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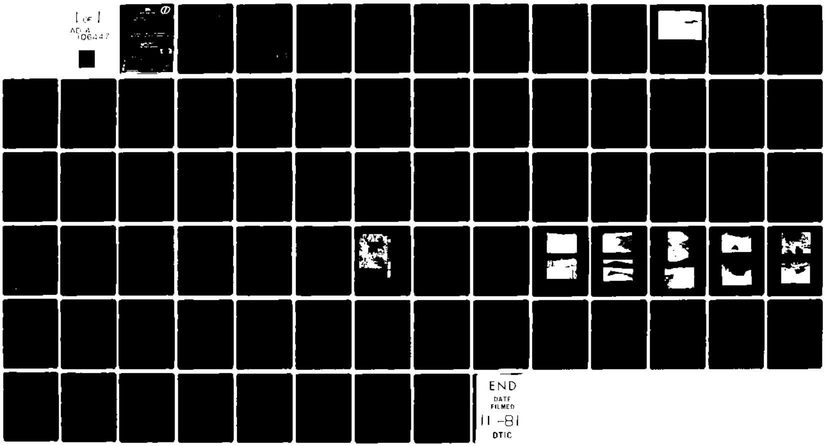

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PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY INSPECTION

United States Army
Corps of Engineers

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR STATE OF MISSOURI

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This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO
ATTENTION OF

SUBJECT: Buick Mine Tailings Dam, MO 30162

This report presents the results of field inspection and evaluation of the Buick Mine Tailings Dam. It was prepared under the National Program of Inspection of Non-Federal Dams.

SUBMITTED BY:	SIGNED Chief, Engineering Division	20 MAY 1981 Date
APPROVED BY:	SIGNED Colonel, CE, District Engineer	22 MAY 1981 Date

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BUICK MINE TAILINGS DAM

Reynolds County, Missouri

Missouri Inventory Number 30162

Phase I Inspection Report

National Dam Safety Program

Prepared by

Woodward-Clyde Consultants

Chicago, Illinois

Under Direction of

St Louis District, Corps of Engineers

for

Governor of Missouri

April 1981

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of the Chief of Engineers, Washington, D. C., 20314. The purpose of a Phase I investigation is not to provide a complete evaluation of the safety of the structure nor to provide a guarantee on its future integrity. Rather the purpose of the program is to identify potentially hazardous conditions to the extent they can be identified by a visual examination. The assessment of the general condition of the dam is based upon available data (if any) and visual inspections. Detailed investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify the need for more detailed studies. In view of the limited nature of the Phase I studies no assurance can be given that all deficiencies have been identified.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with any data which may be available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action removes the normal load on the structure, as well as the reservoir head along with seepage pressures, and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected, so that corrective action can be taken. Likewise continued care and maintenance are necessary to minimize the possibility of development of unsafe conditions.

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam	Buick Mine Tailings Dam
State Located	Missouri
County Located	Reynolds
Stream	Strother Creek
Date of Inspection	12 November 1980

Buick Mine Tailings Dam, Missouri Inventory Number 30162, was inspected by Richard Berggreen (engineering geologist), Leonard Krazynski (geotechnical engineer), and Sean Tseng (hydrologist). The dam was constructed to impound lead tailings.

The dam inspection was made following the guidelines presented in the "Recommended Guidelines for Safety Inspection of Dams." These guidelines were developed by the Chief of Engineers, U.S. Army, Washington, D.C., with the help of federal and state agencies, professional engineering organizations, and private engineers. The resulting guidelines represent a consensus of the engineering profession. These guidelines are intended to provide for an expeditious identification of those dams which may pose hazards to human life or property, based on available data and a visual inspection. In view of the limited scope of the study, no assurance can be given that all deficiencies have been identified.

Buick Mine Tailings Dam is classified as a large dam based on its present height of 141 ft. The maximum storage capacity is approximately 19,300 ac-ft. The large dam classification criteria are: height over 100 ft, or storage capacity over 50,000 ac-ft.

The St Louis District (SLD), Corps of Engineers, has classified this dam as having a high hazard potential. The SLD estimated damage zone length extends 16 mi downstream of the dam. Within this estimated damage zone are approximately 25 dwellings, a lake and dam (MO 31142), and the town of Edgehill. The contents of a portion of the estimated damage zone were verified by aerial reconnaissance.

Our visual inspection and evaluation of available data indicate the dam is in generally good condition. The slopes of the dam showed no evidence of movement or instability. No evidence was noted of cracking, settlement, animal burrows, or sinkhole development, although it should be noted these observations were made during construction of the dam. No seepage was noted through the embankment or abutments. Discharge from the drain outlet downstream of the toe dam was estimated at approximately 1/2 ft^3/sec.

The hydraulic/hydrologic analyses indicate the decant system, spillway and reservoir will store and pass a flood equivalent to 94 percent of the Probable Maximum Flood (PMF) without overtopping the dam. The PMF is defined as the flood event which may be expected to occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The capacity to store and pass less than 100 percent of the PMF is considered a deficiency for large dams under the "Recommended Guidelines for Safety Inspection of Dams." Overtopping of the embankment is judged to have the potential of causing severe erosion and could lead to an effective breach of the dam. However, continued construction of the dam since the visual inspection may have raised the dam crest above the critical height for overtopping.

The spillway and discharge channel are located well away from the dam, and possible erosion in these areas during flood flows will not pose an unusual hazard to the safety of the dam.

Seepage and stability analyses were prepared by Barr Engineering Co for the completed dam. As the dam is still under construction, conformance of the design and as-built dam configurations cannot be evaluated at present. The Barr Engineering report indicates the behavior of the phreatic surface warrants special attention with regards to the stability of the embankment.

Based on our inspection and review of available data, it is recommended that the following topics be addressed as soon as practical.

1. Evaluate methods of increasing the height of the dam crest and/or increasing the spillway capacity to store and pass 100 percent of the PMF, without overtopping the embankment. This recommendation may have already been satisfied by the normal construction progress. The spillway should be protected to prevent erosion.

2. Additional study should be made of the behavior of the phreatic surface in response to construction activity (cycloning) and heavy rainfall. Additional study should also be made of the influence of the phreatic surface position on both the static and seismic stability of construction and finished slope configurations. A program should be developed to monitor and control the phreatic surface and construction activities in such a way as to maintain a safe embankment condition at all times.

3. Evaluate the feasibility of a practical and effective warning system to alert downstream residents in the event unsafe conditions develop at this dam.

It is also recommended that a program of periodic inspections and maintenance be developed for this facility. This program should include but not be limited to the following items.

1. Inspect the embankment for evidence of slope instability such as cracking, deformation, or settling of the dam crest.

2. Monitor drainage discharge for evidence of increased flow or turbidity in the drainage water.

3. Maintain the decant line free of debris to prevent clogging and reduction of flow.

4. Monitor erosion on the embankment, especially at the junction of the embankment and abutments.

All remedial measures and maintenance should be performed by or under the direction of an engineer experienced in the design, construction and maintenance of tailings dams.

It is recommended that the owner takes action on these recommendations as soon as practical to preclude the development of hazardous conditions at this dam.

