



BUILDING CLIMATE RESILIENT TRANSPORTATION

CLIMATE CHANGE ALREADY DISRUPTING U.S. TRANSPORTATION

State and regional transportation agencies across the country are facing extreme weather events that damage roads and bridges and cost large sums to repair, not to mention the cost to the economy from disrupted travel. Extreme weather events—including heat waves, drought, tropical storms, high winds, storm surges and heavy downpours—are becoming more frequent and severe as the climate changes.

FHWA IS RESPONDING

These climate risks threaten the considerable federal investment in transportation infrastructure and FHWA is responding:

- FHWA issued an order committing the agency to integrating climate risk considerations into the delivery and stewardship of FHWA programs.
- Climate adaptation activities are eligible for FHWA funding, including vulnerability assessments and design and construction of projects or features to protect assets from damage associated with climate change.
- FHWA's updated emergency relief program guidance reflects climate resilience.
- Transportation law passed in 2012 requires states to develop risk-based asset management plans and to consider alternatives for facilities repeatedly needing repair or replacement with federal funding.

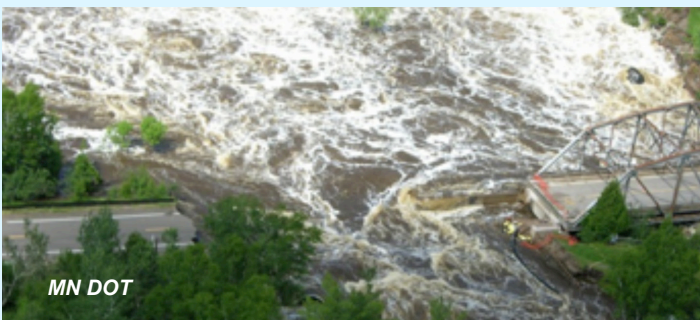
- FHWA developed tools and guidance for systematic consideration of climate risks at transportation system and project levels.

WHAT CAN TRANSPORTATION AGENCIES DO TO BUILD RESILIENCE?

Know your vulnerabilities

Departments of transportation (DOTs), metropolitan planning organizations (MPOs), and others can begin with a vulnerability assessment for their area using FHWA's Vulnerability Assessment Framework, a guidebook and online resource detailing key steps and in-practice examples. Based on the experience of pilot projects and other work, each step of the framework has tools, case studies, videos and other resources associated with it. For instance, FHWA's Climate Data Processing Tool processes publicly available, but large and unwieldy data sets into local temperature and precipitation projections tailored to transportation practitioners.

Using the FHWA framework and climate data from its local university, the Washington State Department of Transportation (WSDOT) held workshops with maintenance and engineering staff in all regions of the state. WSDOT asked participants, "What keeps you up at night?" and "What happens if the climate-related conditions get worse?" The DOT leveraged local staff knowledge and GIS overlays of climate and asset management data to develop a map showing road segments at high, medium, and low vulnerability.



MN DOT

As part of an FHWA pilot, Minnesota DOT assessed vulnerability to climate change in two districts and analyzed adaptation options for two facilities at high risk of flash flooding.



North Coast Land Conservancy.

Oregon purchased land and removed a levee to allow flood water to flow onto a natural floodplain. This protected the highway from flooding and provided habitat. Oregon DOT is now conducting an FHWA-funded pilot analyzing protection options for other vulnerable sites.

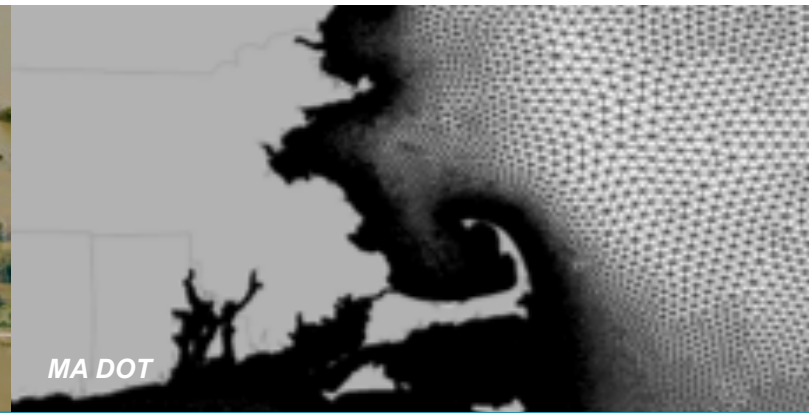
Transportation Agencies Using FHWA Resources to Build Resilience

FHWA partnered with 22 climate resilience pilots in two rounds as well as four cooperative projects in the Gulf Coast, Northeast, Southeast, and New Mexico. These 26 projects are shown in the map below. In total, at FHWA's latest count, 24 state DOTs and 30 MPOs have conducted vulnerability assessments of the highway system to address climate change and extreme weather events.

