ATLANTIC COAST PIPELINE, LLC
ATLANTIC COAST PIPELINE

and

DOMINION TRANSMISSION, INC.
SUPPLY HEADER PROJECT

Supplemental Filing
February 24, 2017

APPENDIX A

Update to the Karst Assessment and Survey Report

Dominion Resources Services, Inc.
5000 Dominion Boulevard,
Glen Allen, VA 23060

Dominion

February 24, 2017

BY OVERNIGHT (OR EXPRESS) MAIL

Clyde Thompson
Forest Supervisor
U.S. Forest Service
Monongahela National Forest
200 Sycamore Street
Elkins, WV 26241

Mr. Joby Timm
Forest Supervisor
U.S. Forest Service
George Washington and Jefferson National Forests
5162 Valleypointe Parkway
Roanoke, Virginia 24019

Re: Atlantic Coast Pipeline, LLC, Atlantic Coast Pipeline Project
Revised Karst Assessment and Survey Report

Dear Mr. Thompson and Mr. Timm,

Enclosed please find an update to Atlantic Coast Pipeline, LLC's *Karst Assessment and Survey Report* for the Atlantic Coast Pipeline (ACP). The revised report includes data from an additional 9.2 miles of field survey along the proposed pipeline route, as well as appendices identifying karst features found in the ACP Project area in the George Washington National Forest (Appendix D) and Monongahela National Forest (Appendix). Please contact Richard B. Gangle at (804) 273-2814 or Richard.B.Gangle@dom.com if you have questions regarding this report. Please direct written responses to:

Richard B. Gangle
Dominion Resources Services, Inc.
5000 Dominion Boulevard
Glen Allen, Virginia 23060

Sincerely,

FOR RICHARD GANGLE
Robert M. Bisha
Technical Advisor, Atlantic Coast Pipeline

cc: Jennifer Adams, U.S. Forest Service

Attachment: Revised Karst Assessment and Survey Report

February 21, 2017

Karst Survey Report
Revision 1

Atlantic Coast Pipeline
Augusta, Bath and Highland Counties, VA & Pocahontas and Randolph Counties, WV

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February 21, 2017

Colin Olness, PE
Contractor
Atlantic Coast Pipeline - Construction
99 Edmiston Way
Buckhannon, WV 26201

Subject: **Karst Survey Report, Revision 1: Atlantic Coast Pipeline (ACP), Augusta, Bath and Highland Counties, VA & Pocahontas and Randolph Counties, WV (GeoConcepts Project No. 11002.04)**

Dear Mr. Olness:

GeoConcepts Engineering, Inc. (GeoConcepts) is pleased to present the following karst survey report prepared for the ACP, located in Augusta, Bath and Highland Counties, VA, and Pocahontas and Randolph Counties, WV. This report summarizes the results of the remote sensing and data review for the entire ACP alignment that intercepts karst terrain, and the field survey results for all parcels where access permission was granted by the landowners.

We appreciate the opportunity to serve as your geotechnical consultant on this project. Please do not hesitate to contact me if you have any questions or want to meet to discuss the findings and recommendations contained in the report.

Sincerely,

GEOCONCEPTS ENGINEERING, INC.

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Executive Summary

GeoConcepts conducted a karst survey of the proposed alignment of the Atlantic Coast Pipeline[1] (ACP) natural gas pipeline located in Augusta, Bath and Highland Counties Virginia, and Pocahontas and Randolph Counties, West Virginia. The survey was performed in two phases: a data review and remote sensing phase to identify karst surface features (sinkholes, caves, swallets or sinking streams, springs, etc.) prior to field assessment; and a field survey phase to verify, characterize and document karst features identified in the data review as well as documenting previously unidentified karst features.

The data review phase examined the length of the entire proposed ACP alignment mapped as underlain by karst-forming bedrock (59.8 miles), and/ or within areas of known karst terrain (based on the presence of karst surface features), encompassing a total karst survey length of 71.3 linear miles. Features identified in the data review were:

1. 300-Foot Corridor Closed Depressions/Features (identified as "cCD"), defined as any closed depression which occurred within, touched or received drainage (based on topography) from a 300 foot wide corridor concurrent with the planned pipeline right of way (ROW);
2. Suspect Closed Depressions (identified as "sCD"), defined as any closed depression occurring within a ¼-mile wide "karst review area" concurrent with the ROW;
3. Cave entrance locations;

The data review identified approximately 265 cCD Features, 54 sCD, and eight caves (three in WV and five in VA), located within or inferred to receive drainage from the 300 foot corridor.

The field survey was limited to those parcels where the survey personnel had been granted access permission by the landowners. To date, 62.3 miles of the proposed alignment mapped in karst and inferred karst terrain has been completed. However, access has been prohibited for approximately 9 miles of the alignment, which remain to be assessed. Within the 62.3 miles where the field survey phase has been completed, a total of 339 karst features were identified and documented within the 300-foot corridor, or which received drainage from the corridor. Each feature was assigned a unique identifier utilizing the parcel number and an integer, and a risk ranking based on the following criteria:

1. Located on or immediately adjacent to the proposed construction trench;
2. Presence of an open "throat" leading into the subsurface;
3. Drainage characteristics (i.e. showing evidence of receiving surface drainage);
4. Evidence of active soil raveling, tension cracks or collapse.

Risk ranking was assigned as follows:

High Risk – Presence of any combination of two or more of the above criteria

Moderate Risk – Presence of any one of the above criteria

Low Risk – Absence of any of the above criteria

Of the field documented features (sinkholes, closed depressions, caves, swallets, springs, etc.) 107 were classified as "high" risk, 72 as "moderate risk", and 32 as "low" risk.

This report summarizes the methods and procedures used to conduct the karst survey, detailed descriptions of the regional and local geology, and a summary of findings based on both the data review and field survey phases. Previous experience has indicated that the number and types of karst features identified during the data review portion of the project may vary significantly from the number of karst features

[1]ACP is owned by Atlantic Coast Pipeline, LLC (Atlantic). Atlantic has contracted with Dominion Transmission Inc., a subsidiary of Dominion Resources, Inc. to construct and operate the ACP on the behalf of Atlantic.

identified during the field survey portion of the project. Once the remaining field survey is completed this report should be updated by supplement or addendum.

Introduction

Based on the National Karst Map (Weary and Doctor, 2014) and landscape feature analysis, the ACP route is planned to cross approximately 71.3 miles of karst terrain, characterized by the presence of closed depressions, sinkholes, caves, sinking streams, and large springs. Karst is a known geohazard, and any infrastructure development in karst terrain must be carefully planned and managed. In addition, the karst environment could provide habitat for rare, threatened and endangered species, and is an important source of drinking water for municipalities and private landowners. In order to conserve this important natural resource, and also to protect the integrity of the pipeline, in October 2014 Dominion Transmission Incorporated (DTI) staff contracted GeoConcepts to conduct a survey of the karst features which could potentially affect the construction of the pipeline and/or be impacted by the proposed construction.

This report summarizes the methods and procedures used to conduct the karst survey, detailed descriptions of the regional and local geology, and a summary of findings based on both the data review and field survey phases.

Scope of Services

The ACP project involves the proposed installation of a gas pipeline extending through West Virginia and Virginia. Referencing the currently proposed pipeline construction alignment information sent to us (hereinafter referred to as "the alignment"), we estimated that the route currently being considered for the pipeline passed across approximately 59.8 miles of terrain underlain by karst-forming bedrock[2] located in Randolph and Pocahontas Counties in West Virginia, and Highland, Bath and Augusta Counties, Virginia, based on regional geological mapping. The "Area of Interest" for the survey (hereinafter referred to as the "AOI") was thus divided into two sections: a "Karst Review Area" (KRA) which extended ¼-mile from either side of the proposed centerline; and a 300-foot corridor (300FC) which extended 150 feet from either side of the centerline which would be examined in the field. Only features located within, or which touched the 300FC, would be documented; however, if observed or mapped karst features received drainage from the 300FC then these features would also be delineated and documented to the extent possible and included in the assessment.

Specifically, GeoConcepts provided the following services and deliverables:

- Locate and delineate surface karst features (e.g. sinkholes and karst related subsidence, cave entrances, closed depressions, and sinking and losing streams) within the KRA and 300FC as described above, with particular emphasis on features that have direct communication with the phreatic zone such as "open-throat" sinkholes, karst windows, cave entrances, abandoned wells, sinking streams and areas that could affect the integrity of the pipeline itself such as actively forming cover-collapse sinkholes, areas of soil subsidence, or caves which had passages that extend below the proposed ROW at elevations less than 15 feet below the surface. Direct field observations will be made by walking the entire 300FC and any adjacent areas where the KRA data indicated a feature might receive drainage from the 300FC.
- Delineate zones of karst terrain, subsidence and drainages based on the surface karst features assessment.
- A report summarizing the methods and findings of the assessment.

[2]However it became apparent during the data review phase of the project that numerous karst features, in particular cave entrances and closed depressions (sinkholes), were present outside of the areas indicated as "karst terrain" by the USGS map, and that the total area which would need to be surveyed was more than 71.3 miles in length. The details of the discrepancy between the National Karst Map and the presence of karst terrain are discussed in more detail in the following sections of this report.

Methodology

The above scope of services was accomplished by the following means:

Phase 1: Existing Data Review and Analysis – GeoConcepts conducted a review of existing karst feature locations within a ½-mile wide KRA (i.e. ¼-mile from either side of the proposed centerline) that were available from the following sources:

1. The (proprietary) Cave Databases of the Virginia Speleological Survey (VSS) and the West Virginia Speleological Survey (WVSS);
2. Caves of Virginia (Douglass, 1964);
3. Caverns of West Virginia (Davies, 1958);
4. Maps of selected karst features (sinkholes, caves, springs) available from the Virginia Division of Mines and Mineral Resources and the United State Geological Survey (Hubbard, 1988; 2003);
5. Two-foot and 4-foot contour interval maps for the AOI (to determine the presence of surface karst features not included in the above listed databases based on the presence of closed, descending contours or other suspect karst "fingerprint" features) derived from county level digital terrain models (DTMs), and 1- and 3-meter contour maps derived from state level digital elevation models (DEMs);
6. Aerial photographs (both recent and historical);
7. USGS Topographic 7.5-minute topographic quadrangles;
8. Sinkhole and depression locations available from the USDA-NRCS soil studies for the counties through which the project will pass;
9. LIDAR data (where available).

In addition, GeoConcepts reviewed the readily available geological literature for bedrock and structural characteristics. The closest resolution mapping that existed for the particular area being examined was relied on when conducting the review.

Phase 2: Field Survey – Concurrent with the Phase 1 activities, GeoConcepts conducted the field survey activities. Typically, the field survey phase immediately followed the routing and civil survey activities by DTI's staff. Specifically, the field survey entailed:

1. Location and verification of surface karst features identified in the Phase 1 review that fall within, contact, or receive drainage from the 300FC along the proposed centerline;
2. Location of uncatalogued or previously unidentified surface karst features, specifically sinkholes, cave entrances, dry runs and sinking streams within the 300FC as described above.

The field survey placed particular emphasis on locations where pathways existed to phreatic groundwater such as open-throat sinkholes, cave entrances, karst "windows", and sinking streams.

The 300FC was delineated and then examined during the field survey for karst features (both features previously located during the data review phase and features which were previously unidentified). This entailed conducting a site reconnaissance of the 300FC (i.e. the proposed pipeline route) in a systematic manner, to observe any existing surface karst features that fit the criteria. The locations and outlines of all relevant features were recorded using a sub-meter accurate GPS device. For the purpose of this study, the outline (parapet) of sinkholes was defined by the last closed descending contour at mapping interval available for the area under study. Cave entrances were identified as single points, unless the entrance was located within a larger sinkhole structure, in which case the cave entrance was indicated as a point within the sinkhole's parapet. Sinking streams were located as points of entry into the subsurface; however, losing streams were identified as linear features. The features were each assigned a unique identifier, and the feature data was subsequently recorded on an individual "karst description sheet".

Phase 3: Data Analysis – The data analysis phase followed the field survey phase for each routed area. Based on the field survey observations any feature that was indicated as present in the 300FC, touched it, or received drainage from it was documented and described.

In many cases sinkholes and/or cave entrances have been filled, graded and or obliterated; thus if a 300FC feature could not be found in the field, this was noted and the feature was eliminated. If a feature was present, but the data review indicated an error in its position, the accurate data was recorded and the feature's coordinates were corrected accordingly.

Upon review of all available data, each field located feature was assigned a "risk rank" based on the following criteria:

1. Located on or immediately adjacent to the proposed construction trench;
2. Presence of an open "throat" leading into the subsurface;
3. Drainage characteristics (i.e. presence of a clear-cut drainage path leading into the structure);
4. Evidence of active soil raveling, tension cracks or collapse.

Risk ranking was assigned as follows:

High Risk – Presence of any combination of two or more of the ranking criteria

Moderate Risk – Presence of any one of the ranking criteria

Low Risk – Absence of any ranking criteria

Definitions

(Adapted from Field, 2002: "A Lexicon of Cave and Karst Terminology, with special reference to Environmental Karst Hydrology)

Cave – A natural hole in the ground, large enough for human entry. This covers the enormous variety of caves that do occur, but eliminates the many artificial tunnels and galleries incorrectly named caves. The size criterion is arbitrary and subjective, but practical, as it eliminates narrow openings irrelevant to explorers but very significant hydrologically, that may be better referred to as *proto-caves*, *sub-conduits*, or *fissures*. A cave may be a single, short length of accessible passage, or an extensive and complex network of tunnels as long as hundreds of kilometers.

Doline; Sinkhole – A basin- or funnel-shaped hollow or depression in limestone, dolostone or other soluble bedrock, ranging in diameter from a few meters up to a kilometer and in depth from a few to several hundred meters. Some dolines are gentle grassy hollows or depressions; others are rocky cliff-bounded basins. A distinction may be made by direct solution of the limestone surface zone (solution dolines), and those formed by collapse over a cave (collapse dolines), but it is generally not possible to establish the origin of individual examples. Generally referred to as a "sinkhole" in the United States, the term doline is more widely accepted by the international geology community.

Throat – An opening within a sinkhole leading into the subsurface through which material passes or has passed from the sinkhole into underlying solutional voids and conduits, which is generally too small to qualify as a cave and often called a *proto-cave*, *sub-conduit*, or *fissure*. Throats may be "open" (i.e. air-filled or water-filled), or "closed/clogged" (filled with debris including but not limited to: loose-soil; gravel; rock; dead-fall wood or brush; or trash).

Parapet – The outer edge or perimeter of a doline (sinkhole).

Ponor – a) Hole or opening in the bottom or side of a depression where a surface stream or lake flows either partially or completely underground into the karst groundwater system; b) Hole in the bottom or side of a doline through which water passes to or from an underground channel. Also known as a swallow hole or swallet.

Solution Cavity – A natural cavity or depression formed by the dissolution of soluble bedrock, typically not large enough to allow the entry of a human being and, therefore, not classified as a cave.

Breccia – Angular fragments of rock commonly, but not always, cemented by finer-grained materials including silica, iron minerals, and calcite to form a new rock. Many fault planes are marked by zones of broken rock, either loose or re-cemented, forming a fault breccia.

Non-Karst Closed Depression – A natural or non-natural topographic depression that is not formed by karst processes and is not floored by bedrock. Examples include (but are not limited to) construction-related soil subsidence, silage pits, farm ponds, scour pools, animal wallows, large animal burrows, and pits created by removal of tree stumps.

Sinking Stream/Swallet – A perennial or intermittent stream whose bed and bank disappear entirely underground, usually through an open throat sinkhole or cave entrance.

Losing Stream – A perennial or intermittent stream which loses flow volume into its bed due to the presence of sub-channel (hyporheic) solution cavities or conduits.

Geological Setting

Overview of Karst Terrain along the Project Alignment

The term "karst" refers to a type of landform or terrain, just like "desert", "marsh", "tundra", "steppe" or "montane". It was named for a province in Slovenia where it was first described in the late 17th and early 18th century by geologists of the former Austro-Hungarian Empire. Simply stated, the karst terrain is characterized by the presence of sinkholes, caverns, an irregular "pinnacled" bedrock surface, and many large springs; however, the development of karst terrain is a result of the presence of soluble bedrock such as limestone, dolomite, marble or gypsum. Any landscape that is underlain by soluble bedrock has the potential to develop a karst terrain landform.

As in any region where soluble bedrock is present, a karst landform regime has developed in a portion of the planned route for the ACP. Folding and faulting of the local carbonate rocks has opened up numerous fractures both parallel with the axis of the geologic structures, as well as perpendicular to them. Surface fractures and joints weather differentially, producing a pinnacled or "saw-tooth" profile at the bedrock/soil interface (referred to as the "epikarst" zone). In contrast, rock-enclosed fractures can be secondarily enlarged by the action of carbon dioxide charged groundwater, in some cases forming water-filled or air-filled conduits. As the regional terrain is "mature" karst, nearly all the fractures have undergone successive cycles of sediment filling and flushing (Ford & Williams, 1989), (Moore & Moore, 2019).

<u>Sinkholes</u> - Sinkholes fall into two broad categories, "vault-collapse" sinkholes, and "cover-collapse" sinkholes. Vault-collapse type sinkholes were not observed in the project area (i.e. where the cavern "vault" or roof had failed catastrophically), and these structures are regionally quite rare. (Campbell, et al., 2006)

In contrast, cover-collapse sinkholes are relatively common regionally. Cover-collapse sinkholes develop by the raveling of fines from the soil overburden into solution channels within the bedrock mass, in which water is the transport medium for the movement of the soil fines. The natural raveling process is generally a very slow one, such that sinkhole development generally occurs over a very long time span. However, various changes at a site can sometimes lead to the very sudden development of sinkholes. The most common changes that will exacerbate sinkhole development are:

1. Increase or redirection of overland or subsurface water flow paths, which accelerates the raveling of soil fines;
2. Removal of vegetation cover and topsoil (i.e. stripping and grubbing), which can reduce the cohesive strength of the soils overlying a conduit;
3. Sudden changes in the elevation of the water table (such as drought, over-pumping of wells, or quarry dewatering), which removes the neutral buoyancy of the water supporting a conduit's soil plug, and can often result in rapid and catastrophic soil collapse.

Regional Geology

The ACP Project will cross three distinct provinces of karst geology (see Figure 1), from east to west:

1. The **Great Valley subsection of the Valley and Ridge physiographic province**, extending from the Blue Ridge on the east to Little North Mountain on the west, the majority of the proposed alignment in Augusta County is located within the Great Valley Province.
2. The **Folded Appalachian subsection of the Ridge and Valley province**, encompassing western Augusta County, and all of Bath County and Highland County, VA, this province extends from the North Mountain area on the east to Allegheny Mountain on the west;
3. The **Allegheny Front and Appalachian Plateau** provinces of West Virginia, encompassing Pocahontas and Randolph Counties, West Virginia.

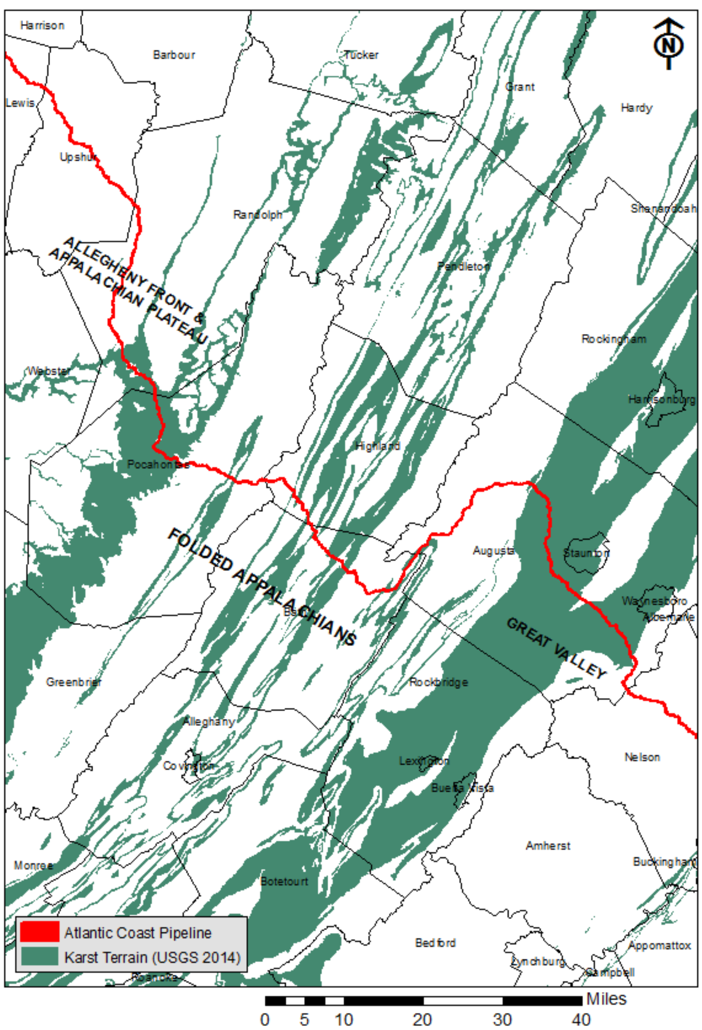

Figure 1. Map showing the karst geology provinces along the ACP Alignment.

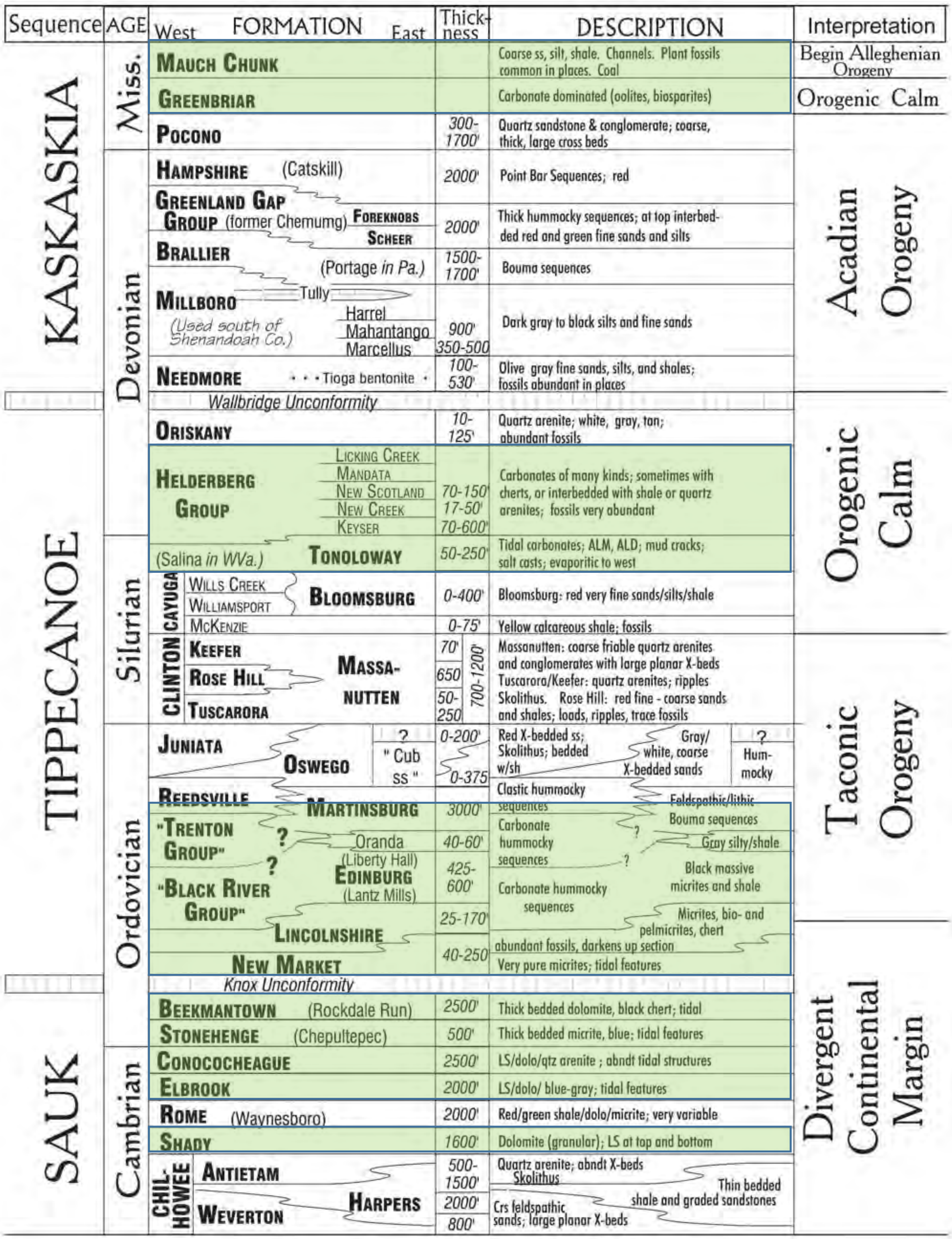

Figure 2. Stratigraphic Column of the central Virginia Great Valley, Folded Appalachians, and eastern Allegheny Front of west central Virginia and eastern West Virginia. (Fichter, 2010). Karst-forming units are highlighted in green.

The Great Valley (Augusta County, VA)

Appendix A, Maps 38-48

The Great Valley section is a generally downwarped trough (synclinorium) of Paleozoic limestones, shales and sandstones, that lie between the Blue Ridge Massif on the east, and the Allegheny Mountains to the west. The Valley extends between the two mountain uplands from northeast to southwest, parallel with the average strike of the bedrock.

The karst terrain of the Great Valley section of the project is characterized by numerous circular to oval-shaped sinkholes, ranging in size from a few feet to several hundred feet in diameter, the majority of which are completely vegetated and lack any (visible) opening to the subsurface ("throat") at their base. Sinkhole depths can vary, but are usually controlled by the angle of repose of the sediments lining their walls. Steep, rock-walled sinkholes are rare in this section, but generally occur in the small hills and uplands that are erosional remnants of the prior valley floor.

The Great Valley section contains some of the largest karst springs in the region. It is also characterized by sinkholes called "estavelles", which are insurgences for water during dry periods, and flood or act as springs (resurgences) during wet seasons. There are also numerous caves (i.e. air-filled voids large enough to permit the entry of a human being that have an entrance to the surface) and subsurface cavernous voids (air-filled voids large enough for human entry with no connection to the surface) in the region.

A unique type of karst terrain has developed in the eastern portion of Augusta County along the base of the Blue Ridge Mountains. Here, the characteristic karst terrain has been buried beneath a mantle of unconsolidated sediments (gravel, sand, silt and clay) which were eroded from the mountains to the east. These sediments range in age from less than 1 million years (Quaternary Period) to over 50 million years (Paleogene Period). The unconsolidated sediment thins towards the west, and disappears completely west of Waynesboro, VA. Although the primary karst terrain is covered by these sediments, numerous shallow broad sinkholes are present and suggest the presence of large karst features in the underlying bedrock. (Southworth, et al., 2009; Rader & Gathright, 2001; Hubbard, 1988)

Bedrock Geology of the Karst-forming Units

Specifically, the proposed ACP alignment in the Great Valley section has been mapped (VDMR, 1993) as being underlain by a series of karst-forming carbonate and calcareous clastic rocks ranging in age from the Lower Cambrian to Middle Ordovician geological periods (Campbell et al., 2006; DMME, 1993; Rader & Gathright, 2001; Rader & Wilkes, 2001; Hubbard, 1988). The individual geological units are described from youngest to oldest as follows:

Ordovician Period

Martinsburg Formation (Om) – The upper 100 to 200 feet of this formation is a brown, medium-to coarse-grained, fossiliferous sandstone. An olive-green silty shale and dark-gray siltstone comprises the middle portion of this formation, along with a medium-to coarse-grained, locally pebbly sandstone. The Stickley Run Member exists as the lower 400 to 900 feet of the formation. This is a medium-gray to grayish-black, very-fine-grained (aphanitic), very-thin- to thin-bedded, argillaceous limestone with interbedded medium- to dark-gray, calcareous shale.

Edinburg Formation (Oeln) – A black, fine-grained to aphanitic limestone with layered black shale that commonly contains pyrite, and medium- to light-gray, fine- to coarse-grained, nodular limestone with thin partings of black shale. This formation lies in thicknesses ranging from 450 to 1,000 feet throughout the three subject areas. The Edinburg is typically divided into two distinct members based on lithology, the Liberty Hall and Lantz Mill.

Lincolnshire Limestone (Oeln) – The Lincolnshire has a gradational contact with the overlying Edinburg. The Lincolnshire is a light- to very-dark-gray, fine- to coarse-grained, medium to very-thick-bedded limestone with black chert nodules. The Murat Limestone Member, generally found at the top of the formation, is a light colored, coarse-grained limestone composed of fossil fragments. Thicknesses throughout our subject areas range from 50 to 250 feet.

New Market Limestone (Oeln) – Unconformable upper contact with the Lincolnshire. The upper unit of this formation is a medium-gray, aphanitic, thick-bedded, limestone with scattered calcite crystals. The lower unit is a medium- to dark-gray, fine-grained, thin-bedded, argillaceous, bioturbated limestone that is dolomitic in parts, with its base being a carbonate pebble conglomerate. Formation thicknesses throughout the subject areas range from 100 to 250 feet.

Beekmantown Group (Note – This group consists collectively of the Pinesburg Station Dolomite, Rockdale Run Formation, and the Stonehenge Limestone)

Pinesburg Station Dolomite (Ob) – This formation is a medium-to light gray, fine-grained, medium- to thick-bedded dolostone, with sparse fossils. When weathered, this dolomite is very-light-gray, and exhibits a "butcher-block" structure. A medium-gray, fine-grained limestone exists as the base of this unit. The formation's average thickness is 400 feet.

Rockdale Run Formation (Ob) – The upper contact with the overlying Pinesburg Station is unconformable. This formation is comprised of a medium-gray, fine-grained, fossiliferous limestone and a light- to medium-gray, fine-grained, laminated dolomitic limestone and dolostone with mottled beds. Thin lenses of gray chert are common near the base of the formation. Formation thickness ranges from 1500 to 2400 feet.

Stonehenge Limestone (Ob) – Upper contact with the Rockdale Run Formation is gradational. The upper 400 to 500 feet is comprised of a medium- to dark-gray and black, fine- to medium-grained limestone, with thin beds of macerated fossil debris. The lower 50 to 150 feet (Stoufferstown Member) is a dark-gray to black, fine-grained limestone with thin sheet-like, crinkly partings due to cleavage, and thin beds of coarse-grained, bioclastic limestone.

