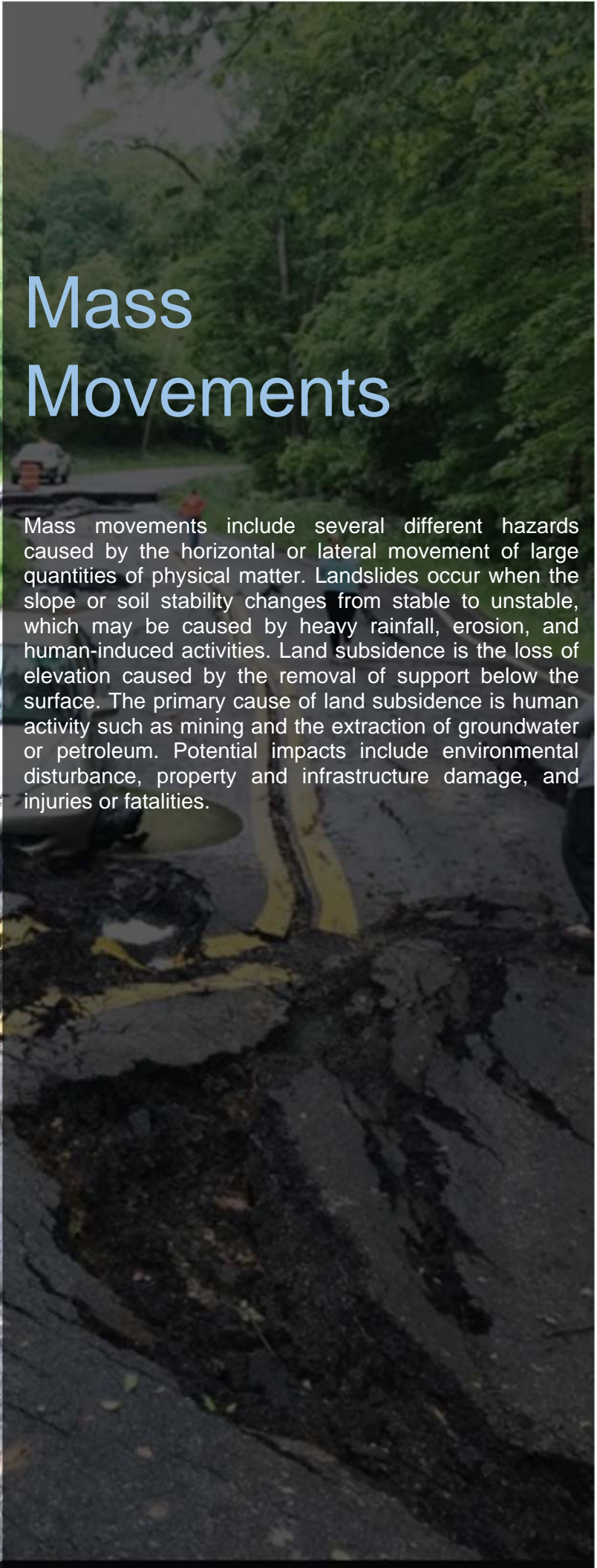




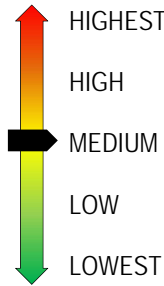
Mass Movements

Mass movements include several different hazards caused by the horizontal or lateral movement of large quantities of physical matter. Landslides occur when the slope or soil stability changes from stable to unstable, which may be caused by heavy rainfall, erosion, and human-induced activities. Land subsidence is the loss of elevation caused by the removal of support below the surface. The primary cause of land subsidence is human activity such as mining and the extraction of groundwater or petroleum. Potential impacts include environmental disturbance, property and infrastructure damage, and injuries or fatalities.



