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Measuring Climate Resilience – A Review of Select Critical Infrastructure Sectors in Montgomery County

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OLO Report 2021-5 **EXECUTIVE SUMMARY** **April 6, 2021**

This Office of Legislative Oversight (OLO) report responds to Council's request to better understand how well Montgomery County's critical infrastructure systems and assets are designed to handle extreme weather conditions. In sum, OLO found that the County requires significantly more data and analysis to properly plan for the security and resiliency of County infrastructure. OLO identified opportunities exist to build coordination, conduct risk assessments, and strengthen community preparedness.

Critical Infrastructure. Critical infrastructure describes vital systems and assets whose incapacity or destruction would have a debilitating impact on the County's physical or economic security, or public health or safety. There are 16 critical infrastructure sectors (on the right) - four of which are "lifeline" sectors, where the disruption or loss of functions would directly affect the security and resiliency of other sectors. These include: Communications, Energy, Transportation, and Water and Wastewater Systems. All sectors are connected – the loss or disruption of a lifeline function will have an immediate impact on the operation or mission of multiple sectors (known as cascading effects). Based on Councilmember and stakeholder feedback, this report examines six critical infrastructure sectors: **Agriculture, Communication, Dams, Energy, Transportation, and Water and Wastewater Systems.**

U.S. Department of Homeland Security Critical Infrastructure Sectors

- Chemical
- Commercial Facilities
- Communications
- Critical Manufacturing
- Dams
- Defense Industrial Base
- Emergency Services
- Energy
- Financial Services
- Food and Agriculture
- Government Facilities
- Healthcare and Public Health
- Information Technology
- Nuclear Reactors, Materials, and Waste Sector
- Transportation Systems
- Water and Wastewater Systems

County Weather Trends. OLO identified six climate risks to Montgomery County infrastructure systems and assets – floods, droughts, high winds, winter storms, hurricanes/tropical storms, and earthquakes. Of these, flooding poses the most serious risk. Historic data show:

- Increase in urban flooding from two to four occurrences per year before 2010 to 11 to 39 occurrences per year since 2010;
- Average of nine flash flood warnings per year; and
- Increase in the number of complaints related to nuisance flooding (e.g., water in basement, flooded yards).

The County's response to flooding is reactive – the County has not proactively evaluated its existing infrastructure to determine flood risks. Further, the County does not have a comprehensive model to show how water flows through the County and where potential problems lie. County department efforts are siloed and there is no single point of contact in the County to manage flood prevention programs.

For a complete copy of OLO-Report 2021-5, go to:
http://www.montgomerycountymd.gov/OLO/Reports/CurrentOLOReports.html

County Infrastructure Security and Planning. According to stakeholders, the County is barely meeting investment needs for maintaining existing infrastructure, let alone future risks. There is a lack of climate data available, and available data is siloed in County departments (often offline). Stakeholders also report a lack of expertise among County staff to understand the extent of climate risks and adaptation strategies necessary to protect critical infrastructure. Other specific resiliency planning risks for the County include:

- **Risk assessments**. Best practices indicate governments should engage in risk assessments to identify vulnerable infrastructure assets. The County has not conducted a facility risk assessment.
- **Coordination**. Information sharing is key to building strong resiliency programs. OLO found that coordination within the County is reactive (after a disaster), rather than proactive and it was difficult to secure data, information, and contacts from relevant stakeholders, particularly non-County entities.
- **Storm Data**. The County does not maintain a central, electronic repository of storm cost data. Costs for FEMA-declared disasters are not available prior to 2008. For other storm events, data is tracked and recorded by individual departments.

County Infrastructure Sector Risks. For each of the six sectors reviewed, OLO identified assets, determined climate and infrastructure risks, and presented potential next steps to address risks. The following are selected high risks identified by OLO:

- Washington Suburban Sanitary Commission's (WSSC) Potomac Filtration Plant supplies 70% of the County's drinking water – the Plant does not have an off-grid backup power supply and there is limited redundancy to supply drinking water.
- Dams and ponds in the County, primarily owned by private entities, are at risk of failure. There are limited County resources to monitor and repair these assets.
- Tree maintenance is a preventative action that decreases risk of service outages. The County's tree maintenance program is underfunded and lacks policies aligned with strengthening resiliency.
- Few County facilities are reinforced with multiple pathways to ensure continued operations. In the event of a power outage, County facilities on the FiberNet network may not be able to provide vital services.

Community Preparedness and Economic Impact. OLO found that the County needs to increase investments in community preparedness about climate-related risks. Research shows low-income residents often have less access to information and resources to help prepare for extreme weather events. Further, climate change and the increase of extreme weather events will reinforce and amplify current socioeconomic disparities. Costs for new infrastructure projects and retrofitting existing assets to meet resiliency needs are increasingly expensive and would fall mostly on taxpayers, which would disparately impact low- and fixed-income County residents.

OLO Recommendations

Recommendation #1: Conduct facility and asset risk assessments to identify assets, evaluate climate risk, and close knowledge and data gaps. As a result, the County can develop a resilience strategy and implement projects.

Recommendation #2: Compile all climate-related data, including related costs, in a central repository for access and transparency.

Recommendation #3: Assign a single point of contact to assess and manage flood risks to critical infrastructure and flood prevention programming.

Recommendation #4: Increase coordination across departments and regional partners to promote security and resiliency of County critical infrastructure.

Recommendation #5: Improve communication and outreach activities to strengthen community preparedness for vulnerability populations in the County.

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Measuring Climate Resiliency – A Review of Select Critical Infrastructure Sectors in Montgomery County

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Introduction

Critical infrastructure sectors are vital systems and assets whose incapacity or destruction would have a debilitating impact on our physical or economic security, or public health or safety. They are often the front-line defense against significant weather events. However, these sectors are at an increasing risk due to climate change impacts. Critical infrastructure systems and assets should be designed, built, operated, and maintained to anticipate, prepare for, and adapt to changing climate conditions, known as "climate resilience."

This report responds to the Council's request to better understand how well Montgomery County's critical infrastructure systems and assets are designed to handle extreme weather conditions. OLO examined six critical infrastructure sectors for this report: Agriculture, Communication, Dams, Energy, Transportation, and Water and Wastewater Systems. This report identifies County historical weather trends, the geographic impact of related events, and costs. Additionally, for each sector, this report defines County assets, climate and infrastructure risks, and identifies potential next steps to address resiliency gaps.

OLO staff members Stephanie Bryant and Kaitlyn Simmons conducted this study, with assistance from Kristen Latham and Theo Holt. OLO received a high level of cooperation from everyone involved in this study and appreciates the information and insights shared by all who participated.

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James Murley
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Methodology. To prepare this report, OLO gathered information through document reviews, data analysis, and interviews with staff from Montgomery County Government, regional partners, and utility companies. OLO also conducted interviews with staff from four resiliency programs in Miami-Dade County (FL), King County (WA), Washington (DC), and the City of Baltimore (MD).

Report Organization. The following outlines the organization of this Report.

- **Chapter 1** defines critical infrastructure, security, and resiliency and how they can influence a community's infrastructure policies and programs in response to climate change;

- **Chapter 2** explores climate hazards specific to Montgomery County and provides key data on weather trends and geographic areas in the County vulnerable to climate change;

- **Chapter 3** defines each critical infrastructure sector, including County assets, climate and infrastructure risks, and policy gaps;

- **Chapter 4** highlights takeaways from stakeholder interviews; and

- **Chapter 5** outlines OLO's key findings and recommendations for Council action.

Chapter 1. Defining and Building Climate-Resilient Infrastructure

Risks from climate change are gradual, cumulative, and create an array of socioeconomic impacts.[1] Building the resiliency of infrastructure assets – services, systems, and physical infrastructure – is a means to prepare for climate-related hazards and promote security. This chapter discusses three concepts that will help build an understanding of a community's infrastructure policies and programs:

- **Critical Infrastructure** – systems and assets, physical or virtual, so vital that their incapacity or destruction would have a debilitating impact on security, economic security, public health or safety;
- **Security** – reduction of risk to critical infrastructure by physical means or defensive cyber measures to combat intrusions, attacks, or the effects of natural or manmade disasters; and
- **Resilience** – ability to prepare for, adapt to, and recover from changing conditions.[2]

For this report, OLO examined critical infrastructure and resiliency through a climate change and homeland security/emergency preparedness lens. This chapter is organized as follows:

- **Section A. Defining Critical Infrastructure,** describes critical infrastructure and lists responsible government agencies;
- **Section B. Resiliency in the Context of Critical Infrastructure,** defines resiliency and summarizes what resiliency means in the context of climate change and critical infrastructure; and
- **Section C. Climate Change and Homeland Security Planning,** summarizes government strategies to address climate change risks and identify critical assets.

A. Defining Critical Infrastructure

The U.S. Cybersecurity and Infrastructure Security Agency (CISA) coordinates federal security and resilience efforts.[3] CISA identifies 16 critical infrastructure sectors (listed on the following page), which include "assets, systems, facilities, networks, and other elements that society relies upon to maintain national security, economic vitality, and public health and safety."[4] Communications, Energy, Transportation, and Water and Wastewater Systems Sectors are considered lifeline sectors.[5] This OLO report focuses on these sectors as well as the Agriculture (part of Food and Agriculture) and Dams Sectors. These sectors were selected based on Councilmember and stakeholder feedback.

[1] McKinsey & Company, Addressing Climate Change in a Post-Pandemic World, April 7, 2020, https://www.mckinsey.com/business-functions/sustainability/our-insights/addressing-climate-change-in-a-post-pandemic-world

[2] U.S. Cybersecurity and Infrastructure Security Agency, National Infrastructure Protection Plan 2013, https://www.cisa.gov/sites/default/files/publications/national-infrastructure-protection-plan-2013-508.pdf

[3] U.S. Cybersecurity and Infrastructure Security Agency, About CISA, https://www.cisa.gov/about-cisa

[4] U.S. Cybersecurity and Infrastructure Security Agency, Critical Infrastructure Sectors, https://www.cisa.gov/critical-infrastructure-sectors

[5] U.S. Cybersecurity and Infrastructure Security Agency, A Guide to Critical Infrastructure Security and Resilience, https://www.cisa.gov/sites/default/files/publications/Guide-Critical-Infrastructure-Security-Resilience-110819-508v2.pdf

U.S. CISA Critical Infrastructure Sectors

- Chemical
- Commercial Facilities
- ***Communications***
- Critical Manufacturing
- ***Dams***
- Defense Industrial Base
- Emergency Services
- ***Energy***
- Financial Services
- ***Food and Agriculture***
- Government Facilities
- Healthcare and Public Health
- Information Technology
- Nuclear Reactors, Materials, and Waste Sector
- ***Transportation Systems***
- ***Water and Wastewater Systems***

Source: U.S. CISA

Sectors are connected and interdependent. The loss or disruption of a lifeline function will have an immediate impact on the operation or mission of multiple sectors. Identifying interdependencies and dependencies of each sector is important to assess risk and vulnerability and crucial to increasing security and resilience.[6]

Lead Agencies and Offices for Planning and Protection of Infrastructure Assets. In the United States, private sector entities generally own critical infrastructure assets (such as energy and communications infrastructure). However, the responsibility for security and resiliency of critical infrastructure is shared among infrastructure owners and operators, government entities, and non-governmental organizations. In addition to sector ownership, regulations and threats/hazards shape the development of partnerships and information sharing.[7]

Below are the lead agencies/offices at the federal, state, and county levels for Montgomery County. These stakeholders work to develop programs and plans to protect critical infrastructure. By leveraging effective partnerships and an all-hazards approach, communities can develop adaptable plans to address diverse challenges within an integrated and supportive network.[8]

Federal Government U.S. Department of Homeland Security Cybersecurity and Infrastructure Security Agency	**State of Maryland** Maryland Emergency Management Agency Maryland Coordination and Analysis Center
DC Region Metropolitan Washington Council of Governments	**Montgomery County** Office of Emergency Management and Homeland Security

B. Resiliency in the Context of Critical Infrastructure

The focus of this OLO report is building resiliency. Resiliency, depicted in Figure 1, is the capacity of a system to retain essential functions before, during, and after a hazard strikes.[9] In each diagram, the dotted line represents capacity (e.g., government operations, transportation systems, communication systems, etc.)

[6] *Ibid.*
[7] U.S. Cybersecurity and Infrastructure Security Agency, A Guide to Critical Infrastructure Security and Resilience.
[8] U.S. Department of Homeland Security, The 2014 Quadrennial Homeland Security Review, https://www.dhs.gov/sites/default/files/publications/qhsr/2014-QHSR.pdf
[9] U.S. Climate Resilience Toolkit, Steps to Resilience, https://toolkit.climate.gov/#steps

Figure A represents *business as usual*, with capacity stable across time. With an *acute disaster* (e.g., rain or snow event), disruptions may occur, but services recover over time (**Figure B**). If a *severe disaster* occurs (e.g., hurricane, blizzard, etc.), disruptions to operations or systems may cross a tipping point and not be able to recover completely, resulting in a loss of services or capacity (**Figure C**).

Figure 1. Concept of Resiliency

Figure A. Business as Usual

Figure B. Acute Disaster

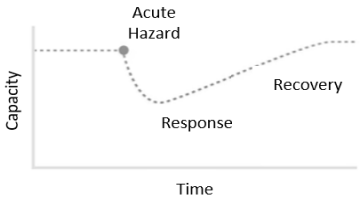
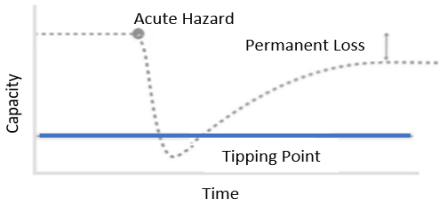


Figure C. Severe Disaster



Source: U.S. Climate Resilience Toolkit

Climate-Resilient Infrastructure. Climate-resilient infrastructure is "planned, designed, built and operated in a way that anticipates, prepares for, and adapts to changing-climate conditions. It can also withstand, respond to, and recover from disruptions caused by climate conditions."[10] Climate resilience of individual assets must be viewed in the context of the entire system. Adaptation is a strategy to anticipate and deal with climate change impacts.[11] Critical infrastructure adaptation strategies include both structural and management measures:

- **Structural adaptation measures** – Examples include changing the composition of road surfaces, so they do not deform in high temperatures, using natural infrastructure (e.g., watershed restoration can protect drinking water), building seawalls, and using permeable paving surfaces.
- **Management (non-structural adaptation) measures** – Examples include timing of maintenance schedules to account for changing patterns in energy demand and enhanced monitoring of existing assets to reduce risk of failure. Management measures provide flexibility to adjust to changing conditions over the asset's lifetime.[12]

Climate-resilient infrastructure has the potential to improve reliability of service provision; reduce costs of providing services and retrofitting assets; and increase the useful life of critical assets. Challenges to making infrastructure resilient include time horizons (results of investments are long-term, while costs are incurred in the short-term), uncertainty in data models, lack of available data about future climate risks, and policy and regulatory decisions limiting the ability to implement strategies.[13]

[10] OECD, Climate-Resilient Infrastructure, OECD Environmental Policy Paper No. 14, 2018.
[11] United Nations Intergovernmental Panel on Climate Change, Climate-Resilient Pathways: Adaptation, Mitigation, and Sustainable Development 2014, https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-Chap20_FINAL.pdf
[12] *Ibid*.
[13] *Ibid*.

Core Tenets of Climate-Resilient Infrastructure Planning. CISA identifies seven core tenets that critical infrastructure partners should consider when planning for critical infrastructure security and resiliency. [14]

- Risks should be identified in a coordinated and comprehensive way across the critical infrastructure community.
- Understanding and addressing risks from cross-sector dependencies and interdependencies is essential to enhancing infrastructure security and resiliency.
- Information sharing is imperative to comprehensively address infrastructure security and resilience.
- Public-private partnership is central to maintaining security and resilience, including clear goals, measurable outcomes, and frequent communication.
- Risks often have local consequences, making it essential to partner across institutions and geographic boundaries.
- Distributed nature and interconnectivity of infrastructure create a complex environment where assets are not contained within borders, increasingly so with information and technology systems.
- Security and resilience should be considered during the design of assets, systems, and networks.[15]

Evaluating Pathways to Achieving Climate-Resilient Critical Infrastructure. The first step in building resiliency is evaluating the vulnerability of infrastructure systems and assets to climate change.[16] The U.S. Climate Resilience Toolkit outlines five best practice steps to build resiliency of services, systems, and physical infrastructure – (1) Explore Hazards; (2) Assess Vulnerabilities and Risks; (3) Investigate Options; (4) Prioritize and Plan; (5) Take Action. This process falls under the mitigation and preparedness phases of emergency management described in Section C. This OLO report focuses on Steps One and Two, defined below. (See Appendix A for fuller discussion).

- **Explore Hazards – develop an understanding of climate risks posed to critical infrastructure.** Jurisdictions should consider the range of climate or weather-related events that could pose a threat and determine potential damages or consequences that could result. [17]
- **Assess Vulnerabilities and Risks – best practices indicate jurisdictions should conduct vulnerability assessments.** Assessments identify and determine the susceptibility of systems and infrastructure to climate-related threats and assets' level of resiliency.[18]

[14] U.S. Cybersecurity and Infrastructure Security Agency, National Infrastructure Protection Plan 2013.
[15] *Ibid*.
[16] Lauren Miller, Boston Society of Civil Engineers, Steps Towards Climate Change Resilience For Critical Infrastructure https://www.bsces.org/news/industry/steps-towards-climate-change-resilience-for-critical-infrastructure-3228
[17] U.S. Climate Resilience Toolkit, Steps to Resilience, Explore Hazards, https://toolkit.climate.gov/steps-to-resilience/explore-hazards
[18] U.S. Climate Resilience Toolkit, Steps to Resilience, Assess Vulnerability and Risks, https://toolkit.climate.gov/steps-to-resilience/assess-vulnerability-risks

C. Climate Change and Homeland Security Planning

While climate change risks may seem distant, the lifecycle of infrastructure spans many decades. Much of the infrastructure that will be in service 30, 50, or 100 years from now is being conceived, designed, and constructed today.[19] Therefore, the U.S. National Security Strategy identifies climate change as a major challenge and threat to national security and critical infrastructure.[20]

These events can have severe consequences including fatalities, economic loss, widespread disruption of essential services. Aging infrastructure, increased population density in high-risk areas, and climate change trends increase the level of risk associated with natural disasters. As storms become more intense, the cost of preparing, mitigating, responding, and recovering from events grows.[21] For these reasons, climate change is a threat multiplier and a strategic driver of policy for protecting critical infrastructure systems and assets.[22]

Climate Change and Emergency Management Planning in the County. The response to climate change is a two-pronged approach – *mitigation* (reducing emissions and stabilizing greenhouse gas levels) and *adaptation* (adjusting to actual or expected climate change). [23] The Federal Emergency Management Agency (FEMA) developed the emergency management cycle (consisting of four phases) to prioritize hazards/threats, plan for emergency response, and aid in recovery operations. All communities are in at least one phase of this cycle at a given time.[24]

[19] U.S. Department of Homeland Security Climate Change Adaptation Plan.
[20] The National Security Implications of Climate Change, President Obama White House Archives, https://obamawhitehouse.archives.gov/sites/default/files/docs/National_Security_Implications_of_Changing_Climate_Final_051915.pdf
[21] U.S Department of Homeland Security, The 2014 Quadrennial Homeland Security Review. U.S. Department of Homeland Security Climate Change Adaptation Plan. Federal Emergency Management Agency, National Preparedness Goal, https://www.fema.gov/emergency-managers/national-preparedness/goal#:~:text=The%20goal%20itself%20is%20succinct,that%20pose%20the%20greatest%20risk.%E2%80%9D
[22] *Ibid*; U.S. Cybersecurity and Infrastructure Security Agency, National Infrastructure Protection Plan 2013.
[23] *Ibid*.
[24] Federal Emergency Management Agency, Emergency Management in the U.S., https://training.fema.gov/emiweb/downloads/is111_unit%204.pdf

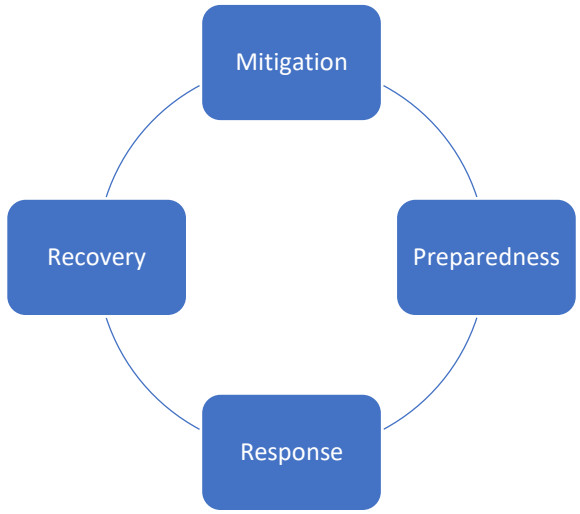
Mitigation – Includes actions to reduce the loss of life and property by lessening the impact of future disasters (e.g., constructing permanent barriers to control flooding, planting vegetation to absorb water, buying insurance policies, etc.).

Preparedness – Includes planning, training, and educational activities for events that cannot be mitigated (e.g., developing plans, conducting exercises, examining assets for vulnerabilities, etc.).

Response – Occurs immediately after the disaster when businesses or other functions may not operate as usual (e.g., implementing preparedness plans, addressing the public, conducting search and rescue missions, etc.).

Recovery – Occurs simultaneously with regular operations and recovery efforts may be long-term (e.g., rebuilding assets, reducing vulnerabilities to future disasters, etc.).

Figure 2. Phases of Emergency Management



Source: FEMA

Selected Planning Documents. The following outlines several policy guidelines and strategies to address climate change risks and identify critical systems and assets.

- **Department of Homeland Security, Climate Change Adaptation Roadmap**, fulfills an Executive Order that requires all federal departments to develop a national climate change adaptation strategy. The Roadmap is a long-range planning document that presents risks, objectives, and actions.[25]
- **Department of Homeland Security, 2014 Quadrennial Homeland Security Review**, outlines DHS missions and actions to address threats and hazards.[26]
- **Department of Homeland Security, NIPP 2013**, **Partnering for Critical Infrastructure Security and Resilience**, outlines how government and private sector participants in the critical infrastructure community work together to manage risks and achieve security and resilience outcomes.
- **Cybersecurity and Infrastructure Security Agency, Critical Infrastructure Sector-Specific Plans,** provides clear action to leverage partnerships, manage risk, and outcome-based actions. [27]
- **Montgomery County, Draft Climate Action Plan 2020**, is the County's strategic plan to cut greenhouse gas emissions and reduce climate-related risks. [28]
- **Montgomery County, Office of Emergency Management and Homeland Security, Hazard Mitigation Plan 2018**, serves as a blueprint for coordinating and implementing hazard mitigation policies and

[25]U.S. Department of Homeland Security, Climate Change Adaptation Plan.
[26] U.S. Department of Homeland Security, The 2014 Quadrennial Homeland Security Review.
[27] U.S. Cybersecurity and Infrastructure Security Agency, National Infrastructure Protection Plan 2013.
[28] Montgomery County Government, Draft Climate Action Plan, 2020, https://www.montgomerycountymd.gov/green/climate/index.html

programs. This plan fulfills a federal requirement for mitigation planning and assists the County in meeting eligibility requirements for federal hazard mitigation project funding.[29]

- **Montgomery Country, Office of Emergency Management and Homeland Security**, **Critical Infrastructure and Key Resources Protection Plan 2020,** serves as an initial planning document that identifies key critical infrastructure and assets in the County and identifies lead departments/offices and responsibilities.[30]
- **Montgomery County, Office of Emergency Management and Homeland Security, Extreme Temperature Plan,** outlines response actions to minimize the effects of extreme cold and heat on residents, workers, and visitors.[31]
- **Montgomery County, Office of Emergency Management and Homeland Security, Water Security Plan,** coordinates response efforts to a water emergency within or directly affecting the County, including contamination, system disruption, security threats, and equipment failure. OEMHS staff report the plan is currently in draft form due to a lack of staff capacity to complete the plan.[32]

[29] Montgomery County Office of Emergency Management and Homeland Security, Hazard Mitigation Plan, https://www.montgomerycountymd.gov/OEMHS/Resources/Files/HMP2018-FinalPlan-FEMAApproved.pdf
[30] Office of Emergency Management and Homeland Security.
[31] *Ibid*.
[32] *Ibid*.

Chapter 2. Climate Trends and Weather Risks

The Earth's climate is changing and as a result, temperatures, rainfall, and snow patterns are also going to change, leading to more frequent extreme climate events.[33] The National Oceanic and Atmospheric Association (NOAA) reports that temperatures for most of Maryland increased 1.5 degrees Fahrenheit in the last century.[34] Maryland has experienced warmer winters and summers, wetter falls and springs, and drier summers.[35] Further, State weather patterns are increasingly unpredictable.

This chapter summarizes climate hazards specific to Montgomery County, provides key data on weather events and trends, and explores vulnerable areas and populations within the County. This chapter is organized as follows:

- **Section A. Montgomery County Climate Trends and Risks,** summarizes weather trends and hazard risks across eight climate categories, with a focus on infrastructure;
- **Section B. Montgomery County Vulnerable Geographic Areas and Populations,** reviews geographic locations and demographic groups that are most vulnerable to climate risks in the County; and
- **Section C. Estimated County Costs of Significant Weather Events Since 2000,** examines County costs of past extreme weather events.

Some key takeaways include:

- Temperatures in Maryland have increased nearly 1.5 degrees Fahrenheit since the beginning of the century, and State weather patterns are becoming increasingly unpredictable;[36]
- Among climate risks, Montgomery County critical infrastructure is most vulnerable to flooding; and
- It is likely that climate change and the subsequent increase of extreme weather events will reinforce and amplify current socioeconomic disparities, with low-income communities and communities of color being the most impacted.

[33] Environmental Protection Agency, Climate Change Indicators in the United States, 2016 4th Edition, https://www.epa.gov/sites/production/files/2016-08/documents/climate_indicators_2016.pdf

[34] NOAA National Centers for Environmental Information, State Climate Summaries: Maryland and District of Columbia 2017, https://statesummaries.ncics.org/chapter/md/

[35] Maryland Department of Natural Resources, Climate Change in Maryland, https://dnr.maryland.gov/climateresilience/Pages/about_climatechange.aspx#:~:text=In%20the%20future%2C%20it%20is%20expected%20that%20climate,lowlying%20areas%20along%20the%20State%E2%80%99s%20shoreline%20and%20coast

[36] See Appendices B and C for a more in-depth review of climate trends for the Mid-Atlantic region and the State of Maryland.

A. Montgomery County Climate Trends and Climate Risks

This section examines the County's climate and weather trends and explores climate hazards across eight categories – **Section One** summarizes temperature and precipitation trends in the County and **Section Two** reviews the remaining climate risks (floods, droughts, high winds, snowstorms, hurricanes, and earthquakes) and their impact on infrastructure assets. This section relies on weather and climate data from NOAA, the 2018 Montgomery County Hazard Mitigation Plan, and the Montgomery County Draft Climate Action Plan (DCAP). Future projections provided for each climate hazard use climate change projections from the DCAP, which were based on two scenarios:

- **Stabilization Scenario.** This scenario assumes that there will be climate adaptation strategies and interventions that will lead to a moderate increase in greenhouse gas emissions until 2050. Emissions will then stop increasing and level off.
- **Worst-Case/Business-As-Usual Scenario.** This scenario assumes that there will not be a significant amount of climate change interventions and that greenhouse gas emissions will continue to increase through the end of 2100, resulting in the worst-case scenario.

1. Temperature and Precipitation Trends

This section examines temperature and precipitation trends using data from 2000 to 2019 (and 2020 where available) to see how the 21st century trends compare to the 20th century mean temperatures.[37]

[37] NOAA standard for analyzing temperature and precipitation trends is to compare current years to the mean of data collected from 1901-2000.

