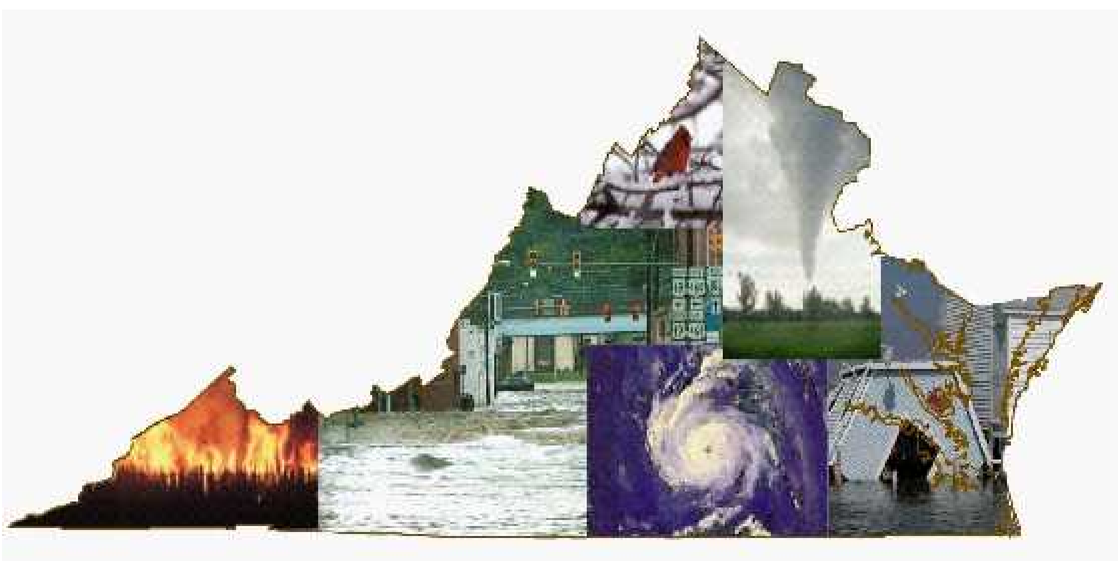
Loss Avoidance Study for the Commonwealth of Virginia's 2018 Update to the State Hazard Mitigation Plan



March 2018

Developed and published by the Virginia Department of Emergency Management and Witt O'Brien's.

Appendix L:

Loss Avoidance Study

A. Introduction

The Commonwealth of Virginia has a history and exposure to a wide array of natural hazards – from wind to earthquakes to wildfires to flooding. Because of this exposure and risk, the Commonwealth has a long-established commitment to hazard mitigation, specifically to encouraging, promoting, assisting with, and funding actions and projects to reduce or eliminate long-term risks to people and property from natural hazards and their effects.

Through the Virginia Department of Emergency Management (VDEM), and in conjunction with a number of federal agencies (including FEMA), the Commonwealth has made project and planning dollars available to Virginia communities to implement hazard mitigation measures. Since 1989, more than $122 million in hazard mitigation funding has been awarded to Virginia communities and agencies, for a range of mitigation activities and projects[1].

To document and examine the impact that this mitigation funding has had in Virginia requires an examination of completed mitigation projects. As part of the 2018 update to the *Commonwealth of Virginia Hazard Mitigation Plan*, VDEM determined that it is appropriate to examine a selection of completed mitigation projects and determine the real-world losses avoided through those projects. This study is the final product of that process.

A review of completed mitigation projects in Virginia determined two areas of the state that were especially ideal for this study – the City of Poquoson and the City of Roanoke. The City of Poquoson has a long history of coastal flooding, and has completed more than a hundred private property mitigation projects because of that flood history. The City of Roanoke has an extensive history of riverine flooding, and completed several private property acquisitions, in addition to an extensive greenway and several other drainage and flood control projects. The mitigation projects these two communities completed were also far enough back in time that they allowed for other flood events to have occurred in the project areas. This is necessary for a study such as this one, to determine what losses would have occurred from those events if those structures had remained unmitigated when the later flood occurred.

A discussion of the location and property selection process follows later in this study.

B. Flooding History

Flooding is one of the most common and frequent hazards in both the US and in the Commonwealth of Virginia. Between 1957 and 2016, there were 38 federal disaster declarations in Virginia that involved flooding – this equates to almost 60% of the federal disaster declarations during that time frame. Hundreds of other, smaller floods have impacted communities in the Commonwealth during that same period. Virginia experiences both coastal and riverine flooding, depending on the location within the Commonwealth. Virginia's most urbanized areas lay within broad, flat coastal plains, prone to both coastal and riverine flooding. In the mountainous western portion of the Commonwealth, most urban development lays along relatively flat river valleys, which experience both riverine and flash flooding.

1. B.1 City of Poquoson

Located on the lower Chesapeake Bay, Poquoson occupies 15 miles² of land and 63 miles² of water. The entire eastern side of the City is home to the Plum Island National Wildlife Refuge, which – together with privately owned salt marsh lands – makes up the largest saline marsh in the lower Chesapeake Bay[2]. Most of the City has an elevation of no more than seven feet above mean sea level, making it vulnerable to all types of coastal flooding, including tropical storms, hurricanes, nor'easters, and tidal flooding. Most flooding in Poquoson does not occur because of hurricanes, but rather because of unnamed low-pressure systems[3].

