HYDROGEOLOGICAL ASSESSMENT OF THE PROPOSED 401 WATER QUALITY CERTIFICATION TO BE ISSUED FOR THE ATLANTIC COASTAL PIPELINE PROJECT, VIRGINIA, BY THE VIRGINIA STATE WATER CONTROL BOARD

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SUMMARY STATEMENT

The draft "401 Water Quality Certification" addressed herein pertains to Atlantic Coast Pipeline (ACP) construction "activities in upland areas outside the Corps jurisdictional areas under 33U.S.C.§1344 which may result in an indirect discharge to waters of the United States" such that the State Water Control Board (SWCB) will be reasonably assured that the ACP construction activities will not violate applicable Water Quality Standards in 9VAC25-260-5, *et seq.*, and will comply with the applicable provisions of 33U.S.C.§§1311, 1312, 1313, 1316, and 1317. However, violations of Water Quality Standards (**9VAC25-260-5, *et seq.***) pertaining to water temperature, dissolved oxygen, and sediment, which will impair the beneficial uses of state waters or result in a net loss of functions in surface waters, would result from the proposed Atlantic Coast Pipeline (ACP) construction activities due to deforestation in headwater areas of upland first order high gradient streams and increased turbidity and sedimentation due to increased stormwater discharge to receiving streams. The proposed ACP construction activities are **inconsistent with:**

1) **"Code of Virginia, Title 62.1**. **Waters of the State, Ports and Harbors" under "§62.1-11. Waters declared natural resource; state regulation and conservation; limitations upon right to use,** F. The quality of state waters is affected by the quantity of water and it is the intent of the Commonwealth, to the extent practicable, to maintain flow conditions to protect instream beneficial uses and public water supplies for human consumption."
2) "**Chapter 3.1 State Water Control Law, Article 2.4 Erosion and Sediment Control Law §62.1-44.15:52,** requiring "the effective control of soil erosion, sediment deposition, and nonagricultural runoff that shall be met in any control program to prevent the unreasonable degradation of properties, stream channels, waters, and other natural resources." Specifically, "For plans approved on and after July 1, 2014, the flow rate capacity and velocity requirements of this subsection shall be satisfied by compliance with water quantity requirements in the Stormwater Management Act (§ 62.1-44.15:24 et seq.) and attendant

regulations." The stated requirements of this subsection are: "flow rate capacity and velocity requirements for natural or man-made channels shall satisfy the flow rate capacity and velocity requirements for natural or man-made channels if the practices are designed to (i) detain the water quality volume and to release it over 48 hours; (ii) detain and release over a 24-hour period the expected rainfall resulting from the one-year, 24-hour storm; and (iii) reduce the allowable peak flow rate resulting from the 1.5-year, two-year, and 10-year, 24-hour storms to a level that is less than or equal to the peak flow rate from the site assuming it was in a good forested condition, achieved through multiplication of the forested peak flow rate by a reduction factor that is equal to the runoff volume from the site when it was in a good forested condition divided by the runoff volume from the site in its proposed condition".

The proposed ACP construction activities would result in degradation to upland headwater areas of upland first order high gradient streams. The degradation would result in the following detrimental impacts:

1) **Decrease in the groundwater table, groundwater quantities, and hydraulic head of groundwater** due to deforestation, soil compaction, and trench dewatering. This results in **decreased groundwater** available 1) to maintain seeps and springs which supply water to upland headwater areas, including wetlands, in first order stream watersheds and also 2) to maintain groundwater baseflow to provide water to receiving streams during times of drought. **This is inconsistent with Code of Virginia §62.1-11 because the quantity of groundwater will be decreased.**
2) **Degradation of conditions, specifically increased light and temperatures** due to deforestation in upland headwater areas of first order streams. Filtered light and lower temperatures in upland headwater areas are required to sustain aquatic habitats for aquatic macroinvertebrates at the base of the food chain. **This is inconsistent with Code of Virginia §62.1-11 because construction activities will cause failure to maintain flow conditions to protect instream beneficial uses**. **9VAC25-260-20 (Water Quality Standards) includes limits on increases in stream temperatures.**
3) **Degradation of ecological connectivity** for the river continuum due to destruction of aquatic habitats in upland headwater areas of first order streams. Destruction of the aquatic habitats for macroinvertebrates at the base of the food chain in upland headwater areas will disrupt connectivity with downstream aquatic organisms. **This is inconsistent with §62.1-11 because degradation of the upland headwater areas will result in failure to maintain flow conditions to protect instream beneficial uses.**
4) **Degradation of receiving streams** within watersheds crossed by the proposed ACP construction due to **increased sedimentation**, causing increased turbidity and embeddedness. Increased turbidity causes reduced water quality for filter feeding aquatic organisms and also obstruction of gills in fish. ACP has not

accurately delineated watersheds 1) to determine accurate peak stormwater discharge to receiving streams or 2) to determine increased soil loss due to changes in ground cover caused by the proposed ACP construction. **This is inconsistent with §62.1-11 because degradation of the upland headwater areas will result in degradation of water quality required to conditions to protect instream beneficial uses. 9VAC25-260-20** (Water Quality Standards), explains that turbidity is a substance to be controlled because it can be harmful to aquatic life.

5) **Deficiencies in Best Management Practices** descriptions: the Best Management Practices (BMPs) described for use during the proposed ACP construction in upland headwater areas are deficient and will result in **increased sedimentation** to receiving streams and increased embeddedness. The BMPs listed by ACP for use at the proposed construction areas do not include sediment basins, which would constitute the only BMP capable of detaining the water quality volume for release over 48 hours, or detaining and releasing over a 24-hour period the expected rainfall resulting from the one-year, 24-hour storm. Additionally, there are no sediment basins shown on the construction plans submitted in Appendix X, provided to the Virginia Department of Environmental Quality (VDEQ). **This is inconsistent with §62.1-44.15:52 because of ineffective control of soil erosion and sediment deposition which will result in unreasonable degradation of stream water and stream channels.**
6) The RUSLE calculations were provided by ACP for two areas of unknown location in Bath County, VA. The slope length of 100 feet was selected to pertain to that required for slope breakers as a BMP. In the first example, there was an increase from pre-construction soil loss of 0.015 tons per acre per year (t/ac/yr) to post-construction soil loss of 3.7 t/ac/yr, which is an increase of 246 times the pre-construction amount. In the second example, there was an increase from pre-construction soil loss of 0.022 tons per acre per year (t/ac/yr) to post-construction soil loss of 5 t/ac/yr, which is an increase of 227 times the pre-construction amount. This verifies increases in release of sediment to receiving streams as a result of ACP construction activities. **This is inconsistent with §62.1-11 and §62.1-44.15:52 and 9VAC25-260-40 because construction impacts will cause sedimentation to the receiving stream, resulting in increased embeddedness in the receiving stream, causing degradation of aquatic habitats.**
7) **Inadequate assessment of karst features**. Deforestation, soil compaction, and trench dewatering will result in decreased groundwater recharge increased stormwater discharge and sediment transport due to the proposed ACP construction in the upland headwater areas of karst terrain. ACP has delineated drainage areas ranging from 36 acres to 84,092 acres, with only 120 watersheds of meaningful sizes to evaluate stormwater discharge. As a result, there is no assurance that stormwater discharge to karst areas has been evaluated. In some areas, ACP evaluations have not recognized or have ignored karst. **This is**

inconsistent with §62.1-11 because increased sedimentation into karst features is detrimental to maintaining the ecological integrity of cave environments and also detrimental to groundwater resources.

8) **Inadequate assessment of landslide potential and seismic activity potential**. The proposed ACP route partially traverses the Central Virginia Seismic Zone, where the epicenter of the Mineral, Virginia earthquake occurred. Liquefaction of soils was reported during the earthquake. If soil liquefaction occurs where the soils are supporting a pipeline, the soils could collapse and a pipeline rupture could occur where the pipeline is not supported. Colluvium has been observed by ACP on numerous steep slopes along the proposed ACP route. Colluvium is defined as sediment which continually moves downslope as a form of soil landslide. Because earthquakes are known to cause landslides, the steep slope areas would be subject to greater landslide activity during an earthquake. Soil moves downslope during a landslide, delivering sediment to receiving streams and thus causing increased turbidity and embeddedness in receiving streams. **This is inconsistent §62.1-11 and §62.1-44.15:52 because the increased sedimentation to receiving streams will result in degradation of the stream water and aquatic habitats and will impair beneficial uses of the receiving streams.** Additionally, **9VAC25-260-20** (Water Quality Standards) explains that turbidity is a substance to be controlled because it can be harmful to aquatic life.
9) **Cumulative and permanent degradation of receiving streams and reduced groundwater quantities** will result from deforestation, soil compaction, and trench dewatering in upland areas crossed by the proposed ACP construction. Increased stormwater discharge results from deforestation, soil compaction, and trench dewatering (which directs water within trenches to the ground surface). Cumulative and permanent impacts will also result from reduced groundwater recharge due to deforestation, soil compaction, and trench dewatering. **This is inconsistent with §62.1-44.15:52 or 9VAC25-260-40 because the construction areas will not be reforested and soil functions cannot be restored to pre-construction conditions, thereby resulting in continual increased stormwater discharge, which will cause downstream stream bank erosion, resulting in increased embeddedness. The decreased groundwater recharge will lower the water table and the hydraulic gradient such that water will not be available to seeps and springs in the headwater areas of high gradient first order streams or downstream as groundwater baseflow for streams during times of drought. The impact is cumulative because numerous upland first order stream tributaries to higher order streams will increase sediment transport and stream bank erosion downstream.**

1.0 ACP EVALUATION OF UPLAND WATERSHEDS IS DEFICIENT

The definition of a watershed provided in “9VAC25-870-10. Definitions”: "Watershed" means a defined land area drained by a river or stream…”. In the Unified Stream Methodology (USACE, 2007), “watershed” is referenced as a “stream’s watershed”. The Virginia Stormwater Management Handbook (2013) provides the following definitions: “Watershed - A defined land area drained by a river or stream, karst system, or system of connecting rivers or streams such that all surface water within the area flows through a single outlet” and “Watershed Area - All land and water within the confines of a drainage divide” and “Drainage Basin - A geographical area or region where the earth’s surface is so sloped and contoured that surface runoff from streams and other natural watercourses flows by gravity to a given location or common outlet at some point along a stream channel.” **Figure 1.0-1** depicts a watershed, showing the watershed divide (or drainage divide) along the highest elevations, the headwater tributaries, and the larger stream receiving water from the headwater tributaries.

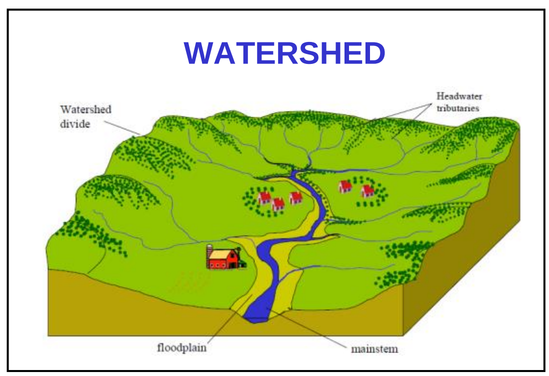


Figure 1.0-1 – Headwaters of first order stream tributaries are located at the highest elevations on the watershed divides.

A watershed can refer to the overall system of streams that drain into a river, or can pertain to a smaller tributary. Stream order is a measure of the relative size of streams. The smallest tributary is a first order stream, which originates in the highest elevations. Strahler (1952) defined a hierarchy of stream tributaries to depict the relationships of stream order. Where two first order streams connect, a second order stream is designated. Where two second order streams connect, a third order stream is designated (**Figure 1.0-2**).

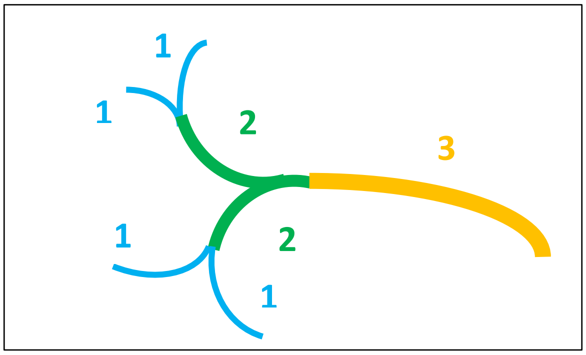


Figure 1.0-2 – Schematic diagram of the relationship of first order streams (designated "1", shown in blue), second order streams (designated "2", shown in green), and third order streams (designated "3", shown in orange). First order streams form in headwater areas at the highest elevations in watersheds. (Diagram based on Strahler, 1952).

1.1 Watershed Sizes

The Federal Government Agencies have established a hierarchical ordering of Hydrological Unit Codes (HUC), described as areas of land upstream from a specific point on the stream (generally the mouth or outlet) that contributes surface water runoff directly to this outlet point (**Table 1.1-1**). HUC designations were developed by Seaber, Paul R., F. Paul Kapinos, and George L. Knapp ("Hydrologic Unit Maps", U.S. Geological Survey Water-Supply Paper 2294; 1987) as a "standardized base for use by water-resources organizations in locating, storing, retrieving, and exchanging hydrologic data, in indexing and inventorying hydrologic data and information, in cataloging water-data acquisition activities…" HUC-8 Subbasin designations were based on a drainage area of greater than 700 square miles (448,000 acres). The smallest HUC is the HUC-12 Subwatershed, which typically encompasses an area from 10,000 acres to 40,000 acres. The HUC designations were not intended to determine specific details for smaller watersheds of tributaries which provide water quality and biotic functions of aquatic organisms for the overall watershed evaluations.

