1. Our solution from start a 9% to 15%  

Geology

The Elmy Creek shale, Judithburg limestone, Rooser shale, Kiska limestone and  
Stevens shale may be encountered in the ditch sections of the shallow boxcloppe  
through this location. The shale, which consists of these shales and limestone units,  
consists of a silty clay that varies in thickness from one to four feet.  

At station 95'-10', a normal fault occurs containing a displacement of  
approximately five feet. A few hundred feet from this location, in the Table  
Creek railway, the fault displacement is twenty-two feet.  

The reason for the difference in displacement between these two locations is  
that the bedrock layers were bent, as well as faulted, in the vicinity of outcrops  
which reduced the amount of displacement of the fault. The bending of the bedrock  
as facilitated by the strong local dip that existed prior to faulting. The re  
duction of fault displacement is a local situation, since displacement is required  
unfavorably along the fault zone.  

The strong dip and faulting will not affect the proposed roadway.  

Backalages of 2:1 or steeper are suggested for the mantle.  

The Elmy Creek shale that will be encountered has weathered to common exca  
vation. Backalages of 1:2 or steeper are suggested for this shale formation.  

Backalages of 1:4 are suggested for the Judithburg limestone member.  

Backalages of 1:1 for common excavation, and 1:1 for rock excavation are sug  
ggested for the Rooser shale member.  

Backalages of 1:1 will stand satisfactorily for the Kiska limestone member.  

Backalages of 1:1 or steeper will stand satisfactorily for the weathered  
Stevens shale formation that will be encountered.  

Rock Excavation

The shale zones in the Elmy Creek shale that will be encountered have weathered  
to common excavation. The limestone zones in this shale formation is rock excavatio
The Cottonwood Limestone is rock excavation.

The Shale unit, which will be encountered, is weathered to common excavation.

The Limestone units of the Mississippian member are rock excavation. The shale unit of this member is common excavation when weathered. It is weathered at this location unless it is overlain by the upper Mississippian units.

The shale unit that will be encountered has weathered to common excavation.

2. Cut Section from Station 107/50 to Station 110/50

Breachway

The lower 3 to 4 feet of the Cottonwood Limestone is exposed at the surface between the above stations. The Enbridge Shale, which underlies the Cottonwood Limestone, is weathered to a depth of 3 to 4 feet under the remnants of the overlying limestones.

The Cottonwood Limestone, at this location, is weathered and contains numerous horizontal and vertical joints. Backslope of 1:1 or flatter will stand satisfactorily.

Baseslope of 1:1 or flatter are suggested for the weathered Enbridge shale. Baseslope of 1:1 or flatter will stand satisfactorily for the Enbridge shale that is rock excavation.

Rock Excavation

The Cottonwood Limestone is rock excavation. The Enbridge Shale has weathered to common excavation to a depth of three feet under the Cottonwood Limestone at station 109/00, at centerline, and to a depth of four feet at the outcropping edge of the overlying limestones.

Overbreakages

The Cottonwood Limestone at this location is weathered and has numerous horizontal and vertical joints. However, several of the limestone blocks will be of large size, therefore, a small amount of overbreakage, depending upon the grade line, may be encountered.

3. Cut Section from Station 113/50 to 125/00

Breachway
a small amount of the Eakridge shale will be encountered at this location. These bedrock units are overlain by one foot or less of mantle which is predominantly a silty clay. The lower portion of the weathered Stearne shale will be encountered in the extreme upper portion of the backlopes. The Merrill limestone consists of a thin, brown, impure, cellular limestone at this location and has weathered to common excavation. The Florence shale is weathered and has a moisture content that varies from being very moist to dry. All three of these bedrock units have had ground water moving through them from left to right across centerline. This ground water movement will have a tendency to cause the left backslope to become unstable unless it is laid back on a fairly flat slope.

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

A slope of 1:1 for the left backslope and 1:1 for the right backslope is suggested for the Stearne shale, Merrill limestone and the Florence shale through this location.

The Cottonwood limestone will stand on a 4:1 slope satisfactorily.

Backlopes of 4:1 or flatter for rock excavation and 1:1 or flatter for common excavation are suggested for the Eakridge shale.

Rock Excavation

The Stearne shale, the thin, impure Merrill limestone and the Florence shale have been subjected to ground water movement at this location; therefore, they have been weathered to common excavation.

The Cottonwood limestone is rock excavation.

