Using LAHARZ to determine potential inundation associated with a surface mining-related debris flow in the Appalachian coalfields of southwestern Virginia, USA.

August 15-17, 2017

Geohazards in Transportation in Appalachia Technical Forum

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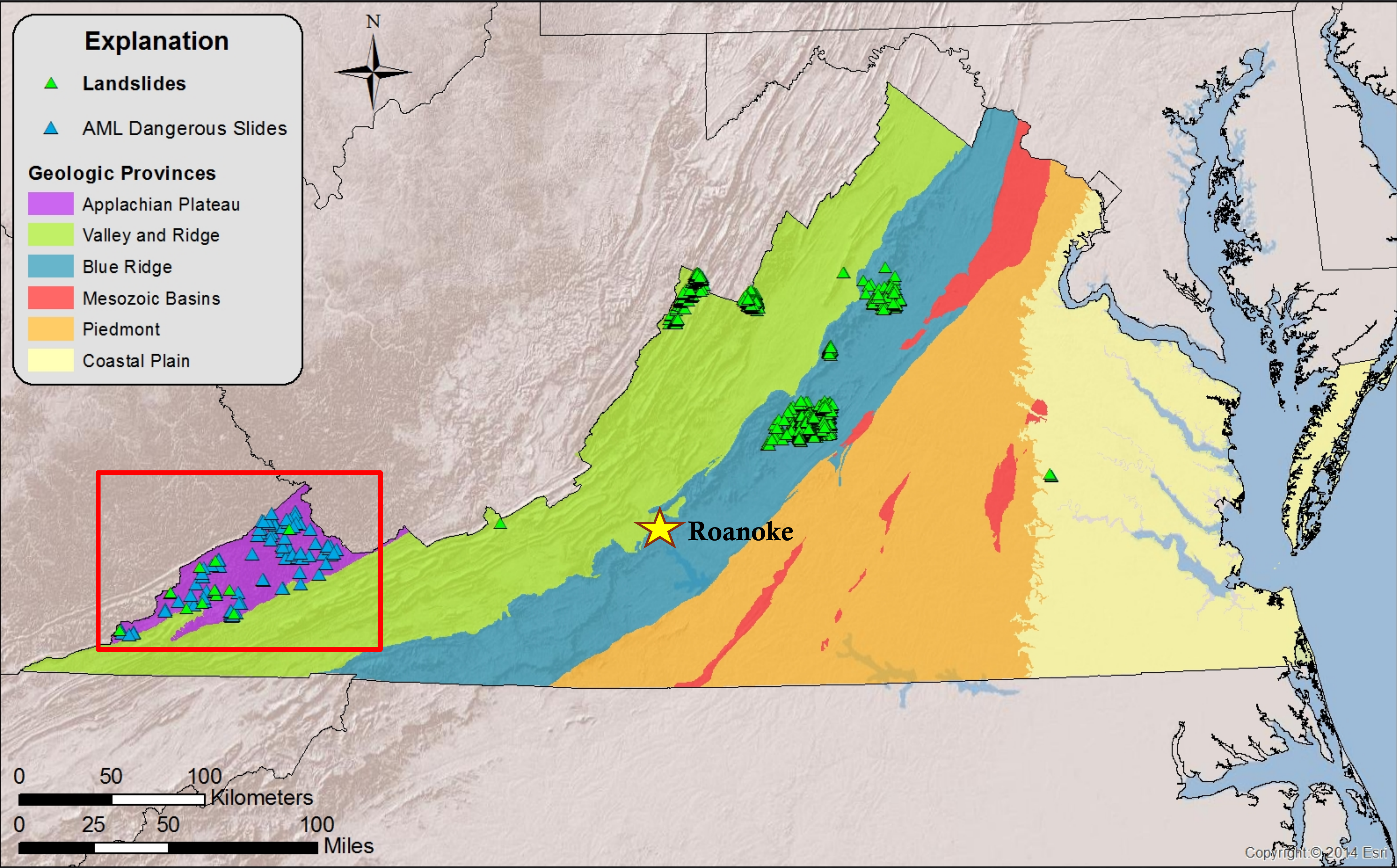
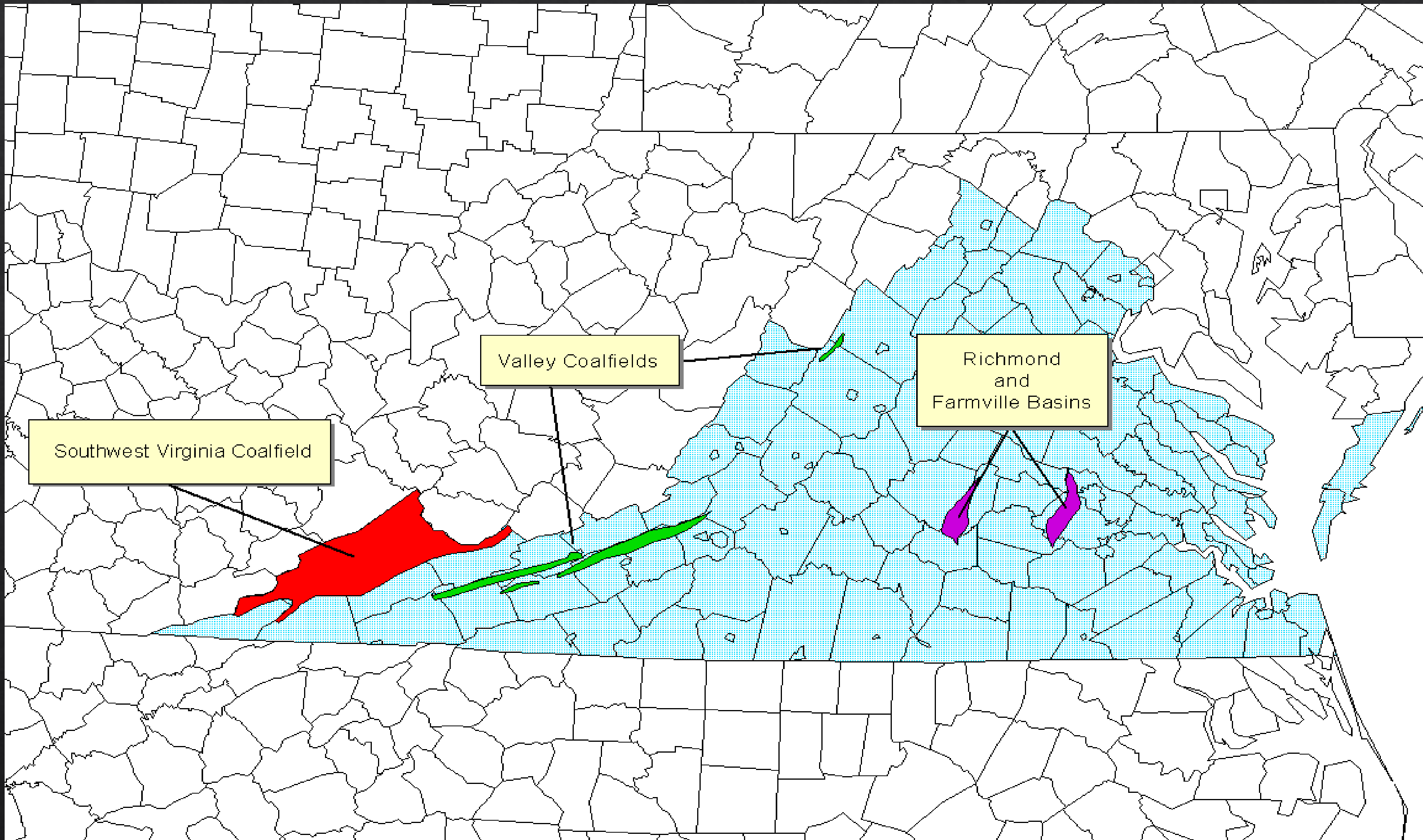
DMME Virginia Department of Mines Minerals and Energy



The VA DGMR landslide geodatabase currently has >5,300 landslide points, primarily associated with Hurricane Camille in 1969 (3,700+)



SW Virginia has accounted for nearly all of Virginia’s coal production since the 1950’s

