BUCKEYE LAKE DAM

SPILLWAY ADEQUACY AND EMBANKMENT STABILITY AND SEEPAGE STUDY

Prepared by
DODSON-LINDBLOM ASSOCIATES, INC.
COLUMBUS, OHIO

For
THE OHIO DEPARTMENT OF NATURAL RESOURCES
COLUMBUS, OHIO

AUGUST 1987

BUCKEYE LAKE DAM

SPILLWAY CAPACITY AND EMBANKMENT
STABILITY AND SEEPAGE STUDY

TABLE OF CONTENTS

	Page
TITLE PAGE	i
TABLE OF CONTENTS	ii
LIST OF TABLES	iv
LIST OF EXHIBITS	v
SUMMARY	vii
1.0 INTRODUCTION	1
2.0 PURPOSE AND SCOPE OF STUDY	1
3.0 DESCRIPTION OF PROJECT	3
4.0 PAST STUDIES	5
5.0 SPILLWAY ADEQUACY STUDY	8
5.1 Study Procedures	8
5.1.1 Dam, Spillway, and Reservoir Data	9
5.1.2 Determination of Best Synthetic Unit Hydrograph Method	9
5.1.3 Feeder Canal Analysis	11
5.1.4 Development of Design Inflow Hydrographs	11
5.1.5 Analysis of Alternate Spillway and Outlet Systems	12
5.1.6 Downstream Channel Capacity	13
5.2 Discussion of Results	14
5.2.1 Open-Cut Saddle Spillway on Ohio Canal below Millersport	15
5.2.2 Open-Cut Saddle Spillway near Thornport	15
5.2.3 Open-Cut Saddle Spillway at Maple Bay	16
5.2.4 Gated Weir Spillway near Sellers Point	18
5.2.5 Ungated Weir Spillway near Sellers Point	19
5.2.6 Downstream Channel Requirements	20
5.2.7 Comparison of Various Spillway Systems	22
5.2.7.1 Estimated Costs	25
5.2.7.2 Advantages/Disadvantages of Various Spillway Systems	30
5.2.7.2.1 Open-cut Saddle at Maple Bay	30
5.2.7.2.2 Ungated weir near Sellers Point	31
5.2.7.2.3 Gated weir near Sellers Point	31

TABLE OF CONTENTS (Continued)

	Page
5.3 Conclusions and Recommendations	32
6.0 EMBANKMENT STABILITY AND SEEPAGE STUDY	33
6.1 Study Procedures	33
6.1.1 Soil Boring and Sampling Program	34
6.1.2 Laboratory Testing Program	35
6.2 Investigational Findings	35
6.2.1 Section 2 (Boring Nos. 7 and 8)	36
6.2.1.1 Generalized Soil Profile at Section 2	37
6.2.1.2 Groundwater Conditions at Section 2	37
6.2.2 Section 3 (Boring Nos. 1, 2, 2A, and 3)	38
6.2.2.1 Generalized Soil Profile at Section 3	38
6.2.2.2 Groundwater Conditions at Section 3	39
6.2.3 Section 4 (Boring Nos. 4, 4A, 5 and 6)	41
6.2.3.1 Generalized Soil Profile at Section 4	41
6.2.3.2 Groundwater Conditions at Section 4	41
6.3 Discussion of Results	42
6.3.1 Stability Analysis	42
6.3.2 Seepage	44
6.4 Conclusion and Recommendations	48
6.4.1 Stability of the Embankment	48
6.4.2 Seepage	49
7.0 GENERAL CONCLUSIONS AND RECOMMENDATIONS	52
8.0 LIST OF REFERENCES	57

APPENDIXES

I - EXHIBITS

II - PHOTOGRAPHS

III - BORING LOGS AND SOIL TEST RESULTS

IV - HYDROLOGY AND HYDRAULIC COMPUTATIONS

V - GEOTECHNICAL COMPUTATIONS

VI - DEVELOPMENT OF PRELIMINARY PLANS

LIST OF TABLES

Table		Page
1	Comparison of Spillway Widths Required for Various Spillway Systems	24
2	Summary of Approximate Costs of Various Spillway Systems Studied	26
3	Soil Parameters Used in Stability Analysis	45
4	Computed Factors of Safety	45

LIST OF EXHIBITS

Number	Title
1	General Plan of Buckeye Lake and Surrounding Areas
2	Area-Capacity Curves
3	Top of Dam Profile
4	Synthetic Unit Hydrograph Data Summary
5	June 1981 Storm
6	May 1983 Storm
7	Water Surface Profile for Maximum Flows Possible in Kirkersville Feeder Canal
8	6-HR PMF Composite Inflow Hydrograph
9	Water Surface Profile for Maximum Safe Flows Possible in Outlet Channel
10	Water Surface Profiles for South Fork Licking River
11	Effect of Spillway Location on South Fork Licking River Water Surface Elevation near Buckeye Lake
12	Ohio Canal Spillway Rating Curves
13	Profile of Thornport Spillway and Outlet Channel
14	Thornport Spillway Rating Curves
15	Profile of Maple Bay Spillway and Outlet Channel
16	Maple Bay Spillway Rating Curves
17	Flood Routing Results for Open-Cut Saddle Spillway at Maple Bay
18	Spillway Rating Curve for 50' Principal Spillway
19	Gate Operating Schedule and Associated Discharges
20	Gated Spillway Rating Curves
21	Flood Routing Results for Gated Weir Spillway
22	Spillway Rating Curves for Ungated Weir Spillway

LIST OF EXHIBITS (Cont'd)

Number	Title
23	Flood Routing Results for Ungated Weir Spillway
24	Estimated Major Unit Construction Costs
25	Boring Location Plan and Generalized Soil Section at Section 2
26	Boring Location Plan and Generalized Soil Section at Section 3
27	Boring Location Plan and Generalized Soil Section at Section 4
28	Water Level Measurements
29	Cross-Sections Showing Theoretical Phreatic Surface and Water Level Measurements

BUCKEYE LAKE DAM

SPILLWAY CAPACITY AND EMBANKMENT
STABILITY AND SEEPAGE STUDY

SUMMARY

Buckeye Lake is located in Licking, Fairfield, and Perry Counties, Ohio. The reservoir was originally constructed as a feeder lake for the Ohio and Erie Canal System. Work on the project was reportedly initiated in 1825 and completed in 1832. The lake is presently used for public recreation, including swimming, fishing, and boating. The surface area of the lake is approximately 2700 acres at the normal summer pool level. The drainage area of the lake is 44.1 square miles. The reservoir outlets into the South Fork Licking River, a tributary of the Muskingum River.

Buckeye Lake Dam is an earthen embankment about 4 miles long with a maximum structural height of approximately 15 feet. Houses are situated on the crest and downstream slope along virtually the entire embankment, and a sheet pile or masonry wall extends along the upstream face of the embankment. A combination drop spillway and gated outlet works concrete structure is located in the northeastern portion of the embankment. This spillway structure was constructed around 1910.

Several communities are located either immediately below the dam or downstream along the South Fork Licking River. Based on the size of the lake and the possibility of loss of life due to failure of the dam, the structure is considered a Class I structure by the Ohio Department of Natural Resources (ODNR) Division of Water standards.

The lake, the combined spillway and outlet works, and most of the dam are owned by the State of Ohio and are operated and maintained by the ODNR Division of Parks and Recreation.

Several past preliminary inspections or studies of the Buckeye Lake Dam revealed that the spillway capacity did not meet current state design standards and that the stability of the embankment was questionable. The ODNR thus contracted with Dodson-Lindblom Associates, Inc. on March 20, 1985, to perform a comprehensive study of the spillway capacity requirements of Buckeye Lake and to analyze the structural integrity of the Buckeye Lake Dam. This report presents and discusses the results of this study.

Based on the results of this study as discussed herein, the following recommendations are made for the Buckeye Lake Dam and spillway:

1. A U-shaped, concrete gravity ungated weir structure should be constructed in the vicinity of the old dry dock located near Sellers Point. The weir should have a crest length of 460 feet at elevation 891.75. The normal pool would thus be maintained at the current normal pool level. A new outlet channel to the South Fork Licking River will be required as well as a bridge over the outlet channel just below the dam. The estimated cost of this spillway, outlet channel, bridge, and associated improvements to the embankment and the South Fork Licking River as described in the subsequent recommendations is approximately $4,655,000.
2. The existing spillway structure should be removed or rendered inoperative and earthfill should be compacted along the upstream and downstream portions of the structure to incorporate the structure into a new segment of the embankment in that area. Some type of gated outlet should be provided at

this site, however, to provide drainage and fresh water augmentation to the current outlet channel.

3. Channel improvements should be made to the South Fork Licking River below the new outlet channel. These improvements should be coordinated with the basin flood control project proposed by the SCS and the South Licking River Watershed Conservancy District.
4. A concrete parapet wall should be added along the crest of the embankment where needed to raise the embankment height to elevation 896.5.
5. A sheet pile wall should be added in front of the old masonry wall where no sheet pile wall currently exists. The top of the new sheet pile wall should also be set at elevation 896.5.
6. All trees less than 4-6 inches in diameter should be removed from the embankment, and the state should prohibit the planting of any additional trees on the embankment in the future.
7. The state should require permits for the construction of future docks, building, etc, along the embankment. All proposed construction should be carefully assessed in light of how it would affect the structural integrity of the embankment.
8. All drain pipes located on the top of the dam presently being used to drain water from the crest of the dam into the lake should be removed. The flow from these drains should be diverted to the downstream slope. All holes or openings (drain holes, handling holes, etc.) in the slope protection wall should be adequately covered.

9. Seepage through the embankment and foundation should be addressed as necessary on a case-by-case basis by constructing a slurry cutoff wall or a toe drain in the immediate seepage area. If the current normal pool level is maintained, as recommended above, the integrity of the dam is not considered to be adversely affected by the degree of seepage currently evident. Nevertheless, the embankment should be regularly monitored for seepage increases, especially when the pool level exceeds the normal pool level.
10. Concrete sand should be stockpiled at four or five readily accessible locations and suitable equipment should be kept available to help control seepage on an emergency basis.

Following a review of the preliminary submittal of this report, the ODNR generally concurred with the recommendations given above and requested that additional work be done to develop in more detail various recommendations concerning the construction of a new spillway and outlet channel and the raising of the effective embankment height. Additional soil borings were thus taken within the lake area at Sellers Point and preliminary drawings were developed to show more specifically the improvements recommended. These drawings, soil borings, and additional description of this work are included in Appendix VI, as well as a more detailed cost estimate of the proposed work. As noted in Appendix VI the estimated cost of the proposed work is $5,392,200, including the costs of improvements to the South Fork Licking River below the proposed

outlet channel and improvements to the existing outlet channel, Kirkersville feeder canal, and Bloody Run weir. This value is based on more detailed drawings than the estimate given in the first recommendation above and is thus considered more accurate.

BUCKEYE LAKE DAM

SPILLWAY CAPACITY AND EMBANKMENT STABILITY AND SEEPAGE STUDY

1.0 INTRODUCTION

Buckeye Lake is located in Central Ohio in Licking, Fairfield, and Perry Counties. The reservoir was originally constructed as a feeder lake for the Ohio and Erie Canal system and was formerly known as the Licking Summit Reservoir. Work on the project was reportedly initiated in 1825 and completed in 1832. The lake is presently used for public recreation, including swimming, fishing, and boating. The reservoir outlets into the South Fork Licking River, a tributary of the Muskingum River.

The lake, the combined spillway and outlet works, and most of the dam are owned by the State of Ohio and are operated and maintained by the Ohio Department of Natural Resources, Division of Parks and Recreation.

2.0 PURPOSE AND SCOPE OF STUDY

The Ohio Department of Natural Resources (ODNR) contracted with Dodson-Lindblom Associates, Inc. on March 20, 1985, to perform a comprehensive study of the spillway capacity requirements of Buckeye Lake and to analyze the structural integrity of the Buckeye Lake Dam. This investigation was to be conducted in two phases: first, a preliminary analysis/investigation to assess the situation at Buckeye Lake and plan a detailed investigation and, second, a more detailed analysis/investigation subsequent to the review by ODNR of the results of the preliminary study.

The preliminary analysis/investigation involved: (1) reviewing background material on the project; (2) making a field investigation to identify areas where the integrity of the embankment is questionable, with an evaluation of the seriousness of the identified problem areas and a proposed plan for any required additional soils investigations; (3) itemizing proposed procedures for conducting a detailed investigation of the spillway, outlet works and downstream channel requirements; and (4) providing a progress schedule for the proposed detailed investigation. A preliminary report summarizing the work completed under the first phase of the overall study was submitted to ODNR on July 31, 1985.

The preliminary report recommended that additional soils investigations be made on the dam to properly analyze the seepage and strength characteristics of the embankment. This recommendation was approved by ODNR, following their review of the preliminary report, and a supplemental contract was subsequently added to the original contract for the embankment soils investigation study. Consequently, the second phase of the overall study included a detailed soils investigation of the embankment as well as an investigation of the required spillway, outlet and downstream channel capacities.

The detailed soils investigation included field surveys, soil borings, laboratory testing and subsequent embankment stability and seepage analyses. The condition of the upstream slope protection was also evaluated.

The spillway adequacy analysis consisted of an investigation of alternate types and locations of a spillway and outlet works system which could safely pass the Probable Maximum Flood (PMF). The adequacy

of the alternate systems, including the downstream outlet channel, was evaluated for the 100 year flood, 25% PMF, 50% PMF and full PMF.

This report presents and discusses the results of these detailed investigations.

3.0 DESCRIPTION OF PROJECT

Buckeye Lake Dam is an earthen embankment approximately 4 miles in length with a maximum structural height of about 15 feet. Houses are situated on virtually the entire length of the embankment, with most of the foundations and/or basements excavated into a portion of the embankment. A sheet pile or masonry wall extends along the upstream face of the embankment the entire length of the dam. Photographs 1 through 6 in Appendix II show typical views of the upstream face and crest at various locations along the dam.

A combination drop spillway and gated outlet works concrete structure is located in the northeast portion of the embankment. The structure consists of ten overflow bays, each 6'8" wide, and five 4'x5' sluice gates located under the overflow portion of the structure. A sidewalk spans the spillway, and controls for the gates are accessible from the sidewalk. Photographs 7 through 10 show various views of the spillway and outlet works.

The crest of the concrete overflow section is at elevation 890.7, but 19-inch-high metal flashboards are currently in place, bringing the normal pool level to elevation 892.25. Because of seepage problems, however, the normal pool level has been maintained about 6 inches below the crest of the flashboards for many years by operation of the gates.

The lake has a surface area of approximately 2700 acres at normal pool elevation 892.25. The lake is fed by several small streams and by a feeder canal which extends from Kirkersville to the west side of the lake near Millersport. This canal was constructed to provide additional inflow to Buckeye Lake and thus additional water supply for the Ohio and Erie Canal system. Photograph 11 shows a typical view of the canal. A diversion channel and gated structure located near Kirkersville were also originally provided to allow additional diversion of flow from the South Fork Licking River to Buckeye Lake; this channel and gated structure are no longer in use. Levees extend along the east side and portions of the west side of the canal. They were originally constructed to contain flow in the canal and/or provide suitable channel capacity. Since the canal intercepts streams originally flowing to the South Fork Licking River and not Buckeye Lake, discharge over the east levee during high flow conditions does not enter Buckeye Lake but flows directly to the South Fork Licking River.

The total drainage area of the lake is 44.1 square miles, including the 16.7 square mile drainage area of the feeder canal.

Millersport, Fairfield Beach, Buckeye Lake and several smaller communities are located on the shores of Buckeye Lake, and Lakeside and portions of the Village of Buckeye Lake are situated below the dam. Hebron and Newark are also located downstream along the South Fork Licking River. Based on the size of the lake and the possibility of loss of life due to failure of the dam, the structure is considered a Class I structure by ODNR Division of Water standards.

4.0 PAST STUDIES

In March 1939, the U.S. Engineers Office (Corps of Engineers) inspected the embankment and spillway and noted seepage through the embankment at that time. A subsequent hydrologic and hydraulic study also indicated the spillway capacity of the existing spillway was inadequate. Consequently, the U.S. Engineers Office recommended that the embankment be strengthened and that the spillway capacity be increased substantially.

In 1972, several state and Federal agencies formed an Ad Hoc Task Force to study the spillway requirements of Buckeye Lake and recommend an operational plan. The agencies involved included the U.S. Soil Conservation Service and the Ohio Departments of Public Works, Highways, and Natural Resources, with the Department of Natural Resources being designated the lead agency.

The Task Force first considered structural measures which could contain the probable maximum flood (PMF-ODNR Class I design flood) generally within the existing lake without overtopping the dikes. The required alternatives estimated at that time proved highly expensive and were felt to be impractical. Alternative structural measures were then studied to contain the 50% PMF (ODNR Class II design flood) essentially within the existing lake. The excess runoff between the Class I and Class II storms was to be handled by a combination of structural and non-structural means by which the loss of human life would not be envisioned.

The major structural alternatives investigated by the Task Force included:

1. New spillway at existing site with improved outlet channel.

2. New spillway channel under I-70 east of S.R. 79.
3. Diversion channel near Thornport to Jonathan Creek (Moxahala Creek Basin).
4. New spillway near Sellers Point with new outlet channel to South Fork Licking River.
5. All the above alternatives assuming various normal pool and top of dam elevations.

Of these alternatives studied, the Task Force recommended that either a gated or ungated weir structure be constructed at Sellers Point or at the site of the existing spillway and the embankment height increased as necessary. The selection of one of these four alternatives was to be made on the basis of which would be most acceptable to the citizens of the Buckeye Lake area.

The dam was inspected again in 1978 by GAI Consultants, Inc. as part of the National Dam Safety Inspection Program. This inspection revealed that the overall condition of the facility was poor and that it was potentially unsafe. Potentially serious problems noted at the time included: (1) a seriously inadequate spillway system; (2) seepage through the embankment; (3) instability of the shore protection wall; and (4) holes and low spots on the crest. Because of these conditions, the GAI report recommended that the state: (1) retain a qualified engineer to make in-depth studies of specific areas of the dam to evaluate its structural integrity and to design a spillway system and downstream improvements to pass the probable maximum flood; (2) develop an emergency warning and evacuation plan for downstream areas; (3) locate and investigate holes, low spots and areas of seepage in the dam;

(4) make regular inspections; and (5) install a continuously recording lake level gage.

Additional analyses in 1980 and 1982 by the Ohio Department of Natural Resources, Division of Water, confirmed the need for increased spillway and outlet channel capacity to meet present state design standards.

An extensive study of the South Fork Licking River watershed has been made by the U.S. Soil Conservative Service and the South Licking Watershed Conservancy District in developing a flood control and recreation project for the watershed. The plan for the project was originally developed in 1980 but was revised in 1983. The goals of the project are: (1) to reduce flood water damage to agricultural, commercial, industrial and residential areas; (2) to reduce erosion and sediment damage; (3) to improve agricultural water management; (4) to develop recreation areas; and (5) to improve the appearance of the natural environment.

The main features of the project in the Buckeye Lake vicinity include a by-pass channel along the north side of I-70, as shown on Exhibit 1, to handle flood flows in the South Fork Licking River; the removal of obstructions in the river from the by-pass channel to the confluence with Raccoon Creek; and a flood protection dike near Hebron.

Federal approval and funding are currently being sought for the project; none of the projected flood control measures listed above has therefore been implemented to date.

5.0 SPILLWAY ADEQUACY STUDY

5.1 Study Procedures

The overall goal of this study was to develop the design inflow hydrograph (PMF) and route it through the lake and various spillway and outlet channel alternatives to determine the best system that would safely pass the design flood. Although a continuous lake level gage has been in place since October 1979, sufficient data were not available to develop an actual design unit hydrograph. Thus, in analyzing the required spillway capacity for Buckeye Lake, one of the major tasks involved determining the most appropriate synthetic hydrograph method to use in developing the design inflow hydrograph. Therefore, preliminary studies were made to estimate which of two common methods best matched historic flood data.

Following this analysis, an estimate of the peak flows possible in the feeder canal was required, as excess flow in the canal would overtop the east levee of the canal and would therefore not enter Buckeye Lake. Thus backwater analyses were conducted to estimate the peak flows possible in the canal under existing conditions. The runoff hydrograph for the feeder canal basin was then adjusted to reflect these peak flows possible and combined with the runoff hydrographs from the other subareas to form the composite inflow hydrograph. This hydrograph in turn was routed through the lake to estimate the required spillway capacity.

The following paragraphs describe in more detail the analyses outlined above.

5.1.1 Dam, Spillway, and Reservoir Data. To verify the inadequacy of the present system and to reconstitute historic floods, the discharge rating curve for the existing spillway was developed from field surveyed data. The discharge rating curves for the outlet works were developed using existing lake drawdown records which indicate the rate of drawdown for the lake for a specified gate opening.

The reservoir elevation - storage data were estimated from USGS 7½ minute quadrangle topographical maps, as no greater detail mapping was available. The area and capacity curves used in this study are shown on Exhibit 2. The existing top of dam profile was surveyed by Dodson-Lindblom Associates, Inc. and is shown on Exhibit 3. The profile extends from the west end of the dam near Liebs Island to Crane Lake. The profile indicates the top elevation of the existing embankment, the top elevation of the sheet piling or masonry slope protection wall along the upstream face of the dam and the lake bottom elevation along the slope protection wall. From this profile it can be seen that the existing top of dam elevation varies from a low elevation of about 894 to a high elevation of 897, with an average crest elevation of approximately 895.5.

5.1.2 Determination of Best Synthetic Unit Hydrograph Method. The Soil Conservation Service (SCS) and Snyders Methods were selected as the two most viable synthetic hydrograph methods for the Buckeye Lake watershed. The watershed was divided into several subareas and the parameters required by the SCS and Snyders Methods were developed for the various subareas. These parameters are listed in Exhibit 4. The SCS lag time, which is assumed equivalent to 0.6 t_c, the time of

concentration, was estimated from USGS quadrangle maps, and the basic Snyder parameters, C_t and C_p, were estimated from values computed for actual unit hydrographs recorded at neighboring watersheds.

Since the Snyder Method was originally developed for larger drainage areas which had well defined channels, this method was not used for the subareas that had either no channel or no well defined, dominant channel. Thus, in determining the best means of matching historic data, a combination of the SCS and Snyders methods was used in one analysis (Snyders for the larger subareas and SCS for the smaller subareas) and the SCS method only in another analysis. For both analyses, however, the runoff was estimated using the SCS runoff curve number method. Curve numbers for each subarea were determined from USGS quadrangle maps and SCS soils maps of the area. The subarea curve numbers are also shown on Exhibit 4.

Using the HEC-1 computer program, these synthetic unit hydrographs were used to reconstitute several historic floods, including the January 1959, May 1968, June 1981 and May 1983 floods. However, results obtained in modeling the 1959 and 1968 storms were inconclusive since lake elevation data prior to October 1979 were taken only once a day. (A continuous lake level recording gage was added in October 1979). With limited actual data it was not possible to determine which method produced the best results for these two storms. Results from modeling the 1981 and 1983 floods indicated that the SCS and Snyder methods combined were able to match the recorded lake levels slightly better than the SCS method alone. These results are shown in Exhibits 5 and 6. Thus the SCS and Snyders methods were combined as described above and used in the subsequent development of the PMF design inflow hydrograph.

5.1.3 Feeder Canal Analysis. Cross-sections of the feeder canal were field surveyed from the canal confluence with the lake to the Bloody Run waste weir, located between I-70 and Kirkersville. These cross-section locations are shown on Exhibit 1. Using the HEC-2 computer program, backwater curve analyses were then made on the canal to estimate the peak discharges possible in the canal before overtopping of the left (east) bank levee would occur. These analyses were made assuming existing conditions in the canal. The backwater curve computed assuming optimal discharge at the mouth of the canal is shown on Exhibit 7. As indicated on this exhibit, the peak discharge possible from the canal to the lake was thus estimated to be about 2000 cfs.

5.1.4 Development of Design Inflow Hydrographs. The probable maximum precipitation (PMP) for the Buckeye Lake watershed, assuming a 6-hour storm duration, was estimated from Hydrometeorological Report 51 to be 23.6 inches. Using this rainfall amount and the SCS curve number runoff method, the inflow hydrograph for the probable maximum flood (PMF) was then determined from the unit hydrographs developed by the combination of the Snyder and SCS methods discussed previously. In computing the composite inflow hydrograph, the hydrographs for the feeder canal subarea were adjusted to reflect the maximum discharges computed previously that are physically possible in the canal. Excess discharge was assumed to bypass Buckeye Lake and flow overland to the South Fork Licking River. The composite PMF inflow hydrograph thus computed is shown on Exhibit 8.

According to current state standards, the spillway design flood for a Class I structure is the full PMF. To provide additional flood

routing information, however, inflow hydrographs for the 25% PMF and 50% PMF storm events were also estimated. These hydrographs were estimated from the full PMF based on a corresponding percentage of the runoff, not the precipitation. Likewise the 100-year inflow hydrograph was also estimated and was assumed to be approximately equal to a 12% PMF flood, based on runoff estimates for the 100-year precipitation.

5.1.5 Analysis of Alternate Spillway and Outlet Systems. The composite inflow hydrographs were used to analyze various spillway and outlet systems to determine which were most feasible and/or most cost effective. The various systems investigated include the following:

1. Open cut saddle spillway near Maple Bay with new outlet channel to South Fork Licking River.

2. Open cut saddle spillway near Thornport with new outlet channel to Jonathan Creek (Moxahala Creek Basin).

3. Open cut saddle spillway on Ohio Canal below Millersport with new outlet channel to a tributary of Big Walnut Creek.

4. Gated weir structure near Sellers Point with new outlet channel to South Fork Licking River.

5. Ungated weir structure near Sellers Point with new outlet channel to South Fork Licking River.

6. Rebuilding or improving existing spillway to use as a principal spillway.

7. Raising top of dam elevation.

8. Lowering normal pool elevation.

9. Various combinations of the above schemes.

The results of these analyses are discussed in section 5.2.

5.1.6 Downstream Channel Capacity. The scope of the detailed investigation also included an analysis of the adequacy of the downstream outlet channel to handle the anticipated spillway discharge for the various design storms. Since some of the alternative spillway and outlet works systems investigated included rebuilding or improving the spillway at the existing site, cross-sections were field surveyed along the entire length of the existing Buckeye Lake outlet channel and backwater analyses were made of the existing Buckeye Lake outlet channel to estimate the maximum discharge possible in the channel without significant flooding occurring. The locations of these sections are shown on Exhibit 1, and Photograph 12 shows a typical view of the outlet channel. The results of these analyses, as shown on Exhibit 9, indicate that the maximum safe discharge in the channel is approximately 1000 cfs.

To properly analyze the capacity requirements for an emergency spillway outlet channel, it became apparent that backwater analyses would be required on the South Fork Licking River, since discharges of the magnitude expected under PMF or even 50% PMF conditions would cause substantial backwater in the river and would thus affect flood levels in the outlet channel as well. Thus cross-sections were field surveyed along the South Fork Licking River from below U.S. Rt. 40 to above Sellers Point, as also indicated on Exhibit 1. Backwater analyses were then made along the river for the anticipated discharges, assuming the spillway was located near either Sellers Point or Maple Bay.

Water surface profiles for various river discharges, assuming the spillway is located near Sellers Point, are shown on Exhibit 10. As can be seen from this exhibit, the slope of the stream is very flat in this

area. Thus backwater effects from the U.S. Rt. 40 bridge extend a considerable distance and affect the water surface profiles in the vicinity of the dam and the two spillway outlet locations. As a result, since this bridge is located downstream from both spillway discharge entry points, the spillway location does not have a major effect on the South Fork Licking River flood elevations in the vicinity of Buckeye Lake Dam for the higher discharges analyzed. This can be seen from Exhibit 11, which compares the water surface elevation computed for the river near the town of Buckeye Lake (at cross-section 10) assuming the two different spillway locations.

5.2 Discussion of Results

From earlier discussions with ODNR personnel, it was evident that certain limitations existed in developing alternate spillway schemes. Namely, the top of dam elevation could not be increased more than one or two feet, due to aesthetic and practical problems for homes along the dam and the increased flooding that would result under high pool conditions along the northern, eastern and southern shores if the dam height were increased. Also, since the lake is very shallow, the normal pool level cannot be lowered much without affecting boating in many portions of the lake.

From preliminary flood routings through the lake it was also evident that to safely pass the PMF without increasing the height of dam more than approximately 1 to 2 feet would require a spillway peak discharge capacity of 20,000 to 30,000 cfs. These general guidelines were thus used to assess the following spillway schemes in a preliminary manner.

5.2.1 Open-Cut Saddle Spillway on Ohio Canal below Millersport. For this spillway scheme it was assumed that a 1000-foot-long saddle spillway was located about 17,000 feet above the lake on the Ohio Canal, which would outlet to a tributary of Big Walnut Creek (see location on Exhibit 1). Assuming the existing conditions in the canal as a trapezoidal channel with a 15-foot bottom width, 3H:1V side slopes, a 6-foot normal depth, Mannings "n" value of 0.06 and a horizontal bed slope, backwater profiles for various discharges were generated using the HEC-2 computer program. As shown on Exhibit 12, under these conditions the maximum discharge would only be about 400-500 cfs, well below the required 20,000-30,000 cfs peak discharge. Even assuming the canal was cleared and widened to 150 feet would result in a peak discharge of only about 3000 to 4000 cfs, again well below the required discharge. Assuming a wider spillway crest would not significantly affect the discharge capacity, either, since friction losses in the long channel affect the lake elevation required for a given discharge much more than the spillway width. This scheme was thus abandoned as being impractical, based on the low discharge capacity obtained for the amount of channel excavation required and the possible legal problems of transferring flow from the South Fork Licking River watershed to the Big Walnut Creek watershed.

5.2.2 Open-Cut Saddle Spillway near Thornport. As shown on Exhibit 1, this scheme assumed a spillway crest was located adjacent to the lake just above Thornport, with an outlet channel to Jonathan Creek, a tributary of Moxahala Creek. As can be seen from this exhibit, several bridges would be required over the channel to maintain current

roads in the area. A profile of the projected spillway and outlet channel is shown on Exhibit 13, as well as the original ground profile along the channel centerline, as taken from USGS 7½ minute quadrangle maps.

Various combinations of spillway crest widths and outlet channel widths were analyzed for this scheme and spillway rating curves were developed for each of these combinations using backwater curve analyses. These curves are shown on Exhibit 14. For these analyses the Mannings "n" value in the outlet channel was assumed to be 0.035. Due to the flat slope of the outlet channel, backwater in the channel for the channel widths studied would "drown" out the weir and prevent a control section from developing at the weir crest for the anticipated discharges. As can be seen from this exhibit, to provide the necessary peak discharge capacity would require approximately a 1200-foot-wide spillway crest and a 400-foot-wide trapezoidal outlet channel. This scheme was thus also abandoned, again due to anticipated high excavation and construction costs and possible legal problems involved in transferring flow to a different watershed.

5.2.3 Open-Cut Saddle Spillway at Maple Bay. This spillway scheme assumed a spillway crest was located at the northwestern corner of Maple Bay, with an outlet channel to the South Fork Licking River. The location of the spillway is shown on Exhibit 1, and Photograph 13 shows a general view of Maple Bay in the vicinity of the proposed spillway crest. This scheme would require bridges over the outlet channel at I-70 and at a county road. A profile of the projected spillway and outlet channel is shown on Exhibit 15, as well as the

original ground profile along the channel centerline, as estimated from USGS 7½ minute quadrangle maps. Spillway rating curves for numerous crest widths were again developed by assuming a control section at the spillway crest and using backwater curve analyses through the Maple Bay approach channel to estimate the lake elevation corresponding to the control section elevation and associated discharge. For these analyses, the Maple Bay approach channel was assumed to have a depth of 6 feet at the normal pool elevation, a 300-foot bottom width, 2H:1V side slopes, and a Mannings "n" value of 0.025. These rating curves are shown on Exhibit 16.

From these analyses it appeared that this scheme might provide the necessary spillway discharge capacity without excessive excavation and construction costs. Thus flood routings for the 100-year, 25% PMF, 50% PMF and PMF storm events were made using each of the spillway rating curves developed for the Maple Bay area. The results of these flood routings are shown on Exhibit 17, where the maximum lake level and peak discharge attained for each event are plotted against the corresponding spillway width. Each of these flood routings assumes that the dam is higher than the maximum lake level obtained and thus no flow occurs over the dam. Therefore, from these curves an estimate of the required embankment height for a given spillway width can be made.

Since this spillway would be an open-cut, grassed spillway and would suffer substantial erosion and maintenance problems if used on a daily basis, it is recommended that a principal spillway structure be used to handle the daily flows and to provide a drainage facility. This would help to ensure the integrity of the grassed spillway. The existing spillway could be improved or a new spillway constructed at the

existing site or some other site to serve as the principal spillway. For these flood routings a new spillway with a 50-foot-wide crest at either elevation 891.75 or elevation 891.25 was assumed to be located at the existing site. This assumed spillway would provide discharge capacity similar to the existing spillway. As indicated by the rating curve shown on Exhibit 18, discharge from this spillway would not exceed the maximum safe discharge previously estimated for the outlet channel, except under exceptionally high pool conditions (lake elevation over 895.0). Thus, each flood routing shown on Exhibit 17 assumes that a principal spillway exists and that the pool level at the onset of each storm event is at the principal spillway crest elevation. The Maple Bay spillway crest was assumed at elevation 892.25 for all routings.

From the results of the flood routings shown on Exhibit 17, it can be seen that the required spillway width varies from approximately 480 to 1660 feet for corresponding maximum lake levels of about elevation 897 and elevation 896, respectively, during passage of the PMF. As also can be seen from this exhibit, lowering the principal spillway crest elevation 0.5 foot results in a fairly significant drop in the emergency spillway width required.

5.2.4 Gated Weir Spillway near Sellers Point. A gated or ungated weir spillway could be located along the dam at several locations, including the existing spillway site as proposed in the 1972 Task Force report. However, from preliminary analyses it appeared that the best overall location would be in the vicinity of the old dry dock near Sellers Point. This site was thus chosen as a representative location for a gated or ungated weir structure. This location is shown

on Exhibit 1, and Photograph 14 gives a view of the area downstream of the dry dock.

Since the mode of operation of a gated spillway determines to a great extent the capacity of the spillway, one must first establish an approximate gate size and operating schedule to properly assess the spillway capacity. Again knowing the required peak discharge capacity to be around 20,000 to 30,000 cfs, a total of 2, 4, 6, 8 or 10 forty-foot-wide taintor gates, situated on a concrete weir structure with a crest at elevation 886, were assumed to be operated under the schedules shown in Exhibit 19. Spillway rating curves were developed using these operating schedules, as shown on Exhibit 20.

Using these spillway rating curves, and again assuming a 50-foot-wide principal spillway weir structure with a crest elevation of 891.75, the design storms were routed through the lake and spillways. The results of these routings are shown on Exhibit 21, which shows the maximum lake level and corresponding peak discharge attained for each design storm event for the various spillway widths. These results indicate that the required spillway width varies from about 120 feet to 280 feet for corresponding maximum lake levels of elevation 897 and elevation 895.5, respectively, during the PMF storm event.

5.2.5 Ungated Weir Spillway near Sellers Point. As explained in the previous section, an ungated weir spillway could also be located at several locations along the dam. Similar to the ungated weir spillway scheme, though, the area of the dry dock near Sellers Point was chosen as a representative location for a gated spillway.

For this scheme, a 50-foot principal spillway, as assumed for the other schemes, would not be necessary, since the structure would be concrete and could thus handle the daily flows without erosion or maintenance problems and without the necessity of daily opening or closing any gates. Thus, for this scheme the spillway crest was assumed to be at elevation 891.75 and spillway rating curves for various length spillways were developed. These rating curves are shown on Exhibit 22.

Using these curves, the design storms were then routed through the lake and spillway. The results of these routings are shown on Exhibit 23, which indicates the maximum lake level attained and the corresponding peak discharge for the various spillway crest lengths assumed. These results indicate that the required spillway crest length varies from about 340 feet to 1420 feet for corresponding maximum lake levels of elevation 897 and elevation 895, respectively, during the PMF storm event.

Since these required crest lengths would necessitate a significant purchase and subsequent displacement of property along the dam, an attempt was made to estimate whether or not the spillway crest could extend into the lake area in a U-shaped configuration, as suggested in the 1972 Task Force report. Preliminary computations indicate this could be a viable option which might substantially reduce the amount of property required and the total cost of the structure.

5.2.6 Downstream Channel Requirements. Based on the backwater elevations computed for the South Fork Licking River, backwater profiles were estimated for outlet channels near Sellers Point and Maple Bay. These analyses indicate that water surface profiles

along a channel near Sellers Point would be controlled by flooding from the South Fork Licking River if the channel is wider than the general width of the river. Therefore to increase the outlet channel capacity near Sellers Point would also require increasing the capacity of the South Fork Licking River.

The analysis of the outlet channel size required for a spillway located near Maple Bay concentrated on estimating the minimum trapezoidal channel bottom width required for a given discharge that would not result in backwater drowning out the control section at the weir crest. Assuming 2H:1V side slopes and a Mannings "n" of 0.035 in the channel, it was estimated that the required channel bottom width varies from 50 feet for a peak discharge of 10,000 cfs to 125 feet for a peak discharge of 30,000 cfs.

From the backwater analyses of the South Fork Licking River it is obvious that significant flooding would occur in the vicinity of the dam under the spillway discharges anticipated for the PMF as well as for the lesser storm events. From Exhibits 10 and 11 the approximate peak water surface elevations near the dam for various spillway widths and corresponding peak discharges for the various spillway systems can be estimated. However, to properly estimate the water surface elevations in the South Fork Licking River, the total discharge must include the spillway discharge plus the base flow in the river, which includes the portion of flow in the feeder canal that was assumed to overtop the levee and thus bypass Buckeye Lake. From analyses of the diverted hydrographs, it is estimated that the base flow in the river from the feeder canal excess flow alone would be approximately 10,000 cfs for the PMF event, 5000 cfs for the 50% PMF event, 2500 cfs for the 25% PMF

event, and 1200 cfs for the 100 year event. Thus approximately 10,000 cfs should be added to the PMF discharges shown on the various flood routing exhibits to estimate the maximum water surface elevation near the dam for the various spillway systems studied. (Please note, however, that this estimated base flow of 10,000 cfs does not include flow entering the South Fork Licking River upstream of the Buckeye Lake watershed. For the purposes of this analysis, this additional flow was not estimated and therefore not taken into consideration). The peak discharge in the South Fork Licking River under PMF conditions would therefore vary from approximately 25,000 to 45,000 cfs, depending on the spillway system and spillway width assumed. The corresponding peak flood elevations along the downstream face of the dam would thus vary from approximately elevation 890 to elevation 895, as estimated from Exhibit 10.

5.2.7 Comparison of Various Spillway Systems. From the previous discussion, it is apparent that only three of the possible spillway systems are viable options. These are: an open-cut saddle spillway near Maple Bay or a gated or ungated weir spillway near Sellers Point. As discussed previously, the gated or ungated spillway structure could actually be located along the dam at several other locations other than near Sellers Point. However, from preliminary analyses it appeared that Sellers Point would likely be the best overall location and was thus chosen as a representative location for the gated or ungated weir structure. The cost of a weir structure at other locations along the dam would likely be similar to those estimated herein for a structure at Sellers Point.

The possibility also exists of placing a gated or ungated concrete weir spillway at the Maple Bay location, but this would add to the total costs substantially. The hydraulics of these spillways would be slightly less efficient, due to energy losses of flow through the Maple Bay area, but they would be somewhat equivalent to those computed for a similar spillway at Sellers Point.

Using the assumptions listed in previous sections, Table 1 summarizes some of the results discussed previously. The table indicates the required spillway width for a given spillway system, with the resulting peak discharge, for a specific maximum lake level attained during passage of the PMF.

Although the data shown in the exhibits and in Table 1 were computed assuming specific crest elevations for the principal and emergency spillways, as discussed previously, these data can be readily adjusted for the uncontrolled spillway systems to provide estimated maximum lake levels assuming other spillway crest elevations. (The resulting maximum lake levels for the gated spillway system are dependent on the gate operating schedule as well, and not just on the height of the spillway crest.) For example, if the crest of a saddle spillway near Maple Bay was raised to elevation 892.75 and the principal crest raised to elevation 892.25, an increase of 0.5 foot over one of the assumed conditions, the resulting maximum lake level during passage of the PMF would be about elevation 896.5 for a 1660-foot-wide spillway crest, instead of elevation 896 as shown in the table. Also, if the crest of an ungated weir spillway near Sellers Point, or some other location along the dam, were lowered to elevation 891.25, a decrease of

Table 1 - Comparison of Spillway Widths Required for Various Spillway Systems

Maximum Lake Level Attained during PMF	Spillway System							
	Saddle Spillway near Maple Bay Pr. Sp. Crest Elev. 891.25		Saddle Spillway near Maple Bay Pr. Sp. Crest Elev. 891.75		Ungated Weir Spillway near Sellers Point		Gated Weir Spillway near Sellers Point	
	Sp. Width (ft)	Peak Discharge (cfs)	Sp. Width (ft)	Peak Discharge (cfs)	Sp. Width (ft)	Peak Discharge (cfs)	Sp. Width (ft)	Peak Discharge (cfs)
895.0	---(1)	---	---(1)	---	1420	32,000	450(2)	38,000(2)
895.5	---(1)	---	---(1)	---	950	27,000	260	27,000
896.0	1280	20,000	1660	22,000	650	23,000	180	22,000
896.5	700	17,000	860	19,000	460	20,000	140	18,000
897.0	480	15,000	560	17,000	340	17,000	110	16,000

(1) - Required spillway width excessive. This maximum lake level not feasible for this spillway system for the assumed spillway crest elevations.

(2) - Extrapolated from curves shown on Exhibits.

0.5 foot, the required spillway width for a maximum lake level of elevation 896.0 would be 460 feet, not 650 feet as shown in the table.

5.2.7.1 Estimated Costs. Using the types of data adjustments discussed in the previous paragraph, different spillway widths and different spillway crest elevations were assumed for each viable spillway system and the total construction costs were estimated for each situation. The major unit construction costs assumed for each system are shown on Exhibit 24 and a summary of the total costs is shown on Table 2. In light of the flood control project plans developed by the SCS for the South Fork Licking River, as discussed in Section 4, as well as the results of the backwater analyses conducted herein, it is anticipated that widening of the South Fork Licking River will be required in vicinity of the dam, if the spillway is located near Sellers Point or some other location along the dam. Thus the total costs shown in Table 2 include an estimated cost of widening the river by approximately 50 to 75 percent.

The data shown in Table 2 are grouped together based on the maximum lake level attained during passage of the PMF. Spillway widths and crest elevations and associated estimated costs required for each of the viable spillway options are shown for maximum lake levels ranging from elevation 895.0 to elevation 896.5. These elevation limits were chosen for practical reasons: for maximum lake levels under elevation 895 the required spillway widths and consequent costs are excessive, and for maximum lake levels greater than 896.5 the increase in crest height required would likely be excessively disruptive to property owners along the dam. For a maximum lake level at elevation 895.0, only a minimal

Table 2 - Summary of Approximate Costs of Various Spillway System Studied

Case No.	Maximum Lake Level Attained During PMF/50%PMF Assuming No Overtopping	Type and Location of Principal Spillway	Principal Spillway Crest Elev./Normal Pool Elev. (1)	Type and Location of Emergency Spillway	Emergency Spillway Crest Elev.	Emergency Spillway Width Required to Pass PMF (ft)	Average Increase in Embankment Height Required (2) (ft)	Outlet Channel Width (ft)	Approximate Cost
1	895.0/894.2	50' weir @ existing spillway site	891.75	Gated weir @ Sellers Point	886.00	440	---	150	$ 6,920,000
2	895.0/893.5	Same as emergency spillway	891.25	Ungated weir @ Sellers Point	891.25	950	---	150	$ 6,625,000
3	895.0/893.7	Same as emergency spillway	891.75	Ungated weir @ Sellers Point	891.75	1420	---	150	$ 9,305,000
4	895.0/893.9	Same as emergency spillway	892.25	Ungated weir @ Sellers Point	892.25	2150	---	150	$12,325,000
5	895.5/893.7	50' weir @ existing spillway site	890.75	Open-cut saddle @ Maple Bay	891.75	1280	0	100	$ 4,845,000
6	895.5/893.8	50' weir @ existing spillway site	891.25	Open-cut saddle @ Maple Bay	891.75	1660	0	100	$ 5,050,000
7	895.5/894.3	50' weir @ existing spillway site	891.75	Gated weir @ Sellers Point	886.00	280	0	150	$ 5,560,000
8	895.5/893.8	Same as emergency spillway	891.25	Ungated weir @ Sellers Point	891.25	650	0	150	$ 5,425,000
9	895.5/894.0	Same as emergency spillway	891.75	Ungated weir @ Sellers Point	891.75	950	0	150	$ 6,825,000

Table 2 (Cont'd) - Summary of Approximate Costs of Various Spillway System Studied

Case No.	Maximum Lake Level Attained During PMF/50%PMF Assuming No Overtopping	Type and Location of Principal Spillway	Principal Spillway Crest Elev./Normal Pool Elev. (1)	Type and Location of Emergency Spillway	Emergency Spillway Crest Elev.	Emergency Spillway Width Required to Pass PMF (ft)	Average Increase in Embankment Height Required (2) (ft)	Outlet Channel Width (ft)	Approximate Cost
10	896.0/894.2	50' weir @ existing spillway site	891.25	Open-cut saddle @ Maple Bay	891.75	860	0.5	75	$ 4,310,000
11	896.0/894.2	50' weir @ existing spillway site	891.25	Open-cut saddle @ Maple Bay	892.25	1280	0.5	100	$ 4,885,000
12	896.0/894.3	50' weir @ existing spillway site	891.75	Open-cut saddle @ Maple Bay	892.25	1660	0.5	100	$ 5,075,000
13	896.0/894.4	50' weir @ existing spillway site	891.75	Gated weir @ Sellers Point	886.00	200	0.5	150	$ 4,980,000
14	896.0/894.1	Same as emergency spillway	891.25	Ungated weir @ Sellers Point	891.25	460	0.5	150	$ 4,615,000
15	896.0/894.3	Same as emergency spillway	891.75	Ungated weir @ Sellers Point	891.75	650	0.5	150	$ 5,525,000
16	896.0/894.5	Same as emergency spillway	892.25	Ungated weir @ Sellers Point	892.25	950	0.5	150	$ 6,925,000

Table 2 (Cont'd) - Summary of Approximate Costs of Various Spillway System Studied

Case No.	Maximum Lake Level Attained During PMF/50%PMF Assuming No Overtopping	Type and Location of Principal Spillway	Principal Spillway Crest Elev./Normal Pool Elev. (1)	Type and Location of Emergency Spillway	Emergency Spillway Crest Elev.	Emergency Spillway Width Required to Pass PMF (ft)	Average Increase in Embankment Height Required (2) (ft)	Outlet Channel Width (ft)	Approximate Cost
17	896.5/894.6	50' weir @ existing spillway site	891.25	Open-cut saddle @ Maple Bay	892.25	700	1.0	75	$ 4,240,000
18	896.5/894.6	50' weir @ existing spillway site	891.75	Open-cut saddle @ Maple Bay	892.25	860	1.0	75	$ 4,320,000
19	896.5/894.7	50' weir @ existing spillway site	891.75	Open-cut saddle @ Maple Bay	892.75	1280	1.0	100	$ 4,890,000
20	896.5/894.8	50' weir @ existing spillway site	892.25	Open-cut saddle @ Maple Bay	892.75	1660	1.0	100	$ 5,070,000
21	896.5/894.5	50' weir @ existing spillway site	891.75	Gated weir @ Sellers Point	886.00	160	1.0	150	$ 4,705,000
22	896.5/894.4	Same as emergency spillway	891.25	Ungated weir @ Sellers Point	891.25	340	1.0	150	$ 4,175,000
23	896.5/894.6	Same as emergency spillway	891.75	Ungated weir @ Sellers Point	891.75	460	1.0	150	$ 4,655,000
24	896.5/894.8	Same as emergency spillway	892.25	Ungated weir @ Sellers Point	892.25	650	1.0	150	$ 5,565,000

(1) Note: Normal pool currently maintained at approximately elev. 891.75 by operation of gates. Top of flashboards at elev. 892.25.

(2) Assumes average top of dam elevation is 895.5.

amount of work and subsequent disruption to property owners along the dam would be required to bring the entire crest to at least this elevation. However, maximum lake levels greater than elevation 896.5 would require increases in the crest height by two or more feet in some areas.

As noted in Section 5.25, an ungated weir structure could possibly be constructed in a U-shaped configuration which might reduce the amount of property required and the overall cost of the structure. Therefore, the estimated costs for an ungated weir structure assume the spillway would be constructed as such.

Although the cost estimates shown in Table 2 are very approximate, they can be used to indicate various trends in the overall cost of the spillway systems. One trend is that, in general, the lower the desired maximum lake level the higher the total estimated costs are. This is because the increased spillway widths required for lower maximum lake levels are substantially more expensive than the estimated costs for increasing the embankment height by either adding additional earth fill or constructing a concrete parapet wall along the crest.

Second, the options associated with an open-cut saddle spillway at Maple Bay are more limited than those for the other systems. Excessively wide spillway crests would be required to provide a maximum lake level lower than elevation 896, if the current normal pool level (elev. 891.75) is maintained. A maximum lake level less than 896.0 would be possible if the normal pool level and emergency spillway crest were lowered accordingly (i.e. if the spillway crests were lowered 0.5 foot, the maximum lake level would be lowered about 0.5 foot for a similar width spillway).

Third, a gated weir spillway near Sellers Point generally appears to be the most economical system for comparable normal pool and maximum lake level elevations. However, the required spillway width for this system, and subsequent costs, are generally dependent on the gate operating schedule assumed. If a gate operating schedule different from that assumed herein is used, these results could change significantly.

5.2.7.2 Advantages/Disadvantages of Various Spillway Systems. As another means of evaluating the various spillway systems studied, several relative advantages and disadvantages of each system are summarized below.

5.2.7.2.1 Open-cut Saddle at Maple Bay.

Advantages

1. Earth spillway requires little routine or costly maintenance.
2. No houses displaced for construction of spillway.
3. Discharge from spillway will not significantly affect flooding near community of Buckeye Lake for lesser floods.

Disadvantages

1. Erosion in outlet channel may occur during major floods, requiring some repairs.
2. I-70 and county road traffic disrupted during construction of bridges.
3. Farming practices disrupted and some farmland taken.
4. Maintenance and repairs required for bridges.
5. If current normal pool level is maintained, maximum pool level will be elev. 896.0 or greater.

5.2.7.2.2 Ungated weir near Sellers Point.

Advantages

1. Maintenance costs less than for gated weir.
2. No additional principal spillway structure required. Therefore, no need to maintain two structures.
3. No disruption of I-70 traffic.

Disadvantages

1. Some houses required to be displaced.
2. Discharge may add to flooding problems near community of Buckeye Lake.
3. Traffic disrupted near dam.
4. Pedestrian traffic along dam crest disrupted unless bridge over spillway provided.
5. Maintenance and repairs required for bridge.
6. Channel improvements required for South Fork Licking River.

5.2.7.2.3 Gated weir near Sellers Point.

Advantages

1. No disruption of I-70 traffic.
2. Principal spillway structure could be part of gated structure. Therefore, no need to maintain two structures.

Disadvantages

1. Operation and maintenance costs high.
2. Skilled operator and maintenance workers required.
3. Some houses required to be displaced.
4. Discharge may add to flooding problems near community of Buckeye Lake.
5. Traffic disrupted near dam.
6. Maintenance and repairs required for bridge.

7. Channel improvements required for South Fork Licking River.

5.3 Conclusions and Recommendations

From analyses discussed herein, it is apparent that only three spillway systems are viable options for Buckeye Lake. These are: an open-cut saddle spillway situated north of Maple Bay and outletting to the South Fork Licking River via a new outlet channel that would pass under I-70; or a gated or ungated weir spillway located near Sellers Point or some other location along the dam.

In light of the various advantages and disadvantages of each spillway system discussed in the previous section, it is recommended that a U-shaped, concrete gravity ungated weir spillway be constructed near Sellers Point, in the vicinity of the old dry dock. As discussed previously, this spillway system would not require skilled operators or maintenance workers, and the overall maintenance required would be less than that for a gated weir structure. Although the traffic near the dam would be disrupted, it could easily be rerouted during construction. No disruption of I-70 traffic would be required, as would be the case for a spillway located near Maple Bay. Also, no additional principal or service spillway would be necessary, as the service and emergency spillways would be combined in one structure. Thus there would be no need to maintain two larger structures.

Since a principal spillway structure would no longer be required, it is also recommended that the current spillway structure be removed or incorporated within a new segment of earthfill embankment in that area. However, to continue to provide drainage and fresh water augmentation to

the current outlet channel, some type of gated outlet should be provided at this site.

Also, since discharge from Buckeye Lake would enter the South Fork Licking River near the area where current flooding problems exist, channel improvements should be made to the South Fork Licking River below the proposed lake outlet channel. These improvements should be coordinated with the overall basin flood control project proposed by the SCS and the South Licking River Watershed Conservancy District, which was discussed in Section 4. Without this type of coordination, the proposed spillway improvements at Buckeye Lake may adversely affect or negate some of the proposals of the basin flood control project.

As shown in Table 2, Case 23, the estimated cost of this spillway, outlet channel, bridge and the associated improvements to the embankment and the South Fork Licking River is approximately $4,655,000.

These recommendations are also discussed in Section 7, as well as additional recommendations based on the results of the embankment stability and seepage study, which is discussed in the following section.

6.0 EMBANKMENT STABILITY AND SEEPAGE STUDY

6.1 Study Procedures

The purpose of the embankment stability and seepage study was to determine the various soil profile components of the dam embankment and underlying foundation soils, together with the strength and other engineering characteristics of these soils, and to evaluate these data with respect to the general stability of the embankment and seepage patterns through the dam.

6.1.1 Soil Boring and Sampling Program. The soil borings were made by means of a truck mounted rotary type drill rig and were performed between January 9, 1986, and January 16, 1986.

The initial intent of the soil boring program was to procure three borings at each of four areas reported by Mr. Ken Vesselen, the park manager, to have experienced significant seepage under higher pool conditions. The general locations of these seepage areas, indicated as Sections 1, 2, 3, and 4, are shown on Exhibit 1. Borings were originally planned to be taken at the top of the upstream slope, at the top of the downstream slope, and at the toe of the downstream slope. However, because of various obstructions along the dam and also due to the fact that right of entry on to private property could not be obtained in several instances, the boring program had to be modified somewhat.

At Section 1, access to the boring locations was not possible and thus no borings were procured at this section. At Section 2, only two borings were procured as access to one of the borings at the top of the dam was not available. At Section 3, permission to drill on the property where the seepage was reported could not be obtained. Only one boring at the top of the upstream slope could be drilled near this property so three additional borings were drilled along the fire lane about 100 feet west. At Section 4, three borings were procured along one section and a additional boring was procured at the top of the dam about 50 feet west, in the area referred to as Black Diamond Point. The relative locations of all the borings are shown on Exhibits 25, 26 and 27.

Observation wells were set in all of the bore holes at completion of drilling. The observation wells consisted of one-inch hand-slotted schedule 20 PVC pipe backfilled with pea gravel.

Split spoon sampling was performed continuously in 1.5 foot increments for the total depth of the boring. Standard penetration data were developed and one or more representative samples were preserved from each sampling increment. Ten thin wall "undisturbed" samples were obtained of representative samples of both the dam embankment and foundation soils for shear strength testing by hydraulically pressing 3.0-inch outside diameter thin wall tubes.

6.1.2 Laboratory Testing Program. All samples were examined and visually classified by a soils engineer in the laboratory. Moisture contents of all fine-grained soil samples were determined. A limited number of samples were considered representative of the materials encountered and were selected for performance of general engineering index tests (grain size analysis and plasticity characteristics).

Seven "undisturbed" press samples were selected to determine the shear strength of the dam embankment and foundation soils by means of triaxial testing (consolidated - undrained, with pore water pressure measurements). The results of the shear strength testing are presented in Appendix III.

6.2 Investigational Findings

Historical records report that the dam embankment was constructed as a homogenous earthfill structure, with mule-drawn wagons being used to transport fill material for the dam. The embankment reportedly

failed in 1832, shortly after the lake was filled, in the vicinity of the "Black Diamond" wreck site and was repaired with ten thousand wagon loads of coarse stone.

Internal drainage was not provided in the embankment, probably because concepts of phreatic surface or seepage through soils were not well understood at that time. A cutoff trench was not constructed either beneath the embankment through the underlying organic and lacustrine deposits as a positive seepage barrier.

A masonry stone wall was placed directly against the earthfill embankment for slope protection on the upstream side of the dam. Because of deterioration to the store masonry wall, a sheet pile wall was later added in front of the stone masonry wall over most of the length of the dam for shoreline protection and to restrict seepage through the embankment.

Generalized geologic bulletins report the dam site to lie on a post-glacial swamp. The underlying soils consist of lacustrine type deposits, silt and clay commonly laminated and interbedded with sand, and sand and gravel layers. These deposits in turn overlie glacial till. Bedrock underlying the site is reported at depths in excess of 100 feet and to be of the Mississippian age, Waverly or Maxville Group, sandstones, limestones, and shales.

6.2.1 Section 2 (Boring Nos. 7 and 8). Two borings were taken at this section, one at the top of the dam between the old masonry wall and the sidewalk, and one at the toe of the downstream slope. In this area a relatively new sheet pile wall has been constructed in front of the old stone masonry wall.

6.2.1.1 Generalized Soil Profile at Section 2. Dam embankment fill was encountered to a depth of 9.6 feet. The fill was comprised primarily of fine grained silt and clay mixtures with varying percentages of sand and gravel and was organically contaminated in the upper four feet. The borings disclosed the embankment fill to be fairly well compacted and to be of a stiff consistency.

The foundation soils immediately underlying the embankment fill are comprised primarily of organically contaminated silts and clays. The thickness of this layer was about 2.0 feet. The consistency of these deposits was medium stiff.

Lacustrine type deposits, generally laminated, were encountered underlying the organically contaminated silty clay and silt layer. The consistency of these deposits was generally medium stiff to stiff. Several wet, fine sand and/or silt streaks and seams were encountered within these deposits.

Glacial till deposits were encountered at a depth of 18.3 feet in Boring No. 8, which is located at the top of the dam. These deposits were indicated to be damp and very stiff. Boring No. 7, located at the toe of the slope, did not penetrate deeply enough to encounter these deposits.

6.2.1.2 Groundwater Conditions at Section 2. Water seepage was encountered in the borings at various depths, but it was found generally in the underlying soils below the embankment fill. A trace of water seepage was encountered in the embankment fill at Boring No. 8.

The water levels were measured in the observation wells after the water levels had stabilized. The water level measured in the observation wells was 4 to 5 feet below the pool level, at the time of the readings, indicating some loss of hydraulic head through the sheet pile wall and embankment. The level of the water in the observation wells generally coincided with the level of the top of the underlying foundation soils, suggesting that most of the seepage is occurring through the foundation soils in this area and not through the embankment.

A site plan showing the locations of the borings and a generalized soil section are shown on Exhibit 25 in Appendix I. Logs of the borings are presented in Appendix III.

6.2.2 Section 3 (Boring Nos. 1, 2, 2A, and 3). Based on discussions with the property owners in the area of Section 3 and from observations made at the site at the time of drilling, it appears that a sheet pile wall was recently installed approximately 10 to 13 feet in front of the old masonry wall, and 3 to 4 feet in front of an older deteriorated sheet pile wall from Station 103 + 50 and eastward. In this area it is understood that the old masonry wall was broken down and the material from this wall placed between the old masonry wall and the sheet pile walls. Boring Nos. 2 and 2A were located in this area between the old masonry wall and the sheet pile walls.

6.2.2.1 Generalized Soil Profile at Section 3. Dam embankment fill was encountered to a depth of 9.1 to 10.8 feet in the borings located on top of the dam. Fill was encountered to a depth of

7.0 feet in Boring No. 1, which is located on the downstream slope in the fire lane. The borings indicated the embankment fill was comprised primarily of fine grained, silt and clay mixtures, with varying percentages of sand and gravel, and was partially organically contaminated. The fill encountered in Boring Nos. 2 and 2A, located between the old masonry retaining wall and the new sheet pile wall, was soft to medium stiff, indicating the fill was probably loosely placed and not adequately compacted. The fill encountered in Boring No. 3, located in the original embankment, was stiff to very stiff. Sand streaks or seams were encountered near the bottom of the embankment fill in all three of the borings taken through the embankment. In both Boring Nos. 2 and 2A, refusal was encountered at a depth of 8.5 to 9.0 feet, on what is probably concrete or stone from the old masonry wall.

The foundation soils immediately underlying the embankment fill are comprised primarily of organically contaminated silts and clays. The thickness of this zone ranges from 1 to 3 feet. These deposits are indicated to be of a medium stiff to stiff consistency and to be moist to wet.

Silty clay and silt lacustrine type deposits, generally laminated, were encountered underlying this organically contaminated layer. The consistency of these deposits was generally medium stiff. Wet fine sand streaks and seams were also encountered within these deposits in two of the borings.

6.2.2.2 Groundwater Conditions at Section 3. Water seepage was encountered at various depths in all of the borings, but the seepage was generally encountered at or below the interface between the embankment fill and underlying soils. One exception to this was Boring

No. 2A, located in an area of reported severe seepage under higher pool conditions, in which water seepage was encountered in the fine sand streaks and seams in the embankment fill.

The water levels were measured in the observation wells after the water levels had stabilized. The water level in Boring No. 2, located at the top of the upstream slope, was measured at 3± feet below the water level in the pool. The water level in Boring No. 3 and Boring No. 1, located at the top and toe of the downstream slope, respectively, was measured at 5 to 6 feet below the pool level. These measurements indicate that there is some loss of hydraulic head through the sheet pile wall and further loss in head through the earthfill dam embankment.

At Boring No. 2A, there was only a one foot difference in the water level measured at the boring from that in the pool. This would indicate that seepage is probably occurring through the embankment in the sand seam encountered at a depth of 6.5 to 6.8 feet.

A site plan showing the locations of the borings and a generalized soil section are also shown on Exhibit 26 in Appendix I. Logs of the borings are presented in Appendix III.

6.2.3 Section 4 (Boring Nos. 4, 4A, 5, and 6). This section is located in the area of the dam which is referred to as "Black Diamond Point". Because of access problems, only one boring (Boring No. 4A) was procured at the top of the embankment in the immediate area of reported severe seepage during higher pool conditions. Three borings (Boring Nos. 4, 5, and 6) were thus also taken along a section approximately 50 feet to the east of Boring No. 4A.

A relatively new sheet pile wall has been constructed in this area in front of the old stone masonry wall.

6.2.3.1 Generalized Soil Profile at Section 4. Embankment fill was encountered to a depth of 9.0 to 10.0 feet in the borings located on top of the dam. The borings indicated the embankment fill was comprised primarily of fine grained, silt and clay mixtures, with varying percentages of sand and gravel and for the most part organically contaminated. The borings disclosed the fill to be fairly well compacted and to be of a stiff consistency. Sandstone fragments and concrete, probably from the old masonry wall, were encountered at a depth of 5.3 feet to 6.2 feet in Boring No. 4A. No sand streaks or seams were encountered in any of the borings.

The foundation soils immediately underlying the embankment fill are comprised primarily of organically contaminated silts and clays. The thickness of this layer ranges from 1 to 5 feet. These deposits are indicated to be moist and of a medium stiff to stiff consistency.

Silty clay and silt lacustrine-type deposits, generally laminated, were encountered underlying the organically contaminated layer. The consistency of these deposits ranged from soft to stiff. Wet fine sand and/or silt seams were also encountered within these deposits.

6.2.3.2 Groundwater Conditions at Section 4. Water seepage was encountered in all of the borings at various depths. With the exception of Boring No. 4A, the water seepage was encountered in the foundation soils below the embankment fill. The water seepage in Boring No. 4A was encountered at a depth of 6.2 feet.

The water levels were measured in the observation wells after the water levels had stabilized. The water level in Boring No. 4, located at the top of the upstream slope, was measured at 3± feet below the water level in the pool at the time of the readings. The water level in Boring Nos. 5 and 6 were 5 to 7 feet below the pool level. These measurements indicate that there is some loss of hydraulic head through the sheet pile wall and embankment.

