# Nelson County Report

## *Prepared by Blackburn Consulting Services, LLC*

Reference: Report Analysis and Field Verification of Soil and Geologic Concerns with the Atlantic Coast Pipeline (ACP) in Nelson County, VA

# TABLE OF CONTENTS:



Soil | Foundations

**FIGURES:**



**TABLES:**

# Executive Summary

Blackburn Consulting was contracted to review, assess, and comment on information submitted by Dominion to Federal Energy Regulatory Commission (FERC) related to the construction and operation of the proposed Atlantic Coast Pipeline (ACP) through Nelson County. Our review was limited to information pertaining to soils/soil structure, slope stability and the associated geohazards or erosion/water quality concerns that the ACP project could create in Nelson County.

In preparing this report Blackburn Consulting reviewed documents submitted by Dominion to FERC through December 1, 2016. We looked at the information Dominion was using to determine the pipeline route, soil types along that route, slope stability and erodibility. We also relied on our past experiences, professional network, literature review, and field verification.

Blackburn Consulting used Arc Info software and our knowledge of landscape positions to predict and identify concave/colluvial landforms both along and adjacent to the proposed ACP pipeline route. These landforms are areas where soil has collected over time in geographic depressions, having been moved there either by gravity or water. Concave/colluvial landforms, particularly when associated with steep slopes and a storm event, are known to be sites that are at high risk of debris flows/landslides. This mapping was fashioned after a predictive model that we had previously developed in conjunction with the United States Geological Survey (USGS) for Loudoun County, Virginia. Our model was limited to the best information that we had available and therefore needs to be improved once better data (soil and topographic) is available. The map produced by our model was then checked for accuracy by overlaying it with a USGS map of all known debris flows in the area. These two maps matched up well, confirming the validity of our predictive model and map. We then identified a number of sites, based on our predictive model along the pipeline route, that we believed would be either concave/colluvial landforms or shallow to bedrock. Next, we undertook two days of field reconnaissance that confirmed our prediction of either colluvial or shallow rocky soils in these areas and their susceptibility to debris flows/landslides or that required blasting.

**Our conclusion from this work is that the potential for debris flows in the very steep mountainous portions of Nelson County are underestimated by the reports submitted to FERC by Dominion**. Although Dominion was using the best information publicly available at the time, the referenced materials were created more for regional interpretation and were never intended to be used for the siting of major infrastructure. The soil maps published in the Web Soil Survey were created at a scale that lacks sufficient detail to discern the vulnerable land forms that must be identified and either avoided or adequately mitigated, if possible, to insure the safety of the pipeline as well as protect the surrounding slopes, waterways and residents from a potentially catastrophic failure.

Our review has discovered that, due to the reliance on this regional-based and publicly available information, many of the statements made in Dominion's FERC filings represent gross generalities. Dominion has not adequately identified those soils and landforms that are prone to debris flows/landslides, nor have they adequately addressed how they plan to mitigate those site-specific hazards that can put people, property and water quality at extreme risk.

In order to adequately assess the debris flow/land slide risk or specific blasting needs posed by the ACP pipeline route through Nelson County; our professional opinion is that Dominion must: 1) update its corridor studies with much more detailed topographic analysis, 2) perform an Order 1 soil study along Nelson's ridgetops and steep slopes, and 3) identify and map all recent, historical, and potential debris flow areas within the pipeline alignment and its buffer. We further contend that a 125-foot study corridor is not enough as changes within the right-of-way can have far-reaching affects on laterally adjacent areas. To address this concern, we recommend the study corridor for ridgetops and steep slopes be increased to a minimum of 200 feet on either side of the 125' right-of-way.

# I. Introduction

This report represents the culmination of our review of the documents submitted to Federal Energy Regulation Committee (FERC) through December 1, 2016, and of our research including, but not limited to, our past experiences, professional network, current industry trends and publications, and field verification. Although the primary focus of our review was on the stability and erodibility of steep slopes, soils and geology specific to Nelson County, we have commented on other topics as pertinent and within our expertise or knowledge base.

## A. Project Description

Based on the initial and revised filing on the FERC website (www.ferc/acp) and other information provided to us by Friends of Nelson and the Dominion Pipeline Monitoring Coalition, the pipeline project is approximately 600 miles long, originating in WV and terminating in NC. Within Nelson County, the pipeline enters at the western boundary at the ACP mile-marker 158.2 in a proposed boring underneath the Blue Ridge Parkway and Appalachian Trail. The proposed alignment heads southeast, crossing Virginia Route 29 and exiting the County at mile marker 184.7.

The ACP crosses both the Blue Ridge and Piedmont provinces within Nelson County and the assessment of the alignment and reports involved analysis of all of the corresponding soils, geology and landforms.

## B. Purpose and Scope of Work

The purpose of this study was to review and assess the reports and information, filed by Dominion to FERC for the ACP project, specific to Nelson County, VA. This review and assessment included background research, review of the submitted materials, familiarization of the local and regional geology and soils, interviews, mapping and development of predictive models.

The review identified discrepancies and generalizations in the submitted reports and subsequent analysis developed by Dominion or their consultants specific to Nelson County that have considerations or impacts that are not fully addressed in the reports.

Soil and landform characteristics related to geomorphic instability, and the resulting geohazards, landslides, and mass wasting, is the primary focus of our comments. Erosion, water quality impacts and construction issues are also addressed.

# II. Literature Review and Background

## A. Mass Wasting Potential in the United States

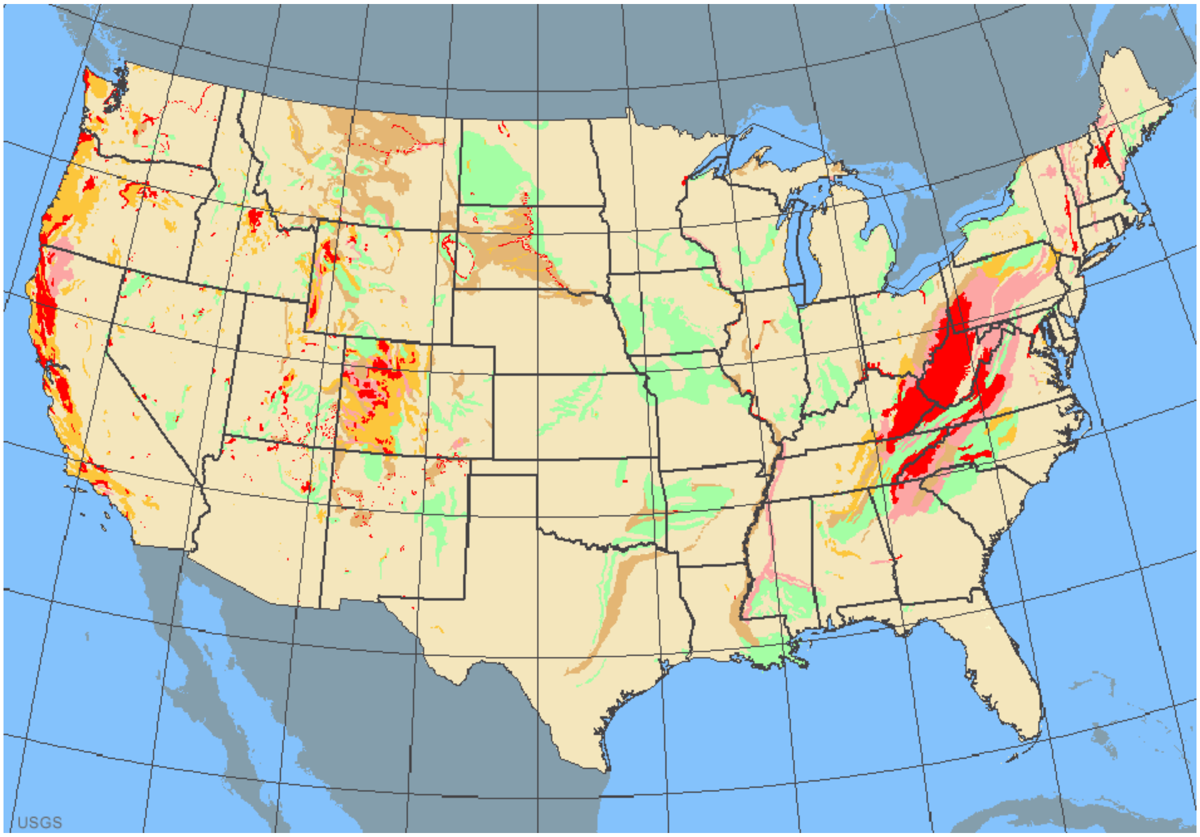



**Figure 1 Landslide Incidence and Susceptibility Map of the Conterminous United States**[1]

This map (Figure 1) developed by the USGS, identifies the locations of, and susceptibility to, landslides.

"Generally, the authors assumed that anomalous precipitation or changes in existing conditions can initiate landslide movement in rock and soils that have numerous landslides in parts of their outcrop areas."[2]

## B. Factors Influencing Mass Wasting or Debris Flows[2]

- Gravity
- Angle of Repose
- Climate (Freezing and Thawing)
- Water

---

[1] Highland, 2004, accessed at http://geology.com/usgs/landslides/
[2] Godt & Radbruch-Hall, 1997

- Vegetation- Trees hold the soil the most stable
- Geology
- Human activity including- clearing, grading, blasting, vibration of heavy equipment
- Soils

| **Driving Force: Gravity (sometimes aided by tectonic activity)** | | |
|---|---|---|
| *Contributing Factors* | Most Stable Situation | Most Unstable Situation |
| Slope angle | Gentle slopes or horizontal surface | Steep or vertical slopes |
| Local relief | Low | High |
| Thickness of colluvium over bedrock | Thin thickness (usually) | Great thickness |
| Orientation of planes of weakness in bedrock | Planes perpendicular to slope angle | Planes parallel to slope angle |
| **Climatic factors:** | | |
| Freeze / Thaw | Temperature stays above freezing | Freezing and thawing multiple times a year |
| Soil Water | Water held closely to individual soil particle surface. Pore space is 50% or more atmospheric air | Soil matrix is saturated, pore space is dominated by water |
| Precipitation | Frequent but light rainfall or snow | Periods of drought with episodes of heavy precipitation |
| Vegetation | Heavily vegetated with trees | Sparsely vegetated or cleared |

**Table 1 Summary of factors influencing debris flows commonly referenced throughout literature.**

## C. Debris Flows and Mass Wasting in Mountainous Areas

The Appalachian Mountains of the Eastern United States have long been recognized as uniquely susceptible to debris flows. The three physiographic provinces that represent the Appalachians, the Blue Ridge, the Valley and Ridge and the Appalachian Plateau each have specific geomorphic features that create this hazard. Michael Clark identified fifty-one debris flows within the Appalachian region between 1844 and 1985[3]. There have been a tremendous number of studies done on the nature, occurrences, causes and dangers of debris flows and slope instability. In 1986, due to increasing pressures to build homes in Loudoun County on the mountainsides, staff now with Blackburn Consulting Services, formerly with VA Tech, worked directly with the United States Geological Survey (USGS) to develop a predictive model in efforts to determine where actual debris flows were most likely to occur in Loudoun County. As a result of this work Alex Blackburn (author) worked on a team with members of the USGS to develop a

[3] Clark, 1987

Mountainside Overlay District that informed landowners of potential hazards and provided safeguards to keep them from building where their home or families would be in danger. Since 2002, Ryan Reed (co-author) has implemented those regulations and performed site-specific analysis of potential hazard areas.

During the research for this project we reviewed not only the documents submitted to FERC but also many other relative studies, reports and documents. **Our review discovered many of the statements made in the materials submitted to FERC represented gross generalities.** Although they used the best information currently available, much of it was never intended for such use **and, in our opinion, underemphasizes the true risks that this project imposes on Nelson County and its residents.**

The following is a brief report of our assessment and an analysis of our research for this project.

> "*Mass wasting* [or debris flows] *occurs throughout the world, continually sculpting the landscape. The areas at greatest risk for mass wasting events are in mountainous regions with relatively steep slopes. In the United States, those areas are found in the Appalachian Mountains, the Rocky Mountains, and along the Pacific Coast. However, the potential for mass wasting is not determined by slope angle alone. The highest peaks rise in western states, but the largest area at risk from landslides is in the eastern Appalachian states. Water, much more plentiful in the eastern than in the western part of the country (with the exception of the Pacific Northwest), plays a significant role in mass wasting* [particularly the intensity of rainfall]. *Other factors play other roles. Earthquakes and other natural disasters, the absence or removal of vegetation, and human activities can also influence the potential for mass wasting. Playing chief roles in the mass wasting process are weathering, gravity, and water."*[4] (Emphasis added)

Focusing on the eastern US and Virginia (Figure 2), the Appalachian and Blue Ridge mountains have high susceptibility for debris flows. Also note the number of specific events of interest that are known to have impacted the region. Seven major cyclonic storms have tracked over the Appalachian mountains of Virginia, West Virginia and North Carolina in the last century, setting off thousands of debris flows.[5] Weather patterns that move from east to west or from west to east often get stalled over these mountainous areas and result in reoccurring rain events with higher volumes of precipitation. Heavy rainfall has been identified as the primary trigger for debris flow events in the Appalachian and Blue Ridge mountains when all the factors influencing debris-flows (referenced above) are present[5], specifically creating excess pore-water within the soil, thereby exceeding the cohesive forces between soil particles and the tensile strength of the root structure[6].

[4] http://www.scienceclarified.com/landforms/Faults-to-Mountains/Landslide-and-Other-Gravity-Movements.html, accessed November 25, 2016

[5] Wooten, Witt, Miniat, Hales & Aldred, 2016.

[6] Dietrich, McKean, Bellugi & Perron, 2007; Lehman & Or, 2012

Furthermore, landscape position has a contributing effect on the soil genesis, accumulation of surface and subsurface water flow, structural discontinuities (lithic or para-lithic contact) and previous debris-flow events. While some studies in the Western United States have illustrated that the thicker soil profiles typically found in colluvial (convergent) landscape positions contribute to a more stable soil structure (the soil is better able to support itself while in super-saturated conditions[7], overwhelming research in the Appalachians has identified concave, colluvial landscapes as the most important "source" or origination of debris-flows[8], specifically "steep upper slopes above the highest extent of a stream channel (0 order basins) where topography is dissected into minor ridges. . .and convergent colluvial accumulation zones" as shown in Figure 3[9]. Information and studies of present and historical debris-flow events "suggests that the minimum distance from a ridge where failure can occur may be defined primarily by the local ridgecrest convexity, and not by hydrologic constraints"[10]. This concludes that the scarps of debris flows receive sufficient water for failure in some cases from direct rainfall and very limited watershed, therefore susceptible debris-flow areas can be immediately adjacent to a ridge.