Virginia’s Abandoned Mine Land (AML) Program

- AML maintains a GIS inventory of hazards associated with coal mines excavated before 1977
  - Subsidence, acid mine drainage, stream sedimentation
  - Landslides from mine benches and spoil
  - Rockfalls from steep highwalls
  - Currently there are 150+ “dangerous slides” in the AML GIS database
- If the mine is considered abandoned AML can apply for grant from OSM to repair and reclaim the site
- AML requested assistance from DGMR in June 2015 for several landslides originating from coal mines in March 2015

Debris Slide

Fawn Branch
Lee County, VA
March 2015

Debris Slide

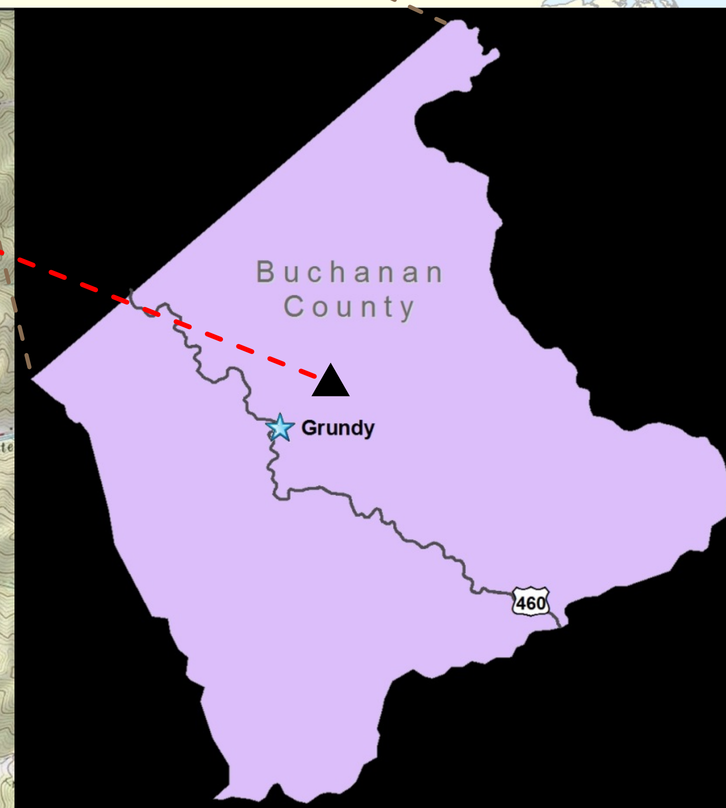
Jakes Branch
Dickenson County, VA
May 2015???