Because of this history and geography, Poquoson is committed to hazard mitigation. In the last two decades, they have sought and received funding through VDEM for more than 60 private property elevation projects, to help their residents protect their property from flooding. After Hurricane Isabel in 2003, the City sought and received funding for more than 30 elevation projects. As more than ten years have passed since these structures were elevated, this study focused on elevations that were completed after Isabel (2003).

A review of the City's hazard mitigation plan found dozens of documented occurrences of flooding – rainfall, high tides, storms, etc. Because of the extensive and well-documented history, this study will focus on two recent events – Hurricane Irene, which passed by Poquoson as a Category 1 hurricane in August of 2011, and 'Nor'Ida', a mid-Atlantic nor'easter that impacted the City in November 2009.

Details of the specific structures studied and the selection process follows later in this study.

2. B.2 City of Roanoke

Situated on the eastern border of the Appalachian Plateau and the western slope of the Blue Ridge Mountains, the City of Roanoke is the largest and most populous city in an otherwise mostly rural area. The watersheds in the region around the City are typical of the area, with smaller streams collecting water flowing through steep terrain, picking up in velocity, and flowing into the valleys and flatlands along major rivers, including the Roanoke River, which runs through the City. The most severe flooding on the Roanoke River usually results from heavy rains associated with tropical storms, while tributary stream flooding usually happens following localized thunderstorms or stalled frontal systems. Flooding along the tributaries is compounded when waterways at lower elevations backup into feeder streams[4].

Most of the severe flooding in the City occurs along the 13 major creeks and rivers in the area: Barnhardt (or Cravens) Creek, Garnand Branch, Glade Creek, Gum Spring, Lick Run, Mudlick Creek, Murdock Creek, Murray Run, Ore Branch, Peters Creek, Roanoke River, Tinker Creek, and Trout Run. In November 1985, the City experiencing the worst flood of record on the Roanoke River and many of its tributaries. In September 2004, a significant flood event caused more than $14 million in property damage in the Roanoke Valley[5].

The City of Roanoke is home to part of the Roanoke Valley Greenways. These areas of intentionally undeveloped (or formerly developed) land began with a project to replace the City's sewer lines in 1993. In 1995, at the urging of residents, four local governments – including the City of Roanoke – established a Greenways/Open Space Steering Committee, and began to seriously study other communities with similar issues and concerns. The outcome was the decision to create a greenway plan and to hire a Greenway Coordinator through the Roanoke Valley-Alleghany Regional Commission, to facilitate the planning and development process. The Conceptual Greenway Plan was completed in late 1995, and in early 1996 the Steering Committee began a pilot project. Since then, work has been continuous on the creation of Greenway space in the area, including the City[6].

While the Greenway is not solely a flood mitigation project, is has reduced flooding in the region and the City. By creating open space for water to pass over with no obstructions and no property to damage, Roanoke has seen less severe floods and experienced less property damage as a result. In addition, the City has completed two significant flood reduction projects in the previous thirty years – the Peters Creek Flood Reduction Project and the Roanoke River Flood Reduction Project.

The Peters Creek Project was completed by the City in three phases. The first phase, completed in 1991, consisted of five culvert upgrades and stream channelization, which was performed by removing earthen fill material along the Peters Creek tributary for approximately ¾ mile. The second phased (1993) involved clearing vegetative debris along the tributary. The final phase (2000) included construction of two regional stormwater management detention facilities, located near the top of the Peters Creek watershed, to provide controlled releases during storm events[7].

The Roanoke River Project was implemented in partnership with the US Army Corps of Engineers – Wilmington District (USACE), as part of the Energy and Water Development Appropriations Act of 1990. The project included approximately 6.2 miles of channel widening along the 10-mile reach. Channel widening was accomplished through the construction of a benched channel above the elevation of the average stream flow. Other project activities included flood proofing a hospital and the waste water treatment plant, two training walls to prevent floodwater intrusion into low-lying areas along the river, and the installation of a flood warning system (IFLOWS). Additionally, the project, which was implemented between 2004 and 2012, created a 7-mile stretch of greenway trail along the project reach.

In addition, the City has worked with VDEM to obtain hazard mitigation grant funding to acquire flood damaged residential structures in the City, largely in the Garden City area. Since 1996, the City has received funds to acquire 15 residential structures and to covert the lots to permanent green space, thereby permanently removing the threat of future flood damages to the structures on those lots.

Details of the specific structures studied and the selection process follows later in this study.

C. Project Methodology

A loss avoidance study (LAS) provides a justification for existing and future mitigation projects and activities. The ability to assess the economic performance of mitigation projects over time is important to encourage future funding and continued support of mitigation projects, activities, and programs. An LAS requires that the projects studied be completed prior to the event(s) analyzed, as losses avoided though the mitigation measure are determined by comparing the damage that would have been caused by the event, had the projects not be implemented.

