West Virginia Risk Explorer

Localized risk assessment tools for analysis and visualization

West Virginia Flood Resiliency Framework (WVFRF)

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Behrang Bidadian

Joint Legislative Committee on Flooding (JLCF)

September 2025

WV GIS Technical Center
West Virginia University

WVFRF

About Us

WV GIS Technical Center
West Virginia University

Director/Project Manager:

Kurt Donaldson

Faculty Director:

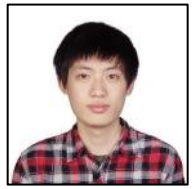
Aaron Maxwell

Mission:

- Spatial data infrastructure enhancement
- Advisory services and training programs in geographic information science
- GIS research and education
- **Support disaster resilience in the state: Flood & Landslide risk assessment**

WVGISTC Team:

- Three Risk & GIS Analysts
- Two GIS Programmers/Developers
- Contractors/Consultants
- Graduate Research Assistants
- Student Workers



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Sponsors

GOVERNMENT & NON-PROFIT ORGANIZATIONS

WV State Resiliency Office

Greenbrier County Homeland Security & Emergency Management

WV Emergency Management Division

West Virginia Voluntary Organizations Active in Disaster (WV VOAD)

Meadow River Valley Association (MRVA)

FUNDING SPONSORS

Federal Emergency Management Agency (FEMA) Region 3 Office

National Science Foundation

WV Flood Resiliency Framework (WVFRF)

A virtual hub of risk assessment, visualization, planning, and training resources for building community flood resiliency in WV

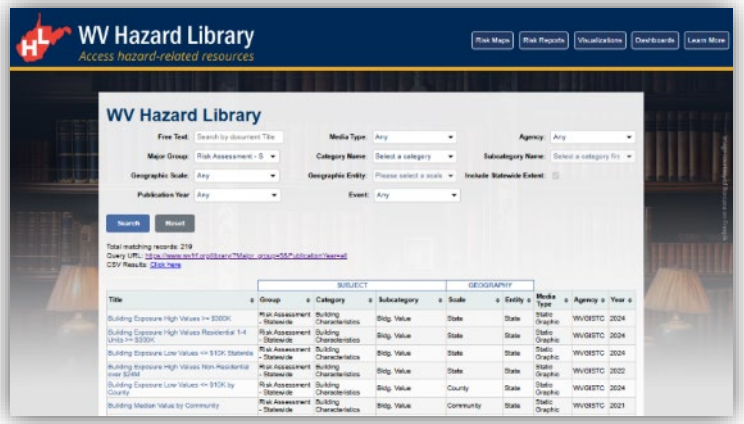
Flood Visualizations

WV Flood Tool

Flood Dashboards

WV Risk Explorer

Example Tools



Hazard Library

RISK TOOLS

- WV Risk Explorer
- WV Flood Tool
- Visualizations
- Dashboards

9 Geographic Scales

COMMUNITY ENGAGEMENT

- Focused Outreach Meetings
- Flood Symposium
- Resiliency Tools & Products
- Learning Resources & Reports

HAZARD LIBRARY

Search online hazard resources by title, subject, media, event, geography, data, etc.

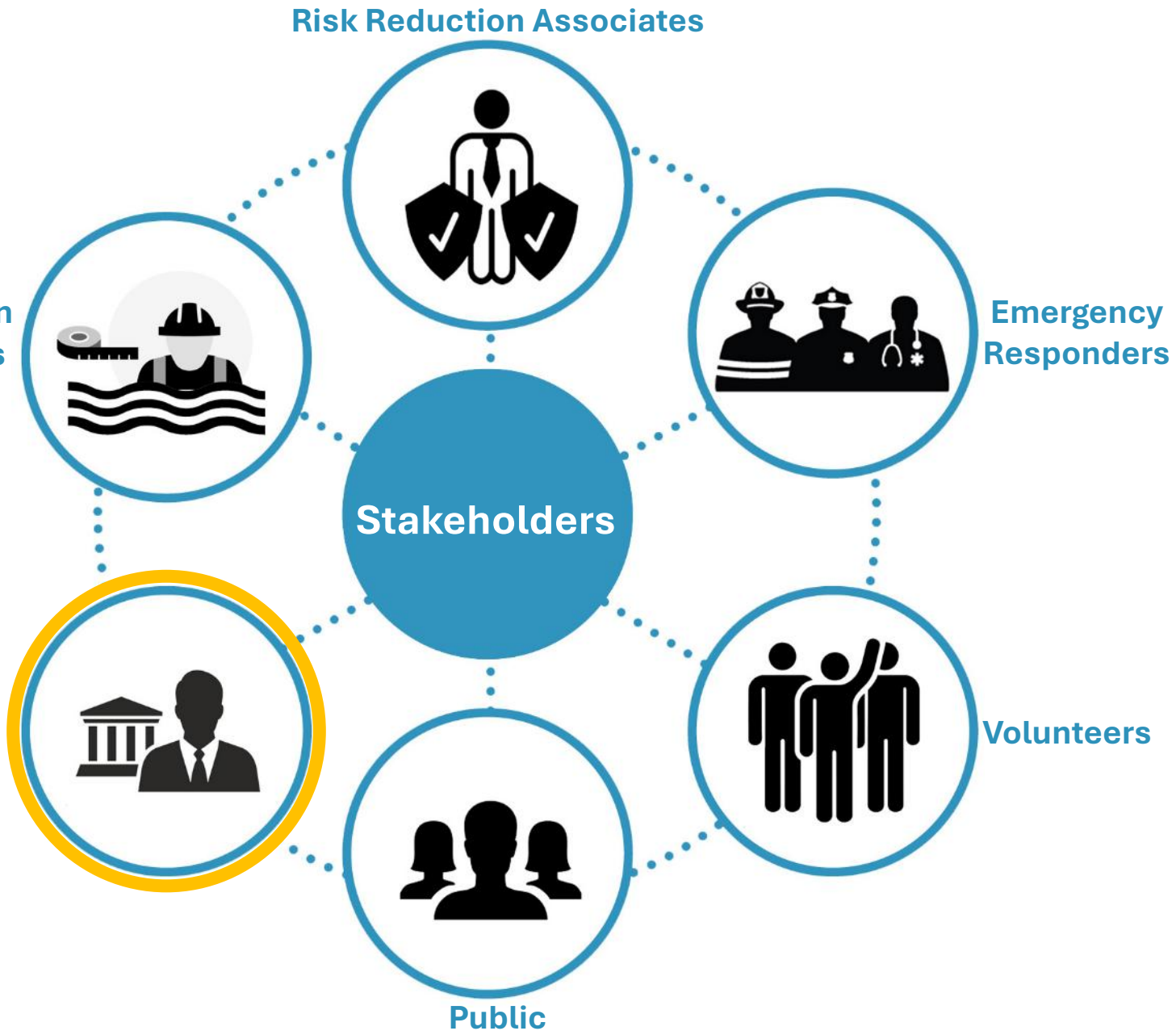
STAKEHOLDERS

- Risk Reduction Associates
- Emergency Responders
- Floodplain Managers
- Local Officials
- Volunteers
- Public

Community Engagement Meeting

Flood Symposium **Stakeholders**

Stakeholders



Supporting policy updates, state resilience initiatives, and hazard mitigation planning

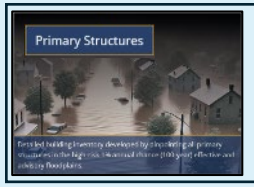
WVFRF Integrated Tools

West Virginia Risk Explorer (WVRE)

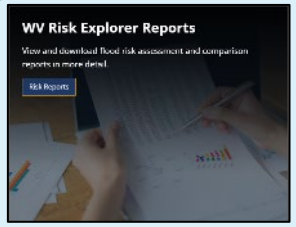
Risk Assessment Tools

- Localized riverine flood risk assessment including a broad range of risk categories by aggregating detailed building-level data at multiple scales
- Help identify the communities most at risk of riverine flooding for efficient allocation of limited mitigation resources

