APPENDIX F – GEOTECHNICAL OVERVIEW

Report of Geotechnical Overview

US 127 Russell Springs
Improvements Study
Russell County, Kentucky
P-005-2020

Prepared by:
Stantec Consulting Services Inc.

June 22, 2020

Stantec Consulting Services Inc.
3052 Beaumont Centre Circle, Lexington KY 40513-1703

June 22, 2020
File: rpt_001_let_178558003

Attention: Mr. Michael Carpenter, PE
Kentucky Department of Highways
Division of Structural Design
Geotechnical Branch
1236 Wilkinson Boulevard
Frankfort, Kentucky 40601

Reference: Geotechnical Overview
US 127 Russell Springs Improvements Study
Russell County, Kentucky
P-005-2020

Dear Mr. Carpenter,

Enclosed is the geotechnical overview for the proposed Planning Study overview for the referenced project. The geotechnical overview is based upon research of available published data and preliminary data for the study area. The scope of work performed, and results of the overview are presented in the accompanying report.

Regards,

STANTEC CONSULTING SERVICES INC.

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/rws

Table of Contents

LIST OF APPENDICES

1.0 PROJECT DESCRIPTION

The Kentucky Transportation Cabinet (KYTC) is conducting a planning study for US 127 and the surrounding area between Russell Springs and Jamestown, Kentucky. The potential corridor will begin north of Jamestown, Kentucky and extend north to Russell Springs, Kentucky. The project study area is shown in Figure 1. This project will examine transportation issues related to safety and congestion within the study area and to develop strategies to address these issues. The study will identify and evaluate potential improvement options to increase mobility and connectivity on US 127 in Russell County. This overview will be utilized to identify geotechnical considerations for the study area. The project location and corridor are presented on the drawing provided in Appendix A.

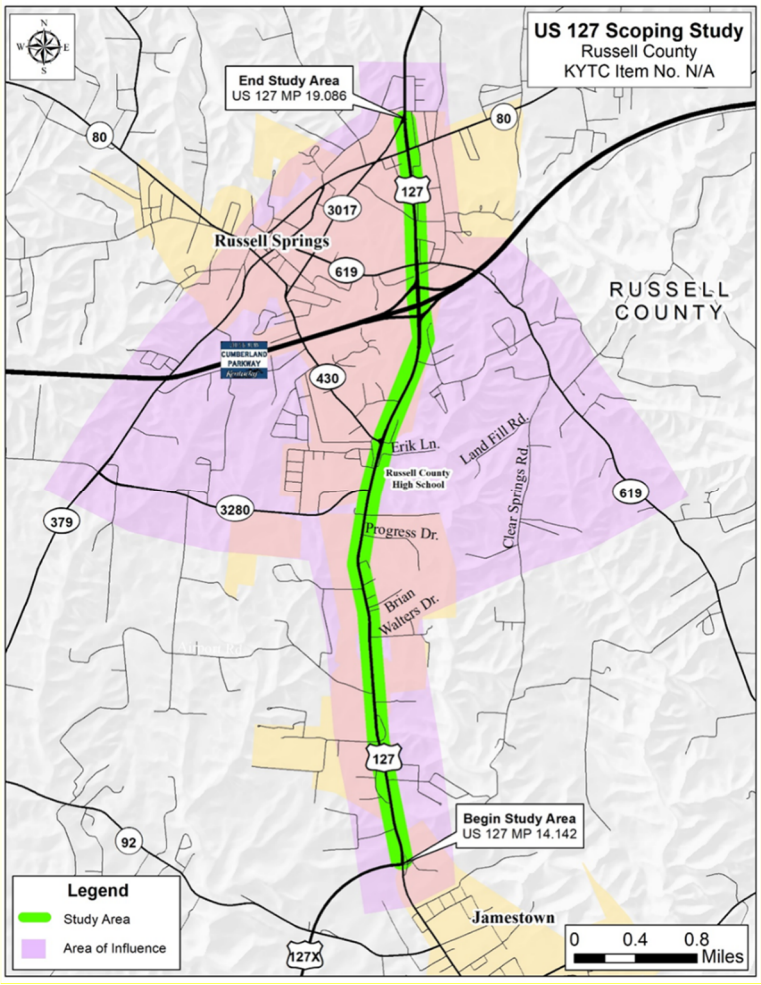


Figure 1. Study Area

2.0 SCOPE OF WORK

The scope of work for this study consists of performing a geotechnical overview for the proposed study area 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;
- KYTC Projects Nearby (Identified by KYTC Report Number):

