Flooded Bus Barns and Buckled Rails:
Public Transportation and Climate Change Adaptation

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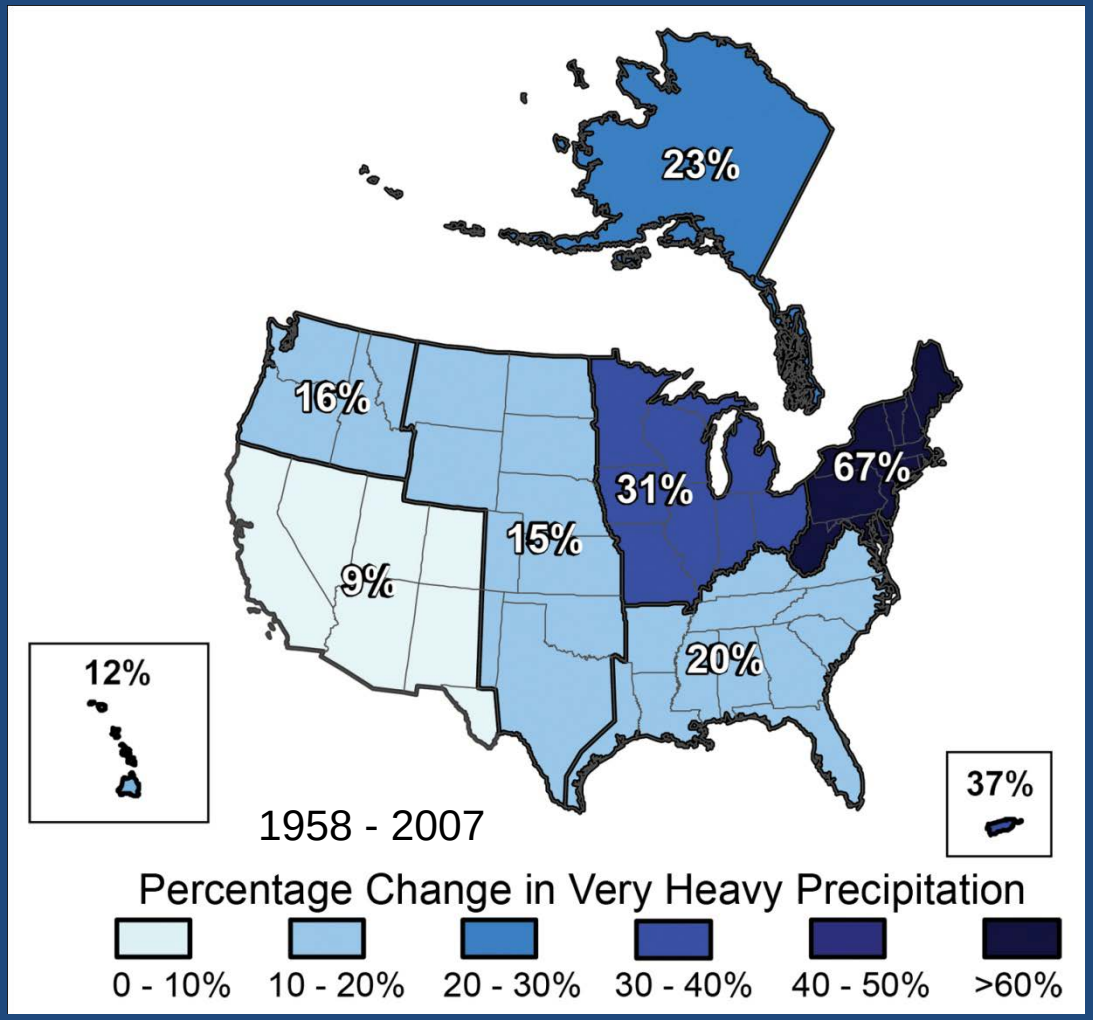
4 Transit Impacts

↑ Intense Precipitation (very likely, >90%)	• Flooding of track, bus ways, tunnels, lots, facilities • Landslides
↑ Very Hot Days & Heat Waves (very likely, >90%)	• Track buckling leads to slow order or derail • Customer comfort issue • Worker safety issue
Rising Sea Levels (virtually certain, >99%)	• Flooded track, bus ways, tunnels, lots, facilities • Higher groundwater level floods tunnels
↑ Hurricane Intensity (likely, >66%)	• Flooding from storm surge, rain • High winds – debris, wind damage • Transit provision of evacuation service

Climate Impacts Already Occurring



- "When it rains, it pours"
- Note that largest impact is in Northeast, home of some of largest and oldest rail transit systems.

