COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS
FRANKFORT

HENRY WARD
COMMISSIONER OF HIGHWAYS

June 21, 1965

ADDRESS REPLY TO
DEPARTMENT OF HIGHWAYS
DIVISION OF RESEARCH
132 GRAHAM AVENUE
LEXINGTON, KENTUCKY 40506

MEMORANDUM

H. 2. 22

TO: W. B. Drake, Assistant State Highway Engineer
Chairman, Kentucky Highway Research Committee

SUBJECT: Research Report: "Fifth Annual Performance Survey of Reinforced Concrete Pipe Culverts;" KYHPR-64-22, Part II, HPS-HPR-1(26)

The attached report is the fifth one of a planned series concerning the structural performance of reinforced concrete pipe culverts. The present report up-dates the performance records of the culverts and summarizes the significant observations that have emerged; some of those cited here merely paraphrase and reiterate contexts of preceding issues. Because of the apparent fact that the culverts which have been under surveillance have attained equilibrum and inasmuch as significant additional discoveries will not likely be forthcoming soon from continued inspections of these installations, the annual routine inspections and reports will be discontinued. From this standpoint, the present report is the final one of the series. Follow-up inspections and reports--perhaps 5 and 10 years hence--should be made. Never-the-less, this report formally concludes the active phase of the study; and I shall proceed, accordingly, to obtain the concurrence of the Bureau of Public Roads in this action.

Respectfully submitted,

Jas. H. Havens
Director of Research
Secretary, Kentucky Highway Research Committee

JHH:jsm
Attachment
cc: Research Committee Members
A. O. Neiser
R. O. Beauchamp
T. J. Hopgood
Russell Johnson

Research Report

FIFTH ANNUAL PERFORMANCE SURVEY OF REINFORCED CONCRETE PIPE CULVERTS KYHPR-64-22; HPS-HPR-1(26)

by

R. D. Hughes
Research Engineer
Research Division
DEPARTMENT OF HIGHWAYS
Commonwealth of Kentucky

in cooperation with the
BUREAU OF PUBLIC ROADS
U. S. Department of Commerce

132 Graham Avenue
Lexington, Kentucky

June, 1965

INTRODUCTION

For many years, engineers have sought a simplified method for determining the strength requirements for underground conduits under various conditions of bedding and backfilling. Methods of installation and the general lack of a uniform design criteria tended to restrict the usefulness of rigid pipe culverts. With the advent of the interstate construction program and the increased mileage of highways meeting high design standards, the number of pipe culverts installed under high fills was significantly increased. This, of course, accented even more so the need for a more straightforward criteria for design and installation of rigid pipe in order that maximum utilization of pipe strengths might be realized and that settlement in the roadway surface near the installation might be minimized. In an effort to satisfy the needs for a simplified design method for rigid pipe, the Bureau of Public Roads in cooperation with Professor M. G. Spangler of Iowa State College and the American Concrete Pipe Association initiated a study of reinforced concrete pipe design and installation procedures. As a result of this study, a stylized, rational criterion was developed and distributed to the various state highway agencies as B. P. R. Circular Memorandum 22-40*, dated April 4, 1957.

----

*Also reported by D. P. Babcock in the Proceedings of the Highway Research Board, Vol. 35, 1956.

The highway agencies were urged to adopt the criterion for use on all Federal-aid projects; and, accordingly, the Kentucky Department of Highways issued Amendments No. 15 and No. 16 (Feb. 28, 1958) to its 1956 edition of Standard Specifications for Road and Bridge Construction. Standard Drawings No. 11.22 (Pipe Bedding Details) and No. 11.23 (Fill Cover Heights, Gages and Dimensions for Circular Pipe and Non Circular Pipe) were issued along with the amendments. These amendments and standard drawings were faithfully patterned after the criterion outlined by the Bureau of Public Roads. Included were some practical modifications which, for the most part, were incidental to the transformation of the design criterion to specification style. Amendment No. 15 was superseded by Amendment No. 15a (Dec., 1961) which in turn was superseded by Amendment No. 15b (Apr. 23, 1964). Amendment 15b, per se, was included in the Department's 1965 edition of Standard Specifications for Road and Bridge Construction. Standard Drawings No. 11.22 and No. 11.23 were revised from time to time with the latest revisions being dated Sept. 23, 1963. Class B (standard) bedding and its B_1 (High Fill) modification were adopted as standards. Each class is similar to the same respective designation as described under the Bureau's Circular Memorandum 22-40.

The Bureau of Public Roads requested (Ref., C. M. 22-42, dated Nov. 12, 1959) that a number of reinforced concrete pipe culverts, designed and installed in accordance with the outlined procedures, be inspected periodically and reported at the end of each calendar year in order to further evaluate the design and installation criterion. In response to this request, a group of 113 reinforced concrete pipe culverts was selected early in 1960 for these inspections. The culverts selected for the yearly inspections are located in Jefferson, Shelby, Franklin, Clark, Montgomery, Scott, Grant, and Kenton Counties on Interstate Routes I-64 and I-75. Each culvert was inspected once each summer during the five summers from 1960 through 1964. This report summarizes the design and construction factors and the performance for each pipe inspected during the five summers.

Previous reports covering the first four performance surveys are:

1. "Performance Survey of Reinforced Concrete Pipe Culverts," by R. C. Deen and R. D. Hughes, dated March, 1961.

2. "Second Annual Performance Survey of Reinforced Concrete Pipe Culverts," by R. D. Hughes, dated February, 1962.

3. "Third Annual Performance Survey of Reinforced Concrete Pipe Culverts," by R. D. Hughes, dated January, 1963.

4. "Fourth Annual Performance Survey of Reinforced Concrete Pipe Culverts," by R. D. Hughes, Dated January, 1964.

Other reports related to but not directly a part of this series of performance-survey reports are:

1. "Camber Design Study, for Concrete Pipe Culverts," by Aubrey D. May, dated February, 1960.

2. "Performance of a Reinforced Concrete Pipe Culvert, with Standard and B_1, High-Fill Bedding, under Rock Embankment (Scott County, I-74-6(5) 123," by Ralph R. Taylor, dated August, 1961.

3. "Some Effects of Fabrication Practices on the Strength Characteristics of Reinforced Concrete Culvert Pipe," by R. C. Deen and J. H.

Havens, dated February, 1963.

Reference is also made to the following publication which revises and updates the original, BPR criterion:

> Reinforced Concrete Pipe Culverts, Criteria for Structural Design and Installation, U. S. Dept. of Commerce, Bureau of Public Roads; GPO, August, 1963.

Prior studies made by the Department in connection with the first-three performance surveys were sustained entirely by State funds. Although most of the field inspections for the year 1963 had been prior to July 1, 1963, the project was fully authorized under Part II of HPS-HPR-1(25) July 1, 1963, and henceforth is subordinately identified as KYHPR-64-22.

THEORETICAL CONSIDERATIONS

Factors governing the maximum height of fill that may safely be placed above a reinforced concrete pipe are: 1) pipe strength, 2) unit weight of fill material over the pipe, 3) character of the foundation material, 4) method of bedding and installation of the pipe, 5) width of trench (if any) in which the pipe is installed, and 6) settlement of material above the pipe relative to that of the material on each side of the pipe. The actual load that must be supported by a pipe is not necessarily equivalent to the weight of the fill material directly above the pipe. Shearing forces may be developed between the prism of soil directly above the pipe and adjacent prisms of soil at the sides--thus increasing or decreasing the load to be supported by the pipe. The actual load-carrying capacity of a given strength of pipe is variable and depends upon the load distribution over the bottom of the pipe as well as the lateral pressure exerted by the backfill against the sides of the pipe.

The strength of reinforced concrete pipe is commonly stated in terms of D-load strength, the load in pounds per linear foot per foot of internal diameter. D-load terminology, to be correct, must be referred to as D-load (0.01 in.) or D-load (ultimate). D-load (0.01 in.) is that load, when tested by the three-edge bearing test, that will produce a crack 0.01 in. wide and 12 in. in length. D-load (ultimate) refers to the three-edge bearing test load that will produce failure of the pipe. An advantage of the D-load designation is that all sizes of pipe of a given D-load strength, installed under similar conditions of bedding and backfilling, may be expected to support the same maximum height of fill above the top of the pipe. For convenience, reinforced concrete pipe are classified according to their D-load strength (0.01-in. crack strength or ultimate strength). Minimum D-load strength requirements for the five, recognized, strength classes of pipe (AASHO M170, ASTM C76) are listed in Table I.

Table I

Pipe Class	Min. D-Load-Lbs. per ft. per ft. Diam.	
	0.01 in. Crack	Ultimate
I	800	1200
II	1000	1500
III	1350	2000
IV	2000	3000
V	3000	3750

The three-edge bearing test is extremely severe inasmuch as the load applied to the conduit is in the form of point loading and inasmuch as there is no side support applied as would be the case in a field installation where lateral pressure would exist at the sides due to backfill. Under field conditions of loading, the vertically applied loads are distributed over a portion of the pipe rather than at a point, and lateral pressures will be exerted; thus under field conditions, the conduit should sustain loads which are in excess of those indicated by the three-edge bearing test. This fact is accounted for in design by use of a load factor (L_f). The load factor is defined as the ratio of the strength of a pipe under a design condition of loading to its strength when tested by the three-edge bearing method.

Underground conduits are divided into two classes for purposes of load computations: 1) trench conduit and 2) projecting conduit--the classification being based upon construction or surrounding conditions influencing the load. A trench condition is defined as one in which the pipe is installed in a relatively narrow ditch dug in a passive or undisturbed soil and then covered with earth backfill. Ditch (or trench) installations are seldom used for highway culverts and therefore no further reference is made thereto in this report. Projecting conduits are divided into positive-projecting and negative-projecting conduits--depending upon the elevation of the top of the pipe in reference to the natural (or specially constructed) ground line. A positive-projecting conduit is one which is installed so that the top of the pipe is above the natural ground line, and a negative-projecting conduit is one which is installed in a relatively shallow and narrow ditch with the top of the pipe at some elevation below the natural ground surface. If so desired, a conduit may be installed as either a positive-projecting conduit or a negative-projecting conduit, regardless of the existing ground line. This may be accomplished by backfilling and compacting above the existing ground line for a sufficient width and to an elevation that will be above the top of the pipe or by excavating the existing ground line over a sufficient width down to an elevation that will be below the top of the pipe. The classes of underground conduit are depicted in Figure 1.

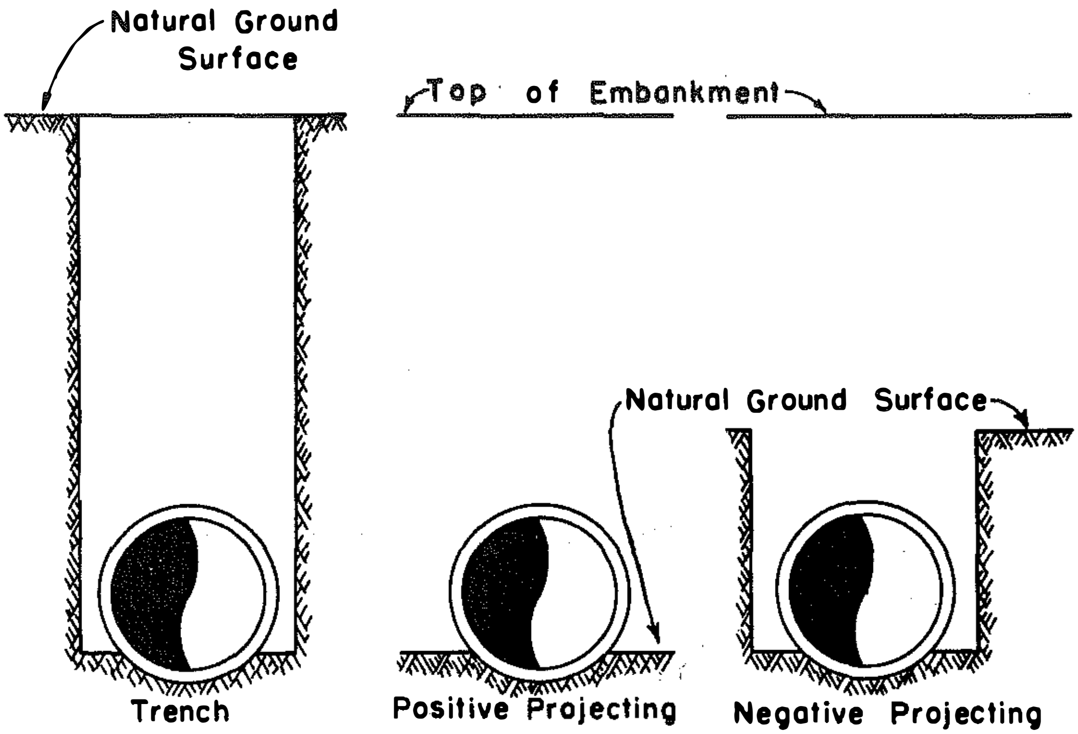


Fig. 1. Classifications of Conduits

When calculating the loads to be supported by positive projective conduit, it is customary to designate that prism of backfill directly above the conduit and bounded by vertical planes tangent to the sides of the conduit as the interior prism. The exterior prisms are the masses of backfill adjacent to the vertical planes on both sides of the pipe and are of indefinite width. Neglecting live loads, the load to be supported by a pipe will be equal to the weight of backfill within the interior prism plus or minus the frictional forces which develop along the vertical planes bounding the interior prism. The direction of these frictional or shearing forces developed between the interior and exterior prisms is dependent upon the relative settlement of material within the interior prism to that of the materials within the exterior prisms.

Unless the embankment material on each side of a positive projecting pipe is thoroughly compacted, there is a tendency for the exterior prisms of soil to compress more than the interior prism. The attendant shearing forces along the vertical planes will thereby act to cause the load on the pipe to be greater than the weight of the interior prism of soil. However, if the embankment material on each side of the pipe is thoroughly compacted and the pipe is placed on a slightly yielding foundation, the material within the interior prism may settle more than that within the exterior prisms. This may tend to reverse the shearing forces--thus causing the load on the pipe to be less than the weight of material within the interior prism. The load on a positive-projecting conduit may be computed by the Marston equation:

$$W = C_c \, w \, B_c^2$$

where

W = load per unit length of pipe

C_c = load coefficient

w = unit weight of backfill

B_c = outside diameter of pipe

The factors W and B_c may readily be determined from the design data. The value of C_c, the load coefficient, is not so easily determined because its value is dependent upon such physical factors as: 1) the ratio of the height of fill above the top of the pipe to the outside diameter of the pipe or H/B_c, 2) the coefficient of internal friction of the soil, 3) the projection ratio, and 4) the settlement ratio. H/B_c may be determined from design data, and the coefficient of internal friction of the soil may be determined from laboratory tests. For positive-projecting conduit, the projection ratio (p) is defined as the vertical distance from the top of the pipe to the natural ground line divided by the outside diameter of the pipe. The settlement ratio (r_{sd}) is an abstract ratio, the value of which depends upon the deflection of the pipe, settlement of the pipe, settlement of the pipe grade, settlement of the embankment foundation adjacent to the pipe, and deformation of the fill material adjacent to and between the top of the pipe and existing ground surface. The direction of the shearing forces is dependent upon this factor.

M. G. Spangler * followed the same general principles of Marston's theory of loads on positive-projecting conduit and presented a theory of loads on negative-projecting conduits. Generally speaking, loads on negative-projecting conduits may be less than those on positive-projecting conduits and may thereby permit construction of higher fills for similar conditions of bedding. As the width of the trench increases, the load on the pipe increases to a value equaling that for positive-projecting conduit--at which point the load becomes constant for increasing trench widths. The projection ratio, p, for a

---

*Spangler, M. G., "A Theory of Loads on Negative Projecting Conduits," Proceedings, Highway Research Board, Vol. 30, 1950, pp. 153-161.

negative-projecting conduit is defined as the distance from the top of the pipe up to the natural ground surface divided by the width of the trench. The relationship developed by Spangler for use in predicting the load on a negative-projective conduit due to an earth fill is:

$$W_c = C_n \, w \, B_d^2$$

W_c = load per unit length on pipe

C_n = load coefficient for negative-projecting conduits

w = unit weight of fill material

B_d = the width of the trench level with the top of the pipe

The value of C_n is dependent upon such physical factors as: 1) the projection ratio, p,2) the settlement ratio, r_{sd}, and 3) the ratio of the height of fill to the width of the trench at the top of the pipe, H/B_d. The projection ratio and H/B_d may be determined quite readily from the design data; however, the value of the settlement ratio is not so readily obtained. If the backfill in the trench over the pipe is more compressible than the natural soil in which the trench is dug, the interior prism tends to settle more than the exterior prisms. In such case, the numerical value of the settlement ratio is negative which indicates that the load on the pipe will be less than the actual weight of the interior prism of soil. In the event the backfill within the trench were well compacted, conditions would be somewhat similar to those of positive-projecting conduits, and the load to be supported by the conduit might exceed the actual weight of backfill in the interior prism.

