Hazard Mitigation
Loss Avoidance Study
Russell County, Virginia

Town of Cleveland Acquisition(s)
2014 Pre-Disaster Mitigation

March 2022

Developed and published by the Virginia Department of Emergency Management and the Virginia Modeling, Analysis and Simulation Center of Old Dominion University

Introduction

The Commonwealth of Virginia has a history and exposure to a wide array of natural hazards as demonstrated by 71 federal disaster declarations occurring since 1957 (Table 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 & Russell County[1]

Incident Type	Virginia (#)	Russell County (#)
Severe Storm(s)	17	5
Flood	16	1
Hurricane	16	4
Fire	8	
Snow	6	4
Biological	2	2
Drought	2	1
Earthquake	1	
Freezing	1	
Severe Ice Storm	1	
Terrorist	1	
Total	**71**	**17**

Since 1990, more than $200 million of Hazard Mitigation Assistance (HMA) funding has been allocated to Virginia communities and agencies (Table 2). In order 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

Table 2: Hazard Mitigation Assistance Grants Open & Closed 1990 - 2021[2]

Hazard Mitigation Assistance Project Type	Amount Allocated
Elevation	$65,558,053
Acquisition	$65,052,415
Infrastructure Protective Measures	$21,542,612
Hazard Mitigation Plan	$12,549,092
Management Costs	$12,163,922
Stormwater Management	$4,498,605
Generators	$3,828,450
Flood Control - Dam	$2,510,440
Shoreline Stabilization	$2,328,770
Other Equipment Purchase and Installation	$1,748,805
Miscellaneous	$1,680,426
Other Non-Construction	$1,358,447
Warning Systems	$1,179,492
Retrofitting - Wind	$1,023,034
Public Awareness and Education	$965,089
Water & Sanitary Sewer System Protective Measures	$734,432
Advanced Assistance	$642,082
Dry Floodproofing	$622,036
Landslide Stabilization	$516,994
Mitigation Reconstruction	$502,221
Feasibility, Engineering and Design Studies	$461,076
Utility Protective Measures	$370,389
(blank)	$335,335
Relocation	$151,079
Codes, Standards, Ordinances and Regulations	$118,712
Technical Assistance	$116,666
Planning	$66,920
Grand Total	**$202,625,595**

This report presents the study in the following sections: 1) Study Summary, 2) Project Summary, 3) Flood History, 4) Methodology, and 5) Loss Avoidance Calculations.

[2] FEMA Open Data: https://www.fema.gov/openfema-data-page/hazard-mitigation-assistance-projects-v2

Study Summary

The study area is located in Russell County, Town of Cleveland which is part of the Cumberland Plateau Planning District Commission (CPPDC).[3] The CPPDC has identified, through a Hazard Identification and Risk Assessment (HIRA) process, 14 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 five private property acquisitions located adjacent to the Clinch River. This area has an extensive history of 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 – Russell County, Town of Cleveland
Hazard Type – Riverine Flooding
Project Type – Acquisition Demolition
Total Project Cost – $391,677
Total Losses Avoided – $357,202 - $421,578
Return on Investment (ROI) | Benefit-Cost Ratio – 0.91 – 1.08

This LAS demonstrated the total losses avoided with and without environmental benefits. Losses avoided were returned far in advance of the project useful life of 100 years. The properties were purchased and demolished in 2016, and exceeded the desired costs saved in an approximate 3.5-year period.

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[3] Cumberland Plateau Planning District Commission Hazard Mitigation Plan Update 2018 at https://www.cppdc.com/Reports/Hazard%20Mitigation%20Plan.pdf;