*defined as the heaviest 1 percent of all daily events

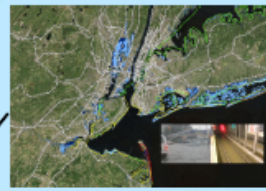
Source: Groisman et al as cited in USGCRP 2009.

Nashville Flood, May 2010

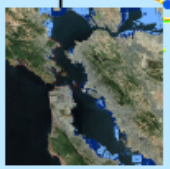
Photos courtesy of Nashville MTA

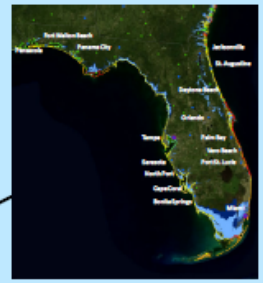
Cumberland River floods MTA property on Nestor Street

Impacts of Climate Change on U.S. Public Transportation: Intense Precipitation and Sea Level Rise Projections



Nashville, TE
Heavy rains in Nashville in May 2010 caused the Cumberland River to flood its banks, inundating transit agency offices, maintenance facilities, and bus storage lots.





Vicksburg, MS
River flooding from heavy rains in 2011 forced Vicksburg transit providers to shutter routes and relocate paratransit operations.

Legend

Transit
- Bus
- Bus and Ferry
- Bus and Rail
- Bus, Rail, and Ferry
- Rural Transit

Change in Forecast Average Annual Precipitation Intensity (in standard deviation units; negative (positive) numbers represent a decline (increase) in over time)
- -0.8 - -0.5
- -0.5 - 0.0
- 0.0
- 0.0 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0

Coastal Vulnerability Index
- Very High
- High
- Moderate
- Low

- Areas Below 1 Meter Elevation
- Areas Between 1 and 2 Meter Elevation

1 meter (3.3 ft)

Precipitation Intensity: Total Annual Precipitation Amount Divided by Total Number of Wet Days in The Year, 2080-2099 under A1B emission scenario minus 1980-1999 Average, normalized by 1960-2099 standard deviations. (The standard deviation is a measure of variability in a data set, with one standard deviation (either positive or negative) representing a little more than a third of the observations in a normal distribution.)

Coastal Vulnerability Index: This is an index value calculated by combining rankings of geomorphology, regional coastal slope, rate of relative sea level rise, historical shoreline change rate, mean tidal range, and mean significant wave height, for 1-kilometer grid cells along the coast. The index, when combined with the elevation data, provide a better general picture of potential sea level rise vulnerability since factors such as erosion, subsidence, uplift, and other factors can increase or decrease the vulnerability of low elevation coastal areas.

Projections show for each 1.8°F increase in tropical sea surface temperatures, core rainfall rates will increase by 6 to 18 percent and the surface wind speeds of the strongest hurricanes will increase by about 1 to 8 percent.

Transit ridership (unlinked passenger trips), used to determine symbol size, from the National Transit Database (2008); one dot per urbanized area, which can reflect multiple transit agencies in that area. Precipitation density derived from data provided by Meehl et al. ("Understanding future patterns of increased precipitation intensity in climate model simulations," Geophysical Research Letters, Volume 32, 2005) under an emission scenario that assumes very rapid economic growth, global population peaking in mid-century and declining thereafter, and rapid introduction of new and more efficient technologies with balanced energy sources; areas below 1 meter or 2 meter elevation from Weiss et al ("Implications of recent sea level rise science for low-elevation areas in coastal cities of the conterminous U.S.A." Climate Change, Volume 105, 2011). Coastal Vulnerability Index from Pendleton et al, USGS ("Coastal Vulnerability Assessment of the Northern Gulf of Mexico to Sea Level Rise and Coastal Change." U.S. Geological Survey, 2010). Climate change projections for rainfall are simulations results from a subset of models of the World Climate Research Programs / Coupled Model Intercomparison Project 3 (WCRP/CMIP3). Some modeling work has been performed by the authors sited here, however further data processing was required to generate precipitation intensity. Alaska, Hawaii and Puerto Rico not included due to lack of data

