NIST Grant/Contractor Report
NIST GCR 23-042

ASCE-NOAA Leadership Summit on Climate-Ready Infrastructure

Summary Report from a Summit held February 2, 2023 at ASCE Headquarters, Reston, VA

Adam Parris, ICF
Samantha Heitsch, ICF
D'Arcy Carlson, ICF

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NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
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April 2023

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Abstract

This document summarizes presentations and discussions from the February 2023 ASCE-NOAA Leadership Summit. It also presents key takeaways from the Summit for NIST to consider in advancing community resilience planning and assessment through community user guidance, particularly via updates to NIST's Community Resilience Program published the Community Resilience Planning Guide (CRPG).

Keywords

American Society of Civil Engineers; climate change; climate resilience; climate science; engineering; equity; National Oceanic and Atmospheric Administration.

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Executive Summary

Facing a steady drumbeat of billion-dollar disasters over the past decade, communities across the United States are making urgent upgrades to aging infrastructure. As part of infrastructure planning, engineers, urban planners, and community residents need climate data to ensure that projects withstand future climate change. The American Society of Civil Engineers (ASCE) and the National Oceanic and Atmospheric Administration (NOAA) share a goal to support civil engineers in designing climate resilient and sustainable infrastructure. ASCE and NOAA entered into a formal partnership and held a one-day Leadership Summit (Summit; https://go.asce.org/asce-noaa-climate-summit) on February 2, 2023, bringing together scientists, civil engineers, planners, and infrastructure managers (see Appendix B for a complete list of participants). Appendix C provides the ASCE-NOAA Memorandum of Understanding (MOU).

Several themes emerged from the Summit, including the following:

- Engineers have immediate needs for climate data in order to support climate-resilient infrastructure investments.
- Communities should have a stronger role in infrastructure planning.
- Civil engineers and urban planners are increasingly aware of and anticipating changes in climate. Many design standards are based on a premise of a stationary climate. However, all fields largely recognize the climate and social, environmental, and economic conditions are changing and require improved design processes and standards.
- ASCE standards and manuals are used by engineers across the world. Revising those standards to incorporate climate science will require strong collaboration among civil engineers and climate scientists. There is a growing body of research and practice related to using climate data in infrastructure design. For example, engineers typically use the best available observational data (e.g., an estimate of extreme precipitation). Given non-stationarity, climate scientists regard such estimates for future conditions to be of limited value; projections themselves introduce uncertainty of their own. While leading practices are emerging, use of climate data in infrastructure design largely remains ad-hoc.
- Interaction between scientists and the engineering community can support seemingly simple tasks such as developing shared definitions for technical terms, guidance for how to choose a design criterion among a range of values, and where to access existing tools and information.

To support revision of the Community Resilience Planning Guide (CRPG) and build on discussions at the Summit, National Institute of Standards and Technology (NIST), NOAA, and ASCE will hold three workshops in 2023. This report provides a summary of the discussions at the Summit as a foundation for planning the three workshops. The brief Executive Summary highlights themes that emerged throughout the Summit, and the remaining sections are organized according to the panel presentations and discussions as follows:

- Plenary Session - Welcome, MOU, and Introductions
- Panel 1 – Climate Resilience in Engineering Practice: Progress and Way Forward
- Panel 2 – Climate Resilience in Engineering Practice: Broader Perspectives
- Climate Change: The Engineer’s Dilemma

- Panel 3 – Designing for Equity in Climate-Ready Infrastructure
- Discussion

1. Plenary Session – Welcome, MOU, and Introductions

During the plenary, speakers provided background on ASCE and NOAA and their partnership under the recent MOU. The ASCE-NOAA partnership aims to build climate resilient and sustainable infrastructure, with equity as a priority. The MOU provides an overview of how NOAA's science and resources can be used to inform civil engineering and building codes, standards, and best practices.

1.1. Panelists

- **Bilal Ayyub**, Ph.D., P.E., Dist.M.ASCE, Professor & Director of the Center for Technology and Systems Management, University of Maryland (UMD)
- **Richard W. Spinrad**, Ph.D., CMarSci, Under Secretary of Commerce for Oceans and Atmosphere and NOAA Administrator
- **Tom Smith**, CAE, ENV SP, F.ASCE, Executive Director, ASCE
- **Maria Lehman**, P.E., ENV SP, F.ASCE, 2023 ASCE President