Ordovician/Cambrian Period

Conococheague Formation (O_co) – The upper contact with the Stonehenge Limestone of the Beekmantown Group is unconformable. The upper 2,000 feet of this formation is a light- to dark-gray, fine-grained, laminated limestone, dolomitic limestone, and dolostone with flat-pebble conglomerate beds. Some cross laminated sandstone beds occur in the uppermost part of this unit. The Lower 200 to 500 feet (Big Spring Station Member) consists of a light-gray, fine-grained dolostone, medium- to dark-gray, fine-grained laminated limestone and dolomitic limestone, and gray, coarse-grained sandstone and dolomitic sandstone. Beds of flat-pebble conglomerate occur in the dolomite. It is of note that although the majority of the Conococheague is considered Cambrian in age, the upper part is dated to the Ordovician Period based on biostratigaphy .

Cambrian Period

Elbrook Formation (_e) – This unit's thickness ranges from 2,000 to 2,500 feet. It has a conformable contact with the overlying Conococheague Formation and in places the contact is not easily distinguishable in the field. The Elbrook is a dark- to medium-gray, fine- to medium-grained limestone, with dolomitic limestone, dolostone, and dolomitic shale. These lithologies commonly occur as erosion-surface-bounded sequences of algal limestone overlain by laminated dolomite. Decalcified, red ocherous shale-like chips on the ground surface characterize this unit. The lower 300 to 400 feet is green to greenish-gray, fine-grained dolostone, dolomitic limestone, and shale.

Waynesboro Formation (_w) – The upper contact with the Elbrook Formation is gradational. A dusky-red to olive-gray, fine- to medium-grained sandstone and dusky-red to gray shale exists as the upper 300 feet. The middle 400 feet is a medium- to dark-gray, saccharoidal dolomite and fine-grained limestone. The lower 500 feet is dusky-red, olive-gray, and dark-gray shale and dusky-red to brownish-gray, fine- to medium-grained sandstone. Overall thickness is approximately 1,200 feet.

Tomstown Dolomite/Shady Dolomite (_t/_s) – The upper 600 feet is light- to dark-gray, fine- to coarse-grained, medium- to thick-bedded, locally laminated dolostone with white chert rosettes and nodules in the upper 50 feet. The middle unit (about 210 feet) is very-light- to medium-gray, medium-grained, very-thick-bedded dolostone and high-magnesium dolostone. The lower unit (about 325 feet) is dark-gray to black, very-fine-grained, thin- to very-thin-bedded limestone and dolomitic limestone with argillaceous laminations. The overall unit thickness ranges from 1,100 to 1,200 feet. The Shady Dolomite is the homologous unit in the southeastern Great Valley at the base of the western edge of the Blue Ridge Mountains.

The Folded Appalachians (Highland County, Bath County VA, and Eastern Pocahontas County, WV)

Appendix A, Maps 37 – 20

The western edge of the Great Valley is demarcated by the North Mountain Fault, and the ridges of Little North and Great North Mountain. Further to the west, Highland and Bath Counties are divided from Augusta County by a series of high mountain ridges and deep intervening valleys, collectively referred to as "Shenandoah Mountain". The rocks underlying the Shenandoah Mountain section are younger than those of the Great Valley, dating primarily from the Late Ordovician through the Middle Silurian periods in age, and are all clastic rocks (e.g. sandstone, siltstone, shale, etc.) and not prone to the development of karst terrain (Hubbard, 1988; Rader & Wilkes, 2001; DMME, 1993). The ACP alignment passes over the last section of the folded Appalachians as it crosses Michael Mountain in eastern Pocahontas County.

Bedrock Geology of the Karst-forming Units

The ACP in the Folded Appalachians section has been mapped (DMME, 1993) as being underlain by a series of karst-forming carbonate rocks ranging in age from the Lower Ordovician to Lower Devonian geological periods. The individual geological units are described from youngest to oldest as follows:

Devonian Period

Helderberg Group (Dh) – This group consists of thick- to massive-bedded, dark gray/black micritic limestone with reef structures. The limestone shows some degree of recrystallization. The uppermost Helderberg is typically silicified near its contact with the overlying Oriskany sandstone. In many areas the Helderberg gives off a distinct petroliferous odor when freshly broken. The contact with the overlying Oriskany Sandstone is poorly exposed regionally, but the contact with the underlying Tonoloway Formation is distinct and often unconformable, where the massive bedding of the Helderberg gives way to the thin-bedding of the Tonoloway Formation. The contact can be identified in places by a lag deposit consisting of flat, packstone rip-ups and pebble conglomerate.

The group is a major cave forming unit of the Folded Appalachian section; however, it is of note that the stratigraphy of this unit has been the subject of a much detailed study in recent years (Haynes, et al., 2014). The Helderberg Group consists of a series of individual formations, from oldest to youngest, respectively: the Keyser Limestone, New Creek Limestone, Corriganville Limestone, and Licking Creek Limestone formations. It should be noted that based on biostratigraphic analysis the Keyser Limestone, the basal formation of the Helderberg Group, is considered to straddle the boundary of the Silurian and Devonian periods (Denkler and Harris, 1988a).

Silurian Period

Tonoloway Limestone (Sto) – Extremely thin bedded (1 cm or less) dark gray micritic limestone interbedded with fissile, calcareous shale. Gives off a distinct petroliferous odor when freshly broken. The contact with the overlying Helderberg is distinct; however, it grades into the underlying Wills Creek Limestone. Thickness is approximately 300 feet.
Wills Creek Limestone (Swc) – Thin bedded (less than 10 cm) dark gray calcareous shale and fossiliferous micrite. Poorly exposed in the survey area. Thickness is approximately 200 feet.

The above units are sometimes referred to collectively as members of the "Cayugan Group".

Ordovician Period

Juniata, Oswego, Reedsville, Dolly Ridge, and Eggleston Formations (Oun)
Karst-forming unit present only in the westernmost Valley and Ridge section of the ACP alignment (Highland and Bath Counties). The Dolly Ridge and Eggleston Formations are the only karst-forming units and consist of a medium-gray, fine-grained, thin-bedded, argillaceous limestone with interbedded olive-gray calcareous claystone, silt argillaceous limestone, gray shale, and K-bentonite beds. Thickness is about 400 feet in Bath and Highland Counties. The unit is laterally equivalent to the Middle Ordovician ("Trenton Group") limestones and part of the lower Martinsburg Formation.

Middle Ordovician Limestones, Undivided (Olm)
Consists of the Edinburg Formation, the Lincolnshire Formation and the New Market Limestone. The Edinburg is a black, fine-grained to aphanitic limestone with layered black shale that commonly contains pyrite, and medium- to light-gray, fine- to coarse-grained, nodular limestone with thin partings of black shale. Thickness is 400 feet to 500 feet. The Edinburg grades downward into the Lincolnshire Formation, a light- to very-dark-gray, fine- to coarse-grained, medium to very-thick-bedded limestone with black chert nodules. Thicknesses throughout our subject areas range from 25 feet to 250 feet. This unit is underlain by the New Market Limestone. Upper contact with the Lincolnshire is generally unconformable. The upper unit of this formation is a medium-gray, aphanitic, thick-bedded, limestone with scattered calcite crystals. The lower unit is a medium- to dark-gray, fine-grained, thin-bedded, argillaceous, bioturbated limestone that is dolomitic in parts, with its base being a carbonate pebble conglomerate. Formation thicknesses throughout the subject areas range from 0 to 150 feet.

Beekmantown Formation (Ob) – This formation is a medium-to light gray, fine-grained, medium- to thick-bedded dolostone, with sparse fossils. When weathered, this dolomite is very-light-gray, and exhibits a "butcher-block" structure. A medium-gray, fine-grained limestone exists as the base of this unit. This formation is comprised of a medium-gray, fine-grained, fossiliferous limestone and a light- to medium-gray, fine-grained, laminated dolomitic limestone and dolostone with mottled beds. Thin lenses of gray chert are common near the base of the formation. Formation thickness ranges from 1,500 feet to 2,400 feet. The Beekmantown Formation typically consists of three members, which although distinct in the Great Valley region are hard to distinguish in the Folded Appalachian province.

The Allegheny Front and Appalachian Plateau (Pocahontas and Randolph Counties, WV)

Appendix A, Maps 1 - 19

The proposed alignment crosses the last section of the folded Appalachian karst in eastern Pocahontas County along the flanks of Michael Mountain, and then enters the relatively flat-bedded geology of the Allegheny Front and Appalachian Plateau provinces. The alignment crosses the karst-forming Greenbrier Group limestone on the as it climbs the east face of Cloverlick Mountain and eventually passes over the clastic rocks and limestone of the Mauch Chunk Group on the uplands of the Appalachian Plateau.

In general, the Mauch Chunk and Greenbrier group carbonates exhibit a high density of caves relative to the other two karst section along the pipeline. There are several factors that contribute to this, the main one being that the units act as a drain system for groundwater infiltrating downward through the fractured clastic rocks above them. Where they are exposed along the mountain flanks, the steep groundwater gradients have enhanced this cavern development. In many places surface water plunges directly into the carbonates via steep-walled, open throat sinkholes (swallets). Most of the caves are linear networks, and exhibit conduit flow, capturing surface streams upgradient which then emerge as springs at the downgradient end.

Bedrock Geology of the Karst-forming Units

The ACP alignment in the Appalachian Plateau section has been mapped (Cardwell, et al., 1968; Davies, 1958) as being underlain by the karst-forming carbonate rocks of the Greenbrier and Mauch Chunk groups, exclusively. The geology is described from youngest to oldest as follows:

Mississippian Period

Mauch Chunk Group – Includes the Bluestone and Princeton Formations (Mbp), Hinton Formation (Mh), and Bluefield Formation (Mbf). The group is predominantly red, green and medium-gray shale and sandstone, with a few thin limestone lenses in each formation. Although the limestone strata in the unit are considered secondary, the topographic position of the Mauch Chunk along the edges of the eroded upland of the Allegheny Plateau where there is a relatively steep downward hydraulic gradient has enhanced water flow through the carbonate lenses, forming karst conduit networks with high transmissivity (Kozar & Mathes, 2001), thus from a karst hydrology viewpoint this unit is significant.

Greenbrier Group (Mg) – In the project area the Greenbrier Group (or "Big Lime" as it is known locally) is up to 400 feet in thickness. It is primarily a gray to dark gray, massively bedded marine limestone, with interbeds of red and green marine and nonmarine shale and thin discontinuous beds of sandstone. The Group is divided into six stratigraphic units; from oldest to youngest they are: the Denmar Limestone, Taggard Shale, Pickaway Limestone, Union Limestone, Greenville Shale, and Alderson Limestone. The principle cave forming units are the Pickaway and Union limestones.

Survey Results and Discussion

Surface Karst Concentrations – For the purposes of coordinating the data review and field survey services, and to facilitate the discussion of the survey findings, the ACP alignment is discussed by county (see Figure 1). The findings of both the data review and field survey phases of the assessment are summarized in the following section. The county sections are described from west to east. Geology of the mapped features is included as Appendix A; topography of mapped features is included as Appendix B, and a summary of data in tabular form is included as Appendix C.

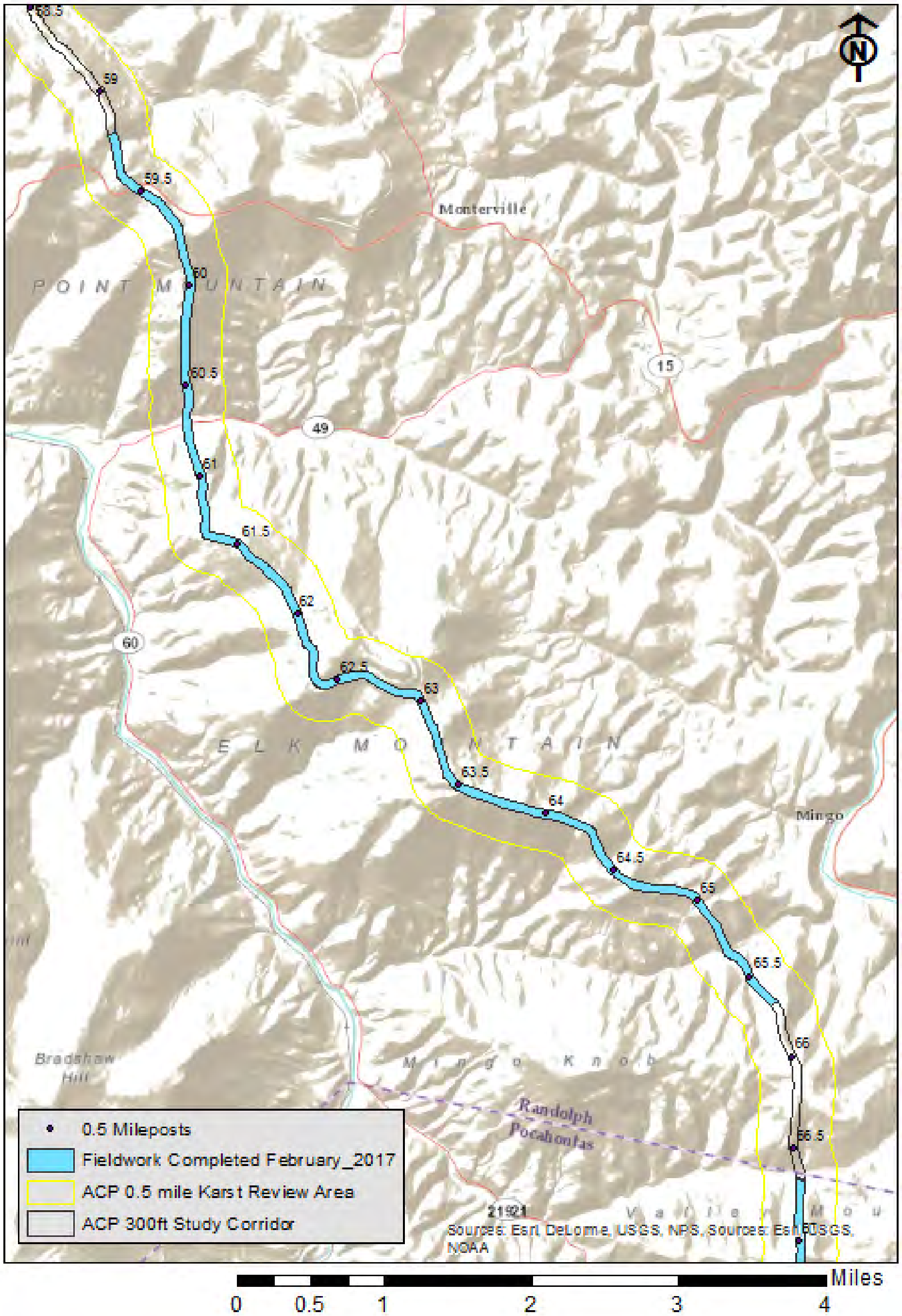

Figure 3. Map of completed field survey section in Randolph County, WV

Randolph County, West Virginia (Allegheny Front and Appalachian Plateau)

Milepost 59.2 to 66.7 – Appendix B: Maps 1-14

The Randolph County, West Virginia section of the survey extends from milepost 59.2 on the eastern end of Point Mountain, to milepost 66.7. Elevations range from over EL 3,500 feet on the summit of Point Mountain, to EL 2,300 in the valley of the Elk River, approximately 2.2 miles southwest of Monterville, WV.

Data Review – The largest scale mapping available for Randolph County was 1/9-arc Digital Elevation Models (DEMs) obtained from the USGS National Elevation Dataset, which were converted to 1 meter interval contour maps for terrain analysis using GIS software. LIDAR provided by the DTI staff was available from mileposts 59.6 to 60.6. The Data review indicated the presence of a total of 29 closed depressions. Of these, 26 were classified as cCD features and three were classified as sCD features; however it should be noted that two of the cCD features (cCD49 and cCD50) were subsequently shown to be abandoned strip mines and not karst features. All 29 features were mapped as being located within the clastic and carbonate rocks of the Mauch Chunk Group and the overlying Pottsville Group.

Review of the literature also indicated 10 cave entrances were located in the Randolph County section (Medville & Medville, 1995). All of the cave entrances were located outside of the 300FC, but within the KRA. Based on analysis of the topography, none of these cave entrances are downgradient from the 300FC. Survey data suggest that none of the cave passages extend into the 300FC. Surveyed cave lengths were short, ranging from 35 feet to 220 feet. A total of nine of the caves are developed in the Greenbrier Group limestone, the remaining cave (County Line Pit) is developed in the Bluefield Formation of the Mauch Chunk Group.

Field Survey (Fig. 3.) – The field survey for the West Virginia section was performed in summer 2016. The field survey extended from milepost 59.2 to milepost 65.7, which comprised approximately 87 percent of the proposed alignment in Randolph County located in mapped or inferred karst terrain. Landowner permission was not granted to survey the remaining 13 percent.

A total of 38 karst features were identified in the Randolph County section: 29 point features; and nine area features. A total of 23 of the identified features were located in the Mauch Chunk Group, and 15 in the overlying New River Formation of the Pottsville Group.

Pocahontas County, West Virginia (Allegheny Front and Appalachian Plateau/Folded Appalachians)

Milepost 66.7 to 83.9 – Appendix B: Maps 15 - 43

The Pocahontas County, West Virginia section of the survey extends from milepost 66.7 on the northern pediment of Valley Mountain, to milepost 83.9 on Allegheny Mountain. Elevations range from over EL 4,300 feet on the summit of Tallow Knob, to EL 2,290 in the valley of the Greenbrier River, in Cloverlick, West Virginia.

Data Review – The largest scale mapping available for Pocahontas County was 1/9-arc Digital Elevation Models (DEMs) obtained from the USGS National Elevation Dataset, which were converted to 1 meter interval contour maps for terrain analysis using GIS software. LIDAR data provided subsequently by DTI staff covered the majority of the survey corridor (300FC) in Pocahontas County. The Data review indicated the presence of a total of 91 closed depressions, all of which were classified as cCD. There were no sCD features identified in the data review in Pocahontas County. A total of 45 of the cCD features were located in the karst-forming Greenbrier and Mauch Chunk group rocks. A total of 24 features were located in the karst-forming Silurian age Tonoloway Formation. One cCD (ID = cCD44) was located in the Pocono Group, a non-karst forming clastic unit. This feature was subsequently identified as a depression in alluvium associated with a stream meander. A total of five other cCD features were identified on the flanks of Michael Mountain, two in the carbonate-rich Oriskany Sandstone of the Helderberg Group and three in the clastic Brallier Formation.

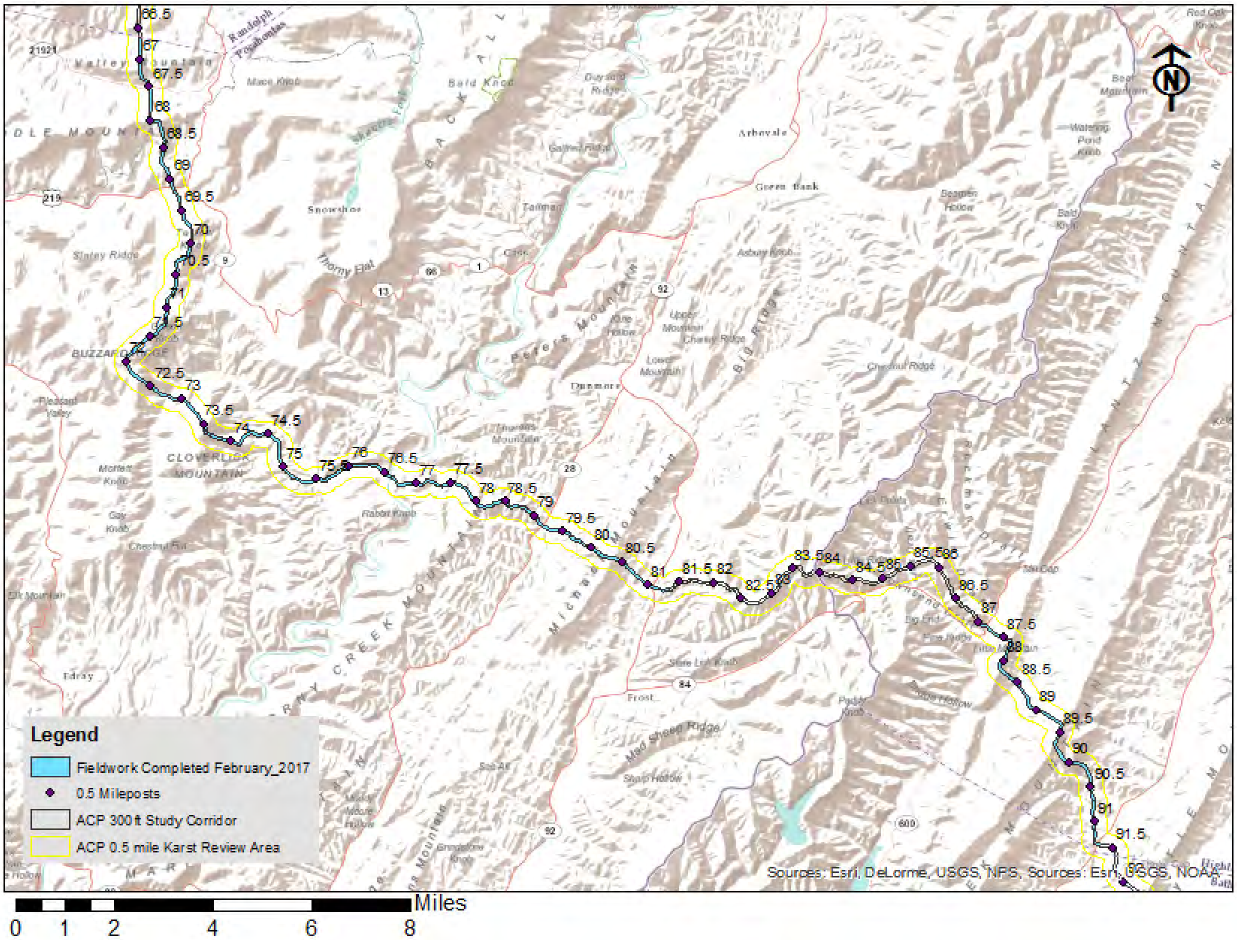

Figure 4. Map of completed field survey section in Pocahontas County, WV

Review of the literature indicated 18 cave entrances were located in the Pocahontas County section (Medville & Medville, 1976; Storrick, 1992). All of the cave entrances were located outside of the 300FC with the exception of Tapp's Trap; however, the entrance could not be located by the field crew and reportedly the WVASS could not locate the entrance during a reconnaissance survey of the county in the 1990s (Springer, verb.comm., 2017). Analysis of the topography showed that none of these cave entrances are downgradient from the 300FC centerline. Surveyed cave lengths ranged from 8 feet to 12,612 feet. A total of three of the caves are developed in the Bluefield Formation of the Mauch Chunk Group, with the remaining 15 caves being developed in the Greenbrier Group limestones. The two longest caves are Piddling Pit and Canis Majoris, at 12,612 feet and 5,800 feet in length, respectively (Fig. 5). Piddling Pit, the larger of the two extends towards the south, based on mapping provided by the WVSS, and does not underlie the 300FC. However Canis Majoris Cave extends roughly horizontally for approximately 2,400 feet to the north, and passes underneath the 300FC from south to north. The highest ceiling in the cave is 70 feet, and is located in a chamber south of the 300FC. The mapped cave passages below the 300FC have a maximum ceiling height of 25 feet, and are at least 170 to 175 vertical feet below the ground surface (Medville and Medville, 1976).

Field Survey (Fig. 4) – The Field survey for the Pocahontas County section was performed in summer and early autumn 2016. The field survey extended from milepost 66.7 in the valley between Mingo Knob and Valley Mountain, to milepost 81.3. The survey comprised all of the mapped and inferred karst terrain in the Pocahontas County section.

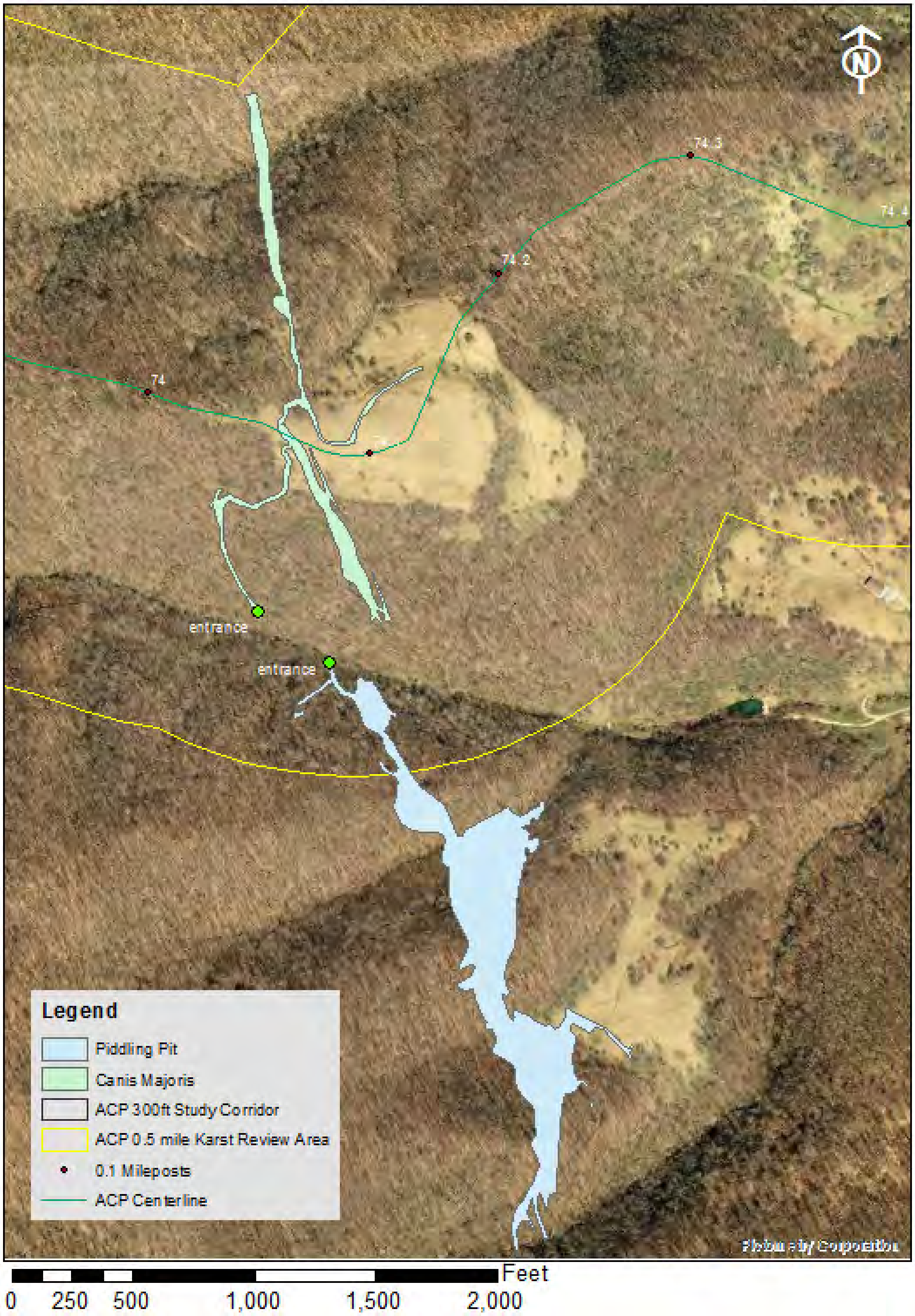

Figure 5. Outline maps of Canis Majoris Cave and Piddling Pit Cave with respect to the ACP Centerline

A total of 87 karst features were identified in the Pocahontas County section: 61 point features; and 26 area features. The majority of features were located in the Mississippian age Greenbrier and Mauch Chunk group rocks.

Highland County, Virginia (Folded Appalachians)

Milepost 83.9 to 91.6 – Appendix B: Maps 43 - 57

The Highland County, Virginia section of the survey extends from milepost 83.9 to milepost 91.6 in the valley of the Jackson River 1.2 miles west of Bolar, Virginia. Elevations range from approximately EL 3,800 feet on the crest of Allegheny Mountain, to EL 2,090 in the Jackson River valley.