At Boring No. 4A, located at "Black Diamond Point", the water level in the well was the same as the pool level. This would appear to indicate that seepage is occurring through the dam at that location, although there were no noticeable "wet" areas on the downstream side of the embankment.

A site plan showing the locations of the borings and a generalized soil section are shown on Exhibit 27 in Appendix I. Logs of the borings are presented in Appendix III.

6.3 Discussion of Results

6.3.1 Stability Analysis. Because of the manner in which Buckeye Lake Dam was constructed and because of the subsequent development of the houses along the downstream slope of the embankment, no "typical" cross section of the dam exists. The height, width, and downstream slope of the dam varies along the length of the dam, and the extent to which the various property owners have cut into the downstream slope of the dam, in order to construct the residences or other structures, varies from house to house.

However, for purposes of a stability analysis, three sections in the areas of reported seepage were analyzed and assumed to be fairly

representative of the most critical conditions from a stability standpoint. It should be noted, though, that more severe conditions may or may not exist elsewhere along the dam. However, it was not considered to be either practically or economically feasible to investigate the entire length of the dam.

The stability of the embankment was analyzed using the STABL2 computer program developed by Purdue University for general slope stability problems. Factors of safety were computed at the three sections assuming the following conditions:

1. Normal summer pool at elevation 892.0, under steady seepage conditions.
2. Maximum pool, assuming the pool elevation to be at the approximate top of the existing dam, elevation 895±, and under steady seepage conditions.
3. Maximum pool at elevation 897±, under steady seepage conditions and with the tailwater at elevation 890±.

   This condition has been analyzed as one of the measures discussed previously in Section 5.0 for handling the PMF, and involves raising the height of the dam to elevation 897± for increased temporary pool storage.

Conditions 2 and 3 have been analyzed assuming steady seepage conditions. This is a conservative assumption, however, as the pool levels assumed for these conditions would occur only during storm events and the maximum pool would only be maintained for a short period of time, say less than 24 hours. Therefore, steady seepage conditions under these higher pool levels would not likely have time to fully

develop and the phreatic surface through the dam would more closely approximate that for normal pool conditions.

Table 3 shows the soil parameters used in the stability analysis, and Table 4 presents the factors of safety computed for the various assumed conditions.

6.3.2 Seepage. During the course of this investigation, no significant seepage was noted. This is possibly due to the fact that the pool level was at or below the normal pool level when the embankment was investigated.

In those areas of reported significant seepage under higher pool conditions, the condition of the dam and upstream slope protection was inspected for any holes, deteriorated sheet piling, and large trees or structures that may have contributed to the seepage and that may have an effect on the integrity of the embankment. With the possible exception of root holes from existing trees, or from the past removal of trees, there was no visible evidence of other contributing factors to the reported seepage. It is understood that the deteriorated sheet pile wall with large tie-back-holes which was previously reported as a potential source of the seepage has either been replaced or repaired. At several locations, however, the handling holes at the tops of some of the older sheet pile walls were not covered, allowing some minor erosion to occur at the back of the walls due to wave action.

The data developed from the borings and observation wells generally indicate that the majority of the seepage is occurring through the foundation soils and not through the embankment, and that there is some hydraulic head loss through the sheet pile wall and embankment under

Table 3 - Soil Parameters used in Stability Analysis

Soil Parameters	Section 2		Section 3		Section 4	
	Embankment	Foundation	Embankment	Foundation	Embankment	Foundation
Saturated unit weight (pcf)	125	125	125	125	125	125
Effective angle of internal friction (0)	33	30	25	30	25	30
Effective cohesion (psf)	0	0	300	0	300	0

Table 4 - Computed Factors of Safety

Condition	Section 2	Section 3	Section 4
1. Normal summer pool at elevation 892.0, under steady seepage conditions.	1.35	1.82	1.79
2. Maximum pool, assuming pool elevation to be at the approximate top of existing dam, elevation 895±. Steady seepage with no tailwater.	1.03	1.68	1.57
3. Dam height increased to elevation 897± to handle PMF with tailwater at elevation 890±. Steady seepage conditions assumed.	1.10	1.60	1.29

lower pool conditions. All water level readings made in the monitoring wells to date have been for conditions lower than normal summer pool conditions. Additional water level readings will be taken once the level of the lake is at summer pool elevation 892.0±. The water level readings taken to date in the observation wells are listed in Exhibit 28, and cross-sections showing the relative location of the water level readings are given in Exhibit 29.

The water level readings in the two observation wells set in the supplemental Boring Nos. 2A and 4A, located as close as possible to the areas of reported significant seepage, indicated little hydraulic head loss in these areas. These borings also encountered permeable seams within the embankment.

Due to the fact that the dam was constructed without any internal drainage or cutoff under the dam for seepage control, it is inevitable that some seepage will occur at the downstream toe of the dam during higher pool levels. The present sheet pile wall installed along most of the dam is considered to act as a partial cutoff and it is understood that this wall has greatly reduced seepage through the dam.

Based on the data developed from this investigation and from discussions with various homeowners and Mr. Ken Vesselen, the park manager, this seepage at the downstream toe of the dam is minimal when the summer pool is kept at elevation 891.75. However, when the pool elevation is raised by only six inches to the top of the spillway flashboards, this seepage becomes more significant at certain locations. These locations were studied in this investigation.

Boring No. 2A at Section 3 and Boring No. 4A at Section 4 encountered streaks or seams of more permeable fine sand or other

seepage paths within the embankment fill which, most likely, contribute to the seepage through the dam observed in these locations. Although the sheet pile wall may help retard the seepage through the dam, it is not considered to be an impermeable barrier for complete cut off of seepage.

Seepage through the dam under normal summer pool conditions, elevation 892±, is not considered to be severe enough to affect the integrity of the dam, although it apparently is a nuisance to several homeowners. Raising the pool level much higher than elevation 892± for an extended period of time, such as to elevation 895±, will, however, present more severe seepage problems for the following reasons:

1. Within the upper 2 to 3 feet of the top of the dam, homeowners have installed various tile drains, electrical conduits, patio and boat dock foundations, etc. (See photographs 1 through 6). All of these, together with the various trees planted on the top of the dam, will provide various conduits for the water to seep through the dam.
2. If the pool is maintained at this higher elevation and steady seepage conditions do occur, the theoretical phreatic surface is indicated to intersect the downstream slope some distance up from the toe of the slope. As there is no internal drainage for seepage control, these high pore pressures could eventually lead to some shallow embankment failures at the downstream slope and possibly piping through the dam, which could possibly cause the dam to fail.

6.4 Conclusions and Recommendations

6.4.1 Stability of the Embankment. Based on the results of the stability analysis, the embankment is considered to be stable under normal summer pool conditions (elevation 892±). The factors of safety obtained from the stability analysis performed on the downstream slope for normal summer pool conditions range from 1.35 to 1.82.

If maximum pool conditions (elevation 895± or 897±) are maintained for only a short period of time, say 24 hours or less, the dam embankment is still considered to be stable. However, if the pool is maintained at these higher elevations for an extended period of time and steady seepage conditions develop, the dam embankment in certain areas is considered to be only marginally stable. The factors of safety obtained from the stability analysis performed on the downstream slope for the maximum pool under such steady seepage conditions ranged from 1.03 to 1.68.

The stability analysis does not take into account the effect of the basement walls of houses cut into the downstream slope of the dam. These walls are considered to act as retaining walls and, if it can be assumed that these basement walls are presently structurally sound and have proper drainage back of the walls to prevent a buildup of hydrostatic pressure, failure of these walls is not anticipated.

Because of the many and varied factors that may contribute to the stability or instability of the embankment, a simple stability analysis incorporating all these factors is not possible. However, based on the results of the stability analysis and other visual observations made at the dam, the overall embankment is considered to be stable under normal

pool conditions and should remain stable if the level of the pool is raised temporarily to elevation 895 to 897 to pass the PMF.

No stability analysis was performed on the upstream side of the dam. In the areas where the sheet pile wall has been added, it was assumed that the wall has been designed to ensure stability. However, several home owners have installed structures along the top of the dam that cantilever out over the sheet pile wall, such as boat docks, boat hoists, etc. (See Photographs 1 through 6). Unless the sheet pile wall has been designed to withstand these additional forces, failure of the wall may occur. In those areas where no sheet piling has been added in front of the stone masonry wall, wave action has undermined and eroded the soil immediately behind the wall in several areas.

It is thus recommended that a sheet pile wall be constructed in front of the old stone masonry wall along the remainder of the dam that does not already have a sheet pile wall. It is understood that the old stone masonry wall requires constant maintenance. A permanent sheet pile wall would eliminate this maintenance, provide erosion protection, and act as a partial cutoff of seepage through the dam. If the height of the dam is raised, the top of the new sheet pile wall should be set at the new top of the dam elevation.

6.4.2 Seepage. Although the dam embankment may be considered as being fairly homogenous, several streaks or seams of sand and the remains of an old masonry wall were encountered by some of the borings. The dam was not constructed with any internal drainage system and, though the present sheet pile wall may act as a partial cutoff, no cutoff trench was constructed under the dam. Seepage at the downstream

slope is therefore considered to be inevitable under higher pool conditions. This seepage condition has been alleviated somewhat by the sheet pile wall and by the fact that many of the homeowners have installed drain tile around their basements and in their yards at the downstream slope to intercept and drain off the seepage.

If the lake level is maintained at the present summer pool level (elevation 892±), seepage through the dam is not considered to adversely affect the integrity of the dam, although it is understood that a few of the homeowners do still experience some seepage on their property at the downstream toe of the dam. If it is considered necessary to alleviate the seepage in these areas, consideration should be given to either the construction of a cutoff wall, such as a bentonite slurry wall, through the embankment and some distance into the underlying foundation soils, or to the placement of a toe drain at the toe of the downstream slope of the embankment to intercept the seepage. The seepage could then be pumped back into the lake or drained away from the embankment by means of a collector drain. Because of all the construction by the homeowners both at the top and the toe of the dam, neither of these proposed remedies will be easily achieved.

If the normal pool level is raised much above elevation 892.0±, seepage through the dam may be significant and may possibly affect the integrity of the dam. Thus, if the normal pool level is raised, precautions should be taken to control the seepage either on an emergency basis and/or by installing a more permanent cutoff along the top of the dam to intercept and prevent the flow of water through the various seepage paths (tile drains, root holes, electrical

installations, etc.). However, it is recommended that the normal pool level be maintained at the current normal pool level, elevation 892±.

Even if the current normal pool level is maintained, it is recommended that all drain pipes located on top of the dam presently being used to drain water from the crest of the dam into the lake be removed. These drain pipes are generally 3 to 4 feet below the existing crest of the dam and outlet through the sheet pile wall into the lake. If a parapet wall is added along the dam and the pool level raises to above the top of the existing dam during passage of a major flood, such as the PMF, water will flow through these drains and outlet at the top of the dam. Any tile drainage from the top of the dam presently draining into the lake should thus be diverted to flow towards the downstream slope.

Regardless of the normal pool level maintained, it is also recommended that concrete sand be stockpiled at four or five readily accessible locations and suitable equipment be available to handle the sand for control of seepage on an emergency basis. The embankment should be systematically monitored for seepage increases at all times, especially at times when the pool level rises above the normal summer pool level during passage of significant floods.

Removal of all trees from the crest of the dam, although generally considered to be sound engineering practice, is not necessarily recommended at Buckeye Lake. Because of the large size of many of the trees and depth of the root systems, removal of all the trees and repair of the large holes caused by this tree removal would possibly cause more problems than if the trees were left in place. It is recommended that only the smaller trees be removed and that any seepage problems, such as

seepage through the decayed root system, should be acted on an individual basis if and when they occur. The major danger in not removing the larger trees is the potential for significant structural damage to the dam should one of the larger trees be uprooted during a storm, leaving a large hole in the dam. If this should occur, it is proposed that the dam be repaired on an emergency basis by filling the hole with concrete sand. It is also recommended that the state prohibit the planting of any additional trees on the dam.

7.0 GENERAL CONCLUSIONS AND RECOMMENDATIONS

From the spillway capacity study it is apparent that the existing spillway structure is inadequate and that only the following three spillway systems are viable options for increasing the spillway capacity at Buckeye Lake to meet current state design standards: an open-cut saddle spillway situated north of Maple Bay and outletting to the South Fork Licking River via a new outlet channel; or a gated or ungated weir spillway located near Sellers Point or some other location along the dam. Of these three options, an ungated weir spillway located near Sellers Point appears to be the most viable. This spillway system would not require any disruption to I-70 traffic during construction and would not require skilled operators and maintenance workers or excessive maintenance.

From this study it is also apparent that, to maintain the current normal pool level and to reduce the spillway length required and the associated costs, the embankment height should be increased slightly by adding additional earth fill or a concrete parapet wall along the crest of the embankment. A new spillway structure would also require the

excavation of a new outlet channel to the South Fork Licking River. Some channel improvements to the South Fork Licking River below the outlet channel would also be required.

Since the existing spillway is about 75 years old and would require extensive rehabilitation to remain operational, and since a principal spillway would no longer be required if an ungated weir spillway is constructed near Sellers Point, the existing spillway structure should be removed or rendered inoperative by incorporating it within a new segment of an earthfill embankment in that area. However, to continue to provide drainage and fresh water augmentation to the current outlet channel, some type of gated outlet should be provided at this site.

From the study of the seepage and stability of the embankment it appears that the embankment is stable under existing normal pool conditions and would also remain stable under higher pool conditions expected during passage of the design flood, the probable maximum flood. The addition of more fill or a parapet wall to increase the height of the embankment would not adversely affect the stability of the structure under high pool conditions if the current normal pool conditions are maintained.

Since the embankment appears to have been constructed without an internal drainage system, it is inevitable that seepage through or under the dam will occur at the downstream toe under higher pool conditions. Although this condition can become a nuisance to property owners along the downstream slope of the embankment, it does not appear likely to affect the integrity of the embankment. Thus the seepage problems should be addressed on a case-by-case basis and either a slurry cutoff wall or a toe drain added in the seepage areas if it is considered

necessary to alleviate the seepage problem. Nevertheless, concrete sand should be stockpiled at several convenient locations and suitable equipment kept available to be used to control seepage on an emergency basis. The embankment should be regularly monitored for seepage increases, especially when the pool level exceeds the normal pool level.

The masonry upstream slope protection wall is deteriorating in some locations and should be replaced by constructing a sheet pile wall in front of the old masonry wall as has been done along other segments of the embankment. The top of this new wall should be set at the height required to safely pass the PMF.

Although the removal of all trees from a dam is generally considered to be sound engineering practice, it is not recommended for the embankment at Buckeye Lake. Because of the large size of many of the trees and the associated depth of the root systems, removal of the larger trees could be difficult and costly and may cause additional problems. The smaller trees should be removed, however, and no additional trees permitted to be planted in the future.

Based on the results of this study the following recommendations are made:

1. A U-shaped, concrete gravity ungated weir structure should be constructed in the vicinity of the old dry dock located near Sellers Point. The weir should have a crest length of 460 feet at elevation 891.75. The normal pool would thus be maintained at the current normal pool level. A new outlet channel to the South Fork Licking River will be required as well as a bridge over the outlet channel just below the dam. The estimated cost of this spillway, outlet, channel, bridge,

and associated improvements to the embankment and the South Fork Licking River as described in the subsequent recommendations is approximately $4,655,000.

2. The existing spillway structure should be removed or rendered inoperative and earthfill should be compacted along the upstream and downstream portions of the structure to incorporate the structure into a new segment of the embankment in that area. Some type of gated outlet should be provided at this site, however, to provide drainage and fresh water augmentation to the current outlet channel.
3. Channel improvements should be made to the South Fork Licking River below the new outlet channel. These improvements should be coordinated with the basin flood control project proposed by the SCS and the South Licking River Watershed Conservancy District.
4. A concrete parapet wall should be added along the crest of the embankment where needed to raise the embankment height to elevation 896.5.
5. A sheet pile wall should be added in front of the old masonry wall where no sheet pile wall currently exists. The top of the new sheet pile wall should also be set at elevation 896.5.
6. All trees less than 4-6 inches in diameter should be removed from the embankment, and the state should prohibit the planting of any additional trees on the embankment in the future.
7. The state should require permits for the construction of future docks, building, etc, along the embankment. All proposed construction should be carefully assessed in light of how it

would affect the structural integrity of the embankment.

8. All drain pipes located on the top of the dam presently being used to drain water from the crest of the dam into the lake should be removed. The flow from these drains should be diverted to the downstream slope. All holes or openings (drain holes, handling holes, etc.) in the slope protection wall should be adequately covered.
9. Seepage through the embankment and foundation should be addressed as necessary on a case-by-case basis by constructing a slurry cutoff wall or a toe drain in the immediate seepage area. If the current normal pool level is maintained, as recommended above, the integrity of the dam is not considered to be adversely affected by the degree of seepage currently evident. Nevertheless, the embankment should be regularly monitored for seepage increases, especially when the pool level exceeds the normal pool level.
10. Concrete sand should be stockpiled at four or five readily accessible locations and suitable equipment should be kept available to help control seepage on an emergency basis.

Following a review of the preliminary submittal of this report, the ODNR generally concurred with the recommendations given above and requested that additional work be done to develop in more detail various recommendations concerning the construction of a new spillway and outlet channel and the raising of the effective embankment height. Additional soil borings were thus taken within the lake area at Sellers Point and

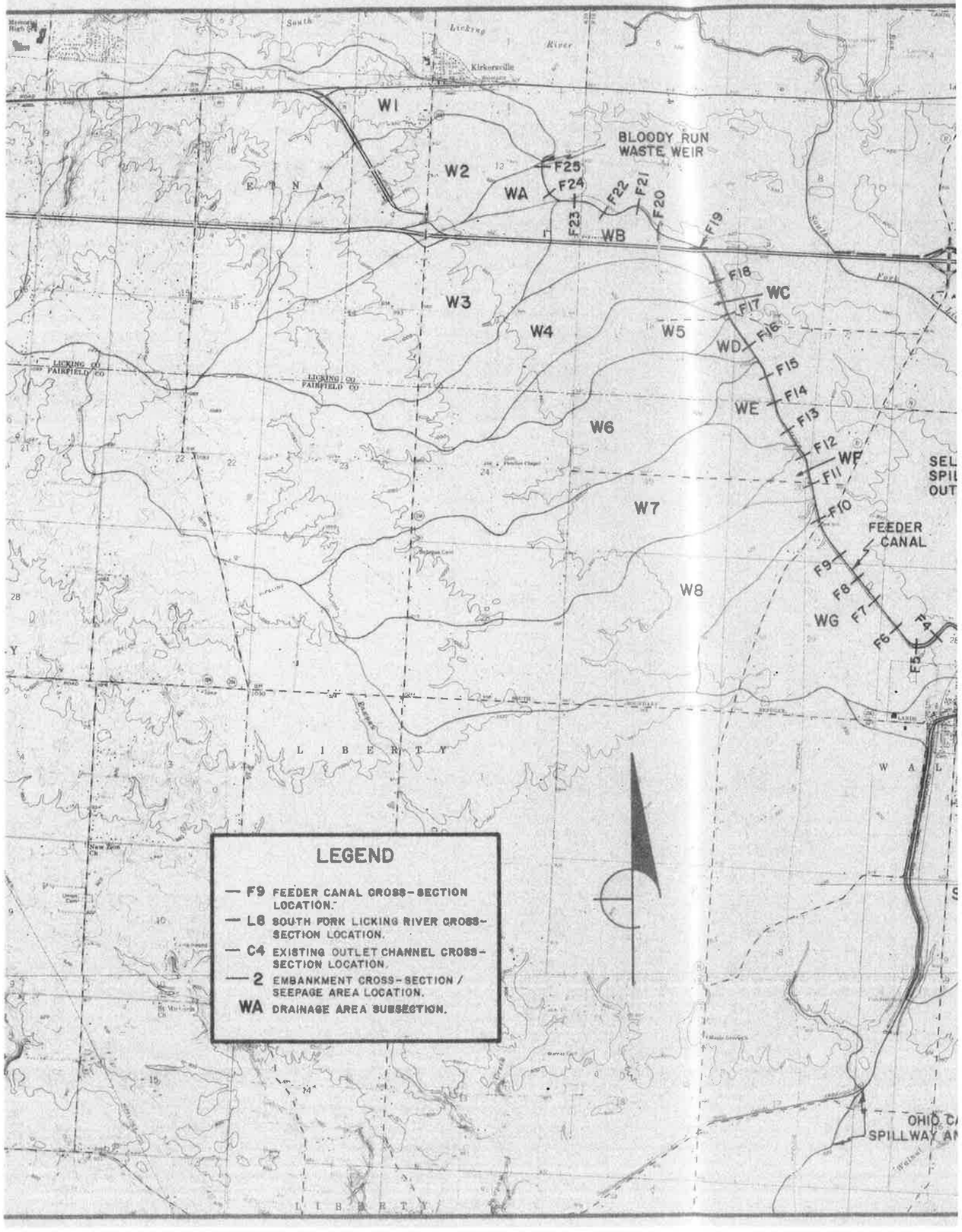
preliminary drawings were developed to show more specifically the improvements recommended. These drawings, soil borings, and additional description of this work are included in Appendix VI, as well as a more detailed cost estimate of the proposed work. As noted in Appendix VI the estimated cost of the proposed work is $5,392,200, including the costs of improvements to the South Fork Licking River below the proposed outlet channel and improvements to the existing outlet channel, Kirkersville feeder canal, and Bloody Run weir. This value is based on more detailed drawings than the estimate given in the first recommendation above and is thus considered more accurate.

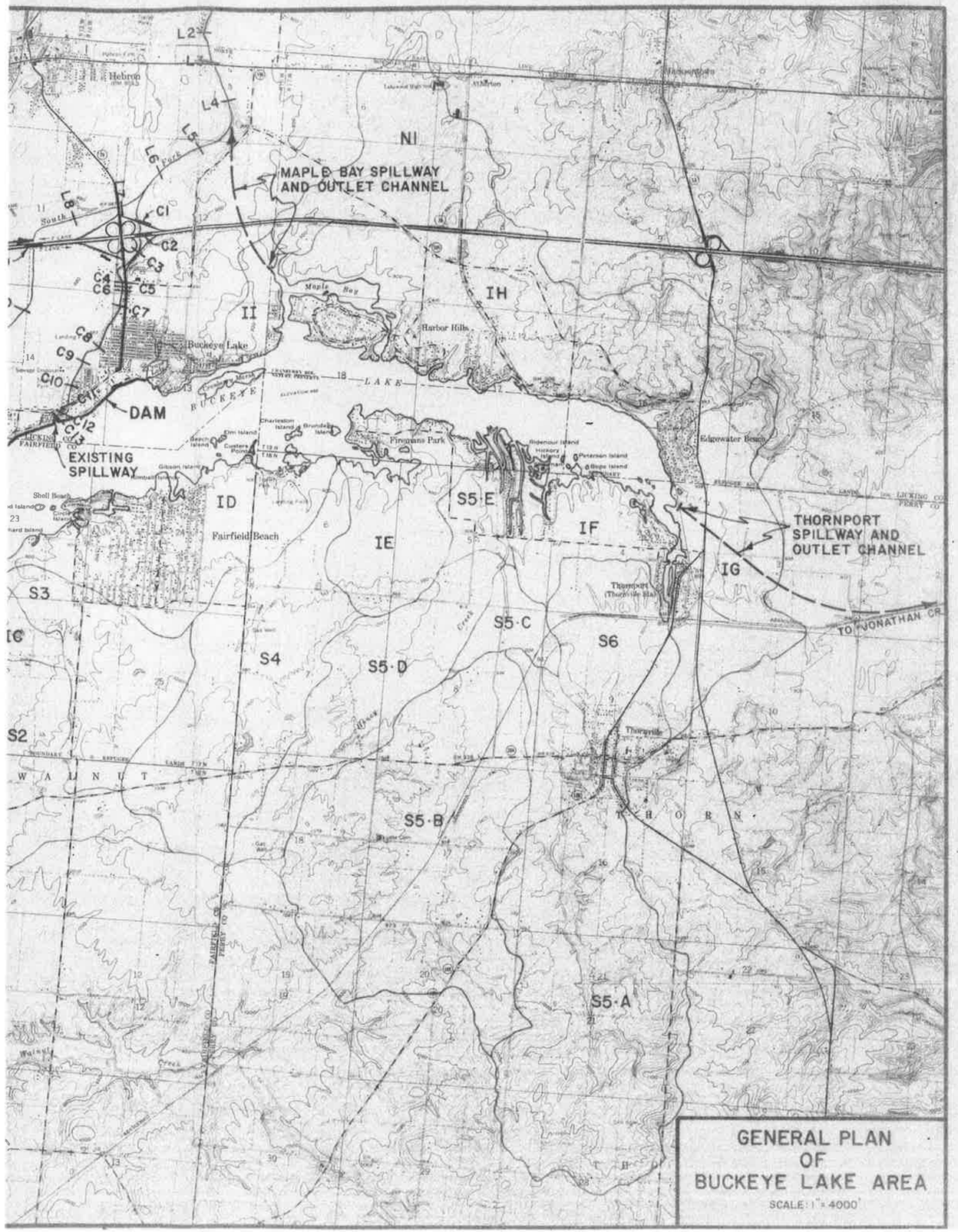
8.0 LIST OF REFERENCES

1. U.S. Army Corps of Engineers, Pittsburgh District, Phase I Inspection Report, National Program of Inspection of non-Federal Dams, Buckeye Lake Dam, 1978.
2. U.S. Department of Agriculture, Soil Conservation Service, and the South Licking Watershed Conservancy District, Watershed Plan and Environmental Impact Statement for South Fork Licking River Watershed, Licking, Perry and Fairfield Counties, Ohio, June 1980.
3. Ohio Department of Natural Resources, Ad Hoc Task Force, "Ad Hoc Task Force Report on the South Licking Watershed", 1972.
4. U.S. Engineers Office (Corps of Engineers), Buckeye Lake Dam Inspection Report, March 1939.
5. Ohio Department of Natural Resources, Division of Water, "Summary of Hydrologic and Hydraulic Analyses of the Buckeye Lake (Kirkersville) Feeder Canal" (Draft), September 1980.
6. Purdue University, Engineering Experiment Station, STABL2 - Programmed Solution for the General Slope Stability Problem, June 1975, Revised June 1978.
7. U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-2 Water Surface Profiles, Generalized Computer Program, November 1976, updated May 1984.
8. U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-1 Flood Hydrograph Package, September 1981, revised January 1985.

APPENDIX I

EXHIBITS


South
Licking
River
Kirkersville
W1
W2
WA
BLOODY RUN
WASTE WEIR
F25
F24
F23
F22
F21
F20
F19
WB
F18
WC
F17
F16
WD
F15
F14
WE
F13
F12
WF
F11
F10
FEEDER
CANAL
F9
F8
WG
F7
F6
F5
F4
W3
W4
W5
W6
W7
W8
LICKING CO
FAIRFIELD CO
E N A
L I B E R T Y
W A L
LEGEND
— F9 FEEDER CANAL CROSS-SECTION LOCATION.
— L8 SOUTH FORK LICKING RIVER CROSS-SECTION LOCATION.
— C4 EXISTING OUTLET CHANNEL CROSS-SECTION LOCATION.
— 2 EMBANKMENT CROSS-SECTION / SEEPAGE AREA LOCATION.
WA DRAINAGE AREA SUBSECTION.


MAPLE BAY SPILLWAY
AND OUTLET CHANNEL
DAM
EXISTING
SPILLWAY
THORNPORT
SPILLWAY AND
OUTLET CHANNEL
TO JONATHAN CR.
NI
IH
II
ID
IE
IF
IG
S5·E
S5·C
S6
S4
S5·D
S3
S2
S5·B
S5·A
Hebron
Buckeye Lake
Harbor Hills
Fairfield Beach
Thornport
Thornville
Maple Bay
Firemans Park
Edgewater Beach
BUCKEYE
LAKE
WALNUT
THORN
GENERAL PLAN
OF
BUCKEYE LAKE AREA
SCALE: 1" = 4000'

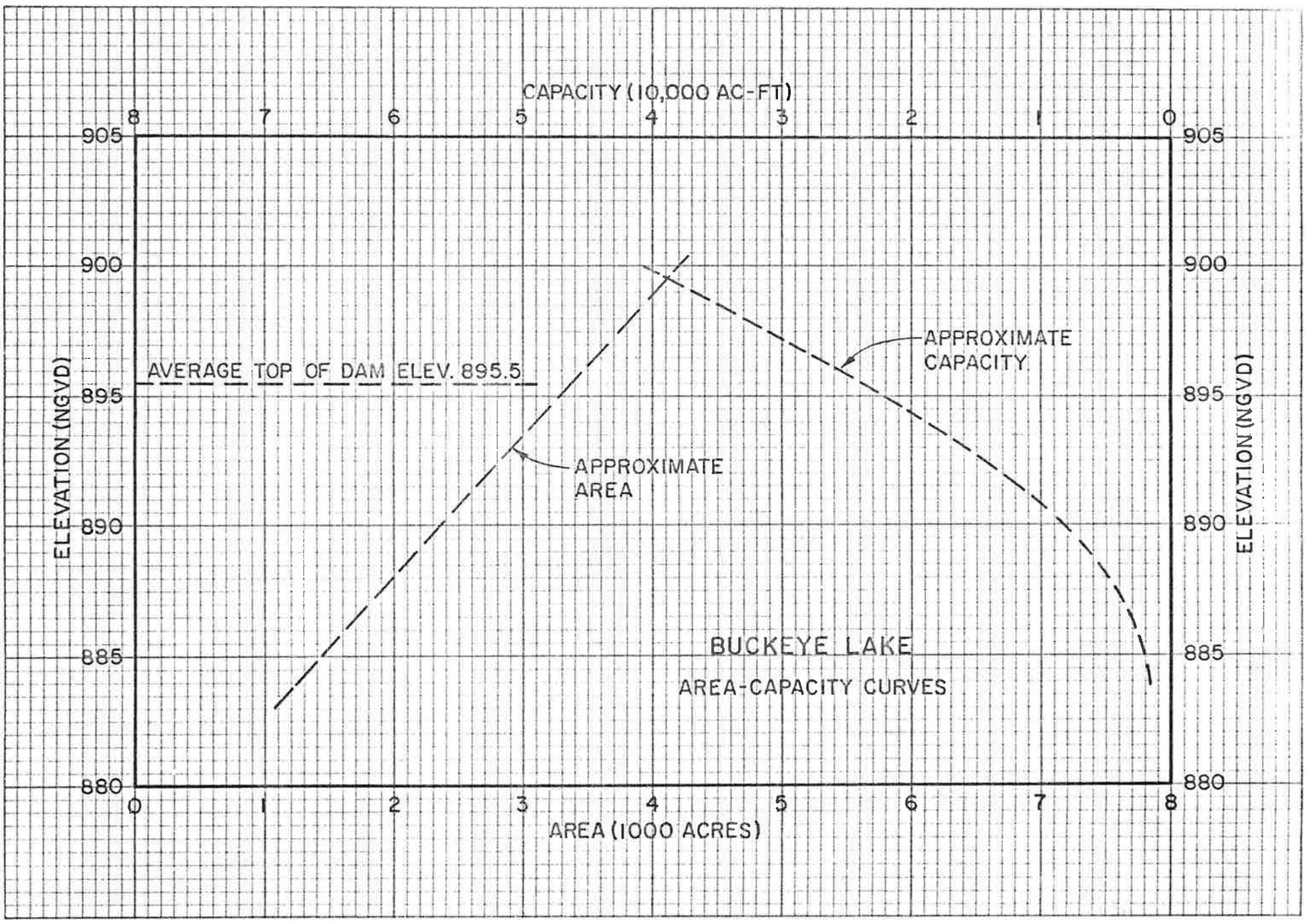

CAPACITY (10,000 AC-FT)
8
7
6
5
4
3
2
1
0
905
900
895
890
885
880
ELEVATION (NGVD)
AVERAGE TOP OF DAM ELEV. 895.5
APPROXIMATE CAPACITY
APPROXIMATE AREA
BUCKEYE LAKE
AREA-CAPACITY CURVES
0
1
2
3
4
5
6
7
8
AREA (1000 ACRES)

EXHIBIT 2

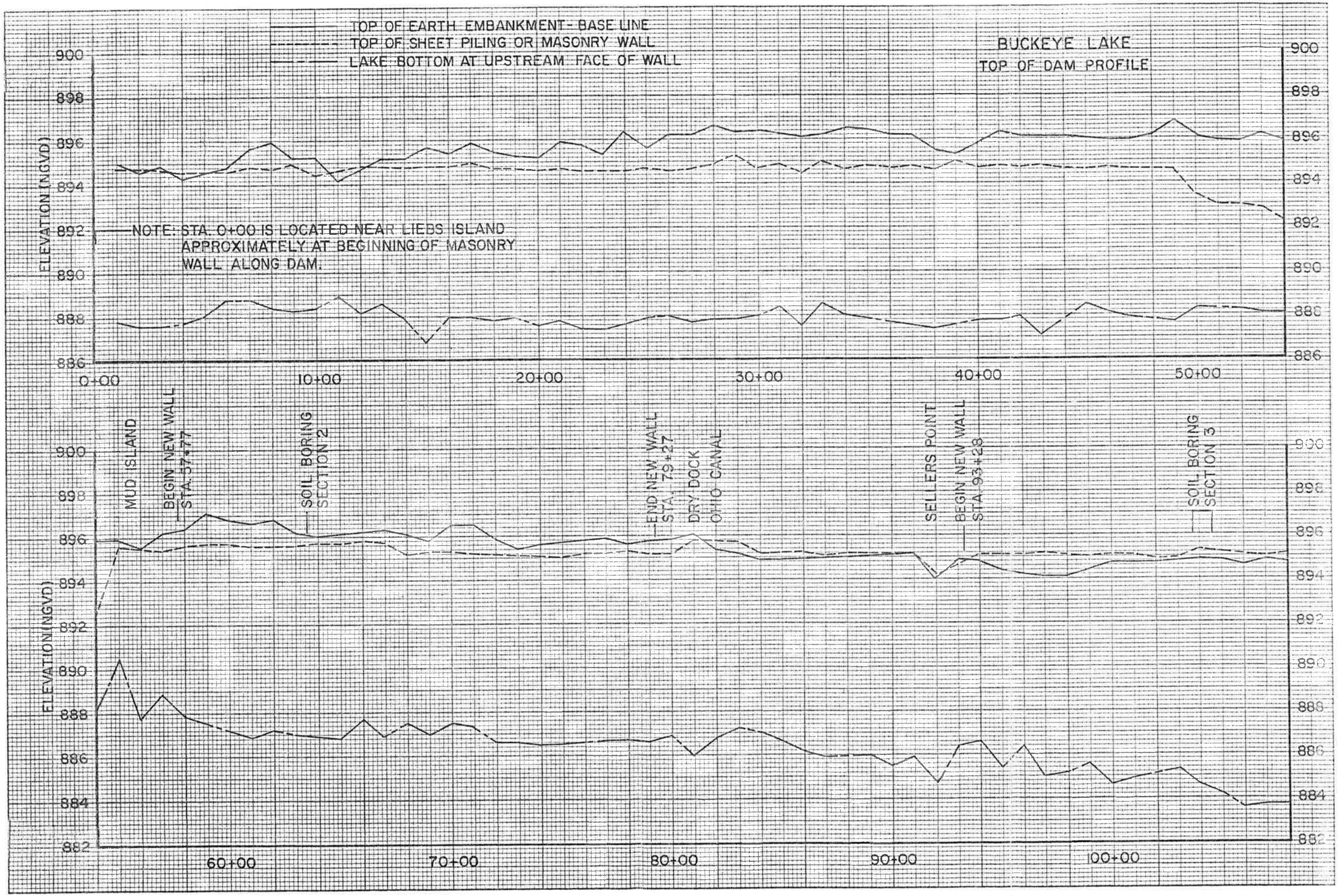


EXHIBIT 3
SHEET 1 OF 2

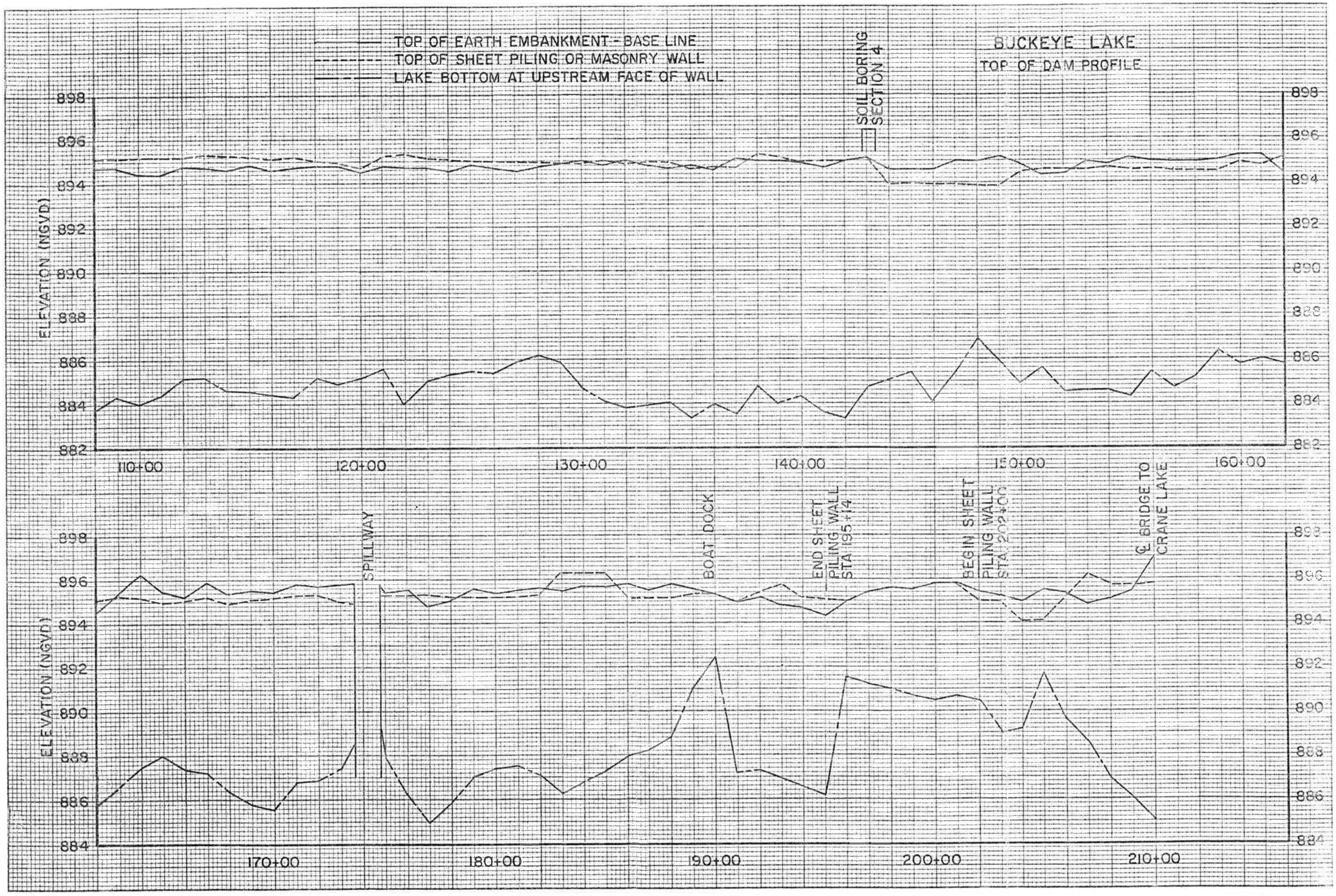


EXHIBIT 3
SHEET 2 OF 2

Synthetic Unit Hydrograph Data Summary

Subarea	Drainage Area (sq. mi.)	SCS Lag Time (hr)	Snyder Tp* (hr)	SCS Curve Number
W1	3.74	3.7	7.9	81
W2	1.07	1.3	4.8	82
W3	1.56	1.8	5.4	83
W4	.82	1.7	5.6	82
W5	.48	1.9	4.4	82
W6	3.30	4.8	8.6	83
W7	1.80	2.7	6.6	83
W8	1.89	3.6	6.8	83
WA	.11	1.6	**	77
WB	.35	2.7	**	76
WC	.03	0.6	**	79
WD	.06	1.0	**	83
WE	.19	1.9	**	83
WF	.10	1.0	**	86
WG	1.24	6.1	**	83
S1	1.32	2.2	4.5	84
S2	1.08	1.6	5.0	83
S3	.87	1.0	4.7	81
S4	1.73	1.5	5.9	82
S5A	2.87	1.9		77
S5B	2.60	1.8		79
S5C	.23	1.2	8.1***	80
S5D	1.08	1.2		79
S5E	.22	1.3		77
S6	.83	0.9	3.3	79
SA	1.23	4.4	**	84
IA	.61	1.0	**	84
IB	.39	0.7	**	83
IC	.18	1.3	**	81
ID	1.26	0.9	**	80
IE	.83	1.0	**	79
IF	.61	1.0	**	80
IG	1.23	2.0	**	80
IH	2.21	1.2	**	79
II	.28	0.7	**	79
N1	1.00	1.6	4.3	81
	Total = 44.14			

* Snyder Ct = 3.7; Cp = 0.60

** No Snyder Tp value computed for this subarea

*** Total for Subarea S5

EXHIBIT 4

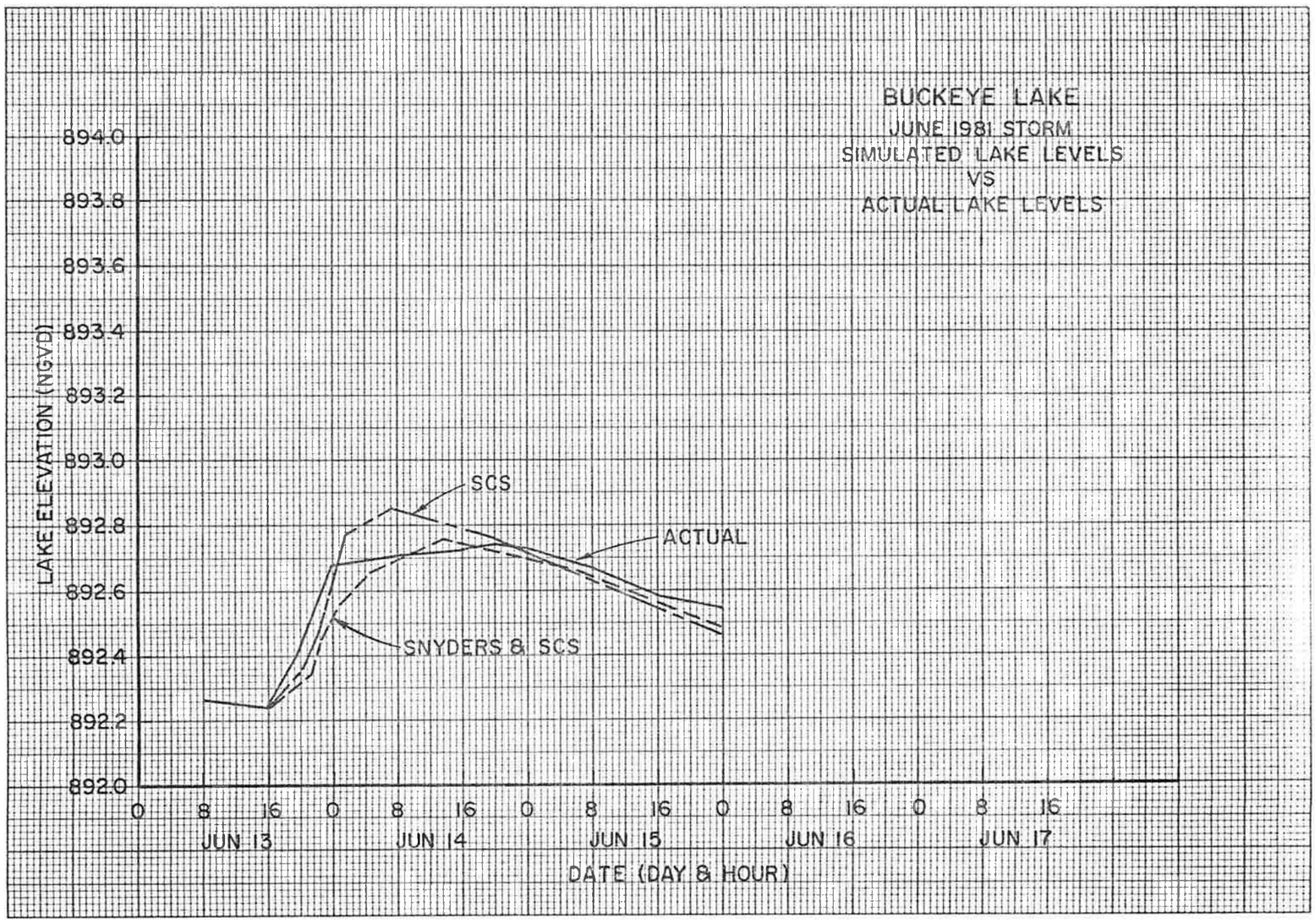

BUCKEYE LAKE
JUNE 1981 STORM
SIMULATED LAKE LEVELS
VS
ACTUAL LAKE LEVELS
LAKE ELEVATION (NGVD)
894.0
893.8
893.6
893.4
893.2
893.0
892.8
892.6
892.4
892.2
892.0
SCS
ACTUAL
SNYDERS & SCS
0
8
16
JUN 13
JUN 14
JUN 15
JUN 16
JUN 17
DATE (DAY & HOUR)

EXHIBIT 5

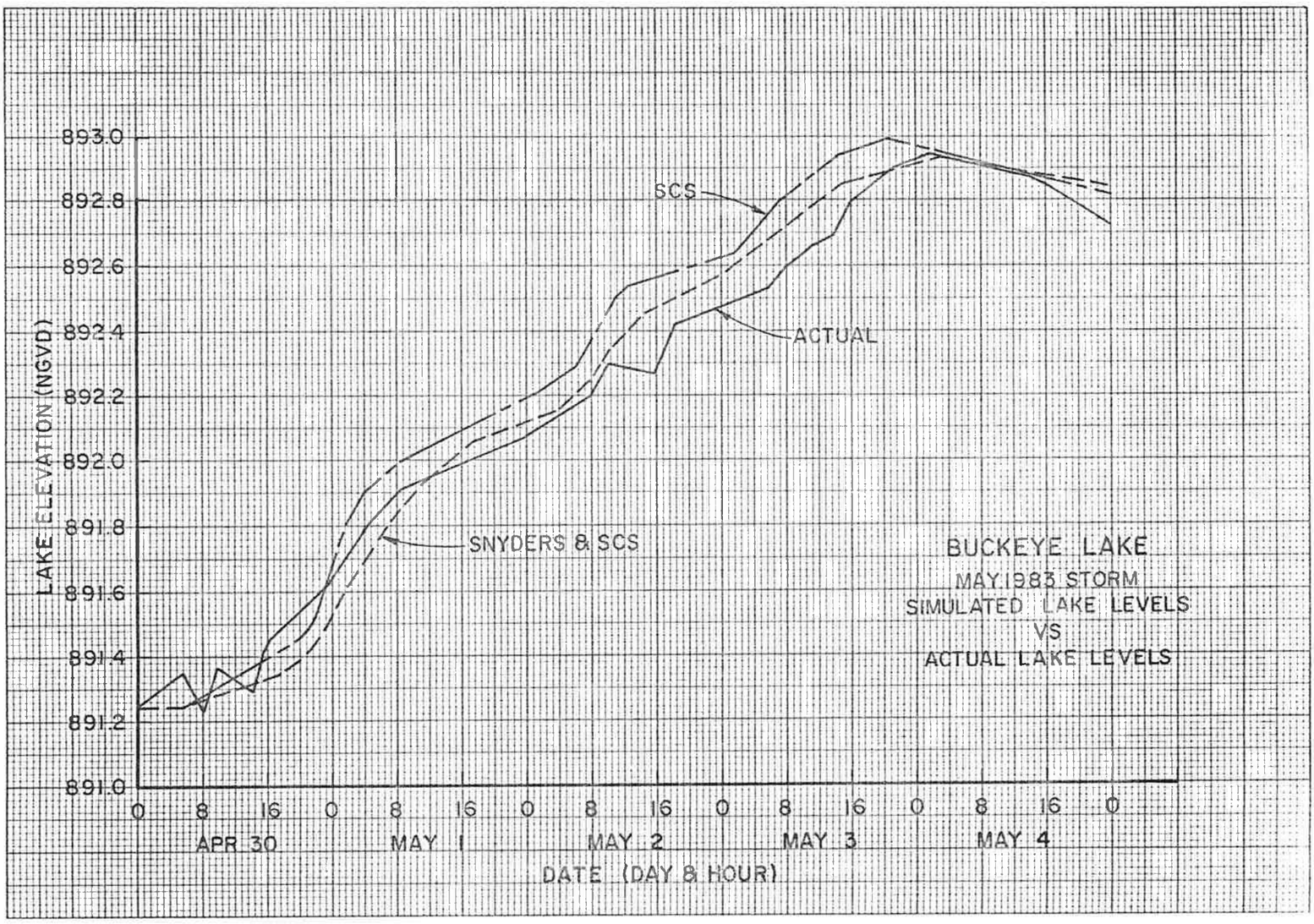

BUCKEYE LAKE
MAY 1983 STORM
SIMULATED LAKE LEVELS
VS
ACTUAL LAKE LEVELS
SCS
ACTUAL
SNYDERS & SCS
LAKE ELEVATION (NGVD)
893.0
892.8
892.6
892.4
892.2
892.0
891.8
891.6
891.4
891.2
891.0
0
8
16
APR 30
MAY 1
MAY 2
MAY 3
MAY 4
DATE (DAY & HOUR)

EXHIBIT 6

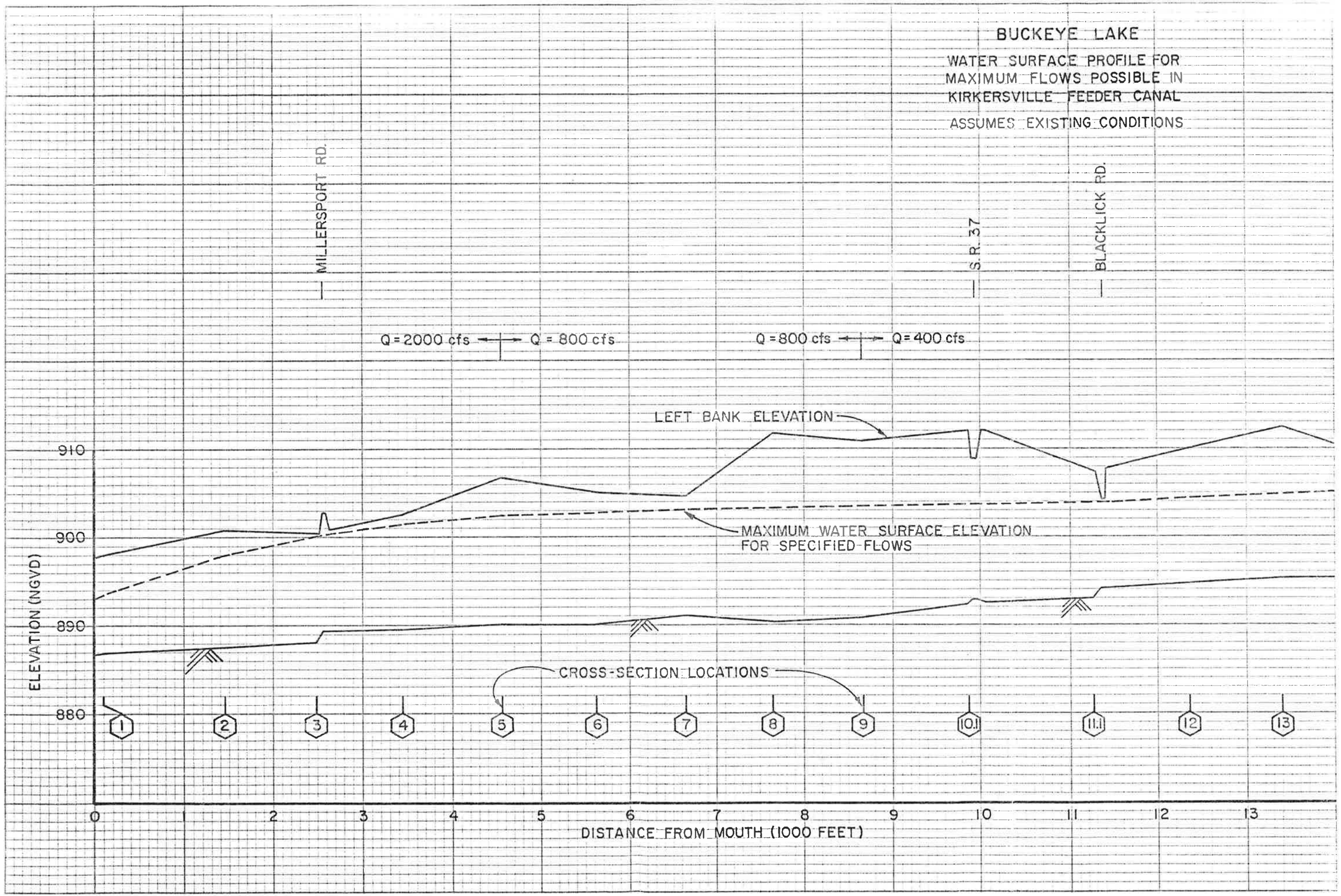


EXHIBIT 7
SHEET 1 OF 2

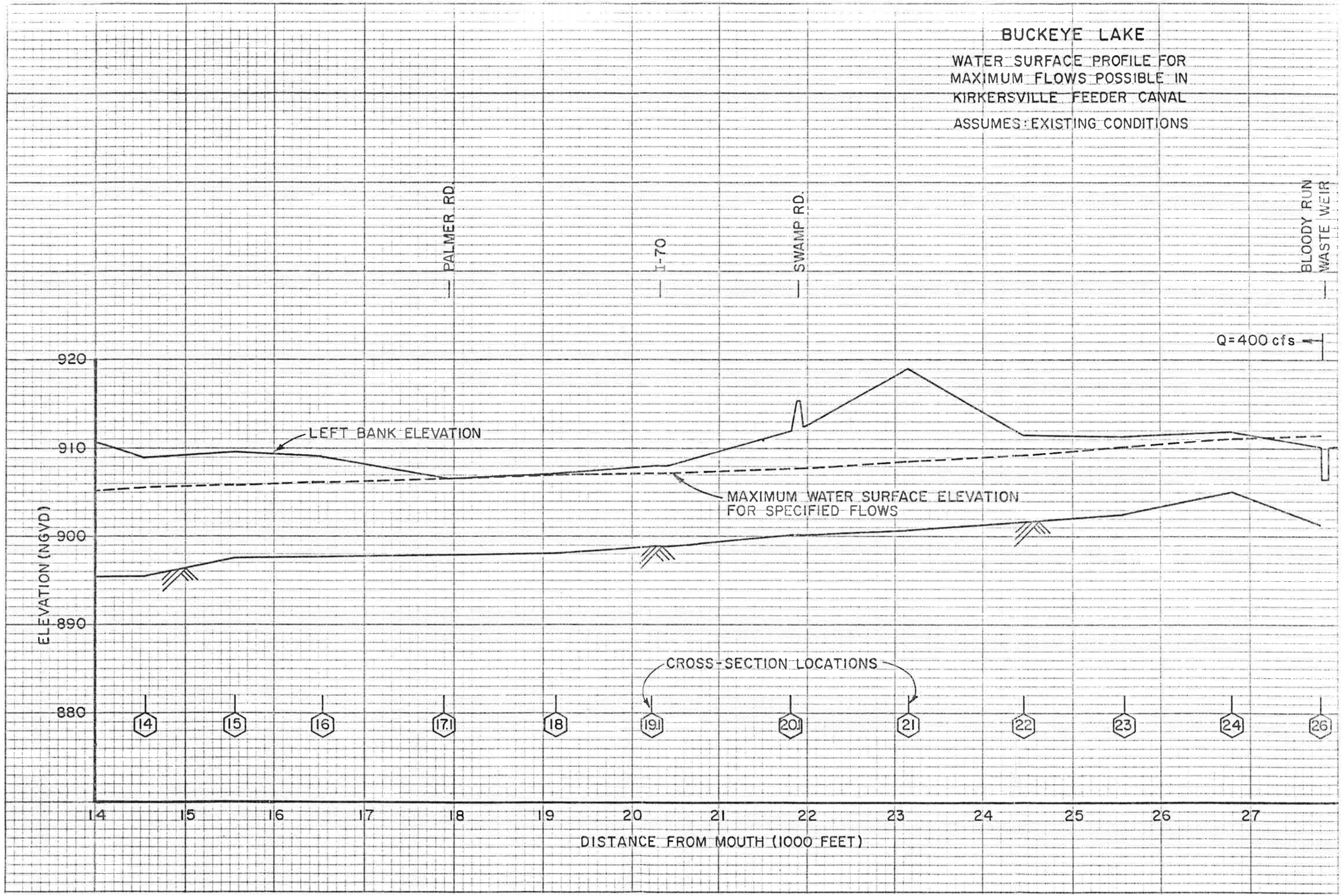


EXHIBIT 7
SHEET 2 OF 2

DLA FORM 1

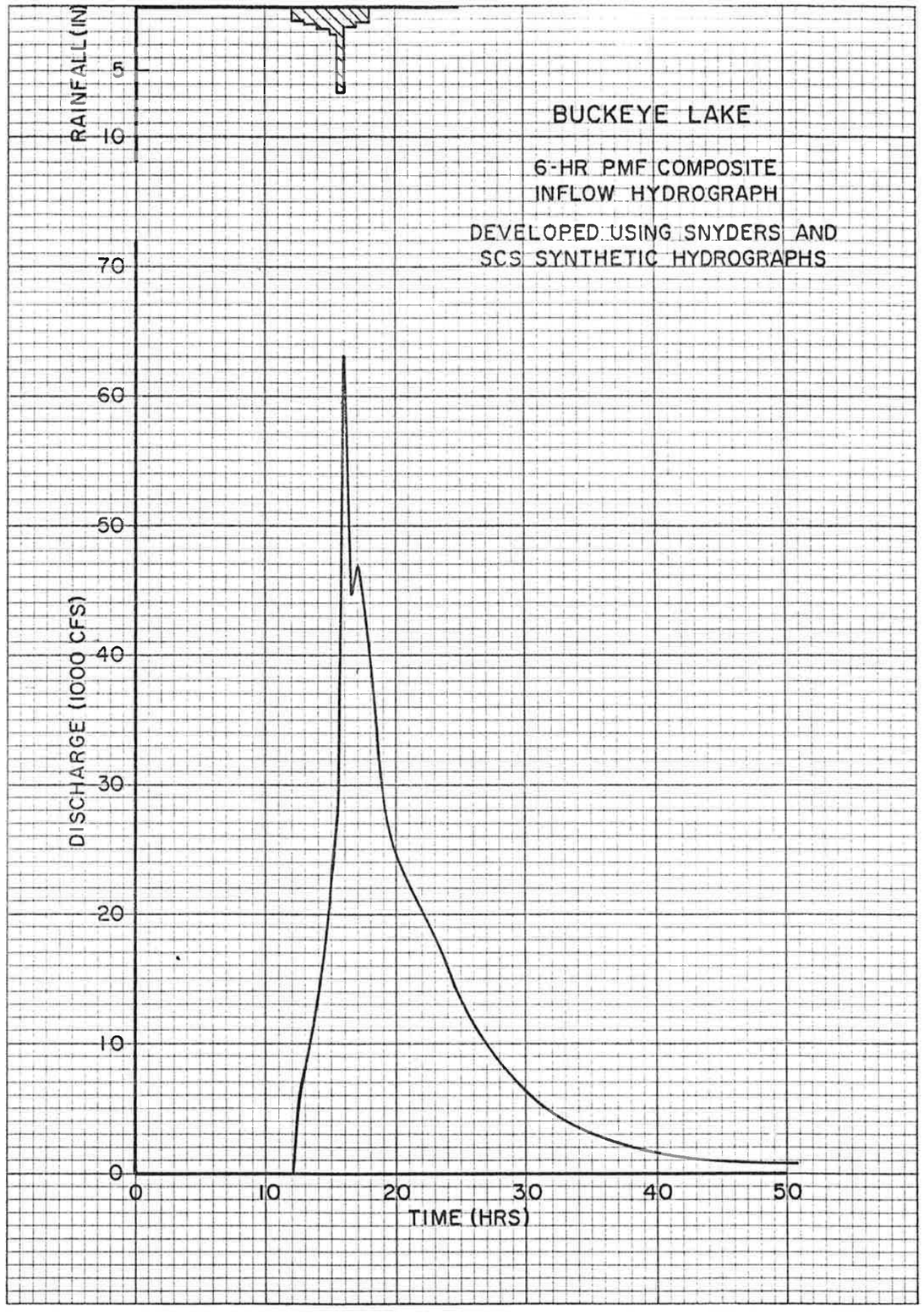


EXHIBIT 8

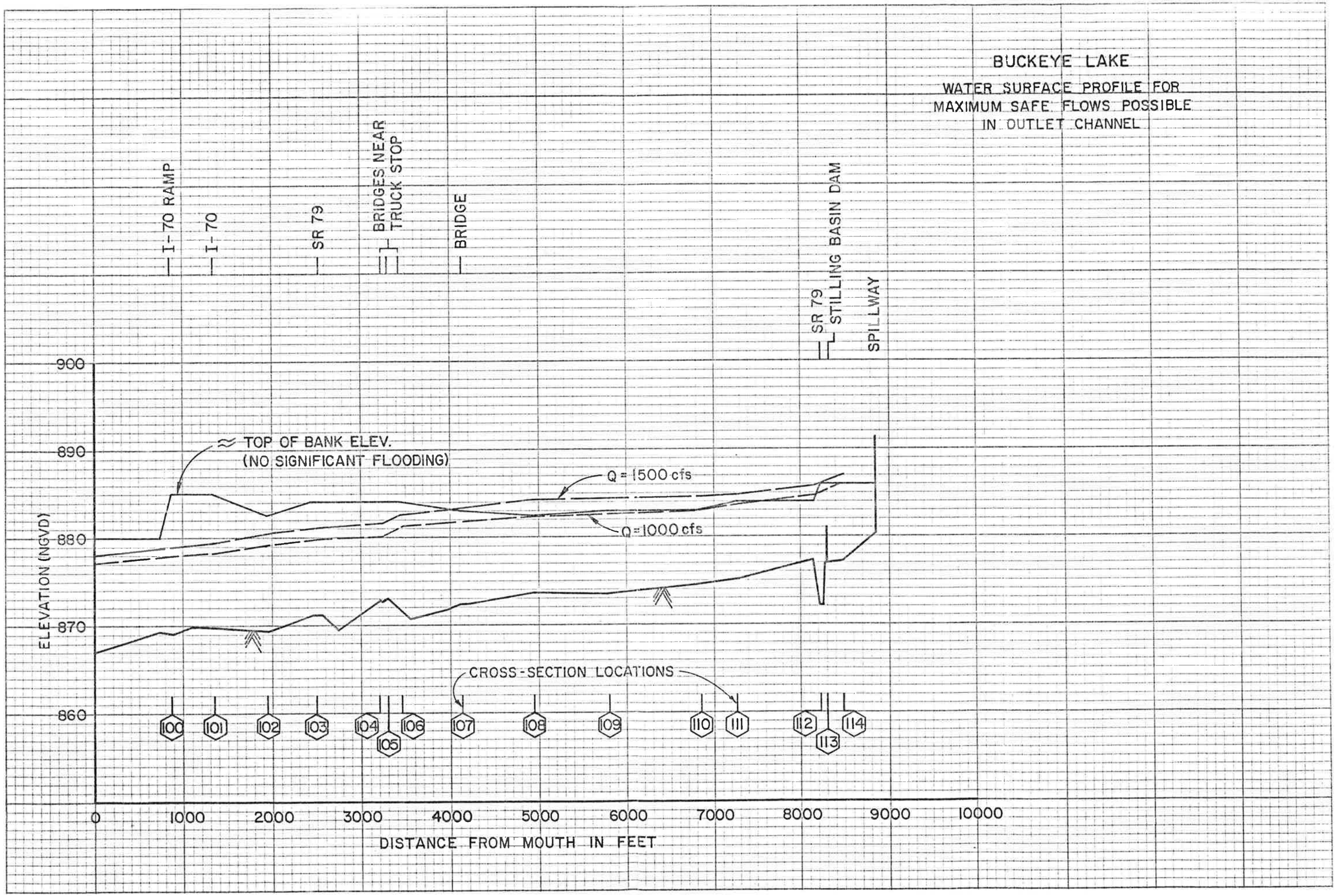

BUCKEYE LAKE
WATER SURFACE PROFILE FOR
MAXIMUM SAFE FLOWS POSSIBLE
IN OUTLET CHANNEL
I-70 RAMP
I-70
SR 79
BRIDGES NEAR
TRUCK STOP
BRIDGE
SR 79
STILLING BASIN DAM
SPILLWAY
TOP OF BANK ELEV.
(NO SIGNIFICANT FLOODING)
Q = 1500 cfs
Q = 1000 cfs
CROSS-SECTION LOCATIONS
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
ELEVATION (NGVD)
900
890
880
870
860
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
DISTANCE FROM MOUTH IN FEET

