



U.S. Department of Transportation
Federal Highway Administration

Climate Resilience and Planning Peer Exchange: Atlanta Regional Commission

Atlanta, Georgia
October 4-5, 2016

CONTENTS

Introduction	1
Overview presentations.....	4
Presentations on climate change impacts	6
Peer presentations.....	8
Atlanta-area presentations	12
Key take-aways from Discussion.....	14
Appendix A: Agenda.....	17
Appendix B: Peer exchange participants	18

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INTRODUCTION

This report summarizes a peer exchange on climate change resilience that was held October 4-5, 2016 in Atlanta, Georgia and hosted by the Atlanta Regional Commission (ARC). The peer exchange was co-organized by the Federal Highway Administration (FHWA) and ARC.

The transportation sector plays an important role in addressing climate change both through reducing greenhouse gas emissions (mitigation) and addressing the impacts of climate change (adaptation). A concept closely related to adaptation is resilience, which FHWA defines as the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions.¹ Climate adaptation and resilience are gaining momentum in the transportation sector as transportation agencies realize their infrastructure is vulnerable to the effects of climate change. In the last several years, FHWA has been supporting state and regional transportation agencies in climate change adaptation activities, especially in assessing vulnerability to climate change. Building off of these vulnerability assessments, transportation agencies are beginning to identify adaptation strategies and integrate climate change considerations into the transportation planning and project development processes.

The Fixing America's Surface Transportation (FAST) Act, which was signed into law on December 4, 2015, includes new requirements for state departments of transportation (DOTs) and metropolitan planning organizations (MPOs) to integrate resilience into the transportation planning process. Following the authorization of the FAST Act, FHWA and the Federal Transit Administration (FTA) updated their planning regulations² with a requirement that the metropolitan transportation plan assess capital investment and other strategies that reduce the vulnerability of the existing transportation infrastructure to natural disasters (23 CFR 450.324(f)(7)). In addition, the planning rule states that MPOs should coordinate with officials responsible for disaster risk reduction when developing a metropolitan transportation plan and the Transportation Improvement Program (23 CFR 450.316(b)). The updated planning final rule also added improving the resilience and reliability of the transportation system as a new planning factor for states and MPOs to consider and implement in the transportation planning process (23 CFR 450.206(a)(9) and 23 CFR 450.306(b)(9)).

The purpose of this peer exchange was for staff from MPOs and state DOTs to learn from peers about best practices for integrating climate resilience into the planning process, including assessing risks, developing adaptation options, and prioritizing projects for implementation. It also provided an opportunity for stakeholders from the Atlanta area to connect with others in the region working on climate resilience. Finally, FHWA will be producing resources and information to help MPOs and state DOTs meet the FAST Act requirements related to integrating resilience into the planning process. The peer exchange allowed FHWA to gather

¹ See FHWA Order 5520 at <http://www.fhwa.dot.gov/legsregs/directives/orders/5520.cfm>.

² The Final Rule for Statewide and Nonmetropolitan Transportation Planning and Metropolitan Transportation Planning can be accessed at <https://www.federalregister.gov/documents/2016/05/27/2016-11964/statewide-and-nonmetropolitan-transportation-planning-metropolitan-transportation-planning>.

information on what resources and information would be helpful for state DOTs and MPOs in developing strategies to address climate risks and meet the FAST Act requirements.

Peer exchange participants

The peer exchange involved presentations by representatives from MPOs and state DOTs from around the country, presentations by Atlanta-based stakeholders working on resilience, and facilitated discussion sessions. In addition, presenters from WSP Parsons Brinkerhoff and the Centers for Disease Control and Prevention provided information on climate risks related to the transportation system and public health, respectively. ARC and FHWA also presented about their work on climate resilience to date. See Table 1 for a list of the organizations that gave presentations during the peer exchange.

Table 1: Presenter organizations

Peer Agencies	Overview Presentations	Atlanta-based Organizations
Broward MPO Hillsborough County MPO Massachusetts DOT Maryland State Highway Administration North Central Texas Council of Governments Puget Sound Regional Council	Atlanta Regional Commission Centers for Disease Control and Prevention Federal Highway Administration WSP Parsons Brinkerhoff	City of Atlanta Office of Sustainability Metropolitan North Georgia Water Planning District Southface

The following organizations participated in the peer exchange as observers and discussion participants:

- AECOM
- Agnes Scott University
- Cambridge Systematics
- DeKalb County
- Emory University
- FHWA – Georgia Division
- FTA – Region 4
- Georgia Conservancy
- Georgia Environmental Protection Division
- Georgia Institute of Technology
- Rockdale County
- Southern Environmental Law Center
- Volpe Center

This report provides brief summaries of the presentations, followed by an overview of the major themes raised in the presentations and discussion sessions.

