APPENDIX E:
Geotechnical Overview

M E M O R A N D U M

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SUBJECT: **Rowan County**
FH02 103 0032 004-008
KY 32 Corridor Study
From KY 377 Intersection to US 60 Intersection
MP 4.497 to 8.439
Mars # 1202407P
Geotechnical Overview Report

1.0 Project Description

The Kentucky Transportation Cabinet (KYTC) is conducting a study to identify and evaluate the KY 32 corridor in Rowan County, stretching from the KY 377 (MP 4.5) intersection to the US 60 (MP 8.4) intersection. This overview will be utilized to identify geotechnical considerations for the study area. The project location and corridor are presented on the drawing provided (Appendix A).

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 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:

- USGS Professional Paper 1151-H: The Geology of Kentucky: Physiography;
- USGS Professional Paper 1151-H: The Geology of Kentucky: Mississippian System;
- Geologic Map of the Morehead Quadrangle (GQ# 1022), by Harry P. Hoge and James R. Chaplin, published by the USGS, 1972;
- Quaternary Geologic Map of the Morehead 7.5 Minute Quadrangle, Eastern Kentucky, by Monte Rivers and Charlie Mason, compiled by Scott Waninger, published by the KGS, Contract Report 44 Series 12, 2011;
- USDA Web Soil Survey, https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm;
- Available KYTC Arcmap Datasets and Layers
- KYTC Projects Nearby (KYTC Geotechnical Report Number):

- Structures situated along the relocated KY-32 (S-082→084-2001)
- KY-32 relocation from Morehead to Flemingsburg Road (R-032-2001)
- Relocation of 2nd Street (CS-1008) (R-031-2008)
- US 60 cut slope and MSE slope retention (R-013-1993)
- KY-377 reconstruction from KY-32 to KY-799 (R-010-2015)

2.1 Topography and Drainage

The project study area is located in a small wedge of the Mississippian Plateau Physiographic Region sandwiched between the Outer Bluegrass Physiographic Region and the Eastern Kentucky Coal Field Physiographic Region. This region is characterized with rounded hills and ridges, narrow valleys with high gradient streams, and a few wide, locally swampy bottoms underlain by weak shales. Typical vertical relief is in the magnitude of 200-300 feet.

Surface drainage from the study area is directed towards unnamed tributaries of the North Fork of Triplett Creek and Triplett Creek and follows a dendritic pattern as a result of bedrock with fairly uniform resistance to erosion. The North Fork of Triplett Creek is located just north of the KY-32 and I-64 intersection and flows approximately southwest. Triplett Creek is located on the south edge of downtown Morehead with a southwest bearing. The two creeks meet approximately 3.5 miles southwest of the project area where they eventually flow into the Licking River near the community of Farmers, Kentucky.

2.2 Stratigraphy

Available geologic mapping (Morehead Geologic Quadrangle (#1022)) indicates the project area to be underlain by a mixture of Mississippian-age through Devonian-age sedimentary rocks. In descending order, they are the Cowbell, Nancy, and Farmers Members of the Borden Formation, the Sunbury Shale and Bedford Shale, and Ohio Shale formations.

The Cowbell Member of the Borden Formation is located at the top of hillsides within the study area. It is composed of siltstone with interbedded silty shale. This formation tends to be very resistant, forming steep slopes throughout the area.

The Nancy Member of the Borden Formation underlies the Cowbell Member and forms gentle slopes. Bluish-gray shale, silty shale, and thin-bedded siltstones are interbedded throughout the formation. The Nancy Member is less resistant than the Cowbell Member.

The Farmers Member of the Borden Formation underlies the Nancy Member and is typically exposed along tributaries at lower elevations. It is composed of evenly bedded siltstone or very fine sandstone. This formation tends to be resistant to weathering and forms steep slopes.

Figure 1. Base of the Farmers Member 0.2 miles south of KY-377.

The sequence of the Sunbury Shale and Bedford Shale of the Mississippian Epoch and the Ohio Shale of the Devonian Period occurs only in northeastern Kentucky. The Bedford Shale consists of gray or greenish-gray shale with sparse to abundant, very thin silty beds, and pyritic nodules. The Sunbury Shale is a black carbonaceous and pyritic shale that is lithologically identical to the Ohio Shale.

Figure 2. Exposed Sunbury Shale on KY-32 at bridge over North Fork of Triplett Creek.

2.3 Soils and Unconsolidated Materials

The ridgetops consists of residual soils. Residual soils are derived in-place from a weathering process of the parent bedrock material. These thin units are typically interbedded fine-grained rock and silt soil, few large angular rock pieces that maintain sedimentary rock structure.