With the objective in mind of insuring greater settlement of the backfill within the interior prism than that within the exterior prisms. Marston developed a special technique of construction which is referred to as the "imperfect trench". In construction of the imperfect trench, the conduit is installed as a projecting conduit (positive or negative), and then backfill is placed on both sides and above the pipe and thoroughly compacted by rolling and tamping. Next, a trench equal in width to the outside diameter of the pipe is excavated in the backfill directly above the pipe. The trench is then backfilled with loose, compressible material and the remainder of the embankment is then placed in a normal manner. The theoretical analysis of loads on negative-projecting conduits may be used to estimate loads on conduits installed by the imperfect trench method. The surface of the initially compacted backfill may be considered as the natural ground surface for purposes of determining the various factors for load computations. The width of the trench may be narrower than that for a negative-projecting conduit; and, for the most favorable results, it should be no wider than the outside width of the conduit. It is most important that the trench be directly over the conduit.

The method by which a conduit is bedded greatly influences its load carrying capacity, because the bedding governs the distribution of load over the bottom portion of the conduit. Four general classes of bedding are recognized; they are: A, B, C and D. Under Class A bedding, the conduit is bedded in a concrete cradle--thereby providing uniform bearing over the lower portion of the conduit. Class B bedding is that condition wherein the foundation soil is shaped and a sand cushion is placed so as to fit the contour over approximately 75 percent of the lower arc of the conduit. Backfill is then carefully placed and compacted under the hauches of the conduit in order to provide for uniform bearing. For Class C bedding, the foundation is shaped to fit the lower portion of the pipe for a height of 10 percent of its outside diameter. Class D bedding is a condition wherein the conduit is simply placed on the foundation with no particular attention being given to uniformity of support. The load-carrying capacity of a conduit is maximum for Class A bedding and minimum for Class D bedding. The various conditions of bedding are depicted in Figure 2.

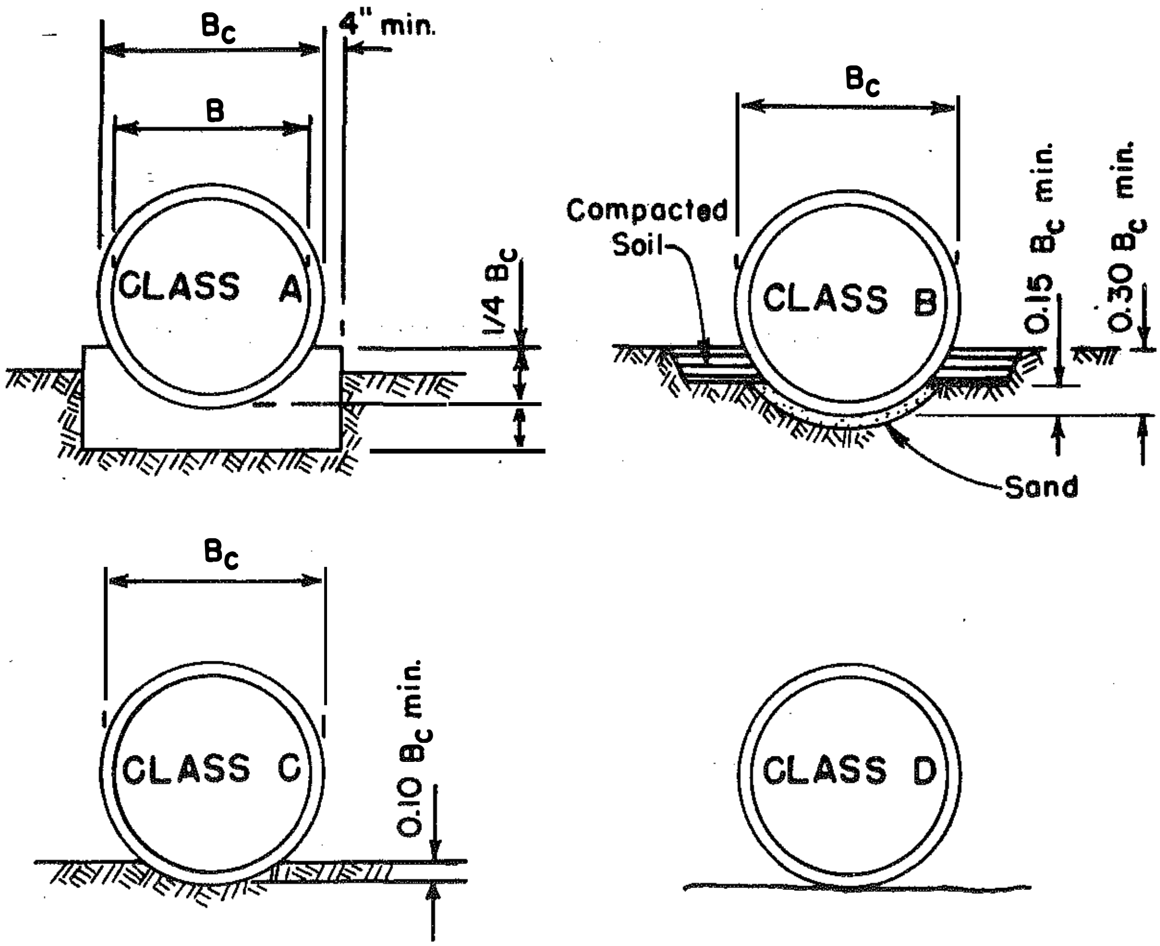


Fig. 2. Classes of Bedding for Rei forced Concrete Pipe.

The maximum permissible height of fill that may safely be placed above a reinforced concrete pipe may be determined by use of design curves contained on Chart II of the B. P. R.'s report, Reinforced Concrete Pipe Culverts, dated August, 1963. Under stated conditions of bedding, D-load strength, unit weight of backfill, and other factors influencing the load and supporting strength of the conduit, the maximum permissible fill that may be placed over the conduit is independent of the conduit diameter. For most design computations, the unit weight of backfill is assumed to be 120 pcf. The followings values for settlement ratio have been suggested by Spangler:

For positive-projecting installations:

On rock or unyielding solid - + 1.0
On ordinary soil bed - + 0.5 to + 0.8
On slightly yielding bed - 0 to + 0.5

For negative-projecting installations:

On average soil bed - -0.3 to -0.5

Values for other variables may be determined from the design data. For any given set of conditions, the height of fill that may be placed above a reinforced concrete pipe is directly proportional the ultimate D-load strength of the pipe. The factor of safety, based on ultimate D-load strength, is suggested to be from 1.33 to 1.50.

On the hypothesis that the increase in supporting strength of a conduit bedded in accordance with Class A bedding is more than offset by the additional cost of the concrete cradle but realizing the importance of uniform load distribution over the bottom of the conduit, the Kentucky Department of Highways specifies that all reinforced concrete pipe be bedded in a manner similar to that previously described for Class B bedding. Both positive and negative-projecting installations are permitted; however, the theoretical advantages of negative-projecting conduit are not utilized by the Department. This is attributable to the fact that the original ground line is usually not parallel to the flow line (or top) of the conduit--thereby, creating zones wherein the projection may of practical necessity alternate from positive to negative. It is also foreseeable that the backfill above negative-projecting conduits may be compacted in such a manner that factors would be similar to those of positive-projecting conduits.

The imperfect trench method of construction is specified for use in cases of high fills. This is referred to as B_1 bedding and is, in essence, the case wherein the conduit is bedded in accordance with the requirements for Class B bedding but with the addition of the imperfect trench above the conduit. The imperfect trench is required only over that portion of a conduit having a fill height in excess of the maximum permissible for standard B-bedding. Bedding details as well as construction procedures for the imperfect trench are contained in Figure 3 for positive-projection conditions. Bedding requirements for negative-projecting conduits are very much the same as those for positive-projecting conduit but have have additionally the details concerning the width of the trench and backfilling. Rock or unyielding foundation material is required to be undercut and excavated to a depth of 1/2 inch per foot of fill to be placed over the pipe; except that the depth shall be at least 12 inches but shall never exceed 3/4 the height of the pipe; it is replaced with compressible soil.

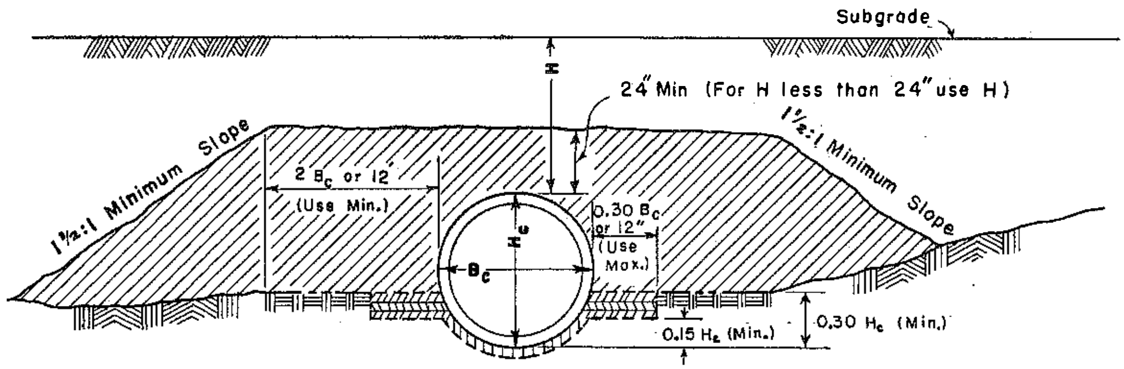
The three classes of reinforced concrete pipe permitted for use as cross drains by the Department are: III, IV, and V. Within certain ranges of fill height, various combinations of pipe class and bedding (B or B_1) may be used in fulfilling design requirements. In order to eliminate unnecessary design computations and to provide uniformity on a statewide basis, the class of bedding and the class pipe for use within given fill-height ranges are specified by the Department. A table is included on Standard Drawing 11.23 for use in determining pipe bedding and class for given fill heights. The table is based on a factor of safety of 1.50 in reference to ultimate D-load strength and is included herein as Table II.

TABLE II

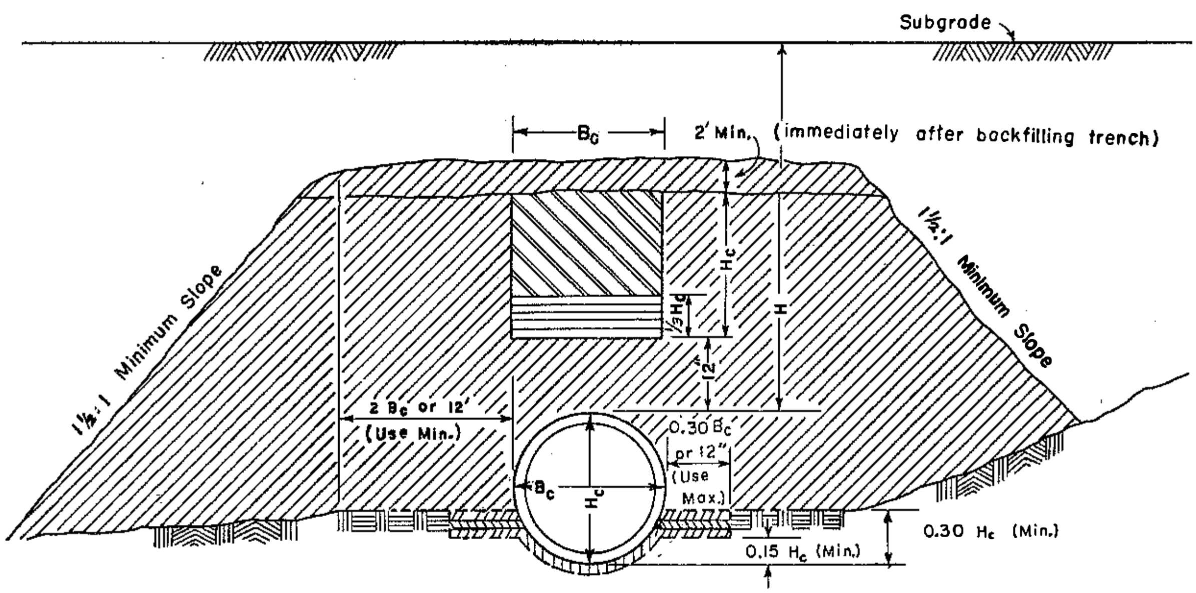
TABLE FOR SAFE FILL COVER HEIGHTS AND CLASSES
FOR REINFORCED CONCRETE CIRCULAR PIPE

SIZE OF PIPE	Maximum Height of Fill Cover From Top of Pipe to Subgrade (Dimension H of Standard Drawing No. 11.22c)				
	Standard Bedding		B_1 (High Fill) Bedding		
	From 2' to 18'	From 18' to 27'	From 27' to 37'	From 37' to 55'	From 55' to 65'
	CLASS OF PIPE				
15"	III	IV	III ④		
18"	III	IV	III ④		
24"	III	IV	III	IV	V
30"	III	IV	III	IV	V
36"	III	IV	III	IV	V
42"	III	IV	III	IV	V
48"	III	IV	III	IV	V
54"	III	IV	III	IV	V
60"	III	IV	III	IV	V
66"	III	IV	III	IV	V
72"	III	IV	III	IV	V
78"	III	IV	III	IV	
84"	III	IV	III	IV	

④ No pipe of diameter less than 24" shall be laid under fills greater than 30'.



STANDARD BEDDING (B)



HIGH FILL BEDDING (B_1)

- Top of embankment. (Subgrade)
- Compacted soil, placed in six inch layers loose depth, thoroughly rammed and compacted.
- Sand layer two inches in depth.
- Minimum elevation of smooth and compacted original ground or maximum elevation of constructed earth embankment foundation.
- Original ground or maximum elevation of constructed earth embankment foundation or grading template line when in cut sections.
- Area shall be backfilled and thoroughly compacted in 6 inch layers to meet density requirements of adjacent embankment over entire length of pipe for protection before compaction of adjacent embankment.
- Trench shall be excavated after construction of backfill and the lower third of excavated trench shall be filled with loose hay or straw.
- The remainder of the trench shall be filled with lightly compacted soil. Immediately after this, backfill must be placed a minimum of 2 ft. above.

Fig. 3. Kentucky Department of Highways Bedding Standards

PERFORMANCE SURVEY

Results of the five, yearly performance surveys are presented diagrammatically in the Appendix. A diagram for each installation is presented directly below the tabulation of its respective design and construction data. The inlet of each conduit has been plotted on the left side of the diagrams, and sections are numbered from the inlet toward the outlet. Signs of distress that were noted during the first inspection are shown symbolically (see legend) in black. Signs of distress that developed between the first and second surveys or any changes that were observed during the second survey are noted by red symbols. Any changes and/or developments in signs of distress noted during the third, fourth, and fifth inspections have been noted by green, blue, and yellow symbols respectively. No walk-through inspections, as such, were made in the 18-and 24-inch diameter conduits. Only visual inspections from the inlet and outlet were made on these small-diameter installations.

The culverts at stations 71 + 00 and 97 + 50 on project I 75-6(4)129, Scott County, had not been installed at the time of the first inspection but were installed prior to the second inspection--thus, the second, yearly survey represents the first inspection for those culverts. At the time of the first inspection, fills had not been completed above any of the culverts on project I 75-6(5)123 in Scott County, nor had the pipes been installed at stations 36 + 50, S. W. Ramp or 47 + 40, U. S. 62. All installations on this project, excepting the one at station 36 + 50, S. W. Ramp, were completed between the first and second surveys and the second survey represented the first inspection of those culverts. The installation at 36 + 50, S. W. Ramp was completed prior to the third survey and that survey represented the first inspection thereof.

During that period between the first and second surveys, a slide developed within the embankment above the culvert at station 7 + 34, F. R 2, on project I75-7(11)151 in Grant County. Several sections of conduit were damaged during backfilling in correction of the slide. The damages were noted during the second survey and were adjudged not serious; therefore, no repairs were deemed necessary at that time. No further signs of distress were observed during the third, fourth, or fifth surveys. Thirty-three sections of conduit were added at the outlet of the culvert at station 566 + 65, N. B. L. on this same project during the period between the first and second surveys. Two sections of the initial installation were damaged during placement of the additional sections. Damage was not severe and no repairs were recommended.