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N

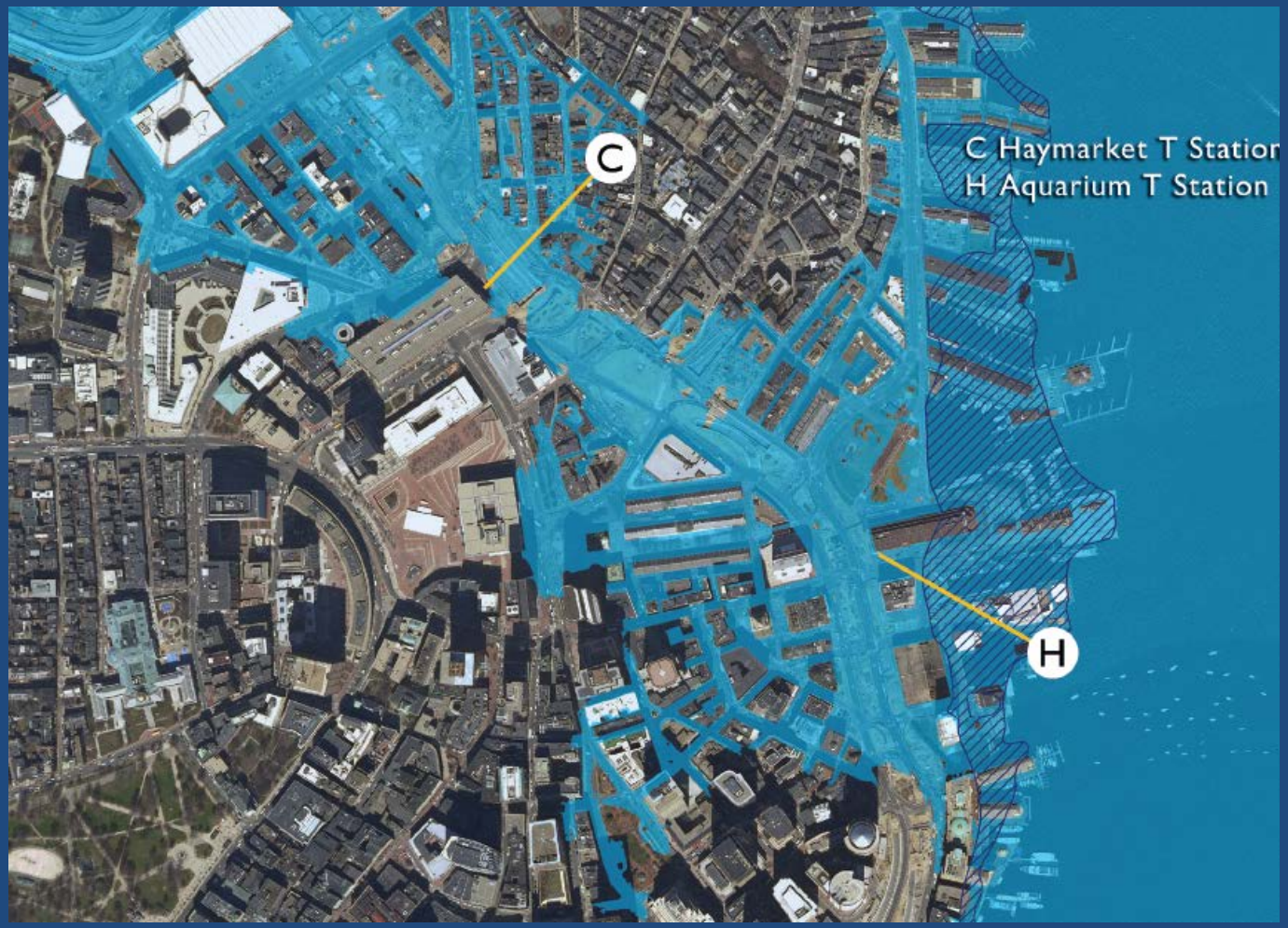
0 100 200 Miles

Sea Level Rise – San Francisco Bay Area

- Blue: Areas that could be inundated by 16 inch sea level rise
- Purple: Areas that could be inundated by 55 inches sea level rise

Source: San Francisco Bay Conservation and Development Commission, *Living with a Rising Bay: Vulnerability and Adaptation in San Francisco Bay and on its Shoreline*, April 7, 2009.

Sea-level Rise + Bigger Storms = More Flooding



Boston

Dark blue hashed area = current 100-yr flood zone

Light blue = projected 100-yr flood zone

Source: UCS / NECIA

Impacts of Climate Change on U.S. Public Transportation: High Heat Projections

Portland:
Designed with the Pacific Northwest's historically mild climate in mind, Portland's light rail system experienced overheating of rail electrical systems, ticket vending machines, and the electrical equipment housed on the roofs of low floor vehicles during recent heat waves. The agency has also installed expansion joints to reduce track buckling.

Chicago:
Innovative Ways of Mitigating Heat Impacts
Chicago's Climate Action Plan calls for planting more than a million trees in the city by 2020 to reduce the impact of heat waves and the urban heat island effect. In particular, the city used satellite images to identify hot spots in the city where urban heat island reduction strategies will have the greatest impact. Many of the hot spots are areas with a notable percentage of transit dependent residents.

Rural Transit:
Rural transit agencies provide lifeline services to many senior citizens and individuals with disabilities who are particularly vulnerable to high heat.

Tucson:
Transit stops and other shelter facilities can provide shading and natural ventilation for passenger comfort and safety -- The station design for the new Tucson Modern Streetcar system incorporates a double-tiered shade structure that decreases temperatures by 10 to 15°F and provides shade at all times of day.

