APPENDIX L
GEOTECHNICAL OVERVIEW

Report of Geotechnical Overview

KY 377 – KY 344 – KY 59
Rowan and Lewis Counties, Kentucky
Item No. 9.231.00

Prepared for:
Qk4, Inc.

Prepared by:
Stantec Consulting Services Inc.

May 5, 2015

Stantec

Stantec Consulting Services Inc.
1409 North Forbes Road, Lexington KY 40511-2024

May 5, 2015
File: let_001_175565004

Attention: Annette Coffey, PE
Qk4, Inc.
2225 Lawrenceburg Road
Building C, 2nd Floor
Frankfort, Kentucky 40601

Reference: Report of Geotechnical Overview
KY 377 – KY 344 – KY 59
Rowan and Lewis Counties, Kentucky
Item No. 9-231.00

Dear Annette,

Stantec Consulting Services Inc. (Stantec) is pleased to submit this geotechnical overview for the proposed Scoping Study and Environmental overview for KY 377, KY 344 and KY 59 located in Rowan and Lewis Counties. The overview is based upon research of available published data.

Qk4, Inc. provided Stantec with preliminary data for the study area. The scope of work performed and results of the overview are presented in the accompanying attachment. Stantec appreciates having the opportunity to provide these engineering services and would be happy to answer any questions and further assist you concerning this project.

Regards,

STANTEC CONSULTING SERVICES INC.

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1.0 PROJECT DESCRIPTION

The Kentucky Transportation Cabinet (KYTC) is proposing to widen and reconstruct a portion of the route between Morehead and Vanceburg, Kentucky. The reconstruction will utilize the separate state routes, KY 377, KY 344 and KY 59. The area of corridor will begin near the intersection of KY 377/KY 799 in the community of Triplett and extend north and end near the intersection of KY 59/KY 9 (AA Highway) in Vanceburg, KY. The project corridor generally follows the existing alignments of KY 377 and KY 344. Beyond KY 344 the corridor is wider along KY 59 to Vanceburg. This project will improve safety by: addressing geometric deficiencies in the roadway, and adjusting the alignment, improve sight distances and improve roadside design. This overview will be utilized to identify geotechnical considerations for the study area. The project location and corridor is presented on the drawings provided in Appendix A.

2.0 SCOPE OF WORK

The scope of work for this study consists of performing a geotechnical overview for the proposed corridor based upon research of available published data and Stantec's experience with highway design and construction within the region. General geotechnical and geologic characteristics of the study area have been identified and are discussed in this report. Stantec personnel, using a variety of sources, performed a literature search that included reviews of the following sources:

- Available topographic and geologic mapping of the project area published by the United States Geological Survey (USGS) and the Kentucky Geological Survey (KGS);
- The Geologic Map of Kentucky, published by the USGS and the KGS (1988);
- KYTC Geotechnical Data, published by the KGS and KYTC, http://kgs.uky.edu/kgsmap/kytcLinks.asp;

  Prior Projects Nearby

  - P-002-2011
  - S-025-1997
  - R-037-1986
  - L-001-1976
  - L-004-1975
- United States Department of Agriculture, Soil Conservation Service (SCS) Soil Survey Publications for affected counties;
- Physiographic Regions, published by KGS, http://kgs.uky.edu/kgsweb.

3.0 PHYSIOGRAPHIC AND STRATIGRAPHIC SETTING

3.1 TOPOGRAPHY AND DRAINAGE

The project corridor is located along/near the Outer Bluegrass and the Eastern Kentucky Coal Fields (Pottsville Escarpment) physiographic region. Subsurface conditions are characteristic of Devonian and Mississippian age bedrock, which typically consists of cyclic sequences of sandstones and shale along the alignment. Marketable coal reserves are not prevalent in the area. However, there are productive gas fields in the vicinity of the corridor. Pyritic shales (Ohio and Sunbury Shales) are present within the corridor. The pyrite reacts with air and water to produce an acidic solution which could also affect the study alternatives. Additional discussion on these formations are provided in Section 3.2.