WOODWARD-CLYDE CONSULTANTS

Richard G. Berggreen
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Leonard M. Krazynski, PE No. C-14953, CA
Vice President

OVERVIEW

BUICK MINE TAILINGS DAM

MISSOURI INVENTORY NUMBER 30162

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

BUICK MINE TAILINGS DAM, MISSOURI INVENTORY NO. 30162

TABLE OF CONTENTS

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
BUICK MINE TAILINGS DAM, MISSOURI INVENTORY NO. 30162

SECTION 1
PROJECT INFORMATION

1.1 General

a. **Authority.** The National Dam Inspection Act, Public Law 92-367, provides for a national inventory and inspection of dams throughout the United States. Pursuant to the above, an inspection was conducted of Buick Mine Tailings Dam, Missouri Inventory Number 30162.

b. **Purpose of inspection.** "The primary purpose of the Phase I investigation program is to identify expeditiously those dams which may pose hazards to human life or property... The Phase I investigation will develop an assessment of the general condition with respect to safety of the project based upon available data and a visual inspection, determine any need for emergency measures and conclude if additional studies, investigations and analyses are necessary and warranted" (Chapter 3, "Recommended Guidelines for Safety Inspection of Dams").

c. **Evaluation criteria.** The criteria used to evaluate the dam were established in the "Recommended Guidelines for Safety Inspection of Dams," and Engineering Regulation No. 1110-2-106 and Engineering Circular No. 1110-2-188, "Engineering and Design National Program for Inspection of Non-Federal Dams," prepared by the Office of the Chief of Engineers, Department of the Army; and "Hydrologic/Hydraulic Standards, Phase I Safety Inspecton of Non-Federal Dams," prepared by the St Louis District (SLD), Corps of Engineers. These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 Description of Project

a. **Description of dam and appurtenances.** Buick Mine Tailings Dam is a lead tailings dam. Although its construction and usage are typical of other lead tailings dams in the area, it is atypical of dams constructed for the impoundment of water. The unique nature of these lead tailings dams has a significant impact on their evaluation. A brief description of their construction and usage is necessary to distinguish the differences between these dams and conventional water-retaining dams.

The lead tailings dams in southeastern Missouri have been constructed over a long period of time and include dams ranging from old abandoned dams constructed in the 1800's to modern dams still under construction. Although some construction techniques have changed, these dams share many similarities.

At the beginning of a mining operation a starter dam is frequently constructed of waste rock and residual soil. This dam is used to impound surface runoff and mine water pumped from the underground workings. The water is used in the ore processing and the transport of tailings waste. The reservoir formed by the starter dam constitutes the initial tailings disposal area.

The tailings are the waste material produced by the beneficiation and processing of the lead ore to form a high-grade lead concentrate. The coarse tailings fraction (medium to fine sand) is used to construct the dam embankment; the fine fraction (silt and fine sand) is deposited in the reservoir area. Separation of the coarse and fine fractions usually is done at a cyclone separator or a series of cyclones installed on the crest of the dam. The underflow or coarse fraction is deposited on the dam and the overflow or fine fraction is deposited in the reservoir.

The dams are typically constructed using the downstream method. That is, as the tailings are added to the dam, they are deposited on the crest and downstream face. As a result, the centerline of the dam crest migrates downstream as the dam is raised.

Frequently the dam has a drainage system built into the foundation to aid in lowering the phreatic surface (water table) within the embankment. Water enters the dam both at the crest from the cyclone-deposited tailings and from the upstream face where the dam is in contact with the reservoir. A clay blanket may be constructed on the upsteam face to reduce this infiltration from the reservoir.

A decant or water disposal system is typically constructed beneath the dam. This decant system consists of a vertical tower or sloping structure within the reservoir which decants or draws water from near the surface of the reservoir where the water contains the least sediment. This water is then carried beneath the dam and exits downstream of the toe of the dam. From there it may be recycled or released to the natural stream drainage. The intake level of the decant tower or structure is regulated as the tailings and reservoir level rises to maintain a balanced system of inflow and outflow. The decant system also serves as additional discharge in the event of heavy precipitation, which is generally additional to the other spillway provisions.

Two characteristics are noteworthy regarding the silt and sand tailings used in the construction of these dams. First, the very uniform grain size and lack of clay or other binder makes this material extremely susceptible to erosion by flowing water. It is unlikely that embankments composed of this material could survive overtopping without dam failure. Second, the finely ground limestone and dolomite tailings are almost barren of nutrients necessary to support vegetation. It is frequently necessary to import topsoil or fertilizer in order to successfully vegetate the dam embankment. This difficulty in vegetating the surface of the dam contributes to the potential for erosion of the dam.

Buick Mine Tailings Dam basically complies with these local practices. A starter dam was constructed and later covered by cyclone deposited tailings. A drain field is present below the downstream tailings portion of the dam. A decant system drains water through a notch cut in the hillside south of the dam and reservoir.

Tailings are currently being added to the embankment and, thus, the dam is considered still under construction. The design and construction history is presented in Section 1.2g.

b. **Location.** Buick Mine Tailings Dam is located approximately two miles northwest of Oates, Missouri, in northern Reynolds County on Strother Creek (Fig. 1). The dam is in Section 6, T33N, R1W on the USGS Greeley and Oates 7.5-minute quadrangle maps (1967).

c. **Size classification.** The dam is classified as large based on its height of 141 ft. Its maximum storage is 19,300 ac-ft. The large size classification includes dams with a height greater than 100 ft or a storage capacity greater than 50,000 ac-ft.

d. **Hazard classification.** The St Louis District (SLD), Corps of Engineers, has classified this dam as having a high hazard potential; we concur with this classification. The SLD estimated damage zone length extends 16 mi downstream of the dam. Within this hazard zone are approximately 25 dwellings, a lake and dam (MO 31142), and the town of Edgehill. The contents of a portion of the downstream damage zone were verified by aerial reconnaissance. The potential for loss of life and property damage could be high in the event of dam failure.

e. **Ownership.** We understand the dam is owned by AMAX Lead Inc, Boss, Missouri 65440. Correspondence should be sent to the attention of Mr William E. Whittaker.

f. **Purpose of dam.** The dam was constructed to impound tailings produced in the milling and processing of lead ore mined in the vicinity.

g. **Design and construction history.** Construction of the dam was begun in 1966. A clay starter dam was initially constructed to about elevation 1145 ft. The starter dam was keyed to the soil in the area as bedrock was too deep, reported to be in excess of 50 ft. The first tailings portion of the dam was constructed by depositing tailings from cyclones downstream of the starter dam and subsequently above the crest of the starter dam. Design drawings in the Barr Engineering report and our observations in the field indicate the dam is being built by downstream construction method. A clay blanket was built on the upstream face to limit infiltration from the reservoir. This initial tailings construction built the dam crest to elevation approximately 1160 ft.

Following completion of this phase, a clay blanket was placed on the downstream face of the dam to prevent erosion of the tailings. It was later decided to raise the dam to provide additional storage volume. Design plans and specifications were prepared and construction of this phase was underway at the time of our inspection visit. Tailings were being deposited on the downstream face from a single cyclone (at the time of inspection) on the dam crest, and had covered the downstream clay blanket on about the right half of the downstream face. It is proposed this construction will ultimately raise the dam crest to an elevation of approximately 1230 ft. A downstream method of construction is expected to be used. At the time of our inspection, the dam crest was at approximately elevation 1192 ft.

h. **Normal operating procedures.** As the dam is still under construction there were no operating procedures, other than construction procedures, in effect at this facility. Reservoir level is controlled by discharge through the ungated decant line.