The hillsides consists of colluvium. Colluvium is a locally derived residuum that has accumulated and/or migrated downslope due to gravity. They can consist of unconsolidated sand, gravel, silt, clay, cobbles, and boulders. Thicknesses can range in depth depending on the landscape position and underlying bedrock lithology. Typically colluvial slopes are thickest at the base (toe slopes) and thin and discontinuous on the side slopes.

At the base of the hillsides, wedge shaped deposits with a hummocky topography have accumulated. These deposits are an accumulation of the gravity driven residuum that were located on the hillsides. These deposits tend to be thick with accumulations of up to 40 feet and consist of unconsolidated sandy, gravel, silty, clay, cobbles, and boulders.

Alluvium deposits occupy the modern stream channels and floodplains. They consist of unconsolidated sand, silty, gravel, and clay.

3.7 Geologic Structures and Hazards

Structural contours mapped in the northwest corner of the Morehead Geologic Quadrangle (GQ # 1022) were drawn on top of the Farmers Member of the Borden Formation. The structural contours reveal the top (crest) of an anticline with a NE/SW bearing running through the middle of the study area. From the crest, the rock declines approximately four degrees southeast towards downtown Morehead and eight degrees northwest towards I-64. The Geotechnical Branch does not anticipate any concerns due to the structural geology of the area.

Faults, karst (Appendix C), or other geologic structures that could have a detrimental effect on the project are not noted on the geologic mapping.

Pyrite oxidation in the Sunbury Shale and Ohio Shale can cause serious geotechnical and environmental problems. They contain various clay and 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 mine drainage, and accelerated weathering of rock. Problems are also related to expanding clays in the shale.

3.8 Quarries

On the east side of KY 32, at approximate mile point 6.9, lies what appears to be an abandoned surface quarry. Mine maps at the Department of Mines and Minerals were not available. However, geologic mapping indicates that the Farmers Member of the Borden Formation has been quarried for building stone for local use. Surficial mapping indicates that unconsolidated and consolidated material generated from surface rock quarries has been placed in the narrow valleys of the area.

Figure 3. Abandoned surface quarry on the east side of KY-32.

3.0 Geotechnical Considerations

A site investigation was performed on May 6th, 2021 to help identify any geotechnical deficiencies with the current alignment. Based on the available resources combined with a site investigation the Geotechnical Branch does not anticipate any large scale geotechnical concerns.

3.1 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. Slope configurations for rock cuts in durable bedrock can generally be 1H:2V 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 2H:1V slopes or flatter.

The Nancy and Cowbell Members of the Borden Formation are the dominant rock formation in the project corridor. Several cuts, with the largest measuring 108 feet by hand level, were observed during a field visit. General observations include: near vertical cut slopes, interbedded non-durable shale and more weather resistant siltstone, over hanging bedrock caused by differential weathering, block failures caused by fractures, debris filled ditches, and Jersey Barrier lined ditches.

Fig. 4

Fig. 5

Fig. 6

Figure 4. Overhang on east side of KY-32.
Figure 5. Road cut exposing Nancy and Cowbell Members of the Borden Formation.
Figure 6. Large rock debris in ditch of KY-32 caused by differential weathering and joints paralleling cut surface.

A detailed geotechnical exploration will be required for areas that involve widening existing cuts or creating entirely new cuts. Based on observations of the current cut slopes, areas that contain higher amounts of more durable siltstone can be anticipated to support pre-split slopes of 1H:2V with carefully placed intermediate benches. The use of extended roadside ditch benches and Jersey Barriers appear to be effective against falling debris. Cuts located in the Sunbury Shale, Bedford Shale, and Ohio Shale can be anticipated to be constructed on 2H:1V slopes or flatter due to their low resistance to weathering.

The Sunbury Shale and Ohio Shale may be encountered on the northern part of the study area. As previously stated, these clay and iron-sulfide bearing formations can have adverse geotechnical reactions when exposed to water and air. Typically, when encountered in cut sections, to prevent exposure to the elements, it is recommended to excavate 4.5 feet (perpendicular to the 2:1 slope) and cover the iron-sulfide bearing shale with a minimum of 4 feet of compacted clay shale or soil and 0.5 feet of top soil.

The project location tends to have shallow soil depths. In the case where insufficient quantities of clay shale is available from roadway excavation it may be required to further excavate the iron-sulfide bearing shale and cover it with a thicker layer of excavated material. Any stockpiling of the acidic shales will require controlled drainage.