The Eakridge shale has weathered to common excavation to a depth of 13.0 feet at the edge of the Cottonwood limestone exposed at station 114/31, centerline, 12.0 feet at station 121/68, centerline, and 14.0 feet at station 124/39, centerline.

This depth of weathering is due to past ground water movement at the base of the Cottonwood limestone and through the Eakridge shale. The depth of weathering of the shale will decrease from 13.0 feet at station 114/31 to 0.0 at station 116/30 and from 12.0 feet at station 121/68 to 0.0 at station 123/30.
There is evidence that there has been a moving flow of ground water from left to right across this location. The lower limestone in this area has had ground water moving through it. The Florina shale is at a point that lies between an elevation of 115' 0" and 105' 0" at station 125/00, that was very moist and soft at the time of this investigation.

It is probable that the base of the Cottoverd limestone will be carrying ground water during normal annual rainfall periods.

Subdrainage should be considered if the grade line crosses over the area mentioned in the Florina shale if the left ditch does not cut below it one foot.

The base of the Cottoverd limestone should be designed if it is cut by the grade line.

At 61 feet right of station 125/00 is the edge of a small pond. The elevation of the water level in this pond is 115' 0". This water level appears to be rather stable. The pond is being used for watering cattle. It appears that this pond is spring fed, although there is no visible evidence to support this. There is evidence, however, that there has been ground water moving through this area from left to right across contours. Therefore, since the water level has been stable through the past dry season and the drainage into the pond is very small, it is assumed that the pond has ground water springing into it.

b. Cut Section from Station 125/00 to Station 125/00

The Sandstone that is encountered by a silty clay mantle will be encountered at this location. The mantle thickness varies from 1.5 to the left of centerline to 12 feet at station 125/00, centerline.

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

Backhowses of 1:1 or flatter for common excavation and 1:1 or flatter for rock excavation are suggested for the Erskine shale formation.
Rock Formation

The Schmidake shale is common excavation where it is weathered. It is weathered
to an average depth of 8.4 feet at the cross-section of station 155/00.

5. Cut section from Station 156/00 to Station 158/00

Backslope

The Schmidake shale, Rome Limestone and possibly a small amount of Salem Point
shale will be encountered through this location; however, the majority of the mater-
ial will consist of a lens-like silty clay that is 8.5 feet thick at station 156/00.
This thick mantle deposit lies in a buried valley that extends from station 156/00
to station 158/00. The Schmidake shale will be encountered on a side hill between
stations 156/00 and 158/00. The Rome Limestone and Salem Point shale may be
encountered in the vicinity of station 157/00, depending upon the grade line.

Backslopes of 1:1 or flatter are suggested for the silty clay mantle. Care
should be taken to divert any surface drainage that would flow over the mantle
backslopes as it is susceptible to erosion.

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

Backslopes of 1:1 are suggested for the Rome Limestone member. The shale
units in this limestone member are either very clay and resistant or so thin that
they will cause no concern as far as backslope stability.

Backslopes of 1:1 or flatter for common excavation and 1:1 or flatter for
rock excavation are suggested for the Salem Point shale.

Rock Formation

The Schmidake shale formation has weathered to common excavation to a depth of
from 9 to 10 feet through this location.

The limestone units of the Rome Limestone member are rock excavation. The
upper shale zone of the Rome Limestone is quite clay and resistant to weathering.
It has weathered to common excavation to a depth of 1 foot in the vicinity of
station 155/00.

The Salem Point shale is weathered to common excavation where it is exposed
by four or more feet of Rome Limestone.
The Cuttenwood limestone, Eshbridge shale and Eocene limestone will be encountered in the right backhoe through this side hill location. The bedrock is covered with a thin mantle that consists of silty clay and limestone fragments and blocks.

Backhoes of 211 or footer are suggested for the mantle.

The Cuttenwood limestone will stand on a 211 slope satisfactorily.

Backhoes of 211 or footer for common excavation and 211 or footer for rock excavation are suggested for the Eshbridge shale formation.

Backhoes of 211 or footer will stand satisfactorily for the Eocene limestone mantle. The shale units in this limestone mantle are either very lumpy and resistant or so thin that they will be stable on the 211 slope.

Rock Excavation

The Cuttenwood limestone is rock excavation.

The Eshbridge shale has weathered to common excavation to a depth of 7 to 8 feet than it is not overlain by the Cuttenwood limestone.