Building/Property-Level



Aggregated



Mitigation Assessment Tools

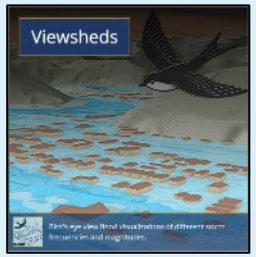
- Quantifying of mitigation efforts such as elevation, relocation, and buyouts and calculation of loss estimates
- Enable planners and decision-makers to evaluate past and ongoing efforts, identify gaps, and prioritize future investments

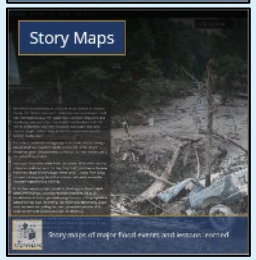
Mitigated Structures Dashboard

Open-Space Mitigation Dashboard

Risk Communication Tools

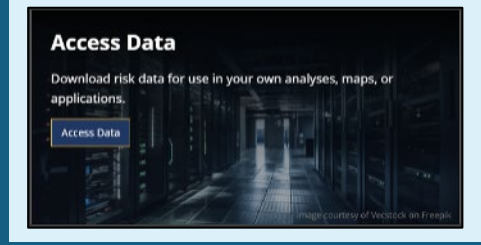
- Scenario-based 2D and 3D visualizations to translate complex data into accessible insights
- Facilitate risk comprehension for different groups of stakeholders to support informed decision-making and encourage public engagement





Hazard Library and Data Access

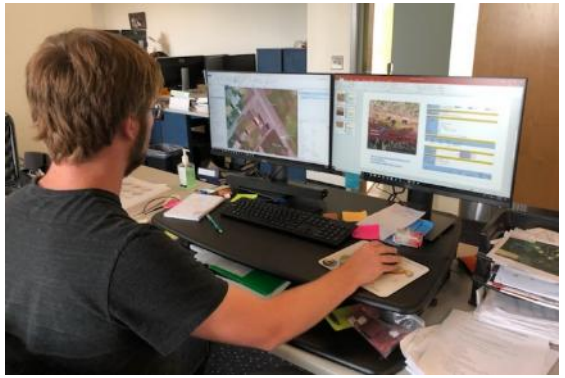
- Access to online hazard resources including data, documents, and media searchable by title, subject, event, geography, and more.
- Allow users to access comprehensive datasets for use in analyses, maps, or applications to support planning, research, and decision-making related to hazard mitigation and response



WV Floodplain Building Inventory (BI)

Riverine Flood Exposure Assessment (Building-Level)

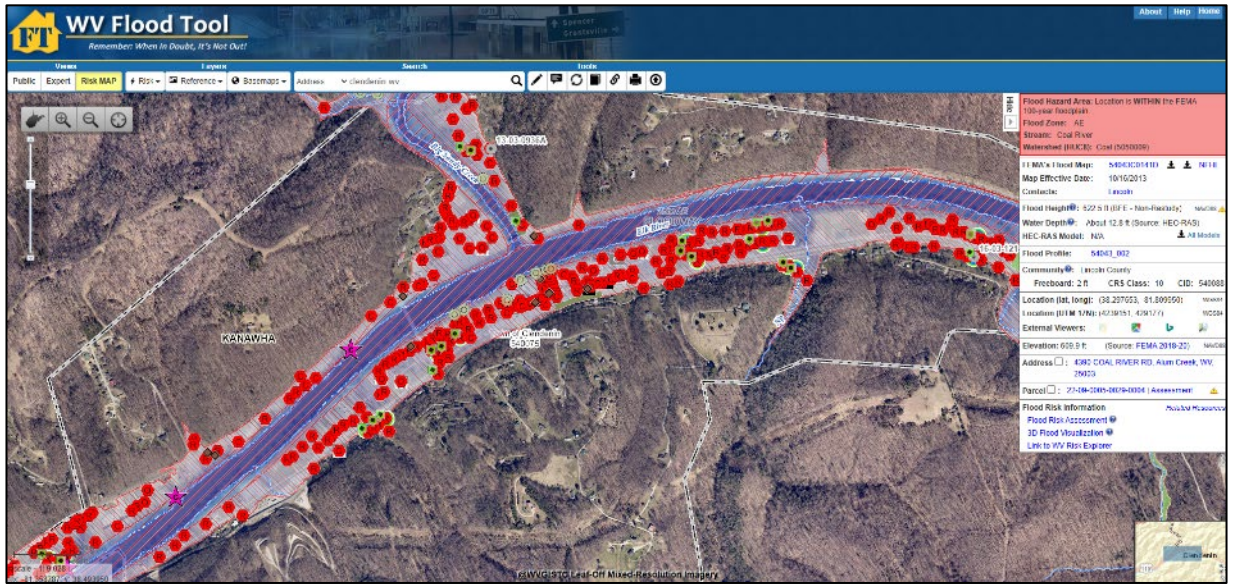
- All primary (insurable) structures in FEMA's 1%-annual-chance (100-yr) floodplain
- Community Assets (Historical & Non-Historical) in the 100-yr floodplain
- Essential Facilities in the 100-yr and 500-yr floodplains



Essential Facilities

Community Assets

Product: WV Flood Tool mapwv.gov/flood



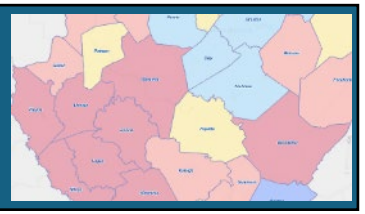
Analytical & Visualization Tools at Multiple Scales

Political Boundaries

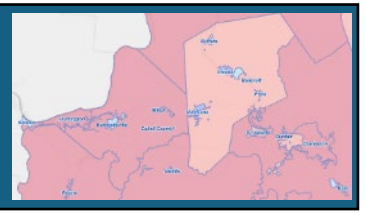
State

PDC Regions (11)

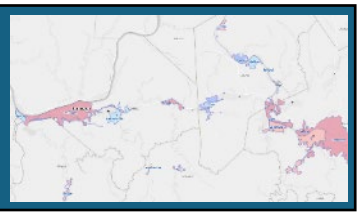
Counties (55)



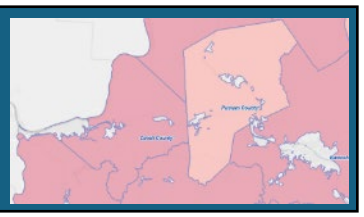
Communities (284)



Incorporated Places (229)

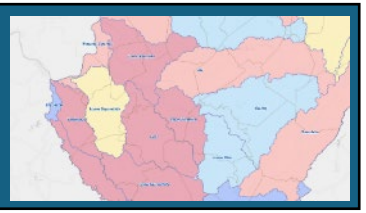


Unincorporated Areas (55)



Drainage Areas / Streams

Watersheds (33)



Streams/Rivers (156)