Washington:
Impact of High Heat on Rails
The Washington DC area rail system has already experienced multiple incidents in which extended high temperatures caused 'heat kinks' or buckling of the rails, leading to requirements to reduce speeds and to remove and replace sections of rail. Heat kinks pose safety risks and can even cause trains to derail. Heat waves in 2007 and 2010 also caused heat kinks and significant passenger delays in Boston and Philadelphia.

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Annual Average Increase In Number of Days Above 90° F (1961-1971 vs. 2080-2099)
- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- 80- 100
- 100 +

Phoenix:
A solar-powered cooling system is being built that will allow travelers to push a button at the 3rd Street/Washington light rail stop for a release of cool air. From May through September, fans will blow chilled air from a downtown district cooling system to help cool passengers.

By the end of the century, average temperatures in the United States are projected to increase by 7 to 11°F under a high emission scenario and 4 to 6.5°F under a low emissions scenario.
US Global Change Research Program

Transit ridership (unlinked passenger trips), used to determine symbol size, from the National Transit Database (2008); one dot per urbanized area, which can reflect multiple transit agencies in that area. Change in number of days above 90 degrees based on data provided by NOAA's National Climatic Data Center, reflecting information presented in U.S. Global Change Research Program's Global Climate Change Impacts in the United States (2009); very high emissions scenario (a2). Climate change projections are simulation results from a subset of models of the World Climate Research Programs / Coupled Model Intercomparison Project 3 (WCRP/CMIP3). Alaska, Hawaii and Puerto Rico not included due to lack of data.