- State DOT Pilot
- MPO Pilot
- Cooperative Projects



IOWA DOT



MA DOT



PANYNJ

Iowa DOT and local universities used global climate models and the state's hydrological model to project future flood frequencies and identify bridge and roadway vulnerabilities in two river basins. Iowa plans to integrate the information into its real-time warning system to protect the traveling public. The results of the pilot may also influence guidelines for the design of bridges and culverts on Iowa's primary highways.

The Massachusetts Department of Transportation developed high resolution computer modeling of coastal storm inundation and risks to the Central Artery highway tunnel system in Boston.

New Jersey's 2011 climate pilot analysis of which roads could flood with higher sea levels and storm surge was unfortunately validated when Superstorm Sandy hit in October 2012. Following the storm, FHWA partnered with the tri-state region on a multi-jurisdictional vulnerability assessment and analysis of adaptation solutions for particularly vulnerable assets, such as the Hugh L. Carey Tunnel and NJ 7. Photo shows flood protection installed by the Port Authority of NY and NJ.



FHWA

In Albuquerque, New Mexico, FHWA partnered with the MPO on a scenario planning process to assess the impact of growth scenarios on climate resilience and mitigation, along with other community goals. The project analyzed how different scenarios performed on development in wildfire risk areas, development in flood risk areas, water consumption, and emissions levels. During stakeholder workshops, participants discussed policies that would help achieve a preferred scenario for the 2040 metropolitan transportation plan.

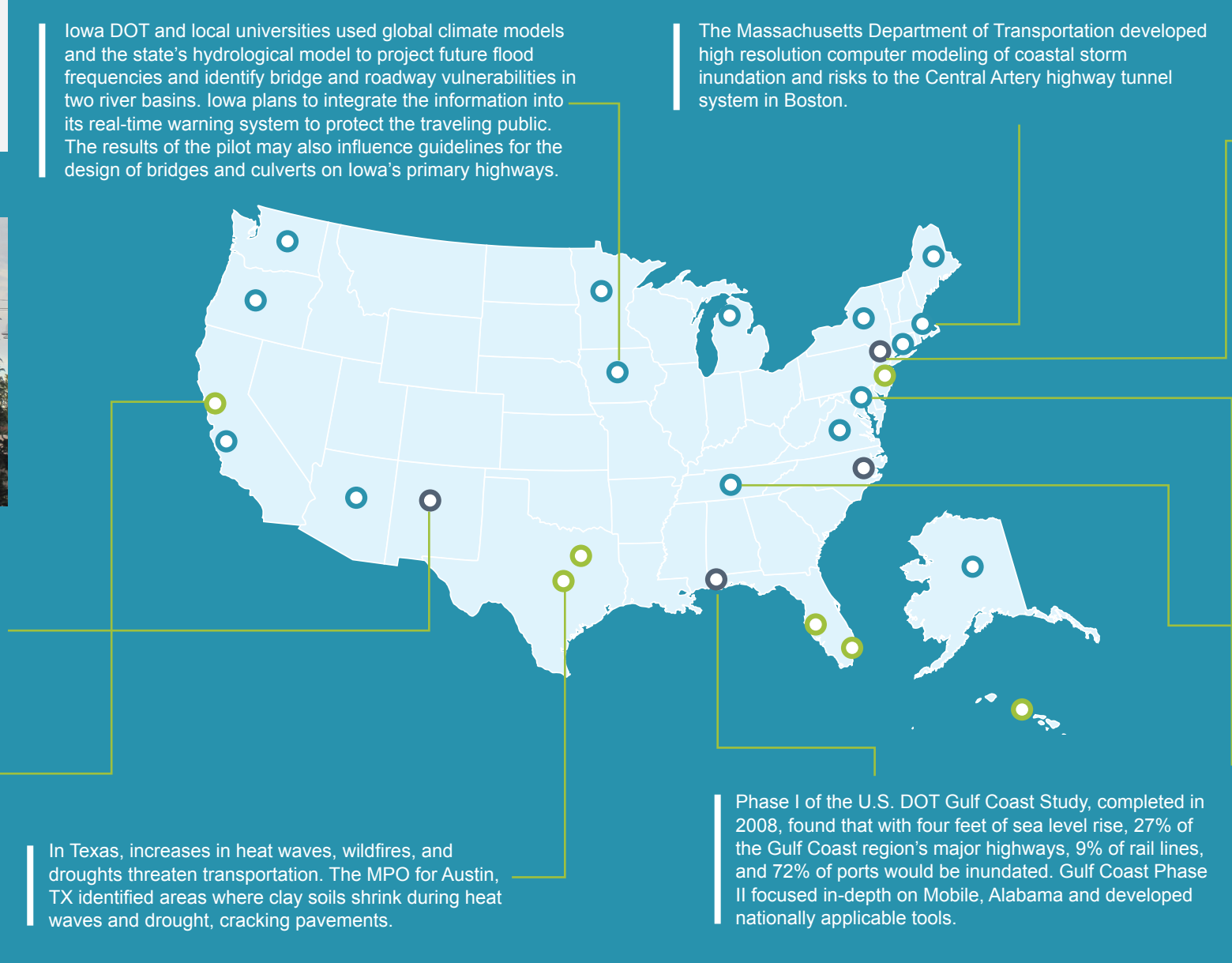
San Francisco's Metropolitan Transportation Commission (MTC) analyzed options for protecting transportation infrastructure, including an artificial dune or living levee north of the Bay Bridge touchdown to protect the bridge.

