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WVU Faculty Supporting Hazard Mitigation Projects

Partnerships among faculty members expand the subject matter expertise for hazard mitigation planning

HAZARD MITIGATION PROJECT	FUNDING SOURCE	FACULTY MEMBER	ORGANIZATION & EXPERTISE	LINK
Statewide Risk Assessments	HMGP, CTP	Kurt Donaldson 	WVU GIS Technical Center (online interactive map viewing applications, <i>TEIF/TEAL¹ risk assessments, flood visualizations</i>)	WV Flood Tool Statewide RA Products & Data WV Region 3 Plan w TEIF data
Landslide Susceptibility Modeling	HMGP	Aaron Maxwell 	WVU Geography Professor (<i>landslide modeling, machine learning, remote sensing</i>)	Published Landslide Paper
Flood Buyouts	NRCS	Katherine Garvey 	WVU Land Use and Sustainability Law Clinic (legal and planning services)	Region 3 Resilience Report WV Public Broadcasting
Community Recovery and Resiliency	NSF	Jamie Shinn 	Adjunct WVU Geography Professor (<i>social science, community engagement</i>)	WV Public Broadcasting

¹ Total Exposure in Floodplain (TEIF), Total Exposure Area Landslide (TEAL)



FEMA



Example 1: Landslide Hazard Risk Assessment



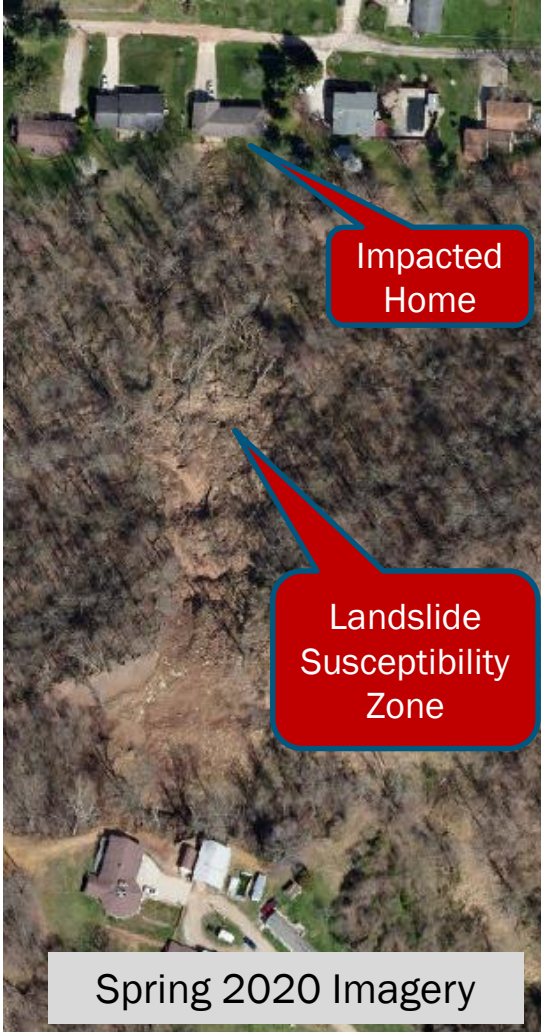
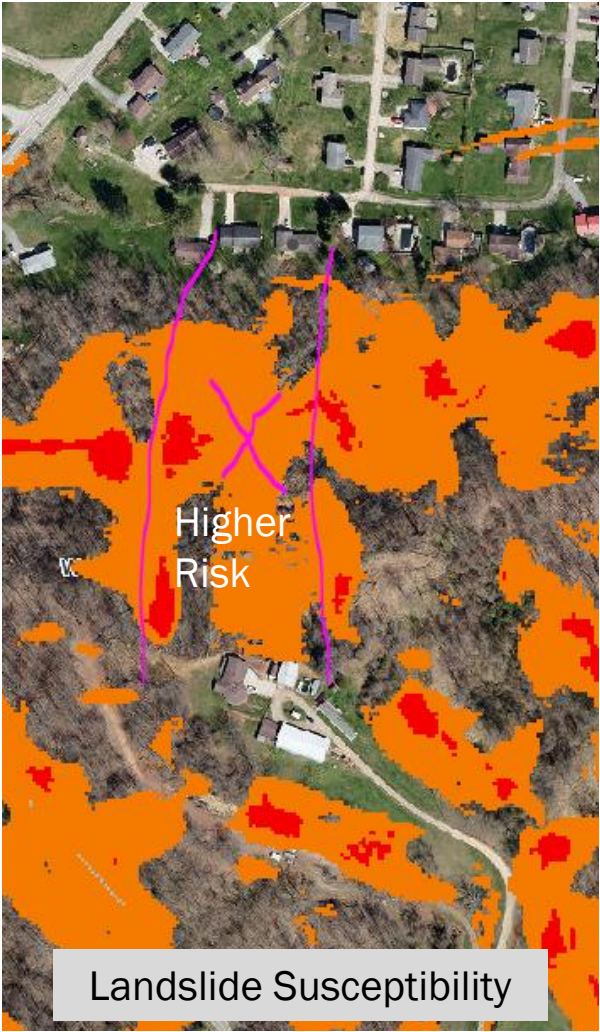
Landslide damages Washington Bottom home, threatens others