1.2. Notes from Speakers

- **Dr. Bilal Ayyub** provided background on the ASCE-NOAA partnership, which aims to make the nation's infrastructure climate resilient. The ASCE-NOAA partnership originated in November of 2021 when a cooperative agreement was formed between NOAA, University of Maryland (UMD), and ASCE. NOAA priorities are to provide climate information and services, equity-centered decision support, and economic development. ASCE aims to support engineers in designing climate resilient and sustainable infrastructure. Technical activities of this partnership include the ASCE-NOAA Task Force Workshops.
- **Dr. Richard Spinrad** framed the concept of a climate-ready nation (CRN), whose prosperity, growth, and benefits depend on a shared understanding of the impacts of climate change and collective action to reduce these impacts. As new funding emerges for climate-related efforts (e.g., from BIL, IRA), it is critical to sustain partnerships and relationships. The 2021 agreement with UMD facilitated important dialogue between NOAA scientists and engineers, as well as technical workshops. NOAA and ASCE's shared principles and objectives will allow them to accelerate the resilience space at the intersection of engineering and climate science. A major goal is to have climate science mainstreamed into civil engineering.
- **Tom Smith** (the Executive Director of ASCE) provided an overview of ASCE. ASCE's new vision statement is, "Engineering and natural system working in harmony for humanity." Smith emphasized the importance of being forward-looking in climate resilience work. Communication and clear, reliable information are critical, and the NOAA-ASCE partnership will help facilitate them.

- **Maria Lehman** (the President of ASCE) explained that ASCE has long been interested in climate resilience and were awaiting funding, which they now have as a result of recent federal funding. ASCE has been advocating for federal investments in infrastructure for decades. Now that recent funding has been secured, ASCE must change "everything we do," from focusing on advocacy to focusing on supporting implementation of resilient design and construction. For example, ASCE would like infrastructure designed today to have a 50 to 100-year functional lifespan and to consider both the anticipated future social and climate conditions.

2. Panel 1 – Climate Resilience in Engineering Practice: Progress and Way Forward

The ASCE-NOAA Taskforce (facilitated by a cooperative agreement between NOAA and the University of Maryland (UMD)) organized a series of technical workshops to consider the role of environmental hazards in standards and building codes. Panel 1 provided an overview and takeaways from the four workshops which focused on distinct climate-related hazards – intense rainfall, extreme temperatures, coastal hazards with a focus on flooding, and straight-line winds, along with the identified information needs, sources, and processes that resulted from those workshops.

2.1. Moderators

- **Dan Walker**, Ph.D., A.M.ASCE, Associate Director for Multidisciplinary Studies, University of Maryland and EA Engineering, Science, and Technology, Inc. (PBC)
- **Benjamin J. DeAngelo**, Deputy Director, NOAA Climate Program Office, NOAA Principal to the U.S. Global Change Research Program

2.2. Panelists

- **Don Scott**, P.E., S.E., F.SEI, F.ASCE, President – Don Scott Consulting
- **Mari Tye**, Ph.D., Scientist, The National Center for Atmospheric Research
- **John Dai**, P.E., Seismic & Climate Adaptation Civil Engineer, SoCal Edison
- **Mark S. Osler**, NOAA, Senior Advisor for Coastal Inundation and Resilience
- **Dan Barrie**, Ph.D., Climate Modeling, Analysis, Predictions, and Projections Program Manager (MAPP), NOAA

2.3. Synthesis

There were several overarching takeaways from Panel 1. There is a need to have better communication between scientists and engineers to develop shared priorities in climate and infrastructure resilience, especially considering the distinct considerations that engineers and climate scientists bring to understanding and addressing problems. NOAA expressed interest in bringing the best available climate science to the ongoing discussions and collaborations through both its federal and non-federal partners. The NOAA representatives further expressed the desirability of an "unbranded" climate science input into engineering standards. There should be consensus by multiple agencies or institutions on the climate science. ASCE should review available climate science for engineering applications to help determine what is the ‘best available.’ Finally, there are many tools and data that are readily available across all hazards, and it would be beneficial to have a ‘toolbox’ to provide these resources to civil engineers.

