COMMONWEALTH OF KENTUCKY
DEPARTMENT OF TRANSPORTATION
FRANKFORT, KENTUCKY 40601
BUREAU OF HIGHWAYS
JAMES E. GRAY
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GOVERNOR

August 10, 1973

H.3.38

MEMORANDUM TO: A. R. Romine, Director
Division of Maintenance

ATTENTION: B. H. Banks, Assistant Director
Division of Maintenance

SUBJECT: Report on Stability Analysis of Slide at Milepost 152.7, I 64, Carter County

Attached is the report of the stability analysis for the aabove-cited slide on I 64 in Carter County. The analysis has been undertaken in response to requirements imposed by the Federal Highway Administration. It will be noted that this analysis verifies the solution that was recommended some 13 months ago as a result of the field inspection and synthesis analysis.

Respectfully submitted,

Jas. H. Havens

James H. Havens, Director
Division of Research

JHH:dw
Attachment
cc's: Research Committee

Research Report
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STABILITY ANALYSIS OF SLIDE
AT MILEPOST 152.7, I 64, CARTER COUNTY

KYP-72-38; HPR-1(9), Part III

by

H. F. Girdler
Research Engineer Associate

and

T. C. Hopkins
Research Engineer Principal

Division of Research
Bureau of Highways
DEPARTMENT OF TRANSPORTATION
Commonwealth of Kentucky

August 1973

INTRODUCTION

A visual inspection of a slide near Milepost 153 on I 64 was made April 11, 1972, and reported in a memorandum prepared by B. H. Banks on April 12, 1972. The Division of Research made recommendations for correcting this situation in a memorandum to A. R. Romine on June 30, 1972. These recommendations were based on a limited field investigation and a stability analysis of a proposed berm to be located near Station 3483+00. In a letter dated August 18, 1972, Mr. A. J. Horner of FHWA requested borings be made at the site to establish rock depth and to obtain samples for triaxial testing. That correspondence indicated that, to be eligible for FAI participation, a more complete analysis of the slip would be needed.

Results of the present investigation which conform to the FHWA request are presented herein. Translatory slope stability analyses were not performed since the circular slope stability analysis was more applicable in this particular situation. Slope stability computations (Bishop's circular method) were carried out in terms of effective stress using shear strength parameters obtained from consolidated, isotropic, undrained triaxial tests with pore pressure measurements. The major objective of the study was to check a remedial solution previously proposed (see APPENDIX). The investigation was conducted under Research Study KYP-72-38 entitled "Landslides" and maintenance project SP 22-538-28L.

GEOLOGY AND TOPOGRAPHY

The topography in the vicinity of the I-64 site located in Carter County near Olive Hill is characterized by round, hilly areas of moderate relief. Geologically, it lies in the Lower Breathitt Formation consisting of Magoffin beds, Fire Clay coal, and Kendrick shale. The siltstones and clays of this area exhibit poor stability characteristics in natural formations as can be seen from escarpments existing on natural slopes in the area. When water is present in large quantities, these formations exhibit very poor stability when used as fill materials.

FIELD INVESTIGATION

Cross sections of the slide were taken near Station 3483+00 to establish an existing ground line and to define the major cracks. The sliding section begins (see Figures 1, 2 and 3) approximately 78 feet from centerline at Station 3483+00 and extends to the right and left about 50 feet. At mid-slope on the east end of the slide area, slope movement has partially covered a small outlet headwall and filled the paved ditch (Figure 1). Water is running from the pipe into the slip area at this point.

Borings (Figure 4) were obtained at Station 3483+00 on the slope and in the toe area of the slide using a drill mounted on a dozer. Hole 1 was located 126 feet from centerline in the upper portion of the unstable mass (Figure 3). The embankment consists of a brown clay with weathered shale. The foundation is soft sandstone overlaying a green weathered shale formation common to the area. Hole 2 is located 176 feet from centerline at the toe of the slide. The material in this area is some 18 feet thick and consists of brown clay, red weathered shale, and sandstone. Three Shelby tubes obtained from this hole produced four undisturbed triaxial specimens. One tube from Hole 1 produced two undisturbed samples suitable for triaxial testing. Water table elevations were not available and could not be accurately obtained from the boreholes drilled at the site.

