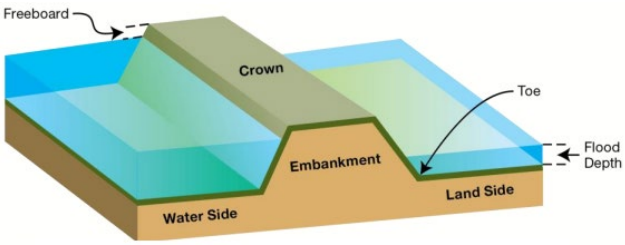
5.8. Levee Failure

2023 SHMP Update Changes

- The hazard profile was reorganized and significantly enhanced to include detailed descriptions of the following: hazard definition, location, extent, previous occurrences, and probability of future occurrences (including how future conditions may impact the hazard).
- Levee failure events that occurred in the State of West Virginia (the State) from January 1, 2018, through December 31, 2022, were researched for this 2023 SHMP update.
- New and updated figures from federal, state, and local agencies are incorporated.
- Analyzed state asset exposure to levee failures.

5.8.1. Hazard Profile



Title 44, Chapter 1, Section 59.1 of the Code of Federal Regulations (44 C.F.R. §59.1) defines a levee as "a man-made structure, usually an earthen embankment, designed and constructed in accordance with sound engineering practices to contain, control, or divert the flow of water so as to reduce risk from temporary flooding" and a levee system as "a flood protection system which consists of a levee, or levees, and associated structures, such as closure and drainage devices, which are constructed and operated in accordance with sound engineering practices" (44 C.F.R. §59.1). Levees are built along waterways, usually rivers, to reduce the flood risk of areas on the landward side of the levee (FEMA 2020).

Hazard Description

Levees can pose a risk to communities if not designed, constructed, operated, and maintained properly. Causes of levee failure include a flood exceeding the capacity of the levee, lack of maintenance, inadequate foundations, erosion, seepage, earthquakes or other seismic activity, or even animals burrowing into the earth that forms the levee (FEMA 2020). In the event of a catastrophic levee failure, the energy the water released from even a small structure can cause extensive property damage, injury, and potential loss of life. This is especially true in West Virginia, where many communities lie along steep (or high) gradient streams and rivers within narrow valleys.

Failure of any one of the levees in West Virginia has the potential to inundate the surrounding areas, particularly those that are low-lying. Levee failure can occur with little or no advance warning; however, there is likely to be some warning for larger levees that are being loaded by water and not performing adequately.

LOCATION

According to the U.S. Army Corps of Engineers National Levee Database (NLD) there are 21 levees in the State (USACE 2023). Of these 21 levees, 18 were federally constructed and turned over to the public for operations and maintenance, and 5 were locally constructed, operated, and maintained. However, two levees (East Bayard and West Bayard) are listed in the NLD as both federally constructed and locally constructed. Table 5.8-1 shows the name, location, and ownership of levees in the state. All 21 levees in the state were constructed for flood risk protection. They are shown on the map in Figure 5.8-1.

Table 5.8-1. Levees in West Virginia

Name	Location	Summary	Risk
Benwood – Left Bank Ohio River, Locally Preferred Plan (LPP)	Benwood, Marshall County	Non-federally authorized urban flood protection project maintained by the City of Benwood. Levee includes 1,900 feet of earthen levee, a concrete floodwall, a total of five gravity drains structures, three pump stations, and two gate closure structures incorporated to allow for rail traffic. Rail lines are no longer in use and tracks have been removed.	Low
Blackwater River Levee (Left Bank)	Hendricks, Tucker County	No data entered	Not Screened
Blackwater River Levee (Right Bank)	Hendricks, Tucker County	No data entered	Not Screened
Blaine Flood Risk Management System (FRMS), Flood Risk Management Project (FRMP)	Mineral County	Part of the Kitzmiller federally authorized and constructed FRMP. Designed to provide flood risk management for discharge of 52,000 cubic feet per second on the North Branch of the Potomac River.	Low
Ceredo-Kenova, WV, LPP	Kenova, Wayne County	USACE constructed the Ceredo-Kenova System in 1940 to provide flood damage reduction to the Town of Ceredo and City of Kenova. The Town and City now operate and maintain their respective segments.	Moderate
East Bayard, FRMS, FRMP	Bayard, Grant County	Part of Federally authorized and constructed FRMP. System contains both East and West Bayard. Originally designed to provide flood risk management for a discharge of 5,000 cubic feet per second on Buffalo Creek. Both systems are owned and maintained by the Town of Bayard.	Low
Elkins, WV – Tygart River	Elkins, Randolph County	A federally authorized urban flood protection project that was Designed by USACE and maintained and operated by City of Elkins. The protection levee is 43 feet high and includes 5’-2”H x 6’-2”V reinforced concrete outlet structures with sluice gates and emergency closures.	Low
Huntington, WV, LPP	Huntington, Cabell County	The LPP serves as a flood damage reduction measure to urban lands and consists of two systems: Huntington and Guyandotte systems. The project is federally authorized, non-federally operated and maintained, and does not serve as a multipurpose project.	High
Huntington, WV, LPP – Guyandotte	Huntington, Cabell County	The project is federally authorized, non-federally operated and maintained, and does not serve as a multipurpose project.	Moderate
Magnolia Ringwall, WV	Matewan, Mingo County	The Magnolia School Ringwall Project is located along the right descending bank of the Tug Fork of the Big Sandy River. The project is approximately 2.6 miles downstream of the Town of Matewan, WV. The project is located on the WV/KY border in Mingo County. The project consists of 2,200 feet of concrete I-Wall type	Low

