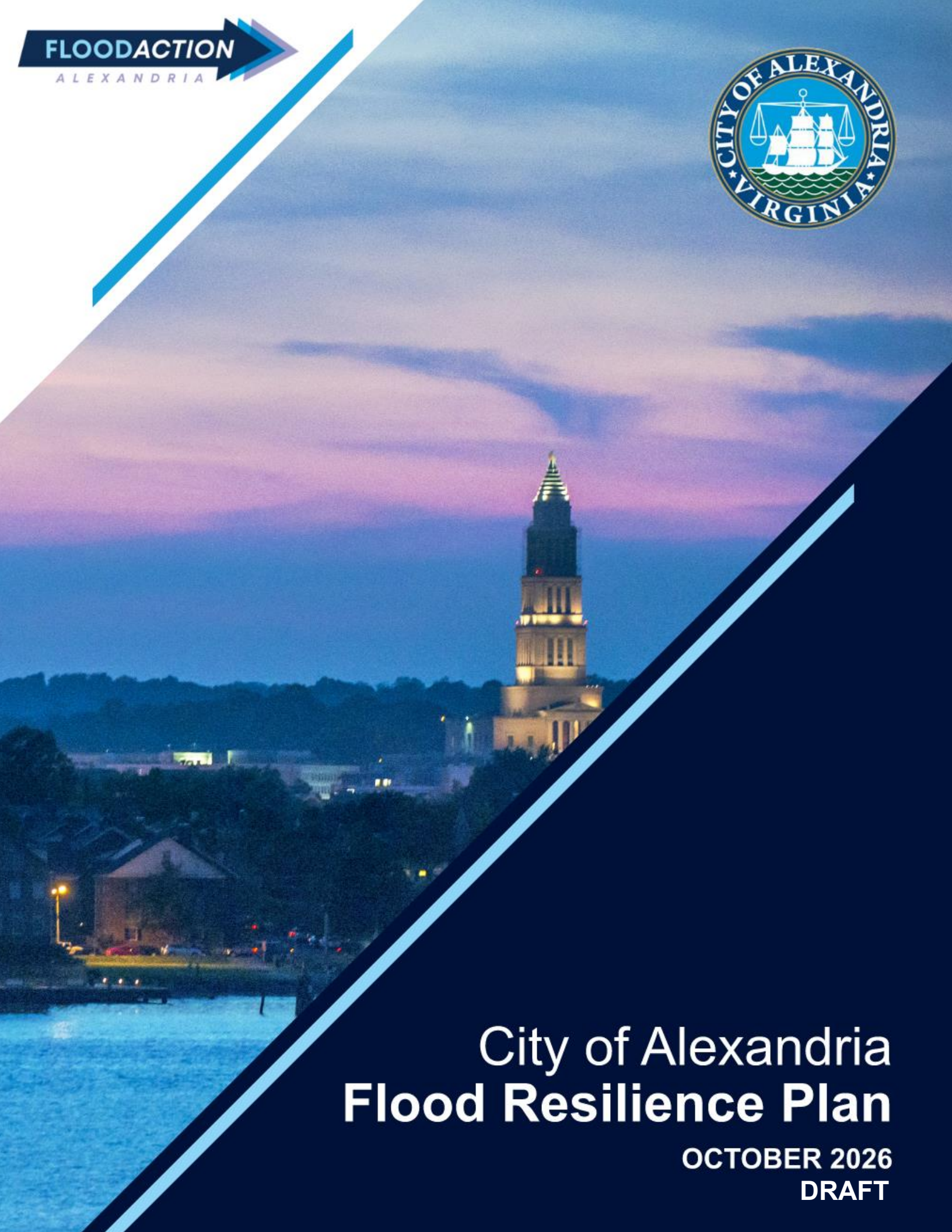
FLOODACTION
ALEXANDRIA



City of Alexandria
Flood Resilience Plan

OCTOBER 2026
DRAFT

ACKNOWLEDGEMENTS

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FUNDERS

Virginia Department of Conservation and Recreation

This project received funding from the Virginia Community Flood Preparedness Fund Grant Program through the Virginia Department of Conservation and Recreation (DCR), via CFPF-24-04-38.

DRAFT

FLOODACTION ALEXANDRIA

Jacobs

DCR Virginia Department of Conservation & Recreation

DEPARTMENT OF TRANSPORTATION & ENVIRONMENTAL SERVICES

PRR

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ACRONYMS AND ABBREVIATIONS

°F	degrees Fahrenheit
AlexRenew	Alexandria Renew Enterprises
BFE	base flood elevation
BMP	best management practice
CASSCA	City of Alexandria Storm Sewer Capacity Analysis
CBO	community-based organization
CFPF	Community Flood Preparedness Fund
cfs	cubic foot (feet) per second
CIP	Capital Improvement Program
DCR	Virginia Department of Conservation and Recreation
City	City of Alexandria, Virginia
CRS	Community Rating System
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FPA	flood-prone area
FRP	Flood Resilience Plan
FUP	Floodplain Use Permit
FY27	Fiscal Year 2027
FY37	Fiscal Year 2037
LBWID	Lake Barcroft Watershed Improvement District
MS4	Municipal Separate Storm Sewer System
NFIP	National Flood Insurance Program
RPA	Resource Protection Area
SFHA	Special Flood Hazard Area
SVI	social vulnerability index
SWU	Stormwater Utility
T&ES	Alexandria Department of Transportation and Environmental Services
VDOT	Virginia Department of Transportation

Executive Summary



EXECUTIVE SUMMARY

WHY THIS PLAN?

Flooding is an increasing challenge for the City of Alexandria, Virginia, as intense storms, rising water levels, and aging infrastructure place residents, businesses, and critical community assets at risk. As a historic waterfront city, Alexandria must proactively address current and future flood hazards to protect public safety, community well-being, environmental resources, and economic vitality.

Since 2021, the City has been working to address flooding through Flood Action Alexandria, the City's comprehensive program to address current and future flood risks by combining infrastructure investment, resilience planning, stormwater management, public outreach, and emergency preparedness. The initiative focuses on reducing the impacts of interior, riverine, and coastal flooding. Elements of the program include major flood mitigation and stormwater capacity projects and maintaining critical drainage and sewer infrastructure. Flood Action Alexandria also provides residents and businesses with tools, resources, and grant opportunities to help protect their properties. Through these coordinated efforts, the program aims to strengthen community resilience and improve public safety.

In 2024, the Virginia Department of Conservation and Recreation (DCR) awarded the City a grant through the Community Flood Preparedness Fund (CFPF) to support the development of this Flood Resilience Plan (FRP). The FRP expands on the original 2021 Resilience Plan.

This plan will help Alexandria by identifying where flooding is more likely to occur, who is most affected, and which actions will provide the greatest benefit to the community. Rather than reacting to flooding after it happens, the plan provides a roadmap for reducing and mitigating risks before future flooding occurs.

For residents, businesses, and other community members, the plan will:

- Reduce flood risks to homes, businesses, and neighborhoods by guiding City investments toward areas where drainage improvements, flood mitigation projects, and resilience measures will have the greatest long-term impact.
- Protect critical community services by prioritizing essential facilities including schools, healthcare facilities, utilities, and public infrastructure that community members rely on every day.
- Support socially vulnerable populations by prioritizing areas where residents may have fewer resources to prepare for flooding or face greater challenges recovering after flood events.
- Prepare for future flood conditions by incorporating projected increases in rainfall and water levels into planning decisions today

This FRP provides a clear, science-based assessment of flood risks and establishes a strategy to protect people, property, infrastructure, quality of life, environment, and economy. By prioritizing practical and cost-effective solutions, the plan aims to make Alexandria safer, more resilient, and better prepared for future flood events.

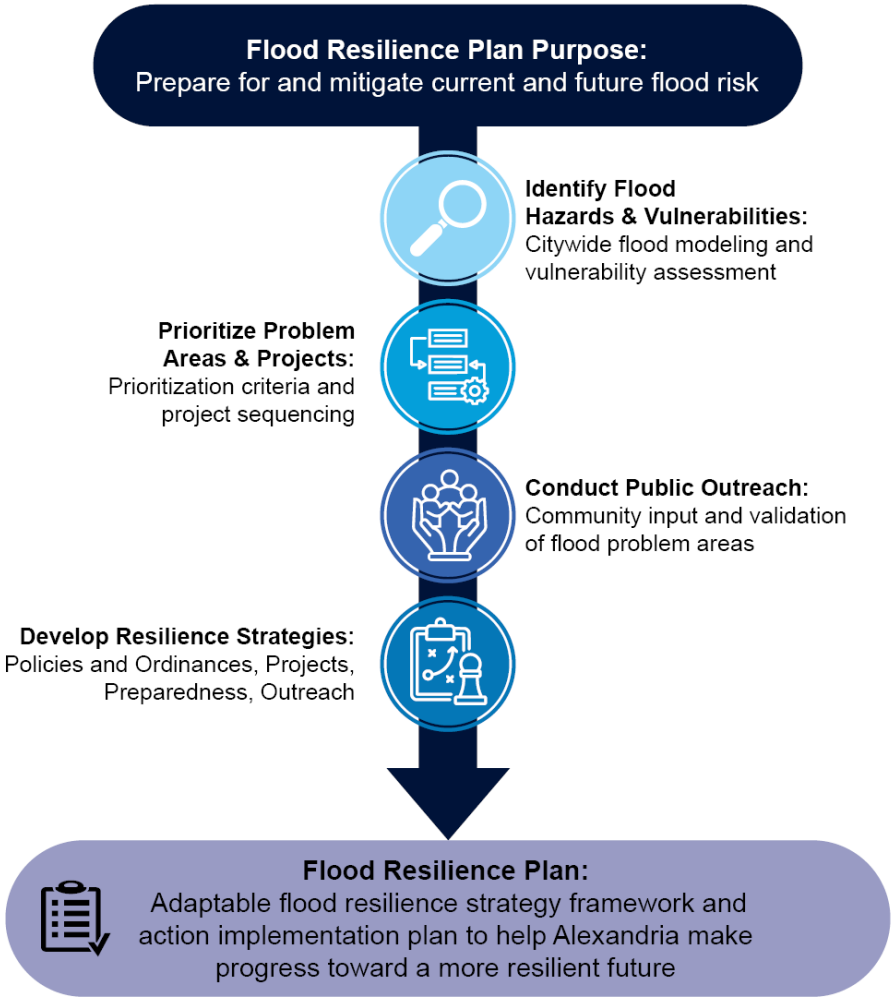


Figure ES-1. Flood Resilience Plan Purpose, Planning Process and Outcomes.

Approach to Understanding Flood Risk

This FRP was developed through a process that included flood risk and vulnerability assessments, evaluation and prioritization of resilience strategies projects, and stakeholder engagement to inform implementation, outreach, and education efforts (Figure ES-1). Plan development was centered around several key components:

- Citywide flood hazard mapping to understand types and locations of current and future flooding in the city.
- A flood vulnerability assessment to identify priority risk areas and to understand how flooding could affect residents, homes, businesses, transportation routes, critical facilities, and community services.
- A comprehensive public outreach effort to solicit input from the community to inform and validate flood analyses, priority areas, and resilience strategies.
- Development of recommended strategies to strengthen flood resilience in the near- and long-term, Strategies include enhancements to City policies, programs and initiatives and a prioritized list of future flood mitigation projects to address vulnerable areas.

This FRP combined flood modeling and a vulnerability assessment to assess flood risk throughout the city. The analysis considered three primary flood mechanisms: interior flooding from

intense rainfall that overwhelms stormwater drainage systems, riverine flooding from streams and rivers overtopping their banks, and coastal flooding driven by tidal influences, storm surge, and rising water levels in the Potomac River. To account for changing rainfall conditions, modeling was completed for baseline 2020 conditions and projected 2075 scenarios, including representative 10-year and 100-year storm events.

Flood hazard mapping integrated multiple data sources and models, including Federal Emergency Management Agency (FEMA) flood studies and detailed watershed models for Hooffs Run and Four Mile Run. The analysis also incorporated citywide two-dimensional surface flooding analyses and regional coastal flood modeling. Rainfall intensity and coastal water levels are projected to increase significantly over time, expanding the extent of riverine and interior flooding across the city and increasing the frequency and impacts of coastal flooding in vulnerable waterfront and low-lying areas.

A citywide vulnerability assessment was conducted to identify locations where flood hazards pose the greatest risk to people and critical infrastructure. The assessment evaluated flood exposure to residential and non-residential buildings, critical facilities, transportation infrastructure, socially vulnerable populations, and environmental resources at the subwatershed scale. Several locations across the city were identified as having elevated risk because they contain a combination of flood-prone properties, critical infrastructure, and socially vulnerable populations.

The planning effort incorporated robust community engagement to gather local knowledge and verify that the FRP reflected residents' and stakeholders' experiences and priorities. Outreach activities included six community events that engaged approximately 400 participants, an online survey that received 149 responses, two public community meetings attended by participants both in person and online, and bi-monthly updates to the Stormwater Utility and Flood Mitigation Advisory Committee. Community input played a key role in validating modeled flood-risk areas, identifying locations for further study, informing and supporting flood resilience strategies, and helping the project team better understand flood impacts, community concerns, and costs associated with flooding and mitigation efforts.

Together, these activities provide a citywide understanding of Alexandria's flood challenges and help identify where investments can provide the greatest benefit. The results form the foundation for the FRP's recommendations, guiding future projects and strategies that will reduce flood impacts, improve public safety, and strengthen long-term resilience.

From Analysis to Action

The City's comprehensive approach to reducing flood risk and strengthening community resilience includes a broad portfolio of recommended strategies designed to address current and future flood hazards. Recommendations are organized into the following eight focus areas:

- Policies and Ordinances
- Flood Mitigation
- Integrating Flood Resilience Across City Programs and Beyond
- Flood Preparedness and Response
- Asset Management
- Communication and Outreach
- Socio-Economic Inclusion
- Funding Strategies

A key component is the prioritization of projects in high-priority flood problem areas and vulnerable subwatersheds. In addition to engineered solutions and planning projects, the plan highlights the role of policy initiatives, nature-based strategies, proactive maintenance, public education, interdepartmental coordination, and community partnerships in reducing flood risk and building a more resilient Alexandria.

The implementation framework for the FRP translates resilience strategies and recommendations into a coordinated action plan. The framework organizes recommended actions into short-term, mid-term, and long-term planning horizons, which recognizes that some initiatives can be advanced immediately while others require additional study, funding, or coordination.

Understanding that flood risks, community needs, funding opportunities, and regulatory requirements will continue to evolve, the implementation plan is intended to function as an adaptive framework that can be refined as new information becomes available. Through continued investment, collaboration, and periodic reassessment, the framework will guide project prioritization, inform funding decisions, and track progress toward achieving Alexandria's long-term flood resilience goals.

How to Use This Plan

This FRP is designed as both a technical reference and a practical decision-making tool for City staff, policymakers, stakeholders, and the public. The document is organized to guide the reader from understanding flood risks to identifying vulnerabilities and implementing targeted solutions. The plan includes the following sections:

- **Section 1 – Introduction.** Section 1 introduces the FRP by establishing the need for a comprehensive, citywide approach to addressing increasing flood risks from intense rainfall, tidal influences, and changing environmental conditions. It provides background on Alexandria's physical, environmental, and socio-economic characteristics; describes the City's history of flooding, flood hazards, and associated impacts; outlines the Flood Action Alexandria Program; explains the factors that contribute to flood risk and community vulnerability; and summarizes the key studies, plans, and initiatives that provide the foundation for the development of this FRP.
- **Section 2 – Hazard Identification.** This section describes the key drivers of flood risk in Alexandria incorporated into the citywide flood assessment models, including changing rainfall conditions and Potomac River dynamics. It summarizes the modeling approach and presents baseline and future flood extents maps. Finally, this section explains the vulnerability assessment used to evaluate the impacts of flooding on neighborhoods, critical facilities, and vulnerable populations. These findings provide a baseline to inform planning, design standards, and policy discussions.
- **Section 3 – Flood Resilience Strategies.** This section functions as the core implementation guide, providing a description of the flood resilience strategies already in place and a vision of what the City hopes to improve to strengthen resilience. The section outlines the tools and actions available to reduce flood risk and is organized into eight focus areas.
- **Section 4 – Path Forward.** The final section translates the strategy into action by presenting an implementation framework that includes an action plan and proposed schedule for execution. The section allows decision makers to track progress, adjust priorities, and ensure accountability.

Taken together, the plan serves multiple purposes:

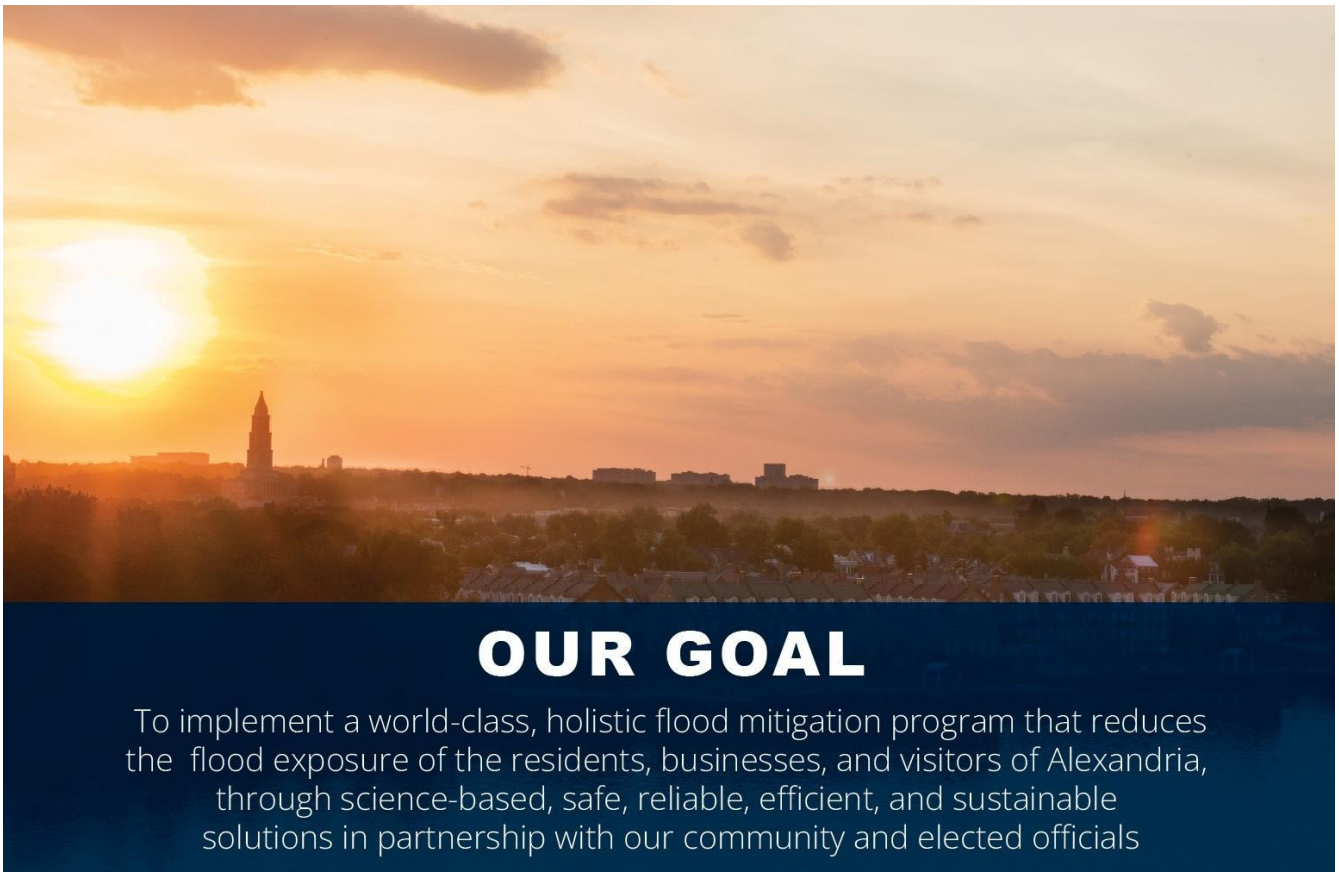
- Informing decisions: Provides data and analysis to guide policy development and infrastructure investments.
- Prioritizing actions: Identifies where risks are highest and where interventions will be most effective.
- Coordinating efforts: Aligns City departments and external partners around shared resilience goals.
- Supporting implementation: Outlines specific projects, programs, and funding strategies.
- Adapting over time: Establishes a framework that can evolve as conditions and risks change.

Section 1
Introduction



1 INTRODUCTION

1.1 OUR DRIVING MOTIVATION



Flooding is an increasing challenge for the City of Alexandria (City), Virginia, where stronger storms and rising water levels put more people, residences, businesses, and infrastructure at risk. As a historic waterfront community, the City faces unique vulnerabilities that make preparing for future flood events especially important. The City is preparing for this challenge by working to better understand flood risks and investing in practical and forward-looking solutions to help protect residents, support a resilient economy, and preserve the character and safety of the community for years to come.

Alexandria's approach to flood resilience is guided by a goal: ***To implement a world-class, holistic flood mitigation program that reduces the flood exposure of the residents, businesses, and visitors of Alexandria, through science-based, safe, reliable, efficient, and sustainable solutions in partnership with our community and elected officials.***

The Flood Resilience Plan (FRP) provides a clear roadmap for the City to reduce current and future flood risk. Through technically sound analysis and innovative strategies, this plan aims to minimize flood exposure, while protecting public safety, quality of life, the environment, and the local economy for Alexandria's residents and businesses.

To develop this plan, flood hazard mapping was expanded to previously unstudied areas, resulting in a more comprehensive understanding of flood risk. Priority areas were identified where flood risk is highest, and a set of strategies was developed that focuses on improving flood resilience now and in the future. These strategies include:

- Policy and ordinance updates
- Flood mitigation projects and programs
- Integrating flood resilience across City programs and beyond
- Flood preparedness and response

- Asset management
- Communication and outreach efforts
- Socio-economic inclusion
- Funding strategies

In addition, this plan supports the City's broader goals and responsibilities by aligning with key initiatives and requirements such as the Virginia Department of Conservation and Recreation's (DCR) Community Flood Preparedness Fund (CFPF), the Federal Emergency Management Agency (FEMA) Community Rating System (CRS), and the City's Energy and Climate Change Action Plan.

Resilience is…

"the capability to anticipate, prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to social well-being, health, the economy, and the environment."

Source: Code of Virginia 2022.

1.2 Characterization of Alexandria

Alexandria is a densely populated, highly urbanized community of approximately 160,000 residents in northern Virginia along the western bank of the Potomac River in the Washington, D.C. metropolitan region. Bordered by Arlington County to the north, Fairfax County to the west, and the Capital Beltway (Interstate 495) to the south, Alexandria is one of the most densely developed communities in the country.

As a historic waterfront city founded in 1749, Alexandria has long been shaped by its relationship with the Potomac River. The Old Town area, with its preserved architecture, walkable streets, and active waterfront, reflects centuries of economic and cultural activity tied to maritime trade and regional connectivity. Today, Old Town remains a major destination, attracting millions of visitors annually and contributing to more than $1 billion in annual visitor spending (Visit Alexandria 2025).

The city is characterized by a diverse, well-educated population and a strong local economy. Approximately 66% of residents hold a bachelor's degree or higher, and the median household income is $124,593 (AEDP 2024). The city is racially and ethnically diverse (Figure 1-1); approximately one-quarter of residents are foreign born. At the same time, economic disparities persist, with roughly 1 in 12 residents (8.4%) living in poverty (City of Alexandria 2025a).

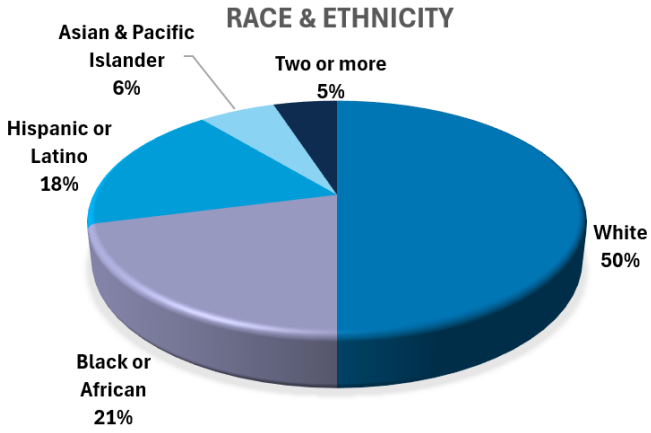


Figure 1-1: Race and Ethnicity Distribution in Alexandria

Source: City of Alexandria 2025a

Alexandria is a compact and highly urbanized city. Land use reflects a mix of historic and modern patterns, ranging from low-lying waterfront neighborhoods in Old Town to suburban-style higher-density, mixed-use redevelopment areas in the western portions of the city, with single-family detached and townhouse neighborhoods throughout. Since the late 1980s, sustained commercial and office growth has reinforced Alexandria's role as a regional employment center, with a strong concentration of professional services, associations, and institutional uses integrated throughout the urban landscape. The city now has one of the highest concentrations of professional and trade associations in the country (AEDP 2024; VEDP 2026).

Climate, Topography, and Drainage

Alexandria has a temperate climate, with approximately 40 inches of annual rainfall and 17 inches of annual snowfall. Summers are typically warm and humid, while winters are generally mild. Average temperatures are 79 degrees Fahrenheit (°F) in July and 36°F in January (City of Alexandria 2023).

The city's topography offers gently rolling terrain that slopes eastward toward the Potomac River, with elevations ranging from approximately 3 to 280 feet above sea level (Figure 1-2).

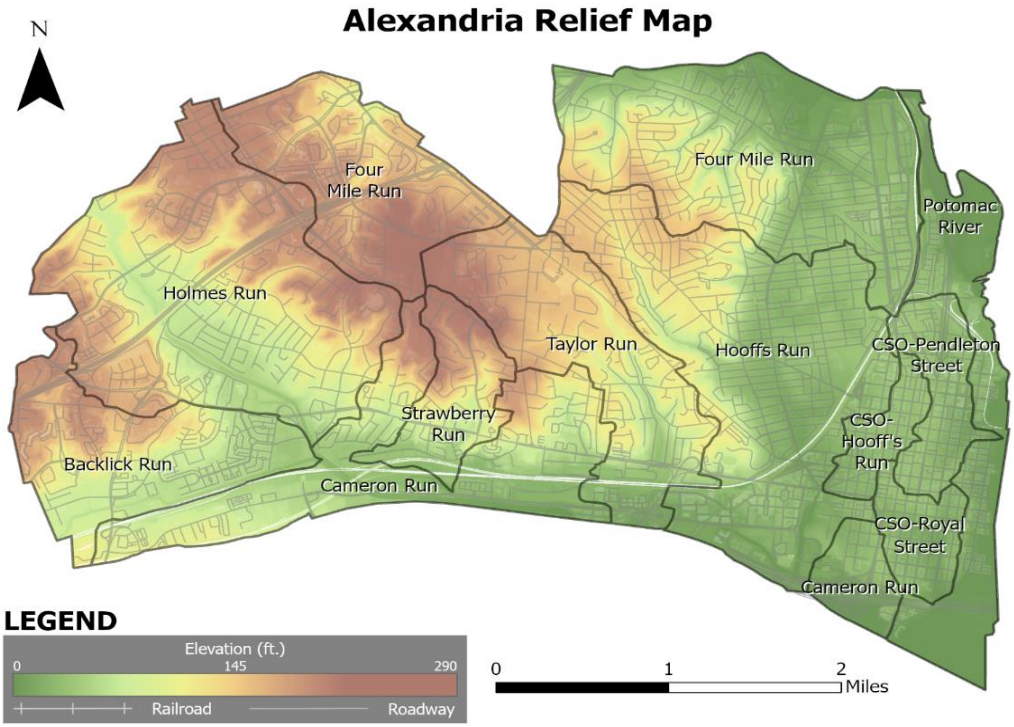


Figure 1-2: Alexandria Topography and Watersheds

Alexandria is divided into eight local watersheds, including portions of the Four Mile Run, Cameron Run, and Holmes Run watersheds, as well as all of Hooffs Run watershed. These watersheds drain into the Potomac River and are part of the broader Chesapeake Bay watershed. Watersheds in Alexandria have been shaped by historic and dense urban development. The city is about 48% impervious surfaces on average, with the older, eastern portions having greater-than-average imperviousness and western portions having less than average. Impervious surfaces, such as rooftops, roads, sidewalks, and parking lots, prevent water from soaking into the ground and generate larger volumes of stormwater runoff during rainfall events (Figure1-3). This runoff is managed by stormwater drainage infrastructure, which consists of surface drains and underground pipe networks to collect and convey runoff away from streets and properties. Collected runoff is conveyed through the drainage system and discharged to the nearest channel, stream, or river in each watershed.