This LAS looked at previously completed private property mitigation activities in two areas of the Commonwealth – the Cities of Poquoson and Roanoke – and determined the damages the properties would have sustained had they not been acquired or elevated. As the two areas of study implemented different mitigation measures, the specific methodology used for each area is discussed below.

An array of data points was collected to determine the effectiveness of the mitigation projects completed in both study areas. These data points included:

- Original finished floor elevations (pre-mitigation)
- Post-mitigation finished flood elevations
- Base Flood Elevations

- Square footage of the structures
- Structure type
- Cost of the mitigation measure
- Value of the structure
- Value of the structure's contents
- Depth of flooding in project area (post-mitigation)

For both study areas selected, a review of the mitigated properties was conducted. The review included grant documents provided by VDEM, NFIP claims data for the community, and flood history data from both the community and the National Weather Service. After review of this data, specific properties were identified within each study area. The identified properties were found to have the most complete data sets of all properties reviewed.

Figure 1: Loss Avoidance Study Process

3. C.1 City of Poquoson

The structures studied in Poquoson were all elevated to a minimum of one foot above the applicable base flood elevation (BFE) at the time the project was completed[1]. The selected properties were all elevated after Hurricane Isabel (2003), and are in areas of the City that continue to experience flooding to the present day. The LAS team used a depth-damage calculation that determined the dollar value of losses avoided, based on the likely depth of inundation the structure would have received prior to mitigation. This calculation was then compared to the project cost to elevate the structure to determine the cost-effectiveness of the mitigation. These depth-damage calculations appear in the following tables.

Table 1: Residential Building Depth-Damage Calculations (Generic)[8]

Building Type	One Story (no basement)	Two story (no basement)
Flood Depth (in feet)	**Percent Damaged**	**Percent Damaged**
-1.5 to -0.5	2.5%	3%
-0.5 to 0.5	13.4%	9.3%
0.5 to 1.5	23.3%	15.2%
1.5 to 2.5	32.1%	20.9%
2.5 to 3.5	40.1%	31.4%
3.5 to 4.5	47.1%	31.4%
4.5 to 5.5	53.2%	36.2%

Table 2: Residential Building Contents Depth-Damage Calculations (Generic)[9]

Building Type	One Story (no basement)	Two story (no basement)

[1] As of December 2014, Poquoson's ordinance now requires a minimum of three feet of freeboard.

Flood Depth (in feet)	Percent Damaged	Percent Damaged
-1.5 to -0.5	2.4%	1%
-0.5 to 0.5	8.1%	5%
0.5 to 1.5	13.3%	8.7%
1.5 to 2.5	17.9%	12.2%
2.5 to 3.5	22%	15.5%
3.5 to 4.5	25.7%	18.5%
4.5 to 5.5	28.8%	21.3%

4. C.2 City of Roanoke

The subject structures in the City of Roanoke were all acquired and demolished, with the remaining land being converted to greenspace in perpetuity. The majority of the structures (11) were acquired in approximately 1996, with a handful (four) acquired approximately ten years later, in approximately 2005.

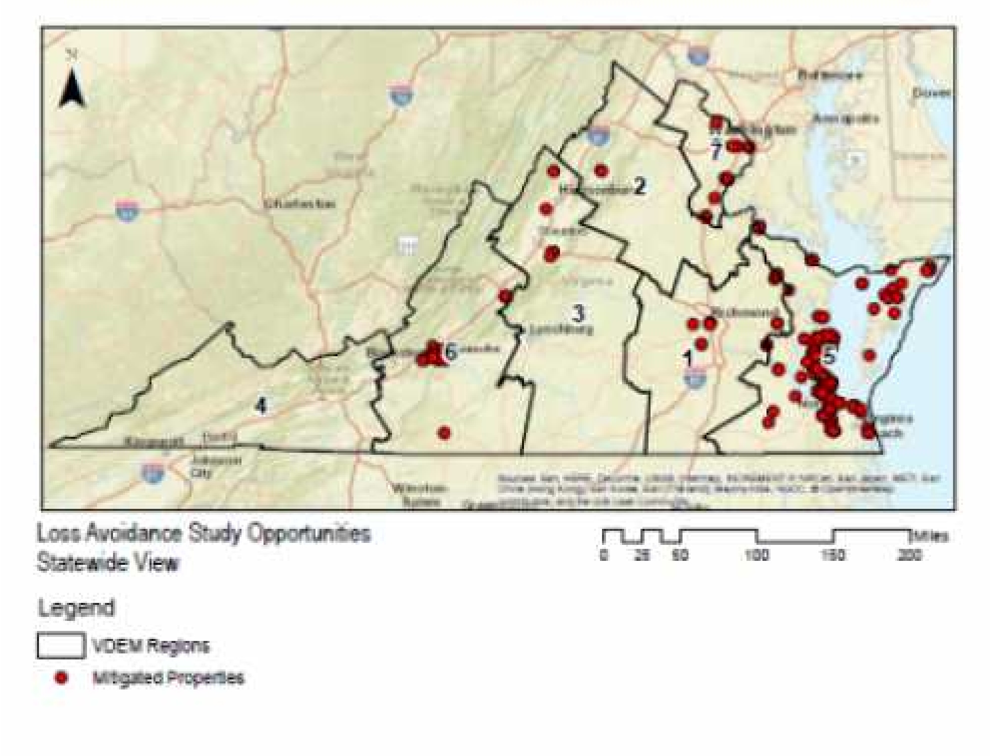
In the approximately two decades since the original structures were acquired, the City has undertaken the previously discussed array of other flood mitigation measures – namely, the creation of the greenway, the Peters Creek project, and the Roanoke River project. Each of these projects were implemented or completed during the same timeframe as the study period of the mitigated structures.

