MEMORANDUM **P-004-2022**

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DATE: April 12, 2022

Subject: Marion County
Item # 4-80153.00
STP 6000190
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East Lebanon Bypass (New Route)
Mars # 1336401D
Preliminary Geotechnical Assessment for New Route

1.0 General Overview

This planning study focuses on the central portion of Marion County, Kentucky, in Lebanon. The southwestern extent of the study area begins at the intersection of KY 208 and KY 2154, south of US 68, and continues east by northeast across KY 49 [south of Lebanon], before bending northward over the knobs straddling Sulphur Springs Road. The study area continues north, across US 68, trending with KY 2154 [in East Lebanon] to the intersection of KY 55 and KY 2154. The breadth of the study area at US 68 is approximately 1.2 miles wide, narrowing to approximately 0.5 mile wide along KY 55, and converges to the intersection of KY 208 and KY 2154.

The purpose of the study is to identify any geological or geotechnical hazards or concerns in the provided study area that could be problematic for the continuation/completion of the bypass around Lebanon. Special attention was given to the knobs in the eastern portion of the study area, particularly the type of rock and associated drainage.

1.1 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 the Geotechnical Branch'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. The following sources were used to perform a literature search:

- Kelley, John A., William H. Craddock, et al. "Soil Survey of Marion County, Kentucky." United States Department of Agriculture, Soil Conservation Service. 1991. https://www.nrcs.usda.gov
- Moore, Samuel L. "Geologic Map of the Lebanon East Quadrangle, Marion County, Kentucky." Kentucky Geological Survey: USGS. GQ 1508. 1978.
- Moore, Samuel L. "Geologic Map of the Lebanon West Quadrangle, Marion County, Kentucky." Kentucky Geological Survey: USGS. GQ 1509. 1978.
- USGS Professional Paper 1151-H: The Geology of Kentucky: Physiography
- Available KYTC Arcmap Datasets and Layers
- KYTC Projects Nearby (see Section 6.0 – Past [Relevant] Geotechnical Reports]

2.0 Physiography and Topography

Marion County is at the edge of the Outer Bluegrass/Knobs physiographic region of the Central Lowland Province of the United States. The Outer Bluegrass region is characterized as an upland area primarily consisting of interbedded limestones and shales. The limestones are less karstic, thus producing/resulting in fewer sinkholes. The shales are more easily eroded than those of the Inner Bluegrass, which can impede groundwater flow, thus there are fewer wells and springs. The Knobs consists of hundreds of independent, steep-sloping, often conoidal hills lying at the outer edge of the Bluegrass Region. The Knobs are associated with the outcrop belt of Silurian and Devonian black and clay shales. Streams flowing in and through the Knobs generally carve wide valleys with fertile alluvium deposits.

Topography within Marion County is gently rolling with local relief generally less than 100 feet with steeper terrain along the southern, western, and eastern borders with neighboring counties. Within Marion County, elevation varies from approximately 580 feet above mean sea level (MSL) south/southwest of Lebanon, just west of KY 208 to over 1,200 feet above MSL near the southeastern edge of the county. Site specifically, the elevation ranges from approximately 780 to 1150 feet above MSL, based on the United States Geological Survey (USGS) 7.5-minute series map of the Lebanon West (GQ-1509) and Lebanon East (GQ-1508), Kentucky quadrangles.

3.0 Geology

Available mapping by the Kentucky Geologic Survey (KGS) Geologic Map Service (2022) indicates the study area is primarily underlain by bedrock belonging to the Middle Devonian New Albany Shale, a pyritic shale unit. Fluvial channels in the study area expose the Middle to Upper Devonian Boyle Dolomite, and the Drakes Formation, Grant Lake Limestone, Ashlock Formation, and Calloway Creek Limestone – all Upper Ordovician. The Knobs in the east central portion of the study area comprised of the Borden Formation, including the Muldraugh, Hall's Gap, Nancy, and New Providence Members. See the attached Geologic Map for reference.