To make room for urbanization, many of the natural drainage channels and streams have been altered by legacy practices, such as confining streams into underground pipes and construction of culverts and engineered channels. In many watersheds, storm drainage infrastructure was constructed prior to current design standards. As a result, today's stormwater can overwhelm the drainage system and flow into streets and adjacent properties. Low-lying areas—particularly in Old Town, neighborhoods along the Potomac River, and tributary corridors in Rosemont and Del Ray—are left especially vulnerable to flooding.

Because rainfall intensity and the frequency of storms are anticipated to increase in the future, these changing conditions will continue to challenge the city's drainage system capacity. This situation underscores the need for integrated, citywide flood resilience planning, including capital infrastructure projects and programs taking place under Flood Action Alexandria.

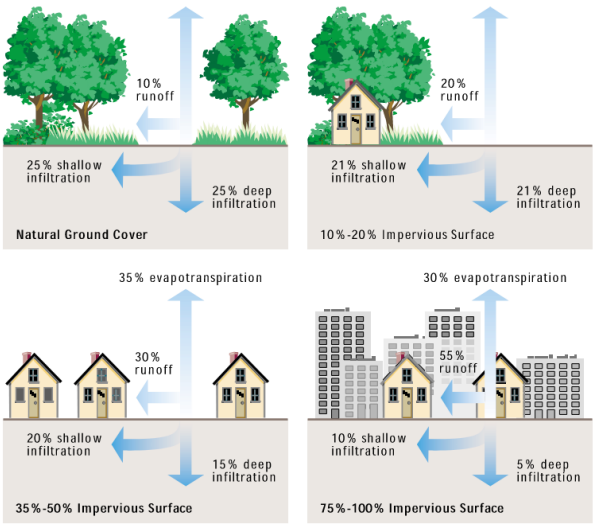


Figure 1-3: Effects of Imperviousness on Runoff and Infiltration

Source: FISRWG 2001

1.3 History of Storms, Flooding, and Flood Impacts

Flooding has been a persistent challenge for the City, shaped by its location along the Potomac River and its low-lying waterfront (Figure 1-4). While the City is proud of its waterfront heritage—a location that has long been a defining asset—it is also understood that the location contributes to exposure to flooding.

Flood risk along the Potomac River is partly influenced by historic land reclamation, which created much of Alexandria's waterfront by filling in former wetlands and river bottom. Because these reclaimed areas sit at low elevations near the river, they remain particularly vulnerable to coastal flooding from storm surge and tidal influences. Two of the worst floods of the 19th century occurred in 1861 and 1889 (Alexandria Times 2017), flooding

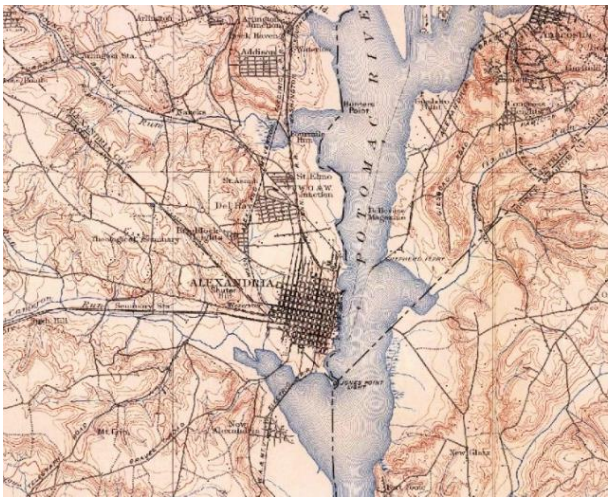


Figure 1-4: 19th Century Map of Alexandria's Location

Source: Flood Action Alexandria n.d.



Figure 1-5: Types of Storms that Impact Alexandria

buildings along Union Street, Queen Street, and Cameron Street by the city's waterfront.

In addition to areas along the Potomac River, interior flooding—also called urban flooding and flash flooding—is most prevalent in flat, low-lying inland areas and frequently occurs in the Rosemont and Del Ray neighborhoods. These areas are also susceptible to riverine flooding from local streams that can overtop their banks during periods of high flow.



Photo 1-1: Flooding on King Street caused by Tropical Depression Debby in 2024. (Source: City of Alexandria)

Alexandria is exposed to three main types of storms, including tropical systems, frontal storms, and thunderstorms. Each storm type has the potential to cause different types of flooding (Figure 1-5), as further discussed in Section 1.5. Tropical systems, including hurricanes and tropical storms, generate prolonged rainfall, strong winds, and coastal storm surges (Photo 1-1). Frontal storms typically bring sustained rainfall over large areas, resulting in large volumes of rain and runoff. Thunderstorms bring short-duration, high-intensity rainfall and frequently overwhelm drainage systems.

As shown in Table 1-1, Alexandria has experienced extreme flooding impacts from all three types of storms. Tropical systems have produced some of the most severe and well-documented flood impacts in the city. During Hurricane Isabel in 2003, regional storm surge levels reached 5 to 9 feet above normal tides, setting new benchmarks in portions of the Chesapeake Bay and tidal tributaries and contributing to more than $1.6 billion in damages across Virginia (NOAA 2003).

In 2011, large-scale storms associated with the remnants of Tropical Depression Lee dropped more than 5 inches of rain in 24 hours and caused widespread damage and road closures from flash floods. Tropical systems are major drivers of flooding in Virginia and account for the largest share of disaster-related costs statewide.

Frontal systems have also caused major flooding. In June 2006, prolonged rainfall across the Potomac River basin resulted in widespread riverine flooding throughout the region. Localized flash flooding from thunderstorms also has become increasingly common and more intense. Since 1996, Alexandria has documented more than 100 flood events caused by high-intensity thunderstorms, with a marked increase in frequency and intensity since 2015. Three severe storms that took place during a 14-month period between 2019 and 2020 caused repeated roadway and property damage (Photo 1-2) and prompted the City to establish the Flood Action Alexandria program in 2021.

These events illustrate how Alexandria's flood risk is driven by a combination of storm surge and tidal influences associated with tropical systems, prolonged regional frontal storms, and short, intense thunderstorm events.



Photo 1-2: Interior flash flooding on Glebe Road near Commonwealth Avenue in the Del Ray neighborhood, caused by thunderstorms. (Source: @DrainALX 2023)

Table 1-1: Significant Historical Storm Events in the City of Alexandria

Event Date and Name	Event Characterization (Flood Depth and/or Rainfall Depth)	Impacts
Tropical Systems		
June 21-22, 1972 Hurricane Agnes	Rainfall: 8.16 inches over 2 days[a] Cameron Run Flood Stage: 18.14 feet Cameron Run Peak Flow: 19,900 cfs	One of the highest flood events on record in Alexandria. Extensive riverine flooding throughout the Cameron Run watershed and surrounding areas (USGS 2026).
September 23, 2003 Hurricane Isabel	Rainfall: ~2 inches across the region Cameron Run Flood Stage: 11.29 feet (5 to 9 feet above normal tides) Cameron Run Peak Flow: 9,330 cfs	Floodwaters inundated Old Town streets and entered homes, reaching approximately 2 feet above floor level in some homes. Prompted evacuations and extensive recovery efforts (FEMA 2021). Damage exceeded $1.6 billion across Virginia (NOAA 2003).
September 8, 2011 Tropical Depression Lee	Rainfall: 5 inches in 24 hours[a]	Widespread riverine flooding throughout the region. Overtopped roadways, including Telegraph Road and portions of Interstate 495/Interstate 95. Inundated residential and commercial properties and overwhelmed stormwater infrastructure.
August 9, 2024 Tropical Depression Debby	Specific rainfall depth and flood depth not reported.	Floodwaters inundated King Street and other areas of Old Town.
Frontal Storms		
June 2006	Rainfall: 7.96 inches over 32 hours[b] Four Mile Run Flood Stage: 20.20 feet Four Mile Run Peak Flow: 8,100 cfs	Widespread riverine flooding throughout the region. Overtopped roadways, including Telegraph Road and portions of Interstate 495/Interstate 95. Inundated residential and commercial properties and overwhelmed stormwater infrastructure. Nearby Huntington area sustained approximately $10 million in damages (USACE 2007).
Thunderstorms		
1996 to **Present**, **Recurring Localized Flood and Flash Flood Events** Alexandria has documented more than 100 flood events since 1996, including numerous flash floods from intense thunderstorm rainfall.		
July 8, 2019	Rainfall: 3.1 inches in 2 hours[a]	Localized flooding, roadway impacts, and property damage as part of a series of recurring flash flood events in Alexandria. Contributed to roadway flooding and property damage. Repeated flood events between 2019 and 2020 led to the launch of Flood Action Alexandria in 2021.
July 23, 2020	Rainfall: 2.5 inches in 30 min[b]	
September 10, 2020	Rainfall: 2.0 inches in 1 hour[b]	
August 15, 2021	Rainfall: 5.12 inches in 2 hours[c]	

[a] Rainfall totals at National Airport.
[b] Rainfall total at USGS gage Four Mile Run
[c] Rainfall total at City of Alexandria rain gage

~ = approximately
cfs = cubic foot (feet) per second

1.4 Flood Action Alexandria

Launched in August 2021, Flood Action Alexandria is the City's comprehensive initiative to address flooding through a coordinated, long-term approach to make the City more resilient. Building on prior studies and community input, the program guides investments in stormwater infrastructure improvements and operating programs and capital improvement projects, to increase system capacity and implement targeted flood mitigation measures.

Flood Action Alexandria also emphasizes the shared responsibility of flood mitigation by supporting private property owners through the Flood Mitigation Grant and Backflow Preventer Reimbursement Grant programs. Complementary efforts to these programs include improved data collection, early warning systems, sanitary and storm sewer upgrades, large capacity and spot improvement flood mitigation capital projects, and ongoing stream and channel maintenance.

The Flood Action Alexandria initiative receives community input from several sources, including the Stormwater Utility and Flood Mitigation Advisory Committee, which was established in 2023 from an initial ad hoc group formed in 2021. The Committee advises City staff and leadership, reviews program priorities and funding, serves as a community liaison, and provides annual recommendations to guide the program's continued evolution.

Through these efforts, Flood Action Alexandria functions as the central framework for reducing flood risk and strengthening long-term resilience.

1.5 Types of Flooding

As noted previously, the city is affected by three types of flooding: interior flooding, riverine flooding, and coastal flooding. These flooding types, shown on Figure 1-6, often occur simultaneously during major storm events and create compounding flooding conditions, particularly in areas where tributaries discharge into tidally influenced water bodies. The following sections discuss these three types of flooding in more detail.

Why do we refer to flooding from the Potomac River as Coastal Flooding?

Although Alexandria is located along the Potomac River rather than directly on the Chesapeake Bay or Atlantic coast, water levels in the river are strongly influenced by coastal processes. Tides, storm surge, and sea level rise travel upstream from the Chesapeake Bay into the Potomac River, causing elevated water levels and flooding along Alexandria's waterfront and low-lying areas.

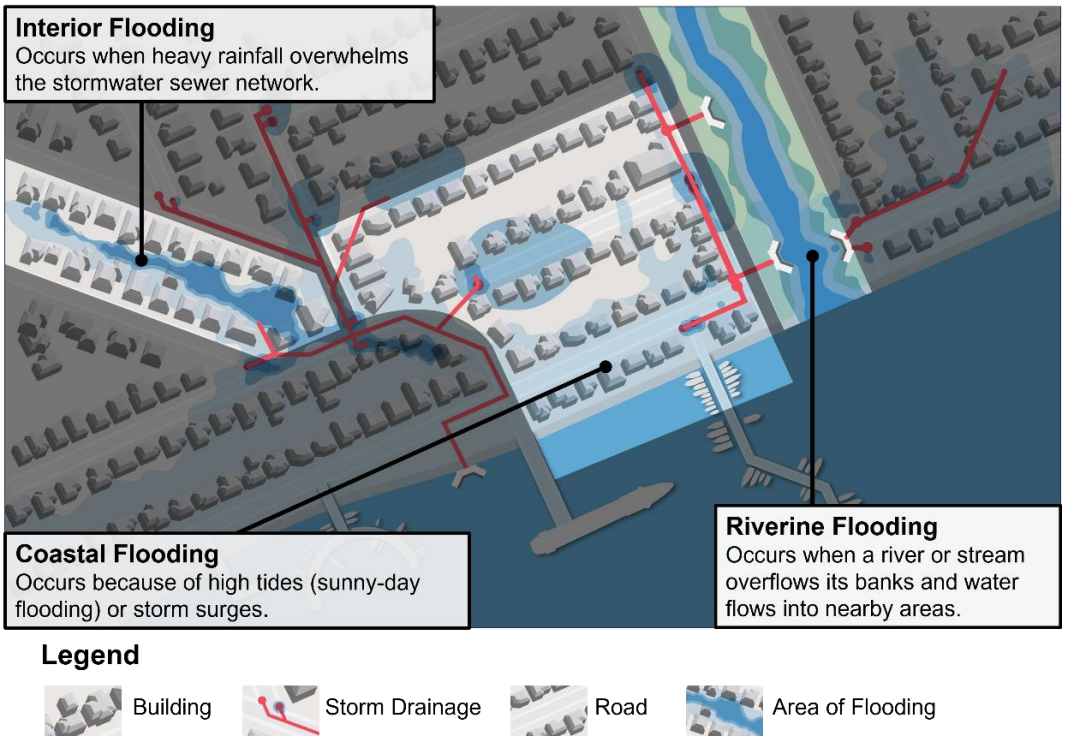


Figure 1-6: Types of Flooding

Interior Flooding

Interior flooding is caused by storms that produce heavy rainfall over a short period and is the most common type of flooding that occurs in Alexandria. Interior flooding results in water flowing through streets and properties because storm system capacity has been exceeded by the storm's intensity. The rapid accumulation of water can create hazardous conditions within minutes (Photo 1-3).



Photo 1-3: Interior flash flooding on roadways can accumulate quickly and create hazardous conditions for motorists (Source: @DrainALX 2021).

In addition to surface water accumulation, interior flooding also can cause sanitary sewer backups, groundwater seepage, and flooding of below-ground structures. As reflected in the 2025 Online Flooding Survey, interior flooding was the most widely reported flood type experienced by survey respondents (Figure 1-7).

Interior flooding has become more frequent and severe because of increased rainfall intensity, the urbanized landscape, and an old stormwater drainage network, much of which was installed prior to current standards.

Heat maps (Figure 1-8 and Figure 1-9) were developed for two large interior-flooding events in 2020, which caused significant flash flooding throughout the city. Brighter colors indicate areas with a high density of flood-related service requests received through the Alex311 system. Although the intensity of rainfall can vary geographically during the same event, the highest density of service requests and flood reports generally come from the eastern region in the low-lying areas of the coastal plain.

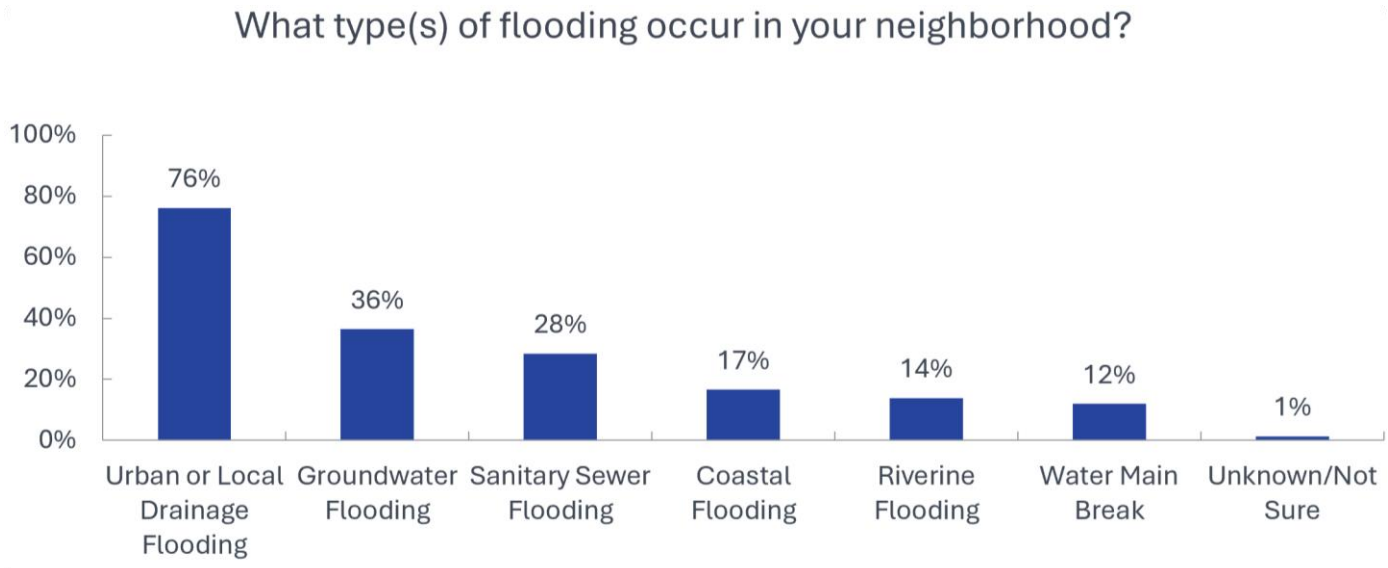


Figure 1-7: Alexandria 2025 Online Flooding Survey

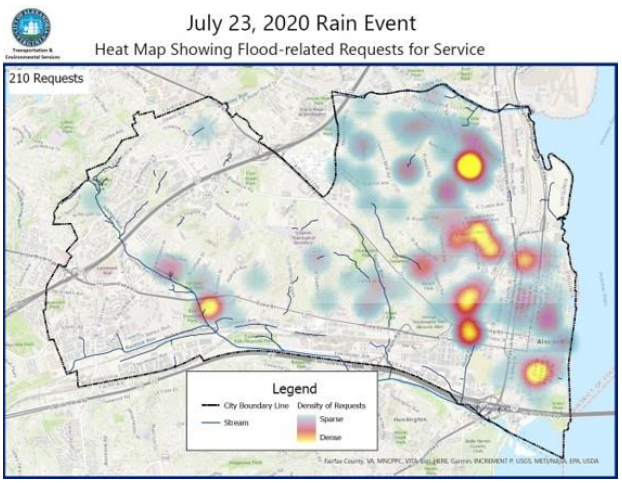


Figure 1-8: July 23, 2020, Density of Reported Flooding
(City of Alexandria 2025b)

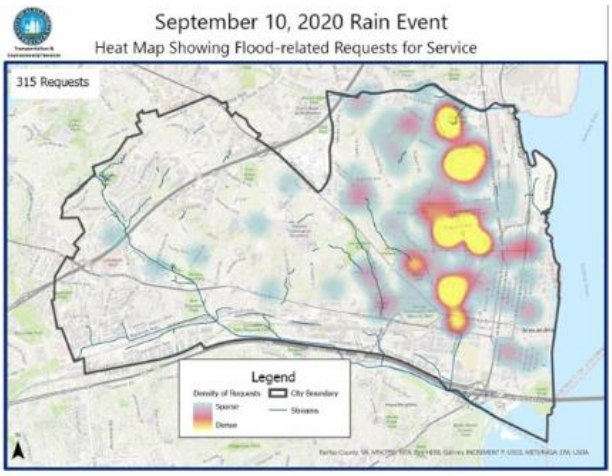


Figure 1-9: September 10, 2020, Density of Reported Flooding
((City of Alexandria 2025b)

Riverine Flooding

Riverine flooding occurs when excess flow in rivers and streams causes water levels to rise above the top of banks and inundate adjacent areas and floodplains (Photo 1-4). This condition may occur from heavy and prolonged rainfall events associated with tropical systems and frontal storms. In addition, high tides in tidal portions of rivers can worsen flooding conditions. The highest recorded riverine flows in Alexandria were in 1972, 2003, and 2006 at two U.S. Geological Survey gaging stations located along Four Mile Run and Cameron Run (FEMA 2024).



Photo 1-4: High water levels on Cameron Run come close to a bridge on the Capital Beltway/ Interstate 495 in 2013. (Source: City of Alexandria)

Riverine flood risk is a growing challenge in urban areas as gradual changes in rainfall patterns increase the frequency and severity of flood events. Encroachment of developed areas within natural floodplains, coupled with the historic practice of piping streams and channels, reduced the capacity of these systems to carry floodwaters. As a result, flood risk and storm-related property damage can increase.

Coastal Flooding

Coastal flooding, also referred to as tidal flooding, occurs when water from the Potomac River rises above the existing shoreline elevation and moves inland, affecting Alexandria's waterfront and nearby areas. Storm surges from tropical systems and irregular high tides can travel upstream from the Atlantic Ocean through the Chesapeake Bay and Potomac River, causing flooding in areas adjacent to the Potomac River. Although Alexandria does not have FEMA coastal high-hazard zones (FEMA Zone VE), coastal flooding from storm surges has caused significant flooding along the Potomac River and other tidally influenced stream reaches in the city (Photo 1-5) and is projected to get worse because of sea level rise.



Photo 1-5: Tidally influenced coastal flooding along Alexandria's waterfront during a tropical storm in 2024 (Source: City of Alexandria)

Recurrent flooding can also take place along the Potomac River waterfront even without storm surges. Tidal backflow flooding occurs in Alexandria during high-tide events that can happen without local rainfall (sunny-day flooding), and it causes the river water to back up into the storm system, which can lead to interior flooding and sewer backups.

The frequency of tidal backflow and storm surge flooding was assessed using historic Potomac River levels in Alexandria from July 2004 to December 2021 (Carollo 2022). Figure 1-10 shows the highest-recorded water levels (historic crests) as red points, and the horizontal dashed lines are the action levels used by the National Weather Service to determine critical Potomac River levels. The highest water levels observed in that timeframe were 5.54 feet, recorded in September 2006 from Tropical Storm Ernesto, and 5.99 feet, recorded in October 2021 from a Nor'easter. Those observed high river levels exceeded the moderate flood stage elevation (yellow dashed line) but did not reach the major flood stage elevation (red dashed line).

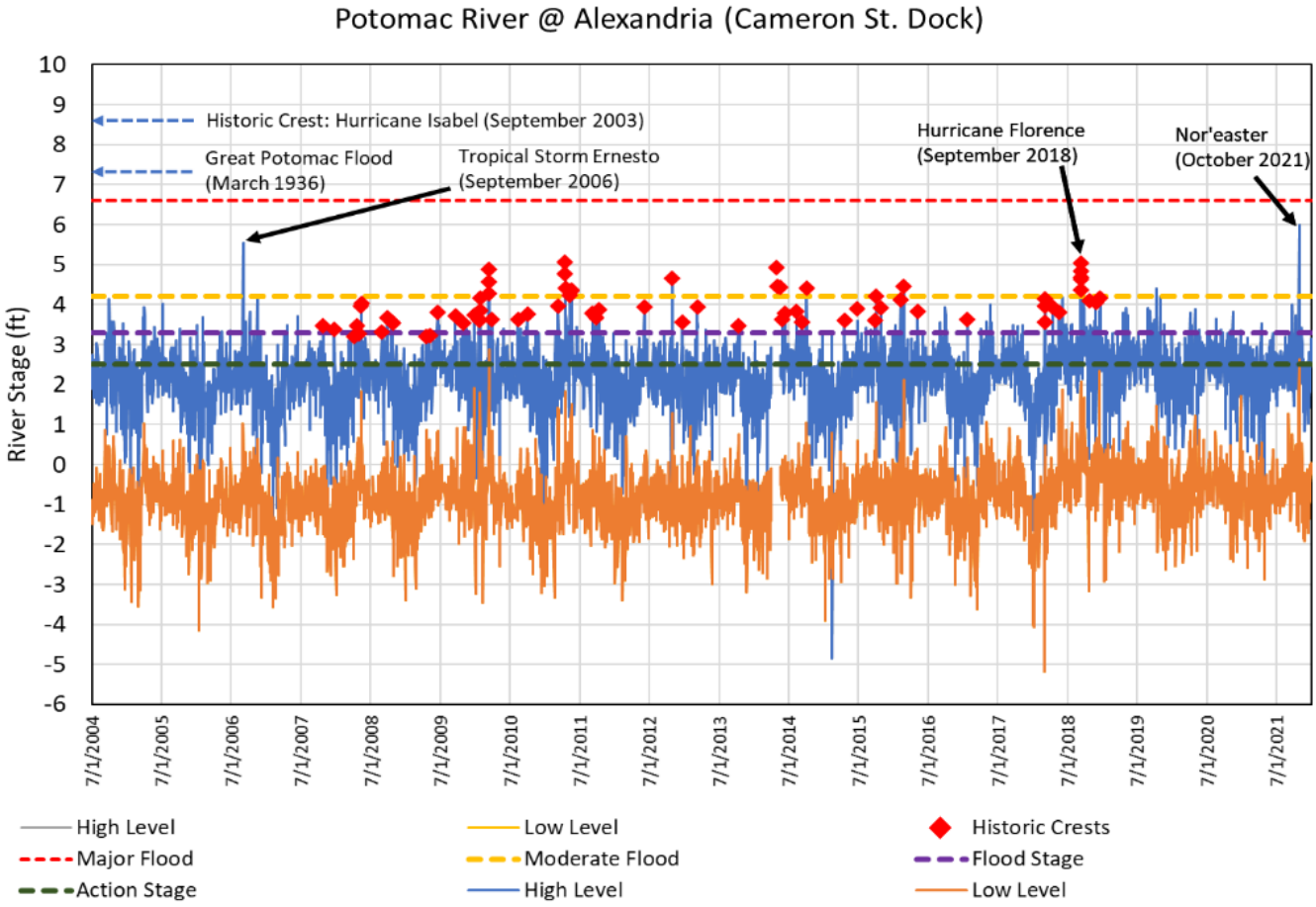


Figure 1-10: Potomac River Daily High and Low Levels (July 2004 – December 2021)
(Carollo 2022)

1.6 Factors that Compound Flood Risk

Flood risk in Alexandria is driven by a combination of interacting factors tied to its history, urban form, and changing environmental conditions. As the city was urbanized over time, natural land cover has been replaced with impervious surfaces. As discussed in Section 1.2, impervious surfaces significantly increase the volume of stormwater runoff and reduce infiltration, overwhelming drainage systems during heavy rain events. This challenge is compounded by a past legacy of altered natural waterways**,** where many streams were buried, piped, or channelized to support urban growth. These modifications eliminated natural floodplains and storage areas, restricting the ability of water to spread out and increasing the likelihood of concentrated flooding in constrained corridors.

Alexandria is an older city that dates back before the founding of the country. Large portions of the city's stormwater drainage infrastructure that have not undergone more recent redevelopment were designed prior to current standards and cannot manage more-intense storm events or increased runoff volumes. During heavy rainfall, these systems can become surcharged (Photo 1-6), leading to street and property flooding and even sewer backups into buildings.

While some development projects going back to the 1970s had to install detention systems, this requirement occurred much later. After the Chesapeake Bay Act was promulgated via local ordinance in 1992, Alexandria significantly strengthened its stormwater ordinances by establishing water quality requirements and formalizing detention standards for development projects. Today, applicable projects are required to capture, store, and control a portion of stormwater runoff onsite through measures such as detention and retention, with a requirement to not increase post-development flow rates above existing conditions.

Changing environmental conditions exacerbate these issues by increasing the frequency and intensity of extreme rainfall events, generating higher stormwater flows and more-frequent interior flash flooding. In addition, Alexandria's location along the Potomac River makes it vulnerable to sea level rise and tidal influences**,** which can elevate water levels, reduce drainage capacity at outfalls, and worsen flooding when storms coincide with high tides.



Photo 1-6: Storm sewer surcharging at a manhole or drainage inlet in Alexandria (Source: @DrainALX 2023).

Together, these factors—urbanization, constrained and modified waterways, undersized legacy infrastructure, historic neighborhoods constructed prior to onsite stormwater management requirements, and increases in rainfall and water levels—compound flood risk, making flooding more frequent and widespread across the city.

1.7 Understanding Flood Impacts

There are several significant consequences of flooding in Alexandria, ranging from property and infrastructure damage and immediate safety risks to long-term economic disruption and disproportionate impacts on socially vulnerable communities (Figure 1-11).

Physical Damages

Flooding is among the costliest hazards affecting Virginia. From 1980 to 2024, flooding events contributed to billions of dollars in losses, with total disaster damage across all hazards during this period reaching $20 billion to $50 billion statewide (NOAA 2024a).