[7] Dietrich, McKean, Bellugi & Perron, 2007
[8] Burton, 1996; Cameron, 2016; Chen & Major 2007, Eaton, Morgan, Kochel & Howard, 2003; Gao, 1993; Jacobson, 1993; Larsen & Wieczorek, 2006; Morgan, Iovine, Chirico & Wieczorek, 1999; Morgan, Wieczorek, Campbell & Gori, 1997; Pontrelli, Bryan,& Fritsch, 1999; Shultz & Jibson, 1989; Schultz & Southworth, 1987; Wieczorek, Eaton, Morgan, Wooten & Morressey, 2009; Wieczorek, Morgan & Campbell, 2000; Wieczorek, Mossa,& Morgan, 2004
[9] Wooten, Witt, Miniat, Hales & Aldred, 2016
[10] Schwarz, Giadrossich, Lehmann & Or, 2010

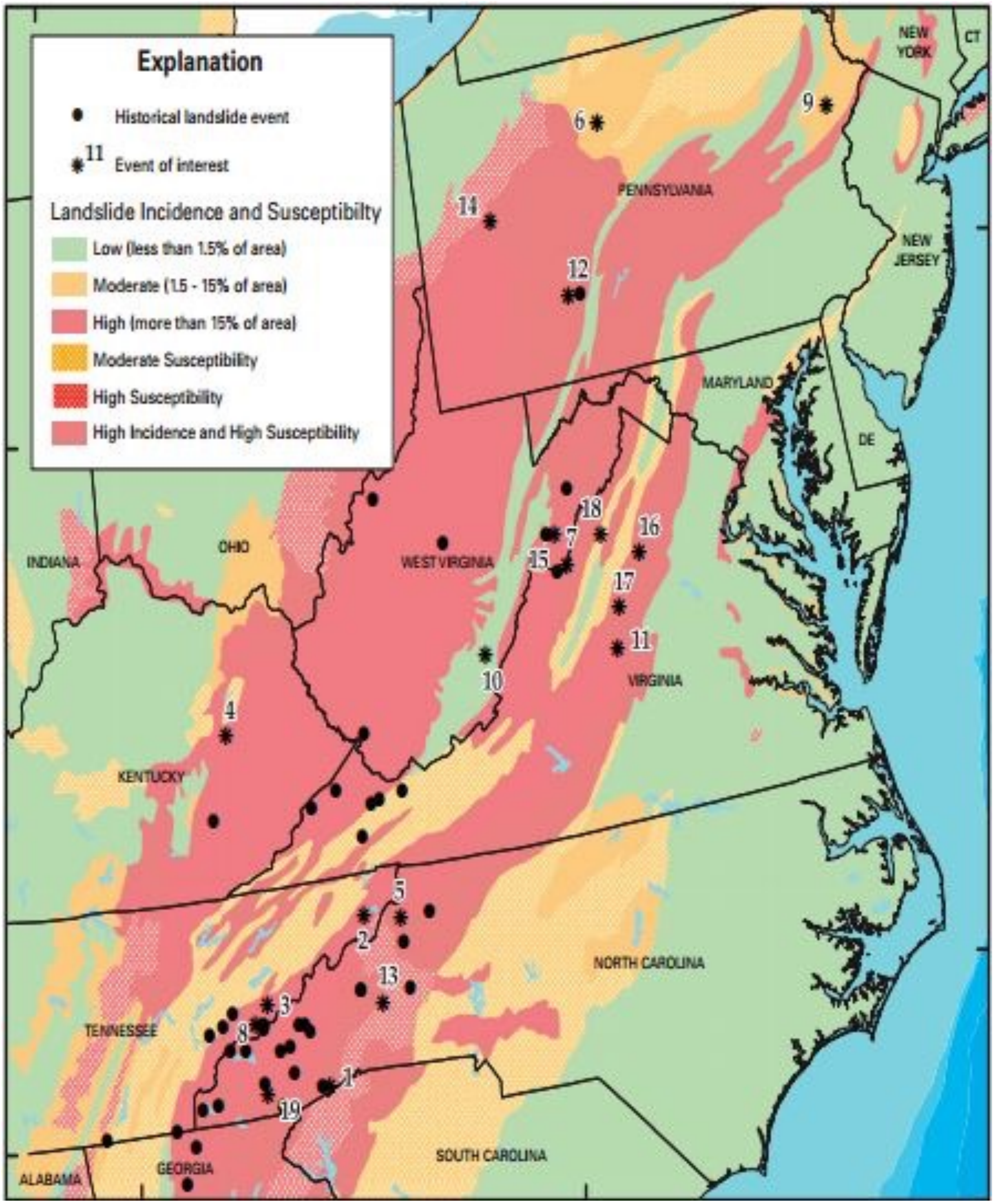



**Figure 2 Historical Landslide Events Virginia**[11]

[11] Wieczorek, Eaton, Morgan, Wooten, & Morrissey, 2009


**Figure 3 Outlines of 1969 landslides in Fortunes Cove area of Nelson County illustrate typical debris flow "sources" or origination points.**[9]

## D. Nelson County – Recent and Historical Debris Flows

There have been hundreds of recent (1969 to present) and historical (prior to 1969) debris flows in Nelson County alone. Even though Nelson and Madison counties have more of the recent debris flows, in our experience, which includes of 50 years of mapping soils throughout Virginia, the evidence of historic debris flows is not unique to Nelson County. We have personally observed debris-flow evidence, from head scarps to depositional areas, along the Blue Ridge and Appalachian mountains from Loudoun County through Washington County.

These debris flows, as described by USGS and evident in pictures from the 1995 Madison County event, often reoccur in the same areas as previous flows. Investigations by many professionals after the Madison County event, including Alex Blackburn, confirmed this phenomenon. Both the scours (Figure 4 and Figure 5) and the depositional fans (Figure 6) demonstrated evidence of previous events. Many additional pictures of recent debris flows over older debris flows are available in numerous USGS documents.

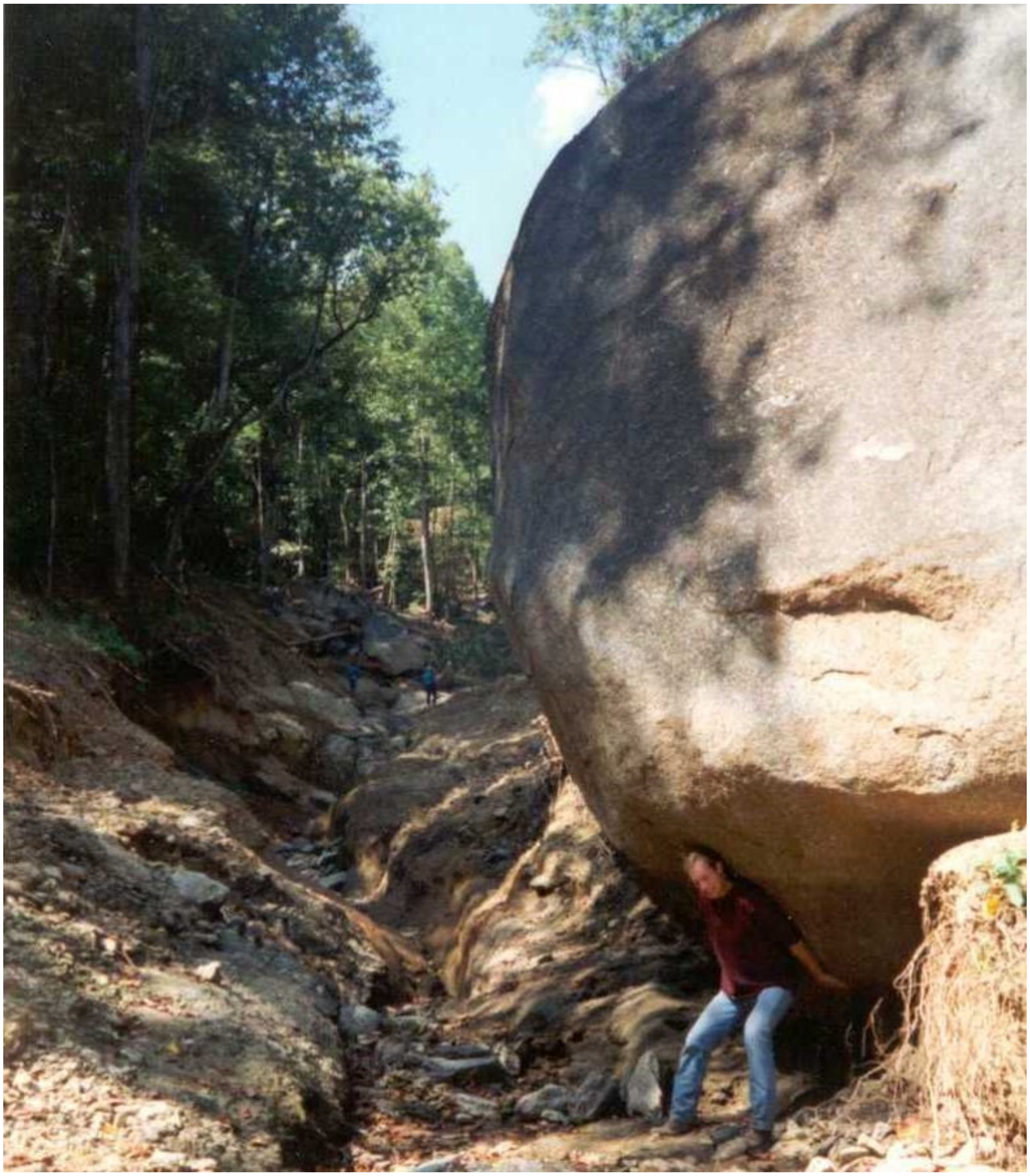


**Figure 4 Alex Blackburn demonstrating the size of material transported in a scour during the Madison County event.**

**Figure 5 Scour from June 27, 1995, debris flow in Madison County, Va., revealing older debris-flow deposits[11].**

Figure 6 Example of a depositional fan in Madison County, VA investigated by Alex Blackburn.

# E. Soils and Landforms

Nelson County represents two physiographic provinces: the Blue Ridge in the western 40 percent and the Piedmont in the eastern 60 percent. The geology and soils of the two provinces are very different and reflect different characteristics and concerns in respect to the ACP. The County ranges in elevation from approximately 300 feet above mean sea level to 4,063 feet at its highest point. The Blue Ridge province portion of the County has a significantly higher slope gradient than the Piedmont province area. The Piedmont province is underlain by crystalline rocks, the majority of which is gneiss and schist. The Blue Ridge province is largely underlain by granodiorite and greenstone as well as other variants of metamorphic, igneous and metasedimentary rocks (Figure 7). Nellysford gneiss is recognized as the oldest rock in Virginia, approximately 1.8 billion years old.

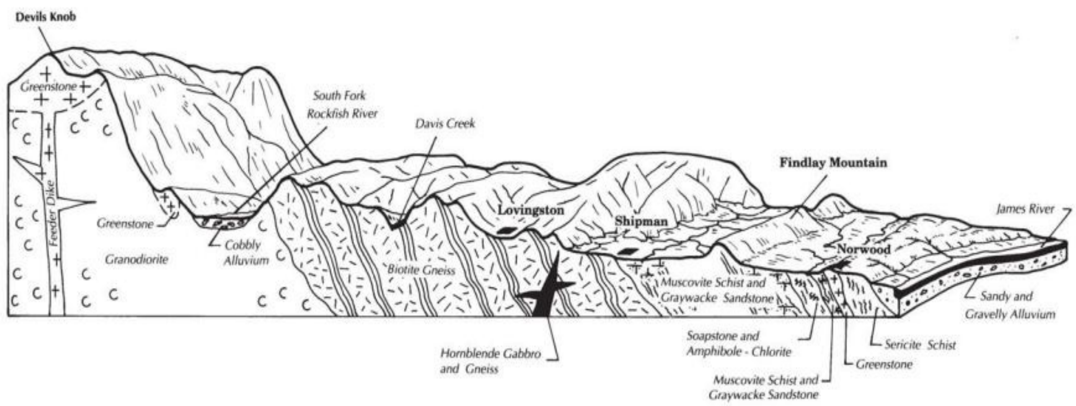



**Figure 11.—Cross section of the typical landforms and rock patterns in Nelson County.**

**Figure 7 Soil Survey Staff (1992).**

## 1. Nelson County Soil Survey and Soil Scientist

The soils work/study completed within Nelson County for Dominion was based on the information in the Natural Resource Conservation Service's "Soil Survey" (an Order 2/3 mapping job) and the USDA SSURGO data[12]. The original soil survey in Nelson County was mapped between 1984 and 1989 at a scale of 1"=24,000". This scale of mapping was even less detailed than most previous soil mapping in other areas of Virginia which was 1"=15,840". Due to the scale at which mapping occurred, the smallest mapping unit that could be delineated was approximately 5 acres in size. In some places, there might be 2 acres of bedrock sticking out of the ground, unable to be shown as anything more than a check mark, indicating a rock outcrop, on the original field sheetmaps. These check marks provided additional, important information but unfortunately, most or all of that data was not transferred from the original field sheets to the published Web Soil Survey and is no longer available.

[12] Resource Report 7 (Soils), Section 7.1 "Background and Methodology," submitted to FERC by Dominion/ACP in September 2015.

Soil mapping that was conducted for the National Cooperative Soil Survey Program in the open and/or active farm fields was generally looked at much more critically and carefully. However, mapping in the very steep mountainsides was done at a level of detail far less than other areas. Why? Because these areas were considered to be of value for forestry, wildlife and recreation only. Hence, the number of evaluations and differentiating micro relief were, at the time, considered less important. As a result, the soil mapping units delineated in the steep mountainous areas have a much higher percentage of inclusions (dissimilar soils) which will include, but is not limited to; colluvial soils, perched water tables, springs, shallow soils to rock, and rock outcrops.

Based on personal experience in the National Cooperative Soil Survey program and in conversations with the two members/soil scientists of the soil survey team responsible for mapping the soils in Nelson County (party leader, Steve Thomas, and party member, Bruce Legge) this data, although presently the best information available, is inadequate for evaluating the impacts of this pipeline. **This type of mapping was completed with the intent it would be used on a regional basis. It is not intended to be interpreted for a project that is this detailed with potentially high consequence**.

The soils in the steep mountainous portions of Nelson County are dominantly formed from either granite gneiss/granodiorite or greenstone. Soils formed from granite gneiss or granodiorite are coarse textured (sandy loam or coarse sandy loams) with subsoils that are seldom heavier than loams. The granite gneiss and granodiorite are generally more resistant to weathering and therefore, are reflective of the higher landforms (ridge forming bedrock). According to Mr. Thomas, any of the narrow ridgetops will have a very high proportion of soils that are shallow to hard bedrock. This rock will require either blasting or chiseling to get a trench 60 inches or more in the ground. This observation was echoed by a local excavator that conducts most of his business in the mountainous portions of Nelson County. Finally, according to Table 7.4.1-1 in the Resource Report 7 (Soils) submitted to FERC[13], Nelson County ranks 3rd highest of all counties in Virginia for having soils with shallow bedrock.

The soils formed from greenstone bedrock are finer textured but seldom get heavier than silty clay loam in the steeper portions of the County. Most of what we saw during our field investigations was the coarser textured soils formed from granodiorite or biotite gneiss.

The sandier textures allow for higher infiltration of rain and snow melt water into the soil. Once in the soil, this water can and does move through these soils laterally to the concave areas thus supersaturating these concave landforms.

[13] Resource Report 7 (Soils), Table 7.4.1-1, "Acres of Soil Characteristics Affected by the Proposed Pipelines for the Atlantic Coast Pipeline and Supply Header Project", originally submitted to FERC by Dominion/ACP in September 2015, and updated in Appendix I of their July 18, 2016 Supplemental Filing.

Fractured bedrock above hard slightly fractured or non-fractured bedrock compounds this phenomenon by holding the water up above it while also forming a natural surface on which the movement of the supersaturated soil material can occur. Generally, all that may be required is a catalyst such as a large tree that tumbles over when the soil is wet to initiate a sluff or debris flow. The intense weather event in 1969 as a result of Hurricane Camille created a super-saturating environment, which resulted in the multiple catastrophic debris-flows (Figure 8).