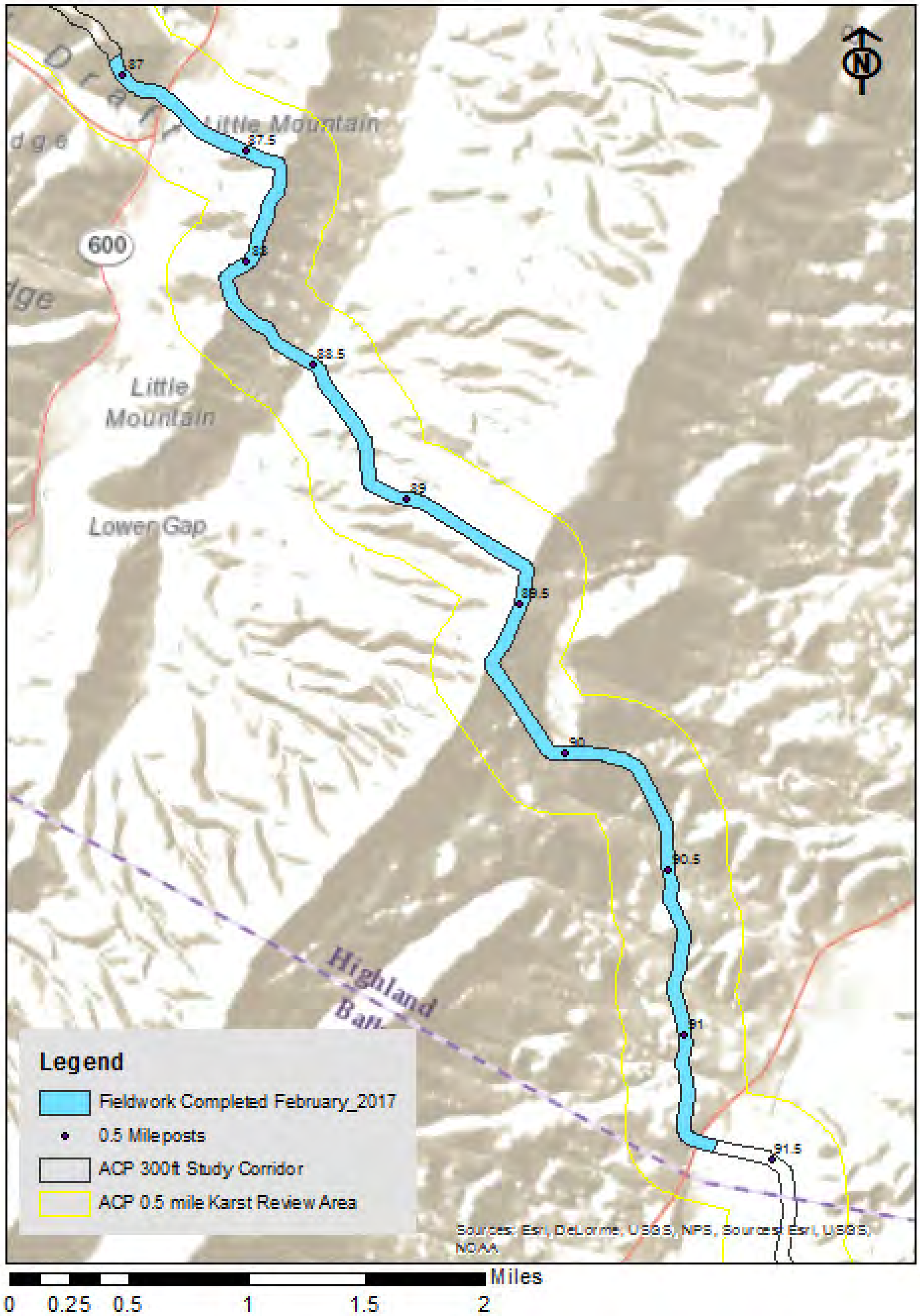

Figure 6. Map of completed field survey sections in Highland County, VA

Data Review – The largest scale maps available initially for terrain analysis for Highland County were 2-foot interval contour maps derived from county level DTMs using GIS software. However subsequently DTI staff provided LIDAR data for the entire karst section of Highland County. The data review indicated the presence of a total of 53 closed depressions, all of which were classified as cCD. There were no sCD features identified in the data review in Highland County. One of the features was located in the Ordovician age Moccasin and Bays Formation unit just west of Valley Center, and the other two were located on the eastern flank of Back Creek Mountain in the Silurian age Tuscarora Formation. The Moccasin and Bays Formations are karst-forming units equivalent to the Middle Ordovician Limestones of the Great Valley. However, the Tuscarora Formation is not a karst-forming unit and the feature may represent areas where the Tuscarora has collapsed into underlying karst structures.

Referencing proprietary cave location data provided by the Virginia Speleological Survey (VSS) four cave entrances were located in the Highland County section. All of the caves were listed as very short (less than 250 feet). Two of the cave entrances were verified and located in the field (Rock Well Cave and Sinking Stream Cave); however the entrance of a third cave (Impatient Pit) could not be found and may have been filled-in by the landowner.

Field Survey (Fig. 6) – The field survey for the Highland County, VA section was performed in June, 2016. The field survey extended from milepost 83.9 to milepost 91.3, which comprised approximately 96 percent of the proposed alignment in Highland County, and covering 100 percent of the areas mapped as karst terrain.

A total of 56 karst features were identified in the Highland County section: 18 point features; and 38 area features. The majority of features were located in the Valley Center area. The remaining features were located in the Tuscarora Formation outcrop zone on the eastern flank of Back Creek Mountain.

Bath County, Virginia (Folded Appalachians)

Milepost 91.6 to 106.8 – Appendix B: Maps 58 - 83

The Bath County, Virginia section of the survey extends from milepost 91.6 near Bolar, Virginia to milepost 106.8 in the Mill Creek Valley. Elevations range from approximately EL 3,600 feet on the crest of Jack Mountain, to EL 1,600 in the Cowpasture River valley.

Data review – The largest scale maps available for terrain analysis for Bath County were 2 foot interval contour maps derived from county level DTMs using GIS software and LIDAR data provided by DTI. The Data review indicated the presence seven sCD features, and 44 cCD, all of which were located in the Helderberg Group rocks along the western pediment of Walker Mountain.

Referencing proprietary cave location data provided by the Virginia Speleological Survey (VSS) two small caves were located on the east flank of Tower Mountain; however, the survey crew did not have landowner permission to survey this section of the alignment, so the cave entrance locations could not be verified.

Field survey (Fig. 7) – The field survey for the Bath County, Virginia section was performed in June, 2016 and February 2017. The field survey was conducted in four discontinuous sections: mileposts 94.6 to 95.9, 101.4 to 101.8, 103.0 to 104.2 and 105.2 to 106.7. Landowner permissions was not granted for the remaining areas of either mapped or inferred karst terrain. This includes the section of the proposed alignment southwest of Burnsville Cove from milepost 96.8 to 97.2 within the known recharge area of the extensive cavern systems located in that internally-drained karst valley, and the southern section of the Deerfield Valley from milepost 102.2 to 103. With the exception of the aforementioned sections, all of the remaining mapped or inferred karst terrain in the Bath County section were surveyed.

A total of 44 karst features were identified in the Bath County section, 43 of which were point features and one area feature. The majority of field identified features were located along the western pediment of Walker Mountain in the valley of the Mill Creek. It is of note that over half of these features, located primarily in the southern section of the Mill Creek Valley area, were mapped as being in the Millboro Shale and Needmore Formation, neither of which are considered karst-forming units. However throughout the Bath and Highland County area, numerous sinkholes are known to form in these units, and a small cave has been discovered in the Needmore Formation in Berkeley County, West Virginia. Both of these units are primarily shale; however, they are highly calcitic and can be prone to dissolution. In addition, where the pyritic Millboro Shale is exposed at the surface, the sulfide minerals in it oxidize forming sulfuric acid, which can accelerate the groundwater dissolution process of the underlying Needmore Formation. Finally, both of these shales are located directly above the karst-forming Helderberg Group rocks, and can collapse into large cavernous voids which may be located in the Helderberg carbonates below.

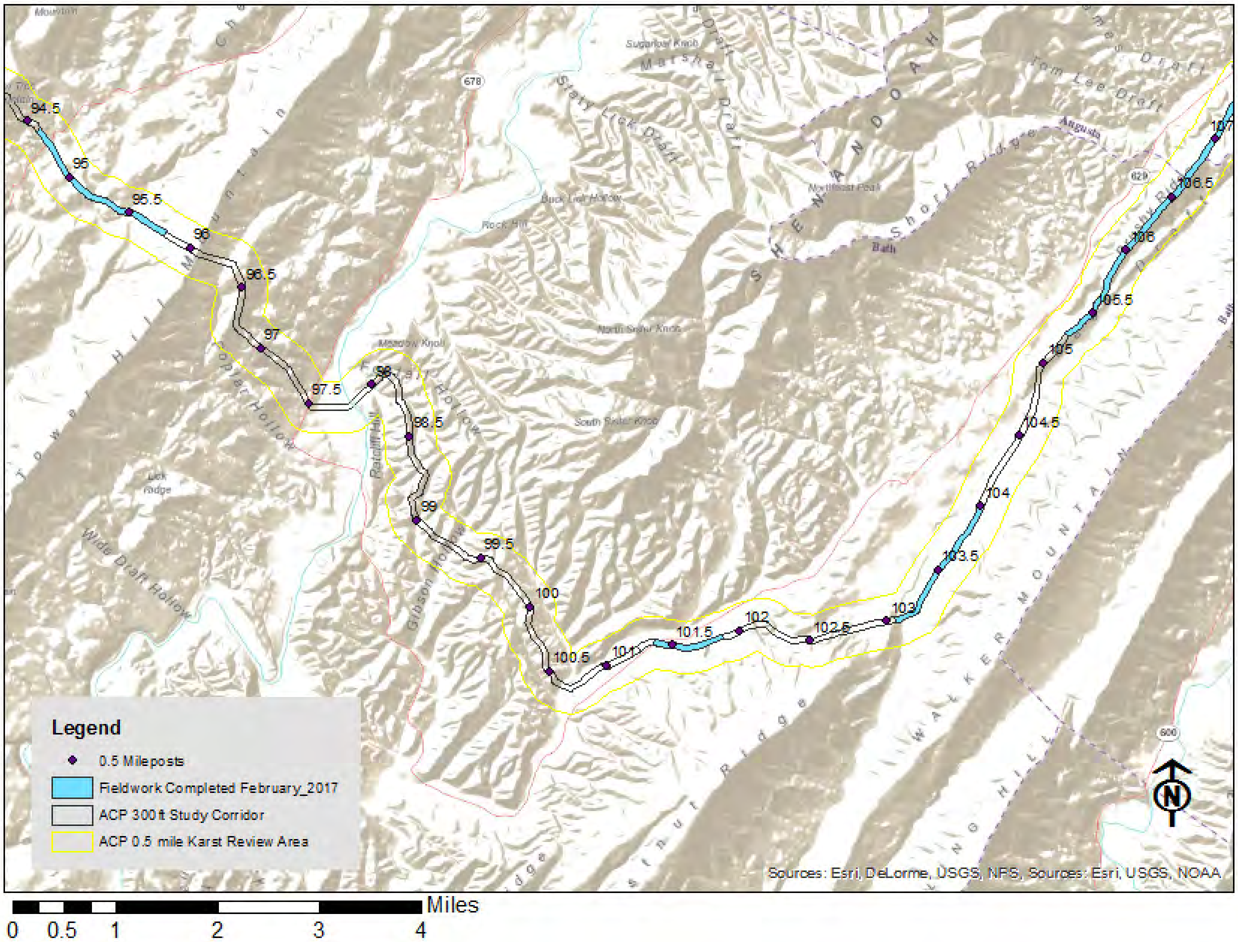

Figure 7. Map of completed field survey sections in Bath County, VA.

Augusta County, Virginia (Great Valley)

Milepost 106.8 to 158.2 – Appendix B: Maps 83 - 154

The Augusta County, Virginia section of the survey extends from milepost 106.8 southwest of Deerfield, Virginia, to milepost 158.2, southeast of Waynesboro, Virginia. Elevations range from approximately EL 2,798 on the crest of Chestnut Oak Knob, to EL 1,380 in the valley of the South River.

Data Review – The largest scale maps available for terrain analysis for Augusta County were LIDAR generated DEMs for selected areas of the central and southern portion of the survey, and 2-foot interval contour maps derived from county level DTMs using GIS software with LIDAR provided by DTI for the northern section. The Data review indicated the presence 44 sCD features, and 51 cCD. In addition, 20 small suspected sinkhole features were located during the analysis of the LIDAR data.

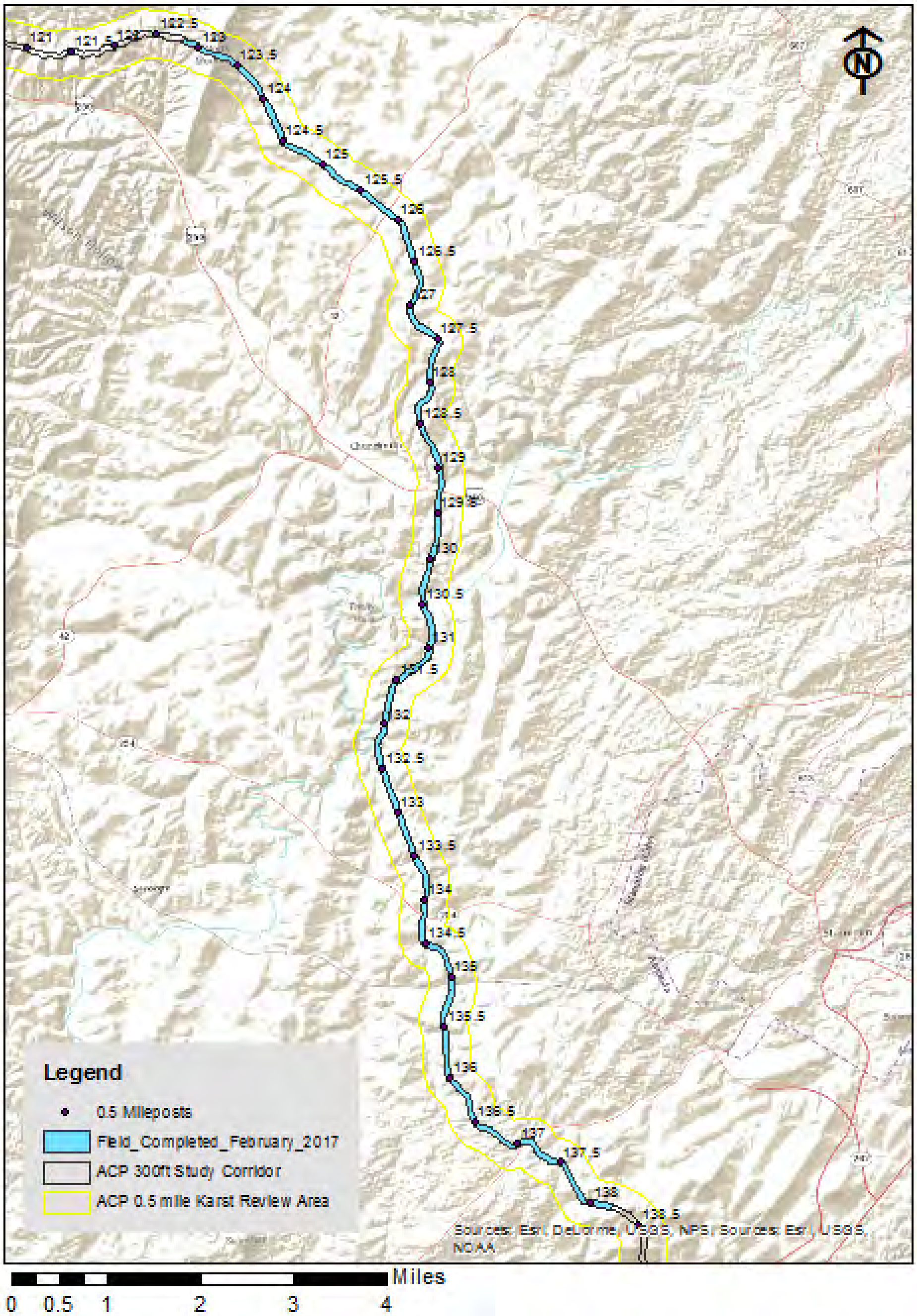

Figure 8. Map of completed field survey sections in northern Augusta County, VA

Referencing proprietary cave location data provided by the Virginia Speleological Survey (VSS) two caves were located in Augusta County within the KRA: Cochran's Cave No. 2 and Cochran's Cave No. 3, the former of which is classified as a significant cave by the VSS and for which a conservation area has been delineated by the Karst Program of the Virginia Division of Conservation and Recreation – Natural Heritage Program (DCR-NHP).

Field Survey (Fig. 8-9) – The field survey for the Augusta County, VA section was performed during October through early November 2014, May – June 2015, June 2016 and September 2016. It is of note that based on the USGS National Karst Map (2014) the karst terrain extended from milepost 122.9 to 153.2, with an inferred section running parallel with the base of the Blue Ridge from milepost 153.2 to 156.7 in the Back Creek Valley. This section was included because several suspect features had been reported by the ACP routing crews, and it was located immediately east of the known karst area of the Shady Dolomite. Of the 33.8 miles of mapped or inferred karst terrain in Augusta County, 31.6 miles have been surveyed (approximately 93.4 percent) in four discontinuous sections of varying length where landowner permission was obtained.

A total of 111 features were identified and located during the field survey, which included 85 point features and 26 area features. Nearly half of the features were located in the Beekmantown Group carbonates, including the cluster of sinkholes, springs and cave entrances in the Cochran Cave area southwest of Staunton, Virginia. A second concentration of features was identified in the Cambrian age units (the Elbrook, Waynesboro and Shady Dolomite formations) in a section from just southeast of Stuart's Draft and extending southward towards Sherando Camp.

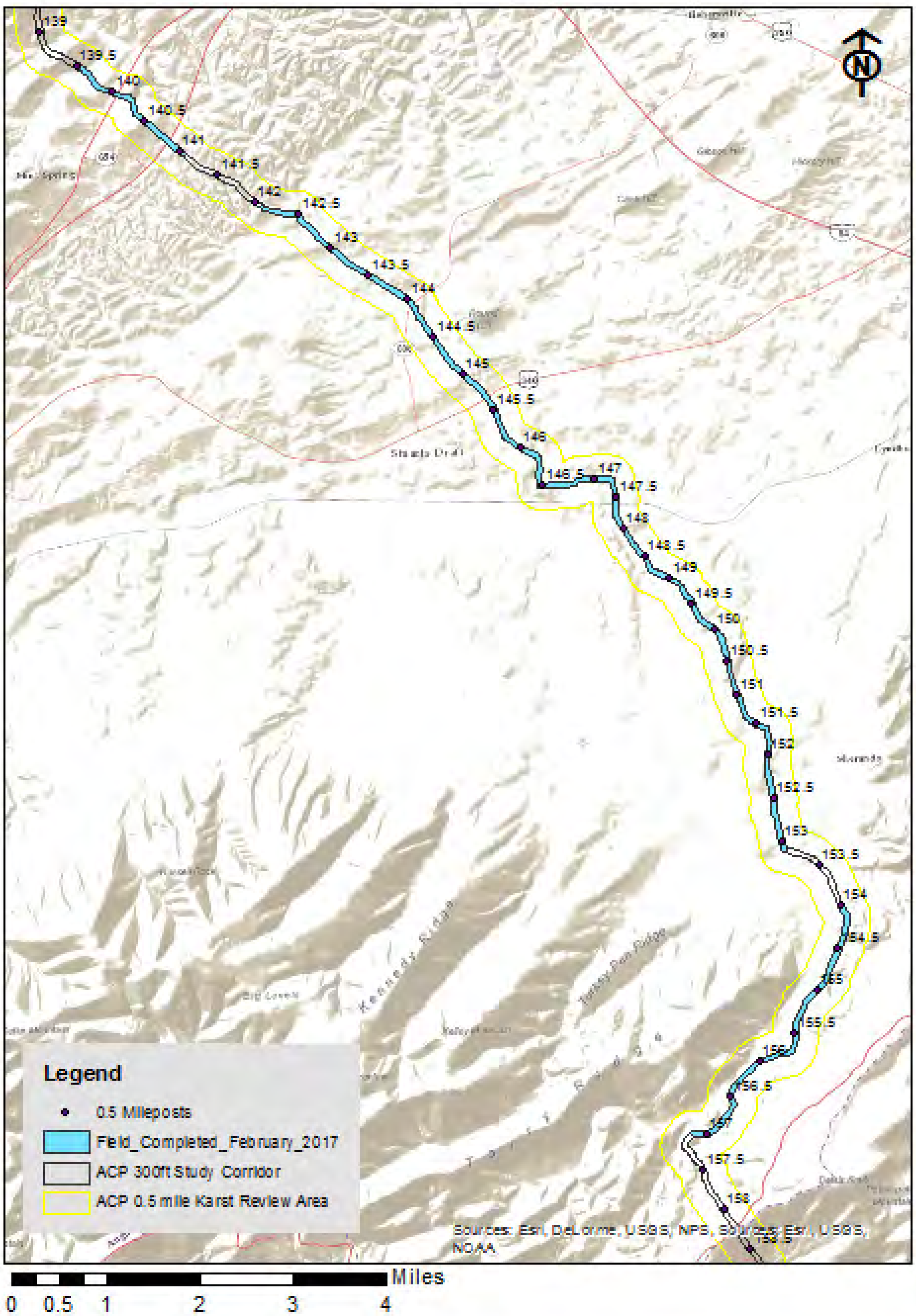

Figure 9. Map of completed field survey sections in southern Augusta County, VA

Summary of Findings

The findings of the data review and field survey are summarized as a series of tables in Appendix C. Each table includes the Feature ID, coordinates (system = UTM in US feet), geologic formation (abbreviation and full name), geologic age (period name), karst feature type and risk ranking (field survey data only).

General Limitations

Findings contained in this report are based upon the data obtained from the data review and field survey services detailed herein. It is essential that on-site observations as per the Karst Survey and Mitigation Plan be performed during the construction period to determine if re-evaluation of the recommendations in this report must be made.

This report was prepared in accordance with generally accepted geologic and geotechnical engineering practices. No warranties, expressed or implied, are made as to the professional services included in this report.

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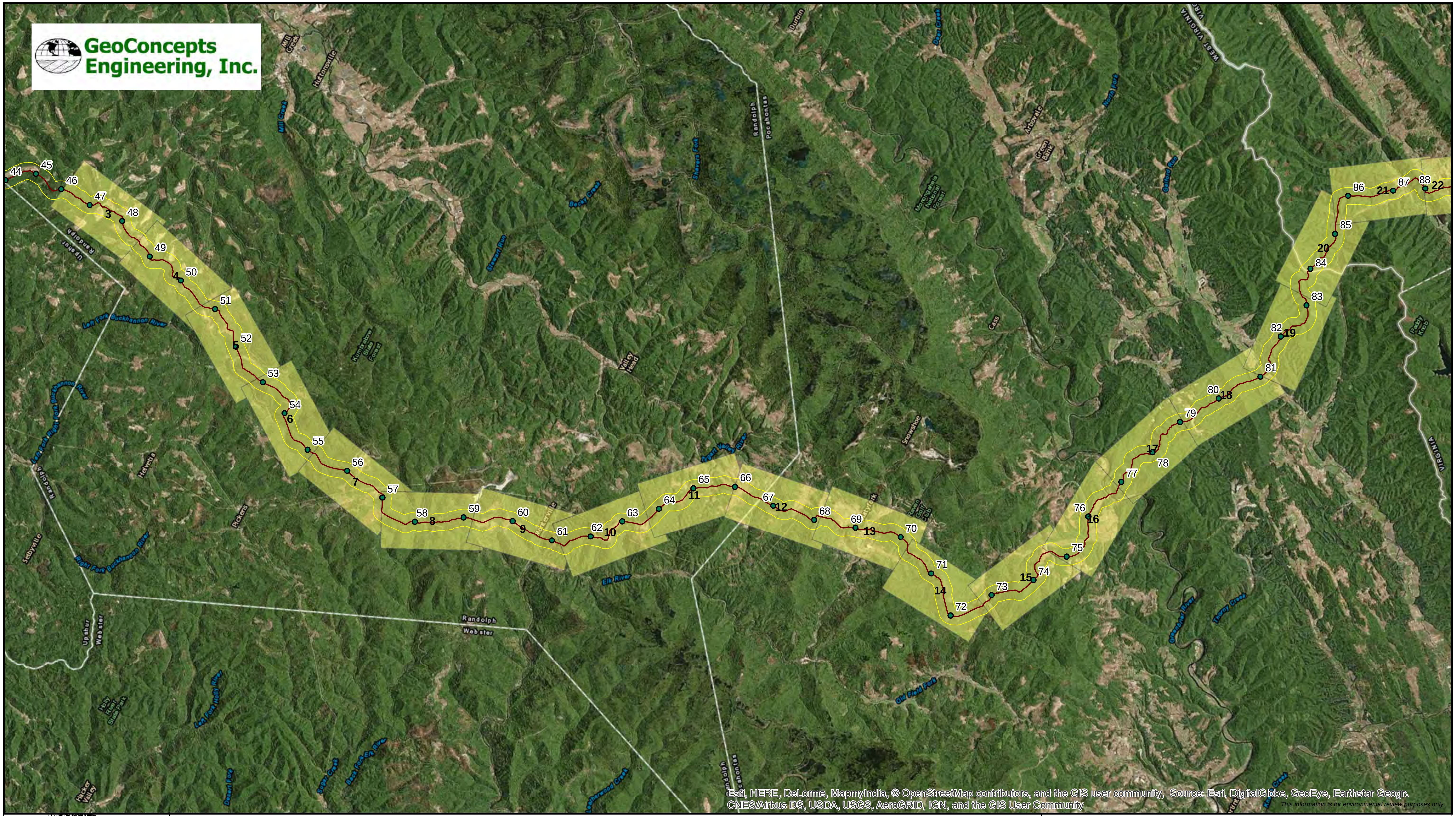
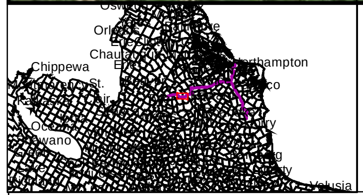
APPENDIX A
Geologic Maps





• Mileposts (1.0 mile)

Rev 12 Centerline

Rev 12 0.50 KRA

Geologic Maps

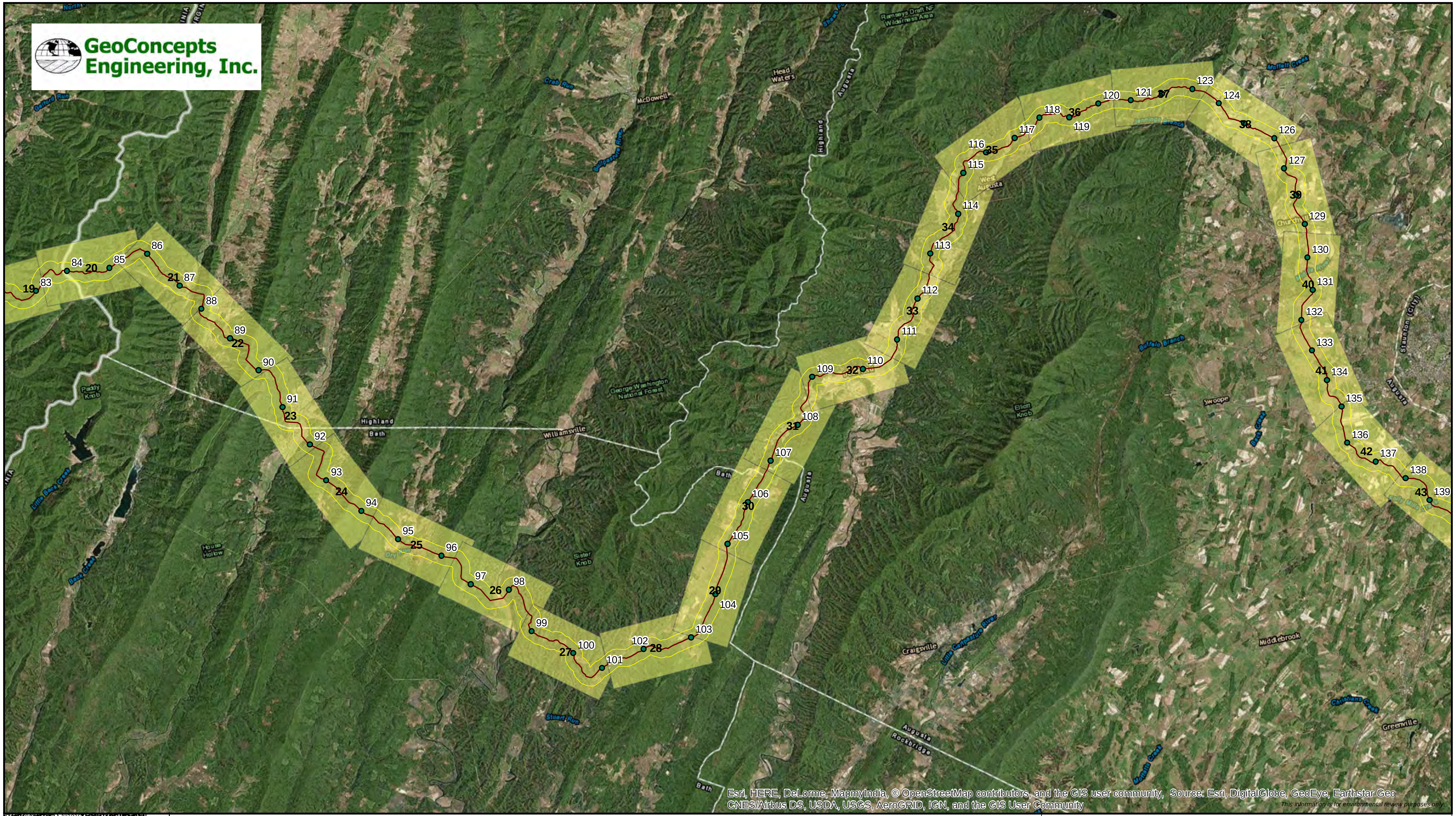
0 10,000 20,000
Feet

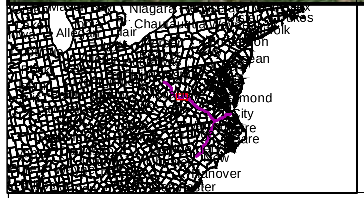
INDEX GEOLOGIC MAP I
ATLANTIC COAST PIPELINE
11002.04

Dominion

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\index mapbook.mxd | REVISED: 02/15/2017 | SCALE: 1:170,000 when printed at 11x17

DRAWN BY: JDV





- Mileposts (1.0 mile)
- Rev 12 Centerline
- Rev 12 0.50 KRA
- Geologic Maps

0 10,000 20,000
Feet

INDEX GEOLOGIC MAP II
ATLANTIC COAST PIPELINE
11002.04

Dominion

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\index mapbook.mxd | REVISED: 02/15/2017 | SCALE: 1:170,000 when printed at 11x17

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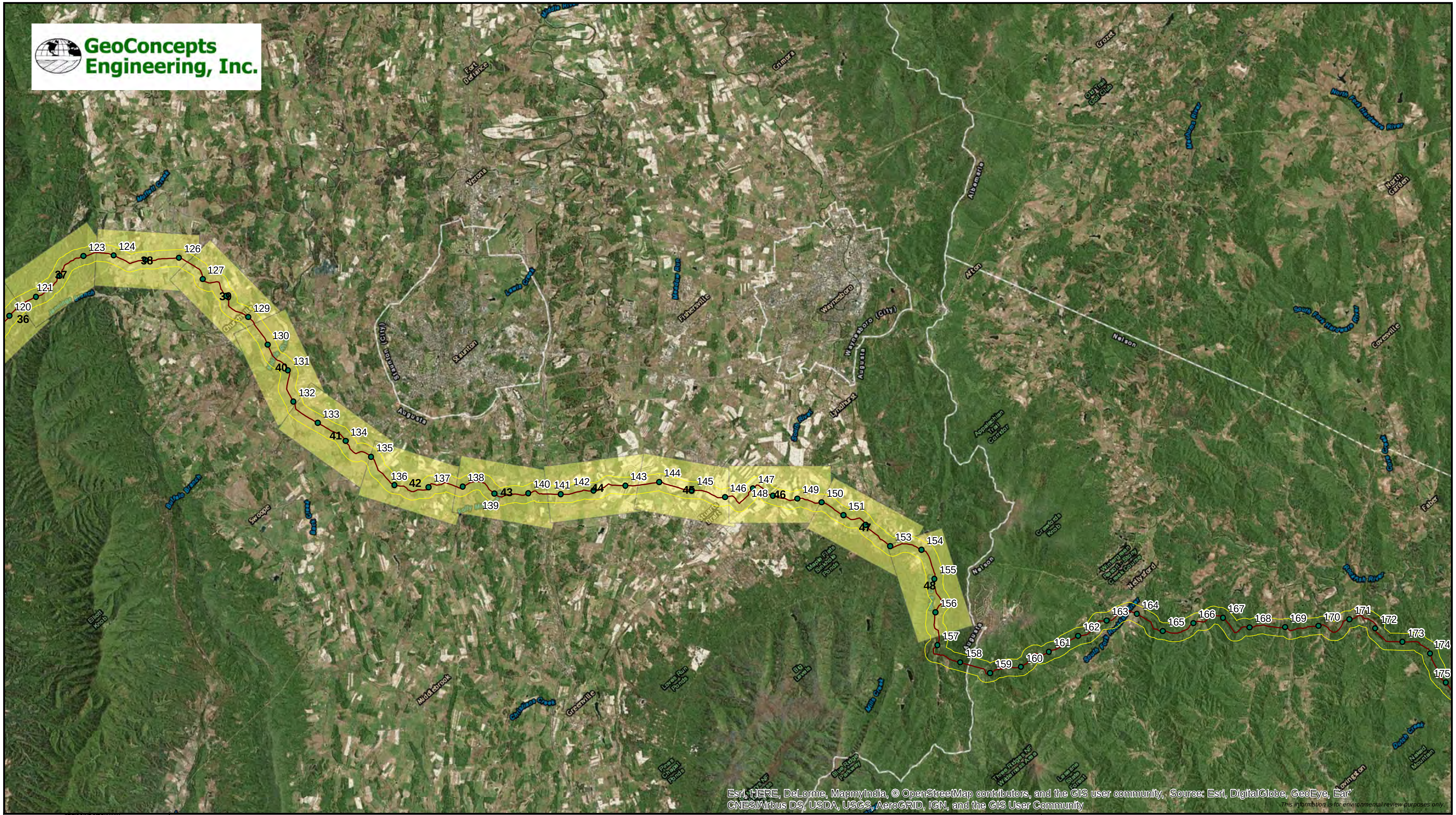

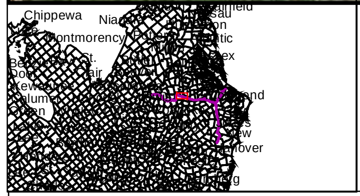

Mileposts (1.0 mile)

Rev 12 Centerline

Rev 12 0.50 KRA

Geologic Maps

0 10,000 20,000
Feet

INDEX GEOLOGIC MAP III
ATLANTIC COAST PIPELINE
11002.04

Dominion

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\index mapbook.mxd | REVISED: 02/15/2017 | SCALE: 1:170,000 when printed at 11x17

DRAWN BY: JDV

GeoConcepts Engineering, Inc.

