The Blue Rapids shale and Function limestone will be encountered in the left backslope. These two formations are overlain by a reddish-brown clay type mantle. Backslopes of 3/4:1 or flatter are suggested for the mantle.

The limestones of the Function formation will stand on a vertical slope satisfactorily. The shale units in this formation will stand on a 3/4:1 or flatter slope when rock excavation and a 1:1 or flatter slope when common excavation. However, as all three units are sand, the recommended slopes for the shale should govern for the entire Function, i.e., 3/4:1 if the shale is rock excavation and 1:1 if the shale is common.

Backslopes of 3/4:1 or flatter for rock excavation and 1:1 or flatter for common excavation are suggested for the Blue Rapids shale.

Excavation

The limestones of the Function limestone are rock excavation. The shale near is common excavation where it is weathered. It is weathered at this location unless it is overlain by the upper Function limestone and four feet of the Speizer shale formation.

The Blue Rapids shale is rock excavation where it is not weathered. It is weathered rather badly through this location, especially when it is not overlain by the Function limestone formation. The depth of weathering is approximately 12 feet when it is not overlain by the Function limestone and gradually reduces to zero when overlain by the complete Function limestone and four feet of the Speizer shale formation.

Hydrology

It appears that the Function limestone is carrying some ground water through this location. This is indicated by the depth of weathering of the underlying shale and the moist to wet zones within the shale. At Stations 333/00 to 335/00, centerline, there is a zone in the shale at an elevation of 1270.0 to 1250.5 that is wet.
The Three Mile Limestone, Spaulding shale and Punston limestone will be encountered through this side hill location. The overlying mantle is thin and consists of clay and short fragments with the exception of Station 385/00 where the mantle is 7.2 feet thick where centerline drops down into a small floodplain.

The Three Mile Limestone will be encountered in the top of the left backlobe. A slope of 1:1 is suggested for this limestone section.

The Spaulding shale formation is weathered rather badly at this location due to ground water seepage. Backsteps of 1:1 or flatter for common excavation and 1:1 or flatter for rock excavation are suggested.

The limestone of the Punston limestone will stand on a vertical slope. Backsteps of 1:1 or flatter for rock excavation and 1:1 or flatter for common excavation are suggested for the shale zone. See recommendation for Punston, Station 339/00 to Station 335/00.

Excavation

The Three Mile Limestone member is rock excavation.

The Spaulding shale formation is rock excavation where it is unweathered. This shale formation has weathered rather badly through this location due to ground water seepage. To be weathered to a depth of approximately 15 feet along centerline.

To the left of centerline there is a unique situation of having common excavation under rock excavation due to seepage in the lower portion of this shale. For instance at Station 343/00, 20 feet left, the shale in rock excavation between an elevation of 1277.1 and 1281.0 and from 1281.6 on down to the top of the Punston limestone.

The limestone of the Punston limestone formation are rock excavation. The shale zone of this limestone formation has weathered to common excavation unless it is campaigners by the very weathered outbreak and one foot of the Spaulding shale.

Footnote:

- 10 -
amount of ground water seepage taking place at this time is very small. It is thought that the ground water originates from the base of the Three Mile Limestone and moves down through the Spelder Shale where it is recharged. The preliminary grade line falls in the lower portion of this shale formation, therefore it is thought that the left ditch will intercept any ground water movement that could endanger the subgrade of the proposed road. It is suggested that this location should be checked during construction with substructures in mind.

**Section 35/60, 1st Royl Mine**

**Hydrology**

At section 35/60, 144 feet right is the location of a spring that is dried up at this time. The ground water originates at the base of the upper Puckett Limestone which is quite porous and solutional.

**Cut Section From Section 35/60 to Section 37/60**

The Three Mile Limestone and the Spelder Shale that are overlain by a relative thin clay type mantle will be encountered in the right hand slope through this location.

- The mantle will stand on a 3½% or flatter slope satisfactorily.
- The Three Mile Limestone will stand on a 1½% slope satisfactorily.
- The Spelder Shale has a tendency to undercut the Three Mile Limestone, therefore, back slopes of 1½% or flatter for rock excavation and 1½% or flatter for overburden excavation are suggested for this shale formation.