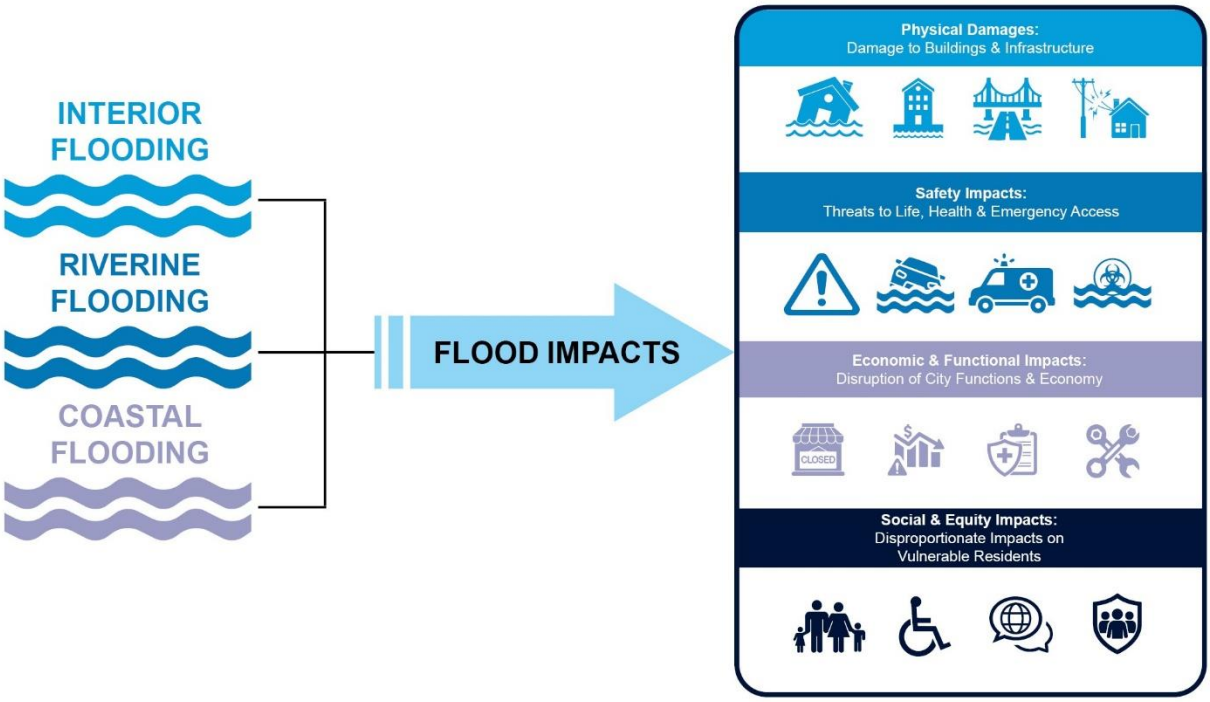


Figure 1-11: Citywide Flooding Results in Numerous Impacts

Flooding causes direct damage to a wide range of physical assets, including the following:

- **Residential properties:** Basement flooding, structural damage, and mold growth are common, particularly in low-lying neighborhoods and areas with undersized infrastructure.
- **Commercial buildings and businesses:** Flooding can damage inventory, disrupt operations, and lead to costly closures or long-term economic losses.
- **Transportation infrastructure:** Roads, bridges, and underpasses are frequently inundated, limiting mobility and emergency access. Streets often act as overland flow paths, increasing wear and damage. Damage to cars, trucks, and other vehicles costs individuals and businesses thousands of dollars, making flood recovery more difficult.
- **Utilities and critical infrastructure**: Stormwater and sanitary sewer systems can become overloaded, leading to sewer backups. Electrical systems and public facilities also may be affected.
- **Parks and public spaces:** Waterfront areas and stream corridors are vulnerable to erosion, inundation, and damage to recreational amenities.

These impacts are often concentrated in areas where infrastructure capacity is constrained or where development has occurred in low-lying areas or along buried waterways.

Safety Impacts

Flooding poses significant risks to human safety, particularly during intense storm events, and can cause the following:

- **Flash-flooding hazards:** Water can accumulate rapidly, creating dangerous conditions for pedestrians and drivers, including vehicle entrapment in flooded roadways, and flooding of the first floor and basements of structures.
- **Emergency response limitations:** Flooded streets and infrastructure can delay emergency services and evacuation efforts. Critical facilities such as police stations, fire stations, and hospitals can be affected, which worsens the risks by slowing down the capacity to respond.

- **Public health risks:** Sewer backups and contaminated floodwaters can expose residents to pollutants, bacteria and other microbes, and debris.
- **Structural hazards:** Flooded buildings risk developing electrical hazards, utility service outages, and other unsafe living conditions, including weakened foundations.

These safety concerns are more pressing in areas with limited warning time before a flood or where drainage systems are quickly overwhelmed by storm intensity.

Indirect Economic and Functional Impacts

Beyond immediate physical damage and safety concerns, flooding disrupts the functioning of the city. Depending on the time that it takes to recover, the economic losses can be prolonged. Losses and disruptions include the following:

- **Business interruptions:** Temporary closures and reduced customer access lead to lost revenue.
- **Transportation disruptions:** Impacts to road networks and transit reduce commuting reliability and regional connectivity.
- **Increased maintenance and repair costs:** Flooding accelerates degradation of infrastructure and increases long-term capital needs.
- **Insurance and property value impacts:** Repeated flooding can increase insurance costs and reduce property values.

These indirect impacts contribute to cumulative economic strain on individuals, businesses, and the city.

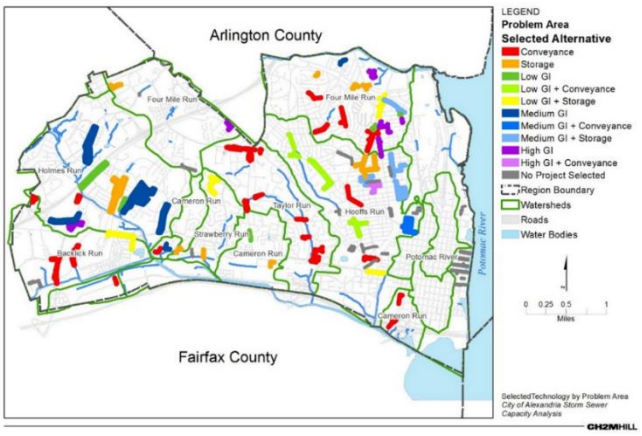


Figure 1-12: Selected Problem Areas from CASSCA Analysis

Social and Equity Impacts

Flooding affects all residents of Alexandria, but the impact is not equally distributed. Flooding events often have the greatest impact on vulnerable communities, including the following:

- **Low-income households:** May lack resources for floodproofing, recovery, or insurance, making them more susceptible to repeated impacts.
- **Renters:** Often have limited control over property-level mitigation measures and may face displacement or delayed cleanup after flood events.
- **Communities in high-risk areas:** Some neighborhoods with higher proportions of low-income, minority, or immigrant residents may be located in more flood-prone areas or near constrained infrastructure.
- **Limited English proficiency populations:** May face challenges accessing emergency warnings and information, recovery assistance, and educational information on flood preparedness and protection measures.
- **Elderly or limited-mobility residents:** May face increased challenges to evacuate safely or access essential services.

Flooding can exacerbate existing social and economic inequalities, particularly where historic development patterns and infrastructure limitations intersect with vulnerable populations.

1.8 Past Studies

Alexandria has conducted multiple studies to understand and characterize flooding and inform its action plan to address these risks. These studies and improvement projects demonstrate a sustained and progressive commitment to understanding flood risks and prioritizing mitigation across the city.

Citywide Studies and Plans

- **City of Alexandria Storm Sewer Capacity Analysis (CASSCA)** (CH2M Hill 2016)

  A comprehensive assessment of the storm sewer system using hydraulic modeling to identify pipe capacity problem areas. It identified 83 high-risk locations and recommended solutions such as storage, conveyance, and green infrastructure as a complementary approach (Figure 1-12). The study serves as a foundational baseline and

informs many current capital improvement projects.

- **Environmental Action Plan 2040** (City of Alexandria 2019)

  A comprehensive roadmap affirming a commitment to create a thriving, sustainable community. This plan provides an update to its predecessor and includes updated technology, evolving infrastructure needs, and new approaches for reducing environmental impacts.

- **City of Alexandria Flood Response Plan** (City of Alexandria 2020)

  Establishes procedures and responsibilities for coordinating the City's response before, during, and after flood events to protect life, property, and critical infrastructure.

- **Sanitary Sewer Master Plan** (CDM Smith 2021)

  Evaluated wastewater collection system and treatment capacity and identified future infrastructure needs to support growth. While focused on sewer performance rather than surface flooding, it contributes to overall resilience by identifying system limitations and priorities for future infrastructure upgrades.

- **Stormwater Management Primer** (Stormwater Utility and Flood Mitigation Advisory Group 2021)

  Provides an overview of what stormwater management is and how the Stormwater Management Division addresses it. The Primer summarizes how the division functions, outlines relevant policies, and presents key challenges to support informed decision-making and public understanding.

- **Northern Virginia Hazard Mitigation Plan and Annex 2: City of Alexandria** (IEM 2022)

  A regional evaluation of hazard risk and disaster resilience efforts with the aim of reducing long-term vulnerability for all jurisdictions in the region. Annex 2 provides Alexandria-specific risk assessments, mitigation strategies, and actions aligned with the regional hazard mitigation plan to reduce long-term vulnerability to natural hazards.

- **Energy & Climate Change Action Plan** (ICF 2023)

  Comprehensive strategy to reduce greenhouse gas emissions and address climate impacts in Alexandria through coordinated actions across buildings, transportation, energy, and waste systems. It identifies priority adaptation measures and implementation steps to integrate climate resilience into City decision making and covers strategies to mitigate the risks from extreme heat and flooding.

- **FEMA Flood Insurance Study** (FEMA 2024)

  Defines regional flood hazards and maps 100-year floodplains across major waterways (Potomac River, Holmes Run, Four Mile Run). These maps guide floodplain management and insurance rates and are used to define riverine flood extents.

- **Floodplain Management Plan** (City of Alexandria 2024)

  Documents Alexandria's ongoing implementation of floodplain management and hazard mitigation actions as part of its participation in FEMA's Community Rating System, with the goal of reducing flood risk and maintaining flood insurance discounts for residents. It tracks progress on mitigation initiatives while demonstrating the continued commitment to long-term flood resilience planning.

- **City of Alexandria Emergency Operations Plan** (Office of Emergency Management 2025)

  Defines the framework for emergency management across all hazards, outlining how the City and other agencies coordinate resources, communication, and response actions during major incidents. Provides an all-hazards framework for emergency preparedness, response, and recovery, detailing coordination among agencies and continuity of operations during emergencies.

- **Stormwater Management Ten-Year Capital Improvement Program Plan (FY27-FY36)** (City of Alexandria 2026a)

  Outlines the City's long-term funding strategy and capital investments to maintain and upgrade stormwater infrastructure, support flood mitigation projects, and meet regulatory requirements. It is updated annually.

Targeted Watershed & Neighborhood Studies

- **Neighborhood Flood Studies** (AECOM 2021-2023)

  Evaluations were conducted following major flash floods in 2019 and 2020 to investigate localized flooding in multiple neighborhoods. These studies combine field data, closed-circuit television inspections, and hydraulic modeling to identify causes and develop solutions ranging from property-level protections to large infrastructure projects. Flood studies were conducted in the following neighborhoods:

- Alexandria and Luray Avenue
- W. Taylor Run
- Glebe, Ashby, and Commonwealth
- Upper King Street
- Commonwealth, Maple, and Rosemont Avenue
- Edison and Dale
- Del Ray Avenue
- Park Fairfax
- Sanford and Caton
- Masonic Avenue
- Mason Avenue
- East Mason and Monroe Avenue
- East Linden Street
- South Jordan Street
- Hume Avenue
- Clifford, Manning, and Fulton Street
- Summers Glendale
- South Pitt and Gibbon Street
- Valley Drive
- Bellefonte Avenue

- **Alexandria's Master Plan and Small Area Master Plans** (City of Alexandria 2026b)

  The Alexandria Master Plan comprises a total of 19 Small Area Plans for neighborhoods across the city, as well as chapters of citywide relevance, such as Historic Preservation, Urban Design, Green Building, Housing, Mobility, and Open Space.

Major Resilience & Infrastructure Projects

- **Four Mile Run Flood Control Project** (Construction completed by U.S. Army Corps of Engineers in 1980)

  A federal project providing regional flood protection through channel modifications, floodwalls, and hydraulic improvements. Originally designed for 100-year flood protection, though not currently certified at that level.

- **Waterfront Flood Mitigation Project** (City of Alexandria 2012 – ongoing)

  Multi-phase project addressing coastal flooding along the Potomac River in Old Town through a combination of structural and nature-based solutions. Includes a proposed bulkhead, storm sewer upgrades, and other flood mitigation measures, supported by detailed hydraulic modeling of the pipe system and surface flooding.

- **Commonwealth, Ashby, and Glebe Flood Mitigation Project** (City of Alexandria 2026c)

  A major project resulting from CASSCA, this effort combines two large projects that will provide flood relief for the surrounding area by increasing the storm sewer system capacity and implementing green infrastructure practices (Figure 1-13).

- **RiverRenew** (RiverRenew 2026)

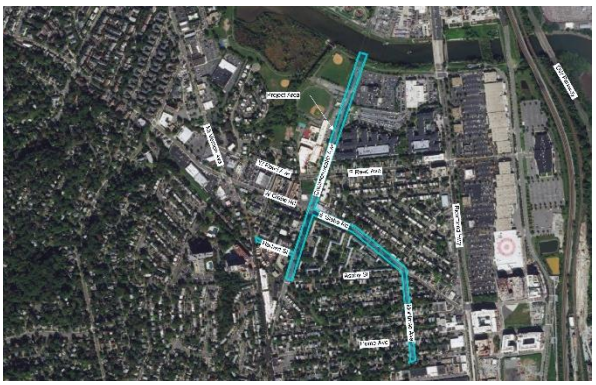


Figure 1-13: Location of Commonwealth, Ashby, and Glebe Flood Mitigation Project

A major stormwater pollution control initiative undertaken in partnership between the City and Alexandria Renew Enterprises (AlexRenew). The project involves construction of an underground storage tunnel beneath the Potomac River, storage at Jones Point Park, and a pumping station at the AlexRenew Plant to reduce overflow of combined stormwater and sanitary sewage during heavy rain events. Work on the project was completed in July 2026.

- **Storm Sewer Capacity Projects FY2027-2036)** (City of Alexandria 2026a)

  An ongoing citywide strategic effort to modernize Alexandria's stormwater system by expanding pipe capacity, adding storage, and improving drainage performance. Implementation of these projects is tracked and updated annually in the 10-year CIP plan. This is a central component of the Flood Action Alexandria program, and projects are mapped on a program dashboard (Figure 1-14).

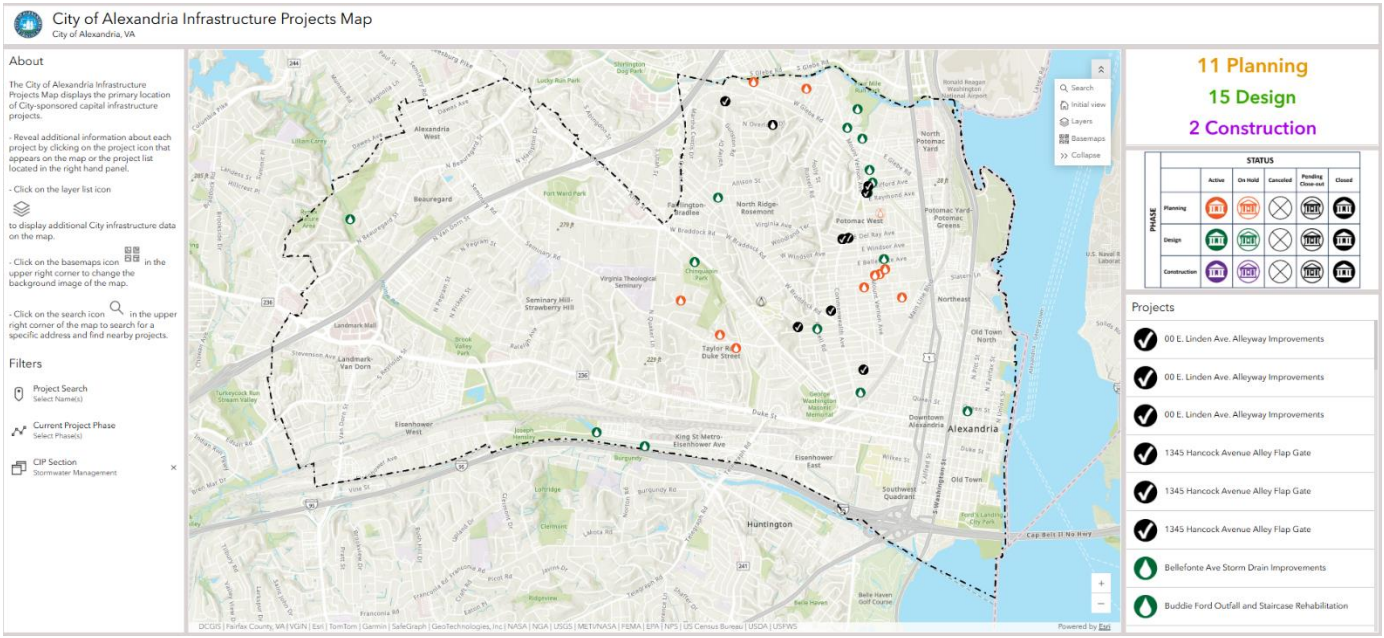
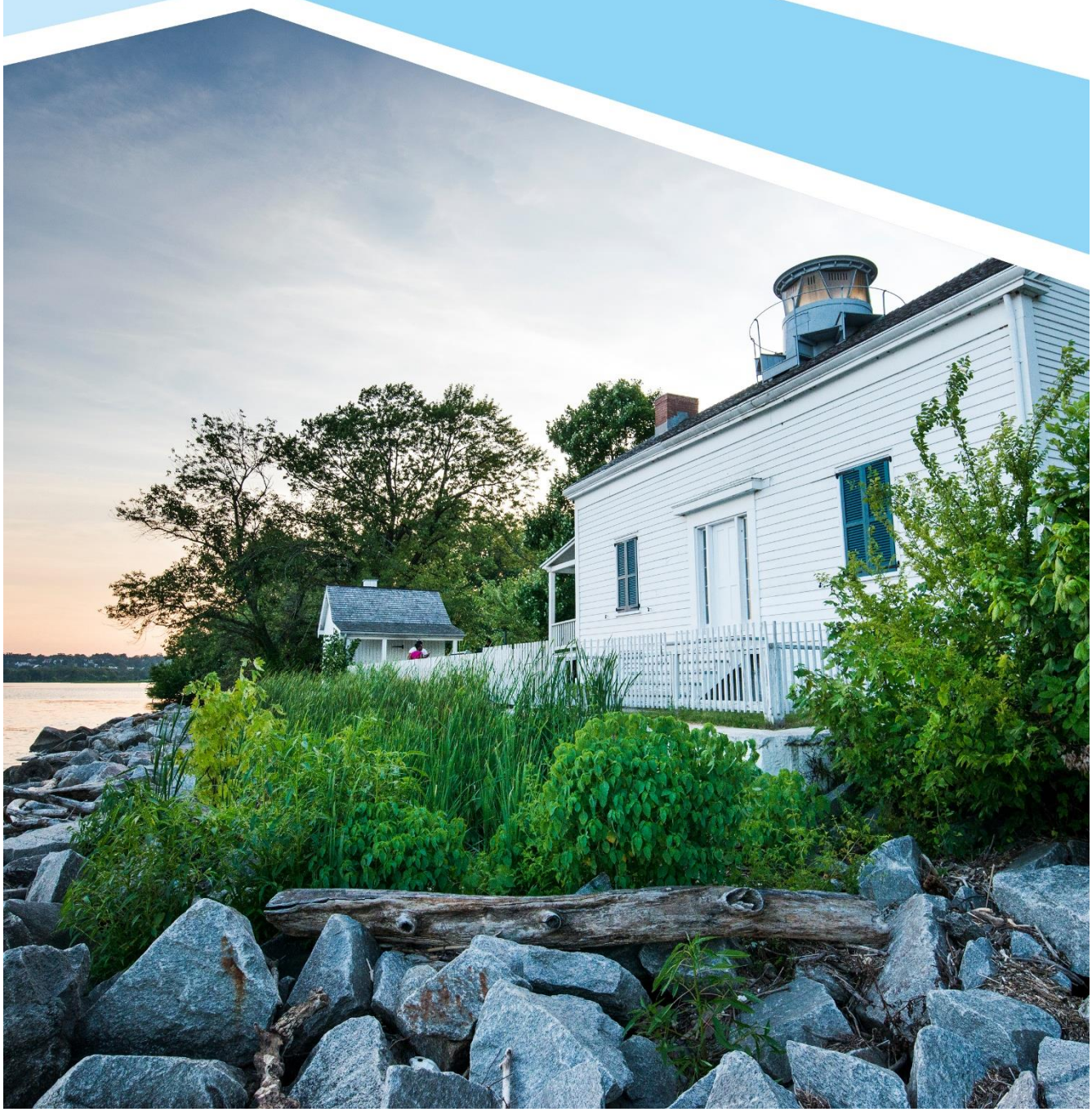


Figure 1-14: City of Alexandria Infrastructure Projects Dashboard

Section 2
Hazard Identification



2 HAZARD IDENTIFICATION

2.1 UNDERSTANDING TODAY AND PLANNING FOR THE FUTURE

Flood risk in the City of Alexandria is influenced by the complex interaction of precipitation patterns, watershed characteristics, stormwater infrastructure performance, and river and tidal conditions. While historical data provide insight into existing flood hazards, recent observations and modeling indicate environmental conditions are evolving and leading to increased storm intensity, higher runoff volumes, and elevated water levels in rivers and streams (Caretta et al. 2022).

To capture the full range of potential flood risks, this FRP considers both baseline conditions (year 2020) and projected future conditions (year 2075). These scenarios represent a range of storm frequencies and magnitudes, allowing for evaluation of both frequent nuisance flooding and more-extreme, lower-probability events.

Flood hazards in the city are categorized into three primary types: interior flooding, riverine flooding, and coastal flooding, as described in Section 1.5.

Specialized flood models are used to simulate the specific physical processes that contribute to flooding (Figure 2-1). Interior flooding is simulated using interior overland drainage models that represent rainfall on the land surface and the resulting surface runoff. Riverine flooding is evaluated using river and stream flow models that simulate how runoff is conveyed through the stream and river network during extreme storm events. Coastal flooding is assessed using coastal hydrodynamic models that simulate storm surge and tidal propagation from the Chesapeake Bay up the Potomac River. Together, these modeling approaches capture the primary sources of flood risk and provide a more comprehensive understanding of flood hazards across the city and the region.

Rainfall Conditions

Storm-driven rainfall is the dominant flood hazard across much of the city and induces both riverine and interior flooding. These events can submerge roadways and flood properties and buildings.

Data indicate these storm events are becoming more intense and bringing heavier rainfall (Caretta et al. 2022). The severity of a rainfall event is described statistically based on the probability that

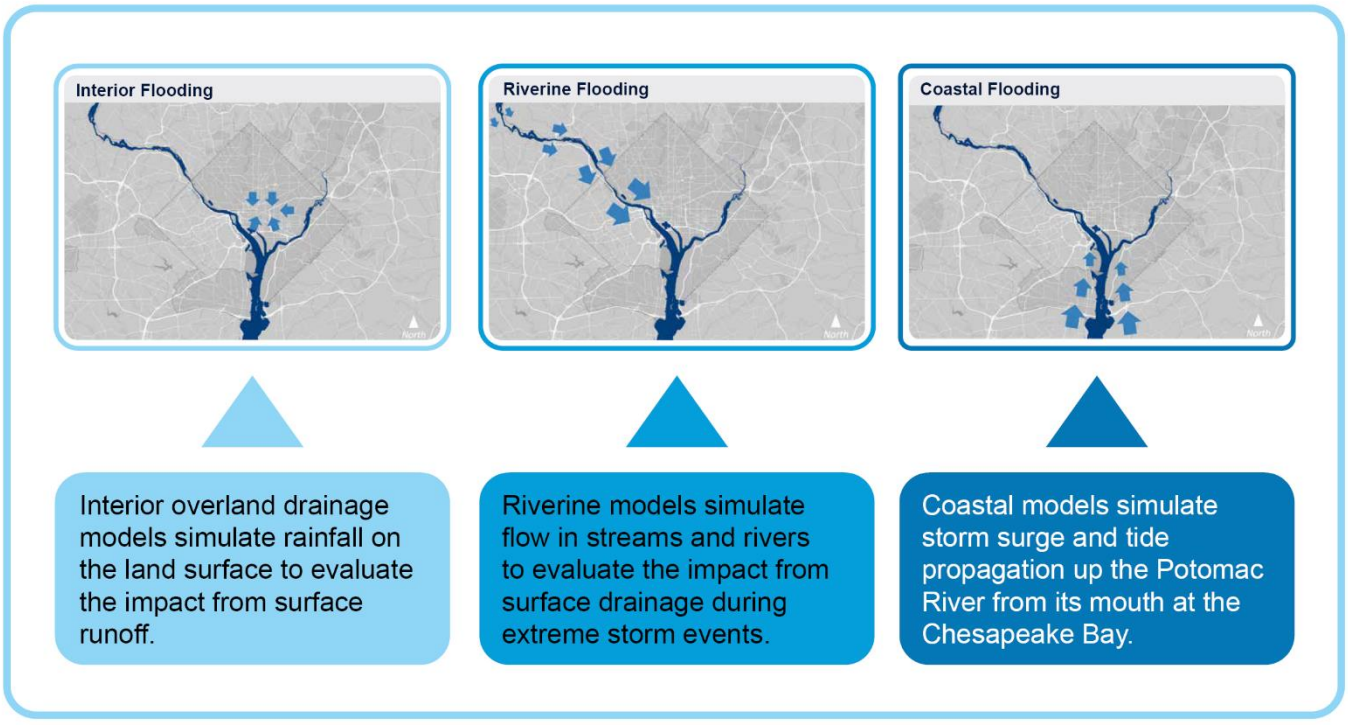


Figure 2-1: Flooding Types Evaluated Using Flood Models

Source: NCPC 2018

an event of a certain magnitude (rainfall depth) will be equaled or exceeded in any given year.

What is a 100-year storm event?

A "100-year storm" is a statistical term for a rainfall event with a depth that has a 1% chance of occurring or being exceeded in any given year. It does not mean that it happens only once every 100 years. This is a relatively rare, severe precipitation event. This type of storm could occur multiple times within a few years or even multiple times in the same year.

For example, a 100-year storm event has a depth that has a 1 in 100 chance of occurring in any given year. Figure 2-2 shows how the rainfall depth of the 10-year, 100-year, and 500-year events may increase from the year 2020 until 2075 based on a study commissioned by AlexRenew (Jacobs 2024).

From the range of storm events evaluated by the AlexRenew study, three rainfall events were selected that are representative of storms that the city could experience in the near term or in the future. Total rainfall in 24 hours for the three events used for interior and riverine modeling is as follows:

- Baseline (Year 2020) 100-year storm: 8.5 inches
- Future (Year 2075) 10-year storm: 6.0 inches
- Future (Year 2075) 100-year storm: 10.6 inches

Potomac River Conditions

While Alexandria is not on the coast, it is influenced by coastal changes as described in Section 1.5. The Potomac River and its tidal tributaries are critical drivers of flood risk, particularly for waterfront and low-lying areas in the city (Photo 2-1). Coastal flooding is influenced by a combination of the following:

- Storm surge originating in the Chesapeake Bay
- Tidal fluctuations
- Sea level rise



Photo 2-1: Coastal flooding from the Potomac River in 2021 caused flooding and property damage on King Street (Source: City of Alexandria).