1.3 Pertinent Data

a. **Drainage area.** 3.8 mi^2

b. **Discharge at dam site.**

Maximum known flood at damsite	6 in. in 24 hrs, Nov. 1972 (Reported in Barr Eng Report)
Warm water outlet at pool elevation	N/A (not applicable)
Diversion tunnel low pool outlet at pool elevation	N/A
Diversion tunnel outlet at pool elevation	N/A
Gated spillway capacity at pool elevation	N/A
Gated spillway capacity at maximum pool elevation	N/A
Ungated spillway capacity at maximum pool elevation	600 ft^3/sec*
Total spillway capacity at maximum pool elevation	600 ft^3/sec*

*(includes decant line discharge capacity)

c. **Elevations (ft above MSL).**

Top of dam	1192
Maximum pool-design surcharge	N/A

Full flood control pool	N/A
Recreation pool	N/A
Spillway crest (gated)	N/A
Upstream portal invert diversion tunnel	N/A
Downstream portal invert diversion tunnel	N/A
Streambed at centerline of dam	1055 (from Barr Eng Report)
Maximum tailwater	Unknown
Toe of dam at maximum section	1051

d. <u>**Reservoir.**</u>

Length of maximum pool	Approximately 10,500 ft
Length of recreation pool	N/A
Length of flood control pool	N/A

e. <u>**Storage (acre-feet).**</u>

Recreation pool	N/A
Flood control pool	N/A
Design surcharge	N/A
Top of dam	19,300 (includes approximately 11,3000 ac-ft tailings)

f. <u>**Reservoir surface (acres).**</u>

Top of dam	400
Maximum pool	400
Flood control pool	N/A
Recreation pool	N/A
Spillway crest (decant pipe inlet el 1165 ft)	240

g. <u>**Dam.**</u>

Type	Lead tailings
Length	1490
Height	141 ft
Top width	20 ft (typical)

Side slopes	Downstream varies 2.5 - 3.5(H) to 1(V), steeper near dam crest Upstream, 3(H) to 1(V) from waterline to dam crest
Zoning	Clay starter dam; clay blanket on upstream and downstream slopes of initial tailings embankment, initial and current embankment construction is with tailings.
Impervious core	Clay starter dam to elevation 1145
Cutoff	None shown on plans
Grout curtain	None

h. **Diversion and regulating tunnel.**

Type	None
Length	N/A
Closure	N/A
Access	N/A
Regulating facilities	N/A

i. **Spillway.**

Type	Trapezoidal notch cut through hillside forming right abutment. Notch has been filled with soil dike to elevation 1191 ft.
Length of weir	Approximately 70 ft at top of soil dike.
Crest elevation	1191 ft
Gates	None
Downstream channel	Deep cut through hillside; flows into natural drainage for basin southeast of dam.

j. **Regulating outlets.** Two inlet pipes combining into 54-in. diameter decant pipe passing beneath spillway and downstream channel. Outlet at confluence of downstream channel and natural drainage. Riprap and concrete energy dissipation at outlet end. No control valves. Trash racks at upstream end. Inlets at elevation 1165 ft. Discharge capacity approximately 390 ft^3/sec with reservoir elevation at spillway crest, el 1191 ft.

SECTION 2
ENGINEERING DATA

2.1 Design

Design reports, analyses, and drawings were provided by AMAX for the Buick Mine Tailings Dam evaluation. These reports, prepared by Barr Engineering Company of Minneapolis, Minnesota consisted of: "Phase II, Preliminary Design Study, Expansion of Existing Tailing Basin, April 1978"; "Phase II, Appendix A, B, and C, April 1978"; and "Design and Construction Reports - 1979." These reports dealt primarily with modifications to the dam as it existed in 1977. These modifications consist of raising the dam crest to provide additional storage capacity and associated modifications to appurtenant structures. The analyses included the decant system, spillway, seepage control alternatives, drainage system alternatives, static and dynamic stability analyses, and construction.

The Barr Engineering reports pertaining to the various phases of work on this dam are quite voluminous, as are the other available reports and date concerning site investigation, early construction, inspection and evaluation visits and subsequent construction reports. Reproduction of all of this material in multiple copies was not practical and there were no satisfactory basis for selection or omission of any particular information. The reports available in our files are listed in Appendix C together with their Tables of Contents. They are available for perusal by interested parties. Also, these and other reports can be examined at (or requested from) AMAX Lead Inc, Boss, Missouri 65440.

2.2 Construction

Information on construction of this dam was obtained from the Barr Engineering reports listed above, and from discussions with Buick Mine personnel, primarily Mr Mike Kearney.

Construction of the dam has progressed in several phases. Construction began in 1966 with a clay fill starter dam to an elevation of about 1145 ft. Cyclone deposited tailings were then deposited on the crest and downstream face of the starter dam, raising the crest of the embankment to approximately elevation 1160 ft. The upstream slope of the tailings was covered with a clay blanket to reduce infiltration of reservoir water. Following completion of this construction phase, a clay blanket was also placed on the downstream face of the dam in order to control surface erosion.

It was subsequently decided to raise the dam crest to provide additional storage in the reservoir and work began on the second phase of tailings construction of the embankment. This work was continuing at the time of our visual inspection. The clay blanket on the upstream face is being continued as the tailings embankment is raised. The crest of the embankment at the time of the inspection was reported by AMAX to be 1192 ft.

2.3 Operation

The dam is still under construction as tailings are being deposited on the crest and downstream face. There are no records or evidence of flow through the present spillway. There were no records or evidence that the embankment had ever been overtopped. The decant line was flowing an estimated 2 ft^3/sec at the time of the visual inspection.

2.4 Evaluation

a. **Availability.** Engineering data supplied to the inspection team by AMAX consisted of the Barr Engineering reports listed in Appendix C, and a topographic map of the site at a scale of 1 in. equals 500 ft prepared by Surdex Corp, dated August 1978. Some previous reports related to the original construction of the starter dam in this location were also briefly reviewed during the inspection team's visit in the AMAX offices.

b. **Adequacy.** The information furnished by AMAX to the inspection team was substantially more complete than was generally the case in the course of a typical inspection of tailings dams in this area. No detailed checking of all design assumptions, calculations and conclusions was undertaken for the various phases of this evolving design. However, the information was adequate to indicate that the design of this facility was receiving competent professional attention performed to the current standards of the profession.

c. **Validity.** The information obtained from the AMAX personnel and from the Barr Engineering reports appears to be valid and is in agreement with the observations made during the visual inspection.

2.5 Project Geology

The dam is located on the southwestern flank of the Ozark structural dome. The regional dip is to the southwest. The bedrock at the dam site is mapped on the Geologic Map of Missouri (1979) as Cambrian age Eminence and Potosi Dolomite formations (Fig. 4). The overlying Eminence Dolomite is a light gray finely crystalline dolomite with some chert and quartz druse characteristic of chert-bearing formations. The Potosi Dolomite is similar to the Eminence Dolomite but contains greater amounts of chert and quartz. The Eminence Dolomite is very deeply weathered and solutioned at the site, according to the Barr Engineering report. Evidence of weathering and solution activity was also reported in the Potosi Dolomite.

The soil in the vicinity of the dam is a residual soil developed by deep weathering of carbonate bedrock. The soil is a gravelly to sandy, plastic, dark red clay (CL-CH). The gravel consists of chert and quartz weathered from the dolomite bedrock. The soil in this area is mapped on the Missouri General Soils Map (1979) as Captina-Clarksville-Doniphan Soil Association.

The Black Fault and Ellington Fault are mapped on the Geologic Map of Missouri (1979) approximately 5 mi northeast and 16 mi southwest of the dam, respectively. The Black Fault has a mapped length of approximately 15 mi trending northwest-southeast. The Ellington Fault has a mapped length of approximately 22 mi, also trending northwest-southeast. Both faults show mapped displacements of northeast side up.

The Palmer Fault system is a complex branching network of faults approximately 40 miles in length, trending roughly east-west across southern Crawford and Washington counties. This system is located about 18 mi north of the dam site. Displacements on faults in this system are typically south side up.

