OVERVIEW
BUCKEYE LAKE DAM
ODNR PHASE III

PRESENTED BY
SAVE THE LAKE COMMITTEE
SEPTEMBER 29, 1995

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W. S. Gardner and Associates
Consultants in Geo-Engineering

September 8, 1995
95J931

Buckeye Lake Association
P.O. Box 952
Buckeye Lake, OH 43008

Attention: Mr. Wayne Radcliff

Re: INTERIM REPORT
BUCKEYE LAKE DAM

Gentlemen:

Pursuant to your request, I have made on in-depth review of the Dodson-Linblom Associates (DLA) reports concerning the stability of the Buckeye Lake Dam. Based on the DLA report and independent analyses, it is my opinion that there is a significant risk of failure, should the earth dam be raised to accommodate the probable maximum flood (PMF). Further, I believe the pool elevation should not significantly exceed elevation 892, pending the results of the ongoing stability analyses.

With regard to dam stability, it should also be appreciated that the DLA study has apparently not considered the added risk of seismic occurrences. In assessing dam stability, this risk is recognized by the USA Corps of Engineers and other federal and state agencies. To address the seismic impact on earth dams, pseudo static stability analyses are generally conducted although more rigorous techniques are available. Consequently, pseudo static analyses should have been provided for the Buckeye Lake Dam.

In my opinion, the most likely failure mechanisms of the dam consist of internal piping through the sandy and silty seams encountered at the base and within the embankment, as well as progressive sliding or slumping of the downstream slope of the dam. Although only temporary pool increases to accommodate the PMF are proposed, there likely remains a substantial risk of failure. In this regard, storage durations at or near elevation 897 can be much more substantial than the 24 hours considered to pass the PMF. For example, a storm closely following the PMF would prolong the impoundment. Piping can also occur quite rapidly, particularly with the smaller widths of the embankments.

We hope to have the results of the stability analyses, including the effects of seismicity, by the end of the week. Assuming that an in-depth review of the hydrology need not be conducted at this time, I will try to provide the final report on the dam stability by the week

W. S. Gardner and Associates
Consultants in Geo-Engineering

of September 18th. Please call me if there are any questions concerning this Interim Report.

Very truly yours,

W.S. GARDNER AND ASSOCIATES

WS Gardner

Williams S. Gardner, P.E.

2

W. S. Gardner and Associates
Consultants in Geo–Engineering

September 29, 1995
95J031

Buckeye Lake Association
P.O. Box 952
Buckeye Lake, OH 43008

Attention: Mr. Wayne Radcliff

Gentlemen:

Enclosed are two copies of the final report for the Buckeye Lake Dam. As indicated, the dam hydrology had only a cursory overview. Should a detailed study be beneficial, we would be pleased to conduct such a study.

Should there be any questions concerning this report, please call at your convenience. We appreciate the opportunity to have worked with you and trust that our work will influence the State to provide a truly stable dam.

Very truly yours,

W.S. GARDNER AND ASSOCIATES

W S Gardner

William S. Gardner, P.E.

Enclosures

221 West Germantown Pike • Plymouth Meeting, PA 19462 • 610-825-6900 • Fax: 610-825-8570

BUCKEYE LAKE DAM
REVIEW OF EMBANKMENT STABILITY

Prepared For

BUCKEYE LAKE ASSOCIATION
Buckeye Lake, Ohio

Submitted By

W.S. GARDNER AND ASSOCIATES
Plymouth Meeting, Pennsylvania

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W. S. Gardner and Associates
Consultants in Geo-Engineering

BUCKEYE LAKE DAM
REVIEW OF EMBANKMENT STABILITY

INTRODUCTION

The purpose of this report is to review the safety of Buckeye Lake Dam based on the Dodson-Linbloom Associates' (DLA) reports dated August 7, 1987 and independent analysis. Specifically, this study has emphasized investigation into the potential risks of raising current pool levels to accommodate the Probable Maximum Flood (PMF). A cursory examination of the hydrology of the dam has also been made, pending the need for more detailed studies. The abbreviated interim report dated September 8, 1995 is superseded by this report.

1. OVERVIEW OF DAM AND SPILLWAY

It is understood that the Buckeye Lake Dam had its beginnings in 1825 as a reservoir to feed water to the Ohio and Erie Canals. The impoundment was constructed of uncompacted earth and was completed in 1832. The earth dam is used for public recreation, is four miles long, and is currently rated by the State of Ohio as a Class I dam. At a pool elevation of 892, the dam impounds 2,700 acres and the maximum height of the embankment is about 15 ft. A U-shaped concrete gravity weir structure, constructed in 1992, has a crest length of 460 ft. at elevation 891.75. It is also understood that an additional spillway has been constructed with an automatic gate to regulate flow. Shoreline sheet piling has also been constructed in front of the old masonry shoreline. Additional sheets were also driven at other locations.

It is understood that the current spillway system is capable of passing a flood equivalent to 50 percent of the Probable Maximum Flood. To accommodate 100 percent of the PMF, the Ohio Department of Natural Resources (ODNR) plans to raise the dam to elevation 896.5 by constructing a parapet around the dam. It is further understood that to pass the PMF it will be necessary to maintain a temporary water surface as high as 896.5.

2. EMBANKMENT SOILS

As part of the dam investigation in 1986, ten test borings were made and soil samples were recovered. Subsequently, soil classifications, laboratory testing and characterization of the soil properties were conducted at three locations along the four-mile long dam. The cross sections through the embankment were numbered 2, 3 and 4 and are enclosed herein as Figures 1 through 3, after DLA. Embankment materials were reported to be a "homogeneous" fill and were transported to the dam site by mule-drawn wagons. Additional embankment materials were provided in 1832 after failure of the dam on initial filling. These materials consisted of "coarse stone" and were used to help repair the breach. The embankment materials, based on the current borings, indicate the embankment soils to be predominantly of clayey silt with varying amounts of sand, gravel and organic inclusions. The foundation materials are thought to have been a post-glacial bog underlain by lacustrine deposits of laminated clayey silts interbedded with sand and sandy gravel layers.

In general, the embankment heights encountered by the exploration ranged from 7 to 10 ft. although at one location the embankment was found to be only 3 ft. high. Of the ten borings drilled, six contained sand or silt seams. A tabulation of the depth of the seams below the crest is included in Table 1. Note that one of the sand layers (0.9 ft. thick) was found in the embankment and another was encountered at the base of the embankment. The remaining sand or silt seams recorded (up to 20 ft.) ranged from depths of 11.5 to 15.6 ft. below the dam crest.

In summary, sand and/or silt partings and seams were encountered in the embankment and foundation of the dam, primarily at Cross Sections 2 and 3. In addition, Boring 2A of Cross Section 3 reported significant seepage through the sand seams within the embankment. In Cross Section 4, water seepage was encountered in all of the borings at various depths with the exception of Boring 4A. The seepage was encountered in the foundation soils below the embankment soils at a depth of 6.2 ft. below the dam crest. It is also noted that the current phreatic surface is lower than the summer average.

3. EARTH DAM FAILURE

There are a number of potential failure modes of earth dams. However, those relevant to the Buckeye Lake Dam can be identified as follows:

(1) Erosion due to overtopping of the dam crest.

(2) Instability of the dam slopes due to high phreatic surfaces, seismicity and poorly constructed embankments.

(3) Internal piping due to high phreatic surfaces and soils that are susceptible to erosion.

Other potential risks of failure which are less likely to occur include decomposition of trees within the embankment, earthquake induced liquefaction and burrowing animals.

Internal piping in a dam occurs when there is a high phreatic surface, no protective filters, and soils which are susceptible to erosion. Based on Sherard, et al (1963), susceptible soil types consist of sand (SP), silty sand (SM), and sandy silt (ML). The piping mechanism starts by seepage concentrations which create erosion and cause a progressive soil loss. This is followed by tunneling through the embankment, eventually causing a dam breach. The lack of protective filters, seepage within and below the uncompacted embankment materials, and increasing seepage rates pose a significant piping hazard. In this regard, it has been reported that small increases in the pool elevation significantly accelerate seepage rates and that temporary pool levels may be as high as 896.5. These concerns, when taken together, indicate that piping is a significant hazard unless pool elevations do not significantly exceed about elevation 892.

The down-stream slope of the dam is also a significant hazard when there is a high phreatic surface together with a poorly compacted embankment. Slope failures typically occur by a down-stream slide, the slide mass having a wedge or circular configuration. Failure may occur by a single slide or by progressive sliding on over-steepened slide scarps. However, the occurrence of an earthquake in the vicinity of the dam site has by far the largest risk of failure.

4. FACTORS OF SAFETY

The minimum factors of safety as provided by the USA Corps of Engineers are enclosed in Table 2. The relevant safety factor for dams such as Buckeye Lake Dam is 1.5 for steady seepage with a maximum or partial pool. For seismic conditions, the factor of safety is 1.0 for a conventional stability analysis. More rigorous methods of evaluating seismic stability, including pseudo-static analyses, are provided in Sections 5 and 7. Considering the conditions of the 170-year old Buckeye Lake Dam and the down-stream risk, conventional safety factors much less than 1.5 would not be prudent for steady state seepage conditions.

5. SLOPE STABILITY ANALYSIS

Excluding seismic risk, the safety factors against instability of the dam slopes were investigated by independent slope stability analysis, assuming circular slide configurations. Both the Modified Bishop and Janbu computer programs, implemented by STABL 5, were used with the same input parameters as DLA. The results of this study are summarized in Table 3 and include the results of DLA's STABL 2 study. The earlier STABL 2 software was used with the Janbu option. By comparison, the STABL 2 and STABL 5 results are not identical but the differences are not great. It is noted that the Janbu option often provides smaller safety factors than the more frequently used Modified Bishop program. The Janbu program is most often employed for noncircular slide planes.

Based on the STABL 5 slope stability programs, Figure 4 provides safety factors as a function of the pool elevations of the dam. Thus, safety factors for a variety of pool elevations can be determined for both the Modified Bishop and Janbu slope stability analyses.