Cut slopes on ridge flanks where deep deposits of colluvium have accrued should be avoided. These areas can be subjected to groundwater seepage, erosion, creep displacement, and expansion/contraction of the shales and residual soils. The removal of toe support can accelerate the rate of creep or cause outright slope failures.

3.2 Embankment Considerations

Material excavated from the project would most likely consist of a mix of durable and non-durable shales. Embankments principally of non-durable shale (SDI less than 95 according to KM 64-513) should be constructed using special shale compaction methods. If this construction method is not followed the shale can break down in a few years causing settlement and potential failures.

With proper construction methods embankments constructed on 2H:1V slope configurations or flatter can be anticipated for slopes up to 20-feet tall. Foundation soils are likely to be shallow and consist of low plasticity clays. Any embankments built 20-feet or taller will require stability analysis and may require flatter slopes.

If the excavated Sunbury Shale or Ohio Shale is placed within an embankment, the iron-sulfide shale is typically wrapped with a minimum 2.5 feet thick layer of clay soil. However, a minimum of 4 feet of soil is recommended at the top of the embankment to control the corrosion of guardrail and/or sign posts, etc. from the acidic shale.

3.3 Saturated, Soft, or Unstable Soils

Based on review it appears durable rock will not be sufficient to construct a roadbed for the entire project. Therefore, other methods of improving the 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.

If chemical stabilization is utilized pH testing of soils that directly overlie the Sunbury Shale and Ohio Shale formations may be required. In areas where the two shale formations are encountered at proposed grade in cuts or have a pH less than or equal to 6, the represented interval should be pretreated with lime 24-48 hours before chemical stabilization begins.

Natural streams or drains may be encountered within the project limits along with possible springs. Any saturated or unstable areas encountered within embankment foundation limits may need to be stabilized and the stream channel may need to be redirected or have pipes installed.

3.4 Water Wells and Springs

Springs may be present within the proposed study area. These locations should be inventoried to verify their locations. Spring boxes and/or granular material may be required in the vicinity of springs. All water wells and/or cisterns within the limits of construction, whether shown on the plans or not, shall be plugged in accordance with Section 708 of the current Standard Specifications for Road and Bridge Construction.

3.5 Gas and Oil Wells

Based on the available mapping, there are oil and gas wells in the vicinity of the project study area. These wells are depicted on the mapping in Appendix D. Any gas wells within the proposed right-of-way limits, shall be treated in accordance with Mines and Mineral Specifications.

3.6 Structures

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. Culverts along the proposed alignments may be replaced or widened. The culverts within the study area are likely supported by either 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.

3.7 Abandoned Quarry

As previously stated there lies an abandoned surface quarry on the east side of KY-32 at mile point 6.9. Directly adjacent to KY-32 lies what is described on geologic surficial mapping as "Artificial fill" which is unconsolidated and consolidated material generated from surface rock quarries during mining and placed in valleys and narrow valleys. As is, the fill reaches 20-feet in height and lies on a 2H:1V slope with Jersey Barriers placed at the toe of the slope.

Figure 7. Artificial fill from mine activities.

Mine spoil is notorious for slope instability and poor subgrade quality. Extended disturbed limits should be considered when dealing with this area to account for special construction methods that may be required to achieve maximum safety.