These faults, like most faults in the Ozark area are within Precambrian and Paleozoic rock, and are likely Paleozoic in age.

The site is located approximately 100 mi northwest of the line of epicenters for the very large 1811 and 1812 New Madrid earthquakes. This location places the site within Seismic Zone 2 to which the guidelines assign a moderate damage potential. A recurrence of an earthquake of the magnitude of the New Madrid event could cause significant damage to the dam, but a study of this aspect of risk is beyond the scope of this Phase I report.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. **General.** A visual inspection was made of the Buick Mine Tailings Dam on 12 November 1980 accompanied by Mike Kearney of AMAX Lead Co.

b. **Dam.** The embankment of this dam is constructed of several different materials (see Section 1.2g and Fig. 3B). On the downstream face of the main embankment, two materials are exposed (Photo 1). The older portion consists of a rock and clay cover on an earlier tailings phase of the embankment. This rock and clay cover is composed of local residual soil. The newer portion of the downstream face consists of tailings currently being discharged from a single cyclone separator on the crest of the dam (Photo 2). The fine fraction from the separator flows through a pipe back along the dam crest and is discharged on the upstream side into the reservoir area (Photo 3). The inclination of the tailings on the downstream slope varies from 22 degrees near the cyclone to approximately 16 degrees near the toe of the tailings.

No signs of slope instability such as cracking or slumping were noted. The vertical and horizontal alignment of the dam crest appeared undisturbed (Photo 4). No detrimental settlement or sinkhole development was noted. The tailings surface is barren of vegetation. The rock and soil covered portion has scattered weed and grass vegetation. No animal burrows were noted.

Several erosion gullies have developed near the right abutment of the downstream face (Photo 5). The deepest is about 5 ft wide and 5 ft deep. The gully becomes shallower and narrower downstream onto the face of the dam, apparently as the water flowing off the abutment percolates into the embankment.

A toe dam has been constructed downstream of the main dam to act as a buttress for the tailings portion of the embankment currently being constructed. This dam is composed of coarse gravel to approximately 2-in. diameter (Photo 6). A drainfield has been constructed beneath the tailings embankment and the outlet exits downstream of the toe dam. This drain was flowing about 1/2 ft^3/sec at the time of the inspection (Photo 7). No springs or other seepage areas were noted during the field inspection.

On the upstream face of the dam, a clay blanket has been constructed to limit infiltration of water from the reservoir through the embankment (see Photos 3 and 4). No riprap or other erosion protection is present on the upstream face, and some wave erosion of the clay blanket is likely. The clay blanket is apparently composed of residual soil and erosion will likely result in concentration of gravel in the soil, leaving a lag gravel mantle less susceptible to erosion.

Several piezometer pipes were noted projecting vertically from the downstream slope. These are used to measure the phreatic surface (water table) within the embankment.

c. Appurtenant structures.

1. Spillway. The final spillway for this dam had not been constructed as of the date of our visual inspection. The area which will temporarily act as the spillway (Photo 8) is a cut through the ridge south of the dam and reservoir (Fig A-1). The cut was made to construct the decant pipe, described below (Section 3.1c.2.). Following construction of the decant line, the cut was backfilled adjacent to the reservoir to within 1 ft of the elevation of the top of dam at the time of our inspection. The compacted soil and rock which forms the weir of this temporary spillway is not likely to be significantly eroded by the anticipated flow velocities. Flow from the spillway will enter a separate drainage basin south of the dam and will not pose any safety hazard to the dam.

2. Decant system. The decant system consists of two inlet pipes joining together into a 54-in. diameter pipe through a Y-shaped connection. This 54-in. diameter pipe runs beneath the present temporary spillway into the drainage basin to the south. A concrete post and large rock riprap have been placed for energy dissipation at the outlet end of the pipe (Photo 9). Trash

racks have been constructed at the inlets to prevent obstruction or clogging of the decant system (Photo 10).

d. **Reservoir.** The reservoir is used for the impoundment of lead tailings. Much of the storage volume is occupied by tailings. Little sediment is likely to be eroded from the wooded slopes surrounding the reservoir, and relative to the tailings supplied to the impoundment, this sediment is insignificant. There was no evidence of unstable slopes surrounding the reservoir.

e. **Downstream channel.** The downstream discharge channel for this dam serves both the temporary spillway and the decant system. The channel is in a separate drainage basin south of the dam and reservoir. The channel is unlined, follows the natural stream channel and poses no hazard of erosion to the dam. The proposed location for the final spillway has essentially the same configuration as the temporary spillway, with the discharge channel in the drainage south of the dam.

3.2 Evaluation

The visual inspection did not find any indication of sinkhole development, disruption of the horizontal or vertical alignment of the dam crest, detrimental settlement, slides, cracking or other evidence of slope instability. It should be noted that the dam embankment was in the process of construction during our inspection. Evidence of slow displacements or deformations which develop over a long period of time are usually not detectable when such evidence is obscured by ongoing construction activity. Some deep erosion gullying was noted along the junction of the embankment with the right abutment.

No animal burrows or detrimental vegetation were noted on the dam.

The temporary spillway and decant system pass through the ridge south of the dam. Both the spillway and decant system appear to be in good repair and do not appear subject to significant erosion.

The drain at the downstream toe of the dam was flowing at a rate of approximately 1/2 ft^3/sec at the time of the visual inspection. No other seepage or springs were noted during the inspection.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures

The dam is currently under construction and no records of formal operational procedures were identified at this facility. Water level is controlled by flow through the ungated decant line. Normal operating procedure is to allow drainage through this decant line.

4.2 Maintenance of Dam

As the dam is still under construction, maintenance of the dam is not applicable. No records were available for a maintenance program on this facility.

4.3 Maintenance of Operating Facilities

The only facilities requiring operation identified at the dam were those associated with the current dam construction, such as the cyclone separator at the crest of the dam. Evaluation of this equipment is not a part of the Phase I program. No operations are required for the functioning of the decant, spillway, or drain system.

4.4 Description of Any Warning System in Effect

Our visual inspection and review of available data did not identify any warning system in effect at this facility.

4.5 Evaluation

As the dam is still under construction, there were no formal operational procedures available. The existing embankment and decant line appeared to be well maintained. The final spillway has not yet been excavated. The temporary spillway does not appear subject to obstruction or reduced flow. The clay blanket on the upstream face of the dam is being raised as the dam crest is raised.

The feasibility of a practical and effective warning system should be evaluated to warn downstream residents and traffic in the event hazardous conditions develop at this dam.

SECTION 5
HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. **Design data.** Hydraulic and hydrologic design data prepared by Barr Engineering Co for the modifications on the Buick Mine Dam included:

1. Mining Enforcement and Safety Administration (MESA) Requirements,
2. Probable Maximum (6 hr) and 100-year Frequency Precipitation and Runoff, and Historic Rainfall Records,
3. Flood Discharge,
4. Flood Storage,
5. Natural Watershed Runoff,
6. Mine Dewatering Discharge,
7. Volume-Elevation and Time-Elevation Curves, and
8. Decant Line Discharge Capacity.

This information was reviewed for the hydrology analysis. However, differences between analyses performed by Barr Engineering and the format for Phase I analyses preclude a direct comparison of results. Barr used a 6 hr PMP while the Phase I program uses a 24 or 48 hr PMP. No unit hydrographs or flood hydrographs were included in the Barr report. Also, much of the Barr analysis was directed at final elevations and configurations, whereas this Phase I analysis was performed for conditions at the time of our visual inspection.

