

***Interagency Collaborative on
Environmental Modeling and Monitoring (ICEMM)***

Annual Public Meeting: March 17-18, 2020

U.S. Geological Survey (USGS) Headquarters,
(Dallas Peck Auditorium)

12201 Sunrise Valley Drive, Reston, VA 20191

Theme: Integrated Modeling, Monitoring, and Working with Nature

Speaker Abstracts and Biographical Information (in order of presentations)

Tuesday morning introductions (9:00 AM), March 17, 2020

Geoff Plumlee, Senior Science Advisor to the USGS Director

Geoff Plumlee has 33 years of research and science management experience with the USGS, through which he has established research collaborations with scientists from a broad range of earth, health, social, emergency response, and engineering science disciplines. Early in his career, Geoff's research integrating economic geology and environmental geochemistry gained new insights into how mineral deposits form and how resource extraction can be accomplished while better protecting the environment. Geoff conceived of and led the development of geoenvironmental models of mineral deposits, which provide the geologic basis for better anticipating and preventing adverse environmental impacts from mineral resource development. From 1996-2001, Geoff served as Director for two USGS science centers, providing scientific and managerial leadership for more than 200 scientists and support staff. After rotating back to research in 2001, he helped lead USGS science collaborations with health experts to understand human health implications of geologic materials such as asbestos, mine wastes, and volcanic ash, and materials produced by disasters such as the World Trade Center collapse, hurricanes, floods, wildfires, and mine tailings spills. Through his work with USGS hazards experts, Geoff developed methods to help anticipate environmental and health implications of looming or future disasters. Geoff is an adjunct clinical assistant professor at University of Colorado School of Public Health, Past Chair of the Geological Society of America's Geology and Health Division, a contributing editor to Earth Magazine, a Fellow of the Geological Society of America, and an appointed Council Member of the American Geophysical Union. He is a lead author or coauthor on over 140 scientific papers, including articles in technical journals and books spanning disciplines such as environmental geochemistry, public health, natural hazards, economic geology, and geology.

Pierre Glynn, USGS, ICEMM Chair

Pierre Glynn currently heads the Hydro-Ecological Interactions Branch (HEIB) in the Water Mission Area at the U.S. Geological Survey (USGS). Scientists in the Branch conduct research to advance the qualitative and quantitative understanding of the water cycle, its dynamics, and its interactions with ecological and societal needs. HEIB scientist goals include: (1) characterizing and anticipating changes and threats to water quality and quantity related to changes in climate, land-use, management practices, and human and ecological needs, and (2) understanding the interactions among aquatic ecosystems, hydrology, and hydrochemistry. Beyond his Branch management responsibilities, Pierre also serves as the Water Mission Area representative to the USGS Science and Decisions Center. The Center seeks to maximize the usefulness of science to policies and decisions relating to the management of natural resources and environments, and to the mitigation of natural hazards and catastrophes. Pierre's current research interests include studies on (1) the role of human biases, beliefs, heuristics and values in the conduct of science, (2) public participation in science, (3) integrated modeling and the study of complex systems. His earlier research efforts focused on geochemical modeling, groundwater contamination, nuclear waste disposal, and groundwater dating. Pierre's academic background includes a B.A. (with a major in Geological Sciences) from Columbia College and Lamont Doherty Earth Observatory, an M.Sc. from University of Quebec in Montreal in isotopic environmental geochemistry and the cycling of atmospheric $^{14}\text{CO}_2$, and a Ph.D. from the University of Waterloo, where his studies focused on groundwater studies and the thermodynamics of water-rock interactions.

Karl Rockne, National Science Foundation (NSF), ICEMM Vice-Chair

Karl Rockne manages an \$80M research portfolio as Director of the Environmental Engineering program in the Division of Chemical, Bioengineering, Environmental, and Transport Systems (CBET) at the National Science Foundation. He is currently on leave from the University of Illinois, Chicago where he is a Professor of Environmental Engineering and former Head of the Department of Civil and Materials Engineering. He received numerous teaching and research awards, starting with the National Science Foundation’s CAREER young investigator award for research on “active capping” technology for contaminated sediment remediation. He has published over 100 scientific articles in the fields of pollutant fate, dental materials, environmental forensics, microbial ecology, bioremediation, and sediment treatment. Karl’s past administrative positions include the Director of Undergraduate Studies and Interim Department Head for the Department of Civil and Materials Engineering. He has serves on numerous interdisciplinary national governmental science and advisory committees, including the intergovernmental Disaster Science Standing Committee on the National Academy of Sciences, vice chair of the Intergovernmental Collaborative for Environmental Modeling and Monitoring (ICEMM), and the Subcommittee on Water Availability and Quality (SWAQ) for the Office of Science and Technology Policy (OSTP), Executive Office of the President of the United States.

Abstracts (in order of presentation) followed by Speaker Information

Tuesday March 17 Keynote (9:15 AM)

Engineering With Nature for Sustainable Systems: The Role of Integrated Modeling and Monitoring

Practical approaches are needed to integrate natural and infrastructure systems in a manner that achieves more socially acceptable, economically viable and environmentally sustainable systems. The Engineering With Nature® Initiative, led by the U.S. Army Corps of Engineers, is a collaborative approach to engineering that seeks to leverage natural process, produce operational efficiencies, and broaden the range of services and value provided by infrastructure. Project examples in the US and other countries related to navigation, flood risk management, and water infrastructure will be used to illustrate the approach and highlight needs and opportunities to advance practice.

Todd Bridges, U.S. Army Corps of Engineers (USACE)

Dr. Todd S. Bridges is the U.S. Army’s Senior Research Scientist for Environmental Science. He leads research, development and environmental initiatives for the U.S. Army and U.S. Army Corps of Engineers in the areas of sustainable infrastructure, risk and decision analysis, and sediment assessment and management. He is the National Lead for the USACE Engineering with Nature® initiative (EWN®), which includes a network of research projects, field demonstrations, and communication activities to advance the development of sustainable, resilient infrastructure systems. He leads the USACE Dredging Operations Environmental Research Program and has chaired development of environmental standards of practice related to water infrastructure projects. Dr. Bridges chairs the Environmental Commission for the World Association of Waterborne Transport Infrastructure.

