

REGIONAL TRANSPORTATION RESILIENCE ECONOMIC ANALYSIS

Cost-Benefit Analyses of Case Study Transportation Assets & Example Resilience Measures

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Regional Transportation Resilience Economic Analysis

- Analysis to demonstrate the cost of inaction and provide support for the benefits of proactive resilience investment
- Five case studies quantifying the costs and benefits of resilience and adaptation
- Transportation assets (one of each: rail stops, bus stops, road segments, rail segments, bridges)
- Natural hazards (flooding and extreme heat)
- Develop a framework for risk-based economic impact analysis, and guidance for the evaluation of further assets and projects



Case Studies

-  **Bus Stop: Army Navy Drive & S. Joyce St stop in Arlington**
-  **Rail Stop: Greenbelt MARC Station**
-  **Bridge: Liverpool Point Road**
-  **Railway: Silver line between Loudon Gateway and Washington Dulles**
-  **Roadway: Anacostia Freeway**

Key Takeaways

- Shelters and foliage solutions at bus stops can significantly lower ambient temperatures, resulting in decreased health costs.
- Over 20 years, no investment could result in nearly \$7,000 in health impacts at a single location.
- Results suggest a 3.1 ROI for proactive investment.
- Similar action could be taken at a regional level to address health concerns in the National Capital Region.

Results: BCA results suggest that the low-cost and high-cost solutions have discounted (3.1%)^a benefit-cost ratios of 3.0 and 2.7, respectively. These results imply that for every \$1 invested in solutions, there is a return of nearly \$3 in health and advertising revenue benefits. Net benefits are estimated at around \$100,000 over 20 years.



Case Study: Bus Stop Army Navy Drive & S. Joyce St stop in Arlington

Impacts of Extreme Heat on Bus Commuters

Inputs:

- Ridership
- Heat-related emergencies
- Cost of heat-related health emergencies
- Heat days

Solutions:

- No Action
- Low-Cost – bus shelter solution
- High-Cost – bus shelter plus vegetation solution



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Transportation Resilience
Transit: Bus Stop

Case Study

Overview: The National Capital Region Transportation Planning Board (TPB) is conducting five benefit-cost analysis (BCA) case studies of transportation assets within the National Capital Region to demonstrate the cost of inaction, compare low-cost and high-cost solutions, and provide support for the benefits of proactive resilience investment.

Study Site: The focus of this case study is the Army Navy Drive & South Joyce Street westbound/southbound bus stop in Arlington, VA. This Metrobus and Arlington Transit bus stop serves roughly 70 riders per day and lacks existing shelter or vegetation.

Context: Studies, such as those by the Center for American Progress,¹ show that exposure to extreme heat results in increased emergency department (ED) visits and hospitalizations, and that the number of days with extreme heat is expected to increase. Research published by Arizona's Sun Tran bus service² and Lanza et al. (2025)³ shows that shelters and surrounding vegetation can lower ambient and ground temperatures and help mitigate health impacts at bus stops. This case study examines a low-cost solution of erecting a bus shelter and a high-cost solution of supplementing the shelter with additional trees and foliage to lower temperatures around the stop. In addition, the new bus shelter would provide space for advertising, thereby producing advertising revenue.

Results: BCA results suggest that the low-cost and high-cost solutions have discounted (3.1%)⁴ benefit-cost ratios of 3.0 and 2.7, respectively. These results imply that for every \$1 invested in solutions, there is a return of nearly \$3 in health and advertising revenue benefits. Net benefits are estimated at around \$100,000 over 20 years.

Key Takeaways

- Shelters and foliage solutions at bus stops can significantly lower ambient temperatures, resulting in decreased health costs.
- Over 20 years, no investment could result in nearly \$7,000 in health impacts at a single location.
- Results suggest a 3:1 ROI for proactive investment.
- Similar action could be taken at a regional level to address health concerns in the National Capital Region.