OVERVIEW PRESENTATIONS

The peer exchange organizers from ARC and FHWA began the meeting by describing their past and current work on climate resilience.

ARC's Planning Work on Climate Change – David D'Onofrio, ARC

ARC's climate change work to date has primarily focused on climate change mitigation, including conducting a greenhouse gas emissions inventory, using scenario planning to evaluate the carbon emissions impacts of various land use and transportation strategies, and incorporating carbon pricing into all proposed projects. ARC is also pursuing projects to reduce vehicle miles traveled and evaluating how changes in community design can reduce emissions.

ARC is beginning to work on climate change adaptation as well. The agency used FHWA's Coupled Model Intercomparison Project (CMIP) climate data processing tool to identify ways in which the Atlanta region's climate will change in the future. ARC found that by 2100 Atlanta is likely to experience more hot days, fewer days with temperatures below freezing, more frequent heavy precipitation events, and longer periods between rain events. Moving forward, ARC is planning to evaluate how these impacts will affect the region's transportation system, as well as develop strategies to prepare communities and infrastructure for these future weather conditions.

Climate Change Resilience: 20 Questions in 20 Minutes – Heather Holsinger and Corbin Davis, FHWA

Staff from FHWA's Sustainable Transport and Climate Change (STACC) team and Office of Planning discussed FHWA's work on climate resilience. Definitions from [FHWA Order 5520](#), Transportation System Preparedness and Resilience to Climate Change and Extreme Weather Events, can provide participants with a common vocabulary (see sidebar). The presenters emphasized that the concept of resilience incorporates both preparedness and adaptation as defined in Order 5520, and also involves both asset level and transportation system level interventions.

FHWA has developed, and is currently revising, a [Climate Change and Extreme Weather Vulnerability Assessment Framework](#) that provides guidance on how to assess the vulnerability of transportation assets to climate change and extreme weather events. Between 2011 and 2015, FHWA partnered with 24 state DOTs and MPOs to conduct vulnerability assessments based on this framework. FHWA has also produced engineering guidance related to

FHWA Order 5520 Definitions

Preparedness means actions taken to plan, organize, equip, train, and exercise to build, apply, and sustain the capabilities necessary to prevent, protect against, ameliorate the effects of, respond to, and recover from climate change related damages to life, health, property, livelihoods, ecosystems, and national security.

Adaptation is adjustment in natural or human systems in anticipation of or response to a changing environment in a way that effectively uses beneficial opportunities or reduces negative effects.

Resilience or resiliency is the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions.

assessing the effects of climate change and extreme weather events on highways in both coastal and riverine environments ([Hydraulic Engineering Circular 25](#) and [Hydraulic Engineering Circular 17](#)). Moving forward, FHWA will continue to support state and local transportation agencies in adapting to climate change, including producing resources and information to help MPOs and state DOTs meet the FAST Act requirements related to integrating resilience into the planning process.

PRESENTATIONS ON CLIMATE CHANGE IMPACTS

Two presentations provided participants with information on expected climate conditions and impacts. Dr. Mike Meyer from WSP Parsons Brinkerhoff presented an overview of expected climate changes and the effects climate change is likely to have on the transportation sector. Paul Schramm of the Centers for Disease Control and Prevention (CDC) focused his presentation on the effects that climate change will have on human health.

Climate Change Overview – Mike Meyer, WSP Parsons Brinkerhoff

Dr. Meyer described expected climate change impacts globally and in the Atlanta region. Globally, temperatures are predicted to rise, extreme weather events are likely to become more frequent and severe, and some regions of the world will experience more precipitation while others will experience more drought. In Georgia, parts of the state are likely to experience as many as 75 additional days above 95° F by 2070, and average temperatures may increase by 5-6° F. In terms of precipitation, Georgia is likely to experience both an increase in the number of high rainfall events and an increase in the length of time between rain events; in other words, it is vulnerable to both flooding and drought.