2.4. Notes from Speakers

- **Dr. Dan Walker** emphasized the need for relevant climate science and research to transition into action and design for engineering. The Summit is the first step in a 5+ year relationship meant to accomplish that transition. He acknowledged that scientists and engineers have different approaches and mentalities, and that working together is necessary but will include challenges and require shifts in approach from both sides.
- **Ben D’Angelo** gave a background on the technical workshops that led to the Summit. The workshops were implemented under a cooperative agreement with the University of Maryland and each focused on one of four climate-related risks: temperature, rainfall, straight line winds, and coastal hazards. The workshops were organized around risks and environmental hazards because that was a starting point around which both scientists and engineers could communicate. He believes these workshops provide a model for communications moving forward (i.e., maintaining clusters around climate risk areas and environmental hazards).
- **Don Scott** discussed how climate resilience may be advanced through ASCE Standards and Manuals of Practice. ASCE has issued over 70 standards (many of which are adopted into building codes) and has published over 150 manuals of practice using the best data available at the time. Many of these manuals of practice reference ASCE 7 (Minimum Design Loads and Associated Criteria for Buildings and Other Structures) to determine loads on buildings and systems caused by environmental hazards. Updates occur every 6 years, and the 2028 development cycle (ASCE 7-28 cycle) just began, meaning that its adoption of updated standards and recommendations will not be incorporated into local building codes until at least 2030. ASCE hosted its own Climate Impacts Workshops and will incorporate takeaways learned from the ASCE-NOAA Leadership Summit.
- **Dr. Mari Tye** focused her comments on the rainfall intensity workshop, which had two sessions and brought together engineers and scientists. The first session established the basics (e.g., What does everyone bring to the table? How do you balance the different priorities?) and talked broadly about the challenges of extreme precipitation on infrastructure. The second session was practice-focused and discussed intensity-duration-frequency (IDF) curves, what Atlas 15 could look like, what information is needed, and next steps. The workshop did not cover the changing nature of rainfall patterns or other aspects of precipitation (e.g., flood depths are currently outsourced to NOAA), nor dialogue with economists. There was a strong push for best practice guidance from ASCE and NOAA on the appropriate use of climate information.
- **John Dai** noted that the extreme temperature workshop started with a consideration of needs and, specifically, where climate science can be incorporated. The workshop focused primarily on ASCE-32 (Design and Construction of Frost-Protected Shallow Foundations) and ASCE-21 (Automated People Mover Standards), which were identified as the ASCE standards directly related to extreme temperature. Climate science is needed to support ASCE standards regarding transportation engineering, cold weather engineering, hydrology and hydraulics, and structural engineering. Participants also

discussed that non-stationarity is not currently accounted for in the standards, although it should be.

- **Mark Osler** covered the coastal hazards workshop, which focused specifically on building standards (primarily ASCE-24, Flood Resistant Design and Construction, and ASCE-7, Minimum Design Loads and Associated Criteria for Buildings and Other Structures). Coastal hazards are a subset under flooding, and standards are typically centered on the depth of flooding. Future steps identified include NOAA alignment to decision-making and consensus-building on research application, and ensuring access to nationally consistent, locally relevant, and authoritative hazard information to support the engineering community. It is also important to determine base flood elevation (BFE) under a changing climate, as well as recognize that there are uncertainties not well understood by the engineering communities.
- **Dr. Dan Barrie** discussed the straight-line winds workshop, which centered on the need to consider wind speed risk for engineer structures. NOAA capabilities that could be used include multi-scale modeling capabilities, the strong understanding of the atmosphere in its lowest levels, and projection updates for wind speeds for ASCE standards. The Wind Improvement and Forecast project seeks to understand spatial and temporal variability in this part of the atmosphere, which can help bias-correct models and provide fine-scale meteorological forecasts. The workshop also touched on NOAA's MAPP Program approach. A critical wind data need is to have information over longer, multi-decadal to centennial timescales.

3. Panel 2 – Climate Resilience in Engineering Practice: Broader Perspectives

In Panel 2, infrastructure is defined as resources and services to sustain modern communities (such as transportation, energy, water, telecommunication, and the public/private sector buildings). A key question of this panel is how to pay for climate-ready resilience infrastructure.

3.1. Moderators

- **Deborah H. Lee**, F.ASCE, 2020 EWRI President, NOAA, Director, Great Lakes Environmental Research Laboratory
- **Thomas O'Rourke**, Dist.M.ASCE, NAE, Thomas R. Briggs Professor in Engineering Emeritus, Cornell University

3.2. Panelists

- **Jason Averill**, Chief, Materials and Structural Systems Division, Engineering Laboratory, NIST
- **Sarah Kapnick**, Ph.D., Chief Scientist, NOAA
- **Pete Perez**, P.E., Chief of Engineering and Construction, U.S. Army Corps of Engineers
- **John Ingargiola**, Lead Physical Scientist, FEMA
- **Kit Ng**, Ph.D., P.E., Hydraulics and Hydrology Manager, Geotechnical and Hydraulic Engineering Services, Bechtel

3.3. Synthesis

A major ongoing question being asked is how to best pay for climate-ready resilience infrastructure. There is a significant opportunity to leverage existing knowledge and resources (such as from NOAA and FEMA), and some large infrastructure providers or managers are actively considering how they can better incorporate and/or improve climate resilience as climate change becomes a mainstream consideration in their work (such as NOAA, FEMA, USACE, and firms like Bechtel Corporation).

