State of West Virginia
Hazard Mitigation Grant Program Application

West Virginia Division of Homeland Security
& Emergency Management (WV DHSEM)

PROJECT NARRATIVE

Applicant Name: **West Virginia University Research Corporation, on behalf of West Virginia University and its WV Geographic Information Systems Technical Center (WVGISTC)**

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FIPS Code: **54 – West Virginia**

Communities Covered by This Application: **Statewide (55 counties and 232 communities)**

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PROJECT ABSTRACT SUMMARY

Overview: Site-specific risk assessments focused on flood and landslide hazards will be conducted for all 55 counties and 232 incorporated communities in West Virginia to supplement local and state hazard mitigation plans. The State Hazard Mitigation Officer refers to these studies for assessing and mitigating risks to communities in West Virginia as the Total Exposure in Floodplain (TEIF) and Total Exposure in Landslides (TEIL). This statewide approach to multi-hazard risk assessments at the building or structure level for every community in the State and for a geographic area over 24,000 square miles may constitute one of the largest risk assessment studies ever undertaken in the Nation.

Mitigation Actions: This project will implement priority statewide mitigation actions specified in the 2010 and 2013 State Hazard Mitigation Plan Updates (Appendix G) to include: (1) develop a standardized, comprehensive building exposure inventory that includes critical facilities and state-owned properties; (2) create a statewide parcel file for hazard identification and risk assessments; (3) standardize the data analysis process so that future local and state plan updates are consistent and utilize comparable methodologies; (4) conduct a statewide Hazus Level 2 flood risk analysis with more accurate local building inventories (user-defined facilities), effective DFIRM floodplains, and high-resolution elevation data; and (5) build a statewide landslide incident database for improving landslide susceptibility assessments. Standardized risk assessments for flood and landslide hazards will be made available to integrate into local and state hazard mitigation plan updates. The project team will coordinate with the USACE and other partners on supplementing hazard mitigation plans with dam/levee failure risk assessments.

3 Major Work Tasks: Because this project is quite large in scope, it is subdivided into three major work tasks: flood risk assessments, landslide risk assessments, and data development focused on building inventories and reference layers that are necessary for achieving quality hazard risk assessments at the structure level. Where possible the work tasks will be automated to improve efficiencies and reduce costs. In-house personnel will be assigned to specific work tasks according to their expertise and experience, while professional services and mapping contractors are required for certain aspects of the project.

Flood Risk Assessments: Structure-specific flood risk assessments to determine economic and social losses for 287 jurisdictions will be conducted for a riverine 1% annual chance flood event and with a Hazus Level 2 analysis. The Hazus flood loss models will use the best available building inventory and flood water depth to estimate physical building damage and content loss at the structure level, while computing debris removal and shelter requirements for people displaced at the aggregate level or from the general building stock. Building exposure values and loss estimates will be calculated using the same methodology for each local mitigation plan and therefore will allow for comparative studies of flood loss estimates among jurisdictions. Flood risk loss data, tables, and maps will be summarized at the community level and integrated into regional and state hazard mitigation plans. Pilot flood risk studies were completed for Berkeley and Morgan Counties with the preliminary building-specific risk data

viewable on the WV Flood Tool. The USACE has provided a Letter of Support for this project and is the lead agency in providing dam/levee risk assessments for communities.

3D Flood Visualizations: 3D flood visualizations allow non-technical users to better understand flood risks to their property in feet of water rather than comprehending the adjacent base flood elevation. Consequently, where flood water depths exist the WV Flood Tool will display 3D flood visualizations at the individual building and neighborhood viewing scales. Individual Sketchup building models are pre-drawn with the appropriate flood visualization picture displayed according to the parcel building attributes (building use, stories, exterior type, etc.) and water depth value. The public not only can visualize the flood height for a specific structure but also link to interactive depth-damage tools for measuring the cost of damage. The second type of flood visualization occurs at the neighborhood scale for select communities. It requires extruding building footprints to known story heights and then symbolizing the sugar-cube or photo-textured 3D buildings according to the amount of physical damage. In addition, the project team will pursue innovative research applicable to the project and tap into the expertise of Dr. Trevor Harris, an Eberly Distinguished Professor of Geography at West Virginia University with research interests in 3D modeling, geovisualization, and exploratory spatial data analysis. All flood risk data and flood visualizations shall be shared with the local communities and published on federal and state geo-platforms such as the Risk MAP View of the WV Flood Tool (www.mapwv.gov/Flood).

Landslide Risk Assessments: County-level resolution landslide hazard risk assessments will be completed for all 55 counties and validated with a statewide inventory of known landslides. A more detailed and accurate landslide susceptibility model for West Virginia will be developed to include regional variations in geology, soils, and terrain. The scientific team for developing the landslide susceptibility model will include Dr. J. Steven Kite, an Associate Professor at West Virginia University Associate and a skilled geomorphologist who has conducted research on the many aspects of landslides. An interactive web map application named the WV Landslide Tool (www.mapwv.gov/Landslide) will allow public access to the landslide incident inventory and landslide susceptibility maps. To demonstrate a more detailed landslide susceptibility map and quantitative risk analysis of buildings exposed to landslide hazards, a county-level scale pilot study was completed for Berkeley County. County-level resolution landslide hazard risk assessment maps and reports similar to the preliminary Berkeley County landslide study will be incorporated into the local and state hazard mitigation plans.

Data Development for Quality Risk Assessments: The first major data development activity includes creating a structure-level inventory of buildings and facilities in West Virginia exposed to multi-hazards. Although the primary focus of the project is to create more detailed flood and landslide risk assessments, the statewide building inventory can be valuable for other natural or man-made disasters to include dam or levee failures. The second principal data development activity involves the filling in the critical GIS reference layer data gaps that are preventing West Virginia from achieving detailed hazard identification and quality risk assessments: parcels, addresses, lidar, leaf-off imagery, and building-specific datasets.

Building Inventories: An important aspect of risk assessment studies involves creating inventories of all buildings and facilities exposed to multi-hazards in the State. Building replacement costs for an estimated 1.1 million structures will be computed from 1.5 million parcel centroids and tax assessment attributes. Replacement costs for tax-exempt properties such as educational, religious, and governmental buildings may have to be calculated from other national and state databases (e.g., Infogroup's ReferenceUSA, WV Board of Risk) to generate a comprehensive structure-specific inventory of total building assets for West Virginia. A Building Inventory Tool funded by FEMA and developed by the Polis Center for pilot risk assessment studies in West Virginia will serve as a foundation for streamlining the building inventory process. All structures within effective and advisory floodplains shall be further pinpointed to the building footprint for more detailed flood risk analysis using the best available depth grids.

GIS Reference Layers: A repository of high-quality reference data layers will result in more accurate risk assessments for communities. Consequently, the development of GIS data is necessary to fulfill the above requirements of county and state hazard risk assessments and products. Specifically, this project will focus on data gaps that are preventing West Virginia from achieving detailed hazard identification and risk assessments: parcels, addresses, lidar, leaf-off imagery, and building specific datasets. First, a complete and current statewide parcel layer is necessary to generate replacement values and 3D flood visualizations for individual buildings. Second, a complete statewide addressing and mapping file is required for pinpointing and identifying flood-risk structures in the flood hazard zones. Addresses are valuable for validating physical addresses in assessment databases and for identifying multiple structures within a property. A statewide addressing file is also important in that postal addresses of critical facilities and buildings can be geocoded to geographic coordinates for spatial analysis. Third, the acquisition of lidar data can generate high-resolution elevation surfaces which can result in more accurate floodplain boundary delineations and depth grids. Purchasing lidar should be a consideration for flood-risk communities which have a large number of structures in flood hazard areas exist and where high-resolution topography would result in better flood risk products. Fourth, the acquisition of new leaf-of imagery of 6-inch resolution or better should be considered for counties where properly identifying at-risk properties is essential. Since forests cover 78% of the State, leaf-off imagery without the forest canopy is required for identifying at-risk structures. Fifth, establishment level business data should be acquired if critical data gaps exist in the building inventory for computing replacement costs. A steering committee composed of members of the WV Division of Homeland Security and Emergency Management will assist in determining the data gaps and priorities. If there are no data restrictions then all digital data acquired from this project will reside in the public domain.

BACKGROUND

This proposed HMGP project has been in the scoping and development stages for almost three years, with the project concept initiated by Cynthia McCoy when she was a Risk Analyst for FEMA Region III. Almost all the concepts of this proposal have been tested through pilot studies.

Table 1. Events associated with proposal development

2014	Project concept initiated by Cynthia McCoy, FEMA Region III Risk Analyst
2015	West Virginia selected by FEMA to fund Building Inventory Tool for hazard assessments
2015	The Polis Center at IUPUI Completes Project Workflow for Hazus-MH Model Building Inventory for West Virginia
2016	WV GIS Technical Center (WVGISTC) completes flood and landslide risk assessments for pilot counties
2016	State Hazard Mitigation Office accepts preliminary proposals by WVGISTC for performing flood and landslide risk assessments for both local and state hazard mitigation plan updates for West Virginia
2016	WVGISTC presents to National Capitol Region HAZUS User Group (NCRHUG) about West Virginia's statewide approach to multi-hazard risk studies
2017	WVGISTC provides a preliminary proposal to State Hazard Mitigation Officer regarding the development of GIS data necessary to fulfill the requirements of county and state hazard risk assessments and products
2017	WVGISTC processes nearly 1.5 million property records for Tax Year 2017 which included previously missing building specific data for commercial and industrial properties. This statewide building exposure data is published on the WV Flood Tool.
2017	WVGISTC publishes preliminary flood risk assessment data and 3D flood visualizations on the WV Flood Tool (www.mapwvw.gov/flood) and creates a precursor of the WV Landslide Inventory Tool (www.mapwv.gov/landslide)
2017	Project Submission

FLOOD RISK ASSESSMENT– SCOPE OF WORK

Principal Contacts: (WV GIS Technical Center , West Virginia University):

- Mr. Kurt Donaldson, principal investigator
- Mr. Eric Hopkins, co-investigator and task leader
- Dr. Maneesh Sharma, co-investigator
- Dr. Trevor Harris, co-investigator

Purpose: Create site-specific flood risk studies for 287 jurisdictions to supplement local and state hazard mitigation plans.

Unit of Work: The primary unit of work for flood risk assessments shall be the 55 counties unincorporated and 232 municipalities. The use of standardized methodologies for all jurisdictions allows for the risk assessments completed at the local level to be vertically aggregated into regional and state level flood studies.

Pilot Studies: Site-specific flood risk assessments were completed for Berkeley and Morgan Counties to exhibit flood risk deliverables and products. For demonstration purposes, the building-specific loss estimates for flood risk structures in these two counties were published to the RiskMAP View of the WV Flood Tool.

- Berkeley County Flood Risk Assessment: http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/Berkeley_FloodRiskRpt_20161031.pdf

- Morgan County Flood Risk Assessment: http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/Morgan_FloodRiskRpt_20161031.pdf

Scope of Work: Structure-specific flood risk assessments to determine economic and social losses for 287 jurisdictions will be conducted for a riverine 1% annual chance flood event and with a Hazus Level 2 analysis. The Hazus flood loss models will use the best available building inventory and flood water depth to estimate physical building damage and content loss at the structure level, while computing debris removal and shelter requirements for people displaced at the aggregate level or from the general building stock. Building exposure values and loss estimates will be calculated using the same methodology for each local mitigation plan and therefore will allow for comparative studies of flood loss estimates among jurisdictions.
A statewide geodatabase of site-specific flood risk structures (called “User-Defined Facilities”, or UDFs, in Hazus) located in the Effective/Advisory Floodplains will be created for flood loss models. Flood risk loss data, tables, and maps will be summarized at the community level and integrated into regional and state hazard mitigation plans. Pilot flood risk studies were completed for Berkeley and Morgan Counties with the preliminary building-specific risk data viewable on the WV Flood Tool. In addition, 3D flood risk visualizations will be created for flood-risk structures at both the individual building and neighborhood community viewing scales. Lastly, the USACE has provided a Letter of Support for this project and is the lead agency in providing dam/levee failure flood inundation assessments for communities.

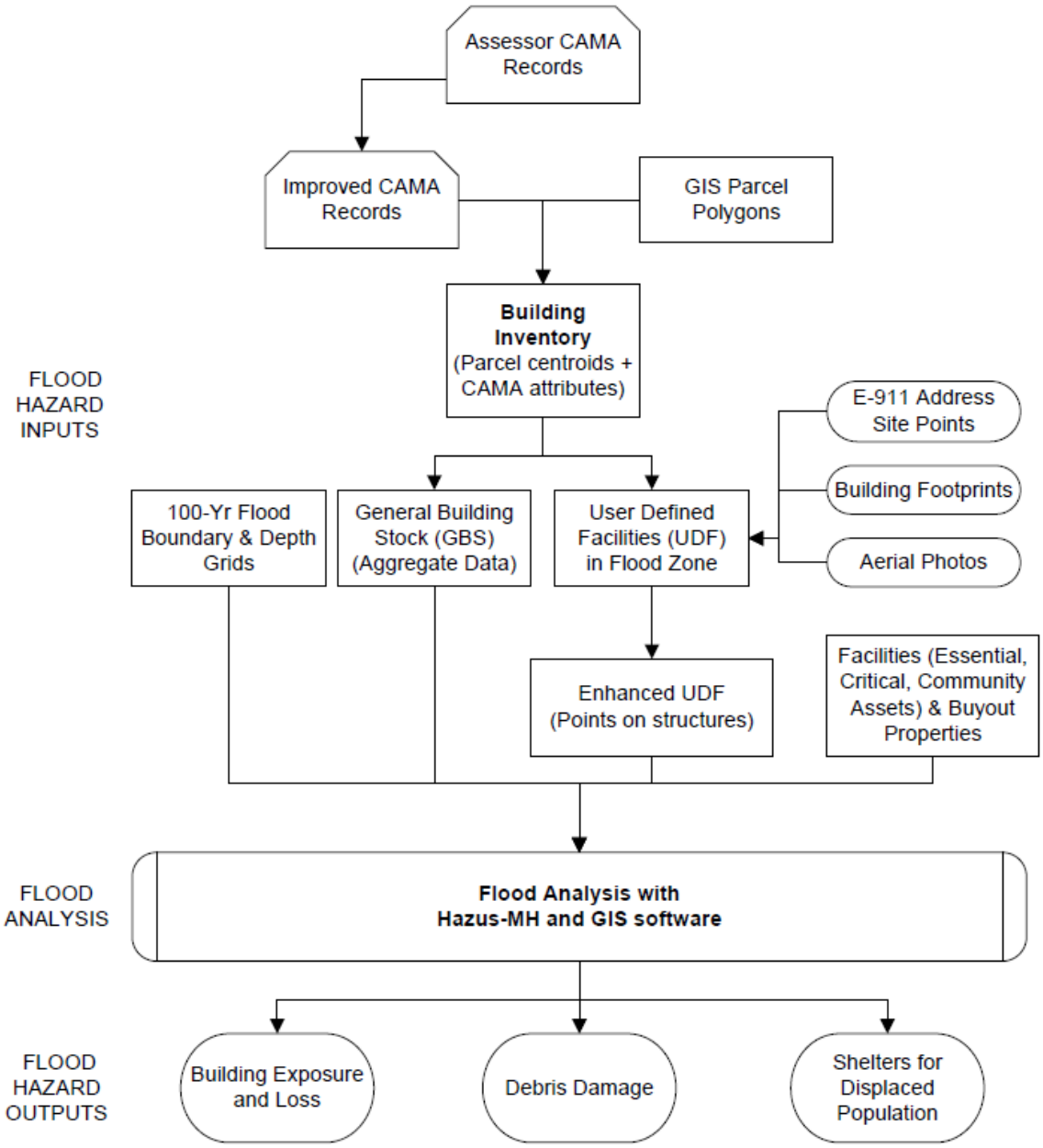
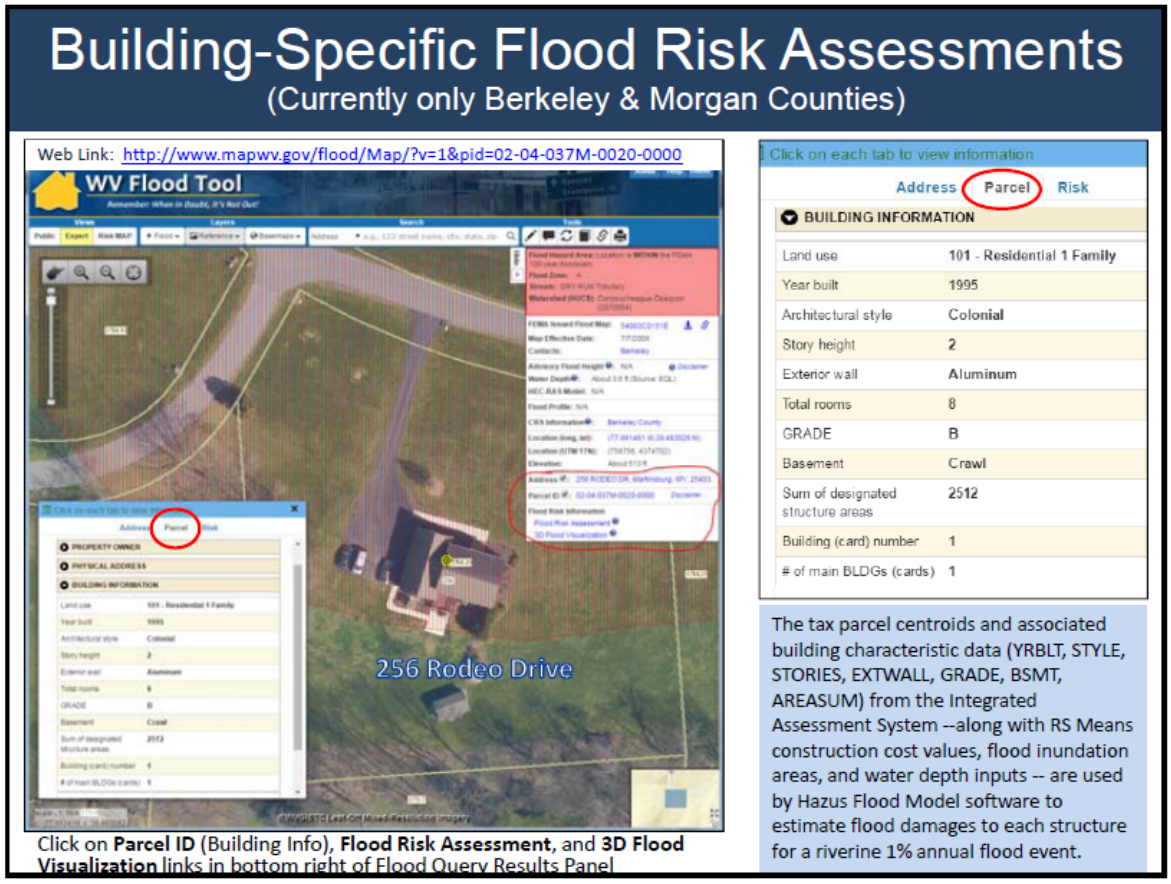