Aerial view, Army Navy Drive/South Joyce Street (Google Maps)



Bus stop with shelter (killane/Shutterstock)

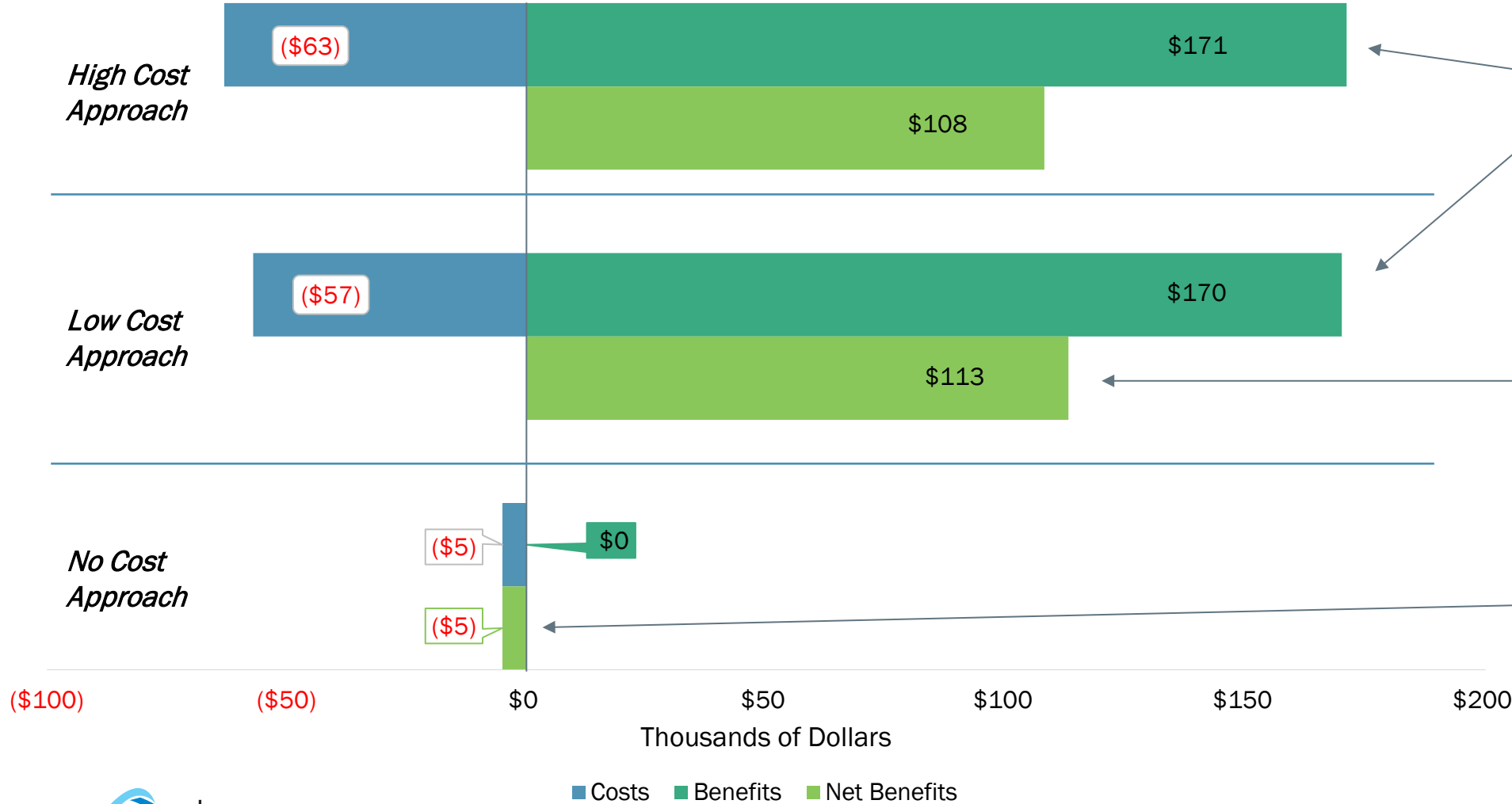


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Cost Comparison, Bus Stop Investment Approaches (Discounted 3.1%)



The **Low Cost approach** yields similar benefits to the High Cost approach at a lower cost.

The **Low Cost approach** also has the highest net benefits.

Lack of investment could cost \$5,000 over 20 years.