3.4. Notes from Speakers

- **Jason Averill** discussed the power of private-public partnerships in achieving solutions for difficult issues, providing the example of the successful push in the 1970s to reduce the number of fire deaths. Averill also noted that there is ongoing NIST research, including the consideration of standards for tornados and urban-wildland fire risk, as well as applied economics of resilience. An important role for applied science is to link science and applications within codes and standards.
- **Dr. Sarah Kapnick** discussed leveraging NOAA climate knowledge and resources to build a climate ready nation, which is especially relevant as there is a growing demand for climate information. NOAA data are used in a variety of ways by various people – companies conduct risk assessments with NOAA data, and companies collect data that NOAA and others can use.
- **Pete Perez** explained that USACE mainstreams climate change into normal business procedures in order to consider uncertainties. USACE also aligns climate resilience with zero carbon – for example, energy and water efficiency; hydropower; nature-based solutions; and consideration of Scope 3 (indirect) GHG emissions in materials to buy "clean." Further, USACE aims to ensure climate preparedness for all (i.e., comprehensive benefits and environmental justice).
- **John Ingargiola** outlined FEMA's role in improving climate resilience (i.e., modeling, planning, and implementation). FEMA provides funding/flood insurance, hazard data products, guidance publications, and technical assistance. Some of FEMA's needs are hazard information data, accounting for future data, and specific climate projections. FEMA has Mitigation Assessment Teams (MATs) deployed after natural disaster events, but they are in need of hazard data such as detailed hindcasting to better understand resilience efforts. Next steps for FEMA include developing future flood risk data (i.e., replacing existing binary maps with data products) and building codes strategy (i.e., integrate building codes and standards across FEMA; strengthen nationwide capability; and drive public action on building codes). The National Initiative to Advance Building Codes (NIABC) is an inter-agency group that brainstorms national strategy, and its priorities include modernizing building codes, improving climate resilience, and prioritizing underserved communities.
- **Dr. Kit Ng** outlined how her work at Bechtel Corporation has evolved to better incorporate climate resilience. There are different stressors, responses, opportunities, and barriers depending on the siting of a project, as well as the customer profile/expectation. A key challenge is that key design parameters are needed early in the engineering process (e.g., FEED). For example, there is often limited time to determine the flood level, and it

is expensive to change design plans. Other challenges include the certainty of outcomes – uncertainty in climate projection, uncertainty in hazard and risk quantification, and uncertainty in performance/investment return quantification – and standards and guides, as one size does not fit all.

4. Climate Change: The Engineer's Dilemma

This Engineer's Dilemma presentation discussed the ASCE Industry Leaders Council & Technical Committee on Future Weather and Climate Extremes.

4.1. Moderator

- **Steve Thur**, Ph.D., Assistant Administrator, Oceanic and Atmospheric Research, NOAA

4.2. Speaker

- **Chris Stone**, P.E., F.NSPE, F.ASCE, LEED AP, Senior Principal, Clark Nexsen

4.3. Notes from Speaker

- There is the ongoing consideration of how to meet the professional engineer's Standard of Care (SoC) in a changing climate.
    - For the SoC, "ordinary and reasonable care" is used as a legal definition.
    - Key questions for discussion: How does this relate to the issues of design and climate change? Are you responding to the standard of care as an engineer? How do engineers defend themselves when making recommendations (i.e., how they can say they are meeting the SoC, which has less of a firm definition in regard to incorporating climate change into decision-making)?
- Code-based standards are primarily focused on individual facilities and are out of sync with community resilience needs, and community-level resilience goals must be integrated, as explained in the ASCE publication *Resilience-Based Performance: Next Generation Guidelines for Buildings and Lifeline Standards*. This 2019 publication provides an outline of a new approach that supports communities' social stability, economic vitality, and environmental sustainability. Existing building codes and standards are not up-to-date with the most recent understanding of climate change, as they assume future weather conditions that would resemble the past (i.e., stationarity).
- Proactively integrating mitigation measures into new construction is often more economically feasible than retrofitting existing structures, such as adopting strategies that exceed model codes. Engineers should seek opportunities that do well across a range of possible future conditions. Standards have improved at representing shocks to the system, but engineers still need to improve their response to stressors in addition to shocks – due to climatic and non-climatic conditions (e.g., increasing temperatures, aging population, population growth, affordability, aging infrastructure).
- The engineering community is diverse, including some skeptics and deniers. As codes must be unanimously approved, there is the need to identify minimum requirements based on science, as well as recommended alternatives.