**Preparation**

The Three Mile Limestone is rock excavation.

The Spelder Shale is common excavation where it is weathered. It has weathered to a depth of approximately 7 feet where it is not overlain by the Three Mile Limestone. This depth of weathering varies off to save when the shale is overlain by the complete Three Mile Limestone.

**Cut Section from Section 37/60 to Section 41/60**

**Becolage**
possibly a small amount of loose loose limestone will be encountered through this location. These formations are normal for a clay type soil and vary from a few tens of a foot to 10 feet in thickness.

Backhoes of 2:1 or flatter are suggested for the clay type soil that will be encountered.

Backhoes of 2:1 or flatter are suggested for the limestones of the Kinsey limestone member. Backhoes of 1:1 or flatter for common excavation and 2:1 or flatter for rock excavation are suggested for the shale zone of this limestone member.

Backhoes of 1:1 or flatter for common excavation and 2:1 or flatter for rock excavation are suggested for the thin shale shale member.

The limestone units of the Schroyer limestone member will stand as a vertical slope satisfactorily. The upper shale zone tends to undercut the upper limestone unit of this member which tends to allow it to slide out. Backhoes of 2:1 for common excavation and 1:1 or flatter for rock excavation are suggested for this upper shale zone. This shale zone is composed of five units in the generalized section, two of which are weak limestone zones that generally weather to clay, therefore, the five units are treated as a shale zone that is 3.5 feet thick.

Backhoes of 2:1 or flatter for common excavation and 2:1 or flatter for rock excavation are suggested for the Barnesville shale member as it is a clayey type shale and has a tendency to be unstable and to undercut the overlying Schroyer limestone.

The Three Mile limestone will stand as a 4:1 slope satisfactorily.

Excavation

The limestone units of the Kinsey limestone member are rock excavation.

The thin shale unit of this limestone member is common excavation if it is weathered. It has weathered to a depth of 9 feet when it is not overlain by the upper Kinsey limestone.

The upper shale in common excavation where it is weathered. Its depth of weathering varies from one side of the hill to the other side. 

Between Sta. 297/00 - 12 -
The depth of weathering is the result of ground water which originates at the base of the lower Kinney Limestone. The depth of weathering on the other side of the hill is 5 feet at Station 404/00 and thins to zero at Station 403/00 where it is overlain by the lower Kinney Limestone.

The limestones of the Schuyler Limestone member are rock excavation. The upper shale zone, which is composed of 2 units, has weathered to common excavation unless it is overlain by the upper Schuyler Limestone and 2 feet of Upper shale member.

The Rovenville shale has weathered to common excavation to a depth of 12 ft. at station 379/00. This depth of weathering decreases to zero at Station 351/00 where it is overlain by 6 feet of Schuyler Limestone. On the other side of the hill at Station 415/00 this shale member is weathered to a depth of 3 feet where it is overlain by 3 feet of Schuyler Limestone. This depth of weathering increases from this location to the top of the underlying limestone unit at Station 415/00, where the limestone is rock excavation.

The Three Mile Limestone is rock excavation.

**Petroleum**

Indications are that the base of the lower Kinney limestone is carrying ground water at Station 403/00. If the grade line cuts this limestone, subdrainage would be desirable.

It is thought that there is a possibility that there has been ground water moving through the upper portion of the Rovenville shale member in the vicinity of Station 380/00. In a test hole at Station 379/25, centerline, the shale was found to badly weathered and had a moisture content that varied from damp to moist. Even if there is not any ground water movement at this location, protective measures such as a thickened base course should be taken when the grade line crosses over the unstable weathered Rovenville shale to insure against a failure. It is suggested that this location be field checked during excavation to determine if subdrainage would be desirable. As there is no impermeable material to act as a subdrain in to intercept any ground water movement, a stair step type subdrain that would give
Between Station 313/63 and Station 416/50 the Havensville shale will also be encountered. There was no evidence encountered that there has been any ground water movement at this location. However, any time the weathered, unstable, clayey Havensville shale member is encountered it is suggested that a thickened bore course be used.