LABORATORY INVESTIGATION

Shear strength parameters of the embankment and foundation soils were established from consolidated, isotropic, undrained triaxial tests (CIU') with pore pressure measurements. Triaxial test results for the embankment and foundation materials are shown in Figures 5 and 6, respectively. The unstable embankment material from Hole 1 had an angle of shearing resistance, ϕ', of 22.1° and a cohesion, c', of 2.70 pounds per square inch. Foundation soils from Hole 2 located near the toe of the slip had a ϕ'-value of 28.5° and a high cohesion, c', of 4.55 pounds per square inch. The limited number of samples successfully recovered prevented further testing and confirmation of these values. Classification results of the soils are recorded in Table 1. Generally, the soils in the slide area are heterogeneous. Liquid limits of materials from Hole 2 ranged from 30 to 43 percent; plasticity indices ranged from 10 to 21 percent.

METHOD OF ANALYSIS

Slope stability of the previously proposed berm was checked using two different approaches. The first method involved calculating the in situ shear strength of the slide materials and was as follows:

1. Assuming a ϕ'-value ot 35° (arbitrarily chosen) and a c'-value of zero, the circular failure surface having a minimum safety factor was determined using the search routine of the slope stability computer program (see Analysis 1, Figure 3). The critical failure circle determined in this matter agreed well with actual ground breaks observed at the site. In performing these computations, a reasonably high water table was assumed. Position of the critical surface did not change when the water table was lowered.
2. Using the critical circle determined in Step 1 and a high water table, the ϕ'-value was adjusted until the safety factor was equal to 1.00 (see Analysis 2, Figure 3). In these computations, the cohesion, c', along the failure surface was assumed to be zero since the unstable mass had moved a considerable distance. It was assumed that, since the slope was failing, the safety factor was by definition equal to one. The ϕ'-value determined in this manner was 30°.
3. Using the adjusted ϕ'-value of 30°, corresponding to a safety factor of 1.00, and the assumed high water table, a grid-type search operation was used to determine the critical shear surface (see Analysis 2, Figure 3). The critical shear surface determined in this manner and the one from Step 1 coincided.
4. Finally, using the adjusted ϕ'-value (30°) corresponding to a safety factor of 1.00, the assumed high water table, and a c' of zero, stability of the proposed embankment-berm configuration was checked as shown by Analysis 3, Figure 7. A ϕ'-value of 30° was assumed for the proposed berm materials. The minimum safety factor obtained from the computer program's search routine was 1.69.

The second method of checking the stability of the proposed berm involved using the shear strengths of the slide materials determined from the CIU' triaxial tests (Figures 5 and 6). For this case, the minimum, long-term safety factor obtained from the computer program's search routine was 2.06 (see Analysis 4, Figure 7). Finally, stability of the embankment-berm configuration was checked based on the assumption that the cohesion, c', obtained from the CIU' tests might decrease to zero at some future time. For this case (Analysis 5, Figure 7) the safety factor was 1.30.

RECOMMENDATIONS

Using a 3:1 slope on the existing embankment and by adding a berm 15 feet high and approximately 30 feet wide at the toe, the critical safety factor can be increased to 2.06 (Analysis 4, Figure 7) at the assumed high water level. The berm should extend from Station 3481+00 to 3484+00, as previously recommended. Since embankment stability in this area is extremely sensitive to moisture, provisions should be made to properly drain the berm and embankment. A drainage blanket of No. 9 stone 24 inches thick placed against the existing embankment below the 980-foot elevation should permit ground water drainage without berm saturation. A surface collector system draining into a pipe placed at the embankment toe in the existing paved ditch should further reduce soil moisture content at the site.

SUMMARY

Based on soil testing and stability analysis, the recommendations presented in the June 30, 1972, memo to A. R. Romine (see APPENDIX) seem to be adequate. Test results indicate that a berm 15 feet high and approximately 30 feet wide will provide adequate embankment stability. Proper drainage to prevent berm saturation will further improve and insure embankment stability. A more recent site investigation indicates some slippage near Station 3480+50. Consideration should be given to extending the berm length to include this area.

Figure 1. General View of the I-64 Embankment Failure Located Near Milepost 153, Station 3483+00.

Figure 2. View of Surface Breaks Located at the Western Flank of the Embankment Failure.