2.0 RISK ASSESSMENT

2.2.8 Mass Movements

"Mass movements include several different hazards caused by the horizontal or lateral movement of large quantities of physical matter" (Haddow, Bullock, & Coppola, 2014, pg.46.)				
Vulnerability 	Period of Occurrence:	At any time. Increased chance following long periods of heavy rain, snowmelt or near construction activity	Hazard Index Ranking:	Medium
	Warning Time:	Ranges from no warning to months	State Risk Ranking:	9
	Probability:	Probable (Likely to occur on an annual basis)	Severity:	Minor (Less than 10% of land area affected)
	Type of Hazard:	Natural	Disaster Declarations:	DR-390 DR-1507 DR-1580 DR-4360 DR-4424

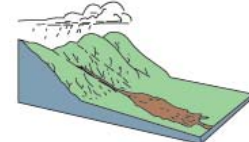
Hazard Introduction and Overview

Mass movements cause damage and loss of life through several processes. Mass movements include pushing, crushing or burying objects in their path and the damming of rivers and waterways (Haddow, Bullock, & Coppola, 2014, pg.46.) There are numerous categories of mass movements: landslides, mudflows, rock falls, land subsidence and expansive soils.

- Landslides:** Landslides occur when areas of relatively dry rock, soil, or debris move uncontrollably down a slope. Landslides may be localized or massive in size and can move at high rates of speed. In Washington County, landslides are most common after a flooding event or significant rainfall.
- Mudflows:** Mudflows are water saturated rivers of earth, rock, and debris. Mudflows develop when water rapidly accumulates in the material, such as during heavy rainfall or rapid snowmelt. Mudflows can develop and move quickly, giving little to no warning.
- Rock falls:** Rock falls occur when rocks or other materials detach from a slope or cliff and descend in a freefall, rolling, or bouncing manner. Rock falls can occur naturally, through faults and seismic activity, or as a product of human activity, such as blasting.



Rotational landslide



Debris flow



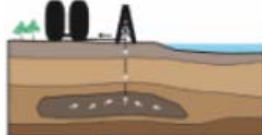


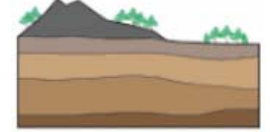




Rockfall



Topple

- Land/Mine Subsidence:** Land subsidence is the loss of elevation caused by the removal of support below the surface. These events can range in size from large regional lowering to severe localized collapses, such as sinkholes. The primary cause of land subsidence is human activity such as mining and the extraction of groundwater or petroleum. Mine subsidence is a geologic hazard that can strike with little or no warning and can result in catastrophic and costly damages.

EFFECTS OF LAND SUBSIDENCE			
Type	Existing Condition	Disturbance	Effect
Oil / Natural Gas Extraction 			
Mining 			

- Expansive Soils:** Expansive soils are soils or soft rocks that will swell or shrink depending on their moisture content. The swelling and shrinking action can cause extensive damage to transportation routes, such as highways and rail line, and structures that are built over these areas.

Washington County Soil Predisposition:

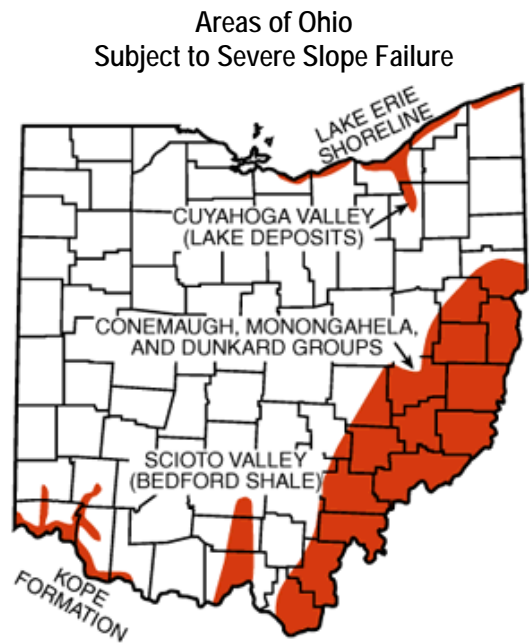
Washington County is located on the unglaciated Allegheny Plateau. From the 1977 United States Department of Agriculture Soil Survey of Washington County, Ohio, soil was broken down into four general soil associations: Upshur-Vandalia, Gilpin-Upshur-Vandalia, Upshur-Gilpin-Lowell, and Elba-Belpre, and three of the four soil types were associated with clayey types of soil. According to the Washington County Soil Survey, the soil composition of Eastern Washington County is comprised mainly of the “red bed” soil Gilpin-Summitville-Upshur Complex. Most importantly the report makes note that accompanying these soil associations are the hazards of landslips, surface erosion and slow or very slow permeability in deep soil layers. Embankment failures are a typical yearly occurrence in Washington County, with the number of embankment failures dependent on a number of weather related factors. The attached Ohio Department of Transportation (ODOT) Landslide Inventory Map created 6/18/19 shows the landslide problem throughout Southeast Ohio. On this map, all of the landslips listed occurred on ODOT roadways. Washington County’s roads are built on the same geology and similar