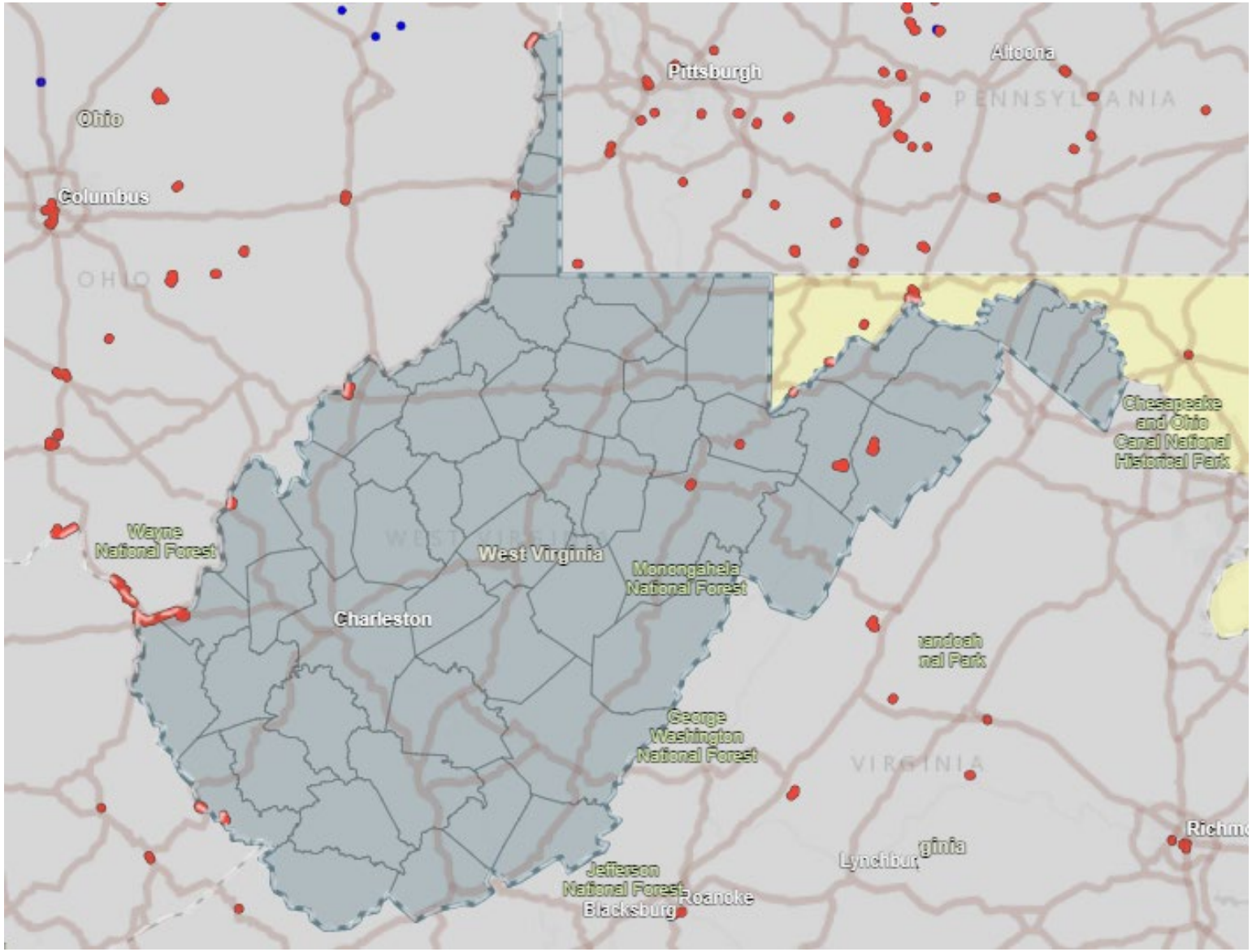
Name	Location	Summary	Risk
		floodwall and steel sheet piling. The project also has about 36 feet of levee constructed to provide access into the project in lieu of another traffic closure. The levee is constructed primarily of impervious soils, and the compaction efforts and construction methods were controlled.	
Matewan, WV, LPP	Matewan, Mingo County	Situated on the Tug Fork of the Big Sandy River in Mingo County, WV, the Matewan Local Protection Project reduces flood risk for the Town of Matewan. The levee is owned by Mingo County but is operated and maintained by the Town of Matewan. The Matewan levee system consists of about ½ mile of concrete floodwall, ten gate closures, and one storm water pump station.	Low
North Moorefield	Moorefield, Hardy County	The Moorefield FRMP consists of two hydraulically independent systems located at the confluence of the South Fork and the South Branch Potomac River in western Hardy County, West Virginia. The North Moorefield system is comprised of 14,140 feet of earthen levee, 898 feet of half-levee with a mechanically stabilized earth (MSE) wall, 332 feet of double-sided MSE wall, a railroad closure, and 15 drainage structures.	Low
North Petersburg	Petersburg, Grant County	The Petersburg LPP consists of two hydraulically independent systems; one on the north and one on the south side of the South Branch of the Potomac River. It consists of 7,000 feet of zoned-earth levees and 913 feet of floodwall (steel sheet piling with precast concrete panels on the landside-face of the piles) along the South Branch, and 4,100 feet of impervious embankment along Lunice Creek.	Low
Parkersburg, WV, LPP	Parkersburg, Wood County	USACE constructed the Parkersburg Levee System in 1950 to provide flood damage reduction to the City of Parkersburg, WV, and now operates and maintains the system. The levee system consists of approximately 1.8 miles of earthen embankment and 2.0 miles of concrete wall for a total length of approximately 3.8 miles. The levee system is located at the confluence of the Little Kanawha and Ohio Rivers. The leveed area includes residential and commercial areas with a population of almost 5,500 people and includes 835 homes and businesses.	Moderate
Point Pleasant, WV, LPP	Point Pleasant, Mason County	USACE constructed the Point Pleasant Levee System in 1951 to provide flood damage reduction to the City of Point Pleasant, WV who now operates and maintains the system. The levee system consists of 0.9 miles of earthen embankment and 1.4 miles of concrete wall for a total length of 2.3 miles. The levee system is located at the confluence of the Ohio and Kanawha Rivers in Mason County. The leveed area includes residential and commercial areas with a population of over 1,200 people and includes 580 homes and businesses.	Moderate
Ridgeley	Ridgeley, Mineral County	The Cumberland-Ridgeley Flood Risk Management (FRM) Project is divided into three independent flood damage reduction (FDR) Systems-- Cumberland, West Cumberland, and Ridgeley. All three systems are operated and maintained by the City of Cumberland, Maryland. The Ridgeley System is located along the right bank of the North Branch Potomac River near the confluence with Wills Creek and provides flood risk reduction for the Town of Ridgeley, WV. The project consists of approximately 7,000 feet of levee embankment, ~ 600 feet of floodwall, 2 sandbag closure structures, and 1 pump station. The line of protection also consists of roughly 800 feet of natural high ground.	Low
South Moorefield	Moorefield, Hardy County	The system consists of two hydraulically independent systems: North Moorefield and South Moorefield. It was designed to provide 0.01 annual chance of exceedance (ACE) protection, but recent reanalysis indicates the design provides about 0.015 ACE protection, and the 0.01 ACE would fully load the project. The South	Low

