SALEM VA

Resilience Plan

City of Salem

2023

For Virginia Community Flood Preparedness Fund by
Department of Conservation and Recreation in
cooperation with the Virginia Resources Authority
Prepared by: City of Salem

Wetland Studies and Solutions, Inc.® a DAVEY company

TABLE OF CONTENTS

FIGURES

TABLES

APPENDIX A: SCORING MATRIX & CRITERIA
APPENDIX B: ADDITIONAL PROJECT SITES

ACRONYMS

Base Flood Elevation	BFE
Best Management Practices	BMPs
Capital Improvement Plan	CIP
Cooperating Technical Partners	CTP
Digital Flood Insurance Rate Maps	DFIRM
Department of Conservation and Recreation	DCR
Federal Emergency Management Agency	FEMA
FEMA Community Rating System	CRS
Flood Insurance Rate Maps	FIRM
Floodplain Overlay District	FOD
Green Infrastructure	GI
Integrated Flood Observing and Warning System	IFLOWS
Intensity-duration-frequency	IDF
International Panel on Climate Change	IPCC
Miles per Hour	mph
Municipal Separate Storm Sewer System	MS4
National Flood Insurance Program	NFIP
Regional Stormwater Advisory Committee	RCSWAC
Repetitive Loss Areas	RLAs
Representative Concentration Pathways	RCPs
Roanoke Valley – Alleghany Regional	RVAR
Roanoke Valley Alleghany Planning Commission	RVAPC
Roanoke Valley Alleghany Regional Commission	RVARC
Roanoke Valley Regional Stormwater Management Plan	RVR SMP
Social Vulnerability Index	SVI
Stormwater Management Plan	SWMP
Total Maximum Daily Load	TMDL
Underground Detention System	UGDS
Urban Tree Canopy	UTC
Virginia Department of Environmental Quality	DEQ
Virginia's Stormwater Management Program	VSMP
Watershed Management Plans	WMPs

EXECUTIVE SUMMARY

The City of Salem presents this Resilience Plan as an important first step toward increasing the City's flood resilience, i.e., the ability to anticipate, prepare for, respond to, and recover from threats resulting from flooding, with minimum damage to social well-being, health, the economy, and the environment. The overarching goal is to plan the actions and measures necessary to balance growth with the need to build greater resilience in natural and human systems. The City formed a team comprised of Community Development personnel from the engineering department and hired Wetland Studies and Solutions Inc. (WSSI) to assist with developing a framework for achieving that goal. The team researched Salem's history and documented resilience initiatives already implemented by the City or in collaboration with regional partners. A thorough review of City plans, protocols, policies, and programs took place, focusing on resiliency, stormwater management, floodplain management, severe weather events, and comprehensive planning. The team then evaluated the City's environmental assets and engineered defenses to understand the green and gray infrastructure defense measures already in place for flood protection. To ensure future climatic conditions and vulnerable populations were considered, literature was reviewed to find the best models available for consideration. Further, the community engagement survey provided valuable feedback to better understand the demographics affected by flooding and specific needs. The team combined the findings on flooding and natural hazards with vulnerability assessments to determine where the socially vulnerable populations intersected with those hazards.

During the final phase of the research, the team synthesized all the findings from the literature review, models, analyses, and community engagement survey to create the gap analysis and apply a ranking matrix to prioritize project evaluation and implementation. Drawing from existing ordinances and policies, the gap analysis identifies studies and projects the City could expand upon or create to boost resilience. The matrix was used to score the final list of studies and projects, using a weighted system for prioritization.

Before its adoption by the City Council, the entire team meticulously reviewed the completed Plan to provide a foundation for forthcoming studies and projects aimed at bolstering Salem's flood resilience. Additionally, it serves as a basis for applying for state funding to support resiliency efforts. While the Plan's initial development phase is complete, the City remains committed to engaging with the community to improve its understanding of flooding issues and resilience. Therefore, this Plan remains open to future revisions that deal with the evolving concepts of flood resilience and community perspectives. It's important to note that this Plan focuses solely on flood resilience, but its methods were developed to be adapted for broader resilience applications.

1.0 INTRODUCTION

Following the guidance of the Virginia Coastal Resilience Master Plan (2021), the City of Salem defines resilience as the capability of individuals and communities 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. As the City increasingly faces the realities of heavier precipitation and storm events, the need to build greater flood resilience in communities has become a prevailing priority. The Resilience Plan lays out Salem's approach to flood protection and adaptation, focused on making adjustments in natural or human systems to the changing environment to moderate the negative effects of climate change and help citizens better prepare for and deal with those challenges.

The City of Salem's Resilience Plan is guided by the following five core principles:

1. Project-based with projects focused on flood control and resilience.
2. Incorporates green infrastructure and nature-based infrastructure to the maximum extent possible.
3. Includes considerations of all parts of a locality regardless of socioeconomics or race, working to identify and address socioeconomic inequities and enhance equity through adaptation and protection efforts.
4. Includes coordination with other local and inter jurisdictional projects, plans, and activities and understands fiscal realities, focusing on the most cost-effective solutions for protection and adaptation of communities, businesses, and critical infrastructure.
5. Based on the best available science, and incorporates climate change, storm surge (where appropriate), and current flood maps.

Salem recognizes that in most cases, additional funding mechanisms will be necessary to implement the measures needed to increase the resilience of homes, businesses, and infrastructure. The City also recognizes that low-income and minority communities are particularly vulnerable due to several factors. Therefore, the studies and projects recommended in this Plan strive to alleviate inequities and maximize the effectiveness of limited resources. The overarching goal is to plan the actions and measures necessary to adapt to the changing climate system, balancing growth with the need to build greater resilience in natural and human systems. This Resilience Plan provides a framework for achieving that goal which includes the following main sections:

- **Section 1.0** - Characterizes resilience and outlines the principles that guide the development of this Plan.
- **Section 2.0** - Evaluates natural hazards and social vulnerabilities to help the City prioritize areas experiencing heavy vulnerability and repetitive loss.
- **Section 3.0** - Reviews the impact of Salem's ongoing efforts on flood resilience.
- **Section 4.0** - Identifies where gaps exist and evaluates additional measures.

Their alignment with the five guiding principles is presented in the final sections, including a discussion of each and the findings from preliminary field assessments. The City intends for the Plan to be regularly updated to maintain its utility in the face of both changing conditions and new information.

1.1 Salem's History

Salem was the first locality established in the Roanoke Valley in 1802, and the growth rate that followed in the last two centuries has left very little developable land within the City's boundaries (City of Salem, 2012). Often restricted to the flat floodplain areas near water bodies, various areas within the City of Salem are susceptible to flooding (City of Salem, n.d.). Therefore, it is important for Salem residents and businesses to take the actions necessary to increase their flood resilience which is the ability to prevent flooding and cope with damage incurred from flood events (Cutter et al., 2008). To start, it is important to take a look at the history of Salem's development and historical flood events, as these often reveal the actions and measures needed to help build greater future resilience in prevention and recovery.

Situated in the Shenandoah Valley between the Allegheny and Blue Ridge Mountains on the Roanoke River, Salem is a prime location for interstate commerce and development. In 1816, the Roanoke Navigation Company was established on the Roanoke River to promote riverboat traffic, which led to Salem's first population boom (City of Salem, 2012). In 1920, Salem's population was 4,159 residents and a large increase occurred between 1950 and 1960, growing the town by 135%, from 6,823 to 16,058 residents. In the next decade, Salem experienced a 37% increase in population. Salem's population is currently 25,346 residents (US Census Bureau, 2020), and as the City becomes more urbanized and developed, the likelihood and severity of flooding increases (National Academies, 2019). Development often replaces the previously existing topsoil, vegetation, and varying elevations (permeable surfaces that hold water) with roads, parking lots, and buildings (impermeable surfaces that do not hold water) (Konrad, 2016). This accelerates the rate of stormwater, as it flows from land into nearby waterways, raising water levels quickly and increasing the chance of flooding (National Academies, 2019). However, Salem does require all new development to comply with Virginia stormwater management criteria which often requires stormwater management facilities to control runoff. Salem's proximity to the Roanoke River has historically exacerbated the effects of flooding because of the vastness of impervious surfaces and mountainous terrain, providing ideal conditions for flood waters to collect and build strength quickly. This heightens the flood hazard in Salem within the City's six watersheds: Barnhardt Watershed, Butt Hollow Watershed, Cole Branch Watershed, Dry Branch Watershed, Mason Watershed, and Gish Branch Watershed.

Since 1877, over 17 large floods have occurred in the Roanoke Valley with four of the largest happening in the past 20 years (RVAR Commission, 2019). The four largest floods on record occurred in June 1972, April 1978, November 1985, and April 1992. The 1972 flood on the Roanoke River, resulting from Tropical Storm Agnes, was a 50-year flood (i.e., a flood that has a 1 in 50 chance of occurring in any given year) damaging approximately 400 homes in the Roanoke-Salem area. On November 5, 1985, a 200-year flood event (i.e., a flood that has a 1 in 200 chance of occurring in a given year) inundated the Roanoke Valley when heavy storms from the remnants of Hurricane Juan stalled over the area (Corrigan, 2020). Damage to the Roanoke-Salem area cost an estimated $440 million, and the floodwaters were so high in Salem, hundreds of residents had to be rescued by boat and helicopter (Carpenter, 1990; Corrigan, 2020) (**Figure 1**).

Figure 1: Rescue operation on East Main Street, Salem, VA (Carpenter, 1990)

While the most severe flooding on the Roanoke River is usually the result of heavy rains from tropical storms and hurricanes, tributary stream flooding from local thunderstorms or frontal systems are more frequent and just as damaging to people and property (Dewberry & Davis, 1997). The most severe flooding in Salem occurs along the major waterways, roads, and Repetitive Loss Areas (RLAs) shown in **Figure 2**. The many flood-prone roads in Salem include the following: Apperson Drive, Colorado Street, East Main Street, East Riverside Drive, Electric Road, Epperly Lane, Front Street, Homer Lane, Lancing Drive, Mill Lane, Pine Bluff, River Side Drive, Sycamore Drive, Union Street, West Main Street, and Wildwood Road (RVAR Commission, 2019). The RLAs are defined as follows:

- Two or more claims of more than $1,000 paid by the National Flood Insurance Program (NFIP) within any rolling ten-year period since 1978;
- Four or more separate claims exceeding $5,000 or more; or
- At least two separate claims that cumulatively exceed the structure's market value (Roanoke Stormwater, 2021).

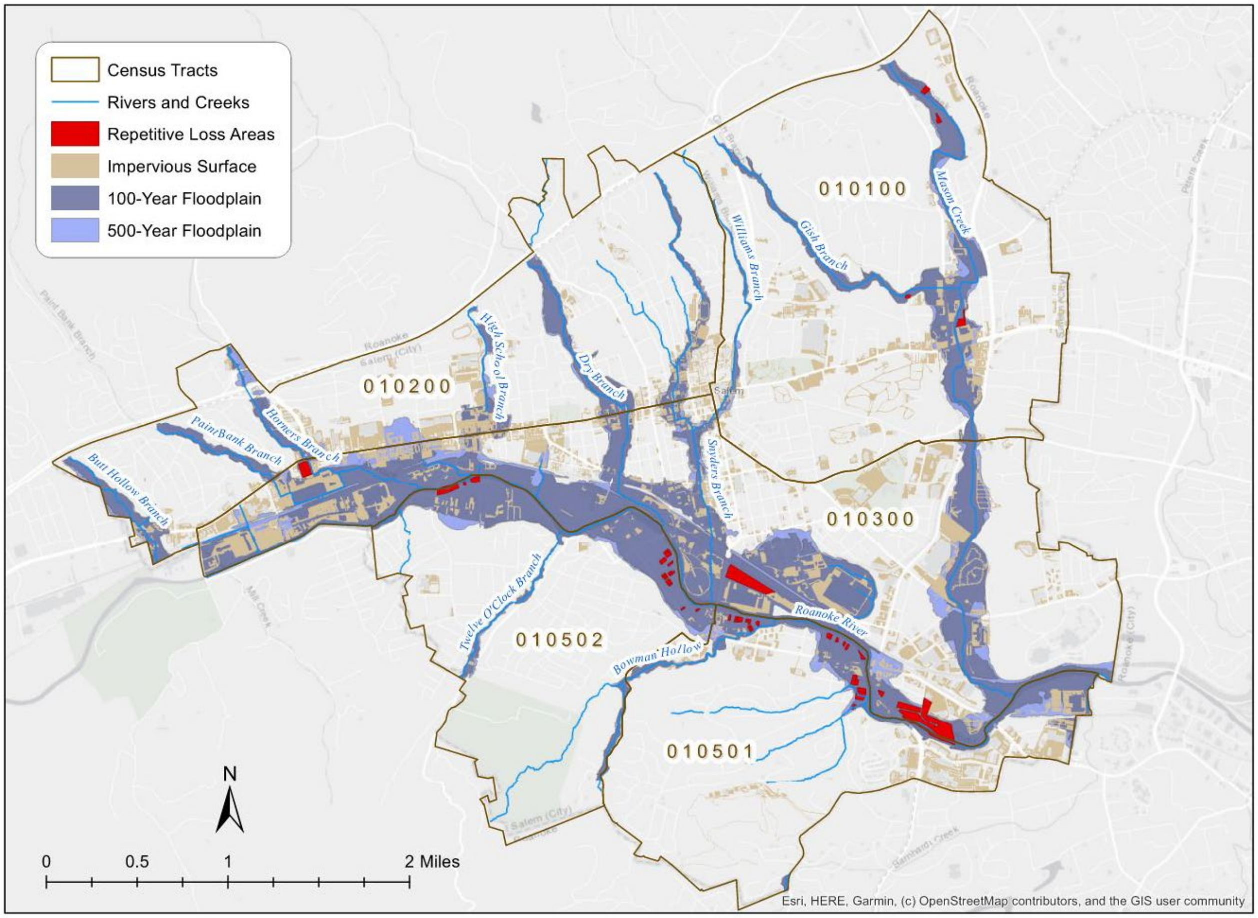


Figure 2: Salem's Flood-prone Areas

With 104 RLAs costing an average of $152,307 a year (RVAR Commission, 2019), Salem ranks in the top 10 communities for repetitive loss claims in Virginia (VA DCR, 2005). To combat this, the Severe Repetitive Loss Grant program was created to help implement mitigation projects for repetitive loss properties. Mitigation projects have included acquisition or relocation of at-risk structures and conversion of the property to open space, elevation of existing structures, or dry floodproofing historic properties (FEMA, 2011). As of 2018 (FEMA), Salem has acquired and demolished 18 residential flood-prone structures and obtained grant funding to floodproof a large business. Although actions have already been taken, additional flood resilience measures are needed in these areas to become more prepared and resilient to flooding.

2.0 NATURAL HAZARDS & VULNERABILITIES

Natural hazard events can impose long-lasting effects that impact people and the natural systems on which they depend for sustenance, protection, livelihoods, and recreation (Summers et al., 2018). In planning for resilience, the increasing prominence of extreme weather events makes it critical for Salem to examine its vulnerability and recoverability. The following sections evaluate the risk that natural hazards impose and level of social vulnerability, which can ultimately help Salem identify areas to target for improvement to reduce vulnerabilities and increase resilience to these events.

2.1 Flooding and Related Natural Hazards

The Roanoke Valley-Alleghany Regional Hazard Mitigation Plan (2019) identifies the areas in Salem most vulnerable to flooding and related natural hazards. This data is summarized below, providing baseline justification for future studies and projects aimed at increasing resiliency.

2.1.1 Flooding

Widespread flooding or flash flooding primarily occurs in the City of Salem during heavy precipitation and storm events. Streams fill up quickly from the heavy rain, allowing floodwater to flow through steep terrain and pick up velocity, before rushing into developed areas. The floodplain, the natural area of land adjacent to streams and rivers, is the first line of defense against flooding, yet development often prevents the floodplain from being able to fully absorb the floodwaters. The houses, businesses, and associated impervious surfaces (e.g., parking lots) located in Salem's floodplain do not absorb and slow water the way natural floodplains do, causing floodwaters to pick up speed and inflict even more damage. Further, gray infrastructure measures, such as culverts, are sometimes overwhelmed when heavy rain falls in a short period of time, extending the flooding into adjacent areas. For these reasons, the RVAR Commission (2019) found that Salem has a high probability of flooding and is highly vulnerable to it. The City of Salem's repetitive loss data helps planners identify areas experiencing repetitive flooding, or RLAs. The RLAs in each watershed are summarized below and depicted in **Figure 3**.

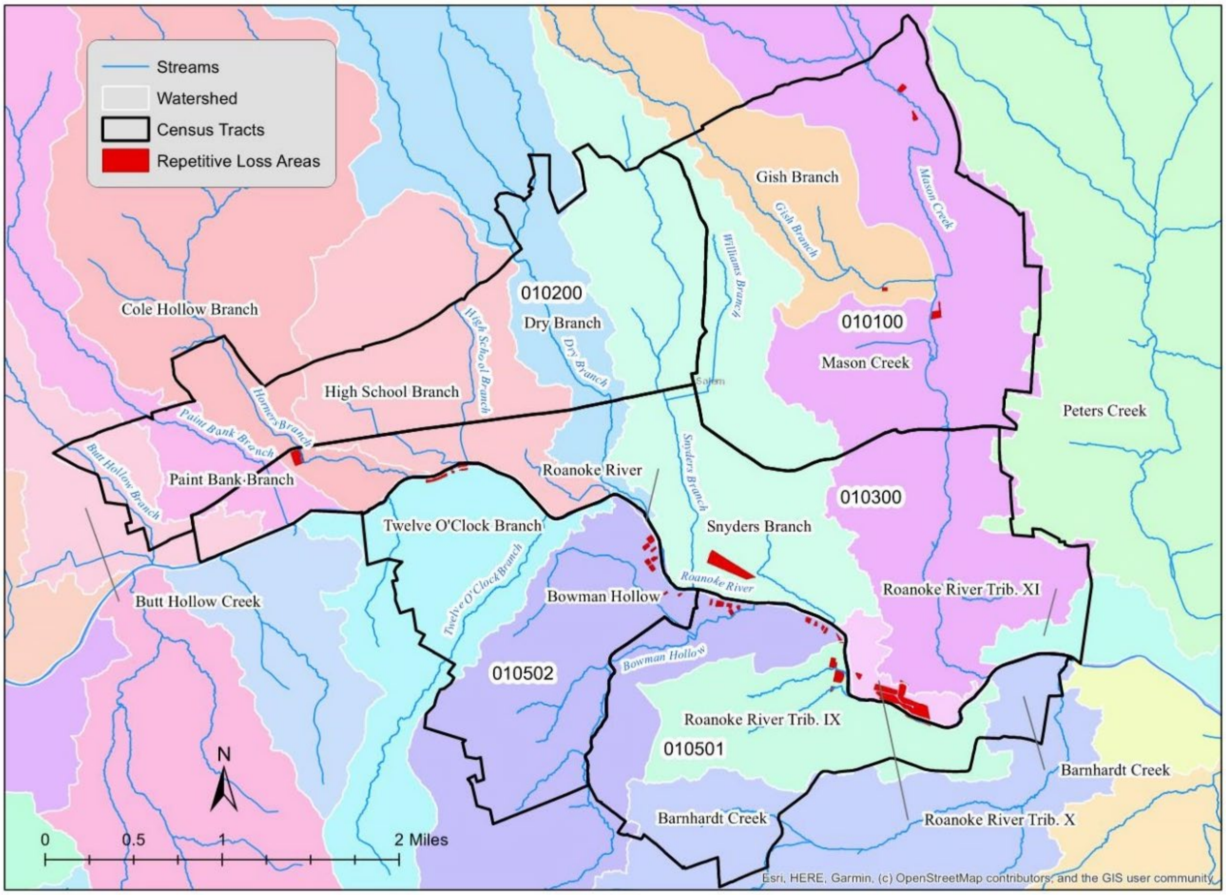


Figure 3: Watersheds in Salem

<u>Barnhardt Creek</u>

Barnhardt Creek is located in southern Salem, and as of 2019, there were approximately 30 homes located in the Barnhardt Creek floodplain, with 20 experiencing heavy flooding. Major flooding issues on Barnhardt Creek is upstream of Cravens Creek Road (located in the westernmost part of Roanoke City at the border with the City of Salem), and upstream of Electric Road – State Route 419 in the Farmingdale subdivision (located between Rt. 685 and Rt. 419 at the junction of Roanoke County, the City of Salem, and City of Roanoke) along Lakemont Drive. The Meadow Creek subdivision located in southwest Roanoke County also experiences flooding, both upstream and downstream of Meadow Creek Drive (off of Rt. 686). The Roanoke Valley Regional Stormwater Management Plan (Dewberry & Davis, 1997) estimated that 36 houses in the watershed would be flooded by a 100-year storm event (1% annual chance of flooding).

<u>Butt Hollow Creek</u>

Butt Hollow Creek is located in the western portion of Salem and flows southeasterly for about three miles to its confluence with the Roanoke River. There are approximately 30 homes located in the Butt Hollow Creek floodplain, and more than 10 experience heavy flooding. The major flooding problems on Butt Hollow Creek are at Routes 11/460 and Butt Hollow Road (Rt. 640) at the western corporate limits of the City of Salem. The Roanoke Valley Regional Stormwater

Management Plan estimated that 29 houses in the watershed would be flooded by a 100-year storm event.

Cole Hollow Brook

From 3,020 feet above sea level on Fort Lewis Mountain, Cole Hollow Brook flows southwesterly and then southeasterly for about 4 miles until its confluence with the Roanoke River in Salem. The southern portion of this watershed is in Salem at Rt. 618 and Rt. 11. Approximately 45 buildings/homes in west Salem along Cole Hollow Brook are located in the 100-year floodplain, with more than 10 experiencing heavy flooding. One of the major flooding problems on Cole Hollow Brook is upstream of West Main Street in the City of Salem at Horner Lane, and another is downstream of Interstate 81 in the Mitchell subdivision in west Salem along Windsor Avenue. The Roanoke Valley Regional Stormwater Management Plan estimated that 43 houses in the watershed would be flooded by a 100-year storm event.

Dry Branch

The southern portion of the Dry Branch watershed is in northern Salem. The major flooding problems occur in the Hockman Subdivision at Dry Branch's crossing of East Main Street (Rt. 11) and Burwell Street and at the Cameron Court subdivision at Dry Branch's crossing of Carrollton Avenue in Salem. The Roanoke Valley Regional Stormwater Management Plan estimated that 149 houses in the watershed would be flooded by a 100-year storm event.

Gish Branch

Originating on Fort Lewis Mountain in north Roanoke County, the Gish Branch watershed descends from 3,080 feet above sea level. It flows in a southeasterly direction for about 3.5 miles until its confluence with Mason Creek in the City of Salem. Gish Branch lies wholly within north central Roanoke County and the north central portion of Salem. Approximately 11 homes along Gish Branch on North Mill Road (Rt. 631) are located in the floodplain, with more than 8 experiencing frequent flooding. One of the major flooding problems on Gish Branch is upstream of Kessler Mill Road (Rt. 630) in east Salem, where several homes and a commercial building are regularly inundated. The Roanoke Valley Regional Stormwater Management Plan estimated that 12 houses in the watershed would be flooded by a 100-year storm event.

Mason Creek

Originating at an elevation of 3,260 feet above sea level on Fort Lewis Mountain in northern Roanoke County near Big Bear Rock Gap, the Mason Creek watershed is a 29.6 square mile drainage basin. It includes the Gish Branch watershed and is in north central Roanoke County, eastern Salem, and western City of Roanoke. The watershed is fan-shaped and has a length of about 8.5 miles and a maximum width of 9 miles near its headwaters. From Fort Lewis Mountain, Mason Creek flows northeasterly for about seven miles to Mason Cove where it turns and flows southeasterly 7.5 miles to its confluence with the Roanoke River in the City of Salem. Buildings and roads located in the floodplain experience regular flooding, and excessive debris accumulation clogs exacerbates flooding issues. In the downstream portion of Mason Creek, the major flooding problems are at two trailer parks, the Salem Village Trailer Park (south of the intersection of Rt. 460 and Kessler Mill Road in Salem) and a trailer park located along Schrader Street in eastern Salem, south of the Salem Turnpike (Rt. 460). These trailer parks are subject to frequent flooding. Another major problem in the Mason Creek watershed is in the vicinity of East Main Street, where several buildings and houses are frequently inundated, including the Lakeside Plaza Shopping Center. Other areas vulnerable to flooding include North Electric Road to Janee Drive (north of Interstate 81), Janee Drive to Carvins Cove Road, Carvins Cove Road to Catawba Valley Road, and Catawba Valley Road to Plunkett Road (all sections parallel Mason Creek and Kessler Mill Road from the City of Salem and then north along Catawba Road, Rt. 311, into Roanoke County). The Roanoke Valley Regional Stormwater Management Plan estimated that 519 houses in the watershed would be flooded by a 100-year storm event. **Figure 4** shows that Mason Creek and Dry Branch watershed have a greater number of houses that are vulnerable to flood hazards.