Between the second and third surveys, additional sections were placed at the inlet and outlet of the culvert at station 428 + 07, project I64-5(5)93 in Clark County. Twenty additional sections were placed at the inlet and 11 were placed at the outlet--to provide drainage under ramps connecting I64 and the Mountain Parkway. No signs of distress were noted within the original or additional sections other than minor hairline cracks.

Several culverts were found to be in serious distress at the time of the first inspection, and repairs were deemed necessary. The culverts recommended for repair and the repairs as made are listed in Table III. The more seriously distressed sections were lined with corrugated metal pipe and grout was pumped between the original pipe and liners. The liners were of a gage equivalent to that as would normally be required for a standard, corrugated metal pipe under a fill height equal to that above the damage conduit. Naturally, the liners were effective in preventing futher development of distress and more than likely less conservative (structurally) repairs should be effected in the future, if necessary. The mortaring and epoxy patching of cracks proved rather ineffective in that cracks reflected through the patching material in a rather short period of time. The epoxy used in the repair of cracks was of a type which is adversely affected by moisture. Figures 4 through 8 show some of the failures that were observed in the more distressed sections. Figures 9 and 10 are views of a corrugated metal liner as installed in one distressed conduit.

Upon review of the plots, it is somewhat significant to note that the more serious signs of distress developed within the first year after installation. Progressive signs of distress were noted during the second, third, fourth, and fifth surveys; however, none were of a nature requiring remedial work. It appears quite evident that signs of major distress may be expected to develop within a short period after installation--that is, disregarding unusual events such as slides, addition of sections, etc. It is quite possible that early damages may have been the result of the operation of heavy equipment above the conduits prior to construction of sufficient backfill for adequate protection.

TABLE III

Repairs made on Pipe Found in Distress During First Inspection

Project No.	County	Station No.	Patching	Corrugated Metal Liners		
				Sec. *	Gauge	Min. Dia.
I-64-3(3)31	Shelby	1255+25		10-13	12	42"
I-64-3(5)45	Franklin	2233+50R	Top & Bottom Sec. 13-32			
I-64-3(7)35	Shelby	1604+04R**	Bottom, Sec. 12-16			
		1619+45L		11-32	8	48"
		1633+30L		10-41	8	48"
		1635+82L	Lift Holes			
		1637+32L		13-47	8	42"
I-75-7(5)160	Grant	978+12		15-45	10	36"
		1085+44	Joints, Sec. 65-73			
		1087+50	Joints, Sec. 19-21	34-79	8	48"
		27+82FR 9a	Joints & lift holes	5-12	8	60"

* Sections numbered for inlet of culvert.

** Repair recommended but not made prior to second inspection.

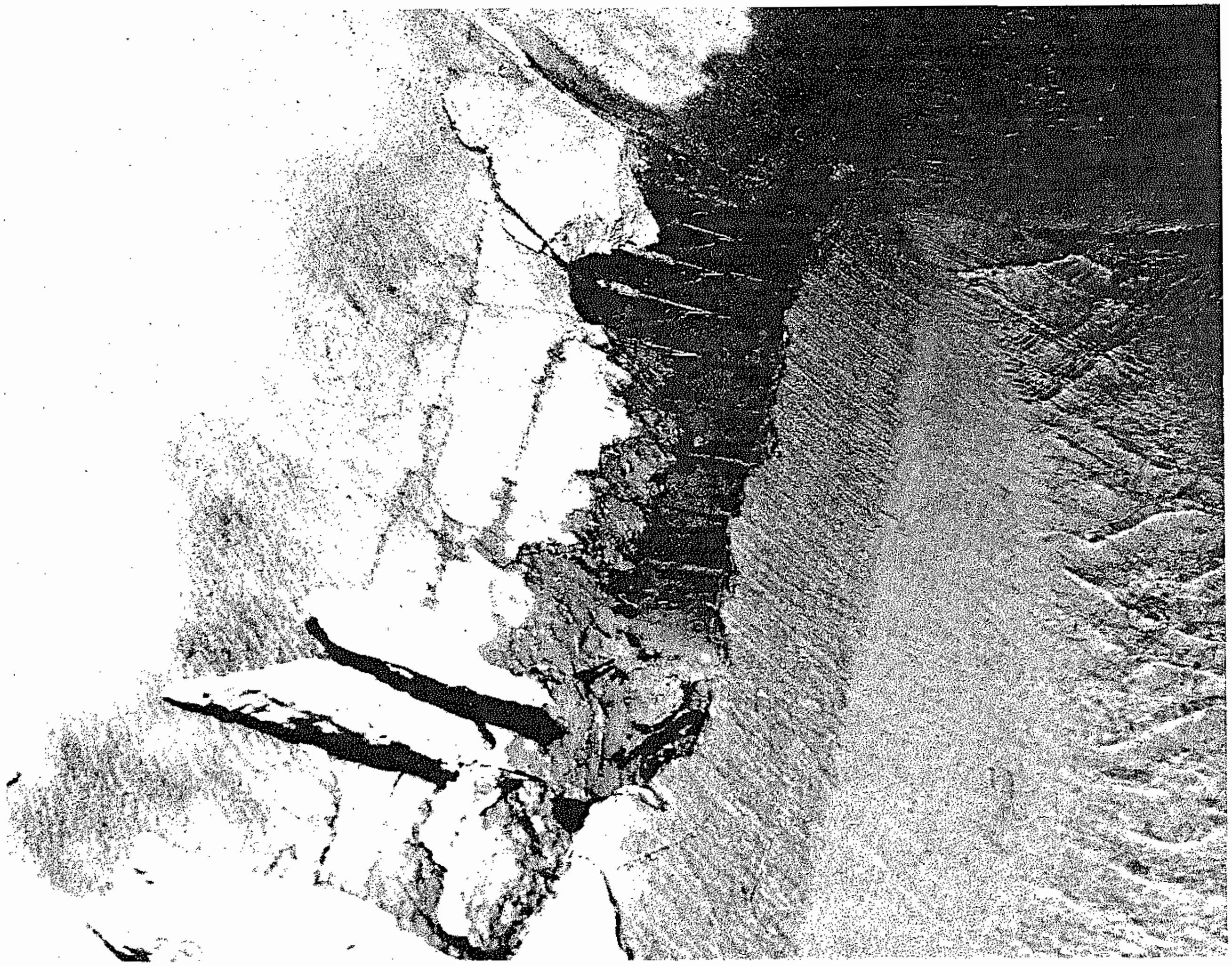


Fig. 4. Failure in Bottom of 60-inch Culvert Under a 28-foot Fill, Station 1619 + 45L, I64-3(7)35, Shelby County

Fig. 5. Failure in Top of 60-inch Culvert Under a 28-foot Fill, Station 1619 + 45L, I64-3(7)35, Shelby County

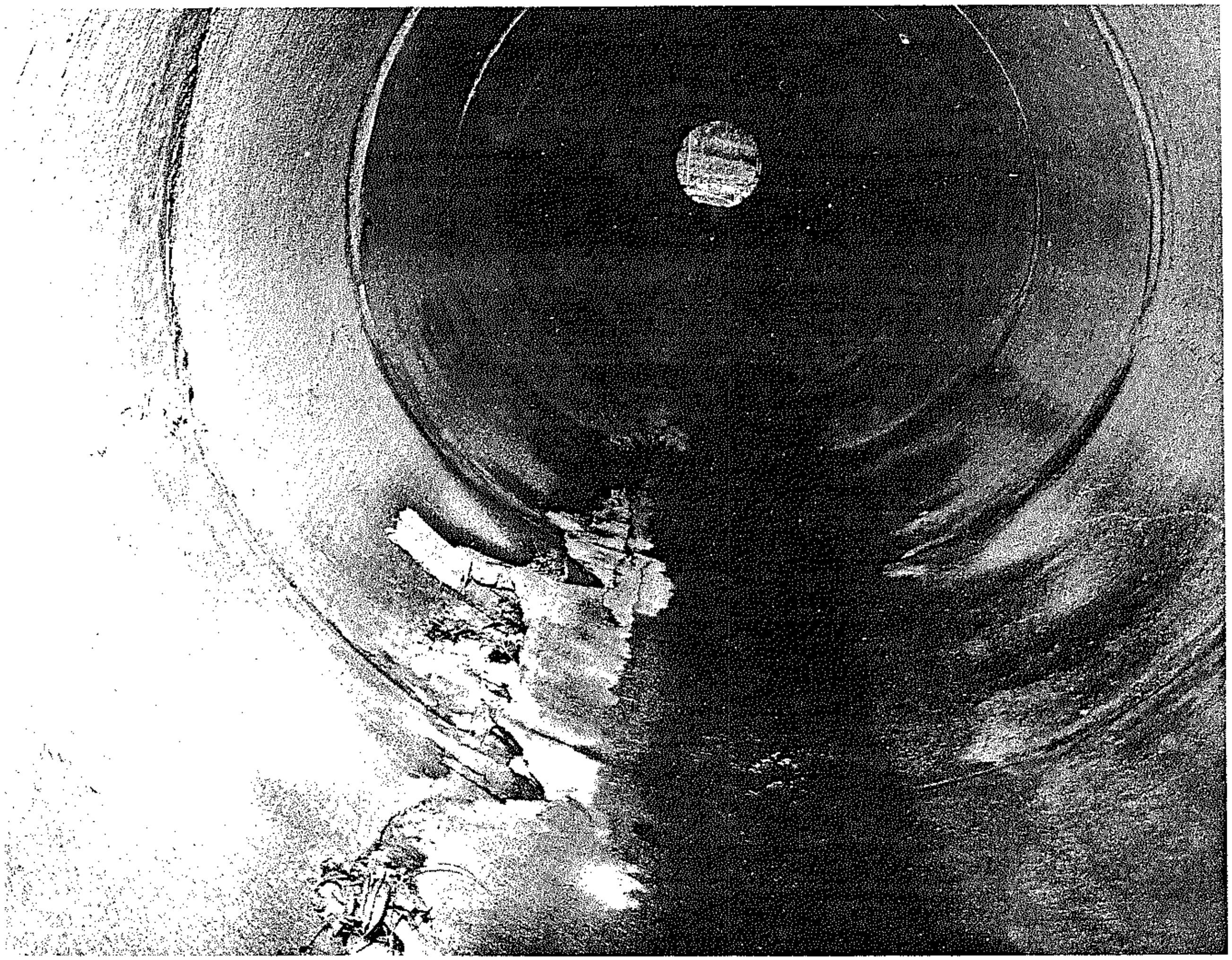


Fig. 6. Failure in Bottom of 54-inch Culvert Under a 32-foot Fill, Station 1633 + I64-3(7)35, Shelby County

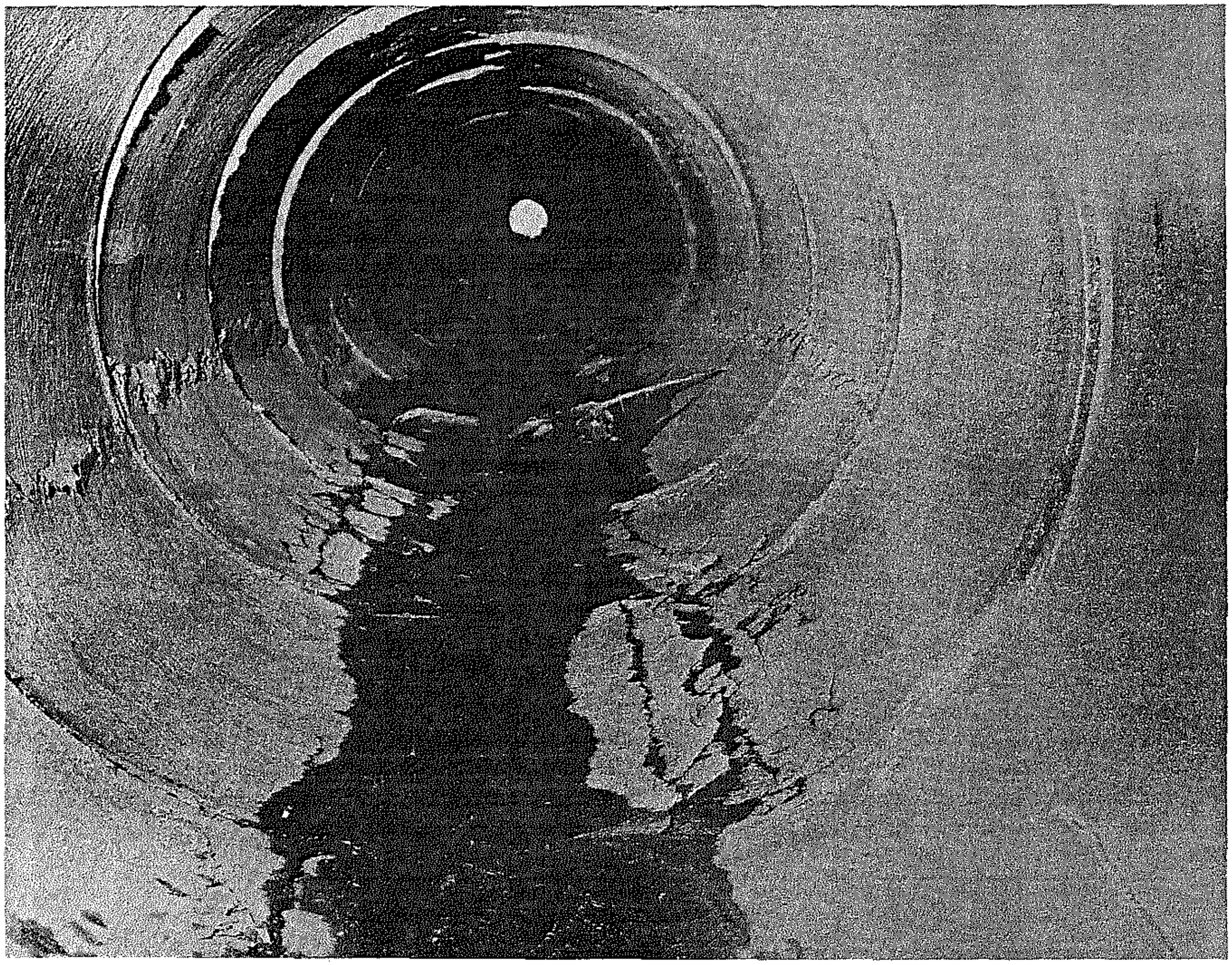


Fig. 7. Failure in Bottom of 54-inch Culvert Under a 53-foot Fill, Station 1087 + 50, I75-7(5)160, Grant County