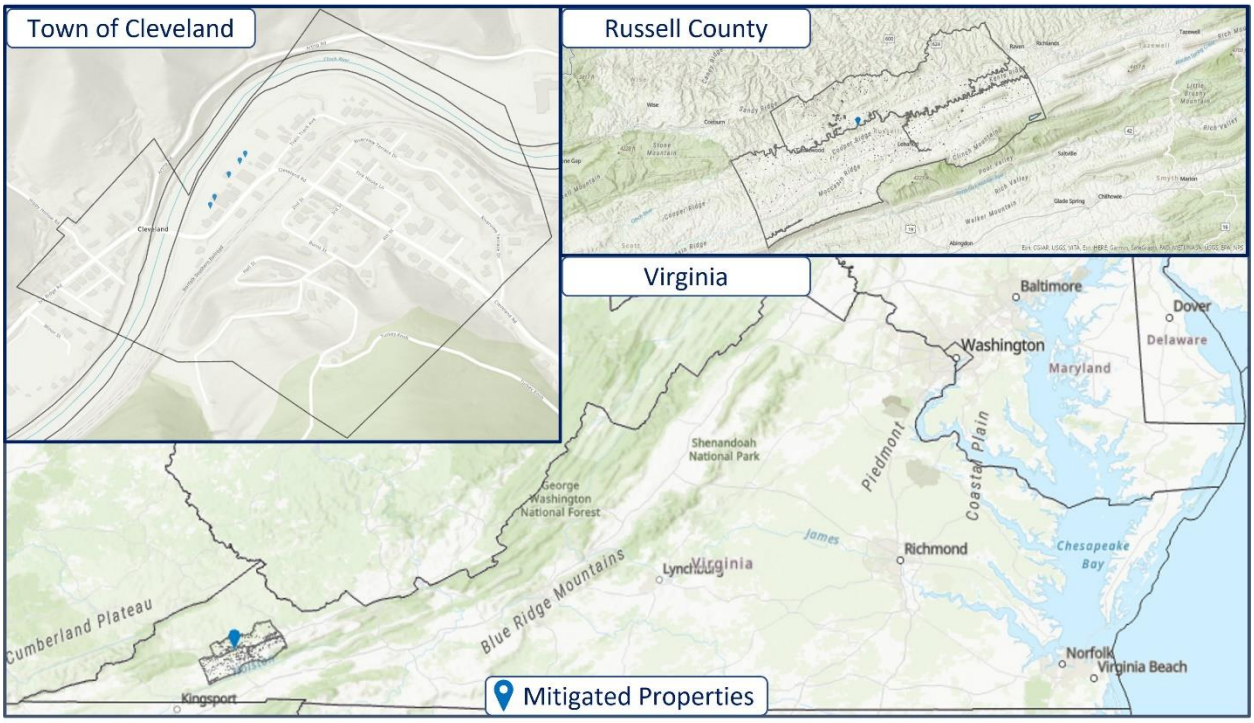

Figure 1: Location of mitigated properties

Project Summary

The project structures in Russell County were all acquired and demolished, with the remaining land being converted to greenspace in perpetuity. The five properties (six structures) included in this study were acquired and demolished in 2016. 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.

Grant | Subgrant – Hazard Mitigation Assistance (HMA) **|** Pre-Disaster Mitigation (PDM)
Year – 2014
Project Number - PDMC-PJ-03-VA-2014-002
Applicant – Town of Cleveland
FEMA Approved Multi-Hazard Mitigation Plan – Cumberland Plateau Hazard Mitigation Plan
Flood Zone Designation – Zone A
FIRM Panel Number - 51167C0210C[4]
Federal | Non-Federal Cost Share – 90%[5] | 10%

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[4] Flood Insurance Study Russell County, Virginia, and Incorporated Areas, 51167CV000A, September 29, 2010; 2014 Pre-Disaster Mitigation Project Application

[5] The Town of Cleveland meets the criteria of a small impoverished community as defined by 44 CFR § 201.2 with a population of approximately 341 persons, an average per capita income 45.3 percent of the national per capita income, and an unimplemented rate of 11.8 percent. This is based on documented criteria submitted by the Town,

Non-Federal Cost Share Source(s) – Virginia Department of Housing and Community Development
Project Type – Acquisition, demolition, and clearance of seven[6] structures along the Clinch River to be deed-restricted to greenspace in perpetuity
Project Useful Life – 100 Years[7]
Benefit-Cost Analysis – N/A
Substantially Damaged – N/A

Pre-Mitigation Problem Description

The Town of Cleveland is located in the southwest central portion of Russell County along State Route 82, approximately seven miles northwest of the County seat (Lebanon). The mitigated properties were located along the Clinch River which runs through the Town of Cleveland. The buildings were blighted and collapsing (Figure 2). The property owners were contacted and agreed to the demolition.