EXHIBIT 9

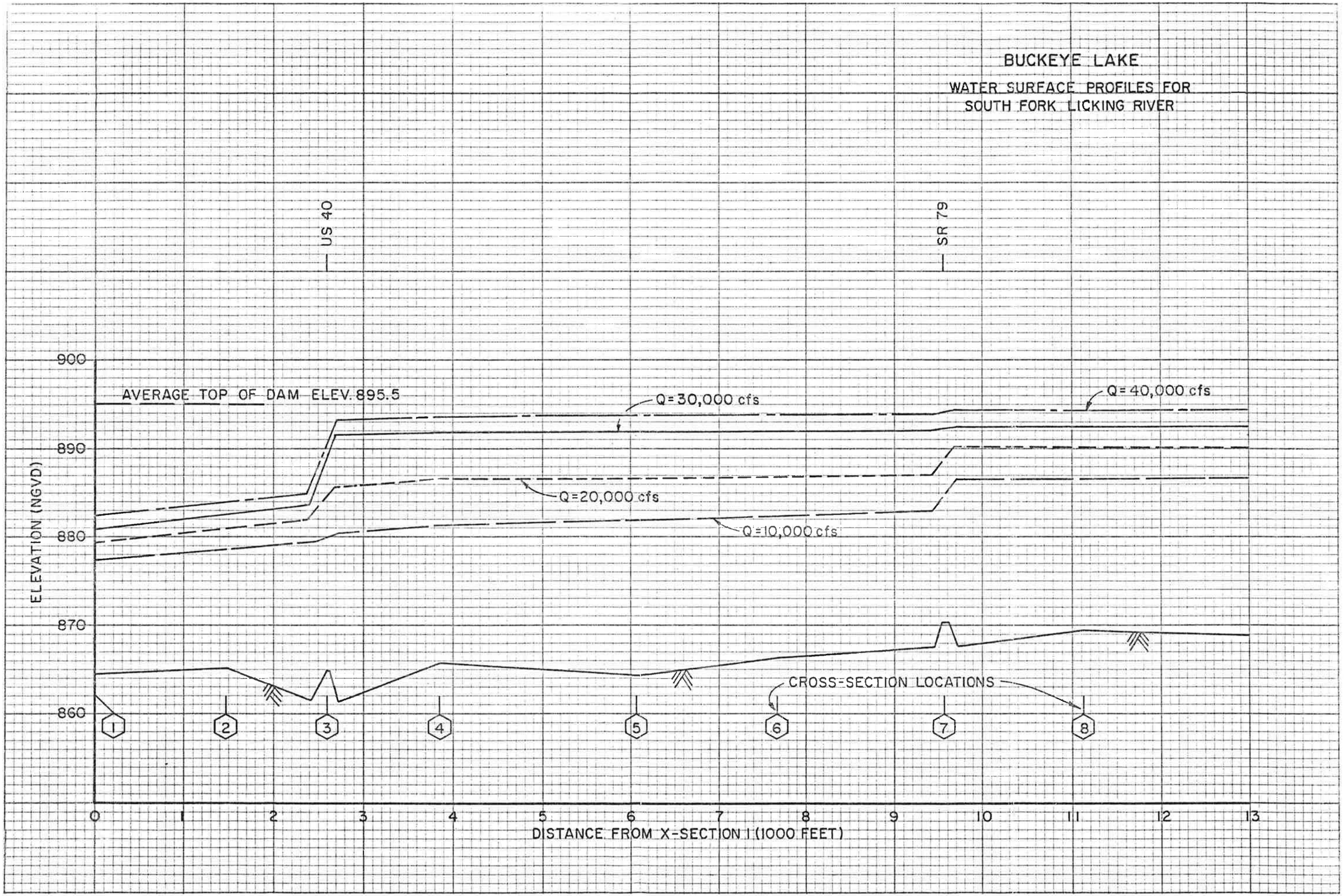


EXHIBIT 10
SHEET 1 OF 2

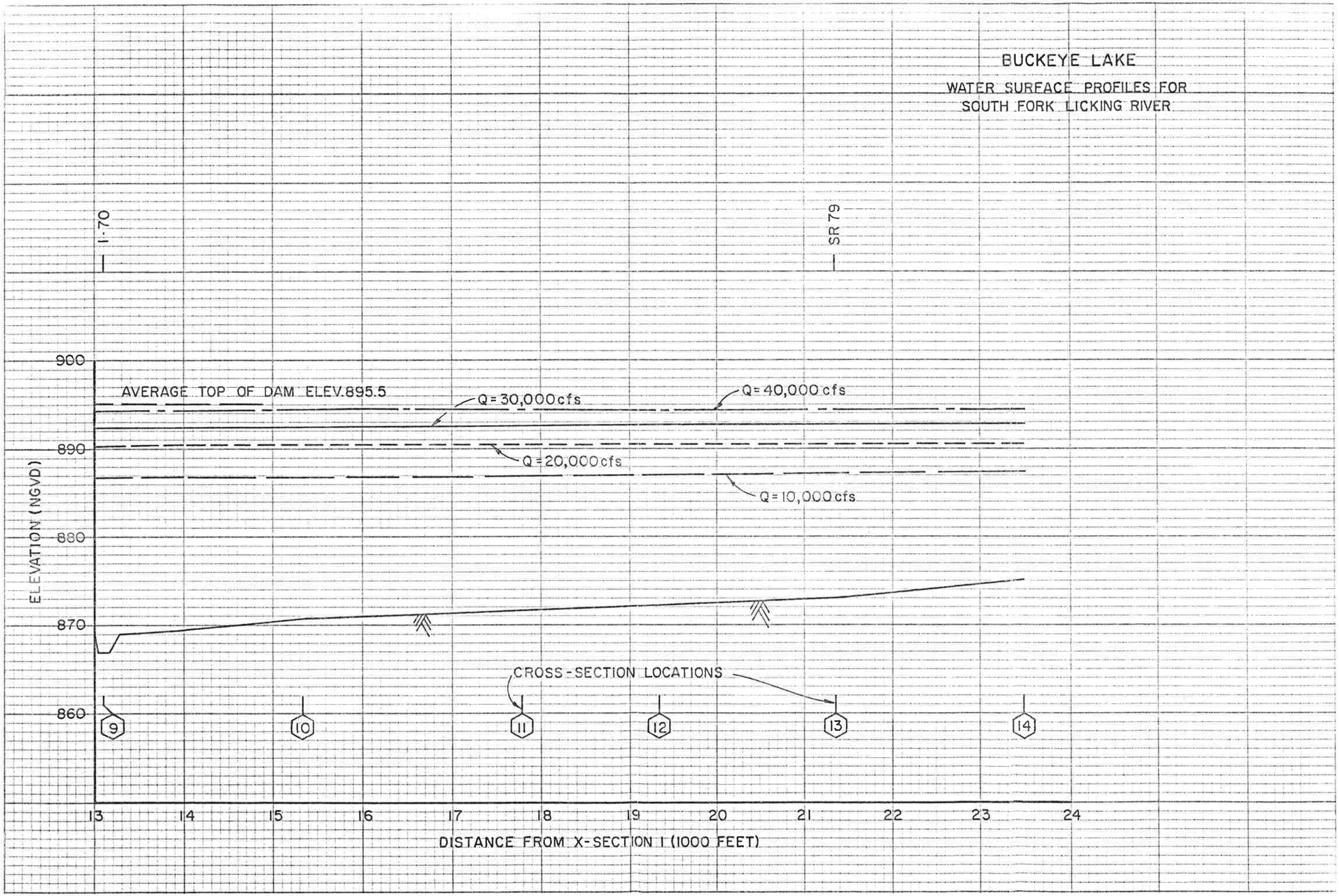


EXHIBIT 10
SHEET 2 OF 2

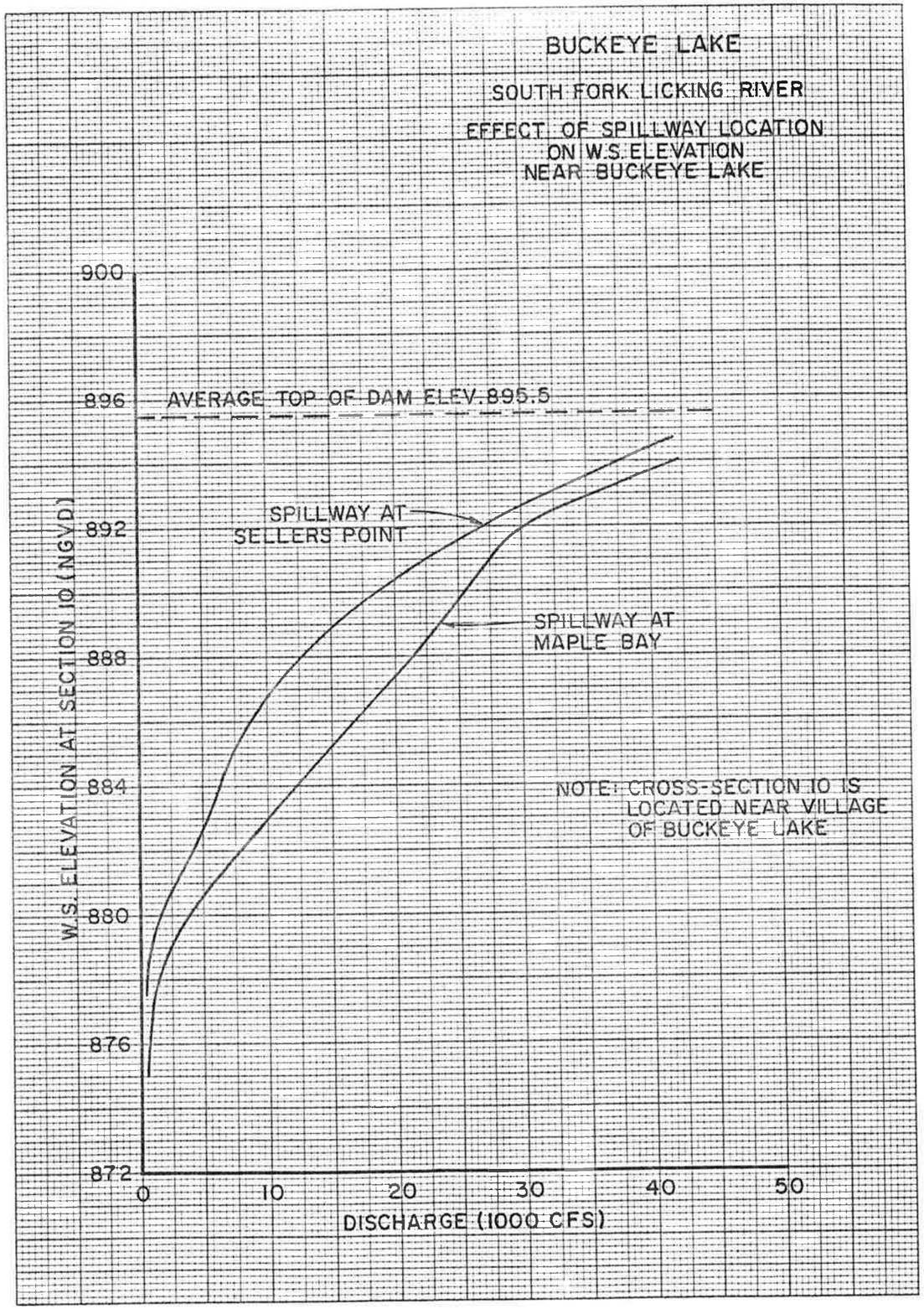

BUCKEYE LAKE
SOUTH FORK LICKING RIVER
EFFECT OF SPILLWAY LOCATION ON W.S. ELEVATION NEAR BUCKEYE LAKE
900
896
892
888
884
880
876
872
AVERAGE TOP OF DAM ELEV. 895.5
SPILLWAY AT SELLERS POINT
SPILLWAY AT MAPLE BAY
NOTE: CROSS-SECTION 10 IS LOCATED NEAR VILLAGE OF BUCKEYE LAKE
W.S. ELEVATION AT SECTION 10 (NGVD)
0
10
20
30
40
50
DISCHARGE (1000 CFS)

EXHIBIT 11

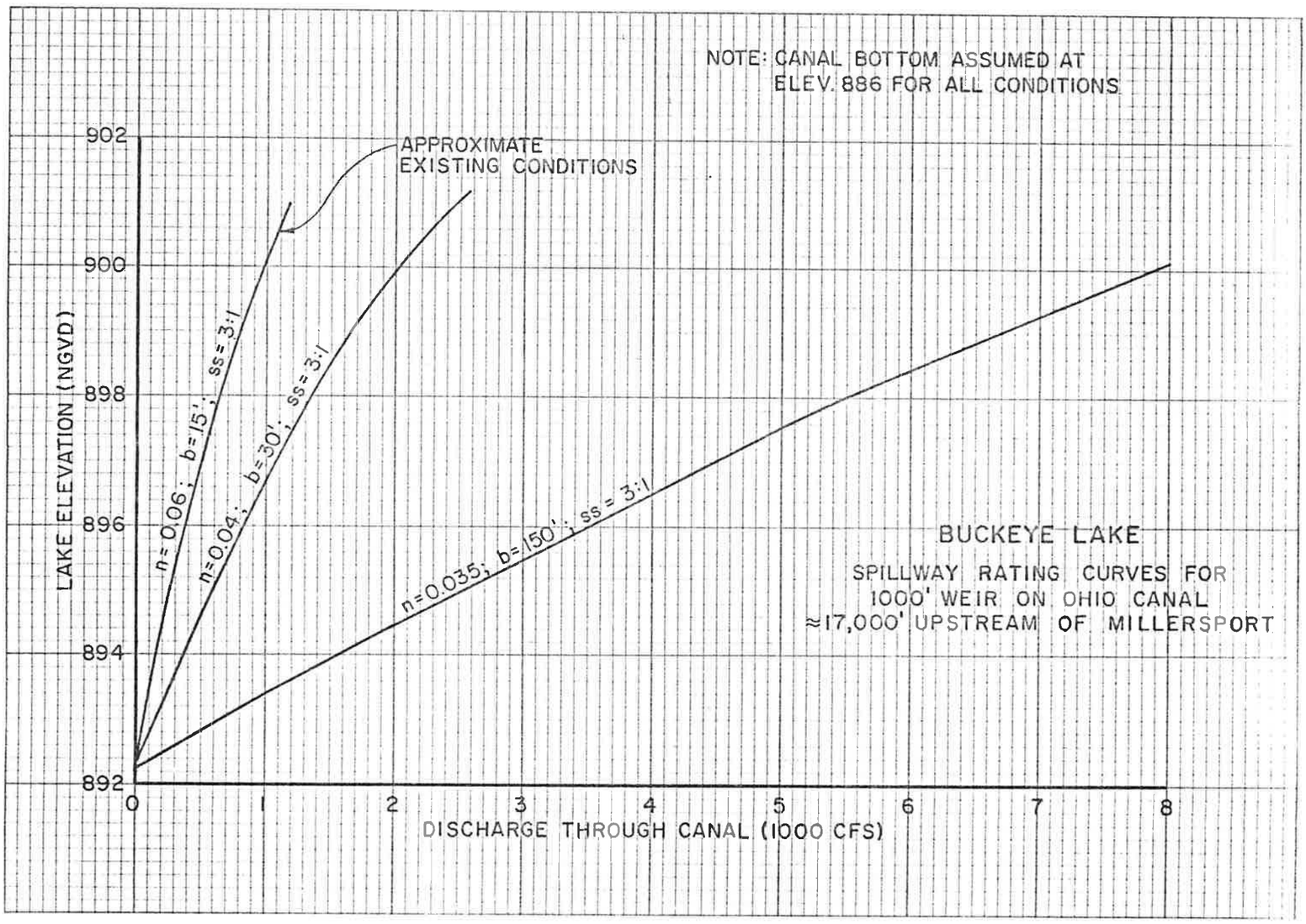

NOTE: CANAL BOTTOM ASSUMED AT
ELEV. 886 FOR ALL CONDITIONS
APPROXIMATE
EXISTING CONDITIONS
n=0.06; b=15'; ss=3:1
n=0.04; b=30'; ss=3:1
n=0.035; b=150'; ss=3:1
BUCKEYE LAKE
SPILLWAY RATING CURVES FOR
1000' WEIR ON OHIO CANAL
≈17,000' UPSTREAM OF MILLERSPORT
LAKE ELEVATION (NGVD)
902
900
898
896
894
892
0
1
2
3
4
5
6
7
8
DISCHARGE THROUGH CANAL (1000 CFS)

EXHIBIT 12

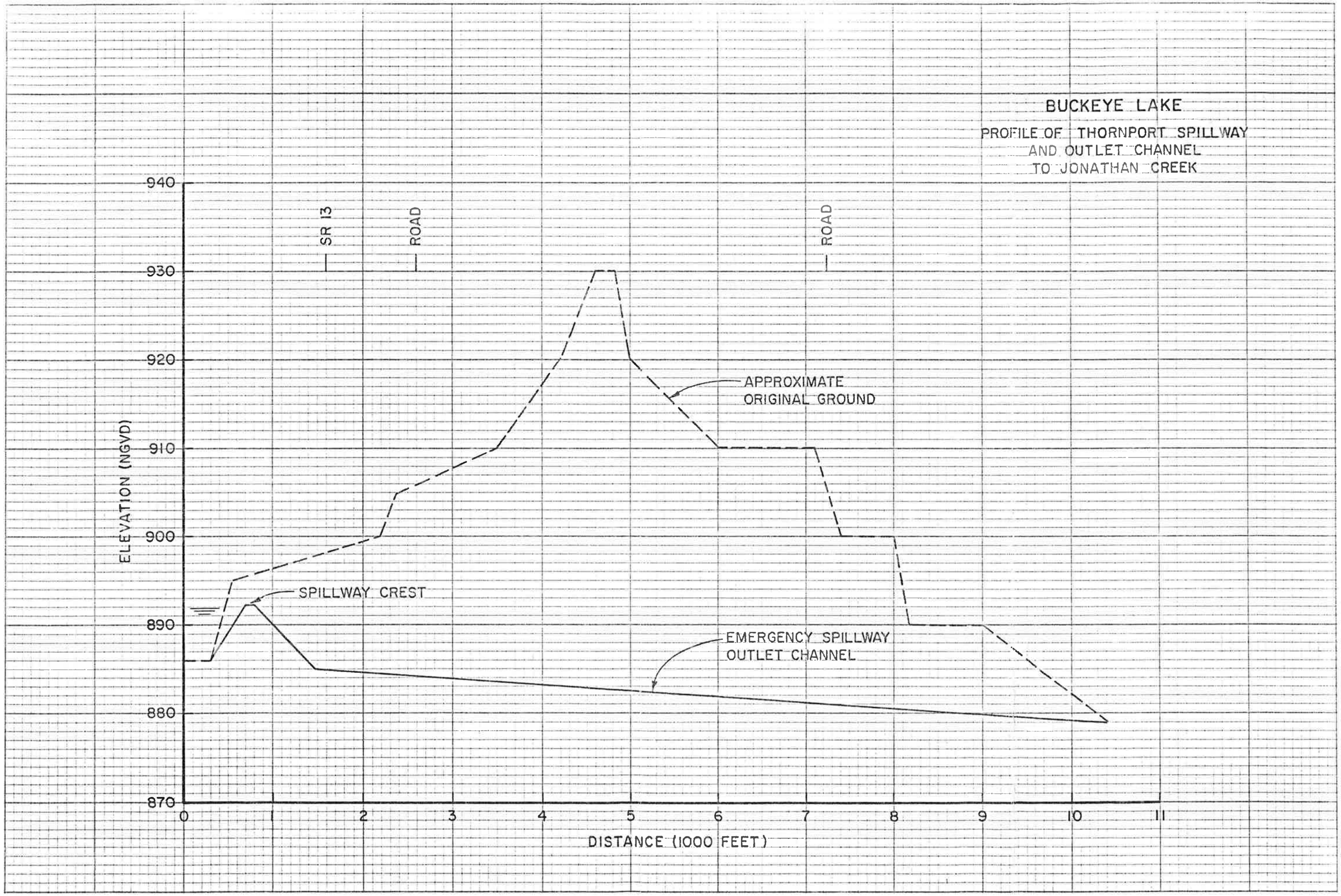

BUCKEYE LAKE
PROFILE OF THORNPORT SPILLWAY
AND OUTLET CHANNEL
TO JONATHAN CREEK
SR 13
ROAD
ROAD
APPROXIMATE
ORIGINAL GROUND
SPILLWAY CREST
EMERGENCY SPILLWAY
OUTLET CHANNEL
ELEVATION (NGVD)
940
930
920
910
900
890
880
870
0
1
2
3
4
5
6
7
8
9
10
11
DISTANCE (1000 FEET)

EXHIBIT 13

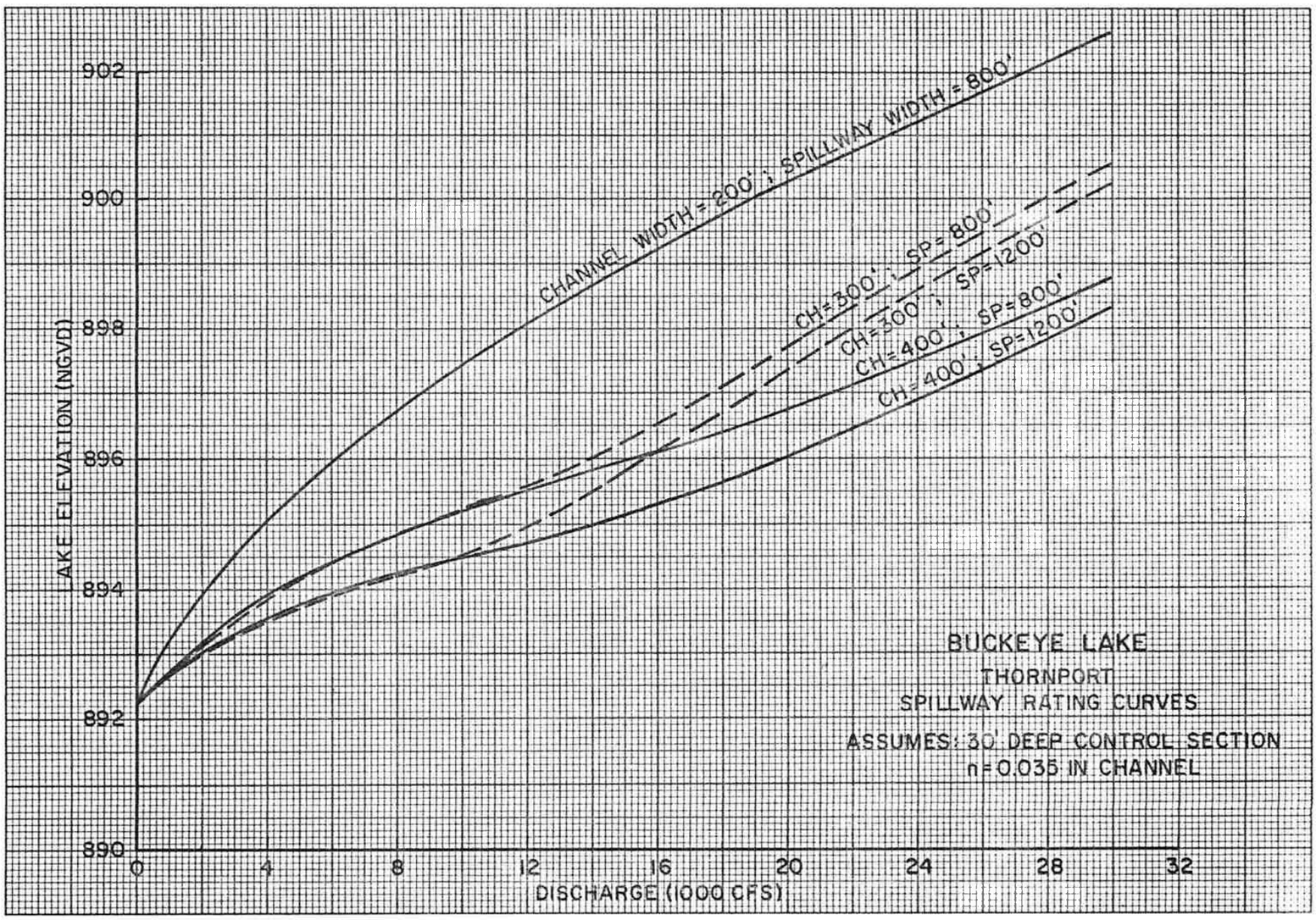

BUCKEYE LAKE
THORNPORT
SPILLWAY RATING CURVES
ASSUMES: 30' DEEP CONTROL SECTION
n=0.035 IN CHANNEL
CHANNEL WIDTH = 200' ; SPILLWAY WIDTH = 800'
CH=300' ; SP=800'
CH=300' ; SP=1200'
CH=400' ; SP=800'
CH=400' ; SP=1200'
LAKE ELEVATION (NGVD)
902
900
898
896
894
892
890
0
4
8
12
16
20
24
28
32
DISCHARGE (1000 CFS)

EXHIBIT 14

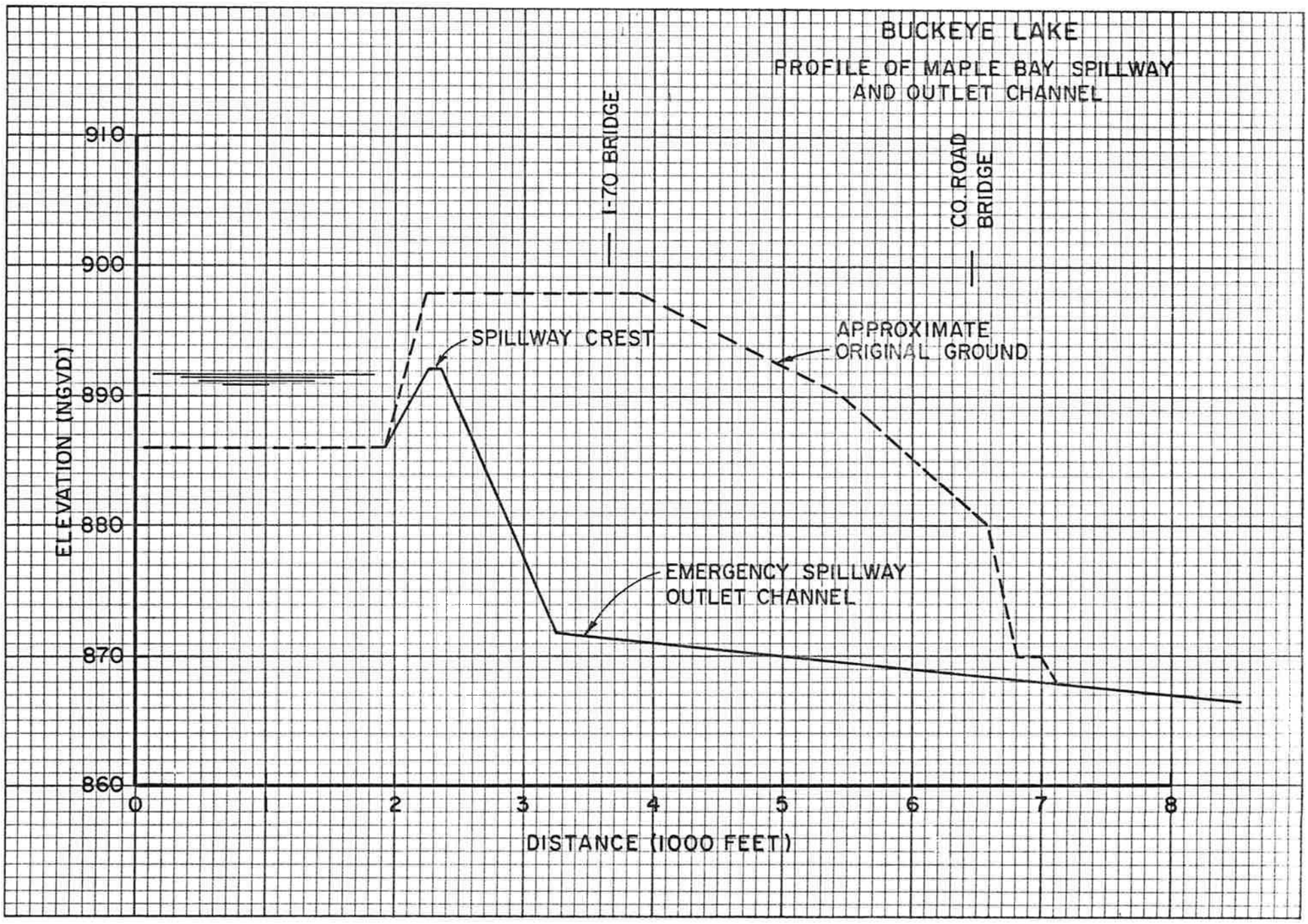

BUCKEYE LAKE
PROFILE OF MAPLE BAY SPILLWAY
AND OUTLET CHANNEL
I-70 BRIDGE
CO. ROAD
BRIDGE
SPILLWAY CREST
APPROXIMATE
ORIGINAL GROUND
EMERGENCY SPILLWAY
OUTLET CHANNEL
ELEVATION (NGVD)
910
900
890
880
870
860
0
1
2
3
4
5
6
7
8
DISTANCE (1000 FEET)

EXHIBIT 15

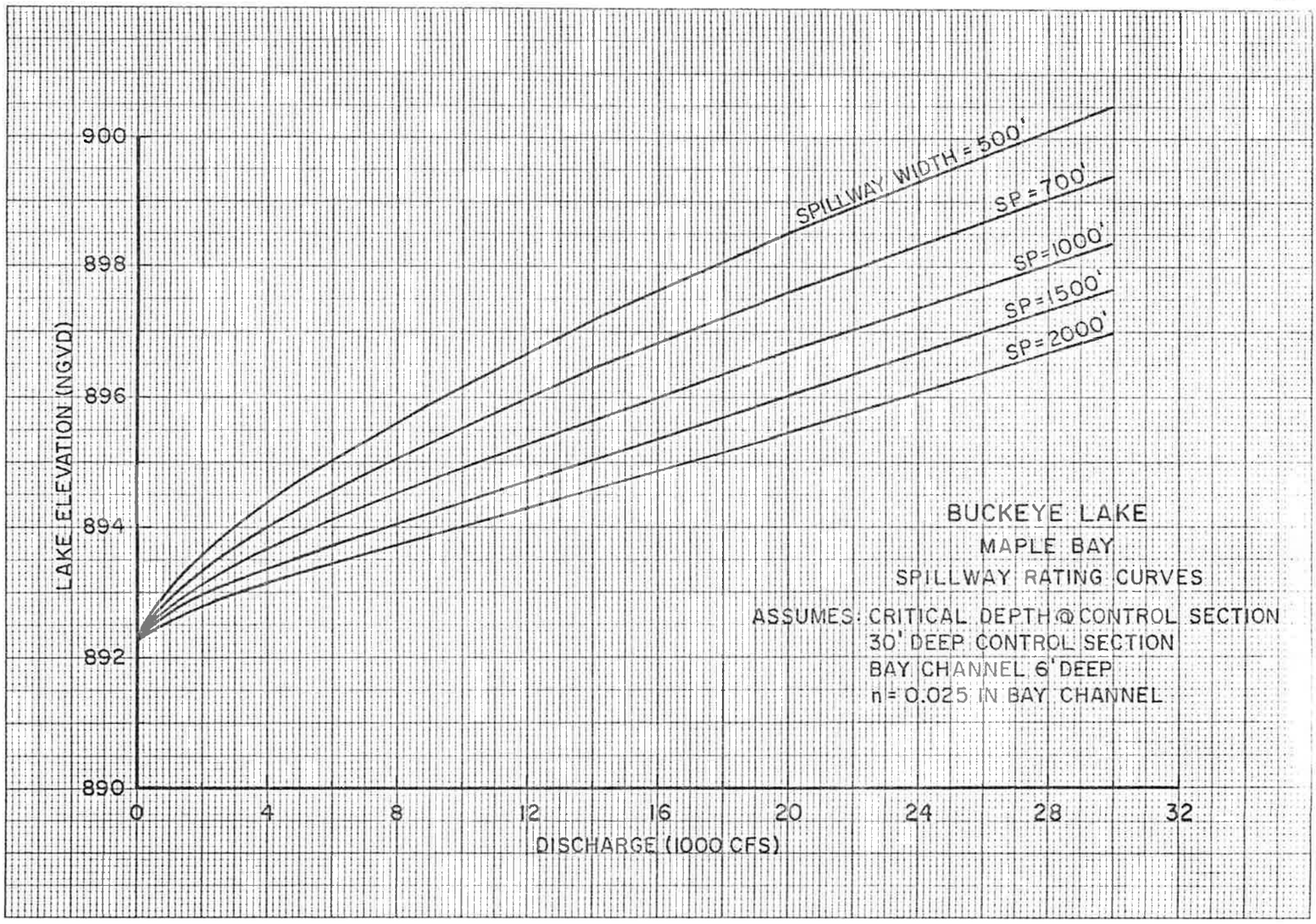

900
898
896
894
892
890
LAKE ELEVATION (NGVD)
0
4
8
12
16
20
24
28
32
DISCHARGE (1000 CFS)
SPILLWAY WIDTH = 500'
SP = 700'
SP = 1000'
SP = 1500'
SP = 2000'
BUCKEYE LAKE
MAPLE BAY
SPILLWAY RATING CURVES
ASSUMES: CRITICAL DEPTH @ CONTROL SECTION
30' DEEP CONTROL SECTION
BAY CHANNEL 6' DEEP
n = 0.025 IN BAY CHANNEL

EXHIBIT 16

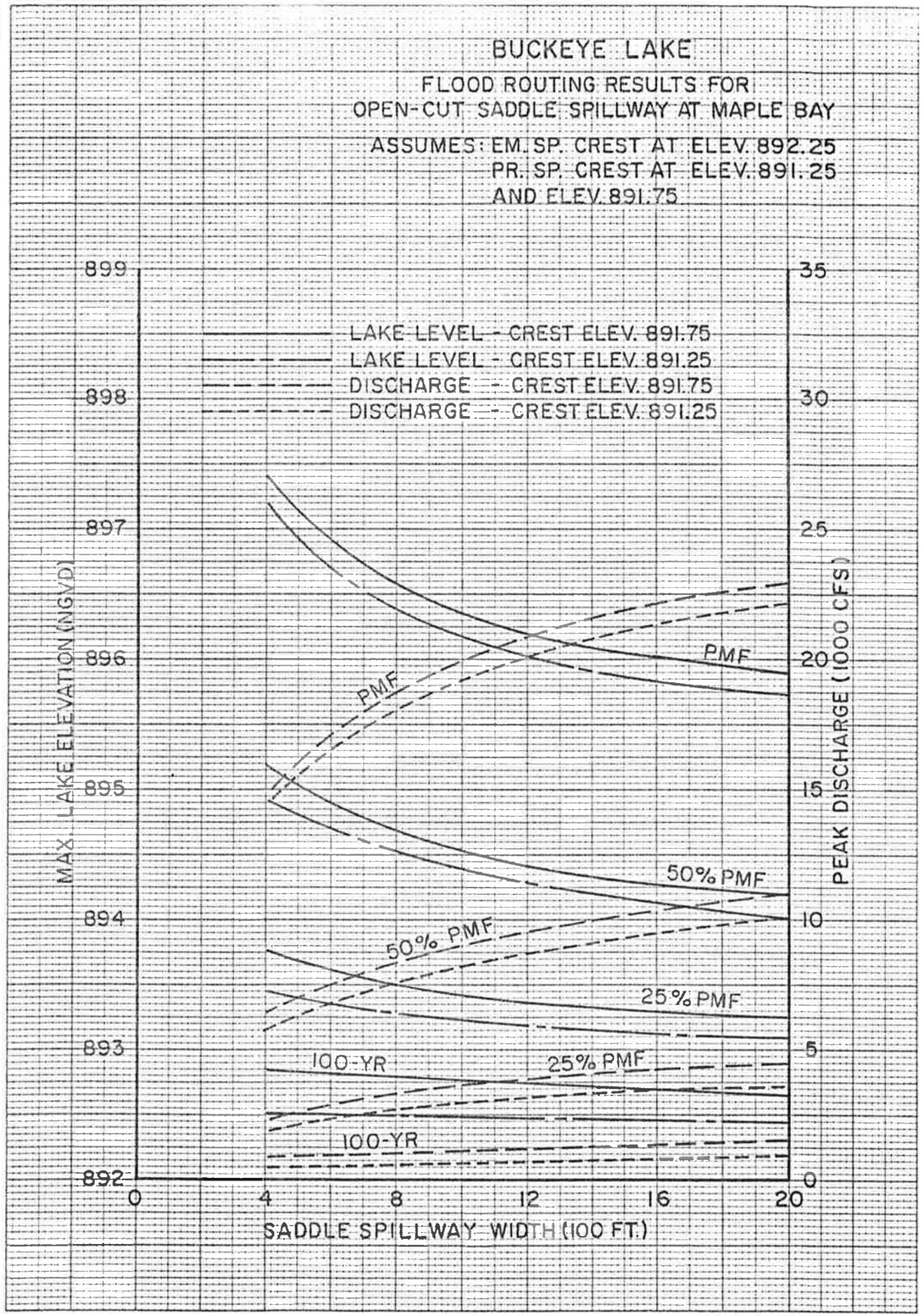

BUCKEYE LAKE
FLOOD ROUTING RESULTS FOR
OPEN-CUT SADDLE SPILLWAY AT MAPLE BAY
ASSUMES: EM. SP. CREST AT ELEV. 892.25
PR. SP. CREST AT ELEV. 891.25
AND ELEV. 891.75
LAKE LEVEL - CREST ELEV. 891.75
LAKE LEVEL - CREST ELEV. 891.25
DISCHARGE - CREST ELEV. 891.75
DISCHARGE - CREST ELEV. 891.25
MAX. LAKE ELEVATION (NGVD)
PEAK DISCHARGE (1000 CFS)
SADDLE SPILLWAY WIDTH (100 FT.)
PMF
50% PMF
25% PMF
100-YR
899
898
897
896
895
894
893
892
35
30
25
20
15
10
5
0
0
4
8
12
16
20

EXHIBIT 17

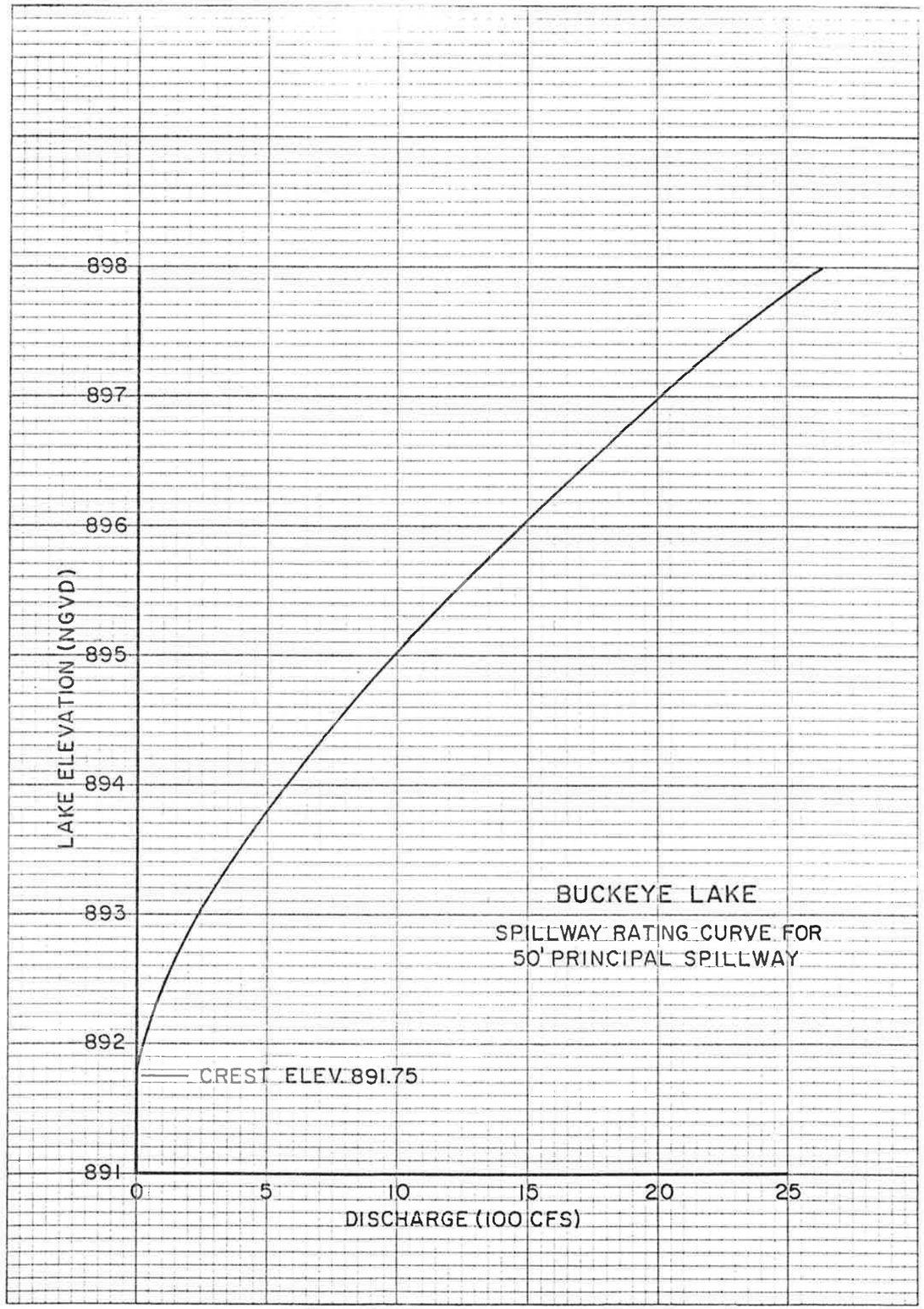

BUCKEYE LAKE
SPILLWAY RATING CURVE FOR
50' PRINCIPAL SPILLWAY
CREST ELEV. 891.75
LAKE ELEVATION (NGVD)
898
897
896
895
894
893
892
891
0
5
10
15
20
25
DISCHARGE (100 CFS)

EXHIBIT 18

Gate Operating Schedule and Associated Discharges

Lake Elevation (NGVD)	2 Gates Gate Op. (ft)/ Q(cfs)	4 Gates Gate Op. (ft)/ Q(cfs)	6 Gates Gate Op. (ft)/ Q(cfs)	8 Gates Gate Op. (ft)/ Q(cfs)	10 Gates Gate Op. (ft)/ Q(cfs)
892.5	Pr. Spillway	Pr. Spillway	Pr. Spillway	Pr. Spillway	Pr. Spillway
892.51-892.75	1 gate op. 2.0' 980 - 1000	1 gate op. 2.0' 980 - 1000	1 gate op. 2.0' 980 - 1000	1 gate op. 2.0' 980 - 1000	1 gate op. 2.0' 980 - 1000
892.76-893.0	1 gate op. 3.5' 1630 - 1670	1 gate op. 3.5' 1630 - 1670	1 gate op. 3.5' 1630 - 1670	1 gate op. 3.5' 1630 1670	1 gate op. 3.5' 1630 - 1670
893.01-893.5	2 gates op. 3.5' 3340 - 3490	2 gates op. 3.5' 3340 - 3490	2 gates op. 3.5' 3340 - 3490	2 gates op. 3.5' 3340 - 3490	2 gates op. 3.5' 3340 - 3490
893.51-894.0	2 gates op. 6.0' 5210 - 5510	3 gates op. 4.0' 5850 - 6110	3 gates op. 4.0' 5850 - 6110	3 gates op. 5.0' 6930 - 7280	4 gates op. 4.0' 8150 - 8480
894.01-894.5	2 gates fully op. 6310 - 6900	4 gates op. 5.0' 9710 - 10150	5 gates op. 5.0' 12140 - 12690	6 gates op. 5.0' 14750 - 15230	7 gates op. 5.0' 17000 - 17770
894.51-895.0	2 gates fully op. 6900 - 7520	4 gates op. 7.0' 13470 - 14710	6 gates op. 7.0' 18090 - 20190	8 gates op. 7.0' 25580 - 26920	10 gates op. 7.0' 31970 - 33650
895.01	2 gates fully op. 7530	4 gates fully op. 15060	6 gates fully op. 22590	8 gates fully op. 30120	10 gates fully op. 37650
896.0	2 gates fully op. 8800	4 gates fully op. 17630	6 gates fully op. 26410	8 gates fully op. 35220	10 gates fully op. 44020
897.0	2 gates fully op. 10160	4 gates fully op. 20310	6 gates fully op. 30470	8 gates fully op. 40630	10 gates fully op. 50780
898.0	2 gates fully op. 11570	4 gates fully op. 23150	6 gates fully op. 34720	8 gates fully op. 46290	10 gates fully op. 57860

EXHIBIT 19

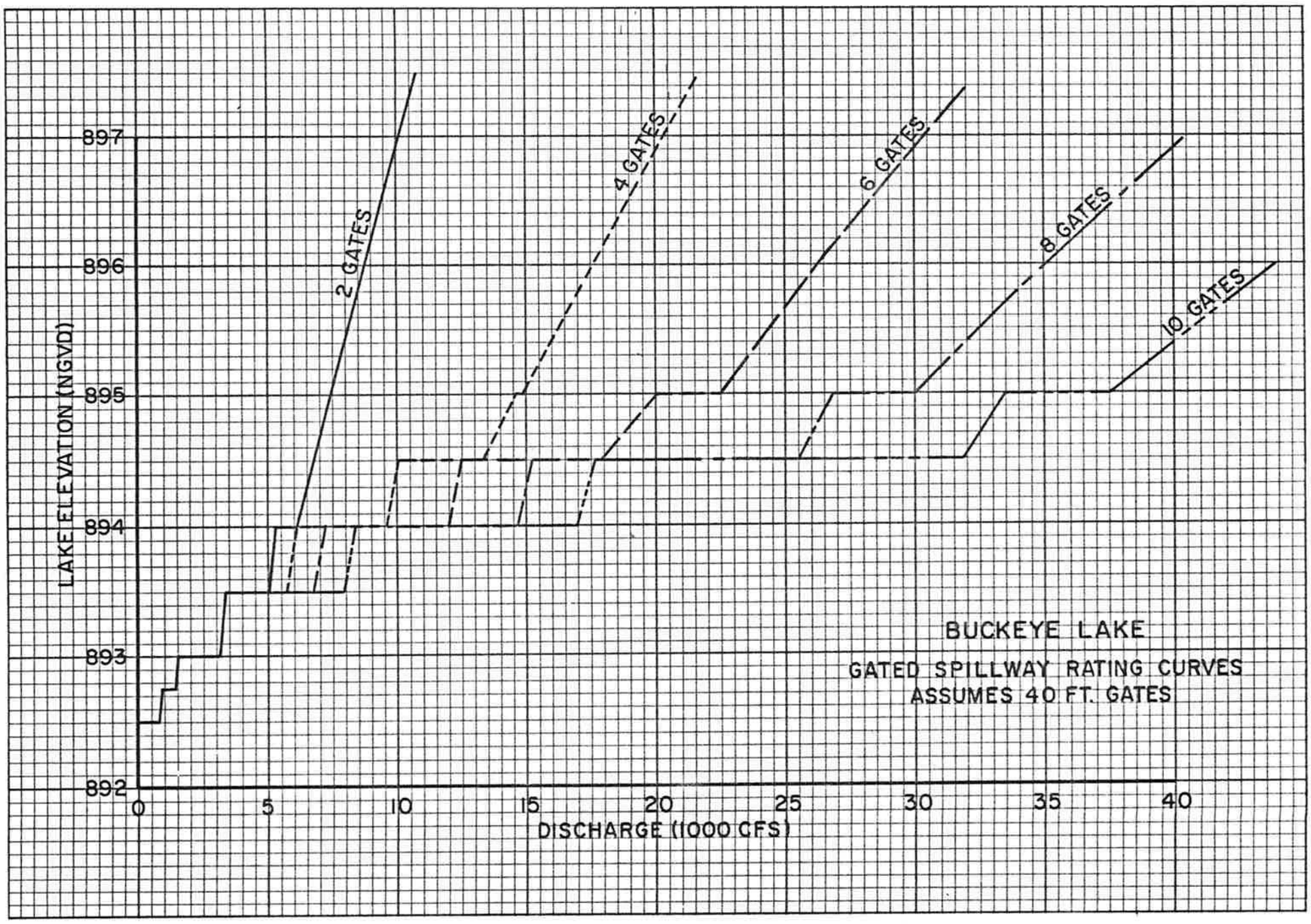

BUCKEYE LAKE
GATED SPILLWAY RATING CURVES
ASSUMES 40 FT. GATES
2 GATES
4 GATES
6 GATES
8 GATES
10 GATES
LAKE ELEVATION (NGVD)
897
896
895
894
893
892
0
5
10
15
20
25
30
35
40
DISCHARGE (1000 CFS)

EXHIBIT 20

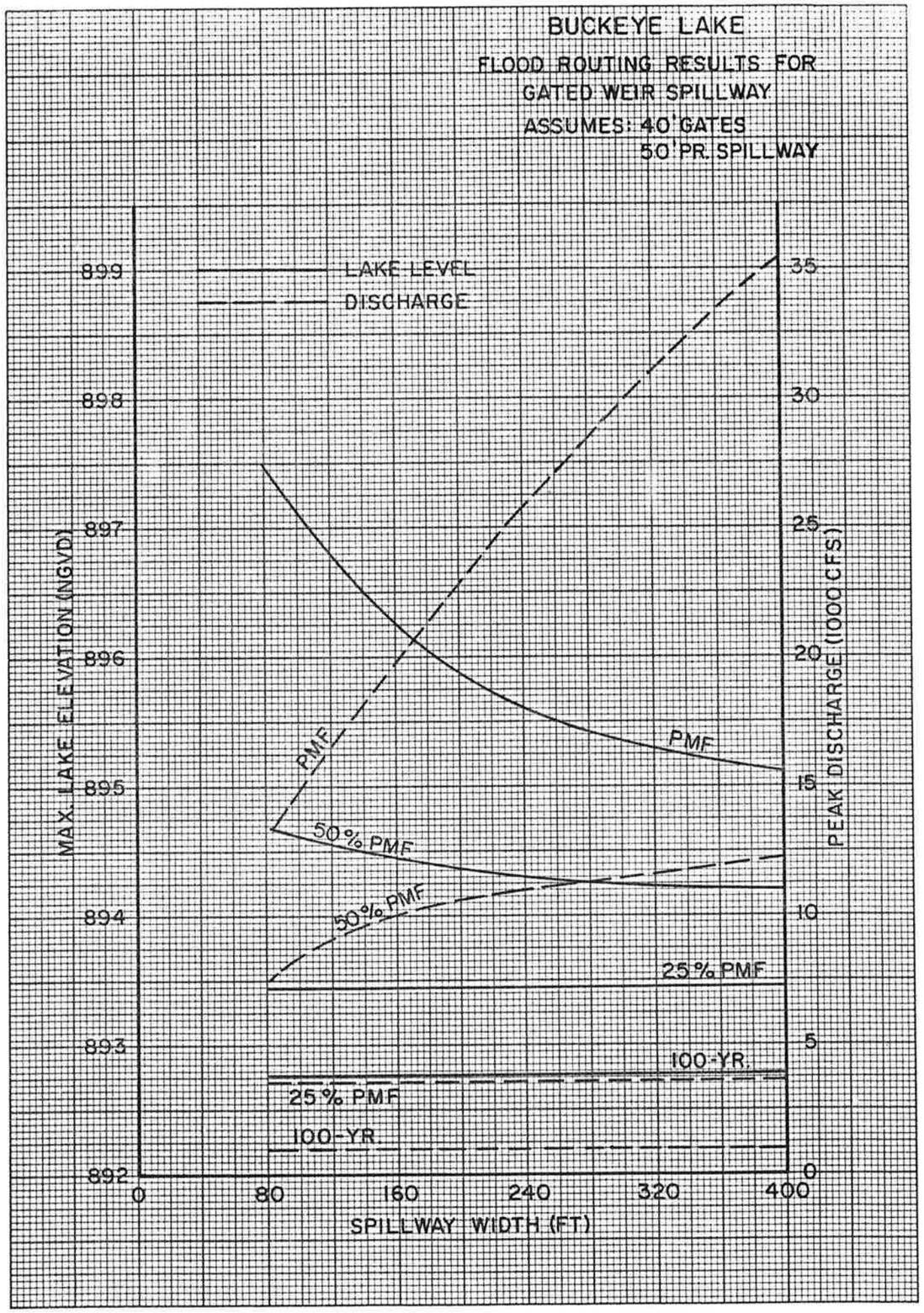

BUCKEYE LAKE
FLOOD ROUTING RESULTS FOR
GATED WEIR SPILLWAY
ASSUMES: 40' GATES
50' PR. SPILLWAY
LAKE LEVEL
DISCHARGE
MAX. LAKE ELEVATION (NGVD)
899
898
897
896
895
894
893
892
PEAK DISCHARGE (1000 CFS)
35
30
25
20
15
10
5
0
PMF
PMF
50% PMF
50% PMF
25% PMF
100-YR.
25% PMF
100-YR.
0
80
160
240
320
400
SPILLWAY WIDTH (FT.)

EXHIBIT 21

DLA FORM I

EXHIBIT 22

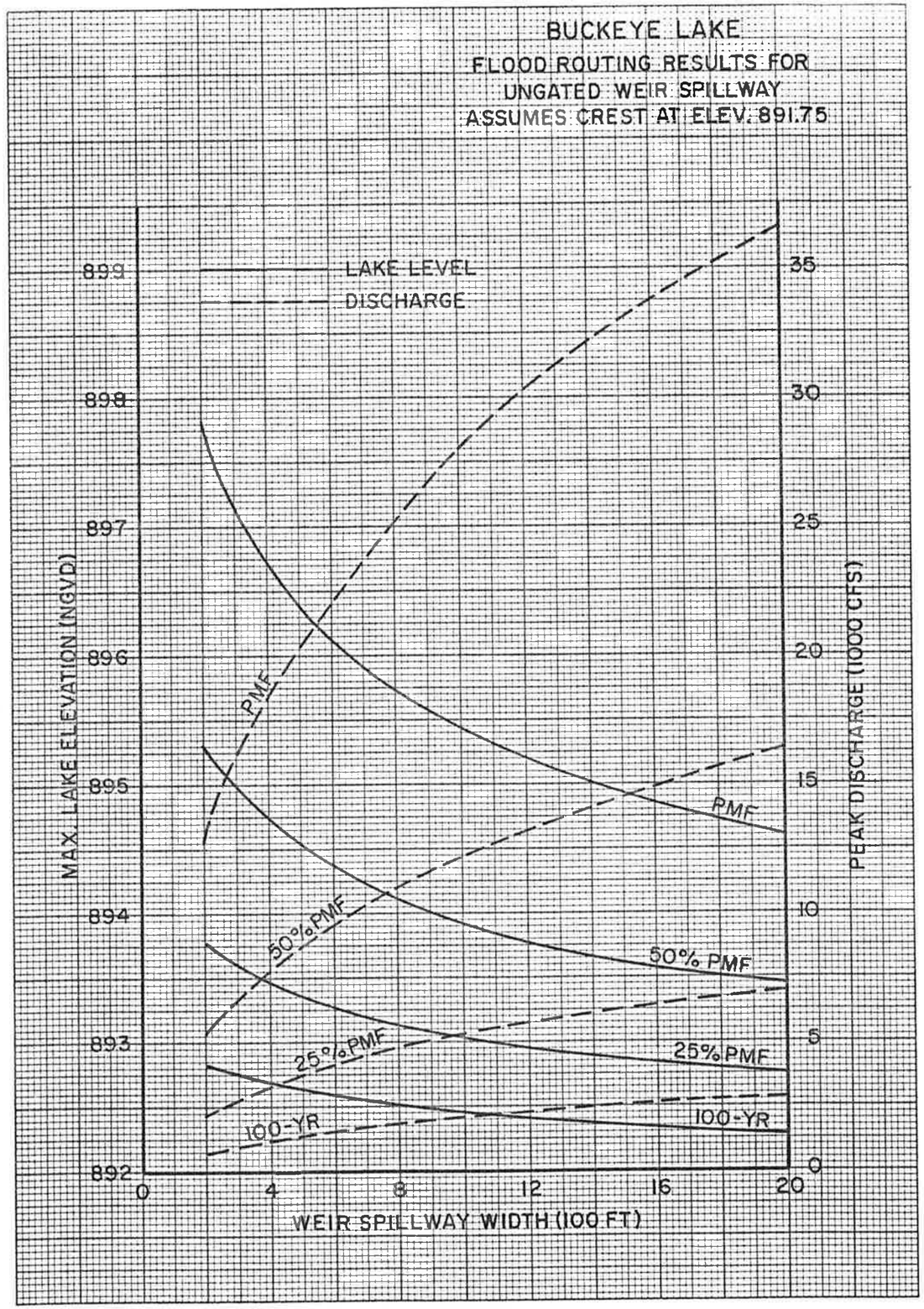
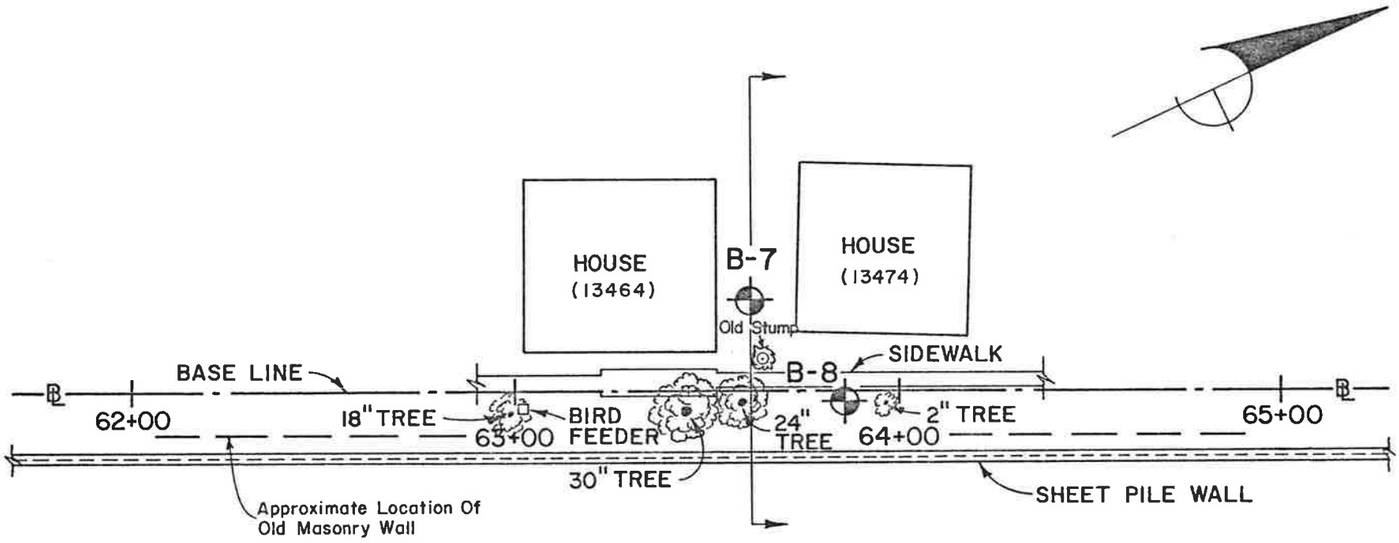

BUCKEYE LAKE
FLOOD ROUTING RESULTS FOR
UNGATED WEIR SPILLWAY
ASSUMES CREST AT ELEV. 891.75
LAKE LEVEL
DISCHARGE
MAX. LAKE ELEVATION (NGVD)
899
898
897
896
895
894
893
892
PEAK DISCHARGE (1000 CFS)
35
30
25
20
15
10
5
0
PMF
PMF
50% PMF
50% PMF
25% PMF
25% PMF
100-YR
100-YR
0
4
8
12
16
20
WEIR SPILLWAY WIDTH (100 FT)

EXHIBIT 23

Estimated Major Unit Construction Costs

Bridges - I-70	$2400/ft.
Other	$2000/ft.
Spillway Outlet Channel Excavation	$3/yd^3
South Fork Licking River Channel Excavation	$5/yd^3
Property	$50,000/house $1,000/acre
50 Ft. Principal Spillway, including demolition of existing structure	$500,000
Ungated Concrete Gravity Weir Structure	$4,000/ft
Gated Concrete Gravity Weir Structure	$165,000/40' gate length
Taintor Gates & Operating Machinery (40-ft gates)	$150,000/gate
Increasing height of embankment (concrete wall)	
to elev. 895.0 : 9000' @ $18/ft	$160,000
895.5 : 18000' @ $20/ft	$360,000
896.0 : 21000' @ $22/ft	$460,000
896.5 : 21000' @ $24/ft	$500,000
Engineering Design and Construction Supervision	$500,000

EXHIBIT 24



BUCKEYE LAKE

SECTION 2

SCALE: 1"= 40'