Based on the results of the independent stability analyses, it is concluded that the DLA study has been reasonably conservative in predicting safety factors for the Buckeye Lake Dam. The most significant findings are the low safety factors found in Cross Section 2, whereas the safety factors of Cross Sections 3 and 4 have significantly larger safety factors. As shown in Table 3, the safety factor is marginal with a pool at and above elevation 895. This is indicated by a safety factor of essentially 1.0. In addition, there are other factors that further increase the risk of failure. These include seismicity effects and the probability that there will be less stable embankment zones within the dam which have not been investigated.

6. SEISMIC CONSIDERATIONS

Seismic occurrence relatively near Buckeye Lake significantly reduces the stability of the earth dam. In this regard, two concentrations of earthquakes are evident in Ohio. Based on the Earthquake History of the United States (1970), the largest of these is located in the northwestern part of the State near the town of Sidney. The largest shock in this area was recorded as an MM VII-VIII[1] (7.5) earthquake, the largest of the historical record. The other concentration of earthquakes is in southeastern Ohio and are most active in the vicinity of Meigs County and its environs. The largest earthquake in this area occurred in 1926 at Zanesville which is about 21 miles from the Buckeye Lake Dam. This earthquake had an intensity of MM VI-VII (6.5).

Conservatively assuming an earthquake similar to the Zanesville shock, the maximum horizontal acceleration near the dam site is 0.10 g, where g is the acceleration due to gravity. Seismic risk studies have been conducted throughout the U.S. by a number of investigators. In this regard, Algermissen and Perkins (1976) provide contours of horizontal acceleration for a return period of 500 years (see Figure 5). Using the risk level for the State of Ohio, the maximum horizontal acceleration near the site is interpreted as 0.06 g.

7. YIELD ACCELERATION AND DISPLACEMENT

To evaluate the effect of seismicity in the dam vicinity, pseudo-static analyses were conducted to investigate the yield accelerations of the embankment, i.e. the acceleration required to produce a safety factor of 1.0. The yield accelerations, (k_y) plotted are shown by Figures 6 and 7. With one exception, these analyses have been conducted using the Modified Bishop program. The yield acceleration for the elevation 895 pool was also calculated, using the Janbu slope stability analysis for comparison with the Modified Bishop analysis. As indicated, the yield accelerations range from 0.015 g to 0.138 g which correspond to pool elevations of 897 and 892, respectively. It is noted that the yield acceleration at elevation 892 (0.138 g) is greater than the maximum acceleration for southeastern Ohio (0.06 g) and, therefore, does not fail. This is consistent with the calculated Safety Factor of 1.46.

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[1]The Modified Mercalli (MM) scale is based on assessment of the earthquake damage. The Mercalli scale was modified in 1931

Earth dams subject to seismicity may cause significant horizontal displacements of the embankment which may lead to a dam breach. The amount of displacement depends on the yield acceleration (k_y) and the maximum horizontal acceleration (A_{max}) of the earthquake. Following Hynes and Franklin (1984), the data required for the displacement analysis is the maximum horizontal acceleration (0.10 g) and the yield accelerations calculated previously. The displacement relationship, given by Figure 8, conservatively utilizes the mean + σ of the curve. The results of the displacement calculations are included in Table 4. As anticipated, the largest permanent embankment displacement is 34 cm which will likely fail the dam when the pool elevation is 896.5. A 21 cm displacement of the embankment with the pool at 895 would also likely be sufficient to fail the dam. With the pool at an elevation of 892, the embankment is stable and there is no displacement during the maximum earthquake.

8. CONCLUSIONS AND RECOMMENDATIONS

Based on review of the DLA report, observations at the dam site, and independent analysis, it is clear that Buckeye Lake Dam has some serious defects other than the extreme age of the dam. These deficiencies include: (1) a current inability to accommodate the PMF; (2) a leaky, uncompacted embankment; and (3) a potential instability of dam slopes if pool elevations significantly exceed about 892. At significantly higher pool elevations than 892, instability of the embankment is likely. In addition, seismic occurrences have the potential to induce rapid failures by large embankment displacements and/or progressive sliding downstream of the order predicted in Table 4.

In summary, analysis of Buckeye Lake Dam indicates that the embankment is unsafe at pool elevations much above 892. At this elevation, the factor of safety against failure is essentially 1.5 which meets conventional safety standards, and is strongly recommended. It is also prudent to provide the dam a freeboard of at least 3 ft. (to elevation 895) and is also a recommended safety provision. The plan by ODNR to construct a parapet wall around the dam to accommodate the PMF is unsafe as a temporary raise in the pool elevation to 896.5 would most likely induce an embankment failure. Consequently, it is recommended that the PMF be accommodated by other means, such as adding an additional spillway.

The recommendations of DLA concerning a staged removal over time of selected trees implanted in the embankment appear to be a reasonable procedure. Further, the width of the embankment may be deficient at some locations and should be investigated and remediated if verified.

FIGURES

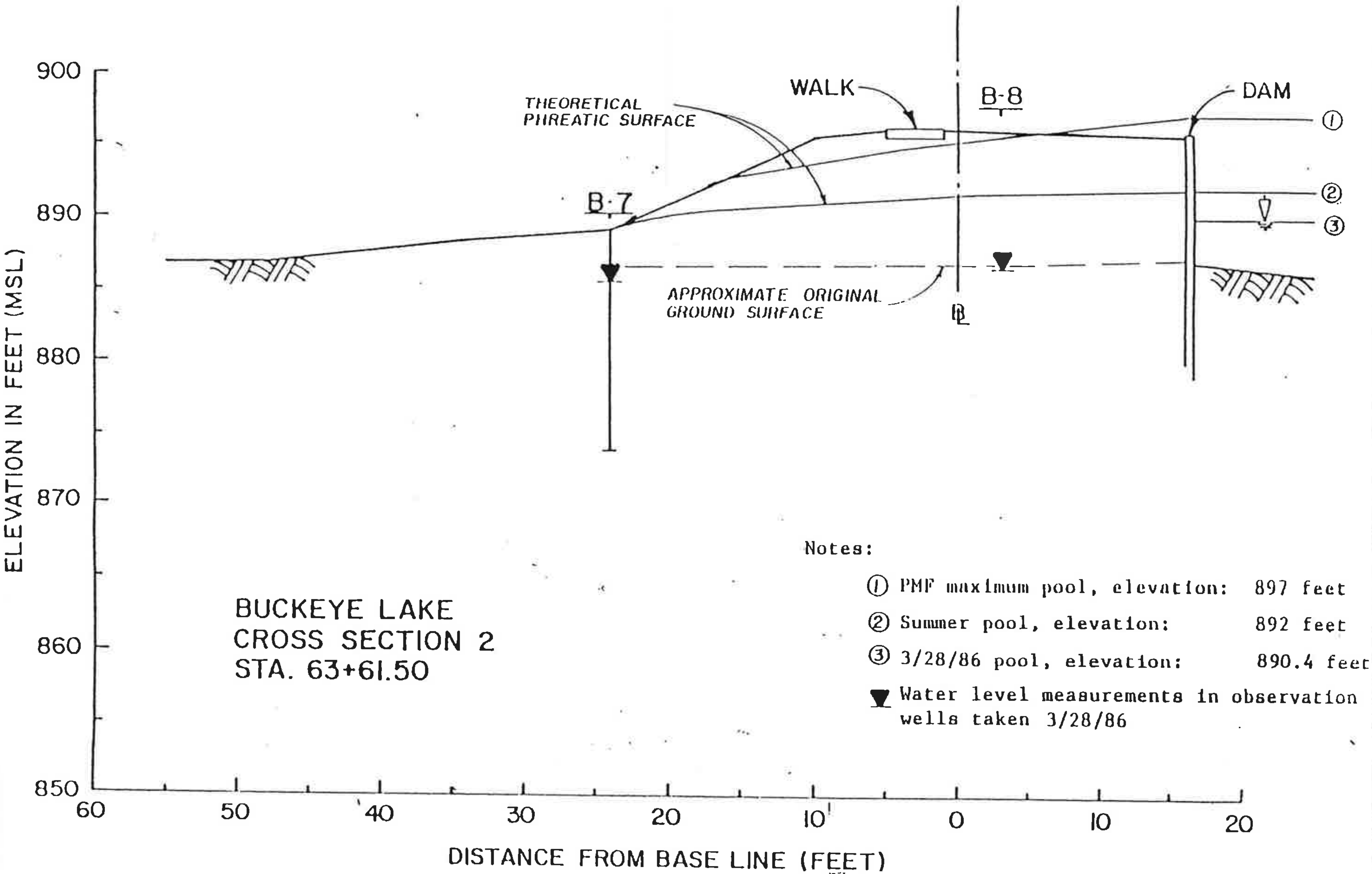

BUCKEYE LAKE
CROSS SECTION 2
STA. 63+61.50
ELEVATION IN FEET (MSL)
900
890
880
870
860
850
60
50
40
30
20
10
0
10
20
DISTANCE FROM BASE LINE (FEET)
THEORETICAL PHREATIC SURFACE
WALK
B-8
DAM
B-7
APPROXIMATE ORIGINAL GROUND SURFACE
℄
①
②
③
Notes:
① PMF maximum pool, elevation: 897 feet
② Summer pool, elevation: 892 feet
③ 3/28/86 pool, elevation: 890.4 feet
▼ Water level measurements in observation wells taken 3/28/86