In Texas, increases in heat waves, wildfires, and droughts threaten transportation. The MPO for Austin, TX identified areas where clay soils shrink during heat waves and drought, cracking pavements.

Phase I of the U.S. DOT Gulf Coast Study, completed in 2008, found that with four feet of sea level rise, 27% of the Gulf Coast region's major highways, 9% of rail lines, and 72% of ports would be inundated. Gulf Coast Phase II focused in-depth on Mobile, Alabama and developed nationally applicable tools.

Tennessee DOT conducted a multimodal vulnerability assessment for the state, obtaining key information for asset management. Landslides, tornados, and river flooding (such as that shown above in 2010), are risks.

Maryland DOT used FHWA's Vulnerability Assessment Scoring Tool to prioritize climate risks to bridges, culverts, and road segments in two counties particularly exposed to sea level rise and storm surge.



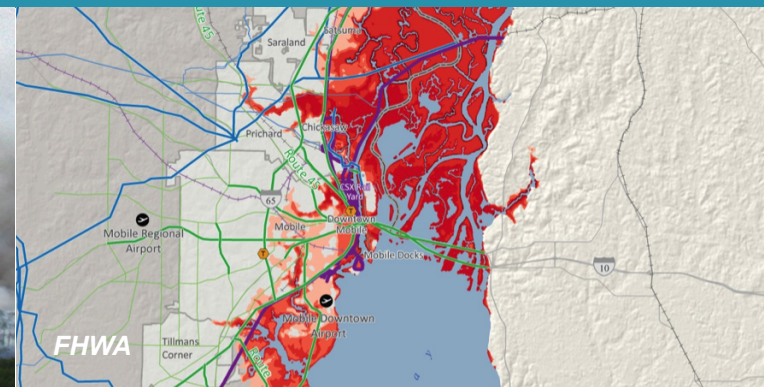
Nashville MTA



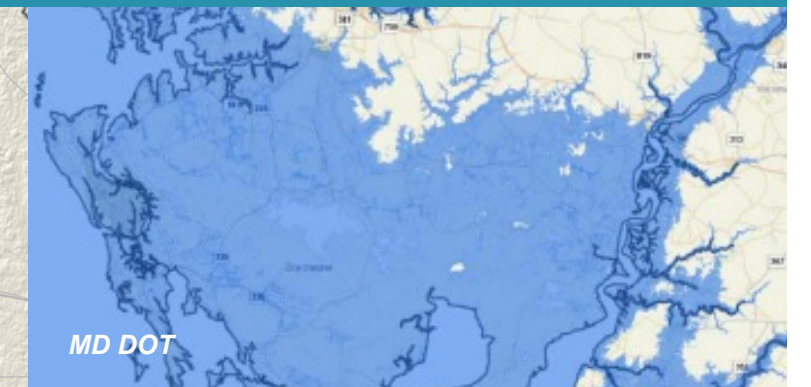
EPA



CAMPO



FHWA



MD DOT

Use the transportation planning process

The metropolitan and statewide transportation planning process provides key opportunities for taking climate change into account. Resilience and sustainability should be considered early during decision-making at the system-wide level, when options and priorities are considered for transportation investments to meet multiple community goals. FHWA's report, *Integrating Climate Change into the Transportation Planning Process*, provides more information.



Rob Kafalenos

FHWA staff inspects a culvert in Mobile, Alabama. The culvert meets state standards under current conditions, but would be overtopped by a 25-yr rainfall under wetter climate change projections, flooding the road and the nearby Interstate highway. Using the 11-Step process, FHWA found that to avoid flooding, the DOT could widen the culvert by adding an additional cell to each side (\$1.7 million cost, \$6 million benefit). Alternatively, the DOT could replace the existing culvert with the largest crossing that will fit within the available space (\$2.5 million cost, \$6.5 million benefit).

Incorporate climate risks into design and asset management

Transportation agencies can consider climate change impacts when planning new assets or rehabilitating existing assets, especially as part of strategic asset management efforts. Risk-based asset management serves as a climate adaptation strategy by providing a platform for inventorying assets, evaluating risks to those assets, and prioritizing capital improvements.

Agencies can use FHWA's 11-step process for engineering transportation assets to be more resilient to climate impacts. Developed under Phase II of the *Gulf Coast Study*, the process includes consideration of multiple alternatives and cost benefit analysis. FHWA is now adding to this work by developing specific recommendations and approaches based on a cross-cutting analysis of a diverse set of transportation assets nation-wide.