County	Report Number	Route	Item Number
Adair/Russell	R-001-1969	LN-9008	08-0000.00
Adair/Russell	R-002-1969	LN-9008	08-0000.00
Russell	S-036-1991	US-127	08-0117.01
Russell	S-037-1991	US-127	08-0117.01
Russell	R-022-2001	US-127	08-0054.00
Russell	S-085-2001	US-127B	08-0054.00
Russell	S-161-2002	US-127	08-0054.00
Russell	R-015-2006	KY-3280	08-0116.00
Russell	S-094-2006	KY-3250	08-0116.00
Russell	S-040-2006	US-127	08-0117.01
Russell	L-019-2007	LN-9008	08-2004.00
Russell	R-029-2012	US-127	08-8504.00

- 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.Physiographic and Stratigraphic Setting.

2.1 TOPOGRAPHY AND DRAINAGE

The project study area is located in the Mississippian Plateau physiographic region of Kentucky. Subsurface conditions are characteristic of Mississippian age bedrock. Surface drainage within the study area is directed towards named and unnamed tributaries of Lake Cumberland.

2.2 STRATIGRAPHY

Available geologic mapping (Geology of the Russell Springs Quadrangle, Kentucky (GQ-383)) indicates that the project corridor is underlain by multiple formations of the Upper and Lower Mississippian System. The Salem and Warsaw Formations (Msw), Fort Payne Formation (Mfp) and the Knifley Sandstone Member (MFk) of the Fort Payne Formation. These materials generally consist of suitable material for most highway purposes. Corridors that traverse over these groups are preferred. The geologic mapping of the area is presented in Appendix B.

2.3 FAULTING IN THE AREA

An unnamed fault system is located approximately 4.5 miles east-northeast of Russell Springs and is not located within the study area. This fault is not known to be active in recent geologic time. This area is depicted on the geologic mapping in Appendix B.

2.4 SOILS AND UNCONSOLIDATED MATERIALS

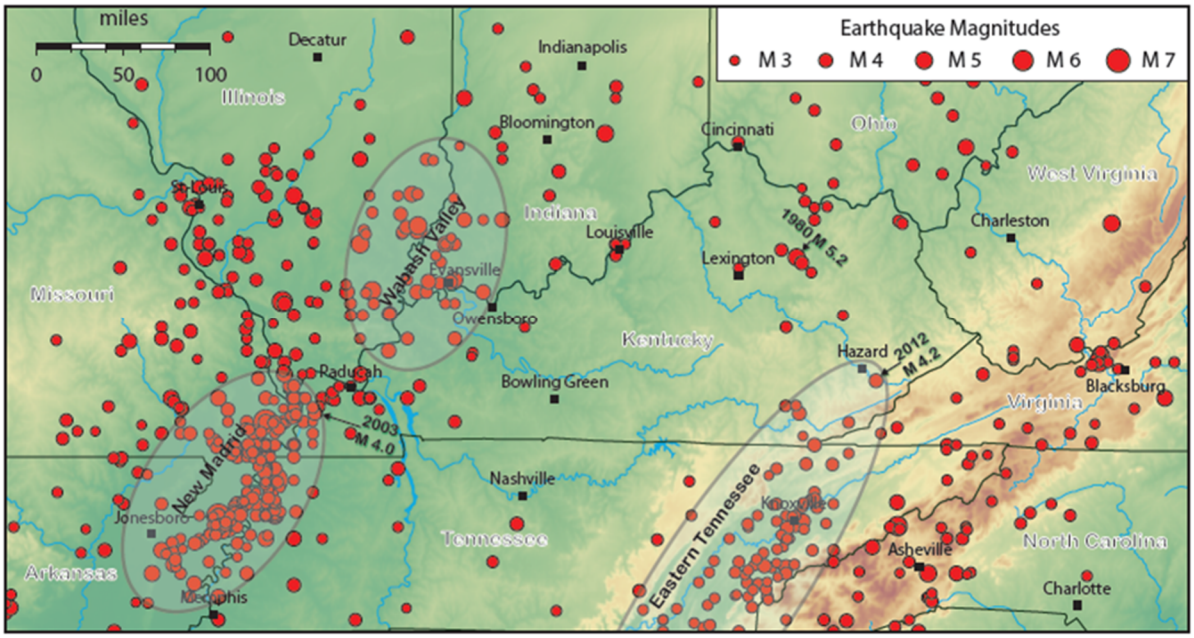
Residual soils are the predominate soil type found within this area. Soil descriptions contained herein are based upon SCS soil surveys and on Stantec's knowledge of the study area. Soils within the area of the roadway have derived in-place from a weathering process of the parent limestone, shale and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

Alluvial deposits consisting of tributary stream alluvium 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 along tributaries.

