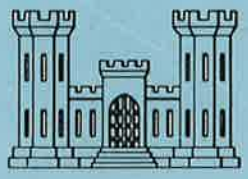
BUCKEYE LAKE DAM
LICKING, FAIRFIELD AND
PERRY COUNTIES, OHIO
FEDERAL INVENTORY NUMBER OH-474
STATE FILE NUMBER 9723-004

PREPARED BY
GAI CONSULTANTS, INC.

JULY 1978

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM



U.S. ARMY ENGINEER DISTRICT, PITTSBURGH
CORPS OF ENGINEERS
PITTSBURGH, PENNSYLVANIA

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NATIONAL PROGRAM OF INSPECTION OF NON-FEDERAL DAMS

BUCKEYE LAKE DAM

OH-474

OHIO FILE NUMBER-9723-004

The findings of this Phase I inspection report on Buckeye Lake Dam, Licking, Fairfield and Perry County, Ohio, indicate that the spillway is seriously inadequate. This dam is accordingly considered unsafe (non-emergency) until more detailed studies prove otherwise or corrective measures are completed.

JOSEPH A. YORE
Colonel, Corps of Engineers
District Engineer, Pittsburgh

Date: 5 December 1978

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
BUCKEYE LAKE DAM, NDI# OH-474, ODNR# 9723-004

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PHASE I INSPECTION REPORT
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ABSTRACT

Buckeye Lake Dam:

Federal Inventory Number: OH-474
State File Number: 9723-004
State Located: Ohio
County Located: Licking, Fairfield, and Perry
River Basin: Muskingum River
Stream: Tributary of South Fork Licking River
Date of Inspection: July 7 and 8, 1978

Buckeye Lake Dam is an earth embankment approximately 4.1 miles in length with a maximum hydraulic height of 14.5 feet and a maximum structural height of 13 feet. A combination drop spillway and gated outlet works structure is located on the north shore of the lake 3,000 feet west of the town of Buckeye Lake. The dam includes either a steel sheetpile or stone masonry shore protection wall. A continuous series of residences is located along the crest and downstream slope of the embankment.

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.

Inspection of Buckeye Lake Dam revealed that the overall condition of the facility is poor and that it is potentially unsafe. Potential serious problems include:

1. A seriously inadequate spillway system;

2. Seepage through the embankment;

3. Instability of the shore protection wall;

4. Holes and low spots on the crest.

The maintenance and operation of the dam is hindered by the presence of residences on the dam and the growth of large trees on the crest and downstream slope. Because of these conditions, it is recommended that the owner take the following immediate actions:

a. Retain a qualified engineer experienced in the design of earth dams and hydraulic structures to conduct the additional investigations needed to evaluate the structural integrity of the facility, to design a new spillway such that the facility can pass the peak flow from the Probable

Maximum Flood (PMF), and to investigate, evaluate, and design corresponding improvements required to enable the downstream channel and the South Fork Licking River to accommodate much larger flows than can be presently accommodated to minimize the potential for downstream property damage and loss of life.

b. Develop and implement a formal written operational procedure involving the daily regulation of the lake water level and actions to be taken during potential flooding; e.g., a formal warning and evacuation plan for downstream residents to include the towns of Buckeye Lake, Lakeside, Hebron, and Newark (primarily low lying areas near the river) in case emergency embankment and/or flooding conditions develop.

c. Locate and document seepage, holes and low spots in the crest of the dam as well as shore protection wall movements (may be done through a property owner survey; each problem should be investigated, the cause determined, and corresponding remedial measures implemented).

d. Have the facility regularly inspected to assure detection of potentially unsafe conditions if and when they develop. Unsafe conditions should be remedied when discovered.

e. Install a continuously recording water level gage, at least until the remedial measures are implemented (this will provide useful data for redesign and also during high flow periods).

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Date October 25, 1978

Approved by:

JOSEPH A. YORE
Colonel, Corps of Engineers
District Engineer, Pittsburgh

Date 5 December 1978

BUCKEYE LAKE DAM
NDI# OH-474
ODNR# 9723-004

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
BUCKEYE LAKE DAM, NDI# OH-474, ODNR# 9723-004

SECTION 1 - GENERAL

1.1 Authority: PL 92-367 "The 1972 Dam Inspection Act".

1.2 Purpose of Inspection: To perform a Phase I technical inspection and evaluation of a non-Federal dam to identify conditions which threaten the public safety.