Surface drainage is directed towards named and unnamed tributaries of the North Fork of Triplett Creek within Rowan County, which flows into the Licking River near the community of Farmers, Kentucky. The surface drainage along the central and southern portion on the corridor is directed toward Indian Creek and Grassy Branch which flow into Kinniconick Creek. The northern most portion of the corridor drains towards named and unnamed tributaries of Salt Lick Creek which flows into the Ohio River in Vanceburg, Kentucky.

3.2 STRATIGRAPHY

Available geologic mapping indicates that the project corridor is underlain by bedrock consisting of the shale and sandstone members of the Borden Formation, the Sunbury Shale, the Berea Sandstone, which includes the Bedford Shale, and the Ohio Shale, in general order of descending lithology. These bedrock formations represent the Mississippian and Upper Devonian Geologic periods. The geologic mapping also indicates that portions of the project corridor are underlain by alluvium and lake sediments along major drainage courses. Based on USGS mapping, the underlying bedrock and soil deposits can be described as follows.

The shale member of the Borden Formation consists primarily of silty shale and shaley siltstone that is medium gray in color, weathers yellow-gray, irregularly bedded, and contains ironstone concretions and lenses. The sandstone member of the Borden formation consists of gray to light brown-gray sandstone that is very fine-grained and is moderately well indurated with a clayey matrix. The sandstone member is generally even bedded and contains pyrite as disseminated specks and crystals. The lower portion of the member is typically thick-bedded with silty shale partings that become thicker and more abundant within the upper portion of the unit. The lower portion of the sandstone member consists of shale that is green-gray to red-brown in color interbedded with fine-grained, even-bedded sandstone as much as two (2) feet thick. The USGS mapping indicates that the shale becomes plastic when wet and may flow laterally into valleys as a result of overburden pressure.

The Sunbury shale is described as being black in color, weathering to yellow-brown flakes, thin-bedded to fissile, highly carbonaceous and containing pyrite specks, crystals and concretions.

The Berea Sandstone consists of light gray sandstone that is very fine-grained to silty, thin- to thick-bedded, locally calcareous, and contains thin beds of dark-gray silty shale.

The Bedford Shale consists of shale, siltstone and sandstone. The shale is described as medium gray silty, thin-bedded and containing pyrite nodules. Siltstone is gray to greenish gray and thin-bedded. The sandstone is gray, very fine grained and occurs near the base and varies in thickness from about 4 feet in the north to just a few inches or non-existence to the south.

The Ohio Shale is described as being dark-gray to black in color, thin-bedded, highly carbonaceous, clayey, rarely pyritic, and weathers to light-gray-brown chips.

Structure contours presented on the various USGS geologic maps (predominately drawn on the base of the Sunbury Shale) indicates that the bedrock to have a regional dip towards the east-southeast. The geologic mapping of the area is presented in Appendix A.2, along with a generalized geologic column.

In general, the geologic formations are encountered at the following approximate elevations.

Table 1. Geologic Formations

Geologic Unit	Approximate Elevation Range (ft)*
Borden Formation: Shale	850 to 1040
Borden Formation: Sandstone	950 to 1150
Sunbury Shale	850 to 950
Berea Sandstone and Bedford Shale	750 to 900
Ohio Shale	580 to 800
Bisher Limestone	560 to 580
Crab Orchard	Below 560

*The elevations presented are approximate and vary along the length of corridor due to regional geology and dipping lithology.

There are no known commercial coal seams impacted by the project.

3.3 FAULTING IN THE AREA

Faults or other geologic structures that could have a detrimental effect on the project are not noted on the geologic mapping.

3.4 SOILS AND UNCONSOLIDATED MATERIALS

Residual soils are the predominate soil type found within this area. Soil descriptions contained herein are based upon SCS soil surveys and on Stantec's knowledge of the study area. Soils within the area of the roadway have derived in-place from a weathering process of the parent shale, siltstone and sandstone rock formations. These soils consist of silty clay and silt loam.

Alluvial deposits consisting of tributary stream alluvium and lake sediments are mapped within the flood plain of the major drainage courses. These deposits consist of clays, sands and gravels with varying thicknesses up to approximately 20 feet with much deeper depths (up to 140 feet for the lake sediments) along Salt Lick Creek near the Ohio River.