2.5 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 B/C can be expected. The 2017 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 could be influenced by seismic activity from the New Madrid and Wabash Valley source zones and "local" seismic events.



From: Earthquakes in Kentucky: Hazards, Mitigation, and Emergency Preparedness, Kentucky Geological Survey.

Figure 2. Earthquake epicenters and seismic zones in and around Kentucky

3.0 GEOTECHNICAL CONSIDERATIONS

3.1 GENERAL

Based on the project study area and Stantec's roadway experience, it is anticipated that the new alignment/reconstruction will generally follow the existing roadway alignments, where possible. Therefore, it is anticipated that portions of the alignment will consist more of widening while some areas will require new cuts and fill. 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 corridor. 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.

3.2 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 can generally be 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. Cuts in nondurable shales and shallow cuts in bedrock may be best handled on 2H:1V slopes. Slope configurations along the corridor will be dependent on many factors, including but not limited to, roadway grade, geology and bedrock durability which will be evaluated during a geotechnical exploration.

Slope configurations for soil cuts are generally constructed on a 2H:1V or flatter. Soil cuts greater than 10-feet may require stability analyses.

3.3 EMBANKMENT CONSIDERATIONS

The anticipated excavated rock materials should be suitable for use in project embankments. Select rock types for use as rock embankment, rock roadbed, channel lining, etc., would be durable limestone. Foundation soils are likely to be plastic clays and silty clays.

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. Embankments constructed out of residuals soil materials (clays) greater than 20 feet in height will require stability analyses and may require flatter slopes depending on the embankment height. Alluvial soils can be expected along major drainage courses. In areas such as this, granular embankment material and/or retaining walls may be necessary depending on the proposed alignment.

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. Controlled embankment construction rates, flatter embankment side slopes, and partial rock embankment are some of the techniques used to reduce these issues.

3.4 STRUCTURES

It is anticipated that if existing routes are utilized, 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. It can be anticipated that most of the bridges within the project study area 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. The culverts within the study area are likely supported by either a non-yielding or yielding foundation systems depending upon the location along the proposed alignment. A detailed geotechnical investigation will be required to determine the foundation support systems.

3.5 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 or durable limestone from roadway excavation. The rock platform shall be underlain with geotextile fabric. Ponds should be drained, and any soft or saturated material should be removed and/or stabilized. Additional rock may be required to stabilize soft soils and to maintain positive drainage. Based on observations, ponds exist within the project study area. Depending on the project alignment, these ponds will require treatment if they are located within the construction limits.

3.6 MINES AND QUARRIES

Based on the available geologic mapping, there are no coal seams mapped in the vicinity of the project alignment. There are however, abandoned quarries near the study area. These sites are mapped outside the geologic map extent presented in Appendix B.

3.7 GAS AND OIL WELLS

Based on the available geologic mapping, there are oil and gas wells in the vicinity of the project study area. These wells are depicted on the geologic mapping in Appendix B.

3.8 WATER WELLS AND SPRINGS

Based on available information, water wells and springs are noted within/near the proposed study area. These locations should be inventoried to verify their locations. If impacted during construction, special construction will be required to close the wells. Spring boxes and/or granular material may be required in the vicinity of springs.

3.9 KARST CONDITIONS

The potential for karst conditions exist within the study area. Sinkholes, springs, underground cavities, and a highly irregular rock surface are commonly found in the Salem and Warsaw Formation (Msw). 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 are noted on the mapping presented in Appendix C. Only one sinkhole area is presented on the mapping within the study area. 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 situation 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 lesson 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. Situation of sinkholes should be avoided, especially those to remain open after construction.

4.0 CONCLUSIONS

4.1. 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.

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

4.3. 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. It should be anticipated that chemically or mechanically stabilized roadbed will be required because CBR values are expected to be 6 or less.

