dams founded on karst; cofferdams; dam removals and case histories. This will be one of the largest concentration of talks on dams assembled at any AEG Annual Meeting and we are fortunate to have so many AEG members working in this important area of our practice.

Time	Speaker	Title
2:00–2:20	Chow, Derek	USACE Participation in High Hazard Dam Evaluations in Hawai'i following the 2006 Kaloko Dam Failure (Presented by Michael Wong)
2:20–2:40	Wehrheim, John	Kauai's 2006 Ka Loko Dam Failure and its Lasting Impact on Hawai'i
2:40–3:00	Durkee, Dean	The State of Dams in Hawai'i - From Early Construction through Current Day
3:00–3:20	Panel Discussion	The 2006 Kaloko Dam Failure and its Implications on Dam Safety in Hawai'i
3:40–4:00	Hlepas, Georgette	The Evolution of USACE Seepage Barrier Wall Contracts (Presented by Vanessa Bateman)
4:00–4:20	Pattermann, Kenneth	Folsom Cofferdam Seepage Incident
4:20–4:40	Orozco, Arturo	Impact of Organic Clay and Peat Deposits on Design and Construction of a Dike within the Prado Dam Flood Control Basin (Presented by Mark McLarty)
4:40–5:00	Godwin, William	The Final Phase of San Clemente Dam - Removal and Stream Restoration

Technical Session #2
Archeology and Engineering Geology Symposium

Room: Naupaka 6 **Convener: Vanessa Bateman**

AEG is pleased to present the first symposium on Archeology & Engineering Geology. This new symposium will have several speakers explaining the importance and significance of having engineering geologists be a part of the team for archeological projects. Often this important interaction is overlooked and this symposium will provide an opportunity to highlight projects that embody this unique relationship. Presentations will cover everything from the T-Rex owned by the Corps on loan to the Smithsonian to challenges encountered at archeological digs in glacial outwash. The goal of the symposium is to highlight this relationship and encourage future cooperation between engineering geologists and archeologists.

Time	Speaker	Title
2:00–2:20	Van Arsdale, Cathy	The Long-Term Loan and Exhibition of Two Government-Owned Tyrannosaurus Rex Fossils
2:20–2:40	Vellone, Daniel	Paleontological Resource Preservation: A Federal Government Perspective on a Non-Renewable Natural Resource (Presented by Ana Vargo)
2:40–3:00	McInvale, Howard	Cumulative Departure Model of the Cryosphere During the Pleistocene—an Application in Computational Engineering Mathematics
3:00–3:20	Rogers, J. David	Salvage of the Capsized Battleship Oklahoma Following the Attack on Pearl Harbor

Technical Session #3
Volcanic and Seismic Hazards of the Circum-Pacific Region

Room: Naupaka 6 **Moderator: Shant Minas**

Time	Speaker	Title
3:40–4:00	Cannon, Eric	Slope Instability on the South Flank of Kilauea Volcano, Island of Hawai'i
4:00–4:20	Nygaard, Christopher	Revisiting the Sediment Management Plan for Mount St. Helens in Response to a Basin Impacted by a Volcanic Eruption
4:20–4:40	Rizkasari, Ana	Potential Hazards Area by Pyroclastic Flow after Merapi Volcano Eruption in 2010, Central Java, Indonesia
4:40–5:00	Rockwell, Thomas	What Happened to the "Big One" on the Southern San Andreas Fault? A System-Level Perspective of Seismic Hazard

Technical Session #4
Rock Engineering-Rock Mechanics Symposium

Room: Naupaka 7 **Conveners: Chad Lukkarila**

A rock mechanics and rock engineering symposium has been organized to cover seven talks that include speakers from academia, government, engineering, and construction industries. Topics include foundations, risk-based design, rockfall mitigation, rock anchors, rock slope stability and design, and testing of rockfall attenuators. We are fortunate to have a great mix of speakers and topics and hope that you will participate in the rock mechanics and rock engineering symposium.

Time	Speaker	Title
2:00–2:20	Rogers, J. David	Construction of the Red Hill Fuel Storage Tanks at Pearl Harbor
2:20–2:40	Deputy, Kami	Risqué Rockfall along US 24 - An inside look at CDOT's Risk Based Mitigation of Geohazards
2:40–3:00	Woodard, Martin	Practical Differences Between Post-Tensioned Anchors and Un-Tensioned (Passive) Dowels
3:00–3:20	Pallua, Thomas	Tehachapi Double-Track Project UPRR, Mojave Sub - Rock Slope Design and Construction
3:40–4:20	Anderson, Doug	Collaborative Design of Context Sensitive Rockfall Mitigation
4:20–4:40	Fisher, Brendan	Evaluating the Stability State of 'Dip Slopes'
4:40–5:00	Shevlin, Tim	Attenuators for Controlling Rockfall: First Results of a State-Of-The-Art Full-Scale Testing Program

Technical Session #5
Reaching the Last Mile:
Our Responsibility to Effectively Communicate to Those in Harms Way What Geohazards They Face and Implement Disaster Mitigation Strategies Symposium

Room: Paniolo 1 **Convener: Ron Harris**

This symposium will explore the widening gap between Geohazards research and implementation of disaster mitigation strategies. Many examples are provided to demonstrate how community based mitigation activities are bridging the gap and saving thousands of lives.

Time	Speaker	Title
2:00–2:20	Harris, Ron	Discovering a Giant Seismic Gap in Java, Indonesia and What Community Based Organizations are Doing About It
2:20–2:40	Keaton, Jeffrey	Interpreting Historical Radar Rainfall: Can Geologists Connect the Dots for Geohazard Communication?
2:40–3:00	Bauer, Jennifer	Landslide Emergency Response Planning – Using the Haywood County, NC Geologic Stability Maps
3:00–3:20	Gath, Eldon	When is Enough? Professional Practice Concerns from Seismic Hazard Investigations of El Rodeo School, Beverly Hills, CA
3:40–4:00	Hall, Sarah	Tsunami Risk Perceptions, Knowledge, and Efficacy in Java, Indonesia
4:00–4:20	Horns, Daniel	Historic and Prehistoric Tsunami Deposits in Java: Implications for Preparation and Evacuation Planning
4:20–4:40	Paripurno, Eko Teguh	Community Based Early Warning System at Kelut Volcano: A Success Story to Manage Huge 2014 Eruption
4:40–5:00	Beckstrand, Darren	Communicating Geotechnical Risk and Complexity

Thursday, September 22, 2016 – Morning

Technical Session #6
Dam and Dam Foundation Design, Repair and Rehabilitation - Part 2

Room: Naupaka 5 **Conveners: Kerry Cato and Derek Morley**

Time	Speaker	Title
8:00–8:20	Godwin, William	Perris Dam Seismic Remediation - Geologic Observations from CDSM Foundation Treatment
8:20–8:40	Henrich, William	Analysis of Optical Televiewer Logging in Support of a Foundation Grouting Evaluation at the Calaveras Dam Replacement Project
8:40–9:00	Nichols, Holly	Seepage Investigation and Remedial Grouting, Crafton Hills Reservoir Dam, California
9:00–9:20	Cole, William	Geologic Influence on Seepage and Remedial Grouting, New Bullards Bar Dam, California
9:20–9:40	Brosi, Brook	Amistad Dam Investigation and Oversight: Karst-Founded Dam on the USA-Mexico Border
9:40–10:00	David, Paul	Mosul Dam - Dam Safety Enhancement through Multinational Cooperation
10:20–10:40	Greene, Brian	History of Internal Erosion at East Branch Dam, PA and Cutoff Wall Remediation Project
10:40–11:00	Nield, Michael	Bolivar Dam Grout Curtain Construction
11:00–11:20	Lyle, Seth	Design, Construction, and Verification of a Partial-Depth Seepage Barrier through Glacial Outwash
11:20–11:40	Friend, Edwin	Rehabilitating a Historic Dam with Seepage Issues over a Complex Geologic Foundation
11:40–Noon	Rogers, J. David	Failure of the Alexander Dam Embankment on Kauai in 1930

Technical Session #7
Landslides and Society: Economics, Social Impacts, and Emergency Management Symposium - Part 1

Room: Naupaka 6 **Convener: Darren Beckstrand**

AEG's Technical Working Group on Landslides has organized a two-session symposium on the impact of landslides and their impact on society, economics, and emergency management. The sessions will be held on Thursday, September 22. Presentations have been hand-selected that describe the spectrum of how owners have just started to get a handle on the landslide issues that they face. The Landslide symposium will be commence with a brief introduction to the symposia and a presentation on the implementation of a statewide unstable slope condition assessment program, followed by a series of presentations of how various organizations of have dealt with their landslide dilemma: how to effectively reduce risk exposure in the face of adverse fiscal and geologic conditions.

Time	Speaker	Title
8:00–8:10	Beckstrand, Darren	Introduction
8:10–8:40	Beckstrand, Darren	Geotechnical Asset Management for the Alaska Department of Transportation & Public Facilities
8:40–9:00	Marshall, Mike	Geologic Route Characterization and Landslide Hazard Assessment of Oregon Coast Range Power Transmission Line
9:00–9:20	Bauer, Jennifer	Geologic Stability Mapping in Haywood County, NC – Involving Users in the Project
9:20–9:40	Dowling, Casey	Use of In Line Inspection Data to Characterize Activity of Deep Seated Landslides in the Boreal Forest, Alberta, Canada
9:40–10:00	Blackwood, Tim	Risk-Based Rockfall Mitigation Strategies in Hawai'i
10:20–10:40	Rosenbaum, Cole	Rio Chama Landslide Mapping and Analysis and Evaluation of Regional Landslide Susceptibility, Archuleta County, Colorado
10:40–11:00	Nandi, Arpita	Application of GIS based logistic regression for debris flow susceptibility mapping in the Great Smoky Mountains National Park, TN.
11:00–11:20	Anderson, Doug	A System for Improving Unstable Slope Management Practices for Federal Land Management Agency Infrastructure
11:20–11:40	Bouali, El Hachemi	Comparing the California Landslide Inventory to Ground Motion Detected by the COSMO-SkyMed Satellite across the Palos Verdes Peninsula
11:40–Noon	Brunet, Ghislain	A New Simplified Methodology to Design Flexible Debris Flow Barrier

Technical Session #8
Coastal and Harbor Projects Symposium

Room: Naupaka 7 **Convener: Vanessa Bateman**

AEG is pleased to present the Coastal & Harbor Projects Symposium. This symposium cover the varied and often complicated geology and site conditions encouraged in coastal and harbor projects. From restoration projects at historical structures with very little to no surface information to projects developed with the latest technology this symposium will stress the importance of sound engineering geology and subsurface exploration for project success. This symposium will bring together experts from across the nation and covers projects from Alaska to California to New York and will explore the variable conditions encountered. Attendees will leave with a better understanding of the complex nature of these projects and the best practices to completing them.

Time	Speaker	Title
8:00–8:20	Babineaux, Claire	Evaluation of Cullet Movement through Coastal Systems with Analytical Sediment Transport Models
8:20–8:40	Cregger, David	Coastal Engineering in the Hudson River
8:40–9:00	Evans, Stephen	P-993 Transport Protection System Forward Operating Location Improvements
9:00–9:20	Foreman, Graham	Geotechnical Design and Construction of Rubble-mound Breakwater on Soft Soils - Valdez, Alaska
9:20–9:40	Smith, Thomas	Kikiaola Small Boat Harbor, Kauai, Hawai'i: Keeping Sediment from the Grand Canyon of the Pacific out of the Harbor
9:40–10:00	Kloster, Rebecca	Cape Lisburne Seawall Reconstruction Project
10:20–10:40	Podoski, Jessic	National Shoreline Management Study: An Overview of the Impacts of Shoreline Change in Hawai'i
10:40–11:00	Schug, David	"Soft" Shore Protection Proposed at the Beacon's Beach Landslide, Encinitas, California
11:00–11:20	Leifer, Anne	Shoreline Remediation: Transforming a Coastal Brownfield to a Park
11:20–11:40	Kissane, Joseph	Planning and Technical Considerations for Large Stone Use on Chicago Shoreline Project, Lake Michigan (Presented by Richard Olsen)
11:40–Noon	Yang, Yongchao	Blind Extraction of Full-Field Structural Dynamics by Video Motion Manipulations for Remote Assessment of Infrastructures

Technical Session #9
Engineering Geology for Tunnels and Underground Construction Symposium

Room: Paniolo 1 **Conveners: Richard Escandon and Alan Howard**

Geologic conditions associated with tunnels and underground projects generally dominate the design and cost of a project and often present significant challenges associated with predicting ground behavior and groundwater conditions. This symposium for the 2016 AEG Annual Meeting includes eight abstracts and presentations covering a number of topics of interest to the engineering geologic community involved in tunnels and underground construction. The symposium will begin with a presentation on geologic risk and underground construction by Dr. Priscilla Nelson, Colorado School of Mines, followed by several case history presentations covering active fault crossing for a sewer tunnel project in Los Angeles, geologic/geotechnical investigations for tunnels, construction of the Kaneohe-Kailua Wastewater Tunnel, and repair of the Spirit Lake Outlet Tunnel at Mount St. Helens, Washington which was constructed in difficult conditions associated with a 90–meter wide shear zone. The second half of the symposium will continue with a lessons learned presentation that will cover squeezing ground, groundwater inflow, "rumbling" ground at the Crystal Springs Lake Tap, large fracture flow at the San Jacinto tunnel, difficult ground, sinkholes, and many other interesting lessons. The lessons learned will be followed by a presentation on groundwater pressure, conductivity, and temperature impacts on deep tunnels, a case study comparing anticipated versus actual conditions encountered on the New Irvington Tunnel Project in California, and finally a review of geologic conditions and tunnel operations that lead to sinkholes, ground loss and surface damage at Los Angeles International Airport and surrounding areas on a project 25 years ago.

Time	Speaker	Title
8:00–8:40	Nelson, Priscilla	Geologic Risk and Underground Construction
8:40–9:00	Van Etten, Greg	"Under the Volcano": Tunneling and Geologic Mapping in Variable Basalt for the Kaneohe/Kailua Sewer Tunnel, Oahu, Hawai'i (Presented by Alan Howard)
9:00–9:20	Perry, David	Geotechnical Investigation for the Northeast Interceptor Sewer (NEIS) Phase 2A Project at the Hollywood Fault crossing in the Los Feliz District of Los Angeles, California
9:20–10:00	Budai, Christine	Spirit Lake Outlet Tunnel Repair, Mount St. Helens, Washington, USA
10:20–11:00	Kaneshiro, Jon	The Rest of the Story - Tunneling Geologic Lessons and Other Geotechnical Geology Potpourri
11:00–11:20	Guptill, Paul	Measuring In-Situ Pressures, Hydraulic Conductivities, and Ground Temperatures Affecting Deep Tunnel Feasibility
11:20–11:40	Fusee, Rebecca	New Irvington Tunnel Anticipated and Actual Geologic Conditions - A Case Study
11:40–Noon	Escandon, Richard	Lessons Learned - North Outfall Replacement Sewer Tunnel 25 Years Later

Thursday, September 22, 2016 – Afternoon

Technical Session #10
Dam and Dam Foundation Design, Repair and Rehabilitation - Part 3

Room: Naupaka 5 **Convener: Edwin Friend**

Time	Speaker	Title
2:00–2:20	Salter, Paul	Geologic Mapping Methodology for Borinquen Dam 1E Foundation, Panama Canal Expansion
2:20–2:40	Schug, David	Investigations of the Pedro Miguel Fault During Borinquen Dam 1E Construction, Panama Canal Expansion
2:40–3:00	Taylor, Tatia	Structural Geology of the Folsom Auxiliary Dam and Spillway Foundation, Joint Federal Project, Folsom CA
3:00–3:20	Wilhite, Coralie	Construction of Large Slab Anchors in Shear Zones for the Folsom Auxiliary Spillway Approach Channel
3:40–4:00	Davidson, Thomas	Pilot Test Program Utilizing Glass Bead Filter Packs for Relief Well Construction
4:00–4:20	Fox, Catherine	Relief Well Maintenance, Rehabilitation and Installation
4:20–4:40	Rogers, Gary	Hardy Dam - How 100 Years of Old Dusty Records, Observations by Karl Terzaghi, and a Walk in the Woods Answered the Artesian Question
4:40–5:00	George, Michael	Prototype Measurements of Rock Block Erosion: Implications for Dam Foundation and Spillway Erodibility Assessment

Technical Session #11
Landslides and Society: Economics, Social Impacts, and Emergency Management Symposium - Part 2

Room: Naupaka 6 **Convener: Darren Beckstrand**

Time	Speaker	Title
2:00–2:40	deLaChapelle, John	A Case Study of the Development of a Landslide Hazard Management Program for PG&E's Natural Gas Pipeline System in California
2:40–3:00	Johnson, Clayton	A Case Study of the Development of a Landslide Hazard Program for PG&E's Natural Gas Pipeline System in California
3:00–3:20	Cohen-Waeber, Julien	InSAR Tracking and Characterization of Seasonal Landslide Displacements in the San Francisco East Bay Hills, USA
3:40–4:00	Bishop, Kim	The Kohala Landslide - A Newly Defined Giant Landslide on Kohala Volcano, Island of Hawai'i
4:00–4:20	Jones, Mallory	Flexible Debris Flow Barriers Allow Homes to be Re-built Quickly After Damaging Event
4:20–5:00	Cato, Kerry	2010 Storm-Induced Debris Flows in the San Bernardino Mountains, California

Technical Session #12
Application of Geophysics to Geotechnical Investigations

Room: Naupaka 7 **Moderator: Alan Troup**

Time	Speaker	Title
2:00–2:20	Troup, Alan	Analysis of Borehole Geophysical and Acoustic Televiewer Data Aids in Calculating Rock Mass Properties for a Proposed Nuclear Power Plant
2:20–2:40	Pendergrass, Gary	Geophysical Methods for Screening and Investigating Utility Waste Landfill Sites in Karst Terrain
2:40–3:00	Hunter, Lewis	Geophysical Investigations at Isabella Dam, Lake Isabella, California
3:00–3:20	Pendergrass, Gary	CCR Rule: Geophysical Techniques to Certify Utility Waste Landfill Stability and Groundwater Monitoring in Karst

Technical Session #13
Geophysics and Remote Sensing in Engineering Geology: Case Studies and Advances using Geophysics, Drones and Satellites

Room: Naupaka 7 **Moderator: Alan Troup**

Time	Speaker	Title
3:40–4:00	Bouali, El Hachemi	Rockfall Hazard Analysis using Satellite, UAV, and Field Data: A Comparison of Techniques and RHRS Results
4:00–4:20	Bunds, Michael	High-Resolution Topography for Geologic Hazard Studies Using UAV-Based Photography and Structure from Motion Software
4:20–4:40	Carnevale, Mario	Rock Mechanical Properties from Full Waveform Sonic (FWS) Log vs Lab Testing
4:40–5:00	VanderMeer, Sarah	Interdisciplinary Benefits of the HVSR Passive Seismic Geophysical Method

Technical Session #14
Groundwater and Hydrogeologic Projects

Room: Paniolo 1 **Convener: Anna Saindon**

Time	Speaker	Title
2:00–2:20	Liane, George	2D or not 2D, that is the Question: Insights on the Dimension Debate for Pore Pressure Modeling of Open Pit Mines
2:20–2:40	German, Madeline	"Landfills and Groundwater" - A Case Study of Impact in North Carolina
2:40–3:00	Nigro, Steve	Sorption Coupled with Enhanced Biodegradation to Treat Petroleum and Chlorinated Contaminants in Groundwater
3:00–3:20	Schmitz, Darrel	Spring Water Source Demonstration for Jackson Spring, Tishomingo Mississippi
3:40–4:00	Jennings, Casey	Modeling the Effects of Carbon Dioxide Injection on Coalbed Methane-Associated Water in the Central Appalachian Basin
4:00–4:20	West, Terry	Backfilling of a Gravel Pit with Road Construction Debris, Risks Water Supply Concerns for Nearby Residential Area, Lafayette, Tippecanoe Co., IN
4:20–4:40	Lautze, Nichole	Introducing Two Projects Focused on Groundwater in Hawai'i
4:40–5:00	Evans, Stephen	Groundwater Aspects and Impacts on the North Jetty Rehabilitation Project

Friday, September 23, 2016 – Morning

Technical Session #15
Dam and Dam Foundation Design, Repair and Rehabilitation - Part 4

Room: Naupaka 5 **Convener: Brian Greene**

Dave Rogers will present an entertaining synopsis of the fascinating professional career of Dick Goodman, Professor of Geological Engineering at the University of California, Berkeley from 1964-94. Dr. Rogers presentation will be followed by a special presentation from the 2016 Honorary Member, Dr. Richard Goodman. Dick authored more books on engineering geology and rock mechanics than any other member of our profession, and wrote an award-winning biography of Karl Terzaghi, the father of geotechnical engineering. He is the only engineering geologist to be elected to the National Academy of Engineering and serve as a Rankine Lecturer of the Institute of Civil Engineers, as well as numerous ASCE awards, including the Seed, Lee, Sowers, and Leonards Lectures. He is being inducted as an Honorary Member of AEG at this meeting.

Time	Speaker	Title
8:30–9:15	J. David Rogers	A Renaissance Man: the Career of Professor Richard E. Goodman
9:15–10:00	Dr. Richard Goodman	Presentation

Technical Session #16
Naturally Occurring Geohazards

Room: Naupaka 5 **Moderator: Sarah Kalika**

Time	Speaker	Title
10:20–10:40	Bailey, Mark	Potential Impacts on Construction Projects of Naturally Occurrences of Asbestos in Rock & Soil
10:40–11:00	Bailey, Mark	The Calaveras Dam Replacement Project-A Case Study in Managing Naturally Occurring Asbestos at a Large Construction Site
11:00–11:20	Kalika, Sarah	Evaluation of Naturally Occurring Asbestos Mitigation Measures in California Construction Projects
11:20–11:40	Sederquist, David	Management Strategies for Naturally Occurring Asbestos During Construction in the Sierra Nevada Foothills of California
11:40–Noon	Kaunda, Rennie	Characterization of Under Seepage-Induced Dam Erosion Due to Hydraulic Parameters and Soil Properties Using Artificial Neural Network Models

Technical Session #17
Transportation and Infrastructure Project: Rebuilding our Pipelines, Tunnels, Bridges, Highways and Railways

Room: Naupaka 6 **Moderator: Alan Howard**

Time	Speaker	Title
9:00–9:40	Castelli, Kathryn	Sheep Creek Bridge vs. Sheep Creek Landslide
9:40–10:00	Freitag, George	Engineering Geology of the Meyers Cone, Interstate 84, Columbia River Gorge, Oregon
10:20–11:00	Hay, Stephen	US 26 Mount Hood Highway Safety & Preservation Project (Presented by Benjamin George)
11:00–11:20	Steckel, Richard	Drone Operations in the United States: An Update on Current Requirements to Fly Safely and Legally
11:20–11:40	Metz, Paul	Comparison of Field and Laboratory Test Methods for Material Site Selection for the Alaska North Slope Rail Project
11:40–Noon	Gath, Eldon	Geologic investigation for Fault Rupture Mitigation, SR 710 North Study's Tunnel Alternative's Design, Eastern Los Angeles, California

Technical Session #18
Geologic Hazards, Communication and Mitigation of Volcanic, Seismic, Liquefaction and Tsunami Hazards

Room: Naupaka 7 **Moderator: Dave Fenster**

Time	Speaker	Title
9:00–9:20	Addison, Priscilla	Regional Influence on Predicting Post-Wildfire Debris Flow Occurrence in Western United States
9:20–9:40	Cline, K. Michael	A Probabilistic Fault Displacement Hazard Analysis Case History
9:40–10:00	Gladney, Amarra	Seismic Movement Monitoring & Alerting Using Time Domain Reflectometry
10:20–10:40	Ferriz, Horacio	Investigation of Earth Embankments Through Shear-Wave Velocity and Resistivity Surveys
10:40–11:00	Saines, Nick	Educating Building and Safety Officials in the Las Vegas Valley about Seismic Hazard
11:00–11:20	Molinari, Mark	Quaternary Fault Investigation and Probabilistic (PSHA) and Deterministic (DSHA) Seismic Hazard Analyses for Guam
11:20–11:40	Lim, Robin	Properties of the Volcanic Ash on the Island of Hawai'i
11:40–Noon	El-Hussain, Issa	Seismic Hazard Assessment at Duqm Area, Sultanate of Oman

Technical Session #19
Environmental Remediation Projects

Room: Paniolo 1 **Moderator: Loren Lasky**

Time	Speaker	Title
9:00–9:40	Misra, Debasmita	Monitoring Goldstream Creek Turbidity for Potential TMDL Development in Interior Alaska
9:40–10:00	Hart, Megan	Soil Mixing Using Waste Fly Ash Byproducts
10:20–10:40	Hart, Megan	Development of Permeable Reactive Concrete for Enhanced Heavy Metal Removal
10:40 -11:00	Hatheway, Allen W.	Universal Guide to Coal-Tar Cleanup – Case History (Massachusetts - 1823-2017)
11:00–11:20	Torrance, Keith	Migration of Contaminants in Permafrost Active Layer; New Insights from Ongoing Studies at the Former Naval Arctic Research Laboratory, Barrow, Alaska
11:20–11:40	Murphy, Ralph	Treatment of Inorganic Constituents in Leachate Collected at an Unlined Municipal Solid Waste Landfill
11:40–Noon		Q&A

Technical Session #20
Challenges for the Geotechnical Practice

Room: Naupaka 5 **Moderator: Rex Upp**

Time	Speaker	Title
2:00–2:20	Fox, Catherine	Challenges Encountered and Subsurface Investigation in Glacial Outwash
2:20–2:40	Mathewson, Christopher	Where IS Your New Entry-Level Engineering Geologist Coming From?
2:40–3:00	Minas, Shant	The Applied Geologist in the Construction Industry: Navigating the Murky Waters Where Science, Business, Policy and Politics Mix
3:00–3:20	Upp, Rex	Erosion Damage to Water Canal Caused by Homeowner - NOT!!

Technical Session #21
Climate Change and Engineering Geology: Coast Line effects and Mitigation Projects

Room: Naupaka 5 **Moderator: Shant Minas**

Time	Speaker	Title
3:40–4:00	Wilson, Susan	Correlation of Transgressions on Alaska's North Slope
4:00–4:40	Kissane, Joseph	Planning and Technical Considerations for Large Stone Use on Chicago Shoreline Project, Lake Michigan (Presented by Richard Olsen)
4:40–5:00	Kao, Patrick	Mortar Bar Expansion Study on Known Proportions of Chert in Aggregate for Determining Potential Alkali Silica Reactivity

Technical Session #22
Slope Movements: Landslides and Rockfall Hazard Remediation and Mitigation Projects

Room: Naupaka 7 **Moderator: Yonathan Admassu**

Time	Speaker	Title
2:00–2:20	Scheevel, Caroline	Modeling Reactivation Conditions for Cook Lake, Wyoming Landslide
2:20–2:40	Anderson, Byron	Ferguson Rock Slide Update: Designing California's Largest Rock Shed Structure with Real-Time Geologic Data
2:40–3:00	Admassu, Yonathan	Designing Cut Slopes In Weak Rock Using Slake Durability Index
3:00–3:20	Brunet, Ghislain	Case Histories on Light Anchor Post System for Flexible Rockfall Barriers
3:40–4:00	Gyswyt, Nora	Topographic Change Analysis Using LiDAR Differencing: a Case Study from a Frozen Debris Lobe, Brooks Range, Alaska
4:00–4:20	Obermiller, Kyle	Rockfall Hazard Assessment along Interstate 90, Keechelus Lake, Washington
4:20–4:40	Painter, Paul	Emergency Rockfall Slope Assessment and Remediation - US 52, Lawrence County, Ohio
4:40–5:00	Pattermann, Kenneth	Construction of Two Secant-Pile Seepage Cutoff Walls at the Folsom Auxiliary Spillway Project

Technical Session #23
Subsidence/Sinkhole Hazards in Karst and other Terrains

Room: Paniolo 1 **Moderator: Michael Knight**

Time	Speaker	Title
2:00–2:20	Addison, Priscilla	Utilizing Vegetation Index as a Proxy to Characterize Railway Embankment Stability in a Permafrost Region
2:20–2:40	Conway, Brian	Using Interferometric Synthetic Aperture Radar Data for Land Subsidence Monitoring and Groundwater Management in Arizona
2:40–3:20	Reid, Craig	Localized Differential Foundation Movement within the Willow Glen area of the Santa Clara Valley, California

Technical Session #24
Unique Engineering Geology Projects

Room: Paniolo 1 **Moderator: Gary Luce**

Time	Speaker	Title
3:40–4:00	Luce, Gary	“It Was a Dark and Stormy Night” on the Comstock…Emergency Repair and Relocation of State Route 342
4:00–4:20	Cohen-Waeber, Julian	The Usefulness of Useless Concretions: One’s Trash is Another’s Treasure
4:20–4:40	Hamel, James	Forensic Investigation of a Cracked House in Western Pennsylvania
4:40–5:00	Wilson, Susan	Geologic Terrain and Hazard Analyses of Permafrost Soils in Support of Project Siting and Engineering

Poster Presentations and Awards Reception

Wednesday, September 21 to Friday, September 23

Times: **Wednesday – Thursday: 8:00am–5:00 pm, Friday: 8:00am–11:30am**

Poster Presentation Reception – Thursday: 6:00pm–7:00pm

Location: **Exhibit Hall in Naupaka Ballroom Foyer**

See each poster for presenter’s schedule. A list of presenters and poster numbers along with a map will be included in the registration packets and be available at the registration desk.

Presenter	Title
Bordal, Max	Quantifying Rapid Erosion with Terrestrial Laser Scanning and Point Cloud Analysis in an Urbanized Watershed
Duran, Robert	Characterization and Analysis of the Rio Chama Rockslide, Archuleta County, Colorado
Ellison, Ariel	Site Characterization of the Proposed North Slope Railroad Extension with Focus on Livengood to Coldfoot, Alaska
Kaunda, Rennie	Extrapolation of a Laboratory-Based Dam Failure Risk Assessment Method to the Field Scale
LaPorte, David	Monitoring of Urban Landslides Around Guatemala City Through Community Engagement
Lowry, Donald	Deterministic and Probabilistic Evaluation at a Site East of La Paz, Baja California Sur, Mexico
Mendbayar, Uyanga	Investigation and Quantification of Water Track Networks in Boreal Regions of Alaska
Parker, Lauren	Assessment of Fill Time and Potential Interbasin Transfer of Water for Proposed Reservoirs in George County Mississippi
Peterson, Justin	Navajo Nation Environmental Response Trust, Assessment of Abandoned Uranium Mines (AUMs)
Piller, Angela	Precipitation Intensity Required for Landslide Initiation in Rwanda
Semmens, Stephen	An Examination of the Impact of the Natural Environment on the Development of Levee Distress Features
Son, Jin	Spatial Analysis and Mapping Methods of Rockfall Prone Area during Thawing Periods in South Korea
Vargo, Ana	A Case Study of a Cracked Dam, Frog Hollow Debris Basin, Washington County, Utah
Wallace, John	History and Mechanisms of Rock Slope Instability Along Telegraph Hill, San Francisco, California
Yang, Jiaming	Quantifying the Effects of Crustal Thickening and Viscous Decoupling on Melt Production in the Cascadia Mantle Wedge

Vote for Your Favorite Poster!

