

SECTION II

Geology of the Project

The proposed project is a relocation of 8.6 miles of K-16. It begins $1\frac{1}{2}$ miles south of Wheaton (on a graveled county road) and runs due east parallel to or coinciding with a township road to a point where it ties into present K-16 $\frac{1}{2}$ mile south and $\frac{1}{2}$ mile east of Onaga. At two locations centerline was shifted right of the township roadway to bypass farmsteads. Approximately two miles from the east end of the project, centerline was shifted left off the township roadway to miss a large drainage ditch. This ditch lies approximately 500 feet right of and runs parallel to centerline between Station 396+00 and Station 410+00.

The rolling topography of the project area was developed by deep dissection of an upland mass by numerous gullies and seasonal streams. These streams and gullies are fairly short in length and occupy narrow, steep walled valleys. Stream gradient is steep and runoff is rapid and turbulent.

The direction of drainage in the first $1\frac{1}{2}$ miles of project is to the south. From this point east to the end of the project the direction of flow is predominantly to the north. Mill Creek, the only perennial stream encountered on this project, collects all of the north flowing water and carries it southeast into the Vermillion River. The Mill Creek Valley is fairly wide and flat with its floor blanketed by a thick layer of alluvium. The moderate stream gradient allows the U-shaped stream channel to meander from valley wall to valley wall in its flow downstream. Some man-made channel changes have occurred in the vicinity of Station 410+00.

Sediments of the Permian and Pennsylvanian systems will compose the geology of the project area. Bedrock is covered by 0.0 to 35.0 feet of mantle which consists of soil, alluvium, residual clay and/or glacial outwash material. The glacial outwash material is composed primarily of clay with scattered sand lenses

and glacial erratics of varying size. (Erratics exceeding the 2 cubic yard limit were observed exposed at the surface not too far off the project in the vicinity of Station 200700.)

Stratigraphically the highest and lowest bedrock units that will be encountered are the Crouse limestone member of the Permian System and the Burlingame limestone member of the Pennsylvanian System, respectively, and approximately 650 feet of intervening strata. The depositional sequence (shale-limestone-shale) is the same in both the Permian and Pennsylvanian system strata; however, lithologically the Permian sediments show marked dissimilarity from the underlying Pennsylvanian sediments. A vast majority of Permian shales show a high lime content while Pennsylvanian shales are micaceous to sandy in nature. Permian limestones tend to be more shaly, less brittle, less crystalline and offer a much less distinct top and/or base than limestones of the Pennsylvanian system.

The Pennsylvanian strata lying between the Brownsville limestone member and the Dover limestone member consists of micaceous shales and cross-bedded sandstone. The shale that occupies the upper portion of this section has the characteristics and composition of the type shale that is normally deposited in this position; however, the lower portion (predominantly cross-bedded sandstone) occupies the position normally filled by limestones and shales of the Richardson Subgroup.

In Department of Interior Geological Survey Bulletin 1060-C, titled "Geology and Construction Material Resources of Pottawatomie County, Kansas" the sediments lying between the Brownsville limestone member and the Dover limestone member are identified as the Dry-Pony Creek shale members undifferentiated. In the survey bulletin this bed is described as lying in a 3 mile wide band running from north of Louisville, Kansas to a point west of Onaga. The sandstone which occupies the lower portion of this bed normally rests on the Dover limestone member, but indications are that localized channels of sandstone occur down to the Willard shale. The existence of all the members of the Richardson Subgroup on the north and the east flanks of this sandstone and shale deposit

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indicates that channel development and filling occurred during the early stages of deposition of the Pony Creek shale member.

Water is plentiful in the Dry-Pony Creek shale and sandstone. Numerous other water producing formations will be encountered during construction. Underdrains, where needed, will be designed and submitted in Section III of this report.

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SECTION III

Geo-Engineering Aspects and Recommendations

Special Note on Subgrade Recommendation

The following locations where subgrading is recommended were determined by the unstable characteristics of the shale. There is only one shale member on this project, the Harveyville Shale, that was found to have these undesirable characteristics. It is a clayey type shale with P.I. that varies from 34 to 43, depending upon how much weathering has taken place. This high P.I. is not a direct indication that the shale is an unstable one. Two of the major factors that are considered are the percentage of clay size particles and the type of clay that it contains. A clay shale that contains montmorillite as its basic clay mineral will be much more unstable than one where Kaolinite is the clay mineral. The Harveyville Shale has the ability to take on and hold large quantities of water and will break down and weather to a soft unstable condition. This shale should be subgraded where it is encountered. The present grade line will encounter it from Station 390/50 to Station 393/00, Station 434/75 to Station 438/00 and Station 459/50 to Station 463/00.