Cleveland sits in the 100-year floodplain (Figure 3) and has had major flooding in the past that has damaged the buildings beyond a cost-effective repair strategy. Because these buildings were not habitable because of flood damage they posed a persistent maintenance and health threat to the residents of the community. The lack of structural integrity posed a risk of building collapse into public roadways and powerlines. They also posed a fire risk as they were not under the same watchful eye for fire hazards as an occupied structure.

to VDEM, in February of 2015. Meeting these criteria increases the federal cost share for HMA projects from 75% to 90%.

[6] There were seven acquired properties. However, two were not included in this study because one was already vacant, and the other was the old Cleveland Elementary School which had already been deeded to the County and was geographically separate from the other properties.

[7] FEMA Benefit-Cost Analysis *BCA Reference Guide*, June 2009 at https://www.fema.gov/grants/guidance-tools/benefit-cost-analysis

Through repetitive annual flood cycles, it was inevitable that the already damaged buildings would collapse. The age of the buildings and an asbestos study suggested that there was a strong likelihood that flooring would cause asbestos-laden debris to wash downstream in the Clinch River. This posed a significant threat to the ecologically sensitive Clinch River which is one of the most biologically diverse rivers of native species in North America. One sensitive concentration of mussels lies just downstream of Cleveland at the Cleveland Island and is recognized by the Nature Conservancy and Virginia's Department of Game and Inland Fisheries as a high priority conservation area. The controlled demolition and removal of the structures would further enhance not only the quality of life of Cleveland residents, but also, the ecological health and financial impacts of flood mitigation.