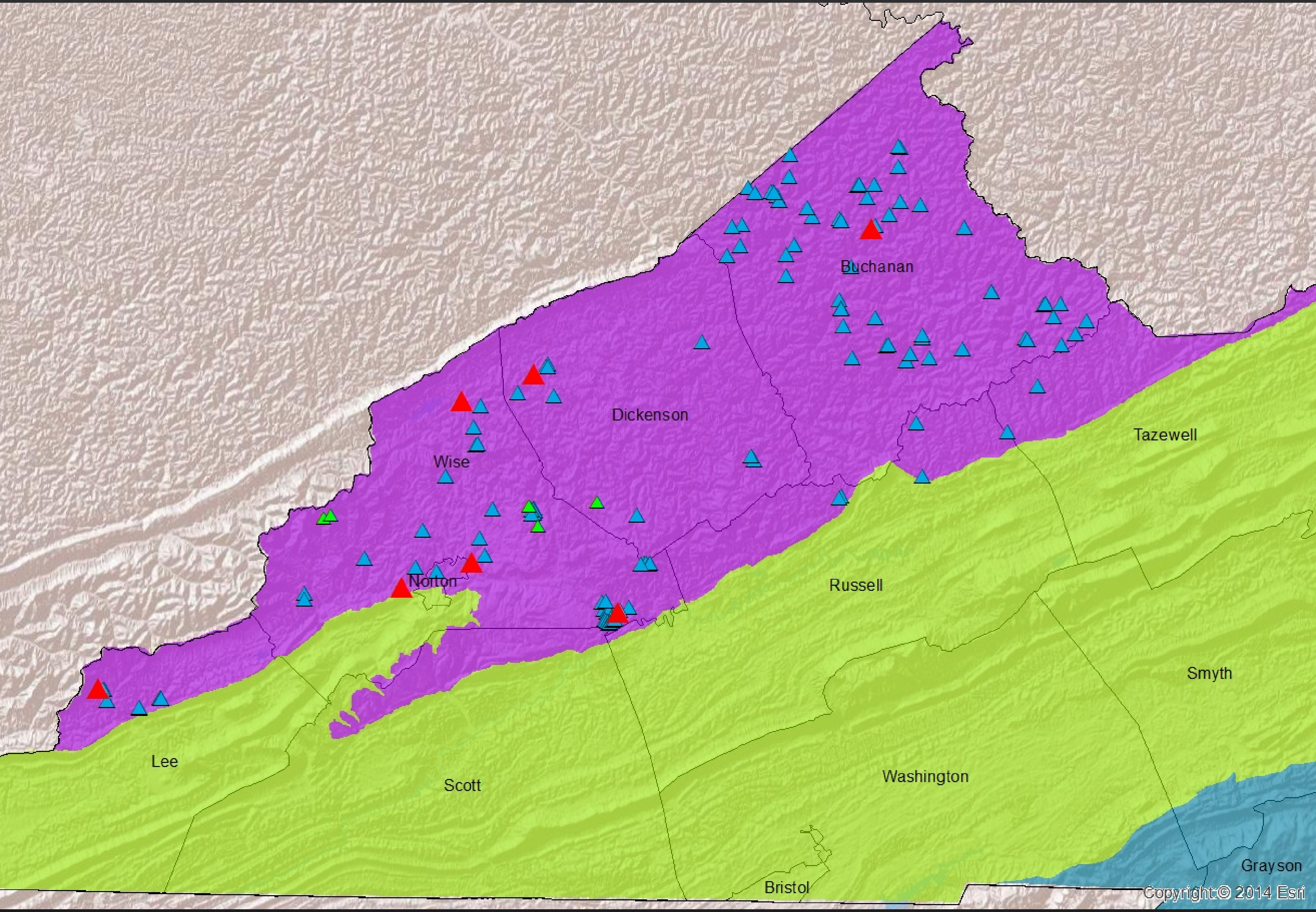
Debris Slide

Bolling Slide
Pound, VA; Wise County
March 2015

Debris Slide-Flow

Elkins Branch
Buchanan County
March 2015




Buchanan
Dickenson
Wise
Norton
Tazewell
Russell
Smyth
Lee
Scott
Washington
Grayson
Bristol
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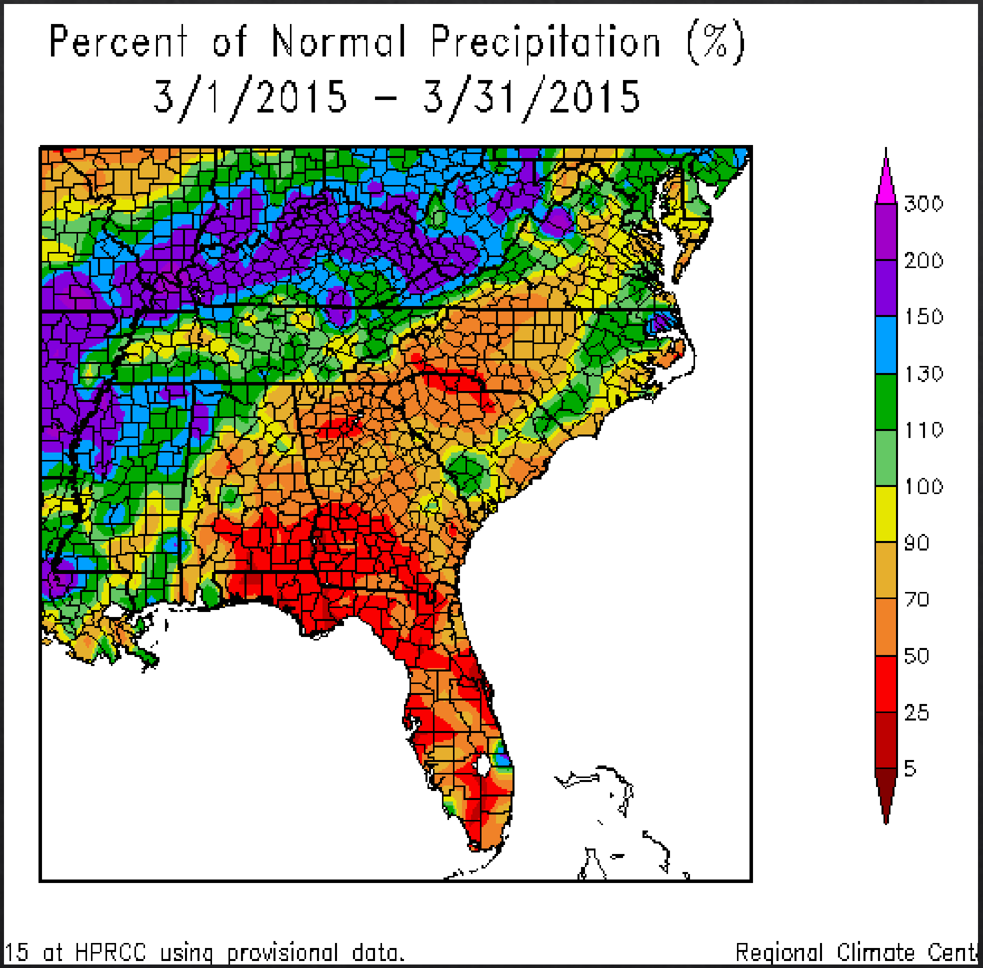
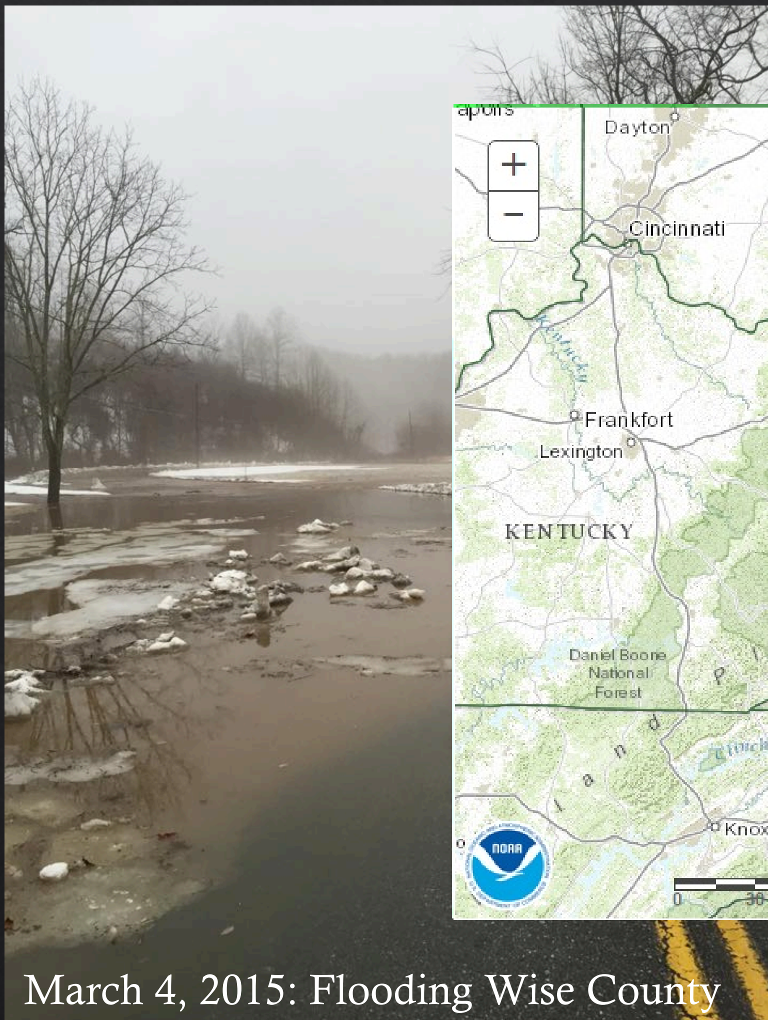
Meteorological Conditions

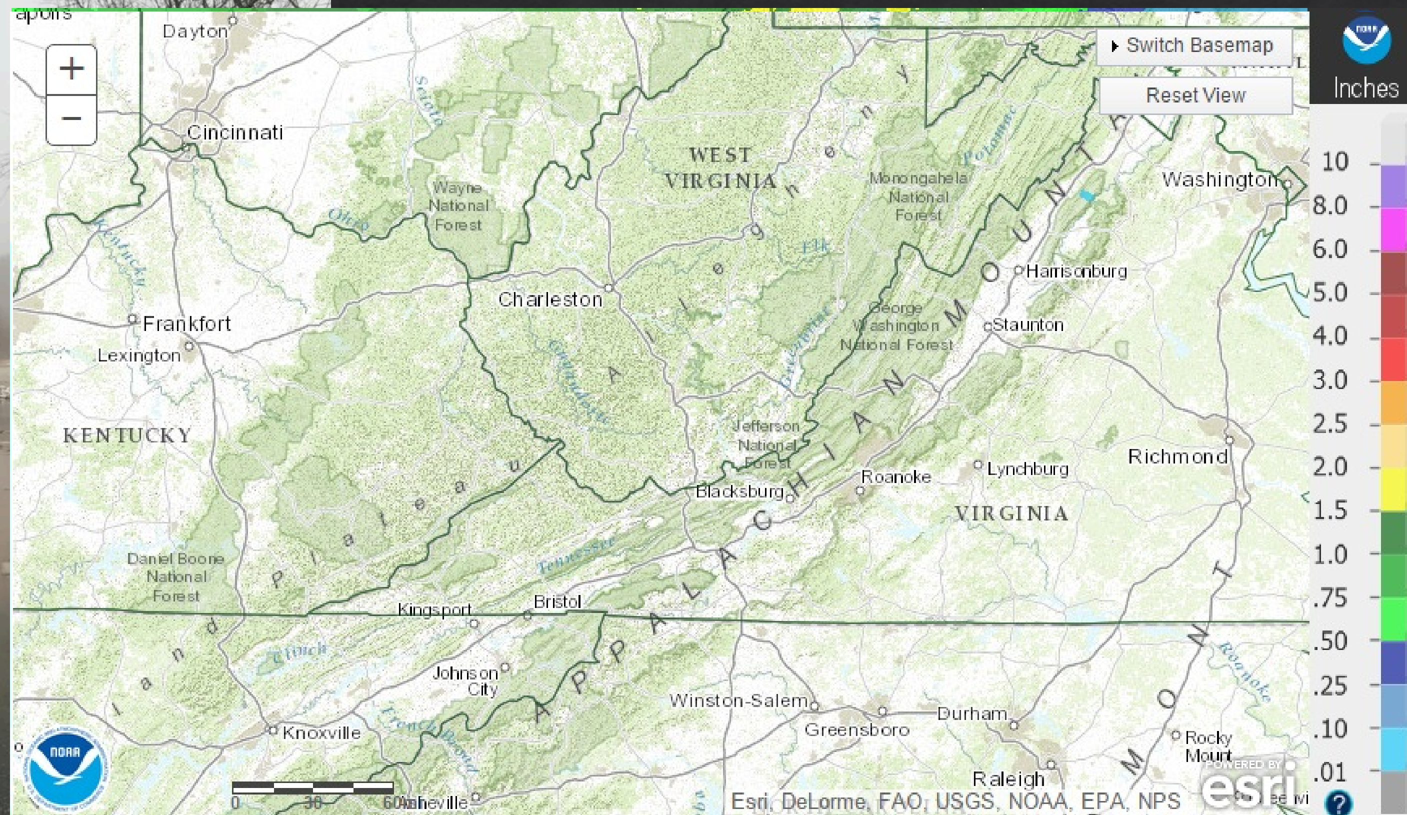


March 3-6 Rainfall/snowmelt was a likely trigger for numerous slides across SW Virginia