In view of its apparent unstable characteristics, it is recommended that all Harveyville Shale be removed from the top 8 inches of the subgrade across the full roadway width and backfilled with 8 inches crushed stone aggregate for backfill. Also the Harveyville Shale should not be used in the top 18 inches of the subgrade in the fill section.

The balance of the shales that will be encountered on this project, insofar as is known, do not show the unstable characteristic that would make it desirable to have them subgraded. These shales will, for the most part be weathered to common excavation and have a moisture content. The moisture content will vary locally; therefore, there will be soft and pliable zones. Locally, very soft and moist zones may be encountered during construction that may be several feet deep. It would be desirable to remove this soft material and recompact it or similar material in order to obtain a uniform density. These locations can only be determined during construction.

Cut and Fill Sections from Station 32/00 to Station 51/50

The Easley Creek, Middleburg, Hooser, Eiss and Stearns Members may be encountered in the ditch sections through these areas. They are overlain by 0.0 to 12 feet of mantle.

Backslopes

Backslopes of 3:1 or flatter are suggested for the mantle.

Slopes of 2:1 for common excavation and $1\frac{1}{2}$:1 for rock excavation are suggested for the Easley Creek Member.

The Middleburg Member will stand satisfactorily on a $\frac{1}{4}$:1 slope.

Slopes of 2:1 for common excavation and $1\frac{1}{2}$:1 for rock excavation are suggested for the Hooser Member.

The upper massive zone #24 in the Eiss Member will stand satisfactorily on a $\frac{1}{4}$:1 slope. Slopes of 1:1 for common excavation and $\frac{1}{2}$:1 for rock excavation are suggested for the lower two zones #25 and #26 in the Eiss Member.

Slopes of $1\frac{1}{2}$:1 for rock excavation and 2:1 for common excavation are suggested for the Stearns Member.

Excavation

The Easley Creek Member which will be encountered has weathered to common excavation to depths varying from 0.0 to 11 feet.

The Middleburg Member will be rock excavation.

The Hooser Member which may be encountered has weathered to common excavation.

Zones #24 and #26 in the Eiss Member will be rock excavation. Zone #25 has weathered to common excavation where it will be encountered through this area.

The Stearns Member has weathered to common excavation to depths varying from 1.5 to 3.2 feet.

Adjustment Factors

Easley Creek Member (rock)	f05%
(common)	f 0%
Limestone Zone #9 (rock)	f30%
Middleburg Member (rock)	f40%
Hooser Member (rock)	f10%
(common)	f 0%
Eiss Member	
Limestone Zone #24 (rock)	f35%
Limestone Zone #26 (rock)	f10%
Shale Zone #25 (common)	f 0%
Stearns Member (rock)	f10%
(common)	f 0%

Pond Area

Between Station 44/75, 27 feet left and Station 45/70, 56 feet left is located a small seasonal pond. If this pond is drained and allowed to dry, no settlement problems are anticipated.

Cut Section from Station 54/00 to Station 65/50

The Easley Creek, Middleburg, Hooser, Eiss and Stearns Members will be encountered through this area. They are overlain by 1 to 9 feet of mantle.

Backslopes

Backslopes of 3:1 or flatter are suggested for the mantle.

Slopes of 2:1 or flatter are suggested for the Easley Creek Member.

The Middleburg Member will stand satisfactorily on a $\frac{1}{2}$:1 slope. It is suggested that a 5 foot berm be placed at the base of the Middleburg Member to prevent undercutting and to act as a catchment area.

Slopes of 2:1 for common excavation and $1\frac{1}{2}$:1 for rock excavation are suggested for the Hooser Member.

The upper massive zone #24 in the Eiss Member will stand satisfactorily on a $\frac{1}{2}$:1 slope.

Slopes of 1:1 for common excavation and 2:1 for rock excavation are suggested for the lower two zones #25 and #26 in the Eiss Member.

Slopes of $1\frac{1}{2}$:1 for rock excavation and 2:1 for common excavation are suggested for the Stearns Member.

Excavation

The Easley Creek Member has weathered to common excavation through this area.

The Middleburg Member will be rock excavation.

The Hooser Member has weathered to common excavation to depths varying from 1 foot along its upper and lower edges where it is overlain by the complete Middleburg Member, to a point where it has completely weathered to common excavation where the Middleburg Member has been removed by weathering.

Zones #24 and 26 in the Eiss Member will be rock excavation. Zone #25 where encountered will be common excavation.

The Stearns Member will be rock excavation where it is overlain by the complete

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Eiss Member. From this point out, depth of weathering to common excavation varies from 0.0 to 10.5 feet.