- It is important to clearly define resilience and sustainability concepts in terms that can be applied during engineering design and assessments.
- A major challenge for the average engineer is actually putting it all into practice. Another major challenge for engineers is that codes are primarily focused on individual buildings and structures and not networks (and, the engineering community is really starting to embrace the need for a network focus). Also, codes have emphasis on life safety, and there is a need to integrate community-level climate resilience goals.
- This session provided many examples and case studies to convey gaps in engineering practice relative to climate effects on hazards and resilience. In addition, ASCE has a number of publications on infrastructure resilience and adaptation. The Virginia case studies in the presentation illustrate several challenges raised by previous presenters, such as:
    - The need to incorporate future flooding into FEMA flood maps.
    - The need to account for changing intensity, duration, and frequency of extreme rainfall in NOAA Atlas 14 and other products.
    - Continued innovation of stormwater management using green infrastructure, best management practices (BMPs), and integrated strategies like the Richmond Coastal Resilience Master Plan.

5. Panel 3 – Designing for Equity in Climate-Ready Infrastructure

Panel 3 discussed experiences in planning and designing for equity, resilience, and environmental justice in climate-ready infrastructure.

5.1. Moderators

- **Kimberly Jones**, Ph.D., Associate Provost and Professor, Civil and Environmental Engineering at Howard University
- **Vankita Brown**, Ph.D., Senior Advisor for Equity, NOAA

5.2. Panelists

- **Catherine Coleman Flowers**, MacArthur Fellow and Founder, Center for Rural Enterprise and Environmental Justice
- **Eric Letvin**, Assistant Administrator for Mitigation, FEMA
- **Marccus Hendricks**, Ph.D., Professor and Director of SIRJ Lab, University of Maryland
- **Renee Collini**, Ph.D., Center for Equitable Climate Resilience Director, The Water Institute
- **Gerry Galloway**, Dist.M.ASCE, Emeritus Research Professor, Civil & Environmental Engineering, University of Maryland

5.3. Synthesis

An overarching takeaway from Panel 3 is that there is still much progress to be made. There are significant disparities across infrastructure resilience, climatic and non-climatic shocks and stressors, and resources. Procedural, distributive, and restorative climate justice must be included in all decision-making and design processes.[1] Further, the incorporation of equity and resilience should be active, not reactive or last-minute. Justice is an intrinsic right and incorporates the consideration of fixing the system to promote fair access and opportunities; whereas equity promotes fair access to resources by identifying specific tools or opportunities. Generally, equity is becoming an increasing area of focus and/or consideration for organizations (e.g., FEMA BRIC) but it can be further improved.

5.4. Notes from Speakers

- **Catherine Coleman Flowers**, the co-chair of the White House Environmental Justice Advisory Council (EJ Council), noted that even with the Bipartisan Infrastructure Law (BIL), there is still progress to be made. Infrastructure should be available and functional before it is forced, or too late. For example, the overflowing of septic systems during storms resulted in the exposure of Alabama communities to hookworm. Partnerships with community-based organizations (CBOs), local governments, and local organizations proactively and early in the stages of infrastructure planning are important to help avoid loss of function and negative impacts, as opposed to discovering them when health and safety problems arise.
- **Eric Letvin** noted that climate and equity are becoming foundational pillars in FEMA grant programs. Last year, 49% of funding for the Building Resilient Infrastructure and Communities (BRIC) program went to disadvantaged communities. FEMA is continually evaluating BRIC program performance relative to equity goals (it will be released shortly). The Cost of Cost-Effectiveness: Expanding Equity in Federal Emergency Management Agency Hazard Mitigation Assistance Grants assesses how FEMA's benefit-cost analysis (CA) process (for projects seeking HMA grants) can be simplified to better include communities with less resources. The Building Resilient Infrastructure and Communities Mitigation Grant Program: Incorporating Hazard Risk and Social Equity into Decisionmaking Processes evaluates FEMA's BRIC program its incorporation of equity considerations (e.g., BRIC's BCA and risk analyses are biases toward wealthy communities and underserved communities see more barriers to meeting the BRIC criteria). FEMA also provides direct technical assistance (DTA). Next year, 40 communities are receiving DTA. FEMA will continue to consider how to lower the barrier(s) to accessing funds and how to improve their tracking of whether money is flowing into those communities that need it.
- **Dr. Marccus Hendricks** discussed infrastructure and hazards: people, pipelines, and pathways. There are disparities within the infrastructure crisis (e.g., lead-lined pipes in Flint), and the nation's environmental laws, regulations, and policies often have not been equitably applied across populations. To advance justice in the infrastructure field, procedural, distributive, and restorative justice must be included; the built environment must be recognized as a continuation of social circumstances; and must recognize that infrastructure dynamics have direct implications for risk exposure.
- In discussing the distribution of infrastructure investments, **Dr. Renee Collini** noted the significant capacity disparities at the regional, state, and local levels. Different states also

