APPENDIX E.

GEOTECHNICAL OVERVIEW

GEOTECHNICAL OVERVIEW

KY 30 SCOPING STUDY

FROM US 421 AT TYNER TO KY 11 NEAR BOONEVILLE
OWSLEY-JACKSON COUNTIES
ITEM NO. 10-279.50

BY:

QORE, INC.
LEXINGTON, KENTUCKY

FOR:

WILBUR SMITH ASSOCIATES
LEXINGTON, KENTUCKY

NOVEMBER 2001

November 27, 2001

Wilbur Smith Associates
465 East High Street, Suite 100
Lexington, KY 40507-1938

Attention: Mr. Michael E. Merriman, P.E.

Reference: Geotechnical Overview for Kentucky State Route 30 Scoping Study
Between US 421 at Tyner and KY 11 at Booneville, Kentucky
Owsley & Jackson Counties
Item No. 10-279.50
QORE Project No. 24301765

Dear Mr. Merriman:

QORE personnel have reviewed the six (6) proposed alternate corridors for the KY 30 scoping study between Tyner and Booneville. This work was performed in general accordance with our letter agreement dated June 29, 2001.

General Topography

The proposed corridors lie in Jackson and Owsley Counties, Kentucky and generally have a southwest/northeast orientation. Moderately sloping mountains with narrow valleys characterize this general area. The project will be constructed across five USGS (United States Geologic Survey) quadrangle maps. General location and topographic information about the potential project site for each quadrangle is listed below:

Quadrangle	*Location on Quadrangle*	*Elevation Ranges*
Tyner	Northeast corner	1060 to 1360 feet
Mauldin	Northwest corner	1060 to 1340 feet
McKee	Southeast corner	1020 to 1340 feet
Sturgeon	Southwest corner extending to the east side	840 to 1367 feet
Booneville	West side	740 to 1320 feet

General Geology

Based on the geologic information from the USGS Geologic Quadrangles for the five quadrangles, the western quadrangles (Tyner and McKee) are underlain by the Breathitt

and Lee Formations. The eastern quadrangles (Maulden, Sturgeon, and Booneville) are underlain by the Breathitt Formation. Alluvium (water transported soils) is indicated along the bottoms of the major drainage ways. The majority of the proposed corridors are underlain by the Pikeville Formation, with the Grundy Formation present near the lower elevations of the valleys. Please reference the attached "Geology of Corridors" exhibit for details. Also, please reference the attached generalized "Geologic Column" exhibit for descriptions of the applicable geologic units.

In general, the Breathitt and Lee Formations are comprised of sandstone, siltstone, shale, and coal seams. There are only a few major coal seams which are commonly mined in this area. The shales are typically considered non-durable, while the sandstones are typically considered durable.

The local dip varies by quadrangle and generalized dips within the project areas are listed below:

Quadrangle	*Dip Direction*	*Dip (percent)*	*Dip (feet per mile)*
Tyner	East	nearly flat	nearly flat
Mauldin	Southeast	1.4	75
McKee	East	0.75	40
Sturgeon	East	1.1	60
Booneville	East	0.9	50

It is probable that the coal seams act as aquifers and allows groundwater flow. Therefore, this groundwater flow would likely be toward the east or southeast, or until it reaches daylight. From this point it would flow downhill to the valley bottoms and creeks. Acid mine drainage is a possibility due to previous coal mining activities. No fault lines were identified on the geologic maps. This project is in Seismic Risk Zone 1, which is defined as an area of minor damage that occurs with earthquake activity.

Previous Surface Mining

Surface (strip) mining has occurred in several areas near the proposed corridors. It appears that the majority of the surface mining is contour stripping, with some minor amounts of mountain top removal. As such, bench backfilling of the mined areas has been used. Further analyses and filed investigations will be necessary to determine if hollowfills have been constructed, or if there are slope instability problems.

Previous Deep Mining

Public records were reviewed at the Kentucky Department of Mines and Minerals in Frankfort, Kentucky to help determine the extent of underground mining within the region. The five quadrangles reviewed were: Tyner, Maulden, McKee, Sturgeon, and Booneville. It should be noted that these maps do not include all of the previous underground mining activity since mapping did not become commonplace until the

1970s. Therefore, unmapped deep mining, especially augering, may exist in some areas. Recorded underground mining is listed in the following table:

Quadrangle	Coal Seam	Status
Tyner	Unnamed seam at Elev. 1200	Not Mined
Maulden	Huckleberry Unnamed seam at Elev. 1060 Manchester	Not Mined Not Mined Not Mined
McKee	Tattlers (or Beattyville) Gray Hawk Manchester	Not Mined Not Mined Not Mined
Sturgeon	Jellico Unnamed seam at Elev. 1200 Gray Hawk Beattyville Manchester	Not Mined Not Mined Strip Mined Not Mined Not Mined
Booneville	Upper Elkhorn Amburgey Whitesburg Copeland Upper Elkhorn #3	Not Mined Not Mined Not Mined Not Mined Strip Mined

USGS geologic maps were reviewed for each of these quadrangles looking for mine adits (openings). Mine adits were indicated on the USGS geologic maps for the Maulden and Booneville Quadrangles. However, these mine adits did not appear on the Department of Mines and Minerals maps. It is possible that some, but not extensive, underground mining occurred near these adits.

Gas and Oil Wells

Gas and oil wells (active and abandoned) have been mapped based on available public records. Additionally, gas wells shown on the USGS topographic maps were also mapped.

Existing Problem Areas

There are several items of geotechnical concern to the proposed project. These are indicated on the attached "Areas of Geotechnical Concern" maps.