Figure 1. Workflow Diagram for Flood Risk Assessments



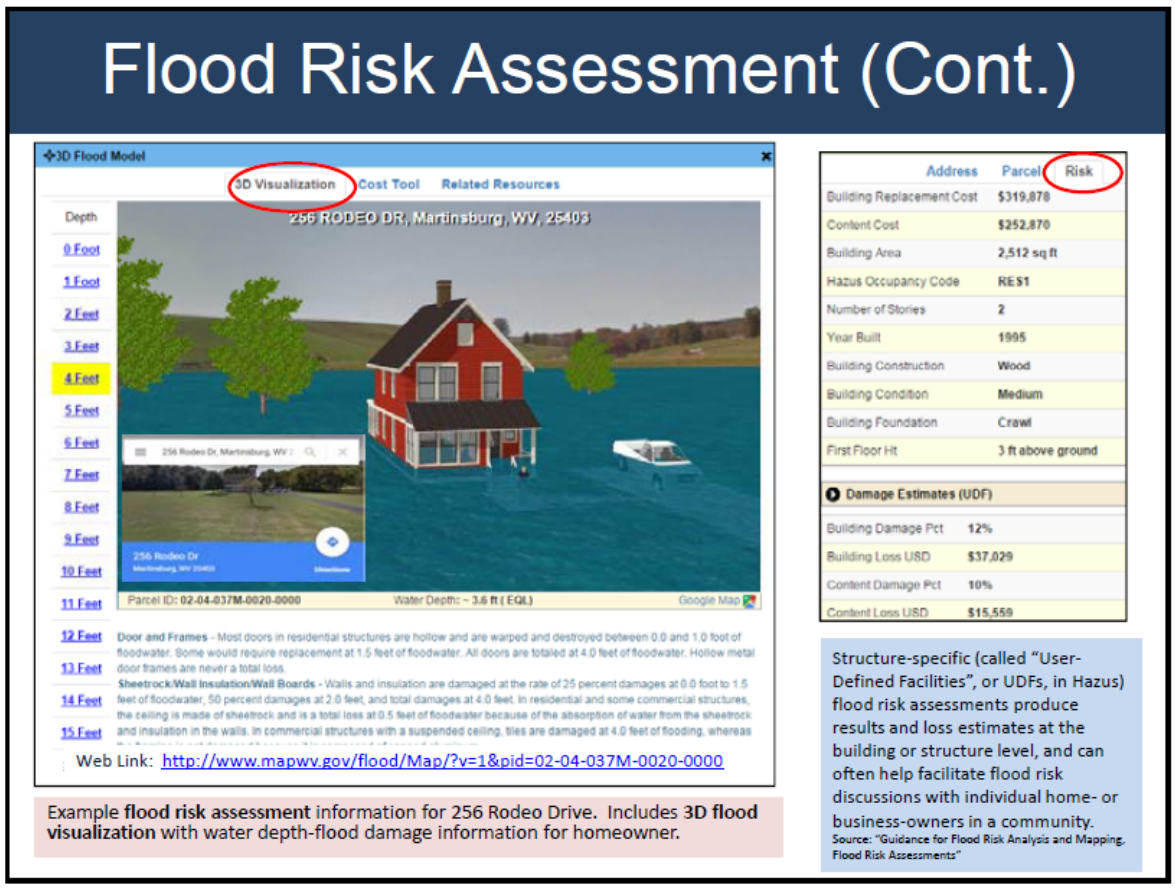
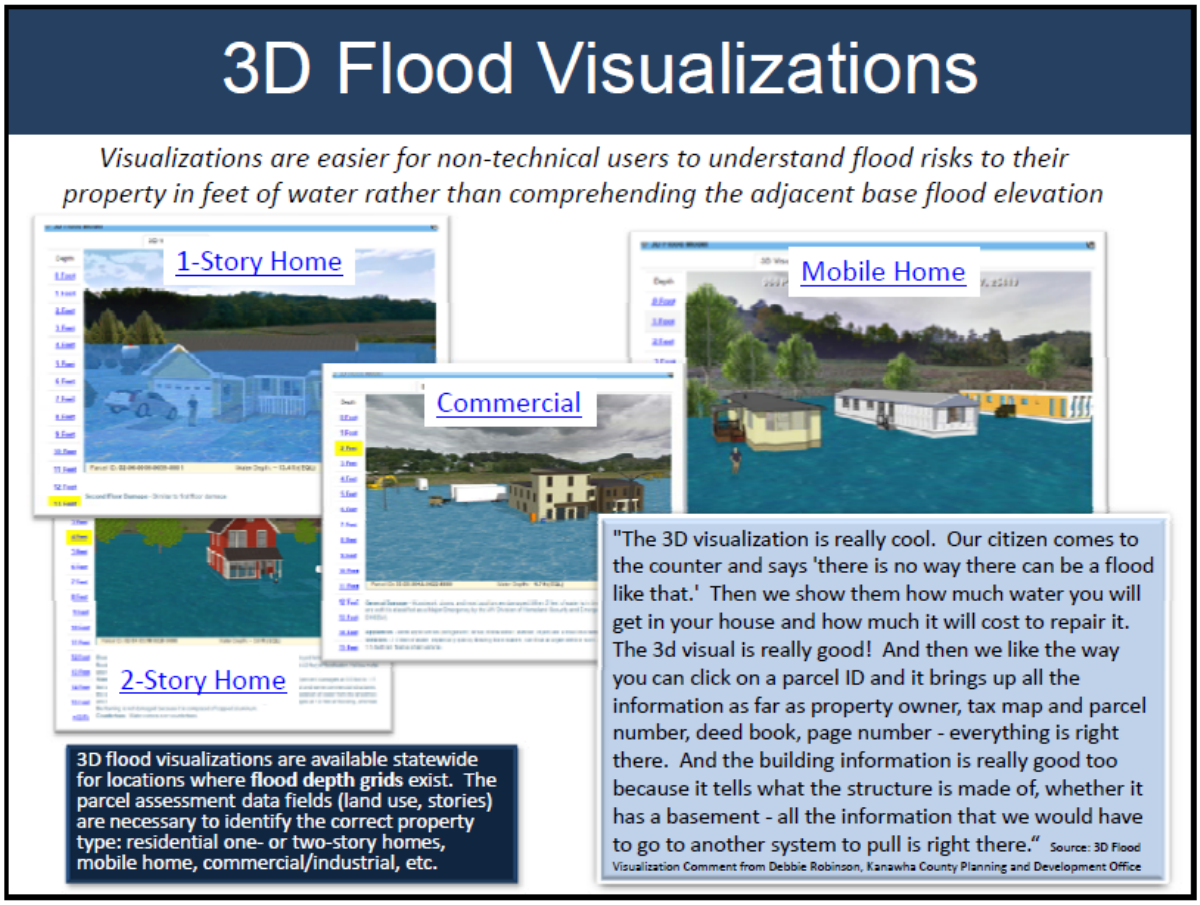


Figure 2. Building-specific flood risk assessments published on WV Flood Tool. More info: http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/WV_Flood_Tool_upgrades 20170716.pdf



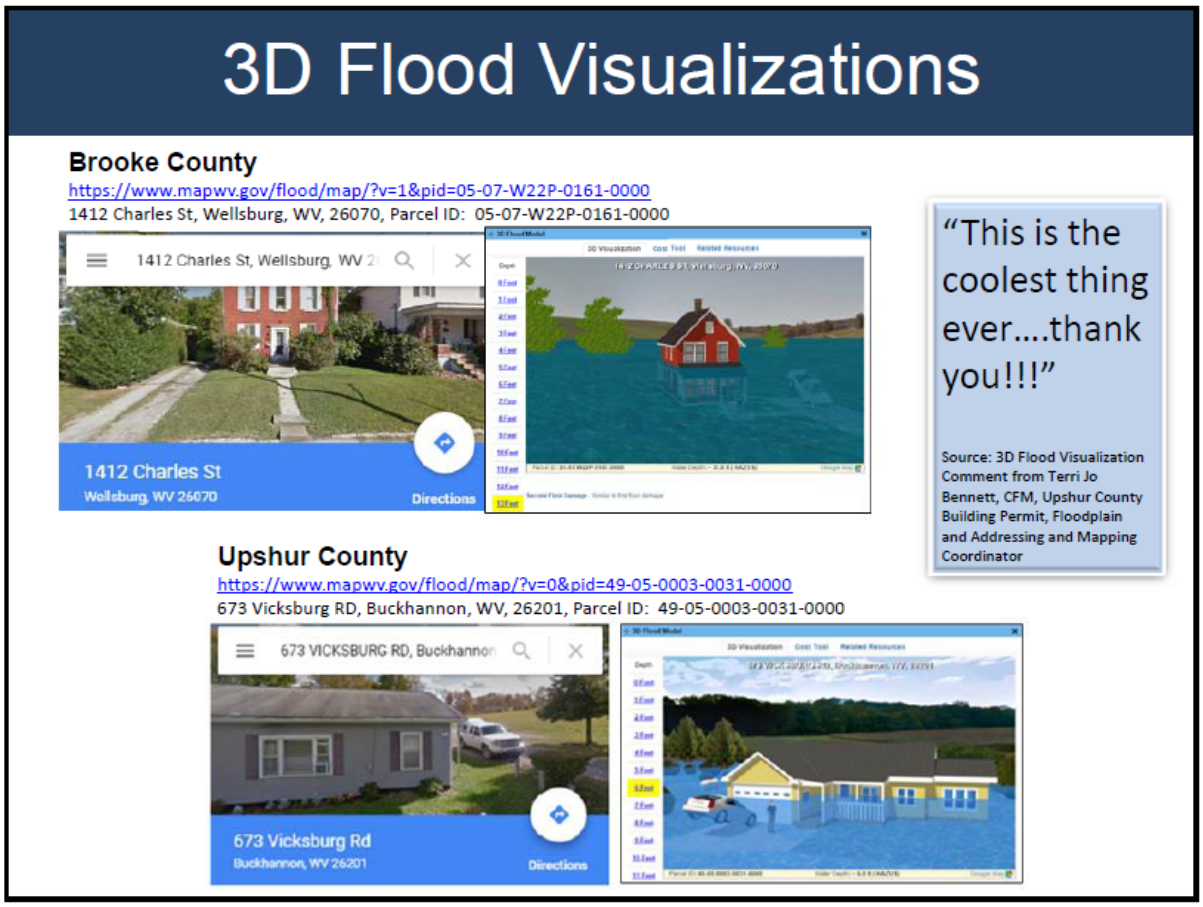


Figure 3. 3D building flood visualizations viewable in WV Flood Tool. More info: http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/WV_Flood_Tool_upgrades 20170716.pdf

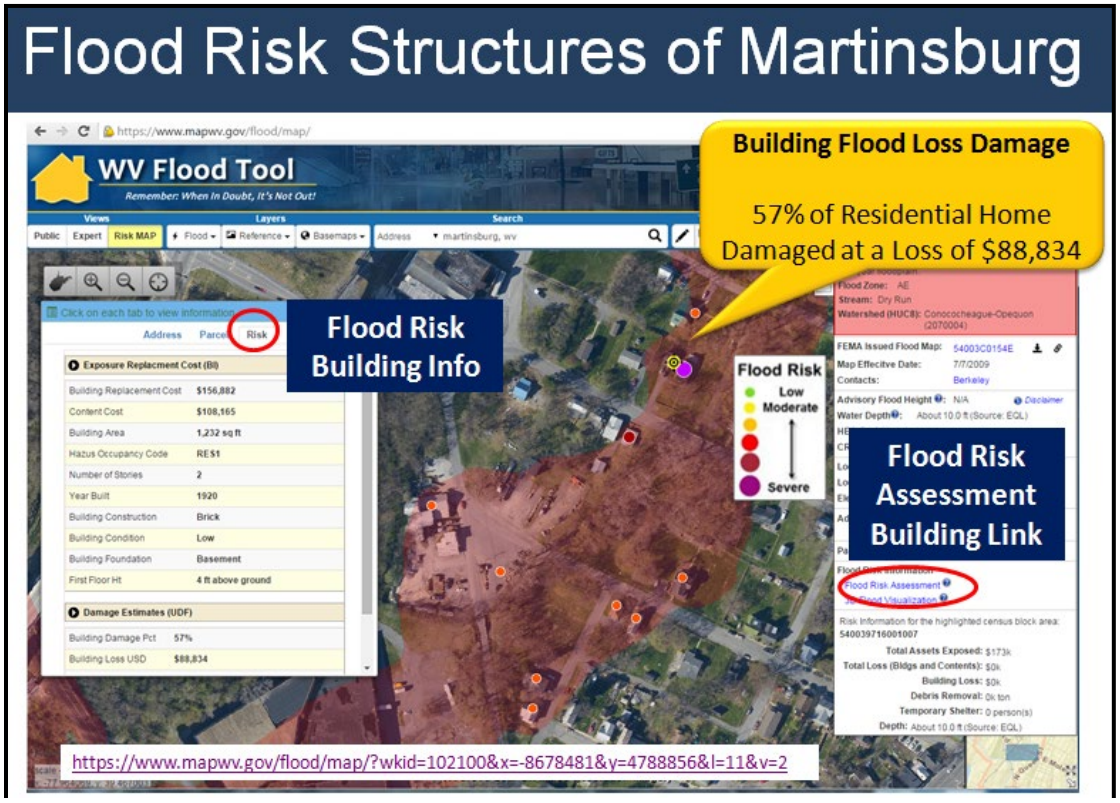


Figure 4. The Risk MAP View of the WV Flood Tool allows for viewing "User-Defined Facility" flood loss estimates at the building or structure level for a 1%-annual-chance flood event. Web link: https://www.mapwv.gov/flood/map/?wkid=102100&x=-8678481&y=4788856&l=11&v=2

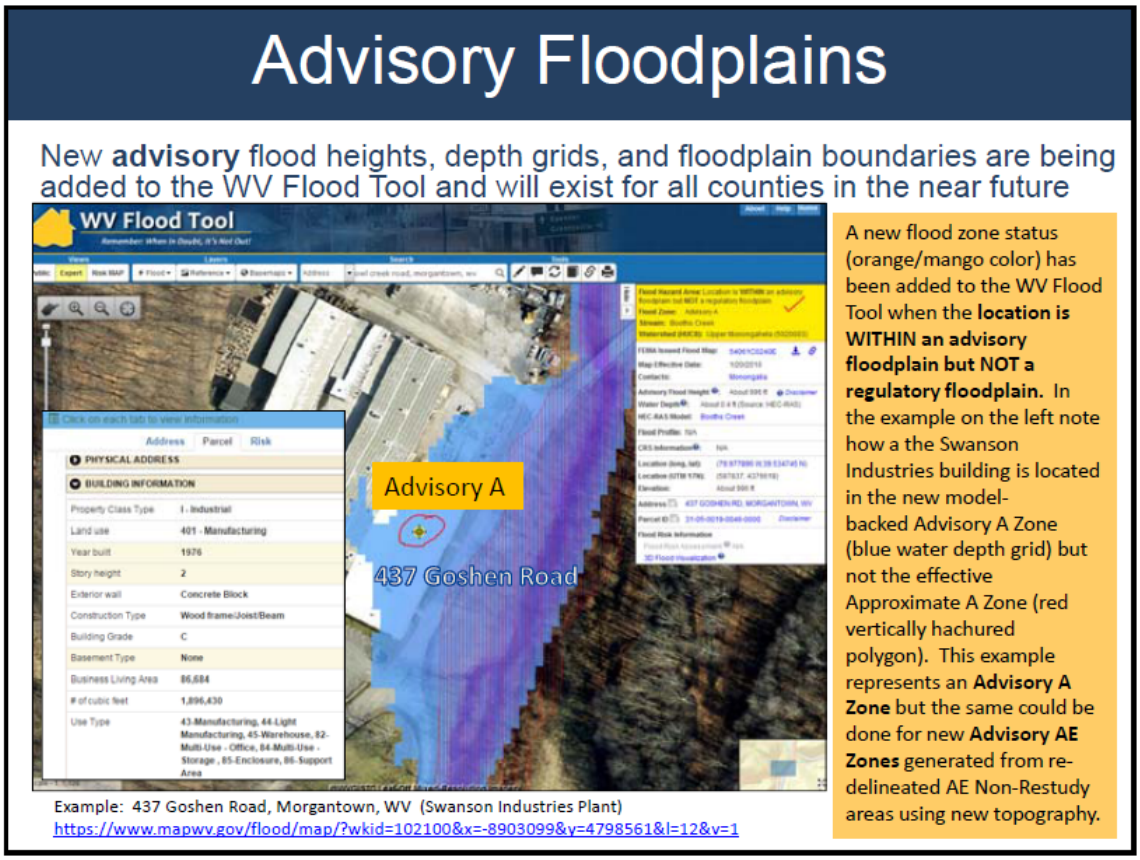


Figure 5. Model-backed Advisory A Zone flood heights and depth grids exist for 27 West Virginia counties, with the remainder 28 counties to be completed in several years.

Work Tasks:

1) *Flood Risk Assessments for 322 Jurisdictions.* Site-specific flood risk assessments for 55 counties and 232 incorporated communities to supplement Local and State Hazard Mitigation Plans.