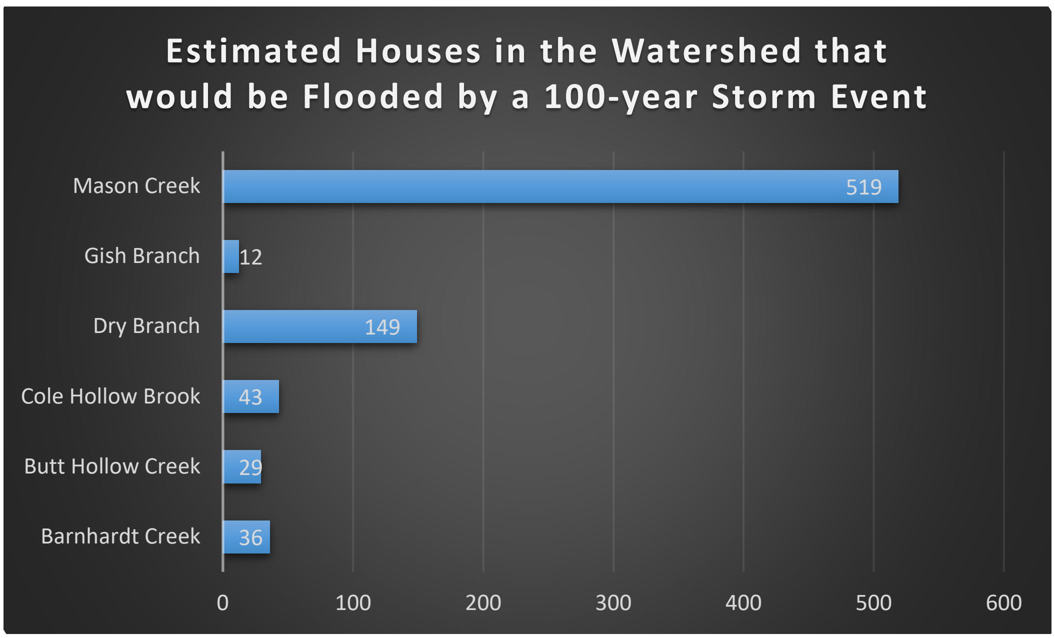


Figure 4: Estimated Residential Flooding

2.1.2 Hurricanes & Tropical Storms

Since 1932, 25 hurricanes and tropical storms have brought damaging floods to the City of Salem (Homefacts, 2023). While hurricanes have a constant speed exceeding 74 miles per hour (mph), some of the greatest rainfall amounts are brought by much slower (1 to 10 mph) yet tenacious tropical systems. Widespread rainfall between 6 and 12 inches or more is common during a hurricane or tropical storm, frequently producing deadly and destructive floods. The risk from flooding depends on several factors: the speed of the storm, its interactions with other weather systems, the terrain it encounters, and ground saturation. Though coastal storms have a higher risk of flooding associated with storm surges, large amounts of rain can occur more than 100 miles inland, where flash floods and landslides are typically the major threats to Salem residents. Though the RVAR Commission (2019) found that Salem has a low probability of a hurricane hazard occurrence, the City has a medium to high vulnerability to hurricanes because when they do occur, the result is often very damaging. Unfortunately, the National Weather Service and other agencies are currently unable to predict the occurrence and location of future hurricanes, though they can track them once they've been identified. Based on past events and a changing climate system, it is likely that hurricane and tropical storm flooding will continue to pose a problem for Salem; therefore, studies and projects are needed to reduce vulnerability and boost resiliency.

2.1.3 Landslides

Landslides and the resulting debris flows in Salem are most often the result of unusually heavy rain from hurricanes and intense storms saturating the soil and reducing the ability of steep slopes to resist the downslope pull of gravity. The debris flows, ranging from watery mud to thick, rocky mud (like wet cement), are dense enough to carry boulders, trees, and cars down the slope. Landslides are unpredictable and can be very damaging to people and property. The best defense is to prevent erosion, which increases the inherent weaknesses in rock or soil, by implementing best management practices (BMPs) that stabilize the soil, especially on slopes. Nature-based BMPs, such as tree canopy and land conservation, prevent erosion and changes in stormwater runoff and drainage, providing some of the most effective ways to prevent landslides from occurring. Primarily due to the mountainous terrain and high probability and vulnerability to flooding, the RVAR Commission (2019) found that Salem has a medium probability of a landslide occurring. Yet, due to the stabilizing vegetation and tree canopy found on most slopes, Salem's vulnerability to landslides is low.

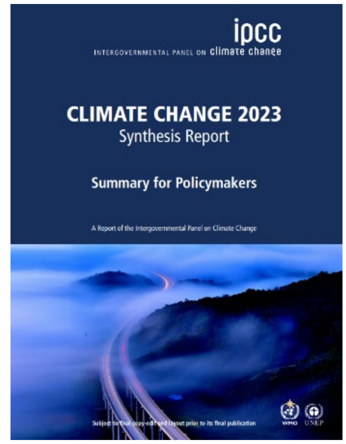
2.1.4 Dam Safety

Virginia Department of Conservation and Recreation (DCR) is responsible for ensuring compliance with dam safety laws and is the lead state agency for assessing and mitigating flood risks related to dams. Owned by the Western Virginia Water Authority, the Clifford D. Craig Memorial Dam at the Spring Hollow Reservoir was classified by DCR as a High Hazard dam, with an inundation zone that flows through the City of Salem adjacent to the Roanoke River. This means that, upon failure, this dam would cause probable loss of life or serious economic damage. However, the dam at Spring Hollow is of a type that has never experienced a structural failure and is unaffected by rainfall or peak mean flow of any rivers or streams. However, if the dam fails, inundation would significantly raise the Roanoke River levels in the City.

The Western Virginia Water Authority inspects the dam annually to ensure it is structurally sound. In the unlikely event of a catastrophic dam failure, or if conditions should occur that would increase the likelihood of such an event occurring, the public would be notified through all major media outlets. Salem residents can also register their phone number with the Western Virginia Water Authority through their Everbridge notification system, a free service with an automated phone dialing system that notifies customers of important information including safety issues and water service interruptions.

2.2 The Changing Climate

The climate is changing, evidenced by the increase in global surface temperature of 1.09°C above historic baseline levels (IPCC, 2023). According to the International Panel on Climate Change (IPCC), it is likely that warming will continue to increase and exceed 1.5°C during the 21st century. Using the EPA CREAT Climate Scenarios Projection Map (n.d.), the City of Salem should expect an estimated 5.3% increase in average annual precipitation by 2035 and a 10.3% increase by 2060. EPA's Streamflow Projections Map (n.d.) shows that by the end of the century, high streamflows in the City could be more than 1.5 times what they are now. In the near term, the projected increase in frequency and intensity of heavy precipitation would increase rain-generated local flooding, and the changes in floods, landslides, and water availability would potentially lead to severe consequences for people, infrastructure, and the economy in Salem's mountain region.



Stormwater BMPs, both grey (pipes, tanks, concrete channels, etc.) and green (vegetated practices like rain gardens, grassed swales, etc.), help Salem guard against the effects of climate change and prepare for the projected increase in precipitation and storm events. Conventional BMP design has relied on historic climate data, which may not prove resilient enough to the increases in precipitation volume (Job, 2020). As the climate continues to warm and precipitation becomes more extreme, scientists (Job, 2020; Montalto et al., 2021; Wood, 2021) anticipate the following BMP performance changes:

- Decreased pollutant load reduction.
- Increased peak flows above design standards.
- Increased downstream channel erosion.
- Shifting vegetation palettes in bioretention systems.
- More mobilized sediment in the contributing drainage area.
- Rising water tables, with unknown impacts on pollutant removal efficiency.
- Increased vulnerability of streams and stormwater channels to erosion.
- Loss of capacity and damage experienced at the outfall.
- Increased erosion, sedimentation, and leaching and resuspension in ponds.
- Flooding through inlets and exceeded soil infiltration capacity.
- Impacted stream restoration structural elements due to increased erosion, inaccurate predictions of design parameters (width, depth, meander radii, etc.), poor reference site selection, and shifting design principles.

As a result, the increase in runoff volumes, peak discharges, and duration of flow velocities will likely result in culvert failures, scour, and stream bank erosion, allowing floodwaters to carry point (from a single source) and nonpoint pollution (from many sources) to downstream waterways.

The prospect of these climate-related impacts necessitates critical decision-making in system management. These decisions are based in large part on the development of climate change projections (understanding how the Earth will warm) and updated intensity-duration-frequency

(IDF) curves (understanding how the precipitation patterns will change), with the overall goal of designing stronger, more resilient stormwater management systems and BMPs. Climate change informed IDF curves, based on multiple global climate models, have recently been developed for Virginia to help localities incorporate climate change projections into local stormwater design standards (https://midatlantic-idf.rcc-acis.org/). The development of these IDF curves was undertaken by a team of individuals from the RAND corporation, Carnegie Mellon University, Cornell University, and a team from NOAA called MARISA. Most cities rely on NOAA's Atlas 14 as the primary source of IDF curves; however, using Atlas 14 has been a problem for many Virginians, primarily because Atlas 14 does not incorporate data after the year 2000 and relies on flawed assumptions of stationarity (i.e., climate does not change through time) (Miro et al., 2021, August 12). This means that Atlas 14 may underestimate current and future precipitation events. The new Virginia IDF curves improve upon past efforts by incorporating updated and projected climate data **(Figure 5)**. Two representative concentration pathways (RCPs), RCP 4.5 and RCP 8.5, are used in the Virginia IDF Curve Data Tool to represent an intermediate scenario and high level of future atmospheric concentrations of greenhouse gas emissions over time, i.e., an optimistic scenario with low emissions (RCP 4.5) and a worst-case future or business as usual scenario with higher emissions (RCP 8.5).

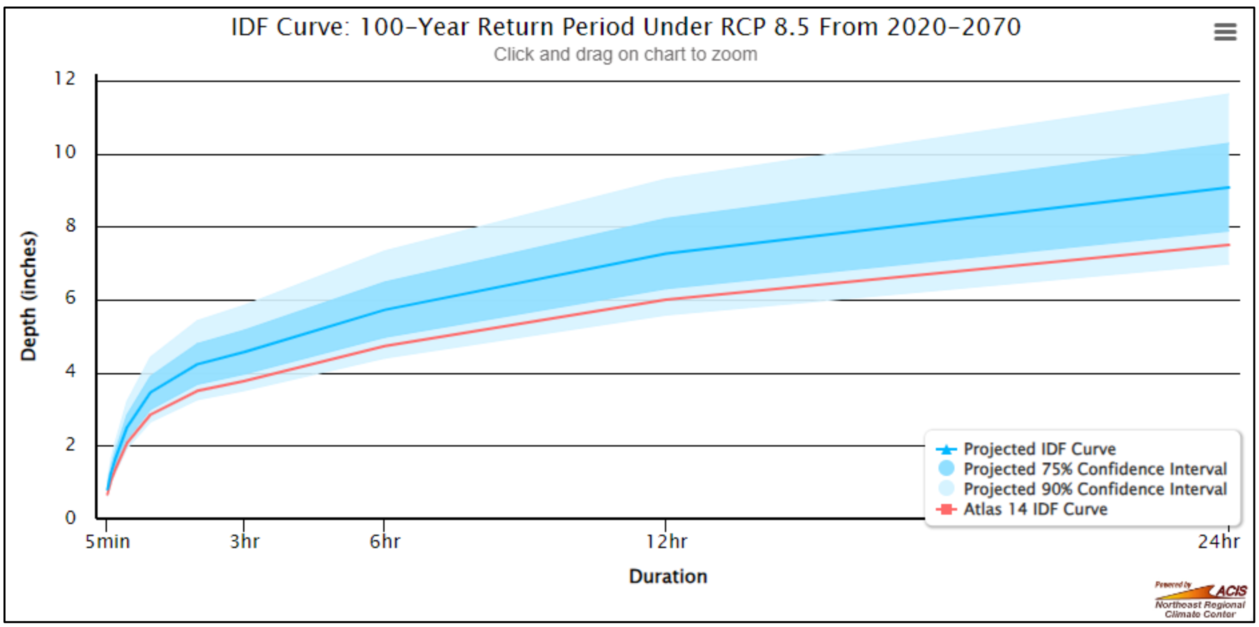


Figure 5: Virginia IDF curve output example

Applying the Virginia IDF Curve Data Tool, a data sample of the anticipated changes in precipitation for the City of Salem is shown below in **Table 1**. The full capabilities of the IDF Curve Data Tool are much more comprehensive. In the table below, the different year storms include the 2-year (50% chance of occurring in one year), 5-year (20%), 10-year (10%), 25-year (4%), 50-year (2%), and 100-year (1%) storms. Two time periods are shown for 2020 - 2070 and 2050 - 2100 to represent future projections, and two scenarios are shown for RCP 4.5 (optimistic, low emissions) and RCP 8.5 (business as usual, high emissions). Since not all rainfall impacts stem from the same storm duration, 1-hour and 24-hour storms are included in the table. Storms that tend to cause damaging urban overland flooding are often short, extreme events, whereas soil saturation and stability may be most impacted by less intense but more persistent and longer storm events (Climatedata.ca, n.d.).

Table 1: Projected Changes in Precipitation for the City of Salem using the Projected Intensity-Duration-Frequency Curve Data Tool for Virginia (https://midatlantic-idf.rcc-acis.org/)

Year Storm	**RCP 4.5, 1-hour Years 2020-2070**	**RCP 4.5, 1-hour Years 2050-2100**	**RCP 8.5, 1-hour Years 2020-2070**	**RCP 8.5, 1-hour Years 2050-2100**
2-year (50%)	1.43”	1.55”	1.47”	1.56”
5-year (20%)	1.86”	2.06”	1.93”	2.01”
10-year (10%)	2.21”	2.48”	2.31”	2.39”
25-year (4%)	2.69”	3.08”	2.74”	2.88”
50-year (2%)	3.06”	3.53”	3.08”	3.26”
100-year (1%)	3.48”	3.59”	3.45”	3.73”
Year Storm	**RCP 4.5, 24-hour Years 2020-2070**	**RCP 4.5, 24-hour Years 2050-2100**	**RCP 8.5, 24-hour Years 2020-2070**	**RCP 8.5, 24-hour Years 2050-2100**
2-year (50%)	3.45”	3.75”	3.55”	3.77”
5-year (20%)	4.48”	4.96”	4.64”	4.84”
10-year (10%)	5.36”	6.02”	5.59”	5.78”
25-year (4%)	6.69”	7.66”	6.81”	7.15”
50-year (2%)	7.82”	9.03”	7.88”	8.34”
100-year (1%)	9.15”	9.45”	9.07”	9.83”

Overall, the data shown in the table indicate an upward trend in the severity of precipitation events and storms for the City of Salem. Using the projected climate change data generated by the IDF Curve Data Tool, the City can design more resilient flood mitigation measures and flood control structures, calculate peak runoff for watersheds, and design more resilient culverts and pipes (Ewea et al., 2018). One option is to replace existing IDF curves with the projected IDF curves, which can easily be integrated with existing planning and design criteria. The new criteria could be used to increase the resiliency of planning, designing, and building infrastructure assets (Miro et al., 2021). The IDF Curve Data Tool can also be used to explore anticipated changes across design storms and apply future change factors to existing design guidelines. Still, another option for the City is to incorporate a factor of safety by adding a percentage to existing IDF curves based on the projections or increasing the design storm criteria, for example, by designing for the 15-year, 24-hour instead of the 10-year, 24-hour storm (Wood, 2021). Next steps include coordination among localities to evaluate the climate change data on BMP performance and resilient design options to estimate the impacts of new design criteria on existing and future projects.

2.3 Critical Facilities

Critical facilities (and critical infrastructure) refer to those assets, systems, and networks, whether physical or cyber, which are so vital that their incapacitation or destruction would have a debilitating effect on physical security, economic vitality, public health or safety, or any combination of thereof at a national, state, or local level. This includes structures from which essential services and functions for victim survival, continuation of public safety actions, and disaster recovery are performed or provided. Disaster or inclement-weather shelters, emergency operation centers; public health, public drinking water, sewer and wastewater facilities are considered critical facilities. The loss of municipal utilities during a major flood has hindered some critical facilities from providing services, and in some cases, the loss of municipal services prevented critical facilities from functioning for weeks after a flood event. Even a minor chance of flooding can present wide-ranging risks to the distribution of services and maintenance offered by the community's critical facilities. By ensuring Salem's critical facilities' functionality during and after a disaster, the City will become more resilient and prepared for flood events.

The City of Salem's critical facilities and their proximity to flood prone areas are shown in **Figure 6** (Roanoke Valley-Alleghany Regional Hazard Mitigation Plan, 2019). The critical facilities are categorized according to the eight descriptions below. The list does not include private utilities (gas/oil lines, electrical supply, communications, fuel storage), state and federal facilities (highways and their associated infrastructure, including bridges), and additional types of linear infrastructure.

1. **Essential Facilities**: Facilities crucial to the health and welfare of the community including hospitals and other medical facilities, police and fire stations, emergency operations centers, and evacuation shelters.
2. **Transportation Systems**: Systems that transport people, goods, and services which include airways (airports, heliports); highways (bridges, tunnels, roadbeds, overpasses, transfer centers); Railways (trackage, tunnels, bridges, rail yards, depots); and waterways (canals, locks, seaports, ferries, harbors, drydocks, piers).
3. **Lifeline Utility Systems:** Systems vital to public health and safety which includes potable water supplies and treatment facilities; wastewater lines and treatment facilities; oil and natural gas lines and supplies; electric power lines and generators; and communications systems.
4. **High Potential Loss Facilities:** Facilities that would have high costs associated with their damage during a hazardous event including nuclear power plants, dams, and military installations.
5. **Hazardous Materials Facilities:** Facilities that produce, store, and/or transport industrial/hazardous materials, such as corrosives, explosives, flammable materials, radioactive materials, and toxins.
6. **Vulnerable Facilities:** Facilities that house vulnerable populations that could lead to high death tolls and injury rates if damaged such as schools, nursing facilities, prisons, major employers and/or financial institutions/centers, and high density residential or commercial centers.

7. **<u>Archival Facilities:</u>** Facilities that have historical value, hold items of historical value, or have a special natural resource value. This includes museums, historical landmarks, recreational areas, parks, and state or federal protected areas.
8. **<u>Important Facilities</u>**: Facilities that are imperative to recovery in the event of a hazard include government properties and commercial establishments such as grocery stores, hardware stores, and gas stations.
   (Virginia Agency, 2003)

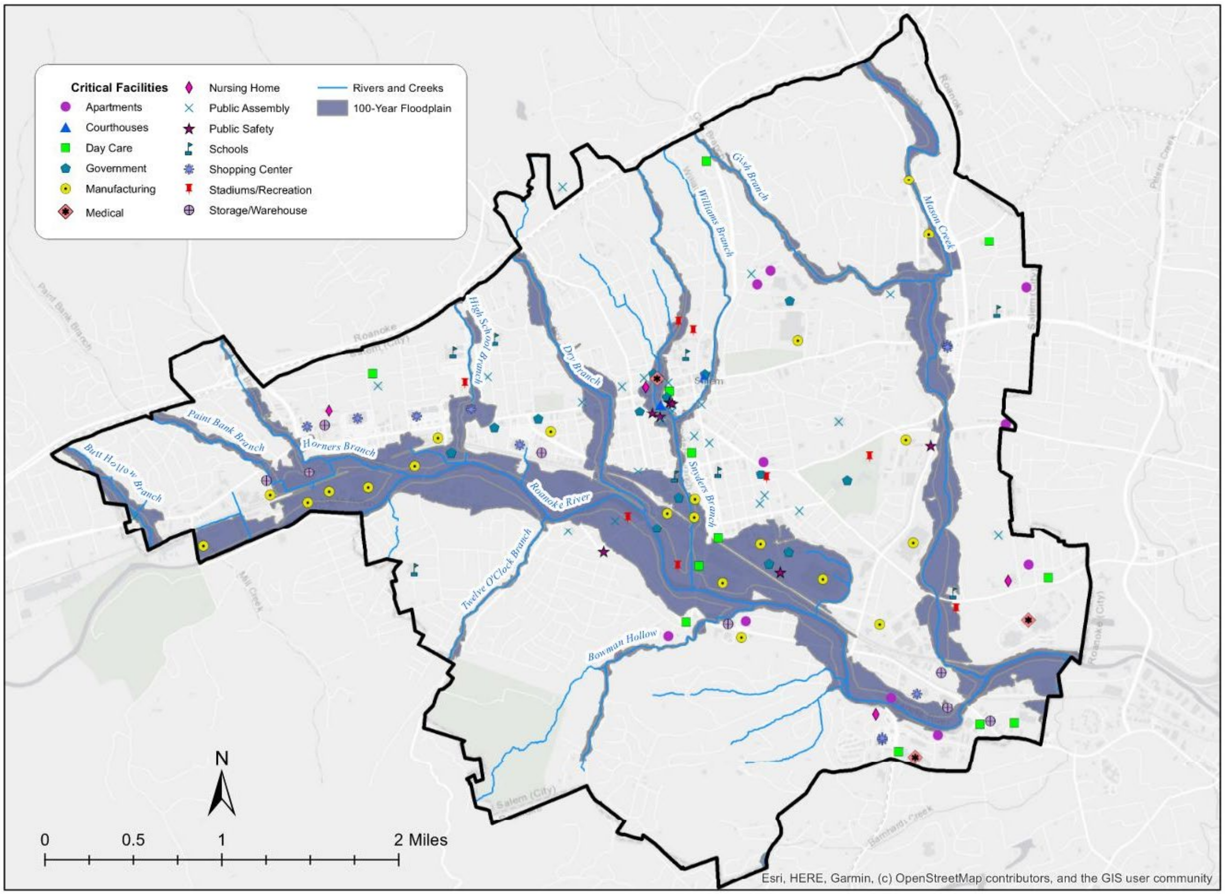
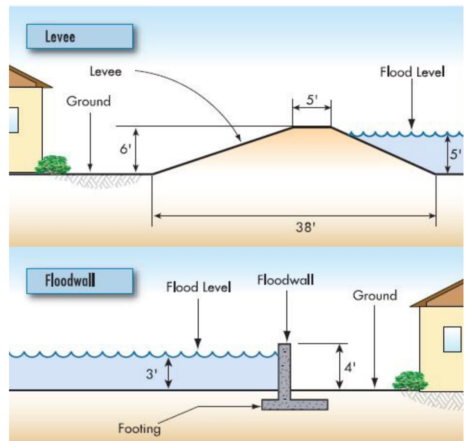


Figure 6: Salem's Critical Facilities

It is important for critical facilities to be located away from high-risk flood hazard areas to ensure essential services continue to function during and after a flood (Federal Insurance and Mitigation Administration, n.d.). When considering a location for a critical facility, FEMA's guidelines emphasize the importance of conducting flood risk assessments, considering factors such as flood zones, historical flood data, and the potential impact on critical infrastructure before these critical facilities are developed. If these facilities already exist within or in proximity of a floodplain as deemed by the City's flood zone maps, Federal Emergency Management Agency (FEMA) standards provide recommendations for elevating critical equipment and systems above potential flood levels, implementing flood-resistant building materials, and employing floodproofing techniques such as sealing vulnerable openings and installing flood barriers.

To improve the City's existing and future building performance, FEMA recommends building owners and operators and key decision makers evaluate the equipment, systems, and functions of current critical facilities and identify vulnerabilities and potential mitigation solutions (Federal Insurance and Mitigation Administration, n.d.). For example, since roads and streets are often the first areas to flood, all access routes to critical facilities should be raised to or above the base flood elevation (BFE), i.e., the elevation of the 1-percent-annual-chance of a flood event. Some communities already require access routes and streets to be a foot or more above the BFE to ensure essential workers can respond safely to an area during and after a flood. Salem's Floodplain Management Ordinance (Chapter 106 – Zoning, Article II., Sec. 106-226) requires this protection measure for new and existing properties under construction in the floodplain, and extending this protection to critical facilities would add a necessary level of protection.



It is best if mitigation measures designed for critical facilities are site-specific and based on an engineering analysis to ensure effectiveness and feasibility. The illustration from FEMA's (2007) Design Guide for Improving Critical Facility Safety from Flooding and High Winds shows the earthen levee is best used if a barrier is needed to keep water completely away from a facility, whereas a floodwall can be used when a certain level of flooding water during major storm events is okay. Since both measures are designed to protect the landside area up to a certain flood level, both measures are usually most effective in areas with relatively shallow flooding and little wave action. Failure of either mitigation measure would likely be disastrous, so they are usually designed for a 0.2-percent-annual-chance flood in any given year (in a given year, there is a 2% chance of flooding). It is also important that long-term maintenance, inspections, and repairs are routinely conducted so the measures are not overtopped or breached. Additionally, FEMA encourages the development of flood emergency response plans, including evacuation procedures and relocation strategies for critical facility staff and occupants.