AEG is offering three cash prizes ($250, $175, $75) for the top three vote recipients. Voting will be conducted exclusively through the Guidebook app, so bring your mobile device to vote for your favorite. Winners will be announced and prizes awarded at the

Poster Presentations and Awards Reception

Thursday, September 22

6:00–7:00 pm on the Naupaka Ballroom Foyer

Abstracts

Regional Influence on Predicting Post-Wildfire Debris Flow Occurrence in Western United States

Addison, Priscilla, Michigan Technological University, peaddiso@mtu.edu; Ashley Kern, ankern@mtu.edu; Qiuying Sha, qsha@mtu.edu; Thomas Oommen, toommen@mtu.edu (TS #18)

Besides the dangers of an actively burning wildfire, there are a plethora of other hazardous consequences associated with its aftermath. Debris flows are among such consequences. In recent years, the occurrence of post wildfire debris flows in the western United States has spiked in frequency. Although debris flows are not exclusive to wildfire affected areas, a wildfire can transform a basin that had no such history into a substantial hazard for any life and/or infrastructure in its path. In an attempt to curb this hazard, regression models have been developed to predict the occurrence of these post-wildfire debris flow events to aid in their mitigation and prevention. These past models, however, assumed a linear relationship between the response and the predictor variables, producing results of 44% sensitivity for the best model developed for Intermountain western United States region. The results suggest that approximately only four out of ten of these potential hazardous events will be correctly predicted. Our initial work on the same Intermountain western USA dataset utilizing machine learning algorithms produced an improved sensitivity of 72% with the nonlinear Naïve Bayes model, alluding to the fact that the response-predictor relationship of this dataset is nonlinear as opposed to the suggested linear relationship by earlier studies. This study is, therefore, a buildup on the machine learning analyses where we explore different data combinations to investigate the regional influence on predictive capabilities on six different machine learning models. The regional splits were Southern California, Intermountain Western and combined Western USA data. Ten-fold cross-validation was applied to the 80% training data to obtain reflective model performance profiles, which were tested with the remaining 20% validation dataset. The results showed the Intermountain Western region dataset to have the best predictive capability with an even increased sensitivity of 90.9% from the nonlinear Mixture Discriminant Analysis model. Comparing this to the 44% sensitivity of the previous linear model shows more than a two-fold increase, depicting increased ability in predicting the potential locations of these hazardous debris flows.

Utilizing Vegetation Index as a Proxy to Characterize Railway Embankment Stability in a Permafrost Region

Addison, Priscilla, Michigan Technological University, peaddiso@mtu.edu; Pasi Lautala, ptlautal@mtu.edu; Thomas Oommen, toommen@mtu.edu (TS #23)

Degrading permafrost conditions around the world leads to instability issues for infrastructure founded on top of them. Railway lines have exceptionally low tolerances for differential settlements due to the risk for train derailments. Many of these settlements can be attributed to permafrost degradation so railway owners with tracks in permafrost regions make it a priority to identify potential settlement locations for proper maintenance and/or embankment stabilization needs. The extensive discontinuous permafrost zone along the Hudson Bay Railway (HBR) in Northern Manitoba, Canada, has been experiencing accelerated deterioration, resulting in differential settlements that necessitate continuous annual maintenance to avoid slow orders and operational interruptions. Currently, the maintenance protocol is done on an as need basis, but the railway owners are interested in developing a more data-driven understanding of the corridor conditions. They believe this understanding will help to efficiently allocate limited maintenance resources and also evaluate potentially long-term stabilization measures for the severely affected sections. In a bid to address the challenge posed, this study seeks to characterize the different permafrost degradation characteristics along the HBR. We compare records of track geometry exceptions against remotely sensed vegetation indices, to establish a relationship between track quality and vegetation health since past studies have shown vegetation pattern to have a strong influence on permafrost health. This relationship was then used as a proxy for subsurface condition delineated by electrical resistivity tomography. The established relationship was finally used to develop a three-level degradation susceptibility chart that divided the corridor into low, moderate and high susceptibility regions. The defined susceptibility regions can be used to better allocate the limited maintenance resources and also help inform long-term stabilization measures for the severely affected sections.

Designing Cut Slopes in Weak Rock Using Slake Durability Index

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Seven cut slope sites along Ohio highways, containing thick (>10 ft) units of shales, claystones, and mudstones, were selected for investigating slope stability problems and developing a design approach based on slake durability index. Stability problems affecting slopes in these rocks include raveling, gully erosion, mudflows, and, occasionally, deep-seated rotational slides. Field data regarding slope height, slope angle, slope stratigraphy, catchment ditch dimensions, natural slope angle, and talus slope angle were collected for the seven sites. Laboratory test data from the samples collected from the study sites included point load strength index (I_s50), 2nd-cycle slake durability index (Id_2), plasticity index ($_{IP}$), and geologic strength index (GSI). The Franklin shale rating system, global stability analysis using the SLIDE software, natural slope angle, and talus slope angle were used to determine safe cut slope angles for weak rock units. Based on the correlation between Id_2 and stable slope angles, as indicated by the shale rating system, we propose cut slope angles for weak rock units as follows: Id_2 <20% - flatter than 2H:1V (<27o); Id_2 = 20–60% - 2H:1V (27o); Id_2 = 60-85% - 1.5H:1V (34o); Id_2 = 85-95% - 1H:1V (45o); Id_2 >95% - 0.5H:1V (63o). These angles are corroborated by talus slope angles, the natural angles attained by talus material covering cut slopes in weak rocks. Redbeds, consisting of very weak claystones and mudstones, should be analyzed on a case-by-case basis. Additionally, surface drainage, including backslope, midslope, and downslope drains, jute matting to promote vegetation growth, and adequate catchment ditches should be provided for all weak rock slopes.

Ferguson Rock Slide Update: Designing California's Largest Rock Shed Structure with Real-Time Geologic Data

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California State Route 140 (SR-140) was damaged in the spring of 2006 during a series of major rockslides at the Ferguson Ridge in Mariposa County, burying approximately 600 feet of the highway. SR-140 is the central route to Yosemite National Park from the west and is utilized daily by thousands of tourists, residents, workers, and businesses. In order to accommodate these users Caltrans installed two temporary bridges over the Merced River to detour motorists around the slide toe in 2008. A permanent rock shed solution was selected by the Caltrans Permanent Restoration Project Team in 2014 that includes the construction of a 750-foot-long covered structure at the original highway grade to allow future rockslide talus to fall over the roadway and into the Merced River channel. This rockshed concept is the largest of its kind ever to be considered in California. This presentation provides an account of the rock shed's many design challenges and changes, as a result of collecting and incorporating site-specific engineering geologic data during the design process. Anchor design components considered during this process ranged from single whaler anchor systems to high capacity, multi-strand rock anchors. The geologic and geotechnical data was also used to develop lateral and vertical earth pressures, rock fall energies impacting the rock shed structure, foundation alternatives, and development of the rock anchor test program. Each exploration advanced at the site brought new revelations regarding geologic character of the bedrock and the slide's material properties, relative age, and geometry. This presentation will also address the unique interaction between engineering geologists, geotechnical engineers, Caltrans structural engineers, the general contractor, and policy makers working together under a Construction Manager/General Contractor type project.

Collaborative Design of Context Sensitive Rockfall Mitigation

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Traditionally, development of new rock cuts and mitigation measures for rockfall hazards associated with transportation assets has been a balancing act between project safety requirements, available right-of-way, and economic constraints. Established rockfall mitigation categories include avoidance, removal, stabilization, and protection. The importance of understanding how new rock cuts and rockfall mitigation projects will affect, or impact the surrounding area has become a major consideration in the past few decades. Context sensitive considerations include visual impairments, unique historical considerations, and scenic characteristics. The inclusion of aesthetics and other context sensitive considerations in the design process has increased the complexity of project development and implementation, but has resulted in more owners and partners investing in new rock cuts and rockfall mitigation safety improvements if context sensitive solutions are adapted for their project area constraints. Collaborative efforts between teams comprised of federal and state agencies, their geotechnical consultants, and other stakeholders are needed to develop an acceptable design that meets the context sensitive goals of all the partners involved. Examples of recent successful rockfall mitigation projects in context sensitive areas on National Park Service and U.S. Forest Service lands with a strong technical team from the FHWA ñ Western Federal Lands Highway Division and Landslide Technology, include Going-to-the-Sun Road in Glacier National Park, Montana, Yellowstone National Park, Wyoming, Crater Lake National Park, Oregon, and the Banks-Lowman Highway and Ketchum-Challis Highway in Idaho.

A System for Improving Unstable Slope Management Practices for Federal Land Management Agency Infrastructure

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Transportation corridors (roads and trails) on Federal Lands contain numerous unstable and potentially unstable slopes. The effects of these unstable slopes can range in severity from maintenance nuisances that go unnoticed by the public, to occasional blockage of roads and trails, to injuries and property damage. Consistent with federal efforts for overall disaster preparedness and risk reduction, many state transportation agencies are moving towards proactive risk management strategies to partially, or fully mitigate unstable slopes. However, there is little in the literature to guide Federal Land Management Agencies (FLMAs), Tribes, and local state agencies (like County, City, and State and Metro Parks) with low to very low traffic volumes and various levels of trail usage in how to manage slopes using asset management principles. This project establishes a standardized methodology for unstable slope management using an asset management- based system for adoption by FLMAs or other agencies with similar assets and infrastructure assessment needs. Inventorying and assessing the condition of unstable slopes is the first step in the management process. However, understanding the magnitude of the problems associated with unstable slopes requires more than simply identifying them. In order to manage, we must understand the costs associated with maintaining, preserving, and replacing such assets. Unlike bridges and pavements, geotechnical assets are typically mitigated in reaction to when a failure closes a trail or roadway. The geotechnical asset management decision-support methodology developed through this program provides a proactive approach to inventorying, assessing, and prioritizing slope management project nominations and distribution of funding.

Evaluation of Cullet Movement through Coastal Systems with Analytical Sediment Transport Models

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Recycled glass cullet is an aggregate material composed of broken glass containers that can be produced with prescribed grain size distributions. It has been evaluated by investigators as an unconventional source of material for beach nourishment. The goal of this study is to determine whether cullet moves through littoral systems in a similar manner to natural sand through the use of analytical sediment transport models. The geologic compatibility of cullet to beach sand relies heavily on the comparison of physical characteristics of the grains including size, shape, angularity, and composition. It is expected that because the sand and cullet are equivalent in grain size and specific gravity, they will move through a littoral environment in the same manner. The use of analytical sediment transport models can help both researchers and environmental managers assess the impact of cullet on the health and morphology of the coastal system.

Potential Impacts on Construction Projects of Naturally Occurrences of Asbestos in Rock & Soil

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Natural occurrences of asbestos, or NOA, are increasingly recognized as potential health hazards to communities and construction workers and may result in severe and costly restrictions on dust generating construction activities. To assess the presence of NOA, review of geologic maps, geologic site inspections and appropriate rock and soil sampling and testing must first occur. If NOA is found, restrictions on construction activities may be in the form of regulations imposed by local governmental agencies, or may be self-imposed to protect against potential liability. Such restrictions typically require addressing NOA in EIRs, construction management plans, dust control plans, and health and safety plans, which plans will address comprehensive air monitoring both within and outside the job site. It is critical that geologists and geological engineers be aware of the potential for NOA at any construction site, and of the fact that a significantly greater number of fibrous minerals than the standard regulated six (chrysotile, amosite, crocidolite, anthophyllite, tremolite and actinolite) are now recognized as having the potential to cause asbestos disease. An overview of NOA issues will be discussed, as will EPA's recent release of asbestos toxicity values for non-regulated amphibole asbestos found at the Libby, MT superfund NOA site.

The Calaveras Dam Replacement Project-A Case Study in Managing Naturally Occurring Asbestos at a Large Construction Site

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The San Francisco Public Utilities Commission is well into construction of the Calaveras Dam Replacement Project (CDRP), a new earthen dam in northern California designed to withstand a major earthquake on the nearby active Calaveras fault. The first phase of construction involved excavation and on-site disposal of 3 million tons of material including a highly complex assemblage of Franciscan subduction zone mélange containing fibrous minerals across the amphibole chemical spectrum. To date, 30 amphibole species and subspecies have been detected in air monitoring samples using the CARB AHERA counting rules. The second phase, in progress, is construction of the zoned dam using on-site materials. The upstream shell is constructed of blueschist rock composed primarily of fibrous glaucophane, a sodic amphibole similar to riebeckite, and winchite, one amphibole comprising the "Libby amphibole mix." This material is blasted from an on-site quarry, then loaded, hauled, and placed as engineered fill. The limited chemical range of amphibole in solid solution affords the opportunity to fingerprint site amphiboles, distinguish them from offsite amphiboles, and document their containment on site. This project represents the largest construction project involving NOA in the country, and involves disturbance of one of the most complex geological and mineralogical units in the world. As such, applying regulations that were designed for building materials and routine construction sites, and controlling and monitoring airborne emissions on such a massive scale, is a major challenge. After a review of the dam history and design, this presentation will document how the NOA team, composed of geologists and industrial hygienists, is managing the field determination of NOA, on-site control measures, personal air monitoring, and perimeter air monitoring to assure that construction is conducted in a safe manner, and offsite risk is properly managed.

Geologic Stability Mapping in Haywood County, NC – Involving Users in the Project

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In 2014, Appalachian Landslide Consultants, PLLC (ALC), completed the first two sub-watersheds of the Geologic Stability Mapping Project in Haywood County, NC (2014 AEG Annual Meeting Program with Abstracts). In 2016, ALC completed mapping in an additional two sub-watersheds, with continued funding by non-profit organizations. Recognizing the importance of the use of these maps, project partners included a user's workshop component in the grant application. Including letters of support from users of the map information, such as real estate agents, home builders association members, appraisers, and mortgage lenders, along with having representatives from these user groups at the grant application presentation, met the grantors desire for a public involvement component and helped with grant approval. The project completed inventory and susceptibility mapping for over 62,000 acres within the Fines Creek and East Fork Pigeon River sub-watersheds. Inventory mapping identified 88 landslides; 17 on unmodified slopes and 71 occurring on modified, constructed slopes. This mapping increases the number of landslides in all of Haywood County to 333, with 86% on constructed slopes. Susceptibility maps included layers for "where natural debris flows might start," "where natural debris flows might go," and "slope construction caution areas." An online map viewer and a User's Guide for these maps is publicly available at https://appalachianlandslide.com/landslide-hazard-maps/. To better engage one primary user group, a workshop for Real Estate Industry Professionals was held. This 1.5-hour workshop explained different types of landslides and a hands-on portion to walk attendees through using the maps. Twenty-four people attended, ranging from real estate agents, attorneys, inspectors, and construction managers. A post-workshop survey indicates that attendees found the workshop very to extremely helpful and 80% of respondents find it extremely important to map the remainder of Haywood County. Many now understand how to use the maps as a tool for helping their clients.

Landslide Emergency Response Planning – Using the Haywood County, NC Geologic Stability Maps

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Haywood County Local Emergency Planning Committee hosted a Landslide Emergency Response Meeting at the Jonathan Creek Fire Department in Waynesville, NC, on August 4th, 2016. The purpose of the meeting was to bring together first responders, subjects matter experts, and emergency planners to discuss the hazards, vulnerabilities and capabilities available to safely and efficiently respond to landslide incidents. Landslide Emergency Response Planning is necessary in order to ensure the safety of WNC citizens and all responders before, during and after landslide incidents. Appalachian Landside Consultants, PLLC (ALC) has been working on mapping landslides and creating geologic stability maps for four different watersheds in Haywood County since 2012, through grant funding from area non-profit organizations. This experience put ALC in the position to discuss landslides and tools available through the mapping with the emergency managers and responders. This paper will show examples of how landslide inventory and susceptibility mapping can be used for hazard mitigation, planning before an emergency, and during response to a landslide incident. It will show

examples given to the emergency responders about accessing the online Landslide Inventory and Susceptibility maps and User's Guide available to the public on ALC's website
(www.appalachianlandslide.com). The landslide inventory database was given to the attendees, highlighting the fields related to relative potential for future movement
of a slope, relative potential for impact to public safety should that slope fail, and relative potential impact to water quality after a failure. Emergency managers and responders can used this list to focus their attention on the areas indicated as "high" relative potential. The presentation will conclude with a discussion of signs of instability that emergency responders can be aware of during a landslide emergency to help protect themselves and the public.

Geotechnical Asset Management for the Alaska Department of Transportation & Public Facilities

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The Alaska Department of Transportation and Public Facilities (AKDOT&PF) has developed the nation's first Geotechnical Asset Management Program. This program encompasses rock slopes, unstable soil slopes and embankments, retaining walls, and material sources along the State's highway system. Like bridges and pavements, geotechnical assets are subject to deterioration and when not actively managed, maintained, and mitigated; high life cycle costs, reduced mobility, and increased life-safety risks are the unfortunate result. This proactive program has inventoried and assessed the condition of 1,636 slopes on the National Highway System (NHS) and select portions of the Alaska Highway System (AHS), or about 45% of AKDOT&PF's road miles. Assessments of 210 retaining walls on portions of the NHS and AHS, or about 17% of AKDOT&PF's inventory, have been completed. Geographic scarcity of quality aggregate materials is assessed on a Maintenance Station basis. All assets are evaluated within a consistent rubric of five condition states and classified in terms of Good, Fair, or Poor condition. A number of tools to store and communicate the results are part of the project deliverables. The online geodatabase created to store all project information utilized the Department's enterprise GIS. Forward-looking tools to record geotechnical events and related information allow the Department to track asset performance over time. Life cycle cost estimation and investment analysis, using first-of-its-kind condition-based programmatic cost estimation, deterioration rates and maintenance costs permit the Department to make informed decisions, all in terms of hazard, risk, and cost as stewards of the Public trust. This project has estimated that every $1.00 spent on improving slope and wall conditions today not only pays for itself, but also returns an additional $1.06 (106% ROI) to the Department and road users.

Communicating Geotechnical Risk and Complexity

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Despite today's tough fiscal environment and permitting process, geotechnical practitioners need to make the strong case for early and proper geotechnical evaluations during project planning and design, but communicating the presence of geologic hazards and geotechnical risk for scoping design complexity in transportation projects has been challenging. Recently, a geotechnical planning project for Idaho Transportation Department's (ITD) District 6 took into account principles of the developing field of Geotechnical Asset Management with established geologic reconnaissance and evaluation techniques. This project evaluated the condition and risk aspects of over 50 landslides, rock slopes, and embankments along a 30-mile corridor of U.S. 26 in eastern Idaho. The terrain poses risks for upcoming highway modernization where, given comprehensive early evaluations, these risks can be addressed during project planning, thus enabling early and cost-effective project scope decisions. Following a comprehensive inventory, condition, and risk assessment, innovative communication tools utilizing ITD's existing ArcGIS online platform (IPLAN) were developed to host project data. All assessed features and existing information were housed within IPLAN's geodatabases. An early planning phase exploration and instrumentation program was developed to quantify the geohazards and project risks. Layers for risk and complexity for a variety of widening and realignment options were generated for use by highway planners and engineers when performing project scoping and widening/alignment options. Stakeholder agencies can also interact with the data and use it for their own purposes. The project has demonstrated innovation and effectiveness for proactive geotechnical planning.

The Kohala Landslide—A Newly Defined Giant Landslide on Kohala Volcano, Island of Hawai'i

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Bathymetric studies on the northeast side of the Kohala volcano have led to the recognition of a giant landslide known as the Pololu landslide. Since 1988, however, various researchers have come to different conclusions as to the nature and size of the landslide. Study of the contours of Kohala volcano's northeast sub-aerial flank provides critical evidence to understanding the Pololu landslide. Offset of contour trends on the volcano's northeast slope gives evidence that the slope is underlain by a landslide that extends from the volcano's summit to the coast. Furthermore, the offsets indicate that the surface of sliding is planar down-slope from the head area and is less steep than the topographic surface. Cross-sectional retro-deformation of the landslide mass, whereby the zone of depletion is re-filled, shows the landslide displacement to be approximately 250 meters. Using this result and the principal of mass balance, the depth of the slide plane just down-slope from the zone of depletion is calculated to be approximately 1 km. From the various parameters determined by contour analysis and cross-section balancing, it is concluded that the slide plane daylights at the base of the 1,000-meter-high coastal cliffs at the base of the sub-aerial slope. Based on this daylight location, a logical conclusion is that the cliffs formed when the lower part of the landslide catastrophically slid far offshore. The location and geometry of the slide plane indicates that the landslide on Kohala volcano's sub-aerial slope cannot be part of the Pololu landslide.

Risk-Based Rockfall Mitigation Strategies in Hawai'i

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Rockfall hazards are common within the State of Hawai'i, exposing the public to potential property damage or physical harm along roadways, in public gathering spaces, and within their homes. Three approaches to address rockfall hazards are to: 1) identify a hazard and mitigate it regardless of the level of risk, 2) classify or rank the hazard at multiple sites relative to others and mitigate based on an agreed to or relative risk threshold, and 3) complete a quantitative risk-based assessment of a site and mitigate the risk that exceeds an acceptable level to society. Method 1 is limited in that the risk is neither ranked nor quantified, resulting in potential higher expense, construction of unsightly structures and damage to natural areas to mitigate hazards that may present a low risk. Method 2 addresses relative risk within a selected hazard population, but not relative to other hazard populations, and may also lead to expenditures for hazards with low risks compared to other hazards. Method 3 has the benefit of evaluating risks relative to a quantitative risk threshold in the context of other risks to which society is exposed. This presentation discusses the application of Method 3 to three sites in Hawai'i, the Palolo Valley and Kaiwi Shoreline sites on Oahu, and the Ko Road site on Kauai. The presentation will describe the analytical methods used, selection of appropriate parameters for input, and the results and mitigation strategies selected for each site.

Quantifying Rapid Erosion with Terrestrial Laser Scanning and Point Cloud Analysis in an Urbanized Watershed

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Quantifying spatial and temporal patterns of rapid channelized erosion, on human time scales, is critical to understanding its consequences. This investigation utilizes field observations and repeat terrestrial laser scanning (TLS) to document the size and retreat rates of knickpoints, defined as localized near-vertical reaches of a fluvial channel, and their contribution to erosion, in an urbanizing landscape with a loess substrate. The Bull Mountain area, in Washington County, southwest of Portland, Oregon, is an ideal study area, offering measurable knickpoints that translate the response of the rapid erosion throughout this transient system. Rapid urbanization there has increased peak flows in streams, potentially initiating rapid channel incision and associated slope instability and sediment pollution, affecting property and infrastructure. Despite the documented increase in discharge, upstream migration rates of knickpoints, as well as the overall channel erosion rate, are unknown. Sequential TLS and point cloud analysis can quantify topographic changes in the landscape, in three dimensions, throughout time. Here we difference multi-interval scans of two knickpoint sites to produce a high resolution map of the spatial pattern of erosion and a precise estimate of the volume of material eroded. Initial results reveal a thin uniform layer of material (~2cm) being removed across the knickpoint face, attributed to slaking, along with isolated areas of deeper erosion (~15 cm), where planes of weakness in the loess lead to block failures. As erosion forces the retreat of these knickpoints upstream, the effects of increasing urban runoff is felt throughout the watershed. The work presented here provides insight on the physical controls driving erosion and can serve as a prologue for future mitigation.

Comparing the California Landslide Inventory to Ground Motion Detected by the COSMO-SkyMed Satellite across the Palos Verdes Peninsula

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The California Landslide Inventory (CLI), prepared by the California Geological Survey, is a digital landslide map database. A landslide inventory map establishes the extent of historic ground deformation and aids in the identification of potential locations of future activity. Incorporating landslides that have occurred statewide over the past 50 years, the CLI documents the spatial, temporal, and geologic information, acquired from various field observations, of each mass movement. Interferometric Synthetic Aperture Radar (InSAR) techniques have become a widely-used remote sensing technique for the detection and monitoring of ground deformation. Forty COSMO-SkyMed synthetic aperture radar images, acquired between July 2012 and September 2014, were processed using the Persistent Scatterer Interferometry (PSI) InSAR technique. PSI allows for the pixel-scale (3 m) displacement rate calculations with an accuracy of 1 mm/year. A benefit of using InSAR is that the technique can detect very slow landslides, with velocities on the mm-scale, which may not be immediately detectable by field crews. The study area is the Palos Verdes Peninsula. Located southwest of the Los Angeles metropolitan area, the peninsula contains landslide-prone regions that experience significant ground deformation, especially during wet seasons. The goal of this project is to combine available resources (CLI, InSAR displacement rates, and InSAR displacement time-series) to determine whether areas of relatively high displacement rates (measured using InSAR) correspond to known, historic landslides or previously unnoticed landslides.

Rockfall Hazard Analysis Using Satellite, UAV, and Field Data: A Comparison of Techniques and RHRS Results

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Providing efficient and economically feasible assessment methods is an important component of a geotechnical asset management (GAM) program. Traditionally, the assessment method has been to collect field-based data and observations. This takes time, especially for large transportation corridors. The use of satellites and unmanned aerial vehicles (UAVs) is presently becoming a more viable method for GAM programs. This study uses the Rockfall Hazard Rating System (RHRS) as the metric for assessing rock slope conditions along a railroad corridor in southeastern Nevada. RHRS values, a measure of potential future rock slope instability, were measured along 14 slopes using three data sources: (1) detailed field investigations (the traditional and most widespread approach), (2) historical optical satellite imagery, and (3) optical UAV imagery. RHRS values generated from these three data sets were compared and contrasted. As expected, the field-based RHRS approach is a more robust method when compared to remote sensing techniques. The study found, however, that satellite-based data can provide meaningful RHRS estimates when accounting for image resolution limits and UAV-based data can provide RHRS estimates that are within the statistical variance of traditional field-based data.

Amistad Dam Investigation and Oversight: Karst-Founded Dam on the USA-Mexico Border

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Amistad Dam is on the Rio Grande (Rio Bravo) on the US-Mexico border, 12 miles upstream of Del Rio, TX, USA, and Cuidad Acuna, Coahuila, Mexico, and is operated by the bi-national International Boundary and Water Commission (IBWC). This combination earth-embankment/concrete-gravity dam was built in the 1960s, and has a storage capacity of 5.5 million acre-feet (6.8 km^3). Amistad Dam has a history of seepage through the karstic foundation underlying the dam, including nearby sinkholes, whirlpools, and springs. Risk-informed evaluations of the dam have determined that potential failure modes exist and need to be investigated with possible remediation. During 2015, dye tracing, surface geophysics, and investigational borings, were the three methods used to reduce uncertainty regarding the foundation conditions. Fluorescent dye tracing showed connectivity

between the upstream sinkholes and the downstream springs. Surface geophysics examined the dam's crest, toe, and heel for anomalies to help locate investigational borings. The borings were sonic drilled down to bedrock, and some holes were rock cored with associated laboratory testing and downhole geophysics. In addition, observation wells and piezometers were installed in many of the borings to allow better analysis of the foundation hydrogeology in the future. The investigation was performed by AECOM with oversight by the U.S. Army Corps of Engineers (USACE). IBWC and USACE are nearly complete with a Dam Safety Modification Study to determine a permanent repair for the dam. This paper will document the investigation process.

Case Histories on Light Anchor Post System for Flexible Rockfall Barriers

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The Geohazard mitigation has a well-established testing guideline for flexible fence for rockfall protection, like the European testing guideline ETAG 027 or the USA guideline NCHRP 20-07 Recommended Procedures for the Testing of Rockfall Barriers. These two test procedures describe very well the functionality of a rockfall barrier and describe all the steps necessary to carry out a full scale test and consequently outline the deformability, resistance, performance and forces acting on the foundation of a deformable rockfall fence. The anchor post system (foundation) is not considered as part of these testing guidelines. Designers must design the anchoring system considering the different national standards and the geotechnical characteristics of the site. Oftentimes problems arise from the post anchor system, due to remote access to site locations. Not only does a remote location interfere with the operation of heavy machinery, but also transportation is very difficult. In these situations, the anchor post system can become more expensive than the fence itself, which could result with a rejection of the rockfall barrier, due to the high global cost of the intervention. When a severe rock impact damages a barrier, for safety reasons, a large portion of the structure must be replaced and oftent the anchoring system should be replaced. Then the question becomes whether or not heavy anchor post systems make sense. This presentation presents case studies of Maccaferri rockfall barriers impacted by several blocks. Even though the fences were installed with unusual light post anchoring systems, the fences were able to withstand impacts exceeding their nominal capacity. The analysis of the structure suggests that in certain conditions, displacement and settlement on the anchor post systems represent a benefit.

A New Simplified Methodology to Design Flexible Debris Flow Barrier

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Since the debris flow can travel at high speeds and transport huge volumes of material, they pose a high risk to human life and infrastructures; roads and railway are particularly exposed to the risk as they cannot avoid to across gullies and channels. In these situations the deformable debris flow barriers are one of more often used remedial solutions because they can be easily installed within the path of the debris flow (or shallow landslide). Such barriers are composed by a ring-net interception structure, which restrained to the channel sided by mean of longitudinal cables generally coupled with energy dissipaters. The interaction between barrier and flow is quite difficult to describe, since it changes both in the space and in the time: upon the impact by the debris flow from the bottom to the top, the barrier progressively deforms with the compression brakes and systems absorbing the energy. The hydrostatic pressure within the flow rapidly dissipates once the debris flow has been arrested, leaving the accumulated volume within the fence. If on one hand the debris flow barriers mitigate the risk, on the other one they pose severe problems for the maintenance. Therefore the designer has to face two basic problems: first of all the global design strategy aimed at getting a cost effective remedial barrier and then the calculation of the structure. The presentation recaps a simplified model to design the structure based on the experiences and the researches carried out by Officine Maccaferri with the University of Parma; it allows designing all the components of the fence. The model returns restraining forces and cable stresses that can be used for an appropriate barrier design.

Spirit Lake Outlet Tunnel Repair, Mount St. Helens, Washington, USA

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The May 18, 1980 eruption of Mount St. Helens resulted in blocking the natural outlet of Spirit Lake. To prevent an uncontrolled lake overtopping and probable catastrophic breach of the blockage, the U.S. Army Corps of Engineers (USACE) constructed the Spirit Lake Outlet Tunnel from 1984 to 1985. Continuous year round operations is critical as it provides the only means to safely discharge water from the closed Spirit Lake basin. During original tunnel construction, the most difficult tunneling conditions occurred within the 90-m-wide Julie and Kathy L. shear zone complex. This zone is comprised of sheared, weak, ashy volcanic tuffs and flow breccias that squeezed into the tunnel and required nearly continuous ribsets to provide support. Since completion, this zone has required multiple repairs due to continued squeezing ground conditions. The latest incident was a sudden 0.7 m invert heave discovered during routine inspection in 2014. This heave substantially reduced the cross-sectional area and hydraulic capacity of the tunnel below acceptable limits. The USACE designed a repair based on a heavier ribset-shotcrete support system. The 2015 repair was sized to be compatible with a potential future tunnel rehabilitation involving stabilizing and re-grading the invert profile through the entire length of the shear zone complex. The repair construction contract was awarded in September 2015 for $3 million. Tunnel work consisted of removing and enlarging the tunnel, and placing new ribs in 1.2 m sections. Work was successfully completed and the tunnel was reopened in 65 days in March 2016.

High-Resolution Topography for Geologic Hazard Studies Using UAV-Based Photography and Structure from Motion Software

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Inexpensive remotely piloted aerial vehicles and Structure from Motion (SfM) software enable rapid creation of high resolution digital surface models (DSMs) and orthophotos that are a powerful data set in many types of studies, including evaluation of geologic hazards. We used photographs taken from a DJI Phantom II quadcopter outfitted with a GoPro or Sony A5100 camera and processed with SfM software to construct 1 to 10 cm pixel DSMs that cover ~0.1 to 4.5 km2. We assessed the accuracy of the DSMs using bare ground checkpoints (vertical RMS error = 3.8 to 9.6 cm), evaluated the impact of ground-control point (GCP) abundance on DSM accuracy, and documented a positive correlation between photograph pixel size to DSM error. The DSMs are being used in a range of paleoseismology, mass wasting, and paleotsunami studies. For example, in the Basin and Range

(USA), DSMs were used to estimate the timing and net vertical displacement of three paleo-earthquakes on the Oquirrh Fault (Utah) based on measurements of offset pluvial Lake Bonneville shorelines of varying age, and to confirm an anthropogenic origin for a set of worrisome escarpments in the East Cache Fault zone in Logan, Utah. On the San Andreas Fault (SAF), DSMs and orthophotos were used to make centimeter-scale maps to investigate the surface manifestation of aseismic creep on the creeping section and to show most or all creep was manifested in surface fractures during the 2012–14 drought. Possible creep-induced fractures were documented on the Coachella section of the SAF as a mapping aid and a baseline for measurement of future surface deformation. We also are using DSMs to aid modeling of tsunami inundation and identification of paleotsunami deposits, and to investigate active faults and possible near-shore surface uplift in Java, Indonesia.