Dr. Bridges’ work has been supported by programs within the USACE; the U.S. Army, Navy, and Department of Defense; the U.S. Environmental Protection Agency; and the private sector. His research activities have been recognized through receipt of several USACE and U.S. Army Research and Development Awards, the Government Service Award from the Society of Environmental Toxicology and Chemistry (2009), the Outstanding Practitioner Award from the Society for Risk Analysis (2012), the Army Engineer Association’s Bronze Order of the de Fleury Medal (2014), and the Department of the Army Meritorious Civilian Service Award (2008). The EWN® Initiative was awarded the 2013 USACE Environmental Award in Natural Resource Conservation and the 2014 USACE Sustainability Award for Green Innovation, and the 2019 Outstanding Achievement Award from the Renewal Natural Resources Foundation. Dr. Bridges

also serves as an Adjunct Assistant Professor with the College of Engineering at the University of Georgia. Over the last 25 years, Dr. Bridges has published more than 60 journal articles, book chapters, books and numerous technical reports. He received his B.A. (1985) and M.A. (1988) in Biology/Zoology from California State University, Fresno and his Ph.D. (1992) in Biological Oceanography at North Carolina State University.

Tuesday March 17 Session (10:30 AM) on

Innovation and the Ecosystem Perspective

Presentation (10:30 AM):

Building smarter water systems through improved sensors, autonomy, and data processing

In this era of digital assistants, robots, and other smart things, can we build the same level of autonomy into water systems? There is an unprecedented opportunity to reduce flooding and to improve water quality by equipping existing water systems with low-cost sensors and controllers. This will vastly shrink the size of infrastructure needed to manage runoff pollution and to adapt to the impacts of changing weather. We will give examples of promising smart water test beds, while also describing how to find useful data in unexpected places.

Branko Kerkez, University of Michigan

Branko Kerkez is an associate professor of Civil and Environmental Engineering at the University of Michigan. His research interests include water, data, and sensors. His group is working to enable smart water systems, which autonomously adapt themselves to changing conditions using real-time data and controls. His research projects have spanned wireless sensing of large mountain basin, real-time flood forecasting, aquatic robotics, and the development of real-time control algorithms for water systems. He is the founder of Open-Storm.org, an open source consortium dedicated to freely sharing hardware, software, and case studies on smart water systems. He received his M.S. and Ph.D. in Civil and Environmental Engineering, and an M.S. in Electrical Engineering and Computer Science, all from UC Berkeley. He is a recipient of the National Science Foundation's CAREER award and was recognized by National Academy of Engineering as a Gilbreth Lecturer in 2018.

Presentation (11:10 AM):

Natural Capital Accounting and Measuring Ecosystem Services: The Next Wave

Natural capital accounting (NCA), including any quantification of ecosystem services, demands environmental modeling and monitoring, and will want much more of it. The time is right to actively seek communication, and to convene around a common vocabulary and a common organizing framework, to accelerate sharing of models, data, databases, and data needs.

The UN Statistics Division is an international standard-setting body that has spent more than a decade developing and vetting environmental-economic and natural capital accounting frameworks. It may offer a framework and vocabulary that can help increase the policy-readiness of much environmental modeling and monitoring research and data generation.

This presentation lays out theoretical frameworks and tables relevant to NCA and particularly ecosystem accounting, and reports results from USGS-led US NCA working group papers for land, water, and ecosystem accounts. The presentation also reviews how different organizations and institutions have informed or interacted with early ventures in NCA and ecosystem accounting, and what lessons may be useful for those entering this expanding market for environmental modeling and monitoring products.

References:

US NCA BioScience paper:

<https://www.researchgate.net/publication/329554563> The Natural Capital Accounting Opportunity Let's Really Do the Numbers;

UN Statistics Division, System of Environmental-Economic Accounting, Experimental Ecosystem Accounting, Technical Guidance:

https://seea.un.org/sites/seea.un.org/files/Presentations/Training_China_2017/seea_eea_tech_rec_final_v3.2_16oct2017.pdf;

[NASA's Biodiversity and Ecological Forecasting program](#)

Charles Rhodes (Ecosystems Services Classification Expert)

Charles Rhodes is a PhD agricultural and resource economist, with a deep background in political economy and agricultural policy. His dissertation work used a 2.5-million-observation dataset and multi-stage modeling in conjunction with clinical results from 6 economics-adjacent fields to analyze deep demographic patterns in unhealthy food consumption. It has been downloaded more than 1000 times.

During a 5-year post-doctoral research fellowship sponsored by US EPA's Office of Water and Office of Research and Development, Charles coordinated EPA economists and ecologists developing the National Ecosystem Services Classification System (now NESCS Plus), designed to expand the range of ecosystem services quantified for policy analysis. Through NESCS work, Charles became increasingly involved in UN work on Experimental Ecosystem Accounting, with the US Natural Capital Accounting working group, and with Earth Observation for Ecosystem Accounting (a Group on Earth Observations Initiative), often focusing discussions on themes developed in this presentation. Currently, Charles is a senior economist with TBD Economics, working on blue carbon and sustainable fisheries issues, and continues as a subject expert with all of these organizations. charlesrhodes@gmail.com; [Charles Rhodes on LinkedIn](#)

Tuesday March 17 Keynote (12:45 AM)

Smart One Water Cyber-Physical-Social infrastructure: Transforming the Way People Interact with Water Services, Advancing Adaptive Management and Resilience of Engineered and Natural Water Systems

Adequate quantity and quality of water is necessary for human health and well-being, as well as for supporting ecosystems and the prosperity of water-dependent economic sectors. Engineered water systems that manage water services for communities, face a multitude of challenges that must be identified, assessed, evaluated, and managed. Recent natural disasters, cyber-security breaches, and aging infrastructure failures remind us that natural, technological, and anthropogenic hazards take a high toll on our society and economy. A major national initiative is needed to take advantage of the convergence of scientific disciplines focused on the challenges of water services and management and to advance the deployment of modern data and computational tools in supporting water science and engineering. Building on and integrating advances in ecology, economics, governance, public health, and policy with advances in computationally-intensive modeling and monitoring technologies, data analytics, machine learning, and decision support systems, will improve how we steward the planet's water to enable human development and environmental protection. The Smart One Water paradigm will operationalize resilient and sustainable water systems by coupling cyber-physical and social systems to integrate data and decisions across governance systems, spatio-temporal scales, the natural-to-built infrastructure interface, climatic regions, and natural and anthropogenic threats..

Sunhil Sinha, Virginia Tech

Dr. Sunil Sinha is a Professor of Civil and Environmental Engineering and Director of Sustainable Water Infrastructure Management (SWIM) Center of Excellence at Virginia Tech. Dr. Sunil Sinha is a National Science Foundation (NSF) Career Award recipient in the area of sustainable water infrastructure management systems. Dr. Sinha's research, teaching, and consulting activities are focused in the areas of infrastructure management, sustainability, pattern recognition, sensor informatics, and resilience, especially water systems. Dr. Sinha is working closely with international institutions in the areas of resilient water infrastructure systems such as CSIRO, Australia; NRC, Canada; University of Birmingham, U.K.; SINTEF, Norway; and Indian Institute of Science.