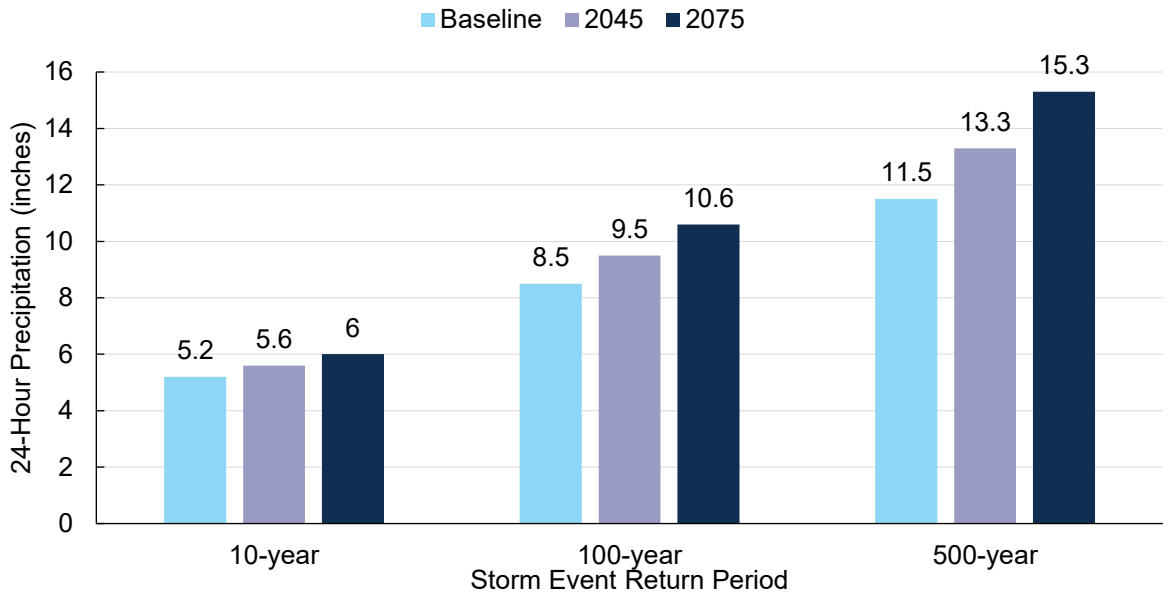


Figure 2-2: Projected Increase in Rainfall Depth Over Time

Like rainfall, tide and storm surges are gradually increasing because of rising sea levels and more frequent and intense storms. Figure 2-3 shows how the average high tide and king tide are predicted to increase from the year 2020 until 2075. Figure 2-4 shows how the 10-year, 100-year, and 500-year storm surges are projected to increase over the same timeframe (Jacobs 2024). For the FRP's coastal flooding analysis, the storm surge conditions for the baseline 100-year, future 10-year, and future 100-year storm events were used to run the coastal flood models.

What is a King Tide?

A king tide is a non-scientific term to describe an exceptionally high tide. This situation happens when several factors line up: the moon is closest to the Earth, the sun and moon are aligned with the Earth, and gravitational pull is strongest, pulling ocean water higher than usual. When these conditions combine, the ocean experiences higher-than-normal high tides. (NOAA 2024b)

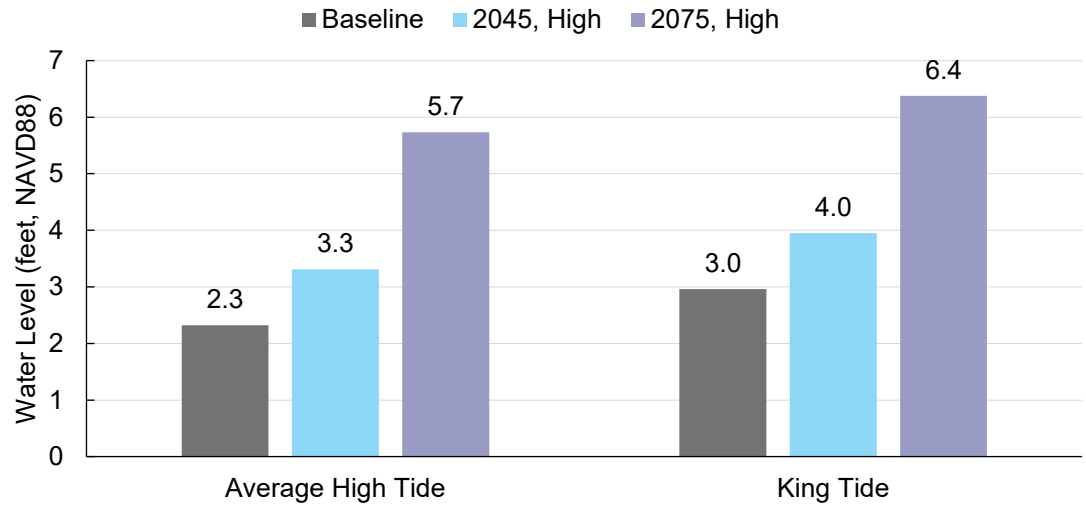


Figure 2-3: Projected Increase in Sunny-Day Tide Levels Over Time, Washington, D.C. Tide Gauge

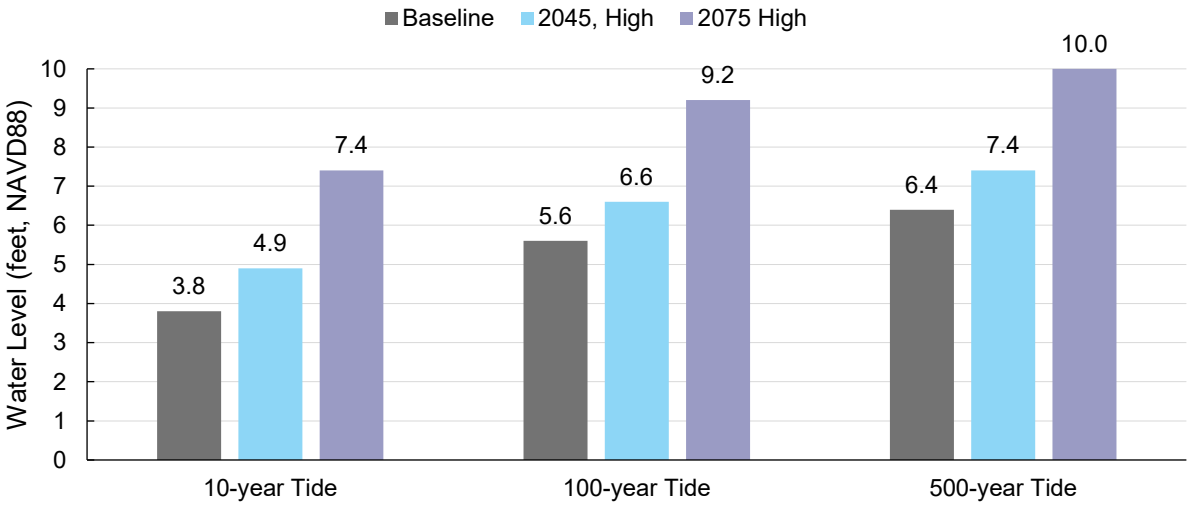


Figure 2-4: Projected Increase in Water Level from Storm Surge Over Time, Lewisetta, VA, Gauge

2.2 Flood Extents

Flood extent maps were developed by integrating the results of the riverine, interior, and coastal flood modeling across the entire city. For this FRP, the results of the following new and existing models were combined to assess flood vulnerability:

- **FEMA Models:** FEMA flood models were used to assess riverine flooding where they were available. These models focus on areas along stream and river channels.
- **Hooffs Run and Four Mile Run Models:** Detailed models were developed previously for design projects that evaluated the storm pipe network and interior flooding that occurs when the pipe network exceeds capacity.
- **Remaining Watershed Models:** Where detailed models were not available to assess interior surface flooding, two-dimensional models were developed that represent water flowing across the land surface when the storm sewers are full. This method captures interior flooding in the areas of the city that are not near the stream channels represented in traditional FEMA floodplain mapping but does not explicitly include an evaluation of the pipe network.
- **Coastal Model:** The results from a coastal flood model that was developed for AlexRenew were used to estimate flooding along the Potomac River and parts of Cameron Run, Hooffs Run, and Four Mile Run that are influenced by storm surge from the Potomac River.

Flood extent maps were generated for each storm event. The following refinements were made to emphasize the most meaningful flood impacts:

- Removing flood depths less than 6 inches
- Excluding isolated flooded areas smaller than 0.5 acre.

Figure 2-5 shows the combined flood extents from all flood models for the three storm events evaluated. The map shows that even relatively small and frequent storm events can produce widespread flooding, particularly in low-lying areas and in locations where storm sewers have capacity constraints. More-extreme events result in even greater flood inundation. Flooding in the Old Town waterfront and Arlandria areas highlights the significant vulnerability of waterfront locations.

The figure shows a clear increase in riverine and interior flood extents for a 100-year storm scenario, from approximately 940 acres (10%) under baseline conditions to 1,186 acres (12%) under future conditions. The extent of flooding varies across watersheds as follows:

- Hooffs Run exhibits the highest increase in flood extent (11% to 15%)
- Cameron Run, Potomac River, and Strawberry Run show moderate flooding (10% to 13%).
- Four Mile Run experiences significant flooding in key corridors.

Key areas of concentrated flooding include the following:

- Commonwealth Avenue and Glebe Road (Four Mile Run watershed)

- King Street and Monroe Avenue (Hooffs Run watershed)
- Holmes Run watershed north of Interstate 395
- Low-lying areas adjacent to Cameron Run and transportation corridors

Coastal flood extents show less variation across the modeled storm events, but flood depths within the extents increase markedly by 2.1 to 2.4 feet for the 100-year event from baseline to future conditions. Future scenarios incorporate higher baseline water levels and surge conditions, resulting in the following:

- Increased frequency of coastal flooding
- Greater inland extent of inundation
- Reduced drainage capacity of tributaries during high river water levels

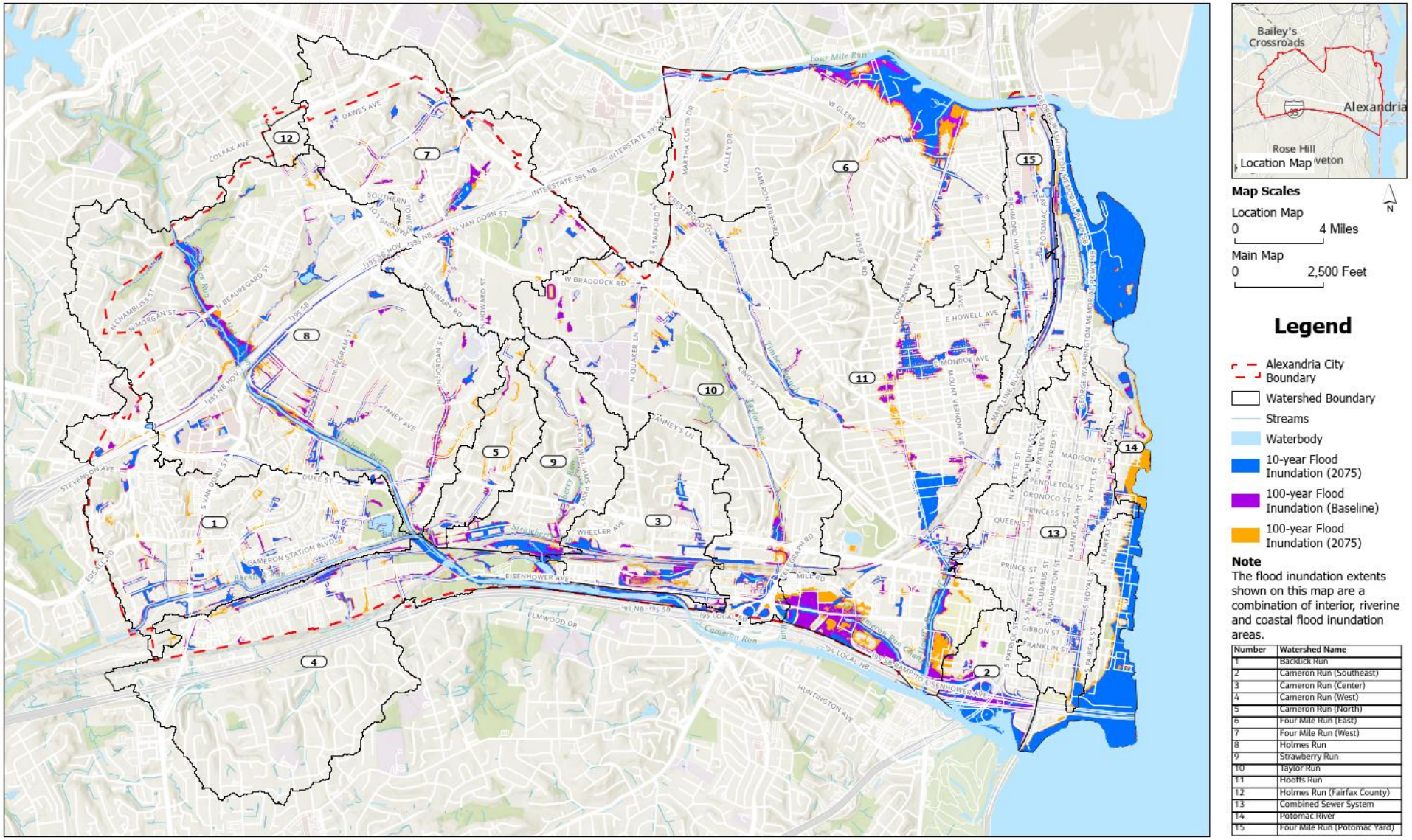


Figure 2-5: Flood Extents for Riverine/Interior and Coastal Flooding

2.3 VULNERABILITY ASSESSMENT

The presence of flooding alone does not tell the whole story. What matters is who and what are impacted by flooding. For instance, short-term flooding in a park or on a roadway is not as big a concern as flooding that enters a building, which can cause costly damage and poses greater safety concerns. An evaluation of who is impacted and what facilities are flooded helps to identify which areas of the city are most vulnerable to flooding. This is called a vulnerability assessment.

Vulnerability Assessment Methodology

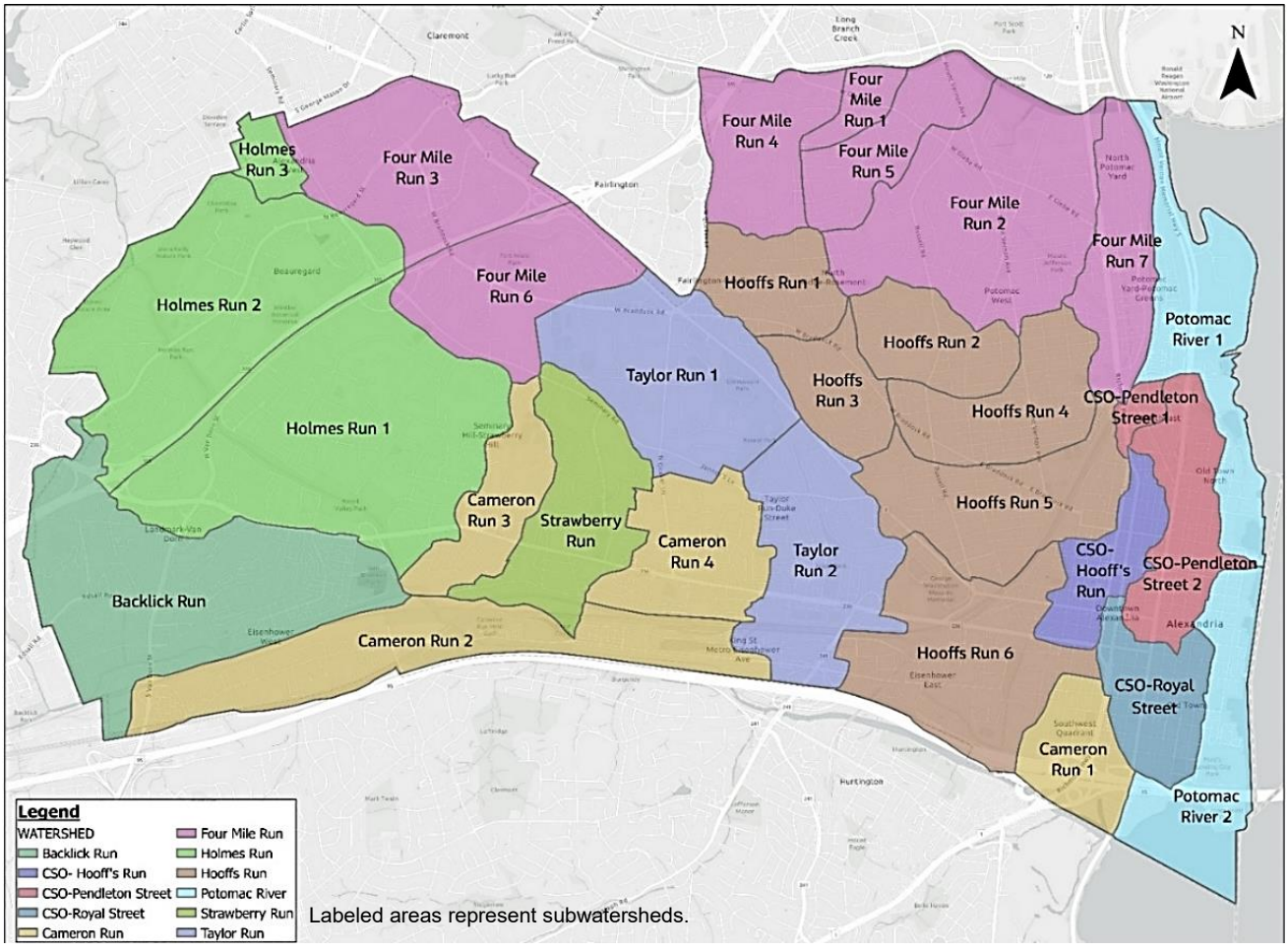
A citywide screening-level vulnerability assessment was conducted to determine key areas of flood vulnerability within Alexandria. The vulnerability assessment evaluates how flood hazards interact with community assets—also called receptors—to identify areas of greatest concern. The analysis overlaps areas of flooding with receptors such as buildings, infrastructure, socially vulnerable communities, and environmental resources to understand where receptors are most vulnerable to flooding.

The assessment was conducted at the subwatershed scale, allowing for consistent, hydrologically meaningful comparisons across the city. Subwatersheds are drainage areas that represent smaller parts or divisions of the eight major watersheds in the city. Figure 2-6 shows the eight watersheds; their subwatersheds are labeled.

The vulnerability assessment methodology includes the following four key steps:

1. Measure flood exposure by quantifying flooded receptors and applying weighting factors to account for sensitivity. For example, buildings with basements were assigned a higher sensitivity weighting compared to buildings without a basement because below-grade spaces are more susceptible to flooding and can result in greater property damage.

2. Apply weighting based on storm event probability. More-probable events such as the 10-year storm are weighted higher than less-



Labeled areas represent subwatersheds.

Figure 2-6: Vulnerability Assessment, Watersheds and Subwatersheds

probable events such as the future 100-year storm.

3. Normalize results across different receptor types. Because receptor types use different units of measurement (e.g. number of buildings, miles of roads, extent of flooded areas), normalization is required. This process converts all metrics into a unified scale from 0 to 5.
4. Apply weighting factors to normalized scores based on the relative importance of each receptor type (Figure 2-7) and combine the scores to produce one total vulnerability score for each subwatershed.

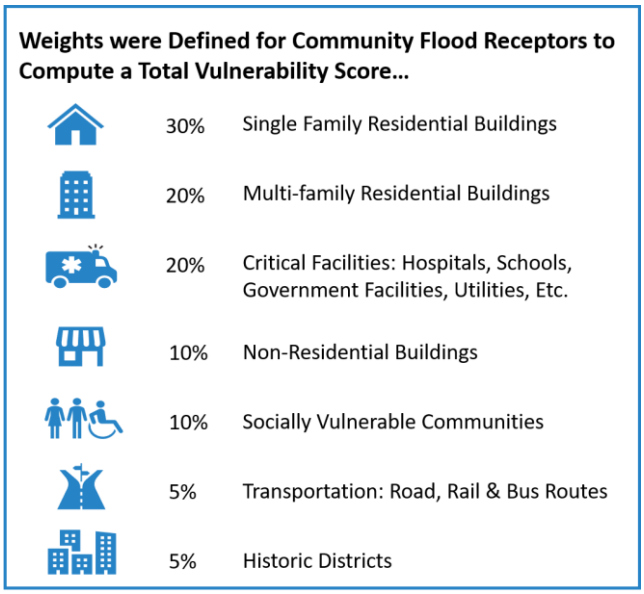


Figure 2-7: Vulnerability Score Weights by Receptor Type

Vulnerability Assessment Results

The vulnerability assessment identified several subwatersheds with elevated risk from combined exposure of residential structures, socially vulnerable populations, and critical infrastructure.

Figure 2-8 shows the scores for each subwatershed based on the receptors exposed to flooding. The most vulnerable areas include the following:

- Backlick Run
- Four Mile Run 2
- Combined Sewer System (CSS)—Pendleton Street 2
- Potomac River 2
- Hooffs Run 5 and 6
- Holmes Run 1

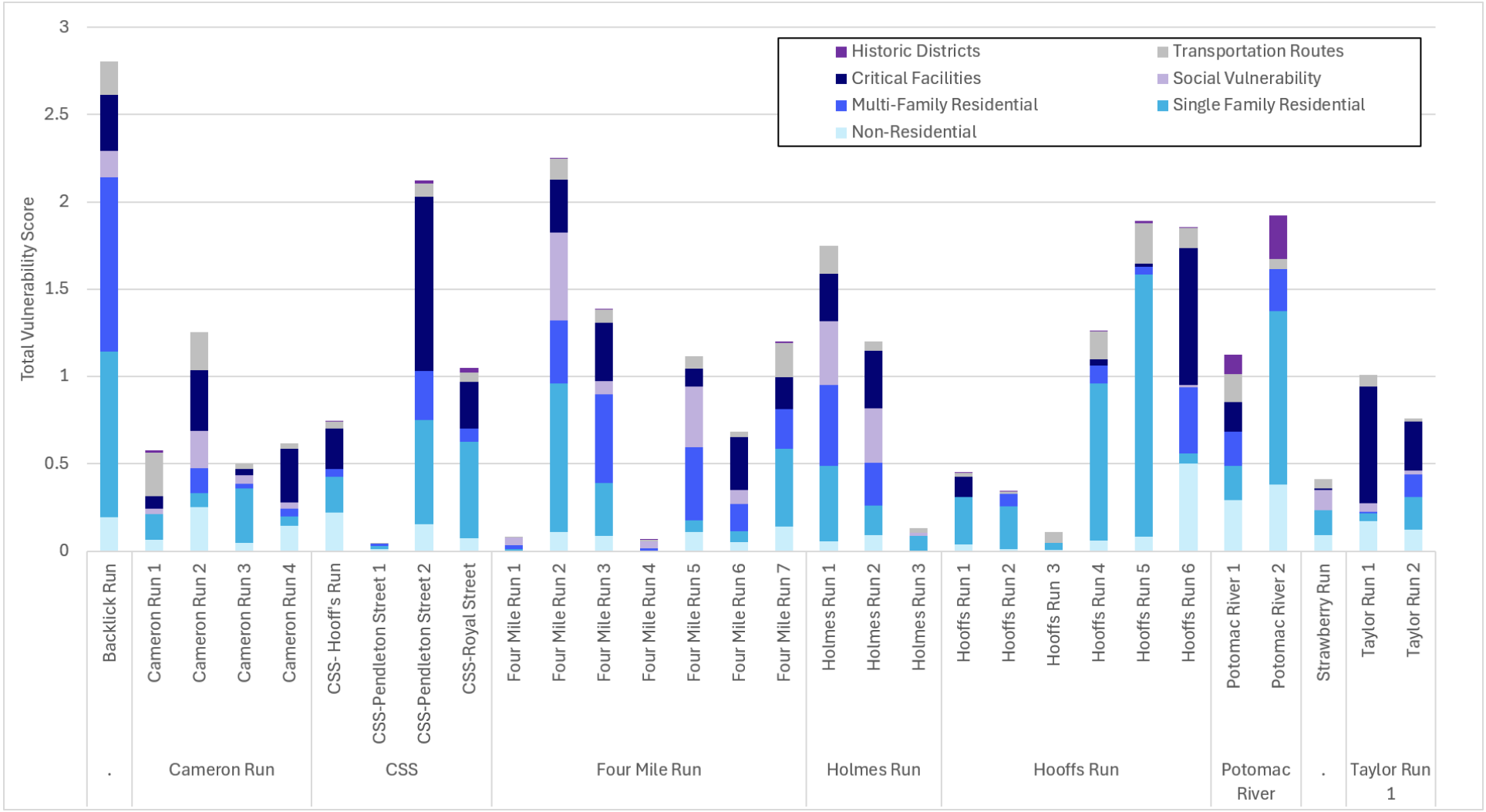


Figure 2-8: Total Vulnerability Score by Subwatershed

Note: Individual receptor scores are weighted as shown on Figure 2-7.

The drivers of vulnerability vary between subwatersheds. Table 2-1 shows the subwatersheds with high vulnerability scores in the assessment and the receptors that contributed to the high scores. Primary contributors to vulnerability include the following:

- High concentrations of single- and multi-family residential flooding
- Presence of socially vulnerable populations
- Impacts to critical facilities

Figure 2-9 shows a map of the vulnerability scores across the city's subwatersheds, with darker colors representing areas of higher vulnerability.

Table 2-1: Most Vulnerable Subwatersheds

Vulnerability Score	Subwatershed	Primary Receptor Vulnerabilities
≥ 2	Backlick Run	Multi-family residential Single-family residential Critical facilities
	Four Mile Run 2	Single-family residential Social vulnerability Multi-family residential Critical facilities
	CSS-Pendleton Street 2	Critical facilities Single-family residential Multi-family residential
1.5 – 1.99	Potomac River 2	Single-family residential Non-residential Historic district Multi-family residential
	Hooffs Run 5	Single-family residential
	Hooffs Run 6	Critical facilities Non-residential Multi-family residential
	Holmes Run 1	Single-family residential Social vulnerability Multi-family residential Critical facilities

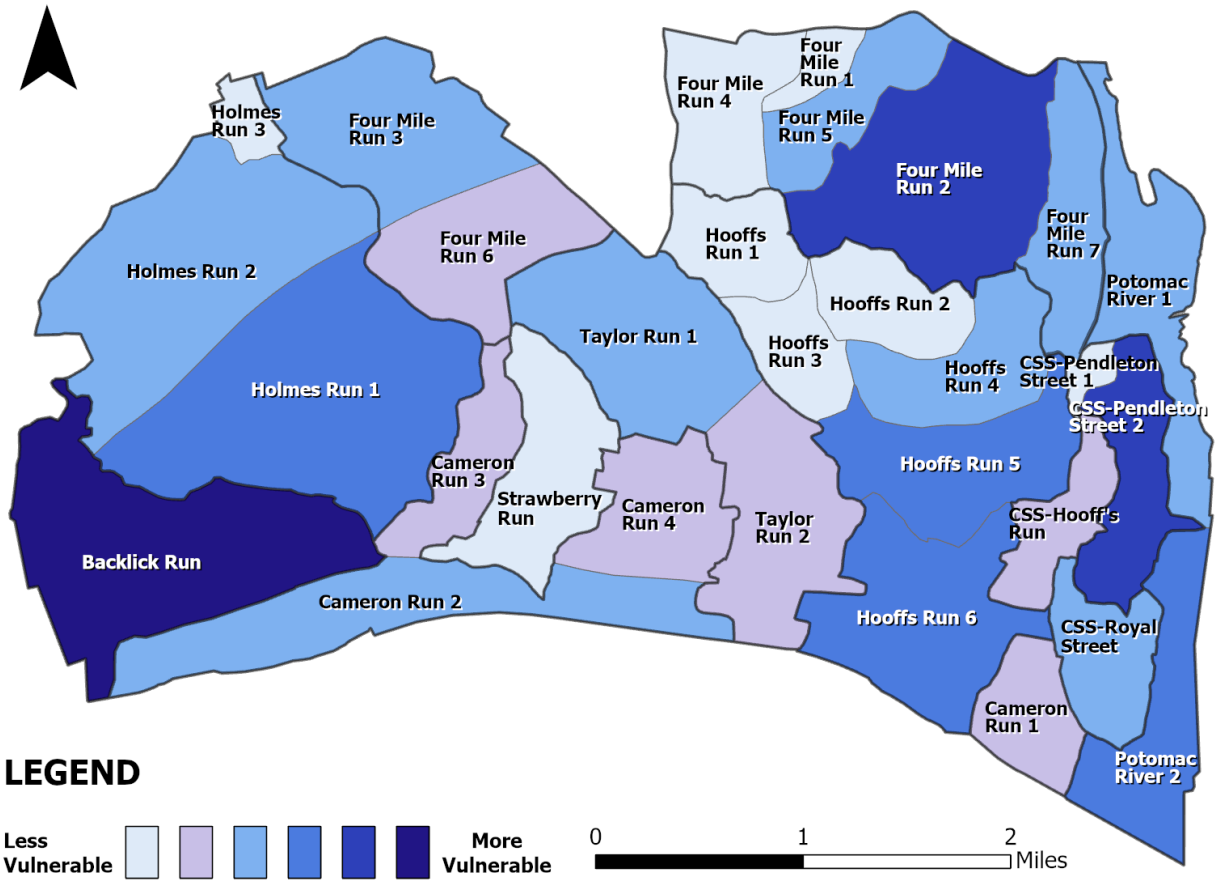


Figure 2-9: Map of Subwatershed Vulnerability

Vulnerable Critical Facilities

Flood impacts are distributed across the city, with heightened concern for critical facilities serving populations with limited mobility and public functions, including the following:

- Healthcare facilities, shelters, and public housing
- Utilities and water/wastewater infrastructure
- Transportation networks

Flood exposure to critical facilities affecting access routes, parking areas, or building interiors can significantly impair operations, even if flooding depths are moderate. These facilities are particularly vulnerable because of the consequences of service disruption and the impact on populations living in or dependent on these facilities. For example, public housing is considered a critical facility because low-income residents may face disproportionate flood impacts and often lack the resources to evacuate. As a result, these facilities require prioritized emergency response, post-flood recovery support, and targeted infrastructure protection to reduce public safety risks.