TEMPERATURE TRENDS

As shown below, the annual average temperatures in the County from 2000 to 2019 have been higher than the 1901 to 2000 mean temperature of 53.4 degrees F for all but one year (2014). More specifically:

- From 2000 to 2020, 12 out of 20 January months been above the 1901 to 2000 mean temperature of 31.9 degrees F.[38] (Chart 1)
- From 2000 to 2020, almost all (17 out of 20) Julys reported above-average temperatures compared to the prior century. The average temperature of July 2020 (79.8 degrees F) was the warmest to date in recorded July temperature averages since 1895. (Chart 2)

Future Trends. Annual temperatures will continue to increase, especially during the summer and fall months. Heat waves are expected to increase in intensity and frequency. From 1950 to 2005, the County experienced four days per year where the average temperature was above 95 degrees. By 2035, this could increase to 12 days per year and by 2100, this could increase to 28 to 60 days above 95 degrees in an average year.[39]

Chart 1. County Average Temperatures for January, 2000-2020[40]

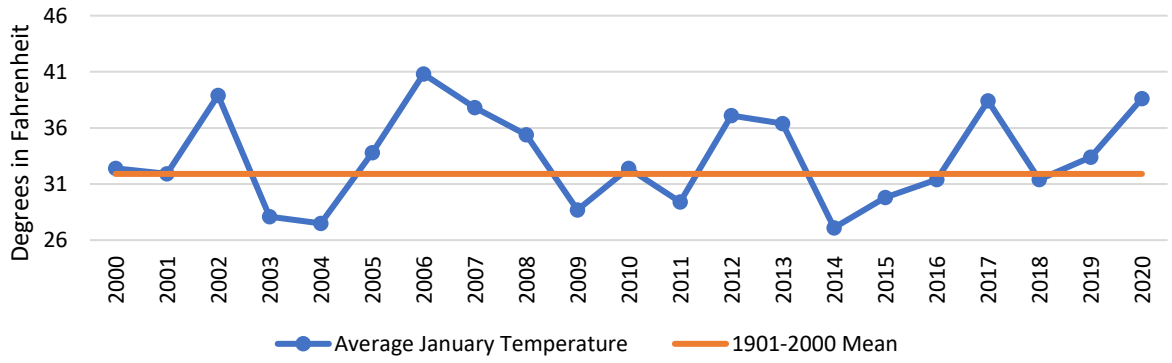
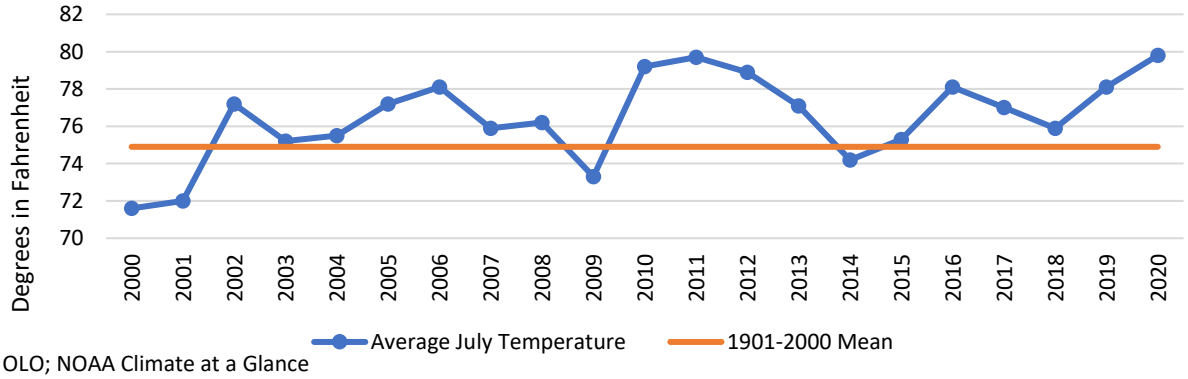


Chart 2. County Average Temperatures for July, 2000-2020



Source: OLO; NOAA Climate at a Glance

[38] National Oceanic and Atmospheric Administration, National Centers for Environmental Information, https://www.ncdc.noaa.gov/cag/county/time-series/MD-031/tavg/1/1/2000-2020?base_prd=true&begbaseyear=1901&endbaseyear=2000

[39] The 28-day estimate is based on the stabilization scenario and the 60-day estimate is based on the business-as-usual scenario.

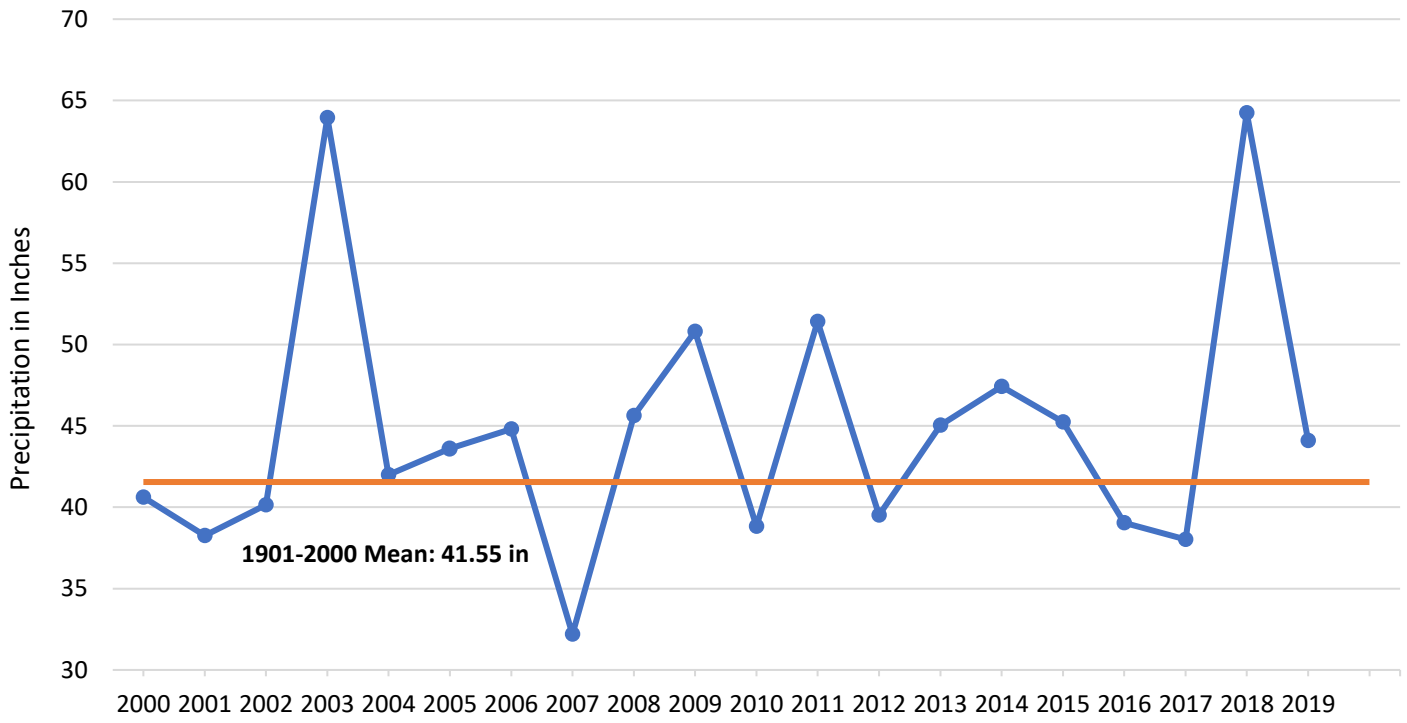
[40] A discussion on the impacts of extreme cold on County infrastructure is included in Appendix E.

PRECIPITATION TRENDS

The average annual precipitation has fluctuated significantly over the past twenty years, from a low of 32 inches in 2007 to a high of 64 inches in 2018. Additionally, OLO found that in 12 years out of the 19 years examined, the mean rainfall was above the 1901 to 2000 mean annual rainfall of 41.55 inches.[41] (Chart 3).

Future Trends. The DCAP predicts an increase in rainfall in the future for both scenarios. In the stabilization scenario, there is a 2% projected increase in the amount of rainfall by 2050 and a 5% increase by 2100. For the worst-case-scenario, it is expected that there will be a 4% increase by 2050 and a 7% increase by 2100.[42]

Chart 3. County Annual Precipitation Totals, 2000-2019



Source: OLO; NOAA Climate at a Glance

[41] National Oceanic and Atmospheric Administration, National Centers for Environmental Information, https://www.ncdc.noaa.gov/cag/county/time-series/MD-031/tavg/1/1/2000-2020?base_prd=true&begbaseyear=1901&endbaseyear=2000

[42] Montgomery County Government, Draft Climate Action Plan, https://www.montgomerycountymd.gov/green/Resources/Files/climate/draft-climate-action-plan.pdf

2. Climate Risks to County Infrastructure

Based on the 2018 Hazard Mitigation Plan, the Draft Climate Action Plan, and stakeholder interviews, OLO identified six climate risks. OLO focused on risks to infrastructure assets in the six sectors reviewed by OLO.[43]. This section defines each risk, highlights historical trends and costs, and identifies areas of the County most vulnerable to each risk.

Climate Risks

[43] Of note, due to this report's focus on infrastructure assets, the climate risks identified by OLO may differ from those identified in the County's Draft Climate Action Plan.

CLIMATE RISK #1 FLOODS

Definition of Risk. Floods occur when a normally dry area is inundated with water, usually from heavy rainfall or snowmelt. Infrastructure can be damaged by either being inundated with flood waters or damaged by flood debris.[44] There are various types of floods including **riverine flooding** (water levels rising from a body of water), **flash floods** (large volume of water, usually from heavy rain or rapid snowmelt, flows over a short period of time), or **urban flooding** (caused by impervious surfaces not absorbing excess water).

Profile of Hazard in Montgomery County. Montgomery County contains three major watersheds (Potomac, Patuxent, and Patapsco Rivers) and 49 sub-watersheds, which are made up of streams and small tributaries. These watersheds, and the properties in and near these floodplains, are subject to flash flooding and other flood events on a yearly basis. Montgomery County is most at risk of riverine flooding.[45]

According to the National Weather Service Local Storm Reports, there has been an upward trend of urban flooding in the County, from two to four occurrences per year before 2010, to 11 to 39 occurrences per year since 2010.[46] One notable flood occurred in 2006, during which severe flooding threatened the stability of the Lake Needwood Dam and caused the evacuation of more than 2,400 residents.[47]

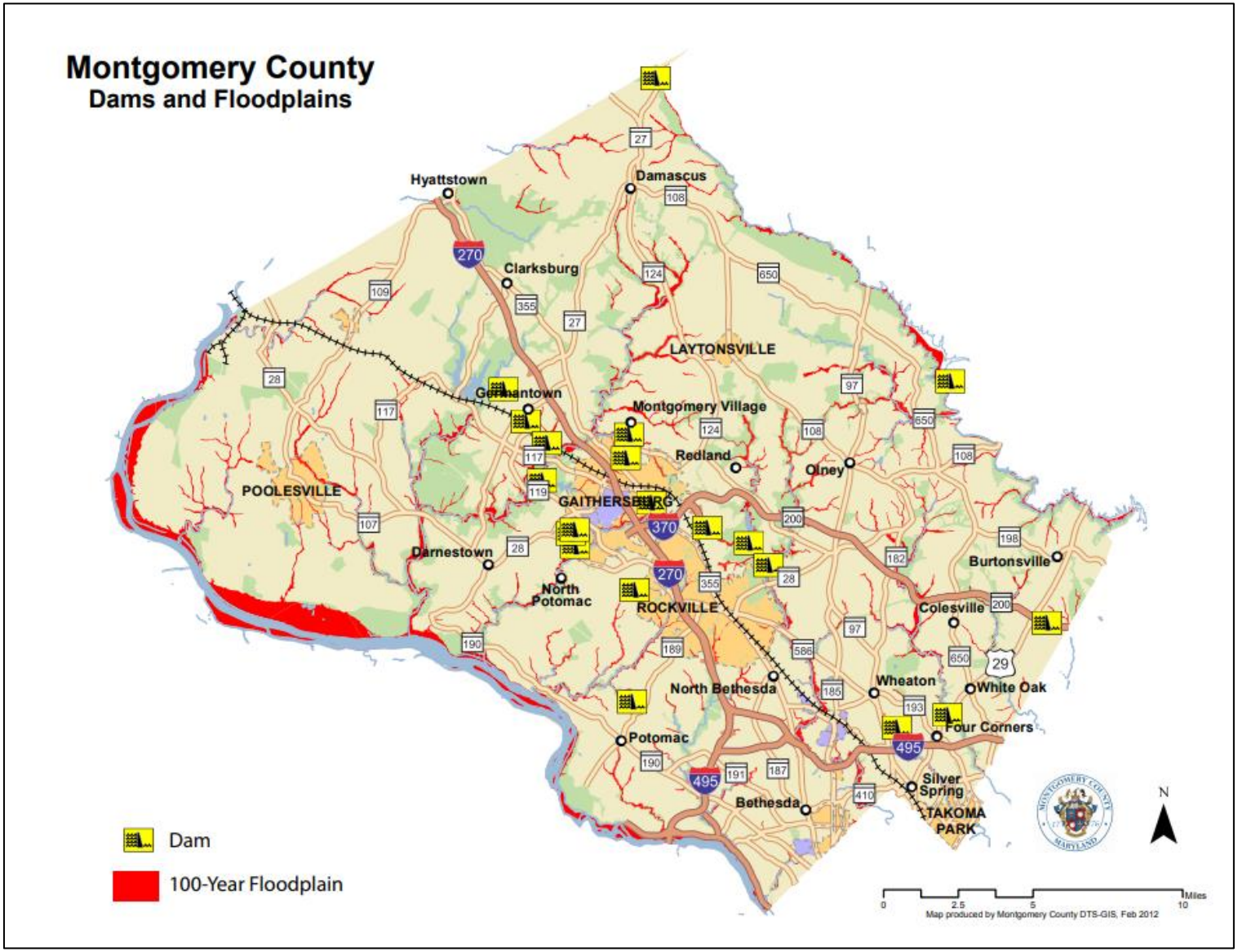
Flash floods also present a danger to the County, as they can occur without warning; and can affect County operations. From 2003 to 2019, there have been an average of nine flash flood warnings per year according to OEMHS, with 2011 having the most warnings (22 warnings).[48]

Future Trends. Urban flooding is projected to be a major climate risk because of the large number of impervious surfaces and older stormwater systems throughout the County. In combination, with the projected increase in precipitation, flooding is a significant risk for the County's infrastructure.[49]

A map of dams and areas within the 100-year floodplain is on the following page (Map 1).

[44] Montgomery County Office of Emergency Management and Homeland Security, Hazard Mitigation Plan 2018; Montgomery County Government, Draft Climate Action Plan, 2020.
[45] Stakeholder Interviews.
[46] Local Storm Reports Dataset provided by OEMHS.
[47] Maryland Department of the Environment, Heavy Rain Seepage Prompts Review and Retrofit of Lake Needwood Dam, August 2007. https://mde.maryland.gov/programs/ResearchCenter/eMDE/Pages/vol3no4/needwood.aspx
[48] Local Storm Reports Dataset provided by OEMHS
[49] Montgomery County Government, Draft Climate Action Plan, 2020. https://www.montgomerycountymd.gov/green/Resources/Files/climate/draft-climate-action-plan.pdf

Map 1. Montgomery County Dams and Floodplains



Source: DTS

CLIMATE RISK #2 DROUGHTS

Definition of Risk. A drought is a shortage of water over an extended period caused by a deficient amount of precipitation. Droughts can be aggravated by high temperatures, high winds, and low humidity.[50] The U.S. Drought Monitor began collecting data on droughts in 2000 and created the following categories based on severity.[51]

Table 1. Drought Severity Categories

Category	Definition	Possible Impacts
D0	Abnormally Dry	Slowing planting and/or growth of crops/pastures, some lingering water deficits
D1	Moderate Drought	Some damage to crops/pastures, some water shortages possible
D2	Severe Drought	Crop or pasture losses likely, water shortages common
D3	Extreme Drought	Major crop/pasture losses, widespread water shortages
D4	Exceptional Drought	Exceptional and widespread crop/pasture losses, water emergencies due to backup shortages

Source: U.S. Drought Monitor

Profile of Hazard in Montgomery County. Since 2000, Montgomery County has experienced four significant drought events:

- September 2001 to September 2002 – Declared an official drought by the State. Most of the State was under mandatory water-use restrictions with precipitation amounts at 57% of normal levels.
- August 2007 – Declared a statewide drought by the U.S. Department of Agriculture. County losses were projected to be over $13 million, and the County approved $1.5 million in aid to impacted farmers.
- July to November 2008 – Central and Northern Maryland experienced drought conditions which contributed to about $40 million in damage to the State's fall harvest.
- June 2010 to August 2010 – Declared a Drought/Excessive Heat Economic Injury Disaster in Maryland by U.S. Small Business Administration.[52]

Future Trends. It is projected that the annual risk of moderate, severe, and extreme droughts will increase significantly by the year 2100. Parts of the Agricultural Reserve will be especially at risk, as projections in this part of the County range from an annual average of 0.6 to 0.9 months of severe drought by 2100 (best case) to 1.2 to 1.5 months of severe drought by 2100 (worst case).[53]

[50] Montgomery County Office of Emergency Management and Homeland Security, Hazard Mitigation Plan 2018, Montgomery County Government, Draft Climate Action Plan, 2020.
[51] United States Drought Monitor, Drought Classification, https://droughtmonitor.unl.edu/About/AbouttheData/DroughtClassification.aspx
[52] Montgomery County Office of Emergency Management and Homeland Security, Hazard Mitigation Plan 2018.
[53] Montgomery County Government, Draft Climate Action Plan, 2020.

CLIMATE RISK #3 HIGH WINDS/TORNADOES

Definition of Risk. High winds are sustained, strong winds that often occur with thunderstorms. There are several climate events that can occur simultaneously with high wind events and pose additional risk:

- *Tornadoes* are violently rotating columns of air touching the ground, usually attached to a thunderstorm. Most likely to occur from March through June, tornadoes can disrupt critical services such as transportation, power transmission, and communications.
- *Downbursts* are strong downdrafts that result from a thunderstorm and create straight-line winds on or near the ground, reaching 150 mph.
- *Derechos* are a series of intense, widespread, and fast-moving windstorms and thunderstorms that move across a great distance. Derechos are most common from May to August during periods of high heat and humidity.[54]

Profile of Hazard in Montgomery County. In Montgomery County, there has been a 76% increase in the number of significant wind reports, increasing from an average of 25 wind incidents per year before 2010 to an average of 44 reports per year as of August 2019.[55] Specific data include:

- Since 1950, Montgomery County has experienced between $2.6 and $7.3 million in cumulative tornado-related damages from a reported 17 tornadoes.[56]
- A derecho in June 2012 caused a loss of power for days for four million customers, which resulted in 34 heat-related fatalities. [57] WSSC's Potomac Water Filtration Plant was without power for 11 hours after the storm.[58]

In addition, the County experiences a significant number of severe thunderstorms per year.[59] County data recorded by OEMHS shows that from 2003 to 2019, there have been 586 severe thunderstorm warnings recorded by the National Weather Service (NWS), on average 34 warnings annually. Additionally, there have been 35 tornado warnings recorded by the NWS from 2003-2019.[60]

Future Trends. Future projections of wind conditions have not been conducted. However, with a projected increase in hurricanes and tropical storms, it is likely that high winds will also increase.[61]

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[54] U.S. Department of Commerce & National Oceanic and Atmospheric Administration, The Historic Derecho of June 29, 2012, https://www.weather.gov/media/publications/assessments/derecho12.pdf
[55] Montgomery County Government, Draft Climate Action Plan, 2020.
[56] Montgomery County Office of Emergency Management and Homeland Security, Hazard Mitigation Plan 2018, Montgomery County Government, Draft Climate Action Plan, 2020.
[57] PEPCO, "Pepco Completes Full Restoration of Customers Impacted by Derecho," 2012, https://www.pepco.com/News/Pages/2012-07-08_2.aspx
[58] Bethesda Magazine, A Year Later, Derecho Still Looms Large, June 27, 2013, https://bethesdamagazine.com/bethesda-beat/weather/a-year-later-derecho-still-looms-large/
[59] Severe thunderstorms are identified by having at least one characteristic out of the following: hail that is one inch or more, winds with gusts in excess of 57.5 mph, or a tornado.
[60] Local Storm Reports Dataset provided by OEMHS
[61] Montgomery County Government, Draft Climate Action Plan, 2020.

CLIMATE RISK #4 WINTER STORMS

Definition of Risk. Winter storms are events that produce a combination of winter precipitation, including snow, sleet, and freezing rain.[62] There are three types of winter storms that have significantly impacted the County:

- *Blizzards* – Combination of sustained winds or frequent gusts of 35 mph or greater with visibilities of less than a quarter mile due to falling snow for three hours or more;
- *Heavy Snow* – Six inches or more of snow in a 12-hour period or eight inches or more of snow in 24-hour period;
- *Ice storms* – Storms that results in the accumulation of at least 0.25 inches of ice on exposed surfaces.

Profile of Hazard in Montgomery County. On average, the County experiences around 18 inches of snow per year.[63] In the past 20 years, four winter storms were declared disasters by FEMA, including "Snowmageddon" in 2010, which dropped 17.8 inches of snow on the area.[64] Winter storms can cause disruptions to traffic, communication systems, and utilities.[65] Critical infrastructure facilities can be damaged by excess snow on rooftops and large deposits of ice. Older structures that have not been well maintained or do not have access to back-up generators are more at risk of damage due to winter storms.[66]

Future Trends. State projections conducted by the Maryland Commission on Climate Change, Scientific and Technical Working Group found that by 2100, precipitation is projected to increase about 20% during winter months. The projections also state that extreme winter storms will become more unpredictable. It is expected that winter and early spring will be wetter in the future, with increased frequency and intensity of extreme precipitation events occurring.[67]

[62] Federal Emergency Management Agency, Winter Weather, 2020, https://www.ready.gov/winter-weather
[63] National Oceanic and Atmospheric Administration, National Centers for Environmental Information, https://www.ncdc.noaa.gov/cag/county/time-series/MD-031/tavg/1/1/2000-2020?base_prd=true&begbaseyear=1901&endbaseyear=2000
[64] Federal Emergency Management Agency, Declared Disasters, https://www.fema.gov/disasters/disaster-declarations?field_dv2_state_territory_tribal_value=MD&field_year_value=All&field_dv2_declaration_type_value=All&field_dv2_incident_type_target_id_selective=All; Bethesda Magazine, The Eight Biggest Snowstorms to Hit Southern Montgomery County, January 20, 2016, https://bethesdamagazine.com/bethesda-beat/news/the-eight-biggest-snowstorms-to-hit-southern-montgomery-county/
[65] Federal Emergency Management Agency, "Winter Weather", 2020.
[66] Montgomery County Office of Emergency Management and Homeland Security, Hazard Mitigation Plan 2018; Montgomery County Government, Draft Climate Action Plan, 2020.
[67] Maryland Commission on Climate Change, "Re-examining Projected Climate Changes for Maryland, October 25, 2016, https://mde.maryland.gov/programs/Air/ClimateChange/MCCC/STWG/STWGRe-examinCC01252016.pdf

CLIMATE RISK #5 HURRICANES/TROPICAL STORMS

Definition of Risk. Tropical cyclones, which include tropical storms and hurricanes, are low-pressure systems that generally form over the tropics. As these storms move inland, they can cause severe flooding, structural damage, and downed trees and power lines. The three categories of tropical cyclones are:

- *Tropical depression* with a maximum sustained wind speed less than 39 mph;
- *Tropical Storm* with a maximum sustained wind speed of 39 to 73 mph; and
- *Hurricane* with a maximum sustained wind speed greater than 73 mph.[68]

Hurricanes are further categorized using the Saffir/Simpson scale based on sustained wind speed and potential property damage.

Table 2. Hurricane Classifications

Storm Category	Wind Speed (mph)	Damages
1	74-95	No significant structural damage
2	96-110	Some roofing material, door and window damage
3	111-130	Some structural damage to small residences and utility buildings
4	131-155	Extensive damage to roofs, windows, and doors and roods on small buildings completely fail
5	>155	Complete roof failure on many residences and industrial buildings with some small utility buildings damage

Source: 2018 Montgomery County Hazard Mitigation Plan

Profile of Hazard in Montgomery County. While the National Capital Region has been affected by many hurricanes, only two hurricanes since 2000 have either made landfall, passed through, or passed near D.C. and surrounding areas.[69] The most pressing threat that increased hurricane activity poses to the County is the resulting risk of extreme flooding events, which can shut down roads and other essential infrastructure.

Future Trends. A report released by the U.S. Global Change Research Program projects that hurricanes are anticipated to become more frequent and intense in the future and will bring greater amounts of precipitation and winds.[70]

[68] Montgomery County Office of Emergency Management and Homeland Security, Hazard Mitigation Plan 2018.
[69] WUSA9, Every Hurricane to Ever Hit the DMV, May 19, 2020, https://www.wusa9.com/article/weather/every-hurricane-to-ever-hit-dc-maryland-virginia/65-14f8191d-9eb6-4e30-9d6a-f45307f44df4
[70] The biggest threat that hurricanes pose to Maryland is to the Coastal Plain regions (Eastern and Western Shores). Maryland Commission on Climate Change, Comprehensive Assessment of Climate Change Impacts in Maryland, July 2008, https://mde.state.md.us/programs/Air/ClimateChange/Documents/FINAL-Chapt%202%20Impacts_web.pdf

CLIMATE RISK #6 EARTHQUAKES

Definition of Risk. Earthquakes are a sudden and violent shaking of the ground due to movements within the earth's crust or volcanic action. Earthquakes can affect a huge radius from the center and can cause structures to collapse. Earthquakes cannot be predicted.[71]

Profile of Hazard in Montgomery County. Earthquakes in Montgomery County are rare. The last recorded earthquake was in August 2011, which measured 5.8 on the Richter Scale. The epicenter was in Louisa County, VA. While there were no reports of significant damage in the County, some County facilities were closed temporarily.[72]

Future Trends. Currently, there are no reliable ways to predict when an earthquake will occur. Further, there are no reliable models for predicting earthquakes based on climate change projections. The United States Geological Survey focuses on the long-term mitigation of earthquake hazards by improving the safety of structures.[73]

[71] United States Geological Survey, Can You Predict Earthquakes?, 2020, https://www.usgs.gov/faqs/can-you-predict-earthquakes?qt-news_science_products=0#qt-news_science_products
[72] Washington Post, 5.8 Virginia Earthquake Shakes East Coast, Rattles Residents, 2011, https://www.washingtonpost.com/earthquake-rattles-washington-area/2011/08/23/gIQATMOGZJ_story.html
[73] United States Geological Survey, Can You Predict Earthquakes?, 2020.