Several landslides are noted on the USGS topographic map presented in Appendix A.1. The landslide inventory presented was obtained from the Kentucky Geological Survey (KGS) map information service. Based on the site visit conducted by Stantec, the noted landslides along KY 377, KY 344 and KY 59 correlate with existing rail retaining walls along the alignment. Numerous rail retaining walls exist along the alignment, photos of some are presented on the map in Appendix A.1. Many of the rail walls appear to have been installed as a mitigation measure to help stabilize the roadway embankments due to the nearby streams and/or because of over steepened embankments. Colluvial materials may be present above a rail wall/roadway near the confluence of Briary Creek and Indian Creek.

3.5 REGIONAL SEISMICITY

Seismicity within the Commonwealth of Kentucky varies widely depending on location. The western portion of the state is dominated by the New Madrid and Wabash Valley source zones. In general, these zones are fairly active with many documented historical seismic events. Central and eastern portions of the state experience less frequent earthquakes because the source zones are quite distant from these areas.

The seismic hazard at a bridge site shall be characterized by the acceleration response spectrum for the site and the site factors for the relevant site class. A comprehensive geotechnical investigation will be required to determine the site class. However, based on anticipated depths to bedrock at/near stream locations, Site Class C or D can be expected. The 2014 AASHTO LRFD Bridge Design specifications provide guidelines for selecting a seismic performance category and a soil profile type for bridge sites. This information establishes the elastic seismic response coefficient and spectrum for use in further structural design and analyses. Refer to Section 3.10.2 of the AASHTO guidelines for specifications. It does not appear the corridor alignment will be affected by seismic activity; however, to determine the acceleration response spectrum and the site factors, a geotechnical exploration will be required.

4.0 GEOTECHNICAL CONSIDERATIONS

4.1 GENERAL

Based on the project corridor and Stantec's roadway experience, it is anticipated that the new alignment/reconstruction will generally follow the existing alignment of KY 377 and KY 344. Therefore, it is anticipated that this portion of the alignment will consist more of widening and not have many new cuts or fills required along the existing highway. The corridor is much wider along the KY 59 portion and there is the potential for many new cuts or fills. For improved safety within portions where the existing roadway may be widened, it appears that several intersections and structures will need to be reworked/realigned along the reconstructed roadway. The revisions to the interchanges will include: providing necessary clear zones, addressing geometric deficiencies in the roadway and adjusting the alignment. As the interchanges are reworked, the Project Team should keep in mind the geotechnical considerations that are included in Section 4 as they pertain to existing utilities, cut slopes, embankments and widened structures.

4.2 CUT SLOPE CONSIDERATIONS

Cut slope configurations in rock are generally controlled by bedrock lithology, bedrock quality, results of Slake Durability Index (SDI) tests in shales and siltstones, and by the presence of any fractures and/or joints. In general, if joint/fracture angles are high (as measured from horizontal), steeper cut slopes can be constructed and an acceptable level of stability can be maintained. If discontinuities exhibit low angles and steep cut slopes are utilized, large block failures may occur along the open cut face.

Slope configurations for rock cuts in durable or Type I non-durable rock generally range from 1H:4V to 1H:2V pre-split slopes on approximate 30-foot intervals of vertical height with 18 to 20-foot intermediate benches. These types of cuts could be anticipated within this alignment with rock cuts slopes of 1H:2V being likely most common. Cuts in nondurable shales and shallow cuts in bedrock may be best handled on 2H:1V slopes, covered with a soil layer and vegetated. Excerpts from the available geologic mapping regarding the Nancy Member of the Borden Formation states, "The instability of the Nancy Member of the Borden Formation is a factor affecting construction projects. Over steepening of slopes by artificial cuts may result in sliding of shale." Also "Sliding of colluvium mantling the Ohio Shale may occur on moderate to steep slopes, especially where recently undercut by road construction." The mapping presented in Appendix A.1 shows several known landslide areas within/near the project corridor.

Within the project vicinity, the Ohio Shale and the Sunbury Shale are known to be "pyritic shales" which can be acid producing. These formations, for the most part, presently lie below a soil and/or bedrock overburden within the project corridor. In this encased condition, it remains in stable equilibrium with the environment. Any small amount of contamination picked up from the shale by groundwater is easily absorbed by the environment and neutralized by natural processes. This is the natural process of weathering and breakdown of pyritic rocks.