3.1 Stratigraphy

The Borden Formation is characterized by shale and siltstone. As previously mentioned, the Knobs are composed of the Borden Formation. Of specific interest is the New Providence Shale

Member of the Borden formation. This shale is gray to yellowish, clayey, and contains nodules, lenses, and interbeds of sideritic limestone and few scattered phosphatic nodules. This member is typified by class III non-durable shale that is highly erodible. The New Providence Shale Member ranges between 80 and 120 feet thick and approximately elevations 860 to 930.

The New Albany Shale is characterized by dark gray to black, carbonaceous shale veinlets, laminae, blebs, and nodules of pyrite. Locally, the New Albany is estimated between 30 and 50 feet thick starting at an elevation below 860. The primary issue associated with the New Albany is the oxidation and weathering of the pyrite contained within freshly exposed bedrock.

The Boyle Dolomite consists of light- to medium-olive-gray, dolomite conglomerate and dolomitic limestone with silicified horn corals and coarsely crystalline calcite. Local thickness ranges from zero to 20 feet thick.

The Drakes Formation consists of dolomite and limestone. The dolomite is light gray to light-yellowish-gray, silty, argillaceous, thin bedded, and faintly laminated. The limestone is light-olive-gray to medium-gray, fossiliferous (brachiopods, gastropods, and a few cup corals), and weathers light-olive-gray to light-yellowish-gray. In the study area, the Drakes Formation is between 30 and 105 feet thick.

The Grant Lake Limestone, locally between 20 and 40 feet thick, consists of medium- to olive-gray, silty, argillaceous, limestone in irregular beds and medium-gray, calcareous shale.

The Ashlock Formation is comprised of light-olive-gray, medium-bedded limestone containing 4- to 8-inch thick interbeds with medium-gray, argillaceous fossiliferous limestone with dark-gray fossiliferous shale and light-greenish-gray dolomitic limestone sparsely populated with glauconitic granules, and locally ranges between 60 and 70 feet thick.

The Calloway Creek Limestone, briefly exposed in the northernmost extent of the study area, is light-gray to olive-gray, fossiliferous limestone in irregular beds with light-gray, calcareous, silty shale thinly bedded throughout the unit. This unit is between 120 and 140 feet thick.

3.2 Soils and Unconsolidated Material

A 1991 soil survey report obtained from the United States Department of Agriculture (USDA), Soil Conservation Service (SCS) indicates that the surficial soil deposits within approximately 40 inches of the ground surface consists of silt loam, silty clay loam, gravelly silty loam, silty clay, and bedrock. The soil survey also indicates the surficial soil deposits within approximately 40 inches of the ground surface in the Knobs consist of moderately deep, well-drained, complex soils. These soils are primarily derived from their parent material – the unconsolidated mass of weathered and eroded bedrock in which a soil forms, and local topographic relief – steepness directly influences the ease of water- and gravity-driven transportation and deposition of soil materials.

4.0 Geologic Hazards and Considerations

Pyrite oxidation in the New Albany Shale can cause serious geotechnical and environmental problems. This formation contains iron-sulfide minerals (pyrite) that can react with water to form sulfates and a mild sulfuric acid. Consequences of pyritic oxidation include heave, concrete degradation, steel corrosion, environmental damage, acid drainage, and accelerated weathering of rock. Non-corrosive materials and sulfate resistant cement for subsurface structures are required in location where there is contact with the New Albany Shale.

4.1 Karst

Due to the prevalence of shales overlying the study area, there is limited karst potential. The Mississippian and Devonian shales and dolomites are non-karst. The Ordovician limestones and interbedded shales and limestones are prone to karst. In the study area, the greatest karst potential can be found in two places – north of US 68 and in the southeastern portion, south of the knobs. Few sinkholes are mapped on the geologic quadrangle within the Drakes Formation. See attached Karst Potential Map for reference.

4.2 Faults

A fault trending west to east that briefly transects the southern-most boundary of the study area. Mapping indicates the fault extends between tributaries (Stewarts Creek and Caney Creek) of the Rolling Fork. The bedrock to the north of the fault is the uplifted section. There are no geotechnical concerns associated with this fault.

