APPENDIX F – GEOTECHNICAL OVERVIEW

Report of Geotechnical Overview

KY 90
Barren County, Kentucky
Item No. 03-8819.00
P-004-2016

Prepared for:
Kentucky Transportation Cabinet
Central Office
Highway District 3

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1.0 PROJECT DESCRIPTION

The Kentucky Transportation Cabinet (KYTC) is proposing to widen and reconstruct a portion of KY 90 in Barren County, Kentucky. The reconstruction will generally utilize the existing roadway corridor. The corridor will begin at the intersection of Sanders Street in Cave City and KY 90, and extend south where it is projected to end at the intersection of KY 90/US 68 in Glasgow, KY. The project corridor generally follows the existing alignment of KY 90 and is approximately 500 feet wide.

The study area is well known for its rolling terrain, red clay soils and the karst behavior of the underlying bedrock (karst features may include sinkholes, caves and solution features in the bedrock). Therefore, the project team will need to be aware and cautious in relation to potential karst.

This project will improve safety by: addressing geometric deficiencies in the roadway, and adjusting the alignment, improve sight distances and improve roadside design. Information from this report 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);
- Kentucky Geologic Map Information Service http://kgs.uky.edu/kgsmap/kgsgeoserver/viewer.asp;
- KYTC Geotechnical Data, published by the KGS and KYTC, http://kgs.uky.edu/kgsmap/kytcLinks.asp;
- Prior Projects Nearby:
    - R-003-1971
    - R-023-2000
    - R-027-1989
    - S-018-2011
    - S-105-2000
- 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 in the Horse Cave and Glasgow North Quadrangles of Kentucky. Subsurface conditions are characteristic of Upper and Lower Mississippian age bedrock, which typically consists of cyclic sequences of sandstones, limestone, shale, and siltstone. Generally, this area is known for its karst landscape; characterized by gently rolling hills, red clay soils and numerous sinkholes and depressions. The limestone bedrock, which lies below the ground surface in the study area, is highly soluble and prone to dissolution and the resulting development of karst features such as sinkholes, caves, springs and disappearing streams. Also, there are productive oil and gas fields in the vicinity of the corridor.

Surface drainage in the corridor is directed towards named and unnamed tributaries of Beaver Creek along the southern portion of the alignment. Underground drainage is a function of surface and groundwater flows that are controlled by the nature of these rocks and the associated surface features. Slopes generally control the runoff from precipitation and stream drainage, with ridgelines forming drainage boundaries. Underground water in most watersheds and drainage basins tend to follow the topography of the area. In areas containing soluble limestone or karst regions, the underground drainage may differ from the boundary of its surface watershed.

3.2 STRATIGRAPHY

Review of available geologic mapping for the area indicates the site is underlain by, in descending order of lithology, Upper and Lower Mississippian deposits of the Ste. Genevieve Limestone, St. Louis Limestone, Salem and Warsaw Limestones, and Fort Payne Formations. The geologic mapping also indicates that portions of the project corridor are underlain by alluvium along major drainage courses. Based on USGS mapping, the underlying bedrock and soil deposits can be described as follows.

The deposits of the Ste. Genevieve formation are described as oolitic limestone, white, very light gray to dark-gray, brownish-gray, thin to very thick bedded, locally very fossiliferous, dense to coarsely crystalline limestone, thin-bedded to massive, fossiliferous. Beds and lenses of blue and gray chert are more commonly present in upper and basal parts; where argillaceous limestone weathers to form benches and gentle slopes.

The deposits of the St. Louis Limestone formation are described as limestone and siltstone, light-olive-gray to dark-gray, buff, lithographic, dense to coarsely crystalline, thin to very thick bedded, occurs throughout the formation.

The deposits of the Salem and Warsaw Limestones are described as limestone and siltstone: Limestone, light-olive-gray to medium-gray, detrital (calcarenite), fine-to medium –grained, in places cherty; interbedded interfingered with olive-gray thin-bedded silty to very silt limestone; in places contains stringers and nodules of chert.

The deposits of the Fort Payne Formation are described as dolomite, light-olive-gray to olive-gray, silty and argillaceous, weathers yellowish gray; interbedded with light-greenish-gray to medium-gray detrital limestone (calcarenite), poorly sorted, thin- to medium-bedded, in places argillaceous; abundant gypsum geodes, quartz geodes, thin chert lenses and nodules.