- Mileposts (1.0 mile)
- Rev 12 Centerline
- Rev 12 300' Corridor
- Rev 12 0.50 KRA
- All Point Features
- All Area Features
- 300' Corridor Closed Depressions
- Suspect Closed Depressions
- Virginia Caves
- Randolph Caves
- Pocahontas Caves

0 1,000 2,000
Feet

GEOLOGIC MAP 1

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

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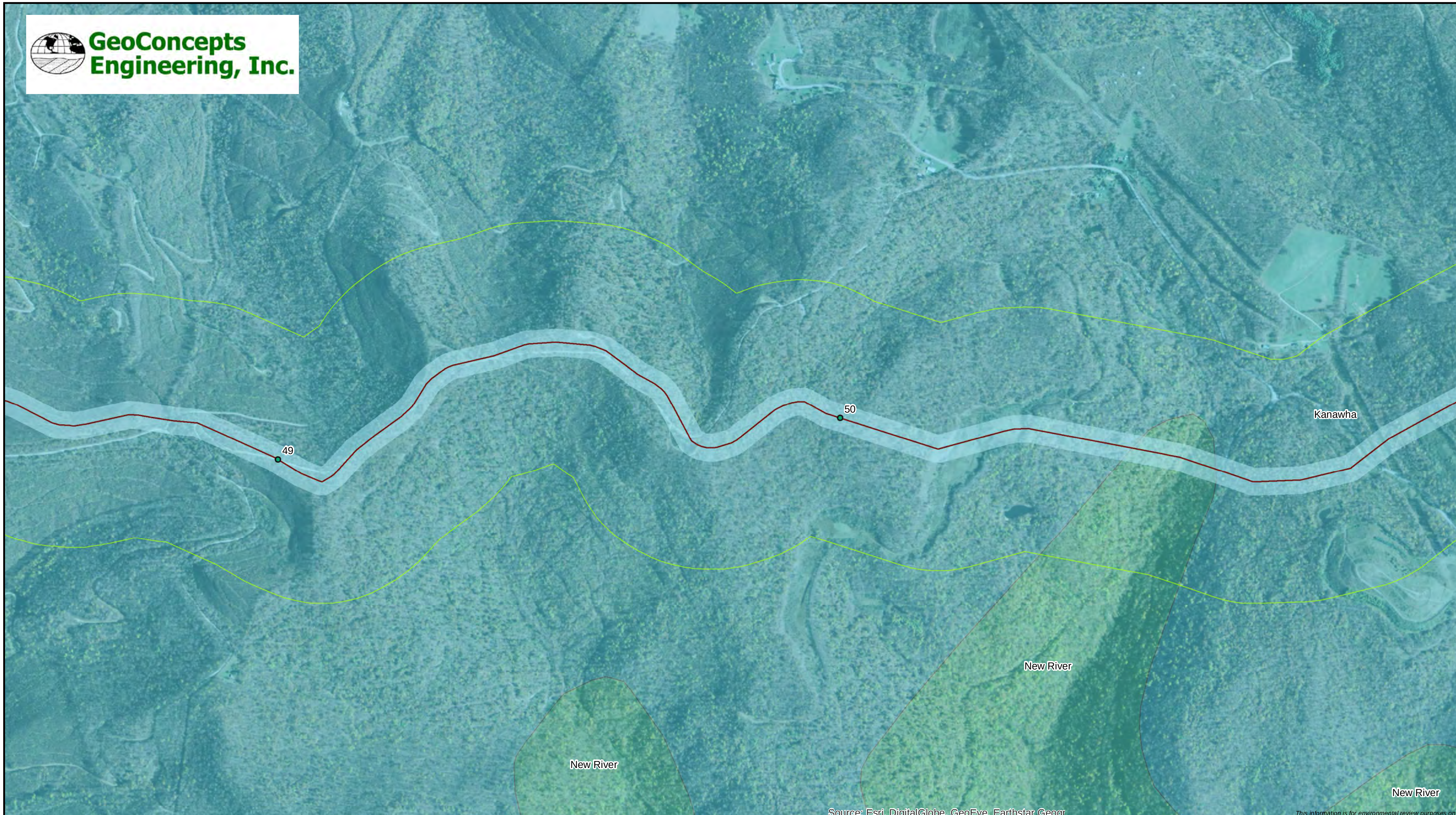


Mileposts (1.0 mile)
Rev 12 Centerline
Rev 12 300' Corridor
Rev 12 0.50 KRA
All Point Features
All Area Features
300' Corridor Closed Depressions
Suspect Closed Depressions
Virginia Caves
Randolph Caves
Pocahontas Caves

0 1,000 2,000
Feet

GEOLOGIC MAP 2

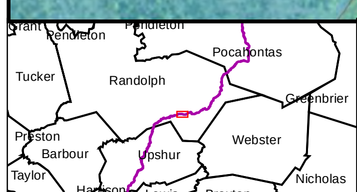
ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV

GeoConcepts Engineering, Inc.



- Mileposts (1.0 mile)
- Rev 12 Centerline
- Rev 12 300' Corridor
- Rev 12 0.50 KRA
- All Point Features
- All Area Features
- 300' Corridor Closed Depressions
- Suspect Closed Depressions
- Virginia Caves
- Randolph Caves
- Pocahontas Caves

0 1,000 2,000
Feet

GEOLOGIC MAP 3

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

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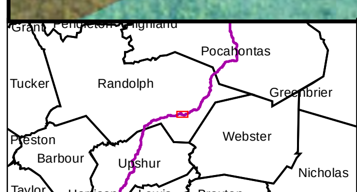

- Mileposts (1.0 mile)
- Rev 12 Centerline
- Rev 12 300' Corridor
- Rev 12 0.50 KRA
- All Point Features
- All Area Features
- 300' Corridor Closed Depressions
- Suspect Closed Depressions
- Virginia Caves
- Randolph Caves
- Pocahontas Caves

0 1,000 2,000
Feet

GEOLOGIC MAP 4

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

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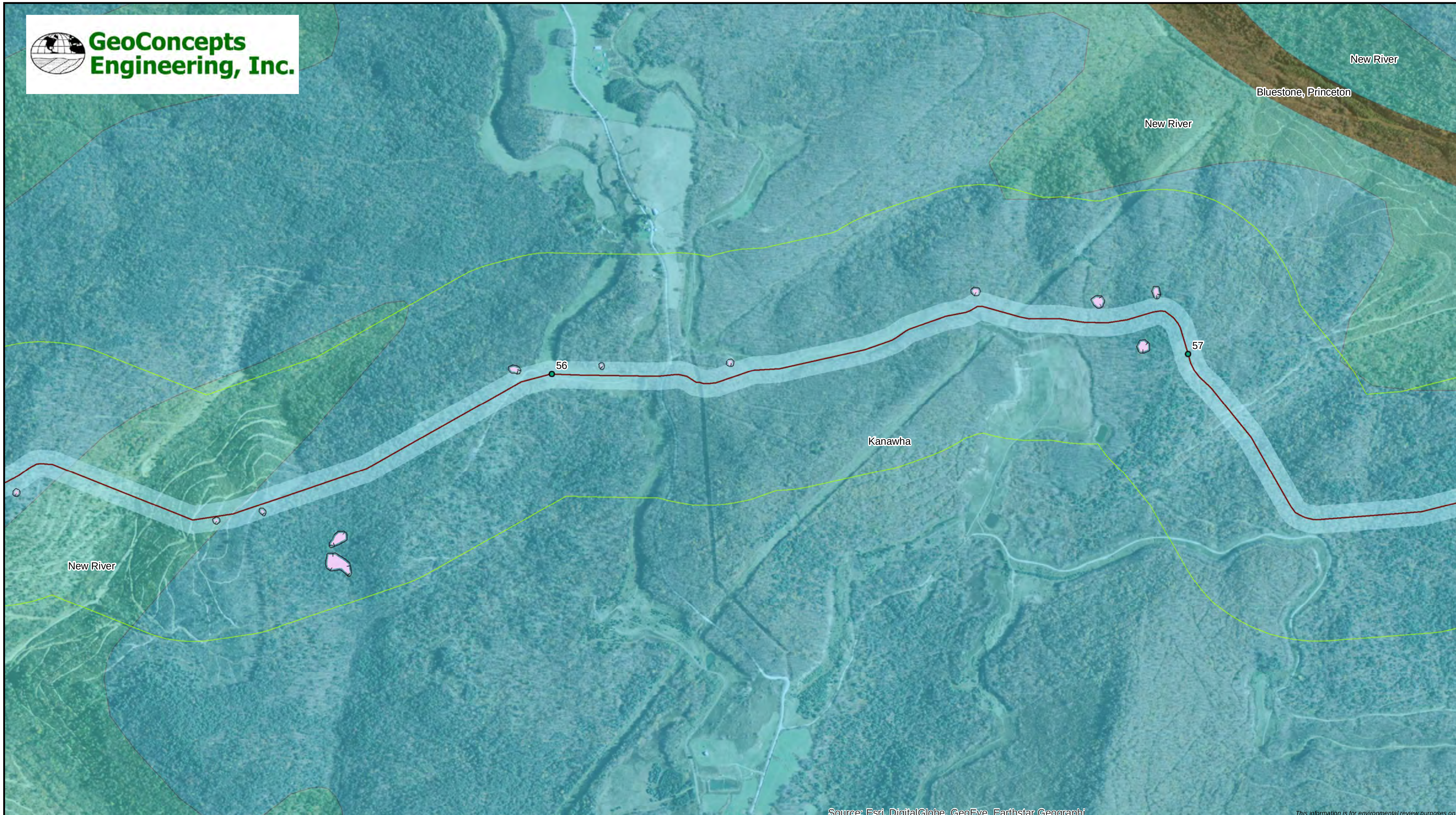

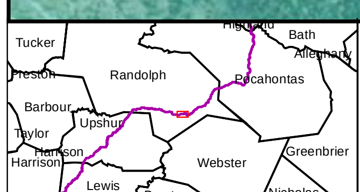

- Mileposts (1.0 mile)
- Rev 12 Centerline
- Rev 12 300' Corridor
- Rev 12 0.50 KRA
- All Point Features
- All Area Features
- 300' Corridor Closed Depressions
- Suspect Closed Depressions
- Virginia Caves
- Randolph Caves
- Pocahontas Caves

0 1,000 2,000
Feet

GEOLOGIC MAP 5

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

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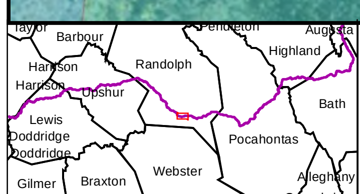


Mileposts (1.0 mile)	Rev 12 0.50 KRA	300' Corridor Closed Depressions
Rev 12 Centerline	All Point Features	Suspect Closed Depressions
Rev 12 300' Corridor	All Area Features	Virginia Caves
Randolph Caves	Pocahontas Caves	

0 1,000 2,000
Feet

GEOLOGIC MAP 6

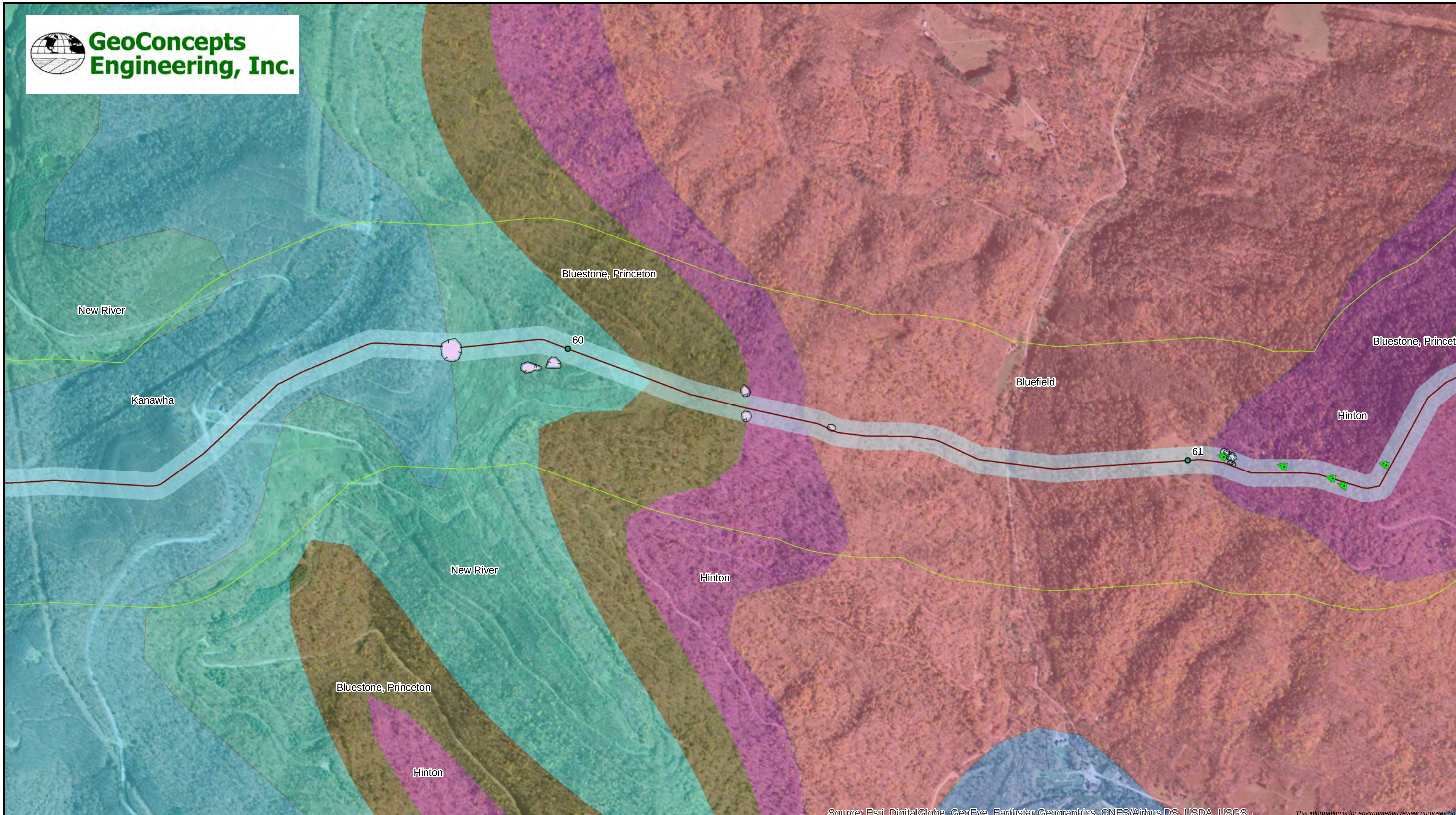
ATLANTIC COAST PIPELINE

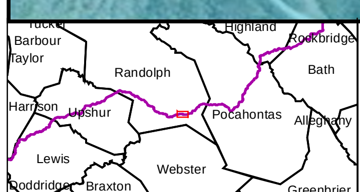
11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV

GeoConcepts Engineering, Inc.





Mileposts (1.0 mile)
Rev 12 Centerline
Rev 12 300' Corridor
Rev 12 0.50 KRA
All Point Features
All Area Features
300' Corridor Closed Depressions
Suspect Closed Depressions
Virginia Caves
Randolph Caves
Pocahontas Caves

0 1,000 2,000
Feet

GEOLOGIC MAP 7

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

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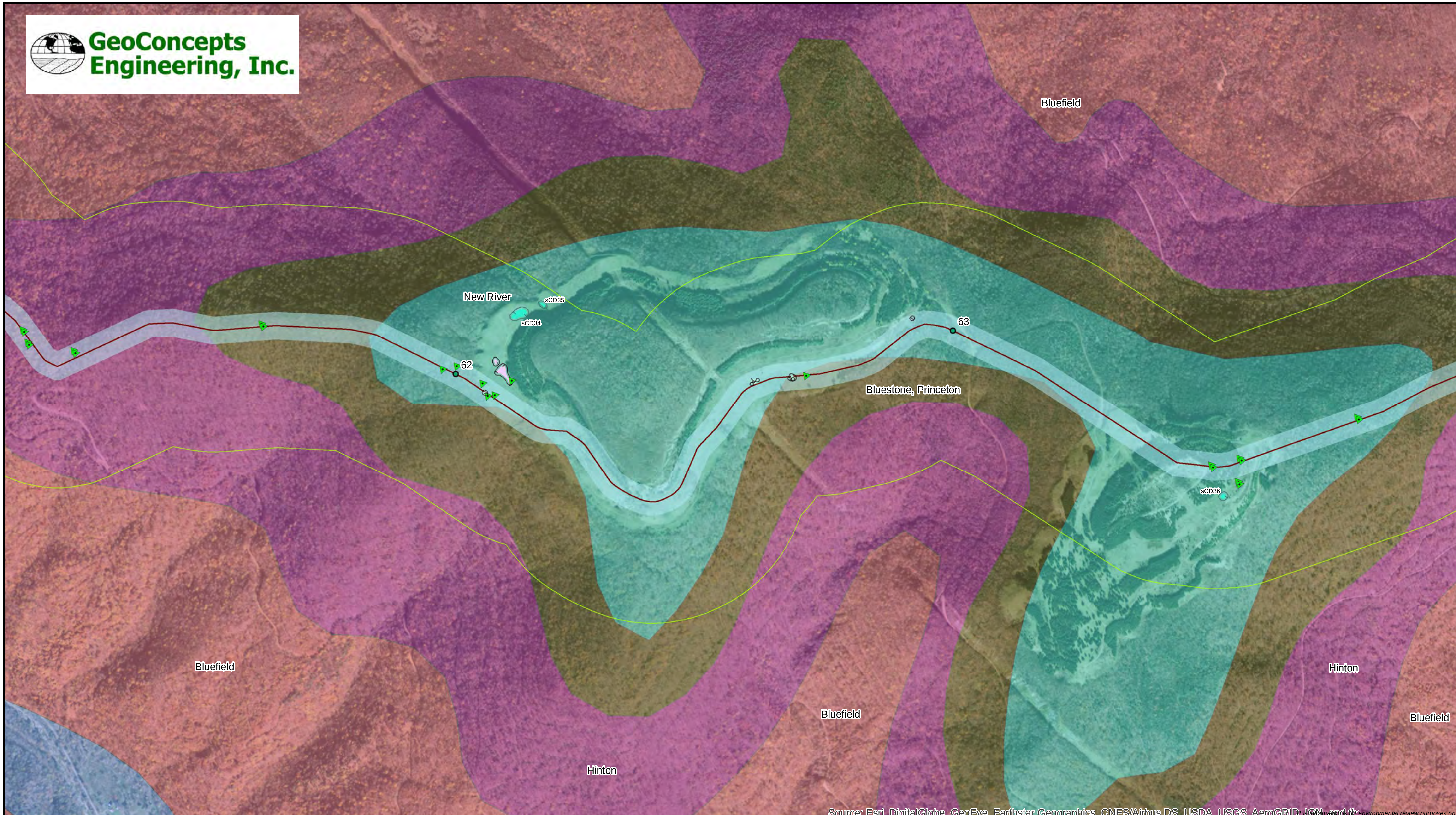

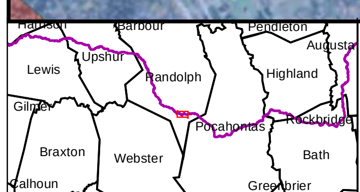

Mileposts (1.0 mile)
Rev 12 Centerline
Rev 12 300' Corridor
Rev 12 0.50 KRA
All Point Features
All Area Features
300' Corridor Closed Depressions
Suspect Closed Depressions
Virginia Caves
Randolph Caves
Pocahontas Caves

0 1,000 2,000
Feet

GEOLOGIC MAP 8
ATLANTIC COAST PIPELINE
11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

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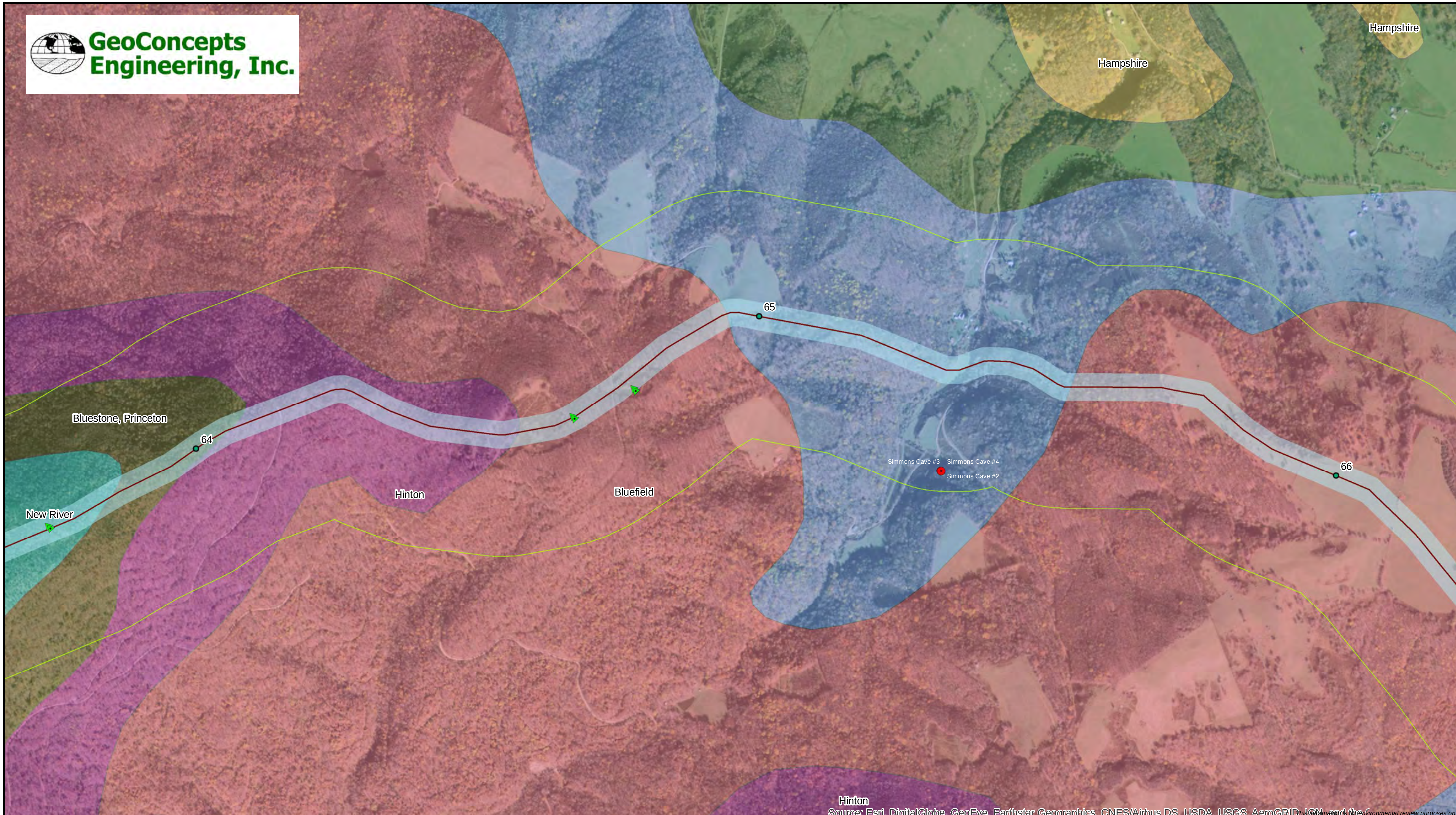

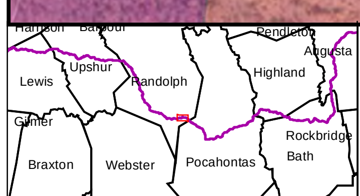

- Mileposts (1.0 mile)
- Rev 12 Centerline
- Rev 12 300' Corridor
- Rev 12 0.50 KRA
- All Point Features
- All Area Features
- 300' Corridor Closed Depressions
- Suspect Closed Depressions
- Virginia Caves
- Randolph Caves
- Pocahontas Caves

0 1,000 2,000
Feet

GEOLOGIC MAP 9

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

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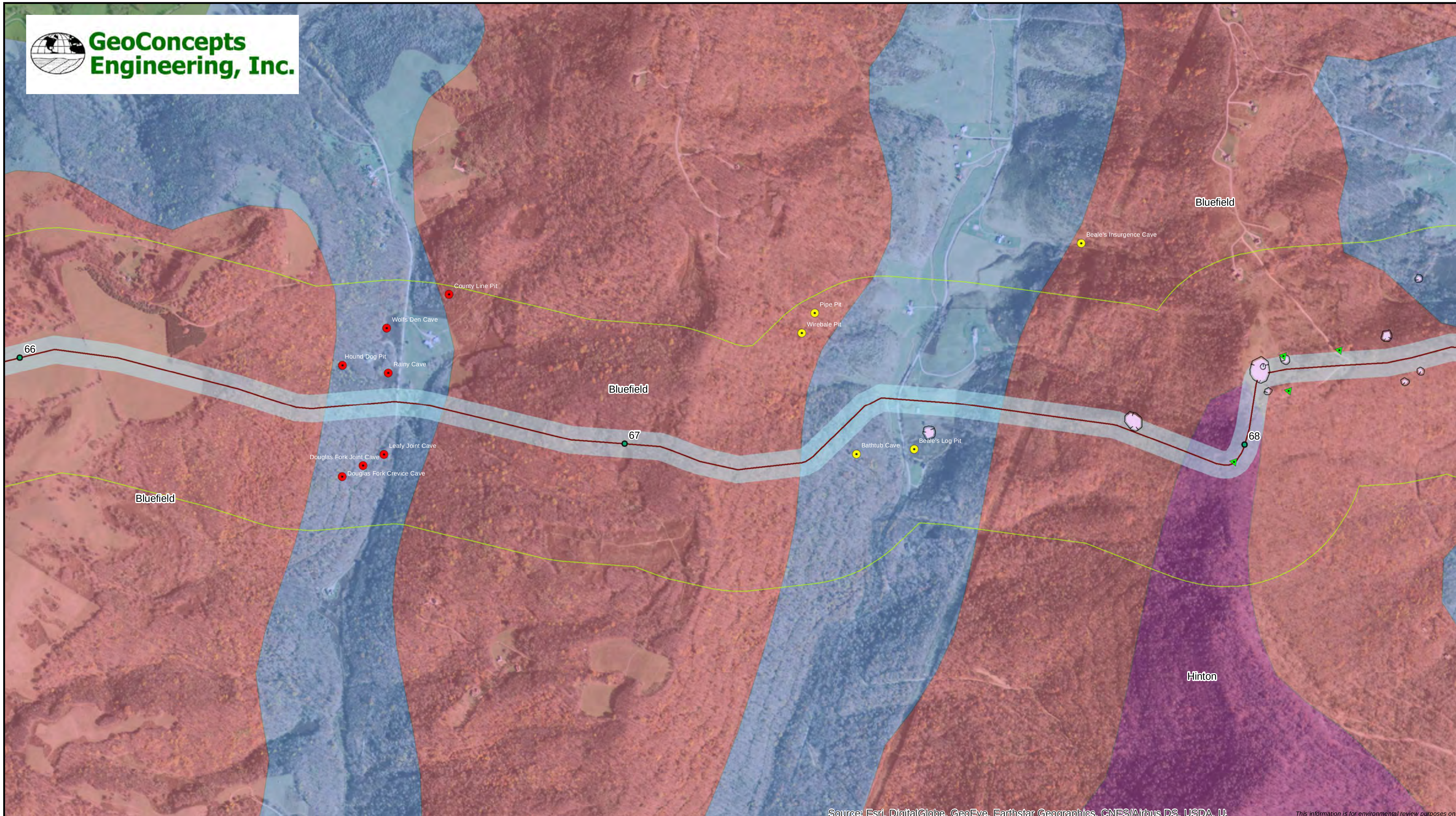
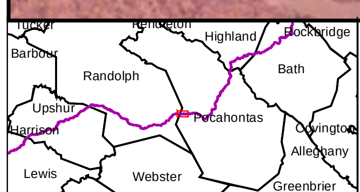