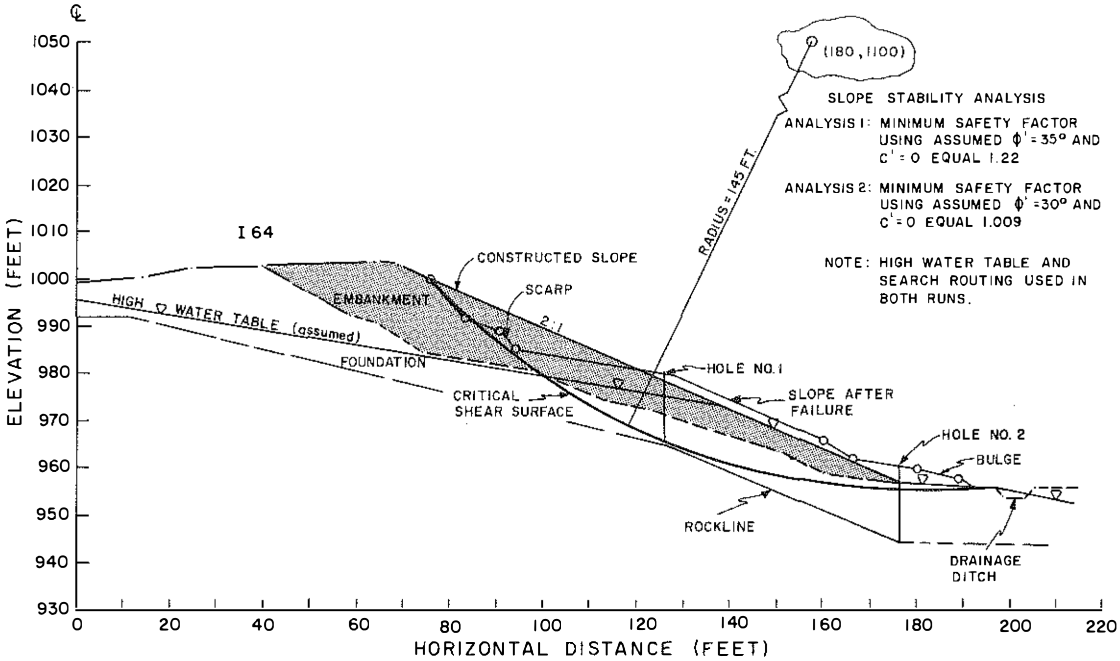


Figure 3. **Cross-Sectional View of Embankment Failure at Station 3483+00 Showing Boring Locations and a Comparison of the Failed Slope and the Critical Shear Surface Obtained from the Slope Stability Analysis.**