4.0 Conclusions

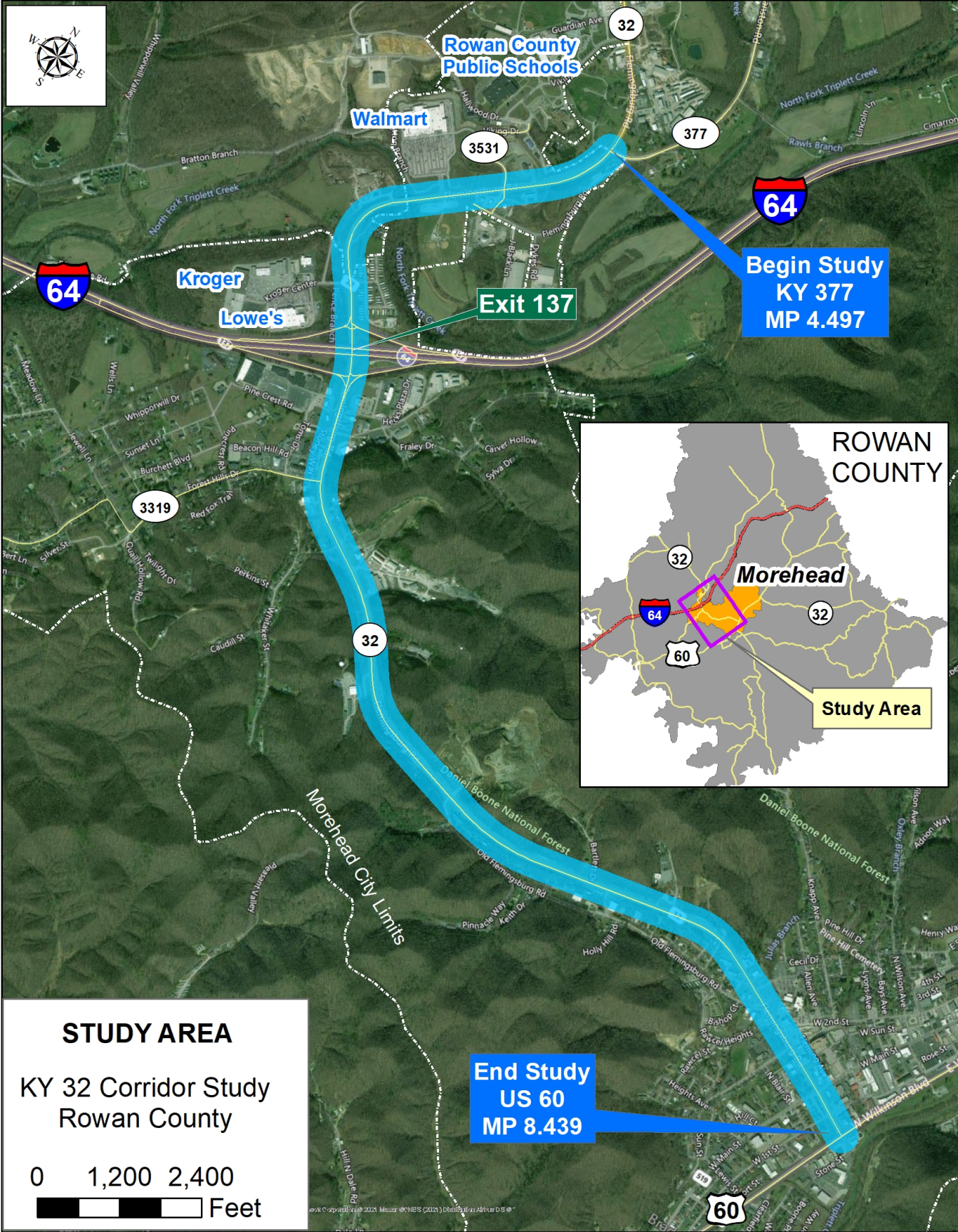
The purpose of this overview was to provide a general summary of the bedrock, soil, and geomorphic features likely to be encountered within the proposed alignment; and to identify geotechnical features that may have an adverse impact on the project.

Geotechnical drilling will be needed for roadway cut/fills and accompanying structures. If a portion of this project is a widening project, information on pavement structure should be obtained to assist the team in pavement design. Sampling of foundation soils should be performed for embankment situations.

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 (Study Area Corridor)
APPENDIX B (Geologic Map)
APPENDIX C (Karst Potential Map)
APPENDIX D (Water, Gas, and Abandoned Wells)

Appendix A
Study Area Corridor


Rowan County Public Schools
Walmart
Kroger
Lowe's
Exit 137
Begin Study
KY 377
MP 4.497
End Study
US 60
MP 8.439
Morehead City Limits
Daniel Boone National Forest
ROWAN COUNTY
Morehead
Study Area
STUDY AREA
KY 32 Corridor Study
Rowan County
0 1,200 2,400
Feet

Appendix B
Geologic Map

Rowan County
KY - 32

Planning Study
Corridor Study from
KY-377 to US-60

Study Area

Legend

Geologic Formations

- Alluvium
- Borden Formation, Upper Part
- Farmers Member, Borden Formation
- Nancy Member, Borden Formation
- Sunbury Shale, Berea Sandstone, and Bedford Shale
- Ohio Shale
- Lake

0 875 1,750 3,500 Feet

USGS, DGI

Appendix C
Karst Potential Map

Rowan County
KY - 32

Planning Study
Corridor Study from
KY-377 to US-60

Study Area

Legend

- Interstates
- US Highways
- State Roads
- Local Roads

Karst

- INTENSE
- PRONE

0 875 1,750 3,500 Feet

USGS, DGI, Kentucky Division of Geographic Information (DGI) & USGS

Appendix D
Water, Gas, and Abandoned Wells

Rowan County
KY - 32

Planning Study
Corridor Study from
KY-377 to US-60

Study Area

Legend

- Interstates
- US Highways
- State Roads
- Local Roads
- Gas Well
- Dry and Abandoned Well
- Water Wells (Agriculture)

0 875 1,750 3,500 Feet