Table 1.1-1 – Descriptions of Hydrological Unit Codes (HUC).

Code	**Official Name**	**General Description**
HUC-2	REGION	Major land areas. The lower 48 states have 18 total, 1 additional each for Alaska, Hawaii, and the Caribbean. (21 total in US), called 1st Level – or Watershed 1st Level.
HUC-4	SUBREGION	Each Region has from 3 to 30 Subregions. The Missouri River Region has 30 Subregions. The lower 48 states have 204 (222 total in US), called 2nd Level.
HUC-6	BASIN	Accounting Unit (352 total in US), called 3rd Level.
HUC-8	SUBBASIN	Cataloging Unit. The smallest is 448,000 acres (700 square miles). Most are much larger. National HQ compilations have this as the smallest size unit (2,149 total in US), called 4th Level.
HUC-10	WATERSHED	Typically, from 40,000 to 25,000 acres (62 to 390 square miles). Work continues per new Interagency guidelines presented to Federal Geographic Data Committee on December 2000 (was formerly called HUC-11), called 5th Level or Watershed 5th Level.
HUC-12	SUBWATERSHED	Typically, from 10,000 to 40,000 acres (15 to 62 square miles). Work continues per new Interagency guidelines presented to Federal Geographic Data Committee on December 2000 (was formerly called HUC-14), called 6th Level or Watershed 6th Level.

1.2 Meaningful Watershed Delineation Sizes

In 2007, the U.S. Fish and Wildlife Service (USFWS) prepared a document, "Functional Assessment Approach for High Gradient Streams", for the U.S. Army Corps of Engineers to use in assessing impacts and mitigation with respect to processing Clean Water Act 404 permit applications. Upland high gradient headwater streams are characterized as first and second order ephemeral and intermittent streams with channel slopes ranging from 4% to greater than 10%, within watersheds of approximately 200 acres. The significance of this report relates to the proposed ACP gas pipeline construction with regard to how watersheds are evaluated. Because of the impacts of construction on the functions of headwater areas in the watersheds of upland first order high gradient streams, it is critical to evaluate these areas not simply as a small acreage within the area encompassing the construction project, but rather as functionally contributing areas which are the basis of water quality and aquatic habitat quality within the overall watershed.

In order to evaluate the interactions of precipitation, stormwater discharge, groundwater recharge and retention, and stream baseflow, calculations must be performed at the headwater tributary level. Because upland first order high gradient streams are well defined (Rosgen, 1994) and are considered to provide the basis for watershed evaluation (USFWS, 2007), it is essential to select these smaller watersheds, typically 200 acres in size, to evaluate the impact of construction projects.

It is critical to delineate the areas of different ground covers within a watershed in order to accurately calculate stormwater discharge. In the Watershed Protection Research Monograph No. 1, prepared by the Center for Watershed Protection (2003), it is emphasized that the relationship between impervious cover and stream quality applies to watersheds of first order streams, second order streams, and third order streams. It is therefore extremely important to evaluate watersheds of the first order streams, second order streams, and third order streams impacted by proposed ACP construction in order to adequately determine the impacts of increased stormwater discharge due to an increase in impervious surfaces within a watershed rather than with just a portion of a watershed.

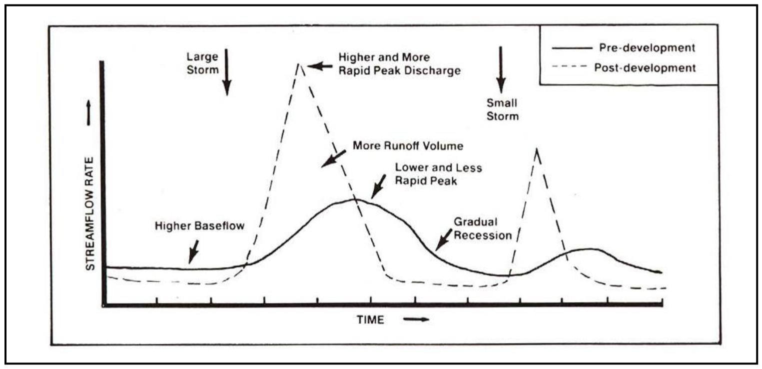
In Chapter 4 of the DEQ Virginia Stormwater Management Handbook (2013), it is stated in section "4.5.1.5 Increased Imperviousness of the Land Surface" that:

> "Impervious cover has emerged as a measurable, integrating concept used to describe the overall health or, conversely, degradation of a watershed. Research has established that when impervious cover in a watershed reaches between 10 and 25 percent …, ecological stress becomes apparent (Schueler et al., 2009). Beyond 25 percent impervious cover, stream stability is reduced, habitat is lost, water quality is degraded, and biological diversity is diminished."

Additionally, in Chapter 4 of the DEQ Virginia Stormwater Management Handbook (2013), it is stated in section “4.5.2. Stream Channel and Floodplain Impacts” that

> “Increased peak discharges for a developed watershed can be two to five times higher than those for an undisturbed watershed. As runoff velocities increase, it takes less time for water to run off the land and reach a stream or other water body (time of concentration). Streams in developed areas are often characterized as very "flashy" or “spiky” because of their response to these altered runoff characteristics. This characterization translates into the sharp peak and increased size of the post-development hydrograph as seen in **Figure 4.21** [provided as **Figure 1.2-1** herein] below, which depict typical pre-development and post-development streamflow hydrographs for a developed watershed. The combination of greater volumes of runoff more often and at higher flow rates can create altered stream flows, localized flooding, stream channel degradation and property damage, even in small storm events.”

Figure 1.2-1 – Pre- and Post-Development Stormwater Runoff Hydrographs (this is Figure 4.21 excerpted from the DEQ Virginia Stormwater Management Handbook, 2013).



Also provided in Chapter 4 of the DEQ Virginia Stormwater Management Handbook (2013), it is the following summary:

> “The impacts of altered stormwater runoff characteristics on stream channels and floodplains include the following:
>
> - Altered stream flow
> - Channel erosion, widening and downcutting
> - Increased frequency of bank-full and over-bank floods
> - Floodplain expansion
>
> **4.5.2.1. Altered Stream Flow**
>
> A comprehensive nationwide study by the United States Geological Survey (Carlisle et al., 2010) found that water flowing in streams and rivers has been significantly altered in nearly 90 percent of waters that were assessed... Flow alterations are considered to be the primary contributor to degraded river ecosystems and loss of native species. The USGS considers this assessment to

provide the most geographically extensive analysis to date of stream flow alteration."

It is therefore critically important to recognize that where stormwater discharge is increased, due to an increase in less permeable surfaces, even without strictly impermeable surfaces, it is the increase of stormwater discharge to specific quantities that causes the damage to streams by downstream stream bank erosion. Watersheds must be evaluated for stormwater discharge from all the ground covers within the watershed in order to determine if the stormwater discharge is equal to or greater than the stormwater discharge that would result from a 10 percent impervious area within the watershed.

1.3 ACP Watershed Delineations are Deficient

Dominion Energy Transmission, Inc. (DETI) developed "Annual Standards and Specifications for Erosion and Sediment Control and Stormwater Management for Construction and Maintenance of Gas Transmission Facility Projects in Virginia" (DETI Standards and Specifications), dated June 2017, which pertain to the proposed Atlantic Coast Pipeline (ACP) construction project. It is stated in the DETI Standards and Specifications that, "A complete stormwater management plan shall include the following elements: … 6. Hydrologic and hydraulic computations, including runoff characteristics; 7. Documentation and calculations verifying compliance with the water quality and quantity requirements of these regulations; 8. A map or maps of the site that depicts the topography of the site and includes: a. All contributing drainage areas… e. Sufficient information on adjoining parcels to assess the impacts of stormwater from the site on these parcels." Appendix X of the ACP Site Specific Plans, provided to the Virginia Department of Environmental Quality (DEQ), includes the drainage areas delineated. However, ACP has not used a meaningful approach to delineating drainage areas.

The drainage areas delineated by Environmental Resources Management (ERM) for DETI are provided in the report, "Appendix X – Access Road and Right-of-Way Post-Construction Stormwater Management Evaluation Report, *Atlantic Coast Pipeline*", dated June 12, 2017, for the stated intent of addressing "compliance of ACP with Virginia's water quantity and quality criteria as set forth in 9VAC25-870-66 and 9VAC25-870-63, respectively, and related Virginia Department of Environmental Quality (VDEQ) guidance." ERM delineated 170 drainage basins within the entire area proposed for the ACP construction in Virginia. The drainage basins used for water quantity calculations range from 36 acres to 84,092 acres. Only 20 of the drainage basin areas are less than or slightly greater than 200 acres, which is the typical size for meaningful stormwater discharge calculations. The larger delineated drainage basins extend far beyond the watershed of upland first order high gradient streams that will be impacted by ACP construction activities. Ground cover estimates and stormwater calculations for watersheds exceeding the area of the upland first order streams, second order streams, and third order streams obscure the impacts to functions within the smaller watersheds. For example, the impervious area created by the proposed ACP work corridor and access roads constitutes a larger percentage of impervious ground cover in the watershed of approximately 185 acres for the upland first order high gradient stream (tributary to Little Valley Run) extending from approximately Mile Post (MP) 93.0 to approximately MP 93.7 than for the watershed area of 19,215 acres delineated by ERM for ACP. **Figure 1.3-1**, which depicts drainage area 132 for the area encompassing the watershed extending from MP 93.0 to MP 93.7, is excerpted from ACP's Appendix X. **Figure 1.3-2** highlights the small area of the upland first order unnamed tributary (UNT) stream within the ACP drainage area 132. **Figure 1.3-3** provides the delineation of the upland first order UNT stream impacted by the proposed ACP construction.

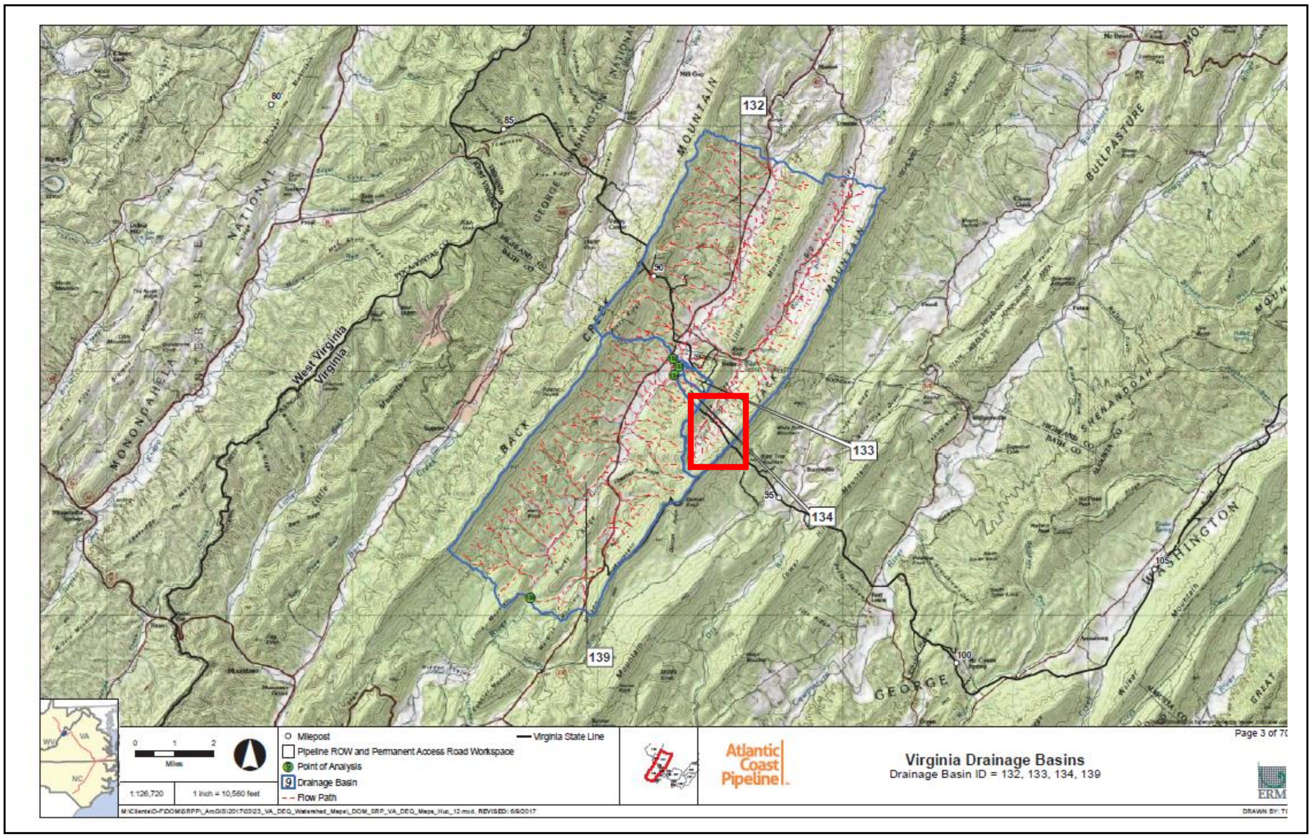


Figure 1.3-1 – ERM's drainage area 132 for the area encompassing the watershed extending from MP 93.0 to MP 93.7, excerpted from ACP's Appendix X.