Case Study: Rail Stop Greenbelt MARC Station in Maryland

Impacts of Heat and Flooding on MARC Commuters

Inputs:

- Ridership
- Heat days
- Heat-related emergencies
- Risk of heat-related track failure
- Nuisance flooding

Solutions:

- No Action
- Low-Cost – Temporary signage, pumps for nuisance flooding
- High-Cost – Shelter for heat, track hardening eliminates track flooding entirely

Transportation Resilience **Transit: Rail Stop**

Case Study

Overview: The National Capital Region Transportation Planning Board (TPB) is conducting five benefit-cost analysis (BCA) case studies of transportation assets within the National Capital Region to demonstrate the cost of inaction, compare low-cost and high-cost solutions, and provide support for the benefits of proactive resilience investment.

Study Site: The focus of this case study is Greenbelt station in Greenbelt, MD. This station is served by both Maryland Area Rail Commuter (MARC) and Washington Metropolitan Area Transit Authority (WMATA) and serves roughly 2,100 passengers per day during the summer (2,060 WMATA¹ and 30 MARC²). The site also contains a WMATA railyard which has capacity for 284 railcars³ and is a potential location for the future FBI headquarters.⁴

Context: The MARC station at Greenbelt is exposed to the elements, and studies show that exposure to extreme heat results in increased healthcare costs, and that heat impact days are expected to increase across the region.⁵ Research suggests that shelters can help mitigate health impacts.⁶ Historically, the station and railyard are also at risk of flooding.⁷ This case study examines a low-cost solution to address heat and minor flooding impacts, and a high-cost solution for mitigating future flood impacts.

Results: BCA results suggest that the low-cost and high-cost solutions have discounted (3.1%)⁸ benefit-cost ratios of 1.07 and 0.85, respectively. These results imply that for every \$1 invested, the low-cost solution will return about \$1.07 in health and flooding response benefits. The high-cost solution would result in about \$0.85 in benefits per dollar invested. Net benefits are estimated at around \$100,000 over 20 years.

Methods: This analysis uses data on regional heat event days to identify summer health impacts at the Greenbelt station. Assuming health care costs of about \$750 for ED visits, hospitalization costs of about \$15,000,⁹ and roughly 30 commuters per day,¹⁰ the no action heat-related health impacts are

Key Takeaways

- Heat and flood impacts pose a risk to commuters that can be abated by proactive investments.
- Over 20 years, no investment could result in nearly \$3,000 in heat-related health impacts and \$830,000 in flood related impacts at Greenbelt station.
- Results suggest a 1.07:1 ROI for proactive investment in the low-cost solution.
- Similar action could be taken at a regional level to address health and infrastructure concerns in the National Capital Region.

Aerial View, Greenbelt Station

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Cost Comparison, Rail Stop Investment Approaches (Discounted 3.1%)



The **High Cost approach** yields the highest benefits, but costs more than it would save.

The **Low Cost approach** offers the highest net benefits.

Noninvestment could cost over \$900,000 over 20 years.





Case Study: Road Segment Anacostia Freeway in Washington

Impacts of Flooding on Road Users

Inputs:

- Average Annual Daily Traffic
- Frequency and duration of roadway flooding
- Value of travel time
- Cost of road closure

Solutions:

- No Action
- Low-Cost – semi-permanent deployable flood barrier
- High-Cost – permanent raising of road

Transportation Resilience Road Segment

Case Study

Overview: The National Capital Region Transportation Planning Board (TPB) is conducting five benefit-cost analysis (BCA) case studies of transportation assets within the National Capital Region to demonstrate the cost of inaction, compare low-cost and high-cost solutions, and provide support for the benefits of proactive resilience investment.

Key Takeaways

- Flood impacts pose a significant risk to commuters, particularly on limited access roads where flooding cannot easily be avoided.
- Over 20 years, non-investment could result in nearly \$17.3 million in flood related impacts at the Anacostia Freeway location.
- Results suggest a 1.5:1 ROI for proactive investment in a high-cost flooding solution, and 8.1 ROI for the low-cost solution.
- Similar action could be taken at a regional level to address infrastructure concerns in the National Capital Region.