subsurface conditions as ODOT roads, with all exhibiting failure due to the same weather related factors. According to the ODNR, the most slide-prone rocks in eastern Ohio are red mudstones ("red beds") of Pennsylvanian and Permian age. These rocks tend to lose strength when wet, forming rotational slumps or earth flows. According to the ODNR, about 85 percent of slope failures in Washington County are in "red beds."

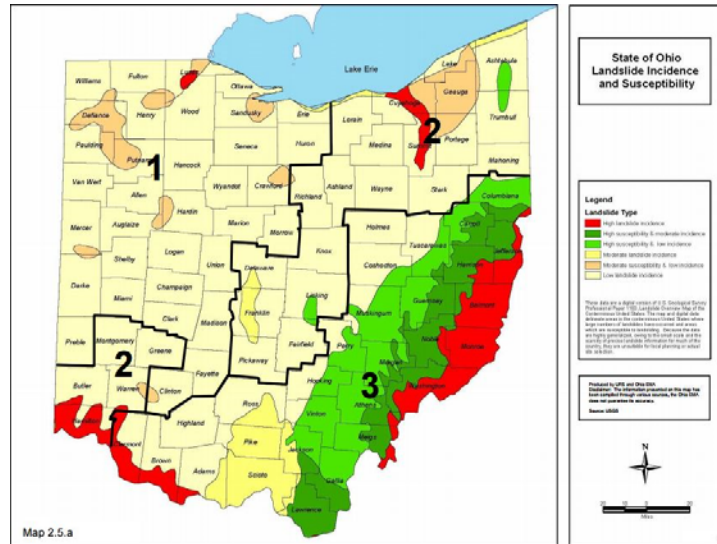
Another condition required for a landslide event, requires the area to contain steep topography; the topography of Washington County ranges from rolling to very steep. The Western and Central parts of Washington County have generally rolling topography with its steep slopes found along the waterways. However, the Eastern portion of the county contains steep and rugged slopes and ridge tops. The majority of these can be found in the areas near and in the Wayne Nation Forest and along the Ohio River. This steep topography makes the region more susceptible to slope failure and thus rotational slump and earth flow landslides. The figure above illustrates (in red) the areas of Ohio subject to severe slope failure. Washington County is also subject to rock falls. Thick, massive sandstones form steep cliffs in many areas of the region and, periodically, large blocks may suddenly fall or tumble downslope.

Although many areas in the county possess one or more of the above conditions (slide prone soil and steep topography), a landslide requires a trigger event to initiate downslope movement. Events or circumstances, either natural or man-made, which commonly trigger landslides in Ohio include vibrations, over-steepened slope, increased weight on a slope, and removal of vegetation.