FIGURE 1

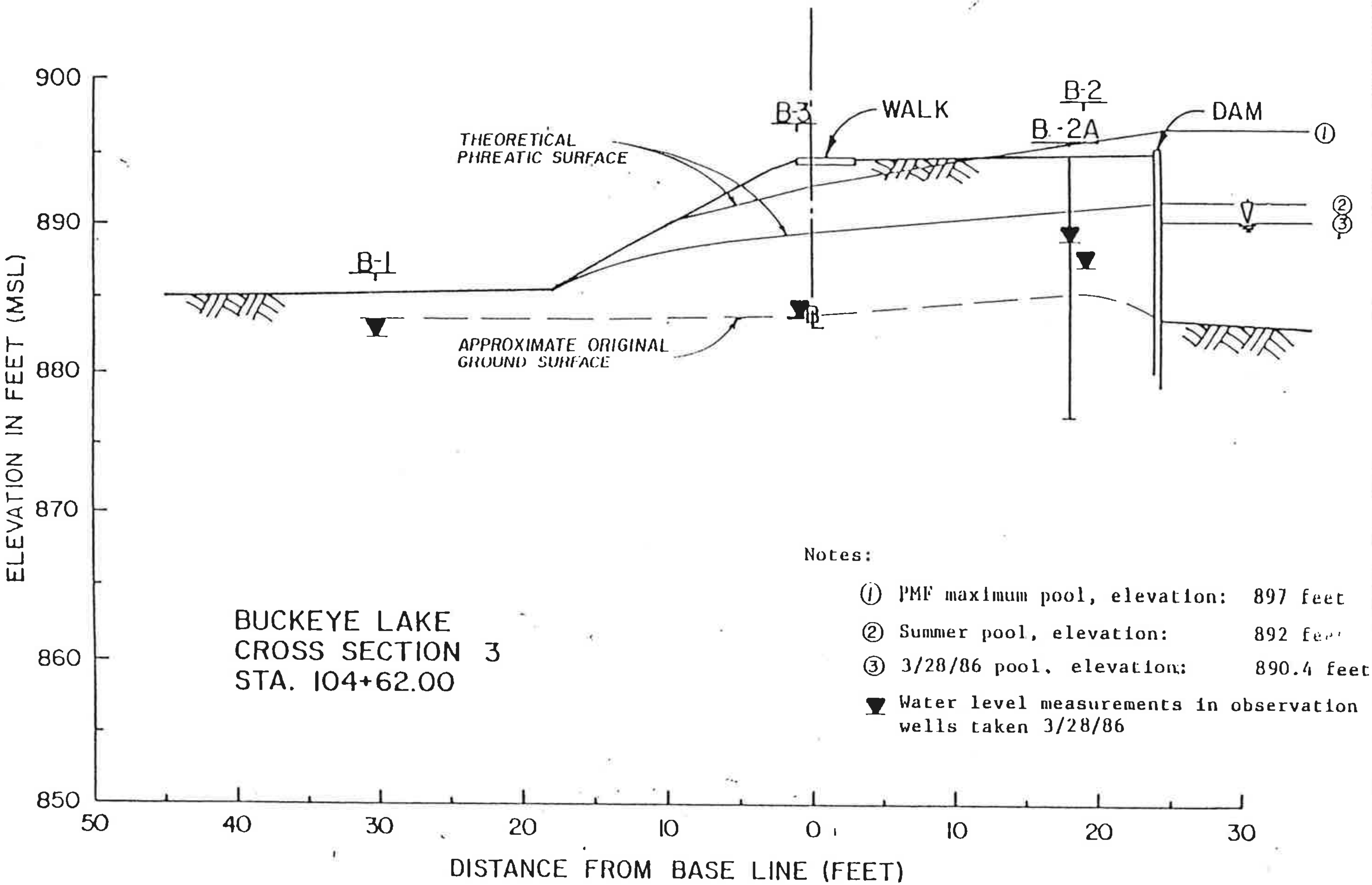

900
890
880
870
860
850
ELEVATION IN FEET (MSL)
50
40
30
20
10
0
10
20
30
DISTANCE FROM BASE LINE (FEET)
B-1
B-3
WALK
B-2
B-2A
DAM
THEORETICAL PHREATIC SURFACE
APPROXIMATE ORIGINAL GROUND SURFACE
BUCKEYE LAKE
CROSS SECTION 3
STA. 104+62.00
Notes:
① PMF maximum pool, elevation: 897 feet
② Summer pool, elevation: 892 feet
③ 3/28/86 pool, elevation: 890.4 feet
▼ Water level measurements in observation wells taken 3/28/86

FIGURE 2

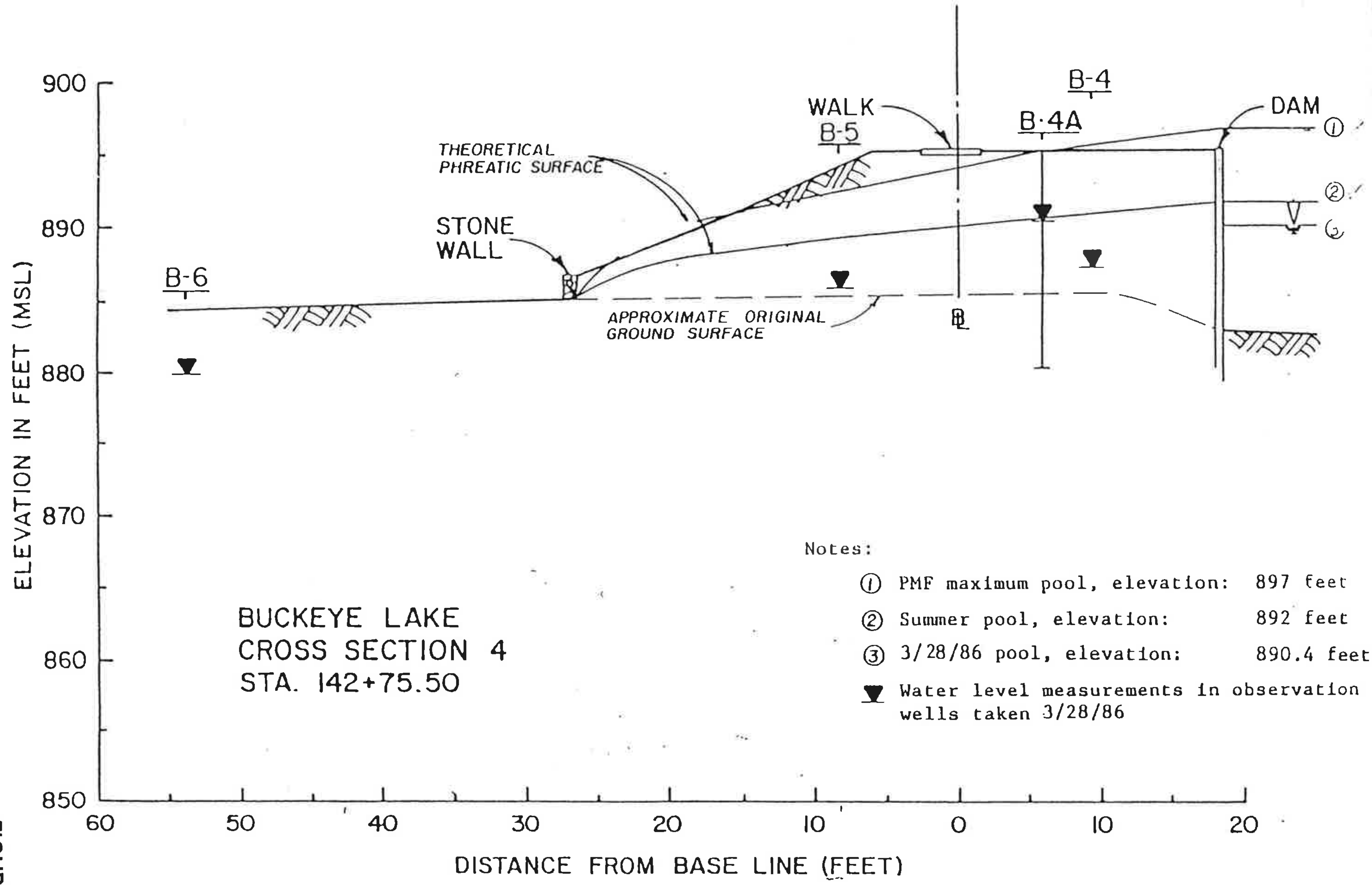
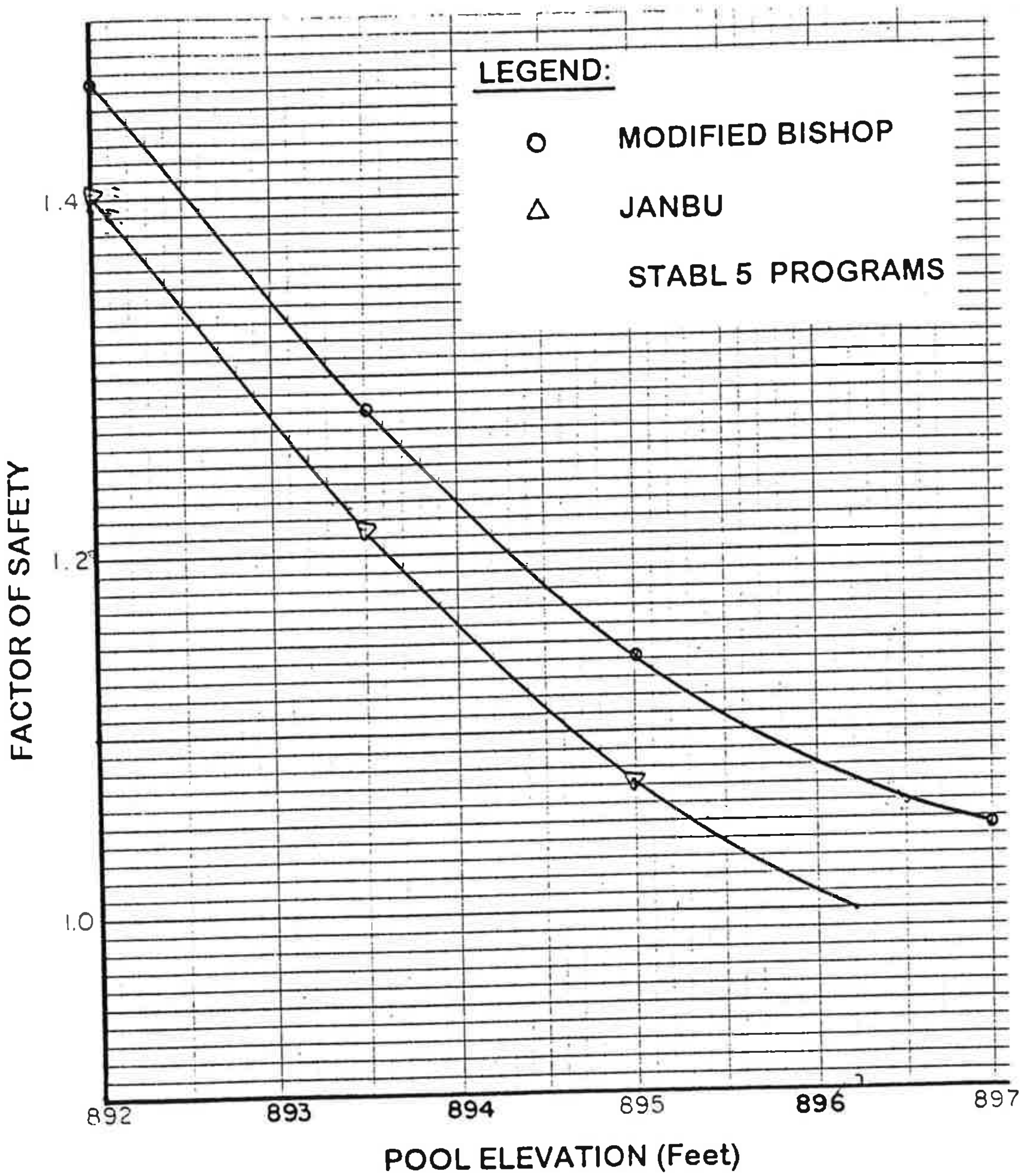
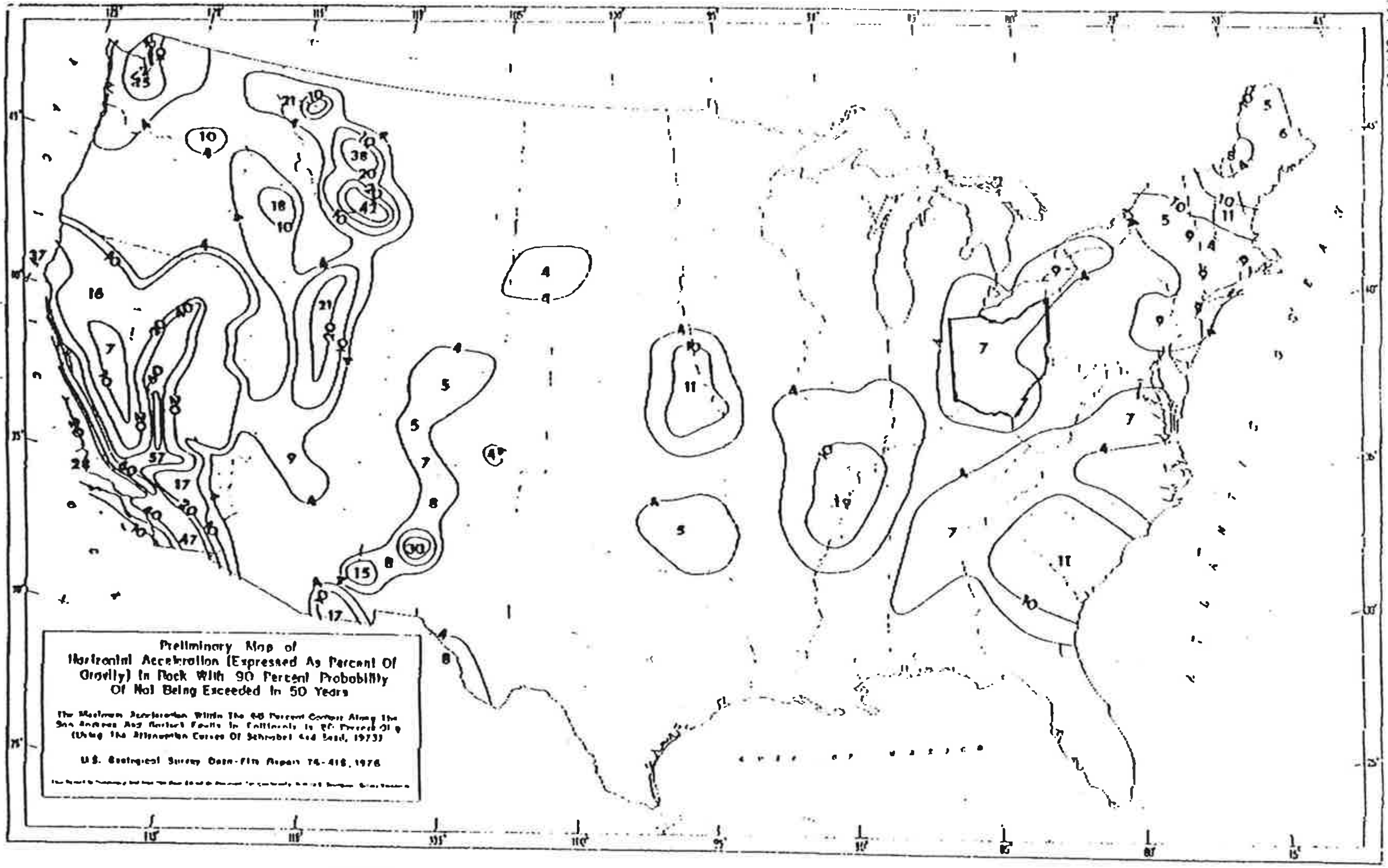