4.3 Mining/Quarry Activity

Haydon Materials operates the Lebanon Quarry that sits just southwest of the study area, along KY 208. The active quarry extracts limestone within the Drakes Formation for the purposes of crushed aggregate. The northern limit of the Lebanon Quarry is bound by the fault mentioned above.

4.4 Drainage

Surface drainage in the area trends west toward Hardins Creek, north toward Cartwright Creek, or southeast toward Caney Creek. The abundance of shale – and associated limited karst potential – restricts flow and facilitates ponding. Extreme or prolonged precipitation events can result in extremely wet soils, ponding, and flooding of low-lying areas.

Subsurface contours mapped along the New Albany Shale (central and southern parts of the quadrangle) indicate bedrock dips north and south toward Lebanon creating a shallow syncline/basin with an axis paralleling the head of Hardins Creek, trending east just south of the Lebanon Fairgrounds. West of the knobs in the study area, groundwater is directed toward the axis of the syncline and ultimately drains into Hardins Creek through springs and tributaries. Wet or saturated conditions can be expected along and around the axis.

5.0 Design Expectations and Expected Foundation Considerations

5.1 Embankments

Generally, embankments built from the native soils and bedrock can be constructed to a height of 20 feet with 2H:1V side-slopes – if the foundation is suitable and proper compaction methods are used. Embankments constructed using the New Albany Shale are recommended to be encapsulated with two feet of clay shale to reduce oxidization. Any embankment built 20 feet or taller will require a stability analysis, which could necessitate a flatter slope be used.

5.2 Cut Slopes

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. Slope configurations for rock cuts in durable bedrock can generally be 1H:2V or 1H:4V presplit slopes on approximate 30-foot intervals of vertical height with 18 to 20-feet intermediate benches or 15-foot overburden benches. Slope configurations for non-durable bedrock or soils are generally constructed on a range of 2H:1V to 3H:1V slopes or flatter based on the height of the slopes and content of the material. A detailed cut stability analysis will most likely be necessary in the project area.

Any cut slopes encountering the New Albany Shale will require mitigation to prevent the oxidization of the pyrite. The typical recommendation is to encapsulate the exposed acid producing shale by excavating 4.5 feet (perpendicular to the 2:1 slope) using a serrated slope with benches spanning eight (8) feet horizontally and four (4) feet vertically. When the benches are built, the iron-sulfide bearing shale is covered with a minimum of four (4) feet of compacted clay shale or soil and 0.5 feet of topsoil (see example below).