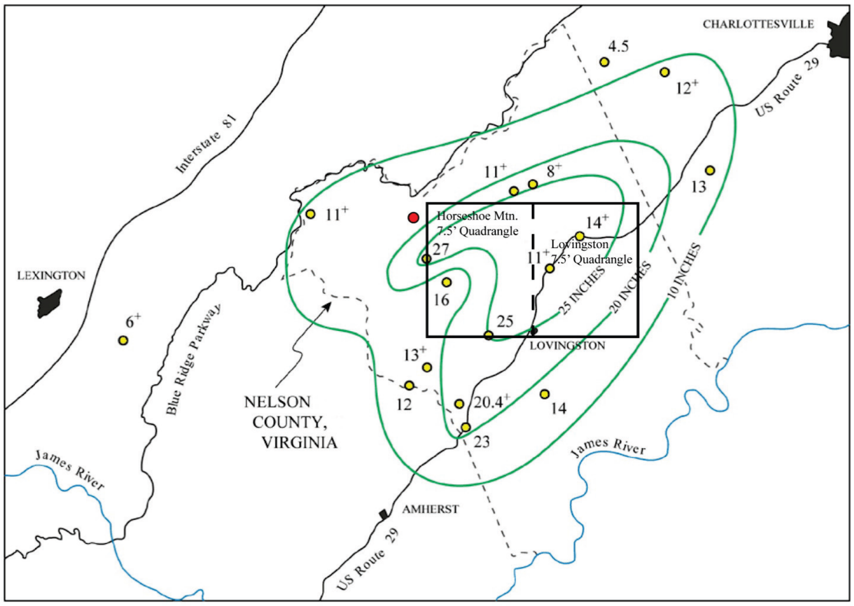



**Figure 8 Representation of the most intense areas of rainfall in the Central Appalachians during Hurricane Camille**[11]

Concave landforms are where colluvial soil material (moved by gravity with the assistance of water, in the east) can be and are found. Again, according to the Nelson County Soil Survey party leader Mr. Thomas and party member Bruce Legge, none or "very little of the colluvial soils on the upper two thirds of the steep mountain slopes were recognized or mapped in the correlated soils map". "Concave vs. convex landforms particularly in steep areas, become very important when you are looking for slope stability and debris flow potential" according to Rob Jacobson of the USGS. Concave landforms in the steep mountainsides always contain some colluvial material. Depth of this colluvium may range from a few inches to several feet deep. These same concave areas with colluvium have considerable volumes of laterally moving groundwater moving through them during certain periods of the year. Water is commonly known as one of the primary factors that increases the instability of soils on steep slopes.

The following is a chart that we prepared based on the soils within the ACP Right-of-Way (ROW) including a buffer on either side. The soils information used to complete this came from the USDA Web Soil Survey, conversations with the soil scientists that mapped Nelson County and our fieldwork and knowledge of these soil types.

| MUSYM | Soil Mapping Unit Name | Parent Material | Depth to Rock | Debris Flow Potential | Inclusions <60" to bedrock |
|---|---|---|---|---|---|
| 5C | Bugley channery silt loam, 7 to 15 percent slopes | Residuum | <3' | low-mod | yes |
| 5D | Bugley channery silt loam, 15 to 25 percent slopes | Residuum | <3' | mod | yes |
| 5E | Bugley channery silt loam, 25 to 50 percent slopes | Residuum | <3' | mod-high | yes |
| 8A | Codorus silt loam, 0 to 2 percent slopes, occasionally flooded | Alluvial | >60" | flood | no |
| 10A | Colvard fine sandy loam, 0 to 2 percent slopes, occasionally flooded | Alluvial | >60" | flood | no |
| 11A | Craigsville very cobbly loam, 0 to 2 percent slopes, frequently flooded | Alluvial | >60" | flood | no |
| 12B | Delanco loam, 2 to 7 percent slopes | Stream Terrace | >60" | flood | no |
| 12C | Delanco loam, 7 to 15 percent slopes | Stream Terrace | >60" | flood | no |
| 13C | Edneytown loam, 7 to 15 percent slopes | Residuum | 5-10' | low | incl |
| 13D | Edneytown loam, 15 to 25 percent slopes | Residuum | 5-10' | low-mod | incl |
| 14C | Edneytown-Peaks complex, 7 to 15 percent slopes, extremely stony | Residuum | 20-60+ | low-mod | yes |

| MUSYM | Soil Mapping Unit Name | Parent Material | Depth to Rock | Debris Flow Potential | Inclusions <60" to bedrock |
|---|---|---|---|---|---|
| 14D | Edneytown-Peaks complex, 15 to 35 percent slopes, extremely stony | Residuum | 20-60+ | mod-high | yes |
| 14E | Edneytown-Peaks complex, 35 to 55 percent slopes, extremely stony | Residuum | 20-60+ | high | yes |
| 15B | Elioak loam, 2 to 7 percent slopes | Residuum | 6-10' | low | no |
| 15C | Elioak loam, 7 to 15 percent slopes | Residuum | 6-10' | low | no |
| 15D | Elioak loam, 15 to 25 percent slopes | Residuum | 6-10' | low | incl |
| 16C | Elioak clay loam, 7 to 15 percent slopes, severely eroded | Residuum | 6-10' | low | no |
| 16D | Elioak clay loam, 15 to 25 percent slopes, severely eroded | Residuum | 6-10' | low | incl |
| 17B | Elsinboro loam, 2 to 7 percent slopes, rarely flooded | Alluvial | 6-10' | flood | no |
| 18C | Fauquier loam, 7 to 15 percent slopes, very stony | Residuum | 6-10' | low | no |
| 18D | Fauquier loam, 15 to 25 percent slopes, very stony | Residuum | 6-10' | low | no |
| 18E | Fauquier loam, 25 to 50 percent slopes, very stony | Residuum | 6-10' | low-mod | incl |
| 19A | Galtsmill fine sandy loam, 0 to 2 percent slopes, occasionally flooded | Alluvial | >60" | flood | no |
| 1D | Arcola gravelly silt loam, 15 to 25 percent slopes | Residuum | 40-60" | low | yes |

| MUSYM | Soil Mapping Unit Name | Parent Material | Depth to Rock | Debris Flow Potential | Inclusions <60" to bedrock |
|---|---|---|---|---|---|
| 1E | Arcola gravelly silt loam, 25 to 50 percent slopes | residuum | 40-60" | low-mod | yes |
| 21A | Hatboro loam, 0 to 2 percent slopes, frequently flooded | Alluvial | n/a | flood | no |
| 22B | Hayesville loam, 2 to 7 percent slopes | Residuum | 5-10' | low | incl |
| 22C | Hayesville loam, 7 to 15 percent slopes | Residuum | 5-10' | low-mod | incl |
| 22D | Hayesville loam, 15 to 25 percent slopes | Residuum | 5-10' | mod | incl |
| 22E | Hayesville loam, 25 to 50 percent slopes | Residuum | 5-10' | mod-high | incl |
| 23C | Hayesville clay loam, 7 to 15 percent slopes, severely eroded | Residuum | 5-10' | low-mod | incl |
| 23D | Hayesville clay loam, 15 to 25 percent slopes, severely eroded | Residuum | 5-10' | mod | incl |
| 23E | Hayesville clay loam, 25 to 50 percent slopes, severely eroded | Residuum | 5-10' | mod-high | incl |
| 24D | Hayesville loam, 15 to 25 percent slopes, very stony | Residuum | 5-10' | mod | incl |
| 24E | Hayesville loam, 25 to 50 percent slopes, very stony | Residuum | 5-10' | mod-high | incl |
| 25C | Hazel channery loam, 7 to 15 percent slopes | Residuum | 20-40" | low-mod | yes |
| 25D | Hazel channery loam, 15 to 25 percent slopes | Residuum | 20-40" | mod | yes |
| 25E | Hazel channery loam, 25 to 50 percent slopes | Residuum | 20-40" | mod-high | yes |

| MUSYM | Soil Mapping Unit Name | Parent Material | Depth to Rock | Debris Flow Potential | Inclusions <60" to bedrock |
|---|---|---|---|---|---|
| 27C | Jackland gravelly silt loam, 7-15 percent slopes | Residuum Triassic | 6-8' | low | yes |
| 30C | Lew channery silt loam, 7 to 15 percent slopes, extremely bouldery | colluvial | 6-10' | mod | no |
| 30D | Lew channery silt loam, 15 to 25 percent slopes, extremely bouldery | colluvial | 6-10' | high | no |
| 30E | Lew channery silt loam, 25 to 75 percent slopes, extremely bouldery | colluvial | 6-10' | high | no |
| 31B | Littlejoe silt loam, 2 to 7 percent slopes | Residuum | 40-60" | low | yes |
| 31C | Littlejoe silt loam, 7 to 15 percent slopes | Residuum | 40-60" | low | yes |
| 32B | Minnieville loam, 2 to 7 percent slopes | Residuum | 6-10' | low | no |
| 32C | Minnieville loam, 7 to 15 percent slopes | Residuum | 6-10' | low-mod | no |
| 32D | Minnieville loam, 15 to 25 percent slopes | Residuum | 6-10' | low-mod | no |
| 32E | Minnieville loam, 25 to 50 percent slopes | Residuum | 6-10' | mod | no |
| 33E | Myersville-Catoctin complex, 35 to 55 percent slopes, extremely stony | Residuum | 20->60" | mod-high | yes |
| 34C | Occoquan loam, 7 to 15 percent slopes | Residuum | 6-8' | low | para BR, incl |
| 34D | Occoquan loam, 15 to 25 percent slopes | Residuum | 6-8' | low-mod | para BR, incl |
| 34E | Occoquan loam, 25 to 50 percent slopes | Residuum | 6-8' | mod-high | para BR, incl |

| MUSYM | Soil Mapping Unit Name | Parent Material | Depth to Rock | Debris Flow Potential | Inclusions <60" to bedrock |
|---|---|---|---|---|---|
| 35D | Occoquan loam, 15 to 25 percent slopes, very stony | Residuum | 6-8' | low-mod | para BR, incl |
| 35E | Occoquan loam, 25 to 50 percent slopes, very stony | Residuum | 6-8' | mod-high | para BR, incl |
| 36E | Peaks-Rock outcrop complex, 35 to 55 percent slopes | Residuum | 0-40" | high | yes |
| 39C | Saunook loam, 7 to 15 percent slopes | colluvial | 5-10' | high | incl |
| 40C | Saunook loam, 7 to 15 percent slopes, very stony | colluvial | 5-10' | high | incl |
| 42E | Spriggs loam, 25 to 50 percent slopes, very stony | Residuum | 40-60" | mod | yes |
| 43A | Suches loam, 0 to 2 percent slopes, frequently flooded | Alluvial | >60 | flood | no |
| 46C | Thurmont loam, 7 to 15 percent slopes | colluvial-residuum | 5-10' | mod | no |
| 46D | Thurmont loam, 15 to 25 percent slopes | colluvial-residuum | 5-10' | mod-high | incl |
| 49B | Unison loam, 2 to 7 percent slopes | colluvial | 6-10' | low-mod | no |
| 49C | Unison loam, 7 to 15 percent slopes | colluvial | 6-10' | mod | no |
| 4B | Buffstat silt loam, 2 to 7 percent slopes | Residuum | 40-60" | low | para BR, incl |
| 4C | Buffstat silt loam, 7 to 15 percent slopes | Residuum | 40-60" | low | para BR, incl |
| 4D | Buffstat silt loam, 15 to 25 percent slopes | Residuum | 40-60" | low-mod | para BR, incl |
| 50B | Warminster clay loam, 2 to 7 percent slopes | Residuum Triassic | 6-10' | low | no |

| MUSYM | Soil Mapping Unit Name | Parent Material | Depth to Rock | Debris Flow Potential | Inclusions <60" to bedrock |
|---|---|---|---|---|---|
| 50C | Warminster clay loam, 7 to 15 percent slopes | Residuum Triassic | 6-10' | low | no |
| 51A | Wingina loam, 0 to 2 percent slopes, occasionally flooded | Alluvial | >60" | flood | no |
| 52B | Wintergreen loam, 2 to 7 percent slopes | colluvial | >60" | low-mod | no |
| 52C | Wintergreen loam, 7 to 15 percent slopes | colluvial | >60" | low-mod | no |
| 52D | Wintergreen loam, 15 to 25 percent slopes | colluvial | >60" | mod-high | no |
| 53B | Wintergreen clay loam, 2 to 7 percent slopes, severely eroded | colluvial | >60" | low-mod | no |
| 53C | Wintergreen clay loam, 7 to 15 percent slopes, severely eroded | colluvial | >60" | mod | no |

**Table 2 Nelson County Soil Mapping Units. (MUSYM – Mapping Unit Symbol)**

# III. Analysis

## A. Factors Influencing Mass Wasting or Debris Flows

How will this pipeline influence these factors?

### 1. Gravity

Due to the fact that Nelson County has many extremely steep slopes, the influence of gravity, especially combined with something like a storm event or the removal of vegetation in or adjacent to potentially unstable landforms, can be extensive. Gravitational force is a constant force interacting with the soil unit (Figure 9) that, coupled with inter-particle attraction, root tensile strength, and other frictional forces create a static, stable soil environment under normal conditions.

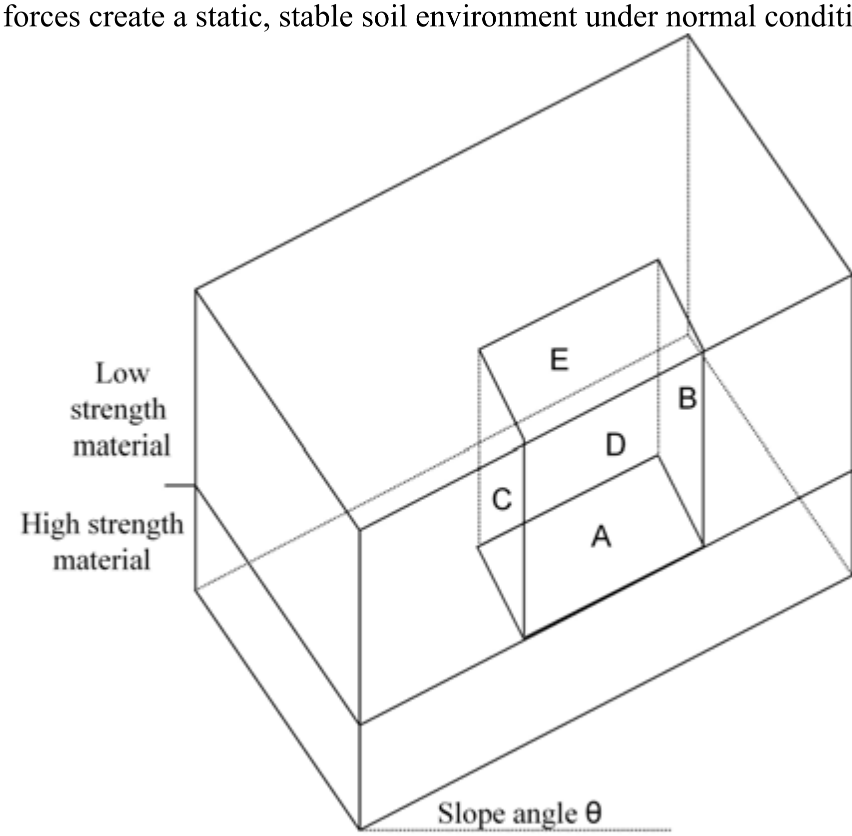



Figure 9 Three-dimensional force balance stability analysis of a soil element on a slope. [7]

> "Force A on the element bottom boundary results primarily from the lithostatic stress of the element mass. Forces B and C arise from active and passive earth pressure, respectively, while forces D and E result from at rest earth pressure on the element lateral margins. At shallow soil depths, root cohesion through the base creates a high FS."[7]

### 2. Angle of Repose

The angle of repose or the maximum angle at which the soil will remain intact is represented in natural condition by the existing slope. However, this will be changed in areas where the slope may be steepened by construction activities. Also because the soil and rock will be dug out and then put back, the existing soil structure will be destroyed, directly affecting and consequently reducing the cohesiveness of the soil and therefore the current angle of repose.