EXHIBIT 25
SHEET 1 of 2

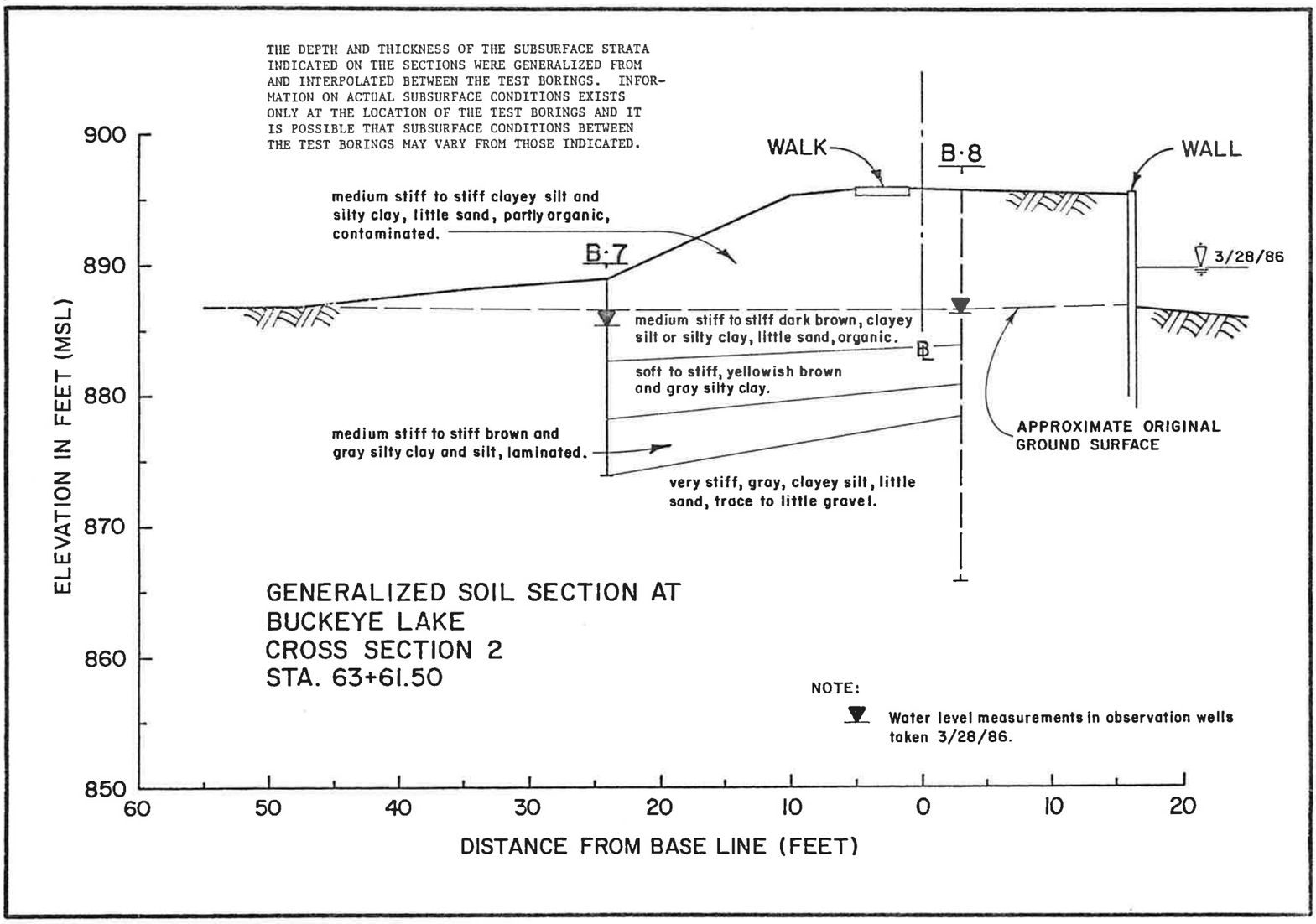
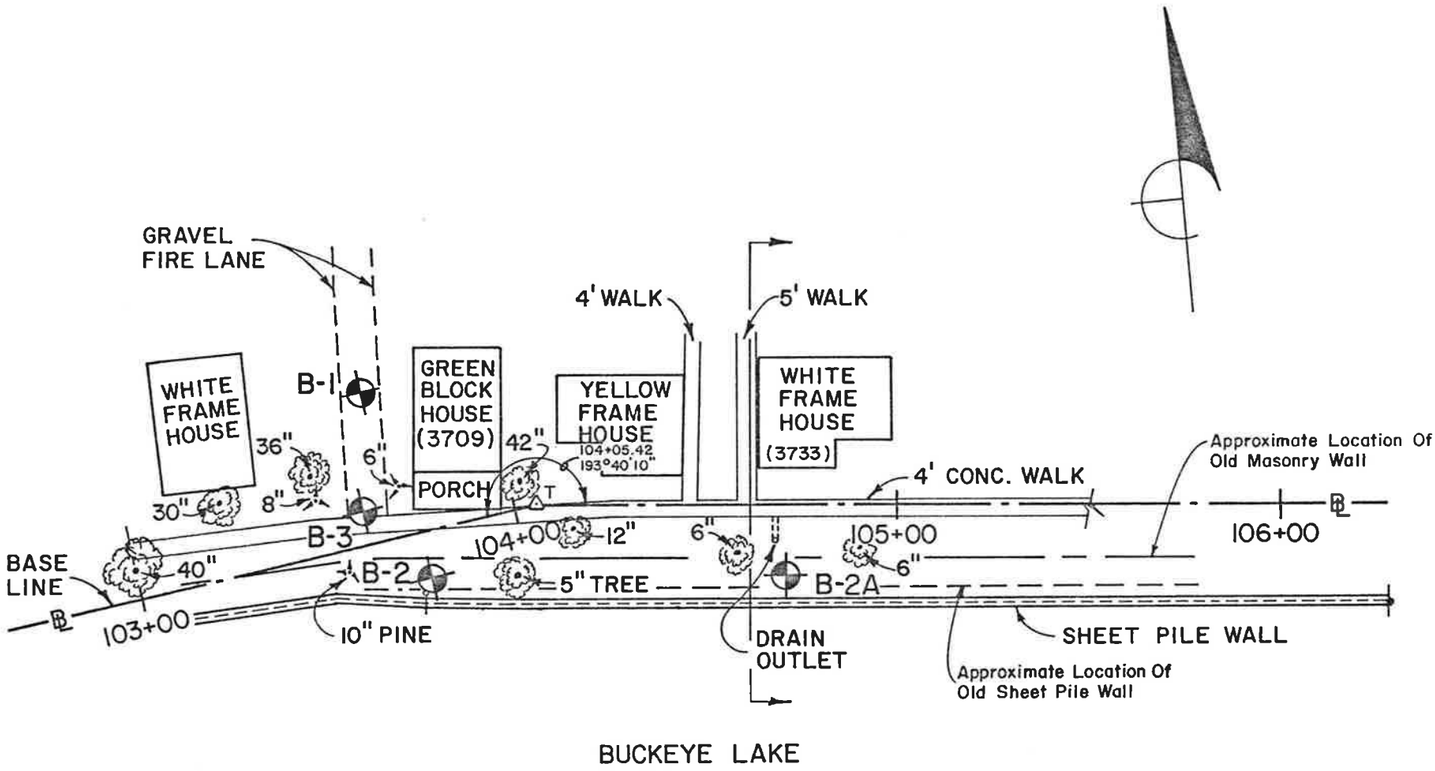


EXHIBIT 25
SHEET 2 of 2



SECTION 3

SCALE: 1"= 40'

EXHIBIT 26
SHEET 1 of 2

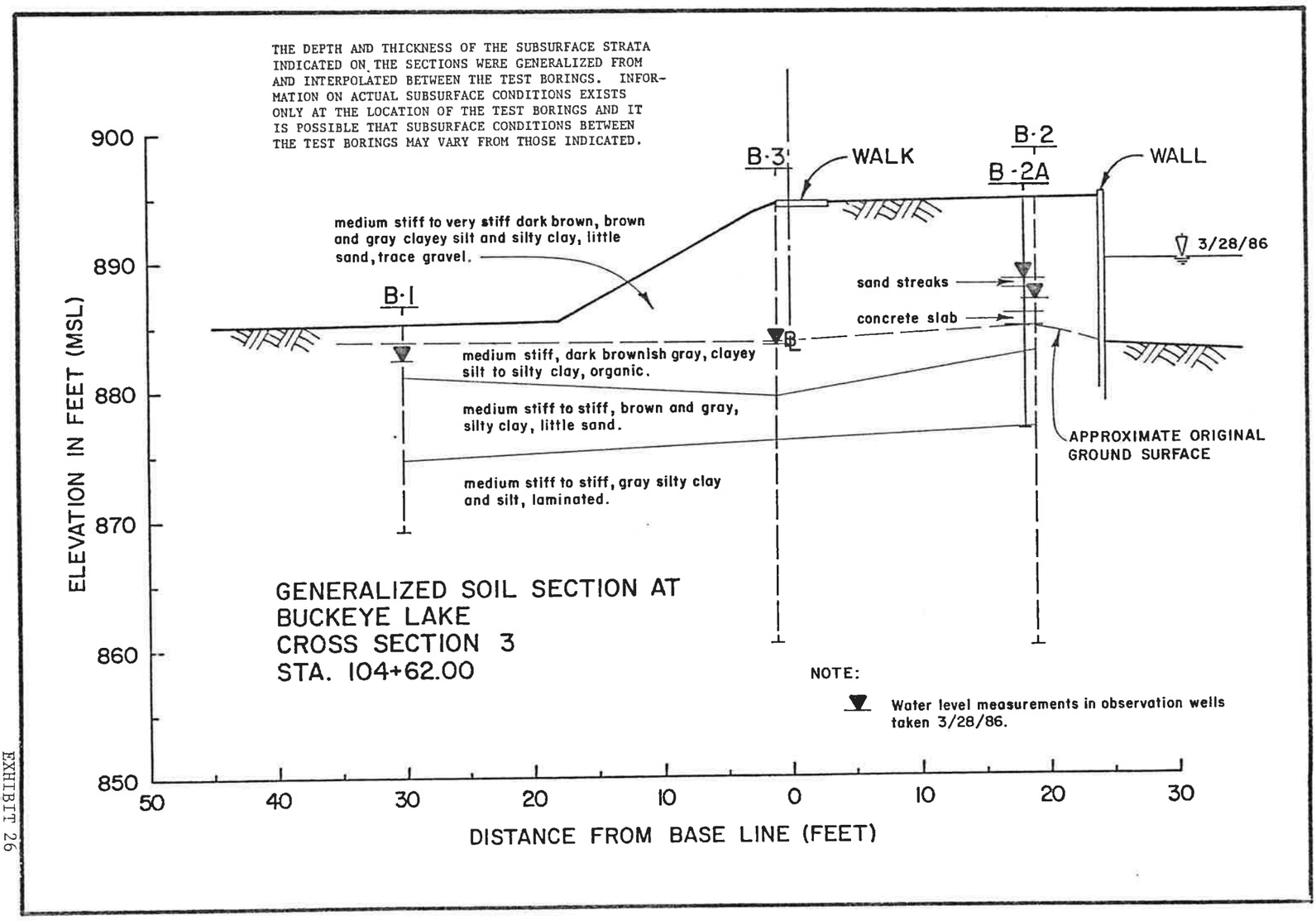
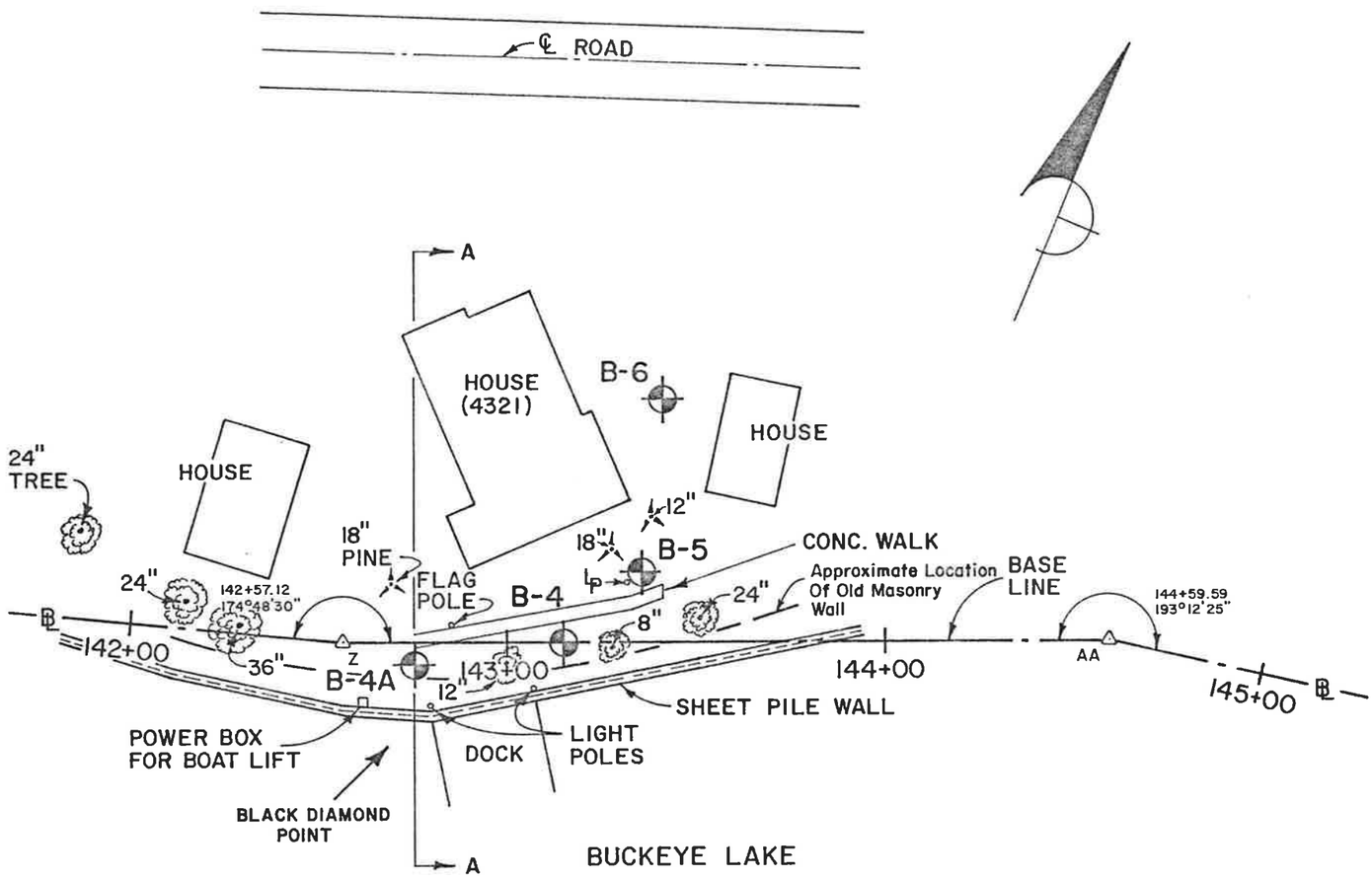


EXHIBIT 26
SHEET 2 of 2



SECTION 4

SCALE: 1" = 40'

EXHIBIT 27
SHEET 1 of 2

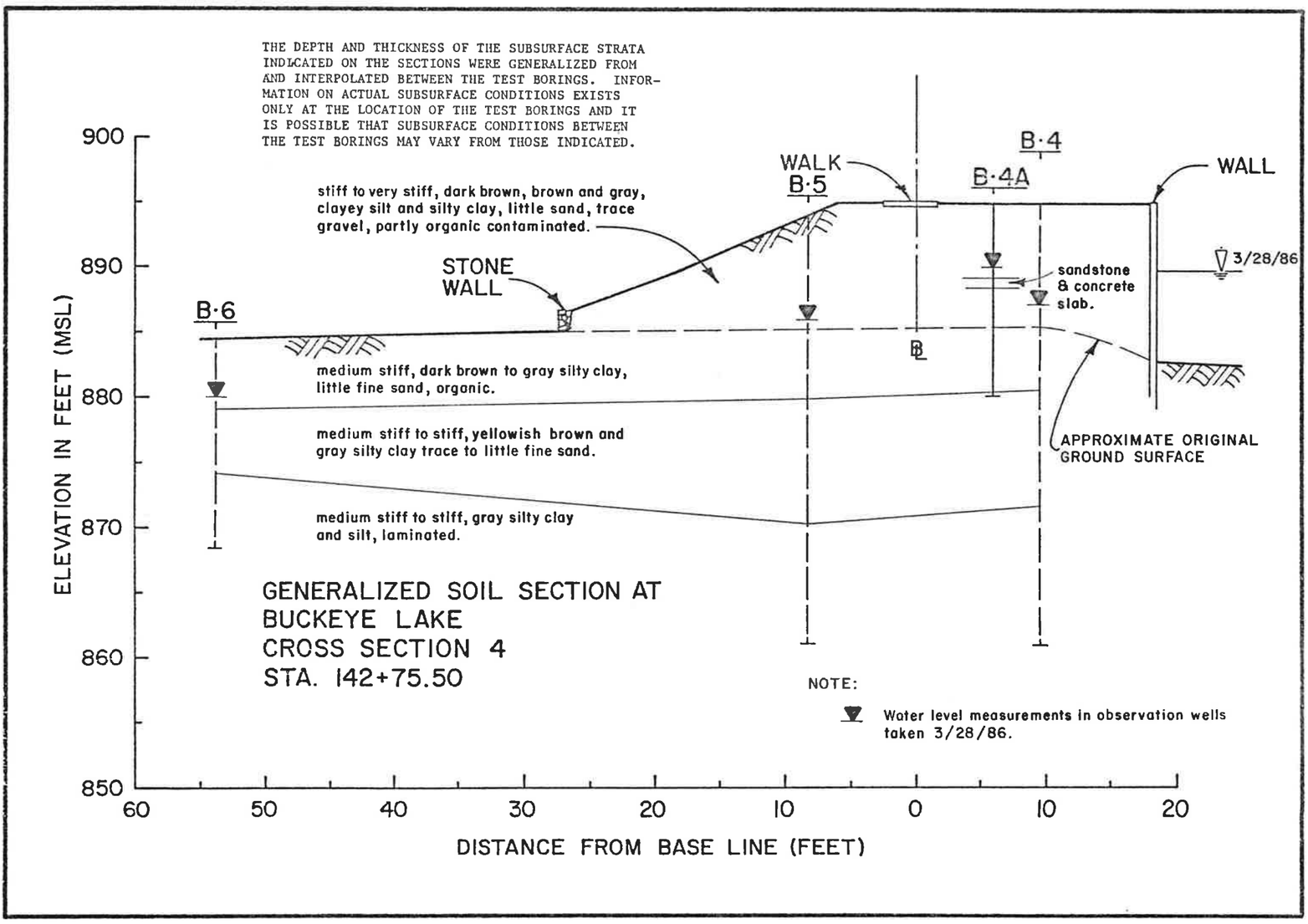


EXHIBIT 27
SHEET 2 of 2

Client: Ohio Department of Natural Resources	Project: Buckeye Lake Dam	M,[redacted]V 807 Job No.

WATER LEVEL MEASUREMENTS

		OBSERVATION WELLS										POOL LEVEL
		B-1	B-2	B-2A	B-3	B-4	B-4A	B-5	B-6	B-7	B-8	
Depth of Well (ft.)		20.0	35.0	15.0	34.0	32.0	15.0	33.2	14.7	14.7	30.0	
Ground Surface Elevation (ft.)		890.0	894.8	894.8	894.8	895.1	895.1	895.0	883.4	889.0	896.0	
Water Level (feet) (Depth/Elevation)	Date											
	1-16-86	12.0/ 878.0	9.5/ 885.3	7.0/ 887.8	12.0/ 882.8	9.7/ 885.4	5.8/ 889.3	11.0/ 884.0	3.7/ 879.7	5.0/ 884.0	14.2/ 881.8	889.5
	2- 5-86	6.1/ 883.9	7.3/ 887.5	5.9/ 888.9	10.0/ 884.8	8.0/ 887.1	4.8/ 890.3	9.1/ 885.9	1.7/ 881.7	-	9.0/ 887.0	889.9
	3-28-86	7.4/ 882.6	8.0/ 886.8	6.2/ 888.6	11.4/ 883.4	8.3/ 886.8	5.0/ 890.1	9.4/ 885.6	3.2/ 880.2	3.4/ 885.6	9.9/ 886.7	890.4
	5-10-86	7.6/ 882.4	8.0/ 886.8	6.0/ 888.8	11.2/ 883.6	8.0/ 887.1	5.0/ 890.1	9.3/ 885.7	3.4/ 880.0	3.4/ 885.6	9.9/ 886.7	890.3

EXHIBIT 28

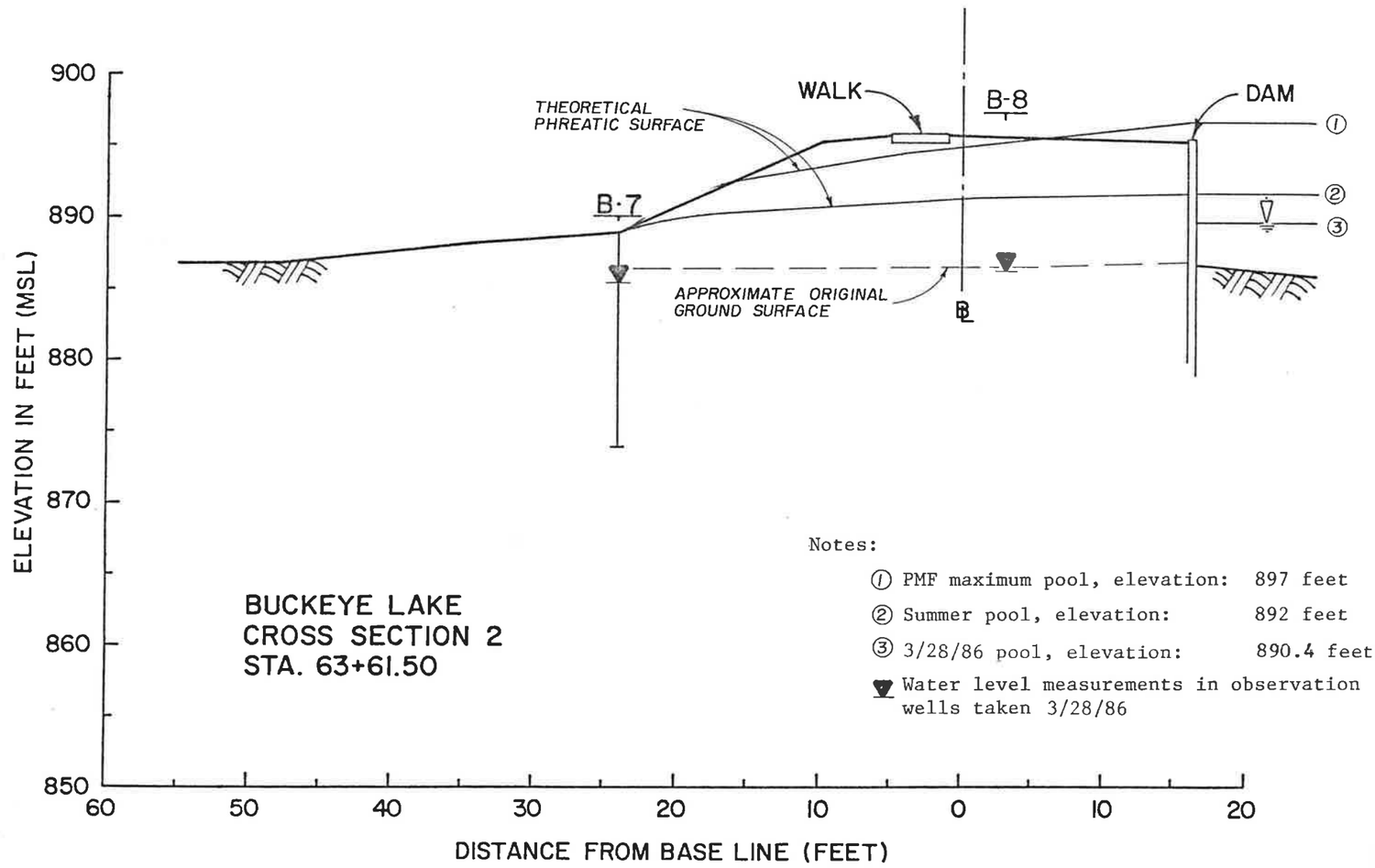


EXHIBIT 29
SHEET 1 of 3

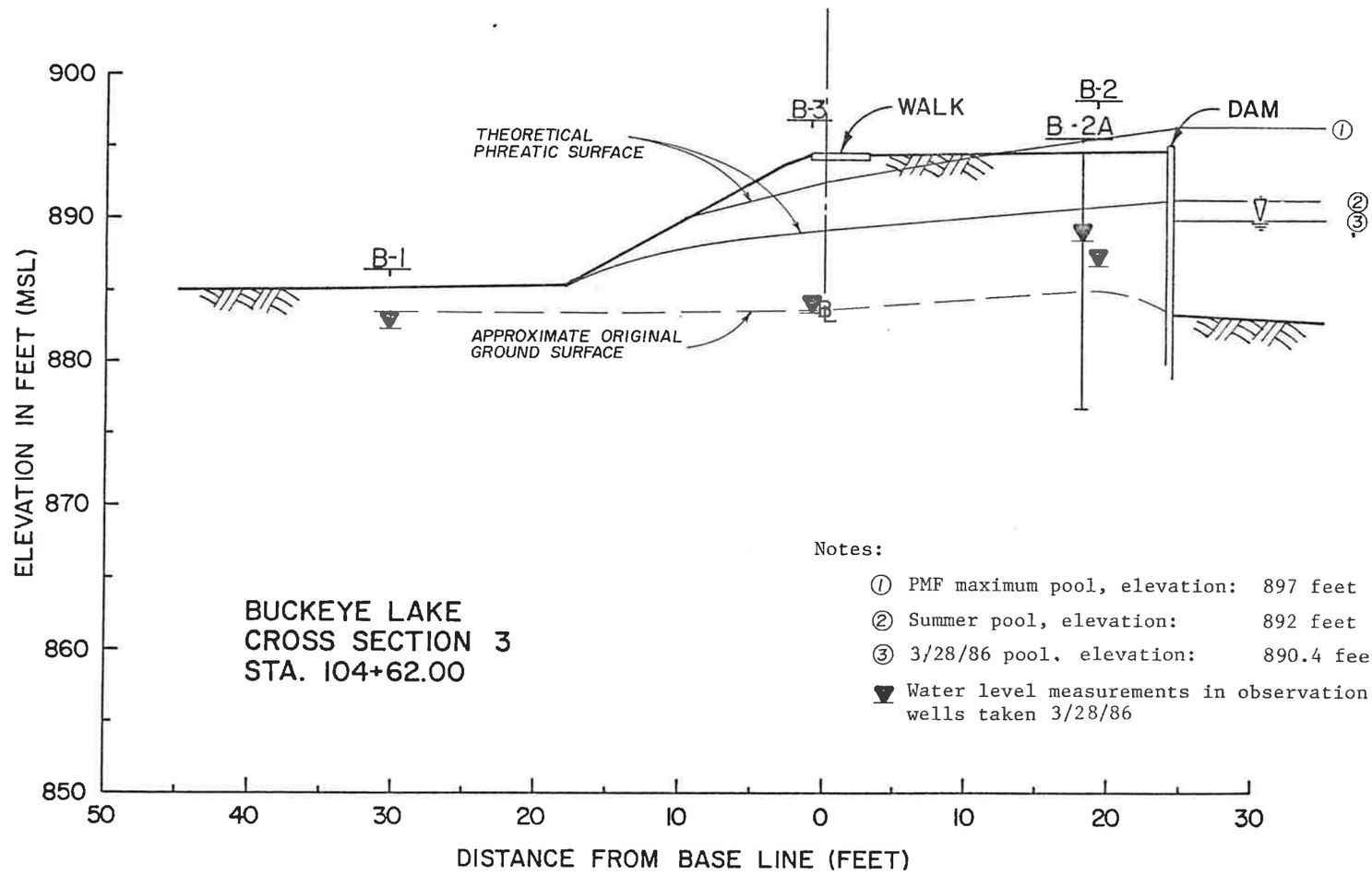


EXHIBIT 29
SHEET 2 of 3

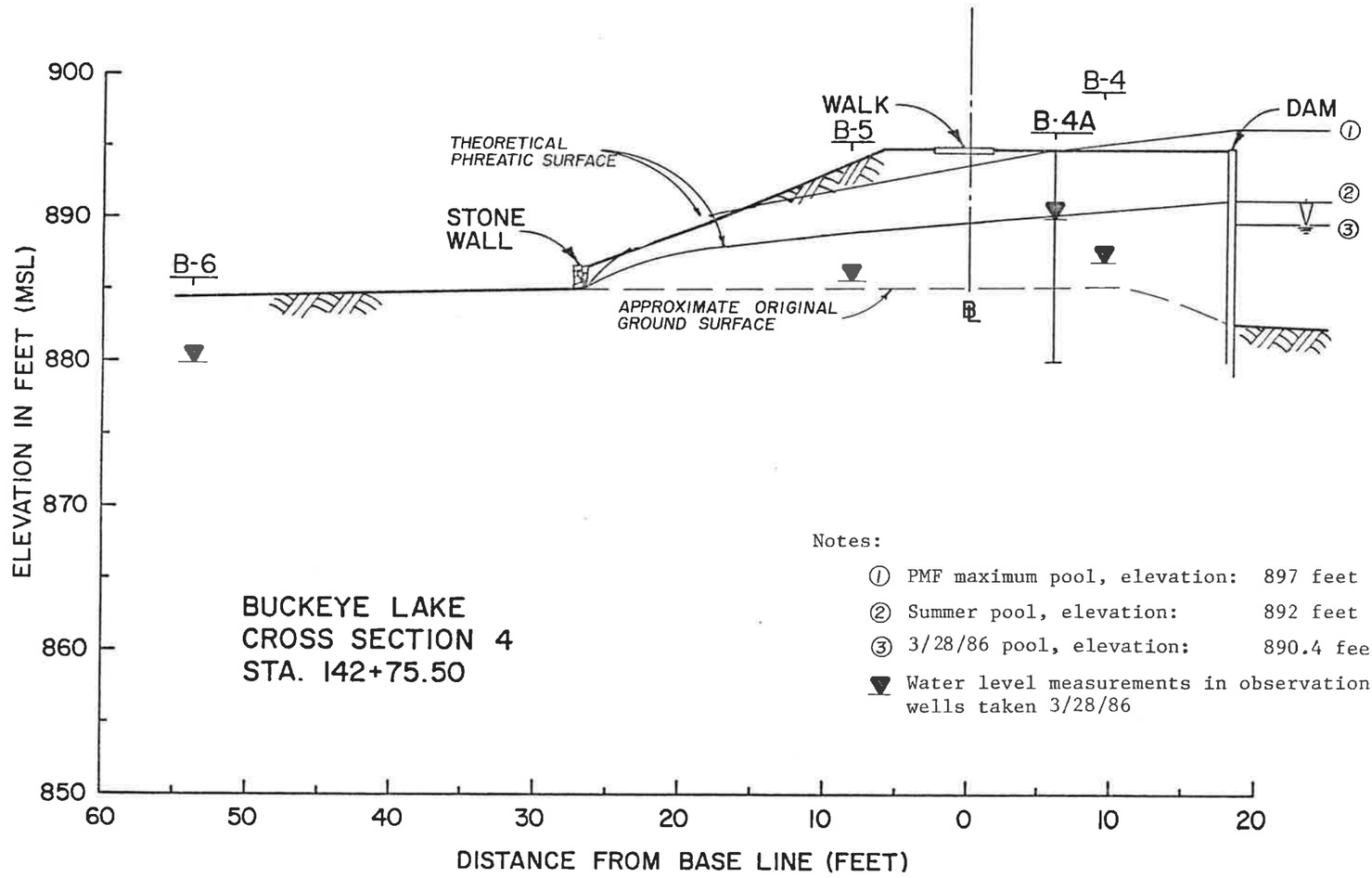


EXHIBIT 29
SHEET 3 of 3

APPENDIX II

PHOTOGRAPHS

Photograph 1 - View of embankment just west of spillway.

Photograph 2 - View of embankment near Black Diamond Point.

Photograph 3 - View of embankment near soil boring section 3. Note cantilevered boat docks extending from embankment.

Photograph 4 - View along crest of embankment near soil boring section 3. Note embankment drain and outlet through sheet pile wall near center of photograph.

Photograph 5 - View of embankment just southwest of Mud Island. Note boat storage shelter built into embankment and condition of masonry wall.

Photograph 6 - View of embankment southwest of Mud Island. Note drain pipe extending through masonry wall.

Photograph 7 - View of upstream face of spillway. Note condition of slope protection wall along left side of approach channel.

Photograph 8 - View of downstream face of spillway.

Photograph No. 9 -

View of buttresses along downstream toe of spillway. Note spalling of concrete.

Photograph 10 - Close-up view of portion of upstream face of spillway. Note spalling and broken concrete.

Photograph 11 - View of Kirkersville feeder canal looking downstream from Millersport Road bridge, near entrance of canal to lake.

Photograph 12 - View of Buckeye Lake outlet channel looking downstream from SR 79 bridge.

Photograph 13 - View of Maple Bay near location of possible spillway crest.

Photograph 14 - View of Sellers Point area looking downstream from dry dock.

APPENDIX III

BORING LOGS AND SOIL TEST RESULTS

LEGEND - BORING LOG TERMINOLOGY

Explanation of each column, progressing from left to right.

1. Depth (in feet) - is distance below the ground surface.

2. Elevation (in feet) - is referenced to mean sea level, unless otherwise noted.

3. Standard Penetration (N) - the number of blows required to drive a 2-inch O.D., 1-3/8 inch. I.D., split-spoon sampler, using a 140 pound hammer with a 30-inch free fall, recorded for 6-inch drive increments. Standard penetration resistance is based on total number of blows required for one-foot of penetration.

4. Length of sampler drive is indicated graphically by horizontal lines across the "Standard Penetration" and "Recovery" columns.

5. Recovery from each drive is indicated numerically, in the column headed "Recovery".

6. Drive sample location is designated by the heavy vertical bar in the "Sample No., Drive" column.

7. Length of hydraulically pressing "Undisturbed" sample is indicated graphically by horizontal lines across the "Press" column.

8. Sample numbers are designated consecutively, increasing in depth.

9. Description

   a. Moisture content of cohesive soils (silts and clays) is expressed relative to plastic properties:

Term	Relative Moisture or Appearance
Dry	Powdery
Damp	Moisture content slightly below plastic limit
Moist	Moisture content above plastic limit, but below liquid limit
Wet	Moisture content above liquid limit

   b. Moisture content of cohesionless soils (sands and gravels) is described as follows:

Term	Relative Moisture of Appearance
Dry	No moisture present
Damp	Internal moisture, but none to little surface moisture
Moist	Free water on surface
Saturated	Voids filled with free water

   c. Texture is based on the Unified Classification System. Soil particle size definitions are as follows:

Description	Size	Description	Size
Boulders	Larger than 8"	Sand - Coarse	4.76 mm. to 2.00 mm.
Cobbles	8" to 3"	- Medium	2.00 mm. to 0.42 mm.
Gravel - Coarse	3" to 3/4"	- Fine	0.42 mm. to 0.074 mm.
- Fine	3/4" to 4.76 mm.	Silt	0.074 mm. to 0.005 mm.
		Clay	Smaller than 0.005 mm.

LEGEND (Continued)

d. Main soil descriptions are listed in order of increasing percentage of particle size and/or general behavior of soil based on plasticity characteristics.

e. Modifiers to main soil descriptions are indicated as a percentage of particle sizes:

trace - 0 to 10
little - 10 to 20
some - 20 to 35
and - 35 to 50

f. Color - If a soil is uniform color throughout, the term is single, modified by such adjectives as light and dark. If the predominant color is shaded by a secondary color, the secondary color precedes the primary color separated by a hyphen. If two major and distinct colors are swirled throughout the soil, the colors are modified by the term "mottled".

10. Gradation - when tests are performed, the percentage of each particle size is listed in the indicated column (defined in Item 9c.).

11. Moisture content is indicated graphically when test is performed for natural moisture content, liquid limit moisture content or plastic limit moisture content.

The following terms are used to describe the relative compactness and consistency of soils:

Granular Soils - Compactness

Term	Blows/Foot Standard Penetration
Very loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	over 50

Cohesive Soils - Consistency

Term	Unconfined Compression tons/sq.ft.	Blows/Foot Standard Penetration	Hand Manipulation
Very Soft	less than 0.25	below 2	Easily penetrated by fist
Soft	0.25 - 0.50	2 - 4	Easily penetrated by thumb
Medium Stiff	0.50 - 1.00	4 - 8	Penetrated by thumb with moderate effort
Stiff	1.0 - 2.0	8 - 15	Readily indented by thumb, but not penetrated
Very Stiff	2.0 - 4.0	15 - 30	Readily indented by thumb nail
Hard	over 4.0	over 30	Indented with difficulty with thumb nail

MASON - deVERTEUIL GEOTECHNICAL SERVICES, 60? 'UNTLEY ROAD, COLUMBUS, OHIO 43229, 614/888-0576

Client: The Ohio Department of Natural Resources | Project: Buckeye Lake Dam | M-V Job No. 807

BORING LOG

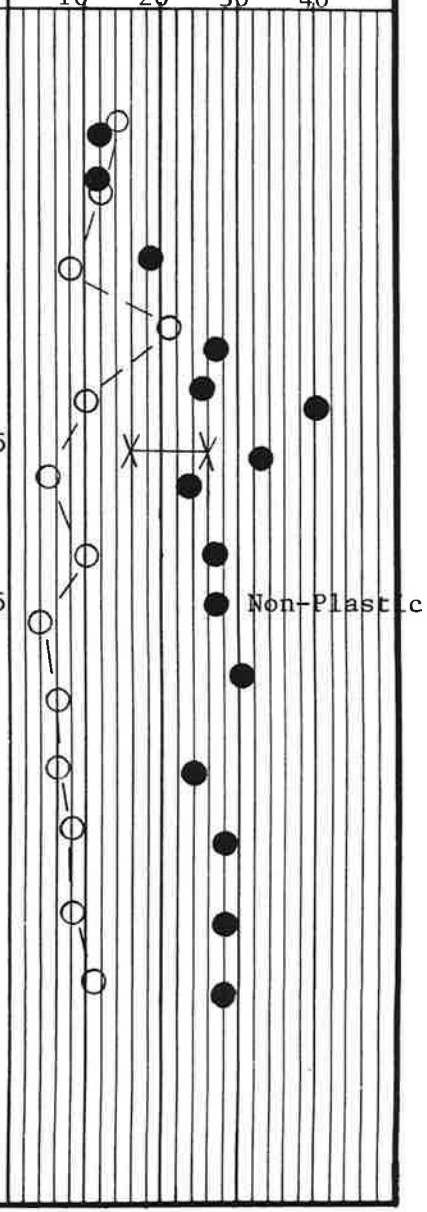
Boring No. 1 | Location: Station 103 + 68, 38.5' Left | Date Drilled: 1-9-86

WATER OBSERVATIONS: Water seepage at: 8.4', 8.6' (trace), 9.5', 11.0, 19.9'
Water level at completion: None
Drilling Water level at completion:

DEPTH in feet	ELEVATION in feet	PENETRATION Blows per 6"	RECOVERY in inches	SAMPLE NO. DRIVE	SAMPLE NO. PRESS	DESCRIPTION	Soil Classification	% Agg.	% C.S.	% M.S.	% F.S.	% Silt	% Clay
0	890.0												
		11 7 7	18	1		FILL: Brown, sandy, clayey silt, little gravel. Stiff. Damp to moist							
		5 6 6	10	2									
5		5 5 3	12	3									
5.8						Yellowish brown and dark brown, silty clay, little sand, trace gravel. Very stiff. Moist							
7.0	883.0	6 8 13	14	4 5									
		2 4 6	16	6 7		Dark brownish gray, clayey silt, organic. Stiff. Moist							
8.3						Dark brown, silty clay, little sand, trace gravel, wood fragments, organic. Medium stiff. Very moist		1	4	6	32	32	25
9.5		1 2 3	14	8 9		Gray, silt, some fine sand, little clay. Soft. Wet							
10 10.3		2 4 6	14	10 11		Brownish gray, silt, little fine sand, little clay. Medium stiff. Moist to wet.		0	0	0	21	64	15
		7 1 3	9	12									
		0 3 3	6	13									
15 15.7		0 2 4	18	14		Gray, silty clay and silt, laminated. Medium stiff to stiff. Moist to wet. (Silt and fine sand seam 16.5' to 17.7' and at 19.9' to 20.2')							
		2 3 5	17	15									
		2 3 5	18	16 17									
20		2 6 5	17	18 19									
21.0						Bottom of Boring - 21.0'							

STANDARD PENETRATION (N) Blows per foot ○ 10 20 30 40

MOISTURE CONTENT - % PL Natural LL 10 20 30 40



MASON - deVERTEUIL GEOTECHNICAL SERVICES, 60 HUNTLEY ROAD, COLUMBUS, OHIO 43229, 614/888-0576

Client: The Ohio Department of Natural Resources | Project: Buckeye Lake Dam | M-V Job No. 807

BORING LOG

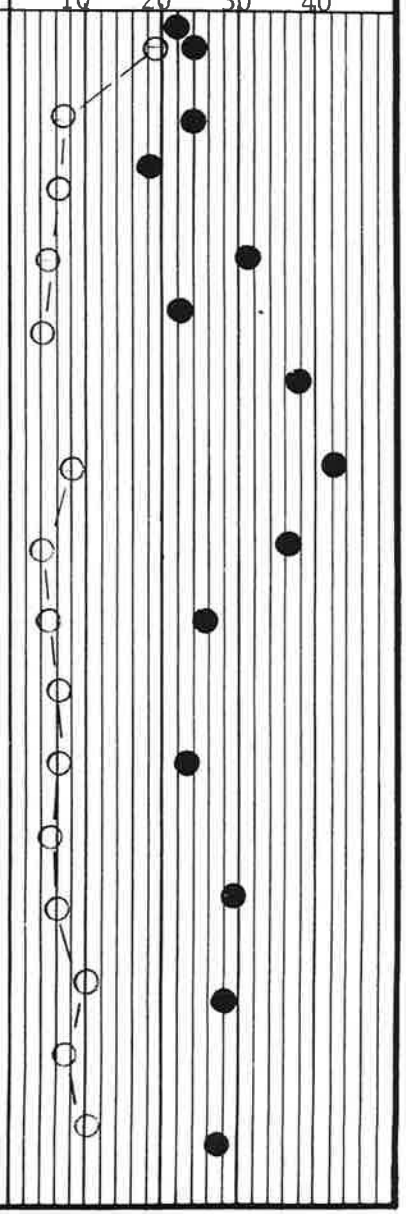
Boring No. 2 | Location: Station 103 + 75.5, 12.5' Right | Date Drilled: 1-8-86

WATER OBSERVATIONS: Water seepage at: 9.0', 16.5' - 18.0'(Slight)
Water level at completion: 24.3'
Drilling Water level at completion:

DEPTH in feet	ELEVATION in feet	PENETRATION Blows per 6"	RECOVERY in inches	SAMPLE NO. DRIVE	SAMPLE NO. PRESS	DESCRIPTION	Soil Classification	GRADATION % Agg.	% C.S.	% M.S.	% F.S.	% Silt	% Clay
0	894.8												
0.4		11 10 9	12	1 2		Topsoil							
1.7		2 3 4	13	3		Dark brown, clayey silt, little sand, organic contaminated. Stiff. Damp.							
3.0		2 3 3	3	4		Brownish gray, silt, little clay, little sand, trace gravel. Medium stiff. Moist							
5		1 2 3	13	5		Yellowish brown and gray, silty clay, little sand, trace gravel. Medium stiff. Moist.							
		1 2 2	6	6		FILL: (Fine sand streaks 7.0' to 7.5')							
7.5		1 27	6	7		Dark brown, silty clay, little sand, organic contaminated. Moist (Drillers note: driving on something hard)							
9.1	885.7												
10		1 3 5	13	8		Dark brownish gray, clayey silt, trace fine sand, organic. Medium stiff. Moist							
		0 2 2	14	9									
12.0		1 2 3	13	10		Dark brown changing to gray, silty clay, little sand. Medium stiff. Moist							
		2 2 4	6	11									
15.0		1 3 3	14	12		Gray, clayey sandy silt. Medium stiff. Moist							
16.5		2 3 2	18	13		Gray, silt, little clay, trace fine sand. Medium stiff. Wet							
18.0		1 3 3	15	14 15		Gray, silty clay and silt, laminated. Medium stiff. Moist to wet							
20		2 5 5	16	16									
		2 3 4	17	17									
		3 5 5		18									
25		3 5	11	19									

STANDARD PENETRATION (N) Blows per foot ○ 10 20 30 40

MOISTURE CONTENT - % PL Natural LL ● 10 20 30 40



MASON - deVERTEUIL GEOTECHNICAL SERVICES, 60' 'UNTLEY ROAD, COLUMBUS, OHIO 43229, 614/888-0576

Client: The Ohio Department of Natural Resources | Project: Buckeye Lake Dam | M-V Job No. 807

BORING LOG

Boring No. 2 | Location: Station 103 + 75.5, 12.5' Right | Date Drilled: 1-8-86

WATER OBSERVATIONS: Water seepage at: 9.0', 16.5' - 18.0' (Slight)
Water level at completion: 24.3'
Drilling Water level at completion:

DEPTH in feet	ELEVATION in feet	PENETRATION Blows per 6"	RECOVERY in inches	SAMPLE NO. DRIVE	SAMPLE NO. PRESS	DESCRIPTION	Soil Classification	% Agg.	% C.S.	% M.S.	% F.S.	% Silt	% Clay
25		6											
		WOR*	9	20		Gray, silty clay and silt, laminated, medium stiff. Moist to wet.							
		0 3 4	10	21									
		2 3 5	13	22									
30		3 3 4	18	23									
		3 3 6	18	24									
33.5		3 5 7	18	25		Gray, clayey silt. Stiff. Moist							
35						Bottom of Boring - 35.0'							

Note: *WOR - Sample spoon driven by weight of rod

STANDARD PENETRATION (N) Blows per foot ○ 10 20 30 40

MOISTURE CONTENT - % PL Natural LL ● 10 20 30 40

MASON - deVERTEUIL GEOTECHNICAL SERVICES, 603 UNTLEY ROAD, COLUMBUS, OHIO 43229, 614/888-0576

Client: The Ohio Department of Natural Resources | Project: Buckeye Lake Dam | M-V Job No. 807

BORING LOG

Boring No. 2A | Location: Station 104 + 71, 17' Right | Date Drilled: 1-16-86

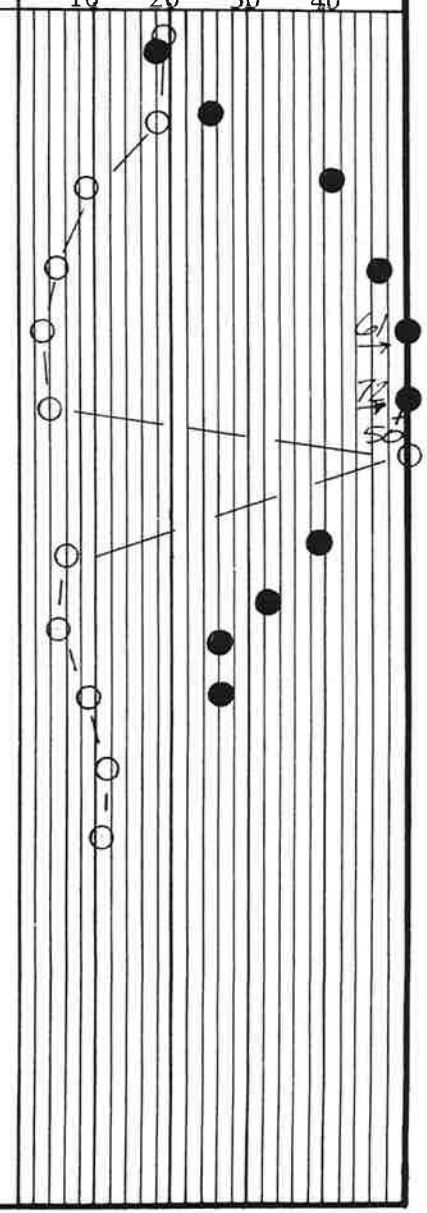
WATER OBSERVATIONS: Water seepage at: 6.5', 8.1'; Water level at completion: 10.8'; Drilling Water level at completion:

DEPTH in feet	ELEVATION in feet	PENETRATION Blows per 6"	RECOVERY in inches	SAMPLE NO. DRIVE	SAMPLE NO. PRESS	DESCRIPTION	Soil Classification	GRADATION % Agg.	% C.S.	% M.S.	% F.S.	% Silt	% Clay
0	894.8												
		12 9 10	16	1		Dark brown, clayey silt, some sand, little gravel, organic contaminated. Stiff. Damp							
1.5		5 8 10	18	2		Dark brown and yellowish brown, silty clay, trace fine sand, organic contaminated. Medium stiff. Moist							
		4 4 5	14	3									
5		2 2 3	12	4		FILL:							
6.5		2 1 2	14	5		(Fine sand seam 6.5' - 6.8')							
8.1		2 2 2	10	6		Dark brown, silty clay, trace sand, organic contaminated. Soft. Wet							
9.0		50⓪				Yellowish brown, fine sand, little silt. Loose. Wet							
10	884.3					Drillers Note: Concrete slab 9.0' to 10.5'							
10.5		2 2 4	18	7		Dark brownish gray, silty clay, trace fine sand. Medium stiff. Moist							
12.4		1 2 3	18	8 9		Gray and yellowish brown, silty clay, little fine sand. Stiff. Moist.							
		1 4 5	17	10									
15		3 4 7	15	11									
16.5		2 4 7	14	12		Gray and yellowish brown, silty clay and silt, laminated. Stiff. Moist.							
18.0						Bottom of Boring - 18.0'							

Note: 50⓪ - 50 blows for 0.0' penetration

STANDARD PENETRATION (N) Blows per foot ○ 10 20 30 40

MOISTURE CONTENT - % PL Natural LL 10 20 30 40



MASON - deVERTEUIL GEOTECHNICAL SERVICES, 60? 'UNTLEY ROAD, COLUMBUS, OHIO 43229, 614/888-0576

Client: The Ohio Department of Natural Resources | Project: Buckeye Lake Dam | M-V Job No. 807

BORING LOG

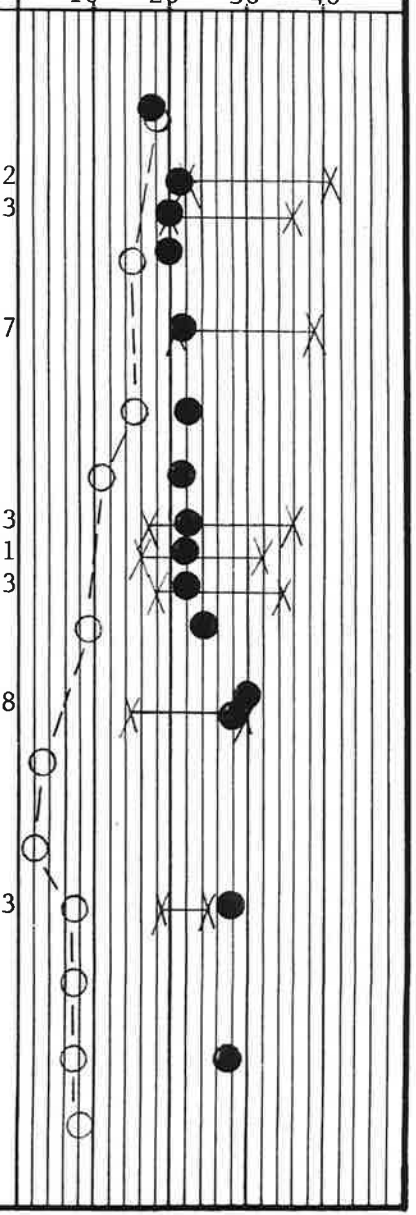
Boring No. 3 | Location: Station 103 + 61.5, 9.0' Left | Date Drilled: 1-10-86

WATER OBSERVATIONS: Water seepage at: 10.8', 13.5', 23.8'
Water level at completion: 16.0'
Drilling Water level at completion:

DEPTH in feet	ELEVATION in feet	PENETRATION Blows per 6"	RECOVERY in inches	SAMPLE NO. DRIVE	SAMPLE NO. PRESS	DESCRIPTION	Soil Classification	% Agg.	% C.S.	% M.S.	% F.S.	% Silt	% Clay
0	894.8												
		3 7 11	13	1		Yellowish brown, clayey silt, little sand, trace gravel, very stiff. Damp							
3.0					1	Brown and gray silty clay, little sand, trace gravel somewhat organic contaminated.		0	1	2	15	40	42
								0	1	4	20	32	43
5		3 6 9	14	2		Stiff to very stiff. Moist to damp. FILL:							
					2			3	3	5	16	36	37
		4 6 9	18	3									
		4 5 6	14	4									
10													
10.8	884.0					(Sand lens @ 10.8')							
					3	Brown and gray, silty clay, some fine to coarse sand, trace gravel, organic contaminated in part. Medium to stiff. Moist to wet.		2	6	6	20	33	33
								1	2	7	25	33	31
		2 3 6	16	5				1	3	7	22	34	33
					4			6	6	7	22	31	28
15.0													
		1 1 2	18	6		Gray, silty clay and silt, laminated. Soft to medium stiff. Moist to wet.							
		0 1 1	0			(Fine sand streaks and seams 19.5' to 24.0')							
		1 2 5	18	7				0	0	0	1	66	33
20		1 3 4	16	8									
		1 3 4	17	9									
		2 3 5	18	10									
25		2 3											

STANDARD PENETRATION (N) Blows per foot ○ 10 20 30 40

MOISTURE CONTENT - % PL Natural LL ✕ ● ✕ 10 20 30 40



MASON - deVERTEUIL GEOTECHNICAL SERVICES, 60' 'UNTLEY ROAD, COLUMBUS, OHIO 43229, 614/888-0576

Client: The Ohio Department of Natural Resources | Project: Buckeye Lake Dam | M-V Job No. 807

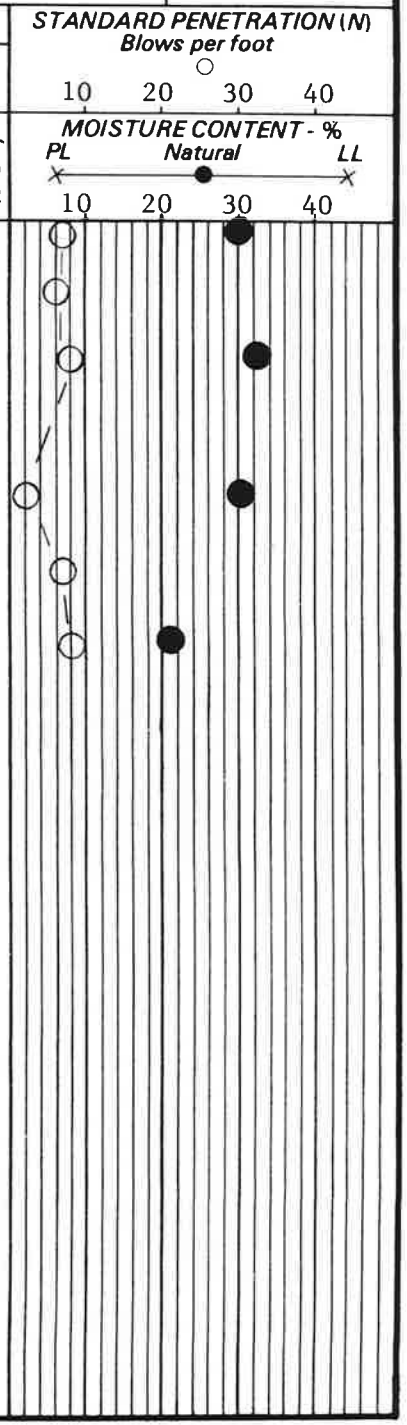
BORING LOG

Boring No. 3 | Location: Station 103 + 61.5, 9.0' Left | Date Drilled:

WATER OBSERVATIONS: Water seepage at: 10.8', 13.5', 23,8'
Water level at completion: 16.0'
Drilling Water level at completion:

DEPTH in feet	ELEVATION in feet	PENETRATION Blows per 6"	RECOVERY in inches	SAMPLE NO. DRIVE	SAMPLE NO. PRESS	DESCRIPTION	Soil Classification	% Agg.	% C.S.	% M.S.	% F.S.	% Silt	% Clay
25		4	18	11									
		1 2 4	17	12		Gray, silty clay and silt, laminated. Soft to medium stiff. Moist							
		1 3 5	15	13									
		W O R *	6	14									
30		0 1 1	8	15									
		2 3 4	12	16									
		2 4 4	14	17									
34.5						Bottom of Boring - 34.5'							

Note: *Sampler driven by weight of rods



MASON - deVERTEUIL GEOTECHNICAL SERVICES, 603 UNTLEY ROAD, COLUMBUS, OHIO 43229, 614/888-0576

Client: The Ohio Department of Natural Resources | Project: Buckeye Lake Dam | M-V Job No. 807

BORING LOG

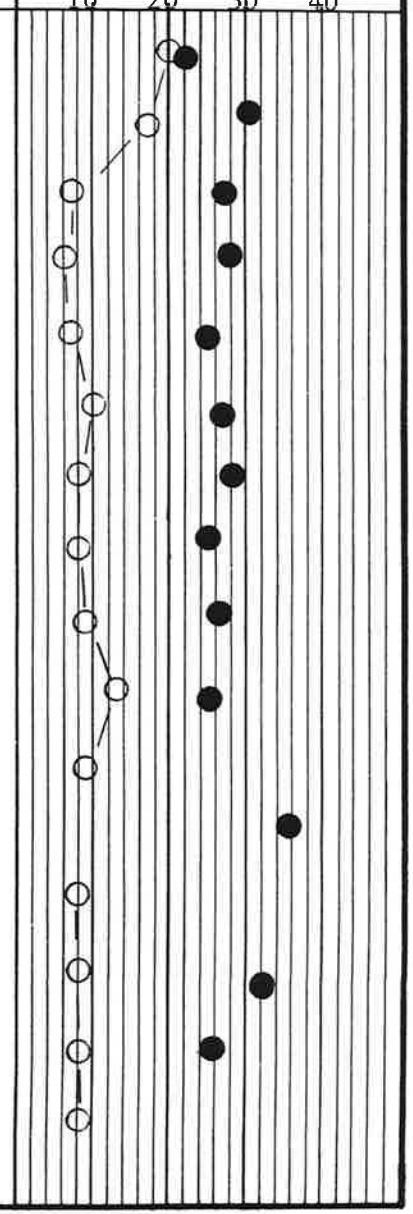
Boring No. 4 | Location: Station 143 + 14.3, on ℄ | Date Drilled: 1-13-86

WATER OBSERVATIONS: Water seepage at: 15.6' (trace), 22.0' (trace), 23.5', 27.0'-28.0' (trace)
Water level at completion: 25.0'
Drilling Water level at completion: 8.0'

DEPTH in feet	ELEVATION in feet	PENETRATION Blows per 6"	RECOVERY in inches	SAMPLE NO. DRIVE	SAMPLE NO. PRESS	DESCRIPTION	Soil Classification	GRADATION % Agg.	% C.S.	% M.S.	% F.S.	% Silt	% Clay
0	895.1												
		13 11 9	17	1		Brown and dark brown, silty clay, trace to little fine to coarse sand, organic contaminated. Stiff. Damp to moist. (Sandstone fragments 1.5' to 3.0')							
		5 8 9	13	2									
		4 4 3	12	3		FILL:							
5.0		2 2 4	12	4									
		3 3 4	17	5		Yellowish brown and gray, silty clay, trace fine sand, root fibers and leaves. Stiff. Moist.							
		2 4 6	18	6									
9.0	886.1												
10		2 4 4	14	7		Dark brownish gray, silty clay, trace fine sand, organic. Stiff. Moist (Wood fragments 10.5' to 12.0')							
		2 4 4	13	8									
		1 4 5	15	9									
14.2		4 5 8	18	10		Gray, silty clay, trace fine sand. Medium stiff to stiff. Moist. (Fine sand seam @ 15.6') (Wood fragment, possibly buried log 17.3' - 18.0')							
15		3 4 5	12	11									
		2 27	12	12									
		1 3 5	0										
20		1 2 6	15	13		Color change to yellowish brown and gray at 19.5'							
		3 3 5	12	14		(Silt seam @ 22.0')							
23.5		3 3 5	16	15		Gray, silty clay and silt, laminated. Medium stiff. Moist.							
25		4 7											

STANDARD PENETRATION (N) Blows per foot ○ — 10 20 30 40

MOISTURE CONTENT - % PL ✕ Natural ● LL ✕ — 10 20 30 40



MASON - deVERTEUIL GEOTECHNICAL SERVICES, 603 'UNTLEY ROAD, COLUMBUS, OHIO 43229, 614/888-0576

Client: The Ohio Department of Natural Resources | Project: Buckeye Lake Dam | M-V Job No. 807

BORING LOG

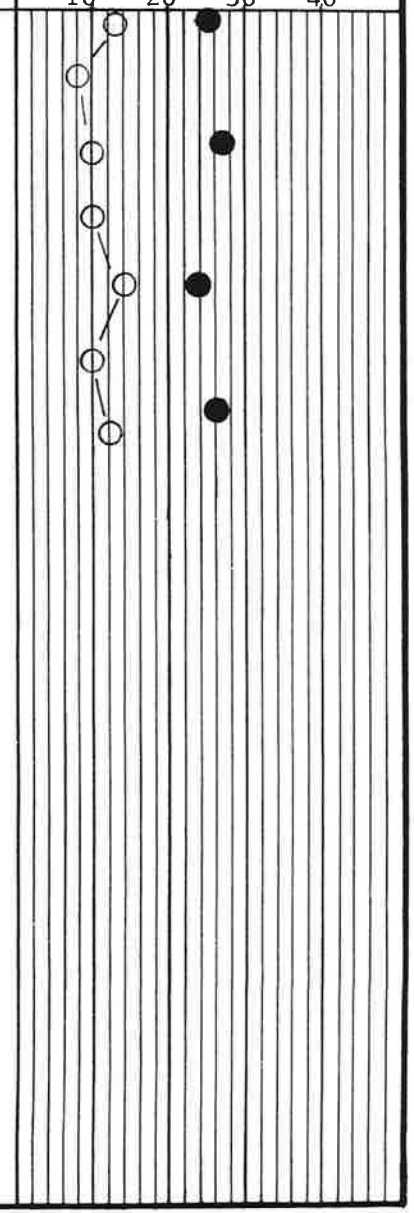
Boring No. 4 | Location: Station 143 + 14.3, on ℄ | Date Drilled: 1-13-86

WATER OBSERVATIONS: Water seepage at: 15.6' (trace), 22.0' (trace), 23.5'
Water level at completion: 25.0' 27.0'-28.0' (trace)
Drilling Water level at completion: 8.0'

DEPTH in feet	ELEVATION in feet	PENETRATION Blows per 6"	RECOVERY in inches	SAMPLE NO. DRIVE	SAMPLE NO. PRESS	DESCRIPTION	Soil Classification	% Agg.	% C.S.	% M.S.	% F.S.	% Silt	% Clay
25		6	14	16		Gray, silty clay and silt, laminated. Medium stiff. Moist to wet.							
		2 3 5	10	17									
		3 5 5	14	18									
		3 4 6	12	19									
30		3 6 8	16	20									
		3 4 6	12	21									
		4 5 7	10	22									
34.5						Bottom of Boring - 34.5'							

STANDARD PENETRATION (N) Blows per foot ○ 10 20 30 40

MOISTURE CONTENT - % PL Natural LL ● 10 20 30 40



MASON - deVERTEUIL GEOTECHNICAL SERVICES, 60: JNTLEY ROAD, COLUMBUS, OHIO 43229, 614/888-0576

Client: The Ohio Department of Natural Resources | Project: Buckeye Lake Dam | M-V Job No. 807

BORING LOG

Boring No. 4A | Location: Station 142 + 75.5, 6.3' Right | Date Drilled: 1-14-86

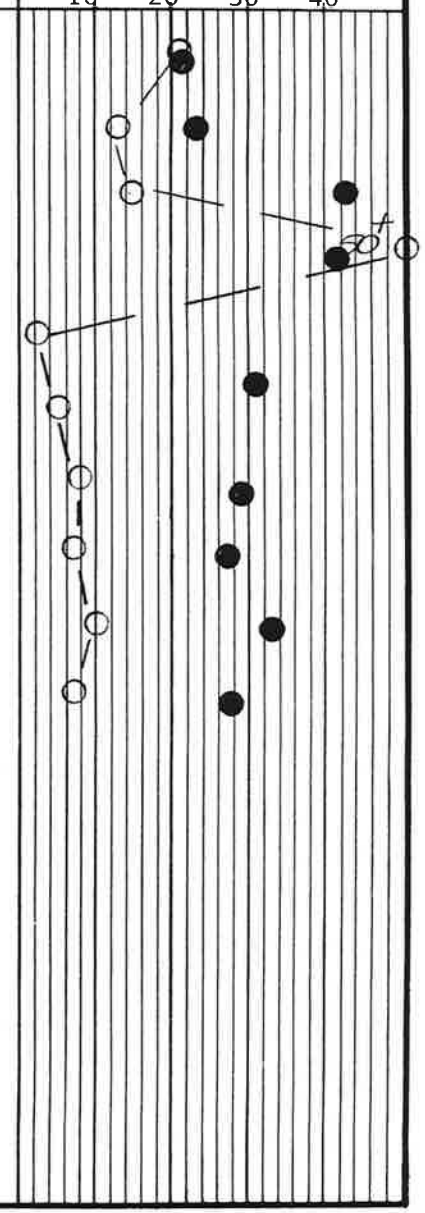
WATER OBSERVATIONS: Water seepage at: 6.2'
Water level at completion: 6.4'
Drilling Water level at completion:

DEPTH in feet	ELEVATION in feet	PENETRATION Blows per 6"	RECOVERY in inches	SAMPLE NO. DRIVE	SAMPLE NO. PRESS	DESCRIPTION	Soil Classification	% Agg.	% C.S.	% M.S.	% F.S.	% Silt	% Clay
0	895.1												
		14 12 9	16	1		Brown, silty clay, little sand, trace gravel. Stiff. Damp to Moist. organic contaminated							
		6 5 8	18	2		FILL:							
		2 5 10	15	3									
5		11 50③	8	4		Drillers Note: Sandstone fragments and concrete slab 5.3' to 6.2'							
		0 1 1	0										
7.2	887.9												
		2 2 3	5	5		Gray silty clay, little sand, trace gravel, organic contaminated. Medium stiff. Moist							
10		2 3 5	18	6									
		3 3 4	13	7		Yellowish brown and gray, silty clay, little fine sand. Medium stiff. Moist.							
		3 4 6	18	8		(Wood fragments @ 13.0')							
		7 3 4	18	9									
15.0						Bottom of Boring - 15.0'							

Note: 50③ - 50 blows for 0.3' penetration

STANDARD PENETRATION (N) Blows per foot ○ 10 20 30 40

MOISTURE CONTENT - % PL Natural LL 10 20 30 40



MASON - deVERTEUIL GEOTECHNICAL SERVICES, 60[illegible] UNTLEY ROAD, COLUMBUS, OHIO 43229, 614/888-0576

Client: The Ohio Department of Natural Resources | Project: Buckeye Lake Dam | M-V Job No. 807

BORING LOG

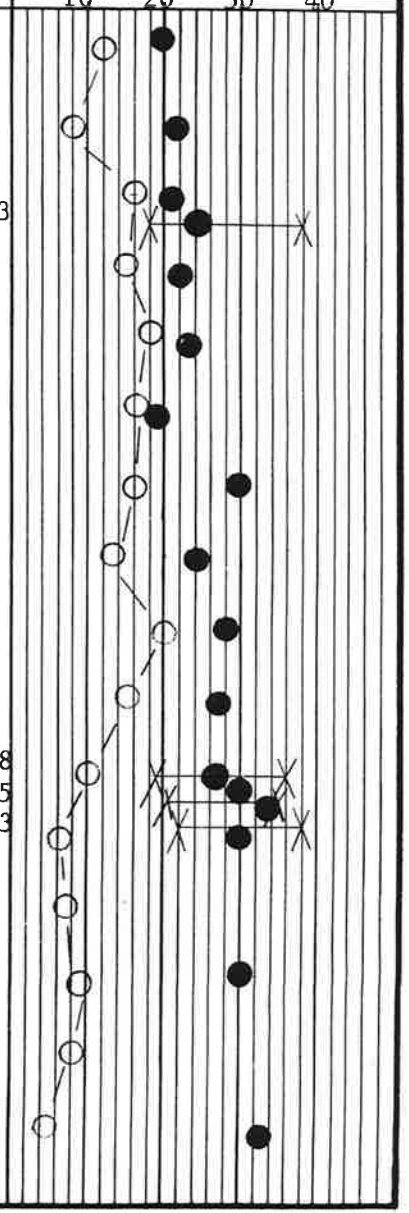
Boring No. 5 | Location: Station 143 + 41, 18.3' Left | Date Drilled: 1-14-86

WATER OBSERVATIONS: Water seepage at: 17.5', 21.6' (trace), 23.5', 24.4' (trace)
Water level at completion: 27.6'
Drilling Water level at completion: 1.8' (in riser pipe)

DEPTH in feet	ELEVATION in feet	PENETRATION Blows per 6"	RECOVERY in inches	SAMPLE NO. DRIVE	SAMPLE NO. PRESS	DESCRIPTION	Soil Classification	GRADATION % Agg.	% C.S.	% M.S.	% F.S.	% Silt	% Clay
	895.0												
0		12 7 5	8	1		Brown, clayey silt, little sand. Stiff. Damp							
2.0		3 3 5	16	2		Brown, silty clay, little fine sand, organic contaminated							
3.3		5 5 11	18	3		Yellowish brown and gray, silty clay little fine to coarse sand, trace gravel. Stiff to very stiff. Moist.							
5		6 7 8	18	4	1	FILL:		3	5	3	14	42	33
		6 8 10	18	5									
		5 7 9	18	6									
10.0	885.0	4 7 9	17	7									
10.8		3 5 8	17	8	2	Black, silty clay, little fine sand, organic, wood fragments. Moist							
		5 9 11	18	9		Yellowish brown and gray, silty clay, trace fine sand. Stiff. Moist							
14.4		4 7 8	18	10									
15		3 4 6	12	11		Dark gray, silty clay, little fine sand, organic, wood fragments. Stiff. Moist.		0	1	1	18	42	38
16.5		3 3 3	18	12	3	Yellowish brown and gray, silty clay, trace fine sand. Stiff. Moist		0	2	1	16	46	35
		1 2 5	16	13				0	0	1	19	47	33
20		2 4 5	12	14									
21.6		1 3 5	16	15		Yellowish brown and gray, silt, with gray seams. Soft. Wet							
23.8		1 2 3	18	16									
24.4		2 2				Yellowish brown and gray, silty clay, trace fine sand. Stiff. Moist							
25													

STANDARD PENETRATION (N) Blows per foot ○ 10 20 30 40

MOISTURE CONTENT - % PL Natural LL 10 20 30 40



MASON - deVERTEUIL GEOTECHNICAL SERVICES, 60? 'UNTLEY ROAD, COLUMBUS, OHIO 43229, 614/888-0576

Client: The Ohio Department of Natural Resources | Project: Buckeye Lake Dam | M-V Job No. 807

BORING LOG

Boring No. 5 | Location: Station 143 + 41, 18.3' Left | Date Drilled: 1-14-86

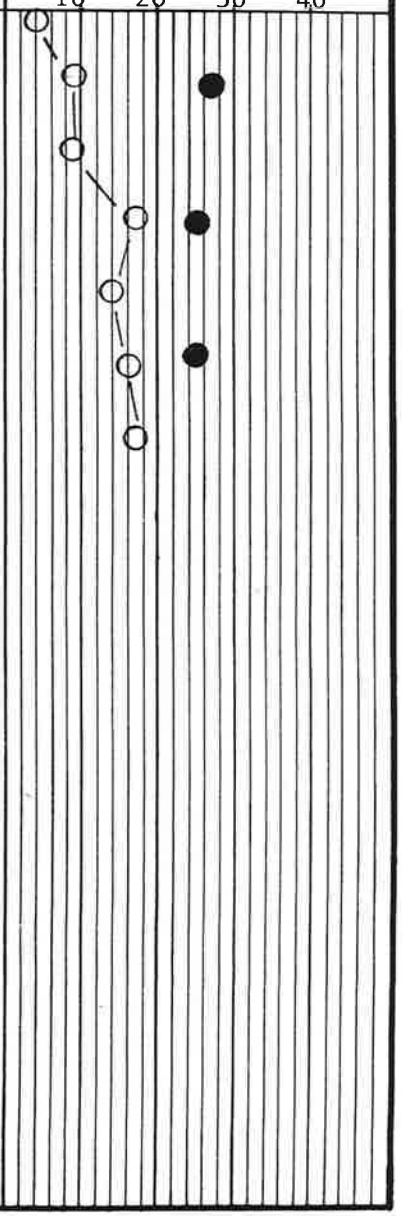
WATER OBSERVATIONS: Water seepage at: 17.5', 21.6' (trace), 23.5', 24.4' (trace)
Water level at completion: 27.6'
Drilling Water level at completion: 1.8' (in riser pipe)

DEPTH in feet	ELEVATION in feet	PENETRATION Blows per 6"	RECOVERY in inches	SAMPLE NO. DRIVE	SAMPLE NO. PRESS	DESCRIPTION	Soil Classification	% Agg.	% C.S.	% M.S.	% F.S.	% Silt	% Clay
25		2	18	17		Gray, silty clay and silt, laminated. Medium stiff to stiff. Moist to wet. (Silt seams 24.0' to 27.0')							
		2 3 6	18	18									
		2 4 5	18	19									
		5 7 10	18	20									
30		5 6 8	18	21									
		5 7 9	13	22									
		5 7 10	16	23									
34.5						Bottom of Boring - 34.5'							

GRADATION

STANDARD PENETRATION (N) Blows per foot ○ 10 20 30 40

MOISTURE CONTENT - % PL Natural LL ● 10 20 30 40



MASON - deVERTEUIL GEOTECHNICAL SERVICES, 60: UNTLEY ROAD, COLUMBUS, OHIO 43229, 614/888-0576

Client: The Ohio Department of Natural Resources | Project: Buckeye Lake Dam | M-V Job No. 807

BORING LOG

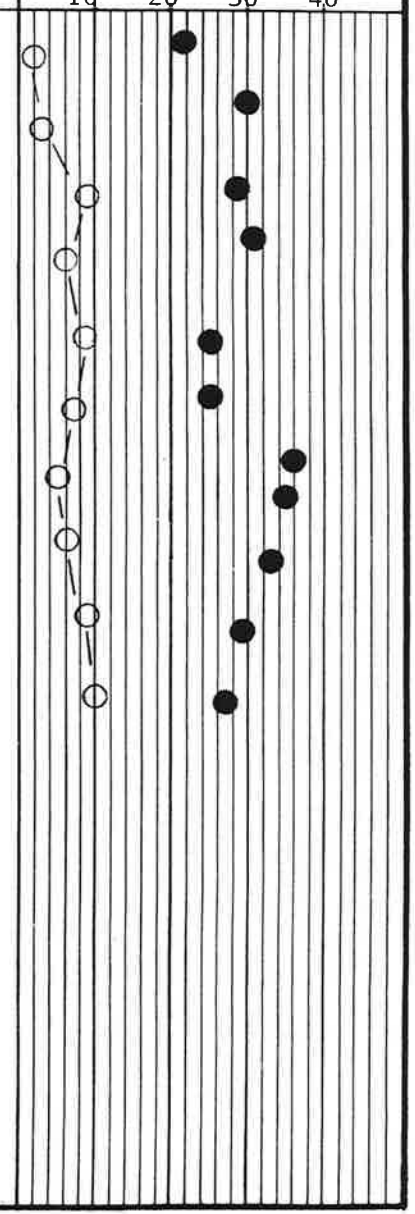
Boring No. 6 | Location: Station 143 + 36, 64.5' Left | Date Drilled: 1-15-86

WATER OBSERVATIONS: Water seepage at: 4.3',(trace),6.6',(trace),9.5'-10.0',11.5',14.3'(trace)
Water level at completion: 10.0
Drilling Water level at completion:

DEPTH in feet	ELEVATION in feet	PENETRATION Blows per 6"	RECOVERY in inches	SAMPLE NO. DRIVE	SAMPLE NO. PRESS	DESCRIPTION	Soil Classification	GRADATION % Agg.	% C.S.	% M.S.	% F.S.	% Silt	% Clay
0	883.4												
0.3		3 1 1	13	1		Topsoil							
		1 2 1	8	2		Brown, silty clay, little fine to coarse sand. Soft to medium stiff. Damp to moist. (Wood fragments)							
4.0		5 5 4	16	3									
5		4 3 3	2	4		Yellowish brown and gray, silty clay, little fine sand. Medium stiff to stiff. Damp to moist. (Slightly organic with root fibers 4.0' to 6.0')							
		3 4 5	18	5									
		2 3 4	8	6									
9.0													
10		2 2 3	18	7 8		Gray, silty clay and silt, laminated. Medium stiff. Moist to wet. (Silt seam at 11.5')							
		2 2 4	16	9									
		2 3 6	18	10									
		2 5 5	18	11									
15.0						Bottom of Boring - 15.0'							

STANDARD PENETRATION (N) Blows per foot ○ 10 20 30 40

MOISTURE CONTENT - % PL Natural LL ● 10 20 30 40



MASON - deVERTEUIL GEOTECHNICAL SERVICES, 60 UNTLEY ROAD, COLUMBUS, OHIO 43229, 614/888-0576

Client: The Ohio Department of Natural Resources | Project: Buckeye Lake Dam | M-V Job No. 807

BORING LOG

Boring No. 7 | Location: Station 61 + 50, 24.0' Left | Date Drilled: 1-15-86

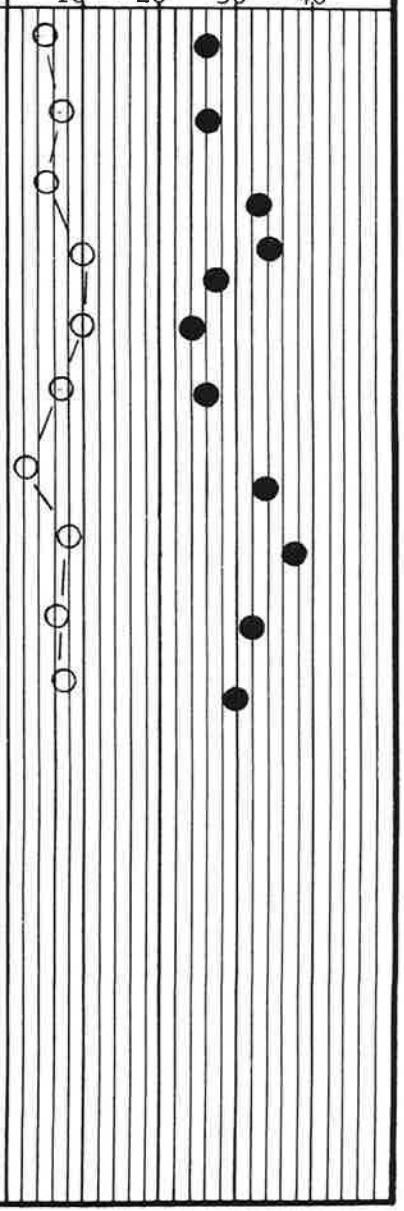
WATER OBSERVATIONS: Water seepage at: 3.7'(trace), 6.5', (trace), 8.5', 9.0'-9.7'(trace)
Water level at completion: 5.0'
Drilling Water level at completion:

DEPTH in feet	ELEVATION in feet	PENETRATION Blows per 6"	RECOVERY in inches	SAMPLE NO. DRIVE	SAMPLE NO. PRESS	DESCRIPTION	Soil Classification	% Agg.	% C.S.	% M.S.	% F.S.	% Silt	% Clay
0	889.0												
0.6		3 3 2	13	1		Topsoil							
	886.0	2 3 4	12	2		FILL: Dark brown and brown, clayey silt, to silty clay, organic contaminated, root fibers. Medium stiff. Damp to moist.							
3.0		2 2 3	18	3		Dark brown, clayey silt, little sand, organic contaminated, (topsoil). Medium stiff. Moist							
5.0		1 4 6	18	4		Dark gray, silty clay, little fine sand, organic. Stiff. Moist							
6.5		4 4 6	13	5		Yellowish brown and gray, silty clay, little fine sand. Soft to medium stiff. Moist to very moist.							
		2 3 4	12	6									
10		0 0 2	18	7									
10.5		2 3 5	16	8		Brownish gray to gray, silty clay and silt, laminated. Medium stiff. Moist							
		2 2 4	18	9									
		2 3 4	18	10		(Fine sand streaks 13.5' to 15.0')							
15.0				11		Bottom of Boring - 15.0'							

GRADATION

STANDARD PENETRATION (N) Blows per foot ○ 10 20 30 40

MOISTURE CONTENT - % PL Natural LL ● 10 20 30 40



MASON - deVERTEUIL GEOTECHNICAL SERVICES, 6(HUNTLEY ROAD, COLUMBUS, OHIO 43229, 614/888-0576

Client: The Ohio Department of Natural Resources | Project: Buckeye Lake Dam | M-V Job No. 807

BORING LOG

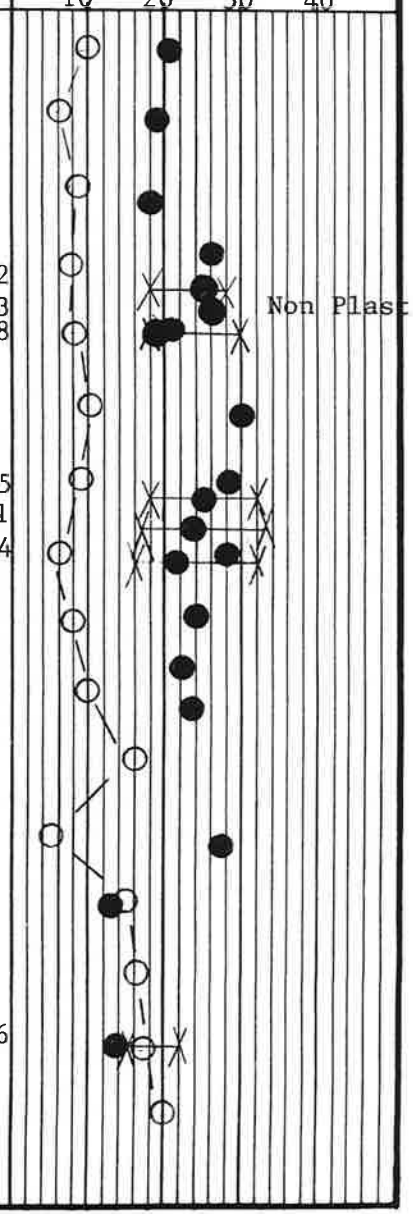
Boring No. 8 | Location: Station 63 + 86.5, 2.5' Right | Date Drilled: 1-16-86

WATER OBSERVATIONS: Water seepage at: 5.5' (trace), 7.7' (trace), 17.1'-18.0' 26.1' (trace)
Water level at completion: 14.2'
Drilling Water level at completion:

DEPTH in feet	ELEVATION in feet	PENETRATION Blows per 6"	RECOVERY in inches	SAMPLE NO. DRIVE	SAMPLE NO. PRESS	DESCRIPTION	Soil Classification	% Agg.	% C.S.	% M.S.	% F.S.	% Silt	% Clay
0	896.0												
0.7		10 7 3	15	1		Topsoil							
		2 3 3	16	2		Dark brown, clayey silt, some sand, organic contaminated, root fibers. Medium stiff. Damp to moist.							
4.0		4 3 6	18	3									
5		4 4 4	12	4		FILL: Brown, clayey silt to silty clay, little to some fine to coarse sand, trace gravel. Stiff. Damp to moist.		1	2	4	8	53	32
		2 4 4	14	5	1			0	0	1	6	80	13
								0	4	11	15	42	28
7.7		3 4 6	18	6		Yellowish brown and gray, silty clay, little fine sand. Stiff. Moist							
9.6	886.4												
10		3 3 6	17	7		Dark grayish brown, silty clay, little fine sand, organic, root fibers. Medium stiff. Moist		2	17	5	15	36	25
		2 2 4	18	8	2			2	10	11	19	27	31
								1	3	14	17	31	34
12.0		2 3 5	12	9		Yellowish brown and gray, silty clay, little fine sand. Stiff. Moist.							
		2 4 6	18	10 11									
15.0		4 7 9	18	12	3	Yellowish brown and gray, silty clay and silt laminated. Very stiff. Moist.							
17.1		2 2 3	18	13		Gray, silt, little clay, little fine sand. Medium stiff. Wet.							
18.3		1 5 10	12	14 15		Gray, clayey silt, little sand, trace to little gravel, shale fragments. Very stiff. Damp.							
20		3 6 10	18	16									
		3 7 10	18	17				8	3	9	16	38	26
		4 8 12	12	18									
25		5 7											

STANDARD PENETRATION (N) Blows per foot ○ 10 20 30 40

MOISTURE CONTENT - % PL Natural LL 10 20 30 40



Non Plastic

MASON - deVERTEUIL GEOTECHNICAL SERVICES, 603' 'INTLEY ROAD, COLUMBUS, OHIO 43229, 614/888-0576

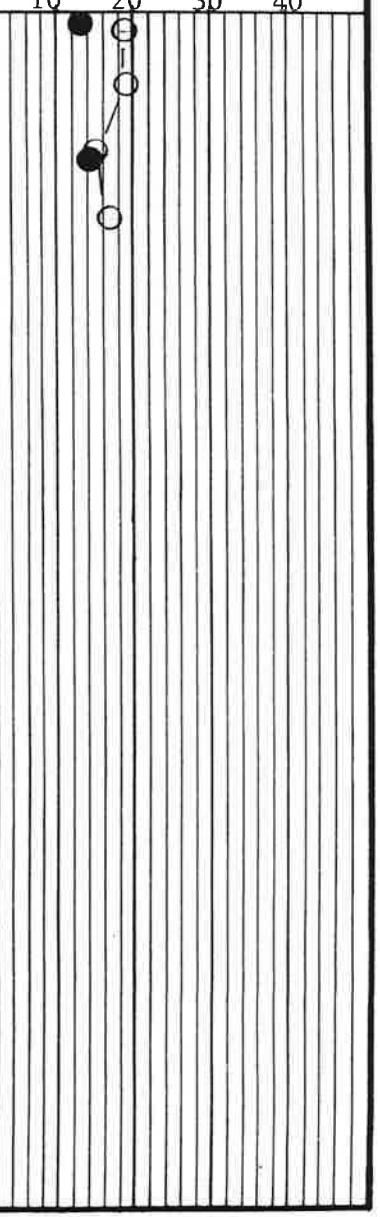
Client: The Ohio Department of Natural Resources | Project: Buckeye Lake Dam | M-V Job No. 807

BORING LOG

Boring No. 8 | Location: Station 63 + 86.5, 2.5' Right | Date Drilled: 1-16-86

WATER OBSERVATIONS: Water seepage at: 5.5' (trace), 7.7' (trace), 17.1'-18.0' 26.1' (trace)
Water level at completion: 14.2'
Drilling Water level at completion:

DEPTH in feet	ELEVATION in feet	PENETRATION Blows per 6"	RECOVERY in inches	SAMPLE NO. DRIVE	SAMPLE NO. PRESS	DESCRIPTION	Soil Classification	GRADATION % Agg.	% C.S.	% M.S.	% F.S.	% Silt	% Clay	STANDARD PENETRATION (N) Blows per foot	MOISTURE CONTENT - % PL Natural LL
25		12	16	19		Gray, clayey silt, little sand, trace to little gravel, shale fragments. Very stiff. Damp.									
		4 8 11	12	20											
		4 5 10	15	21											
		3 6 11	10	22											
30.0						Bottom of Boring - 30.0'									



Client: Ohio Department of Natural Resources

Project: Buckeye Lake Dam

M. [redacted] V 807
Job No.

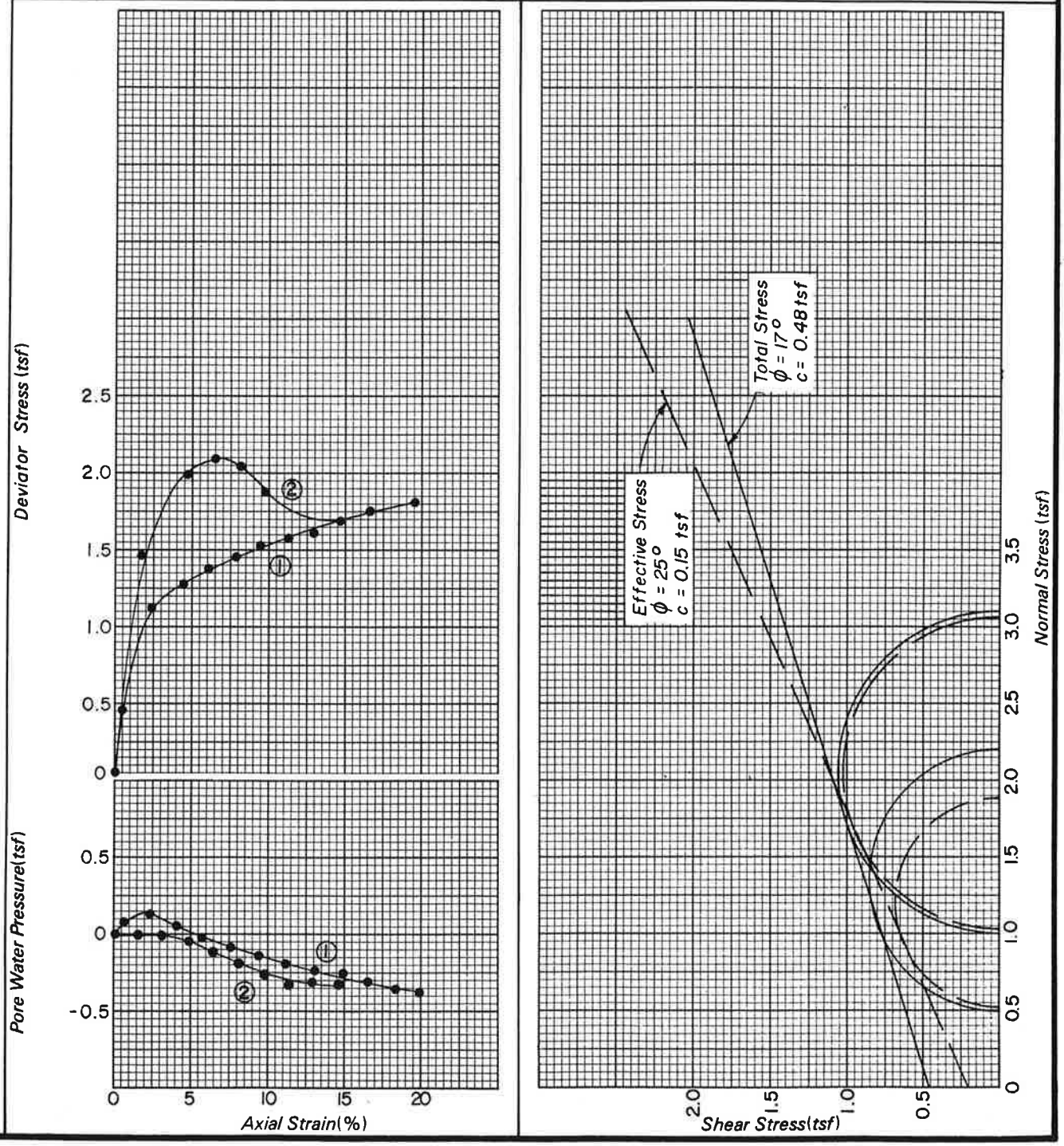
TRIAXIAL COMPRESSION TEST RESULTS

Sample Data

Boring No.	Sample No.	Depth from (ft.)	Depth to (ft.)	Gradation Agg. (%)	Gradation C.S. (%)	Gradation M.S. (%)	Gradation F.S. (%)	Gradation Silt (%)	Gradation Clay (%)	Plasticity LL (%)	Plasticity PL (%)	Plasticity PI (%)	Initial Water Content (%)	Final Water Content (%)	Dry Unit Wt. (pcf)	Specific Gravity	Consolidation Pressure (tsf)	Start of Test Back Pressure (tsf)	Start of Test Cell Pressure (tsf)	Type of Test*
3	P1-S1	4.1	4.4	0	1	2	15	40	42	41	22	19	21.4	23.6	105		0.5	4.0	4.5	Q_c
3	P1-S2	3.7	4.1	0	1	4	20	32	43	36	20	16	19.9	23.5	104		1.0	3.0	4.0	Q_c

*Note: Q = Unconsolidated - undrained, Q_c = Consolidated - undrained, S = Drained

Remarks: Effective stress envelope based on maximum value of σ_1'/σ_3'



Client: Ohio Department of Natural Resources

Project: Buckeye Lake Dam

M, [redacted] V Job No. 807

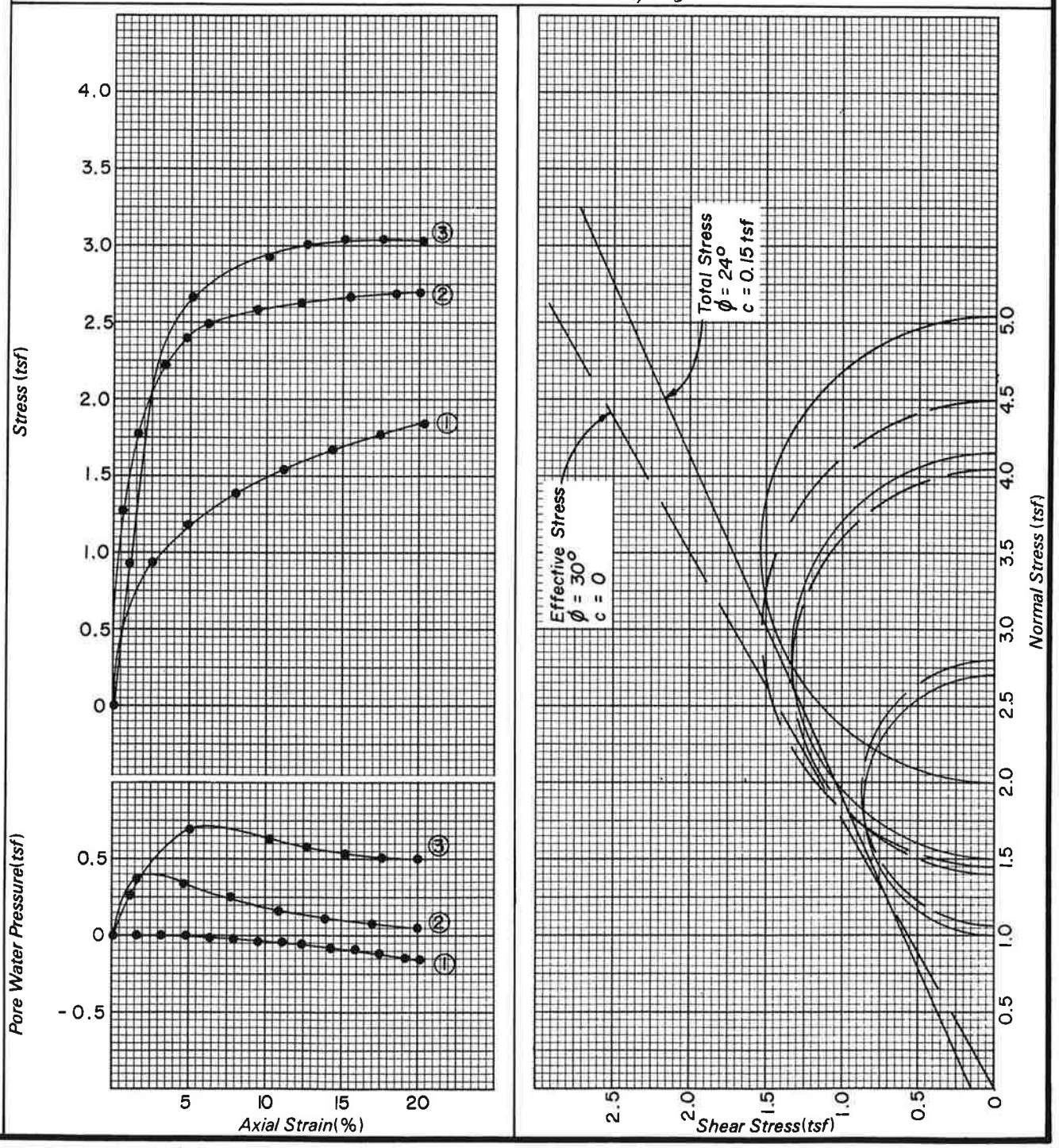
TRIAXIAL COMPRESSION TEST RESULTS

Sample Data

Boring No.	Sample No.	Depth from (ft.)	Depth to (ft.)	Gradation Agg. (%)	Gradation C.S. (%)	Gradation M.S. (%)	Gradation F.S. (%)	Gradation Silt (%)	Gradation Clay (%)	Plasticity LL (%)	Plasticity PL (%)	Plasticity PI (%)	Initial Water Content (%)	Final Water Content (%)	Dry Unit Wt. (pcf)	Specific Gravity	Consolidation Pressure (tsf)	Start of Test Back Pressure (tsf)	Start of Test Cell Pressure (tsf)	Type of Test*
3	P3-S1	10.5	10.8	2	6	6	20	33	33	36	17	19	22.6	23.1	98.5		1.0	3.0	4.0	Q_c
3	P3-S2	10.8	11.1	1	2	7	25	33	31	32	16	16	21.6	–	104.3		1.5	3.0	4.5	Q_c
3	P3-S3	11.1	11.5	1	3	7	22	34	33	35	18	17	21.9	21.6	105.6		2.0	2.0	4.0	Q_c

*Note: Q = Unconsolidated - undrained, Q_c = Consolidated - undrained, S = Drained

Remarks: Effective Stress envelope based on Max σ_1'/σ_3'



Client: Ohio Department of Natural Resources

Project: Buckeye Lake Dam

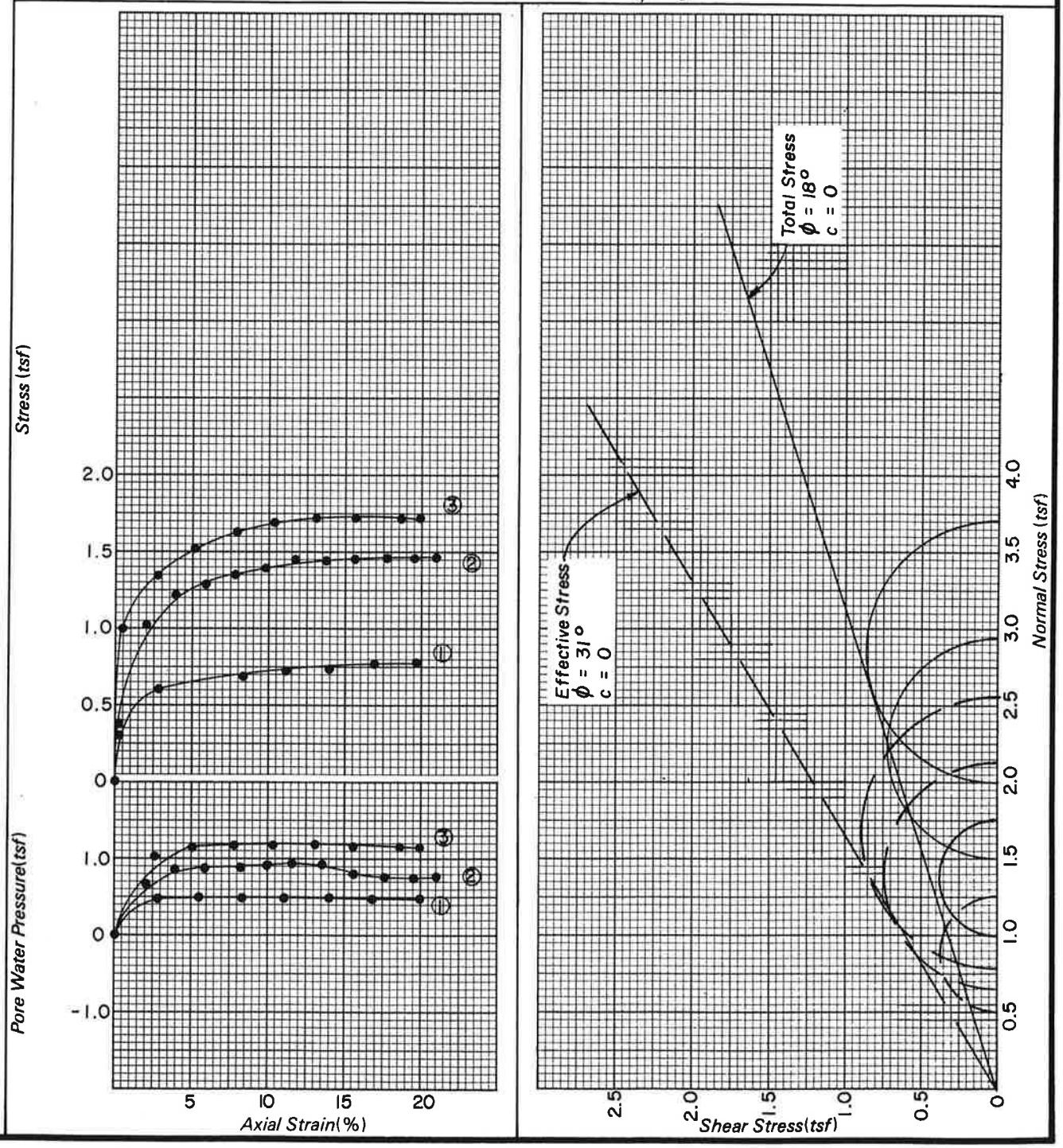
M. [redacted] V 807
Job No.

TRIAXIAL COMPRESSION TEST RESULTS

Sample Data																				
Boring No.	Sample No.	Depth from (ft.)	Depth to (ft.)	Gradation Agg. (%)	C.S. (%)	M.S. (%)	F.S. (%)	Silt (%)	Clay (%)	Plasticity LL (%)	PL (%)	PI (%)	Initial Water Content (%)	Final Water Content (%)	Dry Unit Wt. (pcf)	Specific Gravity	Consolidation Pressure (tsf)	Start of Test Back Pressure (tsf)	Start of Test Cell Pressure (tsf)	Type of Test*
3	P4-S1	13.5	14.0	-	-	-	-	-	-	-	-	-	-	24.3	99.7		1.0	3.0	4.0	Q_c
3	P4-S2	14.0	14.5	-	-	-	-	-	-	-	-	-	29.8	-	97.6		1.5	3.0	4.5	Q_c
3	P4-S3	14.5	15.0	6	6	7	22	31	28	30	15	15	27.8	23.2	95.4		2.0	2.0	4.0	Q_c

*Note: Q = Unconsolidated - undrained, Q_c = Consolidated - undrained, S = Drained

Remarks: Effective stress envelope based on Max σ_1'/σ_3'



Client: Ohio Department of Natural Resources

Project: Buckeye Lake Dam

M, [redacted] Job No. 807

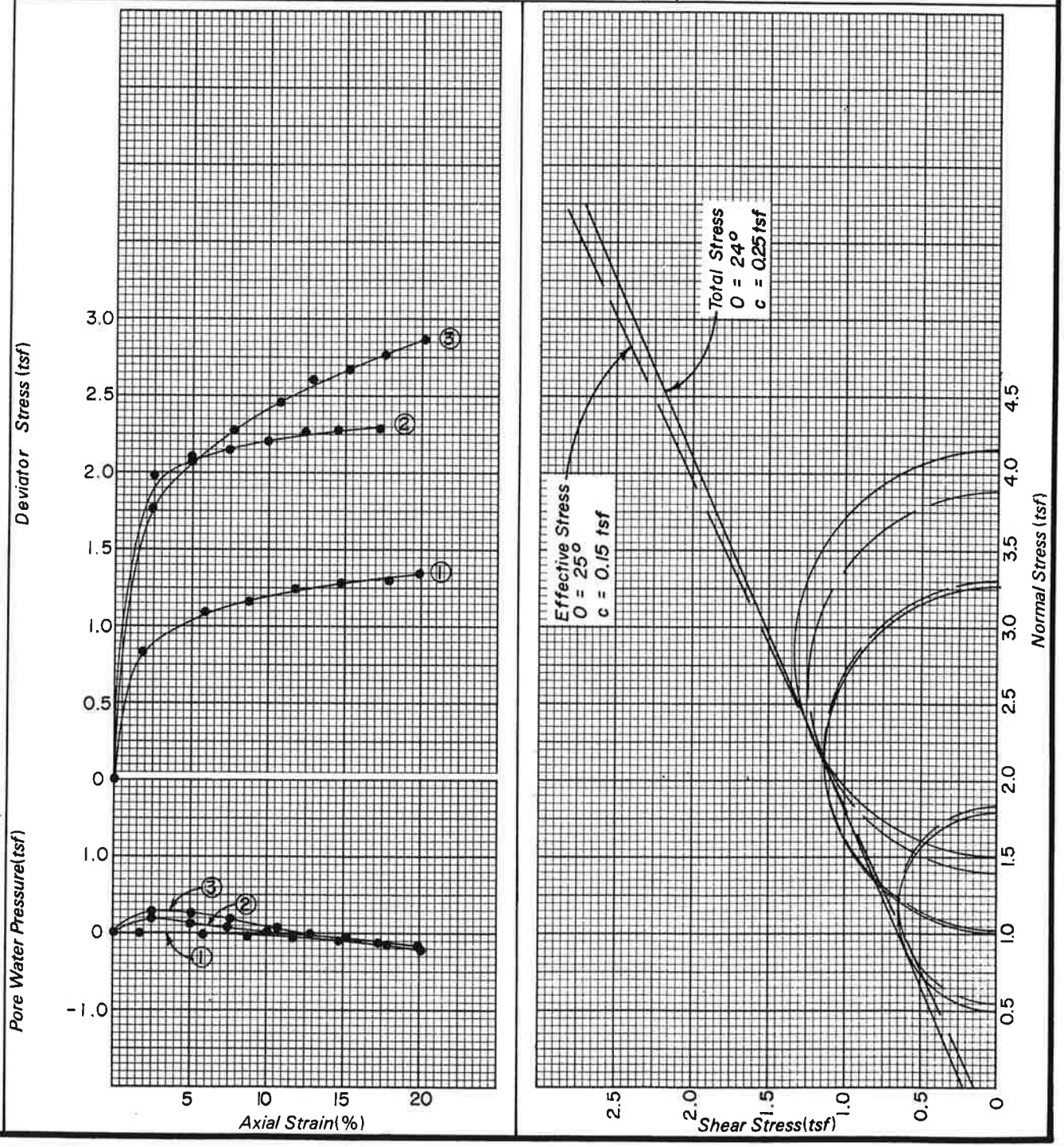
TRIAXIAL COMPRESSION TEST RESULTS

Sample Data

Boring No.	Sample No.	Depth from (ft.)	Depth to (ft.)	Gradation Agg. (%)	Gradation C.S. (%)	Gradation M.S. (%)	Gradation F.S. (%)	Gradation Silt (%)	Gradation Clay (%)	Plasticity LL (%)	Plasticity PL (%)	Plasticity PI (%)	Initial Water Content (%)	Final Water Content (%)	Dry Unit Wt. (pcf)	Specific Gravity	Consolidation Pressure (tsf)	Start of Test Back Pressure (tsf)	Start of Test Cell Pressure (tsf)	Type of Test*
5	P1-S1	4.0	4.5	3	5	3	14	42	33	38	18	20	24.3	25.8	95		0.5	3.5	4.0	Q_c
5	P1-S2	4.5	5.0	–	–	–	–	–	–	–	–	–	–	–	99		1.0	3.0	4.0	Q_c
5	P1-S3	5.0	5.5	–	–	–	–	–	–	–	–	–	–	23.1	102		1.5	3.0	4.5	Q_c

*Note: Q = Unconsolidated - undrained, Q_c = Consolidated - undrained, S = Drained

Remarks: Effective stress envelope based on Max σ_1'/σ_3'



Client: Ohio Department of Natural Resources

Project: Buckeye Lake Dam

M.[redacted]V 807 Job No.

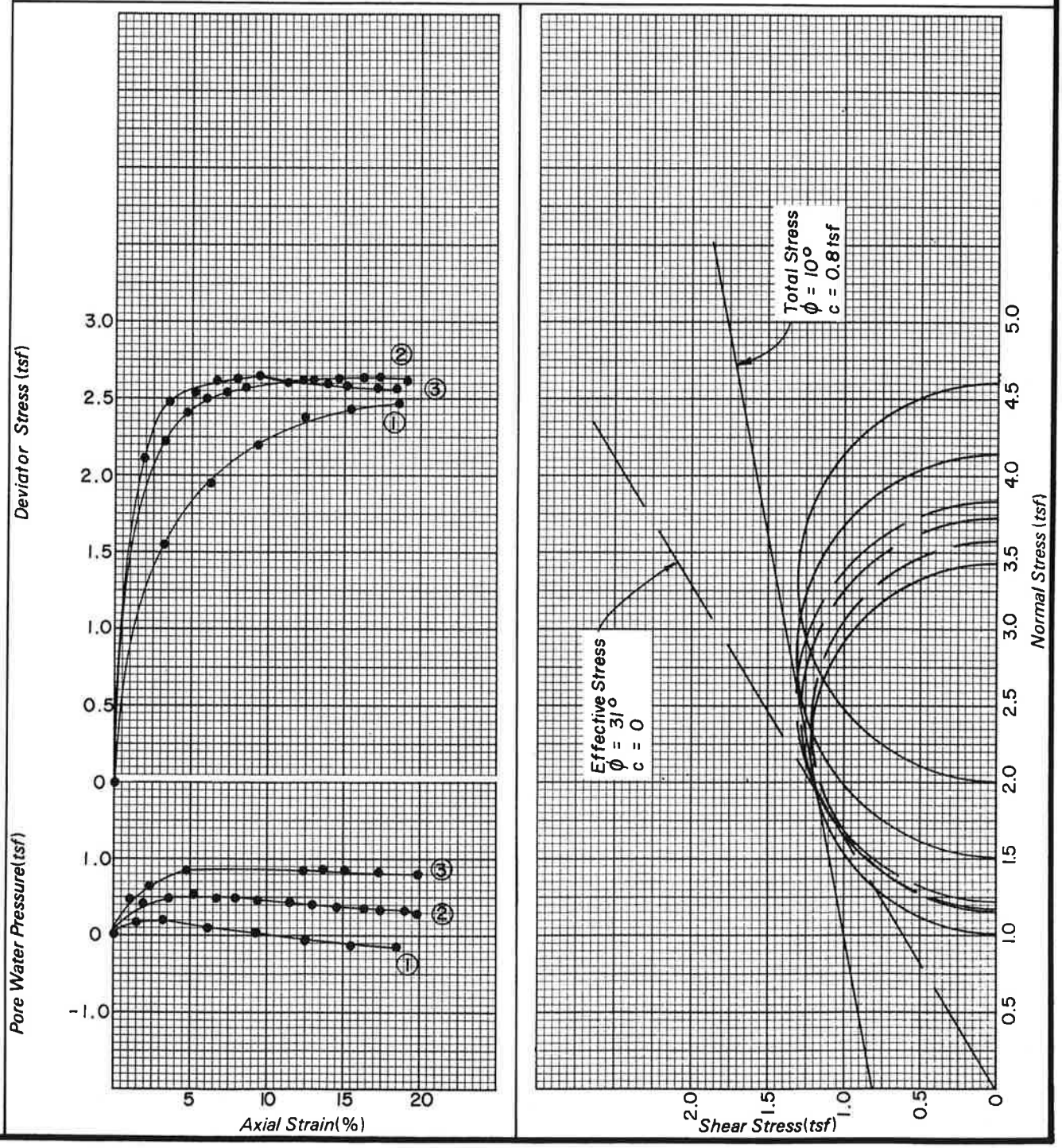
TRIAXIAL COMPRESSION TEST RESULTS

Sample Data

Boring No.	Sample No.	Depth from (ft.)	Depth to (ft.)	Gradation Agg. (%)	C.S. (%)	M.S. (%)	F.S. (%)	Silt (%)	Clay (%)	Plasticity LL (%)	PL (%)	PI (%)	Initial Water Content (%)	Final Water Content (%)	Dry Unit Wt. (pcf)	Specific Gravity	Consolidation Pressure (tsf)	Start of Test Back Pressure (tsf)	Start of Test Cell Pressure (tsf)	Type of Test*
5	P3-S1	16.0	16.5	0	1	1	18	42	38	36	19	17	26.6	23.6	97		1.0	4.0	5.0	Q_c
5	P3-S2	15.5	17.5	0	2	1	16	46	35	35	21	14	29.6	–	96		1.5	3.5	5.0	Q_c
5	P3-S3	15.5	17.5	0	0	1	19	47	33	38	22	16	33.7	30.3	85		2.0	3.0	5.0	Q_c

*Note: Q = Unconsolidated - undrained, Q_c = Consolidated - undrained, S = Drained

Remarks: Effective stress envelope based on 15% strain



Client: Ohio Department of Natural Resources

Project: Buckeye Lake Dam

M, [redacted]V 807 Job No.

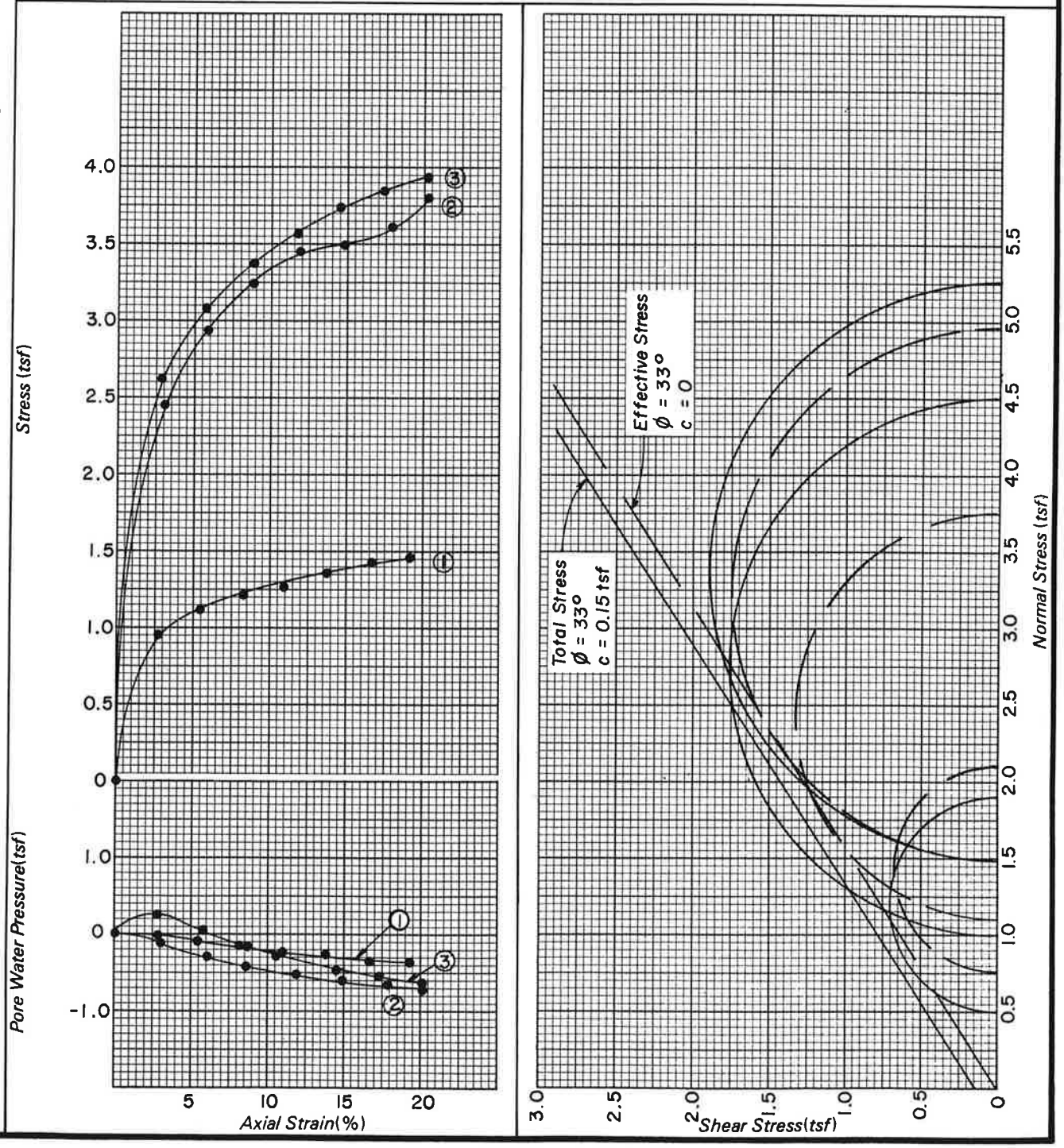
TRIAXIAL COMPRESSION TEST RESULTS

Sample Data

Boring No.	Sample No.	Depth from (ft.)	Depth to (ft.)	Gradation Agg. (%)	Gradation C.S. (%)	Gradation M.S. (%)	Gradation F.S. (%)	Gradation Silt (%)	Gradation Clay (%)	Plasticity LL (%)	Plasticity PL (%)	Plasticity PI (%)	Initial Water Content (%)	Final Water Content (%)	Dry Unit Wt. (pcf)	Specific Gravity	Consolidation Pressure (tsf)	Start of Test Back Pressure (tsf)	Start of Test Cell Pressure (tsf)	Type of Test*
8	P1-S1	5.0	5.5	1	2	4	8	53	32	28	18	10	24.9	24.7	98		0.5	3.5	4.0	Q_c
8	P1-S2	5.5	6.0	-	-	-	-	-	-	-	-	-	-	23.3	99		1.0	3.0	4.0	Q_c
8	P1-S3	6.0	6.5	0	4	11	15	42	28	30	18	12	18.6	18.2	103		1.5	3.0	4.5	Q_c

*Note: Q = Unconsolidated - undrained, Q_c = Consolidated - undrained, S = Drained

Remarks: Effective stress envelope based on Max σ_1'/σ_3'



Client: Ohio Department of Natural Resources

Project: Buckeye Lake Dam

M, [redacted] V 807 Job No.

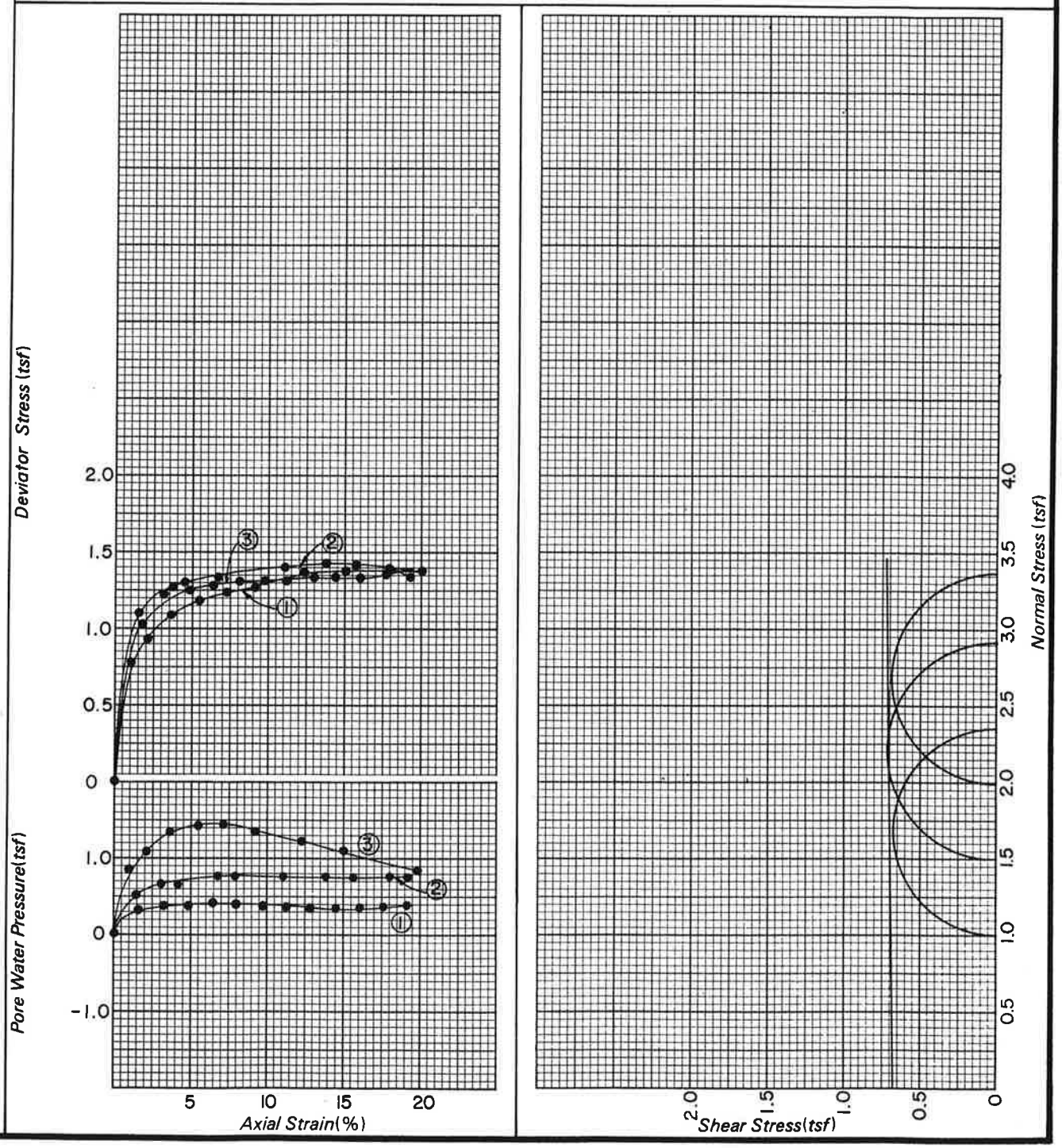
TRIAXIAL COMPRESSION TEST RESULTS

Sample Data

Boring No.	Sample No.	Depth from (ft.)	Depth to (ft.)	Gradation Agg. (%)	C.S. (%)	M.S. (%)	F.S. (%)	Silt (%)	Clay (%)	Plasticity LL (%)	PL (%)	PI (%)	Initial Water Content (%)	Final Water Content (%)	Dry Unit Wt. (pcf)	Specific Gravity	Consolidation Pressure (tsf)	Start of Test Back Pressure (tsf)	Start of Test Cell Pressure (tsf)	Type of Test*
8	P2-S1	10.0	10.5	2	17	5	15	36	25	32	18	14	25.0	21.8	97		1.0	4.0	5.0	Q
8	P2-S2	10.5	11.0	2	10	11	19	27	31	33	17	16	23.5	21.8	104		1.5	3.5	5.0	Q
8	P2-S3	11.0	11.5	1	3	14	17	31	34	32	16	16	24.7	21.2	103		2.0	3.0	5.0	Q

*Note: Q = Unconsolidated - undrained, Q_c = Consolidated - undrained, S = Drained

Remarks: Stress envelope based on 15% strain



APPENDIX IV

HYDROLOGY AND HYDRAULIC COMPUTATIONS

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB: BUCKEYE LAKE
SHEET NO. 1 OF 17
CALCULATED BY: RCD DATE: 7/2/85
CHECKED BY: MPG DATE: 7-19-85
SCALE: SCS - TIME OF CONC. CALCULATIONS

TIME OF CONCENTRATION CALCULATIONS

SUBAREA W-1

PATH #1

OVERLAND: (fallow)
length = 3450'
slope = (1123 − 1085)/3450 = 1.10%
$\bar{V}$ = 0.51 ft/sec.
travel time = 3450/0.51 = 1.88 hrs.

PATH #2

length = 2300' (fallow)
slope = (1100 − 1085)/2300 = 0.65%
$\bar{V}$ = 0.39 ft/sec.
travel time = 2300/0.39 = 1.64 hrs.

SMALL TRIB:
length = 25,500'
slope = (1085 − 907)/25,500 = 0.70%
$\bar{V}$ = 1.7 ft/sec.
travel time = 25,500/1.7 = 4.17 hrs.

USE PATH #1: TIME OF CONCENTRATION = 1.88 + 4.17 = 6.05, say 6.1 hrs.

SUBAREA W-2

PATH #1 (northern route)

OVERLAND: (fallow)
length = 1300'
slope = (1050 − 1020)/1300 = 2.3%
$\bar{V}$ = 0.76 ft/sec.
travel time = 1300/0.76 = 0.48 hrs.

SMALL TRIB:
length = 9050 ft.
slope = (1020 − 907)/9050 = 1.25%
$\bar{V}$ = 2.3 ft/sec.
travel time = 9050/2.3 = 1.09 hrs.

PATH #2 (southern route)

length = 2200' (fallow)
slope = (1065 − 1022)/2200 = 2.0%
$\bar{V}$ = 0.71 ft/sec.
travel time = 2200/0.71 = 0.86 hrs.

length = 10,200 ft.
slope = (1022 − 907)/10,200 = 1.12%
$\bar{V}$ = 2.2 ft/sec.
travel time = 10,200/2.2 = 1.29 hrs.

USE PATH #2: TIME OF CONCENTRATION = 0.86 + 1.29 = 2.15, say 2.2 hrs.

REACH ROUTING LENGTH BETWEEN W-1/W-2 and W/3 CONFLUENCES = 1700 FT

SUBAREA W-A

OVERLAND: (woods)
length = 900'
slope = (940 − 929)/900 = 1.22%
$\bar{V}$ = 0.28 ft/sec.
travel time = 900/0.28 = 0.89 hrs.

OVERLAND: (fallow)
length = 2300'
slope = (929 − 906.5)/2300 = 0.98%
$\bar{V}$ = 0.5 ft/sec.
travel time = 2300/0.5 = 1.28 hrs.

(cont. on next page)

PRODUCT 204-1 NEBS Inc., Groton, Mass. 01471

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

TIME OF CONCENTRATION CALCULATIONS (cont.)

SUBAREA W-A (cont.)

SMALL TRIB: (canal) length = 1150'
slope = (925.5 - 905)/1150 = 0.13%
$\bar{V}$ = 0.74 ft/sec.
travel time = 1150/0.74 = 0.43 hrs.

TIME OF CONCENTRATION = 0.39 + 1.28 + 0.43 = 2.60 hrs.

SUBAREA W-3

PATH #1 - (southern route)

OVERLAND: (fallow) length = 950'
slope = (1080-1060)/950 = 2.1%
$\bar{V}$ = 0.72 ft/sec
travel time = 950/0.72 = 0.37 hrs.

SMALL TRIB: length = 13,500'
slope = (1060-905)/13,500 = 1.15%
$\bar{V}$ = 2.25 ft/sec.
travel time = 13,500/2.25 = 1.67 hrs

PATH #2 - north route w/s. bran

length = 2450' (fallow)
slope = (1078-1037)/2450 = 1.67%
$\bar{V}$ = 0.64 ft/sec.
travel time = 2450/0.64 = 1.06 hrs.

length = 11,250'
slope = (1037-905)/11,250 = 1.17%
$\bar{V}$ = 2.3 ft/sec.
travel time = 11250/2.3 = 1.36 hrs

PATH #2A - north route w/N. bran

OVERLAND: (fallow) length = 1550'
slope = (1086-1072)/1550 = 0.90%
$\bar{V}$ = 0.47 ft/sec.
travel time = 1550/0.47 = 0.92 hrs

OVERLAND: (woods) length = 700'
slope = (1072-1060)/700 = 1.7%
$\bar{V}$ = 0.33 ft/sec.
travel time = 700/0.33 = 0.59 hrs

SMALL TRIB: length = 12,600'
slope = (1060-905)/12600 = 1.23%
$\bar{V}$ = 2.3 ft/sec.
travel time = 12600/2.3 = 1.52 hrs.

USE PATH #2A: TIME OF CONCENTRATION = 0.92 + 0.59 + 1.52 = 3.03, say 3.0 hrs.

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB BUCKEYE LAKE
SHEET NO. 3 OF 17
CALCULATED BY RCP DATE 7/3/85
CHECKED BY MPG DATE 7-19-85
SCALE

TIME OF CONCENTRATION CALCULATIONS (cont.)

REACH ROUTING LENGTH BETWEEN W-3 and W-4 CONFLUENCES = 7500 FT.

SUBAREA W-B

OVERLAND : length = 2100'
(fallow) slope = (942-920)/2100 = 1.05%
$\bar{V}$ = 0.51 ft/sec.
travel time = 2100/0.51 = 1.14 hrs.

OVERLAND : length = 400'
(woods) slope = (920-919)/400 = 0.25%
$\bar{V}$ = 0.13 ft/sec.
travel time = 400/0.13 = 0.85 hrs.

OVERLAND : length = 1050'
(fallow) slope = (919-915)/1050 = 0.38%
$\bar{V}$ = 0.30 ft/sec.
travel time = 1050/0.30 = 0.97 hrs.

OVERLAND : length = 3250'
(grassed water-way) slope = (915-901.5)/3250 = 0.42%
$\bar{V}$ = 0.98 ft/sec.
travel time = 3250/0.98 = 0.92 hrs.

SMALL TRIB : length = 1500'
(canal) slope = (901.5-900)/1500 = 0.10%
$\bar{V}$ = 0.65 ft/sec.
travel time = 1500/0.65 = 0.64 hrs.

TIME OF CONCENTRATION = 1.14 + 0.85 + 0.97 + 0.92 + 0.64 = 4.52, say 4.5 hrs.

SUBAREA W-4

OVERLAND : length = 1100'
(fallow) slope = (1030-1018)/1100 = 1.09%
$\bar{V}$ = 0.52 ft/sec.
travel time = 1100/0.52 = 0.59 hrs.

(continued on next page)

PRODUCT 204-1 NEBS Inc. Groton Mass 01471

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

TIME OF CONCENTRATION CALCULATIONS (cont.)