The number and types of critical facilities impacted by flooding in the future 100-year flood event are shown in Figure 2-10.

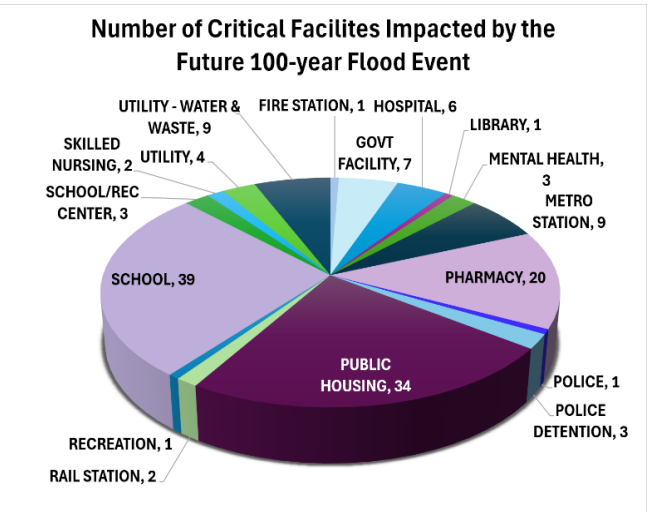


Figure 2-10: Number and Type of Critical Facilities Exposed to Flooding under the Future 100-year Flood

2.4 DAM SAFETY

In addition to locally generated flood hazards, upstream infrastructure can contribute to flood risk within the city. The Lake Barcroft Dam (Photo 2-2), located one mile upstream from city limits along Holmes Run and within the Cameron Run watershed, is particularly relevant (LBWID 2026; *The Register Guard* 2026).

Originally completed in 1915, Lake Barcroft Dam is classified as a high hazard potential dam. If the dam were to fail, it could result in significant economic damage and potential loss of life because of the extensive development and critical infrastructure located downstream (Cameron 2024). The Lake Barcroft Dam experienced a partial failure once before during Hurricane Agnes in 1972, which demonstrated system vulnerability under extreme rainfall (NVRC 2007). Given the significant amount of development downstream since then, a similar or larger event would likely be even more consequential.

Potentially affected areas include the low-lying portions of western and southern Alexandria, particularly along the Cameron Run floodplain and adjacent transportation and utility corridors such as Interstate 395 and Interstate 95.

While the likelihood of dam failure is low and the structure is actively maintained, this type of event represents a low-probability, high-consequence hazard. The risk may be further influenced by increasing rainfall intensity and runoff volumes, which can place additional stress on dam spillways and embankments during extreme storm events.

Because of these factors, Lake Barcroft Dam is considered an upstream hazard that warrants consideration in flood risk planning, particularly for emergency preparedness, interagency coordination, and resilience strategy development.



Photo 2-2: The masonry dam across Holmes Run that creates Barcroft Lake, Fairfax County, Virginia, October 22, 2017.

(Source: Photo by Taylordw Image: Barcroft-Dam-Fairfax-County-Virginia-22-Oct-2017; License at https://creativecommons.org/licenses/by-sa/4.0)

The Lake Barcroft Watershed Improvement District (LBWID) is responsible for maintaining this privately owned dam. The LBWID coordinates with local governments, including the City of Alexandria, to make upgrades in dam monitoring and other projects (NVRC 2007). Recent funding initiatives specifically target spillway and embankment upgrades to improve resilience to larger storms (Grant 2023). Given the significant risk that this dam could pose to the city, it is crucial for continued cooperation with dam management to ensure long-term maintenance and safety. Because the city does not manage this dam, no management strategies will be provided in Section 3.

Section 3
Flood Resilience Strategies



3 FLOOD RESILIENCE STRATEGIES

3.1 IMPLEMENTING RESILIENCE

Improving flood resilience in Alexandria requires a comprehensive, evidence-based approach through policy changes, investments, and action at the municipal level. Building on technical analyses, historical data, and results presented earlier in this FRP, this section focuses on mitigation measures to reduce flood risk across Alexandria (Photo 3-1). It lays out the recommendations for advancing flood resilience through future planning efforts, policy initiatives, and capital improvement projects. The strategy outlined is also designed to align City efforts with state and federal programs and support efforts to qualify for grant funding and financial incentives for best practices implementation.

To support implementation of the FRP, the City evaluated existing flood resilience efforts, best practices from other communities, and applicable state and federal program requirements. This process identified a range of opportunities to strengthen flood resilience in both the near- and long-term. These recommendations provide a comprehensive framework for reducing flood risk and enhancing community preparedness.



Photo 3-1: Implementing FRP strategies will help reduce the occurrence of repeated flooding along the waterfront and elsewhere as experienced here in 2021 (Source: City of Alexandria).

The strategy recommendations presented in this section were developed and refined through collaboration with City staff and community stakeholders and are organized into the following eight key focus areas:

- Policies and Ordinances
- Flood Mitigation
- Integrating Flood Resilience Across City Programs and Beyond
- Flood Preparedness and Response
- Asset Management
- Communication and Outreach
- Socio-Economic Inclusion
- Funding Strategies

Aligning FRP Resilience Strategies to the National Flood Insurance Program Community Rating System

In addition to satisfying the Virginia DCR CFPF grant requirements, which funded the development of this FRP, many of the strategies and initiatives described have the potential to improve the City's rating under FEMA's CRS. The CRS is a voluntary initiative that recognizes high-standard floodplain management activities. Rating classes range from 10 to 1 and qualify a community for National Flood Insurance Program (NFIP) premium reductions based on verification of eligible flood mitigation activities (from 0 to 45% premium reduction on all policies within a community). Lower rating class numbers are associated with a more robust community flood resilience program and increased premium discounts.

The City's commitment to flood management made Alexandria the first community in Virginia to earn a Class 6 rating under the CRS in 2013, a designation it has maintained ever since. By reducing flood risk to insurable property, strengthening and supporting the insurance aspects of the NFIP, and encouraging a comprehensive approach to flood management, Alexandria residents are entitled to a 20% discount on flood insurance premiums.

Many flood resilience strategies described in this section could help the City earn more points for activities under the CRS. The CRS assigns points for activities that reduce flood risk, improve public awareness, and strengthen floodplain management practices. For Alexandria, earning more points

under CRS activities would provide the following benefits:

- **Lower flood insurance premiums for residents and businesses.** As explained previously, CRS points can improve the City's overall CRS classification, which can reduce NFIP premiums for policyholders citywide. The more points a community earns, the greater the potential discount.
- **Recognition of enhanced flood resilience.** Higher CRS scores demonstrate that the City is proactively managing flood risk beyond minimum federal requirements, helping to protect people, property, and infrastructure.
- **Reduced future flood damage**. Many activities that earn CRS credit, such as increased freeboard requirements and stronger building standards, result in new structures that are less vulnerable to flooding and benefit from reduced recovery costs after flood events.
- **Improved competitiveness for funding opportunities.** Strong floodplain management programs and documented resilience measures can support applications for state and federal grants, including funding for flood mitigation and adaptation projects.
- **Long-term community benefits.** CRS-creditable activities help guide safer development and encourage risk-informed decision making.

For these reasons, CRS points are more than an administrative metric. They represent tangible actions to improve community resilience while providing direct financial benefits to residents and businesses through reduced flood insurance costs. The recommendations in this section are designed not only to reduce flood risk but also to increase the City's CRS score and provide the associated benefits to the community.

3.2 Policies & Ordinances

As the understanding of existing and future flood risk – and the ways development patterns influence those risks – evolves, Alexandria should continue to evaluate whether updates to stormwater management practices, regulatory flood overlay zones, and building codes are warranted. As part of the FRP, the City is evaluating potential revisions to ordinances and policy standards to enhance flood resilience and reduce long-term vulnerability. The City should continue its existing efforts to evaluate and modify future development and infrastructure investments to minimize risk from predicted flood hazards and changing environmental conditions, while also identifying opportunities to further strengthen these practices.

The following policy and regulatory implementation strategies are organized into three categories: (1) floodplain management strategies (2) stormwater management ordinances; and (3) other planning and permitting initiatives.

Floodplain Management Strategies

Floodplain management strategies are being evaluated by the City. By evaluating higher regulatory standards, the City seeks to improve the performance of future development in flood-prone areas, reduce potential flood damage, and enhance public safety. These strategies also represent opportunities to achieve additional CRS credit through higher regulatory standards by updating floodplain ordinances to exceed minimum federal requirements. In turn, this may contribute to reduced flood insurance costs for residents and businesses while improving the overall resilience of the city's building stock.

Strengthen Freeboard Standard

The current freeboard standard is found in Section 6-300 (Floodplain District) of Article VI (Special and Overlay Zones) of the City's Zoning Ordinance. The current ordinance is consistent with the Virginia Uniform Statewide Building Code, which requires the first floor elevation of structures in Special Flood Hazard Areas (SFHAs), as designated and mapped by FEMA Flood Insurance Rate Maps (FIRMs), to be floodproofed or elevated a minimum of 1 foot above the base flood elevation (BFE), which is the height of floodwater expected during a 100-year storm scenario. The safety buffer of additional elevation above the BFE is called freeboard (Figure 3-1).

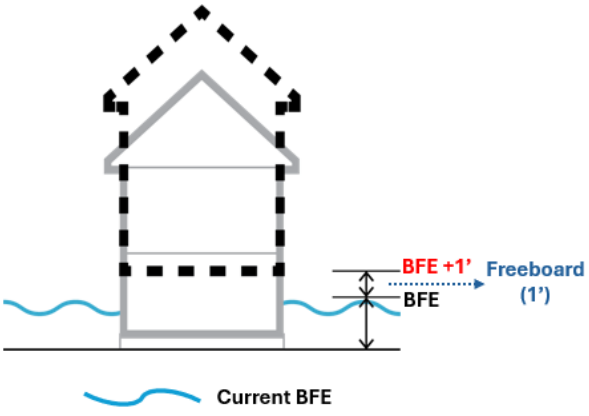


Figure 3-1: Current Freeboard Standard

A proposed strategy is to amend the floodplain ordinance to increase the minimum freeboard requirement for new construction and substantial improvements to structures located within the SFHA (Figure 3-2). Substantial improvement is defined as any improvement to a building or structure where the cost of the improvement equals or exceeds 50% of the market value of the structure before the improvement is constructed. This strategy would provide additional protection against future flood conditions, including increased rainfall intensities, changing hydrologic conditions, and flood events that exceed the elevations reflected in current FEMA mapping. The primary objective of the proposed update is to provide a greater margin of safety for future development and reduce the vulnerability of buildings to flood-related damage over their useful life.

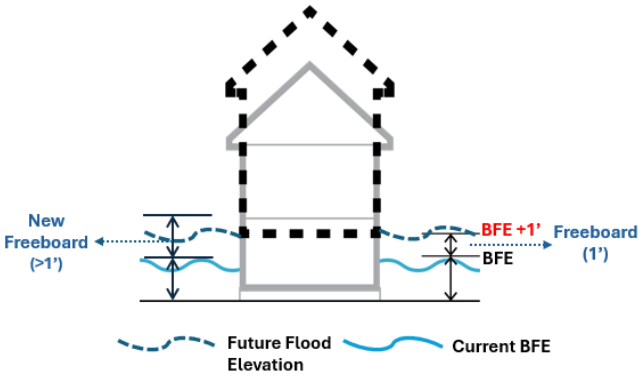


Figure 3-2: Higher Freeboard Standard

The recommended increase in freeboard is informed by technical analyses that compare existing FEMA flood elevations with projected future flood conditions generated by flood models described in Section 2, as well as estimated 500-year flood scenarios (ASCE 2025). Analyses indicate that additional freeboard could provide meaningful risk reduction benefits. Based on these analyses, a 2.5-foot freeboard is recommended for SFHAs along the Potomac River because of the influence of storm surge and sea level rise, while a 2-foot freeboard is recommended for all other SFHAs in the city. These freeboard increases are being proposed to address the potential increase in future flood elevations, which may exceed current regulatory flood elevations.

Potential benefits of a higher freeboard standard include reduced structural damage during flood events, greater protection of building systems and utilities, lower long-term maintenance and repair costs, and enhanced safety for occupants.

Since higher freeboard requirements may result in taller building profiles or modifications to building design, the staff in the Department of Transportation & Environmental Services (T&ES) are coordinating with Planning and Zoning staff, floodplain management personnel, the development community, property owners, and other stakeholders to better understand potential implementation challenges and opportunities. These discussions are intended to support future potential floodplain ordinance amendments that appropriately balance flood risk reduction objectives with urban design goals, development feasibility, housing considerations, and broader community planning priorities.

Why increase the freeboard for buildings in the SFHA?

As of 2025, the U.S. Department of Housing and Urban Development requires newly constructed homes within SFHAs to be elevated at least 2 feet above the BFE to qualify for Federal Housing Administration-insured financing.

The Commonwealth of Virginia has recognized the benefits of standards that exceed FEMA minimum requirements by adopting updated floodplain regulations for state-owned facilities that require a minimum of 2 feet of freeboard in riverine floodplains and 3 feet of freeboard in coastal floodplains (DCR 2025).

Several Virginia localities have adopted freeboard requirements greater than 1 foot, demonstrating an increasing recognition that additional elevation can improve long-term resilience and reduce future flood losses.

Improve Floodplain Permitting

Currently, projects within the floodplain are reviewed as part of the standard building permit and development review process, manually assigning review tasks to appropriate staff. This approach can make it challenging to identify and address building permit floodplain requirements after review and approval, such as receiving required elevation certificates prior to issuance of the certificate of occupancy.

To improve coordination and administration for development project reviews and approval for building activities within SFHAs, the City is exploring the use of a special Floodplain Use Permit (FUP). This new permit would be connected to any

new building permit and certificate of occupancy for new construction or substantial improvement in the SFHA, including required FEMA certifications (elevation certificates, floodproofing certificates). The FUP would be required to be closed and approved, as applicable, before a certificate of occupancy is issued.

The FUP process would streamline the review and permitting of development projects subject to the floodplain ordinance by facilitating review by the appropriate City staff at the time additional required certifications are due. This process change would improve interdepartmental coordination and establish a mechanism to collect, verify, and track elevation certificates and other FEMA-required documentation before project occupancy.

Stormwater Management Ordinance Strategies

As a built-out community, there are limited opportunities in Alexandria for large-scale flood mitigation projects to address current and future flooding risks. Virginia Code, as incorporated into local ordinance, requires that development and redevelopment do not increase the post-development stormwater runoff rate beyond the pre-development runoff rate. In a built-out city, this often puts stormwater management in late 20th-century standards. Guiding new development and redevelopment toward flood-risk reduction by strengthening stormwater quantity and peak flow rate requirements is a critical component of the City's resilience strategy.

Strengthen Stormwater Quantity Requirements

The current stormwater quantity and peak flow rate requirements are regulated under Article XIII (Environmental Management), Section 13-109, of the Zoning Ordinance. Under this ordinance, post-development peak discharge flow rates must be less than pre-development conditions for a 10-year storm event. While this approach prevents projects from making flooding worse, it often does not improve existing flooding conditions or help to improve conditions for future storm events.

This situation is particularly important in older neighborhoods and commercial areas constructed before modern stormwater management standards were in place. Under the current ordinance, redevelopment today can meet current requirements without providing meaningful reductions in runoff flow rates or improvements to downstream flood conditions. Consequently, stormwater runoff and flooding are not positively affected and remain largely unchanged.

What are Stormwater Quantity and Peak Rate Controls?

When land is developed, impervious areas prevent rainwater from soaking into the ground. This effect can increase runoff volume and cause water to flow more quickly into streams and drainage systems. Stormwater management regulations require that new development manage runoff so it does not increase flooding, erosion, or damage to downstream properties and infrastructure. This is achieved by providing storage facilities—also called detention facilities—to temporarily hold runoff and to control the maximum or peak flow rate of the runoff discharged from the site.

To help reduce future flood risks, the City has evaluated options that would require new development and redevelopment to effectively manage stormwater for larger storm events that would address future increased rainfall. As part of developing the FRP, the City analyzed three peak flow reduction factors—10%, 15%, and 20%—to be applied to pre-development peak flow rates when establishing allowable post-development discharge rates. By reducing peak discharge rates, redevelopment projects can incrementally improve watershed conditions over time and provide cumulative flood reduction benefits across the city.

The analysis was conducted using representative sites across the city with variable impervious surface percentages. Of the three reduction factors analyzed, 20% provides the greatest estimated benefit, reducing future post-development peak flow rates by an average of approximately 7% and, for highly impervious sites, reducing more than half of the projected increase in peak discharge associated with future rainfall conditions (Figure 3-3).

In the event of an amendment to the stormwater quantity ordinance, the City would retain currently accepted hydrologic calculation methods, design procedures, and rainfall depths to the greatest extent practicable. Proposed changes could instead focus on increasing the level of stormwater management performance rather than fundamentally changing the regulatory framework used by applicants and designers.

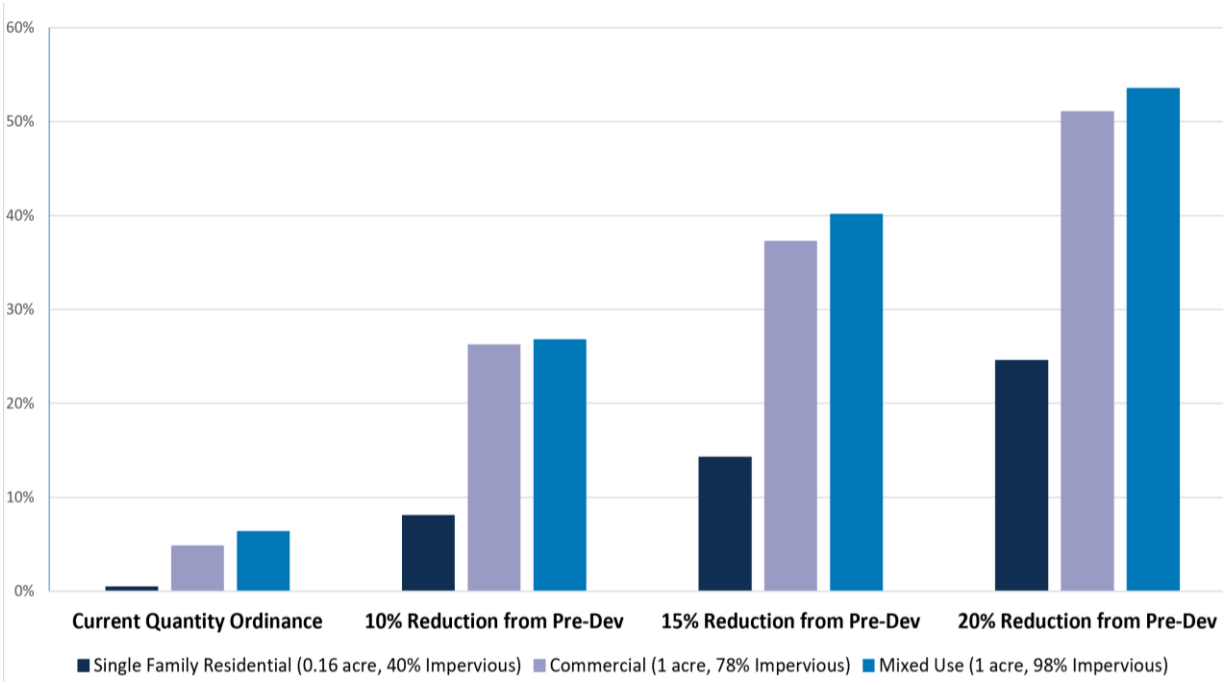


Figure 3-3: Comparison of How Different Pre-Development Runoff Reduction Rates Affect Peak Runoff Under Future Rainfall Conditions Across Residential, Commercial, and Mixed-Use Development

Recommended ordinance updates include the following:

- Increase stormwater quantity requirements by requiring post-development peak discharge rates for the 10-year storm event to be reduced below pre-development rates through application of a reduction factor. These requirements would apply to concentrated discharges regardless of whether the receiving conveyance system currently experiences localized flooding.
- Eliminate stormwater quantity waivers currently allowed under the current ordinance in Section 13-109, Part F.2.

These recommendations support the FEMA CRS Stormwater Management activity. They are expected to increase the City's eligibility for more CRS credit by strengthening stormwater management requirements and eliminating provisions that currently limit credit opportunities.

The City recognizes that implementation of enhanced stormwater requirements must be practical and achievable. It is committed to working collaboratively with the development community through stakeholder engagement, education, technical guidance, and the development of design tools to support compliance.

Recognizing some highly constrained redevelopment sites may face physical limitations making full compliance difficult or infeasible, the City may evaluate alternative compliance pathways. Policies such as fee-in-lieu programs or other compensatory approaches can allow redevelopment to contribute toward citywide flood resilience goals while maintaining flexibility for unique site conditions.

Other Policy, Programmatic, and Planning Initiatives for Flood Resilience

Updating the City's floodplain and stormwater management ordinances is only one part of a broader strategy to increase community resilience to current and future flood hazards. Because Alexandria's future growth will occur primarily through redevelopment and infill on previously developed sites, it is important that flood resilience considerations be integrated across the City's planning, development review, capital improvement, and stormwater management programs. A range of complementary policy, programmatic, and planning initiatives are recommended to support implementation of the FRP and reinforce the benefits of proposed regulatory updates.

Develop Maps for Flood-Prone Areas and Voluntary Flood Resilience Guidance for Flood Hazard Areas

Through the Flood Action Alexandria website, the City provides a variety of tools and resources related to flood hazards in FEMA flood zones, including the latest FEMA FIRM maps that identify SFHAs associated with riverine and coastal flooding. However, FEMA maps rarely capture localized interior flooding risks that occur throughout Alexandria. To better communicate flood hazards outside of SFHAs and support long-term resilience planning, it is recommended that the City develop maps of flood-prone areas (FPAs) based on the current and future 10-year and 100-year flood extents presented earlier in this FRP (refer to Figure 2-5). The proposed FPA map would identify areas subject to future flood risk from interior drainage systems, localized flooding, and projected future rainfall conditions, in areas outside mapped FEMA floodplains (refer to Section 3.7 for additional discussion about publishing the FPA map). The FPA map would serve as a planning and educational tool to increase public awareness of flood risk beyond SFHAs and the Potomac River waterfront.

In addition to providing FPA mapping, it is recommended that the City develop comprehensive flood resilience guidance for design and construction in flood hazard areas. The guidance could provide property owners, developers, and design professionals with information about future flood hazards and resiliency measures to inform development, investment decisions, and strategies to reduce flood damage in both regulated SFHAs and non-regulated FPAs. The guidance would be voluntary and informational in nature and serve to provide guidance for property owners to reduce their exposure to flood damage.

The guidelines may include measures such as elevating habitable space in buildings above current and future 100-year flood elevations, avoiding the placement of structures within natural conveyance corridors and topographic low points, providing safe emergency access and egress during flood events, and elevating critical systems, such as mechanical and electric systems, above flood-prone elevations. Floodproofing practices such as those used within SFHAs also may be encouraged on a voluntary basis in non-regulated FPAs. These measures can help reduce flood exposure and improve community resilience in areas where flood risk is not currently addressed through FEMA floodplain regulations.

Expand the Use of Nature-Based and Low-Impact Stormwater Practices

Alexandria has long shown a commitment to incorporating nature-based stormwater management practices into development through requirements that prioritize tree protection and water quality treatment using green infrastructure. The City should continue to build on this commitment by exploring opportunities to expand the use of green infrastructure and runoff reduction practices that provide both water quality and flood resilience benefits.

As the City evaluates enhanced stormwater quantity requirements, it will also consider strategies incentivizing best management practices (BMPs) including pervious pavement, green roofs, bioretention facilities, urban tree canopy, and soil restoration, among other accepted BMPs. These approaches can reduce runoff volumes, slow peak flows, increase infiltration and evapotranspiration, and help applicants meet future stormwater detention requirements while providing additional environmental and community benefits. Expanding the use of nature-based solutions also can supplement traditional end-of-pipe detention facilities, particularly on constrained redevelopment sites where available space is limited.

Update Design Guidance and Development Standards

Currently, the City lacks a centralized, localized stormwater drainage design guidance document. While developers must comply with general state regulatory requirements, such as the *Virginia Stormwater Management Handbook* (Virginia DEQ 2025), and local zoning ordinances, there is no unified, Citywide framework for stormwater guidance.

Supporting the implementation of enhanced flood resilience requirements would include the development of a comprehensive Alexandria Stormwater and Drainage Design Manual to offer clear technical guidance for development.

The manual could show recommended design approaches and resilience best practices and provide examples of compliance pathways for meeting enhanced floodplain and stormwater performance standards. It also could provide guidance on green infrastructure integration and runoff reduction practices and should be complementary to the City's current *Green Streets and Sidewalks Stormwater Design Guidance* (City of Alexandria n.d.), to help applicants achieve more protective stormwater management outcomes.

Engage Stakeholders and Support Implementation of Policy and Ordinance Updates

The City recognizes that successfully implementing resilience initiatives will require collaboration with residents, businesses, developers, consultants, and other stakeholders. An additional strategic recommendation for this plan is to continue improving engagement between the City, the development community, and the public as ordinance updates and policy initiatives are advanced. Through outreach and education, technical guidance, and design tools, the City could help stakeholders effectively navigate and apply new ordinance requirements.

The City also acknowledges that highly constrained redevelopment sites may face challenges in meeting future resilience goals. As policies and ordinances evolve, the City will continue to evaluate practical implementation strategies and alternative compliance mechanisms that balance flood resilience goals with site-specific constraints.

Integrate Flood Resilience into Future Planning Efforts

Alexandria incorporates future flood risk information into long-range planning, redevelopment initiatives, capital improvement programming, watershed management efforts, and other policy decisions. The City should continue to strengthen these efforts by incorporating evolving flood risk information into planning and decision making and by identifying opportunities to improve stormwater performance and reduce flood risk over time.

In addition, the City supports state-level policies and legislation to advance resilience objectives and provide local governments with additional tools to manage flood risk. By integrating future flood conditions into planning and decision making across multiple programs, Alexandria can better position itself to address increasing flood risks associated with continued development, aging infrastructure, and changing environmental conditions.

3.3 Flood Mitigation

Alexandria is committed to advancing flood mitigation strategies that build on the success of its Flood Action Alexandria Program while expanding efforts in vulnerable watersheds and communities identified through the flood mapping and vulnerability assessment prepared for this FRP (Section 2). The City continues to prioritize projects and initiatives that reduce recurrent flooding, strengthen resilience in vulnerable watersheds, and proactively address future flood risks through a combination of major capital improvements, targeted planning and analysis, conservation and nature-based solutions, and incentive-based programs.

Engineered Flood Mitigation Projects

To support future infrastructure investments, the City maintains and annually updates a 10-year Stormwater Capital Improvement Program (CIP). The CIP serves as a long-term roadmap for constructing, rehabilitating, and replacing major infrastructure assets, allowing the City to prioritize capital projects and provide a framework for budgeting and scheduling project implementation.

The CIP for the current fiscal year (FY27) includes large-capacity flood mitigation projects identified through the CASSCA Project (CH2M Hill 2016), including conveyance improvements, underground storage, and green infrastructure; improvement projects identified through local neighborhood studies; and the Waterfront Flood Mitigation Project. These projects address some of the worst flooding concerns in Alexandria. The City has completed 16 flood mitigation projects to date since the initiation of the Flood Action Alexandria Program and will continue implementation of projects included in the FY27 CIP (Figure 3-4).

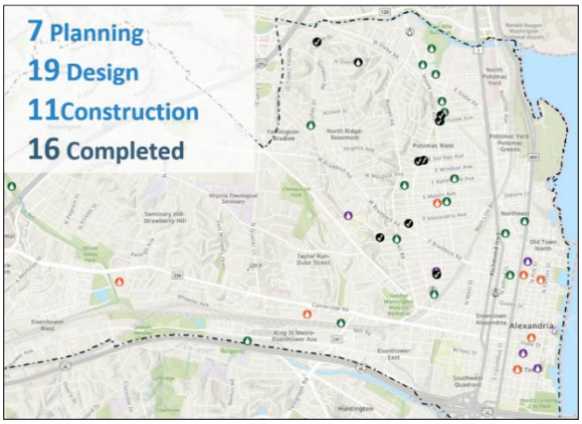


Figure 3-4: The City's Infrastructure Project Dashboard

(Source: https://alexgis.maps.arcgis.com/apps/dashboards/2a448a4307284eb5b0de9b304b5634ee#)

The remaining 73 projects identified through CASSCA were re-evaluated and reprioritized during development of this FRP using a methodology similar to the watershed vulnerability assessment discussed in Section 2.3. Project rankings were based not only on the extent of flooding, but also on the potential impacts to buildings, critical facilities, socially vulnerable areas, and other community assets located within affected areas. Project cost estimates initially developed under CASSCA were escalated to current dollar value and were used to assign a cost-benefit metric, such as dollars per gallon of flood reduction, that was integrated into the prioritization analysis. The results of this analysis are shown on Figure 3-5.