Figure 2: Mitigated Properties

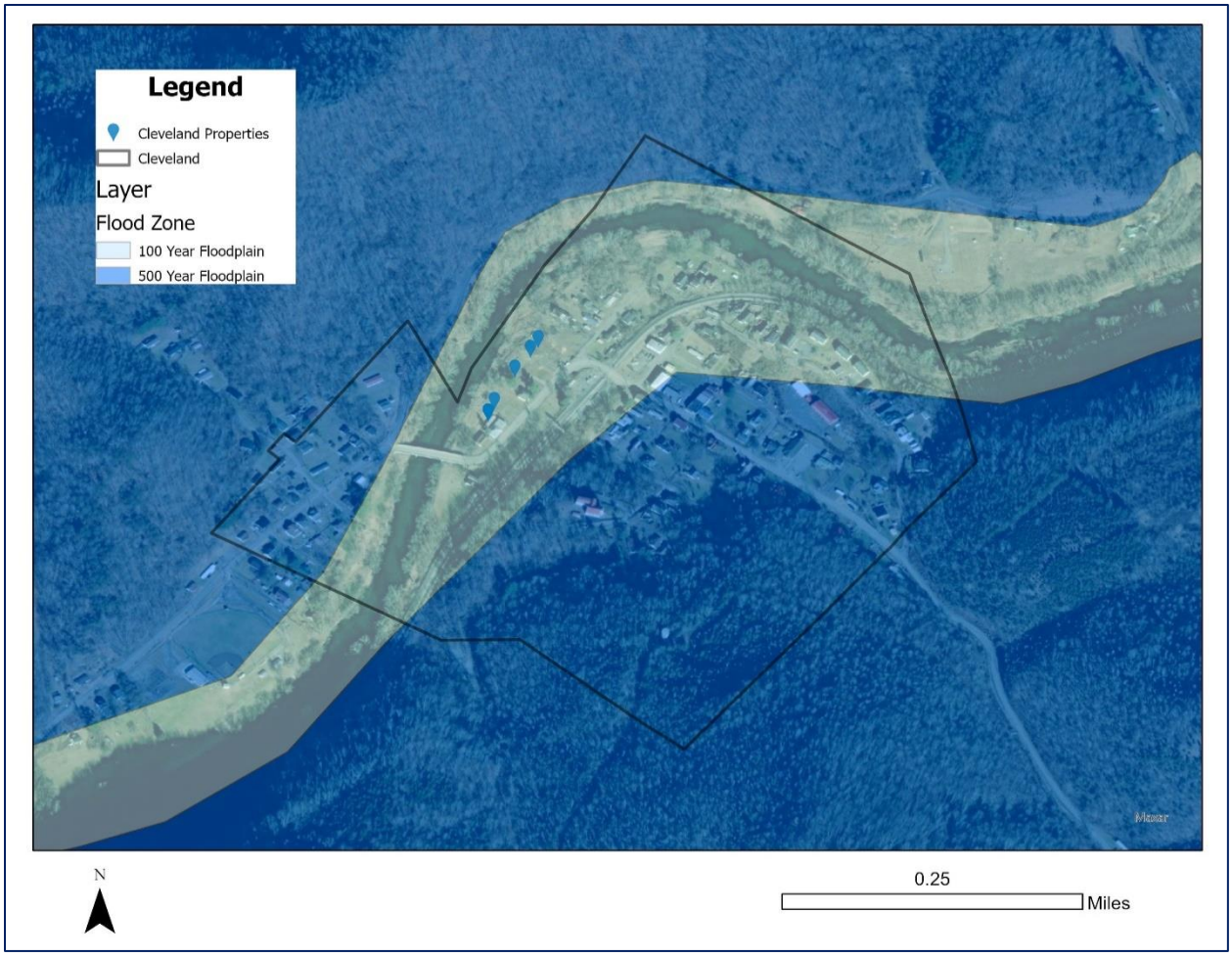

Figure 3: Mitigated properties in relation to the Clinch River and floodplain

Flood History

The Cumberland Plateau area is mountainous with steep ridges and pronounced valleys with three major watersheds including the Clinch River Basin which flows through Russell County. The Clinch River is a major river flowing through the county with an approximate drainage area of 670 square miles. It is fed by numerous tributaries originating from the high mountain ridges throughout the drainage area. The primary tributaries are the Guest River, flowing from the northwestern portion (Wise County) of the watershed and the Little River, flowing from the east near the headwaters of the watershed in Tazewell County. Due to steep mountainous terrain in the area, the potential for rapid flooding following a moderate to significant rain event or spring snowmelt is high.

The determined flood stages for the Clinch is 16 feet at Cleveland in Russell County. There have been approximately 29 recorded floods since 1862 that have crested above this level on the Clinch. The two largest recorded floods occurred in April 1977 and January 1957 with the river cresting at approximately 26.4 and 24.4 feet, respectively at Cleveland. As for most floods in this

area, much information is not available regarding damages due to these events. A Tennessee Valley Authority (TVA) report produced in 1964 provides much information of previous floods and compares all floods to the January 30, 1957, flood. Records from this event indicate that several buildings were inundated with floodwaters, and roadways were blocked. Velocities of water in the 1957 flood ranged from 7 feet per second in the river channel and up to 4 feet per second on the flood plain in the Cleveland vicinity. During a Maximum Probable Flood, the crest would be 12 to 16 feet higher