# Hazard Mitigation
# Loss Avoidance Study
# Chesapeake, Virginia

Elevations

Hazard Mitigation Grant Program (HMGP) 1491

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# Introduction

The Commonwealth of Virginia has a history and exposure to a wide array of natural hazards as demonstrated by 73 federal disaster declarations occurring since 1953 (Table 1).[1] As such, the Commonwealth has a long-established commitment to hazard mitigation in the encouragement, promotion, assistance with, and funding of the implementation of measures to reduce or eliminate long-term risk to people and property from natural hazards and their effects.

*Table 1: Federally Declared Disaster Declarations in Virginia and the City of Chesapeake*

| Incident Type | Virginia (#) | Chesapeake (#) |
|---|---|---|
| **Severe Storm** | 19 | 1 |
| **Flood** | 16 | 1 |
| **Hurricane** | 16 | 10 |
| **Fire** | 8 | |
| **Snowstorm** | 6 | 2 |
| **Biological** | 2 | 2 |
| **Drought** | 2 | |
| **Earthquake** | 1 | |
| **Freezing** | 1 | 1 |
| **Severe Ice Storm** | 1 | |
| **Terrorist** | 1 | |
| **Total** | **73** | **17** |

Since 1990, more than $200 million of Hazard Mitigation Assistance (HMA) funding has been allocated[2] to Virginia communities and agencies (Table 2).[3] Of those dollars $13M has been spent on various projects in the City of Chesapeake (Table 3).

To document and evaluate the impact of this funding, and update the *Commonwealth of Virginia Hazard Mitigation Plan*, VDEM determined that it is appropriate to examine a selection of completed mitigation projects and estimate the real-world losses avoided through those projects.

[1] FEMA Open Data: https://www.fema.gov/openfema-data-page/disaster-declarations-summaries-v2
[2] Includes closed, obligated, and approved projects.
[3] FEMA Open Data: https://www.fema.gov/openfema-data-page/hazard-mitigation-assistance-projects-v2

*Table 2: Hazard Mitigation Assistance (HMA) grants 1990 – 2022 Virginia*

| HMA Project Type - Virginia | $ Amount | # Projects |
|---|---|---|
| Elevation of Private Structures - Coastal | $51,382,872 | 58 |
| Acquisition of Private Real Property (Structures and Land) - Riverine | $34,982,356 | 96 |
| Acquisition of Private Real Property (Structures and Land) - Coastal | $24,779,435 | 27 |
| Infrastructure Protective Measures | $21,542,612 | 2 |
| Management Costs | $19,229,850 | 40 |
| Elevation of Private Structures - Riverine | $14,175,181 | 29 |
| Multihazard Mitigation Plan | $13,815,496 | 101 |
| Generators | $4,391,898 | 22 |
| Acquisition of Public Real Property (Structures and Land) - Riverine | $4,176,433 | 9 |
| Acquisition of Public Real Property (Structures and Land) - Coastal | $2,621,939 | 3 |
| Stormwater Management - Diversions | $2,538,191 | 3 |
| Flood Control - Dam | $2,510,440 | 1 |
| Shoreline Stabilization (Riprap, etc.) | $2,328,770 | 1 |
| Stormwater Management - Culverts | $2,203,414 | 3 |
| Other Equipment Purchase and Installation | $1,833,474 | 15 |
| Miscellaneous | $1,680,426 | 18 |
| Other Non Construction (Regular Project Only) | $1,358,447 | 12 |
| Warning Systems (as a Component of a Planned, Adopted, and Exercised Risk Reduction Plan) | $1,179,492 | 14 |
| Retrofitting Public Structures - Wind | $1,023,034 | 5 |
| Public Awareness and Education (Brochures, Workshops, Videos, etc.) | $965,089 | 22 |
| Water and Sanitary Sewer System Protective Measures | $734,432 | 7 |
| Stormwater Management - Detention/Retention Basins | $730,000 | 1 |
| Dry Floodproofing Private Structures - Riverine (Commercial) | $576,176 | 4 |
| Advance Assistance (FMA and PDMC) | $517,082 | 3 |
| Landslide Stabilization - Structural | $516,994 | 1 |
| Mitigation Reconstruction | $502,221 | 3 |
| Feasibility, Engineering and Design Studies | $461,076 | 6 |
| Utility Protective Measures (Electric, Gas, etc.) | $370,389 | 3 |
| No Data | $335,335 | 10 |
| Relocation of Private Structures - Riverine | $151,079 | 3 |