Mileposts (1.0 mile)
Rev 12 Centerline
Rev 12 300' Corridor
Rev 12 0.50 KRA
All Point Features
All Area Features
300' Corridor Closed Depressions
Suspect Closed Depressions
Virginia Caves
Randolph Caves
Pocahontas Caves

0 1,000 2,000
Feet

GEOLOGIC MAP 10

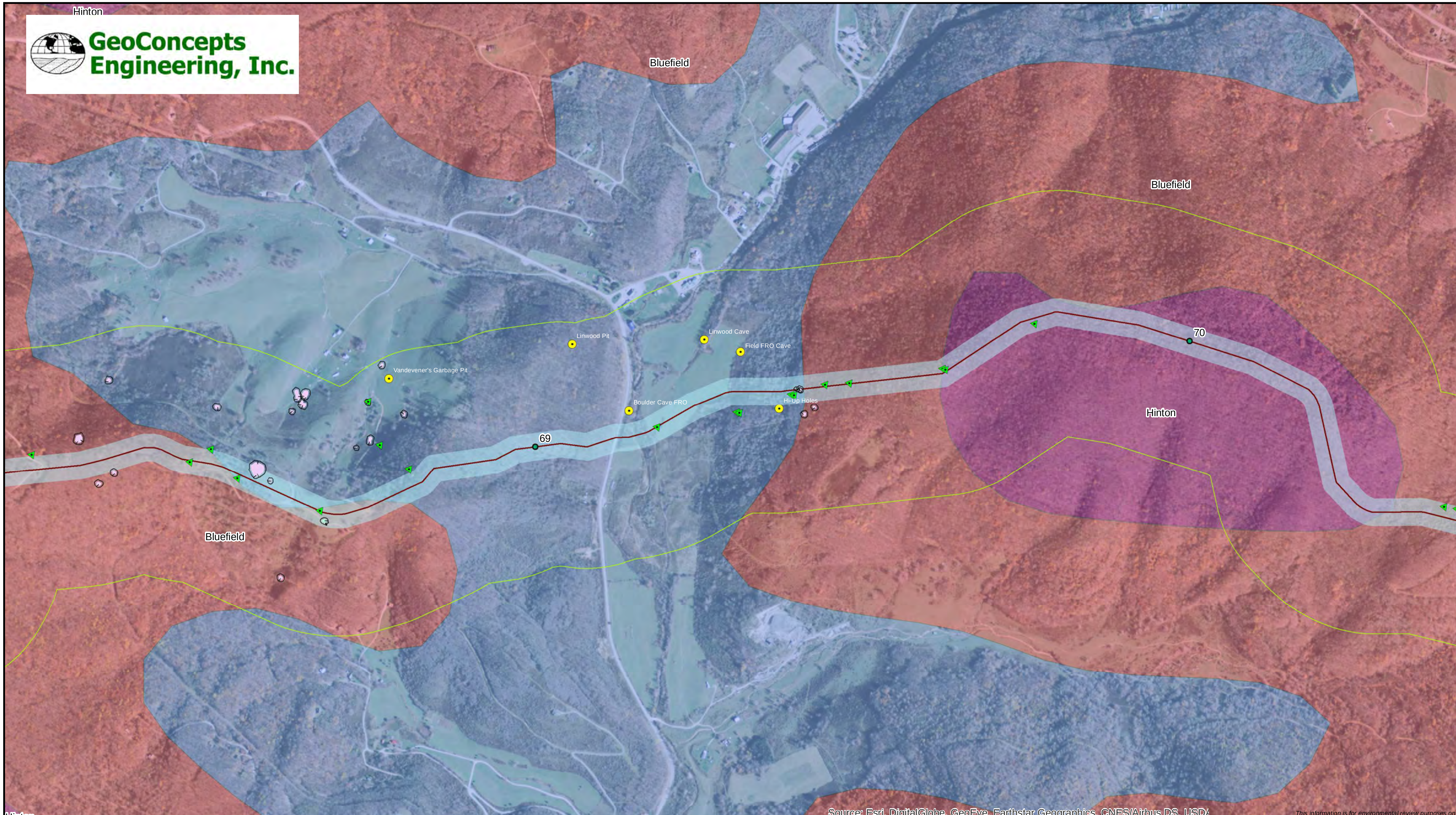
ATLANTIC COAST PIPELINE

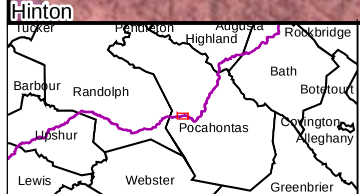
11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV

GeoConcepts Engineering, Inc.





- Mileposts (1.0 mile)
- Rev 12 Centerline
- Rev 12 300' Corridor
- Rev 12 0.50 KRA
- All Point Features
- All Area Features
- 300' Corridor Closed Depressions
- Suspect Closed Depressions
- Virginia Caves
- Randolph Caves
- Pocahontas Caves

0 1,000 2,000
Feet

GEOLOGIC MAP 11

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

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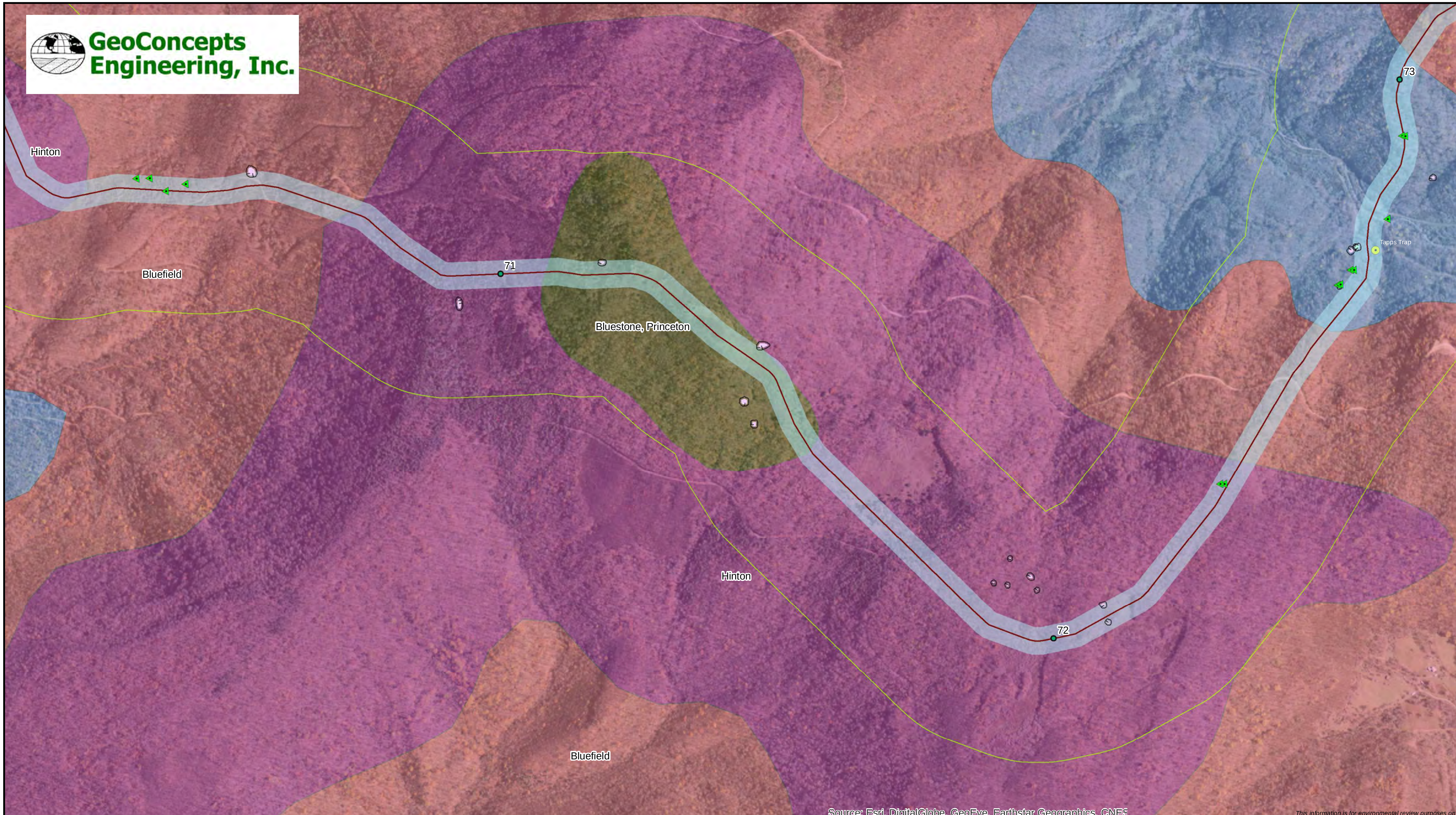

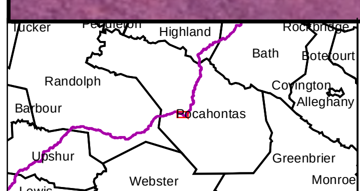

Mileposts (1.0 mile)
Rev 12 Centerline
Rev 12 300' Corridor
Rev 12 0.50 KRA
All Point Features
All Area Features
300' Corridor Closed Depressions
Suspect Closed Depressions
Virginia Caves
Randolph Caves
Pocahontas Caves

0 1,000 2,000
Feet

GEOLOGIC MAP 12

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

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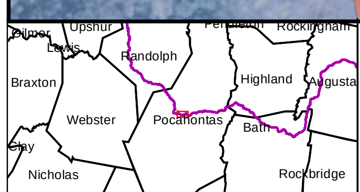

●	Mileposts (1.0 mile)		Rev 12 0.50 KRA		300' Corridor Closed Depressions	!	Randolph Caves
—	Rev 12 Centerline	0	All Point Features		Suspect Closed Depressions	!	Pocahontas Caves
	Rev 12 300' Corridor		All Area Features	!	Virginia Caves		

0 1,000 2,000
Feet

μ

GEOLOGIC MAP 13

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

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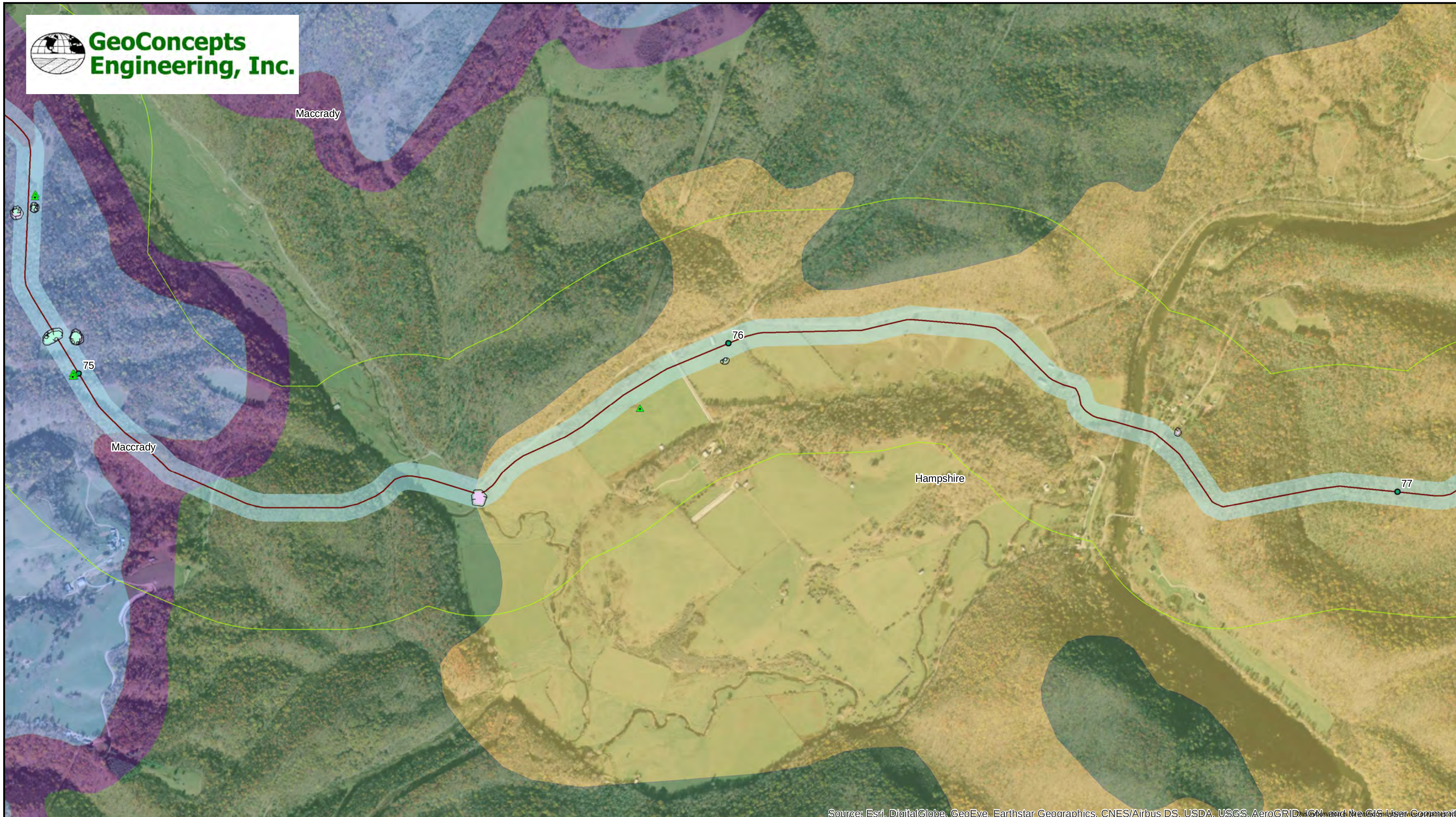

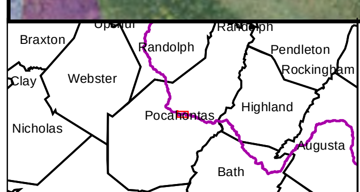

- Mileposts (1.0 mile)
- Rev 12 Centerline
- Rev 12 300' Corridor
- Rev 12 0.50 KRA
- All Point Features
- All Area Features
- 300' Corridor Closed Depressions
- Suspect Closed Depressions
- Virginia Caves
- Randolph Caves
- Pocahontas Caves

0 1,000 2,000
Feet

GEOLOGIC MAP 14

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

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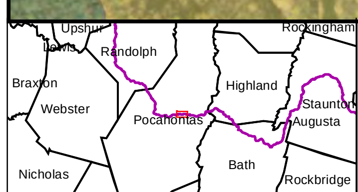


Mileposts (1.0 mile)	Rev 12 0.50 KRA	300' Corridor Closed Depressions
Rev 12 Centerline	All Point Features	Suspect Closed Depressions
Rev 12 300' Corridor	All Area Features	Virginia Caves

Randolph Caves

Pocahontas Caves

0 1,000 2,000

Feet

GEOLOGIC MAP 15

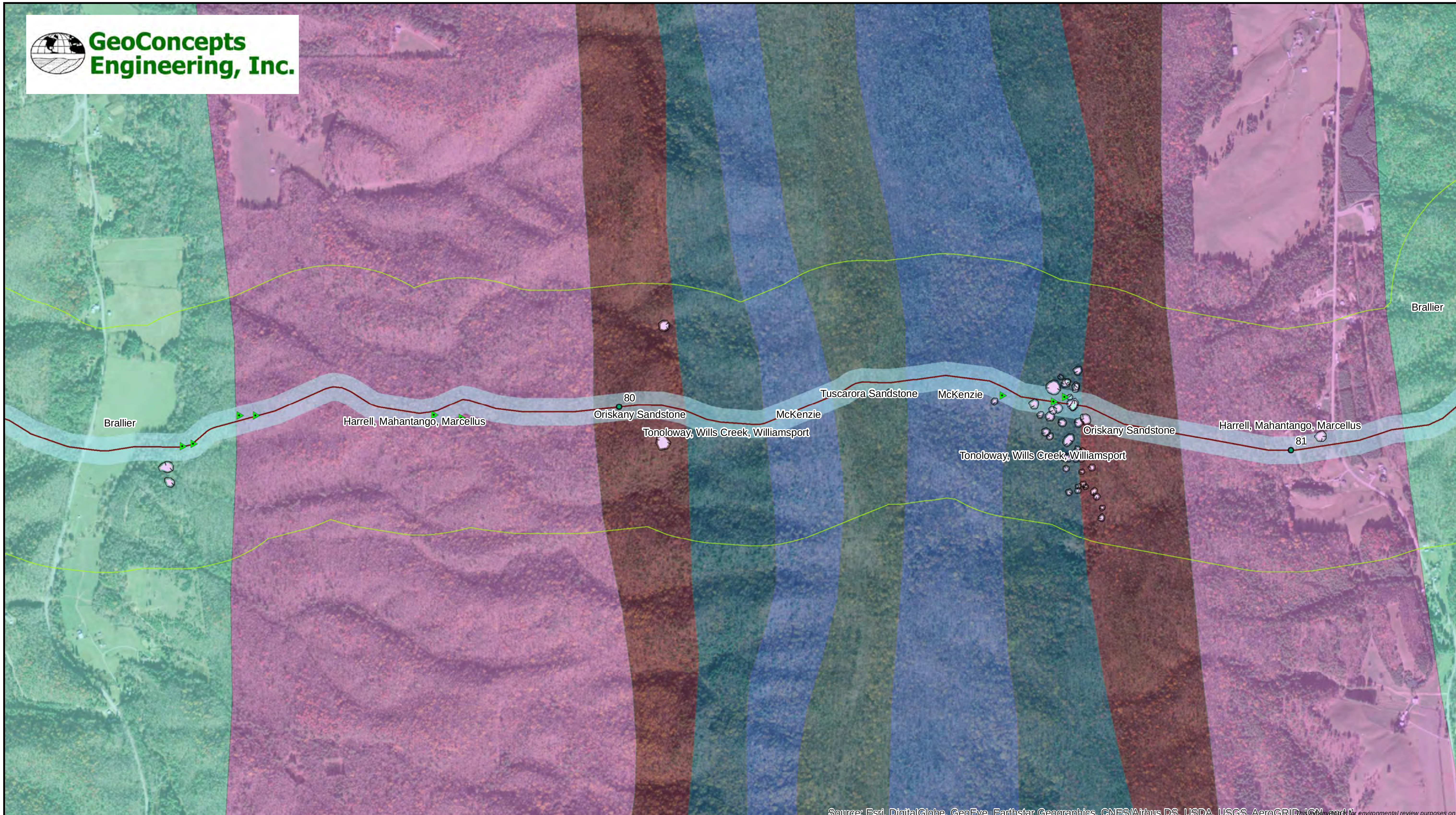
ATLANTIC COAST PIPELINE

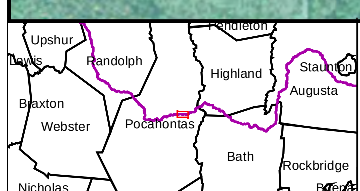
11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV

GeoConcepts Engineering, Inc.





Mileposts (1.0 mile)
Rev 12 Centerline
Rev 12 300' Corridor
Rev 12 0.50 KRA
All Point Features
All Area Features
300' Corridor Closed Depressions
Suspect Closed Depressions
Virginia Caves
Randolph Caves
Pocahontas Caves

0 1,000 2,000
Feet

GEOLOGIC MAP 16

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

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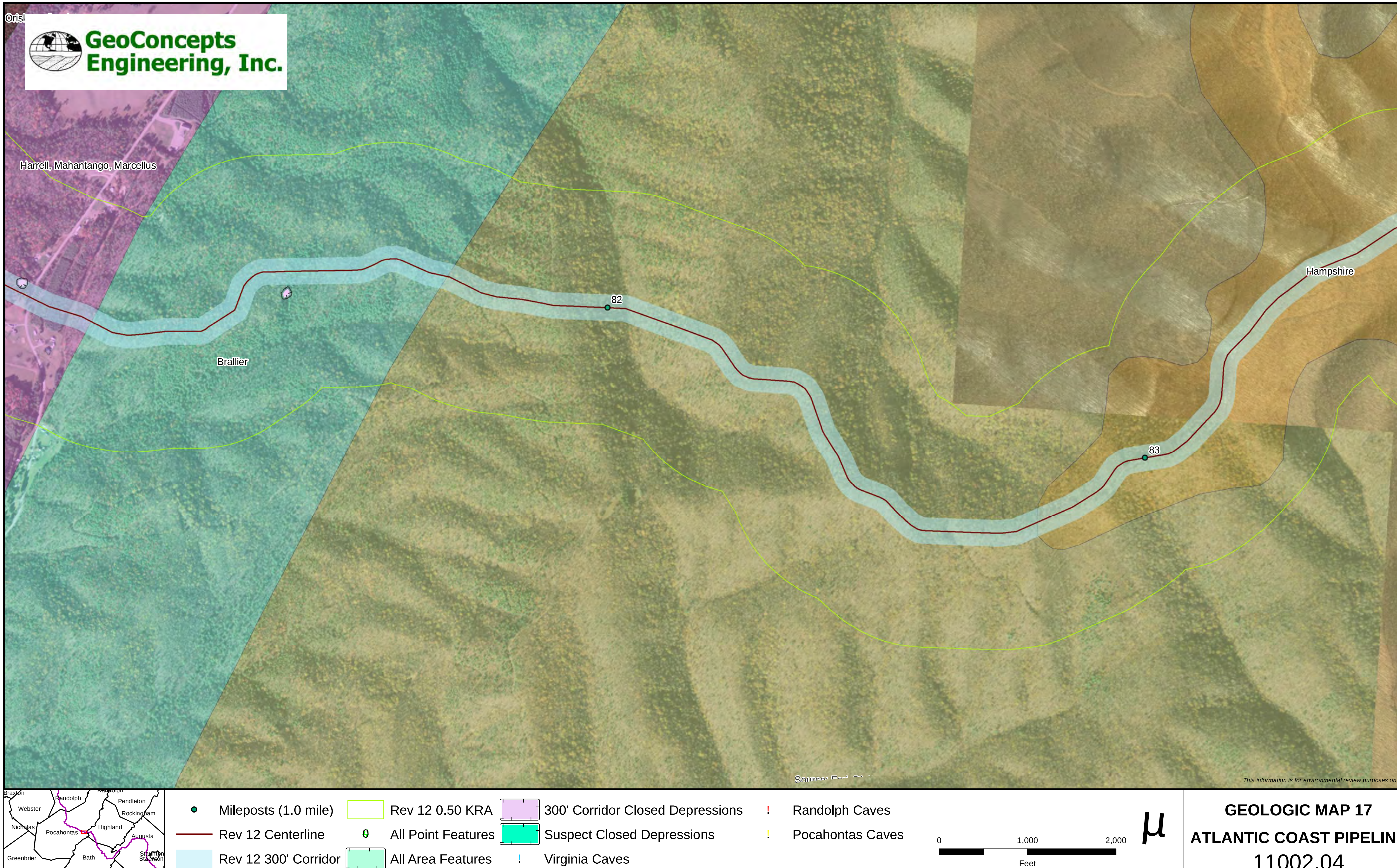

Mileposts (1.0 mile)
Rev 12 Centerline
Rev 12 300' Corridor
Rev 12 0.50 KRA
All Point Features
All Area Features
300' Corridor Closed Depressions
Suspect Closed Depressions
Virginia Caves
Randolph Caves
Pocahontas Caves

0 1,000 2,000
Feet

GEOLOGIC MAP 17

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

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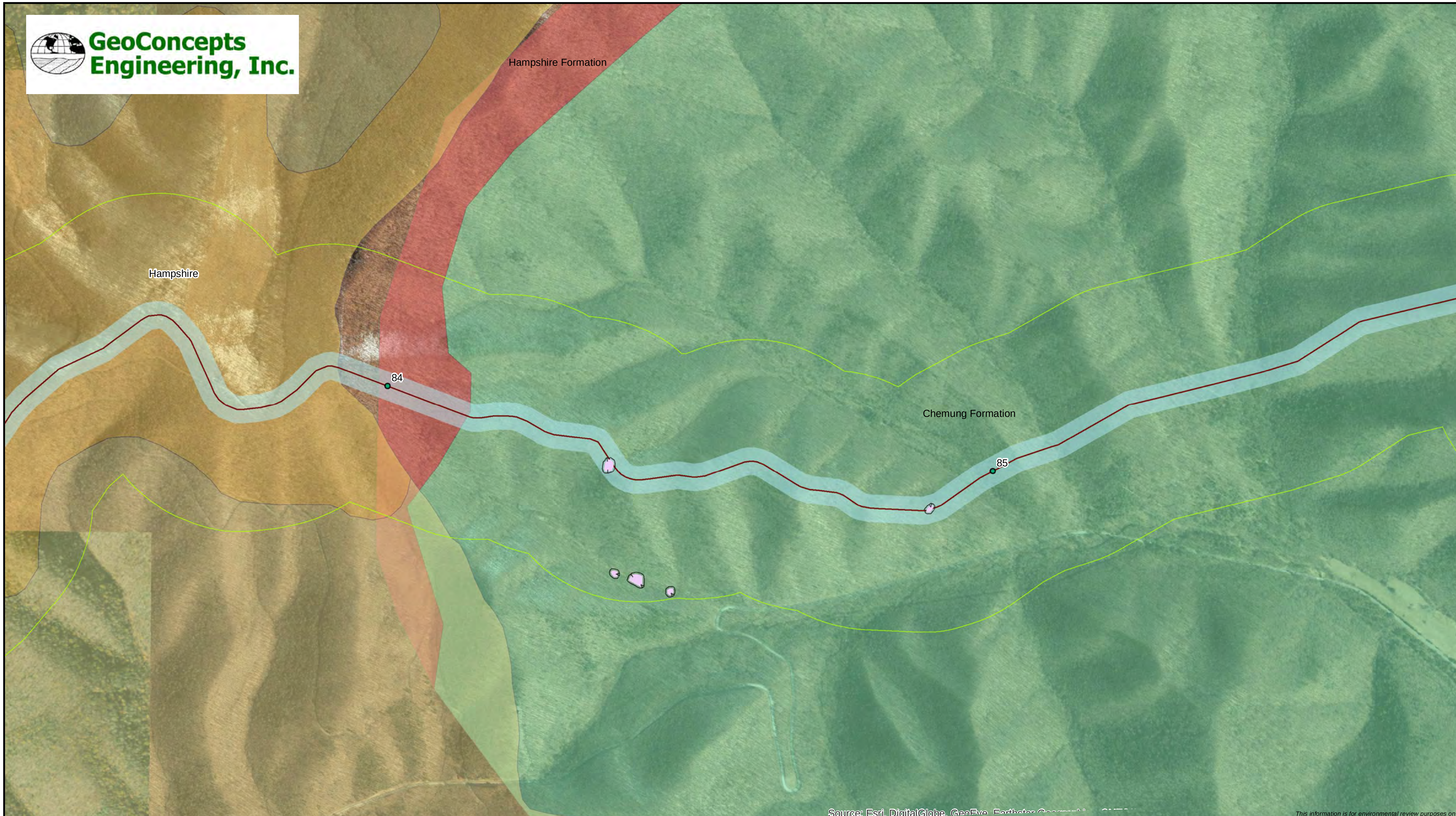

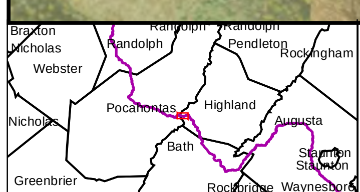

Mileposts (1.0 mile)	Rev 12 0.50 KRA	300' Corridor Closed Depressions
Rev 12 Centerline	All Point Features	Suspect Closed Depressions
Rev 12 300' Corridor	All Area Features	Virginia Caves
Randolph Caves		
Pocahontas Caves		

0 1,000 2,000
Feet

GEOLOGIC MAP 18

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV

GeoConcepts Engineering, Inc.