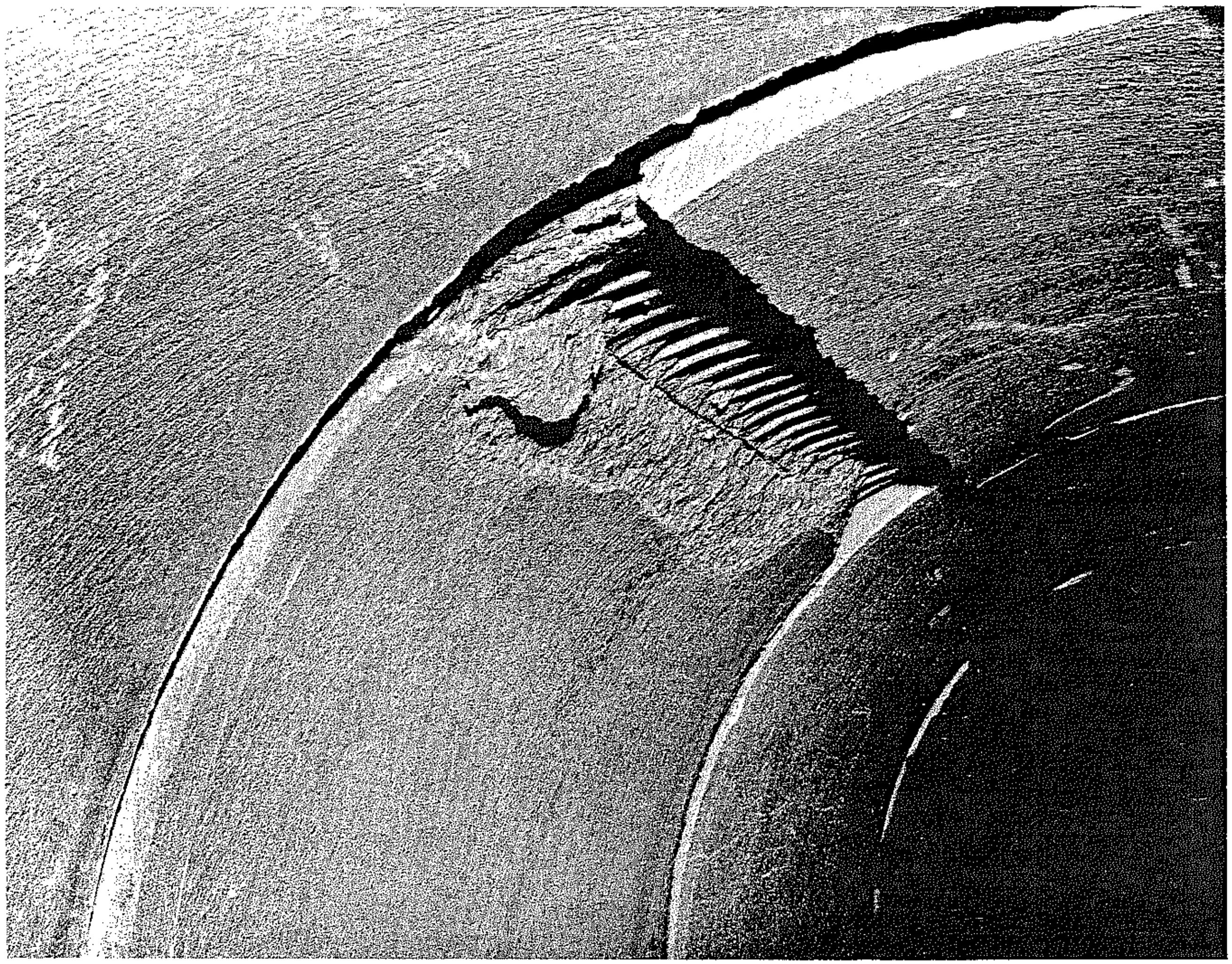


Fig. 8. Failure in Top of 54-inch Culvert Under a 53-foot Fill,
Station 1087 + 50, I75-7(5)160, Grant County

151

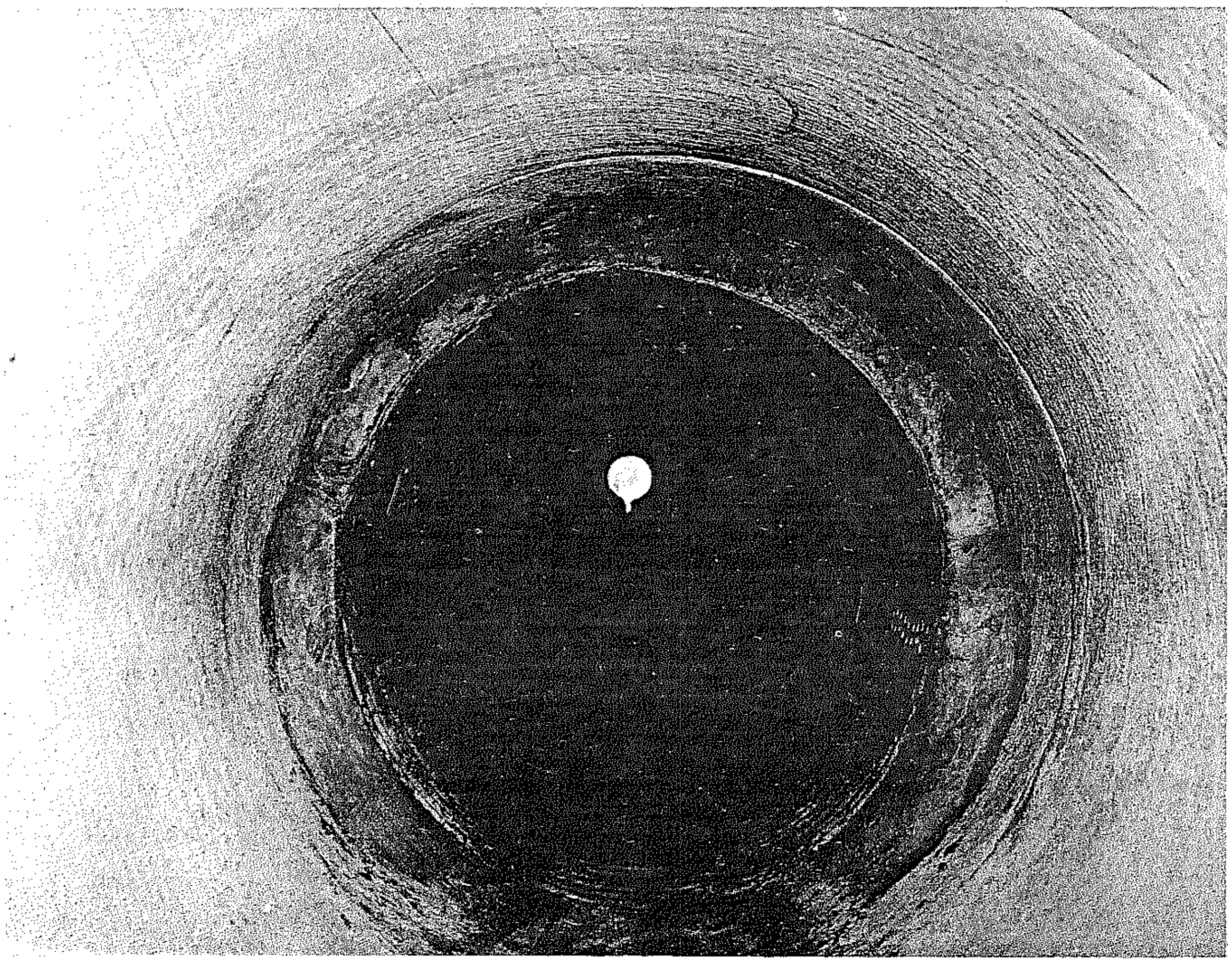


Fig. 9. Transition from concrete pipe to corrugated metal liner in culvert at Station 1255 + 25 on Project I64-3(3)31 in Shelby County

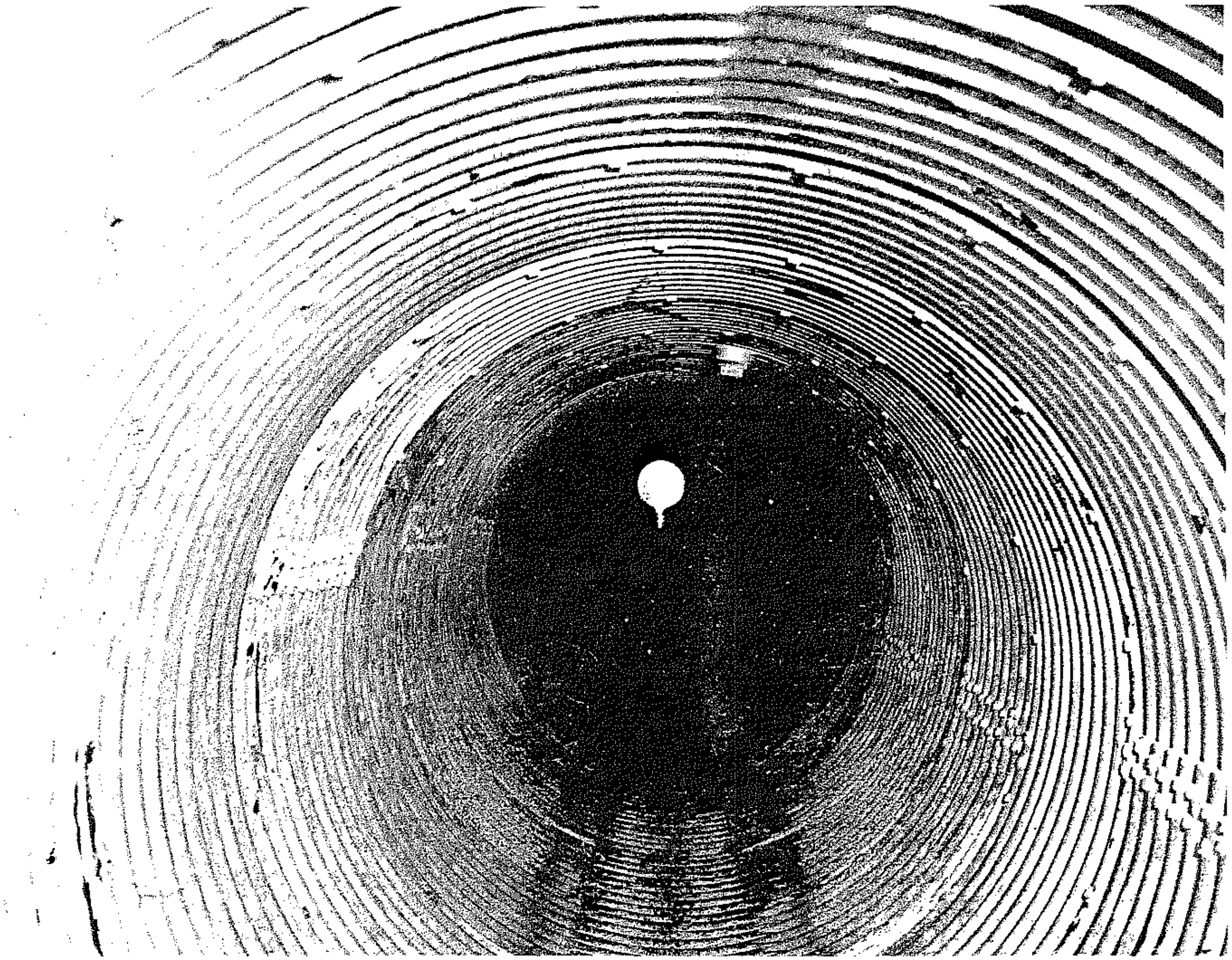


Fig. 10. Corrugated metal liner in culvert at Station 1255 + 25 on Project I64-3(3)31 in Shelby County

DISCUSSION

The maximum, safe, fill heights permitted for use above each strength-class of pipe and condition of bedding were determined on basis of the design criterion and were presented in a table on Standard Drawing No. 11.23. Each strength-class of pipe for a given condition of bedding was thereby qualified and authorized for use in situations in which the height of fill did not exceed the specified maximum as was determined upon the basis of the suggested, minimum, factor of safety. In practice, situations arise wherein the height of fill to be placed above a conduit just exceeds the maximum permissible for one strength-class and wherein a stronger class pipe provides more strength than actually required. This factor oftentimes results in greatly increased factors of safety for the installed conduits and thereby provides further opportunity for evaluating performance from the standpoint of design. On the assumption that all conduits included in this survey were bedded in accordance with the details as perscribed by the specifications, the as-constructed factor of safety for each installation was determined in reference to the actual height of fill placed above the pipe. These factors of safety are included in the Appendix of this report.

At the outset of this investigation, there was some skepticism in regard to the long-time benefits of the imperfect-trench method of construction. In large, it appeared reasonable that the imperfect trench would provide for a reduction in load to be supported by the conduit initially--that is, as long as there was unequal settlement within the interior and exterior prisms and a portion of the load was transferred from the interior to the exterior prisms through shearing stresses. However, it was foreseeable that, once settlement was complete, the conduit might then come to bear the full load imposed by the weight of backfill within the interior prism. In this hypothesis, the effect of bridging action was discredited; and it was theorized that the load to be supported by the conduit would gradually increase as shearing stresses subsided and as the embankment attained equilibrum. A review of the performance diagrams might possibly be construed to substantiate the foregoing hypothesis. Of the 113 conduits included in this performance survey, 82 were 30 inches in diameter or above and were actually explored and critically inspected once each year. Of this group, 36 percent were bedded as standard B-bedding, and 64 percent were bedded as high-fill, B_1-bedding. Fourteen of these installations showed signs of somewhat serious distress in that shear failures developed within several sections of each. Of those considered to be in serious distress, one was susposedly bedded in accordance with B-bedding, and the remaining had the addition of the imperfect trench. Twenty-five conduits had one or more sections containing shear failures; of this group, 2 were suposedly bedded in accordance with B-bedding, and the remaining had the addition of the imperfect trench. On the basis of these experiences alone, the theoretical advantages of the imperfect-trench method of construction would be more or less nullified.

Further investigation of several of the distressed conduits revealed that in many instances the conduits had not been constructed in full accordance with the perscribed bedding details. Soundings were made within several sections of the distressed culverts; and, in numerous instances, rock or other unyielding material was found to exist at an elevation above that specified. On the basis of the fact that the higher fills occur at natural valleys and realizing that bedrock may be found to exist nearer the ground surface in these areas, it is quite likely that a larger percentage of those installations requiring B_1-bedding were founded upon somewhat less yielding foundations than those requiring B-bedding. If this were the case and if all distresses noted were to be attributed soley to the existance of bedrock being too close to the bottom of the conduit, the importance of a yielding foundation is verified. However, there is no tenable proof that the occurance of bedrock near the bottom of the conduit was the sole cause of distresses noted. Since the initial inspections were conducted after the majority of conduits had been installed and inasmuch as signs of distress were then present, other causes of distress such as the operation of heavy equipment above the conduits, improper backfilling, poor compaction under the haunches of the sections, poor alignment of the trench, etc. may not be rejected completely.

On the other hand, it is significant to note that numerous installations having the imperfect trench have performed quite well. The installation at station 37 + 50, U. S. 460 S. W. Ramp, on project I75-6(5)123, Shelby County, is somewhat positive proof of the value of the imperfect-trench method of construction. Well over half of the conduit was installed as B-bedding, and the embankment was constructed thereover when it was discovered that the conduit should have been bedded as perscribed for B_1-bedding. The remainder of the conduit was, there upon, installed under B_1-bedding; and the performance of that portion was markedly better than that of the section installed under B-bedding. It is significant to note that those sections of pipe installed under B-bedding that were under the major embankment had an as-constructed factor of safety of 0.76; yet, no signs of serious distress were noted during any of the performance surveys.

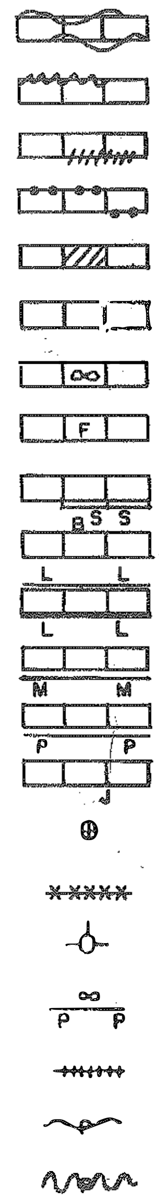
Odd occurrences of shear failures in a long line of pipe may be attributed to local stress concentrations and uneven load-bearing conditions and are of somewhat minor concern. However, the prevalence of shear failures in a line of pipe having a factor of safety greater than unity presents the more perplexing aspect of this evaluation; and, even though there was evidence of nonconformance with bedding details in some instances, more tenable proof of the causes of failure are desirable. The discovery of distress at some remote time following completion of the embankment does not provide adequate proof that the burden of the embankment was too great nor does it exclude the possibility of faulty construction. Thus, the most meaningful information is that concerned with circumstances coincident with the first appearance of signs of distress. Project Engineers have thereby been urged to make daily inspections of all larger-size culverts during construction and to make frequent inspections thereafter during the remainder of the project.

The culverts that were included in this inspection survey were those which were installed immediately or very soon after adoption of the new design and installation criteria. In some cases, misunderstanding of plans and specifications were disclosed. Findings of the first-yearly inspection resulted in widespread alarm; and, as a consequence, great emphasis was placed upon rigid inspection of all reinforced concrete pipe installations. To date, only two additional concrete pipe failures have been reported and observed. In both cases, soundings revealed the presence of rock above the specified elevation. On the basis of all information, it is generally concluded that the design and installation criteria as presented in the B. P. R. Circular Memorandum 22-40 is valid, but the importance of adherence to the perscribed bedding details is forever evident.