than the 1957 flood, velocities in the channel would range up to 12 feet per second and up to 8 feet per second in the flood plain. The January 1957 flood caused $60,350 worth of damage in Cleveland and the April 1977 flood caused $9.5 million in destruction along the Clinch River. Both events where Presidentially declared disasters. Using the data from the USGS gauge at Cleveland and the 1964 TVA Report, there have been 29 recorded events that have exceeded the flood stage on the Clinch in the past 141 years for a flood recurrence interval of approximately once every 4.7 years. According to the flood profiles included in the Flood Insurance Study (FIS), the 100-year flood elevation at the USGS gauge is 1534 (NGVD 29), which corresponds to a flood crest of 33.76 feet, about 5.4 feet higher than the highest recorded flood level.

Table 3: Historical Floods on the Clinch River TVA 1964 and 1977, USGS

Occurrence	Location	Height at Cleveland Gage (Zero = 1500.24 ft)	Details
March 1826	Clinton, Tennessee		Greatest known flood on the Clinch River. No information obtained about flood. Probably a great flood occurred in upper reaches of the river in the Planning District.
Feb 22, 1862	Clinch River Area	1523.0 ft	Highest known flood over most of the Clinch River area.
March 1867	Dungannon		No records, but residents say that flood was exceeded only by the flood of 1862.
March 31, 1886	Clinton, Tennessee		Only minor flooding in the Planning District.
April 1, 1896	Speers Ferry		First known flood reported in the records at Speers Ferry. Not a major flood up stream.
Feb 22, 1897	Clinch River Area		Minor flooding, no high-water marks found.
June 22, 1901	Entire River		Intense storms in the head water area caused great damage and loss of life in the Richlands area.
March 1, 1902	Clinch River Area	1520.5 ft	One of the largest known floods in the area. Washouts and slides occurred on the Clinch