LOCAL NEWS
APR 28, 2020
MICHAEL ERB
Staff Reporter
merb@newsandsentinel.com

SHARE TWEET

A landslide Sunday evening damaged a Washington Bottom home and forced the evacuation of several neighboring houses. (Photo by Michael Erb)

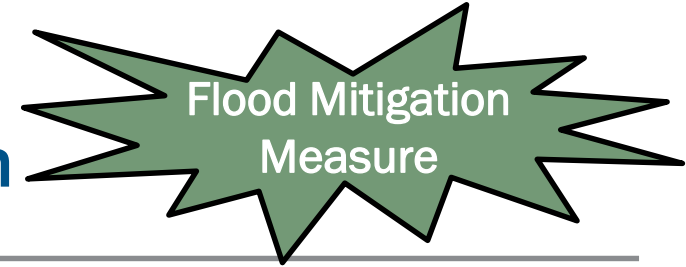
April 2020 Landslide
Wood County, WV
Impacted home moved from foundation



[WV Flood Tool](#)

[WV Landslide Tool](#)

A statewide landslide susceptibility (high, moderate, low risk) map was created from FEMA-purchased QL2 LiDAR data



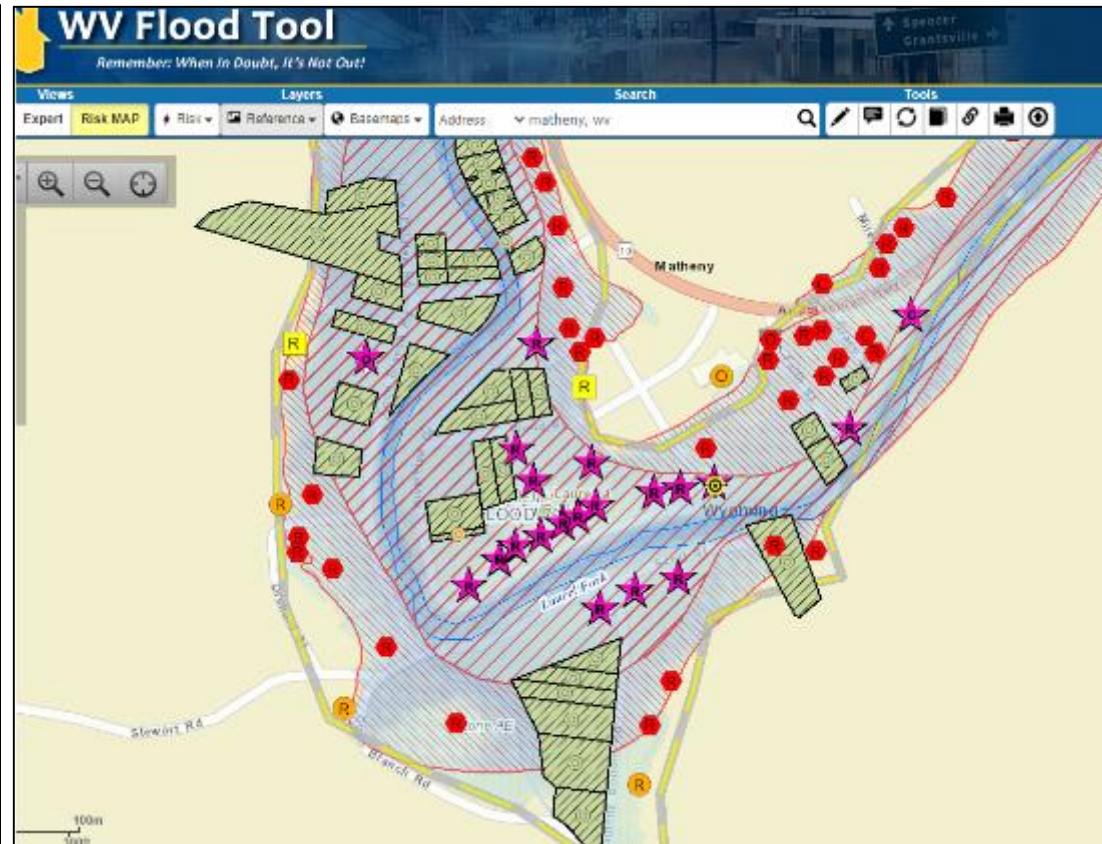
Example 2: Voluntary Floodplain Buyout Mitigation



Success Story: West Virginia Partnerships Drive Cost-Effective Mitigation

In 2018, the West Virginia University (WVU) Land Use and Sustainable Development Law Clinic began assisting the Natural Resources Conservation Service (NRCS) in watershed planning for McDowell County. Frequent flooding occurs in the Elkhorn Creek/Tug Fork River watershed and causes major damage to structures and infrastructure. The NRCS, the Land Use Clinic, and other local sponsors worked together to study the costs and benefits of a voluntary floodplain buyout project. Using data available through the [WV Flood Tool](#) saved time and money.