4.4. Once alignment and sections are identified, then open-faced logging of exposed cuts and/or drilling should be performed. Depending on the project alignment and grade, additional geotechnical information may be desired along the corridor. Sampling of foundation soils should be performed for embankment situations of sufficient height to evaluate stability.

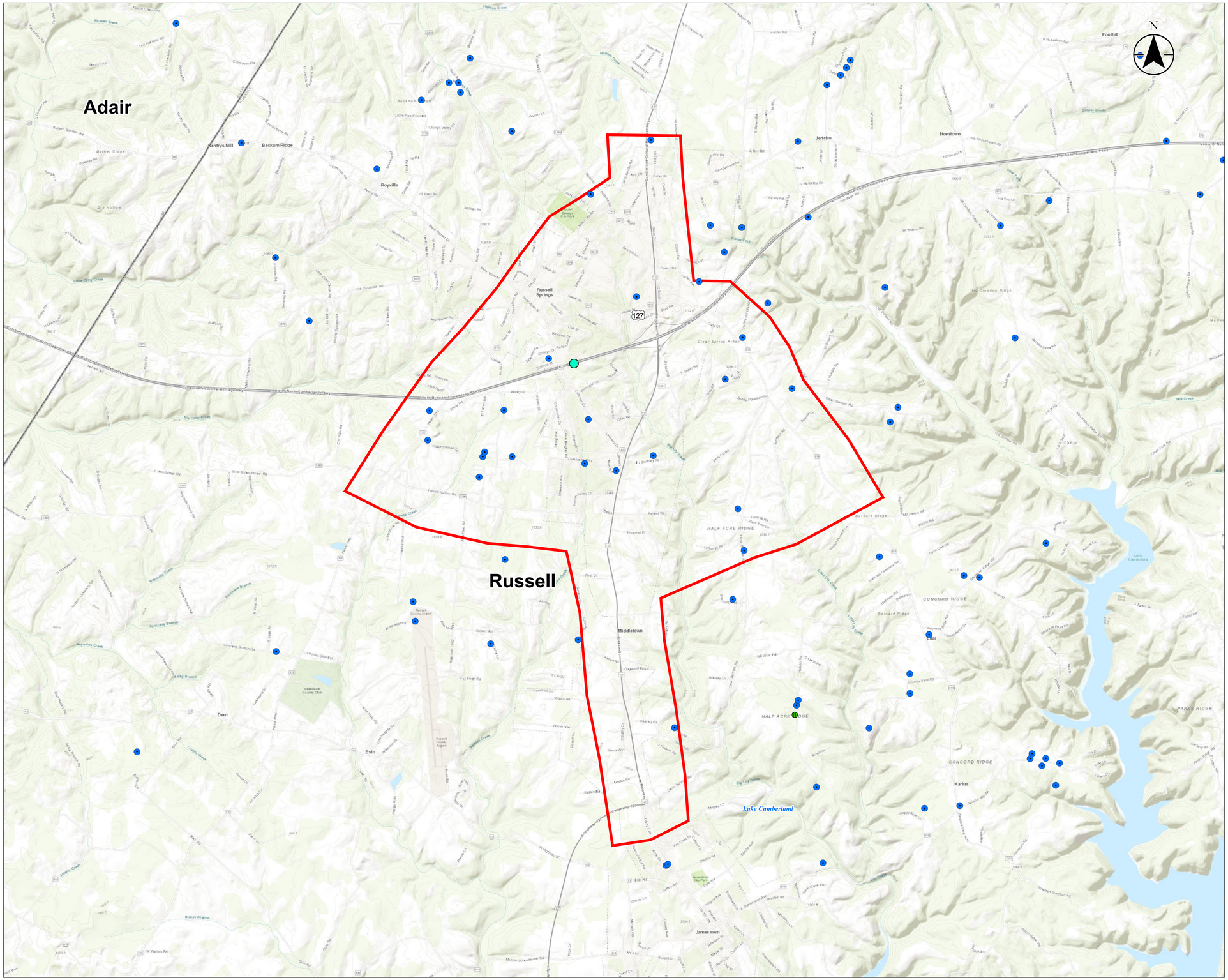
4.5. Water wells, monitoring wells and springs exist along/near the proposed corridor. The design team should inventory and survey active wells and springs.

4.6. The potential for karst conditions exists within the project study area. 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.

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 situation of open sinkholes. 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.