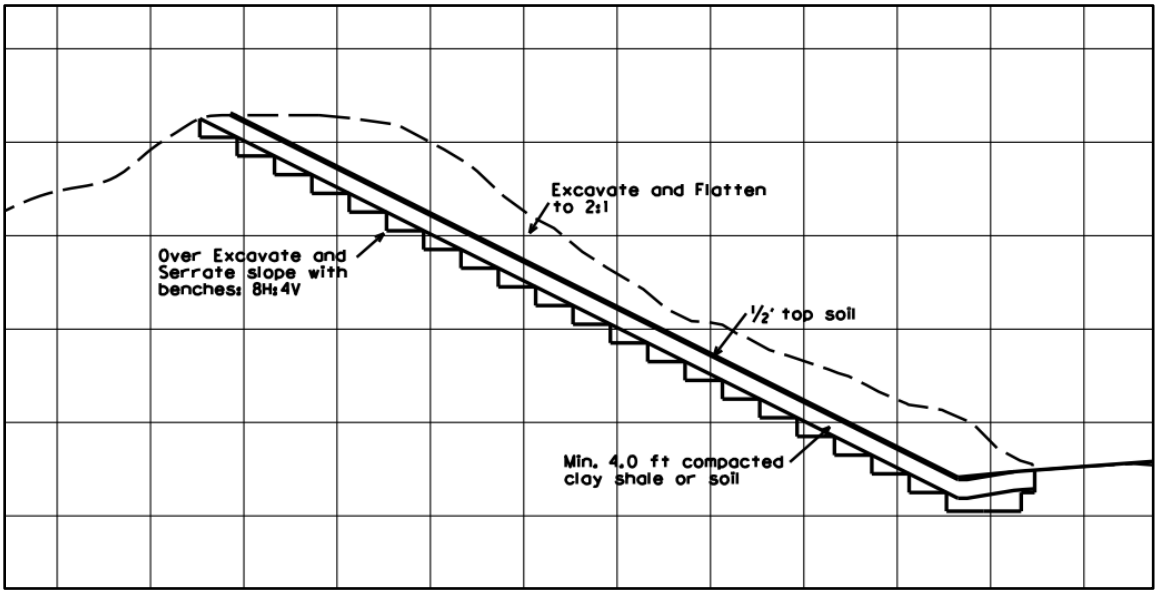


Figure 1: Typical cut slope recommendation for New Albany Shale

5.3 Structures

Past geotechnical projects along US 68 and KY 49 indicate shallow soils around structure foundations. Bridges in the study area are generally rock bearing (spread footings). Smaller structures such as retaining walls and box culverts may be constructed on soil or bedrock.

5.4 Saturated, Soft, or Unstable Soils

California Bearing Ratio (CBR) values in the area are generally low (in the range of 1-3). If rock roadbed is not available other methods of improving subgrade can be considered. Chemical stabilization is the preferred method of subgrade improvement. In areas where lanes are being added or chemical stabilization is not feasible (such as cross-overs, tie-ins, etc.) the subgrade can be constructed with Kentucky Coarse Aggregate No. 2, No. 3, or No. 23 sized stone with geotextile fabric.

Low and high plasticity clays can be very moisture sensitive. Working platforms may be necessary for cut and/or fill situations where soft and/or saturated soil is encountered. In these areas a working platform consisting of Kentucky Coarse Aggregate #2's, 3's, or 23's or limestone from roadway excavation wrapped with Geotextile Fabric may be required.

6.0 Past [Relevant] Geotechnical Reports

The following is a list of geotechnical reports that have been previously issued near the study area:

Roadway	**Landslide**	**Planning**	**Structure**
R-025-2007	L-015-2009	P-004-2001	S-097-2004
R-003-2008	L-060-1997	P-010-2013	S-061-2015
R-016-2013			S-089-2015
R-021-2013			S-005-2017
R-016-2015			
RA-008-2008			

7.0 Conclusion

This is a general overview of the geotechnical considerations that need to be taken in to account during alignment selection and construction. This includes the bedrock, soil, and geotechnical hazards that are expected to be encountered in the project corridor. These features may have adverse impacts on the project.

A complete Geotechnical investigation including drilling, sampling, and testing of materials will be needed to anticipate and plan for any special treatment of issues encountered during that phase. This may include the taking of pavement cores were directed by the project team. Analysis of rock core and soil sample testing will be compiled and presented in a Geotechnical Engineering Roadway Report and a Structure Report if needed.

Attachments:

- Site Photos
- Site Map
- Geologic Map
- Karst Potential Map

Site Photos

Image 1: East Lebanon, looking West along US 68. Note the poor quality and natural slope of the shale.