Name	Location	Summary	Risk
		Moorefield system is comprised of 9,115 feet of levee, a 20'-wide by 6'8"-high swing gate at a railroad closure that is loaded by about the 0.04 ACE event, and 7 drainage structures.	
South Petersburg, LPP	Petersburg, Grant County	The Petersburg LPP consists of two hydraulically independent systems; one on the north and one on the south side of the South Branch of the Potomac River. The South Petersburg system consists of 11,560 feet of earth levees and 4 drainage structures to provide conveyance of water through the line of protection.	Low
West Bayard	Bayard, Grant County	The West Bayard FRMS is part of the Bayard federally authorized and constructed FRMP located in Grant County, West Virginia, along both banks of Buffalo Creek, immediately upstream of its confluence with the North Fork of the Potomac River. The project includes two systems: East Bayard and West Bayard. The project was originally designed to provide flood risk management for a discharge of 5,000 cubic feet per second (cfs) on Buffalo Creek. Both systems are operated and maintained locally by the Town of Bayard, West Virginia. The West Bayard system is comprised of one segment and is located along the west bank (left descending) of Buffalo Creek immediately upstream of its confluence with the North Branch of the Potomac River. The system reduces the flood risk from Buffalo Creek for the Town of Bayard.	Low
West Williamson, WV, LPP	Williamson, Mingo County	The West Williamson levee system is located on the Tug Fork of the Big Sandy River and reduces flood risk for the western area of the City of Williamson, West Virginia. The levee is owned by Mingo County but is operated and maintained by the City of Williamson. The system consists of about 1 mile of concrete floodwall and 120 feet of earthen levee. It has one pumping station and six traffic openings that must be closed quickly during a flood event.	Low – The levee system is over 30 years old and has not been tested by a major flood.
Williamson, WV, LPP	Williamson, Mingo County	The Williamson levee system is located on the Tug Fork of the Big Sandy River and reduces flood risk for the central business district of Williamson, West Virginia. The levee is owned by Mingo County but is operated and maintained by the City of Williamson. The system is ¾ miles long with ½ mile of 53-ft tall steel sheet pile cells and ¼ mile of concrete floodwall. It has two pumping stations and five traffic openings that must be closed quickly during a flood event.	Low – The levee system is over 30 years old and has not been tested by a major flood.

Source: USACE 2023

Notes: *FRMS – Flood Risk Management System, FRMP – Flood Risk Management Project, LPP – Local Protection Project, USACE – United State Army Corps of Engineers*

Figure 5.8-1. Levees in West Virginia



Source: USACE 2023

There are levee systems that are identified as Moderate/High risk. These systems have a large number of residents and businesses located within the protected area. Failure of any one of the levees in West Virginia has the potential to inundate the surrounding areas, particularly those that are low-lying.

Table 5.8-2 summarizes the number of levee systems and the area that they protect by county. Eight levee systems are located in Grant and Mingo County alone.

Table 5.8-2. Total Square Miles of Levee Failure Inundation Area in each County

County	Total Levee Count	Total Square Miles of Land Area	Total Square Miles of Land Area (Excluding Waterbodies) Located in the Levee Failure Inundation Hazard Areas	
			Total Square Miles	Percent of Total
Barbour	0	342	0.00	0.0%
Berkeley	0	321	0.00	0.0%
Boone	0	503	0.00	0.0%
Braxton	0	513	0.00	0.0%
Brooke	0	93	0.00	0.0%
Cabell	2*	288	5.56	1.9%
Calhoun	0	280	0.00	0.0%
Clay	0	344	0.00	0.0%
Doddridge	0	320	0.00	0.0%
Fayette	0	668	0.00	0.0%
Gilmer	0	339	0.00	0.0%
Grant	4	477	1.08	0.2%
Greenbrier	0	1,022	0.00	0.0%
Hampshire	0	644	0.00	0.0%
Hancock	0	88	0.00	0.0%
Hardy	2	584	1.33	0.2%
Harrison	0	416	0.00	0.0%
Jackson	0	470	0.00	0.0%
Jefferson	0	211	0.00	0.0%
Kanawha	0	910	0.00	0.0%
Lewis	0	385	0.00	0.0%
Lincoln	0	438	0.00	0.0%
Logan	0	455	0.00	0.0%
Marion	0	311	0.00	0.0%
Marshall	1	311	0.05	0.0%
Mason	1	444	0.37	0.1%
McDowell	0	535	0.00	0.0%
Mercer	0	420	0.00	0.0%
Mineral	2	328	0.15	0.0%
Mingo	4	423	0.33	0.1%
Monongalia	0	363	0.00	0.0%

County	Total Levee Count	Total Square Miles of Land Area	Total Square Miles of Land Area (Excluding Waterbodies) Located in the Levee Failure Inundation Hazard Areas	
			Total Square Miles	Percent of Total
Monroe	0	473	0.00	0.0%
Morgan	0	229	0.00	0.0%
Nicholas	0	649	0.00	0.0%
Ohio	0	109	0.00	0.0%
Pendleton	0	698	0.00	0.0%
Pleasants	0	134	0.00	0.0%
Pocahontas	0	940	0.00	0.0%
Preston	0	649	0.00	0.0%
Putnam	0	350	0.00	0.0%
Raleigh	0	607	0.00	0.0%
Randolph	1	1,039	1.72	0.2%
Ritchie	0	454	0.00	0.0%
Roane	0	483	0.00	0.0%
Summers	0	365	0.00	0.0%
Taylor	0	173	0.00	0.0%
Tucker	2	415	0.04	0.0%
Tyler	0	261	0.00	0.0%
Upshur	0	354	0.00	0.0%
Wayne	2*	509	2.15	0.4%
Webster	0	556	0.00	0.0%
Wetzel	0	361	0.00	0.0%
Wirt	0	235	0.00	0.0%
Wood	1	377	1.19	0.3%
Wyoming	0	501	0.00	0.0%
Total	**22***	**24,167**	**13.97**	**0.1%**

