PRELIMINARY RESULTS OF RECENT LANDSLIDE SUSCEPTIBILITY MAPPING IN ALBEMARLE AND NELSON COUNTIES, VIRGINIA

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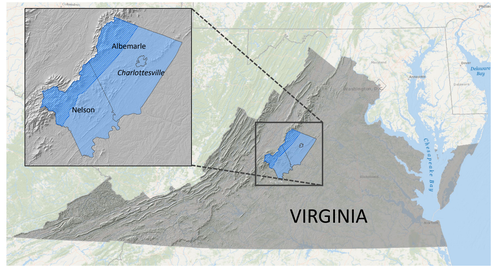
In 2018 and 2020, the Virginia Department Energy – Geology and Mineral Resources Program (GMR) was awarded Pre-Disaster Mitigation (PDM) grant funds from the Federal Emergency Management Agency (FEMA), through the Virginia Department of Emergency Management (VDEM), to conduct landslide susceptibility mapping in the Nelson and Albemarle Counties in central Virginia. Located along the eastern slopes of the Blue Ridge Mountains, these counties suffered severe landslide damage due to Hurricane Camille in 1969 and a strong series of storms in 1995.



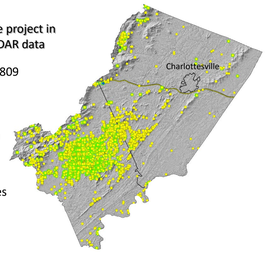
The PDM project areas are indicated in blue. The areas with dark blue hatching were completed and delivered to VDEM and FEMA in 2022. The remainder of the study area will be delivered in September 2024.

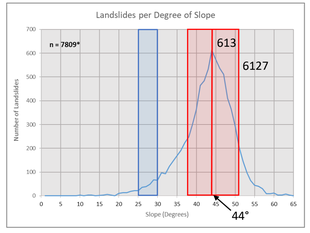
Landslide Inventory Update: April 2024

A robust landslide inventory is useful for performing spatial statistics using pre-existing datasets such as slope, aspect, elevation, geology, etc. This data is used to constrain the susceptibility modeling and provides valuable information to planners and emergency managers about past landslide activity.

This will be the first county-scale landslide project in Virginia to use high-resolution 1-meter LIDAR data

- Landslides identified (headscarps): 7809
- Hurricane Camille 1969: 7241 (93%)
- June 27, 1995 Storm: 189 (2%)
- Landslides field verified by a Virginia Energy geologist: 415 (5%)
- Landslide outlines (tracks): 1772
- 73 Weathered & 146 Relict Landslides
- Ancient landslide deposits: 1592
- 98% of landslides occur on slopes greater than 25°

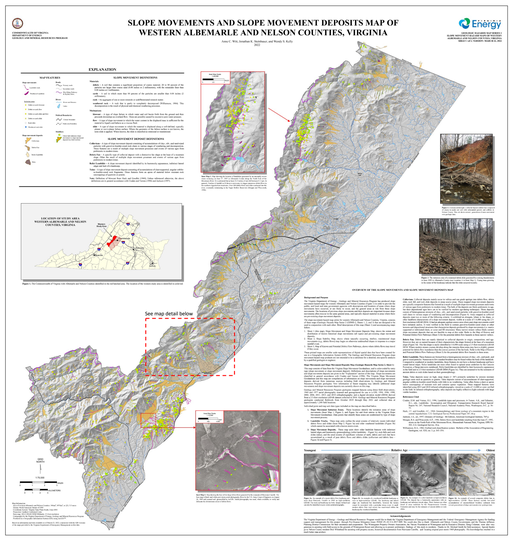




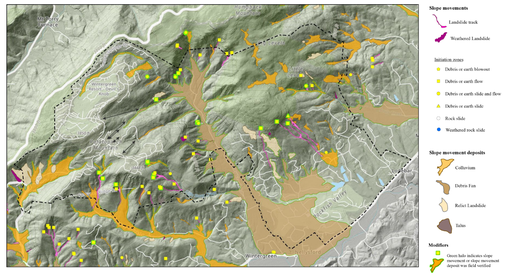
Slope values were calculated from a LIDAR slope raster for each landslide location. The median slope value for all landslides was 44° with 6127 (78%) of the slides falling between 37° and 51° (the STD of the dataset). Nearly 98% of all slides occur on slopes ≥25° which comprises only 11% of the study area. This results in a landslide density of 59/mi². For higher degrees of slope, between 40° and 50°, landslide density increases to 754/ mi².