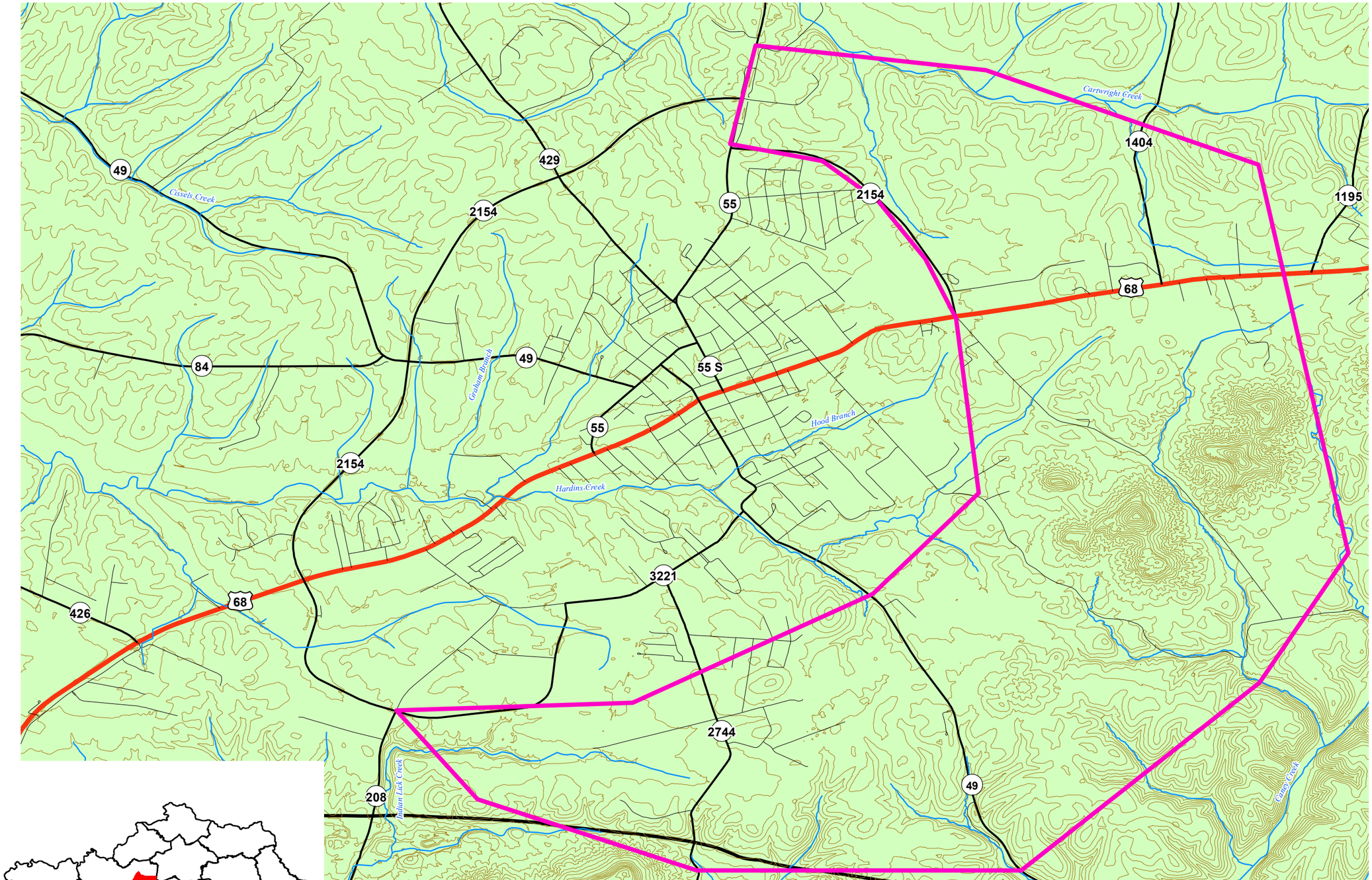
Image 2: On Fairgrounds Road, south of knobs in study area. Not the strata underlying the knob and present drainage issues.

Image 3: Under bridge on KY 1195, looking west. Note the outcrop.

Image 4: Looking East toward the knobs across from intersection of KY 55 and the bypass (KY 2154). Note the general topography of the study area north of US 68.

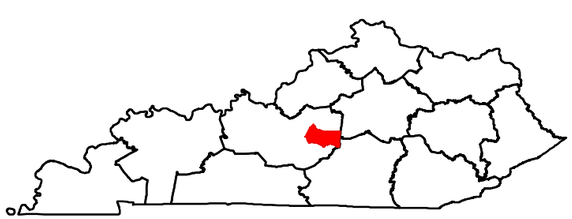
Image 5: Looking south along tributary to Hardins Creek under KY 2154. Notice the vegetation bent by water flowing beyond its banks.