1.3 Past Inspection:

a. March 14 and 15, 1939, by U. S. Engineer Office, Huntington, West Virginia (Corps of Engineers) - did flood routing and commented on leaks, etc.

b. May 28, 1968, observations during flooding and near overtopping, by Ohio Department of Natural Resources (ODNR) Division of Water.

c. 1972 and 1975 by ODNR Division of Engineering to determine areas needing sheetpiling.

SECTION 2 - PROJECT DESCRIPTION

2.1 Location: Buckeye Lake is located in Licking, Fairfield and Perry Counties, Ohio (see Location Maps in Appendix D). The towns of Millersport, Buckeye Lake, Fairfield Beach and several smaller towns are located on the shores of Buckeye Lake. The lake is fed by several small creeks and a feeder canal which enters the lake on the west side near Millersport. The lake outlets into the South Fork Licking River.

2.2 Description and Appurtenances:

2.2.1 Description -

Buckeye Lake Dam is an earth embankment approximately 4.1 miles in length with a maximum hydraulic height of 14.5 feet and a maximum structural height of 13 feet. A combination drop spillway and gated outlet works structure is located on the north shore of the lake 3,000 feet west of the town of Buckeye Lake.

2.2.2 Size Classification - INTERMEDIATE

Storage is approximately 11,200 acre-feet at normal pool elevation 892.5 (crest elevation of drop spillway), with a pool area of about 2,800 acres. The pool elevation corresponding to the effective top of the dam (elevation 894.4) provides storage of about 18,488 acre-feet and a pool area of about 3,030 acres. The hydraulic height of the dam is 14.5 feet. On the basis of storage, the dam size classification is intermediate.

2.2.3 Hazard Classification - HIGH

The hazard classification for this dam is high. This hazard rating is based on the judgment that dwellings in the towns of Buckeye Lake and Lakeside which are adjacent to the lake and the towns of Hebron and Newark which are downstream along the South Fork Licking River may be damaged with possible loss of life due to failure of the dam. In addition, the State of Ohio has sold essentially the downstream face of the dam, and houses exist virtually side-by-side along the entire length. It is estimated that up to 5,000 persons may be affected, with possible loss of life, if Buckeye Lake Dam should fail, particularly if it fails in conjunction with a large intense storm.

2.2.4 Ownership -

The facility is owned by the State of Ohio and operated and maintained by the Ohio Department of Natural Resources (ODNR), Division of Parks and Recreation.

2.2.5 Purpose of Dam -

Buckeye Lake is used for public recreation including swimming, fishing, and boating. In addition, the State of Ohio has sold essentially the downstream face of the dam, and houses exist virtually side-by-side along the entire length and serve as permanent or recreational homes to several hundred persons.

2.3 Design and Construction History: The Buckeye Lake area was a post-glacial swamp until 1825 (see references for historical data in Appendix C), when it was diked to form the Licking Summit Reservoir. Water from the reservoir was used to regulate water levels in the Ohio-Erie Canal from Carroll to Newark. In addition, boats passed across the west end of the lake as they crossed the divide between the Scioto and Muskingum River basins.

In 1909 (or 1914) the present spillway and outlet works were constructed. In 1913 the section of the canal serviced by Buckeye Lake was abandoned, and the lake subsequently became a recreational facility. From the 1930's to the present time, the State of Ohio has placed sheetpiling along the dam for over one-half its length. The purposes of this sheeting were to restrict seepage through the embankment, provide shore protection, and replace the original masonry wall which had deteriorated over the years from wave action, ice, and freeze-thaw effects.

During the history of the lake there have been private developments of cottages, homes, and service-type facilities along much of the shoreline and on the downstream slope of the entire dam. Homeowners have excavated into the downstream slope to construct basements and, in some cases, to increase the useable level area in their yards. In a few instances the unreinforced block walls placed along these vertical cuts have moved out of their original location and have been cracked or otherwise damaged.