While there has been flooding in the City since these structures were acquired, there has been little flooding in the areas where the subject structures were previously located. This is likely due to a combination of factors – most notably the other mitigation activities in the watersheds – and not due to a natural decrease in flooding, as a review of rainfall data in the City does not indicate a decrease in rainfall during the study period.

D. Project & Property Selection

Using completed mitigation project data, the LAS team mapped each mitigated private property structure in the Commonwealth, focusing on those that were either elevated or acquired. No other mitigation types were considered for this effort. The overall results of this initial effort appear in the figure following.

Figure 2: LAS Opportunities - Statewide View



Once the structures were mapped, the maps were examined to determine clusters of structures in various areas of the Commonwealth – similar topography, similar or same source of flooding, similar timeframe for implementation of the mitigation measure. The following communities were initially considered for this study:

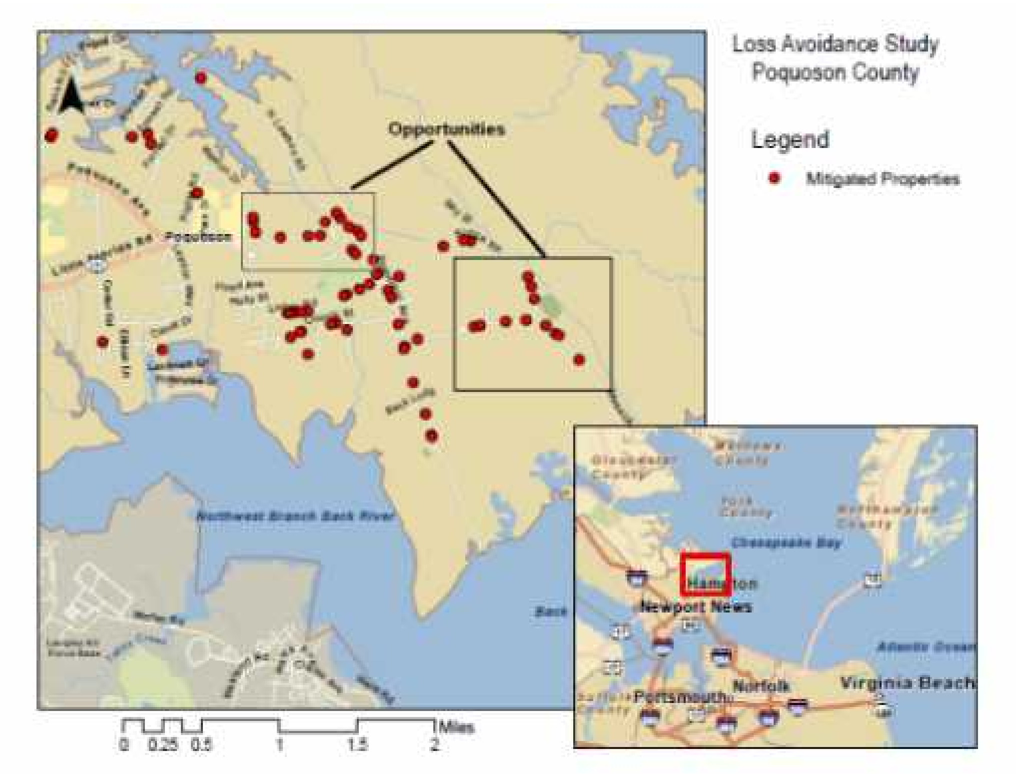
1. Chesapeake County
2. Gloucester County
3. Hampton County
4. Northumberland County
5. Prince William County
6. Virginia Beach County
7. City of Newport News
8. City of Norfolk
9. City of Poquoson
10. City of Roanoke
11. City of Tangier Island

Discussed with the LAS team and VDEM staff determined that the best candidates for this effort were likely the City of Poquoson and the City of Roanoke. It was important to all that both a riverine flood area and a coastal flood area be included, and that both elevations and acquisitions be included, if possible, and it was determined that these communities best fit the established criteria.

5. D.1 City of Poquoson

Once selected, it was necessary to further refine the properties for inclusion in the study. It was determined that two areas of the City had the strongest potential to yield results, based on location, topography, and project completion date.