1. Previous surface mined areas are a concern due to their inherent problems (poor backfilling practices, random fill particle size, inadequate fill placement/compaction procedures, and acid mine drainage). The surface mined areas are indicated on the attached maps as vertical, blue crosshatched areas. Quarries were also indicated on the Tyner Quadrangle, but are not located within the project area.

2. Deep mined areas carry a risk of subsidence, or encountering the old mine works associated with shallow deep mines. The deep mined areas are indicated on the attached maps as horizontal, blue crosshatched areas.

3. Oil and/or gas wells are also of some concern to the proposed project. They present constructability (blasting, etc.) and monetary issues. Active wells are indicated in red, while dry or abandoned wells are shown in black.

Proposed Corridors

At present, there are six proposed corridors for this project — Corridors A through F. Each of these is presented in different colors on topographic maps that are attached to this report. Generally, all of the corridors diverge from Tyner, converge near Sturgeon, and then diverge again before converging near Levi.

Conclusions

From a geotechnical and constructability perspective, any proposed corridor alignment should avoid certain problem areas or potential geotechnical problems. A preferred corridor should avoid strip or deep mined areas because of the inherent problems associated with these types of mined areas. Additionally, the preferred corridor should avoid oil and/or gas wells for reasons previously discussed. Finally, the preferred corridor should be located along the up-dip side (north or west side) of any side hill cut area(s) to lessen the possibility of future groundwater problems.

From our initial geotechnical overview and based on the geologic considerations discussed in the previous sections, the proposed corridors would be ranked in the following order:

1) Corridor E – Contains the fewest areas of surface mining or potential deep mining, and avoids concentrations of oil and gas wells.
2) Corridor F – Avoids concentrations of oil and gas wells, but contains a small number of surface mining or potential deep mining sites in the northern portion of the study area.
3) Corridor A and Corridor C (tie) – Contain few areas of surface mining or potential deep mining, but cross a concentration of oil and gas wells just east of Mummie.
5) Corridor B – Also crosses a concentration of oil and gas wells just east of Mummie and contains a small number of surface mining or potential deep mining sites in the northern portion of the study area.

6) Corridor D - Crosses a concentration of oil and gas wells just northeast of Mummie and contains a small number of surface mining or potential deep mining sites in the northern portion of the study area.

Since all of the proposed corridors basically converge near Sturgeon, we also divided the corridors into two "sections" – from Tyner to Sturgeon, and from Sturgeon to Levi. Based on previously discussed criteria, the southern route from Tyner to Sturgeon (Corridors E and F) presents the best options. From Sturgeon to Levi, the all of the southern routes (Corridors A, C, and E) again presents the best options.
Further refinement of the proposed corridors and field observations will be necessary to provide a definitive "preferred" geotechnical corridor. Each of the proposed corridors should provide adequate fill disposal areas within the project limits. Therefore, the proposed corridors were not evaluated based on fill limitations.

Recommendations

The following general recommendations are applicable to any of the proposed corridors:

1. Fill for embankments will likely consist primarily of shot rock since soil overburden is thin in most areas. Shot rock fill can be placed according to requirements as specified in the *Kentucky Transportation Cabinet, Department of Highways, Standard Specifications for Road and Bridge Construction* (*latest edition*).

2. Shrink/swell of newly placed fill should not be of significant concern in most areas. However, consolidation of soft, alluvial soils near the valley bottoms may present some settlement concerns for embankments or for box culverts or other drainage structures.

3. For preliminary estimating purposes only, a California bearing ratio (CBR) of 5 percent is recommended. This value represents a conservative value based on the assumption that the majority of the fill placed for the pavement subgrade will consist of a mixture of soil and shot rock materials. If a 2-foot thick durable rock roadbed is specified, a CBR value of 11 can be considered. The local geology suggests that there may be durable sandstone available within certain portions of the proposed corridors.

4. It is recommended that the preferred corridor avoid contour strip or deep mined areas, if possible. Acid mine drainage is one concern for these areas and could be encountered—either from new cuts or from old mined areas. Special construction considerations or methods may be required to mitigate the acid mine drainage.

5. Groundwater seeps or springs should be expected in down-dip cut areas—especially those cuts that intersect a coal seam. As such, special construction

considerations will likely be required to collect and pipe groundwater in these areas.

6. Cut slopes in massive, durable sandstone are typically stable at 1H:20V (horizontal to vertical). Cut slopes in durable shale or fractured sandstone are typically stable at 0.5H:1V. Cut slopes in non-durable shale should be stable at 1H:1V or flatter. Pre-splitting will be required once the rock disintegration zone (RDZ) has been encountered. An overburden bench and flattened cuts slopes will be required above the RDZ. Since there has been no geotechnical work completed for this project, rock coring and additional geologic evaluation will be required before specific cut slope recommendations can be defined.

7. Cut slopes in mine spoil fill will likely require 3H:1V outslopes. Due to the likelihood of highly variable subsurface conditions in mine spoil fill areas, special construction considerations may be required dependent upon the specific conditions encountered.

8. Fill slopes constructed of shot rock fill are generally stable at 2H:1V. Flatter slopes may be required depending upon the shear strength parameters of the fill material. Rock toe buttresses may be necessary at the toe of fill slopes in deep alluvium soil areas.

CLOSURE

QORE appreciates the opportunity to participate in this project. Please contact us if you have any questions about this report.

Respectfully submitted,

QORE, INC.