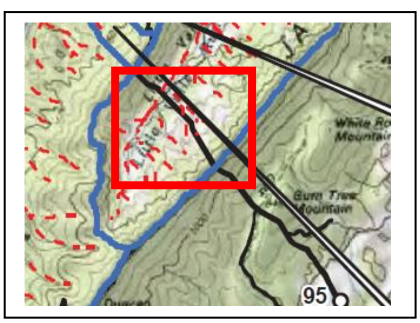


Figure 1.3-2 – Larger view of ACP drainage area 132 (outlined in blue), encompassing the smaller area (in red rectangle) of proposed ACP construction impact.

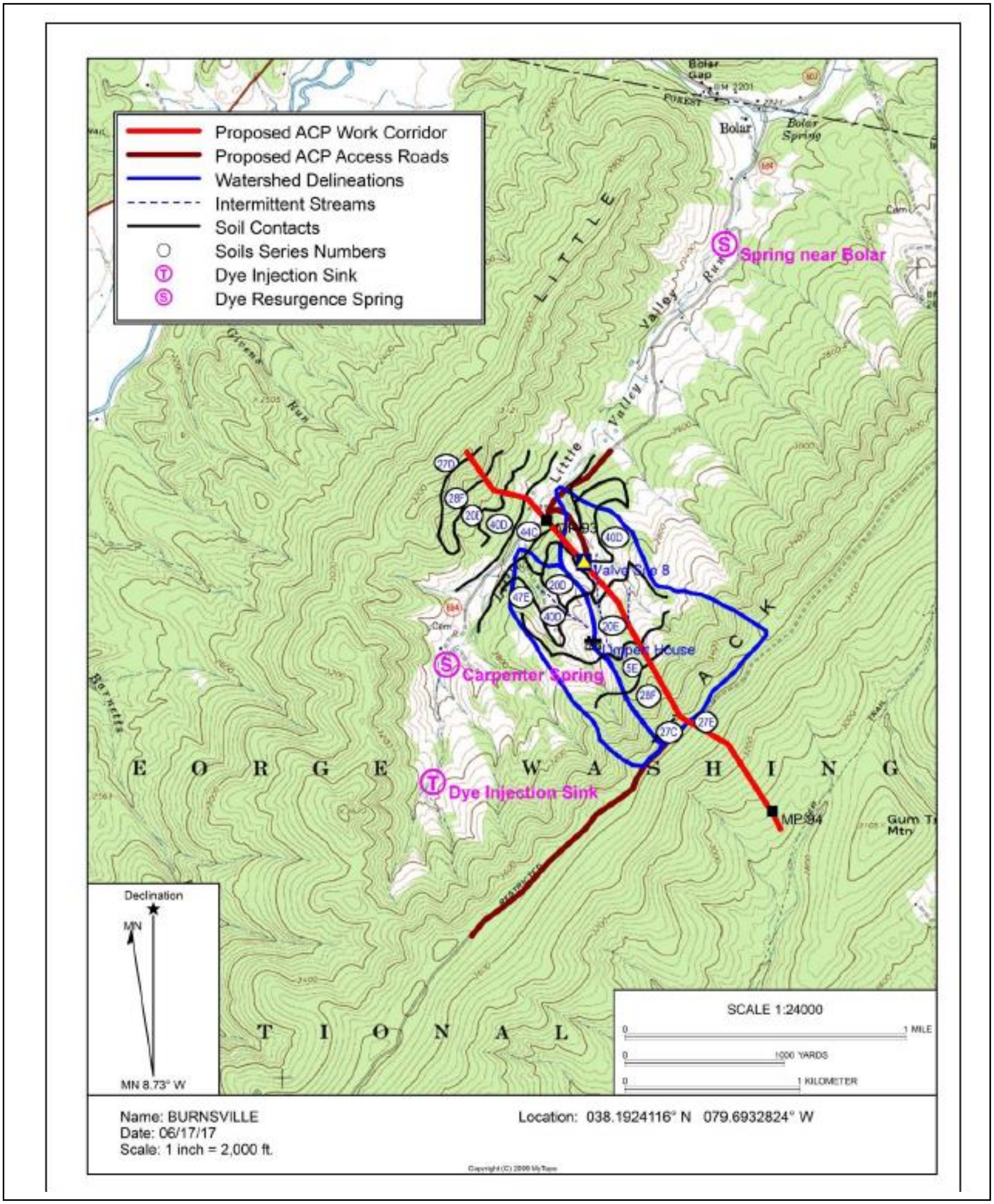


Figure 1.3-3 – Watershed or drainage area, approximately 185 acres, of the upland first order UNT stream (tributary to Little Valley Run in Bath County, VA) impacted by proposed ACP construction area between approximately MP 93.0 and approximately MP 93.7. (Map developed by P.C. Dodds using Terrain Navigator Pro software).

1.4 ACP's Deficient Watershed Delineations Result in Inaccurate Stormwater Discharge Calculations

Of the drainage areas delineated by ERM for stormwater calculations provided in ACP Appendix X, 150 of the 170 delineated drainage areas exceed the acreages of functionally contributing areas which are the basis of water quality and aquatic habitat quality within the watershed. ERM calculated pre-construction and post-construction peak stormwater discharge calculations using the TR-55 method, which uses curve numbers to represent various ground covers. The Virginia Stormwater Management Handbook (2013) states that: "When soil is disturbed by grading, stockpiling, and heavy equipment traffic, the soil becomes compacted, structure is lost and porosity decreases. When this happens, the soil's ability to take in water (permeability) is substantially reduced and surface runoff increases. Even if topsoil is stripped, stockpiled and reapplied following construction (a practice DEQ strongly recommends), the resultant loss of structure reduces the permeability of the topsoil. The loss of structure in the topsoil, together with compaction of the subsoil by construction equipment, is so profound that the bulk density of a lawn soil can approach that of concrete… The result is a surface that is *functionally impervious* because the soil's permeability is so greatly reduced." However, ERM states in ACP Appendix X that "all areas categorized as Forest within the pipeline permanent and temporary ROW will be converted to the Shrub land cover category."

Appendix 2-B, "VSMP Permit Regulations" of the DEQ Virginia Stormwater Management Handbook (2013) provides the following definitions: 1) *"Runoff" or "stormwater runoff"* means that portion of precipitation that is discharged across the land surface or through conveyances to one or more waterways; 2) *"Runoff characteristics"* include maximum velocity, peak flow rate, volume, and flow duration; 3) *"Runoff volume"* means the volume of water that runs off the site from a prescribed design storm. Additionally, groundwater that has been diverted to the surface must be included in stormwater calculations: "**9VAC25-870-55. Stormwater management plans.**

> A. A stormwater management plan shall be developed and submitted to the VSMP authority. The stormwater management plan shall be implemented as approved or modified by the VSMP authority and shall be developed in accordance with the following:
> 2. A stormwater management plan shall consider all sources of surface runoff and all sources of subsurface and groundwater flows converted to surface runoff…
> 6. Hydrologic and hydraulic computations, including runoff characteristics;
> 7. Documentation and calculations verifying compliance with the water quality and quantity requirements of these regulations;
> 8. A map or maps of the site that depicts the topography of the site and includes:
> a. All contributing drainage areas."

ACP cannot provide accurate calculations of peak stormwater discharge in upland first order, second order, or third order streams because ERM did not delineate pertinent watersheds. The number of upland first order, second order, or third order watersheds that would be crossed by the 307 miles of proposed ACP construction in Virginia is simply not provided because drainage areas delineated by ERM greatly exceed the sizes of the smaller watersheds which should have been delineated.

In order to comply with "**Code of Virginia, Title 62.1. Waters of the State, Ports and Harbors, Chapter 3.1 State Water Control Law, Article 2.4 Erosion and Sediment Control Law § 62.1-44.15:52**", it is necessary to analyze the peak rate of runoff for a 24-hour storm event. A study of natural channels is presented in "Fluvial Processes in Geomorphology" (Leopold, L.B., M.G. Wolman, and J.P. Miller, 1964, W.H. Freeman, San Francisco) which concludes that natural stream channels are shaped by the 1½ frequency storm event. Furthermore, the U.S. Geological Survey has developed a bankfull discharge classification system for streams based on the premise that bankfull discharge in streams results from peak stormwater flow and determines the shape of the stream. Increased peak stormwater runoff discharge to receiving streams increases the bankfull discharge, which is the reason for the required analysis of peak rates of stormwater discharge stated in the Virginia Erosion and Sediment Control law. The intent of this is to detain stormwater runoff discharge from construction sites for a specified time period in order to control the peak stormwater discharge to the receiving stream. However, because of the increased impervious areas developed at large construction sites, the impact becomes more complicated. The Virginia Runoff Reduction Method defines impervious to include roadways and driveways as distinctly different from forested areas with respect to ground cover and stormwater runoff coefficients. However, ERM has used curve numbers weighted for drainage area sizes that far exceed the pertinent watershed sizes of first order, second order, or third order streams and used a curve number for "Shrub land" for post-construction work corridor construction areas. At best, even though this area is considered as functionally impervious by the VDEQ, the post-construction areas would be better ascribed curve numbers for managed turf. In all of the ERM calculations for peak stormwater discharge, the weighted curve number values for pre-construction ground cover is the same or less than the post-construction weighted curve numbers. This would indicate no change in ground cover before and after construction, or an improvement in ground cover after construction.

In the publication, "Technical Bulletin No. 1 – Stream Channel Erosion Control (1999, http://www.deq.virginia.gov/Portals/0/DEQ/Water/Publications/TechBulletin1.pdf), the Virginia Department of Conservation and Recreation explains that deforestation and soil compaction at large construction sites not only increase the amount of stormwater discharge to receiving streams, but also increase the frequency of peak runoff rate because the increased amount of impervious areas results in less infiltration. As a consequence, "it takes less rainfall to produce the same *volume* of runoff. Therefore, the *peak rate of runoff* that normally occurs on a 2-year frequency before development, may occur several times a year following development." (VDCR, 1999).

ERM simply does not provide peak stormwater discharge calculations required to determine the peak stormwater runoff for watersheds of upland first order streams, second order streams, or third order streams. Only the peak stormwater discharge from the actual watershed can provide a basis to determine the increased stream bank erosion downstream. Increased peak stormwater discharge from construction activities will result in increased sedimentation in streams 1) directly, because BMPs are not 100 percent effective in preventing sediment transport to streams; and 2) indirectly, because peak stormwater discharge will cause stream bed scour and stream bank erosion downstream, resulting in the introduction of turbidity and sediment to the streams. The increased turbidity and sedimentation will 1) degrade water quality, which is inconsistent with **Code of Virginia, Title 62.1**. **Waters of the State, Ports and Harbors" under "§62.1-11. Waters declared natural resource; state regulation and conservation; limitations upon right to use**; and will 2) increase embeddedness in the stream beds, degrading or destroying aquatic habitats, which is inconsistent with **Code of Virginia, Title 62.1. Waters of the State, Ports and Harbors, Chapter 3.1 State Water Control Law, Article 2.4 Erosion and Sediment Control Law § 62.1-44.15:52;** the **Virginia Water Protection Permit (§ 62.1-44.15:20);** and **9VAC25-260-20 (Water Quality Standards), which explains that turbidity is a substance to be controlled because it can be harmful to aquatic life.**

Accurate water quantities, evaluated by determination of peak stormwater discharge, is required by Virginia Administrative Code "**9VAC25-870-66. Water quantity.**

> B.1. Manmade stormwater conveyance systems. When stormwater from a development is discharged to a manmade stormwater conveyance system, following the land-disturbing activity, either:
>
> a. The manmade stormwater conveyance system shall convey the post-development peak flow rate from the two-year 24-hour storm event without causing erosion of the system. Detention of stormwater or downstream improvements may be incorporated into the approved land-disturbing activity to meet this criterion, at the discretion of the VSMP authority; or
>
> b. The peak discharge requirements for concentrated stormwater flow to natural stormwater conveyance systems in subdivision 3 of this subsection shall be met."

Clearly, peak stormwater discharge from an upland first order stream, second order stream, or third order stream cannot be calculated 1) if the stream's watershed is not accurately delineated; 2) the various ground covers are not accurately delineated; and 3) if there is no consideration of the additional amount of surface runoff due to the groundwater flow diversion from trench dewatering and from seeps and springs intercepted during hill slope excavation for the ACP construction activities.