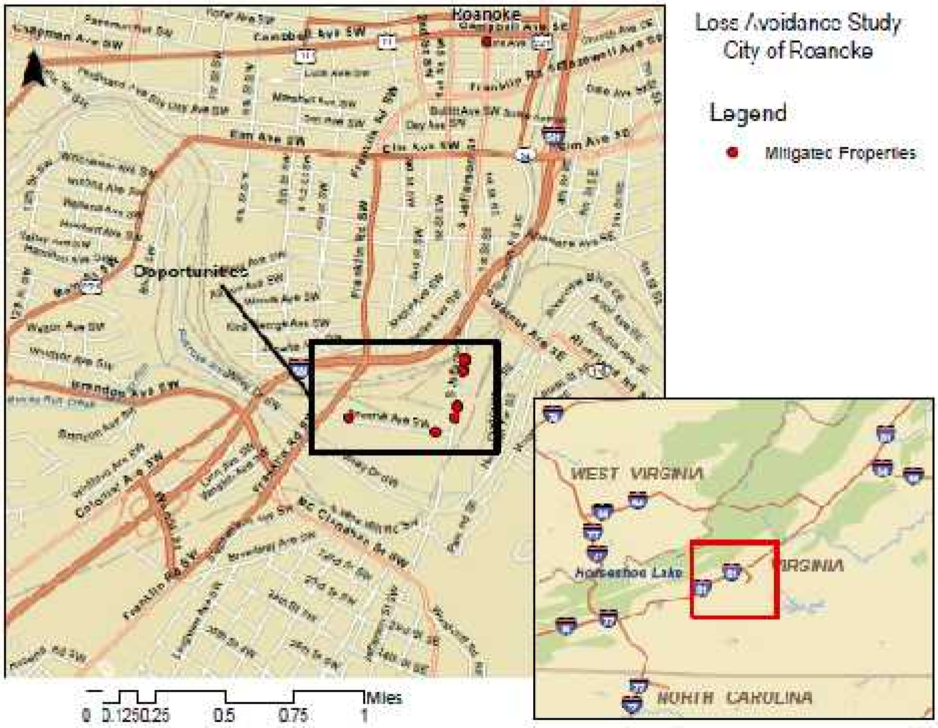
Figure 3: LAS Opportunities - City of Poquoson



6. D.2 City of Roanoke

A similar process was followed for property selection in the City of Roanoke. It was important that the study properties be in approximate relation to one another in terms of topography and flood history, and that the projects were completed early enough to allow time for post-mitigation flood events to occur.

Figure 4: LAS Opportunities - City of Roanoke



E. Losses Avoided

To complete this study, the following calculations were performed:

- Losses to the community from the subject storm events
- Storm surge elevations
- Historic crest elevations
- Residential building depth-damage
- Residential building contents depth-damage
- Losses avoided through mitigation

7. E.1 City of Poquoson

The week of September 25, 2017, a site visit was made to Poquoson. The purpose was to meet and interview local and state officials and view the mitigated structures. The City of Poquoson provided documentation and anecdotal information regarding two coastal flood events in 2009 (Nor'Ida) and 2011 (Hurricane Irene), as well as a wealth of other local information. During the site visits GPS and address information was confirmed, and photographs of the current condition of the mitigated structures were taken. Based on the interviews and documentation, the 2009 and the 2011 coastal flood events were used to measure cost effectiveness.

1. E.1.1 Storm History Calculations

The following calculations were made and used for the 2009 and 2011 storm events in Poquoson.

DR-1862 Tropical Depression (Nor' Ida)
Declaration Date: 12/09/2009
Incident Period: 11/11/2009 through 11/16/2009

Table 3: Nor'Ida Damage Estimates (from PDA)[10]

Type Property	Major Damage	Minor Damage	Dollar Loss
Single Dwelling	150	400	$6,950,000
Multi-Family		1	$20,000
Business Industry		5	$50,000
Non-Profit Buildings		2	$20,000
Total	**150**	**408**	**$7,040,000**

FEMA Public Assistance was estimated at an additional $412,514 (infrastructure damage and emergency protective measures). This brings the total storm preliminary damage estimate to **$7,452,514**.

Surge Elevation - NOAA Gage at James River (VA) Sewell's Point
7.74 feet on 11/12/2009 (3rd highest recorded elevation)

DR-4024 Hurricane Irene
Declaration Date: 09/03/2011
Incident Period: 08/26/2011 through 08/28/2011

Table 4: Hurricane Irene Damage Estimates (from PDA)[11]

Type Property	Major Damage	Minor Damage	Dollar Loss
Single Dwelling	42	40	$930,000
Multi-Family	0	0	0
Business Industry	0	0	0
Non-Profit Buildings	1	0	$50,000
Total	**43**	**40**	**$980,000**

FEMA Public Assistance was estimated at $ 170,393 (infrastructure damage and emergency protective measures). This brings the total storm preliminary damage estimate to **$1,150,393.**

Surge Elevation - NOAA Gage at James River (VA) Sewell's Point
7.55 feet on 08/27/2011 (4th highest recorded elevation)

Historic crest calculations for both the York and James Rivers can be found in the tables following.
Table 5: York River - Highest Historic Crests

York River – NOAA Gage Historic Crests[2]		
Ranking	**Elevation**	**Date**
1	7.61 feet	11/12/2009

[2] Gage since discontinued.