Meteorological Conditions

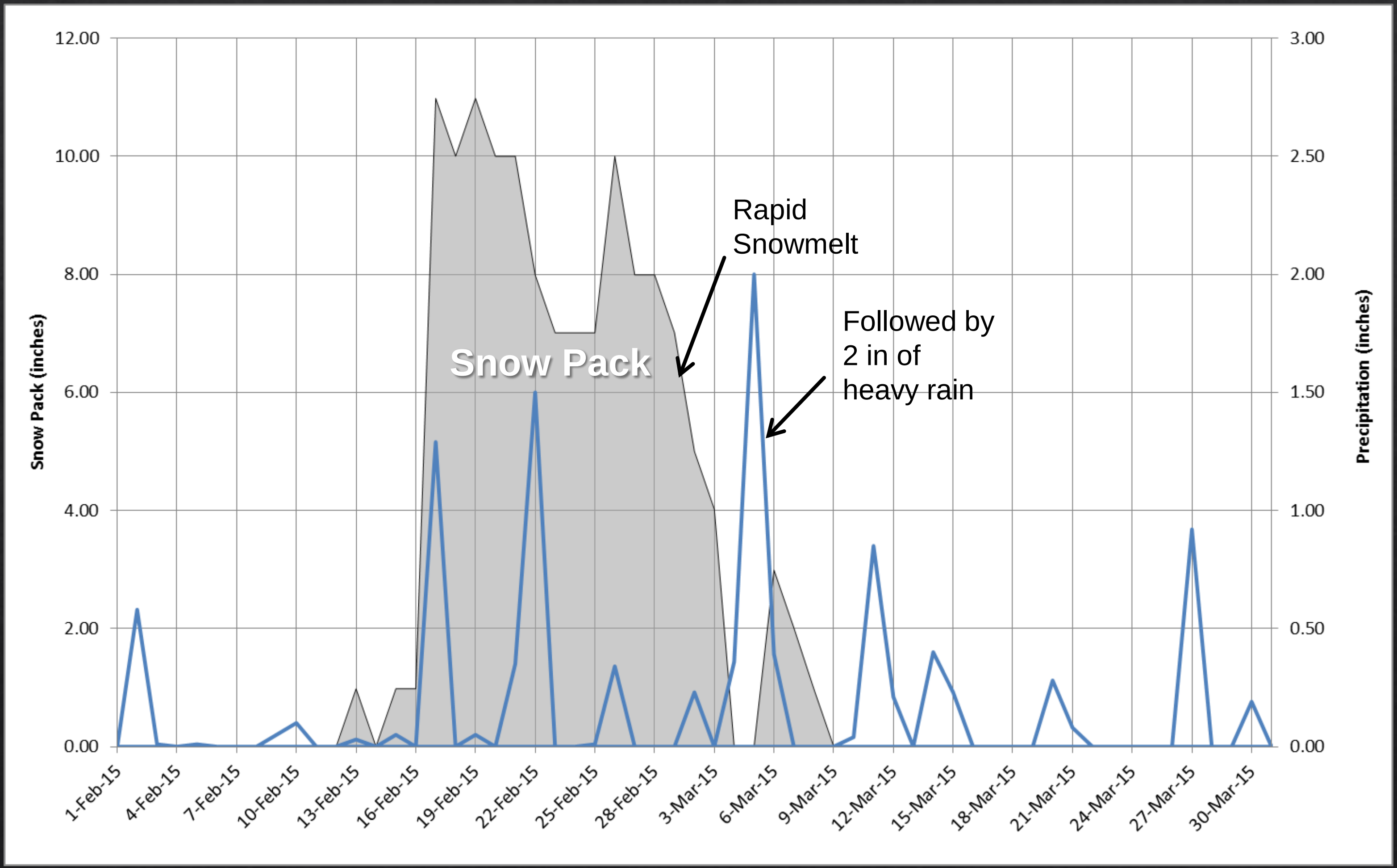


March 4, 2015: Flooding Wise County



March 3-6 Rainfall/snowmelt was a likely trigger for numerous slides across SW Virginia

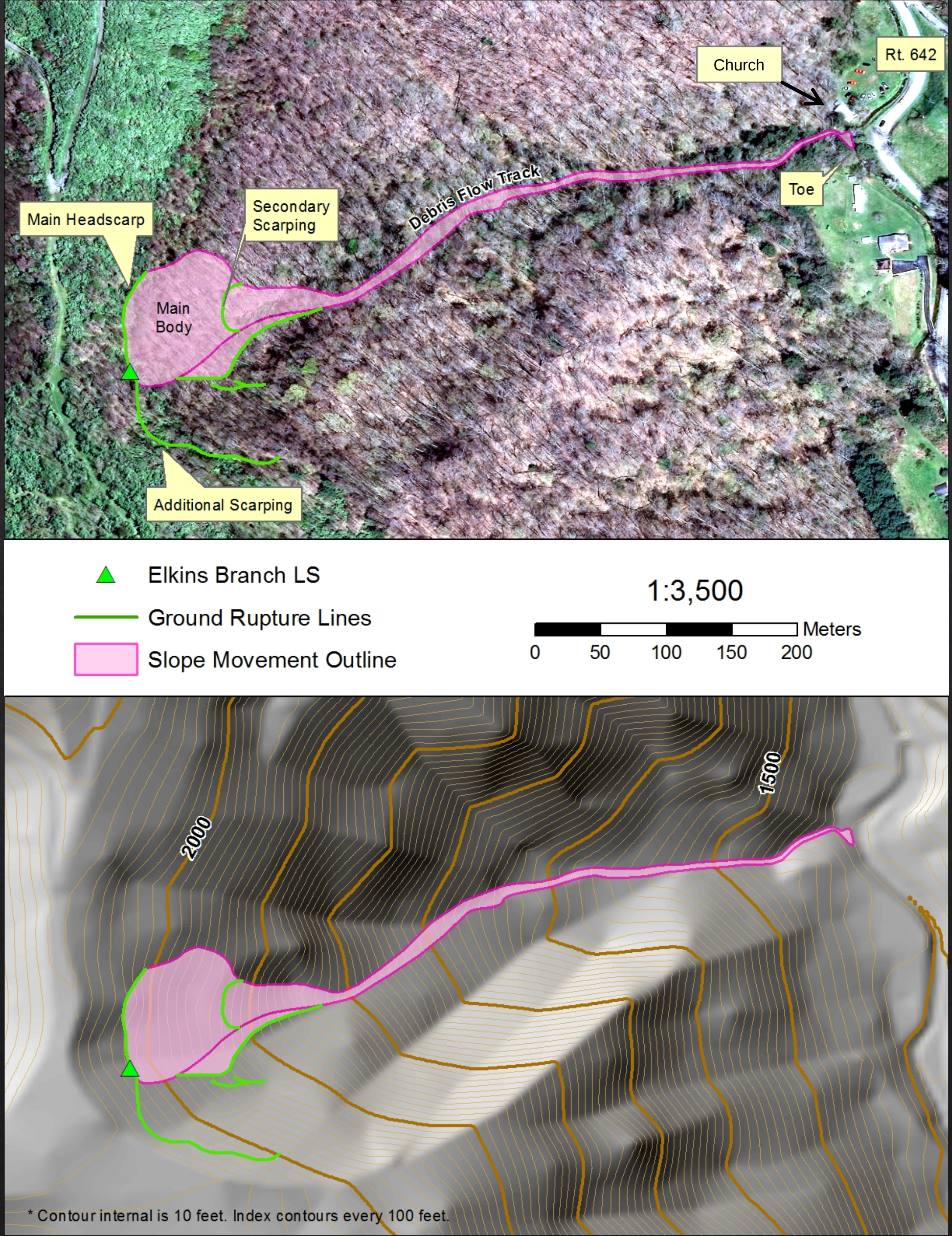
Meteorological Conditions
Grundy Station

