ITEM 9 – Notice
May 15, 2024

Transportation Resilience Improvement Plan (TRIP) Update

Background: Staff will provide an update on the Transportation Resilience Improvement Plan (TRIP). The board will be asked to approve the TRIP at its June meeting.

ATTACHMENTS

- Item 9 – Transportation Resilience Planning Memo
- Item 9 – Draft Transportation Resilience Improvement Plan
- Item 9 – Transportation Resilience Improvement Plan Presentation

DRAFT

National Capital Region Transportation Resilience Improvement Plan

May 15, 2024

National Capital Region
Transportation Planning Board

TRANSPORTATION RESILIENCE IMPROVEMENT PLAN

May 15, 2024

ABOUT THE TPB

The National Capital Region Transportation Planning Board (TPB) is the federally designated metropolitan planning organization (MPO) for metropolitan Washington. It is responsible for developing and carrying out a continuing, cooperative, and comprehensive transportation planning process in the metropolitan area. Members of the TPB include representatives of the transportation agencies of the states of Maryland and Virginia and the District of Columbia (DC), local governments, the Washington Metropolitan Area Transit Authority, the Maryland and Virginia General Assemblies, and nonvoting members from the Metropolitan Washington Airports Authority and federal agencies. The TPB is staffed by the Department of Transportation Planning at the Metropolitan Washington Council of Governments (COG).

CREDITS

This report was prepared for the Metropolitan Washington Council of Governments (COG) Transportation Planning Board (TPB) by ICF. This project was led by Katherine Rainone from TPB and this report was prepared by individuals from ICF including Brenda Dix, Kaitlyn Cyr, Amanda Vargo, Eva Burgos, and Katrina Starbird in close collaboration with TPB.
Photo Credit: Icon of the Anacostia (Emma Alexandra/Flickr)

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Acronyms Used in this Report

Terms	
BCA	Benefit Cost Analysis
DC	District of Columbia
DOT	Department of Transportation
EEA	Equity Emphasis Areas
EV	Electric vehicle
GHG	Greenhouse gas
HMP	Hazard Mitigation Plans
LRTP	Long-range transportation plan
MPO	Metropolitan Planning Organization
NCRTP	National Capital Region Transportation Plan
PROTECT	Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation
RIP	Resilience Improvement Plans
TIP	Transportation Improvement Program
TRIP	Transportation Resilience Improvement Plan

Organizations	
COG	Metropolitan Washington Council of Governments
DDOT	DC Department of Transportation
DOEE	DC Department of Energy and Environment
FEMA	Federal Emergency Management Administration
FHWA	Federal Highway Administration
IPCC	Intergovernmental Panel on Climate Change
MATOC	Metropolitan Area Transportation Operations Coordination
MDOT	Maryland Department of Transportation
NVRC	Northern Virginia Regional Commission
RITIS	Regional Integrated Transportation Information System
TPB	National Capital Region Transportation Planning Board
VDOT	Virginia Department of Transportation
VRE	Virginia Railway Express
WMATA	Washington Metropolitan Area Transit Authority

Executive Summary

Metropolitan Washington is already adversely affected by extreme weather events, from heat waves to blizzards to severe coastal storms and flooding, and the frequency and severity of significant climate hazard events are expected to increase in the future due to climate change. To improve the preparedness and resilience of the region's transportation system to the impacts of climate change, the Metropolitan Washington Council of Government (COG) National Capital Region Transportation Planning Board (TPB) developed this Transportation Resilience Improvement Plan (TRIP). The purpose of this TRIP is to serve as a regional resource that describes key transportation asset vulnerabilities in the region identified through a risk-based climate vulnerability assessment and identify priority resilience investments in the context of the region's climate and resilience goals.

Road damage from flooding event, 2018 (Maryland GovPics/Flickr).

This TRIP was developed in coordination with TPB member agencies and constitutes the first comprehensive regional transportation resilience plan for the metropolitan Washington region. In addition to building on the strong foundation of transportation resilience work in the region, the TRIP meets the Federal Highway Administration's Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) program requirements for a Resilience Improvement Plan (RIP) (see Appendix A. PROTECT Requirements Checklist for the full PROTECT requirements). The PROTECT program provides a unique opportunity to access increased funding for improving surface transportation resilience to natural hazards, and the TRIP will position the metropolitan Washington region to be competitive for these funds.

The TRIP is organized as follows:

- Chapter 1: Introduction provides an overview of the purpose, key goals, and objectives of the TRIP. This chapter also includes a high-level summary of historical climate impacts in the metropolitan Washington region from extreme heat, temporary flooding (coastal and riverine), permanent flooding (sea level rise), extreme winter conditions, and extreme wind. These historical impacts are important context for the focus of the TRIP's assessment of the region's vulnerability to climate hazards.
- Chapter 2: TPB's Regional Approach to Resilience explains how the TRIP is aligned with existing COG plans, such as the National Capital Region Transportation Plan (NCRTP) or Visualize 2045. This chapter also describes how the TRIP is aligned with existing state and local long-range transportation plans and hazard mitigation plans. As the first transportation resilience plan for the region, the TRIP must be aligned with ongoing processes and plans for transportation investments across the region in consideration of the varying jurisdictions and local priorities.
- Chapter 3: Systemic Approach to TRIP Development describes the scope of the TRIP and provides a high-level overview of the approach the TPB used to develop this TRIP, including the stakeholder engagement process used. As a regional plan, the incorporation of regional perspectives and priorities was key, and the TPB developed a Working Group comprised of regional transportation

agencies to provide ongoing input and feedback.

- Chapter 4: Risk-Based Vulnerability Assessment provides an overview of the methodology used to conduct the vulnerability assessment, the key findings from the assessment, and the interactive online mapping tool that displays the vulnerability assessment results. The assessment found that roads and highways, public transit, and active transportation are the transportation asset types with the highest need for adaptation measures to address potential impacts from increasing climate hazards. This chapter also describes critical interdependencies in the metropolitan Washington region to consider with transportation resilience investments, including emergency management, deployment of electric vehicles, and future development of transportation asset infrastructure.
- Chapter 5: Priority Project List outlines the priority transportation resilience projects identified using the results of the vulnerability assessment and input from COG member agencies. Through this process, several localities and regional agencies put forward an ambitious set of multimodal strategies to advance regional transportation resilience. Eight localities and transportation agencies in the metropolitan Washington region submitted a total of 34 projects. All projects fall into PROTECT eligible categories as resilience plans (14 projects) or resilience improvements (20 projects), and one resilience project fits an additional PROTECT eligible category by aiming to improve at-risk coastal infrastructure.
- Chapter 6: Implementing Resilience describes the role of the TPB and key partners in facilitating resilience-related work across the metropolitan Washington region and outlines measurable outcomes and goals of the TRIP. The TPB plays a key role in transportation planning in metropolitan Washington as a convening body for regional cooperation to bring together stakeholders, including the owners and operations of transportation infrastructure, to inform transportation resilience investments and implementation activities.
- Chapter 7: Future Regional Transportation Resilience Enhancements summarizes potential future updates to the TRIP and the vulnerability assessment. This chapter also describes other analyses that the TPB could potentially conduct for future TRIP updates.
- Appendix A: PROTECT Requirements Checklist lists FHWA's requirements for a RIP and indicates which sections of the TRIP meet each requirement.
- Appendix B: Existing Plans provides more details on existing plans from COG's member agencies.
- Appendix C: Priority Resilience Investment Submission Form includes a blank version of the form used to solicit projects for submission in the TRIP.
- Appendix D: Priority Resilience Investment Submissions includes member agency-responses to the submission form and details on each project included in the TRIP.

The TPB is dedicated to increasing the resilience of the transportation system in the metropolitan Washington region and will continue to build upon this TRIP to ensure that the resilience of the region is long-lasting. To support continued resilience work, the TPB identified several potential future enhancements for the TRIP. These include maintaining and updating the vulnerability assessment and identifying additional resilience projects to include in the priority project list. The TPB will also continue to serve its role as a multi-jurisdictional resource to support regional resilience planning across its member agencies.

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CHAPTER 1

Introduction

The Metropolitan Washington Council of Governments (COG) National Capital Region Transportation Planning Board (TPB) is the federally designated Metropolitan Planning Organization (MPO) for metropolitan Washington and the lead agency for this Transportation Resilience Improvement Plan (TRIP). The TPB works to address some of the region's most significant issues such as equity, climate change, the economy, public health, traffic safety, land use, funding, and emerging technologies. The TPB prepares plans and programs that the federal government must approve for federal transportation funds to flow to the metropolitan Washington region. The TPB developed this TRIP in coordination with member agencies to help improve the preparedness and resilience of the region's transportation system to the impacts of climate change.

TPB Partners

The TPB works with local jurisdictions in Maryland and northern Virginia, the two states, and the District of Columbia (DC), and multiple transportation agencies in transportation program decision making and plan development.

A. TRIP CONTEXT AND PURPOSE

The metropolitan Washington region's transportation system is essential for residents, businesses, and visitors to work and recreate. The transportation system includes roads and highways, public transit, heavy rail lines, three airports, and active transportation infrastructure (e.g., sidewalks and bus routes) that are critical for travel and the transport of goods. While the region's transportation system has been developed and maintained to withstand weather, the system and individual transportation assets may not be prepared for the intensified effects of climate change over time (e.g., increasing temperatures and heavy rain events).[1] Climate change is resulting in more frequent significant weather events and related hazards that can impact the region's transportation system by damaging infrastructure and disrupting services. The U.S. Environmental Protection Agency identifies the following key climate impacts on transportation: impacts on system safety and function, system costs such as increased maintenance, repair, and replacement costs, and reduced access to social and other critical services.[2]

B. AT A GLANCE: CLIMATE IMPACTS IN THE COG REGION

The metropolitan Washington region is already experiencing adverse impacts from climate change. As the frequency and severity of significant climate hazard events are expected to increase, the region must make resilience investments to minimize potential future impacts.

- Temperatures in the region have been increasing over time, and heat waves are becoming more common.[3] Extreme heat can limit the number of active transportation users and temperatures above 85°F may cause rail lines to buckle and become misshapen.[4,5] In 2012, ten consecutive days of temperatures over 95°F caused a heat kink that led three railcars to derail in Prince George's County.[6]

Figure 1: Vehicle in Washington, DC stuck in flash flood, 2019 (Alex Brandon/Associated Press).

- Annual precipitation in the region has been increasing since 1961 with more extreme storms causing flooding.[7,8] Recent significant flood events include a storm in 2019 which caused sinkholes, road collapse, and suspension of rail line services; heavy precipitation in 2020 closed Route 50 for six hours and led many drivers to abandon their vehicles in Prince George's County, Montgomery County, and Washington DC. [9,10,11,12,13] Storms in 2021, 2022, and 2023 overwhelmed stormwater systems in Washington DC that flooded buildings and contributed to road closures.[14] Businesses affected by floodwaters have considered relocating.[15]
- Sea level in the Mid-Atlantic is rising faster than any other region along the East Coast, resulting in coastal flooding during high tide, King Tide, and coastal storm events in the region.[16] For example, the Potomac River rose up to six feet during a 2021 coastal storm leading to severe coastal flooding, road closures, and blackouts.[17,18] Hurricane Isabel (2003) and Hurricane Irene (2011) closed roads, bridges, and flooded rail station tunnels.[19,20]
- Winter storms and strong wind events also regularly impact the transportation system. Severe winter storms delay and suspend public transit services in the region, and a 2022 storm trapped 600 cars for 7 to 21 hours on I-95 in Virginia.[21,22] High winds accompanying storm systems down trees and powerlines, blocking roads and causing blackouts, and forcing rail lines to suspend services.[23,24,25,26]

Figure 2: Vehicles and drivers stranded in Arlington, VA during a snowstorm in 2022 (New York Times).

Figure 3: Fallen trees and broken power lines after the severe storm in 2023 (Washington Post).

The TPB, in collaboration with member agencies, is continuing to build on the strong foundation of transportation resilience work in the region to further assess transportation system vulnerabilities and identify priority resilience investments through the development of this TRIP. As defined by the Federal Highway Administration (FHWA), a resilient project has the ability to:

- Resist hazards or withstand impacts from weather events and natural disasters.
- Reduce the magnitude or duration of impacts of a disruptive weather event or natural disaster.
- Have absorptive capacity, adaptive capacity, and recoverability to decrease project vulnerability to weather events or other natural disasters.
- Consider incorporating natural infrastructure.[27]

This TRIP uses the FHWA definition of resilience as "the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions."

The region's transportation system includes different infrastructure types, scales, ownership and asset

management structures, and functionality. The system also requires ongoing regional coordination and engagement to ensure that vulnerabilities are identified and addressed. The purpose of this TRIP is to serve as a regional resource that describes key transportation asset vulnerabilities in the region identified through a risk-based climate vulnerability assessment (see Chapter 4. Risk-Based Vulnerability Assessment) and identify priority resilience investments (see Chapter 5. Resilience Investment Plan) in the context of the region's climate and resilience goals. The TRIP is a significant component of the TPB's ongoing climate change mitigation and resilience work and will help to support future planning and investments in regional transportation resilience (Chapter 6. Implementing Resilience and Chapter 7. Future Regional Transportation Resilience Enhancements).

C. GOALS AND OBJECTIVES

The TRIP supports regional climate resilience efforts by assessing current and future climate risks, streamlining the integration of climate resilience into planning, operations, and communications, and increasing the region's ability to maintain essential transportation functions during climate-related events.

The priority objectives of this TRIP are to:

- Provide a systemic understanding of climate risks to the transportation network in the region.
- Identify and prioritize transportation resilience projects, including projects that meet the requirements for the FHWA's Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) program.
- Advance equity and environmental justice by increasing consideration of underserved communities and prioritizing equitable access to affordable and reliable transportation.
- Serve as a resource for the TPB to support efforts to facilitate coordination among infrastructure owners and planning agencies across the region to support a systemic approach to resilience.
- Provide a multi-jurisdictional resource to support regional resilience planning.

The TRIP supports the TPB's commitment to incorporate an equity lens in its work. In 2020, the TPB established a resolution to Establish Equity as a Fundamental Value and Integral Part of all Transportation Planning Board's Work Activities, which affirms that equity will be woven throughout the TPB's analyses, operations, procurement, programs, and priorities to ensure a more prosperous, accessible, livable, sustainable, and equitable future for all residents.[28]

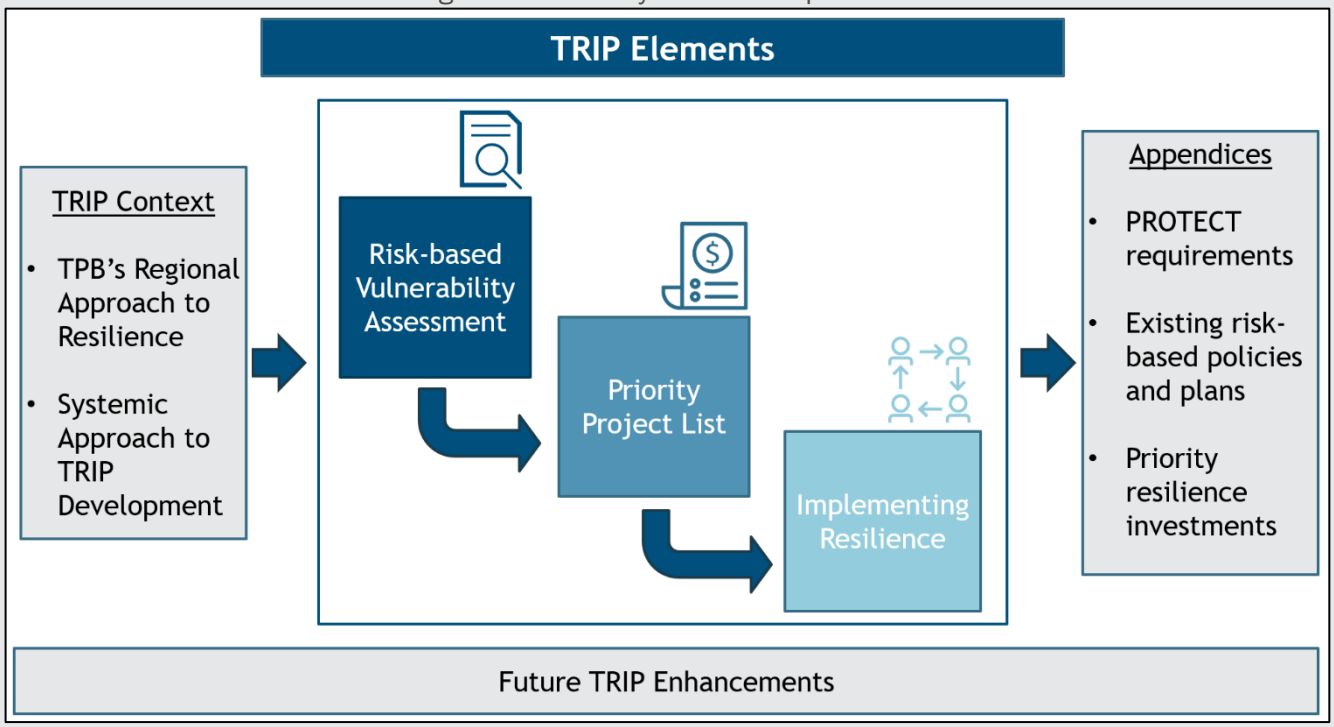
FHWA states that a central goal of transportation equity is to provide equitable access to affordable and reliable transportation options based on a population's needs, particularly for underserved communities.

The PROTECT program provides a unique opportunity to access increased funding for improving surface transportation resilience to natural hazards. State departments of transportation (DOTs) and MPOs that develop Resilience Improvement Plans (RIPs) that meet program requirements reduce the non-federal cost share for projects by 7%. An additional 3% will be reduced if the RIP is incorporated into the statewide or regional long-range transportation plan (LRTP).[29] Additionally, projects that are included in the RIP do not require a Benefit Cost Analysis (BCA) as part of the competitive grant application.[30] The TRIP will serve as the RIP for this region. The TRIP will position the region to be competitive for these funds and help stretch the

funding further due to the match reduction.

The TRIP summarizes the systemic approach that the TPB used to assess the vulnerability of the region's transportation system, provides a list of prioritized resilience projects, and identifies focus areas for future resilience assessments. Figure 4 summarizes the components of the TRIP.

Figure 4: Summary of TRIP components.



CHAPTER 2

TPB's Regional Approach to Resilience

Regional resilience planning requires interagency coordination to identify priorities, resources, and actions that the TPB and COG jurisdictions and member agencies can take to invest in the resilience of the transportation system. The TRIP builds upon the extensive climate resilience work that COG and its member agencies have completed to date, from establishing climate resilience goals to publishing plans that outline frameworks to advance resilience goals and facilitate the implementation of resilience projects. This chapter provides an overview of how the TRIP is aligned with and builds upon COG's climate resilience goals and planning efforts, past resilience work completed by the TPB, and existing COG and member agency hazard mitigation and transportation plans.

A. REGIONAL TRANSPORTATION PLANNING

COG and its member agencies recognize the urgent need for regional coordination and action to reduce greenhouse gas (GHG) emissions and increase resilience to future climate impacts, as is evident in COG's ambitious climate resilience goals. According to the Intergovernmental Panel on Climate Change (IPCC), global emissions need to fall by 45 percent from 2010 levels by 2030 and reach carbon neutral by 2050 to limit global warming to 1.5 degrees Celsius and avoid more severe climate impacts.[31] On October 14, 2020, the COG Board of Directors adopted 2030 GHG emission reduction goals that are aligned with the level of effort called for by the IPCC. COG Board Resolution R45-2020 established interim climate change goals including:

- Reducing GHG emissions 50 percent below 2005 levels by 2030;
- Becoming a Climate Ready Region and making significant progress to be a Climate Resilient Region by 2030; and
- Incorporating equity principles and expanding education on climate change in COG's Climate, Energy, and Environment Policy Committee and its members' actions to reach the climate mitigation and resilience goals.

The TPB's climate resilience goals are aligned with COG's goals. The TPB officially endorsed COG's economy-wide GHG reduction goals, and in June 2022, adopted the same goals specifically for the on-road sector. This made TPB the first MPO to voluntarily adopt GHG reduction goals specifically for the on-road transportation sector. The TPB's goals for on-road transportation are:

- Reducing GHG emissions 50 percent below 2005 levels by 2030;
- Reducing GHG emissions 80% below 2005 levels by 2050.

Both COG and the TPB are working to advance these climate ready and climate resilience goals through regional planning efforts. For example, COG's 2030 Climate and Energy Action Plan establishes priority collaborative actions for COG and its member agencies to address over the next ten years to help achieve the 2030 GHG mitigation and resilience goals. The plan includes COG's Regional Climate Resilience Strategy, which outlines collaborative actions to support the region's climate resilience goals. The Strategy includes ten priority collaboratives, with multiple priority actions highlighting the importance of increasing the resilience of the transportation system, including Action PL-4: Update Local and Regional Plans to Address Climate Risks and Action RI-2: Improve the Resilience of Critical Infrastructure. Climate resilience goals and

policies from COG's member agencies are included in Appendix B. Existing Policies and Plans.

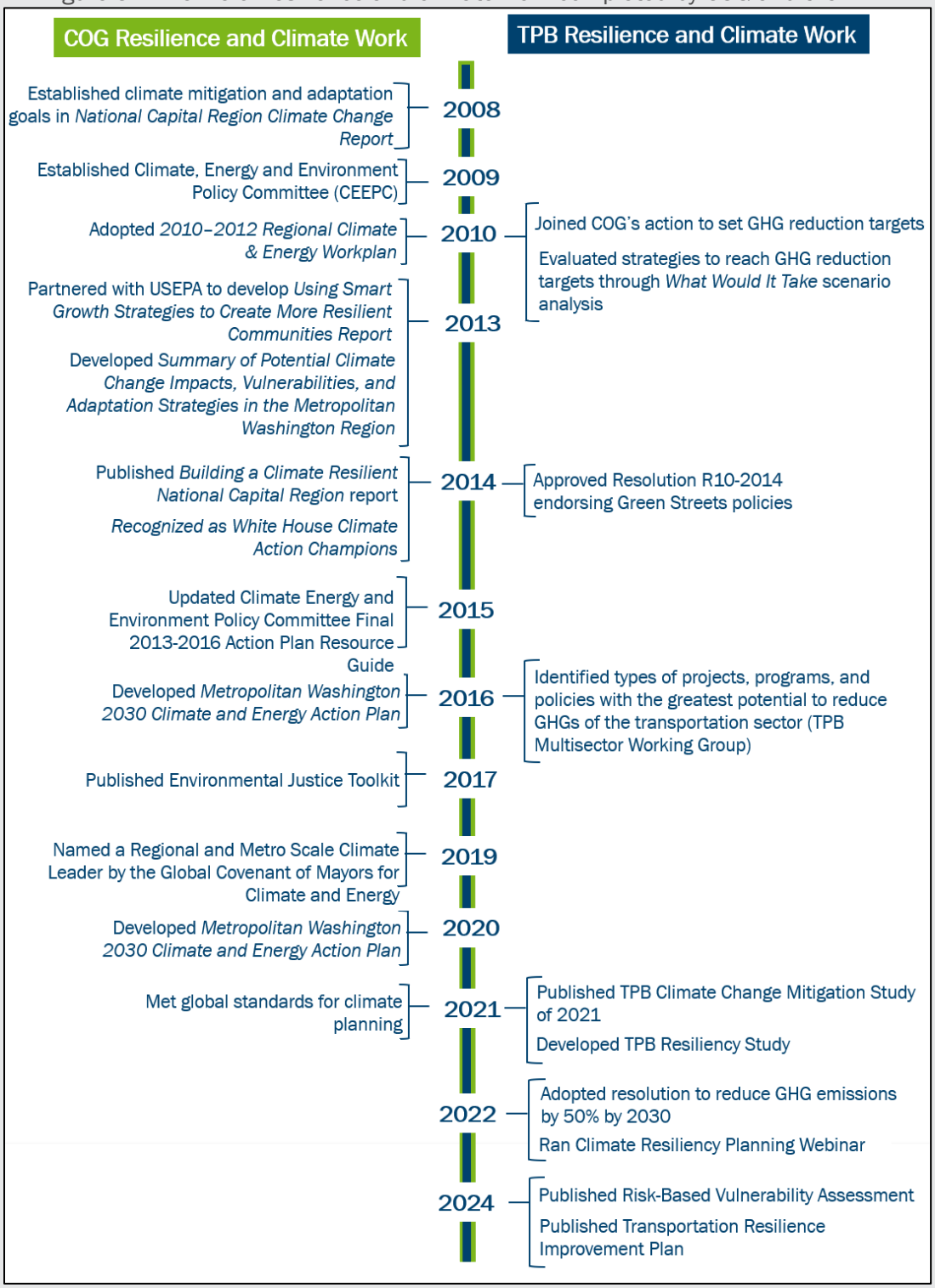
The development and update of the TPB's National Capital Region Transportation Plan (NCRTP), Visualize, is another key regional planning collaborative to help the National Capital Region become a climate ready and resilient region. For the purposes of the NCRTP, TPB and its member agencies regularly conduct studies and analyses to identify regional transportation and related issues and support the identification of priority projects and strategies to address the issues. Projects are identified through a variety of mechanisms throughout the region, including state-level long-range transportation planning, state-level project identification by state departments of transportation (DOTs), regional plans and studies, local government plans, and corridor and sub-area studies. The TPB's transportation planning process is a key mechanism through which TPB facilitates regional coordination to address the region's biggest issues and align transportation investments. The NCRTP is discussed in more detail in TRIP Alignment with Existing Plans below. Efforts like this TRIP help to inform specific priorities for transportation planning such as resilience investments in vulnerable areas.

B. PAST RESILIENCE WORK

In addition to supporting the regional resilience goals established by COG and its member agencies, the TRIP also incorporates and builds upon past resilience work completed by the TPB. Figure 5 provides a timeline of resilience and climate work completed by both COG and the TPB to date. These efforts include the TPB's 2021 Resiliency Study whitepaper, which was completed as part of *Visualize 2045*.[32] The whitepaper synthesized research findings on adaptation planning and mitigation activities within the region, documents strategies for resilience, addresses equity in resiliency planning, and outlines COG's role in future resilience planning efforts. The whitepaper helped to inform the regionally relevant transportation assets and climate hazards included in this TRIP's risk-based vulnerability assessment (Chapter 4. Risk-Based Vulnerability Assessment).

The TPB also hosted a webinar series in 2022 to engage and build the capacity of member agencies to understand pressing climate challenges in the region and advance resilience efforts at both the agency and regional scales. The webinars built on one another to help participants understand climate impacts to the transportation system, climate vulnerability assessment approaches, how to integrate resilience considerations into planning and programming, and project development and design.

Figure 5: Timeline of resilience and climate work completed by COG and the TPB.



C. TRIP ALIGNMENT WITH EXISTING PLANS

The policies and plans described in the previous section establish a variety of climate mitigation and resilience goals and demonstrate a region-wide dedication to increasing resilience. The funding and implementation of climate resilience actions to achieve those goals are typically carried out through plans approved by Federal Emergency Management Administration (FEMA) such as hazard mitigation plans (HMPs), LRTPs, and other resilience-focused plans such as the TRIP. FEMA requires that states and DC update their HMPs every five years. To ensure a coordinated approach to transportation system resilience across the metropolitan Washington region, the TRIP is consistent with and complementary to existing COG plans, as well as state and local HMPs within the region.

Table 1 summarizes how the TRIP builds on existing plans such as Visualize 2045 and transportation and HMPs for DC, Maryland, and Virginia (see Appendix B. Existing Policies and Plans for more details on member agency plans). Future updates to these plans may build on the work done to develop the TRIP.

Table 1: COG and State Plans Related to the TRIP

Plan	Relation to Climate Change Resilience and the TRIP
COG & State Long-Range Transportation Plans	
Visualize 2045 (2022)	**The TRIP is designed to enable the goals of integrating climate resilience in long-range planning as set out in Visualize 2045.** The FY 2023-2026 Transportation Improvement Program (TIP) development process, part of the Visualize 2045 update, provides the schedule for the next four years for distributing federal, state, and local funds for state and local transportation projects. Transportation agencies were asked to describe how the new and existing projects submitted for inclusion in Visualize 2045 would support equity and climate considerations. This TRIP identifies priority climate resilience projects, which provides an opportunity for future project alignment with the TIP. The TPB updates the long-range plan on a three year cycle.
moveDC (2021)	**The TRIP is aligned with the goals and policies outlined in DDOT's Multimodal LRTP, moveDC.** This includes the goal of strengthening the resilience of the transportation system to climate change, especially in disadvantaged neighborhoods. moveDC is updated every 5-6 years, so an update to the plan can be expected by 2026/2027.
The Playbook (2024)	**The TRIP is aligned with the guiding principles of Maryland's 2050 LRTP, The Playbook, specifically resilience and equity.** The guiding principles of the Playbook are intended to guide Maryland DOT's decision-making process. The TRIP will help further multiple goals and objectives in the plan which addresses changing climate conditions and increasing resilience. The Maryland DOT updates their LRTP every five years, so an update to the plan can be expected by 2029.