Adjustment Factors

Easley Creek Member (common)	100%
Middleburg Member (rock)	40%
Hooser Member (rock)	10%
(common)	100%
Eiss Member (rock)	35%
(common)	100%
Stearns Member (rock)	10%
(common)	100%

Hydrology

It is probable that the base of the Eiss Limestone will not carry groundwater during normal rainfall periods in the vicinity of Station 58/00. It is recommended that this location be investigated during construction in order to determine if underdrainage might be necessary.

Spring Area

In the vicinity of Station 54/67, 68 feet left of centerline is located a spring which will be partly covered by the proposed construction. This spring consists of an area 40 feet wide which has been dug out so as to produce a ponding area for water flowing along the top of the Morrill Member. This same type of spring should be relocated to the left of the present location. Water elevation 1419.3. It is used for watering livestock. A plan for this area will be submitted at a later date with the final report.

Cut and Fill Sections from Station 74/00 to Station 96/00

The Crouse and Easley Creek Members will be encountered through this area. They are overlain by 0.0 to 8 feet of mantle.

Backslopes

Backslopes of 3:1 or flatter are suggested for the mantle.

The Crouse Member through this area is well jointed and contains numerous horizontal partings. An overall slope of 1:1 or flatter is suggested for this member.

Slopes of 2:1 or flatter are suggested for the weathered Easley Creek Member that is shale. The Limestone zone in this member will stand on a $\frac{1}{4}$:1 slope.

Excavation

The Crouse Member will be rock excavation.

The shale zones in the Easley Creek Member has weathered to common excavation through this area. The thin limestone zone is rock excavation.

Adjustment Factors

Crouse Member (rock)	+25%
Easley Creek Member (common) - shale	+ 0%
(rock) - limestone	+25%

Hydrology

Underdrainage may be necessary at the base of the Crouse Member in the vicinity of Station 80/00 depending upon the final grade. Underdrain layouts will be submitted as needed when the final grade is established.

Cut and Fill Sections from Station 111/00 to Station 123/00

Bedrock through this area is overlain by 3.5 to 8.5 feet of silty clay. A very small amount of Middleburg and Eiss Limestone will be encountered in the ditch section. The Hooser Shale will be encountered between Station 118/00 and Station 123/00.

Backslopes

Backslopes of 3:1 or flatter are suggested for the mantle.

The Middleburg Member will stand on a $\frac{1}{4}$:1 slope.

Slopes of 2:1 or flatter are suggested for the Hooser Member which will be encountered.

The Eiss Member will stand on a $\frac{1}{4}$:1 slope.

Excavation

The small amount of Middleburg Limestone that will be encountered is rock excavation.

The Hooser Member is common excavation where it is weathered. It has weathered to a depth of from 2 to 3 feet along its upper contact.

The Eiss Limestone is rock excavation.

Adjustment Factors

Middleburg Member (rock)	+30%
Hooser Member (rock)	+10%
(common)	0%
Eiss Member (rock)	+30%

Cut Section from Station 128/50 to Station 134/00

The Hooser, Eiss and Stearns Members will be encountered through this area. They are overlain by 2.5 to 4.5 feet of mantle.

Backslopes

Backslopes of 3:1 or flatter are suggested for the mantle.

Slopes of 2:1 or flatter are suggested for the weathered Hooser Member which will be encountered through this area.

An overall slope of $\frac{1}{4}$:1 is suggested for the Eiss Member.

A slope of $1\frac{1}{2}$:1 or flatter is suggested for the Stearns Member that will be encountered.

Excavation

The Hooser Member through this area has weathered to common excavation.

The Eiss Member will be rock excavation.

The Stearns Member is rock excavation unless it is weathered.

Adjustment Factors

Hooser Member (common)	+0%
Eiss Member (rock)	+35%
Stearns Member (rock)	+10%
(common)	0%

Fill Section from Station 135/00 to Station 146/50

The Florena, Cottonwood and Eskridge Members will be encountered here. They are overlain by a thin mantle covering.

Backslopes

A 2:1 or flatter slope is suggested for the Florena Member.

The Cottonwood Member will stand on a vertical slope.

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A 2:1 or flatter slope is suggested for the Eskridge Member when common and $1\frac{1}{2}$:1 or flatter when rock excavation.

Excavation

The Florena and Eskridge Members have weathered to common excavation where they will be encountered.

The Cottonwood Limestone is rock excavation.

Adjustment Factors

Florena Member (common)	0%
(rock)	+10%
Cottonwood Member (rock)	+40%
Eskridge Member (common)	0%
(rock)	+10%

Cut Section from Station 146+50 to Station 154+50

The Stearns, Morrill, and Florena Members will be encountered through this cut. They are overlain by 0.0 to 13.5 feet of mantle.

Backslopes

Backslopes of 3:1 or flatter are suggested for the mantle.

Slopes of 2:1 are suggested for the weathered Stearns Member which will be encountered.

An overall slope of $1\frac{1}{2}$:1 is suggested for the Morrill Member.