York River – NOAA Gage Historic Crests[2]		
Ranking	**Elevation**	**Date**
2	7.54 feet	09/18/2003
3	7.38 feet	08/27/2011
4	7.15 feet	10/28/2012
5	7.13 feet	10/29/2012

Table 6: James River - Highest Historic Crests

James River – NOAA Gage Historic Crests		
Ranking	**Elevation**	**Date**
1	8.02 feet	08/23/1933
2	7.89 feet	09/18/2003
3	7.74 feet	11/12/2009
4	7.55 feet	08/27/2011
5	7.22 feet	03/07/1962
6	6.81 feet	03/07/1962
7	6.72 feet	09/18/1936
8	6.63 feet	11/22/2006
9	6.58 feet	02/05/1998
10	6.52 feet	10/07/2006

2. E.1.2 Project Funding

On March 31, 2006, the City of Poquoson entered into an agreement with VDEM to receive DR-1491 HMGP funding. On April 24, 2006, the Poquoson City Council passed a resolution accepting an HMGP sub- grant for elevating fifteen residential structures. The project had an initial estimated budget of $655,650; this figure was revised in December 2007 to $830,650[12].

Note: Five of the original structures were not included in this review. One structure was not elevated; two structures no longer exist, and two structures were later replaced with new structures. Seven additional structures were moved to the CDBG program. These seven were included in this study, bringing the total number of structures in the study to 17.

3. E.1.3 Loss Avoidance Calculations

The surge elevation was obtained from the James River Gage for both the 2009 and 2011 coastal flood events. The finished floor elevations were subtracted from the James River Gage reading to arrive at the flood depth. The flood depth was used in the building and content depth damage function described below, and seen in Tables 1 and 2 (earlier in this document).

Residential Building Depth Damage – The USACE residential building depth damage function was used to calculate building damage. The residential building depth damage curve was used to assign the percent damaged based on depth of water and number of stories. The percent damage was multiplied by the value of the structure to arrive at a damage cost.

Residential Building Contents Depth Damage – The USACE residential building content depth damage function was used to calculate content damage. The residential building content depth damage curve was used to assign the percent damaged based on depth of water and number of stories. The percent damage was multiplied by the value of the structure to arrive at a damage cost.

Building and content depth damage calculations were made for the 2009 and 2011 coastal flood events. The sum of building and content damage for both flood events equals losses avoided.

The losses avoided divided by the project cost provides the ratio. The table on the following page provides the calculation details for each structure included in the final study.

Table 7: Losses Avoided - 2009 Storm Event

Property ID	Year Built	Number of Stories	Finished Floor Elevation (pre-mitigation)	Finished Floor Elevation (post-mitigation)	Cost of Mitigation	Structure Value	2009 Losses Avoided (Structure)	2009 Losses Avoided (Contents)	2009 Total Losses Avoided	2009 Benefit-Cost Ratio
7	1949	2	3.6 feet	10 feet	$31,850	$65,900	$20,693	$12,192	$32,885	1.03
31	1939	1	4.0 feet	11 feet	$28,150	$63,000	$29,673	$16,191	$45,864	1.63
12	1957	1	4.1 feet	11 feet	$44,350	$86,000	$40,506	$22,102	$62,608	1.41
18	1949	1	4.4 feet	11 feet	$28,150	$51,300	$20,571	$11,286	$31,857	1.13
10	1949	1	4.5 feet	11 feet	$44,350	$73,300	$29,393	$16,126	$45,519	1.03
6	1948	1	4.8 feet	10 feet	$43,150	$94,300	$37,814	$20,746	$58,560	1.36
4	1958	1	5.0 feet	10 feet	$43,150	$105,800	$42,426	$23,276	$65,702	1.52
2	1949	1	5.3 feet	10 feet	$43,250	$95,900	$30,784	$17,166	$47,950	1.11
9	1965	1	5.5 feet	10 feet	$49,350	$75,900	$24,364	$13,586	$37,950	0.77
11	1965	1	5.9 feet	10 feet	$43,150	$97,000	$31,137	$17,363	$48,500	1.12
5[3]	1949	2	4.6 feet	11 feet	$43,450	$113,500	$29,851	$17,593	$47,444	1.09
15	1949	2	5.0 feet	10 feet	$39,250	$99,100	$26,063	$17,361	$41,424	1.06
16	1949	2	5.0 feet	11 feet	$43,450	$97,600	$25,669	$15,128	$40,797	0.94
24	1955	1	5.0 feet	10 feet	$38,170	$101,800	$40,822	$22,396	$63,218	1.66
14	1949	2	5.3 feet	10 feet	$58,150	$78,000	$16,302	$9,516	$25,818	0.44
23	1949	1	5.5 feet	10 feet	$56,050	$106,500	$34,187	$19,064	$53,251	0.95
25	1970	1	5.8 feet	10 feet	$74,950	$185,700	$59,610	$33,240	$92,850	1.24
--	**--**	**--**	**4.9 feet (Average)**	**10.35 feet (Average)**	**$752,370 (Total)**	**$1,590,600 (Total)**	**$539,864 (Total)**	**$302,330 (Total)**	**$842,194 (Total)**	**1.12 (Aggregate)**

[3] Properties 5, 15, 16, 24, 14, 23, and 25 were funded using CDBG rather than HMGP funds.