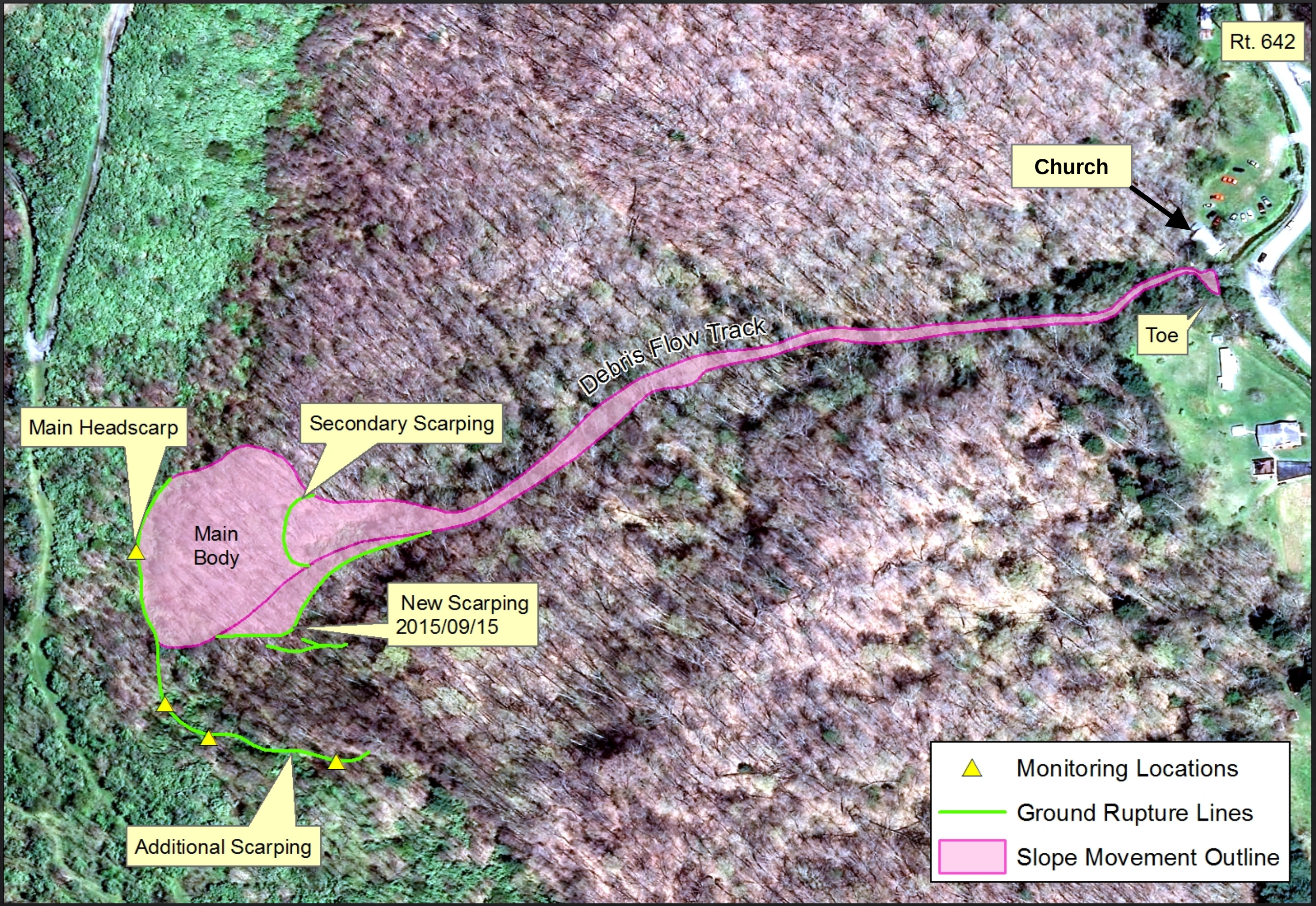


March 3-6 Rainfall/snowmelt was a likely trigger for the reactivation of this landslide

Field Investigation

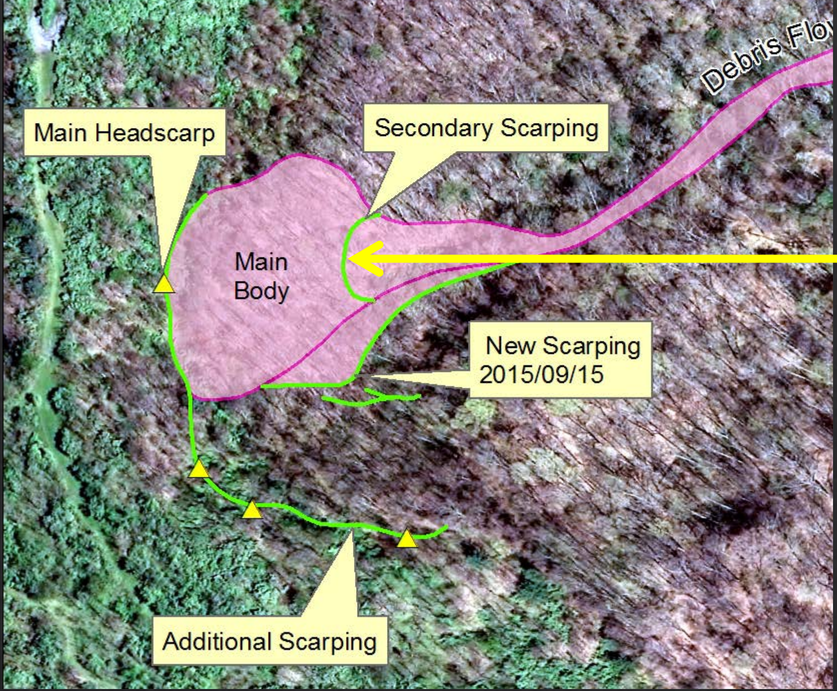
- 487 m long (1600 ft)
- Dropped ~180 m (600 ft) in elevation
- Inundated area = 6800 m^2 (1.7 acres)
- Estimated Volume of Failed Material (along track and toe) = 766 m^3 (1000 yd^3)
- All data collected using the ArcGIS Collector app for iOS





- Originated within mine spoil related to pre-1977 surface mining
- Scarping worsened between site visits in June, July, & September, probably due to heavy rain in mid-August
- Movement is occurring within the main body of the slide and along scarping to the south, actively shedding debris into Elkins Branch


Debris Flo
Main Headscarp
Secondary Scarping
Main
Body
New Scarping
2015/09/15
Additional Scarping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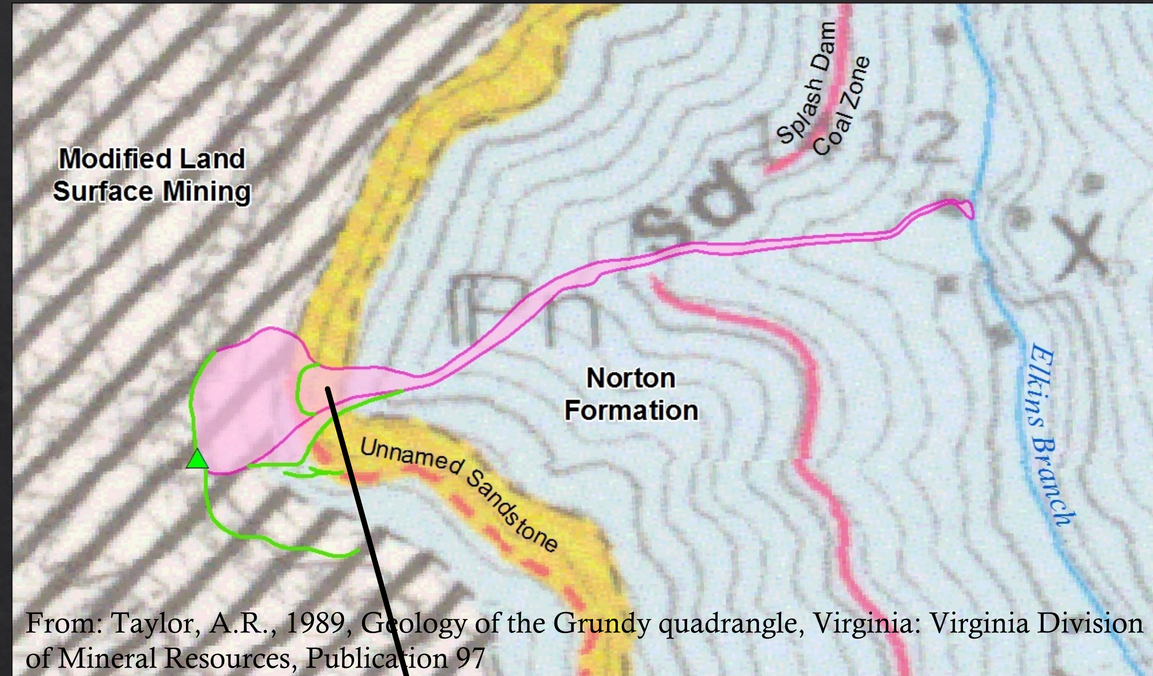
Additional Scarping