At Station 375/63, 83 feet left, there is a spring location that is not flowing at this time. It stopped flowing in the Spring of 1956. It is fed up with a pipe and stock tank. This spring flows from the base of the Three Mile Limestone.

At Station 375/63, 15 feet left, there is a good well that has an engine-driven pump mounted on it. The elevation of the water is 120.30.

Cut Sections from Station 405/60 to Station 500/50

Backslope

The Yumara shale, Schuyler limestone, Havensville shale and a small amount of Three Mile limestone will be encountered through these cut sections. The mantle overlying these shales and limestones consists predominantly of a clay type mantle that varies from a tan-brown to a reddish-brown color. It ranges from 1.0 to 12.0 feet in thickness.

Backslopes of 2:1 or flatter are suggested for the mantle.

Backslopes of 1:1 or flatter for common excavation and 3:1 or flatter for rock excavation are suggested for the Yumara shale member.

The limestones of the Schuyler limestone member will stand on a vertical slope satisfactorily. Backslopes of 2:1 or flatter for common excavation and 1:1 or flatter for rock excavation are suggested for the 3.0 foot thick shale and weak limestone zones that underlie the upper limestone of the Schuyler member.

Backslopes of 2:1 or flatter for common excavation and 1:1 or flatter for rock excavation are suggested for both the shale and shaly limestone zones of the Havensville shale member to prevent a clayey type slide and have a tendency to be unstable and undercut the overlying Schuyler limestone.
The water table, weathered Evavsville shale is encountered in the vicinity of Station 409/40, consideration should be given to increased base strength. There does not appear to be any ground water moving at this particular location, however the Evansville shale is badly weathered and has a high affinity for water.

At Station 457/50 and Station 464/60 it is apparent that the base of the Schroyer Limestone has carried ground water in the past. To the left of Station 454/40 in a normal, the owner says that there have been numerous springs, however, they have not been active since 1968. The preliminary proposed grade line indicates that it will cross high enough over the Schroyer Limestone base to eliminate any hydrology problem.

There are indications that the Schroyer Limestone has had some ground water moving through it in the past in the vicinity of Station 56/50. The weathered shale and Joint clay between an elevation of 1334.2 and 1341.2 was found to be wet and soft at 60 feet left of Station 56/50. The weathered shales and shaly limestones below this wet zone had only a slight moisture content. If the basal portion of the Schroyer Limestone was not cut for the grade line at this location — 15 —
then a stair-step type sub-drain should be considered to intercept ground water from the base of zone 50 and 60 of the upper limestone and the upper portion of the Pennsylvanian shale member. Consideration should be given to the general low stability of the Pennsylvanian shale in designing a base course.

Cut Section from Station 517600 to Station 51840

Backslope

A small amount of three mile limestone and Speiser shale will be encountered in this cut section. A small amount of a thin, silty clay deposit will also be encountered.

Basclopes of 3:1 or flatter are suggested for the silty clay mantle.

A 1:1 slope is suggested for the three mile limestone member.

The Speiser shale has a tendency to undercut the three mile limestone, therefore backlopes of 1:1 or flatter for common excavation and 1:1 or flatter for rock excavation are suggested for this shale formation.

Excavation

The three mile limestone member is rock excavation.

The Speiser shale is common excavation where it is weathered. It has weathered to a depth of 3 feet at this location where it is not overlain by the three mile limestone. It would be completely unweathered if it was overlain by five or more feet of three mile limestone.

Hydrology

The upper Funston limestone has carried ground water at its base at various locations along its outcrop edge between Station 522/96, 50 feet right and 524/93, 56 feet left. At the time of the primary field investigation of this area in February the ground water movement was nil or very slight. This location was rechecked during the last part of April, 1957, after substantial moisture had fallen and ground water movement of fairly large quantity was observed at three locations. They are at Station 522/96, 52 feet right; 523/97, 51 feet right and Station 524/91, 32 feet left.

At Station 522/96, 52 feet right, at an elevation of 1275.00, there is a 1 1/2 inch diameter pipe sticking out from the base of the upper Funston limestone that is carrying a 1/2 inch stream of water. This pipe is back under an overhanging rock.
At Station 583/67, 21 feet south, at an elevation of 1279.32, there is a 3 inch diameter stream of water flowing out of it on the 8th day of April, 1957. The water came from the base of the upper Funston Limestone whose outcrop edge is 10 feet below the bank on 21 feet right of centerline.