SUBAREA W-4 (cont.)

SMALL TRIB: length = 14,600'
slope = (1018 − 900)/14600 = 0.81%
$\bar{V}$ = 1.85 ft/sec.
travel time = 14600/1.85 = 2.19 hrs.

TIME OF CONCENTRATION = 0.59 + 2.19 = 2.78, say 2.8 hours

REACH ROUTING LENGTH BETWEEN W-4 & W-5 CONFLUENCES = 1050 FT.

SUBAREA W-C

OVERLAND: length = 1200'
(fallow) slope = (911 − 900)/1200 = 0.92%
$\bar{V}$ = 0.48 ft/sec.
travel time = 1200/0.48 = 0.69 hrs.

SMALL TRIB: length = 800'
(canal) slope = (900 − 899)/800 = 0.125%
$\bar{V}$ = 0.73 ft/sec.
travel time = 800/0.73 = 0.30 hrs.

TIME OF CONCENTRATION = 0.69 + 0.30 = 0.99, say 1.0 hr.

SUBAREA W-5

PATH #1	PATH #2
OVERLAND: length = 3700'	length = 2550'
(fallow) slope = (980 − 935)/3700 = 1.21%	slope = (955 − 935)/2550 = 0.78%
$\bar{V}$ = 0.54 ft/sec.	$\bar{V}$ = 0.44 ft/sec.
travel time = 3700/0.54 = 1.90 hrs.	travel time = 2550/0.44 = 1.61 hrs

SMALL TRIB.: length = 6600'
slope = (935 − 899)/6600 = 0.55%
$\bar{V}$ = 1.5 ft/sec.
travel time = 6600/1.5 = 1.22 hrs.

USE PATH #1: TIME OF CONCENTRATION = 1.90 + 1.22 = 3.12, say 3.1 hrs.

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

TIME OF CONCENTRATION CALCULATIONS (cont.)

REACH ROUTING LENGTH BETWEEN W-5 & W-6 CONFLUENCES = 1750 FT.

SUBAREA W-D

OVERLAND: length = 1550'
(fallow) slope = (912 − 893.5)/1550 = 0.87%
$\bar{v}$ = 0.47 ft/sec.
travel time = 1550/0.47 = 0.92 hrs.

SMALL TRIB.: length = 1050'
(canal) slope = (893.5 − 893)/1050 = 0.05%
$\bar{v}$ = 0.46 ft/sec.
travel time = 1050/0.46 = 0.63 hrs.

TIME OF CONCENTRATION = 0.92 + 0.63 = 1.55, say 1.6 hrs.

SUBAREA W-6

OVERLAND: length = 5000'
(fallow) slope = (1110 − 1074)/5000 = 0.72%
$\bar{v}$ = 0.42 ft/sec.
travel time = 5000/0.42 = 3.31 hrs.

SMALL TRIB: length = 27,650'
slope = (1074 − 898)/27,650 = 0.64%
$\bar{v}$ = 1.65 ft/sec.
travel time = 27650/1.65 = 4.65 hrs.

TIME OF CONCENTRATION = 3.31 + 4.65 = 7.96, say 8.0 hrs.

REACH ROUTING LENGTH BETWEEN W-6 & W-7 CONFLUENCES = 3350 FT.

SUBAREA W-E

OVERLAND: length = 2500'
(fallow) slope = (916 − 897.5)/2500 = 0.74%
$\bar{v}$ = 0.42 ft/sec.
travel time = 2500/0.42 = 1.65 hrs

SMALL TRIB.: length = 2600'
(canal) slope = (897.5 − 896)/2600 = 0.06%
$\bar{v}$ = 0.50 ft/sec.
travel time = 2600/0.50 = 1.44 hrs.

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

TIME OF CONCENTRATION CALCULATIONS (cont.)

SUBAREA W-E (cont.)

TIME OF CONCENTRATION = 1.65 + 1.44 = 3.09, say 3.1 hrs.

SUBAREA W-7

OVERLAND (fallow): length = 900'
slope = (1062-1050)/900 = 1.33%
$\bar{v}$ = 0.57 ft/sec
travel time = 900/0.57 = 0.44 hrs.

OVERLAND (woods): length = 1300'
slope = (1050-1025)/1300 = 1.92%
$\bar{v}$ = 0.35 ft/sec.
travel time = 1300/0.35 = 1.03 hrs.

SMALL TRIB.: length = 18,400'
slope = (1025-896)/18400 = 0.70%
$\bar{v}$ = 1.7 ft/sec.
travel time = 18400/1.7 = 3.01 hrs.

TIME OF CONCENTRATION = 0.44 + 1.03 + 3.01 = 4.48, say 4.5 hrs.

REACH ROUTING LENGTH BETWEEN W-7 & W-8 CONFLUENCES = 2000 FT.

SUBAREA W-F

OVERLAND (fallow): length = 1400'
slope = (917-910)/1400 = 0.50%
$\bar{v}$ = 0.35 ft/sec.
travel time = 1400/0.35 = 1.11 hrs.

OVERLAND (grass waterway): length = 1100'
slope = (910-895.3)/1100 = 1.34%
$\bar{v}$ = 1.7 ft/sec.
travel time = 1100/1.7 = 0.18 hrs.

(cont. on next page)

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

TIME OF CONCENTRATION CALCULATIONS (cont.)

SUBAREA W-F (cont.)

SMALL TRIB.: (canal)
length = 600'
slope = (895.3 − 895)/600 = 0.05%
$\bar{V}$ = 0.46 ft/sec.
travel time = 600/0.46 = 0.36 hr.

TIME OF CONCENTRATION = 1.11 + 0.18 + 0.36 = 1.65, say 1.6 hrs.

SUBAREA W-8

PATH #1

OVERLAND: (fallow)
length = 2400'
slope = (1035 − 1005)/2400 = 1.25%
$\bar{V}$ = 0.55 ft/sec.
travel time = 2400/0.55 = 1.21 hrs.

SMALL TRIB.:
length = 18,350'
slope = (1005 − 895)/18,350 = 0.60%
$\bar{V}$ = 1.6 ft/sec.
travel time = 18350/1.6 = 3.19 hrs.

PATH #2

length = 2100' (fallow)
slope = (1015 − 998)/2100 = 0.81%
$\bar{V}$ = 0.45 ft/sec.
travel time = 2100/0.45 = 1.30 hrs.

length = 17,800'
slope = (998 − 895)/17800 = 0.58%
$\bar{V}$ = 1.6 ft/sec.
travel time = 17800/1.6 = 3.09 hrs

PATH #3A

OVERLAND: (fallow)
length = 6300'
slope = (1050 − 975)/6300 = 1.19%
$\bar{V}$ = 0.54 ft/sec.
travel time = 6300/0.54 = 3.24 hrs.

SMALL TRIB.:
length = 14,800'
slope = (975 − 895)/14800 = 0.54%
$\bar{V}$ = 1.5 ft/sec.
travel time = 14800/1.5 = 2.74 hrs.

PATH #3B

length = 4900' (fallow)
slope = (1027 − 975)/4900 = 1.06%
$\bar{V}$ = 0.51 ft/sec.
travel time = 4900/0.51 = 2.67 hrs

length = 14,800'
slope = (975 − 895)/14800 = 0.54%
$\bar{V}$ = 1.5 ft/sec.
travel time = 14800/1.5 = 2.74 hrs

USE PATH #3A: TIME OF CONCENTRATION = 3.24 + 2.74 = 5.98, say 6.0 hrs.

(cont. on next page)

PRODUCT 204-1 NEBS INC. Groton, Mass. 01471

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB: [illegible] LAKE
SHEET NO. 3 OF 17
CALCULATED BY RCD DATE 7/3/85
CHECKED BY MPG DATE 7-19-85
SCALE

TIME OF CONCENTRATION CALCULATIONS (cont.)

REACH ROUTING LENGTH BETWEEN W-8 CONFLUENCE & LAKE = 10,300 FT.

SUBAREA W-G

PATH #1

OVERLAND (fallow): length = 7000'
slope = (955 − 894.5)/7000 = 0.86%
$\bar{V}$ = 0.47 ft/sec.
travel time = 7000/0.47 = 4.14 hrs.

SMALL TRIB. (canal): length = 8850'
slope = (894.5 − 891)/8850 = 0.040%
$\bar{V}$ = 0.41 ft/sec.
travel time = 8850/0.41 = 6.00 hrs.

PATH #2

length = 6800'
slope = (935 − 893)/6800 = 0.62%
$\bar{V}$ = 0.38 ft/sec.
travel time = 6800/0.38 = 4.97 hrs

length = 6700'
slope = (893 − 891)/6700 = 0.030%
$\bar{V}$ = 0.36 ft/sec.
travel time = 6700/0.36 = 5.17 hr

TIME OF CONCENTRATION = 4.14 + 6.00 / 4.97 + 5.17 = 10.14, say **10.1 hrs.**

SUBAREA S-A

PATH #1

OVERLAND (fallow): length = 750'
slope = (955 − 938)/750' = 2.27%
$\bar{V}$ = 0.76 ft/sec.
travel time = 750/0.76 = 0.27 hr.

SMALL TRIB.: length = 20,800'
slope = (938 − 890)/20,800 = 0.23%
$\bar{V}$ = 1.0 ft/sec.
travel time = 20,800/1.0 = 5.78 hr.

PATH #2

length = 1400' (fallow)
slope = (950 − 932)/1400 = 1.29%
$\bar{V}$ = 0.57 ft/sec.
travel time = 1400/0.57 = 0.68 hr.

length = 1750' (grass channel)
slope = (932 − 920)/1750 = 0.69%
$\bar{V}$ = 1.25 ft/sec.
travel time = 1750/1.25 = 0.39 hr

length = 18,600' (small trib.)
slope = (920 − 890)/18600 = 0.16%
$\bar{V}$ = 0.82 ft/sec.
travel time = 18600/0.82 = 6.30 hr

USE PATH #2: TIME OF CONCENTRATION = 0.68 + 0.39 + 6.30 = 7.37, say **7.4 hrs.**

SUBAREA I-A

OVERLAND (fallow): length = 2500'
slope = (960 − 925)/2500 = 1.4%
$\bar{V}$ = 0.59 ft/sec.
travel time = 2500/0.59 = 1.18 hrs.

PRODUCT 204-1 NEBS Inc., Groton, Mass. 01471.

(cont. on next page)

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

TIME OF CONCENTRATION CALCULATIONS (cont.)

SUBAREA I-A (cont.)

SMALL TRIB.: length = 3250 ft.
slope = (925 − 892)/3250 = 1.02%
$\bar{V}$ = 2.1 ft/sec.
travel time = 3250/2.1 = 0.43 hr.

TIME OF CONCENTRATION = 1.18 + 0.43 = 1.61, say 1.6 hrs.

SUBAREA S-1

PATH #1

OVERLAND: length = 350'
(fallow) slope = (1002 − 1001)/350 = 0.29%
$\bar{V}$ = 0.27 ft/sec.
travel time = 350/0.27 = 0.36 hr.

OVERLAND: length = 600'
(woods) slope = (1001 − 993)/600 = 1.33%
$\bar{V}$ = 0.29 ft/sec.
travel time = 600/0.29 = 0.57 hr

OVERLAND: length = 2050'
(fallow) slope = (993 − 968)/2050 = 1.22%
$\bar{V}$ = 0.55 ft/sec.
travel time = 2050/0.55 = 1.04 hr.

PATH #2

length = 300' (woods)
slope = (950 − 945)/300 = 1.67%
$\bar{V}$ = 0.33 ft/sec.
travel time = 300/0.33 = 0.25 hr.

length = 4200' (fallow)
slope = (945 − 915)/4200 = 0.71%
$\bar{V}$ = 0.42 ft/sec.
travel time = 4200/0.42 = 2.78 hr.

length = 3750' (small trib.)
slope = (915 − 892)/3750 = 0.61%
$\bar{V}$ = 1.6 ft/sec.
travel time = 3750/1.6 = 0.65 hr

SMALL TRIB.: length = 9150'
slope = (968 − 892)/9150 = 0.83%
$\bar{V}$ = 1.9 ft/sec.
travel time = 9150/1.9 = 1.34 hr.

USE PATH #2: TIME OF CONCENTRATION = 0.25 + 2.78 + 0.65 = 3.68, say 3.7 hrs.

SUBAREA I-B

PATH #1

OVERLAND: length = 850'
(woods) slope = (970 − 935)/850 = 4.1%
$\bar{V}$ = 0.52 ft/sec.
travel time = 850/0.52 = 0.45 hr.

PATH #2

length = 2350' (fallow)
slope = (943 − 892)/2350 = 2.17%
$\bar{V}$ = 0.74 ft/sec.
travel time = 2350/0.74 = 0.88 hr.

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB: BUCKEYE LAKE
SHEET NO. 10 OF
CALCULATED BY: RCD DATE: 7/5/85
CHECKED BY: MPG DATE: 7-19-85
SCALE:

TIME OF CONCENTRATION CALCULATIONS (cont.)

PATH #1 (cont.)

SUBAREA I-B (cont.)

OVERLAND: length = 1350'
(fallow) slope = (935-910)/1350 = 1.85%
$\bar{V}$ = 0.68 ft/sec.
travel time = 1350/0.68 = 0.55 hr.

SMALL TRIB.: length = 1450'
slope = (910-892)/1450 = 1.24%
$\bar{V}$ = 2.3 ft/sec.
travel time = 1450/2.3 = 0.18 hr.

USE PATH #1: TIME OF CONCENTRATION = 0.45 + 0.55 + 0.18 = 1.18, say 1.2 hrs

SUBAREA S-2

OVERLAND: length = 3000'
(fallow) slope = (1040-1020)/3000 = 2.3%
$\bar{V}$ = 0.76 ft/sec
travel time = 3000/0.76 = 1.10 hrs.

SMALL TRIB.: length = 11,700'
slope = (1020-892)/11700 = 1.09%
$\bar{V}$ = 2.2 ft/sec.
travel time = 11700/2.2 = 1.48 hrs.

TIME OF CONCENTRATION = 1.10 + 1.48 = 2.58, say 2.6 hrs.

SUBAREA I-C

OVERLAND: length = 450'
(fallow) slope = (955-940)/450 = 3.33%
.92 $\bar{V}$ = 0.92 ft/sec
travel time = 450/0.92 = 0.14 hr.

OVERLAND: length = 350'
(woods) slope = (940-930)/350 = 2.86%
$\bar{V}$ = 0.43 ft/sec.
travel time = 350/0.43 = 0.23 hr.

(cont. on next page)

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

TIME OF CONCENTRATION CALCULATIONS (cont.)

SUBAREA I-C (cont.)

OVERLAND (fallow): length = 2800'
slope = (930-898)/2800 = 1.14%
$\bar{V}$ = 0.53 ft/sec.
travel time = 2800/0.53 = 1.47 hrs.

OVERLAND (woods): length = 400'
slope = (898-892)/400 = 1.5%
$\bar{V}$ = 0.31 ft/sec.
travel time = 400/0.31 = 0.36 hrs.

TIME OF CONCENTRATION = 0.14 + 0.23 + 1.47 + 0.36 = **2.2 hrs.**

SUBAREA S-3

OVERLAND (fallow): length = 1400'
slope = (1040-1010)/1400 = 2.14%
$\bar{V}$ = 0.73 ft/sec.
travel time = 1400/0.73 = 0.53 hr.

SMALL TRIB.: length = 9900'
slope = (1010-892)/9900 = 1.19%
$\bar{V}$ = 2.3 ft/sec.
travel time = 9900/2.3 = 1.20 hr.

TIME OF CONCENTRATION = 0.53 + 1.20 = 1.73, say **1.7 hrs.**

SUBAREA I-D

PATH #1

OVERLAND (fallow): length = 350'
slope = (990-970)/350 = 5.7%
$\bar{V}$ = 1.2 ft/sec.
travel time = 350/1.2 = 0.08 hr.

OVERLAND (woods): length = 450'
slope = (970-955)/450 = 3.3%
$\bar{V}$ = 0.46 ft/sec.
travel time = 450/0.46 = 0.27 hr.

PATH #2

length = 1050' (fallow)
slope = (985-965)/1050 = 1.90%
$\bar{V}$ = 0.69 ft/sec.
travel time = 1050/0.69 = 0.42 hr.

length = 3800' (small trib.)
slope = (965-892)/3800 = 1.92%
$\bar{V}$ = 2.8 ft/sec.
travel time = 3800/2.8 = 0.38 hr.

(cont. on next page)

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

TIME OF CONCENTRATION CALCULATIONS (cont.)

SUBAREA I-D (cont.)

PATH #1 - (cont)

SMALL TRIB.: length = 3800'
slope = (955 - 892)/3800 = 1.66%
$\bar{V}$ = 2.7 ft/sec.
travel time = 3800/2.7 = 0.39 hr.

PATH #3

OVERLAND: (fallow) length = 2900'
slope = (990 - 925)/2900 = 2.24%
$\bar{V}$ = 0.75 ft/sec.
travel time = 2900/0.75 = 1.07 hrs.

OVERLAND: (short grass) length = 1400'
slope = (925 - 892)/1400 = 2.36%
$\bar{V}$ = 1.1 ft/sec.
travel time = 1400/1.1 = 0.35 hr.

PATH #4

length = 2850' (fallow)
slope = (947 - 897)/2850 = 1.75%
$\bar{V}$ = 0.66 ft/sec.
travel time = 2850/0.66 = 1.20 hrs

length = 150' (paved)
slope = (897 - 896)/150 = 0.67%
$\bar{V}$ = 1.6 ft/sec.
travel time = 150/1.6 = 0.03 hr.

length = 500' (short grass)
slope = (896 - 892)/500 = 0.8%
$\bar{V}$ = 0.62 ft/sec.
travel time = 500/0.62 = 0.22 hr.

USE PATH #4: TIME OF CONCENTRATION = 1.20 + 0.03 + 0.22 = 1.45, say 1.5 hrs.

SUBAREA S-4

PATH #1

OVERLAND: (fallow) length = 1000'
slope = (1085 - 1074)/1000 = 1.10%
$\bar{V}$ = 0.52 ft/sec.
travel time = 1000/0.52 = 0.53 hr.

SMALL TRIB.: length = 15,600'
slope = (1074 - 892)/15,600 = 1.17%
$\bar{V}$ = 2.25 ft/sec.
travel time = 15600/2.25 = 1.93 hrs.

PATH #2

length = 1600' (fallow)
slope = (1090 - 1050)/1600 = 2.5%
$\bar{V}$ = 0.79 ft/sec.
travel time = 1600/0.79 = 0.56 hr

length = 15,000' (small trib.)
slope = (1050 - 892)/15000 = 1.05%
$\bar{V}$ = 2.15 ft/sec.
travel time = 15000/2.15 = 1.94 hr

USE PATH #2: TIME OF CONCENTRATION = 0.56 + 1.94 = 2.5 hrs.

(cont. on next page)

PRODUCT 204-1 NEBS Inc., Groton, Mass. 01471.

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

TIME OF CONCENTRATION CALCULATIONS (cont.)

SUBAREA I-E

PATH #1

OVERLAND: length = 550'
(fallow) slope = (1010 − 980)/550 = 5.45%
$\bar{V}$ = 1.2 ft/sec.
travel time = 550/1.2 = 0.13 hr.

OVERLAND: length = 450'
(woods) slope = (930 − 963)/450 = 3.78%
$\bar{V}$ = 0.5 ft/sec.
travel time = 450/0.5 = 0.25 hr.

OVERLAND: length = 150'
(fallow) slope = (963 − 958)/150 = 3.33%
$\bar{V}$ = 0.91 ft/sec.
travel time = 150/0.91 = 0.05 hr.

SMALL TRIB.: length = 4700'
slope = (958 − 892)/4700 = 1.40%
$\bar{V}$ = 2.5 ft/sec
travel time = 4700/2.5 = 0.52 hr.

PATH #2

length = 4100' (fallow)
slope = (990 − 896)/4100 = 2.29%
$\bar{V}$ = 0.76 ft/sec.
travel time = 4100/0.76 = 1.50 hrs

length = 600' (small trib.)
slope = (896 − 892)/600 = 0.67%
$\bar{V}$ = 1.7 ft/sec.
travel time = 600/1.7 = 0.10 hr.

PATH #3

length = 2700' (fallow)
slope = (930 − 900)/2700 = 1.11%
$\bar{V}$ = 0.52 ft/sec.
travel time = 2700/0.52 = 1.44 hrs

length = 300' (woods)
slope = (900 − 892)/300 = 2.67%
$\bar{V}$ = 0.42 ft/sec.
travel time = 300/0.42 = 0.20 hr

USE PATH #3: TIME OF CONCENTRATION = 1.44 + 0.20 = 1.64, say 1.6 hrs.

SUBAREA S-5A

OVERLAND: length = 1200'
(fallow) slope = (1142 − 1100)/1200 = 3.5%
$\bar{V}$ = 0.94 ft/sec
travel time = 1200/0.94 = 0.35 hr.

SMALL TRIB.: length = 20,900'
slope = (1110 − 905)/20,900 = 0.98%
$\bar{V}$ = 2.0 ft/sec.
travel time = 20,900/2.0 = 2.90 hrs.

TIME OF CONCENTRATION = 0.35 + 2.90 = 3.25, say 3.2 hrs.

PRODUCT 204-1 NEBS Inc. Groton, Mass. 01471.

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

TIME OF CONCENTRATION CALCULATIONS (cont.)

PATH #1

SUBAREA S-5B (fallow)

OVERLAND: length = 750'
slope = (1095 − 1053)/750 = 5.6%
$\bar{V}$ = 1.2 ft/sec.
travel time = 750/1.2 = 0.17 hr.

SMALL TRIB.: length = 15,200'
slope = (1053 − 905)/15,200 = 0.97%
$\bar{V}$ = 2.0 ft/sec.
travel time = 15,200/2.0 = 2.11 hrs.

PATH #2

length = 2350' (fallow)
slope = (1100 − 1040)/2350 = 2.55%
$\bar{V}$ = 0.80 ft/sec.
travel time = 2350/0.80 = 0.32 hr.

length = 14,950' (small trib.)
slope = (1040 − 905)/14950 = 0.90%
$\bar{V}$ = 1.95 ft/sec.
travel time = 14950/1.95 = 2.13 hr.

USE PATH #2: TIME OF CONCENTRATION = 0.32 + 2.13 = 2.45, say 3.0 hrs.

REACH ROUTING LENGTH BETWEEN S-5A/B & S-5D CONFLUENCES = 3100 FT.

SUBAREA S-5C

OVERLAND: length = 3400'
(fallow) slope = (960 − 900)/3400 = 1.76%
$\bar{V}$ = 0.66 ft/sec.
travel time = 3400/0.66 = 1.43 hrs.

SMALL TRIB.: length = 1850'
slope = (900 − 896)/1850 = 0.22%
$\bar{V}$ = 0.96 ft/sec.
travel time = 1850/0.96 = 0.54 hr.

TIME OF CONCENTRATION = 1.43 + 0.54 = 1.97, say 2.0 hrs.

SUBAREA S-5D

OVERLAND: length = 900'
(fallow) slope = (1087 − 1068)/900 = 2.11%
$\bar{V}$ = 0.72 ft/sec.
travel time = 900/0.72 = 0.35 hr.

SMALL TRIB.: length = 14,000'
slope = (1068 − 896)/14,000 = 1.23%
$\bar{V}$ = 2.3 ft/sec.
travel time = 14000/2.3 = 1.69 hrs.

PRODUCT 204-1 NEBS Inc., Groton, Mass. 01471.

(cont. on next page)

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

TIME OF CONCENTRATION CALCULATIONS (cont.)

SUBAREA S-5D (cont.)

TIME OF CONCENTRATION = 0.35 + 1.69 = 2.04, say 2.0 hrs.

REACH ROUTING LENGTH BETWEEN S-5D CONFLUENCE & LAKE = 3500 FT.

SUBAREA S-5E

OVERLAND: length = 3350'
(fallow) slope = (930 − 893)/3350 = 1.10%
$\bar{V}$ = 0.52 ft/sec.
travel time = 3350/0.52 = 1.79 hrs.

SMALL TRIB.: length = 1350'
slope = (893 − 890)/1350 = 0.22%
$\bar{V}$ = 0.96 ft/sec.
travel time = 1350/0.96 = 0.39 hrs.

TIME OF CONCENTRATION = 1.79 + 0.39 = 2.18, say 2.2 hrs.

SUBAREA I-F

PATH #1

OVERLAND: length = 2550'
(fallow) slope = (920 − 892)/2550 = 1.10%
$\bar{V}$ = 0.52 ft/sec
travel time = 2550/0.52 = 1.36 hrs.

PATH #2

length = 2900' (fallow)
slope = (920 − 892)/2900 = 0.97%
$\bar{V}$ = 0.49 ft/sec.
travel time = 2900/0.49 = 1.67 hr

USE PATH #2: TIME OF CONCENTRATION = 1.6 hrs.

SUBAREA S-6

PATH #1 - SW route

OVERLAND: length = 2200'
(short grass) slope = (1040 − 940)/2200 = 4.5%
$\bar{V}$ = 1.5 ft/sec.
travel time = 2200/1.5 = 0.41 hr.

SMALL TRIB.: length = 4800'
slope = (940 − 892)/4800 = 1.0%
$\bar{V}$ = 2.05 ft/sec.
travel time = 4800/2.05 = 0.65 hr.

PATH #2 - SE route

length = 850' (short grass)
slope = (1050 − 1000)/850 = 5.9%
$\bar{V}$ = 1.7 ft/sec.
travel time = 850/1.7 = 0.14 hr

length = 350' (woods)
slope = (1000 − 985)/350 = 4.3%
$\bar{V}$ = 0.53 ft/sec.
travel time = 350/0.53 = 0.18 hr.

PRODUCT 204-1 NEBS Inc., Groton, Mass. 01471

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

TIME OF CONCENTRATION CALCULATIONS (cont.)

SUBAREA S-6 (cont.)

PATH #2 (cont.)

OVERLAND: length = 2500' (fallow)
slope = (985-907)/2500 = 3.12%
$\bar{V}$ = 0.88 ft/sec.
travel time = 2500/0.88 = 0.79 hr.

SMALL TRIB.: length = 2200'
slope = (907-892)/2200 = 0.68%
$\bar{V}$ = 1.7 ft/sec.
travel time = 2200/1.7 = 0.36 hr.

USE PATH #2: TIME OF CONCENTRATION = 0.14 + 0.18 + 0.79 + 0.36 = 1.47, say 1.5

SUBAREA I-G

OVERLAND: length = 2050'
(woods) slope = (1140-952)/2050 = 9.2%
$\bar{V}$ = 0.78 ft/sec.
travel time = 2050/0.78 = 0.73 hr.

OVERLAND: length = 5100'
(fallow) slope = (952-892)/5100 = 1.18%
$\bar{V}$ = 0.54 ft/sec
travel time = 5100/0.54 = 2.62 hr.

TIME OF CONCENTRATION = 0.73 + 2.62 = 3.35, say 3.4 hrs.

SUBAREA I-H

PATH #1

OVERLAND: length = 1400'
(fallow) slope = (1080-1040)/1400' = 2.9%
$\bar{V}$ = 0.85 ft/sec.
travel time = 1400/0.85 = 0.46 hr.

SMALL TRIB.: length = 7200'
slope = (1040-892)/7200 = 2.1%
$\bar{V}$ = 3.0 ft/sec.
travel time = 7200/3.0 = 0.67 hr.

PATH #2

length = 2750' (fallow)
slope = (950-925)/2750 = 0.91%
$\bar{V}$ = 0.48 ft/sec.
travel time = 2750/0.48 = 1.59 hr

length = 3200' (small trib.)
slope = (925-892)/3200 = 1.03%
$\bar{V}$ = 2.2 ft/sec.
travel time = 3200/2.2 = 0.40 hr.

(cont. on next page)

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

TIME OF CONCENTRATION CALCULATIONS (cont.)

SUBAREA I-H (cont.)

USE PATH #2: TIME OF CONCENTRATION = 1.59 + 0.40 = 1.99, say 2.0 hrs.

SUBAREA I-I

OVERLAND (woods): length = 1300'
slope = (920 − 895)/1300 = 1.9%
$\bar{V}$ = 0.35 ft/sec.
travel time = 1300/0.35 = 1.03 hrs.

OVERLAND (fallow): length = 300'
slope = (895 − 892)/300 = 1.0%
$\bar{V}$ = 0.50 ft/sec.
travel time = 300/0.5 = 0.17 hr.

TIME OF CONCENTRATION = 1.03 + 0.17 = 1.20 hrs.

SUBAREA N-1

PATH #1:

OVERLAND (fallow): length = 400'
slope = (950 − 948)/400' = 0.50%
$\bar{V}$ = 0.35 ft/sec.
travel time = 400/0.35 = 0.32 hr.

SMALL TRIB.: length = 9500'
slope = (948 − 892)/9500 = 0.59%
$\bar{V}$ = 1.6 ft/sec.
travel time = 9500/1.6 = 1.65 hrs.

PATH #2:

length = 2900' (fallow)
slope = (950 − 916)/2900' = 1.17%
$\bar{V}$ = 0.54 ft/sec.
travel time = 2900/0.54 = 1.49 hr

length = 5600' (small trib.)
slope = (916 − 892)/5600 = 0.43%
$\bar{V}$ = 1.35 ft/sec.
travel time = 5600/1.35 = 1.15 hr

USE PATH #2: TIME OF CONCENTRATION = 1.49 + 1.15 = 2.64, say 2.6 hrs.

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB Buckeye Lake
SHEET NO. 1 OF
CALCULATED BY RCD DATE 7/13/85
CHECKED BY MPG DATE 7-18-85
SCALE CURVE NUMBER CALCULATIONS

LAND USE	SOIL TYPE A %	CN	PROD.	SOIL TYPE B 10% %	CN	PROD.	SOIL TYPE C 70% %	CN	PROD.	SOIL TYPE D 20% %	CN	PROD.
SUBAREA W-1												
Cultivated (mixed)				70	75	5250	70	83	5810	70	87	6090
Pasture/Open space (good)				5	61	305	5	74	370	5	80	400
Woods (good)				15	55	825	15	70	1050	15	77	1155
Commercial/business				1	92	92	1	94	94	1	95	95
Residential (1/6 ac)				2	80	160	2	87	174	2	89	178
Residential (1+ ac.)				3	68	204	3	79	237	3	84	252
Paved area				3	98	294	3	98	294	3	98	294
Water				1	100	100	1	100	100	1	100	100
TOTALS				100		7230			8129			8564

WEIGHTED CURVE NUMBER = $\frac{(0.10)(7230) + (0.70)(8129) + (0.20)(8564)}{100} = \frac{8126.1}{100} = 81.3$, say 81

LAND USE	SOIL TYPE A %	CN	PROD.	SOIL TYPE B 10% %	CN	PROD.	SOIL TYPE C 75% %	CN	PROD.	SOIL TYPE D 15% %	CN	PROD.
SUBAREA W-2												
Cultivated (mixed)				80	75	6000	80	83	6640	80	87	6960
Pasture/Open space (good)				6	61	366	6	74	444	6	80	480
Woods (good)				10	55	550	10	70	700	10	77	770
Paved area				3	98	294	3	98	294	3	98	294
Water				1	100	100	1	100	100	1	100	100
TOTALS				100		7310			8178			8604

WEIGHTED CURVE NUMBER = $\frac{(0.10)(7310) + (0.75)(8178) + (0.15)(8604)}{100} = \frac{8155.1}{100} = 81.6$, say 82

PRODUCT 204A NEBS INC. Groton Mass. 01471

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB: [illegible] LAKES
SHEET NO. 2 OF 18
CALCULATED BY: RCD DATE: 7/18/85
CHECKED BY: MPG DATE: 7-18-85
SCALE: CURVE NUMBER CALCULATIONS
20

LAND U.	SOIL TYPE A			SOIL TYPE		15%	SOIL TYPE C		35%	SOIL TYPE D		20%
SUBAREA W-A	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.
Cultivated (mixed)				78	75	58 50	78	83	64 74	73	87	67 86
Pasture/Open space (good)				0			0			0		
Woods (good)				20	55	11 00	20	70	14 00	20	77	15 40
Water				2	100	2 00	2	100	2 00	2	100	2 00
TOTALS				100		71 50			80 74			85 26

WEIGHTED CURVE NUMBER = $\frac{(0.15)(7150) + (0.35)(8074) + (0.20)(8526)}{100} = \frac{7714.6}{100} = 77.14$, Say 77

LAND USE	SOIL TYPE A			SOIL TYPE B		5%	SOIL TYPE C		65%	SOIL TYPE D		30%
SUBAREA W-3	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.
Cultivated (mixed)				86	75	64 50	86	83	71 38	86	87	74 82
Pasture/Open space (good)				5	61	3 05	5	74	3 70	5	80	4 00
Woods (good)				7	55	3 85	7	70	4 90	7	77	5 39
Paved area				1	98	98	1	98	98	1	98	98
Water				1	100	1 00	1	100	1 00	1	100	1 00
TOTALS				100		73 38			81 96			86 19

WEIGHTED CURVE NUMBER = $\frac{(0.05)(7338) + (0.65)(8196) + (0.30)(8619)}{100} = \frac{8280.0}{100} = 82.8$, Say 83

PRODUCT 2041 (NEBS) Inc. Groton, Mass. 01471.

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB: BUCKEYE LAKE
SHEET NO. 13 OF
CALCULATED BY: RCD DATE: 7/18/85
CHECKED BY: MPL DATE: 7-18-85
SUBJECT: CURVE NUMBER CALCULATIONS

LAND USE	SOIL TYPE A %	CN	PROD.	SOIL TYPE B 80% %	CN	PROD.	SOIL TYPE C 5% %	CN	PROD.	SOIL TYPE D 15% %	CN	PROD.
SUBAREA W-B												
Cultivated (mixed)				67	75	50.25	67	83	55.61	67	87	58.29
Pasture/Open space (good)				10	61	6.10	10	74	7.40	10	80	8.00
Woods (good)				9	55	4.95	9	70	6.30	9	77	6.93
Paved area				9	98	8.82	9	98	8.82	9	98	8.82
Residential (1/4 ac)				5	75	3.75	5	83	4.15	5	87	4.35
TOTALS				100		73.87			82.28			86.39

WEIGHTED CURVE NUMBER = $\frac{(0.80)(73.87)+(0.05)(82.28)+(0.15)(86.39)}{100} = \frac{7616.85}{100} = 76.2$, say **76**

LAND USE	SOIL TYPE A %	CN	PROD.	SOIL TYPE B 25% %	CN	PROD.	SOIL TYPE C 30% %	CN	PROD.	SOIL TYPE D 45% %	CN	PROD.
SUBAREA W-A												
Cultivated (mixed)				90	75	67.50	90	83	74.70	90	87	78.30
Pasture/Open space (good)				5	61	3.05	5	74	3.70	5	80	4.00
Woods (good)				3	55	1.65	3	70	2.10	3	77	2.31
Paved area				1	98	.98	1	98	.98	1	98	.98
Water				1	100	1.00	1	100	1.00	1	100	1.00
TOTALS				100		74.18			82.48			86.59

WEIGHTED CURVE NUMBER = $\frac{(0.25)(74.18)+(0.30)(82.48)+(0.45)(86.59)}{100} = \frac{8225.45}{100} = 82.3$, say **82**

PRODUCT 2041 NEBS Inc. Groton, Mass 01471

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB _____ SHEET NO. 4 OF _____
CALCULATED BY RCD DATE 7-18-85
CHECKED BY MPG DATE 7-18-85
SCALE CURVE NUMBER CALCULATIONS

LAND USE	SOIL TYPE A %	CN	PROD.	SOIL TYPE B 85% %	CN	PROD.	SOIL TYPE C 15% %	CN	PROD.	SOIL TYPE D %	CN	PROD.
SUBAREA W-C												
Cultivated (mixed)				90	75	6750	90	83	7470			
Water				10	100	1000	10	100	1000			
TOTALS				100		7750			8470			

WEIGHTED CURVE NUMBER = $\frac{(0.85)(7750) + (0.15)(8470)}{100} = \frac{7858.0}{100} = 78.6$, say **79**

LAND USE	SOIL TYPE A %	CN	PROD.	SOIL TYPE B 40% %	CN	PROD.	SOIL TYPE C 10% %	CN	PROD.	SOIL TYPE D 50% %	CN	PROD.
SUBAREA W-5												
Cultivated (mixed)				95	75	7125	95	83	7885	95	87	8265
Pasture/Open space (good)				3	61	183	3	74	222	3	80	240
Paved area				1	98	98	1	98	98	1	98	98
Water				1	100	100	1	100	100	1	100	100
TOTALS				100		7506			8305			8703

WEIGHTED CURVE NUMBER = $\frac{(0.40)(7506) + (0.10)(8305) + (0.50)(8703)}{100} = \frac{8184.4}{100} = 81.8$, say **82**

PRODUCT 204-1 NEBS Inc. Groton, Mass. 01471

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB: Survey Lake
SHEET NO. 5 OF 18
CALCULATED BY: RCD DATE: 7/18/85
CHECKED BY: MPG DATE: 7-18-85
SCALE: CURVE NUMBER CALCULATIONS

LAND USE	SOIL TYPE A			SOIL TYPE B 15%			SOIL TYPE C 70%			SOIL TYPE D 15%		
SUBAREA W-D	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.
Cultivated (mixed)				90	75	6750	90	83	7470	90	87	7830
Woods (good)				5	55	275	5	70	350	5	77	385
Water				5	100	500	5	100	500	5	100	500
TOTALS				100		7525			8320			8715

WEIGHTED CURVE NUMBER = $\frac{(0.15)(7525) + (0.70)(8320) + (0.15)(8715)}{100} = \frac{8260.0}{100} = 82.6$, say **83**

LAND USE	SOIL TYPE A			SOIL TYPE B 5%			SOIL TYPE C 55%			SOIL TYPE D 40%		
SUBAREA W-6	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.
Cultivated (mixed)				82	75	6150	82	83	6806	82	87	7134
Pasture/Open space (good)				5	61	305	5	74	370	5	80	400
Woods (good)				10	55	550	10	70	700	10	77	770
Paved area				1	98	98	1	98	98	1	98	98
Water				2	100	200	2	100	200	2	100	200
TOTALS				100		7303			8174			8602

WEIGHTED CURVE NUMBER = $\frac{(0.05)(7303) + (0.55)(8174) + (0.40)(8602)}{100} = \frac{8301.65}{100} = 83.0$, say **83**

PRODUCT 204-1 NEBS Inc. Groton, Mass. 01471.

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB # 807

SHEET NO. ____ OF ____

CALCULATED BY RCD DATE 7/18/85

CHECKED BY MPG DATE 7-18-85

SCALE: CURVE NUMBER CALCULATIONS

LAND USE	SOIL TYPE A			SOIL TYPE B 15%			SOIL TYPE C 45%			SOIL TYPE D 40%		
SUBAREA W-E	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.
Cultivated (mixed)				83	75	6225	83	83	6889	83	87	7221
Woods (good)				10	55	550	10	70	700	10	77	770
Water				7	100	700	7	100	700	7	100	700
TOTALS				100		7475			8289			8691

WEIGHTED CURVE NUMBER = $\frac{(0.15)(7475) + (0.45)(8289) + (0.40)(8691)}{100} = \frac{8327.7}{100} = 83.3$, say **83**

LAND USE	SOIL TYPE A			SOIL TYPE B			SOIL TYPE C 60%			SOIL TYPE D 40%		
SUBAREA W-7	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.
Cultivated (mixed)							85	83	7055	85	87	7395
Pasture/Open space (good)							3	74	222	3	80	240
Woods (good)							10	70	700	10	77	770
Water							2	100	200	2	100	200
TOTALS							100		8177			8605

WEIGHTED CURVE NUMBER = $\frac{(0.60)(8177) + (0.40)(8605)}{100} = \frac{8348.2}{100} = 83.48$, say **83**

PROJECT 2041 NEBS INC. Quincy, Mass. 02171

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB: Burgoyne Lake # 807
SHEET NO. 7 OF 18
CALCULATED BY: RCD DATE: 7/18/85
CHECKED BY: MPG DATE: 7-18-85
SCALE: CURVE NUMBER CALCULATIONS

LAND USE	SOIL TYPE A %	CN	PROD.	SOIL TYPE B %	CN	PROD.	SOIL TYPE C 45% %	CN	PROD.	SOIL TYPE D 55% %	CN	PROD.
SUBAREA W-F												
Cultivated (mixed)							90	83	7470	90	87	7830
Woods (good)							3	70	210	3	77	231
Paved area							2	98	196	2	98	196
Water							5	100	500	5	100	500
TOTALS							100		8376			8757

WEIGHTED CURVE NUMBER = $\frac{(0.45)(8376) + (0.55)(8757)}{100} = \frac{8585.55}{100} = 85.9$, say **86**

LAND USE	SOIL TYPE A %	CN	PROD.	SOIL TYPE B %	CN	PROD.	SOIL TYPE C 60% %	CN	PROD.	SOIL TYPE D 40% %	CN	PROD.
SUBAREA W-8												
Cultivated (mixed)							80	83	6640	80	87	6960
Pasture/Open space (good)							5	74	370	5	80	400
Woods (good)							13	70	910	13	77	1001
Paved area							1	98	98	1	98	98
Water							1	100	100	1	100	100
TOTALS							100		8118			8559

WEIGHTED CURVE NUMBER = $\frac{(0.60)(8118) + (0.40)(8559)}{100} = \frac{8294.4}{100} = 82.9$, say **83**

PRODUCT 204-1 NEBS Inc. Gordon, Mass. 01472

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB BUCKEYE LAKES
SHEET NO. 2 OF 10
CALCULATED BY RCD DATE 7/18/85
CHECKED BY MPG DATE 7-18-85
SUBJECT CURVE NUMBER CALCULATIONS

LAND USE	SOIL TYPE A %	CN	PROD.	SOIL TYPE B 7% %	CN	PROD.	SOIL TYPE C 53% %	CN	PROD.	SOIL TYPE D 40% %	CN	PROD.
SUBAREA W-G												
Cultivated (mixed)				83	75	6225	83	83	6889	83	87	7221
Pasture / open space (good)				5	61	305	5	74	370	5	80	400
Woods (good)				7	55	385	7	70	490	7	77	539
Residential (1/6 ac)				3	80	240	3	87	261	3	89	267
Paved area				1	98	98	1	98	98	1	98	98
Water				1	100	100	1	100	100	1	100	100
TOTALS				100		7353			8208			8625

WEIGHTED CURVE NUMBER = $\frac{(0.07)(7353) + (0.53)(8208) + (0.40)(8625)}{100} = \frac{8314.95}{100} = 83.1$, say **83**

LAND USE	SOIL TYPE A %	CN	PROD.	SOIL TYPE B %	CN	PROD.	SOIL TYPE C 55% %	CN	PROD.	SOIL TYPE D 45% %	CN	PROD.
SUBAREA S-A												
Cultivated (mixed)							60	83	4980	60	87	5220
Pasture / Open Space (good)							15	74	1110	15	80	1200
Woods (good)							4	70	280	4	77	308
Commercial / business							1	94	94	1	95	95
Residential (1/6 ac)							15	87	1305	15	89	1335
Paved area							3	98	294	3	98	294
Water							2	100	200	2	100	200
TOTALS							100		8263			8652

WEIGHTED CURVE NUMBER = $\frac{(0.55)(8263) + (0.45)(8652)}{100} = \frac{8138.05}{100} = 81.4$, say **84**

PRODUCT 20041 NEBS Inc. Groton, Mass. 01471.

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB: BUCKEYE LAKE #807 SHEET NO. 5 OF 18
CALCULATED BY: RCD DATE: 7/18/85
CHECKED BY: MPG DATE: 7-18-85
SUBJECT: CURVE NUMBER CALCULATIONS

LAND USE	SOIL TYPE A %	CN	PROD.	SOIL TYPE B %	CN	PROD.	SOIL TYPE C 30% %	CN	PROD.	SOIL TYPE D 70% %	CN	PROD.
SUBAREA I-A												
Cultivated (mixed)							55	83	4565	55	87	4785
Pasture/Open space (good)							15	74	1110	15	80	1200
Woods (good)							5	70	350	5	77	385
Residential (1/6 ac)							15	87	1305	15	89	1335
Residential (1/2 ac)							10	80	800	10	85	850
TOTALS							100		8130			8555

WEIGHTED CURVE NUMBER = $\frac{(0.30)(8130) + (0.70)(8555)}{100} = \frac{8427.5}{100} = 84.3$, say **84**

LAND USE	SOIL TYPE A %	CN	PROD.	SOIL TYPE B 2% %	CN	PROD.	SOIL TYPE C 58% %	CN	PROD.	SOIL TYPE D 40% %	CN	PROD.
SUBAREA S-1												
Cultivated (mixed)				92	75	6900	92	83	7636	92	87	8004
Pasture/Open space (good)				5	61	305	5	74	370	5	80	400
Woods (good)				1	55	55	1	70	70	1	77	77
Paved area				1	98	98	1	98	98	1	98	98
Water				1	100	100	1	100	100	1	100	100
TOTALS				100		7458			8274			8679

WEIGHTED CURVE NUMBER = $\frac{(0.02)(7458) + (0.58)(8274) + (0.40)(8679)}{100} = \frac{8419.68}{100} = 84.2$, say **84**

PRODUCT 204-1 NEBS Inc. Groton, Mass. 01471.

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB ____ SHEET NO. ____ OF 18

CALCULATED BY RCD DATE 7/18/85

CHECKED BY MPG DATE 7-18-85

SCALE ____ CURVE NUMBER CALCULATIONS

LAND USE	SOIL TYPE A			SOIL TYPE B 20%			SOIL TYPE C 45%			SOIL TYPE D 35%		
SUBAREA I-B	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.
Cultivated (mixed)				75	75	5625	75	83	6225	75	87	6525
Pasture/Open space (good)				6	61	366	6	74	444	6	80	480
Woods (good)				5	55	275	5	70	350	5	77	385
Paved area				2	98	196	2	98	196	2	98	196
Residential (1/8 ac)				7	85	595	7	90	630	7	92	644
Residential (1/6 ac)				5	80	400	5	87	435	5	89	445
TOTALS				100		7457			8280			8675

WEIGHTED CURVE NUMBER = $\frac{(0.20)(7457)+(0.45)(8280)+(0.35)(8675)}{100} = \frac{8253.65}{100} = 82.5$, Say 83

LAND USE	SOIL TYPE A			SOIL TYPE B 10%			SOIL TYPE C 65%			SOIL TYPE D 25%		
SUBAREA S-2	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.
Cultivated (mixed)				95	75	7125	95	83	7885	95	87	8265
Pasture/Open space (good)				2	61	122	2	74	148	2	80	160
Woods (good)				1	55	55	1	70	70	1	77	77
Paved area				1	98	98	1	98	98	1	98	98
Water				1	100	100	1	100	100	1	100	100
TOTALS				100		7500			8301			8700

WEIGHTED CURVE NUMBER = $\frac{(0.10)(7500)+(0.65)(8301)+(0.25)(8700)}{100} = \frac{8320.65}{100} = 83.2$, Say 83

PRODUCT 204-1 NEBS Inc. Groton, Mass. 01471.

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB: [illegible] LAKE
SHEET NO. 11 OF 18
CALCULATED BY: RCD DATE: 7/18/85
CHECKED BY: MPG DATE: 7-18-85
SCALE: CURVE NUMBER CALCULATIONS

LAND USE	SOIL TYPE A			SOIL TYPE B 35%			SOIL TYPE C 50%			SOIL TYPE D 15%		
SUBAREA I-C	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.
Cultivated (mixed)				70	75	5250	70	83	5810	70	87	6090
Pasture/Open space (good)				7	61	427	7	74	518	7	80	560
Woods (good)				10	55	550	10	70	700	10	77	770
Paved area				3	98	294	3	98	294	3	98	294
Water				10	100	1000	10	100	1000	10	100	1000
TOTALS				100		7521			8322			8714

WEIGHTED CURVE NUMBER = $\frac{(0.35)(7521) + (0.50)(8322) + (0.15)(8714)}{100} = \frac{8100.45}{100} = 81.0$, say **81**

LAND USE	SOIL TYPE A			SOIL TYPE B 20%			SOIL TYPE C 60%			SOIL TYPE D 20%		
SUBAREA S-3	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.
Cultivated (mixed)				85	75	6375	85	83	7055	85	87	7395
Pasture/Open space (good)				5	61	305	5	74	370	5	80	400
Woods (good)				5	55	275	5	70	350	5	77	385
Paved area				1	98	98	1	98	98	1	98	98
Water				1	100	100	1	100	100	1	100	100
Residential (1/4 ac)				3	75	225	3	83	249	3	87	261
TOTALS				100		7378			8222			8639

WEIGHTED CURVE NUMBER = $\frac{(0.20)(7378) + (0.60)(8222) + (0.20)(8639)}{100} = \frac{8136.6}{100} = 81.4$, say **81**

PRODUCT 204-1 NEBS Inc. Groton, Mass. 01471.

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB: BUCKEYE LAKE
SHEET NO. 12 OF
CALCULATED BY: RCD DATE: 7/18/85
CHECKED BY: MPG DATE: 7-18-85
SCALE:

CURVE NUMBER CALCULATIONS

LAND USE	SOIL TYPE A			SOIL TYPE B 45%			SOIL TYPE C 40%			SOIL TYPE D 15%		
SUBAREA I-D	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.
Cultivated (mixed)				20	75	1500	20	83	1660	20	87	1740
Pasture/Open space (good)				23	61	1403	23	74	1702	23	80	1840
Woods (good)				2	55	110	2	70	140	2	77	154
Residential (1/6 ac)				20	80	1600	20	87	1740	20	89	1780
Residential (1/4 ac)				25	75	1875	25	83	2075	25	87	2175
Paved area				10	98	980	10	98	980	10	98	980
TOTALS				100		7468			8297			8669

WEIGHTED CURVE NUMBER = $\frac{(0.45)(7468) + (0.40)(8297) + (0.15)(8669)}{100} = \frac{7979.75}{100} = 79.8$, say 80.

LAND USE	SOIL TYPE A			SOIL TYPE B 25%			SOIL TYPE C 55%			SOIL TYPE D 20%		
SUBAREA S-4	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.
Cultivated (mixed)				92	75	6900	92	83	7636	92	87	8004
Pasture/Open space (good)				5	61	305	5	74	370	5	80	400
Woods (good)				1	55	55	1	70	70	1	77	77
Paved area				1	98	98	1	98	98	1	98	98
Water				1	100	100	1	100	100	1	100	100
TOTALS				100		7458			8274			8679

WEIGHTED CURVE NUMBER = $\frac{(0.25)(7458) + (0.55)(8274) + (0.20)(8679)}{100} = \frac{8151.0}{100} = 81.5$, say 82

PRODUCT 204-1 AVERY INC. Boston, Mass. 01471.

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB: BUCKEYE LAKE #807 SHEET NO. 13 OF 18

CALCULATED BY: RCD DATE: 7/18/85

CHECKED BY: MPG DATE: 7-18-85

SCALE: CURVE NUMBER CALCULATIONS

LAND USE	SOIL TYPE A			SOIL TYPE B 30%			SOIL TYPE C 65%			SOIL TYPE D 5%		
SUBAREA I-E	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.
Cultivated (mixed)				65	75	4875	65	83	5395	65	87	5655
Pasture/open space (good)				10	61	610	10	74	740	10	80	800
Woods (good)				10	55	550	10	70	700	10	77	770
Residential (1 ac)				5	68	340	5	79	395	5	84	420
Residential (1/8 ac)				10	85	850	10	90	900	10	92	920
TOTALS				100		7225			8130			8565

WEIGHTED CURVE NUMBER = $\frac{(0.30)(7225) + (0.65)(8130) + (0.05)(8565)}{100} = \frac{7880.25}{100} = 78.8$, say **79**

LAND USE	SOIL TYPE A			SOIL TYPE B 50%			SOIL TYPE C 40%			SOIL TYPE D 10%		
SUBAREA S-5A	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.
Cultivated (mixed)				75	75	5625	75	83	6225	75	87	6525
Pasture/open space (good)				5	61	305	5	74	370	5	80	400
Woods (good)				14	55	770	14	70	980	14	77	1078
Residential (1/4 ac)				4	75	300	4	83	332	4	87	348
Paved area				1	98	98	1	98	98	1	98	98
Water				1	100	100	1	100	100	1	100	100
TOTALS				100		7198			8105			8549

WEIGHTED CURVE NUMBER = $\frac{(0.50)(7198) + (0.40)(8105) + (0.10)(8549)}{100} = \frac{7695.9}{100} = 77.0$, say **77**

PRODUCT 204-1 NEBS Inc., Groton, Mass. 01471.

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB

SHEET NO. 14 OF

CALCULATED BY RCD DATE 7/18/85

CHECKED BY MPG DATE 7-18-85

SCALE

CURVE NUMBER CALCULATIONS

LAND USE	SOIL TYPE A			SOIL TYPE B 45%			SOIL TYPE C 45%			SOIL TYPE D 10%		
SUBAREA S-5B	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.
Cultivated (mixed)				85	75	6375	85	83	7055	85	87	7395
Pasture/Open space (good)				5	61	305	5	74	370	5	80	400
Woods (good)				7	55	385	7	70	490	7	77	539
Gravel road (RR bed)				1	85	85	1	89	89	1	91	91
Paved area				1	98	98	1	98	98	1	98	98
Water				1	100	100	1	100	100	1	100	100
TOTALS				100		7348			8202			8623

WEIGHTED CURVE NUMBER = $\frac{(0.45)(7348) + (0.45)(8202) + (0.10)(8623)}{100} = \frac{7859.8}{100} = 78.6$, say **79**

LAND USE	SOIL TYPE A			SOIL TYPE B 35%			SOIL TYPE C 55%			SOIL TYPE D 10%		
SUBAREA S-5C	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.
Cultivated (mixed)				85	75	6375	85	83	7055	85	87	7395
Pasture/Open space (good)				5	61	305	5	74	370	5	80	400
Woods (good)				5	55	275	5	70	350	5	77	385
Gravel road (RR bed)				1	85	85	1	89	89	1	91	91
Paved area				2	98	196	2	98	196	2	98	196
Water				2	100	200	2	100	200	2	100	200
TOTALS				100		7436			8260			8667

WEIGHTED CURVE NUMBER = $\frac{(0.35)(7436) + (0.55)(8260) + (0.10)(8667)}{100} = \frac{8012.3}{100} = 80.1$, say **80**

PRODUCT 204-1 NEBS Inc. Groton, Mass. 01471.

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB ____ SHEET NO. 15 OF 18
CALCULATED BY RCD DATE 7/18/85
CHECKED BY MPb DATE 7-18-85
SCALES CURVE NUMBER CALCULATIONS

LAND USE	SOIL TYPE A %	CN	PROD.	SOIL TYPE B 40% %	CN	PROD.	SOIL TYPE C 50% %	CN	PROD.	SOIL TYPE D 10% %	CN	PROD.
SUBAREA S-5D												
Cultivated (mixed)				85	75	6375	85	83	7055	85	87	7395
Pasture/Open space (good)				5	61	305	5	74	370	5	80	400
Woods (good)				8	55	440	8	70	560	8	77	616
Paved area				1	98	98	1	98	98	1	98	98
Water				1	100	100	1	100	100	1	100	100
TOTALS				100		7318			8183			8609

WEIGHTED CURVE NUMBER = $\frac{(0.40)(7318) + (0.50)(8183) + (0.10)(8609)}{100} = \frac{7879.6}{100} = 78.8$, say **79**

LAND USE	SOIL TYPE A %	CN	PROD.	SOIL TYPE B 40% %	CN	PROD.	SOIL TYPE C 50% %	CN	PROD.	SOIL TYPE D 10% %	CN	PROD.
SUBAREA S-5E												
Cultivated (mixed)				50	75	3750	50	83	4150	50	87	4350
Pasture/Open space (good)				10	61	610	10	74	740	10	80	800
Meadow				14	58	812	14	71	994	14	78	1092
Woods (good)				12	55	660	12	70	840	12	77	924
Residential (1/4 ac)				10	80	800	10	87	870	10	89	890
Paved area				2	98	196	2	98	196	2	98	196
Water				2	100	200	2	100	200	2	100	200
TOTALS				100		7028			7990			8452

WEIGHTED CURVE NUMBER = $\frac{(0.40)(7028) + (0.50)(7990) + (0.10)(8452)}{100} = \frac{7651.4}{100} = 76.5$, say **77**

PRODUCT 204-1 NEBS INC. CONTOOK, MASS. 01471.

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB [illegible] SHEET NO. 16 OF 18
CALCULATED BY PCD DATE 7/18/85
CHECKED BY MPG DATE 7-18-85
SCALE CURVE NUMBER CALCULATIONS

LAND USE	SOIL TYPE A %	CN	PROD.	SOIL TYPE B 10% %	CN	PROD.	SOIL TYPE C 85% %	CN	PROD.	SOIL TYPE D 5% %	CN	PROD.
SUBAREA I-F												
Cultivated (mixed)				53	75	3975	53	83	4399	53	87	4611
Pasture/Open space (good)				15	61	915	15	74	1110	15	80	1200
Woods (good)				15	55	825	15	70	1050	15	77	1155
Residential (1/6 ac)				15	80	1200	15	87	1305	15	89	1335
Paved area				2	98	196	2	98	196	2	98	196
TOTALS				100		7111			8060			8497

WEIGHTED CURVE NUMBER $= \frac{(0.10)(7111) + (0.85)(8060) + (0.05)(8497)}{100} = \frac{7986.95}{100} = 79.9$, say **80**

LAND USE	SOIL TYPE A %	CN	PROD.	SOIL TYPE B 40% %	CN	PROD.	SOIL TYPE C 55% %	CN	PROD.	SOIL TYPE D 5% %	CN	PROD.
SUBAREA 5-6												
Cultivated (mixed)				70	75	5250	70	83	5810	70	87	6090
Pasture/Open space (good)				5	61	305	5	74	370	5	80	400
Woods (good)				6	55	330	6	70	420	6	77	462
Residential (1/4 ac)				15	75	1125	15	83	1245	15	87	1305
Paved area				2	98	196	2	98	196	2	98	196
Gravel road (RR bed)				1	85	85	1	89	89	1	91	91
Water				1	100	100	1	100	100	1	100	100
TOTALS				100		7391			8230			8644

WEIGHTED CURVE NUMBER $= \frac{(0.40)(7391) + (0.55)(8230) + (0.05)(8644)}{100} = \frac{7915.1}{100} = 79.2$, say **79**

PRODUCT 204-1 NEBS Inc. Groton, Mass. 01471

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB ____ SHEET NO. ____ OF 18
CALCULATED BY TCD DATE 7/18/85
CHECKED BY MPG DATE 7-18-85
SUBJECT CURVE NUMBER CALCULATIONS

LAND USE	SOIL TYPE A			SOIL TYPE B 30%			SOIL TYPE C 50%			SOIL TYPE D 20%		
SUBAREA I-G	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.
Cultivated (mixed)				65	75	4875	65	83	5395	65	87	5655
Pasture/Open space (good)				10	61	610	10	74	740	10	80	800
Woods (good)				10	55	550	10	70	700	10	77	770
Residential (1/6 ac)				10	80	800	10	87	870	10	89	890
Gravel road (RR bed)				1	85	85	1	89	89	1	91	91
Paved area				4	98	392	4	98	392	4	98	392
TOTALS				100		7312			8186			8598

WEIGHTED CURVE NUMBER = $\frac{(0.30)(7312) + (0.50)(8186) + (0.20)(8598)}{100} = \frac{8006.2}{100} = 80.1$, say 80

LAND USE	SOIL TYPE A			SOIL TYPE B 45%			SOIL TYPE C 25%			SOIL TYPE D 30%		
SUBAREA I-H	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.
Cultivated (mixed)				50	75	3750	50	83	4150	50	87	4350
Pasture/Open space (good)				10	61	610	10	74	740	10	80	800
Woods (good)				15	55	825	15	70	1050	15	77	1155
Residential (1/6 ac)				21	80	1680	21	87	1827	21	89	1869
Gravel road (RR bed)				1	85	85	1	89	89	1	91	91
Paved area				3	98	294	3	98	294	3	98	294
TOTALS				100		7244			8150			8559

WEIGHTED CURVE NUMBER = $\frac{(0.45)(7244) + (0.25)(8150) + (0.30)(8559)}{100} = \frac{7865.0}{100} = 78.7$, say 79

PRODUCT 204-1 NEBS Inc. Groton, Mass. 01471.

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB ____ SHEET NO. 18 OF 18

CALCULATED BY RCD DATE 7/18/85

CHECKED BY MPG DATE 7-18-85

SCALE ____ CURVE NUMBER CALCULATIONS

LAND USE	SOIL TYPE A			SOIL TYPE B 40%			SOIL TYPE C			SOIL TYPE D 60%		
SUBAREA I-I	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.
Cultivated (mixed)				20	75	1500				20	87	1740
Pasture/Open space (good)				7	61	427				7	80	560
Woods (good)				40	55	2200				40	77	3080
Paved road				8	98	784				8	98	784
Residential (1/8 ac)				25	85	2125				25	92	2300
TOTALS				100		7036						8464

WEIGHTED CURVE NUMBER = $\frac{(0.40)(7036) + (0.60)(8464)}{100} = \frac{7892.8}{100} = 78.9$, say **79**

LAND USE	SOIL TYPE A			SOIL TYPE B 45%			SOIL TYPE C 5%			SOIL TYPE D 50%		
SUBAREA N-1	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.	%	CN	PROD.
Cultivated (mixed)				88	75	6600	88	83	7304	88	87	7656
Pasture/Open space (good)				5	61	305	5	74	370	5	80	400
Woods (good)				4	55	220	4	70	280	4	77	308
Gravel road (RR bed)				1	85	85	1	89	89	1	91	91
Paved road				1	98	98	1	98	98	1	98	98
Water				1	100	100	1	100	100	1	100	100
TOTALS				100		7408			8241			8653

WEIGHTED CURVE NUMBER = $\frac{(0.45)(7408) + (0.05)(8241) + (0.50)(8653)}{100} = \frac{8072.15}{100} = 80.7$, say **81**

PRODUCT 204-1 AVERY Inc. Groton, Mass. 01471

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB 807 - Buckeye Lake
SHEET NO. 1 OF 3
CALCULATED BY DEH DATE 6/13/85
CHECKED BY DATE
~~SCALE~~ Estimate Snyders coefficients

Computation of Snyders coefficients for given unit hydrographs at three neighboring watersheds near Buckeye Lake. U.G. data (Q_p, t_p & duration) obtained from data used in 1980 ODNR Feeder Canal study. Snyder parameters L & L_{ca} obtained from 15 min. quads.

