US DOT Climate Adaptation and Mitigation Workshop
February 25, 2015

U.S. Department of Transportation
Federal Highway Administration

Integrating Climate Change into Planning and Engineering Practice: Lessons Learned

Robert Kafalenos, FHWA

Three breaches in NC12 after Hurricane Irene. Credit: Tom MacKenzie, FWS

Importance of Resilience

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Climate change and extreme weather events are disrupting transportation systems across the country

- Increased temperature
- More intense precipitation events
- Sea level rise in the past century and more recently

Impacts of climate change are being felt now, and will accelerate significantly in the future.

–National Academy of Sciences and National Climate Assessment

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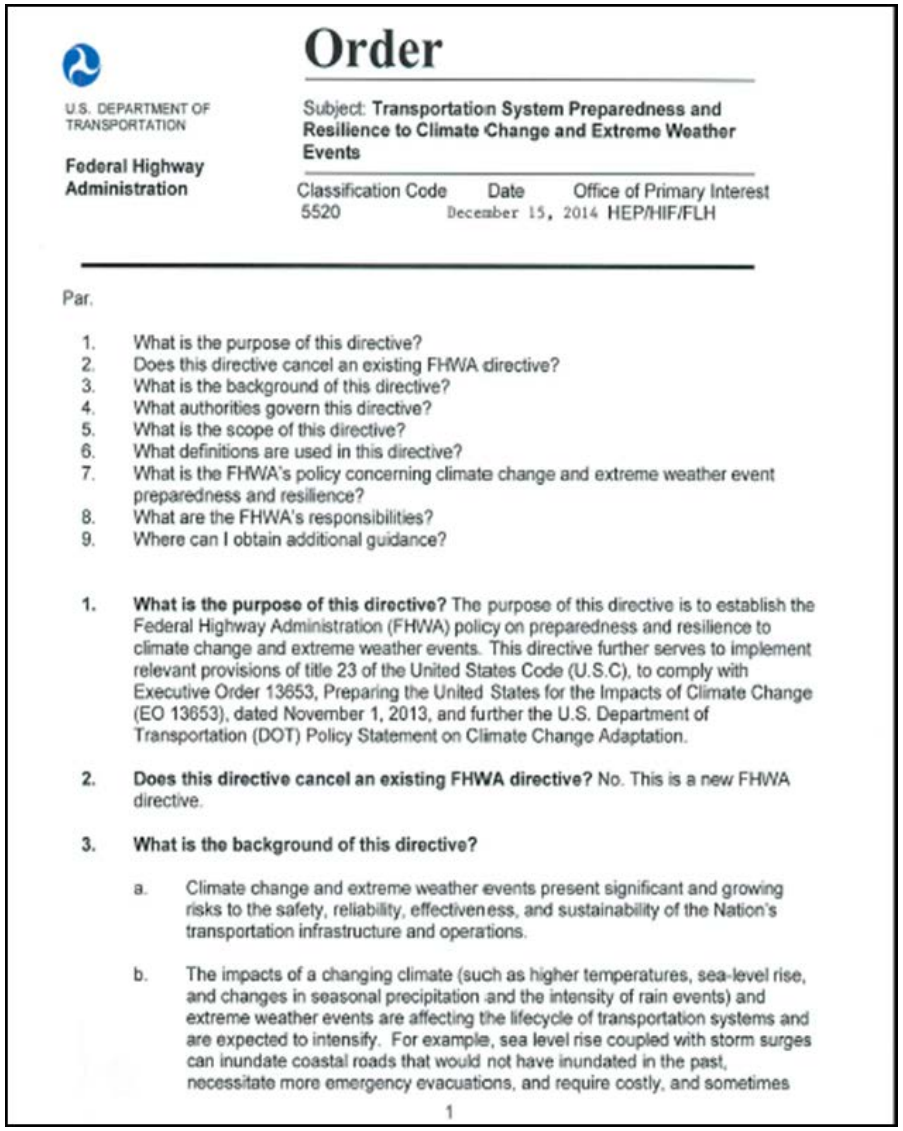
FHWA Order 5520 on Climate Resilience



U.S. DEPARTMENT OF TRANSPORTATION

Federal Highway Administration

Order

Subject: **Transportation System Preparedness and Resilience to Climate Change and Extreme Weather Events**

Classification Code	Date	Office of Primary Interest
5520	December 15, 2014	HEP/HIF/FLH

Par.