2) *Statewide Geodatabase of Site-Specific Flood Risk Structures.* Create a statewide geodatabase of site-specific flood risk structures (called "User-Defined Facilities", or UDFs, in Hazus) located in the Effective/Advisory Floodplains.

3) *3D flood risk visualizations* for every individual at-risk structure and select communities.

4) *Assemble statewide composite flood risk products* to include a statewide advisory floodplain from Advisory A and Advisory AE flood zones, statewide flood depth and water surface elevation grids.

5) *Update State Hazard Mitigation Plan.* Integrate county flood assessment data and reports into state hazard mitigation plan. A standardized data analysis process will ensure that future local and state plan updates are consistent and utilize comparable methodologies.

6) *Publish flood risk data and products* on state (www.MapWV.gov/flood) and FEMA's federal geo-platforms according to required specifications. Flood risk deliverables for every county include Flood Risk Assessment Report, maps, and GIS data.

Table 2. Work Tasks Descriptions for Flood Risk Assessments

Task	Work Task Description	Goals
Site-Specific Flood Risk Assessments	**TASK 1: [Site-specific flood risk assessments]** Complete Hazus Level 2 flood risk assessments for 55 counties and 232 incorporated communities to supplement Local and State Hazard Mitigation Plans] The flood risk assessments for the 287 study areas are calculated for a riverine 1% annual chance flood event with Hazus flood loss models using as inputs the flood inundation area and composite of the best available depth grids. • Conduct Hazus Level 2 flood loss analysis using the best available building inventory and water depth grids to estimate physical building damage and content losses at the structure level. Execute Hazus models for flood debris and flood shelter requirements. Summarize inventory and loss data at the community level, stream name, flood zone, etc. • See Appendix B for more detailed procedures for creating flood risk assessments • Prototype Flood Risk Supplemental Reports: ○ Berkeley County (October 2016) http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/Berkeley_FloodRiskRpt_20161031.pdf	Goal F1

Task	Work Task Description	Goals
	○ Morgan County (October 2016) http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/Morgan_FloodRiskRpt_20161031.pdf • Obtain best available data from county and state sources • Coordinate meetings with state, regional, and county hazard planners and GIS data stewards regarding risk assessments.	
Statewide Geodatabase of Site-Specific Flood Risk Structures	**TASK 2: [Statewide Geodatabase of Site-Specific Flood Risk Structures]** Create a statewide geodatabase of site-specific flood risk structures (called "User-Defined Facilities", or UDFs, in Hazus) located in the Effective/Advisory Floodplains attributed with building exposure and flood loss values. • Spatially pinpoint Building Inventory parcel centroids to the building centroids using the best available data: E-911 addresses, building footprints, aerial imagery, and other reference data. Use manual or semi-automated methods to execute this task. • Attributes to include: ○ Building exposure values and flood loss values ○ Building specific information (year built, square footage, construction type, stories, etc.) ○ Property classification and property/building address information. • Add missing structures not captured in parcel database.	Goal F2
3D Flood Risk Visualizations	**TASK 3: [3D flood risk visualizations]** 3D visualizations for every individual flood-risk structure and neighborhood scale flood visualizations for select communities. • Create 3D flood visualizations for every flood-risk structure in 100-year floodplain. Data requirements: ○ Building specific data (building use, exterior wall, number of stories) ○ Flood Layers: Flood Hazard Area, Depth Grid, WSEL Grid ○ Sketchup Building Models • Generate 3D flood neighborhood visualizations for select communities. Data requirements: ○ Building specific data (building use, exterior wall, number of stories) ○ Flood Layers: Flood Hazard Area, Depth Grid, WSEL Grid ○ Building footprints to generate sugar-cube or photo-textured 3D buildings	Goal F3
Statewide Composite Flood Risk Products	**TASK 4: [Assemble statewide composite flood risk products]** Composite flood risk products include a statewide advisory floodplain from Advisory A and Advisory AE flood zones, statewide flood depth and water surface elevation grids. The target cell resolution for the composite flood risk grids is 5 feet.	Goal F4
Update State Hazard Mitigation Plan.	**TASK 5: [Update State Hazard Mitigation Plan]** Integrate county flood assessment data and reports into state hazard mitigation plan. A standardized data analysis process will ensure that future local and state plan updates are consistent and utilize comparable methodologies.	Goal F5
Publish Flood Risk Data and Products	**TASK 6: [Publish flood risk data and products]** Publish flood risk data and products on state (www.MapWV.gov/flood) and FEMA's federal geo-platforms according to required specifications. Flood risk deliverables for every county include Flood Risk Assessment reports, maps, and GIS data.	Goal F6

Task	Work Task Description	Goals

	• Reports
	  ○ Publish risk data in county reports to WV Flood Tool
	  ○ Integrate county flood risk studies into regional and state hazard mitigation plan updates.
	• Maps
	  ○ Building Exposure
	  ○ Physical damage map of buildings and facilities (large size)
	  ○ Debris map
	  ○ Population Displacement / Shelter map
	  ○ Select 3D maps (if building footprints available)
	  ○ Miscellaneous maps
	• GIS Data
	  ○ Building Inventory replacement costs
	  ○ User Defined Facilities loss estimates
	  ○ GIS parcel polygons
	  ○ E-911 Addressable Structures
	  ○ Essential Facilities
	  ○ Critical Facilities
	  ○ Community Assets
	  ○ Mitigated Properties
	  ○ Hazuus-MH .hpr files (available on request)	

System Admin Tasks for Flood Risk Assessments	**TASK 7: [PROVIDE SYSTEM ADMINISTRATION SERVICES] Maintain application and web map services for Flood Risk Assessments work task** • Project Management, Specifications, Standards, Contract Scope of Work, Data Integration, Quality Assurance, Progress Reports. • Perform system administration and maintenance of applications. Technical support services include hardware and software operating system upgrades. Maintain backup system with virtual servers. Maintain a high level of performance of application including the processing of troubleshooting calls regarding system issues. Update monthly security patches on all servers. Install and maintain all necessary hardware and software licenses. • Publish and maintain all local web map services that support flood risk assessments work task.	

Table 3. Timeline for Flood Risk Assessments

Year / Tasks	**Year 1**	**Year 2**	**Year 3**
TASK 1: [Site-specific flood risk assessments]	9 counties	22 counties	22 counties
TASK 2: [Statewide geodatabase of site-specific flood risk structures]			
TASK 3: [3D flood risk visualizations]			
TASK 4: [Assemble statewide composite flood risk products]			
TASK 5: [Update State Hazard Mitigation Plan]			

TASK 6: [Publish flood risk data and products]			

LANDSLIDE RISK ASSESSMENT – SCOPE OF WORK

Principal Contacts: (West Virginia University):

- Mr. Kurt Donaldson, principal investigator
- Dr. Maneesh Sharma, co-investigator and task leader
- Dr. Steven Kite, co-investigator

Purpose: To create 55 county-scale landslide risk assessments to supplement local and state hazard mitigation plans.

Pilot Study: A pilot landslide risk assessment was created for Berkeley County. The assessment included a county-scale landslide susceptibility map and building exposure statistics.

- Berkeley County Landslide Risk Assessment: http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/Landslide_Susceptibility_Pilot_Study_BerkleyCounty_20160408.pdf

Background: The present West Virginia Statewide hazard mitigation plan provides statewide guidance to reduce loss and prevent injury from natural and man-made hazards. The landslide risks addressed in the 2013 West Virginia Statewide hazard mitigation plan are mainly based on USGS work on "Landslide overview map of Conterminous United States" (Radbruch-Hall et.al., 1982). The study delineates areas of reported landslides and areas which are susceptible to landslide. The focus of the USGS study was to identify areas of landslide risk at the regional level (digitized polygons from the study are at a scale of 1:3,750,000). In this study, most of the West Virginia is displayed as a high-risk area. However, this generalized delineation of potential landslide areas does not help in hazard mitigation planning on local and county scales. For better land-use planning, there is a strong need to develop a better methodology that can show more granularity in landslide hazard identification at the sub-county level, and help identify the slopes that are most susceptible to landslide at a higher resolution.

This project will develop the methodology and update landslide risk and hazard assessment at county scale. Landslides may be controlled by the topography (inclination and shape of the slope), the

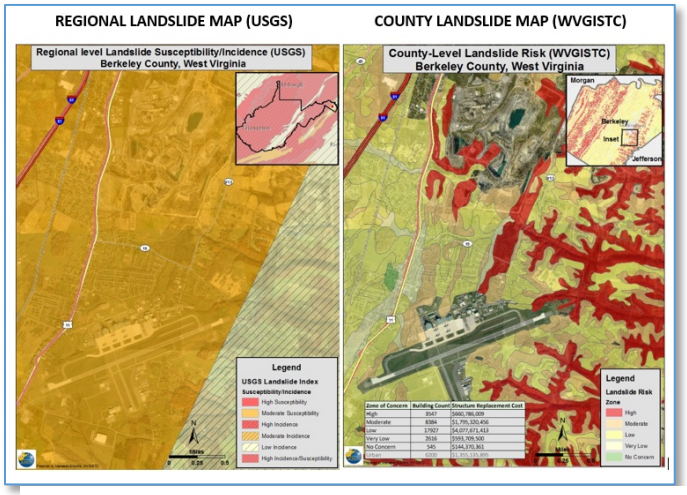


Figure 6. Landslide susceptibility map showing generalized USGS map and detailed WVGISTC map

lithology (physical and geomechanical characteristics), the geological structure (dip, fault, discontinuity), the hillslope hydrology (pore pressures, water contents) or a combination of all these factors. Apart from this, they are also controlled by triggering factors such as static or dynamic load, change in land use, rainfall, etc. Different areas in West Virginia have different geomorphology, geology and land use pattern. We have created a prototype county-level landslide susceptibility report for Berkley county. Figure 6 shows the difference in Landslide susceptibility between USGS and WVGISTC maps

Scope of Work: County-level resolution landslide hazard risk assessments will be completed for all 55 counties and validated with a statewide inventory of known landslides. A more detailed and accurate landslide susceptibility model for West Virginia will be developed to include regional variations in geology, soils, and terrain. The scientific team for developing the landslide susceptibility model will include Dr. J. Steven Kite, an Associate Professor at West Virginia University and a skilled geomorphologist who has conducted research on the many aspects of landslides. An interactive web map application named the WV Landslide Tool (www.mapwv.gov/Landslide) will allow public access to the landslide incident inventory and landslide susceptibility maps. To demonstrate a more detailed landslide susceptibility map and quantitative risk analysis of buildings exposed to landslide hazards, a county-level scale pilot study was completed for Berkeley County. County-level resolution landslide hazard risk assessment maps and reports similar to the preliminary Berkeley County landslide study will be incorporated into the local and state hazard mitigation plans.

Methodology: We propose to research heuristic and statistical methods for landslide susceptibility and hazard analysis for counties in West Virginia. Previous studies by Professor Kite in Horse Shoe Run Watershed, Lower New River George and by the West Virginia Geological and Economic Survey will help us in refining our methodology. In addition, the research will investigate how regional geological, soil, and terrain variations affect the landslide risk assessment models. Lastly, the building assets exposed to landslide hazards will be included in the landslide assessments. See Appendix D for a detailed explanation by Dr. Maneesh Sharma of the proposed methodology and literature review.

Work Tasks:

1) A *statewide landslide incident inventory* from various sources: WVGES, WVDOT, USGS, FEMA landslide buy-out properties, etc.

2) A more detailed and accurate *landslide susceptibility model* for West Virginia which includes regional variations in geology, soils, and terrain.

3) *55 county-level resolution landslide susceptibility maps and reports* to supplement local hazard mitigation plans.

4) *A Landslide Tool* (www.mapwv.gov/landslides), an interactive web map application that provides online access to landslide incidents and landslide susceptibility zones.

5) *Update State Hazard Mitigation Plan* with current and landslide hazard identification and risk assessment.

Table 4. Work Task Descriptions for Landslide Risk Assessments

Task	Work Task Description	Cost
Landslide Inventory	**TASK 1: [LANDSLIDE INVENTORY] – Data Collection** • Digitize historical landslide records. Digitize historical landslide data in ESRI feature class format. WVGISTC already houses geo-referenced landslide maps from Landslide study done in 1976 by State Geological Survey. Maps can be found at http://wvgis.wvu.edu/data/dataset.php?ID=277 • Inventory and collect existing landslide data from various agencies (WVGES, WV DOT, WV DHSEM, USGS, etc.). Publish landslide incidences to an online interactive inventory (www.mapwv.gov/landslide). • Outreach and coordinate with city engineers, planners, emergency responders, etc. for local knowledge about landslides • Employ high-resolution imagery and lidar for verification of known landslides.	Goal L1
Landslide Method Development	**TASK 2: [LANDSLIDE METHOD DEVELOPMENT] – Methodology and validation of landslide susceptibility models** • *Literature review.* Conduct a literature review to identify different landslide methodologies • *Research methodology to assess landslide risk.* Research various landslide methodologies for different geological regions of West Virginia. Determine the appropriate methodology for specific sub-regions within the state • *Validation.* Validate the different landslide methods with the inventory of existing landslide incidences • *Consultations.* Consult on the methodology development and validation of landslide models with landslide experts to include the State Geological Survey, WV DOT, and other stakeholders. The lead landslide expert is Professor Steve Kite, a geomorphologist in the Department of Geology and Geography at WVU.	Goal L2
County level landslide map and report generation	**TASK 3: [COUNTY LEVEL LANDSLIDE MAP AND REPORT GENERATION] – Generation of landslide County maps** • Create programming scripts to automate the generation of county landslide risk maps • Tweak and re-run models based on local feedback • Review , validate, and publish county-scale landslide risk hazard maps. For all 55 counties a landslide maps will be created. • Compute building exposure values by landslide susceptibility zones	Goal L3
Web Application	**TASK 4: [WEB APPLICATION] – Interactive web application of landslide incidents and susceptibility zones**	Goal L4

Task	Work Task Description	Cost
	• Create an interactive web application for viewing known landslide incidence and susceptibility in West Virginia (www.mapwv.gov/landslide) • Users will be able to query information from these model layers	
Update State Hazard Mitigation Plan	**TASK 5: [UPDATE STATE PLAN] – Update State Hazard mitigation plan** • Write description of landslide section for State hazard mitigation master plan that includes regional geomorphological and geological variations in West Virginia. • Create a statewide landslide hazard map • Create digital print-ready landslide risk maps on topographic or imagery base layer • Summarize building exposure values according to landslide susceptibility zones for counties and municipalities	Goal L5
System Admin for Landslide Assessments Work Task	**TASK 6: [PROVIDE SYSTEM ADMINISTRATION SERVICES] – Maintain application and web map services for Landslide Risk Assessments work task** • Project Management, Specifications, Standards, Contract Scope of Work, Data Integration, Quality Assurance, Progress Reports. • Perform system administration and maintenance of applications. Technical support services include hardware and software operating system upgrades. Maintain backup system with virtual servers. Maintain a high level of performance of application including the processing of troubleshooting calls regarding system issues. Update monthly security patches on all servers. Install and maintain all necessary hardware and software licenses. • Publish and maintain all local web map services that support WV Landslide Inventory web application	

Table 5. Timeline for Landslide Risk Assessments

Year / Tasks	**Year 1**	**Year 2**	**Year 3**
TASK 1: [Landslide Inventory]			
TASK 2: [Landslide Method Development]			
TASK 3: [County Level Landslide Map Generation]		25 counties	30 counties
TASK 4: [Web Application]			
TASK 5: [Update State Plan]			
TASK 6: [Provide System Administration Services**] =**			

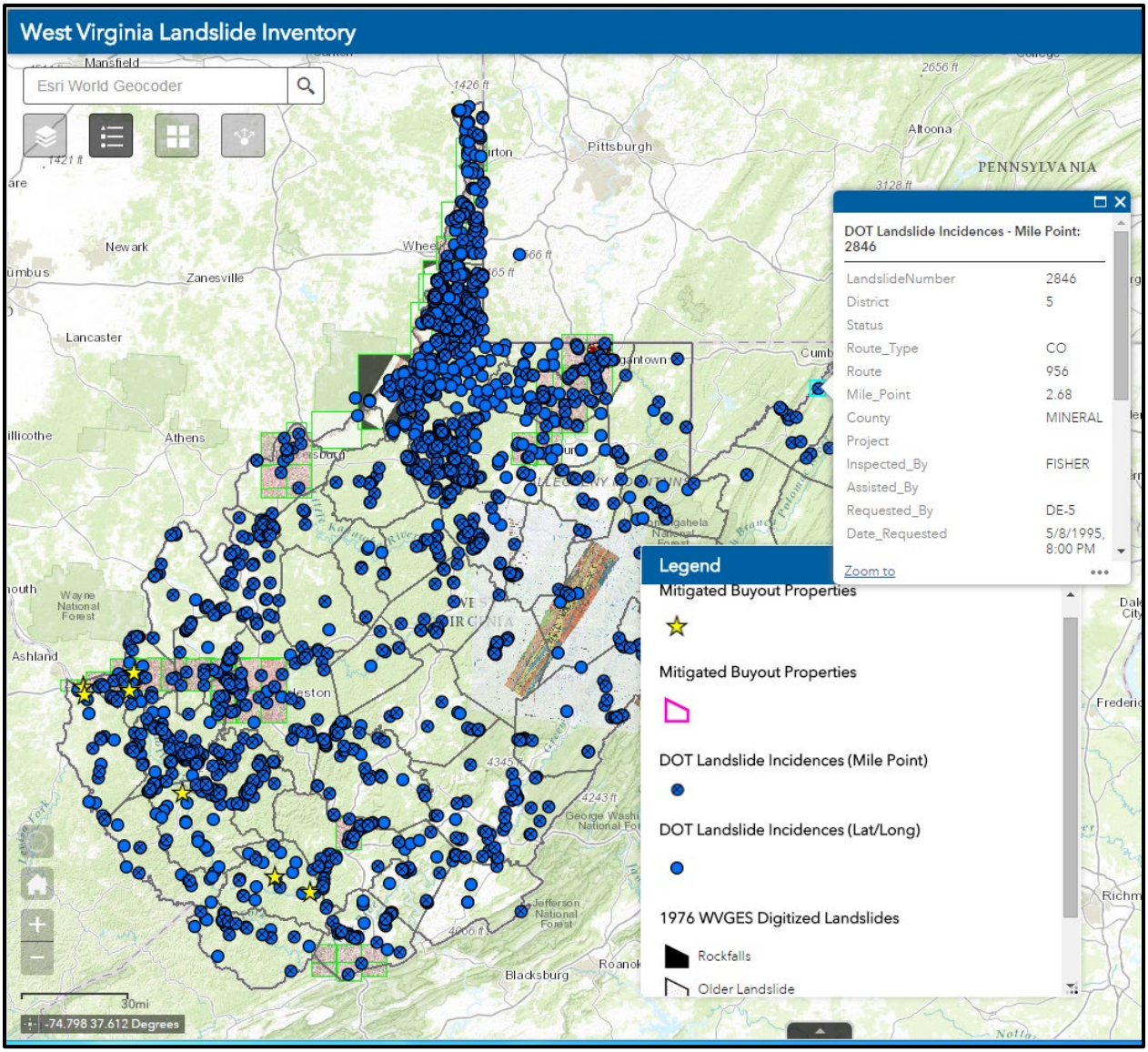


Figure 7. Prototype web application for viewing landslide incidence and susceptibility in West Virginia (www.mapwv.gov/landslide)

GIS DATA DEVELOPMENT – SCOPE OF WORK

Principal Contacts:

- Mr. Kurt Donaldson, principal investigator
- Mr. Kevin Kuhn, co-investigator and task leader
- Mr. Frank LaFone, co-investigator

Purpose: To develop building inventory and GIS reference data necessary to fulfill the requirements of county and state hazard risk assessments and products.