Plan	Relation to Climate Change Resilience and the TRIP
VTrans (2022)	**The TRIP is aligned with the overall vision and goals of VTrans, which include increasing the resilience of Virginia's transportation system.** VTrans is Virginia's statewide transportation plan which considers both mid-term (0-10 years) and long-term (20+ years) planning needs. The TRIP will help further some of the strategic actions identified in the plan, including actions to assess and reduce impacts related to the transportation system. VTrans is expected to be updated by 2026.
TransAction (2022)	**The TRIP is aligned with the objective of TransAction: improving regional resilience.** TransAction is the long-range multimodal plan for Northern Virginia which addresses regional transportation needs through 2045. One of TransAction's three goals is improving resilience, including infrastructure resilience to extreme weather events. TransAction also acknowledges the desire within the region to address climate change within planning processes. TransAction is expected to be updated by 2027.
State Hazard Mitigation Plans	
District of Columbia Mitigation Program (includes an All-Hazard Mitigation Plan)	**The TRIP is aligned with the objectives and guiding principles of DC's Mitigation Program.** The objective of the program is to create better prepared and more resilient communities by providing a common approach to support protection and prevention activities. The guiding principles include resilience and sustainability, leadership and neighborhood-focused implementation, engaged partnerships and inclusiveness, and risk-consciousness. The program includes an All-Hazard Mitigation Plan, which outlines specific goals and actions to help improve the District's ability to deter, deflect, absorb, or withstand impacts from a range of hazards.
Maryland Hazard Mitigation Plan (2021)	**The TRIP will help advance multiple priority actions and goals outlined in Maryland's HMP and addresses some of the climate hazards that are of greatest concern for the state of Maryland, including temporary and permanent flooding and extreme winter conditions.** One of the priority mitigation actions outlined in Maryland's HMP is protecting state assets, infrastructure, and critical facilities from hazard events, and the TRIP prioritizes transportation assets for resilience investments. The TRIP is also aligned with Maryland's goal of prioritizing equity and environmental justice. The TPB's emphasis on coordination and collaboration throughout the development of the TRIP and the TPB's role in resilience implementation will also help further Maryland's goal of enhancing coordination, strengthening existing linkages, and creating new linkages between state and local mitigation and resiliency efforts. HMPs need to be updated every five years, so an update to Maryland's plan can be expected by 2026.

Plan	Relation to Climate Change Resilience and the TRIP
Commonwealth of Virginia Hazard Mitigation Plan (2023)	**The TRIP helps advance multiple goals outlined in Virginia's HMP and addresses the climate hazards of greatest concern– temporary and permanent flooding and extreme winter conditions.** The HMP sets priorities for mitigation activities that protect people and infrastructure from a range of hazards, and the TRIP identifies priority resilience investments for the transportation system. One goal of the HMP is to evaluate potential climate impacts to vulnerable populations, which is aligned with the TRIP's emphasis on equity and the prioritization of projects that benefit underserved communities. Another goal is to identify and prioritize projects that improve community resilience. HMPs need to be updated every five years, so an update to Virginia's plan can be expected by 2028.
Northern Virginia Hazard Mitigation Plan (2022)	**The TRIP helps advance the hazard mitigation goals outlined in Northern Virginia's HMP, including reducing the impacts of natural hazards on the community.** The main objective of the HMP is to reduce long-term vulnerability to natural hazards for all jurisdictions in the region. The HMP planning process helps reduce vulnerability by assessing hazard-related risks and identifying and prioritizing mitigation actions that participating jurisdictions can implement to reduce their vulnerability. Northern Virginia's HMP provides priority mitigation actions across four categories: local plans and regulations, structure and infrastructure, natural systems protection, and public education and awareness. HMPs need to be updated every five years, so an update to Northern Virginia's plan can be expected by 2027.
State Resilience Improvement Plans	
VDOT Resilience Plan (2022)	**The TRIP operates in conjunction with VDOT Resilience Plan to support transportation resilience in the region.** The VDOT Resilience Plan is Virginia's PROTECT eligible RIP and provides guidance for how Virginia can promote resilience in the face of changing environmental conditions. The RIP stipulates that VDOT will enhance climate data accessibility, develop a plan to engage stakeholders in resilience efforts, establish a risk-based vulnerability assessment methodology, identify resilience measures, and make smart funding decisions to support projects. The RIP also overviews ongoing resilience projects in the Commonwealth.

Plan	Relation to Climate Change Resilience and the TRIP
Transportation Resilience Improvement Plan (2024)	**The TRIP operates alongside MDOT's Transportation Resilience Improvement Plan 2024 to enhance regional resilience.** The Transportation Resilience Improvement Plan is MDOT's PROTECT eligible RIP. The RIP identifies coastal hazards, flood hazards, extreme temperatures, soil movement, severe weather, and climate change as threats to MDOT's transportation system. The RIP provides a risk-based vulnerability assessment, lays out a process for identifying priority areas for resilience improvements, and describes statewide alignment of transportation planning and programming.

CHAPTER 3

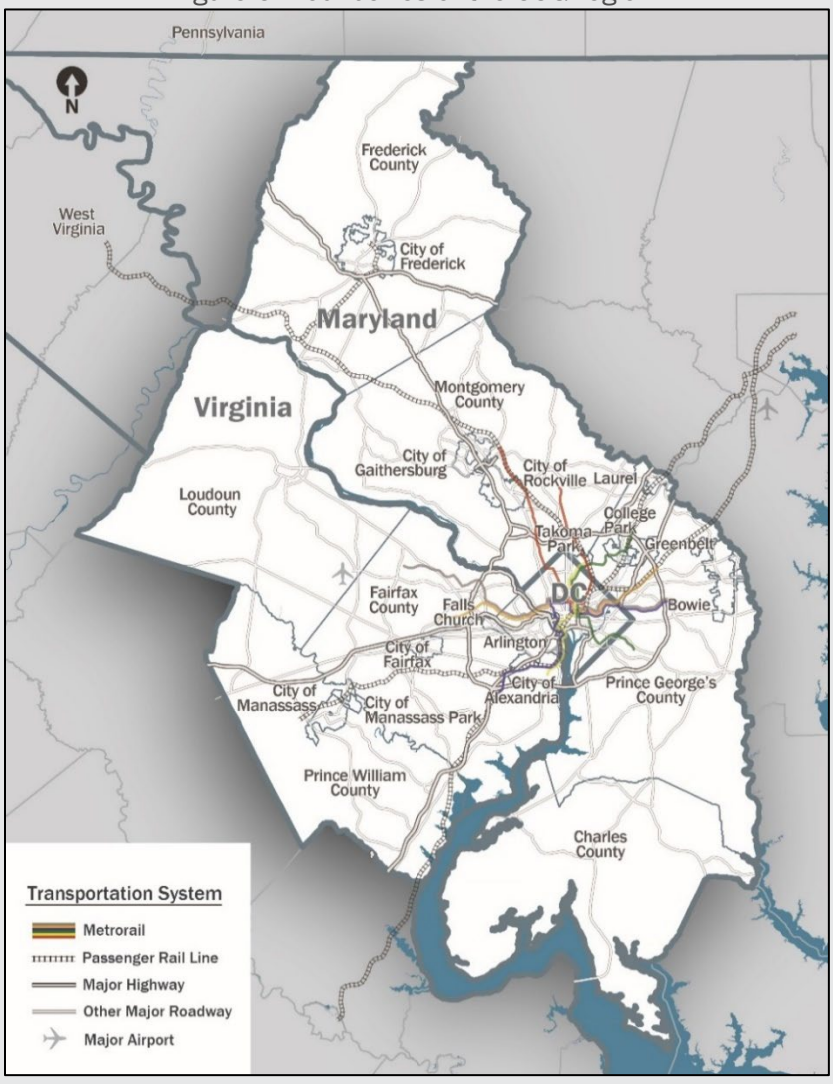
Systemic Approach to TRIP Development

This chapter outlines the TPB's systemic approach to understanding transportation vulnerabilities across the metropolitan Washington region and identifying priority resilience projects. The development of the TRIP was a collaborative effort that included significant stakeholder engagement with agencies in the region.

A. SCOPE AND APPROACH

The TRIP considers overall risk across modes, geographic regions, and critical interdependent sectors to holistically assess climate risk across the transportation system. Additionally, the TRIP was developed in line with existing transportation planning processes and was informed by existing plans from the region, including HMPs and transportation asset management plans (see Chapter 2. TPB's Regional Approach to Resilience). The TRIP is consistent with the FHWA's RIP requirements, which can be found in Appendix A. PROTECT Requirements Checklist.

Figure 6: Boundaries of the COG region.



Geographic Scale

The TPB developed the TRIP to guide resilience planning across the metropolitan Washington region (see Figure 6).[33] COG is comprised of 23 jurisdictions in Northern Virginia, Maryland, and the entirety of Washington, DC featuring urban, suburban, and rural communities that range in size from about 10,000 to more than one million residents.[1] Transportation connections throughout the region require regional planning, led by the TPB, to ensure a cohesive and connected transportation system.

[1] Following the 2020 Census, Fauquier County's urban areas were redefined and are no longer contiguous to those in Prince William County. Fauquier County is now entirely outside of the Washington DC-VA-MD urban area for which the TPB is the designated MPO. As of February 21, 2024, after the completion of this vulnerability assessment, Fauquier County is no longer a TPB member.

Timeframe

This TRIP is for the immediate and long-range planning activities and investments with respect to resilience of the surface transportation system within the region. The timeframe of this TRIP is aligned with the TPB's next long-range plan, Visualize 2050. The TRIP considers both historical trends and climate change projections through 2050 so projects built today remain resilient to tomorrow's climate hazards. Additional information on how the TRIP is aligned with other jurisdictional plans and assessments in the region is detailed in Chapter 3. Systemic Approach to TRIP Development.

Transportation Assets and Climate Hazards

A major focus of the TRIP is identifying vulnerable transportation assets and increasing regional agencies' capacity to strategically plan resilience investments. The TPB completed a two-phase climate vulnerability assessment as part of the development of this TRIP to identify the greatest climate vulnerabilities of the region's transportation system (see Chapter 4. Risk-Based Vulnerability Assessment). Table 2 and Table 3 identifies and defines the transportation assets and climate hazards considered in the assessment. The TPB selected the focus hazards for the vulnerability assessment with working group members based on review of local vulnerability assessments, studies, and hazard mitigation plans and past impacts to the transportation system from these types of events, as well as in consideration of the project scope and timeline for completing the TRIP. The vulnerability assessment results helped identify potential resilience projects to include in this TRIP (see Chapter 5. Resilience Investment Plan).

Table 2: Transportation Assets Included in the Risk-Based Vulnerability Assessment

	Transportation Asset Groups
	Roads and highways: Paved surfaces and embankments that are part of roads used for vehicle travel (infrastructure) and the ability to utilize road and highways (service).
	Bridges: Paved surfaces, supporting structures, foundation, and joints of bridge structures (infrastructure) and the ability to utilize bridge infrastructure (service).
	Public transit: Bus, rail, other transit fleet vehicles, and their associated public use stations (infrastructure) and the ability to utilize or access public transit / the established schedule for transit service (service).
	Active transportation: Paved surfaces used for pedestrian, bicycle, or other non-motorized transportation (infrastructure) and ability to utilize active transportation (service).
	Airports: Airfields and surrounding areas, runways, airport facilities and buildings (infrastructure) and ability to utilize air travel (service).
	Maritime: Port structures and equipment (infrastructure) and operations of maritime travel (service).

	Transportation Asset Groups
	**Stormwater:** Culvert crossings and stormwater systems including tunnels, pipes, gutters, and embankments (infrastructure) and the ability to convey stormwater (service).

Freight Rail is another key transportation asset supporting the movement of goods and contributing towards the economic health of the region. While the regional rail system infrastructure supports both passenger and freight rail and impacts to the rail system may have implications for both, freight rail services were not included as a focus of this assessment.

Table 3: Climate Hazards Included in the Risk-Based Vulnerability Assessment

	Climate Hazards
	**Extreme heat:** The quantitative analysis considered median land surface temperature in order to identify current hot spots, as these locations are likely to remain hot spots in the future. The qualitative analysis considered a broader set of variables to understand how extreme heat is projected to change, such as number of days where maximum temperature exceeds 95°F.
	**Temporary flooding (coastal and riverine):** The quantitative analysis includes assets exposed to the FEMA FIRM coastal and riverine 100-year and 500-year floods (plus an expanded buffer on the 500-year event). The qualitative analysis highlights that local records indicate a prevalence of urban (i.e., pluvial) flooding issues outside of these floodplains, which the region is working to better understand.
	**Permanent flooding (sea level rise):** The quantitative analysis considered inundation depth under the 2060 intermediate-high sea level rise scenario (i.e., 2 feet of sea level rise compared to 2012). In exposed locations along the tidal portions of the Potomac and Anacostia riverfronts, this flooding represents areas that would be flooded during the average high tide event (i.e., more-or-less permanently with flooding becoming more and more common over time). The qualitative analysis considered a wider range of potential impacts (e.g., 4 to 8 feet of sea level rise by 2100), and the ancillary impacts of shoreline erosion and coastal storm surge.
	**Extreme winter conditions:** Geospatial data was not available to complete a quantitative GIS analysis. However, there is a large body of literature on historical and projected extreme winter conditions. The qualitative analysis considered how the frequency and intensity of extreme winter conditions are expected to change in the future, with a focus on the impacts of heavy snow and freezing temperatures.
	**Extreme wind:** Geospatial data was not available to complete a quantitative GIS. However, there is a large body of literature on historical and projected extreme wind. The qualitative analysis considered how the frequency and intensity of extreme wind events are expected to change in the future, with a focus on the impacts of extreme storms with high winds, such as hurricanes, tropical storms, and microbursts.

Equity and Environmental Justice

The TPB is continuously prioritizing equity and environmental justice considerations in its work. Historically, transportation planning often inadequately considered, and adversely impacted, disadvantaged and vulnerable communities, creating inequitable access to transportation options.[34] The TPB discussed the best approach to incorporating an equity lens in the TRIP vulnerability assessment with agency stakeholders, in alignment with the federal Justice40 goals where benefits from climate investments flow to disadvantaged communities that are marginalized by underinvestment and overburdened by pollution. Stakeholder consensus was to utilize the region's recent work to identify disadvantaged communities through an Equity Emphasis Areas (EEA) designation, which provides a more regionally relevant identification relative to the Justice40 tracts.

Key Considerations for EEAs

Greater exposure: Extreme heat impacts are stronger in highly urbanized areas with abundant pavement and little green space, known as the urban heat island effect. The urban heat island effect tends to be highest in neighborhoods with a lot of rental properties and households making lower incomes.

Higher sensitivity: Vulnerable populations can include elderly persons or those with medical conditions that may make them more susceptible to harm during a climate event. For example, these populations are more likely to suffer from heatstroke during a heat wave or experience respiratory issues from smoke during a wildfire.

Less adaptive capacity: Underserved communities may lack resources needed to adapt to climate shocks and stressors, such as air conditioning, air filters, or the ability to easily evacuate and relocate if necessary.

EEAs are census tracts determined to have high concentrations of low-income individuals and/or communities of color.[35] Though the 364 EEA census tracts make up only 10% of the land area in the metropolitan Washington region, they house 30% of the region's population.[36] EEAs have a higher share of renters, individuals with disabilities, and workers who cannot telecommute.[37] The TPB 2030 Climate and Energy Action Plan found that EEAs in the region are overburdened with climate hazard risks, such as temporary inland and coastal flooding and permanent inundation from sea level rise, potentially impacting access to transportation systems.[38] This TRIP integrates an environmental justice focus that reflects the TPB's commitment to applying an equity lens to transportation planning.

B. STAKEHOLDER ENGAGEMENT

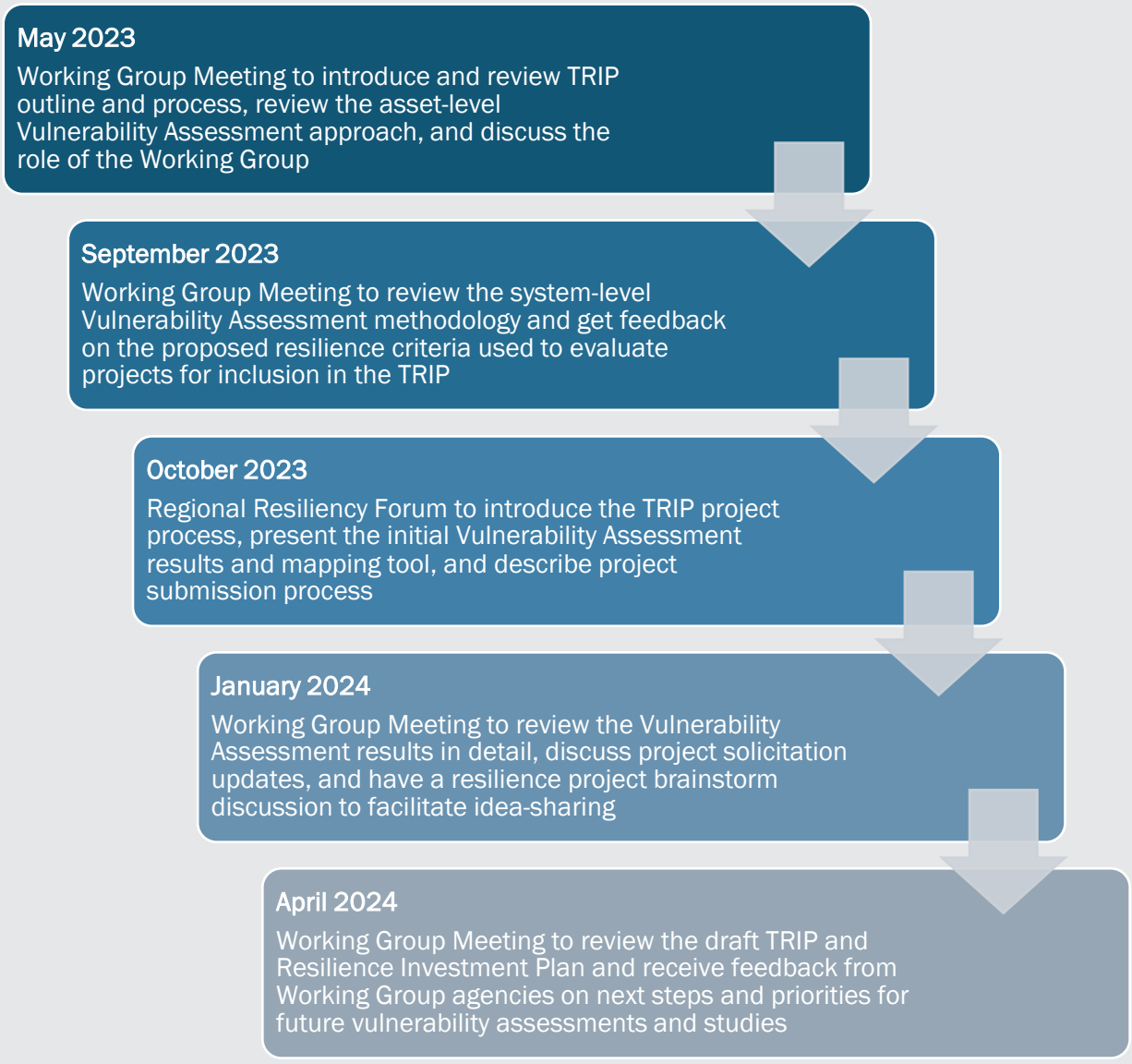
A resilient transportation network requires interagency and cross-jurisdictional collaboration. As such, stakeholder engagement was a core component of the TRIP development process. Figure 7 provides an overview of stakeholder engagement throughout the TRIP development process. A Working Group was established to engage with agencies in the region and get feedback on process and priorities for the TRIP. The Working Group consisted of transportation and planning agencies across DC, Maryland, and Virginia, including:

- Charles County, Maryland
- City of Alexandria, Virginia
- DC Department of Energy and Environment (DOEE)
- DC Department of Transportation (DDOT)

- DC Homeland Security and Emergency Management Agency (HSEMA)
- Fairfax County, Virginia
- Maryland Department of Transportation (MDOT)
- Northern Virginia Regional Commission (NVRC)
- Prince George's County, Maryland
- Prince William County, Virginia
- Virginia Department of Transportation (VDOT)
- Virginia Railway Express (VRE)
- Washington Metropolitan Area Transit Authority (WMATA)

The TPB also designed and held a Regional Resiliency Forum in October 2023 to engage with a broader set of regional stakeholders and get input on planning priorities and additional considerations. The TPB provided an overview of the TRIP development process and sought input on the approach to the vulnerability assessment and development of the priority project list. Over 60 people attended from agencies and organizations across the metropolitan Washington region and beyond. The Forum and the Working Group meetings facilitated interagency coordination and resource sharing and ensured consideration of regional perspectives.

Figure 7: Overview of stakeholder engagement during the development of the TRIP.



CHAPTER 4

Risk-Based Vulnerability Assessment

This chapter provides an overview of the methodology and findings of the vulnerability assessment undertaken for this TRIP. It also includes a discussion of critical interdependences in the region. For additional details on the TPB climate vulnerability assessment, see the National Capital Region Transportation System Climate Vulnerability Assessment.

A. TRIP VULNERABILITY ASSESSMENT OVERVIEW

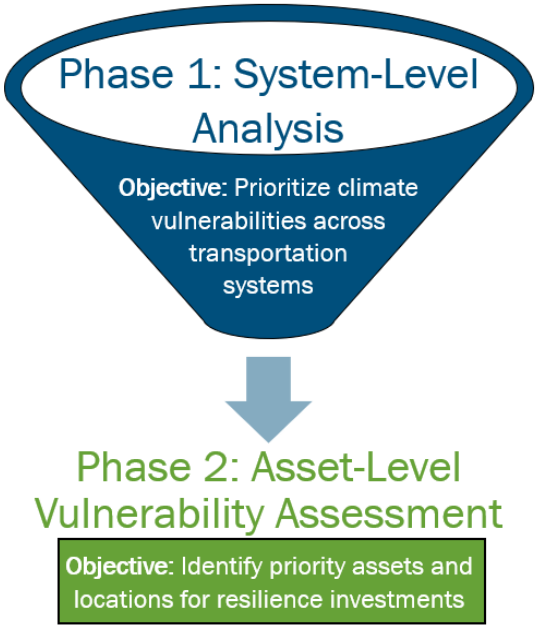
The TRIP vulnerability assessment builds on the TPB's 2021 Resiliency Study to systematically identify high vulnerability transportation assets throughout the region. The 2021 Resiliency Study included a summary of local vulnerability analyses in the region. The most common hazards across these analyses included extreme heat, extreme winter conditions, flooding (flash flooding, stream and river flooding, coastal flooding), and lightning and severe storms. Table 4 (sourced from the 2021 study) summarizes the types of assets jurisdictions analyzed in their local vulnerability assessments. The study recommended that the TPB overlay climate hazards with transportation assets in the region to create a system-level understanding of climate vulnerability.

Table 4: Infrastructure Identified in Local Vulnerability Assessments[39]

Vulnerable Infrastructure	Jurisdictions
Roads and highways	DC, MD, VA NVRC, WMATA Charles County, Fairfax County, Frederick County, Montgomery County, Prince George's County, Prince William County
Bridges	DC, MD, VA NVRC, National Capital Planning Commission Charles County, Fairfax County, Frederick County, Montgomery County, Prince George's County, Prince William County
Public transit and active transportation infrastructure (e.g., rail, buses, bikes, etc.)	MD NVRC, National Capital Planning Commission, WMATA Charles County, Fairfax County, Frederick County, Montgomery County, Prince George's County
Airports and maritime infrastructure	MD, VA NVRC Montgomery County
Stormwater infrastructure (e.g., drainage, culverts, etc.)	DC, MD, VA Charles County

The TRIP vulnerability assessment takes a more systemic approach than the 2021 Resiliency Study and responds to the COG 2030 Climate Risk Vulnerability Analysis finding that EEAs in the region are overburdened with climate hazard risks. The TRIP vulnerability assessment includes an equity factor to elevate vulnerable population considerations in the identification of highly vulnerable assets. The results of the vulnerability assessment identify highly vulnerable transportation assets that may need future resilience investments. The vulnerability assessment was conducted in two phases to identify how transportation infrastructure in the region is vulnerable to climate hazards (see Figure 8).).

Figure 8: Overview of Vulnerability Assessment Phase 1 and Phase 2.



- Phase 1 applied a system-level sensitivity analysis to identify priority climate hazard/transportation asset pairs for further analysis in Phase 2.
- Phase 2 applied an asset-level vulnerability assessment (exposure and criticality) to identify specific areas and assets that are particularly vulnerable to climate hazards. This was paired with a literature review to provide information on historical and future trends for each climate hazard.

Phase 1 rated the sensitivity of transportation asset types to climate hazards included in the 2021 Resiliency Study and selected in consultation with the TPB and the Working Group (see Transportation Assets and Climate Hazards section for complete list). Phase 1 of the assessment generated two sensitivity scores for each asset/hazard pair on a low-to-high scale: one score measured infrastructure sensitivity and the other measured service sensitivity. This dual score is because failures in the physical infrastructure and barriers to usability can both impede transportation systems and services. Asset/hazard pairs that received a high sensitivity rating, moved forward to Phase 2.

Key Term: Sensitivity

Sensitivity is the degree to which an asset is affected by exposure to a climate hazard. If an asset has high sensitivity to a climate hazard, it will experience more significant impacts from the hazard than assets with low sensitivity..

Phase 2 further evaluated the highly sensitive pairs from Phase 1 through a literature review, a region-wide temperature map, and an asset-level geospatial analysis. The asset-level analysis focused on pairs with adequate geospatial data to complete a geospatial analysis. This analysis evaluated the vulnerability of roads and highways, public transit (bus routes, rail stops, and rail lines), and bridges to extreme heat, temporary flooding (coastal and riverine), and permanent flooding (sea level rise) on a low-to-high scale to identify specific assets or areas within the region that are highly vulnerable. The final vulnerability rating encompasses exposure and criticality (see textbox for definitions):

Key Terms	EEA Inclusion in Criticality Score
Exposure refers to whether an asset is located in an area that is affected by climate hazards. **Criticality** refers to the importance of an asset to the transportation system. Criteria to evaluate an asset's criticality may include functional classification and whether or not the asset is located in an Equity Emphasis Area (EEA). **Vulnerability** is the degree to which an asset is unable to cope with adverse climate impacts. Vulnerability can be used to understand how susceptible or at-risk an asset is to a climate hazard. In this assessment, exposure and criticality are used to determine an asset's vulnerability, with high exposure and criticality indicating high vulnerability or high risk to the asset.	EEAs are census tracts that COG has identified as containing high concentrations of low-income individuals and/or traditionally disadvantaged racial and ethnic population groups. Including EEA considerations as part of the criticality evaluation criteria emphasizes the TPB's commitment to prioritizing projects that benefit the most vulnerable. For roads and bridges, the criticality score incorporated both EEA status and a measure of how central the asset is to transportation connectivity. For public transit assets, the criticality score was solely based on whether the asset is in an EEA. EEA status makes up a larger share of the public transit vulnerability score because non-car households that rely on public transit have limited alternatives when public transit is not available.[40]

For more information on the vulnerability assessment methodology, see the National Capital Region Transportation System Climate Vulnerability Assessment.

B. TRIP VULNERABILITY ASSESSMENT RESULTS

Climate hazards can cause severe infrastructure damage and service disruptions to the transportation system. The vulnerability assessment explores how and to what degree transportation assets are vulnerable to a range of climate hazards across the region. The assessment found that roads and highways, public transit, and active transportation are the transportation asset types with the highest need for adaptation measures to address potential impacts from increasing climate hazards. Public transit was vulnerable to all climate hazards considered in this analysis. The high level of vulnerability for public transit assets is significant given the importance of transit to disadvantaged populations with more limited transportation options. All public transit assets and the single bridge asset that received a high vulnerability score are in an EEA and approximately half of all roads that received a high vulnerability score are in an EEA.