APPENDIX

LEGEND

Hairline Crack —
Crack (.Olin. or above) —
Shear Failure —
Spalling —
Broken —
Mortar Missing —
Steel Exposed —
Faulted —
Section Settled —
Buckling —
C. M. Liner —
Mortared —
Patched —
Joint Separated —
Hairline Crack Changed To Crack
Crack Or Cracks To Shear
Mortar Or Patch Out
Steel Exposed Through Patch
Hairline Crack Changed To Shear
Hairline Crack Through Patch
Crack Through Patch



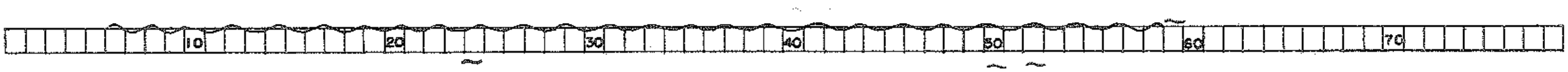
Black — 1960 Survey
Red — 1961 Survey
Green — 1962 Survey
Blue — 1963 Survey
Yellow — 1964 Survey

PROJECT NO. I 64-2(5)17 JEFFERSON COUNTY

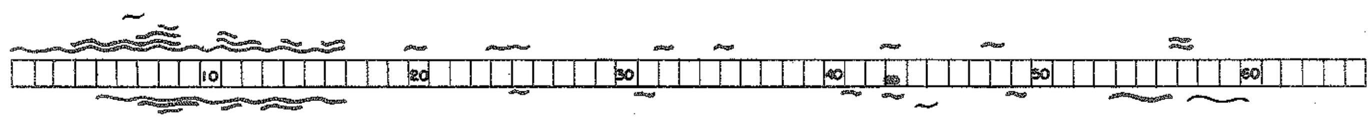
WEST OF ENGLISH STATION ROAD TO SHELBY COUNTY LINE

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
577 + 65	36	260	260	III	Std.	Negative	3.19	3.19	16.0	14.0	45 R	Soil & Rock	1.65-1.89	South

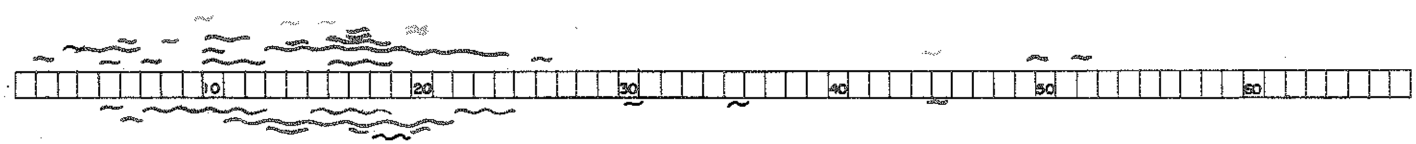
588 + 50	36	312	312	III	B_1	Positive	3.48	3.48	36.0	33.5	30 R	Soil & Rock	1.51-1.62	South



597 + 00	48	260	260	III	B_1	Positive	3.30	3.30	34.0	31.0	0	Soil & Rock	1.60-1.75	South



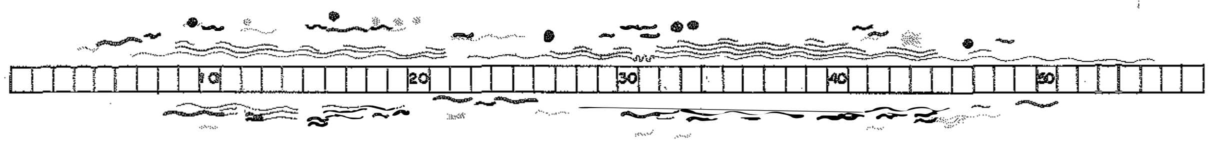
608 + 75	42	268	268	III	B_1	Positive	2.00	2.00	27.0	26.0	30 R	Rock	2.01-2.09	North



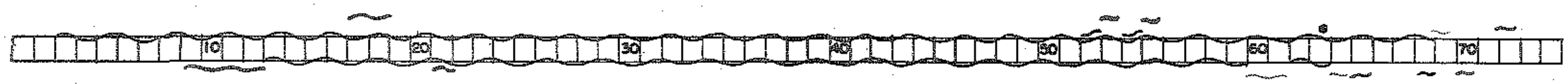
PROJECT NO. I 64-2(5)17 JEFFERSON COUNTY

WEST OF ENGLISH STATION ROAD TO SHELBY COUNTY LINE

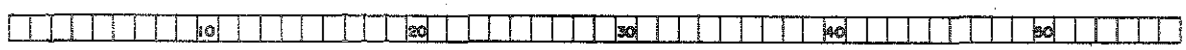
Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
652 + 68	42	228	228	III	B_1	Positive	3.50	3.50	22.0	25.0	15 R	Soil & Rock	2.[illegible]-2.18	North



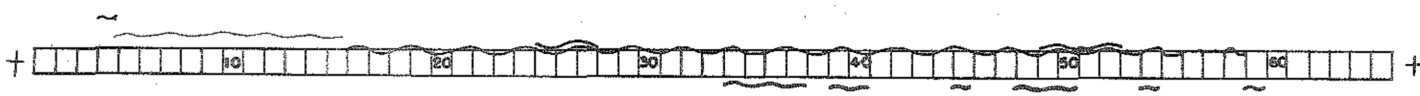
668 + 00	30	296	296	III	Std.	Positive	3.45	3.23	16.0	19.5	45 R	Soil & Rock	1.65-1.36	North



698 + 00	24	224	224	III	Out to 100'-B_1 100' to 224'-Std.	Out. to 52'-Pos. 52' to 140'-Neg. 140' to 224'-Pos.	4.69	4.69	20.0	24.0	0	Soil & Rock	1.32-2.27	North



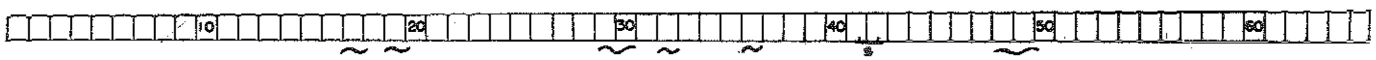
744 + 30	30	260	260	III	B_1	Positive	2.08	2.08	23.5	25.0	30 R	Soil & Rock	2.31-2.18	North

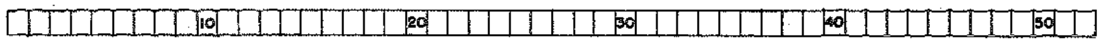


PROJECT NO. I 64-2(5)17 JEFFERSON COUNTY

WEST OF ENGLISH STATION ROAD TO SHELBY COUNTY LINE

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
776 + 50	30	260	260	III	B_1	Positive	3.15	3.15	32.0	30.0	15 L	Soil & Rock	1.70-1.81	South
790 + 35	24	208	208	III	Std.	Positive	3.89	3.89	11.0	15.0	30 L	Soil & Rock	2.41-1.77	North

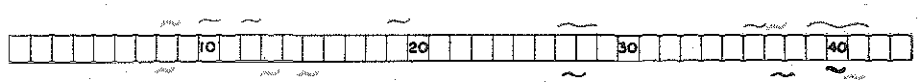


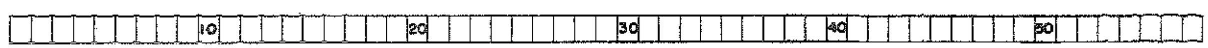


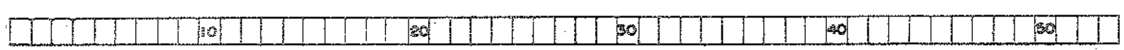
PROJECT NO. I 64-2(3)22 SHELBY COUNTY

JEFFERSON COUNTY LINE TO JOYCE STATION ROAD

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
900 + 15	48	156	156	III	Std.	Positive	0.32	0.32	4.5	4.5	0	Soil	5.89	North
968 + 25	42	172	172	III	Std.	Positive	2.00	2.00	8.0	9.5	0	Rock	3.31-2.79	North
983 + 90	18	228	228	III	Std.	Positive	1.89	1.89	24	22.5	0	Rock	1.10-1.18	South
988 + 75	24	212	212	III	Std.	Positive	1.98	1.98	17.0	15.0	0	Rock	1.56-1.77	South





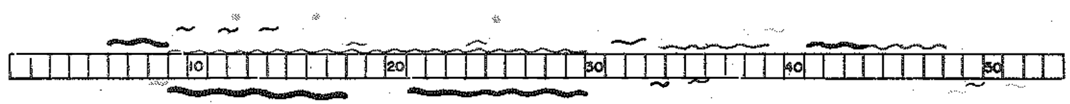


PROJECT NO. I 64-2(3)22 SHELBY COUNTY

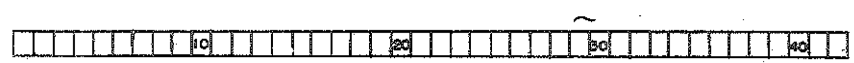
JEFFERSON COUNTY LINE TO JOYCE STATION ROAD

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
1000 + 50	30	200	200	III	Std.	Out. to 58'-Pos. 58' to 200'-Neg.	1.90	1.90	13.5	12.0	0	Soil	1.96-2.21	South

1057 + 35	30	212	212	III	Std.	Positive	0.99	0.99	19.0	19.5	15 L	Rock	1.39-1.36	North



1133 + 10	36	168	168	III	Std.	Positive	1.01	1.01	4.5	6.0	0	Soil	5.89-4.41	North



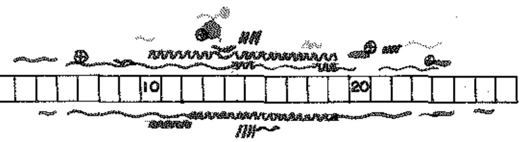
PROJECT NO. I 64-2(3)22 SHELBY COUNTY
JEFFERSON COUNTY LINE TO JOYCE STATION ROAD

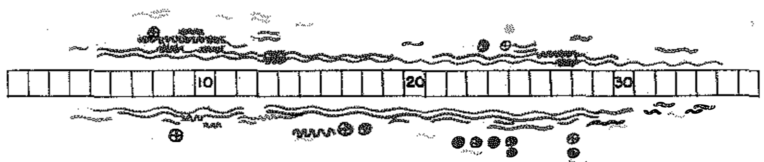
Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
Ramp 1 10 + 70	36	144	144	III	B_1	Positive	0.90	0.90	29.0		0	Soil & Rock	1.87	North
Ramp 5 9 + 50	18	100	100	III	Std.	31'-Pos. 69'-Neg.	2.50	2.50	12.0		0	Soil & Rock	2.21	South
Veechdale Rd. 70 + 00	18	148	148	III	B_1	In. to 30'-Neg. 30' to 148'-Pos.	4.39	4.39	28.0		0	Rock	1.94	South
Veechdale Rd. 74 + 00	24	168	168	III	B_1	Negative	0.60	0.60	32.5		0	Rock	1.67	South

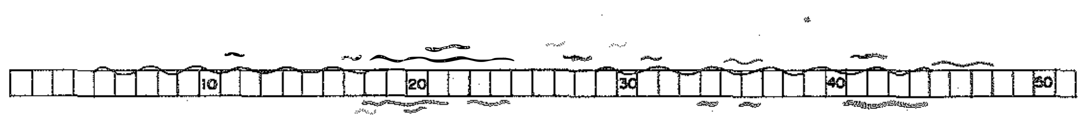
PROJECT NOS. I 64-2(7)29 & I 64-3(3)31 SHELBY COUNTY

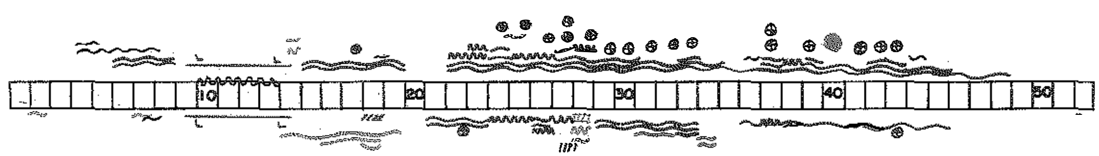
JOYCE STATION ROAD TO KY. 55 (OLD) & KY. 55 (OLD) TO SEVEN MILE PIKE

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
Joyce Station Road 78 + 50	30	108	108	III	B_1	Positive	1.02	1.02	24		30 L	Soil	2.27	North
Joyce Station Road 81 + 79	48	144	144	III	B_1	130' -Pos. 14'- Neg.	2.03	2.03	29.5		17.5 R	Soil	1.84	North
1168 + 37	42	204	204	III	Std.	Out. to 53'-Neg. 53' to 204'-Pos.	1.10	1.10	13.0		30 R	Soil & Rock	2.04	North
1255 + 25	48	208	208	III	Std.	Positive	2.74	2.74	19	21	0	Rock	1.39-1.26	North









PROJECT NOS. I 64-2(7)29 & I 64-3(3)31 SHELBY COUNTY

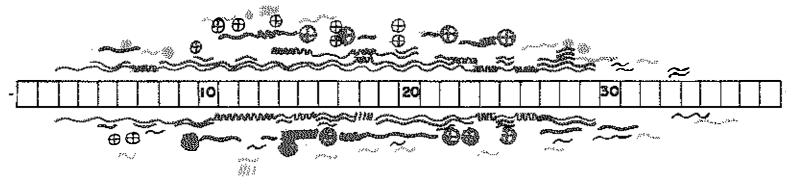
JOYCE STATION ROAD TO KY. 55 (OLD) & KY. 55 (OLD) TO SEVEN MILE PIKE

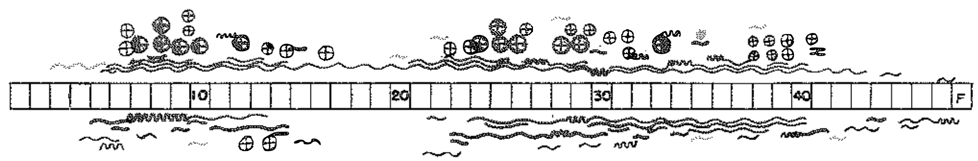
Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
1403 + 10	36	208	208	III	Std.	Positive	2.00	2.00	7.0	6.0	30 L	Rock	3.78-4.41	South

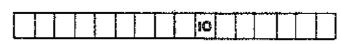
PROJECT NO. I 64-3(7)35 SHELBY COUNTY

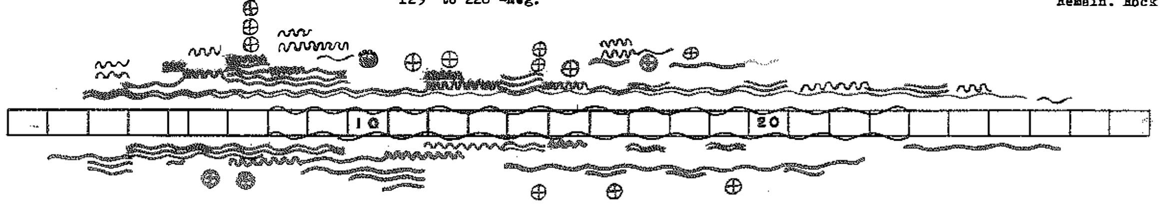
SEVEN MILE PIKE TO 5000 ft. EAST OF KY. 714

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment material	Factor of Safety as Constructed	Location of Inlet
1456 + 90R	42	152	152	III	Std.	Out to 26'-Pos. 26' to 152'-Neg.	6.15	6.32		14.0	45 R	8' Soil & Remain. Soil & Rock	1.89	South
1458 + 35L	42	204	192	III	B_1	Positive	3.97	3.97	23.5		45 R	Soil & Rock	2.31	South
1471 + 00R	18	64	64	III	Std.	Negative	0.47	0.47		3.0	30 R	Soil & Rock	8.83	South
1536 + 51R	72	228	228	III	B_1	Out to 129'-Pos. 129' to 228'-Neg.	2.50			28.5	45 R	12'Soil & Remain. Rock	1.91	North





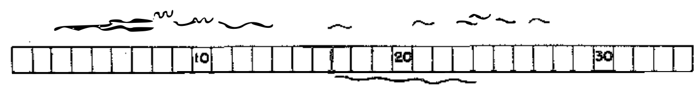




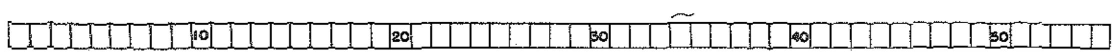
PROJECT NO. I 64-3(7) 35 SHELBY COUNTY

SEVEN MILE PIKE TO 5000 ft. EAST OF KY. 714

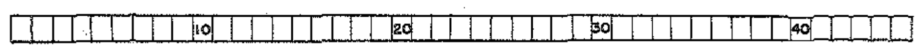
Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
1552 + 10R	60	136	136	III	Std.	Positive	0.96	0.96		12.5	45 L	4.5' Soil & Remain. Rock	2.12	South