Further, the installation of green infrastructure (GI) (e.g., rain garden, green roof, permeable pavement) provides both flood protection and pollution prevention for Salem's critical utilities. As an example, the Roanoke River and three public wells provide Salem's water supply, and about four million gallons are treated per day by the City's water treatment plant prior to distribution (City of Salem, 2012). By soaking up and preventing the release of stormwater, GI measures help prevent flood waters and stormwater pollutants, such as trash, bacteria, and heavy metals, from adversely affecting these municipal utility systems (United State Environmental Protection Agency, 2023).

2.4 Vulnerable Populations

Social Vulnerability captures the degree to which a community exhibits certain social conditions that make a community more susceptible to human suffering and financial loss following a flood disaster (Commonwealth of Virginia, 2021). These conditions include disparities in health, income, and access to services related to age, race or ethnicity, language, or other characteristics (CRMP, 2021; HUD, n.d.). As of the 2020 census and the 2021 American Community Survey, a majority of the 25,346 people living in the City of Salem are white (86%), female (52%), and between the ages of 18 and 64 (62%). English is the primary language (95%) for most residents, and a small percentage (7.4%) are foreign-born. Of those under the age of 65, 6.6% have a disability. The median household income is $66,472, a little higher (10%) than the amount in the Roanoke Metro Area ($60,907). Two census tracts (51775010100 and 51775010300) are low-income geographic areas (ACS, 2016-2020). The percentage of people living in poverty is about the same as the rate for Virginia (10%). There are 11,086 housing units, mostly single units (76%), with 35% rental and 65% owned.

The Social Vulnerability Index (SVI) (CDC/ATSDR, 2018) is a widely accepted approach for quantifying social vulnerability in a city. Developed by the Centers for Disease Control and Prevention and the Agency for Toxic Substances and Disease Registry, SVI was the approach chosen to quantify social vulnerability in Virginia's Coastal Resilience Master Plan (2021) because it was considered the most publicly accessible, replicable, and acceptable approach used for federal agency grant programs. The Index uses 15 census variables to represent four categories, shown in **Figure 7**. The SVI is used in this Resilience Plan to identify socially vulnerable areas and help focus flood resilience efforts in these communities.

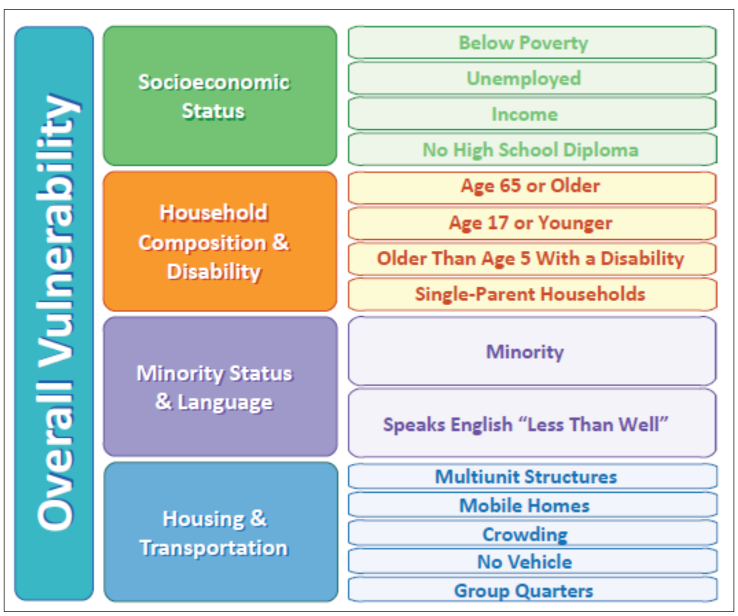


Figure 7: Variables and themes included in the Social Vulnerability Index

Using the SVI, **Table 2** shows the social vulnerability data for each census tract in the City of Salem. The areas with a high level of vulnerability are located in the 51775010100 and 51775010300 census tracts. The other three census tracts have low social vulnerability.

The RLAs shown in **Figure 3** are labeled according to their tributary, i.e., HB is in Horners Branch, MC is in Mason Creek, GB is in Gish Branch, BH is in Bowman Hollow, RR is in the Roanoke River, and RRT is in the Roanoke River Tributary (unnamed). The overlap between social vulnerability and RLAs, summarized in **Table 2** and illustrated in **Figure 8**, helps the City prioritize studies and projects in census tracts with high social vulnerability, at least one repetitive loss area, or both. Therefore, a higher priority ranking can be applied to studies or projects located in the 51775010100 and 51775010300 census tracts (high social vulnerability and RLAs) and the 51775010501 and 51775010502 census tracts (low social vulnerability but has RLAs). Projects and studies in the 51775010200 census tract (low social vulnerability and no RLAs) would receive a lower rank.

Table 2: Intersect between Social Vulnerability and RLAs in Salem, Virginia

Salem Census Tract	Level of Social Vulnerability	Repetitive Loss Areas
51775010100	High	MC-1, MC-2, MC-3, GB-1
51775010200	Low	N/A
51775010300	High	HB-1, RR-17, RR-32, RR-33, RR-34
51775010501	Low	RR-20, RR-21, RR-22, RR-23, RR-24, RR-25, RR-26, RR-27, RR-28, RR-29, RR-30, RR-31, RRT-1, RRT-2, RRT-3, RRT-4, RRT-5, RRT-6, BH-1, BH-2
51775010502	Low	RR-1, RR-2, RR-3, RR-4, RR-5, RR-6, RR-7, RR-8, RR-9, RR-10, RR-11, RR-12, RR-13, RR-14, RR-15, RR-16, RR-18, RR-19

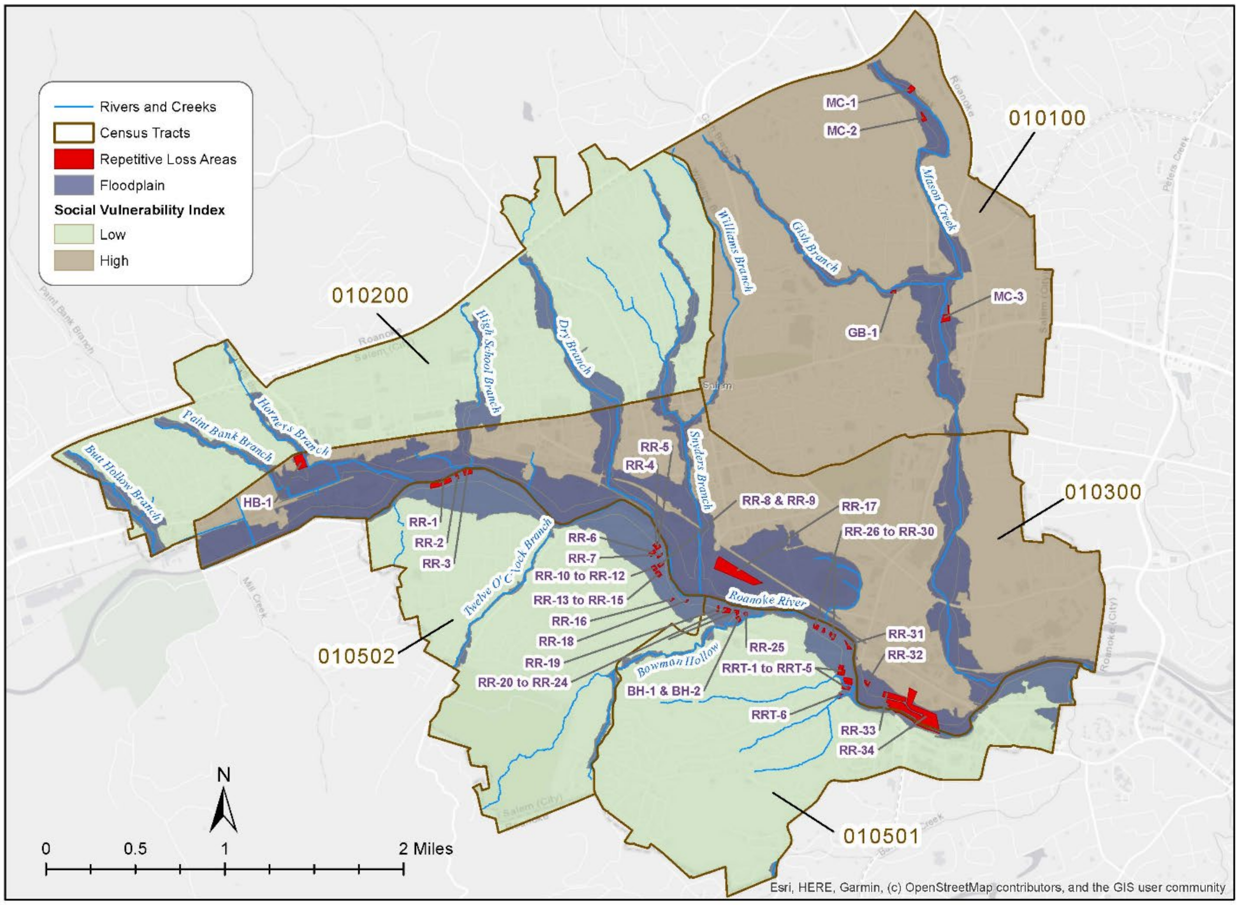


Figure 8: Salem's RLAs and Social Vulnerability

3.0 CURRENT EFFORTS TO REDUCE FLOODING & DEVELOP RESILIENCE

Salem recognizes that securing proper community engagement and mitigation are key to building flood resilience (Ling et al., 2022). The City engages the public through community outreach, city plans and programs, and regional efforts to both educate the public and learn about the local factors influencing flood resilience. The following sections evaluate the impact of Salem's current efforts on flooding and resilience, and the findings are used later to help identify where gaps exist and additional measures may be necessary to increase the ability of communities to adapt and recover from flood events.

3.1 Community Education and Engagement

The City of Salem has developed several programs, plans, and processes to engage the public on flood resiliency. These demonstrate Salem's commitment to fostering a flood-resilient community, involving a wide range of citizens from all walks of life. By educating and actively involving those directly affected by plans, agencies help ensure community interests are represented during the planning process. Simultaneously, the City gains a greater understanding of how to successfully address local challenges, often leading to more successful resolutions.

3.1.1 Council and Committee Involvement

Salem remains actively engaged in staying informed in pertinent regional subjects, concerns, and objectives related to stormwater management and the utilization of water resources. This commitment is achieved through collaborations with neighboring communities, municipal entities, statewide agencies, and nonprofit organizations through dedicated committees. These assemblages serve as platforms for discussing pressing local challenges, forming proactive campaigns to enhance public awareness, and the dissemination of actionable measures that empower the community to effectively tackle water-related issues.

Salem continues to be an active participant in the Roanoke Valley Alleghany Regional Commission's (RVARC) Roanoke River Blueway Committee, Stormwater Advisory Committee, and Regional Pre-Disaster Mitigation Planning Committee. Established in 2013, the Roanoke River Blueway Committee was created to further advance planning, tourism, and outreach regarding the Roanoke River (Roanoke River Blueway, n.d.). The group consists of the City of Salem, neighboring municipalities and counties, the National Park Service, and additional stakeholders. The committee orchestrates events that serve as catalysts for heightened awareness, stewardship, and education concerning the river. Next, the Regional Stormwater Advisory Committee (RCSWAC) includes members from the same cities, counties, and agencies. They discuss current needs for floodplain management and infrastructure projects related to stormwater, along with state and federally mandated stormwater requirements (City of Roanoke, 2018). Last, the Regional Pre-Disaster Mitigation Planning Committee engages with the City of Salem and various other local entities, all dedicated to ensuring their residents are well-informed and equipped to face natural disasters through hazard mitigation strategies. This committee wrote the 2019 Regional Hazard Mitigation Plan, which provided valuable insights on flooding concerns throughout the region (Roanoke Valley-Alleghany Regional Commission, 2019).

Salem has been involved with the Clean Valley Council since 2018, occupying a single position on the Council's Boards of Directors. This council also includes representatives from the City of Roanoke, Town of Vinton, Botetourt County, and Roanoke County. Since the council's inception in 1978, a primary objective has been combating litter through citizen engagement and educational initiatives within the Roanoke Valley and nearby regions. Over time, this mission has expanded to encompass the protection of our waters from impairment and pollution for the availability and prosperity of the community (Clean Valley Council, n.d.).

3.1.2 Community Education

As a member of the Clean Valley Council, Salem helps facilitate watershed stewardship and educational activities. At least two events are held every year in which volunteers help remove litter from local roads and waterways. Stream School Seminars are offered to help identify high priority stormwater issues and encourage participants to take action to mitigate negative impacts (City of Salem, 2018). A storm drain stencil marking initiative mobilizes volunteers in hands-on stenciling tasks on drainage inlets, effectively enhancing public awareness and participation. A quarterly Stormwater Newsletter publication informs citizens about excess sediment, pollution prevention, and stormwater events and activities (City of Salem, 2022). Salem also has a

Stormwater Comment form online where citizens can submit comments or questions regarding stormwater management. Further, Salem recognizes Virginia Flood Awareness week on their blog and website, describing the purpose of the week with information on flood risk and flood insurance. Here, Virginians can learn about the different types of potential flood risks, flood insurance eligibility, and find contact information for flood insurances agents (City of Salem, 2020).

Salem's Emergency Alert Program allows citizens to sign up to receive emergency messages with critical information. Alerts about emergencies, such as severe weather, road closures and building/neighborhood evacuations, are sent to a person's choice mode of communication (Everbridge, n.d.).

3.1.3 Public Meetings

Public meetings provide Salem citizens an opportunity to openly discuss issues that arise during the planning process. From 2001 to 2012, seven community-wide meetings were held to discuss zoning, land use, government services, education, community appearance, open space, and infrastructure. Some of these discussions turned into initiatives or led to partnerships charged with planning environmental education, stormwater management, and flood reduction facilities and programs. Many of these initiatives were then recommended to City Council for adoption in June 2012.

During the creation of the Downtown Plan (2016), much effort was made to inform citizens of the upcoming meetings that would be held through Salems website, flyers, and mailed notices. Multiple meetings were arranged, and on January 20, 2015, an open house was held, providing a forum for the more than 100 attendees to provide input. The City incorporated some of this input into the Downtown Plan. In regard to flood resilience, for example, the public's concern over the lack of tree canopy led to the planting of additional trees.

3.2 City Plans & Ordinances

Several Salem planning documents touch on flood resilience, namely the City of Salem Comprehensive Plan (2012), Downtown Plan (2016), Capital Improvement Plan (2023), and TMDL Action Plans. Objectives within these plans focus on stormwater infrastructure and capital improvements, enhanced tree canopy, and stormwater management. Shown in **Table 3** are the four themes and objectives in Salem's Comprehensive Plan, serving as a call to implement specific flood resilience measures.

Table 3: Comprehensive Plan Themes and Objectives that Increase Flood Resiliency

Themes	Objectives
Government Services	• Expand and improve the use of technology in the dissemination of information to the citizens of Salem. • Provide effective, timely, and efficient emergency response to all areas of the City of Salem in a fiscally responsible manner. • As part of the development plan review process, ensure that all structures and land uses comply with the City's floodplain and stormwater management regulations. • Work with neighboring jurisdictions on regional stormwater detention and flood reduction facilities and programs. • Using available state and federal funding, continue to purchase homes within designated floodplains. • Strive to lower the environmental impact of construction by exploring ways to encourage developers to use environmentally friendly (green) construction techniques on City projects.
Land Use and Community Appearance	• Expand the specimen list of trees in the Urban Forest Overlay District to include more native species and extend canopy tree requirements to all development. • Work to preserve existing riparian areas along the Roanoke River where appropriate by installing native plantings and reconsider land management practices such as mowing and other activities.
Open Space	• Consider adopting zoning amendments that provide developers density and other incentives in exchange for the permanent preservation of open space areas incorporated as part of new development. • Develop a plan for maintenance and improvement of the Greenway system in Salem through the capital improvement budget and maintenance for riparian areas along the Greenway.
Transportation and Infrastructure	• Continue to manage the City's urban forest by providing services such as maintenance pruning, hazard removal, replacement planting, new tree installation, fertilization, and pest control. • Continue to improve, monitor, maintain, and repair all streets, curbs, gutters, storm drains, sidewalks, and driveway entrances along public roadways.

Salem's Downtown Plan and Capital Improvement Plan play an important role in informing Salem's current and future flood resilience efforts, as follows:

- **Downtown Plan (2016)** – Salem adopted the Downtown Plan in 2016 which informs its citizens on ten themes with goals and strategies to improve Downtown Salem. The plan discusses how, over time, Salem's mature trees have been removed and replaced with attractive but not useful trees. Instead of large stable trees that take considerable time to grow, smaller less stable trees are preferred due to their ability to grow much faster.

However, these smaller trees often lack the tree cover needed to reduce the Urban Heat Island effect, a known cause of increased precipitation in cities. To help alleviate this effect, the Plan calls for the planting of additional trees and green spaces in Salem's downtown area.

- **Capital Improvement Plan (2023)** –Salem's Capital Improvement Plan (CIP) includes short and long-term financial planning for the capital needs of the City. Salem has budgets for projects that will provide flood mitigation and stormwater management, including storm sewer upgrades, culvert replacements, greenway construction, stormwater ponds construction, and storm drain upgrades and expansions.

Salem Ordinances

To ensure citizens' safety and protect against flooding, Salem continues to examine ordinances to find support for additional flood mitigation and prevention. Ordinances most relevant to flood resilience are listed in **Table 4**, as these include flood mitigation provisions for floodplain management, stormwater management, and impervious surfaces.

Table 4: Ordinances Regarding Flood Resilience

Ordinance Citation	City of Salem Ordinance
Chapter 106 – Zoning, Article II., Sec. 106-226	Floodplain Overlay District (FOD)
Chapter 30 – Environment, Article IV. – Stormwater Management	Stormwater Management
Chapter 106 – Zoning, Article II., Sec. 106-230	Urban Forest Overlay District
Chapter 106 – Zoning, Article IV., Sec. 106-402	Buffer Yards, Screening, and Landscaping
Chapter 106 – Zoning, Article IV., Sec. 106-404	Off-street Parking Requirements

The Floodplain Overlay District Ordinance was adopted in 1993 and revised in 2007 for the purpose of providing safety and protection from flooding. The ordinance aims to prevent health and safety hazards, the loss of property and life, and the extraordinary and unnecessary expenditure of public funds for flood protection and relief by:

- restricting the unwise use, development and occupancy of lands subject to inundation;
- regulating activities and development which will cause unacceptable increases in flood heights, velocities and frequencies;
- requiring all activities and developments that occur in a flood prone area to be protected and/or flood proofed; and
- protecting individuals from purchasing land and structures that are unviable for intended uses because of flood hazards.

The ordinance also requires the lowest floor elevation of any new residential structure, non-residential structure, or ‘substantial improvements’ to existing buildings constructed within a floodplain to be at least one foot above base flood elevation or floodproofed to a minimum of one foot above the base flood elevation. Substantial improvements are considered any modification, alteration, repair, or reconstruction to an existing structure to an extent or amount of less than 50 percent of its market value. Existing structures and/or uses located in floodways shall not be expanded or enlarged unless the effect of the proposed expansion or enlargement on flood heights is fully offset by accompanying improvements. This enables Salem to be more resilient by managing citizens safety and flood damage in high-risk areas.

Similarly, the purpose of the Stormwater Management Ordinance is to protect properties and the general health and safety of the public from flooding and stormwater pollution. To do this, the ordinance requires developers to control the amount and quality of stormwater leaving a construction site and flowing into nearby water resources. BMPs are installed to reduce the magnitude and frequency of flooding, thus preventing siltation, stream bank erosion, and property damage that often accompanies a flood. To prevent damage to downstream properties, the city requires developers to prevent land disturbance activities from increasing stormwater runoff velocity, frequency, duration, and peak flow rate.

In addition to BMPs, Salem recognizes that a healthy tree canopy, a nature-based solution, is effective at flood prevention, as trees absorb stormwater through their leaves, branches, and root zones. Salem’s Urban Forest Overlay District Ordinance **(Figure 9)** helps protect the City’s tree canopy, requiring developers to plant at least one tree per acre from the approved species list shown in **Figure 10**. All approved trees must have a minimum diameter of three inches, be locally adapted to the area, and be replaced immediately by the owner if the tree is unhealthy, misshapen, or dead. The preservation of appropriate, already existing trees is encouraged and may be required if they are deemed critical for managing stormwater.

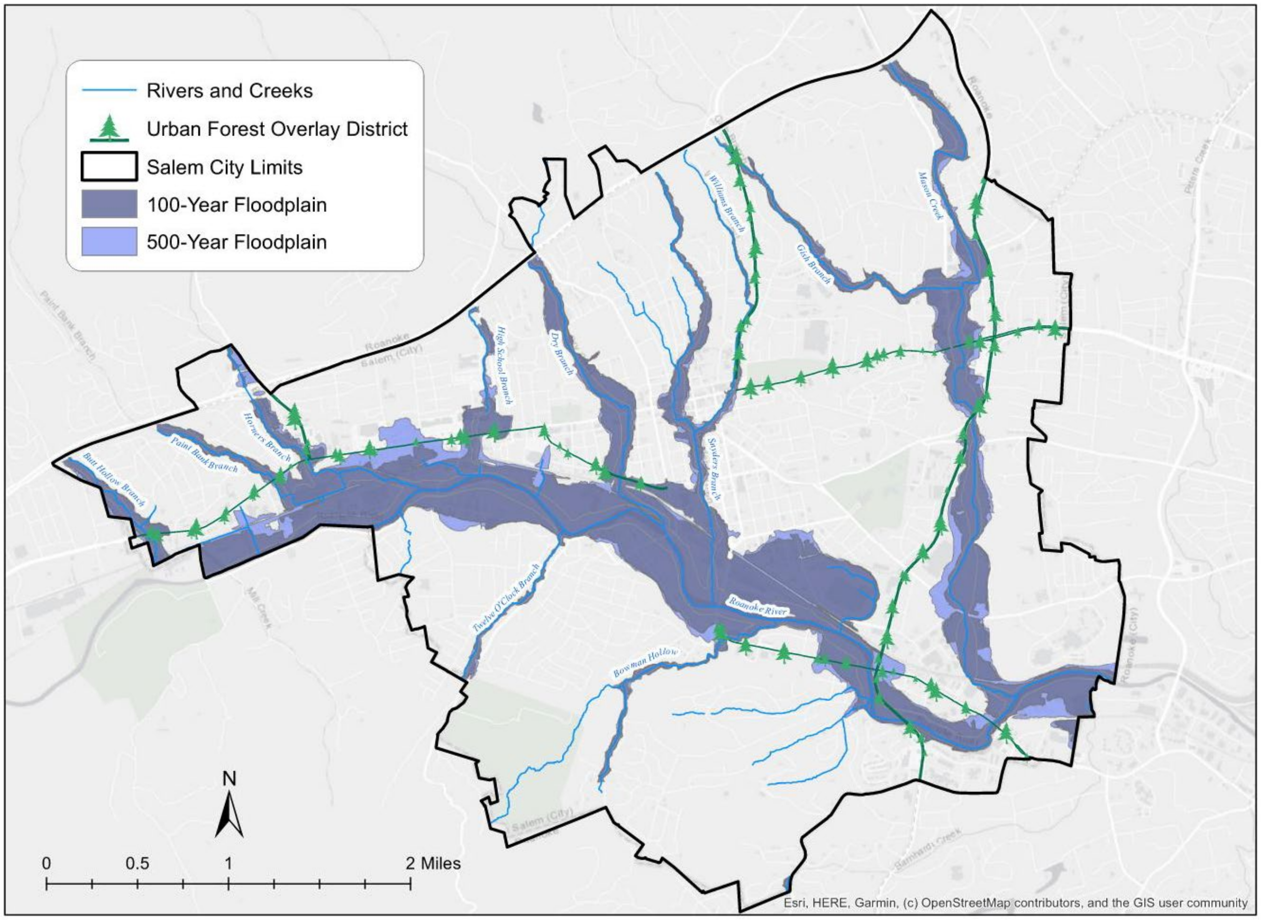


Figure 9: Salem's Urban Forest Overlay District

Approved Trees: (NOTE: pH and soil samples are strongly recommended before selecting a particular species.)