Scope of Work: The scope of work is subdivided into developing (1) *building inventories* with replacement or resell values and (2) *reference data* to include parcels, addresses, lidar, imagery, and building-specific data.

Building Inventories: An important aspect of risk assessment studies involves creating inventories of all buildings and facilities exposed to multi-hazards in the State. Building replacement costs for an estimated 1.1 million structures will be computed from 1.5 million parcel centroids and tax assessment attributes. Replacement costs for tax-exempt properties such as educational, religious, and governmental buildings may have to be calculated from other national and state databases (e.g., Infogroup ReferenceUSA, WV Board of Risk) to generate a comprehensive structure-specific inventory of total building assets for West Virginia. A Building Inventory Tool funded by FEMA and developed by the Polis Center for pilot risk assessment studies in West Virginia will serve as a foundation for streamlining the building inventory process. All structures within effective and advisory floodplains shall be further pinpointed to the building footprint for more detailed flood risk analysis using the best available depth grids.

GIS Reference Layers: A repository of high-quality reference data layers will result in more accurate risk assessments for communities. Consequently, the development of GIS data is necessary to fulfill the above requirements of county and state hazard risk assessments and products. Specifically, this project will focus on data gaps that are preventing West Virginia from achieving detailed hazard identification and risk assessments: parcels, addresses, lidar, leaf-off imagery, and building specific datasets. First, a complete and current statewide parcel layer is necessary to generate replacement values and 3D flood visualizations for individual buildings. Second, a complete statewide addressing and mapping file is required for pinpointing and identifying flood-risk structures in the flood hazard zones. Addresses are valuable for validating physical addresses in assessment databases and for identifying multiple structures within a property. A statewide addressing file is also important in that postal addresses of critical facilities and buildings can be geocoded to geographic coordinates for spatial analysis. Third, the acquisition of lidar data can generate high-resolution elevation surfaces which can result in more accurate floodplain boundary delineations and depth grids. Purchasing lidar should be a consideration for flood-risk communities which have a large

number of structures in flood hazard areas exist and where high-resolution topography would result in better flood risk products. Fourth, the acquisition of new leaf-off imagery of 6-inch resolution or better should be considered for counties where properly identifying at-risk properties is essential. Since forests cover 78% of the State, leaf-off imagery without the forest canopy is required for identifying at-risk structures. Fifth, establishment level business data should be acquired if critical data gaps exist in the building inventory for computing replacement costs. West Virginia University has an account with the Infogroup company's Reference USA database that allows search access to about 800,000 business (n=78,030), healthcare (n=6,433), and white page (n=780,169) addresses in West Virginia. However, the current WVU user account is limited to 250 record downloads per search. To assist in determining the data gaps and priorities listed above, a pro tem committee composed of members of the WV Division of Homeland Security and Emergency Management will be formed. If there are no data restrictions then all digital data acquired from this project will reside in the public domain.

Work Tasks:

1) Create a *structure-level inventory* of all buildings and facilities in West Virginia exposed to multi-hazards.

2) Fill in the *GIS data gaps* that are preventing West Virginia from achieving detailed hazard identification and quality risk assessments: parcels, addresses, lidar, leaf-off imagery, and building specific datasets.

3) Report *data gaps* at the county level for key geodatabase reference layers (parcels, addresses/geocoding, imagery, elevation, building footprints, critical infrastructure, etc.) that are hindering quality risk assessments.

4) Exchange the *best available risk assessment information* among local, state, and federal geo-platforms.

Table 6. Work Task Descriptions for Data Development

Task	Work Task Description	Goal
Create Statewide Building Inventory	**TASK 1: [Statewide Building Inventory] –** Create a *structure-level inventory* of all buildings and facilities exposed to multi-hazards. The inventory includes each building's replacement or resell value and allows for site-specific risk analysis. A *Building Inventory Tool* will streamline the process of identifying buildings assets exposed to multi-hazards and for executing Hazus flood loss models at the building or structure level. The Building Inventory Tool requires further refinements like updating the building construction tables for commercial/industrial properties and including building information from non-assessment sources. In addition, the Building Inventory Tool should be upgraded to the most current Hazus 4.0 full versioned software release. • Develop a standardized, comprehensive building exposure inventory that includes critical facilities and state-owned properties. • Building exposure values will be computed from building specific information or acquired from other sources like appraisal and insurance databases. These replacement values are used by loss estimation models, such as Hazus, to derive building and content loss values. • Taxable properties are organized by occupancy or land use categories: Residential, Agricultural, Commercial, Industrial, Government, Education, and Religion. Information for tax-exempt properties are collected from national and state databases (e.g., Infogroup ReferenceUSA, WV Board of Risk) to generate a comprehensive structure-specific inventory of total building assets for West Virginia. • All critical facilities and individual structures located in the Regulatory/Advisory floodplains are spatially adjusted to the building centroid and not the parcel centroid. If available, building footprints are used to further enhance the process of building identification. • Data sources for developing and validating the building replacements costs and building location: property parcels and assessor attributes, E-911 addresses, leaf-off imagery, and building footprints. Supplemental sources for non-taxable structures include school and insurance databases. • Update State Hazard Mitigation Plan with detailed building exposure information	Goal D1
Fill in Critical GIS Data Gaps for Quality Risk Assessments	• **TASK 2: [Fill in GIS Data Gaps**] – Fill in the GIS data gaps that are preventing West Virginia from achieving detailed hazard identification and quality risk assessments: parcels, addresses, lidar, leaf-off imagery, and building specific datasets. • A continuously maintained statewide digital parcel boundary file with building-specific attributes for determining building exposure costs (Priority 1). ○ A *statewide digital parcel boundary file* by mapping missing or obsolete parcels for 12 counties (Priority 1a).	Goal D2

Task	Work Task Description	Goal
	○ All 55 county assessors have *digital tax maps statewide* by funding select counties with paper-to-digital conversion. This objective assists counties still producing tax maps manually in migrating to a sustained digital maintenance program so that the capital investment of the paper-to-digital parcel boundary conversion – or the primary objective of a current statewide parcel boundary file -- is not lost over time. A cost share may be required by select counties (Priority 1b). ○ The parcels and addresses are the most critical data layers for achieving quality hazard risk assessments. Creation of a statewide parcel file is a high priority mitigation action (# 2013-16) of the 2013 WV State Hazard Mitigation Plan. It is estimated 33 of the 606 tax districts (5%) in West Virginia have not been digitized or have obsolete/erroneous digital parcels. • A *statewide address and mapping file* by mapping missing or incorrect addresses for 3 counties (Priority 2). • Acquire *lidar elevation data* to construct water surface elevation and depth grids (Priority 3) for select flood hazard areas. • Collect *leaf-off imagery* for an estimated 3,000 square miles in West Virginia. Targeted areas are based on repeated disaster declarations, cost-share, benefits to other data collection projects, etc. (Priority 4). • Acquire *business level data* from vendors if critical data gaps exist in the building inventory for computing replacement costs. (Priority 5). WVU has an account with the Infogroup company's Reference USA database that allows search access to 8000,000 business (n=78,030), healthcare (n=6,433), and white page (n=780,169) addresses in West Virginia. However, the current WVU user account is limited to 250 record downloads per search.	
Report Data Gaps to Stakeholders	**TASK 3: [Report Data Gaps**] – Report data gaps at the county level for key geodatabase reference layers (parcels, addresses/geocoding, imagery, elevation, building footprints, critical infrastructure, etc.) that are hindering quality risk assessment studies. Provide recommendations to the appropriate organizations to improve data management and governance.	Goal D3
Exchange Risk Assessment Information	**TASK 4: [Exchange Risk Assessment Information**] – Exchange the best available risk assessment information among local, state, and federal geo-platforms. • Incorporate historical hazard data into risk assessment studies. • Use online map validation tools such as ArcGIS online viewer applications for local communities and floodplain managers to validate risk assessment data. • Assist State Hazard Mitigation Office in updating Local HMGP applications so that hazard data collections and analysis are consistent and utilize comparable methodologies for both local and state plan updates. Serve as Data Clearinghouse for Statewide Hazard Data	Goal D4

Task	Work Task Description	Goal
System Admin for Data Development Work Task	**TASK 5: [PROVIDE SYSTEM ADMINISTRATION SERVICES] Maintain application and web map services for Data Development work task** • Project Management, Specifications, Standards, Contract Scope of Work, Data Integration, Quality Assurance, Progress Reports. • Perform system administration and maintenance of applications. Technical support services include hardware and software operating system upgrades. Maintain backup system with virtual servers. Maintain a high level of performance of application including the processing of troubleshooting calls regarding system issues. Update monthly security patches on all servers. Install and maintain all necessary hardware and software licenses. • Publish and maintain all local web map services that support data development activities	

Table 7. Priority Data Collections

Priority	Data Theme
1	Continuously maintained Surface Tax Parcels ○ Statewide Digital Parcel Boundary File (Priority 1A) ○ Sustained Digital Parcel Maintenance by Assessor Offices (Priority 1B)
2	Site Addresses
3	Lidar Elevation Data
4	Leaf-Off Aerial Imagery
5	Business Level Data

Table 8. Timeline for GIS Data Development

Year / Tasks	Year 1	Year 2	Year 3
TASK 1: [Statewide Building Inventory]			
TASK 2: [Fill in GIS Data Gaps]			
TASK 3: [Report Data Gaps]			
TASK 4: [Exchange Risk Assessment Information]			
TASK 5: [Provide System Administrative Services]			

Targeted Collection Areas (Data Development Goal #2)

Data collection efforts to fill in GIS data gaps for accurate hazard risk assessments are further prioritized by data theme, funding availability, potential hazard risk, and local cost share.

Table 9. Targeted Areas

#	Missing or Obsolete Data Parcels	Finished digital tax maps for sustained digital parcels	Missing or Incorrect Addresses	Lidar for Flood Risk Grids	Leaf-Off Imagery	Business Level Data
	Priority 1A	**Priority 1B**	**Priority 2**	**Priority 3**	**Priority 4**	**Priority 5**
1	Boone	Boone	Morgan	Select flood hazard areas TBD	Select counties TBD	Statewide building classes such as churches, govt. bldgs., etc.
2	Braxton	Braxton	Roane			
3	Calhoun	Calhoun	City of Elkins			
4	Clay	Clay				
5	Jackson	Jackson				
6	Logan	Logan				
7	McDowell	McDowell				
8	Roane	Roane				
9	Tucker	Tucker				
10	Tyler	Tyler				
11	Wirt	Wirt				
12	Wyoming	Wyoming				
Price	$2.30 per parcel	$3.50 per parcel (requires county assessor's participation)	$2.43 per address	$230 per square mile – prices vary depending on lidar specifications and delivered products	$70 per square mile	Not to exceed $10K purchase

Assessment Building Info

West Virginia Parcel Property Class Breakdown for Tax Year 2017

Code	Property Class	# of Parcels	Percent (%)
R	Residential	1,164,470	79.61%
F	Farm	121,384	8.30%
A	Apartment	3,222	0.22%
C	Commercial	65,784	4.50%
I	Industrial	3,105	0.21%
X	Exempt	97,773	6.68%
U	Utility	192	0.01%
Other	Not classified	6,837	0.47%
		1,462,767	100.00%

*Assessment records are important for **building inventories** and are used to estimate the total building exposure ($) and building loss ($) for multi-hazards. Often building inventories and corresponding loss estimates are organized by **property class**.*

Figure 8. Data Development Example 1: Parcel attributes are important for determining building replacement values for taxable properties.

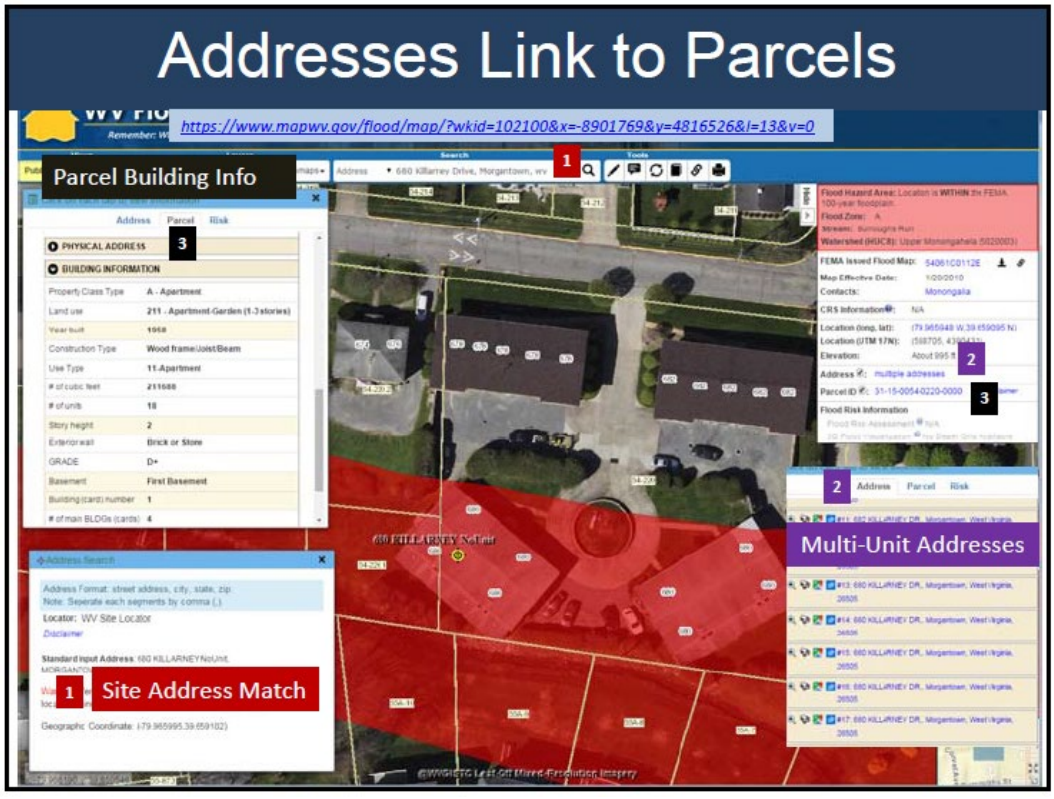


Figure 9. Data Development Example 2: Addresses are valuable for validating physical addresses in assessment databases and for identifying multiple structures within a property.

RESPONSIBILITIES

Table 10. Responsibilities of FEMA, SHMO, WVGISTC, and RPDC's.

Entity	***General Responsibilities***
FEMA	• *High-level coordination* • *Marketing and educational component* • *Solicit state and local data participation*
WV State Hazard Mitigation Officer	• *Administer grants and funding* • *Oversee local and state hazard mitigation plan updates* • *Publish local HMGP application template that conforms to WV statewide approach to multi-hazard risk assessments set forth in this project proposal* • *Ensure local hazard mitigation plans are aligned with project goals* • *Monitor project milestones and deliverables* • *Provide necessary training and support to regions* • *Solicit state and local data participation* • *WV DHSEM agency support for critical facility datasets*
WV GIS Technical Center, West Virginia University	• *Create statewide building inventories* • *Perform county-level flood and landslide risk assessments* • *Publish risk assessment data on the web-based WV Flood Tool and WV Landslide Inventory* • *Serve as Data Clearinghouse for Statewide Risk Assessment Data* • *Provide knowledge transfer and GIS expertise to FEMA, State, and Regional Planning and Development Councils* • *Assist State Hazard Mitigation Office in updating Local HMGP applications so that hazard data collections and analysis are consistent and utilize comparable methodologies for both local and state plan updates.*
Regional Planning & Development Councils	• *Submit application grants to SHMO* • *Assist with the collection and validation of building inventories and risk assessment data* • *Update mitigation plan strategies* • *Start Early is the Best Practice! Data collection and exchange efforts for Local Hazard Mitigation Plan updates should begin a minimum of one year in advance, preferably two years before the expiration date*

PROFESSIONAL SERVICES

Professional Services: The WV GIS Technical Center will contract with other professional organizations for the following expert services:

- Upgrade the Hazus-MH Building Inventory Tool
- Technical support for Hazus Flood Hazard Loss Estimation Software and Workflows
- Support for creating landslide susceptibility maps

Table 11. Work Task Descriptions for Professional Services

Services	Work Task Description	Goal
Upgrade Building Inventory Tool	**SERVICE 1: [Upgrade Hazus-MH Building Inventory Tool]** – Upgrade the data inputs and programming scripts for Building Inventory Tool for flood and landslide risk assessments. • Upgrade of the Building Inventory Tool that the Polis Center created for FEMA Region III/West Virginia to Hazus release version 4.0 • Modify the Building Inventory Tool to include commercial/industrial attributes. Modify the FME toolkit to allow for the use of building footprints or E-911 address points to move parcel centroids to structural centroids • Update the Building Inventory Tool workflow to reflect updates and modifications • Provide algorithms for determining building footprints for individual structures with limited building specific information • See the current Building Inventory Tool procedures and workflow by the Polis Center. This workflow needs to be modified for future risk assessments: http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/WV_BI_Workflow_1.0-052215.pdf	D1 F1 F2 F5 L3 L5
Support for Hazus Flood Loss Estimation	**SERVICE 2: [Technical Support for Hazus Software**] – Support by Hazus Experts for calculating building exposure costs and flood loss estimates at the structure level. • Validate proper Hazus inputs and outputs are generated correctly • Verify correct damage-depth equations are utilized in flood loss models • Develop and automate workflows for data inputs/outputs for Hazus flood loss estimates	D1 F1
Consulting services for landslide maps	**SERVICE 3: [Consulting Services for Landslide Susceptibility Map**] – Consulting services for creating and publishing landslide susceptibility maps.	L1 L2 L3

VENDOR DATA SUBCONTRACTS

Vendor Subcontracts: The WV GIS Technical Center will subcontract to vendors for mapping services or for purchasing existing data required to achieve quality risk assessments.