[1] Procedural climate justice is the process of making climate-related decisions that are fair, accountable, and transparent. Distributive climate justice considers how costs and benefits are spatially and temporally allocated across society (Newell et al. 2021). Restorative climate justice considers the climate-related impacts and how to hold accountability for those impacts.

have different capacities to support local communities. The distribution of infrastructure investments depends on valuation, decision processes, and policy ripples. Decision processes are typically top-down decisions by elected leaders, which results in an exclusive structure that does not include the entire community in the decision-making process. The policy process is also important in considering who bears the burden and absorbs the extra costs. For example, under FEMA Risk Rating 2.0, people are assuming flood risk in premiums which they cannot afford, as it does not consider who lives in certain areas and why (and who bears the burden). Equitable infrastructure must not only include the technical design process but also the process for deciding what infrastructure is built for whom, which will require funding to support stakeholder engagement. Stakeholder engagement has to be developed over a long period of time.

- **Gerry Galloway** illustrated that infrastructure is often not equal, not equitable, and not just. For example, in Houston communities, homes were built in areas with known drainage issues; 80% of open drainage ditch service areas were in Black communities, and 70% of these service areas were not capable of conveying the appropriate volume of stormwater. Equity and infrastructure is still new for the field of civil engineering. Challenges to producing equitable outcomes include inclusive education, limited analysis (e.g., single focus BCA), nineteenth century governance, and project vs. holistic system.

6. Discussion

In parallel, ASCE, NOAA, and NIST are collaborating to improve the application of climate science to civil engineering resilience guidance. NIST is working to advance community resilience planning and assessment through community user guidance. NIST's Community Resilience Program published the Community Resilience Planning Guide (CRPG) for Buildings and Infrastructure Systems (2015) and the companion Playbook (2020). The CRPG — and accompanying Economic Decision Guide (EDG) for Buildings and Infrastructure Systems — has since been used by U.S. communities (e.g., municipalities, counties, community organizations, etc.) to aid their resilience planning efforts. The CRPG focuses on resilience planning for the built environment (buildings and structures, water, energy, transportation, communication) as foundational elements for ensuring that community services can recover functions quickly. As forward-looking climate projections are being incorporated by communities into their planning, NIST seeks to update the CRPG with emerging leading practices to ensure that future climate impacts on infrastructure systems and communities are incorporated in community resilience planning.

Some takeaways from the Summit for NIST to consider are as follows:

- In considering engineers' immediate needs for climate data in order to support climate-resilient infrastructure investments, it is important to note that CRPG and interim guidance and standards can support large investments in infrastructure that will occur as ASCE-7 (Minimum Design Loads and Associated Criteria for Buildings and Other Structures) and other standards are formally revised over the next several years.
- The objective of communities to have a stronger role in infrastructure planning can be supported by including community leaders in future workshops and engagements related to the NIST-ASCE-NOAA effort. However, meeting this objective will also require efforts to build community capacity to expand and strengthen community participation

over time, especially given the highly technical nature of infrastructure planning (e.g., NOAA Climate Smart Communities Initiative; NIST community resilience work; and community resilience work of EPA, FEMA, and HUD).

- Sustained knowledge exchange between engineers, scientists, planners, and community leaders at venues like the Summit and the forthcoming NIST-ASCE-NOAA workshops can strengthen collaboration between partners.