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0 100 200 Miles

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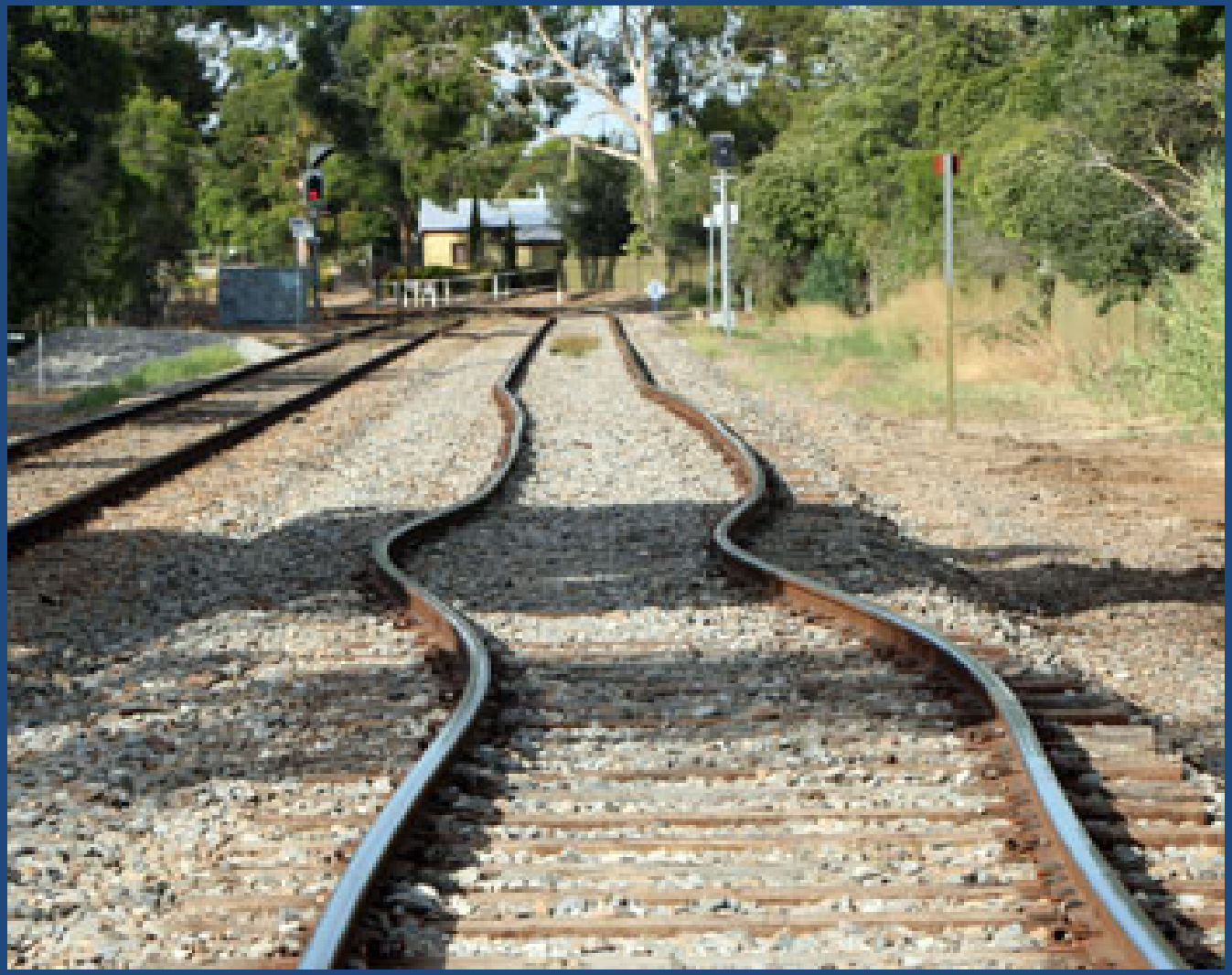
Rail Buckling