The Land Use Clinic and NRCS used data from the WV Flood Tool to identify the highest priority areas for buyouts and estimate damages to individual properties. Data gathered from the WV Flood Tool included information related to flood zones, structure type, flood depth, and real estate values. WVU also collected Total Exposure in Floodplain (TEIF) and Total Exposure Area Landslide (TEAL) structural-level data. This information helped the NRCS identify a list of 310 properties that would meet the goal of reducing flood damage. 30 properties may be eligible to participate in a voluntary buyout program.



[FEMA R3 Resiliency Report](#) | [WVPBS](#) | [Buyout Report](#)

[WV Flood Tool: Building-Level Risk Assessments](#)

Risk assessments using FEMA's Hazus methodology helped NRCS identify 310 properties in McDowell County for flood buyouts

Example 3: Community Hazard Planning (Focus Group Meetings)



White Sulphur Springs, WV (11/17/2022; 5/24/2023)

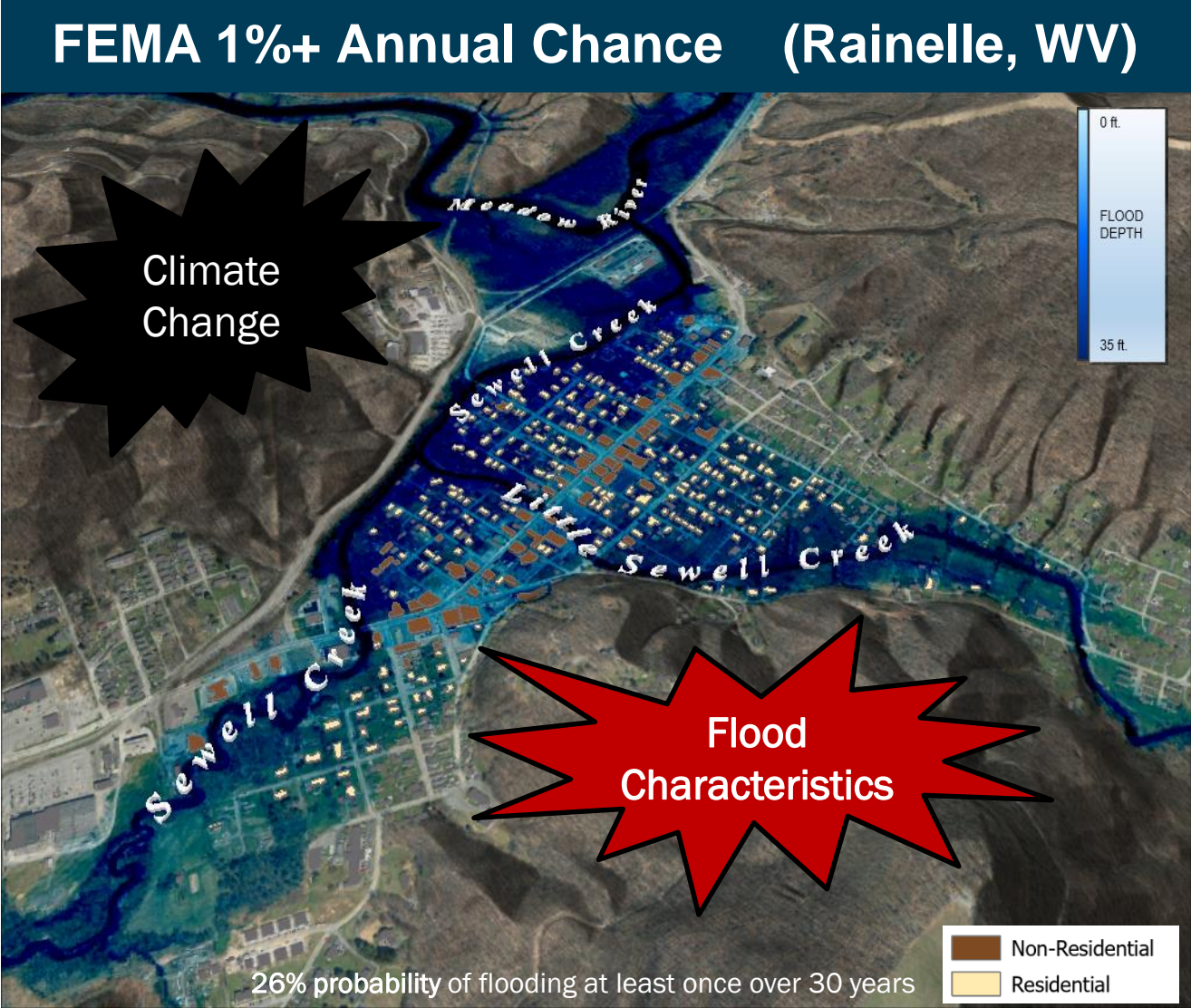


Rainelle, WV (11/18/2022; 5/23/2023)

- Feedback desired from Focus Groups:
 - What lessons were learned from the immediate response and longer-term recovery from the 2016 flood?
 - What priorities are needed for a stronger flood response and recovery plan in the event of a future flood?