## 3. Climate

Removal of forests and leaving the ROW open could impact the microclimate in the area by: 1) reducing the evapotranspiration of water from the site through the trees and, 2) increasing winds, exposing the ground to harsher temperatures and impacting the natural infiltration of water, thereby increasing freezing and thawing of surface materials. Increased winds in these sensitive areas can also cause remaining trees to topple which can initiate other undesired impacts. It is also generally understood that storms that move from east to west or west to east tend to stall and, because of the orographic lifting phenomenon, create heavier rainfall amounts on the mountains. Since water is a primary contributor to landslides, the local weather patterns at the Blue Ridge are particularly important.

## 4. Water

Concave areas and colluvial soils in the steep mountainsides, by nature, have significant amounts of laterally moving water flowing through them during wet periods and storms. The installation of this pipeline will then act as an additional path for water to get into the soil. Increasing water content, particularly at the top of the mountain where many of the debris flows are known to initiate, will tend to increase rather than decrease the potential for slope failure. (See Figure 10)

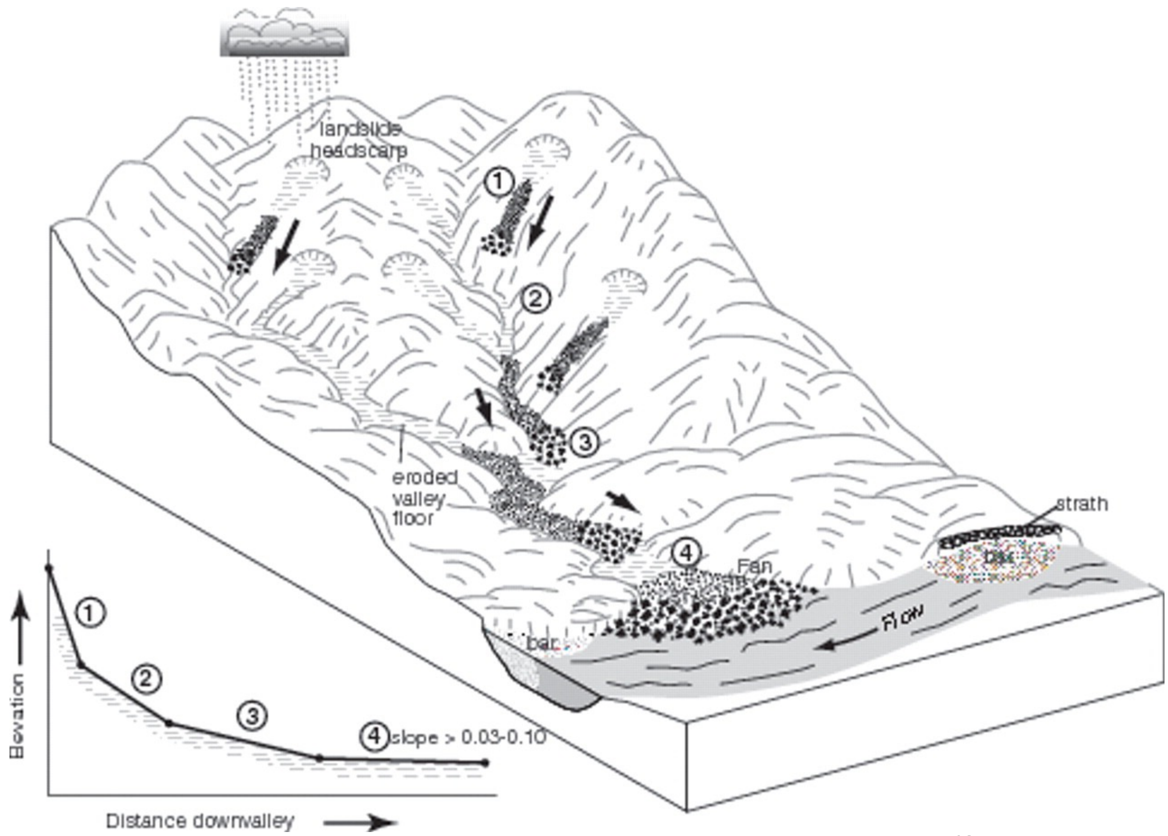



Figure 10 Illustration of debris-flow patterns and processes influenced by rainfall.[14]

## 5. Vegetation

Although trees hold the soil the most stable, the trees and vegetation will be removed from the ROW. Although the plan is to revegetate the ROW, Dominion's own reports raise serious concern for this area. Also, revegetation will not include planting trees which are known to best hold the soil in place. In fact, forest cover has been recognized as one of the most important factors in mountain slope stability. Studies have suggested that up to 78% of the landslides / debris flows in the central and southern Appalachian region have been a result of human activity and clearing.[9] Loss of trees will also continue after the project is completed due to damage to the tree roots during construction activities. Mortality of these trees may not occur for several years after the construction, however, once these trees are dead, falling trees at the edge of the ROW could cause additional impacts. Furthermore, forested areas converted to grass or other "stabilizing vegetation" have been found to significantly decrease the relative root strength in the soil (Figure 11). Therefore the construction of the ACP, specifically the removal of the existing trees, installation of the pipeline and the establishment of grass and shrub ground cover will result in an overall decrease in the important stabilizing effects of the roots in the soil.

[14] Stock and Dietrich, 2006

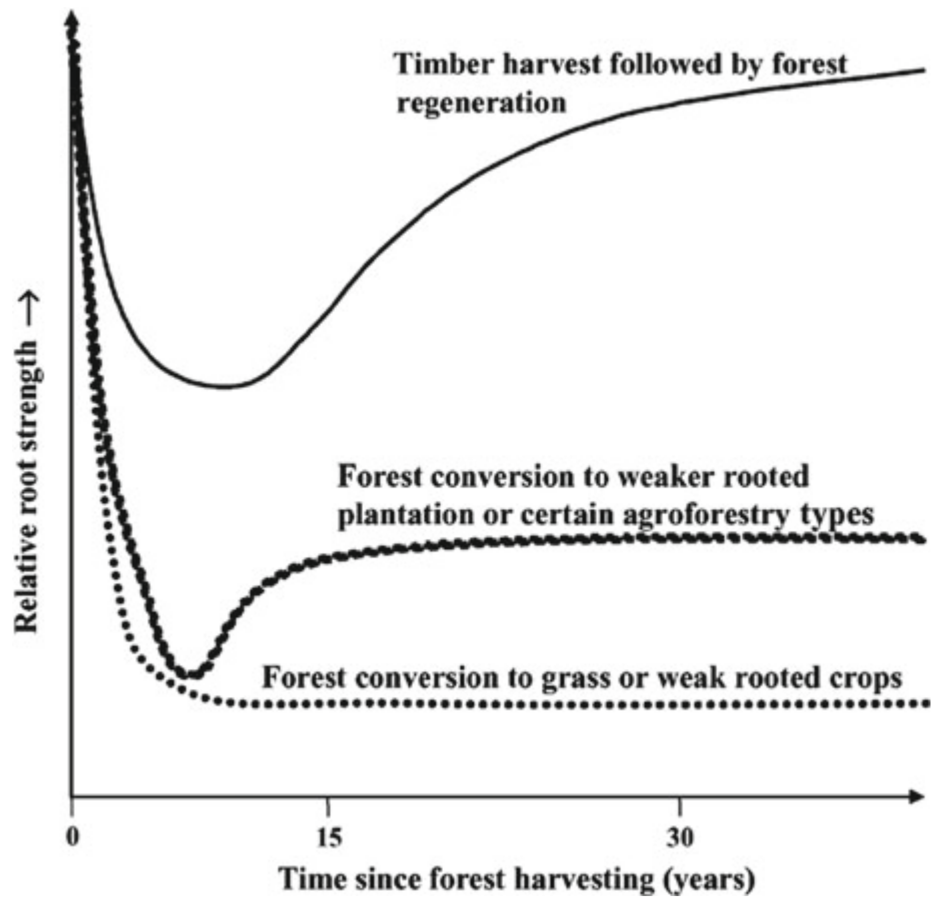



Figure 11 Root strength recovery or different cover vegetation following forest clearing.[9]

## 6. Geology

Depending on the natural structure (bedding plains) of the underlying bedrock, construction could expose slippage plains in the rock. Areas underlain with granodiorite are often fractured-in-place just above (1-3 feet) the hard bedrock. This fractured rock helps to disperse and slow down the laterally moving water in the soil. If this is removed and water is allowed to move directly on the hard bedrock, it will increase velocities of the laterally moving groundwater that enters the trench even after the trench has been filled back in. Based on our experience, the trench then acts as a drain that can cause excessive water to accumulate in lower landforms, increasing the potential for flooding and slope failure. Likewise, this trench/drain can also remove water in other areas that the remaining trees require, causing additional and unwanted tree mortality.

Although beyond the scope of this report other portions of the alignment, outside Nelson County, are underlain by limestone with known karst features and unknown underground solution channels. The areas have an altogether different but equally critical set of problems to both the local residents and to the environment.

## 7. Human Activity (including- clearing, grading, blasting, vibration of heavy equipment)

The destabilizing effects of clearing and grading have been addressed above within the Climate, Water and Vegetation factors. Blasting and vibration from heavy equipment could compound the detrimental effects on soil and slope stability, particularly if construction is happening when the soils are above field capacity.

## 8. Soils

As stated above, during construction the soils will be altered significantly. The natural structure will be destroyed, impacting how water flows through the soil. The structure is critical in allowing excess water through and out of the soil (thereby limiting increased pore pressure during rainfall events) while also contributing to the sheer strength of the soil, and serves to keep the soil in place. Finally, the soil will likely get compacted during construction, which will have a negative effect on getting the site revegetated.

### *a) Cohesiveness*

Soil particles are electrically charged. Smaller soil particles (sand being the largest and clay being the smallest) have a much higher surface area and the electric charge is strongest. Clay will hold much more water than sand before it becomes liquid/flows.

Many of the mapped soil delineations within the alignment are described as coarse-textured soil mapping units (sandy loam, loamy sand). Even though most of the mapping units are generalized as residual soils, which would represent a more stable genesis of the soils, there is still a lower cohesiveness and a higher probability of structural failure than soils with higher clay content. As previously stated, the data used for the environmental assessments was the USDA Web Soil Survey and SSURGO data, which was mapped at a scale far too large to provide site specific, relevant data applicable to the hazards of the ACP construction. Landforms present throughout the alignment as it crosses Nelson County are prone to debris flows, but these landforms are far too small to be adequately represented on the existing maps. Concave landforms, many existing immediately adjacent to the narrow ridges on which the ACP is proposed to be constructed, have colluvial soils which inherently do not possess the same cohesiveness as similarly textured (distribution of particle sizes) soils that were formed in place. Furthermore, while inter-particle cohesion is generally a minor contributor to soil strength in shallow soils, and root strength / reinforcement is a much more dominant factor, in colluvial landscape positions where the soil thickness is generally deeper and the function of inter-particle cohesion is more influential.[15] Therefore, these forces and stability suggest that when cutting and clearing of the tree cover occurs, "instability spreads to a progressively wider range of soil thickness as lateral root strength decays"[7]. See Figure 12.

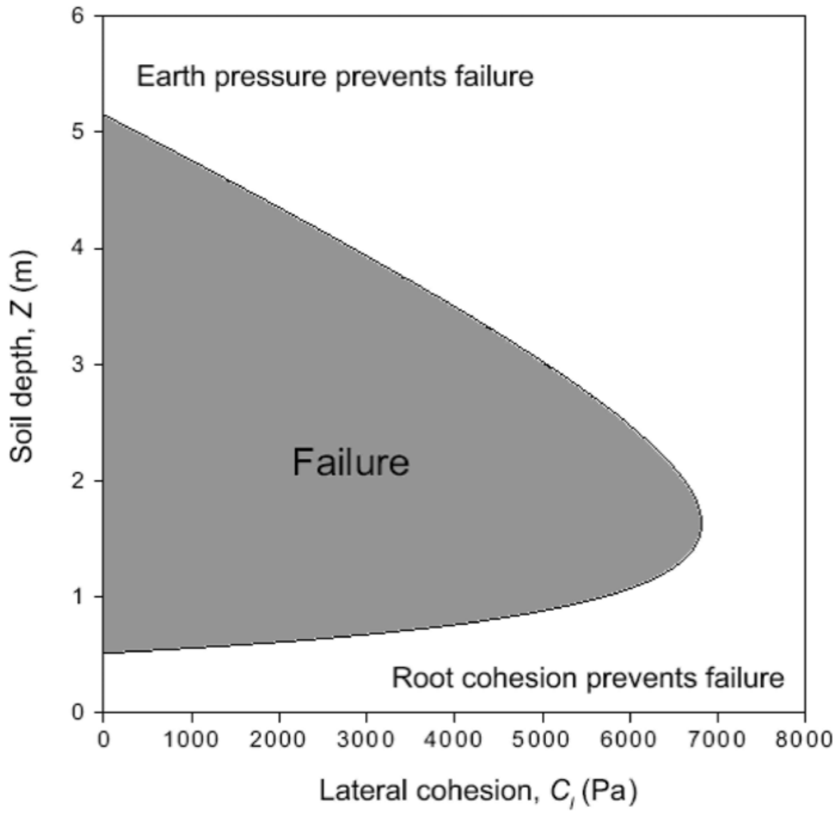



**Figure 12 Relationship of soil depth, cohesion and the influence of roots.**[7]

This concept was further realized during our field visit in December of 2016. Each concave landscape position that was investigated was verified to be colluvial soil, and each had a restrictive horizon in which the non-cohesive soils in place above such horizons would be increasingly susceptible to over-saturation and failure by virtue of mass-wasting. Restrictive horizons observed were bedrock, lithologic discontinuity, massive saprolite and fragipans. The stability of several of the sites investigated was also dependent on the deep tree roots, existing cover vegetation and leaf litter debris. The deep root phenomena observed supports the findings discussed as "ecohydrological controls" in *Frequency and magnitude of selected historical landslide events in the southern Appalachian Highlands of North Carolina and Virginia: Relationships to rainfall, geological and ecohydrological controls, and effects*[5] where soils in hollows (colluvial landscapes) were found to have a larger amount of roots at depths greater than 50cm (~20") than those soils in residual landscape positions (Figure 13.).