The Rational Method (or Formula) and the TR-55, which was developed by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), are two methods commonly used to calculate peak stormwater discharge. It is stated in the Virginia Department of Transportation Drainage Design Manual, 2002 (VDOT Drainage Manual) that the Rational Formula is best suited to use for watersheds of 200 acres or less, the TR-55 method is best suited to use for watersheds 200 acres to 2000 acres, and the USGS Regional Equations are best suited for watersheds greater than 2000 acres. The VDOT Drainage Manual provides that, "The rational formula estimates the peak rate of runoff at any location in a watershed as a function of the drainage area, runoff coefficient, and mean rainfall intensity for a duration equal to the time of concentration (the time required for water to flow from the most hydraulically remote point of the basin to the point of study)." It is explained in the VDOT Drainage Manual that the TR-55 method uses "the same basic data as the Rational Method: drainage area, a runoff factor, time of concentration, and rainfall", and "also considers the time distribution of the rainfall, the initial rainfall losses to interception and depression storage and an infiltration rate that decreases during the course of a storm." The Rational Method is described in the Virginia Stormwater Management Handbook (2013) as follows:

"The Rational Formula estimates the peak rate of runoff at any location in a drainage area as a function of the *runoff coefficient*, *mean rainfall intensity*, and *drainage area*. The ***Rational Formula*** is expressed as follows:

Equation 11.1. Rational Formula $Q = C\ I\ A$

Where: Q = maximum rate of runoff (cfs); C = dimensionless runoff coefficient, dependent upon land use …; I = design rainfall intensity (in./hr.), for a duration equal to the time of concentration of the watershed; A = drainage area (acres)."

The time of concentration is determined by using the Kirpich nomograph or other standard methods. The intensity is determined by using B, D, and E factors provided for each county of Virginia and presented in the Virginia Department of Transportation Drainage Manual (revised 2009). The equation using these factors to determine intensity is provided in the Virginia Stormwater Management Handbook (2013) as follows:

Equation 11.2 Rational Method Rainfall Intensity $I_f = \frac{B}{(T_c+D)^E}$

Where:

I_f = Rainfall intensity for a given year recurrence interval (2, 5, 10, 25, 50, & 100-year) in inches/hour

T_c = Drainage area time of concentration assumed equal to the storm duration), in minutes"

The TR-55 method is described in the Virginia Stormwater Management Handbook (2013) as follows: “The techniques outlined in *TR-55* require the same basic data as the rational method: drainage area, time of concentration, land use and rainfall. The NRCS approach, however, is more sophisticated in that it allows the designer to manipulate the time distribution of the rainfall, the initial rainfall losses to interception and depression storage, and the moisture condition of the soils prior to the storm.” Computer software is generally used to calculate peak stormwater discharge using the TR-55 method.

ERM used the TR-55 method for determining the 24-hour 2-year peak stormwater discharges, and additional time events, for the drainage areas delineated. By using the drainage delineations for areas far exceeding the drainage areas of upland first order streams, second order streams, and third order streams, and by using the “Shrub land” ground cover coefficient for the ACP post-construction areas, the impacts were effectively obscured for the upland first order streams, second order streams, and third order streams. All of the ERM post-construction peak stormwater discharge values were the same as, or less than, those of the pre-construction conditions.

As shown in **Figure 1.3-1**, **Figure 1.3-2**, and **Figure 1.3-3**, the drainage area (or watershed) for the upland first order stream UNT to Little Valley Run is approximately 185 acres, which is far less than the 19,251-acre ERM delineated drainage area that includes the upland first order stream UNT to Little Valley Run. Calculations using the Rational Method and the TR-55 Method were performed by Dan Shaffer (Spatial Analyst, Dominion Pipeline Monitoring Coalition, personal communication) and Ari Daniels, EIT (Center for Watershed Protection, personal communication), respectively, to determine the 24-hour 2-year peak stormwater discharges for 4 upland first order streams, as summarized in **Table 1.4-1**. Ground cover coefficients used in the Rational Method included those for forest, pasture, and impervious (ACP construction areas). Ground cover coefficients used in the TR-55 Method included those for forest, pasture, and, for the ACP construction areas, brush, open space, and gravel road. The Virginia Stormwater Management Handbook (VSMH), 2013, states that: “When soil is disturbed by grading, stockpiling, and heavy equipment traffic, the soil becomes compacted, structure is lost and porosity decreases. When this happens, the soil’s ability to take in water (permeability) is substantially reduced and surface runoff increases…. The result is a surface that is *functionally impervious* because the soil’s permeability is so greatly reduced.” However, ERM states in ACP Appendix X that “all areas categorized as Forest within the pipeline permanent and temporary ROW will be converted to the “Shrub land cover category”. In **Table 1.4-1**, the TR-55 Method peak stormwater discharges are based on ground cover coefficients similar to those used by ERM in their TR-55 stormwater calculations. According to VSMH, the use of ground cover coefficients reflecting more pervious conditions is not accurate; however, the TR-55 method results in **Table 1.4-1** are provided as a comparison, using more accurate drainage area sizes (**Figure 1.3-1** through **Figure 1.3-3** and **Figure 1.4-1** through **Figure 1.4-9**) and more pervious ground cover coefficients.

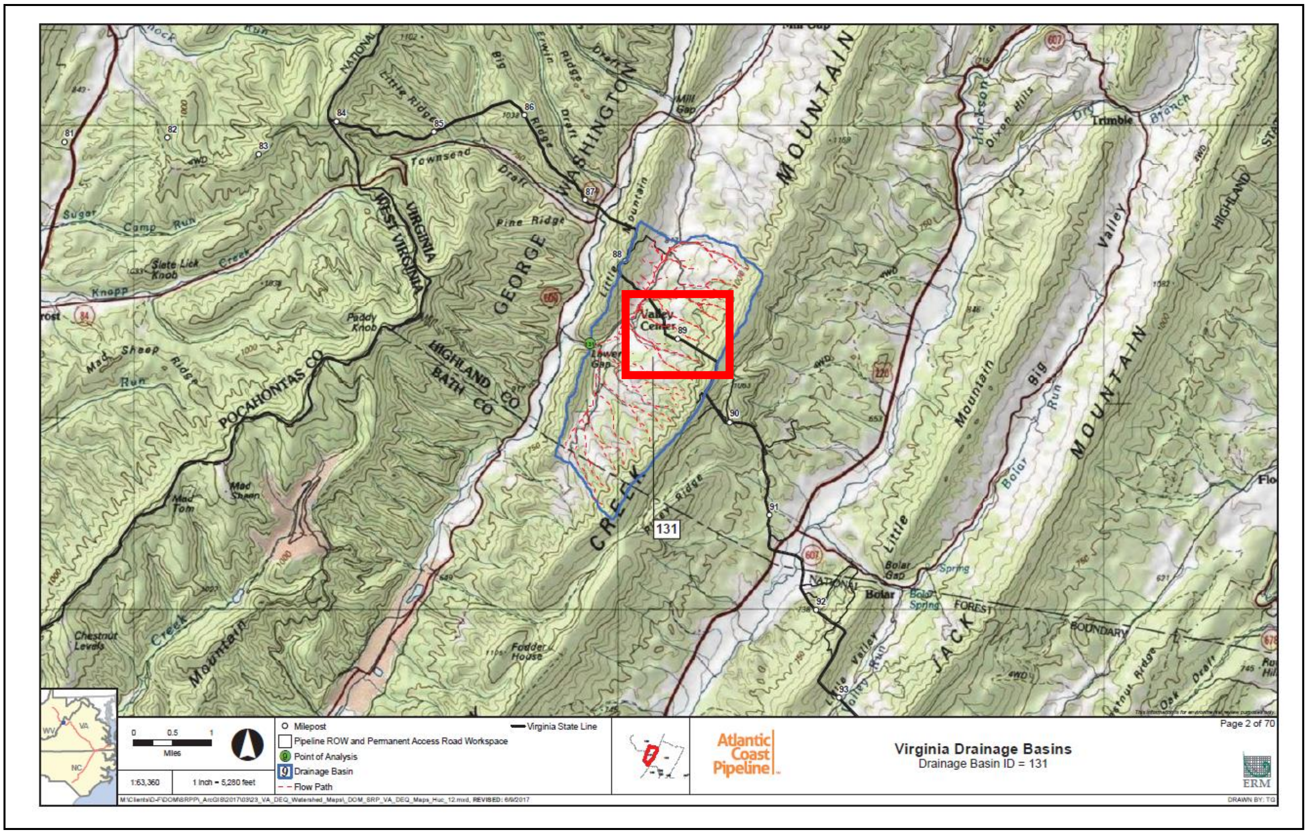


Figure 1.4-1 – Excerpt from ACP Appendix X showing delineated drainage area 131 (outlined in blue), delineated by ERM as 3,340 acres, encompassing the smaller area (in red rectangle) of proposed ACP construction impact.

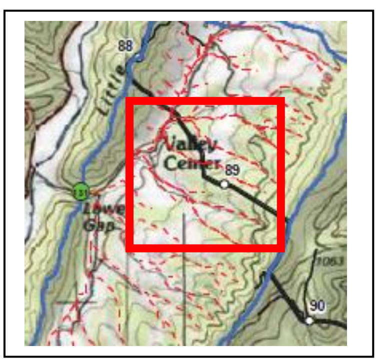


Figure 1.4-2 – Larger view of ACP drainage area 131 (outlined in blue), encompassing the smaller area (in red rectangle) of proposed ACP construction impact.

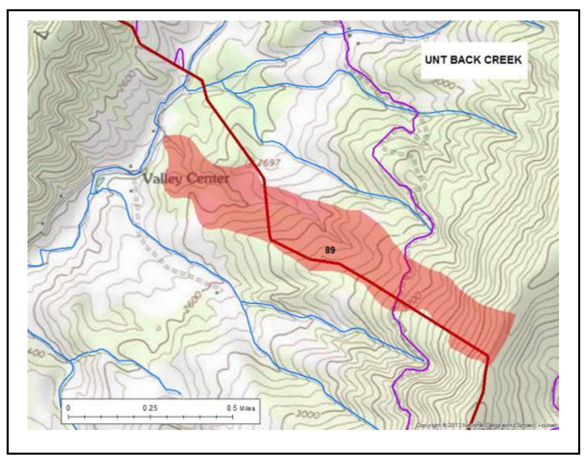


Figure 1.4-3 – Watershed or drainage area, approximately 128.25 acres, of the upland first order UNT stream (tributary to Back Creek in Highland County, VA) impacted by proposed ACP construction area between approximately MP 88.0 and approximately MP 89.7. (Map developed by D. Shaffer using GIS software).

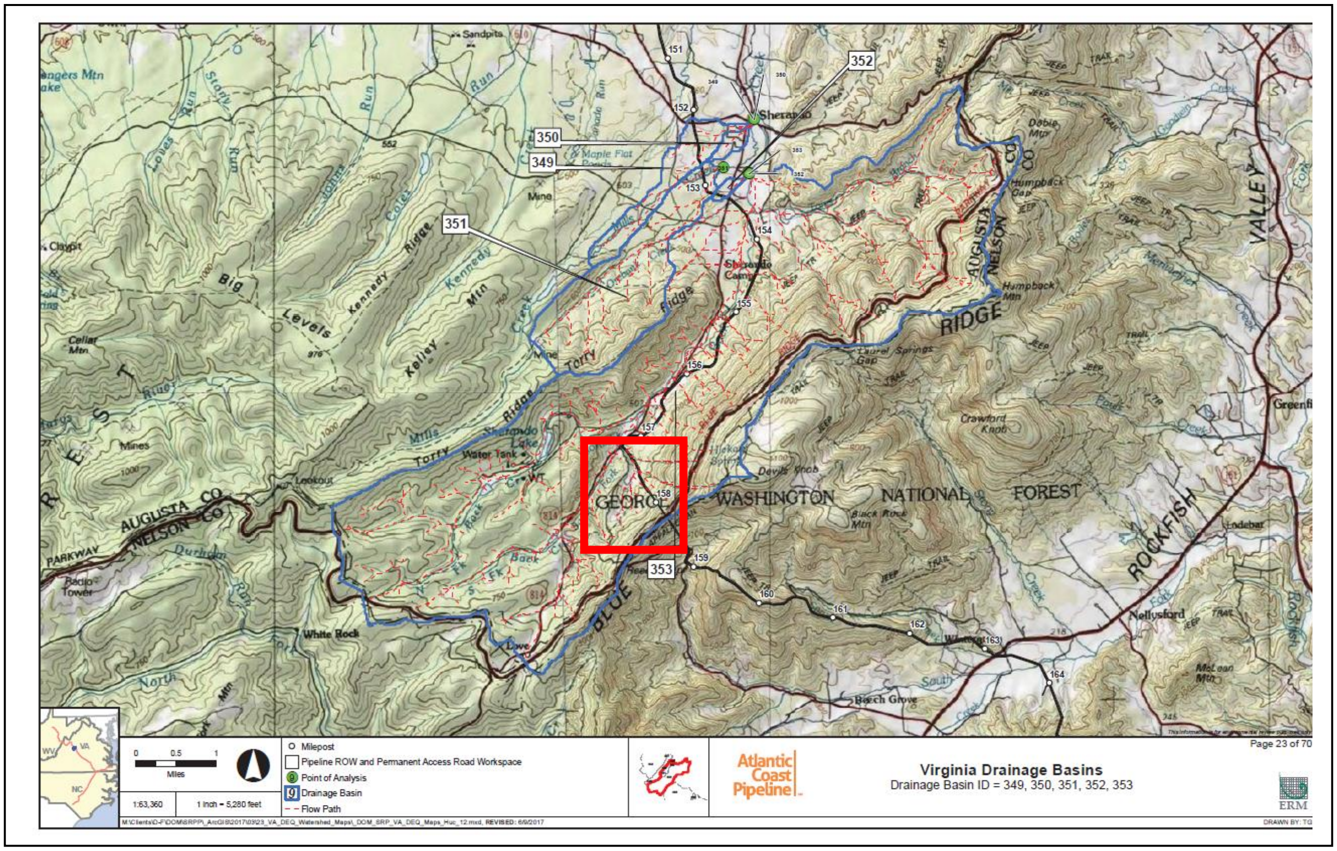


Figure 1.4-4 – Excerpt from ACP Appendix X showing delineated drainage area 353 (outlined in blue), delineated by ERM as 13,344 acres, encompassing the smaller area (in red rectangle) of proposed ACP construction impact.

