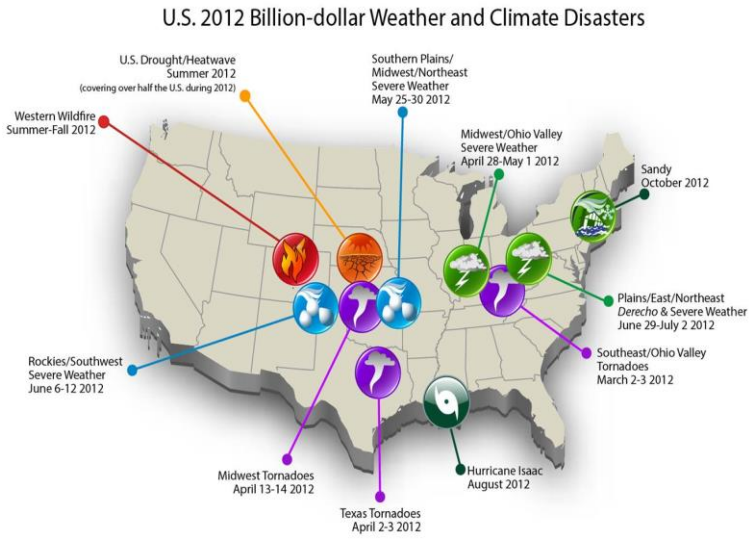
AASHTO

EXTREME WEATHER & THE TRANSPORTATION SYSTEM

How Do Extreme Weather Events Affect Hydrologic and Hydraulic Engineering?

Extreme weather events affect nearly every state in the U.S. In 2012, for example, a total of 133 disaster events[i] occurred resulting in about $881 billion in damages[ii] (see NOAA NCDC graphic[iii] at right). Events ranged from hurricanes, droughts, heat waves, severe local storms, non-tropical floods, and winter storms, to wildfires and freezes. In addition, many parts of the country have witnessed gradual shifts in average temperatures and rainfall patterns over the past several decades. There is strong evidence that events related to heat, heavy precipitation, and coastal flooding will grow in frequency and severity in coming decades. These trends prompt questions about whether and how to approach hydrologic and hydraulic (H&H) design differently given these changes.



How Can Hydrologic and Hydraulic Engineers Prepare for Extreme Weather Events?

Although transportation agency experiences will vary by state and topic, below is a "Top 10" list of suggestions to better prepare for extreme weather and shifting climate trends.

1. **Identify and Review Climate Assumptions:** Identify the climate and weather-related assumptions in H&H design and engineering, and review whether those assumptions should be updated to incorporate recent trends or future projections.
2. **Monitor Trends:** Develop and track performance metrics related to weather (e.g., number and severity of weather events, flow trends, scour condition, drainage adequacy) to improve decision-making over time given a better to understanding of how weather variables are changing and how H&H systems are responding.
3. **Coordinate:** Improve coordination and communication between maintenance staff and H&H engineers to improve understanding of how systems are responding in the field.
4. **Consider Lifecycle Costs:** Consider lifetime project costs and benefits—including revised assumptions of weather risk—in the design process.
5. **Use Scenario-based Engineering Analysis**: When considering potential impacts of changing weather conditions, marry historical information with forecasts to identify potential stresses on assets. Consider application of a robust design process that uses a range of estimated climate conditions (scenarios) to establish design inputs that aim to minimize project life-cycle costs across possible scenarios.
6. **Be Flexible:** For locations or assets that are particularly vulnerable to extreme weather impacts and that carry high consequences of asset failure, incorporate flexible or adaptive design concepts into project design.
7. **Revisit Manuals:** Review and revise design manuals as needed to incorporate changing conditions—for example, consider whether it's best to use historic-based information or a forecasting process.
8. **Design:** Incorporate extreme weather event trends in design processes. For example, prepare for higher-than-normal precipitation events by designing drainage and stormwater management systems to handle (divert, store, etc.) higher expected flows, consider stream morphology, overflow routes, and the possible impacts to aquatic species.
9. **Use Asset Management:** Use risk-based asset management systems to track relevant information on extreme weather vulnerabilities to inform decision-making over time.
10. **Use "Smart" Technology**: For critical assets or in areas of potential vulnerability, consider including sensor technology to monitor and warn of serious stresses (water or temperatures) impacting assets in real time.