- Mapping services for parcels, addresses, lidar, or leaf-off imagery
- Purchase existing lidar data or business level datasets

If feasible the subcontracts with the mapping vendors will be set up for multi-county data acquisition projects to increase savings and data collection efficiencies. A committee of representatives from WVU, WV DHSEM, and State Tax Department will prioritize and coordinate data collection efforts with vendors. Standard procurement guidelines will be used to select vendors based on costs, qualifications, and experience with state mapping procedures.

Table 12. Mapping Contracts

Contracts	Work Task Description	Goal
Fill in data gaps needed for risk assessments	**Various Contracts: [Fill in data gaps for quality risk assessments**] – Subcontract mapping services for the following data priorities: 1) Surface Parcels a) Statewide Digital Parcel Boundary File b) Sustained Digital Parcel Maintenance by Assessor Offices 2) Site Addresses 3) Lidar Elevation Data 4) Leaf-Off Aerial Imagery 5) Business Level Data	D2

DELIVERABLES

The deliverables are organized the same as the work tasks and corresponding goals. There are a total of 15 deliverables that align with the work tasks or goals: 6 flood risk assessment, 5 landslide risk assessment, and 4 data development.

Table 13. Deliverables organized by three major work tasks

Major Work Tasks	Designation Letter	# Deliverables
Flood Risk Assessments	F	6
Landslide Risk Assessments	L	5
Data Development	D	4

F. FLOOD RISK ASSESSMENTS AND PRODUCTS

F.1. **Site-specific flood risk assessments** for 55 counties and 232 incorporated communities to supplement Local and State Hazard Mitigation Plans. The flood risk assessments for the 287 study areas are calculated for a riverine 1% annual chance flood event with Hazus flood loss models using as inputs the flood inundation area and composite of the best available depth grids.

- Physical Building Damage Assessments. Losses are categorized as building losses associated with damage to the fixed elements of a structure, such as the foundation, walls, or floors; and contents losses associated with damage to structural elements not permanently fixed within a structure, such as furniture, appliances, and personal possessions.
- Flood Debris Generated
- Flood Shelter Requirements
- Additional tables that summarize inventory and loss data at the community level, stream name, flood zone, etc. and can be incorporated in the Flood Risk Assessment dataset.

F.2. A statewide geodatabase of **site-specific flood risk structures** (called "User-Defined Facilities", or UDFs, in Hazus) located in the Regulatory/Advisory Floodplains.

- The Flood Risk Assessment dataset reflects potential loss estimates (damages) resulting from a 1-percent annual chance flood.
- The loss estimates are derived at the individual building/structure level.

F.3. **3D flood risk visualizations** for *every* individual at-risk structure and select communities. Requires flood inundation zone boundaries, depth grids, and building footprints.

F.4. **Assemble statewide composite flood risk products** to include a statewide advisory floodplain from Advisory A and Advisory AE flood zones, statewide flood depth and water surface elevation grids. See Appendix C.

F.5. **Update State Hazard Mitigation Plan.** Integrate county flood assessment data and reports into state hazard mitigation plan. A standardized data analysis process will ensure that future local and state plan updates are consistent and utilize comparable methodologies.

F.6. **Published flood risk data and products** on state (www.MapWV.gov/flood) and FEMA's federal geo-platforms according to required specifications. Flood risk deliverables for every county include:

- Reports
  - Publish risk data in county reports to WV Flood Tool
  - Integrate county flood risk studies into regional and state hazard mitigation plan updates.
- Maps
  - Building Exposure
  - Physical damage map of buildings and facilities (large size)
  - Debris map
  - Population Displacement / Shelter map
  - Select 3D maps (if building footprints available)
  - Miscellaneous maps
- GIS Data
  - Building Inventory replacement costs
  - User Defined Facilities loss estimates
  - GIS parcel polygons
  - E-911 Addressable Structures
  - Essential Facilities
  - Critical Facilities
  - Community Assets
  - Mitigated Properties
  - Hazuus-MH .hpr files (available on request)

L. LANDSLIDE RISK ASSESSMENTS AND PRODUCTS

L.1. A **statewide landslide incident inventory** from various sources: WV GES, WV DOT, USGS, FEMA landslide buy-out properties, etc.

L.2. A more detailed and accurate **landslide susceptibility model** for West Virginia which includes regional variations in geology, soils, and terrain.

L.3. **55 county-level resolution landslide susceptibility maps and reports** to supplement local hazard mitigation plans.

L.4. An interactive web map application named the **WV Landslide Tool** (www.mapwv.gov/landslides) of landslide incidents and landslide susceptibility zones

L.5. Update the landslide hazard identification and risk assessment for the **State Hazard Mitigation Plan**.

D. DATA DEVELOPMENT & EXCHANGE OF RISK ASSESSMENTS AND PRODUCTS

D.1. A **structure-level inventory** of all buildings and facilities *exposed* to multi-hazards. The inventory includes each building's replacement or resell value and allows for site-specific risk analysis. A **Building Inventory Tool** will streamlines the process of identifying buildings assets exposed to multi-hazards and for executing Hazus flood loss models at the building or structure level. The Building Inventory Tool requires further refinements like updating the building construction tables for commercial/industrial properties and including building information from non-assessment sources. In addition, the Building Inventory Tool should be upgraded to be compatible with the Hazus Release 4.0 full versioned software release.

- Develop a standardized, comprehensive building exposure inventory that includes critical facilities and state-owned properties.
- Building exposure values will be computed from building specific information or acquired from other sources like appraisal and insurance databases.
- Taxable properties are organized by occupancy or land use categories: Residential, Agricultural, Commercial, Industrial, Government, Education, and Religion. Information for tax-exempt properties is collected from national and state databases (e.g., Infogroup ReferenceUSA, WV Board of Risk) to generate a comprehensive structure-specific inventory of total building assets for West Virginia.
- Data sources for developing and validating the building replacements costs and building location: property parcels and assessor attributes, E-911 addresses, leaf-off imagery, and building footprints. Supplemental sources for non-taxable structures include school and insurance databases.
- All critical facilities and individual structures located in the Regulatory/Advisory floodplains are spatially adjusted to the building centroid and not the parcel centroid. Where available building footprints are used to further enhance the process of building identification.
- The inventory data are based on estimates of total assets for building and contents replacement values. These replacement values are used by loss estimation models, such as Hazus, to derive building and content loss values.

D.2. Fill in **critical data gaps** for statewide parcels, address, leaf-off imagery, and business level data.

D.2.1. A statewide digital parcel boundary file that is a high priority mitigation action according to the 2013 State Hazard Mitigation Plan.

D.2.1.1. A **statewide digital parcel boundary file** by mapping missing or obsolete parcels for 12 counties (Priority 1a).

D.2.1.2. All 55 county assessors have **digital tax maps statewide** by funding select counties with paper-to-digital conversion. This objective assists counties

still producing tax maps manually in migrating to a sustained digital maintenance program so that the capital investment of the paper-to-digital parcel boundary conversion – or the primary objective of a current statewide parcel boundary file – is not lost over time. A cost share may be required by select counties (Priority 1b).

D.2.2. A **statewide address and mapping file** by mapping missing or incorrect addresses for three counties (Priority 2).

D.2.3. Acquire **lidar elevation data** to construct water surface elevation and depth grids (Priority 3).

D.2.4. Collect **leaf-off imagery** for an estimated 3,000 square miles in West Virginia. Targeted areas are based on repeated disaster declarations, cost-share, benefits to other data collection projects, etc. (Priority 4).

D.2.5. Acquire **business level data** from vendors if critical data gaps exist in the building inventory for computing replacement costs. (Priority 5)

D.3. Report **data gaps** at the county level for key geodatabase reference layers (parcels, addresses/geocoding, imagery, elevation, building footprints, critical infrastructure, etc.) that hinder the attainment of quality risk assessment studies. Provide recommendations to the appropriate organizations to improve data management and governance.

D.4. Exchange the **best available risk assessment information** among local, state, and federal geo-platforms. Incorporate **historical hazard data** into risk assessment studies. Use **online map validation tools** such as ArcGIS online viewer applications for local communities and floodplain managers to validate risk assessment data. Assist State Hazard Mitigation Office in updating **Local HMGP applications** so that hazard data collections and analysis are consistent and utilize comparable methodologies for both local and state plan updates.

- Multi-agency coordination and data exchange among organizations allow for comprehensive risk assessment for communities. A multi-hazard Risk Assessment Lifecycle should be applied to regularly evolving risk assessment studies.
- Start Early is the Best Practice! Data collection and exchange efforts for Local Hazard Mitigation Plan updates should begin a minimum of one year in advance, preferably two years before the expiration date

❖ Other external projects and products that enhance deliverables listed above

- FEMA/WV NFIP
  - Risk MAP products from new Flood Insurance Studies for select watersheds
  - Floodplain Redelineation and Flood Risk Products (WSEL & Depth Grids) for Flood Hazard Zones AE & A using existing LiDAR-derived elevation data
  - Building footprints from Region III pilot by ORNL
- USACE/NRCS
  - Dam and levee failure flood inundation assessments
  - Labor support for project proposal via Silver Jacket Program

- USGS
  - Historical Flood Inundation Maps
  - Landslide Consultation Services
- State Tax Department
  - Detailed assessment reports for both residential and commercial properties that include assessment information for multiple structures. Reports linked to online flood risk maps.
- WV Department of Transportation
  - Create geodatabase from bridge and road closure reports due to flooding and landslides
- WV Voluntary Organizations Active in Disaster (VOAD)
  - Inventory of private bridges susceptible to flooding
- Other Agencies – cost share for data development efforts of parcels, addresses, and imagery

PERFORMANCE PERIOD

The performance period is three years from the contract start date.

BUDGET

See the budget narrative document.

PROJECT TIMELINE/MILESTONES

Table 14: Project Timeline/Milestones

Task/Activity	Timeline	Task Milestones
Execute Grantee-Sub grantee Agreement for Proposed Project	1 month	
County Flood Risk Assessments	4 months	F1
Statewide geodatabase of site-specific flood risk structures	2 months	F2
3D Flood risk Visualizations completed	1 month	F3
Assemble statewide composite flood risk products	1 month	F4
Updates for State Hazard Mitigation Plan (flood hazards)	1 month	F5
Publish flood risk data and products	1 month	F6
Landslide Inventory	2 months	L1
Landslide Methodology	2 months	L2
County Landslide Risk Assessments	3 months	L3
Landslide Web Application	2 months	L4
Updates for State Hazard Mitigation Plan (landslides)	1 month	L5
Statewide Building Inventory	3 months	D1
Fill in GIS Reference Data Gaps via Subcontracts	3 months	D2
Report Data Gaps	1 month	D3
Exchange Risk Assessment Information	1 month	D4
Reimbursement	3 months	
Project Close Out	4 months	

F = Flood Risk
L = Landslide Risk
D = Data Development

PERSONNEL

Project Management: The WV GIS Technical Center has the staff capacity and resources to manage all the goals and deliverables for this project. Mr. Kurt Donaldson is responsible for the administrative oversight and budget of this project. The project is organized and managed by the fifteen goals/deliverables in which the major task leaders for Flood Risk Assessments, Landslide Risk Assessments, and Data Development are Mr. Eric Hopkins, Dr. Maneesh Sharma, and Mr. Kevin Kuhn, respectively. Vendors will be subcontracted for assistance with the Building Inventory/Hazus software and mapping services. More information about key personnel is listed below.

Principal Investigator: Kurt Donaldson

Mr. Kurt Donaldson is the manager of the West Virginia GIS Technical Center, located in the Department of Geology and Geography at West Virginia University. Mr. Donaldson has 22 years of GIS management experience in which he has completed over 160 funded grant and service projects worth 13 million dollars. Every year since 2003 Mr. Donaldson has supervised FEMA-related projects involving the data development and viewing applications of flood hazard data. In 2016 the Center received a Geospatial Excellence Award from the National States Geographic Information Council for the WV Flood Tool web application that has garnered national acclaim. Mr. Donaldson is a charter member and past president of the WV Association of Geospatial Professionals and in 2012 was awarded a GIS Professional Lifetime Achievement Award. In 2007 he was appointed as a citizen member of the Property Valuation Training & Procedures Commission in which has been active in modernizing the digital tax map guidelines. He has a B.S. in Computer Science from Augusta University and an M.S. in Geology from West Virginia University. For project information and GIS services provided by the Center, please refer to the 2016 Annual Report. http://www.wvgis.wvu.edu/about/WVGISTC_2016_annual_report.pdf

Co-Investigator: Maneesh Sharma, Ph.D.

Dr. Maneesh Sharma is a Research Associate at WVGISTC. He has a PhD in Geology, GISP certification, and 19 years of GIS experience. He has worked as technical lead on US Department of Agriculture's carbon storage project CarbonScapes (www.carbonscapes.org), NRCS's Interagency Coordination Tool for West Virginia and Kentucky (http://ict.mapwv.org/ict_ci/index.php/ ; http://kict.mapwv.org/kict/index.php). Sharma is also technical lead on the current Exchange network grant on "Accounting for hydrologic change in West Virginia due to surface disturbances." He has been national coordinator and lead of several national web-based initiatives like US Department of Energy's Unconventional Gas Resources Database (www.unconventionalenergyresources.org), National Carbon Sequestration Database Interactive Viewer (www.natcarbviewer.org).

Co-Investigator: Eric Hopkins

Mr. Eric Hopkins earned a Bachelor of Science degree in geology in 1983, and a Master of Arts in geography in 2006, both from West Virginia University. Eric began working at WVU in 1991 as a research assistant in a materials analysis group in the Department of Physics. In 1998 he experienced a homecoming of sorts when he returned to the Department of Geology and Geography and the West Virginia GIS Technical Center, where he has worked since. Eric contributes to multiple Tech Center projects, and is the primary point of contact and lead analyst for the development of flood hazard data published on the West Virginia Flood Tool website and flood risk data used for county,

regional and statewide preparedness response planning.

Co-Investigator: Kevin Kuhn

Mr. Kevin Kuhn has over 15 years of experience developing a strong technical background in applied GIS science, spatial theory and application, proven by a history of successfully completed projects. He has knowledge and capabilities in applying cartographic design principals, implemented through multiple media formats, which convey complex data, concepts, and relationships to a variety of users. He has worked with multiple state and local agencies to provide solutions that incorporate GIS technologies that improve workflows that increase data accessibility and analysis capabilities. Mr. Kuhn is also a GIS instructor, and has taught hundreds of new GIS users in the state of WV and beyond. He also serves on the WVAGP executive board.

Co-Investigator: Yibing Han

Mr. Yibing Han is a GIS programmer with WVGISTC and has over two years of experience. He has extensive skills and experience in GIS programming with Python and web programming with JavaScript. He has worked on a web-based GIS application for the West Virginia State Historic Preservation Office (SHPO) and a web-based LiDAR data download tool for West Virginia View. Recently, he has been working on interactive web mapping application for the WV Division of Natural Resources Hunting and Fishing Tool. Han has a B.S. in Urban and Rural Planning and M.S. in GIS for Development and Environment.

Co-Investigator: Frank LaFone

Frank Lafone has been working with WV GIS Technical Center for the last 16 years. He is Senior Programming coordinator, Applications Engineer, and Systems Architect and Administrator. He has Master's degrees in Political Science and International Relations as well as Bachelor's degrees in International Studies and Computer Science. He has been a professional software engineer for the last 20 years, the last 15 of which have focused upon Internet Mapping, GIS Applications, and Web based GIS. At the WV GIS Technical Center, he has worked on diverse federal projects including NRCS Interagency Coordination Tool, USDA's CarbonScapes Application, the National Energy Technology Laboratory Carbon Sequestration Atlas, and US Dept. of Energy Marcellus Shale Energy and Environment Laboratory. Furthermore, he has developed or overseen development on a host of state based projects, such as WV Division of Natural Resources Hunting and Fishing Tool, WV Dept. of Energy Carbon Tool, and WV DEP Water Resources Tool.

Co-Investigator: J. Steven Kite, Ph.D.

Dr. Steven Kite is an Associate Professor at West Virginia University and a skilled geomorphologist who has conducted research on the many aspects of landslides.
More information: http://www.geology.wvu.edu/people/faculty/steven-kite

Co-Investigator: Trevor Harris, Ph.D.