B. Montgomery County Vulnerable Geographic Areas and Populations

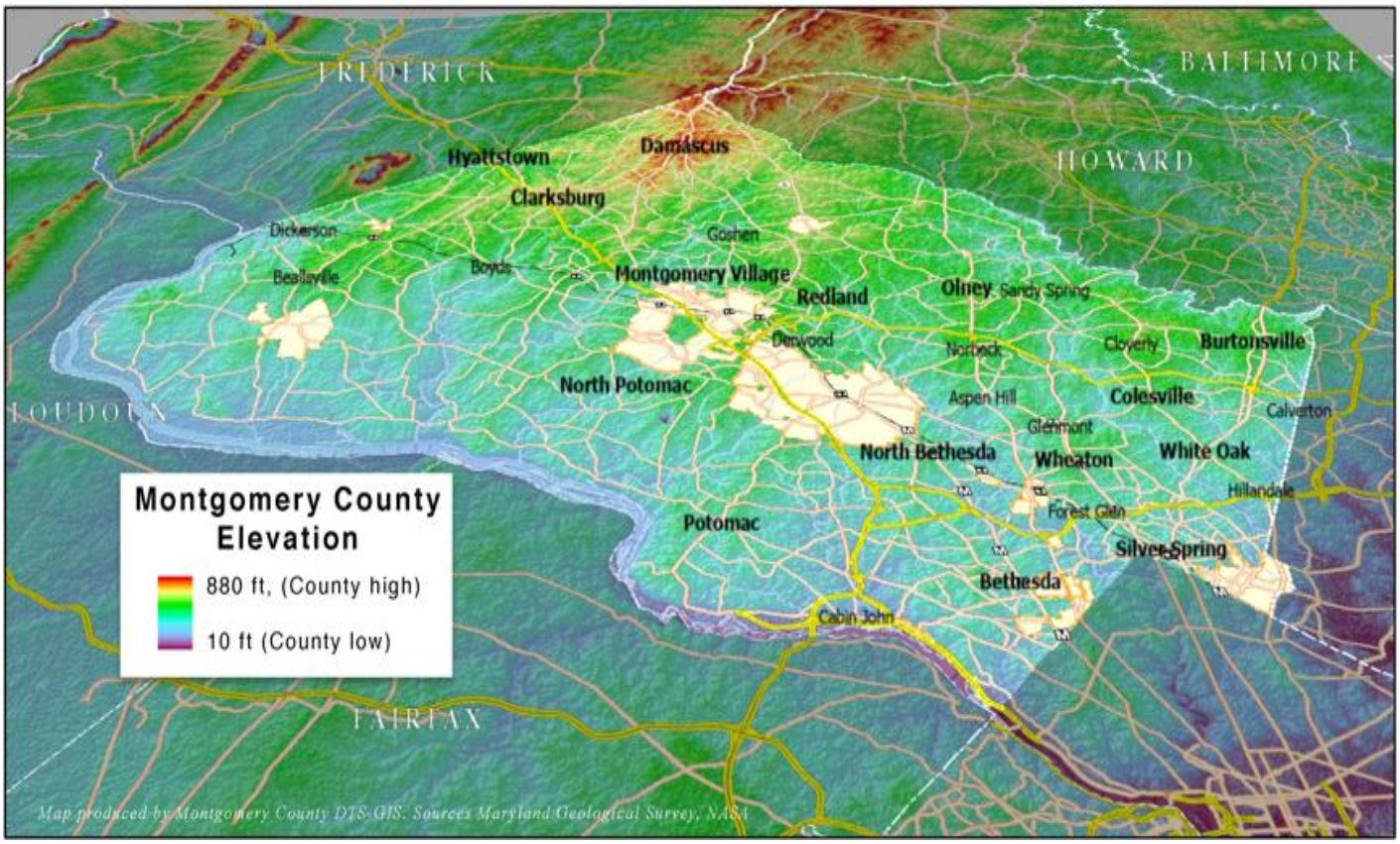
This section discusses vulnerable geographic areas and populations in Montgomery County and how climate change can disproportionately affect them.

1. Climate Risks and Vulnerable Geographic Areas

When deciding where to place new infrastructure at the local level, it is important to understand how topography can affect local weather and climate.[74] This section describes the extent to which geographic areas of Montgomery County could be affected by various climate risks.

Elevation. Different levels of elevation can experience varying intensity and prevalence of climate risks. As shown in the elevation map, Montgomery County is a relatively low-lying County with elevation ranging from 10 ft above sea level (areas near the Potomac River) to 880 ft above sea level (area near Damascus). In general, the southwest and southeastern areas of the County, especially near the Potomac River, tend to have lower elevations.

Map 2. Montgomery County Elevation Map



Source: DTS

[74] National Oceanic and Atmospheric Administration, The Highs and Lows of Climate, November 25, 2016, https://www.climate.gov/news-features/blogs/beyond-data/highs-and-lows-climate

Flooding. While flooding can occur anywhere, regardless of elevation, low-lying areas, especially those located near a body of water are particularly susceptible to flooding events. More research, such as hydrologic studies, is needed to understand the specific impacts that elevation has in the County in regard to the movement of water.

Extreme Precipitation. One of the greatest climate risks to the County is extreme precipitation, which can lead to flooding. Overall, 16 square miles out of the total County area of 507 square miles consists of water, which includes the nearly two dozen lakes scattered across the County.[75] Map 3 shows some of the most vulnerable roadways to flooding in Montgomery County.

Executive staff reported that the County suffers from flash floods and nuisance flooding.[76] Maps 4 and 5 show additional information on where floods can occur in the County – (1) where floods and flash floods were reported and then recorded by the National Weather Service (Map 4) and (2) where high and significant hazard dams are located in the County (Map 5). A map that shows high and significant hazard levees and dams owned and operated by the DEP can be found in Appendix D.

Extreme Temperatures. There is no area in the County high enough to experience a significant variation in temperatures based on elevation, as this normally occurs in mountainous areas (1000 ft above sea level and higher).

High Winds. There is no area in the County high enough to experience a significant variation in high winds based on elevation. Generally, winds increase more rapidly with height in mountainous areas (1000 ft or higher).[77]

Drought. In general, downslope areas typically have wetter soils than side slopes or ridges. Downslope areas may be less impacted than other areas by moderate drought, even in dry years. Hydrological studies are needed to determine the exact locations of the downslope, side slope, and ridges in the County and how they may be impacted differently during drought conditions.[78]

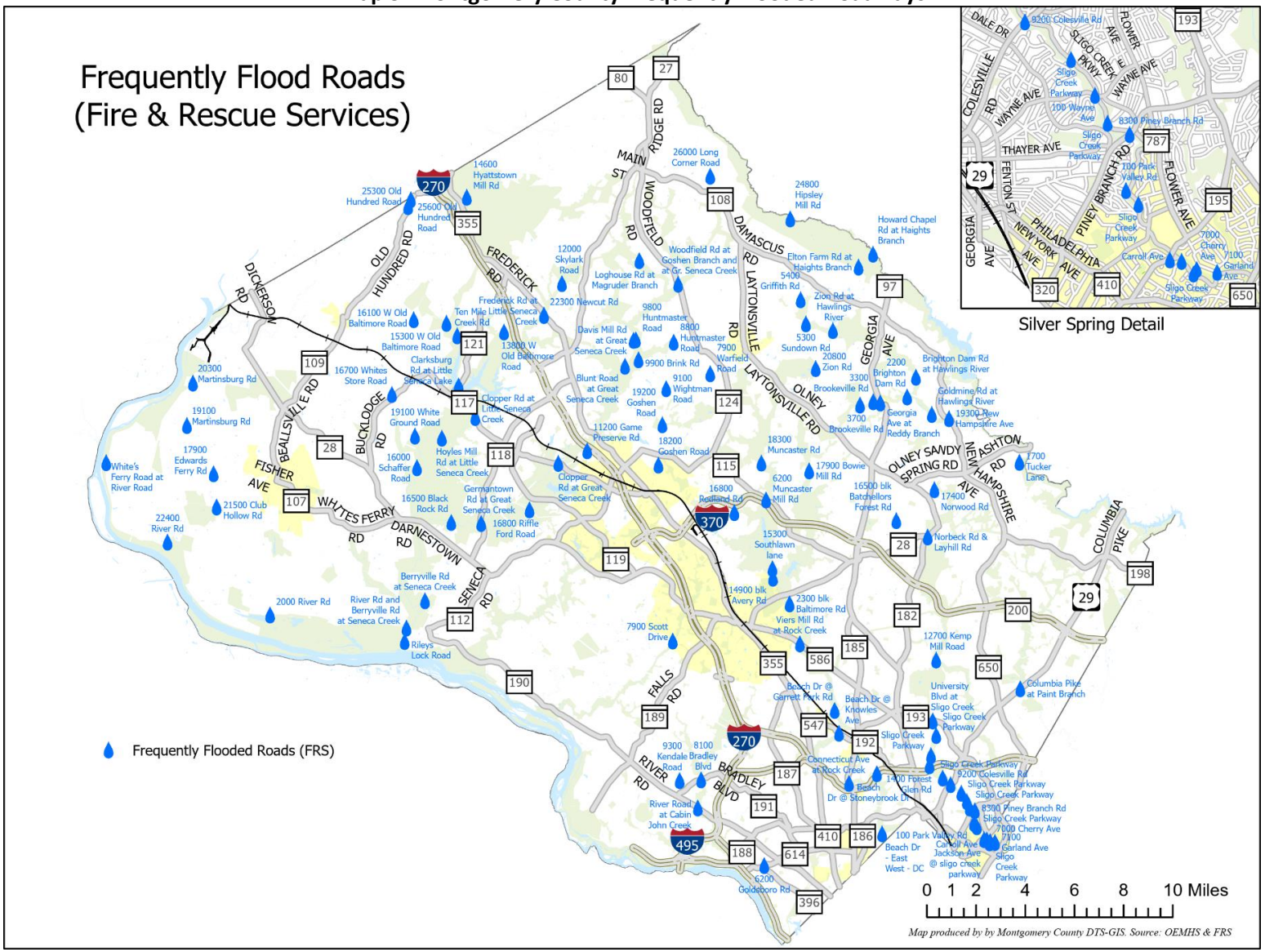
[75] Montgomery County, County Information, https://visitmontgomery.com/about/county-information/

[76] Flash floods can occur after a few minutes or hours of excessive rainfall or from a dam or levee failure. Nuisance flooding is defined as flooding that does not cause major property damage or seriously threaten public safety.

[77] National Oceanic and Atmospheric Administration, Air Pressure and Wind, https://www.weather.gov/media/zhu/ZHU_Training_Page/winds/pressure_winds/pressure_winds.pdf

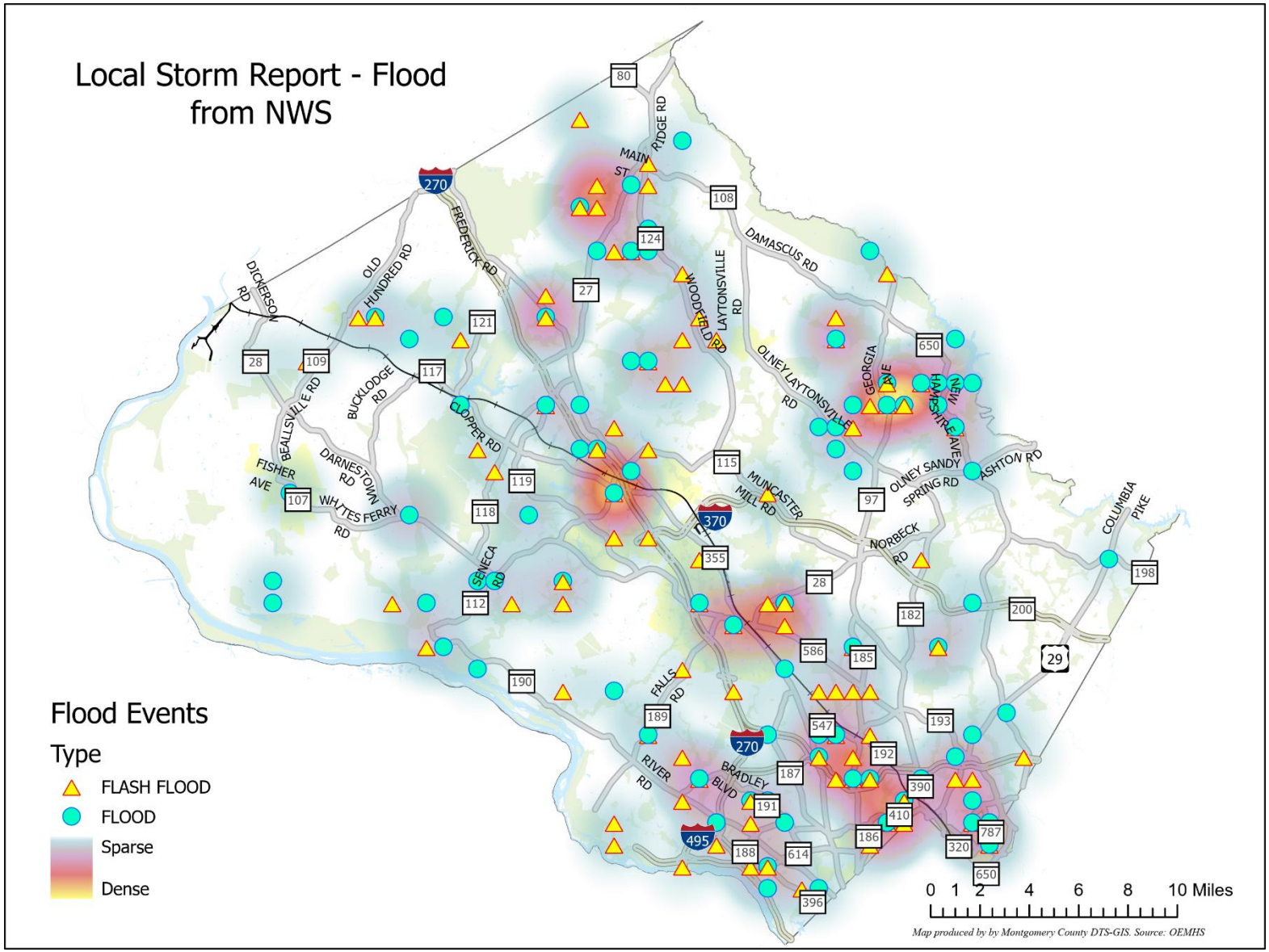
[78] United States Department of Agriculture, Topography May Mitigate Drought Effects on Vegetation Along a Hillslope Gradient, December 11, 2016, https://www.srs.fs.usda.gov/pubs/ja/2016/ja_2016_miniat_005.pdf

Map 3. Montgomery County Frequently Flooded Roadways



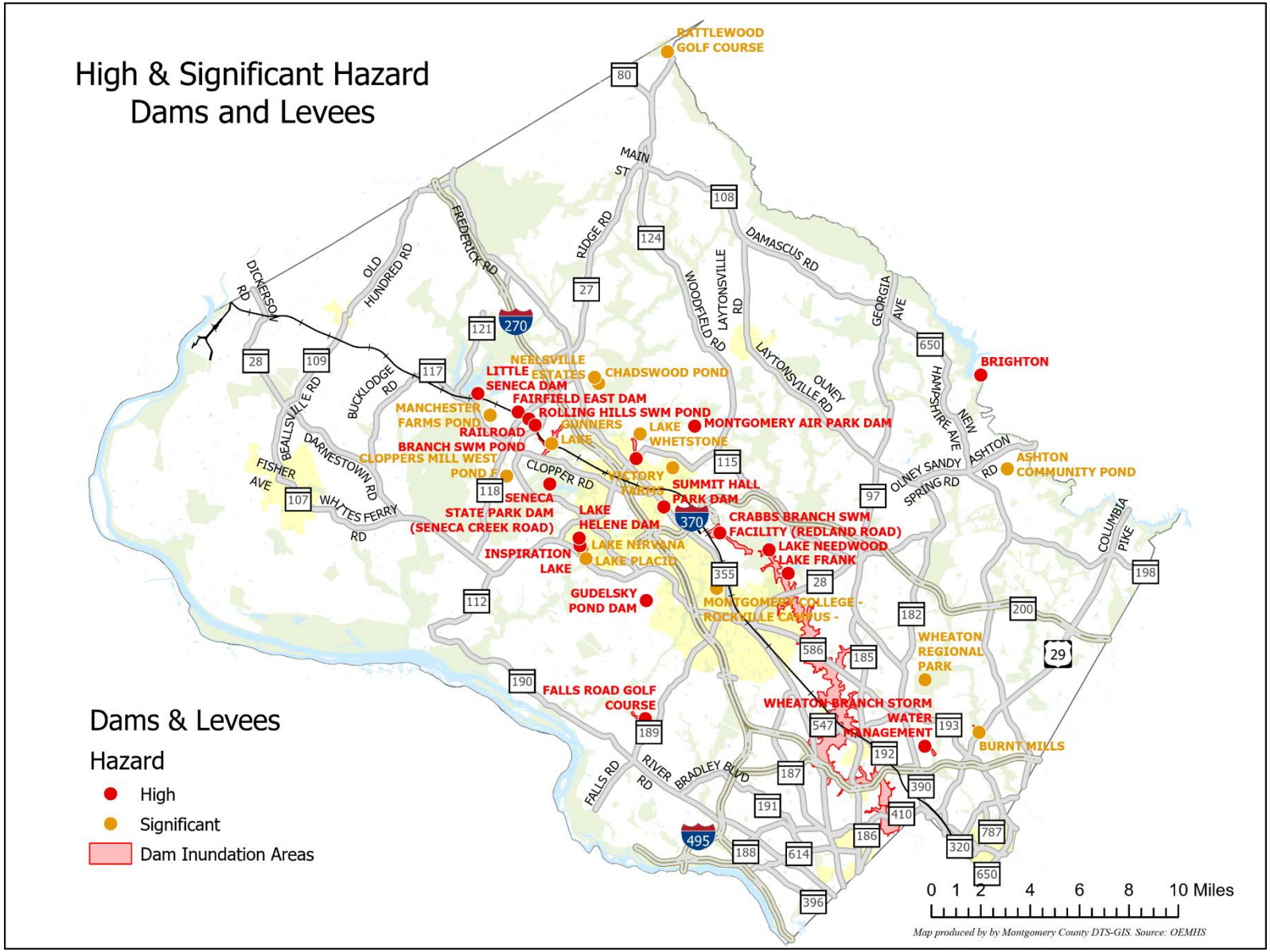
Source: DTS

Map 4. National Weather Service Location of Floods and Flash Floods



Source: DTS

Map 5. Location of High and Significant Hazard Dams and Levees



Source: DTS

2. Climate Risks and Vulnerable Populations

The "climate gap" refers to specific segments of the population who have the least resources and are disproportionately affected by climate change. Factors that contribute to increased climate vulnerability include:[79]

- Poverty;
- Age, disability, and chronic illness;
- Historical and systemic racism that is replicated in environmental injustices;
- Poor and inefficient housing;
- Lack of access to critical services (e.g., water, transportation, and energy); and
- Lack of access to resources (e.g., information, knowledge, and technology).

Low-income populations and communities of color are more vulnerable to extreme weather conditions as these events exacerbate existing health, financial, and other socioeconomic problems.[80] Some specific socioeconomic problems facing these communities include:

- Decades of underinvestment in infrastructure have led to increased vulnerability to natural disasters;[81]
- Geographic location near industrial sites, like chemical plants and refineries, increases vulnerability to toxic waste exposure during flooding events;[82]
- Location in urban areas are particularly vulnerable to the increased frequency of heat waves and the resulting heat island effects; and[83]
- Federal labor laws do not require employers to pay non-salaried workers for lost wages during a natural disaster, which disproportionately impacts low-income workers.[84]

Further, research shows low-income residents in high-income regions often have less access to information and resources to help them prepare for and avoid the negative health and economic risks that stem from extreme weather events.[85]

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[79] Montgomery County Government, Draft Climate Action Plan, 2020.
[80] Environmental Protection Agency, Climate Change, Public Health, and Environmental Justice: Caring for our Most Vulnerable Communities, January 5, 2017, https://blog.epa.gov/2017/01/05/ej-climate-change/
[81] Substance Abuse and Mental Health Services Administration, Greater Impact: How Disasters Affect People of Low Socioeconomic Status, July 2017, https://www.samhsa.gov/sites/default/files/dtac/srb-low-ses_2.pdf
[82] The Atlantic, Trump's EPA Concludes Environmental Racism is Real, February 28, 2018, https://www.theatlantic.com/politics/archive/2018/02/the-trump-administration-finds-that-environmental-racism-is-real/554315/
[83] Environmental Protection Agency, Reducing urban heat islands, 2008, https://www.epa.gov/heat-islands/heat-island-compendium
[84] U.S. Department of Labor, Fact Sheet #72: Employment and Wages Under Federal Law During Natural Disasters & Recovery, https://www.dol.gov/agencies/whd/fact-sheets/72-flsa-disasters-recovery
[85] U.S. Global Change Research Program, Fourth National Climate Assessment, 2018 https://nca2018.globalchange.gov/chapter/14/

Disaster Recovery. After an extreme weather event (such as a hurricane or a tornado) low-income residents often experience difficulty finding safe and affordable housing which is referred to as the "second disaster." Research shows that disaster recovery housing assistance often favors homeowners and middle-class populations – not low-income residents who are more likely to be renters.[86] Furthermore, the dispersal of federal aid after a disaster is not equitable. It was found that white families in communities with significant damage from natural disasters generally saw an increase in wealth from reinvestment initiatives, while minority families in communities with similar damages from natural disasters saw a significantly smaller increase in wealth, or even a decrease in wealth.[87] (See Appendix F for a fuller discussion on dispersal of disaster aid). OLO notes further study may be needed to determine the impacts of disaster aid dispersal to vulnerable populations in Montgomery County. Other challenges that marginalized populations can face during or after a disaster include:

- Disruptions to transportation infrastructure can have an increased impact on low-income residents who depend on public transit for transportation.
- Low-income households may be more exposed to heat waves, since they may not have access to or ability to pay for air conditioning.[88]

Vulnerable Populations in Montgomery County. Without significant policy interventions, it is likely that climate change and the subsequent increase of extreme weather events will reinforce and amplify current socioeconomic disparities.[89] The most vulnerable populations are indicated by poverty levels, age, and race among other factors. The following table provides a general overview of vulnerable populations in the County. To increase equity, it is important to expand investment in equitable, healthy, and climate change-ready community development projects among these populations, especially considering the COVID-19 pandemic.[90] (See Appendix G for a discussion on extreme heat impacts).

[86]U.S. Government Accountability Office, Federal Assistance for Permanent Housing Primarily Benefited Homeowners; Opportunities Exist to Better Target Rental Housing Needs, February 16, 2010, https://www.gao.gov/products/GAO-10-17

[87] Wealth refers to data collected from the Panel Study of Income Dynamics (PSID), which includes reported values of all checking and saving accounts, real estate holdings, vehicles, stocks, annuities, and other savings at the immediate family level and subtracts this from the sum of all reported debts. In the study, individual families' wealth was tracked from 1999-2013.

[88] Scientific American, Extreme Weather Hits Poorest Hardest, July 28, 2014, https://www.scientificamerican.com/article/extreme-weather-hits-poorest-hardest/

[89] Journal of Climatic Change, The Climate Gap: Environmental Health and Equity Implications of Climate Change And Mitigation Policies In California- A Review Of The Literature, November 24, 2011, https://escholarship.org/content/qt4815h61w/qt4815h61w.pdf

[90] Centers for Disease Control and Prevention, Health Equity Considerations and Racial and Ethnic Minority Groups, July 24, 2020, https://www.cdc.gov/coronavirus/2019-ncov/community/health-equity/race-ethnicity.html

Table 3. Montgomery County Population in Identified Vulnerable Populations (2019)[91]

Population Characteristic	County Population	% of Total County Population
Race/Ethnicity		
Black or African American	211,188	20.1%
American Indian and Alaska Native	7,354	0.7%
Asian	163,907	15.6%
Native Hawaiian or other Pacific Islander	1,051	0.1%
Latinx	211,188	20.1%
Socioeconomic/Housing		
Persons Living in Poverty	76,700	7.3%
Households that Rent	131,791	35.3%
Rent-Burdened Renters (Paying 35% or more of Household Income)	149,711	40.1%
Persons without a Home*	647	.06%
Persons Living Alone (18 Years and Over)	58,848	5.6%
Combined Persons Employed in Agriculture and Construction Industry	34,847	3.3%
Age		
Persons 65 Years and Over	169,044	16.1%
Persons Under 5 Years	64,618	6.2%
Other		
Persons with a Disability	83,602	7.9%

Sources: OLO; U.S. Census 2019; MCG 2019; MNPPC 2019

[91] United States Census Bureau, https://www.census.gov/quickfacts/montgomerycountymaryland ; Montgomery County Government, Ending Homelessness in Montgomery County, https://www.montgomerycountymd.gov/Homelessness/Numbers.html; The Maryland-National Capital Park and Planning Commission, Montgomery County Trends A Look at People, Housing and Jobs Since 1990, January 2019, https://montgomeryplanning.org/wp-content/uploads/2019/01/MP_TrendsReport_final.pdf

C. Estimated County Costs of Significant Weather Events Since 2000

To understand the financial impact of extreme weather events, OLO reviewed available cost data from previous storms.[92] This section presents cost data collected by OEMHS and the County's snow and storm removal budget. Below is a list of storm events in the past 20 years that were declared major disasters by FEMA and included Montgomery County in the designated areas for public assistance. [93]

Table 4. FEMA Declared Disasters that Designated Montgomery County as Eligible for Public Assistance, 2000-2020

Dates of Event	Description of Event and Disaster Declaration ID
January 25, 2000 - January 30, 2000	Maryland Winter Storm (DR-1324-MD)
September 18, 2003 - September 29, 2003	Hurricane Isabel (DR-1492-MD)
June 22, 2006 - July 12, 2006	Severe Storms, Flooding, and Tornadoes (DR-1652-MD)
December 18, 2009 - December 20, 2009	Severe Winter Storm and Snowstorm (DR-1875-MD)
February 5, 2010 - February 11, 2010	Severe Winter Storm and Snowstorm (DR-1910-MD)
June 29, 2012 - July 8, 2012	Severe Storms and Straight-line Winds (DR-4075-MD)
October 26, 2012 - November 4, 2012	Hurricane Sandy (DR-4091-MD)
January 22, 2016 - January 23, 2016	Severe Winter Storm and Snowstorm (DR-4261-MD)

Source: FEMA

Out of the eight declared disasters, OEMHS had the costs for two, the 2012 derecho and Hurricane Sandy. Data on earlier declarations (before 2008) is not available. OEMHS staff report two reasons for this lack of data – (1) earlier data were not stored in computer files and instead are kept in storage boxes, and (2) data was not transferred when OEMHS became a stand-alone office in 2008.

Generally, OEMHS only collects costs that either were submitted or would likely be submitted to FEMA for public assistance. OEMHS does not track all County department costs, only those eligible for public assistance, such as overtime costs. In addition to cost data for the two declared disasters, OEMHS provided cost data for two preliminary wind events. The wind event costs did not rise to the public assistance threshold required for a disaster declaration (Table 5).[94]

[92] Stakeholders and OLO note that it is difficult to project costs of inaction.
[93] Federal Emergency Management Agency, Declared Disasters, https://www.fema.gov/disasters/disaster-declarations
[94] Stakeholder Interviews.

Table 5. County Storm Cost Data Collected by OEMHS

Event	Response	Type of Costs	Cost
Derecho June / July 2012	Debris Removal	Labor, Contractors, Equipment, Materials	$7,893,185
Hurricane Sandy - September 2012	Debris Removal	Labor, Contractors, Equipment, Materials	$1,881,576
Wind Event March 2018	Debris Removal	Labor, Contractors, Equipment, Materials	$77,286 (preliminary estimate)
Wind Event March 2018	Building Damage	Roof Damage - MCDC Seven Locks	$20,000 (preliminary estimate)

Source: OEMHS

OLO found that storm cost data is fragmented across departments and there is no central repository tracking County storm cost data. Instead, departments track costs related to their response and recovery actions after a disaster. Specifically:

- DOT tracks the costs to clean roads (e.g., snow and debris removal);
- DGS tracks the facility clearing, damage, and fleet costs;
- DEP is responsible for debris management;[95]
- MCPS, FRS, and HHS track their response costs; and
- If a disaster is declared by FEMA, OEMHS works with County departments to determine eligible costs to submit to FEMA for funding.[96]

OLO also examined Montgomery County Department of Transportation's Snow and Storm Removal budget and expenditures (Table 6). The County generally underestimated the costs of snow and storm removals however, OLO notes this is a generally accepted practice among local governments.[97] Due to report timelines and length of time to collect data from departments, staff time and investment are needed to fully understand the scope of weather-related costs to the County.

[95] During the 2012 derecho, DEP had a role in managing the debris that resulted from the storm. The storm debris was predominantly wood from fallen trees. In July 2012, the grinding operation at the Transfer Station shipped over 22,000 tons of single grind wood. This included 1,187 tons from the Silver Spring Depot and 1,200 tons from the Gude Landfill (temporary receiving sites). The July 2012 total tons of Singled Grinded Wood was five times greater than the FY09 to FY12 average for the same month.
[96] Stakeholder Interviews.
[97] *Ibid*.