For the transportation sector, these climate impacts can cause flooded roads, structural damage to bridges and roadways, and worsened traffic conditions. In terms of flooding, much of the work on transportation and climate change to date has focused on the impacts of sea level rise and coastal storms. However, inland flooding can also cause major damage to transportation systems, as evidenced by the Tennessee Superflood in 2010 and the I-680 flood in Iowa in 2011. Heat can also negatively affect transportation infrastructure in many ways, including:

- Instability of materials exposed to high temperatures can lead to pavement heave or track buckling;
- Exposure of encased equipment to high heat can lead to failure of equipment such as traffic control devices and signal control systems;
- Increased electricity usage and power outages during heat waves can affect the power supply to rail operations;
- Extended periods of high temperatures will affect safety conditions for employees that work long hours outdoors, such as those working on infrastructure reconstruction and maintenance activities;
- Extreme temperatures will create dangerous conditions for many users of the transportation system, placing greater emphasis on the use of air conditioning for transit vehicles and stations; and
- High temperatures will also negatively affect bicycle use and the desire and propensity of individuals to walk outdoors.

Dr. Meyer concluded his presentation by discussing various ways in which climate resilience can be considered in transportation planning, from setting goals and performance measures related to resilience, to conducting site-specific studies, to using climate change in scenario planning or as a criteria in project prioritization.

Climate Change and Human Health – Paul Schramm, Centers for Disease Control and Prevention

Mr. Schramm of the CDC, which is based in Atlanta, discussed how climate change threatens human health and wellbeing by amplifying some existing health threats as well as creating new ones. Increased heat can lead to heat-related illnesses as well as worsening air pollution, which itself contributes to poor health. In addition, changes in pollen production due to heat can worsen the impacts of asthma. Fresh water supplies are affected by climate change, both through salt water intrusion into fresh water sources in areas experiencing sea level rise and through droughts leading to water shortages. Climate change also affects the spread of disease. For example, heavy precipitation can increase the risks of water borne illnesses and changes in temperatures can shift the range of mosquito-borne illnesses.

Studies have shown that reframing discussions of climate change to focus on health can be a powerful motivator in getting people to recognize the risks and take action. The CDC's Climate Change and Health Program helps health departments at the state and local level prepare for the effects of climate change by providing scientific guidance, developing decision support tools, ensuring public concerns are considered in climate change adaptation and mitigation strategies, and developing partnerships between public health and other sectors. This program has provided funding to 16 states and two cities through the Climate Ready States and Cities Initiative. Funded states and cities use the CDC's Building Resilience Against Climate Effects (BRACE) framework to identify likely climate impacts in their communities, potential health effects associated with these impacts, and their most at-risk populations and locations.

PEER PRESENTATIONS

The peer exchange provided an opportunity for MPOs and state DOTs from around the country to share their experience with climate resilience planning. The organizations that presented varied in the actions they have taken to date, from just beginning to consider the effects of climate change and how to plan for them, to conducting detailed vulnerability assessments, to developing projects that address climate change impacts. All of the MPOs and state DOTs that presented, with the exception of the Puget Sound Regional Council, received funding from FHWA from 2013-2015 as part of the Climate Resilience Pilot Program.

Accommodating Extreme Weather Adaptation to Planning and Sustainability in North Central Texas – Jory Dille, North Central Texas Council of Governments

North Central Texas Council of Governments (NCTCOG) covers a 12-county area with a population of seven million in the Dallas-Fort Worth metropolitan area. The region's population is expected to grow nearly 50 percent through 2040. NCTCOG is developing strategies to address increased vehicle-miles traveled and congestion costs, plan necessary repairs on existing infrastructure, and improve efficiency and resiliency.

NCTCOG conducted a climate change vulnerability assessment and found that climate change is both a current and future problem. The main climate risks faced in the region are extreme heat, heavy precipitation events and significant flooding, and lower annual rainfall and increased risk of drought. The assessment found that roadways will be affected by both heat and flooding, and identified significant arterial road segments that are vulnerable to these climate impacts. To address these climate risks along with aging infrastructure and population growth, NCTCOG has focused on transportation asset management. The agency's long-range transportation plan, [Mobility 2040](#), identifies \$118.9 billion for system improvements and focuses on strategies that maximize the existing system. This represents a 27 percent increase from the last long-range plan in funding for existing system maximization strategies. To prioritize projects, NCTCOG scores potential projects based on performance measures, including system reliability and environmental sustainability.