A problem develops, however, when a large quantity of unweathered (or partially weathered) pyritic rock is suddenly exposed to weathering elements – air and water. This is the process which frequently occurs during coal mining operations and which will occur when excavations are opened into the Ohio and Sunbury Shales along the planned corridor.

These formations contain significant quantities of the minerals pyrite and marcasite, consisting primarily of FeS_2. These compounds react readily with air and water producing an acidic solution. This solution then readily dissolves other heavy metals present in the exposed rock including aluminum, calcium, magnesium, sodium, and manganese. Untreated water runoff from areas of newly exposed Ohio and/or Sunbury Shale could have a negative impact on the environment. Because this project may very likely contain cuts within these formations, remedial measures will need to be implemented to reduce the potential generation of acidic run-off during and after construction. Such measures are outlined in Section 5 of this report.

Historically, pyritic shales have the potential to produce acid runoff containing heavy metals when exposed to weathering elements – air and water. An FMSM/KYTC report titled "Study of Acidic Drainage Potential and Remedial Measures to Acidic Drainage Associated with the Devonian Black Shales - U.S. 127 Relocation - Lincoln and Boyle Counties, Kentucky" (1990) suggested four approaches to be considered as guidelines to reduce the acid runoff potential for cuts made within such bedrock: 1) Direct Treatment, 2) Encasement, 3) Chemical Treatment, and 4) Biological Treatment. Encasement is generally the preferred alternate because the materials are readily available.

Slope configurations for soil cuts in alluvial deposits are generally constructed on a 2H:1V or flatter.

4.3 EMBANKMENT CONSIDERATIONS

The anticipated excavated rock materials should be suitable for use in project embankments. Select rock types for use as rock embankment, rock road bed, channel lining, etc., would be durable shale. With the shales and siltstones present along the corridor, sufficient quantities of durable rock may not be generated during construction and the use of off-site sources should be considered. Foundation soils are likely to be silty clays and silt loam. Silt loam is considered a moderate to poor soil for use in roadway construction.

Embankments constructed of durable rock materials generally exhibit adequate stability at 2H:1V slope configurations. However, flatter embankment slopes may be required for tall embankments constructed from nondurable shales or in areas where embankments are founded on alluvial materials. Alluvial soils can be expected along major drainage courses.

Low shear strengths and high settlement potentials are generally associated with alluvial deposits. Consolidation settlements and short-term embankment stability problems are common for roadway embankments in alluvial floodplains, and controlled embankment construction rates and/or flatter embankment side slopes should be anticipated for these areas.

Pyritic shales used in roadway embankments or placed in waste areas should not be exposed to weathering elements such as air and water. This will require that the pyritic shales be encased with at least four feet of compacted non-acid producing clay soil and/or clay shales obtained from excavations within the rock disintegration zone (RDZ). When encasement is required, the outer surface of any embankment should be covered with six inches of topsoil and properly vegetated.

4.4 STRUCTURES

It is anticipated that mainline bridges will need to be widened and or replaced to meet horizontal clearances with the new highway. At this time, it is unknown as to whether the proposed roadway would require new and/or widened substructure elements. Based on Stantec's knowledge of the area, it can be anticipated that the majority of the bridges within the project corridor are likely supported by rock bearing foundation systems, which could be a spread footing or steel H-piles driven to bedrock. Culverts along the proposed alignment may be replaced or widened. It can be anticipated the culverts within the project corridor are likely supported by either a non-yielding or yielding foundation system depending upon the location along the proposed alignment. A detailed geotechnical investigation will be required to determine the foundation support system.

There are a number of railroad rail retaining walls that vary in length and height, along the existing KY 377, KY 344 and KY 59 alignments. As mentioned previously, some of these walls are shown on the map presented in Appendix A.1. These type of walls are generally installed as a mitigation measure to help stabilize the roadway embankment adjacent to waterways. Based on the improved alignment, these walls may need to be replaced with cast-in-place walls, MSE or other type of retaining structures. In areas where stream bank stabilization appears to be a problem (outside bends), stream stabilization techniques may be employed to help reduce stream bank erosion and scour.