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Kentucky 14527

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Senior Engineer

24301765/GEOreport

Leighton
Heidelberg
Beattyville
Booneville
Sturgeon
Maulden
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327GRND
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Location Map

Information Source: Kentucky Geologic Survey

Legend

- Corridor A
- Corridor B
- Corridor C
- Corridor D
- Corridor E
- Corridor F

EDUCATION PAYS

Geology of Corridors

Owsley and Jackson Counties
Item No. 10-279.50

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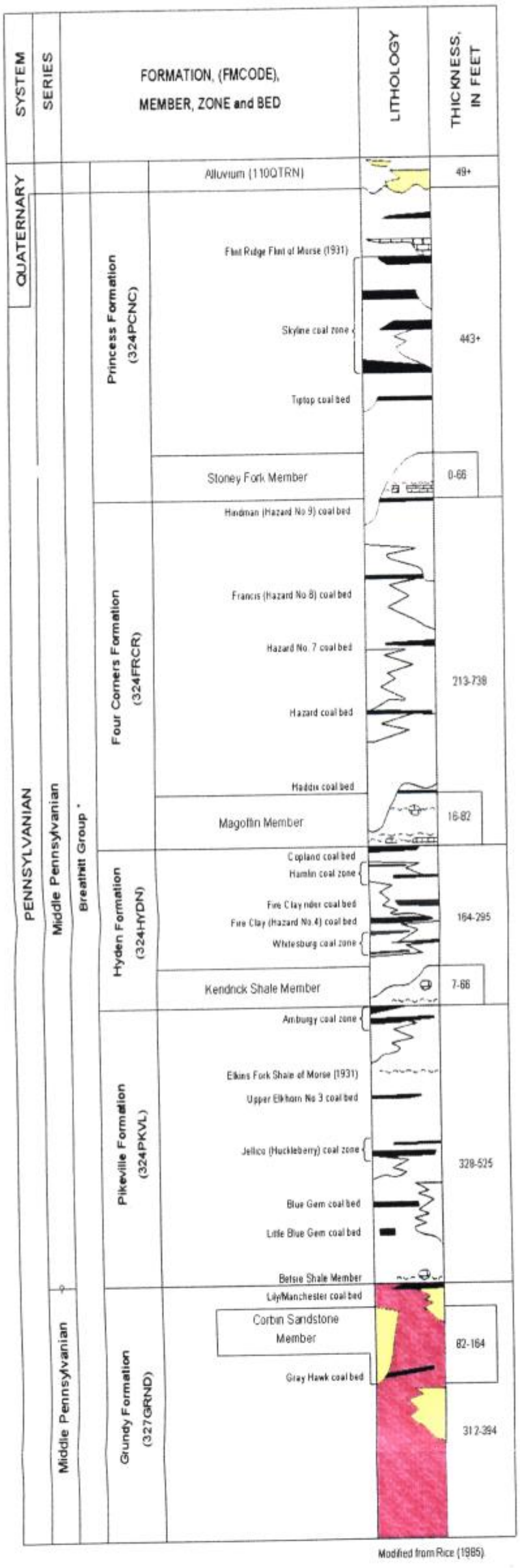

Modified from Rice (1985)

*Breathitt Group replaces Breathitt Formation (Chesnut, 1992). Group is divided into formations based upon widespread shales with marine fossils (all previously recognized as members). Formations occurring in this quadrangle are the Grundy, Pikeville, Hyden, Four Corners, and Princess (Chesnut, 1992).

DESCRIPTIONS OF MAPPED UNITS

Qal

ALLUVIUM (QUATERNARY) — Sand, silt, clay, and gravel. Clay, silt, and sand dominate rivers and tributaries, but pebbles and cobbles of locally derived sandstone, limestone, and coal also occur, especially in tributaries. Silts locally occur as remnants of alluvium on cutoff meanders and terrace deposits of larger rivers. Unit commonly grades into colluvium and landslide debris (not mapped) along valley sides. Only larger alluvial deposits are mapped, and contacts are approximately located.

BREATHITT GROUP (LOWER TO MIDDLE PENNSYLVANIAN) — The Breathitt was mapped as a formation on the twenty-four 7 5-minute geologic quadrangle maps that were used to construct the Hazard 30 x 45 minute quadrangle map, but Chesnut (1992) elevated the Breathitt to Group status and divided the group into formations based on regionally widespread shale members with marine fauna. Several of these shale members were mapped on the 7 5-minute maps and are described below. The Breathitt Group contains conglomerates, sandstones, siltstones, shales, coals, and limestones. Two types of sandstones occur: quartzarenites (more than 90 percent quartz), in the Corbin Sandstone Member, which was previously assigned to the Lee Formation, but was reassigned to the Grundy Formation by Chesnut (1992), and an unnamed sandstone beneath the Corbin Sandstone, informally called the Hazel Patch sandstone (Blancher and Brown, 1970). More common in the rest of the Breathitt Group are light- to medium-gray, tan- to brown-weathering sandstones that are fine to medium grained, locally coarse grained, siliceous but locally calcareous, and arkosic to sublitharenitic. They consist of 60 to 80 percent quartz, 2 to 15 percent feldspar, and lesser amounts of mica, opaque minerals, and rock fragments. Conglomerates in the Corbin are composed of quartz pebbles; in other Breathitt sandstones they consist of shale, siderite, and coal clasts.

All the formations in the Breathitt Group are lithologically similar. The shale members (Betsie, Kendrick, Magoffin, Stoney Fork) at the base of each formation generally contain a thin, black to dark-gray clay shale and discontinuous, dark-gray to black limestone or sideritic sandstone with common marine fossils (summarized in Chesnut, 1991a). Basal shales grade upward into laminated, dark-gray silty shale with abundant siderite laminae and nodules, elliptical saucer-shaped carbonate concretions, and scarce fossils. Silty shales coarsen upward into thin-bedded, often bioturbated siltstone interbedded with fine-grained, ripple-bedded sandstone and shale; the siltstone-sandstone-shale unit in turn coarsens upward into massive to crossbedded sandstone, which may truncate the coarsening-upward profile.