Surface Transportation Resiliency Planning in Hillsborough County, FL – Allison Yeh, Hillsborough County Metropolitan Planning Organization

Hillsborough County, Florida has a population of 1.3 million and covers the Tampa metropolitan area. The county is highly vulnerable to sea level rise and coastal flooding, with 158 miles of coastline and a significant portion of the population living in areas prone to flooding. Although the region has experienced flooding recently, it has not faced a direct hit by a hurricane in over 90 years, creating a false sense of security for residents.

Hillsborough County MPO used FHWA's framework to conduct its vulnerability assessment. The agency collected data on three climate variables: sea level rise, storm surge, and flooding. It then used mapping and the regional transportation demand model to identify climate risks to transportation assets, and sought feedback on the results from local transportation

stakeholders. Hillsborough County MPO also conducted an economic analysis, identifying transportation delays and economic losses resulting from climate impacts. The MPO then selected several assets on which to conduct a more detailed analysis to illustrate climate risks, costs, and potential adaptation options.

Hillsborough County MPO has integrated climate considerations into its [2040 long-range transportation plan](#) by evaluating how investing in resilience could address the performance measures of reduced vulnerability and crashes. The MPO found that by raising roads and preventing shorelines from wave damage, it could reduce the time that roads would be unusable after a Category 3 storm from eight weeks to three weeks and cut economic losses in half over the course of the plan. Moving forward, Hillsborough County MPO will continue to integrate climate change considerations into its next long-range transportation plan update and coordinate with local jurisdictions on mainstreaming adaptation options for projects.

Climate Change and Extreme Weather Vulnerability Assessments and Adaptation Options of the Central Artery – Steven Miller, Massachusetts Department of Transportation

The Massachusetts Department of Transportation (MassDOT) conducted an evaluation of climate risks to the Central Artery/Tunnel system, a critical transportation asset in the Boston region. The Central Artery/Tunnel is vulnerable to flooding from extreme coastal storms under present and future conditions. MassDOT felt that the existing projections for flooding, which were based on a bathtub model, did not give it the high quality hydrodynamic data it needed to understand the effects of winds and waves from hurricanes and Nor'easters and the effects of dams on the Charles and Mystic Rivers. As a result, MassDOT, along with regional partners, conducted high resolution hydrodynamic modeling and created a new dataset showing the effects of future sea level rise and storm surge flooding in Boston.

This data allowed MassDOT to better understand the vulnerabilities of the Central Artery/Tunnel and develop adaptation strategies to address them. Although the modeling was a costly project, MassDOT justified the cost because it had a low tolerance for risk to the Central Artery/Tunnel, given that it is a new piece of infrastructure and a critical transportation asset for the region. The new data from the Boston Harbor Flood Risk Model has been used by local stakeholders conducting their own climate risk assessments, including the City of Boston and surrounding municipalities, universities, and other state agencies. MassDOT is currently expanding the model to the state's entire coast and islands.

Maryland Adaptation and Vulnerability Assessment – Elizabeth Habic, Maryland Department of Transportation/State Highway Administration

The State of Maryland is vulnerable to several impacts of climate change, including sea level rise, increases in temperature, and increases in precipitation intensity and frequency. The Maryland Department of Transportation/State Highway Administration (DOT/SHA) conducted a FHWA climate change vulnerability assessment pilot study to assess the vulnerability of its assets to climate change, develop methods to address current and future risk to the roadway network, and provide process and policy recommendations. Maryland DOT/SHA chose to focus

its vulnerability assessment on three climate stressors related to flooding: sea level change, storm surge, and precipitation. The vulnerability assessment focused on risks to bridges and roadways in two coastal counties, Anne Arundel and Somerset.

To narrow down the number of assets it evaluated in detail, the Maryland DOT/SHA conducted an initial screen to identify bridge assets located in areas vulnerable to climate change impacts. It identified these areas based on the outer limits of the 2100 mean higher high water mark³, the Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model for a Category 3 Hurricane, and the Federal Emergency Management Agency (FEMA) 100-year floodplain boundary plus a 50 foot buffer. Maryland DOT/SHA used FHWA's Vulnerability Assessment Scoring Tool (VAST) to evaluate vulnerability of the assets selected in the initial screen and develop a vulnerability score. For its evaluation of roadways, Maryland DOT/SHA developed a Hazard Vulnerability Index (HVI) that scores risk to a roadway asset based on whether it is an evacuation route, the flood depth under future sea level and storm events, and the functional class of the roadway. By combining both the highway locations identified by HVI and the bridges that scored highest in VAST, the agency was able to identify "Vulnerable Areas at Risk." Finally, Maryland DOT/SHA conducted an origin/destination analysis to evaluate travel times and access to random locations both before and after a hypothetical future flood event. The analysis identified destinations that would take longer to reach or would not be reachable in 2100 due to sea level rise and flooding.