Dr. Sinha was seen behind “90-minutes” PBS documentary titled “Liquid Assets: The Story of Our Water Infrastructure,” that throws light on a long-buried problem — America’s aging water system. He has given many NPR interviews and featured as a water infrastructure expert in a History Channel documentary titled “The Crumbling of America.”

**Tuesday March 17 Session (1:30 PM) on
Integrating Natural Processes, Features, and Structures into Models and Monitoring**

Presentation (1:30 PM):

Long-Term Performance of Engineered Systems in Nature

Based on lessons learned in licensing reviews, the U.S. NRC staff has recently developed guidance pertaining to the incorporation of risk-significant features, events, and processes (FEPs) into performance assessments (PA) for low-level radioactive waste disposal systems (NUREG-2175). A FEPs analysis provides confidence that risk-significant phenomena are considered in the PA model(s). The subsequent understanding of the interactions between these phenomena and the site features and engineered system barriers is critical to the understanding of both short-term and long-term site performance. A key component of the FEPs analysis is the identification and characterization of credible scenarios and alternative conceptual site models to understand the local environmental conditions, events and processes. Operational experience of these facilities indicate that systems evolve towards the established natural conditions of the local environment (i.e., a local equilibrium) for physical (e.g., erosion, development of soil structure, vadose zone hydrology), biotic (e.g., flora, fauna), and chemical (e.g., oxidation, dissolution, leaching, mineral precipitation) mechanisms. Because engineered systems evolve towards a long-term equilibrium, the further the systems are initially from equilibrium, the faster they evolve to the surrounding natural conditions. The recognition of this concept of system evolution has led, in some instances, to the transition from resistive barriers (i.e., rock covers) to integrated engineered systems more compatible with nature. Closure caps at uranium mill tailings sites provides an example of this paradigm shift from resistive covers to evapotranspiration covers.

References:

NUREG-2175, *Guidance for Conducting Technical Analyses for 10 CFR Part 61*, Draft Report for Comment, U.S. Nuclear Regulatory Commission, Washington, DC, March 2015. <https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr2175/>

NUREG/CR-7028, *Engineered Covers for Waste Containment: Changes in Engineering Properties and Implications for Long-Term Performance Assessment*, U.S. NRC, Dec. 2011. <https://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr7028/>

NUREG/CP-0312, *Proceedings of the Radon Barriers Workshop*, U.S. NRC, August 2019. <https://www.nrc.gov/reading-rm/doc-collections/nuregs/conference/cp0312/>

NUREG/CP-0195, *Proceedings of the Workshop on Engineered Barrier Performance Related to Low-Level Radioactive Waste, Decommissioning, and Uranium Mill Tailings Facilities: Held at the U.S. Nuclear Regulatory Commission Headquarters, Rockville, MD, August 3-5, 2010*, U.S. NRC, August 2011. <https://www.nrc.gov/reading-rm/doc-collections/nuregs/conference/cp0195/>

George Alexander, U.S. Nuclear Regulatory Commission

Dr. George Alexander is a Risk Analyst for the U.S. Nuclear Regulatory Commission. He has worked in the Risk and Technical Analysis Branch for the past 12 years as a technical reviewer for the Savannah River Site tank closures and Saltstone Disposal Facility, materials decommissioning sites, and uranium mill tailing sites. His areas of focus include geochemistry, degradation of cementitious materials, groundwater flow and transport. Dr. Alexander earned his degrees from Penn State University in Energy and Geo-Environmental Engineering.

Doug Mandeville, U.S. Nuclear Regulatory Commission

Doug Mandeville is a Senior Project Manager the U.S. Nuclear Regulatory Commission. He has worked in the Uranium Recovery and Materials Decommissioning Branch for the past 13 years. Mr. Mandeville's experience includes various aspects of licensing and reclamation of uranium mill tailing sites. Prior to joining the NRC, Mr. Mandeville worked in private engineering practice on the design and construction of near surface disposal facilities for solid and hazardous waste. Doug Mandeville obtained his bachelor's and master's degrees from Clarkson University in Civil Engineering.

Tom Nicholson, U.S. Nuclear Regulatory Commission

Thomas Nicholson is the Senior Technical Advisor for Radionuclide Transport in the Environment, Division of Risk Analysis, Office of Nuclear Regulatory Research (RES), U.S. Nuclear Regulatory Commission (NRC). He has worked at the NRC for 43 years, primarily in RES. His principal responsibility is to provide technical advice to NRC senior management concerning radionuclide migration in the subsurface at NRC-licensed facilities. His work focuses on research in radionuclide transport at nuclear facilities primarily due to abnormal, accidental releases to the subsurface. He has formulated and directed numerous research studies as a senior project manager involving mitigative techniques for ground-water contamination associated with severe nuclear accidents; radionuclide transport in fractured rock; and integration of subsurface monitoring and modeling strategies. He has developed training courses and lectured on groundwater monitoring and modeling issues to the NRC licensing staff and regional inspectors. He co-edited the American Geophysical Union's (AGU) Special Publication 69 on Groundwater Vulnerability: Chernobyl Nuclear Disaster with Dr. Boris Faybishenko, Lawrence Berkeley National Laboratory. He holds a B.S. with distinction in geological sciences from Pennsylvania State University and a M.S. in hydrogeology from Stanford University. In 1989, he received the Meritorious Service Award for his scientific excellence. He is a registered Professional Geologist in Indiana and a certified Professional Hydrogeologist with the American Institute of Hydrology. He is a member of the AGU, Geological Society of America, International Association of Hydrological Sciences, the International Hydrogeologic Society, and the National Ground Water Association. He serves on the Steering Committee of the Federal Remediation Technologies Roundtable and the Interagency Collaborative for Environmental Modeling and Monitoring.

Vicky Freedman, Pacific Northwest National Laboratory

Dr. Vicky Freedman is the Soil and Groundwater Program Manager for the DOE Office of Environmental Management Sector at Pacific Northwest National Laboratory with 20 years of experience in practical applications of contaminant fate and transport in environmental systems. At PNNL, she leads the Deep Vadose Zone program, integrating investments from basic science, applied research, and site contractors to collaboratively identify innovative remediation alternatives for deep vadose zone challenges in characterization, prediction, remediation, and monitoring.