Dr. Trevor Harris is an Eberly Distinguished Professor of Geography at West Virginia University with research interests in 3D modeling, geovisualization, and exploratory spatial data analysis.
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APPENDIX A: Resources

**** STATEWIDE APPROACH TO MULTI-HAZARD RISK ASSESSMENTS ****

Project Overview Presentation to National Capitol Region HAZUS User Group (October 2016)

- http://www.usehazus.com/uploads/forum/October272016__NationalCapitolRegionHUG_Presentation_FINAL.pdf

- http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/WV_Statewide_Approach_Risk_Studies_20161027.pdf

**** WV HAZARD MITIGATION PLANS ****

- **2013 WV State Hazard Mitigation Plan**
  http://www.dhsem.wv.gov/MitigationRecovery/Documents/2013%20WV%20Statewide%20Hazard%20Mitigation%20Plan%20Update.pdf

- **Regional Planning and Development Councils – Local Hazard Mitigation Plans**
  http://www.dhsem.wv.gov/MitigationRecovery/Pages/Hazard-Mitigation-Planning.aspx

- **Local Hazard Mitigation Plan Application**
  http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/WV_HMGP_Local_Application_v1_201602.docx

**** FLOOD RISK ****

WV County Flood Risk Assessment Reports

- Berkeley County (October 2016)
  http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/Berkeley_FloodRiskRpt_20161031.pdf

- Morgan County (October 2016)
  http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/Morgan_FloodRiskRpt_20161031.pdf

WV Flood Tool
http://www.mapwv.gov/flood/

WV Flood Tool Recent Upgrades (August 2017):
http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/WV_Flood_Tool_upgrades 20170828.pdf

WV Flood Tool Future Directions (July 2017)
http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/FutureFloodToolDirection20170715.pdf

**** LANDSLIDE RISK ****

WV Landslide Inventory
http://www.mapwv.gov/landslide

Prototype Landslide Risk Assessment Report (April 2016)
http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/Landslide_Susceptibility_Pilot_Study_BerkleyCounty_20160408.pdf

**** WV BUILDING INVENTORY TOOL ****

Building Inventory Workflow (IUPUI Polis Center)
http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/WV_BI_Workflow_1.0-052215.pdf

WVU Access to Infogroup Company's Reference USA Database
https://lib.wvu.edu/databases/AtoZ/?id=R&status=

**** WV GIS DATA STATUS MAPS ****

Parcels

Parcel Boundary Digital Conversion
http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/graphics/DigitalParcelBoundary_20170519.pdf

Parcel Management by Counties
http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/graphics/Parcel_Management_03142017.pdf

Parcel Vendors
http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/graphics/Parcel_vendor_assistance_05042017.pdf

Addresses
http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/graphics/SAMS_county_status_20170804.pdf

Aerial Imagery (leaf-off)
http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/graphics/LeafOffAerialPhotography_06022017.pdf

Building Footprints
http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/graphics/BuildingFootprints_20151207.pdf

Dams/Levees
http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/graphics/USACE_District_Divisions_WV_Dams-Levees_20160817.pdf

Flood Hazard Zones

Detailed versus Approximate Flood Hazard Zones
http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/graphics/WVFloodHazardZones_20170731.pdf

Advisory A Flood Zones Acquisition Status
http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/graphics/Advisory_A_Status_20170630.pdf

Proposed Future FEMA-Sponsored Flood Studies
http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/graphics/ProposedStudies_Status_20170630.pdf

**** FEMA GUIDELINES ****

Guidelines and Standards for Flood Risk Analysis and Mapping
https://www.fema.gov/guidelines-and-standards-flood-risk-analysis-and-mapping

Hazard Mitigation Grant Program
https://www.fema.gov/hazard-mitigation-grant-program

Hazard Mitigation Assistance Guidance
https://www.fema.gov/media-library-data/1424983165449-38f5dfc69c0bd4ea8a161e8bb7b79553/HMA_Guidance_022715_508.pdf

Hazard Mitigation Assistance Guidance Addendum
https://www.fema.gov/media-library-data/1424983165449-38f5dfc69c0bd4ea8a161e8bb7b79553/HMA_Addendum_022715_508.pdf

**** FINANCIAL GUIDELINES ****

OMB 2 CFR 200 - Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards
https://www.gpo.gov/fdsys/pkg/CFR-2014-title2-vol1/pdf/CFR-2014-title2-vol1-part200.pdf

**** MISCELLANEOUS ****

Missouri State Hazard Mitigation Plan Update Overview (2017) (Amec Foster Wheeler)
http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/Missouri_State_Hazard_Mitigation_Plan_Update_2017.pdf

Hazus-MH Analyses for City of Beverly, MA: Hazard Mitigation Plan Update (Flood UDF) (2017) (Dewberry)
http://www.usehazus.com/uploads/main/JUN_2017_NCRHUG_Presentation.pdf

Data Creation Geared to the World as We Know it! (2016)– Steve Kocsis, Cambria County, PA GIS Center; Visualization of the Month – 3D Flood Impact
http://www.usehazus.com/uploads/forum/March312016_NationalCapitolRegionHUG_Presentaiton.pdf

Multi-Hazard Risk Assessment Lifecycle Cradle-to-Cradle - Rethinking the Way We Use Risk Assessments (2016) – Cynthia McCoy, FEMA Region X
http://www.usehazus.com/uploads/forum/February252016_NationalCapitolRegionHUG_Presentaiton2.pdf

Upper Monongahela Watershed Flood Risk Review Meeting (2016)
http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/FRR_Presentation_Upper_Monogahela.pdf

Regional Planning and Development Councils Graphic (2015)
http://data.wvgis.wvu.edu/pub/temp/FEMA/FRA/P/graphics/WV_Regional_Planning&Development_Councils_052115.pdf

Cook County HMP Risk Assessment (2015) – Carol Bauman, Tetra Tech
http://www.usehazus.com/uploads/forum/March262015_NationalCapitolRegionHUG_Presentaiton.pdf

Total Exposure in Floodplain (TEIF) 2.0 (2013) – Glenn Locke, Tetra Tech
http://www.usehazus.com/uploads/forum/December192013_NationalCapitolRegionHUG_Presentaiton_FINAL.pdf

APPENDIX B: Workflow for Building Inventory Tool and Flood Risk Assessment

Building Inventory Tool and Flood Risk Assessment Workflow (Refer to Figure 1 diagram)
1/11/2017

1) Prepare County Data Sources

a) FEMA National Flood Hazard Layer (NFHL) Floodplains and related features
   i) 1 Pct Floodplain polygons (S_Fld_Haz_Ar)
   ii) Cross Section lines (S_XS) for flood water surface and depth grid

b) CAMA records with necessary attributes
   i) County extract from statewide CAMA db.
   ii) Duplicate/Multiple Improvements/Structures
      (1) Multiple addresses in same parcel
      (2) Multiple structures (e.g. outbuildings) filtered

c) GIS Parcel Polygon File with necessary attributes
   i) Parcel ID (PID, PAR_ID, ROOT_ID)

d) Building footprints
   i) Multiple footprints within single parcels identified/filtered

e) E-911 Structures

f) Aerial Imagery – most recent, highest resolution, leaf-off

g) Elevation
   i) Local Resolution / DEM Mosaic
   ii) USGS NED

h) Depth Grid – best available from the following ranked list:
   i) Advisory
   ii) Detailed Re-Study
   iii) Detailed Re-Delineation using XS lines
   iv) Hazus L1 2010 Study
   v) EQL

i) Critical Infrastructure Data
   i) Emergency Service Centers
   ii) Fire Stations
   iii) Health Care Facilities
   iv) Police Stations
   v) Schools

j) Community Assets
   i) Campgrounds
   ii) Churches
   iii) Emergency Shelters
   iv) Government Offices
   v) Hazmat Non-Facility
   vi) Mobile Home Parks
   vii) Polling Places

viii) Poultry Slaughtering Stations
ix) Water Towers
x) Other Features as determined by the community

2) Create Building Inventory from Parcel Data using FME Tool

a) Gather county parcel and assessment data
b) Prepare County Inventory Data
   i) Prepare Hazus Boundaries
      (1) County (Hazus-MH)
      (2) 100-year floodplain (FEMA NFHL 1% S_Fld_Haz_ar)
      (3) Census blocks or tracts (Hazus-MH)
   ii) Convert parcel polygons to parcel centroids
c) Prepare Building Inventory
   i) Prepare matrices and domains to convert CAMA codes recognized by Hazus. The Improvements table consists of domains where the CAMA codes are converted to descriptive attributes. In addition, CAMA cost values are aggregated by the occupancy classes.
d) Run cama to CAMA tool (TOOL #1)
   i) Pre-process CAMA data to enhance the LUC tables so that data can be pre-processed based on the Hazus occupancy classes. The Hazus occupancy codes/classes serve as a guide to convert the existing CAMA attributes to Hazus specific attributes. Codes that are unmatchable with Hazus occupancy class are assigned "UNK".
e) Convert CAMA to Improvements (TOOL #2)
   i) Filter out CAMA records that are unlikely associated with a building structure. For example, vacant lands (LU Codes), other building and yard improvements (OBYVAL), dwelling codes (DWELVAL).
f) Convert CAMA Improvements to Building Points (TOOL #3)
   i) Join GIS building points with Hazus-ready CAMA records
   ii) Tools:
      (1) Year Built creator
      (2) Dollar Per Square foot creator
g) Convert Building Points to Building Inventory (TOOL #4)
   i) Tools written to generate a Building Inventory feature class based on the domains and matrix as well as the Building Points created earlier in workflow
   ii) Domains: Year_built, FirstFloorHt, BldgCondition, BldgFoundation, BldgConstruction
      (1) Domains are tables created in Access geodatabase which give descriptions of the codes
   iii) Matrices: BldgCondition, BldgConstruction, BldgFoundation
      (1) Matrix are Access tables that convert the CAMA codes into Hazus compliant codes so that features can be imported into Hazus for analysis
   iv) XFactors: DOLqFt
      (1) This table is created to calculate Average Dollar per Square Foot using the Improvements table.
   v) RS Means Table
      (1) The replacement values of the buildings in Hazus database are developed by applying the RS Means for typical building floor areas for each occupancy class.
h) Output building inventory GBS and UDF files
i) **Table 1:** Local Building Inventory

j) **Appendix A:** Building Inventory Process

3) Calculate Building Exposure for County and Communities using GBS Inventory

a) Update Hazus GBS Inventory
   i) USE CDMS to update the GBS for <County_Name> and <Community_Name>
   ii) Create a Flood Study Region for the county to be modeled
   iii) Verify Building Inventory count is uploaded into Hazus
b) **Table 2a:** Countywide Building Number and Exposure ($) from updated General Building Stock
c) **Table 2b:** Countywide Building Number and Exposure ($) from CAMA Building Appraisal Values
d) **Figure 3:** Sample Map of Countywide General Building Stock Exposure by Census Block. Replacement building costs are aggregated to Census Blocks.
e) **Figure 4:** Zoomed-in View of Spatially Enhanced UDF Structures in Flood Zone

4) Calculate Building Exposure in Floodplain using UDF Inventory

a) Update Hazus UDF Inventory
   i) Spatially adjust parcel centroids to structure center.
   ii) Create a Flood Study Region for the county to be modeled.
   iii) Verify Building Inventory count is uploaded into Hazus
b) Import UDF within Flood Hazard Area directly into the study region (must be < 10,000 facilities)
   i) Create Building Inventory by processing the building points to fit the Hazus database structure and domains
   ii) Link populated Access tables to Study Region SQL tables
   iii) Review UDFs in Hazus (page 19)
      (1) UDF Count should match the BI count
      (2) UDFs should not be outside the county/study region boundaries
      (3) UDF locations should be the same as the BI locations
c) **Table 3a:** County Flood Hazard Building Exposure in 100-year Floodplain. Data input of choice is User Defined Facilities
d) **Table 3b**: Community Building Exposure in 100-year Floodplain. Data input of choice is User Defined Facilities.
e) **Figure 4:** Zoomed-in View of Spatially Enhanced UDF Structures in Flood Zone

5) Inventory of Facilities and Community Assets

a) **Table 4:** Essential Facilities
b) **Table 5:** Critical Facilities
c) **Table 6:** Community Assets

6) Inventory Mitigated Properties

a) **Table 7 :** Mitigated Properties

7) Setup Model Scenario for Riverine Flood Assessments for 1% event. Derive Flood Layer Inputs

a) Select 1% floodplain boundaries
b) Select User-Defined Water Depth Grid
   i) Enhanced Quick Look (Hazus MH)
   ii) User-Defined Flood Depth Grid
      (1) WV Depth Grids for Approximate A Zones
         (a) HEC-RAS models available

(2) HEC-RAS Depth Grids
(3) **Figure 5:** Zoomed-in View of Water Depth Grid. Overlain with UDF individual building structures.

iii) Flood Information Tool extension - Generate grid from x-sections

8) Perform Riverine Flood Hazus Analysis

a) Riverine 1% Flood Building Damages
   i) **Table 8:** County Riverine Floodplain (1% Flood) Related Losses
   ii) **Table 9:** Top 5 Flooded Structures by Replacement Cost
   iii) **Table 10:** Building and Facility Damages
      (1) Building Inventory
      (2) Essential Facilities
      (3) Critical Facilities
      (4) Community Facilities
   iv) **Figure 6A:** County (1% Flood) Damaged Building Losses
   v) **Figure 6B:** Community (1% Flood) Damaged Building Losses
   vi) **Figure 7:** Facilities and Community Assets in 100-year Floodplain
   vii) **Figure 8:** Mitigated or Buyout Properties in County
b) Riverine 1% Flood Debris Generation
   i) Debris Summary Report from Hazus
   ii) **Figure 9:** Riverine 1% Flood Debris Weight (Tons)
c) Riverine 1% Flood Shelter Requirements
   i) Shelter Summary Report from Hazus
   ii) **Figure 10:** Riverine 1% Flood Shelter Requirements

9) Data Deliverables to County (QC & Delivery)

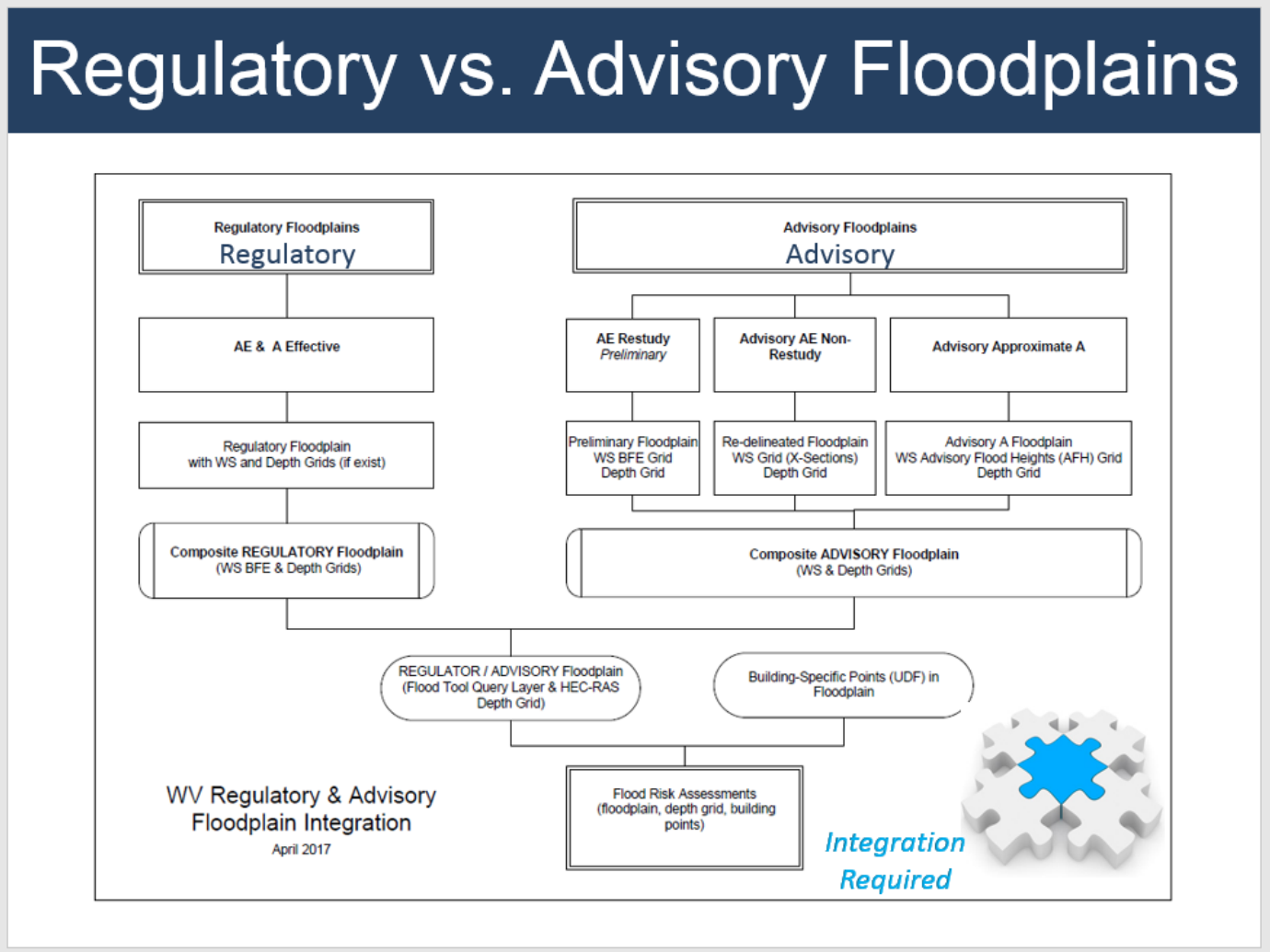
a) Maps
   i) Building Exposure
   ii) Physical damage map of buildings and facilities (large size)
   iii) Debris map
   iv) Population Displacement / Shelter map
   v) Select 3D maps (if building footprints available)
   vi) Miscellaneous maps
b) GIS Data
   i) GIS parcel polygons
   ii) E-911 Addressable Structures
   iii) Building Inventory
   iv) UDF Floodplain Structures
   v) Essential Facilities
   vi) Critical Facilities
   vii) Community Assets
   viii) Mitigated Properties
   ix) Hazus-MH .hpr files (available on request)

10) Integration of County Flood Risk Results in the State Hazard Mitigation Plan

APPENDIX C: Composite Effective and Advisory Flood Products

Statewide flood risk assessments require assembling composites of the following regulatory and advisory flood layers:

- Floodplains
- Depth Grids
- Water Surface Elevation Grids



APPENDIX D: Landslide Literature Review and Proposed Methodology

LANDSLIDE LITERATURE REVIEW AND PROPOSED METHODOLOGY

Author: Dr. Maneesh Sharma, Geoscientist and GIS Analyst, WV GIS Technical Center, West Virginia University

Published Date: May 1, 2017

Introduction: The West Virginia GIS Technical Center proposes to perform landslide susceptibility study for West Virginia. We will research and implement a valid methodology for landslide susceptibility. We also propose to generate 55 county-level resolution and a state level landslide susceptibility maps and supplemental reports for local and state hazard mitigation plans.