4.5 SATURATED, SOFT OR UNSTABLE AREAS

Based on topographic mapping and literature reviewed, the alignment may be near ponds, drainage swales or stream channels. Any saturated, soft or unstable areas encountered within embankment foundation limits should be drained and stabilized utilizing non-erodible granular embankment. The coarse aggregate shall be underlain with Geotextile fabric. Ponds should be drained and any soft or saturated material should be removed and/or stabilized. For stabilization purposes, a sufficient thickness of non-erodible granular embankment should be placed over all soft / saturated foundation areas. Additional rock may be required to stabilize soft soils and to maintain positive drainage.

4.6 GAS AND OIL WELLS

There have been 2 productive natural gas fields within/near the project vicinity. These are the North Triplett Field and the Bluestone Field. Production at both fields was from the Bisher Limestone which underlies the Ohio Shale. Gas has been produced from 2 small fields on the Cranston quadrangle. Reportedly the production from fields was from the Bisher Limestone. Production was minor and the fields have been abandoned based upon the information Stantec has reviewed. Well locations are shown on the geologic mapping in Appendix A.2. Recommendations are being provided in Section 5 to inventory the wells and verify what is active and what has been abandoned.

5.0 CONCLUSIONS

5.1. The purpose of this overview was to provide a general summary of the bedrock, soil and geomorphic features likely to be encountered within the proposed alignment; and to identify geotechnical features that may have an adverse impact on the project alignment.

5.2. The potential exists for acid drainage within the project corridor. The Ohio Shale and Sunbury Shale are present and are known acidic stratums. Particular attention should be given to the design of cut slopes and embankments near where these formations exist. Cuts and embankments within these shale formations will require special design considerations. The Sunbury Shale is shown on the geologic map to exist within the corridor from confluence of Stamm Fork and Indian Creek to the north throughout the remaining portion of the project corridor. The Ohio Shale is presented on the geologic mapping near Vanceburg in Sulpher Branch, Hazel Branch, Dry Run, and Appletree Branch.

Cuts in acid producing shale will require the cut slope to be flattened and over excavated a minimum of 4.5 feet and covered with clay soil or non-durable shale to prevent production of acidic run-off.

Embankments that contain acid producing shales will also require encasement. A minimum of 4 feet of clay soil or non-durable shale should be placed on the top of the embankment to control corrosion of guard rail and 2.5 feet of material should be placed on side slopes.

5.3. Geotechnical drilling will be needed for replacement or widened culverts, bridges and retaining walls. It is anticipated that conventional spread footing and/or pile foundation systems can be utilized for these structures.

5.4. Because a portion of this project may be a widening project, information on pavement structure should be obtained to assist the team on pavement structure and California Bearing Ratio (CBR) information. Other projects in the vicinity have utilized rock roadbed and generally CBR valves of 6 or less.

5.5. Once alignment and sections are identified, then open faced logging of exposed cuts and/or drilling should be performed. Sampling of foundation soils should be performed for embankment situations of sufficient height to evaluate stability.

5.6 Landslides are known to exist in the area. Several landslides are noted along the existing alignments of KY 344 and KY 59. These slides appear to coincide with the location of existing rail retaining walls. Colluvial materials may be presented above the roadway near the confluence of Briary Creek and Indian Creek.

5.7 Numerous railroad rail retaining walls exist along the current alignment of KY 377, KY 344, and KY 59. These walls should be surveyed and overall condition evaluated. Depending on the selected alignment, the affected walls will likely require repairs and/or replacement. The Design Team should consider additional costs for repair/replacement of these walls. In addition, maintenance of the traffic should be considered when selecting wall replacement types, with consideration given to the limits of excavation required to construct the wall.

5.8 Several oil and gas wells have been drilled near/along the proposed corridor. Many have reportedly been abandoned. The Design Team should inventory and survey active wells. Additional costs could be incurred if the selected alignment disturbs an active well site.

5.9. The information presented in this overview should be reviewed in the general nature in which it was intended. A thorough geotechnical exploration of the proposed alignment and grade will be required to properly anticipate and plan for special requirements necessary for the design and construction of the proposed alignment.