Property Levels

Parcels

Buildings

WV Flood Risk Index

Overall Flood Risk

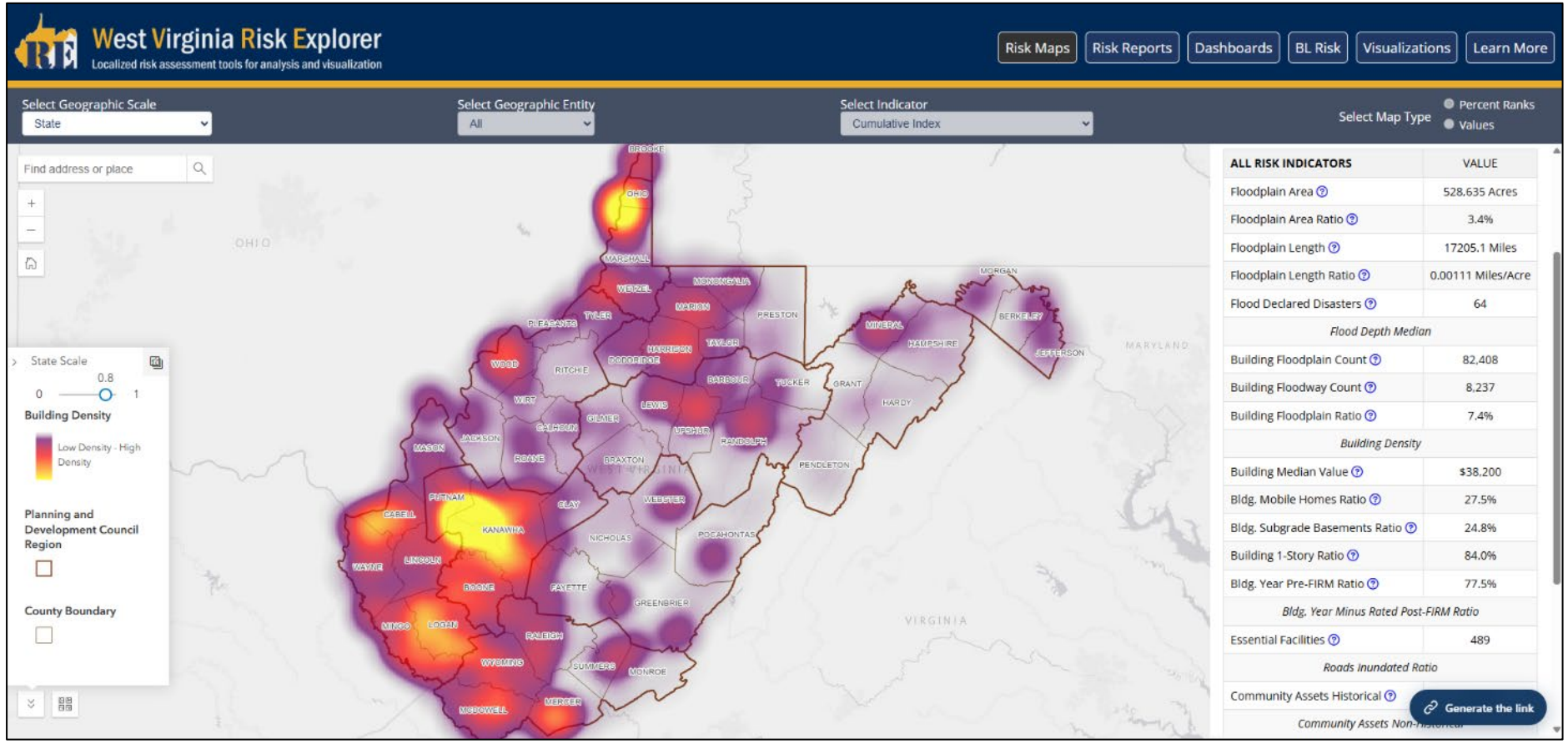
(1) FLOODPLAIN CHARACTERISTICS	(2) BUILDING EXPOSURE	(3) BUILDING CHARACTERISTICS	(4) CRITICAL INFRASTRUCTURE	(5) COMMUNITY ASSETS	(6) BUILDING DAMAGE LOSS	(7) PEOPLE / SOCIAL VULNERABILITIES	(8) OTHER HAZARDS
Floodplain Area	Building Floodplain Count[1 2]	Building Value[1 2]	Essential Facilities	Historical Assets	Substantial Damage Estimates*[1 2]	Population in Floodplain	Landslides
Floodplain Length[1 2]	Building Floodway Count[1 2]	Mobile Homes	Roads Inundated	Non-Historical Assets	Previous Claims	Population Displaced	Karst**
Floodplain Depth[1 2]	Building Floodplain Ratio[2]	Basement			Repetitive Losses	WV Social Vulnerability Index	Dam/Levee Failure**
Flood Disaster Frequency	Building Density[1 2]	One Story					
		Building Year*					

Used for the Index

* Multiple Indicators ** In Progress [1] River/Stream Indicator [2] Watershed Indicator

Riverine Flood Risk Assessment

Statewide Flood Risk Assessment



Geographic Entities at VERY HIGH Risk (Top 10%)

RANK	All Communities	Index Score
1	New Martinsville - Incorporated	100.0%
2	Boone County* - Unincorporated	99.6%
3	Clendenin - Incorporated	99.2%
4	Marlinton - Incorporated	98.9%
5	Wheeling** - Incorporated	98.5%
6	McDowell County* - Unincorporated	98.2%
7	Alderson** - Incorporated	97.8%
8	Wayne County* - Unincorporated	97.5%
9	Parsons - Incorporated	97.1%
10	Kanawha County* - Unincorporated	96.8%
11	Madison - Incorporated	96.4%
12	Kimball - Incorporated	96.1%
13	Lincoln County* - Unincorporated	95.7%
14	Milton - Incorporated	95.4%
15	Mingo County* - Unincorporated	95.0%
16	Logan County* - Unincorporated	94.6%
17	Danville - Incorporated	94.3%
18	Wellsburg - Incorporated	93.9%
19	Oceana - Incorporated	93.6%
20	Rowlesburg - Incorporated	93.2%
21	Northfork - Incorporated	92.9%
22	Gary - Incorporated	92.5%
23	Wyoming County* - Unincorporated	92.2%
24	Welch - Incorporated	91.8%
25	Summers County* - Unincorporated	91.5%
26	Buckhannon - Incorporated	91.1%
27	Richwood - Incorporated	90.8%
28	Ceredo - Incorporated	90.4%
29	Mannington - Incorporated	90.1%

Incorporated Places	Index Score
Clendenin - Incorporated	100.0%
New Martinsville - Incorporated	99.5%
Alderson** - Incorporated	99.1%
Marlinton - Incorporated	98.6%
Kimball - Incorporated	98.2%
Parsons - Incorporated	97.8%
Wheeling** - Incorporated	97.3%
Northfork - Incorporated	96.9%
Danville - Incorporated	96.4%
Madison - Incorporated	96.0%
Milton - Incorporated	95.6%
Oceana - Incorporated	95.1%
Keystone - Incorporated	94.7%
Wellsburg - Incorporated	94.2%
Gary - Incorporated	93.8%
Rowlesburg - Incorporated	93.4%
Grantsville - Incorporated	92.9%
Richwood - Incorporated	92.5%
Rainelle - Incorporated	92.1%
Mannington - Incorporated	91.6%
Spencer - Incorporated	91.2%
Welch - Incorporated	90.7%
Buckhannon - Incorporated	90.3%

Unincorporated Areas	Index Score
Kanawha County* - Unincorporated	100.0%
Boone County* - Unincorporated	98.1%
Wayne County* - Unincorporated	96.2%
McDowell County* - Unincorporated	94.4%
Mingo County* - Unincorporated	92.5%
Logan County* - Unincorporated	90.7%

Counties	Index Score
Kanawha	100.0%
Boone	98.1%
McDowell	96.2%
Logan	94.4%
Mingo	92.5%
Wyoming	90.7%

Regions	Index Score
PDC Region 2	100%
PDC Region 3	90%

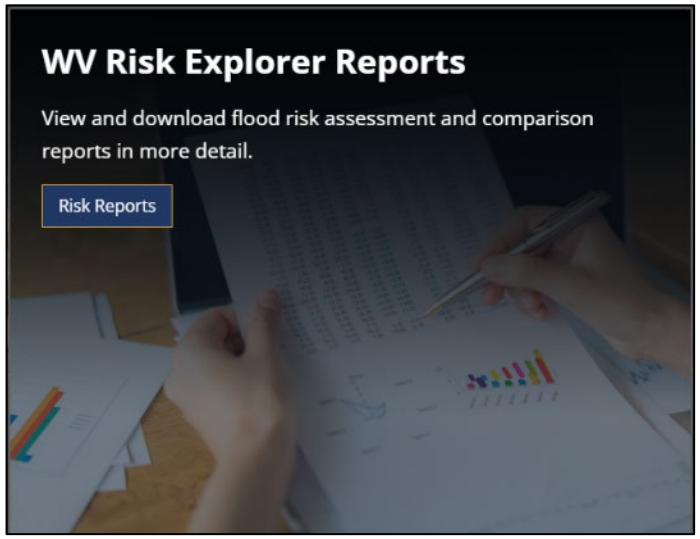
RANK	Streams (Top 20)	Index Score
1	Coal River	100.0%
2	Ohio River	99.7%
3	Little Coal River	99.5%
4	Greenbrier River	99.3%
5	Davis Creek	99.1%
6	Island Creek	98.9%
7	Kanawha River	98.7%
8	Campbells Creek	98.4%
9	Wheeling Creek	98.2%
10	Pocatalico River	98.0%
11	Cacapon River	97.8%
12	Big Coal River	97.6%
13	Mud River	97.4%
14	Cabin Creek	97.1%
15	Pond Fork	96.9%
16	Elk River	96.7%
17	Twelvepole Creek	96.5%
18	Buckhannon River	96.3%
19	South Branch Potomac River	96.1%
20	Paint Creek	95.8%