The initial 2022 deliverables to FEMA/VDEM included a set of three maps (Geologic Hazards Map Series 2, Sheets 1, 2, and 3) designed to be used in conjunction with each other. Sheet 1 shows an inventory of modern landslides and prehistoric landslide deposits, Sheet 2 uses a weighted raster overlay to show where shallow landslides like debris flows are likely to start during a heavy rainfall event, and Sheet 3 shows where debris flows are likely to inundate if they occur and vulnerable infrastructure that could be at risk. Virginia Energy also provided a "how-to" guide for landowners to assist them with interpreting the maps. The initial 2022 susceptibility mapping provided a "proof of concept" for the county-wide study area. Finalized map deliverables and GIS data will be provided to VDEM in September 2024.

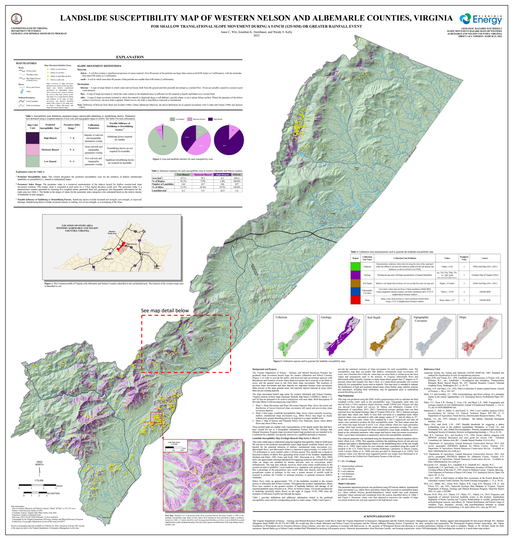
1 Landslide Inventory Map



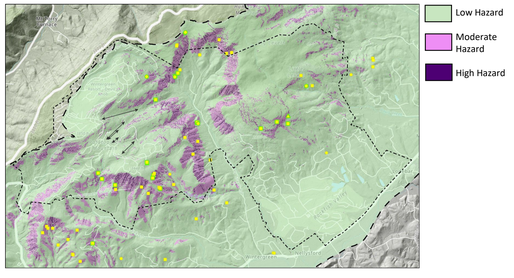
Sheet 1 consists of data from the Virginia Slope Movement Geodatabase and is color-coded by landslide type. Slope movements are classified in general accordance with Cruden and Varnes (1996) and include landslide initiation zones (points), landslide tracks (polygons), and ancient landslide deposits (polygons). Features were mapped using a combination of direct field observations, post-Camille historical aerial photography, 1994-2022 orthophotography, and 2016 1-meter resolution LIDAR.