4.7. 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 MAP



Stantec

Legend

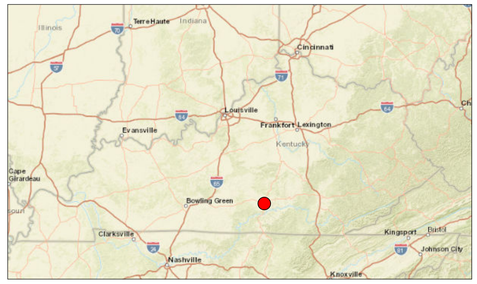
- Springs
- Groundwater Well
- KGS Landslide Inventory Data
- Focus Area

0 2,000 4,000 6,000 US Feet

1:24,000 (At original document size of 22x34)

Notes

1. Coordinate System: NAD 1983 StatePlane Kentucky FIPS 1600 Feet
2. Basemap Sources: ESRI World Topographic Map and ESRI World Street Map
3. Data Sources: Springs and Groundwater Wells Courtesy of Kentucky Division of Water (KDOW). Landslide location data courtesy of Kentucky Geological Survey (KGS). This map shows the locations of known landslides and areas susceptible to landslides in a geologic and geomorphic context. This map serves as an overall view of landslide hazards across the state. There are several landslide data layers represented as points, lines, and polygons. Locations come from Kentucky Geological Survey research, state and local government agencies, the public, and the media, thus making attributes and spatial accuracy highly variable. All landslide types, sizes, and states of activity are represented. This map can be used to identify landslide locations and serve as a basis for landslide hazard assessment and risk reduction. It is not intended for site specific investigations. A professional geologist or geotechnical engineer should be consulted for planned construction at identified landslide locations or in identified landslide areas. A professional geologist or geotechnical engineer should also be consulted for control and mitigation efforts of existing slides.



Project Location
Russell County, Kentucky

178558003
Prepared by WSW on 2020-05-13
Technical Review by DB on 2020-05-13
Independent Review by XXX on 2020-05-13

Client/Project
Kentucky Transportation Cabinet
Geotechnical Overview
Russell Springs Improvement Study

Figure No.

Title
Russell Springs Improvement Study
Topographic Map

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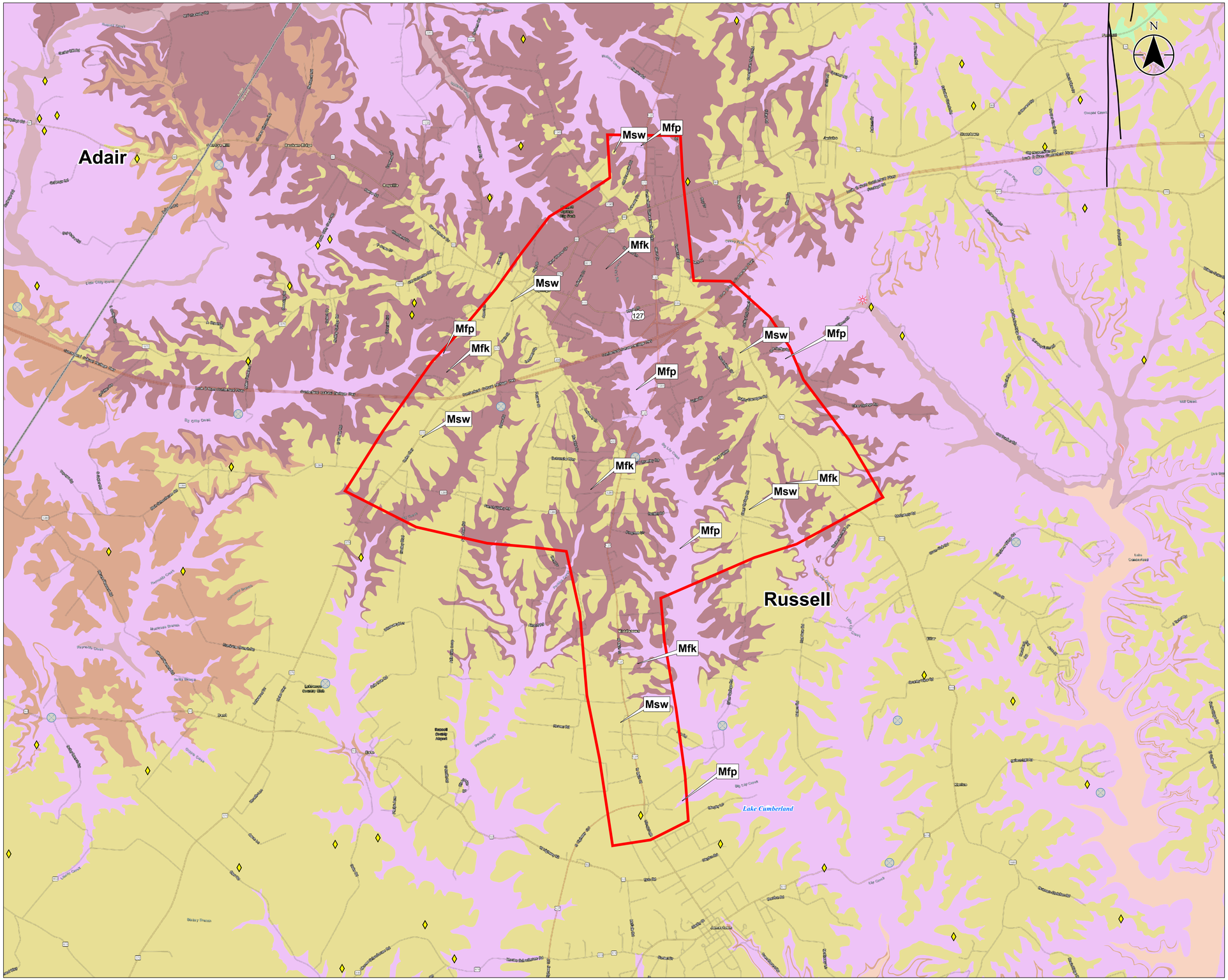
APPENDIX B
USGS GEOLOGIC MAP