| HMA Project Type - Virginia | $ Amount | # Projects |
|---|---|---|
| Advanced Assistance | $125,000 | 1 |
| Developing, Implementing and Enforcing Codes, Standards, Ordinances and Regulations | $118,712 | 1 |
| Technical Assistance - Outreach/Training | $116,666 | 2 |
| FMA or CRS Plan | $54,800 | 1 |
| Dry Floodproofing Private Structures - Coastal (Commercial) | $45,860 | 1 |
| Stormwater Management - Flapgates/Floodgates | $27,000 | 1 |
| Planning Related Activities | $12,120 | 1 |
| Technical Assistance - Application Development/Review | $0 | 1 |
| **Grand Total** | **$214,113,791** | **531** |

*Table 3: Hazard Mitigation Assistance (HMA) grants 1990 – 2022 City of Chesapeake*

| HMA Project Type – City of Chesapeake | $ Amount | # Projects |
|---|---|---|
| Acquisition of Private Real Property (Structures and Land) - Coastal | $11,845,424 | 11 |
| Elevation of Private Structures - Coastal | $418,164 | 1 |
| Generators | $334,996 | 1 |
| Other Equipment Purchase and Installation | $5,500 | 1 |
| Public Awareness and Education (Brochures, Workshops, Videos, etc.) | $12,566 | 4 |
| Water and Sanitary Sewer System Protective Measures | $52,006 | 2 |
| Multihazard Mitigation Plan | $312,580 | 2 |
| **Grand Total** | $12,981,236 | 22 |

This report presents the study in the following sections: 1) Study Summary, 2) Project Summary, 3) Study Methodology, and 4) Loss Avoidance Calculations.

## Study Summary

The study area is located in the City of Chesapeake which is part of the Hampton Roads Planning District Commission (HRPDC).[4] The HRPDC has identified, through a Hazard Identification and Risk Assessment (HIRA) process, 13 natural hazards most likely to impact the district's communities. Flooding was assessed as the highest risk to mitigate. The projects selected for the study include four private property elevations located adjacent to the Southern Branch of the Elizabeth River. This area has an extensive history of coastal and riverine flooding. It has also experienced post-mitigation flooding necessary for a study such as this one, to determine what losses would have occurred had those structures remained unmitigated when later flooding occurred.

**Study Area** – City of Chesapeake
**Hazard Type** – Coastal Flooding
**Project Type** – Elevation
**Total Project Cost** – $417,729
**Total Losses Avoided** – $430,598
**Return on Investment (ROI) | Benefit-Cost Ratio** – 1.03

This LAS demonstrated losses avoided that were returned far in advance of the project useful life of 30 years. The project exceeded the desired costs saved in an approximate 2-year period.

[4] Hampton Roads Planning District Commission Hazard Mitigation Plan Update 2022 at https://www.hrpdcva.gov/departments/emergency-management/2022-hampton-roads-hazard-mitigation-plan


*Figure 1: Location of mitigated properties*

# Project Summary

The four project structures included in this LAS were all elevated in 2009.

**Grant:** Hazard Mitigation Assistance (HMA)
**Subgrant(s):** Hazard Mitigation Grant Program (HMGP) DR-1491-VA[5]
**Project Number** - VA 1491-550-032
**Applicant** – City of Chesapeake
**FEMA Approved Multi-Hazard Mitigation Plan** – Hampton Roads Hazard Mitigation Plan[6]
**Flood Zone Designation** – Zone AE
**Flood Insurance Study** - 510034V000A[7]
**Project Type** – Elevation of 4 residential properties
**Project Useful Life** – 30 Years[8]

## *Pre-Mitigation Problem Description*

The City of Chesapeake is located in the Hampton Roads region of southeastern Virginia. The mitigated properties are located along the Southern Branch of the Elizabeth River. The buildings are primary residences located in the 100-year floodplain and have experienced repetitive flooding.