Debris Flo
Main Headscarp
Secondary Scarping
Main
Body
New Scarping
2015/09/15
Additional Scarping

Geological Conditions

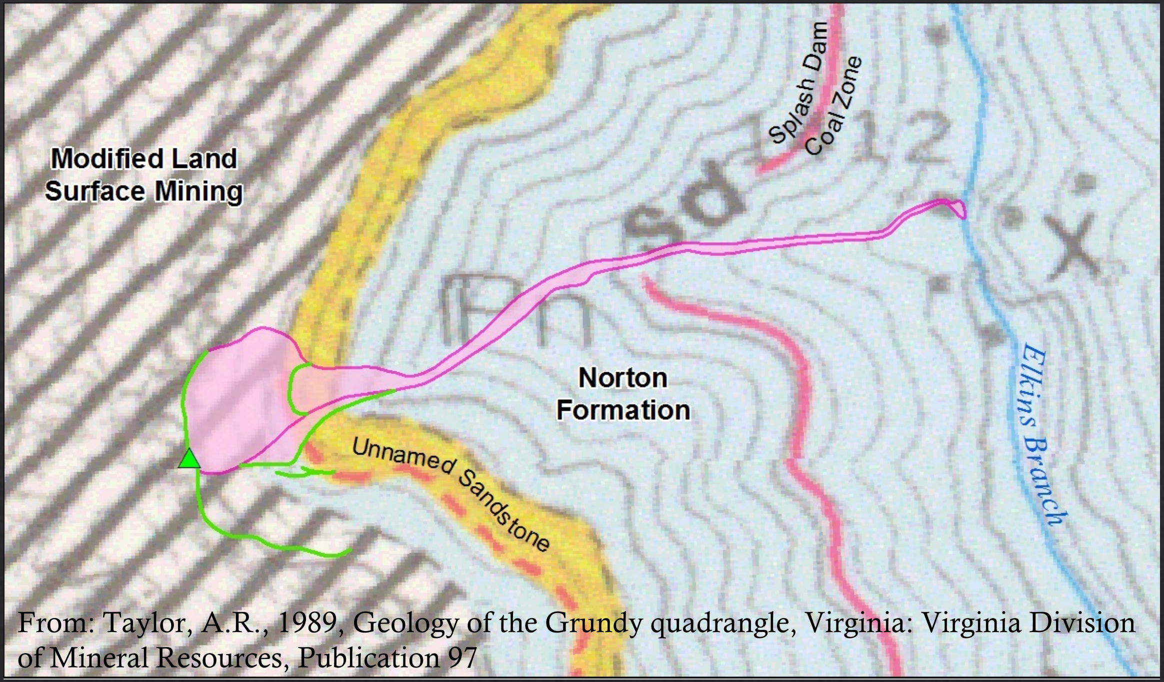
- Slide material: medium-to-fine-grained soil/spoil material with coarse, angular fragments of sandstone, siltstone and coal
- Included boulders up to 3 feet
- Underlain by Norton Fm. - Pennsylvanian-aged sedimentary unit



From: Taylor, A.R., 1989, Geology of the Grundy quadrangle, Virginia: Virginia Division of Mineral Resources, Publication 97

Geological Conditions

- Outerbridge (1979) used a combination of aerial photography interpretation and field mapping to identify surficial features
- Upper slide area noted as “earth flow in strip castings” indicating this area my have been active as early as 1979



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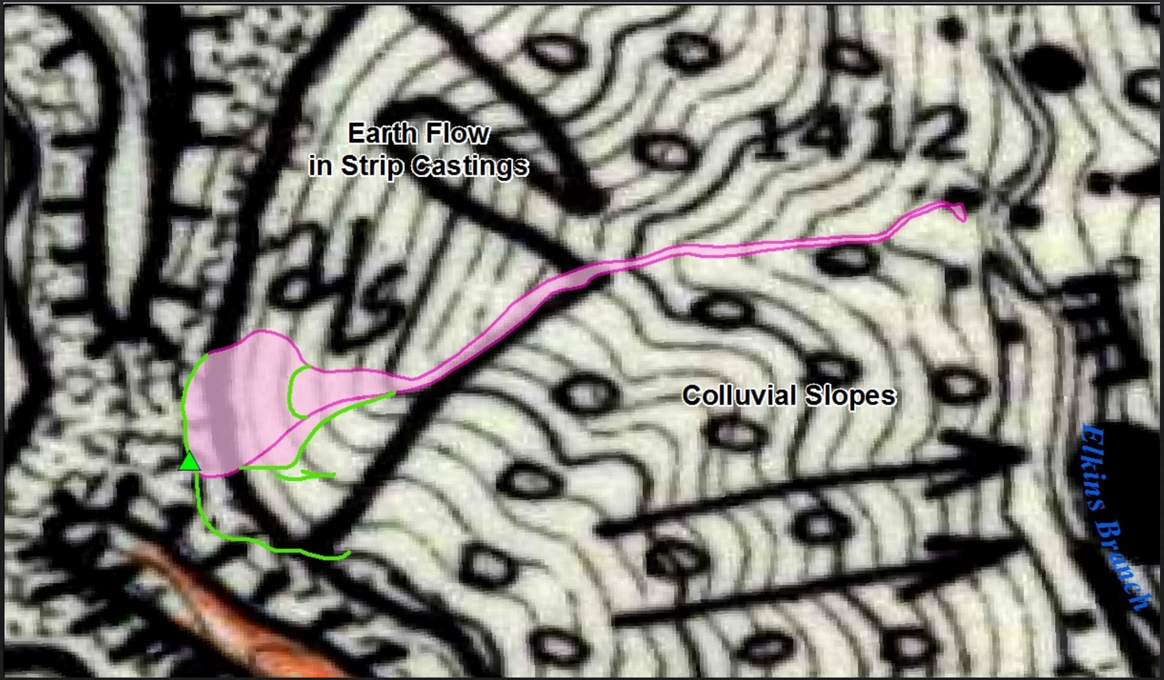


From: Outerbridge, W.F., 1979, Landslides and Related Features of the Grundy, VA. Quadrangle: U.S. Geological Survey, Open-File Report OF-79-714 (C-16)

The LAHARZ Model

Schilling and Iverson (1997); Iverson et al (1998); Griswold and Iverson (2008); Schilling (2014)

- Originally developed for volcanic debris flows
- Uses an ArcGIS interface; written in Python
- Software requires:
  - DEM to model topography, generate hydrologic flow paths
  - Set of estimated volumes (m^3)
  - Location of debris flow initiation
- Result: Hazard Map of "nested" inundation scenarios