---

[15] Schwartz, Preti, Giadrossich, Lehmann, & Or, 2010

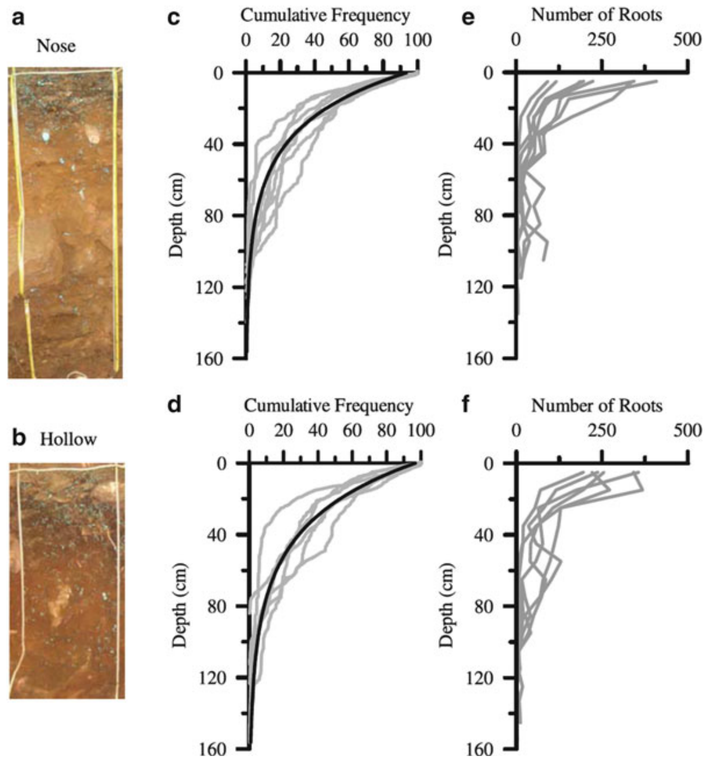



**Figure 13 Root frequency and distribution within soil profile in two different landscape positions**[5]

### *b) Erosion Potential*

Erosion potential on these slopes and soils will be high. Based on the site work that we performed in the steeply sloping gniess and granodiorite areas, these soils dominantly have sandy loam or coarse sandy loam surface and saprolite textures while the subsoil is dominantly loam. **These textures in combination with the very steep slopes (some we measured at 83%) increase susceptability for failure. See Figure 14.**

**Figure 14 Steep slopes observed along pipeline path during field reconnaissance.**

As documented by the USGS, most of the debris flows are initiated high up on the mountain (at or near the ridgeline) in concave landform positions that contain colluvial material where water will concentrate (Figure 3). Other areas at lower elevations are where the threat becomes both debris flow and flooding. "Watch the patterns of storm-water drainage on slopes near your home, and note especially the places where runoff water converges, increasing flow over soil-covered slopes."[16]

According to ACP's own submission to FERC, Nelson County ranks third of 36 counties in the entire proposed pipeline ROW (PA, WV, VA and NC) for having

[16] USGS Staff, "Landslide Preparedness, What To Do Before a Landslide" http://landslides.usgs.gov/learn/prepare.php, accessed, November 30, 2016

major revegetation concerns13[13], and ranks first in acreage with slopes >30%[17]. We believe that this will result in significant erosion and water quality problems both immediately and for many years in the future.

### c) Additional Soils Considerations

After digging soil pits for over 40 years, we have noticed that the amount of soil that comes out of a pit will never fit back in the same space. This excavation will be substantially bigger than the pits that we generally dig in our normal profession. Our question is what does the contractor plan to do with the tremendous amount of excess soil and rock that will not fit back into the excavated trench along with the 42" pipe and gravel?

## B. Spatial Analysis

Maps are a visual tool that can speak 10,000 words. We created several different maps/coverages for the Nelson County portion of this project. This mapping was done using Arc Info software so that we can reproduce maps using as many or few of the coverages as we desire or feel is appropriate for a given need. Coverages include the following: aerial photography, topography (USGS), soils (Web Soil Survey), mapped debris flows (USGS), geology (USGS), proposed ROW, and proposed access roads. In addition to these coverages we also mapped (based on soil types in Web Soil Survey only) debris flow potential and depth to rock. These predictive models could and should be revised with better topo and soil data.

Currently the only topography available is the USGS topo maps at 1"=24000" scale with 20' contour intervals. We found this data to be poor at best[18]. While interviewing Steve Thomas, we found out that the placement of soil boundaries completed by him and his party members was also based on the USGS topographic data. Therefore, any inaccuracies in that topo data are also reflected in the soil boundaries. Detailed analysis of better topo data will provide a more accurate picture of the concave, steeply sloping areas of the County. These areas are considered to have increased potential for slope instability and debris flows. All concave landforms, particularly on slopes in excess of 30%, will be areas that the surface runoff and laterally moving groundwater will both migrate toward, increasing the soil saturation and therefore, the potential for slope failure in those areas even without first denuding the slopes. Removal of the large trees on and adjacent to these steeply sloping concave areas will dramatically increase the vulnerability to failure.

[17] Resource Report 7 (Soils), Table 7.4.1-2 "Topsoil Depths Along the Proposed Pipeline Routes for the Atlantic Coast Pipeline and Supply Header Project", originally submitted to FERC by Dominion/ACP in September 2015, and updated in Appendix I of their July 18, 2016 Supplemental Filing.

[18] Additional detailed elevation datasets from USGS are now available, as of January 2017, which should be used to more accurately define steep slope areas.

Based on the lack of existing maps that accurately delineate colluvial soils in the steep mountainous areas of the County as well as our previous work/experiences with USGS identifying potential debris flow areas, we felt it was important we experiment with this. Given the limitations of the base data available, we were able to perform reconnaissance-level topographic analysis. We mapped out landforms that we know to be concave/colluvial landform positions based on the USGS topo for a section of the County. After doing this we overlaid the mapped debris flows on top of that. These matched up very well. **This indicates further to us that the Web Soil Survey was not done intensely enough for evaluating a project of this large of scale. It also shows that the potential for debris flows in this area is far greater than one would expect.**

Based on our predictive model and other mapping sources, we created a series of maps to illustrate debris flow potential (Appendix A) and depth to bedrock (Appendix B) along the entire ACP route in Nelson. These maps are important because they focus attention on areas that reflect specific soil characteristics or landforms which are either based on soil data (when mapped) or are inferred by the landform or soil type. **These anticipated characteristics indicate potential challenges and/or dangers that we recommend be properly addressed prior to permitting such an extensive construction project.**

## C. Field Reconnaissance

Field reconnaissance and pit investigations were conducted on December 13th and 14th, 2016. Detailed site and soil descriptions can be found in Appendix C, Soil Profile Descriptions Report.

The field investigation confirmed our staff's assumptions regarding landscape position and soil genesis. Those at the top of the ridges were found to be residual soils, with depth dependent on the orientation of the underlying parent material (bedrock) and the extent of the fracturing of that bedrock. The concave, side slope landscape positions all exhibited various amounts of colluvium, whether it was colluvium over residuum or colluvium to the maximum depth of the pit. These colluvial soils were observed adjacent to the ridges, and several were within the proposed right-of-way. All of the colluvial soils exhibited low inter-particle cohesion, with predominant subsoil textures ranging from sandy loam to loamy sand. Furthermore, those sandy-textured subsoils were loosely structured and generally dominated by subangular and rounded sand grains, thereby reducing the cohesion and structural stability even more. As referenced above, many of the colluvial soils exhibited the distinct phenomenon of medium and coarse roots at deeper depths than the ridge-top investigations. The soils in these landscape positions also exhibited planes of potential failure parallel to the surface (slope of land), evidenced by fragipans, bedrock contact, lithologic discontinuities or other confining layers that would impede the vertical transmission of water. Finally, many of the colluvial soils investigated were in landforms that exhibited evidence of previous debris-flow events, whether documented from the 1969 event or other failures.

Field investigations were limited to those areas that could be accessed by a tracked mini-excavator, as excessively-steep slopes greater than 60%, were commonly encountered adjacent to the ridge and within or in proximity of the proposed ACP right-of-way.

## D. HDD Exit at Wintergreen and initial ascent up Piney Mountain

The location of the directional drilling through the mountain and its exit near Wintergreen as well as the initial ascent up the slope of Piney Mountain is of particular concern. After visiting this area during our field explorations, we found it to be heavily impacted by debris flows. These, from our experience, appeared to be deposited from multiple events. In Figure 15, below, the darker red line indicates areas and landforms significantly impacted by previous debris flow events in this area. The lighter gray line indicates areas and landforms that may have been previously impacted by debris flows or are susceptible to debris flows during a significant storm event. The exit itself, where significant excavation will occur, is located in an area that we have identified as high potential for debris flow hazard. Furthermore, additional areas (depicted with lighter "gray" color boundary) above that location have moderate to high debris flow potential based on soils and landform.

If the directional drilling is completed as scheduled, clearing the trees and other vegetation from the boring point down, along with the disturbance of excavation, certainly increases the potential for failure. If the HDD is not possible and Dominion's contingency plan is used, it will cause the clearing of significantly more trees in areas that show previous debris flows. The potential for failure on either option will be dramatically increased if combined with a significant storm event. Even after the pipeline is completed, the root structure of the cover vegetation will not provide the soil stability that exists today. In addition the cleared right-of-way on both options will provide a path of least resistance for any future debris flow to follow. This path will almost certainly impact the northernmost access road for the Wintergreen community as well as State Route 664 (Beech Grove Road).

The same arguments are true of the proposed alignment from the HDD exit through that valley and its initial ascent up Piney Mountain (Figure 15.).

Erosion control and water quality protection in this area, as in other areas with similar boulder debris flows, will be difficult to achieve. Tremendous void space is present in these boulder fields where water flows freely although not visible on top of the ground. Therefore, due to the nature of these old debris flows, there may be little surficial evidence of erosion and sediment being carried by water. However, it is our experience that a high volume of water flows through these areas during many portions of the year and the sediment may not show up in the surface water until much further down in the stream.

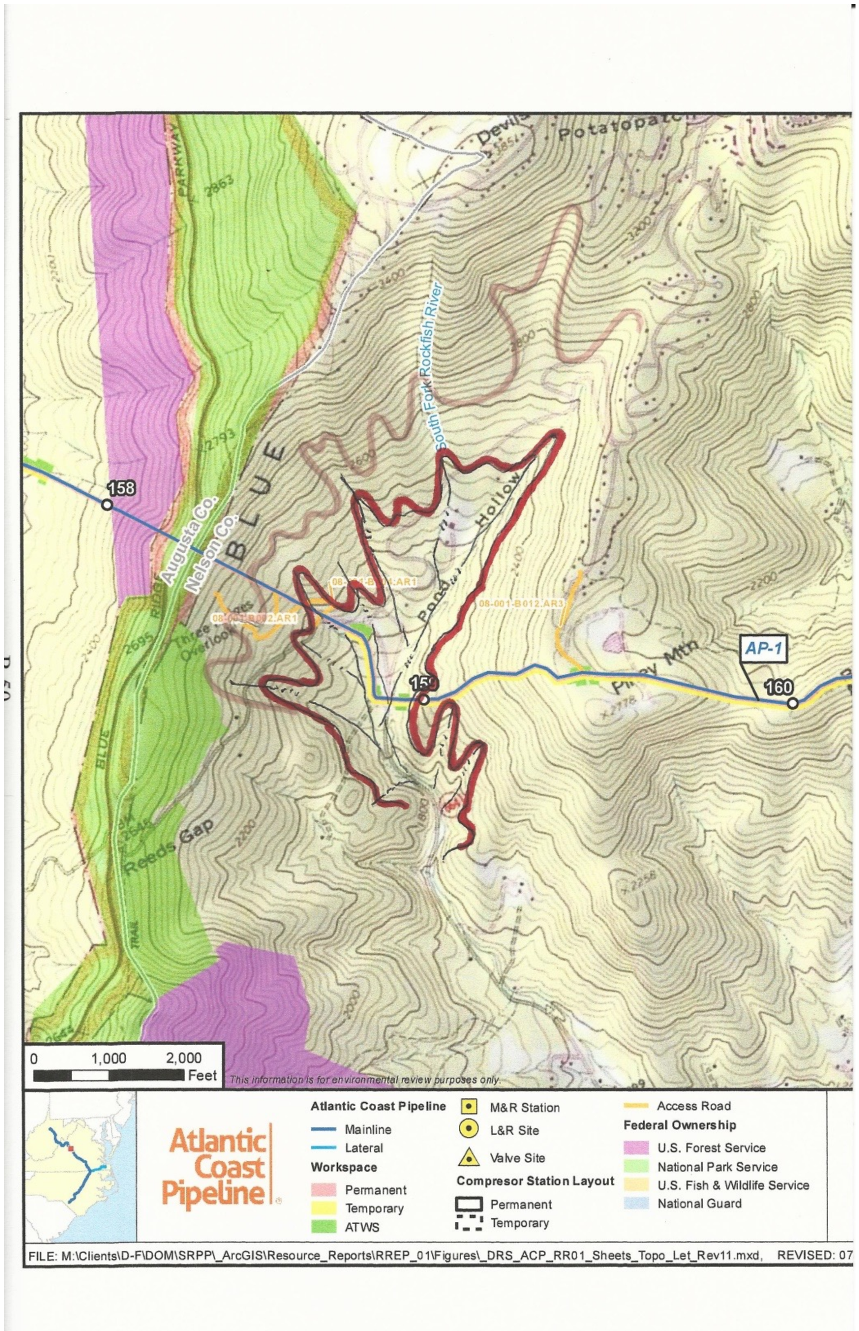



**Figure 15 Illustration developed by Blackburn Consulting Services, LLC**

# IV. Key Findings:

- Steeply sloping, concave, colluvial landscapes (such as those found throughout Nelson County) are the predominant source of debris-flows, and areas immediately adjacent to ridges are particularly susceptible.

- Evidence of historic debris flows often point to increased susceptibility to future debris flows in the same area.

- Field investigations confirmed colluvial soils with poor cohesive qualities located adjacent to the ridges and within the proposed right of way. Evidence of previous debris flow events was found in the many of these locations as well.

- Alteration in land profiles and the destabilization of the underlying soil structure, (which can affect its angle of repose) will compromise the stability of side slopes along the ROW and access roads.

- Potential for mass wasting is not determined by a single factor but the combination of many factors acting together.

- The specific soil characteristics found on Nelson's steep, concave landforms, often unmapped, allow for high infiltration of rain and snow meltwater in certain subsurface layers. This can result in super-saturation of the soils, instability and dangerous debris flow potential.

- Field investigations confirmed concave landscape positions along the route that are highly susceptible to over-saturation and failure and rely on roots and vegetation to maintain soil stability.

- The pipeline trench will alter the flow of water over the underlying bedrock, acting as a drain and allowing excess water to accumulate in the colluvial soils of adjacent concave landforms, thereby increasing risk of their failure.

- Tree removal from the ROW will further decrease soil stability by 1) loss of anchoring tree roots, 2) increased soil saturation in the absence of evapotranspiration, and 3) increased exposure to wind, harsher temperatures and increasing freeze/thaw of soils. Even if they can be successfully established, grass and shrub ground cover will not provide comparable protection and stabilization to the existing trees.

- Fire, the risk of which will be heightened due to increased human use both during and after construction, can further compromise slope stability.

- The proposed HDD exit site is in an area with evidence of multiple prior debris flows. Debris flow potential will be exacerbated by the extensive clearing and land disturbance required to create the drilling-related workspace. Should the HDD attempt fail and the contingency plan be implemented, significantly more clearing will be necessary on the landslide-prone slopes directly above the Wintergreen entrance.

- Field investigation confirmed soil types with high erosion potential on most of the examined slopes.

- Anticipated difficulties in revegetation would result in significant erosion and water quality problems both immediately and for many years in the future.

- Erosion control can be particularly difficult in boulder fields like those found along the proposed alignment near Wintergreen. High volumes of water typically flow through these areas without being visible on the surface, and large quantities of sediment can remain undetected until they show up far downstream.