North Fork Licking River nr. Utica

$DA = 116\ mi^2$
$L = 23.6\ mi$
$L_{ca} = 10.6\ mi$
U.G. $Q_p = 4320\ cfs$
U.G. $t_{pR} = 16 - 6/2 = 13\ hrs$
U.G. $t_R = 6\ hrs$

$$t_{pR} = t_p + \frac{t_R - t_r}{4} \quad \& \quad t_r = \frac{t_p}{5.5}$$

$$\therefore 4t_p - \frac{t_p}{5.5} = 4t_{pR} - t_R \Rightarrow t_p = \frac{22}{21} t_{pR} - \frac{5.5}{21} t_R$$

$$t_p = \frac{22}{21} \times 13 - \frac{5.5}{21} \times 6 = 12.05$$

$$t_p = C_t (L \cdot L_{ca})^{0.3} \Rightarrow C_t = \frac{t_p}{(L \cdot L_{ca})^{.3}} = \frac{12.05}{(23.6 \times 10.6)^{.3}} = 2.3 \Rightarrow \underline{C_t = 2.3}$$

$$Q_p = \frac{640 C_p A}{t_{pR}} \Rightarrow C_p = \frac{Q_p t_{pR}}{640 A} = \frac{4320 \times 13}{640 \times 116} = 0.76 \Rightarrow \underline{C_p = 0.76}$$

South Fork Licking River nr. Hebron

$DA = 133\ mi^2$
$L = 27.5\ mi$
$L_{ca} = 12.0\ mi$
U.G. $Q_p = 1950\ cfs$
U.G. $t_{pR} = 27 - \frac{6}{2} = 24\ hrs$
U.G. $t_R = 6\ hrs.$

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

$$t_p = \frac{22}{21} \times 24 - \frac{5.5}{21} \times 6$$

$$t_p = 23.57$$

$$C_t = \frac{23.57}{(27.5 \times 12.0)^{.3}} = 4.1 \Rightarrow \quad \underline{C_t = 4.1}$$

$$C_p = \frac{1950 \times 24}{640 \times 133} = 0.55 \Rightarrow \quad \underline{C_p = 0.55}$$

Raccoon Creek @ Granville

DA = 83 mi²
L = 19 mi
Lca = 8.3 mi
U.G. Q_p = 2900 cfs
U.G. t_{pR} = 18 - 6/2 = 15 hrs
U.G. t_R = 6 hrs.

$$t_p = \frac{22}{21} \times 15 - \frac{5.5}{21} \times 6$$

$$t_p = 14.14$$

$$C_t = \frac{14.14}{(19 \times 8.3)^{.3}} = 3.1 \Rightarrow \quad \underline{C_t = 3.1}$$

$$C_p = \frac{2900 \times 15}{640 \times 83} = 0.82 \Rightarrow \quad \underline{C_p = 0.82}$$

An analysis by Huntington COE in 1971 resulted in the following estimated Snyder coef. for Raccoon Cr. @ Granville: $C_t = 2.8$, $C_p = 0.82$

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

From study by DLA in 1974 of the spillway adequacy of the Corps' Muskingum Basin dams, the following Snyder coefficients were derived for several Muskingum Basin dams whose drainage areas lie almost entirely w/in glaciated areas:

Charles Mill Lake: $C_t = 4.8$
$C_p = 0.56$

Mohicanville Dam: $C_t = 3.4$
$C_p = 0.53$

Pleasant Hill Lake: $C_t = 1.8$
$C_p = 0.54$

Summary

From the above analyses, the Snyder coefficients range as follows:

C_t: 1.8 - 4.8 mean = 3.3
C_p: 0.53 - 0.87 mean = 0.63

Since Buckeye Lake is situated w/in the watershed of South Fork Licking River, it is recommended that more weight be given to the coeff. estimated for that watershed. Therefore, assume the following coeff. for Buckeye Lake:

$C_t = 3.7$
$C_p = 0.60$

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB 807 Buckeye Lake
SHEET NO. 1 OF 1
CALCULATED BY DEH DATE 8/26/85
CHECKED BY DATE
SCALE Snyder coeff. for subareas

From previous analyses, assume $C_t = 3.7$ & $C_p = 0.60$

Use Snyder synthetic hydrograph for subareas W1 – W8, S1 – S6, & N1 for the analyses of historic floods where Snyder's method is used. Use SCS runoff computations so runoff values are the same between the two analyses made using only SCS synthetic hydrographs and a combination of SCS and Snyder synthetic hydrographs. (Snyder's method not used for subareas where streams are not well defined or where subareas are quite small)

Area	Drainage Area (mi^2)	L (mi)	L_c (mi)	t_p * (hrs)
W1	3.74	4.39	2.80	7.85
W2	1.07	2.12	1.14	4.82
W3	1.56	2.65	1.33	5.40
W4	.82	2.84	1.40	5.60
W5	.48	1.89	.95	4.41
W6	3.30	5.53	2.95	8.55
W7	1.80	3.60	1.89	6.58
W8	1.89	3.71	2.08	6.83
S1	1.32	2.16	.91	4.53
S2	1.08	2.54	1.10	5.04
S3	.87	2.01	1.10	4.69
S4	1.73	2.84	1.71	5.94
S5	7.00	5.08	2.65	8.07
S6	.83	1.33	.49	3.25
N1	1.00	1.70	.95	4.27

* $t_p = C_t (L L_c)^{.3}$

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB 807 - Buckeye Lake
SHEET NO. 1 OF 1
CALCULATED BY DEH DATE 8/22/85
CHECKED BY DATE
~~SCALE~~ Elevation - Storage Data

From USGS Quads:

Area @ elev. 892 = 4.31 mi² = 2758 acres*
Area @ elev 900 = 6.40 mi² = 4096 acres

* Acreage obtained by planimetering the lake area shown on the USGS quads. Elevation shown on quads is 892 for lake level, based on photos taken in 1959 & 1961. From lake level records, it appears the lake level seldom reached elev 892 in 1959 & 1960, except for the Jan. 1959 flood & during the summer months. Without additional information, however, it is assumed that the USGS maps are correct & the lake level shown is indeed

Elev. (msl)	Area** (acre)	Avg Area (acre)	ΔH (ft)	ΔV (ac-ft)	Storage*** (ac-ft)
890.0	2424				8,080
891.0	2591	2508	1.0	2508	10,588
892.0	2758	2675	1.0	2675	13,263
892.25 (Spillway crest el. from DLA survey)	2800	2779	0.25	695	13,958
893.0	2925	2863	0.75	2147	16,105
894.0	3093	3009	1.0	3009	19,114
895.0	3260	3177	1.0	3177	22,291
896.0	3427	3344	1.0	3344	25,635
898.0	3762	3595	2.0	7190	32,825
900.0	4096	3929	2.0	7858	40,683

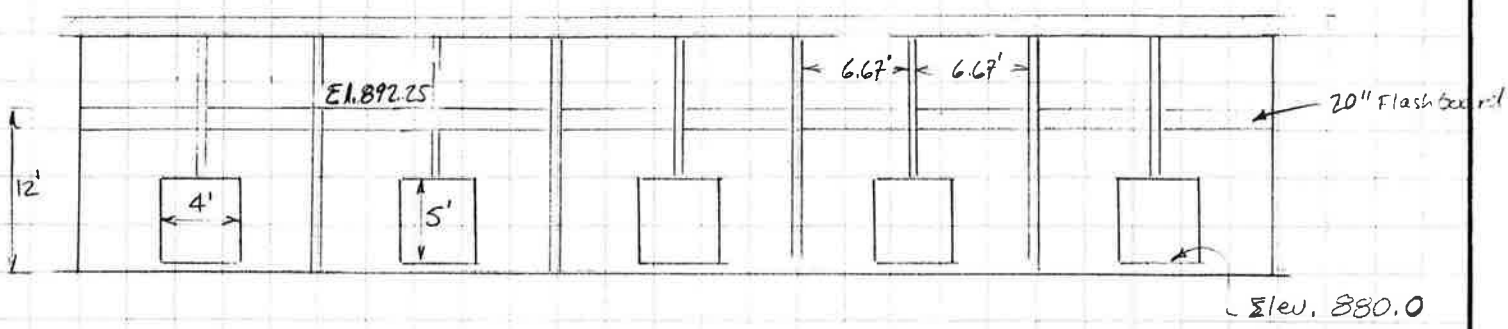
** Assumes linear relationship between elev & area from data @ elev's 892 & 900.

*** Assumes storage @ elev 890.0 = 1/3 HA = 1/3 (890 - 880) 2424
= 8080 ac-ft

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB 807 Buckeye Lake
SHEET NO. 1 OF 4
CALCULATED BY DEH DATE 8/22/85
CHECKED BY DATE
~~SCALE~~ Rating Curve - Existing Spillway

Spillway Structure



Assume sharp-crested weir with end contractions at top of flashboards.

$$Q = C_e L_e H_e^{3/2}$$

$$L_e = L - 2(N K_p + K_a) H_e \quad \text{(Design of Small Dams)}$$
$$= 66.7 - 2(9(0.02) + 0.20) H_e$$
$$L_e = 66.7 - 0.76 H_e$$

$$C_e = 3.22 + 0.40\, H/P \quad \text{(Handbook of Hydraulics)}$$
$$P \approx 12'$$
$$C_e = 3.22 + 0.033 H$$

Assume $h_v \approx 0.0 \Rightarrow H_e = H$

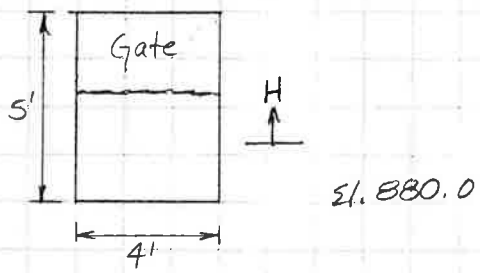
Sharp-crested weir - flow over flashboards

Elev. (msl)	H_e (ft)	L_e (ft)	C_e	Q (cfs)
892.25	0	66.7	—	0
892.3	0.05	66.7	3.22	2
892.4	0.15	66.6	3.22	12
892.5	0.25	66.5	3.23	27
892.6	0.35	66.4	3.23	44
892.8	0.55	66.3	3.24	88
893.0	0.75	66.1	3.24	139
893.5	1.25	65.8	3.26	300
894.0	1.75	65.4	3.28	496
894.5	2.25	65.0	3.29	723

PRODUCT 204-1 NEBS Inc., Groton, Mass 01471.

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

Outlet Gate Opening



Sluice Flow

$Q = CA\sqrt{2gH}$ (Handbook of Hydraulics Eq. 4-10)
($H > 2 \times$ gate opening $\therefore$ this equation $\approx$ same as low head eq)

Estimate "C" coefficient in above equation

According to Kenny Jesselen, Buckeye Lake Park Manager, with one gate open 15 notches the lake level can be lowered $\approx$ 1 in / 24 hr, with negligible inflow. From August 1980 lake level records, though, it appears the lake level drops $\approx$ 0.1 ft in 24 hrs, not 1 inch. Also, the August 1980 records indicate that, with 1 gate open 10 notches, the average drop is $\approx$ 0.07' / 24 hrs. Both situations recorded occurred when lake level was $\approx$ 892.0 (Surface area $\approx$ 2758 acres).

$\therefore$ For 1 gate open 15 notches (30 in)

$$Q = \frac{0.1\ ft}{24\ hr} \times 2758\ ac \times \frac{1\ hr}{3600\ sec} \times \frac{43560\ ft^2}{ac}$$

$Q = 139$ cfs (assume inflow $\approx$ evaporation losses)

$H = 892 - (880 + 2.5/2) = 10.75$ ft ; $A = 4 \times 2.5 = 10\ ft^2$

$\therefore C = Q / A\sqrt{2gH}$

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

$C = 139/10\sqrt{2g(10.75)}$

$\underline{C = 0.53}$

For 1 gate open 10 notches (20 in)

$Q = 139 \times \frac{0.07}{0.10} = 97$ cfs

$H = 892 - (880 + 1.67/2) = 11.17$ ft ; $A = 4 \times 1.67 = 6.68$ ft^2

$C = 97/6.68\sqrt{2g(11.17)}$

$\underline{C = 0.54}$

From Handbook of Hydraulics, p 4-11, the mean "C" value for a 4'x5' sluice gate on a dam was found experimentally to be 0.545.
∴ Assume $\underline{\underline{C \approx 0.54}}$ for all low-flow gate openings

① Assume 1 gate open 10 notches
$A = 6.68$ ft^2

Elev. (msl)	H (ft)	C	Q (cfs)
891.0	10.2	0.54	92
891.5	10.7	↓	95
892.0	11.2		97
892.25	11.4		98
892.5	11.7		99
893.0	12.2		101
893.5	12.7		103
894.0	13.2		105

② Assume 1 gate open 15 notches
$A = 10$ ft^2

Elev (msl)	H (ft)	C	Q (cfs)
891.0	9.75	0.54	135
891.5	10.25	↓	139
892.0	10.75		142
892.25	11.0		144
892.5	11.25		145
893.0	11.75		149
893.5	12.25		152
894.0	12.75		155

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB 55 - Buckeye Lake
SHEET NO. 4 OF 4
CALCULATED BY DEH DATE 8/22/85
CHECKED BY DATE
~~SCALE~~ Rating Curve - Existing - 2 gates 15 N. + weir

(3) Assume 2 gates open 15 notches w/ weir flow over flashboards

Elev. (msl)	Qgates (cfs)	Qweir (cfs)	Qtotal (cfs)
891.0	270	–	270
891.5	278	–	278
892.0	284	–	284
892.25	288	0	288
892.3	288	2	290
892.4	289	12	301
892.5	290	27	317
892.6	292	44	336
892.8	295	88	383
893.0	298	139	437
893.5	304	300	604
894.0	310	496	806

PRODUCT 204-1 NEBS Inc., Groton, Mass. 01471.

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB 807 - Buckeye Lake
SHEET NO. 1 OF 3
CALCULATED BY DEH DATE 8/29/85
CHECKED BY DATE
SCALE Jan 59 Precip.

1. Rainfall distribution recorded @ Columbus Airport, Newark & Lancaster 5NW

	Jan 20							Jan 21																						
	am 11-6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	total
Cols	.38						.02	.10	.14	.02	.28	.44	.16	.07	.35	.48	.62	.74	.41	.01	.06		.59	.29	.03				5.19
LancSNW	.65						.08	.21	.07	.21	.03	.03			.05	.07	.02	.03			.03		.08	.41	.16	.10		.03	2.26
New	.43					.01	.09	.25	.14	.11	.27	.18	.01	.09	.12	.12	.37	.24	.02	.04	.04	.01	.34	.76	.06		.02	.01	3.73

2. Total Precip recorded @ stations near Buckeye Lake

Station	Jan 20	Jan 21	Jan 22	Total	Comments
Buckeye Lake	0.22	1.11	0.87	2.20	Gage read @ 8 AM
Alexandria	0.10	1.85	2.84	4.79	" " " 7 AM
Zanesville Lock 10	0.22	0.60	0.37	1.19	" " " 7 AM
Zanesville AP	0.66	0.79	T	1.45	" " " Midnight
Lancaster 6N	—	—	→ 2.30 total	2.30	" " " 6 PM
Lithopolis	0.28	1.13	1.37	2.78	" " " 7 AM

3. Estimated runoff / inflow to Buckeye Lake

Pool level increased from -6 inches (891.8) to +11 inches (893.2) from ≈ 8 AM Jan 19 to 8 AM Jan 21. ∴ Storage in pool increased from ≈ 12728 ac-ft to ≈ 16707 ac-ft for a net storage increase of 3979 ac-ft. Outflow during this period was both gate & weir flow. Since one gate was open during this time period, assume average gate flow ≈ 120 cfs (10-15 notches) for 48 hours. Assume average weir flow for 24 hours ≈ 80 cfs.

$$120 \frac{ft^3}{s} \times 48 hrs \Rightarrow 476 \text{ ac-ft} \; ; \; 80 \text{ cfs} \times 24 hrs \Rightarrow 159 \text{ ac-ft}$$

$$\therefore \underline{\text{Total inflow}} \approx 3979 + 476 + 159 = \underline{4614 \text{ ac-ft}} = 86.5 \text{ mi}^2\text{-in}$$

Assuming avg. rainfall over lake = 2.2 inches, the runoff from the DA =

$$4.3 \times 2.2 + 39.84 \times R = 86.5 \Rightarrow R = 1.93 \text{ inches, say } \underline{R \approx 1.9 \text{ inches}}$$

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

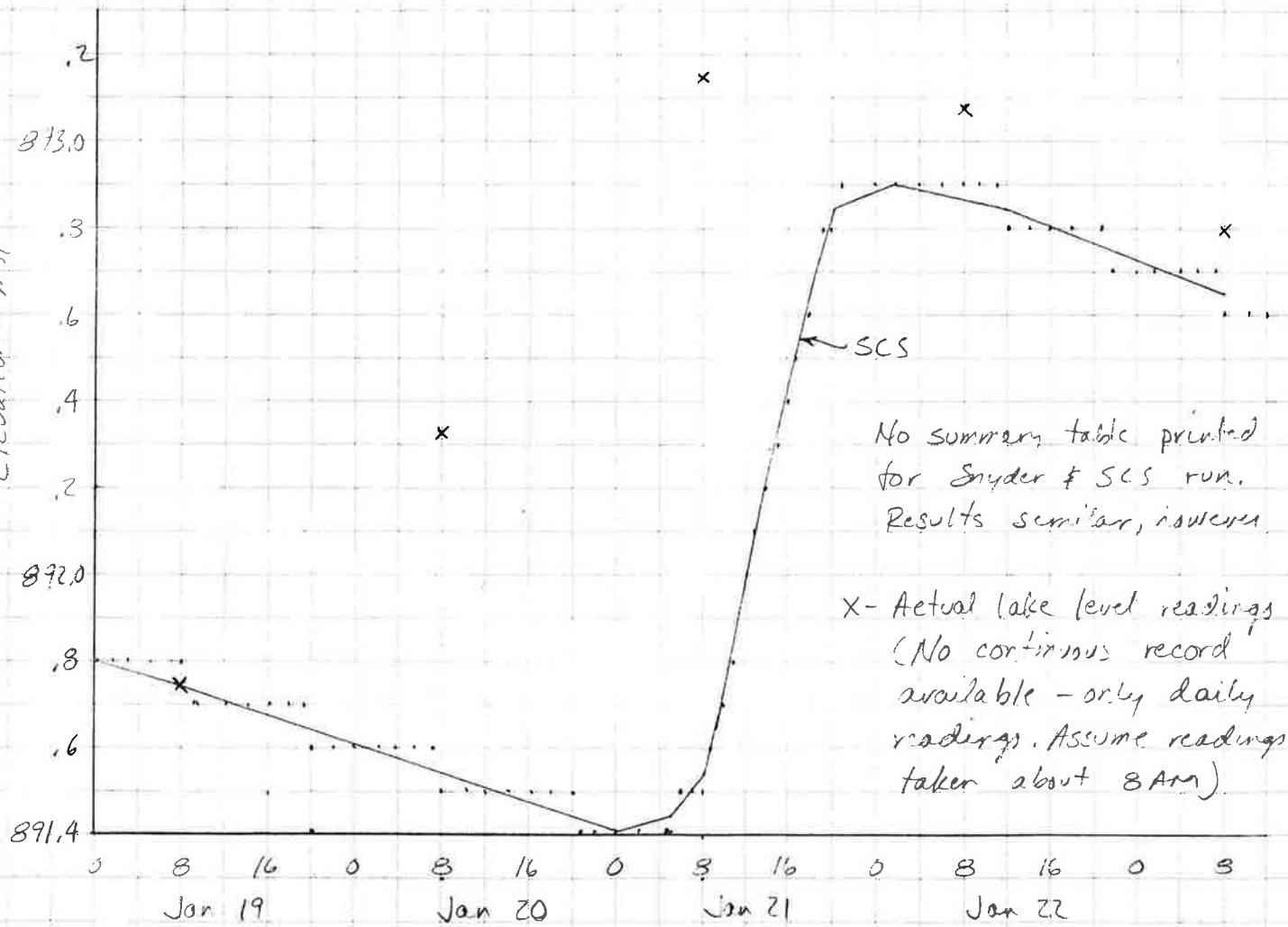
JOB 807 Buckeye Lake
SHEET NO. 2 OF 3
CALCULATED BY DEH DATE 8/29/85
CHECKED BY DATE
SCALE Jan 59 Precip.

4. Rainfall amount & distribution to use in HEC-1 model

A high % of runoff occurred for '59 storm because of high antecendent moisture conditions & frozen ground. ∴ The curve numbers should be adjusted to reflect AMC III conditions.

Since storms in central Ohio tend to move from west to east, the Columbus rainfall distribution will be used, but the total precip. amount will be adjusted so that ≈ 2 inches of runoff results.

5. Simulated lake levels vs actual lake levels. Compare lake levels computed using SCS method only & SCS & Snyder's method combined.



No summary table printed for Snyder & SCS run. Results similar, however.

X- Actual lake level readings (No continuous record available - only daily readings. Assume readings taken about 8 AM).

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB 807- Buckeye Lake
SHEET NO. 3 OF 3
CALCULATED BY DEH DATE 9/4/85
CHECKED BY DATE
SCALE Jan 59 Storm

6. Comments

As it turns out, this storm is difficult to model because more runoff occurs than normal & much earlier than normal due to the frozen ground & due to the snowmelt that occurs. ∴ Results from modeling this storm are obviously inconclusive.

DEPARTMENT OF NATURAL RESOURCES
DIVISION OF PARKS

REPORT OF GAUGE AT Buckeye Lake

FOR MONTH OF January **19**59

Date	Inches + or — Wasteway	Direction of Prevailing Wind	Weather & Temperature	Rain Fall	Gates
1	−10	NW	Cloudy	.73	1 open
2	−10	NW	Cloudy	.65	1 open
3	−08	NE	Clear	.00	1 open
4	−06	N	P Cloudy	TSNOW	1 open
5	−06	NW	Clear	TSNOW	1 open
6	−06	SW	Clear	.00	Closed
7	−06	SW	Cloudy	.00	Closed
8	−06	SW	Clear	TSNOW	Closed
9	−06	NW	Clear	TSNOW	Closed
10	−05	NW	Clear	.00	Closed
11	−05	NW	Clear	.00	1 open
12	−05	NE	Cloudy	.00	1 open
13	−05	SW	Clear	.00	1 open
14	−05	SW	Cloudy	.57	1 open
15	−04	SW	Cloudy	.36	1 open
16	−04	SW	Cloudy	.00	1 open
17	−04	SW	Cloudy	.00	1 open
18	−05	SW	Cloudy	.00	1 open
19	−06	SW	Cloudy	.22	1 open
20	+01	E	Cloudy	1.11	1 open
21	+11	SW	Cloudy	.87	2 open
22	+10	NW	Clear	.00	2 open
23	+07	NW	Clear	.00	3 open
24	+04	NW	Clear	.00	3 open
25	+02	NE	Clear	2" snow .07	3 open
26	00	NE	P Cloudy	1" snow 0.3	3 open
27	−02	NE	P Cloudy	.00	3 open
28	−04	NW	Cloudy	.00	3 open
29	−06	NW	Cloudy	.09	3 open
30	−08	NW	Cloudy	.01	3 open
31	−10	NW	Cloudy	.00	3 open

GAUGE READER Ralph Baughman

REMARKS

Total 4.21

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB 807 - Buckeye Lake
SHEET NO. 1 OF 3
CALCULATED BY DEH DATE 8/30/85
CHECKED BY _____ DATE _____
SCALE May 1968 Storm - Compare SCS & Snyder Meth.

1. Rainfall distribution recorded @ Columbus Airport, Newark & Lancaster WW

Station	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	Total
May 23, 1968																									
Columbus	.02	.03	.07	.13	.15	.22	.21	.10	.03	.03	.13	.04	.03	.06	.20	.03						.04	.28	.12	1.92
Newark			.1		.2	.2	.2	.1		.1	.1	.1	.1		.1	.2							.3	.1	1.9
Lancaster	.04	.01	.03	.03	.09	.18	.34	.20	.22	.06		.04	.05		.16	.02		.01					.79	.39	2.66
May 24, 1968																									
Columbus	.22	.25	.06	.02	.01	.01	.02	.03	.02																.64
Newark	.2	.3	.1							.1															.7
Lancaster	.33	.30	.17	.07	.04	.01	.04																		.96
May 25, 1968 - No precip recorded																									
May 26, 1968																									
Columbus									.01		.02		.01	.04	.05	.12	.03	.06	.19	.30	.17	.44	.37	.01	1.82
Newark															.2	.1	.1	.1	.3					.1	.9
Lancaster															.29	.32	.06	.31	.10	.11		.04	.20	.07	1.50
May 27, 1968																									
Columbus	.03		.02	.03	.02		.01			.08	.11	.01	.01	.34	.37	.06	.04		.02						1.15
Newark				.2	.1	.1			.1			.2	.1		.4										1.2
Lancaster		.02	.08	.03	.04	.02	.05	.09	.10	.02	.01	.45	.35	.64	.18	.11	.02		.02						2.23
May 28, 1968																									
Columbus														.09											.09
Newark															.2										.2
Lancaster														.06	.01	.01									.08
May 29, 1968																									
Columbus													.01	.01											.02
Newark																								.2	.2
Lancaster											.01	.03	.06	.01	.01										.12

PRODUCT 204-1 NEBS Inc., Groton, Mass. 01471.

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

2. Estimated runoff/inflow to Buckeye Lake 5/24 to 5/28

Change in pool level: 892.25 → 894.17 ⇒ Storage increased
≈8AM 5/24 → 8AM 5/29 from 13958 to 19654 ac-ft

∴ Net storage increase ≈ 5696 ac-ft

Outflow - All gates closed ∴ all outflow is weir flow

5/24 – 5/25	Avg elev ≈	892.75	⇒ Qavg ≈	77 cfs	x 24 hr	= 153 ac-ft
5/25 - 5/26	" "	893.4	⇒ Qavg ≈	268 cfs	x "	= 532 "
5/26 - 5/27	" "	893.75	⇒ Qavg ≈	398 cfs	x "	= 789 "
5/27 - 5/28	" "	894.1	⇒ Qavg ≈	541 cfs	x "	= 1073 "
5/28 - 5/29	" "	894.17	⇒ Qavg ≈	573	x "	= 1137 "
						3684 ac-ft

∴ total inflow ≈ 5696 + 3684 = 9380 ac-ft = 175.9 mi²-in

Assume avg rainfall over lake ≈ 6.7 inches ∴ the runoff from the rest of the DA =

$$6.7 \times 4.3 + 39.84 \times R = 175.9 \Rightarrow R \approx 3.7 \text{ inches}$$

3. Rainfall amount & distribution to use in HEC-1 Model

		Buckeye Lake	Cols.	New	Lanc. (8AM - 8AM)
Buckeye Lake Rainfall	May 23	.84	.93	.8	.92
	May 24	2.26	1.61	1.7	2.70
	May 25	.22	.02	.1	–
Gage read at 8AM	May 26	–	–	–	–
	May 27	2.05	1.93	1.3	1.83
	May 28	1.16	1.04	.8	1.90
	May 29	.15	.09	.2	.08
		6.68	5.62	4.9	7.43

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB 807 · Buckeye Lake
SHEET NO. 3 OF 3
CALCULATED BY DEH DATE 9/3/85
CHECKED BY DATE
~~SCALE~~ May 1968 Storm

Rainfall varies from 4.9 inches @ Newark to 7.43 inches @ Lancaster. Assume avg rainfall over basin ≈ 6.0 inches

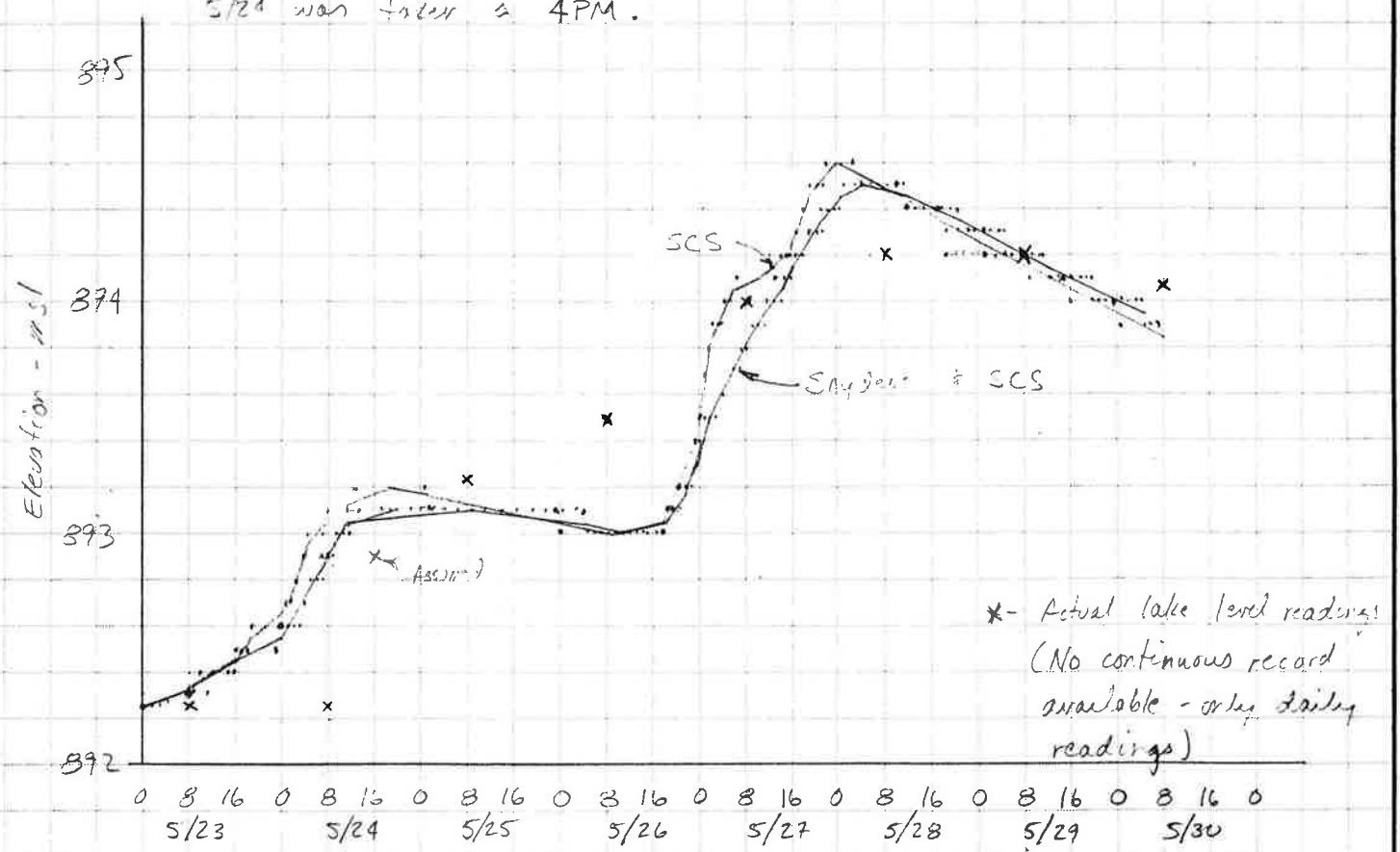
Since the Columbus rainfall distribution matches the daily rainfall recorded @ Buckeye Lake fairly well & has a total rainfall amount of about 6 inches, the Columbus distribution will be used.

4. Gate Operation @ Spillway Structure

All gates closed for the duration of the storm. Outflow by weir flow only.

5. Simulated lake levels vs. actual lake levels

Assume lake level read ≈ 8AM each day, & that additional level read 5/24 was taken ≈ 4PM.



DEPARTMENT OF NATURAL RESOURCES
DIVISION OF PARKS

REPORT OF GAUGE AT Buckeye Lake State Park

FOR MONTH OF May 1968

Date	Inches + or — Wasteway	Direction of Prevailing Wind	Weather & Temperature	Rain Fall	Gates
1	-0	W	52°	.06	closed
2	-0	N	45°	.00	closed
3	-0	N.W.	59°	trace	Closed
4	-0	N	50°	.00	closed
5	-0	N	46°	.00	closed
6	-0	N.E.	36	.00	Closed
7	-0	N.E	38.	.00	Closed
8	-0	S.W	57	.00	Closed
9	-0	SW	60°	.08	Closed
10	-0.	N.W.	52°	.20	Closed
11	-0	E.	34°	.14	Closed
12	-0	N W	57°	1.00	Closed
13	-0	N	50°	.00	Closed
14	-0	S.E.	55°	trace	Closed
15	-0	S.W	62°	.16	Closed
16	-0	S.W.	64°	.92	Closed
17	-0	S.W.	62°	.03	Closed
18	-0	S.	52°	.22	Closed
19	-0	S.W	55°	.09	Closed
20	-0	W	50°	.04	Closed
21	-0	W.	52°	trace	Closed
22	-0	S.W.	53°	.00	Closed
23	-0	S.E.	52°	.70	Closed
24	-0 (+8)	S.W.	58°	2.00	Closed
25	+12	E	58°	.08	Closed
26	+15	S	62°	.00	Closed
27	+21	S.	54°	1.77	Closed
28	+23	S.E	52	1.24	Closed
29	+23	E.	58°	.00	Closed
30	+22	S. W	56°	.07	Closed
31	+20	N. W.	48	.06	Closed

GAUGE READER

REMARKS

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB 807 - Buckeye Lake
SHEET NO. 1 OF 3
CALCULATED BY DEH DATE 7/3/85
CHECKED BY DATE
SCALE June 81 Storm

1. Rainfall distribution recorded @ Columbus Airport, Newark & Lancaster WW

June 10, 1981

Station	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	total
Columbus	.52	.06			.01	.25		.01		.01															.86
Newark	.4	.3	.1				.1																		.9
Lancaster	.1			.1																					.2

June 11 & 12, 1981 - No precip. recorded

June 13, 1981

Columbus								.35		.05					.12		.96	.22	.02	.06	.75	.02			2.55
Newark									.8						1.3		.7	.1	.2	.3	.3	.1		.1	3.9
Lancaster						.1										.8	.7			.6	1.3				3.5

2. Total Precip. recorded @ stations near Buckeye Lake

Station	June 10	June 11-12	June 13	Total	Time Gage Read
Buckeye Lake	*	*	*	*	
Alexandria	.93	0	2.83	3.76	7AM
Zanesville Cuy Pl	3.1	0	2.2	5.3	Hourly
Lancaster 2NW	0	0	2.97	2.97	7AM
Dillon Lake	.66	0	2.75	3.41	Hourly
Zanesville FAA AP	1.58	T	2.62	4.20	Midnight

* No data recorded for Buckeye Lake 2WNW gage. Park managers records indicate little precip occurred in this period.

3. Estimated runoff/inflow to Buckeye Lake for June 13 precip. only

Change in pool level: 892.24 → 892.73 ⇒ Storage increased from ≈ 13958 to 15332 ac-ft

∴ Net storage = 1374 ac-ft

PRODUCT 204-1 NEBS Inc., Groton, Mass. 01471.

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

Outflow: 4PM 6/13 → 4PM 6/14

Gate: 24 hr w/ 2 gates 15 notches ∴ Avg Q ≈ 290 cfs ⇒ ≈ 575 ac-ft

Weir: 24 hr w/ avg Q ≈ 40 cfs ⇒ 79 ac-ft

total inflow ≈ 1374 + 575 + 79 = 2028 ac-ft = 38.0 mi²-in

Assume avg. rainfall over lake ≈ 2 in ∴ the runoff from the rest of the DA =

$$2 \times 4.3 + 39.84 \times R = 38.0 \Rightarrow R \approx 0.74, \text{ say } 0.8 \text{ inches}$$

4. Rainfall amount & distribution to use in HEC-1 Model

Rainfall amounts recorded at the Park Office are somewhat suspect, as only .16 inch recorded for June 10 & 11 & only .12 inch for June 13 & 14.

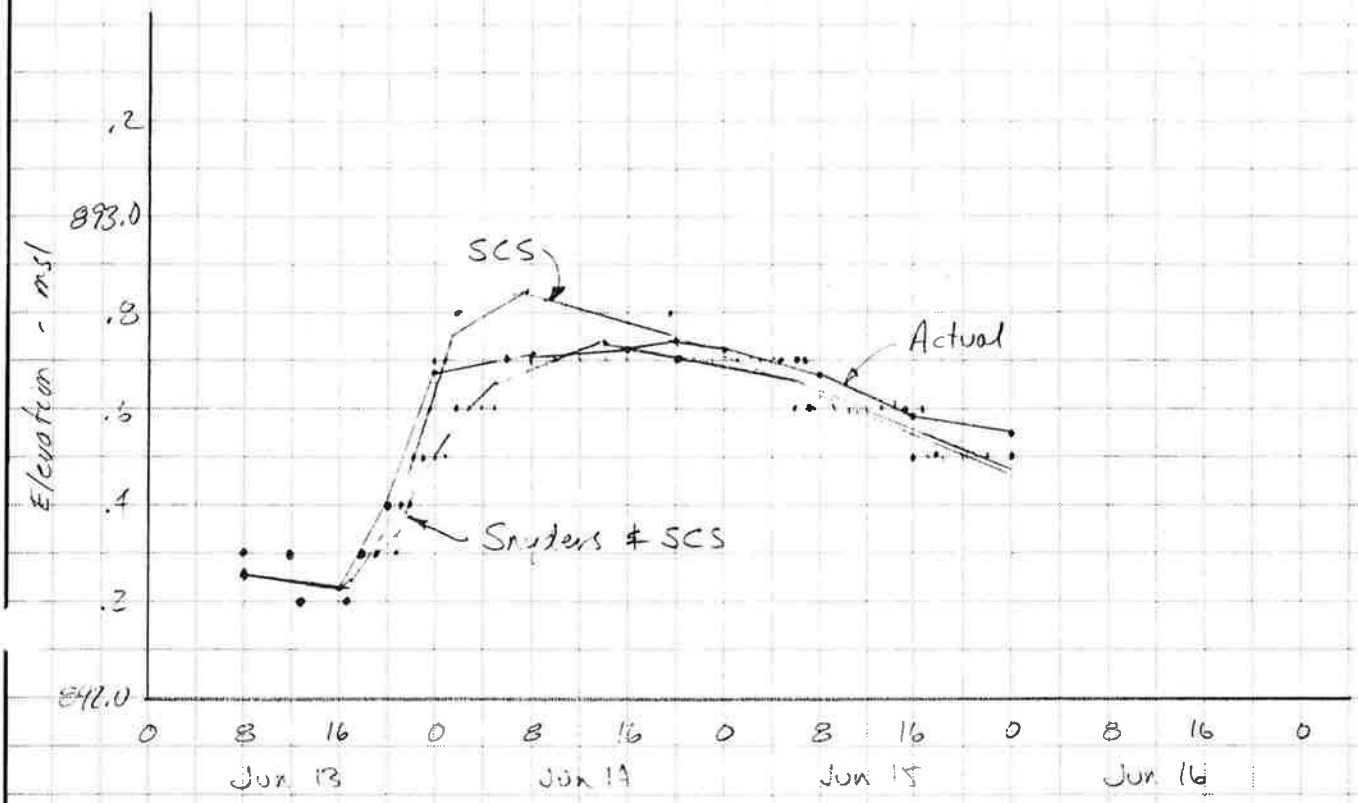
Since Buckeye Lake is situated on an east-west line through Columbus & Zanesville, the rainfall amount assumed for Buckeye Lake DA will be based mainly on the rainfall recorded at these stations. Also, since it is possible that the Park records are fairly accurate, assume the rainfall amount at Buckeye Lake is generally less than that recorded at these stations. ∴ Assume precip ≈ 2.2 to 2.6 inches, say 2.4 inches

Distribution: Use Columbus distribution

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB 807 - Buckeye Lake
SHEET NO. 3 OF 3
CALCULATED BY DEH DATE 9/4/85
CHECKED BY DATE
SCALE June 31 Storm

5. Simulated lake levels vs actual lake levels



DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB 807 - Buckeye Lake
SHEET NO. 1 OF 3
CALCULATED BY DEH DATE 6/25/85
CHECKED BY DATE
~~SCALE~~ Gate Ope: .: info from Park Office - June 8

June 1981

Date	Lake level Ht. from top of flashboards (ft)	Rainfall	Gate Openings
Jun 5	-.24	.08	2 gates, 15 notches each
6	-.14	.07	
7	-.13	.06	
8	-.21	.00	
9	-.25	.04	
10	+.27	.08	
11	+.30	.08	
12	+.19	.01	
13	+.04	.06	
14	+.52	.06	
15	+.47	.10	
16	+.30	.00	
17	+.26	.10	
18	+.10	.00	
19	-.07	.13	
20	-.25	.03	
21	-.46	.01	
22	-.50	.01	
23			all gates closed

Notes:

1. Top of flashboards @ el. 892.43', flashboards are 19" high
2. one notch = 2 inches .: 15 notches = 30" opening
3. Lake level can be lowered ≈ 1"/24hr w/ one gate open 15 notches

Above data obtained from park records, 6/24/85.

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB 302 - Buckeye Lake
SHEET NO. 1 OF 3
CALCULATED BY DEH DATE 8/29/85
CHECKED BY DATE
SCALE May 83 Storm - Compare SCS & Snyders

1. Rainfall distribution recorded @ Columbus Airport, Newark & Lancaster SWW

Station	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
April 30, 1983																								
Columbus			.09	.18	.13	.01	.24	.14	.13	.07	.01						.04	.01		.17	.37	.25	.14	.05
Newark				.1	.1	.2	.1	.1	.1	.1	.1	.1						.1	.2			.4	.2	.2
Lancaster			.2	.5	.2		.2			.1													.1	.1
May 1, 1983																								
Columbus	.01	.03					.01	.01	.05	.11		.01					.03	.05					.06	.07
Newark		.1									.1				.1									
Lancaster			.1							.1				.1										
May 2, 1983																								
Columbus	.02	.01	.05	.19	.08	.07	.02																.10	.09
Newark	.1			.1		.3	.2														.1			
Lancaster	.1		.2		.1	.1	.2	.1															.1	
May 3, 1983																								
Columbus	.03	.06		.03	.12	.11					.14	.03							.01					
Newark	.1		.1	.1	.1						.1	.1												
Lancaster		.1		.1	.2	.2					.1	.3	.1	.1									.1	.1

	4-Day total
Columbus	3.63
Newark	3.8
Lancaster	4.0

2. Estimated runoff/inflow to Buckeye Lake

Change in pool level: 891.25 → 892.95 ⇒ storage increased
0AM 4/30/83 → 8AM 5/4/83 from 11257 to ≈ 16,100 ac-ft

net storage increase ≈ 4843 ac-ft

Outflow:

Gate - 48hr w/ 1 gate 10 notches ∴ avg Q ≈ 100 cfs ⇒ ≈ 397 ac-ft
24hr w/ 2 gates 10 notches " " ≈ 200 cfs ⇒ ≈ 397 ac-ft

Weir - 48hr w/ avg Q ≈ 50 cfs ⇒ ≈ 198 ac-ft

PRODUCT 204-1 NEBS Inc., Groton, Mass. 01471.

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

∴ total inflow ≈ 4843 + 397 + 397 + 198 = 5835 ac-ft = 109.4 mi²-in

Assume avg rainfall over lake ≈ 4.7 inches ∴ the runoff from the rest of the DA =

$$4.7 \times 4.3 + 39.84 \times R = 109.4 \Rightarrow R \approx 2.2 \text{ inches}$$

3. Rainfall amount & distribution to use in HEC-1 Model

			Cols	New	Lanc (7AM-7AM
Buckeye Lake rainfall :	April 30	- 0.82 in	.65	.5	1.1
	May 1	- 1.75	1.43	1.7	.4
	May 2	- .88	.83	.9	.9
	May 3	- .70	.54	.5	.8
	May 4	- .55 *	.18	.2	.8
		4.7 in	3.63 in	3.8 in	4.0 in

* Note - Since gage read at 7 AM, assume all rainfall recorded on May 4 occurred before midnight May 3, as virtually no rainfall recorded at the hourly recording stations at Columbus, Newark, & Lancaster after midnight May 3.

∴ Rainfall varies from ≈ 3.6 inches at Columbus to ≈ 4.7 at Buckeye Lake. Assume average rainfall over basin is ≈ 4.2 in

For the rainfall distribution, it appears from the table above that both the Columbus & Newark gages match the distribution recorded at Buckeye Lake fairly well. Since Newark is closer & had a total precip amount nearer to that recorded at Buckeye Lake, the Newark distribution will be used.

4. Gate Opening at Spillway Structure

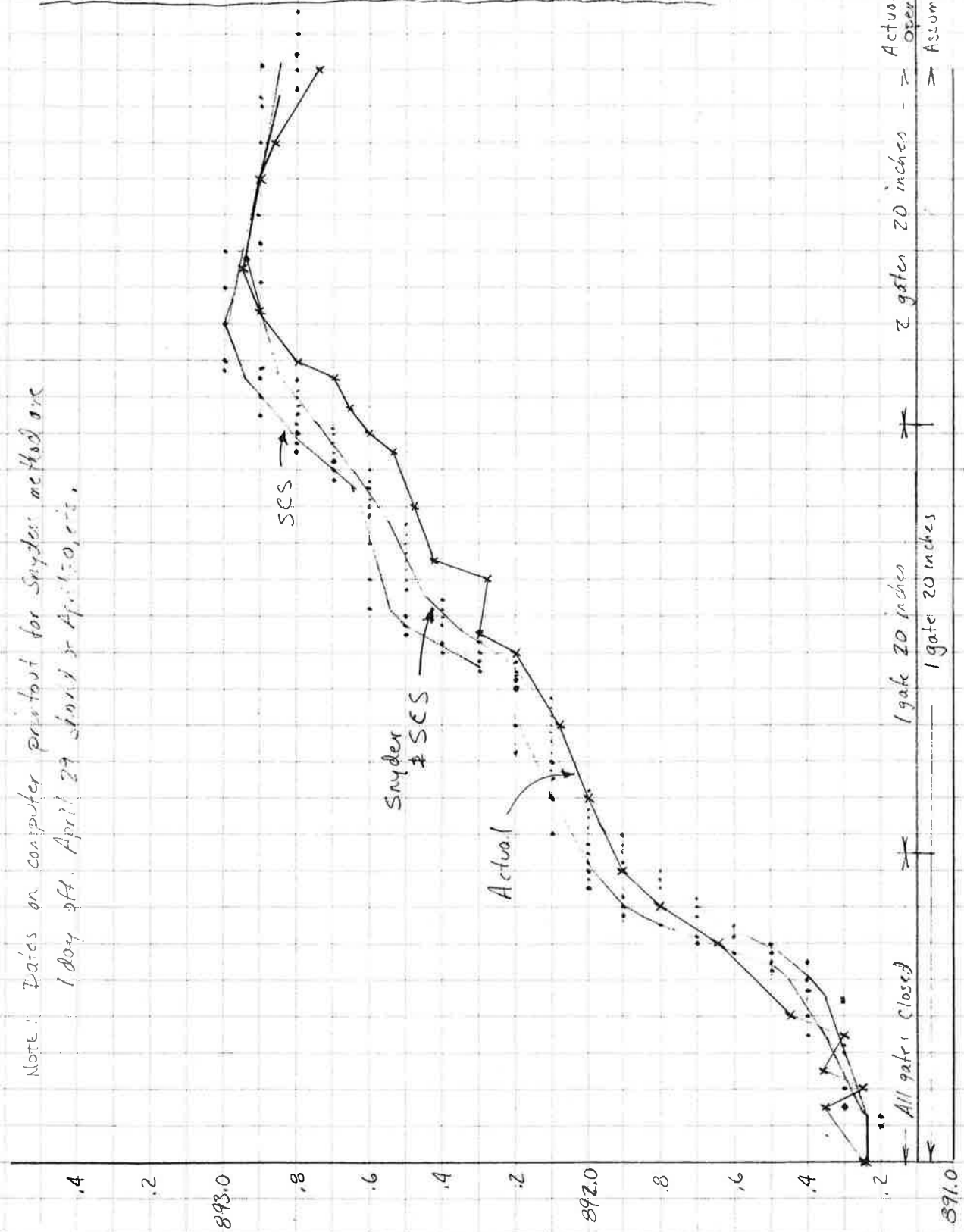
Apr 30 - All gates closed
May 1 - 1 gate opened 10 notches @ 10 AM
May 2 1 gate open 10 notches
May 3 2 gates open 10 notches after 9AM

∴ Assume 1 gate open 10 notches for entire duration of storm.

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB 807 Buckeye Lake
SHEET NO. 3 OF 3
CALCULATED BY DEH DATE 8/30/85
CHECKED BY _____ DATE _____
~~SCALE~~ May 1983 Storm

5. Simulated lake levels vs actual lake levels



DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB 807 - Buckeye Lake
SHEET NO. 3 OF 3
CALCULATED BY DEH DATE 6/25/85
CHECKED BY DATE
~~SCALE~~ Gate opening info. Apr & May 83

April & May 1983

Date	Lake level Ht. from top of flashboards (ft)	Rainfall	Gates	Gate Openings
Apr 28	-.96	.00		Closed
29	-.95	.00		
30	-.95	.00		
May 1	-.35	2.25	(1)	1 gate, 10 notches, 10:00 AM
2	+.03	.26	(1)	" "
3	+.42 -.66 Damaged	.15	(2)	Add. gate, 10 notches, 9:00 AM
4	+.73 -.41 "	.22	(2)	Both gates to 15 notches
5	+.60	.14	(3)	Add gate, 15 notches, 10:15 am
6	+.32	.05	(3)	" " "
7	+.02	.00	(3)	" " "
8	-.25	.10	(3)	" " "
9	-.50	.00		All 3 gates closed
10	-.52	.00		
11	-.51	.00		
12	-.52	.00		
13	-.52	.00		
14	-.54	.00		
15	-.38	.70		

PRODUCT 204-1 NEBS Inc., Groton, Mass. 01471.

DODSON-LINDBLOM ASSOCIATES, INC.
Consulting Engineers
5 East Long Street
COLUMBUS, OHIO 43215
(614) 224-1251

JOB 807 - Buckeye Lake
SHEET NO. 1 OF
CALCULATED BY DEH DATE 9/18/85
CHECKED BY DATE
~~SCALE~~ Hypothetical Precip. Data

1. 100-yr. precipitation

			% 24-hr
From TP 40:	100 yr - 24-hr precip.	= 4.85 in.	100
	100-yr - 12-hr precip.	= 4.60 in.	95
	100-yr - 6-hr precip.	= 3.85 in	79

2. PMP

- From 'State of Ohio PMP vs Latitude & Depth-Area Relationships for Dam Safety Analysis

Latitude = 39.92° ⇒ 72-hr 10 mi² PMP = 38.0 inches

For DA = 44.14 mi²:

			% 24-hr
6hr PMP	= .62 x 38.0"	= 23.6"	81
12hr PMP	= .71 x 38.0"	= 27.0"	92
24hr PMP	= .77 x 38.0"	= 29.3"	100

∴ 100-yr 24-hr precip = 4.85/29.3 = 17% of 24 hr PMP

Use following runoff ratios in HEC-1 analyses

100 yr	=	0.12 (Based on comparison of runoff for PMF & 100-yr storm event
25% PMF	=	0.25
50% PMF	=	0.50
100% PMF	=	1.00

APPENDIX V

GEOTECHNICAL COMPUTATIONS

STABILITY ANALYSIS

SECTION 2

CASE 1
NORMAL POOL CONDITIONS

--SLOPE STABILITY ANALYSIS--
SIMPLIFIED JANBU METHOD OF SLICES
IRREGULAR FAILURE SURFACES

PROBLEM DESCRIPTION 807 - SECTION 2B; STATION 63+61.5; STEAD
Y SEEPAGE AND FLOOD CONDITIONS

BOUNDARY COORDINATES

4 TOP BOUNDARIES
5 TOTAL BOUNDARIES

BOUNDARY NO.	X-LEFT (FT)	Y-LEFT (FT)	X-RIGHT (FT)	Y-RIGHT (FT)	SOIL TYPE BELOW BND
1	.00	22.00	12.50	22.00	2
2	12.50	22.00	30.00	30.00	1
3	30.00	30.00	37.00	30.50	1
4	37.00	30.50	50.00	30.00	1
5	12.50	22.00	50.00	21.30	2

ISOTROPIC SOIL PARAMETERS

2 TYPE(S) OF SOIL

OMETRIC RFACE NO.	SOIL TYPE NO.	TOTAL UNIT WT. (PCF)	SATURATED UNIT WT. (PCF)	COHESION INTERCEPT (PSF)	FRICTION ANGLE (DEG)	PORE PRESSURE PARAMETER	PRESSURE CONSTANT (PSF)	PIEZ SU
1	1	125.0	125.0	.0	33.0	.00	.0	
1	2	125.0	125.0	.0	30.0	.00	.0	

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

UNITWEIGHT OF WATER = 62.40

PIEZOMETRIC SURFACE NO. 1 SPECIFIED BY 3 COORDINATE POINTS

POINT NO.	X-WATER (FT)	Y-WATER (FT)
1	.00	22.00
2	12.50	22.00
3	50.00	26.00

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM TECHNIQUE FOR GENERATING CIRCULAR SURFACES, HAS BEEN SPECIFIED.

100 TRIAL SURFACES HAVE BEEN GENERATED.

10 SURFACES INITIATE FROM EACH OF 10 POINTS EQUALLY SPACED
ALONG THE GROUND SURFACE BETWEEN X = 5.00 FT.
AND X = 10.00 FT.

EACH SURFACE TERMINATES BETWEEN X = 30.00 FT.
AND X = 45.00 FT.

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION
AT WHICH A SURFACE EXTENDS IS Y = .00 FT.

5.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

FOLLOWING ARE DISPLAYED THE TEN MOST CRITICAL OF THE TRIAL FAILURE SURFACES EXAMINED. THEY ARE ORDERED - MOST CRITICAL FIRST.

FAILURE SURFACE SPECIFIED BY 7 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	7.78	22.00
2	12.42	20.15
3	17.41	19.83
4	22.26	21.06
5	26.48	23.74
6	29.68	27.58
7	30.66	30.05

*** 1.350 ***

FAILURE SURFACE SPECIFIED BY 7 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	8.33	22.00
2	13.08	20.43
3	18.08	20.27
4	22.91	21.55
5	27.18	24.15
6	30.53	27.87
7	31.60	30.11

*** 1.366 ***

FAILURE SURFACE SPECIFIED BY 7 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	8.89	22.00
2	13.53	20.15
3	18.52	19.81
4	23.37	21.02
5	27.62	23.66
6	30.86	27.47
7	31.96	30.14

*** 1.375 ***

FAILURE SURFACE SPECIFIED BY 7 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	10.00	22.00
2	14.60	20.04
3	19.59	19.76
4	24.38	21.19
5	28.40	24.17
6	31.16	28.33
7	31.59	30.11

*** 1.385 ***

FAILURE SURFACE SPECIFIED BY 8 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	5.00	22.00
2	9.43	19.69
3	14.34	18.75
4	19.32	19.28
5	23.92	21.23
6	27.77	24.42
7	30.52	28.60
8	30.96	30.07

*** 1.389 ***

FAILURE SURFACE SPECIFIED BY 8 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	6.67	22.00
2	11.36	20.27
3	16.34	19.81
4	21.26	20.66
5	25.80	22.76
6	29.64	25.96
7	32.52	30.05
8	32.57	30.18

*** 1.390 ***

FAILURE SURFACE SPECIFIED BY 7 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	9.44	22.00
2	14.02	19.97
3	19.00	19.52
4	23.86	20.67
5	28.10	23.33
6	31.27	27.19
7	32.39	30.17

*** 1.397 ***

FAILURE SURFACE SPECIFIED BY 7 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	5.56	22.00
2	10.35	20.57
3	15.34	20.32
4	20.25	21.25
5	24.80	23.32
6	28.74	26.41
7	31.65	30.12

*** 1.399 ***

FAILURE SURFACE SPECIFIED BY 7 COORDINATE POINTS

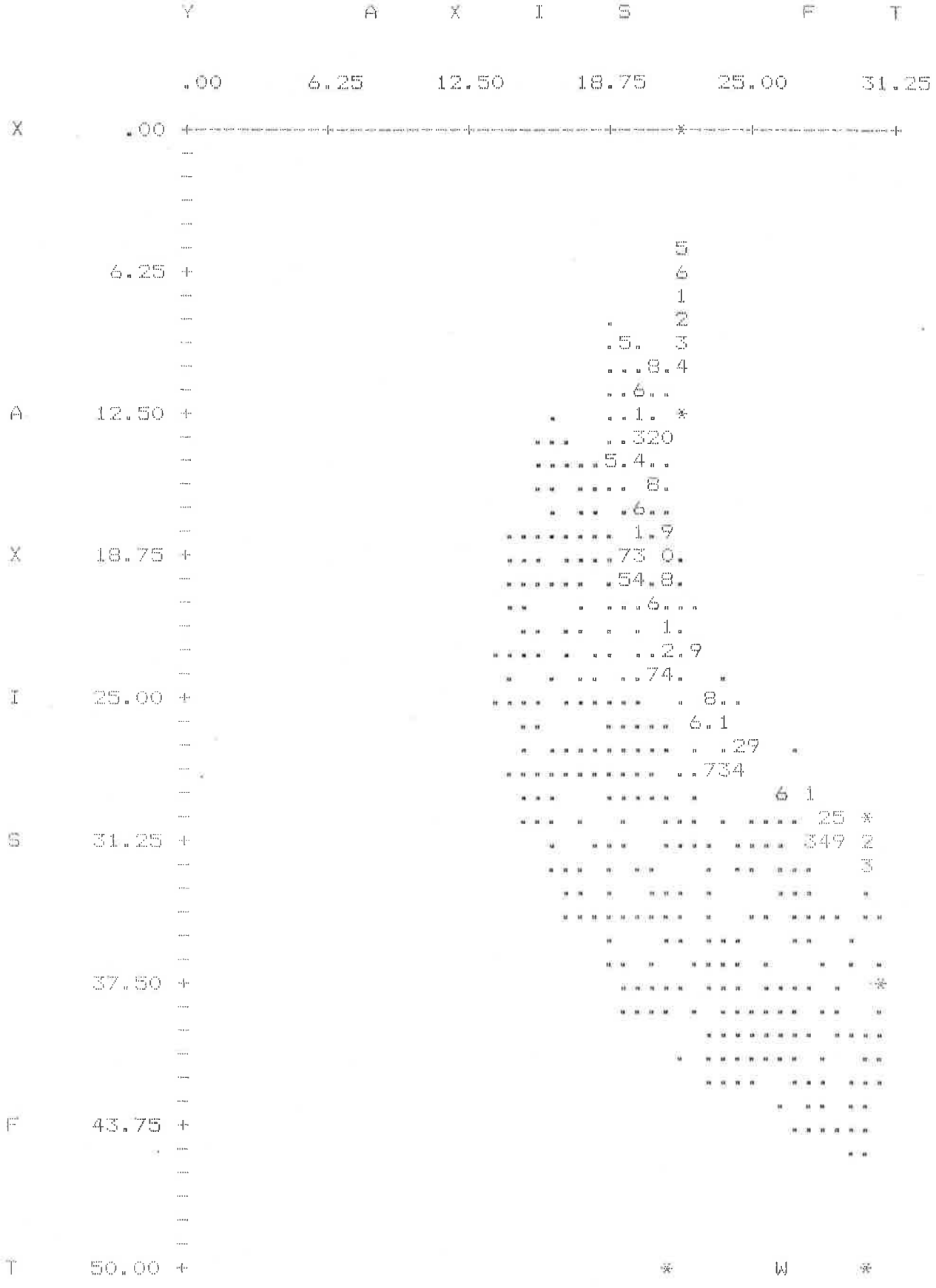
POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	8.33	22.00
2	13.21	20.90
3	18.21	21.05
4	23.01	22.44
5	27.32	24.97
6	30.87	28.50
7	31.85	30.13

*** 1.403 ***

FAILURE SURFACE SPECIFIED BY 7 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	8.33	22.00
2	13.23	21.01
3	18.23	21.22
4	23.03	22.62
5	27.35	25.13
6	30.94	28.61
7	31.90	30.14

*** 1.414 ***


Y A X I S F T
.00 6.25 12.50 18.75 25.00 31.25
X .00
6.25
A 12.50
X 18.75
I 25.00
S 31.25
37.50
F 43.75
T 50.00

STABILITY ANALYSIS

SECTION 2

CASE 2
POOL AT ELEV. 895 WITH STEADY SEEPAGE

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

UNITWEIGHT OF WATER = 62.40

PIEZOMETRIC SURFACE NO. 1 SPECIFIED BY 4 COORDINATE POINTS

POINT NO.	X-WATER (FT)	Y-WATER (FT)
1	.00	22.00
2	12.50	22.00
3	30.00	27.50
4	50.00	30.00

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM TECHNIQUE FOR GENERATING CIRCULAR SURFACES, HAS BEEN SPECIFIED.

100 TRIAL SURFACES HAVE BEEN GENERATED.

10 SURFACES INITIATE FROM EACH OF 10 POINTS EQUALLY SPACED
ALONG THE GROUND SURFACE BETWEEN X = 5.00 FT.
AND X = 15.00 FT.

EACH SURFACE TERMINATES BETWEEN X = 30.00 FT.
AND X = 40.00 FT.

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION
AT WHICH A SURFACE EXTENDS IS Y = .00 FT.

5.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

FOLLOWING ARE DISPLAYED THE TEN MOST CRITICAL OF THE TRIAL FAILURE SURFACES EXAMINED. THEY ARE ORDERED - MOST CRITICAL FIRST.

FAILURE SURFACE SPECIFIED BY 6 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	10.56	22.00
2	15.25	20.29
3	20.25	20.39
4	24.87	22.31
5	28.48	25.77
6	30.46	30.03

*** 1.033 ***

FAILURE SURFACE SPECIFIED BY 7 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	9.44	22.00
2	14.22	20.51
3	19.22	20.47
4	24.02	21.87
5	28.21	24.60
6	31.44	28.42
7	32.19	30.16

*** 1.043 ***

FAILURE SURFACE SPECIFIED BY 6 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	11.67	22.00
2	16.44	20.52
3	21.43	20.89
4	25.93	23.07
5	29.31	26.76
6	30.57	30.04

*** 1.051 ***

FAILURE SURFACE SPECIFIED BY 7 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	9.44	22.00
2	14.00	19.93
3	18.97	19.47
4	23.82	20.69
5	28.00	23.44
6	31.04	27.41
7	31.93	30.14

*** 1.054 ***

FAILURE SURFACE SPECIFIED BY 7 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	10.56	22.00
2	15.34	20.55
3	20.34	20.62
4	25.08	22.20
5	29.13	25.14
6	32.09	29.17
7	32.42	30.17

*** 1.055 ***

FAILURE SURFACE SPECIFIED BY 7 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	9.44	22.00
2	13.90	19.73
3	18.87	19.16
4	23.72	20.37
5	27.84	23.20
6	30.70	27.30
7	31.42	30.10

*** 1.061 ***

FAILURE SURFACE SPECIFIED BY 7 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	6.11	22.00
2	10.81	20.30
3	15.80	19.93
4	20.70	20.91
5	25.16	23.17
6	28.85	26.55
7	31.05	30.07

*** 1.065 ***

FAILURE SURFACE SPECIFIED BY 7 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	7.22	22.00
2	11.65	19.67
3	16.59	18.89
4	21.51	19.74
5	25.91	22.13
6	29.29	25.81
7	31.19	30.08

*** 1.068 ***

STABILITY ANALYSIS

SECTION 2

CASE 3
EMBANKMENT & POOL LEVEL RAISED TO ELEV. 897,
STEADY SEEPAGE, TAILWATER AT ELEV. 890

--SLOPE STABILITY ANALYSIS--
SIMPLIFIED JANBU METHOD OF SLICES
IRREGULAR FAILURE SURFACES

PROBLEM DESCRIPTION 807-SECTION 2B; PMF FLOOD AND SEEPAGE CO NDITIONS; EMBANKMENT RAISED 1-2'; TW AT ELEV 850

BOUNDARY COORDINATES

4 TOP BOUNDARIES
7 TOTAL BOUNDARIES

BOUNDARY NO.	X-LEFT (FT)	Y-LEFT (FT)	X-RIGHT (FT)	Y-RIGHT (FT)	SOIL TYPE BELOW BND
1	.00	22.00	12.50	22.00	3
2	12.50	22.00	30.00	30.00	2
3	30.00	30.00	34.00	32.00	1
4	34.00	32.00	56.00	32.00	1
5	30.00	30.00	37.00	30.50	2
6	37.00	30.50	56.00	29.80	2
7	12.50	22.00	56.00	21.50	3

ISOTROPIC SOIL PARAMETERS

3 TYPE(S) OF SOIL

OmeTRIC RFACE NO.	SOIL TYPE NO.	TOTAL UNIT WT. (PCF)	SATURATED UNIT WT. (PCF)	COHESION INTERCEPT (PSF)	FRICTION ANGLE (DEG)	PORE PRESSURE PARAMETER	PRESSURE CONSTANT (PSF)	PIEZ SU
1	1	130.0	130.0	.0	27.0	.00	.0	
1	2	125.0	125.0	.0	33.0	.00	.0	
1	3	125.0	125.0	.0	30.0	.00	.0	

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

UNITWEIGHT OF WATER = 62.40

PIEZOMETRIC SURFACE NO. 1 SPECIFIED BY 3 COORDINATE POINTS

POINT NO.	X-WATER (FT)	Y-WATER (FT)
1	.00	25.00
2	18.00	25.00
3	56.00	32.00

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM TECHNIQUE FOR GENERATING CIRCULAR SURFACES, HAS BEEN SPECIFIED.

100 TRIAL SURFACES HAVE BEEN GENERATED.

10 SURFACES INITIATE FROM EACH OF 10 POINTS EQUALLY SPACED
ALONG THE GROUND SURFACE BETWEEN X = .00 FT.
AND X = 20.00 FT.