Maryland DOT/SHA plans to use the results of its vulnerability assessment in several ways. It plans to flag vulnerable areas as part of its Highway Needs Inventory, a planning document that lists major capital construction projects. It will also provide the results to the counties and municipalities addressed in the study to help them in their planning processes. The agency is also undergoing a reorganization, and sustainability and climate change will become the focus of a unit within the Innovative Planning and Performance Division.

Planning for Climate Resiliency – Kelly McGourty, Puget Sound Regional Council

The Puget Sound Regional Council (PSRC) covers four counties in the Seattle metropolitan area, with a population of approximately four million. Previous planning efforts related to climate change largely focused on mitigation, although PSRC is now prioritizing adaptation as well. The last long-range transportation plan, [Transportation 2040](#), which was published in 2010 and updated in 2014, included a [white paper](#) on adaptation to climate change for transportation planning in the Puget Sound region. The white paper had information on identifying potential impacts, conducting sea level rise mapping, reviewing economic impacts, and identifying potential future adaptation strategies.

In 2015, PSRC formed a regional collaborative on climate preparedness consisting of municipalities, government agencies and other regional organizations. The collaborative is currently working on expanding its membership, developing a work program, and hosting a

³ The mean higher high water (MHHW) mark is the average of the higher of the two high tides per day over a 19 year period called the National Tidal Datum Epoch.

webinar series. Seattle was recently selected as a pilot community under the National Academies Resilient America Roundtable program, which convenes experts from the academic, public, and private sectors to design or catalyze activities that build or enhance communities' resilience. As part of this program, Seattle will develop resilience strategies focused on equity and transportation. Seattle will coordinate these efforts with the regional collaborative. PSRC's Transportation 2040 Update will occur in 2018, and PSRC is working to expand its previous climate change white paper with information on expected impacts, current adaptation efforts around the region, and economic resiliency. PSRC staff are also working to communicate the importance of climate resiliency to its board and other decision-makers, which can be challenging given that this is a relatively new topic and faces many competing priorities.

Climate Resilience: A Southeast Florida Perspective – James Cromar, Broward Metropolitan Planning Organization

Four counties in Southeast Florida (Palm Beach, Broward, Miami-Dade and Monroe) collaborate on climate adaptation planning through the [Southeast Florida Regional Climate Change Compact](#). These counties have coordinated on a FHWA climate change resilience pilot project, long range planning related to sea level rise, and emergency actions. Southeast Florida faces many climate impacts, including sea level rise, storm surge, increasing temperatures, inland flooding, and a rising water table. The FHWA pilot project was developed to build upon existing vulnerability assessments, minimize the impacts of extreme weather events and sea level rise on the regional transportation network, develop tools that integrate climate change adaptation goals into the transportation decision making process, and prepare a climate change adaptation model for other public transportation agencies.

As part of the pilot project, the Compact conducted a vulnerability assessment for the regional road network and the Tri Rail network. Vulnerability scores were calculated based on sensitivity, exposure, and adaptive capacity, and the assets most vulnerable to flooding were identified for each county. The Compact is now working to integrate climate and vulnerability data into decision-making through transportation planning and prioritization, the rehabilitation of existing facilities in high risk areas, and changes to operations and maintenance. Communities within the region are also beginning to develop adaptation strategies that address some of the risks and vulnerable assets identified in the pilot.

ATLANTA-AREA PRESENTATIONS

Several presentations provided participants with information on climate resilience work that is happening in Atlanta outside of the transportation sector. Presenters covered the topics of municipal resilience strategies, green infrastructure, and the impacts of climate change on water utilities.