Slope Instability on the South Flank of Kilauea Volcano, Island of Hawai‘i

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The south flank of Kilauea Volcano is a region of ongoing ground deformation resulting from volcanic and gravitational slope instability processes. The region is bounded to the north by the Kilauea Volcano southwest and east rift zones, and caldera; and at depth by the basal detachment upon which the volcanic edifice of Hawai‘i has formed over the Pacific oceanic plate. Large historic earthquakes have occurred in the south flank region, including the 1868 magnitude 7.9 Great Ka‘u and 1975 magnitude 7.2 Kalapana earthquakes. Along the southern coast of Hawai‘i, the Hilina fault system (HFS) has developed along the unbuttressed southern margin of Kilauea Volcano. The HFS is a Quaternary fault system with several faults yielding historic surface deformation. I present field observations and analysis of surface faulting along the HFS to constrain faulting mechanisms and deformation of the south flank of Kilauea Volcano. The HFS is approximately 31 miles (50 km) long in the northeast-southwest direction, and 3–5 miles (5–8 km) wide in the northwest-southeast direction. The fault system consists of a complex geometry of generally northeast-striking arcuate normal faults with dip to the southeast. Surface faulting recorded in faulted and fractured lava flows as old as 1,500-3,000 radiocarbon years B.P. suggest rotation of hanging wall blocks on listric normal faults located within the mobile south flank block. Offshore of the HFS, evidence for submarine slope instability of the mobile south flank block includes slumps, hummocky bathymetry, and isolated blocks.

Rock Mechanical Properties from Full Waveform Sonic (FWS) Log vs Lab Testing

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Borehole geophysical methods are commonly used to characterize bedrock structures for various end uses, particularly for bedrock fracture models addressing rock integrity. Over the past ten years, the use of acoustic and optical imaging probes has increased steadily. These methods provide a cost-effective means for identifying bedrock structures and obtaining their geometry. However, Full Waveform Sonic (FWS) logging is one borehole geophysical method that appears to be underutilized in many projectsÖ particularly tunneling projects. As part of a comprehensive logging suite, FWS logging is a cost-effective means for obtaining P-wave, S-wave, and Stoneley-wave velocities of rock in an open borehole. These data can be used to calculate mechanical properties of rock useful in tunnel design analysis, including Poisson's Ratio, Young's Modulus, Shear Modulus, and Bulk Modulus. This paper will compare the results of mechanical properties calculated from FWS data with those obtained from laboratory measurements. The comparison will be made with data obtained from a tunnel exploration program in the Hartford, Connecticut area and include meta-sedimentary sequences of sandstone, siltstone, and shale. The objective is to demonstrate the cost-effectiveness of FWS logging when included as part of a comprehensive logging suite.

Sheep Creek Bridge vs. Sheep Creek Landslide

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Sheep Creek Bridge is located on US20 in the Cascade Mountain Range of Oregon. The bridge was built in 1963 and the eastern end of the bridge was constructed on an active margin of Sheep Creek Landslide. The slide measures approximately 7,200 feet long by 1,200 feet wide. Movement was historically accommodated by sliding the bridge back into position across the top of the east abutment. Once all available slack had been taken up, the east abutment was reconstructed to accommodate further movement. Recently, movement has accelerated and reconstruction of the abutment has been necessary every few years, which is not economically sustainable. Knowing we could not realistically stop this slide, mitigation to redirect the slide away from the end of the bridge was designed. A row of heavy, wide flange, drilled in beams to act as shear piles was installed just uphill of the bridge abutment in the summer of 2015. In the summer of 2016 the east end of the bridge will be demolished, slide material in front of the shear piles will be excavated and replaced with rock to form a shear key, and the east end of the bridge will be reconstructed to allow for future adjustments if necessary. The shear piles are intended to help redirect the slide away from the bridge, but also to act as shoring during the excavation of the shear key. Updates on construction and performance of this mitigation will be presented at the AEG Annual Meeting in September 2016.

2010 Storm-Induced Debris Flows in the San Bernardino Mountains, California

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In late 2010, a large number of debris flows occurred along the southern front of the San Bernardino Mountains, San Bernardino County, CA. The event was triggered by a series of winter storms in an otherwise dry La Niña weather pattern. Previous debris flows have been documented on this steep, orographic mountain escarpment, some caused by post-fire conditions and others by intense storm events. The last fire in the area was the massive Old Fire in 2003, and it burned much of the area impacted by 2010 flows, but with normal rainfall in subsequent years a lingering effect fire-effect was not thought to be a factor. The 2010 debris flows had several unique attributes not observed in past debris flows including: the number of flows, the large affected area of the mountain front, and probable infiltration causative mechanism. The most noticeable characteristic is the sheer number of flows that occurred and that were not confined to large drainages. Most debris flows apparently initiated as shallow soil slips or flows and then transformed into full debris flow type movement as the flow concentrated into distinct channel flow downslope. In one case, the debris flow extended a distance of approximately 1.5 miles from the mountain front where it inundated a residential area and destroyed a bridge. While 2016 El Niño storm events have not occurred as predicted, this single, intense storm event shows the extensive and widespread damage that can occur when the proper storm threshold is exceeded and other debris flow conditions exist. This type of debris flow event along mountain fronts should be considered as a distinct hazard in the Southern California and other urban environments.

USACE Participation in High Hazard Dam Evaluations in Hawai'i Following the 2006 Kaloko Dam Failure

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On March 14, 2006, the privately-owned Kaloko Dam on the island of Kauai failed resulting in seven fatalities. In support to the State of Hawai'i, the U.S. Army Corps of Engineers conducted two rounds of visual dam safety inspections with the main objective to advise the State if there were risks of imminent failure to any of the remaining high hazard dams throughout the islands. Following the inspections, USACE conducted specific dam break analysis of 11 dams identified by the State to evaluate the downstream inundation area and hazards to the communities in the case of a dam failure. The inspections and dam break analysis were conducted in collaboration with other Federal agencies, State of Hawai'i Dam Safety Office, counties, and private consultants. The presentation will summarize the dam inspection findings and dam break analysis methodologies that are standard in USACE dam break training today.

A Probabilistic Fault Displacement Hazard Analysis Case History

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Probabilistic fault displacement hazard analysis (PFDHA) provides information to support risk-informed regulatory decision-making. Deterministic assessments of fault capability have difficulty dealing with the uncertainties typically associated with fault characterization. Such uncertainties can be naturally incorporated within a probabilistic framework. We present a case study for a nuclear power plant site in Slovenia in which a PFDHA was conducted to provide insight into the significance of possible capable faults near a nuclear power plant site to nuclear safety. The PFDHA used the earthquake approach (Youngs et. al., 2003) and methodology of Petersen (Petersen et. al., 2011). Based on results of the field and laboratory investigations and other available data, faults within 5 to 10 km of the site of interest were characterized in terms of their likelihood of being active, geographic location, length and maximum magnitude. A logic tree approach was used to represent uncertainty in the relative probability of alternative interpretations. Characterization of principal and distributed fault displacement as a function of earthquake magnitude and distance from the main rupture plane was based on published relationships. PFDHA results are determined as the mean annual frequency of exceedance for various levels of surface displacement. Sensitivity analyses were performed to assess the sensitivity of the results to varying PFDHA inputs (varying the weights assigned to input parameters). For a displacement threshold of engineering significance a value of 5 cm was used in the analysis. The calculated mean annual frequencies of exceedance can be considered in the context of frequencies for other external initiating events to evaluate the safety significance of fault displacement hazard compared to other hazards. This information can be used in a risk-informed regulatory environment to increase confidence in how fault displacement may impact the safety of an NPP.

InSAR Tracking and Characterization of Seasonal Landslide Displacements in the San Francisco East Bay Hills, USA

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Through the use of Interferometric Synthetic Aperture Radar (InSAR) time series analyses, we investigate spatial and temporal ground surface deformation of extremely slow-moving (30 mm/yr) earthflow-earthslide type landslide failures in the San Francisco East Bay Hills. Several independent InSAR analyses from different data sets between 1992 and 2011 have previously shown and confirmed landslide surface deformation throughout the study area, with similar velocities and accelerated ground motion as an effect of precipitation. The work presented here is based on an unprecedented data set of 119 German Aerospace Center (DLR) TerraSAR-X satellite scenes from 2009 to 2014, with repeat pass cycles as short as 11 days. The data is processed using an improved algorithm (SqueeSARTM) developed by Tele-Rilevamento Europa (TRE) which allows for a higher density of surface observations than was previously possible. In addition to observing intricate intra-slide deformation patterns, we explore seasonal variations through Linear Regression Analyses (LRA), Independent Component Analyses (ICA) and Principal Component Analyses (PCA). LRA reveals an evident temporal variability in surface ground motions tied to annual seasonal precipitation, while ICA and PCA segregate different patterns of temporal variability into individual components. Using up to five components, the ICA and PCA reveal a primary component tied to continuous landslide deformation with no seasonal variability and an additional three components exhibiting various correlations to seasonal precipitation.

The Usefulness of Useless Concretions: One's Trash is Another's Treasure

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The Panoche Formation is a thick and complex sequence of discontinuous and generally weak cretaceous aged sedimentary rocks, often of submarine landslide origin, with randomly distributed hard and resistant concretions. At two mass excavation sites in the East San Francisco Bay Hills, underlain by Panoche bedrock, concretions have been found to compose anywhere from 5 to 15 percent in volume of the formation's sandstone deposits. They are typically massive, little fractured, rounded to sub-rounded, ranging in size from several inches to greater than 10 feet (largest diameter) and have an approximate density of 165 pcf. The siliceous mineralization, which forms these blocks, has significant construction considerations from aggravated damage and wear to equipment due to abrasion. In an otherwise relatively weak rock mass where traditional mechanical excavation methods are typically employed (ripping and scraping), significantly more costly and invasive measures are required in concretion rich areas (hydraulic jack-hammering and blasting). As a result of their size and hardness, significant stockpiles of precariously stacked concretions have been accumulated and occupy valuable space. Conversely, the Panoche Formation concretions have finally found new homes through the necessity for equally large and resistant rocks at two project sites along the California coast. We discuss here the practical application of Panoche formation concretions through these two case histories. The first as rip-rap energy dissipation pads and buried energy dissipation control

structures to manage erosion and sediment transport from precipitation runoff. The second as boulders to construct weirs and fish passage pools in a dam removal and river restoration project.

Geologic Influence on Seepage and Remedial Grouting, New Bullards Bar Dam, California

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New Bullards Bar Dam, a 200-meter-high concrete arch dam, is located on the North Fork Yuba River in the northern Sierra Nevada foothills. Historical seepage measurements indicate that foundation seepage has gradually increased since the dam was completed in 1970. A pilot program to remediate foundation seepage was performed beneath the tallest blocks in the dam, and included: 1) sealing of several flowing holes from the original grout curtain, 2) supplemental grout holes to further reduce seepage, and 3) drilling/installing instrumentation to monitor foundation deformation and uplift pressures. The dam is situated in a region of accreted terranes, which are fault-bounded blocks of former ocean floor sediment and volcanic rock that have been added to the western margin of the North America continent. The meta-volcanic rock foundation, characterized from rock core and downhole imagery, is massive, hard and moderately fractured. The dam-foundation contact is a tight transition from concrete to rock, typically along an inclined rock joint surface. Most rock joints are tight, but a few are slightly open and others were filled with secondary mineralization. An inclined, weathered and open joint was observed just below the contact. Significant inflow was observed from just below the dam-foundation contact, generally from the open joint. More minor seepage inflow, from a deeper, parallel joint, also was identified in several foundation drains. Water pressure testing and monitoring of foundation drains and uplift pressure instruments were performed throughout the remedial grouting operations. Constraints to achieving project objectives included high hydrostatic pressures in boreholes drilled at the toe of the dam, and hydraulic communication between drains and grout holes. The project successfully reduced foundation seepage without increasing uplift pressures beneath the lowest block in the dam. Monitoring of deformation and uplift are ongoing, and future work is planned for other parts of the dam.

Using Interferometric Synthetic Aperture Radar Data for Land Subsidence Monitoring and Groundwater Management in Arizona

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The Arizona Department of Water Resources (ADWR) land subsidence monitoring program has been using Interferometric Synthetic Aperture Radar (InSAR) since 2002 with the awarding of a three year NASA Earth Science grant. ADWR has developed an extensive library of over 1,500 SAR scenes used to process insar data, covering an area greater than 150,000 square miles at a cost of more than $1.3 million. ADWR has compiled a statewide dataset for the active land subsidence areas identified with InSAR data in Arizona. Most datasets cover time periods between 1992–2000, 2004–10, 2006–11, and 2010–present. ADWR has identified more than 25 individual land subsidence features in Arizona, collectively covering more than 2,800 square miles and has determined the spatial extent, deformation rates, and time-series history of each land subsidence feature. ADWR has produced a total of 240 land subsidence maps for all the land subsidence features covering different time periods. The InSAR data are used by water resources managers and others to see where excessive groundwater pumping and declining groundwater levels are resulting in land subsidence and also where groundwater recharge is resulting in land uplift. InSAR data is also used as a tool for geological mapping and investigations; locating earth fissures; and identifying areas where conditions may exist for future earth fissure formation. In addition, InSAR data can be used for dam hazard mitigation and land subsidence modeling.

Coastal Engineering in the Hudson River

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Geologic hazard and construction mitigation preparedness in large river systems tributary to the coast is essential for resilience in the face of sea level change. Better understanding of geologic conditions for planning is enhanced by adequate subaqueous exploration to map ground hardness. Full multi-discipline consideration of alternatives may take many years in the planning stage, which are mainly vetted during the permit applications. Bathymetry landforms were detected from multibeam and side scan sonar surveys of Hudson River bottom. Geologic hazards included rock pinnacles and nested boulders requiring special excavation procedures impacting marine fisheries. Excavation studies included rock mass classifications of strength and rock fracture spacing evaluating whether blasting would be required. Empirical relationships predict the distance of air bubble overpressures, which can be damaging to fish and shoreline structures or buried utilities. To blast or not to blast and selection of proper dredging equipment are major environmental planning decisions. At the other end of the hardness spectrum, extremely soft sediment deposits were detected from seismic reflection and confirmed by vibracore samples. Loose soils were detected, including large sand waves once mobile on the river bottom. Currents resulting from storm events may cause unintended burial of structures by sand waves. Proper plowing equipment for buried cable, and anchor drop protection need prediction along an evolving coast. This paper discusses recent investigations for power cable laying in the Hudson River and identifies potential geologic hazards considered during the planning and permitting process.

Mosul Dam - Dam Safety Enhancement through Multinational Cooperation

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Mosul Dam has been the subject of significant media attention lately and consequences would be catastrophic for the country of Iraq if the dam were to fail. Construction of the dam began in 1981 with closure in June 1984. The grouting sub-contractor (Rodio/Keller) completed blanket grouting under the clay core after excavation of the foundation. However, due to the accelerated schedule for construction of the embankment, completion of the original curtain grout line was performed from the grouting gallery. First filling of the reservoir was initiated in the spring of 1985. Seepage was immediately observed due to the high permeability of the karstic foundation units and solutioning of interbedded gypsum and anhydrite layers within the foundation. The U.S. Army Corps of Engineers (USACE) has been involved with the project since 2003 and currently is providing technical assistance to the Government of Iraq (GoI) for remediation of the dam. The GoI has awarded a contract to the Trevi Group for foundation grouting and repair of the Bottom Outlet (low level outlet). The Government of Iraq and the Ministry of Water Resources has designated the USACE to be their agent as the Engineer and provide oversight of the contract. A detailed Risk Analysis (RA) is being completed by USACE to advise on further dam safety actions. The USACE is working closely with the Ministry of Water Resources and Trevi to plan and execute the work.

The existing instrumentation system is being also being evaluated and upgraded to provide for assessment of the performance of the dam. The paper will summarize the USACE role in the ongoing dam safety activities and plans for remedial grouting of the foundation.

Pilot Test Program Utilizing Glass Bead Filter Packs for Relief Well Construction

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Long-term O&M costs for maintaining significant numbers of Relief Wells is very costly. Over the last eight years Water Supply wells have started to utilize glass bead filter packs to reduce long-term O&M costs. Can this approach be used in relief well construction for long-term cost savings? This program will monitor 12 relief wells (six with sand packs and six with glass beads) at Chain of Rocks Lock and Levee. The glass beads will replace currently designed sand well pack with glass bead filter media on six relief wells being installed in spring 2016. The glass bead filter media is perfectly spherical creating higher porosity, has higher material strengths to limit breakdown and screen clogging, and is very smooth to limit biota growth. These geotechnical advantages allow the wells to be developed quickly, perform efficiently, which can increase the amount of time between routine purging reducing long-term O&M costs. This pilot program would be the first application of this filter media for relief well construction. A more efficient and durable screen pack could save significant money in annual O&M costs across the large RW networks. The Chain of Rocks East Levee project site was chosen due to its extensive relief well network with scheduled routine O&M, and well replacements. Past performance and O&M costs are well documented. The site geology is comprised of Pleistocene braided stream deposits at depth (outwash) overlain by more recent Holocene meandering stream deposits. The designs are identical the only difference will be the well screen packs which will be analyzed during development and future performance over the next two years.

A Case Study of the Development of a Landslide Hazard Management Program for PG&E's Natural Gas Pipeline System in California

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Increasingly, natural gas pipeline owners and operators are developing centralized, system-wide landslide risk management programs for their pipeline systems. These programs include a multi-phased approach to identify, characterize, and provide an estimate of potential landslide threats to pipelines. In 2015, Pacific Gas & Electric (PG&E) developed a centralized landslide hazard management program for 6,600 lineal miles of natural gas pipelines, which represent the majority of the PG&E natural gas transmission pipelines in California. The transmission pipeline system crosses several physiographic provinces with variable topographic, geologic, and climatic conditions. Golder Associates Inc. (Golder) supported PG&E in the development of a landslide hazard geospatial database, which included a landslide classification schema and a landslide threat index. For the first phase of database development, Golder performed a system-wide desktop assessment focused on identifying and delineating potential landslides observed primarily from a geomorphic review of remote sensing data focused on project-specific, high-resolution Lidar data and aerial imagery. The remote sensing data were supplemented with review of published geologic maps, as well as PG&E site historical data. Golder identified, mapped, and provided preliminary hazard/threat classifications for over 11,700 potential landslides within a 2,000-foot-wide mapping corridor centered on the pipelines. Site-specific, field-based landslide assessments were then completed by PG&E, with support from Golder, at selected landslides. The field-based assessments were completed in order to further characterize the landslide hazard and confirm or refine the threat estimate. Subsequent site-specific assessments (both non-intrusive and intrusive) are ongoing to characterize, evaluate, and if necessary, mitigate and monitor landslides that may have the potential to affect PG&E pipelines. The value added by centralizing the landslide database is essential to PG&E's compliance and safety goals. The database is used across multiple lines of business within PG&E, including risk analysis, assessment planning, patrol planning, dig planning, mitigation planning, and emergency preparedness.

Risqué Rockfall along US-24 - An Inside Look at CDOT's Risk Based Mitigation of Geohazards

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Geological and geotechnical hazards occur throughout Colorado's mountain and canyon roads. The Colorado Department of Transportation (CDOT) has developed a Geohazard Management Plan (GMP) to evaluate the safety, mobility, and maintenance risks from geohazards. Through this risk-based approach, CDOT has selected US-24 through Ute Canyon to be evaluated for mitigation. Mitigation alternatives are selected to optimize dollars spent and influence safety and mobility risk factors. Preliminary risk evaluations for the GMP assigned a Level of Risk (LOR) to highway corridors, consisting of a letter grade ranging from ìAî to ìF,î where ìAî poses the lowest relative risk and ìFî represents a higher risk. Ute Canyon was identified as having a LOR of ìDî between approximate mile posts 294 and 299. A feasibility study along US-24 identified locations in need of mitigation, and based on risk level and cost recommended 16 sites to have final design and construction improvements. Existing mitigation along this corridor includes concrete barrier, catchment ditches, slope mesh, and rock bolts. Mitigation improvements include placing concrete barrier, cleaning and reestablishing ditches, adding and modifying slope mesh, and scaling along select slopes. In addition to performing mitigation at recommended sites, previously implemented mitigation systems will be updated/improved based on improved technology and CDOT's experience.

Use of In Line Inspection Data to Characterize Activity of Deep Seated Landslides in the Boreal Forest, Alberta, Canada

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In Line Inspection (ILI) tools equipped with a Global Positioning System (GPS) have been in use in the pipeline industry since the early 2000s. These tools are capable of reporting the x, y, and z coordinates of specified pipeline features (typically girth welds) and detect dents, corrosion and other anomalies along the pipeline. While useful at detecting localized pipe defects, georeferenced ILI data can also be utilized to detect ground movement along a pipeline before a critical stress state is reached and damage occurs. Multiple runs of georeferenced ILI tools over time can provide time dependent displacement information, similar to a slope inclinometer (SI). When properly processed, ILI data, combined with Lidar and ground observations, can be used to characterize landslide movement, particularly in areas where data from other forms of instrumentation is limited. Georeferenced ILI data has been used in the boreal forests and prairies of Alberta, where deep seated bedrock controlled landslides are difficult to assess due their immense size and complex movement. Often, SIs only provide limited data and cannot fully characterize complex slope movement. Georeferenced ILI data was successfully utilized for pipelines crossing two very large landslides in northern Alberta to investigate the pattern and rate of movement on one slope following a failure and to assess the activity and suitability of a similar slope for future pipeline construction. Georeferenced ILI data can be utilized to identify potential problematic slopes and design proper monitoring schemes to help operators prevent damage to their pipelines.

Characterization and Analysis of the Rio Chama Rockslide, Archuleta County, Colorado

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A plastering contractor (hereafter owner) constructed a half million dollar house for himself in 2011 on one of the last empty lots in a 1980s housing development near Pittsburgh, PA. He obtained house plans from the Internet, modified these plans, and received plan approval from the local municipality. No geotechnical investigation was done. The owner, who had limited experience in home remodeling and no experience in home building, acted as General Contractor on the project. He made several design and construction changes from the approved plans. None of these changes was approved by the municipality. The owner added a geothermal heating and cooling system with six geothermal holes behind the house. The first hole 23 feet from the house was drilled with compressed air to 160-foot-depth without difficulty. The second hole, 23 feet from the house, encountered groundwater at 10 foot depth, then had caving problems and loss of air return. At that time, workers in the house reported cracking and heave of the reinforced concrete basement floor and cracking of plaster walls in overlying rooms. The owner alleged this damage resulted from negligent drilling and he sued the driller. The writer investigated for the driller's insurance company and found the owner had (1) excavated the toe of a large prehistoric landslide to level his backyard and construct the basement of the house, (2) changed thicknesses and characteristics of foundation and house walls, (3) eliminated some first floor wood support beams, and (4) provided inadequate bearing lengths and bearing plates under ends of steel beams supporting first floor wood beams. The writer concluded that compressed air from the second geothermal hole traveled through landslide debris and fissures to crack and heave the basement floor, but cracks in various walls resulted from the owner's design and construction deficiencies.

The State of Dams in Hawai'i - From Early Construction through Current Day

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Following the Kaloko Dam failure on the Island of Kauai, the State of Hawai'i, Department of Land and Natural Resources (DLNR), Dam Safety Division, initiated Phase I Inspections of all regulated dams on the islands of Oahu, Maui, Kauai, Hawai'i, and Molokai. Existing documents including design drawings, previous inspection reports, computations, specifications, and design reports were also reviewed to evaluate the overall compliance of each dam with current design standards and to identify potential failure modes. Of particular note from the Phase I Inspections was the wide range of operating and maintenance standards encountered at the dams. Operating and maintenance practices ranged from a very formal and aggressive program with the dam maintained in near pristine condition, to complete abandonment of the dam with no maintenance activities performed for over 30 years. The contrast between the dams with good and poor maintenance practices, and the consequences and costs of deferred maintenance were readily apparent, and provide a compelling case for dam owners to develop and follow a formal operation and maintenance plan. Following the Phase I Inspections the State instituted significant changes to the Dam Safety Program, including updated Rules and Regulations and multiple training seminars. This presentation provides a historical summary of dam construction and operation practices in Hawai'i dating back to the late 1800s, economic and industrial changes within the state that led to changes in dam safety practices leading up to the failure at Kaloko, and discussion of the efforts that have taken place since the failure to improve the state-of-practice throughout the State. Findings from the Phase I inspections as well as remediation work completed on a number of dams throughout the state are used as examples to illustrate the benefits of a strong dam safety program.

Seismic Hazard Assessment at Duqm Area, Sultanate of Oman

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Seismic hazard assessment at Duqm area is conducted utilizing probabilistic and deterministic seismic hazard approaches in the framework of logic tree. Appropriate seismotectonic model is selected and the recurrence parameters for all the seismogenic zones were determined. The horizontal ground accelerations were estimated using ground-motion prediction equations developed based upon seismic data obtained from active tectonic environments similar to those surrounding Oman. Site characterization was evaluated using borehole data and 2D MASW results at 90 selected sites in Duqm. 2D shear wave velocity profiles were generated to a depth of 20–23m. Boreholes and geophysical data indicate low velocity surface layer with thickness range from 0.0m at the northern and western parts to about 20m in the east parts of the study area. The average shear-wave velocity in the upper 30m ranges from 306 to 1197m/sec. The vertical Vs profiles were used in the SHAKE91 software in combination with suitable seismic input strong motion records to obtain the soil effect. Most of the study area has amplification values around 2.0 for all the considered spectral periods. Horizontal to vertical spectral ratio method is utilized to determine the fundamental frequencies for the selected sites in the area. Maps of peak ground and spectral accelerations are produced. The ground motion maps show low hazard level with expected PGA ranging 0.025–0.06g for 475 years return period. While soil liquefaction susceptibility exists in some locations in the area, the ground motion is not high enough to cause liquefaction in Duqm area.

Site Characterization of the Proposed North Slope Railroad Extension with Focus on Livengood to Coldfoot, Alaska

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Since 1974 and the construction of the Trans-Alaska Pipeline, the only surface connection between Prudhoe Bay and interior Alaska has been the rugged, nearly 500-mile stretch of highway. The proposed North Slope Railroad Extension from Dunbar Siding, near Nenana to Prudhoe Bay would provide access to the energy and mineral resources of northern Alaska via a bulk transportation system. This system would reduce the distance by approximately 100 miles and would lower the cost of transporting resources that are essential to the economy of Alaska. The proposed rail extension transects six major Physiographic Provinces with each province encompassing several distinctive geomorphic landforms. The older un-glaciated landforms of the Yukon Tanana Uplands Schist Terrane, the Yukon-Koyukuk Basin, and the Porcupine Plateau have been superimposed with periglacial landforms that contain variable depths of discontinuous permafrost. The Brooks Range and Arctic Foothills Provinces contain a multitude of alpine glacial landforms and are underlain by continuous permafrost that extends northward through the un-glaciated Arctic Coastal Plain Province to Prudhoe Bay. With focus on the Livengood to Coldfoot section of the rail route, this project compiles landform data for a comprehensive site characterization of the study area. Field studies include engineering geologic mapping, sample collection, and material testing. In the final compilation, this data is used in conjunction with topographic and bedrock geologic maps, aerial photography, and satellite imagery. The presentation includes a tabulation of the geologic terrains, engineering geomorphology, and geologic hazards along the proposed route in an effort to design the railroad extension around the many problematic areas.

Lessons Learned - North Outfall Replacement Sewer Tunnel 25 Years Later

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The North Outfall Replacement Sewer (NORS) tunnel was constructed in the early 1990s in the City of Los Angeles as a partial remedy to increase sewer capacity and decrease pollution caused by overflow into Santa Monica Bay. The 18-foot-diameter, eight-mile-long mainline tunnel and associated diversion tunnels were excavated in soft-ground conditions using open-face shield and Earth-Pressure Balance (EPB) tunnel boring machines (TBMs). Shield tunneling in running ground conditions beneath Los Angeles International Airport (LAX) resulted in significant ground losses and numerous sinkholes on airport property. EPB tunneling also resulted in ground losses and damage to surface improvements due to inappropriate operation of tunneling equipment. Throughout the 1980s and 1990s open-face shield tunneling was commonly used for large tunnel projects in the Los Angeles area including NORS and the Los Angeles Metro Rail subway tunnels. Advances in TBM technology over the past 25 years have resulted in increased use of pressurized TBMs and decreased use of open-face shields for large tunnel projects in the Los Angeles area. However, the use of open-face shield TBMs still remains viable as a method of excavation in soft ground conditions if properly designed, operated, and monitored. This presentation reviews the construction history of the NORS tunnel project and some of the lessons learned using both open-face shields and EPB TBMs.

P-993 Transport Protection System Forward Operating Location Improvements

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The Transit Protection System (TPS) vessels serve to escort Navy submarines to and from missions in the Pacific Northwest. The vessels and personnel have been operating from temporary facilities and piers at the Port of Port Angeles and U.S. Coast Guard Station on Ediz Hook since 2006. The P-993 TPS Forward Operation Location includes the design and construction of a new pier and on-shore support facilities for the tender vessels. Project requirements include design and construction of a pier capable of berthing two 250-foot-long TPS vessels and five smaller support craft. BergerABAM was selected as the prime design consultant for design of the facilities, and PanGEO, Inc. was contracted for geotechnical services. Field exploration included offshore and onshore drilling for the pier and support facilities. The offshore drilling program was conducted in February of 2014, to accommodate salmon migration times. This proved problematic, as winter storms brought high winds that prevented drilling through much of the drilling window, which limited to footage that was completed. Onshore drilling followed in October of 2014, and included 100-foot borings for downhole seismic analysis for the site. Geotechnical challenges, in addition to the seismic analysis of the sandy soils of Ediz Hook, included the analysis of the stability of the offshore marine sediments. Challenges with adjacent uses resulted in shifting the pier location from the original site to the east, requiring additional engineering studies. Geotechnical studies were complete in June, 2015, and final design documents followed in September, 2015.

Groundwater Aspects and Impacts on the North Jetty Rehabilitation Project

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To minimize navigation maintenance, a system of jetties was constructed at the mouth of the Columbia River between 1885 and 1935. One result of the jetty construction was the accretion of a large wedge of sand north of the north jetty. Over the years, this jetty has been subject to erosion of the foundation sands by tidal and wave action, resulting in the formation of lagoons along the north side of the jetty and settlement of the jetty as a result of piping. In 2013 the United States Army Corps of Engineers (USACE) issued a contract for design and construction support for a scheme to stabilize the jetty. The repair included a graded filter to prevent piping of dredge spoil sand through the jetty, and a requirement to preclude any loss of existing wetlands behind the jetty. To document any impact to the wetland, borings were drilled at the margins of the wetland and data loggers were placed in monitoring wells. The loggers provided documentation of the water table starting one year before construction and extending through construction. While not part of the original work scope, the USACE sought a design to create a tidal wetland just inside the jetty, with a requirement that the newly created wetland would not impact existing adjacent freshwater wetlands. As part of this effort, ground water studies were conducted to confirm that the new wetlands would not affect the existing wetlands. This effort led to the creation of a new saltwater wetland behind the jetty. The graded filter allowed dredge spoil sand to be placed behind the jetty, and prevented piping and scouring through and below the jetty, which should extend the life of the jetty.