Source: USACE 2023; West Virginia University GIS Technical Center (WVU GISTC) 2022
Notes:
**The Huntington, WV, LPP levee is listed in the NLD in both Cabell and Wayne Counties. Therefore, it is double counted in the totals above. The Square Mileage in this table excludes waterbody area.*

Extent

A complete levee failure, like a dam failure, is infrequent and typically coincides with incidents like heavy rainfall or tropical cyclones. In the event of a levee failure, floodwaters may ultimately inundate the protected area landward of the levee. The extent of inundation is dependent on the flooding intensity. Failure of a levee during a 1 percent annual chance flood will inundate the approximate 100-year flood plain previously protected by the levee. Residential and commercial buildings located nearest the levee failure or breach location will suffer the most damage from the initial embankment failure flood wave. Landward buildings will be damaged by inundation (FEMA 2020).

Warning Time

The amount of time that a community may have before a levee fails varies by the cause of the levee failure. A levee failing due to seismic activity will likely have no warning time. The possibility of a levee failure due to overtopping during a flood event can be identified by monitoring flood levels and comparing them to the design elevation of the levee; when a river with a levee is predicted to flood higher than the levee, the community can issue warnings of the possibility of a failure. Levee failure due to seepage, erosion, or animal activity may be predicted well ahead of time during routine inspections and maintenance of the levee, assuming that inspections and maintenance occur.

Previous Occurrences and Losses

Federal Emergency Management Agency (FEMA) Disaster Declarations

Between 1953 and 2022, the State was not included in any disaster (DR) or emergency (EM) declarations for levee failure events (FEMA 2023).

U.S. Department of Agriculture (USDA) Disaster Declarations

The Secretary of Agriculture from the U.S. Department of Agriculture (USDA) is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2016 and 2022, West Virginia was not included in any agricultural disaster declarations pertaining to levee failure (USDA 2023).

Previous Events

No records of levee failure incidents in the State were identified during the SHMP update.

Probability of Future Hazard Events

Overall Probability

The probability of a levee failure is difficult to quantify. As discussed above and shown in Table 5.8-3, the likelihood of a future levee failure cannot be determined based on past occurrences, as there have been none in the state.

Table 5.8-3. Probability of Future Levee Failure Events

Hazard Type	Number of Occurrences	Percent Chance of Occurrence in Any Given Year
Levee Failure	None identified	Cannot be determined based on past events

However, there is a concern for the possibility of levee failures nationwide, including in West Virginia, based on the condition and maintenance of the levees in the state. In its 2021 Infrastructure Report Card, the American Society of Civil Engineers (ASCE) noted a need for significant funding for the maintenance and improvement of high-risk levees across the country (ASCE 2022):

> "In 2018, it was [estimated] that $21 billion is needed to improve and maintain the moderate-, high-, and very high-risk levees in the USACE's levee portfolio. This estimate does not include any of the levees

outside of the USACE portfolio, so the actual cost to improve and maintain levees is unknown and is likely much higher. Federal funding for non-federally operated and maintained levees is limited, and most levee operation, maintenance, and repair is the responsibility of the levee owner."

This is of particular concern given the number of levees across West Virginia, their average age, and the number of residents being protected.

Projected Future Conditions

Future climate conditions may impact storm patterns, increasing the probability of more frequent, intense storms with varying duration. Because levee failure is often caused by excessive rainfall, it is appropriate to relate the future vulnerability of levees directly with the potential for increased rainfall.

As predictions indicate increased precipitation and more extreme weather events, the flood control and impoundment infrastructure in West Virginia becomes more of a concern. Like most of the country, the infrastructure in West Virginia is overwhelmingly privately owned and maintained, and it is aging to the end of its design life in many cases. The occurrence of more frequent high-intensity rainfall events may create conditions that exceed the original design criteria of these aging facilities.

5.8.2. Vulnerability Assessment

This section describes the vulnerability of state facilities, critical facilities across the state, and people to the levee failure hazard.

State Assets

To assess the vulnerability of the state-owned or -leased facilities, GIS software was used to overlay the statewide levee inundation hazard area with the state facilities. Table 5.8-4 and Table 5.8-5 summarize the state buildings located in the areas protected by levees by county and by agency, respectively. The spatial analysis indicates that there are 54 state-owned or -leased buildings vulnerable to levee failure. Cabell County has the highest number of state buildings (13) and the highest replacement cost value ($113.2 million) exposed to this hazard. The Supreme Court of Appeals has the most state facilities (11), and Marshall University has the highest replacement cost value ($82.7 million) in the levee hazard area.

Table 5.8-4. State Buildings Exposed to Levee Failure by County

State Facilities Located Within the Levee Hazard Area		Replacement Cost Value for State Facilities Within the Levee Hazard Area by County		
County	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value
Barbour	0	$0	$0	$0
Berkeley	0	$0	$0	$0
Boone	0	$0	$0	$0
Braxton	0	$0	$0	$0
Brooke	0	$0	$0	$0
Cabell	13	$107,719,188	$5,440,383	$113,159,571