The assessment also found that stormwater infrastructure is highly vulnerable because overwhelmed stormwater infrastructure worsens temporary flooding risk (both coastal and riverine) for all transportation assets. Stormwater adaptation efforts could help mitigate flooding impacts to other assets. Local planners can use these findings to identify and prioritize projects that enhance the resilience of vulnerable assets and provide benefits to EEA communities.

Table 5 summarizes the historical trends and future conditions of key climate hazards and the potential impacts on transportation assets uncovered during the vulnerability assessment. These impacts may increase in severity as climate hazards become more intense or frequent due to climate change. For additional information on the potential impacts described in Table 5 and the detailed results of the Phase 1 and Phase 2 vulnerability assessment, see the National Capital Region Transportation System Climate Vulnerability Assessment.

Table 5: Climate Trends, Projections, and Impacts to Transportation Assets

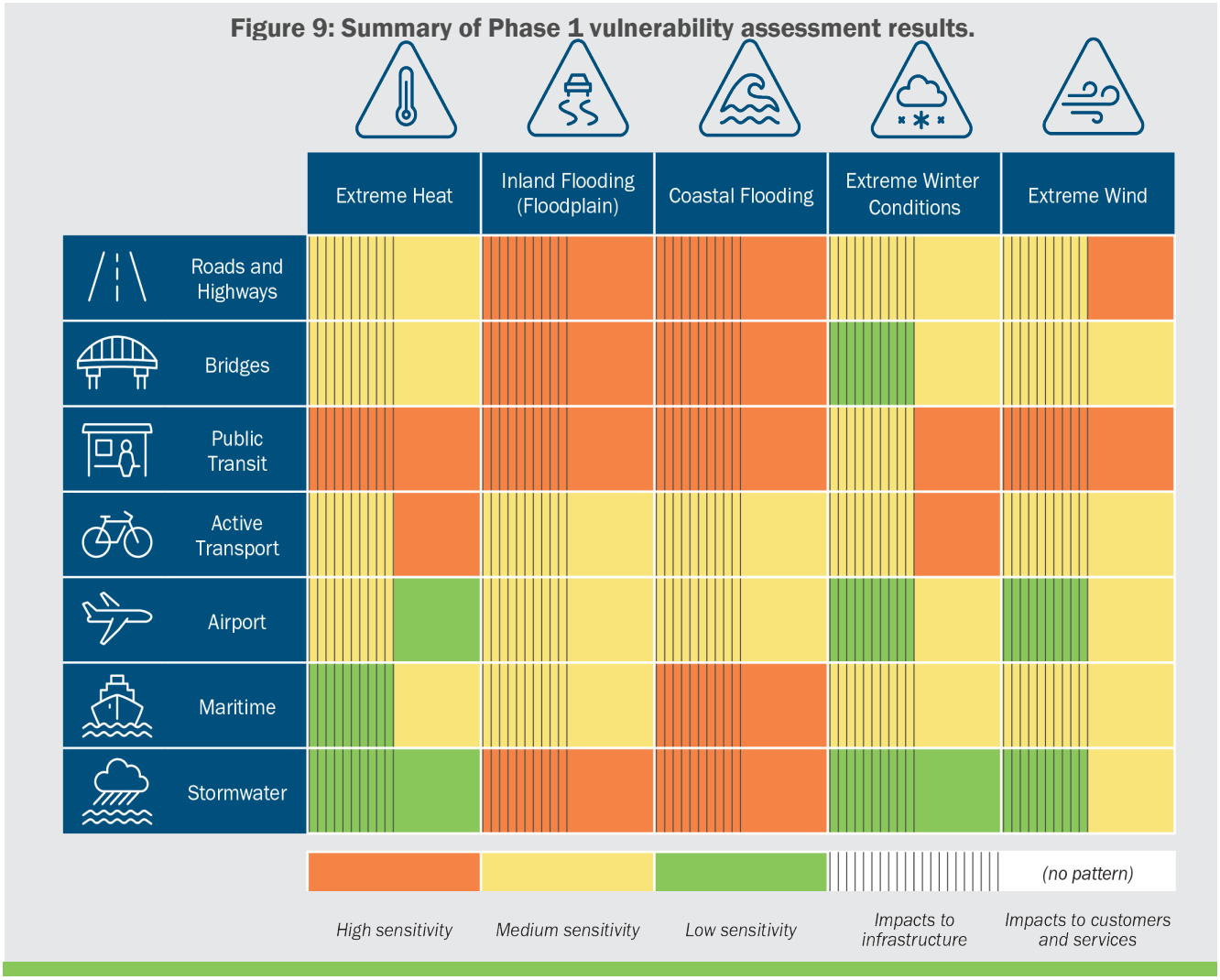
Hazard	Historical Trends	Future Conditions	Potential Impacts to Transportation Assets
 Extreme Heat	Temperatures in the metropolitan Washington region have been increasing over time. Heat waves have also become more common.	Projections indicate that by 2050 there will be an average of 38.9 days per year with temperatures above 95°F, up from the historical average of 4.4 days per year.	• Create "sun kinks" and warp rail tracks. • Cause cracks and damage to roads and highways. • Stress air conditioning systems for public transit users, causing equipment failure and exposing riders waiting at stations to higher risk of heat stress. • Pose safety and health risks to public transit employees and passengers.
 Temporary Flooding (Coastal and Riverine)	The metropolitan Washington region typically receives about 42 inches of rain each year, but annual precipitation has been increasing in the region since 1961.	Precipitation is expected to become more variable each year. Heavy rainfall events are expected to become more frequent and intense, leading to flooding.	• Overwhelm stormwater infrastructure causing combined sewer overflow events or creating standing or flowing water on driving surfaces, bike lanes, and sidewalks. • Wash out pavements or cause sinkholes. • Scour and erode bridge foundations or bridge support structures. • Partially flood underground rail stations. *Other effects listed under permanent flooding (sea level rise).*
 Permanent Flooding (Sea Level Rise)	Sea level has risen over 1 foot in the metropolitan Washington region since 1920 and numerous coastal storms have caused extensive flooding along the Anacostia and Potomac Rivers.	Sea level is projected to rise by approximately 1.3-1.5 ft by 2050 and 2.5-5.2 ft by 2100. While the number of storms is expected to remain the same, storm intensity is projected to increase.	• Accumulate debris and sediment at culvert crossings, limiting drainage capacity. • Overtop bridges and coastal roads. • Wash out coastal rail tracks and erode coastal pavements or support structures. • Damage pier structures. *Other effects listed under temporary flooding (coastal and riverine).*

Hazard	Historical Trends	Future Conditions	Potential Impacts to Transportation Assets
 Extreme Winter Conditions	Annual average snowfall has decreased in the Mid-Atlantic.	Though climate projections are uncertain, the frequency of winter conditions (i.e., snow, ice) across the Mid-Atlantic could decrease. However, winter storms that do occur may be more severe.	• Close roads and highways, creating detours and delays. • Disrupt public transit service due to track conditions and equipment limitations. • Pose safety and health risks to passengers waiting at public transit stops. • Ice over aboveground rail tracks and make rail yards impassable. • Limit active transportation mobility.
 Extreme Wind	Thunderstorms, extratropical cyclones, and tropical systems have brought heavy winds to the region.	Though average and extreme wind speeds are difficult to project, wind intensity during storms could increase. Average wind speeds are not expected to increase.	• Down trees and power lines that block roads, damage vehicles, and damage physical infrastructure. • Power outages for roads signals and public transit stations. • Reduce safe transportation speeds for high profile vehicles. • Create unsafe conditions for active transportation.

Phase 1 Results

Phase 1 evaluated the sensitivity of transportation asset types to each climate hazard, reflecting on the types of impacts to physical infrastructure and services described above in Table 5. summarizes the findings of the Phase 1 sensitivity ratings for each asset/hazard pair, including separate ratings for impacts to infrastructure and impacts to customers and services.

Figure 9: Summary of Phase 1 vulnerability assessment results.



Phase 2 Results

The TPB conducted further analysis of all highly sensitive asset/hazard pairs from Phase 1 (highlighted in orange in) in Phase 2, including completing a literature review on historical climate trends, future projections, and potential impacts to transportation assets (summarized earlier in Table 5). Due to data limitations, the Phase 2 indicator-based, asset-level assessment could only be completed for the following pairs:

- **Temporary flooding (coastal and riverine):** roads and highways, bridges, public transit
- **Permanent flooding (sea level rise):** roads and highways, bridges, public transit
- **Extreme heat:** public transit

The following sections summarize the Phase 2 asset-level vulnerability assessment findings, including the number and percentage of assets that scored high, medium, and low vulnerability for each climate hazard.

Roads and Highways

The assessment identified 1,097 miles (5%) of roads and highways with high vulnerability to temporary flooding and 50 miles (0.2%) with high vulnerability to permanent flooding (Table 6).

Table 6: Vulnerability of Roads and Highways to Temporary Flooding (Coastal and Riverine) and Permanent Flooding (Sea Level Rise)

	Temporary Flooding (Coastal and Riverine)				Permanent Flooding (Sea Level Rise)			
Vulnerability Level	High	Medium	Low	Not Exposed	High	Medium	Low	Not Exposed
Roads /Highways (miles)	1,097 (5%)	1,318 (6%)	733 (3%)	19,754 (86%)	50 (0.2%)	17 (0.1%)	14 (0.1%)	22,820 (99.6%)

Road Vulnerability Scores
Highly vulnerable road segments have high exposure to the hazard and are critical to the transportation system. Roads that carry more traffic or that are within an EEA have higher criticality.

Bridges

The assessment identified one bridge with high vulnerability to flooding located in Washington, DC (Table 7). Bridge vulnerability to flooding is based on bridge condition and potential susceptibility to failure rather than level of exposure to a specific temporary or permanent flooding event, as with the other asset types included in this analysis. This vulnerability rating therefore represents vulnerability to all types of flooding.

Table 7: Vulnerability of Bridges to Flooding

	Flooding			
Vulnerability Level	High	Medium	Low	Not Exposed
Bridges	1 (0%)	39 (3%)	1,281 (97%)	0 (0%)

Bridge Vulnerability Scores
Bridge vulnerability considerations included bridge condition data, recognizing that bridges in poor condition may be more likely to be damaged or fail during a flood event, and criticality to the transportation system. Bridges are critical if they serve as a major road or serve an EEA.

Public Transit

Bus stops, rail lines, and rail stops across the region are vulnerable to extreme heat, temporary flooding , and permanent flooding (Table 8). Bus stops have the greatest percentage of assets with high vulnerability to extreme heat (3%) and rail lines have the greatest percentage of mileage with high vulnerability to temporary flooding (11%) and permanent flooding (2%). Rail lines tend to be highly vulnerable where they are exposed to some degree of temporary or permanent flooding . One third of all rail lines exposed to temporary or permanent flooding received high vulnerability ratings. Only one rail stop, the Brunswick Maryland Area Regional Commuter stop in Frederick, Maryland, has high vulnerability to temporary flooding while Smithsonian, Federal Triangle, Federal Center SW, and McLean WMATA Metrorail stops and Frederick MARC stop have medium vulnerability to temporary flooding.

Due to data limitations, the flood exposure methodology was applied to all rail stations and rail lines, regardless of whether those assets are located above or below ground. Underground stations and lines may not be as directly exposed to flooding and typically have pump systems in place. The degree of vulnerability to underground infrastructure is at the discretion of the rail owner.

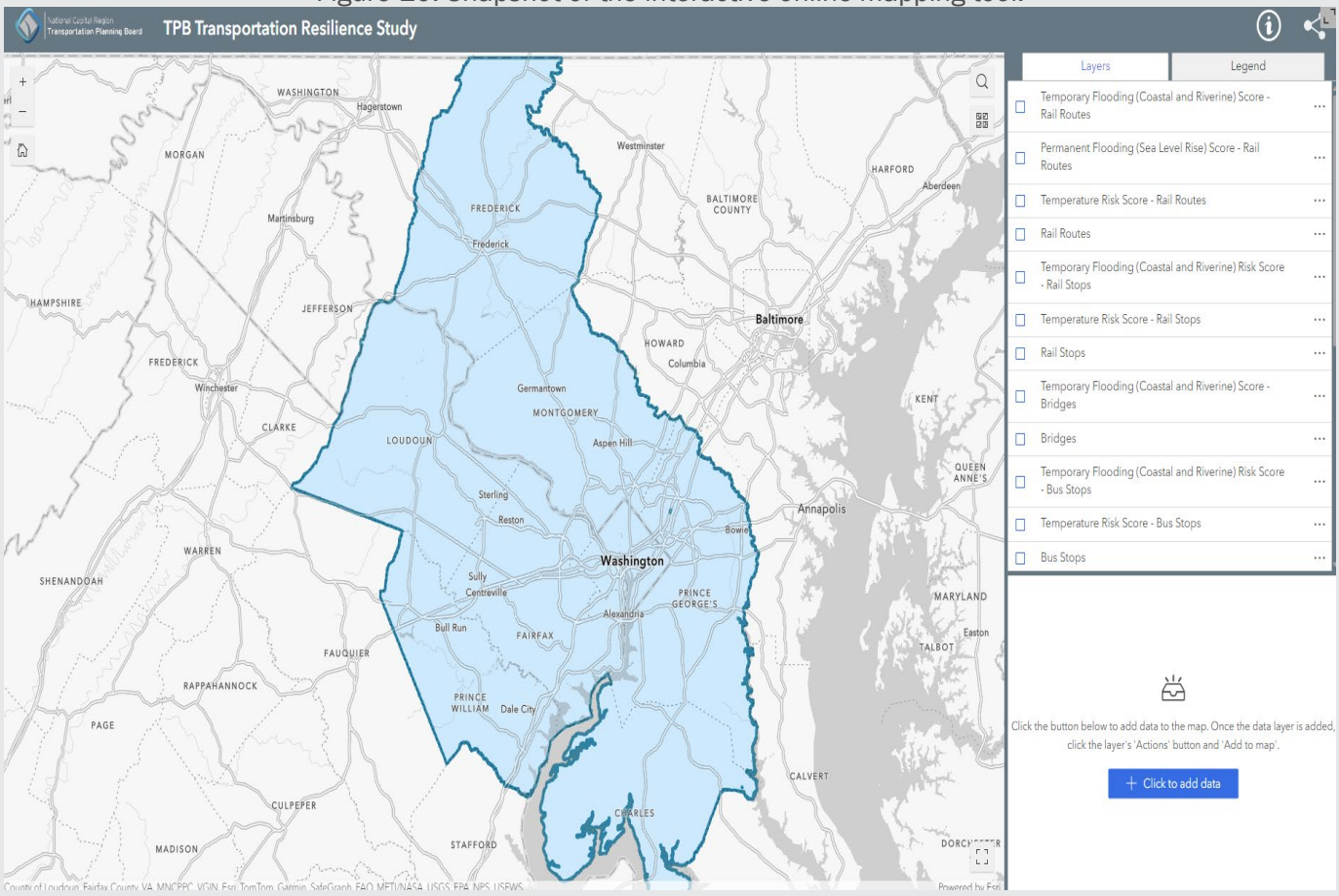
Table 8: Vulnerability of Public Transit to Extreme Heat, Temporary Flooding (Coastal and Riverine), and Permanent Flooding (Sea Level Rise)

	Extreme Heat				Temporary Flooding (Coastal and Riverine)				Permanent Flooding (Sea Level Rise)			
Vulnerability Level	High	Medium	Low	Not Exposed	High	Medium	Low	Not Exposed	High	Medium	Low	Not Exposed
Bus Stops	196 (3%)	6,467 (89%)	583 (8%)	0 (0%)	173 (2%)	336 (5%)	377 (5%)	6,360 (88%)	0 (0%)	0 (0%)	0 (0%)	7,246 (100%)
Rail Line (miles)	18 (2%)	352 (35%)	646 (64%)	0 (0%)	115 (11%)	154 (15%)	128 (13%)	619 (61%)	19 (2%)	42 (4%)	2 (0.2%)	954 (94%)
Rail Stops	0 (0%)	53 (33%)	107 (67%)	0 (0%)	1 (1%)	6 (4%)	4 (3%)	149 (93%)	0 (0%)	0 (0%)	0 (0%)	160 (100%)

C. INTERACTIVE ONLINE MAPPING TOOL

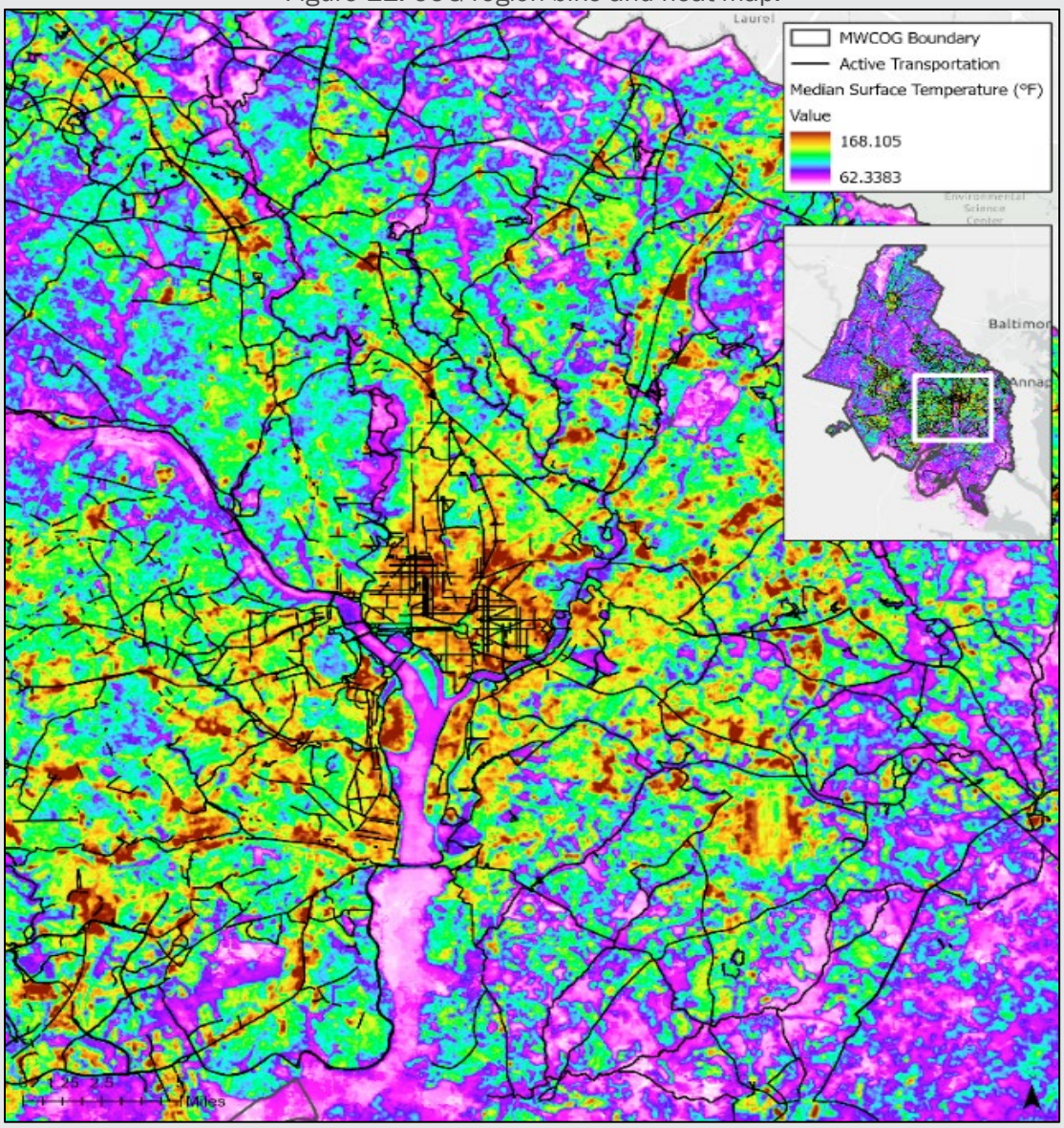
Results of the geospatial analysis conducted for Phase 2 of the TRIP were integrated into an interactive online mapping tool that was shared with agencies in the region (Figure 10). The mapping tool enabled agencies to use the vulnerability assessment results to assess which transportation assets in their jurisdiction are the most vulnerable to particular climate hazards and to help them identify projects that could address these vulnerabilities. Agencies are also able to add their own data as a layer in the mapping tool to consider alongside the TRIP vulnerability results to further support their assessment of transportation assets in their jurisdiction.

Figure 10: Snapshot of the interactive online mapping tool.



While active transportation and extreme heat was identified as a highly sensitive pair, available data for active transportation routes were not sufficient for the geospatial analysis approach. The online mapping tool enables users to visualize impacts to active transportation through the median surface temperature layer, as seen in Figure 11 which shows bike routes overlaid with a map of median surface temperature for the metropolitan Washington region. The highest median surface temperatures coincide with densest urban development, indicating that active transportation users are most vulnerable to extreme heat in city centers. This is likely due to the urban heat island effect, where densely built structures such as buildings, roads, and other infrastructure absorb and re-emit the sun's heat.[41]

Figure 11: COG region bike and heat map.



D. CRITICAL INTERDEPENDENCIES

The transportation system is just one component of the much larger and interconnected system that makes up a region. Given that the transportation system relies, in part, on other sectors to provide reliable and safe transportation, the TPB recognizes that consideration of critical interdependencies and potential cascading impacts from outages in other sectors is essential to achieve a truly climate resilient region. *Visualize 2045* notes the importance of implementing strategies across sectors to see significant progress toward both mitigation and resilience goals. While the vulnerability assessment focuses on the individual impacts of one hazard on one type of asset, the TPB acknowledges that the cumulative and ongoing impacts of climate hazards must be considered for system-level planning. This will require additional study and analysis of climate impacts and the existing interdependencies between transportation infrastructure and other sectors. These critical interdependencies include workforce and human capital, electric power and grid systems, urban forestry, and other sectors providing resources to support the transportation system.

Figure 12: Potomac Yard Metroway, Virginia (BeyondDC/Flickr).

In addition to being critical for everyday functions, the transportation system is a key aspect of planning for emergency situations by providing evacuation routes and systems to transport emergency goods and services. The need for coordination among transportation agencies during emergency events having multi-jurisdictional or regional impacts led to the creation of the Metropolitan Area Transportation Operations Coordination (MATOC) Program.[42] MATOC coordinates interjurisdictional incident notification practices, interagency procedures and protocols, and regional public traveler information. Resilient infrastructure is better at providing connectivity during climate hazard events and enables communities to recover more quickly after a hazardous event. According to the Viriginia HMP, climate hazards can severely impact regional economies by closing transportation routes.[43] Maryland's HMP identifies protecting infrastructure and transportation routes as a priority to support emergency response.[44] Regional agencies may also benefit from analyses focusing on the interdependency of vehicle traffic and how potential impacts to roadways may have resultant impacts on public transportation, whether during an emergency situation or during a significant event impacting travel, where diverted vehicle travelers may rely on rail systems. A better understanding of car traffic interdependencies could help regional transit agencies with capacity planning to accommodate these potential impacts.

COG and the TPB support regional planning and response efforts for emergency situations, including specific coordination efforts to support and maintain access via transportation systems to community assets (e.g., hospitals) during these situations. COG and TPB have multiple committees and programs dedicated to emergency preparedness and public safety. For example, COG's NCR RESF-1 Transportation Committee is responsible for the transportation sector's role in emergency response, coordination, and recovery planning and activities. This includes facilitating open communication between key transportation stakeholders and

supporting evacuation planning. The TPB, WMATA, and the DC, MD, and VA DOTs also created the Metropolitan Area Transportation Operations Coordination (MATOC) Program to improve coordination and collaboration across transportation agencies during emergency events. MATOC facilitates multi-agency coordination and advises agencies as they respond to incidents/emergencies by improving data sharing across agencies, coordinating notification procedures, and making transportation information more easily available to the public.

Figure 13: EV charging station (MDOT).

The electric power and transportation sectors are also interconnected. For example, WMATA's rail system is electric, so if there is a power outage, MetroRail cannot run. The electric power and transportation sectors will become increasingly connected in the future with widescale deployment of electric vehicles (EVs). This will require strategic planning for impacts to the grid such as outages and the resulting impacts on EV charging and use. The Metropolitan Washington 2030 Climate and Energy Action Plan identified EV deployment as a regional priority.[45] The board recognizes the need for increased collaboration to support EV plans, programs, and policies as necessary to meet regional climate goals. COG developed an EV Deployment Clearinghouse to support COG member agencies on EV deployment within their government operations and community-wide, which is one resource that could be leveraged to integrate resilience planning for electrified vehicles, particularly for transit EVs.[46] As a higher proportion of vehicles electrify, the need for emergency backup power at charging stations will become more critical to ensure transportation system access during climate hazards, such as all those assessed in the TRIP, that can impact the grid and cause power outages.

Critical interdependencies and considerations may also include new and expanding infrastructure in the future. While there are currently no ports in the COG area, any potential new maritime transit and other maritime infrastructure will have to consider the impacts of both temporary coastal flooding and permanent flooding due to sea level rise. These hazards can significantly affect maritime infrastructure and services including shipping and tourism, which may have regional economic impacts. The TPB will continue to coordinate with stakeholders in other sectors to identify changing considerations and address these critical interdependencies. For example, the TPB is actively engaged with COG's Department of Environmental Planning on strategies to reduce the urban heat island effect, such as by stabilizing and improving the region's tree canopy and land cover. Although the focus of the TRIP is the vulnerable assets of the transportation system, the TPB will leverage the TRIP to further this coordination and ensure a systemic regional approach to climate resilience.

CHAPTER 5

Resilience Investment Plan

While the region's transportation system was built to withstand a broad range of weather conditions, specific resilience projects are needed to increase system resilience to the increasing frequency and severity of climate hazards. A key intended outcome of the TRIP was the identification of priority regional resilience projects. The TPB collaboratively engaged member agencies in this effort and conducted a project solicitation process for project submissions to include in the TRIP. As required by PROTECT, regional agencies prioritized projects to submit using the vulnerability assessment results, online mapping tool, and other local resources to determine the most impactful projects. Regional agencies then submitted a project information form with their project details including location, specific transportation assets, and which resources were used to identify the project as a priority resilience investment, (e.g., the vulnerability assessment mapping tool or other studies) (see Appendix C. Priority Resilience Investments Submission Form). Any priority projects that receive funding from a federal grant will go through the process of being added to the TPB's TIP.

This chapter provides an overview of the approach TPB used to solicit priority projects, the priority project list, and examples of potential resilience projects as a resource to regional agencies who will be given the opportunity annually to submit additional resilience projects to this TRIP.

A. APPROACH

The TPB solicited resilience projects from its member agencies from November 2023-February 2024. Along with the project submission form, the TPB also developed an accompanying guidance document to provide additional context and to support member agencies and other regional organizations in developing strong project submissions that meet the PROTECT program guidelines and clearly address a transportation system vulnerability (Appendix C. Priority Resilience Investments Submission Form). The guidance document provided a definition of resilience, as defined in this TRIP, and described the minimum resilience criteria requirements for a project to be included in the priority project list (see Table 9). In addition, the TPB also encouraged agencies to consider other best practices while developing project proposals, such as whether the proposed project incorporates innovative solutions; ensures that relevant stakeholders, including frontline communities, are included throughout the project planning process; and provides co-benefits that can further increase community resilience.

Table 9: Resilience Criteria

Criteria	Description
Eligible transportation asset	The submitted project must concern one of the following transportation assets: roads and highways, bridges, public transit infrastructure, active transportation infrastructure, airports, maritime infrastructure, and stormwater infrastructure. Note, PROTECT discretionary grants can only be awarded to eligible highway projects, transportation facilities or services, intercity passenger rail facilities or services, and port facilities.