Table 6. Montgomery County Department of Transportation
Snow and Storm Removal Budget and Expenditures, FY01-FY19[98]

Fiscal Year	Snow and Storm Budget	Total Expenditures	Difference	Notable Storms
FY01	$2,811,530	$5,093,250	($2,281,720)	"January Surprise Snowstorm"*
FY02	$2,489,830	$2,081,670	$408,160	
FY03	$2,596,151	$14,854,951	($12,258,800)	Maryland Snowstorm*
FY04	$2,654,243	$16,550,495	($13,896,252)	Hurricane Isabel*
FY05	$2,903,963	$10,549,283	($7,645,320)	Remnants of Hurricane Jean
FY06	$3,058,330	$8,816,030	($5,757,700)	Hurricane Katrina, Severe storms, flooding and tornadoes*, Extreme precipitation which led to Lake Needwood Dam leak
FY07	$3,297,525	$15,203,575	($11,906,050)	February 2007 Blizzard
FY08	$3,316,130	$11,750,600	($8,434,470)	Derecho of June 2008
FY09	$3,528,630	$12,785,170	($9,256,540)	Above average occurrence of Severe Thunderstorms
FY10	$3,243,000	$64,097,250	($60,854,250)	The Holiday Blizzard of 2009*, Snowmageddon*
FY11	$3,649,210	$27,062,140	($23,412,930)	Severe line of Thunderstorms in August 2010
FY12	$9,000,000	$7,611,377	$1,388,623	
FY13	$9,156,978	$24,305,483	($15,148,505)	The 2012 Derecho*, Hurricane Sandy*
FY14	$9,099,050	$37,958,700	($28,859,650)	Severe storms in May 2014 that brought golf ball sized hail and high winds
FY15	$9,166,708	$32,912,572	($23,745,864)	27 Separate Snow & Ice events that accumulated a total of 46.6 inches
FY16	$9,228,749	$39,166,258	($29,937,509)	Winter Storm Jonas*
FY17	$9,227,197	$10,656,139	($1,428,942)	Severe Winter Storm and Snowstorm*
FY18	$6,262,006	$18,237,460	($11,975,454)	March 2018 Nor'easter
FY19	$6,302,368	$20,803,455	($14,501,087)	Tropical Storm Michael
Average	**$5,315,347**	**$20,026,098**	**($14,710,751)**	

Source: DOT
*Refers to FEMA declared disasters in the County

[98] Table does not include Department of General Services snow costs.

Chapter 3. Overview of Critical Infrastructure Sectors

The U.S. Cybersecurity and Infrastructure Security Agency (CISA) identifies 16 critical infrastructure sectors "whose assets, systems, and networks, whether physical or virtual, are considered so vital to the United States that their incapacitation or destruction would have a debilitating effect on security, national economic security, national public health or safety, or any combination of these things." For this report, OLO focused on six of these sectors. Four of the six sectors provide lifeline functions (transportation, water, energy, and communications), which means that "their reliable operations are so critical that a disruption or loss of one of these functions will directly affect the security and resilience ... across numerous sectors."[99] These sectors were selected based on Councilmember and stakeholder feedback. This chapter contains high-level profiles for each of the six critical infrastructure sectors reviewed by OLO. For each profile, OLO:

- Defines the sector;
- Highlights selected sector dependencies;
- Lists responsible County departments or offices;
- Identifies County-specific assets;[100]
- Highlights sector-related climate and infrastructure risks; and
- Presents potential next steps to address climate and infrastructure risks.

Sector Profiles

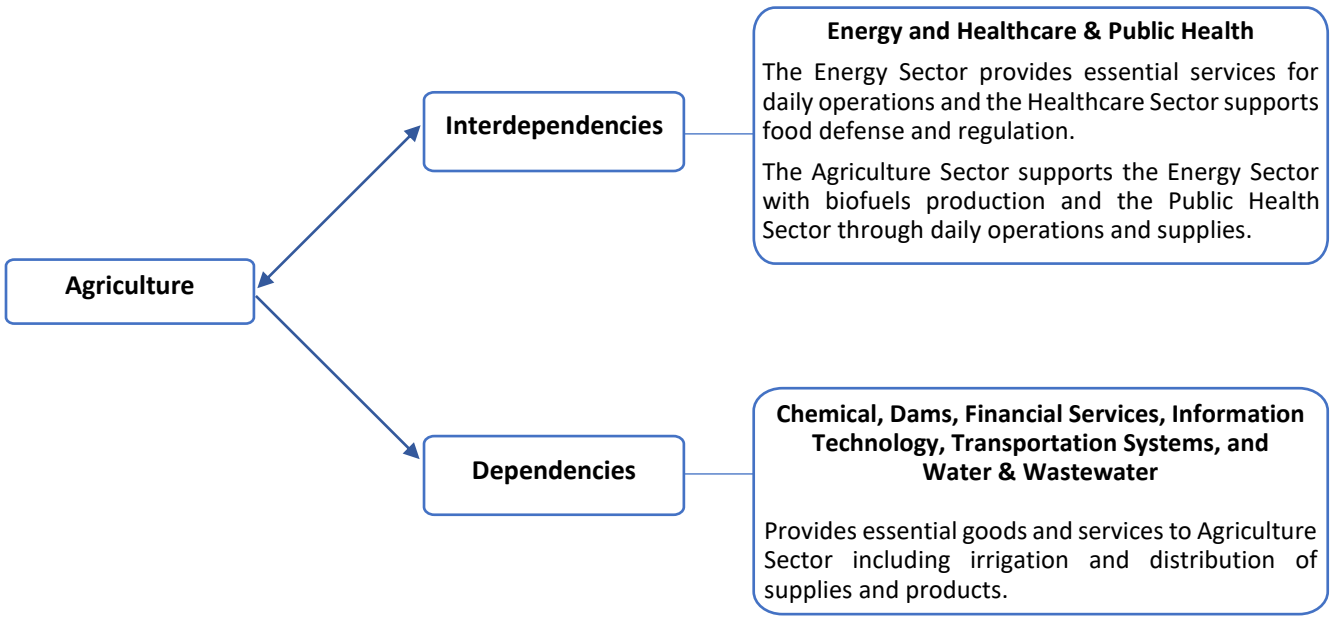
[99] U.S. Cybersecurity and Infrastructure Agency, A Guide to Critical Infrastructure and Resilience, November 2019, https://www.cisa.gov/sites/default/files/publications/Guide-Critical-Infrastructure-Security-Resilience-110819-508v2.pdf

[100] Due to report scope, OLO limited its identification of critical assets to the sectors reviewed. OLO acknowledges that Montgomery County has other critical infrastructure assets in the remaining ten U.S. DHS Critical Infrastructure Sectors. For example, police and fire assets are included under the Emergency Services Sector and shelters and centers for public health (such as vaccination sites) are included under the Healthcare and Public Health Sector. OLO notes future opportunities to review these sectors are available at the Council's request.

AGRICULTURE SECTOR

Agriculture is part of the Food and Agriculture Sector, which covers animal and crop supply chains to food supply, storage, and consumption.[101] The Food and Agriculture Sector is composed of an estimated 2.1 million farms, 935,000 restaurants, and more than 200,000 registered food manufacturing, processing, and storage facilities nationwide.[102] For this report, OLO limited its review to the Agriculture Sector in Montgomery County and did not include the Food Sector.

AGRICULTURE SECTOR DEPENDENCIES AND INTERDEPENDENCIES. Sectors may be dependent and interdependent on one another, which can lead to multi-sector disruptions following threats (known as "cascading failures"). The following highlights dependencies and interdependencies for the Agriculture Sector identified by the U.S. Department of Homeland Security. An *interdependency* is a bidirectional relationship, where the operations of sector A affect the operations of sector B, and vice versa. A *dependency* is a unidirectional relationship where the operations of sector A are reliant on the operations of sector B. Sectors listed may be outside the scope of this OLO report.[103]



Source: U.S. DHS

[101] U.S. Cybersecurity and Infrastructure Security Agency, Food and Agriculture Sector-Specific Plan, 2015, https://www.cisa.gov/publication/nipp-ssp-food-ag-2015

[102] U.S. Department of Agriculture, Ag and Food Statistics, https://www.ers.usda.gov/webdocs/publications/96957/ap-083.pdf?v=1803.7; U.S. Department of Homeland Security, Sector Risk Snapshots 2014, https://www.hsdl.org/?abstract&did=754033

[103] U.S. Cybersecurity and Infrastructure Security Agency, Food and Agriculture Sector-Specific Plan 2015. https://www.cisa.gov/food-and-agriculture-sector ; U.S. Department of Homeland Security, Sector Risk Snapshots, 2014; U.S. Department of Energy, Argonne National Laboratory, Analysis of Critical Infrastructure Dependencies and Interdependencies, June 2015, https://publications.anl.gov/anlpubs/2015/06/111906.pdf

AGRICULTURE SECTOR CONT'D.

SECTOR OWNERSHIP AND LEAD COUNTY DEPARTMENT. The Sector is almost entirely under private ownership. For emergency planning, the County designates lead departments and offices to manage planning, response, and recovery efforts. The following County departments and offices serve as the sector-specific agencies:[104]

- Department of Health and Human Services (Lead)
- Office of Agriculture
- Office of Emergency Management and Homeland Security
- Montgomery County Police Department

COUNTY ASSETS. Montgomery County is home to 558 farms, accounting for 21.3% of land in the County. Most farms are family-run and employ more than 10,000 people in total. Crop land in the Agricultural Reserve is 15% to 50% cultivated.[105] Additional statistics include:

- 81.3% of farms in the County produce food for direct human consumption;
- Agriculture contributes $281 million to the County's economy; and
- The predominant use of agricultural land in the County is for grain farms, much of which supports Eastern Shore chicken farms and local livestock farms.[106]

AGRICULTURE SECTOR CLIMATE RISKS. The Sector's open nature and global interconnectivity leave agriculture assets vulnerable to a variety of hazards, including severe weather, pests, and disease.[107] The following highlights the impacts of select climate risks.[108]

[104] Montgomery County Office of Emergency Management and Homeland Security, Critical Infrastructure and Key Resource Protection Plan, December 2020.
[105] Montgomery County Office of Emergency Management and Homeland Security, Hazard Mitigation Plan, 2018
[106] Montgomery County Office of Agriculture, Ag Facts, https://montgomerycountymd.gov/agservices/ag-facts.html; Montgomery County Ag Fact Sheet, https://montgomerycountymd.gov/agservices/Resources/Files/2017AGCensusMCFactSheetFINAL.pdf
[107] U.S. Department of Homeland Security, Sector Risk Snapshots 2014, https://www.hsdl.org/?abstract&did=754033; U.S Environmental Protection Agency, Climate Impacts of Agriculture and Food Supply, https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-agriculture-and-food-supply_.html
[108] U.S Environmental Protection Agency, Climate Impacts of Agriculture and Food Supply; U.S. Department of Agriculture, Northeast Regional Hub Vulnerability Assessment, https://www.climatehubs.usda.gov/sites/default/files/Northeast%20Regional%20Hub%20Vulnerability%20Assessment%20Final.pdf; Montgomery County Ag Fact Sheet; Stakeholders Interviews.

AGRICULTURE SECTOR CONT'D.

RISK	SECTOR IMPACT
Temperature Increase	• Changes the migration and reproduction of aquatic animals • Increases risk of disease and increased use of pesticides to manage disease • Results in the inability to grow crops
Extreme Precipitation	• Reduces crop yields which can threaten food security • Produces soil erosion, reduces number of workable field days, delays planting of crops, and increases excess runoff of fertilizers and pesticides
Extreme Temperature	• Increases risk of disease and reduced animal fertility • Impacts on livestock health due to the prevalence of heatwaves • Decreases bee pollination due to heatwaves which decreases crop yields
Drought	• Results in significant crop loss • Lowers crop yields and increases reliance on irrigation during summer months • Reduces availability of pastures and land
Carbon Dioxide Increase[109]	• Reduces nutritional value in crops • Increases number of weeds/pests and use of pesticides
High Wind	• Results in damage to crops (particularly fruit and vegetable crops) and farm structures

Source: EPA; USDA; Montgomery County Office of Agriculture

AGRICULTURE SECTOR INFRASTRUCTURE RISKS. The Office of Agriculture reported several risks to the County's agriculture industry:

- **Forty percent of farmers rent land in the Agricultural Reserve.** This impacts the ability of farmers to improve agricultural structures due to lease length and terms.
- **Aging agricultural ponds are essential to crop irrigation.** Many ponds are at capacity and restoration must comply with federal standards. Restoration is expensive and requires technical expertise.
- **Over 300 properties in the Agriculture Reserve lack internet access.** Lack of access limits accessibility to County and State information and connections to other sectors.
- **The pandemic exposed inabilities to pivot market streams.** Farmers, who relied on restaurants, had difficulty transitioning to meet other consumer demand and livestock producers lost the ability to process products due to outbreaks at regional processing plants.

[109] Office of Agriculture staff note that the agricultural community is uniquely positioned to contribute significant amounts of carbon sequestration through conservation and best management practices. The Office of Agriculture reports 10 years of data showing best management practice implementation and their corresponding reductions of greenhouse gases/carbon sequestered and reductions of nitrogen and phosphorus. This data is available at https://montgomerycountymd.gov/agservices/

AGRICULTURE SECTOR CONT'D.

EMERGENCY MANAGEMENT AND IDENTIFICATION OF GAPS. OLO identified actions from the County's Draft Climate Action Plan (DCAP) and stakeholder interviews that could address climate and infrastructure risks identified for the Agriculture Sector.[110] Actions to address infrastructure risks may also address climate risks. For potential actions to address climate risks, obtained from the DCAP, OLO selected actions the County has the authority to implement, however these actions may require new policy or a policy amendment. OLO has not evaluated the potential actions to address climate or infrastructure risks for prioritization. These recommended actions align with the Four Phases of Emergency Management in Chapter One.

	Preparedness	Mitigation	Response	Recovery
POTENTIAL ACTIONS TO ADDRESS CLIMATE RISKS				
Enhance use of regenerative agriculture (a set of practices focused on conservation and rehabilitation of food and farming systems)		✓	✓	
Restoring soil fertility, microbial activity, and moisture holding capacity to improve carbon, water, and energy cycles		✓	✓	
Expanded community gardens to offer an accessible way for residents to grow food for consumption and sales	✓		✓	
POTENTIAL ACTIONS TO ADDRESS INFRASTRUCTURE RISK				
Identify impacts of land lease agreements on hardening of critical agricultural assets, such as ponds	✓	✓		
Identify resources needed to aid the County's farming community in pond restoration	✓	✓		
Improve and maintain networks established during the pandemic to create a more robust local food distribution network			✓	✓
Work with the Communications Sector stakeholders to identify properties in the Agricultural Reserve that lack access to an internet service provider	✓			

[110] Stakeholder Interviews; Montgomery County Government, Draft Climate Action Plan 2020. US Department of Agriculture, Cover Cropping to Improve Climate Resilience, https://www.climatehubs.usda.gov/hubs/northeast/topic/cover-cropping-improve-climate-resilience ; R. Islam, et. al. No-till and conservation agriculture in the United States: An example from the David Brandt farm, Carroll, Ohio, International Soil and Water Conservation Research, 2014, https://www.sciencedirect.com/science/article/pii/S2095633915300174; U.S Environmental Protection Agency, Climate Impacts of Agriculture and Food Supply.

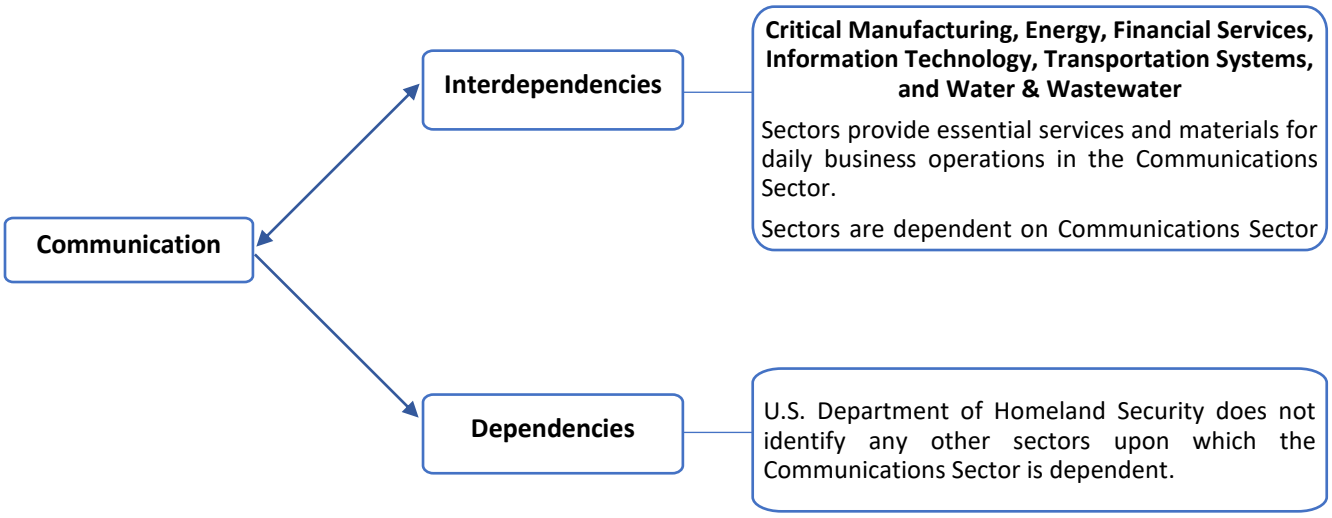
COMMUNICATIONS SECTOR

The Communication Sector is integral to the economy and the operations of all businesses, public safety organizations, and government. Since the late 1990s, the Sector has evolved from predominantly voice services into a diverse industry using terrestrial, satellite, and wireless transmission services.[111] For this report, OLO focuses on County-operated wireline and broadcasting communication infrastructure:

- **Wireline Communications** – Includes telephone, cable, and enterprise networks, as well as internet infrastructure and submarine cable infrastructure.

- **Broadcasting** – Includes free over-the-air radio and television stations.[112]

COMMUNICATIONS SECTOR DEPENDENCIES AND INTERDEPENDENCIES. Sectors may be dependent and interdependent on one another, which can lead to multi-sector disruptions following threats (known as "cascading failures"). The following highlights dependencies and interdependencies for the Communications Sector identified by the U.S. Department of Homeland Security (DHS). An *interdependency* is a bidirectional relationship, where the operations of sector A affect the operations of sector B, and vice versa. A *dependency* is a unidirectional relationship where the operations of sector A are reliant on the operations of sector B. Sectors listed may be outside the scope of this OLO report.[113]



Source: U.S. DHS

[111] U.S. Department of Homeland Security, Sector Risk Snapshots 2014, https://www.hsdl.org/?abstract&did=754033
[112] U.S. Department of Homeland Security, Sector Risk Snapshots 2014, https://www.hsdl.org/?abstract&did=754033
[113] U.S. Cybersecurity and Infrastructure Security Agency, Communication Sector-Specific Plan 2015, https://www.cisa.gov/sites/default/files/publications/nipp-ssp-communications-2015-508.pdf; U.S. Department of Homeland Security, Sector Risk Snapshots, 2014; U.S. Department of Energy, Argonne National Laboratory, Analysis of Critical Infrastructure Dependencies and Interdependencies, June 2015, https://publications.anl.gov/anlpubs/2015/06/111906.pdf

COMMUNICATIONS SECTOR CONT'D.

SECTOR OWNERSHIP AND LEAD COUNTY DEPARTMENT. The Sector is almost entirely under private ownership. For emergency planning, the County designates lead departments and offices to manage planning, response, and recovery efforts. The following departments and offices serve as the sector-specific agencies:[114]

- Department of Technology Services (Lead)
- Office of Public Information
- Fire and Rescue Services
- Office of Emergency Management and Homeland Security
- Montgomery County Police Department

COUNTY ASSETS. The following highlights key infrastructure components of County government wireline and broadcast infrastructure.[115]

FiberNet. County services and operations depend on the County's FiberNet infrastructure. There are three categories of FiberNet infrastructure in use. Staff report that data servers are housed both in central County locations and individual departments and offices.

- FiberNet 1 provides radio networks for County operations including police, fire, corrections, and park police. Stakeholders report that new microwave towers will be operational this winter.
- FiberNet 2 provides Cisco network services for all County communications and resources. This includes County government, Montgomery County Public Schools, the Washington Suburban Sanitation Commission, the Maryland-National Capital Park and Planning Commission, and Montgomery College.
- FiberNet 3 infrastructure includes a cloud storage data center in Ashburn, VA and is projected to be operational by the end of 2021. This will enable faster operations for end-users, assist with teleworking, and reduce risk.[116]

Broadcast. Among other duties, the Office of Cable Communications (part of the Department of Technology Services) is responsible for administering cable television franchise agreements for the County, facilitating the entry of telecom providers, and managing the County government access channel.[117] Stakeholders report that during emergency events, the Office will communicate major weather conditions, work with traffic management to provide up-to-date information, report on government and school closures, and provide the status of snow removal and cleanup. Announcements are made on all public access channels and social media.

[114] Montgomery County Office of Emergency Management and Homeland Security, Critical Infrastructure and Key Resource Protection Plan, December 2020.
[115] Stakeholder Interviews.
[116] Stakeholder Interviews.
[117] Montgomery County Office of Cable Communications, About Us, https://montgomerycountymd.gov/cable/about.html

COMMUNICATIONS SECTOR CONT'D.

COMMUNICATIONS SECTOR CLIMATE RISKS. Public and private entities share responsibility for securing critical communications infrastructure.[118] The following highlights the impact of climate risks on the Communications Sector. These events are increasing in frequency and severity.[119]

RISK	SECTOR IMPACT
Temperature Increase	• Results in potential changes to infrastructure locations to adapt to higher temperatures • Reduces service quality • Increases business costs to maintain infrastructure and provide service reliability
Extreme Precipitation	• Increases in humidity can degrade structures • Increases flood risk to facilities and risk of damages to transport structures • Reduces services and increases operational costs
Extreme Temperature	• Increases likelihood that data centers, exchanges, and base station will overheat – leading to service disruptions • Increases risk of health and safety risks for crews
Drought	• Increases risk of sinking and instability of structures • Reduces available water for cooling of communication infrastructure • Increases risk of fires which threaten infrastructure
High Wind	• May cause damage to above-ground transmission infrastructure

Source: United Nations; U.S. GSA; U.S. DHS; Montgomery County Department of Technology Services

COMMUNICATIONS SECTOR INFRASTRUCTURE RISKS. The Department of Technology Services reported several risks to the County's communication infrastructure. These include:

- **County refreshes IT equipment every fifteen years**. The industry standard is five to seven years and stakeholders report that aging IT infrastructure places the County at risk for service outages.
- **Several County buildings will not be able to upgrade its FiberNet infrastructure to FiberNet 3 due to building age.** Several buildings would require hundreds of thousands of dollars in investments to be able to take advantage of technology upgrades.
- **Majority of the FiberNet network is above ground**. Three-quarters of the County's FiberNet network is in overhead transmission lines, which can be significantly impacted by severe weather.
- **Underground networks are also at risk**. Hazards, specifically water main breaks, put underground networks at risk.
- **Majority of County equipment is located in the basement or first floor levels of County buildings**. These assets are at risk of flooding.

[118] U.S. Department of Homeland Security, Communications Sector Plan 2015, https://www.cisa.gov/sites/default/files/publications/nipp-ssp-communications-2015-508.pdf

COMMUNICATIONS SECTOR CONT'D.

- **Traffic signal equipment at risk due to rising temperatures.** Executive Branch staff report traffic signals are housed in aluminum boxes, which are not designed to handle extreme heat. Larger, noisier fans will be needed to cool equipment.
- **Majority of County buildings lack backup power for network capabilities**. Staff report that of the 500 buildings on the County's FiberNet network, only 20 buildings are reinforced with multiple pathways to ensure continued operations.
- **Migration to cloud services increases cyber-security threats**. The County is presently migrating data and operations to cloud systems. While this creates redundancies and ensures continued operations, it also presents an increased risk from cyber-threats. Technology is also essential for monitoring the status of critical infrastructure assets, but this opens the County to risk.
- **DTS establishes protocols to ensure security and resilience of critical infrastructure like data centers; however, many County departments have established their own data centers**. This limits the effectiveness of universal policies and uniform security and technology policies. Staff report difficulty ensuring these systems are protected.

COMMUNICATIONS SECTOR CONT'D.

EMERGENCY MANAGEMENT AND IDENTIFICATION OF GAPS. OLO identified actions from the County's Draft Climate Action Plan (DCAP) and stakeholder interviews that could address climate and infrastructure risks identified for the Communications Sector. Actions to address infrastructure risks may also address climate risks. For potential actions to address climate risks, obtained from the DCAP, OLO selected actions the County has the authority to implement, however these actions may require new policy or a policy amendment. OLO has not evaluated the potential actions to address climate or infrastructure risks for prioritization. These recommended actions align with the Four Phases of Emergency Management in Chapter One.[120]

	Preparedness	Mitigation	Response	Recovery
POTENTIAL ACTIONS TO ADDRESS CLIMATE RISKS				
Install a network of small temperature and humidity sensors to monitor heat and accurately report extreme temperatures to better monitor temperature impacts on equipment.	✓	✓	✓	
POTENTIAL ACTIONS TO ADDRESS INFRASTRUCTURE RISK				
Identify opportunities to decrease time between infrastructure updates.	✓			
Identify and plan for maintenance of overhead lines and infrastructure at risk due to extreme weather events.	✓	✓		
Identify opportunities to expand critical technology redundancies to ensure continued County and school operations.			✓	✓
Work with stakeholders to define and prepare for cyber-threats to County communication infrastructure.	✓			✓
Work with County departments to develop a policy for the location of servers and routine maintenance to protect against cyber and infrastructure threats.		✓	✓	✓

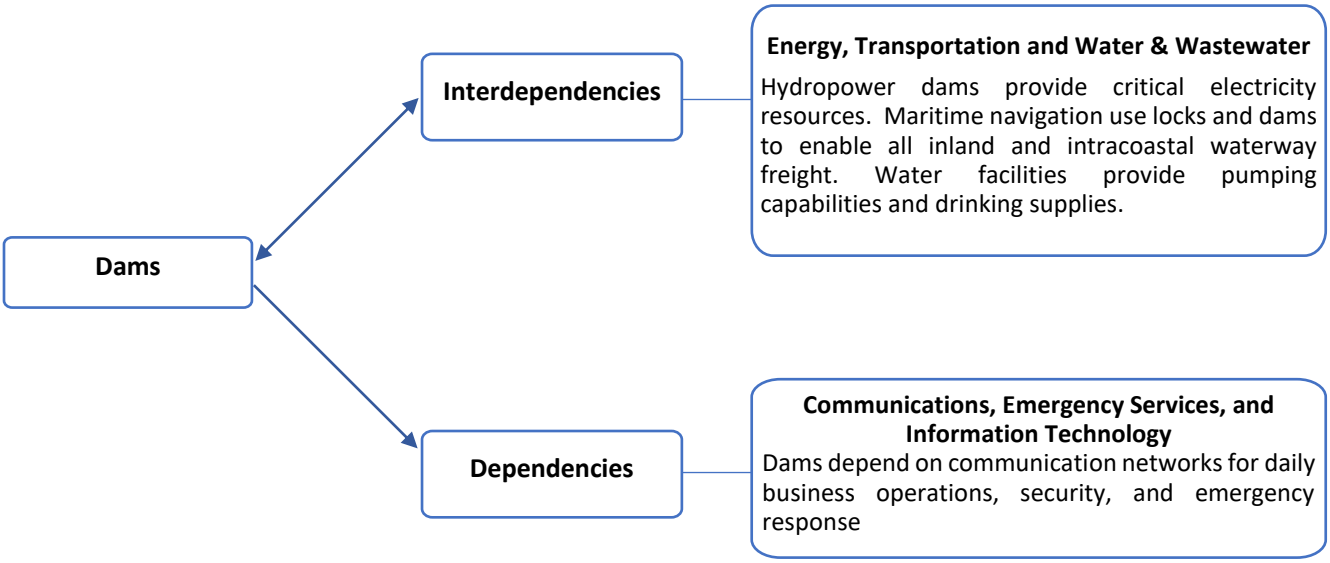
[120] Stakeholder Interviews; Montgomery County Government, Draft Climate Action Plan, 2020. U.S. General Services Administration, Climate Risks Study for Telecommunications and Data Center Services, https://toolkit.climate.gov/reports/climate-risks-study-telecommunications-and-data-center-services ; U.S. Department of Homeland Security, Communications Sector Plan 2015.