- Many of the statements made in the materials Dominion has submitted to FERC were gross generalities, generated from the use of regional-level soil and topographic materials that lack sufficient detail to be the basis for the siting of major infrastructure. Because of this, the true risks that this project imposes on Nelson County are misrepresented.

- Based on our professional experience, our assessment is that the combination of the soil types and the concave very steep slopes (many measured above 60%) along and adjacent to the pipeline will increase the risk of future slope failure/debris flows if the tree cover is cleared and pipeline installed.

- Based on the research and site evaluation, areas that will likely require blasting were underestimated by Dominion.

# V. Recommendations

## A. Widen Study Corridor for All Proposed Alignments Along Ridgetops and/or Steep Slopes

Our recommendation is that in order to adequately assess the debris flow risk posed by the ACP project through Nelson County, Dominion's pipeline corridor studies must be updated with the following:
1) detailed topo analysis with data better than the pre-2017 USGS topo data,
2) new "Order 1" soil mapping with specific attention to delineating concave/colluvial landscape positions; and
3) identification and mapping of actual recent and historical debris flows within the alignment and its buffer.

Furthermore, conducting these studies on the 125-foot ROW is simply not enough. The 125-foot ROW often extends just into or right up to the areas that are more vulnerable to failure, and clearing the ROW may be enough of a catalyst, particularly if combined with a major storm event, to initiate serious problems. We therefore recommend that these studies extend beyond the actual limits of the proposed impact. We believe an additional analysis of a minimum of 200-foot buffer on both sides of any proposed limits of impact is required.

Finally, as previously mentioned, during the very short time that we have been working on this project, we have seen multiple alignments of the proposed pipeline. We suspect that the proposed alignment will continue to change as certain issues arise. Needless to say, our above recommendations should be implemented on all future proposed alignments through Nelson's steep slope areas as well.

### 1. Recommended Mapping Needs

#### *a) Topo/Landform Analysis*

We recommend detailed topo/landform analysis of the entire route as well as the proposed access roads and other work areas. Obtaining accurate topo data, whether it is the publicly available data which is better than the (pre-2017) USGS, or data that Dominion has prepared specifically for this job at a better scale and contour interval. Any new data produced for this process should be made available for those impacted to review. Again this will need to extend well beyond the "proposed" ROW, associated work areas and access roads so that topo analysis can be performed. As the final edits of this report were being prepared, we received notification that additional detailed elevation datasets became available in January 2017, which could be used to more accurately define steep slope areas.

#### *b) Order 1 Soil Survey*

Due to the extent of proposed disturbance of unstable and potentially unstable landscapes, a project such as this requires an Order 1 Soil Survey be completed and evaluated in detail. This is required by the US Forest Service where there are fewer homes and less risk of damage to personal property or human lives. Due to the uniquely steep areas and the previous history of debris flows in Nelson County we strongly recommend that an Order 1 soil survey be completed. We recommend that this study include a minimum of a 200-foot buffer on both sides of the proposed ROW easement resulting in a minimum of a 525-foot wide study area, and 200 feet on both sides of proposed work areas and proposed access roads. If study of this extended buffer shows that landforms, geologic or soil materials exist that are susceptible to, or have previously been impacted by landslides, we recommend detailed studies be required to address potential downslope impacts to water quality, personal or state properties or human life, that may result from such failures.

Studying the landform/topo analysis and Order 1 Soil Survey simultaneously, will produce a much more accurate picture of where stability hazards/concerns exist. Evaluating landform/topo analysis in combination with detailed soil mapping to identify any colluvial positions/soils on slopes greater than 15% will reveal areas with debris flow potential. Disturbance on or near slopes that exceed 30% are particularly suspect. Areas with any debris flow potential should be delineated and evaluated in detail.

### c) Map Debris/Landslides

Based on this overwhelming evidence in documents and our field evaluations, we recommend that all recent and historic debris flows be mapped within a 500-foot distance from edges of the proposed 125-foot ROW, including proposed access roads and additional work areas. In the course of our fieldwork, we discovered additional slides/debris flows not previously mapped by USGS. Furthermore, as previously stated, should the route or proposed impact areas change, this mapping should also be revised to assure that accurate data is being used.

## B. Other Soil Related Questions

As previously discussed above, our question is what does the contractor plan to do with the tremendous amount of excess soil and rock that will not fit back into the excavated trench along with the 42” pipe and gravel?

If the excess soil and rock is spread on site within the ROW, it almost always changes how water flows at the site and also adds excess weight to slopes that are already at risk for debris flows during heavy storm events. Also, if fill is placed on the ROW and adjacent to the remaining trees along the ROW, it will smother the tree roots and eventually kill additional trees unnecessarily. If, on the other hand, this material is trucked off the mountain ridges, what is the impact on access roads? Are these roads going to be built wide enough for two trucks to pass each other? There will literally be thousands of truckloads of soil and rock to be taken off very steep slopes!

If excess soil is deposited as fill material somewhere else, each and every site must be carefully evaluated to make sure that there will be no environmental or geotechnical impacts at those locations. Also, fill must be permitted and not placed in areas that will impact wetlands, waterways or other drainage patterns.

Each fill site whether on the ROW or elsewhere must be properly stabilized. Furthermore, we suggest that each area (extent) be mapped and documented with the building official's department within each county where they are deposited. The reason for this is so that no one will later unknowingly build a home or structure in those areas without adequate details as to the type of material, extent and depth of the fill. Building on uncontrolled fill material can and does cause foundation failures.

The Atlantic Coast Pipeline must adequately address how construction can occur during times when the soils are wet. Working the soils wet will:

- damage soil structure;
- reduce the ability to get the site properly stabilized;
- have additional negative impacts on adjacent trees (particularly older trees);
- increase erosion potential and runoff into streams; and,
- increase the potential for slope failure.

## C. Additional Pipeline Concerns

### 1. Fire Impacts During and After Construction

Forest or wildfires such as the fire that recently occurred in Tennessee are known to have impacts on slope stability. Slope stability issues in these situations are mainly due to loss of vegetative cover and organic matter in the surface topsoil followed by heavy precipitation. This fact combined with the removal of trees and installation of the pipeline in soils largely containing coarse sandy loam and sandy loam surface textures on very steep slopes will result in even higher risk of debris flow and erosion. Even when a fire destroys the forest, much of the roots and debris on top of the ground surface remain in place, somewhat protecting the land and soil from erosion. The potential for fire during the clearing of forests and installation of this pipeline is increased significantly due to human activity. Dominion has addressed fire prevention by identifying ways to reduce fire hazards during that process. However, after the construction is completed, our experience is that these areas then get used by the public far more that they were previously. This increased use, whether by tractors, four-wheel drive vehicles, or hikers/campers, also increases future fire potential.

### 2. Survey of Potential Homes, Properties, Roads and Businesses

Once the analysis for potential debris flow areas is done, we recommend an analysis of all existing homes, roads and businesses that may potentially be impacted if mountain failure should occur as a result of the construction, removal of trees and continued use of this ROW by tractors or other 4-wheel drive vehicles. Debris flows have been known to travel in excess of a mile from the initiating point of failure.

## 3. Graphitic Schist

The current pipeline alignment is proposed to go through areas underlain by phylite and graphitic schist. Graphitic schist, especially after being exposed, is known to react and cause the soil pH to become extremely acid. The acid that is formed is sulfuric acid and is known to cause catastrophic damage to infrastructure and the nearby vegetation. Although we did not specifically identify these areas in the field and we do not expect them to be extensive, they should certainly be investigated prior to approval of the ACP.

# VI. Conclusion

*"Debris flows can be frequent in any area of steep slopes and heavy rainfall, either seasonally or intermittently, and especially in areas that have been recently burned or the vegetation removed by other means."*[19]

Vulnerability to landslide hazards is a function of soil and geologic conditions, location, human manipulation of the land, and frequency of storm events. The effects of landslides on people and structures can be lessened by total avoidance of landslide hazard areas or by restricting, prohibiting, or imposing conditions on hazard-zone activity.

As evidenced from the multitude of historical debris flow events, the steep slopes in Nelson County have long been naturally susceptible to landslides. The ubiquity of concave landforms and unmapped colluvial soils in Nelson's mountains, combined with the substantial rainfall events commonly seen in mountainous areas that experience orthographic lifting has already resulted in catastrophic debris flows in the past and it is acknowledged that past debris flows often point to a heightened risk of further debris flows in the same or similar areas.

Dominion's filings with FERC do not appear to fully take into account the potentially dangerous conditions that the project poses to Nelson's slopes and residents. Dominions findings are based on regional data sets that are inadequate to meaningfully assess the site-specific risks within Nelson County or the effect that the proposed pipeline installation has on those risks.

Our study, and the resultant predictive model demonstrates a need for more detailed mapping and a thorough examination of the soils and topography on *and adjacent to* the route of the proposed pipeline, its related work areas and access roads. Without site-specific investigation of the terrain and debris flow potential surrounding the pipeline right-of-way within Nelson County it will be impossible to adequately design stabilization and water management strategies to address erosion and sedimentation controls or protect these landforms from factors that may increase the risk of catastrophic slope failure. In Dominion's filings is it commonly indicated that they will address these concerns during the construction process. We recommend that these additional examinations be performed — and that appropriate, site-specific stabilization plans be developed and made available for stakeholder comment — BEFORE the pipeline is approved by FERC.

[19] Highland and Bobrowsky, 2008

# VII. Literature References

Aleotti, P. (2004). A warning system for rainfall-induced shallow failures. *Engineering Geology*, 73(3), 247-265.

Anderson, M.G., & Crozier, M.J. (2005). Landslide hazard and risk (pp. 41-74) T. Glade (ed.). *Chichester: Wiley*.

Burton, W.C., (1996). Mudslides of Madison County. June 12, 1996. *Washington Post*.

Cameron, M.G.Jr., (2016). The proposed Atlantic Coast Pipeline route through Little Valley in Bath County, Virginia. An assessment of landslide risk and slope stability factors. *Dominion Pipeline Monitoring Coalition*. December 23, 2016 letter to Bose, K., Secretary, Federal Energy Regulatory Commission.

Chen, C.L and Major, J.J., (2007). Debris-Flow Hazards Mitigation: Mechanics, Prediction, and Assessment. Rotterdam, Netherlands*. Millpress Science Publishers*

Costa, J.E., & Wieczorek, G.F. (Eds.) (1987). Debris flows/avalanches: process, recognition, and mitigation (Vol. 7). *Geological Society of America*.

Dietrich, W.E., McKean, J., Bellugi, D. & Perron, T. (2007). The prediction of shallow landslide location and size using a multidimensional landslide analysis in a digital terrain model.

Eaton, L.S., Morgan, B.A., Kochel, R.C., and Howard, A.D., (2003). Role of debris flows in long-term landscape denudation in the central Appalachians of Virginia. *Geological Society of America; Geology* April 2003, v. 31; no. 4; p. 339-342

Gao, J. (1993). Identification of topographic settings conducive to landsliding from DEM in Nelson County, Virginia, USA. *Earth surface processes and landforms*, *18*(7), 579-591.

Godt, J. W., & Radbruch-Hall, D. H. (1997). *Digital representation of" Landslide Overview Map of Conterminous United States* (No. 97-289-B).

Highland, L.M., and Bobrowsky, Peter, (2008), The landslide handbook – A guide to understanding landslides: Reston, Virginia, *U.S. Geological Survey Circular* 1325, 129 p.

Highland, L.M. (2004). Landslide Types and Processes. Reston, Virginia, *U.S. Geological Survey* Fact Sheet 2004-3072.

Jacobson, R.B. (1993). Geomorphic studies of the storm and flood of November 3-5, 1985, in the upper Potomac and Cheat River Basins in West Virginia and Virginia (No. 1981). *USGPO; US Geological Survey*, Map Distribution.

Jacobson, R.B., McGeehin, J.P., Cron, E.D., Carr, C.E., Harper, J.M., and Howard, A.D., (1993). Landslides triggered by the storm of November 3-5, 1985, Wills Mountain Anticline, West Virginia and Virginia . *US Geological Survey Bulletin*, 1981, C1-C33.

Larsen, M.C., and Wieczorek, G.F. (2006). Geomorphic effects of large debris flows and flash floods, northern Venezuela, 1999. *Zeitschrift fur Geomorphologie, Supplementband*, 145, 147-175.

Lehmann, P., & Or, D. (2012). Hydromechanical triggering of landslides: From progressive local failures to mass release. *Water Resources Research*, 48(3).

Morgan, B.A., Iovine, G., Chirico, P., and Wieczorek, G.F. (1999). Inventory of debris flows and floods in the Lovingston and Horseshoe Mountain, VA, 7.5' quadrangles, from the August 19/20 1969, storm in Nelson County, Virginia. *U.S. Geological Survey* Open-file report 99-518.

Morgan, B.A., Wieczorek, G.F., Campbell, R.H., and Gori, P.I. (1997). Debris-flow hazards in areas affected by the June 27, 1995 storm in Madison County, Virginia. *U.S. Geological Survey* Open-file report 97-438.

Morrissey, M.M., Wiesczorek, G.F., & Morgan, B.A. (2004). Transient hazard model using radar data for predicting debris flows in Madison County, Virginia. *Environmental & Engineering Geoscience*, 10(4), 285-296

Nicas, J. (2011). Chance of Oil Spill Rises With Floodwaters. *Wall Street Journal*, New York. http://online.wsj.com. 8-4-2011

Pontrelli, M.D, Bryan, G., and Fritsch, J.M. (1999). The Madison County, Virginia flash flood of 27 June 1995. *American Meteorological Society: Weather and Forecasting*, Vol. 14: Issue 3: pp 384-404

Price, K., & Leigh, D.S. (2006). Morphological and sedimentological responses of streams to human impact in the southern Blue Ridge Mountains, USA. *Geomorphology*, 78(1), 142-160.

Reneau, S.L. & Dietrich, W.E. (1987). Size and location of colluvial landslides in a steep forested landscape. Erosion and Sedimentation in the Pacific Rim (Proceedings of the Corvallis Symposium, August, 1987). *IAHS Publ. no*. 165

Schultz, A.P. & Jibson, R.W. (Eds.). (1989). Landslide processes of the eastern United States and Puerto Rico (Vol. 236). *Geological Society of America*.

Schultz, A.P., & Southworth, C.S. (1987). Landslides of Eastern North America. *I Eastern North America I*, 1.

Schwarz, M., Preti, F., Giadrossich, F., Lehmann, P., & Or. D. (2010). Quantifying the role of vegetation in slope stability: a case study in Tuscany (Italy). *Ecological Engineering*, 36(3), 285-291.

Science Clarified, Faults to Mountains, Landslide and other Gravity Movements

Smith, J.A., Baeck, M.L., Steiner, M & Miller, A.J. (1996). Catastrophic rainfall from an upslope thunderstorm in the central Appalachians: The Rapidan storm of June 27, 1995. *Water Resources Research*, 32(10), 3099-3113.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Soil Survey Geographic (SSURGO) Database for Nelson County, Virginia. Available online. Accessed September 8, 2016.

Stock, J. D., & Dietrich, W. E. (2006). Erosion of steepland valleys by debris flows. *Geological Society of America Bulletin*, *118*(9-10), 1125-1148.