Criteria	Description
Qualifying project type for PROTECT	The submitted project must be one of the four types of projects that can be submitted for PROTECT grants: 1) **Resilience Planning** – Resilience planning activities, capacity building, and evacuation planning and preparation. 2) **Resilience Improvements** – Projects that make existing surface transportation infrastructure more resilient such as improving drainage, upgrades to meet or exceed design standards, relocating roadways, or elevating bridges. 3) **Community Resilience and Evacuation Routes** – Improvements to make evacuation routes more resilient or add capacity and redundant evacuation routes. 4) **At-Risk Coastal Infrastructure** – Projects that protect, strengthen, or relocate coastal highway and non-rail infrastructure.
Targets high priority risks	The proposed project should protect the most vulnerable and critical assets/services identified via the TPB Climate Vulnerability Assessment or identified through local studies and assessments, or areas with historic evidence of natural hazard damage. To view and explore the results of the TPB Climate Vulnerability Assessment, see the Interactive Mapping Tool on the TPB ArcGIS website. The Mapping Tool is a product of a vulnerability assessment conducted as part of the TPB TRIP development that layered transportation asset, climate, and equity spatial data to identify highly vulnerable assets. Assets that score a 2.5 or above for any hazard are considered priority risks. While projects that protect the identified highly vulnerable critical assets/services may be prioritized, any resilience project for a transportation system(s) can be submitted.
Reduces climate risks	The proposed project must reduce the risks associated with one or more climate hazards: extreme heat, temporary flooding (coastal and riverine), permanent flooding (sea level rise), extreme winter conditions, and extreme wind. In addressing climate risks, the proposed project ensures the continuity and/or reliability of the transportation service/system. *Examples of projects that reduce climate risks include:* • *Elevating roadways and other critical infrastructure out of floodplains* • *Upgrading stormwater infrastructure to increase water storage capacity and reduce flooding during extreme storm events* • *Increasing shading around outdoor transit stops to reduce extreme heat impacts on passengers*

B. PRIORITY PROJECT LIST

TPB provided an opportunity for its member agencies to prioritize resilience projects they may plan to pursue in their jurisdictions. Through this process, several localities and regional agencies put forward an ambitious set of multimodal strategies to advance regional transportation resilience with a focus on increasing the resilience of public transit infrastructure, roads and highways, stormwater infrastructure, and bridges. Eight localities and transportation agencies in the metropolitan Washington region submitted a total of 34 projects. All projects fall into PROTECT eligible categories as resilience plans (14 projects) or resilience improvements (20 projects), and one resilience project fits an additional PROTECT eligible category by aiming to improve at-risk coastal infrastructure. Eight of the resilience planning projects concern flood hazards, five concern heat hazards, and one concerns multiple hazards. The list of 34 projects (see Appendix D. Priority Resilience Investment Submissions) represents an impressive starting point for action that the region plans to continue to build on over time.

Consideration of Natural Infrastructure

Using natural infrastructure, otherwise known as green infrastructure or nature-based solutions, is an emerging resilience strategy that is highly recommended for consideration under current federal policies. These types of solutions not only help reduce flooding, wave damage, and erosion, as well as mitigate the impacts of extreme heat, but also provide numerous co-benefits such as improved water and air quality, improved habitat for native species, and community beautification. Types of natural infrastructure solutions include watershed, and streambed restoration, shoreline/bank protection and stabilization, bioretention ponds, bioswales, green roofs, and rain gardens among others.

Eight of the TRIP projects include development of some form of natural infrastructure, and four plans requested funding to help future implementation of natural infrastructure.

Figure 14 shows the distribution for the type of asset to be improved and Figure 15 shows the project distribution for type of hazards addressed. Some projects address multiple types of hazards and assets. Resilience improvements made to an asset may have multiple benefits for both the infrastructure and services; for example, many roads are Complete Streets which are designed to be used by vehicle and active transportation users and therefore a resilience improvement to a roadway would provide benefits to multiple transportation modes.

Figure 14: Number of projects that address each type of climate hazard.

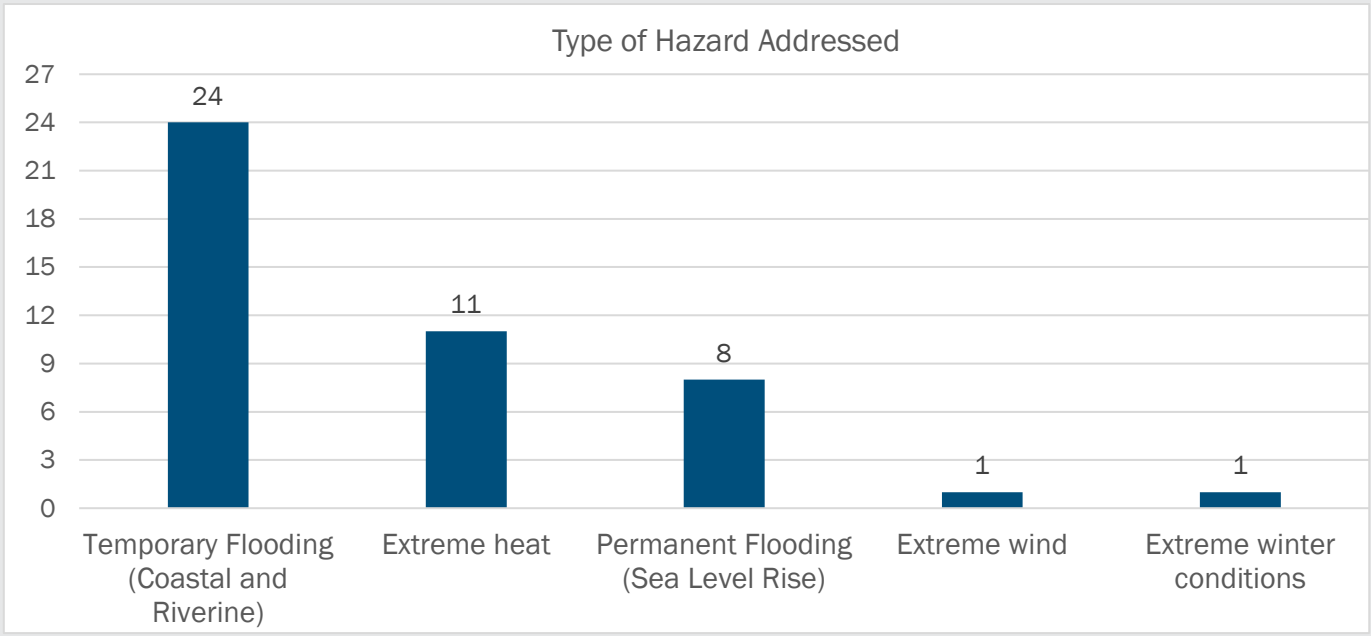
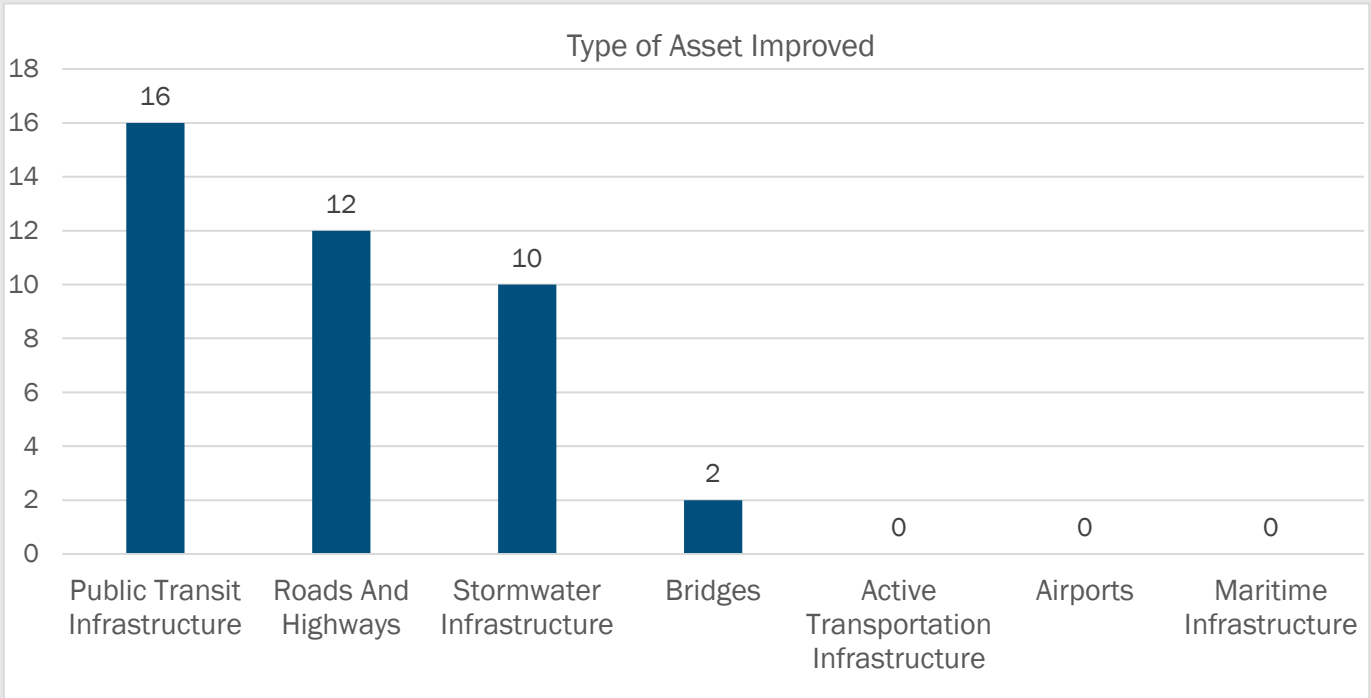


Figure 15: Number of projects that mention resilience improvements for each type of asset.



For each submission, localities and agencies were asked to indicate whether the project addresses a high priority risk identified through the vulnerability assessment mapping tool, local studies and assessments, or historical evidence of natural hazard damage. Projects were not excluded if they did not address a high priority risk identified through the vulnerability assessment or other data source as the mapping tool may have some limitations for location specific evaluation. A portion of an asset location may fall within varying levels of hazard exposure and therefore limit the tool's ability to indicate exposure for the entirety of an asset. Therefore, the RIP includes all projects submitted that were within the metropolitan Washington region boundary and provided a description satisfying the resilience project definition.

The following tables, grouped by asset type, summarize the projects identified by member agencies as highest priority projects to implement in the short term given known and projected asset vulnerabilities. This investment plan is not financially constrained. While some of the projects have identified funding, many of them will be seeking grant funds (e.g., PROTECT) to advance to implementation. This list of priority resilience projects will be updated on an annual basis as agencies are able to further refine and advance their resilience priorities. The project submission form will be sent to all relevant stakeholders each calendar year prior to the following PROTECT grant application due date. In addition, TPB will continually produce updated resilience plans and studies to better understand regional vulnerabilities and to support resilience efforts.

Bridges

Table 10: Bridge Resilience Investment Projects

Lead Agency	Project Title	Location	Description	Hazards
Charles County Government (supported by the Resilience Authority of Charles County)	Cobb Island (MD-254) - Bridge Approach	MD-254 (Cobb Island Road) between MD-257 and the Cobb Island Bridge.	While the Cobb Island Bridge was recently replaced in 2020, the bridge approach and surrounding roadways still experience tidal flooding and inundation from sea level rise. There is ongoing planning for this project, and possible options include a range of possible nature-based and innovative interventions to address flood vulnerability from multiple hazards.	

Public Transit Infrastructure

Table 11: Public Transit Resilient Investment Projects

Lead Agency	Project Title	Location	Description	Hazards
Virginia Passenger Rail Authority	RF&P Track Infrastructure Heat Impacts and Mitigation Study	The Richmond, Fredericksburg and Potomac railroad line from Quantico, Prince William County, VA to Control Point VA in Washington, DC; Intercity (Amtrak) and Commuter (VRE) rail routes on the corridor.	When the region has high temperatures, host railroads (CSX and Norfolk Southern) issue slow orders as a safety precaution to limit/prevent derailments. As temperatures continue to rise and temperatures remain elevated for longer periods of time, railroads will issue more heat orders, slowing rail traffic in the region. The heat impacts study would identify existing conditions, assess adverse conditions based on historical data, recommend specific mitigation strategies, and translate these strategies into capital or operational improvements to limit slow orders during heat events and increase the reliability of the transportation system.	

Lead Agency	Project Title	Location	Description	Hazards
Virginia Railway Express	VRE Stations Heat Vulnerability and Mitigation Strategies Analysis	Station assets located on VRE's Manassas and Fredericksburg Lines, as well as on the joint line between Alexandria and Union Station.	Increasing temperatures have the potential to cause significant passenger discomfort to VRE riders. This project will identify the appropriate mitigation strategies to address the adverse effects of heat in five VRE station facilities. The project will detail potential effects on passengers and facilities, and will propose, at a planning level, conceptual projects that could mitigate or eliminate the adverse condition(s) through the horizon planning year.	
Virginia Railway Express	VRE Manassas Line Track Heat Vulnerability and Mitigation Strategies Analysis	Track infrastructure on VRE's Manassas Line between the Broad Run station and "AF Interlocking".	Temperatures that continue to rise and temperatures that remain elevated for longer periods of time threaten the structural integrity of rail tracks. This project will identify the appropriate mitigation strategies to address the adverse effects of heat on track and ancillary facilities identified as high risk in the TPB vulnerability assessment. This study would detail potential effects of heat events on the track infrastructure and will propose, at a planning level, conceptual projects that could mitigate or eliminate the adverse condition(s) through the horizon planning year.	
Virginia Railway Express	VRE Maintenance and Storage Facilities Heat Vulnerability and Mitigation Strategies Analysis	VRE-controlled property at the Broad Run and Crossroads Maintenance and Storage Facilities.	The TPB vulnerability assessment has identified these locations as highly vulnerable to extreme heat. The study aims to detail how exposure to extreme heat can affect VRE maintenance and storage facilities. The project will propose conceptual mitigation projects and review projected impacts on VRE service and yard personnel.	

Lead Agency	Project Title	Location	Description	Hazards
Virginia Railway Express	VRE Assets Flooding Vulnerability and Mitigation Strategies Analysis	L'Enfant and Quantico stations; Broad Run Maintenance and Storage Facility (excluding the passenger station platform, including the parking facilities).	The TPB vulnerability assessment has identified this area as having high vulnerability to inland flood. The study will analyze the proposed effects to this infrastructure from adverse future inland flooding events, and will propose, at a planning level, conceptual projects that could mitigate or eliminate the adverse condition(s) through the horizon planning year.	
WMATA	Systemwide Flood Resiliency Infrastructure Upgrades Implementation	Cleveland Park, Federal Triangle, Smithsonian, Archives/Navy Memorial, Rhode Island Ave/Brentwood, Capitol South, and Waterfront Stations (DC); Greenbelt Rail Yard (Greenbelt, MD).	All stations included in this project are either within the FEMA 100 year flood zone or are regularly impacted by interior flooding. The proposed upgrades address flood vulnerability in the MetroRail system and include measures such as new grading at station entrances, temporary flood barriers, raising vent shaft openings, and improving drainage capacity around stations. Improvements will lower the risk of adverse impacts to passenger service and system operations.	
WMATA	Drainage Pump Stations Rehabilitation Program	L'Enfant, Wheaton, Federal Triangle, Metro Center, and Glenmont Stations (DC); Noyes Road (Silver Springs, MD), Medical Center (Bethesda, MD).	Pumping stations remove water from WMATA's tunnels when aboveground rainfall or flood fills the tunnels. This equipment has exceeded its life cycle and needs replacement. The project would replace and improve the 59 drainage pumping stations located at low points in MetroRail tunnels to facilitate the removal of excess water from MetroRail tunnels and stations. The project would also replace and improve pumping equipment and tunnel piping systems that have exceeded their lifecycle throughout the MetroRail system. This program prioritizes the highest risk locations based on flooding and equipment need.	

Lead Agency	Project Title	Location	Description	Hazards
WMATA	Comprehensive Stormwater System Program (Planning)	Systemwide.	WMATA systems experience flooding due to storms and other rainfall events. Current stormwater planning is piecemeal and based on the facility. A comprehensive stormwater system program would allow WMATA to evaluate existing assets and risks and would provide a basis for Metro's future decisions about how to design, construct, and rehabilitate stormwater infrastructure.	
WMATA	Stormwater System Rehabilitation	Carmen Turner Center; Branch Ave, Glenmont, and Greenbelt, New Carrollton and Shady Grove Rail Yards; Landover, Montgomery, and Southern Ave Bus Division (all in Maryland).	WMATA has identified many of these facilities as highly vulnerable to inland, sea-level, and riverine flooding. Flooding here and to nearby operational facilities can create significant time delays. The project will use green infrastructure to install or retrofit stormwater management systems.	
WMATA	Rehabilitation of Station Vault Pre-Cast Supports	Dupont Circle, Woodley Park, Cleveland Park, Van Ness, Tenleytown, Friendship Heights Stations in DC. Bethesda and Medical Center Stations in MD.	In severe storms and flood events, rainwater can percolate through the ground, leak into MetroRail stations, and, on the Red Line, flow into the vaulted ceilings. The connecting supports for the vaulted ceilings at several stations have begun to deteriorate. The project will conduct a detailed inspection and condition report to determine the extent and location of where repairs will be needed, and rehabilitation of the identified issues.	
WMATA	Tunnel Chilled Water Piping Assessment	Systemwide.	Increasing temperatures have the potential to cause significant passenger discomfort to MetroRail riders. Chilled water is used to cool stations and all designs are outdated due to increasing population, increased density, and more high heat days. The study would conduct a systemwide assessment of chilled water piping in tunnels to identify the need to improve this piping.	

Lead Agency	Project Title	Location	Description	Hazards
WMATA	MetroBus Shelter Replacement	Systemwide.	As high heat and intense rain events occur, passengers will increasingly require shade and shelter at bus stops. The project would replace aging shelters, provide shade, and decrease unnecessary wait times at outdoor bus shelters by improving communication with customers.	
WMATA	Traction Power/Rectifier Replacement	33 traction power substations though DC, VA, and MD.	High heat has the potential to impact traction power substations and result in slow or interrupted MetroRail services. The project would answer this concern and decrease heat buildup in traction substations critical to the MetroRail train system and enhance power stability. Improvements would replace rectifiers in multiple traction substations across the service area to improve electrical efficiency. This not only increases resilience but also stabilizes the rail system and reduces electricity consumption.	
WMATA	Shaft Damper and Attenuator Replacement Program	221 shafts throughout the MetroRail system in DC, MD, and VA.	High heat weather will require better circulation of MetroRail tunnels and stations for comfort and operability. The project would address heat strain on fans, dampers, and attenuators that circulate air through shafts in the Metro system. These improvements would maintain customer comfort and equipment functionality as temperatures rise.	
WMATA	Non-Revenue Facility HVAC Replacement	L'Enfant, Wheaton, Federal Triangle, Metro Center, and Glenmont Stations (DC); Noyes Road (Silver Springs, MD), Medical Center (Bethesda, MD).	Multiple Metro non-revenue facilities were not built for projected future weather conditions and do not account for increased average temperatures or for the increase in heat-producing electric controls. These facilities often heats to an uncomfortable level. The project would replace aging and inefficient heating at these facilities and implement a Building Energy Management Control System that would allow for greater operational and maintenance efficiency. Facilities included in this project are crucial for the operation of the Metro system.	

Public Transit & Stormwater Infrastructure

Table 12: Public Transit and Stormwater Infrastructure Resilience Investment Projects

Lead Agency	Project Title	Location	Description	Hazards
Virginia Passenger Rail Authority	Flooding Mitigation Study for Quantico and Pohick Creek Rail Bridges	RF&P Rail Corridor, owned by CSX/Virginia Passenger Rail Authority. Quantico Creek Rail Bridge and Pohick Creek Rail Bridge (38.526743, -77.288966 to 38.712765, -77.217392).	The two rail bridges associated with the project lie within the 100-year floodplain. Should flooding be significant or damage occur to these bridges, passenger and freight rail traffic within the entire region could be halted to make emergency repairs. The flood mitigation study would identify existing conditions, assess expected adverse conditions, recommend specific mitigation strategies, and translate these strategies into capital improvements for future rounds of funding to ensure the rail infrastructure will with stand future flooding or storm inundation.	

Roads and Highways

Table 13: Road and Highway Resilience Investment Projects

Lead Agency	Project Title	Location	Description	Hazards
DDOT in partnership with District DOEE	Nannie Helen Burroughs Avenue DC-295 Underpass [2]	Nannie Helen Burroughs Avenue NE underpass beneath DC-295 in DC.	The Nannie Helen Burroughs Avenue experiences frequent flash flooding due to the impermeable surfaces in the nearby Watts Branch watershed. Flooding happens quickly, leaving disadvantaged neighborhoods with vulnerable populations between DC-295 and the Anacostia River isolated with very little warning. The proposed Engineering Feasibility Study would identify methods to improve the flood resilience of transportation infrastructure while creating additional greenspaces between the Anacostia River and Kenilworth Park and the Nannie Helen Burroughs Avenue Commercial Corridor.	

[2] This project received PROTECT funding in 2024.

Lead Agency	Project Title	Location	Description	Hazards
DDOT in partnership with District DOEE	Watts Branch Flood Resilience Strategy Implementation	Nannie Helen Burroughs Ave, between the I-295 underpass, and Division Ave.	Nannie Helen Burroughs Ave lies within the FEMA 100-year floodplain within the Watts Branch watershed and already experiences regular flooding during storm events. Flooding risk will increase with climate change. Options to address flooding risk will be established in the Watts Branch Flood Resilience Strategy (expected publication date April 2025). This project would implement the results of that study and create blue, green, and gray infrastructure along the corridor to reduce flooding and improve mobility for residents during storms.	
Prince William County Department of Transportation	Fuller Road Flooding Mitigation	Fuller Road (VA Route 619) from the I-95 exit ramp to Mason Drive.	Fuller Road, which provides the only direct access to the main operating area of Quantico Marine Corps Base, is vulnerable to inland flooding and flooding at the gate. Flooding here has significant implications on operational readiness. The project will mitigate flooding of Fuller Road by increasing the capacity of the storm water facility near the National Museum of the Marine Corps and by restoring the Little Creek watershed.	
Prince William County Department of Transportation (supported by VDOT)	PWC Evacuation Operationalization Plan	Countywide.	Parts of Prince William County and its independent jurisdictions lack a countywide evacuation plan. The County seeks to fill these gaps and develop this plan. The completed plan would quantify the impact of catastrophic emergencies; describe how different hazards may call for different localized, neighborhood-level, town-level, or large-scale evacuations; and provide real-time data visualization tools to assist responding agencies in emergency scenarios. This plan will minimize disruptions and impacts on transportation infrastructure during emergencies.	

Lead Agency	Project Title	Location	Description	Hazards
Prince William County Department of Transportation	Implement Shoreline Protection and Nature-Based Solutions	Countywide.	Numerous major transportation corridors located along coastal areas of the County are vulnerable to shoreline erosion caused by rising sea levels. The project will develop guidance for Prince William County to develop nature-based solutions for shoreline protection. The project will mitigate shoreline erosion to improve the resiliency of the transportation network to flooding.	
Prince William County Department of Transportation	Restore Streams to Reduce Flooding	High risk roadways in Prince William County as identified by existing vulnerability assessments from the TPB and the County.	County and TPB Vulnerability Assessments have identified several roadways as having a high risk of flooding. This project to develop and implement stream restoration would reduce flooding impacts on roadways within the County. Restoring natural flood resilience would protect the county's transportation infrastructure.	
Prince William County Department of Transportation	Incorporating Green Infrastructure into a Multimodal Transportation Corridor	Richmond Highway / US-1 from West Russel Road (Southbound near the limit with Stafford County) to Annapolis Way (Northbound near Occoquan River Bridge and the limit with Fairfax County).Includes bridge Asset Number 6228 Northbound / 6229 Southbound.	Route 1 (Richmond Highway / US-1) is a busy thoroughfare that crosses Prince William County from southwest to northeast and lies in a flood prone area in proximity to important water bodies and environmental protected areas. The area has historically experienced flooding, road closures, and swift water reports. This project would identify and design green infrastructure to detain stormwater flows, improve transportation resiliency, and improve the natural ecosystem by reducing stormwater runoff that could carry harmful pollutants left on roadways into protected natural areas. The project would provide an evaluation of possible projects, report on the prioritized list of projects, and create a Multimodal Corridor Green Infrastructure preliminary design with the respective Evaluation Memorandum.	

Roads and Highways & Bridges

Table 14: Road, Highway, and Bridge Resilience Investment Projects

Lead Agency	Project Title	Location	Description	Hazards
Prince William County Department of Transportation	Residency Road Flooding Mitigation	Residency Road (VA Route 782) from the current dead end of Residency Road across the rail tracks to Broad Run Station parking lot.	Residency Road has a history of flooding but stands to be a primary access point to the soon-to-be expanding Broad Run VRE Station and a subsidiary access point to the Manassas Regional Airport. The airport is also planned for expansion and all three current access points to the airport have moderate inland flooding risk. This project will design and construct a flood-resilient bridge to provide continuous access between Residency Road and the Station and airport.	

Roads and Highways & Stormwater Infrastructure

Table 15: Road, Highway, and Stormwater Infrastructure Resilience Investment Projects

Lead Agency	Project Title	Location	Description	Hazards
Charles County Government (supported by the Resilience Authority of Charles County)	MD 6 Port Tobacco Road Resilience Improvements	Seven miles of Liverpool Point Rd from its intersection with Port Tobacco Rd to its intersection with Riverside Rd. This includes Bridge 8015 over Nanjemoy Creek.	Increasingly, severe precipitation events cause flooding at this location. The flood events have created the need for pavement reconstruction/ resurfacing, and reinforcement of roadway shoulders, and drainage improvements to handle both average and significant storm event flows. The project to mitigate these flood issues is in its planning phase and funding will support the implementation of the chosen project. This rural area of Charles County is highly dependent on this roadway and has an average income that is below 65% of the county average.	

Lead Agency	Project Title	Location	Description	Hazards
Charles County Government (supported by the Resilience Authority of Charles County)	Zekiah Watershed Roadway Improvements	Project 1: less than one mile of roadway improvements along Old Washington Rd upstream of Pembrooke Sq. Project 2: less than one mile of roadway near the intersection of Post Office Rd and Industrial Park Dr. Project 3: culvert at the low point in Poplar Hill road.	Several locations within the Zekiah Swamp Watershed experience nuisance and urban flooding and require swale updates and stormwater redirection. The proposed project incorporates green infrastructure solutions such as vegetative infiltration interventions to decrease roadway flooding and to minimize the environmental impact of stormwater runoff. Project locations 1 and 2 are identified as EEAs while Project 3 is adjacent to an EEA and resilience improvements here can improve resilience for neighboring disadvantaged communities.	
District Department of Transportation	Soapstone Culvert Reconstruction	Soapstone stream from 250 ft upstream of where the stream passes under Broad branch Rd to 100 ft downstream of this point.	The single barrel stone masonry semicircular arch culvert is undersized to accommodate the current and modeled future rates of flows. Culvert overtopping can cause road closures during storms and has started compromising the integrity of the head walls and streambed downstream. This project aims to replace the soap stone culvert and stabilize the stream upstream and downstream stream banks to make the structure and the roadway more resilient to flooding and subsequent damage.	

Stormwater Infrastructure

Table 16: Stormwater Infrastructure Resilience Investment Projects

Lead Agency	Project Title	Location	Description	Hazards
City of Manassas	City of Manassas Flood Hazard Assessment	Citywide street network.	City of Manassas records show that various parts of the hydraulic conveyance system in the City regularly experience localized flooding. This study will identify areas of local flooding, evaluate potential remediation measures, and provide a list of recommendations to address this flooding. A Final Project Summary Report will include potential flood mitigation projects and their approximate construction cost estimates. This information provides the foundation for the City to carry out flood resilience projects.	
Prince William County Department of Transportation	Manage Stormwater Flooding Outside of the Floodplain	All roadways in Prince William County adopted in the State maintained roadway system that are not in delineated FEMA floodplains.	Prince William County's existing vulnerability assessment has identified lack of knowledge about flooding outside the FEMA floodplains as a limitation to the County's understanding of roadway vulnerability. This study seeks to use modeling and/or historic flood records to enhance the County's understanding of flooding. Based on this data analysis, the study will identify appropriate resilience measures for implementation and make the most use of funding the County has set aside for adaptation projects.	

Lead Agency	Project Title	Location	Description	Hazards
Prince William County Government Department of Transportation (supported by VDOT)	Flooded Roadway Mitigation Study	Valley View Drive (VA Route 611 sequences 50/60), structure no. 8: 000000000014300. Old Church Road (VA Route 649), structure no. 8: 000000000024232. Fleetwood Drive (VA Route 611 sequence 20), structure no. 8: 000000000014301.	These locations are prone to flooding and flash flooding that cause vehicular damage. The study will identify resilient improvements to the impacted streams and surface transportation assets to reduce the magnitude and duration of impacts of current and future weather events and natural disasters. The resilience measures can be deployed to reduce the risk to life and of vehicular damage.	
District Department of Transportation	Cleveland Park Stormwater and Drainage Improvement	Porter-Ordway Sewershed in DC's Northwest quadrant Ward 3.	The area around Cleveland metro station (e.g., Connecticut Ave. NW) has flooded multiple times due to insufficient drainage infrastructure that creates ponding on the street surface. This project would carry out infiltration, detention, and capacity improvements to drainage conveyance structures, flood mitigation detention reservoirs, roads, and sidewalks. These improvements will aim to manage a 15-Year return period storm without impacting the rate and erodibility at the outfall into Rock Creek.	