Watersheds	Index Score
Lower Kanawha	100%
Coal	96.7%
Upper Kanawha	93.5%
Tug	90.3%

Last update: Aug. 2024
Streams & Watersheds: Jul. 2025

Colors:
Black --> Incorporated places
Black on yellow** --> Split communities
Black on blue: Incorporated communities included in the detailed risk report (Camden-on-Gauley, Clendenin, Marlinton, Rainelle, Richwood, and White Sulphur Springs)
Brown on gray --> Unincorporated areas
Green --> Counties (Total)

Kanawha County Risk Report



Kanawha County

WV PDC Region: 3

September 2025

(County Scale, Top 20 Percent Risk Indicators Report)

Cumulative Flood Risk Score 1

100% Very High

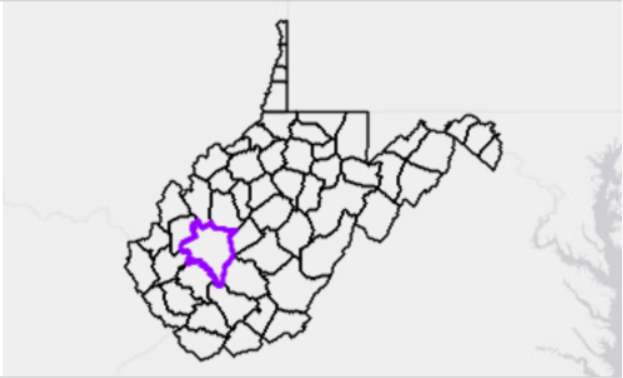
Ranks 1st of 55 counties in the state

13 of 25 risk indicators among the **top 10%** counties.

14 of 25 risk indicators among the top 20% counties.

View Risk Map

View Flood Tool

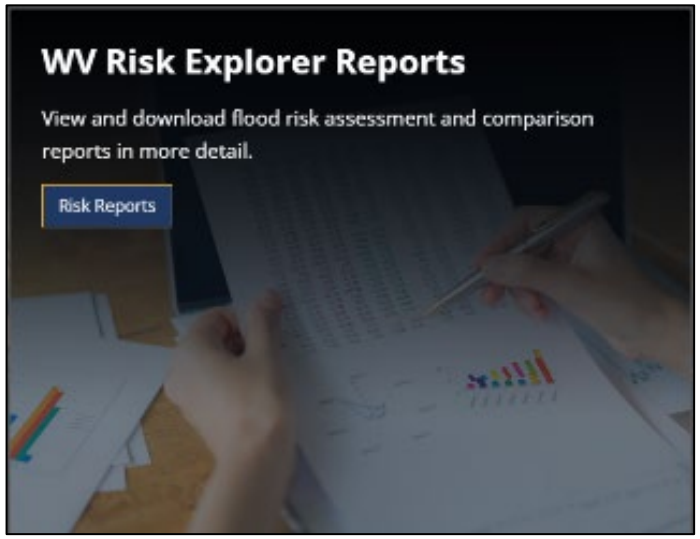


Flood Risk Index Scores for Kanawha County

Table 2. Flood Risk Index Scores: A Cumulative Flood Risk Index of 25 flood factors reveals that **Kanawha County** ranks 1st of 55 counties in the state with a Cumulative Flood Risk Score of **100%**. Below are 14 flood risk indicators for which Kanawha County is ranked among the top 20% counties.

CATEGORY	FLOOD RISK INDICATOR	VALUE FOR KANAWHA	INDICATOR SCORE (0 - 100%)	INDICATOR RATING
Floodplain Characteristics	Floodplain Area	23,929 Acres	**98.1%**	**VERY HIGH** 2
	Floodplain Length	911.2 Miles	**100.0%**	**VERY HIGH** 1
	Flood Declared Disasters	24	**94.4%**	**VERY HIGH** 4
Building Exposure	Building Floodplain Count	13,452	**100.0%**	**VERY HIGH** 1
	Building Floodway Count	1,462	**100.0%**	**VERY HIGH** 1
	Building Density	0.56 /Acre	**94.4%**	**VERY HIGH** 4
Building Characteristics	Building Median Value	$53,100	81.4%	Very High
Critical Infrastructure	Essential Facilities	80	**100.0%**	**VERY HIGH** 1
	Roads Inundated Ratio	11.8%	**90.7%**	**VERY HIGH** 6
Community Assets	Community Assets Historical	208	**96.2%**	**VERY HIGH** 3
	Community Assets Non-Historical	261	**100.0%**	**VERY HIGH** 1
Building Damage Loss	Bldg. Substantial Damage Count	975	**100.0%**	**VERY HIGH** 1
	Bldg. Previous Damage Claims	2,376	**96.2%**	**VERY HIGH** 3
	Bldg. Repetitive Loss Structures	779	**96.2%**	**VERY HIGH** 3

Clendenin Risk Report



Clendenin - Incorporated

County: Kanawha, WV PDC Region: 3

September 2025

(Incorporated Place Scale, All Risk Indicators Report)

Cumulative Flood Risk Score 100% Very High

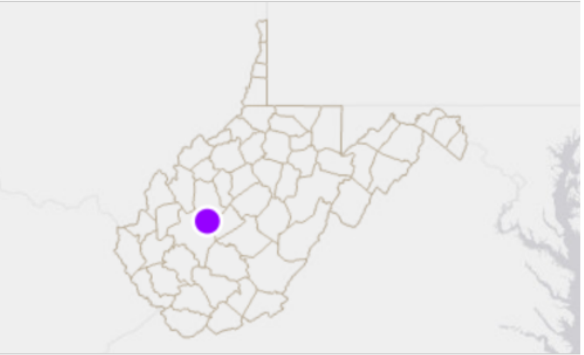
Ranks 1st of 229 incorporated places in the state 1

9 of 25 risk indicators among the **top 10%** incorporated places.

15 of 25 risk indicators among the top 20% incorporated places.

View Risk Map

View Flood Tool



Flood Risk Index Scores for Clendenin - Incorporated

Table 2. Flood Risk Index Scores: A Cumulative Flood Risk Index of 25 flood factors reveals that **Clendenin - Incorporated** ranks 1st of 229 incorporated places in the state with a Cumulative Flood Risk Score of **100%**. Below are 15 flood risk indicators for which Clendenin - Incorporated is ranked among the top 20% incorporated places.