2.4 Normal Operational Procedure: Because of the previously mentioned residential development and the associated recreational usage, the lake is maintained at a near constant level throughout the summer. According to the park manager, Mr. Melvin Pillow, the lake is generally maintained about six inches below the spillway crest throughout the summer. If the water level rises more than six inches, then significant seepage occurs through the dam. If the water level falls more than six inches, there is a lack of sufficient water for boating along the east, west, and south shores of the lake. To maintain this nearly constant level, the park staff takes daily water level readings near the spillway and the park manager decides upon the number of gates to be opened and the degree of opening required to maintain the proper level.

From November through March the water level is drawn down about 3 to 4 feet to provide protection of the shore wall along the dam from ice and freeze-thaw effects and secondarily as a flood control measure for the South Fork Licking River. During this time, when the water level is down, work crews repair the worst sections of the masonry walls.

For purposes of the Phase I inspection, normal pool elevation is defined to be at the crest of the drop spillway (892.5).

2.5 General Geology: The site lies on a post-glacial swamp. Water well holes from around the lake indicate that the soil depth is greater than 100 feet and consists of alternating layers of cohesive and cohesionless material. The cohesive soil is generally clay while the cohesionless soils are sand to sand and gravel. Generally when the sand was encountered, it was described as being in a "quick" condition. This indicates that the surrounding areas are under an artesian condition. According to the Ohio Soil Survey Map, the soil composition was formed by glacial drift. Soils identified on the site near the west shore were sands and gravels. Rock underlying the site is of Mississippian age, Waverly or Maxville Group, sandstones, limestones, and shales.

SECTION 3 - INSPECTION FINDINGS

3.1 Findings:

3.1.1 Brief Summary -

Based on the visual inspection and past performance, the overall condition of the facility is poor and potentially dangerous. The problem areas are: 1) inadequate spillway capacity; 2) instability of the shore protection wall; and 3) seepage through the dam. The problems are compounded by the fact that the crest of the dam is lined with residences and operational procedures require a nearly constant lake level.

3.1.2 Dam -

Buckeye Lake Dam is an unusual facility in that the downstream face of virtually the entire dam is lined with residences and other structures. By permitting these residences on the dam, additional problems and constraints are created.

The visible portion of the upstream face of the dam is nearly vertical with either a concrete and stone masonry or steel sheetpile shore protection wall. The steel sheetpile wall is typically tied back to sheeting driven just behind the original concrete or stone masonry wall. The shore protection wall serves as a seepage barrier, particularly where the sheetpiling exists. The crest of the dam ranges from 10 to 30 feet in width and is generally tree lined. The downstream edge of a sidewalk along the entire dam delineates the property boundary between the State of Ohio and private owners. The State requires the owners to obtain permission for any modification of the State's property (such as installing a boat dock), and it requires that the owners maintain the crest area. Beyond the downstream edge of the sidewalk, the owners can do whatever they wish. As a result, much of the downstream face is essentially a vertical slope caused by the erection of basement or retaining walls by residents.

Seepage is occurring in isolated locations but is present along the entire dam. The typical indications of seepage were: 1) wet lower yards; 2) water leaking into basements and through retaining walls; and 3) the presence of tile drain systems designed to intercept the water around basements and along the downstream slope.

The degree of seepage appears to correlate with the lake level and with past removal of trees on the crest. When the lake level rises by approximately six inches (to or above the waler level on the sheetpiling), a dramatic increase in seepage occurs. This is attributed to seepage around the

tie-rods through the overly large tie-back holes in the sheetpile wall. The seepage through the dam is also to some extent attributed to and compounded by decaying roots which act as conduits for the water.

Another indication of potential seepage problems is the presence of holes and/or low spots on the crest. It appears that many of these low spots occur where trees have been removed. Low spots occur behind the stone wall where wave action and erosion have piped away the soil through cracks in the wall. They also occur behind the sheetpile wall and/or stone masonry wall where movement of the wall outward has occurred leading to a void behind the wall into which the crest settles. Many people living on the crest must continually backfill these low spots and holes.

As mentioned, both the stone masonry wall and sheetpile wall are moving. These movements are caused partially by earth pressures on the walls. Anchor sheeting connection failures and tie rod failures have probably contributed to the movement. In many places the crest has settled into voids created behind the original wall locations where the anchor sheeting has moved forward.