Pertinent dimensions on the dam and spillway were taken from the Barr Engineering reports, where applicable, supplied by AMAX, or measured in the field or from topographic mapping. The maps used in the analysis were the USGS Greeley and Oates 7.5 minute quadrangle maps (1967).

b. **Experience data.** The Barr Engineering reports include a record of a 6-in. rainfall in 24 hrs which occurred in November 1972. This was approximately equal to a 25-year frequency event (4 percent probability event). No other records of runoff, discharge, or pool stage data were available for this reservoir or watershed. According to AMAX personnel, the dam has not been overtopped since construction started in 1966.

c. **Visual inspection.**

1. The watershed is covered by natural woods, forested with mixed hardwoods and softwoods. The area of the reservoir is approximately 11 percent of the total drainage area of 3.8 mi^2.

2. Reservoir. The reservoir and dam are best described by the maps and photographs enclosed herewith. The reservoir is used for storage of lead tailings.

3. Spillway. The main spillway consists of an uncontrolled embankment about 70 ft wide. The top of the embankment is at elevation 1191 ft which is just 1 ft below the crest of the dam embankment at the time of our field inspection. A decant outlet consisting of a 54-in. diameter pipe was also present. The elevation of the decant pipe inlet is 1165 ft.

4. Seepage. The magnitude of seepage through the dam is not hydraulically significant to the overtopping potential.

d. **Overtopping potential.**

One of the primary considerations in the evaluation of Buick Mine Tailings Dam is the assessment of the potential for overtopping and possible consequent failure by erosion of the embankment. For this analysis the dam crest is considered to be level at an elevation of 1192 ft, which is reasonably representative of actual field conditions at the time of our inspection. However, as previously noted, the dam crest was being systematically raised by deposition from cyclones.

Hydrologic analysis of this dam for the 1 and 10 percent probability-of-occurrence events were based on initial water surface elevations equal to the invert elevation of the decant pipe inlet. For the Probable Maximum Flood (PMF) events the initial water surface was determined by the antecedent storm according to the guidelines. The results of the analysis indicate that a flood of greater than 94 percent of the PMF would overtop the dam for the conditions observed during our inspection. The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The analyses also indicate that the 1 percent probability-of-occurrence will not reach the spillway crest elevation, but will be stored in the reservoir and passed through the decant outlet. The total outflow capacity through the decant system and spillway at maximum pool elevation (top of dam at el 1192.0 ft) is 600 ft^3/sec.

The following overtopping analysis data for the various precipitation events were computed for the dam assuming no erosion of the dam crest or spillway:

Precipitation Event	Max. Reservoir WS Elev., ft, MSL	Max. Depth Over Dam, ft	Max. Outflow, ft^3/sec	Duration of Overtopping, hrs
1% Prob	1174.1	0	125	0
50% PMF	1182.9	0	320	0
95% PMF	1192.1	.1	1000	5.5
100% PMF	1192.6	.6	3900	7.3

It should be noted that for the conditions observed during our inspection at 100 percent of the PMF the depth of overtopping would reach 0.6 ft and the dam would be overtopped for 7.3 hours. During this period significant erosion very likely would take place and could develop an effective breach of this dam. The "Recommended Guidelines for Safety Inspection of Dams" require that large dams be capable of passing 100 percent of the PMF at all times without overtopping.

The input data and output summaries for the hydrologic analyses are presented in Appendix B.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. **Visual observations.** Results of the visual inspection of the dam are discussed in Section 3.1b. There were no visual indications of structural instability of the dam. The vertical and horizontal alignments of the dam were not disturbed. There was no visual evidence of excessive settlement, depressions, sinkholes, or cracking. As was discussed in Section 3 of this report, the dam embankment was in the process of construction during our inspection. Evidence of some slow deformations may have been obscured by ongoing construction activity.

The toe drain connected to the drainfield beneath the embankment was flowing at a rate of approximately 1/2 ft^3/sec. This rate is consistent with the infiltration rates anticipated by the designers. No other seepage or springs were noted during the inspection. Erosion gullies up to 5-ft deep were noted at the junction of the downstream face of the embankment and the right abutment.

b. **Design and construction data.** Design and construction information is available. Copies of design and construction reports, analyses and drawings, prepared by Barr Engineering Co of Minneapolis, Minnesota, were provided by AMAX. These documents are in the project file and are listed in Appendix C. The available design and construction information pertains to the expansion of the dam and tailing basin undertaken in 1978 and 1979. Other reports and documents available in AMAX files cover design or construction of the dam prior to 1977.

Barr Engineering Co evaluated the stability of the embankment under the conditions existing in July 1977 (crest elevation 1160) and for the interim construction phase of crest elevation 1200 which is close to the condition observed during our inspections. They also predicted the expected stability of the dam when it will be completed at a crest elevation of 1230 ft. They recommended various measures (installation of a drainage system and/or flattening of the slopes) to obtain a factor of safety of at least 1.5 against slope failure.

Barr Engineering Co prepared a report summarizing design and construction activities at this site during 1979. This report covers the abandonment of an existing decant line, construction of a new decant line, and construction of a drain system to control seepage. In that report Barr Engineering Co concludes that the long-term factor of safety against slope failure for the completed dam, as designed, will be larger than 1.5 after an adequate period of drainage.

It is noteworthy to observe that the analyses indicate substantially lower factors of safety for conditions where a high phreatic surface is assumed. Such a condition does develop to a certain degree over a portion of the dam during a cycloning operation and could become further aggravated by a period of prolonged heavy rain. Since the position of the phreatic surface has a strong influence on both the static and seismic stability of the dam, this aspect of the design should receive some further attention. The behavior of the phreatic surface as a function of various construction and rainfall events should be studied by observation of existing and/or weir piezometers. Influence of the phreatic surface position on the stability of construction and finished slopes should be evaluated more precisely by further studies. The objective would be to control the construction activities in such a way as to create and maintain a safe embankment condition at all times, including a consideration of an earthquake hazard.

The embankment is presently under construction. It is not known whether construction records will be kept as the embankment is completed.

c. <u>Operating records</u>. No operating records were available.

d. <u>Post construction changes</u>. The dam is still under construction; therefore, there are no post construction changes.

e. Seismic stability. The dam is in Seismic Zone 2, to which the guidelines assign a moderate damage potential. Barr Engineering Co made a seismic stability analysis and concluded: "...a relative density greater than 60% in the tailing will make the probability of liquefaction low... Relative density tests made previously in the dam and the results of the standard penetration tests show that the dam as presently designed should not be subject to liquefaction from the earthquake accelerations which could occur at the site. This statement is based on the low phreatic surface; however, for a higher phreatic surface there are zones within the dam which could potentially liquify."

SECTION 7
ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

a. **Safety.** Based on our visual inspection and the evaluation of the available data, the dam appears to be in generally good condition.

The slopes of the dam indicate no signs of movement or instability. Discharge from the drain outlet downstream from the toe dam was estimated to be approximately 1/2 ft^3/sec which is compatible with the design assumptions. The water was clear and did not appear to be carrying any soil or tailings. No other seepage was noted through the embankment or abutments. No evidence was noted of cracking, settlement, animal burrows or sinkhole development, although it should be noted that the observations were made during the period of construction.

The hydraulic/hydrologic analysis indicates the decant system, spillway, and reservoir will store and pass a flood equivalent to 94 percent of the PMF. The capacity to store and pass less than 100 percent of the PMF is considered a deficiency for large dams under the "Recommended Guidelines for Safety Inspection of Dams." Overtopping of the embankment by floods greater than 94 percent of the PMF is judged to have the potential of causing severe erosion of the tailings embankment and could lead to an effective breach of the embankment. However, the dam crest elevation used in this analysis was the elevation at the time of the visual inspection. The crest may have been raised above the critical overtopping elevation due to continued construction following the visual inspection visit.