1. What is the purpose of this directive?
2. Does this directive cancel an existing FHWA directive?
3. What is the background of this directive?
4. What authorities govern this directive?
5. What is the scope of this directive?
6. What definitions are used in this directive?
7. What is the FHWA's policy concerning climate change and extreme weather event preparedness and resilience?
8. What are the FHWA's responsibilities?
9. Where can I obtain additional guidance?

1. **What is the purpose of this directive?** The purpose of this directive is to establish the Federal Highway Administration (FHWA) policy on preparedness and resilience to climate change and extreme weather events. This directive further serves to implement relevant provisions of title 23 of the United States Code (U.S.C), to comply with Executive Order 13653, Preparing the United States for the Impacts of Climate Change (EO 13653), dated November 1, 2013, and further the U.S. Department of Transportation (DOT) Policy Statement on Climate Change Adaptation.

2. **Does this directive cancel an existing FHWA directive?** No. This is a new FHWA directive.

3. **What is the background of this directive?**

   a. Climate change and extreme weather events present significant and growing risks to the safety, reliability, effectiveness, and sustainability of the Nation's transportation infrastructure and operations.

   b. The impacts of a changing climate (such as higher temperatures, sea-level rise, and changes in seasonal precipitation and the intensity of rain events) and extreme weather events are affecting the lifecycle of transportation systems and are expected to intensify. For example, sea level rise coupled with storm surges can inundate coastal roads that would not have inundated in the past, necessitate more emergency evacuations, and require costly, and sometimes

1

FHWA Order 5520: Transportation System Preparedness and Resilience to Climate Change and Extreme Weather Events

- Purpose: Establish FHWA policy and responsibilities related to preparedness and resilience to climate change and extreme weather events
- Issued jointly by Environment & Planning, Infrastructure, Federal Lands Offices
- Released: December 15, 2014
- Available on FHWA's website

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FHWA Efforts on Climate Adaptation

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Integrate into FHWA programs / policies

- Risk based asset management NPRM (2/20/15) includes climate change risks
- FHWA funding can be used for climate adaptation Memo (9/24/12)
- Emergency relief program manual includes climate

Research, Technical Assistance

- FHWA Adaptation Framework and Tools
- 19 FHWA Climate Resilience Pilots
- Gulf Coast Phase 2 Project
- Hydraulic Engineering Circulars 25 (Coast), 17 (River)
- Hurricane Sandy Follow-up Project
- Albuquerque Scenario Planning Project
- Engineering Approaches for Resiliency

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Transportation Agencies Using FHWA Resources to Build Resilience

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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 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.

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.

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.

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.

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.

Integrating Resilience

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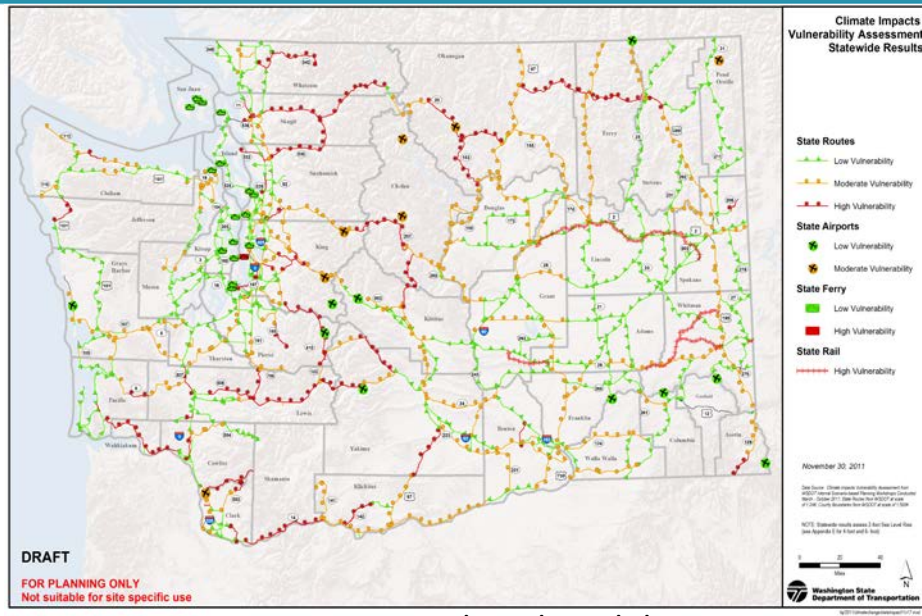
Goal: Mainstream consideration of climate change vulnerability and risk in transportation decision making