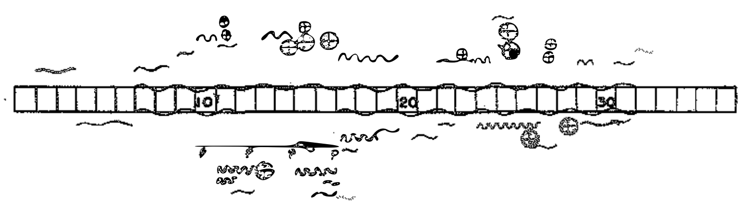
1595 + 91R	36	220	220	IV	B_1	Positive	3.24	3.18		42.5	15 R	Soil & Rock	1.92	North



1596 + 71L	36	184	180	III	B_1	Positive	3.24	3.34	34.0		15 R	12' Soil & Remain. Rock	1.60	North



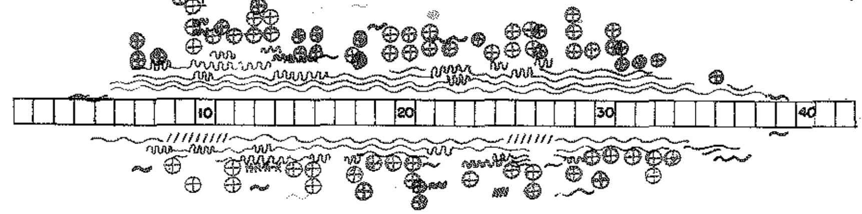
1604 + 04R	48	144	144	III	B_1	Positive	0.90	1.17		24.5	0	8' Soil & Remain. Rock	2.22	North

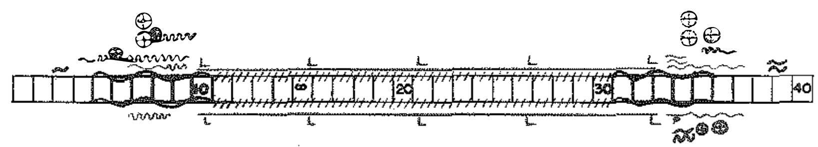


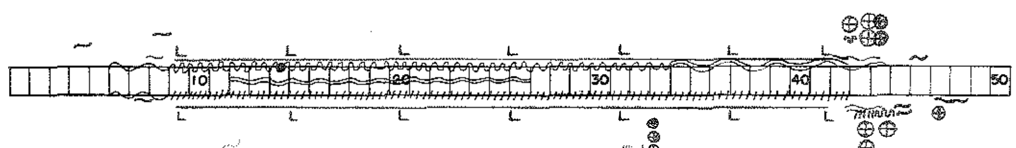
PROJECT NO. I 64-3(7)35 SHELBY COUNTY

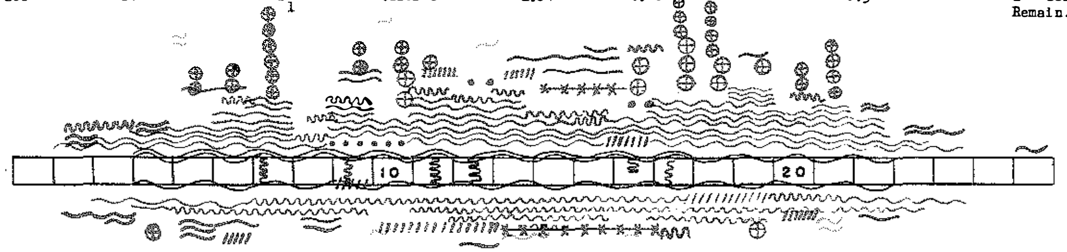
SEVEN MILE PIKE TO 5000 ft. EAST OF KY. 714

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
1619 + 44 R	60	168	168	III	B_1	Positive	2.80	2.18		24.0	30 L	10' Soil & Remain. Rock	2.27	North
1619 + 45 L	60.	160	160	III	B_1	Positive	2.56	1.44	27.5		15 L	Rock	1.98	North
1633 + 30 L	54	200	200	III	B_1	Positive	2.75	3.16	32.0		30 L	Soil & Rock	1.70	North
1635 + 82 R	72	208	208	IV	B_1	Positive	2.64	2.60		40.5	0	14' Soil & Remain. Rock	2.01	North





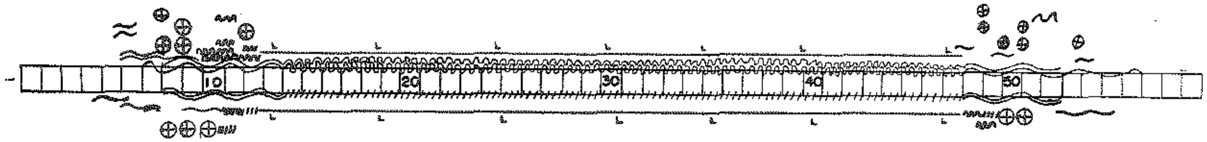


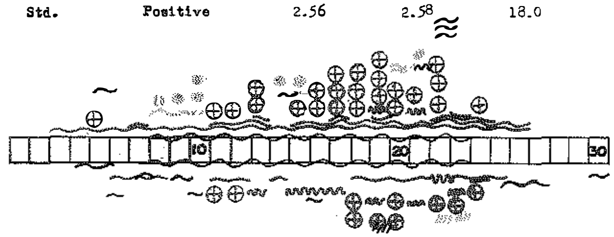


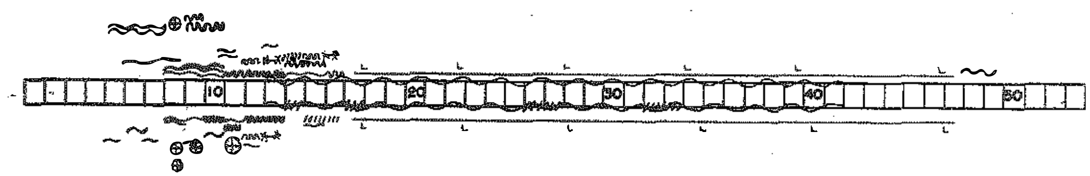
PROJECT NO. I 64-3(7)35 SHELBY COUNTY

SEVEN MILE PIKE TO 5000 ft. EAST OF KY. 714

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
1637 + 32 L	48	236	236	III	B_1	Positive	4.11	4.38	39.0		30 R	Soil	1.39	North
1653 + 30 L	54	120	120	III	Std.	Positive	2.56	2.58	18.0		15 L	Soil	1.47	North
1635 + 69 L	36	212	212	III	B_1	Inlet to 56'-Pos. 56' to 186'- Neg. 186' to 212'-Pos.	4.25	5.37	39.0		15 L	8' Soil & Remain. Rock	1.39	North



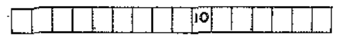




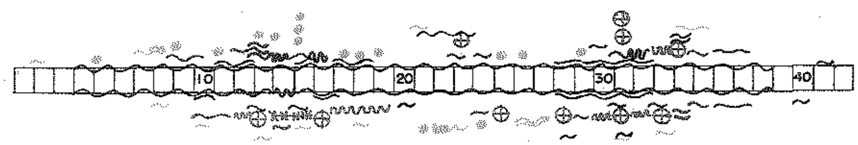
PROJECT NO. I 64-3(5)45 FRANKLIN COUNTY

SHELBY COUNTY LINE TO .3 MILES EAST OF NEW KY. 35

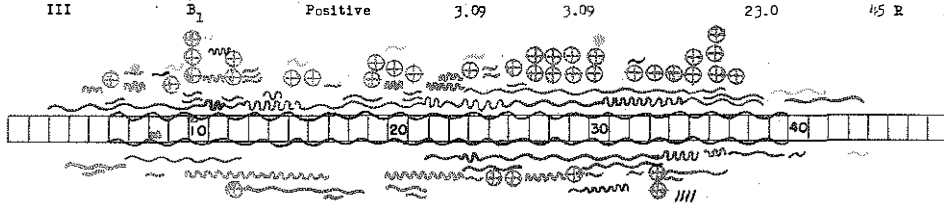
Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
2043 + 50 R	18	64	64	III	Std.	In. to 19'-Neg. 19' to 64'-Pos.	0.78	0.78		3.0	0		8.83	North



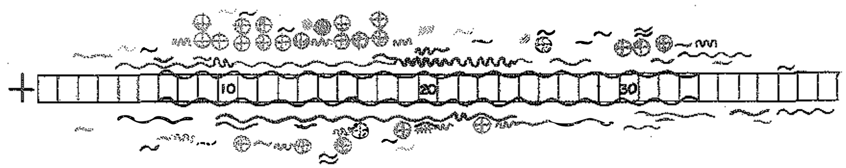
2054 + 75 R	30	168	168	III	Std.	Positive	3.39	3.39		19.5	45 L	Soil & Rock	1.36	North



2059 + 00 R	36	188	188	III	B_1	Positive	3.09	3.09		23.0	45 R	Rock	2.37	South



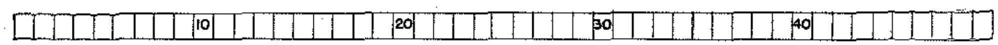
2060 + 85 L	42	160	160	III	Std.	Positive	1.69	1.50	18.0		45 R	Soil & Rock	1.47	South



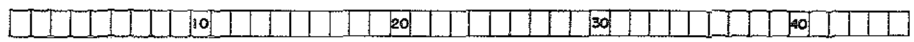
PROJECT NO. I 64-3(5)45 FRANKLIN COUNTY

SHELBY COUNTY LINE TO .3 MILES EAST OF NEW KY. 35

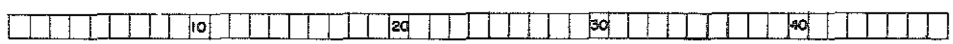
Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
2064 + 92 R	24	196	196	III	Std.	Positive	8.67	8.67		22.5	45 L	Soil & Rock	1.18	South



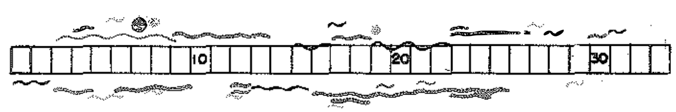
Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
2129 + 50 R	18	176	176	III	Std.	Positive	5.40	4.66		20.0	45 L	Soil & Rock	1.32	North



Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
2152 + 50 R	18	152	148	III	Std.	In. to 13'-Neg. 13' to 148'-Pos.	1.64	1.35		27.0	0	Soil & Rock	0.98	South



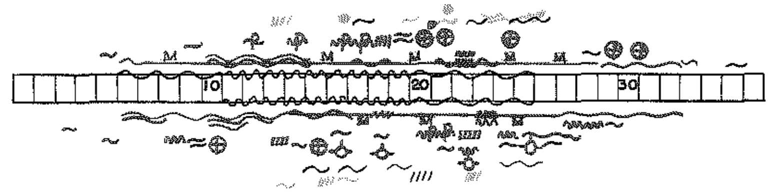
Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
2154 + 50 L	48	132	132	III	Std.	Positive	0.53	0.53	14.9		45 R	Soil & Rock	1.83	South

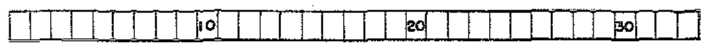


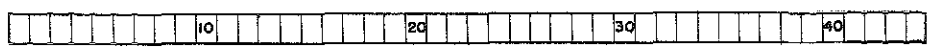
PROJECT NO. I 64-3(5)45 FRANKLIN COUNTY

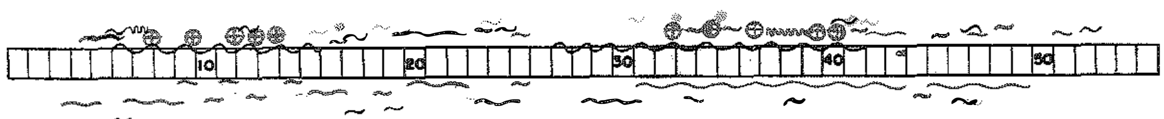
SHELBY COUNTY LINE TO .3 MILES EAST OF NEW KY. 35

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
2233 + 50 R	36	144	144	III	B_1	Positive	2.57	2.57		25.0	0	Soil & Rock	2.18	North
2246 + 00 L	18	132	132	III	B_1	Positive	0.76	0.76	22.0		0	Soil & Rock	2.47	North
2343 + 00	18	200	176	III	Std.	Positive	1.30	0.74	10		0	Soil & Rock	2.65	North
9 + 50 Ramp "J"	30	232	220'	III	B_1	In. to 69'-Pos. 69' to 220'-Neg.	9.22	9.73	28.5	38.5	0	Soil & Rock	1.91-1.41	South





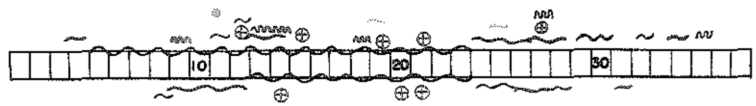




PROJECT NO. I 64-3(5)45 FRANKLIN COUNTY

SHELBY COUNTY LINE TO .3 MILES EAST OF NEW KY. 35

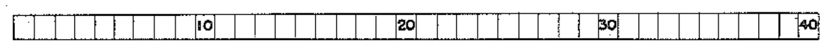
Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
38 + 00 Ky. 35	30	148	148	III	Std.	Negative	0.68	0.66	24.0		0	Soil & Rock	1.10	North



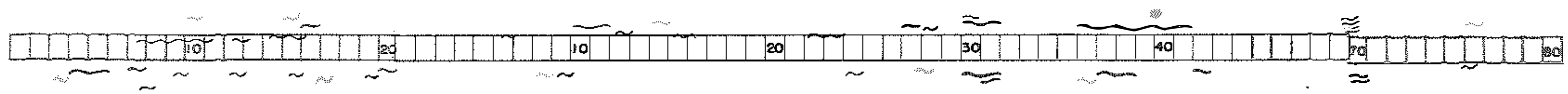
PROJECT NO. I 64-5(5)93 CLARK COUNTY

WINCHESTER TO MONTGOMERY COUNTY LINE

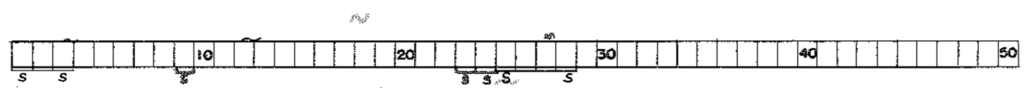
Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	*Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
419 + 50	18	160	160	III	Std.	Positive	0.94	0.81	5.0	5.0	0	Soil	5.3	North



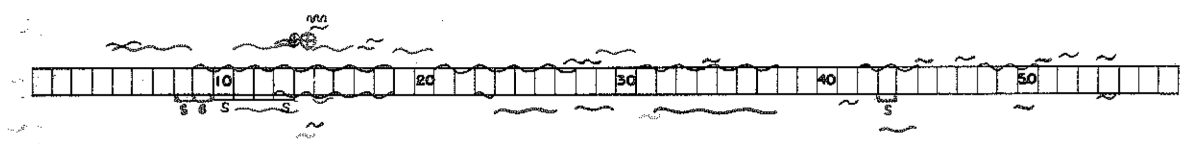
Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	*Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
428 + 07	36	204	[illegible]	III	Std.	Positive	1.76	1.72	15.0	17.0	0	Soil & Rock	1.77-1.56	North



Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	*Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
438 + 90	42	200	200	III	Std.	Positive	0.70	1.08	9.0	10.0	15 R	Soil & Rock	2.94-2.65	North



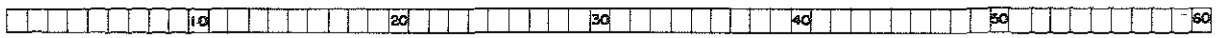
Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	*Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
450 + 40	48	244	228	III	Std.	Positive	1.19	0.88	17.0	17.0	30 R	4' Soil & Remain. Rock	1.56	North



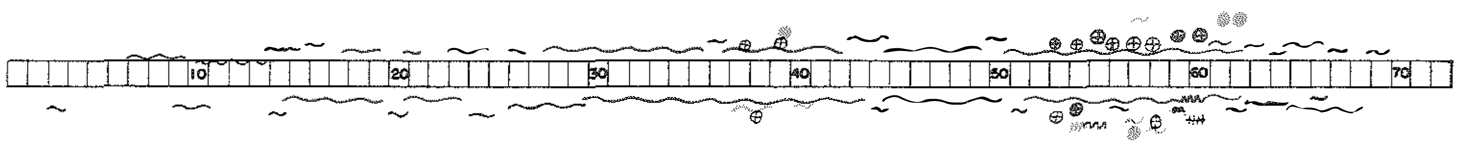
PROJECT NO. I 64-5(5)93 CLARK COUNTY

WINCHESTER TO MONTGOMERY COUNTY LINE

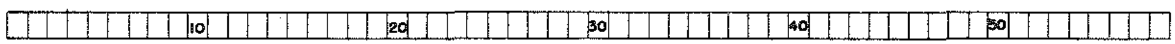
Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	*Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (o)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
487 + 00	18	240	240	III	B_1	In. to 127'-Neg. 127' to 240'-Pos.	3.33	3.33	30.0	27.0	0	Soil & Rock	1.81-2.01	South