Interior Parking Lots	Size at Maturity	Shape
As required under 106-203.5 A1.		
'Regal' Elm	55' tall x 30' wide	Pyramidal
'Allee' Elm	60' tall x 50' wide	Vase
'Regal' Elm	55' tall x 30' wide	Pyramidal
'Autumn Blaze' Maple	50' tall x 40' wide	Oval
'Red Sunset' Maple	50' tall x 40' wide	Oval
'Armstrong' Maple	60' tall x 15' wide	Fastigiated
Pin Oak	70' tall x 40' wide	Pyramidal
Willow Oak	60' tall x 40' wide	Pyramidal
'Green Vase' Zelkova serrata	65' tall x 45' wide	Vase

Roadside Planting Strips	Size at Maturity	Shape
As required under 106-203.5 A2.		
Redbud	25' tall x 25' wide	rounded
Serviceberry varieties	20' tall x 15' wide	Oval
Star Magnolia	20' tall x 20' wide	Pyramidal
Hedge maples	35' tall x 30' wide	Oval
'Winter King' Hawthorn	20' tall x 20' wide	Pyramidal
Disease resistant crabapple varieties	20' tall x 20' wide	rounded
Crepe Myrtle	20' tall x 20' wide	Vase
Snowgoose Cherry	20' tall x 20' wide	oval
Yoshino Cherry	35' tall x 35' wide	rounded
Kwanzan cherry	35' tall x 35' wide	Vase

Figure 10: Salem's Approved Tree Species

The Buffer Yards, Screening, and Landscaping ordinance increases the City's flood resilience by requiring interior landscaping in parking lots to reduce the ratio of greenspace to impervious area. Requirements include having at least one deciduous shade tree for every ten parking spaces, a continuous vegetative strip installed between every four rows of parking, large planting islands (over 200 square feet) at the end of parking rows, and planting islands required between every 15 parking spaces to avoid long rows of parked cars. These measures improve stormwater quality and slow the velocity of flood waters.

Impervious surfaces are also regulated in the Off-street Parking Requirements ordinance, as it considers the stormwater quality and quantity impacts of adding impervious parking areas. The city engineer can require a developer to use certain paving surfaces and/or construction techniques (e.g., porous-type asphalt paving, detention basins) to minimize surface stormwater runoff if necessary. In combination, these ordinances and mitigations measures help reduce flooding and the associated damage throughout the City of Salem.

3.3 Federal, State, and Local Programs

The City of Salem has implemented federal, state, and local programs aimed at protecting and improving the well-being of citizens, infrastructure, and the environment. The programs often incorporate flood resiliency objectives, particularly as society gains an increased understanding of the real impacts of heavier participation and storm events on people, natural landscapes, and the built environment. The following demonstrates the intersect between federal, state, and local programs and Salem's efforts to increase flood resiliency.

3.3.1 FEMA National Flood Insurance Program

The City of Salem participates in FEMA's National Flood Insurance Program, which allows property owners to purchase federally backed flood insurance at discounted rates (City of Salem, n.d.). The program was created and developed through an evolving series of acts from 1968 – 2004, accessible through the FEMA.gov website under Laws and Regulations. The program requires that Salem's floodplain management regulations meet and enforce federal requirements and regulations (Roanoke Valley-Alleghany Regional Commission, 2019). This includes assisting in the preparation and revision of floodplain maps, regulating development in the mapped floodplains, maintaining records of floodplain development, and assisting residents in obtaining information on flood hazards, floodplain map data, flood insurance, and proper construction measures (FEMA, 2005). If Salem's Department of Community Development determines that a property is located within the floodplain, the owners are required to obtain an NFIP insurance policy, and Salem currently provides 523 NFIP policies to city residents (City of Salem, n.d). Funding from the federal Flood Mitigation Assistance Grant Program would help further reduce or remove the risk of repetitive flood damage to properties insured by NFIP (FEMA, 2023).

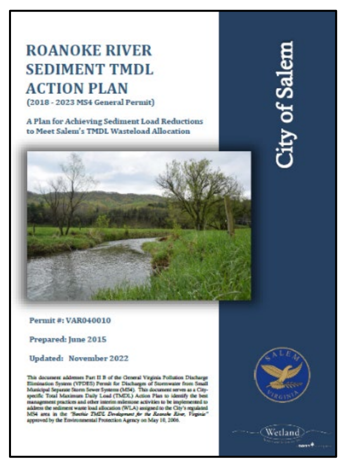
3.3.2 IFLOWS

To prepare for a severe flood event, Salem participates in an Integrated Flood Observing and Warning System (IFLOWS) (Roanoke Valley-Alleghany Regional Commission, 2019). IFLOWS was developed by the National Weather Service to issue the earliest possible notification of an approaching flash flood. Radio-transmitted information from strategically placed rain gauges send advanced flood forecast reports to the City Emergency Operation Center, so city officials have as much time as possible to warn the public of an impending flood. There is currently one active IFLOW station in Salem.

3.3.3 MS4

As a regulated small municipal separate storm sewer system (MS4), the City of Salem is obligated to meet the requirements of the MS4 General Permit. The MS4 Permit is issued through Virginia's Stormwater Management Program (VSMP) regulations, which is administered at the state level by the Virginia Department of Environmental Quality (DEQ) (City of Salem, 2020). The VSMP requires compliance with state-issued criteria aimed at flooding, water quality, and stream channel erosion prevention. To prevent excessive flooding, Salem relies on ordinances, permits, orders, specific contract language, and interjectional agreements to regulate construction site stormwater runoff (General VPDES Permit, 2005). Post-construction runoff quantity and quality is also managed through the implementation of the Virginia Stormwater Management Program. For example, inspections of all stormwater facilities are required annually or after any storm event that exceeds the emergency spillway, which is an emergency exit for stormwater when a flood event occurs, and water level exceeds the facilities capacity (City of Salem, 2020). The inspections document the state of each component within the facility and any maintenance actions required, so the facility can properly collect the correct volume of stormwater. Routine maintenance helps ensure failure of a stormwater BMP does not cause downstream flooding. This is done in accordance with the MS4 Permit and enforced by Salem through the Post-Construction Stormwater Management program, a series of written procedures that ensure adequate long-term operation and maintenance of BMPs for the City (City of Salem, 2020).

Salem is required by the MS4 permit to develop Total Maximum Daily Load (TMDL) Action Plans, aimed at reducing the discharge of bacteria, sediment, and PCBs into nearby waterways (General VPDES Permit, 2005). To meet water quality standards, the plans outline a set of reduction goals and specific programs and projects for achieving those goals (EPA, 2022). The TMDL Action Plans also describe programmatic BMPs, such as community storm sewer inspections, city-wide trash clean ups, and the public education partnership with Clean Valley Council, all help raise awareness of the importance of water quality protection and flood prevention (City of Salem, 2021).



3.4 Regional Efforts & Partners

The City of Salem is committed to working with regional partners on flood resilience and mitigation plans and projects. As a contributing member of the Roanoke Valley Alleghany Planning Commission (RVAPC), Salem has helped prepare the Roanoke Valley – Alleghany Regional (RVAR) Hazard Mitigation Plan (2019), Roanoke Valley Regional Stormwater Management Plan (RVR SMP) (Dewberry & Davis, 1997), Roanoke Valley Greenway Plan (2018), Urban Tree Canopy Analysis for the Roanoke Valley (2010) and the Roanoke Valley-Alleghany Planning Region Local Wildlife Action Plan (2015). The contributions of the greenway, tree analysis, and wildlife plans to resiliency are discussed in **Section 3.6 - Environmental Assets.** The RVAR Hazard Mitigation Plan has several recommendations pertinent to flood resiliency, organized around five goals and strategies to achieve each goal, detailed below.

GOAL #1: Mitigation of loss of life and property from flooding and flood related disasters.

Strategies:

- In cooperation with local governments, support a comprehensive public information and education program on flooding, living in the floodplain, flood risks, low-cost simple flood mitigation measures, flood insurance, stream remediation, hydrology, floodplain ordinances, and NFIP.
- Develop and maintain an inventory of flood prone roadways in cooperation with the Virginia Department of Transportation.
- Develop and maintain an inventory of flood prone critical facilities such as hospitals, public utility sites, airports, etc.
- Participate in FEMA Hazard Mitigation Programs such as SRL, FMA, PDM, RCL, and HMGP for acquisition/demolition projects, structure elevation, relocation, mitigation reconstruction, flood-proofing critical facilities, flood-proofing commercial facilities, infrastructure upgrades, and technology upgrades.
- Participate in, and remain in good standing with, the National Flood Insurance Program by enforcing floodplain management regulations that meet federal requirements.
- Acquisition of flood prone properties followed by the appropriate mitigation action of flood-proofing, demolition, or relocation.
- Soil stabilization along rivers, creeks, and streams to prevent undercutting of roads from erosion due to flooding.

GOAL #2: Update existing GIS data layers related to natural hazards.

Strategies:

- Consider seeking funding and support programs that update FEMA's Flood Insurance Rate Maps (FIRM). Consider participation in FEMA's Cooperating Technical Partners (CTP) program that establishes partners with local jurisdictions to develop and maintain up-to-date flood maps. RVAR Regional Hazard Mitigation Plan 252
- Utilize GIS to inventory at risk infrastructure and public and private structures within flood prone areas.
- Participate in FEMA's Digital Flood Insurance Rate Maps (DFIRM) program.
- Support FIRM remapping projects that address areas in the region that have the most serious mapping problems and where flooding is a repetitive problem.
- Use HEC-GeoRAS, HEC-GeoHMS, and HAZUS software to model potential flood scenarios and identify high-hazard areas.
- Annual review of floodplain ordinances and make any necessary changes to remain in compliance with NFIP regulations.

GOAL #3: Provide early warning of flooding.

Strategies:

- Identify areas with recurring flood problems and request additional IFLOW stream/rain gauges as appropriate to ensure that these areas are adequately covered and monitored.
- Identify areas with recurring flood problems and incorporate the addresses and phone numbers into an early warning database, specifically the Reverse 911 system.

GOAL #4: Identification of structural projects that could mitigate the impact of flooding.

Strategies:

- Consider seeking funding to prepare site-specific hydrologic and hydraulic studies that look at areas that have chronic and repetitive flooding problems.
- Support Virginia Department of Transportation projects that call for improved ditching, replacement of inadequate and undersized culverts, enlargements of bridge openings and drainage piping needed to minimize flooding.
- Identify congested streams and remove debris to enhance flow and mitigate flooding.

GOAL #5: Maintain an accurate database and map of repetitive loss properties.

Strategies:

- Work with VDEM and FEMA to update list of repetitive loss properties annually.
- Obtain updated list of repetitive loss properties annually from VDEM/FEMA.
- Review property addresses for accuracy and make necessary corrections.
- Determine if and by what means each property has been mitigated.
- Map properties to show general site locations (not parcel specific in order to maintain anonymity of the property owners).
- Determine if properties have been mitigated and inform FEMA/VDEM through submission of an updated list/database and mapping.

Adding to the list, the RVR SMP proposes the following mitigation solutions for Salem: clear stream channels, enlarge drainage openings, construct regional detention facilities, and floodproof individual structures. The full list of Salem's Hazard Mitigation Projects in need of State and Federal Assistance is included in **Appendix X**. With such a long list of potential solutions often expensive to implement, projects must be prioritized. The RVAR Hazard Mitigation Plan recommends scoring projects based on benefit-to-cost criteria, mitigating potential, availability of funding, technical capability, and project feasibility. To help fund these projects, the RVR SMP encourages localities to charge a regional stormwater utility fee.

3.5 Engineered Defenses

Engineered stormwater facilities are the gray infrastructure measures used to prevent heavy runoff volume and velocity during and following a precipitation or storm event. Salem has 134 stormwater facilities currently installed throughout the City, including detention, retention, infiltration, bioretention, underground detention system (UGDS), manufactured, and permeable pavement. Due to the anticipated increase in rainfall, citizens need to gain an increased understanding of where these BMPs are located and how they function, before considering potential modifications needed to boost flood resilience. Therefore, the BMP map shown below in **Figure 11** is accompanied by an explanation of these BMP types and the key components of each.

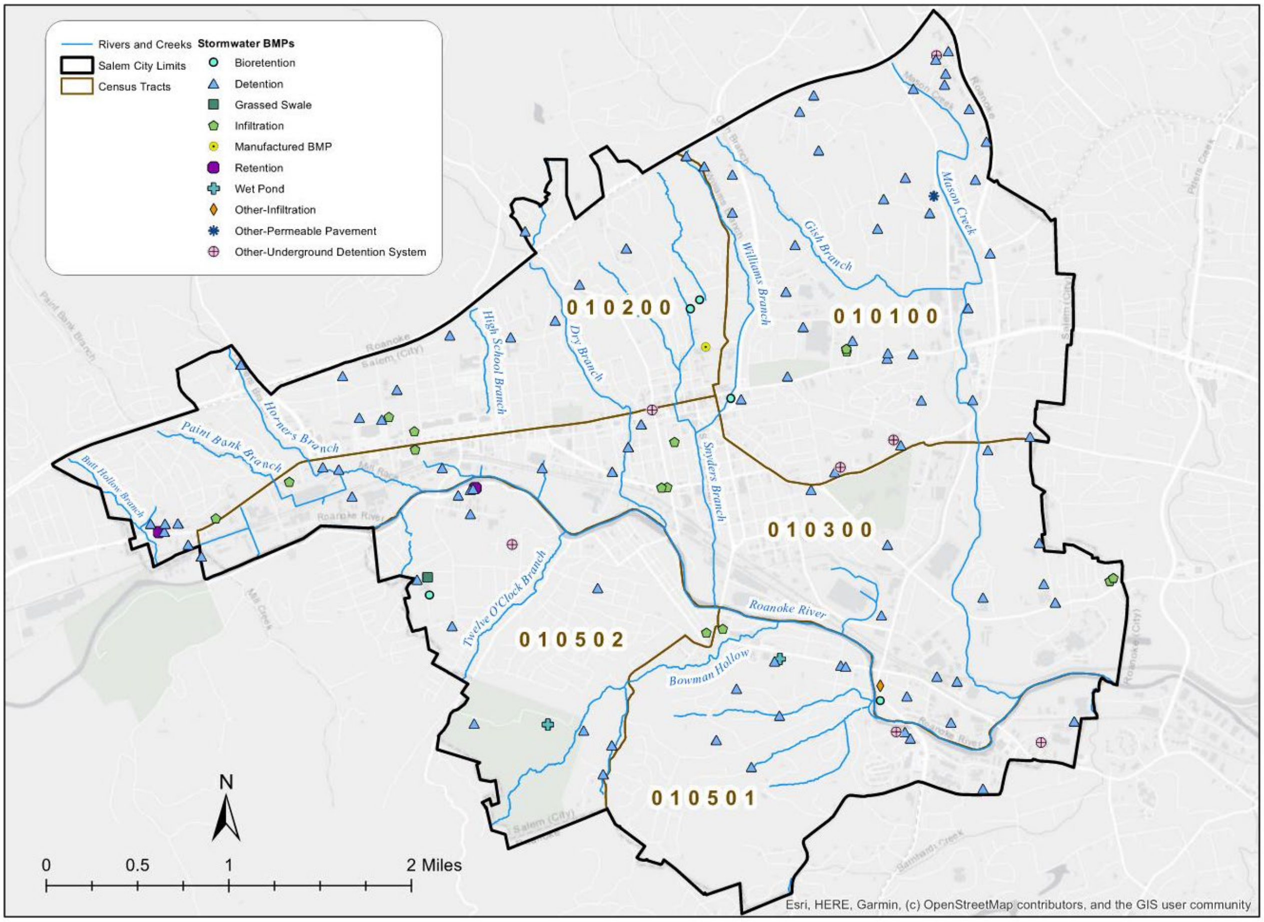


Figure 11: Salem's Stormwater BMPs

3.5.1 Detention

This City of Salem has 89 detention facilities, with 37 flowing into Mason Creek and 52 into the Roanoke River. Six detention facilities are scheduled to come online in the future to treat stormwater before discharging into the Roanoke River. They are currently in the planning phase or under construction.

Detention basins have at least one inflow channel, an embankment/dam, a bottom-level orifice, a principal spillway structure to route drainage through the dam, and an outlet structure (**Figure 12**). These basins do not have a normal pool and remain dry except during and shortly after storm events. Some extended detention facilities may have a wet marsh with plantings in the bottom for additional pollutant removal. On rare occasions, the extended detention basin may be designed to have a wet normal pool. If a plan does not indicate a wet marsh or normal pool elevation, the constant pool of water may be due to blockage that needs to be removed to ensure functionality.

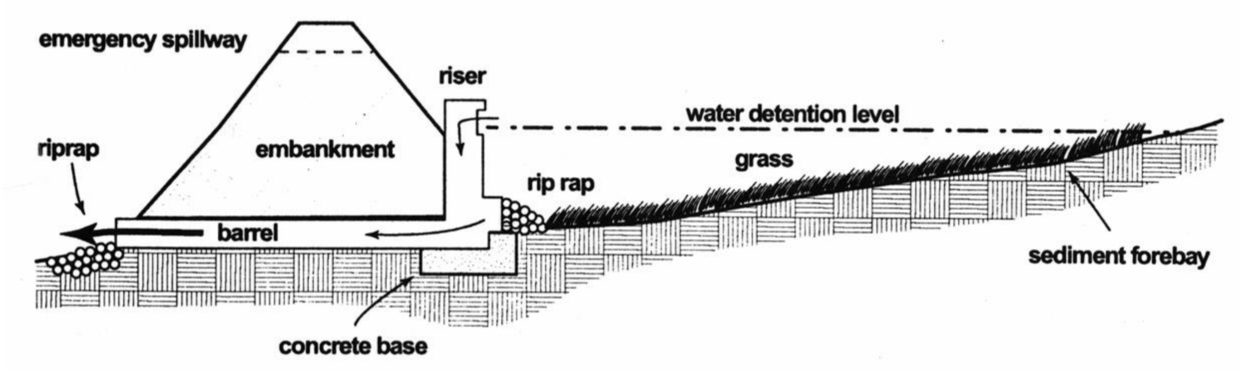


Figure 12: Typical Dry Detention Basin Section

3.5.2 Retention

Salem has four retention basins, often referred to as wet ponds, that slowly discharge filtered stormwater into the Roanoke River. Retention basins have at least one inflow channel, an embankment/dam, a principal spillway structure to route the drainage through the embankment, and an outlet structure (**Figure 13**). Wet ponds consist of a permanent pool of standing water that promotes pollution removal and reduces flooding. In drought conditions, retention basins can also mimic dry facilities. Runoff from each storm enters the pond and raises the normal water level, and the outlet structure releases the drainage at a slower rate over a longer period. This "draw down" or holding time allows pollutants to settle out of the stormwater and lessens the impact of the flow volume on the outlet channel.

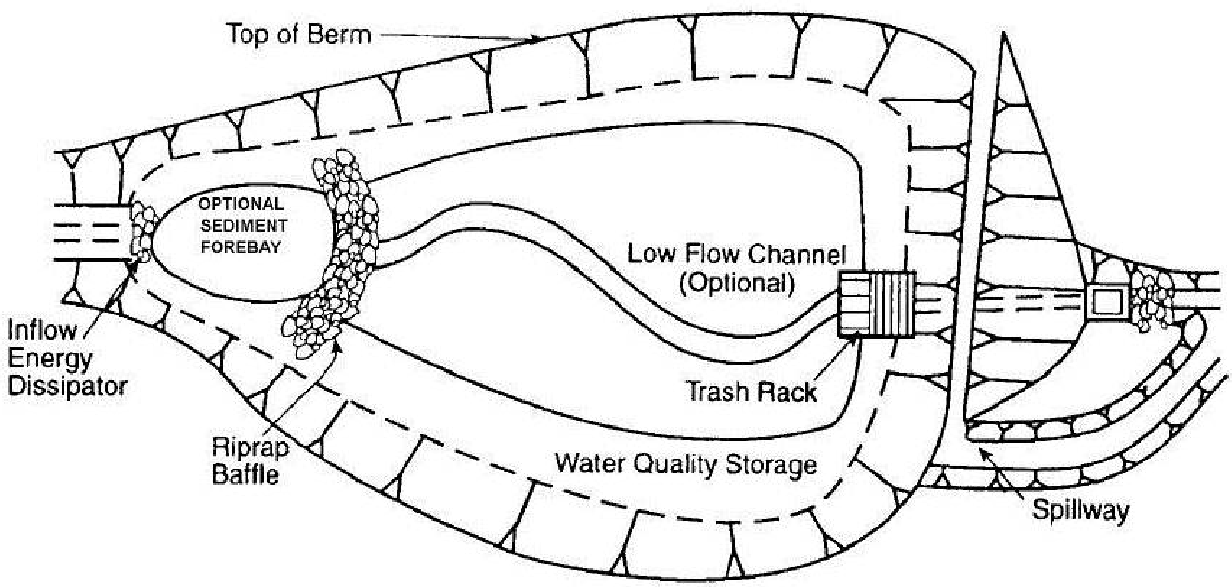
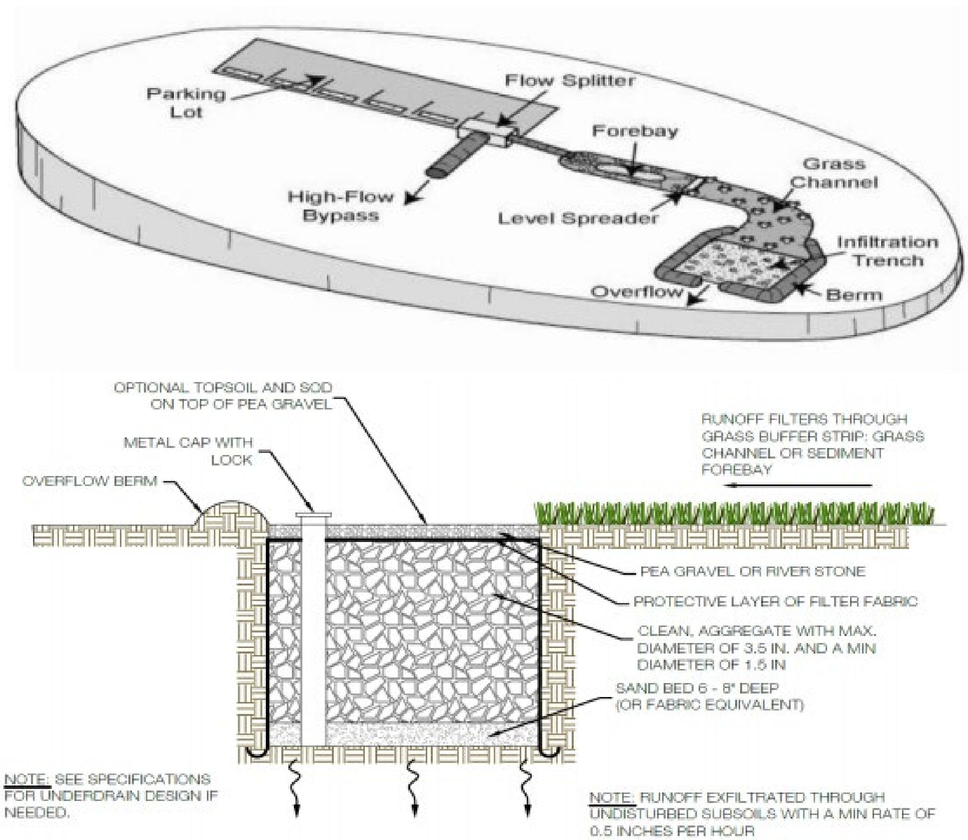


Figure 13: Typical Retention Facility Plan

3.5.3 Infiltration

Salem has sixteen infiltration measures installed, with four draining to Mason Creek and twelve to the Roanoke River. Infiltration practices utilize temporary surface or underground storage that allows the incoming stormwater runoff to settle into underlying soils (**Figure 14**). Typically, the runoff will first pass through pretreatment mechanisms to trap sediment and organic matter before it reaches the practice and then settles into the underlying soils. As stormwater penetrates the underlying soil, chemical and physical adsorption processes will remove pollutants. Infiltration practices come in many types such as rain gardens, infiltration trenches, vegetated swales, porous pavement, and others.



Source: http://www.vwrrc.vt.edu/swc/documents/2013/DEQ%20BMP%20Spec%20No%208_INFILTRATION_Final%20Draft_v1-9_03012011.pdf

Figure 14: Possible Infiltration Facility Section

3.5.4 Bioretention

Salem has five bioretention areas draining to the Roanoke River. Bioretention facilities are shallow landscaped depressions that incorporate many of the pollutant removal mechanisms that operate in our natural environment (**Figure 15**). The primary component of a bioretention practice is the filter bed, which has a mixture of sand, soil, and organic material as the filtering media in the ground with a surface mulch layer. During storms, runoff temporarily ponds 6 to 12 inches above the mulch layer and then rapidly filters through the bed. Normally, the filtered runoff is collected in an underdrain and returned to the storm drain system or receiving channel. The underdrain consists of a perforated pipe in a gravel layer installed along the bottom of the filter bed. Bioretention facilities can also be designed to infiltrate runoff into native soils without an underdrain. This can be done at sites with permeable soils, a low groundwater table, and a low risk of groundwater contamination. The second most critical component of bioretention facilities is the landscaping plan and plantings. The plantings are designed specifically for the site and facility and they remove and store pollution. Small residential applications of bioretention are termed rain gardens.