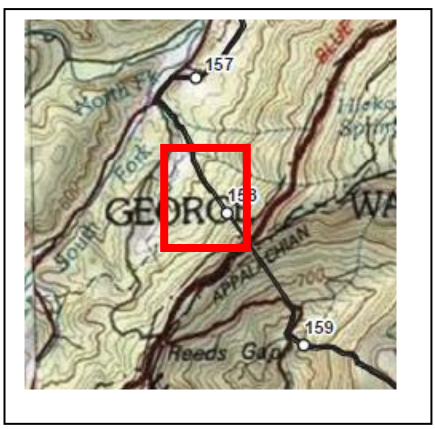


Figure 1.4-5 – Larger view of ACP drainage area 353 (outlined in blue), encompassing the smaller area (in red rectangle) of proposed ACP construction impact.

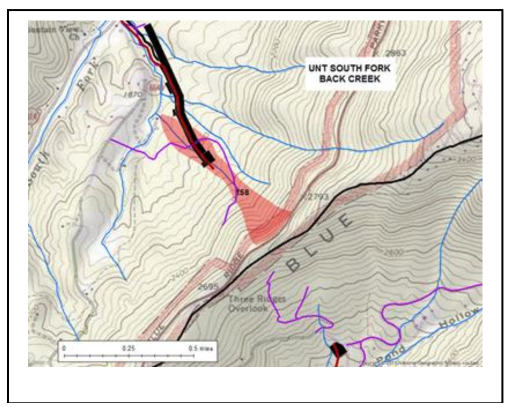


Figure 1.4-6 – Watershed or drainage area, approximately 46.34 acres, of the upland first order UNT stream (tributary to South Back Creek in Augusta County, VA) impacted by proposed ACP construction area between approximately MP 157.5 and approximately MP 158.0. (Map developed by D. Shaffer using GIS software).

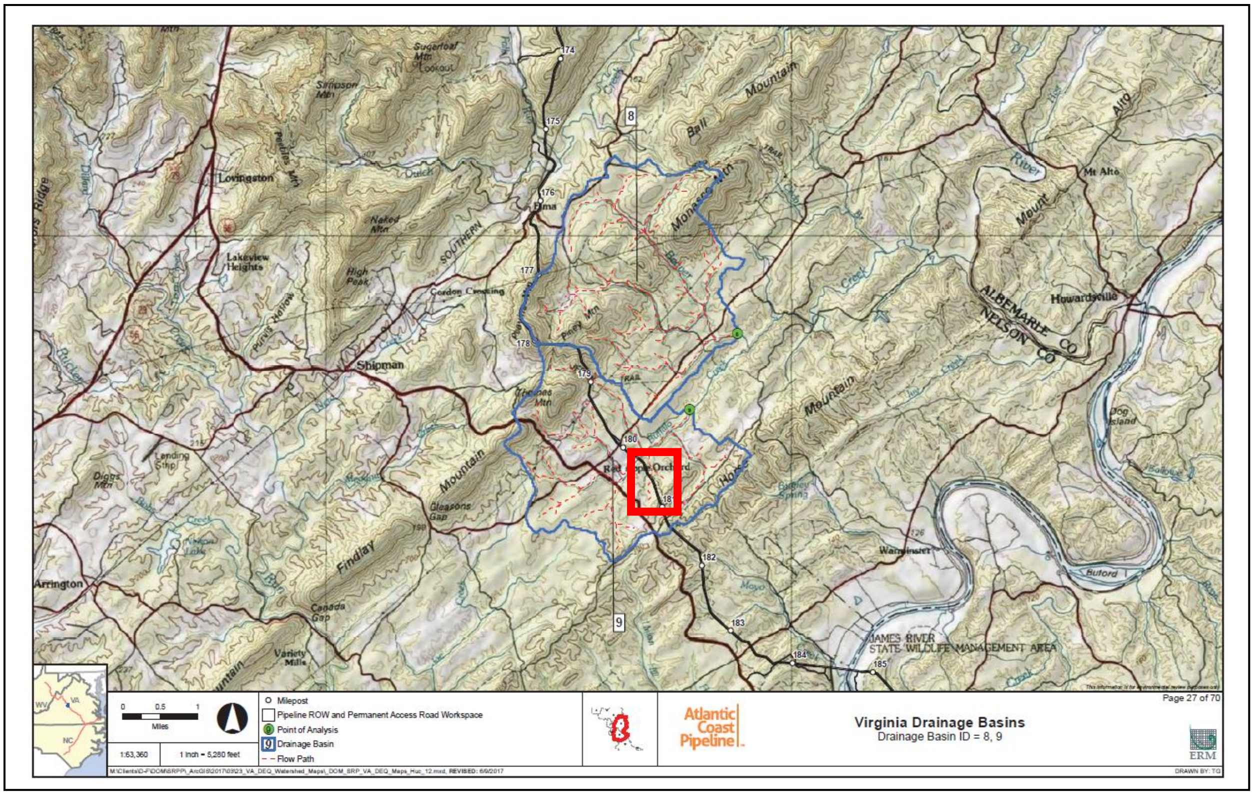


Figure 1.4-7 – Excerpt from ACP Appendix X showing delineated drainage area 9 (outlined in blue), delineated by ERM as 3,284 acres, encompassing the smaller area (in red rectangle) of proposed ACP construction impact.

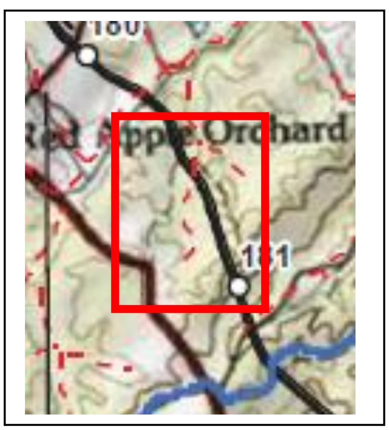


Figure 1.4-8 – Larger view of ACP drainage area 9 (outlined in blue), encompassing the smaller area (in red rectangle) of proposed ACP construction impact.

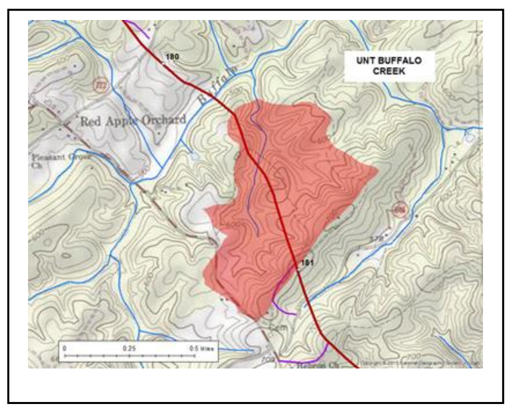


Figure 1.4-9 – Watershed or drainage area, approximately 200.7 acres, of the upland first order UNT stream (tributary to Buffalo Creek in Nelson County, VA) impacted by proposed ACP construction area between approximately MP 180.4 and approximately MP 181.0. (Map developed by D. Shaffer using GIS software).

Table 1.4-1 – Pre-construction (current conditions) and post-construction 24-hour 2-year peak stormwater discharges for 4 upland first order streams. Post-construction conditions in the Rational Method include the “impervious” ground cover coefficient for proposed ACP construction areas. Post-construction conditions in the TR-55 Method include two approaches: 1) “impervious” ground cover coefficient for proposed ACP construction areas and 2) “brush, good condition” (C soils, except for UNT to Little Valley using B to D soils), “open space, good condition” (C soils, except for UNT to Little Valley using B to D soils), and “gravel” (D soils) ground cover coefficients for proposed ACP construction areas. ERM used the TR-55 Method for all their drainage areas (36 acres to 84,092 acres) and used “shrub land cover” ground cover for proposed ACP construction areas.

Stream	**Location (Virginia)**	**Drainage Area**	**Pre-construction Discharge**	**Post-construction Discharge**
UNT to Little Valley Run **Figure 1.3-1** **Figure 1.3-2** **Figure 1.3-3**	Bath Co. ACP MP 93.0 to MP 93.7	185.05 acres	Rational Method: 192.08 cfs TR-55 Method: 4.35 cfs	Rational Method: 216.88 cfs TR-55 Method: 1) 13.25 cfs 2) 6.29 cfs
UNT to Back Creek **Figure 1.4-1** **Figure 1.4-2** **Figure 1.4-3**	Highland Co. ACP MP 88.0 to MP 89.7	128.25 acres	Rational Method: 116.24 cfs TR-55 Method: 10.65 cfs	Rational Method: 138.70 cfs TR-55 Method: 1) 28.19 cfs 2) 19.19 cfs
UNT to South Back Creek **Figure 1.4-4** **Figure 1.4-5** **Figure 1.4-6**	Augusta Co. ACP MP 157.5 to MP 158.0	46.34 acres	Rational Method: 54.17 cfs TR-55 Method: 6.86 cfs	Rational Method: 67.72 cfs TR-55 Method: 1) 18.67 cfs 2) 12.3 cfs
UNT Buffalo Creek **Figure 1.4-7** **Figure 1.4-8** **Figure 1.4-9**	Nelson Co. ACP MP 180.4 to MP 181.0	200.7 acres	Rational Method: 246.09 cfs TR-55 Method: 51.62 cfs	Rational Method: 265.52 cfs TR-55 Method: 1) 66.06 cfs 2) 51.62 cfs

The most critical observation pertaining to peak stormwater discharges is that for watersheds of upland first order streams, the calculations demonstrate a significant increase in stormwater discharge for post-construction conditions, even if the post-construction ground cover for the proposed ACP work corridor is considered to include “brush, good condition, over Hydrologic Soils Group C” soils, “open space, good condition, over Hydrologic Soils Group C” soils, and “gravel, over Hydrologic Soils Group D” ground cover coefficients for proposed ACP construction areas.

Ari Daniels, EIT, (personal communication) summarized that for the 4 sample drainage areas provided, there is, respectively:

- 88% greater runoff flow rate
- 45% greater runoff flow rate
- 79% greater runoff flow rate
- No change in runoff rate (catchment already had a lot of pasture and roads through it, and the same Tc was used for pre- and post-construction conditions).

Again, the ERM calculations show no peak stormwater discharge change between pre-construction and post-construction ground cover conditions for the excessively large drainage areas ERM delineated.

ERM also provided calculations for sizing culverts and ditches. Again, the calculations result in no change in the post-construction stormwater discharge from the pre-construction stormwater discharge. The drainage areas are appropriate for sizing culverts and ditches. However, there are no sizing calculations for other BMPs, specifically, the limit of one-quarter acre per 100 feet of silt fence length, 1 acre for a drainage area to silt fence in minor swales or ditch lines and flow no greater than 1 cubic feet per second, or 5 acres for sizing temporary diversion dikes. It should be noted that there are no sediment basins shown on the construction plans.

1.5 Proposed ACP Construction Would Result in Adverse Impacts to Watershed Functions

Forested ridges intercept rainfall so that it gently penetrates the ground as groundwater rather than flowing overland as runoff. This means that 1) the rain will gently fall to the ground and recharge groundwater and 2) the surface flow of rainwater on the ground will be slower than in cleared areas, thereby reducing the velocity and quantity of stormwater drainage. Conversely, deforestation removes the protective tree canopy, causing increased stormwater discharge and decreased groundwater recharge. The proposed ACP construction would result in deforestation, dewatering, and soil compaction, causing increased stormwater discharge and decreased groundwater recharge. **Figure 1.5-1** provides an illustration of a typical pipeline installation work corridor. Leveling of the work corridor and access roads, along with trenching for pipe installation within a deforested 125-foot wide corridor, will intercept groundwater, thereby reducing or eliminating the flow of water to rock fractures which serve as a conduit to provide water to seeps, springs, and wetlands, as well as to streams during times of drought. It is further stated that additional acreage is required for proposed additional temporary workspaces, pipe yards, staging areas, access roads, and construction associated with aboveground facilities. These additional areas will also increase stormwater discharge and reduce groundwater recharge.

Figure 1.5-1 – Leveled work corridor for pipeline installation, showing cut hillsides and dewatering. Heavy equipment and truck traffic, along with soil stockpiles, will compact soils.