Presentation (2:00 PM):

Improvements in Cover Performance at Engineered Disposal Cells When Working with Nature to Inform Environmental Design

The Office of Legacy Management (LM) was formally established as a new DOE office on December 15, 2003. LM is responsible for ensuring that DOE's post-closure responsibilities are met, while providing DOE programs for long-term surveillance and maintenance, records management, work force restructuring and benefits continuity, property management, land use planning, and community assistance. LM is also responsible for the continued safety of radioactive and chemical-waste disposal cells, environmental contamination, and hazardous material at over 100 sites across the country. LM established its Applied Studies and Technology (AS&T) program to perform applied evaluations and laboratory-scale demonstrations of soil and groundwater remediation and treatment technologies. One component of the AS&T program assesses the long-term performance and sustainability of disposal-cell covers at radioactive tailings, which are regulated under the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA). Our work on disposal-

cell covers has shown that long-term performance and sustainability are enhanced by integrating natural systems into the basis for design. This has led LM to begin implementing water-balance covers, also known as evapotranspiration (ET) covers, rather than conventional rock covers, into our program. Lessons learned from the successful deployment of water-balance covers at DOE disposal facilities are creating new opportunities for improved designs at other disposal cells that are being constructed by other agencies. This paper offers insight into why our design basis has evolved from rock covers to water-balance covers and why we can expect the new designs to be more resilient.

Mark Kautsky, U.S. Department of Energy, Office of Legacy Management

Mark Kautsky is a program manager within the DOE Office of Legacy Management (LM). His primary area of responsibility is on the Uranium Mill Tailings Radiation Control Act, or (UMTRCA) sites for which LM has the long-term stewardship responsibility. Mark is responsible for managing the UMTRCA disposal sites and groundwater restoration activities at the Shiprock, NM and Tuba City, AZ sites. He is trained as a groundwater hydrologist, having obtained his MS degree in hydrogeology from the University of Nevada-Reno. Mark joined the Department of Energy in 2007.

Presentation (2:30 PM):

Black swans, disappearing lakes, and the societal value of integrated modeling and monitoring

Declining lake stage, and associated retreat of a lakeshore on the scale of hundreds of meters, is a rare and alarming “black swan” event that elicits expert advice like few others when numerous property owners and communities are affected. The value of combining field data with numerical modeling is demonstrated by comparing results from two studies of large lake-stage decline, one where modeling was part of the study and the other where it was not. In the first case, large lake-stage decline over several years was not related to reduced precipitation. Missing water from the lake water budget was suspected to be flowing to nearby municipal water-supply wells. However, field data indicated that groundwater was flowing toward the lake along the entire shoreline. Additional work, including rare measurements of vertical hydraulic gradients and seepage from the central, deepest portions of the lake, indicated loss of lake water to the underlying aquifer through portions of the lakebed farther from shore. Numerical modeling indicated loss from the lake to underlying groundwater was on the order of 5 million to 6 million gallons per day, larger than lake evaporation. In the second case, lake residents installed a high-capacity well to pump groundwater into the lake, which would restore lake levels as well as surrounding property values. After months of pumping, the lake stage had barely risen. Subsequent measurements by USGS indicated that groundwater was flowing to the lake along all shoreline segments except for a lakebed area within 200 m of the pumping well, where rapid downward flow through the lakebed was occurring. Prior study, along with modeling of exchange between groundwater and the lake, might have suggested a more judicious placement of the pumping well. Both cases demonstrate the importance and societal relevance of quantifying linkages between groundwater and surface water, and the efficacy of combining locally collected field data with scalable modeling results to better understand those connections.

Donald Rosenberry, U.S. Geological Survey

Dr. Donald Rosenberry is a research hydrologist with the U.S. Geological Survey in Lakewood, Colorado, with degrees in geology, hydrogeology, and geomorphology. Don studies the hydrology and hydrogeology of lakes, wetlands and streams, emphasizing flow between groundwater and surface water and the processes that affect and control that exchange. New tools and methods have been put to the test at numerous sites across the country, particularly where external factors have altered the natural or normal exchanges between groundwater and surface water. Don is a member of AGU, International Association of Hydrogeologists, and Geological Society of America, and is an associate editor of *Hydrological Processes*.

**Tuesday March 17 Session (3:15 PM) on
Global Change, Resilience, Adaptation, and Decision Science: Integrated Modeling, Monitoring and
Working with Nature**

Presentation (3:15 PM):

The National Climate Assessment: What Insights Does it Provide for Environmental Modeling, Monitoring, and Nature-Based Solutions?

The 4th National Climate Assessment report provides a wealth of data, information, and knowledge about how the Nation is and will be affected by a changing climate, as well as how we are responding. After an overview of the US Global Change Research Program and the NCA, several nature-based examples from the report will be presented. A quick tour of the website and its linked resources will encourage further exploration of this authoritative resource.

Fred Lipschultz, U.S. Global Change Research Program

Dr. Fred Lipschultz is a Senior Scientist at USGCRP where his responsibilities include working on the recently issued Fourth National Climate Assessment, coordinating with U.S. regional and state assessments, and serving as an advisor to international assessment activities. He also works on climate data provision issues.

Fred is now on assignment from Universities Space Research Association (USRA) to USGCRP. Previously he was on mobility assignments to NASA and NSF from the Bermuda Institute of Ocean Sciences, where he was a faculty member for 25 years. At NASA, Fred worked as a Program Scientist for the Ocean Biology and Biogeochemistry Program in the Earth Sciences Division and then was assigned to USGCRP. Before that, he served at NSF as Program Officer in the Chemical Oceanography Program in the Geosciences Directorate.

Fred's research career focused on the biogeochemistry of the marine nitrogen cycle in various ecosystems including Bermuda's coral reefs, the Sargasso Sea, and the Eastern Tropical Pacific. He earned his Ph.D. in Environmental Engineering from Harvard University after a Master's degree in Botany and B.S. in Biochemistry from the University of Maryland.

Presentation (3:45 PM):

Environmental Modeling and Monitoring: Resilience and Adaptive Management in the context of Nature-Based Solutions

Environmental models are of crucial importance for undertaking environmental assessment and management. Environmental models can range from simple qualitative cartoons reflecting major processes, to quantitative process-based mathematical models, all the way to miniaturized recreations of major physical environments. What is important about environmental models is their use. Rarely are environmental models developed in the abstract; more frequently, they are built to address specific decision needs. Nevertheless, the linkage of environmental models and decisions is defined with even less clarity than the taxonomy of environmental models itself. The decision maker with her/his values, goals, and mission (within the context of a limited funding stream and deadline) is often isolated from modeling efforts and has very little control over the modeling process and structure. This presentations will discuss a way that decision models can be added to the environmental modeling toolset to increase the usefulness of the totality of efforts in the field of environmental assessment and management. Resilience and Adaptive Management will be presented as examples where explicit linkage of environmental models and decision-analytical approaches is required.