- Mileposts (1.0 mile)
- Rev 12 Centerline
- Rev 12 300' Corridor
- Rev 12 0.50 KRA
- All Point Features
- All Area Features
- 300' Corridor Closed Depressions
- Suspect Closed Depressions
- Virginia Caves
- Randolph Caves
- Pocahontas Caves

0 1,000 2,000
Feet

GEOLOGIC MAP 19

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

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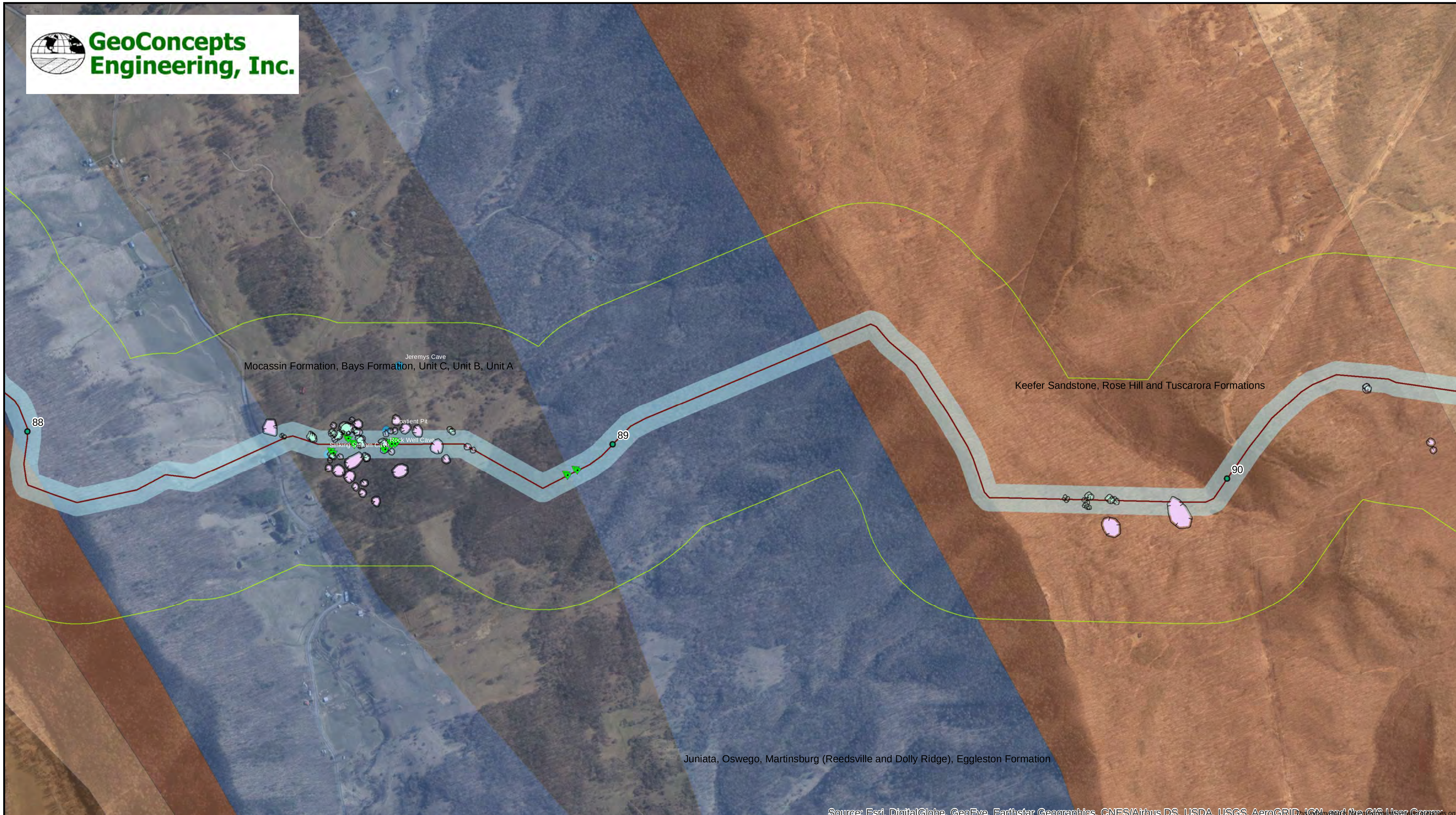
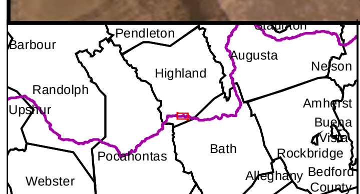




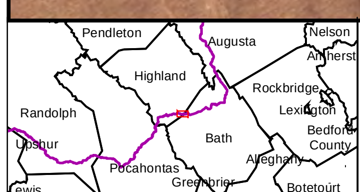
●	Mileposts (1.0 mile)
—	Rev 12 Centerline
	Rev 12 300' Corridor
	Rev 12 0.50 KRA
	All Point Features
	All Area Features
	300' Corridor Closed Depressions
	Suspect Closed Depressions
!	Virginia Caves
!	Randolph Caves
!	Pocahontas Caves

0 1,000 2,000
Feet

GEOLOGIC MAP 20
ATLANTIC COAST PIPELINE
11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV



- Mileposts (1.0 mile)
- Rev 12 Centerline
- Rev 12 300' Corridor
- Rev 12 0.50 KRA
- All Point Features
- All Area Features
- 300' Corridor Closed Depressions
- Suspect Closed Depressions
- Virginia Caves
- Randolph Caves
- Pocahontas Caves

0 1,000 2,000
Feet

GEOLOGIC MAP 21

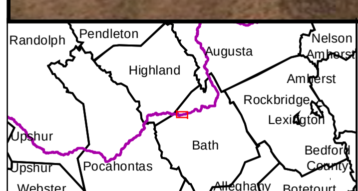
ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV

GeoConcepts Engineering, Inc.



Mileposts (1.0 mile)
Rev 12 Centerline
Rev 12 300' Corridor
Rev 12 0.50 KRA
All Point Features
All Area Features
300' Corridor Closed Depressions
Suspect Closed Depressions
Virginia Caves
Randolph Caves
Pocahontas Caves

0 1,000 2,000
Feet

GEOLOGIC MAP 22

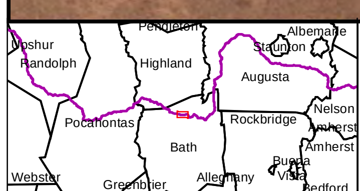
ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV

GeoConcepts Engineering, Inc.



Mileposts (1.0 mile)	Rev 12 0.50 KRA	300' Corridor Closed Depressions
Rev 12 Centerline	All Point Features	Suspect Closed Depressions
Rev 12 300' Corridor	All Area Features	Virginia Caves
Randolph Caves		
Pocahontas Caves		

0 1,000 2,000
Feet

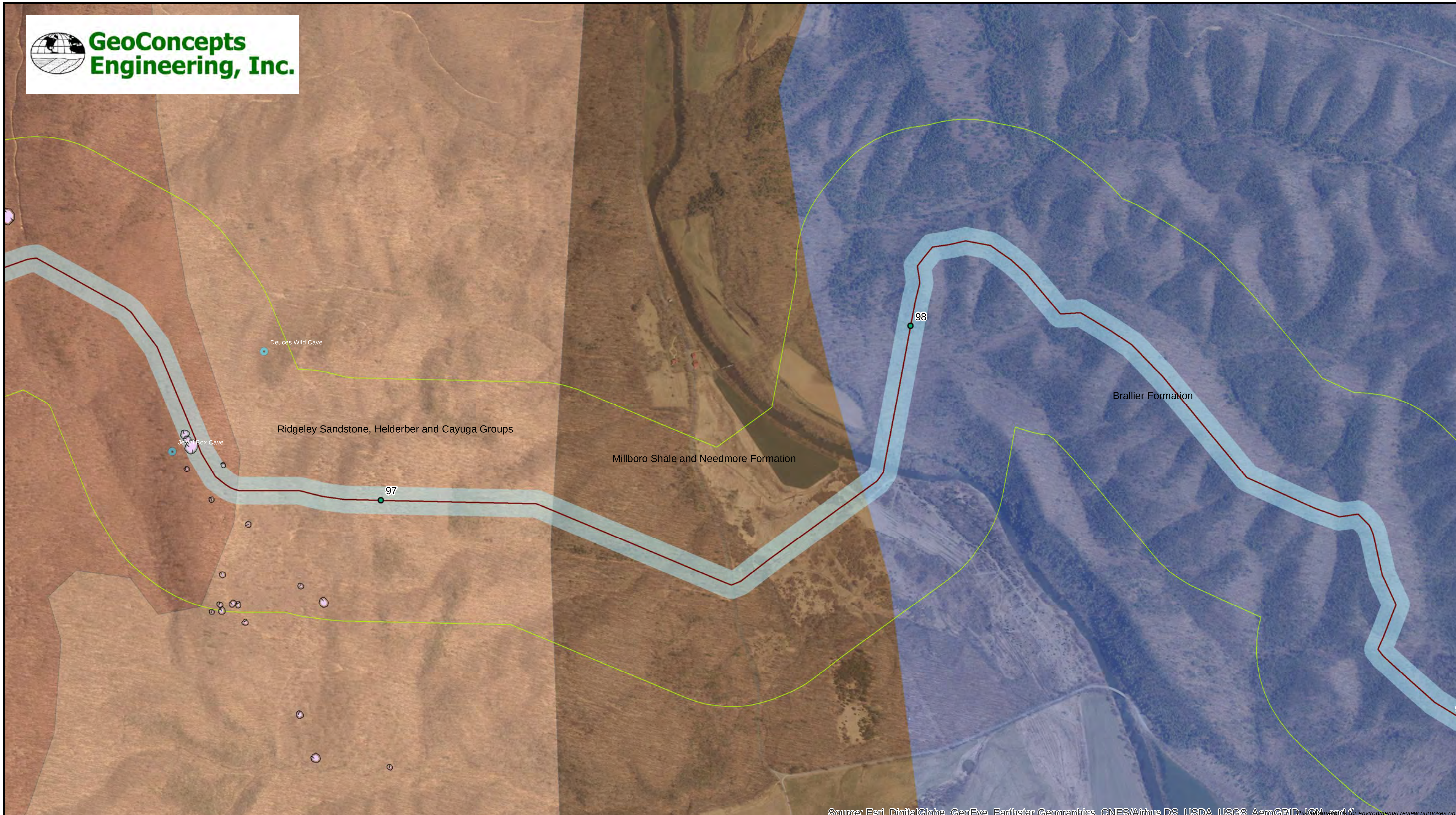
GEOLOGIC MAP 23

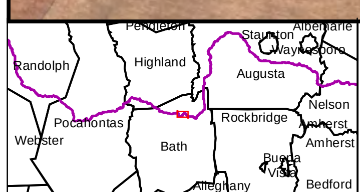
ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV





Mileposts (1.0 mile)	Rev 12 0.50 KRA	300' Corridor Closed Depressions
Rev 12 Centerline	All Point Features	Suspect Closed Depressions
Rev 12 300' Corridor	All Area Features	Virginia Caves

Randolph Caves

Pocahontas Caves

0 1,000 2,000

Feet

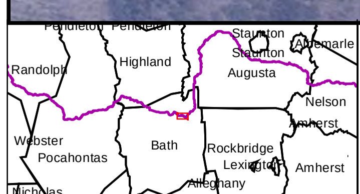
GEOLOGIC MAP 24

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV



Mileposts (1.0 mile)	Rev 12 0.50 KRA	300' Corridor Closed Depressions
Rev 12 Centerline	All Point Features	Suspect Closed Depressions
Rev 12 300' Corridor	All Area Features	Virginia Caves

Randolph Caves

Pocahontas Caves

0 1,000 2,000

Feet

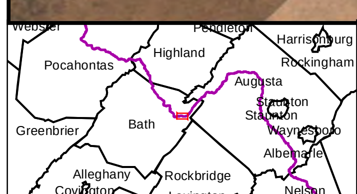
GEOLOGIC MAP 25

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV



Mileposts (1.0 mile)	Rev 12 0.50 KRA	300' Corridor Closed Depressions
Rev 12 Centerline	All Point Features	Suspect Closed Depressions
Rev 12 300' Corridor	All Area Features	Virginia Caves

Randolph Caves

Pocahontas Caves

0 1,000 2,000

Feet

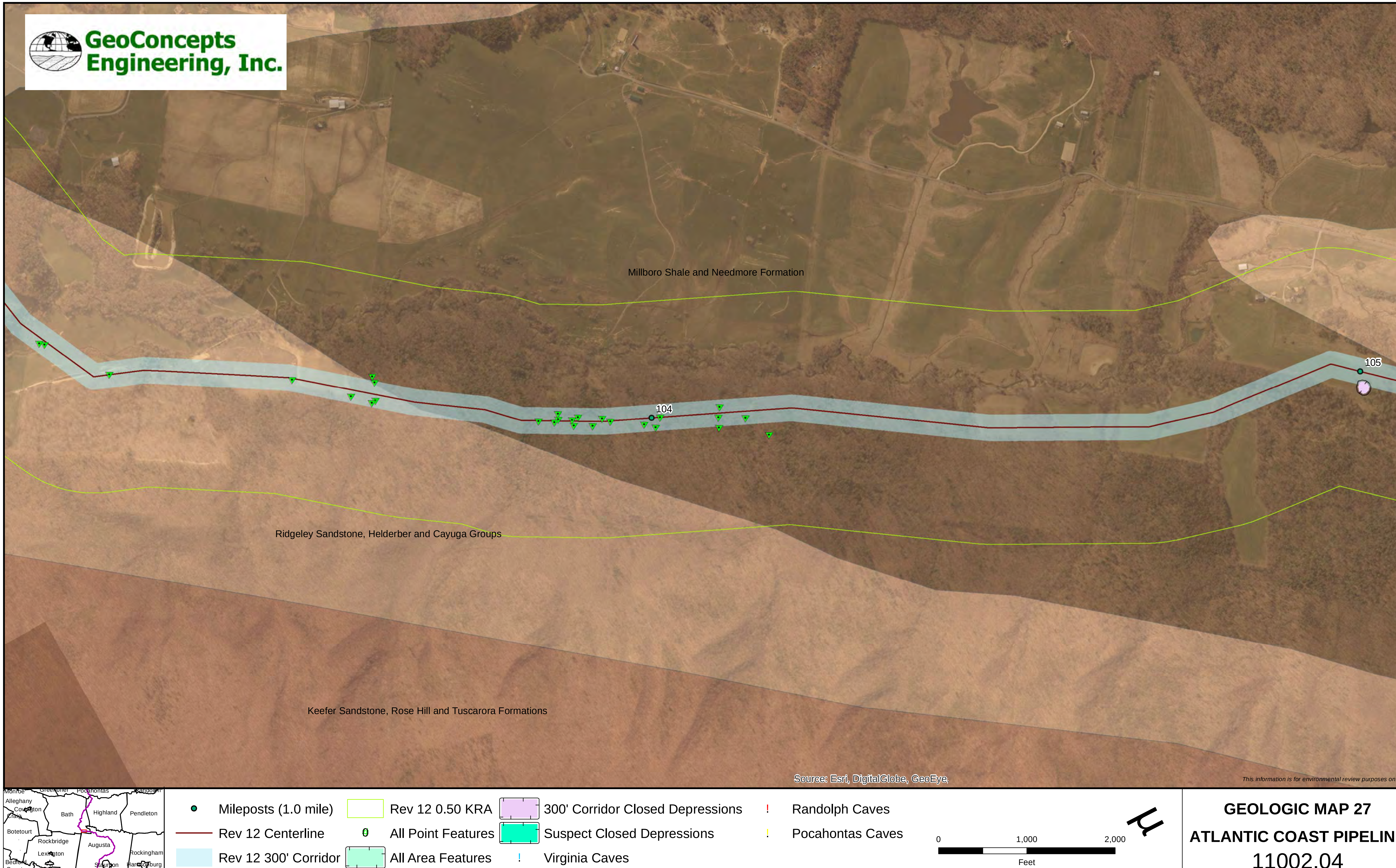
GEOLOGIC MAP 26

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV

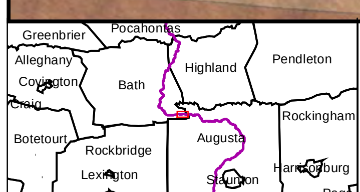


GEOLOGIC MAP 27

ATLANTIC COAST PIPELINE

11002.04

GeoConcepts Engineering, Inc.



Mileposts (1.0 mile)
Rev 12 Centerline
Rev 12 300' Corridor
Rev 12 0.50 KRA
All Point Features
All Area Features
300' Corridor Closed Depressions
Suspect Closed Depressions
Virginia Caves
Randolph Caves
Pocahontas Caves

0 1,000 2,000
Feet

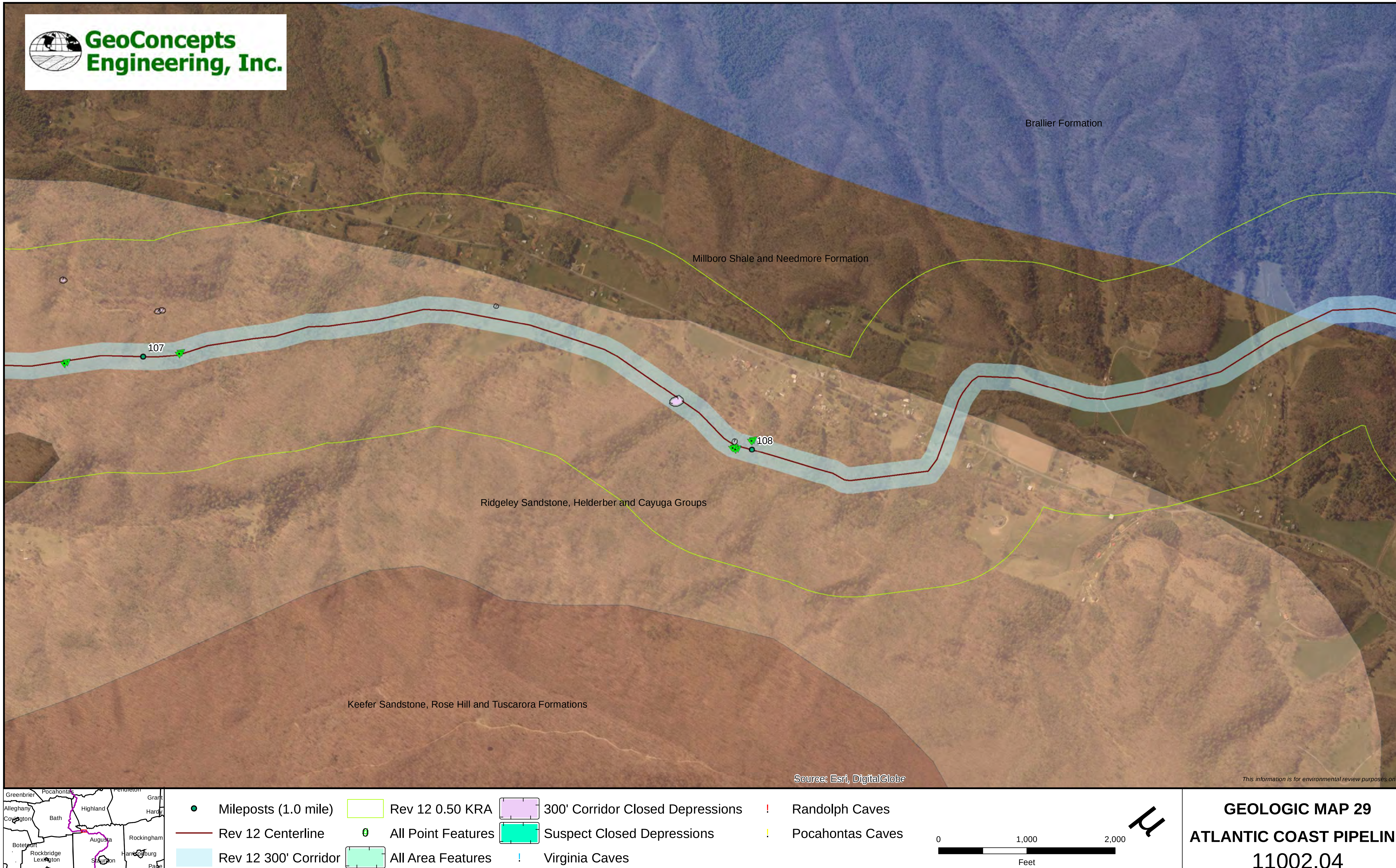
GEOLOGIC MAP 28

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV



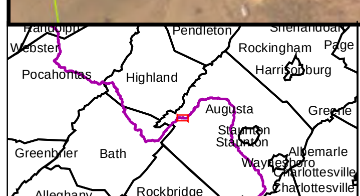
GEOLOGIC MAP 29

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV



- Mileposts (1.0 mile)
- Rev 12 Centerline
- Rev 12 300' Corridor
- Rev 12 0.50 KRA
- All Point Features
- All Area Features
- 300' Corridor Closed Depressions
- Suspect Closed Depressions
- Virginia Caves
- Randolph Caves
- Pocahontas Caves

0 1,000 2,000
Feet

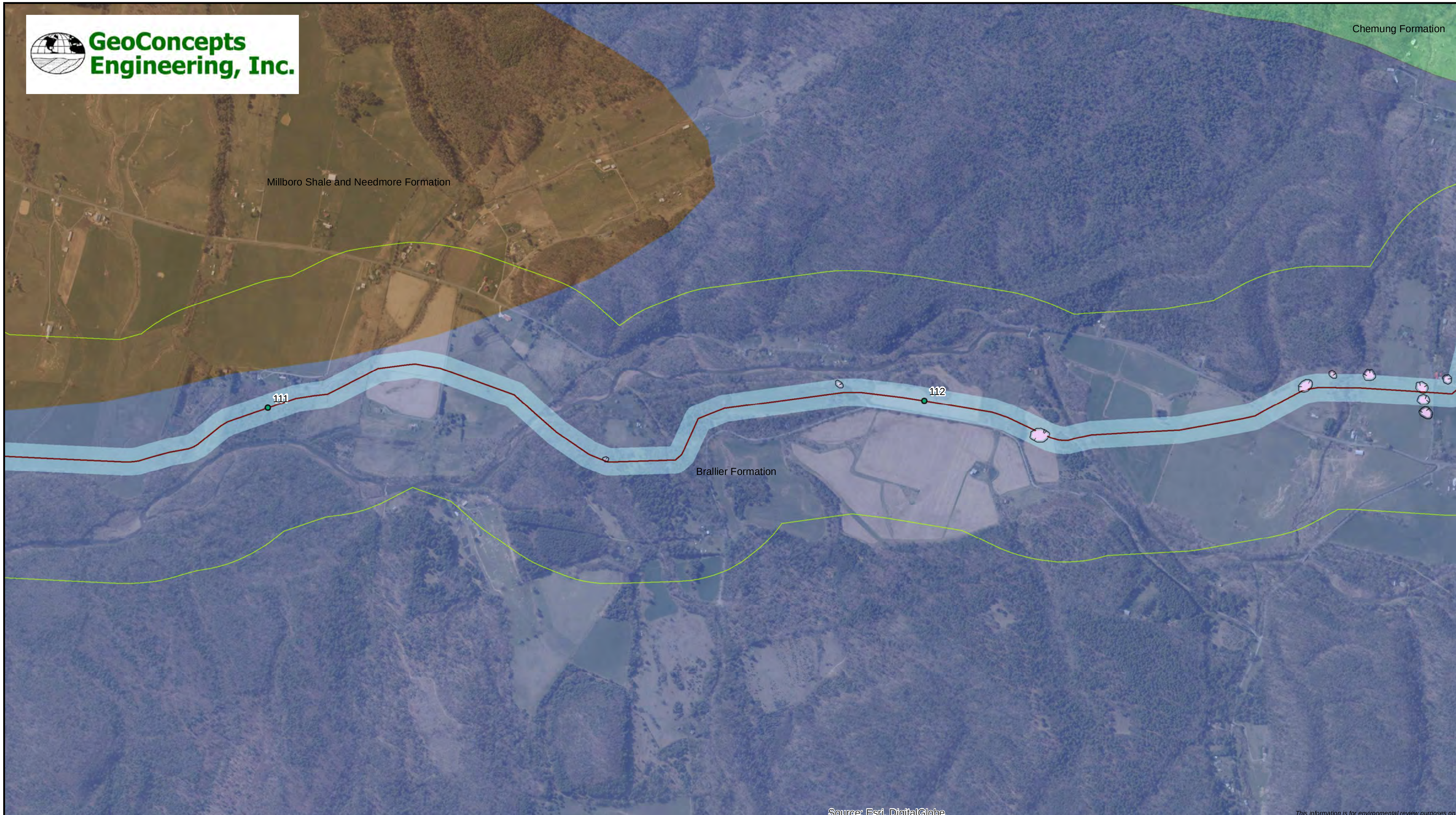
GEOLOGIC MAP 30

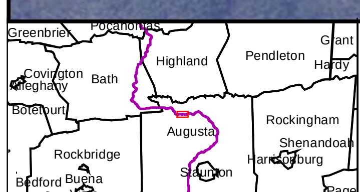
ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV





Mileposts (1.0 mile)
Rev 12 Centerline
Rev 12 300' Corridor
Rev 12 0.50 KRA
All Point Features
All Area Features
300' Corridor Closed Depressions
Suspect Closed Depressions
Virginia Caves
Randolph Caves
Pocahontas Caves

0 1,000 2,000
Feet

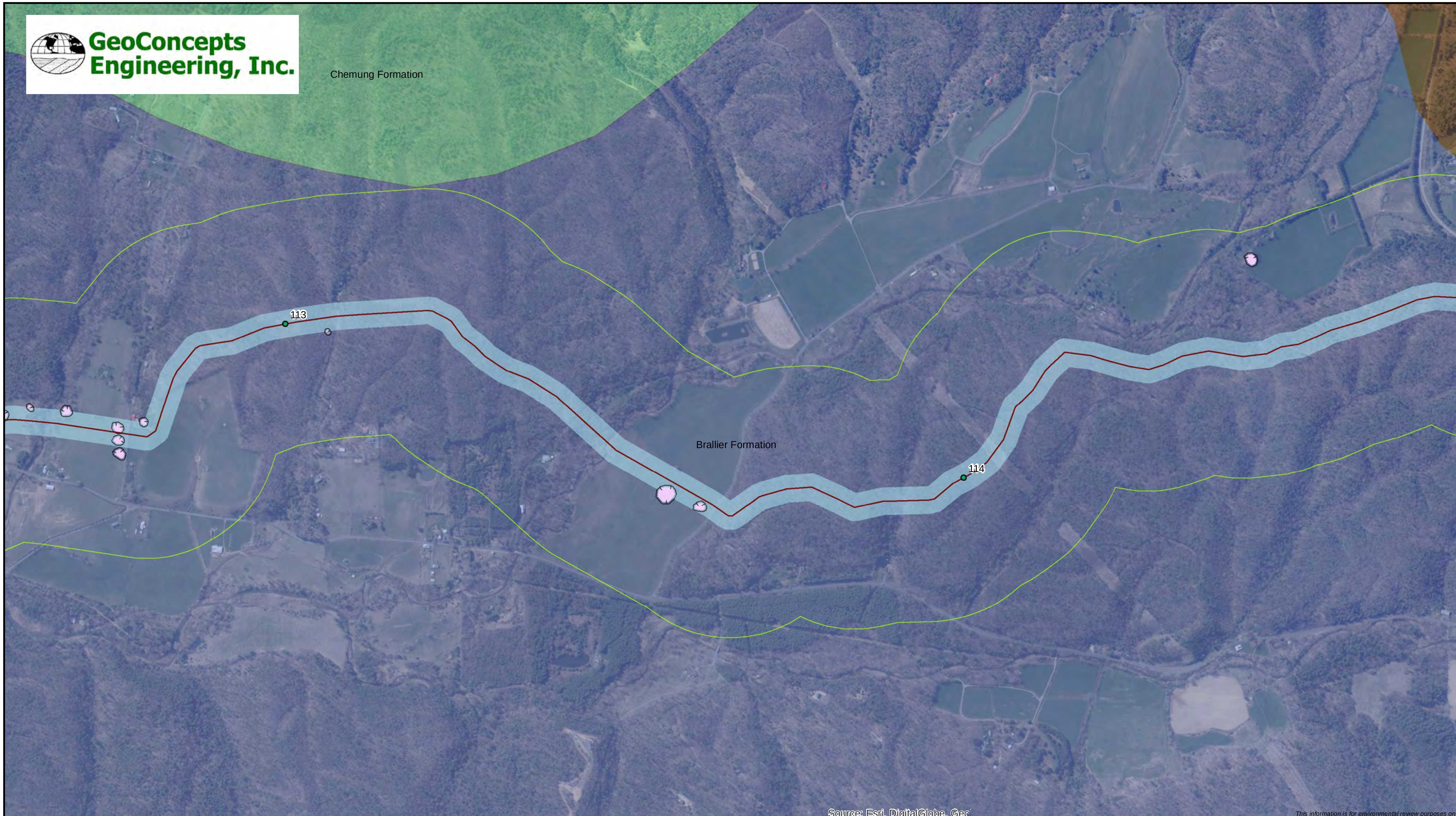
GEOLOGIC MAP 31

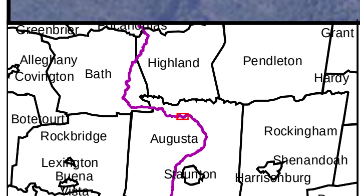
ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV





Mileposts (1.0 mile)
Rev 12 Centerline
Rev 12 300' Corridor
Rev 12 0.50 KRA
All Point Features
All Area Features
300' Corridor Closed Depressions
Suspect Closed Depressions
Virginia Caves
Randolph Caves
Pocahontas Caves

0 1,000 2,000
Feet

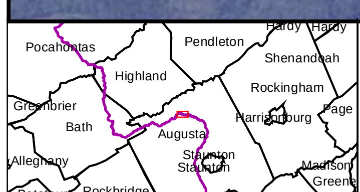
GEOLOGIC MAP 32

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV



Mileposts (1.0 mile)
Rev 12 Centerline
Rev 12 300' Corridor
Rev 12 0.50 KRA
All Point Features
All Area Features
300' Corridor Closed Depressions
Suspect Closed Depressions
Virginia Caves
Randolph Caves
Pocahontas Caves

0 1,000 2,000
Feet

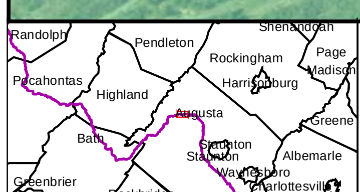
GEOLOGIC MAP 33

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV



Mileposts (1.0 mile)	Rev 12 0.50 KRA	300' Corridor Closed Depressions
Rev 12 Centerline	All Point Features	Suspect Closed Depressions
Rev 12 300' Corridor	All Area Features	Virginia Caves

Randolph Caves

Pocahontas Caves

0 1,000 2,000
Feet

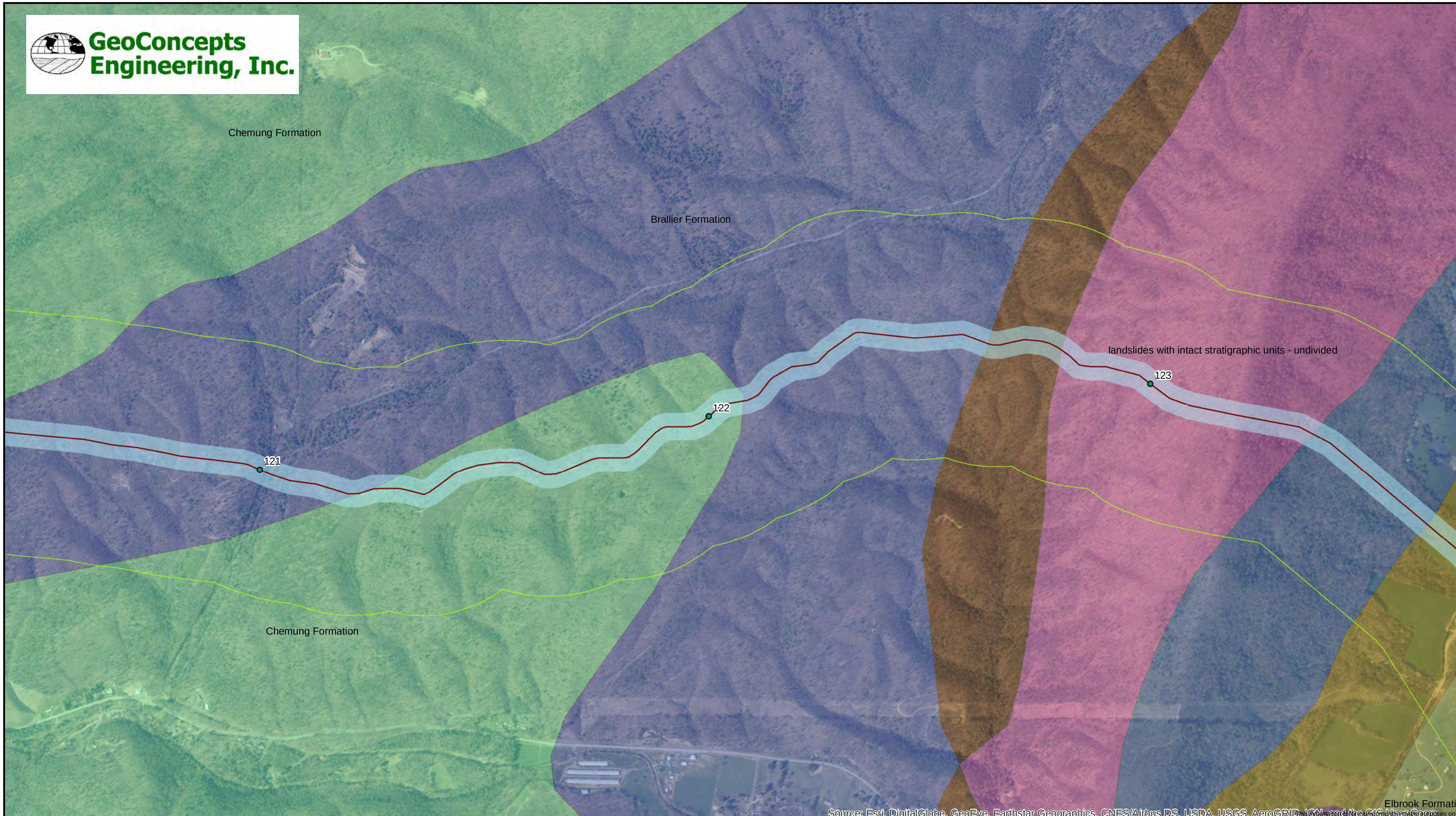
GEOLOGIC MAP 34

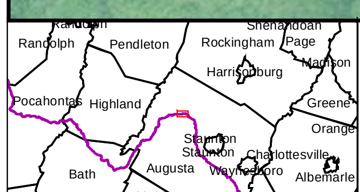
ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV





Mileposts (1.0 mile)	Rev 12 0.50 KRA	300' Corridor Closed Depressions
Rev 12 Centerline	All Point Features	Suspect Closed Depressions
Rev 12 300' Corridor	All Area Features	Virginia Caves

Randolph Caves

Pocahontas Caves

0 1,000 2,000
Feet

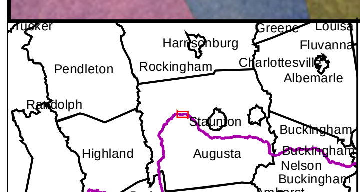
GEOLOGIC MAP 35

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV



Mileposts (1.0 mile)	Rev 12 0.50 KRA	300' Corridor Closed Depressions	Randolph Caves
Rev 12 Centerline	All Point Features	Suspect Closed Depressions	Pocahontas Caves
Rev 12 300' Corridor	All Area Features	Virginia Caves	

0 1,000 2,000
Feet

GEOLOGIC MAP 36

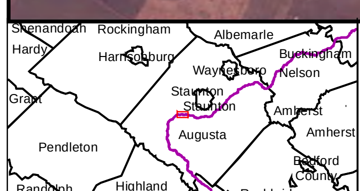
ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV

GeoConcepts Engineering, Inc.