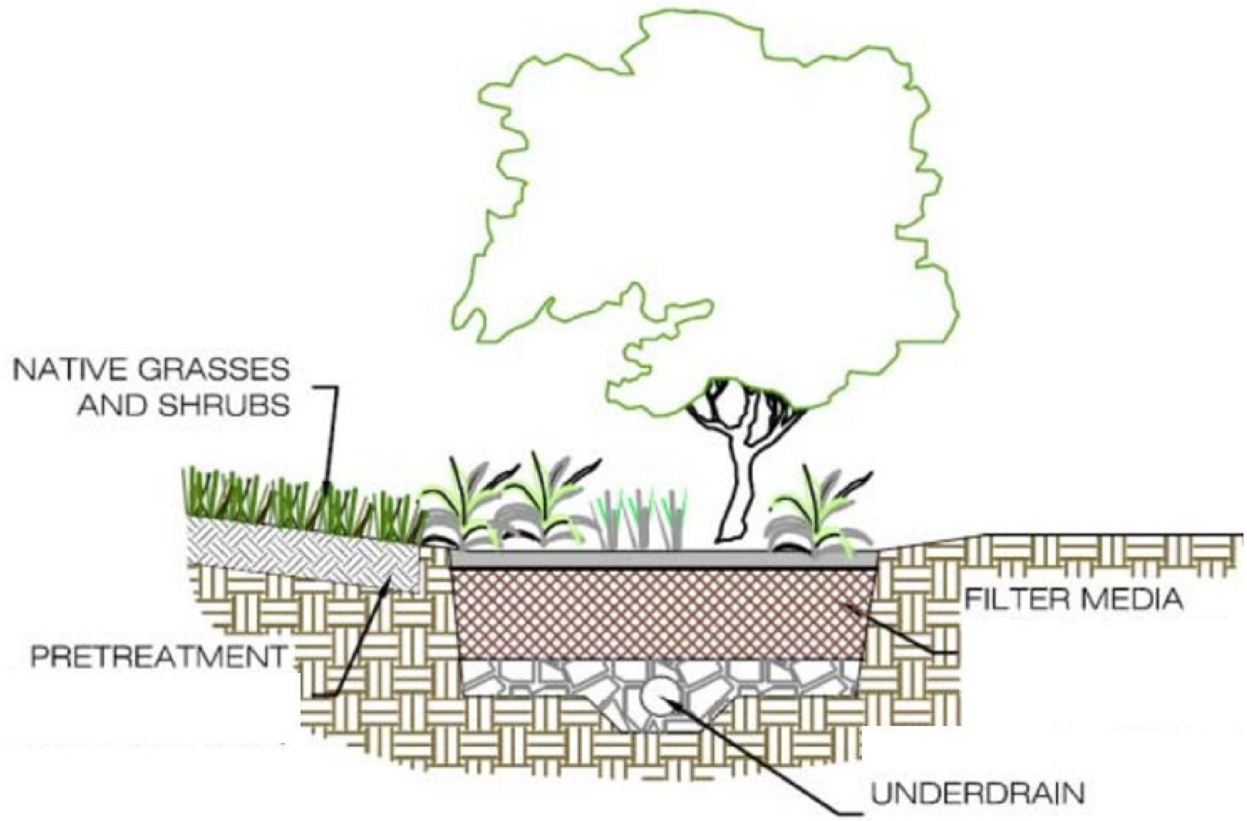


Figure 15: Typical Bioretention Facility Schematic

3.5.5 UGDS

There are seven underground detention systems installed in the City of Salem. Three UGDS drain to Mason Creek, and four discharge to the Roanoke River. Underground detention facilities, such as vaults, pipes, tanks, and other subsurface structures, are designed to temporarily store stormwater runoff for water quantity control (**Figure 16**). StormTech®, an underground stormwater chamber system, is an intricate engineered system comprised of polypropylene chambers, aggregate, geotextile, and geomembrane. Together, they collect rainwater, separate sediment material, and allow clean water to percolate into the ground. When it rains, water enters the system through a catch basin and is directed to an isolation area where sediment is flushed. As the water rises, it flows out of the isolation area into adjacent chambers where it passes through fabric and flows back into the ground. The Isolator Row is a row or rows of StormTech thermoplastic chambers that are wrapped in filter fabric and installed below grade. Stormwater enters the chambers and must pass through the filter fabric media where sediments and other contaminants are filtered out as stormwater exits the Isolator Row through the fabric.

Some of the unique features of the Isolator Row that contribute to its effectiveness and practicality include:

- Vast filtration area – each chamber has a large surface area which permits filtration of stormwater through the bottom filter fabric
- Large sediment storage volume
- Entire bottom area accessible for cleaning without obstructions within the row
- A state-of-the-art structural design that meets AASHTO safety factors for both live loads and permanent dead loads

Figure 16: Typical UGDS

3.5.6 Manufactured

There is one manufactured hydrodynamic device draining to the Roanoke River. This manufactured facility is a proprietary system guiding stormwater into a separation chamber where water velocities create a swirling vortex (**Figure 17**). The swirling vortex forces floatables and solids to the center of the separation chamber and sediment settles into an isolated sump. All pollutants remain in these sections of the unit until removed during maintenance. Treated water exits the system. The Stormwater Management StormFilter® is an underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff, such as total suspended solids, hydrocarbons, nutrients, metals, and other common pollutants. The process for treating stormwater in this manufactured device is as follows:

- During a storm, runoff passes through the filtration media and starts filling the cartridge center tube. The air inside the hood is purged through a one-way check valve as the water rises.

- When water reaches the top of the float, buoyant forces pull the float free and allow filtered water to exit the cartridge. A siphon is established within each cartridge that draws water uniformly across the full height of the media bed ensuring even distribution of pollutants and prolonged media longevity.

- After the storm, the water level in the structure starts falling. A hanging water column remains under the cartridge hood until the water level reaches the scrubbing regulators at the bottom of the hood.
- Air then rushes through the regulators, breaking the siphon and creating air bubbles that agitate the surface of the filter media, causing accumulated sediment to settle on the treatment bay floor. This unique surface-cleaning mechanism prevents surface blinding and further extends cartridge life.

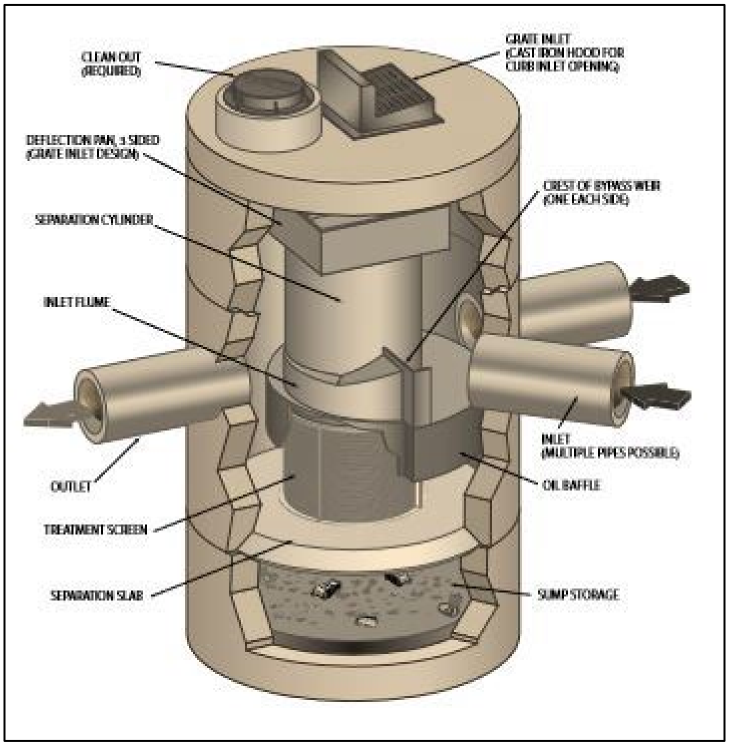


Figure 17: Typical CDS Schematic

3.5.7 Permeable Pavement

There is one area of permeable pavement installed at the Parkway Brewery, draining to Mason Creek. Permeable pavements are alternative paving surfaces that allow stormwater runoff to filter through voids in the pavement surface into an underlying stone reservoir, where it is temporarily stored and/or infiltrated. A variety of permeable pavement surfaces are available, including pervious concrete, porous asphalt, and permeable interlocking concrete pavers. While the specific design may vary, all permeable pavements have a similar structure, consisting of a surface pavement layer, an underlying stone aggregate reservoir layer, and a filter layer or fabric installed on the bottom (See **Figure 18** below). The reservoir layer serves to retain stormwater and supports the design traffic loads for the pavement. In low-infiltration soils, some or all of the filtered runoff is collected in an underdrain and returned to the storm drain system. If infiltration rates in the native soils permit, permeable pavement can be designed without an underdrain to enable full infiltration of runoff. The major role of permeable pavement is to maximize nutrient removal and runoff reduction. Careful sediment and small debris control is required to avoid clogging.

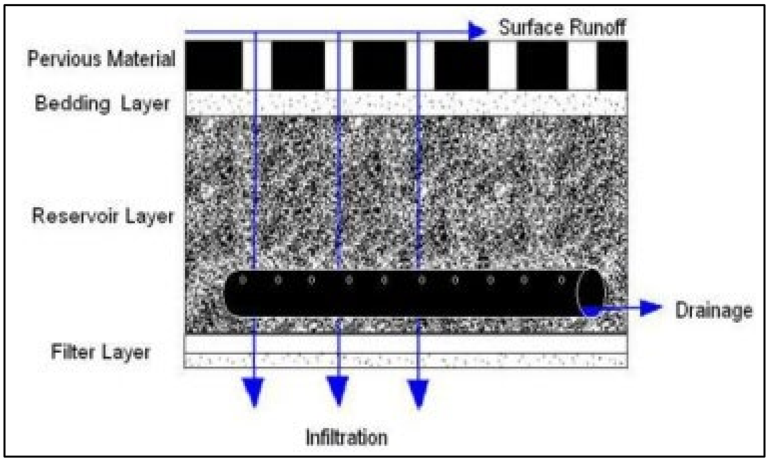


Figure 18: Typical Permeable Pavement Section

3.6 Environmental Assets

Environmental assets, such as healthy streams and forests, are natural resources that can help communities become more resilient to extreme weather events and other environmental hazards. The City of Salem's environmental assets have been expanded and preserved through a network of public and private stakeholders. Given the rising and often conflicting calls for both economic growth and flood resilience, Salem works to balance the ongoing protection and maintenance of existing assets with new development. The subsections below describe the environmental assets in Salem that reduce vulnerability to flooding and can be used to increase community resilience.

3.6.1 Forests & Trees

Salem's forests and trees play a central role in flood protection. Playing an active role in the water cycle, the tree canopy intercepts and slows down rain before hitting the ground, while allowing time for some of the water to evaporate back into the atmosphere. The root systems help water penetrate deep into the soil at a fast rate, reducing surface run-off and increasing water storage in the soil under and around trees. Illustrated in **Figure 19**, unlike open fields or impervious surfaces such as parking lots, trees release water more gradually into surface waters, significantly reducing the pace of water discharge and its potential to cause floods. Forested tracts of riparian corridors help control stormwater and reduce flooding from adjacent water bodies, and native tree and shrub species can be used in maintenance and restoration efforts to boost resilience (Virginia Department of Game and Inland Fisheries, 2015).

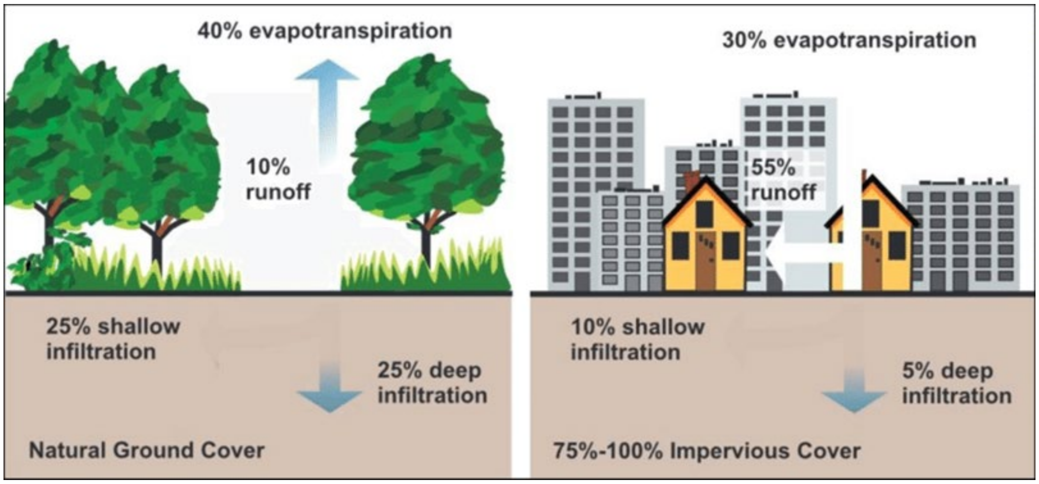


Figure 19: Relationship between Natural Features and Impervious Cover with Surface Runoff (EPA, 2003)

Shown in **Figure 20**, an estimated 3,722 acres in Salem are currently covered by tree canopy (i.e., Existing urban tree canopy (UTC)), accounting for 40.1% of the City's entire land area cover (Roanoke Valley-Alleghany Regional Commission et al., 2010), whereas **Figure 21** shows an estimated 3,853 acres could potentially accommodate additional urban tree canopy (i.e., Possible UTC). The findings provide a baseline for effectively managing and tracking changes in tree canopy coverage.

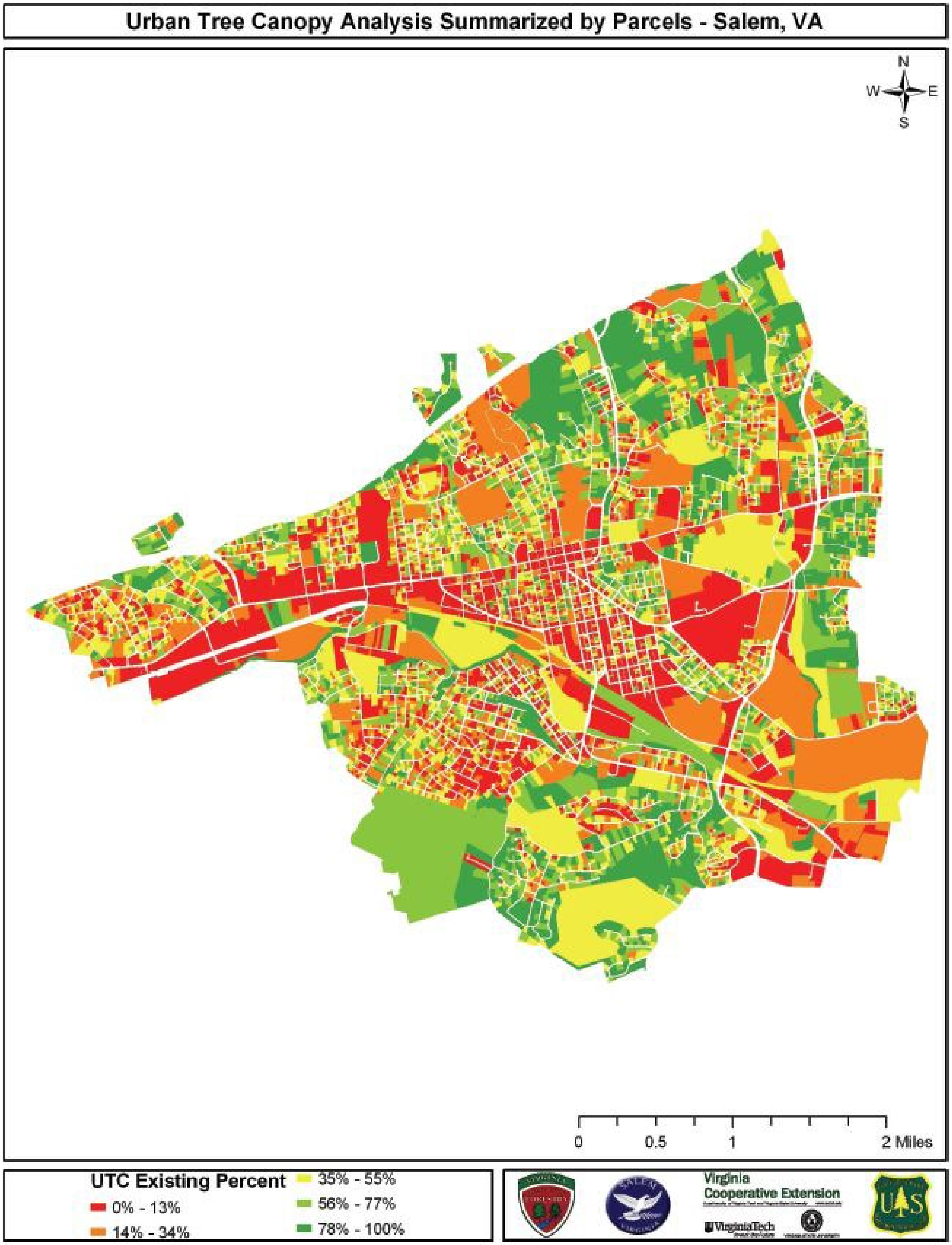


Figure 20: UTC Cover (Roanoke Valley-Alleghany Regional Commission et al., 2010)

Figure 21: UTC Potential Cover (Roanoke Valley-Alleghany Regional Commission et al., 2010)

3.6.2 Vacant Parcels & Open Space

Salem's open spaces, parks, and recreational facilities are communal public spaces, whereas vacant parcels are privately owned lots or tracts lacking a designated land use or assessed structure (City of Salem, 2012). Both have the potential to play an important part in flood resilience. The City intends to preserve and maintain parks and open spaces on city-owned properties, while exploring additional opportunities to expand or add greenspace to vacant parcels, presently occupying approximately 14% of Salem's total land area (**Figure 22**). For example, Mowles Spring Park, previously a landfill, is a large area of city-owned property with vacant land that will house a new athletic complex in 2029 (Capital Improvement Plan, 2023). To encourage private property owners to incorporate parks and open spaces in new development, the City could promote the use of conservation easements or offer high-density development benefits.

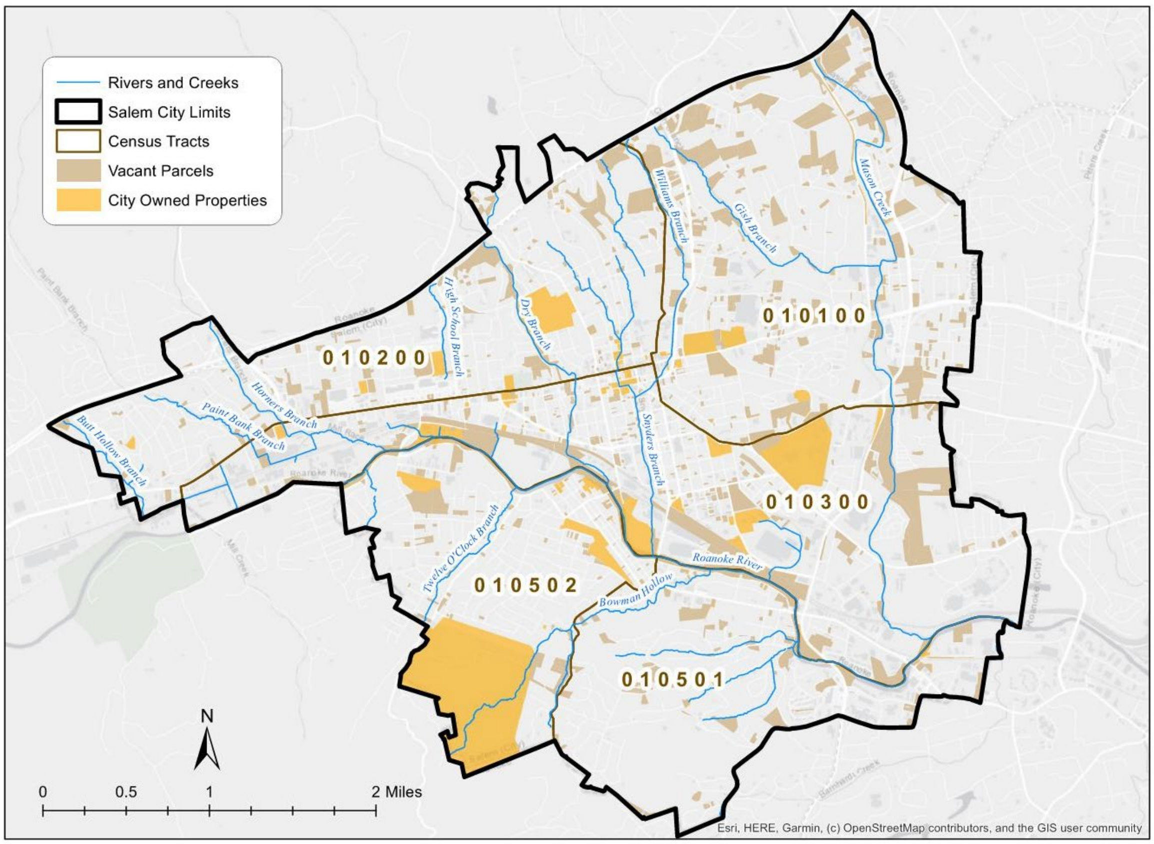


Figure 22: Salem's Vacant Parcels & City Owned Properties

3.6.3 Floodplain

Floodplains are typically located in level, low-lying areas adjacent to streams and rivers. Floodplains help disperse and absorb the force of floodwaters, as they diffuse and decelerate surging waters during substantial precipitation events. This ability helps prevent downstream damage and loss. FEMA uses FIRMS to designate floodplain areas and delineate the extent of potential flooding. These maps outline critical zones, including the floodway encompassing the stream channel and adjoining lands, the 100-year floodplain subject to a 1% annual chance flood event, and the 500-year floodplain subject to a 0.2% annual chance flood event. In AE Zones, one can obtain information about the flood elevation and flow depth for controlled storm events. Preserving or enhancing the innate and beneficial functions of floodplains remains one of the most economically efficient and impactful strategies for increasing flood resilience.

3.6.4 Greenways

Greenways often expand and preserve tree canopies and riparian buffers, which help absorb stormwater and prevent excessive flooding (Roanoke Valley Greenway Commission & Roanoke Valley-Alleghany Regional Commission, 2018). Often running parallel to water bodies, they are in a good position to do so alongside rivers, streams, canals, utility corridors, ridges, or rail lines. However, greenways often flood and require maintenance to repair erosion and clear debris from trails and fencing. Salem's greenways are shown in **Figure 23**, and the descriptions below provides an example of how each plays a role in flood resilience:

- *Roanoke River Greenway*: The greenway mitigates runoff into the river and establishes riparian buffers.
- *Hanging Rock Battlefield Trail*: This greenway has native wildflowers planted along the trail.
- *Mason Creek Greenway*: The greenway establishes a north-south corridor connecting the river to Carvins Cove, Havens Wildlife Management Area, Jefferson National Forest, the Appalachian Trail, and neighborhoods in North County.
- *Elizabeth Greenway*: Roanoke College retains ownership of a segment of the Elizabeth Campus used for recreational activities. Once constructed, the greenway will connect to the Hanging Rock Battlefield Trail and Mason Creek Greenway
- *Gish Branch Greenway*: Once constructed, this greenway has the potential to increase riparian corridor connectivity along Gish Branch.