The spillway and discharge channel are located well away from the embankment and erosion in these areas during possible flood flows will not pose a hazard to the safety of the dam.

Seepage and stability analyses were prepared by Barr Engineering for the completed dam. As the dam is still under construction, conformance of the design and as-built dam configurations cannot be evaluated at present. The behavior of the phreatic surface appears to warrant special attention and study.

b. <u>Adequacy of information.</u> The visual inspection and information obtained from AMAX provided sufficient information to support the conclusions presented in this Phase I inspection report.

Seepage and stability analyses are available for the dam under construction but do not reflect the condition of the dam at the time of the visual inspection. Design and construction inspection reports were provided for the work done on the closing of the old decant system, installation of the new decant line and installation of the drainfield. Recommendations were also made on installation of piezometers to monitor the phreatic surface in the embankment. Several such piezometers are now in place and periodic observations are being made.

c. <u>Urgency.</u> Overtopping of the embankment by a flood of less than 100 percent of the PMF (in this case 95 percent) is considered a deficiency under the "Recommended Guidelines for Safety Inspection of Dams." This deficiency should be rectified as soon as practical. Continued construction following the visual inspection may have already raised the dam crest elevation above the critical overtopping elevation.

d. <u>Necessity for Phase II.</u> In accordance with the "Recommended Guidelines for Safety Inspection of Dams," the subject investigation was a minimum study. Final assessment of the safety of the dam will require an evaluation of the as-built configuration of the dam and appurtenant structures. It is our understanding from discussions with the SLD that any additional investigations are the responsibility of the owner.

7.2 Remedial Measures

a. Alternatives. There are several general options which may be considered to reduce the possibility of dam failure or to diminish the harmful consequences of such a failure. Some of these general options are listed below.

1. Remove the dam, or breach it to prevent storage of water.

2. Increase the height of dam and/or spillway size to pass the PMF without overtopping the dam.

3. Purchase downstream land that would be adversely impacted by dam failure and restrict human occupancy.

4. Provide a highly reliable flood warning system (generally does not prevent damage but diminishes chances for loss of life).

b. Recommendations. Based on our inspection of the Buick Mine Tailings Dam, it is recommended that the following topics be evaluated as soon as practical.

1. Evaluate the methods of increasing the height of the dam crest and/or increasing the spillway capacity to store and pass 100 percent of the PMF without overtopping the embankment. This requirement may already be satisfied by the normal construction progress. The spillway should be protected to prevent erosion.

2. Make an additional study of the behavior of phreatic surface in response to construction activity (e.g., cycloning) and heavy rainfall. Additional study should also be made of the influence of the phreatic surface position on both the static and seismic stability of construction and finished slopes. A method should be developed to control the construction activities in such a way as to maintain a safe embankment condition at all times.

3. Evaluate the feasibility of an effective and practical warning system for this facility.

c. O & M procedures. It is recommended that a program of periodic inspections and maintenance be developed for this facility. This program should include but not be limited to the following items.

1. Inspect the embankment for evidence of slope instability such as cracking, deformation, or settling of the dam crest.

2. Monitor drainage discharge for evidence of increased flow or turbidity in the drainage water.

3. Maintain the decant line free of debris to prevent clogging and reduction of flow.

4. Monitor erosion on the embankment, specifically at the junction of the embankment and the abutments.

All remedial measures should be performed by or under the guidance of an engineer experienced in the design, construction, and maintenance of tailings dams.