ELEVATION IN FEET (MSL)
900
890
880
870
860
850
60
50
40
30
20
10
0
10
20
DISTANCE FROM BASE LINE (FEET)
B-6
STONE WALL
THEORETICAL PHREATIC SURFACE
B-5
WALK
B-4
B·4A
DAM
APPROXIMATE ORIGINAL GROUND SURFACE
BUCKEYE LAKE
CROSS SECTION 4
STA. 142+75.50
Notes:
① PMF maximum pool, elevation: 897 feet
② Summer pool, elevation: 892 feet
③ 3/28/86 pool, elevation: 890.4 feet
Water level measurements in observation wells taken 3/28/86

FIGURE 3



CROSS SECTION 2
FACTOR OF SAFETY vs POOL ELEVATION

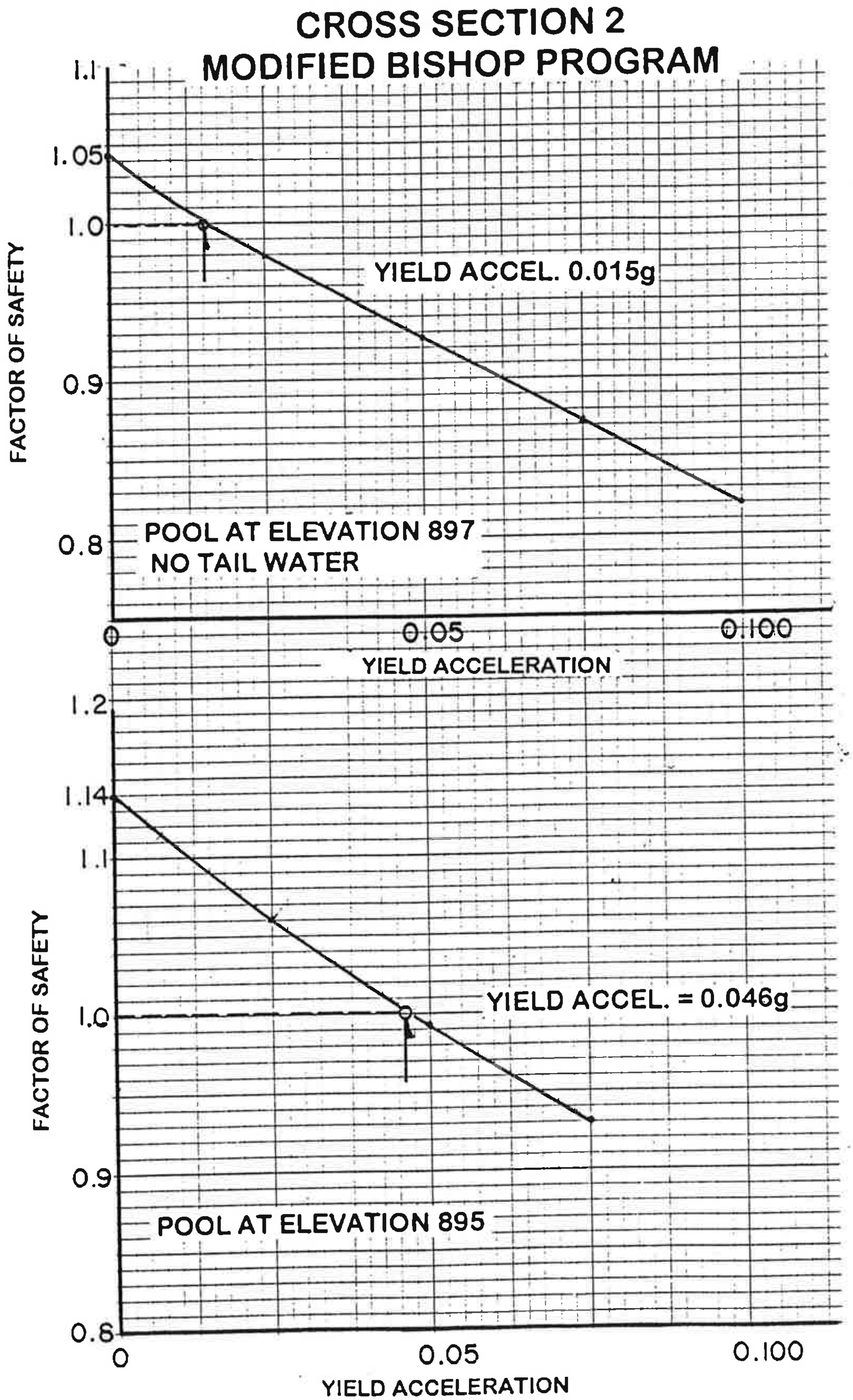
FIGURE 4



SEISMIC RISK DEVELOPED BY ALGERMISSEN AND PERKINS

FIGURE 5

HORIZONTAL ACCELERATIONS FOR 500-YEAR RETURN PERIOD



CROSS SECTION 2
MODIFIED BISHOP PROGRAM
1.1
1.05
1.0
0.9
0.8
FACTOR OF SAFETY
YIELD ACCEL. 0.015g
POOL AT ELEVATION 897
NO TAIL WATER
0
0.05
0.100
YIELD ACCELERATION
1.2
1.14
1.1
1.0
0.9
0.8
FACTOR OF SAFETY
YIELD ACCEL. = 0.046g
POOL AT ELEVATION 895
0
0.05
0.100
YIELD ACCELERATION