Coarsening-upward shale members are overlain by four to five coal zones. Each zone consists of multiple coals that may split laterally or grade into carbonaceous shales and rooted seat rocks, although at least one of the coals is usually extensive and mapped on the 7 5-minute quadrangle maps. Coal zones are separated by shales, siltstones, and sandstones, and generally exhibit considerable lateral variability. Some sandstones are locally extensive and useful as stratigraphic markers.

Ppr

PRINCESS FORMATION (MIDDLE PENNSYLVANIAN) — Named by Chesnut (1992) for strata between the base of the Stoney Fork Member and the base of the Conemaugh Formation, which is not preserved in this quadrangle. The formation is equivalent to a unit mapped as the upper Breathitt Formation by Rice (1985). The base of the Stoney Fork Member (Ping and Rice, 1979) is locally a thin (0 to 4 ft) carbonate, which was mapped on some 7 5-minute quadrangle maps as the Lost Creek Limestone of Morse (1931); the Lost Creek Limestone is not currently recognized as a formal bed. In the northeastern part of the Hazard Quadrangle, a second carbonate, the Flint Ridge Flint (Morse, 1931), occurs above the Skyline coal zone and is mapped on some 7 5-minute quadrangle maps. The Flint Ridge Flint consists of tan chert and yellowish-gray to dark-gray, sparsely fossiliferous, thin-bedded limestone and sandstone; it is generally less than 3 ft thick, although it may be as much as 30 ft thick in channel deposits (Hinrichs, 1978b). Coals in the Princess Formation, in descending order, are the Skyline coal zone (Hazard No. 11), equivalent to the upper and lower Knob coal zone (Hinrichs, 1978b), (Mixon, 1965a–b), and the Tiptop (Hazard No. 10) coal. Because the formation occurs only in the tops of hills in the northeastern part of the Hazard Quadrangle, it is generally not well exposed, although the Stoney Fork Member is exposed in upper roadcuts along Kentucky Highway 80 in the Hazard North 7 5 minute quadrangle (Cobb and others, 1981; Chesnut, 1991b).

Pfc

FOUR CORNERS FORMATION (MIDDLE PENNSYLVANIAN) — Named by Chesnut (1992) for strata between the base of the Magoffin Member and the base of the Stoney Fork Member, which is equivalent to the middle Breathitt Formation of Rice (1985). The Magoffin Member (Outerbridge, 1978), which is equivalent to the Magoffin Beds of Morse (1931) and earlier usage, is the most widely recognized of the marine zones in the Breathitt Group; it varies from 0 to 85 ft in thickness across the Hazard Quadrangle, thickening to the east. The base of the unit was used as a color break on many of the 7 5-minute quadrangle maps that compose the Hazard Quadrangle. Coals in the Four Corners Formation, in descending order, are the Hindman (Hazard No. 9), Francis (Hazard No. 8), Hazard No. 7, Hazard zone (which includes the Leatherwood, Hazard No. 5, Hazard No. 5A, and Hazard No. 6 coals), and the Haddix zone. This unit was named for the Four Corners exposure at the intersection of Kentucky Highway 15 and Kentucky Highway 80 (Cobb and others, 1981), and is also well exposed along the Daniel Boone Parkway west of Hazard (Horne, 1978) and along Kentucky Highway 80 east of Hazard (Chesnut, 1991b).

Ph

HYDEN FORMATION (MIDDLE PENNSYLVANIAN) — Named by Chesnut (1992) for strata between the base of the Kendrick Shale Member and the base of the Magoffin Member. The Kendrick (Jillson, 1919) varies from 0 to 45 ft in thickness and was not mapped on several 7 5-minute quadrangle maps because it had been replaced by sandstone (e g , Rice and Lee, 1978). Where the Hyden Formation is missing, the top of the Amburgy coal is considered the base of the formation. Coals in the Hyden Formation, in descending order, are the Copland, Hamlin zone, Fire Clay rider, Fire Clay (Hazard No. 4), and Whitesburg zone. The Fire Clay coal contains a distinctive 2- to 6-in -thick, black to brown flint clay with conchoidal fracture that was deposited as a volcanic ash deposit. Sanidines in the flint clay have been radiometrically dated at 312 ±1 Ma by Lyons and others (1992) and 311 ±1 Ma by Rice and others (1994). The Fire Clay coal and flint clay are well exposed along Kentucky Highway 15 near Carr Fork Lake (Eble and others, 1995). The formation crops out along the Daniel Boone Parkway west of Buckhorn Reservoir (Cobb and others, 1981), near the dam at Buckhorn State Park (Danilchik and Lewis, 1978a), and along the Kentucky Highway 15 bypass around Hazard (Eble and others, 1995).

Ppk

PIKEVILLE FORMATION (MIDDLE PENNSYLVANIAN) — Named by Chesnut (1992) for strata between the base of the Betsie Shale Member and the base of the Kendrick Shale Member. The Betsie Shale was defined by Rice and others in 1987 and was not shown on 7 5-minute quadrangle maps, although it normally occurs just above the Manchester-Lily coal, which was extensively mapped in 7 5-minute quadrangles in the western part of the Hazard Quadrangle. Coals in the Pikeville Formation that were mapped on 7 5-minute quadrangle maps are, in descending order, the Amburgy zone, Upper Elkhorn No. 3 zone, Jellico-Huckleberry zone, and the Blue Gem/Pond Creek zone. The Upper Elkhorn No. 3 coal is overlain by a carbonaceous shale containing marine fossils, called the Elkins Fork Shale, which was described on several 7 5-minute quadrangle maps. The Kendrick and Elkins Fork Shales are well exposed along the Daniel Boone Parkway in Clay County (Cobb and others, 1981).