CATEGORY	FLOOD RISK INDICATOR	VALUE FOR CLENDENIN - INCORPORATED	INDICATOR SCORE (0 - 100%)	INDICATOR RATING
Floodplain Characteristics	Flood Declared Disasters	24	88.1%	Very High
	Flood Depth Median	6.4 Ft	**96.0%**	**VERY HIGH**
Building Exposure	Building Floodplain Count	302	**91.2%**	**VERY HIGH**
	Building Floodplain Ratio	52.5%	**97.8%**	**VERY HIGH**
	Building Density	1.29 /Acre	80.2%	Very High
Building Characteristics	Bldg. Year Minus Rated Post-FIRM Ratio	10.9%	88.5%	Very High
Critical Infrastructure	Roads Inundated Ratio	51.8%	**98.6%**	**VERY HIGH** 4
Community Assets	Community Assets Historical	54	**98.2%**	**VERY HIGH** 5
	Community Assets Non-Historical	15	**97.3%**	**VERY HIGH** 6
Building Damage Loss	Bldg. Substantial Damage Count	46	**98.2%**	**VERY HIGH** 5
	Bldg. Substantial Damage Ratio	15.2%	88.5%	Very High
	Bldg. Previous Damage Claims	122	88.1%	Very High
	Bldg. Repetitive Loss Structures	24	83.3%	Very High
People / Social Vulnerabilities	Population in Floodplain Ratio	66.8%	**94.7%**	**VERY HIGH**
	Population Displaced Ratio	63.0%	**96.9%**	**VERY HIGH** 8

Clendenin – Charleston Risk Comparison

Flood Risk Comparison Report

(Incorporated Place Scale)

September 2025

For comparison, this report summarizes the Cumulative Flood Risk Index as well as 25 flood factors in seven major risk categories for the selected Incorporated Places.

Flood Risk Index Comparison

Table 1. Flood Risk Index: Below is a comparison of the Cumulative Flood Risk Index for the selected **Incorporated Places**.

#	STATE INDEX RANK	INCORPORATED PLACE	COUNTY	CUMULATIVE FLOOD RISK INDEX	
				INDEX SCORE	INDEX RATING
1	1	Clendenin - Incorporated	Kanawha	100%	VERY HIGH
2	39	Charleston - Incorporated	Kanawha	83.3%	Very High

Critical Infrastructure Comparison

Table 5. Critical Infrastructure: Below is a comparison of **2** flood factors under the Critical Infrastructure category for the selected **Incorporated Places**.

#	STATE CATEGORY RANK	INCORPORATED PLACE	CRITICAL INFRASTRUCTURE		CATEGORY SCORE
			ESSENTIAL FACILITIES	ROADS INUNDATED RATIO	
1	13	Clendenin - Incorporated	2	51.8%	94.7%
2	62	Charleston - Incorporated	20	5.6%	73.2%

Community Assets Comparison

Table 6. Community Assets: Below is a comparison of **2** flood factors under the Community Assets category for the selected **Incorporated Places**.

#	STATE CATEGORY RANK	INCORPORATED PLACE	COMMUNITY ASSETS		CATEGORY SCORE
			COMMUNITY ASSETS HISTORICAL	COMMUNITY ASSETS NON-HISTORICAL	
1	2	Charleston - Incorporated	154	55	99.5%
2	4	Clendenin - Incorporated	54	15	98.6%

Building Damage Loss Comparison

Table 7. Building Damage Loss: Below is a comparison of **4** flood factors under the Building Damage Loss category for the selected **Incorporated Places**.

#	STATE CATEGORY RANK	INCORPORATED PLACE	BUILDING DAMAGE LOSS				CATEGORY SCORE
			BLDG. SUBSTANTIAL DAMAGE COUNT	BLDG. SUBSTANTIAL DAMAGE RATIO	BLDG. PREVIOUS DAMAGE CLAIMS	BLDG. REPETITIVE LOSS STRUCTURES	
1	9	Clendenin - Incorporated	46	15.2%	122	24	96.4%
2	11	Charleston - Incorporated	35	2.3%	357	113	95.6%

Floodplain Characteristics Comparison

Table 2. Floodplain Characteristics: Below is a comparison of **4** flood factors under the Floodplain Characteristics category for the selected **Incorporated Places**.

#	STATE CATEGORY RANK	INCORPORATED PLACE	FLOODPLAIN CHARACTERISTICS				CATEGORY SCORE
			FLOODPLAIN AREA RATIO	FLOODPLAIN LENGTH RATIO	FLOOD DECLARED DISASTERS	FLOOD DEPTH MEDIAN	
1	22	Clendenin - Incorporated	24.1%	0.00389 Miles/Acre	24	6.4 Ft	90.7%
2	150	Charleston - Incorporated	4.7%	0.00175 Miles/Acre	24	1.7 Ft	34.6%

Building Exposure Comparison

Table 3. Building Exposure: Below is a comparison of **4** flood factors under the Building Exposure category for the selected **Incorporated Places**.

#	STATE CATEGORY RANK	INCORPORATED PLACE	BUILDING EXPOSURE				CATEGORY SCORE
			BUILDING FLOODPLAIN COUNT	BUILDING FLOODWAY COUNT	BUILDING FLOODPLAIN RATIO	BUILDING DENSITY	
1	18	Clendenin - Incorporated	302	4	52.5%	1.29 /Acre	92.1%
2	32	Charleston - Incorporated	1,512	25	5.4%	1.57 /Acre	86.4%

Building Characteristics Comparison

Table 4. Building Characteristics: Below is a comparison of **6** flood factors under the Building Characteristics category for the selected **Incorporated Places**.

#	STATE CATEGORY RANK	INCORPORATED PLACE	BUILDING CHARACTERISTICS						CATEGORY SCORE
			BUILDING MEDIAN VALUE	BLDG. MOBILE HOMES RATIO	BLDG. SUBGRADE BASEMENTS RATIO	BUILDING 1-STORY RATIO	BLDG. YEAR PRE-FIRM RATIO	BLDG. YEAR MINUS RATED POST-FIRM RATIO	
1	50	Clendenin - Incorporated	$49,000	6.4%	34.8%	75.5%	84.5%	10.9%	78.5%
2	81	Charleston - Incorporated	$47,900	0.7%	50.1%	70.8%	90.8%	1.4%	64.9%

People / Social Vulnerabilities Comparison

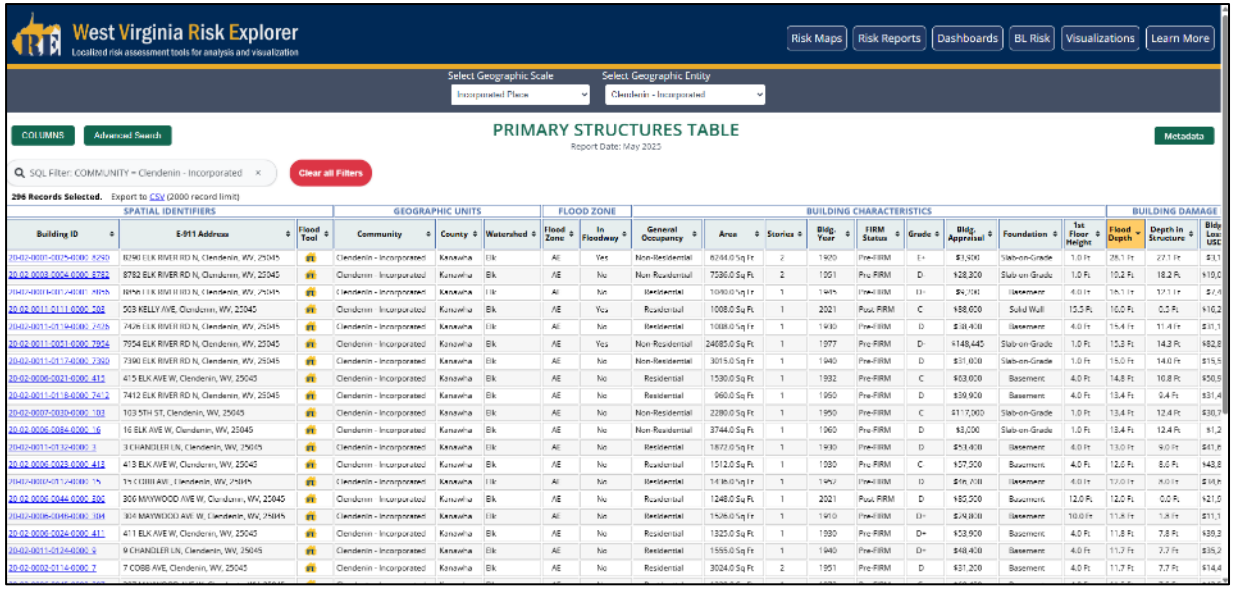
Table 8. People / Social Vulnerabilities: Below is a comparison of **3** flood factors under the People / Social Vulnerabilities category for the selected **Incorporated Places**.