Hampton Roads is located in southeastern Virginia on the Atlantic Coastal Plain, bordered to the east by the Atlantic Ocean and Chesapeake Bay, and characterized by low, flat relief. The highest elevation in the region is 177 feet above sea level, while the average elevation for the City of Chesapeake is 12.2 feet above sea level. The region is comprised of portions of four major river basins including the James River Basin, York River Basin, Chesapeake Bay, and Albemarle-Chowan Basin. The study area is located in the Hampton Roads – Elizabeth subbasin of the James River and Chesapeake Bay.

Large sections of Chesapeake are subject to tidal flooding during hurricanes and severe storms with average tidal flooding of seven feet in vulnerable areas, especially along the Elizabeth River and it's tributary branches.

In 2003, Hurricane Isabel made landfall on September 8th in the Outer Banks of North Carolina and tracked northward through Virginia. Though Isabel had weakened to a Tropical

[5] DR-1491-VA was declared September 18, 2003 – Hurricane Isabel
[6] 2022 version at https://www.hrpdcva.gov/departments/emergency-management/2022-hampton-roads-hazard-mitigation-plan
[7] Flood Insurance Study City of Chesapeake, Virginia, 510034V000A, December 16, 2014
[8] FEMA Benefit-Cost Analysis *BCA Reference Guide*, June 2009 at https://www.fema.gov/grants/guidance-tools/benefit-cost-analysis

Storm by the time it entered Virginia it caused high winds, storm surge flooding, and extensive property damage throughout the Chesapeake Bay region. Isabel was the costliest disaster in Virginia history and resulted in average rainfall of 4-7 inches and four to five foot storm surge in southside Hampton Road.

### *Post-Mitigation Event*

In 2011 Hurricane Irene passed northward just off the coast of Virginia, producing heavy rains and extensive flooding with rainfall of 6-12 inches and storm surge 8.5 feet above mean sea level. Low lying south Hampton Roads communities experienced widespread flooding.

*Figure 2: Mitigated properties photos*

*Figure 3: September 2008 flooding photos*

*Figure 4: Hurricane Irene 2011 high water mark photos*

# Study 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 project(s) studied be completed prior to the event(s) analyzed, as losses avoided through the mitigation measure are determined by comparing the damage that would have been caused by the event had the projects not be implemented.

The following list provides examples of standard data inputs for conducting an LAS:

- Cost of the mitigation measure
- First floor elevations (pre-mitigation)
- First floor elevations (post-mitigation – Elevations only)
- Base Flood Elevations
- Stillwater elevations
- Building type
- Number of stories
- Foundation type
- Square footage of the structures
- Building replacement value
- Number of residents, and number employed
- Depth of flooding in project area (post-mitigation event)

## *Assumptions*

- All buildings have an active NFIP Policy.
- Building replacement value is based on FEMA BCA 6.0 Toolkit default value of $100 per square foot.
- Contents replacement value is based on FEMA BCA 6.0 Toolkit default of 100% for residential properties.
- Depth damage function values are based on FEMA BCA 6.0 Toolkit to determine avoided building, contents, and displacement costs during the post-mitigation event.
- For elevated properties there is a social benefit assuming on average a 2 plus person household with at least one person working.
- Flood depth at property location were estimated using post-mitigation event photos of high-water marks on structures.

## Loss Avoidance Calculations

To complete this study, the following calculations were performed to estimate losses avoided through mitigation from the Hurricane Irene post-mitigation storm event:

- Building depth-damage
- Building contents depth-damage
- Displacement costs
- Social benefits
- Benefit cost ratio

*Table 4: Example of stillwater elevations*

| Recurrence Interval | Stillwater Elevations |
|---|---|
| 10 | 5.7 |
| 50 | 7.1 |
| 100 | 7.7 |
| 500 | 9.1 |

