NSF Engineering Research Visioning Alliance

Engineering Research Solutions for Water Events: The Recent California Floods

On Jan. 30, 2023, a Virtual Town Hall convened by the [Engineering Research Visioning Alliance (ERVA)](https://www.ervacommunity.org) explored the topic of ***Engineering Research Solutions for Water Events: The Recent California Floods***. The event featured insights from University of California Irvine professors David Feldman and Brett Sanders and was moderated by Anna Gemolas of DuPont Water Solutions.

The event was motivated by extreme weather events in the preceding month. Heavy rains triggered flooding, power outages, and over 700 landslides; these events have caused at least 20 deaths and over $1 billion in damages.[1] Climate change makes extreme events—drought cycles and severe flooding—increasingly likely. While the role of climate change in recent California rain events is the subject of current investigations, it is clear that global warming leads to more water vapor in the atmosphere, playing a key role in catastrophic rain events.

California and other sites of such events face the reality that stormwater from these floods is not systematically captured or stored to address future needs. This is a concern as California and other Western U.S. states were scorched by drought for much of 2022, and an overarching megadrought has had its grip on the West for over 20 years.[2] Stormwater is a challenge as it can be both a potential resource and a pollutant. Although the science of pre-treatment in runoff is well established, adjoining communities must agree to accept water that potentially impacts both of their managed systems, despite likely having differing standards for health and environmental protection. Users must reach common ground on water end uses and regulatory standards.

Stormwater management difficulties are exacerbated by the limited time available in some areas for capture and storage—as well as the intended use/treatment of the captured water— for example, landscaping that would not compete with drinking water. A mix of green infrastructure (e.g., swales for infiltration) and gray infrastructure (e.g., cisterns, distributed treatment systems) will be needed. Innovative engineering solutions must be developed and implemented to mitigate damage from flooding and capture water from future events for community use if we hope to leverage knowledge gained from these events.

Town Hall panelists considered the causes of flooding events, challenges to rebuilding and re-envisioning infrastructure, and ways in which stormwater can be harnessed for community benefit. They also discussed how digital tools, including simulation technologies, could assist in effective stormwater management.

Climate change is not the only contributing factor to extreme flooding. Urban development in high-hazard areas has increased in recent decades. One result is that natural buffers, such as grasslands, have been marginalized or replaced by impervious surfaces that cannot protect nearby areas. Existing infrastructure is aging and losing capacity to deal with a sudden large water influx. As recent research has demonstrated, flood risk, particularly

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[1] Masters, J. (2023, Jan. 27). Climate change is increasing the risk of a California mega flood. *Yale Climate* Connections. Retrieved Jan.30, 2023 from https://yaleclimateconnections.org/2023/01/climate-change-is-increasing-the-risk-of-a-california-megaflood/.

[2] Thomson, J. (2023, Jan. 6). Is California still in a drought? Newsweek. Retrieved Jan. 31, 2023, from https://www.newsweek.com/california-drought-still-climate-change-rainfall-1771800.

from rainfall, has been underestimated in many flood-risk models. Underestimating or ignoring risk can result in increased development in hazardous areas, with consequent potential for severe flooding.

The combination of climate variability and aging infrastructure increases the likelihood of severe flooding. To combat the drought/flood cycle, the engineering research community must rethink infrastructure needs and address the current and future urban environment. But revamping infrastructure won't be a simple task.

Planning, resource use, and funding at federal and local levels must find areas of alignment between the visions and needs of communities and stakeholders served by infrastructure, including disadvantaged communities, and reconcile tradeoffs in the risks and benefits of adaptation options. In particular, green infrastructure deployed throughout urban watersheds could help to store and process more stormwater runoff, reduce the stress on mainstem drainage channels during extreme weather events, enhance human well-being with park spaces, and create more shade to help with increasingly frequent heat waves. However, acquiring the lands needed to impact flood risk and water security significantly would present enormous costs and conflicts.

A substantial challenge noted by the panel is that green infrastructure looks different from historic norms. To gain acceptance of green infrastructure, water agencies, metro community planners, and local governments must work together to emphasize the importance of community benefits beyond stormwater management.

Digital technologies, including simulation technology with intuitive visualizations, help orient stakeholders to the type and scope of problems we face.[3] Simulations can examine questions with many parameters, including "What might happen if a flood occurs in this location?" and "What can we do to respond, mitigate, and anticipate?" These simulations can increase understanding of the problem and alter inaccurate perceptions of what could happen by demonstrating the implications of what the best science tells us about where, who, what, how, and why communities are affected. These technologies can contribute to constructive dialogue and planning by helping to visualize the flooding distribution problem and identify where green infrastructure would make the most sense. They could also aid in factoring how resources should be most equitably distributed.

Technology also has a role to play in how data is shared among stakeholders. Data security is paramount in all operations; system integrity must be protected to maintain public trust in the information generated by simulations or other hydrology operations.

Fortunately, examples of good models for stormwater management exist, particularly in Australia, which has adopted a holistic approach to management since the early 2000s, and in Singapore, which has committed to recycling wastewater, harvesting rainwater, monitoring reservoir quality, and developing land use regulations. For urban governments looking to start or enhance their pursuit of sustainable water systems, The City Water Optimisation Index provides a tool to understand how cities worldwide have worked toward safeguarding current and future water supplies.

The United States is on the cusp of a generational opportunity to invest in water infrastructure with the potential to provide multi-faceted benefits. Today's extreme weather events provide an opportunity for communities and regions to learn from the errors of the past and develop adaptive management practices—and retool for the decades ahead. Doing so will require cross-sector innovation and commitment from engineers, urban planners, and the public.

[3] Sanders, B.F. et al. (2020, January) *Earth's Future* 8(1) e2019EF001391. Retrieved Jan. 31, 2023 from https://doi.org/10.1029/2019EF001391