Study Site: The focus of this case study is the portion of the Anacostia Freeway in Washington, DC, between 11th Street and Pennsylvania Avenue. This section coincides with interstate 295, an auxiliary highway connecting major roadways in Maryland and Washington, D.C. This key access point serves roughly 128,000 vehicles per day and has been identified as at high risk for flooding impacts.^{1, 2, 3, 4}

Context: The South-bound and West-bound section of the Anacostia Freeway that ultimately crosses the bridge over the Anacostia River is at high risk of flooding, particularly in sections close to the Anacostia Recreation Center. Flooding in this section, particularly during morning rush hour traffic can snarl access into the city, which has cascading effects throughout the region. Flooding impacts on limited access freeways are particularly troublesome because there are few opportunities to exit the road and slowdowns can extend for miles.

Results: BCA results suggest that the low-cost and high-cost solutions have discounted (3.1%)⁵ benefit-cost ratios of 8.40 and 1.49, respectively. These results imply that for every \$1 invested, the low-cost solution could return about \$8.40 in flooding benefits, and the high-cost solution could result in about \$1.49 in benefits per dollar invested. Net benefits for the low- and high-cost solutions are estimated at around roughly \$6 to \$11 million discounted at 3.1%.

Methods: This analysis examines flooding across three discrete scenarios: nuisance flooding, 100-year events, and 500-year events. The analysis assumes that nuisance flooding occurs 2 times per year, with 100- and 500-year events occurring at an annual return interval of 1% and 0.2%, respectively. For nuisance flooding, the analysis assumes that a 1-hour event partially closes the road.

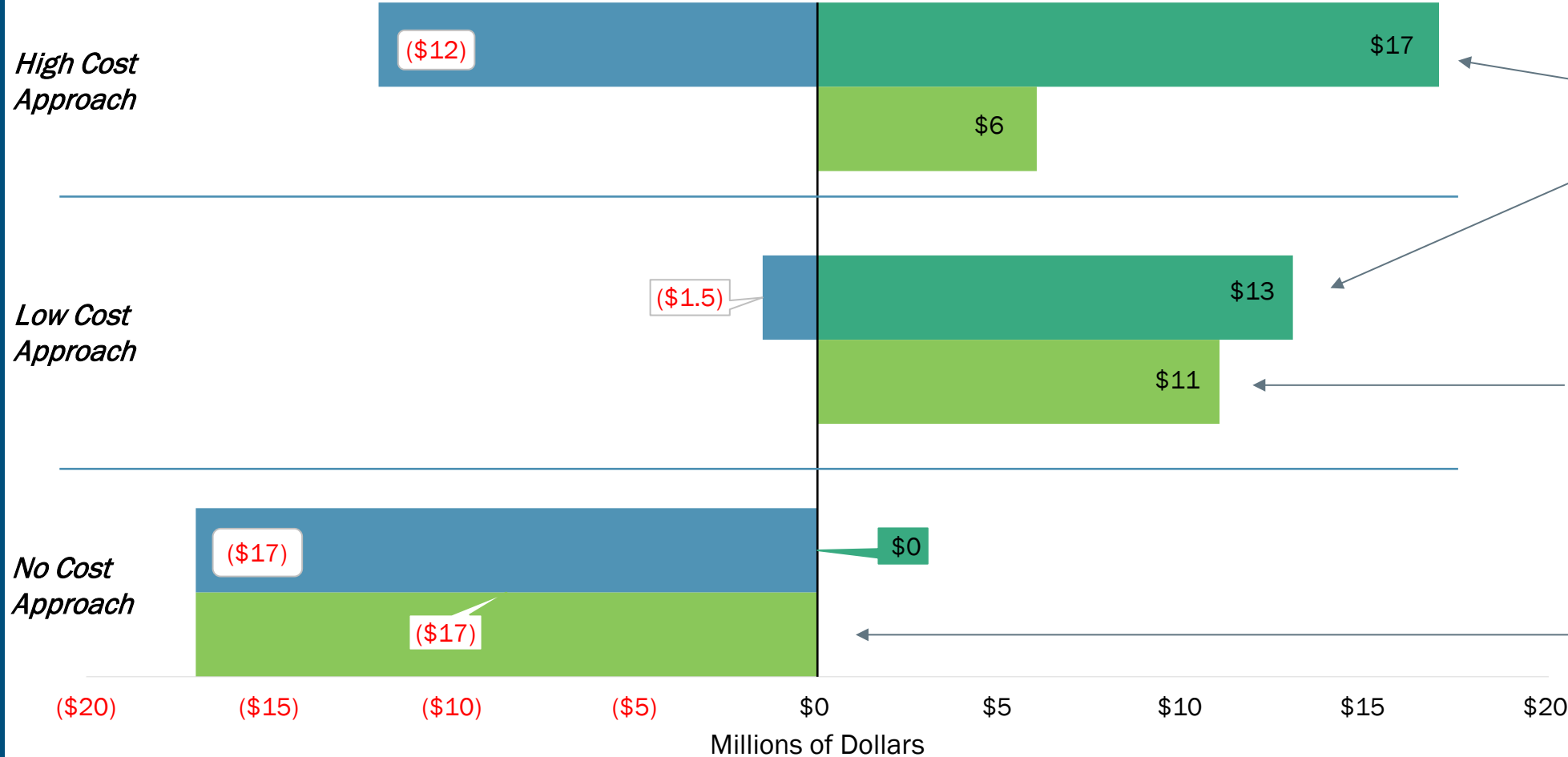
Aerial view, Anacostia Freeway (Google Maps)