● References

[1] Newell P (2021) Toward transformative climate justice: An emerging research agenda. *Wiley Interdisciplinary Reviews: Climate Change* 12(6):e733. https://doi.org/10.1002/wcc.733

Appendix A. Agenda

Thursday, February 2, 2023		
Time	**Objective**	
8:00 AM	**Registration & Breakfast**	
8:30 AM – 9:15 AM	**Plenary Session** **Welcome, MOU and Introductions** **Speakers:** ● Bilal Ayyub, Ph.D., P.E., Dist.M.ASCE, Professor & Director of the Center for Technology and Systems Management, University of Maryland (UMD) ● Tom Smith, CAE, ENV SP, F.ASCE, Executive Director, ASCE ● Maria Lehman, P.E., ENV SP, F.ASCE, 2023 ASCE, President ● Richard W. Spinrad, Ph.D., CMarSci, Under Secretary of Commerce for Oceans and Atmosphere and NOAA Administrator	ASCE Big Three
9:15 AM – 10:10 AM	**Panel 1: Climate Resilience in Engineering Practice: Progress and Way Forward** **Speakers:** ● John Dai, P.E., Seismic & Climate Adaptation Civil Engineer, SoCal Edison ● Mark S. Osler, NOAA, Senior Advisor for Coastal Inundation and Resilience ● Mari Tye, Ph.D., Scientist, The National Center for Atmospheric Research ● Don Scott, P.E., S.E., F.SEI, F.ASCE, Senior Consultant - PCS Structural Solutions (C&S)	55 minutes
10:10 AM – 10:30 AM	**Moderators:** ● Dan Walker, Ph.D., A.M.ASCE, Associate Director for Multidisciplinary Studies, University of Maryland and EA Engineering, Science, and Technology, Inc. (PBC)	20 minutes

	• Benjamin J. DeAngelo, Deputy Director, NOAA Climate Program Office, NOAA Principal to the U.S. Global Change Research Program **Question & Answer**	
10:30 AM – 11:00 AM	**Networking Break**	30 minutes
11:00 AM – 11:55 AM	**Panel 2: Climate Resilience in Engineering Practice: Broader Perspectives** **Speakers:** • Jason Averill, Chief, Materials and Structural Systems Division, Engineering Laboratory at NIST • Sarah Kapnick, Ph.D., Chief Scientist, NOAA • SES Pete Perez, P.E., Chief of Engineering and Construction, U.S. Army Corps of Engineers • John Ingargiola, Lead Physical Scientist, FEMA • Kit Ng, Ph.D., P.E., Hydraulics and Hydrology Manager, Geotechnical and Hydraulic Engineering Services, Bechtel	55 minutes
11:55 AM – 12:15 PM	**Moderators:** • Deborah H. Lee, F.ASCE, 2020 EWRI President, NOAA, Director, Great Lakes Environmental Research Laboratory • Thomas O'Rourke, Dist.M.ASCE, NAE, Thomas R. Briggs Professor in Engineering Emeritus, Cornell University **Question & Answer**	20 minutes
12:15 PM – 12:45 PM	**LUNCH**	30 minutes
12:45 PM – 1:15 PM	**Climate Change: The Engineer's Dilemma** As sea levels rise, intensifying precipitation, increasing temperatures, and other extreme weather-related events affect America's infrastructure at an accelerating rate, it is the duty of the engineering community to meet this challenge through our policies, planning, and professional practice in collaboration with other built environment stakeholders. In response, ASCE published Policy Statement 500 ("Resilient Infrastructure") which outlines ASCE's commitment to supporting "initiatives that increase the resilience of infrastructure, buildings, and communities against man-made and natural hazards." As stewards of our public infrastructure, engineers must make sure future risks are reflected in the design, construction, and management of these assets. During this discussion we will explore some of the innovative ways that engineers have been responding to the climate change dilemma to also include a "standard of care" and MOP 140. **Speaker:** • Chris Stone P.E., F.NSPE, F.ASCE, LEED AP, Senior Principal, Clark Nexsen	30 minutes
1:15 PM – 1:45 PM	**Moderator:** • Steve Thur, Ph.D., Assistant Administrator, Oceanic and Atmospheric Research, NOAA **Question & Answer**	30 minutes
1:45 PM – 2:40 PM	**Panel 3: Designing for Equity in Climate-Ready Infrastructure**	55 minutes