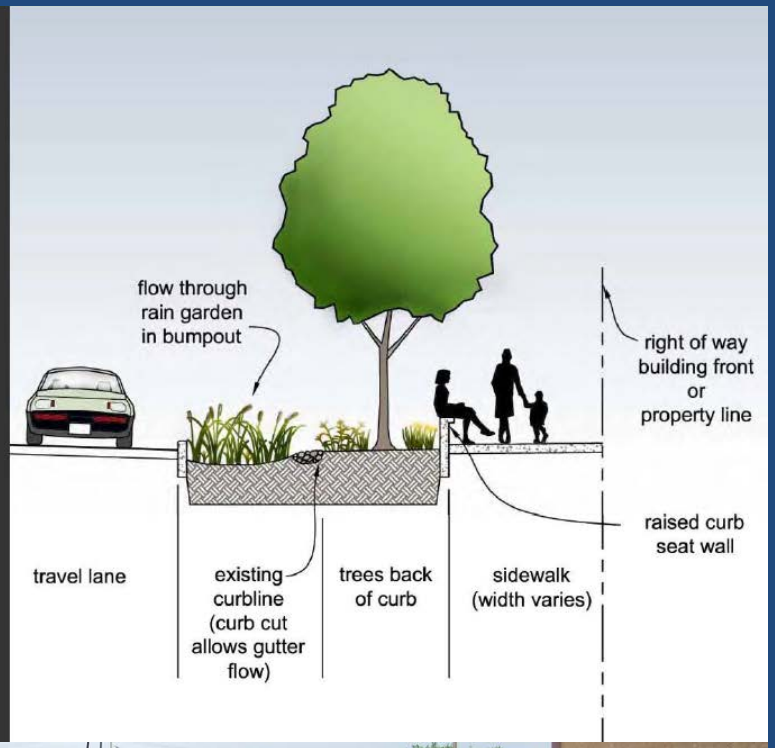
State of the Practice: Transit & Adaptation

Transit Agency	Adaptation Actions
New York MTA	1st report on climate change hazards at a US transit agency. Partnered with state and local adaptation efforts. Raised ventilation grates.
Los Angeles MTA	Conducting climate change risk assessment of assets, to be completed July
New Jersey Transit	Conducting climate change risk assessment of assets, to be completed Oct. Participating in FHWA adaptation pilot
Waves Transit, AL	Part of multi-modal US DOT Gulf Coast Study, Phase II
TriMet	Participating in regional adaptation efforts
Cape Cod Transit	Part of interagency climate change pilot, assessment of sea level rise impacts.
Honolulu Transit	Participating in FHWA adaptation pilot
King County Metro	Stakeholder in county adaptation efforts, which are at forefront of field
Transport for London	Adaptation included in risk and asset management systems. Adding air conditioning, addressing flooding to existing system. Climate impacts incorporated into design of major project – “Crossrail.”
Istanbul	New rail link built for 3 ft sea level rise + 1 in 10,000 yr flood
Taipei	After typhoon dumped 50 inches of rain in two days, set new standards for entrances: 2-4’ above ground + 6” above 100 yr flood, tunnel floodgates

Kansas City Bus Rapid Transit

Flow - through rain garden in bumpout designed to collect runoff from road and sidewalk.