- Systems Level: Transportation Planning, Asset Management, Operations, Maintenance
- Project Level: Environmental Processes, Preliminary Engineering, Design, Construction



WSDOT Statewide Vulnerability Assessment

Rebuilding to be more resilient in Colorado

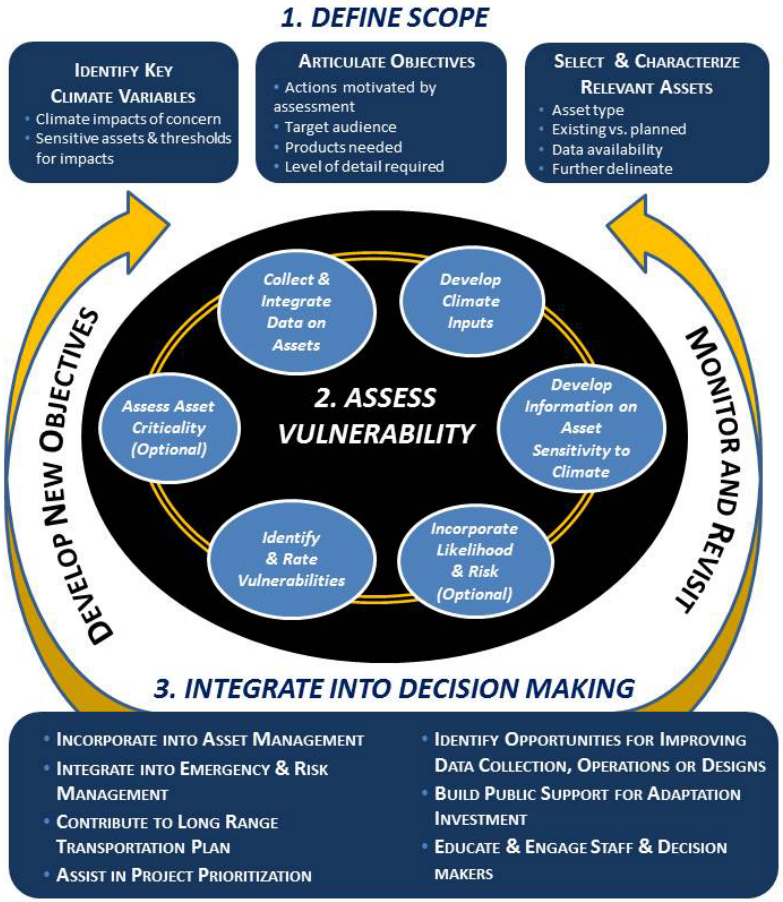
Transportation Planning

FHWA Resources:

- Vulnerability Assessment Framework
- Sensitivity Matrix
- Criticality Guidance
- CMIP Climate Data Processing Tool
- Vulnerability Assessment Scoring Tool

Lessons Learned:

- Vulnerability assessment aligns well with transportation plan development
- Uncertainty is already an issue planners deal with
- Climate data is more readably usable at planning level
- Scenario Planning process can be utilized to test potential impacts of future climate scenarios
- Climate impacts are felt across the country, including inland areas