Investigation of Earth Embankments Through Shear-Wave Velocity and Resistivity Surveys

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The investigation of earth embankments can be facilitated by a preliminary stage of geophysical surveys, the results of which can be used to plan a costly campaign of geotechnical testing. We present the results of shear-wave seismic velocity surveys using a landstreamer rather than fixed geophones, and capacitively coupled resistivity rather than galvanic resistivity. Both approaches provide a good compromise between reproducible tomograms and the speed of deployment needed for prioritizing the geotechnical assessment of long or multiple earth embankments. Shear-wave velocity is directly proportional to the square root of the shear modulus and inversely proportional to the square root of the bulk density *p* [Vs = SQRT(μ/*p*)], which in turn are linked to the stiffness and compaction of the soil materials. In some instances it is possible to identify in the shear-wave velocity tomograms internal shear failures by steep gradients in velocity, and loose portions of the embankment by velocities lower than 200 m/sec. Resistivity tomograms can be used to map the interface between clay core (low resistivity) and the silty sand shells of embankments (higher resistivity), or to target potential low-resistivity seepage zones for geotechnical investigation. Pre- and post-remediation surveys can be used to assess the effectiveness of remediation efforts.

Evaluating the Stability State of 'Dip Slopes'

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Uncertainty is inherent in geotechnical design. In regard to estimating the stability state of dip slopes, most of the uncertainty lies in the geologic model assumed and the geotechnical parameters used in the evaluation. Biplanar (or active-passive) sliding in dip slopes occurs along a slope-parallel sliding surface with toe breakout occurring at the base of the failure. Internal shearing is required to facilitate kinematic release. All three of these release surfaces work together for the slope to fail, but with different degrees of importance depending mainly on the dip-slope inclination. Two case histories (time permitting) will be used to illustrate the importance of properly evaluating dip slope failure mechanisms with an emphasis on including the influence of internal shearing. The first case history is from a dam abutment failure and remediation project in Northern Peru where the slope failure mechanisms were confirmed using distinct and finite element modeling and data from several years of movement monitoring. The second case history is from a footwall slope within a coalmine of British Columbia where slope modeling was completed using both limit equilibrium finite element methods. Performance monitoring during the footwall excavation confirmed that the finite element method provided a more accurate estimate of the slope's stability state than the limit equilibrium modeling. This was because of the inherent limitation of common limit equilibrium methods to model internal shearing and kinematic release of the slope.

Geotechnical Design and Construction of Rubble-Mound Breakwater on Soft Soils - Valdez, Alaska

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The Valdez Navigation Improvements project is a multi-year, phased project to build a new harbor basin and upland facilities on the south side of Hotel Hill. Benefits include increased moorage capacity, additional launch ramps, waterfront access, and additional local economic activity. The project includes the construction of three rubble-mound breakwaters at a location with soft soil conditions. The geotechnical design, especially for the eastern and southern breakwater segments, was an engineering challenge due to foundations soils with low shear strength, natural and proposed dredge slopes, and the prospect of significant settlement during construction. A natural descending slope of approximately 22 degrees is adjacent to the southern edge of the project boundaries. In order to maximize the harbor basin, it was necessary to design the breakwater as close to this natural slope as possible while maintaining required factors of safety. Successful construction of the breakwater system will require a three-stage construction sequence, geotextile installation, a 2-foot drainage layer, and prefabricated vertical drains (PVDs). Construction is scheduled to begin in April 2016 and finish in September 2017. This presentation will illustrate several design considerations and provides a comparison of design assumptions and construction realities.

Challenges Encountered and Subsurface Investigation in Glacial Outwash

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The area for recent subsurface investigation occupies a unique position, as it is the location where deposits made by glaciers from the northeast are overlapped by deposits made by glaciers from the northwest; it is also where the outwash drainage ways from the northeast, north, and northwest converged. The area is located on the Quaternary Cahokia Formation, consisting of stratified clay, silt and sand, which unconformably overlies the Mackinaw Member of the Wisconsin-age Henry Formation. The Mackinaw Member of the Henry Formation consists of sand and gravel outwash deposited in the valleys. Major river valleys (Mississippi River) had repeated intervals of filling and cutting. The difficulty of drilling and sampling through the resulting outwash boulder and cobble field, and hard glacial till presented many challenges for the exploration crew. A case study of the challenges encountered and methodology of the investigation techniques employed during recent exploration within Mississippi River alluvium will be presented. The author hopes to provide information to assist other exploration in similar geologic terrane.

Relief Well Maintenance, Rehabilitation and Installation

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St. Louis District Corps of Engineers regulates and maintains approximately 4,000 relief wells with other regulating bodies along the Mississippi River. Nearly 3,000 of the wells are older than 50 years and constructed of wood stave or galvanized well materials; wells which have been installed since approximately 2000, have used wire-wrapped stainless steel materials. The older well materials limit the rehabilitation methods that can be utilized, while the new well materials allow for more aggressive methods of rehabilitation. Since 2002, St. Louis District has established pump testing and rehabilitation programs for the many relief wells within the District. Rehabilitation methods used in the past have been chlorine gas, hydrochloric, acetic, and oxalic acids, super heating, various combinations of heat, chemicals and mechanical surging and brushing the interior of the wells. In addition to chemical and heat, shock and impulse technology has been utilized to break up the iron bacteria biomass followed by mechanical surging and brushing the interior of the wells to mobilize the resulting debris. An analysis of the various rehabilitation and maintenance methods used will be presented, along with the schedules that have been established, and the long-term O&M costs. Which rehabilitation methods will be the most effective in re-establishing specific capacity in terms of cost and efficacy?

Engineering Geology of the Meyers Cone, Interstate 84, Columbia River Gorge, Oregon

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Lidar and new geologic data have revealed a previously unmapped Quaternary volcanic vent system near MP 49 along Interstate-84 in Hood River County, Oregon. The Meyers Cone* is a 650-ft-high olivine basalt edifice with two prominent flow lobes, the Anderson Point and Trotter Point lobes, that extend under I-84 into the Bonneville Pool. Features including a 25-ft-high, 1,200 ft-long flow are preserved on the inside of the cone. A northeast-southwest rampart system is present on the west side of the cone and trends toward other newly identified vents to the southwest. Eruptions on the east side of the cone deposited on a pre-existing, north-sloping, alluvial fan complex. A band of east-west-oriented tension features (scarps) on the upper portion of the fan are interpreted to be the result of destabilization of the fan by deposition of Meyers material near the fan toe. The historic Fountain Landslide along I-84 east of the Meyers Cone is located near the toe of the fan. Previous workers interpreted the Meyers area solely as a distal portion of the Trout Creek Hill basalt (385 Ka) that flowed down the Wind River drainage from Washington and temporarily blocked the Columbia River. Beginning with railroad construction in the 1880s, the Historic Columbia River Highway in 1914–15, US-30 in the 1950s, and I-80N/I-84 in the 1960s, transportation geology has been influenced by the Meyer Cone. *We propose the name after Joseph Meyers, the Oregon geologist who first identified some of the flow features in the 1950s.

Rehabilitating a Historic Dam with Seepage Issues over a Complex Geologic Foundation

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Antero Dam is an earthen embankment about 45 feet high and about 4,200 feet long located on the South Platte River in Park County, CO, at an elevation of about 9,000 feet. The dam and reservoir are owned and operated by Denver Water. Embankment construction was completed between 1908 and 1909 with a hydraulic fill core in a wide, shallow valley with variable alluvial soils over highly variable sedimentary and volcanic geology. Concerns related to seepage stability began shortly after construction of the dam and prevented complete filling of the reservoir. In 2010, RJH Consultants, Inc (RJH) completed a comprehensive review and evaluation of existing data and reaffirmed potential dam safety concerns. In 2011, Denver Water assembled a Risk Estimating Team to perform a potential failure modes analysis and a quantitative risk analysis to identify and evaluate potential failure modes. In 2013, Denver Water and RJH performed a benefit-cost analysis to identify the preferred rehabilitation concept. Based on potential benefits, risks, dam safety improvements, and minimal permitting, the selected option was a phased rehabilitation of the dam that included a downstream filter trench installed with the bio-polymer method, toe and chimney drain, flattening the upstream and downstream slopes, additional upstream slope protection, installation of a soil-bentonite barrier wall through the center of the embankment, and hardening of the spillway. This presentation will discuss the design development and construction for the embankment rehabilitation. Key technical design and construction challenges will be discussed with the corresponding solutions.

New Irvington Tunnel Anticipated and Actual Geologic Conditions - A Case Study

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The existing Irvington Tunnel (EIT) and New Irvington Tunnel (NIT) are part of the Hetch Hetchy Regional Water System in northern California, and were excavated through the Sunol Valley from 1928–32 and 2011–13, respectively. The sub-parallel EIT and NIT tunnel alignments cross beneath the western Diablo Range, part of a structural slice between two active right lateral strike slip faults, the Calaveras and Hayward faults. The 3.5-mile-long alignments penetrate faulted, folded, and overall highly deformed sandstone, shale, and siltstone bedrock that contains varying amounts of fault gouge. Both tunnels were excavated using conventional methods including drill and blast and hand mining; roadheaders were also used to excavate the NIT. The conventional excavation methods and timber or steel set initial support systems allowed geologists to make continuous observations of the exposed ground. Although the geologic records kept during the 1928–32 excavation were sometimes inconsistent and contained gaps, they were more comprehensive and detailed than other projects completed in that time period and created a unique opportunity to understand ground conditions for the new tunnel construction. The EIT records were combined with geotechnical data collected during field explorations for the new tunnel to develop anticipated ground conditions. When the NIT construction was completed in 2013, the meticulous geologic face and perimeter mapping performed throughout excavation resulted in a complete, continuous log of the alignment. This paper will discuss the anticipated and actual geologic conditions in the NIT, and compare the geology of the EIT and NIT as mapped during construction. We also present thoughts for developing geologic condition baselines and note which data is critical to collect and document during construction.

When is Enough? Professional Practice Concerns from Seismic Hazard Investigations of El Rodeo School, Beverly Hills, CA

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A three-year fault hazard investigation of El Rodeo School in Beverly Hills recently concluded that no faults younger than about 200 kya are present under the campus. This multimillion-dollar study was driven by the California Geological Survey's regulatory concerns over the possibility of a series of Holocene faults that were interpreted by others, though never actually seen, as trending towards or through the school site. Surface fault rupture studies were required before structural seismic retrofitting of the 1920s-era buildings could commence. This talk will explore several professional practice issues that are becoming common: 1) prioritizing a low-risk investigation before a high-risk mitigation is permitted; 2) paradigm and model-driven interpretations; 3) requirements to "preclude" the presence of an inferred/interpreted fault hazard; and so 4) enough is never enough. El Rodeo school is located within what has been interpreted as a geologically complex ~N-trending step-over structure between the ~ENE-striking Hollywood fault to the N and the ~W-trending Santa Monica fault to the SW. The step-over has also been interpreted to connect to the ~N-striking Newport-Inglewood fault to the S. Although no fault has ever been observed in this area, fault rupture hazard investigations were required before the school could be seismically strengthened. The studies involved seven 80-200+ foot-deep continuously cored auger borings within the school property, two trenches across the basketball courts, a series of 15 borings down Wilshire Boulevard, and a ~300-foot-long trench across the track and soccer field. The results are definitive: there are no faults or even minor fractures in the >200ka sediments underlying the school, despite the supposed presence of a Holocene, transtensive, three-fault, step-over structure. While some investigation is appropriate, we must question the hazard reduction value of such fault-specific, intensive and costly investigations being prioritized ahead of critical structural retrofits for higher-risk regional seismic hazards.

Geologic Investigation for Fault Rupture Mitigation, SR 710 North Study's Tunnel Alternative's Design, Eastern Los Angeles, California

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Light rail (LRT) and freeway tunnel alternatives were evaluated as part of multiple transportation alternatives in the environmental documentation of the SR-710 North Study. The N-S tunnels would extend the I-710 from its current termination at the I-10 in East Los Angeles northward 4+ miles to the I-210 in Pasadena. The LRT tunnel would be about 80 feet in depth, while the freeway tunnel would be 200+ feet deep. Both encounter complex geology involving multiple fault zones, but only the Raymond fault is known to be "active" per the California's Holocene definition. Two other faults, the San Rafael and Eagle Rock, are potentially active but were considered in the analysis as active. The geological investigation used a series of borings to constrain the locations of the three fault zones. No new paleoseismic information was collected during this study. The Raymond fault was encountered in the drill core, and based on this and surface geomorphology, the fault was constrained to a 25-m-wide zone at tunnel depth. The ability to constrain the Eagle Rock and San Rafael faults at depth is retarded due to the fault's subdued surface expression and multiple splays, but the investigation was able to improved understanding of the fault locations. The Raymond fault, 21 km in length, is capable of a 0.5–0.9 m left lateral rupture, and the published paleoseismic results, while equivocal, indicate a recurrence interval of thousands of years. The Eagle Rock and San Rafael faults, 11 km in length, could generate a 0.2–0.3 m rupture, but have no data on their earthquake activity. Both are significantly less expressed than the Raymond fault, indicating a longer time since the last rupture, a longer return time between earthquakes, and/or much smaller displacements.

Prototype Measurements of Rock Block Erosion: Implications for Dam Foundation and Spillway Erodibility Assessment

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Prototype measurements of hydrodynamic pressure and displacement were captured in real-time leading up to the removal of an instrumented 3D rock block installed from an unlined spillway channel at a dam site in Northern California. The data represent the first prototype measurements obtained for such phenomenon outside of an idealized laboratory setting. The experiment was performed as part of a larger, multi-component, research study to investigate 3D block erodibility. The results are compared to those obtained from a physical hydraulic model, also performed as part of the same study, to begin to bridge the knowledge gap between scouring processes occurring in the field and those performed under simplified model conditions. Observations from both prototype and model experiments are used in the development of a block theory based framework for analysis of 3D block erosion in dam foundation and spillway erodibility assessments. Financial support for this study was principally provided by the National Science Foundation under Grant No. CMMI-1363354, with additional funding provided by the University of California Edward G. Cahill and John R. Cahill Chair fund, the Hydro Research Foundation, and the United States Society on Dams. All opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation or any other funding agency.

"Landfills and Groundwater" - A Case Study of Impact in North Carolina

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In accordance with state and federal regulations landfill facilities across the Country have been collecting water quality samples on regular basis to evaluate potential impact. In North Carolina, the NC Department of Environmental Quality (NCDEQ) has collected this data in a statewide database since 2007. This database includes monitoring results from closed and active MSW landfills, and C&D landfill facilities. Smith Gardner, Inc. used this information from across the State to evaluate what constituents are typically detected at landfills, what constituents typically exceed NC groundwater standards or EPA MCLs, are there regional differences in detected constituents, and other questions pertinent to the data received. In this presentation we will report our findings of what these data show so far, and how analysis of long-term data can be useful in future evaluations of appropriate monitoring at facilities.

Seismic Movement Monitoring & Alerting Using Time Domain Reflectometry

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The Pickwick Dam is approximately 7,500-ft long located on the Tennessee River at the border of Tennessee, Alabama, and Mississippi. Its locks are large enough to hold vessels up to 63 feet in length, and are widely used in transporting goods. A recent investigation determined a low Factor of Safety for a hydraulic fill embankment in the event of an earthquake. Because seismic activity on the New Madrid Fault Zone could trigger failure of the embankment, a real-time monitoring system intended to broadcast warning of failure was implemented. Final design of the system included Time Domain Reflectometry (TDR) monitoring. TDR is a method of monitoring for earth movement using a signal pulse in a coaxial sensor cable. The pulse travels along the sensor and is reflected wherever it encounters a deformation or break in the sensor. By timing the signal, the location of movement is determined. TDR has been used for the past 20 years in vertical boreholes as a replacement for inclinometers to determine movement. In an innovative application, the Tennessee Valley Authority decided to install horizontal TDR sensors, up to 4,000 feet long, in the potentially liquefiable embankment. The sensors were tied into a fully operating system, which included cameras and strong motion detectors. This presentation describes the goals, design, construction, and the challenges involved in implementing the TDR system.

Perris Dam Seismic Remediation - Geologic Observations from CDSM Foundation Treatment

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Perris Dam, a key component of California's State Water Project, is a zoned earthfill embankment dam measuring 2.2 miles in length and 126 feet in height. It was built in the early 1970s near Perris, CA. California's Division of Safety of Dams is requiring remediation of the dam's potentially liquefiable foundation before operating restrictions are removed, and the reservoir can be filled back to its original design level. The owner, the California Department of Water Resources, is in the construction phase of a multi-component remediation design that includes Cement Deep Soil Mixing (CDSM), a new toe drain, extension of the drainage blanket, and a new downstream stability berm on the left half of the embankment. Local subsurface stratigraphy consists chiefly of a variably thick sequence of young (Holocene) and old (Plio-Pleistocene) alluvium overlying igneous and metasedimentary rocks of the Perris Block. Detailed studies of the dam foundation by DWR indicated the presence of thin sandy layers that are potentially susceptible to liquefaction and severe loss of strength during a scenario M7.5 earthquake on the San Jacinto fault, which lies approximately 8 km to the northeast. The liquefaction of the foundation soils could potentially result in slope failure of the embankment dam and uncontrolled reservoir release from Lake Perris. To strengthen the foundation of the new stability berm, CDSM specialty work was performed by JAFEC USA directly downstream of the toe of the existing embankment. DWR inspectors observed treatment activities in 2015–16 that included installation of test cells, and production cells, and a Quality Control program that includes CDSM element coring and laboratory strength testing. Periodic venting of air and water from the ground surface occurred as a result of CDSM installation and was carefully documented due to its close proximity to the dam and the risk of hydrofracture to the embankment. Observations of venting during predrilling required addressing the subcontractors CDSM procedures with respect to air injection pressures. This presentation will discuss the CDSM design, determination of design parameters made during the Field Validation Test Sections (two test walls and one test cell), inspection observation methodology, and some insight into observations of soil venting.

The Final Phase of San Clemente Dam - Removal and Stream Restoration

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San Clemente Dam, a thin arch concrete dam built in the early 1920s in Carmel Valley, CA, was removed as part of the design-build process to eliminate the unsafe structure and to restore the river to its pre dam condition. A plan developed during the environmental review process was implemented to construct a new combined flow reach through a rerouted channel and stabilize the impounded river sediments. During 2015, the third and final year of construction, activities included final design and construction of the Combined Flow Reach, topping off of the Stabilized Sediment Slope (SSS) and removal of San Clemente Dam. To achieve this, several engineering geologic tasks were completed including evaluations of 1) small landslides, 2) global slope and channel stability via mapped cleaning strips, 3) onsite and offsite sources of rock fill and boulders for step pool construction, as well as mapping of the SSS rock foundation, and design of a rock sill in the reroute channel. A five-year monitoring program has been initiated to monitor slope stability and habitat restoration prior to turnover of the site to the US Bureau of Land Management. This presentation will discuss the geologic and geomorphic conditions that were important in demonstrating that the site was ready for dam removal, the approval of the final stream restoration design and some preliminary results of the early stages of the monitoring program.

History of Internal Erosion at East Branch Dam, PA and Cutoff Wall Remediation Project

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East Branch Dam is a Pittsburgh District of the U.S. Army Corps of Engineers dam, which nearly failed in 1957, several years after construction. The dam is a zoned embankment 184 feet high and 1,725 feet long. The primary purpose of the dam is flood control, however, it also provides low-water regulation and recreation. In May 1957, project personnel observed muddy water flowing from a rock drain at the downstream toe of the dam. Drilling through the dam exposed a void located just above the cutoff trench, which led to an immediate pool lowering and commencement of emergency grouting. Repairs consisted of filling the void with grout and consolidation grouting of the surrounding area of the foundation and the embankment. A permanent weir was constructed at the toe of the dam, and piezometers were installed in the area of the void. The project has been closely monitored since the near-failure incident with large array of instrumentation including piezometers, weirs and alignment-settlement pins. Even though evidence of further internal erosion has not reappeared, the fundamental conditions that caused the original problem were not corrected by the 1957 emergency repairs. Consequently, a comprehensive remediation of the dam is underway which involves installation of a full-depth full-length cutoff wall through the embankment into foundation bedrock. The presentation will briefly describe the internal erosion history at the project and the current remediation project to install a cutoff wall.

Measuring In-Situ Pressures, Hydraulic Conductivities, and Ground Temperatures Affecting Deep Tunnel Feasibility

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Tunnels have become more important for both transportation and utilities (i.e. water, sewer, and storm water) to avoid interference with existing infrastructure and surface uses. Tunnel corridors often take shortcuts beneath environmentally sensitive mountainous terrain including wilderness, and national forests as protected lands that come with stringent environmental restrictions. Environmental restrictions are often challenging or prohibitive for design and construction. Historically, tunnels have been constructed by allowing groundwater to drain to the portal, however, this practice has caused impacts to surface water and groundwater resources unacceptable to agencies managing the public land trust. Agencies now require demonstration of “no impacts” to the natural resources including groundwater and surface water resources. Designers and constructors can meet such environmental and challenging design constraints by carefully collecting in-situ data for use in modeling of groundwater pressures, hydraulic conductivity, and ground temperatures along deep tunnels. Results from field investigations of several tunnel projects are reviewed demonstrating that deep tunnels can be designed and constructed to address environmental constraints if documented in advance of permitting and design. Data indicate that in-situ groundwater pressures are often 40–60 percent of the expected hydraulic gradient in fractured rock helping establish criteria for tunnel lining design. The hydraulic conductivity also significantly decreases with greater depth reducing potential groundwater in-flow during construction. The ground temperature trends, which elevate with depth according to the geothermal gradient can also be anticipated for design. With collection of in-situ data for feasibility and design, site conditions can be evaluated by designers for developing mitigation measures acceptable to the agencies managing sensitive land management issues for deep tunnels.

Topographic Change Analysis Using Lidar Differencing: A Case Study from a Frozen Debris Lobe, Brooks Range, Alaska

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Digital Elevation Models (DEMs) derived from 2011 and 2015 airborne Light Detecting and Ranging (Lidar) data were differenced to sense change in Frozen Debris Lobes (FDLs), which are continuously moving landslide features in permafrost-affected areas. We applied DEM differencing to analyze the movement of a singular lobe, FDL-D, adjacent to the Dalton Highway in the southern Brooks Range, Alaska. The two sets of lidar data were evaluated for accuracy, and then processed in a GIS environment to create concurrent DEMs (1 m resolution). Error analysis indicated the DEM of difference was accurate to a ±23.7 cm minimum level of detection (99% confidence interval), allowing small-scale vertical changes to be detected in a study area characterized by dramatic geomorphological change. The DEM of difference confirms trends found by Differential GPS surveying conducted from 2013 to 2015. The accelerating toe of the lobe showed a 100 m advance in position and a positive 22 m vertical elevation change. Areas of large negative elevation change correspond to tension cracks and retrogressive thaw slump development, with scarps that displayed losses up to 7 m in vertical elevation. Compared to repeat DGPS surveys in the field, DEM differencing provided a method to monitor change with greater spatial resolution and less intensive fieldwork. The DEM differencing resulted in a clear representation of mass wasting and accumulation on the FDL. Lidar data provides another dimension with which to study change in FDL volume and differential movement behavior, an objective of future research on these geohazards.

Tsunami Risk Perceptions, Knowledge, and Efficacy in Java, Indonesia

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The Indian Ocean tsunami of 2004 killed over 167,000 people in Indonesia alone. Since then, other tsunamis in 2006 and 2010 have claimed over 1,300 lives in Indonesia. Over 10 million Indonesians live in areas at high-risk for tsunamis. Interventions at the citizen level, such as education and evacuation simulations, are crucial to preventing unnecessary loss of life. While the mechanisms of tsunamis are relatively well understood and vital to disaster mitigation, the human psychology surrounding individual disaster responsiveness needs more attention in order to create successful educational interventions. Working in conjunction with geologists and education specialists, this survey-based study combines constructs from several theories related to disaster mitigation and tsunami hazard at the citizen level. Survey results include (1) a comparative analysis of perceived threat of various hazards, (2) critical awareness of causes and warning signs of tsunamis, (3) knowledge of what to do in the case of an impending tsunami, (4) trust of government warning systems, (5) evacuation knowledge, perceived efficacy, and outcome expectancy, (6) intrinsic and extrinsic vulnerability factors, (7) history of tsunami education, evacuation simulations, and family emergency planning, and (8) feedback about how to best mark a tsunami safe zone and what actors should be responsible for education, warning systems, and coordinating evacuation procedures.

Forensic Investigation of a Cracked House in Western Pennsylvania

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A plastering contractor (hereafter owner) constructed a half million dollar house for himself in 2011 on one of the last empty lots in a 1980s housing development near Pittsburgh, PA. He obtained house plans from the internet, modified these plans, and received plan approval from the local municipality. No geotechnical investigation was done. The owner, who had limited experience in home remodeling and no experience in home building, acted as General Contractor on the project. He made several design and construction changes from the approved plans. None of these changes was approved by the municipality. The owner added a geothermal heating and cooling system with six geothermal holes behind the house. The first hole 23 feet from the house was drilled with compressed air to a 160-foot depth without difficulty. Drilling the second hole 23 feet from the house encountered groundwater at a 10-foot depth, then had caving problems and loss of air return. At that time, workers in the house reported cracking and heave of the reinforced concrete basement floor and cracking of plaster walls in overlying rooms. The owner alleged this damage resulted from negligent drilling and he sued the driller. The writer investigated for the driller's insurance company and found the owner had (1) excavated the toe of a large prehistoric landslide to level his backyard and construct the basement of the house, (2) changed thicknesses and characteristics of foundation and house walls, (3) eliminated some first floor wood support beams, and (4) provided inadequate bearing lengths and bearing plates under ends of steel beams supporting first floor wood beams. The writer concluded that compressed air from the second geothermal hole traveled through landslide debris and fissures to crack and heave the basement floor, but cracks in various walls resulted from the owner's design and construction deficiencies.

Discovering a Giant Seismic Gap in Java, Indonesia, and What Community Based Organizations are Doing About It

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Historical records we have compiled from 1584–present of major geophysical events throughout Indonesia show recurring mega-thrust earthquakes and tsunamis in every region except for Java, which is the most densely populated region. Tsunami deposits are also not common in the Java region, which indicates that the seismic quiescence reaches even further into the past. Historical accounts before 1900 document 75 regional earthquakes and 37 tsunamis in the Indonesian region. Most of these events caused damage over a broad region, are associated with years of likely aftershocks, left many cities in "rubble-heaps," and generated tsunamis with run-up heights > 15 meters. Since 1900 there have been at least 74 tsunamis and 120 fatal earthquakes throughout Indonesia. However, the rate of these events in the Java region has decreased significantly during this time. On average Indonesia experiences a tsunami every 4 years over the past 400 years, but the rate for Java region is 1 every 85 years. The Java region accumulates strain at two–three times the rate of Sumatra, but there is no evidence over the past several hundreds of years of mega-thrust earthquakes. Where is the 7-8 cm/a of convergence at the Java Trench taken up? At least 30 m of potential slip may be stored along the trench, which could generate a Mw=9.0 mega-thrust event. Community based

organizations in the region are using tsunami models and inundation maps we have developed of such a scenario earthquake to conduct evacuation drills in the region.

Development of Permeable Reactive Concrete for Enhanced Heavy Metal Removal

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Catastrophic release of heavy metals from the King River mine and Minas Gerais dam in Brazil has brought to the forefront the importance of contaminate stabilization and remediation. Permeable reactive barriers are a known method of remediation using a reactive media to remove contaminates. This research investigates the use of permeable reactive concrete made using Portland cement, class C, high carbon, and high sulfur fly ash for the removal of lead, cadmium, and zinc in permeable reactive concrete systems. Batch reactor testing was performed to evaluate the removal of all three heavy metals with 30–100% removed. Leach testing confirmed a high level of permanency for removal that was also confirmed through SEM evaluation of precipitates and distribution of metals within the concrete matrix. Freundlich isotherms were also generated with strong linear correlations that indicate high capacity of removal and favorable sorption mechanisms. Using high sulfur and high carbon fly ashes reduced the removal at higher concentrations however improved removal at lower concentrations. These results suggest permeable reactive concrete to be a novel and effective remediation technique.

Soil Mixing Using Waste Fly Ash Byproducts

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The broad hypothesis of this project was that waste fly ash containing unacceptably high levels of sulfate (HS) and carbon (HC) can be valorized in fine-grained soils through solidification using soil mixing techniques. Specifically, the proposed research demonstrates: 1) compatibility of soil mixing incorporating waste fly ash materials containing high levels of carbon and sulfate, and that 2) the remedial potential of waste fly ash material is comparable or better than conventional fly ash. Testing will be performed by the incorporation of the waste fly ash into contaminated soil, gyratory compaction of the soil mixtures, followed by unconfined compressive strength tests and measurements of expansion after mixing. High sulfur mixtures are compared to traditional Portland cement concrete mixtures as well as control fly ash. While soil mixing using fly ash for ground modification/stabilization and contaminant encasement is not a novel concept, the incorporation of the HS and HC fly ash as reactive agents, a currently landfilled waste byproduct, is an extremely novel, transferable, and potentially highly profitable technology.

Universal Guide to Coal-Tar Cleanup – Case History (Massachusetts – 1823–2017)

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We have made an exhaustive study of “all matters coal-tar” in Massachusetts as a case study of the problem of FMGPs and related sites, and the documentary record of gas industry operations within the Commonwealth. The conditions discussed by this study are a microcosm of the problems associated with the manufactured gas industry’s worldwide legacy. We identified over 170 confirmed FMGPs and related sites, including a large gasworks lying below a university campus, and another untouched below a large high school. Of these, 95 represent gasworks that formerly supplied gas to citizens, 17 private gasworks or producer gas (fuel) plants, 26 district holder stations, 20 off-site waste dumps, one immense coking plant, and 31 by-product plants processing coal tar feedstocks. Our private gas plant discoveries are a representative sample of a much larger number; in particular, numerous undiscovered gasworks dumps are anticipated to exist. The Commonwealth initiated its current assessment and remediation program in 1993. Fifty-one of the 170 sites in our primary population are not listed with MassDEP. Thirty-four of the sites have attained temporary solutions, and 31 remain ongoing. Statewide, utilities retain the lion’s share of liability, holding PRP status for 69 of 105 listed sites, including a number of sites where the real estate is no longer owned by utilities. Private entities are PRPs for 28 sites, and municipalities are PRPs at eight sites. The authors have the highest levels of confidence in the “numbers.” We are in press with Taylor & Francis for a 2017 release.

US-26 Mount Hood Highway Safety & Preservation Project

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The Mount Hood Highway (US-26) is a primary transportation corridor between the Portland Metropolitan Area and Central Oregon. It travels through the Mount Hood National Forest through steep mountainous terrain. Recreational activities within the forest are accessed from the highway throughout the year, including skiing, snowshoeing, and snowmobiling in the winter and hiking, biking and camping in the summer. The highway between MP 49.20 and MP 57.45 has experienced a higher than average crash frequency, especially under winter driving conditions, as compared to other rural highways. From 2003–13, 98 crashes resulted in 88 injuries and 4 fatalities. A majority of the crashes were run-off-the-road and crossover accidents. Existing rock slopes in this section are up to 160 feet high and the catchment areas at the base of the slopes are not designed to today’s standards. Rock blocks frequently fall onto the travel lanes of the highway. The FFO: US-26 MP 49.20 – MP 57.45 Sec. Project is improving safety by reducing severe crossover crashes that lead to fatalities and serious injuries. Project elements include installation of a median barrier between the eastbound and westbound travel lanes, extension of downhill passing lanes, cutting more stable rock slopes, and constructing adequate catchment areas. Pavement throughout the project will be rehabilitated with a grind and inlay. The presenters will discuss the multi-discipline coordination required to address project challenges and develop unique solutions. Geotechnical project design elements will be discussed in detail including a summary of construction activities.