City of Atlanta Climate Action Plan and Resilience Plan – Stephanie Stuckey Benfield and Jairo Garcia, Mayor’s Office of Sustainability, City of Atlanta

Atlanta was the first city in Georgia to develop a Climate Action Plan, which it did in 2015. The city’s Climate Action Plan has a goal of reducing greenhouse gas emissions by 80 percent of 2009 levels by 2040, and the city is working to meet this goal through initiatives like improving energy efficiency in buildings and promoting renewable energy and electric vehicles. Now, Atlanta is working to improve climate resilience as well. In May 2016 Atlanta was selected as one of the Rockefeller Foundation’s 100 Resilient Cities, and through this program will receive funding to hire a Chief Resilience Officer, expertise to develop a resilience strategy, and access to partners, technologies, and services.

Atlanta is considering resilience to both climate change and other stressors. The city held a workshop in 2015 with experts from various sectors and identified the following major vulnerabilities that threaten the city’s resilience: infrastructure failure and aging infrastructure, inequality, terrorism and cyber-attacks, transportation, rainfall flooding, droughts and water shortage, and food security. Moving forward, the city will hold additional workshops to gather input from the public on these vulnerabilities and will develop a resilience strategy to address them.

Green Infrastructure and Resilience – Robert Reed, Southface

The Southface Green Infrastructure and Resilience Institute (GIRI) works to provide training and certification to regional professionals to install and maintain green infrastructure. In addition to its role in workforce development, GIRI also aims to educate the public on the benefits of green infrastructure. Green infrastructure can address climate risks by reducing negative impacts of extreme weather events and sewer overflows. It can also have economic and social benefits through creating green spaces, parks, and other amenities in disinvested and impoverished areas. Green infrastructure provides an example of tactical, small-scale resilience, in contrast to the major infrastructure projects that are typically considered when addressing vulnerability to climate impacts.

Metro Water District Climate Utility Resiliency Study – Danny Johnson, Metropolitan North Georgia Water Planning District, Atlanta Regional Commission

Metropolitan North Georgia Water Planning District (Metro Water District) is staffed by ARC and includes 15 counties and 93 cities in the region. The Metro Water District conducts planning related to water supply and conservation, stormwater, wastewater, and watershed management. The Metro Water District recently conducted a Utility Climate Resilience Study

with the goal of assessing the potential vulnerability of water resources and related infrastructure given potential climate conditions in the future. The purpose of the study was not to predict future climate conditions or the likelihood that certain conditions will occur, but rather to identify climate conditions that would pose risks if they did occur.

The Metro Water District developed five representative scenarios of possible future climate conditions based on global climate models: hot/wet, hot/dry, warm/wet, warm/dry, and a middle scenario between the other four. It then identified the water demand, water supply, and water quality impacts of these climate scenarios. Metro Water District also evaluated infrastructure vulnerability, including the vulnerability of wastewater treatment plants to the various climate scenarios. The overall findings from this study were that the most severe climate impacts would occur in a hot/dry scenario, while the highest risk to infrastructure would occur in a hot/wet scenario. Recommendations from the study include for the Metro Water District to establish climate tracking protocols and identify trigger levels for adaptive measures, as well as to implement preemptive adaptation measures such as green infrastructure and drought management plans.

KEY TAKE-AWAYS FROM DISCUSSION

The peer exchange included three dedicated discussion sessions, as well as time for questions and discussion after most presentations. The major topics and themes raised in the discussion are presented below.

Climate impacts

Although much of the work on transportation and climate change impacts to date has focused on sea level rise and coastal storms, participants discussed other climate impacts that their communities are facing and for which they are preparing. One impact that some areas, including Atlanta, are facing is the dual problem of more severe precipitation events that cause flooding and longer periods between precipitation events, leading to drought. Heat is also a major concern for the transportation sector, both through its direct impact on infrastructure (pavement, rail, etc.) but also through its impact on the electricity supply and on the people using the transportation system. The social impacts of climate change also affect the transportation sector. For example, some non-coastal areas are considering whether they will see an increase in migration from coastal areas as a result of sea level rise, and the impacts on the transportation system that this migration could cause.

Data collection

In order to conduct a vulnerability assessment, there is a need for data on climate impacts. Agencies face tradeoffs in deciding what climate data or modeling to use. Tools are available for downscaling global climate data to a given region. However, this data may not consider all climate risks or recognize all local geographic features that may affect climate impacts. On the other hand, it is costly for agencies to conduct their own climate model downscaling; this may only be cost-effective for large jurisdictions or for those with a low risk tolerance, where accurate and detailed climate data is essential for designing solutions. In addition, state agencies may be more equipped than MPOs to conduct climate model downscaling, and then can provide this data to jurisdictions within their state. For example, Maryland DOT/SHA and Massachusetts DOT collected climate data and conducted modeling and/or vulnerability assessments, and provided the results to other jurisdictions.