Occurrence	Location	Height at Cleveland Gage (Zero = 1500.24 ft)	Details
			Valley Division of the Norfolk and Western Railway.
Nov 20, 1906	Clinch River Area		Minor flooding reported. Railroad traffic delayed.
June 14, 1907	Clinch River Valley	1520.5 ft	Extensive crop damage. Widely remembered flood.
April 3, 1912	Clinch River Area		Minor flooding.
April 1, 1913	Clinch River Area		Minor flooding.
March 5, 1917	Lower Clinch area		Major flooding in the lower reaches of the Clinch River. Only minor flooding in the upper reaches.
Jan 29, 1918	Clinch River	1520.1 ft	Known as the "ice tide" Two to three inches of rain fell on snow covered frozen ground causing major flooding. Schools flooded at Dante.
Feb 3 & June 13, 1923	Clinch River	1517.4 ft	Two floods caused some damage to the Clinch Valley Division of the Norfolk and Western Railway.
Dec 22, 1926	Clinch River Area	1520.3 ft	Prolonged period of rain in the lower Clinch Basin. Many washouts occurred on the smaller streams.
Aug 14, 1940	Clinch River Basin	1520.8 ft	Tropical storm produced two to four inches of rain caused heavy flow in the upper reaches of the river.
1940 to 1957	Clinch River Area		Seven minor floods occurred that caused no particular damage.
Jan 30, 1957	Clinch River	1524.4 ft	Highest known flood of its time. $180,000 flood damages in St. Paul and $60,350 damages in Russell County.
May 7, 1958	Clinch River	1515.8 ft	Minor flood.
March 12, 1963	Clinch River	1522.9 ft	Over 100 families force to be evacuated in Richlands with two bridges in the Brooklyn area and one in the Hill Creek section were washed away or damages. Two houses in the Doran/Raven area were washed away.

Occurrence	Location	Height at Cleveland Gage (Zero = 1500.24 ft)	Details
March 17. 1973	Clinch River	1520.2 ft	No record of flood damage.
April 1977	Clinch River Area	1526.6 ft	Flood of record. $9.5 million in damages, heavy agricultural damages.
Jan 26, 1978	Clinch River	1521.1 ft	No record of flood damage.
Feb 16, 2003	Clinch River Area		Rainfall of up to 10" of snow with rising temperatures caused flooding.

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 standard data inputs for conducting an LAS:

- Cost of the mitigation measure
- Square footage of the structures[8]
- Structure type
- Value of the structure
- Value of the structure's contents
- Finished first floor elevations (pre-mitigation)[9]
- Post-mitigation finished floor elevations (elevations only)
- Base Flood Elevations[10]

[8] Structure characteristics were obtained from the property tax assessment provided with the application.

[9] Finished first floor elevations can be obtained from property elevation certificates but were not available for these properties. Finished first floor elevations were estimated using ground elevation (U.S. Geologic Survey) USGS 1/3 Arc Second Digital Elevation Model (DEM) and FEMA Hazus default values based on foundation type.
USGS Data Download: https://apps.nationalmap.gov/downloader/#/
Hazus Flood Model Technical Manual, 2018: https://www.fema.gov/sites/default/files/2020-09/fema_hazus_flood-model_technical-manual_2.1.pdf

[10] Base Flood Elevation (BFE) can be obtained from the Flood Insurance Study (FIS) or Flood Insurance Rate Map (FIRM). THE FIS and FIRM were available for these properties, but the BFE was not calculated. BFE was estimated using a combination of estimated recurrence intervals from the FIS and USGS stream gage data. This data was also used to estimate depth of flooding in the project area.

- Depth of flooding in project area (post-mitigation)

Assumptions

- Building replacement value - R.S. Means 2014, values adjusted to location, estimated at the time of application for acquisition were used. Three different valuations based on property use at the time without depreciating factors include 1) apartment at $133.24/sq foot, 2) storage at $101.00/sq floor, and 3) garage/repair service at 127.87/sq foot.
- Contents replacement value – Value is based on defaults from the FEMA BCA 6.0 Toolkit for property type and include 1) apartment at 12%, 2) storage at 47%, and 3) garage/repair services at 83%.
- Depth damage function – Derived from the FEMA BCA 6.0 Toolkit were used for each structure to determine avoided building, contents, and displacement costs during the post-mitigation event.
- Flood depth at property location – Flood depths were estimated using U.S Geologic Survey elevation and stream gage data.