Lead Agency	Project Title	Location	Description	Hazards
DDOT (supported by the DOEE)	SW & Buzzard Point Blue-Green Infrastructure (BGI) Network	2nd St SW (Anacostia River to P St SW). 1st ST SW (Anacostia to T St SW). Canal St. (P to N St SW). Delaware Avenue (Canal to G St). M St SW (Maine Avenue to South Capitol Street). I Street SW (5th St to Delaware). G Street SW (5th St to Delaware).	Inland flooding threatens Southwest and Buzzard Points. ROW segments in this project will convey and detain excess stormwater in parks and on right-of-way so that it does not impact the adjacent roadways and local residential areas. This project will complete the Blue-Green Infrastructure Network to safeguard Southwest and Buzzard Points.	

C. POTENTIAL RESILIENCE STRATEGIES

As noted above, agencies will have the opportunity to submit additional priority resilience projects to the project list on an annual basis. To support agencies in developing strong resilience projects, Table 17 provides an illustrative set of examples of resilience improvement strategies that are eligible under PROTECT. There is a wide range of potential projects that the TPB and its key partners can leverage to increase system-wide transportation resilience in the region. These include planning and policy-based measures that can be implemented in advance of extreme events, such as updating infrastructure design standards to be climate-resilient and designating evacuation routes, in addition to infrastructure upgrades and improvements. TPB and its key partners can also use asset-level measures to build back better following extreme events. These can include upgrading stormwater management infrastructure or elevating roads or bridges to reduce impacts during flooding events.

Table 17. Select Examples of Resilience Improvement Strategies

Upgrades to or installation of stormwater management infrastructure		
	 (NTM Engineering)	Upgrading or installing stormwater management infrastructure (e.g., culverts, pipes, drains, etc.) can reduce flooding risk by increasing the capacity of stormwater infrastructure to capture and store surface runoff during flooding events. This can help prevent culverts and drains from overflowing, preventing standing water on roads and reducing inundation of critical infrastructure.
Relocating or elevating roadways out of the floodplain		
	 (Risk Factor)	Relocating or elevating roadways out of the floodplain can significantly reduce flooding risk by preventing inundation of the roadway. Elevating the roadway can be completed incrementally by adding pavement thickness to raise the road surface. For roadways with high risk of inundation, relocating the roadway out of the floodplain entirely may be a more effective option.

Upgrades to or installation of stormwater management infrastructure

Implementing nature-based solutions to reduce flooding risk

(Fairfax County, VA)

(LDP Watersheds)

Incorporating natural infrastructure in resilience projects can help reduce flooding risk in addition to providing environmental co-benefits. There are many nature-based solutions that can be implemented to reduce flooding risk to transportation infrastructure.

For infrastructure located along streams and rivers, nature-based solutions can help reduce erosion and undercutting along the bank while also helping reduce water flow and riverine flooding. Examples include:

- Using vegetated riprap
- Placing large woody debris (fallen trees, logs, and branches) in streams

Other nature-based solutions can be implemented in the built environment to help decrease stormwater runoff and consequently reduce the severity and duration of flooding events. Examples include:

- Installing retention/detention ponds and bioswales
- Planting vegetation buffers along roads

Installing shade structures along sidewalks and at outdoor transit stops

(Springer)

Installing temporary or permanent shade structures, such as canopies, shade sails, or trees, can reduce extreme heat impacts for people using sidewalks or waiting at outdoor transit stops or platforms.

Removing trees that are unhealthy, dead, or dangerous

Trimming or cutting down unhealthy, dead, or dangerous trees can reduce the risk of trees bending or falling during extreme wind events. Preventing downed trees due to wind is especially important near critical roads, bridges, rail lines, and utility poles and wires.

CHAPTER 6

Implementing Resilience

Creating a resilient regional transportation system requires significant collaboration and coordination across agencies and jurisdictions. This is especially true for the metropolitan Washington region given that there are many different transportation infrastructure owners in the region, and member agencies have varying responsibilities, from overseeing road construction to operating transit services. This chapter provides an overview of how the TPB and its key partners currently coordinate and identified opportunities for continued collaboration to ultimately create a more resilient regional transportation system.

A. ROLE OF THE TPB

Although the TPB does not own or manage any transportation infrastructure, it plays a key role in transportation planning in metropolitan Washington as a convening body for regional cooperation to bring together stakeholders to discuss issues of regional significance. The TPB is also a leading resource for information sharing and develops relevant resources for the region. As described in Chapter 2. TPB's Regional Approach to Resilience, the TPB has a history of helping the region understand and tackle climate risks, and this TRIP continues the TPB's resilience work by providing actionable data that stakeholders can use to inform decision-making. The TPB can continue helping member agencies by conducting further studies and developing resources, providing training and professional development opportunities, and facilitating collaboration.

Additional Studies and Resources

The TPB can build upon the data and information compiled through the development of the TRIP to continue to refine the region's understanding of risks. Further study and resource development efforts may include:

- Implementing many of the suggestions in Chapter 7. Future Regional Transportation Resilience Enhancements to provide more detailed analyses, including a deeper understanding on urban flood risks and the economic impacts of inaction.
- Developing guides and publications to help streamline the implementation of resilience projects. Potential focus topics could include funding opportunities for resilience projects, regional resilience best practices, case studies of successful resilience projects, and specific resilience strategies or features that can be incorporated into projects.
- Providing recommendations for incorporating equity and environmental justice considerations into resilience projects.
- Developing additional guidance on climate change risks, the cost of inaction, and co-benefits of resilience projects for stakeholders that may not typically view resilience as their responsibility.
- Gathering input from stakeholders to inform the development of additional resources to help member agencies increase their resilience.
- Developing regionally consistent data metrics to inform future studies and measure progress.

Trainings and Professional Development

In addition to sharing information and resources, the TPB can host trainings, webinars, and peer exchanges to help member agencies build capacity to implement resilience projects and share best practices and lessons learned. The TPB already has experience doing this. For example, the TPB's 2022 webinar series

engaged member agencies and helped them build capacity to understand climate challenges in the region. A key intended outcome of future trainings is to support agencies in understanding what a resilience project is, how to define resilience measures, and how to design existing processes to better incorporate resilience.

Potential future trainings and webinars could highlight co-benefits of resilient infrastructure and help break down silos across agencies, especially for those agencies that do not typically consider their work as being focused on resilience. Trainings and webinars could be especially helpful for providing more information on funding opportunities, including guidance for developing strong grant applications. The TPB can also use these capacity-building opportunities to ensure that resilience and transportation practitioners and planners across the region can easily understand and identify if a proposed project can be considered a resilience project. Additionally, peer exchanges could provide an opportunity for more in-depth conservations on existing practices related to resilience, challenges and successful approaches, and lessons learned for future resilience projects. Some infrastructure owners may also benefit from training on how to conduct a more detailed vulnerability assessment for their assets.

Collaboration

The TPB plays an essential role in convening stakeholders and facilitating collaboration across the region. The TRIP is one example of how the TPB has successfully convened stakeholders to help increase resilience (Chapter 3. Systemic Approach to TRIP Development). As MDOT, VDOT, and DDOT develop and update their own vulnerability assessments and resilience improvement plans that include areas in the metropolitan Washington region, the TPB will continue to regularly engage with these agencies to ensure each TRIP works together towards improved regional resilience (e.g., sharing and improving data across jurisdictional boundaries, coordinating on identifying, funding, and implementing resilience projects). TPB plans to convene a formal Regional Transportation Resilience Subcommittee, through which much of this collaboration will occur.

The TPB can continue to facilitate collaboration across its member agencies by determining where multiple agencies can pool resources and efforts to implement resilience projects, especially when individual agencies do not have sufficient capacity to lead resilience efforts. The TPB can also convene the formal regional transportation resilience subcommittee to continue coordination between transportation resilience professionals in the region. Additionally, the TPB can conduct cross-jurisdictional studies to understand where resilience projects could be implemented to prevent cascading failures. The TPB can also develop an online tracker of resilience projects similar to the Hampton Roads Resilience Projects dashboard to identify regional resilience success. This tracker would provide data on the types of projects underway, percent of projects using natural infrastructure, approximate locations of projects, and project status, the TPB may also consider looking beyond the metropolitan Washington region and explore additional opportunities for collaboration through efforts such as the Transportation and Climate Initiative.

Short-Term Financial Planning

The TPB can continue to incorporate an emphasis on resilience in short-term financial planning through the TIP. Previously, the TPB has included a question about resilience projects in the TIP Call for Projects to encourage more resilience-focused submissions or support agencies in incorporating a resilience lens in project evaluation. The TIP is a four-year federally obligated document that describes the TPB board-

approved transportation projects scheduled to receive federal transportation funding and all regionally significant air quality projects. The TIP includes highway projects, rail, bus, and streetcar projects and bicycle and pedestrian improvements, as well as roadway and transit maintenance projects, operational programs, and many other transportation-related activities. Integrating resilience-thinking into the project planning process may increasingly result in the adoption of resilient strategies.

Long-Range Planning

The TPB can also further integrate resilience in its long-range planning. This can include strengthening the resilience lens in the TPB's 20-year horizon vision document, the NCRTP (Visualize 2045), in future long-range plans. The next NCRTP (Visualize 2050) for the National Capital Region is currently under development, providing an opportunity to incorporate the resilience priority projects identified in the TRIP with the next NCRTP and ultimately programmed with funding in the TIP. The TRIP identifies a desired project list to address resilience issues in the region, and projects that are priorities with reasonably anticipated funding will be submitted for inclusion in a future NCRTP. Projects submitted for inclusion in Visualize 2045 described how they included equity and climate considerations, and a similar measure is expected in future NCRTPs. Projects included in this TRIP have already identified climate and equity considerations, and agencies can use the mapping tool to identify similar information for new projects.

The TPB aims to expand education around climate resilience in transportation. The vulnerability mapping tool can be used as an educational tool to tell transportation agencies where their assets may soon face challenges from climate change. The vulnerability assessment literature review provides a foundation for understanding climate hazards to the transportation system in the region. The methodology of the asset-level vulnerability assessment can break down what makes each type of asset resilient to specific climate hazards or not. This TRIP will help to inform future long-range planning and support progress toward becoming a Climate Ready Region, which COG defines as a region that has the "ability to adapt and absorb against disturbances caused by current and future, acute and chronic climate impacts and successfully maintain essential functions."[47]

As agencies submit projects to future NCRTP updates, the hope is that more resilience projects will be developed and more investments will be proposed to strengthen the region's vulnerable infrastructure and make the transportation network more reliable and less impacted by severe weather.

B. ROLE OF KEY PARTNERS

Although the TPB plays an essential role in transportation planning and convening in the metropolitan Washington region, it relies upon its member agencies to implement most resilience projects and to adopt supporting policies, codes, and standards. The state and District DOTs have jurisdiction over required and prioritized project implementation, such as regular and deferred maintenance and general transportation system improvements and are therefore key implementers for any transportation resilience investments.

Regional agencies have begun to incorporate resilience priorities in their regular operations; for example, Maryland DOT and Virginia DOT have both updated elements of their design manuals to incorporate future changes in climate. Individual jurisdictions are beginning to explore this as well; for example, Prince William County is currently undergoing a Transportation Land-Use Connections project aimed at providing green infrastructure implementation guidance to help updating policy documents like local design and constructure standards to help the county promote strategic green infrastructure implementation in planned transportation-related capital improvement projects. In the long term, resilience investments may reduce operational and maintenance costs and reduce the likelihood of significant system or asset damage from climate hazards. Member agencies such as DOTs can utilize planning processes like the development of asset management plans and capital improvement plans to increase resilience considerations and priorities.

Resilience Policies

Transportation agencies in DC, Maryland, and Virginia each have policies that guide climate adaptation within their jurisdictions. For example, Maryland has created the CoastSmart Council and authorized local Resilience Authorities to oversee and support construction of resilient infrastructure.[48,49] Maryland's government emphasized resilience through climate adaptation as a core objective in the 2024 State Plan.[50] In Virginia, the Commonwealth Transportation Board considers resilience when adopting the Statewide Transportation Plan and the Virginia Department of Conservation and Recreation plans for flooding impact to critical transportation and emergency services infrastructure.[51,52]

The TPB's partners will continue to play a key role in the implementation of resilience projects across the region, including by providing a voice from practitioners on the ground as to the climate impacts they are experiencing firsthand, the types of solutions they are or are not able to implement, the plans they are working on, and the data they have access to. Key partners can also help push the TPB to think outside the box with new ideas to increase the region's resilience to natural hazards.

C. MONITORING PROCESS AND IMPACT

The implementation of climate change resilience measures is a relatively new area, and as such, limited resources are available on best practices and lessons learned. To ensure progress toward key goals, the TPB can monitor and measure resilience work across the region. Potential measurable outcomes that the TPB can track include but are not limited to:

- Number of resilience projects that receive resilience grant funding annually
- Number of regional meetings held and meeting attendance
- Number of resilience projects/studies within EEAs
- Number of resilience projects that address high or medium vulnerabilities identified in the Climate Vulnerability Assessment
- Establishment of a baseline definition for a resilience project and improved identification of resilience projects

- Number of trainings and capacity-building opportunities to educate member and regional agencies on identifying and/or developing resilience projects
- Number of new staff positions at regional and member agencies dedicated to transportation resilience
- Percentage of projects included in the TIP that increase resilience
- Percentage of projects that incorporate natural infrastructure as part of the resilience solution
- Qualitative discussions with member agencies on the success or lessons learned from implemented projects
- Percentage of resilience planning studies that then advance to implementation phases

The TPB will continue to evaluate opportunities to integrate resilience metrics into ongoing planning processes, such as the development of future NCRTPs and updates to the TRIP or related studies. The TPB will also continue to engage with regional stakeholders to learn about how they are monitoring and measuring the impact of resilience investments made in the region. Increased engagement and education on how to define a resilience project and why resilience investments are needed is a key component of advancing resilience work and sharing the impact of such projects. As a lead agency supporting capacity building and information sharing, the TPB aims to increase these engagement and education opportunities and their impact and reach.

CHAPTER 7

Future Regional Transportation Resilience Enhancements

This TRIP is the first comprehensive regional transportation resilience plan created for the metropolitan Washington region. The TPB is committed to continuous efforts to identify vulnerabilities to inform transportation resilience planning and investments in the region and plans to refine the TRIP annually. Resources developed for this TRIP, such as the mapping tool, will be maintained and updated as improvements are made, including the integration of additional datasets or analyses described below. Future transportation resilience efforts may increasingly address transportation electrification and nature-based solutions (i.e., tree canopy) through land-use planning processes. The TPB will also strive to be inclusive of other considerations, such as climate mitigation opportunities and socioeconomic factors such as access to job centers and resources, in the identification or design of resilience investments.

Future resilience studies and plans, and potential improvements to the TRIP, may be based on best practices learned from other agencies' TRIPs or the TPB's and regional agencies' expertise and areas identified for improvement. Future resilience plans and studies may also change the approach used in articulating climate resilience needs and building adaptation strategies. The TPB has identified several potential enhancements to assessing system vulnerabilities for future additional analysis of the transportation system. The TPB looks forward to continued coordination with member agencies and to including more priority transportation resilience projects in future TRIPs.

A. ADDITIONAL FLOODING IMPACT ANALYSIS

Although the FEMA floodplain maps used in the vulnerability assessment were useful to understand temporary flood likelihood at a specific location, these maps are based on historical data and do not consider future climate change. Moreover, current FEMA maps only represent temporary fluvial (riverine) and coastal flooding. The TPB has identified several potential improvements for the temporary flooding analysis to address the limitations of the floodplain maps. One improvement could be the consideration of other types of temporary flooding such as urban or pluvial flooding (i.e., when heavy rainfall overwhelms drainage systems and natural water pathways), which is a growing concern for certain areas in the metropolitan Washington region. Another improvement could be the integration of forward-looking changes in precipitation due to climate change and the impacts of those changes on riverine floodplains. This would build on the historical FEMA data to help evaluate future impacts. It would also be beneficial to ground-truth the flooding results based on existing knowledge within the region. Regional agencies with historical and other data for their jurisdiction could utilize the 'add data' feature in the online mapping tool to include these in their own review of projects within their jurisdiction.

The current vulnerability assessment considers the effects of temporary flooding and permanent flooding from sea level rise separately, but these two types of flooding can have compounding effects. For example, sea level rise that raises the height of the Anacostia and the Potomac Rivers may submerge municipal stormwater drainage outflows, preventing effective drainage. In this event, extreme precipitation would more easily overwhelm stormwater systems and bring increased flooding to affected regions. This effect can be particularly pronounced when tropical and extratropical storms pass through the region causing a storm surge that raises sea levels even higher than the average level combined with simultaneous extreme precipitation. Integrated modeling of the combined impacts of sea level rise and changes in precipitation would be necessary to evaluate the extent of impacts from these events.

Other improvements could include incorporating asset-specific information on elevation to improve the representation of each asset's potential exposure to flooding. Assets that sit in an area that is exposed to flood risk may not be vulnerable if they are elevated above the expected inundation level. On the other hand, bridge approaches may have higher flood risk as they are lower than the current point-based representation of the bridge. As noted in Chapter 4. Risk-Based Vulnerability Assessment, due to data limitations, the flood exposure methodology was applied to all rail stations and rail lines, regardless of whether those assets are located above or below ground. The TPB could refine the understanding of flood risk by compiling or creating asset elevation data, including centerline data for roads, and incorporating this into the vulnerability assessment.

B. INCREASED CONSIDERATION OF EQUITY AND POTENTIAL IMPACTS TO CRITICAL SERVICES

Equity is a central consideration for resilience planning, and there are opportunities to further consider equity impacts in a future vulnerability assessment update. Conducting an analysis that considers not just where an asset is located relative to disadvantaged populations, but who the actual users of the asset are would provide much more accurate insights on the equity implications of potential damage. Future analyses can also consider how assets are critical to the transportation system if they connect people to critical community facilities such as hospitals, police/fire stations, and schools. Individuals may experience greater need for these services and access to these community facilities during climate hazard events. One way to incorporate this need in future assessments could be weighing criticality scores to give higher scores to transportation routes that provide connectivity to critical community facilities. Another method could be based on the Hampton Roads Transportation Planning Organization's model of how flooding impacts disadvantaged communities' access to essential services.[53]

C. ECONOMIC IMPACTS AND SYSTEM-LEVEL ANALYSIS

Future TRIPs may change the framework used to identify vulnerability. The current TRIP identifies priorities by looking at each asset type in isolation. A future TRIP could consider the ways that riders use multiple modes of transportation or can use multiple types of transportation to reach their destinations. This set-up recognizes that areas that only have access to one mode of transportation may be more vulnerable than those that have access to multiple modes. A future TRIP could also take a different approach and conduct deep dive vulnerability analyses for specific sites to provide more information on what constitutes vulnerability and what cost-effective adaptation solutions may be. Future analyses could also create a monetized understanding of the risks posed by climate change. An analysis of this nature would allow for better comparison with other, non-climate risks and could allow agencies to weigh climate adaptation needs against competing priorities. Ideally, this monetary analysis would account for costs to both the agency (e.g., costs to repair damage) and user (e.g., lost time due to detours) costs.

D. MAPPING REGIONAL CLOSURES DUE TO NATURAL HAZARDS

Future analyses could incorporate data from the Regional Integrated Transportation Information System

(RITIS) which provides real-time transportation data from each of the region's transportation agencies. The TPB could analyze RITIS data for all TPB localities to identify where transportation closures have occurred due to natural hazards over the past 20 years. This could help further ground-truth the results of the vulnerability assessment and confirm that specific routes or locations that are frequently closed due to natural hazards have been captured in the assessment. Analyzing RITIS data could also help the TPB understand whether closures related to natural hazards have been increasing over time. Similarly, as more resilience projects are implemented in the future, the TPB could use this data to measure how effectively resilience projects may reduce closures related to natural hazards.

E. EXTREME HEAT TRANSIT RIDER ANALYSIS

The TPB or its transit partners could conduct further studies to understand how extreme heat impacts public transit riders. Such studies could focus on populations that rely heavily on public transportation and could consider the intersections of equity and public health, especially for communities located in urban heat islands. The TPB's transit partners could use the findings from these studies to inform the development of resilience improvement projects to reduce extreme heat impacts, such as the installation of additional shade structures or misting stations at public transit stops. The TPB's transit partners may also consider ways to adapt transit schedules to reduce rider vulnerability, especially during heatwaves.[54]

CHAPTER 8

Conclusion

Figure 16: Bike lanes in the NoMa neighborhood in DC (COG).

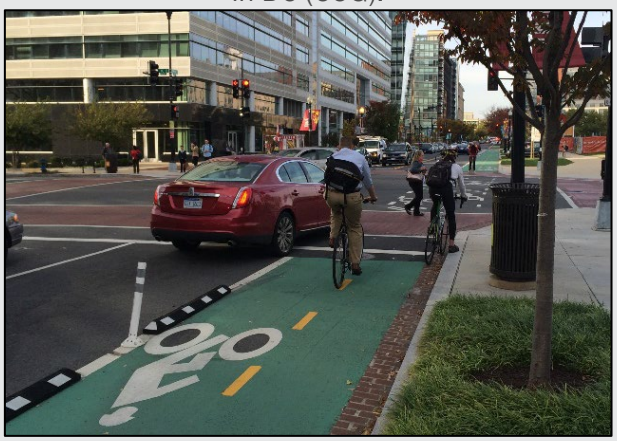


Figure 17: FLASH bus in Montgomery County (MCDOT).

Figure 18: Bike paths along the GW Parkway in Arlington, VA (COG).

The TPB developed this TRIP in coordination with member agencies to build on the strong foundation of transportation resilience work in the region, advance the region's climate resilience goals, and support the TPB's commitment to incorporate an equity lens in its work. The TRIP is another milestone in the region's resilience efforts and will serve as a resource to further these efforts. The vulnerability assessment has equipped the TPB and its member agencies with a stronger understanding of climate vulnerabilities across the region's transportation system.

This TRIP positions the key stakeholders managing metropolitan Washington's transportation system to make climate-informed decisions about future investments and support a climate ready and resilient region. The TPB will continue to focus on facilitating coordination among infrastructure owners and planning agencies and serve as a multi-jurisdictional resource to support regional resilience planning.

APPENDIX A

PROTECT Requirements Checklist

Appendix A. PROTECT Requirements Checklist

This appendix lists the required and optional elements of a Resilience Improvement Plan (RIP) per the PROTECT program guidelines and where each element is addressed in this document.

Table 18: PROTECT Requirements of a State or MPO RIP

The RIP…	Corresponding TRIP Section
Shall…	
Be for the **immediate and long-range planning activities** and investments of the State or metropolitan planning organization with respect to resilience of the surface transportation system within the boundaries of the State or metropolitan planning organization, as applicable	Chapter 3. Systemic Approach to TRIP Development
Demonstrate a **systemic approach** to surface transportation system resilience, and	Chapter 3. Systemic Approach to TRIP Development
Be **consistent with and complementary of the State and local mitigation plans** required under section 322 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (42 U.S.C. 5165).	Chapter 2. TPB's Regional Approach to Resilience: TRIP Alignment with Existing Plans Appendix B. Existing Policies and Plans
Include a risk-based assessment of vulnerabilities of transportation assets and systems to current and future weather events and natural disasters, such as severe storms, flooding, drought, levee and dam failures, wildfire, rockslides, mudslides, sea level rise, extreme weather, including extreme temperatures, and earthquakes (23 U.S.C. 176(e)(2)(A-C)).	Chapter 4. Risk-Based Vulnerability Assessment
Shall, as appropriate…	
Include a description of **how the agency is prepared to respond** to the impacts of weather events, natural disasters and is prepared for changing conditions;	Chapter 3. Systemic Approach to TRIP Development
Describe the **codes, standards, and regulatory framework**, adopted and enforced by the agencies, to ensure that resilience improvements within the impacted area of proposed projects that are included in the plan;	Chapter 2. TPB's Regional Approach to Resilience: TRIP Alignment with Existing Plans Chapter 6. Implementing Resilience Appendix B. Existing Policies and Plans
Consider the benefits of combining hard surface transportation assets, and **natural infrastructure**, through coordinated efforts by the Federal Government and the States;	Chapter 5. Resilience Investment Plan

Appendix A. PROTECT Requirements Checklist

The RIP…	Corresponding TRIP Section
Assess the resilience of **other community assets**, including buildings and housing, emergency management assets, and energy, water, and communication infrastructure;	Chapter 4. Risk-Based Vulnerability Assessment: Critical Interdependencies
Include such **other information** as the State or metropolitan planning organization considers appropriate.	Chapter 3. Systemic Approach to TRIP Development: Scope and Approach Chapter 7. Future TRIP Enhancements
May also…	
Designate evacuation routes and strategies, including multimodal facilities, designated with consideration for individuals without access to personal vehicles;	Not applicable
Plan for **response to anticipated emergencies**, including plans for the mobility of emergency response personnel and equipment and access to emergency services, including for vulnerable or disadvantaged populations;	Not applicable
Describe the resilience improvement policies, including strategies, land use and zoning changes, investments in natural infrastructure, or performance measures that will inform the transportation investment decisions of the State or metropolitan planning organization with the goal of increasing resilience;	Chapter 5. Resilience Investment Plan Chapter 6. Implementing Resilience
Include an **investment plan** that includes a list of priority projects and describes how funds apportioned to the State under section 104(b)(8), or provided by a grant under the PROTECT program would be invested and matched, which shall not be subject to fiscal constraint requirements;	Chapter 5. Resilience Investment Plan Appendix C. Priority Resilience Investments
Use science and data and indicate the source of data and methodologies.	Chapter 4. Risk-Based Vulnerability Assessment

APPENDIX B

Existing Policies and Plans

Appendix B. Existing Policies and Plans

This appendix provides more details on member agency policies and plans related to climate resilience. Details on COG and the TPB's resilience goals and plans, as well as member agency transportation and hazard mitigation plans (HMPs), are included in Chapter 2. TPB's Regional Approach to Resilience. Table 19 summarizes the key climate change policies and plans related to transportation resilience for the TPB, DC, Maryland, and Virginia.

Table 19: Climate Change Policies and Transportation Resilience Plans for the TPB, DC, MD, and VA

Policies and Plans	Descriptions
TPB	
Visualize 2045 (2022)	Visualize 2045 serves as the TPB's long-range plan. The FY 2023-2026 TIP development process, part of the Visualize 2045 update, provides the schedule for the next four years for distributing federal, state, and local funds for state and local transportation projects. Transportation agencies were asked to describe how the new and existing projects submitted for inclusion in Visualize 2045 would support equity and climate considerations. The TPB is in the process of developing Visualize 2050, the update to Visualize 2045 by June 2025.
DC	
Sustainable DC Act of 2012	This act created the Property Assessed Clean Energy financing program to increase sustainability efforts across DC. The program incentivizes large building energy efficiency retrofits in addition to providing various measures to advance sustainability goals. These include specific measures to clean the Anacostia River, protect children's health, and improve energy efficiency in low-income households.
Commission on Climate Change and Resiliency Establishment Act of 2016	In 2016, this act established a commission responsible for assessing climate change impacts and the District's ability to mitigate and adapt to said impacts. Adaptation includes being able to prepare, plan for, absorb, and recover from climate impacts, and modify operations moving forward. The Commission published their first report in 2019, which describes the progress the Commissions had made.
Clean Energy DC Omnibus Amendment Act of 2018	This act, established in 2018, mandated that 100% of the District's energy supply come from Tier 1 renewable energy sources by 2032.
Climate Commitment Act of 2022	The Climate Commitment Act of 2022 codified the District's commitment to the Paris Agreement by mandating that the city neutralize GHG emissions by 2045, reach carbon neutrality in government operations by 2040, and end new purchases of fossil fuel-based heating equipment and vehicles by 2025 and 2026.