Agencies can prioritize “no regrets” actions that improve resilience of assets to existing stressors, have co-benefits, or cost little relative to the overall value of the asset. They can build flexibility into designs to allow for changes in the future given inevitable uncertainty regarding future emissions levels and precise timing and severity of impacts. For example, agencies can design flood walls that can be heightened in the future with minimum additional expense.

FHWA's newly updated *Hydraulic Engineering Circular (HEC) 25: Highways in the Coastal Environment*, includes guidance on estimating future sea levels and storm surges along with designing protection measures such as revetments, beach nourishment, and bridge deck elevation. FHWA is also updating engineering guidance on riverine areas and hydrology. Finally, FHWA is conducting research to better pinpoint projections for the input variables transportation engineers need when designing infrastructure, including precipitation patterns, geohazards, and watershed sensitivity.

Operations and maintenance

Operations and maintenance strategies can also lessen climate impacts on transportation. Examples include more frequent cleaning of storm-drains, improved plans for weather emergencies, closures and rerouting, traveler information systems, debris removal, early warning systems, prepositioning materials, damage repairs, and performance monitoring. See FHWA's white paper on this topic and upcoming primer for more information.



CO DOT

Using FHWA Emergency Relief (ER) funds, Colorado DOT rebuilt this roadway damaged by 2013 flooding to be more resilient to future floods by shifting the road a few feet further from the river, and using grouted riprap and native vegetation to stabilize the riverbank. Betterments involving added protective features are eligible for FHWA ER funds if economically justified. In addition, repaired facilities may be built to current design standards (which may be more resilient), without being considered a betterment. Finally, states may use their regularly apportioned Federal-aid funds for incremental costs.

FHWA will continue partnering with federal, state and local agencies on the shared goal of a transportation system that provides safe mobility under current and future conditions, supporting the nation's economy and quality of life.

LEARN MORE

FHWA's climate change website offers publications, policies, guidance, webinar recordings, and tools for assessing vulnerabilities and building resilience.

http://www.fhwa.dot.gov/environment/climate_change/adaptation/

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