- Feedback of Flood Study Products:
 - Flood Characteristics and Models
 - Flood Risk Assessment (vulnerability, exposure, loss)
 - Mitigation Maps
 - Flood Visualization Tools

Example 3: Community Hazard Planning (Flood Risk Characteristics)



Category	Flood Characteristic (in context to 2016 Flood)	White Sulphur Springs	Rainelle
Frequency (new flood maps)	<p>Probability that a flood of a specific size will be equaled or exceeded in any given year.</p> <p>FEMA Flood Models (new): 10-, 25-, 50-, 100-, 100+, and 500-year flood elevations.</p> <p>First Street Foundation Flood Models: 5-, 20-, 100-, and 500-year flood elevations.</p>	<p><u>2016 Flood</u> Between 100- and 500-year</p> <p><u>FEMA Climate</u> BFE+6ft</p> <p><u>FSF Climate</u> 2052 or 30 years in the future</p>	<p><u>2016 Flood</u> Between 100- and 500-year</p> <p><u>FEMA Climate</u> BFE+1ft</p> <p><u>FSF Climate</u> 2052 or 30 years in the future</p>
Depth	Flood depth. Source USGS high-water marks	6 feet	8 feet
Velocity	Speed at which the floodwaters are flowing	High	Moderate
Duration	Measure of how long water remains above normal levels	24 hours	72 hours
Rise and Fall	Floodwater that rises very quickly with little or no warning	Quick Rise	Quick Rise

Example 3: Community Hazard Planning (Risk Indicators)

Social Vulnerability Indicators White Sulphur Springs and Rainelle

Vulnerability Indicators	White Sulphur Springs	Rainelle	State Ratio	National Ratio
Poverty Rate	14.4%	37.0%	17.3%	12.9%
Unemployment Rate	21.4%	33.6%	23.8%	14.7%
Vulnerable Ages Ratio	41.7%	39.8%	30.8%	28.3%
Disability Ratio	17.8%	26.9%	18.7%	13.0%
Population Growth Ratio	-9.1%	-20.9%	-3.2%	7.4%
Renter-Occupied Ratio	42.8%	43.0%	26.8%	36.0%
Housing Values Less than \$50K	3.9%	37.5%	16.9%	6.6%
Housing Median Value	\$125,700	\$59,400	\$119,600	\$229,800

The red texts show more than 5% of difference, to the vulnerability side, from the state ratios.

Building Exposure White Sulphur Springs and Rainelle

Category	Exposure Indicator	White Sulphur Springs	Rainelle	Ratio* in WV Incorporated Areas (2021)
Buildings by Flood Zone (Count & Value)	Total Primary Building Count in Floodplain	425 (Rank***: 12 th)	338 (Rank: 18 th)	59 (Median)
	Building Ratio b/w Floodplain & Community Total	26%	34%	9%
	Total Primary Building Value in Floodplain of Community	\$41.02M (Rank: 16 th)	\$16.89M	\$6.42M (Median)
	Median Building Value in Floodplain	\$49K	\$38K	\$42K
	Building Count in Floodway** (High Velocity)	105 (Rank: 6 th)	47 (Rank: 18 th)	12 (Avg.)
	Percent of SFHA Buildings in Floodway (High Velocity & Depth)	25%	14%	8%
New Flood Maps	New Maps: Bldgs. "Mapped In" SFHA	75 (Rank: 11 th)	325 (Rank: 3 rd)	19 (Avg.)
	New Maps: Bldgs. % Count "Mapped In" SFHA	18%	96%	14%

*Vulnerability, Exposure, and Hazus Loss Indicators
for the disadvantaged communities of Rainelle and White Sulphur Springs*



FEMA





Rainelle, Flood Risk Summary

The information below includes estimates derived from the BLRA as of May 2023. The demographic information is based on the Census Bureau's American Community Survey (ACS) 5-year estimates of 2017.

Hazard	Ratio of Floodplain to Community Area: 31.1% <small>Incorporated Community Median: 10.2%</small>		Federally Declared Flood Disasters in Greenbrier County since 1989: 9 <small>Statewide County Median: 12</small>	
	Exposure	Physical Total Buildings in High-Risk Floodplains: 338 (34%) <small>Incorporated Community Median: 59 (9%)</small>		Human Estimated Population Residing in Floodplains: 582 (43%) <small>Incorporated Community Median: 114 (10%)</small>
Newly Mapped in Structures: 325 Newly Mapped out Structures: 1		Total Building Value in Floodplains: \$16,889K <small>Incorporated Community Median: \$6,417K</small>		Estimated Population Displaced by Flooding: 487 (36%) <small>Incorporated Community Median: 56 (13%)</small>
Total At-Risk Residential Structures: 250 <small>Incorporated Community Median: 44</small>		Total Estimated Building Loss: \$994K <small>Incorporated Community Median: \$240K</small>		Estimated Population in Need of Short-Term Shelters: 123 <small>Incorporated Community Median: 12</small>
Vulnerability		Mobile Homes in Floodplains: 14 <small>Incorporated Community Median: 5</small>	Critical Buildings in Floodplains (Essential Facilities and Non-Historical Community Assets): 9 <small>Incorporated Community Median: 3</small>	
	Social Vulnerability Index (SVI) of Greenbrier County: 0.55 <small>Statewide County Median: 0.48</small>			

Rainelle, Flood Mitigation Summary

The information below includes estimates derived from the BLRA as of May 2023. The flood insurance information is based on the FEMA's Community Engagement Prioritization (CEP) of 2019.