Igor Linkov, U.S. Army Corps of Engineers

Dr. Igor Linkov is the Risk and Decision Science Focus Area Lead with the US Army Engineer Research and Development Center, and Adjunct Professor with Carnegie Mellon University. Dr. Linkov has managed multiple risk and resilience assessments and management projects in many application domains, including

transportation, supply chain, homeland security and defense, cybersecurity, and critical infrastructure. Dr. Linkov has organized more than forty national and international conferences and continuing education workshops. He has published widely on environmental policy, environmental modeling, and risk analysis, including twenty five books and over 400 peer-reviewed papers and book chapters in top journals, like Nature, Nature Nanotechnology, Nature Climate Change, among others. Dr. Linkov is Society for Risk Analysis Fellow and recipient of 2005 Chauncey Starr Award for exceptional contribution to Risk Analysis as well as 2014 Outstanding Practitioner Award and 2019 Distinguished Educator Award. He is Elected Fellow with the American Association for the Advancement of Science (AAAS). Dr. Linkov has a B.S. and M.Sc. in Physics and Mathematics (Polytechnic Institute) and a Ph.D. in Environmental, Occupational and Radiation Health (University of Pittsburgh). He completed his postdoctoral training in Risk Assessment at Harvard University.

**Tuesday March 17 Panel Discussion (4:15 PM)
moderated by Pierre Glynn and Patrick Deliman**

Patrick Deliman, U.S. Army Corps of Engineers

Dr. Patrick Deliman is a Supervisory Research Civil Engineer with the U.S. Army Corps of Engineers, and a former Chair of ICEMM and its precursor organization ISCMEM (Interagency Steering Committee for Multimedia Environmental Modeling). Dr. Deliman received B.S. and M.Sc. degrees from Mississippi State University, and a Ph.D. from Texas A&M University in the field of Agricultural Engineering.

**Wednesday March 18 Session (9:20 AM) on
Integrated Modeling and Monitoring Across Scales**

Presentation (9:20 AM):

Integrated Water Prediction at the U.S. Geological Survey

Abstract to be added later.

David Lesmes, U.S. Geological Survey

Dr. David Lesmes is the Water Prediction Work Program (2WP) Manager in the Water Mission Area (WMA). He reports to the Office of the Associate Director for Water. 2WP is a large scale program to develop a multi-agency Federal Water Prediction Capability to address critical societal problems such as water availability, flood hazards, harmful algal blooms and hypoxia, and invasive species. The program has many internal and external complexities and dependencies that will require this position to work with executives, managers, and technical staff at USGS, DOI and its bureaus, and other Cabinet level agencies such as the National Oceanic Atmospheric Administration, U.S. Department of Agriculture, U.S. Environmental Protection Agency, and the Department of Energy. In this position, David provides leadership and direction in the planning, development and implementation of water science and information programs for 2WP. David joined WMA from the Department of Energy's (DOE) Office of Biological and Environmental Research where he managed the Subsurface Biogeochemical Research (SBR) program in the Climate and Environmental Sciences Division.

At the DOE, David utilized a complex system science approach, encouraging SBR researchers to work in interdisciplinary teams across many different National Laboratories and institutions, to advance basic understanding of watershed system functioning and to develop core scientific capacities (e.g., High Performance Computing modeling tools, analytical capabilities, community data archives, and field research sites) that can become resources for the broader watershed system science community. David's technical area of expertise is in hydrogeophysics. Before joining DOE he worked as an Assistant Professor at Boston College and as a Postdoctoral Fellow at the Massachusetts Institute of Technology. David received a PhD in Geophysics from Texas A&M University and a B.A. in Physics from the University of California at San Diego. He has served on many interagency committees including the White House Office of Science and Technology Policy (OSTP) Subcommittee on Water Quality and Availability (SWAQ), the Community Advisory Committee for Water Prediction (CAC-WP), the U.S. Group on Earth Observations (USGEO), and the U.S. Global Change Research Program (USGCRP) Integrated Water Cycle Working Group.

Harry Jenter, U.S. Geological Survey

Biographical information to be added later.

Presentation (9:50 AM):

Next Generation Integrated Modeling of Water Availability in the Delaware River Basin and Beyond

For decades, rainfall-runoff models have been used to predict storm runoff for floods and water flows available for surface reservoir storage. More recently, multiple U.S. Science Agencies have been developing Land-Climate models that simulate the hydrologic cycle at the Earth's surface across the globe. These models, however, all lack a robust treatment of the flow of water in the subsurface—a process that is critical in controlling the amount of water in streams and rivers during low flow and drought conditions. Current work at the USGS is presented here that describes a new national-scale modeling project that simulates flow within the shallow groundwater system and its interaction with the full national network of rivers and streams. Results from the national model have produced wall-to-wall maps of depth to the water table and the transmissivity of the surficial aquifer system. Transient versions of the model are now being tested in the Delaware River Basin, where a variety of novel methods and observation types are being incorporated into a wholistic simulation of the watershed and its potential response to changes in climate and water demands forecast for the 21st century. The work is one of a number of pilot projects for EARTHMAP, a new USGS program being developed that will access 21st century technologies to integrate interdisciplinary human and landscape interactions into simulated forecasts for the CONUS of natural resources and hazards expected through this coming century.

Ward Sanford, U.S. Geological Survey

Ward Sanford received a PhD in Hydrogeology from Penn State University in 1987. He has spent over 30 years as a Research Hydrologist at the U. S. Geological Survey (USGS) in Reston, Virginia. He is a Senior Fellow of the Geological Society of America and has coauthored a textbook on Groundwater in Geologic Processes. The main focus of his research has been the development of regional groundwater flow and transport models and their calibration using environmental tracers. He has also worked internationally with the International Atomic Energy Agency, the US State Department, and the USGS in Thailand, Libya, Hungary, and the United Arab Emirates. In recent years as a Senior Scientist he has been mentoring postdocs and young scientists who are developing national-extent hydrologic simulation models of the surface and shallow subsurface to forecast the water table and stream flows under drought conditions. Current model development in the Delaware River Basin is being coupled with landcover forecast modeling to predict potential changes in water availability and streamflow conditions in response to projected changes in human demands and climate out to the year 2100.