Pg

GRUNDY FORMATION (LOWER PENNSYLVANIAN) — Named by Chesnut (1992) for strata from the top of the Bee Rock Sandstone to the base of the Betsie Shale. The upper part of the formation is locally dominated by thick, crossbedded, sandstones. The Corbin Sandstone Member may interfinger with lateral facies at the top of the unit. The upper part of the Grundy contains the Manchester-Lily coal, which is underlain by the Gray Hawk and Beattyville-Tattlers coal. The lower part of the Grundy does not crop out in the mapped area, but it does contain similar coal-bearing rocks.

Geologic Column

Owsley and Jackson Counties
Item No. 10-279.50

EDUCATION PAYS

Wilbur Smith Associates

Information Source: Kentucky Geologic Survey

LEE COUNTY

Leighton

Heidelberg

Beattyville

Pebworth

Levi

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Vincent

New Zion

Scoville

Travellers Rest

847

Erdee

JACKSON COUNTY

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Sturgeon

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OWSLEY COUNTY

Privett

Mummie

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Elias

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Blake

Booneville

Sturgeon

McKee

Oneida

Maulden

Tyner

Island City

Herd

Maulden

Zekes Point

1431

Tyner

Sourwood

CLAY COUNTY

Egypt

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Corridor A

Owsley and Jackson Counties
Item No. 10-279.50

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EDUCATION PAYS

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Corridor B

Owsley and Jackson Counties
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Owsley and Jackson Counties
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Owsley and Jackson Counties
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Corridor F

Owsley and Jackson Counties
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Location Map

Information Source: Kentucky Geologic Survey

Legend

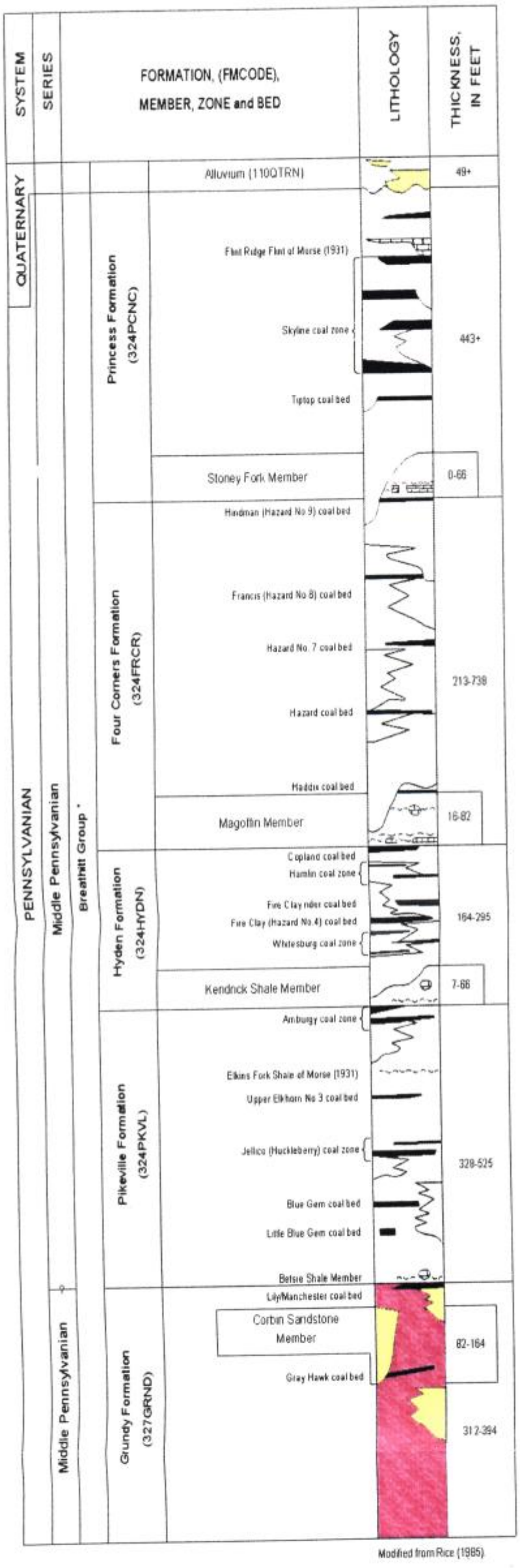
- Corridor A
- Corridor B
- Corridor C
- Corridor D
- Corridor E
- Corridor F

EDUCATION PAYS

Geology of Corridors

Owsley and Jackson Counties
Item No. 10-279.50

Printed: 12/03/01



Modified from Rice (1985)

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ALLUVIUM (QUATERNARY) — Sand, silt, clay, and gravel. Clay, silt, and sand dominate rivers and tributaries, but pebbles and cobbles of locally derived sandstone, limestone, and coal also occur, especially in tributaries. Silts locally occur as remnants of alluvium on cutoff meanders and terrace deposits of larger rivers. Unit commonly grades into colluvium and landslide debris (not mapped) along valley sides. Only larger alluvial deposits are mapped, and contacts are approximately located.

BREATHITT GROUP (LOWER TO MIDDLE PENNSYLVANIAN) — The Breathitt was mapped as a formation on the twenty-four 7 5-minute geologic quadrangle maps that were used to construct the Hazard 30 x 45 minute quadrangle map, but Chesnut (1992) elevated the Breathitt to Group status and divided the group into formations based on regionally widespread shale members with marine fauna. Several of these shale members were mapped on the 7 5-minute maps and are described below. The Breathitt Group contains conglomerates, sandstones, siltstones, shales, coals, and limestones. Two types of sandstones occur: quartzarenites (more than 90 percent quartz), in the Corbin Sandstone Member, which was previously assigned to the Lee Formation, but was reassigned to the Grundy Formation by Chesnut (1992), and an unnamed sandstone beneath the Corbin Sandstone, informally called the Hazel Patch sandstone (Blancher and Brown, 1970). More common in the rest of the Breathitt Group are light- to medium-gray, tan- to brown-weathering sandstones that are fine to medium grained, locally coarse grained, siliceous but locally calcareous, and arkosic to sublitharenitic. They consist of 60 to 80 percent quartz, 2 to 15 percent feldspar, and lesser amounts of mica, opaque minerals, and rock fragments. Conglomerates in the Corbin are composed of quartz pebbles; in other Breathitt sandstones they consist of shale, siderite, and coal clasts.