Loss Avoidance Calculations

The flooding event that occurred post-mitigation being studied is a February 2020 rain event. On February 4, 2020, the National Weather Service (NWS) issued a Flash Flood Watch for southwest Virginia for a strong storm system moving through the area producing heavy rain with 2 to 4 inches of rainfall. On February 6, the Emergency Management Assistant Director for Russell County declared a local emergency due to a record amount of rainfall and flash flooding, rock/mud slides, and high water on roadways. It was estimated that $244,124 of damage occurred to private property, and $348,825 to public property totaling $592,949 in damages. Figure 5 depicts area flood conditions. A remaining structure in an adjacent parcel to the mitigated properties sustained $4,850.00 in damages. Figure 5 depicts receding flood waters at the location of the mitigated properties.

FEMA Map Service Center – Town of Cleveland Data Download: https://msc.fema.gov/portal/availabilitySearch?addcommunity=515522&communityName=CLEVELAND,%20TOWN%20OF#searchresultsanchor
Clinch River Gage at Cleveland 03524000: https://waterdata.usgs.gov/monitoring-location/03524000/#parameterCode=00065&period=P7D

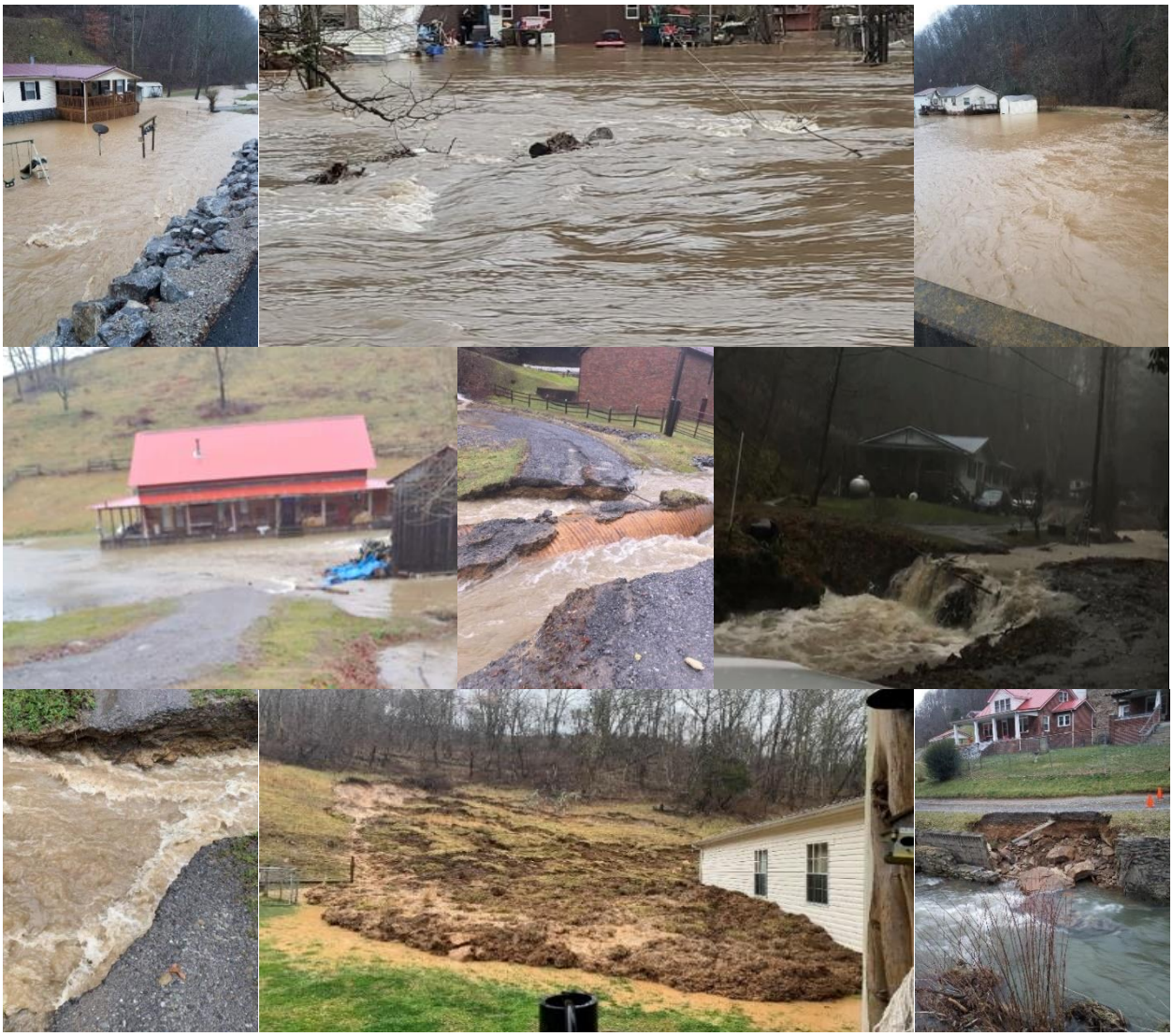

Figure 4: February 2020 flooding

Figure 5: Image of mitigated property parcels flooded in February 2020 rain/flood event

Loss Avoidance Calculations

To complete this study, the following calculations were performed to estimate losses avoided through mitigation from the February 2020 post-mitigation storm event:

- Stream discharge
- Flood depth elevations
- Residential building depth-damage curve
- Residential building contents depth-damage curve
- Displacement Costs
- Expected annual ecosystem services benefit from reverting the properties to open green space