1. Collaborations with potential partners

West Virginia GIS Technical Center will work closely with West Virginia Geological and Economic Survey, WV Department of Transportation, United States Geological Survey etc. Additionally, WVGISTC will work closely with Professor Steve Kite in the department of Geology and Geography, West Virginia University, who is a landslide expert in the state of West Virginia.

2. Literature Review

West Virginia is physiographically divided into different major provinces (Lessing et al., 1976). Table 1 shows different physiographic divisions and subdivisions in West Virginia. The Appalachian Plateau forms the eastern most physiographic province and covers the western two-thirds portion of the state. A study by USGS (Outerbridge, 1987) identified Logan Plateau as a major physiographic subdivision within the Appalachian Plateau. The area consists of sandstones, silts and shales. Shallow earth flows in soil and weathered bedrock are more common in this region. Folded Allegheny Mountains and Front are to the east of the plateau. This area consists of orthoquartzite, sandstone, shale and is dominated by slumps and debris flows. The Valley and Ridge province covers eastern one-third of the state and has folded and faulted rocks. This area is dominated by quartzite, sandstone, siltstone, shale and limestone. Debris avalanche, flow and slump dominate this area. The eastern part of Valley and Ridge is the Great Valley Area. This area is relatively flat and dominated by limestone and shale. The eastern most section of state consists of Blue Ridge province. This area has the oldest rocks in the state. This area contains sandstone, silt and shale and is dominated by debris slides, flows and slumps.

Table 1. Different physiographic regions of West Virginia
(http://www.wvgs.wvnet.edu/www/geology/geolphyp.htm, https://pubs.usgs.gov/bul/1620/report.pdf)

Region	Structure	Bedrock type	Slope	Relief (m)	Landslides
Appalachian Plateau	Flat	Sandstone, shale and siltstone	Gentle to steep		Abundant slumps and flows
Logan Plateau (subregion of Appalachian Plateau)	Flat	Subgraywacke sandstone, siltstone and shale	Steep	150-750	Debris avalanches, debris flows
Alleghany plateau and mountain	Flat	Orthoquartzite, sandstone and shale	Gentle to steep	100-400	Few slumps and debris flows
Valley and Ridge	Folded and Faulted	Quartzite, sandstone, siltstone, shale and limestone	Flat to steep	0-750	Debris avalanches, flow and slump
Great Valley	Flat	Limestone and shale	Flat		Few flows and slump
Blue Ridge	Folded and Faulted	Sandstone, silt and shale	Flat to steep		Debris slide, flow and slumps

Figure 1. Different physiographic provinces of West Virginia (WVGES; http://www.wvgs.wvnet.edu/www/geology/geolphyp.htm)

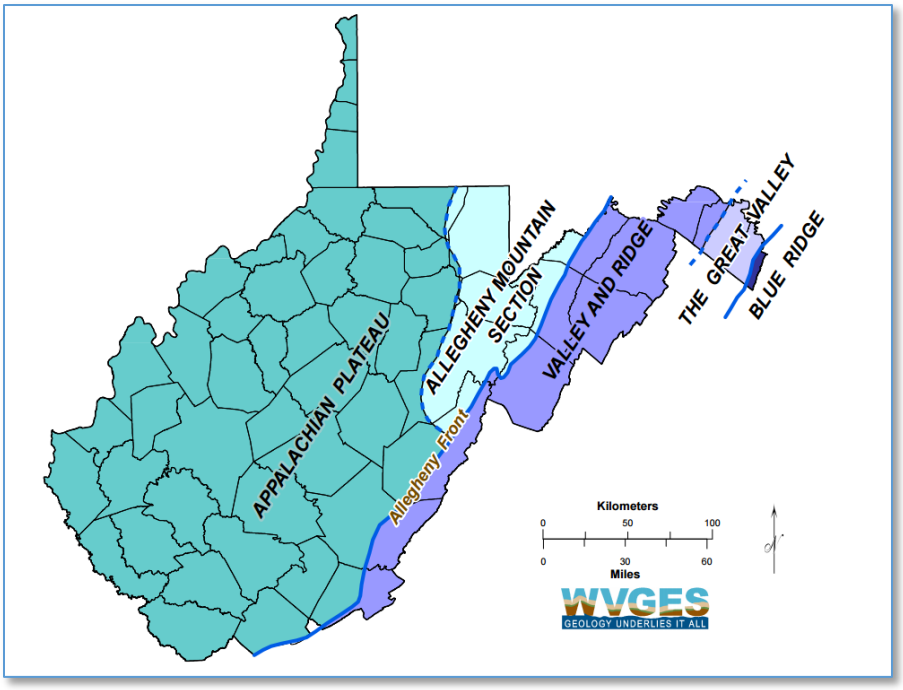
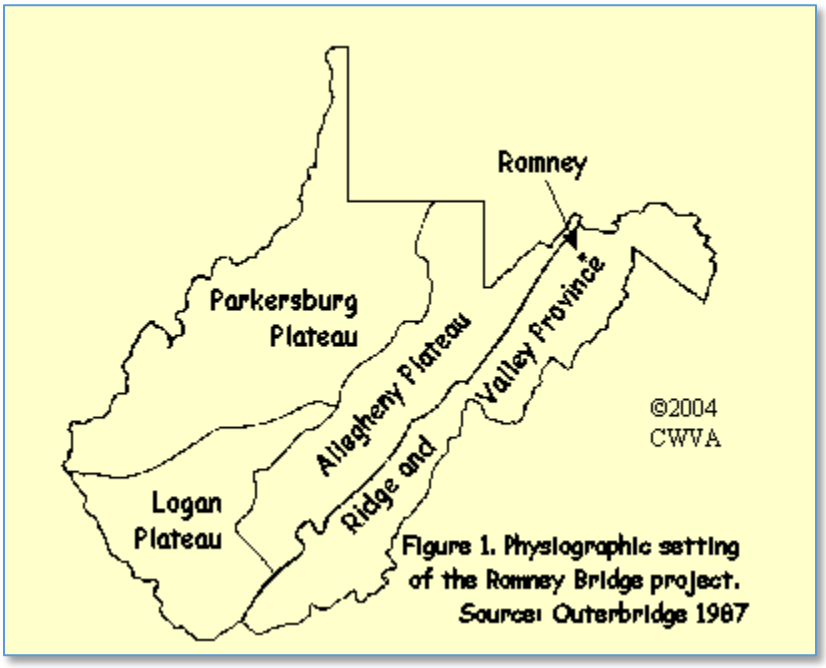


Figure 2. Figure showing generalized outline for Logan plateau (https://cwva.org/research_reports/romney_bridge/romney_bridge_ph1b.htm)



In a landslide study conducted by USGS (Radbruch-Hall et al., 1982), all of West Virginia is a high-risk region for landslides. The USGS study was done at a scale of 1:3,750,000.

Kish (2004) conducted a study on the factors controlling landslide initiation in a section of lower New River Gorge, West Virginia. Results of the study show that landslides preferentially initiated within the colluvium and mine spoil units, and the transport network also show spatial correlation. In this area, northeast and east facing slopes had a correlation with slope failures. Slope failures occurred between 15°-35° in DEM measured landslides and between 35°-50° in field measured slope angles. Hillside hollows produced most slides as compared to the nose and planar slopes. The three physical factors of transport networks, slopes greater than 35° and hillslope hollow geometry were used to create landslide hazard risk maps. In the hazard risk map, a moderate risk was deemed as an area where two factors were encountered and high-risk areas where hillslope hollows coincide with road networks and slope angle greater than 35°.

Konoser and Kite (2014) studied slope failure in Horseshoe Run watershed (part Preston and Tucker counties), West Virginia using application of LiDAR and discriminant analysis. This study is very detailed and distinguished planar slides, rotational slumps, debris flows, debris fans, debris slides and active slopes. The study used several criteria such as elevation, slope angle, slope aspect, distance from roads, distance from streams, plan curvature and profile curvature. Results show that differences between varying classes of failure and slope angle, aspect, curvature and proximity to streams were factors influencing the type of failure. According to the authors, these are most likely related to structural geology and microclimate of the area. Results indicate that slope angle, elevation, plan and profile curvature, and aspect are the dominant factors influencing the slope failure. The majority of failures occurred within Foreknobs formation that contains interbedded sandstone and shale.

The West Virginia Geological and Economic Survey (Lessing et al., 1976) conducted a landslide-mapping program in 1976. The effort focused on seven urban areas: Morgantown, Fairmont, Clarksburg, Charleston, Huntington, Parkersburg, Wheeling, and some additional work along parts of Ohio River. Most landslides in Alleghany plateau do not involve bedrock. Slides are confined to the soil, colluvium or weathered rock veneer. A dominant triggering factor for a landslide is the presence of subsurface water. Rock falls are common on cliff faces where bedrock is exposed. This is most common where sand blocks fall from a natural cliff or steep excavated slopes along highways. Mostly underlying weak shale rock gets weathered thus removing support from overlying sand blocks and thus triggering a rockfall.

According to the study, several factors that contribute to landslide are i) Surface and subsurface water condition – Heavy precipitation or cumulative heavy precipitation in short to medium time is a trigger for slides. The increase in groundwater saturation adds weight to slope material, increases water pressure and lowers cohesion of unconsolidated material. These factors decrease frictional resistance to sliding. The study also found that the effect of groundwater increased where highways and construction site required large excavation and fill. This modification changed drainage resulting in more discharge of groundwater at excavation face. ii) Slope configuration – 69% of landslides occur on concave slopes and 81% of slopes occur on slopes between 15-35%. iii) Loading – Loading a slope by improper placement of material during construction results in slides or failures especially in areas where loading has occurred in response to surface and deep mining. iv) Undercutting – Removal of slope support by undercutting is one of the most common factors for instability and slide activity. Undercutting can be either natural or man-made. v) Bedrock factors – Many slides occur because rock and soil are weak and incompetent. Red shales in Dunkard, Monongahela and Conemaugh group bedrock weather rapidly and are prone to landslides. vi) Soil factors – Most landslide are confined to shallow soils. There is a good correlation between soil and landslide. The thicker the colluvium, the more probability for landslide. Slide activity enhances where clay-rich layers are present in soil or colluvium mass. These type of soils when inclined

downslope facilitates sliding. Since clays have low permeability they decrease groundwater infiltration and cause saturation of soils above. vii) Removal of vegetation – Trees promote slope stability through deep and extensive root system. Once trees are cut in a susceptible area it increases the chances of a potential landslide.
Another factor analyzed by WVGES study was an Overdip factor. Overdip occurs where land surface slopes in the same general direction but at a higher angle than the dip of the underlying rock. No correlation of overdip to landslide was found and is questionable in Alleghany Plateau area. However, Konoser, 2014 found overdip to be a factor in eastern part of the state.

3. Landslide Data Inventory

Existing landslide data will be collected from the Lessing et al., 1976 landslide susceptibility study. This study consists of 26 quads centered around Morgantown, Fairmont, Clarksburg, Charleston, Huntington, Parkersburg, Wheeling, and along parts of Ohio River. These quads will be geo-referenced and landslide and rock fall locations for each quad will be digitized in ESRI's ArcGIS environment. Apart from this, landslide inventory data from WV Department of Transportation, FEMA landslide property buyout locations and dataset from previously published studies by Professor Kite will also be integrated into the database.
Additionally, an interactive web application (www.mapwv.gov/landslide) will be created for displaying landslide inventory data. This website will serve as a crowd-sourcing tool for input of future landslide locations in the state. A user who has access to the internet will be able to access this web application and update the database with a landslide incidence.

4. Methodology

GIS has been used to create susceptibility maps using the different methodologies such as heuristic, statistical or deterministic models (Guzetti et al., 2005; Martha et al., 2013). In the heuristic method, expert assigns weights to parameters and to each class within parameters. Weighted layers are then combined to produce susceptibility maps (Martha et al., 2013). In statistical methods, bivariate or multivariate methods are most commonly used. Factors that have led to a landslide are determined using a series of statistical methods. Statistically significant factors are then used to predict future landslide and create susceptibility maps. This method requires the collection of data to determine significant factors contributing to the landslide (Barredo et al., 2000). Deterministic methods are most commonly used at a higher resolution or local scale. This method uses geotechnical, hydrological , soil depth and properties derived from DEM. This method is most commonly used when a construction needs to be done at a specific site.

a. Previous Heuristic methodology for Berkley County pilot study

In 2015, a pilot study for landslide susceptibility in Berkley County was done using heuristic methodology. A pilot study done in Schenectady County, New York, was used as a reference for a weight-based method for determining landslide susceptibility (Kappel et al 2007). The Berkley County study used U.S. Department of Agriculture Natural Resource Conservation Service's SSURGO Digital Soil Survey and United States Geological Survey's 1/3 arc second resolution Digital Elevation Model (DEM). The SSURGO soil data has several attributes that were used to model landslide susceptibility. The soil attributes used in the pilot study were:

1. American Association of State Highway and Transportation Officials (ASSHTO) Soil Classification
2. Liquid Limit
3. Hydrologic Group
4. Physical Soil Properties (%silt and %clay); and
5. Hazard of Erosion

The above-mentioned soil attributes were used in conjunction with DEM derived slopes to developing a landslide susceptibility model for the study area. Each of the attributes was assigned a weighted value based on their contributing factor in predicting landslide susceptibility (Table 2)

Prediction Properties	Weight Range	Source
ASSHTO Soil Classification	1-14	SSURGO
Liquid Limit	2-8	SSURGO
Hydrologic Group	1-4	SSURGO
Physical Soil Properties	1-4	SSURGO
Hazard of Erosion	1-12	SSURGO
Slope	10-50	DEM

Table 2. The list of attributes and their calculated weighted range used to predict landslide

Since the slope is one of the most important controls on landslide susceptibility it is assigned the highest weighted value, in the range of 10-50. The six properties containing the weighted values were then summed to establish a landslide susceptibility "total score". The total score ranged from 37 to 84. Range groupings were established from "total score" values to assign landslide susceptibility descriptive zones as "High" – greater than 75 (Red); "Moderate" – 61 – 75 (Orange); "Low" – 51 – 60 (Yellow); "Very Low" – 41 – 50 (Beige); "No Concern" – less than 41 (Green) (Figure D3). The approach for calculating landslide susceptibility in this pilot study shows high variability in landslide susceptibility risk in Berkeley County (Figure D3).

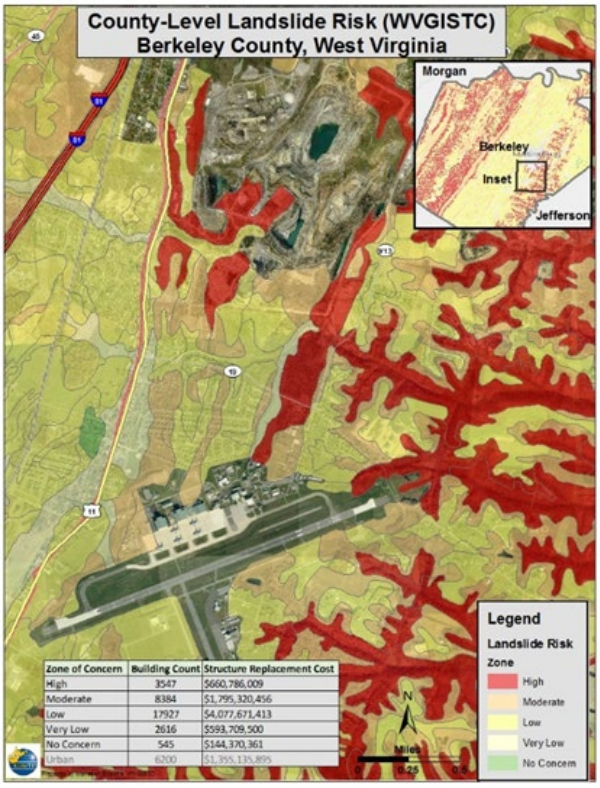


Figure 3. Map County level landslide risk for Berkeley County, WV performed by WVGISTC using heuristic methodology

b. Proposed methodology for West Virginia landslide risk assessment

We propose to research heuristic and statistical methods for landslide susceptibility and hazard analysis for counties in West Virginia. Previous studies by Professor Kite in Horse Shoe Run Watershed, Lower New River George and by the West Virginia Geological and Economic Survey will help us in refining our methodology.

The research will investigate regional variation in attributes for landslide risk assessment. A hybrid model of heuristic and statistical methods may be required to generate a statewide landslide susceptibility and risk assessment map. We will work with Professor Kite to research significant data attributes and their weightage for heuristic analysis. In statistical methods, we intend to research multivariate analysis. The multivariate statistical analysis explores the relationship among different type of attributes. We will analyze landslides using already identified potential explanatory variables from Professor Kite and WVGES studies and run regression analysis to test the impact of geography on variables. Some of the attributes that have been identified as statistically significant are elevation, slope angle, aspect, plan curvature, profile curvature, proximity to roads, proximity to streams, soils and bed rock factors. Statistical checks (Statistically significant probability, Koenker test, VIF, Jarque-Bera test, clustered residuals, adjusted R-squared and AIC) will be performed on the model to reduce the bias. If there is a need, geographically weighted regression (GWR) will be performed for the analysis. GWR is a local regression model as compared to an exploratory regression that is global regression model.

The validation will be done to perform analysis in the regions where landslide data is available. Results will be used to create landslide susceptibility and risk assessment maps for counties and the entire state.

5. Output

Landslide susceptibility maps for each of the 55 counties will created. Results from the counties will be integrated to create statewide landslide susceptibility maps. In addition, supplemental reports for local and state hazard mitigation plans will be compiled.