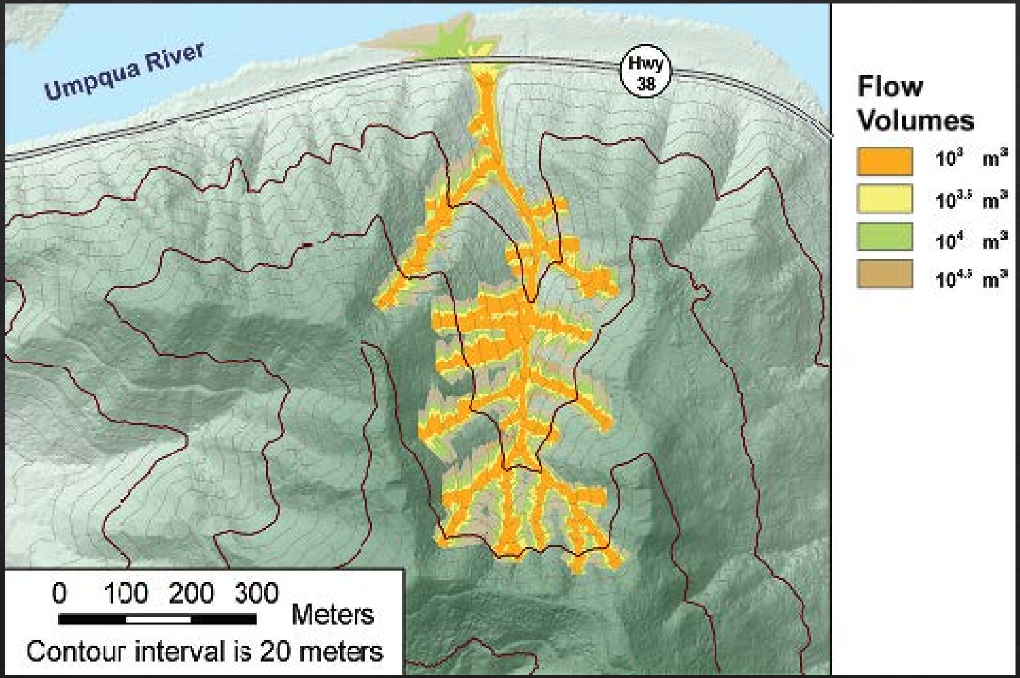


Figure from Griswold and Iverson (2008)

The LAHARZ Model

Schilling and Iverson (1997); Iverson et al (1998); Griswold and Iverson (2008); Schilling (2014)

Two Predictive Equations:

- A = Maximum Cross-sectional Area
- B = Total Planimetric Area
- V = Flow Volume raised to the 2/3 power
- α = proportionality coefficient

$A = \alpha_1 V^{2/3}$, and

$B = \alpha_2 V^{2/3}$,

Figure from Griswold and Iverson (2008)

Lahars:

$A = 0.05 V^{2/3}$

$B = 200\ V^{2/3}$

Debris Flows:

$A = 0.1 V^{2/3}$

$B = 20\ V^{2/3}$

Model Parameterization

- 10-foot DTM derived from 2011 orthophotography
- Measured volume of debris flow track (766 m^3)
- Adjusted proportionality coefficients:

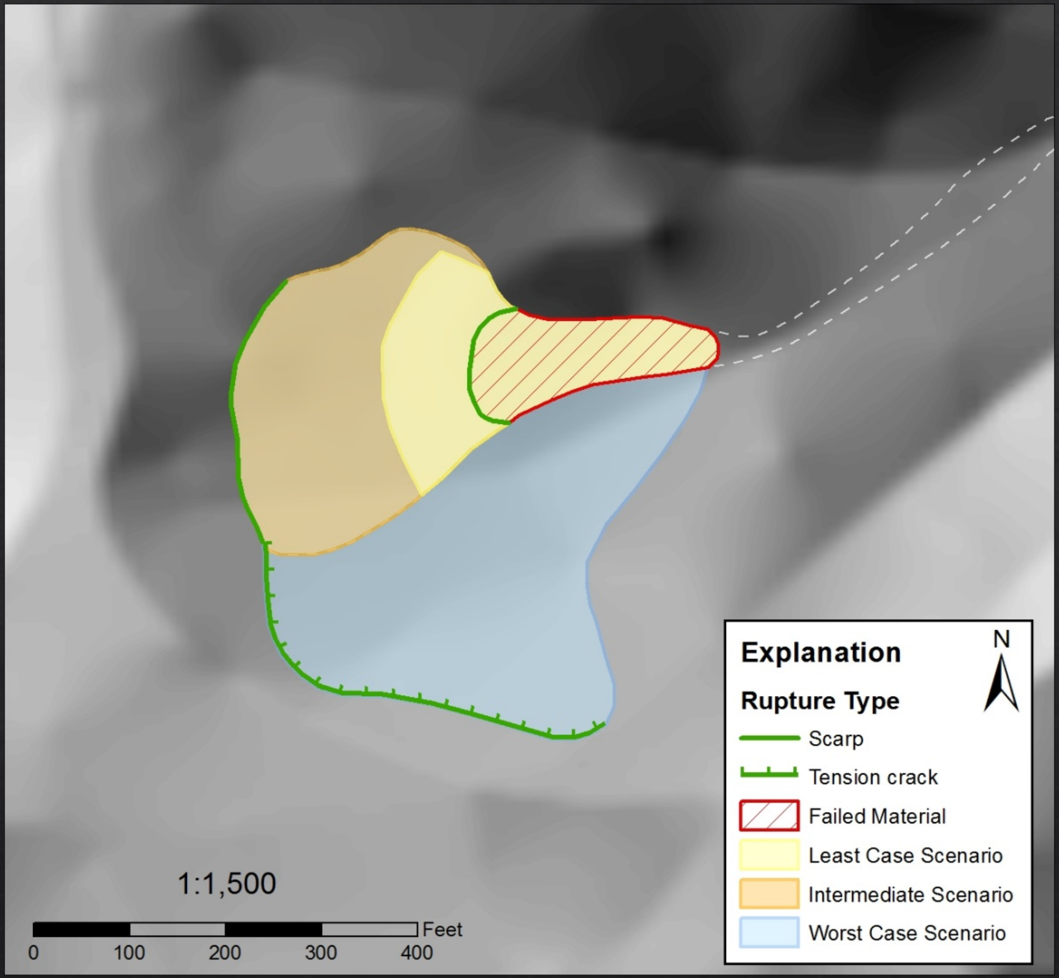
$$A = 0.03V^{2/3}$$

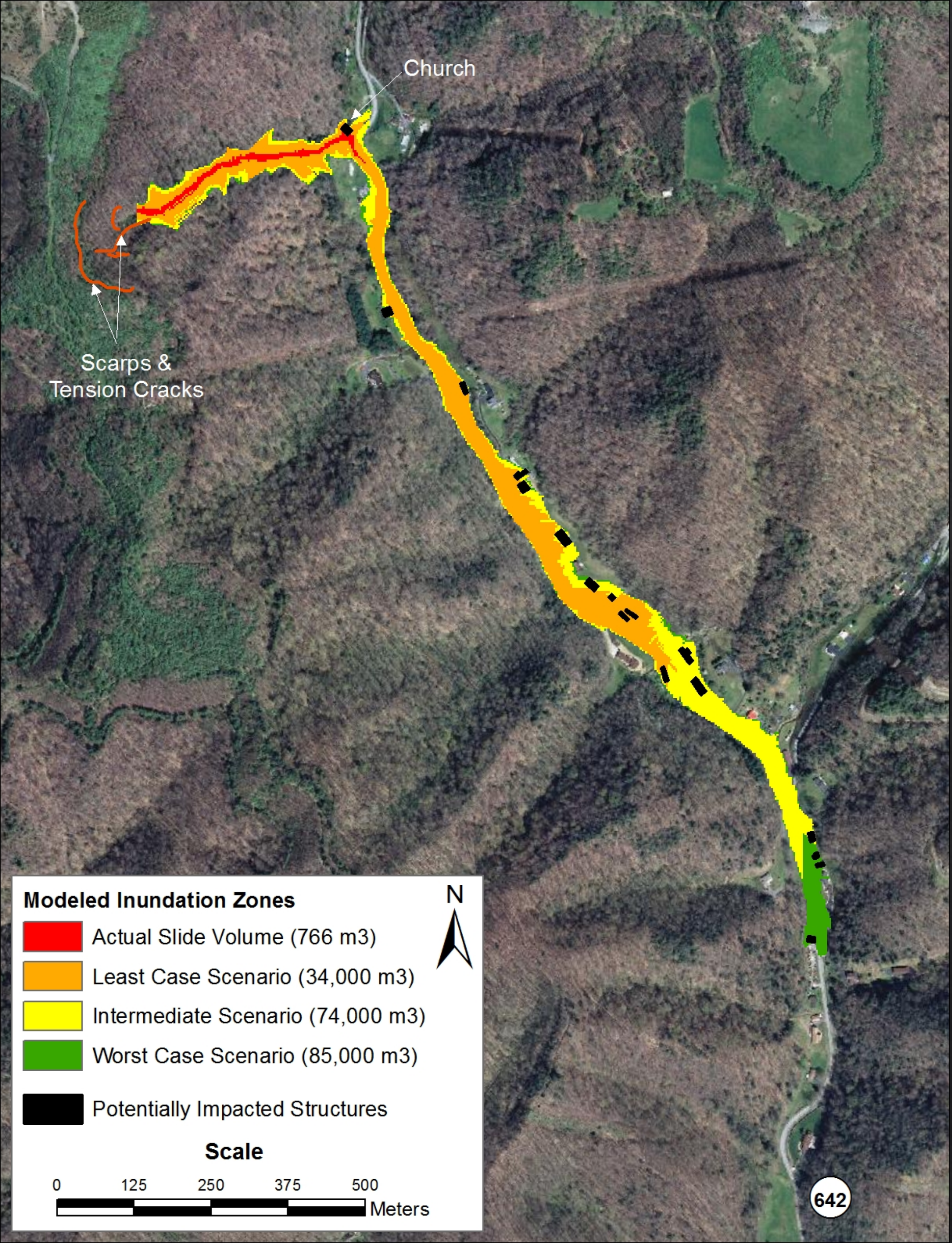
$$B = 45V^{2/3}$$

- Without a historical debris flow dataset, could not adjust the 2/3 slope best-fit regression model