Presentation (10:30 AM):

Integrating Natural Processes and Features into Watershed Modeling

The U.S. Army Corps of Engineers is developing environmental modeling capabilities for existing hydraulic and hydrologic modeling programs, which will facilitate integrated water quality modeling of rivers, reservoirs, and watershed runoff as well as river vegetation modeling. New water quality capabilities in HEC-ResSim (Reservoir System Simulation) will allow water quality objectives to be directly incorporated into the reservoir release decision-making process. Modelers can efficiently and rapidly extend existing reservoir operation models to build water quality models for environmental impacts assessment, planning, and real-time reservoir management. Modelers can specify reservoir operation rules based on water quality objectives, as specified in temperature or concentration units. Previously, environmental rules were determined by estimating the flows or water depths that might meet the objectives under ideal conditions, and they often conflated multiple objectives, such as minimum requirements for navigation and water supply. The new capabilities allow environmental objectives to directly influence the reservoir release decision-making process and facilitate computing environmental benefits. Riparian vegetation modeling capabilities were developed for HEC-RAS (River Analysis System) by coupling it with the Riparian Vegetation Simulation Module (RVSM). The new software allows evaluation of complex and dynamic interactions between vegetation, hydraulics, and sediment in natural and restored river ecosystems where natural features have been designed or installed. Modelers can evaluate and compare the stability, viability, and resilience of various river restoration plans, and improved water quality capabilities in HEC-RAS facilitate environmental assessment and management of rivers. The new tools will provide interdisciplinary teams the tools needed to perform integrated watershed-scale water quality assessments for real-time water management, planning studies, environmental impacts analysis, and ecosystem restoration.

Todd Steissberg, U.S. Army Corps of Engineers

Dr. Todd Steissberg is a Research Environmental Engineer at the U.S. Army Engineer Research and Development Center's Environmental Laboratory (ERDC-EL). He is currently leading a team that is developing water quality and vegetation simulation and analysis capabilities for hydraulic and hydrologic modeling programs. These are being used to solve complex water quality and ecosystem restoration problems in river systems, including the Missouri River Basin, the Columbia River Basin, and the Minnesota River Watershed. Dr. Steissberg is also collaborating to develop satellite-based tools for geospatial ecosystem assessment. The ultimate goal of his research and development activities is to provide interdisciplinary teams with the tools needed to perform integrated watershed-scale water quality assessments, which serve a critical role in real-time water management, planning studies, environmental impacts analysis, and ecosystem restoration.

Dr. Steissberg received his BS in Civil Engineering from Washington State University, where he participated in air pollution research and aquatic ecosystem restoration design. He received his MS and PhD in Civil and Environmental Engineering from the University of California, Davis, where he collaborated with NASA/JPL on research in satellite remote sensing, physical limnology, and water quality. He also served as a hydraulic engineering intern at the U.S. Army Corps of Engineers (USACE) Sacramento District, designing aquatic ecosystem restoration and fish passage projects. Dr. Steissberg worked as a postdoctoral researcher at UC Davis' John Muir Institute of the Environment at the Tahoe Environmental Research Center in Incline Village, NV, before joining the staff of the USACE Hydrologic Engineering Center (HEC) as a research hydraulic engineer in 2008. At HEC, Dr. Steissberg contributed to a variety of hydrology, hydraulics, geospatial, and water quality software research and development projects and studies. Dr. Steissberg served as the water quality software development lead at HEC from 2015 until his 2019 transfer to the Environmental Laboratory at ERDC, collaborating closely with staff from USACE and other organizations.

Presentation (11:00 AM):

Ecological Modeling and Emerging Directions for Understanding Ecosystem Impacts

The advent of mathematical models in ecology long preceded the age of computers. Ecologists used simple mathematical constructs in an effort to understand the dynamics of processes such as growth, competition, predation, and parasitism. As computers became increasingly available and powerful, ecologists began to utilize models for more complex analyses and for the management of environmental problems. The International Biological Program (IBP) was the catalyst for development of a number of large scale ecological models, designed to describe and predict the dynamics of a variety of ecosystems. Within the Federal Government, models have been increasingly employed to assist with managing natural resources and assessing hazard and risk to human health and natural systems from such stressors as radiation, pesticides, and toxic substances. There has been a transition in ecology from a data poor science to a data rich science, a trend which will enhance the quality of ecological models and expand the scope of modeling studies. We can expect increasing degrees of modularity and connectivity resulting in more complex models to take advantage of advances in computational power. There will need to be more emphasis on analyzing model results through such techniques as visualization and characterization of model uncertainty. We can also expect an expansion in the availability of sophisticated modeling tools such as EcoSim, R, Stella, and NetLogo. Lastly, we provide a short list of useful references and websites.

David Mauriello, University of Maryland

David Mauriello is a Systems Ecologist with experience in building and using models to facilitate decision making in a regulatory environment and to quantify risk to ecosystems from toxic chemicals. He received B.S. and M.S. degrees in electrical engineering from New York University. For the next six years, he was employed as an engineer by Bell Telephone Laboratories and Hewlett Packard. A life-long interest in nature led him back to graduate school, earning a Ph.D. in Ecology from Rutgers University, with a specialty in the then nascent field of Systems Ecology. He taught ecology at San Diego State University, before returning to the east coast to take a position as Deputy Director of the Maryland Coastal Zone Management Program. Subsequently, he joined the new Toxic Substance Office at the US Environmental Protection Agency, where he served as a Senior Ecologist. He developed ecological models and methodologies to quantify the risk of chemicals to aquatic organisms and ecosystems. He served as an author of the EPA Framework for Ecological Risk Assessment. After retiring from the EPA, he has served on the Anne Arundel County Severn River Commission, which serves as an advisory group on environmental issues in the Severn River watershed. He currently serves as Treasurer of the International Society for Ecological Modelling (ISEM).

Brenda Rashleigh, U.S. Environmental Protection Agency

Dr. Brenda Rashleigh is the Assistant Center Director/Matrix Interface for the Safe and Sustainable Water Resources (SSWR) Research program in the Environmental Protection Agency's Office of Research and Development, Center for Public Health and Environmental Assessment. She coordinates water research in the areas of aquatic resources, aquatic mapping, stormwater, nutrients and harmful algal blooms. Brenda's educational background includes a Ph.D. in Ecology and Evolutionary Biology (Complex Systems Group), M.S. in Environmental Science - Water Resources, and B.S. in Biological Science. Her technical expertise is in the area of scenarios and models for aquatic systems, including rivers, lakes, estuaries, and coasts using a range of approaches, from simple empirical models to complex mechanistic models and integrated modeling systems.