In August 1972, ODNR performed a level survey of the dam crest. The results of this survey are shown on Figures 7 and 8, Appendix D. These results indicate that the crest is somewhat low (as low as elevation 894.4) in places (see Figures 7 and 8, Appendix D).

3.1.3 Appurtenant Structures -

Water can exit from the lake via either a gated discharge structure to the fish hatchery or the combination drop spillway and gated outlet works structure through the old canal. The operation of the gated structure to the fish hatchery is unimportant to the overall operation of the dam, since discharge through this structure is insignificant, and since the channel to the fish hatchery just downstream of the structure has essentially zero freeboard before overtopping of its banks would occur. However, the operation of the main outlet works is crucial to the operation of the lake as a recreational facility and the passing of flood waters. The basic arrangement consists of a straight drop spillway of ten bays, each one being 6 feet 6 inches long with essentially permanent flashboards (removal would require manual lifting) controlling the crest elevation (see Photographs 13 and 14, Appendix E). The outlet works consists of five gates, each 5 feet by 4 feet, located 12 feet below the spillway crest (see Photograph 12, Appendix E).

Visual observations indicate that the concrete is severely deteriorated. This deterioration is primarily scaling and is caused by the weather. While the concrete

should be immediately repaired, it is not believed that this scaling has yet had a serious impact on the overall structural integrity of the spillway, though localized portions may be weakened.

3.1.4 Reservoir Area -

As the site was initially a marsh, the slopes adjoining the lake are quite flat; thus, small rises and falls in the lake level cause large changes in the surface area of the lake. This also causes problems for the residents along the shore in that a rise in the water level of one foot may cause their property to be flooded, while a lowering of the water level by one foot may prohibit boat usage by the same property. For this reason, the water level within the reservoir has to remain essentially constant.

3.1.5 Downstream Channel -

The towns of Buckeye Lake and Lakeside, immediately adjacent to the lake, and Hebron and Newark, further downstream, all may suffer property damage and loss of life if embankment failure occurs, particularly if in conjunction with a large storm. The populated areas adjacent to and along the entire embankment may likewise sustain property damage and loss of life should embankment failure and/or overtopping occur.

Buckeye Lake outlets into the South Fork Licking River about 1-1/2 miles downstream from the spillway. Flooding along this river is a relatively common occurrence. Partly for this reason, the lake level is lowered during the winter to allow storage of water from the spring thaw and rains. During the flood of May 1968, the outlet works gates were kept closed, and Buckeye Lake was used to store water during the flooding rather than discharging additional flows (flows above those discharging over the drop spillway crest) downstream.

Because of the inadequate ability of Buckeye Lake to pass and/or store large floods an ad-hoc task force consisting of representatives from the Ohio Department of Highways, U. S. Soil Conservation Service, Ohio Department of Public Works, and Ohio Department of Natural Resources (designated the lead agency) was set up in 1972. The purpose of this task force was to discuss and recommend an operational plan for Buckeye Lake which would coordinate with the final plan prepared by the U. S. Soil Conservation Service for the South Fork Licking River Basin. In this report, it was recommended that a new and large capacity spillway be installed and that, in addition, land use controls and flood control construction be implemented downstream of Buckeye Lake Dam.

3.1.6 Operational Procedures -

Buckeye Lake Dam is operated and partially maintained by the ODNR Division of Parks and Recreation. Regular maintenance such as mowing the grass on the crest is the responsibility of each home owner on the dam. The Division of Parks and Recreation has responsibility for maintaining and/or replacing the shore protection wall. In addition, they monitor the lake level daily and adjust the outflow accordingly.

Proper operation and maintenance of the dam is hampered by the following: 1) deterioration of the embankment and spillway is occurring much faster than the rate of repairs; 2) the presence of residences on the dam and along the shoreline prevents the enlarging of the embankment which could provide additional storage for flood waters; and 3) proper repair of the embankment is hindered by the presence of these residences and by the trees growing on the dam.

3.2 Conclusions and Recommendations:

3.2.1 Safety -

The visual inspection and history of the dam indicate that the structure is in poor condition. Hydraulic and hydrologic calculations performed as part of this investigation indicate that the present spillway is seriously inadequate. Flood routing calculations have shown that under the PMF condition Buckeye Lake Dam will overtop for a time period upwards of 27.6 hours to a maximum depth of overtopping of about 2.0 feet; and that for the 1/2 PMF condition, it will overtop for a time period upwards of 22-1/2 hours to a maximum depth of overtopping of about 1.0 feet. Therefore, it is evident that the spillway capacity is seriously inadequate and should be increased to ensure safe operation.