	Speakers: • Catherine Coleman Flowers, MacArthur Fellow and Founder, Center for Rural Enterprise and Environmental Justice • Eric Letvin, Assistant Administrator for Mitigation, FEMA • Marccus Hendricks, Ph.D., Professor and Director of SIRJ Lab, University of Maryland • Renee Collini, Ph.D., Center for Equitable Climate Resilience Director, The Water Institute • Gerry Galloway, Dist.M.ASCE, Emeritus Research Professor, Civil & Environmental Engineering, University of Maryland	
2:40 PM – 3:00 PM	**Moderators:** • Kimberly Jones, Ph.D., Associate Provost and Professor, Civil & Environmental Engineering at Howard University • Vankita Brown, Ph.D., Senior Advisor for Equity, NOAA **Question & Answer**	20 minutes
3:00 PM – 3:30 PM	**Summary and Closure** **Speakers:** • Bilal Ayyub, Ph.D., P.E., Dist.M.ASCE, Professor & Director of the Center for Technology and Systems Management, University of Maryland (UMD) • Benjamin J. DeAngelo, Deputy Director, NOAA Climate Program Office, NOAA Principal to the U.S. Global Change Research Program • Norma Jean Mattei, Ph.D., P.E., F.SEI, F.ASCE, National Infrastructure Advisory Council, 2017 ASCE President, University of New Orleans	30 minutes

Appendix B. List of Speakers

- Bilal Ayyub, Ph.D., P.E., Dist.M.ASCE, Professor & Director of the Center for Technology and Systems Management, University of Maryland (UMD)
- Tom Smith, CAE, ENV SP, F.ASCE, Executive Director, ASCE
- Maria Lehman, P.E., ENV SP, F.ASCE, 2023 ASCE, President
- Richard W. Spinrad, Ph.D., CMarSci, Under Secretary of Commerce for Oceans
- John Dai, P.E., Seismic & Climate Adaptation Civil Engineer, SoCal Edison
- Mark S. Osler, NOAA, Senior Advisor for Coastal Inundation and Resilience
- Mari Tye, Ph.D., Scientist, The National Center for Atmospheric Research
- Don Scott, P.E., S.E., F.SEI, F.ASCE, President - Don Scott Consulting
- Dan Barrie, Ph.D., Climate Modeling, Analysis, Predictions, and Projections Program Manager (MAPP), NOAA

- Dan Walker, Ph.D., A.M.ASCE, Associate Director for Multidisciplinary Studies, University of Maryland and EA Engineering, Science, and Technology, Inc. (PBC)
- Benjamin J. DeAngelo, Deputy Director, NOAA Climate Program Office, NOAA Principal to the U.S. Global Change Research Program
- Jason Averill, Chief, Materials and Structural Systems Division, Engineering Laboratory at NIST
- Sarah Kapnick, Ph.D., Chief Scientist, NOAA
- SES Pete Perez, P.E., Chief of Engineering and Construction, U.S. Army Corps of Engineers
- John Ingargiola, Lead Physical Scientist, FEMA
- Kit Ng, Ph.D., P.E., Hydraulics and Hydrology Manager, Geotechnical and Hydraulic Engineering Services, Bechtel
- Deborah H. Lee, F.ASCE, 2020 EWRI President, NOAA, Director, Great Lakes Environmental Research Laboratory
- Thomas O'Rourke, Dist.M.ASCE, NAE, Thomas R. Briggs Professor in Engineering Emeritus, Cornell University
- Chris Stone P.E., F.NSPE, F.ASCE, LEED AP, Senior Principal, Clark Nexsen
- Steve Thur, Ph.D., Assistant Administrator, Oceanic and Atmospheric Research, NOAA
- Catherine Coleman Flowers, MacArthur Fellow and Founder, Center for Rural Enterprise and Environmental Justice
- Eric Letvin, Assistant Administrator for Mitigation, FEMA
- Marccus Hendricks, Ph.D., Professor and Director of SIRJ Lab, University of Maryland
- Renee Collini, Ph.D., Center for Equitable Climate Resilience Director, The Water Institute
- Gerry Galloway, Dist.M.ASCE, Emeritus Research Professor, Civil & Environmental Engineering, University of Maryland
- Kimberly Jones, Ph.D., Associate Provost and Professor, Civil & Environmental Engineering at Howard University
- Vankita Brown, Ph.D., Senior Advisor for Equity, NOAA
- Bilal Ayyub, Ph.D., P.E., Dist.M.ASCE, Professor & Director of the Center for Technology and Systems Management, University of Maryland (UMD)
- Benjamin J. DeAngelo, Deputy Director, NOAA Climate Program Office, NOAA Principal to the U.S. Global Change Research Program
- Norma Jean Mattei, Ph.D., P.E., F.SEI, F.ASCE, National Infrastructure Advisory Council, 2017 ASCE President, University of New Orleans

Appendix C. ASCE-NOAA Memorandum of Understanding (MOU)

The ASCE-NOAA Memorandum of Understanding (MOU) can be viewed online at: https://www.noaa.gov/sites/default/files/2023-02/MOU_between_the_American_Society_of_Civil_Engineers_and_NOAA.pdf .