DAMS SECTOR

Dams provide critical water retention and control services in the United States, including municipal water supplies, agricultural irrigation, and flood control. The Dams Sector includes dams, levees, and navigation locks:

- **Dams** may include multiple water impoundment or control structures, reservoirs, spillways, outlet works, powerhouses, canals, or aqueducts;
- **Levees** are flood protection systems that contain, control, or divert the flow of water to reduce public safety risks from floods, rain, or extreme weather; and
- **Locks** create viable inland waterways for commercial/recreational traffic to move between rivers.[121]

DAMS SECTOR DEPENDENCIES AND INTERDEPENDENCIES. Sectors may be dependent and interdependent on one another, which can lead to multi-sector disruptions following threats (known as "cascading failures"). The following highlights dependencies and interdependencies for the Dams Sector identified by the U.S. Department of Homeland Security (DHS). An *interdependency* is a bidirectional relationship, where the operations of sector A affect the operations of sector B, and vice versa. A *dependency* is a unidirectional relationship where the operations of sector A are reliant on the operations of sector B. Sectors listed may be outside the scope of this OLO report.[122]



Source: U.S. DHS

[121] U.S. Cybersecurity and Infrastructure Security Agency, Dams Sector- Specific Plan, https://www.cisa.gov/publication/nipp-ssp-dams-2015

[122] *Ibid*.; U.S. Department of Homeland Security, Sector Risk Snapshots, 2014; U.S. Department of Energy, Argonne National Laboratory, Analysis of Critical Infrastructure Dependencies and Interdependencies, June 2015, https://publications.anl.gov/anlpubs/2015/06/111906.pdf

DAMS SECTOR CONT'D.

SECTOR OWNERSHIP AND LEAD COUNTY DEPARTMENT. In the County, public and private entities own dams (including homeowner's associations and golf courses).[123] Dams are regulated by the Maryland Department of Environment Dam Safety Division. For emergency planning, the County designates lead agencies to manage planning, response, and recovery efforts. The following departments and offices serve as the sector-specific agencies:[124]

- Department of Environmental Protection (Lead)
- Washington Suburban Sanitation Commission
- Office of Emergency Management and Homeland Security
- Maryland National Capital Park and Planning Commission

COUNTY ASSETS. The National Inventory of Dams (NID collects data from federal and state regulatory authorities for dams that meet the following characteristics:

- High or significant hazard potential; or
- Low hazard, but at least 25 feet high (and hold 15 acres of water) or hold at least 50 acres of water (and are at least six feet high).[125]

OEMHS and DEP provided OLO the following list of significant and high hazard dams in the County along with ownership. There are approximately 20 low hazard dams in the County, but several of these may transition to a significant or high hazard structure due to development and population growth.[126]

[123] Stakeholder Interviews.
[124] Montgomery County Office of Emergency Management and Homeland Security, Critical Infrastructure and Key Resource Protection Plan, December 2020.
[125] U.S. Cybersecurity and Infrastructure Security Agency, Dams Sector-Specific Plan. American Society of Civil Engineers, Report Card for Maryland's Infrastructure 2020, available at https://www.infrastructurereportcard.org/wp-content/uploads/2016/10/Maryland-ASCE-Report-Card-2020-Full-Sections.pdf
[126] Montgomery County Office of Emergency Management and Homeland Security. See Appendix D for maps on geographic areas susceptible to flooding due to dam failure.

DAMS SECTOR CONT'D

List of Significant and High Hazard Dams in Montgomery County and Ownership*

Maryland Department of Natural Resources
- Seneca Creek State Park Dam

Department of Environmental Protection
- Crabbs Branch SWM Dam
- Gunners Lake SWM Dam
- Manchester Farm Regional SWM Pond Dam
- Montclair Manor Levee
- Montgomery Auto Park Dam
- Railroad Branch SWM Pond
- Turkey Branch Levee
- Wheaton Branch SWM

Montgomery County Revenue Authority
- Falls Road Golf Course Dam
- Montgomery Airpark Dam
- Rattlewood Golf Course Irrigation Pond Dam

Maryland National Capital Park and Planning Commission
- Burnt Mills Dam
- Lake Needwood Dam
- Lake Bernard Frank
- Wheaton Regional Park Dam

Montgomery College
- Rockville Campus SWM Dam

University of Maryland- Shady Grove
- Gudelsky Pond Dam

City of Gaithersburg
- Inspiration Lake Dam
- Lake Helene Dam
- Lake Lynette Dam
- Lake Nirvana
- Lake Placid Dam
- Summit Hall Park Dam

Washington Suburban Sanitation Commission
- Little Seneca Dam
- Brighton Dam

Private Ownership
- Ashton Community Pond Dam
- Chadswood SWM Pond
- Clopper's Mill West Pond
- Fairfield East Dam
- Lake Walker Dam
- Lake Whetstone Dam
- Neelsville Estates Dam
- Rolling Hills SWM Pond
- West Farm Regional SWM Pond

*SWM stands for Stormwater Management

DAMS SECTOR CONT'D.

DAMS SECTOR CLIMATE RISKS. Dam failure could result in casualties, major destruction, and economic loss. Consequences are dependent on the scope of the incident, the asset's critical functions, system redundancies, population density, and regional infrastructure.[127] The following highlights the impact of climate risks on the Dams Sector.

RISK	SECTOR IMPACT
Erosion	• Creates an increased risk of failure through debris blockage or internal erosion
Extreme Precipitation	• Increases likelihood of frequent, severe flooding, which has the potential to overwhelm storage capacity • Climate change has undermined historical flood and precipitation assumptions that dam construction was based on, which increases risk of failure.
Drought	• Reduces available water flow in a reservoir
High Wind	• May topple trees, which creates voids or embankment losses, leading to potential dam failure

Source: U.S. CISA; U.S. Department of Energy; Yale School of the Environment;

DAMS SECTOR INFRASTRUCTURE RISKS. OEMHS reported several risks to the County's dam infrastructure.

- **Private ownership of dams impacts security**. Many dams are located on HOA and golf courses properties, which are often difficult to access.
- **Communication with private dam owners is lax**. Stakeholders report difficulty in establishing effective communication with dam owners. Often dam breaches are discovered when adjacent infrastructure is flooded.

[127] U.S. Cybersecurity and Infrastructure Security Agency, 2015 Dams Sector-Specific Plan, https://www.cisa.gov/sites/default/files/publications/nipp-ssp-dams-2015-508.pdf; U.S. Department of Energy, Office of Scientific and Technical Information, Current State-of-Practice in Dam Safety Risk Assessment, December 2019, https://www.osti.gov/servlets/purl/1592163/ Yale School of the Environment. Yale Environment 360, In an Era of Extreme Weather, Concerns Grow Over Dam Safety, July 9, 2019, https://e360.yale.edu/features/in-an-era-of-extreme-weather-concerns-grow-over-dam-safety

DAMS SECTOR CONT'D.

EMERGENCY MANAGEMENT AND IDENTIFICATION OF GAPS. OLO identified actions from the County's Draft Climate Action Plan (DCAP) and stakeholder interviews that could address climate and infrastructure risks identified for the Dams Sector. Actions to address infrastructure risks may also address climate risks. For potential actions to address climate risks, obtained from the DCAP, OLO selected actions the County has the authority to implement, however these actions may require new policy or a policy amendment. OLO has not evaluated the potential actions to address climate or infrastructure risks for prioritization. These recommended actions align with the Four Phases of Emergency Management in Chapter One.[128]

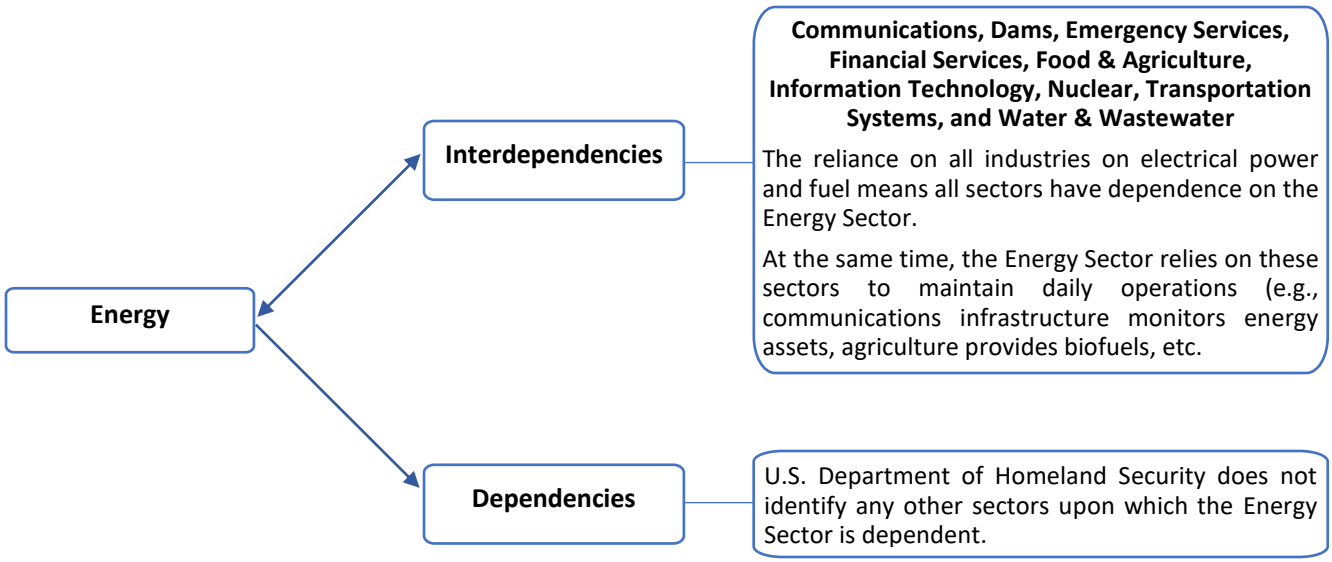
	Preparedness	Mitigation	Response	Recovery
POTENTIAL ACTIONS TO ADDRESS CLIMATE RISKS				
No actions identified in the Draft Climate Action Plan that specifically address climate risks to dams				
POTENTIAL ACTIONS TO ADDRESS INFRASTRUCTURE RISK				
Improve County access to private dams to better assess dam infrastructure, including data collection	✓	✓		
Establish clear lines of communication with private dam owners		✓		✓
Require private dam owners to report dam failures			✓	

[128] Stakeholder Interviews; U.S. Department of Homeland Security, Dams Sector Plan 2015; Federal Emergency Management Agency (FEMA), Risk Reduction Measures for Dams, 2018.

ENERGY SECTOR

U.S. energy infrastructure fuels the national economy. Without a stable energy supply, health and welfare are threatened, and the economy cannot function. [129] The Energy Sector is comprised of two subsectors – (1) Oil and Gas and (2) Electricity.

ENERGY SECTOR DEPENDENCIES AND INTERDEPENDENCIES. Sectors may be dependent and interdependent on one another, which can lead to multi-sector disruptions following threats (known as "cascading failures"). The following highlights dependencies and interdependencies for the Energy Sector identified by the U.S. Department of Homeland Security (DHS). An *interdependency* is a bidirectional relationship, where the operations of sector A affect the operations of sector B, and vice versa. A *dependency* is a unidirectional relationship where the operations of sector A are reliant on the operations of sector B. Sectors listed may be outside the scope of this OLO report.[130]



Source: U.S. DHS

SECTOR OWNERSHIP AND LEAD COUNTY DEPARTMENT. The Energy Sector is primarily privately owned.[131] For emergency planning, the County designates lead agencies to manage planning, response, and recovery efforts. The following departments and offices serve as the sector-specific agencies:[132]

- Department of General Services (Lead)
- Department of Environmental Protection
- Washington Gas
- Pepco
- Baltimore Gas & Electric
- Potomac Edison

[129] U.S. Department of Homeland Security, Sector Risk Snapshots 2014, https://www.hsdl.org/?abstract&did=754033

[130] Stakeholder Interviews; U.S. Cybersecurity and Infrastructure Security Agency, Energy Sector-Specific Plan 2015, https://www.cisa.gov/sites/default/files/publications/nipp-ssp-energy-2015-508.pdf; U.S. Department of Homeland Security, Sector Risk Snapshots, 2014; U.S. Department of Energy, Argonne National Laboratory, Analysis of Critical Infrastructure Dependencies and Interdependencies, June 2015, https://publications.anl.gov/anlpubs/2015/06/111906.pdf

[131] Montgomery County Office of Emergency Management and Homeland Security.

[132] Montgomery County Office of Emergency Management and Homeland Security, Critical Infrastructure and Key Resource Protection Plan, December 2020.

ENERGY SECTOR CONT'D.

COUNTY ASSETS. The following highlights County energy assets. For security reasons, OLO did not report on the total number or location of assets.

Gas. In Montgomery County, Washington Gas and Baltimore Gas and Electric provides natural gas to County residents. Washington Gas serves about 236,000 customers and BGE serves about 50 customers. The majority of Washington Gas and Baltimore Gas and Electric natural gas infrastructure is located underground, except for a few pumping stations.[133]

Electricity. Maryland is not an electricity-rich state and must import a significant percent of its resources from out-of-state (in 2015, Maryland imported 44% of its electricity).[134] There are three electricity providers in Montgomery County – Pepco, Baltimore Gas and Electric, and Potomac Edison. The maps below depict the geographic service area of each provider and major transmission and substation lines.[135] Note, infrastructure may be located in another provider's geographic service area.

- Pepco (Exelon Company) – Serves most of Montgomery County (329, 274 customers);
- Baltimore Gas and Electric (Exelon Company) – Serves parts of eastern Montgomery County (14,000 customers);
- Potomac Edison (First Energy) – Serves mostly rural areas of northern Montgomery County (36,048 customers).[136]

Map 6. Service Area

Source: American Society of Civil Engineers

[133] Stakeholder Interviews, Baltimore Gas and Electric Company, Fact Sheet, https://www.exeloncorp.com/company/Documents/bge-fact-sheet.pdf
[134] American Society of Civil Engineers, Maryland Infrastructure Report Card 2020, https://www.infrastructurereportcard.org/wp-content/uploads/2016/10/Maryland-ASCE-Report-Card-2020-Full-Sections.pdf
[135] American Society of Civil Engineers, Maryland Infrastructure Report Card 2020, https://www.infrastructurereportcard.org/wp-content/uploads/2016/10/Maryland-ASCE-Report-Card-2020-Full-Sections.pdf.
[136] Stakeholder Interviews.

ENERGY SECTOR CONT'D.

ENERGY SECTOR CLIMATE RISKS. The Energy Sector is uniquely critical in that it provides "an enabling function" to all other sectors.[137] Weather events and climate change have the capacity to cause extensive and widespread damage to energy infrastructure, which can impact an area for days to weeks.[138] This chart summarizes the impact of several climate risks to the Energy Sector.

RISK	SECTOR IMPACT
Temperature Increase	• Decreases technical efficiency of thermal and solar power generation • Increases risk of transmission loss and sagging of wires • Results in overheating of electric lines and transformers
Extreme Precipitation	• Increases flood risk to facilities • May cause damage to facilities and equipment, leading to service disruptions and longer recovery times
Extreme Temperature	• Increases demand for electricity for cooling during heat waves
Drought	• Reduces water supply for hydropower generation and cooling for thermal power • Heightens risk of land sinking and fires as vegetation dries out, causing structural instability
High Wind	• Results in damage to power lines and service disruptions

Source: U.S. DHS; International Atomic Energy Agency; U.S. CSIS; Stakeholder Interviews

ENERGY SECTOR INFRASTRUCTURE RISKS. Utility companies reported several infrastructure risks.

- **Risk of outages due to aerial wires**. A number of electrical lines in the northern and eastern areas of the County cross open fields and forested areas, leaving many lines exposed to the environment and weather. Of particular concern are line maintenance and vegetation control.
- **Burying wires underground is required in residential neighborhoods but poses its own risks**. The State requires all lines in residential neighborhoods to be underground. However, this can increase length of service disruptions and repair costs, as damaged underground lines are difficult to find and repair.
- **Investment in dual feeds is necessary**. Dual feeds allow utility companies to switch consumers from one transmission line to another in case of an outage. This creates redundancy but is expensive.
- **Lack of communication and coordination**. Stakeholders reported a lack of coordination and communication with leaders in the County. Additionally, OLO notes difficulty with securing interviews and requesting data for this report, limiting the ability to determine sector risks and resiliency efforts.

[137] U.S. Department of Homeland Security, Sector Risk Snapshots 2014, https://www.hsdl.org/?abstract&did=754033
[138] International Atomic Energy Agency, Adapting the Energy Sector to Climate Change, https://www-pub.iaea.org/MTCD/Publications/PDF/P1847_web.pdf ;U.S. Department of Homeland Security, Sector Risk Snapshots 2014, https://www.hsdl.org/?abstract&did=754033; Stephen Naimoli and Sarah Ladislaw, Oil and Gas Industry Engagement on Climate Change, Center for Strategic and International Studies, https://csis-website-prod.s3.amazonaws.com/s3fs-public/publication/191003_LadislawNaimoli_OilandGasIndustry_WEB_v3.pdf

ENERGY SECTOR CONT'D.

EMERGENCY MANAGEMENT AND IDENTIFICATION OF GAPS. OLO identified actions from the County's Draft Climate Action Plan (DCAP) and stakeholder interviews that could address climate and infrastructure risks identified for the Energy Sector. Actions to address infrastructure risks may also address climate risks. For potential actions to address climate risks, obtained from the DCAP, OLO selected actions the County has the authority to implement, however these actions may require new policy or a policy amendment. OLO has not evaluated the potential actions to address climate or infrastructure risks for prioritization. These recommended actions align with the Four Phases of Emergency Management in Chapter One.[139]

	Preparedness	Mitigation	Response	Recovery
POTENTIAL ACTIONS TO ADDRESS CLIMATE RISKS				
Amend the building code to require that all new developments install solar or meet solar-ready requirements	✓	✓		
Significantly develop more public facility multi-site solar projects, including exploring use of County parking garages	✓	✓		
Advocate for a 100% Renewable Portfolio Standard by 2030[140]	✓	✓		
Amend the building code to require all newly constructed buildings in the County are net-zero energy, beginning in 2030	✓	✓	✓	✓
POTENTIAL ACTIONS TO ADDRESS INFRASTRUCTURE RISKS				
Review County's tree trimming policy and budget	✓	✓		
Improve existing partnerships and lines of communication with energy stakeholders	✓		✓	✓
Identify investments to ensure critical facilities have dual feeds	✓			✓
Identify and address issues of grid reliability, particularly as the County seeks greater electrification of buildings and transportation sectors	✓	✓	✓	✓

[139] Stakeholder Interviews; National Association of State Energy Officials, Petroleum Shortage Emergency Response, Fuel Diversity, and Planning 2018, http://energyoutlook.naseo.org/data/energymeetings/presentations/Pillon.pdf; U.S. General Services Administration, Climate Risks Study for Telecommunications and Data Center Services; U.S. Department of Homeland Security, Energy Sector Plan 2015; U.S. Department of Energy's National Renewable Energy Laboratory, Power Sector Resilience Planning Guidebook, https://www.nrel.gov/docs/fy19osti/73489.pdf; Edison Electric Institute, Understanding the Electric Power Industry's Response and Restoration Process, https://www.eei.org/issuesandpolicy/electricreliability/mutualassistance/Documents/MA_101FINAL.pdf

[140] Stakeholders note that while advocating for a renewable energy portfolio would reduce emissions contributing to climate change, this does not necessarily increase the resilience of the electricity supply to Montgomery County. Issues of grid reliability must be addressed regardless of the source of electricity, particularly as the County seeks greater electrification of buildings and transportation sectors.

ENERGY SECTOR CONT'D.

Utility Stakeholder Actions. Since utilities are privately owned, providers shared with OLO selected efforts undertaken to build infrastructure resiliency.

- Increased routine tree trimming to limit outages from fallen trees;
- Increased standards for Grade-B construction on overhead infrastructure (This grade provides the highest margin of safety, as defined by the National Electrical Safety Code).
- Baltimore Gas and Electric has addressed all identified substations that are at-risk for flood;
- Reconfigured supply lines to substations to mitigate single points of failure;
- Deployed overhead and underground switching equipment to automatically reconfigure and restore customers in the event of an outage; and
- Selective undergrounding of overhead lines.[141]

[141] Stakeholder Interviews.

TRANSPORTATION SECTOR

The Transportation Sector moves people and goods quickly, safely, and securely moves. OLO's review covers the following subsectors: Aviation, Freight Rail, Highway and Motor Carrier, and Mass Transit.[142]

TRANSPORTATION SECTOR DEPENDENCIES AND INTERDEPENDENCIES. Sectors may be dependent and interdependent on one another, which can lead to multi-sector disruptions following threats (known as "cascading failures"). The following highlights dependencies and interdependencies for the Transportation Sector identified by the U.S. Department of Homeland Security (DHS). An interdependency is a bidirectional relationship, where the operations of sector A affect the operations of sector B, and vice versa. A dependency is a unidirectional relationship where the operations of sector A are reliant on the operations of sector B. Sectors listed may be outside the scope of this OLO report.[143] For the Transportation Sector, interdependencies and dependencies depend on the mode. Sectors listed may be outside the scope of this OLO report.

Aviation	**Interdependencies** *Energy*. Aviation is dependent on the Energy Sector for daily operations. The Energy Sector is dependent upon the Aviation Sector for movement of supplies and raw materials that are essential for energy production.
	Dependencies *Communications, Information Technology, Financial Services, and Water & Wastewater*. Aviation is dependent on these sectors for daily operations.
Freight Rail	**Interdependencies** *Energy*. Freight Rail is dependent on the Energy Sector for daily operations. Energy is dependent upon the Freight Rail for movement of coal, crude oil, petroleum products, and natural gas.
	Dependencies *Communications, Information Technology, Financial Services, Emergency Services, and Water & Wastewater Systems.* Freight Rail is dependent upon these Sectors for daily operations.
Highway and Motor Carrier	**Interdependencies** *Energy, Emergency Services, and Water & Wastewater***.** Energy sector provides fuel and transportation sector facilitates the movement of oil and gas. Emergency Services are interdependent for effective emergency response. Water is needed for daily operations and the highway system transport chemicals, materials, and water.
	Dependencies *Communications & Information Technology*. Highway and Motor Carrier are dependent upon these Sectors for the operation of traffic signal controllers, roadway sensors, and road weather information sensors.

[142] The Transportation Sector also includes postal, marine, and pipeline subsectors. More information on these sectors can be found at https://www.cisa.gov/transportation-systems-sector

[143] U.S. Cybersecurity and Infrastructure Security Agency, Transportation Sector-Specific Plan 2015, https://www.cisa.gov/sites/default/files/publications/nipp-ssp-transportation-systems-2015-508.pdf; U.S. Department of Homeland Security, Sector Risk Snapshots, 2014; U.S. Department of Energy, Argonne National Laboratory, Analysis of Critical Infrastructure Dependencies and Interdependencies, June 2015, https://publications.anl.gov/anlpubs/2015/06/111906.pdf

TRANSPORTATION SECTOR CONT'D.

Mass Transit	**Interdependencies** U.S. Department of Homeland Security does not identify interdependencies.
	Dependencies *Energy, Emergency Services, Communications, Information Technology, and Financial Services*. Mass transit depends on these sectors for daily operations (e.g., communications, fuel, emergency response, and daily financial transactions).

Source: U.S. CISA; U.S. DHS

SECTOR OWNERSHIP AND LEAD COUNTY DEPARTMENT. The Sector is publicly and privately owned. For emergency planning, the County designates lead agencies to manage planning, response, and recovery efforts. The following departments and offices serve as the sector-specific agencies:[144]

- Department of Transportation (Lead)
- Department of Environmental Protection
- Department of Finance
- Department of General Services
- Department of Liquor Control
- Office of Emergency Management and Homeland Security
- Montgomery County Police Department
- Fire and Rescue Services

[144] Montgomery County Office of Emergency Management and Homeland Security, Critical Infrastructure and Key Resource Protection Plan, December 2020.

TRANSPORTATION SECTOR CONT'D.

COUNTY ASSETS. The following highlights County transportation assets.

Sector	Assets
Aviation	• The Montgomery County Airpark has 156 based aircrafts, 51K annual aircraft operations, supports 290 jobs, and generated $11.8M in business revenue (2015).[145] • The Montgomery County Airpark serves as a backup facility to Reagan National Airport.[146] • Davis Airport is a privately-owned, public use airport located in Laytonsville.
Freight Rail	• Maryland rail network consists of 1,150 miles of track and carries over 80 million tons of freight worth $5.4 billion.[147]
Highway and Motor Carrier	• This Sector includes bridges, tunnels, commercial freight vehicles, motor coaches, and school buses. • Montgomery County has 476 highway bridges; 262 defined as long span (length greater than 20 feet) and 214 classified as short span (between 6 feet and 20 feet).[148] • The average age of bridges in the County is 44 years old.[149] • There are 1,150.4 miles of existing and planned highways and transit-ways in the County. [150]
Mass Transit	• This Sector includes Includes transit buses, trolleybuses, monorails, heavy rail, light and passenger rails, commuter rail, and rideshare. • Total unlinked passenger trips in Montgomery County: Metrorail (WMATA) 40 million; Ride On (MCDOT) 22 million; and Metrobus (WMATA) 15 million.[151]

[145] Maryland Aviation Administration, Maryland Economic Impact of Airports, July 2015, https://marylandregionalaviation.aero/wp-content/uploads/2020/03/2015-Economic-Study-Full-Report.pdf
[146] Stakeholder Interviews.
[147] American Society of Civil Engineers, Maryland Infrastructure Report Card 2020, https://www.infrastructurereportcard.org/wp-content/uploads/2016/10/Maryland-ASCE-Report-Card-2020-Full-Sections.pdf
[148] Montgomery County Department of Transportation, 2017 Bridge Inventory Summary, https://www.montgomerycountymd.gov/dot-dte/Resources/Files/2017%20Inventory%20Summary%20Book.pdf
[149] *Ibid*.
[150] Maryland-National Capital Park and Planning Commission, Master Plan of Highways and Transitways, https://montgomeryplanning.org/planning/transportation/highway-planning/master-plan-of-highways-and-transitways/
[151] Office of Legislative Oversight, Report 2020-10 https://www.montgomerycountymd.gov/OLO/Resources/Files/2020%20Reports/OLOReport2020-10.pdf

TRANSPORTATION SECTOR CONT'D.

TRANSPORTATION SECTOR CLIMATE RISKS. Climate risks to Transportation Sector assets include:[152]

RISK	SECTOR IMPACT
Temperature Increase	• Increases risk to structural integrity of bridges and roadways • May case track kinks/misalignment and risk of thermal expansion of rail track • Results in changes aircraft performance
Extreme Precipitation	• Increases flood risk to facilities, rail, and roadways • Increases sediment build up on roadways and bridges • Disrupts traffic, leading to more accidents and delays • Heightens rail safety risks, including train derailment • Disrupts to airport operations
Extreme Temperature	• Increases safety risks for crews • Changes how residents use transit or engage in walking and biking, due to excessive heat or cold
High Wind	• Results in damage to electrical lines and downed power lines • Causes potential disruption to airport operations
Extreme Weather	• Results in loss of productivity if passengers cannot commute to destinations • Disrupts rail operations (e.g., decreased access to supplies and goods) • Disrupts airport operations, ground transport access, utilities

Source: U.S. DHS; Metropolitan Transit Authority; U.S. DOT; International Air Transport Association; Stakeholder Interviews

TRANSPORTATION SECTOR INFRASTRUCTURE RISKS. Stakeholders reported several infrastructure risks.

- **Risk of financial resiliency of the Montgomery County Airpark.** The Montgomery County Airpark is operated by the Montgomery County Revenue Authority through a long-term lease agreement. Stakeholders report limited ability to raise funds necessary to improve infrastructure.
- **Lack of integration of the Airpark as a vital County resource into emergency planning.** Stakeholders report an absence of coordination between County officials to develop and integrate the use of the Airpark in the event of emergencies. Stakeholders report the importance of having an Airpark in the event major highways or other supply lines are disrupted.
- **Highway and bridge design needs to adjust for climate change, but exact standards and data are undefined**. Stakeholders report that there is no consensus between state and local governments on how design standards and data should adapt to climate change projections for highway and bridge design.

[152] Metropolitan Transit Authority, MTA Adaptations to Climate Change – A Categorical Imperative, https://new.mta.info/document/10451 National Climate Assessment, Transportation, https://nca2014.globalchange.gov/report/sectors/transportation ; Michael A. Rossetti, Potential Impacts of Climate Change of Railroads, https://www.transportation.gov/sites/dot.gov/files/docs/rossetti_CC_Impact_Railroads.pdf; International Air Transport Association, The Impact of Climate Change on Aviation, https://www.iata.org/contentassets/0772118eec2e40bbba472b862e4f45ec/sfo2019-day3-climate-change.pdf

TRANSPORTATION SECTOR CONT'D.