Both the Ste. Genevieve Limestone and the St. Louis Limestone Formations are known for karst landscapes. These formations are a result of lithified calcium carbonate-rich deposits derived from warm, shallow sea environments during the Mississippian Geologic Period. Limestone, especially relatively pure limestones like those which underlie the study area, are soluble in water and weak acid solutions. Sinkholes, springs and caves are typical of landscapes underlain by these soluble limestones. As with most karst landscapes, soil overburden thickness varies greatly due to variant rates of chemical weathering and patterns of surface drainage.

Structure contours presented on the various USGS geologic maps indicates that the bedrock to have a regional dip towards the north- northwest. The geologic mapping of the area is presented in Appendix B.

3.3 FAULTING IN THE AREA

Faults are not located in the intermediate area of the proposed corridor and are not expected to have a detrimental effect on the project.

3.4 SOILS AND UNCONSOLIDATED MATERIALS

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

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 along a roadway and its structures 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 B or C 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. The corridor alignment will likely be affected by seismic activity from the New Madrid and Wabash Valley source zones; 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 90. 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. For improved safety within portions where the existing roadway may be widened, it appears that 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 cut slopes of 1H:2V being likely most common. Rock cuts in the area can be problematic due to the karst nature of the bedrock. Solution features can cause the bedrock surface to be erratic. Cuts in nondurable shales and shallow cuts in bedrock may be best handled on 2H:1V slopes.

Slope configurations for soil cuts 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 limestone. Based on the existing grade and existing cuts, 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 clays. Based on the anticipated clay soils present, soil stabilization for pavement subgrade should be anticipated.

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 and clay soils, 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.

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 deep foundations 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.

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. Based on observations, several ponds exist within the project

corridor. Depending on the project alignment, these ponds will require treatment if they are located within the construction limits.

4.6 KARST CONDITIONS

As mentioned previously, karst conditions are within the vicinity of the project. Any open sinkholes or solution cavities identified within the construction limits that are not utilized for drainage purposes should be filled and/or capped in accordance with Section 215 of the current edition of the Standard Specifications for Road and Bridge Construction.

Sinkholes were noted within the study area on adjacent properties which are currently utilized for drainage purposes. Any sinkholes utilized for drainage purposes for new roadway construction should incorporate adequate measures to minimize water infiltration into the subgrade and erosion control measures to minimize siltation of open sinkholes.

Adequate drainage will be of primary concern with any new design or new construction in the area to minimize environmental impacts by surface runoff into the underlying karst network. Proper management of surface water will also lessen the occurrence of sinkhole dropouts during construction. Mitigation of surface runoff should be performed by silt checks, silt traps, sediment basins and lined ditches where appropriate. Siltation of sinkholes should be avoided, especially those to remain open after construction.

4.7 GAS AND OIL WELLS

There are several oil and gas wells in the vicinity on the project corridor. Well locations are shown on the geologic mapping in Appendix B. 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. Karst topography/sinkholes and basins were noted along the alignment. Sinkholes or solution cavities identified within the construction limits that are not accepting drainage should be filled and/or capped in accordance with Section 215 of the current edition of the Standard Specifications for Road and Bridge Construction.

A sinkhole was noted within the study area that is currently utilized for drainage purposes. Any sinkholes utilized for drainage purposes for the new roadway construction should incorporate adequate measures to minimize water infiltration into the subgrade and erosion control measures to minimize siltation of open sinkholes.

Karst terrain in the study area will likely be the most detrimental factor to any new construction in the area. Rock cuts in the area can be problematic due to the karst topography. Solution features can cause the bedrock surface to be erratic.

Numerous sinkholes and karst related features exist within the region. The Design Team should inventory the sinkholes and other karst features, such as caves, along the proposed alignment. The inventory should note whether or not the sinkhole accepts drainage.

5.3. Geotechnical drilling will be critical in this region for replacement or widened culverts, bridges, retaining walls, and design due to the karst potential. It is anticipated that conventional spread footing and/or pile foundation systems can be utilized for structures. However, if voids/caves are present, additional costs associated with karst mitigation should be anticipated.

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 mechanical or chemical stabilization and generally CBR values of approximately 6 or less.