Mileposts (1.0 mile)
Rev 12 Centerline
Rev 12 300' Corridor
Rev 12 0.50 KRA
All Point Features
All Area Features
300' Corridor Closed Depressions
Suspect Closed Depressions
Virginia Caves
Randolph Caves
Pocahontas Caves

0 1,000 2,000
Feet

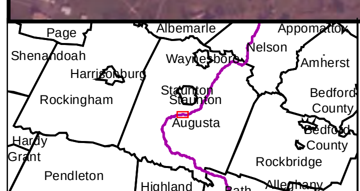
GEOLOGIC MAP 37

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV



Mileposts (1.0 mile)	Rev 12 0.50 KRA
Rev 12 Centerline	All Point Features
Rev 12 300' Corridor	All Area Features
300' Corridor Closed Depressions	Randolph Caves
Suspect Closed Depressions	Pocahontas Caves
Virginia Caves	

0 1,000 2,000
Feet

GEOLOGIC MAP 38

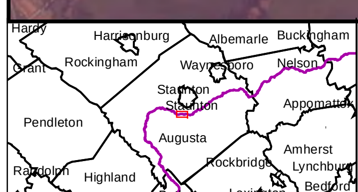
ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV

GeoConcepts Engineering, Inc.



- Mileposts (1.0 mile)
- Rev 12 Centerline
- Rev 12 300' Corridor
- Rev 12 0.50 KRA
- All Point Features
- All Area Features
- 300' Corridor Closed Depressions
- Suspect Closed Depressions
- Virginia Caves
- Randolph Caves
- Pocahontas Caves

0 1,000 2,000
Feet

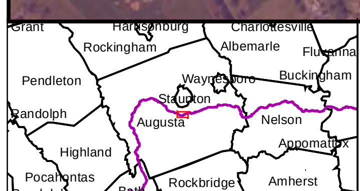
GEOLOGIC MAP 39

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV



Mileposts (1.0 mile)	Rev 12 0.50 KRA	300' Corridor Closed Depressions	Randolph Caves
Rev 12 Centerline	All Point Features	Suspect Closed Depressions	Pocahontas Caves
Rev 12 300' Corridor	All Area Features	Virginia Caves	

0 1,000 2,000

Feet

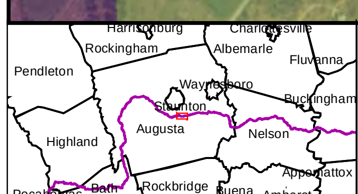
GEOLOGIC MAP 40

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV



- Mileposts (1.0 mile)
- Rev 12 Centerline
- Rev 12 300' Corridor
- Rev 12 0.50 KRA
- All Point Features
- All Area Features
- 300' Corridor Closed Depressions
- Suspect Closed Depressions
- Virginia Caves
- Randolph Caves
- Pocahontas Caves

0 1,000 2,000
Feet

GEOLOGIC MAP 41

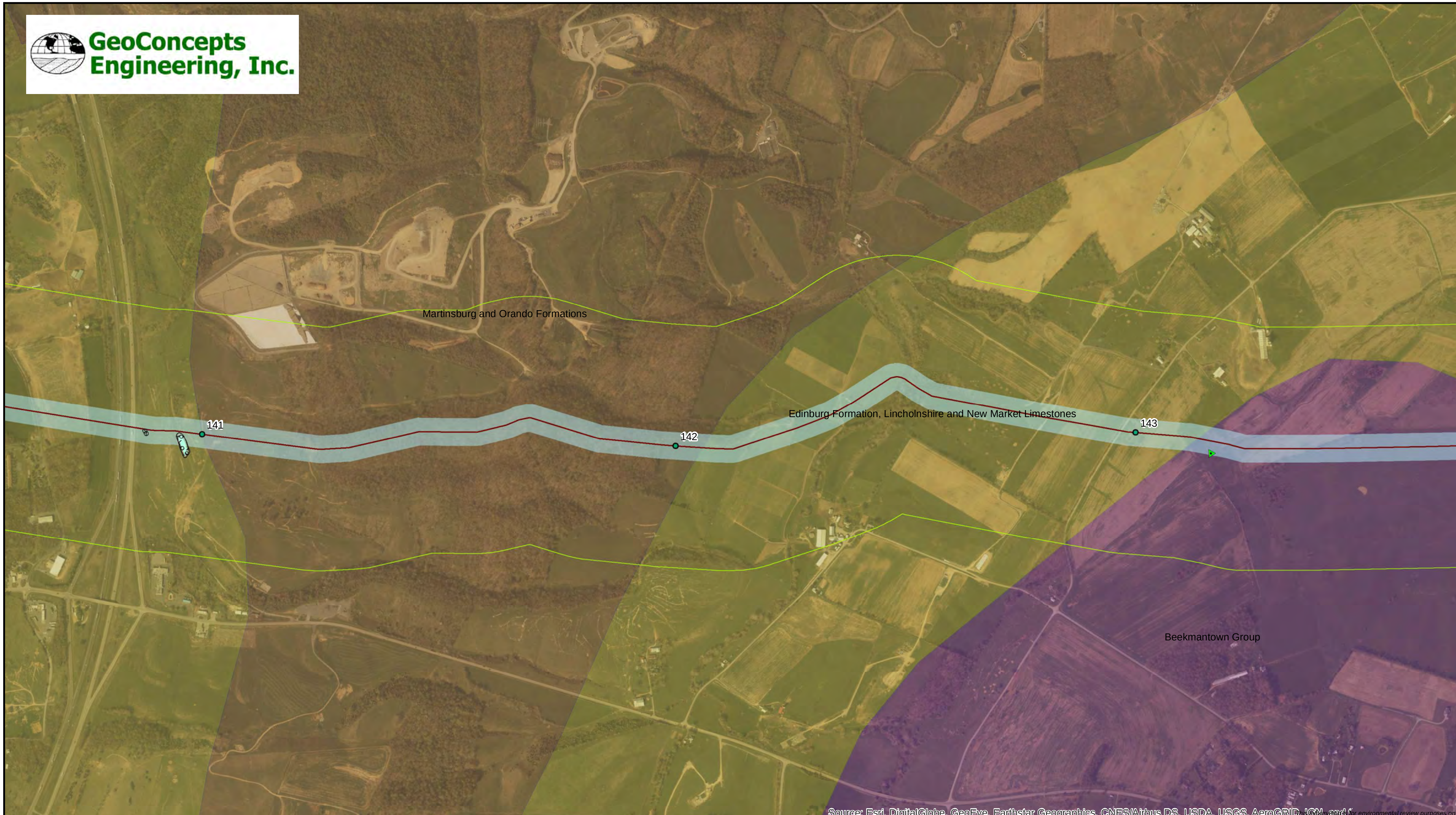
ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV

GeoConcepts Engineering, Inc.



Mileposts (1.0 mile)	Rev 12 0.50 KRA	300' Corridor Closed Depressions
Rev 12 Centerline	All Point Features	Suspect Closed Depressions
Rev 12 300' Corridor	All Area Features	Virginia Caves

Randolph Caves

Pocahontas Caves

0 1,000 2,000

Feet

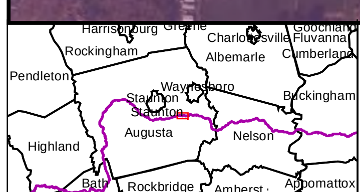
GEOLOGIC MAP 42

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV



- Mileposts (1.0 mile)
- Rev 12 Centerline
- Rev 12 300' Corridor
- Rev 12 0.50 KRA
- All Point Features
- All Area Features
- 300' Corridor Closed Depressions
- Suspect Closed Depressions
- Virginia Caves
- Randolph Caves
- Pocahontas Caves

0 1,000 2,000
Feet

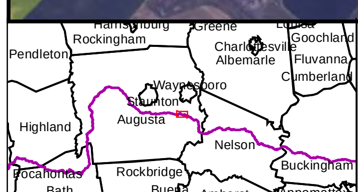
GEOLOGIC MAP 43

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV



Mileposts (1.0 mile)	Rev 12 0.50 KRA	300' Corridor Closed Depressions
Rev 12 Centerline	All Point Features	Suspect Closed Depressions
Rev 12 300' Corridor	All Area Features	Virginia Caves

Randolph Caves
Pocahontas Caves

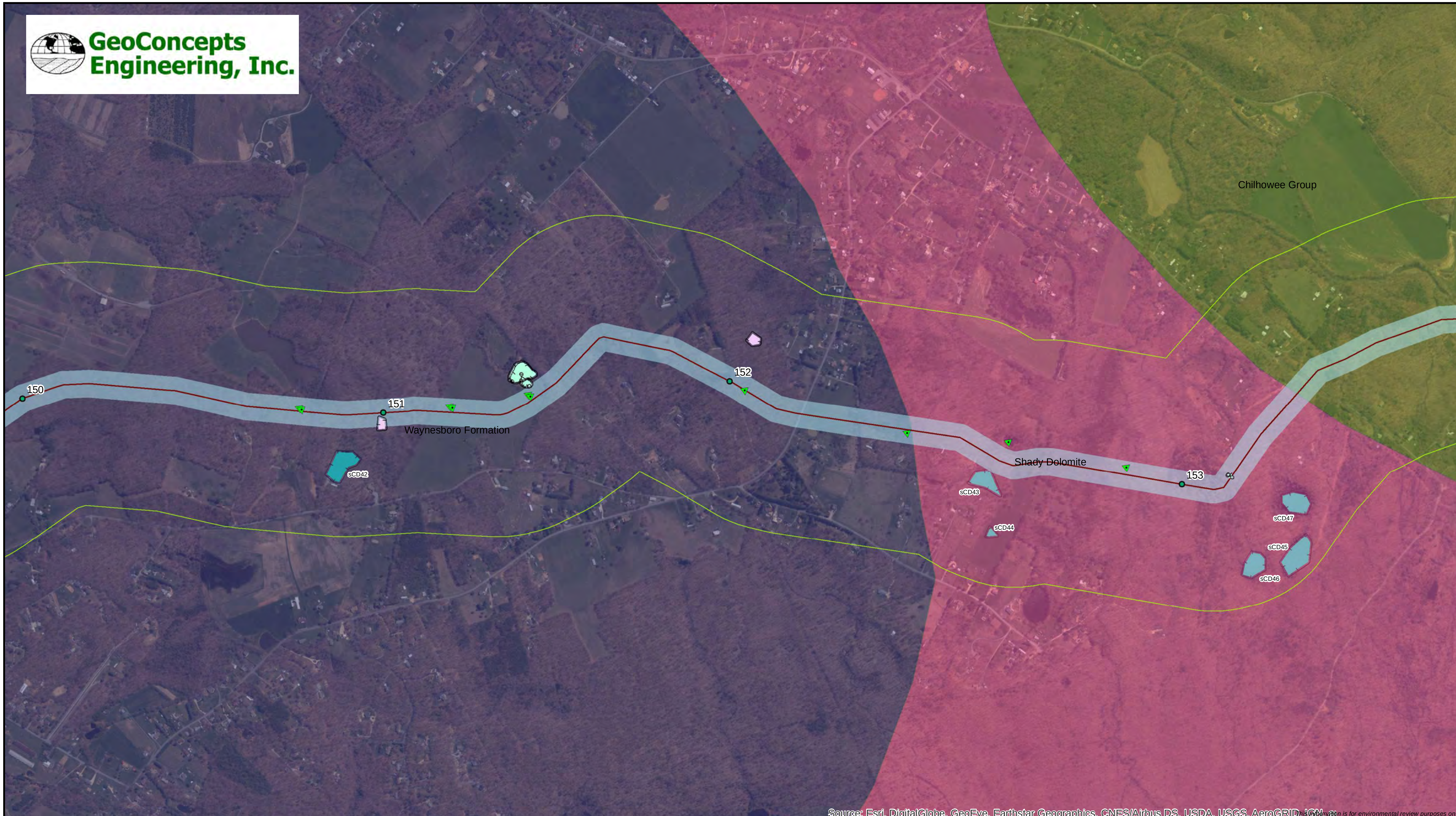
0 1,000 2,000
Feet

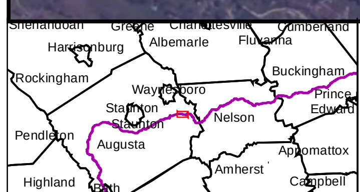
GEOLOGIC MAP 44
ATLANTIC COAST PIPELINE
11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV

GeoConcepts Engineering, Inc.





Mileposts (1.0 mile)	Rev 12 0.50 KRA	300' Corridor Closed Depressions	Randolph Caves
Rev 12 Centerline	All Point Features	Suspect Closed Depressions	Pocahontas Caves
Rev 12 300' Corridor	All Area Features	Virginia Caves	

0 1,000 2,000
Feet

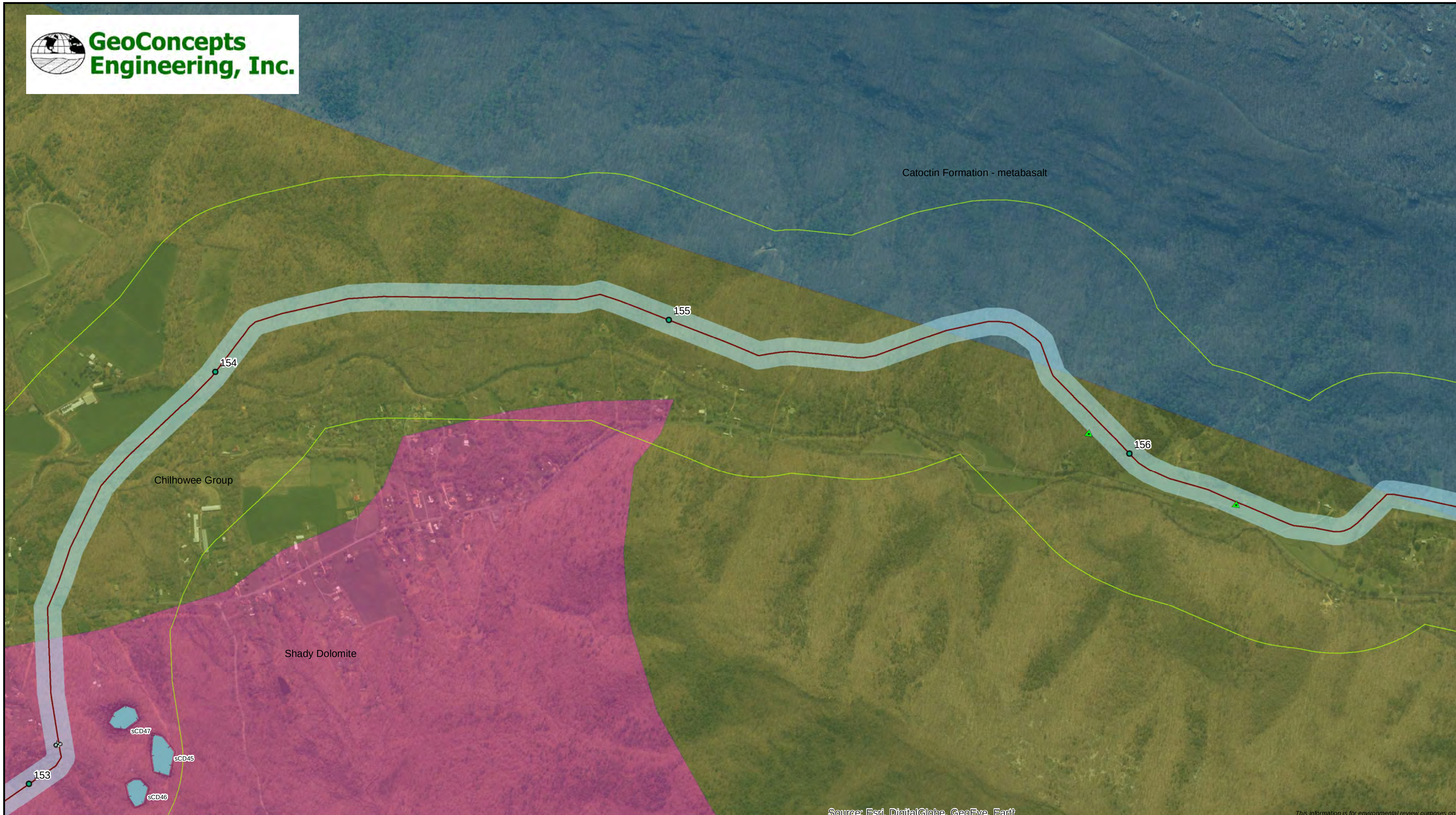
GEOLOGIC MAP 45

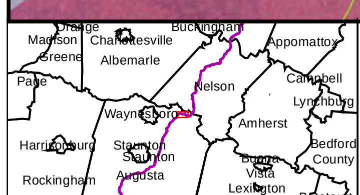
ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV





- Mileposts (1.0 mile)
- Rev 12 Centerline
- Rev 12 300' Corridor
- Rev 12 0.50 KRA
- All Point Features
- All Area Features
- 300' Corridor Closed Depressions
- Suspect Closed Depressions
- Virginia Caves
- Randolph Caves
- Pocahontas Caves

0 1,000 2,000
Feet

GEOLOGIC MAP 46

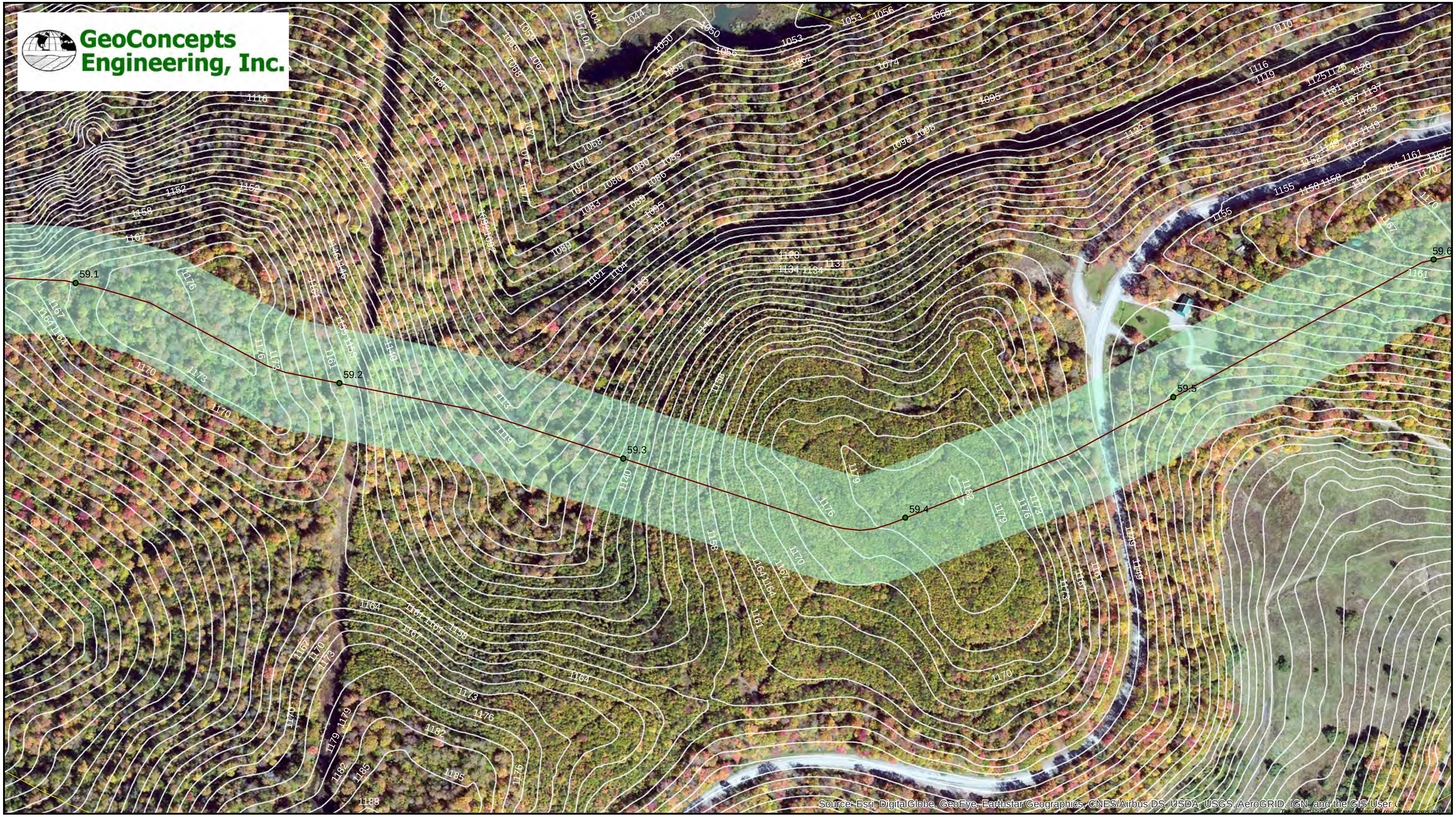
ATLANTIC COAST PIPELINE

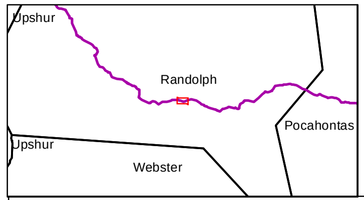
11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Geologic.mxd | REVISED: 02/14/2017 | SCALE: 1:12,000 when printed at 11x17

DRAWN BY: JDV

APPENDIX B
Contour Maps





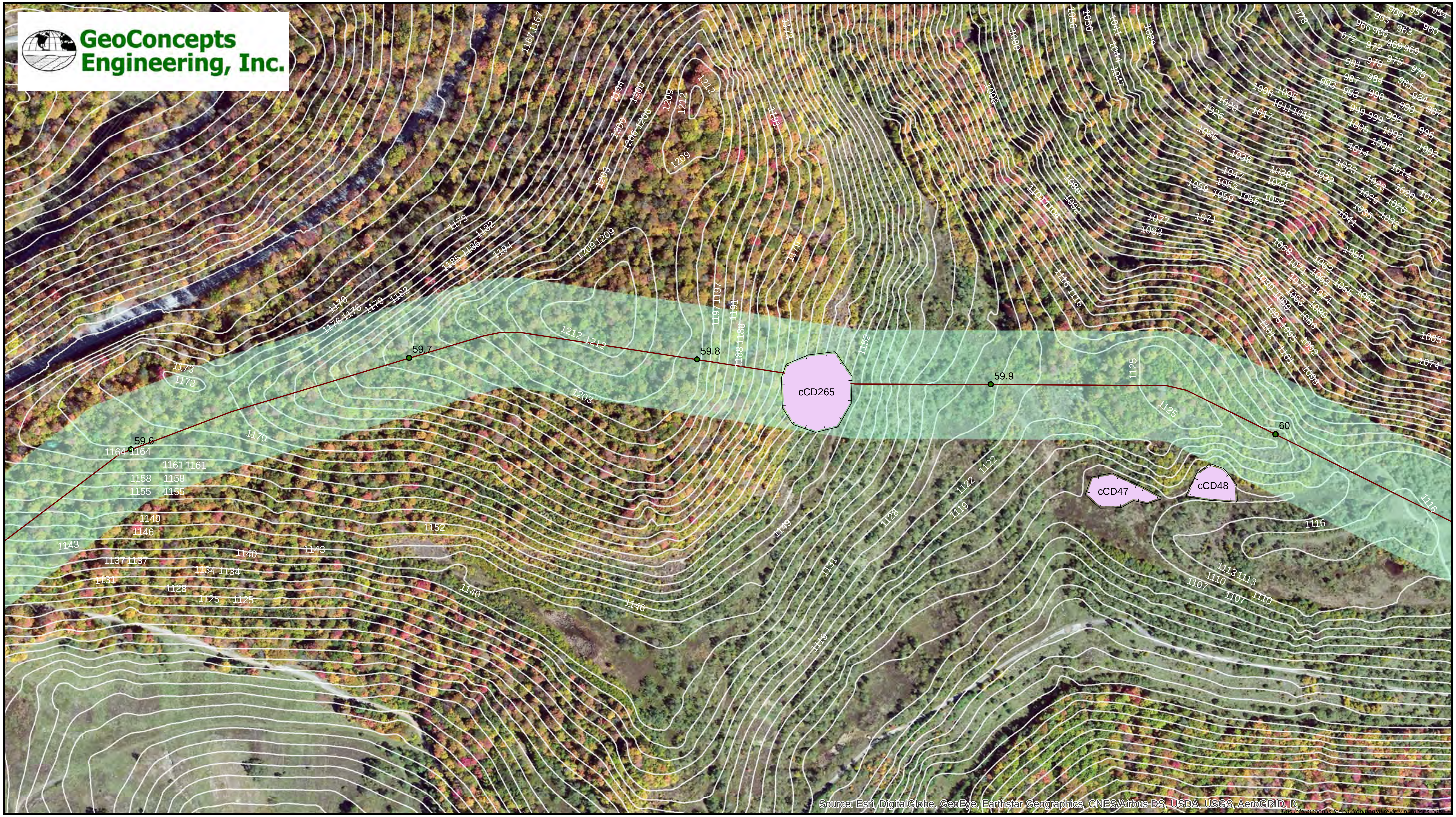
Mileposts (0.1 mile)
Centerline
300' Corridor
0.50 KRA
All Point Features
All Area Features
300' Corridor Closed Depressions
Suspect Closed Depressions
Randolph Caves
Pocahontas Caves
Virginia Caves

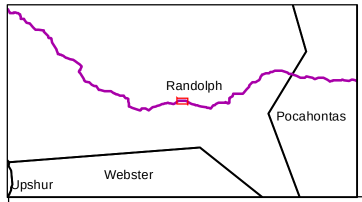
0 250 500
Feet

CONTOUR MAP 1

ATLANTIC COAST PIPELINE

11002.04





- Mileposts (0.1 mile)
- Centerline
- 300' Corridor
- 0.50 KRA
- All Point Features
- All Area Features
- 300' Corridor Closed Depressions
- Suspect Closed Depressions
- Randolph Caves
- Pocahontas Caves
- Virginia Caves