Brian Fath, Towson University

Brian D. Fath is Professor in the Department of Biological Sciences at Towson University (Maryland, USA) and Senior Research Scholar at the International Institute for Applied Systems Analysis (Laxenburg, Austria). He has published over 180 research papers, reports, and book chapters on environmental systems modeling, specifically in the areas of network analysis, urban metabolism, and sustainability. He co-authored the books *A New Ecology: Systems Perspective* (2020) *Foundations for Sustainability: A Coherent Framework of Life-Environment Relations* (2019) and *Flourishing Within Limits to Growth: Following nature's way* (2015). He is also Editor-in-Chief for the journal *Ecological Modelling* and co-

Editor in Chief for Current Research in Environmental Sustainability. Dr. Fath was the 2016 recipient of the Prigogine Medal for outstanding work in systems ecology, and twice a Fulbright Distinguished Chair (Parthenope University, Naples, Italy in 2012 and Masaryk University, Czech Republic in 2019).

Presentation (12:30 PM):

MultiSector Dynamics in Earth and Environmental Systems Modeling: Exploring Cross-Scale Interfaces Among Human and Natural Systems

The human-Earth system is highly complex and continuously changing. Influences and stressors take many forms and operate at myriad spatial and temporal scales, often in unanticipated ways. MultiSector Dynamics (MSD) seeks to advance a scientific understanding of these interactions with the ultimate goal of exploring the structure, function, and evolution of complex landscapes, in the broader sense of the term, consisting of human and natural systems and their interplay. With a significant emphasis on multi-model, multi-scale capabilities and open source frameworks, data systems, and tools spanning sub-regional to regional, and ultimately global scales, MSD focuses on these highly coupled systems...and geographies...under change. An important dimension of the work is to improve understanding of the non-linear system behaviors, tipping points, cascading affects, adaptations, and resilience among sectors, infrastructures, socioeconomic systems, and natural systems and environment. Capabilities often provide critical boundary conditions for fine-scale, more disciplinary modeling as well as the inputs and the initial conditions that drive computationally intense models of the global Earth system. A broad range of influences and stressors are often considered, including those contributing to both gradual and abrupt change. These may include individual and compounding effects of weather and its extremes (e.g., droughts, floods, heat waves, tropical cyclones), changing demographics and populations, infrastructure expansions, other forms of natural disturbances, land use changes, economic transitions, use and depletion of resources such as groundwater, and discovery of new energy resources and/or the role of new and/or shifting deployments of technologies. Accordingly, MSD builds from...and combines...a variety of modeling forms and methods, ranging from detailed physical and natural systems models to socio-economic, risk, and complex decision-theoretic models, most typically integrated within probabilistic frameworks.

Robert Vallario, U.S. Department of Energy, Office of Science

Robert Vallario is the Program Manager for Multisector Dynamics, Earth and Environmental Systems Modeling, within the U.S. Department of Energy's Office of Science. In his role, he oversees and coordinates a broad portfolio of basic research in data, modeling, and analysis exploring complex dynamics among human systems, sectors, and the environment. Much of the work focuses on interactions, interdependencies, and potential co-evolutionary pathways within the coupled human-Earth system, including connections among water, energy, and land systems and sectors. With a 29-year history at DOE, Mr. Vallario has been an active leader on various interagency committees, including but not limited to working groups on the integrated water cycle, scenarios and interpretive science, integrative modeling, and adaptation research within the U.S. Global Change Research Program and the National Science and Technology Council. He was recently a co-convening lead author along with an NSF colleague on a chapter of the National Climate Assessment on Sectoral Interactions, Compounding Stressors, and Complex Systems. He co-chaired the Department of Energy's cross-cutting activities at the energy-water nexus where he led the major components on data, modeling, and analysis. In previous positions within the Office of Science, Mr. Vallario has coordinated department-wide (as well as Office of Science) strategic planning and, earlier still, he held management positions in the areas of science and technology analysis and evaluation. Prior to joining DOE, Mr. Vallario was a program manager with Science Applications International Corporation (SAIC) and a senior research scientist and project manager with the DOE's Pacific Northwest National Laboratory (PNNL) where he was stationed both in Richland, Washington and the Washington DC offices, the latter involving activities for the Nuclear Regulatory Commission. He holds an undergraduate degree in environmental engineering from the University of Florida (1979) and a graduate degree in environmental sciences from Northwestern University (1981).

Presentation (1:15 PM):

Remote sensing for multi-scale monitoring of agricultural water use

Across the U.S. and globally there are ever increasing and competing demands for freshwater resources in support of food production, ecosystems services and human/industrial consumption. To facilitate wise water management, and to develop sustainable agricultural systems that will feed the Earth’s growing population into the future, there is a critical need for robust assessments of daily water use, or evapotranspiration (ET), over a wide range in spatial scales – from field to globe. While Earth Observing (EO) satellites can play a significant role in this endeavor, no single satellite provides the combined spatial, spectral and temporal characteristics required for actionable ET monitoring world-wide. In this presentation we discuss new methods for combining information from the current suite of EO satellites to address issues of water use, water quality and water security, particularly as they pertain to agricultural production. These methods fuse multi-scale diagnostic ET retrievals generated using shortwave and thermal infrared datasets from multiple EO platforms to generate ET datacubes with both high spatial (30-m pixels) and temporal (daily) resolution. We highlight several case studies where such ET datacubes are being mined to investigate changes in water use patterns over agricultural landscapes in response to changing land use, land management, and climate forcings.

Martha Anderson, U.S. Department of Agriculture, Agricultural Research Service

Martha C. Anderson is a Research Physical Scientist for the USDA Agricultural Research Service in the Hydrology and Remote Sensing Laboratory in Beltsville, MD. Her research interests focus on mapping water, energy, and carbon land-surface fluxes at field to continental scales using thermal remote sensing, with applications in irrigation management, drought monitoring and yield estimation. She is currently a member of the Landsat and ECOSTRESS Science Teams.

Wednesday March 18 Session (1:45 PM) on

Socio-Economic Considerations for Sustainable and Resilient Futures

Presentation (1:45 PM):

New Economic and Modeling Frameworks to Inform More Sustainable and Resilient Futures

Designed to support community-level resilience planning, the powerful online Economic Decision Guide Software (EDGe\$) Tool assists in selecting cost-effective community resilience projects. Produced by the National Institute of Standards and Technology (NIST), the EDGe\$ platform-independent app can help community planners and resilience officers, as well as economic development, budget, and public works officials.