Slopes of 2:1 are suggested for the weathered Florena Member which will be encountered.

Excavation

The Stearns Member has weathered to common excavation through this area.

The Morrill Member will be rock excavation.

The Florena Member which will be encountered has weathered to common excavation.

Adjustment Factors

Stearns Member (common)	+ 0%
Morrill Member (rock)	+30%
Florena Member (common)	+ 0%

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Cut and Fill Sections from Station 155/50 to Station 164/50

The Cottonwood and Eskridge Members will be encountered through this area.

Backslopes

Backslopes of 3:1 or flatter are suggested for the mantle.

The Cottonwood Member will stand satisfactorily on a vertical slope.

Slopes of 1½:1 for rock excavation and 2:1 for common excavation are suggested for the Eskridge Member.

Excavation

The Cottonwood Member will be rock excavation.

The Eskridge Member will be common excavation where weathered and rock excavation where unweathered. Its weathering depth is variable due to a difference in lithology.

Adjustment Factors

Cottonwood Member (Rock)	+40%
Eskridge Member (Common)	0%
(rock)	+10%

Cut Section from Station 166/50 to Station 180/00

The Cottonwood, Eskridge, and Neva Members will be encountered through this area. They are overlain by a thin mantle covering.

Backslopes

Backslopes of 3:1 or flatter are suggested for the mantle.

The Cottonwood Member will stand on a vertical slope. It is suggested that a small bench (6 feet) be placed at the base of the Cottonwood Member to act as a catchment area and to prevent undercutting.

Overall slopes of 1½:1 for rock excavation and 2:1 for common excavation are suggested for the Eskridge Member.

An overall slope of ½:1 is suggested for the Neva Member.

Excavation

The Cottonwood Member will be rock excavation.

The Eskridge Member will be common excavation where weathered and rock excavation where unweathered. The depth of weathering is very irregular and can

best be determined from the profile and soundings.

The Neva Member will be rock excavation.

Adjustment Factors

Cottonwood Member (rock)	40%
Eskridge Member (common)	0%
(rock)	10%
Neva Member (rock)	40%

Hydrology

Zone #46 in the Eskridge Member is carrying groundwater. Depending upon final grade underdrainage may be advisable. Underdrain layouts will be submitted as needed when the final grade is established.

Fill Section from Station 180+00 to Station 192+00

A small amount of Burr, Legion, Sallyyards and Roca Members may be encountered here in the ditch sections.

Backslopes

The Burr Member will stand on a $\frac{1}{4}$:1 slope.

A slope of 2:1 or flatter for common excavation and $1\frac{1}{2}$:1 or flatter for rock excavation is suggested for the Legion Member.

The Sallyyards Member will stand on a $\frac{1}{4}$:1 slope.

A slope of 2:1 or flatter for common excavation and $1\frac{1}{2}$:1 or flatter for rock excavation is suggested for the Roca Member.

Excavation

The Burr Member is rock excavation.

The Legion Member has weathered to common excavation where it will be encountered.

The Sallyyards Member will be rock excavation.

The Roca Member, that is shale, has weathered to common excavation to a depth of 6.0 along its outcropping edge. The thin limestones are rock excavation.

Adjustment Factors

Burr Member (rock)	35%
Legion Member (common)	0%

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Legion Member (rock)	f10%
Sallyards Member (rock)	f25%
Roca Member (common)	0%
(rock)	f10%
Salem Point Shale (common)	0%
(rock)	f10%

Soft Area

Centerline crosses a small stream in the vicinity of Station 186/33. The bottom of this gully is 15 feet wide and has four feet of soft material. It is suggested that this soft material be removed and wasted. Illustration showing limits will be supplied.

Cut Section from Station 192/50 to Station 214/00

The Roca, Howe and Bennett Members will be encountered through this area. They are overlain by 0.0 to 43.3 feet of glacial till.

Backslopes

Backslopes of 3:1 or flatter are suggested for the glacial till.

Slopes of $1\frac{1}{2}:1$ for rock excavation and 2:1 for common excavation are suggested for the Roca Member.

An overall slope of $\frac{1}{4}:1$ is suggested for the Howe Member.

Slopes of $1\frac{1}{2}:1$ for rock excavation and 2:1 for common excavation are suggested for the Bennett Member.

Excavation

The Roca Member has weathered to common excavation to a depth of 1.5 feet.

The Howe Limestone will be rock excavation.

The Bennett Member will be rock excavation where it is overlain by the Howe Member and 4.5 feet of the Roca Member. At the outcrop edge of the Howe Member the Bennett Member has weathered to common excavation to a depth of 7.2 feet.