Appendix A CORRIDOR MAPPING

A.1 USGS TOPOGRAPHIC MAP

A.2 USGS GEOLOGIC MAP

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APPENDIX A
CORRIDOR MAPPING

APPENDIX A.1
USGS TOPOGRAPHIC MAP

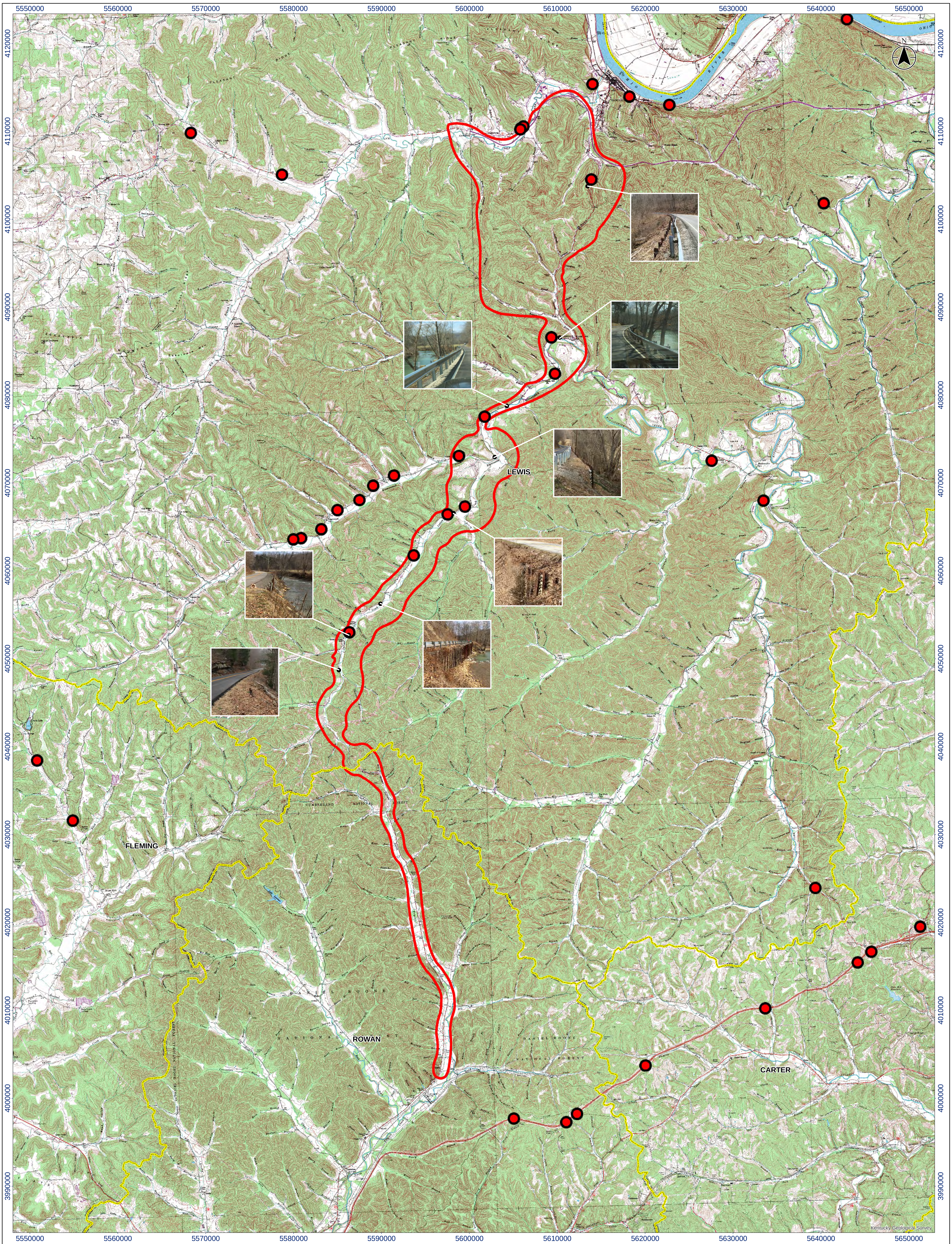

Figure No.
1

Title
KY 377 Geotechnical Overview
Topographic Information

Client/Project
QK4

175565004
Prepared by BSJ on 2015-02-24
Technical Review by ABC on 2015-01-16
Independent Review by ABC on 2015-01-16