FIGURE 6

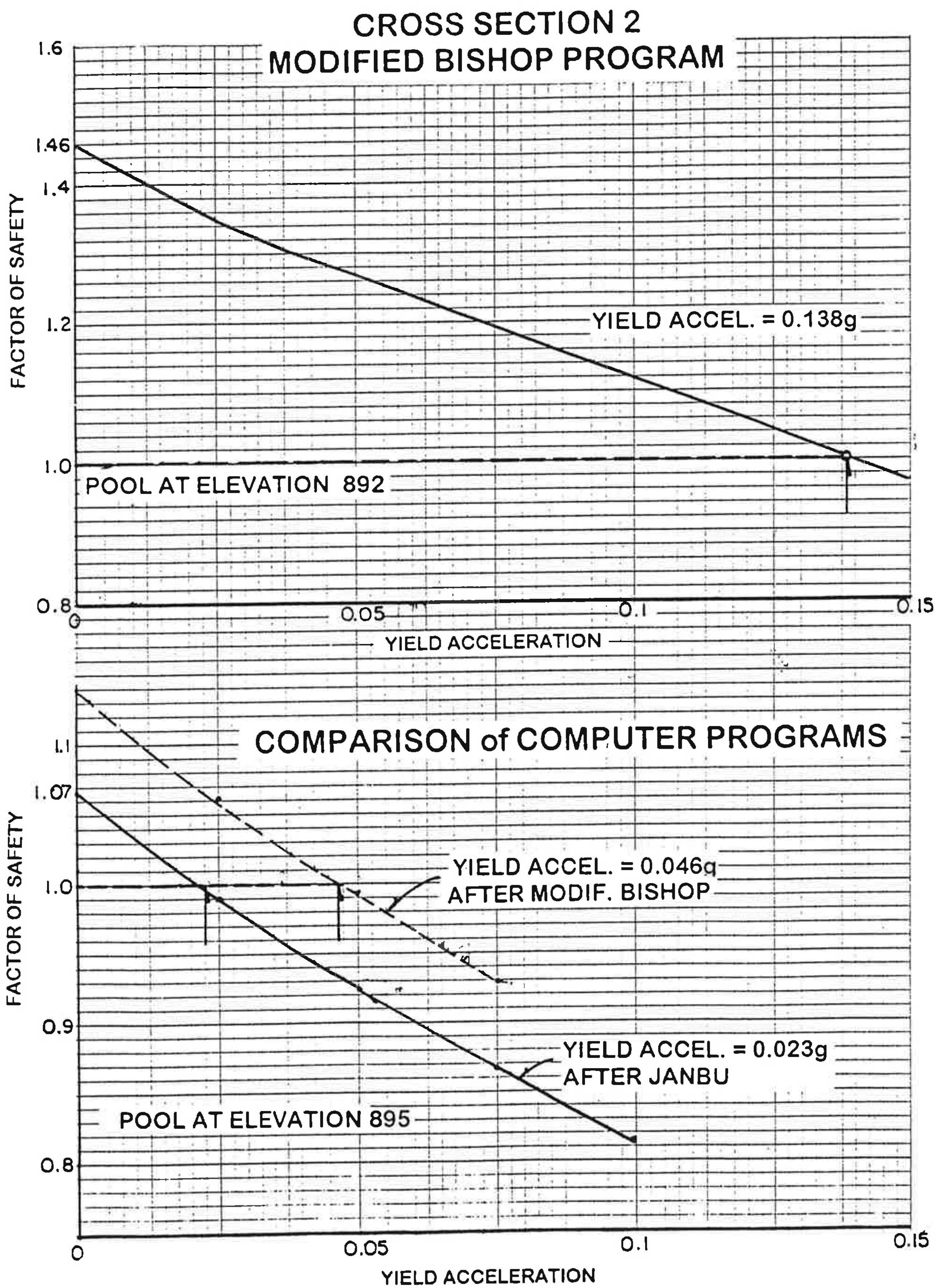

CROSS SECTION 2
MODIFIED BISHOP PROGRAM
FACTOR OF SAFETY
1.6
1.46
1.4
1.2
1.0
0.8
YIELD ACCEL. = 0.138g
POOL AT ELEVATION 892
0
0.05
0.1
0.15
YIELD ACCELERATION
COMPARISON of COMPUTER PROGRAMS
FACTOR OF SAFETY
1.1
1.07
1.0
0.9
0.8
YIELD ACCEL. = 0.046g
AFTER MODIF. BISHOP
YIELD ACCEL. = 0.023g
AFTER JANBU
POOL AT ELEVATION 895
0
0.05
0.1
0.15
YIELD ACCELERATION

FIGURE 7

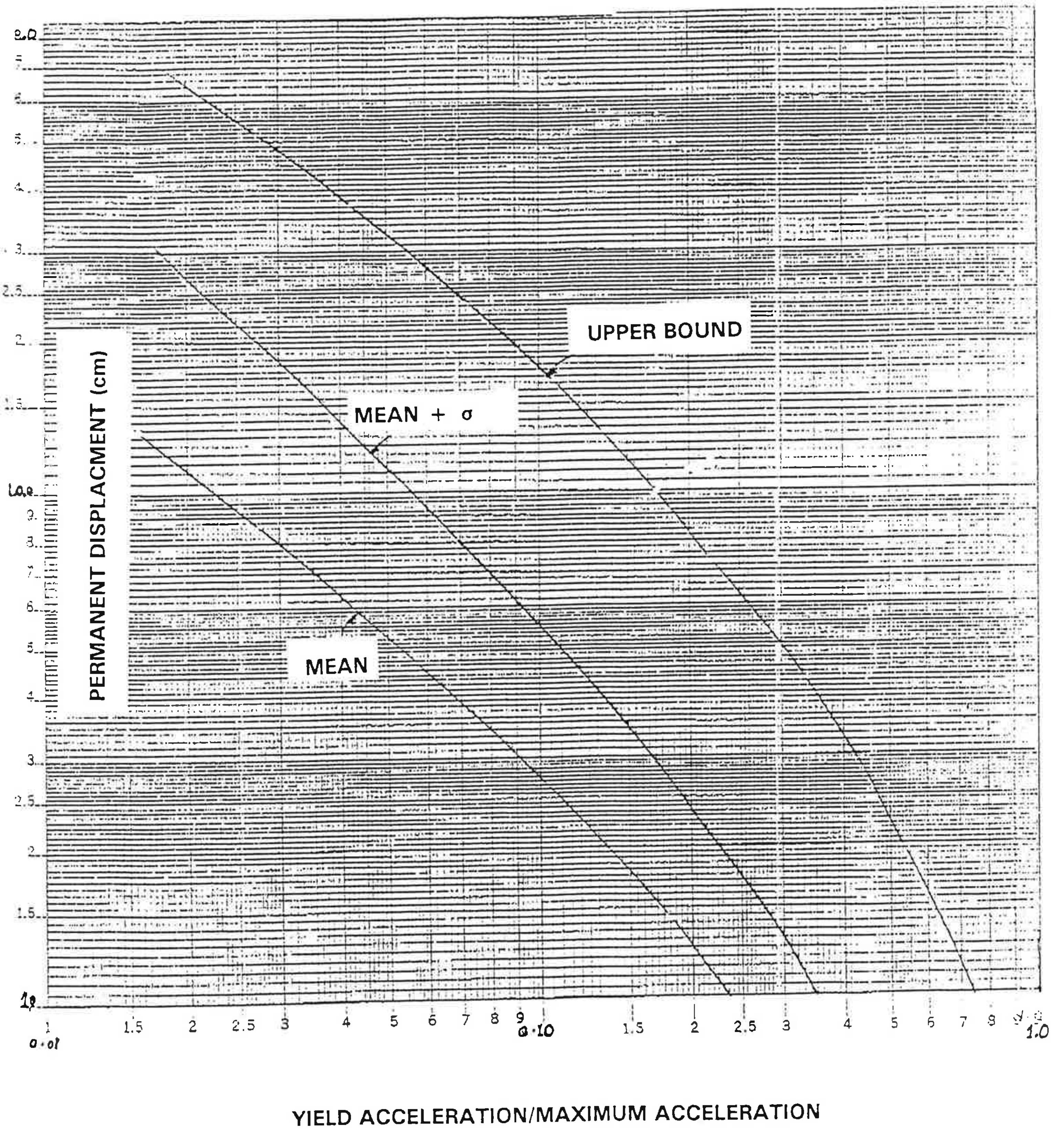


FIGURE 8

DISPLACEMENT OF EMBANKMENT
AFTER HYNES & FRANKLIN (1984)

TABLES

TABLE 1

SUMMARY OF BORINGS CONTAINING SANDS AND SILTS[1]

Boring No.	Embankment Depth (ft)	Sand Inclusions	
		Depth (ft)	Thickness (ft)
1	7.0	16.5 & 17.7 19.9 & 20.2	partings & seams partings & seams
2	9.1	—	—
2A	10.3	6.5 8.1	0.3 0.9
3	10.8	10.8	seams
4	9.0	15.6	seams
4A	7.2	—	—
5	10.0	—	—
6	4.0	11.5	partings[2]
7	3.0	13.5 & 15.0	partings or seams
8	9.6	—	—

[1]Depths not to exceed 20 ft.