Volume Calculation

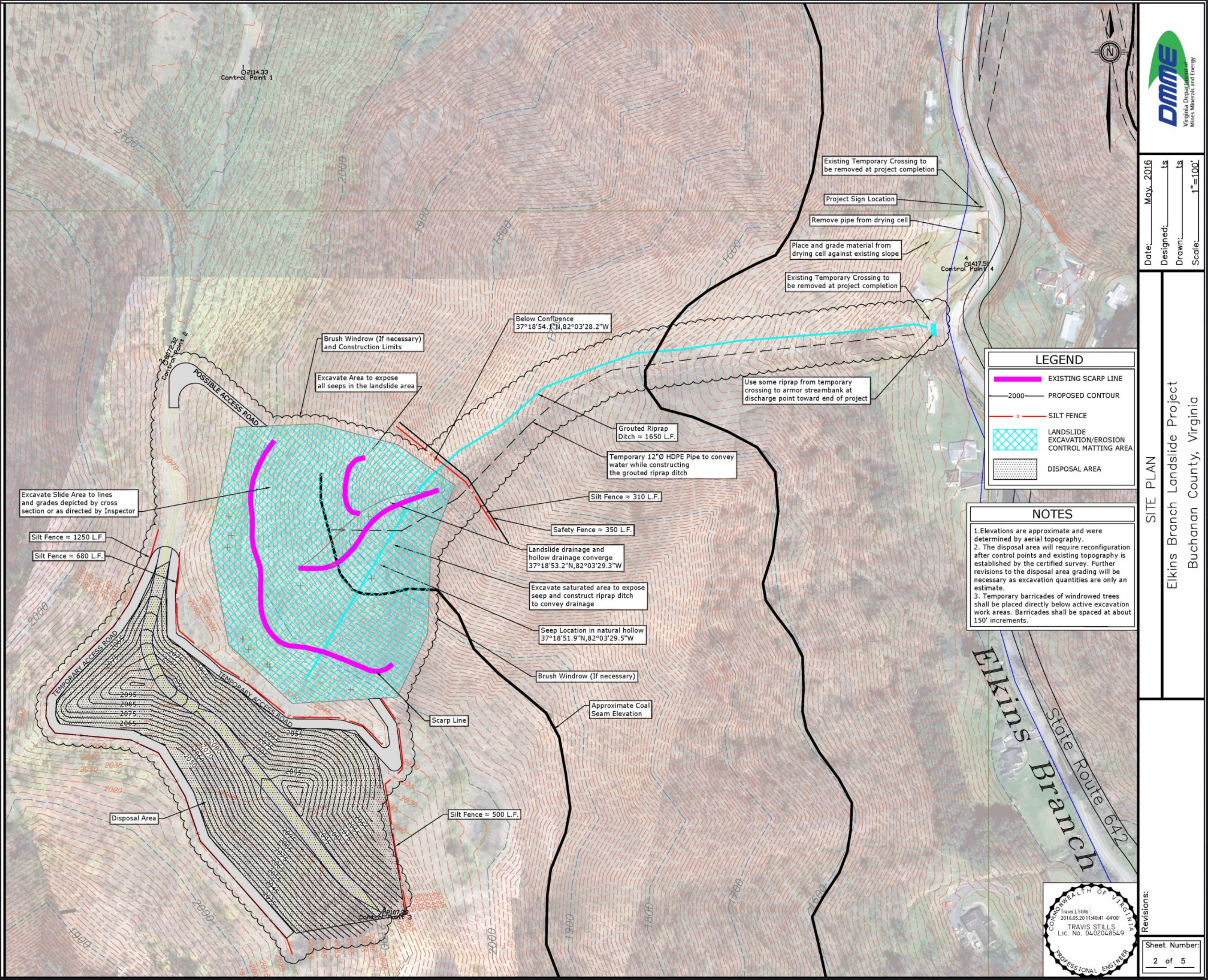
- Estimated measurements of material remaining at top of slope – soils thickness & depth to bedrock
- Three Volume Scenarios:
  - Least Case: 34,000 m^3
  - Interm: 74,000 m^3
  - Worst Case: 85,000 m^3





Output Results

- Produced hazard zonation map of Elkins Branch area
- 17 structures (primarily residential) were in the potential inundation zones
- DMME provided information to EM to help plan for evacuations in the case of heavy rain


Control Point 1
Existing Temporary Crossing to be removed at project completion
Project Sign Location
Remove pipe from drying cell
Place and grade material from drying cell against existing slope
Control Point 4
Existing Temporary Crossing to be removed at project completion
Below Confluence 37°18'54.1"N,82°03'28.2"W
Brush Windrow (If necessary) and Construction Limits
Excavate Area to expose all seeps in the landslide area
Control Point 2
POSSIBLE ACCESS ROAD
Use some riprap from temporary crossing to armor streambank at discharge point toward end of project
Grouted Riprap Ditch ≈ 1650 L.F.
Temporary 12"Ø HDPE Pipe to convey water while constructing the grouted riprap ditch
Excavate Slide Area to lines and grades depicted by cross section or as directed by Inspector
Silt Fence ≈ 310 L.F.
Safety Fence ≈ 350 L.F.
Silt Fence ≈ 1250 L.F.
Silt Fence ≈ 680 L.F.
Landslide drainage and hollow drainage converge 37°18'53.2"N,82°03'29.3"W
Excavate saturated area to expose seep and construct riprap ditch to convey drainage
Seep Location in natural hollow 37°18'51.9"N,82°03'29.5"W
Brush Windrow (If necessary)
TEMPORARY ACCESS ROAD
Approximate Coal Seam Elevation
Scarp Line
Disposal Area
Silt Fence ≈ 500 L.F.
Control Point 3
Elkins Branch
State Route 642
LEGEND
EXISTING SCARP LINE
2000 PROPOSED CONTOUR
SILT FENCE
LANDSLIDE EXCAVATION/EROSION CONTROL MATTING AREA
DISPOSAL AREA
NOTES
1. Elevations are approximate and were determined by aerial topography.
2. The disposal area will require reconfiguration after control points and existing topography is established by the certified survey. Further revisions to the disposal area grading will be necessary as excavation quantities are only an estimate.
3. Temporary barricades of windrowed trees shall be placed directly below active excavation work areas. Barricades shall be spaced at about 150' increments.
DMME
Virginia Department of Mines Minerals and Energy
Date: May, 2016
Designed: ts
Drawn: ts
Scale: 1"=100'
SITE PLAN
Elkins Branch Landslide Project
Buchanan County, Virginia
COMMONWEALTH OF VIRGINIA
TRAVIS STILLS
Lic. No. 0402048549
PROFESSIONAL ENGINEER
Revisions:
Sheet Number:
2 of 5

Update

- Excavation of toe and stream began in Aug 2015
- Temporary berm installed to protect church at toe
- Repairs are currently underway and estimated at $1.3 million with a completion date of October 2017
- Current plan is to remove all slide material to competent bedrock; slide material will be placed on ridge


5/ 2/2017 13:16


5/ 2/2017 13:10

Thanks!

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