Higher priority was assigned to locations with documented flooding or stormwater collection system issues identified through citizen reports, maintenance records, and field observations. Areas where modeled flood extents did not align with known flooding concerns were flagged for targeted outreach and model refinement to validate conditions before mitigation projects are advanced. The flood modeling also identified some areas at risk of flooding where mitigation projects have not yet been developed. The resulting prioritized project list should be used to inform future updates to the CIP. The flood mitigation projects have been phased into the following three implementation categories:

- Short-Term Projects: 11 large-capacity projects, the Waterfront Flood Mitigation Project in the Potomac River Watershed, and targeted spot improvement projects currently included in the FY27 CIP
- Mid-Term Projects: Nine projects identified through the CASSCA study, reprioritized through the FRP vulnerability assessment, and supported by documented flooding reports and community input may be included in future CIPs beyond FY37.
- Long-Term Projects: Flood-vulnerable areas that require additional validation, analysis, or planning before a mitigation strategy can be defined and advanced for implementation

Table 3-1 shows the number of short-term and mid-term projects by watershed. Long-term projects require validation before being advanced for implementation.

Table 3-1: Number of Short-Term and Mid-Term Projects by Watershed

Watershed	Short-Term Projects	Mid-Term Projects
Backlick Run	-	2 large capacity
Cameron Run	1 spot improvement	-
CSS	1 spot improvement	-
Four Mile Run	4 large capacity + 7 spot improvement	2 large capacity
Holmes Run	1 spot improvement	2 large capacity
Hooffs Run	7 large capacity + 6 spot improvement	1 large capacity
Potomac River	1 large capacity	1 large capacity
Strawberry Run	-	-
Taylor Run	2 spot improvement	1 large capacity

Note: The Four Mile Run and Hooffs Run Inlet Installation and Enhancement project is included in the spot improvement project count for both watersheds.

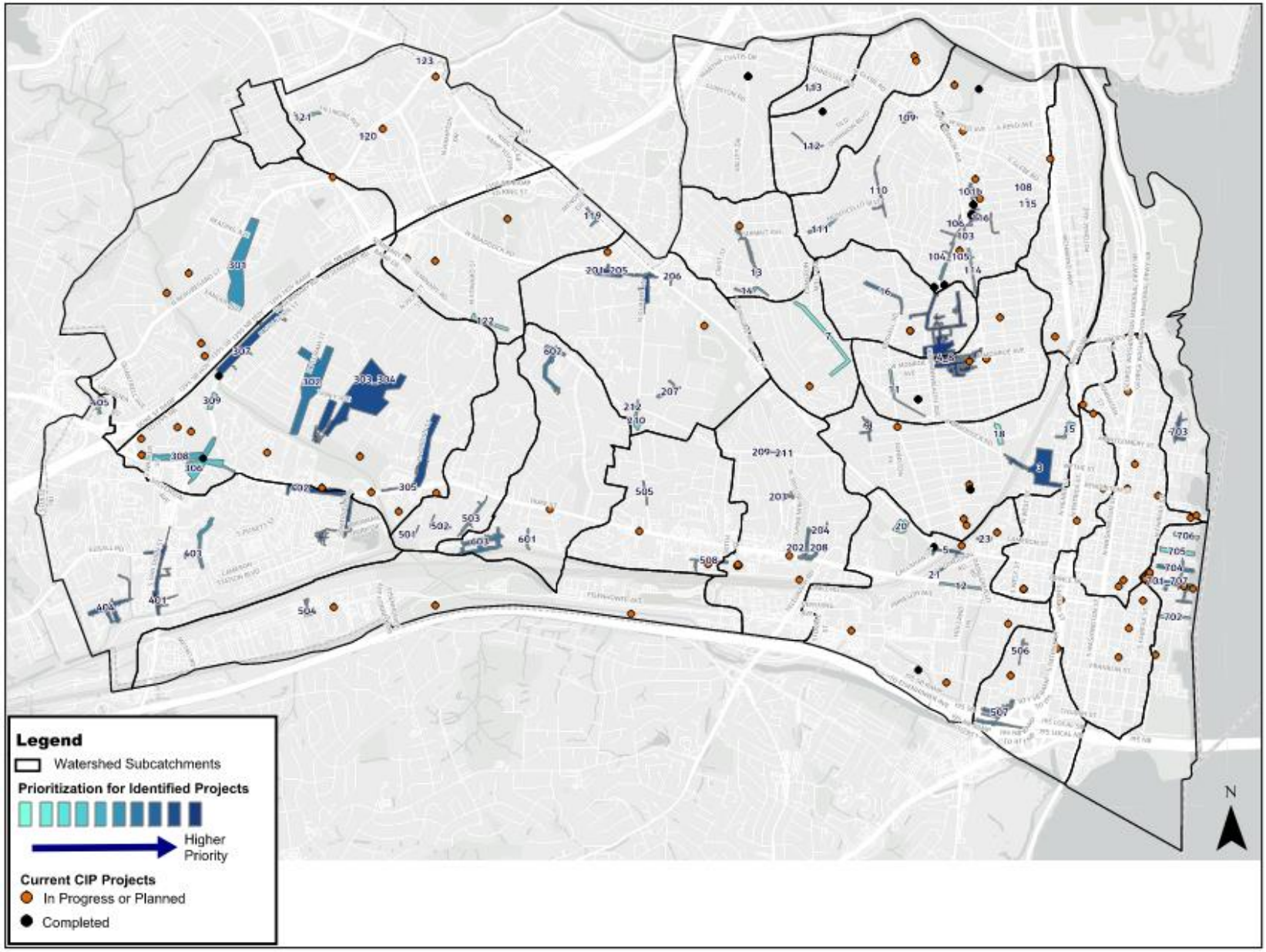


Figure 3-5: Map of Prioritized Flood Problem Areas Associated with Future Projects

Planning for Future Flood Mitigation Projects

The results of the FRP vulnerability assessment were used to identify and prioritize subwatersheds where additional planning and analysis are needed to better understand flood risk and develop future mitigation strategies. This citywide screening effort helped identify subwatersheds with elevated flood vulnerability that have not previously been studied in detail or for which flood mitigation projects have not yet been defined.

Project planning was prioritized in subwatersheds exhibiting significant flood risk and potential consequences to people, property, infrastructure, and community assets that also have generalized indicators of sensitivity, such as the presence of basements, critical facilities, and populations with limited mobility. However, site-specific conditions were not evaluated as part of this screening-level assessment and should be examined as part of future planning and analysis efforts.

The recommended planning activities will fill key information gaps, validate flood risk in areas with high modeled vulnerability and limited observed flooding, and support the development of targeted mitigation solutions. Potential study activities include targeted community outreach, refined flood modeling, neighborhood-scale flood investigations, risk assessments for vulnerable assets, identification and prioritization of CIP projects, and benefit-cost analyses of potential mitigation measures in at-risk areas.

Planning projects were ranked by implementation priority and planning-level cost estimates were developed, creating a roadmap for advancing flood risk reduction initiatives in vulnerable subwatersheds. Figure 3-6 provides a summary of project types for planning needed in high priority subwatersheds. The project descriptions provide details on general activities associated with each project type. For example, Backlick Run is prioritized for community outreach and model refinement because FRP analyses showed high flood vulnerability that did not align with flooding observations. Therefore, a phased approach is recommended to first validate predicted flooding through community outreach and, if confirmed, model refinement is proposed to more accurately locate flood problem areas and identify mitigation projects. Additional details can be found in Section 4.

Flood Validation, Model Refinement and Planning Projects

PROJECT TYPE	DESCRIPTION	SUBWATERSHEDS
OUTREACH & MODEL REFINEMENT FOR VALIDATION Validate flood risk in areas with high modeled flood vulnerability but few complaints.	**Phase 1:** High-level study with community outreach and limited model refinement. **Phase 2:** Detailed modeling if needed.	• Backlick Run • Four Mile Run 3 • Cameron Run 2 • Holmes Run 2 • Taylor Run 1
MODEL REFINEMENT/ SMALL-AREA STUDIES Address gaps where modeled flooding aligns with observations, but projects are missing.	Refine flood models; conduct small-area studies; identify additional mitigation projects.	• Four Mile Run 2 • Holmes Run 1 • Four Mile Run 7
PLANNING STUDY – COMBINED SEWER Identify flood mitigation projects in combined sewer areas with high flood vulnerability.	**Phase 1:** Community outreach. **Phase 2:** Detailed combined sewer system (CSS) modeling	• CSS – Pendleton Street 2
PLANNING STUDY – COASTAL PLAN Develop coastal resilience strategies for vulnerable low-lying areas.	Coastal resilience study to identify mitigation projects; develop high-level CIP concepts.	• Potomac River 1 & 2 • Four Mile Run 5 • CSS-Royal Street

Figure 3-6: Subwatershed Planning-Level Analysis Needs

Land Conservation and Nature-Based Solutions

Protecting environmental resources is a key flood mitigation strategy, especially in urbanized watersheds where natural hydrologic processes have been altered by development. Conservation of floodplains, wetlands, and other natural lands helps maintain watershed function, attenuate storm flows, and reduce the burden on drainage infrastructure. Integrating conservation measures with structural flood mitigation projects can improve watershed resilience and provide multiple environmental and community benefits.

The City will continue to implement policies and programs that preserve and protect natural areas as public parks and open spaces, stewarded by the Department of Recreation, Parks, and Cultural Resources. These protected lands include resource protection areas (RPAs) located along streams, rivers, and other bodies of water and wetland parks, floodplains, and other environmentally sensitive habitats. These preserved natural areas serve an important flood mitigation function by providing floodwater storage, reducing runoff, and minimizing erosion along waterways. By continuing current limitations on development and other activities within RPAs, the City can mitigate flooding to reduce potential risk to public safety and property.

A potential strategy is for City staff to consider properties that experience repetitive flooding for conservation or other protective measures. Where appropriate, these properties may be converted to permanent open space or natural areas, preventing future development in high-risk locations.

Opportunities for nature-based flood mitigation exist along rivers, streams, and shorelines through measures such as living shorelines, wetland restoration, riparian buffer enhancement, and floodplain preservation. Along the Potomac River and tidal reaches of Four Mile Run, Cameron Run, and other waterways, these approaches can help reduce flood impacts while strengthening ecological function.

Opportunities also exist to integrate green infrastructure into public capital projects (Photo 3-2). Parks, transportation improvements, streetscape projects, parking facilities, and other public investments can incorporate features such as bioretention, permeable pavement, enhanced landscaping, and other stormwater management practices. Beyond water quality, some larger projects may provide opportunities to integrate stormwater storage and detention facilities that manage both onsite and offsite runoff. The City will continue to identify and advance opportunities to incorporate green infrastructure solutions into public projects wherever they can provide meaningful flood mitigation and environmental benefits.



Photo 3-2: A green stormwater median similar to the photo was integrated into the design of the new flood relief sewer to be constructed along Commonwealth Avenue in Four Mile Run Watershed.

Community Resilience Incentive Programs

The City encourages property owners to take an active role in reducing flood risk and improving community resilience. Through the Flood Action Alexandria Program, the City established the **Flood Mitigation Grant Program** to support property-level flood protection measures. Property owners may apply for funding to reimburse up to 50% of the costs associated with eligible flood mitigation and floodproofing improvements. The program provides grants of up to $5,000 for individuals and residential homeowner associations. By implementing these measures, property owners can help protect their properties while contributing to the city's broader flood resilience efforts.

In addition, the City established a **Stormwater Utility (SWU) Fee Credit Program** that reduces stormwater utility fees when property owners install and maintain stormwater management practices, eligible landscaping, and dry floodproofing practices such as those shown on Figure 3-7 and Photo 3-3. All property owners (residential and nonresidential) are eligible to receive up to a 50% discount on their SWU fee and must reapply every 2 years for continued fee reductions. The City provides

resources, including a detailed *SWU Fee Credit Manual, Flood Mitigation Grant Policies and Procedures Manual,* and guidance on eligible mitigation measures.

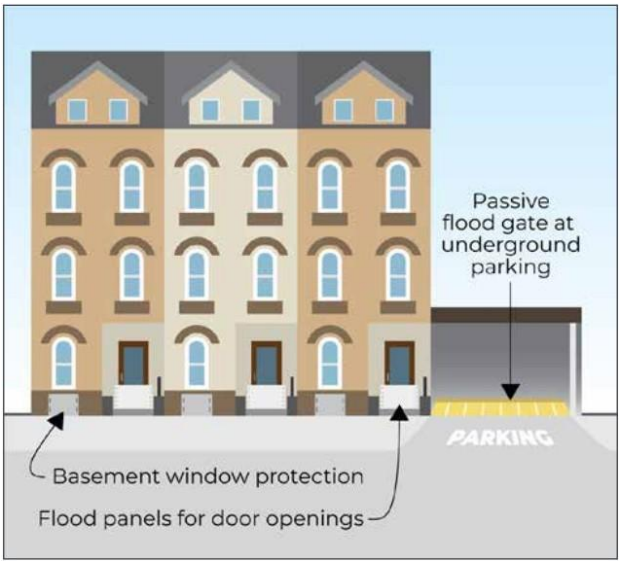


Figure 3-7: Examples of Dry Floodproofing
(Source: Stormwater Utility Fee Credit Manual)

The City may evaluate opportunities to enhance the Flood Mitigation Grant Program and other incentive programs to support property-level improvements in areas where large-scale public flood mitigation projects are not cost effective or are not planned in the near term. The City may also consider ways in which it can expand existing guidance and educational resources to help residents and property owners identify qualified contractors and make informed decisions regarding stormwater management and flood mitigation measures.

Private Partnerships

There may be opportunities to partner with property owners who are willing to make land available or grant easements for public flood mitigation projects. These partnerships can help advance flood risk reduction, lower project costs, and expand opportunities for mitigation in areas where public and private interests align. For example, when flooding affects multiple neighboring properties, a property owner, such as a homeowners association, may choose to grant an easement that enables the City to construct a flood mitigation improvement benefiting the broader area. In return, the City may consider incentives such as SWU fee credits or other mutually beneficial arrangements, where appropriate. Through collaborative partnerships, the City can leverage public and private resources to advance cost-effective flood resilience solutions and deliver greater communitywide benefits.

3.4 Integrating Flood Resilience Across City Programs and Beyond



Photo 3-3: Examples of floodproofing measures installed on residential properties, including basement window protection, a protective barrier, and elevated service equipment. (Source: City of Alexandria)

Integrating flood risk requires coordination across many City programs and departments. Alexandria has made significant investments in flood resilience through Flood Action Alexandria, and Figure 3-8 shows the organizational structure of the program. Because many flood mitigation projects involve work within public roadways, utility corridors, and other shared infrastructure systems, coordinating these efforts with broader City initiatives can reduce costs, improve project delivery, minimize disruptions to residents, and maximize community benefits. Therefore, the City considers flood resilience not as a standalone program, but as an integrated part of transportation, public works, parks, and more.

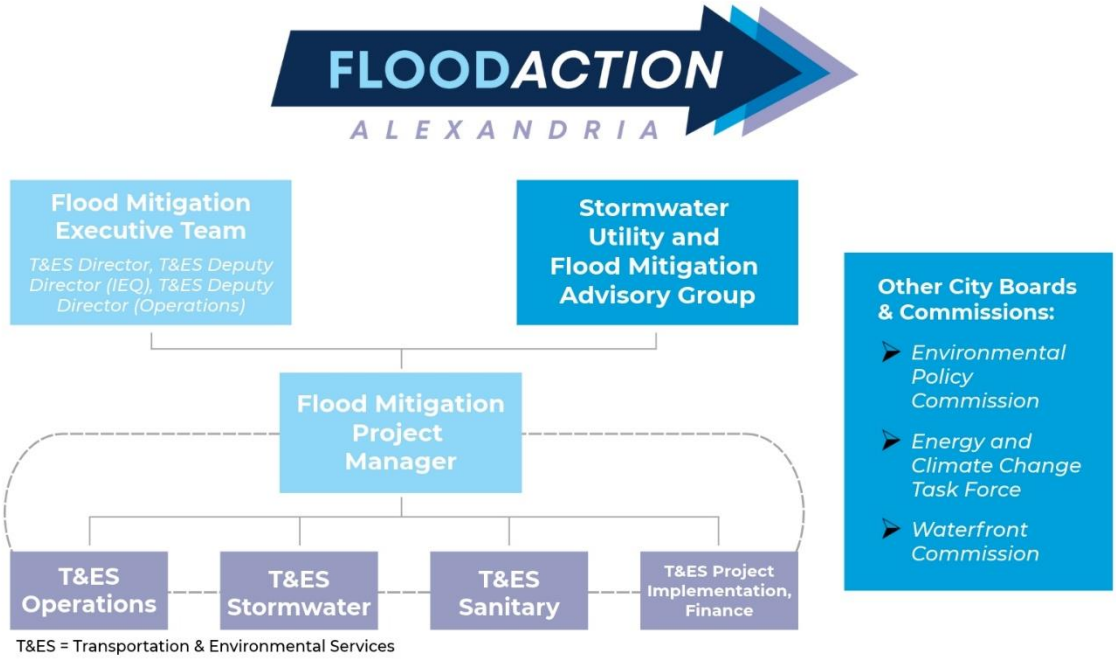


Figure 3-8: Flood Action Alexandria Program Organization Structure

Coordinating Infrastructure Investments to Maximize Community Benefits

The City works across departments to identify opportunities where planned infrastructure improvements can also address flood risks. Figure 3-9 shows critical ongoing interactions between T&ES and other City departments. Transportation projects, roadway rehabilitation efforts, sidewalk improvements, utility replacements, sanitary sewer upgrades, streetscape enhancements, and public facility investments may all provide opportunities to incorporate flood mitigation measures. Even relatively small projects can offer opportunities to improve drainage conditions through modified grading, additional inlet capacity, localized storm sewer upgrades, green infrastructure, or other flood reduction measures. The City considers flood resilience needs during project planning to verify that future investments contribute to multiple City objectives while reducing the need for separate construction activities.



Figure 3-9: Interdepartmental Coordination with Transportation and Environmental Services

The City will continue to use existing coordination processes to identify opportunities for integrating flood mitigation into capital projects early in project development. By evaluating flood risks and flood mitigation opportunities during the planning and design stages, departments can identify ways to align schedules, share costs, and improve overall project outcomes. The following existing interdepartmental coordination efforts provide prime opportunities for this collaboration:

- **Flood Mitigation Executive Team meetings** bring together leadership from the Department of T&ES and include the Director of T&ES, Environmental Services Deputy Director, Sanitary Infrastructure Division Chief, Stormwater Management Division Chief, Project Implementation Deputy Director, and Flood Action Alexandria Program Manager. The executive team meets monthly to provide updates on the Flood Action Alexandria Program and to discuss emerging challenges, identify implementation opportunities, and verify that flood resilience objectives remain aligned across City programs.
- **City Interdepartmental Review meetings** are held biweekly and include representatives from T&ES to coordinate projects across the city. These meetings are used to share information and coordinate ongoing projects. They provide an opportunity to discuss project specifics, help identify potential conflicts, and identify opportunities where multiple objectives might be met, including flood resilience.
- **Coordination with the Street and Sidewalk Maintenance Division** helps to align paving schedules and infrastructure improvements and avoid situations where newly paved streets are impacted by stormwater improvements.
- **Coordination with external utility providers** helps reduce conflicts, improve project sequencing, and expedite necessary utility relocations associated with flood mitigation projects**.**

The City will continue to identify more opportunities to increase engagement, collaboration, and coordination among departments to integrate flood resilience into CIP projects and other initiatives.

Through the Flood Action Alexandria Program, the City may consider scheduling regular planning and coordination meetings with Transportation and Mobility Planning Division staff because large transportation improvement projects provide one of the greatest opportunities to integrate flood infrastructure improvements in coordination with other capital projects. These meetings could be used to achieve the following:

- Identify opportunities to integrate previously identified flood mitigation projects with other City projects.
- Verify that projects in the right-of-way are reviewed for flood risk to address flooding in areas that may not have been prioritized but can be addressed before or at the same time as a planned transportation project.
- Identify opportunities to address nuisance flooding through adjustments such as modified grading or inlet improvements.

In addition, these meetings may provide opportunities for departments to enhance coordination with external utilities and consider whether new or updated franchise agreements may be possible as projects are implemented.

Coordinating Flood Resilience Documentation to Maximize Community Benefits

Documentation of flood resilience improvements affords the City multiple benefits. Documenting flood mitigation design standards enhances the City's ability to achieve consistent public project designs. Documenting CRS activities helps the City organize CRS reporting to earn all the flood risk reduction benefits deserved. The following sections describe how enhancing documentation processes can achieve the greatest level of community benefits.

City Standards Documentation

The Flood Action Alexandria team is refining internal design guidance to promote a consistent approach to public flood mitigation project design. These updated standards establish clear criteria for evaluating, prioritizing, and implementing City-funded flood mitigation projects through the Flood Action Alexandria Program, helping verify that projects are designed to effectively reduce flood risk and enhance community resilience. The internal guidance provides recommendations that would strengthen the design of stormwater systems, inlets, and overland flow paths to reduce roadway and structural flooding. As these standards are implemented for flood mitigation projects, the City will explore opportunities to apply them more broadly across other CIP projects where appropriate.

Improve CRS Documentation

Documentation for tracking certain CRS activities is currently managed within the Stormwater Management Division using Forerunner, a geospatial data and workflow software platform designed to help communities manage floodplain information and meet NFIP and CRS requirements. The platform provides a centralized system for organizing flood-related records and supporting documentation used in the City's CRS activities and reporting.

A potential strategy for further streamlining CRS reporting is to establish a standardized, coordinated process for tracking and maintaining flood mitigation information across City departments. Program staff could compile and manage required documentation, including elevation certificates or building retrofit certifications, records of pre- and post-project levels of protection, maps identifying protected structures, implementation dates, and applicable regulatory, environmental, and historic preservation approvals or certifications. This coordinated approach would support the consistent documentation of qualifying flood mitigation investments, incorporation into CRS reporting, and recognition for the flood risk reduction benefits they provide.

3.5 Flood Preparedness and Response

Flood preparedness and response are essential components of Alexandria's comprehensive flood risk management strategy. While flood mitigation projects can significantly reduce risk, no system can eliminate flooding entirely. Some areas will remain vulnerable, and extreme storm events may exceed the level of protection provided by existing infrastructure. As a result, it is critical for the City to plan and prepare for flood events before they occur.

The City's goal is to protect public safety while minimizing injuries, property damage, and disruptions to the community. To achieve this, Alexandria has developed a comprehensive preparedness and response program that includes flood monitoring and forecasting, early warning systems, public outreach and communication, routine maintenance and pre-event preparation activities, emergency coordination and response during flood events, and recovery support following storms (Photo 3-4). Together, these efforts reflect the recognition that reducing flood risk requires not only proactive mitigation investments, but also effective preparedness, response, and recovery capabilities.



Photo 3-4: In preparation for storm events, the City distributes sandbags to be placed around doors and basement entrances to mitigate damage from rising flood waters (Source: City of Alexandria).

Planning for the Inevitable – Preparedness and Emergency Response

The City maintains multiple plans and operational procedures that guide emergency response before, during, and after flood events. These include the Flood Response Plan, Emergency Operations Plan, Standard Operating Procedures for Hot Spot Inspections, and the Northern Virginia Hazard Mitigation Plan.

Update Flood Response Plan

The City developed the 2020 Flood Response Plan in coordination with the Office of Emergency Management, T&ES, public safety agencies, and other City departments to provide a comprehensive framework for flood preparedness, response, and recovery. As a hazard-specific annex to the City's Emergency Operations Plan, the Flood Response Plan establishes procedures for managing coastal, flash, riverine, and dam-related flood events. It serves as a foundational component of Flood Action Alexandria. The plan is designed to protect life and safety, reduce damage to property and critical infrastructure, support effective communication with the public, and coordinate recovery efforts following flood events. Key elements of this plan include the following:

- **Flood monitoring and early warning** through National Weather Service forecasts, stream and tide gauges, and other real-time monitoring systems.

- **Defined response thresholds** and emergency procedures that guide operational actions, public notifications, road closures, and evacuation decisions as flood conditions worsen.
- **Coordinated roles and responsibilities** for City departments and partner agencies to support efficient emergency response and decision making.
- **Public communication and protective actions**, including templates for emergency notifications, flood warnings, sandbag distribution, shelter operations, and evacuation support.
- **Post-flood recovery and damage assessment** activities to restore services, support affected residents and businesses, and document impacts for potential disaster assistance.
- **Specialized procedures for coastal, flash, riverine, and dam-related flooding**, including coordination with regional partners and Lake Barcroft Dam operators.

It is recommended that the City update the 2020 Flood Response Plan in coordination with the Office of Emergency Management and other departments and seek formal adoption by the City Council. The update should incorporate flood extent data developed as part of this FRP, reflect current flood risk management practices and operational procedures, and improve consistency with CRS requirements. Revisions would strengthen the City's preparedness, response, and recovery framework while improving coordination, documentation, and public communication before, during, and after flood events.

Updates should include the following:

- **Additional flood-level-specific response actions** for a range of flooding scenarios beyond coastal flooding.
- **Updated flood inundation mapping** for multiple storm and flood events and operational response decisions associated with defined flood extents and impact thresholds.
- **A current inventory of flood-vulnerable critical facilities** and procedures for emergency coordination and communication with these facilities.
- **Annual training, exercises, and equipment-testing procedures** to evaluate plan effectiveness and verify the operational readiness of systems such as flood warning lights.
- **Detailed communication protocols**, **including pre-scripted messages** that meet CRS requirements, to be maintained and regularly updated in multiple languages to effectively serve Alexandria's diverse community.

After the plan has been revised, a regularly scheduled periodic update should be implemented to verify that the plan reflects current conditions and changing priorities.

Expand Real-Time Monitoring

Real-time monitoring is a critical component of the City's flood preparedness framework. Through ALX Floodwatch (Photo 3-5), City staff continuously monitor rainfall, stream and tide levels, and National Weather Service forecasts to assess developing flood conditions. Predefined thresholds are used to trigger response actions, enabling the City to take timely and coordinated measures before, during, and after flood events. When conditions warrant, the City can deploy barricades, activate warning systems, distribute sandbags, conduct targeted inspections of vulnerable locations, coordinate with regional partners, and provide emergency notifications to residents through multiple communication platforms.



Photo 3-5: ALX Floodwatch reports real-time data from stream-level monitoring stations such as this one that are located throughout the city (Source: City of Alexandria).

The City will explore the advantages of expanding flood monitoring, including additional meter locations and flood monitoring technologies that could be implemented in additional areas of concern identified in this FRP.

Improve Flood Warning Systems

When the National Weather Service identifies the potential for a flood event, or when developing conditions are detected through the City's monitoring systems, Alexandria uses its eNews notification system through the Everbridge software platform to provide timely warnings and information to residents, businesses, and other stakeholders. The eNews system (www.alexandriava.gov/eNews) is an opt-in service that allows subscribers to register through the City's website and receive notifications on topics of interest, including flooding and emergency management. To support rapid communication during time-sensitive events, the City maintains pre-scripted notification templates that can be quickly customized and distributed.

Currently, flood notifications are issued manually based on the procedures established in the Flood Response Plan and the professional judgment of City staff. This approach allows messages to incorporate event-specific information and reflect real-time conditions. However, it also can introduce delays in message dissemination. To enhance warning capabilities, the City could evaluate the feasibility of implementing automated alert systems that are triggered by rainfall, stream gauge, or water level thresholds when accelerated notification is warranted. Reverse 911 and similar technologies to deliver flood warnings to landlines and registered mobile devices also could be explored, expanding outreach to community members who have not subscribed to the eNews system.

In addition, there are opportunities for the City to evaluate the development of predictive flood forecasting tools that use weather forecasts and real-time monitoring data to estimate future flood conditions and support earlier decision making. Alexandria has access to gauge-adjusted rainfall data through OneRain and real-time monitoring data through ALX Floodwatch, which provide a strong foundation for developing forecasting capabilities that can further enhance the City's flood warning and emergency response systems (https://alxfloodwatch.onerain.com/).

Conduct Pre-Event Inspections

Alexandria's flood preparedness strategy extends beyond emergency response and includes proactive inspection of the stormwater infrastructure system (Photo 3-6). A well-functioning storm sewer network is essential for reducing flood risk and supporting effective drainage system performance during storm events, as discussed in more detail in Section 3.6.