Whittecar, G.R., and Ryter, D.W., (1992). Boulder streams, debris fans, and Pliestocene climate change in the Blue Ridge Mountains of Central Virginia: *Journal of Geology*, v. 100, p. 487-494

Wieczorek, G.F., 1993, Assessment and prediction of debris-flow hazards: *Hydraulic engineering '93, Proc. 1993 ASCE Conf.*, p. 1272-1283

Wieczorek, G.F., Eaton, L.S., Morgan, B.A, Wooten, R.M., & Morrissey, M. (2009). An examination of selected historical rainfall-induced debris-flow events within the central and southern Appalachian Mountains of the eastern United States: *US Geological Survey* open-file report 2009-1155. Reston, Virginia, U.S. Geological Survey

Wieczorek, G.F., Gori, P.L., Campbell, R.H., and Morgan, B.A., (1995), Landslide and debris-flow hazards caused by the June 27, 1995, storm in Madison County, Virginia: *US Geological Survey*, Open file report 95-822, p. 14.

Wieczorek, G.F, Morgan, B.A., & Campbell, R.H. (2000) Debris-flow hazards in the Blue Ridge of central Virginia. *Environmental & Engineering Geoscience*, 6(1), 3-23

Wieczorek, G.F., Morgan, B.A., Campbell, R.H., Orndorff, R.C., Burton, W.C., Southworth, C.S., and Smith, J.A., (1996). Preliminary inventory of debris-flow and flooding effects of the June 27, 1995, Storm in Madison County, Virginia, Showing time sequence of positions of storm cell center*: U.S. Geological Survey*, Open file report, 96-13, p. 8.

Wieczorek, G.F., Mossa, G.S. and Morgan, B.A., (2004), Regional debris-flow distribution and preliminary risk assessment from severe-storm events in the Appalachian Blue Ridge province, USA: *Landslides*, v. 1, p. 53-59, available at http://springerlink.com/content/atmj2qx90yh24q0q/fulltext.html.

Wold, R.L., & Jochim, C.L. (1989). Landslide loss reduction: A guide for state and local government planning. In *Earthquake Hazards Reduction Series* (Vol. 52). US Federal Emergency Management Agency (FEMA).

Wooten, R.M, Witt, A.C, Miniat, C.F., Hales, T.C. & Aldred, J.L. (2016). Frequency and magnitude of selected historical landslide events in the southern Appalachian Highlands of North Carolina and Virginia: Relationships to rainfall, geological and ecohydrological controls, and effects. In *Natural Disturbances and Historic Range of Variation* (pp. 203-262). Springer International Publishing.

Yoshimatsu, H., (1994), Debris flows and landslides due to heavy rainfall, 19-21 July 1993, Nepal: *Landslide News* (Japan Landslide Society), no. 8, p.31-33.

# Predictive Debris Flow Potential

**DRAFT**

Appendix A-1


Soil Foundations

Prepared by
Blackburn Consulting Services, LLC
http://www.soilfoundations.com/

- ACP HDD Boring Paths (2/1/2016)
- ACP HDD Staging Pullback Areas
- ACP Access Roads (7/18/2016)
- NHD Rivers and Streams

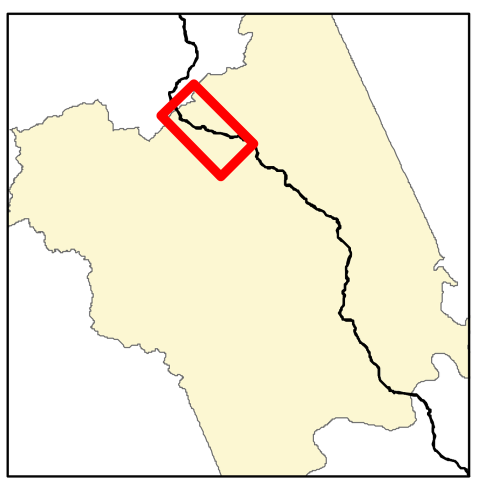
0 — 1,000 — 2,000
Feet

**USGS Debris Flow (1969 Storm)**

- Debris Flow
- Flood Effects
- ACP Filed Centerline (325' wide buffer)
- Contingency Path
- Soils (Web Soil Survey)

**Debris Potential (Upd Jan 2017)**

- Low
- Low - Mod
- Mod
- Mod - High
- High
- Flood
- Not Classified

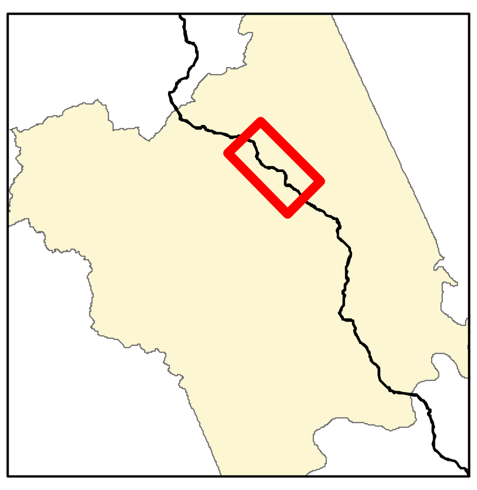



ACP HDD Boring Paths (2/1/2016)
ACP HDD Staging Pullback Areas
ACP Access Roads (7/18/2016)
NHD Rivers and Streams

**USGS Debris Flow (1969 Storm)**
Debris Flow
Flood Effects
ACP Filed Centerline (325' wide buffer)
Soils (Web Soil Survey)

**Debris Potential (Upd Jan 2017)**
Low
Low - Mod
Mod
Mod - High
High
Flood
Not Classified

0 1,000 2,000
Feet



Soil Foundations
**Prepared by**
**Blackburn Consulting Services, LLC**
**http://www.soilfoundations.com/**

# Predictive Debris Flow Potential

Appendix A-3


Soil Foundations

Prepared by
Blackburn Consulting Services, LLC
http://www.soilfoundations.com/

- ACP HDD Boring Paths (2/1/2016)
- ACP HDD Staging Pullback Areas
- ACP Access Roads (7/18/2016)
- NHD Rivers and Streams

0 1,000 2,000
Feet

**USGS Debris Flow (1969 Storm)**

- Debris Flow
- Flood Effects
- ACP Filed Centerline (325' wide buffer)
- Soils (Web Soil Survey)

**Debris Potential (Upd Jan 2017)**

- Low
- Low - Mod
- Mod
- Mod - High
- High
- Flood
- Not Classified

# Predictive Debris Flow Potential

DRAFT

Appendix A-4


Soil Foundations

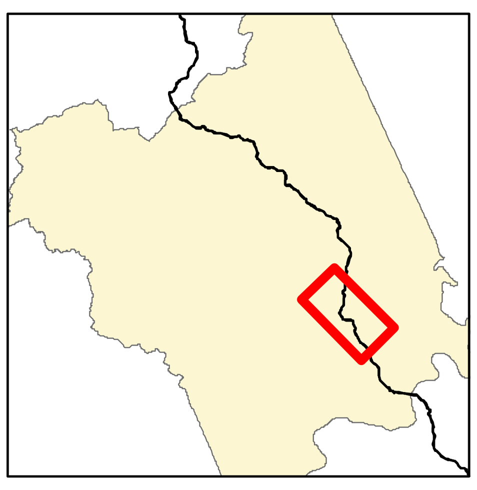
Prepared by
Blackburn Consulting Services, LLC
http://www.soilfoundations.com/

ACP HDD Boring Paths (2/1/2016)
ACP HDD Staging Pullback Areas
ACP Access Roads (7/18/2016)
NHD Rivers and Streams

0 1,000 2,000
Feet

**USGS Debris Flow (1969 Storm)**
Debris Flow
Flood Effects
ACP Filed Centerline (325' wide buffer)
Soils (Web Soil Survey)

**Debris Potential (Upd Jan 2017)**
Low
Low - Mod
Mod
Mod - High
High
Flood
Not Classified



# Predictive Debris Flow Potential

**DRAFT**

Appendix A-5

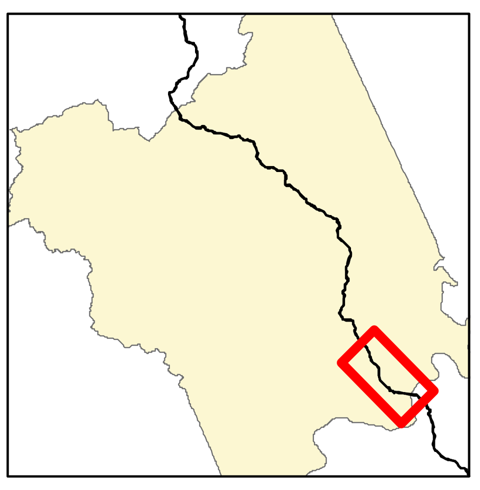

Prepared by
Blackburn Consulting Services, LLC
http://www.soilfoundations.com/

- ACP HDD Boring Paths (2/1/2016)
- ACP HDD Staging Pullback Areas
- ACP Access Roads (7/18/2016)
- NHD Rivers and Streams

0 — 1,000 — 2,000
Feet

**USGS Debris Flow (1969 Storm)**
- Debris Flow
- Flood Effects
- ACP Filed Centerline (325' wide buffer)
- Soils (Web Soil Survey)

**Debris Potential (Upd Jan 2017)**
- Low
- Low - Mod
- Mod
- Mod - High
- Flood
- Not Classified



# Predictive Depth to Bedrock

**DRAFT**

Appendix B-1


0 1,000 2,000 Feet

Soil Foundations

Prepared by
Blackburn Consulting Services, LLC
http://www.soilfoundations.com/

- ACP HDD Boring Paths (2/1/2016)
- ACP HDD Staging Pullback Areas
- ACP Access Roads (7/18/2016)
- NHD Rivers and Streams

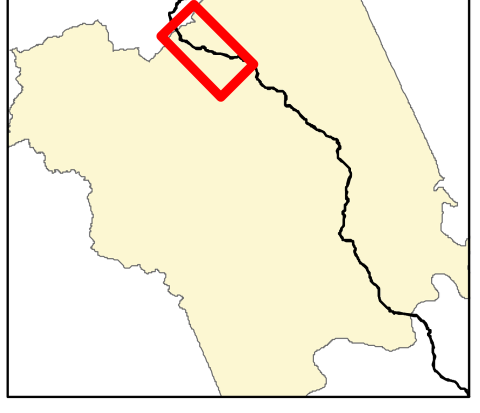
**USGS Debris Flow (1969 Storm)**

- Debris Flow
- Flood Effects
- ACP Filed Centerline (325' wide buffer)
- Contingency Path
- Soils (Web Soil Survey)

**Depth to Bedrock (Upd Jan 2017)**

- Areas that may include bedrock < 60"
- Areas with depth to bedrock < 60"

*Pits and locations are based on either GPS data or are located as accurately as possible when GPS data was not available



# Predictive Depth to Bedrock

**DRAFT**

Appendix B-2


*Pits and locations are based on either GPS data or are located as accurately as possible when GPS data was not available

| | | |
|---|---|---|
| ACP HDD Boring Paths (2/1/2016) | **USGS Debris Flow (1969 Storm)** | **Depth to Bedrock (Upd Jan 2017)** |
| ACP HDD Staging Pullback Areas | Debris Flow | Areas that may include bedrock < 60" |
| ACP Access Roads (7/18/2016) | Flood Effects | Areas with depth to bedrock < 60" |
| NHD Rivers and Streams | ACP Filed Centerline (325' wide buffer) | |
| | Soils (Web Soil Survey) | |

Soil Foundations

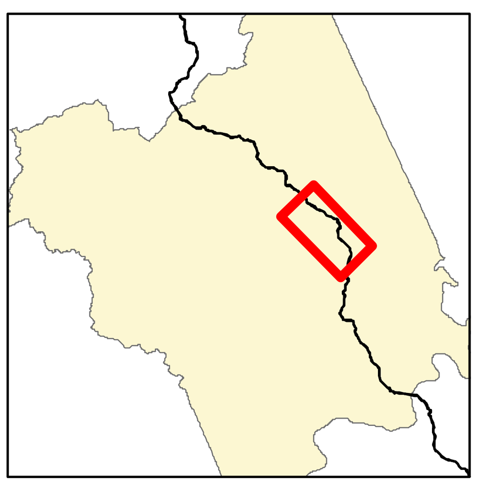
Prepared by
Blackburn Consulting Services, LLC
http://www.soilfoundations.com/

# Predictive Depth to Bedrock

DRAFT

Appendix B-3


*Pits and locations are based on either GPS data or are located as accurately as possible when GPS data was not available



Soil Foundations

Prepared by
Blackburn Consulting Services, LLC
http://www.soilfoundations.com/

| | | |
|---|---|---|
| ACP HDD Boring Paths (2/1/2016) | **USGS Debris Flow (1969 Storm)** | **Depth to Bedrock (Upd Jan 2017)** |
| ACP HDD Staging Pullback Areas | Debris Flow | Areas that may include bedrock < 60" |
| ACP Access Roads (7/18/2016) | Flood Effects | Areas with depth to bedrock < 60" |
| NHD Rivers and Streams | ACP Filed Centerline (325' wide buffer) | |
| | Soils (Web Soil Survey) | |

# Predictive Depth to Bedrock

DRAFT

Appendix B-4


0 1,000 2,000 Feet

*Pits and locations are based on either GPS data or are located as accurately as possible when GPS data was not available

Soil Foundations

Prepared by
Blackburn Consulting Services, LLC
http://www.soilfoundations.com/

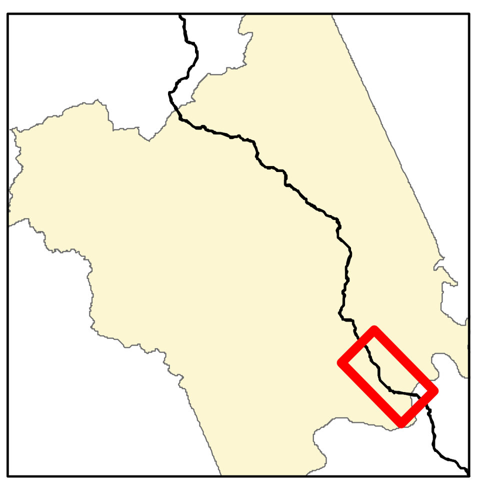
ACP HDD Boring Paths (2/1/2016)
ACP HDD Staging Pullback Areas
ACP Access Roads (7/18/2016)
NHD Rivers and Streams

**USGS Debris Flow (1969 Storm)**
Debris Flow
Flood Effects
ACP Filed Centerline (325' wide buffer)
Soils (Web Soil Survey)

**Depth to Bedrock (Upd Jan 2017)**
Areas that may include bedrock < 60"
Areas with depth to bedrock < 60"


0 1,000 2,000 Feet

*Pits and locations are based on either GPS data or are located as accurately as possible when GPS data was not available



Prepared by
Blackburn Consulting Services, LLC
http://www.soilfoundations.com/

| | | |
|---|---|---|
| ACP HDD Boring Paths (2/1/2016) | **USGS Debris Flow (1969 Storm)** | **Depth to Bedrock (Upd Jan 2017)** |
| ACP HDD Staging Pullback Areas | Debris Flow | Areas that may include bedrock < 60" |
| ACP Access Roads (7/18/2016) | Flood Effects | Areas with depth to bedrock < 60" |
| NHD Rivers and Streams | ACP Filed Centerline (325' wide buffer) | |
| | Soils (Web Soil Survey) | |