All the formations in the Breathitt Group are lithologically similar. The shale members (Betsie, Kendrick, Magoffin, Stoney Fork) at the base of each formation generally contain a thin, black to dark-gray clay shale and discontinuous, dark-gray to black limestone or sideritic sandstone with common marine fossils (summarized in Chesnut, 1991a). Basal shales grade upward into laminated, dark-gray silty shale with abundant siderite laminae and nodules, elliptical saucer-shaped carbonate concretions, and scarce fossils. Silty shales coarsen upward into thin-bedded, often bioturbated siltstone interbedded with fine-grained, ripple-bedded sandstone and shale; the siltstone-sandstone-shale unit in turn coarsens upward into massive to crossbedded sandstone, which may truncate the coarsening-upward profile.

Coarsening-upward shale members are overlain by four to five coal zones. Each zone consists of multiple coals that may split laterally or grade into carbonaceous shales and rooted seat rocks, although at least one of the coals is usually extensive and mapped on the 7 5-minute quadrangle maps. Coal zones are separated by shales, siltstones, and sandstones, and generally exhibit considerable lateral variability. Some sandstones are locally extensive and useful as stratigraphic markers.

Ppr

PRINCESS FORMATION (MIDDLE PENNSYLVANIAN) — Named by Chesnut (1992) for strata between the base of the Stoney Fork Member and the base of the Conemaugh Formation, which is not preserved in this quadrangle. The formation is equivalent to a unit mapped as the upper Breathitt Formation by Rice (1985). The base of the Stoney Fork Member (Ping and Rice, 1979) is locally a thin (0 to 4 ft) carbonate, which was mapped on some 7 5-minute quadrangle maps as the Lost Creek Limestone of Morse (1931); the Lost Creek Limestone is not currently recognized as a formal bed. In the northeastern part of the Hazard Quadrangle, a second carbonate, the Flint Ridge Flint (Morse, 1931), occurs above the Skyline coal zone and is mapped on some 7 5-minute quadrangle maps. The Flint Ridge Flint consists of tan chert and yellowish-gray to dark-gray, sparsely fossiliferous, thin-bedded limestone and sandstone; it is generally less than 3 ft thick, although it may be as much as 30 ft thick in channel deposits (Hinrichs, 1978b). Coals in the Princess Formation, in descending order, are the Skyline coal zone (Hazard No. 11), equivalent to the upper and lower Knob coal zone (Hinrichs, 1978b), (Mixon, 1965a–b), and the Tiptop (Hazard No. 10) coal. Because the formation occurs only in the tops of hills in the northeastern part of the Hazard Quadrangle, it is generally not well exposed, although the Stoney Fork Member is exposed in upper roadcuts along Kentucky Highway 80 in the Hazard North 7 5 minute quadrangle (Cobb and others, 1981; Chesnut, 1991b).

Pfc

FOUR CORNERS FORMATION (MIDDLE PENNSYLVANIAN) — Named by Chesnut (1992) for strata between the base of the Magoffin Member and the base of the Stoney Fork Member, which is equivalent to the middle Breathitt Formation of Rice (1985). The Magoffin Member (Outerbridge, 1978), which is equivalent to the Magoffin Beds of Morse (1931) and earlier usage, is the most widely recognized of the marine zones in the Breathitt Group; it varies from 0 to 85 ft in thickness across the Hazard Quadrangle, thickening to the east. The base of the unit was used as a color break on many of the 7 5-minute quadrangle maps that compose the Hazard Quadrangle. Coals in the Four Corners Formation, in descending order, are the Hindman (Hazard No. 9), Francis (Hazard No. 8), Hazard No. 7, Hazard zone (which includes the Leatherwood, Hazard No. 5, Hazard No. 5A, and Hazard No. 6 coals), and the Haddix zone. This unit was named for the Four Corners exposure at the intersection of Kentucky Highway 15 and Kentucky Highway 80 (Cobb and others, 1981), and is also well exposed along the Daniel Boone Parkway west of Hazard (Horne, 1978) and along Kentucky Highway 80 east of Hazard (Chesnut, 1991b).

Ph

HYDEN FORMATION (MIDDLE PENNSYLVANIAN) — Named by Chesnut (1992) for strata between the base of the Kendrick Shale Member and the base of the Magoffin Member. The Kendrick (Jillson, 1919) varies from 0 to 45 ft in thickness and was not mapped on several 7 5-minute quadrangle maps because it had been replaced by sandstone (e g , Rice and Lee, 1978). Where the Hyden Formation is missing, the top of the Amburgy coal is considered the base of the formation. Coals in the Hyden Formation, in descending order, are the Copland, Hamlin zone, Fire Clay rider, Fire Clay (Hazard No. 4), and Whitesburg zone. The Fire Clay coal contains a distinctive 2- to 6-in -thick, black to brown flint clay with conchoidal fracture that was deposited as a volcanic ash deposit. Sanidines in the flint clay have been radiometrically dated at 312 ±1 Ma by Lyons and others (1992) and 311 ±1 Ma by Rice and others (1994). The Fire Clay coal and flint clay are well exposed along Kentucky Highway 15 near Carr Fork Lake (Eble and others, 1995). The formation crops out along the Daniel Boone Parkway west of Buckhorn Reservoir (Cobb and others, 1981), near the dam at Buckhorn State Park (Danilchik and Lewis, 1978a), and along the Kentucky Highway 15 bypass around Hazard (Eble and others, 1995).