[2]Silt inclusions

Table 2
Minimum Factors of Safety†

Case No.	Design Condition	Minimum Factor of Safety	Shear Strength	Remarks
I	End of construction	1.3††	Q or S‡	Upstream and downstream slopes
II	Sudden drawdown from maximum pool	1.0‡‡	R, S	Upstream slope only. Use composite envelope. See fig. 4
III	Sudden drawdown from spillway crest or top of gates	1.2‡‡	R, S	Upstream slope only. Use composite envelope. See fig. 4
IV	Partial pool with steady seepage	1.5	$\frac{R+S}{2}$ for $R < S$, S for $R > S$	Upstream slope only. Use intermediate envelope. See fig. 5
V	Steady seepage with maximum storage pool	1.5	$\frac{R+S}{2}$ for $R < S$, S for $R > S$	Downstream slope only. Use intermediate envelope. See fig. 5
VI	Steady seepage with surcharge pool	1.4	$\frac{R+S}{2}$ for $R < S$, S for $R > S$	Downstream slope only. Use intermediate envelope. See fig. 5
VII	Earthquake (Cases I, IV, and V with seismic loading)	1.0	§	Upstream and downstream slopes

† Not applicable to embankments on clay shale foundations.

†† For embankments over 50 ft high on relatively weak foundations use minimum factor of safety of 1.4.

‡ In zones where no excess pore water pressures are anticipated, use S strength.

‡‡ The safety factor should not be less than 1.5 when drawdown rate and pore water pressures developed from flow nets (Appendix III) are used in stability analyses.

§ Use shear strength for case analyzed without earthquake except that it is not necessary to analyze sudden drawdown for earthquake effects.

TABLE 3
SLOPE STABILITY ANALYSES

POOL ELEVATION (ft)	FACTOR OF SAFETY	
	DLA	WSGA
CROSS SECTION NO. 2		
892	[1.35]	(1.46) [1.39]
895	[1.03]	(1.14) [1.07]
897	—	(1.05) —
897	[1.10]*	(1.17) [1.13]
CROSS SECTION NO. 3		
892	[1.82]	(1.68)
895	[1.68]	(1.58)
897	[1.60]	(1.54) [1.77]
CROSS SECTION NO. 4		
892	[1.79]	(1.55)
895	[1.57]	(1.36)
897	[1.29]	(1.73) [1.39]

* Includes tail-water to elevation 890

( ) Computer programs by Bishop and Morganstern, "Stability Coefficients of Earth Slopes," Geotechnique, Vol. 10, 1960.

[ ] Janbu, "Slope Stability Computations," Embankment Dam Engineering, 1973, John Wiley and Sons, NY.

TABLE 4 — EMBANKMENT DISPLACEMENT ESTIMATES

Pool Elev.	k_y (q)	k_s (g)	k_y/k_s	Displacement (cm)
897	0.015	0.10	0.15	34
895	0.023*	0.10	0.23	19
895	0.046	0.10	0.46	6.5
892	0.138	0.10	>1	—

*k_y derived for Janbu analysis

W. S. Gardner and Associates
Consultants in Geo–Engineering

September 29, 1995
95J031

Buckeye Lake Association
P.O. Box 952
Buckeye Lake, OH 43008

Attention: Mr. Wayne Radcliff

Gentlemen:

Enclosed are two copies of the final report for the Buckeye Lake Dam. As indicated, the dam hydrology had only a cursory overview. Should a detailed study be beneficial, we would be pleased to conduct such a study.

Should there be any questions concerning this report, please call at your convenience. We appreciate the opportunity to have worked with you and trust that our work will influence the State to provide a truly stable dam.

Very truly yours,

W.S. GARDNER AND ASSOCIATES

W S Gardner

William S. Gardner, P.E.

Enclosures

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ENVIRONMENTAL EDUCATION ENTERPRISES, INC.

RAISING EDUCATION TO A HIGHER POWER FOR THE ENVIRONMENT

August 28, 1995

The Honorable Nancy Chiles Dix
State House
Columbus, Ohio 43266-0604

Dear Senator Dix,

I am a Hydrologist living in Columbus for the past 30 years with a career spanning 40 years of professional effort. While I am not involved in any local projects, as an interested citizen I follow most of what the state does in my area of expertise. Recently I have become quite concerned over some intended foolish activity by ODNR regarding Buckeye Lake.

Various reports I have read indicate that they plan to raise the dam enough to protect down stream citizens from a potential rainfall of 23 inches in 6 hours and concurrently cut down 500 large trees to insure that they are never blown down creating holes behind the dam.

Both of these ideas are absurd by any reasonable hydrologic standards and would be deemed so by any professional hydrologist not being paid by the state.

The record rainfall in Ohio is less than 11 inches in 24 hours. To design a structure for a rainfall twice as great in one quarter of the time is ridiculous by any standard of good engineering practice. Certainly the dam is old and can use some shoring up and a good on going maintenance program but lets not spend 10 million of state dollars so foolishly. In fact if and when the dam were to be raised the prescribed 2.5 feet I guarantee you the total cost will far exceed the 10 million current estimate.

The spill way built to preserve the dam only a few years ago can currently handle any rainfall that has ever been experienced in this area of Ohio. The citizens of this state can not afford to protect them selves from infinitesimal risks when there are so many more worthy causes for public funds.

The cutting down of 500 large trees is equally absurd. The odds on these trees blowing down in a storm and causing damage to the dam is remote considering that it has not happened in the long history of the dam. However

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if the trees are cut down and the roots not removed as is the current plan you can count on the roots rotting and creating voids into which water can channel and weaken the dam thus creating exactly the situation ODNR wants to avoid. Logic would tell any reasonable person not to mess with nature by cutting down 500 large trees in hope of avoiding a wind storm problem. The unforeseen side effects of such an action are always worse than the scenario feared to begin with.

I have no idea what motives ODNR would have to plan such a costly and foolish activity but I believe you would get the same reaction from any experienced local hydrologist. In case you doubt me I have listed a number of local experts none of whom have I discussed this issue with. Give them a call and ask them about 23 inches of rain in 6 hours, or pulling out 500 mature trees from a earthen dam and see what they say. They will probably think you were kidding, and that some one put you up to making prank call.

Since you do not know me I have included a brief and not so brief biographical sketch and a review of my most recent book, RATIONAL READINGS ON ENVIRONMENTAL CONCERNS.

Sincerely,

Jay Lehr, Ph.D.,
Senior Scientist

OTHER HYDROLOGISTS

Truman Bennett
Bennett & Williams
882-9122

Larry Graves
Geraghty & Miller
764-2310

Neil Drobny
ERM
538-1700

Herb Eagon
EAGON & Assoc
888-5760

John French
Hydro Group
800-887-9923

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WILLIAM S. GARDNER

program/project management
geotechnical engineering
civil engineering
research and development

EDUCATION

Columbia University: M.S., Civil Engineering (Geotechnical Engineering)
University of Pennsylvania: B.S., Civil Engineering
University of Michigan: Post Graduate Engineering Studies
Drexel Institute of Technology: Post Graduate Engineering Studies

REGISTRATION

Professional Engineer: Pennsylvania and New Jersey

PROFESSIONAL HISTORY

W.S. Gardner and Associates, President, 1992; Woodward-Clyde Consultants, Chairman of the Board, 1988-1990; Principal and Executive Vice President - Practice, 1975-1991; Woodward-Gardner Associates, President, 1970-1975; Principal and Executive Vice President, Philadelphia, Pennsylvania, office, 1959-1970; Greer Engineering Associates, Senior Project Engineer, 1956-1959; U.S. Army Corps of Engineers, North Pacific Division, Soil and Foundation Engineer, 1953-1955.

REPRESENTATIVE EXPERIENCE

With over 38 years of applied geotechnical and civil engineering practice, Mr. Gardner has been directly concerned with a great variety of projects throughout the United States and abroad. During this time he has directed hundreds of geotechnical studies concerned with the design and construction of power plants, dams, water supply systems, infrastructure remediation, air and ground transportation systems, industrial and commercial facilities, major buildings, rock and earth slopes, embankments, and offshore facilities.

Specifically, Mr. Gardner has been responsible for geotechnical investigations, design, and construction activities on several fossil and nuclear power plant projects in the U.S. and abroad. Typical projects include: Crystal River Nuclear Power Station, Unit 3 (Florida), James H. Campbell Power Plant (Michigan), Perry and Erie Nuclear Power Plants (Ohio), Virgil C. Summer Nuclear Power Station (South Carolina), Mazandaran Thermal Power Station (Iran), and the Songgong Nuclear Power Plant (Korea). Examples of his experience in the geotechnical aspects of transportation and offshore systems include the City of Philadelphia subway extension, New Jersey Turnpike widening (general soil consultant), steel mill and port facilities (Los Truchas, Mexico), offshore petroleum production facilities (Gulf of Cadiz, Spain), the North Rankin Gas Platform (Australia) and long-span highway bridges crossing the Mississippi and the Delaware Rivers.

His work in water and waste impoundment structures involve both investigation and design assignments. Representative projects involving design and construction include geotechnical design for a major landfill, three seismic-safety rated earth dams (V.C. Summer Nuclear

Power Station), a rock-fill water supply dam (Tegucigalpa, Honduras) and a major tailing dam (Schuichang, China). Mr. Gardner was also responsible for the safety assessment of over 70 dams during the Federal Phase I Dam Safety Program.

Mr. Gardner has received recognition for his work in deep foundations, is a co-author of the books, Drilled Pier Foundations and Drilled Pier Construction, and under the auspices of the ASCE, has chaired the development of standards for pile foundations. In this regard, he has been responsible for the design and remediation of numerous building foundations and related facilities including high-rise structures and structures located in potentially hazardous terrains.

AFFILIATIONS

American Society of Civil Engineers
Pennsylvania Society of Professional Engineers
International Society of Soil Mechanics and Foundation Engineering
Consulting Engineers Council

REPRESENTATIVE PUBLICATIONS

Subsidence at bridge approaches. Public Works Magazine, November, 1960.

Stress-strain behavior of granular soils in one-dimension compression. ASCE Preprint No. 325, Structural Engineers Conference, Miami, Florida, 1966.

Construction in Appalachian shales. West Virginia University Conference on Engineering in Appalachian Shales, June 1969.

Grading, drainage and erosion control ordinance. Prince Georges County, Maryland, 1970.