Mitigated Structures	Elevated Structures to Design Flood Elevation (DFE): 87	Rehabilitated/Repaired Structures: 278
	Ratio of Residential Structures in 100-Year Floodplain Elevated to DFE: 35%	
	Structures Removed (Vacant Parcels): 41	Unmitigated Low Value Structures: 47
Open Space Preservation	Loss Avoidance by Elevating or Removing Structures in 100-Year Floodplain (Preliminary Results): \$2.3M	
	Buyout Parcels (Deed Restricted): 18	Community-Owned Vacant Parcels: 88
	Area of Open Space Preservation (OSP): 3 Acres	Ratio of Open Space Preservation (OSP to 100-Year Floodplain): 4.5% <small>Incorporated Community Median: 5%</small>
Flood Insurance	Number of Policies (2023): 36	Number of Paid Claims: 152
	Dollar Amount of Previous Claims: \$9.0M	Repetitive Loss (RL) Paid Losses: \$1.3M

Rationale:

How communities have applied flood adaptive measures in response to major flood events

DFE: 100-Year or Base Flood Elevation (BFE) + 2 feet

Findings:

Rainelle: 35% of residential structures in 100-year floodplain elevated to DFE (n=87, res./non-res.)

White Sulphur Springs: 59% of residential structures in 100-year floodplain elevated to DFE (n=217, res./non-res.)



Building ID: 13-13-0001-0069-0000_108

[Flood Tool Link](#)



Building ID: 13-17-0008-0152-0000_195

[Flood Tool Link](#)



Examples of Mitigation Reconstruction

First Floor Height BELOW: FEMA/FSF 0.2-percent chance (500-yr) floods



12.2' (FSF 0.2% / 500-Yr)

9.9' (FEMA; 0.2% / 500-Yr)

6.5' (2016 High Water)

3.9' (FEMA 1% / 100-Yr)

Mitigation
Reconstruction

How well are mitigated structures protected from new flood maps or changing environmental factors due to climate change? New FEMA flood maps for Rainelle reveal that the mitigated structure above is a risk for the 1%+ (100-yr) and 0.2-percent chance (500-yr) floods.

Flood Visualization 7 feet



First Floor Height ABOVE: 2016 Flood High Water Mark

Flood Visualization 10 feet



First Floor Height BELOW: 0.2% Chance (500-yr) Flood Models

Risk Assessment/Planning using WV Flood Tool



White Sulphur Springs' primary structures viewable on the [Risk MAP View](#) of the WV Flood Tool. Symbol letters indicate general occupancy (Residential, Commercial, Other Non-Residential).

Public Expert **Risk MAP** Risk Reference Basemaps Search Address White Sulphur Springs, WV Tools

Click on each tab to view information

Address Parcel Risk

Building #1 in Parcel: 13-17-0008-0139-0000

Flood Exposure for Building: 13-17-0008-0139-0000_220

Building Replacement Cost	\$23,400	Building Exposure
Content Cost	\$11,700	
Building Info	Area: 1,665 sq ft Stories: 1	
Occupancy Class	RES1 (Single Family Dwelling)	
Year Built	1949 (Pre-FIRM)	
Foundation Type	Crawlspace (View Photo)	
First Floor Height	3.0 ft above ground	
Water Depth-in-Structure	0.9 ft (minus rated -1 ft)	

Flood Damage Estimates for Building: 13-17-0008-0139-0000_220

Building Damage Pct	22% (Moderate Damage)	HAZUS Loss Estimate
Building Loss USD	\$5,148	
Content Damage Pct	25%	
Content Loss USD	\$2,925	