Appendix B. Existing Policies and Plans

Policies and Plans	Descriptions
DC Mitigation Program (includes an All-Hazard Mitigation Plan)	The objective of DC's Mitigation Program is to create better prepared and more resilient communities by providing a common approach to support protection and prevention activities. The guiding principles include resilience and sustainability, leadership, and neighborhood-focused implementation, engaged partnerships and inclusiveness, and risk-consciousness. The program includes an All-Hazard Mitigation Plan, which outlines specific goals and actions to help improve the District's ability to deter, deflect, absorb, or withstand impacts from a range of hazards.
moveDC (2021)	moveDC is DDOT's Multimodal LRTP. The goals in this plan include strengthening the resilience of the transportation system to climate change, especially in disadvantaged neighborhoods. moveDC is updated every 5-6 years, so an update to the plan can be expected by 2026/2027.
MD	
MDOT Transportation Resilience Improvement Plan (2024)	In 2024, Maryland Department of Transportation developed a Transportation Resilience Improvement Plan to guide strategic infrastructure investments and proactively identify actions that can be taken to enhance both resilience and mitigation. The plan includes a risk-based vulnerability assessment, recommended priority areas for investments, and a general implementation plan.
Maryland Environment 2-1305	This statute from 2022 requires state agencies to report to the Governor and the Maryland Commission on Climate Change on the status of programs and activities to reduce GHG emissions.
Maryland Commission on Climate Change Act (2015)	This act codified the Maryland Commission on Climate Change into law. The commission is responsible for advising the Governor and General Assembly on methods for mitigating and adapting to the impacts of climate change.
Maryland Climate Solutions Now Act (2022) (SB528)	The Maryland Climate Solutions Now Act called for Maryland to reduce GHGs by 60% (compared to a 2006 baseline) by 2031 and for the Maryland economy to reach net-zero emissions by 2045.
Maryland Climate Pollution Reduction Plan	The statewide Climate Pollution Reduction Plan provides strategies that Maryland will use to achieve the GHG reduction goals set out in the Maryland Climate Solutions Now Act.
MDOT Climate Pollution Reduction Plan	The MDOT Climate Pollution Reduction Plan presents transportation sector-specific strategies to achieve the GHG reduction goals established in the Maryland Climate Solutions Now Act.

Appendix B. Existing Policies and Plans

Policies and Plans	Descriptions
Maryland Climate Adaptation and Resilience Framework Recommendations	This set of recommendations, set out in 2020, provides a framework for the next ten years of climate adaptation goals, strategies, and activities across the state. Recommendations include protecting critical infrastructure, building environmental justice and local adaptation capacity, and protecting human health, among others.
MDOT's Climate Change Status Reports	Each year, MDOT submits an annual report to describe progress toward state GHG reduction goals as outlined in the Maryland Greenhouse Gas Reduction Act and progress made toward enhancing resilience of Maryland's transportation system.
Maryland State Agency Annual Climate Change Reports	Eleven state agencies submit an annual report on the status of their GHG reduction efforts. The reports describe programs that are in place, program successes and challenges, funding, and estimated greenhouse gas reductions. The MDOT Climate Change Status Report is one of these such plans.
Maryland Senate Bill 457: Resilience Authorities	This bill outlines the requirements for local governments to establish and fund a Resilience Authority. The Resilience Authority allows municipalities the flexibility to organize the funding and management of large-scale infrastructure projects intended to address climate change impacts. Powers of the Resilience Authority are specified in this bill.
Maryland Hazard Mitigation Plan (2021)	One of the priority mitigation actions outlined in Maryland's HMP is protecting state assets, infrastructure, and critical facilities from hazard events. The HMP also includes the goals of prioritizing equity and environmental justice and enhancing coordination, strengthening existing linkages, and creating new linkages between state and local mitigation and resiliency efforts. HMPs need to be updated every five years, so an update to Maryland's plan can be expected by 2026.
The Playbook (2024)	The Playbook is Maryland's 2050 LRTP. The guiding principles of the Playbook are intended to guide MDOT's decision-making process, and the principles include resilience and equity. The Playbook includes multiple goals and objectives in the plan that relate to addressing changing climate conditions and increasing resilience. MDOT updates their LRTP every five years, so an update to the plan can be expected by 2029.
VA	

Appendix B. Existing Policies and Plans

Policies and Plans	Descriptions
VDOT Resilience Plan (2022)	The Virginia Department of Transportation created a resilience plan in 2022 to formalize a framework for building a more resilient transportation system. Through collaboration with stakeholders and the use of up-to-date climate data, the Plan identifies at-risk infrastructure, prioritizes needs, identifies resilience measures, assesses feasibility and cost-effectiveness, and finally incorporates resilience into current funding policies.
Virginia Clean Economy Act (2020)	This act established a renewable energy portfolio standard, which mandates that the two utilities in the state, Dominion Energy Virginia and Appalachian Electric Power, produce 100% renewable energy by 2045 and 2050, respectively. Additionally, the act established energy efficiency standards.
Environmental Justice Act (2020)	In 2020, the Environmental Justice Act permanently established the state Council on Environmental Justice. The purpose of this council is to aid the governor in protecting vulnerable communities from the disproportionate burdens of climate change (such as pollution). The council will provide the governor with recommendations on how best to protect these communities.
Clean Energy and Community Flood Preparedness Act (2020)	This act established the Virginia Community Flood Preparedness Fund to provide support for regions and municipalities across Virginia to reduce the impacts of flooding.
Commonwealth of Virginia Hazard Mitigation Plan (2023)	The HMP sets priorities for mitigation activities that protect people and infrastructure from a range of hazards. One goal of the HMP is to evaluate potential climate impacts to vulnerable populations. Another goal is to identify and prioritize projects that improve community resilience. HMPs need to be updated every five years, so an update to Virginia's plan can be expected by 2028.
VTrans (2022)	VTrans is Virginia's statewide transportation plan which considers both mid-term (0-10 years) and long-term (20+ years) planning needs. The overall vision and goals of VTrans include increasing the resilience of Virginia's transportation system. VTrans is expected to be updated by 2026.

Appendix B. Existing Policies and Plans

Policies and Plans	Descriptions
TransAction (2022)	TransAction is the long-range multimodal plan for Northern Virginia which addresses regional transportation needs through 2045. One of TransAction's three goals is improving resilience, including infrastructure resilience to extreme weather events. TransAction also acknowledges the desire within the region to address climate change within planning processes. TransAction is expected to be updated by 2027.
Northern Virginia Hazard Mitigation Plan (2022)	The main objective of the HMP is to reduce long-term vulnerability to natural hazards for all jurisdictions in the region. North Virginia's HMP provides priority mitigation actions across four categories: local plans and regulations, structure and infrastructure, natural systems protection, and public education and awareness. HMPs need to be updated every five years, so an update to North Virginia's plan can be expected by 2027.
Northern Virginia Military Installation Resilience Review (2023)	The North Virginia Regional Commission completed a Military Installation Resilience Review to assess the impacts of current and future climate hazards on four counties and three military installations in Northern Virginia. The Resilience Review allowed the region to assess the vulnerability of assets and essential services in the region to climate hazards and ultimately develop a list of potential mitigation measures and adaptation strategies at the regional, installation, and county levels. Given that the installations, counties, and utility providers in North Virginia are highly interdependent, this project provided a unique opportunity to enhance regional resilience.
Resilient Critical Infrastructure: A Roadmap for Northern Virginia (2018)	MWCOG and Northern Virginia Regional Commission established a framework for use in planning documents that prepare northern Virginia and DC for projected changes in heat, precipitation, and sea level over an 80-year planning horizon. The roadmap identifies the following as strategic objectives to prepare for climate impacts: understanding climate conditions and timelines, assessing critical infrastructure vulnerability, creating resilience goals and metrics, creating regional partnerships centered on resilience, incorporating resilience into existing policies, developing a database of resilience projects, and communicating with stakeholders.

In addition to the key transportation and HMPs in the metropolitan Washington region, there are many other local studies that have been completed that provide additional insights on climate change and extreme weather vulnerabilities and needs within the region. Many of these studies were reviewed and included in the TPB's November 2021 Resiliency Study Whitepaper. Some of the studies take a deeper dive into specific hazards, or use data sets that are more robust on past events or future projections that simply are not available at a region-wide scale. When developing the TRIP, some of these other existing studies/plans were

Appendix B. Existing Policies and Plans

cited as the foundation for project ideas and referenced in the project submissions for the priority project list (Chapter 5. Resilience Investment Plan). Table 20 summarizes the plans referenced in the TRIP project submissions.

Table 20: TPB and Member Agency Plans Referenced in the TRIP Project Submissions

Plans
DC • Broad Branch Road Environmental Assessment • Climate Ready DC Plan • DC Comprehensive Plan • Resilient DC • Southwest & Buzzard Point Flood Resilience Strategy • Southwest Neighborhood Plan • Watts Branch Flood Resilience Strategy (expected 2024 MD • Charles County's 2020 Nuisance & Urban Flood Plan • Charles County's Transportation Priorities Letter to MDOT For FY 2024 VA • Manassas 2040 Comprehensive Plan MOB 644; ESH 83; ESH 84 • Northern Virginia Hazard Mitigation Plan • Northern Virginia Regional Commission Military Installation Resilience Review Study • Prince William County Community Energy and Sustainability Master Plan • VRE Broad Run Station Expansion Project Planning Study • Prince William County DOT Transportation-Land Use Connections Planning Study

APPENDIX C

Priority Resilience Investments Submission Form

Appendix C. Priority Resilience Investments Submission Form

The National Capital Region Transportation Planning Board (TPB) is soliciting transportation resilience projects to include in the TPB Transportation Resilience Improvement Plan (TRIP). Per the Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) Program Guidance from the Federal Highway Administration, priority resilience projects included in the TRIP will receive extra evaluation points and will be eligible for a 7% reduction in the non-federal share of project costs for the PROTECT Discretionary Grant Program. If projects are incorporated into the TPB NCRTP, they will be eligible for an additional 3% reduction and may receive the maximum 10% reduction in non-Federal share of project costs.

Submitted projects will be evaluated for inclusion in the TRIP according to the resilience criteria established in the TRIP Project Request Guidance. Project evaluation will consider whether the project:

- Is for an eligible transportation asset (Roads and Highways, Bridges, Public Transit Infrastructure, Active Transportation Infrastructure, Airports, Maritime Infrastructure, Stormwater Infrastructure).
- Is a qualifying project type for PROTECT (Resilience Planning, Resilience Improvements, Community Resilience and Evacuation Routes, At-Risk Coastal Infrastructure).
- Targets a high priority risk identified in the TPB Climate Vulnerability Assessment or risk(s) identified through another assessment/data source.
- Reduces climate risks.

Please submit one form per project. Project submissions will be accepted through January 31, 2024. To see the full TRIP Project Request Guidance, see https://www.mwcog.org/assets/1/6/TRIP_Project_Request_Form1.pdf.

The TPB will contact you with any additional questions about your submission and updates about the evaluation of the project to include in the TRIP by the end of February 2024. If you have any questions about the TRIP and project request process, please contact the TPB.

Estimate 9 minutes to complete this form.

Question	Answer Option
1. Provide your full name.	[Text answer]
2. Provide your email address	[Text answer]
3. Provide lead agency name.	[Text answer]
4. Provide lead agency entity type.	[Select one] • State (including DC) • Metropolitan Planning Organization • Unit of local government • Special purpose district or public authority with a transportation function • Multi-State or multi-jurisdictional group of entities
5. Provide secondary agency name if applicable.	[Text answer]

Appendix C. Priority Resilience Investments Submission Form

Question	Answer Option
6. Provide secondary agency entity type if applicable.	[Select one] • State (including DC) • Metropolitan Planning Organization • Unit of local government • Special purpose district or public authority with a transportation function • Multi-State or multi-jurisdictional group of entities
7. Project Type	[Select one] • Roadway system (Functional Class 1-3, 5) • Local street system (Functional Class 4, 7) • Facility or service for public transportation • Facility or service for intercity passenger rail • Active transportation (not eligible for PROTECT funding) • Maritime infrastructure (not eligible for PROTECT funding unless connected to a port facility) • Airports (not eligible for PROTECT funding) • Study or plan • Service or Operations
8. Project Title	[Text answer]
9. Identify the project location and asset(s) and describe the project activities and intended outcomes.	[Text answer]
10. Identify the system or route where the project is located, including the beginning project limit or location of a spot improvement and the distance in miles of the complete project. For bridges, provide the federal or state bridge asset identification number.	[Text answer]
11. Describe the climate hazard(s) impacting the asset(s) and what resilience measure(s) will be completed through the project.	[Text answer]
12. Describe the proposed project timeline and indicate the estimated year for project completion.	[Text answer]

Appendix C. Priority Resilience Investments Submission Form

Question	Answer Option
13. Provide an order of magnitude estimated cost.	[Select one] • Under $50,000 • $50,000 - $250,000 • $250,000 - $500,000 • $500,000 - $1,000,000 • $1,000,000 - $5,000,000
14. Describe any current funding commitments for the project.	[Text answer]
15. Indicate whether this project has been included in one of the following:	[Select all that apply] • Visualize 2045 • TIP • None of the above
16. If the project has been included in Visualize 2045 or TIP, state the Project ID.	[Text answer]
17. Indicate whether this project has been included in an application to the PROTECT program.	[Select one] • Yes • No
18. Indicate if the project has been identified through another planning process or is included in an existing agency policy or planning document.	[Select one] • Yes • No
19. If yes, state which planning process, policy, or document.	[Text answer]
20. Indicate whether the project addresses a high priority risk identified through the TPB Climate Vulnerability Assessment, local studies and assessments, or historic evidence of natural hazard damage.	[Select one] • Yes, identified through the Vulnerability Assessment • Yes, identified through other studies, data, or assessments • No

Appendix C. Priority Resilience Investments Submission Form

Question	Answer Option
21. *If Yes, identified through other studies, data, or assessments:* If your organization has additional data or record of historical incidents indicating at-risk transportation assets that are not represented on the Interactive Mapping Tool, please describe the data sources and how this data was used to inform the project.	[Text answer]
22. Describe how the project will reduce the risks associated with one or more climate hazards and ensures the continuity and/or reliability of the transportation service/system.	[Text answer]
23. Describe any additional strengths of the project (e.g., incorporates innovative solutions like nature-based solutions).	[Text answer]
24. Indicate whether this project is physically in an EEA or provides direct benefits to an EEA.	[Select one] • Yes • No
25. Provide any additional relevant information that describes how this project further supports or advances equity as described by the TPB in the July 2020 *Resolution to Establish Equity as a Fundamental Value and Integral Part of all Transportation Planning Board's Work Activities.*	[Text answer]

Appendix D. Priority Resilience Investment Submissions

Appendix D. Priority Resilience Investment Submissions

Table 21 provides the project form submissions for inclusion in the TRIP. The question numbers correspond to the questions listed in Appendix C. Priority Resilience Investments Submission Form. The TPB has removed the high-level planning cost estimates and personal identifying information. This appendix serves as the priority project list for the TRIP and will be updated each year through an annual call for projects using the same Submission Form.

Table 21: Priority Resilience Investment Submissions

Submitting Agency	Question	Answers
Charles County Government (Unit of local government) Supported by Resilience Authority of Charles County (Nonprofit Government Instrumentality)	**Project**	**MD 6 Port Tobacco Road Resilience Improvements**
	8.	Roadway system (Functional Class 1-3, 5)
	9.	This project pertains to the section of MD 6 Port Tobacco Rd that runs between Liverpool Point and Riverside Roads in Nanjemoy. Road improvements are needed to include pavement reconstruction/ resurfacing, reinforcement and improvement of the roadway shoulders, and drainage improvements to handle both average and significant storm event flows. This rural area of Charles County is highly dependent on this roadway and is greatly affected by its deteriorating conditions.
	10.	This road improvement project would begin at the intersection of Port Tobacco Rd and Liverpool Point Rd, and continue along the 7-mile stretch of Port Tobacco Rd between Liverpool Point Rd and the intersection with Riverside Rd. This stretch of road includes Bridge 8015 over Nanjemoy Creek.
	11.	This road is currently threatened by both average and significant storm events. Increasingly severe precipitation events cause flooding along portions of this seven-mile stretch. This area will require further evaluation to determine which specific measures will be necessary to improve drainage.
	12.	To be determined
	14.	N/A
	15.	None of the above
	17.	No
	18.	Yes
	19.	This project was included in Charles County's 2020 Nuisance & Urban Flood Plan, the purpose of which is to identify

Appendix D. Priority Resilience Investment Submissions

Submitting Agency	Question	Answers
		sources of nuisance and urban flooding, analyze flood hazards, and recommend actions to reduce flooding and increase community resiliency. It is also included in the County's transportation priorities letter to MDOT for FY2024.
	20.	Yes, identified through the Vulnerability Assessment
	22.	This project will reduce the risks associated with extreme weather, precipitation, and tidal flooding by reducing and redirecting runoff that currently invades this roadway. By improving infiltration and redirecting runoff along this roadway, Charles County can protect the resilience of its transportation corridors to extreme weather events.
	23.	This project is still in the planning phase and has the potential to include a range of possible nature-based and innovative interventions to address stormwater runoff, each with their own co-benefits. Ensuring that the solution considers climate change will make our transportation system more resilient.
	24.	Yes
	25.	The Census tract in which this project is located is considered to be an EEA and has a median household income of $75,813 compared to the County median household income of $116,882. The median income for Black residents in this Census Tract is even lower, at $59, 091. Improving this section of MD 6 would support equity by ensuring that people living in low-income and/or historically disenfranchised communities are meaningfully included in investments. Rural and low-income communities are too often overlooked for improvement projects; focusing on MD 6 would work toward TPB's goal of providing "reasonable access at a reasonable cost to everyone in the region."
Charles County Government (Unit of local government) Supported by Resilience Authority (Nonprofit Government Instrumentality)	Project	**Zekiah Watershed Roadway Improvements**
	8.	Local street system (Functional Class 4, 7)
	9.	Culvert and swale updates and stormwater redirection are needed to alleviate flooding at multiple locations within the Zekiah Swamp Watershed. These locations include: 1) The intersection of Old Washington Rd and Pembrooke Square 2) the intersection of Post Office Rd and Industrial Park Dr 3) Poplar Hill Rd between St. Peters Church Rd and Mattawoman Beantown Rd.
	10.	For "Project 1: Old Washington Rd and Pembrooke Square," less than one mile of roadway improvements along Old Washington Rd upstream of Pembrooke Sq will be necessary in order to prevent downstream swale overflow at the Pembrooke Sq location. For "Project 2: Post Office Rd and Industrial Park Dr," less than one mile of roadway improvements will be needed to prevent culvert overflow at the intersection of Post Office Rd and Industrial Park Dr.

Appendix D. Priority Resilience Investment Submissions

Submitting Agency	Question	Answers
		For "Project 3: Poplar Hill Rd between St. Peters Church Rd and Mattawoman Beantown Rd," a ¾ mile stretch of poplar road floods as a result of culvert overflow at the low point in the road. Culvert expansion will be necessary at this location, and pipes flowing through this culvert may need to be enlarged.
	11.	Climate hazards impacting these assets include increased incidence of extreme weather events and associated precipitation, runoff, and inland flooding. Resilience measures may include culvert and swale expansion, stormwater reuse for power plant gray water, vegetative drainage aids or other runoff reduction techniques.
	12.	To be determined
	14.	N/A
	15.	None of the above
	17.	No
	18.	Yes
	19.	This project is included in Charles County's Nuisance & Urban Flood Plan, the purpose of which is to identify sources of nuisance and urban flooding, analyze flood hazards, and recommend actions to reduce flooding and increase community resiliency. https://www.charlescountymd.gov/home/showpublisheddocument/6485/637376819241070000
	20.	Yes, identified through other studies, data, or assessments
	21.	In 2020, the Charles County Department of Emergency Services published their Nuisance & Urban Flood Plan in accordance with the 2018 Charles County Hazard Mitigation Plan and state law. As an initial step in the data gathering process, flood event data was obtained from the National Center for Environmental Information. This data was reviewed to aid in the determination of nuisance and urban flood locations. Additional information gathered by the Department of Emergency Services of known flood areas resulted in a listing of roadways and intersections. This listing was used to develop a flood location map. Staff from Department of Emergency Services and Department of Planning and Growth Management along with consultants working on the planning project conducted a tour of identified nuisance and urban flood areas on January 23, 2020.
	22.	This project will reduce the risks associated with extreme weather and precipitation by reducing and redirecting runoff that currently invades roadways. By improving infiltration, redirecting runoff, and collecting stormwater for use as gray

Appendix D. Priority Resilience Investment Submissions

Submitting Agency	Question	Answers
		water, Charles County can protect the resilience of its transportation corridors in the face of extreme weather events.
	23.	This project is still in the planning phase and has the potential to include a range of possible nature-based and innovative interventions to address stormwater runoff. Ensuring that the solution considers climate change will make our transportation system more resilient.
	24.	Yes
	25.	Project 1 at Old Washington Rd is located within an EEA as identified by the TPB. It is also within an area with hazardous median surface temperatures as identified by the TPB. Vegetative infiltration interventions installed in this area could combat both roadway flooding risks and risks associated with urban heat island effects, which disproportionately affect EEA and EJ communities. Project 2 at Post Office Rd is located within an EEA and federally identified EJ community. This tract is 62% Black and in the 90th percentile for share of households making less than 80% of the area median family income and spending more than 30% of income on housing. Improvements to drainage and reduction of runoff in this area would help improve the resilience of a transportation corridor for residents of this disadvantaged community and reduce cost burdens associated with flooded roadways. Project 3 at Poplar Hill is perpendicular to an EEA and federally identified EJ community and improvements to the drainage of Poplar Hill would improve transportation flow into and out of that adjacent EEA.
Charles County Government (Unit of local government) Supported by Resilience Authority of Charles County (Nonprofit/Government Instrumentality)	**Project**	**Cobb Island (MD-254) - Bridge Approach**
	8.	Local street system (Functional Class 4, 7)
	9.	The project location would encompass MD-254 (Cobb Island Road) between MD-257 and the bridge leading to Cobb Island. The Cobb Island Bridge was recently replaced in 2020. Necessary improvements to address tidal flooding and sea level rise issues will need to be determined.
	10.	The route along MD-254 (Cobb Island Road) begins at MD-257 and ends at the Cobb Island Bridge.
	11.	Tidal flooding, storm surge, sea level rise, and extreme weather/ precipitation.
	12.	To be determined.
	14.	None.
	15.	None of the above
	16.	N/A
	17.	No

Appendix D. Priority Resilience Investment Submissions

Submitting Agency	Question	Answers
	18.	Yes
	19.	This project was included in Charles County's 2020 Nuisance & Urban Flood Plan identified as project #21.
	20.	Yes, identified through the Vulnerability Assessment
	21.	N/A
	22.	While the solution or solutions have not been determined yet, the intent of this project will reduce the risks associated with extreme weather, precipitation, sea level rise, and tidal flooding.
	23.	This project is still in the very initial planning phase and has the potential to include a range of possible nature-based and innovative interventions to address tidal flooding and sea level rise, each with their own co-benefits. Ensuring that the solution considers climate change will make our transportation system more resilient.
	24.	Yes
	25.	The Census tract in which this project is located is considered to be an EEA. Improving this section of MD-254 would support equity by ensuring that people living in low-income and/or historically disenfranchised communities are meaningfully included in investments. Rural and low-income communities are too often overlooked for improvement projects.
City of Manassas (Unit of local government)	**Project**	**City of Manassas Flood Hazard Assessment**
	8.	Study or plan
	9.	The purpose of the study is to assess flood hazards within the City of Manassas. The assessment will include evaluation of a portion of the hydraulic conveyance systems (culverts, pipes, channels, streams and stormwater detention facilities) that are experiencing localized flooding. Areas of flooding will be identified, potential remedial measures will be evaluated, and a list of recommendations will be prepared. A Final Project Summary Report will be prepared which will include potential flood mitigation projects along with approximate (order of magnitude) construction cost estimates to help guide the City in prioritizing future projects. Subtasks within the assessment may include the following: a. Review historical data such as the City's drainage complaint lot, CCTV, drainage, GIS data, and site plans. b. Prepare a topographic base map of the flooding areas using the City's GIS topographic data. Surveying portions of the storm drain network and overland relief areas may be necessary.

Appendix D. Priority Resilience Investment Submissions

Submitting Agency	Question	Answers
		c. Computation of peak discharges using NRCS Hydroximic Methods d. Assessment of pipe conditions in areas of flooding. e. Assessment of flooding issues and development of potential flood mitigation projects (develop possible remediation measures to alleviate flooding) f. Preparation of report.
	10.	Citywide street network
	11.	Inland flooding impacting the street network and/or evacuation routes.
	12.	Project timeline: Spring 2024 – Spring 2025. The City has started with a small portion of this work as a pilot study within one watershed already - Cockrell Branch Watershed, which started in December 2023. The Cockrell Branch Watershed is 7.5% of the City, so there will be 92.5% remaining to complete. To complete the remaining portion of the City, we expect it to take about one year to complete.
	14.	Stormwater Utility Funds were used for the pilot Cockrell Branch Watershed portion. No other funds are currently committed.
	15.	None of the above;
	16.	n/a
	17.	No
	18.	Yes
	19.	Manassas 2040 Comprehensive Plan MOB 6.4.4; ESH 8.3; ESH8.4
	20.	Yes, identified through the Vulnerability Assessment
	21.	n/a
	22.	The study aims to identify streets and bridges that are likely to flood to undersized capacity of the storm sewer system. By identifying the areas, the City will be able to remediate these problems which in turns will reduce flooding on City streets to ensure continuity and reduce infrastructure damage. This project will also help identify evacuation routes in the City by selecting streets that are less likely to flood.
	23.	One major strength of this project is that it is taking a holistic look at the City to first identity flooding hazards and then to understand the root cause of the hazards. This will in turn help the City prioritize and fund future repair projects to alleviate the identified flooding hazards.

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Submitting Agency	Question	Answers
	24.	Yes
	25.	This study will provide a citywide assessment, address issues citywide, as well as identify evacuation routes which will serve all communities for the better. In addition, equity criteria will be discussed during the ranking process.
DDOT (Unit of local government) Supported by DOEE (Unit of local government)	**Project**	**Nannie Helen Burroughs (NHB) Avenue DC-295 Underpass**
	8.	Study or plan
	9.	The DDOT requests $1 million in Fiscal Year (FY) 2022 or 2023 PROTECT discretionary program planning grant dollars to fund an Engineering Feasibility Study to identify concepts that improve the flood resilience of transportation infrastructure in and around the NHB Avenue NE underpass beneath DC-295 in the District of Columbia (the District). The roadway provides a critical access route to historically disadvantaged neighborhoods with vulnerable populations between DC-295 and the Anacostia River that can become isolated with little warning during flood events. In addition to flood mitigation concepts, the study will investigate options to create a green gateway that connects the green spaces of Kenilworth Park and the Anacostia waterfront with the nearby NHB Avenue Commercial Corridor; thereby, supporting economic development while addressing flood resilience.
	10.	NHB Avenue NE underpass beneath DC-295 in the District of Columbia
	11.	The NHB Avenue DC-295 Underpass lies in the FEMA 100-year (1 percent) Floodplain but is also vulnerable to more frequent flooding. Due to the urbanized nature of the nearby Watts Branch watershed as well as its geography, flash flooding often occurs, providing residents with very little warning time. When the area in and around the NHB Avenue NE underpass beneath DC-295 floods in this manner, the neighborhoods of Eastland Gardens, Paradise-Parkside, and Mayfair that lie between DC-295 and the Anacostia River are cut off, with residents unable to evacuate easily and emergency first responders unable to enter. The situation will only become worse as climate change increases the frequency and intensity of flood events.
	12.	If awarded, this grant investment will fund an Engineering Feasibility Study and engagement effort that will take approximately 18 months.
	14.	DC has received $581,250 of FEMA Flood Mitigation Assistance funding for the Watts Branch Flood Resilience Strategy, which will be focused on reducing flood risk along Watts Branch, and surrounding corridor area including NHB Ave. COG has also received $1.43 Million of funding from FEMA's Regional Catastrophic Preparedness Grant, where over $1M is allocated toward BGI planning in areas including Watts Branch, which will likely include NHB Ave. Finally, DDOT submitted a $1 million PROTECT grant proposal for an engineering feasibility study specifically focused on flood resilience strategies at the intersection of the NHB Ave underpass at I-295. The District is still waiting to hear back on

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Submitting Agency	Question	Answers
		the status of this proposal.
	15.	None of the above;
	17.	Yes
	18.	No
	19.	would need to check with DDOT
	20.	Yes, identified through the Vulnerability Assessment
	22.	The anticipated engineering concepts will make the roadway underpass and surrounding Project area more resilient to flooding while creating additional green spaces between the Anacostia River and Kenilworth Park and the NHB Avenue Commercial Corridor.
	23.	This project is meant to connect with nature-based solutions being developed in the project vicinity
	24.	Yes
DDOT (State (including DC))	**Project**	**Nannie Helen Burrows underpass Flood Mitigation**
	8.	Local street system (Functional Class 4, 7)
	9.	Nannie Helen Burrows Ave is one of the major arterials connecting the neighborhoods East and West sides of the DC-295 Highway that created a communication barrier between these neighborhoods. Besides serving as one of the major connecting roads, it is also access to and from DC 295 to the same community. The underpass carries CSX railroad tracks over Nannie Helen Burrows Ave. NE West of intersection with Minnesota Ave NE. As this is a low point in the area, the underpass is frequently subjected to flooding from larger storms to a degree of street closures and use of boats for rescue operations. The project is intended to conduct a study of the cause of flooding, design a mitigation measure and implement.
	10.	The Nannie Helen Burrows Ave. underpass carries CSX railroad tracks over Nannie Helen Burrows Ave. NE West of intersection with Minnesota Ave NE.
	11.	Location of Nannie Helen Burrows Ave. underpass is close by Watts Branch which frequently floods upstream communities from the underpass. Due to continued urbanization of Watts branch catchment area and relative reach of the stream in the vicinity of the underpass (close to its confluence with the Anacostia river and flatter slopes), the stream is susceptible to be flowing bank full in less than peak flow conditions. The drainage system from local roadways including parts of Nannie Helen Burrows and Minnesota Avenues empties into this downstream reach of the stream.