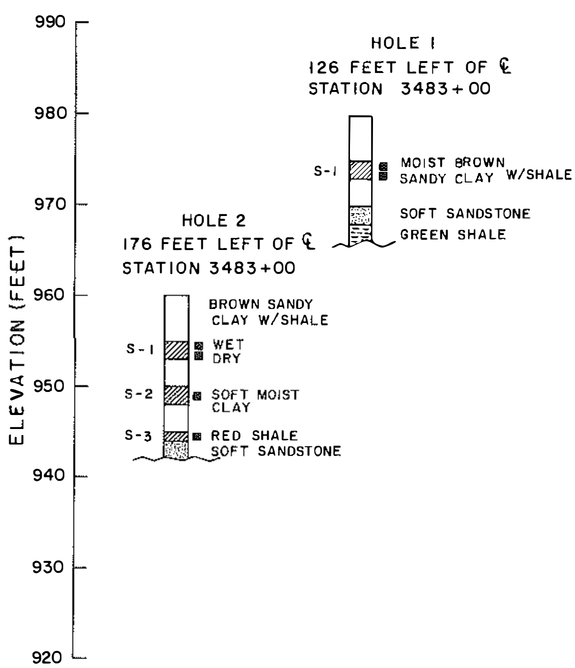


Figure 4. **Boring Logs.**

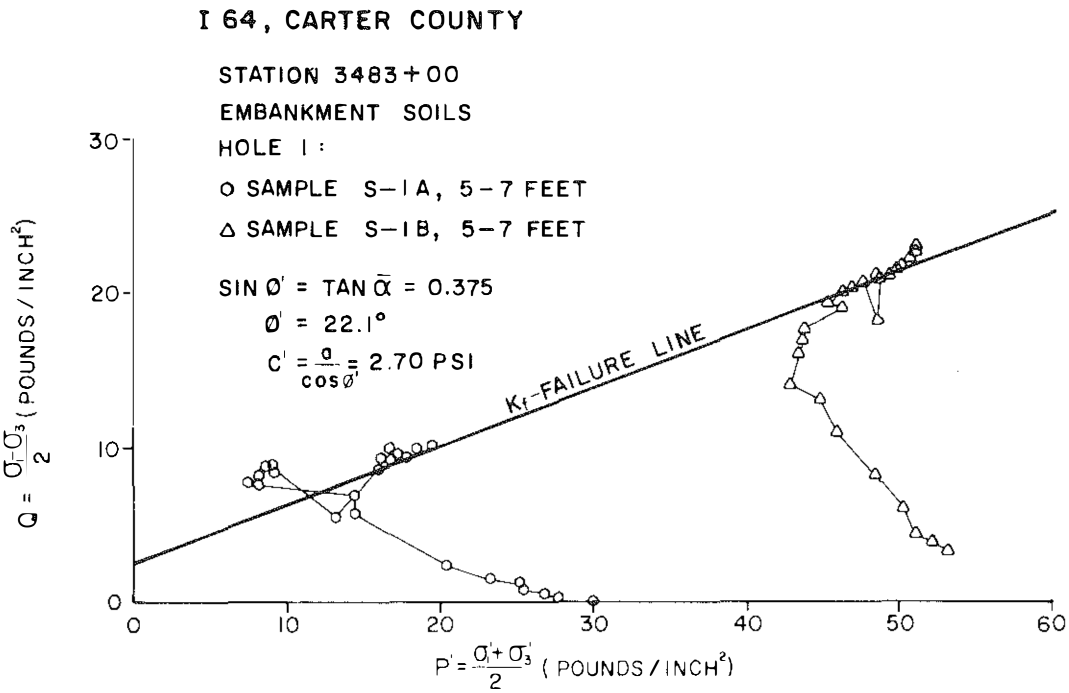


Figure 5. **Consolidated, Isotropic, Undrained Triaxial Test Results, Embankment Soils, Hole 1.**

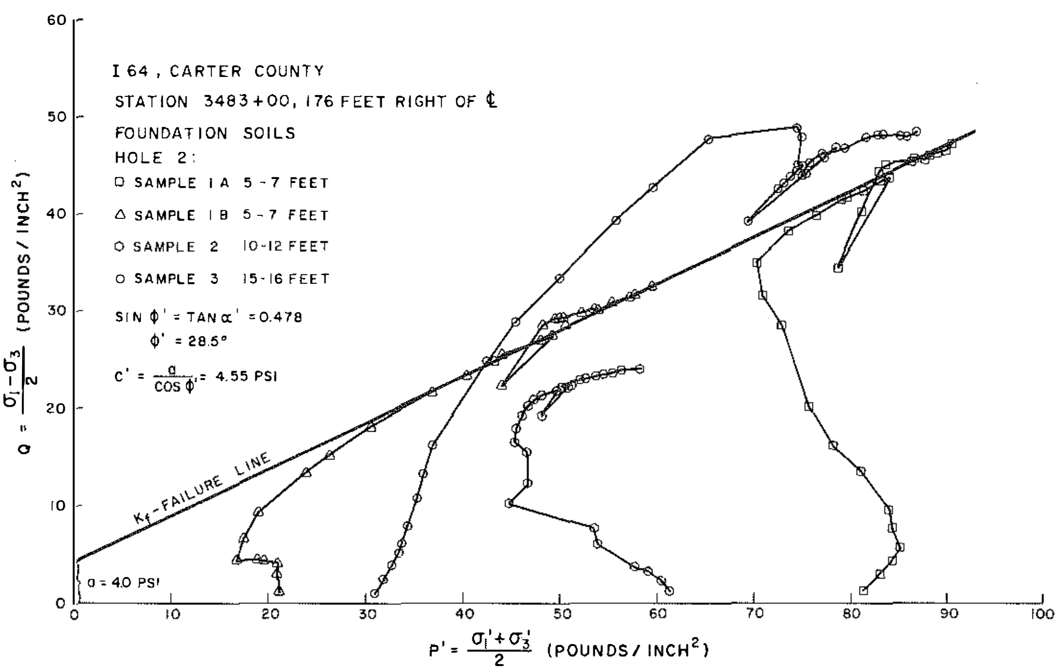


Figure 6. **Consolidated, Isotropic, Undrained Triaxial Test Results, Foundation Soils, Hole 2.**