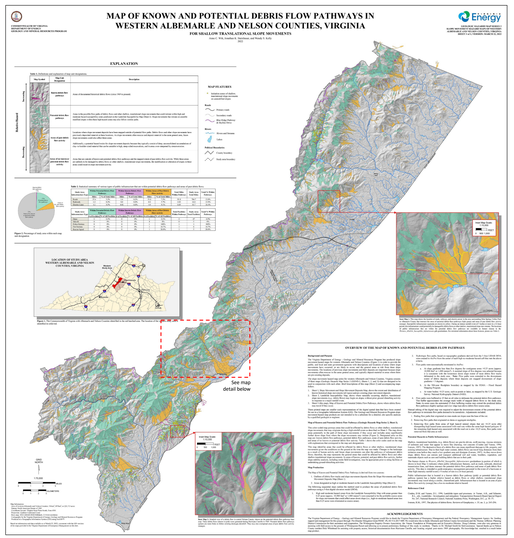
2 Landslide Susceptibility Map



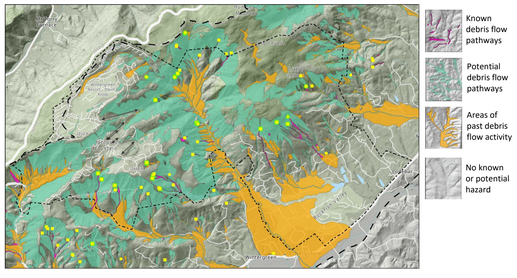
Sheet 2 shows predicted susceptibility zones for the potential initiation of shallow, translational landslides like debris flows and slides in response to ≥5-inches of rainfall within a 24-hour period. The map was produced using ESRI ArcPro geoprocessing tools to calculate a weighted overlay raster. Parameters for topographic curvature and slope were derived from 5-foot resolution LIDAR while those for soil (depth, cohesion) and geology were derived from USDA digital soil surveys (2013, 2021) and the digital Geologic Map of Virginia (2021).



3 Landslide Pathway Map

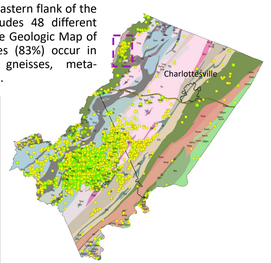


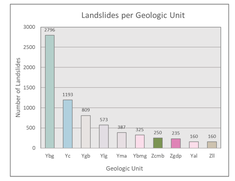
Sheet 3 shows areas that could be affected by debris flows that may originate during a high-rainfall event. Predicted pathways were generated through a series of steps using ESRI ArcPro. Hydrologic flow paths were generated from the high and moderate hazard zones in Sheet 2 and automatically terminated downslope at slope gradients of ≤5° or at mapped FEMA floodplains. Flow paths were buffered to 25 feet to delineate the width of the pathways. The buffer approximates the average track width of mapped debris flows from Sheet 1.



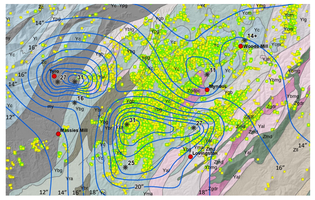
Updated Landslide Statistics: Geology

The study area is within the central and eastern flank of the Blue Ridge Geologic Province and includes 48 different geologic units, based on geology from the Geologic Map of Virginia (2021). Nearly all the landslides (83%) occur in middle-to-late Proterozoic basement gneisses, meta-granitoids, and other meta-intrusive rocks.





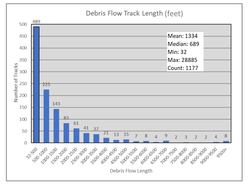
Porphyroblastic biotite-plagioclase augen gneiss (Ybg) and charnockite (Yc) underlies 10% of the county, and 3989 landslides initiate from these units. There are also ~250 landslides that initiate in the Catoctin Formation metabasalt (Zcmb), however this cohort is primarily associated with a 1995 storm event (purple dashed box above).

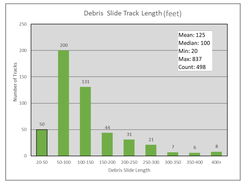


Unlike the 1995 storm event in Albemarle County, there is not a clear correlation between precipitation and landslides generated during Hurricane Camille in 1969. While extreme rain occurred west of the Rockfish Valley high-strain zone (my), relatively few landslides occurred in these areas. Other factors, such as geologic structure or foliation, may have played a larger role in landslide initiation.

Updated Landslide Statistics: Track Length

Statistics regarding landslide track length and width are necessary for creating the potential debris flow pathways map (Sheet 3). Centerline measurements for over 1600 tracks were compiled using automated processing in ESRI ArcPro. Results were as expected, debris flows tended to have much longer runout lengths than debris slides, however a handful of flows had extreme lengths up to 5.3 miles.





GIS map of Davis Creek in Nelson County. Nearly every first and second order stream in this area was inundated, generating a massive debris flow 5.3 miles long.

Aerial photograph of the Davis Creek area of Nelson County, where 52 lives were lost in 1969.

For more information about this project, please visit our website: **https://www.energy.virginia.gov/geology/FEMA_landslide.shtml**

References:

Cruden, D.M. and Varnes, D.J., 1996, Landslide types and processes, in Turner, A.K., and Schuster, R.L., eds., Landslides - Investigation and mitigation: Transportation Research Board Special Report No. 247, National Research Council, National Academy Press, Washington, D.C., p. 36-75.

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