- **There is difficulty in designing bridges to handle increased waterflow.** Bridges serve as impromptu dams, restricting water flow during heavy precipitation events from downflow properties. However, changing bridge design to handle increased waterflow places more properties at risk for flooding.
- **Financial investment in existing infrastructure is lacking.** One of the largest risks to County infrastructure is age. Most of the transportation infrastructure in the County was constructed 40 to 50 years ago, and the County will need to make strategic investments to improve this infrastructure and address changing climate risks.
- **Flood rescue resources are underfunded in the DC region.** Roadway flooding in the DC region is unique, as it not only involves flooded roadways, but also swift downstream currents. This puts many drivers at risk. Stakeholders report that flood rescue units are historically under-resourced due to low demand. However, as risks from extreme storms increase, jurisdictions will need to increase resources.

EMERGENCY MANAGEMENT AND IDENTIFICATION OF GAPS. OLO identified actions from the County's Draft Climate Action Plan (DCAP) and stakeholder interviews that could address climate and infrastructure risks identified for the Transportation Sector. Actions to address infrastructure risks may also address climate risks. For potential actions to address climate risks, obtained from the DCAP, OLO selected actions the County has the authority to implement, however these actions may require new policy or a policy amendment. OLO has not evaluated the potential actions to address climate or infrastructure risks for prioritization. These recommended actions align with the Four Phases of Emergency Management in Chapter One. [153]

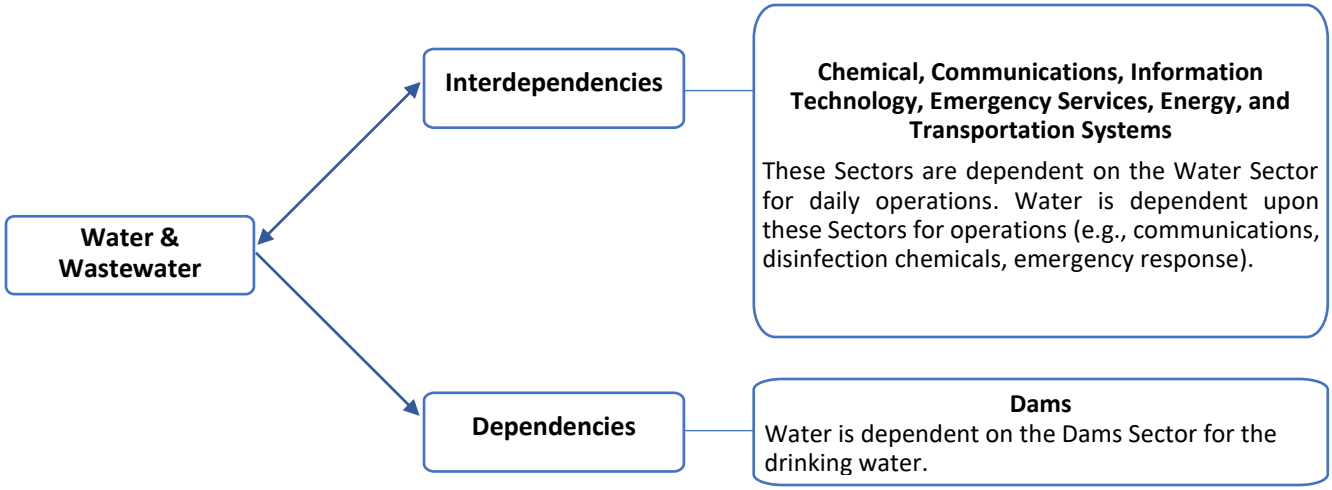
	Preparedness	Mitigation	Response	Recovery
POTENTIAL ACTIONS TO ADDRESS CLIMATE RISKS				
Expand active transportation and shared micromobility networks by increasing bike and pedestrian corridors	✓	✓	✓	✓
Expand Transportation Demand Management by encouraging alternative travel modes and increased teleworking	✓	✓	✓	✓
Partner with MDOT to explore alternative fuels for railcars		✓		
Expand use of green streetscapes to manage stormwater flow and increase urban greening	✓	✓	✓	
POTENTIAL ACTIONS TO ADDRESS INFRASTRUCTURE RISKS				
Identifying and repairing damaged or failing culverts to ensure the long-term performance and safety of roads	✓	✓		
Assess first responder resources for floods and coordinate with local jurisdictions to ensure adequate funding and staffing	✓		✓	✓
Examine opportunities to close funding gaps to meet current infrastructure needs	✓	✓		✓
Increase coordination between key transportation operators to ensure adequate emergency planning	✓			

[153] Stakeholder Interviews; Montgomery County Government, Draft Climate Action Plan, 2020; Weilant, Sarah, Aaron Strong, and Benjamin M. Miller, Incorporating Resilience into Transportation Planning and Assessment. Santa Monica, CA: RAND Corporation, 2019. https://www.rand.org/pubs/research_reports/RR3038.html.

WATER AND WASTEWATER SECTOR

Safe drinking water is required for all human activity, and properly treated wastewater is vital for preventing disease and protecting the environment. Water utilities consist of source waters, treatment facilities, pumping stations, storage sites, and distribution, collection, and monitoring systems.[154]

WATER AND WASTEWATER SECTOR DEPENDENCIES AND INTERDEPENDENCIES. Sectors may be dependent and interdependent on one another, which can lead to multi-sector disruptions following threats (known as "cascading failures"). The following highlights dependencies and interdependencies for the Water and Wastewater Sector identified by the U.S. Department of Homeland Security (DHS). An *interdependency* is a bidirectional relationship, where the operations of sector A affect the operations of sector B, and vice versa. A *dependency* is a unidirectional relationship where the operations of sector A are reliant on the operations of sector B. Sectors listed may be outside the scope of this OLO report [155]



Source: U.S. Cybersecurity and Infrastructure Security Agency

[154] U.S. Department of Homeland Security, Sector Risk Snapshots 2014, https://www.hsdl.org/?abstract&did=754033

[155] U.S. Cybersecurity and Infrastructure Security Agency, Water and Wastewater Systems Sector-Specific Plan 2015, https://www.cisa.gov/sites/default/files/publications/nipp-ssp-water-2015-508.pdf; U.S. Department of Energy, Water Energy Nexus Executive Summary, https://www.energy.gov/sites/prod/files/2014/07/f17/Water%20Energy%20Nexus%20Executive%20Summary%20July%202014.pdf; U.S. Department of Homeland Security, Sector Risk Snapshots, 2014; U.S. Department of Energy, Argonne National Laboratory, Analysis of Critical Infrastructure Dependencies and Interdependencies, June 2015, https://publications.anl.gov/anlpubs/2015/06/111906.pdf

WATER AND WASTEWATER SECTOR CONT'D.

SECTOR OWNERSHIP AND LEAD COUNTY DEPARTMENT. The sector is primarily publicly owned. For emergency planning, the County designates lead agencies to manage planning, response, and recovery efforts. The following departments and offices serve as the sector-specific agencies:[156]

- Department of Environmental Protection (Lead)
- Washington Suburban Sanitary Commission
- City of Rockville
- City of Gaithersburg

COUNTY ASSETS. The following highlights County drinking water and wastewater assets.

Washington Suburban Sanitary Commission (WSSC). WSSC provides drinking water to 1.8 million customers in Prince George's and Montgomery Counties. The WSSC wastewater system has 5,400 miles of sewer mains and treats 70 million gallons of wastewater daily. In total, WSSC has six wastewater treatment plants, 52 wastewater pumping stations, and two wastewater storage facilities. In Montgomery County, WSSC owns the majority of water and sewer lines. One of the two WSSC water filtration plants and two of the dams that WSSC operates are in Montgomery County (Brighton and Little Seneca). The third (T. Howard Duckett) spans the Patuxent River from Howard County to Prince George's County.[157]

DC Water. DC Water provides wastewater treatment for much of the National Capital Region, including Montgomery County. In the County, WSSC maintains the sewer infrastructure and pays for treatment at DC Water's Blue Plains Facility in Washington, DC.

City of Rockville. The City provides service to 70% of city residents (12,000 accounts). Facilities include the Rockville Water Filtration Plant and three potable water storage facilities. Wastewater is carried from Rockville to the DC Water Blue Plains Wastewater Treatment Plant in pipes owned by WSSC.[158]

Town of Poolesville. The Town supplies its public water system from municipal groundwater systems. Facilities include one wastewater treatment plant near Dry Seneca Creek and four wastewater pumping stations.

[156] Montgomery County Office of Emergency Management and Homeland Security, Critical Infrastructure and Key Resource Protection Plan, December 2020.
[157] Washington Suburban Sanitation Commission, Wastewater Collection System https://www.wsscwater.com/education-and-recreation/about-wastewater/wastewater-collection-system.html
[158] Montgomery County Comprehensive Water Supply and Sewerage Systems Plan, https://www.montgomerycountymd.gov/DEP/Resources/Files/ReportsandPublications/Water/Water%20supply%20%26%20Waste%20water/ws-plan-2018-chapter-3.pdf

WATER AND WASTEWATER SECTOR CONT'D.

WATER AND WASTEWATER SECTOR CLIMATE RISKS. Climate risks to water sector assets include:[159]

RISK	SECTOR IMPACT
Temperature Increase	• Increases demand for water for living, power, and economic activities
Extreme Precipitation	• Increases flood risk to facilities and damage to structures • Causes larger flows in wastewater collection and treatment facilities, which could lead to overflows and negatively affect treatment
Extreme Temperature	• Creates conditions for parasites and bacteria to survive longer and increase the chance for transmission into drinking water • Decreases water supply, which impacts ability to manage demand
Droughts	• Affects the availability of stored water in reservoirs and increases threat to geographic locations with less diversified source water portfolios • Reduces water use, which reduces flows to sewers and increases costs of collection and treatment • Heightens risk to infrastructure, if systems and assets are not upgraded to deal with variable flows
High Wind	• Increases risk of water disruptions due to power outages
Water Quality	• Increases pollutants from runoff in waterways, leading to a need for additional treatment • Declines as rising sea levels increase saltwater migration to fresh water sources

Source: US DHS; EPA; CISA; Public Policy Institute of California

WATER AND WASTEWATER SECTOR INFRASTRUCTURE RISKS. Stakeholders reported several infrastructure risks.

- **Interconnectedness of the National Capital Region on the Potomac River is a homeland security risk.** The Potomac River supplies much of the drinking water for the region. If the WSSC Water Potomac Water Filtration Plant is unable to produce drinking water for an extended period time (more than 24 hours), it would impact the entire National Capital Region. The Potomac Water Filtration Plant is only one part of the larger regional picture.

[159] U.S. Environmental Protection Agency, Climate Impacts on Water Resources, https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-water-resources .html, Public Policy Institute of California, Managing Wastewater in a Changing Climate, https://www.ppic.org/wp-content/uploads/managing-wastewater-in-a-changing-climate.pdf, National Infrastructure Advisory Council, Water Sector Resilience Final Report and Recommendations, https://www.cisa.gov/sites/default/files/publications/niac-water-resilience-final-report-508.pdf, Environmental Protection Agency, Being Prepared for Climate Change A Workbook for Developing Risk-Based Adaptation Plans, https://www.epa.gov/sites/production/files/2014-09/documents/being_prepared_workbook_508.pdf

WATER AND WASTEWATER SECTOR CONT'D.

- **WSSC Water's Potomac Water Filtration Plant supplies approximately 70% of the water to Montgomery County – there is limited redundancy between WSSC Water's two water filtration plants for supplying finished drinking water assuming average daily demand remains constant**. Although WSSC also operates the Patuxent Water Filtration Plant which utilizes water stored in Triadelphia and Duckett reservoirs on the Patuxent River, the drinking water production capacity of the Patuxent Water Filtration Plant does not offer full redundancy to meet daily demand.
- **Montgomery County has one water intake on the Potomac.** WSSC's Potomac Plant only has a surface water intake and no submerged water intakes. During a 2016 event in Fairfax County, an unknown chemical lingered for an extended period near the intakes of Fairfax Water. Fairfax Water has the ability to shutdown their surface intake and utilize a submerged intake to continue operations. Had there been similar conditions at WSSC Water's intake, because there is only a surface intake, WSSC Water's response may have been to close the intake to protect the plant from potential contamination. This could have led to a disruption in drinking water services.
- **The Potomac Water Filtration Plant does not have an off-grid backup power supply.** If there is a power grid failure, there would be a power outage at the filtration plant. Building an off-grid backup power system would be expensive. Installing a microgrid at the site is less expensive, but was politically difficult to implement because of the installation needs in the surrounding neighborhoods.
- **Building resilience of the water system comes down to responsibility and cost.** WSSC's resiliency budget has decreased 7% in the last 10 years. The region needs critical upgrades, particularly to the Potomac Water Filtration Plant, but cost is a factor – with revenues from rate payors decreasing.
- **The region relies on the DC Water Blue Plains Facility for wastewater treatment.** WSSC Water operates six wastewater treatment facilities including three in Montgomery County (Seneca, Damascus, and Hyattstown). However, the region utilizes DC Water's Blue Plains facility (a significant portion of wastewater collected by WSSC Water is treated at Blue Plains). DC Water is planning for resiliency upgrades to ensure the Blue Plains Facility can meet changing climate risks; however, there is an inherent risk of the National Capital Region depending heavily on a single wastewater treatment plant.
- **Aging workforce contributes to infrastructure maintenance risks.** Stakeholders noted that the workforce in the water and wastewater sector, as well as other utilities, is aging. As more technical advancements are implemented, there will be a need for a skilled workforce to help maintain the water infrastructure.
- **There is a lack of communication and coordination**. Stakeholders reported a need to form better lines of coordination with leaders in Montgomery County, similar to other sectors discussed earlier.

WATER AND WASTEWATER SECTOR CONT'D.

EMERGENCY MANAGEMENT AND IDENTIFICATION OF GAPS. OLO identified actions from the County's Draft Climate Action Plan (DCAP) and stakeholder interviews that could address climate and infrastructure risks identified for the Water and Wastewater Sector. Actions to address infrastructure risks may also address climate risks. For potential actions to address climate risks, obtained from the DCAP, OLO selected actions the County has the authority to implement, however these actions may require new policy or a policy amendment. OLO has not evaluated the potential actions to address climate or infrastructure risks for prioritization. These recommended actions align with the Four Phases of Emergency Management in Chapter One. [160]

	Preparedness	Mitigation	Response	Recovery
POTENTIAL ACTIONS TO ADDRESS CLIMATE RISKS[161]				
Establish a stormwater retention credit trading program to allow third-party developers to earn revenue for reducing runoff[162]		✓	✓	
Revise the building code to ban stormwater management requirement waivers for new construction or renovated sites and revisit the definition of minor land-disturbing activities	✓	✓		
Update its floodplain maps to the 30-acre watershed standard and map small drainage areas that are currently unmapped	✓			
Increase land protections and stream revitalization efforts to protect existing supply aquifers and watersheds	✓	✓		✓
Adopt codes to require green infrastructure practices for new and existing properties and to limit impervious concrete surfaces	✓	✓		
POTENTIAL ACTIONS TO ADDRESS INFRASTRUCTURE RISKS				
Continue to coordinate on identifying, funding, and constructing a backup drinking water source for the County and region	✓	✓	✓	✓
Identify and fund an off grid backup power source for WSSC Potomac Filtration Plant	✓	✓	✓	✓
Identify and fund a secondary, submerged water intake for the Potomac Water Filtration Plant	✓	✓	✓	✓
Review WSSC Water's risk assessment and assist with determining next steps	✓			
Improve existing lines of communication between elected officials and sector partners	✓		✓	✓
Review sector needs and collaborate with workforce development partners to fill employment gaps	✓			
Commission a study to understand County facilities at risk of flooding and possible remedies	✓			

[160] Stakeholder Interviews; Montgomery County Government, Draft Climate Action Plan, 2020. U.S. Cybersecurity and Infrastructure Security Agency, All-Hazard Consequence Management Planning for the Water Sector, https://www.waterisac.org/sites/default/files/2009_CIPAC_All-Hazard-CMP.pdf; American Waterworks Association, Roadmap to a Secure and Resilient Water and Wastewater Sector, https://www.awwa.org/Portals/0/AWWA/Government/2017CIPACWaterSectorRoadmap.pdf?ver=2017-05-16-135131-030,

[161] DEP staff provided OLO with additional potential actions to help address runoff climate risks. See Appendix H for list of options.

[162] Executive Branch staff note revenue to reduce runoff may help, but trading credits may only shift the problem from one area to another.

WATER AND WASTEWATER SECTOR CONT'D.

Utility Stakeholder Actions. Providers shared with OLO selected efforts to build infrastructure resiliency.

- WSSC is working with a consultant on climate change adaptation strategies. The contract includes identification of at-risk assets and cost of upgrades. Using floodplain maps, the consultant identified 18 sites at risk, with eight of those identified as critical. Potential upgrades will cost $2.5 million, compared to a cost of inaction of $26 million.
- DC Water is hardening infrastructure and retrofitting the main pump station. DC Water is currently conducting a resiliency analysis to determine how to harden other facilities.
- National Capital Region stakeholders have worked to identify backup water supplies to the Potomac River, such as the purchase of the Travilah Quarry in Montgomery County.[163]

[163] Stakeholder Interviews.

Chapter 4. Feedback from County Staff and Stakeholders

To gain feedback on the security and resilience of County critical infrastructure, OLO conducted interviews with County Government departments, utility providers, and other government and non-governmental entities. All stakeholders reported climate change adaptation strategies should utilize best practices for implementing infrastructure improvements while remaining cognizant of prior infrastructure investments.

This chapter summarizes stakeholder feedback heard across the following topic areas:

- **Section A** summarizes feedback on infrastructure risks and investments;
- **Section B** provides observations about coordination among local stakeholders; and
- **Section C** reviews stakeholders' thoughts on community preparedness and vulnerable populations.

A. Infrastructure Risks and Investments

The County historically underinvests in critical infrastructure security and routine maintenance/upgrades. The County is "behind the eight-ball" in resilience planning for critical infrastructure. Stakeholders report that the County is barely meeting investment needs for maintaining current infrastructure, let alone for future risks. The County is about one-quarter of where it should be in terms of planning for and securing critical infrastructure to adapt to changing climate conditions. While in a better position than many Maryland counties, the County is behind peer jurisdictions in the National Capital Region. Stakeholders reported lessons from the pandemic demonstrate that strengthening resilience of critical infrastructure should be an all-hazards approach and would have co-benefits to prepare the County for multiple threats.

Design standards and data guidelines are often set by state or national entities. These guidelines do not include climate change effects. County departments face difficulty integrating climate change projections into planning, including how to protect assets and continue service. While some design guidelines may be set by the County, most are guided by State and federal standards. Stakeholders indicate that standards used to design and build critical infrastructure do not account for the increased intensity of storms. Further, in many cases, data used by County departments to adhere to design guidelines are collected by other organizations (e.g., NWS, NOAA, etc.), and it is unclear to Department staff whether these data include climate change projections. To use alternative data would require State approval in some cases.

There is a data gap on climate information in the County. Further, there is a data analysis gap – the County "does not have the expertise to know what it doesn't know." Stakeholders consistently reported a lack of climate data, including how weather data is changing and accurate future projections. Further, the data that is available is often housed in silos, collected and controlled by individual departments. Coupled with the data gap, several departments report a lack of expertise among County staff to understand the extent of climate risks and adaptation strategies necessary to protect critical infrastructure. In particular:

- The County is very proactive at adopting new technologies and services but may not have the required skill sets to implement these strategies; and

- The County was ill-prepared for the pandemic due to lack of staff expertise and must ensure that there is expertise on staff to adequately prepare for climate change (suggestions included a hydrologist, a civil engineer focused on renovating ponds, and staff to develop technical models on flooding and stormwater).

There is a lack of climate change adaptation and resilience policies geared towards existing infrastructure. Stakeholders reported that resilience policies focus on new construction. However, existing infrastructure systems and assets comprise the majority of the built environment, and more work is needed to identify climate vulnerabilities. Additionally, in the past, stakeholders report the County "value engineered" resiliency opportunities from capital projects as cost saving measures during lean budget years. Stakeholders noted that requiring existing infrastructure to comply with new regulations would come at a cost to property owners and renters.

Data collection and geographic information system (GIS) data is critical to resiliency planning. OLO found that available data was often recorded on paper and required time to combine data sets from multiple departments for items like mapping and storm costs. Stakeholders indicate that the County has seen the most success when it houses data in a singular location that can be accessed by relevant stakeholders. Further, GIS technology can help target specific geographic areas for strategic resilience planning and aid in response and recovery efforts. Stakeholders reported using GIS technology could de-silo climate change data and enable integration to better visualize vulnerable areas and improve planning efforts.

Utility providers report that downed trees are one of the largest contributors of power outage risks in the County. The County's tree maintenance program is underfunded and lacks policies aligned with strengthening resiliency. Fallen trees are one of the greatest risks to power outages and with the County reducing its tree trimming budget, the risk of power outages has increased over the years. In addition, utility stakeholders report the County does not restrict property owners from planting trees near or under powerlines.

Dams and ponds in the County, primarily owned by private entities, are at risk for failure. There are limited resources to monitor and repair these critical infrastructure assets.

- Agricultural ponds are critical to farmers' ability to irrigate crops. This infrastructure is aging, with water exceeding the capacity of many ponds. The repairs required to fix these ponds are expensive, time-consuming, and must meet federal standards. This matter is complicated by the fact that upwards of 40% of farmers do not own the land they farm.[164] Staff report if the tenant farmer does not have a long-term lease (10 plus years), there is little incentive to pay for these repairs.

- Many dams in the County are privately owned. The County has limited communication with these owners and is unable to collect data on many dams. The dams in the County are also aging, and, similar to ponds, repairs and redesigns are expensive.

The County has not evaluated the risk of flooding in a comprehensive way; there is not a single point of contact in the County to manage this risk. Flooding is a major climate risk to the County and its critical

[164] Montgomery County Government owns land that is leased for farming. These lease agreements were not reviewed as part of this report.

infrastructure. Stakeholders reported that there is no comprehensive model to show how water flows through the County and where problems lie. County government has not even evaluated its existing infrastructure to determine flood risks; the County's response to flooding is reactive. Further, there is no single point of contact in the County to manage flood prevention programs. Departments handle risks to their infrastructure, but staff report that these efforts are siloed.

The County is more restrictive as to how it defines a floodplain compared to FEMA, resulting in an increased number of properties subjected to floodplain requirements. Due to a lack of data and staffing, Departments were unable to share the number of structures within the County that are in a floodplain. Floodplain permits control development on land located in a floodplain. Requirements are in place for the protection of people and property. Structures built in a floodplain must follow regulations that determine what can and cannot be built on a property.[165] The Department of Permitting Services is the lead agency for the establishment of and permitting of development in floodplains. Stakeholders report that the County's has one of the most restrictive floodplain definitions in Maryland, defining the regulated floodplain at 30 acres or more of contributing drainage (more restrictive than FEMA's floodplain definition of 640 acres). This results in more properties located in County-designated floodplains. Changing floodplain regulations will limit what can be built and may increase construction costs. This is particularly important for residential properties where homeowners may be unable to renovate or rebuild existing structures.

Flood insurance is also a significant concern for stakeholders. Homes and businesses in high-risk flood areas with mortgages from a government-backed lender are required to purchase flood insurance upon the sale of the property, which can be over $3,000 annually. There are currently 2,333 flood insurance policies in force in the County, totaling $675 million in coverage.[166] Homes and businesses located outside a FEMA-designated floodplain, but in a County-designated floodplain may purchase reduced cost insurance for around $550 annually. County staff report several reasons for the low insurance take up rate: (1) homeowners are less likely to purchase insurance due to its low coverage rate (insurance coverage is often less than the median price of homes in the County) and (2) there is a lack of County staff capacity to market and promote flood insurance programs to property owners.

Nuisance flooding is a growing risk for the County. Department staff report a lack of capacity and policies to provide effective assistance. Executive staff report receiving more complaints regarding nuisance flooding (e.g., water in basement, pooling of water in yards, sewer backups). Nuisance flooding is occurring all over the County, particularly in areas where development, and the creation of impervious surfaces, has created more runoff than stormwater systems are designed to handle. This has resulted in flooding of roads, properties, and buildings outside of floodplains that historically have not been subject to flooding. Additionally, stakeholders report that County reviews construction and floodplain permits on a site-by-site basis but does not conduct a review of the cumulative effect of removing land from a floodplain, which can result in an increase of nuisance flooding. DPS

[165] DPS staff note that since the floodplain has not been formally delineated in many areas of smaller streams within the County, construction in the vicinity of such streams requires performance of a flood plain delineation study prior to receiving a construction permit. Montgomery County considers a floodplain as an area inundated by a 100-year storm, in other words a storm that has a one percent change of occurring within any given year. The Maryland Department of the Environment mandates that Counties utilize NOAA Atlas 14 rainfall distributions for determining the characteristics of a 100 year event.

[166] Federal Emergency Management Association, Flood Insurance by the Numbers, Montgomery County, MD. Provided to OLO by OEMHS staff.

staff note that the County could explore compensatory storage requirements for projects that fill in a floodplain.[167] Property owners experiencing nuisance flooding lack both funding and legal recourse – (1) federal and state financial assistance is geared to flooding events, not nuisance flooding, and (2) property owners experiencing nuisance flooding have limited legal recourse due to the strict guidelines of the Maryland Drainage Law.

B. Coordination

Climate hazard and homeland security policies are often siloed, limiting coordination and planning across all levels of government. Federal and state stakeholders report that government response to climate change risks and homeland security are siloed. Each organization has a priority list of investments, which may or may not overlap. In prior years, policies for ensuring physical security of infrastructure were the primary factor in planning efforts. However, new policy approaches are geared towards building resilience to limit the cascading effects of infrastructure disruptions.

There is also no formal coordination between the State and local governments to build resilience programs. The lack of coordination is further complicated because government entities are still determining what resiliency means for each sector. There is no consistent way of designing climate-resilient infrastructure and the State does not publish guidelines for climate resilient designs. This lack of consistent leadership is further complicated by incomplete climate data.

There is a need for increased discussion and action among elected officials around critical infrastructure and resiliency efforts. OEMHS is an all-hazards office that incorporates both emergency management and homeland security planning and policy implementation. Several stakeholders reported that coordination is strong between OEMHS and other County departments, but is currently focused on response activities, rather than preventative measures. Stakeholders report that involvement in these areas is also reactive from elected officials in the County – attention is paid to resiliency when a need arises from a constituent or during budget season. Several stakeholders indicated a need to have more robust conversations around critical infrastructure needs and climate risks outside of the yearly budget cycle.

Coordination is needed across jurisdictional boundaries in the National Capital Region to effectively address climate change. OLO spoke with local jurisdictions and utilities as well as jurisdictions from around the country. In jurisdictions in which public entities operate utilities, information is more readily available and resilience planning is stronger. Locally, OLO found that it is difficult to secure information and contacts from relevant stakeholders. Stakeholders additionally noted that coordination is more difficult due to the private ownership of utilities in the region, resulting in data gaps as some information is privately held and not easily shared. Local stakeholders believed there is a need for building strong public-private relationships and integrating business partnerships into homeland security offices. In addition, by leveraging multiple jurisdictions, there may be more opportunities to use grant funding to purchase resources and build funding mechanisms to increase resiliency.

[167] DPS staff note that the County could explore compensatory storage requirements for projects that fill in a floodplain. Compensatory storage is the volume in the floodplain that is excavated or created to offset the loss of floodplain storage from fill. Staff note the County may need to create a waiver fee to this requirement to allow development at certain sites.

C. Community Preparedness and Vulnerable Populations

There is a lack of investment in preparing and educating the community about climate-related risks. Staff report the County effectively disseminates information regarding major weather events, traffic management updates, and government and school closures. However, stakeholders report there is a lack of public education on climate risks, floodplains, and other emergency preparedness activities. Specifically, regarding climate change, there is little communication from the County and the information that is available is provided by individual departments. Further, while OEMHS provides a wealth of information, including the County's Hazard Mitigation Plan and emergency preparedness tasks, these resources are not well publicized. Stakeholders reported that there may be an opportunity to form robust partnerships with nonprofits and nongovernmental organizations to improve emergency planning and response.

Resiliency hubs boost the capacity of frontline community organizations to coordinate resources with vulnerable populations during and between disasters. Resiliency hubs are community-serving facilities augmented to support residents and coordinate resource distribution and services before, during, or after a natural hazard event. The City of Baltimore has nine hubs that provide a safe place for temporary shelter and relief during days of extreme heat and serve as a central distribution site for necessities after disaster events, such as floods. Resiliency hubs are operated by non-profit organizations, but received funding and staff training from the City of Baltimore. Stakeholders reported that resiliency hubs should be hyperlocal – walkable within a quarter to one-half of a mile radius. This allows residents to walk for services during an emergency and limits residents from driving to various centers. The City does not publicly publish the location of resiliency hubs. The City used quantitative and qualitative information to identify hubs and services. Staff mapped climate, health, and demographic data to inform site selection.