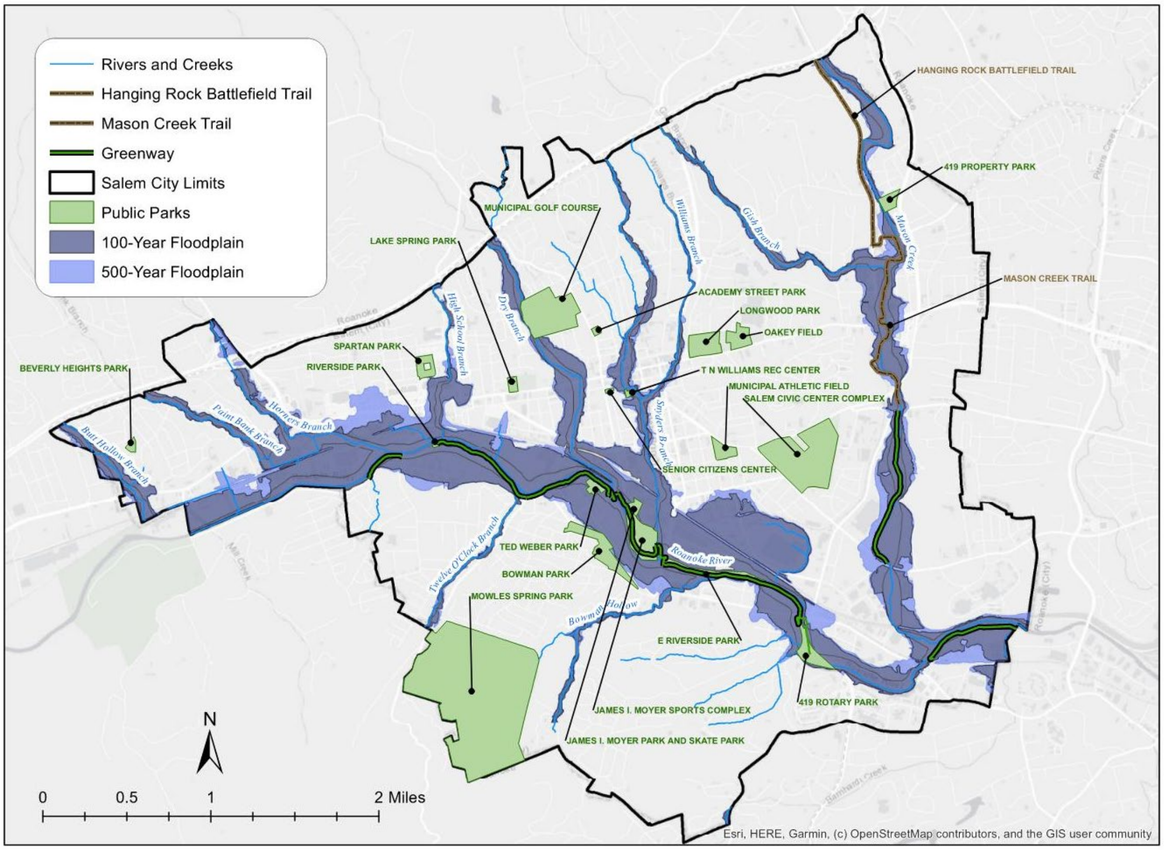


Figure 23: Salem's Greenways, Trails, and Public Parks

3.6.5 Nature-based Solutions

As the City searches for ways to improve flood resilience, Salem realizes that one of the most cost-effective ways to alleviate future flooding is to prioritize nature-based solutions (NBS). NBS is an approach that reduces the impacts of flood and storm events through the use of environmental processes and natural systems. NBS may provide additional benefits beyond flood control, including recreational opportunities and improved water quality. This includes a project that reduces these impacts by protecting, restoring, or emulating natural features. At the watershed scale, NBS can refer to land conservation, stream and wetland restoration/protection, floodplain restoration, greenways, and stormwater parks (FEMA, 2021). At the neighborhood scale, NBS include rain gardens, green roofs, permeable pavement, vegetated swales, rainwater harvesting (rain barrels), green streets, and tree canopy. Salem currently uses both to prevent flooding and associated damage. For example, the City is working to preserve existing riparian areas along the Roanoke River through the installation of native plantings and reduced mowing (City of Salem, 2012). There is one area of permeable pavement installed at the Parkway Brewery, draining to Mason Creek, that infiltrates, treats, and stores rain where it falls.

Both watershed scale and neighborhood scale NBS can be made off-limits to future development through the acquisition of land, creation of conservation easements, or changes made to the zoning ordinance. The City of Salem (2012) is considering evaluating the impacts of providing developers with density and other incentives in exchange for the preservation of open space areas. The benefits of NBS often go beyond flood protection, bringing the added benefits of reduced sewer system maintenance, improved water quality, and improved quality of life for residents (Huang et al., 2020).

4.0 A PLAN FOR RESILIENCE

In this section, the results of the community survey are summarized, and the gap analysis is performed to better understand where flood resilience is not yet covered by existing City efforts. Then, the gaps and community feedback lead to the formulation of a list of studies, projects, and plans that are needed to help the City better prepare for and protect against flooding. The projects are then scored according to DCR criteria. The priorities recommendations are discussed in the final section.

4.1 Community Feedback

The City of Salem received a total of 254 responses from the community survey, titled *Salem Resilience Plan: Community Feedback Survey*, that was administered through the City of Salem Community Development page and social media outlets for several months. The responses, summarized below, helped the City understand the community sentiments and concerns regarding flooding.

The survey results reflect the demographic composition of the City. Notably, 66% of respondents fell within the 40-64 age group and 12% are aged 65 or above, demonstrating the active participation of experienced voices. Additionally, 22% are in the 18-39 age bracket, reflecting the engagement of young adults as well. Most of the respondents are White (90%), and many work full-time (79%), indicating the commitment of the working population to engage in flood resilience.

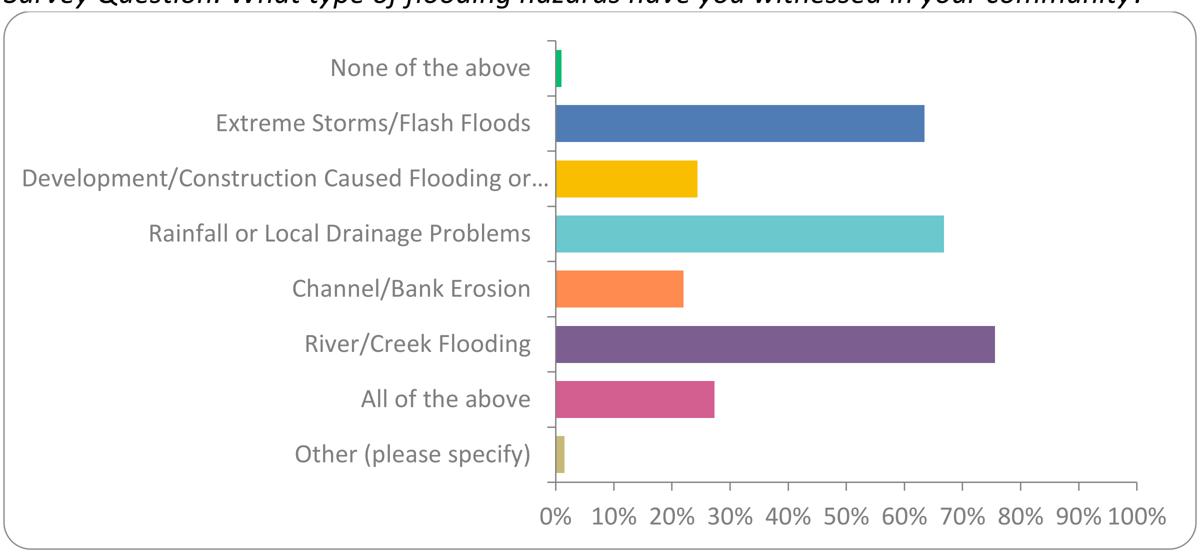
As to the perceptions regarding flood risk, almost half of respondents (49%) perceive flooding as a moderate challenge, and 21% believe it is a serious challenge. Looking ahead, many respondents believe flooding will continue to be a moderate challenge (37%) or serious challenge (32%) in the future.

Table 5: Demographic and Flood Risk Responses

Age	Responses (%)
18-39	22
40-64	66
65+	12
Race	
No answer	6
White	90
Black/African American	2
Hispanic/Latino	0.4
Asian/Asian American	0.8

Native Hawaiian/Pacific Islander	0.8
Occupation	
Unemployed	0.4
Full time employed	79
Part time employed	8
Retired	11
Other	2
Current flood risk	
Not a challenge	5
Minor challenge	22
Moderate challenge	49
Serious challenge	21
Extreme challenge	4
Future flood risk	
Not a challenge	5
Minor challenge	15
Moderate challenge	37
Serious challenge	32
Extreme challenge	11

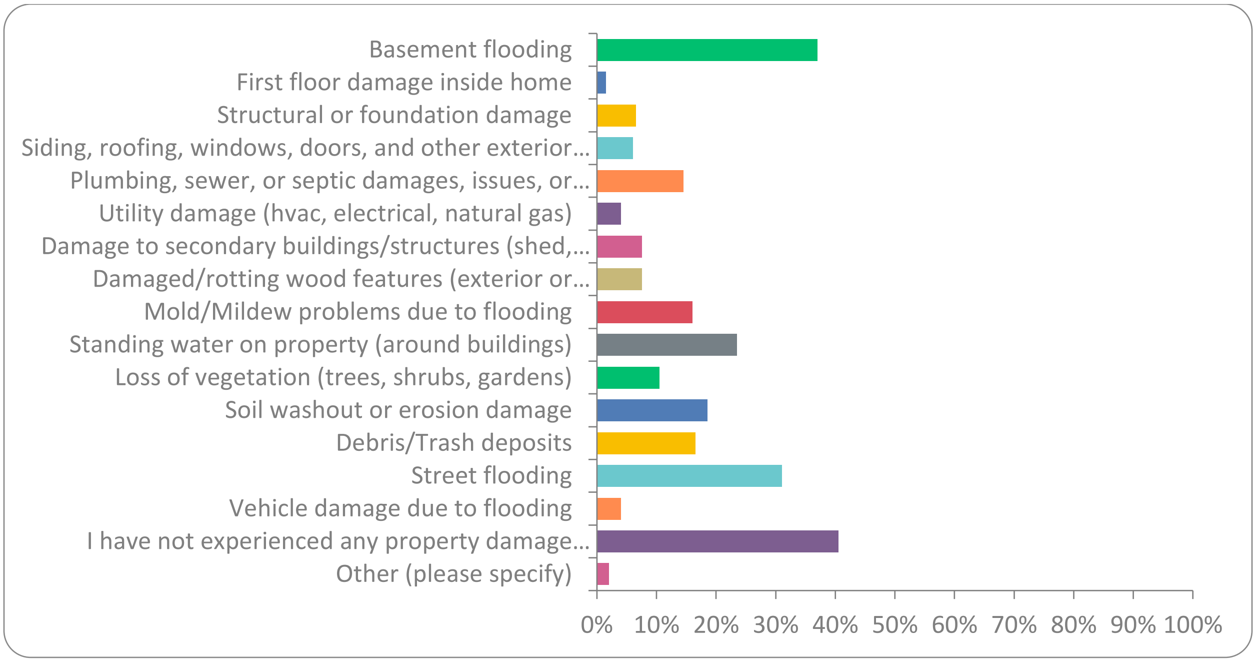
Survey Question: What type of flooding hazards have you witnessed in your community?



For Salem residents, it seems most prevalent flooding hazards stem from river and creek flooding, localized drainage issues related to rainfall, and extreme storms and flash floods.

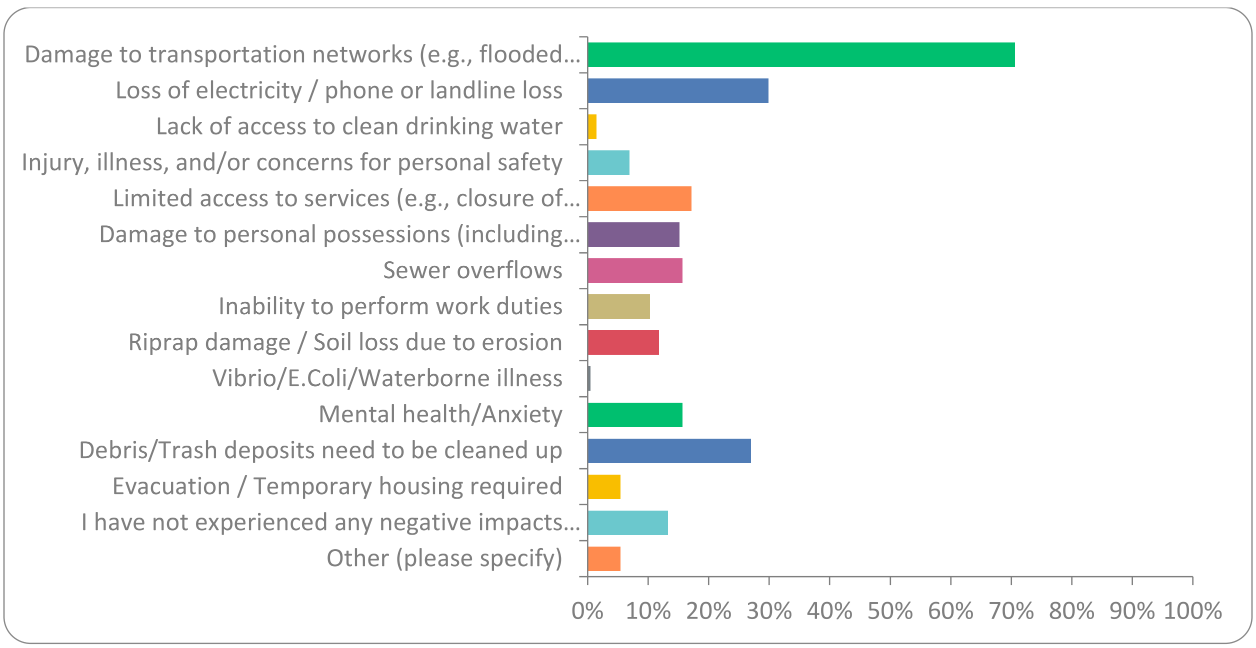
Of the respondents who responded that they have experienced home flooding (25%), many attributed the problem to inadequate drainage infrastructure and sewer system blockages. Fewer residents (5%) reported flooding in businesses.

Survey Question: What type of property damage have you experienced resulting from a flood event?



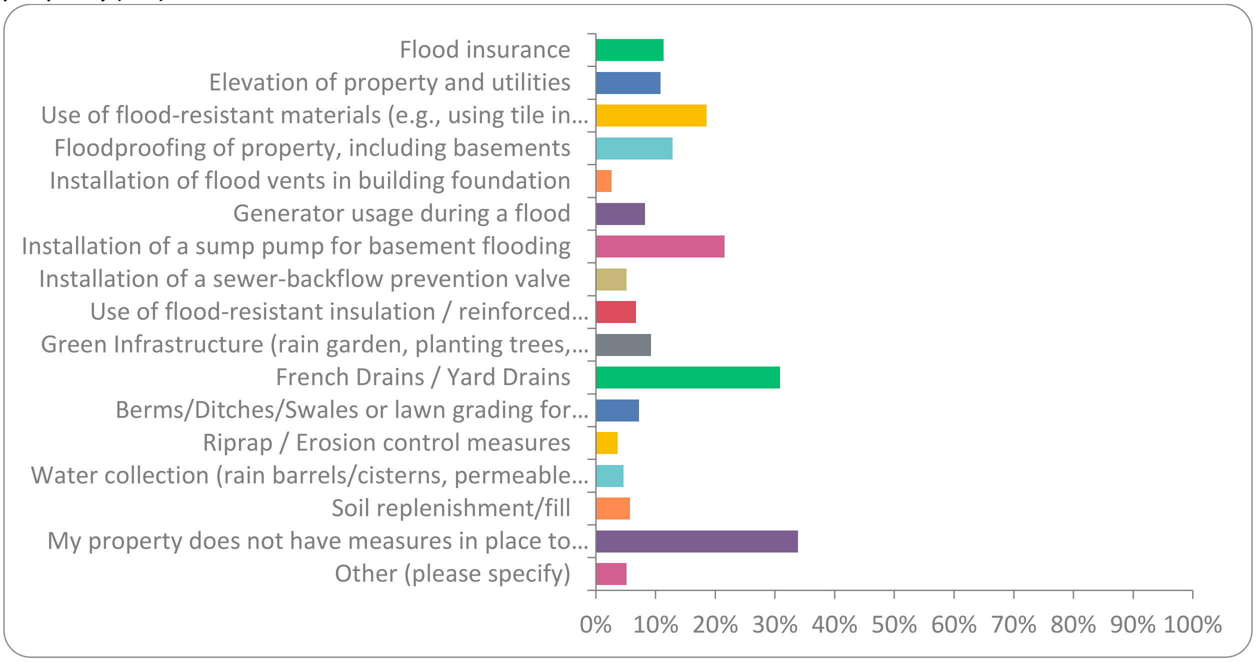
Many respondents (40%) have not encountered any property damage due to flooding, though among those who have, basement flooding, standing water around buildings, and street flooding were prominent issues.

Survey Question: What type of negative impacts have you experienced resulting from a flood event?



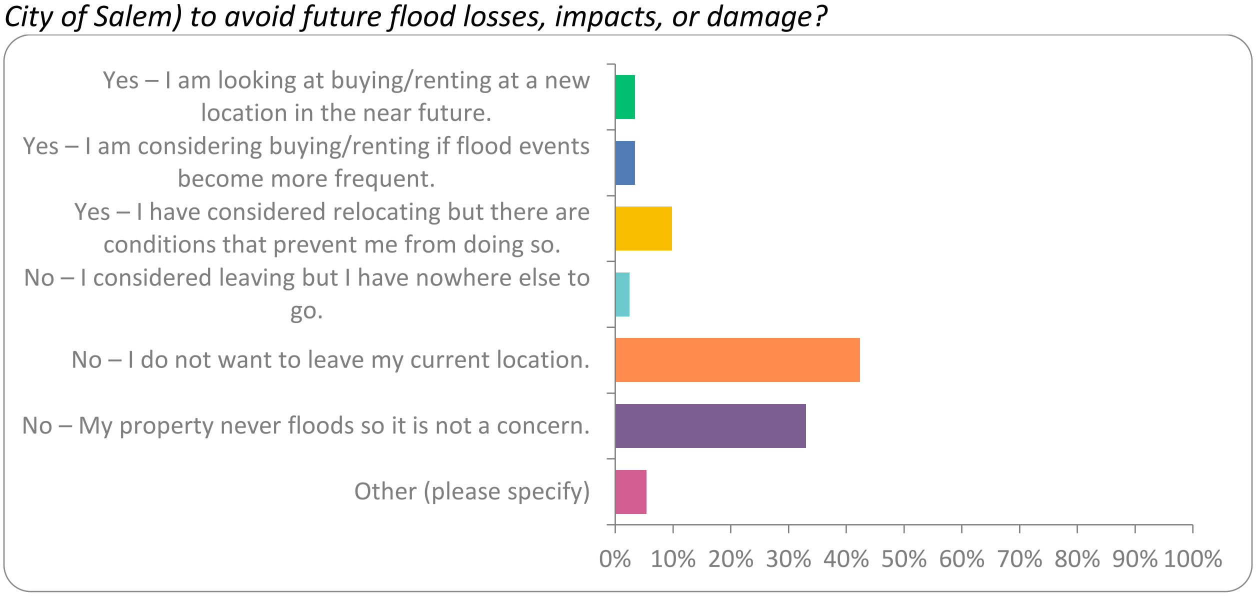
Transportation networks seem to bear the brunt of flood-related damages, with a large majority of respondents (70%) citing damage to these as the major issue. These types of damages encompass flooded roadways, road closures, and transportation delays.

Survey Question: Do you currently have any prevention or mitigation measures in place on your property(ies)?



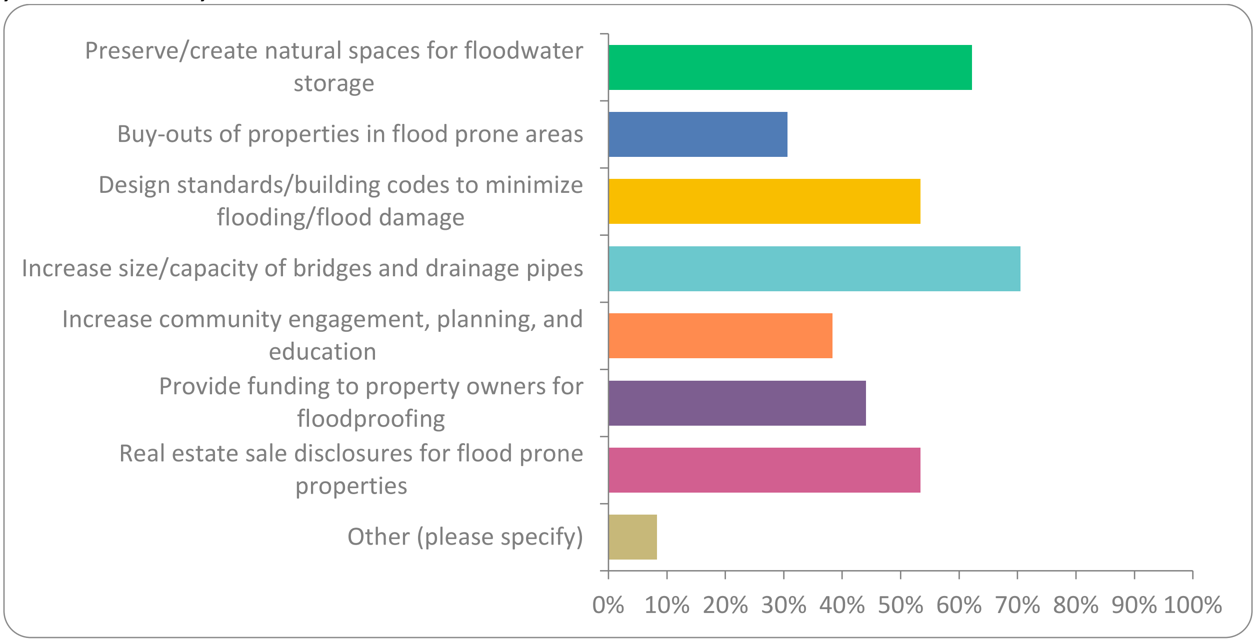
Currently, 34% of respondents lack any flood prevention measures, leaving them vulnerable to future damage. Those who have taken proactive steps often employ strategies such as French drains or yard drains and sump pump installations to safeguard their basements.

Survey Question: Have you ever considered moving to another location (inside or outside the City of Salem) to avoid future flood losses, impacts, or damage?



Despite flood risks, many respondents (42%) indicated they do not intend on relocating, with some (35%) saying their property never floods so it is not a concern, demonstrating a strong attachment of respondents to their homes. Some respondents (10%) did say yes, they had considered relocating but conditions prevented them from doing so.

Survey Question: Do you believe any of the project types listed below would provide benefits to your community?



There seemed to be a general consensus among respondents about which projects should rank high on the City's priority list, including:

- Preserving and creating natural floodwater storage spaces;
- Implementing design standards and building codes to minimize flooding and damage;
- Increasing the size and capacity of drainage infrastructure; and
- Instituting real estate sale disclosures for flood-prone properties.

Respondents were given an opportunity to describe their own recommendations. They recommended making flood insurance more affordable, introducing stormwater management fees, incentivizing rainwater collection, and providing increased educational resources on flood resilience.

Last, most respondents indicated a preference for email communication, with Facebook being the preferred social media platform for outreach. These insights provide valuable guidance to the City of Salem, as they plan future flood resilience and engagement strategies.

The second phase of community engagement will focus on presentation of the Resilience Plan for public comment. The City will place the Plan on the City's website to solicit additional community feedback. The feedback will be used to drive resilience priorities aimed at reducing flood impacts.

4.2 Gap Analysis

Though Salem has implemented a range of programs, plans, and policies with flood resilience components, a review of these documents revealed areas where the City could expand efforts and implement additional measures to bolster resilience. The following gap analysis identifies these areas and recommends logical next steps to move forward with improving resilience.

Current Efforts	Gaps	Recommendations
Plans	• City plans do not address strategies to increase flood resilience.	• Develop Watershed Management Plans. • Conduct a Repetitive Loss Areas Analysis. • Conduct a City-Wide Flood Study and Modeling. • Update Stormwater Management Plan.
Community Outreach	• Evaluate the effectiveness of outreach initiatives across the community.	• Develop a Stormwater Facebook Page.* • Consider the creation of a committee or board composed of citizens, city staff, and strategic partners that will pinpoint areas with flooding issues and develop a plan of action for the city to address with a timeline. * • Conduct training for Building Inspectors, Code Enforcement Officers, and Zoning staff on FEMA guidelines. *
Programs	• Lack of involvement and updates in FEMA programs.	• Consider adopting the FEMA Community Rating System (CRS). • Update FEMA Flood Hazard Maps and Modeling. • Participate in FEMA Hazard Mitigation Programs such as FMA, PDM, and HMGP for acquisition of flood prone properties or floodproofing projects.
Policies	• Lack of flood resilience policies in existing plans.	• Consider incorporating flood resilience policies in the next Salem Comprehensive Plan. • Consider preserving and maintaining parks and open spaces on city-owned properties, while exploring additional opportunities to expand or add greenspace to vacant parcels. • Consider evaluating the impacts of providing developers with density and other incentives in exchange for the preservation of open space areas.

Projects	• Inadequate flood mitigation measures in flood prone areas. • Lack of gray and green infrastructure that contribute to flood resilience.	• Repair headwalls, erosion, and pipe issues and stabilize riverbanks to reduce road undercutting. • Install outlet and upgrade downstream system for stormwater pond located at Texas and Idaho Street. • Design a stream restoration project at different locations in the City to address issues related to erosion, water quality, habitat degradation, and overall stream health. • Consider expanding urban forest overlay district and the species list. • Conduct maintenance on open drainage system. • Consider the design and construction of installing additional storm drains at Broad and Academy Street to improve drainage. * • Conduct closed Stormwater system construction, upgrades, and repairs. • Stabilization of floodplain around bridges that have vegetation, erosion, or debris issues in their last bridge inspection. • Dredging of river and stream channels.
Regulations	• Regulations guided by state code provisions presently do not incorporate factors related to climate change, increased rainfall, and flooding.	• Evaluate the impacts of updating precipitation data and IDF information. • Conduct annual review of floodplain ordinance.
Funding	• Lacks funding mechanisms that would enable the City to increase its flood resilience efforts through various projects and studies.	• Implement a Stormwater Utility Fee. • Consider applying for grants that support flood resilience projects and studies.
*Recommendations from the Community Engagement Survey		

4.3 Priority Recommendations

Drawing from the literature review, gap analysis, and feedback from the community and city staff, a list of potential flood resilience projects, studies, and capacity and planning activities is summarized in **Table 6** and described below. **Table 6** is a matrix showing how each priority aligns with Commonwealth Resilience Planning Principles. The City will continue developing and expanding this project-specific list in the future and amend the plan accordingly.