The Evolution of USACE Seepage Barrier Wall Contracts

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With every project come lessons learned. At the U.S. Army Corps of Engineers, one of the goals of each project is to capture these lessons learned and communicated them forward from project to project and District to District. This not only permits the sharing of knowledge and experiences nationwide, but also helps to improve our contractual methodologies, reduce our overall cost, and improve our designs. A relatively recent example of this communication for improvement is the evolution of seepage barrier wall contract. From Mississinewa Dam to Wolf

Creek Dam to Center Hill Dam to Bolivar and East Branch Dams, lessons have been shared amongst U.S. Army Corps professionals to aid in developing ever increasing efficiency and effectiveness in designs and contract specifications. Although all five projects have their distinct differences, there are key considerations that are similar that have shaped the current state of the art in barrier wall design. Samplings of these lessons-learned are described in this paper and include: contractual philosophy, enterprise database solutions, methodology for verification of barrier wall geometry, and methodology for verification of barrier wall material properties. By implementing an effective contracting mechanism, USACE is able to keep the door open to innovation while also meeting the project needs as well as reducing the cost of modifications. By including an enterprise database solution as part of the contract requirements, USACE is able to have a fully documented product to aid in quality assurance and verification of design. Multiple methodologies have been used for verification of barrier wall final geometry and material properties. This has provided a history of tested methodologies that have proven to be successful such that there is confidence in the final product. Communication of lessons learned and implementation of improvements on future products provides for an environment of improvement over time.

Analysis of Optical Televiewer Logging in Support of a Foundation Grouting Evaluation at the Calaveras Dam Replacement Project

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The San Francisco Public Utilities Commission (SFPUC) is constructing a replacement dam for the Calaveras Reservoir located in Alameda County, California. The replacement dam will be 1210 feet long, 220 feet high, 1,180 feet wide at the base and 80 feet wide at the crest. The foundation grout program consisted of a 100-foot deep, double grout curtain formed parallel to the dam axis (North 81o West). Row A was offset 5 feet north of the centerline with injection boreholes drilled 70 degrees from horizontal and dipping to the east; Row B was offset 5 feet south of the centerline with injection boreholes drilled 70º from horizontal dipping to the west. Primary injection holes were spaced 24 feet apart with secondary splits at 12 feet. The alternating dip directions of the grout injection rows were designed to intercept northeast/southeast dipping fracture sets and northwest/west dipping bedding as determined by previous televiewer surveys and core logging. Our area of investigation concerned upper elevations of the left abutment where the underlying bedrock consisted of fractured Miocene-age Temblor Sandstone. Optical televiewer (OPTV) logging is routinely used to delineate and map the orientation of fractures and bedding. As part of a post grouting evaluation, OPTV logs were conducted in a series of test bores to determine the proportion of intercepted fractures taking grout. The impacts of grout in-filling fractures were clearly visible on OPTV images as whitish grout along fracture traces contrasting with the tan to grey color of the Temblor Formation. The percentage of fractures impacted by grout ranged from 15 to 68 percent per borehole. The majority of fractures impacted by grout were shown to dip in a direction coincident with a prominent southeast dipping fracture population. Critically stressed fractures are more likely to be permeable and open and therefore these SE dipping fractures are potentially aligned to the principle stress direction within the local stress field.

Historic and Prehistoric Tsunami Deposits in Java: Implications for Preparation and Evacuation Planning

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The island of Java lies along an active convergent plate boundary, and it is the most populous island on Earth. While the geologic setting and population of Java indicate a great tsunami risk, the instrumental earthquake record for Java includes no events greater than Mw 7.8, and the island has experienced few historical fatal tsunamis. The geologic record, however, indicates a significant tsunami hazard along the south coast of Java, including the possibility of regional tsunamis generated by megathrust earthquake events (Harris and Major, 2016). Preparation for future tsunami events in Java, including planning evacuation routes, requires knowledge of the probable maximum tsunami run-up elevations and inundation distances. We assessed tsunami run-up elevations and inundation distances in Java by studying the characteristics and landward extent of deposits generated by a recent tsunami and paleotsunamis. Sediment from a 2006 tsunami in Pangandaran in south central Java was used to characterize tsunami deposits in the area. Based on similarity to these sediments, a sand layer exposed in a stream bank near Pangandaran appears to have been produced by a larger paleotsunami. Using test pits, hand augers, and GPR, we mapped the landward extent of this paleotsunami. We then explored for paleotsunami deposits in two other areas, Pelabuhan Ratu in western Java and Lojedjer in the east, to test the extent of the paleotsunami in central Java. Results from the study have been used to inform tsunami education and planning in the three study areas.

Geophysical Investigations at Isabella Dam, Lake Isabella, California

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Isabella Dam located at Lake Isabella, California is a Dam Safety Action Class I (DSAC I) dam owned and operated by the Sacramento District, U.S. Army Corps of Engineers (USACE). The Sacramento District is currently in the modification design phase to mitigate hazards presented by the dam. Several rounds of geophysical investigations have been performed as part of the Dam Safety Assurance Program (DSAP) and Pre-Construction Engineering and Design (PED) phases. These investigations have been performed in-house staff and in collaboration with the U.S. Geological Survey (USGS) since 2007. Investigations have included seismic refraction and reflection, DC resistivity, frequency domain electromagnetics and self-potential. At various phases in the program theses geophysical methods have been used to define depth to bedrock, evaluate liquefaction potential, define faulting and seepage below the Auxiliary Dam, to evaluate bedrock quality along a proposed tunnel route and to search for a suspected, but undefined shear zone in the vicinity of the proposed new Emergency Spillway. This talk will provide an overview of the various investigation phases and demonstrate how the different geophysical methods have been applied to address geotechnical needs.

Modeling the Effects of Carbon Dioxide Injection on Coalbed Methane-Associated Water in the Central Appalachian Basin

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In July 2015, a year-long injection of up to 20,000 tons of carbon dioxide into gas producing coal seams began at a well field in Buchanan County, Virginia. The objective of this project is carbon storage to with a secondary advantage of enhance the coalbed methane (CBM) recovery. These seams are saturated with high salinity water and it is important to understand how the addition of carbon dioxide may affect the water chemistry. Specifically, precipitation and dissolution of minerals can impact permeability in the reservoir, and mobilization of heavy metals can result if they are leached from the coal. The three phases of water monitoring are baseline sampling before injection, sampling during injection, and sampling after injection ends. It is imperative to define the initial water quality because CBM-associated water data is not readily available for the Central Appalachian Basin. The parameters examined include Total Dissolved Solids (TDS), pH, major cations and anions, Total Organic Carbon (TOC), alkalinity, Oxidation/Reduction Potential (ORP), Electrical Conductivity (EC), Dissolved Oxygen (DO), and Sodium Adsorption Ratio (SAR). The ultimate goal is to use PHREEQC and Geochemist's Workbench to model the carbon dioxide-brine-rock reactions to determine if the injection has any negative impacts.

A Case Study of the Development of a Landslide Hazard Program for PG&E's Natural Gas Pipeline System in California

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In an effort to understand and reduce geologic risks posed to their natural gas transmission system and the public, Pacific Gas and Electric (PG&E) hired Golder Associates Inc. (Golder) to perform a system-wide desktop geomorphic assessment of landslide and erosion hazards along PG&E's natural gas pipelines in California. The goal of the project was to identify and characterize landslide and erosion hazards to PG&E's pipelines within a six-month period. To accomplish this goal, a team of eight Golder geoscientists worked to develop and populate a landslide and erosion hazard geodatabase. To streamline the process, Golder developed the database in ArcSDE (Spatial Database Engine), which allowed the Golder team to conduct multi-user editing, resolve data conflicts, and archive datasets at various project milestones. The desktop assessment focused on identifying and delineating existing landslides and erosion sites based on surface morphology as observed in Lidar DEMs. Golder supplemented the desktop assessment by reviewing high resolution aerial imagery, Google EarthTM imagery, and site-specific data provided by PG&E. Furthermore, 238 geologic maps were downloaded and reviewed for applicability to the assessment. Data integrity was maintained by establishing topology rules within the ArcSDE geodatabase, employing logic checks for the datasets, and developing python tools to support repetitive geoprocessing tasks. As a follow up, an intensive, joint Golder and PG&E field verification and hazard mapping program was conducted at targeted sites. The results of the database development and field mapping continue to support PG&E's efforts to monitor and maintain its gas transmission pipelines. The Geospatial database has since been adapted to allow for continued monitoring and mitigation tracking, as well as mobile field mapping and editing. The database is used across multiple lines of business within PG&E and is used for risk analysis and assessment planning, patrol planning, dig planning, mitigation project planning, and emergency preparedness.

Flexible Debris Flow Barriers Allow Homes to be Re-Built Quickly After Damaging Event

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In 2013, the Springs Fire in Ventura County, California burned approximately 24,000 acres and drastically changed the vegetative cover and soil characteristics. Heavy rainfall in late 2014 caused the residential area of Camarillo Springs to experience two massive debris flow events. A number of homes were red-tagged and could not be re-built. With the prospect of an El Niño winter, the City of Camarillo retained a team of specialized geohazard design professionals and contractors. It was imperative to design and construct five flexible debris flow barriers and a system of earth berms in a period of several months. The initial site investigation, analyses, and design were completed in August and September 2015. Political and logistical issues delayed the project. Alternate designs using hardened structures were considered but were deemed inadequate. The original mitigation design was given the green light to proceed in October 2015. Construction began in November 2015 with a hard deadline of January 26, 2016. Under the threat of El Niño storms, construction proceeded at a rapid pace. Five flexible barriers, six earth berms, and approximately 280,000 square feet of grading were completed ahead of schedule on December 31, 2015. On January 5, 2016 Ventura County received the first heavy rain of the year. The barriers and berms performed as intended and prevented large amounts of material from impacting the homes below. This case study describes engineering, political, economic, and construction challenges for the project. Good communication and teamwork by all parties were responsible for successful completion.

Evaluation of Naturally Occurring Asbestos Mitigation Measures in California Construction Projects

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Although various hazardous minerals exist within rock and soil in California, project sites are often purchased before an assessment of soils proposed for grading is performed. Geologic maps are helpful for identifying mafic and ultramafic bedrock, but require interpretation by a skilled geologist to visualize the processes that may have resulted in the deposition of minerals in locations outside mapped mafic and ultramafic zones, including within stream beds, landslide deposits, or fault zones. When soil is sampled as an afterthought prior to disposal, property owners are often surprised by the budget-crippling costs of waste handling and disposal of soil containing naturally occurring asbestos (NOA), as well as the mitigations required to protect the health of construction workers, the public, and future site occupants. A thorough site evaluation includes utilization of the mapping and sampling methods developed by the California Geological Survey, laboratory analytical methods within CARB 435, and mitigation measures required by CARB, DTSC, and OSHA for the protection of construction worker and public health after NOA is discovered. The site evaluation should additionally consider future site usage, as long-term mitigations may be required. This presentation will contrast two case studies: a school project with several years of advance planning and a commercial property where NOA was discovered weeks before the start of construction. The presentation will analyze the regulatory differences, mitigation measures, and financial impacts that the discovery of NOA can have on a school versus a commercial project in California.

The Rest of the Story - Tunneling Geologic Lessons and Other Geotechnical Geology Potpourri

Kaneshiro, Jon Y., Parsons Corporation, jon.y.kaneshiro@parsons.com (TS #9)

A series of engineering geologic lessons learned are provided on a number of tunneling projects. The truth is often realized sometimes well after project investigation, project completion, or left to speculation. The project anecdotes discussed will include the following: SLAC, the missing piece of core and squeezing Eocene shale and elastic rebound in Miocene sandstone; Thomas Shaft, groundwater inflow, disposed muck, and robbing Peter to pay Paul; rumbling ground at the Crystal Springs Lake Tap—earthquake, airplane, or grouting? San Jacinto Tunnel grouting and large fracture groundwater flows; shaft freeze failure and geologic conditions and staying on line in difficult ground for the South Bay Ocean Outfall; sticky clays and sinkholes above Broadway on the New Mississippi Outfall; and supporting the ground and failures on NATM, SEM, ADECO on wine caves, highway tunnels and water tunnels—the untold story; and stabilization of regular and random fractures for the Belden Siphon.

Mortar Bar Expansion Study on Known Proportions of Chert in Aggregate for Determining Potential Alkali Silica Reactivity

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Structural degradation in concrete by means of alkali silica reaction (ASR) has been widely investigated for several decades. An understanding of the structure and properties of chert or other amorphous silica contained in reactive aggregates is essential to the assessment of ASR and consequent expansion in concrete structures. Previous studies documented the depolymerization of silica by means of hydration and the solubility of silica structures in alkali mediums. The breakdown of silica and interaction between silicate polymers and alkali ions in concrete pore fluids triggers ASR, resulting in a volume expanding gel. To better understand the geochemical mechanisms within chert, this paper examines the rate of ASR with reactive chert aggregate. Chert derived from Mississippian aged Keokuk Formation is crushed and mixed with a glacially sourced outwash aggregate. Under guidance of ASTM C1260, mortar bar tests are being conducted using known proportions of the chert in aggregate and a water-cement ratio of 0.47. Mortar bar samples are made in triplicates and immersed in 1M NaOH solution at 80∞ ± 3∞ for a period of 14 days. Preliminary results from comparator readings indicate expansion greater than 0.2% with aggregate containing two percent chert by weight. We will report results of the experiment, yielding mortar bar length changes with various chert percentages. We also document the visual extent of alkali-silica gel for different proportions of reactive chert in aggregate using polarized light microscopy. Analysis of resulting photomicrographs will test microscopy of concrete as an alternative means of a quantifiable ASR expansion test.

Characterization of Under Seepage-Induced Dam Erosion Due to Hydraulic Parameters and Soil Properties Using Artificial Neural Network Models

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Recent studies have brought the assessment of dam failure due to under seepage using strictly blanket theory and critical exit gradients into question. In some cases, dams which should fail, have clearly not failed; and conversely those which should not, have failed. This is troubling in the sense that measurement techniques and precisions have significantly advanced since the ’50s when system field investigations of internal erosion in embankments were first undertaken. Clearly, present understanding of fundamental triggering factors in internal erosion including hydraulic gradients, seepage paths, insitu stresses, and soil mechanics is incomplete at best. In this paper, a decoupling of the roles of hydraulic parameters and soil properties is conducted to predict the initiation of internal erosion using artificial neural networks (ANNs). Three separate ANN models are developed and compared: one with only hydraulic parameters, second with only soil parameters and third a combination both types. The focus is on initiation of internal erosion because at a fundamental level, common deterministic and stochastic risk assessment tools both rely on the factor of safety concept to predict the likelihood of dam failure. Modeling with ANNs is an important computational technique whose functionality is based on the human nervous system information processing through experience. As a practical method ANN models have an ability to investigate and detect nonlinear parametric relationships among data sets with little to no prior assumptions, thus virtually eliminating user subjectivity or bias. Given that ANN modeling approach is empirically based, it provides both a systematic and quantitative method for assessing the initiation of internal erosion without violating key underlying seepage theory and the constitutive laws of soil mechanics. The ANN model developed in this paper is applied in the context of a real levee in the Mississippi River valley.

Extrapolation of a Laboratory-Based Dam Failure Risk Assessment Method to the Field Scale

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Recent studies suggest that most large dam failures are a result of internal erosion, although this particular failure mechanism is often neglected in the standard procedures for dam designs. Over toppling, foundation analysis, spillway, structural and slope stability analyses are more commonly conducted. This is because there is limited understanding of the mechanics of internal erosion with relation to seepage. In addition, current internal erosion/piping risk assessments often tend to be qualitative in nature making it challenging to eliminate bias. Recently a laboratory-based neural network technique for estimating the potential for piping in non-cohesive soils was developed. Although the method, based on fundamental kinetic energy theory, showed promise it was never tested on real field data. In this study the model is extrapolated to the field scale using data from the well-studied Francis levee from the Mississippi River Valley. The method accounts for physical characteristics of the soil, effective stress conditions, and seepage path angles. The results from the lab and field applications are compared and contrasted, and suggested modifications and improvements are made.

Interpreting Historical Radar Rainfall: Can Geologists Connect the Dots for Geohazard Communication?

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Weather radar is familiar to everyone who has seen a weather report on a mobile device or TV. The National Weather Service (NWS) provides updates from the 155 NEXRAD Doppler radar stations in the United States at 4- to 10-minute intervals, and has archived data and derivative products since about 1990. The NWS issues weather hazard alerts based on NEXRAD data and other factors, and issues debris-flow warnings for locations below recently burned slopes. Four reports by Geotechnical Extreme Event Reconnaissance (GEER) Association and one article in AEG News in the past three years

include radar rainfall information; three were storm-induced debris floods from burned slopes in Colorado (2013) and California (2014, 2015), one was a strong convective storm that produced extensive debris floods from unburned slopes in California (2015), and one was the Oso Landslide in Washington (2014). Lessons from these evaluations include 1) ability to estimate rainfall at ungauged locations, 2) recognition of local variability in rainfall intensity and duration, 3) storm-cells can hit or miss burned slopes, and 4) NWS correlation of "rainrate" with Doppler radar signals allows quantitative estimates of rainfall intensities and durations. The GEER reports and AEG News article concluded that weather radar provides useful information for explaining the timing and variability of debris flows or debris floods. The NWS uses weather radar for essentially real-time weather hazard alerts. Is it possible for geologists to use historical radar rainfall for characterizing intensities and durations in ways that can be combined with seasonal aspects of storms and the range of probable climate-change effects to identify susceptible ground conditions (geology, topography, vegetation condition, time since last burn, and burn severity) for estimating ranges of sediment yield? With so many variables and so much uncertainty, will geologists be able to communicate geohazard information effectively?

Planning and Technical Considerations for Large Stone Use on Chicago Shoreline Project, Lake Michigan

Kissane, Joseph, U.S. Army Corps of Engineers Chicago, joseph.a.kissane@usace.army.mil (TS #8 and #21) (Presented by Richard Olsen)

The Chicago Shoreline Project has continued over the past 20 years under a cost-sharing agreement among the U.S. Army Corps of Engineers, the Chicago Park District and the City of Chicago. Project goals included flood protection for Lake Shore Drive and protection of parklands that were built using highly erodible debris from the Great Chicago Fire of 1871 as fill. Planning and technical considerations evolved over that time resulting in a variety of decisions involving engineering geologic considerations. Pre-existing features included armored sections of shoreline protected by revetment of cut limestone blocks in a stepped array on stone-filled timber cribs constructed in the early 20th Century. Aeration of timber cribs caused them to rot, resulting in the fill stone being lost, and the alignment of the overlying stone blocks to collapse. Storms resulted in erosion and overtopping the structure and flooding of parklands and sections of Lake Shore Drive. Preliminary planning included selection of a basic stone-armored rubble mound structure as the most cost-effective design. The Local Sponsors submitted a Locally-Preferred Plan consisting of concrete stepped-structures, mimicking the original step-stone configuration, with a steel sheet pile foundation protected from wave erosion by armoring the toe with over 600,000 tons of large stone. One section was constructed with a hybridized rubble mound design with reconstructed steps of cut stone at the top. The designs of each section were developed by either the Corps or the Chicago Park District/City of Chicago and their respective consultants, with close cross-review to insure smooth transitions.

Cape Lisburne Seawall Reconstruction Project

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Cape Lisburne Air Force Station is located on the Chukchi Sea coast in northwestern Alaska and is the location of one of the Air Force's Long Range Radars. The runway, located along the beach, is exposed to strong wave forces from storms, which cause severe damage to the runway. The storms cause erosion along the Chukchi Sea side of the runway and wave overwashing that floods and leaves large rocks scattered along the runway. The damage to the runway prevents planes from landing and requires significant clean up before the runway is usable. Air travel is one of two ways that people and goods can arrive at the remotely located Air Force Station. In the past, erosion along the runway has been managed by dumping locally sourced, unsorted rock along the beach. This method does well at mitigating beach erosion in the short term, but requires continual long-term maintenance and is one of the sources for the rock that scatters across the runway during a storm. In order to develop a long-term solution to the erosion and overwashing of the runway, the Air Force asked the Army Corps of Engineers to come up with an engineered solution to the problem. The proposed design is a rock seawall to absorb wave energy and to minimize overwashing of the runway. With the construction of the rock seawall, the Air Force will have a 50 year solution to prevent erosion that requires minimal maintenance and decreases flooding on the runway.

Monitoring of Urban Landslides Around Guatemala City Through Community Engagement

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Due to its geologic setting, Guatemala is a country stricken by natural disasters, including earthquakes, volcanic eruptions, and landslides. In the Western Hemisphere, Guatemala is second only to Haiti in landslide-related fatalities in the past decade. This problem is especially serious in the environs of Guatemala City, where poverty and high population density have forced people to settle in unauthorized communities on dangerously steep slopes. The urgency of the need for more research was highlighted on October 1, 2015, when a devastating landslide killed hundreds of Guatemalans in the community of El Cambray II, in metropolitan Guatemala City. Though the country has a pressing need for more research on landslide mitigation, it currently lacks the geological engineers and geologists necessary to monitor all the landslides that occur each rainy season. This project seeks to engage the socioeconomically vulnerable inhabitants of landslide-prone slopes to lower their risk of disaster through understanding the basic mechanics and movement of the slopes on which they live. The project will focus on the development of cost-effective ways for these residents to monitor the movement of those landslides. Community collaboration will increase current monitoring methods, and incorporate an early alert system for evacuation in case of devastating slope failures. Scientific facts and engineering solutions will bring safety and understanding to vulnerable communities around Guatemala City. Technically analyzing a few large landslides, while engaging at-risk residents through education and cooperation will bring a higher quality of life through safety and understanding to the people of Guatemala.

Introducing Two Projects Focused on Groundwater in Hawai'i

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Two ongoing projects are seeking to address limitations in the understanding of Hawai'i's groundwater systems. The project ëlke Waií funded by the National Science Foundation (EPSCoR, Track 1) and Phase 2 of a "Play Fairway" project funded by the U.S. Department of Energy are both seeking to better understanding how and where subsurface geologic structures influence groundwater storage and flow. Together, the two studies focus on 12 areas of interest across the state. Methods include chemical and biological analysis of water well samples, non-invasive geophysical surveys, down well sensor development, and numerical modeling. This presentation will provide an overview of both projects, including preliminary data obtained.

Shoreline Remediation: Transforming a Coastal Brownfield to a Park

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Port Norfolk Park is a 30-acre coastal site owned by the Massachusetts Department of Conservation and Recreation. The site is located at the mouth of the Neponset River and is chiefly comprised of former mudflats that were filled in the mid-1800s. The property was occupied by wharves and industrial uses for about 120 years. The state purchased it for development as a community park. Contamination remaining from the former industrial uses was cleaned up in conjunction with park construction. The main project challenges were posed by the coastal edge which was a mixture of dilapidated seawalls, salt marsh, contaminated soil, and debris-filled bank. The Neponset River at this location is part of the greater Boston Harbor ecosystem as well as a designated Area of Critical Environmental Concern. The design team sought to rehabilitate the tidal habitat and coastal bank during remediation and park construction. The final design includes the replacement of dilapidated seawalls with soft engineering and living banks while creating a passive, naturalistic park. The project included permitting from multiple local, state, and federal agencies. The design focused on minimizing impact to resource areas and minimizing off-site disposal of soil in an effort to keep costs down. Obtaining the required permits required DCR and the design team to negotiate site restoration and ultimate land use with the various stakeholders. The property is one of the final stretches of the Neponset River Greenway, a network of public parks, bikeways, and walking paths, to be cleaned up.

2D or not 2D, that is the Question: Insights on the Dimension Debate for Pore Pressure Modeling of Open Pit Mines

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When open pit mining delves deep, it is inevitable that sectors of the slope will be below local or regional groundwater systems. In turn, pore pressure almost always plays a role in slope design and geotechnical performance. Pore pressure is a dynamic condition due to active mining and dewatering operations and requires careful consideration. Numerical groundwater flow models are a useful tool to aid in evaluation of pit slope pore pressure and design of proactive depressurization programs. Model results can also be used as an input to geotechnical analysis for slope design. Definition of the conceptual model is crucial; a key aspect is model dimension. Standard practice is to construct 2D cross sectional models, or 3D district-scale models. Typically, 2D models are quick to define, build and calibrate, and can include precise geologic conditions along the section, but require assumptions that limit accuracy of results. They can be expanded into quasi-3D to incorporate depressurization elements (e.g. horizontal drains, pumping wells, etc.). 2D sections tend to be the first choice for many pore pressure evaluations, especially if there are known, localized problem areas of the slope. In 3D, models characteristically encompass a large district surrounding the open pit; building and calibrating these models can be time-intensive. They evaluate the pore pressures across the whole pit, and typically represent the flow-field with more accuracy, but are often not focused on specific areas of interest. This presentation discusses/contrasts 2D and 3D groundwater flow models for evaluation and prediction of pit slope pore pressure.

Properties of the Volcanic Ash on the Island of Hawai‘i

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There has been very little information published on the unique engineering properties of the volcanic ash materials on the Island of Hawai‘i. Substantial deposits of volcanic ash with unique engineering properties exist at the eastern portion of the Island of Hawai‘i. The materials are fine-grained with a large fraction of the materials finer than No. 200 sieve. Some of the volcanic ash materials have extremely high in-situ moisture contents ranging from 100% to over 350% with very low dry densities. In addition, the volcanic ash materials have thixotropic properties, e.g. the materials lose significant strength when disturbed by vibrations or construction activities. Because of the high in-situ moisture contents and the naturally wet tropical climate on the eastern side of Hawai‘i, the volcanic ash materials are not workable and cannot be re-used as engineered fill materials when excavated from their natural environment. By contrast, there are widespread deposits of the same volcanic ash materials with appreciably lower in-situ moisture contents and slightly higher in-situ dry densities in the central and northwestern portions of the Island of Hawai‘i. The “drier” volcanic ash materials are still difficult to work with in earthwork operations; however, the “drier” volcanic ash materials are much more workable and are re-used as engineered fill materials. The optimum moisture contents of the “drier” volcanic ash materials are in the range of about 50% to 65%, and the maximum dry densities are in the range of about 800 to 1,100 kg/m^3 (50 to 70 pounds per cubic foot). A series of common geotechnical tests conducted in support of the design and construction of a new highway traversing these volcanic ash materials was conducted and summarized in this paper to highlight the major differences in engineering properties of the unique properties of the volcanic ash materials.

Deterministic and Probabilistic Evaluation at a Site East of La Paz, Baja California Sur, Mexico

Lowry, Donald, Golder Associates Inc., dlowry@golder.com; Eric Cannon, ecannon@golder.com (Poster)

A number of small-scale mining developments are under evaluation in the southern Baja California Sur (BCS) pen-insula. International mining guidelines dictate that these facilities should be designed to withstand earthquake shak-ing and loading hazards that are not well defined in the region. We developed a site-specific seismic hazard analysis (SHA) model for one such site in the eastern BCS region of San Juan de Los Planes containing 14 separate seis-mic sources - twelve (12) crustal fault and two (2) area sources. The model indicated a moderate level of probabilis-tic seismic hazard because the relatively low fault slip rates, and most historic seismicity is offshore - associated with the spreading center. Deterministic earthquake ground motions were found to be very high because of the number of and proximity to active faults, and because DSHA evaluation does not take into account slip rate and/or recurrence intervals. Hazard estimates can be improved with better quantification of Mmax and recurrence intervals for the major on-shore crustal fault sources.

“It Was a Dark and Stormy Night” on the Comstock… Emergency Repair and Relocation of State Route 342

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State Route 342 (SR342) is the primary route for tourists to reach Virginia City, Nevada. SR 342 is located in a prescriptive right of way owned by Comstock Mining Inc. (CMI) which operates the Comstock

Mining Project between Silver City and Virginia City. CMI's Lucerne open pit highwalls parallel SR 342 as little as a few tens of feet away. Historic underground workings are present that extend to the east of the Lucerne pit under the road alignment. The Silver Hills shaft is located directly beneath the highway and had collapsed three times in the last 40 years. The most recent collapse was in 2005 when Nevada Department of Transportation (NDOT) capped the shaft by placing concrete barrier rails over the void approximately 20 feet below grade and then placing compacted rock fill over the shaft. Since 2005 the road over the shaft had gradually settled approximately one foot causing NDOT and CMI to closely monitor the road. In July 2014 as the Lucerne Pit was being deepened in the area of the shaft, tension cracks began appearing along the road. The tension cracks were monitored and showed no significant additional deflection until December when additional tension cracks appeared. CMI and NDOT began an aggressive monitoring program and telemetry was planned to be installed in February of 2016 when a rain event triggered concerns for the shaft collapse and the road was closed by NDOT. The presentation will describe the emergency response, geologic setting, and design of an emergency by-pass and the relocation of the roadway all within 7 months of the initial closure. The potential effect on tourism, multiple jurisdictions, prescriptive ownership of the road, combined with the concurrent need to relocate of Gold Canyon Creek, and related environmental concerns make this project truly unique.

Design, Construction, and Verification of a Partial-Depth Seepage Barrier through Glacial Outwash

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A multiphase, major rehabilitation project is nearing completion at Bolivar Dam, a 6,300 foot long earthen flood control dam owned and operated by the U.S. Army Corps of Engineers (USACE) Huntington District. The dam, which was constructed in 1937, spans the Sandy Creek valley in northeast Ohio just beyond the glacial margin, and is founded on up to 200 feet of pervious, glacial outwash soils. Although a "dry dam" with no normally retained pool, the project has experienced excessive under-seepage and related erosional issues during higher pool events, which has led to the completion of several remedial measures post-construction (e.g. relief wells, seepage berm, toe drain). However, record pool and tailwater levels during the pool of record event in 2005 highlighted the problematic site geometry and adverse foundation stratigraphy and permeability, and confirmed the need for a seepage barrier through the dam's foundation to address internal erosion and piping concerns at all potential pool and tailwater combinations. Following extensive analysis and design using a risk-based approach, installation of a 4,400-foot-long seepage barrier to maximum 145 feet depth was approved. Construction of the seepage barrier, by Treviicos South, is nearing completion. This talk will highlight the foundation conditions and seepage concerns resulting in the barrier design, contract and performance based specifications approach, construction methodology, and results from both insitu verification and laboratory quality control testing. In addition, plans for post-implementation monitoring via automated piezometers and relief wells will be discussed, including preliminary results to date.

Geologic Route Characterization and Landslide Hazard Assessment of Oregon Coast Range Power Transmission Line

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The Bonneville Power Administration (BPA) elected to replace an aging 115-kV power transmission line in the Oregon Coast Range, which is a belt of uplifted sedimentary and volcanic rocks near the Pacific Ocean. A geologic route characterization and landslide hazard assessment was conducted to identify and map landslides and areas of potential slope instability that could damage transmission structures. The type and occurrence of landslides was evaluated using information gathered through review of geologic maps and literature, aerial photography, Statewide Landslide Database for Oregon (SLIDO), and lidar data. Landslides identified from literature and remote sensed data were cataloged in GIS and a surface reconnaissance conducted. A total of 76 structures were located in areas identified as landslide topography. Ground cracks indicative of slope movement were observed at nine structures and four locations were identified with loose guy wires during the surface reconnaissance. Each of the 331 structures assessed were assigned a hazard rating based on documented or observed landslide features, indications of recent mass movement, and/or observed ground cracks. Structures were rated from high to low risk for the prioritization of mitigation efforts. Of the 331 structures assessed, 12 structures were identified as having a high risk for future slope instability. All but three of the high-risk structures appeared to be associated with sidecast fill placed as part of access road and structure work pad construction. In general, the slope instability associated with the roads and bench areas appeared to be the result of oversteepened, loose sidecast fill placed on steep natural slopes or steep cut slopes.