Location and Extent

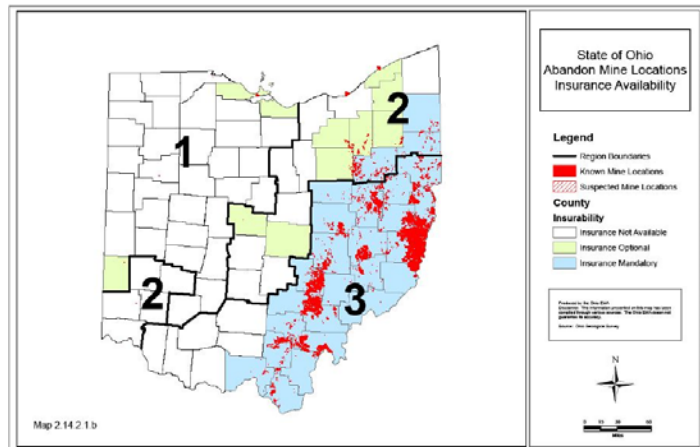
The State of Ohio Hazard Mitigation Plan (HMP) states that large portions of the eastern half of Washington County are areas of high landslide incidence. The western part of the county has a high susceptibility and moderate level of incidence, as illustrated in the image at right, taken from the Ohio HMP.



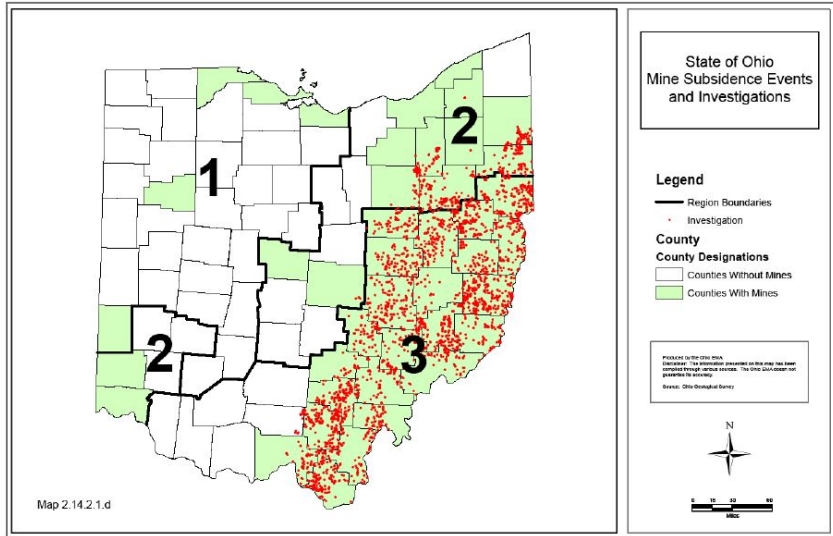
Washington County is also at risk of land subsidence related to

abandoned mines located throughout the region. Beginning in the 1700's and continuing today, there has been considerable coal mining in the Appalachian region of Ohio. According to the land subsidence profile in the statewide Hazard Mitigation Plan (HMP), Washington County is located in the region of the state with multiple known mine locations and insurance is mandatory for land

owners in the county. The image below is the depiction of abandoned mine locations and insurance availability from the statewide plan. The Ohio HMP also shows where mine subsidence events and investigations have occurred, which is shown in the image below. There are an estimated 7,000+ underground mines across Ohio, but only 50% of these are recorded in the Department of Natural Resources' database by 2005 and 2,700 are unmapped (State of Ohio Hazard Mitigation Plan, 2011.)



Washington County has experienced mass movement events on a number of occasions in its history. According to Ohio Department of Transportation (ODOT) records, roads in Washington County have had to be repaired 15 times from landslides/land slips between 2009 and 2015. In total, the road repairs have cost \$9.5 million dollars. Landslides, land slips, and mud



slides have been included in four of the 15 disaster declarations for the county since 1964.

Mine subsidence events will most likely occur with little to no warning, especially if involving an unmapped and unregistered abandoned mine site. The ODNR located abandoned

underground mines in Lawrence Township, near the Fifteenmile Creek and the Little Muskingum River; Aurelius Township, near Duck Creek and the Village of Macksburg; Waterford Township, near the Village of Beverly and the Muskingum River; and Adams Township, near the Big Run Creek.

While the area of the subsidence will most likely be small, damage to roads and structures located within or adjacent to the event can be significant. The potential damage increases as the size of the mine increases. Roadways that are damaged by these types of events will need significant repairs, including the reinforcement of the roadbed. Detours of major travel routes will have significant economic impacts. Detour cost calculations provided by ODOT show that a road closure of 20 days resulting in an 11 minute longer drive time will cost drivers an average of \$1,952.06 per day.