Montgomery County will have one resiliency hub operational by the end of the year- the Scotland Community Recreation Center. The Center will have advanced operations based on renewable energy sources.
Other recreation centers and community buildings are designed with life-safety measures and may have components of resilience hubs (e.g., warming and cooling systems). In past climate events, DGS has installed temporary measures at several sites. However, those sites were not designed specifically to serve as resiliency hubs.

The effects of climate change and required resilience projects are expensive. Funding for these projects, particularly utility improvements, will primarily come from taxpayers which will place an undue burden on low- or fixed-income County residents. Costs for new infrastructure projects and retrofitting existing assets to meet resiliency needs are increasingly expensive as technologies improve. Stakeholders utilize a variety of funding sources to help pay for improvements; often working to secure grants.[168] However, stakeholders offered concern that the cost of future investment would fall mostly on taxpayers, which would disparately impact low-income residents. Some specific concerns include:

[168] While a review of funding mechanisms was outside the scope of this report, stakeholders highlighted that the General Assembly passed Senate Bill 457 (passed in 2020) which authorizes counties to create "resilience authorities" to help fund costs of resilience projects. Charles County was the first County in the State to create a resilience authority.

- Utilities are experiencing a flattening of profits from rates due to energy efficiency standards, even as populations have grown in the region. This comes at a time when increased investment is needed to strengthen resiliency.
- Increased climate risks, like extreme heat, will increase utility bills. This could impact low- and fixed-income residents' ability to pay utility bills. The ability to collect payment will also impact the funds for future infrastructure development.
- Requirements for new buildings and infrastructure are often paid for by developers and passed on to purchasers or renters. This raises affordable housing concerns.
- Retrofitting existing buildings is expensive and resilience adaptations may not have similar returns like energy efficiency efforts.

Chapter 5. OLO Findings and Recommendations

Critical infrastructure are systems and assets so vital that their incapacity or destruction would have a debilitating impact on security, economic security, public health, or safety. This Office of Legislative Oversight (OLO) Report reviews the impact of climate change in the County and identifies key climate and infrastructure risks to County systems and assets. OLO examined six critical infrastructure sectors in Montgomery County: **Agriculture, Communications, Dams, Energy, Transportation, and Water and Wastewater Systems**.

This report responds to the Council's request for information on how well the County's critical infrastructure is designed to handled extreme weather events. Infrastructure is *climate-resilient* when it is planned, constructed, and operated to prepare for, adapt to, and recover from extreme climate conditions.

This chapter summarizes the major findings and OLO's recommendations for Council action.

FINDINGS

INFRASTRUCTURE SECURITY AND RESILIENCE PLANNING

Finding #1. The County is "behind the eight-ball" in resilience planning for critical infrastructure.

Stakeholders reported the County is barely meeting investment needs for maintaining current infrastructure, let alone for future risks. While in a better position than many Maryland counties, the County is behind peer jurisdictions in the National Capital Region. Examples of underinvestment include:

- Many County facilities are aging and at increased risk of failure due to extreme weather events.
- During lean budget years, the County "value engineered" resilience measures out of capital projects to reduce costs.
- The County upgrades IT equipment every 15 years; however, the industry standard is five to seven years.

Best practices identified by the U.S. Climate Resilience Toolkit (a federal inter-agency initiative led by NOAA) include identifying climate risks and undertaking a thorough analysis to identify assets, vulnerabilities, and next steps. Executive Branch staff report that the County needs to engage in this process to increase the security and resilience of critical infrastructure systems and assets.

Finding #2. The County requires significant investment to address climate information data and analysis gaps.

Stakeholders report a lack of climate data, including how weather data is changing and accurate future projections. Further, available County climate data is siloed - maintained by individual County departments. OLO found that key data was often recorded on paper and required time to combine data sets from multiple departments for items like mapping and storm costs.

Several departments report a lack of expertise among County staff to understand the extent of climate risks and adaptation strategies necessary to protect critical infrastructure. In particular:

- The County must ensure there is expertise on staff to adequately prepare for climate change (e.g., hydrologists, civil engineers, and staff to develop technical flood and stormwater models); and
- As the County adopts new technologies to address and adapt to climate change, department staff need required skill sets to implement and maintain these systems and assets.

Finding #3. Best practices indicate that information sharing and coordination are critical to comprehensively address infrastructure security and resiliency. Coordination and planning are siloed at the regional and County-level inhibiting effective planning.

There is no formal coordination between State and local governments to build resilience programs. The lack of coordination is further complicated because government entities are still determining what resiliency means for each infrastructure sector. Regionally, stakeholders report that coordination is needed across jurisdictional boundaries to effectively address climate change. Coordination is more difficult in the region due to private ownership of utilities, resulting in data gaps. In line with this, OLO found it is difficult to secure information and contacts from relevant stakeholders, particularly non-County entities.

Within the County, stakeholders report strong coordination between OEMHS and other County departments, but the focus is on response activities, rather than preventative measures. Several stakeholders indicated a need for more robust conversations with elected officials around critical infrastructure needs and climate risks.

Finding #4. There is no central repository for tracking the total County costs from storms.

Storm cost data is fragmented across departments. OEMHS collects cost data for events that could be or were submitted to FEMA for public assistance. However, OLO found this data is not readily available. Of the eight FEMA declared disasters since 2000, OEMHS was able to provide costs for two events (both occurred in 2012). Lack of data is due to (1) storm cost data not being tracked electronically and (2) data for events prior to 2008 was not transferred to OEMHS when it became a standalone office.

For storm events *not declared* disasters by FEMA (e.g., smaller snow events), departments track costs related to their response and recovery actions. Specifically:

- DOT tracks costs to clean roads (e.g., snow and debris removal);
- DGS tracks facility clearing, damage, and fleet costs;
- DEP is responsible for debris management; and
- MCPS, FRS, and HHS track response costs.

Due to report timelines and length of time to collect data from departments, staff time and investment are needed to fully understand the scope of weather-related costs to the County.

CLIMATE RISKS

Finding #5. Among selected climate risks, Montgomery County infrastructure is most vulnerable to flooding. In particular, the County lacks sufficient resources to manage the growing threat of flash floods and nuisance flooding.

OLO identified six climate risks to Montgomery County infrastructure systems and assets - floods, droughts, high winds, winter storms, hurricanes/tropical storms, and earthquakes. Of these, flooding poses the most serious risk. The National Weather Service reports an upward trend of urban flooding in the County, from two to four occurrences per year before 2010, to 11 to 39 occurrences per year since 2010. An increase in impervious surfaces and aging stormwater systems, coupled with projected precipitation increases, will result in urban flooding becoming a major climate threat to the County.

Flash Floods. Due to the County's geography, flash floods produce fast-moving water hazards capable of trapping motorist and moving cars. From 2003 to 2019, there have been 145 flash flood warnings issued for the County by the National Weather Service, for an average of about nine flash flood warnings per year. Stakeholders report flood rescue resources in the County and region are under-resourced, both with staffing and financially. As the flash flood risk increases due to extreme climate events, more resources will be needed to provide rescue services.

Nuisance Flooding. Executive staff report receiving more complaints regarding nuisance flooding in recent years. Nuisance flooding is occurring all over the County, particularly in areas where development, and the creation of impervious surfaces, has created more runoff than stormwater systems are designed to handle. This has resulted in flooding of roads, properties, and buildings outside of floodplains that historically have not been subject to flooding. Property owners experiencing nuisance flooding lack both funding and legal recourse – (1) federal and state financial assistance is geared to flooding events, not nuisance flooding, and (2) property owners experiencing nuisance flooding have limited legal recourse due to the strict guidelines of the Maryland Drainage Law.

Finding #6. Despite the critical risk posed by flooding, the County has not conducted a comprehensive review of flood risks, including establishing a single point of contact in the County to manage this risk.

The County's response to flooding is reactive – the County has not proactively evaluated its existing infrastructure to determine flood risks. Stakeholders report that there is no comprehensive model to show how water flows through the County and where the potential problems are located. Further, there is no single point of contact in the County to manage flood prevention programs. Departments handle risks to their infrastructure, but staff report that these efforts are siloed. Establishing a single point of contact would also improve community preparedness activities around flood management.

CRITICAL INFRASTRUCTURE SECTOR-SPECIFIC RISKS

Finding #7. Dependencies and interdependencies between critical infrastructure sectors can lead to a cascading failure. More research is needed to determine the extent to which Montgomery County is at risk of cascading infrastructure sector failures.

A cascading failure occurs when one sector experiences a service outage, leading to disruptions in other sectors. For example, the loss of a lifeline sector will have an immediate impact on the operations of multiple sectors. Severe weather events, like high winds and thunderstorms, can exacerbate these relationships. Best practices call for communities to address risks from cross-sector dependencies and interdependencies to enhance infrastructure security and resiliency. OLO highlights dependencies and interdependencies for the sectors reviewed. OLO acknowledges that these are not the only vulnerabilities that could increase the risk of a cascading failure and that further research is needed to identify specific vulnerabilities.

Agriculture. Disruptions to the water supply, transportation systems, and communications networks inhibit a farmer's ability to process and sell products. The COVID-19 pandemic showed the impact of sector disruptions on the County's agricultural community and preparedness gaps.

Communications. Disruptions to the communications network will impact the ability of the County to provide essential services, impact traffic management, and communication with residents. Outages to the Energy and Water Sectors could impact the ability of the Communications Sector to power and cool equipment.

Dams. Dam infrastructure relies on communications to remotely monitor assets. Dam failure could disrupt transportation and communication infrastructure, contaminate water supplies, and impact agriculture. (See Finding #9).

Energy. The Energy Sector provides "an enabling function" to all other sectors. Significant disruptions would have a ripple effect across the County. (See Finding #8 for Water Sector Impacts.)

Transportation. Disruptions to the communications, energy, and water sectors will impact daily operations. Stakeholders report County transportation infrastructure is aging and will need financial investment.

Water and Wastewater. Disruptions to this will impact the operations of all sectors reviewed. There is limited redundancy built-in for the County's major drinking water supply (See Finding #8).

Finding #8. Key County Water Sector assets are at the greatest risk due to lack of resiliency measures. The County's Water Security Plan is not finalized.

The Potomac River supplies much of the water for the region - WSSC's Potomac Water Filtration Plant supplies 70% of drinking water to Montgomery County. There is limited redundancy between WSSC Water's two water filtration plants for supplying finished drinking water (assuming average daily demand remains constant). Additional infrastructure risks with the Potomac Filtration Plant include:

- The Potomac Plant only has one surface water intake from the Potomac River. If an event requires the shutdown of the Plant's surface water intake, this may lead to a disruption in drinking water services.
- The Potomac Plant does not have an off-grid backup power supply. If power is lost to the grid, there would be a power outage at the Plant and drinking water services could be disrupted.

Regional partners are exploring options to increase the resiliency of this infrastructure, including purchasing the Travilah Quarry, but these options are long-term and expensive. Further, OEMHS reports lack of staff capacity to complete the County's Water Security Plan.

Finding #9. Privately-owned dams and ponds in the County are at risk for failure, with limited resources to monitor and repair these assets.

Two assets, dams and ponds, are especially at risk for failure in the County:

- Agricultural ponds are critical to farmers' ability to irrigate crops, but the infrastructure is aging. The repairs required to fix these ponds are expensive, time-consuming, and must meet federal standards. This matter is complicated by the fact that upwards of 40% of farmers do not own the land they farm. Staff report if the farmer does not have a long-term lease (10 plus years), there is little incentive to pay for the repairs.

- The County has limited communication with private dam owners and a lack of data collection. The dam infrastructure in the County is aging, and repairs and redesigns are expensive and difficult to complete.

Finding #10. Tree maintenance is an important preventative action that decreases the risk of service interruptions. The County's tree maintenance program is underfunded and lacks policies aligned with strengthening resiliency.

Utility providers report downed trees are one of the largest contributors to power outages. About 31% of all local storm reports made from 2003 to 2019 (740 reports in total) included incidences of fallen and/or downed trees. With the County reducing its tree trimming budget, the risk of power outages has increased over the years. Further, utility stakeholders report the County does not restrict property owners from planting trees near or under power lines, which can result in increased outages.

COMMUNITY PREPAREDNESS AND VULNERABLE POPULATIONS

Finding #11. The County needs to strengthen investments in community preparedness, including education on climate-related risks.

The County is effective in disseminating information regarding major weather events, traffic management updates, and government and school closures. Stakeholders identified a need for increased public education on climate risks, floodplains, and other emergency preparedness activities. OEMHS provides a wealth of information on its website regarding County-specific plans and emergency preparedness, but these resources are not well publicized. Specific communications regarding climate change from the County is scarce, with siloed information disseminated by individual departments.

Finding #12. Resiliency hubs boost capacity of frontline community organizations to coordinate resources during and between disasters.

Research shows low-income residents in high-income regions often have less access to information and resources to help prepare for and avoid risks that stem from extreme weather events. One method, resiliency hubs, are community-serving facilities that coordinate distribution and services before, during, or after a natural hazard event. Stakeholders report opportunity to increase resiliency hubs in Montgomery County. Currently, the Scotland Community Recreation Center will be operational as a resiliency hub by the end of the year. In past climate events, DGS has installed temporary measures at several sites. However, those sites were not designed specifically to serve as resiliency hubs.

Finding #13. Extreme weather events disproportionately affect low-income populations and communities of color.

Extreme weather conditions exacerbate existing health, financial, and other socioeconomic problems faced by low-income populations and communities of color. Without significant policy interventions, it is likely that climate change and the subsequent increase of extreme weather events will reinforce and amplify current socioeconomic disparities. Specific issues include:

- Decades of underinvestment in infrastructure have led to vulnerability to natural disasters;
- Increased vulnerability of heat waves due to urban residencies;
- Lack of labor laws which require wage payment to non-salaried workers during a disaster;
- Less access to information and resources to help prepare for extreme weather events; and
- Difficulty recovering from extreme weather events, including finding safe and affordable housing and securing disaster aid.

Finding #14. Funding for resilience projects, particularly utility improvements, will place an undue burden on low- or fixed-income County residents.

Costs for new infrastructure projects and retrofitting existing assets to meet resiliency needs are increasingly expensive as technologies improve. The County utilizes a variety of funding sources to pay for improvements, often working to secure grants. However, stakeholders offered concern that the cost of future investment would fall mostly on taxpayers, which would disparately impact low or fixed-income residents. Specific concerns include:

- Utilities are experiencing a flattening of profits from rates due to energy efficiency standards, even as populations have grown in the region. This comes at a time when increased investment is needed to build resiliency;
- Increased climate risks, like extreme heat, will increase utility bills;
- Requirements for new buildings are paid for by developers and passed on to purchasers or rents;
- Retrofitting existing homes or buildings are cost-prohibitive.

RECOMMENDATIONS

Recommendation #1. Request that the County Executive conduct facility and asset risk assessments to evaluate climate risks and fill knowledge and data gaps.

Best practices indicate that governments should engage in risk assessments to identify vulnerable infrastructure. Montgomery County has not conducted facility risk assessments of critical infrastructure and local stakeholders report the County is barely meeting investment needs for maintaining current infrastructure, let alone for future risks.

The County should conduct an assessment that examines and identifies assets (including an asset inventory), risks, and consequences (e.g., economic, infrastructure, socio-cultural, and public health losses). From this assessment, the County can set priorities, develop a resilience strategy, and implement projects with a better understanding of the resources needed. OLO acknowledges this may require additional staff.

Recommendation #2. Request that the County Executive compile all climate-related data in a central, electronic repository for easier access and transparency.

Best practices recommend that information sharing is key to building a comprehensive all-hazards approach to climate-resilient infrastructure. However, County climate data is limited, and information is soiled. The lack of coordination presents an inherent risk to the County.

Historical climate data, climate change projections, and data on infrastructure are critical to resilience planning. Stakeholders need to have easy access to high quality and consistent data to inform planning and adapt strategies. Staff should work together to determine what climate and infrastructure data, including costs, should be collected and where it should be stored.

Recommendation #3. Request that the County Executive assign a single point of contact to assess and manage flood risk to critical infrastructure and flood prevention programming.

Climate data show that flooding is one of the most significant climate risks to County infrastructure. However, there is no single point of contact in the County to manage this risk. Identifying a single point of contact for flood management is a critical first step. A single point of contact can help coordinate and convene the appropriate stakeholders, drive jurisdictional priorities and policies, resolve issues and challenges, and respond to community concerns. Further, centralized risk management will increase coordination of available resources while ensuring equal access and opportunity across resilience efforts. It should be noted that Executive staff report that additional funding and staff may be needed.

Recommendation #4. Request that the County Executive increase coordination across departments and regional partners to promote and improve security and resiliency of County critical infrastructure.

The physical and economic impacts of climate change and extreme events can cross jurisdictional boundaries. The adaptation responses that one community implements can affect neighboring areas, both positively and negatively. Decisionmakers recognize that proactive and effective resilience planning should be coordinated with neighboring jurisdictions on a regional level.

Local stakeholders reported that there is a lack of this coordination between County departments, elected officials, federal/state/local governments, and utility partners. The County should increase coordination with regional stakeholders to develop innovative and collaborative solutions to address climate risks and critical infrastructure needs. In addition, the coordination of efforts with regional partners and local jurisdictions could allow these entities to leverage scarce financial resources and staff time.

Recommendation #5. Request that the County Executive strengthen communication and outreach activities to improve preparedness and mitigation activities for vulnerable populations in the County.

Extreme weather conditions exacerbate existing health, financial, and other socioeconomic problems faced by low-income populations and communities of color. Further, research shows low-income residents in high-income regions often have less access to information and resources to help prepare for and avoid risks that stem from extreme weather events. The County could undertake the following specific actions to help alleviate this disparity:

- Developing an understanding of barriers faced by vulnerable populations accessing County preparedness and disaster recovery resources;
- Evaluating and establishing robust partnerships with nonprofits and nongovernmental organizations in the community to improve emergency planning;
- Establishing additional resiliency hubs to increase community preparedness; and
- Working with utility partners to evaluate options to assist low- or fixed-income individuals to mitigate potentially increasing utility bills.

Chapter 6. Agency Comments

The Office of Legislative Oversight (OLO) shared final drafts of this report with staff from Montgomery County Government. OLO appreciates the time taken by agency staff to review the draft report and to provide technical feedback. This final report incorporates technical corrections and feedback received from agency staff.

The written comments received from the Montgomery County Chief Administrative Officer are attached in their entirety on the following pages.

OFFICE OF THE COUNTY EXECUTIVE

Marc Elrich
County Executive

Richard S. Madaleno
Chief Administrative Officer

M E M O R A N D U M

March 16, 2021

TO: Chris Cihlar, Director
Office of Legislative Oversight

FROM: Richard S. Madaleno, Chief Administrative Officer for

SUBJECT: Draft OLO Report 2021-X: Measuring Climate Resilience

Thank you for the opportunity to comment on the Office of Legislative Oversight's (OLO) Draft Report 2021-X: Measuring Climate Resilience. This report is timely in that it coincides with the County's recent issuance of the Draft Climate Action Plan. The draft report included the following recommendations:

Recommendation #1: Request that the County Executive conduct facility and asset risk assessments to evaluate climate risks and fill knowledge and data gaps.

CAO Response: We agree with this recommendation. The Draft Climate Action Plan includes an action (G-15) for conducting climate vulnerability detailed assessments. The County will develop a list of critical or sensitive facilities and determine if a higher regulatory floodplain standard is appropriate. The County will also review the defunct Executive Order 11988 for the construction and renovation of critical infrastructure to determine if this Executive Order should be restored. Specifically, EO 11988 specifies the design event for critical infrastructure as the 500-year floodplain or +3.0 ft. vertically over the 100-year base flood elevation. Funding and staff resources will need to be identified for this effort.

Recommendation #2: Request that the County Executive compile all climate-related data in central electronic repository for easier access and transparency.

CAO Response: We agree with this recommendation. The Draft Climate Action Plan includes an action (G-16) for consolidating County climate data. A consolidated location where climate and statistical data from the various departments and agencies can be uploaded and shared will expedite planning and development for climate initiatives. As an example, data on rainfall intensity, duration, and frequency for storm events should be shared across departments. Funding and staff resources will need to be identified for this effort.

Recommendation #3: Request that the County Executive assign a single point of contact to assess and manage flood risk to critical infrastructure and flood prevention programming.

CAO Response: We partially agree with this recommendation. The County already has a single point of contact for all of the regulatory and compliance aspects of floodplain management. The Department of Permitting Services (DPS) is the lead agency for all regulatory aspects of floodplain management and appoints a single person to the position of Floodplain Administrator. However, the County does not have a single point of contact to manage all of the non-regulatory aspects of floodplain management, such as grant acquisitions, environmental improvement projects, removal of repetitive loss structures, public outreach, and the National Flood Insurance Program Community Rating System. As noted below, multiple departments and agencies play a role in these aspects of floodplain management, and it would not be practical to combine all of these functions into a single point of contact. Funding and staff resources would need to be identified to provide inter-departmental coordination of floodplain management issues.

In addition to DPS floodplain administrator role indicated above, department roles in floodplain management include:

- The identification of critical facilities in the floodplain as done by Office of Emergency Management and Homeland Security (OEMHS).

- Capital improvement projects for the planned improvement or resiliency of the County's transportation assets are completed by the Department of Transportation.

- Environmental improvement projects for planned stream restoration projects as completed by the Department of Environmental Protection.

- Pursuance of federal grants for the removal of repetitive loss structures for the purpose of creating parks as done by Maryland National Capital Park and Planning Commission.

Recommendation #4: Request that the County Executive increase coordination across departments and regional partners to promote and increase security and resiliency of County critical infrastructure.

CAO Response: We agree with this recommendation. The staff of the Maryland Public Service Commission is an important partner in discussions about electric and gas utility security and resiliency in the County.

Recommendation #5: Request that the County Executive strengthen communication and outreach activities to strengthen preparedness and mitigation activities for vulnerable populations in the County.

CAO Response: We agree with this recommendation. The Draft Climate Action Plan includes an action (G-7) for evaluating and updating County planning, policy, and operations activities to account for the risks of climate change impacts and prioritize the needs of vulnerable residents. These include the needs of children, the elderly, those with underlying health conditions, and economic disadvantaged communities. The Draft Climate Action Plan also includes an action (P-1) for public outreach to empower the public with information on how to reduce emissions and adapt to the impacts from climate change. This includes giving residents and businesses access to information and resources that enable them to protect their families and homes from the impacts of climate change, such as tips on high heat preparedness and information about the National Flood Insurance Program.

We look forward to discussing these items at the Council session.

c: Fariba Kassiri, Deputy Chief Administrative Officer
Adriana Hochberg, Assistant Chief Administrative Officer
Earl Stoddard, Director, Office of Emergency Management and Homeland Security
Marc Hansen, County Attorney, Office of the County Attorney
Jeremy Criss, Director, Office of Agriculture
Mitra Pedoeem, Director, Department of Permitting Services
Adam Ortiz, Director, Department of Environmental Protection
David Dise, Director, Department of General Services
Chris Conklin, Director, Department of Transportation

List of Appendices

Appendix	Title	Begins at
A	**U.S. Climate Resilience Toolkit - Steps to Resilience** – Outlines best practices for evaluating and planning resilience projects.	©1
B	**Mid-Atlantic Weather Trends -** Summarizes climate and weather trends in the Mid-Atlantic.	©3
C	**Maryland Weather Trends –** Describes climate and weather trends in the State of Maryland.	©4
D	**Maps Provided by the Department of Technology Services –** Includes the following maps: • Dam Inundation Areas and DEP Levees and Dams • Roads Maintained by Montgomery County Government • Map of Watersheds in Montgomery County	©5
E	**Extreme Cold Trends and Impacts in Montgomery County –** Defines and describes extreme cold trends.	©8
F	**Disparity in Federal Disaster Aid Dispersal –** Provides a discussion of recent research regarding dispersal of federal disaster aid.	©9
G	**Populations Vulnerable to Extreme Heat –** Identifies populations in Montgomery County vulnerable to heat risks.	©11
H	**Additional Actions to Address Stormwater and Flooding Risks** – Lists additional actions for the County to explore to manage these risks	©12

Appendix A. U.S. Climate Resilience Toolkit – Steps to Resilience

The first step in building resiliency is evaluating infrastructure vulnerability to climate change.[1] The U.S. Climate Resilience Toolkit outlines best practice steps to build resiliency of services, systems, and physical infrastructure – (1) Explore Hazards; (2) Assess Vulnerabilities and Risks; (3) Investigate Options; (4) Prioritize and Plan; (5) Take Action. This process falls under the mitigation and preparedness phases of emergency management described in Chapter One.

Steps to Building Resilience of Infrastructure and Systems

Source: U.S. Climate Resilience Toolkit.

Explore Hazards

Jurisdiction develops an understanding of climate risks posed to critical infrastructure. For each asset, jurisdictions should consider the range of climate or weather-related events that could pose a threat and determine potential damages or consequences that could result. [2] Consequences from historical weather events are useful benchmarks. Historical events help to identify conditions to avoid and offer the opportunity to measure effectiveness of interventions implemented.[3]

Assess Vulnerabilities and Risks

Jurisdictions typically hire consultants to perform vulnerability and risk assessments of critical infrastructure. Vulnerability assessments are a comparative analysis to identify and prioritize the most vulnerable systems and infrastructure. Vulnerability is the susceptibility of an asset to damage from current or future climate variability and extremes. An asset's level of exposure and sensitivity determine potential impact. [4]

- **Exposure** – Probability of exposure examines the threat's occurrence, how frequently it occurred in the past, and how climate change could change the frequency or severity of the threat overtime.
- **Sensitivity** – Degree to which the asset is susceptible or resistant to impacts from climate events.[5]

Assets are also evaluated based on adaptive capacity. Adaptive capacity examines an asset's ability to accommodate the climate impact and return to normalcy after a disruption.[6]

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[1] Lauren Miller, Boston Society of Civil Engineers, Steps Towards Climate Change Resilience for Critical Infrastructure https://www.bsces.org/news/industry/steps-towards-climate-change-resilience-for-critical-infrastructure-3228
[2] U.S. Climate Resilience Toolkit, Steps to Resilience, Explore Hazards, https://toolkit.climate.gov/steps-to-resilience/explore-hazards
[3] U.S. Climate Resilience Toolkit, Steps to Resilience, Explore Hazards.
[4] U.S. Department of Energy Office of Scientific and Technical Information, Vulnerability Assessments and Resilience Planning at Federal Sites, https://www.osti.gov/servlets/purl/1240754
[5] U.S. Climate Resilience Toolkit, Steps to Resilience, Assess Vulnerability and Risks, https://toolkit.climate.gov/steps-to-resilience/assess-vulnerability-risks
[6] Lauren Miller, Boston Society of Civil Engineers, Steps Towards Climate Change Resilience for Critical Infrastructure.