Where IS Your New Entry-Level Engineering Geologist Coming From?

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The source of future geoscience professionals starts with the academic system where they gain their fundamental education at the Bachelor level. Major "Tier One: academic institutions recruited and supported PhD's to develop programs in applied geology during the 1970–1980s. Engineering Geology gained a unique reputation in the applied geosciences that paralleled the Petroleum and Mining programs. The "environmental movement" generated a new academic program in Environmental Science in the 1990s that drew students into the "new solution to protecting our environment." Professional licensure of geologists became a significant effort during the 2000s that currently involves professional licensure in over 30 states, all counting on a National Fundamentals of Geology Examination. While everything looked like a great future, the political and academic politics initiated a decline in the academic preparation of professional engineering geologists. State financial support for academic programs was cut and programs were closed by new deans; "because applied research does NOT belong in a Tier One research institute"! An Engineering Geoscience degree option designed to prepare BS graduates for licensure was replaced with an "Environmental Geoscience" program in Geography. Our PhD researchers and educators are retiring without new young replacements. The fail-rate on the fundamentals examination is over 40% because graduates do not have the critical academic preparation. Your future GIT, Geologist-in-Training, will come from the Tier Two institutions that are committed to fundamental education and to passing the National Fundamentals of Geology examination.

Cumulative Departure Model of the Cryosphere During the Pleistocene- an Application in Computational Engineering Mathematics

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The issues involved with Global Warming include aspects of Cryosphere changes such as reduction in global ice volume with associated rise in ocean levels. The relationship between ocean levels and Cryosphere volume provides an interesting problem tractable by computational modeling of the governing differential equations. In this paper, we examine such a differential equation to track global ice volume changes over the Pleistocene period using computational code solved by common software. The formulation is a problem considered by cadets at the U.S. Military Academy at West Point, as part of a theme of study in Computational Engineering Mathematics. Modeling such changes in ice volume in the cryosphere is useful in assessing future climate impacts currently captured by global circulation models (GCMs) by providing an opportunity to validate GCMs. Leveraging the dominating effects of freezing and thawing in the cryosphere to simplify relevant heat transport equations facilitates the derivation of a mathematical model that can be solved exactly. Such exact solutions are useful in investigating other climatic components. Trends in GCM advancement increase the complexity and sophistication of the various heat transport effects represented in the governing model in cumulative form as the heat forcing function. This paper develops simplified models whose solution directly compares with available data forms representing temperature and ice volume during the Pleistocene. With careful integration of the Pleistocene temperature term in the solution, the well-known cumulative departure method can be resolved using a two-term expansion of the corresponding Taylor series. This simplification is shown to be a good approximation of the Pleistocene ice volume for given Pleistocene temperatures. In addition to this example, an overview of recent institutional advances for Computational Engineering Mathematics in West Point's research and education curricula will also be presented.

Investigation and Quantification of Water Track Networks in Boreal Regions of Alaska

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Water tracks are drainage pathways that route water through the soil over a laterally constraining subsurface layer such as permafrost. Due to the prevalence of permafrost in the polar environments, water tracks form the dominant drainage network, yet they remain relatively unexplored. The objective of this study is to investigate water tracks in thickly vegetated boreal regions for a systematic understanding of their interactions with engineered infrastructures. Such understanding is vital for providing better insights into predicting and mitigating the impacts of climate change to the interaction of water tracks and infrastructure. Two case studies were conducted: one on Goldstream Road north of Fairbanks, Alaska, and another at a residential property northeast of Fairbanks, Alaska. At the study areas, two highly-varying water tracks were characterized, and led to different but quite promising insights. Characterization at the residential area revealed that water tracks not only form due to lateral constraining layer, but can also form along the boundary between two units with contrasting hydraulic properties (e.g., compacted fill and natural soil). The other water track, by the Goldstream Road, suggested that temperature and moisture content are significant parameters of water tracks. Furthermore, several techniques to map water tracks in boreal regions were attempted at each study area. Preliminary analysis of geophysical data correlation was performed as well. Findings from this study emphasize the need for future explorations of water tracks.

Comparison of Field and Laboratory Test Methods for Material Site Selection for the Alaska North Slope Rail Project

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The proposed 450 mile-long North Slope Rail Extension Project would connect major energy and mineral resources of northern Alaska to ice-free and deep-water ports in south central Alaska. The proposed bulk transportation system is necessary for efficient production and transportation of these resources to increasingly competitive world markets. Arctic engineering best practices for the railroad will require very large quantities of high quality construction materials. Assessment of potential material sites includes both field micro-hardness testing and sampling as well as traditional compressive and shear strength, abrasion resistance, and freeze-thaw testing of all lithologies along the proposed alignment. The unglaciated terrains are now subject to periglacial processes and are characterized by extensive chemical and mechanical weathering reflecting earlier periods of landform development. This results in significant loss of rock strength for most lithologies. In the unglaciated terrains micro-hardness testing of chemically resistant lithologies (felsic volcanics, cherts, and quartzites) can facilitate the assessment of materials for more rigorous laboratory testing. Medium to course-grained lithologies are problematic as the testing surface is smaller than the individual grains and the rocks generally fails along the matrix/grain boundaries. Visual examination of lithologies susceptible to chemical weathering is usually sufficient to avoid sampling of these materials for laboratory testing. In alpine glaciated terrains, the weathered regolith has generally been removed but replaced with a diversity of either ice contact deposits or water reworked deposits. As a consequence the larger u-shaped valleys have limited exposures of bedrock. Micro-hardness testing of all lithologies in the field in these terrains can thus be beneficial it identify the limited number of exposures that are suitable for laboratory testing.

The Applied Geologist in the Construction Industry: Navigating the Murky Waters Where Science, Business, Policy and Politics Mix

Minas, Shant, AES, shant@aessoil.com (TS #20)

The profession of engineering geologist was created because a need arose for qualified specialists to describe and characterize landforms and earth conditions for large civil projects, as it became clear that in many cases engineers alone could not provide a satisfactory description. As the profession has blossomed and evolved, today applied geologists find themselves in the center of very responsible decision making with regard to construction projects (think fault locations or landslide activity). Decisions are frequently made where there is incomplete information regarding a site. The various stakeholders involved typically have competing or even diametrically opposed interests. Moreover, these decisions often affect highly contentious projects or very expensive projects or both. The successful practicing geologist will skillfully apply scientific principles to the tasks at hand, and meanwhile find economic solutions within the broader framework of protecting public safety. What makes our work even more challenging is that various agencies that regulate our work can have vastly different policies and practices that affect how we do and present our work. Finally, political environments and pressures often can and do affect our work. It is important for geologists to keep from become project "whipping boys." This talk will discuss the var-

ious challenges we as engineering geologists face as we navigate expectations and maintain allegiance to our professional charter and social contract with the public.

Monitoring Goldstream Creek Turbidity for Potential TMDL Development in Interior Alaska

Misra, Debasmita, University of Alaska Fairbanks, debu.misra@alaska.edu (TS #19)

Goldstream Creek near Fairbanks, AK was listed by ADEC on the Section 303(d) list as impaired for turbidity in 1992 using water quality sampling by ADFG and ADNR in 1987–92. The sources of turbidity were determined to be both point sources, such as active placer mines and several nonpoint sources. Monitoring data to demonstrate compliance with the water quality standards was required to remove Goldstream Creek from the list of waterbodies impaired for turbidity, else there would be a need to develop a TMDL policy. Three sites were identified in the Quality Assurance Project Plan (QAPP) and Sampling and Analysis Plan (SAP) that was developed by ADEC in 2009. A major objective was established to collect steady and near-continuous measurements of turbidity data from both baseflow and stormflow conditions and the stream discharge data at those times at several selected locations from spring to fall of 2010 in order to characterize conditions and potentially locate sources of impairment. Additionally, collection of bi-weekly data of overall water quality, viz., dissolved oxygen, pH, conductivity, temperature, etc. at several selected locations of Goldstream Creek from spring to fall of 2010 were also included in the sampling plan. The Background Natural Turbidity (BNT) of the stream was established as 17.73 NTU and the Alaska Water Quality Standards (WQS) was used to establish that the stream turbidity should not exceed 42.73 NTU for aquatic life, 27.73 NTU for recreation and 22.73 NTU for water supply. Goldstream Creek failed to meet turbidity WQS, when compared to an estimated standard from one season, approximately 50% of the time. More failure of the standard was observed after storm events. It was also observed that the turbidity could be caused due to stream bank erosion rather than anthropogenic activities and may need further investigation.

Quaternary Fault Investigation and Probabilistic (PSHA) and Deterministic (DSHA) Seismic Hazard Analyses for Guam

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As assessment of Quaternary faults and site specific PSHA-DSHA was performed for three sites on Guam for the U.S. Navy and Air Force. Guam is situated on the eastern margin of the Philippine tectonic plate within the southern Marianas Arc. The Mariana Trench, subsea surface expression of the ~2000km long Marianas subduction zone, is situated approximately 120 km offshore of Guam. Northern Guam is a low-relief karst plateau on Miocene (Barrigada) and Pliocene-Pleistocene (Mariana) limestone. Southern Guam is a dissected, mountainous upland of Tertiary limestone and volcanic rocks. The study consisted of: review and compilation of existing data, interpretation of Lidar and geological investigation of the island faults and readily accessible shoreline areas, compilation and analysis of the regional seismicity, seismic source characterization, and PSHA and DSHA per the site-specific procedures in the ASCE 7-10 for three locations on Guam. Three faults on Guam exhibit probable Holocene surface displacement and were considered seismic sources: Adelup (2 events), Ritidian (1), and Machanao (1). These faults were previously reported as normal faults but at least two exhibit reverse displacement. The Ritidian and Machanao faults may be connected at depth; this interpretation was considered in the PSHA. The Quaternary Tumuning-Yigo fault was included as a potential source but assigned a low activity rate. We visited numerous coastal sites around of the island where emerged reef platforms and/or tidal notches are preserved to assess potential differential uplift rates across the island. The seismic source model was developed from the regional geology, tectonics, GPS and historical seismicity. Shallow crustal zones and faults, and subduction (interplate and intraplate) seismic source zones, were delineated and characterized in terms of their annual earthquake rates and maximum earthquake magnitudes. Several ground-motion attenuation equations were selected for each of these source types to model the uncertainty in this PSHA input.

Treatment of Inorganic Constituents in Leachate Collected at an Unlined Municipal Solid Waste Landfill

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A leachate treatment program was implemented to mitigate potential landfill impacts to groundwater at the Heaps Peak Disposal Site (HPDS) in San Bernardino County, California. Leachate is collected in a series of subsurface drains that were installed along the base of this closed, unlined municipal landfill that is located on steep fractured rock slopes at the headwaters of the Mojave River in the San Bernardino Mountains. Leachate was historically hauled from the site for treatment at a municipal wastewater treatment plant, but this has been costly and dangerous to workers and the public. To minimize hazards and keep water within the watershed, the on-site treatment plant has been designed to reduce elevated concentrations of iron, manganese, total petroleum hydrocarbons (TPH; principally oil constituents), and total dissolved solids (TDS; principally bicarbonate) in treated effluent. Treatment is accomplished by aeration, pH adjustment, coagulation and segregation of precipitated iron, manganese, and carbonate byproducts, and by mechanical filtration, carbon polishing, and discharge of effluent to percolation galleries. Insufficient solids removal and low regulatory-prescribed discharge limits required deletion of a soluble air-floatation (SAF) unit from the original treatment train. Instead, precipitated solids are allowed to settle and are pumped from the bottom of the reactor vessels to filtered containment bins. Solids are hauled offsite bi-annually for disposal at a lined solid waste landfill. Since biodegradation of wastes often produces reduced conditions in leachate and groundwater, this relatively inexpensive treatment approach may be applicable at other sites where elevated iron, manganese, bicarbonate, and TPH conditions exist.

Application of GIS Based Logistic Regression for Debris Flow Susceptibility Mapping in the Great Smoky Mountains National Park, TN

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The West Prong Little Pigeon River (WPLPR) watershed is one of the most frequently visited areas in Great Smoky Mountains National Park (GSMNP). The park is known for rainfall-induced landslides that usually start on steep hillslopes as rock slides and transform to debris flows with addition of water. The objective of this study was to produce digital maps identifying potential debris flow prone areas in the WPLPR watershed. Debris flow locations were identified from interpretation of aerial photographs, Light Detection and Ranging (Lidar), and field surveys. Topographical, geological, hydrological, structural, and satellite image data were collected, processed, and constructed into a spatial database using ArcGIS. The landslide inventory map was then used as a calibration tool for a GIS-based logistic regression model to predict debris flow susceptibility of the area. Out of eighteen initial factors, this model retained eight statistically significant factors including bedrock geology, soil thickness, soil type, slope angle, slope curvature, flow accumulation, proximity to the ridge, and annual average rainfall. Each factor's weight was determined by the back-propagation training method, debris flow susceptibility indices were calculated, and the susceptibility map was generated. The area under the curve method was used to validate the results with 82.7% accuracy. This study will provide a better understanding and awareness about the risk associated with debris flow occurrence and susceptibility in GSMNP, thereby aiding visitors in avoiding high risk areas, helping park personnel to make appropriate mitigation choices, and providing future research in the park.

Geologic Risk and Underground Construction

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Population increase means mega-cities will be growing very fast as "compact cities" for which surface space becomes a priority and for which underground space will become increasingly important. This creates a particular urgency to make the underground space of the future cheaper to construct and reliable in construction and operational performance. The cost and performance of underground projects is intimately linked to the understanding and management of geologic risk for both construction and life-cycle performance of subsurface facilities. This includes "normal" uncertainties, but also the expectation that urban growth will extend into increasingly fragile and poor geotechnical environments, and that the projects will involve larger and deeper openings. This paper develops a geologic framework to assess the state-of-practice and future possibilities for improved management of geologic risk, including risk avoidance, new materials and methods, ground improvement, life cycle engineering for sustainability, and better subsurface characterization. Some geologic risks have plagued for centuries, e.g., ground water, shallow cover and weathered rock, subsidence and impact on structures, stresses and stress relief, progressive deterioration. And new risks have arisen associated with new technologies including stickiness and abrasivity, unexpected stress-driven ground behavior, and design for higher water inflows and pressures, increased depth, and variety of excavated shapes. In addition, a better understanding of the spatial variability of rock structure is needed a priori, including application of geophysical and remote sensing techniques. Our site investigations of the future need to be increasingly confirmatory rather than exploratory.

Seepage Investigation and Remedial Grouting, Crafton Hills Reservoir Dam, California

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The original Crafton Hills Reservoir Dam was constructed by the California Department of Water Resources (DWR) between 1999 and 2002. The dam is a 500-foot-long, 95-foot-tall zoned earthen embankment dam with a single row, 50-foot-deep cement grout curtain. About ten days after first filling, seepage was observed on the ground surface at the groin of the downstream left abutment. This seepage, primarily attributed to ungrouted bedrock discontinuities, appeared to concentrate along the margin of a prominent dike in the foliated granitic bedrock. Seepage rates slowly decreased within about two months without the need for remediation. A second dam in an adjacent drainage was constructed by DWR between 2012 and 2014 to increase reservoir capacity. The second dam is a 540-foot-long, 75-foot-tall zoned earthen embankment dam with a dual row, 60-foot-deep high-mobility grout curtain. Within a week of refilling, seepage appeared again in the left groin area of the original dam. Within a month of refilling, new seepage locations were observed on the downstream right side of the original dam. The new seepage areas were coincident with another prominent sub-vertical, moderately- to highly-fractured dike that was mapped across the channel connecting the two reservoirs, through the right abutment of the original dam, and continuing downstream from the original dam. Under the assumption that the through-going dike was either a conduit of higher permeability or acting to focus groundwater flow along the dike, DWR conducted an extensive subsurface investigation to determine the preferential seepage pathway. The results of the investigation were used to develop a remedial high-mobility grouting program aimed to significantly reduce the seepage emanating from the right abutment of the original dam. This presentation will discuss the results of the investigation, how the exploration data shaped the design of the remedial grouting program, and the results of the high-mobility grouting.

Bolivar Dam Grout Curtain Construction

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During flood events, Bolivar Dam, OH, experiences excessive seepage through a network of open joints within the bedrock abutment. This seepage could erode/scour the dam embankment at the bedrock contact, potentially leading to dam failure. To lower this potential risk of dam failure, a grout curtain was constructed in the left abutment. This grout curtain is designed to impede groundwater seepage, resulting in reduced groundwater velocity/energy downstream of the grout curtain, thereby decreasing its potential to scour or transport the embankment material. The double-line grout curtain is approximately 65í deep and 400í long and was completed in November 2015. Two thin limestone units that were encountered proved to be problematic and posed various challenges during construction. This presentation will cover the risk-informed decisions that were made during both design and construction of the grout curtain and will include various lessons that were learned during this process. We will illustrate both the successful and not-so-successful decisions that were made to: estimate bid quantities, respond to excessive grout takes, manage data and establish grout curtain closure criteria.

Sorption Coupled with Enhanced Biodegradation to Treat Petroleum and Chlorinated Contaminants in Groundwater

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Enhanced biodegradation and monitored natural attenuation (MNA) are effective, widely-used tools for elimination of organic contaminants in groundwater. However, the timeframe for treatment by these methods can be on the order of months to years. To significantly improve remediation performance beyond that of traditional enhanced bioremediation, a new in situ colloidal biomatrix has been developed that accelerates biodegradation and drastically shortens the timeframes for reaching groundwater treatment goals. This presentation demonstrates the efficacy of a colloidal in situ remediation agent that consists of highly sorptive activated carbon particles (1–2 microns in size) stabilized to transport widely through an aquifer upon injection. The stabilized colloids deposit on soil surfaces, forming a biomatrix that traps contaminants and accelerates their degradation. Some advantages of this approach include a rapid drop in groundwater concentrations, along with the ability to stop plume migration and protect sensitive property boundaries or environmental receptors. The presentation will review the performance of the colloidal biomatrix material on multiple field sites with varying contaminants and site conditions. Data will be presented from both the source and down-gradient plume area at a former leaking underground storage tank near a school. The direct-push application was a combined remedy that coupled the colloidal biomatrix with oxygen delivery to promote aerobic biodegradation. The presentation will provide pre- and post-application soil cores to demonstrate zone of influence as well as groundwater monitoring to show >99% contaminant reductions within three months of application. A second site will discussed that shows contaminant reduction >99% for TCA and TCE.

Revisiting the Sediment Management Plan for Mount St. Helens in Response to a Basin Impacted by a Volcanic Eruption

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Thirty-five years post-eruption, continued erosion of the debris avalanche at Mount St. Helens continues to supply problematic quantities of sediment to the Toutle-Cowlitz River system, with the potential to increase flood risks to downstream communities. The U.S. Army Corps of Engineers (USACE) has recently revised its long-term sediment management plan (originally published in 1985), with the objective of continuing to provide authorized levels of flood protection for the communities in the Lower Cowlitz River. Development of a revised sediment management plan required a complete and objective alternative analysis as well as developing complete understanding of the existing system. Uncertainty concerning future trends in annual sediment yields dictates that the new strategy must have high adaptive capacity while cost effectiveness requires avoiding actions that later prove unnecessary. The preferred alternative allows for uncertainty based on annual monitoring of flood risks and sediment dynamics and phased implementation of selected sediment management measures only if, and when, they become necessary. The revised plan makes best use of potential to enhance sediment trapping and storage capacity at the existing Sediment Retention Structure (SRS) by incrementally raising its spillway and building up the gradient of the sediment plain upstream of the SRS using river training structures. Dredging the Lower Cowlitz River is held in reserve, to be performed only when necessary to react to unexpectedly high sediment events. In appraising options and selecting measures to be included in the revised plan, a robust monitoring effort has been outlined to assist in making appropriate decisions for plan execution. The over-riding message is that monitoring and adaptive management are crucial components of long-term disaster management, especially in volcanic landscapes where future sediment yields are characterized by uncertainty and natural variability.

Rockfall Hazard Assessment along Interstate 90, Keechelus Lake, Washington

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The Snoqualmie Pass rockfall hazard assessment area is a roughly º mile section of Interstate 90 located in the Snoqualmie Pass area of the High Cascades of Washington State along the shoreline of Lake Keechelus. The subject area involves the replacement of a 500 foot snowshed built in 1950 with two 1,200-foot-long avalanche bridges, one bridge for east-bound traffic and one bridge for west-bound traffic. Each bridge will accommodate three lanes of traffic. The bridges will span active avalanche chutes that allow future avalanche events to pass beneath the road deck. The project is part of a much larger 15-mile corridor improvement project from Snoqualmie Pass to the Easton vicinity aimed at improving driver safety and reliability while reducing traffic congestion, and avalanche closures in the winter. The overall purpose of the rockfall hazard analysis was to evaluate the potential for rockfall to impact the avalanche bridge structure. Parameters used in the rockfall models such as source areas, surface roughness, block size, and coefficients of restitution were based off of field observations made during the field investigation. The initial rockfall models were developed using “as-designed” configurations and USGS topography. Following the construction of the rock slope cut, the cut slope geometries were updated using terrestrial Lidar data and additional analyses were performed to evaluate potential changes in the rockfall trajectories and energies due to differences between “as-constructed” and “as-designed” slopes. A rockfall event that occurred during construction provided the opportunity to evaluate the model input assumptions and calibrate the parameters used through back-analysis. This presentation will illustrate the evolution of the rockfall model, the challenges with back-analyses of the rockfall event, and the differences between the as-constructed sections with both the assumed and calibrated restitution coefficients.

Impact of Organic Clay and Peat Deposits on Design and Construction of a Dike within the Prado Dam Flood Control Basin

Orozco, Arturo; Chitwood, Douglas U.S. Army Corps of Engineers Los Angeles District, Mark McLarty, mark.w.mclarty@usace.army.mil; Scott Kerwin (Presented by Mark McLarty) (TS #1)

The California Institute for Women (CIW) Dike is situated within the Prado Basin approximately four miles upstream of the main embankment of Prado Dam. The basin encompasses roughly 6,600 acres and is capable of impounding 314,400 acre feet. The dike provides flood protection for the California Department of Corrections and Rehabilitation CIW facility initially designed to house roughly 1,398 inmates. The CIW Dike is the fourth of six interior structures designed to protect development subject to flooding as a consequence of the raising of the Prado spillway 20 feet. The occurrence of peat and organic soils is unusual in that the Prado Basin is characterized by coalescing alluvial fans comprised of sands, gravels and silts derived from the Santa Ana Mountains to the south and the San Gabriel Mountains to the north. Southern California peat and organic soil deposits are typically associated with coastal estuaries or where fault barriers and artesian groundwater levels create marshy conditions but are rarely associated with alluvia fans in a relatively arid environment. The presence of organic soil and peat deposits beneath the CIW North Dike was initially recognized during the geotechnical investigation of the foundation soils. As a consequence, the embankments and associated interior drainage facilities were designed to accommodate significant settlement. However, the full character of the deposits, the presence of extensive vertical fissuring and significant lateral ground displacements, were not appreciated until exposed in construction excavations. This presentation will provide a relatively detailed discussion of the history of deposition and subsequent climatic changes thought to be associated with fissuring and lateral deformation.

Emergency Rockfall Slope Assessment and Remediation - US-52, Lawrence County, Ohio

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During the early morning of April 10, 2015, more than 2,000 tons of rock debris was generated from a single event within Lawrence County, Ohio. The vast majority of the debris was generated by a single 20 ft. x 20 ft. x 50 ft. sandstone block, which landed within the westbound lanes of US-52 closing the section to traffic. Immediate response by ODOT was a combined effort using ODOT forces and a contractor to remove the debris to re-open the roadway in under three days. Based in initial evaluations a 2-mile-long study corridor was established to determine risk levels within the rock area and adjacent areas. HDR performed preliminary detailed slope evaluations of the existing cuts and natural slopes along US-52, and identified very high-risk sites that required immediate attention. Emergency plans were developed to perform emergency remediation, including construction of rock fill berm, backstowing, of mine openings, mortar buttress for sandstone bluff support, reinforced earth wall for catchment, as well as slope scaling and trim blasting. The presentation will discuss the history of rockfall events in the area, geologic concerns, emergency remediation approach, and construction of key remediation measures.

Tehachapi Double-Track Project UPRR, Mojave Sub - Rock Slope Design and Construction

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The Union Pacific Railroad (UPRR) and BNSF Railway (BNSF) have identified several segments along the railroad corridor between Tehachapi and Bakersfield, Kern County in California that require construction of a second track to improve operations in this area. The total project proposes an upgrade of five segments along the Tehachapi-Bakersfield route. The authors focused on two segments: Walong to Marcel and Cliff Siding Extension. The second track project comprised design of a through-cut adjacent to an existing tunnel and up to 120-feet-high side-hill cuts (both in granitic rock). The authors characterized the geologic ground conditions and ground behavior, including rock mass quality and strength using a combination of rock core drilling and rock slope mapping. The rock mass is generally characterized as granitic tonalite with strong core stones surrounded by a matrix of decomposed granite (DG). The rock data was used to establish allowable slope excavation geometries and rockfall catchment ditches. Discontinuity orientations were plotted on stereonets using standard geotechnical software. Markland analysis was performed to establish potential kinematic failure mechanisms and designs for the proposed rockslopes. Removal of the existing ground required heavy ripping and blast-excavation depending on the ground conditions. The authors developed detailed blasting specifications, outlining performance criteria for the blasting contractor to include maintaining ground vibrations as peak particle velocity at <4 in/sec at the rail, control of muck pile and fly rock. During construction the authors provided construction observation of the rockslopes and blasting quality assurance for UPRR. During excavation, a wedge type rockslide occurred in the Walong through-cut, necessitating on-site redesign of the rockslope geometry including installation of rock anchors. Blasting QA included review of blast designs, on-site observation and post blast reviews.

Community Based Early Warning System at Kelut Volcano: A Success Story to Manage Huge 2014 Eruption

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Kelud Volcano is an active volcano in Indonesia. About 150 million meter cubic were erupted on 13 February 2013 at 22.30. People were successfully responded the biggest eruption in history without any fatalities, by doing less than two hours evacuation, from 21.15 to 22.50. Analysis on building community resiliency process showed that four aspects of the early warning system have been successfully fulfilled by local authorities and the villagers. Those four aspects are: (1) Knowledge of risk, (2) monitoring and warning service, (3) dissemination and communication, (4) ability of the people to response. Systematic data collection and risk assessment, with its pattern and tendency factors ensured that disaster and vulnerability are well known. In community level, risk assessment and disaster introduction with its factors has been introduced since 2008. Monitoring parameter, strong basic and scientific to create accurate and timely preestimation has been ensured by disaster monitoring and early warning service. In national authority level, Volcano Observatory implemented dissemination. Spatial dissemination and status change dissemination, which are offered in Disaster-Prone Area Map. Communicating information and early warning ensured that the alert can be received by everyone that may be affected by disaster/risk, and its warning can be understood and useful. A good information system will come from one source through specifically prepared channel. Short communication order from Kelud Volcano Observatory to people was ensured to be received as unbiased. Establishing the people's response to ensure the response alone must be renewed, ability and local knowledge can be utilized, and people are ready to response warning. Simulation and training activities were implemented by the people within disaster-prone area. Finally, the powerful of community preparedness may manage the huge level of volcano eruption.

Assessment of Fill Time and Potential Interbasin Transfer of Water for Proposed Reservoirs in George County Mississippi

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The George County Reservoir Lake Project in Mississippi is moving into an Environmental Impact Statement (EIS) phase. The reservoir is proposed in order to maintain flow and ecology of the southern portion of the Pascagoula River and public recreation as a secondary use. Possible reservoir sites include basins of both the Big Cedar Creek and the Little Cedar Creek. The purpose of this study is to determine the rate the reservoir would fill and reach saturation levels in the strata adjacent to the reservoir. Prior investigations established a lower clay layer overlain by a porous sand. This analysis will further determine if the reservoir saturation could cause the ground water to move into adjacent basins. The primary method to determine the fill rate and potential transfer of water to another basin through the groundwater system is a numerical model. The geologic model for developing the numerical model consists of a high permeability unconfined sandy aquifer atop a low-permeability clay. The proposed reservoirs are superimposed within the unconfined sandy aquifer. Water levels from piezometers placed in the unconfined aquifer between the two drainage basins are utilized to determine water table fluctuations in the unconfined aquifer.

Folsom Cofferdam Seepage Incident

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A large seepage incident occurred at the temporary construction cofferdam at the Folsom Auxiliary Spillway Control Structure Project in Folsom, CA. Due to record low lake levels, this new cofferdam was a contractor-de- signed feature built upstream of the concrete control structure in order to finish more approach channel work in the dry. The cofferdam was constructed of embankment fill and founded on riprap and native highly weathered, or better, quartz diorite. The critical flaw was in the embankment fill being placed directly against the riprap with only a PVC liner on the upstream side to "control seepage." Due to concerns over the dam's performance during seepage and internal erosion, USACE and the Contractor formulated an emergency response and monitoring plan. The reservoir began to encroach on the cofferdam on December 23rd, 2015, and the first signs of cloudy seepage were observed coming from the left abutment on January 7th, 2016. An effective seepage berm was placed at that time. On January 20th, as a result of excavation activities in the area, a "large blowout" of sediment-laden seepage occurred at the left abutment, the formation of a failure scarp on the upstream left side, and cracks along the dam crest arose. The approach channel was evacuated precipitously and a large seepage and stability berm was constructed. Over the next six days, a more extensive monitoring program was implemented and plans were developed to finish critical work in the approach channel. By January 26th, all critical work was complete in the approach channel and the cofferdam was intentionally breached on January 28th.

Construction of Two Secant-Pile Seepage Cutoff Walls at the Folsom Auxiliary Spillway Project

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Two secant-pile seepage cutoff walls were constructed at the Folsom Auxiliary Spillway Control Structure Project in Folsom, CA. One wall was a permanent feature in the right abutment of the control structure, and the second wall was a temporary feature constructed in the government designed cofferdam. The permanent wall was constructed of slag-cement-bentonite and is intended to provide seepage reduction between the control structure and the right abutment. The control structure is a new reinforced concrete gravity spillway that is approximately 120 feet tall with a crest length of approximately 337 feet. A notch was blocked out in the far right monolith of the control structure for the secant wall to tie into. The permanent wall has a length of approximately 80 feet with a maximum depth of 40 feet, and the bottom criteria was three feet into moderately weathered quartz diorite. The temporary wall was constructed of concrete and provided a seepage cutoff for the cofferdam which was mostly comprised of rockfill. The temporary wall had a length of approximately 2,000 feet with a maximum depth of 107 feet, and the bottom criteria was five feet into highly weathered quartz diorite. Unweathered core-stones within the rock mass presented many challenges in achieving the design depths for the temporary wall. Details are provided on the excavation and placement of the walls and difficulties observed during construction. The completed temporary concrete wall was excavated during the removal of the cofferdam, and field observations provided some interesting information on how well the wall was constructed.