Beyond routine maintenance, the City has identified and mapped locations or "hot spots" with a history of recurring flooding where debris accumulation has contributed to reduced drainage capacity. A pre-event standard operating procedure has been developed that requires inspection of these known flood-prone locations when significant rainfall is forecast. When necessary, maintenance crews are deployed to remove debris and address drainage obstructions before flooding occurs, helping to maximize system performance and reduce the potential for localized flooding. A map and list of the identified "hot spots" is provided in Appendix A.

Routine system maintenance and asset management is discussed in Section 3.6.



Photo 3-6: City engineers conduct annual stream and drainage infrastructure inspections to identify potential problem areas and prevent debris buildup from creating backups that can cause flooding (Source: City of Alexandria).

Improving Response to Flood Concerns

In Alexandria, Alex311 (Photo 3-7) is a centralized customer service and service-request system that serves as the primary way for residents, businesses, and visitors to report issues, ask questions, and request City services. It is an important tool for flood management. Alex311 provides expedited reporting of problems, allows the City to track responses and response times, and provides data to help identify recurring flooding problems. It is recommended that Flood Action Alexandria program managers work with the Alex311 administrators to implement enhancements to the Alex311 system and, where feasible, include the following:

- Improved flood-related categories to better distinguish different types of flooding
- Expanded knowledge base used by customer-service staff and additional staff training to provide citizens with more timely, accurate, and useful guidance
- Improved database functionality and reporting capabilities to provide greater granularity of complaint classifications
- Improved documentation of resolutions
- Additional outreach to improve community awareness of the system

Strengthen Regional and Technical Partnerships

Flood resilience extends beyond Alexandria's boundaries and requires close coordination with regional partners. City staff actively participate in regional committees, working groups, and interagency coordination efforts that provide opportunities to align policies, share technical expertise, and collaborate on projects and initiatives benefitting multiple jurisdictions, including the Northern Virgina (NOVA) Flood Mitigation and Resiliency Workgroup and watershed-scale flood mitigation planning and stream restoration initiatives such as the Four Mile Run Restoration Project (Northern Virginia Regional Commission 2026). These partnerships help assess flood risks comprehensively across shared watersheds and identify and advance opportunities for regional solutions.

The relationships established through these regional coordination efforts are critical during flood emergencies for supporting information sharing, resource coordination, and recovery activities



Photo 3-7: Alex311 is a centralized customer service and service-request system that is the primary way to report issues, ask questions, and request City services (Source: City of Alexandria).

across jurisdictional boundaries. In addition, the City maintains partnerships with the U.S. Geological Survey and other organizations to support rainfall, streamflow, and water level monitoring throughout the region. Alexandria should continue to strengthen these partnerships to improve flood forecasting, situational awareness, emergency response, and long-term resilience planning, while supporting decision making informed by the best available data and regional collaboration.

3.6 Asset Management

A well-maintained stormwater system is one of the most effective and cost-efficient forms of flood mitigation. The City actively manages approximately 185 miles of storm sewer pipe, more than 13,500 stormwater structures, more than 150 stormwater management facilities, and roughly 25 miles of streams and channels. Routine inspections, cleaning, repairs, street sweeping, stream maintenance, and responses to Alex311 service requests help maintain system performance and reduce flood risks before severe weather occurs.

Across Alexandria, thousands of stormwater assets work together to collect, convey, and manage runoff during storm events, including pipes, culverts, inlets, outfalls, channels, stormwater management facilities, and related infrastructure. Maintaining these assets in good working condition helps

maximize system performance, reduce localized flooding, support emergency response, and extend the useful life of public infrastructure.

Proactive Maintenance Supports Resilience

Alexandria's approach to resilience emphasizes prevention rather than reaction. The City regularly inspects and cleans storm sewer infrastructure on a recurring 3- to 5-year cycle and performs targeted maintenance in advance of forecasted storm events (Photo 3-8). Activities include inspecting and cleaning storm lines, clearing inlets and outfalls, maintaining channels and culverts, repairing damaged infrastructure, and addressing service requests submitted through Alex311. These efforts reduce the likelihood of blockages, improve system capacity, and help prevent avoidable flooding during heavy rainfall.



Photo 3-8: Alexandria maintenance crews use vacuum trucks to clean debris-filled stormwater drainage structures to prevent flooding (Source: City of Alexandria).

Flood resilience depends on the effective management of both public and private stormwater infrastructure. In addition to maintaining and operating the city's stormwater system, Alexandria conducts inspections of privately owned stormwater BMPs in accordance with Municipal Separate Storm Sewer System (MS4) permit requirements. Property owners are responsible for maintaining private stormwater facilities and addressing identified deficiencies, while the City provides oversight and technical guidance as needed.

Building a More Comprehensive Asset Management Program

The City currently tracks infrastructure maintenance, inspections, and repair activities through Cityworks, an asset management software platform that allows staff to inventory infrastructure assets, schedule and document maintenance activities, manage work orders, and track system performance over time. This platform helps efficiently maintain public infrastructure and prioritize operational and capital improvement needs. Continued use of this platform provides valuable information about asset condition, maintenance history, operational needs, and long-term replacement planning. As Alexandria continues to advance its Flood Action Alexandria Program, opportunities exist to further strengthen asset management by integrating additional information related to flood risk, maintenance priorities, property and access information, and infrastructure performance.

One opportunity is the development of a centralized repository of easements and other property interests associated with stormwater infrastructure. Better documentation of access rights can streamline maintenance activities and support future project implementation. This effort would establish a standardized location for maintaining easement data, with records to be populated over time. Eventually, Alexandria may further expand its asset management framework to integrate physical assets, property rights, maintenance needs, risk assessments, and capital planning into a comprehensive decision-support system.

Many of Alexandria's maintenance and operational practices are already well established. However, documenting these activities more consistently can improve efficiency and support staff transitions, which can benefit resilience planning. For example, as formalized inspection procedures are developed and updated, they should be documented in alignment with resiliency initiatives and follow CRS documentation (Element 540) requirements where applicable.

3.7 Communication & Outreach

Having an informed community is one of Alexandria's best tools for building flood resilience. According to the 2025 Online Flooding Survey, nearly two-thirds of residents worry about how flooding will impact their future, and 40% want more information or resources. While City projects, emergency plans, and maintenance programs help lower flood risk, residents, businesses, property owners, and community groups also play a key role. Everyone needs to help prepare for, respond to, and recover from flood events. Effective communication and outreach make this possible by helping people understand their flood risk and how to protect their property before and during a storm.

The following sections discuss Alexandria's current communication and outreach efforts and ways in which they could be strengthened.

Empowering Residents Through Flood Risk Awareness

Alexandria has already created many ways to share flood information with the public. These include the Flood Action Alexandria eNewsletter and webpage, community meetings, educational and public outreach events, social media, emergency alerts, and targeted mailers. These efforts support the City's broader resilience goals by increasing public awareness of existing and future flood risks, fostering trust through transparent communication, and helping residents become active participants in reducing flood impacts throughout the community (Photo 3-9). The City should evaluate ways to improve these efforts by expanding access to flood information, using various communication methods, and sharing clear steps residents can take to improve their own safety and lower flood risk.



Photo 3-9: Working to educate local students builds understanding of flood risk in the next generation that is passed on to whole families (Source: City of Alexandria).

Using Flood Action Alexandria as the Community Information Hub

The Flood Action Alexandria website serves as the City's main resource for flood information. Residents can use the site to find project updates, planning documents, educational materials, flood maps, and details about City programs and services. Alexandria will continue updating and improving the website as the central hub for flood-related information and community involvement.

The Flood Action Alexandria eNewsletter will continue to provide regular updates about maintenance activities, upcoming meetings, and grant opportunities. It helps residents learn about what they can do to reduce their own vulnerability.

Expanding Access to Flood Risk Information

The public needs clear and accessible tools and information to truly understand their local flood risks. Through the City's floodplain management program, residents and businesses located in FEMA floodplains have access to flood maps and other resources provided on the City's Flood Action Alexandria website. In addition, the City's Floodplain Administrator provides free FIRM checks for residents, which indicate whether a property is located within an SFHA. The City also sends yearly mailers to residents in the floodplain to provide useful details on local flood hazards, flood insurance, flood warnings, floodproofing techniques, permit requirements, and the value of preserving floodplains and open spaces. These mailers are an important component of the floodplain management program and CRS participation, but benefits are limited to properties within SFHAs.

As discussed in Section 3.2, the City is considering expanding access to flood hazard information by providing access to flood maps that capture localized interior flooding risks outside of the SFHAs. To this end, the City is evaluating a potential future initiative to expand access to flood risk information through the development of an online flood mapping tool, similar to DCR's Coastal Resilience Web Explorer (Figure 3-10). This tool would help residents find citywide flood hazard information, maps, and other data from this FRP. Making flood information easier to use and understand would support informed decision making by residents, businesses, developers, and emergency responders. Future enhancements may show flood warnings and real-time conditions to help people understand what is happening before and during storms.

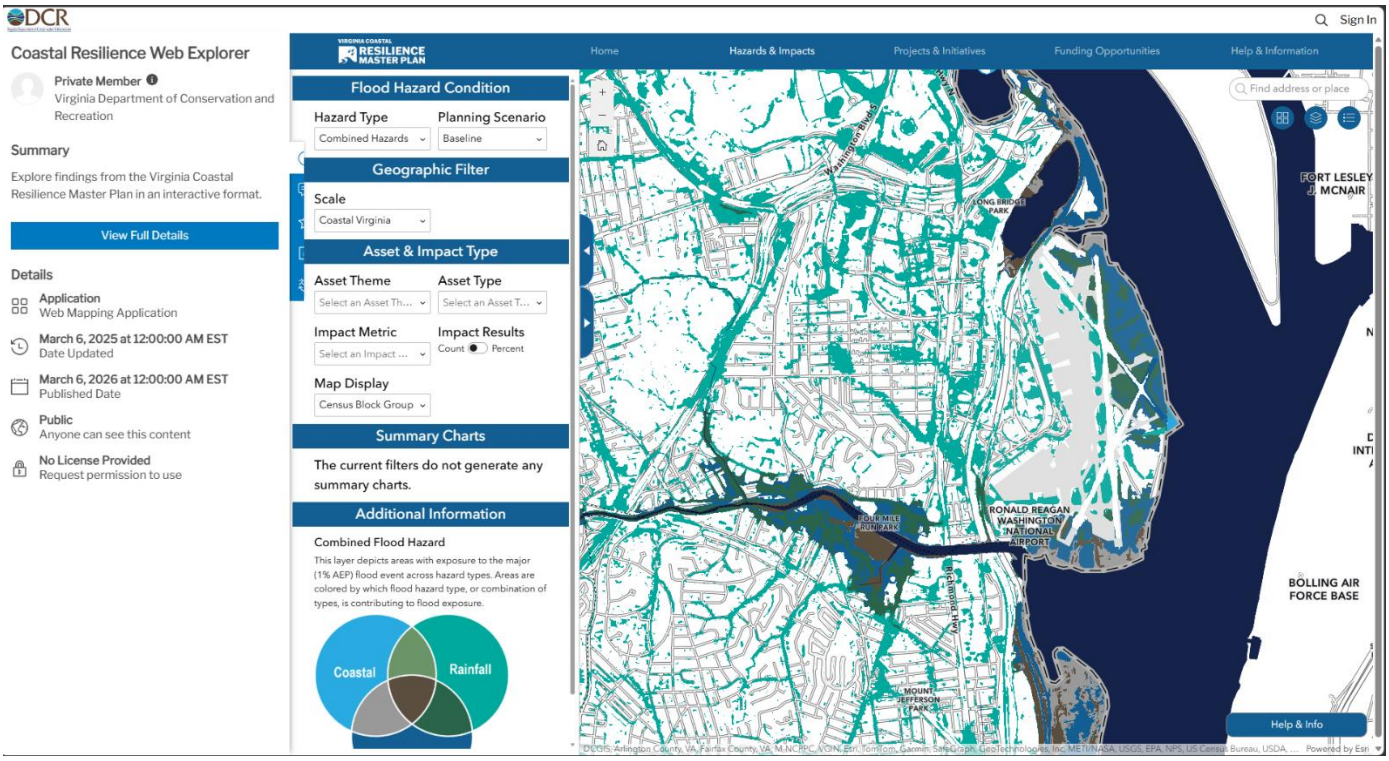


Figure 3-10: Example of an Online Flood Mapping Tool from Virginia DCR

(Source: https://floodplan-vdcr.hub.arcgis.com/apps/6b57939c937745998466751743ed7285/explore)

Reaching Residents Through Multiple Communication Channels

As flood risks evolve, the following recommended strategies will continuously improve and refine how the City communicates critical flood information:

- Emphasize plain language, graphics, and clear action steps to help residents understand what flood risks mean for them.
- Expand the reach of educational materials that focus on practical actions residents and businesses can take such as purchasing flood insurance, raising critical utilities, installing backflow prevention devices, protecting valuables, preparing emergency kits, and signing up for flood alerts.
- Document flood events through photographs, stories, and firsthand experiences to show how flooding affects Alexandria neighborhoods.
- Connect residents to trusted flood resources from organizations such as FEMA, the National Weather Service, the Association of State Floodplain Managers, and other organizations.
- Focus on outreach to neighborhoods with a higher flood risk. Postcard mailers, QR-code-based resources, localized messaging, and neighborhood-specific outreach materials can help connect residents with information relevant to the risks they may face.
- Expand efforts to teach property owners and homeowner organizations about maintenance of privately owned stormwater systems.

Have you heard about Alex311?

The 2025 Online Flooding Survey showed that 60% of respondents were aware that they can use Alex311 to report flooding or impacts from flooding. More than half of those responding had used the resource before.

Partnering with Community Organizations

Trusted community organizations play an important role in helping residents receive and understand important information. Alexandria will continue partnering with neighborhood associations, environmental organizations, civic groups, community-based organizations, local festivals, neighborhood farmers markets (Photo 3-10), and other local partners to help communicate flood risks and resilience strategies. These partnerships help expand the reach of flood information to a broad audience through established and trusted community networks.



Photo 3-10: The City will continue public education by participating in community events throughout the year, including festivals, farmers markets, and other community gatherings (Source: City of Alexandria).

The City will continue participating in public education events throughout the year, including Virginia Flood Awareness Week, Hurricane Awareness Month, National Preparedness Month, Building Safety Month, and Earth Month. These events provide opportunities to share information, answer questions, gather feedback, and encourage residents to take actions that reduce flood risk.

3.8 Socio-Economic Inclusion

Flood risk does not affect everyone in the same way. Some residents may have a harder time preparing for, responding to, and recovering from flooding because of income, age, language proficiency, housing conditions, access to transportation, and other socio-economic conditions. Alexandria recognizes these differences when planning for flood resilience. This helps prioritize flood mitigation investments and programs that support the people who may be most affected.

Supporting Equitable Flood Resilience

The City uses equity-focused decision-making tools such as the City Equity Map and Racial Equity Toolkit (Figure 3-11) to help evaluate potential benefits and impacts of City projects. Recognizing that flood risk is influenced by both physical exposure and social conditions, the FRP vulnerability assessment evaluated social and economic factors and demographic factors alongside flood hazards and infrastructure risks. This information can help prioritize projects and identify areas where flooding may have the greatest impact for residents with fewer resources to prepare for, respond to, or recover from flood events.

The City can use the results of the vulnerability assessment to guide future flood mitigation investments. Social and economic vulnerability will remain an important factor in project prioritization. This approach helps direct resources toward areas where flood reduction efforts can produce the greatest overall community benefit while supporting broader City goals related to equity and resilience.

Many grant programs provide additional funding or increased priority to projects that support socially vulnerable communities. The Virginia CFPF is one example. It prioritizes resilience projects in vulnerable and underserved communities. Many of the City's grant-funded projects have focused on areas with higher social vulnerability. By aligning funding requests with documented community needs, Alexandria can help support future resilience investments that address both risk reduction and equitable community outcomes.

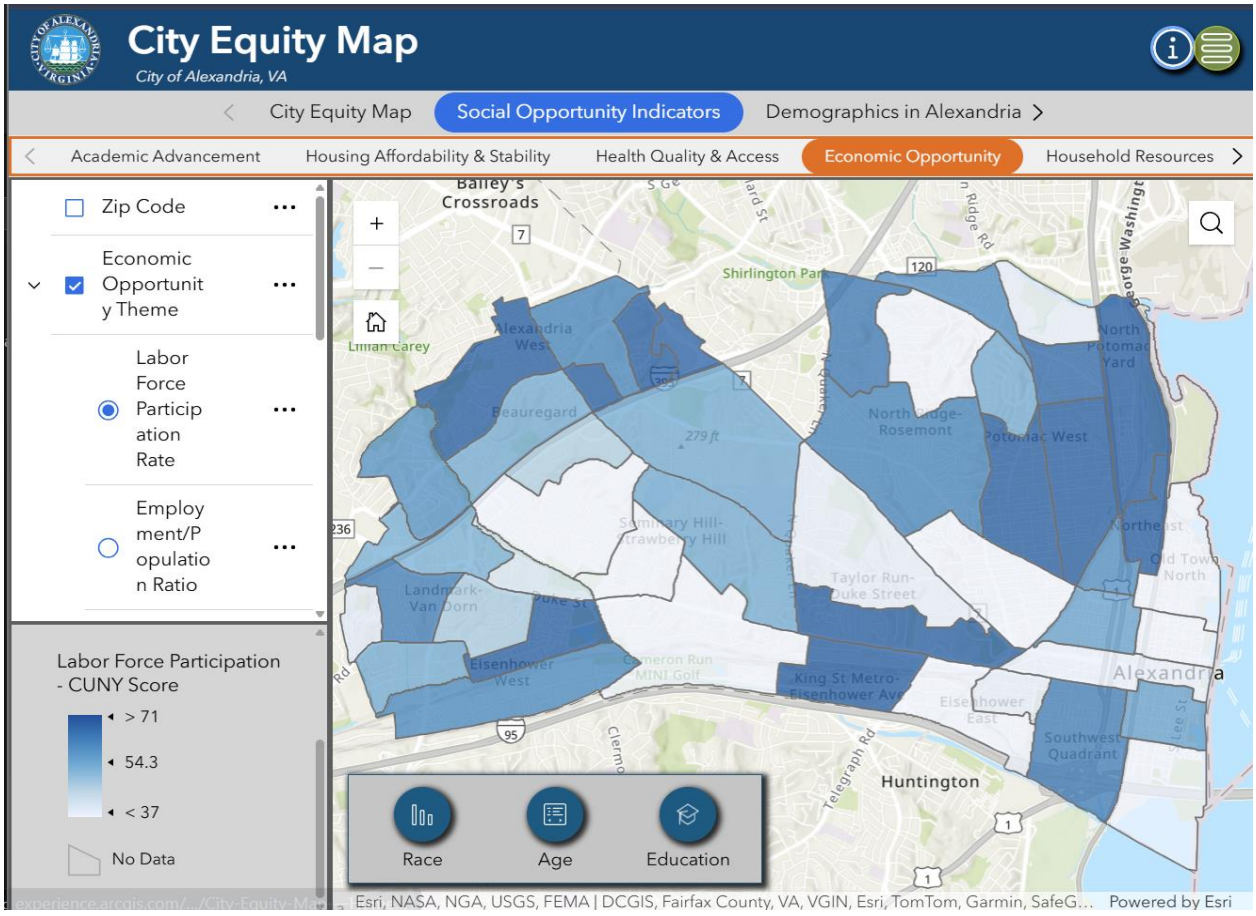


Figure 3-11: City of Alexandria Equity Map and Racial Equity Toolkit

Supporting Community-Led Outreach

Meaningful community engagement is important because all residents should have a voice in shaping flood resilience decisions. Alexandria has already demonstrated this commitment through Flood Action Alexandria, the FRP planning process, community meetings, and outreach activities conducted across the city. It will build on these efforts and continue expanding engagement strategies to better reach people who may not usually participate in the planning process.

Community-based organizations (CBOs) can be particularly critical when working with historically marginalized populations, where trust for government agencies has eroded. City staff should work closely with CBOs, neighborhood groups, faith-based organizations, and other trusted local partners to share information and gather input. This can help reach residents who may otherwise be hesitant to become involved, including people who speak languages other than English. When possible, the City should look for opportunities to train CBOs for their participation as a means of further supporting the community. Through these community leaders, there could be opportunities for community-led engagement initiatives, environmental equity discussions, and resilience workshops that help residents better understand local flood challenges and identify neighborhood priorities. Other platforms of communication may be considered, including radio stations, local/minority-focused media, retirement centers, and gathering places for those without internet access.

These efforts can help make sure flood resilience strategies reflect real community experiences, local knowledge, and resident concerns. Engaging people who face extra challenges in discussions and decision making can help prevent unintended burdens from flood mitigation policies and programs.

3.9 Funding Strategies

Reducing flood risk requires sustained investment in planning, infrastructure improvements, operations and maintenance, emergency preparedness, and community resilience programs. As flood risks continue to evolve and the costs of mitigation increase, securing reliable funding is essential for implementing and maintaining effective flood resilience initiatives. The City must leverage a combination of local, regional, state, and federal funding sources to advance priority projects, support ongoing program activities, and promote long-term progress toward reducing flood impacts on residents, businesses, and public assets.

SWU Fee

The SWU fee serves as the City's primary dedicated funding source for stormwater management and flood resilience activities. Revenue generated through the fee supports a wide range of programs and services, including flood management initiatives, capital improvement projects, stormwater infrastructure maintenance, MS4 permit compliance, stream and channel maintenance, stormwater quality improvements, program administration, and flood mitigation assistance programs. By providing a stable and predictable funding source, the SWU fee enables the City to address both immediate operational needs and long-term resilience investments.

The City will continue collecting the SWU fee to support implementation of priority flood resilience actions while periodically evaluating future funding needs as projects advance and risks evolve. This FRP will help inform future capital improvement programming and provide a basis for assessing long-term funding requirements.

Grants and External Funding

Alexandria has successfully secured funding from a variety of state and federal programs to support flood mitigation, planning, and resilience projects. These investments have accelerated implementation of critical projects while reducing reliance on local funding sources. The City will continue actively pursuing grant opportunities through programs such as the Virginia CFPF, FEMA resilience and hazard mitigation programs, federal Housing and Urban Development grants, and other state and federal funding initiatives that support flood resilience, stormwater management, and climate adaptation.

In addition to grants, the City will continue evaluating loans, cost-share opportunities, and emerging funding programs that can help advance priority projects identified through this FRP. Diversifying funding sources will improve financial flexibility and help position Alexandria to respond to future resilience needs.

Funding Through Partnerships

Many flood resilience benefits extend beyond City-owned infrastructure and can provide value to regional transportation networks, public assets, and partner agencies. Alexandria will continue exploring opportunities to collaborate with external

organizations on projects that achieve shared objectives and leverage additional funding.

Potential partnerships may include coordination with the following:

- Virginia Department of Transportation (VDOT) on projects that reduce flood risks to state-maintained highways, bridges, and transportation corridors
- National Park Service on resilience projects that protect portions of the George Washington Memorial Parkway and other federally managed assets vulnerable to coastal flooding
- Arlington County and the US Army Corps of Engineers for projects along the Four Mile Run Flood Control Project corridor
- Fairfax County for projects along Cameron Run
- AlexRenew for projects involving the combined sewer system

Through continued investment, strategic partnerships, and a diversified funding approach, Alexandria can advance the implementation of its flood resilience program and sustain progress toward reducing flood risk throughout the community. Leveraging local, state, federal, and regional funding sources will help deliver critical projects and programs, maintain essential infrastructure, strengthen emergency preparedness, and enhance long-term resilience. These investments will support the continued protection of residents, businesses, public infrastructure, and community assets from the impacts of flooding for years to come.

Section 4
The Path Forward



4 THE PATH FORWARD

This section serves as the implementation framework for this FRP, translating the strategies and recommendations identified through the FRP planning process into a coordinated program of actions to advance Alexandria's long-term flood resilience objectives.

4.1 IMPLEMENTATION FRAMEWORK AND ACTION PLAN

While Section 3 describes what Alexandria can do to advance flood resilience, Section 4 focuses on a framework to organize these recommendations into a manageable and achievable action plan, identifying implementation priorities and providing a schedule for advancing initiatives over time. This framework is intended to guide decision making, support capital improvement planning, inform budget development, and position the City to pursue funding opportunities while continuing to make measurable progress toward its long-term resilience goals.

The implementation schedule presented in this section is designed to be both ambitious and realistic. Recommendations have been organized into short-term, mid-term, and longer-term implementation horizons that reflect current priorities, funding realities, staffing considerations, and the need for continued technical evaluation in some areas. This phased approach allows the City to build on ongoing initiatives, capitalize on near-term opportunities, and strategically advance more-complex projects and programs as resources become available.

At the same time, flood resilience planning must remain adaptive. Flood risks will continue to evolve as environmental conditions change, additional information becomes available, infrastructure ages, and community priorities shift. Funding availability, regulatory requirements, and partnership opportunities also may influence the timing and sequencing of implementation. For these reasons, the action plan should be viewed as a living framework rather than a fixed roadmap. The strategies and implementation schedule outlined in this section provide a direction for advancing flood resilience while maintaining the flexibility needed to respond to changing conditions, emerging opportunities, and future priorities. By combining a structured implementation approach with adaptive management, Alexandria can make steady, measurable progress toward a more flood-resilient future.

Implementation Horizons

Table 4-1 presents the Flood Resilience Strategy and Action Implementation Plan.

To help guide implementation and support long-term decision-making, the recommended actions have been organized into planning horizons reflecting the relative priority, complexity, and readiness of each initiative (Figure 4-1). The implementation horizons recognize some actions can be advanced immediately through existing programs and resources, while others require additional planning, funding, coordination, or project development before implementation. Together, these phased timeframes provide a practical and achievable approach to advancing flood resilience. The planning horizons are described as follows:

- **Short-Term Actions (0 to 5 Years):** Focus on advancing priority initiatives already underway or able to be implemented using existing programs, policies, and resources. Key actions include updating ordinances and guidance documents, implementing projects currently identified in the CIP, enhancing flood preparedness and response procedures, strengthening interdepartmental coordination, improving asset management processes, and expanding outreach and engagement efforts to the public and to the land development community. These actions provide near-term flood resilience benefits and establish the foundation for long-term action implementation.

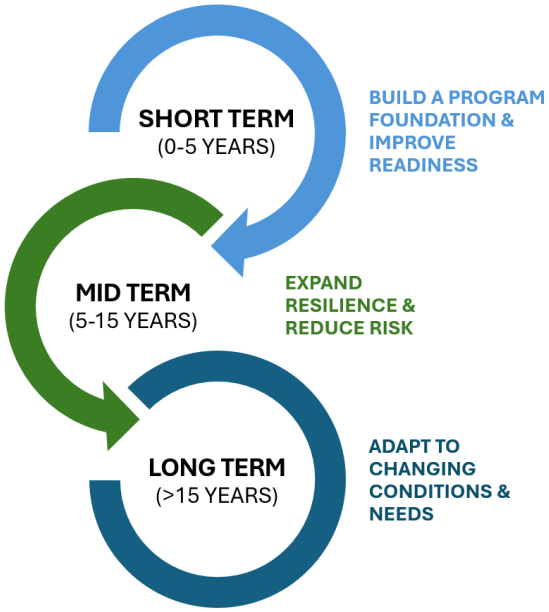


Figure 4-1: Defined Implementation Horizons

- **Mid-Term Actions (5 to 15 Years):** Build on the initial foundation by implementing additional flood mitigation projects prioritized through the FRP, expanding flood monitoring and warning capabilities, increasing the integration of resilience considerations into City programs and capital projects, and advancing improvements to asset management, communications, and community resilience initiatives. These actions are intended to achieve measurable flood risk reduction results while leveraging lessons learned from early implementation efforts.
- **Long-Term Considerations (Beyond 15 Years):** Continue advancing Alexandria's flood resilience goals through the implementation of future mitigation projects, the development of solutions in areas where additional validation and planning are needed, and the adaptation of programs, policies, and investments to address evolving flood risks. Long-term considerations recognize flood resilience is an ongoing process requiring periodic reassessment, continued investment, and flexibility to respond to changing environmental conditions, community priorities, and available funding opportunities.