Ppk

PIKEVILLE FORMATION (MIDDLE PENNSYLVANIAN) — Named by Chesnut (1992) for strata between the base of the Betsie Shale Member and the base of the Kendrick Shale Member. The Betsie Shale was defined by Rice and others in 1987 and was not shown on 7 5-minute quadrangle maps, although it normally occurs just above the Manchester-Lily coal, which was extensively mapped in 7 5-minute quadrangles in the western part of the Hazard Quadrangle. Coals in the Pikeville Formation that were mapped on 7 5-minute quadrangle maps are, in descending order, the Amburgy zone, Upper Elkhorn No. 3 zone, Jellico-Huckleberry zone, and the Blue Gem/Pond Creek zone. The Upper Elkhorn No. 3 coal is overlain by a carbonaceous shale containing marine fossils, called the Elkins Fork Shale, which was described on several 7 5-minute quadrangle maps. The Kendrick and Elkins Fork Shales are well exposed along the Daniel Boone Parkway in Clay County (Cobb and others, 1981).

Pg

GRUNDY FORMATION (LOWER PENNSYLVANIAN) — Named by Chesnut (1992) for strata from the top of the Bee Rock Sandstone to the base of the Betsie Shale. The upper part of the formation is locally dominated by thick, crossbedded, sandstones. The Corbin Sandstone Member may interfinger with lateral facies at the top of the unit. The upper part of the Grundy contains the Manchester-Lily coal, which is underlain by the Gray Hawk and Beattyville-Tattlers coal. The lower part of the Grundy does not crop out in the mapped area, but it does contain similar coal-bearing rocks.

Geologic Column

Owsley and Jackson Counties
Item No. 10-279.50

EDUCATION PAYS

Wilbur Smith Associates

Information Source: Kentucky Geologic Survey

LEE COUNTY

Leighton

Heidelberg

Beattyville

Pebworth

Levi

399

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Vincent

New Zion

Scoville

Travellers Rest

847

Erdee

JACKSON COUNTY

846

Sturgeon

1071

OWSLEY COUNTY

Privett

Mummie

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Elias

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Blake

Booneville

Sturgeon

McKee

Oneida

Maulden

Tyner

Island City

Herd

Maulden

Zekes Point

1431

Tyner

Sourwood

CLAY COUNTY

Egypt

6000 0 6000 12000 Feet

Location Map

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EDUCATION PAYS

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Corridor A

Owsley and Jackson Counties
Item No. 10-279.50

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LEE COUNTY

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Zekes Point

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Sourwood

CLAY COUNTY

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Location Map

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EDUCATION PAYS

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Corridor B

Owsley and Jackson Counties
Item No. 10-279.50

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CLAY COUNTY
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EDUCATION PAYS

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Corridor C

Owsley and Jackson Counties
Item No. 10-279.50

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CLAY COUNTY
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Location Map

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EDUCATION PAYS

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Corridor D

Owsley and Jackson Counties
Item No. 10-279.50

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CLAY COUNTY
Egypt

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Location Map

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EDUCATION PAYS

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Corridor E

Owsley and Jackson Counties
Item No. 10-279.50

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LEE COUNTY
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Beattyville
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Location Map

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EDUCATION PAYS

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Corridor F

Owsley and Jackson Counties
Item No. 10-279.50

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LEE COUNTY

JACKSON COUNTY

OWSLEY COUNTY

CLAY COUNTY

To Beattyville

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To McKee

To London

To Manchester

Pebworth

Levi

Vincent

New Zion

Scoville

Travellers Rest

Endee

Sturgeon

Privett

Mummie

Elias

Blake

Herd

Island City

Maulden

Zekes Point

Tyner

Sourwood

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Legend

- Corridor A
- Corridor B
- Corridor C
- Corridor D
- Corridor E
- Corridor F
- Surface Mined Areas
- Potential Deep Mines
- Oil Well Locations
- Oil well
- Combined Oil and Gas Wells
- Gas Well
- Dry and Abandoned Well
- Abandoned Mine Lands

Location Map

EDUCATION PAYS

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Geotechnical Issues
All Corridors

Owsley and Jackson Counties
Item No. 10-279.50

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LEE COUNTY

JACKSON COUNTY

OWSLEY COUNTY

CLAY COUNTY

To Beattyville

To Booneville

To McKee

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To Manchester

Pebworth

Levi

Vincent

New Zion

Travellers Rest

Scoville

Endee

Sturgeon

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Island City

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Legend

- Corridor A
- Surface Mined Areas
- Potential Deep Mines
- Oil Well Locations
- Oil well
- Combined Oil and Gas Wells
- Gas Well
- Dry and Abandoned Well
- Abandoned Mine Lands

Location Map

EDUCATION PAYS

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Geotechnical Issues
Corridor A

Owsley and Jackson Counties
Item No. 10-279.50

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LEE COUNTY

JACKSON COUNTY

OWSLEY COUNTY

CLAY COUNTY

To Beattyville

To Booneville

To McKee

To London

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Legend

- Corridor B
- Surface Mined Areas
- Potential Deep Mines
- Oil Well Locations
- Oil well
- Combined Oil and Gas Wells
- Gas Well
- Dry and Abandoned Well
- Abandoned Mine Lands

Location Map

EDUCATION PAYS

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Geotechnical Issues
Corridor B

Owsley and Jackson Counties
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LEE COUNTY