6. Deliverables

Following are the landslide risk assessment deliverables:

1) Develop a landslide inventory from various sources: WV GES, WV DOT, FEMA landslide buyout properties, etc.
2) Create valid landslide model for West Virginia
3) Generate 55 county-level resolution landslide susceptibility maps and supplemental reports for Local and State Hazard Mitigation Plans
4) Create an interactive web map application named the WV Landslide Tool of the landslide inventory and landslide susceptibility zones

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APPENDIX E: USACE Support Letter

Partner Support Form: Interagency Flood Risk Management Project Proposal

1. Proposal Name:	**West Virginia University (WVGISTC) State Flood Risk Analysis**
2. Name of Supporting Partner's Organization and Submitter's Name	US Army Corps of Engineers Huntington District Silver Jackets Lead District for West Virginia COL Philip M. Secrist, III
3. Partner Goals **Describe how the proposal helps achieve state or community goals in reducing flood risk.**	WVGISTC is proposing to conduct Flood Risk Hazard Analysis across all 55 counties of West Virginia over a three year period. This effort will mirror the process previously developed for Berkeley County through coordination with multiple State agencies, Federal Emergency Management Agency (FEMA), and the University of Indiana. This process focused on integrating the State's Tax Assessor Data with building inventory. The Corps of Engineers supports the West Virginia Hazard Mitigation Process through a concerted effort to share related data and technical expertise. This project provides an immediate opportunity to begin addressing common flood risk management goals between agencies.
4. Partner Role **Describe the role this partner anticipates taking in the conduct of the proposed effort, if funded.**	As a partner, the Corps will support WVGISTC's risk assessment efforts through the Silver Jackets program. Under the Silver Jacket's program, the Corps will be engaged as a member of an interagency team and will share information regarding available programs and authorities. The Corps also has the ability to develop proposals for interagency projects and provide more specific technical resources pending project selection and receipt of funding. A potential future proposal, which has the opportunity to align with WVGISTC's proposed efforts, may focus on risk communication efforts. Partnership with WVGISTC is also expected to support an existing Silver Jackets interagency project, which was selected for funding in 2016. This project is known as WV Levee Outreach and is being conducted in support of FEMA's efforts to certify levees within the State. It is also recognized that this effort aligns with the 2013 State Hazard Mitigation Plan goals.

5. Long-Term Outcomes **Describe any anticipated actions after the proposed effort is complete that this partner intends to take to further or maintain long-term flood risk reduction or management outcomes.**	- Establish a **communication network** for exchanging risk assessment information among local, state, federal, and other entities. - Provide **technical support for dam and levee flood risk assessments**. ○ Prioritize dam inspections in accordance with risk and those that do not have an EAP digitized ○ Integrate Dam and Levee safety action class (class 1 - 5) for every USACE dam and levee into HIRA and THIRA. ○ Produce documentaries about/on aging dam structures around endangered communities (Develop a list of potential dams on which to focus). ○ Create a task force to address levee safety in West Virginia (Coordination between NRCS and USACE on levee safety issues). - Create a statewide inventory of all **buildings and facilities exposed** (with replacement costs) in flood hazard and dam failure zones. - Create a **statewide water depth grid** (FEMA Risk MAP Studies + Model-Backed Zone A Studies + FIS conversion / water surface elevations from x-sections of detailed studies) using available high- resolution elevation data for 1% Annual Chance Floods. - Create a statewide inventory of **physical building damage** based on Hazus-MH flood loss estimates for a 1% riverine flood using water depth and flood inundation area inputs. - Upload **2D and 3D flood risk/dam failure maps to the WV Flood Tool.** Provide users with visualizations of water depths and flood inundation areas associated with individual at-risk structures and community-scale infrastructures. - Publish **Flood Risk Assessment Reports** for local and state hazard mitigation plans. *(As published in 2013 State Hazard Mitigation Plan)*
6. Other (optional) **Provide any additional desired information**	This specific support task is recognized as part of the State's data governance efforts in support of FEMA's RiskMAP program. RiskMAP (Mapping, Assessment and Planning) provides high quality flood maps and information, tools to better assess the risk from flooding and planning and outreach support to communities to help them take action to reduce (or mitigate) flood risk.
7. Signature: COL PHILIP M SECRIST **Date:** 10 NOV 2016 COMMANDER, HUNTINGTON DISTRICT USACE	

APPENDIX F: Local Hazard Mitigation Plan Deadlines

West Virginia Planning Status as of 7/31/2017

#	County	Plan Title	PDC	Expiration Date	Months until expires
1	McDowell County	McDowell County (PDC 1)	1	1/31/2022	53
2	Mercer County	Mercer County (PDC 1)	1	1/31/2022	53
3	Monroe County	Monroe County (PDC 1)	1	1/31/2022	53
4	Raleigh County	Raleigh County (PDC 1)	1	1/31/2022	53
5	Summers County	Summers County (PDC 1)	1	1/31/2022	53
6	Wyoming County	Wyoming County (PDC 1)	1	1/31/2022	53
7	Cabell County	Cabell County (PDC 2)	2	5/14/2017	0
8	Lincoln County	Lincoln County (PDC 2)	2	5/14/2017	0
9	Logan County	Logan County (PDC 2)	2	5/14/2017	0
10	Mason County	Mason County (PDC 2)	2	5/14/2017	0
11	Mingo County	Mingo County (PDC 2)	2	5/14/2017	0
12	Wayne County	Wayne County (PDC 2)	2	5/14/2017	0
13	Boone County	Boone County (PDC 3)	3	2/21/2017	0
14	Clay County	Clay County (PDC 3)	3	2/21/2017	0
15	Kanawha County	Kanawha County (PDC 3)	3	2/21/2017	0
16	Putnam County	Putnam County (PDC 3)	3	2/21/2017	0
17	Fayette County	Fayette County (PDC 4)	4	2/21/2022	54
18	Greenbrier County	Greenbrier County (PDC 4)	4	2/21/2022	54
19	Nicholas County	Nicholas County (PDC 4)	4	2/21/2022	54
20	Pocahontas County	Pocahontas County (PDC 4)	4	2/21/2022	54
21	Webster County	Webster County (PDC 4)	4	2/21/2022	54
22	Calhoun County	Calhoun County (PDC 5)	5	2/21/2022	54
23	Jackson County	Jackson County (PDC 5)	5	2/21/2022	54
24	Pleasants County	Pleasants County (PDC 5)	5	2/21/2022	54
25	Ritchie County	Ritchie County (PDC 5)	5	2/21/2022	54
26	Roane County	Roane County (PDC 5)	5	2/21/2022	54
27	Tyler County	Tyler County (PDC 5)	5	2/21/2022	54
28	Wirt County	Wirt County (PDC 5)	5	2/21/2022	54
29	Wood County	Wood County (PDC 5)	5	2/21/2022	54
30	Doddridge County	Doddridge County (PDC 6)	6	4/30/2017	0
31	Harrison County	Harrison County (PDC 6)	6	4/30/2017	0
32	Marion County	Marion County (PDC 6)	6	4/30/2017	0
33	Monongalia County	Monongalia County (PDC 6)	6	4/30/2017	0
34	Preston County	Preston County (PDC 6)	6	4/30/2017	0

#	County	Plan Title	PDC	Expiration Date	Months until expires
35	Taylor County	Taylor County (PDC 6)	6	4/30/2017	0
36	Barbour County	Barbour County (PDC 7)	7	8/13/2017	0
37	Braxton County	Braxton County (PDC 7)	7	8/13/2017	0
38	Gilmer County	Gilmer County (PDC 7)	7	8/13/2017	0
39	Lewis County	Lewis County (PDC 7)	7	8/13/2017	0
40	Randolph County	Randolph County (PDC 7)	7	8/13/2017	0
41	Tucker County	Tucker County (PDC 7)	7	8/13/2017	0
42	Upshur County	Upshur County (PDC 7)	7	8/13/2017	0
43	Grant County	Grant County (PDC 8)	8	5/2/2017	0
44	Hampshire County	Hampshire County (PDC 8)	8	5/2/2017	0
45	Hardy County	Hardy County (PDC 8)	8	5/2/2017	0
46	Mineral County	Mineral County (PDC 8)	8	5/2/2017	0
47	Pendleton County	Pendleton County (PDC 8)	8	5/2/2017	0
48	Berkeley County	Berkeley County (PDC 9)	9	2/28/2022	54
49	Jefferson County	Jefferson County	9	9/9/2018	13
50	Morgan County	Morgan County (PDC 9)	9	2/28/2022	54
51	Marshall County	Marshall County (PDC 10)	10	12/13/2016	0
52	Ohio County	Ohio County (PDC 10)	10	12/13/2016	0
53	Wetzel County	Wetzel County (PDC 10)	10	12/13/2016	0
54	Brooke County	Brooke County (PDC 11)	11	1/9/2017	0
55	Hancock County	Hancock County (PDC 11)	11	1/9/2017	0

STATE	2018 State Plan			**10/18/2018**	
STATE	2023 State Plan (aggregate county data)			**2023**	

APPENDIX G: Correlation To State Mitigation Plan Actions

ID	Description	Priority (H,M, L)	Responsible Agency	Potential Funding Sources	Interim Measure of Success	Target Completion Date	Hazard Mitigated	Comments
** Data Development **								
2010-58	Use State facilities vulnerability analysis (potential annualized losses) to prioritize State- owned facilities for mitigation project scoping.	H	DHSEM, Board of Risk and Insurance Management (BRIM)	Agency Budget	Acquire facilities vulnerability analysis from BRIM and establish project timeline	2015	All, except Dam & Levee	Flood, landslide, dams, levees
2010-16	Create advisory flood heights for all approximately detailed study A zones in the State (currently around 8,000 stream miles).	H	DHSEM, Floodplain Management Section	FEMA Risk MAP; FEMA post-disaster funding	Project schedule is on track with no changes.	2016	Flood	Flood
2010-66	Use 2013 State critical facilities risk assessment to target key State critical facilities vulnerable to loss of function due to utility outages, develop strategy for remediation.	H	DHSEM, BRIM	Agency budget	Develop list of key State critical facilities	2015	All, except Drought, Natural Resource Extraction, Hazardous Materials Release, Dan & Levee	Flood, landslide, dams, levees
2010-33	Develop digital mapping of landslide prone areas, updating current maps and making data accessible to others/all.	M	WV Geological and Economic Survey (WVGES), U.S. Army Corps of Engineers (USACE), DHSEM	Agency budget	Perform a cost estimate for mapping.	Ongoing as resources become available.	Karst/Landslide	Landslide
2010-43	Digitize hard-copy paper maps and surveys for karst topography, mine subsidence and landslide. Build on and utilize the statewide databases for geological hazards as new information is available from WVGES.	H	WVGES, WV Geographic Information Systems Technical Center (WVGISTC), USACE, FEMA	Agency budget	WVGES completed one database for earthquake epicenters in WV and has been incorporated into HIRA update. Use HIRA results to pinpoint facilities at risk for geologic hazards and use those areas as pilot studies for developing digitized mapped areas	Ongoing as resources become available.	Earthquake, Karst/Landslide	Landslide
2010-44	Develop a single, standardized critical facilities, geo-coded dataset for State and local critical facilities.	H	WV GIS Technical Center, DHSEM, WV BRIM	Agency budget	Determine facility types to be included in the database and what State facility attributes should be collected.	2014	All, except Dam & Levee	Flood, landslide

ID	Description	Priority (H,M, L)	Responsible Agency	Potential Funding Sources	Interim Measure of Success	Target Completion Date	Hazard Mitigated	Comments
2010-49	Perform a more comprehensive examination of State and critical facility vulnerability to natural hazards.	M	DHSEM, WV Geographic Information System Technical Center (WVGISTC), Contractor Support	Agency budget	Hazard data actions for data creation are in-progress	2015	Earthquake, Karst/Landslide	Landslide
2013-16	Creation of a statewide tax parcel for use in the HIRAITHIRA.	H	DHSEM, WVGISTC	Agency budget	Develop a prototype map that would consist of a pilot study to determine what would be possible if/when data was available or created.	2014 for pilot	All, except Dam & Levee	Flood, landslide
2010-19	Develop prioritized list of State-owned or leased facilities at risk of flooding and conduct detailed site assessment to develop site- specific mitigation action plans.	L	DHSEM	FEMA HMGP program	By January 2014, a list of State-owned or leased facilities has been analyzed and prioritized for flood risk	2014	Flood	Flood
2010-77	Support integration of local data from State vulnerability analysis into local plan updates for use in prioritizing mitigation projects.	H	DHSEM	Agency Budget	State vulnerability data has been compiled and distributed by July 2014	2015	All, except Dam & Levee	Flood, landslide
**** Flood and Landslide Risk Assessments ****								
2013-2	Collaborate with local communities to utilize State hazard categories and risk assessment methodologies in order to facilitate State review and roll-up.	H	DHSEM	Staff time	Plans submitted one year after distribution of the plan standards use the new plan format.	2015	All, except Terrorism, Dam & Levee	Flood, landslide
2010-45	Integrate 2013 HAZUS-MH 2.1 riverine flood analysis into 2016 risk assessment update.	H	DHSEM	Agency budget	Loss estimates from Phase I have been included in HIRA. Annualized losses for Phase II will not be available for the 2013 update and should be integrated into the next plan revision	2014	Flood	Flood
2010-51	Incorporate digitized WV landslide quadrangle maps to support landslide risk analysis for the 2013 Mitigation Plan Update.	M	WVGES, WVU, WV Dept. of Transportation (WVDOT)	Agency budget	Maps have been georeferenced from the USGS reports. WVDOT Tied to 2010-43 and 2013-13 for statewide data sources.	2016	Karst/Landslide	Landslide

ID	Description	Priority (H,M, L)	Responsible Agency	Potential Funding Sources	Interim Measure of Success	Target Completion Date	Hazard Mitigated	Comments
2013-11	Collaborate with PDCs and local jurisdictions for standardization of hazard data and classifications for assessment of hazards in local mitigation plans in order to aid in future roll- up in the State Hazard Mitigation Plan (i.e., standard GIS layers).	H	DHSEM, WVGISTC	Staff time	Plans submitted one year after distribution of the data standards follow the new data format.	2015	All, except Dam & Levee	Flood and Landslide
2013-12	Develop feedback loop between DHSEM and RPDCs to make recommendations to improve process for next planning cycle.	M	DHSEM	Staff time	By December 2013, conduct a survey with RPDCs to gain feedback on current planning process.	2016	All, except Dam & Levee	Flood, Landslide
2013-13	Leverage the landslide inventory database and landslide rating research project. Pilot study will spatially document landslide occurrences along roadways.	M	WVDOT Program, Planning and Admin Division	Agency budget	Consolidate landslide data into single resource. Incorporate District 2 pilot study (Fall 2013) in the 2017 HIRA update.	2014	Karst/Landslide	Landslide
2013-25	Continue community outreach (public meetings) for coal dam emergency warning measures	M	DEP	Agency budget; federal funds	Determine specific venues/time periods in which to conduct outreach	Ongoing	Flood	Flood
2013-28	Disseminate risk assessment information for communities near coal impoundments (i.e., news dept. includes this as a regular feature)	M	Public Broadcasting	Agency budget	Develop content to include talking points	Ongoing	Flood	Flood
**** USACE Dam/Levee Risk Assessment ****								
2013-5	Coordinate with NRCS and USACE on levee safety issues.	M	WV DEP Division of Water and Waste Management	Agency budget; Silver Jackets program	By March 2014, create a task force to address levee safety in West Virginia.	2015	Flood, Crime, Terrorism	Flood
2010-55	Prioritize dam inspections and integrate known dam locations and downstream inundation zones, in accordance with risk, with location of residential communities and critical facilities at risk into the Flood Determination Tool.	Critical	DHSEM, Floodplain Management Section, WVCA, NRCS, USACE, WVGISTC	Agency budget	Prioritize dam inspections in accordance with risk and those that do not have an EAP digitized. Upload dam failure maps into flood tool.	2014	Flood	Flood
	Perform pilot losses-avoided study for				Consolidate benefit- cost			

ID	Description	Priority (H,M, L)	Responsible Agency	Potential Funding Sources	Interim Measure of Success	Target Completion Date	Hazard Mitigated	Comments
2010-79	area with contiguous mitigated properties and convey results to policy makers, local government project sponsors, and property owners.	H	DHSEM, USACE	Agency budget	analysis (BCA) data into single location. USACE pilot study of losses in areas with and without nonstructural mitigation.	2016	Flood	Flood
2010-48	Further investigate implications for the State of climate change as it relates to potential future changes in temperature, storm track, and frequency as well as lake-effect and other winter weather processes.	M	DHSEM, National Oceanic and Atmospheric Administration (NOAA) National Weather Service, State Climatologist, BRIM, Contractual Assistance, Public Service Commission	Agency budget	USACE is leading an interagency climate change study for the Ohio River Basin to evaluate the impact of climate change on water resources and develop mitigation strategies.	2015	All, except Crime, Terrorism, Dam & Levee	Flood, landslide
2010-79	Perform pilot losses-avoided study for area with contiguous mitigated properties and convey results to policy makers, local government project sponsors, and property owners.	H	DHSEM, USACE	Agency budget	Consolidate benefit- cost analysis (BCA) data into single location. USACE pilot study of losses in areas with and without Nonstructural mitigation.	2016	Flood	Flood
2013-14	Incorporate climate change data for operating reservoirs.	H	USACE, NRCS, and WVCA	NIA should be researched for incorporation	Use and review of USACE report data (climate change study in Ohio Basin)	2015	Hurricane/Wind, Thunderstorm, Winter Storm, Flood, Tornado, Drought	Flood
2013-15	Integrate Dam and Levee safety action class (class 1 -5) for every USACE dam and levee into HIRA and THIRA.	H	USACE, FEMA	Agency budget	Obtain the rating and accreditation data for dams and levees in West Virginia.	2015	Flood	Flood
2013-17	Complete inundation flood risk mapping on streams that do not have hydrology & hydraulics modeling.	M	NWS, USGS,USACE, WVGISTC	Agency budget	Review USGS and NWS portals for inundation mapping on stream gages. Prioritize streams that do not have modeling and install stream gauges.	2015	Flood	Flood
2013-19	Develop an inter-agency flood risk management Silver Jackets Team and approve a charter	H	DHSEM, USACE	Agency budget	Assemble a committee of interested agencies for developing the flood risk management team	2014	Flood	Flood