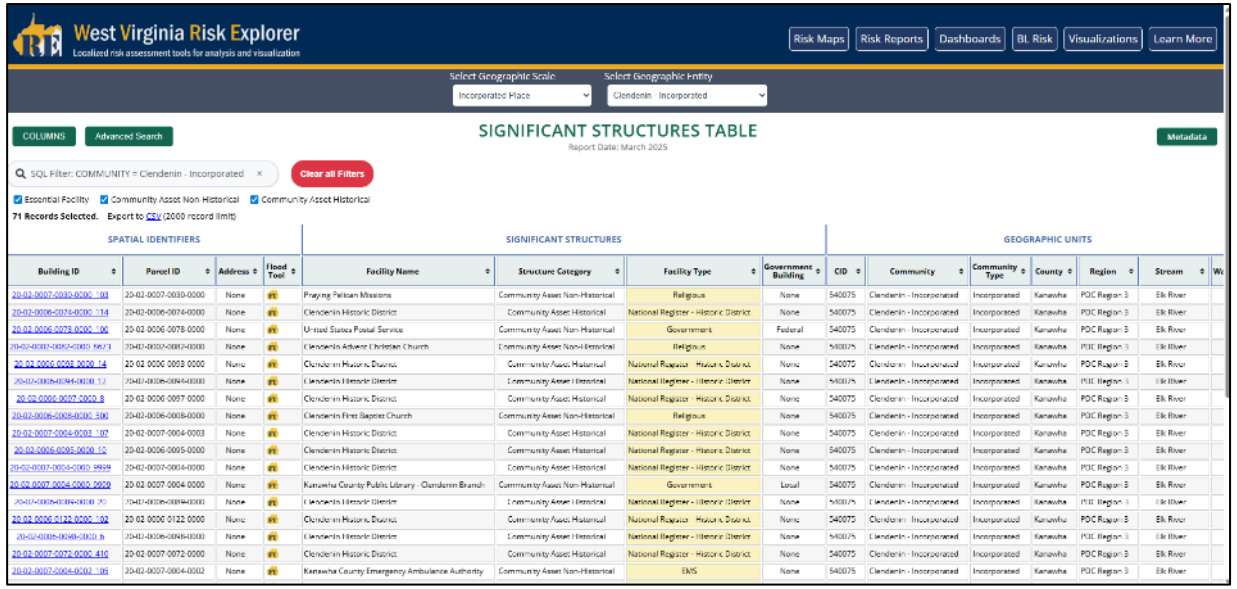
#	STATE CATEGORY RANK	INCORPORATED PLACE	PEOPLE / SOCIAL VULNERABILITIES			CATEGORY SCORE
			POPULATION IN FLOODPLAIN RATIO	POPULATION DISPLACED RATIO	WV SOCIAL VULNERABILITY INDEX	
1	45	Clendenin - Incorporated	66.8%	63.0%	36.6%	80.7%
2	162	Charleston - Incorporated	6.4%	3.5%	15.0%	29.3%