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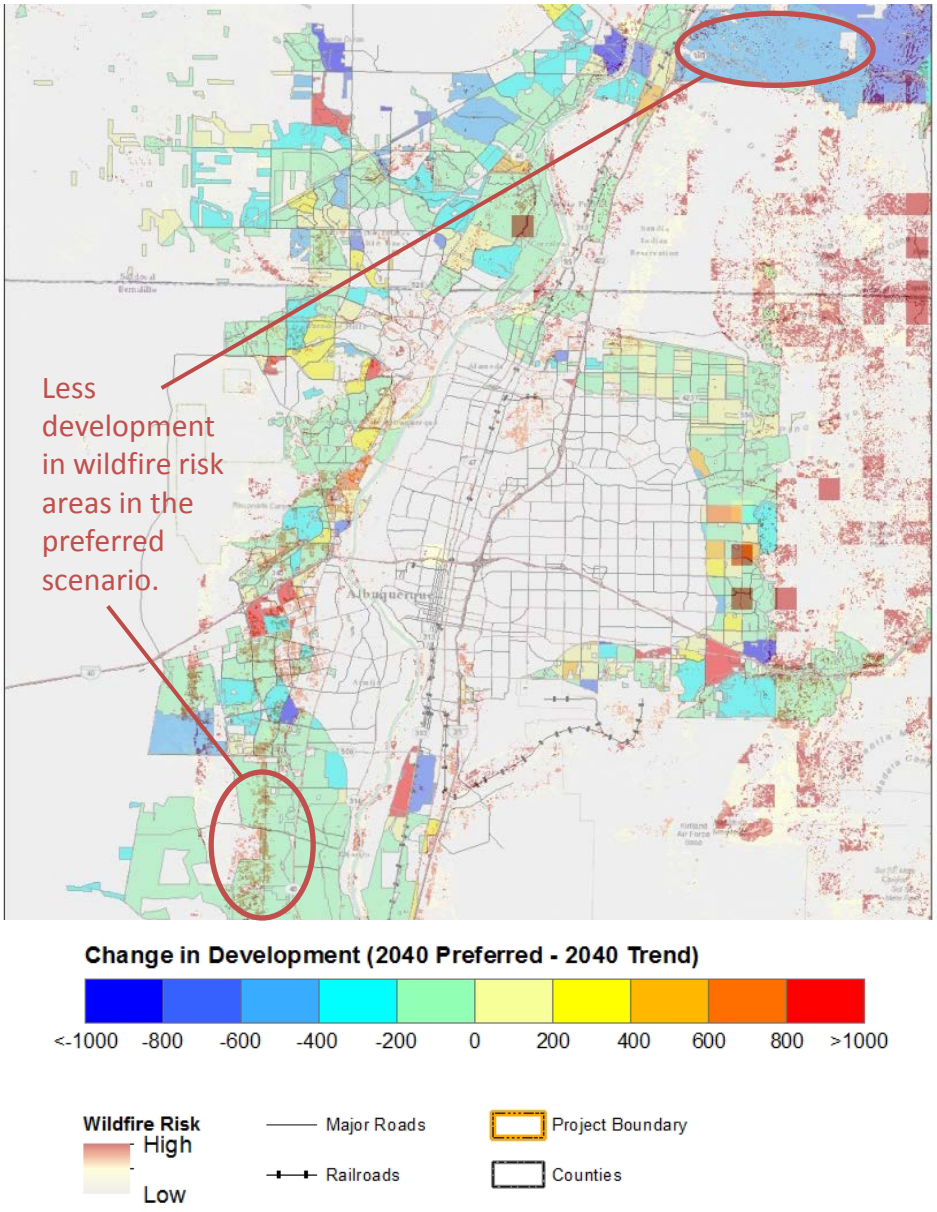
Transportation Planning

More FHWA Resources:

- Scenario Planning – Cape Cod and New Mexico reports

Example:

- 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.



Asset Management

FHWA Resources:

- FLMA Southeast Region Climate Change Transportation Tool
- Managing External Threats through Risk-Based Asset Management

Examples:

- Federal Lands Highway integrated data sets on transportation asset management and climate effects for all of the National Parks and Wildlife Refuges in the southeast region.
- Tennessee DOT conducted a multimodal vulnerability assessment for the state to obtain key information for its risk based asset management plan.