Stantec

Legend

- Dry and Abandoned Well
- Gas Well
- Newly Permitted or Historic Well (Completion Data Not Available)
- Other Well
- Fault
- County Boundaries
- Quarries (No Quarries Identified within Map Extent)
- Focus Area

Formation Unit Name and Name Code

- Alluvium (Qal)
- Chattanooga Shale (Dc)
- Fort Payne Formation (Mfp)
- Knifley Sandstone Member (Mfk)
- Lake (lake)
- Reef Limestones, Fort Payne Formation (rl)
- Salem and Warsaw Limestones (Msw)
- St. Louis Limestone (Msl)

0 2,000 4,000 6,000 Feet

1:24,000 (At original document size of 22x34)

Notes

1. Coordinate System: NAD 1983 StatePlane Kentucky FIPS 1600 Feet
2. Basemap World Hybrid Overlay: Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community
   World Street Map: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
3. Data Sources: Quarries, Oil and Gas Wells, Faults, and Geologic Areas Courtesy of Kentucky Geological Survey (KGS).

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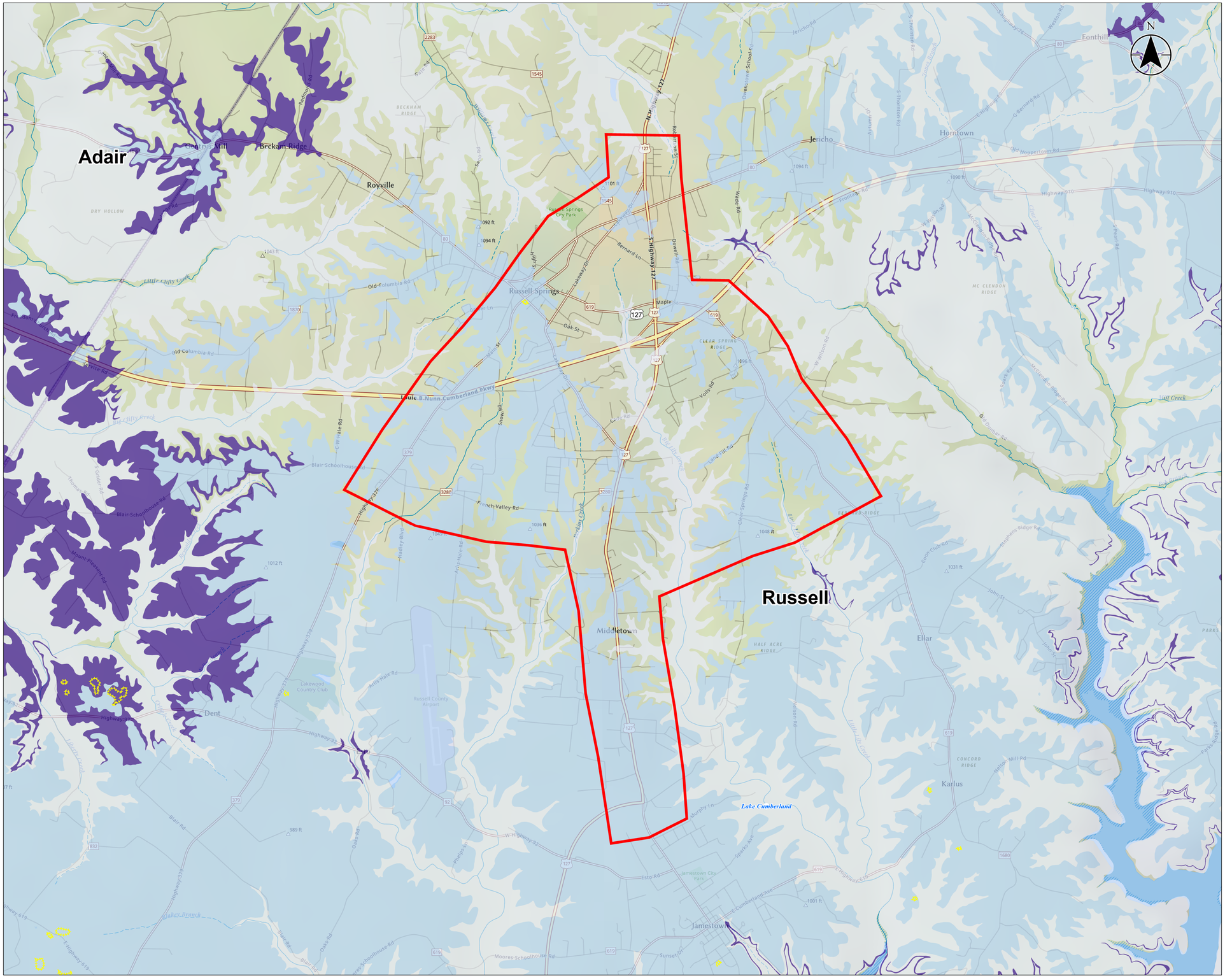
Figure No.

Title
Russell Springs Improvement Study
Geologic Map

APPENDIX C
KARST POTENTIAL MAP



Legend

- County Boundaries
- Focus Area
- Sinkholes

Karst Potential

- Very High
- High
- Medium
- Low

Note: Unshaded areas represent non-karst regions

0 2,000 4,000 6,000 Feet

1:24,000 (At original document size of 22x34)

Notes

1. Coordinate System: NAD 1983 StatePlane Kentucky FIPS 1600 Feet