State Facilities Located Within the Levee Hazard Area		Replacement Cost Value for State Facilities Within the Levee Hazard Area by County		
County	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value
Calhoun	0	$0	$0	$0
Clay	0	$0	$0	$0
Doddridge	0	$0	$0	$0
Fayette	0	$0	$0	$0
Gilmer	0	$0	$0	$0
Grant	3	$423,675	$846,800	$1,270,475
Greenbrier	0	$0	$0	$0
Hampshire	0	$0	$0	$0
Hancock	0	$0	$0	$0
Hardy	6	$0	$485,000	$485,000
Harrison	0	$0	$0	$0
Jackson	0	$0	$0	$0
Jefferson	0	$0	$0	$0
Kanawha	0	$0	$0	$0
Lewis	0	$0	$0	$0
Lincoln	0	$0	$0	$0
Logan	0	$0	$0	$0
Marion	0	$0	$0	$0
Marshall	0	$0	$0	$0
Mason	7	$225,000	$406,050	$631,050
McDowell	0	$0	$0	$0
Mercer	0	$0	$0	$0
Mineral	0	$0	$0	$0
Mingo	11	$15,995,822	$4,415,300	$20,411,122
Monongalia	0	$0	$0	$0
Monroe	0	$0	$0	$0
Morgan	0	$0	$0	$0
Nicholas	0	$0	$0	$0
Ohio	0	$0	$0	$0
Pendleton	0	$0	$0	$0
Pleasants	0	$0	$0	$0
Pocahontas	0	$0	$0	$0
Preston	0	$0	$0	$0
Putnam	0	$0	$0	$0
Raleigh	0	$0	$0	$0
Randolph	4	$401,784	$386,000	$787,784
Ritchie	0	$0	$0	$0

State Facilities Located Within the Levee Hazard Area		Replacement Cost Value for State Facilities Within the Levee Hazard Area by County		
County	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value
Roane	0	$0	$0	$0
Summers	0	$0	$0	$0
Taylor	0	$0	$0	$0
Tucker	0	$0	$0	$0
Tyler	0	$0	$0	$0
Upshur	0	$0	$0	$0
Wayne	0	$0	$0	$0
Webster	0	$0	$0	$0
Wetzel	0	$0	$0	$0
Wirt	0	$0	$0	$0
Wood	10	$8,765,081	$1,603,182	$10,368,263
Wyoming	0	$0	$0	$0
Total	**54**	**$133,530,550**	**$13,582,715**	**$147,113,265**

Source: WVBRIM 2022; USACE 2023

Table 5.8-5. State Buildings Exposed to Levee Failure by Agency

State Facilities Located Within the Levee Hazard Area		Replacement Cost Value for State Facilities Within the Levee Hazard Area by Agency		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value
Adjutant General's Office State of West Virginia	0	$0	$0	$0
Administration, Secretary of Department of Administration	0	$0	$0	$0
Agriculture, Department of State of West Virginia	0	$0	$0	$0
Air And Environmental Quality Boards State of West Virginia	0	$0	$0	$0
Alcohol Beverage Control Administration State of West Virginia	0	$0	$0	$0
Architects, Board of State of West Virginia	0	$0	$0	$0
Armory Board State of West Virginia	2	$0	$0	$0
Arts, Culture & History, Department of State of West Virginia	0	$0	$0	$0
Attorney General, Office of The State of West Virginia	0	$0	$0	$0
Aviation, Division of	0	$0	$0	$0
Bar, State State of West Virginia	0	$0	$0	$0
Barbers & Cosmetologists, Board of State of West Virginia	0	$0	$0	$0
Blue Ridge Community & Technical College	0	$0	$0	$0

State Facilities Located Within the Levee Hazard Area		Replacement Cost Value for State Facilities Within the Levee Hazard Area by Agency		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value
Bluefield State College	0	$0	$0	$0
Board of Treasury Investments	0	$0	$0	$0
Bridgevalley Community & Tech College	0	$0	$0	$0
Cedar Lakes Conference Center State of West Virginia	0	$0	$0	$0
Chiropractic Examiners Board State of West Virginia	0	$0	$0	$0
Commission For National And Community Service, WV	0	$0	$0	$0
Concord University	0	$0	$0	$0
Conservation Agency, West Virginia State of West Virginia	2	$0	$15,400	$15,400
Consolidated Public Retirement Board Department of Administration	0	$0	$0	$0
Consumer Advocate, Division of WV Public Service Commission	0	$0	$0	$0
Corrections, Division of State of West Virginia	0	$0	$0	$0
Courthouse Facilities Improvement Authority	0	$0	$0	$0
Dentistry, Board of State of West Virginia	0	$0	$0	$0
Department of Transportation	0	$0	$0	$0
Dietitians, Board of Licensed	0	$0	$0	$0
Eastern Panhandle Instructional Coop	1	$0	$20,000	$20,000
Eastern WV Community & Tech. College	1	$423,675	$736,000	$1,159,675
Economic Development Authority State of West Virginia	0	$0	$0	$0
Economic Development, WV Dept of	0	$0	$0	$0
Education, Department of State of West Virginia	1	$0	$100,000	$100,000
Educational Broadcasting Authority State of West Virginia	0	$0	$0	$0
Enterprise Resource Planning Board, WV	0	$0	$0	$0
Environmental Protection, Division of State of West Virginia	1	$0	$50,000	$50,000
Ethics Commission, West Virginia Department of Administration	0	$0	$0	$0
Examiners In Counseling, Board of State of West Virginia	0	$0	$0	$0
Fairmont State University	0	$0	$0	$0
Fire Commission State of West Virginia	0	$0	$0	$0
Fleet Management Office, Dept of Admin State of West Virginia	0	$0	$0	$0
Forestry, Division of State of West Virginia	0	$0	$0	$0
General Services Division Department of Administration	1	$10,184,000	$500,000	$10,684,000