Adjustment Factors

Roca Member (common)	f0%
(rock)	f10%
Howe Member (rock)	f35%
Bennett Member (common)	0%
(rock)	f10%
Salem Point Shale (common)	0%
(rock)	f10%

Fill and Cut Sections from Station 215/00 to Station 230/00

The Johnson, Long Creek and Hughes Creek Member will be encountered through this area. They are overlain by a thin covering of mantle.

Backslopes

Backslopes of 3:1 or flatter are suggested for the mantle.

An overall slope of 2:1 or flatter is suggested for the Johnson Member which will be encountered through this area.

An overall slope of $\frac{1}{4}$:1 is suggested for the Long Creek Member.

Slopes of 2:1 for common excavation and $1\frac{1}{2}$:1 for rock excavation are suggested for the Hughes Creek Member. Where the thin shaly limestone zones that are rock excavation have common excavation below them, it is suggested that they be placed on the same overall slope as the weathered shale.

Excavation

The Johnson Member through this area has weathered to common excavation, except for a 0.9 to 1.4 foot limy zone which will be rock excavation.

The Long Creek Member will be rock excavation.

The Hughes Creek Member is rock excavation where it is overlain by the complete Long Creek Member. It has weathered to common excavation along the top of the hill, where it is not overlain by Long Creek Limestone, to a depth of approximately 14.0 with the exception of the limestone zones which are rock excavation. Along the lower slopes of this hill the depth of weathering of this shale varies from 0.0 to 4.0 feet.

Adjustment Factors

Johnson Member (common)	0%
(rock)	±10%
Long Creek Member (rock)	±35%
Hughes Creek (common)	0%
(rock)	±10%

Hydrology

The Long Creek Member is carrying groundwater. Depending upon final grade, underdrainage may be advisable. Underdrain layouts will be submitted as needed

when the final grade is established.

Cut Section from Station 236/00 to Station 244/50

The Long Creek, Hughes Creek, Americus and Oaks Member will be encountered through this area. They are overlain by a thin covering of mantle.

Backslopes

Backslopes of 3:1 or flatter are suggested for the mantle.

An overall slope of $\frac{1}{2}$:1 is suggested for the Long Creek Member through this area.

Slopes of $1\frac{1}{2}$:1 for rock excavation and 2:1 for common excavation are suggested for the Hughes Creek Member. It is suggested, that in the area where there are alternating rock and common excavation zones, that they be placed on the same slope. The slope should be determined by the percentage of common excavation.

The Americus Member will stand on a vertical slope.

Slopes of $1\frac{1}{2}$:1 for rock excavation and 2:1 for common excavation are suggested for the Oaks Member.

Excavation

The Long Creek Member will be rock excavation.

The Hughes Creek Member will be common excavation where weathered and rock excavation where unweathered. Its weathering depth is variable due to a difference in lithology. It contains alternating zones of weathered shale that are common excavation and shaly limestone zones that are rock excavation.

The Americus Member will be rock excavation.

The Oaks Member will be rock excavation where it is overlain by the Americus Member and 7 feet of the Hughes Creek Member. Where the Americus Member has been removed by weathering the Oaks Member has weathered to common excavation to depths of 6.5 to 7.5 feet.

Adjustment Factors

Long Creek Member (rock)	430%
Hughes Creek Member (common)	0%
(rock)	415%
Americus Member (rock)	440%

Oaks Member (common)

0%

(rock)

10%

Hydrology

The Five Point Limestone Member is carrying groundwater in this area. This member is known for its ability to carry large quantities of groundwater even through extended dry periods. In the area to the right of centerline between Station 253/00 and Station 255/00, the Five Point Member is feeding water out along the mantle-shale contact. Groundwater was flowing out from the shale-mantle contact in the present right ditch in the vicinity of Station 253/00.

It is suggested that the proposed right ditch at Station 254/00 be placed at an elevation of 1280.0 in order to intercept a large portion of the groundwater. This will protect the fill section from failing due to the groundwater.

Fill and Cut Section from Station 244/50 to Station 267/00

The Oaks, Houchen Creek, Stine and Five Point Members will be encountered through this area. A small amount of West Branch and Fall City Members will be encountered in ditches along the fill section.

Backslopes

Backslopes of 3:1 or flatter are suggested for the mantle.

Slopes of $1\frac{1}{2}$:1 for rock excavation and 2:1 for common excavation are suggested for the Oaks Member.

Backslopes of $1\frac{1}{2}$:1 or flatter are suggested for the Houchen Creek Member.

Slopes of $1\frac{1}{2}$:1 for rock excavation and 2:1 for common excavation are suggested for the Stine Member. A 10.0 foot wide bench at an elevation of 1305.0 is also suggested as the shales at this location are noted for their instability.

An overall slope of $1\frac{1}{2}$:1 is suggested for the Five Point Member.