Center for Environmental Excellence

Resources for Extreme Weather Preparedness and Resilience

PUBLICATIONS

- **Adapting Infrastructure and Civil Engineering Practice to a Changing Climate** (American Society of Civil Engineers, 2015). Report identifying the technical requirements and civil engineering challenges raised by adaptation to a changing climate.
- **Climate Change, Extreme Weather Events and the Highway System** (NCHRP Report 750, Volume 2, 2014). Guidance for practitioners on adaptation strategies for likely impacts of climate change in the planning, design, construction, operation, and maintenance of infrastructure assets in the United States.
- **Gulf Coast Study Phase II Engineering Assessments of Climate Change Impacts and Adaptation Measures** (U.S. DOT, August 2014). Report discussing engineering assessments and adaptation options for a range of facilities and climate stressors in Mobile, AL (i.e., a culvert vulnerable to increases in heavy precipitation). Includes lessons learned from applying an 11-step climate engineering assessment process.
- **Port Authority of New York and New Jersey (PANYNJ) Engineering Department Design Guidelines for Climate Resilience** (PANYNJ, January 2015). Guidelines for how to address anticipated climate impacts in infrastructure and buildings.
- **Assessment of Key Gaps in the Integration of Climate Change Considerations into Transportation Engineering** (FHWA, September 2014). Report summarizing gaps in information and practice related to integrating climate change into transportation engineering. Public release expected in 2015.

FEDERAL GUIDANCE AND RULES

- **FHWA Order 5520 – Transportation System Preparedness and Resilience to Climate Change and Extreme Weather Events** (Dec. 15, 2014). Directive establishes FHWA policy that FHWA programs, policies, and activities must integrate consideration of climate change and extreme weather event impacts and adaptation into planning, operations, policies, and programs.
- **FHWA Hydraulic Engineering Circular No. 17, Vol. 2** (update pending in 2015). Update will provide technical guidance and methodologies for considering/incorporating floodplain management, risk, extreme weather events, resilience, and adaptation considerations when addressing highway planning and design within the riverine environment.
- **FHWA Hydraulic Engineering Circular No. 25, Vol. 2** (2015). Highways in the Coastal Environment: Assessing Extreme Events provides technical guidance and methods for assessing the vulnerability of coastal transportation facilities to extreme weather events and climate change, focusing on sea level rise, storm surge, and waves.
- **Executive Order 11988: Floodplain Management** (2015). Requires federal agencies to reduce adverse impacts associated with construction in floodplains and discusses possible mechanisms for doing so.

WEBSITES

- **AASHTO Transportation and Climate Change Resource Center:** Extreme Weather Symposium, 2013. Materials on recent extreme weather events, costs, and how DOTs can manage them. climatechange.transportation.org/symposium/
- **FHWA Climate Change Adaptation Website:** www.fhwa.dot.gov/environment/climate_change/adaptation/
- **The Infrastructure and Climate Network:** http://theicnet.org/
- **Center for Climate and Energy Solutions:** Interactive map depicting extreme weather events, 1990-2013. www.c2es.org/science-impacts/maps/extreme-weather

OTHER RESOURCES

AASHTO's Resilient and Sustainable Transportation Systems (RSTS) Technical Assistance Program provides timely information, tools, and technical assistance to State DOTs to manage challenging issues associated with extreme weather events. (http://climatechange.transportation.org/about/technical_assistance_program.aspx)

For questions or for more information, please contact Patricia Bush, Program Manager for Engineering at PBush@aashto.org or Gabriel Weil, Program Manager for Environment at GWeil@aashto.org.

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[i] "Disaster events" in this context have been defined as tropical cyclones (e.g., hurricanes), droughts/heatwaves, severe local storms, non-tropical floods, winter storms, wildfires, and freezes.

[ii] Smith and Katz, Natural Hazards, June 2013, Volume 67, Issue 2, pp. 387-410.

[iii] Source**:** NOAA NCDC at www.ncdc.noaa.gov/billions/summary-stats