EACH SURFACE TERMINATES BETWEEN X = 30.00 FT.
AND X = 50.00 FT.

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION
AT WHICH A SURFACE EXTENDS IS Y = .00 FT.

5.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

FOLLOWING ARE DISPLAYED THE TEN MOST CRITICAL OF THE TRIAL FAILURE SURFACES EXAMINED. THEY ARE ORDERED - MOST CRITICAL FIRST.

FAILURE SURFACE SPECIFIED BY 7 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	13.33	22.38
2	18.20	21.25
3	23.18	21.69
4	27.78	23.67
5	31.52	26.98
6	34.04	31.30
7	34.19	32.00

*** 1.104 ***

FAILURE SURFACE SPECIFIED BY 8 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	8.89	22.00
2	13.76	20.86
3	18.76	20.82
4	23.64	21.87
5	28.18	23.98
6	32.14	27.03
7	35.34	30.87
8	35.92	32.00

*** 1.120 ***

FAILURE SURFACE SPECIFIED BY 6 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	13.33	22.38
2	18.33	22.27
3	23.22	23.31
4	27.74	25.45
5	31.64	28.58
6	34.30	32.00

*** 1.127 ***

FAILURE SURFACE SPECIFIED BY 8 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	6.67	22.00
2	11.32	20.18
3	16.28	19.54
4	21.25	20.11
5	25.93	21.87
6	30.05	24.70
7	33.37	28.44
8	35.23	32.00

*** 1.147 ***

STABILITY ANALYSIS

SECTION 3

CASE 1
NORMAL POOL CONDITIONS

--SLOPE STABILITY ANALYSIS--
SIMPLIFIED JANBU METHOD OF SLICES
IRREGULAR FAILURE SURFACES

PROBLEM DESCRIPTION 807 - SECTION 3-C, STA 104+62.0

BOUNDARY COORDINATES

4 TOP BOUNDARIES
5 TOTAL BOUNDARIES

BOUNDARY NO.	X-LEFT (FT)	Y-LEFT (FT)	X-RIGHT (FT)	Y-RIGHT (FT)	SOIL TYPE BELOW BND
1	.00	20.50	12.00	21.00	2
2	12.00	21.00	27.00	29.50	1
3	27.00	29.50	29.00	30.00	1
4	29.00	30.00	50.00	31.00	1
5	12.00	21.00	50.00	19.00	2

ISOTROPIC SOIL PARAMETERS

2 TYPE(S) OF SOIL

OmeTRIC RFACE NO.	SOIL TYPE NO.	TOTAL UNIT WT. (PCF)	SATURATED UNIT WT. (PCF)	COHESION INTERCEPT (PSF)	FRICTION ANGLE (DEG)	PORE PRESSURE PARAMETER	PRESSURE CONSTANT (PSF)	PIEZ SU
1	1	126.0	126.0	300.0	25.0	.00	.0	
1	2	125.0	125.0	.0	30.0	.00	.0	

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

UNITWEIGHT OF WATER = 62.40

PIEZOMETRIC SURFACE NO. 1 SPECIFIED BY 3 COORDINATE POINTS

POINT NO.	X-WATER (FT)	Y-WATER (FT)
1	.00	20.50
2	12.00	21.00
3	50.00	26.50

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM TECHNIQUE FOR GENERATING CIRCULAR SURFACES, HAS BEEN SPECIFIED.

100 TRIAL SURFACES HAVE BEEN GENERATED.

10 SURFACES INITIATE FROM EACH OF 10 POINTS EQUALLY SPACED
ALONG THE GROUND SURFACE BETWEEN X = .00 FT.
AND X = 20.00 FT.

EACH SURFACE TERMINATES BETWEEN X = 30.00 FT.
AND X = 50.00 FT.

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION
AT WHICH A SURFACE EXTENDS IS Y = .00 FT.

5.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

FOLLOWING ARE DISPLAYED THE TEN MOST CRITICAL OF THE TRIAL FAILURE SURFACES EXAMINED. THEY ARE ORDERED - MOST CRITICAL FIRST.

FAILURE SURFACE SPECIFIED BY 9 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	2.22	20.59
2	6.25	17.63
3	10.92	15.84
4	15.89	15.33
5	20.83	16.15
6	25.37	18.23
7	29.21	21.43
8	32.07	25.53
9	33.76	30.23

*** 1.817 ***

FAILURE SURFACE SPECIFIED BY 9 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	4.44	20.69
2	8.90	18.42
3	13.78	17.33
4	18.78	17.49
5	23.58	18.88
6	27.89	21.42
7	31.43	24.95
8	33.99	29.25
9	34.29	30.25

*** 1.860 ***

FAILURE SURFACE SPECIFIED BY 9 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	4.44	20.69
2	8.90	18.41
3	13.76	17.27
4	18.76	17.35
5	23.60	18.63
6	27.98	21.04
7	31.64	24.44
8	34.38	28.63
9	34.95	30.28

*** 1.866 ***

FAILURE SURFACE SPECIFIED BY 9 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	4.44	20.69
2	8.23	17.42
3	12.80	15.39
4	17.76	14.78
5	22.69	15.63
6	27.16	17.87
7	30.78	21.32
8	33.25	25.67
9	34.28	30.25

*** 1.909 ***

FAILURE SURFACE SPECIFIED BY 11 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	.00	20.50
2	4.36	18.05
3	9.09	16.43
4	14.03	15.67
5	19.03	15.80
6	23.92	16.82
7	28.56	18.70
8	32.78	21.37
9	36.47	24.75
10	39.48	28.74
11	40.40	30.54

*** 1.910 ***

FAILURE SURFACE SPECIFIED BY 10 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	.00	20.50
2	3.78	17.23
3	8.31	15.10
4	13.24	14.29
5	18.21	14.85
6	22.84	16.74
7	26.78	19.81
8	29.74	23.84
9	31.49	28.53
10	31.62	30.12

*** 1.912 ***

FAILURE SURFACE SPECIFIED BY 8 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	6.67	20.78
2	11.20	18.68
3	16.12	17.79
4	21.11	18.17
5	25.84	19.79
6	30.00	22.56
7	33.34	26.29
8	35.40	30.30

*** 1.919 ***

FAILURE SURFACE SPECIFIED BY 10 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	4.44	20.69
2	8.86	18.33
3	13.67	16.98
4	18.66	16.69
5	23.60	17.47
6	28.26	19.29
7	32.42	22.06
8	35.89	25.66
9	38.52	29.91
10	38.71	30.46

*** 1.919 ***

FAILURE SURFACE SPECIFIED BY 10 COORDINATE POINTS

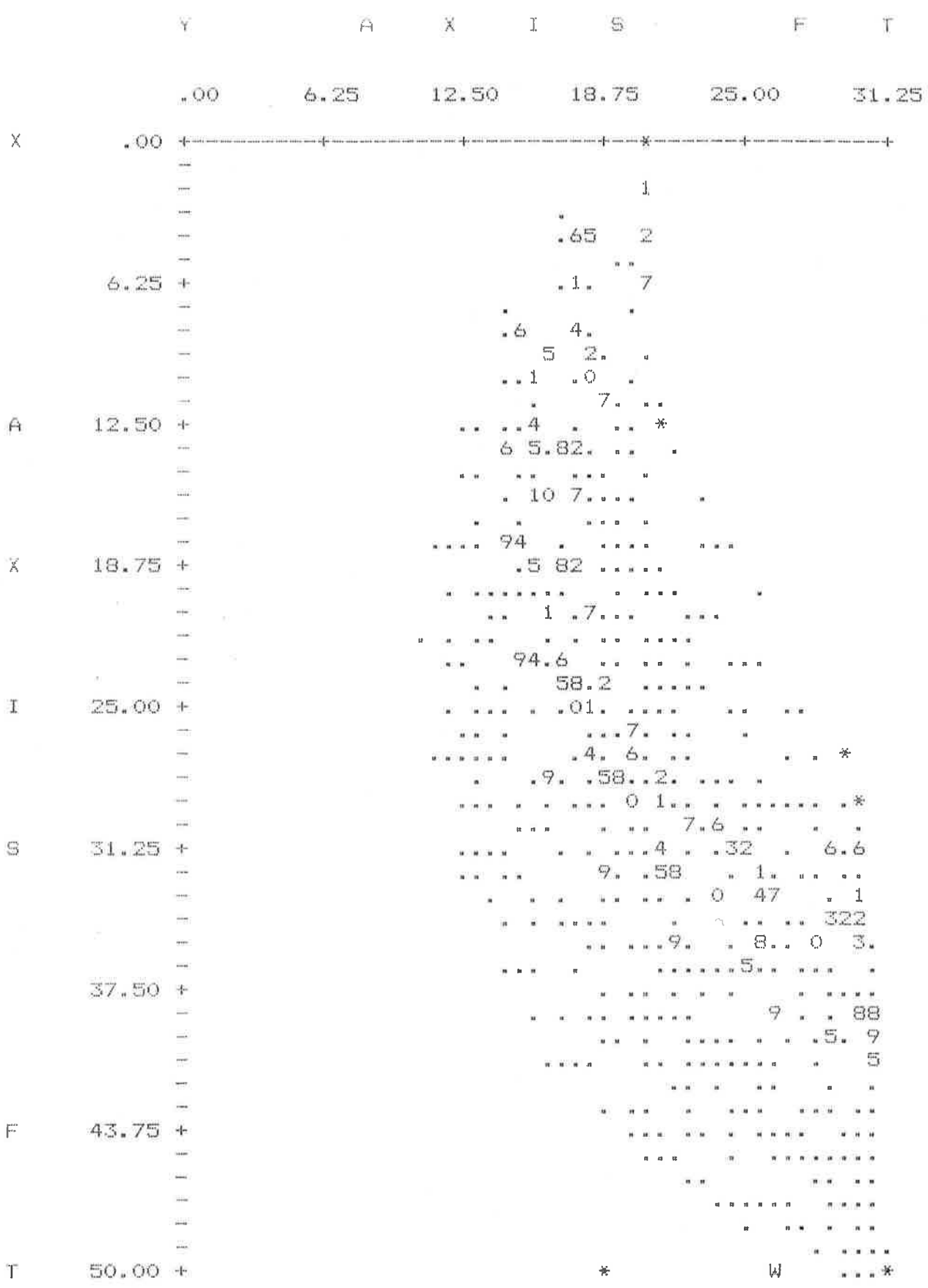
POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	4.44	20.69
2	8.37	17.59
3	12.92	15.51
4	17.83	14.56
5	22.82	14.79
6	27.62	16.19
7	31.96	18.68
8	35.59	22.12
9	38.30	26.31
10	39.77	30.51

*** 1.946 ***

FAILURE SURFACE SPECIFIED BY 9 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	6.67	20.78
2	10.70	17.82
3	15.42	16.16
4	20.41	15.96
5	25.25	17.21
6	29.51	19.83
7	32.83	23.57
8	34.91	28.12
9	35.20	30.30

*** 1.960 ***


Y A X I S F T
.00 6.25 12.50 18.75 25.00 31.25
X .00
6.25
A 12.50
X 18.75
I 25.00
S 31.25
37.50
F 43.75
T 50.00

STABILITY ANALYSIS

SECTION 3

CASE 2
POOL AT ELEV. 895 WITH STEADY SEEPAGE

FAILURE SURFACE SPECIFIED BY 7 COORDINATE POINTS

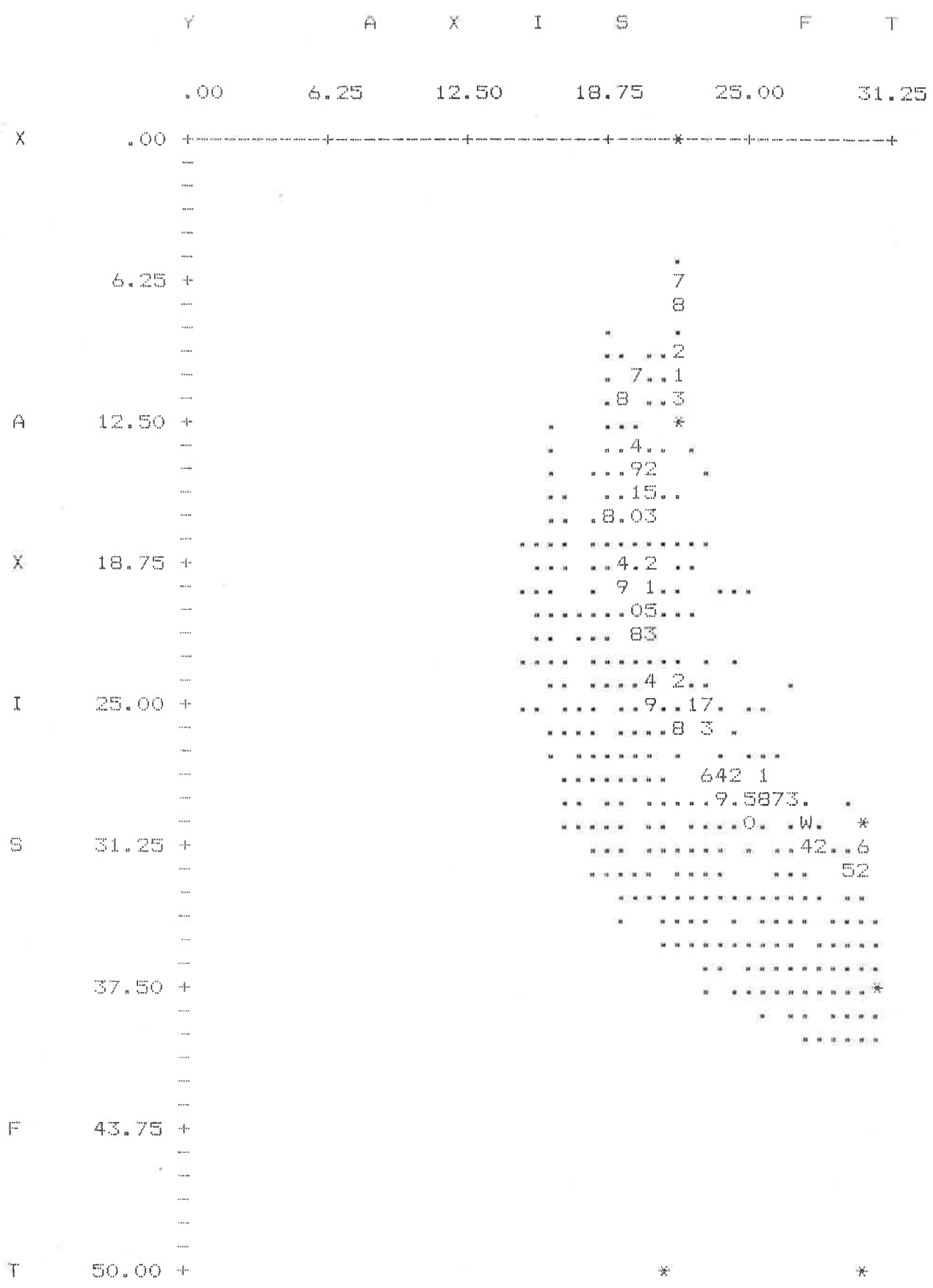
POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	10.56	22.00
2	15.07	19.85
3	20.06	19.46
4	24.85	20.87
5	28.83	23.89
6	31.47	28.14
7	31.86	30.13

*** 1.072 ***

FAILURE SURFACE SPECIFIED BY 7 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	11.67	22.00
2	16.35	20.26
3	21.35	20.23
4	26.06	21.93
5	29.89	25.14
6	32.38	29.47
7	32.51	30.18

*** 1.081 ***


Y A X I S F T
.00 6.25 12.50 18.75 25.00 31.25
X .00
6.25
A 12.50
X 18.75
I 25.00
S 31.25
37.50
F 43.75
T 50.00

STABILITY ANALYSIS

SECTION 3

CASE 3
EMBANKMENT & POOL LEVEL RAISED TO ELEV. 897,
STEADY SEEPAGE, TAILWATER AT ELEV. 890

--SLOPE STABILITY ANALYSIS--
SIMPLIFIED JANBU METHOD OF SLICES
IRREGULAR FAILURE SURFACES

PROBLEM DESCRIPTION 807-SECTION 3C; EMBANKMENT RAISED 1'-2'P
MF FLOOD AND SEEPAGE; NO FREEBOARD;TW AT 840'

BOUNDARY COORDINATES

4 TOP BOUNDARIES
7 TOTAL BOUNDARIES

BOUNDARY NO.	X-LEFT (FT)	Y-LEFT (FT)	X-RIGHT (FT)	Y-RIGHT (FT)	SOIL TYPE BELOW BND
1	.00	20.50	12.00	21.00	3
2	12.00	21.00	27.00	29.50	2
3	27.00	29.50	31.50	32.00	1
4	31.50	32.00	55.00	32.00	1
5	27.00	29.50	29.00	30.00	2
6	29.00	30.00	55.00	31.20	2
7	12.00	21.00	55.00	19.00	3

ISOTROPIC SOIL PARAMETERS

3 TYPE(S) OF SOIL

OmcTRIC RFACE NO.	SOIL TYPE NO.	TOTAL UNIT WT. (PCF)	SATURATED UNIT WT. (PCF)	COHESION INTERCEPT (PSF)	FRICTION ANGLE (DEG)	PORE PRESSURE PARAMETER	PRESSURE CONSTANT (PSF)	PIEZ SU (
1	1	130.0	125.0	.0	27.0	.00	.0	
1	2	126.0	126.0	300.0	25.0	.00	.0	
1	3	125.0	125.0	.0	30.0	.00	.0	

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

UNITWEIGHT OF WATER = 62.40

PIEZOMETRIC SURFACE NO. 1 SPECIFIED BY 3 COORDINATE POINTS

POINT NO.	X-WATER (FT)	Y-WATER (FT)
1	.00	25.00
2	18.00	25.00
3	55.00	32.00

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM TECHNIQUE FOR GENERATING CIRCULAR SURFACES, HAS BEEN SPECIFIED.

100 TRIAL SURFACES HAVE BEEN GENERATED.

10 SURFACES INITIATE FROM EACH OF 10 POINTS EQUALLY SPACED
ALONG THE GROUND SURFACE BETWEEN X = .00 FT.
AND X = 20.00 FT.

EACH SURFACE TERMINATES BETWEEN X = 30.00 FT.
AND X = 50.00 FT.

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION
AT WHICH A SURFACE EXTENDS IS Y = .00 FT.

5.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

FOLLOWING ARE DISPLAYED THE TEN MOST CRITICAL OF THE TRIAL FAILURE SURFACES EXAMINED. THEY ARE ORDERED - MOST CRITICAL FIRST.

FAILURE SURFACE SPECIFIED BY 9 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	6.67	20.78
2	11.20	18.68
3	16.13	17.80
4	21.11	18.22
5	25.82	19.89
6	29.95	22.71
7	33.22	26.49
8	35.42	30.78
9	35.63	32.00

*** 1.601 ***

FAILURE SURFACE SPECIFIED BY 10 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	4.44	20.69
2	8.86	18.33
3	13.68	16.99
4	18.67	16.73
5	23.60	17.55
6	28.24	19.42
7	32.36	22.25
8	35.77	25.90
9	38.31	30.21
10	38.90	32.00

*** 1.611 ***

FAILURE SURFACE SPECIFIED BY 9 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	4.44	20.69
2	8.90	18.42
3	13.79	17.35
4	18.78	17.54
5	23.57	18.97
6	27.85	21.57
7	31.33	25.15
8	33.81	29.50
9	34.49	32.00

*** 1.633 ***

FAILURE SURFACE SPECIFIED BY 9 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	6.67	20.78
2	11.35	19.04
3	16.31	18.34
4	21.27	18.72
5	26.08	20.16
6	30.45	22.59
7	34.20	25.90
8	37.15	29.94
9	38.05	32.00

*** 1.647 ***

FAILURE SURFACE SPECIFIED BY 11 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	4.44	20.69
2	8.79	18.21
3	13.55	16.67
4	18.51	16.10
5	23.49	16.56
6	28.28	17.99
7	32.68	20.36
8	36.52	23.57
9	39.63	27.48
10	41.89	31.94
11	41.91	32.00

*** 1.658 ***

FAILURE SURFACE SPECIFIED BY 9 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	8.89	20.87
2	13.17	18.29
3	17.99	16.94
4	22.99	16.92
5	27.81	18.23
6	32.11	20.78
7	35.58	24.38
8	37.96	28.78
9	38.71	32.00

*** 1.659 ***

FAILURE SURFACE SPECIFIED BY 11 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	.00	20.50
2	4.36	18.05
3	9.09	16.44
4	14.04	15.70
5	19.04	15.88
6	23.92	16.95
7	28.53	18.88
8	32.71	21.62
9	36.33	25.07
10	39.27	29.12
11	40.65	32.00

*** 1.685 ***

FAILURE SURFACE SPECIFIED BY 9 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	8.89	20.87
2	13.03	18.06
3	17.78	16.52
4	22.78	16.35
5	27.63	17.57
6	31.95	20.09
7	35.40	23.70
8	37.71	28.13
9	38.50	32.00

*** 1.687 ***

FAILURE SURFACE SPECIFIED BY 10 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	2.22	20.59
2	6.25	17.63
3	10.92	15.85
4	15.90	15.35
5	20.83	16.19
6	25.36	18.30
7	29.18	21.53
8	32.00	25.69
9	33.64	30.38
10	33.75	32.00

*** 1.691 ***

FAILURE SURFACE SPECIFIED BY 9 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	4.44	20.69
2	9.15	18.98
3	14.11	18.36
4	19.08	18.84
5	23.83	20.41
6	28.11	22.99
7	31.72	26.45
8	34.48	30.62
9	35.00	32.00

*** 1.695 ***

Y A X I S F T
.00 6.88 13.75 20.63 27.50 34.38
X .00
6.88
A 13.75
X 20.63
I 27.50
S 34.38
41.25
F 48.13
T 55.00

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

UNITWEIGHT OF WATER = 62.40

PIEZOMETRIC SURFACE NO. 1 SPECIFIED BY 4 COORDINATE POINTS

POINT NO.	X-WATER (FT)	Y-WATER (FT)
1	.00	20.50
2	12.00	21.00
3	30.00	27.00
4	50.00	30.00

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM TECHNIQUE FOR GENERATING CIRCULAR SURFACES, HAS BEEN SPECIFIED.

100 TRIAL SURFACES HAVE BEEN GENERATED.

10 SURFACES INITIATE FROM EACH OF 10 POINTS EQUALLY SPACED
ALONG THE GROUND SURFACE BETWEEN X = .00 FT.
AND X = 20.00 FT.

EACH SURFACE TERMINATES BETWEEN X = 30.00 FT.
AND X = 50.00 FT.

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION
AT WHICH A SURFACE EXTENDS IS Y = .00 FT.

5.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

FOLLOWING ARE DISPLAYED THE TEN MOST CRITICAL OF THE TRIAL FAILURE SURFACES EXAMINED. THEY ARE ORDERED - MOST CRITICAL FIRST.

FAILURE SURFACE SPECIFIED BY 9 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	2.22	20.59
2	6.69	18.34
3	11.57	17.28
4	16.57	17.46
5	21.37	18.87
6	25.66	21.44
7	29.18	24.99
8	31.71	29.30
9	31.95	30.14

*** 1.681 ***

FAILURE SURFACE SPECIFIED BY 10 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	4.44	20.69
2	8.71	18.08
3	13.43	16.44
4	18.40	15.84
5	23.38	16.30
6	28.14	17.82
7	32.48	20.31
8	36.18	23.67
9	39.09	27.73
10	40.30	30.54

*** 1.684 ***

FAILURE SURFACE SPECIFIED BY 8 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	6.67	20.78
2	11.16	18.59
3	16.10	17.80
4	21.05	18.48
5	25.59	20.58
6	29.33	23.90
7	31.93	28.17
8	32.45	30.16

*** 1.691 ***

FAILURE SURFACE SPECIFIED BY 9 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	.00	20.50
2	4.26	17.87
3	9.04	16.41
4	14.03	16.22
5	18.92	17.29
6	23.37	19.57
7	27.09	22.91
8	29.84	27.08
9	30.86	30.09

*** 1.697 ***

FAILURE SURFACE SPECIFIED BY 12 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	2.22	20.59
2	6.07	17.40
3	10.49	15.06
4	15.29	13.68
5	20.28	13.31
6	25.24	13.98
7	29.95	15.65
8	34.22	18.25
9	37.86	21.68
10	40.73	25.77
11	42.69	30.37
12	42.75	30.65

*** 1.722 ***

FAILURE SURFACE SPECIFIED BY 11 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	2.22	20.59
2	6.69	18.35
3	11.48	16.91
4	16.45	16.32
5	21.44	16.59
6	26.31	17.71
7	30.92	19.65
8	35.12	22.35
9	38.80	25.74
10	41.84	29.71
11	42.33	30.63

*** 1.729 ***

FAILURE SURFACE SPECIFIED BY 12 COORDINATE POINTS

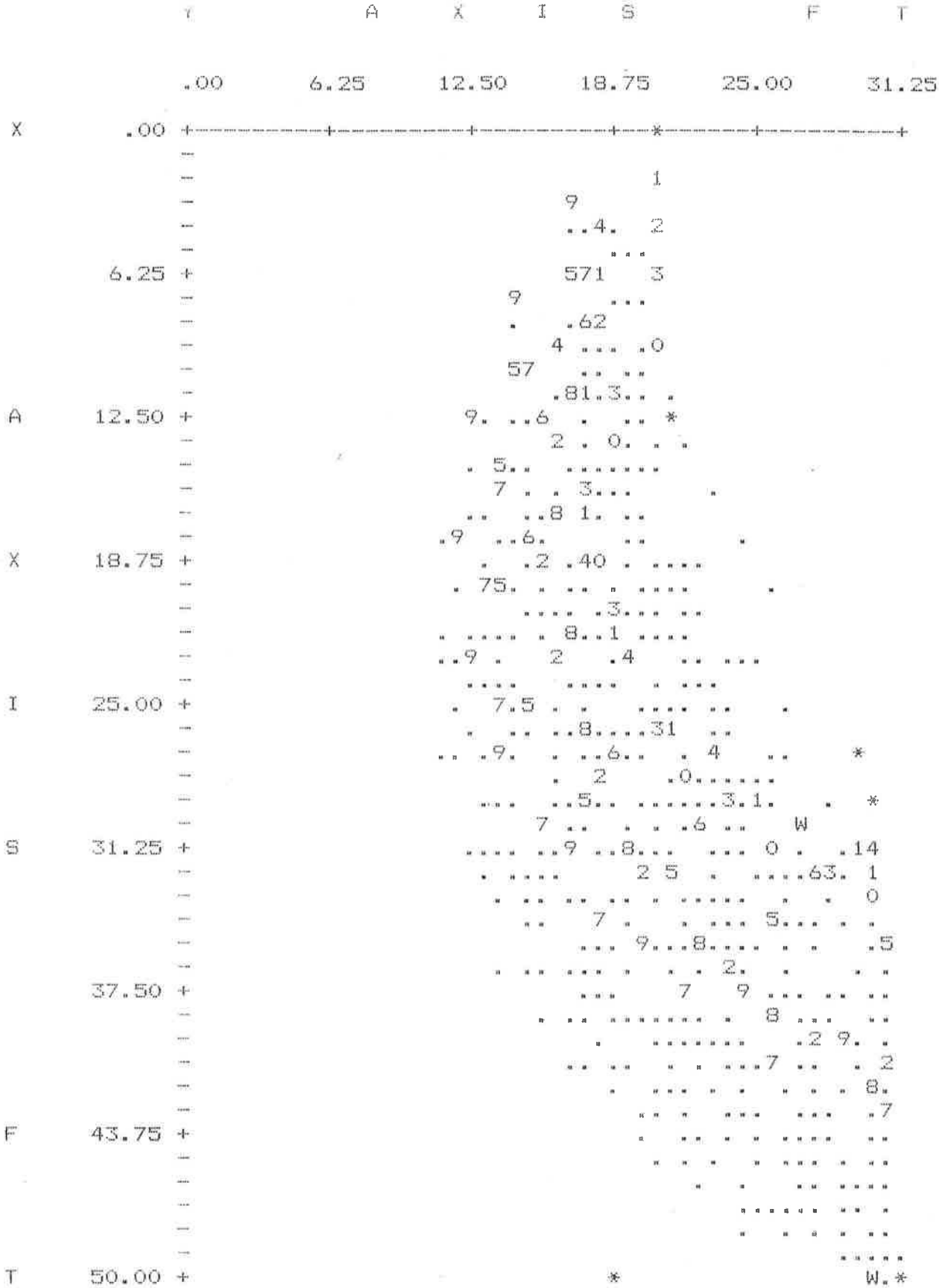
POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	.00	20.50
2	3.55	16.98
3	7.78	14.32
4	12.49	12.63
5	17.45	12.01
6	22.43	12.48
7	27.19	14.03
8	31.49	16.56
9	35.15	19.98
10	37.98	24.10
11	39.84	28.74
12	40.13	30.53

*** 1.733 ***

FAILURE SURFACE SPECIFIED BY 8 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	8.89	20.87
2	13.48	18.90
3	18.46	18.40
4	23.35	19.42
5	27.71	21.86
6	31.14	25.51
7	33.30	30.02
8	33.33	30.21

*** 1.742 ***


Y A X I S F T
.00 6.25 12.50 18.75 25.00 31.25
X .00
6.25
A 12.50
X 18.75
I 25.00
S 31.25
37.50
F 43.75
T 50.00

FAILURE SURFACE SPECIFIED BY 7 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	11.11	22.00
2	15.76	20.15
3	20.76	20.18
4	25.38	22.08
5	28.95	25.58
6	30.95	30.17
7	30.96	30.48

*** 1.149 ***

FAILURE SURFACE SPECIFIED BY 8 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	6.67	22.00
2	11.36	20.27
3	16.33	19.79
4	21.27	20.59
5	25.83	22.63
6	29.73	25.76
7	32.70	29.79
8	33.47	31.74

*** 1.156 ***

FAILURE SURFACE SPECIFIED BY 6 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	13.33	22.38
2	18.32	22.81
3	23.15	24.07
4	27.70	26.14
5	31.84	28.95
6	34.99	32.00

*** 1.156 ***

FAILURE SURFACE SPECIFIED BY 6 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	13.33	22.38
2	18.04	20.68
3	23.02	21.03
4	27.44	23.38
5	30.52	27.31
6	31.37	30.68

*** 1.163 ***

FAILURE SURFACE SPECIFIED BY 6 COORDINATE POINTS

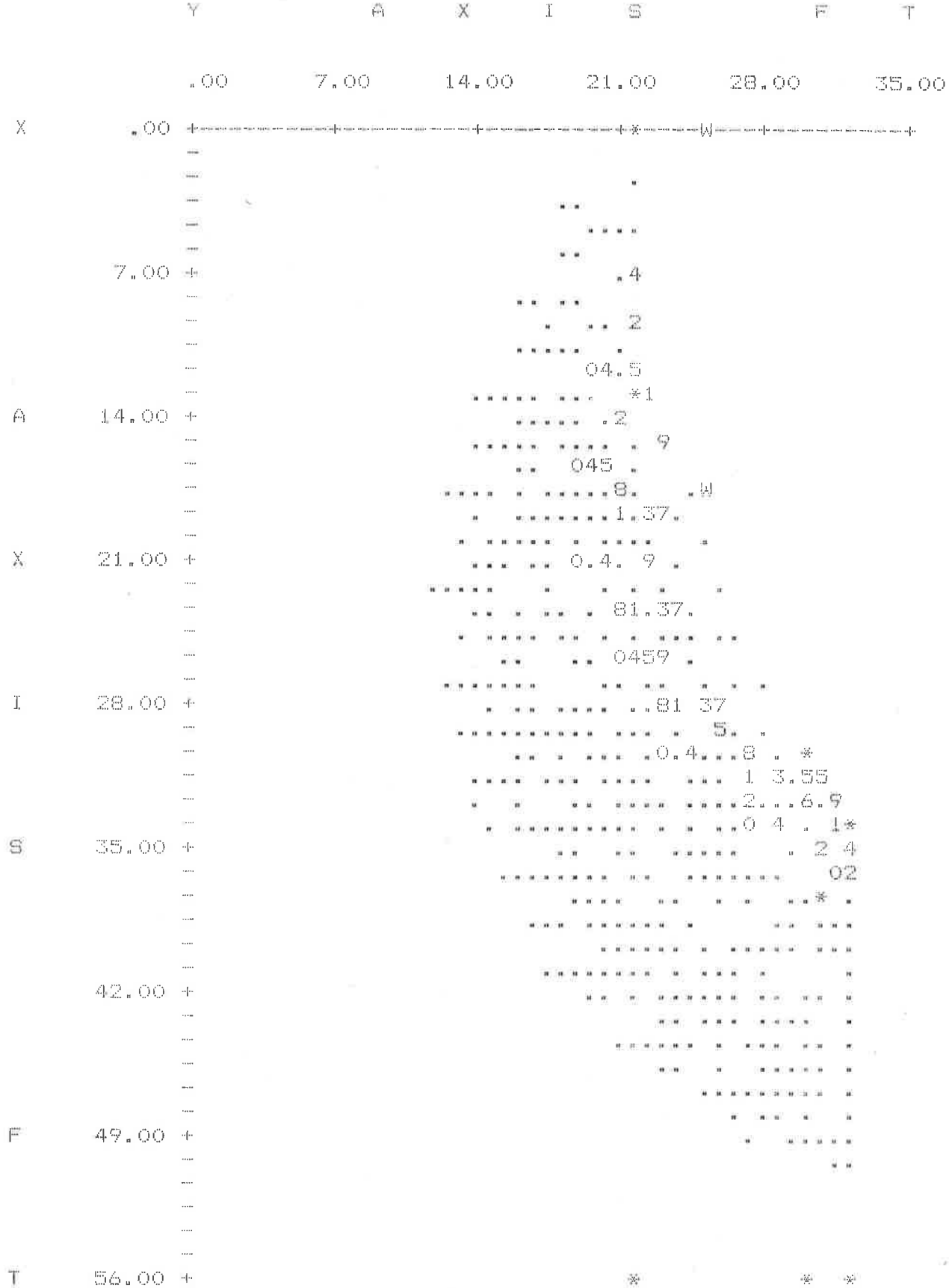
POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	15.56	23.40
2	20.47	22.45
3	25.37	23.43
4	29.54	26.19
5	32.35	30.32
6	32.55	31.27

*** 1.176 ***

FAILURE SURFACE SPECIFIED BY 9 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	6.67	22.00
2	11.16	19.81
3	16.06	18.83
4	21.06	19.12
5	25.81	20.66
6	30.02	23.36
7	33.41	27.03
8	35.76	31.44
9	35.90	32.00

*** 1.177 ***


Y A X I S F T
.00 7.00 14.00 21.00 28.00 35.00
X .00
7.00
A 14.00
X 21.00
I 28.00
S 35.00
42.00
F 49.00
T 56.00

FAILURE SURFACE SPECIFIED BY 10 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	2.22	20.59
2	5.78	17.08
3	10.15	14.64
4	15.00	13.44
5	20.00	13.58
6	24.78	15.03
7	29.01	17.69
8	32.38	21.39
9	34.66	25.84
10	35.58	30.31

*** 1.701 ***

FAILURE SURFACE SPECIFIED BY 9 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	4.44	20.69
2	8.31	17.51
3	12.95	15.65
4	17.94	15.28
5	22.80	16.43
6	27.10	19.00
7	30.42	22.74
8	32.45	27.30
9	32.78	30.18

*** 1.703 ***

STABILITY ANALYSIS

SECTION 4

CASE 1
NORMAL POOL CONDITIONS

--SLOPE STABILITY ANALYSIS--
SIMPLIFIED JANBU METHOD OF SLICES
IRREGULAR FAILURE SURFACES

PROBLEM DESCRIPTION 807 - SECTION 4-A; STATION 142+75.5; STE
ADY SEEPAGE AND FLOOD CONDITIONS

BOUNDARY COORDINATES

4 TOP BOUNDARIES
5 TOTAL BOUNDARIES

BOUNDARY NO.	X-LEFT (FT)	Y-LEFT (FT)	X-RIGHT (FT)	Y-RIGHT (FT)	SOIL TYPE BELOW BND
1	.00	19.50	13.00	20.00	2
2	13.00	20.00	22.50	25.00	1
3	22.50	25.00	34.00	30.00	1
4	34.00	30.00	50.00	30.50	1
5	13.00	20.00	50.00	20.00	2

ISOTROPIC SOIL PARAMETERS

2 TYPE(S) OF SOIL

OMETRIC RFACE NO.	SOIL TYPE NO.	TOTAL UNIT WT. (PCF)	SATURATED UNIT WT. (PCF)	COHESION INTERCEPT (PSF)	FRICTION ANGLE (DEG)	PORE PRESSURE PARAMETER	PRESSURE CONSTANT (PSF)	PIEZ SU
1	1	123.0	123.0	300.0	25.0	.00	.0	
1	2	125.0	125.0	.0	30.0	.00	.0	

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

UNITWEIGHT OF WATER = 62.40

PIEZOMETRIC SURFACE NO. 1 SPECIFIED BY 3 COORDINATE POINTS

POINT NO.	X-WATER (FT)	Y-WATER (FT)
1	.00	19.50
2	13.00	20.00
3	50.00	26.00

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM TECHNIQUE FOR GENERATING CIRCULAR SURFACES, HAS BEEN SPECIFIED.

100 TRIAL SURFACES HAVE BEEN GENERATED.

10 SURFACES INITIATE FROM EACH OF 10 POINTS EQUALLY SPACED
ALONG THE GROUND SURFACE BETWEEN X = .00 FT.
AND X = 15.00 FT.

EACH SURFACE TERMINATES BETWEEN X = 30.00 FT.
AND X = 45.00 FT.

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION
AT WHICH A SURFACE EXTENDS IS Y = .00 FT.

5.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

FOLLOWING ARE DISPLAYED THE TEN MOST CRITICAL OF THE TRIAL FAILURE SURFACES EXAMINED. THEY ARE ORDERED - MOST CRITICAL FIRST.

FAILURE SURFACE SPECIFIED BY 10 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	3.33	19.63
2	7.68	17.15
3	12.44	15.63
4	17.42	15.13
5	22.39	15.68
6	27.13	17.24
7	31.45	19.76
8	35.16	23.12
9	38.08	27.18
10	39.40	30.17

*** 1.788 ***

FAILURE SURFACE SPECIFIED BY 11 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	1.67	19.56
2	5.75	16.67
3	10.31	14.63
4	15.18	13.51
5	20.18	13.36
6	25.11	14.19
7	29.79	15.96
8	34.03	18.60
9	37.68	22.02
10	40.60	26.08
11	42.51	30.27

*** 1.798 ***

FAILURE SURFACE SPECIFIED BY 10 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	5.00	19.69
2	9.11	16.84
3	13.75	14.99
4	18.70	14.24
5	23.68	14.63
6	28.45	16.14
7	32.75	18.68
8	36.37	22.13
9	39.11	26.31
10	40.55	30.20

*** 1.800 ***

FAILURE SURFACE SPECIFIED BY 11 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	.00	19.50
2	4.36	17.05
3	9.10	15.48
4	14.06	14.84
5	19.05	15.15
6	23.89	16.42
7	28.40	18.58
8	32.41	21.56
9	35.78	25.26
10	38.39	29.52
11	38.62	30.14

*** 1.804 ***

FAILURE SURFACE SPECIFIED BY 11 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	1.67	19.56
2	5.84	16.80
3	10.44	14.86
4	15.33	13.81
5	20.33	13.68
6	25.27	14.48
7	29.97	16.18
8	34.27	18.72
9	38.03	22.02
10	41.12	25.95
11	43.37	30.29

*** 1.807 ***

FAILURE SURFACE SPECIFIED BY 10 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	3.33	19.63
2	7.74	17.27
3	12.56	15.93
4	17.55	15.68
5	22.48	16.51
6	27.11	18.40
7	31.22	21.26
8	34.60	24.94
9	37.10	29.27
10	37.37	30.11

*** 1.813 ***

FAILURE SURFACE SPECIFIED BY 12 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	.00	19.50
2	3.90	16.37
3	8.32	14.04
4	13.10	12.58
5	18.08	12.05
6	23.06	12.46
7	27.87	13.81
8	32.35	16.05
9	36.32	19.09
10	39.64	22.82
11	42.20	27.11
12	43.36	30.29

*** 1.825 ***

FAILURE SURFACE SPECIFIED BY 9 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	6.67	19.76
2	10.95	17.17
3	15.75	15.78
4	20.75	15.67
5	25.60	16.86
6	29.99	19.26
7	33.60	22.72
8	36.20	26.99
9	37.11	30.10

*** 1.826 ***

FAILURE SURFACE SPECIFIED BY 11 COORDINATE POINTS

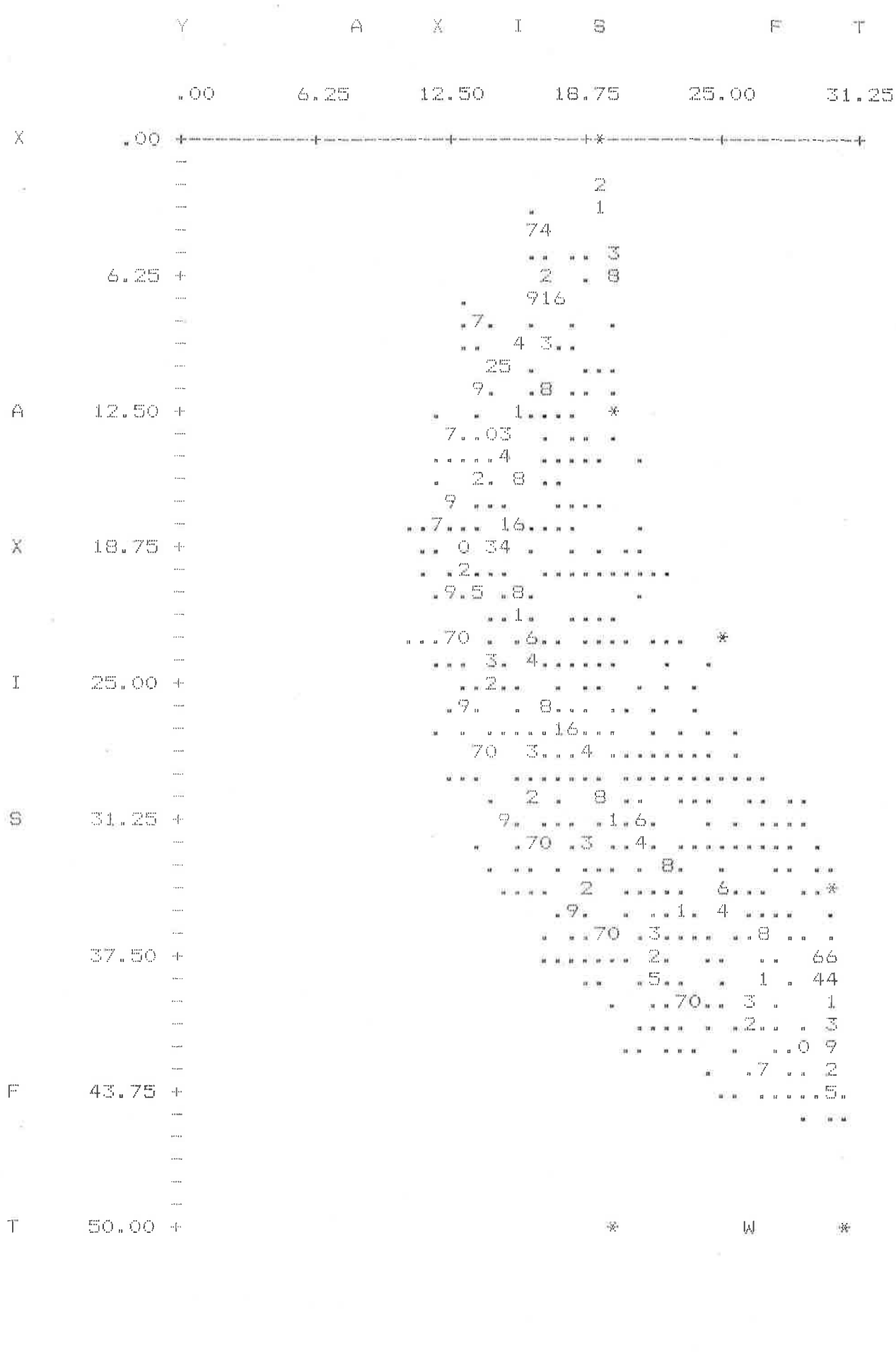
POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	3.33	19.63
2	7.09	16.33
3	11.48	13.94
4	16.29	12.58
5	21.29	12.31
6	26.21	13.16
7	30.84	15.07
8	34.92	17.95
9	38.27	21.66
10	40.71	26.02
11	41.97	30.25

*** 1.844 ***

FAILURE SURFACE SPECIFIED BY 11 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	5.00	19.69
2	8.91	16.57
3	13.42	14.42
4	18.30	13.34
5	23.30	13.39
6	28.16	14.56
7	32.63	16.81
8	36.47	20.01
9	39.49	23.99
10	41.53	28.56
11	41.86	30.25

*** 1.846 ***


Y A X I S F T
.00 6.25 12.50 18.75 25.00 31.25
X .00
6.25
A 12.50
X 18.75
I 25.00
S 31.25
37.50
F 43.75
T 50.00

STABILITY ANALYSIS

SECTION 4

CASE 2
POOL AT ELEV. 895 WITH STEADY SEEPAGE

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

UNITWEIGHT OF WATER = 62.40

PIEZOMETRIC SURFACE NO. 1 SPECIFIED BY 4 COORDINATE POINTS

POINT NO.	X-WATER (FT)	Y-WATER (FT)
1	.00	19.50
2	13.00	20.00
3	35.00	27.00
4	50.00	29.50

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM TECHNIQUE FOR GENERATING CIRCULAR SURFACES, HAS BEEN SPECIFIED.

100 TRIAL SURFACES HAVE BEEN GENERATED.

10 SURFACES INITIATE FROM EACH OF 10 POINTS EQUALLY SPACED
ALONG THE GROUND SURFACE BETWEEN X = .00 FT.
AND X = 15.00 FT.

EACH SURFACE TERMINATES BETWEEN X = 30.00 FT.
AND X = 45.00 FT.

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION
AT WHICH A SURFACE EXTENDS IS Y = .00 FT.

5.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

FOLLOWING ARE DISPLAYED THE TEN MOST CRITICAL OF THE TRIAL FAILURE SURFACES EXAMINED. THEY ARE ORDERED - MOST CRITICAL FIRST.

FAILURE SURFACE SPECIFIED BY 11 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	1.67	19.56
2	5.84	16.81
3	10.50	15.00
4	15.44	14.22
5	20.43	14.50
6	25.25	15.84
7	29.67	18.17
8	33.50	21.38
9	36.56	25.34
10	38.71	29.85
11	38.78	30.15

*** 1.568 ***

FAILURE SURFACE SPECIFIED BY 11 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	1.67	19.56
2	5.79	16.73
3	10.38	14.75
4	15.27	13.71
5	20.27	13.63
6	25.19	14.52
7	29.84	16.36
8	34.05	19.06
9	37.65	22.53
10	40.51	26.63
11	42.10	30.25

*** 1.570 ***

FAILURE SURFACE SPECIFIED BY 12 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	.00	19.50
2	3.85	16.30
3	8.27	13.98
4	13.09	12.63
5	18.08	12.31
6	23.02	13.04
7	27.71	14.79
8	31.93	17.47
9	35.49	20.98
10	38.25	25.15
11	40.07	29.80
12	40.14	30.19

*** 1.597 ***

FAILURE SURFACE SPECIFIED BY 11 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	3.33	19.63
2	7.76	17.31
3	12.54	15.82
4	17.50	15.20
5	22.49	15.48
6	27.35	16.64
7	31.93	18.65
8	36.07	21.45
9	39.65	24.94
10	42.55	29.02
11	43.14	30.29

*** 1.599 ***

FAILURE SURFACE SPECIFIED BY 11 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	3.33	19.63
2	7.66	17.12
3	12.36	15.41
4	17.29	14.56
5	22.29	14.60
6	27.20	15.51
7	31.88	17.28
8	36.17	19.84
9	39.94	23.12
10	43.08	27.02
11	44.89	30.34

*** 1.602 ***

FAILURE SURFACE SPECIFIED BY 12 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	.00	19.50
2	4.34	17.02
3	9.02	15.26
4	13.92	14.27
5	18.92	14.08
6	23.88	14.69
7	28.68	16.09
8	33.20	18.23
9	37.31	21.07
10	40.92	24.53
11	43.93	28.53
12	44.89	30.34

*** 1.609 ***

FAILURE SURFACE SPECIFIED BY 10 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	3.33	19.63
2	7.32	16.61
3	11.94	14.69
4	16.89	13.98
5	21.86	14.54
6	26.53	16.31
7	30.61	19.20
8	33.84	23.02
9	36.02	27.52
10	36.53	30.08

*** 1.616 ***

FAILURE SURFACE SPECIFIED BY 11 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	.00	19.50
2	4.47	17.25
3	9.26	15.82
4	14.22	15.24
5	19.22	15.54
6	24.08	16.70
7	28.67	18.69
8	32.83	21.45
9	36.46	24.90
10	39.43	28.92
11	40.06	30.19

*** 1.617 ***

FAILURE SURFACE SPECIFIED BY 10 COORDINATE POINTS

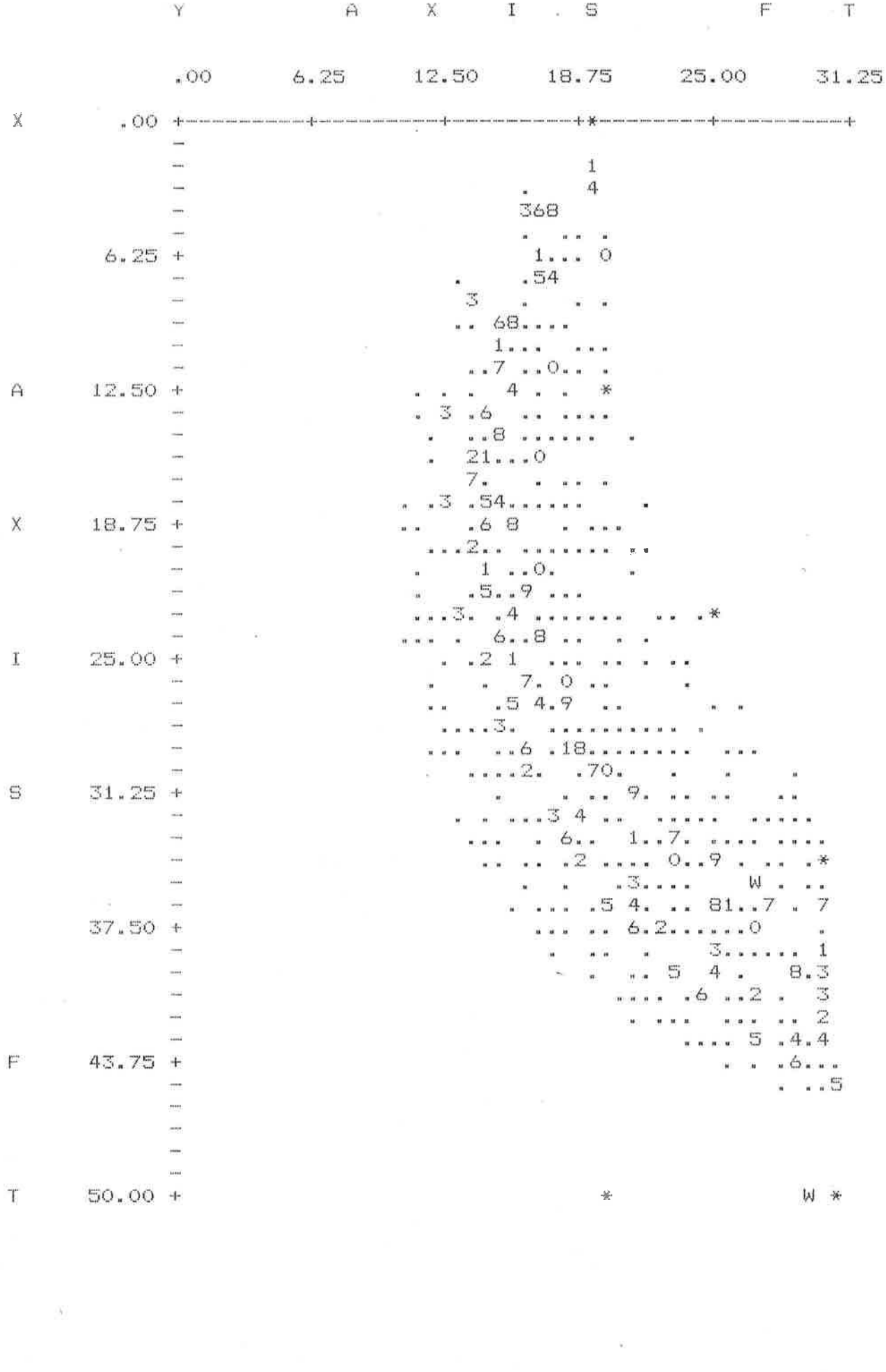
POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	3.33	19.63
2	7.61	17.04
3	12.39	15.55
4	17.38	15.24
5	22.30	16.14
6	26.86	18.18
7	30.81	21.25
8	33.90	25.18
9	35.97	29.73
10	36.04	30.06

*** 1.620 ***

FAILURE SURFACE SPECIFIED BY 9 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	6.67	19.76
2	11.24	17.74
3	16.14	16.72
4	21.14	16.75
5	26.02	17.83
6	30.57	19.91
7	34.58	22.90
8	37.87	26.66
9	39.84	30.18

*** 1.624 ***


Y A X I S F T
.00 6.25 12.50 18.75 25.00 31.25
X .00
6.25
A 12.50
X 18.75
I 25.00
S 31.25
37.50
F 43.75
T 50.00

STABILITY ANALYSIS

SECTION 4

CASE 3
EMBANKMENT & POOL LEVEL RAISED TO ELEV. 897,
STEADY SEEPAGE, TAILWATER AT ELEV. 890

--SLOPE STABILITY ANALYSIS--
SIMPLIFIED JANBU METHOD OF SLICES
IRREGULAR FAILURE SURFACES

807 - SECTION 3C; EMBANKMENT RAISED TO 397'

PROBLEM DESCRIPTION PMF STEADY SEEPAGE CONDITIONS, TW @ 8?0'

BOUNDARY COORDINATES

5 TOP BOUNDARIES
7 TOTAL BOUNDARIES

BOUNDARY NO.	X-LEFT (FT)	Y-LEFT (FT)	X-RIGHT (FT)	Y-RIGHT (FT)	SOIL TYPE BELOW BND
1	.00	19.50	13.00	20.00	3
2	13.00	20.00	22.50	25.00	2
3	22.50	25.00	34.00	30.00	2
4	34.00	30.00	40.00	35.00	1
5	40.00	35.00	55.00	35.00	1
6	34.00	30.00	55.00	31.00	2
7	13.00	20.00	55.00	20.00	3

ISOTROPIC SOIL PARAMETERS

3 TYPE(S) OF SOIL

OMETRIC RFACE NO.	SOIL TYPE NO.	TOTAL UNIT WT. (PCF)	SATURATED UNIT WT. (PCF)	COHESION INTERCEPT (PSF)	FRICTION ANGLE (DEG)	PORE PRESSURE PARAMETER	PRESSURE CONSTANT (PSF)	PIEZ SU
1	1	130.0	130.0	.0	27.0	.00	.0	
1	2	123.0	123.0	300.0	25.0	.00	.0	
1	3	125.0	125.0	.0	30.0	.00	.0	

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

UNITWEIGHT OF WATER = 62.40

PIEZOMETRIC SURFACE NO. 1 SPECIFIED BY 3 COORDINATE POINTS

POINT NO.	X-WATER (FT)	Y-WATER (FT)
1	.00	25.00
2	17.50	25.00
3	55.00	32.00

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM TECHNIQUE FOR GENERATING CIRCULAR SURFACES, HAS BEEN SPECIFIED.

100 TRIAL SURFACES HAVE BEEN GENERATED.

10 SURFACES INITIATE FROM EACH OF 10 POINTS EQUALLY SPACED
ALONG THE GROUND SURFACE BETWEEN X = .00 FT.
AND X = 15.00 FT.

EACH SURFACE TERMINATES BETWEEN X = 40.00 FT.
AND X = 55.00 FT.

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION
AT WHICH A SURFACE EXTENDS IS Y = .00 FT.

5.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

FOLLOWING ARE DISPLAYED THE TEN MOST CRITICAL OF THE TRIAL FAILURE SURFACES EXAMINED. THEY ARE ORDERED - MOST CRITICAL FIRST.

FAILURE SURFACE SPECIFIED BY 11 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	8.33	19.82
2	12.74	17.45
3	17.52	16.01
4	22.50	15.54
5	27.47	16.08
6	32.24	17.60
7	36.60	20.03
8	40.40	23.29
9	43.47	27.24
10	45.69	31.71
11	46.57	35.00

*** 1.291 ***

FAILURE SURFACE SPECIFIED BY 10 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	10.00	19.88
2	14.56	17.84
3	19.46	16.83
4	24.46	16.90
5	29.33	18.04
6	33.83	20.22
7	37.76	23.31
8	40.92	27.18
9	43.18	31.64
10	44.04	35.00

*** 1.298 ***

FAILURE SURFACE SPECIFIED BY 11 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	10.00	19.88
2	14.51	17.73
3	19.35	16.48
4	24.34	16.19
5	29.30	16.86
6	34.03	18.48
7	38.36	20.97
8	42.13	24.26
9	45.20	28.21
10	47.45	32.67
11	48.10	35.00

*** 1.301 ***

FAILURE SURFACE SPECIFIED BY 12 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	5.00	19.69
2	9.28	17.11
3	13.96	15.34
4	18.88	14.46
5	23.88	14.48
6	28.79	15.42
7	33.45	17.24
8	37.70	19.87
9	41.40	23.23
10	44.42	27.21
11	46.67	31.68
12	47.64	35.00

*** 1.312 ***

FAILURE SURFACE SPECIFIED BY 11 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	5.00	19.69
2	9.53	17.58
3	14.37	16.33
4	19.36	15.96
5	24.33	16.51
6	29.12	17.94
7	33.58	20.21
8	37.55	23.24
9	40.91	26.95
10	43.54	31.20
11	45.04	35.00

*** 1.315 ***

FAILURE SURFACE SPECIFIED BY 12 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	8.33	19.82
2	12.57	17.17
3	17.26	15.43
4	22.20	14.66
5	27.20	14.91
6	32.04	16.15
7	36.53	18.35
8	40.49	21.40
9	43.76	25.18
10	46.19	29.55
11	47.70	34.32
12	47.77	35.00

*** 1.316 ***

FAILURE SURFACE SPECIFIED BY 10 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	10.00	19.88
2	14.72	18.24
3	19.68	17.55
4	24.67	17.84
5	29.51	19.09
6	34.01	21.25
7	38.01	24.26
8	41.35	27.98
9	43.90	32.28
10	44.86	35.00

*** 1.326 ***

FAILURE SURFACE SPECIFIED BY 12 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	6.67	19.76
2	10.80	16.95
3	15.41	15.01
4	20.32	14.03
5	25.32	14.05
6	30.22	15.05
7	34.82	17.01
8	38.94	19.83
9	42.42	23.43
10	45.12	27.64
11	46.93	32.30
12	47.39	35.00

*** 1.328 ***

FAILURE SURFACE SPECIFIED BY 11 COORDINATE POINTS

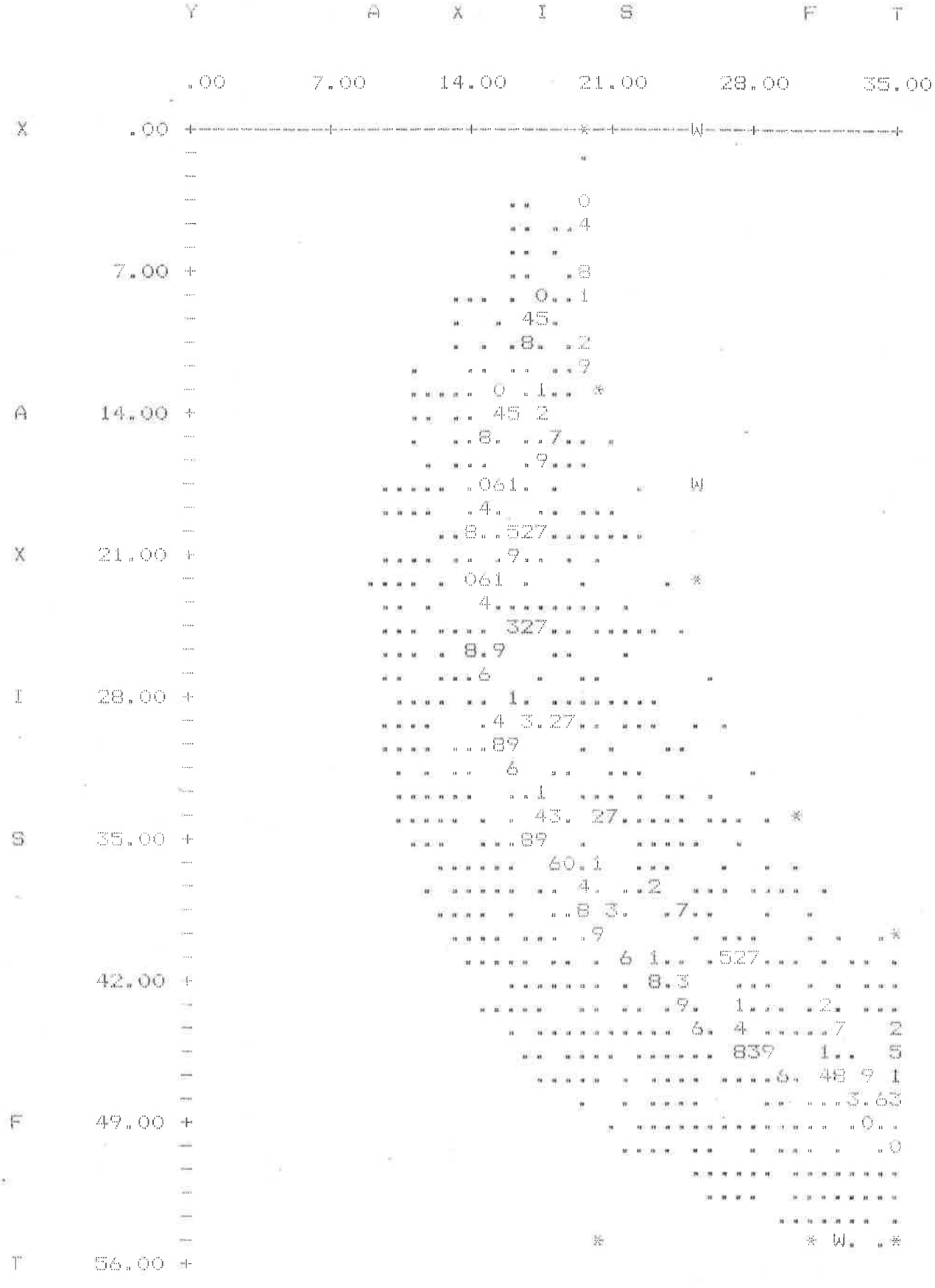
POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	11.67	19.95
2	15.94	17.35
3	20.68	15.78
4	25.66	15.33
5	30.62	16.03
6	35.28	17.83
7	39.42	20.64
8	42.80	24.32
9	45.27	28.67
10	46.68	33.46
11	46.77	35.00

*** 1.334 ***

FAILURE SURFACE SPECIFIED BY 13 COORDINATE POINTS

POINT NO.	X-SURF (FT)	Y-SURF (FT)
1	3.33	19.63
2	7.68	17.15
3	12.36	15.41
4	17.27	14.45
5	22.27	14.30
6	27.23	14.96
7	32.01	16.41
8	36.49	18.62
9	40.56	21.53
10	44.11	25.06
11	47.03	29.11
12	49.26	33.59
13	49.70	35.00

*** 1.336 ***


Y A X I S F T
.00 7.00 14.00 21.00 28.00 35.00
X .00
7.00
A 14.00
X 21.00
I 28.00
S 35.00
42.00
F 49.00
T 56.00