3D Visualization

220 CENTRAL AVE, White Sulphur Springs, WV, 24986

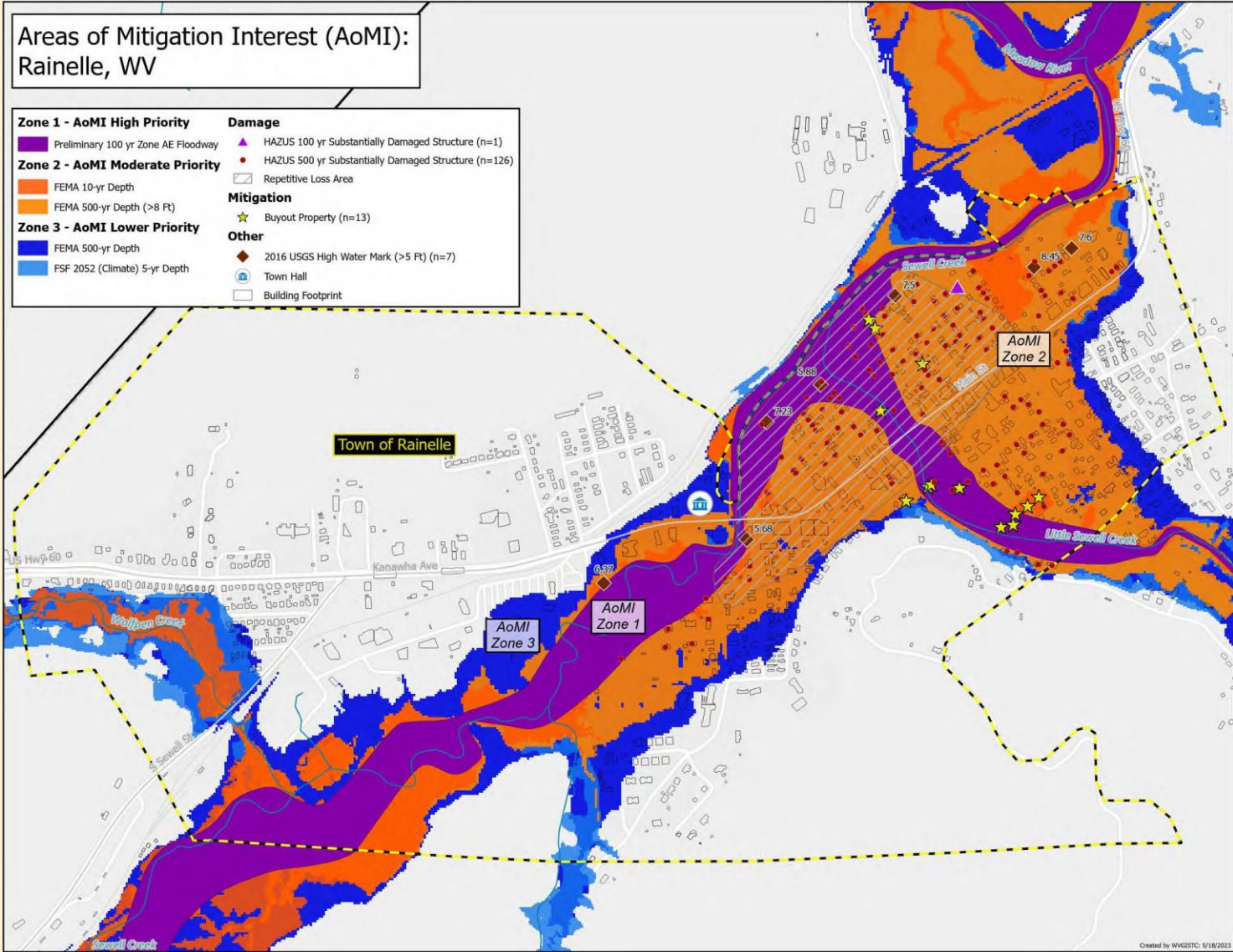
Depth

- 0 Foot
- 1 Foot
- 2 Feet
- 3 Feet
- 4 Feet
- 5 Feet**
- 6 Feet
- 7 Feet
- 8 Feet
- 9 Feet
- 10 Feet
- 11 Feet
- 12 Feet

Parcel ID: 13-17-0008-0139-0000 Water Depth: ~ 4.8 ft (HEC-RAS) Google Map

Wall and Paintings - Second layer of drywall and paintings damaged
Electrical - Light switches, fixtures, and main panel would be destroyed at 5.0 feet.

Rainelle



Recommendations:

Mitigation plans should correspond to the AoMI priorities

Areas of Mitigation Interest (AoMI)

Mitigation Planning

Rationale:

Identifying priority zones for mitigation:

PRIORITY ZONE FACTORS

- **Flood Characteristics** (frequency, depth, velocity)
- **High Water Marks**
- **Repetitive Loss Areas**
- **Substantial Damaged Structures**
- **Vulnerable Structures** (floodway, mobile homes, subgrade basements, minus-rated, red tag structures, etc.)
- **Mitigated Structures**
- **Buyout Parcels** (Open Space Preservation)