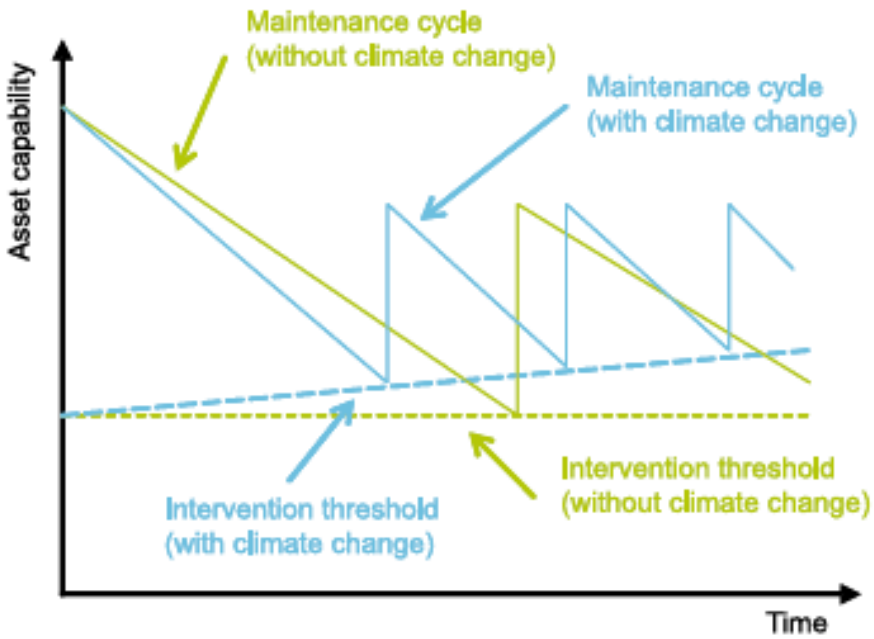
Everglades National Park

2010 flooding in Nashville, TN. Nashville MTA.

Asset Management

Lessons Learned:

- Data integration, availability an issue in many areas; condition, location, as-builts, LIDAR, etc.
- Need to tap and integrate maintenance staff expertise, records of historic events
- Climate change, extreme weather included as risks in DOT's MAP-21 transportation asset management plans
- Climate change will affect decay functions, service life of assets (e.g. effects of increased freeze/thaw on pavement)



UK Highways Agency, Climate Change Adaptation Strategy and Framework.

Integrating Resilience at the Project Level: Project Development and NEPA

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Lessons Learned:

- Coming up more as an issue in PD/NEPA
- No requirement at Federal Level
- Some States require in State-level environmental review
- Can use NEPA process to sort out importance/relevance of issue, scoping, include in PE for alternatives, consider in affected environment
- CEQ guidance looms, but drafts have been fairly consistent

FHWA Resources:

- NEPA Case Study
- Upcoming NEPA Guidebook for Relating Climate Change Effects to Project Development

Examples:

- Portland-Milwaukie Light Rail

Locally Preferred Alternative for the Portland-Milwaukie Light Rail Project

Integrating Resilience at the Project Level: Design

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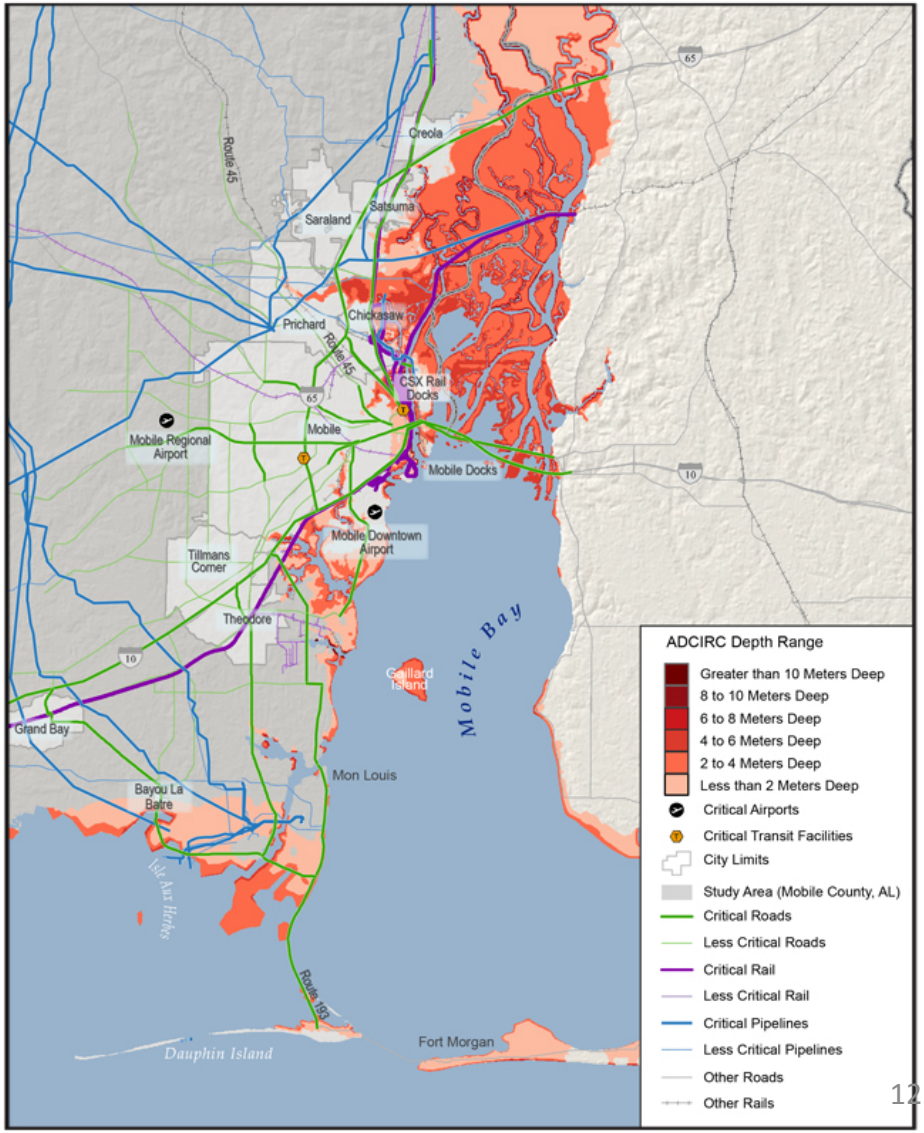
FHWA Resources:

- 11-Step Process for Engineering Transportation Assets to be more Resilient
- HEC-25 Vol 2 Highways in the Coastal Environment: Assessing Extreme Events
- Culvert Mgt. Case Studies
- Upcoming update to HEC-17: Riverine

Examples:

- US DOT's Gulf Coast 2 study: 11-step process to analyze options for making a set of assets more resilient to climate change
- In the MASSDOT Boston Harbor Climate pilot, many of the sophisticated coastal modeling techniques using the ADCIRC surge model were based on techniques in the US DOT Gulf Coast 2 Study

Possible Future Flood Depths in Mobile, AL with Rising Sea Level



Integrating Resilience at the Project Level: Design

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Lessons Learned:

- Assets that score high in vulnerability screens may turn out differently after detailed engineering analyses considering built-in resilience, design forces and damage thresholds.
- General process for engineering analyses can be applied to a wide variety of asset/stressor combinations.
- Limitations on applicability of climate model outputs to engineering design inputs needs to be carefully examined (scales of data, ranges of data, historical data vs. future model projections). Methods to incorporate uncertainty and risk should be explored.
- Economic analyses useful in comparing adaptation options. Careful scoping critical.

Culvert in Mobile, AL would be overtopped by 25-yr rainfall under wetter climate change projections, flooding road and nearby Interstate .
Option 1: add cell to each side of culvert ($1.7 million cost, $6 million benefit).
Option 2: replace with largest crossing that will ($2.5 million cost, $6.5 million benefit)

Lessons Learned:

- What your neighbors do or do not do to adapt matters.
- Solutions can be incrementally applied over time. Start with low cost, no regrets
- Climate considerations need to be integrated with traditional stressors (e.g. age, condition, traffic levels, urbanization, etc.).
- Wed design/maintenance information to GIS and asset mgt. systems (e.g. FHWA Culvert Case Management Study)
- Money spent on analyses can save even more money in materials costs of adaptation… be ready with alternatives post disaster.

In this analysis of vulnerability of underpasses on I-10 in Alabama to future storm surge, FHWA modeled critical flow velocities and depths associated with variations on historical storm events like Hurricane Katrina.