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Submitting Agency	Question	Answers
		When localized storms coincide with high flows in the stream (which has now became a more frequent event than not), the drainage will have nowhere to go but floods low-lying areas such as the underpass until the stream level drops to create a positive flow condition at the drainage outfall. Different resilience measures can be thought f once the studies get traction and data are analyzed. However, solutions such as attenuating the peak flows of the localized drainage through implementation of Green Infrastructures and underground reservoirs (City has limited space for open/surface detention) may be considered as an integrated approach to make the underpass flooding conditions more resilient.
	12.	Depending on the availability of funds, the project feasibility study and design is estimated to be completed in a 18 month time frame to be followed by construction period of 12-18 months without taking into consideration time for procurement of services
	14.	Project has no current funding commitment.
	15.	None of the above
	17.	Yes
	18.	No
	20.	Yes, identified through other studies, data, or assessments
	21.	This project is identified based on reported incidences and monitoring records during and after storm events. The district flood task force has also identified this flooding concern and has listed it as one of the priority flood resiliency projects to address.
	22.	The project will be designed to eliminate flooding hazard resulting from the 50 year return period storms (current DDOT Design Standard for sag-undrepass) and will substantially reduce extent of flooding in less probable events.
	23.	In addition to managing flooding conditions through detention systems, the project will implement stormwater management measures to help reduce peak flows, provide water quality improvement and beautify the landscape. Moreover, the project will have considerable meaning in terms of maintaining continuous connection of underserved communities between neighborhoods and access to and from natural and historical resources of the Anacostia river.
	24.	Yes
	25.	Project will have considerable meaning in terms of maintaining continuous connectivity of underserved communities connecting neighborhoods and enable access to and from natural and historical resources of the Anacostia river. Nannie Helen Burrows Ave. is one of the very few roadways that connect neighborhoods separated by the DC-295

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Submitting Agency	Question	Answers
		(Kenilworth Ave).
DDOT (State (including DC))	Project	**Cleveland Park Stormwater and Drainage Improvement.**
	8.	Roadway system (Functional Class 1-3, 5)
	9.	The Cleveland Park Stormwater and drainage improvement project is located in Ward 3 of the District of Columbia Northwest quadrant (in the vicinity of Cleveland Park Metro Station). The project includes drainage conveyance structures, flood mitigation detention reservoirs, roads, and sidewalks. Flood resilience measure include infiltration, detention, and capacity improvements of existing drainage structures to manage a 15-Year return period storm (City drainage system capacity) without affecting the rate and erodibility at the outfall into Rock Creek
	10.	The Project is located in the Northwest quadrant Ward 3 of the District of Columbia. It is defined by the Porter – Ordway Sewershed. It comprises the area bound by Wisconsin Avenue NW to the west; Woodley Road NW to the south; Rock Creek Park to the east; and Tilden Street NW and Quebec Street NW to the north.
	11.	The Cleveland Park metro station community has experienced recurring flooding events in recent years, many of which have inundated the escalators of the Metro Station and formed ankle-deep ponding at street crossings and sidewalks. These conditions pose a safety hazard to pedestrians, cyclists, and motorists who frequent and/or pass through the area. Once completed the project will mitigate the flooding issues through combinations of existing drainage structures improvements, installation of large underground detention pipes, and green infrastructure practices. The extended detention systems will capture significant stormwater volumes and slowly release the detained volumes at minimal flow rates.
	12.	o Currently the project is under design. o Expected design completion date July 2024 o Expected construction start date February 2025 o Expected construction completion date January 2027
	14.	The District of Columbia ahs allocated 20 million Dollars toward construction
	15.	TIP
	16.	T6193
	17.	No
	18.	No
	20.	Yes, identified through other studies, data, or assessments

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Submitting Agency	Question	Answers
	21.	There have been multiple incidents where the Cleveland metro station was flooded, the recent occurrence been in June 2016. The hydrologic and hydraulic (H&H) analysis during the study phase of the project shows that the 15-Year peak discharge for the Porter-Ordway sewershed is 950 cfs. However, the existing drainage structure only has the capacity of 350 cfs. The excess flow that was not carried by the existing drainage structures creates ponding on the streets and ultimately flooding the metro entrance. The existing drainage conveyance structures are undersized and require an overhaul.
	22.	There are several records of flooding on Connecticut Ave including June 2016 Metro station flooding. H&H modeling done for the area in two consecutive projects (Cleaveland Phase I and II) also demonstrate occurrence of substantial flooding at this location.
	23.	Once completed the project will safely manage and convey the current 15-Year storm volume and create resilience toward the flooding issues through combinations of existing drainage structures improvements, installation of large underground detention pipes, and green infrastructure practices, etc. The improved system will capture significant stormwater volumes and slowly release the detained volumes at minimal flow rates, at a timing that occurs after the overall peak of the main flow. Mitigating the flooding at the Cleveland metro station and adjacent streets directly translates to the improved safety of pedestrians and motorists and increase on the life span of the roadway and rail system. The existing drainage conveyance capacity for the Porter-Ordway is only 350 cfs. However, the H&H analysis study finding shows the peak discharge for the 15-year storm is 950 cfs. The project proposes to address the flooding issue without increasing the peak flow and velocity at Rock Creek outfall thus eliminating any disruption to the existing peak flow on the stream. To achieve the flood mitigation without increasing the peak flow at Rock Creek outfall, the project utilizes green infrastructure and underground detention system to capture significant stormwater volumes and slowly release the detained volumes at minimal flow rates, at a timing that occurs after the overall peak of the main flow.
	24.	No
DDOT (State (including DC))	**Project**	**Soapstone Culvert Reconstruction**
	8.	Roadway system (Functional Class 1-3, 5)
	9.	Soapstone stream is the last tributary of Broad Branch in northwest of the District of Columbia before Broad Branch joins Rock Cree. Soapstone stream, before joining Broad Branch, passes under Broad branch rd. in a single barrel stone masonry semicircular arch culvert. Intent of this project is to stabilize the stream upstream and downstream stream banks and replace the soap stone culvert in consistence with the EA prepared for the Broad branch rd. improvement.

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Submitting Agency	Question	Answers
	10.	Soapstone stream is the last tributary of Broad Branch in northwest of the District of Columbia before Broad Branch joins Rock Cree. Soapstone stream, before joining Broad Branch, passes under Broad branch rd. in a single barrel stone masonry semicircular arch culvert. Project limits extend about 250 ft upstream of Culvert and to about 100 ft downstream including the culvert.
	11.	Overtopping of the culvert structure has become more frequent with increased storm intensity as affected by the climate change the world is experiencing. Since the culvert structure was built a very long time ago, it is very much undersized to accommodate the current rate of flows causing road closures during storms and has started compromising the integrity of the head walls and streambed downstream. A new culvert with appropriate hydraulic sizing will have to replace the current one to make the structure and the roadway more resilient to flooding and subsequent damage.
	12.	Depending on the availability of budget, the project design work can be completed in a 12 month time frame to be followed by construction period of 6 -10 months without taking into consideration time for procurement of services.
	14.	There are no current funding commitments made.
	15.	None of the above
	17.	No
	18.	No
	20.	Yes, identified through other studies, data, or assessments
	21.	The culvert is included in DDOT's culvert inventory and has inventory reports as recent as 2020. It is also included in the Broad branch road Environmental Assessment that has looked at all environmental impacts and necessary coordination.
	22.	Overtopping of the culvert structure has become more frequent with increased storm intensity as affected by the climate change the world is experiencing. Since the culvert structure was built a very long time ago, it is very much undersized to accommodate the current rate of flows causing road closures during storms and has started compromising the integrity of the head walls and streambed downstream. A new culvert with appropriate hydraulic sizing will have to replace the current one to make the structure and the roadway more resilient to flooding and subsequent damage.
	23.	The project will take into consideration localized stream restoration measures including accommodating possible fish passage for continuity along the stream.

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Submitting Agency	Question	Answers
	24.	No
DDOT (State (including DC)) Supported by DOEE (State (including DC))	**Project**	**SW & Buzzard Point BGI Network**
	8.	Local street system (Functional Class 4, 7)
	9.	The right of way segments listed below complete the BGI Network planned in the Southwest & Buzzard Point Flood Resilience Strategy that is planned to protect Southwest and Buzzard Points from interior flooding. Each ROW segment is planned to convey away flood waters to detention parks. The parks detention projects are currently funded through a mix of local and FEMA BRIC funding. The District is seeking now funding for the BGI retrofits to the area's ROWs with BGI to complete the first community-wide interior flood resilience system.
	10.	- 2nd St SW from the Anacostia River to P St SW - 1st ST SW from the Anacostia to T St SW - Canal St. from P to N St SW - Delaware Avenue from Canal to G St - M St SW from Maine Avenue to South Capitol Street - I Street SW from 5th St to Delaware - G Street SW from 5th St to Delaware
	11.	The main climate hazard that this project will mitigate is flooding from extreme rain events. The ROW projects listed will finalize the local BGI Network which will create a network of communicating green infrastructure projects that can convey and detain excess stormwater in parks and on right of way so that it does not impact local residential areas, especially the 1,000 public housing units around the project, the Southwest Police Station and the Southwest Fire and EMS station.
	12.	From funding to implementation the project will take about 5 to 6 years including project design and engineering and construction
	14.	Currently the District invested $500k in the plan + $4 million dollars in match funding for the $18 million FEMA BRIC funding for the BGI upgrade for the detention/floodable parks projects
	15.	None of the above;
	17.	No
	18.	Yes
	19.	SW was identified as a priority planning area for flood resilience work in:

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Submitting Agency	Question	Answers
		- Southwest Neighborhood Plan (DC OP) - Climate Ready DC Plan (DOEE) - Resilient DC (DOEE) - DC Comprehensive Plan (DC OP) - Southwest & Buzzard Point Flood Resilience Strategy (DOEE)
	20.	Yes, identified through other studies, data, or assessments
	22.	When completed the project will handle the 80 year rain storm in 2100 keeping residents and carways free of rainwater flooding and ponding. The network will also alleviate minor storm surge events and help cool the community in the summer months.
	23.	The BGI Network will be the first such comprehensive, community-wide project in DC and probably one of the first in the country. The project redesigns rows and parks utilizing nature-based solutions for conveying and detaining excess rainwater while creating new trails, new park amenities and cooling the community
	24.	Yes
DOEE (Unit of local government) Supported by DDOT (Unit of local government)	**Project**	**Watts Branch Flood Resilience Strategy Implementation**
	8.	Roadway system (Functional Class 1-3, 5)
	9.	NHB Ave is a minor arterial corridor that runs through DC's Ward 7, alongside Watts Branch, a tributary of the Anacostia River. NHB Ave is also largely located in the FEMA 100-year floodplain, and frequently floods during storm events, impacting mobility for local residents. DOEE is currently working on a Watts Branch Flood Resilience Strategy (FRS), that will identify and create preliminary designs for flood mitigation and resilience along the Watts Branch watershed. DOEE anticipates that NHB Ave will serve as a key site for reducing flood risk in this project. Upon completion of the Watts Branch FRS, DOEE plans to partner with DDOT to submit a PROTECT grant application for nature-based and gray infrastructure solutions along NHB Ave to reduce flooding along this corridor.
	10.	The project will be located on NHB Ave, between the I-295 underpass, and Division Ave. The total specifics will be determined in the Watts Branch FRS, due to be completed by April 2025.
	11.	NHB Ave is currently susceptible to riverine and interior/urban flood risk, which is only expected to increase with climate change. The PROTECT grant will seek to implement blue, green, and gray infrastructure along the corridor, to reduce flooding and improve mobility for residents during storms.
	12.	This project is proposed to start in Spring 2026, and estimated for completion by Spring 2028.

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	14.	DC has received $581,250 of FEMA Flood Mitigation Assistance funding for the Watts Branch FRS, which will be focused on reducing flood risk along Watts Branch, and surrounding corridor area including NHB Ave. MWCOG has also received $1.43 Million of funding from FEMA's Regional Catastrophic Preparedness Grant, where over $1M is allocated toward BGI planning in areas including Watts Branch, which will likely include NHB Ave. Finally, DDOT submitted a $1 million PROTECT grant proposal for an engineering feasibility study specifically focused on flood resilience strategies at the intersection of the NHB Ave underpass at I-295. The District is still waiting to hear back on the status of this proposal.
	15.	None of the above;
	17.	No
	18.	Yes
	19.	This project is expected to be included in the Watts Branch FRS, which DOEE will be carrying out in 2024.
	20.	Yes, identified through the Vulnerability Assessment
	22.	This project will construct blue-green and gray infrastructure solutions such as bioswales, raingardens, underground storage cells, and new stormwater pipes to move water underground where surface measures are not appropriate. Under existing conditions, extreme rain events create flooded roadways, which can damage property and disrupt the transportation system. By creating a controlled system of conveying water, this project's solutions will mitigate flood risk.
	23.	This project will incorporate nature-based solutions to provide flood mitigation and resilience, while also providing co-benefits to the surrounding community.
	24.	Yes
	25.	The area around Watts Branch is a high priority area for equity concerns, and has been identified not only in MWCOG's EEA, but also in the District's Resilience Focus Area Strategy. There is a disproportionate amount of low-income and single family homeowners living in the floodplain surrounding Watts Branch, and as a result, the District has prioritized this area for implementing flood resilience strategies.
Prince William County Department of Transportation (Unit of local government)	**Project**	**Residency Road Flooding Mitigation**
	8.	Roadway system (Functional Class 1-3, 5)
	9.	The project will design and construct a bridge over the railroad tracks connecting Residency Road to the Broad Run VRE Station. Residency Road has a history of flooding and with the planned and funded expansion of the Broad Run VRE

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		Station, improving the resiliency of roadway access is critical. In addition to the VRE station, creating a grade separated connection over the tracks via Residency Road provides additional access to the Manassas Regional Airport. The airport is also planned for expansion and all three current access points to the airport have moderate inland flooding risk. The Broad Run Station Expansion is being designed to accommodate a future bridge connection.
	10.	The project is located on Residency Road (VA Route 782). The project extends from the current dead end of Residency Road across the train tracks to the Broad Run Station parking lot. The total distance is approximately 0.1 miles.
	11.	Residency Road the railroad tracks in the project area were assigned a medium risk of inland flooding in the TPB Vulnerability Assessment. The area has a documented history of flooding and future expansions at the Broad Run Station and Manassas Regional Airport necessitate a long-term solution to improving resiliency of the roadway and ensuring continued access. The project will grade separate the roadway over the railroad tracks to mitigate roadway flooding. Additionally, storm water improvements will be made to mitigate flooding on the rail route.
	12.	This project is not funded at this time and timeline will be dependent on funding schedule. The Broad Run Station Expansion project is anticipated to be complete in 2027 and the target date for completion of the bridge is 2030.
	14.	There is no committed funding for this project. This project is being submitted for grant consideration.
	15.	None of the above;
	17.	No
	18.	Yes
	19.	VRE Broad Run Station Expansion project planning study.
	20.	Yes, identified through other studies, data, or assessments
	21.	Project is identified as a medium priority in the Vulnerability Assessment and a high priority through the VRE Broad Run Station Expansion project planning process.
	22.	Project will mitigate roadway and rail route flooding to ensure reliability of Residency Road, the Broad Run Rail Station and the Regional Airport.
	23.	Project is a collaborative effort between Prince William County and VRE that supports expansion of transit at Broad Run Station and Regional Airport.
	24.	No
	25.	Project supports expansion of public transit.

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Prince William County Department of Transportation (MPO) supported by VDOT (State (including DC))	Project	**PWC Evacuation Operationalization Plan**
	8.	Study or plan
	9.	The PWC Evacuation Operationalization Plan is a countywide evacuation plan. This plan would quantify several catastrophic emergencies and its impact to Prince William County and it's independent jurisdictions that are currently not addressed in several National Capital Region evacuation plans and the Quantico Marine Corps Base.
	10.	The Plan is a countywide evacuation plan to include independent jurisdictions located within the county.
	11.	The Plan would look at evacuation causing hazards that may call for localized, neighborhood-level, town-level, or large-scale evacuations (i.e. hurricanes, flash flooding, flooding, and other natural disaster events). This planning document will improve regional transportation resilience, enhance disaster response and recovery, support local communities, and promote environmental sustainability.
	12.	It is estimated to take approximately 16-20 months to develop the PWC Evacuation Operationalization Plan. This timeframe includes agreement execution, procurement process, and planning activities.
	14.	Prince William County has submitted this planning document as part of the FY22-23 PROTECT program requesting $600,000 to develop the plan; however, no other funding commitments for this planning document has been made.
	15.	None of the above;
	17.	Yes
	18.	Yes
	19.	When this planning document is completed, it would be referenced in several other regional/state/federal planning documents as it relates to evacuation plans by organizations such as VDOT, Virginia Department of Emergency Management, Virginia State Police, FEMA, Quantico Marine Corps Base, District of Columbia, and more.
	20.	Yes, identified through the Vulnerability Assessment
	21.	The 2022 Northern Virginia Hazard Mitigation Plan is a document that brings together hazard risk and disaster resilience efforts and other related activities that will help inform the PWC Evacuation Operationalization Plan. The 2022 NOVA Hazard Mitigation Plan also references MWCOG's Cooperative Forecasts. https://www.pwcva.gov/assets/2023-2/NOVA%20Hazard%20Mitigation%20Base%20Plan%20FINAL-%20Natural%20Hazards%20Only%20w%20Annexes.pdf

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	22.	By developing this plan, the document will minimize disruptions and impacts on transportation infrastructure during emergencies. The document will also enhance disaster response and recovery efforts by providing real-time data visualization tools to responding agencies to understand and respond promptly to the impacts of various events causing evacuations or major detours into the region.
	23.	This planning document will incorporate innovative solutions to utilize real-time data visualization tools, geospatial solutions, and data-driven operational evacuation plans to enhance the efficiency and effectiveness of evacuations.
	24.	Yes
	25.	This planning document supports the safety and well-being of all individuals within and around Prince William County. This planning document will address vulnerable populations and provide a more inclusive and effective response during crises.
Prince William County Department of Transportation (Unit of local government)	**Project**	**Incorporating Green Infrastructure into a Multimodal Transportation Corridor**
	8.	Roadway system (Functional Class 1-3, 5)
	9.	In this application we propose the use of green infrastructure on Route 1 (Richmond Highway / US-1), a busy thoroughfare in a vulnerable area identified in the Prince William County Vulnerability Assessment and EEAs, and the Community Energy and Sustainability Master Plan. We will perform an evaluation of alternatives according to multiple metrics and their relative importance for factors such as general feasibility on typical CIP transportation project, space lost for other right of way amenities, appropriateness for site context, life cycle cost, alignment with Prince William County plans, initiatives, and community acceptance. Subsequently, we will develop a project for preliminary engineering and design on the implementation of green infrastructure along Route 1 corridor. In 2013 and 2014, the Virginia Department of Rail and Public Transportation (DRPT) conducted a Multimodal Alternatives Analysis on Route 1, following an earlier 2011 study, directed by the Virginia General Assembly, which instructed DRPT to review and evaluate all previous studies and determine feasibility of transit improvements on Route 1 corridor. The DRPT Multimodal Alternatives Analysis study was conducted in coordination with Fairfax County, Prince William County, the VDOT, and the Office of Intermodal Planning and Investment, recommending a multimodal transportation corridor featuring a Bus Rapid Transit system. Route 1 is classified as an urban principal arterial characterized for heavy traffic* in both directions in a predominant Residential Neighborhood (RN 2-3-4-5) and Mixed Use (MU 3-4-5-6) adjacent land use with small portions of different land use types such as Industrial (I-3), Public Land (PL), Office Mixed Use (OMU-2), and Parks and Open Space in a context with poor landscaping, lack of vegetation/greenery, right of way discontinuity for shoulders/sidewalks in several

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		stretches along the route on both sides. Land cover, roadway design, and other useful project information will be used in this proposal for a 20%-30% preliminary engineering design. The green infrastructure concept developed will use potential design criteria formulated from examples from other jurisdictions in a list of prioritized green infrastructure types, available vulnerability and equity data, and other potential design criteria to be explored. The design, concept-level costs, concept-level design calculations, narrative of benefits and drawbacks relative to the CIP baseline will be summarized. The deliverables for this study will be the Evaluation Criteria Matrix, the Preliminary Report on the evaluated and prioritized alternatives, and the Multimodal Corridor Green Infrastructure preliminary design with respective Evaluation Memorandum. *AADT (2017) 38,000 from Featherstone Rd. to Marys Way. AADT (2040) 57,000 on the same segment. AADT (2017) 28,000 from Bradys Hill Rd. to Dumfries Rd. AADT (2042) 69,000 on the same segment.
	10.	Approximately 12 miles along Route 1 (Richmond Highway / US-1) within Prince William County from West Russel Road (Southbound near the limit with Stafford County) to Annapolis Way (Northbound near Occoquan River Bridge and the limit with Fairfax County). Bridge Asset Number 6228 Northbound / 6229 Southbound.
	11.	Route 1 (Richmond Highway / US-1) crisscrosses Prince William County from southwest to northeast in the southernmost part of the county, in a proximity to important water bodies and environmental protected areas such as the Potomac River, Occoquan River, several creeks and tributaries, the Occoquan Bay National Wildlife Refuge, the Locust Shade Park, and the Neabsco Regional Park. According to the Interactive Floodplain Map from Prince William County Flood Safety Information, Route 1 is located in a flood prone area with historic flooding, road closures and swift water data report. Although this data is for reference purposes only it shows the opportunity and necessity for green infrastructure implementation. Incorporating green infrastructure into a multimodal transportation corridor design is a way to improve water quality, detain stormwater flows, reduce the volume of stormwater runoff, and relieve burden on the county water treatment systems while improving landscape quality reducing the negative effects of motor vehicle use, improve driver behavior and overall conditions for non-motorized street users. The proposed project incorporates green infrastructure solutions to further increase the resilience of the transportation system minimizing disruptions and potential negative impacts of project implementation, including nature-based solutions which can provide a wide range of co-benefits and increase the service life of transportation infrastructure. Green infrastructure helps to improve the natural ecosystem reducing harmful pollutants where vehicles leave oil and other contaminants on the road surface, preventing large amounts of pollution from entering the watershed.
	12.	The anticipated year of completion of the planning and preliminary engineering is 2028. This schedule is dependent on

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		funding availability in 2025.
	14.	There are no funds currently allocated to the project. The County will be seeking grant funds to implement.
	15.	None of the above
	17.	No
	18.	Yes
	19.	Project identified through a FY 2024 Transportation-Land Use Connections planning study.
	20.	Yes, identified through the Vulnerability Assessment
	21.	This project addresses risks identified in a vulnerability assessment conducted as part of the Prince William County Community Energy and Sustainability Master Plan. This assessment used climate scenarios to predict 2050 and 2075 conditions and identify risks to County assets based on exposure, sensitivity and adaptive capacity.
	22.	This project will address risks associated with inland flooding using infrastructure and landscaping to manage stormwater.
	23.	The project will use both nature-based solutions, such as additional landscaping in the right of way and bioswales, as well as infrastructure designed to mimic natural water filtration.
	24.	Yes
Prince William County Department of Transportation (Unit of local government)	**Project**	**Fuller Road Flooding Mitigation**
	8.	Roadway system (Functional Class 1-3, 5)
	9.	Fuller Road provides access to the Quantico Marine Corps Base via the Fuller Gate, and offers the only direct access to the main operating area of the base. Fuller Road is vulnerable to inland flooding and flooding at the gate has significant implications on operational readiness. The project consists of two main components to address flooding: increasing capacity of the existing storm water facility located near the National Museum of the Marine Corps and watershed restoration of Little Creek. This will increase flood capacity and mitigate flooding of the roadway.
	10.	The project is located along Fuller Road (VA Route 619) from the I-95 exit ramp to Mason Drive. The total distance is 0.6 miles.
	11.	A Military Installation Resilience Review conducted by the Northern Virginia Regional Commission identified Fuller Road as vulnerable to inland flooding and identified the storm water expansion and Little Creek stream restoration as measures to improve the resiliency of the roadway.

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	12.	The project has an estimated timeline of three years to design, secure permits and construct. This project is not funded and will be submitted for grant funding consideration. It has an estimated completion year of 2028.
	14.	There is no committed funding for this project.
	15.	None of the above
	17.	No
	18.	Yes
	19.	Northern Virginia Regional Commission Military Installation Resilience Review Study.
	20.	Yes, identified through the Vulnerability Assessment
	22.	Project will increase flood and storm water capacity to reduce risk of roadway flooding. This will improve reliability of transportation on the roadway and operations of the Marine Corps Base.
	23.	Project was identified through a cooperative study that included Prince William County, the Marine Corps and the Northern Virginia Regional Commission and will be implemented through a partnership project.
	24.	Yes
	25.	Project serves two EEAs and a public transit route.
Prince William County Department of Transportation (Unit of local government)	**Project**	**Manage Stormwater Flooding Outside of the Floodplain**
	8.	Study or plan
	9.	This study will increase the County's understanding of flooding outside of the delineated FEMA floodplain through modeling and/or historic flood records and identify mitigation actions to reduce stormwater flooding. The study will be Countywide and the intended outcome is to develop mitigation actions to be implemented for stormwater flooding.
	10.	The study will cover all roadways in Prince William County that have been adopted in the State maintained roadway system that are not in delineated FEMA floodplains.
	11.	The study is intended to better understand and predict inland flooding. Based on the modeling and/or historical data review, the study will identify appropriate resilience measures for implementation.
	12.	The study has a proposed timeline of one year and estimated completion of 2026.
	14.	There is dedicated funding in the County budget for implementation of action strategies identified in the Prince William Community Energy and Sustainability Master Plan.

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	15.	None of the above;
	17.	No
	18.	Yes
	19.	Prince William County Community Energy and Sustainability Master Plan.
	20.	Yes, identified through other studies, data, or assessments
	21.	The Prince William County Community Energy and Sustainability Master Plan conducted a vulnerability assessment that evaluated future climate hazards from extreme temperatures, sea level rise and precipitation and rated the vulnerability of County assets based on exposure, sensitivity and adaptive capacity.
	22.	The project will provide a better understanding of the risks of inland flooding to allow for the development and implementation of effective mitigation measures.
	24.	Yes
Prince William County Department of Transportation (Unit of local government)	**Project**	**Implement Shoreline Protection and** Nature-Based Solutions
	8.	Study or plan
	9.	The project will develop guidance for Prince William County to prioritize nature-based solutions for shoreline protection of costal areas in the County. It will cover all coastal areas of the County, including the shoreline with the Potomac and Occoquan Rivers in the eastern side of Prince William.
	10.	Project is a planning effort to develop guidance that will apply Countywide.
	11.	Project addresses shoreline erosion caused by rising sea levels. The resilience measures will be nature-based solutions identified through the planning process.
	12.	Proposed timeline for the study is one year and anticipated completion date is 2026.
	14.	There is dedicated funding in the County budget to advance strategies identified in the Community Energy and Sustainability Master Plan.
	15.	None of the above
	17.	No
	18.	Yes
	19.	Prince William Community Energy and Sustainability Master Plan.