Slopes of $1\frac{1}{2}$:1 for rock excavation and 2:1 for common excavation are suggested for the West Branch Member.

The Fall City Member will stand on a $\frac{1}{4}$:1 slope.

Excavation

The Oaks Member has weathered to common excavation to depths varying from 5 to

6.2 feet.

The Houchen Creek Member will be rock excavation.

The Stine Member has weathered to common excavation to depths varying from 4.5 to 8.5 feet.

Zone #114 in the Five Point Member will be rock excavation. Zone #115 if encountered will be common excavation.

The West Branch Member has weathered to common excavation to a depth of 8.0 feet where it is not overlain by limestone.

The Fall City Member is rock excavation.

Adjustment Factors

Oaks Member (common)	+0%
(rock)	+10%
Houchen Creek Member (rock)	+35%
Stine Member (common)	0%
(rock)	+10%
Five Point Member (rock)	+40%
(common)	+05%
West Branch Member (rock)	+10%
Fall City Member (common)	0%
(rock)	+30%

Hydrology

Zone #112 in the Stine Member and the Five Point Member was found to be carrying groundwater. Depending upon final grade underdrainage may be advisable. Underdrain layouts will be submitted as needed when the final grade is established.

Cut Section from Station 275+00 to Station 299+50

The Hawxby, Aspinwall, Towle, Brownville and Pony Creek Members will be encountered through this area. They are overlain by 0.0 to 23 feet of silty clay.

Backslopes

Backslopes of 3:1 or flatter are suggested for the mantle.

Slopes of 2:1 or flatter are suggested for both common and rock excavation in the Hawxby Member.

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An overall slope of $\frac{1}{2}$:1 is suggested for the Aspinwall Member.

Slopes of $1\frac{1}{2}$:1 for rock excavation and 2:1 for common excavation are suggested for the Towle Member.

The Brownville Member will stand on $\frac{1}{2}$:1 slope.

Slopes of $1\frac{1}{2}$:1 for rock excavation and 2:1 for common excavation are suggested for the Pony Creek Member.

Excavation

The Hawxby Member has weathered to common excavation to depths varying from 2.1 to 8 feet.

The Aspinwall Member will be rock excavation.

The Towle Member will be rock excavation where it is overlain by the Aspinwall Member. Where the Aspinwall Member has been removed by weathering the Towle Member has weathered to common excavation to depths of 1 to 6.5 feet.

The Brownville Member will be rock excavation.

The Pony Creek Member has weathered to common excavation to depths of 7.5 to 12 feet.

Adjustment Factors

Hawxby Member (common)	f 0%
(rock)	f 05%
Aspinwall Member (rock)	f 35%
Towle Member (common)	f 0%
(rock)	f 10%
Brownville Member (rock)	f 35%
Pony Creek Member (common)	f 0%
(rock)	f 10%

Hydrology

In the vicinity of Station 290/00 groundwater was found moving through a number of small sandy zones in the Pony Creek Member. This water is moving out into the mantle and will produce a soft unstable area during the wet seasons. An underdrain layout will be submitted as needed when the final grade is established.

Cut Section from Station 300/50 to Station 310/50

Channel material of Pony Creek Age will be encountered through this area. This member consists of alternating bands of sandstone and clayey shale. It is overlain by 5 to 10.5 feet of silty clay.

Backslopes

Backslopes of 3:1 or flatter are suggested for the mantle.

Backslopes of 2:1 or flatter are suggested for both rock and common for the channel material.

Excavation

This channel material has weathered to common excavation to depth of 6.4 to 11 feet.

Adjustment Factors

Pony Creek Member

Channel Material (alternating sandstones and shale)

Common excavation	0%
Rock Excavation	405%

Hydrology

A large amount of groundwater was found to be moving through the sandstone stringers in the channel material. Depending upon final grade a draw down type underdrain may be advisable for this location. Underdrain layouts will be furnished as needed.

Cut Section from Station 327/00 to Station 339/50

Channel material consisting of alternating layers of sandstone and shale will be encountered through this cut. It is overlain by 0.5 to 5.5 feet of silty clay.

Backslopes

Backslopes of 3:1 or flatter are suggested for the mantle.

Slopes of 2:1 or flatter are suggested for both rock and common excavation in the channel material.

Excavation

The channel material has weathered to common excavation to depths of 6 to 13 feet.

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Cut Section from Station 300+50 to Station 310+50

Channel material of Pony Creek Age will be encountered through this area. This member consists of alternating bands of sandstone and clayey shale. It is overlain by 5 to 10.5 feet of silty clay.

Backslopes

Backslopes of 3:1 or flatter are suggested for the mantle.

Backslopes of 2:1 or flatter are suggested for both rock and common for the channel material.

Excavation

This channel material has weathered to common excavation to depth of 6.4 to 11 feet.