Where ACP construction is proposed on ridges and slopes. Deforestation and leveling of the work corridor and access roads, along with trenching for pipe installation, will intercept groundwater, thereby reducing or eliminating the flow of water along perched aquifers or to rock fractures. Groundwater flows downgradient providing water to seeps, springs, and wetlands, as well as to streams during times of drought. It is stated in Section “2.3.3.5 STEEP SLOPES” of the ACP Final Environmental Impact Statement (FEIS) that, “Any springs or seeps found in the upslope cut would be carried downslope through polyvinyl chloride pipe and/or gravel French drains during restoration.”

Groundwater recharge occurs in upland areas such that the groundwater table is elevated and a hydraulic gradient develops, forcing the groundwater downgradient. In the Valley and Ridge Physiographic Province, rainfall is greatest in the upland areas because warm air masses cool in the higher elevations, causing condensation and precipitation. Groundwater moves through the soil to bedrock planes and fractures, where the water flows along these paths to intercept the ground surface, forming seeps and springs which facilitate moisture in headwater area aquatic habitats and wetlands. Groundwater also moves downgradient to provide baseflow to streams in times of drought. It is stated in the Virginia Stormwater Management Handbook (2013): “Perennial streams receive continuous baseflow from this groundwater discharge, during both wet and dry periods. Much of the time, all of the natural flow in a stream is from groundwater discharge. In this sense, groundwater discharge can be seen as the “life” of streams, supporting all water-dependent uses and aquatic habitat.”

As shown in **Figure 1.5-1**, hills or ridges that are encountered in the proposed ACP construction zones will be leveled, indicating that such areas will be excavated several feet, potentially below the soil level, such that no root biomass is contained within those specific excavated areas.

Figure 1.5-2 provides a schematic diagram showing ridgetop removal to create a level work corridor surface for pipeline construction activities. ACP documents do not provide information about this procedure, so the diagram is excerpted from the Mountain Valley Pipeline (MVP) typical sections provided in the MVP Final Environmental Impact

Statement (FEIS) submitted to FERC in July 2017. Where elevated areas are present in the work corridor or access road areas, excavation and/or blasting will remove the elevated area to be leveled within the proposed construction areas. The complete soil horizon will be removed, potentially to depths that will eliminate any root mass.

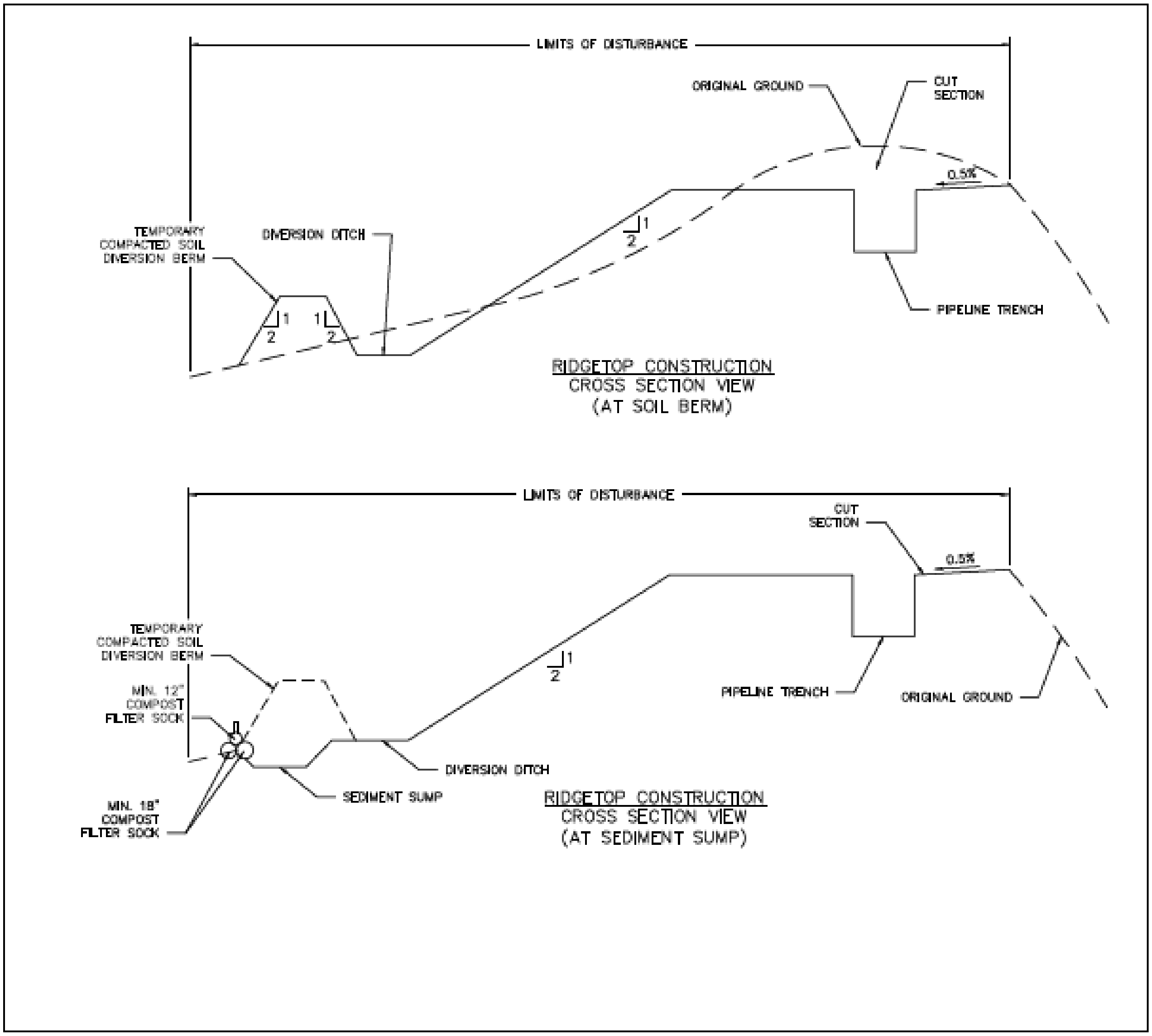


Figure 1.5-2 – MVP typical section demonstrating removal of elevated areas along the proposed MVP construction areas to create level work areas.

Figure 1.5-3 is excerpted from ACP typical construction diagrams, showing the procedure for side slope construction. Water from seeps and springs encountered during this procedure will be directed onto the ground surface.

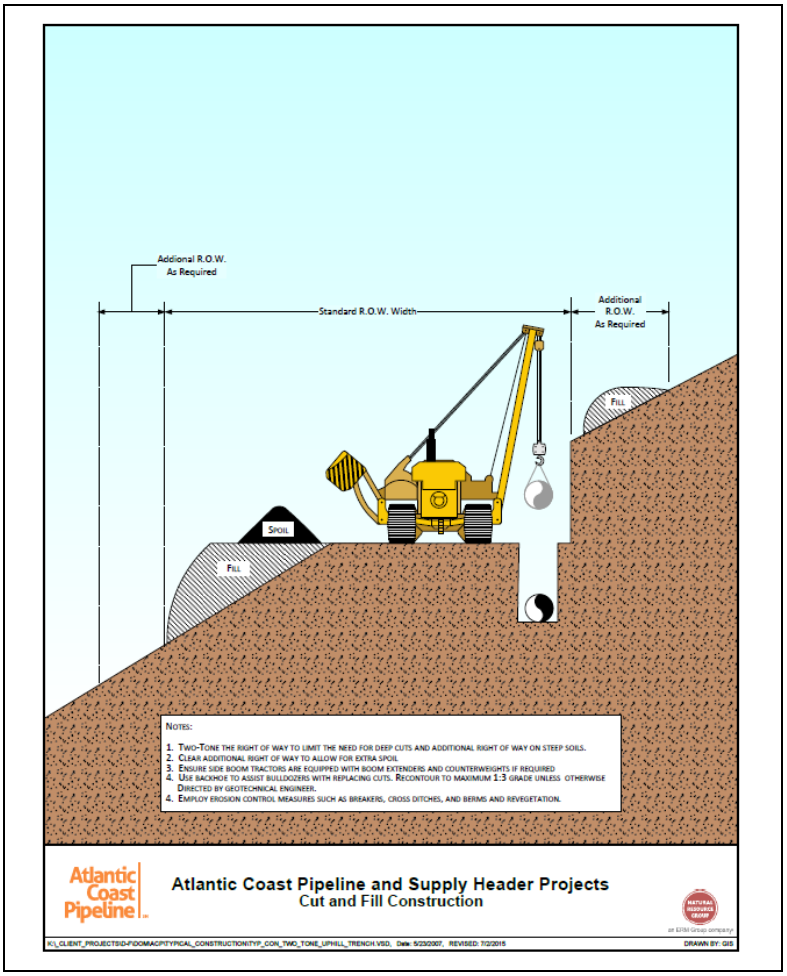


Figure 1.5-3 – ACP typical section demonstrating removal of elevated side slope areas along the proposed ACP construction areas to create level work areas.

2.0 PROPOSED ACP CONSTRUCTION IMPACTS TO AQUATIC HABITATS

The proposed ACP construction activities will cause decreased groundwater discharge and increased light and temperatures, due to deforestation, in headwater areas of first order streams. Filtered light and lower temperatures in headwater areas are required to sustain aquatic habitats for aquatic macroinvertebrates at the base of the food chain. This is **inconsistent with Code of Virginia, Title 62.1. Waters of the State, Ports and Harbors" under "§ 62.1-11**. Waters declared natural resource; state regulation and conservation; limitations upon right to use, F. The quality of state waters is affected by the quantity of water and it is the intent of the Commonwealth, to the extent practicable, to maintain flow conditions to protect instream beneficial uses and public water supplies for human consumption. **9VAC25-260-20** (Water Quality Standards) includes limits on increases in stream temperatures.

2.1 Consequences of Deforestation

As depicted in **Figure 2.1-1**, when rainwater is intercepted by trees on forested ridges, the rainfall gently penetrates the ground surface and migrates downward through the soil to bedrock. The water then flows along perched aquifers or through bedrock fractures and along bedding planes to continue migrating downward or to form seeps and springs where the fractures or bedding planes intercept the ground surface. Seeps and springs can occur at various elevations on mountain slopes, depending on the presence of perched aquifers and also where the bedrock fractures or bedding planes intercept the ground surface. Seeps and springs also occur along streams and rivers. As the quantity of groundwater accumulates beneath the ground surface, a hydraulic gradient forms, causing the groundwater to move downgradient to nearby streams and rivers or to lower areas where the water may reach streams and rivers that are farther away.

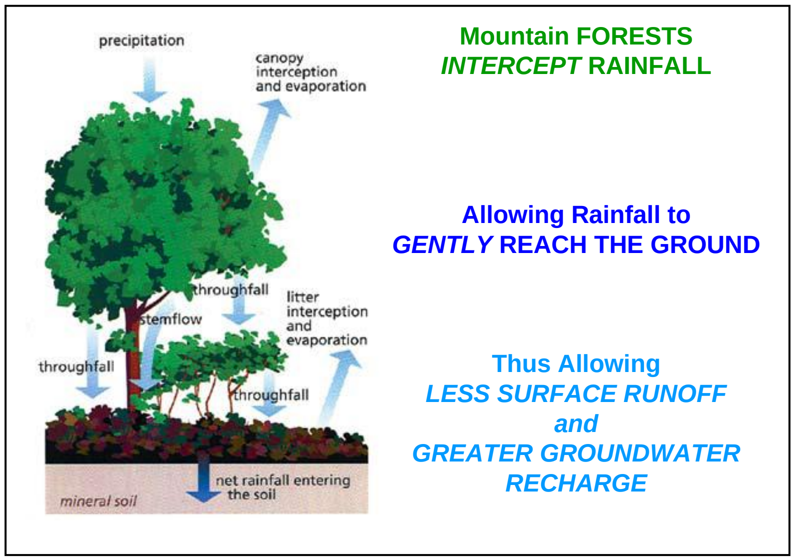


Figure 2.1-1 – Forested areas facilitate groundwater recharge and reduced stormwater runoff.

Headwater areas of first order streams provide the essential aquatic habitats for aquatic species and associated terrestrial fauna and fowl within the entire length of the river continuum in the overall watershed. The soils which have formed in the headwater areas regulate the transport of surface water and also carbon, nitrogen, and oxygen. The shade of the forest canopy provides the filtered light and lower temperatures critical to maintaining the headwater aquatic habitats.

2.2 The River Continuum

The River Continuum Concept was developed by Vannote, R.L., G. W. Minshall, K.W. Cummins, J.R. Sedell, and C.E. Cushing in 1980 and presented in the Canadian Journal of Fisheries and Aquatic Sciences 37: 130-137. The U.S. Environmental Protection Agency and the U.S. Department of Agriculture have embraced the River Continuum Concept as illustrating the strong connection between headwater areas on mountain ridges and various downstream areas. The River Continuum Concept diagram (**Figure 2.2-1**) provides pie diagrams of predominant benthic aquatic organisms associated with various locations, starting at the headwaters, along the river continuum. Shredders, predominant in the forested headwaters, break down organic matter used downstream by collectors, predators, and filter-feeders. The filter-feeders are subsequently consumed by larger benthos and fish.