2. Basemap National Geographic Style: Sources: Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community
World Street Map: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
National Geographic Style Base: Sources: Esri, USGS
World Hillshade: Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community
3. Karst potential was determined by KGS staff for each formation by a weighted matrix of lithologic characteristics determined for each unit: grain size, bedding thickness, %CaCO3, and % insoluble rock and minerals. The last (% insoluble rock and minerals) being weighted the most. Please note, this is unpublished and still a work in-progress. Polygons digitized from the 1:24,000 Geologic Map Series maps (original maps published by Kentucky Geological Survey - U.S. Geological Survey from 1960 to 1980).
4. These data represent digital GIS sinkhole coverage for all of Kentucky. Digitization was done onscreen using digital raster graphic files of the 7 ½ minute topographic contours, registered and projected to the Kentucky State Plane coordinate system. The highest elevation, closed, topographic contour of each mapped sinkhole was digitized as a GIS polygon. The second highest elevation contour was also digitized where very large.

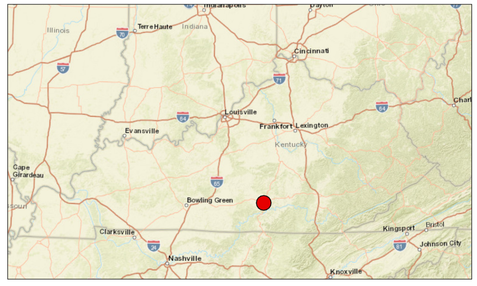


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Figure No.

Title
Russell Springs Improvement Study
Karst Potential Map

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