Table 4-1: Flood Resilience Strategy and Action Implementation Plan

Category	Flood Resilience Strategy Recommendation	Benefits	Implementation Cost to City	Short Term (0-5 years)	Mid Term (5-15 years)	Future Consideration (beyond 15 years)
Policies and Ordinances	Amend Section 6-300 of the City's Zoning Ordinance to increase the minimum freeboard requirement for new construction and for substantial improvements to residential and nonresidential buildings located within SFHAs.	▪ Reduced flood risk to compliant properties.	$	✓		
	Create a special Floodplain Use Permit for development projects subject to the floodplain ordinance within SFHAs.	▪ Improve the floodplain permitting process for projects subject to the floodplain ordinance ▪ Improve coordination among City departments.	$	✓		
	Amend Section 13-109 of the City's Zoning Ordinance to increase stormwater quantity requirements by requiring post-development peak discharge rates for the 10-year, 24-hour storm event to be reduced below pre-development rates through application of a reduction factor.	▪ Reduced flood risk to downstream properties. ▪ Reduced future mitigation needs and incrementally improved watershed conditions over time.	$	✓		
	Develop maps for interior flood-prone areas outside of SFHAs.	▪ Improved understanding of citywide flood risks.	$	✓		
	Develop voluntary resilience guidance for design and construction in flood hazard areas.	▪ Reduced flood risk to compliant properties.	$	✓		
	Establish a comprehensive and updated stormwater and drainage design guidance framework that supports implementation of enhanced flood resilience standards.	▪ Improved understanding of and compliance with City requirements.	$		✓	
Flood Mitigation	Implement large capacity and spot improvement flood mitigation projects identified in the FY27 CIP, including ongoing Waterfront Flood Mitigation Project for coastal flood mitigation.	▪ Interior, riverine, and coastal flood mitigation throughout the city.	$$$$	✓		
	Implement additional interior flood mitigation projects identified during CASSCA and confirmed during the FRP to be in at-risk areas.[a]	▪ Interior, riverine, and coastal flood mitigation throughout the city.	$$$$	✓		
	Validate flood risk and develop flood mitigation projects for areas identified during the FRP as at-risk without defined projects.	▪ Interior and riverine flood mitigation throughout the city.	$$$		✓	
	Implement additional flood mitigation projects to address interior, riverine, and coastal flooding outside of the projects already defined by previous studies.	▪ Interior, riverine, and coastal flood mitigation throughout the city.	$$$$			✓
	Expand the Flood Mitigation Grant Program and other incentive programs	▪ Reduced flood risk on private properties.	$$$	✓		
Integrating Flood Resilience Across City Programs and Beyond	Set up a specific coordination meeting with the Transportation and Mobility Planning Division staff to identify opportunities to combine flood mitigation and drainage upgrades with transportation improvements.	▪ Identify additional mitigation opportunities. ▪ Avoid missed mitigation opportunities. ▪ Cost savings with reduced mobilizations.	$	✓		
	Enhance coordination with external utilities and consider whether additional franchise agreements may be feasible.[a]	▪ Expedited implementation schedules.	$	✓		
	Develop a standard means of documenting and maintaining the key flood mitigation data needed for CRS validation and coordinate this with other departments as appropriate.	▪ Simplify CRS reporting. ▪ Maximize CRS credit.	$	✓		

Category	Flood Resilience Strategy Recommendation	Benefits	Implementation Cost to City	Short Term (0-5 years)	Mid Term (5-15 years)	Future Consideration (beyond 15 years)
Flood Preparedness and Response	Implement the flood mitigation project design guidelines the City is developing to update design criteria for Flood Action Alexandria mitigation projects.	▪ Increased flood resilience. ▪ Standard process reduces need for repeat design decisions.	$$	✓		
	Update the 2020 Flood Response Plan to incorporate what has been learned during development of this Flood Resilience Plan. The plan must be adopted by City Council to meet CRS requirements.	▪ Increased flood resilience. ▪ Standardize communications with critical facilities. ▪ Increased CRS credit.	$	✓		
	Explore the advantages of expanding flood monitoring, including additional meter locations and flood monitoring technologies that could be implemented in additional areas of concern identified in the FRP.	▪ Additional data on which to base flood response.	$$		✓	
	Consider automated alert systems triggered by flow meters or rain gauges.	▪ More efficient communication of risks. ▪ Reduced staff requirements during an emergency.	$$			✓
	Consider the development of predictive flood forecasting tools that function on weather forecasts to drive the flood response and warning system.	▪ Advanced notice of flood risk.	$$			✓
	Coordinate with the Alex311 administrators to implement enhancements to the Alex311 knowledge base and database system, where feasible.	▪ Improved responsiveness and accuracy of feedback.	$	✓		
Asset Management	Establish a standardized repository for maintaining easement data with records to be populated over time.	▪ Improved project cost estimates & feasibility assessments. ▪ Advanced owner communications.	$	✓		
	Further strengthen asset management by integrating additional information related to flood risk, maintenance priorities, property rights, and infrastructure performance into asset management software.	▪ Single location of relevant data.	$$		✓	
	Update inspection documentation and align the documentation to the requirements laid out in CRS Element 540, as the stormwater asset management program is updated.	▪ Simplify CRS reporting. ▪ Maximize CRS credit.	$		✓	
Communication & Outreach	Develop an interactive online Flood Mapper Tool that provides residents, businesses, developers, and emergency responders easy and timely access to flood risk information.	▪ Increased public understanding, awareness, and knowledge of flood risk and potential actions to be taken.	$$	✓		
	Move beyond standard public notifications to a multifaceted approach that personalizes flood risk, uses diverse communications channels, and fosters inclusive community engagement.	▪ Increased public understanding, awareness, and feeling of stronger community connections to City programs and resources.	$	✓		
Socio-Economic Inclusion	Work closely with community-based organizations, neighborhood groups, faith-based organizations, and other trusted local partners to distribute information and gather input from residents who may otherwise be hesitant to become involved.	▪ Increased public understanding, awareness, and feeling of stronger community connections to City programs and resources.	$	✓		

$ = Strategy largely undertaken by City staff with costs estimated in the tens of thousands (<$100,000).

$$ = Strategy involving a study or other efforts that require externally contracted support with costs estimated in the hundreds of thousands ($100,000 to $1,000,000).

$$$ = Strategy involving technical studies that require externally contracted support or other multi-year programs with costs estimated to be over a million dollars ($1M-10M).

$$$$ = Strategy involving capital improvement projects that require multi-year investment with costs estimated to be over ten million dollars (> $10M).

Notes:

[a] Recommended strategy is part of an ongoing program that will extend beyond the short-term planning horizon into mid- and long-term implementation horizons.

4.2 Summary of Implementation Projects and Initiatives

Priority implementation projects corresponding to the problem areas described in Section 3 are listed in Table 4-2. These projects are anticipated to be integrated into future CIPs and implemented after Fiscal Year 2031 (FY31). The table includes prioritization, capital costs, and notes on key considerations that should be evaluated during project scoping. A prioritization score was computed based on the project area vulnerability score and observations of flooding that provide validation of the problem. Several projects were identified as priorities based on the prioritization scores but require additional analysis to further define project scopes, costs, and implementation needs. As a result, project rankings may be refined as additional information becomes available. The projects that require additional analysis are also included in the prioritized planning projects list.

A complete inventory of problem area projects is provided in Appendix B. The top-ranked projects were individually evaluated to confirm that there was sufficient evidence that the project should be included in the next round of CIP updates. In some cases, projects were not prioritized because the location of flooding was not a priority or there was no specific staff knowledge of issues in the area.

Prioritized Planning Projects

Table 4-3 presents the recommended planning projects prioritized for implementation. For each project, the table identifies the subwatershed, vulnerability score and rank, a brief project description, and planning-level cost estimates by phase, where applicable. Outreach costs are excluded because these activities will be conducted by the City.

4.3 Continued Commitment

The Alexandria FRP establishes an ambitious framework for reducing flood risk and preparing the community for future conditions. The City is committed to developing a world-class, holistic flood mitigation program that will support its thriving community. Achieving this vision will require ongoing collaboration among the City, residents, businesses, regional partners, and other stakeholders. Flood resilience is a shared responsibility. The success of this plan depends on continued engagement and participation from the entire Alexandria community.

This plan identifies a range of initiatives and recommendations to strengthen existing programs and address current and future flood risks. Each action presents its own benefits, costs, implementation challenges, and opportunities. Recognizing that resources are finite, the City is committed to moving forward strategically by prioritizing actions in areas facing the greatest vulnerabilities and highest flood-related challenges. Some recommendations can be advanced in the near term, while others will take time to develop and identify an effective solution.

Flood resilience planning is inherently adaptive. As flood risks evolve, new information becomes available, and community needs change, the City will continue to review and refine its approach. Through regular evaluation of progress, monitoring of changing conditions, and incorporation of emerging best practices and solutions, Alexandria will ensure that its flood resilience program continues to look forward. This commitment to continuous improvement will help create a safer, more resilient, and more sustainable future for generations to come.

Table 4-2: Problem Areas Prioritized for Next CIP Projects

Subwatershed	Nearest/ Central Street Intersection	Problem Area ID	Prioritization Rank	Prioritization Score	2025 Project Capital Cost ($M)[a]	Notes
Hooffs Run 2	E Bellefonte Ave/E Monroe Ave & Commonwealth Ave	4_8_19	1	3.8	$42.09	Flood extent would be partially addressed by problem areas 2 and 19 that are already on CIP. This is still one of the larger known areas of flooding with known property damage. Benefits of conveyance improvements may be limited by capacity limitations in Hooffs Run Culvert; therefore, may require storage. Consider including full area in concept planning for problem areas 2 and 19 and then incorporate implementation cost in future CIPs.
Backlick Run	Cameron Station Blvd & Somervelle St	402	2	2.7	$3.81 – $11.80[b]	Flood extent is based on limited modeling and there are limited complaints in the area. Additionally, the storm sewers in this area are privately owned. Combination of FRP and CASSCA results suggest it is a problem area, but project definition is uncertain. Recommend holding on adding to CIP until further validation with a Backlick Run Planning Study.
Four Mile Run 2	E Raymond Ave	116	3	2.4	$21.46	May be sufficiently addressed by Hume Avenue Storm Drain Bypass Neighborhood Spot Improvement and downstream projects. Recommend updating Four Mile Run model with downstream improvements to confirm remaining need.
Holmes Run 1	Taney Ave & Polk Ave	303_304	5	2.3	$12.75	Include in next CIP. CASSCA and FRP results directly overlap, and public notifications further back up the issue. High SVI. Nearby connection to channel should minimize negative downstream impacts.
Holmes Run 1	N & S Jordan St	305	6	2.3	$16.12	Include in next CIP. CASSCA and FRP results directly overlap. No public reports of concerns, but high SVI may reduce reporting. Note S. Jordan St problem area downstream. Take extra care to confirm no impacts there.
Backlick Run	S Pickett St & S Van Dorn St	401	9	2.1	$6.85	Hold for planning study evaluation. Public reports do not align to flooding related to CASSCA project. Recommend further validation and a refined assessment to better define project.

Subwatershed	Nearest/ Central Street Intersection	Problem Area ID	Prioritization Rank	Prioritization Score	2025 Project Capital Cost ($M)[a]	Notes
Taylor Run 1	W Braddock Rd & N Quaker Lane	201_205	10	2.0	$8.45	Hold for planning study evaluation unless City staff know of past problems at intersection of Braddock and Quaker and want to prioritize. No public reports. Flooding is limited to roadway and not structures, but it is a major intersection.
Potomac River 1	N Fairfax St & Second St	703	12	1.6	$1.77 – $3.68[b]	Hold for a Potomac Watershed Planning Study evaluation. No public notifications of concerns and not fully evaluated in CASSCA.
Four Mile Run 2	Russell Rd & Monticello Blvd	110	14	1.5	$5.29	Include in next CIP. CASSCA and FRP results directly overlap, and public notifications further back up the issue, noting decades of issues and specifically flooding from road into garage and basements. High SVI. Downstream project 109 may reduce any negative downstream impacts.

SVI = social vulnerability index

Notes:

[a] Project capital costs are considered rough order of magnitude Class 5 cost estimates as defined by the Association for the Advancement of Cost Engineering (AACE) International with an accuracy range of -50% to +100%.

[b] Multiple technologies were identified during CASSCA project identification that provide a range of costs and flood reduction benefits for select priority problem areas.

Table 4-3: Prioritized List of Planning Projects

Subwatershed	Flood Vulnerability Score Rank	Flood Vulnerability Score	Recommended Planning Project Type & Description	Phase 1 Cost	Phase 2 Cost	2025 Total Cost[a]
Backlick Run	1	2.8	**Outreach & Model Refinement for Validation** Ph 1: Backlick Run Subwatershed Study and Community Outreach Ph 2: Detailed modeling to identify project locations and optimize solutions	$75,000	$375,000	$450,000
Four Mile Run 2	2	2.3	**Model Refinement/Small-Area Studies** Model refinement (as needed) to include implemented projects (CAG & Hume) and continue implementation of CIP projects	$187,000	--	$187,000
CSS-Pendleton Street 2	3	2.1	**Planning Study–Combined Sewer System** Ph 1: Detailed modeling to refine sanitary sewer model and to identify project locations and optimize solutions Ph 2: High-level concepts/project identification for CIP budgeting	$126,000	$101,000	$227,000
Potomac River 2	4	1.9	**Planning Study–Coastal Plan** Coastal Resilience Plan (areas outside of Waterfront Flood Mitigation Project); develop and implement flood mitigation projects (update interior model to identify/size projects)	$154,000	--	$154,000
Holmes Run 1	7	1.7	**Model Refinement/Small-Area Studies** Detailed modeling to identify project locations and optimize solutions outside of CASSCA projects	$455,000	--	$455,000
Four Mile Run 3	8	1.4	**Outreach & Model Refinement for Validation** Ph 1: Four Mile Run West Subwatershed Study and Community Outreach Ph 2: Detailed modeling; identify project locations, and optimize solutions	$44,000	$216,000	$260,000
Cameron Run 2	9	1.3	**Outreach & Model Refinement for Validation** Ph 1: Cameron Run Subwatershed Study and Community Outreach Ph 2: Detailed modeling; identify project locations, and optimize solutions	$51,000	$254,000	$305,000
Holmes Run 2	11	1.2	**Outreach & Model Refinement for Validation** Ph 1: Holmes Run Subwatershed Study and Community Outreach	$75,000	$375,000	$450,000

Subwatershed	Flood Vulnerability Score Rank	Flood Vulnerability Score	Recommended Planning Project Type & Description	Phase 1 Cost	Phase 2 Cost	2025 Total Cost[a]
			Ph 2: Detailed modeling; identify project locations, and optimize solutions			
Four Mile Run 7	11	1.2	**Model Refinement/Small-Area Studies** Small-area study for residential areas between Potomac Avenue and Richmond Highway and south of Swann Avenue; updated/detailed modeling	$158,000	--	$158,000
Four Mile Run 5	13	1.1	**Planning Study–Coastal Plan** Coastal Resilience Plan and coastal project identification along Four Mile Run and low-lying areas	$104,000	--	$104,000
Potomac River 1	13	1.1	**Planning Study–Coastal Plan** Coastal Resilience Plan; develop and implement flood mitigation projects; update interior model to identify/size projects	$175,000	--	$175,000
Taylor Run 1	15	1	**Outreach & Model Refinement for Validation** Ph 1: Taylor Run Subwatershed Study and Community Outreach Ph 2: Detailed modeling; identify project locations and optimize solutions	$48,000	$238,000	$286,000
CSS-Royal Street	15	1	**Planning Study–Coastal Plan** Coastal Resilience Plan but no new project planning	$21,000	--	$21,000
TOTALS				**$1,673,000**	**$1,559,000**	**$3,232,000**

CAG = Commonwealth, Ashby, and Glebe
Ph = phase

Notes:
[a] Planning project costs are considered rough order of magnitude estimates and are based on similar types of evaluations conducted by Jacobs for the City. Where applicable, costs were escalated to 2025.

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Appendicies



APPENDIX A: STANDARD OPERATING PROCEDURE FOR HOT SPOT INSPECTIONS

City of Alexandria
Department of Transportation and Environmental Services
2900-B Business Center Drive
Alexandria, VA 22314

Standard Operating Procedure (SOP) for Hot Spot Inspections

Public Works Services Branch - Operations & Maintenance Staff

1. General Overview

The purpose of this SOP is to provide guidelines for inspecting and maintaining the 25 identified stormwater hot spots within the City of Alexandria. Inspections ensure that the drainage systems function as designed and mitigate the risk of flooding, sedimentation, and debris accumulation, especially before and after major rain events.

2. Inspection Frequency

- **Routine Monthly Inspections:**
  Each hot spot location is inspected **at least once per month** to identify any accumulation of debris, sediment, or structural damage.
- **Pre-Rain Event Inspections:**
  Inspect all hot spots **prior to significant forecasted rain events** to ensure that drainage systems are clear and function properly.
- **Post-Rain Event Inspections:**
  Inspect all hot spots **immediately after significant rain events** to evaluate potential damage or blockage due to increased water flow, debris accumulation, or sedimentation.

3. Inspection Procedure

- **Step 1: Visual Assessment**
  Conduct a comprehensive visual inspection of each hot spot. Look for visible signs of blockages, sediment accumulation, floatable trash, structural damage, or other potential problems.
- **Step 2: Clear Obstructions**
  Remove any visible debris or floatable trash that could block drainage. This includes leaves, branches, litter, and other objects that may impair flow.
- **Step 3: Sediment Check**
  Inspect areas prone to sediment accumulation. If the sediment level exceeds the design capacity, plan for removal during the next maintenance cycle.

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- **Step 4: Inlet and Outlet Inspection**
  Check the inlets and outlets for any signs of clogging. Clear blockages and ensure proper water flow is maintained.

- **Step 5: Documentation**
  Record all findings, including: PWS create a Work Order (WO) in CityWorks.

    - Date and time of inspection
    - Condition of each hot spot (free-flowing, blocked, or requiring maintenance)
    - Any repairs or further actions required (e.g., sediment removal, structural repairs)
    - Post-inspection photos, if applicable

- **Step 6: Immediate Repairs**
  If urgent repairs are needed, document them and schedule the necessary work as soon as practicable to prevent system failure or flooding.

4. Hot Spot Locations:

Next page is the list of the 25 hot spot locations in the City of Alexandria:

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Spots No	Location	Structure ID	Structure Type
1	2500 N. Van Dorn @ Park Place Apartments	000002CD	catch Basin
2	North Hampton Pond (duck pond)	2001-00114-A 01	Wet Lond
3	Cameron Run (Behind Jerry's Sub Shop) Van Dorn & Pickett St.	Al - 13 -68	Bridge
4	Park behind Beverly Drive	000442/3IO	Culvert
5	600 S. Pickett & Tunnel	000215IO	Open channel
6	2647 Duke St. (Headwall next to Better Termite and Pest Control)	000017CP	Culvert
7	(801 E. Taylor run0) Janney's Lane and East Taylor Run Pkwy	000021CP	Culvert
8	418 Summers Drive	005809IN	Channel with pipe
9	Cameron Run Outfall at Wheeler Ave	000230CP	Culvert
10	507 Wilkes St. catch basin on the corner	000635SCIN	Culvert
11	205 Daingerfield	006013IN	catch basin
12	201 S Washington St	000108SCCB	catch basin
13	734 N. St Asaph St.	000165SCIN	catch basin
14	4416 RYNEX	Fair Fax No ID found	Culvert
15	S. Lee St and Wilkes St	003012SMH	catch basin
16	4651 Duke St behind Harris teeter	000771SMH	Catch basin with open channel
17	3528 Saylor Pl	001283IN	Flume with catch basin
18	4251 Eisenhower Ave. (Recycling Facility)	2002-0007 01	Sand Filter
19	Douglas Cemetery (1430 Wilins Ln.)	004988IN	catch basin at curb inlet
20	2932 King St. (1st Baptist Church)	000126CP	Culvert
21	6200 Holmes Run PKWY	ALP-01-13	Pedestrian Bridge
22	Frog Pond	001520IN	Pond overflow
23	Pedestrian Tunnel 2360 Mill Rd	ALP-20-51	Pedestrian tunnel
24	3729 Templeton Place	002896 IN	Catch basin with open channel
25	King St. & Union St	005310 IN	Catch basin with open channel

Stormwater Hot Spots



APPENDIX B: INVENTORY OF POTENTIAL CAPITAL PROJECTS

Appendix B: Inventory of Potential Capital Projects

Subwatershed	Nearest/Central Street Intersection	Problem Area ID	Prioritization Rank	Prioritization Score	2025 Project Capital Cost [a] ($M)	Flood Volume Reduction (%)	Most Cost Effective Solution (Storage/Conveyance/ Green Infrastructure)
Hooffs Run 2	E Bellefonte Ave & E Monroe Ave	4_8_19	1	3.8	$42.09	73%	Conveyance & High GI
Backlick Run	Cameron Station Blvd & Somervelle St	402	2	2.7	$3.81-$11.8	100%	Conveyance
Four Mile Run 2	E Raymond Ave	116	3	2.4	$21.46	31%	High GI
Hooffs Run 6	King St & Callahan Dr	5	4	2.4	$2.76	100%	Conveyance
Holmes Run 1	Taney Ave & Polk Ave	303_304	5	2.3	$12.75	100%	Conveyance
Holmes Run 1	N & S Jordan St	305	6	2.3	$16.12	68%	High GI
Holmes Run 1	Taney Ave & N Van Dorn St	307	8	2.2	$10.39	100%	Conveyance
Backlick Run	S Pickett St & S Van Dorn St	401	9	2.1	$6.85	100%	Conveyance
Taylor Run 1	W Braddock Rd & N Quaker Ln	201_205	10	2.0	$8.45	66%	Conveyance
Hooffs Run 6	Diagonal Rd	21	11	1.6	$0.96	98%	Conveyance
Potomac River 1	N Fairfax St & Second St	703	12	1.6	$1.77-$3.68		Undefined
Hooffs Run 5	E Timber Branch Pkwy	9	13	1.5	$0.62-$49.44	100%	Conveyance
Four Mile Run 2	Russell Rd & Monticello Blvd	110	14	1.5	$5.29	100%	Conveyance
Backlick Run	S Pickett St	404	15	1.3	$0.7-$3.46	99%	Low GI
Potomac River 2	King St & Union St	701_707	16	1.3	$8.82-$18.35		Undefined
Strawberry Run	Wheeler Ave	603	17	1.2	$1.33-$1.46	100%	Conveyance
Four Mile Run 2	Commonwealth Ave & Manning St	101b	18	1.2	$4.97		Conveyance
Hooffs Run 2	Russell Rd	16	19	1.2	$3.33	100%	Conveyance
Holmes Run 1	Taney AveE & N Pegram St	302	20	1.1	$12.82	100%	Conveyance
Taylor Run 2	Duke St & Moncure Dr	202_208	21	1.1	$2.51	89%	Conveyance
Strawberry Run	Seminary Rd	602	22	1.1	$2.81-$4.54	100%	Conveyance
Taylor Run 2	W Taylor Run Parkway	203	23	1.1	$0.85	100%	Conveyance
Potomac River 2	Union St & Cameron St	704	24	1.1	$2.94-$6.13		Undefined
Cameron Run 1	S Payne St & Old Cameron Run Trail	507	25	1.1	$2.66	82%	Storage
Cameron Run 4	Business Center Dr	508	26	1.0	$7.55	100%	Conveyance
Cameron Run 3	S Jenkin St	501	27	1.0	$0.71	64%	High GI
Taylor Run 2	Moncure Dr & Upland PL	204	28	1.0	$1.44	100%	Conveyance
Four Mile Run 2	Mount Vernon Ave & Raymond Ave	103	29	0.9	$3.56	93%	Conveyance
Four Mile Run 2	Russell Rd & W Glebe Rd	109	30	0.9	$2.95	100%	Storage
Hooffs Run 1	Dogwood Dr & Valley Dr	13	31	0.9	$3.89	98%	Conveyance
Backlick Run	Edsall Rd & S Reynolds St	403	32	0.9	$2.9-$4.45	100%	Conveyance
Four Mile Run 2	Commonwealth Ave & Forrest St	104_105	33	0.8	$5.61	85%	Conveyance
Four Mile Run 6	King St & N Dearing St	119	34	0.8	$3.43	89%	Storage
Holmes Run 2	Reading Ave & N Beauregard St	301	35	0.8	$4.29	100%	Conveyance
Cameron Run 3	Vermont Ave	502	36	0.8	$0.70	84%	Conveyance
Cameron Run 3	S Gordon St	503	37	0.7	$0.79-$1.14	100%	Storage
Four Mile Run 2	Ancell St & Commonwealth Ave	106	38	0.7	$1.42	100%	Conveyance
Taylor Run 1	Key Dr	207	39	0.7	$1.29	100%	Conveyance
Holmes Run 1	N Van Dorn St & Duke St	308	40	0.7	$5.39	100%	Conveyance
Cameron Run 2	Eisenhower Ave	504	41	0.6	$0.98-$3.74	100%	Conveyance
Four Mile Run 2	Monticello Blvd & George Mason Pl	111	42	0.6	$2.41	100%	Conveyance
Four Mile Run 3	N Beauregard St & Fillmore Ave	120	43	0.6	$1.06-$2.68	100%	Conveyance
Holmes Run 1	Duke St & S Van Down St	306	44	0.6	$2.55	99%	Conveyance
Hooffs Run 1	W Braddock Rd & Valley Dr	14	45	0.6	$0.53	90%	Conveyance
Four Mile Run 2	La Verne Ave & Montrose Ave	108	46	0.6	$0.68	100%	Conveyance
Four Mile Run 2	Hume Ave & Montrose Ave	115	47	0.6	$0.96	100%	Conveyance
Taylor Run 2	Janney's Ln & W Taylor Run Pkwy	209	48	0.5	$2.17	100%	Conveyance
Cameron Run 1	S Payne St	506	49	0.5	$1.65	63%	Conveyance
Strawberry Run	Wheeler Ave	601	50	0.5	$0.61-$1.45	100%	Storage
Four Mile Run 2	E Mount Ida Ave & Mount Vernon Ave	114	51	0.5	$2.93	100%	Conveyance
Four Mile Run 5	Gilden Dr & Chalfonte Dr	112	52	0.5	$1.95	100%	Conveyance
Taylor Run 2	Janney's Ln & E Taylor Run Pkwy	211	53	0.5	$0.49	100%	Conveyance
Hooffs Run 5	N Henry St	15	54	0.5	$1.99	97%	Conveyance
Taylor Run 1	N Quaker Ln & Seminary Rd	210	55	0.4	$0.34-$0.95	100%	Storage
Four Mile Run 1	Cameron Mills Rd & Pulman Pl	113	56	0.4	$0.89-$1.42	100%	Conveyance
Cameron Run 4	N Quaker Ln	505	57	0.4	$0.67-$0.79	100%	Conveyance
Taylor Run 1	N Quaker Ln & Seminary Rd	212	58	0.3	$0.31-$0.95	100%	Conveyance
Hooffs Run 6	Duke St & Reinekers Ln	12	59	0.3	$1.89	90%	Storage
Four Mile Run 3	Fillmore Ave & Seminary Rd	121	60	0.3	$1.72	89%	Storage
Hooffs Run 6	Cameron St	23	61	0.3	$0.77	80%	Conveyance
Hooffs Run 4	Russell Rd & W Braddock Rd	11	62	0.3	$3.03	100%	Conveyance
Hooffs Run 3	Oakland Trail & W Braddock Rd	7	63	0.3	$5.67	97%	Conveyance
Taylor Run 1	W Braddock Rd & N Radford St	206	64	0.3	$0.92	100%	Conveyance
Holmes Run 1	N Van Dorn St & Holmes Run Pkwy	309	65	0.2	$0.96	100%	Conveyance
Four Mile Run 3	King St	123	66	0.2	$0.84-$1.56	100%	Conveyance
Potomac River 2	N Union St	705	67	0.2	$3.33-$6.93		Undefined
Backlick Run	Lincolnia Rd	405	68	0.2	$1.13-$1.72	100%	Conveyance
Potomac River 2	Duke St & S Union St	702	69	0.2	$5.98-$12.45		Undefined
Hooffs Run 5	Mount Vernon Ave	18	70	0.2	$1.27-$2.86	66%	Storage
Potomac River 2	N Union St	706	71	0.1	$3.06-$6.37		Undefined
Hooffs Run 6	King St	20	72	0.1	$0.64	100%	Conveyance

Subwatershed	Nearest/Central Street Intersection	Problem Area ID	Prioritization Rank	Prioritization Score	2025 Project Capital Cost [a] ($M)	Flood Volume Reduction (%)	Most Cost Effective Solution (Storage/Conveyance/ Green Infrastructure)
Four Mile Run 6	N Howard St & Seminary Rd	122	73	0.1	$2.24	100%	Conveyance

[a] Project capital costs are considered rough order of magnitude Class 5 cost estimates as defined by the Association for the Advancement of Cost Engineering (AACE) International with an accuracy range of -50% to +100%. A range of costs indicates multiple technologies were identified during CASSCA project identification for select priority problem areas. Projects in Potomac Watershed were not defined and cost is based on applying a cost/acre problem area using 75th percentile unit cost from other problem areas

Ave = Avenue
Blvd = Boulevard
E = East
GI = Green Infrastructure
Ln = Lane
M = millions
N = North
Pkwy = Parkway
Rd = Road
S = South
St = Street
W = West