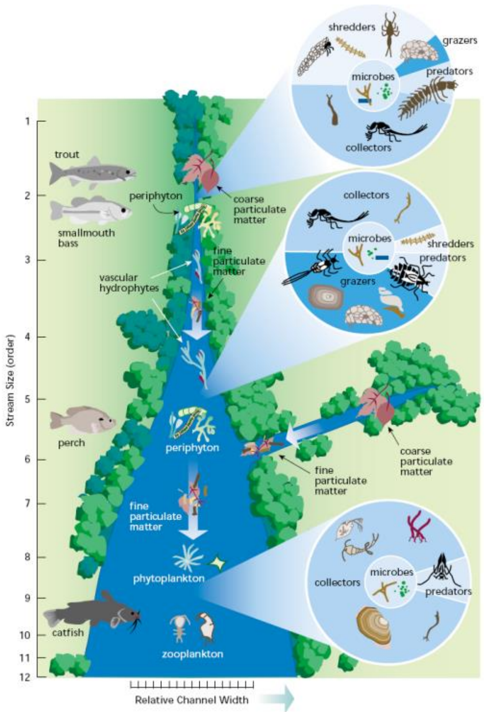


Figure 2.2-1 – The River Continuum (Vannote, et al; 1980) illustrates the food chain connection between headwater areas of first order high gradient streams and the wider, larger downstream areas in the overall watershed.

Ecological communities are typically classified with respect to the vegetation present because it is the most permanent, visible feature of a community. Biodiversity refers to the diversity within an ecological community, with emphasis on the inter-relationships and interdependence among the various species. Trees not only intercept rainfall so that it falls gently to the ground surface and is thus able to penetrate the ground as groundwater recharge, but also store nutrients in their trunks, branches, and roots. Fungi in the soil facilitate transport of nutrients between trees and the soil. The soil stores nutrients which are processed by soil microbes to regulate essential nutrient cycles involving oxygen, carbon dioxide, nitrogen. Roots of the trees and of herbal vegetation help to stabilize the soil so that the soil nutrients are not washed away by stormwater runoff. The ecological communities in the headwater areas of upland first order high gradient streams consist not only of the vegetation, but also the aquatic benthic macroinvertebrates, fungi, and soil microbes. Insect larvae, commonly grouped as shredders, constitute most of the aquatic benthic macroinvertebrates in the headwater areas because they shred organic material into components used by collectors and predators downstream.

3.0 DEFICIENCIES IN SOIL LOSS CALCULATIONS AND STREAM SEDIMENTATION ANALYIS

The Revised Universal Soil Loss Equation (RUSLE) provides a methodology to estimate soil loss from land areas. RUSLE calculations were provided by ACP for two areas of unknown location in Bath County, VA. The slope length of 100 feet was selected to pertain to that required for slope breakers as a BMP. In the first example, there was an increase from pre-construction soil loss of 0.015 tons per acre per year (t/ac/yr) to post-construction soil loss of 3.7 t/ac/yr, which is an increase of 246 times the pre-construction amount. In the second example, there was an increase from pre-construction soil loss of 0.022 tons per acre per year (t/ac/yr) to post-construction soil loss of 5 t/ac/yr, which is an increase of 227 times the pre-construction amount. This verifies increases in release of sediment to receiving streams as a result of ACP construction activities. **This is inconsistent §62.1-11 and §62.1-44.15:52 and 9VAC25-260-40 because construction impacts will cause sedimentation to the receiving stream, resulting in increased embeddedness in the receiving stream, causing degradation of aquatic habitats.**

3.1 Deficient Analysis of Sedimentation Impacts

Stream water turbidity increases with the introduction of sediment to any streams increases. Stream embeddedness (**Figure 3.1-1**) increases when sediment is deposited within openings among cobbles within a stream bed. The U.S. Environmental Protection Agency identifies turbidity as a primary drinking water standard because it is recognized that chemicals and pathogenic contaminants are adsorbed onto sediment particles. The Save Our Streams program, sponsored at the state level in Virginia, includes turbidity and embeddedness in stream monitoring protocol. Turbidity is typically measured as nephelometric turbidity unit (NTU) by using a Secchi disk. Embeddedness is measured by pebble count techniques. It is important to evaluate and monitor streams prior to, during, and after any construction which will contribute sediment to streams. However, ACP documents do not address evaluation and monitoring of streams to determine the impacts of sediment transport and deposition to streams.

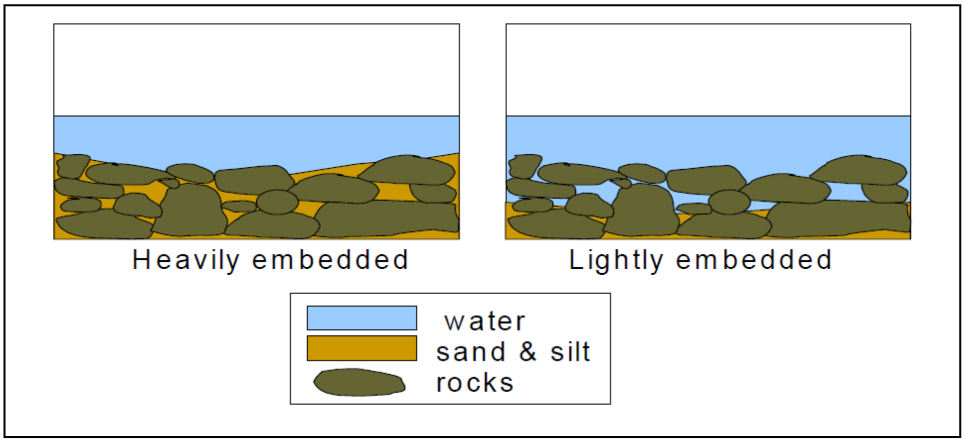


Figure 3.1-1 – Cobbles and pebbles provide aquatic habitats and protection for aquatic organisms. Insect larvae, which constitute the base of the river continuum food chain, reside on the cobbles and pebbles. Minnows and juvenile fish (including trout) hide in the spaces between cobbles and pebbles for protection. When sand and silt fill the spaces between the cobbles and pebbles, the aquatic habitats and protection areas are destroyed. When the aquatic habitats become heavily embedded or are removed for trenching and stream crossing work spaces, they cannot be restored.

The consequences of embeddedness are provided by Jessup and Dressing (2015) as: "1) Displacement of interstitial habitat space; 2) Clogging of water movement under the channel bed (hyporheic zone); 3) Decreased or altered primary algal productivity; 4) Increased macroinvertebrate drift; 5) Abrasion or smothering of gills and other organs; 6) Uptake of sediment-bound toxicants that are increasingly associated with fine particles; and 7) Larger scale homogenization or disturbance of habitat types."

It is stated in the DEQ's Virginia Stormwater Management Handbook, "4.5.3. Habitat and Ecological Impacts", that "As the gravel stream bottom is covered in sediment, the amount and types of microorganisms that live along the stream bottom decline. The stream receives sediment from runoff, but additional sediment is generated as the stream banks are eroded and this material is deposited along the stream bottom, burying the substrate material of the stream bed, which is habitat for many benthic organisms." Such impacts are inconsistent with **"Code of Virginia, Title 62.1**. **Waters of the State, Ports and Harbors" under "§62.1-11. Waters declared natural resource; state regulation and conservation; limitations upon right to use,** F. The quality of state waters is affected by the quantity of water and it is the intent of the Commonwealth, to the extent practicable, to maintain flow conditions to protect instream beneficial uses and public water supplies for human consumption." Also, such impacts are inconsistent with **9VAC25-260-20 (Water Quality Standards), which explains that turbidity is a substance to be controlled because it can be harmful to aquatic life.**

3.2 Limited Best Management Practices

BMPs include sediment erosion control structures intended to reduce stormwater runoff velocities and to reduce the amount of sediment transported in the stormwater runoff. BMPs are required to be part of the Erosion and Sediment Control (E&SC) plan for construction projects. BMPs proposed by ACP and shown on the construction plan sheets incorporate the following BMPs for use in the proposed pipeline construction areas:

- Temporary Diversion Dike
- Silt Fence, Super Silt Fence and Belted Silt Retention Fence
- Compost Filter Sock
- Temporary Slope Breakers
- Trench Plugs
- Erosion Control Blanket/Flexterra/or equivalent
- Vegetative Stabilization

There are numerous ratings for BMPs, providing a range of percent effectiveness values. However, there is agreement that none of the BMPs can provide 100 percent effectiveness. In the Universal Soil Loss Equation guidance document prepared by Peter Wood (Construction Site Soil Loss and Sediment Discharge Calculation, Guidance Document and Calculation Tool, 2015, Wisconsin Department of Natural Resources), the percent effectiveness is provided for the following: silt fence, 40 percent; vegetative buffer, 40 percent. It is stated in the Virginia Department of Environmental Quality (VDEQ) Erosion and Sediment Control Handbook (1992) that sediment traps and sediment basins can achieve, at best, only 60 percent effectiveness. It should be noted that sediment basins are not included on any ACP construction plans. Sediment basins constitute the only commonly used BMP to detain water in a manner consistent with the requirements of the Code of Virginia, **Title 62.1. Waters of the State, Ports and Harbors, Chapter 3.1 State Water Control Law, Article 2.4 Erosion and Sediment Control Law § 62.1-44.15:52** and **Virginia Administrative Code 9VAC25-870-66**.

The VDEQ's silt fence requirements include the following:

- Purposes: 1) intercept and detain small amounts of sediments from disturbed areas during construction; 2) decrease the velocity of sheet flows and low-to-moderate level channel flows, specifically where erosion would occur in the form of sheet and rill erosion.
- The use of silt fences… is limited to situations in which only sheet or overland flows are expected and where concentrated flows originate from drainage areas of 1 acre or less.

- Size of drainage area should be no more than one quarter acre per 100 feet of silt fence length; maximum slope length behind the barrier is 100 feet; and maximum gradient behind the barrier is 50 percent (2:1). Silt fence should be located at least 5 – 7 feet beyond the base of the disturbed slopes with grades greater than 7 percent.
- Can be used in minor swales or ditch lines (concentrated flow) where the maximum contributing drainage area is no greater than 1 acre and flow is no greater than 1 cubic foot per second (cfs).
- Not to be used in areas where rock or other hard surfaces prevent the full and uniform depth of anchoring the barrier.
- Silt fence should stand 24-34 inches above existing grade.

Stormwater calculations for sizing BMPs are provided by ERM. However, these calculations do not include areas delineated for sizing 1) silt fence, with requirements for a limit of one-quarter acre per 100 feet of silt fence length and 1 acre for a drainage area for silt fence in minor swales or ditch lines and 2) a requirement for flow no greater than 1 cfs, or or 5 acres for sizing temporary diversion dikes.

4.0 DEFICIENCIES IN ASSESSMENT OF SEISMIC AND LANDSLIDE HAZARDS

In the ACP FEIS, it is reported that from MP 170 to MP 260, the proposed ACP pipeline traverses the Central Virginia Seismic Zone. Although ACP states that the pipelines should be capable of withstanding seismic events, there is concern for soil liquefaction. During an earthquake, saturated soil can liquify, moving as a fluid and thereby losing soil strength of the soils supporting the pipeline. Soil liquefaction was reported as a result of the earthquake in Mineral, VA, in 2011.

The Virginia Department of Mines, Minerals, and Energy developed an Earthquake Epicenter Density map (**Figure 4.0-1**) which provides the location of the Central Virginia Seismic Zone. Horton, et al (2015) report that earthquakes trigger landslides, citing landslides that were triggered by the earthquake in Mineral, VA, in 2011. Landslides resulting from the Mineral, VA earthquake occurred in an area extending as much as 152 miles from the epicenter.

In the ACP FEIS, numerous steep slopes along the proposed pipeline route are identified by ACP as slope instability hazard sites. Colluvium is defined as sediments, including clay-sized up to boulder-sized sediments, deposited downslope by mass-wasting (landslides) or overland flow. In the ACP FEIS, colluvium is reported to have been observed on most of the steep slopes along the proposed ACP route. Landslide material moves downslope toward receiving streams, providing an additional threat of turbidity and sediment deposition into receiving streams in Virginia.