Marion 4-80153.00 - Site Map



Legend

- Streams
- Other Roads
- State Routes
- US 68
- Area of Study



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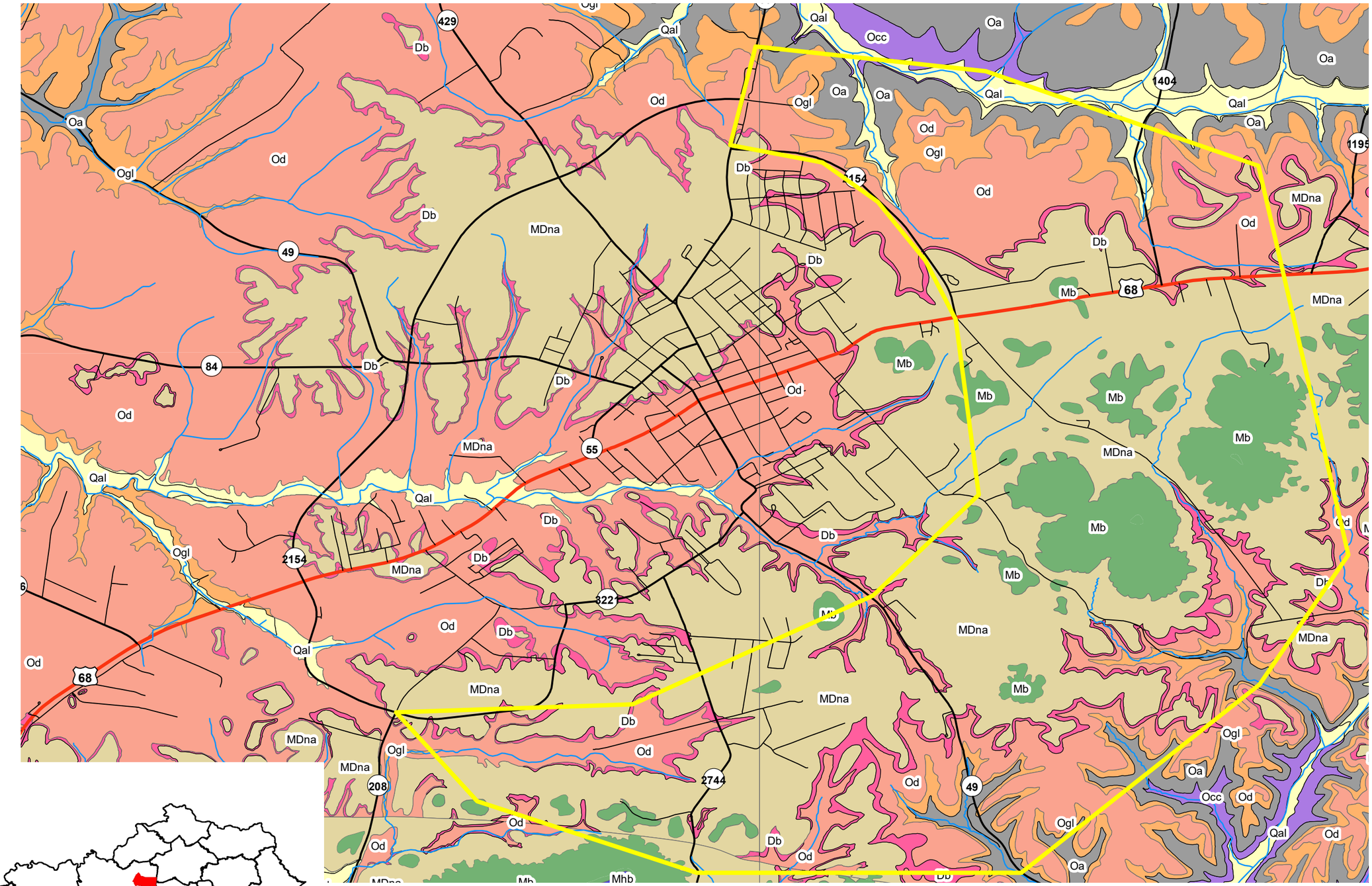
Marion 4-80153.00 Geologic Map



Marion 4-80153.00 Karst Potential