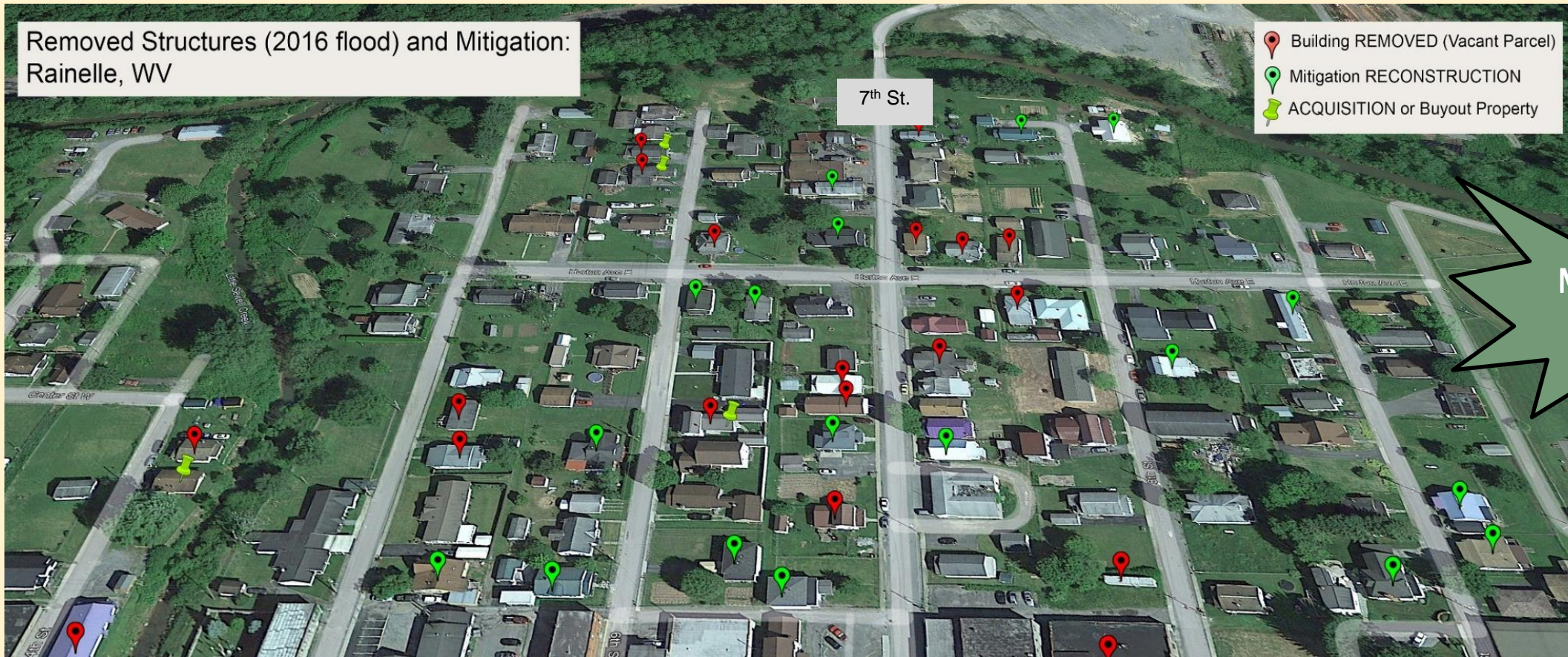
Priority Zone	Criteria	Rationale
Highest	Regulatory Floodway on FEMA flood maps effective July 5, 2023	Highest flood depths and flow velocities. Subject to frequent, recurrent flooding (1 in 25 yr). Development severely restricted
Moderate	FEMA 25-yr Flood Depth	Area subject to frequent flooding (1 in 25 yr) from smaller storms
	FEMA 500-yr Flood Depth > 8 ft. (Rainelle) and > 5 ft. (White Sulphur Springs)	Area subject to high flood inundation depths from larger storms (1 in 500 yr)
Lower	FEMA 500-yr Flood Depth	Area vulnerable to 0.2% (1 in 500 yr) major flood event
	First Street Foundation's 5-yr climate model for the year 2052	Area vulnerable to frequent 1 in 5 year frequent flooding typically along smaller tributaries or unstudied streams

Flood Characteristics: Flood maps/models help to define mitigation zones

Rationale:

Difference between loss estimates for buildings with a first-floor height of 1 foot and elevated to DFE or removed entirely;
The losses avoided by federally funded riverine flood mitigation projects far exceeds the money spent (7x return on investment)*

* FEMA. "Natural Hazard Mitigation Saves Interim Report"