0 250 500
Feet

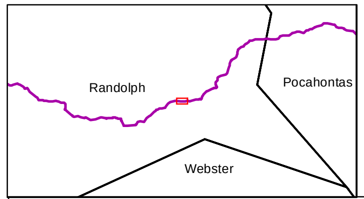
CONTOUR MAP 2

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Contour.mxd | REVISED: 02/14/2017 | SCALE: 1:3,000 when printed at 11x17

DRAWN BY: JDV



Mileposts (0.1 mile)
Centerline
300' Corridor
0.50 KRA
All Point Features
All Area Features
300' Corridor Closed Depressions
Suspect Closed Depressions
Randolph Caves
Pocahontas Caves
Virginia Caves

0 250 500
Feet

CONTOUR MAP 3
ATLANTIC COAST PIPELINE
11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Contour.mxd | REVISED: 02/14/2017 | SCALE: 1:3,000 when printed at 11x17

DRAWN BY: JDV

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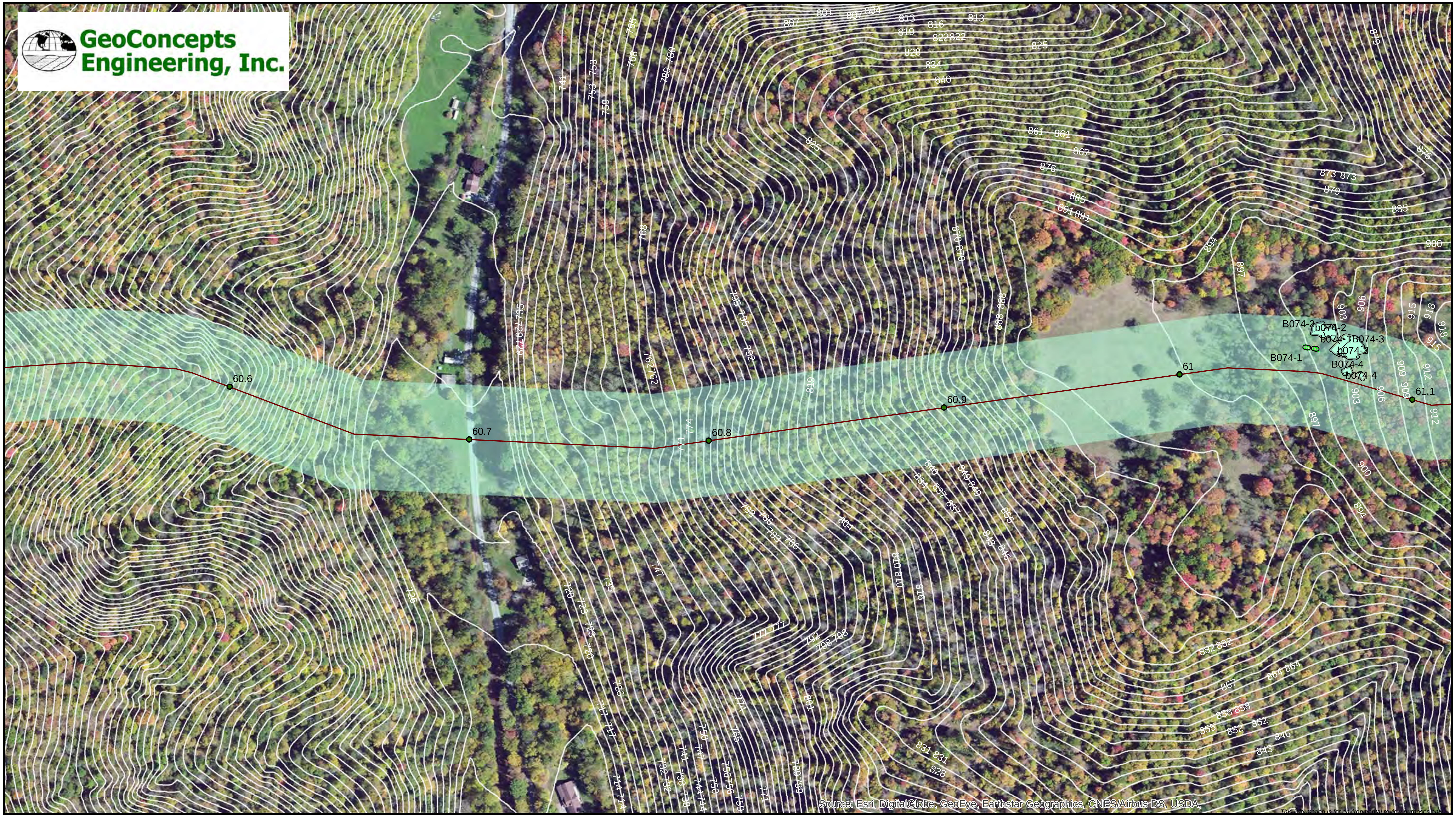
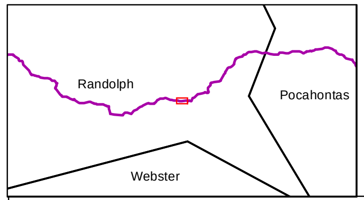




- Mileposts (0.1 mile)
- Centerline
- 300' Corridor
- 0.50 KRA
- All Point Features
- All Area Features
- 300' Corridor Closed Depressions
- Suspect Closed Depressions
- Randolph Caves
- Pocahontas Caves
- Virginia Caves

0 250 500
Feet

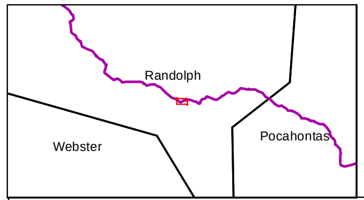
CONTOUR MAP 4

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Contour.mxd | REVISED: 02/14/2017 | SCALE: 1:3,000 when printed at 11x17

DRAWN BY: JDV



Mileposts (0.1 mile)	0.50 KRA	300' Corridor Closed Depressions
Centerline	All Point Features	Suspect Closed Depressions
300' Corridor	All Area Features	Randolph Caves

Pocahontas Caves

Virginia Caves

0 250 500

Feet

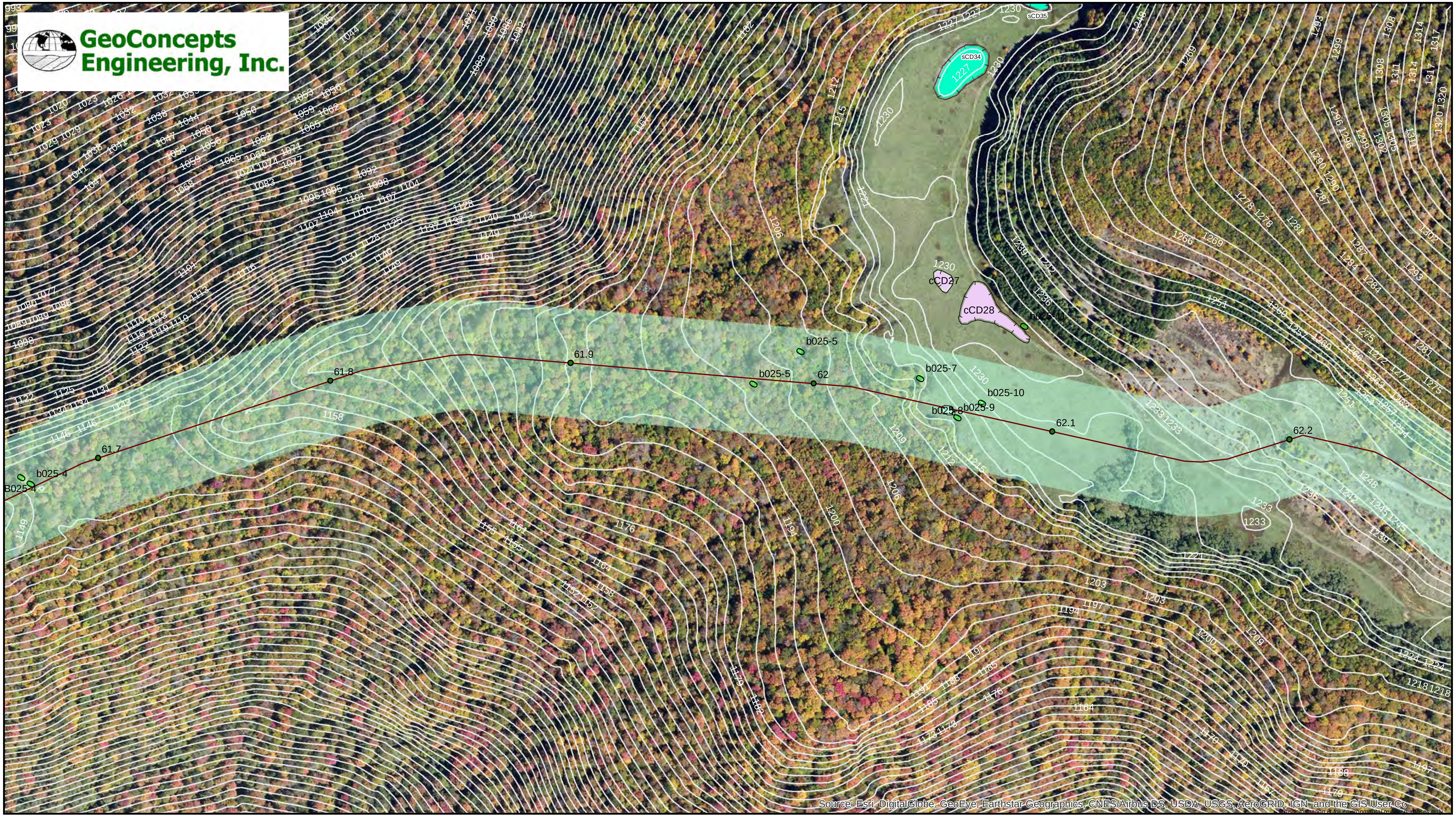
CONTOUR MAP 5

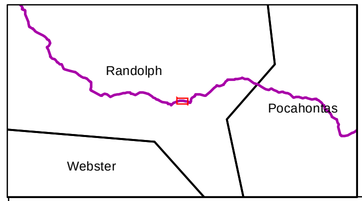
ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Contour.mxd | REVISED: 02/14/2017 | SCALE: 1:3,000 when printed at 11x17

DRAWN BY: JDV





Mileposts (0.1 mile)	0.50 KRA	300' Corridor Closed Depressions
Centerline	All Point Features	Suspect Closed Depressions
300' Corridor	All Area Features	Randolph Caves
Pocahontas Caves		
Virginia Caves		

0 250 500
Feet

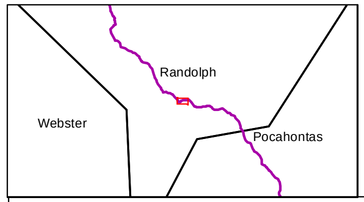
CONTOUR MAP 6

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Contour.mxd | REVISED: 02/14/2017 | SCALE: 1:3,000 when printed at 11x17

DRAWN BY: JDV



- Mileposts (0.1 mile)
- Centerline
- 300' Corridor
- 0.50 KRA
- All Point Features
- All Area Features
- 300' Corridor Closed Depressions
- Suspect Closed Depressions
- Randolph Caves
- Pocahontas Caves
- Virginia Caves

0 250 500
Feet

CONTOUR MAP 7

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Contour.mxd | REVISED: 02/14/2017 | SCALE: 1:3,000 when printed at 11x17

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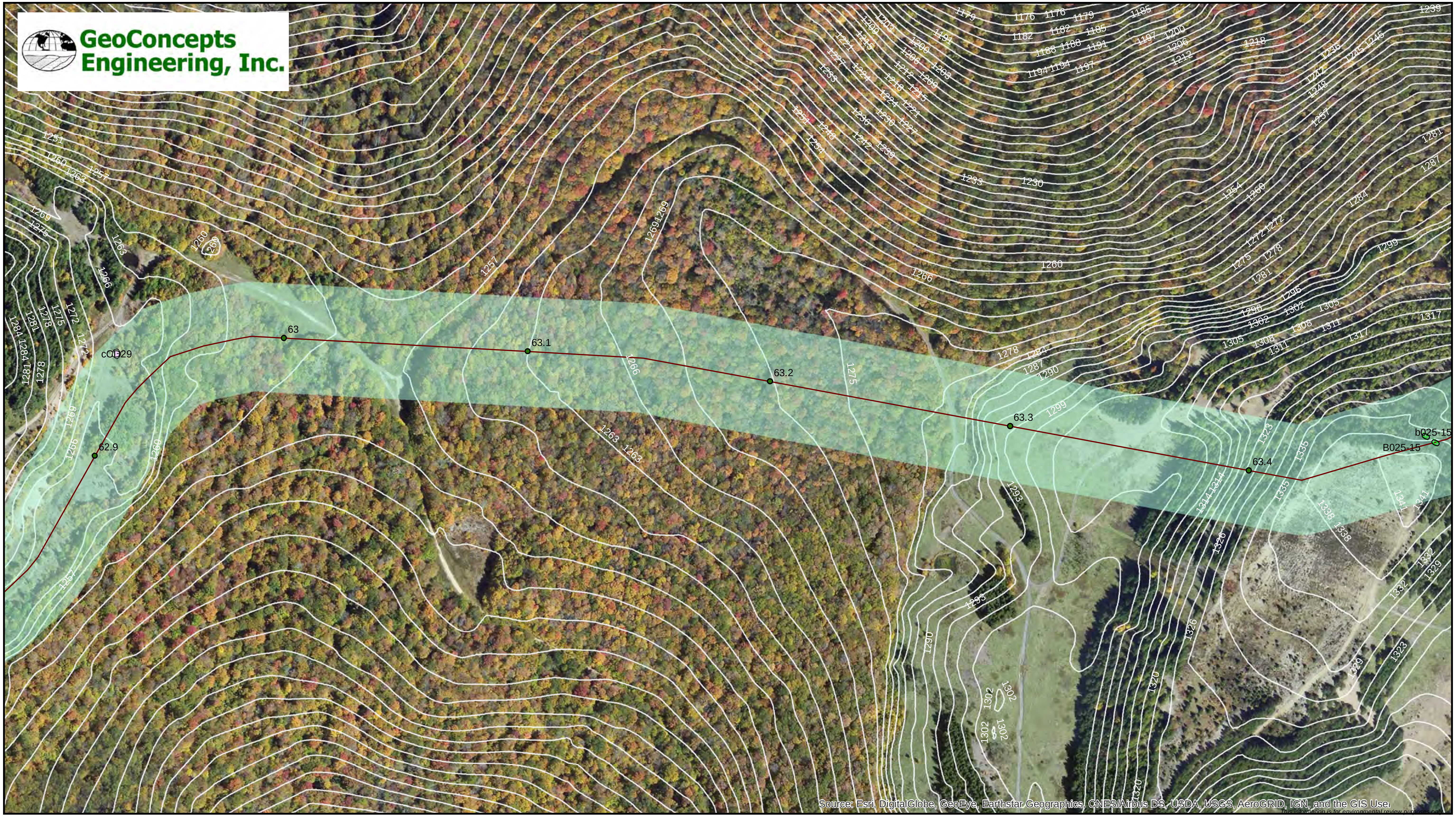
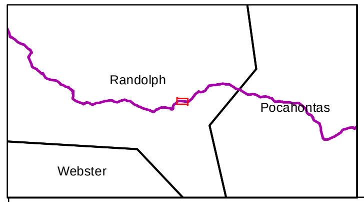




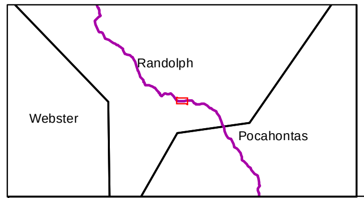
Mileposts (0.1 mile)	0.50 KRA
Centerline	All Point Features
300' Corridor	All Area Features
300' Corridor Closed Depressions	Pocahontas Caves
Suspect Closed Depressions	Virginia Caves
Randolph Caves	

0 250 500
Feet

CONTOUR MAP 8

ATLANTIC COAST PIPELINE

11002.04



Mileposts (0.1 mile)
Centerline
300' Corridor
0.50 KRA
All Point Features
All Area Features
300' Corridor Closed Depressions
Suspect Closed Depressions
Randolph Caves
Pocahontas Caves
Virginia Caves

0 250 500
Feet

CONTOUR MAP 9

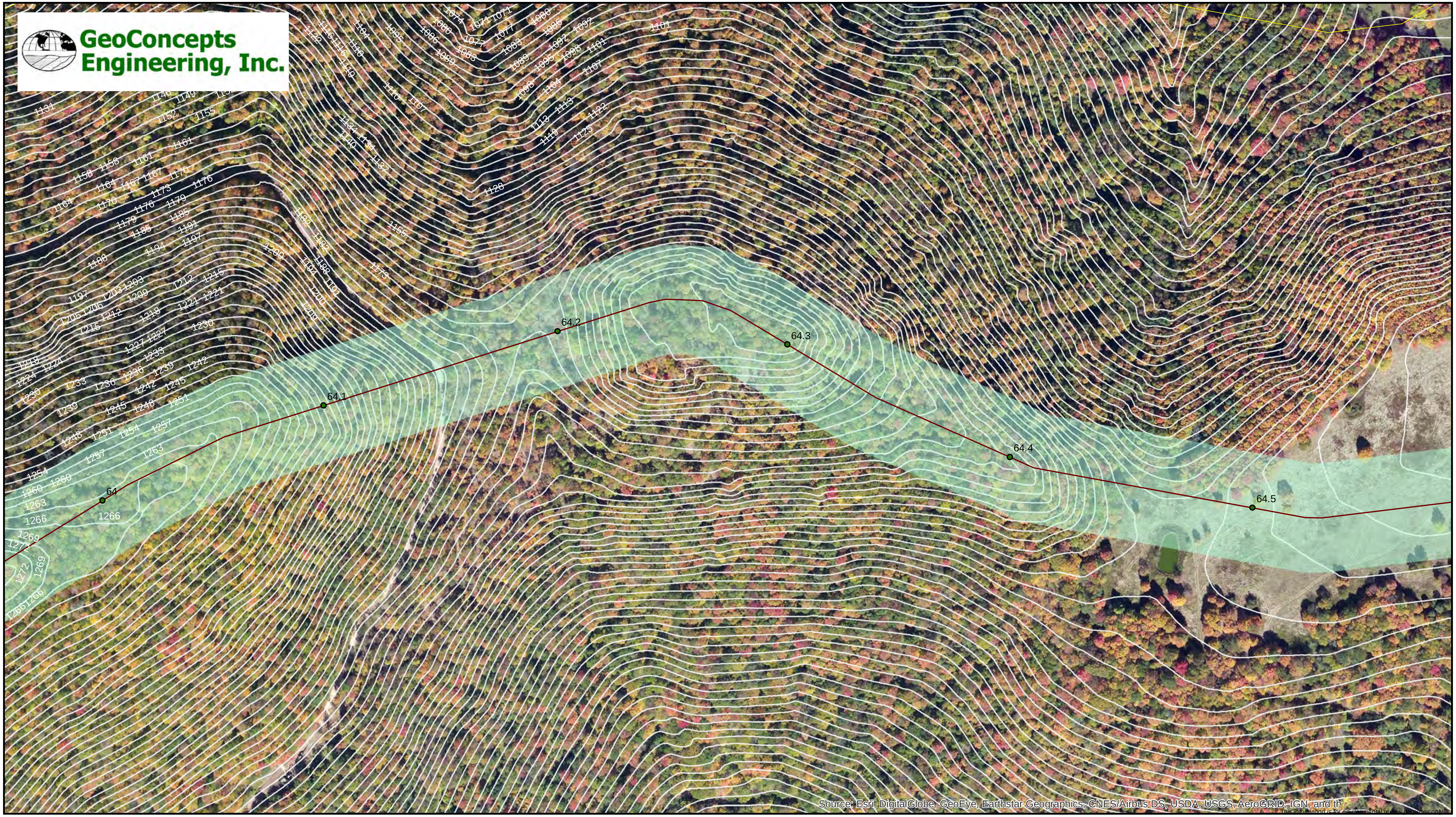
ATLANTIC COAST PIPELINE

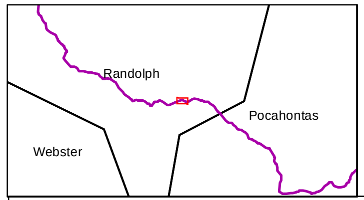
11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Contour.mxd | REVISED: 02/14/2017 | SCALE: 1:3,000 when printed at 11x17

DRAWN BY: JDV

GeoConcepts Engineering, Inc.





Mileposts (0.1 mile)
Centerline
300' Corridor
0.50 KRA
All Point Features
All Area Features
300' Corridor Closed Depressions
Suspect Closed Depressions
Randolph Caves
Pocahontas Caves
Virginia Caves

0 250 500
Feet

CONTOUR MAP 10

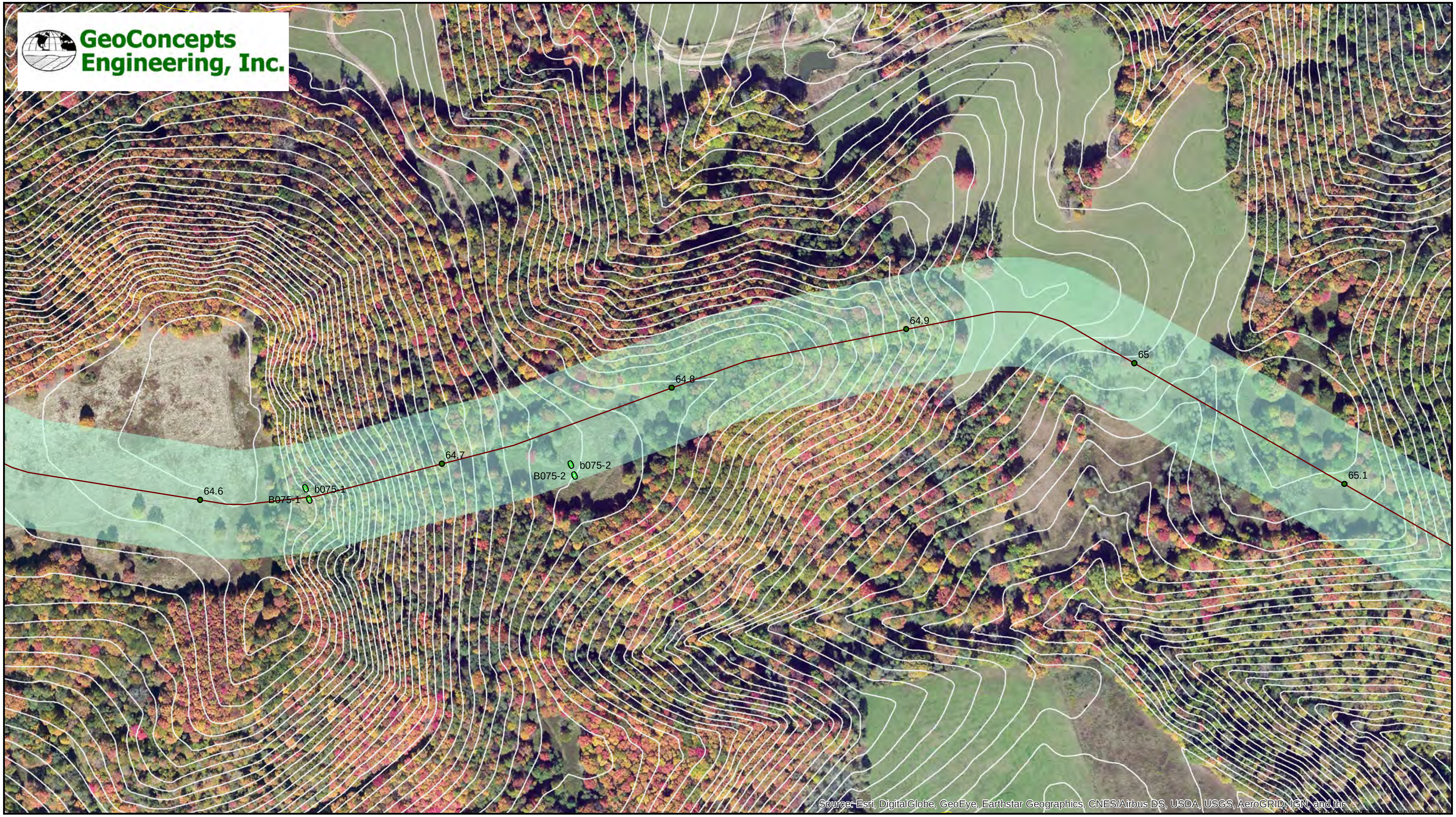
ATLANTIC COAST PIPELINE

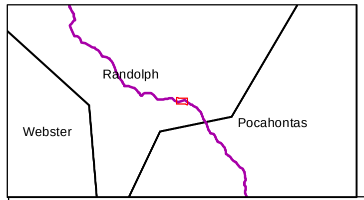
11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Contour.mxd | REVISED: 02/14/2017 | SCALE: 1:3,000 when printed at 11x17

DRAWN BY: JDV

GeoConcepts Engineering, Inc.





- Mileposts (0.1 mile)
- Centerline
- 300' Corridor
- 0.50 KRA
- All Point Features
- All Area Features
- 300' Corridor Closed Depressions
- Suspect Closed Depressions
- Randolph Caves
- Pocahontas Caves
- Virginia Caves

0 250 500
Feet

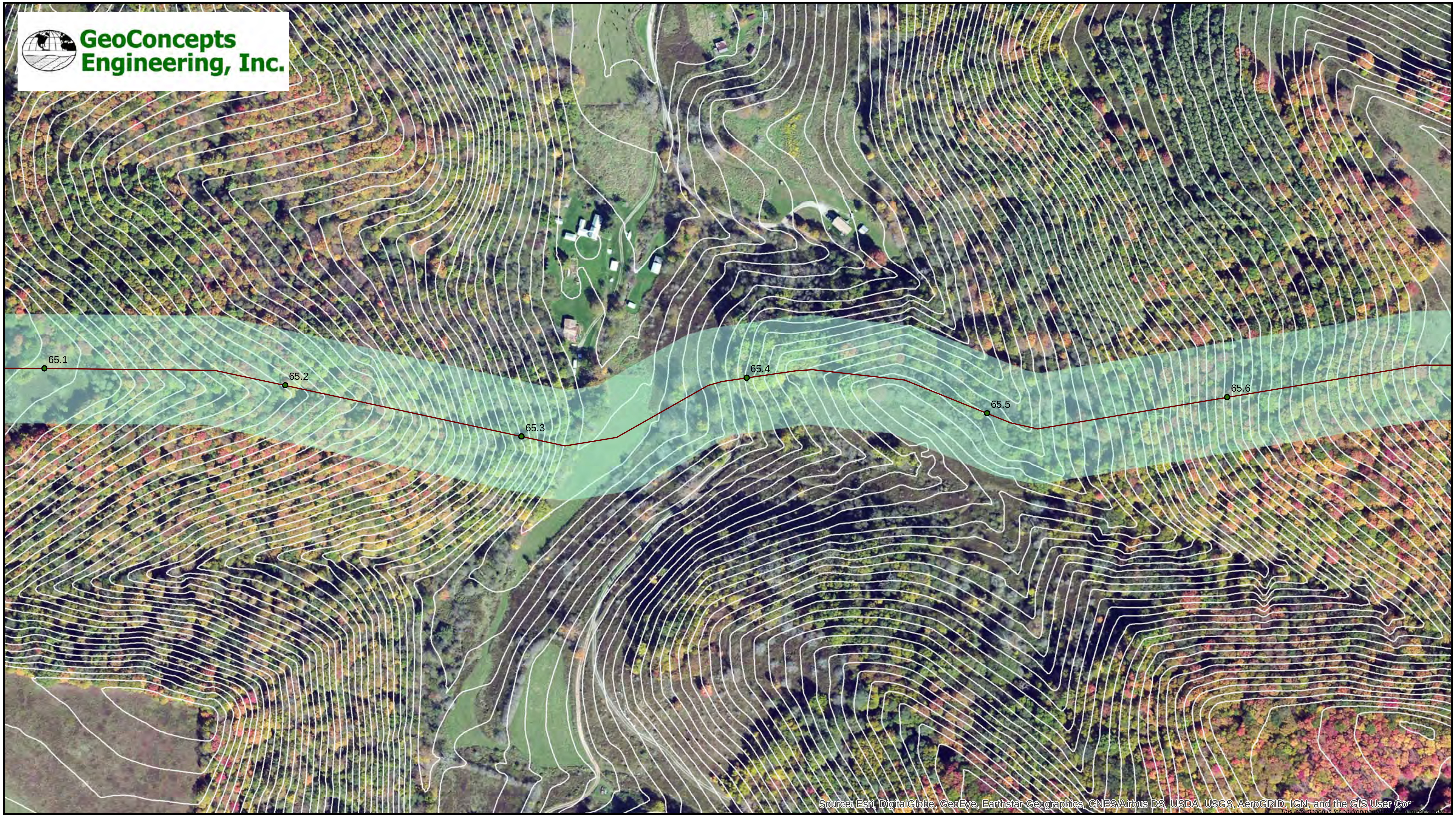
CONTOUR MAP 11

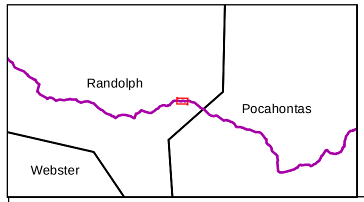
ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Contour.mxd | REVISED: 02/14/2017 | SCALE: 1:3,000 when printed at 11x17

DRAWN BY: JDV





Legend			
Mileposts (0.1 mile)	0.50 KRA	300' Corridor Closed Depressions	Pocahontas Caves
Centerline	All Point Features	Suspect Closed Depressions	Virginia Caves
300' Corridor	All Area Features	Randolph Caves	

0 250 500
Feet

CONTOUR MAP 12

ATLANTIC COAST PIPELINE

11002.04

FILE: N:\PROJECTS\Active 11 Projects\11002.04, Dominion Resources Pipeline - Randolph and Pocahontas Co\Final\GIS Data for Final\reportmap Contour.mxd | REVISED: 02/14/2017 | SCALE: 1:3,000 when printed at 11x17

DRAWN BY: JDV