State Facilities Located Within the Levee Hazard Area		Replacement Cost Value for State Facilities Within the Levee Hazard Area by Agency		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value
Geological And Economic Survey State of West Virginia	0	$0	$0	$0
Glenville State College	0	$0	$0	$0
Governor, Office of The State of West Virginia	0	$0	$0	$0
Health & Human Resources, Department of State of West Virginia	4	$480,000	$1,125,000	$1,605,000
Higher Education Policy Commission, WV	0	$0	$0	$0
Highways, Division of State of West Virginia	5	$19,344,938	$1,090,000	$20,434,938
Homeland Security & Emergency Management Division	0	$0	$0	$0
Insurance Commissioner, Office of The State of West Virginia	0	$0	$0	$0
Investment Management Board, WV State of West Virginia	0	$0	$0	$0
Joint Committee On Government & Finance State of West Virginia	0	$0	$0	$0
Justice & Community Services, Div. of	0	$0	$0	$0
Juvenile Services, Division of	0	$0	$0	$0
Labor, Division of State of West Virginia	0	$0	$0	$0
Land Division/Dept of Agriculture State of West Virginia	0	$0	$0	$0
Landscape Architects, Board of State of West Virginia	0	$0	$0	$0
Library Commission State of West Virginia	0	$0	$0	$0
Lottery Commission State of West Virginia	0	$0	$0	$0
Marshall University	1	$78,454,356	$4,269,858	$82,724,214
Military Affairs, Secretary of And Public Safety	0	$0	$0	$0
Miner's Health Safety, Division of And Training, State of West Virginia	0	$0	$0	$0
Motor Vehicles, Division of State of West Virginia	2	$0	$250,000	$250,000
Mountain State Esc	0	$0	$0	$0
Mountwest Community & Technical College	0	$0	$0	$0
National Coal Heritage Area Authority	0	$0	$0	$0
Natural Resources, Division of State of West Virginia	1	$0	$200,000	$200,000
New River Community & Technical College	0	$0	$0	$0
Northern Community & Tech College, WV College Square	0	$0	$0	$0
Occupational Therapy Board State of West Virginia	0	$0	$0	$0
Office of Technology/Is&C Department of Administration	0	$0	$0	$0
Osteopathic Medicine, WV Board of State of West Virginia	0	$0	$0	$0

State Facilities Located Within the Levee Hazard Area		Replacement Cost Value for State Facilities Within the Levee Hazard Area by Agency		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value
Osteopathic Medicine, WV School of	2	$0	$24,425	$24,425
Parks, West Virginia State C\O Division of Natural Resources	5	$8,760,781	$795,682	$9,556,463
Pharmacy, Board of State of West Virginia	0	$0	$0	$0
Physical Therapy, Board of State of West Virginia	0	$0	$0	$0
Pierpont Community And Technical College	0	$0	$0	$0
Practical Nurses, Board of State of West Virginia	0	$0	$0	$0
Prosecuting Attorneys Institute, WV	0	$0	$0	$0
Psychologists Examiners, Board of State of West Virginia	0	$0	$0	$0
Public Service Commission State of West Virginia	0	$0	$0	$0
Purchasing, Division of Department of Administration	0	$0	$0	$0
Rail Authority State of West Virginia	0	$0	$0	$0
Real Estate Commission State of West Virginia	0	$0	$0	$0
Regional Jail & Corr. Fac. Authority State of West Virginia	0	$0	$0	$0
Registered Nurses, Board of State of West Virginia	0	$0	$0	$0
Rehabilitation Services Division of Commerce	3	$0	$125,650	$125,650
Respiratory Care, WV Board of	0	$0	$0	$0
School Building Authority, West Virginia	0	$0	$0	$0
Schools For The Deaf And The Blind State of West Virginia	0	$0	$0	$0
Senior Services, Bureau of State of West Virginia	0	$0	$0	$0
Shepherd University	0	$0	$0	$0
Southern Educational Services Coop	0	$0	$0	$0
Southern WV Community & Tech College	1	$15,882,800	$3,515,000	$19,397,800
Speech Pathology & Audiology Examiners West Virginia Board of	0	$0	$0	$0
State Police, West Virginia Dept of Military Affairs & Public Safety	2	$0	$0	$0
Supreme Court of Appeals State of West Virginia	11	$0	$662,700	$662,700
Tax Appeals, WV Office of	0	$0	$0	$0
Tax Department State of West Virginia	0	$0	$0	$0
Treasurer of State State of West Virginia	0	$0	$0	$0
University Physicians And Surgeons	0	$0	$0	$0
Unknown	5	$0	$0	$0
Veterans Assistance, Department of State of West Virginia	2	$0	$18,000	$18,000
Veterinary Medicine, Board of State of West Virginia	0	$0	$0	$0

State Facilities Located Within the Levee Hazard Area		Replacement Cost Value for State Facilities Within the Levee Hazard Area by Agency		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value
Water Development Authority State of West Virginia	0	$0	$0	$0
West Liberty University	0	$0	$0	$0
West Virginia Parkways Authority	0	$0	$0	$0
West Virginia State University - Institute	0	$0	$0	$0
West Virginia State University - Malden	0	$0	$0	$0
West Virginia University	0	$0	$0	$0
West Virginia University Arthurdale	0	$0	$0	$0
West Virginia University At Parkersburg	0	$0	$0	$0
West Virginia University Beckley	0	$0	$0	$0
West Virginia University Bruceton Mills	0	$0	$0	$0
West Virginia University Charleston	0	$0	$0	$0
West Virginia University Fort Ashby	0	$0	$0	$0
West Virginia University Granville	0	$0	$0	$0
West Virginia University Jacksons Mill	0	$0	$0	$0
West Virginia University Kearneysville	0	$0	$0	$0
West Virginia University Keyser	0	$0	$0	$0
West Virginia University Montgomery	0	$0	$0	$0
West Virginia University Reedsville	0	$0	$0	$0
West Virginia University Union	0	$0	$0	$0
West Virginia University Wardensville	0	$0	$0	$0
West Virginia University Weston	0	$0	$0	$0
Workforce West Virginia	1	$0	$85,000	$85,000
WV Public Employees Grievance Board	0	$0	$0	$0
WVsom Clinic Inc Dba Robert C Byrd Clinic	0	$0	$0	$0
Total (WV State)	**54**	**$133,530,550**	**$13,582,715**	**$147,113,265**

Source: WVBRIM 2022; USACE 2023

There are portions of state roads that are exposed to flood waters should a levee failure occur. Flood waters can undermine or fully submerge roads for a period of time resulting in closures and cutting off critical access to communities. In addition, the flood waters can degrade the integrity of the roads. Sometimes the damage is apparent — a road that washes away, a sinkhole that appears, a bridge that crumbles — but often the damage is less obvious on the surface. Table 5.8-6 shows the length of state roads in areas protected by levees by county. Wood County has the greatest length of state roads (6.11 miles) exposed to the levee failure.