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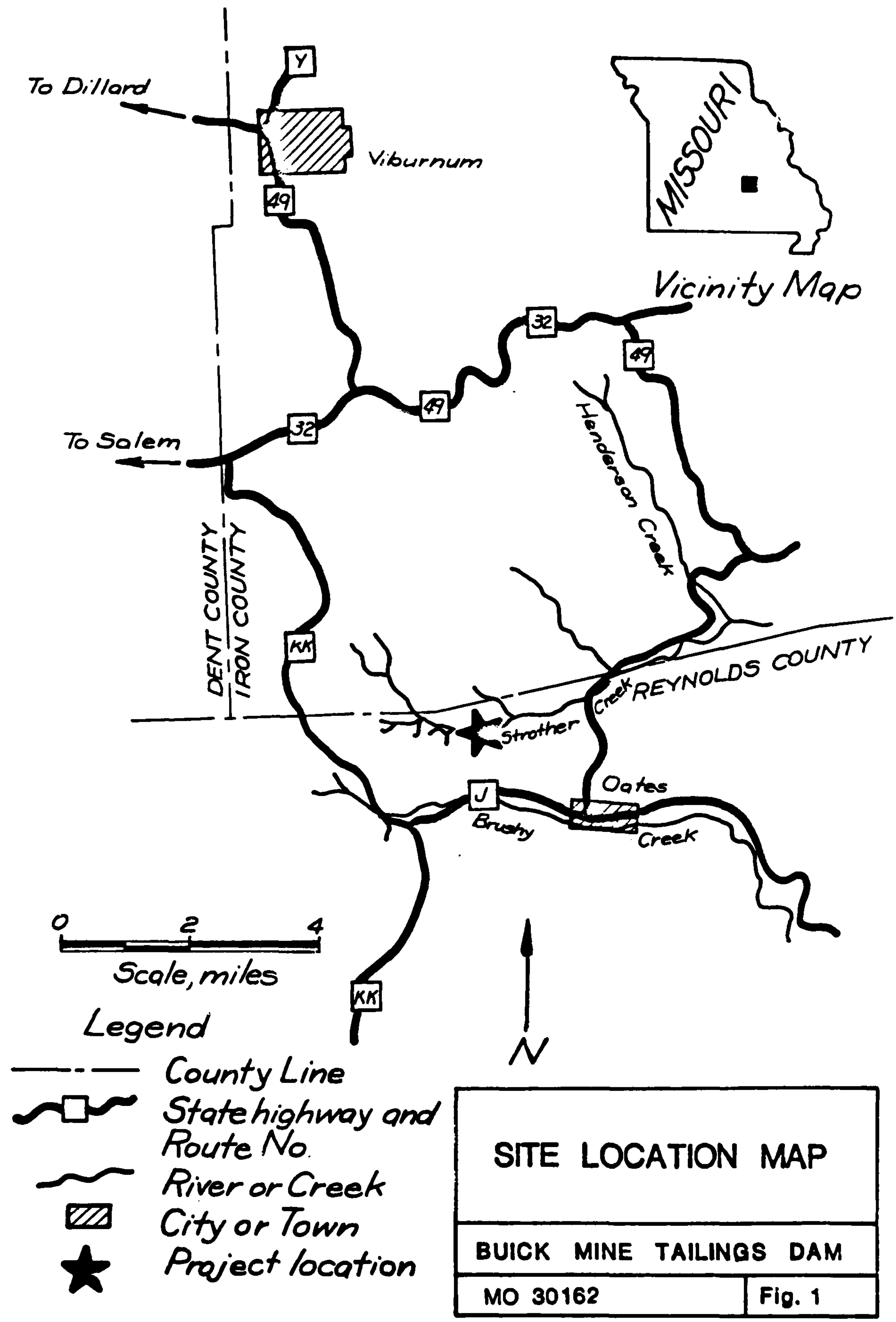
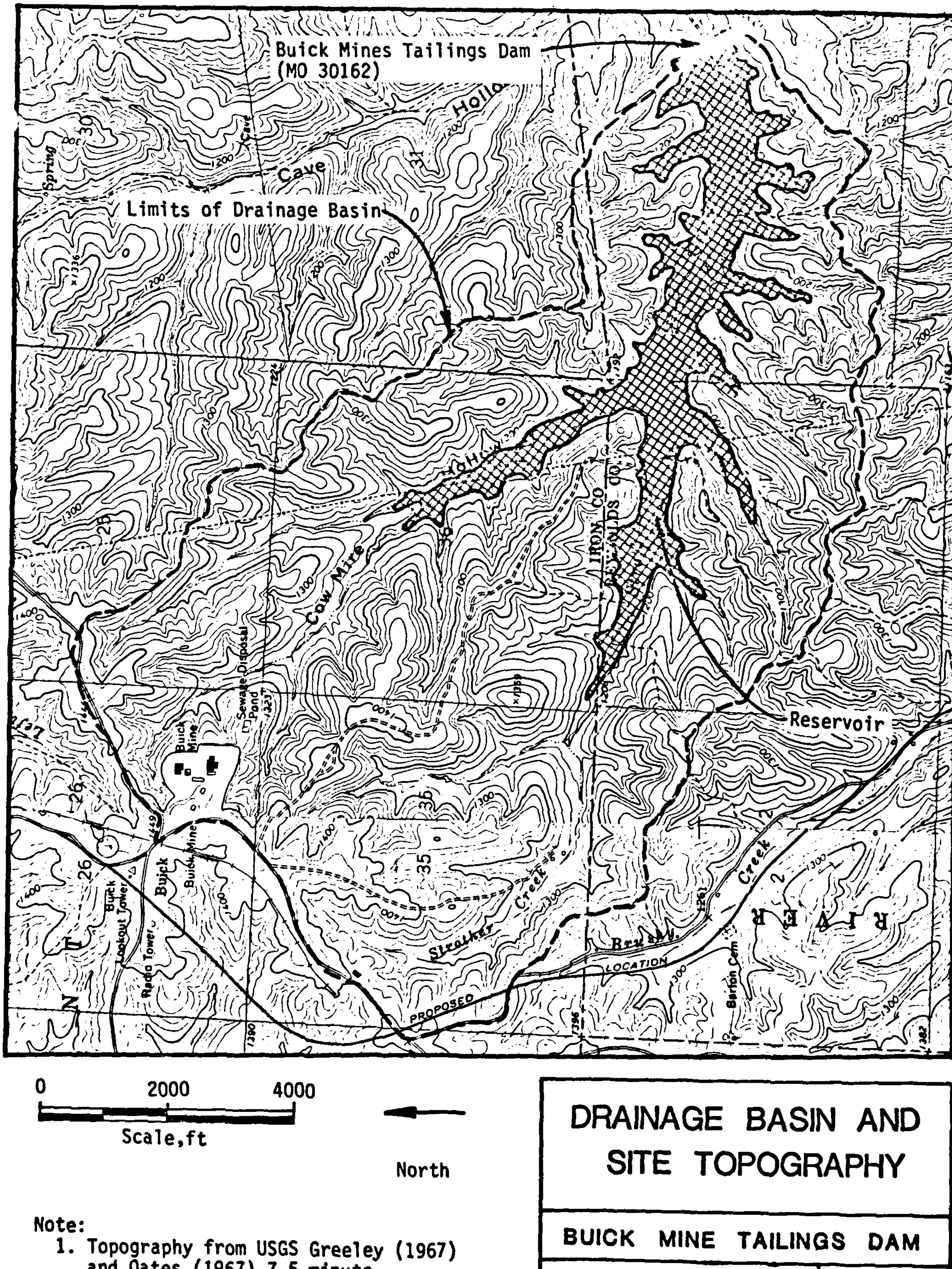
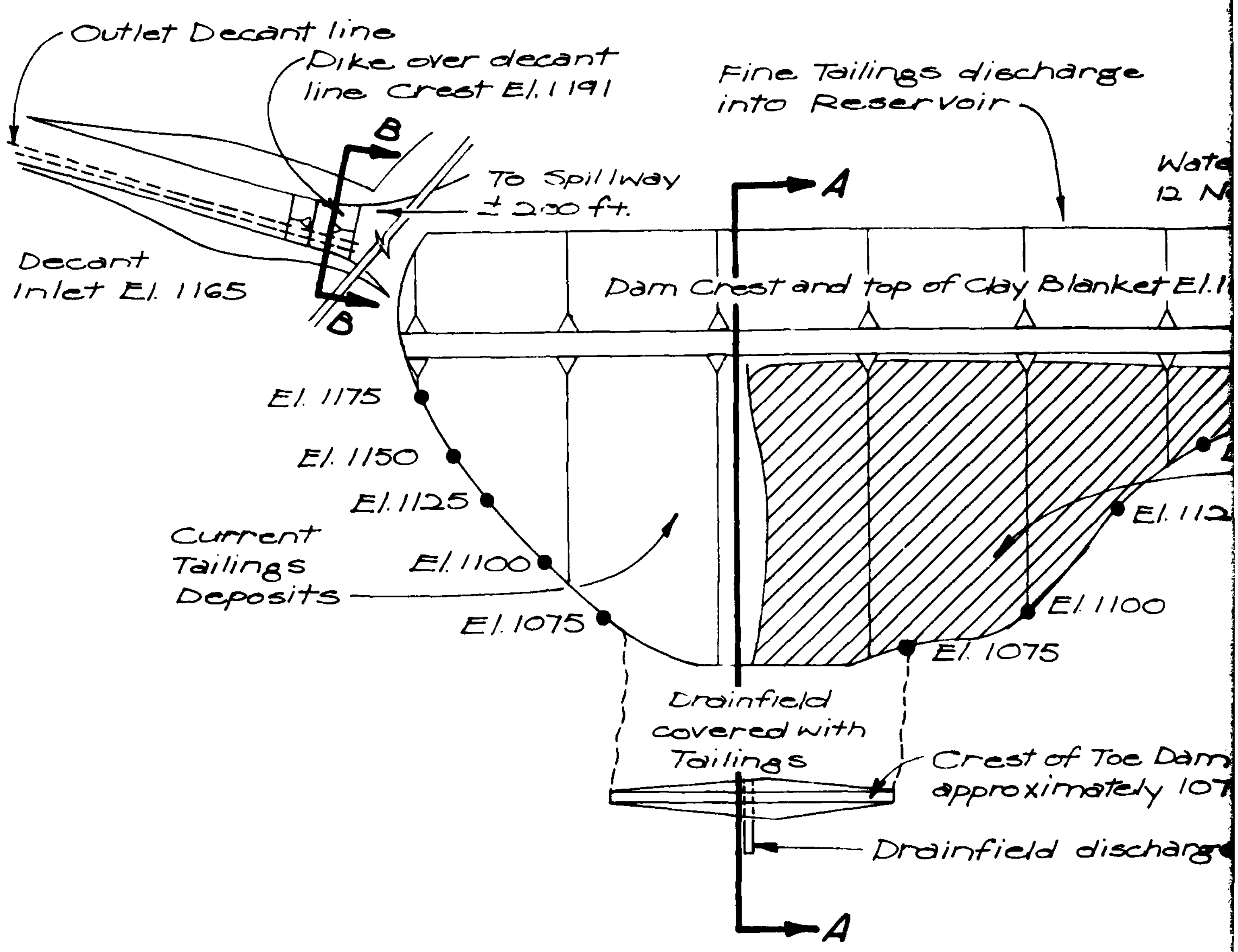
US Soil Conservation Service, 1971, "National Engineering Handbook," Section 4, Hydrology, 1971.