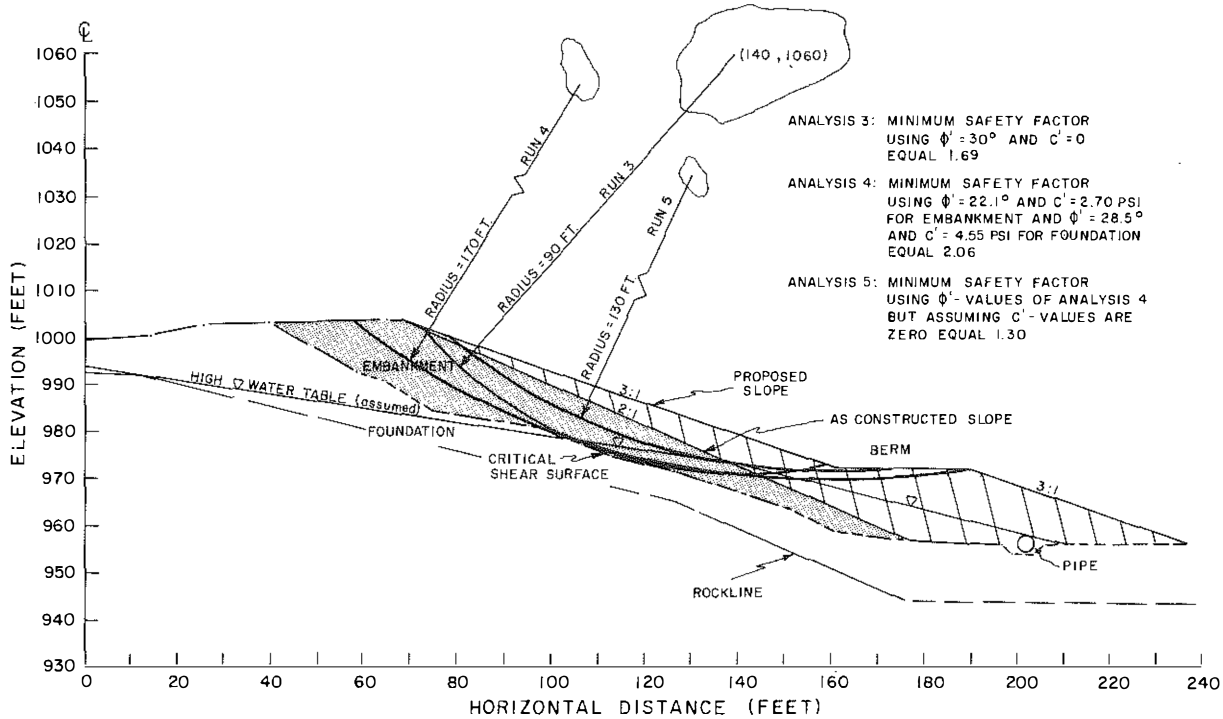


Figure 7. Stability Analysis of the Embankment-Berm Configuration Based on Computed Shear Strengths and Shear Strengths from CIU' Triaxial Tests.

TABLE I

SUMMARY ●F CLASSIFICATION TEST DATA

H●LE NUMBER	SAMPLE	SAMPLE DEPTH (FEET)	MOISTURE CONTENT (PERCENT)	DESCRIPTION	UNIT WEIGHT (POUNDS/FOOT^3)	LIQUID LIMIT (PERCENT)	PLASTICITY INDEX (PERCENT)	REMARKS
1	A	5		Brown silty clay mixed with green shale				These samples similar to those taken from H-2, 5'
	B	6						
2	A	5	16.2	Brown sandy, silty clay with shale particles uniformly dispersed	131.2	30.4	10.4	Samples hard and brittle. Sections of embedded shale. Many rocks.
	B	6						
	C	11	28.9	Brown silty clay, moist and soft	13●.2	43.4	20.8	Sample easily trimmed. Very moist.
	D	15	6.9	Red shale	145.0	34.9	10.9	Sample soft. Easily trimmed.