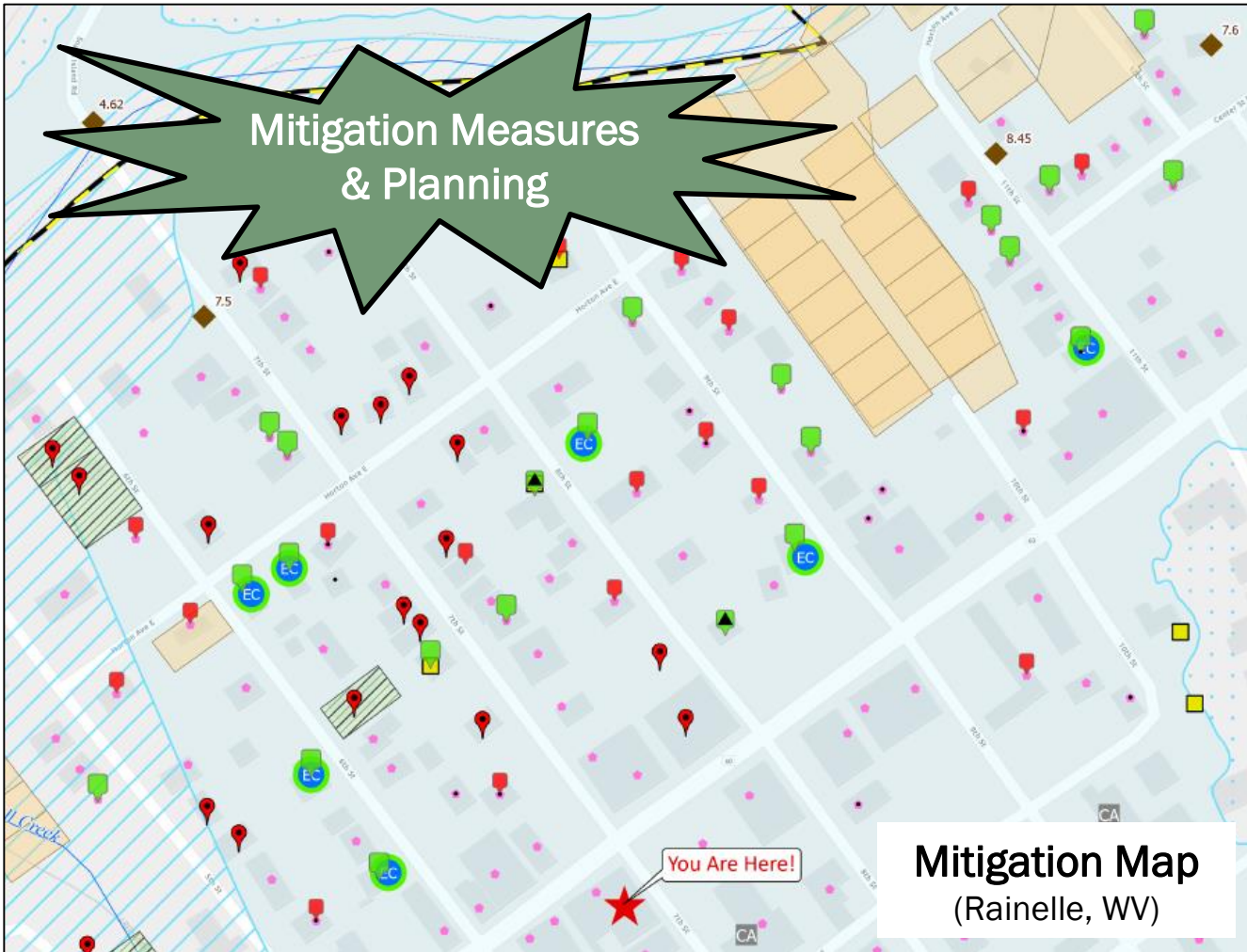


Mitigation Saves \$

Recommendations:

Mitigation efforts of elevating buildings above the base flood and buyouts should be considered as *investment* and not expense

Example 3: Community Hazard Planning (Mitigation Measures)



Mitigation Measures			
Category	Mitigation Indicator	White Sulphur Springs	Rainelle
Mitigated Structures	Mitigation Reconstruction or Elevated Structures to Design Flood Elevation (DFE)	15	45
	Rehabilitated/Repaired Structures	394	278
	Unmitigated Low Value Structures	14	49
	Structures Removed (vacant parcel)	394	278
Open Space Preservation	Buyout Parcels (Deed Restricted)	16	18
	Community-Owned Vacant Parcels	66	88
	Area of Open Space Preservation (OSP)	5 Acres	3 Acres
	Ratio of Open Space Preservation (OSP to SFHA)	2.6%	4.5%
Building Value Recovery	Net Value 2016-2022 Tax Assessment Value	+ \$6.1 Million	- \$1.0 Million
Loss Avoidance 100-year Flood	Loss Avoidance by Elevating or Removing Structures (preliminary results)	\$2.6 million	\$2.3 million

<p>Damaged or Demolished Buildings</p> <ul style="list-style-type: none"> Structure Removed Post-2016 Flood (n=41) <p>Mitigated Properties</p> <ul style="list-style-type: none"> Mitigation Reconstruction to DFE* (n=35) Mitigation Reconstruction not to DFE* (n=6) Elevation Certificate (n=11) Buyout Property (n=18) Open Space Preservation (Community-Owned)** (n=88) <p>Unmitigated Properties</p> <ul style="list-style-type: none"> Low Building Value (n=49) Repaired Structure** (n=311) 	<p>Significant Structures</p> <ul style="list-style-type: none"> Essential Facility (n=1) Community Asset (n=7) <p>Vulnerable Structures</p> <ul style="list-style-type: none"> Manufactured Home (n=14) Subgrade Basement (Full & Part) <p>Preliminary 1% Annual Chance Floodplain</p> <ul style="list-style-type: none"> Zone AE 0.2% Annual Chance Floodplain Zone AE - FLOODWAY <p>Other</p> <ul style="list-style-type: none"> Stream Line Municipal Boundary 2016 High Water Mark (ft) (n=32)
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Field verification and analysis of mitigation measures implemented by property owners and the community in context of the 2016 flood and local floodplain management regulations