EDGe\$ includes, but exceeds, the required Federal Emergency Management Agency (FEMA) Benefit-Cost Analysis (BCA) elements. It encourages users to consider non-disaster related benefits (co-benefits and co-costs) of resilience planning. Topics related to non-market values and uncertainty also are included. The methods are based on best practices in building economics and the economics of community resilience planning. The EDGe\$ Tool is meant to be practical, flexible, and transparent. The approach can be applied across a wide range of community and project types.

Additional discussion will take place on efforts at NIST to extend modeling of the value of the resilience dividend throughout a regional economy to provide greater inputs to tools such as EDGe\$.

Jennifer Helgeson, National Institute of Standards and Technology

Dr. Jennifer Helgeson is a research economist in the Applied Economics Office of the Engineering Laboratory (EL) at the National Institute of Standards and Technology (NIST). She currently leads the office's work on the "Economics of Community Resilience Planning." Dr. Helgeson’s research revolves around resilience to hazards (shocks and stressors) in the built environment, with consideration for cost-effectiveness of community- scale mitigation and adaptation efforts. She earned her M.S. Degree in Environmental Change and Management with a focus on Environmental Economics at the University of Oxford and holds a Ph.D. in Environmental and Developmental Economics from the London School of Economics (LSE).

Presentation 2:15 PM):

Socio-Economic Considerations of Drivers, Impacts, and Responses to Manage our Environmental Futures

Social, economic and environmental systems form tightly coupled, complex and dynamic relationships. Key factors that drive environmental change (e.g., demographic, economic, land use, technology, infrastructure, sociocultural, institution) interact across various spatial and temporal scales. Our understanding and management of environmental issues, including drivers, impacts and responses, therefore require integrated frameworks supported by interdisciplinary approaches and data and informed by decision contexts and user needs. This presentation illustrates some of the key considerations with a case study of socio-environmental indicators of wildfire risks, vulnerability and resilience across a range of scales in the U.S.

Jia Li, U.S. Environmental Protection Agency

Dr. Jia Li is an environmental economist at the U.S. Environmental Protection Agency (EPA)’s Climate Change Division. Jia has 20 years of experience in energy, climate change and environmental policy and analysis. Her current work focuses on the policy, economics and integrated assessment of climate change at global, national and subnational levels, including mitigation, impacts, resilience and adaptation. Jia has served as a Co-Chair of the Social Science Coordinating Committee of the U.S. Global Change Research Program. In that capacity, she has worked on interdisciplinary research efforts and integration of social and behavioral sciences in climate assessments and research programs to inform climate response and resilience decisions. Between 2013 and 2014, she served as the Deputy Associate Director for Energy and Climate Change at the White House Council on Environmental Quality (CEQ). In 2017, Jia worked in Nepal as a State Department Science Fellow on air quality management, climate change and human health issues in the South Asia region. Jia has a Ph.D. in agricultural and resource economics from the University of Maryland, College Park and M.S. in environmental management and policy from the University of North Carolina, Chapel Hill.

Wednesday March 18 Keynote (3:00 PM)

Managing Complex Socio-Environmental Systems – An Evolutionary, System-of-Systems Approach

Following the evolution of Homo sapiens, human cooperation accelerated the emergence of new social, economic and technical systems, while allowing humans to strongly influence existing earth, climate and ecosystems, resulting in the emergence of a globally-connected system of complex, socio-environmental systems (SEs). We briefly review the emergence of the global system of SEs in which our lives are now embedded, and then synthesize our review in a proposal to integrate across knowledge domains and disciplines using an evolutionary, system-of-systems approach. Currently, most studies of SEs focus on a few small subsystems, and simply ignore the dynamics of the larger systems. Consider, for example, food/energy/water, which may include interactions among watershed, land-use, agriculture, climate, energy, transportation, ecosystems, communication, as well as economic, legal and other social systems. A recent systematic review of 245 publications on food/energy/water revealed that most do not even capture interactions among

water, energy and food, let alone the complex dynamics among many systems. In addition, most disciplines tend to begin with their own system and then connect to a few other subsystems meaning that there is no systematic basis to compare results. To make matters worse, many socio-environmental problems (e.g., climate change, food/energy/water, coastal flooding, disaster management, and urban planning) are generally treated as separate problems, but are in fact intimately related and cannot be managed independently. To more effectively deal with these systemic challenges, we propose to divide the world into socioeconomic, technical and environmental systems (e.g., as listed previously for food/energy/water); study and characterize them separately over a range of scales; and then systematically re-combine them in a generic, tiered, system-of-systems (GTSoS) modeling and data science framework to simultaneously address a wide range of socio-environmental problems..

John Little, Virginia Tech

John Little received a BS in Chemical Engineering from the University of Cape Town and an MS and PhD in Environmental Engineering from the University of California, Berkeley. After completing a Postdoc at Lawrence Berkeley National Laboratory, he joined the Department of Civil and Environmental Engineering at Virginia Tech, and is currently Charles E. Via, Jr. Professor. His primary research interests are cross-media mass transfer and process dynamics in environmental systems, focusing on understanding and controlling chemical emissions from building materials and consumer products and managing water quality in lakes and reservoirs. A more recent focus is the management of complex socio-environmental problems using a system-of-systems modeling and data-science framework. Dr. Little received a National Science Foundation Career Award in 1996, was elected to the International Society of Indoor Air Quality and Climate Academy of Fellows in 2008, received the Association of Environmental Engineering and Science Professors (AEESP)/CH2M Hill Outstanding Doctoral Dissertation Award in 2011, and the North American Lake Management Society Technical Merit Research Award in 2014. Dr. Little has been a visiting professor at University of Sydney, Australia; Swiss Federal Institute for Aquatic Science and Technology (Eawag), Switzerland; Tsinghua University, China; National Cheng Kung University, Taiwan; University of Granada, Spain; Centre Scientifique et Technique du Bâtiment, France; and University of La Rochelle, France.

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**Wednesday March 18 Panel Discussion (4:15 PM)
moderated by Tom Nicholson**

**Wednesday March 18 Working Group Presentations and Steering Committee Business (4:30 PM)
moderated by Pierre Glynn**

Further meeting information provided at the ICEMM Website:

<https://my.usgs.gov/confluence/display/cdi/Interagency+Collaborative+for+Environmental+Modeling+and+Monitoring>