Table 5.8-6. State Roads Exposed to Levee Failure by County

County	Miles of State Road		County	Miles of State Road		County	Miles of State Road
Barbour	0.00		Kanawha	0.00		Preston	0.00
Berkeley	0.00		Lewis	0.00		Putnam	0.00
Boone	0.00		Lincoln	0.00		Raleigh	0.00
Braxton	0.00		Logan	0.00		Randolph	0.24
Brooke	0.00		Marion	0.00		Ritchie	0.00
Cabell	4.15		Marshall	0.00		Roane	0.00
Calhoun	0.00		Mason	1.97		Summers	0.00
Clay	0.00		McDowell	0.00		Taylor	0.00
Doddridge	0.00		Mercer	0.00		Tucker	0.17
Fayette	0.00		Mineral	0.68		Tyler	0.00
Gilmer	0.00		Mingo	0.47		Upshur	0.00
Grant	0.46		Monongalia	0.00		Wayne	0.37
Greenbrier	0.00		Monroe	0.00		Webster	0.00
Hampshire	0.00		Morgan	0.00		Wetzel	0.00
Hancock	0.00		Nicholas	0.00		Wirt	0.00
Hardy	0.81		Ohio	0.00		Wood	6.11
Harrison	0.00		Pendleton	0.00		Wyoming	0.00
Jackson	0.00		Pleasants	0.00			
Jefferson	0.00		Pocahontas	0.00		**TOTAL**	**15.44**

Source: USACE 2023

Critical Facilities and Community Lifelines

It is important to determine the critical facilities and infrastructure within the State that may be at risk to flooding due to a levee failure and that may be impacted should damage occur. Critical services during and after a levee failure event may not be available if facilities are directly damaged or transportation routes to access these critical facilities are impacted. Roads that are blocked or damaged can isolate residents and can prevent access throughout the state to many service providers needing to get to vulnerable populations or to make repairs. Utilities such as overhead power, cable, and phone lines could also be vulnerable because of damage to utility poles by standing water or the surge of water from a levee failure event. Loss of these utilities could create additional isolation issues for the inundated areas.

Table 5.8-7 summarizes the total number of critical facilities by lifeline category located in areas protected by a levee by county. Cabell County has the greatest number of critical facilities (3) within the levee-protected areas, with the majority of the facilities being categorized as Safety and Security lifelines.

Table 5.8-7. Critical Facilities Exposed to Levee Failure by County

County	Communi-cations	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Transport-ation	Total
Barbour	0	0	0	0	0	0	0	0
Berkeley	0	0	0	0	0	0	0	0
Boone	0	0	0	0	0	0	0	0

County	Communi-cations	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Transport-ation	Total
Braxton	0	0	0	0	0	0	0	0
Brooke	0	0	0	0	0	0	0	0
Cabell	0	0	0	0	0	2	1	3
Calhoun	0	0	0	0	0	0	0	0
Clay	0	0	0	0	0	0	0	0
Doddridge	0	0	0	0	0	0	0	0
Fayette	0	0	0	0	0	0	0	0
Gilmer	0	0	0	0	0	0	0	0
Grant	0	0	0	0	0	0	0	0
Greenbrier	0	0	0	0	0	0	0	0
Hampshire	0	0	0	0	0	0	0	0
Hancock	0	0	0	0	0	0	0	0
Hardy	0	0	0	0	0	2	0	2
Harrison	0	0	0	0	0	0	0	0
Jackson	0	0	0	0	0	0	0	0
Jefferson	0	0	0	0	0	0	0	0
Kanawha	0	0	0	0	0	0	0	0
Lewis	0	0	0	0	0	0	0	0
Lincoln	0	0	0	0	0	0	0	0
Logan	0	0	0	0	0	0	0	0
Marion	0	0	0	0	0	0	0	0
Marshall	0	0	0	0	0	0	0	0
Mason	0	0	0	0	0	1	0	1
McDowell	0	0	0	0	0	0	0	0
Mercer	0	0	0	0	0	0	0	0
Mineral	0	0	0	0	0	0	0	0
Mingo	0	0	0	0	0	2	0	2
Monongalia	0	0	0	0	0	0	0	0
Monroe	0	0	0	0	0	0	0	0
Morgan	0	0	0	0	0	0	0	0
Nicholas	0	0	0	0	0	0	0	0
Ohio	0	0	0	0	0	0	0	0
Pendleton	0	0	0	0	0	0	0	0
Pleasants	0	0	0	0	0	0	0	0
Pocahontas	0	0	0	0	0	0	0	0
Preston	0	0	0	0	0	0	0	0
Putnam	0	0	0	0	0	0	0	0
Raleigh	0	0	0	0	0	0	0	0
Randolph	0	0	0	0	0	0	0	0

County	Communi-cations	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Transport-ation	Total
Ritchie	0	0	0	0	0	0	0	0
Roane	0	0	0	0	0	0	0	0
Summers	0	0	0	0	0	0	0	0
Taylor	0	0	0	0	0	0	0	0
Tucker	0	0	0	0	0	0	0	0
Tyler	0	0	0	0	0	0	0	0
Upshur	0	0	0	0	0	0	0	0
Wayne	0	0	0	0	0	0	0	0
Webster	0	0	0	0	0	0	0	0
Wetzel	0	0	0	0	0	0	0	0
Wirt	0	0	0	0	0	0	0	0
Wood	0	0	0	0	0	2	0	2
Wyoming	0	0	0	0	0	0	0	0
Total	**0**	**0**	**0**	**0**	**0**	**9**	**1**	**10**

Source: WVEMD 2022, USACE 2023

POPULATION

Vulnerable populations are all populations in areas protected by levees that are incapable of escaping the area within the allowable time frame. This population includes the elderly, young, and individuals with disabilities, access, or functional needs who may be unable to get themselves out of the inundated areas. The vulnerable population also includes those who would not have adequate warning from the emergency warning system (e.g., television or radio).