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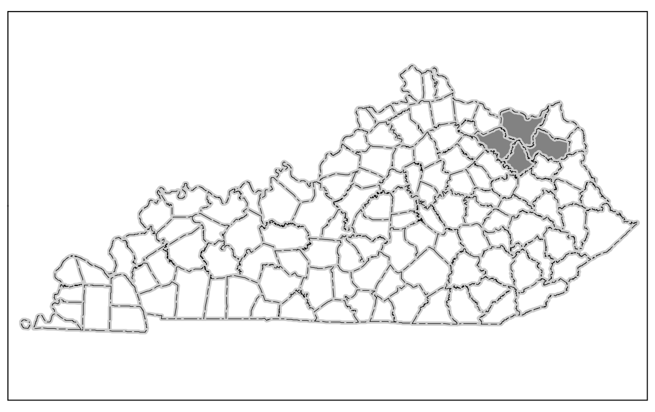

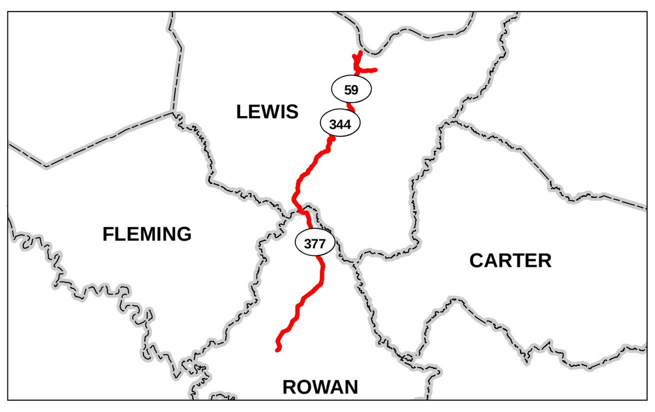

- GPS Photo Points
- KGS landslide inventory data
- County Boundary
- Study Area

Notes
1. Landslide and Topographic Quadrangle Data Source: Kentucky Geological Survey
2. Coordinate System: NAD 1983 StatePlane Kentucky FIPS 1600 Feet

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APPENDIX A.2
USGS GEOLOGIC MAP