Building support for resilience

A major theme of the discussion was building support for resilience among decision-makers. Participants found this especially challenging in places where the state government leadership is not focused on or is opposed to addressing climate change. Participants suggested the following strategies for building support for climate resilience:

- Conduct a cost-benefit analysis and make an economic argument for investing in resilience.
- Discuss the climate risks to public health or the health benefits that investing in resilience can bring. Studies have shown that reframing climate risks with a health lens can motivate people to take action.

- Add a climate resilience component into transportation projects that are currently being planned and designed. Although this will add somewhat to the cost of the project, the incremental cost for resilience improvements will be lower than with a standalone project.
- Reframe climate resilience with a different name (e.g., hurricane planning).
- Identify climate impacts that a community is already facing and frame investments in resilience as a way to address these.
- Use Federal policies as a justification for investing in resilience. For example, the Council of Environmental Quality's guidance encourages looking at climate change impacts in the National Environmental Policy Act process, and the FAST Act requires consideration of resilience and natural disasters in state and metropolitan transportation planning.

Participants also noted that even in states that are not focused on climate resilience, MPOs still have flexibility to assess climate risks and incorporate the results into the transportation planning and project prioritization processes.

Funding

Participants discussed the need for funding to mainstream resilience into transportation decision-making, and potential sources for this funding. One challenge is that while interventions that build resilience typically save organizations money in the long term, such activities cost money in the short term, and transportation agencies need to find the funding to support the additional expenditures. Similarly, the benefits of many resilience interventions are felt throughout a region, not just in the transportation sector; however, the costs for transportation projects are borne solely by the transportation agency. Transportation agencies need to figure out where to draw the line for quantifying the benefits when doing a cost-benefit analysis.

Participants also discussed insurance and whether transportation infrastructure can be insured so that the government is not fully fiscally responsible for replacing a piece of infrastructure when it is damaged by severe weather. For example, MassDOT insured the Central Artery/Tunnel. Participants raised the concern that insuring transportation assets could cause a tendency to remain in vulnerable areas and rebuild rather than moving assets or improving their resilience to climate impacts.

Regional and cross-sectoral collaboration

Participants noted the value of working with other agencies and jurisdictions on assessing climate impacts and planning for resilience. Transportation agencies can partner with water utilities, health departments, or other sectors to gather climate data and assess risks. Even within one MPO, there is value in communicating climate-related work, as other departments may also be working in this area and there may be opportunities for collaboration. For example, within ARC both the transportation and water resource divisions are working on climate resilience. There are also benefits to working on resilience through regional collaboration, such

as the Southeast Florida Regional Climate Compact, or the compact that is being developed in the Puget Sound region.

Participants also discussed the need for expanding resilience beyond a focus on infrastructure. Resilience should also address the people using the infrastructure and how climate change may affect their behavior while using the transportation system. Some participants also raised the need for resilience to consider equity and take an environmental justice perspective.

Resilience and the planning process

Although most of the state DOTs and MPOs that participated in the peer exchange had assessed their transportation system's vulnerability to climate change, progress on integrating these results into the planning process and implementing resiliency plans is still in its early stages. Participants discussed ways to incorporate climate resilience into the planning process. One challenge is that resilience competes with other major priorities. In addition, in areas that are currently experiencing the effects of climate change, some amount of climate funding needs to be dedicated to getting the system up and running in an emergency, rather than to planning for projects that build resilience.

Agencies may be able to integrate resilience into actions that they are doing anyway at a lower incremental cost. For example, for assets that have a long service life, such as a bridge or a tunnel, agencies should consider building climate resilience into the design of the asset from the beginning. In contrast, there are certain actions that are done frequently enough (e.g., pavement design) for which climate-proofing in the short-term can be postponed.

State and MPO needs

FHWA will be developing resources and information to help state DOTs and MPOs meet the resilience requirements in the FAST Act. Participants suggested several resources that would help them integrate resilience into the transportation planning process:

- Suggestions of performance measures related to resilience that could help agencies consider climate change in the project prioritization process.
- Resources for conducting an economic analysis or cost-benefit analysis of resilience strategies.
- A "menu" of adaptation and resiliency strategies.
- Assistance for agencies that do not have any experience with climate resilience, including suggestions for climate data sources.