Floods created from a levee failure and their aftermath present numerous threats to public health and safety, including exposure to unsafe food, contaminated drinking and washing water, mosquitoes, animals, mold, and mildew. For more detailed descriptions of these and additional threats to public health and safety, refer to Section 5.5 (Flood). The best preparation for these effects includes awareness that they can occur, education of the public on prevention, and planning to deal with them during responses to levee failure events.

The population exposed to the failure of a levee is summarized in Table 5.8-8. The table shows the total number of people exposed to levee failure, the number of people identified as “highly vulnerable” in the Centers for Disease Control and Prevention’s (CDC) Social Vulnerability Index (SVI) data, and the percentage of the exposed people who are considered highly vulnerable. Proportionally, Mingo and Wood Counties are the most vulnerable, with all of their exposed population being considered highly vulnerable. Cabell County has the most people and the most highly vulnerable people exposed to levee failure.

Table 5.8-8. 2020 U.S. Census Population Located in the Levee Failure Inundation Areas by County

Population Located Within the Levee Hazard Area								
County	Total Exposed Population	Highly Vulnerable Exposed Population	% Exposed Population Highly Vulnerable		County	Total Exposed Population	Highly Vulnerable Exposed Population	% Exposed Population Highly Vulnerable
Barbour	0	0	0.00%		Mineral	61	1	0.89%
Berkeley	0	0	0.00%		Mingo	290	290	100.00%
Boone	0	0	0.00%		Monongalia	0	0	0.00%
Braxton	0	0	0.00%		Monroe	0	0	0.00%
Brooke	0	0	0.00%		Morgan	0	0	0.00%
Cabell	19,550	9,124	46.67%		Nicholas	0	0	0.00%
Calhoun	0	0	0.00%		Ohio	0	0	0.00%
Clay	0	0	0.00%		Pendleton	0	0	0.00%
Doddridge	0	0	0.00%		Pleasants	0	0	0.00%
Fayette	0	0	0.00%		Pocahontas	0	0	0.00%
Gilmer	0	0	0.00%		Preston	0	0	0.00%
Grant	70	69	98.52%		Putnam	0	0	0.00%
Greenbrier	0	0	0.00%		Raleigh	0	0	0.00%
Hampshire	0	0	0.00%		Randolph	1,580	1,194	75.55%
Hancock	0	0	0.00%		Ritchie	0	0	0.00%
Hardy	468	0	0.00%		Roane	0	0	0.00%
Harrison	0	0	0.00%		Summers	0	0	0.00%
Jackson	0	0	0.00%		Taylor	0	0	0.00%
Jefferson	0	0	0.00%		Tucker	2	0	0.00%
Kanawha	0	0	0.00%		Tyler	0	0	0.00%
Lewis	0	0	0.00%		Upshur	0	0	0.00%
Lincoln	0	0	0.00%		Wayne	5,769	0	0.00%
Logan	0	0	0.00%		Webster	0	0	0.00%
Marion	0	0	0.00%		Wetzel	0	0	0.00%
Marshall	320	0	0.00%		Wirt	0	0	0.00%
Mason	214	0	0.00%		Wood	513	513	100.00%
McDowell	0	0	0.00%		Wyoming	0	0	0.00%
Mercer	0	0	0.00%					
					Total	**28,839**	**11,192**	**38.81%**

Source: CDC 2022; USACE 2023

Impacts on Socially Vulnerable Populations

The potential impacts to socially vulnerable populations due to a levee failure would be similar to impacts due to flooding, as described in Section 5.5. As described in Section 2, social vulnerability in the State is primarily based on socioeconomic factors, particularly low income. Individuals with lower income will need to own or rent

property with lower property values, which is often in areas at higher risk to flooding. Some of these areas will be in communities or parts of communities that are protected by a levee system.

Future Changes That May Impact State Vulnerability

Understanding factors of change that impact vulnerability in the state can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The State considered the following factors to examine potential conditions that may affect vulnerability to levee failures:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of future hazard conditions.

Potential or Projected Development

Throughout the state, little new development is being conducted in areas that were not already developed. That is, development is occurring to fill in or redevelop areas that are already developed rather than clearing natural land for new structures and infrastructure. As the state's levees protect developed communities, projected development will not significantly impact the state's vulnerability to levee failure.

Projected Changes in Population

As shown in Section 2, the State is experiencing a net loss of population. This could lead to fewer people in areas protected by levees, reducing overall vulnerability of the population to a levee failure. On the other hand, as economic conditions decline in the state, more people may move into areas vulnerable to levee failure to take advantage of lower property values and rent levels. As the population ages, more residents may face challenges quickly evacuating an area in the event of a levee failure.

Other Factors of Change

The nature of winter precipitation influences the likelihood of a levee failure. If more winter precipitation falls as rain rather than snow, winter flows in waterways with development protected by levees could increase, raising the water levels and threatening to overtop levees. Increased flows could also erode earthen banks of the levees, making levee failure more likely.

5.8.3. Consequence Analysis

Impacts to the Public

Impacts to the public due to levee failure are described in the Vulnerability Assessment section above. In addition, impacts will mirror the impacts from flooding, as described in Section 5.5.

Impacts to Responders

Impacts to responders due to levee failure will mirror the impacts from flooding, as described in Section 5.5.

Impacts to Continuity of Operations

Impacts to continuity of operations due to levee failure will mirror the impacts from flooding, as described in Section 5.5.

Impacts to Property, Facilities, and Infrastructure

The impact of levee failure on property, facilities, and infrastructure is described in the Vulnerability Assessment section, above.

Impacts to the Environment

The environmental impacts of a levee failure mirror similar impacts from flooding, as described in Section 5.5.

Impacts to the Economic Condition of the State

Impacts to the state's economic condition due to levee failure will mirror the impacts from flooding, as described in Section 5.5. There would be impacts on the cost of flood insurance for property owners in areas that are shown on flood insurance rate maps (FIRM) as being protected by the levee. Based on recent changes to flood insurance risk rating, these economic impacts can be significant.

Impacts to Public Confidence in State Governance

If the levee failure is determined to be due to inadequate maintenance of the levee system, the public may have less confidence in the state's regulatory environment being able to protect people and property in West Virginia.