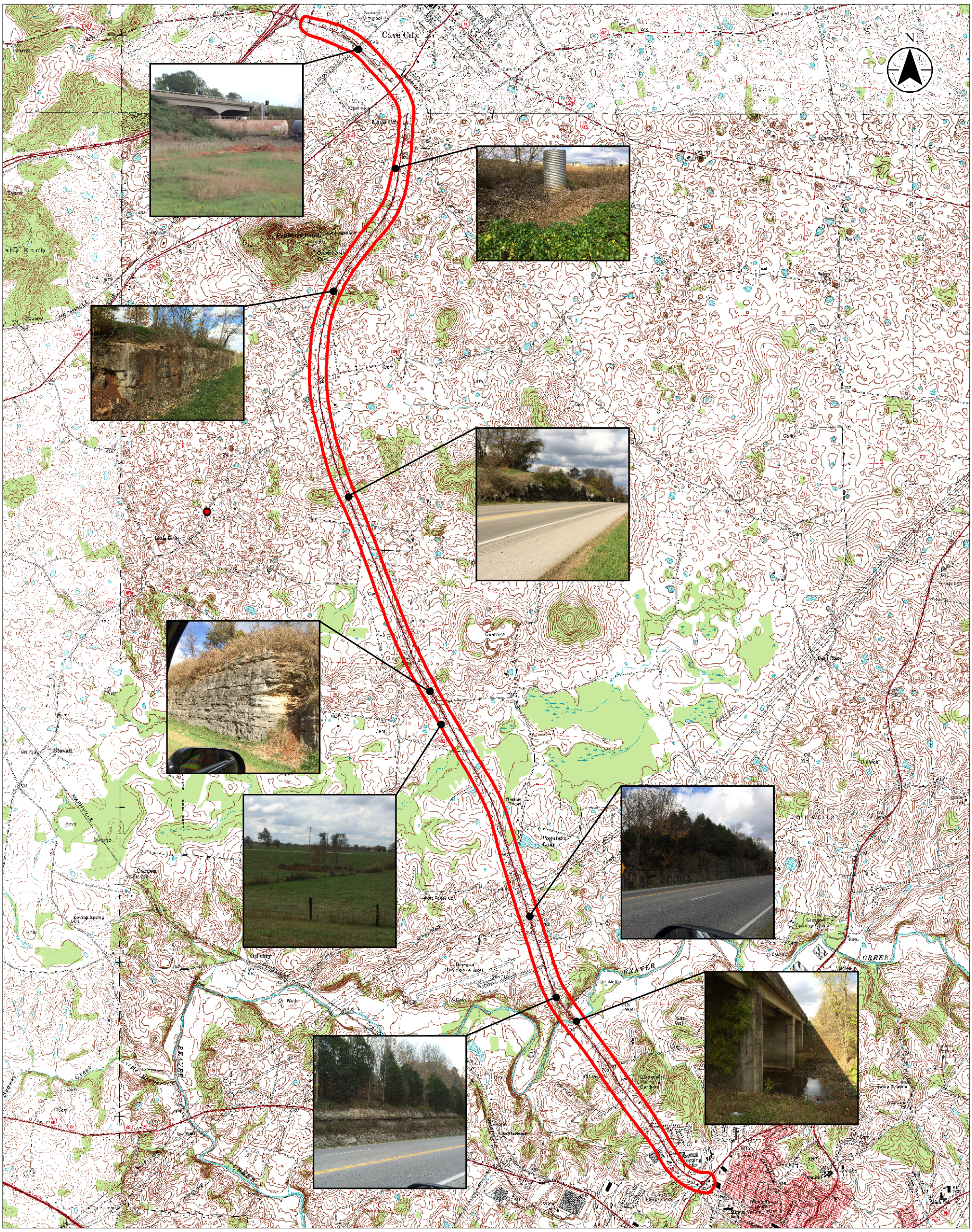
5.5. Once alignment and sections are identified, then open faced logging of exposed cuts and/or drilling should be performed. Sampling of foundation soils should be performed for embankment situations of sufficient height to evaluate stability.

5.6. 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 a well site.

5.7. 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
USGS TOPOGRAPHIC MAPS

Z:\KY90\KY90_Topo.mxd Revised: 2015-11-10 By: eroggenkamp



Legend

- GPS Photo Point
- KGS landslide inventory data
- Study Area

0 4,000 8,000 Feet

1:48,000 (At Original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 StatePlane Kentucky South FIPS 1602 Feet
2. Data Sources Include: Kentucky Geological Survey
3. KGS Topographic Quadrangles

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KENTUCKY TRANSPORTATION CABINET