Building-Level Risk Reports, Clendenin

Clendenin, June 2016

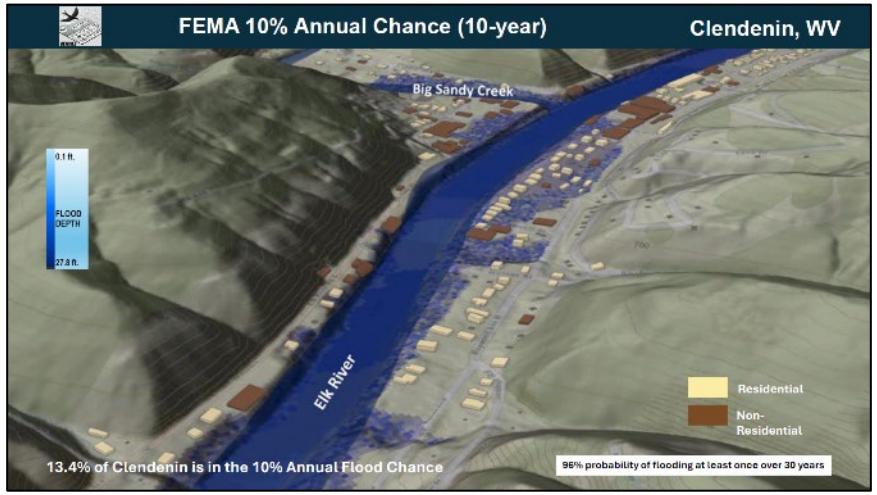
Clendenin, June 2016





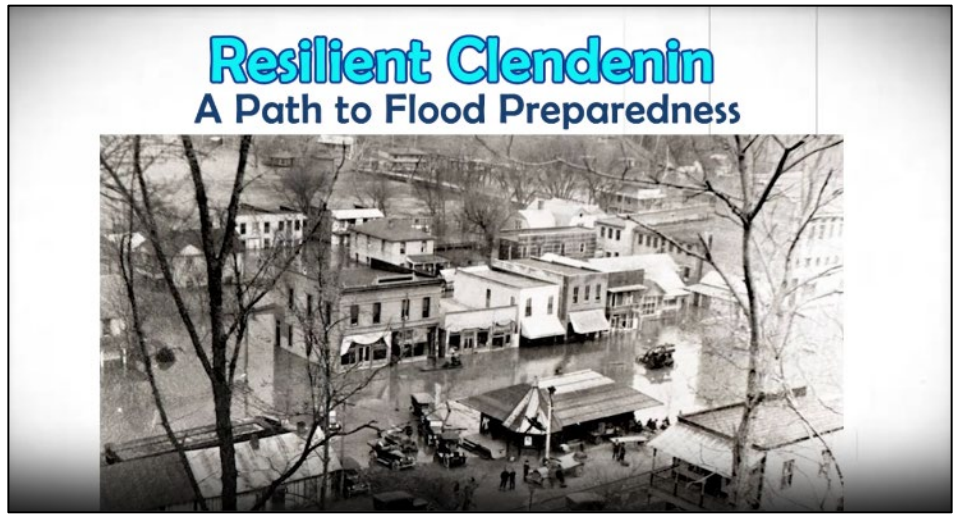
Flood Visualizations

Visualization Tools Examples



Viewshed for Clendenin

Building Profile in Clendenin



3D Movie for Clendenin

Building Profile in Charleston

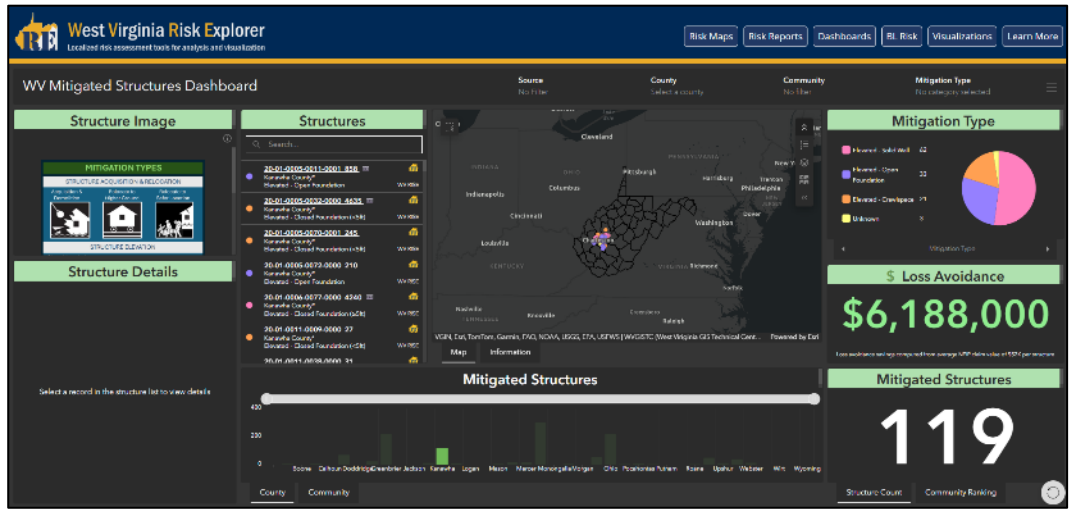
Flood Mitigation

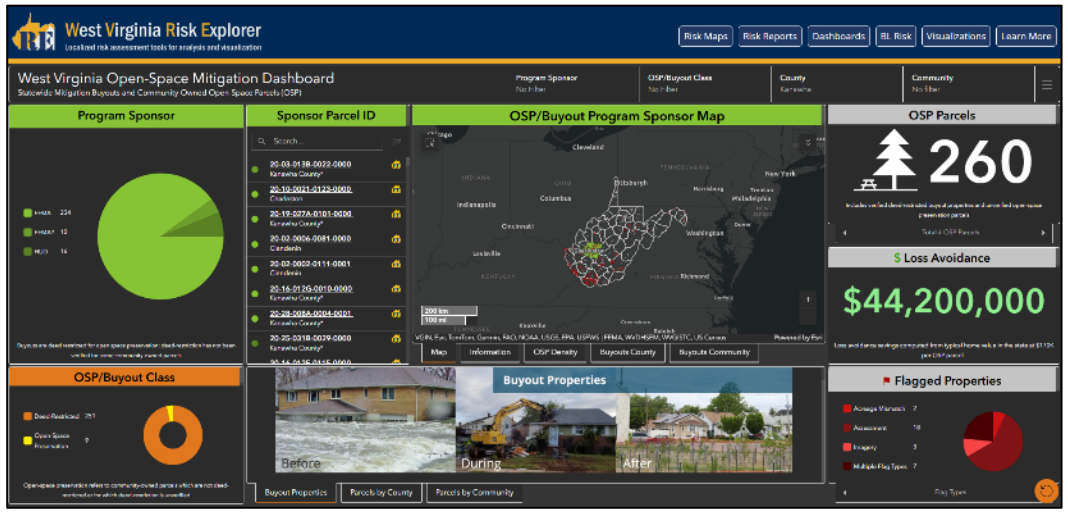
Mitigation Measures, Kanawha County & Clendenin

Mitigated Structures Inventoried

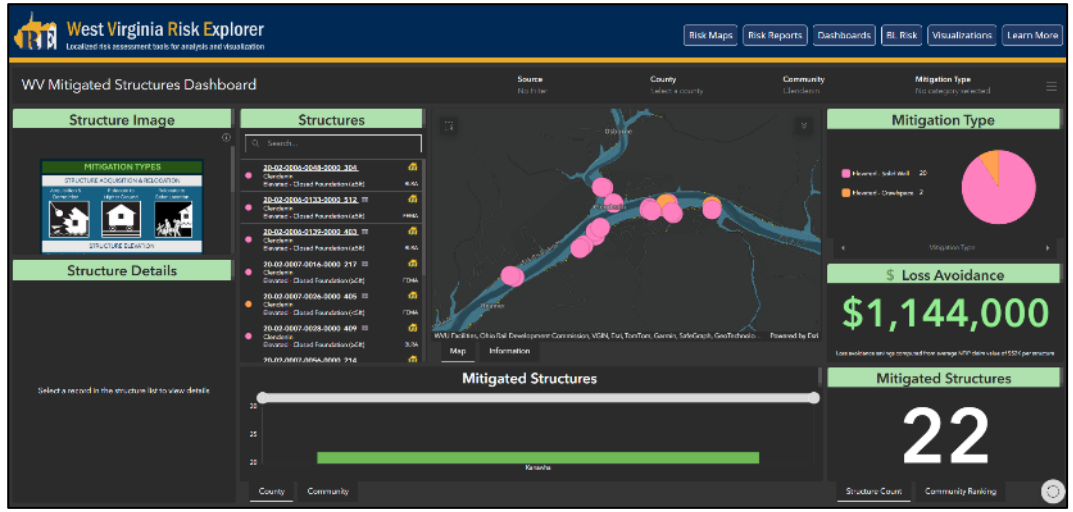
Mitigated/Buyout Parcels

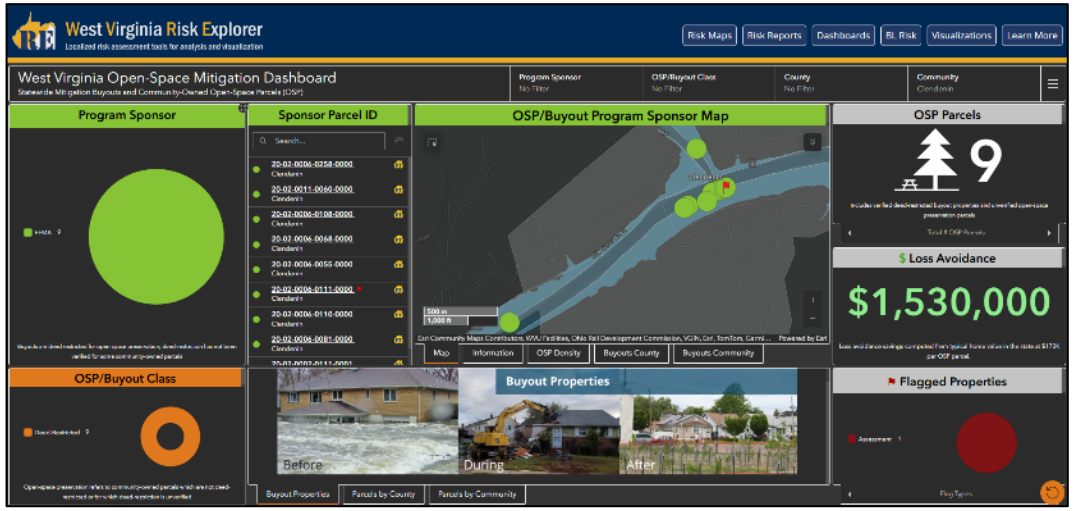
Kanawha County





Clendenin





Future Enhancements

- **Hazard Library Finalization (coming soon)**
  Expanded catalog of hazard layers and supporting data

- **Planned Updates**
  Regular feature data updates, additions, and indicator refinements

- **User Feedback Loop**
  Reporting and feedback for tool improvements

- **Mobile-Friendly Access**
  Responsive design for field use

- **Expanded Hazard Coverage**
  Landslide, Dam Failure, and Karst

- **Future Maintenance**
  Ongoing functioning and system performance improvements

- **Training & Support**
  User training sessions, documentation, and guidance

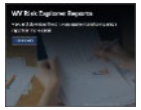
Links to Tools / Data

→ WV Flood Tool: https://www.mapwv.gov/flood/

→ West Virginia Flood Resiliency Framework (WVFRF): https://wvfrf.org/

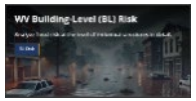
→ West Virginia Risk Explorer (WVRE) (Landing Page): https://www.wvfrf.org/wvre/

→ WV Risk Explorer Maps: https://wvfrf.org/wvre/map/?scaleid=3&gslid=&index=CUM_INDEX&type=pct



→ WV Risk Explorer Reports: https://wvfrf.org/wvre/report/?entityid=68&scaleid=1&type=all

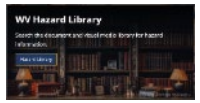
→ WV Flood Dashboards: https://wvfrf.org/wvre/dashboard/home/



→ WV Building-Level (BL) Risk: https://wvfrf.org/wvre/buildings/

→ WV Flood Visualizations: https://wvfrf.org/wvre/visualization/home/

→ Access Data: https://wvfrf.org/wvre/data/home/



→ WV Hazard Library: https://wvfrf.org/library/

→ Landslide Tools: https://wvfrf.org/wvre/landslides/

Thank you!

Questions?