Next Steps for FHWA

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Digest:

- Analyze results of multiple research projects
- Assess impact on existing guidance

Revise:

- Vulnerability Assessment Framework
- Planning, NEPA, Engineering guidance
- Funding eligibility guidance

Create:

- Engineering guidance based on engineering assessment studies
- Complete research on hydrologic/hydraulic effects of climate
- New training

Integrate:

- Implement Order 5520

Source: WSDOT

Upcoming Events

U.S. Department of Transportation
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FHWA Webinar Series:

Building a Climate Resilient Transportation System
Results/lessons learned from *Gulf Coast 2* and *FHWA Climate Resilience Pilots* (February-April)

International Conference on Transportation System Resilience to Climate Change and Extreme Weather Events

September 16-18, 2015
National Academy of Sciences Building, Washington, D.C.

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Thank You!

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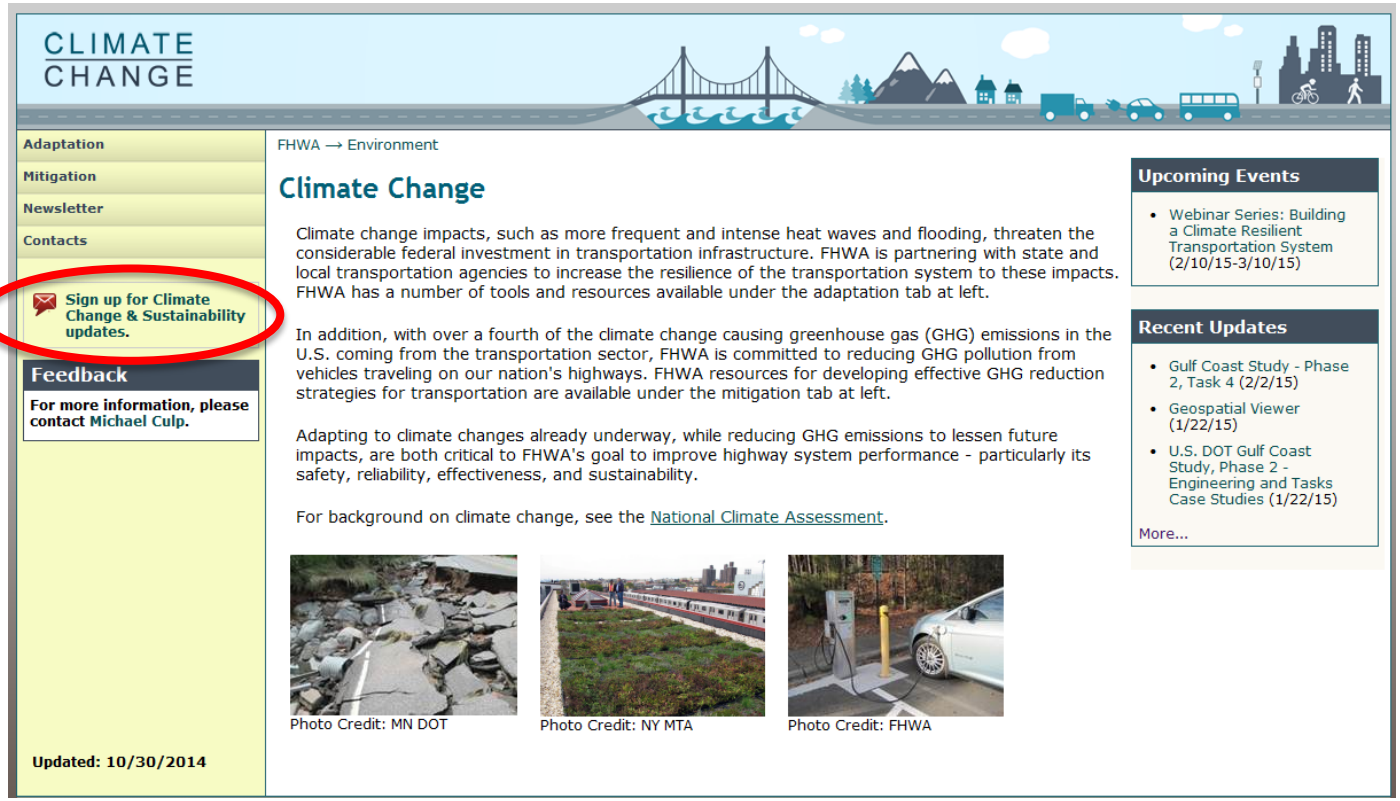
Visit:
www.fhwa.dot.gov/environment/climate_change/
Sign up for Email Updates.



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