Table 8: Losses Avoided - 2011 Storm Event

Property ID	Year Built	Number of Stories	Finished Floor Elevation (pre-mitigation)	Finished Floor Elevation (post-mitigation)	Cost of Mitigation	Structure Value	2011 Losses Avoided (Structure)	2011 Losses Avoided (Contents)	2011 Total Losses Avoided	2011 Benefit-Cost Ratio
7	1949	2	3.6 feet	10 feet	$31,850	$65,900	$20,693	$12,192	$32,884	1.03
31	1939	1	4.0 feet	11 feet	$28,150	$63,000	$29,673	$16,191	$45,864	1.63
12	1957	1	4.1 feet	11 feet	$44,350	$86,000	$34,486	$18,920	$53,406	1.20
18	1949	1	4.4 feet	11 feet	$28,150	$51,300	$20,571	$11,286	$31,857	1.13
10	1949	1	4.5 feet	11 feet	$44,350	$73,300	$29,393	$16,126	$45,519	1.03
6	1948	1	4.8 feet	10 feet	$43,150	$94,300	$37,814	$20,746	$58,560	1.36
4	1958	1	5.0 feet	10 feet	$43,150	$105,800	$42,426	$23,276	$65,702	1.52
2	1949	1	5.3 feet	10 feet	$43,250	$95,900	$30,784	$17,166	$47,950	1.11
9	1965	1	5.5 feet	10 feet	$49,350	$75,900	$24,364	$13,586	$37,950	0.77
11	1965	1	5.9 feet	10 feet	$43,150	$97,000	$31,137	$17,363	$48,500	1.12
5[4]	1949	2	4.6 feet	11 feet	$43,450	$113,500	$29,851	$17,593	$47,443	1.09
15	1949	2	5.0 feet	10 feet	$39,250	$99,100	$26,063	$15,361	$41,424	1.06
16	1949	2	5.0 feet	11 feet	$43,450	$97,600	$25,669	$15,128	$40,797	0.94
24	1955	1	5.0 feet	10 feet	$38,170	$101,800	$40,822	$22,396	$63,218	1.66
14	1949	2	5.3 feet	10 feet	$58,150	$78,000	$16,302	$9,516	$25,818	0.44
23	1949	1	5.5 feet	10 feet	$56,050	$106,500	$34,187	$19,064	$53,250	0.95
25	1970	1	5.8 feet	10 feet	$74,950	$185,700	$59,610	$33,240	$92,850	1.24
--	--	--	**4.9 feet (Average)**	**10.35 feet (Average)**	**$752,370 (Total)**	**$1,590,600 (Total)**	**$533,844 (Total)**	**$299,149 (Total)**	**$832,992 (Total)**	**1.11 (Aggregate)**

[4] Properties 5, 15, 16, 24, 14, 23, and 25 were funded using CDBG rather than HMGP funds.

Table 9: Losses Avoided - Aggregate of Both Storm Events

Property ID	Year Built	Number of Stories	Finished Floor Elevation (pre-mitigation)	Finished Floor Elevation (post-mitigation)	Cost of Mitigation	Structure Value	2009 Losses Avoided (Total)	2011 Losses Avoided (Total)	Aggregate Losses Avoided	Aggregate Benefit-Cost Ratio
7	1949	2	3.6 feet	10 feet	$31,850	$65,900	$32,885	$32,884	$65,768	2.06
31	1939	1	4.0 feet	11 feet	$28,150	$63,000	$45,864	$45,864	$91,728	3.23
12	1957	1	4.1 feet	11 feet	$44,350	$86,000	$62,608	$53,406	$116,014	2.61
18	1949	1	4.4 feet	11 feet	$28,150	$51,300	$31,857	$31,857	$63,715	2.26
10	1949	1	4.5 feet	11 feet	$44,350	$73,300	$45,519	$45,519	$91,039	2.05
6	1948	1	4.8 feet	10 feet	$43,150	$94,300	$58,560	$58,560	$117,121	2.71
4	1958	1	5.0 feet	10 feet	$43,150	$105,800	$65,702	$65,702	$131,404	3.04
2	1949	1	5.3 feet	10 feet	$43,250	$95,900	$47,950	$47,950	$95,900	2.21
9	1965	1	5.5 feet	10 feet	$49,350	$75,900	$37,950	$37,950	$75,900	1.53
11	1965	1	5.9 feet	10 feet	$43, 150	$97,000	$48,500	$48,500	$97,000	2.23
5[13]	1949	2	4.6 feet	11 feet	$43,450	$113,500	$47,444	$47,443	$94,886	2.18
15	1949	2	5.0 feet	10 feet	$39,250	$99,100	$41,424	$41,424	$82,848	2.11
16	1949	2	5.0 feet	11 feet	$43,450	$97,600	$40,797	$40,797	$81,594	1.87
24	1955	1	5.0 feet	10 feet	$38,170	$101,800	$63,218	$63,218	$126,436	3.31
14	1949	2	5.3 feet	10 feet	$58,150	$78,000	$25,818	$25,818	$51,636	088
23	1949	1	5.5 feet	10 feet	$56,050	$106,500	$53,251	$53,250	$106,500	1.90
25	1970	1	5.8 feet	10 feet	$74,950	$185,700	$92,850	$92,850	$185,700	2.47
--	--	--	**4.9 feet (Average)**	**10.35 feet (Average)**	**$752,370 (Total)**	**$1,590,600 (Total)**	**$842,194 (Total)**	**$832,992 (Total)**	**$1,675,186 (Total)**	**2.22 (Aggregate)**