The limestone units of the Eocene limestone mantle are rock excavation. The upper lumpy shale zone is common excavation when weathered. It is weathered to a depth of 0.5 feet at this location.

Hydrology

A spring approximately 30 feet right of station 172/00 is piped to a stock tank. The spring is practically dried up at this time. The source of ground water is from the Norwell limestone.

7. Cut Section from Station 185/00 to Station 204/00

Backhoe

The Norwell limestone, Florence shale, Cuttenwood limestone and Eshbridge shale will be encountered in the right backhoe through this location. The thin mantle deposit that will be encountered consists of silty clay and limestone fragments.

A slope of 211 or footer is suggested for the thin mantle.

The Norwell limestone will stand on a 211 slope satisfactorily.
3. Slope of 1:1 or flatter for normal excavation and 4:1 or flatter for rock excavation as suggested for the Rainbow shale formation. 

Rock Subsurface

The Rainbow Shale is rock excavation.

The Florissant Shale is rock excavation where it is encountered. This shale is weathered along this side hill location unless it is overlain by the Florissant Limestone.

The Florissant Limestone is rock excavation.

The Rainbow Shale is normal excavation where it is encountered. It is weathered to a depth of approximately 7 feet through this location where it is not overlain by the Muscoy Limestone.

6. Cut Sections from Station 110/00 to Station 220/00 and from Station 225/00 to Station 240/00.

Rock Subsurface

The East Creek shale, Storrow Limestone, Moore shale, Lime Limestone, Sonoita shale, and Kootenai Limestone will be encountered through these side hill locations. These formations are overlain by a thin mantle of limestone fragments and clay shales. There will be little if any benching to be done on cutting through this area.

Rock Subsurface

Rock Subsurface

Rock Subsurface
Backfill of 1:1 or sloping for common excavation and 1:2 for rock excavation are suggested for the Uruma sand formation.

The Merrill limestone will stand on a vertical slope satisfactorily.

**Rock Excavation**

The Early Creek shale is common excavationwhen it is weathered. It has been weathered rather extensively at these two locations. The upper 6.6 feet of this formation is weathered unless it is overlain by the 4.1 foot thick limestone of the Lower Crame formation. At this point the rock and common contact projects up until the complete Crame limestone section overlaps it. The lower 16.9 feet of the Early Creek shale has weathered to the depth of 3.3 feet to the right of station 213/00. This depth of weathering is 6 feet between station 233/00 and station 256/00. The limestone units in the Early Creek shale are rock excavation.

The Middleburg limestone is rock excavation.

The Hoover shale is weathered to common excavation through these locations when it is not overlain by a full thickness of Middleburg limestone.

The limestone units of the Elma limestone are rock excavation. The thin shale unit of this member is weathered to common excavation unless it is overlain by four or more feet of bedrock.

The Crame shale is common excavation and it is weathered. It has weathered to a depth of approximately 7 feet through these two locations when it is not overlain by the Elma limestone.

The Merrill limestone is rock excavation.

**Hydrology**

At station 213/09, 96 feet right there is a 10 feet square deep area that has a rank growth of vegetation. This seepage is coming from the base of the Crame limestone. This seepage will not affect the roadway, however, it may cause the underlying Early Creek shale to slide out if it is put on a steep slope.

9. Cut Section from Station 233/00 to Station 256/00

**Backfills**

The Crame limestone, Early Creek shale, Middleburg limestone and Hoover shale
zone from 0 to 6.0 feet and consists of shaly clay with some limestone fragments and blocks.

Backslopes of 2:1 are suggested for the mantle.

The Crouse limestone will be encountered in the left backslope between station 276/50 and station 276/00. The shaly limestone of the upper Crouse limestone formation will stand on a 1:1 or flatter slope satisfactorily. The lower limestone zone is blocky and somewhat massive. It will stand on a vertical slope.

Backslopes of 1:1 or flatter are suggested for the Shaly Creek shale that is common excavation as it has a moisture content that varies from moist to wet. A backslope of 1:1 or flatter will stand satisfactorily for the shale that is classified as rock excavation. The limestone zone in this shale formation will stand on a 1:1 slope.

The Middleburg limestone member will stand on a 1:1 slope or flatter.

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

Rock Excavation

The upper shaly limestone zone of the Crouse limestone formation has weathered to common excavation to a depth of 1.5 feet at this location. The lower limestone zone is rock excavation.