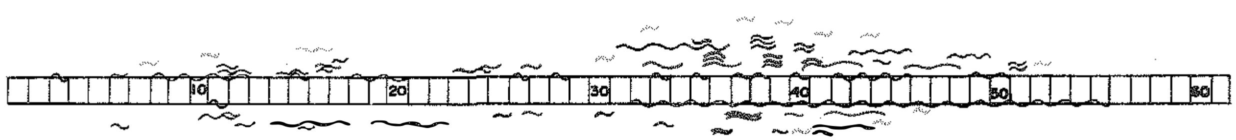
Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	*Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (o)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
557 + 00	30	300	283	III	Std.	Positive	2.23	1.56	17.0	19.5	45 L	Soil & Rock	1.56-1.36	North



Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	*Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (o)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
573 + 50	24	232	232	III	Std.	Positive	1.34	1.34	18.5	19.5	30 L	Rock	1.43-1.36	North



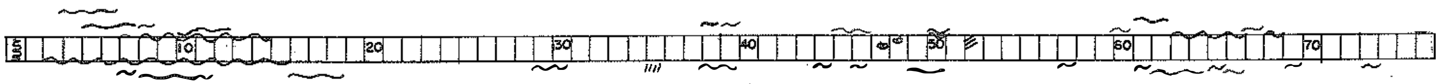
Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	*Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (o)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
602 + 82	42	244	244	III	Std.	Positive	2.05	1.73	16.0	15.0	0	Rock	1.66-1.77	South

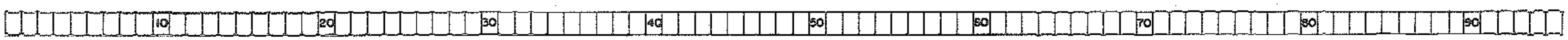


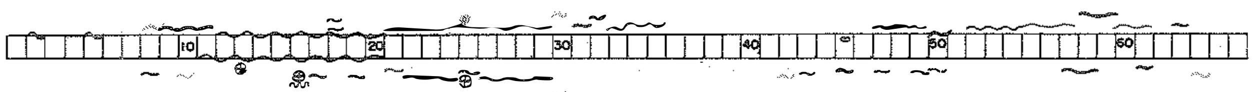
PROJECT NO. I 64-5(5)93 CLARK COUNTY

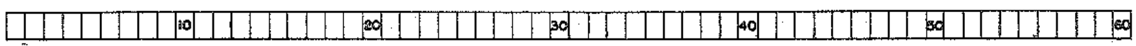
WINCHESTER TO MONTGOMERY COUNTY LINE

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	*Projection	Design Grade (%)	Actual Grade (%)	Embankment North (ft.)	Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
609 + 50	42	308	304	III	B_1	Positive	1.88	0.97	23.0	21.0	45 L	Rock	2.36-2.59	South
656 + 50	18	372	380	III	B_1	Positive	4.89	5.05	34.0 Ramp "C"-41.5	39.0	20 L	Soil & Rock	1.60-1.39	North
725 + 50	30	268	264	III	B_1	In. to 209'-Pos. 209' to 264'-Neg.	3.17	3.30	31.0	34.0	15 L	Rock	1.75-1.60	North
749 + 65	24	236	240	III	Std.	Positive	5.17	5.21	16.0	20.0	15 L	Rock	1.66-1.32	North







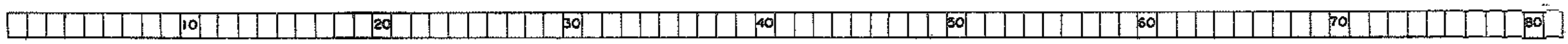


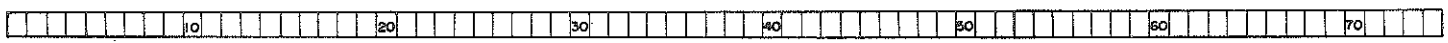
*All pipes laid with negative projection regardless of design projection values shown in tables.

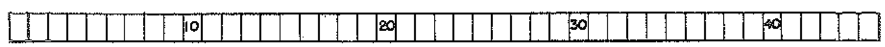
PROJECT NO. I 64-5(6)100 CLARK-MONTGOMERY COUNTY

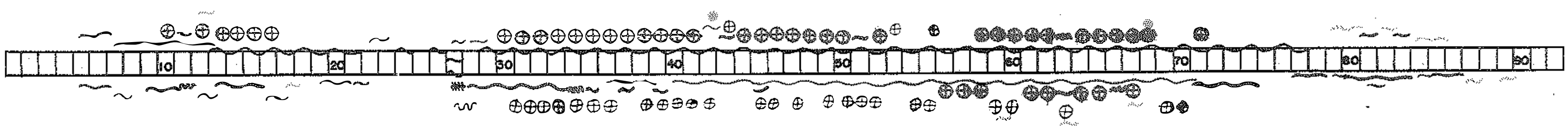
WEST CLARK COUNTY LINE TO U. S. 60

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
788 + 00	24	328	324	IV	B_1	Positive	2.35	4.02	47.0	45.5	15 R	10' Soil & Remain. Rock	1.73-1.79	South
804 + 80	24	308	296	IV	B_1	Positive	4.87	4.40	43.5	39.0	15 L	7' Soil & Remain. Rock	1.87-2.09	South
824 + 31	18	188	180	III	Std.	Positive	7.39	9.45	16.0	10.0	0	Soil	1.66-2.65	South
866 + 50	30	352	368	III	B_1	108'-Pos. 260'-Neg.	3.27	2.17	28.5	31.5	45 R	Soil	1.91-1.73	North





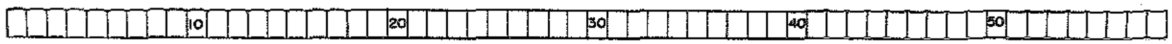


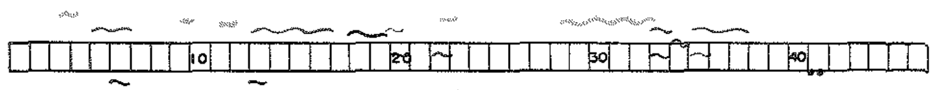


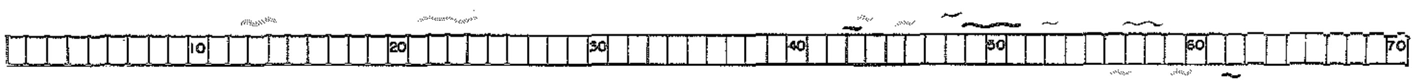
PROJECT NO. I 64-5(6)100 CLARK-MONTGOMERY COUNTY

WEST CLARK COUNTY LINE TO U. S. 60

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
901 + 50	18	232	232	III	B_1	Positive	4.35	4.83	28.0	24.5	0	14' Soil & Remain. Rock	1.94-2.22	South
931 + 00	39	180	184	III	Std.	Positive	0.56	0.89	4.5	4.0	30 L	Soil	5.89-6.62	North
938 + 28	48	272	280	III	Std.	Positive	1.62	1.25	9.0	8.5	45 R	4' Soil & Remain. Rock	2.94-3.12	South
967 + 65	18	240	252	III	B_1	Positive	3.28	4.13	25.0	28.0	15 L	9' Soil & Remain. Rock	2.18-1.94	North



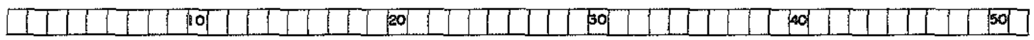




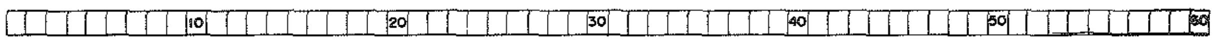
PROJECT NO. I 64-5(6)100 CLARK-MONTGOMERY COUNTY

WEST CLARK COUNTY LINE TO U. S. 60

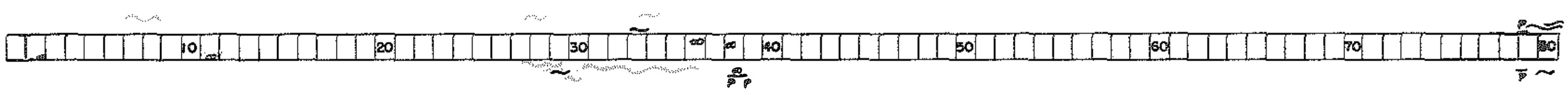
Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
1043 + 90	24	228	204	III	Std.	Positive	3.29	4.61	15.0	11.5	15 R	10' Soil & Remain. Rock	1.77-2.30	South



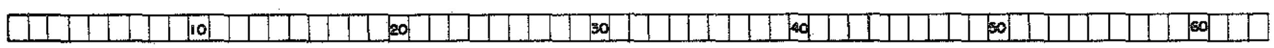
Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
1081 + 10	18	244	240	III	Std.	Positive	3.28	3.54	16.5	19.5	0	10' Soil & Remain. Rock	1.61-1.36	North



Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
1197 + 50	60	320	320	III	B_1	Positive	1.09	7.82	24.0	25.5	45 R	5' Soil & Remain. Rock	2.27-2.13	North

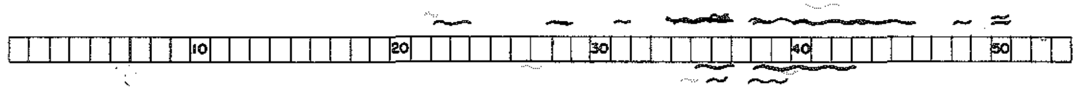


Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
1229 + 73	18	252	252	III	Std.	Positive	3.61	3.57	12.5	16.0	0	6' Soil & Remain. Rock	2.12-1.66	North



PROJECT NO. I 75-6(5)123 SCOTT COUNTY

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height West (ft.)	Embankment Height East (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
65 + 30	48	208	212	III	B	Positive	0.77	0.63	12.0		30 R	Soil & Rock	2.28	East
110 + 50	36	212	212	III	B	Positive	1.98	4.08	20.0	15.0	15 L	Soil & Rock	1.37 - 1.83	East
153 + 25	42	204	204	III	B	Positive	1.86	1.70	8.0	12.5	15 L	Soil & Rock	3.43 - 2.19	East
166 + 25	36	296	298	III	B	Positive	2.03	1.93	19.0	14.5	30 L	Soil & Rock	1.44 - 1.83	East

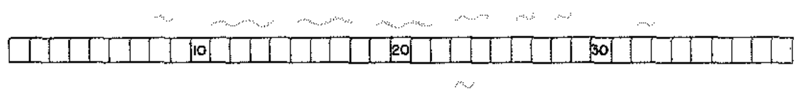


PROJECT NO. I 75-6(5)123 SCOTT COUNTY

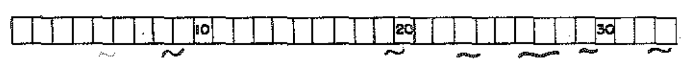
Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height West (ft.)	Embankment Height East (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
212 + 30	30	220	220	III	B_1	Positive	1.86	2.35	22.0	27.0	0	Soil & Rock	2.55 - 2.08	East

322 + 00	54	284	280	III	B_1	Out to 176'- Pos. 176' to Inlet-Neg.	1.13	1.23	21.0	22.5	30 R	Soil & Rock	2.67 - 2.49	West

36 + 50 SW Ramp	30	152	156	III	B_1	Out to 56'-Pos. 56' to Inlet-Neg.	2.43				30 R			East

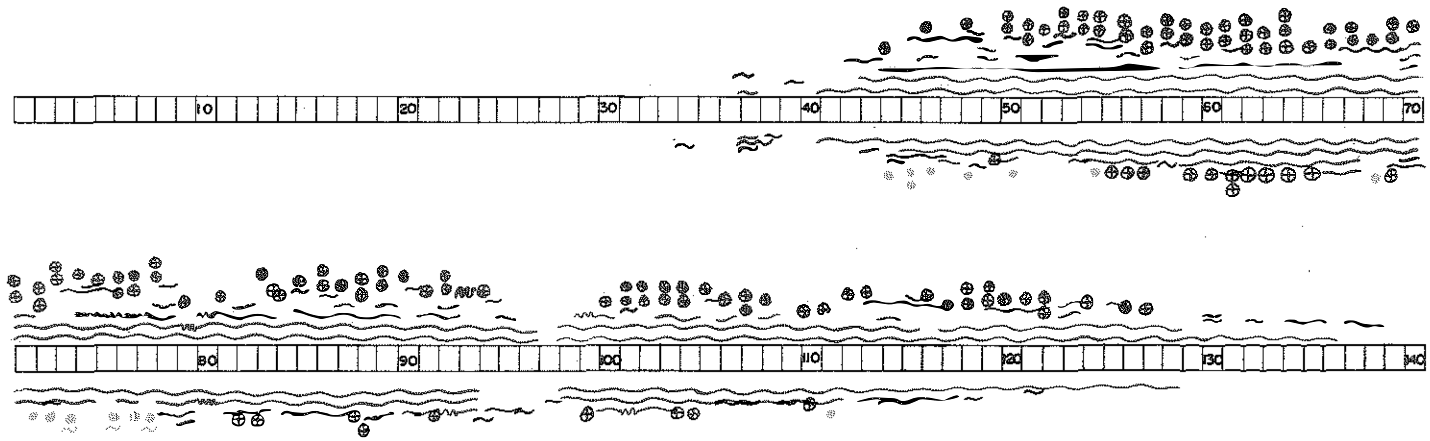


47 + 40 U. S. 62	30	132		III	B_1	Positive	5.15	5.02	24.5	18.0	0	Soil & Rock	2.29 - 3.12	East



PROJECT NO. I 75-6(5)123 SCOTT COUNTY

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height West (ft.)	Embankment Height East (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
37 + 50 US 460 SW Ramp	48	560	56	III	B& B_1	Positive	1.23	1.22	36.0	34.0	51 R	Soil & Rock	0.78 for B 1.60 for B_1	East

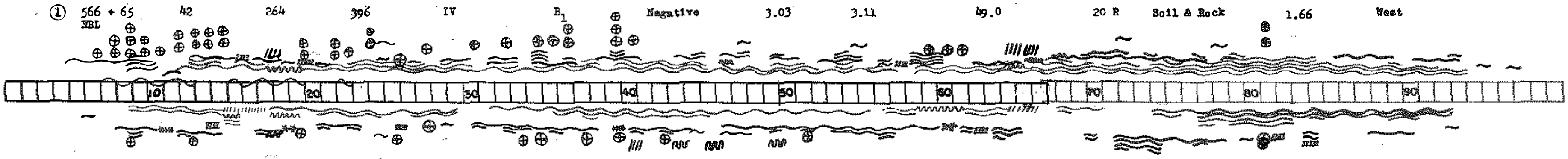


PROJECT NO. I 75-6(4)129 SCOTT COUNTY

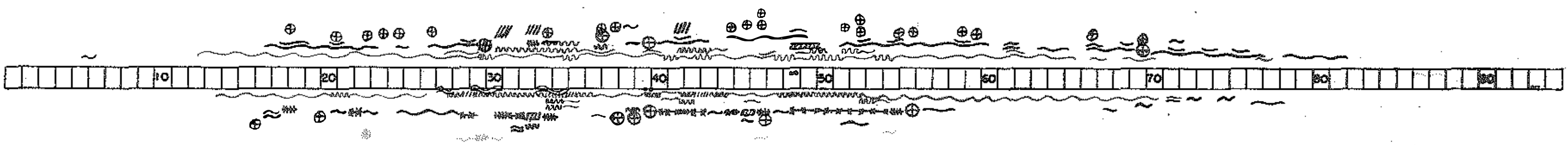
Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height West (ft.)	Embankment Height East (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
71 + 00	24	336	336	IV	B_1	Positive	3.57	0.49	35.5	34.0	25 R	Soil & Rock	2.37 - 2.47	East
97 + 50	30	132	132	III	B_1	Positive	0.97	1.17	18.0	16.5	30 R	Soil & Rock	3.12 - 3.40	East

PROJECT NO. I 75-7(11)151 GRANT COUNTY

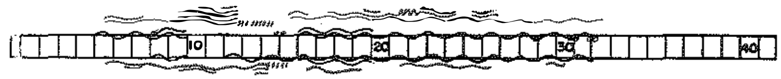
	Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height West (ft.)	Embankment Height East (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
①	566 + 65 NBL	42	264	396	IV	B_1	Negative	3.03	3.11	49.0		20 R	Soil & Rock	1.66	West



	Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height West (ft.)	Embankment Height East (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
	632 + 80 SBL	30	376	376	IV	B_1	Negative	4.52	4.55	45.0	45.0	50 L	Soil	1.81	West



	Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height West (ft.)	Embankment Height East (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
②	7 + 34 FR 2	60	172	168	IV	B_1	Negative	2.33	2.38	44.0	44.0	20 L	Soil & Rock	1.85	East



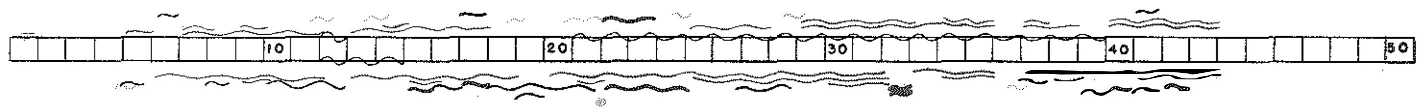
① 90° Bend Sections 66-67 , Sections 67-99 added after 1960 survey

② Slide occurred summer 1961, pipe damaged during replacement of embankment.