As is clear from the preceding tables, the private property elevation projects implemented in the City of Poquoson were cost-beneficial. While not every structure has delivered a positive return on the initial investment to date, the project has resulted in at least $2.22 in avoided losses for every dollar spent on mitigation. This positive return on taxpayer investment demonstrates that VDEM, the City of Poquoson, and the Commonwealth as whole have a sound understanding of where and how to fund and implement effective mitigation projects to prevent or reduce future damages and losses.

8. E.2 City of Roanoke

The week of September 04, 2017, a site visit was made to Roanoke. The purpose was to meet and interview local and state officials and view the mitigated properties. During the site visits GPS and address information was confirmed, and photographs of the current condition of the mitigated properties were taken. The City of Roanoke provided documentation and anecdotal information regarding other flood control and mitigation measures enacted in the City over the previous two decades, as well as a wealth of other local information and insight. City staff confirmed that – while there have been floods in the City since these properties were acquired – no flooding has occurred in the project areas since the properties were acquired. A review of the available, documented flood history of the City confirmed this finding.

1. E.2.1 Project Funding

The mitigation projects funded in the City of Roanoke were all implemented as private property acquisition projects, in which the existing structures were demolished and the remaining lots were deed-restricted to greenspace in perpetuity. Fifteen properties were identified to study. Twelve of these properties were funded through HMGP (using DR-1021 (1998) and DR-1570 (2005) funds), with the remaining three funded through FMA FY05.

In the original project applications for HMGP, ten of the eleven properties were excluded from the general requirement to demonstrate that the project was cost-beneficial. This is because of a FEMA policy which waived the normally required benefit-cost analysis if the property to be acquired meets two conditions:

- The property is located within a FEMA-identified Special Flood Hazard Area (SFHA), also known as the 100-year or 1% annual chance floodplain, but is not located in a coastal high hazard area (i.e., a V-zone); and
- The property has been declared to be substantially damaged by the local authority, meaning that the damage to the property (from any source) is greater than 50% of the value of the structure at the time the damage occurred.

Each of these ten properties met these two conditions at the time of acquisition, and so were assumed to be cost-effective. Therefore, no benefit-cost analysis was performed as part of the application process.

For the remaining property acquired through HMGP funds, a benefit-cost analysis was performed as part of the application. Records provided by VDEM indicate that the benefit-cost ratio for this property was 1.0, meaning that for every $1 spent to acquire and demolish the structure, $1 in damages was assumed to be avoided.

For the three properties acquired using FMA funds, a benefit-cost analysis was performed as part of the application process. These properties had individual benefit-cost ratios of 1.22, 1.69, and 0.56 to 1, for an overall project benefit-cost ratio of 1.15 to 1. This means that for every $1 spent to acquire and demolish these properties, $1.15 in damages was assumed to be avoided[14].

2. E.2.2 Losses Avoided

As there have been no documented flood events in the study area since the properties were acquired and the land returned to greenspace, actual losses avoided cannot be calculated, as there are no post-mitigation damages in the project area to use in the calculation.

Based on the interviews and documentation, it is assumed that these other mitigation and flood control measures (discussed earlier in this document) are a significant reason for the lack of flood occurrences since mitigation, though this cannot be confirmed without a detailed hydrology and hydrological study (H&H), which is outside of the scope of this study.

2. Appendix

An extensive, multi-tab spreadsheet accompanies this study. This spreadsheet contains all data and calculations used to produce this study, for both the City of Poquoson and the City of Roanoke. Due to the amount of data contained in this spreadsheet, it is not practical to import it into this document. Thus, it is submitted as an appendix to this study.

Endnotes

[1] VDEM Hazard Mitigation Project Reports, Open and Closed projects. 2017.
[2] Hampton Roads Hazard Mitigation Plan. 2017.
[3] City of Poquoson website. http://www.ci.poquoson.va.us/264/Flood-Information. 2017.
[4] Roanoke Valley-Alleghany Regional Commission Regional Pre-Disaster Mitigation Plan. 2013.
[5] City of Roanoke. https://www.roanokeva.gov/1884/Flood-Preparedness. 2017.
[6] Roanoke Valley Greenways website. http://greenways.org/?page_id=10. 2017.
[7] City of Roanoke. 2017.
[8] USACE.
[9] USACE.
[10] City of Poquoson Preliminary Damage Assessment. 2009.
[11] City of Poquoson Preliminary Damage Assessment. 2011.
[12] VDEM grant records.
[13] Properties 5, 15, 16, 24, 14, 23, and 25 were funded using CDBG rather than HMGP funds, though they were originally included in the HMGP project application.
[14] VDEM grant records.