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	20.	Yes, identified through the Vulnerability Assessment
	21.	The TPB Transportation Resiliency Study identified several costal areas in Prince William County with a high sea level rise hazard. The proposed project was also identified as a high priority risk through the County's Community Energy and Sustainability Master Plan.
	22.	There are numerous major transportation corridors located along costal areas of the County that are at risk due to sea level rise. The project will mitigate shoreline erosion to improve the resiliency of the transportation network to flooding.
	23.	The project will develop guidance to prioritize the use of nature-based solutions.
	24.	Yes
Prince William County Department of Transportation (Unit of local government)	**Project**	**Restore Streams to Reduce Flooding**
	8.	Roadway system (Functional Class 1-3, 5)
	9.	Project will develop and implement stream restoration projects in support of reduced flooding outcomes for roadways in the County.
	10.	The restoration project will focus on roadways in Prince William identified as high risk in the existing vulnerability assessments conducted by TPB and the County.
	11.	The climate hazard impacting the asset is flooding and the resilience measure is stream restoration.
	12.	The number of total stream restoration projects will be based on available funding. Each project will have a two year timeframe and an estimated completion year of 2030.
	14.	There is dedicated funding for strategies identified in the Community Energy and Sustainability Master Plan.
	15.	None of the above
	17.	No
	18.	Yes
	19.	Prince William County Community Energy and Sustainability Master Plan.
	20.	Yes, identified through the Vulnerability Assessment
	21.	There are multiple roadways in the County identified as high risk in the TPB Transportation Resilience Study. Additionally, the Prince William County Community Energy and Sustainability Master Plan conducted a vulnerability assessment that evaluated future climate hazards from extreme temperatures, sea level rise and precipitation and

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		rated the vulnerability of County assets based on exposure, sensitivity and adaptive capacity. This project was a high priority strategy identified in the plan.
	22.	The project will increase streams ability to manage storm water and mitigate flooding on the roadway to improve the reliability of the transportation system.
	24.	Yes
Prince William County Government Department of Transportation (Unit of local government) Supported by VDOT (State (including DC))	**Project**	**Flooded Roadway Mitigation Study**
	8.	Study or plan
	9.	The Flooded Roadway Mitigation Study will assess flooding vulnerabilities at three specific locations and what transportation alternatives can be accomplished to mitigate flooding. The specific locations are Valley View Drive crossing over Kettle Run Stream, Old Church Road crossing over Slate Run Stream, and Fleetwood Drive crossing over Cedar Run Stream.
	10.	Valley View Drive (VA Route 611 sequences 50/60), structure Number (8): 000000000014300 Old Church Road (VA Route 649), structure Number (8): 000000000024232 Fleetwood Drive (VA Route 611 sequence 20), structure Number (8): 000000000014301
	11.	These locations are prone to flooding and flash flooding causing vehicular damage. The Study will determine what resilience measures can be deployed to reduce the risk of life and vehicular damage.
	12.	The studies proposed timeline collectively is approximately 25-27 months to include agreement executions, procurement processes, and study activities.
	14.	There are no funding commitments on this project, though it was submitted to the latest funding request for the PROTECT grant.
	15.	None of the above;
	17.	Yes
	18.	Yes
	19.	Flooding and flash flooding of these roadways have been identified in the Northern Virginia Hazard Mitigation Plan.
	20.	Yes, identified through the Vulnerability Assessment
	22.	The Mitigation Study will determine which resiliency measures can be utilized to reduce flooding on the roadway and ensure safe operation.

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	23.	The study will identify resilient improvements to the impacted streams and surface transportation assets to reduce the magnitude and duration of impacts of current and future weather events and natural disasters.
	24.	No
	25.	All public engagement and collaboration is guided by Resolution 20-494 approved by the Prince William Board of County Supervisors on June 16, 2020. This resolution requires projects "include an equity lens in all planning and service delivery" to identify social and racial disparities and guide decisions to mitigate adverse impacts and encourage positive impacts. If awarded, the planning study will include analysis of impacts to EEAs, which are census tracts identified by the federally designated MPO that have high concentrations of low-income and/or minority populations, to ensure equitable outcomes and the inclusion of traditionally disadvantaged communities.
Virginia Passenger Rail Authority (Special purpose district or public authority with a transportation function)	**Project**	**Flooding Mitigation Study for Quantico and Pohick Creek Rail Bridges**
	8.	Study or plan
	9.	Project location: Quantico, Prince William County and Fairfax County; Intercity (Amtrak) and Commuter (VRE) rail routes on the RF&P corridor Project activities: Identify Existing Conditions Identify Expected Adverse Conditions Recommend Specific Adverse Condition Mitigation Strategies Translate Mitigation Strategies to Specific Capital Improvements for future TRIP and PROTECT rounds
	10.	RF&P Rail Corridor, owned by CSX/Virginia Passenger Rail Authority. Quantico Creek Rail Bridge and Pohick Creek Rail Bridge 38.526743, -77.288966 and 38.712765, -77.217392
	11.	This study will assess two rail bridges within the 100-year flood plain and propose potential mitigation or resilience measures to ensure the rail infrastructure will with stand future flooding or storm inundation.
	12.	This study will take approximately 18 months to complete. If starting in 2024, estimated completion could be as soon as fall 2025 or winter/spring 2026.
	14.	No budget commitments have been identified at this time.
	15.	None of the above
	17.	No

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	18.	No
	20.	Yes, identified through the Vulnerability Assessment
	22.	The project will assess the need for capital improvements or mitigation to limit or prevent damage to existing rail bridges. Should flooding be significant or damage occur to these bridges, passenger and fight rail traffic within the entire region could be halted to make emergency repairs.
	24.	Yes
Virginia Passenger Rail Authority (Special purpose district or public authority with a transportation function)	**Project**	**RF&P Track Infrastructure Heat Impacts and Mitigation Study**
	8.	Study or plan
	9.	The Richmond, Fredericksburg and Potomac railroad line from Quantico, Prince William County, VA to Control Point VA in Washington, DC; Intercity (Amtrak) and Commuter (VRE) rail routes on the corridor. Project activities: Identify existing conditions Identify adverse conditions using past data on heat/slow orders Recommend specific mitigation strategies Translate mitigation strategies to specific capital or operational improvements for future TRIP and PROTECT rounds
	10.	The Richmond, Fredericksburg and Potomac railroad line from Quantico, Prince William County, VA to Control Point VA in Washington, DC; Intercity (Amtrak) and Commuter (VRE) rail routes on the corridor.
	11.	When the region has high temperatures, host railroads (CSX and Norfolk Southern) issue slow orders as a safety precaution to limit/prevent derailments. As temperatures continue to rise and temperatures remain elevated for longer periods of time, railroads will issue more heat orders, slowing rail traffic in the region and lowering on time performance. This study will look at the ways to ensure safety while limiting heat orders. recommendations could be in the form of capitol or operational improvements.
	12.	This study will take approximately 18 months to complete. If starting in 2024, estimated completion could be as soon as fall 2025 or winter/spring 2026.
	14.	No budget commitments have been identified at this time.
	15.	None of the above
	17.	No

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	18.	No
	20.	Yes, identified through the Vulnerability Assessment
	21.	Portions of the corridor are identified by the Vulnerability Assessment. However, heat orders are not limited to specific areas, they are corridor wide and come from the host/operating railroad. Virginia Passenger Rail Authority has historic data on slow orders and on time performance data for Amtrak trains. Virginia Passenger Rail Authority can also obtain on time performance data from VRE as well.
	22.	The project will assess the need for capital or operational improvements to limit slow orders during heat events. By reducing the number of heat orders, train on time performance will improve, leading to customer satisfaction improvements.
	24.	Yes
VRE (Special purpose district or public authority with a transportation function)	**Project**	**VRE Stations Heat Vulnerability and Mitigation Strategies Analysis**
	8.	Study or plan
	9.	Five VRE station facilities in their entirety will be studied, including: L'Enfant, Manassas, Lorton, Rippon, and Quantico for their level of vulnerability to future adverse heat events. This study will detail potential effects to both passengers and the facilities themselves of adverse future heat events, and will propose, at a planning level, conceptual projects that could mitigate or eliminate the adverse condition(s) through the horizon planning year. These studies will not include an analysis of track infrastructure at the station locations.
	10.	This study would focus on station assets located on VRE's Manassas and Fredericksburg Lines, as well as the joint line between Alexandria and Union Station.
	11.	Heat. The project would be a study that would recommend appropriate resilience measures for each asset location that could be translated into capital projects for future TRIP project submission rounds.
	12.	By end of calendar year 2024
	14.	None
	15.	None of the above
	17.	No
	18.	No
	20.	Yes, identified through the Vulnerability Assessment

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	22.	This project will identify the appropriate mitigation strategies to address the adverse effects of heat on certain VRE passenger facilities identified as higher risk in the TPB Vulnerability Assessment. Starting the project pipeline will allow VRE to submit a more developed project for full design and construction in future rounds of TRIP project solicitations.
	24.	Yes
VRE (Special purpose district or public authority with a transportation function)	**Project**	**VRE Manassas Line Track Heat Vulnerability and Mitigation Strategies Analysis**
	8.	Study or plan
	9.	This effort will include the Norfolk Southern railroad corridor between the "AF Interlocking" in Alexandria, VA and the Broad Run VRE station in Manassas, VA. This study will detail potential effects on the railroad track infrastructure from adverse future heat events, and will propose, at a planning level, conceptual projects that could mitigate or eliminate the adverse condition(s) through the horizon planning year. This study will also review the projected effects to VRE service as a result of adverse heat effects on the rail infrastructure.
	10.	This study would focus on the entirety of the track infrastructure on VRE's Manassas Line between the Broad Run station and "AF Interlocking".
	11.	Heat. The project would be a study that would recommend appropriate resilience measures for track and related assets that could be translated into capital projects for future TRIP project submission rounds.
	12.	By end of calendar year 2024
	14.	None
	15.	None of the above
	17.	No
	18.	No
	20.	Yes, identified through the Vulnerability Assessment
	22.	This project will identify the appropriate mitigation strategies to address the adverse effects of heat on track and ancillary facilities identified as higher risk in the TPB Vulnerability Assessment. The study scope will not include passenger station or yard facilities. Starting the project pipeline will allow VRE to submit a more developed project for full design and construction in future rounds of TRIP project solicitations.
	24.	Yes

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VRE (Special purpose district or public authority with a transportation function)	Project	**VRE Maintenance and Storage Facilities Heat Vulnerability and Mitigation Strategies Analysis**
	8.	Study or plan
	9.	This effort will include VRE's Broad Run and Crossroads Maintenance and Storage Facilities, supporting the Manassas and Fredericksburg Lines, respectively. This study will detail potential effects on the yard infrastructure from adverse future heat events, and will propose, at a planning level, conceptual projects that could mitigate or eliminate the adverse condition(s) through the horizon planning year. This study will also review the projected effects to VRE service and yard personnel as a result of adverse heat effects on the rail infrastructure at yards.
	10.	This study would focus on VRE-controlled property at the Broad Run and Crossroads Maintenance and Storage Facilities.
	11.	Heat. The project would be a study that would recommend appropriate resilience measures for the entire Broad Run and Crossroads Maintenance and Storage Facilities that could be translated into capital projects for future TRIP project submission rounds.
	12.	By end of calendar year 2024
	14.	None
	15.	None of the above
	17.	No
	18.	No
	20.	Yes, identified through the Vulnerability Assessment
	22.	This project will identify the appropriate mitigation strategies to address the adverse effects of heat on track and ancillary yard facilities (including those that support train crews and yard support staff). The study scope will not include passenger station facilities adjacent to these yard facilities. Starting the project pipeline will allow VRE to submit a more developed project for full design and construction in future rounds of TRIP project solicitations.
	24.	No
VRE (Special purpose district or public	Project	**VRE Assets Flooding Vulnerability and Mitigation Strategies Analysis**
	8.	Study or plan

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authority with a transportation function)	9.	This effort will include VRE's Broad Run Maintenance and Storage Facility as well as the L'Enfant and Quantico stations. The study will analyze the proposed effects to this infrastructure from adverse future inland flooding events, and will propose, at a planning level, conceptual projects that could mitigate or eliminate the adverse condition(s) through the horizon planning year.
	10.	This study would focus on the two stations and the entirety of the Broad Run Maintenance and Storage Facility, excluding the passenger station platform, but including the parking facilities at this location that serve a joint use as yard crew employee and passenger parking.
	11.	Inland Flooding. The project would be a study that would recommend appropriate resilience measures for the entire Broad Run Maintenance and Storage Facility as well as the Quantico and L'Enfant stations that could be translated into capital projects for future TRIP project submission rounds.
	12.	By end of calendar year 2024
	14.	None
	15.	None of the above
	17.	No
	18.	No
	20.	Yes, identified through the Vulnerability Assessment
	22.	This project will identify the appropriate mitigation strategies to address the adverse effects of inland flooding on track and ancillary yard facilities (including those that support train crews and yard support staff) at Broad Run, as well as passenger station facilities at identified locations. Starting the project pipeline will allow VRE to submit a more developed project for full design and construction in future rounds of TRIP project solicitations.
	24.	Yes
WMATA (Transit Agency)	**Project**	**Systemwide Flood Resiliency Infrastructure Upgrades Implementation**
	8.	Facility or service for public transportation
	9.	WMATA developed and built the MetroRail system over the last 50 years, beginning with the Red Line, which opened in 1976. Since that time, changes in local development, aging of the system, updates in design guidelines and criteria, and the effects of climate change have led to vulnerabilities in the system due to flooding. Parts of the MetroRail system are now in the 100-year floodplain. Extreme weather events may impact passenger service and system

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Submitting Agency	Question	Answers
		operations and require corrective measures. Investments include new grading at station entrances, installation of temporary flood barriers, raising vent shaft openings to above street level, and improving drainage capacity around stations. This work can be broken out into component parts, focusing on one asset at a time.
	10.	Cleveland Park, Federal Triangle, Smithsonian, Archives/Navy Memorial, Rhode Island Ave/Brentwood, Capitol South, and Waterfront Stations (District of Columbia); Greenbelt Rail Yard (Greenbelt, MD)
	11.	Flooding--investments would minimize passenger and asset impacts from flooding. These include new grading at station entrances, installation of temporary flood barriers, raising vent shaft openings to above street level, and improving drainage capacity around stations.
	12.	This project will be completed in a five-year time period beginning in FY2026. Assumed completion date would by FY2032.
	14.	This project is currently unfunded but is considered part of WMATA's six-year Capital Plan
	15.	None of the above
	17.	No
	18.	Yes
	19.	FY2025 Capital Plan
	20.	Yes, identified through the Vulnerability Assessment
	21.	Many of these sites are in the 100 year flood zone and we have supporting documentation on the risk associated with these sites. An internal memo risk assessment was completed in 2016 and solutions were identified in 2020.
	22.	As exposure to higher frequency, more intense storms has the potential to impact the listed assets more frequently. All listed stations are known to be either in the 100 year flood zone or regularly are impacted by interior flooding due to the increase of impermeable pavement and undersized stormwater systems.
	23.	Creates low impact solutions that do not impact mobility of riders inducing ADA-reliant passengers.
	24.	Yes
	25.	Two of the facilities are in J40 defined areas. Additionally, equity communities have been shown to be more public transit-dependent.
WMATA (Transit	**Project**	**Drainage Pump Stations Rehabilitation Program**

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Submitting Agency	Question	Answers
Agency)	8.	Facility or service for public transportation
	9.	There are 59 Drainage Pumping Station located at low points in MetroRail tunnels. There is a need to replace and improve drainage pumping stations to facilitate the removal of excess water from MetroRail tunnels and stations, and support flood resiliency improvements. There is also a need to replace and improve pumping equipment and tunnel piping systems that have exceeded their lifecycle throughout the MetroRail system. Climate change projections call for increase intensity and frequency of rainfall events making these pumps even more crucial to flood resilience and recovery. This program prioritizes the highest risk locations based on flooding and equipment need. Multiple years beginning in FY2026 and continuing forward. This program can be funded in parts--the whole project does not need to be completed simultaneously.
	10.	L'Enfant, Wheaton, Federal Triangle, Metro Center, and Glenmont Stations (District of Columbia); Noyes Road (Silver Springs, MD), Medical Center (Bethesda, MD)
	11.	Flooding--sea level rise/storm surge, riverine, and interior
	12.	Multiple years beginning in FY2026 and continuing forward. This program can be funded in parts--the whole project does not need to be completed simultaneously.
	14.	The project is currently unfunded but is part of the 6-year capital improvement plan.
	15.	None of the above
	17.	No
	18.	Yes
	19.	FY 2025 6-year Capital Improvement Plan
	20.	Yes, identified through other studies, data, or assessments
	21.	WMATA has conducted multiple flood risk assessments and these locations have been identified as the highest risk.
	22.	When flooding or intense rainfall occurs, WMATA's tunnels can fill with water. These pumps remove the water. A flooded section of track will shut down portions of the system resulting in delays for customers and loss of revenue for WMATA.
	24.	No
	25.	Low-income residents in the DMV are often transit-dependent; having a resilient, efficient public transit system is necessary.
WMATA (Transit	**Project**	**Comprehensive Stormwater System Program (Planning)**

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Submitting Agency	Question	Answers
Agency)	8.	Facility or service for public transportation
	9.	Metro needs a comprehensive program to design, construct, and rehabilitate stormwater infrastructure to reduce the risk of flooding. Flooding can impact customer satisfaction by reducing access to facilities, it can impact assets, and disrupt travel times. Metro wants this systematic look before investing in millions of dollars in green and gray infrastructure.
	10.	Throughout the Metro/WMATA system.
	11.	Flooding--riverine, sea level rise/storm surge, and interior flooding
	12.	Beginning in FY2026 and estimated to take 1-2 years.
	14.	This program is unfunded but part of the FY2025 6 Year Capital Plan
	15.	None of the above
	17.	No
	18.	No
	20.	Yes, identified through other studies, data, or assessments
	21.	Current stormwater planning is piecemeal and based on facility. The creation of this program would allow WMATA to conduct a comprehensive study to better understand needs and prioritize investments. The need is known, the coordination and implementation plan needs to be developed.
	22.	Increased stormwater facilities will reduce runoff to other areas that would otherwise lead to flooding.
	23.	The desire would be to invest as much as possible in green infrastructure. Bioswales, green roofs, rain gardens, and retention ponds, along with other green and gray infrastructure will be evaluated.
	24.	Yes
	25.	Several of Metro's facilities are in Justice40 communities that experience flooding. Increased investment in stormwater facilities will reduce impacts.
WMATA (Transit Agency)	**Project**	**Stormwater System Rehabilitation**
	8.	Facility or service for public transportation
	9.	Metro has an interest in reducing the impacts of stormwater on our customers, assets, and community as well as meeting stormwater regulations.. Metro knows that as projected rainfall events increase in intensity and in frequency

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Submitting Agency	Question	Answers
		local jurisdictions will be looking for increased nature-based solutions to address stormwater runoff. Metro will install or retrofit stormwater management systems including bioretention ponds, wet ponds, and/or tree box filters.
	10.	Carmen Turner Center, Branch Ave Rail Yard, Glenmont Rail Yard, Greenbelt Rail Yard, Landover Bus Division, Montgomery Bus Division, New Carrollton Rail Yard, Shady Grove Rail Yard, and Southern Ave Bus Division (all in Maryland).
	11.	Flooding--riverine, sea level rise/storm surge, and interior flooding
	12.	Work to begin in FY2026 and expected to take 1-2 years. This project can be completed on facility at a time.
	14.	This program is unfunded but part of the FY2025 6 Year Capital Plan
	15.	None of the above
	17.	No
	18.	Yes
	19.	Metro has done assessments under the requirements of the Chesapeake Bay Restoration Act.
	20.	Yes, identified through other studies, data, or assessments
	21.	Metro has conducted studies on facilities vulnerable to flooding for many years. Many of these locations were identified in those plans.
	22.	These sites are in or adjacent to facilities that are necessary to operate the WMATA system. If flooding occurs it can be a burden on the system resulting in time delays and lost revenue.
	23.	Metro will install or retrofit stormwater management systems including bioretention ponds, wet ponds, and/or tree box filters.
	24.	Yes
	25.	Many of the locations are in J40 Communities that are often impacted by flooding. More investments in stormwater retention will reduce those risks.
WMATA (Transit Agency)	**Project**	**Rehabilitation of Station Vault Pre-Cast Supports**
	8.	Facility or service for public transportation
	9.	As rainwater percolates through the ground, the water leaks into MetroRail stations. This water flows into the vaulted ceilings at several stations located along the Red Line. Climate projections indicate that there will be more frequent and

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Submitting Agency	Question	Answers
		intense rainstorms in the region, resulting in more leaking and accelerating the damage to the ceilings. The connecting supports for the vaulted ceilings at several stations have begun to deteriorate, requiring a detailed inspection and condition report to determine the extent and location of where repairs will be needed, and rehabilitation of the identified issues.
	10.	Dupont Circle, Woodley Park, Cleveland Park, Van Ness, Tenleytown, Friendship Heights, DC. Bethesda and Medical Center Stations, MD.
	11.	Projected increased intensity and frequency of rain events. As these events increase, the amount of rainwater percolating into the system will increase.
	12.	FY2026 with a multiple year implementation. This project can be broken down to facility by facility.
	14.	This program is unfunded but part of the FY2025 6 Year Capital Plan
	15.	None of the above
	17.	No
	18.	Yes
	19.	Internal studies have documented the need for this work. The leak mitigation work has been ongoing for years.
	20.	No
	22.	The Red Line is on of the most used routes on the Metro system. This portion connects Montgomery County to the rest of the system. Each of these stations are critical for the operation of the line and if they were required to close there would be a loss in ridership, riders would be delayed, and WMATA would lose revenue.
	24.	No
	25.	Low-income residents in the DMV are often transit-dependent; having a resilient, efficient public transit system is necessary.
WMATA (Transit Agency)	**Project**	**Tunnel Chilled Water Piping Assessment**
	8.	Study or plan
	9.	A full systemwide assessment of the state of chilled water piping in tunnels will be necessary to evaluate the need for improvement of this piping. Chilled water is used to cool stations and all designs are outdated due to increasing population, increased density, and more high heat days. There are nearly 20 miles of pipe in the Metro system and evaluating the system and integrating climate projections will be necessary.

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Submitting Agency	Question	Answers
	10.	Systemwide
	11.	High heat. Likely need larger chillers and better piping.
	12.	Work to begin in FY2026 and expected to take 1-2 years
	14.	This program is unfunded but part of the FY2025 6 Year Capital Plan
	15.	None of the above
	17.	No
	18.	Yes
	19.	The 6 Year Capital Plan
	20.	No
	22.	High heat is going to impact public transit because riders will be more uncomfortable waiting for trains and may choose less environmentally friendly modes of transportation. Keeping stations cool will help keep ridership.
	23.	Will reduce energy consumption.
	24.	Yes
	25.	Low-income residents in the DMV are often transit-dependent; having a resilient, efficient public transit system is necessary.
WMATA (Transit Agency)	**Project**	**MetroBus Shelter Replacement**
	8.	Facility or service for public transportation
	9.	As temperatures rise and the likelihood of intense storm events occur, having functional, well designed bus shelters will make the rider experience more comfortable. Metro will replace bus shelters in service beyond their useful life and improve the rider experience by replacing paper signage, route/sign poles, bus stop decals, and wayfinding signage. In some cases, customer electronic information Displays will be installed. These investments improve customer comfort and improve customer communication and information through proper signage, maps and schedules for customers to see clearly bus stops and bus route timetables.
	10.	Systemwide
	11.	High heat--improved and new shelters will provide shaded areas for bus riders to wait.
	12.	Work to begin in FY2026 and expected to take multiple years. This project can be completed on facility at a time.

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Submitting Agency	Question	Answers
	14.	This program is unfunded but part of the FY2025 6 Year Capital Plan
	15.	None of the above
	17.	No
	18.	Yes
	19.	Internal WMATA plans indicate the need for improved or new bus shelters.
	20.	Yes, identified through the Vulnerability Assessment
	22.	Bus riders will have shaded areas to wait for buses. As high heat (and more frequent rain events) occur, the need for shade will be even greater. This project will help improve the comfort of bus riders.
	24.	Yes
	25.	Low-income residents in the DMV are often transit-dependent; having a resilient, efficient public transit system is necessary.
WMATA (Transit Agency)	**Project**	**Traction Power/Rectifier Replacement**
	8.	Facility or service for intercity passenger rail
	9.	MetroRail trains run on high voltage electricity known as traction power. There are multiple traction substations across the service area. Heat buildup is a concern inside these substations and gaining electrical efficiency will help reduce heat, especially as the regions is projected to get much hotter in the future due to climate change. By using previously successfully tested methods of rectifier replacement MetroRail has improved stability of power which will be particularly important as heat levels rise. This is a win-win-win solution; in addition to increasing resilience, it stabilizes the rail system, and saves the agency money by reducing electricity consumption.
	10.	33 traction power substations though DC, VA, and MD
	11.	This project addresses the concern that high heat will impact traction power substations and result in slow or interrupted MetroRail services
	12.	This is a multiyear project that may be completed in substation by substation.
	14.	This program is unfunded but part of the FY2025 6 Year Capital Plan
	15.	None of the above
	17.	No

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Submitting Agency	Question	Answers
	18.	Yes
	19.	Internal documents describe the need for the rectifier replacement.
	20.	No
	22.	MetroRail depends on traction power substations to propel trains. Each substation has a redundancy but if one overheats, train speed and frequency has to be decreased. This will result in delays for riders and a loss of revenue.
	24.	Yes
	25.	Low-income residents in the DMV are often transit-dependent; having a resilient, efficient public transit system is necessary.
WMATA (Transit Agency)	**Project**	**Shaft Damper and Attenuator Replacement Program**
	8.	Facility or service for public transportation
	9.	Climate projections for the region show much higher temperatures in the future. The climate inside stations and tunnels of the MetroRail system are maintained to keep customers comfortable and equipment running properly. Hotter temperatures will cause strain on those systems. One part of that system is a series of fans that run through shafts to keep air circulating—which is important in the case of fire as well. These shafts have dampers and attenuators that need to be running properly. MetroRail plans to replace older equipment with newer and more efficient ones to help maintain cool conditions in stations and tunnels.
	10.	221 shafts throughout the MetroRail system in DC, MD, and VA
	11.	High heat weather will require better circulation of MetroRail tunnels and stations for comfort and operability. Improving dampers will help address these issues
	12.	This is a multiyear project and can be completed shaft by shaft
	14.	This program is unfunded but part of the FY2025 6 Year Capital Plan
	15.	None of the above
	17.	No
	18.	Yes
	19.	This has been identified as a need by the agency. WMATA has internal documentation.
	20.	No

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Submitting Agency	Question	Answers
	22.	Improved shaft dampers and attenuators will serve multiple purposes including keeping riders more comfortable and reduce the temperature in the tunnels. High heat can hold more water and when this cools at night it results in condensation which can impact assets within the tunnel.
	24.	Yes
	25.	Low-income residents in the DMV are often transit-dependent; having a resilient, efficient public transit system is necessary.
WMATA (Transit Agency)	**Project**	**Non-Revenue Facility HVAC Replacement**
	8.	Facility or service for public transportation
	9.	Climate projections indicate that the Metro region will be experiencing many more high heat days impacting the MetroRail and MetroBus systems. An agency-wide energy audit in 2017 identified issues with aging and inefficient heating and cooling units rooftop (HVAC units and the accompanying building automation systems) at multiple Metro non-revenue facilities. These facilities are crucial for the operation of the system, so it is vitally important to protect the workers and the equipment from high heat. The audit recommended replacing the aging assets and implementing a Building Energy Management Control System that would allow for greater operational and maintenance efficiency and improved resiliency to the changing climate. The solution is win-win: lower energy costs and improved climate resilience.
	10.	locations systemwide in MD, DC, and VA.
	11.	Facilities were built with historical weather in design. With increase heat and the increase in electronic controls (which produce heat), the rooms are often get too hot and this is only projected to increase in the future. This project will address this concern by improving HVAC system.
	12.	This is a multiyear project that can be addressed facility by facility.
	14.	This program is unfunded but part of the FY2025 6 Year Capital Plan
	15.	None of the above
	17.	No
	18.	Yes
	19.	Internal documents describe the need for these improvements including an agency-wide energy audit in 2017.
	20.	No
	22.	These facilities are crucial for the operation of the system, so it is vitally important to protect the workers and the

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Submitting Agency	Question	Answers
		equipment from high heat
	24.	Yes
	25.	Low-income residents in the DMV are often transit-dependent; having a resilient, efficient public transit system is necessary.

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