At Station 583/21, 52 feet east, at an elevation of 1271.62, there is a 3 inch diameter vee hole in the southwest vee wall that has a small amount of ground water coming out of it. The center vee hole in the south wall of the box has a very little seepage coming out of it.

The major flow of ground water is to the right of centerline. This ground water movement could be intercepted and carried out to the right side of the fill section by installing an interceptor drain along the edge of the upper Funston limestone outcrop so that it would intercept the ground water moving at its base and carry it out to the right side of the fill section.

Cut Section from Station 534/400 to Station 566/00

Becklages

The Schroyer limestones and Raveensville shale members will be encountered through this side hill location. The mantle covering consists of a clay with chart and limestone fragments scattered through it.

Becklages of 2½:1 or flatter are suggested for the mantle.

Becklages of 1:1 will stand satisfactorily for the limestones of the Schroyer limestone member. Slopes of 2½:1 or flatter for common excavation and 1:1 or flatter for rock excavation are suggested for the shale units in this member.

As the Raveensville shale has a tendency to be unstable in a beaconage and tends to undercut the overlying Schroyer limestone, beaconages of 2½:1 or flatter for common excavation and 1:1 or flatter for rock excavation are suggested.

Excavation

The limestones of the Schroyer member are rock excavation if they are in place.

As this is a side hill location the short bands have slumped down over the underlying Raveensville shale in an irregular layer which in some cases appears to be in
The Bavenasville shale is common excavation if it is weathered. It is weathered rather badly through this location, and does not pose many daily hazards in it. The depth of weathering is 10 feet when it is not overlain by the Schroyer limestone. This depth of weathering tapers off to zero when it is overlain by 3 or more feet of the Schroyer limestone member.

**Hydrology**

The Bavenasville shale member was found to be badly weathered and has a moisture content that varies from deep to wet or saturated. There does not seem to be a particular zone that is carrying ground water; however there seems to be a general undirected slow movement of ground water seeping through the clayey shale. This is a general condition that is usually found in this shale member. As this is a side hill location, the right ditch will give fair protection against softening of the subgrade material. However, the Bavenasville generally has low stability and this factor should be considered in base course design.

**Cut section from Station 48600 to Station 52100**

**Backslopes**

The Kinney limestone, Wymore shale and Schroyer limestone members will be encountered in this cut section. The shale varies in thickness from 1 to 11 feet and is predominately a clay that is somewhat clity.

Backslopes of 2:1 or flatter are suggested for the clay type shales.

The limestone of the Kinney limestone member will stand on a vertical slope satisfactorily. Backslopes of 1:1 or flatter for common excavation and 2:1 or flatter for rock excavation are suggested for the shale zones of this limestone member.

Backslopes of 1:1 or flatter for common excavation and 2:1 or flatter for rock excavation are suggested for the Wymore shale formation.

The limestone of the Schroyer limestone member will stand on a 2:1 satisfactorily through this cut section. Backslopes of 2:1 or flatter for common excavation and 1:1 or flatter for rock excavation are suggested for the 3 to 5 foot thick shale and weak limestone zones that underlie the upper limestone of the Schroyer member.
shale that separates the upper and lower limestone members of this member is common excavation if it is weathered. It has weathered to a depth of 12-3 feet at 75 ft. left of Station 525/00.

The Vymore shale is common excavation if it is weathered. It has weathered to a depth of from 5 to 9 feet through this location.

The limestones of the Schroyer member are rock excavation. All the 3.6 foot thick lower shale and some limestones that underlie the upper limestone of this member is weathered to common excavation if it is overlain by less than the upper Schroyer limestones and 2 feet of Vymore shale.

Cut Section From Station 335/00 to Station 525/00

Backslopes

The Schroyer limestone and Havensville shale members will be encountered in this cut section. They are covered by a thin clay type mantle that contains numerous chert fragments.