APPENDIX

June 30, 1972

H.3.38

MEMORANDUM TO: A. R. Romine, Director
Division of Maintenance

ATTENTION: B. H. Banks
Assistant Director

FROM: Jas. H. Havens, Director
Division of Research

SUBJECT: Slide at Milepost 152.7, I 64, Carter County

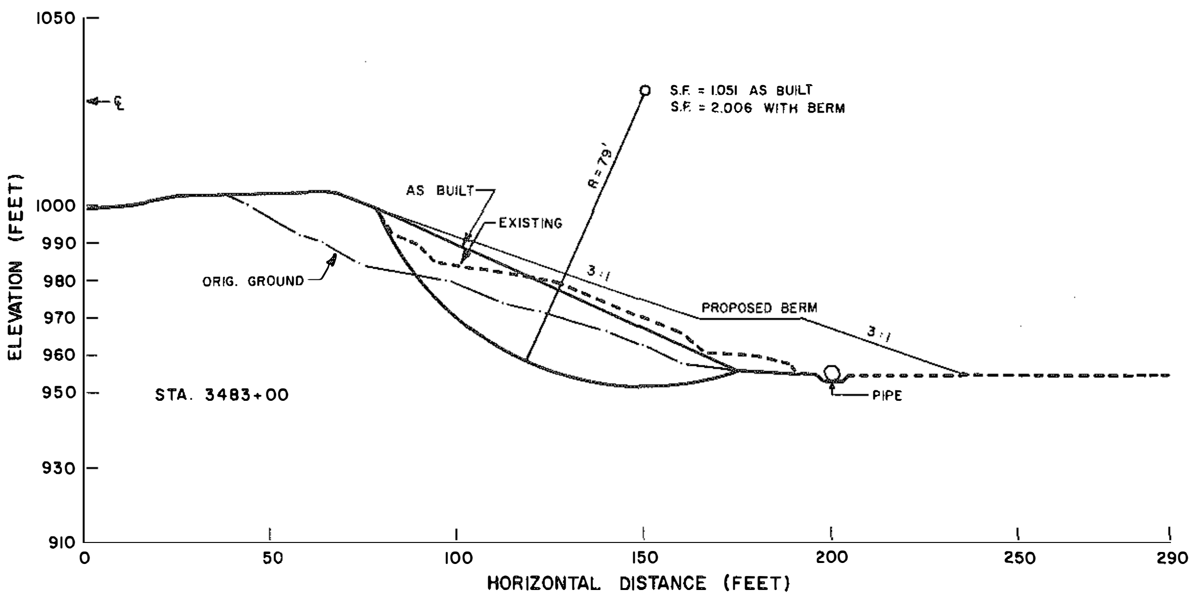
An inspection of the area was made April 11, 1972, and documented in a memo prepared by B. H. Banks on April 12. Since that time, cross sections have been taken and a slope stability analysis run at Station 3483+00 (Figure 1). The analysis shows a design fashioned after the recommendations of the inspection team to be in order. A berm approximately 27 feet wide and 15 feet high and having a slope of 3:1 merging into natural ground and the top of the present scarp should provide sufficient stability (Figure 2). The berm should start near Station 3481+00 and continue to Station 3484+00. The upstream and downstream ends may vary in size, but the full section should extend a sufficient distance to cover the existing slide.

Provisions should be made for proper drainage of the area (Figure 3). The work should include a drainage blanket of No. 9 stone, 24 inches thick, placed against existing material and below the 980-foot elevation. Provisions should be made for drainage of the upper reaches of the berm (Station 3481+00). A collector system should be used to funnel all excess water to the drainage pipe shown in Figure 2. This will help keep saturation of the berm and toe area to a minimum.

Attention should also be given to the area approved for borrow. The hill opposite the slide appears to be marked with ancient slides (Figure 4), and it does not seem likely that removal of any support there would be in the best interest of the Department.

JHH/dw
Attachments
cc: J. E. McChord (attn. Henry Mathis)
L. G. Sturgill
C. S. Layson (attn. J. S. Riley)
Marx Anderson
J. S. Spurrier
G. F. Kemper
W. B. Drake

Figure 1.



S.F. = 1.051 AS BUILT
S.F. = 2.006 WITH BERM
R = 79'
AS BUILT
EXISTING
3:1
PROPOSED BERM
3:1
ORIG. GROUND
PIPE
STA. 3483+00
ELEVATION (FEET)
HORIZONTAL DISTANCE (FEET)
1050
1000
990
980
970
960
950
930
910
0
50
100
150
200
250
290

Figure 2.

Figure 3.

Figure 4.