Geophysical Methods for Screening and Investigating Utility Waste Landfill Sites in Karst Terrain

Pendergrass, Gary, GeoEngineers, Inc., gpendergrass@geoengineers.com (TS #12)

With the existing utility waste landfill (UWL) approaching capacity, City Utilities of Springfield, Missouri needed to locate and develop additional landfill space at its John Twitty Energy Center (JTEC). GeoEngineers, Inc. conducted a detailed screening of the entire 800-acre site to characterize karst features and identify suitable prospective landfill sites. Geophysical surveys utilizing parallel Electrical Resistivity Tomography (ERT) traverses (100-foot spacing) and Multi-channel Analysis of Surface Waves (MASW) soundings (400-foot grid) were conducted and complemented by site reconnaissance, confirmatory drilling, and downhole video. The screening program successfully delineated depth to bedrock, the nature and extent of the karst system beneath the site, and the mode of shallow groundwater movement. Two sites were identified which provided the best opportunities for cost-effective landfill development. A preferred site was selected, and a more detailed geophysical investigation conducted which utilized parallel ERT traverses on a 20-foot spacing and MASW soundings on a 200-foot grid. The closer ERT spacing allowed processing of 3D imagery, which was utilized to 1) develop a conceptual landfill model, 2) design a more detailed drilling program, and 3) site groundwater monitoring wells which would effectively monitor groundwater in karst beneath the landfill. All geophysical and drilling data were input to a comprehensive 3D GIS model for use in public presentations and meetings.

CCR Rule: Geophysical Techniques to Certify Utility Waste Landfill Stability and Groundwater Monitoring in Karst

Pendergrass, Gary, GeoEngineers, Inc., gpendergrass@geoengineers.com (TS #12)

This technical presentation will detail geological and engineering support being provided to City Utilities of Springfield, Missouri by GeoEngineers, Inc. for complying with the U.S. Environmental Protection Agency's Coal Combustion Residuals (CCR) Rule. City Utilities operates two coal-fired power plants (John Twitty Energy Center and James River Power Station) in the Springfield area. The presentation will specifically address innovative geophysical techniques being employed at each power plant, including Electrical Resistivity Tomography (ERT) and Multi-Channel Analysis of Surface Waves (MASW), to certify utility waste landfill (UWL) stability in karst (40 CFR 257.64) and to site groundwater monitoring wells in karst (40 CFR 257.91). The primary concern for UWL stability in a karst setting is the formation of a sinkhole beneath the landfill which could potentially compromise landfill liner integrity. The geophysical techniques employed on this project allowed detailed three-dimensional imaging of the fill material and foundation material. The geophysical techniques were also utilized to delineate solution-widened bedrock joints and highly fractured bedrock in the vicinity of the UWLs to optimize siting of groundwater monitoring wells.

Geotechnical Investigation for the Northeast Interceptor Sewer (NEIS) Phase 2A Project at the Hollywood Fault crossing in the Los Feliz District of Los Angeles, California

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NEIS 2A is a major capital improvement project under design by the LADPW Bureau of Engineering (LABOE), Wastewater Conveyance Engineering Division (WCED). NEIS 2A will consist of a 4-mile-long sewer tunnel beneath the southeastern edge of the San Fernando Valley. The sewer is planned to be installed by tunneling using an Earth Pressure Balance or Slurry machine at depths of approximately 100-140 feet below ground surface. A short reach of the planned tunnel alignment will cross the active Hollywood Fault near Los Feliz. Geotechnical explorations were performed from 2008-2013 to characterize the subsurface conditions in the fault zone. Amec Foster Wheeler executed phased geotechnical investigations, with associated work by URS and the City Standards Division, under direction of the LADPW GEO. This consisted of a series of seismic transects, core-borings, CPTs, and monitoring wells. In-situ testing consisted of a combination of down-hole geophysics, hydraulic conductivity, pressuremeter, groundwater, and gas sample tests. Eight faults will be crossed in the fault zone during tunneling based on data from the exploratory borings and the seismic lines. Two of the faults were identified as probable main strands of the Hollywood Fault and considered more significant for planned tunneling. The northern strand juxtaposed a wedge of older (Pleistocene) alluvium overlying sheared granodiorite against sedimentary bedrock of the Modelo/Monterey Formation. Key geotechnical findings for the NEIS 2A investigation will be presented with respect to the location of concealed fault traces of the Hollywood Fault and the geotechnical characterization of the fault zone.

Navajo Nation Environmental Response Trust, Assessment of Abandoned Uranium Mines (AUMs)

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Extensive uranium mining was conducted for nuclear weapons and energy production across the Navajo Nation post-World War II. Hundreds of small mining claims were developed and produced a network of disconnected mine features including haul roads, open pits, waste piles, and portals and adits from both surface and underground workings. Following cessation of mining, some mines underwent various phases of reclamation while others were left abandoned. This multi-year project focuses on characterization of 16 abandoned uranium mines (AUMs) deemed priority mines by U.S. EPA and collaborating agencies due to elevated radiation levels near potentially inhabited structures. The Navajo Nation Environmental Response Trust (the Trust) was established to manage and execute the work. The Trust manages the project funds, selects contractors to perform the work, and coordinates with a group of Navajo and U.S. regulatory agencies, which provide oversight. The first phase of work involved a series of surveys including: a cultural survey for historic or archeological sites at the AUMs; biological surveys including habitat assessments and species-specific surveys to identify threatened or endangered plants and animals; mapping historic mine or reclamation features, mine structures, and drainages, and; preliminary radiological scans in locations proposed as background sample areas. Future work will include further site characterization activities, soil and well sampling, and pedestrian and unmanned aerial vehicle (UAV) radiological surveys. The results of these surveys will be used to evaluate mine closure and reclamation alternatives.

Precipitation Intensity Required for Landslide Initiation in Rwanda

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Rwanda has a high density of landslides, heavy precipitation events and a shortage of resources to study them, making it an excellent candidate for study using satellite-based remote sensing data. To assess landslide hazards countrywide, I first built a landslide inventory of 254 landslides and used a statistical methodology. Using logistic regression on 24 test variables, I determined that slope and population density are statistically most relevant to landslide occurrence in Rwanda. A preliminary predictive hazard map for Rwanda was produced, with an overall predictive accuracy of 79.6%. Second, I worked to define a relationship between precipitation intensity and landslide density for a landslide-prone study area in western Rwanda. In the 1,180-km^2 study area, I mapped 577 landslides, using CNES/Astrium and WorldView satellite imagery in Google Earth over a study period of 2000 to 2015. One 400-km^2 part of the study area has a high landslide density of 1.4 landslides/km^2, while another 780-km^2 part with identical geology, soils, land-use, and vegetation has a much lower landslide density. To identify possible triggering events for these landslides, I analyzed a 16-year record of TRMM (Tropical Rainfall Measuring Mission) satellite precipitation data. The high landslide density region and the low landslide density region were not notably different in rainfall, as quantified by recurrence interval analysis. A relationship between precipitation and landslide density could therefore not be developed, and the null hypothesis cannot be ruled out. This apparent lack of connection could result from a variety of factors including TRMM grid size, satellite imagery temporal resolution, antecedent soil moisture, or vegetation regrowth rates.

National Shoreline Management Study: An Overview of the Impacts of Shoreline Change in Hawai‘i

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The U.S. Army Corps of Engineers, Institute of Water Resources has initiated the completion of a National Shoreline Management Study (NSMS) to report to Congress on the state of the shorelines of the United States. This Hawai‘i focused portion of the study is an opportunity to highlight unique shoreline management challenges facing Hawai‘i by exploring existing datasets, reviewing previously completed studies, and speaking with coastal managers. The report will include findings on federal and non-federal participation in shoreline management with the potential to impact policy and funding decisions at national level. The objectives of the study include identifying erosion and accretion and their causes and effects upon shorelines; economic implications of shoreline change; environmental implications of shoreline change; agency roles in restoring and renourishing shorelines; and systematic movement of sand and other sediments. In Hawai‘i, some of the major issues facing shoreline management are the limited supply and high cost of beach quality sand for nourishment, infrastructure and population centers along a narrow coastal plain with limited space for retreat, logistical and funding challenges of beneficial use of dredge material, increasing erosion and flooding due to sea level rise, and a unique environmental habitat that is often at odds with accelerating development along the coastline. This paper will discuss the findings of the study, giving an overview of the current state of shorelines in the Hawai‘ian Islands (including case studies), the existing data gaps and recommendations for future shoreline management actions for both Federal and non-Federal partners.

Localized Differential Foundation Movement within the Willow Glen area of the Santa Clara Valley, California

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Over the past three decades we have studied hundreds of dwellings throughout the Willow Glen neighborhood of San Jose, CA, that have been damaged by localized differential foundation movement. The localized ground deformation can occur over isolated areas on a single property or affect several blocks. Damage manifests as tilting of buildings and undulating streets and sidewalks, which were presumably built level. We are not aware of any studies that have conclusively determined the cause of localized ground deformation. Based upon our observations, ground deformation seems related to decomposition and chemical/physical changes in soil that was deposited and buried in a former alluvial valley and flood plain. Willow Glen is within the Santa Clara Valley, a fault bound basin filled with several hundred feet of alluvium between the Santa Cruz and Diablo Mountain Ranges. A combination of shrinking and swelling of expansive soil; shallow soil structure deformation; and differential drying of deformable soil processes may be occurring within the shallow alluvium. The depth of soil subject to

deformation appears to be confined to the upper, silty and clayey layers that persist to depths of between 20 and 35 feet. Underlying the deformable fine-grained soil layers are coarser-grained alluvial deposits that do not appear to be as susceptible to deformation. Given the presence of variable and deformable alluvium, the risk for differential foundation movement can be mitigated, but not eliminated. A risk for deeper-seated deformation is possible due to groundwater extraction. Complicating matters, the modest structures built during the 1930–50s are being replaced and enlarged with high-end finishing, making differential movement more problematic. This paper will illustrate examples of distress arising from localized ground deformation and measures that have been enacted to mitigate the potential for future distress, including a project where mitigation measures were unsuccessful.

Potential Hazards Area by Pyroclastic Flow after Merapi Volcano Eruption in 2010, Central Java, Indonesia

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The main task of mitigating the natural disasters by the eruption of Mount Merapi is to minimize fatalities due to the impact of the eruption, either directly or indirectly after the eruption in 2010. Modeling pyroclastic flows may serve as a powerful tool in the disaster mitigation program for the Merapi Center for Volcanology and Geological Hazards Mitigation (CVGHM). Commonly the activity at Merapi is observed by the growth of the dome. Once the dome collapses or explosion takes place, the pyroclastic density currents rush out from the crater. The peak of dome growth and small collapse activity, with volcanic explosivity index (EVI) of 1–3, occurs at a frequency of 1–5 years. Large eruption is at a circle period of 100 year. The recent violent eruption of Merai took place in 2010, where the summit part of Merapi left the major amphitheater with an open to south-southeast (SSE) slopes, letting the pyroclastic and lava directly merge into Gendol river. Since the valley path goes through the populated part (~1 Mio pop.) of the district Yogyakarta, the anticipated pyroclastic flows might bring this region into severe disaster. The employed model for numerical simulation is a depth-averaged model over general topography, where variant scenarios are designed based on past events. The topographic data is based on a Lidar Digital Elevation Model (DEM) analyzed from the RADARSAT imagery data by means of image fusion method with precision of 4 meter. The simulation results show that the pyroclastic mainly flows down the western and southern slopes of Mount Merapi. With small collapse the sliding distance ranges from 2–6 km, and the maximum traveling distance reaches to 12–15 km for large eruption.

What Happened to the "Big One" on the Southern San Andreas Fault? A System-Level Perspective of Seismic Hazard

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For >30 years, earthquake scientists have suggested that the southernmost San Andreas fault (SAF) is overdue for a large earthquake, as it has been 300 years since the last large rupture and the average recurrence interval is 150–200 years for the past 1,100 years. This assertion is supported by GPS and InSAR strain rate measurements, which indicate 20-25 mm/yr of strain accumulation, similar to geologic slip rate estimates. What happened? If the SAF was that close to failure 30 years ago, why hasn't it failed? Compilation of paleoseismic work conducted over the past 30 years on virtually every fault in the southern 160 km of the plate boundary shows that strain release has been episodic, with periods of lesser and greater earthquake activity. Displacement data have been generated for most of these faults for the past one to several events. Using these observations on timing and displacement in past large earthquakes, and assuming reasonable seismogenic thicknesses, estimates of moment release through time can be made. Based on these estimates, at least three generalizations are clear: 1) M7 and larger earthquakes account for most of the moment release in the southern San Andreas fault system over the past 1,100 years; 2) large earthquakes on individual faults are quasi-periodic but display a relatively high coefficient of variation in recurrence time, similar to most long California records; and 3) moment release has temporally varied during the past 1,100 years but within potentially predictable bounds. Together, the record suggests that the southern San Andreas fault is late in the cycle but not necessarily "overdue," and that a systems level approach may be more accurate in long-term earthquake forecasting than data generated from a single element of the fault system.

Construction of the Red Hill Fuel Storage Tanks at Pearl Harbor

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When the U.S. Pacific Fleet's homeport was moved from Long Beach to Pearl Harbor in January 1940, all of the bunker oil was stored in unprotected above-ground storage tanks at Pearl Harbor. Feeling that these were vulnerable to attack, the Navy's Bureau of Yards & Docks immediately set about engineering below-ground storage chambers for 6 million barrels of oil, kerosene, and gasoline. Engineer James P. Growden of Alcoa Aluminum was brought in as the senior consultant. Within a few months Growden developed a novel scheme employing large vertical chambers instead of horizontal tunnels. These would be the largest underground openings in the world: 20 cylindrical chambers 100 feet diameter and 250 feet high, spaced 200 feet apart in two parallel rows. The chambers were lined with prestressed reinforced concrete and continuous steel linings. The minimum rock cover was to be 100 feet above the crown of each chamber and the project remained classified during the Second World War. Finding a suitable site was problematic because Oahu is underlain by the Koolau Volcanic series, which is perturbed by vugs, clinker, underground streams, and pools. The Navy's design team finally settled on Red Hill, about two miles from Pearl Harbor, as it was mostly homogeneous basalt. Construction began on Christmas 1940, a year before the surprise attack on Pearl Harbor. The Red Hill project received the highest wartime construction priority, and work continued around-the clock for almost three years. Despite many precautions, 16 men died during construction, and the project was declared complete in September 1943, at a final cost of $42 million. The interconnected network of tunnels also provides 30 million gallons per day of drinking water to the surrounding area.

Salvage of the Capsized Battleship Oklahoma Following the Attack on Pearl Harbor

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The battleship USS Oklahoma was built at Camden, New Jersey in 1914–16. She was 583 feet long with a maximum beam of 95 feet and a maximum displacement of 27,500 tons. During the surprise attack on Pearl Harbor in December 1941, The Oklahoma was struck by nine torpedoes—more than any other vessel. The ship had her bilge covers removed for an inspection the following day, which precluded counter-flooding to prevent her capsizing, which trapped 447 men inside the vessel (32 of these were rescued in the days following the attack). Pacific Bridge Company of San Francisco was retained to salvage the Oklahoma to mitigate the obstruction to navigation. A scheme was developed to flip the capsized hull and re-float the vessel, without realizing the extent of the hull damage. 21 power winches with compound pulleys were anchored on Ford Island using tiebacks. Each of these were equipped with 600 tons capacity, using variable-voltage drives and employing 1-inch steel cable on the winches. General Electric supplied the variable-voltage electric drive winches, spaced 17 feet apart. Each winch was deigned to pull 72,000 lbs. one foot per minute, allowing an aggregate pull capacity of 13,000 tons. During a 74-day period between March–May 1943, the ship was overturned to within 18 degrees of level. In order to refloating of the sunken hull, the hull leaks had to be patched and the gaping torpedo holes covered with cofferdam patches. 1,848 dives were made to stuff kapok into gaps between hull plates as water was pumped from hull. The ship was eventually re-floated using twenty 10,000 gallon per minute pumps during an 11-hour period on November 3, 1943. She was placed in drydock in January 1944 for temporary repairs to make her seaworthy for towage to the United States. The hulk was sold for scrap after the war and foundered about 125 miles northeast of Oahu, in July 1946.

Failure of the Alexander Dam Embankment on Kauai in 1930

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Alexander Dam is a hydraulic fill earth dam that was built in 1929-32 to provide irrigation for McBryde Sugar Co. Ltd. that operated on the south shore of Hawai'ian island of Kauai. It was constructed across Wahiawa Stream mauka of Kalaheo to store 800 million gallons of water to irrigate sugar cane fields. The embankment dam was intended to have a maximum height of 125-ft, length of 620-ft, and a maximum base thickness of 640-ft. The total design volume was 580,000 yds3, using hydraulic fill sluiced to the dam site. On March 23, 1930, a 60-ft-wide section of the core pool suddenly dropped ~30 feet and moved downstream, rapidly draining the pool and enlarging the mass. The embankment was at a height of 95-ft and 78% complete when the failure occurred. The failure occurred so quickly it killed six and injured two workmen on the downstream face. The volume of side debris was ~275,000 cubic yds. Thirty vertical feet of the embankment's clay core stood near-vertical after the failure, leading engineers to believe that the materials deposited in the downstream shell had consolidated and thereby failed to allow internal drainage. The embankment was rebuilt by emplacing a 40-ft-high rock buttress across the downstream toe; the downstream shell was widened; and tile drains were inserted to facilitate internal drainage. The retrofitted structure was completed in December 1932 and remains in service. The materials used in the original and rebuilt embankment consisted of fumarole ash from the south abutment and decomposed vesicular lava from the north abutment. The hydraulic fill consisted of "heavy earth, claylike in character and variable in color with red predominating…the fine grains and colloidal material form the core." This material presented two design problems. First, the available materials created an abundance of fine-grained material and a dearth of coarse-grained material for the shells underlying the slopes. Second, the saprolitic soils were disaggregated during excavation, hydraulic transport and surcharge, leading to a much lower hydraulic conductivity than the designers imagined possible beforehand.

Hardy Dam - How 100 Years of Old Dusty Records, Observations by Karl Terzaghi, and a Walk in the Woods Answered the Artesian Question

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Hardy Dam was built from 1929 to 1932 on a foundation of interlayered glacial outwash sands and clay tills on the Muskegon River of Michigan. The pre-construction exploration was extensive, even by today's standards, and benefited from on-site evaluations by Dr. Terzaghi. Artesian aquifers were recognized and documented prior to construction, with sheet piles driven through the upper aquifers to reduce seepage beneath the dam. Boils and springs emanating from the artesian aquifers were present prior to construction, and monitoring of spring flows started shortly after the end of construction. The high water pressures associated with the artesian aquifers are a factor in three Potential Failure Modes (PFM's) of the dam. Recent documentation of boils in the river downstream of the dam led to an in-depth file review and historical summary of the boils, seepage, and foundation geology of the site. One boil was found on the riverbank over one mile downstream of the reservoir. Hundreds of documents were used to develop the historical perspective needed to evaluate the occurrences of the springs and boils within the context of the naturally-occurring artesian conditions at the site. An impressive set of construction photographs provided evidence of pre-construction boils, location and condition of the original river channel, as well as a fascinating insight into how to build a 116-foot-high dam with steam shovels, mules, and manpower. A geotechnical evaluation of the potential for the boils to self-filter found that the fine fraction of the outwash sands washes away during the early life cycle of the boil. This leaves behind a coarse fraction that can develop an effective filter, thus reducing the potential loss of additional fines. The results of the evaluation are consistent with monitoring observations that boils initially carry fine particles, with water becoming clear and flow decreasing with time.

Rio Chama Landslide Mapping and Analysis and Evaluation of Regional Landslide Susceptibility, Archuleta County, Colorado

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Recent landslides, such as the West Salt Creek landslide in Colorado and the Oso landslide in Washington, have brought light to the need for more extensive landslide evaluations in order to prevent disasters. The goal of this project is to characterize and map the Rio Chama landslide, evaluate present and future conditions at failure, and apply these findings to create a regional susceptibility model for similar failures. The Rio Chama Landslide was a debris rotational slide and flow, which occurred between 1985 and 1987 near the headwaters of the Rio Chama River in south-central Colorado. Slide extents and failure dates were evaluated by reviewing local precipitation data and black and white and infrared photos from the National High Altitude Aerial Photography collection. Landslide features were mapped, and surficial samples of slide material were collected in 2015. Soil lab tests including grain size distributions and Atterberg limits characterized the material types and properties. Limit equilibrium analyses aided in estimating strength and groundwater conditions at failure. These conditions were applied to limit equilibrium analysis of the slide based on a range of ground and surface water levels. Sensitivity analyses were conducted to examine the sensitivity of the limit equilibrium analysis to fluctuations in different properties including groundwater level and shear strength, which were then applied to the development of a regional susceptibility model for similar failures. The regional model is intended to identify areas susceptible to similar failure, allowing appropriate preventative action to be taken.

Educating Building and Safety Officials in the Las Vegas Valley about Seismic Hazard

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The City of Las Vegas, Nevada, Department of Building and Safety asked the Southern Nevada Chapter of the AEG to organize a field trip to visit "earthquake faults" and discuss the seismic hazard in the Las Vegas Valley. AEG assembled a team of Nevada earthquake experts to make presentations, followed by a bus tour of Las Vegas Valley faults. Building and safety officials from the cities of Las Vegas, Henderson, Boulder City, and North Las Vegas, Clark County and Clark County School District, and Emergency Operations personnel from Las Vegas, all participated. The purpose was to educate emergency management personnel about the seismic risk and provide information to building and safety officials that could be used to educate real estate developers about the seismic hazard in the Las Vegas Valley. The 2008 magnitude 6.0 Wells, Nevada, earthquake, about 325 miles NE of Las Vegas, caused $10.5 million in damage. This was the largest earthquake in Nevada in 30 years. Las Vegas is in the same earthquake probability zone as Wells, with an estimated 12 percent chance of a magnitude 6.0 earthquake occurring within 50 years and 31 miles. It has been estimated that a magnitude 6.0 earthquake in Las Vegas could cause $11 billion in damage and nine fatalities. The bus tour stopped at several large fault scarps in the Las Vegas Valley. At an outcrop showing soft-sediment deformation, we discussed the occurrence and hazards of liquefaction. At the Whitney Mesa Fault, we pointed out a commendable example of the recommended practice of leaving setbacks along fault strands, i.e., open space and green belts. Feedback on the tour was that it produced a heightened awareness of the seismic hazard in the Las Vegas Valley.

Geologic Mapping Methodology for Borinquen Dam 1E Foundation, Panama Canal Expansion

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Borinquen Dam 1E is a zoned rockfill dam with an earthfill core, which forms part of the new Pacific Access Channel (PAC) that allows ships to navigate from the Gaillard Cut to the new Post-Panamax Pacific Locks. This 2.4-km-long dam is 210 m wide, 32 m high at the maximum section, and inclined 3:1 (H:V). Foundation excavations commenced in February 2011 and final embankment construction was completed in July 2015. Geologic mapping of the dam foundation was a collaborative effort between ACP and URS geologists. Field mapping included the use of GPS-enabled tablets and traditional foundation mapping methods. Fault investigations were undertaken at a number of locations where the excavation exposed faults and overlying alluvium. The mapping methods used to produce the dam foundation map varied between the dam core, inboard shell and outboard shell. A GIS specialist was part of the field team and worked closely with the geologists to develop a GIS model of the dam site. The geology underlying the dam is characterized by a Miocene sedimentary sequence of clay shale, tuffaceous sandstone and volcaniclastic agglomerate. A complex pattern of faulting was mapped along a generally north-south alignment, consistent with regional faulting. Age-dating of specific faults was undertaken to assess their activity. Landsliding occurred during foundation excavation at the outer edge of the inboard shell due to weak clay shale units and the unfavorable orientation of bedding plane shears associated with multiple fault splays. Geologic investigations, stability analyses and a remedial design were undertaken to modify the foundation excavation to remove unsuitable foundation material. This paper examines geologic data collection and processing methodologies used at Dam 1E; how the GIS-based foundation geology map was used during construction; and the implications of fault investigations on final dam design.

Spring Water Source Demonstration for Jackson Spring, Tishomingo Mississippi

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A study was conducted to determine if the same geologic formation exists below a water bottling facility and from which nearby Jackson Spring at Tishomingo, MS, issues. That facility purchases water from the owner of the spring for selling bottled spring water. The facility wants the capability to withdraw the spring water on site from a borehole. That can be done if the borehole is demonstrated to be in the same geologic formation from which the spring water flows. Subsequent to collecting and reviewing existing data, site visits were conducted to confirm locations of well data and to identify locations of mapped geologic units. The preliminary data indicated that the geologic unit from which Jackson Spring water issues would be present below the water bottling facility. Based upon that determination, a test boring was drilled at the bottling facility. The test boring confirmed that the geologic formation from which the spring water flows was present below the water bottling facility. The confirmation was based on the lithology from drilling of the test boring as well as laboratory analyses of water obtained from a well installed in the boring. That water analysis was compared to analyses from water issuing from the spring. Additionally, potential drawdown was predicted using this equation. The Calculations determined the drawdown for different scenarios using the end members of the published ranges of both transmissivity and storage coefficients. The predicted drawdowns did not reach the nearby Jackson Spring from any of the scenarios.

Modeling Reactivation Conditions for Cook Lake, Wyoming Landslide

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A 1997 landslide at Cook Lake, in northeastern Wyoming, lies directly across the lake from a U.S. Forest Service campsite. The scarp is 100 m above lake level and the toe extends into the lake, running roughly 300 m parallel to the shoreline. The campsite is temporarily closed until the stability of the slide can be determined. The 1997 slide plane geometry is unknown, though the Cretaceous Lakota Sandstone, the Jurassic Morrison Formation, and the Jurassic Redwater Shale are all observed in the scarp. Atterberg Limit and direct shear tests were performed on Morrison and Redwater shale samples to constrain the units' cohesion and internal angle of friction (phi). The Morrison was identified as an inorganic silt of low plasticity (ML), while the Redwater was identified as an inorganic clay of low plasticity (CL). The investigators created backward and forward models of three parallel transects using RocScience Slide to identify likely slide plane geometries and evaluate stability conditions. The backward model relies on prefailure topography, values of cohesion and phi similar to experimental values, and three approximated water table levels—“high,” “medium,” and “low”—to simulate pre-failure conditions. The preferred slide plane geometries yielded factors of safety (FS) near one and roughly followed regional dip. The forward model relies on modern topography and the same values of cohesion and phi identified in the backward model. Forward modeled failure planes are forced to exploit portions of the backward-identified failure plane. Forward modeling results indicate that the northern portion of the slide is relatively less stable than it was pre-failure, while the southern portion relatively more stable. The magnitude of relative FS change is not particularly sensitive to water table fluctuations in the forward model.

“Soft” Shore Protection Proposed at the Beacon’s Beach Landslide, Encinitas, California

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Beacon’s Beach is a popular public beach along the coastal bluffs of North San Diego County, California. Previous beach access stairways were damaged by landslide movement during El Nino storms in 1982–83. Since that time access to the beach is via a switchback trail leading down from a public parking lot at the bluff top. The landslide is approximately 400 ft. wide and encompasses virtually all of the 90-ft-high coastal bluff below the parking lot. The beach access trail has been repaired and rerouted many times to avoid minor slumps and steep hazardous slopes. The City of Encinitas is interested in providing long-term safe public beach access. A vertical seawall with tieback anchors and rebuilt slope was proposed previously; however the seawall was not implemented due to coastal policy changes. Since that time the landslide has progressed upslope with the steep scarp only few feet from the parking lot edge. A number of stabilization alternatives were considered in lieu of a seawall. Current design challenges include sea level rise, and beach impacts such as passive erosion. A “soft” shore protection approach is currently proposed using a buttress of erodible soil cement designed with similar strength as the natural sea cliff formation to replicate the natural erosion rate. Erodible soil cement would be less likely to act as a “hard” fixed structure; therefore the erodible buttress would potentially have reduced beach impacts. The proposed stabilization concept is currently under review by the California Coastal Commission.

Investigations of the Pedro Miguel Fault During Borinquen Dam 1E Construction, Panama Canal Expansion

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Borinquen Dam 1E is part of the new Pacific Access Channel (PAC), which provides navigation access from the Gaillard Cut to the new Post-Panamax Pacific Locks. The 2.3-km-long dam is a zoned rockfill dam 150 m wide and 30 m high at the crest, inclined at 3:1 (H:V). Excavations commenced February 2011. Final embankment construction was completed June 2015 and the PAC opened to navigation June 2016. Geologic mapping of the dam foundation and adjoining areas of the PAC was a collaborative effort between Autoridad del Canal de Panama and AECOM (formerly URS) geologists. A key geologic objective was to confirm locations and activity of faults mapped at the dam during design, namely the Pedro Miguel fault and its suspected newly mapped “main trace.” The design allowed for core and filter widening at the anticipated location of the Pedro Miguel fault at the south abutment and at a west branch of the Pedro Miguel fault (believed at the time to be to be the main active trace of the fault) mapped about one third of the way north along the dam axis. As-built geologic mapping revealed a complex pattern of faulting associated with the Pedro Miguel fault crossing the southeast half of the foundation, the PAC and the nearby Dam 1W foundation along a north-south trend. Trenching and age dating alluvium overlying faults crossing the Dam 1E foundation and overlying the Pedro Miguel fault at Dam 1W indicated the unbroken alluvium was latest Pleistocene to early Holocene age. Where significant faults cross Dam 1E, the core and filters were widened to accommodate potential fault rupture. The west branch (“main trace”) of the Pedro Miguel fault was determined to not exist based on mapping of the dam foundation and the extensive excavations in Miocene basalt that were created for the PAC.

Management Strategies for Naturally Occurring Asbestos During Construction in the Sierra Nevada Foothills of California

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After more than 25 years of experience with naturally occurring asbestos (NOA) in the Sierra Nevada Foothills of California, a variety of strategies have evolved to manage and mitigate the health risks. This has been done within an environment of changing understanding, including but not limited to the very definition of asbestos, increasing knowledge on the extent of asbestos in the natural environment, exposure pathways, mitigation methods, health and safety concerns, and education. This presentation will focus on strategies used for residential, commercial, school, and public works construction. In California, there are typically three levels of regulatory agencies regarding NOA. The California Air Resources Board oversees two air toxic control measures pertaining to NOA. The California Department of Toxic Substances Control oversees NOA at schools. Cal-OSHA oversees worker health and safety. The United States EPA and Agency for Toxic Substances and Disease Registry occasionally gets involved with NOA concerns. Local air districts oversee the regulation of the majority of projects impacted by NOA. Design engineers and contractors are responsible for figuring out how to build things within the constraints of NOA rules. Engineering geologists are critical in educating those impacted by NOA on how to characterize, manage, and mitigate the problem. Construction strategies need to consider pre-construction assessment and planning, construction management, and mitigation for post construction land uses.

An Examination of the Impact of the Natural Environment on the Development of Levee Distress Features

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Artificially constructed levees provide a series of valuable services. Extending the service life of levees reduces the potential for levee failures and prolongs their benefits. The objectives of this study were to investigate the relationships between the development of levee distress features caused by under seepage and classify local environments based on their expected impact to levee sustainability. Utilizing geographic information systems (GIS), approximately 225 kilometers (~140 miles) of levees within the Lower Mississippi River Valley were divided into small segments and a series of environmental factors were assigned to each segment. These factors included, amongst others, configuration of Quaternary Geology with respect to levee alignment, the hydrogeological nature of the alluvial aquifer beneath the levee, and soil physical properties. Next, a binary logistic regression applied to evaluate the correlation between environmental factors and the development of levee distress features (seepage lines and

sand boils) and generate a model capable of predicting distress features. Results of the logit model were then fed into a multiple criteria decision-making (MCDM) system to categorize environments into levee sustainability groups. These results indicated significant correlation between the development of levee distress indicators and four environmental characteristics: paleo channel orientation, AASHTO soil classification, normalized difference vegetation index (NDVI), and saturated hydraulic conductivity of the soil. The resulting model correctly predicted the status of distress feature development with up to 62% accuracy. The MCDM system identified forests composed of sweetgum, nuttal oak, and willow oak correlated with decreased development of distress features along adjacent levee segments. Plots of sycamore, pecan, and American elm trees and water bodies identified by ecophysiography contained above average development of distress features.