Hazard Impacts

The Ohio Department of Natural Resources (ODNR) recognizes landslides as a significant risk in Washington County. According to the ODNR, Landslides have the capability of damaging or destroying homes, businesses, and highways, resulting in annual costs of millions of dollars in Ohio. Landslide events typically affect residential areas and the roads in the county. After a landslide event the clean-up projects for the County’s roads are prepared by the Engineering Department and contracted out for completion. These projects range in cost from \$10,000 to



\$6,000,000. According to the Washington County Engineer there have been 2 recent Federal Declarations for road failures due to landslides. DR-4360 in 2018 and DR-4424 in 2019 est. \$15 Million.

Mine subsidence can cause foundation damage to buildings, disrupt underground utilities, and be a potential risk to human life. The ODNR Abandoned Underground Mine Locator indicates there are several small abandoned underground mines located within the county; subsequently, Washington County is at risk to instances of mine subsidence.

Historical Occurrences

Grandview Township – 2014

A 500 foot long landslide affected both lanes of Route 7 just north of Matamoras in early 2014. Repairing the roadway cost \$839,433.23.

Fearing & Muskingum Townships – 2014

In mid-2014, a 200 foot long landslide affected the southbound shoulder of Interstate 77 north of Marietta. Repairing the roadway cost \$180,886.60.

Fearing Township – 2015

In early 2015, State Route 821 was realigned to stabilize the route from a number of landslides that had affected it, and to repair damages made by those slides. This project cost \$5,914,365.91.

Loss and Damages

Loss estimates for landslides are limited to the data available, which are road repair costs. On average a road has to be repaired due to a landslide event 2.5 times a year. Each event costs an average of \$633,333. Therefore Washington County can expect \$1,583,333 in road repair costs annually. The Ohio HMP estimates that Washington County will see \$725,271 in structural losses based on landslide incidence and susceptibility. Vulnerable structure estimates for this hazard are based on the estimation from the Ohio Hazard Mitigation Plan that Washington County is vulnerable to \$725,271.00 in structural loss annually. This figure was broken down into loss estimates for the three categories using the Ohio EMA's HAZUS-MH loss estimation workbook. The loss estimate for each structural category was then divided by the average structure value found in the loss estimation workbook. The table below is the result of these calculations.



MASS MOVEMENTS EXPOSURE ESTIMATE – MIP DATA ENTRY		
<i>Structure Type</i>	<i>Number</i>	<i>Loss Estimate</i>
Residential	4	\$515,667.68
Non-Residential	1	\$171,889.23
Critical Facilities	1	\$37,714.09
TOTALS	6	\$751,271.00

Source: Ohio EMA HAZUS-MH Loss Estimate Workbook Calculation

Using the geocoded state owned and state leased critical facilities listing provided by the Ohio Department of Administrative Services (DAS), and the Landslide Incidence and Susceptibility map created and maintained by USGS, Ohio EMA GIS staff performed a buffer, which joined the two data sets and produced a new data set. This new data set allowed for the quantification of risk to state owned and state leased critical facilities based upon their physical location within each county.

The results were weighted based upon the number of critical facilities in each county that were located within areas of high incidence (having more than 15 % chance of landslide). There are counties who had a larger overall number of critical facilities located within areas that fell within the a category noted on the landslide incidence and susceptibility map, but were not considered to be at the same risk level as those counties with critical facilities located within high incidence areas.

Ohio Region 3 has by far the highest number of counties with critical facilities, which could sustain potential losses from landslides, totaling 715 critical facilities. Region 3 had twenty-eight counties with the potential of loss and nine counties with critical facilities within an area of high incidence.