Adjustment Factors

Pony Creek Member

Channel Material (alternating sandstones and shale)

Common excavation 0%

Rock Excavation 405%

Hydrology

A large amount of groundwater was found to be moving through the sandstone stringers in the channel material. Depending upon final grade a draw down type underdrain may be advisable for this location. Underdrain layouts will be furnished as needed.

Cut Section from Station 327+00 to Station 339+50

Channel material consisting of alternating layers of sandstone and shale will be encountered through this cut. It is overlain by 0.5 to 5.5 feet of silty clay.

Backslopes

Backslopes of 3:1 or flatter are suggested for the mantle.

Slopes of 2:1 or flatter are suggested for both rock and common excavation in the channel material.

Excavation

The channel material has weathered to common excavation to depths of 6 to 13 feet.

Adjustment Factors

Channel material (common)	0%
(rock)	105%

Hydrology

A large amount of groundwater is moving through the sandstone stringers in the channel material. Underdrainage will be needed for this area. Underdrain layouts will be submitted as needed when the final grade is established.

Cut Section from Station 344/50 to Station 351/50

Channel material consisting of sandstone with thin zones of shale will be encountered through this area. It is overlain by 0.5 to 5.5 feet of silty clay.

Backslopes

Backslopes of 3:1 or flatter are suggested for the mantle.

Slopes of 2:1 or flatter are suggested for the channel material.

Excavation

All excavation will be common that will be encountered in the Pony Creek Age material.

Adjustment Factors

Channel material (sandstone with zones of shale)	
(common)	10%

Hydrology

A large amount of groundwater is moving through the sandstone stringers in the channel material. Underdrainage will be needed for this area. Underdrain layouts will be submitted as needed when the final grade is established.

Cut and Fill Sections from Station 356/00 to Station 384/00

Channel material consisting of sandstone with thin zones of shale will be encountered through this area. It is overlain by 0.0 to 8 feet of silty clay.

Backslopes

Backslopes of 3:1 or flatter are suggested for the mantle.

Slopes of 2:1 or flatter are suggested for both rock and common excavation in the channel material.

16-75 S-1305 (2) Pottawatomie County

Excavation

This channel material has weathered to common excavation to depths of 5 to 16.5 feet.

Adjustment Factors

Channel material (sandstone with zones of shale)

(common)

+ 0%

(rock)

+05%

Hydrology

A large amount of groundwater is moving through the sandstone stringers in the channel material. Underdrainage will be needed. Underdrain layouts will be submitted as needed when final grade is established.

Cut Section from Station 386/00 to Station 395/00

A small amount of Elmont Member, the Harveyville Member, the Reading Member and the upper portion of the Auburn Shale Member will be encountered here. They are overlain by a thin mantle covering that consists of silty clay.

Backslopes

The mantle should be placed on a 3:1 or flatter slope.

The small quantity of Elmont Limestone should be placed on a 1/2:1 slope.

The clayey Harveyville Shale that will be encountered is badly weathered and should be placed on a 3:1 or flatter slope.

The Reading Member will stand on a 1/4:1 slope.

The small quantity of Auburn Shale that will be encountered should be placed on a 2:1 or flatter slope.

Subgrade Recommendation

The Harveyville Shale will be encountered between Station 390/50 and Station 393/00. It is recommended that all Harveyville Shale be removed from the top 8 inches of the subgrade across the full roadway width and backfilled with 8 inches crushed stone aggregate for backfill. Also the Harveyville Shale should not be used in the top 18 inches of the subgrade in the fill section.

Excavation

The Elmont Limestone is rock excavation.

Pottawatomie County
16-75 S-1305 (2)

The Harveyville Shale has weathered to common excavation at this location.

The Reading Limestone Member is rock excavation.

The Auburn Shale is rock excavation where it is not weathered. It has weathered to common excavation to a depth of approximately 3.0 feet along its outcrop edge. Where it is overlain by the Reading Limestone Member it is rock excavation.

Adjustment Factors

Elmont Member	
Rock excavation	+35%
Harveyville Member	
Common Excavation	- 5%
Reading Member	
Rock excavation	+40%
Auburn Member	
Common Excavation	+ 0%
Rock Excavation	+10%

Hydrology

The proposed grade line falls close to the base of the Reading Limestone at Station 393/50. There was no indication of groundwater movement at the time of the investigation. It is thought that underdrainage will not be necessary. This location, however, should be checked during construction to see if an underdrain would be desirable.

Cut Section from Station 419/00 to Station 429/50

The Auburn Member will be encountered through this area. Mantle thickness varies from 1 to 21.5 feet.

Backslopes

Backslopes of 3:1 or flatter are suggested for the mantle.

Slopes of $1\frac{1}{2}$:1 for rock excavation and 2:1 for common excavation are suggested for the Auburn Member.