Analysis of load-bearing fills over soft subsoils (with J.K. Mitchell). Journal of SM & FE, ASCE, Vol. 97, SM-11, November 1971.

Drilled pier foundations (with R.J. Woodward and D.M. Greer). McGraw-Hill Book Company, 1972.

Considerations in the design of drilled piers. Proc. Analysis and Design of Building Foundations, Envo Publishing Company, 1976.

Soil property characterization in geotechnical engineering practice. Woodward Lecture, Woodward-Clyde Consultants, San Francisco, California, 1977.

Post cyclic loading behavior of soft clays (with R.D. Singh and R. Dobry). Second International Conference on Microzonation, San Francisco, California, December 1978.

Characterization of dynamic properties of Gulf of Alaska clays (with R. D. Singh). Presented at ASCE Convention at Boston, Massachusetts, April 1979.

Study to investigate the effects of skin friction on the performance of drilled shafts in cohesive soils. U.S. Army Waterways Experiment Station, Contract No. DACA 39-80-C-0001.

The suitcase cone system (with S.V. Nathan). Cone Penetration Testing and Experience, Proc. of the Geotechnical Engineering Div., ASCE National Convention at St. Louis, Missouri, Oct. 1981.

Geotechnical Engineering. Ch. 7.0, Standard Handbook for Civil Engineers, Third Edition, F.S. Merritt, Editor, McGraw-Hill Book Company, 1982.

The proposed ASCE standard on pile foundations (with M.T. Davisson, F.M. Fuller, and F.Y. Yokel). Presented at ASCE Convention in Atlanta, Georgia, May 14-18, 1984.

Pile design for highway bridges, current practice--an overview. Proceedings of the National Bridge Conference, Pittsburgh, PA, 1983.

Construction of drilled pier foundations (with D. M. Greer). John Wiley & Sons, 1986.

Design of drilled piers in the Atlantic Piedmont. Proceedings of Foundations and Excavations in Decomposed Rock of the Piedmont Province, GT Div., ASCE, Atlantic City Conference, April 28, 1987.

Interaction of geology, construction practice and foundation design (theme lecture). Proceedings of the Foundation Engineering Congress, ASCE, Evanston, IL, 1989.

Present to future design considerations of deep foundations. Proceedings of 16th Annual Members Conference, Deep Foundations Institute, Chicago, IL, 1991.

AWARDS AND APPOINTMENTS

Middlebrooks Award, ASCE (1972).
Woodward Lecture (1977).
Geotechnical Engineer of the Year, Philadelphia Section, ASCE (1988).
Geotechnical Board - Member, National Research Council (1991-93).

EXAMPLES OF REPRESENTATIVE DAM PROJECTS CONDUCTED BY WSGA STAFF

V.C. Summer Dams; Fairfield County, South Carolina
South Carolina Electric and Gas Company

Eighty- and one hundred twenty-ft. high earth dams were designed for a nuclear power plant. The dams were designed for the maximum probable earthquake within the seismotectonic province containing the site. The construction of the dams' embankments were supervised and the specifications verified.

Tegucigalpa Dam; Honduras, C.A.
Rockfill Dam for Water Supply for the City of Tegucigalpa

A 170-ft. rock fill dam was designed and the embankment construction supervised. Fracture zones were grouted to stop excessive water flows.

Schuichang Dam; Hobei Province, Peoples Republic of China
Tailings Dam for Iron Ore Processing

The proposed tailings dam was designed to accommodate a height of 350 ft. in a high seismic zone. Special design studies were conducted to determine the Design Basis Earthquake of 0.30 g.

Trout Run Dam; Boyertown, Pennsylvania
Boyertown Water Supply Dam

The 104-ft. earth dam was inspected as a result of seepage on the dam face and loss of water beneath the dam and around its abutments. A detailed assessment of the dam was conducted and recommendations made to remediate the dam.

National Dam Inspection Program
U.S. Corps of Engineers, Baltimore District

More than 50 safety inspections have been made under the direction of W.S. Gardner. These studies, conducted for the U.S. Corps of Engineers, provide dam safety analyses including recommendations for dam remediations, where appropriate.

Background Information on E^3' Senior Scientist

Jay Lehr received the nation's first Ph.D. in Ground Water Hydrology from the University of Arizona in 1962. This followed a degree in Geological Engineering from Princeton University, a brief stint with the U.S. Geological Survey and several years with the U.S Navy's Civil Engineering Corps. After graduate school he taught at the University of Arizona and The Ohio State University before becoming Executive Director of the National Ground Water Association and The Association of Ground Water Scientists and Engineers for 25 years. Dr. Lehr served as Editor of the Journal of Ground Water for 27 years, Co-editor of Ground Water Monitoring Review for 11 years and Editor of the Water Well Journal for 24 years.

Dr. Lehr has published 10 books on ground water hydrology and more than 350 journal articles. He has testified before Congress on more than three dozen occasions, consulted with nearly every agency of the federal government as well as many foreign countries on every continent.

Lehr is an outspoken proponent of sane environmental regulation that does not overly distort problems to the economic detriment of society. His newest book on this subject **Rational Readings on Environmental Concerns** was published in 1992 by Van Nostrand Reinhold and is now in its third printing.

Lehr is also well known for his athletic prowess having completed the Hawaiian Ironman Triathlon Championship in Kona 9 consecutive years. He has 950 skydives to his credit, and plays defense on a top amateur ice hockey team in Columbus, Ohio. His recent book on fitness, entitled Fit, Firm and 50 has been well received.

Lehr is the founder of Environmental Education Enterprises, which is now a Times Mirror company, where he serves as Senior Scientist.

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Nancy Chiles Dix
State Senator
31st District

Senate Building
Columbus, Ohio 43215
614/466-5838

Committees:
Energy, Natural Resources and Environment
Vice Chairman
Financial Institutions, Insurance and Commerce
Highways and Transportation
Agriculture

September 11, 1995

Donald C. Anderson, Director
Department of Natural Resources
Fountain Square
Columbus, Ohio 43224-1387

Dear Director Anderson:

I am writing this to you in order to request an immediate, temporary delay in the Buckeye Lake Dam Project Phase III because of new information from legitimate and qualified sources which has surfaced. We all seem to agree that Buckeye Lake needs a Phase III project, but there is heated disagreement about the extent of the work required.

First is a concern about a potential 23 inches of rainfall in six hours. Local meteorologist Jym Ganahl and Dr. Jay Lehr, a nationally recognized hydrologist, have told me that this amount of rain is not probable nor possible. The 23 inch rainfall in six hour assumption needs to be more fully explored.

Second, Pennsylvania geo-engineer, Dr. W.S. Gardner, who was engaged by Buckeye Lake area people, disagrees with the plan of elevating the steel wall. He claims that elevating the steel wall will cause more danger of piping instead of ensuring the project's safety. Dr. Gardner has also expressed concerns with dam stability in view of seismic occurrence possibility. A detailed report is expected from him in the next two weeks.

Third, the tree removal - a point of emotional frustration among many lake residents - has been disputed by ODNR's Division of Forestry which has disagreed with the plan. Additionally, experts from Dawes Arboratum and qualified hydrologists also dispute the tree removal portion of the Phase III plan. In fact, when some members of your staff told me that previous reports of Phase III did not include removing the trees because of COST - NOT SAFETY - I realized that the tree removal issue is one which should *be aired completely. The proposed construction will kill most of the trees and there is much dispute over this causing or preventing dam failure.*

Fourth, there is considerable misunderstanding, indeed misinformation, about the reasons for the project in the first place. For example, the spillway is for a Class II dam, yet Buckeye Lake should be a Class I. There is a reference to the dam as being unsafe; yet the Dodson Lindblom report in 1988 states the dam is safe. There is a reference to the Ohio Dam Safety Act, yet concerned citizens cannot locate the Ohio Dam Safety Act. There are other examples. The point being, Buckeye Lake area people cannot verify the information they have been given by the Department.

Director Anderson, I know your Department has attempted to create a project that will ensure the safety for all in the Buckeye Lake region. Not withstanding, the Phase III project as currently construed is either misunderstood or possibly over designed. But in any event, an immediate and temporary delay would allow time to review it and perhaps modify it with alternatives more acceptable and more cost efficient and equally as safe.

The rebirth of Jonathan Creek in Perry County as a flood spillway is an alternative many think might work well. I have personally talked to Licking County Commissioners who do NOT want more water. I have talked with Perry County Commissioners who do want more water in the northern part of Perry County. I have talked to landowners along Jonathan Creek who are supportive if the creek were cleaned out and straightened. I have discussed this with U.S. Senator Mike DeWine and Congressman Bob Ney and they are committed to help in getting Federal assistance. I hope this option will be explored in more detail.

Again, in view of all of the information which developed, I respectfully request a postponement of the current Phase III project.

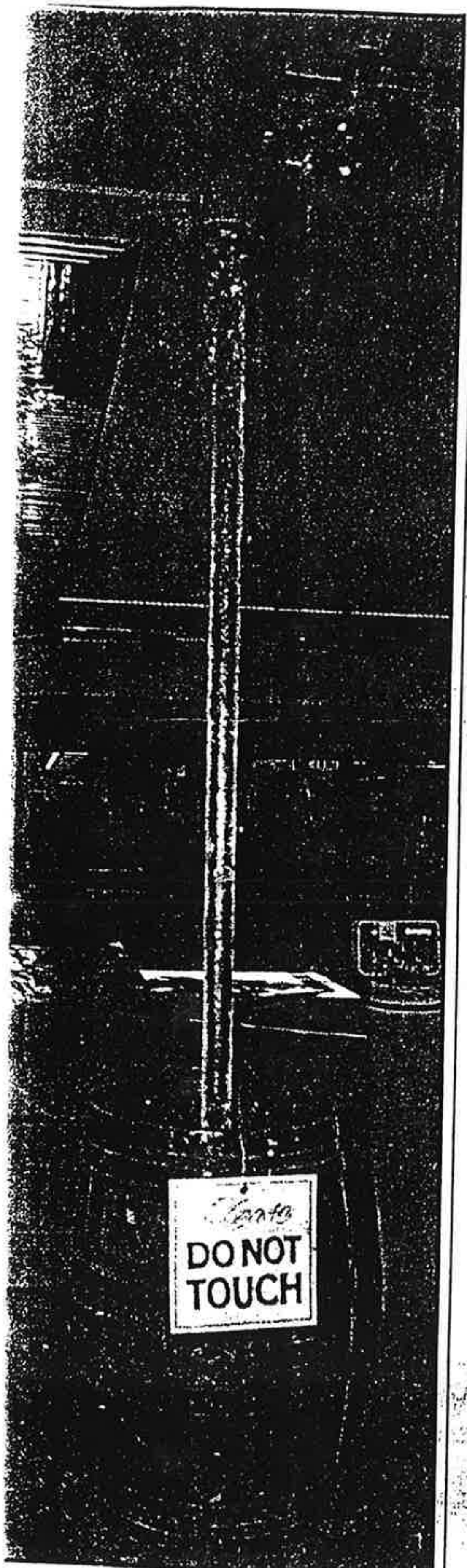
I believe more research is needed and a full airing of the Phase III status is required to bring greater understanding of all of the issues. I pledge to help in this with the goal of a solution that will ensure safety to everyone in the Buckeye Lake region.