Table 6: Priority Recommendations and Commonwealth Resilience Planning Principles Matrix

Project	**Focused on Flood control and resilience**	**Enhances Green/Nature-based Solutions**	**Enhances Equity**	**Community and regional coordination & planning**	**Incorporates climate change and best available science**
Texas/Idaho Stormwater Basin	x			x	x
Outfall Stabilization	x		x	x	x
Stream Restoration	x	x	x	x	x
Stormwater System Upgrades/Repair	x		x	x	x
Bridge Floodplain Restoration	x	x	x	x	x
Dredging	x		x	x	x
Study					
Citywide Flood Study & Modeling	x		x	x	x
Storm Drain Evaluation	x		x	x	x
Watershed Management Plan	x	x	x	x	x
Update FEMA Flood Hazard Maps and Modeling	x		x	x	x
Update Stormwater Management Plan	x	x	x	x	x
Repetitive Loss Area Analysis	x	x	x	x	x
Evaluate the Impacts of Updating Precipitation and IDF data	x		x	x	x
Capacity/Planning					
Flood Resilience Policies	x	x		x	x
FEMA Community Rating System	x		x	x	x
Green City-owned and Vacant Properties	x	x	x	x	x
Preservation & Conservation Incentives	x	x	x	x	x

Urban Forest Overlay	x	x	x	x	x
FEMA Hazard Mitigation Programs	x	x		x	x
Stormwater Utility Fee	x	x		x	
Grant Funding	x	x		x	x
Stormwater Facebook Page	x	x		x	x
Flood Resilience Committees	x	x	x	x	x
Annual Review of Floodplain Ordinance	x	x		x	x
Maintenance on Open Drainage System	x	x	x	x	x
FEMA Staff Training	x			x	x

4.3.1 Projects

The projects mapped in **Figure 24** and described below involve the development of flood protection facilities, acquisition of land, restoration of natural features, and other activities that involve design, construction, or installation of facilities. Activities, such as design and specifications, are necessary to ensure projects achieve their goals and are considered part of the project. Feasibility studies will be needed prior to the implementation, restoration, or remediation of any stormwater facility, outfall or bridge, or stream channel. Each project was ranked by a scoring matrix based on DCR criteria. Projects received points for nature-based solutions, restoration efforts, if located in a socially vulnerable or low-income area, expected lifespan, and the community scale of benefits. Additional information on the scoring matrix and criteria is included in **Appendix A.** The findings from the preliminary field assessments were used to prioritize projects with the highest potential for increasing the City's flood resilience, described below. The projects that were considered but found lacking potential based on the preliminary field assessment are included in **Appendix B**.

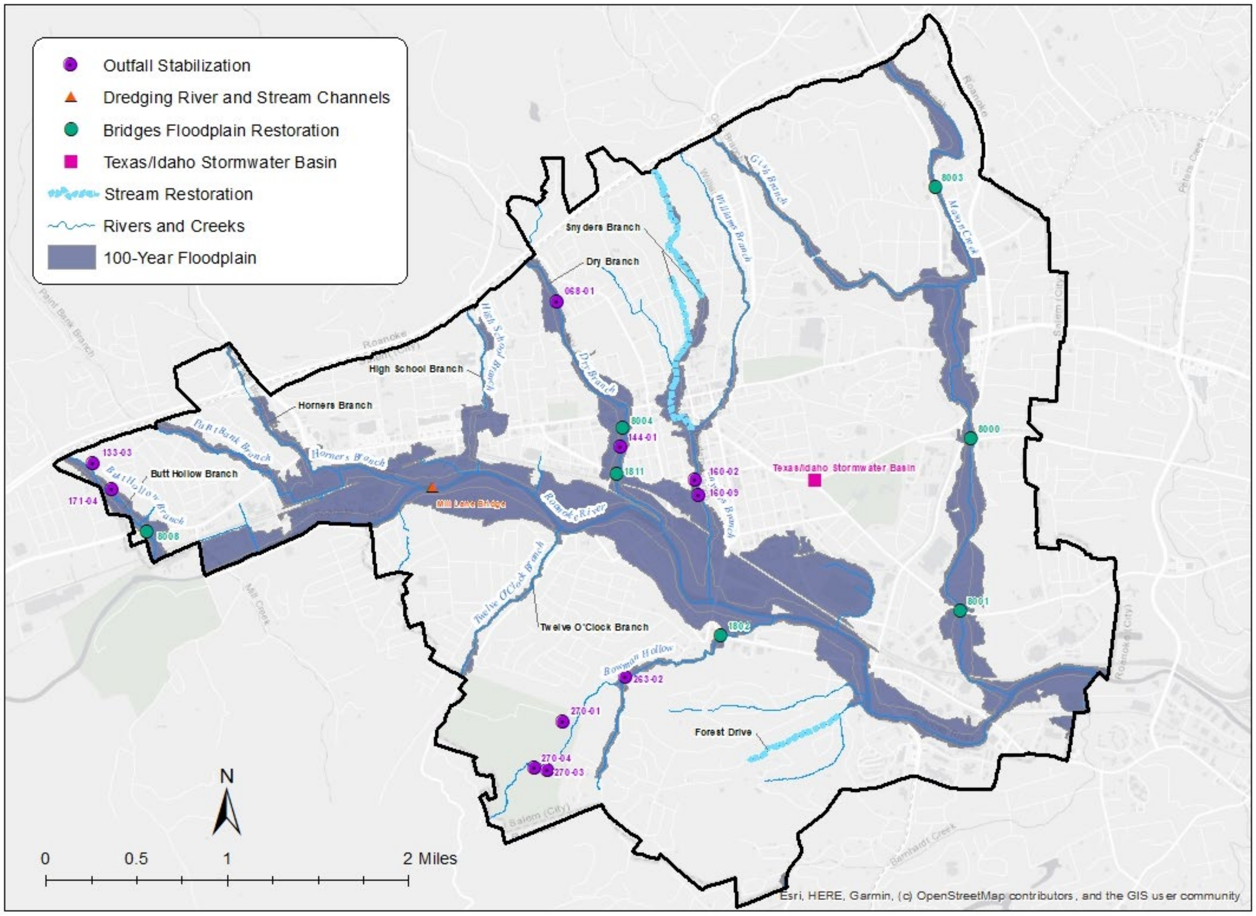


Figure 24: Potential Project Sites

Stormwater Basin Project
Texas/Idaho Pond
Type: Gray Infrastructure
Score: 45

The City wants to install a proper outlet structure in this stormwater basin and upgrade the downstream stormwater system. Outlet structures typically include a principal spillway and an emergency overflow and would accomplish the design functions of the facility. The principal spillway would convey the design storm without allowing flow to enter an emergency outlet. If site restrictions prevent the use of an emergency spillway, then the principal spillway would be sized to safely pass the 100-yr design storm without overtopping the facility. The designer would consider partial clogging (50%) of the principal spillway during the 100-yr design storm to ensure the facility would not be overtopped. For this SWM basin, selecting a flood magnitude for sizing the emergency outlet would be consistent with the potential threat to downstream life and property if the basin embankment were to fail. The minimum flood used to size the emergency spillway would be the 100-yr design storm flood. The sizing of the outlet structure would be based on results of hydrologic routing calculations.

Preliminary assessment of this large pond suggests water quality benefits in support of local MS4 and TMDL goals may be achieved through retrofitting. Further study is needed to understand the potential design constraints and cost-per-pound benefits. The location is valuable due to its highly visible location, and the pond could potentially be transformed from a maintenance burden and eye-sore into an ecological and recreational asset.

Photo 1: Texas/Idaho Pond

Outfall Stabilization Projects

Type: Gray Infrastructure

The City is looking at several outfall areas in need of repairs to alleviate headwall, erosion, and pipe issues. Stabilization measures are needed in the surrounding banks to reduce road undercutting and prevent backflow and flooding. Damaged outfalls require stabilization measures and improvements through the use of rip-rap, bioengineering techniques and/or vegetation. This would help reduce the amount of sediment, erosion, and flooding in the downstream channels and wetlands. Field assessments of the highest scoring outfalls with the most severe conditions, according to GIS desktop analysis and City staff, are included below.

Mowles Spring Park Stream Reach

Outfalls 270-01/270-03/270-04

Score: 20

The channel areas in the southeastern portion of the site upstream of Outfall 270-01 are severely incised, highly confined and actively eroding. The channel instability appears to stem from past land-use activities (logging, etc.). Restoration in this reach could offer significant water quality benefits to downstream receiving waters by limiting the loss of sediment and sediment attached pollutants. This reach offers little ancillary benefit in terms of enhanced protection of vulnerable utilities and/or flood mitigation, as the site is rural and confinement is only topographic and not associated with surrounding development. This reach offers good restoration potential, subject to limitations on property use. Further upstream, outfalls 270-03 and 270-04 are existing metal culverts which appear to have been installed to support past land use activities. Past activities (including the installation of the two culverts) have resulted in severe channel downcutting and erosion with channel depths now exceeding 10-ft in the area of the culverts. Restoration efforts aimed at limiting erosion would likely result in water quality benefits to downstream receiving waters.

Photo 2: Mowles Spring Park Stream Reach

Photo 3: Outfall 270-03

Outfall 263-02
Score: 20
This outfall is downstream of the existing triple box culvert near the intersection of Franklin Street and Tyler Way. Severe erosion has occurred at the outfall location as the stream has shifted toward the outfall. Field inspection found the last section of the CMP pipe to be completely disconnected from the rest, creating a significant channel obstruction. This end section should be removed and riprap outlet protection installed at the new outlet location to avoid issues resulting from the loose section washing downstream and creating an obstruction at the next crossing.

Photo 4: Outfall 263-02

Outfall 068-01
Score: 20
This outfall discharges into Dry Branch at Salem Municipal Golf Course and is severely unstable. **See the Dry Branch stream restoration assessment** for details on the stream and surrounding area.

Photo 5: Outfall 068-01

Outfall 133-03
Score: 20
This outfall pipe is an existing CMP pipe protruding from a steep wooded bank between Butt Hollow Road and Fletcher Street. The pipe is fed by street drainage and appears to be severely undercut with the pipe emanating from the slope at an elevation approximately 8-10 feet above the stream invert. There is significant erosion around the outlet, but the large cobble in the stream bed has prevented a continued progression. Though this outfall is not an immediate maintenance concern, it should be monitored annually due to the fact that any failure in the storm drainage system on this steep slope could lead to geotechnical failure, posing a risk to houses along Fletcher Street.

Photo 6: Outfall 133-03

Outfall 144-01
Score: 35
Though the outfall pipe and outfall area remain relatively stable, channel downcutting has exposed a utility crossing pipe that is now exposed approximately one foot above the surrounding Dry Branch stream bed. **See the Dry Branch stream restoration assessment** for details on the stream and surrounding area.

Photo 7: Outfall 144-01

Outfall 160-02
Score: 35
Heavy vegetation and Market Street development surround this outfall. Floodplain analysis is needed to assess capacity potential. Multiple storm drainage outfalls flow into the stream corridor in this location and surrounding land use strongly impacts downstream water quality.

Photo 8: Outfall 160-02

Outfall 160-09
Score: 35
This outfall is generally stable, conveying surface drainage from within the existing bus lot into Snyder Branch. The inlet of the outfall is located near the garage door of a bus maintenance area. Land use activities should be carefully managed in this lot to avoid contamination of downstream water resources and drainage system modifications considered to lessen potential environmental impacts.

Photo 9: Outfall 160-09

Outfall 171-04
Score: 20
This outfall conveys drainage along Howard Drive under Butt Hollow Road and into the stream system. The existing CMP pipe is severely degraded, with the bottom rusted through and prone to failure.

Photo 10: Outfall 171-04

Stream Restoration Projects
Type: Green Infrastructure/Nature-based Solution
These projects aim to restore and enhance the ecological and environmental integrity of water bodies. They would be designed to address issues related to erosion, water quality, habitat degradation, and overall stream health. Additional flood reduction benefits may also be possible as part of restoration Funding would be used to reestablish the general structure, function, and dynamic, self-sustaining behavior of streams. The restoration would help mitigate erosion and flood risk by restoring floodplains and associated wetlands, increasing the capacity to absorb floodwaters and storm water runoff.

Snyder Branch at Roanoke College
Score: 35
Field assessment characterized this reach by actively eroding channel areas, especially through the forested corridor between Hawthorn Road (upstream) and the culvert entrance where flow is conveyed under college campus buildings adjacent to the existing athletic fields (**Photo X**). Bed material in this stream is generally finer-grained than other area streams, likely contributing to the ongoing erosion observed. This reach may offer excellent restoration potential if Roanoke College (as the landowner) will support restoration efforts. Downstream areas between the campus and Main Street are highly fragmented by piped sections, limiting the viability and effectiveness of restoration efforts downstream of Market Street. Restoration of the upstream reach may also provide an excellent educational opportunity for college staff and students.

Photo 11: Snyder Branch at Roanoke College

Salem High School
Score: 35
This stream segment is highly confined by fencing on school property and adjacent property/structures along Goodwin Ave. The topography is moderately confining, more so on the high school side than on the east private property side. Field observation indicates significant erosion throughout the system. The stream is a reasonable candidate for stream restoration with buy-in from private landowners. Erosion is worst at the downstream end of the system along the athletic field and down to Big Lots. Erosion throughout the system threatens various elements of infrastructure, including high school fencing and storm sewer pipes near the downstream end. The gabion baskets around the inlets and outlets are approaching failure. Restoration would necessitate coordination and permission from numerous small lot landowners along Goodwin Ave. Restoration of this reach should prioritize integrating increased floodplain capacity to reduce flooding issues seen on properties in this area.

Photo 12: Salem High School Branch

Forest Drive
Score: 35
This site consists of a stormwater pond and stream channel. The existing stormwater pond at the east end of Forest Drive provides little benefit or protection for the downstream receiving channel in its current configuration. Retrofitting and installing a staged riser structure along with limited channel restoration of the heavily eroded channel downstream of the pond outlet may offer meaningful water quality benefits to demonstrate MS4 and TMDL progress towards nutrient reductions.

Photo 13: Forest Drive Pond

Photo 14: Forest Drive Stream

Butt Hollow Branch
Score: 35
This section of stream is heavily confined and frequent driveway crossings create multiple constriction points between Howard Drive and Main Street. Restoration in this area would require buy-in from multiple private property owners. Any restoration efforts should seek to integrate flood mitigation strategies - which may help in garnering community support.

Photo 15: Butt Hollow Branch

Dry Branch
Score: 35

Dry Branch at the Salem Municipal Golf Course is highly confined, with large cobble and gravel substrate. Erosion has been caused by confinement and straightening. The cobble substrate limits downcutting, and the system appears to be severely widened with late-stage lateral bank retreat limited by the surrounding property management activities. The surrounding land is held as an HOA common area with houses set back from the riparian corridor. Land ownership in this area may be conducive to restoration due to areas being held by a single entity. The area includes the severely unstable 068-01 outfall. Channel conditions at and upstream of the northern terminus of Highfield Road are improved due to shallow bedrock features.

Photo 16: Dry Branch at the Salem Municipal Golf Course

Dry Branch from Burwell Street to 4th Street is a highly confined urban system with cobble substrate, with limited ongoing erosion. The system is severely constrained by road crossings and surrounding development, limiting the conveyance capacity of the stream and increasing the potential flood impacts to surrounding properties. This reach includes Outfall 144-01, and the riparian corridor is comprised of mainly invasive species, including English Ivy and Japanese Knotweed.

Photo 17: Dry Branch from Burwell Street to 4th Street

Snyder Branch – White Oak Road to Carver Elementary
Score: 50
The section of stream from White Oak Road to Carver Elementary is severely straightened, heavily constrained, and deeply incised due to the surrounding development and modifications made to the stream corridor. Erosion along this channel is a minor issue, but flooding and geotechnical issues are the major system issues. Outfall 160-09 discharges to the stream. Heavy use of gabion baskets throughout portions of this section will require future maintenance, as the wire corrodes and the baskets fail. Preliminary assessment did not observe any gabions where failure appears imminent. An additional concern is that Salem 911 operations and emergency services facilities are located within the Snyder Branch floodway. In the event of a major flood event, EMS operations may be severely hampered. A preliminary review of FEMA data indicates FEMA modeling information was last updated in 2007, and additional study to identify flood mitigation measures may be appropriate to minimize flood impacts to critical facilities.

Photo 18: Snyder Branch – White Oak Road to Carver Elementary

12 O'Clock Branch

Score: 35

This reach is surrounded by a highly confined, relatively steep valley, with large cobble substrate. Erosion has been caused by the confinement and straightening of the channel. The cobble limits ongoing erosion except in very incised areas near the lower end of the system along Mountain Avenue. Additional field assessment on private property is necessary to understand the full extent of the erosion issues. Implementing restoration measures would likely require the participation of more than a dozen property owners.

Photo 19: 12 O'Clock Branch

Horner's Branch
Score: 35
Minor erosion is occurring at the downstream end of this reach, with the road protected by a concrete wall. Most of the channel is not accessible without access through private property. Severe erosion was observed from Windsor Avenue crossing. Based on preliminary field investigation and the surrounding topography, this stream segment may be a good candidate for restoration if approximately six landowners with large lots are supportive. Additional landowner coordination and field investigation is necessary to better understand restoration potential.

Photo 20: Horner's Branch

Bridges
Type: Floodplain Stabilization Projects
The following bridges had vegetation, erosion, or debris issues, which can affect the conveyance capacity and lead to flooding, cited during their last bridge inspections. Field assessments of the highest scoring bridges with the most severe conditions, according to GIS desktop analysis and City staff, are included below.

Bridge 1802
Score: 43
This bridge under Apperson Drive is limited more by surrounding grade downstream of the bridge than by the bridge opening itself.

Photo 21: Bridge 1802

Bridge 8001
Score: 43
This bridge on Mason Creek at Roanoke Blvd, east of Easton Drive appears to be in good condition but is somewhat limited in conveyance capacity. The road embankment and surrounding topography are more conducive to capacity modifications and may allow for boring of floodplain culverts, subject to evaluation of utility conflicts.

Photo 22: Bridge 8001

Bridge 8004
Score: 46
This bridge on W. Burwell Street is one of the few locations where bridge condition issues were more evident. Though overall condition is fair, erosion at the downstream end of the concrete apron is causing subsidence. During the field visit staff also noted that the roadway adjacent to the bridge is lower than the bridge deck. When major repairs or replacement of this bridge become necessary it may be possible to adjust the grade around the bridge to reduce potential flooding for surrounding properties.

Photo 23: Bridge 8004

Bridge 8003
Score: 46
This bridge on Garst Street along Kessler Mill Road is somewhat capacity limited but is founded on bedrock. Topography and surrounding land use (highly constrained by an industrial building and residence) likely make conveyance capacity retrofits at this location more difficult and expensive.
Photo 24: Bridge 8003

Bridge 8000
Score: 38
This bridge on Mason Creek at Lynchburg Turnpike appears to have a lower conveyance capacity relative to the upstream Electric Road bridge. Though bridge condition appears to be good, flooding issues to surrounding properties may warrant additional study and evaluation of alternatives to increase capacity.

Photo 25: Bridge 8000

Bridge 8008
Score: 28
Minor debris build-up, mainly on the downstream side of the crossing. Maintenance dredging should be considered in the short to medium term (1-5 years).

Photo 26: Bridge 8008

Bridge 1811
Score: 43
This bridge along 4th Street over Dry Branch has minor debris build-up and erosion around the concrete apron. A floodplain analysis may be needed for an additional study and evaluation of alternatives to increase capacity.

Photo 27: Bridge 1811

Stormwater System Improvements
Type: Gray Infrastructure
The following capital improvement projects are needed to prevent flooding, protect water quality, and ensure the resilience of urban infrastructure:

- Storm Sewer Upgrades – 4th Street/Union
  Score: 35
- Culvert Replacement – Chamberlain Lane
  Score: 38
- Storm Drain-Boulevard Upgrades
  Score: 35
- Storm Drain Construction – Florida Street
  Score: 35
- Storm Drain Planning and Construction – Market and Clay Street
  Score: 20

Dredging River and Stream Channels
Type: Gray Infrastructure
The following was identified by the City as an area in need of dredging to increase the storage capacity of the river and provide the room needed to access and perform maintenance on bridges and culverts.

Downstream at the Mill Lane Bridge
Score: 38
Maintenance dredging may improve conveyance capacity and limit flooding to surrounding infrastructure and properties. Further study is needed to evaluate the potential benefits of dredging and should include an assessment of sediment transport dynamics to determine the long-term viability of dredging efforts.

Photo 28: Mill Lane Bridge

4.3.2 Studies

The following studies aim to collect critical data and develop innovative tools designed to promote flood resilience on a local, regional, and statewide scale. These comprehensive efforts incorporate social vulnerability data and low-income areas for a robust approach to flood management.

Citywide Flood Study & Modeling
Score: 95
A citywide flood study and modeling will assess and mitigate flood risks within the City's boundaries. This study aims to evaluate the city's vulnerability to flooding, analyze historical flood data, assess the impact of climate change, and develop strategic plans for flood prevention and emergency response. The study would utilize hydraulic and hydrologic studies of floodplains to aid in the creation of tools to identify and display information on citywide flood risks. This would encompass all of Salem, including two low-income geographic areas.

Storm Drain Evaluation
Score: 75
The City is considering the design and construction of installing additional storm drains at Broad and Academy Street in response to citizen complaints in the community engagement survey regarding insufficient drainage during storm events. Addressing this concern would help reduce the risk of flooding and enhance the quality of life for residents relying on effective stormwater management systems. The City can utilize this study for potential land use strategies that reduce damage from riverine flooding as Broad and Academy Street are two main roads in the City. As

part of Broad Street is located in a low-income area, this would be valuable opportunity to create a crowd-sourced mapping platform that gathers data points about real-time flooding in order to decide the most efficient areas for storm drain installation.

Watershed Management Plans
Score: 70
Salem does not have any Watershed Management Plans (WMPs). Developing these plans would help the city understand, restore, and protect the quality and quantity of lakes, rivers, streams, and wetlands in a given watershed. Once these are understood, the City could plan which measures would be most beneficial to increasing flood resilience. The WMPs may utilize hydrologic and hydraulic studies of floodplains to include watershed scale evaluation, updated estimates of rainfall intensity, or other information. These plans would cover each watershed in Salem, prioritizing the ones located in the City's two low-income geographic areas.

Update FEMA Flood Hazard Maps and Modeling
Score: 70
Updating Salem's flood maps would help mortgage lenders determine insurance requirements and help the City develop strategies for reducing flood risk. The mapping process would help the City make more informed decisions about how to reduce or manage flood risk in low-income geographic areas. New or updated delineations may be incorporated into FEMA Flood Hazard Maps, using modeling to determine areas of recurrent flooding and stormwater flooding. The potential of more intense rainfall events in the future or other relevant flood risk factors may be evaluated by conducting hydrologic and hydraulic studies of floodplains.

Update Stormwater Management Plan
Score: 70
The City's Stormwater Management Plan (SWMP) was developed in 1997 and therefore needs an update to prevent any unmanaged stormwater from causing erosion and flooding. The process of updating the SWMP will help ensure measures are in place to recharge groundwater and protect land and streams from erosion, flooding and pollutants. Without proper management in place, there is the potential for runoff stormwater to overflow drainage ditches, sewer systems, and storm drains. The Salem SWMP would contain material describing methods to manage the quality and quantity of runoff resulting from any land-disturbing activity that (i) disturbs one acre or more of land or (ii) disturbs less than one acre of land and is part of a larger common plan of development or sale that results in one acre or more of land disturbance. The plan would delineate areas with known stormwater flooding and include projects for future conditions based on more intense rainfall events or other relevant flood risk factors. This effort will help prevent any excess flow of water from leading to flooding throughout the City, including two low-income geographic areas.

Repetitive Loss Area Analysis
Score: 55

This analysis is a comprehensive assessment that would examine areas prone to repetitive flood losses. The analysis would evaluate historical flood damage data, flood insurance claims, repetitive flooding in low income geographic areas, and flood mitigation efforts in specific regions in the city to identify patterns of recurrent flood events. New or updated delineations of areas of recurrent flooding and stormwater flooding may include projections for future conditions based on more intense rainfall events or other relevant flood risk factors.

Evaluate the impacts of updating precipitation data and IDF information
Score: 55
The City would evaluate the impacts (social, environmental, economic) of updating precipitation and IDF information (rain intensity, duration, frequency estimates) including such data at a sub-state or regional scale on a periodic basis. In anticipation of new stormwater design elements that may soon be required by regulatory agencies, the City would like to proactively conduct a comprehensive assessment of incorporating new climate change factors into stormwater management and design. This would encompass all of Salem, including two low-income geographic areas.