Excavation

The Auburn Member will be common excavation where weathered and rock excavation

where unweathered. Its weathering depth is variable due to a difference in lithology.

Adjustment Factors

Auburn Member (common)	4 0%
(rock)	4 10%

Cut Section from Station 432/00 to Station 449/00

The Willard, Elmont, Harveyville, Reading and Auburn Members will be encountered in this cut. They are overlain by 0.0 to 10 feet of silty clay.

Backslopes

Backslopes of 3:1 or flatter are suggested for the mantle.

Slopes of $1\frac{1}{2}$:1 for rock excavation and 2:1 for common excavation are suggested for the Willard Member.

An overall slope of $\frac{1}{2}$:1 is suggested for the Elmont Member.

Slopes of 2:1 are suggested for the weathered Harveyville Member which will be encountered.

The Reading Member will stand satisfactorily on a $\frac{1}{4}$:1 slope.

Slopes of $1\frac{1}{2}$:1 for rock excavation and 2:1 for common excavation are suggested for the Auburn Member.

Subgrade Recommendation

The Harveyville Shale will be encountered between Station 434/75 and Station 438/75. It is recommended that all Harveyville Shale be removed from the top 8 inches of the subgrade across the full roadway width and backfilled with 8 inches crushed stone aggregate for backfill. Also the Harveyville Shale should not be used in the top 18 inches of the subgrade in the fill section.

Excavation

The Willard Member has weathered to common excavation to depths varying from 5.7 to 16.3 feet.

The Elmont Member will be rock excavation.

The clayey Harveyville Member has weathered to common excavation where it will be encountered.

The Reading Member will be rock excavation.

The Auburn Member will be rock excavation where it is overlain by the Reading Member and 4.5 feet of the Harveyville Member. At the outcrop edge of the Reading Member the Auburn Member has weathered to common excavation to a depth of 8.4 feet.

Adjustment Factors

Willard Member (common)	+ 0%
(rock)	+10%
Elmont Member (rock)	+35%
Harveyville Member (common)	0%
Reading Member (rock)	+40%
Auburn Member (common)	+ 0%
(rock)	+10%

Hydrology

Groundwater was found moving through the Willard Member and along the top of the Reading Member through this area. Depending upon final grade, underdrainage may be advisable. Underdrain layouts will be submitted as needed when the final grade is established.

Soft Area

Between Station 452/17 and Station 452/28 centerline crosses a small spring-fed stream. This stream flows year around. At approximately 21 feet right of centerline this stream turns and parallels centerline for approximately 200 feet. The bottom of this stream is filled with soft unstable material which varies from 1.3 feet thick at centerline to 0.9 foot thick at Station 454/00, 21 to 30 feet right. It is suggested that all of the soft material in the bottom of the stream-bed, under the fill section, between Station 452/17 and Station 454/17 be removed. A plan for this area will be submitted with the final report.

Cut Section from Station 458/50 to Station 465/50 - Includes Side Road Lt. Sta. 465/00

The Elmont, Harveyville, Reading and Auburn Members will be encountered through this cut. They are overlain by a thin covering of mantle.

Backslopes

Backslopes of 3:1 or flatter are suggested for the mantle.

An overall slope of $\frac{1}{2}$:1 is suggested for the Elmont Member.

Slopes of 2:1 are suggested for the weathered Harveyville Member.

The Reading Member will stand on a $\frac{1}{2}$:1 slope.

Slopes of $1\frac{1}{2}$:1 for rock excavation and 2:1 for common excavation are suggested for the Auburn Member.

Subgrade Recommendation

The Harveyville Shale will be encountered between Station 459/25 and Station 463/00. It is recommended that all Harveyville Shale be removed from the top 8 inches of the subgrade across the full roadway width and backfilled with 8 inches crushed stone aggregate for backfill. Also the Harveyville Shale should not be used in the top 18 inches of the subgrade in the fill section.

Excavation

The Elmont Member will be rock excavation.

The clayey Harveyville Member has weathered to common excavation.

The Reading Member will be rock excavation.

The Auburn Member will be rock excavation where it is overlain by the Reading Member and 1.5 feet of the Harveyville Member. At the outcrop edge of the Reading Member the Auburn Member has weathered to common excavation to a depth of 6.1 feet.

Adjustment Factors

Elmont Member (rock)	+35%
Harveyville Member (common)	- 5%
Reading Member (rock)	+40%
Auburn Member (common)	+ 0%
(rock)	+10%

Hydrology

Groundwater was found moving along the top of the Reading Member. Depending upon final grade underdrainage may be advisable. Underdrain layouts will be submitted as needed when the final grade is established.

10-12 P-1307 (2) ROLLAWATOMLE COUNTY