Thank you,

Nancy Dix

Nancy Chiles Dix

NCD/lln
enclosures (Dr. Lehr letter & resume, Dr. Gardner letter & resume)



...ditioning checks to see if his 'Mystery Foun-... the Fall Home and Garden show at the Indian... The Home and Garden show will run through ...)

Dix wants dam project put on hold

Lawmaker asks state to rethink modifications

By JEFF BRUMLEY
Advocate Reporter

COLUMBUS — An geo-engineer's opinion that planned modifications to the Buckeye Lake dam contain "a significant risk of failure" has prompted State Sen. Nancy Chiles Dix, R-Hebron, to ask for a delay in the project.

"I'm asking ODNR to revisit the issue. . .before we head on down the path and spend a lot of money," Dix told *The Advocate* Thursday.

DIX

In a Sept. 11 letter to Donald Anderson, director of the Ohio Department of Natural Resources, Dix asked the agency for an "immediate, temporary delay in the Buckeye Lake Dam Project Phase III because of new information from legitimate and qualified sources that has surfaced."

One of those sources is Williams S. Gardner, a Pennsylvania-based geo-engineer who was hired last month by the Save the Lake Committee in Buckeye Lake to study ODNR's plans. He will release a full report Sept. 18.

Gardner issued a preliminary report Sept. 8 stating his opinion the planned modifications are prone "to a significant risk of failure" if the dam is raised to accommodate maximum flood conditions.

Another weakness in the state's plans is their failure to account for "the added risk of seismic occurrences," Gardner wrote.

Dix cited Gardner's concerns in her letter to ODNR.

"What I have asked them to do is postpone the bidding process, and let's take a look at the project in its entirety," Dix said.

The agency has not responded to the letter.

"I feel we really need to communicate with Sen. Dix, but first we need a little time in the department to discuss the letter," said Michele Willis, chief of ODNR's Division of Water. She

■ ALTERNATIVE PLAN/1B

said the response must be coordinated between the director's office and the divisions of engineering, parks and recreation and water.

The senator's action comes as amidst increasing opposition and vocal criticism of the dam improvements project, which ODNR predicts will cost between $4.5 million and $6.5 million.

The loudest voice has been that of the Save the Lake Committee, a group of Buckeye Lake area residents opposed to several aspects of the plan, especially its call for the removal of trees and docks to facilitate construction. The group has argued that the state's plans will make the dam more unsafe and will not alleviate flooding along the South Fork of the Licking River.

Last month the committee hired Gardner to study the Phase III plans, which deem the dam unsafe and in need of improvements that include the raising of the north and west walls of the dam more than 20 inches in some places to increase storage capacity.

And criticism is surfacing elsewhere.

A Columbus hydrologist, sent a letter to Dix calling Phase III "absurd by any reasonable hydrologic standards. . . ."

In her letter, Dix adds that ODNR's Division of Forestry disagrees with the plan and she criticizes the agency for the "considerable misunderstanding, indeed misinformation, about the reasons for the project in the first place."

Dix said engineering concerns and the numerous phone calls and letters she receives for and against the project warrant reevaluating Phase III.

"We are all in agreement that we need to do some more work on Buckeye Lake to insure safety," Dix said.

"I am hoping ODNR is willing" to delay the project to study alternatives "that satisfy everyone's concerns."

Willis said she could not determine if ODNR will agree to Dix's request.

"We're more than willing to meet with the engineer. . .to explain what our design criteria are and answer any questions."

Getting creative

Balloon artist and floral designer Signe ... Schaal sets up a balloon display ... a storefront she is renting at the ... Mal ... on displays ranging from her specialty of wedding receptions, corporate events and theme parties. The public is invited to see the diplays through Oct. 10. *(Jeff Groves, The Advocate)*

September 15, 1995 B1

Householder has another plan

By JEFF BRUMLEY
Advocate Reporter

NEW LEXINGTON — Perry County Commissioner Larry Householder claims to have a "win-win" solution to the controversy generated by Phase III of the state's Buckeye Lake dam safety improvement project.

Householder wants the Ohio Department of Natural Resources to scrap plans to raise the dam's walls, a move designed to increase the lake's holding capacity.

Then he wants the agency to reopen an outlet in Thornport that connects the lake to Jonathan Creek.

"My challenge (to ODNR) is to step back and take a good look at this," Householder said Thursday.

Using the creek as a spillway will send less water into the South Fork of the Licking River and more into Perry County, which has a sewer project on the creek that needs more water to be effective, Householder explained.

"We need more water," he said.

However, that course of action would require improvements to Jonathan Creek, which Householder described as "snake-like with logjams" that contribute to flooding that annually inundates the Village of Glenford and erodes valuable topsoil.

The creek was used as an outlet from Buckeye Lake from the 1930s to the 1950s. It was discontinued because it contributed to flooding, Householder said.

"I would like to see the creek cleared and straightened," a measure Householder said would end the perpetual flooding of Jonathan Creek.

The Perry County commissioners Thursday took that position, passing a resolution requesting ODNR consider the Jonathan Creek solution.

The agency already looked at that alternative, said Michele Willis, chief ODNR's Division of Water.

"It was evaluated and dismissed in 1987," she said.

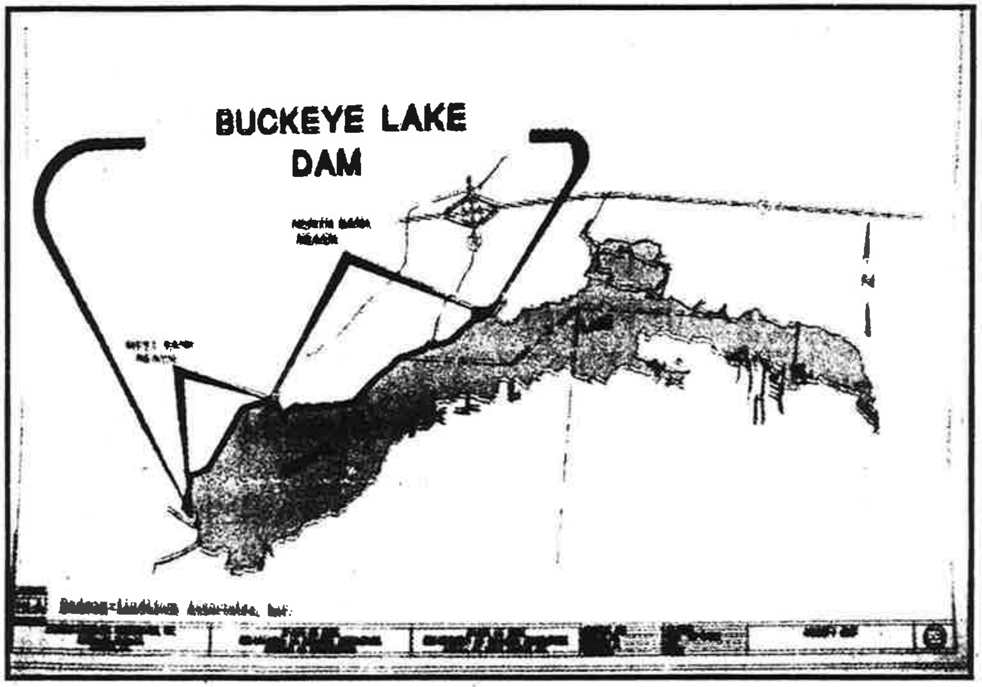
The creek would not have "sufficient discharge capacity. . .without a considerable expense."

Also, the creek crosses an area already used for drainage, meaning the discharge from Buckeye Lake "would change a natural drainage pattern."

State Sen. Nancy Chiles Dix, R-Hebron, is intrigued by the Jonathan Creek idea, however, and has acquired assurances from Rep. Bob Ney, R-St. Clairsville, and Sen. Mike DeWine that they would help find federal assistance for the project.

Dix sent ODNR a letter this week asking ODNR to consider "the rebirth" of the creek as a flood spillway. In the letter, she said land owners along the creek are supportive of the idea if the creek is "cleaned out and straightened."

Willis said effecting those improvements "would be more costly" than the current Phase III plan, which is estimated to run between \$4.5 million and \$6.5 million.



Phase III of the state's Buckeye Lake dam improvements project, as planned, will require the cutting down of all trees along north bank and the removal of all docks and patios along both north and west banks. According to the Ohio Department of Natural Resources, the project will raise the walls in order to increase the lake's water holding capacity.

County residents ready to celebrate anniversary of Constitution's signing

By LARRY FUGATE
Advocate Reporter

NEWARK — It has become the unof- ... commemorate the Constitution's anniversary in their Sunday worship bulletins and by ringing their bells at 4 p.m. Sept. 17 ... displays and local schools will have skits and student writings commemorating the Constitution.

"Today we watch as people through-

Water still contaminated

By Thomson News Service

LANCASTER — Surface water contamination continues to show up in test results at the closed