APPENDIX A: AGENDA

ARC/FHWA Climate Resilience Peer Exchange

Oct 4-5, 2016

Atlanta Regional Commission Office, C Level, Harry West Room

Day 1 – Tuesday, October 4th Agenda

- 1:00 PM – Meeting Kick-off – Doug Hooker, ARC & Steve Luxenberg, FHWA (20 mins)
- 1:20 PM – Participant Introductions (25 mins)
- 1:45 PM – Climate Change Overview – Mike Meyer, WSB PB (30 mins)
- 2:15 PM – ARC’s Planning Work to Date on Climate Change – David D’Onofrio, ARC (20 mins)
- 2:35 PM – FHWA Overview on Climate Resilience Planning – Heather Holsinger and Corbin Davis, FHWA
- 2:55 PM – BREAK (20 mins)
- 3:15 PM – Panel #1 Resiliency Planning Best Practices (1 hour)
 - North Central Texas Council of Governments – Jory Dille
 - Hillsborough County Metropolitan Planning Organization – Allison Yeh
- 4:15 PM – Group Discussion #1 (45 mins)
- 5:00 PM – Break for the day

Day 2 – Wednesday, October 5th Agenda

- 8:30 AM – Climate Change and Human Health – Paul Schramm, Centers for Disease Control and Prevention (40 mins)
- 9:10 AM – Panel #2 Resiliency Planning Best Practices (1 hour)
 - Massachusetts Department of Transportation – Steven Miller
 - Maryland Department of Transportation/State Highway Administration – Elizabeth Habic
- 10:10 AM – BREAK (20 mins)
- 10:30 AM – Atlanta’s Climate Resilience Strategies – Stephanie Stuckey-Benfield, Atlanta (30 mins)
- 11:00 AM – Group Discussion #2 (45 mins)
- 11:45 AM – Lunch (1hr15min)
- 1:00 PM – Southface Green Infrastructure & Resilience Institute – Robert Reed, Southface (25 mins)
- 1:25 PM – Utility Climate Resilience Study – Danny Johnson, ARC (25 mins)
- 1:50 PM – BREAK (20 mins)
- 2:10 PM – MPO/DOT Panel #3 Resiliency Planning Best Practices (1 hours)
 - Puget Sound Regional Council – Kelly McGourty
 - Broward Metropolitan Planning Organization – James Cromar
- 3:10 PM – Group Discussion #3 (45 mins)
- 3:55 PM – Closing Remarks & Wrap-Up (10 mins)

APPENDIX B: PEER EXCHANGE PARTICIPANTS

First Name	Last Name	Organization
Adjo	Amekudzi-Kennedy	Georgia Tech
Stephanie	Amoaning-Yankson	Georgia Tech
Shan	Arora	Southface
Helen	Barnes	Southern Environmental Law Center
Tamara	Christion	FHWA - GA Division
Kirsten	Cook	Rockdale County
James	Cromar	Broward MPO
Corbin	Davis	FHWA
Tiffani	Davis	FHWA - GA Division
Jory	Dille	NCTCOG
David	D'Onofrio	ARC
Jerimiah	Easley	FTA
Jairo	Garcia	City of Atlanta
Gil	Grodzinsky	GA Environmental Protection Division
Elizabeth	Habic	Maryland DOT/SHA
Heather	Holsinger	FHWA
Doug	Hooker	ARC
Crystal	Jackson	ARC
Christy	Jeon	WSB Parsons-Brinckerhoff
Danny	Johnson	ARC
Kyung-Hwa	Kim	ARC
Steve	Luxenberg	FHWA - GA Division
Kelly	McGourty	PSRC
Keith	Melton	FTA
Michael	Meyer	WSB Parsons-Brinckerhoff
Steven	Miller	MA DOT
John	Orr	ARC
Amy	Plovnick	Volpe
Shayna	Pollock	ARC
Jim	Pomfret	GDOT
Larry	Redd	Cambridge Systematics
Robert	Reed	Southface
Daniel	Rochberg	Emory
Elizabeth	Rowe	Agnes Scott
Stephanie	S. Benfield	City of Atlanta
Paul	Schramm	CDC
Sylvia	Smith	DeKalb County
Claire	Still	AECOM
Kofi	Wakhisi	ARC
Allison	Yeh	Hillsborough MPO
Ermis	Zayas	Georgia Conservancy