Email:

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behrang.bidadian@mail.wvu.edu

Backup Slides

Benefits of the Tools

- **Planning**
  - Enhancing state resiliency and hazard mitigation plans
  - Updating emergency operation plans
  - Prioritizing and allocating resources
  - Identifying the need for more refined risk assessments

- **Risk Communications**
  - Encouraging community-level risk communication and engagement
  - Educating new homeowners and renters
  - Informing the insurance and mortgage industries

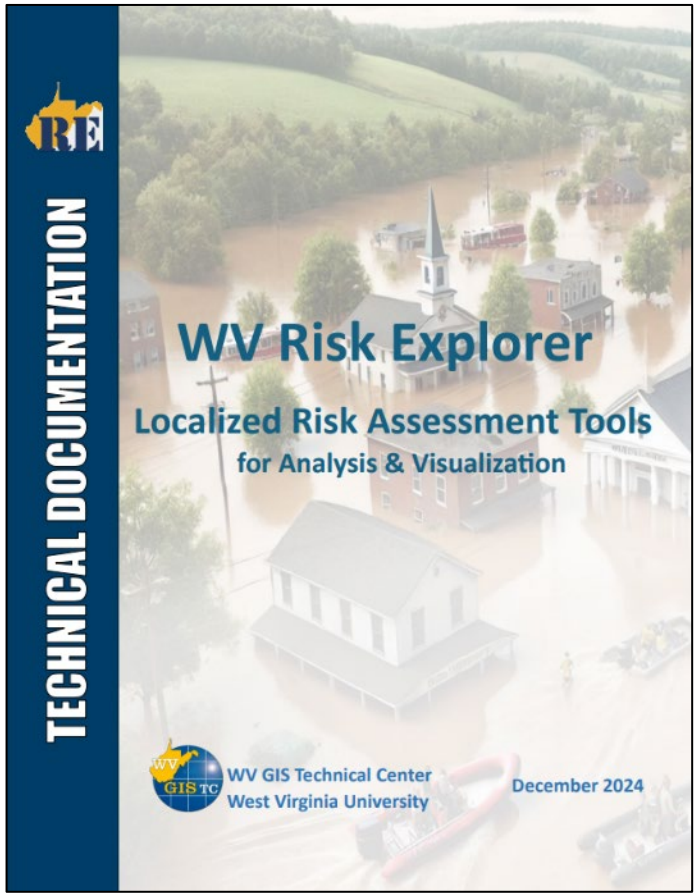
- **Mitigation**
  - Identifying areas of mitigation interest
  - Supporting the development or enhancement of codes and standards
  - Informing long-term community recovery

Unique Features of WV Risk Explorer Tools

- **Risk indicators Rankings to Identify Communities at Higher Risk in Risk Maps & Reports**
  Interactively view and explore flood risk indicators on a map to identify areas of higher risk.
- **Interactive Downloadable Risk Reports by Multi-Scale Aggregation of Detailed Building-Level Inventory**
  View and download flood risk assessment and comparison reports in more detail.
- **Sharable Queries for Risk Reports, Maps, and Tables**
  Share your geographic selections along with data field queries for consistent use across teams.
- **Rationale and Recommendations for Risk Indicators**
  Use the Technical Documentation to understand the rationale for the risk indicators and the recommendations associated with them.
- **Statewide Consistent Methodology and Risk Indicators**
  In-depth flood risk indicators covering all of West Virginia uniformly, not just selected regions.
- **Flood Dashboards**
  Use the interactive dashboards to analyze risk factors and mitigation measures.
- **Flood Visualizations**
  Visualize 3D and 2D flood models at the community and building level scales.
- **Hazard Library Customized to West Virginia**
  Search the document and visual media library for hazard information.
- **Data Access**
  Download risk data for use in your own analyses, maps, or applications.
- **Scalable**
  Scalable for other hazards such as landslides or enhancements to risk indicators.

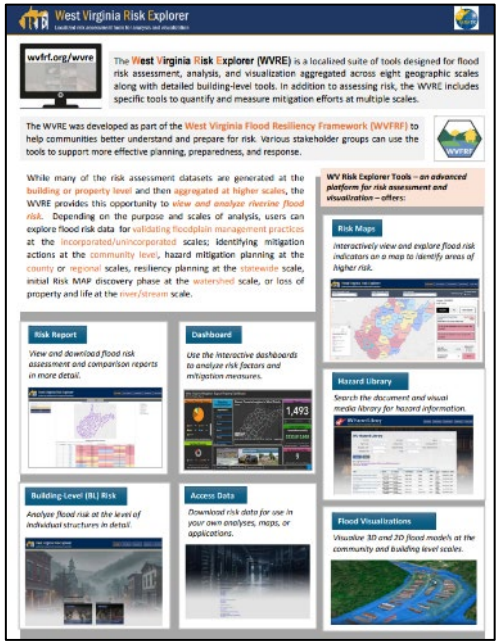
User Guides

WVRE Technical Document



https://data.wvgis.wvu.edu/pub/RA/RI/WVRE/DOCS/WVRE_TechnicalDoc.pdf

WVRE One-Pager



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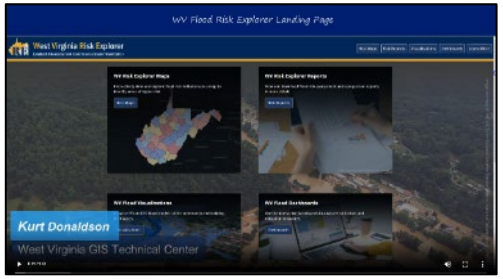
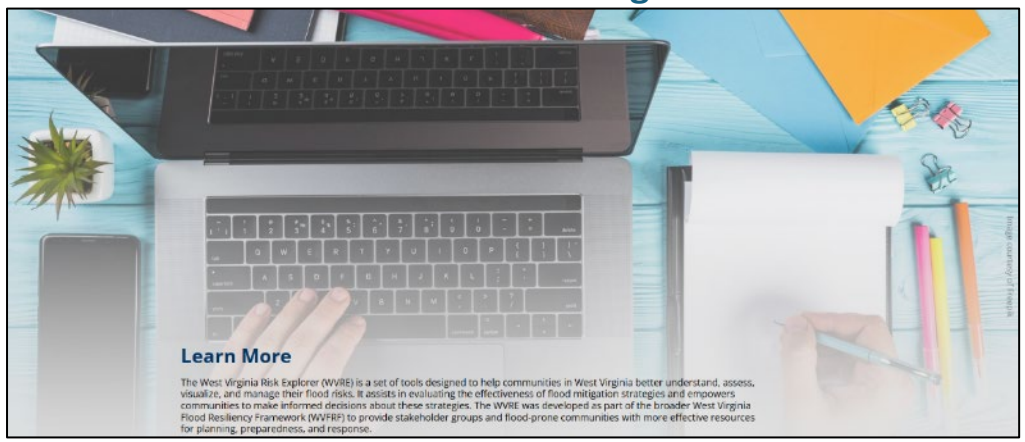
WVRE Demo (Video)



https://data.wvgis.wvu.edu/pub/RA/HL/WVFRF/Video/WV_Risk_Explorer_Movie_20240826.mp4

WVRE Learn More Page



https://wvfrf.org/wvre/more/

Metadata Documents

Data Dictionary (Metadata)
WV Risk Index (Rankings/Scores)

https://data.wvgis.wvu.edu/pub/RA/HL/Data/RA-AL/1a_AL-RISK-INDEX/2_Metadata/WV_RiskIndex_DataDictionary.pdf

Data Dictionary (Metadata)
Risk Full Data Matrix

https://data.wvgis.wvu.edu/pub/RA/HL/Data/RA-AL/1b_AL-MATRIX/2_Metadata/Full_Matrix_DataDictionary.pdf

Metadata,
Full Building-Level Risk Assessment (BLRA) for Primary Structures

https://data.wvgis.wvu.edu/pub/RA/HL/Data/RA-BL/2a_BL-BLRA/3_Metadata/Full_BLRA_Metadata.pdf

Metadata,
Building-Level Significant Structures at Risk

https://data.wvgis.wvu.edu/pub/RA/HL/Data/RA-BL/2b_BL-SIG-STRC/1_All_Sig_Structures/2_Metadata/Significant_Structures_Metadata.pdf