Attenuators for Controlling Rockfall: First Results of a State-Of-The-Art Full-Scale Testing Program

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A joint testing program is being carried out by Wyllie & Norrish Rock Engineers Ltd. and Geobrugg North America LLC to measure and validate the performance of hybrid attenuator rockfall nets. A preliminary round of full-scale testing was performed in the fall of 2014 and was continued with an extensive program in 2016 at the Nicolum Quarry in Hope, BC. Tests were conducted using natural rocks and steel reinforced concrete cubes dropped from heights of 60 m. The tests were documented with a high speed camera, load cells on the support cables, and rock motion sensors in the steel reinforced concrete cubes. The videos have been analyzed to determine velocity and energy changes, and the net deflection while intercepting falling rocks. The objective of the tests is to evaluate the interaction of the rocks and netting system and how the loads are distributed during the attenuation process.

Kikiaola Small Boat Harbor, Kauai, Hawai‘i: Keeping Sediment from the Grand Canyon of the Pacific out of the Harbor

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Kikiaola Light Draft Harbor (KLDH) is located on the west shore on the island of Kauai, Hawai‘i. The project is downdrift from the mouth of Waimea Valley, which is often referred to as the Grand Canyon of the Pacific. Large quantities of terrestrial sediment are directed from the valley outflow towards the harbor under the influence of waves, which approach from the south in the summer months. A large sediment fillet has formed on the updrift (eastern) side of the harbor, which is generally filled to capacity. Under this scenario, sediment arriving at the harbor from the east is directed along the toe of the east breakwater and into the harbor. This results in shoaling of the entrance channel and harbor basin along with erosion of the downdrift (western) shoreline. KLDH is a federally authorized harbor and the non-federal sponsor is the Department of Boating and Outdoor Recreation (DOBOR) of the Hawai‘i Department of Land and Natural Resources. Federally authorized general navigation features of the project include breakwaters (east and west) and channels (entrance and inner). The entrance channel is authorized to a depth of 11 feet (referenced to the mean lower low water tidal datum) and transitions to an inner channel depth of 7 feet. Following federal modification of the harbor in 2007, harbor shoaling increased to approximately 10,000 cubic yards per year. The rate of harbor shoaling has decreased over time due to efforts of the DOBOR to bypass sediment from the updrift to the downdrift side of the harbor as well as the equilibration of the bathymetry offshore of the harbor following federal modification to the project. This paper will describe the coastal processes and the regional sediment budget within the KLDH littoral system.

Spatial Analysis and Mapping Methods of Rockfall Prone Area during Thawing Periods in South Korea

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The rockfall activities of South Korea are annually reported at the end of the winter seasons. The seasonal frost weathering is considered to be the one of the most important causes, as the surface stability dwindles by experiencing the freeze-thaw cycles. In this paper, we present the spatial analysis and mapping methods of rockfall susceptibility using Geographic Information System (GIS) and spatial statistical modeling. The triggering factors of rockfall, including slope, aspect, flow accumulation and soil conditions, are collected from geological and geographical features distributed by Water Resources Management Information System of South Korea. The frequency ratio (FR) analysis is adopted to statistically quantifying the rockfall risks by comparing the triggering factors to the historical rockfall records. Each FR layers of triggering factors is composed and combined to specify the rockfall prone area, where has the highest FR values. To figure out the relation with freeze-thaw cycle, the regression analysis has been conducted the rockfall prone area and the diurnal temperature data acquired at automatic weather stations.

**Drone Operations in the United States:
An Update on Current Requirements to Fly Safely and Legally**

Steckel, Richard, Earthquake Insight, LLC, rjsteckel@charter.net (TS #17)

The use of private and commercial Unmanned Air Vehicles (UAV) or ìdronesî has skyrocketed in the last five years. Unlike manned aircraft, many of the drones are being flown by operators who are not familiar or aware of Federal Aviation Administration (FAA) regulations and certification requirements. These operators are currently being sought out by the FAA and are being grounded and/or fined. This presentation will discuss current regulations, requirements and exemptions for those who wish to operate fixed or rotor wing drones legally and safely in the National Airspace System. Air vehicle requirements, operator training and certification levels and airspace access will be covered. If the FAA is on schedule, FAR Part 107 that will be the final rule for drone operations should be released and will be discussed. The presenter is an FAA commercial pilot with 4000+ hours of manned flight time and who has also successfully applied for and been granted a Certificate of Authorization and a Part 333 exemption from the FAA for commercial drone operations.

Structural Geology of the Folsom Auxiliary Dam and Spillway Foundation, Joint Federal Project, Folsom CA

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Foundation geologic conditions and associated technical construction features on dams and spillways are subject to the local and regional structural geology. The Folsom Auxiliary Dam and Spillway Joint Federal Project is underlain entirely by the Early Cretaceous Rocklin pluton quartz diorite, which intrudes the Foothills Metamorphic Belt, a zone associated with accretionary tectonics of the Late Jurassic Nevadan orogeny. Pervasive joints and localized shear zones are the primary structural features within the Rocklin pluton. Four primary joint sets bound scaled, variably oriented removable blocks. Localized shearing trends along preexisting joints, which were likely original cooling/unroofing features exploited and reactivated by local geologic events. Larger steeply dipping shear zones have subhorizontal slip indicators and anastomosing shear patterns characteristic of strike-slip movement. Several prominent and persistent shallowly dipping, low-cohesion splayed shears form rock wedge sliding planes with variable dip angles and large scale surface undulation. Weathering of the quartz diorite presents a 3D framework of stratified near-surface weathering, and preferentially weathered rock on structures at depth. Rock quality generally increases from surface to depth, as overall weathering decreases, however zones of highly weathered and decomposed granite occur throughout the rock mass, and discontinuity-controlled weathering becomes increasingly important with depth. Structurally controlled rock blocks, shear zones, and rock mass weathering influence rock strength, cohesion, and stability, which contributed substantially to methods and results of blasting, cutslope excavation, and slope stabilization, as well as foundation grouting, cutoff walls, and anchoring at all stages of excavation.

Migration of Contaminants in Permafrost Active Layer; New Insights from Ongoing Studies at the Former Naval Arctic Research Laboratory, Barrow, Alaska

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Accidental releases of fuel on to soils underlain by continuous permafrost are challenging to delineate because of the difficulty in predicting the migration of hydrocarbons through the active layer, that is the shallow sub-surface zone that melts during the summer. Permafrost is an effective aquitard but movement of water through the active zone is constrained by low hydraulic gradients, inhomogeneous aquifers and the morphology of the underlying permafrost surface. Consequently, the movement of contaminants within the active layer is complex. Further, microbial breakdown and oxidation of contaminants is retarded by the low temperatures, so that contaminates remain at elevated concentrations for much longer that at more temperate latitudes. The Naval Arctic Research Laboratory (NARL) was operational from 1947 until 1980 occupying a 350-acre site north of the city of Barrow. Most of the original structures at NARL are still intact and have been put to other uses. However, complete utilization of the facility is limited by soil contamination dating back to its former use. Most of the contamination relates to fuel spills but metals, PCBs and chlorinated solvents are also present at some locations above action levels. Characterization and remediation efforts have been ongoing since the Navy left NARL and are expected to continue for another decade or more. As one of the most intensely studied sites in the Arctic, NARL is an ideal location to investigate long-term migration within the active zone.

Analysis of Borehole Geophysical and Acoustic Televiewer Data Aids in Calculating Rock Mass Properties for a Proposed Nuclear Power Plant

Troup, Alan., Bechtel Corporation, atroup@bechtel.com; David Fenster, Bechtel Corporation (TS #12)

The U.S Nuclear Regulatory Commission (NRC) provides guidance for conducting site characterization investigations for proposed nuclear power plants. Defining rock mass characteristics such as strength and discontinuities is important for evaluating geotechnical site suitability for foundation design and rock slope stability. The proposed nuclear power plant site is located in the Valley and Ridge Physiographic Province of Eastern Tennessee which is characterized by northeast-southwest oriented valleys and ridges that formed due to differential erosion of folded and thrust faulted Paleozoic age sedimentary rocks. Bedrock underlying the site consists of several hundred feet of interbedded Paleozoic limestone, dolomite, and calcareous siltstone and shale comprising five formations of the Ordovician Chickamauga Group underlain by the Cambrian-Ordovician Knox Group. Locally, these rocks dip steeply to the southeast within a regional northwest verging thrust sheet of the Alleghenian Orogeny. Analysis of available rock core, boring logs, pressure meter test results, borehole geophysical data, acoustic televiewer (ATV) data, and geologic mapping data resulted in quantification of rock mass and discontinuity characteristics to calculate geologic strength index ranges (GSI) for each stratigraphic unit. Rock mass strength parameters for each stratigraphic unit were calculated via the empirical Hoek-Brown failure criterion. Analysis of pressuremeter and borehole seismic data allowed for the calculation of a range of rock deformation moduli estimates for each stratigraphic unit. The calculated rock mass strength parameters were used as design guidance for nuclear safety-related engineering calculations required for foundation design and estimating settlement for a range of plant designs and as input to eventual rock slope stability and excavation support.

Erosion Damage to Water Canal Caused by Homeowner - NOT!

Upp, Rexford R., Geotechnical Consultant, rex@rexpertwitness.com (TS #20)

In the 1950s, a canal was built across the lower slopes of the Santa Teressa Hills in San Jose, California to convey water to percolation ponds. The Hills consist of Tertiary sedimentary rocks overlying older serpentinite and melange. The concrete canal crosses numerous naturally formed topographic swales. Runoff in these swales was collected and directed into pipes that carried it across the canal. In the early 1970s the canal was abandoned. In 1991 my client built his house across the hilltop above a swale. By 2003 a gully had eroded in the swale below the house and deposited sediment in the canal. The District filed a claim against the homeowner for damages stating the erosion was caused by excessive runoff from the impermeable surfaces created by the new house. We showed that the topographic swale below the house actually was an alluvial fan that had been actively developing for millennia and that periodic debris flows coming down from above altered the surface runoff pattern that lead to the gully erosion. Also, only about 10% of the runoff from the new house flowed into this watershed. The insurance company agreed to cover the cost of mitigation, consisting principally of re-establishing the historic drainage pattern to flow towards the existing culvert and collecting all runoff them the home's impermeable surfaces in a detention system that discharges onto a different watershed. This mitigation was completed in 2014. In October 2014, the first rain of the season was record-setting for early rainfall, and the resulting runoff eroded a new gully in the yet revegetated re-established historic drainage swale. This new erosion clearly demonstrated that added runoff from my client's house did not cause the erosion, as all runoff from the house was collected and discharged harmlessly into a different watershed.

The Long-Term Loan and Exhibition of Two Government-Owned Tyrannosaurus Rex Fossils

Van Arsdale, Cathy, U.S. Army Corps of Engineers, cathy.vanarsdale@usace.army.mil; Michael K. (Sonny) Trimble, michael.k.trimble@usace.army.mil (TS #2)

The U.S. Army Corps of Engineers (USACE) is the steward of over 40,000 cubic feet of archaeological collections from thousands of prehistoric and historic sites located on land that USACE manages. In addition, myriad paleontological resources have been recovered from those lands, including two of the best preserved and most complete Tyrannosaurus rex fossils ever discovered—the Nation's T., rex, (nee, Wankel T. Rex, MOR 555), and Montana's T. rex (nee, Peck's Rex, MOR 980)—both recovered from Fort Peck Lake in Montana. This paper discusses how USACE, through the St. Louis District's Mandatory Center of Expertise for the Curation and Management of Archaeological Collections, approached its stewardship responsibilities regarding these publically-owned T. rex fossils, including facilitating the loan of the specimens to two of the world's premier institutions—the Smithsonian's National Museum of Natural History and Montana State University's Museum of the Rockies. The fossil loaned to the National Museum of Natural History will be the centerpiece of that institution's new dinosaur hall, scheduled to open in 2019. The other loaned fossil is currently the centerpiece of the Museum of the Rockies Seibel Dinosaur Complex. Both institutions focus on public display, education, and research of their collections. The paper includes the considerations that influenced the loan, and the processes involved in ensuring that the specimens were inventoried, assessed for condition, and safeguarded prior to the loan and exhibition at these museums.

"Under the Volcano": Tunneling and Geologic Mapping in Variable Basalt for the Kaneohe/Kailua Sewer Tunnel, Oahu, Hawai'i

Van Etten, Greg, Brierley Associates Corporation, gvanetten@brierleyassociates.com; Alan L. Howard (TS #9) (Presented by Alan Howard)

Excavation of the Kaneohe/Kailua Sewer Tunnel on Oahu, Hawai'i required tunnel temporary support designed based on three major Rock Mass Types and continuous geologic mapping to confirm actual ground conditions en-countered. Geologic mapping was performed on behalf of the Southland/Mole JV serving as their tunnel engineer throughout construction. The finished tunnel is a 120-inch ID conveyance and storage pipe that helps bring the City and County of Honolulu into compliance with a 2010 Consent Decree by reducing untreated overflows during storm events. The tunnel encountered primarily highly variable basaltic rock, with limited sections of soft ground and mixed face conditions. The rock tunnel was mined using a 13-ft-diameter main beam tunnel boring machine (TBM). The island of Oahu was formed by two volcanoes: the older Waianae Volcano and the younger Ko'olau Volcano nearest to the project. Much of the eastern flank of the Ko'olau Volcano was modified by erosional forces and the occurrence of the massive Nuuanu Landslide. The remnants of the caldera are interpreted to extend from Kaneohe to Waimanalo and from the Ko'olau summit to seaward of Lanikai. The location of the Kaneohe/Kailua Sewer Tunnel is within this compound and collapsed caldera, within a more geologically complex area than that of the existing H-3 and Wilson highway tunnels, which are outside the caldera within the volcanic shield. During cal-dera collapses, ponded lavas and volcanic breccias, were also subjected to hydrothermal alteration and chemical alteration, forming highly variable rock conditions. In addition, the caldera contains high concentrations of strong volcanic dikes. Working with the Contractor required quickly and efficiently obtaining tunnel mapping data while avoiding impacts to production under difficult conditions in a small tunnel. Tunnel geologic mapping was used to confirm temporary support design requirements and compare as-built geology to baseline rock and ground water inflow conditions.

Interdisciplinary Benefits of the HVSR Passive Seismic Geophysical Method

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Horizontal-to-vertical spectral ratio (HVSR) is a non-invasive seismic method in which a Tromino® unit is used to measure point resonance frequency determined from ambient (passive) noise. The resonance frequency can be interpreted using a localized calibration curve to determine the depth to bedrock at each survey location. Conducting several surveys allows accurate interpretation of the bedrock topography of a region, which is standard information necessary for a variety of disciplines. Traditionally, bedrock topography has been inferred using well data and surface outcrops; however, uneven well distribution and often-limited bedrock exposures leave substantial gaps and uncertainty in the true bedrock topography. HVSR passive seismic data is acquired relatively quickly and inexpensively compared to other geophysical techniques and drilling. The Tromino only requires single-person operation for data acquisition and post-processing procedures. It is non-invasive and easily portable, making it a favorable method to implement into several research disciplines. An accurate reconstruction of regional subsurface structures is essential to understand bedrock influence in the geologic history and development of an area in order to accommodate modern planning, or address issues and concerns. Such versatile information is important to numerous applications, which will be explored with case studies, including: geomorphology, hydrogeology, as well as structural, economic, and engineering geology.

A Case Study of a Cracked Dam, Frog Hollow Debris Basin, Washington County, Utah

Vargo, Ana, USDA NRCS, ana.vargo@co.usda.gov; Dave Black, daveb@racivil.com; David Simon, david@utahgeologist.com; Todd Sieber, todd.sieber@ut.usda.gov (Poster)

Frog Hollow Debris Dam is approximately 2.5 miles south of Hurricane, UT, on the Uinkaret Plateau and is founded on Quaternary-age basalt flows. The original dam was constructed in 1956 at a height of 30± feet and length of 600± feet. In 1978, the dam was raised 16± feet and the length increased to 1,900± feet, under the USDA Small Watersheds Program. The dam has no permanent storage, and is classified by NRCS as a high hazard dam. In the next few years, proceeding construction, cracks were observed in the embankment and grouting proved ineffective. A fix in 1983 removed two feet of embankment and installed a sand filled chimney drain. During the 2015 inspection new holes and cracks were observed. A 2015 geotechnical/geologic investigations documented 51 holes in the embankment, transverse cracking, and a 100-foot-long longitudinal crack about 35 feet upstream of the centerline. The cracking and holes appear to be due to desiccation of the gypsiferous, clayey, alluvial 1978 embankment fill. The 2015–16 geotechnical/geologic subsurface investigations determined: a) transverse cracking upstream, downstream, and thru the chimney drain; b) cracking confined to the 1976 embankment material, not extending into 1956 embankment fill or underlying basalt foundation; and, c) cracks range from hairline fractures to five inches wide, narrowing with depth. The use of fluorescein, a diagnostic dye tracer, was very effective in evaluating the vertical and lateral dimensions of the cracks. Temporary repairs to the dam will occur in 2016 and dam rehabilitation in circa 2020.

Paleontological Resource Preservation: A Federal Government Perspective on a Non-Renewable Natural Resource

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Paleontological resources are fossilized remains, traces or imprints preserved in geologic context. Fossils representing organisms provide singular evidence of past life and ecosystems on Earth. The term includes unaltered, permineralized, or mineralized bones, teeth, soft tissue, shells, plant material, and invertebrate and vertebrate traces (ichnofossils). As with archaeological artifacts (cultural resources), each fossil is a singular occurrence—some highly significant, while others are common. Scientifically significant fossils yield information distinctive to understanding pre-human history, climate change, and evolution. Loss of scientifically significant fossils on Federal lands represents an adverse environmental impact. Adverse impacts include natural degradation from weathering, or surface disturbance by humans. As with cultural resources, vandalism or unlawful collection presents a significant challenge due to their allure. Once destroyed, a fossil can never be replaced because of its individualized character - impacts are considered long-term. Federal law now exists fostering preservation of paleontological resources on select Federal lands. Public Law 111-11, (Paleontological Resources Preservation Act (PRPA) of 2009), is the first Federal statue for paleontological resources, applicable to the Department of Agriculture (Forest Service) and Department of Interior (Park Service and Bureau of Land Management). The PRPA directs management of paleontological resources using "scientific principles and expertise," containing explicit "Savings Provisions" (Section 6311) language restricting the degree to which paleontological resources are considered in NEPA actions. Paleontological resources management will continue to be treated as a 'fundamental stewardship responsibility' within Federal entities, functioning largely in a proactive (cultural services), rather than a reactive (compliance) management role.

History and Mechanisms of Rock Slope Instability Along Telegraph Hill, San Francisco, California

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Telegraph Hill has a colorful history extending back over 150 years, where the geology of this iconic San Francisco promontory resulted in an ironic twist of fate that now haunts the nearby urban corridors. Telegraph Hill is underlain by resistant Franciscan Complex sandstone, largely unsheared, and grossly stable. This high-quality rock in close proximity to the burgeoning shipping industry was a valuable commodity in the 1800s, mined extensively for seawalls, jetties, roads, and ship ballast. Telegraph Hill quarrying resulted in near-vertical rock faces up to 150 feet high along the northeastern, eastern, and southern slopes. The sandstone exposed along the old quarried slopes remains standing today at near-vertical angles, with the tops of these slopes retreating at slow rates, resulting in builders "snuggling" up close to the tops and toes of these slopes. However, periodic catastrophic rockslides along these highly fractured slopes are a lasting reminder of the quarrying legacy. The steep quarry walls experienced blast fracturing and relaxation jointing from the removal of large volumes of the hillside. These high-angle relaxation joints and blasting fractures are sites of weathering, joint infilling, and root growth, creating apertures for surface water collection. The result is an outer rind of progressive deformation along these joints, where toppling, buckling, and planar/wedge failures occur. Telegraph Hill rockslides are most often associated with heavy rainfall where hydrostatic pressure is the triggering event. The resultant failures are typically shallow, rapidly moving rock slides and rock topples with high velocities and high risks to persons and property above and below the failure.

Kauai's 2006 Ka Loko Dam Failure and its lasting impact on Hawai'i

Wehrheim, John, Pacific Hydro; jwehrheim@pacific-hydro.org, Kevin L. Gooding (TS #1)

In February 2006, Hawai'i's infamous "40 days of rain" began. During this period the government issued 111 flash flood warnings. Just before dawn on March 14, 2006, Ka Loko Dam broke, releasing 400 million of gallons of water. The floodwaters killed seven, ripped across the dam of a downstream reservoir, damaged the state highway (isolating Kauai's North Shore), washed away homes and farms; and then deposited a torrent of silt and debris in the downstream estuary and across the reefs, destroying marine life. Although the heavy rains were the immediate cause of the disaster, an independent investigation concluded that the dam failed because the spillway had been covered. The lives of many people on Kauai were forever altered by an avoidable disaster. Hubris and a lack of government oversight were important factors in the mismanagement of the dam. The dam's 89-year-old owner was subsequently convicted of reckless endangerment and sentenced to seven months in prison. Hawai'i now has a rigorous and strictly enforced dam safety program. Costs of dam ownership have increased exponentially and Hawai'i's agricultural and energy future will be impacted by the disaster. Agricultural, environmental and power development interests are very concerned about the costs of building, improving and operating dams and reservoirs. In particular, pumped storage hydro, an energy storage technology, will be affected by the legacy of Ka Loko. Hawai'i is committed to 100% renewable energy by 2045 and energy storage, be it pump storage hydro or batteries, is critical for achieving this goal. Can there be compromise between dam safety regulation and the economic use of dams for power storage and agricultural irrigation?

Backfilling of a Gravel Pit with Road Construction Debris, Risks Water Supply Concerns for Nearby Residential Area, Lafayette, Tippecanoe Co., Indiana

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The Crider & Crider Pit is located on a sandy terrace of the Wabash River, Tippecanoe County, IN, with a water table depth of 50–60 feet in an unconfined aquifer containing individual wells in adjacent housing areas. Wells have high production (>30gpm) in a deposit of high hydraulic conductivity (10-2 cm/sec) and a hydraulic gradient of about 0.01. This yields a groundwater average velocity of about 100 ft/yr. toward the nearby houses and a travel time for the 0.5-mile separation of about 13 years. A 25-ft-deep, 16-acre pit is left after sand and gravel were excavated to provide fill for new construction of State Road 25. Crider & Crider plans to backfill the pit with road construction material including broken concrete and asphalt pavement from a US-52 and I-65 widening projects. Asphalt milling material and concrete blocks in a soil mixture will comprise the backfill. Under Indiana solid waste regulations, road construction debris can be placed in a so called "clean fill" with none of the common requirements, such as monitoring wells, liner, landfill cap, or daily cover. The local citizens contend that backfilling the pit with road construction debris will create a threat to their water well supplies. Another concern is that other construction/demolition materials such as metal products, painted wood, plastic and paper products would be deposited as well which could cause groundwater contamination. Crider & Crider improperly placed such material in the pit previously and had to remove it. Approval to backfill road construction material was granted by the local planning board with an understanding that careful monitoring of backfilled materials would be conducted by a state inspector and by local residents. Concerns continue that organic contamination from the milled asphalt could impact the water supply.

Construction of Large Slab Anchors in Shear Zones for the Folsom Auxiliary Spillway Approach Channel

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Three-Hundred and five (305) large slab anchors were installed for the approach slab of the Folsom Auxiliary Spill- way Control Structure in Folsom, CA. The approach slab is a reinforced concrete slab that has a minimum thickness of five feet, measures 200 x 160 feet in plan, and is placed directly on the blasted and excavated quartz diorite foundation. The slab anchors are made of high strength galvanized threaded steel bar and are 3.5-inches in diameter with 16 x 16 x 3-inch-thick galvanized steel plates. The slab anchors were installed in 6-inch diameter boreholes and were 35 feet deep in the shear zones and 25 feet deep outside the shear zones. During investigation and design, two distinct shear zones were identified (the S1 and S2) in the foundation and were depicted on the contract plans as being relatively consistent in trace and width. Once the area was blasted and excavated, drilling and geologic mapping showed that the shear zones varied considerably, which required re-assignment of the 35-ft-deep anchors. Through close coordination with the Contractor, concurrent mapping, and monitoring of drill cuttings, the shear zones were more accurately located and anchors reassigned accordingly. Prior to anchor installation, each borehole was water tightness tested and the few that failed were re-grouted and re-drilled. Once the bars were installed and the grout achieved the required unconfined compressive strength, the anchors were successfully proof tested to a design load of 340 kips.

Correlation of Transgressions on Alaska's North Slope

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Sea level fluctuation has played a vital role in shaping the coastal plain on the North Slope of Alaska. The coastal plain represents a marine-abrasion bedrock platform, which is essentially an exposed extension of the Chukchi and Beaufort Sea continental shelves. Throughout late Pliocene and Pleistocene, world sea levels fluctuated in response to glacial cycles. Though the coastal plain was not glaciated, it has been shaped by transgressive and regressive marine sequences. During each transgressive sequence, relatively rapid sea level rise resulted in erosion with little deposition, once sea level was stabilized, deposition began in areas beneath the wave base. Wave-cut escarpments are evident using the National Elevation Dataset. Previous authors (Black, 1966; Hopkins, 1973; Williams, 1993; Brigham, 1985; and Brigham-Grette and Hopkins, 1995) have correlated the escarpments to differing transgressions. The escarpments are primarily eroded into the Gubik Formation, which lies unconformably on top of a folded and faulted sequence of Cretaceous to Tertiary Bedrock. Marine terraces adjacent to the Colville River Delta, described by Rawlinson in 1993, provide collaborating evidence of static sea stands. In addition to wave-cut escarpments and terraces, features such as beaches, barrier islands, and deltas are also evident. Additional study is needed to fully correlate the elevations of the apparent sea stands with transgressive sequences. This would aid in the understanding of the depositional history of the Gubik formation, which is important for engineering considerations regarding anticipated engineering properties of landforms and the presence and character of ice-rich deposits. The soil properties are also an important consideration when speculating how a warming climate and rising sea levels may affect the landscape of the future.

Geologic Terrain and Hazard Analyses of Permafrost Soils in Support of Project Siting and Engineering

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Geologic terrain and hazard analyses aid in project siting and definition of engineering considerations and potential material sources. These analyses include definition of geologic units within a project area and associated mapping illustrating the locations of identified terrain units, potential geologic hazards, and potential material sources. A landform/geologic unit is an area that is thought to have relatively consistent geologic composition based on surficial characteristics and apparent mode of deposition. Terrain units are expressed in terms of the landform/geologic units indicating a generalized profile. Understanding the general physical characteristics of the soils within a project area provides an indication of geotechnical characteristics of these materials. Anticipated soil properties and geotechnical characteristics typically include suspected permafrost distribution, erosion potential, frost heave potential, thaw settlement potential, thawed bearing strength, and slope stability. Most potential geologic hazards can be avoided or their effects on planned projects can be minimized if they are identified early in the planning process. Potential mapped geologic hazards in permafrost areas may include slope instabilities (landslides, thaw slumps, and solifluction), significant ground ice (areas of potential yedoma and pingos), thermal degradation (tundra fires, erosion, disturbance, snow drifting, ponding water), flooding, coastal and riverbank erosion, aufeis, and snow avalanches.

Practical Differences Between Post-Tensioned Anchors and Un-Tensioned (Passive) Dowels

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During the rock slope stabilization process, reinforcement is commonly accomplished utilizing bolting to secure the rock blocks to the slope. Rock bolts are elements (most commonly steel) that are placed within a drilled hole and secured with a cement grout or epoxy resin. Rock bolts can be characterized as either post-tensioned anchors or un-tensioned (passive) dowels. Post-tensioned anchors have a bonded and an unbonded zone and after their installation the bolt's length is pulled, placing a load from the head of the anchor to the bonded zone. A dowel is an element that is fully grouted and commonly does not have a load placed on the steel. A clear majority of research on rock bolting has been conducted on post-tensioned anchors. Consequently most industry specifications are written for post-tensioned systems. However due to its lower installation cost and shorter installation time, the use of un-tensioned dowels is growing. In many cases dowels can actually match the practical performance of tensioned anchors, are faster/cheaper to install, are more reliable over time, and are not prone to over conservative assumptions in the design process that can lead to bolt failure. This paper discusses the practical differences between post-tensioned anchors and un-tensioned dowels through the use of practical examples and testing results.

Quantifying the Effects of Crustal Thickening and Viscous Decoupling on Melt Production in the Cascadia Mantle Wedge

Yang, Jiaming, Portland State University, jiaming@pdx.edu (Poster)

Subduction zones are often characterized by a narrow chain of active arc volcanoes at the surface. This magmatism is sustained by the complex interactions between the subducting slab and the overlying mantle. Partial melting of mantle peridotite is achieved by fluid induced flux melting and decompression melting due to corner flow. Crustal evolution and changes in temperature, flow, and pressure fields in the mantle wedge have a strong effect on the generation of melt. This study incorporates modern constraints from the Cascadia subduction zone and investigates the effects on melt production of crustal thickening and viscous decoupling of the shallow slab-mantle interface. I modified a 2D finite volume mantle convection code to numerically simulate melt generation based on the parameterization of hydrous, adiabatic melting from Katz et al. (2003). Testable hypotheses include: crustal thickening beneath the arc front causes melting to migrate trenchward, while decoupling shifts the location of melt production landward.

Blind Extraction of Full-Field Structural Dynamics by Video Motion Manipulations for Remote Assessment of Infrastructures

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Infrastructures with complex geometries, material properties, and boundary conditions, exhibit spatially local, temporally transient, dynamic behaviors. High spatial and temporal resolution vibration measurements and modeling are thus required for high-fidelity characterization, analysis, and prediction of the structure's dynamic phenomena. For example, high spatial density mode shapes are needed for accurate vibration-based damage localization. Also, higher order vibration modes typically contain local structural features that are essential for high-fidelity dynamic modeling of the structure. In addition, while it is possible to build a highly refined mathematical model (e.g., a finite element model) of the structure, it needs to be experimentally validated and updated with high-resolution vibration measurements. However, it is a significant challenge to obtain high-resolution vibration measurements using traditional techniques. For example, accelerometers and strain-gauge sensors provide low spatial resolution measurements. Laser vibrometers provide high-resolution measurements, but are expensive and make sequential measurements that are time-consuming. On the other hand, digital video cameras are non-contact, relatively low-cost, agile, and provide high spatial resolution, simultaneous, measurements. A new framework is presented for the blind extraction and visualization of the full-field, high-resolution, dynamic parameters of an operating structure from the digital video measurements using video motion manipulation and unsupervised machine learning techniques. It is demonstrated that this high-resolution, full-field dynamic characterization framework opens up a variety of applications in remote assessment of infrastructures that traditionally have not been possible. These include the ability to accurately localize minute, invisible, structural damage, and a new method enabling realistic video-space, high-fidelity simulations and visualizations/animations of structural dynamics. Video demos of experimental results are shown at http://www.lanl.gov/projects/national-security-educationcenter/engineering/research-projects/blind-modal-id.php.

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GUEST TOURS

- Colorado Springs Fine Arts Center
- Tour Garden of Gods and Lunch in Manitou Springs
- Cog Railroad Ride to the Top of Pikes Peak
- Garden of the Gods Geology

SPECIAL EVENT

Dinner and Tour of Phantom Canyon Brewing Company

Located in the heart of downtown in the historic Cheyenne Building, the three-story brick structure was built in 1901 and housed the Chicago Rock Island and Pacific Railroad. In 1909, the building re-opened as the Cheyenne Hotel. After the hotel shut down, the building changed hands a number of times and was used for a variety of businesses. Saved from the wrecking ball in 1993, the historic site was purchased by Colorado Governor John Hickenlooper who restored the property and opened Phantom Canyon Brewing Co. The main dining area and brewery were the first to open and were a great success. In 1995 the second floor opened as a Billiard Hall, which has been voted the Best Place to Shoot Pool every year since. In 2001 they completed the third floor Banquet Hall.