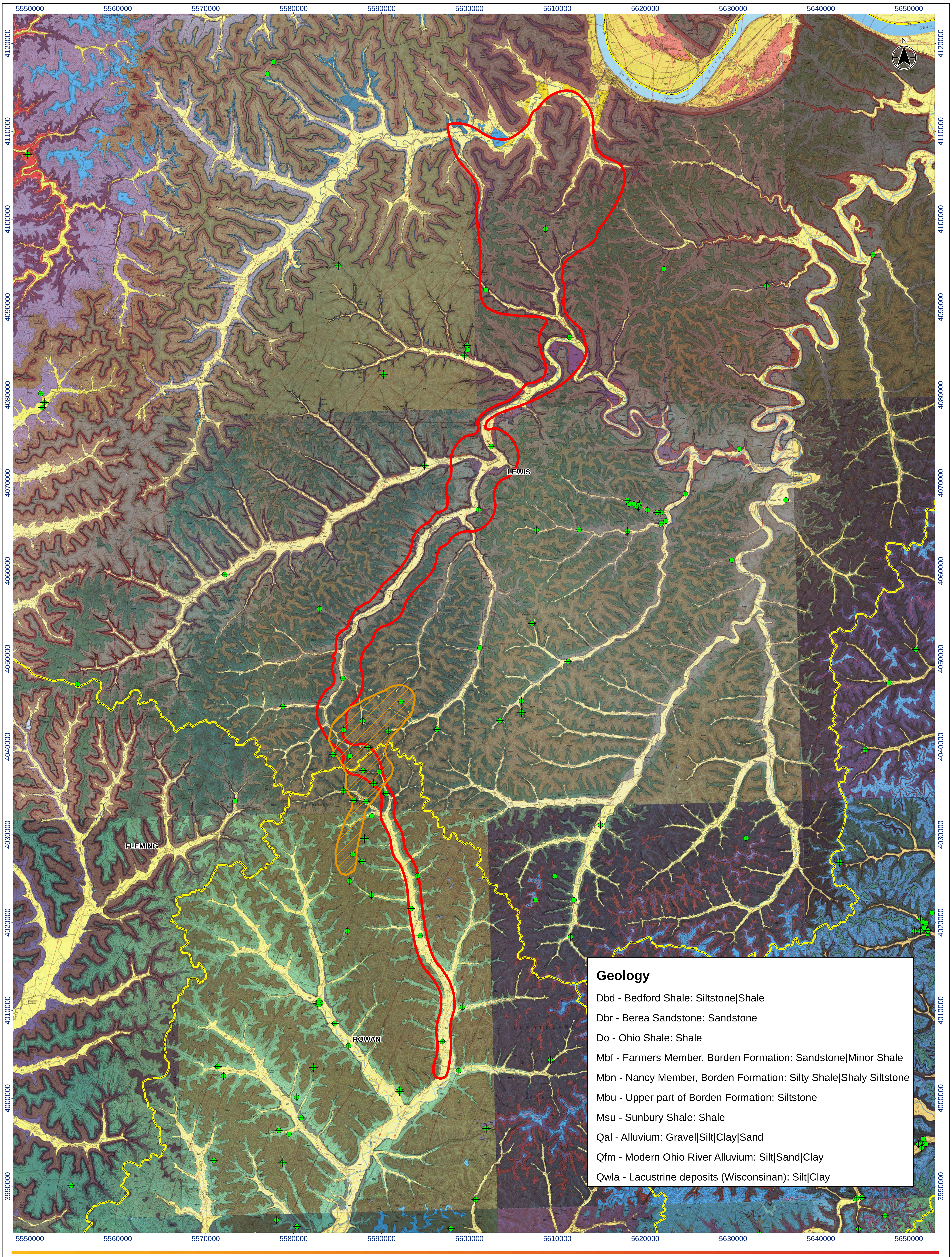

Figure No.
1

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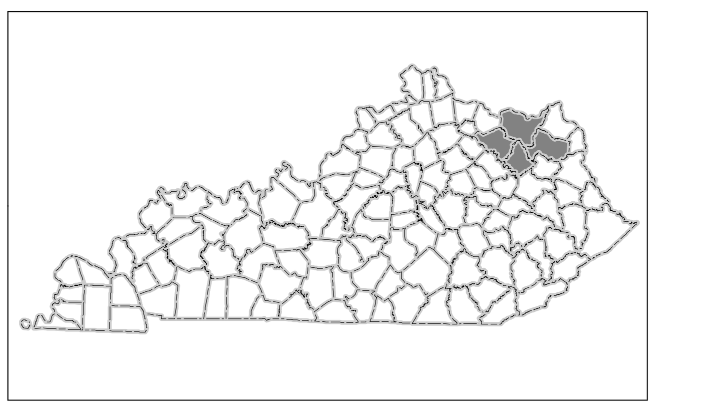

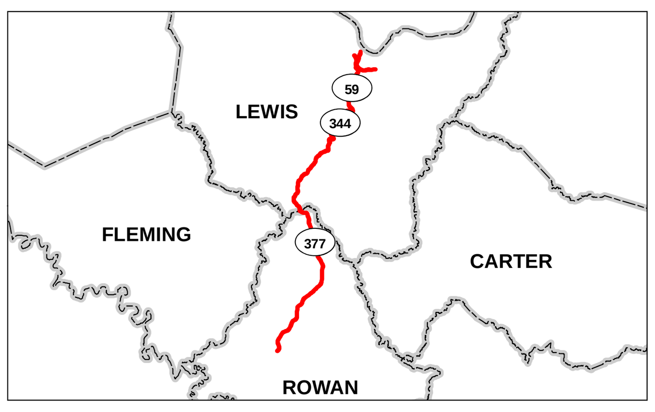

Oil and Gas Wells
Gas Field
Study Area
County Boundary

Notes
1. Oil&Gas and Geologic Quadrangle Data Source: Kentucky Geological Survey
2. Coordinate System: NAD 1983 StatePlane Kentucky FIPS 1600 Feet

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