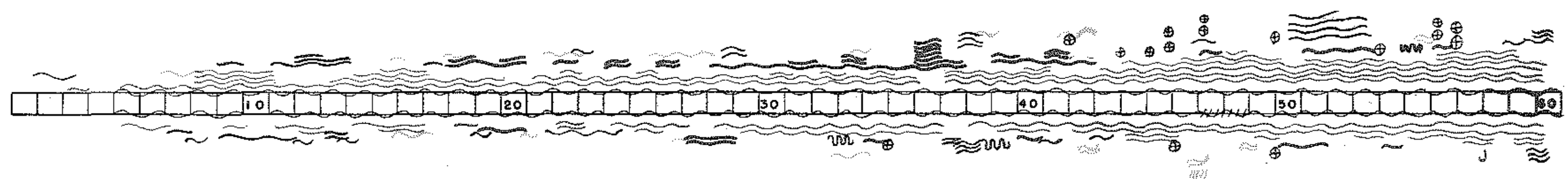
PROJECT NO. I 75-7(3)155 GRANT COUNTY

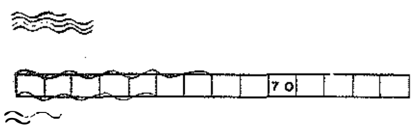
SOUTH OF CLAY LICK CREEK TO NORTH OF CASSON ROAD

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height West (ft.)	Embankment Height East (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
782 + 00	42	300	300	IV	B_1	Out. to 58'-Neg. 58' to 300'-Pos.	2.17	2.18	41.0	44.0	5 L	15' Soil & Remain. Rock	1.99-1.85	West

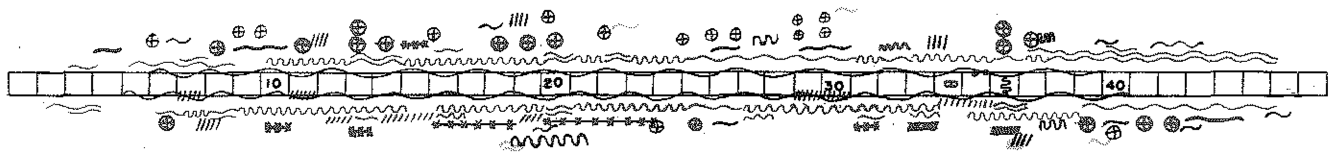


Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height West (ft.)	Embankment Height East (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
794 + 60	72	372	144	III	B_1	Positive	1.91	1.91	35.0	32.5	45 R	Soil & Rock	1.55-1.67	East





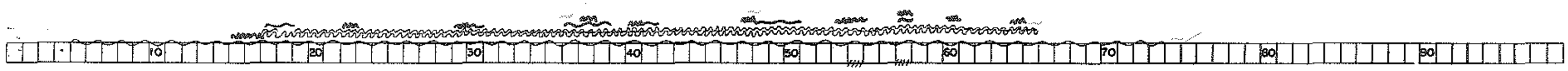
Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height West (ft.)	Embankment Height East (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
807 + 16	36	292	282	III	B_1	Negative	6.10	6.36	39.0	33.0	20 L	Soil & Rock	1.39-1.65	East

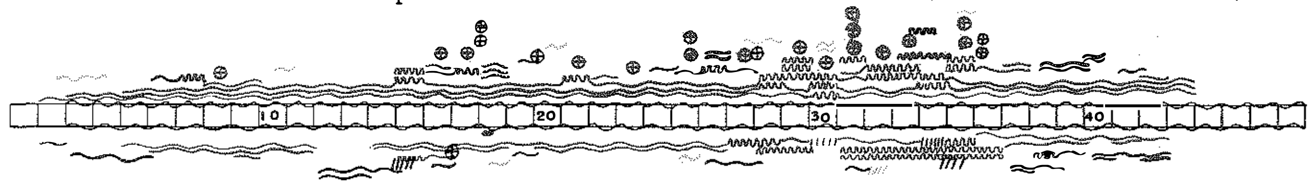


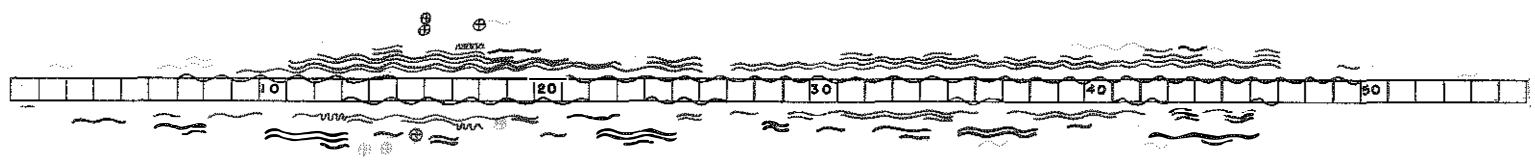
PROJECT NO. I 75-7(3)155 GRANT COUNTY

SOUTH OF CLAY LICK CREEK TO NORTH OF GASSON ROAD

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height West (ft.)	Embankment Height East (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
835 + 90	36	388	394	IV	B_1	Positive	0.13	0.13	48.0	47.0	40 R	10' Soil & Remain. Rock	1.70-1.73	West
902 + 60	66	280	282	III	B_1	Positive	2.29	2.27	28.0	26.5	25 L	Soil	1.94-2.05	East
928 + 95	48	324	330	IV	B_1	Positive	2.16	2.58	50.0	47.5	5 R	20' Soil & Remain. Rock	1.63-1.72	East





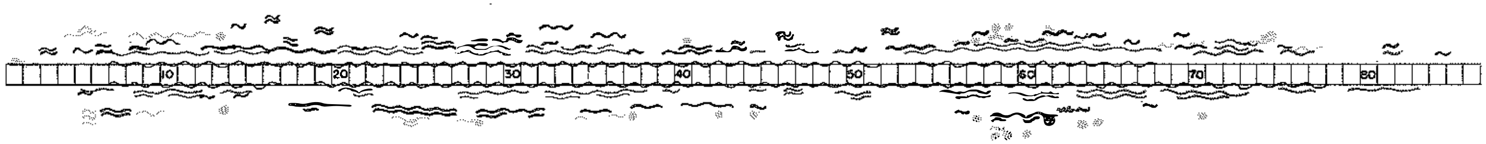


PROJECT NO.: I 75-7(5) 160 GRANT COUNTY

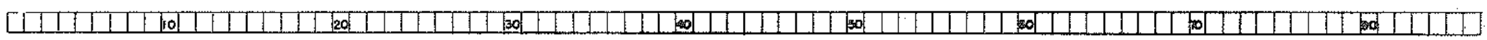
SOUTH OF SHERMAN-MT. ZION ROAD TO KENTON COUNTY LINE

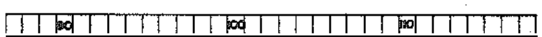
Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height West (ft.)	Embankment Height East (ft.)	Skew (o)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
935 + 70	54	420	420	IV	B_1	Postive	1.05	1.05	44.0	43.0	45 L	20' Soil & Remain. Rock	1.85-1.90	East

963 + 26	60	352	344	IV	B_1	Negative	2.33	3.65	50.0	49.0	20 R	Soil & Rock	1.63-1.66	East



966 + 67	24	488	468	III	B_1	Negative	5.43	6.25	40.0	31.0	55 L	Soil & Rock	1.36-1.75	East



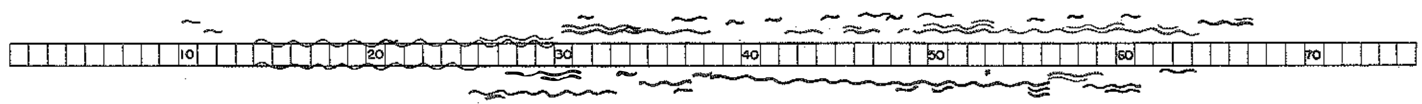


PROJECT NO. I 75-7(5) 160 GRANT COUNTY

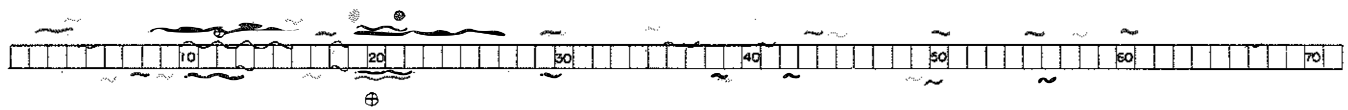
SOUTH OF SHERMAN-MT. ZION ROAD TO KENTON COUNTY LINE

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment West (ft.)	Height East (ft.)	Skew (o)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
978 + 12	42	280	272	III	B_1	Positive	2.36	2.30	40.0	38.0	0	Rock	1.36-1.43	East

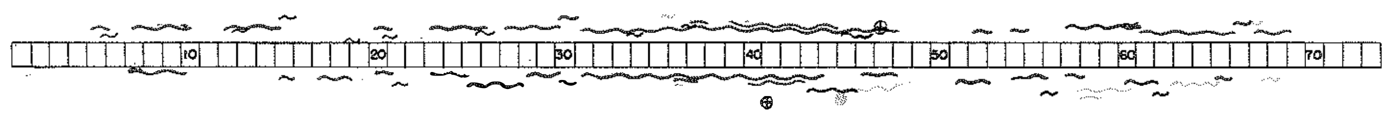
988 + 18	36	296	300	IV	B_1	Positive	2.03	2.00	42.0	43.0	15 L	Rock	1.94-1.90	East



1001 + 22	30	276	284	III	B_1	Positive	3.99	3.88	28.0	25.0	30 R	Soil & Rock	1.94-2.18	East



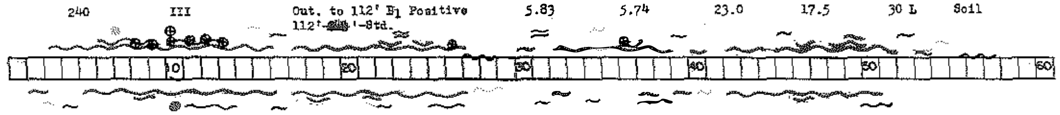
1004 + 33	36	292	292	III	B_1	Positive	3.42	3.42	29.0	26.0	35 L.	Soil & Rock	1.87-2.09	East



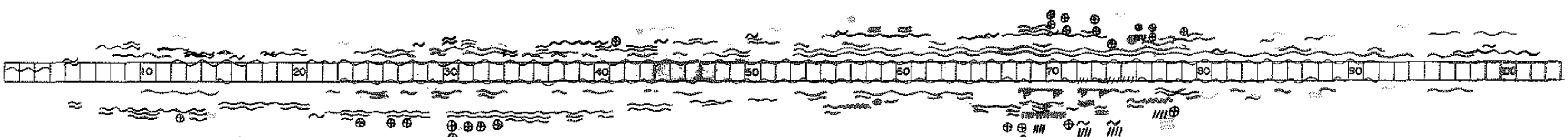
PROJECT NO. I 75-7(5) 160 GRANT COUNTY

SOUTH OF SHERMAN-MT. ZION ROAD TO KENTON COUNTY LINE

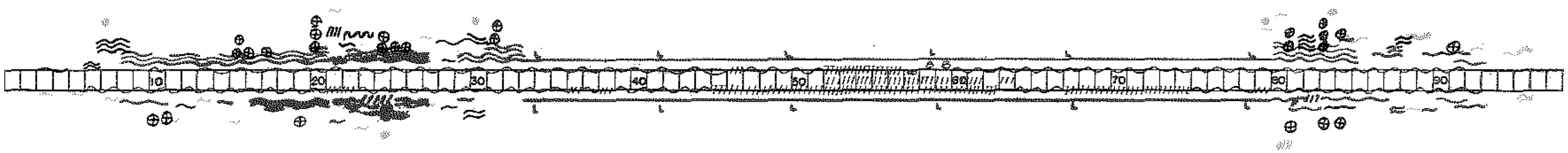
Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment West (ft.)	Height East (ft.)	Skew (o)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
1028 + 05	30	240	240	III	Out. to 112' B_1 112'-[illegible]'-Std.	Positive	5.83	5.74	23.0	17.5	30 L	Soil	2.37-1.51	East



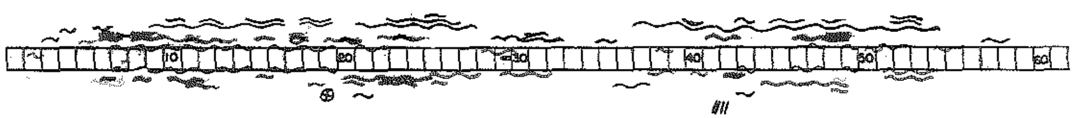
1085 +44	54	412	412	IV	B_1	Positive	1.82	1.82	58.0	56.0	30 R	Rock	1.41-1.46	East



1087 + 50	54	388	388	IV	B_1	Out. to 21'-Pos. 21' to 326'-Neg. 326' to 388'-Pos.	2.86	2.67	55.5	53.0	26 L	Rock	1.47-1.54	East



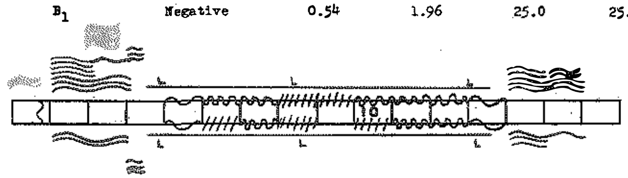
1146 + 04	42	212	[illegible]	III	B_1	Positive	2.50	3.14	23.5	21.5	0	Soil	2.31-2.53	East



PROJECT NO. I75-7(5) 160 GRANT COUNTY

SOUTH OF SHERMAN-MT. ZION ROAD TO KENTON COUNTY LINE

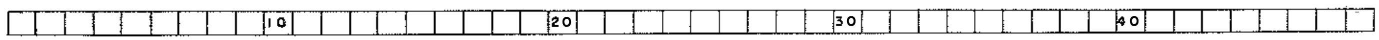
Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height West (ft.)	Embankment Height East (ft.)	Skew (o)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
27 + 82 FR 9A	72	112	128	III	B_1	Negative	0.54	1.96	25.0	25.0	35 R	10' Soil & Remain. Rock	2.18	East



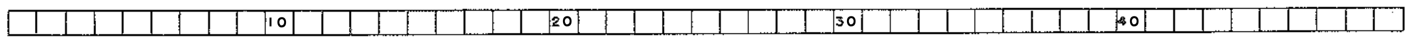
PROJECT NO. I 75-8(12) 181 KENTON COUNTY

BOONE COUNTY LINE TO SOUTH OF U.S. 25 INTERSECTION

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment West (ft.)	Height East (ft.)	Skew (o)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
194 + 21	18	296	288	III	Std.	I to 128-Neg. 128 to 288-Pos.	I to 96'16.3 96' to Out-2.9	14.1 3.2	24.0	17.0	30 L	Soil	1.10-1.56	East



Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment West (ft.)	Height East (ft.)	Skew (o)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
275 + 50	24	344	294	III	Std.	Positive	3.49	1.36	15	15	45 R	Soil	1.76	East



Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment West (ft.)	Height East (ft.)	Skew (o)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
342 + 60	48	264	252	III	Std.	Inlet & Outlet-Pos. 50' in mid.-Neg.	1.44	4.84	26.0	24.0	21 L	10' Soil & Remain. Rock	1.02-1.10	East