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Cost Comparison, Roadway Investment Approaches (Discounted 3.1%)



The **Low Cost approach** yields similar benefits to the High Cost approach at a lower cost.

The **Low Cost approach** also has the highest net benefits.

Lack of investment could cost \$17 million over 20 years.



Case Studies Summary

Key Takeaways

- Taking no action for known climate risks is costly; as much as \$17.2 million over 20 years (discounted 3.1%) in health, repair, and lost time costs at just one of our study locations
- Lower-cost investments often produce similar or more benefits than higher-cost options
- Return on investment, dollar-for-dollar, for low-cost solutions ranges from 1.5:1 to 6:1, depending on the approach taken and the infrastructure type.
- For all infrastructure types studied, taking similar action across the National Capital Region could lead to significant health savings and avoided costs.



Why are resilience investments important?

- Increasing frequency and severity of flooding, heat, storms, and other hazards
- Growing exposure of transportation assets and system users
- Competing funding priorities within TIPs, LRTPs, CIPs: prioritization assistance
- Bond ratings
- High risk/vulnerability does not always mean high reward



Amount spent on preparedness reduces the economic impact on the local community. Every \$1 spent on preparing for disasters is worth \$7 in saved economic costs for the community, including job losses, reduced incomes, and other economic impacts.



Disaster preparedness is a good idea in large cities and small communities alike. Investments in resilience and preparedness have large potential benefits in smaller communities whether it's a large \$1 billion disaster or a smaller one.



The U.S. averages about 10 \$1 billion disasters each year. From 1980 to the present, the U.S. has suffered 383 weather and climate disasters that caused more than \$1 billion in damage. Those disasters caused more than \$2.7 trillion of damage in total.³



Investment in disaster preparedness pays off. Every \$1 invested in resilience and preparedness saves \$13 in economic savings, damage, and cleanup costs after the event.



Investments in resilience and preparedness have economic benefits even if a disaster never occurs. As investments in disaster preparedness climb, communities see more jobs, the workforce grows, more people move to the area, and production and incomes increase.



Where do we go from here?

- We now have five indicative case study BCAs regionally that can help make the case for resilience investment not only at those locations, but for similar projects in other locations or at-risk assets around the region.
- Framework to help members walk through the process on their own, all five individual models should members like to analyze similar assets.
- Helped showcase the importance of BCAs by highlighting the type of information they can provide, can aid with grant applications and board presentations.
- Potential to analyze more assets or project examples.
- Can help guide other economic analyses / model for other parts of TPB's work program (e.g. safety improvements using a similar approach).



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