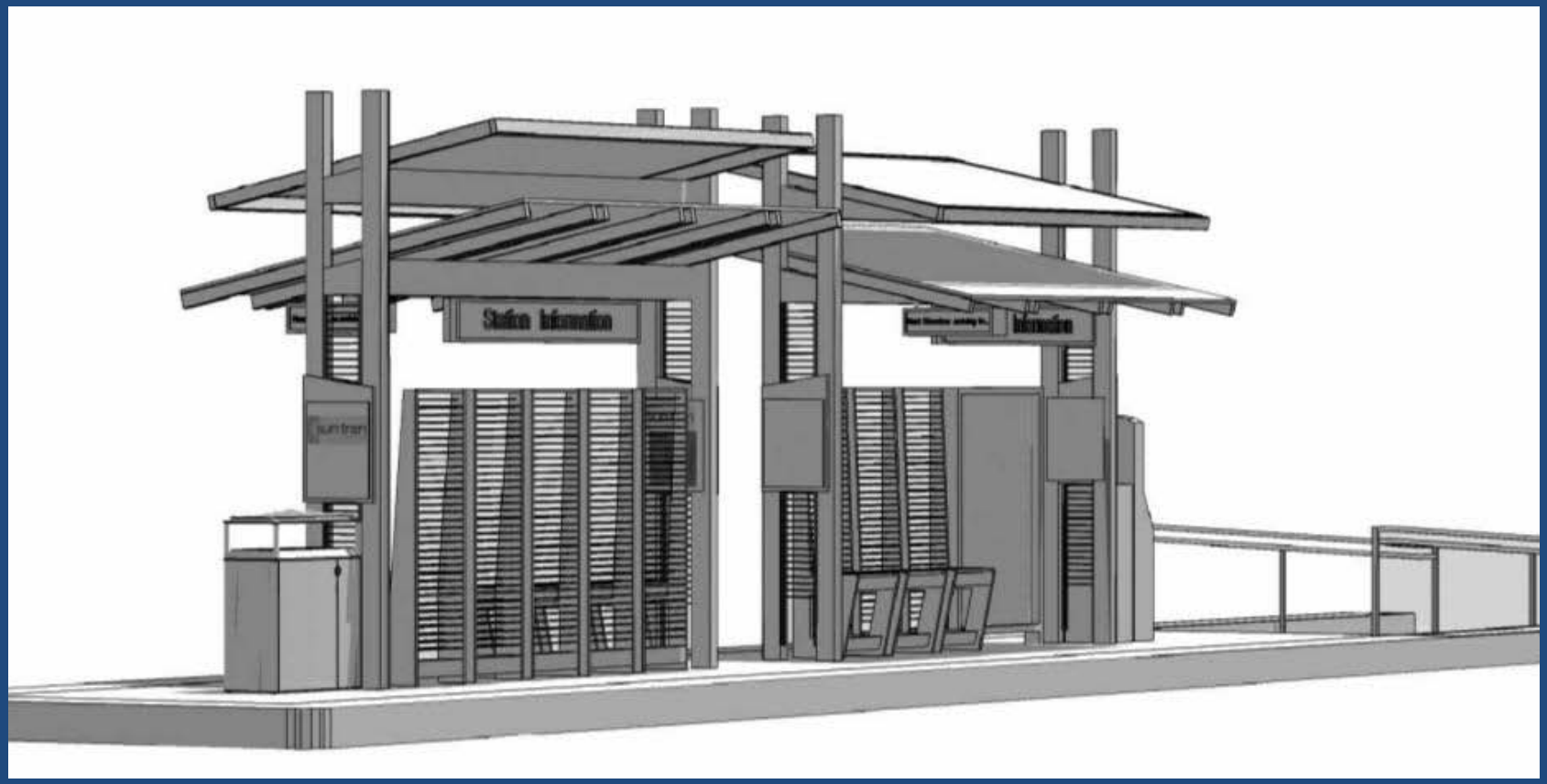
Trees planted back of curb at higher soil level.



Rain Gardens

Pervious Pavement

Tucson Streetcar
Double-Tiered Shade Structures



Mainstreaming Adaptation into Transit Agency Structures & Processes

- Asset management systems: offer useful framework for incorporating climate adaptation into capital plans and budgets.
- Metropolitan and Statewide Transportation Planning
- Environmental Management Systems
- Environmental Review and Project Development
- Floodplain Assessment
- Real Estate Acquisition and Relinquishment of Assets
- Design and Construction
- Retrofit
- Maintenance
- Emergency Preparedness, Response, and Recovery
- Performance Measures
- Organizational Culture and Budget Priorities

FTA Adaptation Work

- Report – released today
- Pilots of transit agency adaptation assessments – applications due August 25 (one to focus on asset management systems)
- Workshops and webinars – first workshop Aug 3. Webinar Aug 8.
- FTA Policy Statement – signed May 2011; explains impact of climate change on state of good repair and safety; commits FTA to taking action

Take away point: Climate adaptation is responsible risk management.

Learn more: www.fta.dot.gov/sustainability click on “climate change”

Thank you!

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