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

The upper limestone unit of the Schroyer limestone member is badly weathered, jointed and clumped at this location. It is considered as mantle, however, there may be some limestone blocks of fair size encountered. These limestone blocks and the weathered shale zone that underlies them should be placed on a slope of 2:1 or flatter. The cherty limestones of this member will stand on a 1:2 slope satisfactorily.

Backslopes of 2:1 or flatter for common excavation and 1:1 or flatter for rock excavation are suggested for the Havensville shale member.

Excavation

The limestones of the Schroyer limestone member that are in place are rock excavation. The shale and weak chaly limestone that overlie the cherty limestones have weathered to common excavation.

The upper 4.8 foot of the Havensville shale has weathered to common excavation unless it is overlain by 8 or more feet of Schroyer limestone. The chaly limestone
This cut section. There is a spring at 165 feet left of Station 577/00 which is at an elevation of 1007.7. There is a small amount of ground water flowing from it.

It is thought that the ground water originates from the base of the Schroyer Limestone basin in the hill. There was no indication that there was any ground water flowing at the base of the Schroyer Limestone along centerline at this time, however, the Evansville shale that underlies it was weathered badly. If the ditches of the proposed roadway cut the base of the Schroyer Limestone as is indicated by the preliminary grade line, then ground water movement will not present a problem. The probability of unstable Evanville shale should be considered in base course design.

Cut Section from Station 602/00 to Station 633/00

Backlopes

A small amount of Kymore shale and Schroyer Limestone that are overlain predominantly by a clay type mantle will be encountered through this location. The mantle would average around 3 feet thick, however it varies from 3 to 12 feet thick. It varies from a tan-brown to a reddish-brown in color.

Backlopes of 1:1 or flatter are suggested for the mantle.

The Kymore shale that will be encountered is weathered. Backlopes of 1:1 or flatter will stand satisfactorily.

Backlopes of 1:1 will stand satisfactorily for the small amount of Schroyer Limestone that may be encountered.

Excavation

The Kymore shale member that will be encountered has weathered to common excavation. The depth of weathering varies from 6 to 10 feet.

The limestones of the Schroyer Limestone member are rock excavation. If a shale zone of the Schroyer member is encountered, it will be weathered to common excavation.

Hydrology

At Station 612/00, 90 feet left, there is an old well that has a broken pump and does not appear to be in use.
At Station 659/40, 100 feet left, there is a well that has a windmill sitting on it but it is not being used.

At Station 659/40, 151 feet left, there is a flowing spring in the present gully. The elevation of the water level is 1,237.0 and is coming out of the base of the Schroyer Limestone. This water is being used for cattle.

cut sections from Station 672/40 to Station 727/40

Backslopes

The Florence Limestone and Blue Springs shale will be encountered through these cut sections. They are overlain by a thin type mantle that consists of clay with scattered chalk fragments.

Backslopes of 2/1 or flatter are suggested for the thin mantle.

The Florence limestone member will stand on a 1/1 slope satisfactorily.

Backslopes of 1/1 or flatter for common excavation and 1/2 or flatter for rock excavation are suggested for the Blue Springs shale member.

Excavation

The Florence limestone member is rock excavation.

The Blue Springs shale member is common excavation when it is weathered. It has weathered to a depth of 3 ft. when it is not overlain by the Florence limestone.

Hydrology

At Station 659/32, 62 feet right, there is a well that is being used. It has an electric pump installed on it.

At Station 699/400, 26 feet left, there is a well that is being used.

At Station 699/42, 92 feet left, there is an abandoned well that appears to have caved.

At Station 708/40 there is a deep V-shaped gully that crosses centerline. This buried gully will not present a problem.

cut section from Station 735/40 to Station 791/40

Backslopes

A small amount of Florence Limestone and a clay type mantle will be encountered through this location. The clay type mantle is predominantly a glacial till type deposit and varies in color from a tan-brown to a red-brown. It is approximately 18 feet thick at Station 778/400.
Decking of 2:1 or flatter are suggested for the stables.

Slopes of 2:1 will stand satisfactorily for the clayey Florence limestone. Slopes of 2:1 are suggested for the small amount of weathered shale of the Florence member that may be encountered.

Excavation

The Cherty limestone of the Florence member is rock excavation. The shale core of the Florence member that may be encountered have weathered to common excavation.