The Shaly Creek shale is common excavation when it is weathered. This shale formation has weathered rather deeply through this location due to ground water movement at the base of the Crouse limestone. The limestone zone in this shale formation is rock excavation. The average depth of weathering of the shale is approximately 13.0 feet when it is not overlain by the Crouse limestone. This depth of weathering decreases to 0.0 when the shale is overlain by the complete portion of the Crouse limestone.

The limestone zones of the Middleburg limestone are rock excavation. The shale is weathered to common excavation unless it is overlain by the upper Middleburg limestone.

The Hoosier shale member is common excavation unless weathered. The depth of weathering varies from 2.0 feet on the side shown to 1.5 feet between station 276/00 and 276/75.
Hydrology

The Ealy Creek shale was found to have a rather high moisture content through this location. At station 269/00, 7/4 foot left, it is moist and soft from an elevation 1200.5 to 1213.9. At station 272/90, centerline, it is very moist and soft from an elevation of 1213.1 to 1213.4. At station 277/92, centerline, it is very moist and soft at an elevation of 1203.5 and saturated at 1212.7. It is thought that this moisture content originated from the base of the Crouse Limestone and has moved from through the weathered shale. The Crouse Limestone is not carrying water at this time due to the prevailing dry condition.

The moisture condition described above is not a concentrated ground water movement. The 1/2" ditch, which will act as a surface interceptor, should give protection from any addition to the present moisture content that will directly affect the roadway. The very moist shale that is encountered during construction may require drying before it is used as subgrade material. It has a tendency to hold its moisture for a considerable length of time, and since the shale is soft and badly weathered, a failure may develop.

10. Cut Sections from Station 263/00 to Station 269/00

Backditches

Centerline cuts across several topographic noses along this location. The Blue Ridge shale, Crouse limestone, and a small amount of Ealy Creek shale will be encountered. The mantle varies in thickness from 1.0 to 3.0 feet and consists of silty clay with varying amounts of limestone fragments and blocks.

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

Backditches of 1:1 or flatter for common excavation and 1:1 or flatter for rock excavation are suggested for the Blue Ridge shale.

Backditches of 1:1 are suggested for the upper Ealy shale of the Cooks limestone. The lower limestone unit of this formation will stand on a vertical slope.

The small amount of Ealy Creek shale that will be encountered is weathered to some extent. Backditches of 1:1 or flatter are suggested for the shale.
of this formation. The limestone unit in the Holly Creek will stand on a 4/1 slope satisfactorily.

Rock Excavation

The Blue Rapids shale is common excavation when weathered. Its depth of weathering varies from 2.8 to 4.5 feet through this location.

The Crouse limestone is rock excavation except where the upper shale limestone is weathered. Its depth of weathering varies from 0.0 to 2.5 feet. However, the 2.5 depth of weathering is an exceptional case. Ordinarily, the weathering depth will be from 0.0 to 0.5 feet.

The Holly Creek shale that will be encountered in the vicinity of station 283/00 has weathered to common excavation. The limestone unit in this formation is rock excavation.

Hydrology

There is very little evidence that the Crouse limestone is carrying ground water in the vicinity of station 283/00. However, it is a good possibility that this limestone formation is a potential ground water carrier at this location and that it will have ground water moving at its base during normal rainfall periods.

It is suggested that this location be checked during construction to determine if subdrainage is desirable if the base of the Crouse limestone formation is cut by the grade line.

Between stations 315/00 and station 319/00, the upper portion of the Crouse limestone and the lower portion of the Blue Rapids shale will be encountered. It is possible that there has been ground water moving along the top of the Crouse limestone at this location. The Blue Rapids shale at waterline was dry, however, at station 313/00, 60 feet east, the shale was not directly above the limestone. This location should be checked during construction to see if subdrainage is desirable. It is possible, depending upon the grade line, that the left creek would intercept any ground water moving along the top of the limestone.

11. Cut Section from Station 320/00 to Station 333/00

The Blue Rapids shale that is overlain by a silty clay mantle will be encountered at this location.
Backshovels of 2:1 or flatter are suggested for the earth.

Backshovels of 1:1 or flatter for common excavation and 1:2 or flatter for rock excavation are suggested for the Blue Rapids shale.

Rock Excavation

The Blue Rapids shale is common excavation than it is weathered. It has weathered to a depth of 5.5 feet through this location.