## Appendix C: SOIL PROFILE DESCRIPTION REPORT



**Date of Evaluation** __**12/13/16 – 12/14/16**__ **Friend of Nelson / ACP Field Evaluation**

| Hole # | Horizon | Depth | Description of color texture, etc. | Texture Group |
|---|---|---|---|---|
| Pit #1 Site 1 | A | 0-9 | Black (10YR 2/1) loam, moderate medium granular structure; friable, non-sticky, non-plastic; many fine, medium & coarse roots; 10% granite gneiss / grandiorite rock fragments | II |
| | Bt | 9-26 | Strong Brown (7.5YR5/6) sandy loam; weak medium subangular blocky structure; very friable, non-sticky, non-plastic; common fine & medium roots; 20% granite gneiss / grandiorite rock fragments | II |
| | C | 26-48 | Yellowish brown (10YR5/6) and strong brown (7.5YR5/6) sandy loam highly variable parent material with common white, black, strong brown, light grayish brown lithochromic features; massive parting to loose structure; slightly firm, non-sticky, non-plastic; few fine & medium roots; 20% highly fractured, granite gneiss / grandiorite rock fragments | II |
| | R | 48+ | Weather rhyolite grandiorite and gneiss rock~~;~~ | |
| Northeast aspect, with sideslopes at 66% adjacent to pit. Landscape slope 34%. Pinnacles of bedrock within 36” | | | | |




**Date of Evaluation** __12/13/16 – 12/14/16__ **Friend of Nelson / ACP Field Evaluation**

| | | | | |
|---|---|---|---|---|
| Pit #2 Site 1 | A | 0-7 | Black (10YR 2/1) loam, moderate medium granular structure; friable, non-sticky, non-plastic; many fine, medium & coarse roots; 10% granite gneiss / grandiorite rock fragments | II |
| | Bt | 7-24 | Strong brown (7.5YR4/6) sandy clay loam; weak fine subangular blocky structure; very friable, slightly-sticky, non-plastic; many fine & medium roots; 10% granite gneiss / grandiorite rock fragments | II |
| | Ab | 24-34 | Dark yellowish brown (10YR4/6) sandy loam; weak fine subangular blocky structure; friable, non-sticky, non-plastic; common fine & medium roots; 10% granite gneiss / grandiorite rock fragments | II |
| | Cx | 34-50 | Reddish yellow (7.5YR6/6) loamy sand, weak, fine platy structure parting to loose structure, very firm in place, 70% brittleness, non-sticky, non-plastic | I |
| | 2C | 50-62 | Brownish yellow (10YR6/6) and reddish yellow (7.5YR6/6) highly variable sandy loam with common white, black, strong brown, light grayish brown lithochromic features; massive parting to loose structure, friable, non-sticky, non-plastic, 20% granite gneiss / grandiorite rock fragments | II |
| Top of large, concave side slope. At top of landscape, slope is 50% with a northwest landscape. Slope measurements below pit elevation within the concave side slope were at or exceeding 82%. | | | | |

**Date of Evaluation** __12/13/16 – 12/14/16__ **Friend of Nelson / ACP Field Evaluation**

| | | | | |
|---|---|---|---|---|
| Pit #3<br>Site 1 | A | 0-9 | Black (10YR 2/1) loam, moderate medium granular structure; friable, non-sticky, non-plastic; many fine, medium & coarse roots; 10% granite gneiss / grandiorite rock fragments | II |
| | BA | 9-22 | Brownish yellow (10YR6/6) sandy loam; weak fine subangular blocky structure; very friable, non-sticky, non-plastic; many fine & medium roots; 10% granite gneiss / grandiorite rock fragments | II |
| | 2C | 22-82 | Brownish yellow (10YR6/6) sandy loam with oxidized ped faces within top 12 inches; massive, structureless; very friable, non-sticky, non-plastic; many fine & medium roots; 10% granite gneiss / grandiorite rock fragments | II |
| Head of small, ephemeral drain, limited concave landscape. Evidence at lower elevation of past debris flow. At top of landscape, slope is 46% with a southeast aspect. | | | | |


| | | | | |
|---|---|---|---|---|
| Pit #4<br>Site 1 | A | 0-5 | Black (10YR 2/1) loam, moderate medium granular structure; friable, non-sticky, non-plastic; many fine, medium & coarse roots; 10% granite gneiss / grandiorite rock fragments | II |
| | C | 5-30 | Brownish yellow (10YR6/6) loamy sand; massive, rock controlled structure; loose, non-sticky, non-plastic; many fine & medium roots; 65% granite gneiss / grandiorite rock fragments | II |
| | R | 30+ | Weather rhyolite grandiorite and gneiss rockj | |
| On top of ridge. Varying between 30-36" to hard bedrock. | | | | |

**Date of Evaluation 12/13/16 – 12/14/16** **Friend of Nelson / ACP Field Evaluation**

| | | | | |
|---|---|---|---|---|
| Pit #1 Site 2 | A | 0-7 | Black (10YR 2/1) loam, moderate medium granular structure; friable, non-sticky, non-plastic; many fine, medium & coarse roots; 10% grandiorite rock fragments | II |
| | $Bt_1$ | 7-22 | Strong brown (7.5YR5/6) clay loam; weak medium subangular blocky structure; friable, sticky, slightly-plastic; many fine, medium & coarse roots; 25% grandiorite rock fragments | IV |
| | $Bt_2$ | 22-40 | Strong brown (7.5YR5/8) clay loam; moderate medium subangular blocky structure; friable, sticky, plastic; common fine, medium & coarse roots; 35% grandiorite rock fragments | IV |
| | 2Bt | 40-49 | Strong brown (7.5YR5/6) sandy clay loam; moderate medium subangular blocky structure; friable, sticky, slightly-plastic; common fine, medium & few coarse roots; 30% grandiorite rock fragments | III |
| | 3BCt | 49-61 | Strong brown (7.5YR4/6) sandy clay loam with common, faint, very pale brown (10YR7/4) lithochromic features and common, prominent, light gray redoximorphic features; massive parting to weak, fine, subangular blocky structure; friable, slightly-sticky, slightly-plastic; few fine roots; 45% grandiorite rock fragments; irregular boundary | III |
| Across from Wintergreen entrance, within site / equipment area for potential HDD tunneling. Distinct debris flow area, very stoney surface. | | | | |

**Date of Evaluation** __**12/13/16 – 12/14/16**__ **Friend of Nelson / ACP Field Evaluation**

| | | | | |
|---|---|---|---|---|
| Pit #2<br>Site 2 | A | 0-2 | Dark brown (10YR 3/3) loam, weak medium granular structure; loose, non-sticky, non-plastic; many fine, medium & coarse roots; 20% grandiorite rock fragments | II |
| | BA | 2-5 | Strong brown (7.5YR4/6) sandy clay loam; weak medium granular structure; friable, sticky, slightly-plastic; many fine, medium & coarse roots; 20% grandiorite rock fragments | III |
| | $Bt_1$ | 5-20 | Strong brown (7.5YR5/6) clay loam; weak fine subangular blocky structure; friable, sticky, plastic; common fine, medium & coarse roots; 30% grandiorite rock fragments | IV |
| | $Bt_2$ | 20-33 | Strong brown (7.5YR5/6) and light yellowish brown (10YR6/4) sandy clay loam with many prominent black Mn coatings; weak medium subangular blocky structure; friable, sticky, slightly-plastic; common fine, medium & few coarse roots; 35% grandiorite rock fragments and boulders | III |
| | BC | 33-44 | Strong brown (7.5YR5/6) and light yellowish brown (10YR6/4) sandy clay loam with many prominent black Mn coatings; massive, rock controlled structure; friable, sticky, slightly-plastic; few fine, medium & few coarse roots; 60% grandiorite boulders | II |
| Across from Wintergreen entrance, within site / equipment area for potential HDD tunneling. Distinct debris flow area, very stoney surface, north of Pit#1 and in a different debris flow event. | | | | |

**Date of Evaluation 12/13/16 – 12/14/16** **Friend of Nelson / ACP Field Evaluation**

| | | | | |
|---|---|---|---|---|
| Pit #3 Site 2 | A | 0-11 | Very dark brown (10YR 2/2) loam, moderate medium granular structure; very friable, non-sticky, non-plastic; many fine, medium & coarse roots; 45% grandiorite rock fragments | II |
| | Bw | 11-22 | Brown (7.5YR4/4) loam / sandy clay loam; rock controlled structure; friable, slightly-sticky, non-plastic; many fine, medium & coarse roots; 50% grandiorite rock fragments and stones | III |
| | C | 22-40 | Strong brown (7.5YR5/6) sandy loam; massive rock controlled structure; loose, non-sticky, non-plastic; common fine and few medium & coarse roots; 75% grandiorite stones and boulders | II |
| Above Wintergreen entrance, above potential HDD tunneling unless routes are changed. above debris flow area, stoney surface, some local colluvium within area, 8% slopes and just east of >50% slopes to the top of the Blue Ridge. | | | | |

**Date of Evaluation** __12/13/16 – 12/14/16__ **Friend of Nelson / ACP Field Evaluation**

| | | | | |
|---|---|---|---|---|
| Pit #1<br>Site 3 | A | 0-7 | Very dark grayish brown (10YR 3/2) silt loam, moderate medium granular structure; very friable, non-sticky, non-plastic; many fine, medium & coarse roots; 20% granite gneiss / grandiorite rock fragments | II |
| | Bt | 7-26 | Strong brown (7.5YR4/6) sandy clay loam; weak fine granular structure; friable, slightly-sticky, slightly-plastic; many fine, medium & coarse roots; 35% granite gneiss / grandiorite rock fragments | III |
| | BC | 26-36 | Brown (10YR5/3) sandy loam with common white, black and light yellow lithochromic features; massive, loose structure; loose, non-sticky, non-plastic; common fine, medium & coarse roots; 40% grandiorite rock fragments | II |
| | $Bt_2$ | 36-60 | Light grayish brown (10YR6/2) sandy loam; rock controlled structure; loose, non-sticky, non-plastic; few fine, medium & few coarse roots; 65% grandiorite rock fragments and boulders | II |
| Roberts Mountain. Slopes 29% downslope from pit along spine ridge, 68% side slopes north of ridge. Pit is influenced by soil creep. | | | | |

**Date of Evaluation** __12/13/16 – 12/14/16__ **Friend of Nelson / ACP Field Evaluation**

| | | | | |
|---|---|---|---|---|
| Pit #2<br>Site 3 | A | 0-5 | Black (10YR 2/1) silt loam, moderate medium granular structure; very friable, non-sticky, non-plastic; many fine, medium & coarse roots;10% granite gneiss / grandiorite rock fragments | II |
| | Bw | 5-19 | Reddish yellow (7.5YR6/8) fine sandy loam; loose, structureless; loose, non-sticky, non-plastic; many fine, medium & coarse roots; 20% granite gneiss / grandiorite rock fragments | II |
| | C | 19-38 | Brownish yellow (10YR6/8) sandy loam; loose, structureless; loose, non-sticky, non-plastic; many medium & coarse roots; 40% granite gneiss / grandiorite rock fragments | II |
| | Cr | 38-63 | Light grayish brown (10YR6/2) sand; massive structure; loose, non-sticky, non-plastic; common medium & coarse roots; 98% highly weathered granite gneiss, easily crushable to sand | I |
| Roberts Mountain. Above Pit #1 and on the edge of a distinct debris flow, mapped from Camille event. | | | | |


| | | | | |
|---|---|---|---|---|
| Pit #3<br>Site 3 | A | 0-4 | Dark yellowish brown (10YR 4/4) silt loam, moderate medium granular structure; very friable, non-sticky, non-plastic; many fine, medium & coarse roots; 15% granite gneiss / grandiorite rock fragments | II |
| | Bw | 4-16 | Brownish yellow (10YR6/8) sandy loam moderate medium granular structure; loose, non-sticky, non-plastic; many fine, medium & coarse roots; 60% granite gneiss / grandiorite rock fragments and stones | II |
| | C / Cr | 16-64 | Pale brown (10YR6/3) sandy loam; massive rock controlled structure; loose, non-sticky, non-plastic; common fine and few medium & coarse roots; 40-90% highly fractured, weathered granite gneiss / grandiorite boulders | II |
| On peak above Pit #2. Sand particles much more angular than Pit#2. | | | | |

**Date of Evaluation 12/13/16 – 12/14/16** **Friend of Nelson / ACP Field Evaluation**

| | | | | |
|---|---|---|---|---|
| Pit #4 Site 3 | A | 0-11 | Black (10YR 2/1) loam, moderate medium granular structure; very friable, non-sticky, non-plastic; many fine, medium & coarse roots; 30% granite gneiss / grandiorite rock fragments | II |
| | Bw | 11-20 | Yellowish brown (10YR5/6) sandy loam; loose, structureless; loose, non-sticky, non-plastic; common fine & , few medium roots; 60% granite gneiss / grandiorite rock fragments and stones | II |
| | Cr | 20-48 | Brownish yellow (10YR6/8) loamy sand; loose, massive rock controlled structure; loose, non-sticky, non-plastic; 80% highly fractured granite gneiss / grandiorite boulders | I |
| Depth to rock check on ridge. | | | | |


| | | | | |
|---|---|---|---|---|
| Pit #5 Site 3 | A | 0-6 | Black (10YR 2/1) silt loam, moderate medium granular structure; very friable, non-sticky, non-plastic; many fine, medium & coarse roots;30% granite gneiss / grandiorite rock fragments | II |
| | Bw | 6-28 | Brownish yellow (10YR6/8) sandy loam; weak, fine subangular blocky structure; very firable, non-sticky, non-plastic; many fine, medium & coarse roots; 20% granite gneiss / grandiorite rock fragments | II |
| | 2Cr | 28-39 | Brownish yellow (10YR6/8) coarse sandy loam; loose, rock controlled structure; loose, non-sticky, non-plastic; common fine & medium roots, granite gneiss / grandiorite | II |
| | 3C | 39-63 | Brownish yellow (10YR6/6) fine sandy loam; massive structure; loose, non-sticky, non-plastic; common fine & medium roots; highly weathered greenstone saprolite | II |
| Side slope at head of access road. Slope approaching ridge is 65%. | | | | |


| | | | | |
|---|---|---|---|---|
| Pit #6<br>Site 3 | A | 0-5 | Very dark brown (10YR 2/2) sandy loam, moderate medium granular structure; very friable, non-sticky, non-plastic; many fine, medium & coarse roots; 30% granite gneiss / grandiorite rock fragments | II |
| | Bw | 5-24 | Reddish yellow (7.5YR6/8) sandy loam; loose, structureless; very friable, non-sticky, non-plastic; common fine & , few medium roots; 55% granite gneiss / grandiorite rock fragments and stones | II |
| | R | 24+ | Hard granite gneiss / grandiorite | I |
| Top of the ridge. | | | | |

| | | | | |
|---|---|---|---|---|
| Pit #7<br>Site 3 | A | 0-4 | Very dark brown (10YR 2/2) silt loam, moderate medium granular structure; very friable, non-sticky, non-plastic; many fine, medium & coarse roots; 30% granite gneiss / grandiorite rock fragments | II |
| | Bw | 4-19 | Yellowish brown (10YR5/6) weak sandy loam; weak, fine granular structure parting to structureless; loose, non-sticky, non-plastic; many fine, medium & coarse roots; 35% granite gneiss / grandiorite rock fragments and stones | II |
| | Cr | 19-58 | Highly weathered and fractured granite gneiss / grandiorite, loamy sand, common fine, medium & coarse roots | I |
| Head of a concave sides slope within ACP construction easement. Appears only slightly more stable than Pit #2. Slopes >60%. | | | | |