4.3.3 Capacity Building & Planning

Capacity building and planning projects are aimed at improving the ability of Salem to assess flood risk and resilience capabilities and to identify and mitigate flood risk and flood impacts. This is done through training of existing staff, hiring personnel, contracting with expert consultants or advisors, and other related actions described below.

Flood Resilience Policies
Score: 60
The findings from the gap analysis indicated that policies focused on flood resilience are largely missing from City plans. Thus, the City intends to incorporate flood resiliency policy into the next iteration of the Comprehensive Plan. Goals, objectives, and strategies for decreasing flood risk and increasing adaptability would be considered. The impacts of new flood resilience policies on economic development, education, government services, housing and neighborhoods, land use and community appearance, open space, and transportation and infrastructure would be evaluated, and new gray/green infrastructure and nature-based solutions would be included on existing and future land use maps.

FEMA Community Rating System (CRS)
Score: 50
The City is considering participating in the FEMA CRS. Costing an estimated $20,000 (Roanoke Valley-Alleghany Regional Hazard Mitigation Plan, 2019), participation could lead to substantial benefits for communities throughout the City in terms of flood mitigation and preparedness and reductions in flood insurance rates. The City would conduct the assessments and formulate the planning and strategies needed to achieve the three goals of the program: (1) Reduce and avoid flood damage to insurable property, (2) Strengthen and support the insurance aspects of the National Flood Insurance Program, and (3) Foster comprehensive floodplain management.

Green City-owned & Vacant Properties
Score: 50
The City is evaluating the potential of using city-owned properties and/or vacant parcels to improve flood resilience and achieve other planning goals. Preserving and maintaining parks and open spaces on these properties has the potential to not only manage stormwater and mitigate flooding but also foster recreational opportunities and enhance quality of life for a wide variety of residents. As Salem continues to grow and develop economically, these open spaces will compete with other land uses, such as residential, commercial, and industrial development, and Salem will need to balance these competing land uses with the goal of increasing resilience (City of Salem, 2012).

Preservation & Conservation Incentives
Score: 45
The City plans on evaluating the impacts of implementing various policy incentives, aimed at increasing the amount of preserved or conserved areas in communities throughout the City. Providing developers with incentives, such as density bonuses in exchange for preserving or conserving open space, would encourage developers to include green spaces and natural areas in their designs that are capable of absorbing floodwaters and buffering nearby residents from flood damage. Incorporating preservation/conservation areas into new developments can also enhance property values and help the City achieve growth and density objectives. This effort would help move forward some of the strategies outlined in Salem's Comprehensive Plan (City of Salem, 2012) that call for preservation of existing wooded areas, vegetation, recreational and open space, and parks.

Urban Forest Overlay
Score: 45
The City is considering expanding the Urban Forest Overlay District to flood-prone areas throughout the City to enhance the natural stormwater management and flood mitigation capabilities of urban forests. The City is evaluating areas in need of tree planting or increased protection. Increasing the specimen list of trees within the district to include more native species and expanding canopy tree requirements to all development (City of Salem, 2012) would expand the coverage and benefits of urban forests to flood resilience and contribute to the sustainability of the City by promoting ecological diversity and improving air quality.

FEMA Hazard Mitigation Programs
Score: 40
Salem is considering applying to FEMA Hazard Mitigation Grant Programs to obtain funding for the acquisition of flood prone properties or flood-proofing projects. The effort would cost an estimated $500,000 and potentially provide funding for acquisition/demolition projects, structure elevation, mitigation reconstruction, flood-proofing critical facilities and commercial structures, infrastructure upgrades, and technology upgrades (Roanoke Valley-Alleghany Regional Hazard Mitigation Plan, 2019). FEMA Flood Mitigation Assistance focuses on reducing

or eliminating the risk of repetitive flood damage to buildings and structures insured by the NFIP, and with NFIP-participating communities. Receiving this assistance would require the City to conduct resource assessments and develop strategies for reducing flood risk and damage to these properties.

Stormwater Utility Fee
Score: 40
The gap analysis revealed a general lack of funding sources available to the City to fund stormwater and resilience projects and studies. By instituting a regional stormwater utility fee, Salem could establish a dedicated source of revenue to conduct resource assessments, planning, strategies, and development. These projects would encompass stormwater management system improvements, drainage enhancements, and floodplain management and mitigation solutions. These projects are pivotal in mitigating the destructive impacts of floods and bolstering resilience.

Grant Funding
Score: 40
The City will consider additional federal, state, and local grant funding opportunities to enhance its resilience efforts through a range of projects and studies. It is crucial to explore alternative sources of revenue to address flood resilience initiatives that close the gaps within Salem's current flood resilience endeavors.

Stormwater Facebook Page
Score: 35
The response from the *Salem Resilience Plan: Community Feedback Survey* suggested the City develop a Stormwater Facebook Page to facilitate communication between Salem and the public regarding vital strategies for flood preparedness. This could provide an additional way for the City to engage a diverse range of stakeholders and provide them with guidance on how to obtain insurance coverage while raising awareness about potential flood hazards, particularly in RLAs.

Flood Resilience Committee
Score: 35
A recommendation that came from the *Salem Resilience Plan: Community Feedback Survey* was the creation of a Flood Resilience Committee, comprised of a wide range of members representing communities throughout the City. Salem is considering the creation of a committee or board composed of citizens, city staff, and strategic partners, tasked with pinpointing areas with flood issues. The committee could establish goals for evaluation and implementation of flood resilience measures, including a timeline for the City to address priority areas of concern.

Annual Review of Floodplain Ordinance
Score: 35
Conducting an Annual Review of the Floodplain Ordinance was a goal included in the Roanoke Valley-Alleghany Regional Hazard Mitigation Plan (2019). The review is vital for the City to

maintain its eligibility and good standing with the FEMA NFIP and provide guidance for development. This would ensure that Salem's floodplain management practices remain in compliance with FEMA guidelines, helping to safeguard its residents, infrastructure, and access to crucial flood insurance benefits in the event of flood disasters.

Maintenance on Open Drainage System
Score: 35
The City is evaluating the best approach for performing maintenance on the open drainage system throughout the City. Over time, the City's drainage system has become obstructed by debris, causing water flow problems and increasing the risk of flooding in various areas. Cleaning and clearing these drainage systems would help the City improve stream flow and mitigate flooding, clear debris and repair banks to prevent backup, prevent erosion and flooding of existing drainage systems (Roanoke Valley-Alleghany Regional Hazard Mitigation Plan, 2019). It would cost an estimated $100,000 for the City to develop a long term maintenance strategy.

FEMA Staff Training
Score: 15
Feedback from the *Salem Resilience Plan: Community Feedback Survey* recommended that City provide training for Building Inspectors, Code Enforcement Officers, and Zoning staff on FEMA guidelines. The training would help facilitate an integrated, whole community, risk-informed, capabilities-based approach to flood preparedness; staff would learn what to do before, during, and after the hazards their communities may face. The training would address urgent and emerging preparedness gaps for the state and region, helping communities to better prepare for incidents and develop disaster response plans.

5.0 CONCLUSION

This Resilience Plan represents the City of Salem's first step toward a coordinated resilience effort for the entire City. The goal is to build greater flood resilience in both natural and human systems, balancing development and growth with the need to better prepare for and recover from flooding. While many of the City's ongoing resilience efforts are already underway, this Plan brings together old and new initiatives to move the City forward. The Plan serves as a basis to apply for additional state funding to support resiliency efforts. City leadership will take the next steps in identifying where funding is needed to implement the most cost-effective and equitable solutions while continuing to align planning and actions with regional hazard mitigation efforts. Through this ongoing and iterative process, Salem remains committed to engaging with the community and regional partners to improve its understanding of flood issues and resilience. City leaders will continue to evolve and update this Plan as conditions, data, and technologies change.

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APPENDIX A: SCORING MATRIX & CRITERIA

PROJECT	Census Tract(s)	Census Block(s)	Social Vulnerability (SV) Score (Level of SV)	Project Area SV points (Up to 10)	Low Income Geographic Area (Yes 10, No 0)	Wetland/floodplain restoration, Construction of swales and settling ponds, Stream bank restoration or stabilization, Restoration of floodplains to natural and beneficial function. (25)	Other projects (10)	Expected Lifespan (Up to 10)	TOTAL SCORE
Stormwater Basin									
Texas/Idaho Pond	010100	Block Group 2	-1.32 (Very Low)	0	10	25	0	10	45
Outfall Stabilization									
060-05	010100	Block Group 3	1.13 (High)	8	10	0	10	10	38
068-01	010200	Block Group 2 Block Group 3	2: -0.38 (Low) 3: -1.16 (Very Low)	0	0	0	10	10	20
133-03	010200	Block Group 5	-1.05 (Very Low)	0	0	0	10	10	20
144-01	010300	Block Group 4	0.99 (Moderate)	5	10	0	10	10	35
160-02	010300	Block Group 2	0.68 (Moderate)	5	10	0	10	10	35
160-09	010300	Block Group 2	0.68 (Moderate)	5	10	0	10	10	35
171-04	010200	Block Group 5	-1.05 (Very Low)	0	0	0	10	10	20
206-03	010502	Block Group 1	-1.25 (Very Low)	0	0	0	10	10	20
217-04	010502	Block Group 3	-0.61 (Low)	0	0	0	10	10	20
233-05	010300	Block Group 2	0.68 (Moderate)	5	10	0	10	10	35
263-02	010501	Block Group 2	-0.13 (Low)	0	0	0	10	10	20
270-01	010502	Block Group 4	-0.24 (Low)	0	0	0	10	10	20
270-03	010502	Block Group 4	-0.24 (Low)	0	0	0	10	10	20
270-04	010502	Block Group 4	-0.24 (Low)	0	0	0	10	10	20
Stream Restoration Projects									
Butt Hollow Branch	010200	Block Group 5	-1.05 (Very Low)	0	0	25	0	10	35
Salem High School	010200	Block Group 4	-0.28 (Low)	0	0	25	0	10	35
Dry Branch	010200	Block Group 3	-1.16 (Very Low)	0	0	25	0	10	35
Snyder Branch at Roanoke College	010200	Block Group 1	-1.94 (Very Low)	0	0	25	0	10	35
Williams Branch – White Oak Road to Carver Elementary	010300	Block Group 2	0.68 (Moderate)	5	10	25	0	10	50

12 O'Clock Branch	010502	Block Group 1	-1.25 (Very Low)	0	0	25	0	10	35
Mill Race – Mill Ln. to Roanoke River Confluence	010300	Block Group 4	0.99 (Moderate)	5	10	25	0	10	50
Horner's Branch	010200	Block Group 5	-1.05 (Very Low)	0	0	25	0	10	35
Forest Drive	010501	Block Group 3	-1.97 (Very Low)	0	0	25	0	10	35
Stormwater System Improvements									
Storm Sewer Upgrades	010300	Block Group 2 Block Group 4	2: 0.68 (Moderate) 4: 0.99 (Moderate)	5	10	0	10	10	35
Culvert Replacement	010100	Block Group 4	1.31 (High)	8	10	0	10	10	38
Storm Drain	010100 010300	101: Block Group 2 103: Block Group 2	101: 2: -1.32 (Very Low) 103: 2: 0.68 (Moderate) Avg: -0.32 (Moderate)	5	10	0	10	10	35
Storm Drain Construction	010300	Block Group 2	0.68 (Moderate)	5	10	0	10	10	35
Storm Drain Planning and Construction	010200	Block Group 1	-1.94 (Very Low)	0	0	0	10	10	20
Floodplain Stabilization around Bridges									
1802	010501 010300	105: Block Group 2 103: Block Group 2	105:2: -0.13 (Low) 103:2:0.68 (Moderate) Avg: 0.55 (Moderate)	5	10	25	0	3	43
8001	010300	Block Group 1, Block Group 3	1:0.84 (Moderate) 3: 1.00 (High) Avg: 0.92 (Moderate)	5	10	25	0	3	43
8004	010300	Block Group 4	1.31 (High)	8	10	25	0	3	46
8006	010200	Block Group 3	-1.16 (Very Low)	0	0	25	0	3	28
8003	010100	Block Group 1	1.17 (High)	8	10	25	0	3	46
8000	010100 010300	101: Block Group 2 103: Block Group 3	2:-1.32 (Very Low) 3: 1.00 (High) Avg: -0.16 (Low)	0	10	25	0	3	38
1821	010100	Block Group 2	-1.32 (Very Low)	0	10	25	0	3	38
1817	010501 010300	501: Block Group 1 103: Block Group 1	501:1: 0.62 (Moderate) 0.84 (Moderate) Avg: 0.73 (Moderate)	5	10	25	0	3	43
1815	010100	Block Group 2, Block Group 1	2: -1.32 (Very Low) 1: 1.17 (High) Avg: -0.08 (Low)	0	10	25	0	3	38
8008	010200	Block Group 5	-1.05 (Very Low)	0	0	25	0	3	28
1811	010300	Block Group 4	0.99 (Moderate)	5	10	25	0	3	43

Dredging Stream Channels									
Downstream from the Eddy Ave bridge	010502 010300	502: Block Group 3 300: Block Group 2	3: -0.61 (Low) 2: 0.68 (Moderate) Avg: 0.07 (Moderate)	5	10	25	0	3	43
Rotary Park	010501 010300	501: Block Group 2 300: Block Group 2	501: 2: -0.13 (Low) 300:2: 0.68 (Moderate) Avg: 0.55 (Moderate)	5	10	25	0	3	43
Downstream at the low water bridge (Mill Ln.)	010502 010300	502: Block Group 1 502: Block Group 2 300: Block Group 4	502: 1: -1.25 (Very Low) 502: 2: -1.01 (Very Low) 300: 0.99 (Moderate) Avg: -1.27 (Very Low)	0	10	25	0	3	38

STUDY	Creating tools or applications to identify, aggregate, or display information on flood risk or creating a crowd-sourced mapping platform that gathers data points about real-time flooding (25)	Conducting hydrologic and hydraulic studies of floodplains (15)	Studies and Data Collection of Statewide and Regional Significance Points (Up to 45)	Low Income Geographic Area (Yes 10, No 0)	TOTAL SCORE
Citywide Flood Study & Modeling	25	15	45	10	95
Storm Drain Evaluation	25	0	40	10	75
Watershed Management Plans	0	15	45	10	70
Update FEMA Flood Hazard Maps and Modeling.	0	15	45	10	70
Update Stormwater Management Plan	0	15	45	10	70
Repetitive Loss Area Analysis	0	0	45	10	55
Evaluate the Impacts of Updating Precipitation and IDF data.	0	0	45	10	55

CAPACITY BUILDING & PLANNING	Eligible Capacity Building and Planning Activities. (Up to 100)	Low Income Geographic Area Yes 10, No	TOTAL SCORE
Flood Resilience Policies	60	0	60
FEMA Community Rating System (CRS).	40	10	50
Greening City-owned and Vacant Properties	40	10	50
Preservation/Conservation Incentives	35	10	45
Urban Forest Overlay	35	10	45
FEMA Hazard Mitigation Programs	40	0	40
Stormwater Utility Fee	40	0	40

Grant Funding	40	0	40
Stormwater Facebook page	35	0	35
Flood Resilience Committee	25	10	35
Annual Review of Floodplain Ordinance	35	0	35
Maintenance on Open Drainage System	25	10	35
FEMA Staff Training	15	0	15

Scoring Criteria

Virginia Department of Conservation and Recreation
Virginia Community Flood Preparedness Fund Grant Program

SCORING CRITERIA PER CATEGORY

Projects

Eligible Projects, up to 30 points.

- Acquisition (30)
- Wetland/floodplain restoration, Construction of swales and settling ponds, Living shorelines and vegetated buffers, Permanent conservation of undeveloped lands identified as having flood resilience value by *ConserveVirginia*'s floodplain and flooding Resilience layer or a similar data driven analytic tool, Dam removal, Stream bank restoration or stabilization, Restoration of floodplains to natural and beneficial function. (25)
- Other nature-based approach (20)
- Hybrid approach resulting in nature-based solution (15)
- All other projects (10)

Social Vulnerability Index Score, up to 10 points.

- Very High Social Vulnerability (More than 1.5) (10)
- High Social Vulnerability (1.0 to 1.5) (8)
- Moderate Social Vulnerability (0.0 to 1.0) (5)
- Low Social Vulnerability (-1.0 to 0.0) (0)
- Very Low Social Vulnerability (Less than -1.0) (0)

Community scale of benefits, up to 30 points.

- More than one census block (30)
- 50-100% of census block (25)
- 25-49% of census block (20)
- Less than 25% of census block (0)

Expected lifespan of project, up to 10 points.

- 10 -14 Years (3)
- 15 - 20 Years (5)
- Over 20 Years (10)

Remedy for NFIP probation or suspension (yes 5, no 0)
Proposed project part of a low-income geographic area (yes 10, no 0)

Proposed project implements a Chesapeake Bay TMDL BMP (yes 5, no 0)

Studies

Revising floodplain ordinances to maintain compliance with the NFIP or to incorporate higher standards that may reduce the risk of flood damage, 30 points.

Creating tools or applications to identify, aggregate, or display information on flood risk or creating a crowd-sourced mapping platform that gathers data points about real-time flooding.

This could include a locally or regionally based web-based mapping product that allows local residents to better understand their flood risk, 25 points.

Conducting hydrologic and hydraulic studies of floodplains. Applicants who create new maps must apply for a Letter of Map Change through the Federal Emergency Management Agency (FEMA), 15 points.

Studies and Data Collection of Statewide and Regional Significance. Funding of studies of statewide and regional significance and proposals will be considered for the studies listed below, Up to 45 points.

- Updating precipitation data and IDF information (rain intensity, duration, frequency estimates) including such data at a sub-state or regional scale on a periodic basis. (45)
- Regional relative sea level rise projections for use in determining future impacts. (45)
- Vulnerability analysis either statewide or regionally to state transportation, water supply, water treatment, impounding structures, or other significant and vital infrastructure from flooding. (45)
- Flash flood studies and modeling in riverine regions of the state. (45)
- Statewide or regional stream gauge monitoring to include expansion of existing gauge networks. (45)
- New or updated delineations of areas of recurrent flooding, stormwater flooding, and storm surge vulnerability in coastal areas that include projections for future conditions based on sea level rise, more intense rainfall events, or other relevant flood risk factors. (45)
- Regional flood studies in riverine communities that may include watershed scale evaluation, updated estimates of rainfall intensity, or other information. (45)
- Regional hydrologic and hydraulic studies of floodplains. (45)
- Studies of potential land use strategies that could be implemented by a local government to reduce or mitigate damage from coastal or riverine flooding. (40)
- Other proposals that will significantly improve protection from flooding on a statewide or regional basis (35)

Social Vulnerability Index Score, up to 10 points.

- Very High Social Vulnerability (More than 1.5) (10)
- High Social Vulnerability (1.0 to 1.5) (8)
- Moderate Social Vulnerability (0.0 to 1.0) (5)
- Low Social Vulnerability (-1.0 to 0.0) (0)
- ery Low Social Vulnerability (Less than -1.0) (0)

Remedy for NFIP probation or suspension (yes 5, no 0)
Proposed project part of a low-income geographic area (yes 10, no 0)
Proposed project implements a Chesapeake Bay TMDL BMP (yes 5, no 0)

Capacity Building and Planning

Eligible Capacity Building and Planning Activities. Up to 100 points.

Development of a new resilience plan (95)
Revisions to existing resilience plans and modifications to existing comprehensive and hazard mitigation plans (60)
Resource assessments, planning, strategies, and development (40)
Policy management and/or development (35)
Stakeholder engagement and strategies (35)
Goal planning, implementation, and evaluation (25)
Long term maintenance strategy (25)
Other proposals that will significantly improve protection from flooding on a statewide or regional basis approved by the Department (15)

Social Vulnerability Index Score, up to 10 points.

- Very High Social Vulnerability (More than 1.5) (10)
- High Social Vulnerability (1.0 to 1.5) (8)
- Moderate Social Vulnerability (0.0 to 1.0) (5)
- Low Social Vulnerability (-1.0 to 0.0) (0)
- Very Low Social Vulnerability (Less than -1.0) (0)

Community scale of benefits, up to 30 points.

- More than one census block (30)
- 50-100% of census block (25)
- 25-49% of census block (20)
- Less than 25% of census block (0)

Remedy for NFIP probation or suspension (yes 5, no 0)
Proposed project part of a low-income geographic area (yes 5, no 0)

APPENDIX B: ADDITIONAL PROJECT SITE INSPECTIONS

Outfall 060-05
Score: 38
Located at Stonewall Street, this suburban stream reach shows signs of significant erosion, largely due to land management practices on private property. Though the identified outfall does show signs of localized erosion, instability is limited and likely not severe enough to warrant action beyond post-storm monitoring. This area is best addressed through landowner outreach and education to encourage owners to plant and preserve riparian vegetation to limit future erosion.

Photo 1: Outfall 060-05

Outfall 206-03
Score: 20
The concrete flume is in good condition and there do not seem to be any pressing issues requiring immediate remediation. Some channel erosion is seen downstream of the flume outfall, but does not present an immediate maintenance need.

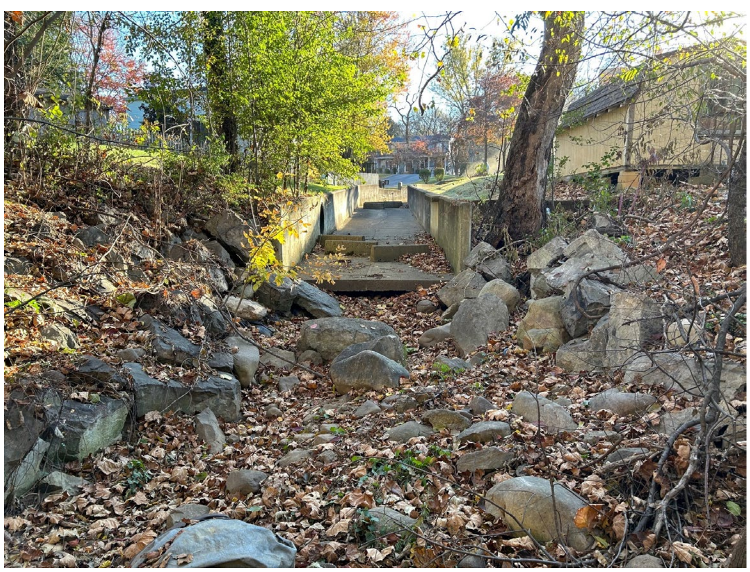

Photo 2: Outfall 206-03

Outfall 217-04
Score: 20
This outfall is located near the Eddy Ave bridge and discharges into the Roanoke River. Minor erosion is observed in the floodplain surrounding the outfall. See the Eddy Ave bridge assessment for more details on the bridge and surrounding area.

Photo 3: Outfall 217-04

Outfall 233-05
Score: 35
This outfall on the Roanoke River at the Graham-White facility did not show any obvious signs of instability at the interface with the main river.

Photo 4: Outfall 233-05

Mill Race to Mill Lane to Roanoke River Confluence
Score: 50
Though this project scores high, this project would be a big undertaking. The reach from Mill Race to Mill Lane directly impacts the Roanoke River system, and restoration or outfall stabilization on the Roanoke River or adjacent Mill Race would likely be a risky endeavor in terms of feasibility, unforeseen impacts and cost. The risk of negatively impacting these large systems is just too great to warrant intervention unless conditions pose an immediate risk to public safety and health.

Photo 5: Mill Race to Mill Lane to Roanoke River Confluence

Bridge 8006
Score: 28
This bridge on Carrollton Avenue over Dry Branch appears to be in good condition and provides adequate conveyance capacity for all but the largest storms.

Photo 6: Bridge 8006

Bridge 1815
Score: 38
This bridge along Main Street east of Kessler Mill Road is in good condition and conveyance appears adequate for all but the largest storms. This bridge location is highly confined by surrounding infrastructure and development, likely making flood capacity retrofits difficult and expensive.

Photo 7: Bridge 1815

Bridge 1817
Score: 43
This bridge on the Roanoke River under Electric Road does not appear to have any major condition issues and conveyance appears adequate for all but the largest storms.

Photo 8: Bridge 1817

Bridge 1821
Score: 38
This bridge on Mason Creek downstream of Lakeside shopping center appears to be in good condition and provides adequate conveyance capacity for all but the largest storms. Retrofit to increase capacity during major floods is likely costly due to roadway configuration and surrounding land use.

Photo 9: Bridge 1821

Downstream from Eddy Ave Bridge
Score: 43
The bridge is downstream of the Mill Lane bridge but less prone to inundation than Mill Lane. The floodplain in this area is relatively low sloping with broad, flat cobble benches flanking the baseflow channel. Only minor erosion was observed around the bridge and in downstream areas. There is limited potential for restoration or dredging in this area.

Photo 10: Eddy Ave Bridge

Photo 11: Rotary Park

Rotary Park
Score: 43
This area offers limited benefit from dredging or other restoration activities. The corridor shows little sign of erosion, and the gravel/cobble deposition is predominantly a product of the surrounding topography. Given the size of the stream system and upstream bridges, preliminary assessment indicates little long-term conveyance capacity benefit may be achieved from dredging operations.