Project Location
Barren County, KY

178554021
Prepared by ER on 2015-11-09
Technical Review by JA on 2015-11-09
Independent Review by JA on 2015-11-09

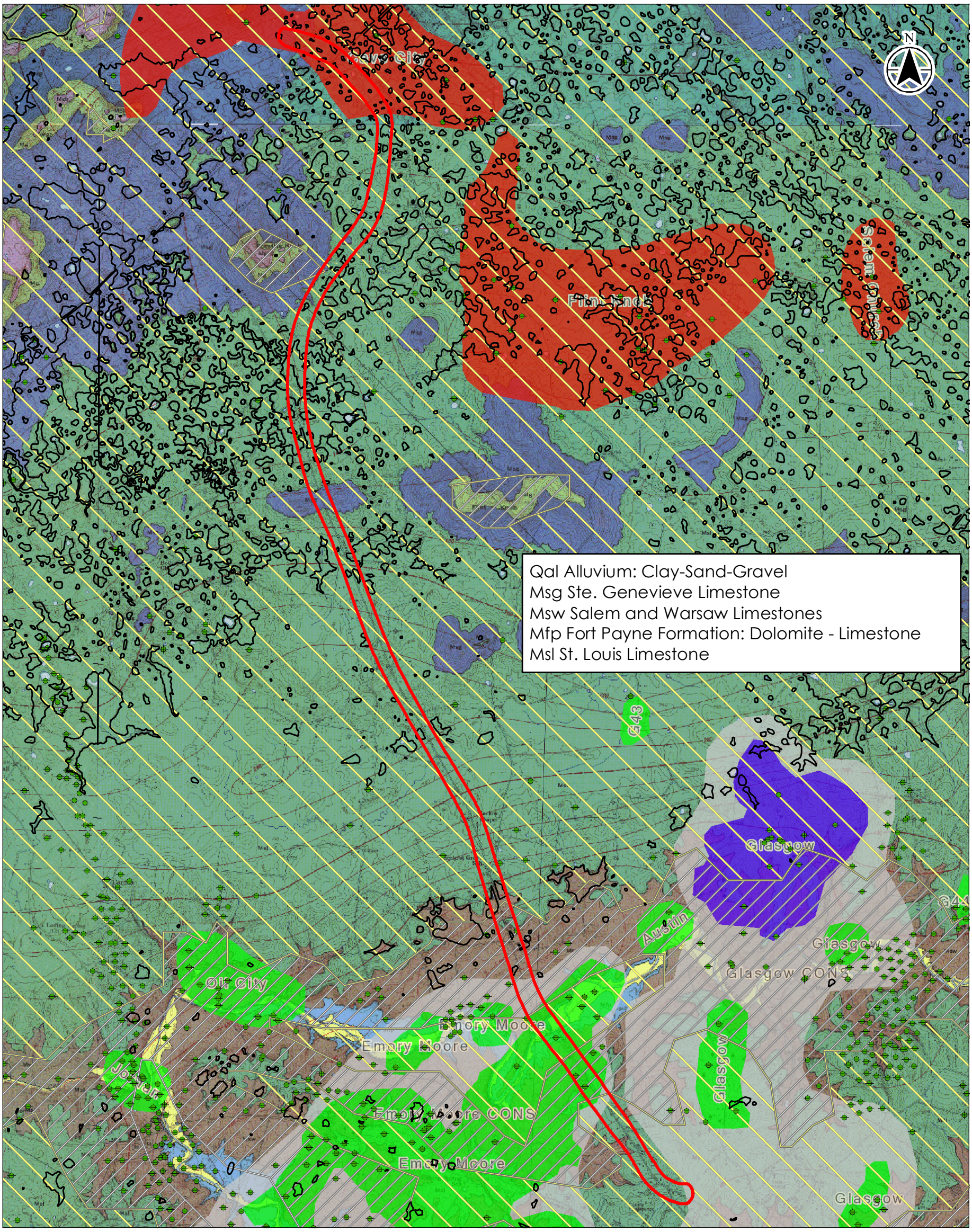
Client/Project
KYTC
KY 90 Scoping Study

Figure No.
1

Title
KY 90 Topographic Overview

APPENDIX B
USGS GEOLOGIC MAP

Z:\KY90\KY90_Geo.mxd Revised: 2015-11-11 By: eroggenkamp



Legend

- Oil and Gas Wells
- StudyArea
- Sinkholes
- Karst - Major
- Karst - Moderate

KY Oil and Gas Fields

- Oil Field
- Gas Field
- Waterflood
- Consolidated

0 4,000 8,000 Feet

1:48,000 (At Original document size of 11x17)

Stantec

KENTUCKY TRANSPORTATION CABINET

Project Location

Barren County, KY

178554021
Prepared by ER on 2015-11-09
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