JACKSON COUNTY

OWSLEY COUNTY

CLAY COUNTY

To Beattyville

To Booneville

To McKee

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Legend

- Corridor C
- Surface Mined Areas
- Potential Deep Mines
- Oil Well Locations
- Oil well
- Combined Oil and Gas Wells
- Gas Well
- Dry and Abandoned Well
- Abandoned Mine Lands

Location Map

EDUCATION PAYS

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Geotechnical Issues
Corridor C

Owsley and Jackson Counties
Item No. 10-279.50

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LEE COUNTY

JACKSON COUNTY

OWSLEY COUNTY

CLAY COUNTY

To Beattyville

To Booneville

To McKee

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Legend

- Surface Mined Areas
- Potential Deep Mines
- Oil Well Locations
- Corridor D
- Oil well
- Combined Oil and Gas Wells
- Gas Well
- Dry and Abandoned Well
- Abandoned Mine Lands

Location Map

EDUCATION PAYS

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Geotechnical Issues
Corridor D

Owsley and Jackson Counties
Item No. 10-279.50

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LEE COUNTY

JACKSON COUNTY

OWSLEY COUNTY

CLAY COUNTY

To Beattyville

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Location Map

Legend

- Surface Mined Areas
- Potential Deep Mines
- Oil Well Locations
- Oil well
- Combined Oil and Gas Wells
- Gas Well
- Dry and Abandoned Well
- Abandoned Mine Lands
- Corridor E

EDUCATION PAYS

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Corridor E

Owsley and Jackson Counties
Item No. 10-279.50

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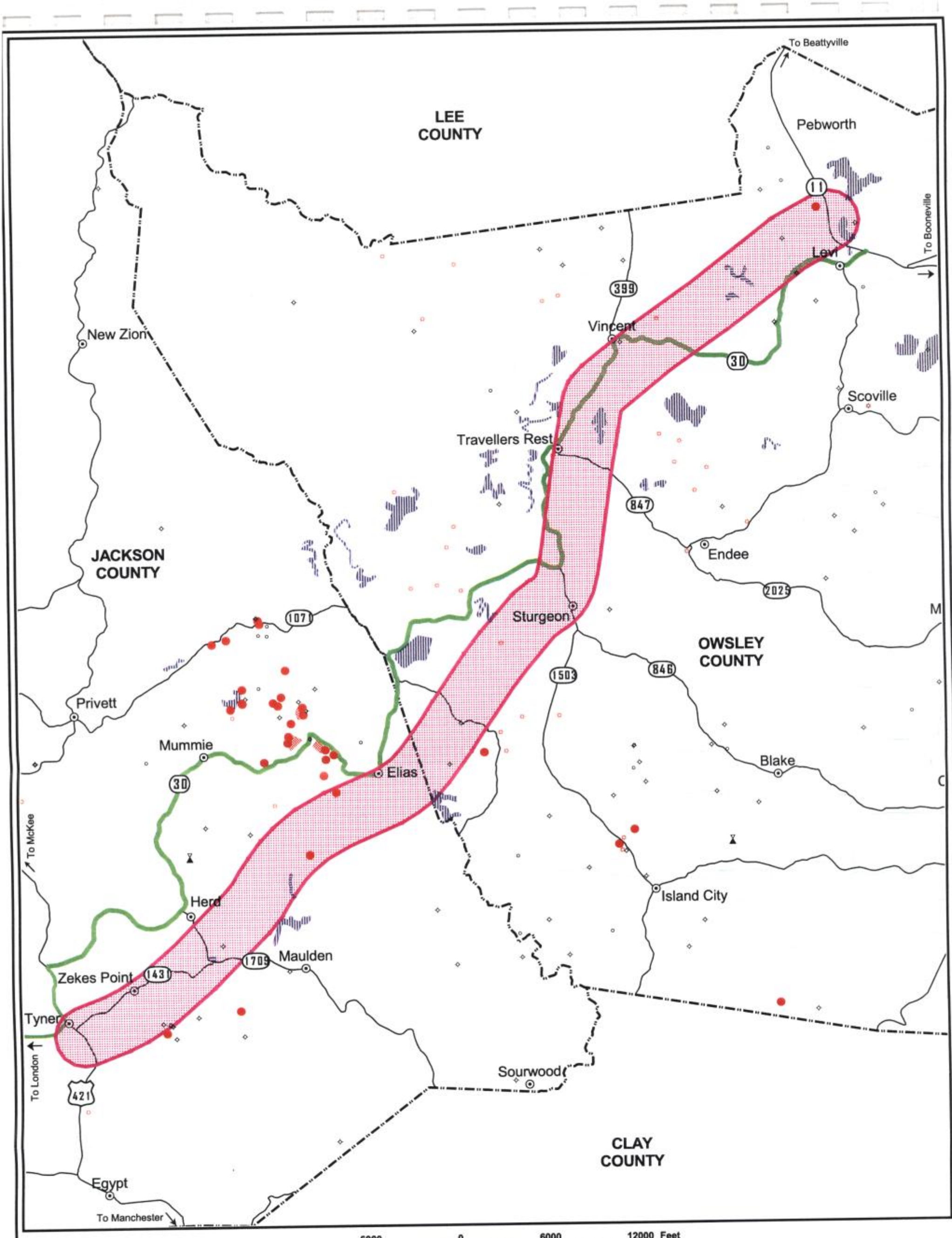
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Legend
Surface Mined Areas
Potential Deep Mines
Oil Well Locations
Oil well
Combined Oil and Gas Wells
Gas Well
Dry and Abandoned Well
Abandoned Mine Lands
Corridor F
Location Map
EDUCATION PAYS
Wilbur Smith Associates
Geotechnical Issues
Corridor F
Owsley and Jackson Counties
Item No. 10-279.50
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