Investigate Options

Jurisdictions evaluate solutions, evaluate other jurisdictions' responses, and develop a list of feasible actions. To increase adaptive capacity, jurisdictions may engage in long-term capital planning. Regardless of the solution, jurisdictions should determine if the solution would improve outcomes of past events and if it would be robust enough to handle future climate threats.[7]

Prioritize and Plan

Jurisdictions evaluate cost benefits and evaluate capacity. When prioritizing activities, communities should ensure essential services remain operational. Actions should lead to future adaptation options, prioritize synergies across assets, and promote costs savings.[8]

Take Action

Jurisdictions move forward with key stakeholders to implement and monitor plans and review project status. Risks and priorities are reevaluated to ensure the plan is increasing climate resilience.[9]

[7] U.S. Climate Resilience Toolkit, Steps to Resilience, Investigate Options, https://toolkit.climate.gov/steps-to-resilience/investigate-options

[8] U.S. Climate Resilience Toolkit, Steps to Resilience, Prioritize & Plan, https://toolkit.climate.gov/steps-to-resilience/prioritize-plan

[9] U.S. Climate Resilience Toolkit, Steps to Resilience, Take Action, https://toolkit.climate.gov/steps-to-resilience/take-action

Appendix B. Mid-Atlantic Weather Trends

- Temperatures in the Mid-Atlantic region have increased the most compared to every other region in the United States – increasing nearly 2 degrees Fahrenheit (F) since 1880.
- Winter is the fastest warming season for the region and future projections show that by the end of the 21st century, the Mid-Atlantic region could experience warm spring temperatures 15 to 26 days earlier.
- Since the 1950s, the Mid-Atlantic region has experienced a larger increase in coastal flooding compared to all other regions in the United States.[10]
- In 2020, Washington D.C. and the City of Baltimore (MD) tied their records for the least snowy spring, with no snowfall recorded from March to May.[11]
- In 2020, the southeastern portion of the Mid-Atlantic region, which includes Virginia, Maryland, Delaware, and the Southeastern portion of Pennsylvania, experienced drier conditions than normal while the northwestern portion of the region experienced up to 150% more precipitation than normal.[12]
- Increased hurricane and tropical storms have caused significant socioeconomic losses. For example, in 2012, Hurricane Sandy caused $74.8 billion in damages (adjusted for inflation).[13]
- By 2100, the Mid-Atlantic region will regularly experience 30 days or more with a heat index above 100 degrees F if no climate actions are taken. Historically, Mid-Atlantic states have experienced an average of 7-10 days with a heat index above 90 degrees Fahrenheit.[14]

[10] Environmental Protection Agency, Climate Change Indicators in the United States, 2016 4th Edition, https://www.epa.gov/sites/production/files/2016-08/documents/climate_indicators_2016.pdf
[11] Cornell University, Northeast Regional Climate Center, http://www.nrcc.cornell.edu/services/blog/2020/06/01/index.html
[12] National Oceanic and Atmospheric Administration, Mid-Atlantic Regional Integrated Sciences and Assessments, 2020, https://www.midatlanticrisa.org/climate-summaries/2020/06.html
[13] National Oceanic and Atmospheric Administration, Billion-Dollar Weather and Climate Disasters: Events, https://www.ncdc.noaa.gov/billions/events/US/1980-2020
[14] Environmental Research Communications, "Increased Frequency of and population exposure to extreme heat index days in the United States during the 21st century", July 16,2019, https://iopscience.iop.org/article/10.1088/2515-7620/ab27cf/pdf

Appendix C. Maryland Weather Trends

- Temperatures for most of Maryland increased 1.5 degrees Fahrenheit (F) in the last century.[15]
- Similar to Mid-Atlantic trends, Maryland has experienced warmer winters and summers, wetter falls and springs, and drier summers.[16]
- Historically, the average annual temperature is 55.1 degrees F. However, summer temperatures are dramatically increasing and could be a major driver in an increase in the annual temperature.
- State weather patterns are increasingly unpredictable. For example, the Chesapeake Bay watershed experienced one of the warmest months of March on record in 2020, immediately followed by one of the coldest months of April on record.[17]
- **Extreme Heat.** Projections show that without climate change mitigation, Maryland will experience an average of 95 days above 90 degrees F and 24 days above 100 degrees F annually by the end of the 21st century. Historically in the late 20th century, the state experienced an average of 30 days above 90 degrees F and two days above 100 degrees F annually.[18]
- **Sea Level Rise.** By the end of the century, sea levels in the State could rise as much as 7 feet. This would threaten most of the Eastern Shore as well as cities built near the water, like Baltimore and Annapolis.[19]
- **Precipitation.** Annual precipitation in Maryland has increased about 5% in the last century. Heavy precipitation events have increased by 55% between 1958-2016 and could increase by another 40% by the end of 2100. [20]
- **Flooding.** Since intense rainfall events are projected to occur more frequently, there is an increased risk of urban flooding.[21]
- **Droughts.** Naturally occurring droughts will continue to occur, with more intense droughts due to higher temperatures. This could lead to a higher rate of soil moisture loss.[22]
- **Extreme Weather Events.** The Atlantic hurricane season has increasingly experienced more major storms threatening coastal homes, highways, and critical infrastructure. For example, Hurricane Sandy (2012) caused roughly 41.6 million gallons of sewage to overflow across the state.[23]

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[15] NOAA National Centers for Environmental Information, State Climate Summaries: Maryland and District of Columbia 2017, https://statesummaries.ncics.org/chapter/md/

[16] Maryland Department of Natural Resources, "Climate Change in Maryland", https://dnr.maryland.gov/climateresilience/Pages/about_climatechange.aspx#:~:text=In%20the%20future%2C%20it%20is%20expected%20that%20climate,low-lying%20areas%20along%20the%20State%E2%80%99s%20shoreline%20and%20coast

[17] National Oceanic and Atmospheric Administration, Mid-Atlantic Regional Integrated Sciences and Assessments, 2020, https://www.midatlanticrisa.org/climate-summaries/2020/06.html

[18] Maryland Commission on Climate Change, Comprehensive Assessment of Climate Change Impacts in Maryland, July 2008, https://mde.state.md.us/programs/Air/ClimateChange/Documents/FINAL-Chapt%202%20Impacts_web.pdf

[19] American University Radio, "Sea Level Rise Could Bring Daily Flooding to Maryland Cities, Dec 17, 2018, https://wamu.org/story/18/12/17/sea-level-rise-could-bring-daily-flooding-to-maryland-cities/

[20] Environmental Protection Agency, "What Climate Change Means for Maryland, August 2016, https://www.epa.gov/sites/production/files/2016-09/documents/climate-change-md.pdf

[21] NOAA National Centers for Environmental Information, State Climate Summaries: Maryland and District of Columbia, 2019, Maryland and District of Columbia - State Summaries 2019 (ncics.org)

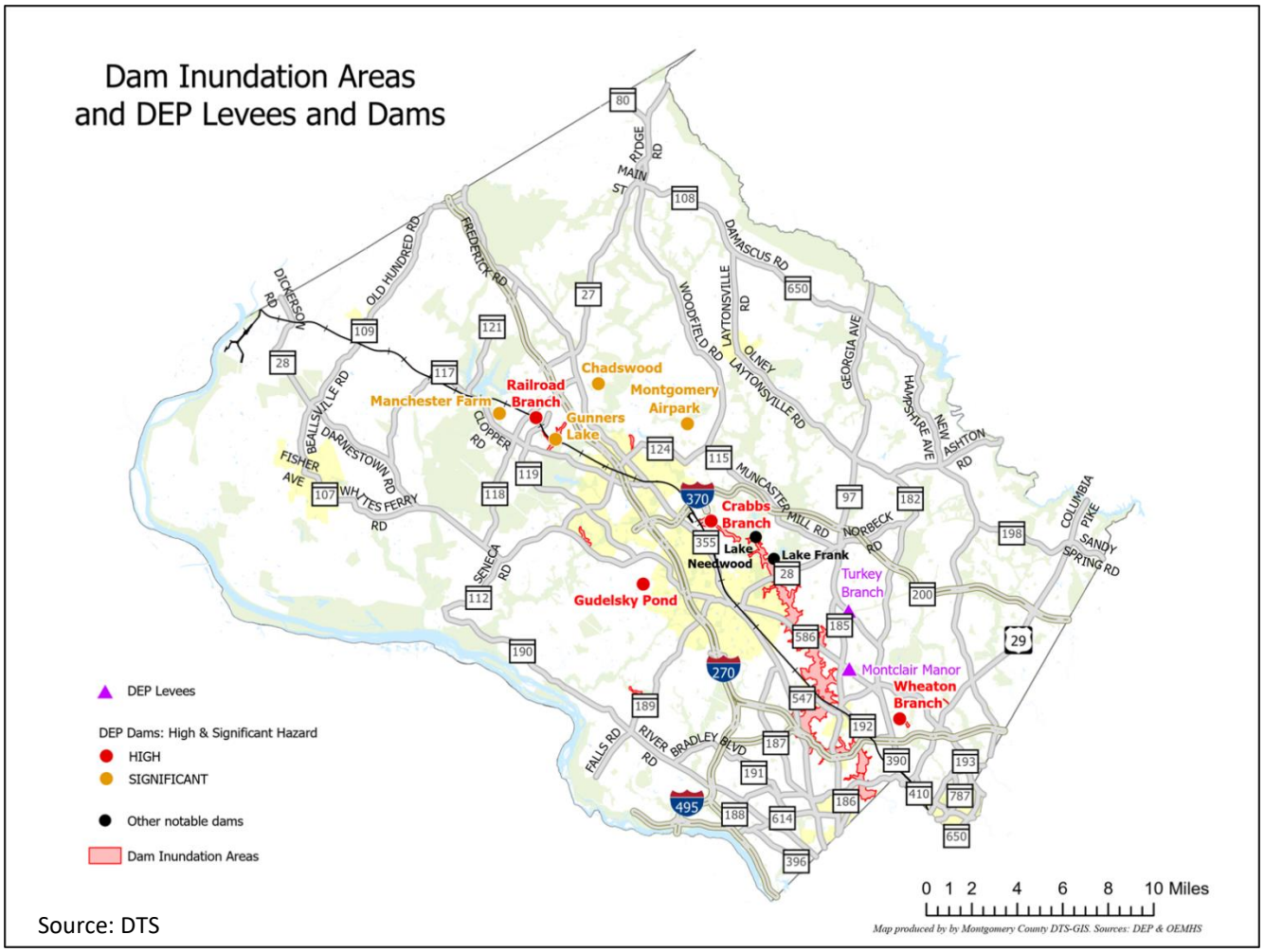
[22] *Ibid*.

[23] Environmental Protection Agency, What Climate Change Means for Maryland, August 2016, https://www.epa.gov/sites/production/files/2016-09/documents/climate-change-md.pdf; Climate Central, "Sewage Overflows From Hurricane Sandy", April 2013, https://www.climatecentral.org/pdfs/Sewage.pdf

Appendix D. Maps Provided by Department of Technology Services

Map 1. Dam Inundation Areas and DEP Levees and Dams

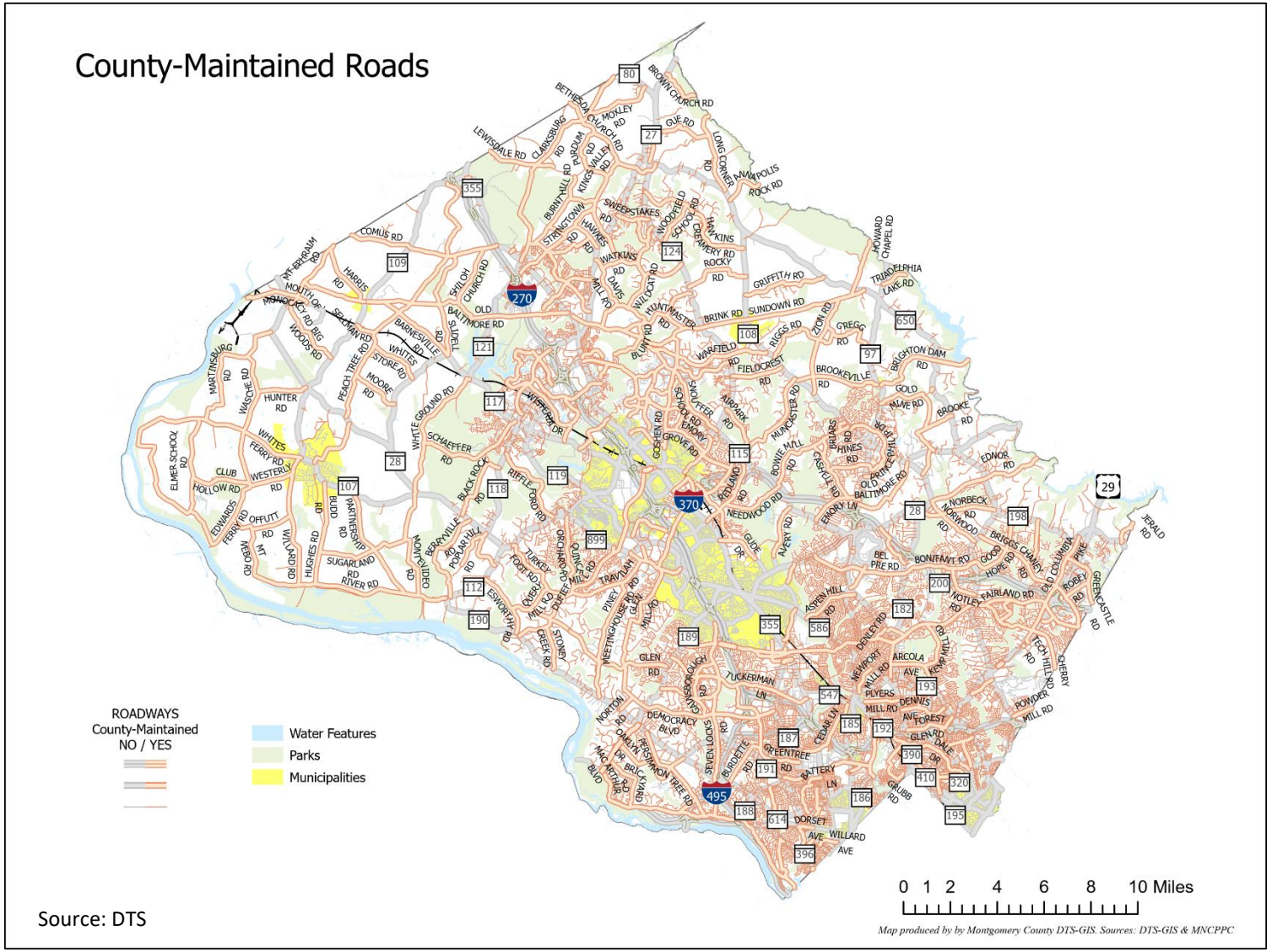
Dam inundation maps identify significant and high hazard dams. This map is used to identify critical infrastructure and geographic areas that may need protective measures and evacuation planning in the event of dam failure or overtopping. (FEMA, https://www.fema.gov/sites/default/files/2020-08/fema_dam-safety_inundation-mapping-flood-risks.pdf)



Source: DTS

Map 2. County Maintained Roads

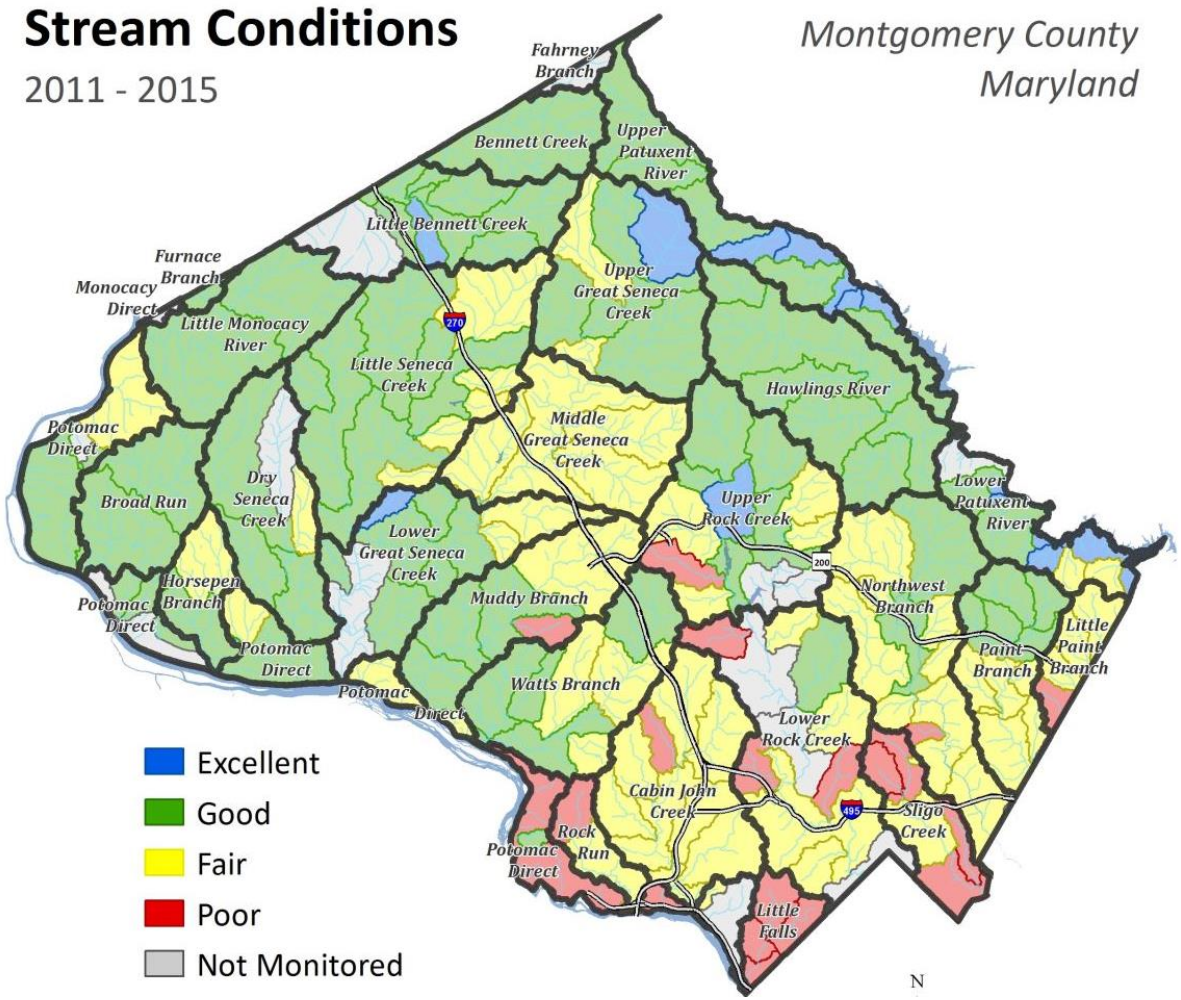
Displays road maintained by Montgomery County Government.



Source: DTS

Map 3. Watersheds in Montgomery County

This map shows the health of subwatersheds in the County, which can serve as a reference for where the subwatersheds are located in the County. An interactive version of this map is available at https://www.montgomerycountymd.gov/water/streams/watershed-health.html



Source: DEP

Appendix E. Extreme Cold Trends and Impacts on Montgomery County

Definition of Risk. Extreme cold can threaten public health (i.e., frostbite and hypothermia), safety and infrastructure, including roadways, utilities. Older infrastructure systems and assets that are poorly maintained are at greater risk of damage from extreme cold. [24] The chart below shows the wind chill and temperature range for each threat category of cold temperatures.

Cold Temperatures Threat Level to Life And/or Property	Description
Extreme	A wind chill of -35° F or below for 3 hours or more or lowest air temperature less than or equal to -20° F
High	A wind chill of -28° F to -35° F for 3 hours or more or lowest air temperature -15° F to -20° F
Moderate	A wind chill of -20° F to -28° F for 3 hours or more or lowest air temperature -10° F to -15° F
Low	A wind chill of -15° F to -20° F for 3 hours or more or lowest air temperature -5° F to -10° F
Very Low	A wind chill of -10° F to -15° F for 3 hours or more or lowest air temperature 0° F to -5° F

Source: 2018 Montgomery County Hazard Mitigation Plan

Profile of Hazard in Montgomery County. The average minimum temperature in Montgomery County ranges from 21-26° F, however extreme cold can be a hazard in any given year. The County's Hazard Mitigation Plan reported two extreme cold events that occurred in the past 20 years, one in 2014 and the other in 2015.[25]

Future Trends. The Draft Climate Action Plan did not identify any future trends for extreme cold.[26] Research shows that climate change is exacerbating polar vortex disruptions, which can lead to extreme cold snaps in the Northeast and Mid-Atlantic states. However, these events are unpredictable, and more research is needed for accurate future projections.[27]

[24] Montgomery County Office of Emergency Management and Homeland Security, Hazard Mitigation Plan 2018.
[25] *Ibid.*
[26] Montgomery County Government, Draft Climate Action Plan, 2020. https://www.montgomerycountymd.gov/green/Resources/Files/climate/draft-climate-action-plan.pdf
[27] National Oceanic and Atmospheric Association, On the Sudden Stratospheric Warming and Polar Vortex of Early 2021, 2021, https://www.climate.gov/news-features/blogs/enso/sudden-stratospheric-warming-and-polar-vortex-early-2021

Appendix F. Disparity in Federal Disaster Aid Dispersal

Populations lacking access to resources, information, or technology are less able to participate in programs focusing on disaster preparation, mitigation, response, and recovery.[28] Disasters can act as a tipping point for vulnerable populations – resulting in housing and financial insecurity.[29] Specifically,

- Residents of areas affected by natural disasters may be more likely to fall behind on mortgage payments or experience foreclosure. The Urban Institute found that residents impacted by Hurricane Sandy had a higher rate of mortgage delinquency and foreclosures. This trend persisted four years after the storm.[30]
- Utility debt among residents in zip codes affected by natural disasters rise in each of the four years following the disaster.[31]

However, Federal disaster aid often exacerbates existing racial and wealth inequalities. Researchers found that White families in communities with significant damage from natural disasters generally experience an increase in wealth from reinvestment initiatives. Comparatively, minority families in communities with similar damages saw a significantly smaller increase in wealth, or even a decrease in wealth.[32] For example, White families living in areas that experienced about $100,000 in damages from a natural disaster saw an average wealth **increase** of about $26,000; while Black families in the same area saw a wealth **increase** of $19,000 on average. In areas with about $10 billion in damages, White families saw a wealth **increase** of about $126,000; while Black families saw a wealth **decrease** of nearly $27,000.[33] These disparities also exist among Latinx and Asian families. Latinx families living in areas with about $10 billion in damages saw an average wealth **decrease** of $29,000 and Asian families saw an average wealth **decrease** of $10,000.

The ability of households to understand available programs and effectively obtain aid diminishes for households with less resources. Federal disaster aid programs (FEMA and US Department of Housing and Urban Development's Community Development Block Grants for Disaster Recovery) do not share common triggers for appropriating funds, consistent eligibility criteria thresholds, or applications. Additionally,

- Damage assessments are based on property ownership, which favors the wealthier areas of communities and disadvantages renters and homeless populations;
- FEMA's Individual Assistance Program, which disperses aid to individuals after a disaster, is more accessible to those with time, income, and access;

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[28] Thomas Frank, Advisors Rebuke FEMA for Racial Disparities in Disaster Aid, Scientific American, January 7, 2021, https://www.scientificamerican.com/article/advisers-rebuke-fema-for-racial-disparities-in-disaster-aid/

[29] Urban Institute, Improving Disaster Recovery of Low-Income Families, https://www.urban.org/debates/improving-disaster-recovery-low-income-families.

[30] *Ibid*.

[31] *Ibid*.

[32]Wealth refers to data collected from the Panel Study of Income Dynamics (PSID), which includes reported values of all checking and saving accounts, real estate holdings, vehicles, stocks, annuities, and other savings at the immediate family level and subtracts this from the sum of all reported debts. In the study, individual families' wealth was tracked from 1999-2013.

[33] Social Problems Volume 66, Issue 3, Damages Done: The Longitudinal Impacts of Natural Hazards on Wealth Inequality in the United States, 2019, https://doi.org/10.1093/socpro/spy016

- Affluent individuals are more likely to qualify for FEMA flood insurance and Small Business Administration disaster loans, which can provide upwards of $250,000 in aid; and
- FEMA grant programs require communities to pay for a portion FEMA-supported of preparedness and mitigation project costs. Poorer communities often struggle to receive grant funding due to the cost-share requirement and lack of expertise to complete grant applications. [34]

As a result, low-income applicants or non-property owners are disproportionately impacted by current disaster aid programs. For example,

- A review of FEMA data on the Individual Assistance Program (Hurricane Harvey) revealed applicants making less than $30,000 comprised 20% of applications, but 48% of aid denials. Researchers found FEMA denial codes affect low-income households, like "occupancy not verified" or "missed inspection." (FEMA relies on human inspectors to visit impacted homes which requires the homeowner be present as well as present necessary paperwork).[35]
- After Superstorm Sandy in New Jersey, renters experienced 43% of the damage, but were targeted to receive only 22% of federal funding.[36]

In a report released in November 2020, FEMA stated that many of programs do not consider the principle of equity in financial assistance relief. FEMA is beginning a review of its traditional aid programs. Part of FEMA's review will likely include a determination of which policies, regulations, and legislation should be revised to produce more equitable outcomes. Local governments will likely need to identify at-risk communities to better target federal funding.[37]

[34] National Advisory Council, Report to the FEMA Administrator, November 2020, https://www.fema.gov/sites/default/files/documents/fema_nac-report_11-2020.pdf; Thomas Frank, FEMA Says It Will Make Disaster Response More Equitable, Scientific American, March 15, 2021, https://www.scientificamerican.com/article/fema-says-it-will-make-disaster-response-more-equitable/#:~:text=Through%20internal%20emails%2C%20public%20advisories,low%2Dincome%20and%20minority%20populations.

[35] Urban Institute, Improving Disaster Recovery of Low-Income Families. Chrishelle Palay, Disaster Aid Perpetuates Inequality, May 13, 2019, Shelter Force, https://shelterforce.org/2019/05/13/disaster-aid-perpetuates-inequality/; Rebecca Hersher and Robert Benincasa, How Federal Disaster Money Favors The Rich, NPR, March 5, 2019, https://www.npr.org/2019/03/05/688786177/how-federal-disaster-money-favors-the-rich

[36] Urban Institute, Improving Disaster Recovery of Low-Income Families

[37] National Advisory Council, Report to the FEMA Administrator.

Appendix G. Populations Vulnerable to Extreme Heat

Heat waves were identified to be among the most dangerous of natural hazards to the County.[38] With rising temperatures across the Northeast and Mid-Atlantic region, heatwaves are becoming a higher public health concern. Extreme heat events in cities can cause heat-related mortality rates to spike dramatically. Populations that are especially vulnerable to heat risks are:[39]

- The elderly
- Young children
- People with underlying medical conditions
- Pregnant women and mothers who are breastfeeding
- Low-income residents, since they are more likely to live in poor-quality housing and have less access to water, green spaces, information, and air-conditioning
- Homeless populations
- Those who live alone
- Outdoor workers, especially those whose jobs require physical exertion

This chart summarizes some of the populations in Montgomery County that are especially vulnerable to heat risks.[40]

Table 1. Populations in Montgomery County Especially Vulnerable to Heat Risks

Population Group	Population Count	% of Total Population
County Total Population	**1,050,688**	**--**
Persons 65 Years and Over	169,044	16.1%
Persons Under 5 Years	64,618	6.2%
Persons with a Disability	83,602	7.9%
Persons Living in Poverty	76,700	7.3%
Persons without a Home*	647	.06%
Persons Living Alone (18 Years and Over)	58,848	5.6%
Combined Persons Employed in Agriculture and Construction Industry	34,847	3.3%

Source: OLO; US Census; Montgomery County Government

[38] Montgomery County Department of Environmental Protection, Draft Climate Action Plan, 2020, https://www.montgomerycountymd.gov/green/Resources/Files/climate/draft-climate-action-plan.pdf
[39] Centers for Disease Control and Prevention, Protecting Vulnerable Groups from Extreme Heat, June 19, 2017, https://www.cdc.gov/disasters/extremeheat/specificgroups.html
[40] United States Census Bureau, https://www.census.gov/quickfacts/montgomerycountymaryland; Montgomery County Government, Ending Homelessness in Montgomery County, https://www.montgomerycountymd.gov/Homelessness/Numbers.html

Appendix H. Additional Actions to Address Stormwater and Flooding Risks

The following suggestions were offered by DEP staff for consideration. DEP staff indicated that the County would need to review existing authorities to determine if additional policies or policy amendments would be needed.

	Preparedness	Mitigation	Response	Recovery
POTENTIAL ACTIONS TO ADDRESS CLIMATE AND/OR INFRASTRUCTURE RISKS				
Set impervious caps for parcels based on zoning and for watersheds	✓	✓		
Reduce impervious surfaces through impervious surface removal and redevelopment	✓	✓		✓
Increase stormwater management volume control and discharge requirements	✓	✓		✓
Retrofit and introduce stormwater management to address flooding issues	✓	✓		✓
Require decompaction of soils during and after site development[41]	✓	✓		✓
Increase County net forest cover and tree canopies		✓		✓

[41] When soils are compacted, they can act as impervious surfaces, increasing the risk of drainage issues and runoff. Center for Watershed Protection, The Compaction of Urban Soils: Technical Note #107 from Watershed Protection Techniques. 3(2): 661-665, 2000, https://stormwater.pca.state.mn.us/index.php/Alleviating_compaction_from_construction_activities