*Table 5: Example depth damage curve - Building*

| Depth Damage Curve - Building | | |
|---|---|---|
| **Flood depth (ft)** | **Percent (%)** | **Damage Value ($)** |
| -2 | 0.5 | 2,110.52 |
| -1 | 0.5 | 2,110.52 |
| 0 | 1.0 | 4,221.04 |
| 1 | 12.5 | 52,763.04 |
| 2 | 20.4 | 86,109.28 |
| 3 | 25.9 | 109,325.01 |
| 4 | 31.7 | 133,807.06 |
| 5 | 33.5 | 141,404.94 |
| 6 | 37.5 | 158,289.12 |
| 7 | 39.4 | 166,309.10 |
| 8 | 42.2 | 178,128.02 |
| 9 | 45.1 | 190,369.04 |
| 10 | 46.6 | 196,700.61 |
| 11 | 46.6 | 196,700.61 |
| 12 | 46.6 | 196,700.61 |
| 13 | 46.6 | 196,700.61 |
| 14 | 46.6 | 196,700.61 |
| 15 | 46.6 | 196,700.61 |

| Depth Damage Curve - Building | | |
|---|---|---|
| Flood depth (ft) | Percent (%) | Damage Value ($) |
| 16 | 46.6 | 196,700.61 |

*Table 6: Example depth damage curve - Contents*

| Depth Damage Curve - Contents | | |
|---|---|---|
| Flood depth (ft) | Percent (%) | Damage Value ($) |
| -2 | 0.0 | - |
| -1 | 0.0 | - |
| 0 | 0.0 | - |
| 1 | 22.0 | 11,143.55 |
| 2 | 30.0 | 15,195.75 |
| 3 | 39.0 | 19,754.48 |
| 4 | 45.0 | 22,793.63 |
| 5 | 48.0 | 24,313.20 |
| 6 | 52.0 | 26,339.30 |
| 7 | 56.0 | 28,365.41 |
| 8 | 59.0 | 29,884.98 |
| 9 | 61.0 | 30,898.03 |
| 10 | 63.0 | 31,911.08 |
| 11 | 63.0 | 31,911.08 |
| 12 | 63.0 | 31,911.08 |
| 13 | 63.0 | 31,911.08 |
| 14 | 63.0 | 31,911.08 |
| 15 | 63.0 | 31,911.08 |
| 16 | 63.0 | 31,911.08 |

*Table 7: Example depth damage curve - Displacement*

| Depth Damage Curve - Displacement | | |
|---|---|---|
| Flood depth (ft) | Days | Damage Value ($) |
| -2 | 0 | - |
| -1 | 0 | - |
| 0 | 0 | - |
| 1 | 45 | 12,748.37 |
| 2 | 90 | 25,496.75 |
| 3 | 135 | 38,245.13 |
| 4 | 180 | 63,741.89 |

| Depth Damage Curve - Displacement | | |
|---|---|---|
| **Flood depth (ft)** | **Days** | **Damage Value ($)** |
| 5 | 255 | 79,677.36 |
| 6 | 270 | 95,612.84 |
| 7 | 315 | 111,548.31 |
| 8 | 360 | 101,987.03 |
| 9 | 405 | 114,735.41 |
| 10 | 450 | 127,483.79 |
| 11 | 450 | 127,483.79 |
| 12 | 450 | 127,483.79 |
| 13 | 450 | 127,483.79 |
| 14 | 450 | 127,483.79 |
| 15 | 450 | 127,483.79 |
| 16 | 450 | 127,483.79 |

## *Losses Avoided*

Losses avoided and the benefit-cost ratio are reported below. Table 8 reports the property ID, total project cost, estimated depth of flooding from the Hurricane Irene storm event, value of damage to the building and contents, displacement costs and benefit cost ratio. Expected annual social benefits are an estimated $13,622 per structure.

*Table 8: Losses avoided*

| ID | Total Project Costs | Flood Depth | Building Damage Value | Contents Damage Value | Displacement Damage Value | Total Damage Losses Avoided | Benefit-Cost Ratio |
|---|---|---|---|---|---|---|---|
| **1** | $71,421 | 1.00 | $45,407 | $24,605 | $9,090 | $79,102 | 1.11 |
| **2** | $103,949 | 1.67 | $73,886 | $39,368 | $15,180 | $128,434 | 1.24 |
| **3** | $117,135 | 2.00 | $60,840 | $32,219 | $18,180 | $111,239 | 0.95 |
| **4** | $125,224 | 1.50 | $63,978.00 | $34,210 | $13,635 | $111,823 | 0.89 |
| | **$417,729** | | **$244,111** | **$130,402** | **$56,085** | **$430,598** | **1.03** |

While not all properties exhibited a cost-effective benefit cost ratio, the overall performance of this project proves cost effective.