OHIO REGION 3 – QUANTIFICATION OF RISK TO STATE OWNED/LEASED CRITICAL FACILITIES				
<i>County</i>	<i>Total Exposed Critical</i>	<i>Total Replacement Value</i>	<i># of Critical Facilities in HIA¹</i>	<i>% of Critical Facilities in HIA</i>
Washington	56	\$29,149,164	37	66.1%
Belmont	62	\$54,856,808	34	54.8%
Jefferson	37	\$7,592,901	23	62.2%
Clermont	23	\$3,710,528	23	100%
Monroe	19	\$6,522,681	19	100%
Harrison	30	\$9,054,441	16	53.3%
Brown	7	\$29,882,234	7	100%
Meigs	19	\$8,547,106	2	10.5%
Columbiana	37	\$13,835,662	1	2.7%
Scioto	55	\$171,351,723	0	0.0%
Noble	31	\$50,299,353	0	0.0%
Athens	31	\$45,496,640	0	0.0%
Guernsey	54	\$39,704,477	0	0.0%
Gallia	71	\$35,860,837	0	0.0%
Ross	19	\$19,248,265	0	0.0%
Jackson	18	\$15,130,501	0	0.0%
Lawrence	27	\$11,760,373	0	0.0%
Muskingum	17	\$9,232,685	0	0.0%
Vinton	20	\$5,854,782	0	0.0%
Morgan	10	\$3,950,084	0	0.0%
Pike	10	\$3,878,547	0	0.0%
Carroll	17	\$3,661,999	0	0.0%
Tuscarawas	17	\$2,921,475	0	0.0%
Ashtabula	12	\$1,889,649	0	0.0%
Hocking	2	\$1,373,320	0	0.0%
Trumbull	8	\$1,052,544	0	0.0%
Perry	5	\$979,866	0	0.0%
Adams	1	\$545,334	0	0.0%
Total	715	\$587,343,979	162	

Source: Ohio Hazard Mitigation Plan, 2019

¹ High Incidence Area (HIA)

As illustrated in the table above, Washington County had the third highest number of exposed state owned/leased critical facilities when compared to the other 27 counties in Region 3. Washington County had the eighth highest replacement value, and the highest number of state owned or leased critical facilities located in High Incidence Areas (HIAs).



Vulnerability Assessment

Washington County conducted an online survey for the public to share its thoughts on hazard vulnerabilities. The following table presents the results of that survey regarding mass movements.

PUBLIC SENTIMENT, MASS MOVEMENTS – WASHINGTON COUNTY					
Hazard	Level of Concern				Total Responses
	Not at All	Somewhat	Concerned	Very	
Mass Movements	7 (19.44%)	13 (36.11%)	12 (33.33%)	4 (11.11%)	36
In the past ten years, do you remember this hazard occurring in your community?				17 (47.22%)	36
Have you noticed an increase in the occurrences or intensity of this hazard?				13 (36.11%)	36
Have you noticed a decrease in the occurrences or intensity of this hazard?				1 (2.78%)	36

Source: Online Public Survey Results

The following table assigns point totals based on the research presented in this profile for each category that appears in Ohio EMA’s Mitigation Information Portal (MIP) tool.

MASS MOVEMENTS VULNERABILITY SUMMARY			
Category	Points	Description	Notes
Frequency	4	High	The State of Ohio Hazard Mitigation Plan (HMP) states that large portions of the eastern half of Washington County are areas of high landslide incidence. Landslides, land slips, and mud slides have been included in four of the 15 disaster declarations for the county since 1964.
Response	3	One week	Most landslides and/or rock falls take a minimum of 1 week to clean-up and repair.
Onset	5	N/A	Some landslides, rock falls, and mudslides can occur with no warning at all.
Magnitude	1	Localized (< 10% of land area affected)	All mass movement events are site specific in natures, and do not affect vast areas.
Business	2	One Week	Businesses located in the affected area of a large-scale mass movement event would be impacted for a minimum of one week.
Human	1	Minimum (minor injuries)	Historically mass movements have only resulted in property damage. The greatest chance of personal injury would be motorists getting struck by falling debris.
Property	1	Less than 10% of property affected	All mass movement events are site specific in natures, and do not affect vast areas.
Total	17	Medium	