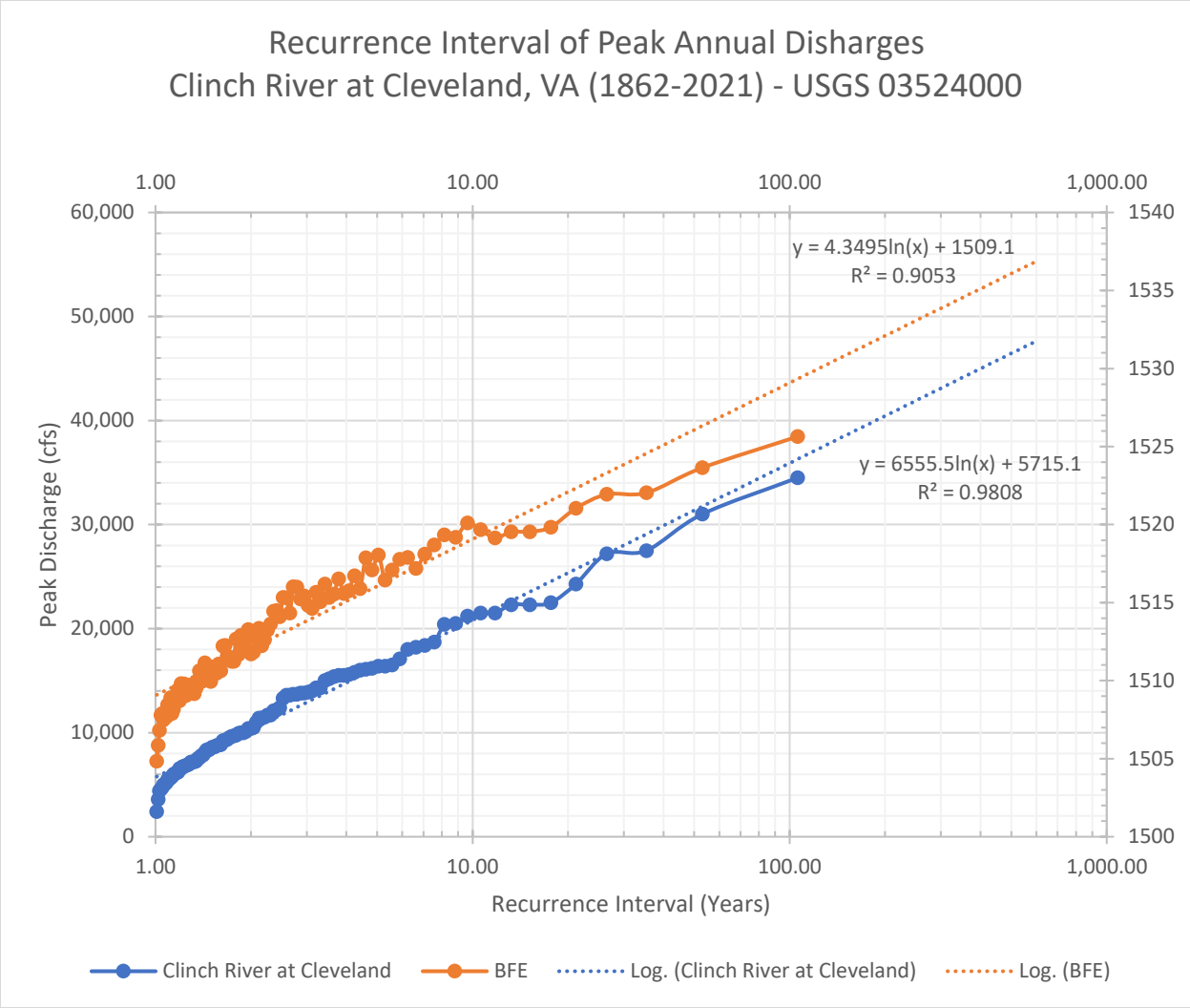

Figure 6: Stream discharge and flood depth elevation

Table 4: Recurrence interval stream discharge and flood depth elevation

Recurrence Interval	Stream Flow (cfs)	BFE
10	20,810	1,519.12
50	31,360	1,526.12
100	35,904	1,529.13
500	46,455	1,536.13

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
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

Depth Damage Curve - Contents		
Flood depth (ft)	Percent (%)	Damage Value ($)
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
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

Table 8: Ecosystem services benefit of acreage returned to greenspace

Property ID	Expected Annual Ecosystem Services Benefit ($)	Expected Annual Ecosystem Services Benefit ($) (Approx. 3.5 Years)
1	$1,914	$6,699
2	$1,382	$4,837
3	$2,020	$7,070
4	$7,336	$25,676
5	$2,977	$10,420
6	$2,764	$9,674
	$18,393	**$64,376**

Losses Avoided

Losses avoided and the benefit-cost ratio are reported in the tables below. Both tables report the property (structure) ID, total project cost, estimated depth of flooding from the February 2020 storm event, value of damage to the building and contents, and displacement costs. Table 9 reports the benefit-cost ratio independent of the added benefit to ecosystem services obtained from reverting the properties to open green space. Table 10 reports the losses avoided plus the added ecosystems services benefit and the benefit-cost ratio. While not all properties are estimated to have incurred damages under this scenario, five of the six structures would have experienced some degree of inundation. While considering the benefit of acquisition green space the aggregate benefit-cost ratio proves cost effectiveness.

Table 9: Losses avoided without ecosystems services benefit

ID	Total Project Costs	Flood Depth	Building Damage Value	Contents Damage Value	Displacement Damage Value	Total Damage Losses Avoided w/out Eco Benefit	Benefit-Cost Ratio w/out Eco Benefit
1	$32,566	3.98	$25,371	$21,646	$1,065	$48,083	1.48
2	$32,566	3.98	$33,793	$55,145	$9,054	$97,992	3.01
3	$90,570	3.06	$109,325	$19,754	$38,245	$167,325	1.85
4	$73,471	0.04	$3,917	$0	$0	$3,917	0.05
5	$61,523	-0.45	$1,151	$0	$0	$1,151	0.02
6	$100,981	0.58	$26,661	$5,631	$6,442	$38,734	0.38
	$391,677		**$200,219**	**$102,177**	**$54,806**	**$357,202**	**0.91**

Table 10: Losses avoided & benefit-cost ratio with ecosystem services benefit

ID	Total Project Costs	Flood Depth	Building Damage Value	Contents Damage Value	Displacement Damage Value	Total Damage Costs Losses Avoided + Eco Benefit	Benefit-Cost Ratio w/ Eco Benefit
1	$32,566	3.98	$25,371	$21,646	$1,065	$54,782	1.68
2	$32,566	3.98	$33,793	$55,145	$9,054	$102,829	3.16
3	$90,570	3.06	$109,325	$19,754	$38,245	$174,395	1.93
4	$73,471	0.04	$3,917	$0	$0	$29,593	0.40
5	$61,523	-0.45	$1,151	$0	$0	$11,571	0.19
6	$100,981	0.58	$26,661	$5,631	$6,442	$48,408	0.48
	$391,677		**$200,219**	**$102,177**	**$54,806**	**$421,578**	**1.08**