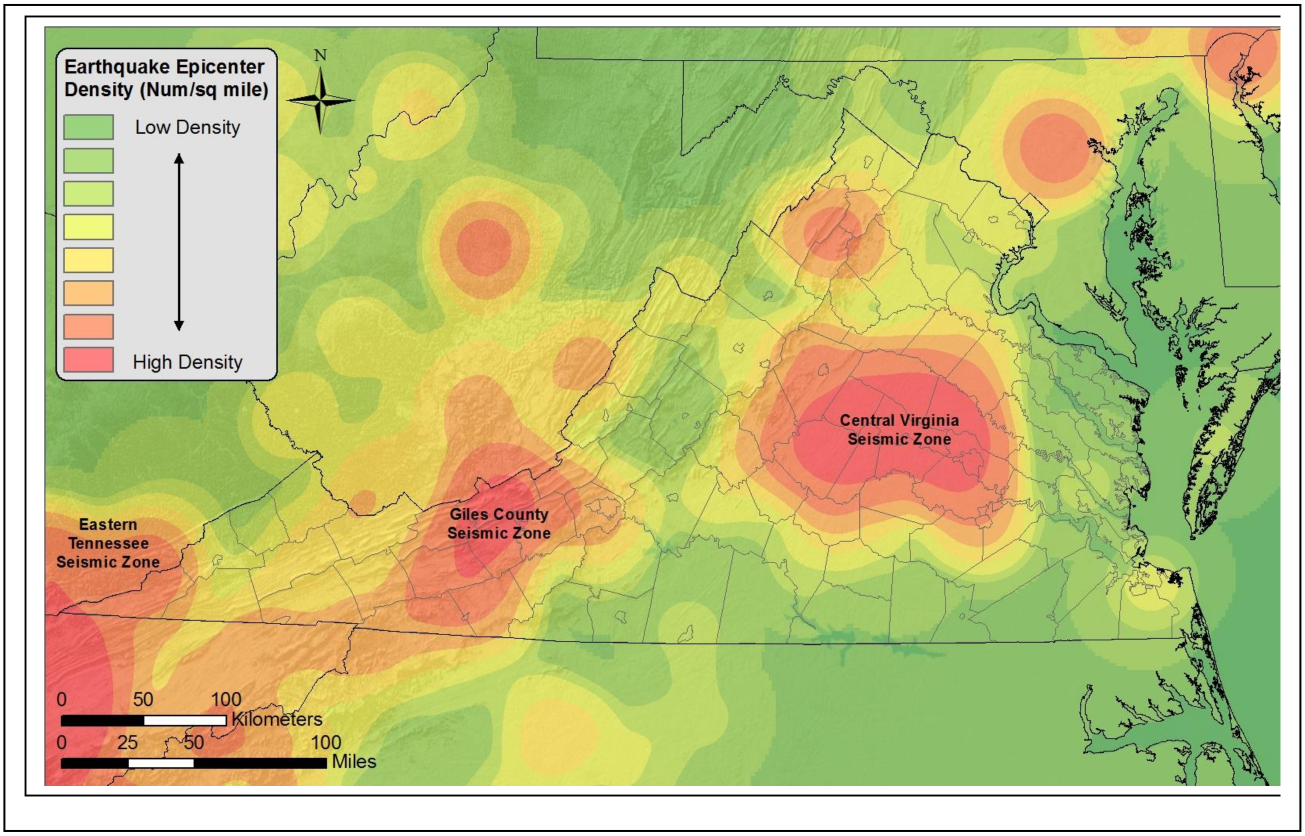


Figure 4.0-1 – Map showing the densities of earthquake epicenters, provided as a color scale indicating the relative densities in numbers per square mile. Three major earthquake zones are identified. In the ACP FEIS, it is reported that from MP 170 to MP 260, the proposed ACP pipeline traverses the Central Virginia Seismic Zone. This map is from https://dmme.virginia.gov/DGMR/EQHazardMapping.shtml.

7.0 CONCLUSIONS

Using scientific documentation, there is compelling evidence that the Virginia State Water Control Board should not issue the 401 Water Quality Certification to ACP, Certification No. 17-002. Due to deforestation in headwater areas of upland first order high gradient streams and increased sedimentation due to increased stormwater discharge to receiving streams, the proposed ACP construction activities in upland areas will result in direct and indirect discharge to waters of the United States and are deficient with respect to protections addressed in applicable Water Quality Standards in

9VAC25-260-5, *et seq*. The SWCB cannot be reasonably assured that the proposed ACP construction activities will not violate applicable Water Quality Standards in **9VAC25-260-5, et seq.**, but rather, the proposed ACP construction activities would result in degradation to upland headwater areas of upland first order high gradient streams as follows:

1) **Decrease in the groundwater table, groundwater quantities, and hydraulic head of groundwater** due to deforestation, soil compaction, and trench dewatering. This results in **decreased groundwater** available 1) to maintain seeps and springs which supply water to upland headwater areas, including wetlands, in first order stream watersheds and also 2) to maintain groundwater baseflow to provide water to receiving streams during times of drought. **This is inconsistent with Code of Virginia §62.1-11 because the quantity of groundwater will be decreased.**

2) **Degradation of conditions, specifically increased light and temperatures** due to deforestation in upland headwater areas of first order streams. Filtered light and lower temperatures in upland headwater areas are required to sustain aquatic habitats for aquatic macroinvertebrates at the base of the food chain. **This is inconsistent with Code of Virginia §62.1-11 because construction activities will cause failure to maintain flow conditions to protect instream beneficial uses**. **9VAC25-260-20** (Water Quality Standards) includes limits on increases in stream temperatures.

3) **Degradation of ecological connectivity** for the river continuum due to destruction of aquatic habitats in upland headwater areas of first order streams. Destruction of the aquatic habitats for macroinvertebrates at the base of the food chain in upland headwater areas will disrupt connectivity with downstream aquatic organisms. **This is inconsistent with §62.1-11 because degradation of the upland headwater areas will result in failure to maintain flow conditions to protect instream beneficial uses.**

4) **Degradation of receiving streams** within watersheds crossed by the proposed ACP construction due to **increased sedimentation**, causing increased turbidity and embeddedness. Increased turbidity causes reduced water quality for filter feeding aquatic organisms and also obstruction of gills in fish. ACP has not accurately delineated watersheds 1) to determine accurate peak stormwater discharge to receiving streams or 2) to determine increased soil loss due to changes in ground cover caused by the proposed ACP construction. **This is inconsistent with §62.1-11 because degradation of the upland headwater areas will result in degradation of water quality required to protect instream beneficial uses.** **9VAC25-260-20** (Water Quality Standards) explains that turbidity is a substance to be controlled because it can be harmful to aquatic life.

5) **Deficiencies in Best Management Practices** descriptions: the Best Management Practices (BMPs) described for use during the proposed ACP construction in upland headwater areas are deficient and will result in **increased sedimentation** to receiving streams and increased embeddedness. The BMPs listed by ACP for use at the proposed construction areas do not include sediment basins, which would constitute the only BMP capable of detaining the water quality volume for release over 48 hours, or detaining and releasing over a 24-hour period the expected rainfall resulting from the one-year, 24-hour storm. **This is inconsistent with §62.1-44.15:52 because of ineffective control of soil erosion and sediment deposition which will result in unreasonable degradation of stream water and stream channels.**

6) The RUSLE calculations were provided by ACP for two areas of unknown location in Bath County, VA. The slope length of 100 feet was selected to pertain to that required for slope breakers as a BMP. In the first example, there was an increase from pre-construction soil loss of 0.015 tons per acre per year (t/ac/yr) to post-construction soil loss of 3.7 t/ac/yr, which is an increase of 246 times the pre-construction amount. In the second example, there was an increase from pre-construction soil loss of 0.022 tons per acre per year (t/ac/yr) to post-construction soil loss of 5 t/ac/yr, which is an increase of 227 times the pre-construction amount. This verifies increases in release of sediment to receiving streams as a result of ACP construction activities. **This is inconsistent with §62.1-11 and §62.1-44.15:52 and 9VAC25-260-40 because construction impacts will cause sedimentation to the receiving stream, resulting in increased embeddedness in the receiving stream, causing degradation of aquatic habitats. Additionally, 9VAC25-260-20** (Water Quality Standards) explains that turbidity is a substance to be controlled because it can be harmful to aquatic life.

7) **Inadequate assessment of karst features**. Deforestation, soil compaction, and trench dewatering will result in decreased groundwater recharge increased stormwater discharge and sediment transport due to the proposed ACP construction in the upland headwater areas of karst terrain. ACP has delineated drainage areas ranging from 36 acres to 84,092 acres, with only 20 watersheds of meaningful sizes to evaluate stormwater discharge. As a result, there is no assurance that stormwater discharge to karst areas has been evaluated. In some areas, ACP evaluations have not recognized or have ignored karst. **This is inconsistent with §62.1-11 because increased sedimentation into karst features is detrimental to maintaining the ecological integrity of cave environments and also detrimental to groundwater resources**.

8) **Inadequate assessment of landslide potential and seismic activity potential**. The proposed ACP route partially traverses the Central Virginia Seismic Zone, where the epicenter of the Mineral, Virginia earthquake occurred. Liquefaction of soils was reported during the earthquake. If soil liquefaction occurs where the soils are supporting a pipeline, the soils could collapse and a pipeline rupture could occur where the pipeline is not supported. Colluvium has been observed by ACP on numerous steep slopes along the proposed ACP route. Colluvium is defined as sediment which continually moves downslope as a form of soil landslide. Because earthquakes are known to cause landslides, the steep slope areas would be subject to greater landslide activity during an earthquake. Soil moves downslope during a landslide, delivering sediment to receiving streams and thus causing increased turbidity and embeddedness in receiving streams. **This is inconsistent §62.1-11 and §62.1-44.15:52 because the increased sedimentation to receiving streams will result in degradation of the stream water and aquatic habitats and will impair beneficial uses of the receiving streams.** Additionally, **9VAC25-260-20** (Water Quality Standards) explains that turbidity is a substance to be controlled because it can be harmful to aquatic life.

9) **Cumulative and permanent degradation of receiving streams and reduced groundwater quantities** will result from deforestation, soil compaction, and trench dewatering in upland areas crossed by the proposed ACP construction. Increased stormwater discharge results from deforestation, soil compaction, and trench dewatering (which directs water within trenches to the ground surface). Cumulative and permanent impacts will also result from reduced groundwater recharge due to deforestation, soil compaction, and trench dewatering. **This is inconsistent with §62.1-44.15:52 or 9VAC25-260-40 because the construction areas will not be reforested and soil functions cannot be restored to pre-construction conditions, thereby resulting in continual increased stormwater discharge, which will cause downstream stream bank erosion, resulting in increased embeddedness. The decreased groundwater recharge will lower the water table and the hydraulic gradient such that water will not be available to seeps and springs in the headwater areas of high gradient first order streams or downstream as groundwater baseflow supply for streams during times of drought. The impact is cumulative because numerous upland first order stream tributaries to higher order streams will increase sediment transport and stream bank erosion downstream.**

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My education includes a bachelor's degree in Geology and a doctoral degree in Marine Science (specializing in Marine Geology), both from the College of William and Mary in Williamsburg, VA. I have a Credential in Ground Water Science from Ohio State University and I am a Licensed Professional Geologist. I have held teaching positions at the high school level and at the college level, and have provided geology and hydrogeology presentations, workshops, and classes to state and federal environmental employees, to participants in the Regional Conference in Cumberland, MD for the American Planning Association, and to participants in the WV Master Naturalist classes. I have served as an expert witness in hydrogeology before West Virginia government agencies.

As a Hydrogeological Consultant (2000 – Present), I have conducted hydrogeological investigations, provided hydrogeological assessment reports, served as an expert witness in hydrogeology before the West Virginia Public Service Commission in three cases and before the West Virginia Environmental Quality Board in one case, and provided numerous presentations and workshops in hydrogeology to state and federal environmental employees (including USFWS and WV FEMA Managers), participants in the Regional Conference in Cumberland, MD for the American Planning Association, participants at civic and landowner meetings, and participants in the WV Master Naturalist classes.

As a Senior Geologist for the Virginia Department of Environmental Quality (1997-1999), I determined direction of groundwater flow and the pollution impacts to surface water and groundwater at petroleum release sites and evaluated corrective actions conducted where petroleum releases occurred. At sites where the Commonwealth of Virginia assumed responsibility for the pollution release investigation and corrective action implementation, I managed the site investigations for the Southwest Regional Office of the Virginia Department of Environmental Quality (DEQ). This included project oversight from contract initiation through closure.

As a Senior Geologist and Project Manager for the Environmental Department at S&ME, Inc. (Blountville, TN, 1992-1997), I conducted geology and groundwater investigations. I supervised technicians, drill crews, geologists, and subcontractors. The investigations were conducted in order to obtain permits for landfill sites and to satisfy regulatory requirements for corrective actions at petroleum release sites. My duties also included conducting geophysical investigations using seismic, electrical resistivity, and ground penetrating radar techniques. I conducted numerous environmental assessments for real estate transactions. I also conducted wetlands delineations and preparation of wetlands mitigation permits.

As the District Geologist for the Virginia Department of Transportation (1985-1992), my job duties included obtaining and interpreting geologic data from fieldwork and review of drilling information in order to provide foundation recommendations for bridge and road construction. My duties included supervision of the drill crew and design of asphalt and concrete pavements for highway projects. Accomplishments included preliminary foundation investigations for interstate bridges and successful cleanup of leaking underground gasoline storage tanks and site closures at numerous VDOT facilities.

While earning my doctoral degree at the College of William and Mary, I worked as a graduate assistant on several grant-funded projects. My work duties included measuring tidal current velocities and tidal fluctuations at tidal inlets; land surveying to determine the geometry and morphology of numerous tidal inlets; determining pollution susceptibilities of drainage basins using data from surface water flow parameters, hydrographs, and chemical analyses; developing a predictive model for shoreline erosion during hurricanes based on calculations of wave bottom orbital velocities resulting from various wind velocities and directions; performing sediment size and water quality analyses on samples from the Chesapeake Bay and James River; conducting multivariate statistical analyses for validation of sediment laboratory quality control measures; reconnaissance mapping of surficial geologic materials in Virginia, North Carolina, and Utah for publication of USGS Quaternary geologic maps; teaching Introductory Geology laboratory classes at the College of William and Mary; and serving as a Sea Grant intern in the Department of Commerce and Resources, Virginia.

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