Furthermore, to continue to allow maximum recreational use of the facility and to minimize damage to near lake level property to the east, south, west, and on islands in the lake as well as to minimize seepage through the dam, the spillway should be able to pass the peak inflow from the PMF event without significant change in the pre-storm lake level. Since the downstream areas currently experience flooding under moderately severe storm conditions, improvements to the downstream channel are also needed in conjunction with spillway improvements to substantially decrease the potential for property damage and loss of life.

In an effort to gain insight into how seriously inadequate the existing spillway is, the unconservative assumption was made that the spillway gates are opened at time zero; i.e., at the start of the rainfall. This assumption results in the lake initially being drawn down during the first several

hours before appreciable runoff begins to refill the lake. The assumption is somewhat unrealistic as it assumes: 1) the accurate prediction of the start of rainfall for the severe storm; and 2) the immediate decision to open the gates and drain the lake down to increase storm runoff storage capacity, in spite of the fact that an unnecessary lowering of the water level results in loss of recreational use of much of the lake with the accompanying pressures from those affected and that a large discharge of water may worsen flooding conditions downstream. Even with this somewhat unrealistic assumption, which results in the lake being able to store a considerable portion of the initial storm runoff, the computed durations and depths of overtopping are still so large that the overall conclusions regarding the danger to the embankment are not changed. In addition, this approach points out the fact that the existing spillway is so seriously inadequate that opening or not opening the gates probably has no real significance in case of large intense storms, such as the PMF and 1/2 PMF, in that it is likely that the embankment will fail due to the severe overtopping with or without the gates open. It should be noted that if the analysis had been carried out with the assumption that no gates were open or that they were opened much later in the storm, the computed durations and depths of overtopping would be greater; however, no information would then be available as to the possible effect that an early opening of the gates could have.

Other deficiencies were also observed during the field investigation. These were: 1) movement of the sheetpile or masonry walls; 2) holes and low spots present on the crest; 3) seepage through the embankment; 4) large trees growing on the crest and downstream slope; and 5) residences present on the dam itself which hinder visual inspection and which may hinder repairs.

3.2.2 Adequacy of Information -

Although no plans or specifications are available, the information and data gathered from literature, interviews, and field inspection are considered sufficient for the Phase I evaluation.

3.2.3 Urgency -

Recommendations and remedial measures listed below should be implemented immediately.

3.2.4 Necessity for Additional Investigations -

Because of the present physical condition of the dam, additional investigations for the purpose of locating and documenting seepage, holes, low spots, and wall movement and the corresponding cause are deemed necessary for the continued

use of this facility. In addition, the design of spillway improvements and improvements in the channel downstream are needed (see discussion in Section 3.2.1).

3.2.5 Recommendations/Remedial Measures -

It is recommended that the owner take the following immediate actions:

a. Retain a qualified engineer experienced in the design of earth dams and hydraulic structures to conduct the additional investigations needed to evaluate the structural integrity of the facility, to design a new spillway such that the facility can pass the peak flow from the Probable Maximum Flood (PMF), and to investigate, evaluate, and design corresponding improvements required to enable the downstream channel and the South Fork Licking River to accommodate much larger flows than can be presently accommodated and to minimize the potential for downstream property damage and loss of life.

b. Develop and implement a formal written operational procedure involving the daily regulation of the lake water level and actions to be taken during potential flooding; e.g., a formal warning and evacuation plan for downstream residents to include the towns of Buckeye Lake, Lakeside, Hebron, and Newark (primarily low lying areas near the river) in case emergency embankment and/or flooding conditions develop.

c. Locate and document seepage, holes, and low spots in the crest of the dam as well as shore protection wall movements (may be done through a property owner survey; each problem should be investigated, the cause determined, and corresponding remedial measures implemented).

d. Have the facility regularly inspected to assure detection of potentially unsafe conditions if and when they develop. Unsafe conditions should be corrected when discovered.

e. Install a continuously recording water level gage, at least until the remedial measures are implemented (this will provide useful data for redesign and also during high flow periods).