To Dillard
Viburnum
MISSOURI
Vicinity Map
To Salem
DENT COUNTY
IRON COUNTY
REYNOLDS COUNTY
Henderson Creek
Strother Creek
Oates
Brushy Creek
Y
49
32
KK
J
0 2 4
Scale, miles
N
Legend
County Line
State highway and Route No.
River or Creek
City or Town
Project location
SITE LOCATION MAP
BUICK MINE TAILINGS DAM
MO 30162
Fig. 1

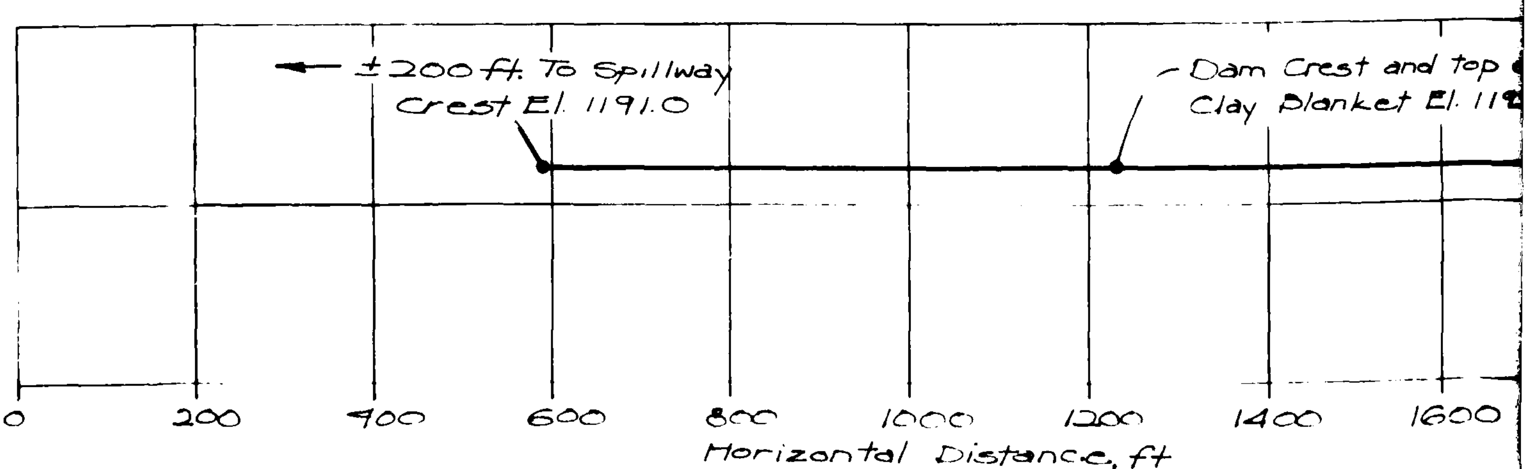


Note:
1. Topography from USGS Greeley (1967) and Oates (1967) 7.5-minute quadrangle maps.

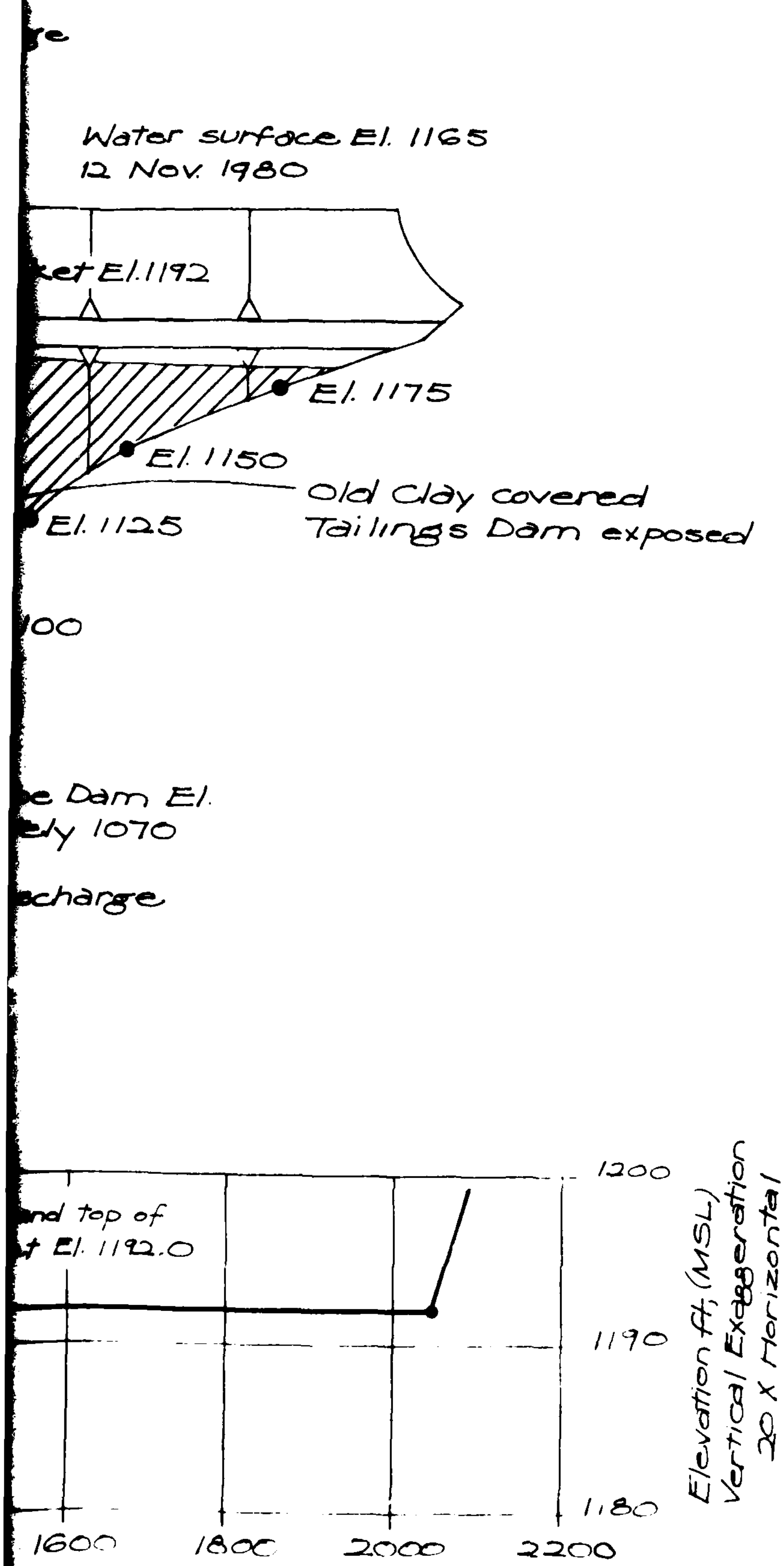
DRAINAGE BASIN AND SITE TOPOGRAPHY	
BUICK MINE TAILINGS DAM	
MO 30162	Fig. 2



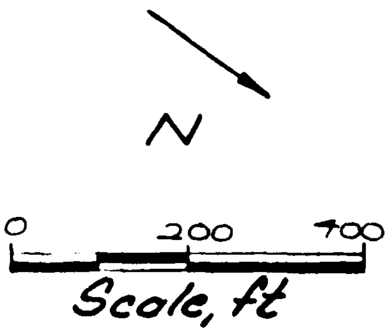
PLAN OF DAM



DAM PROFILE



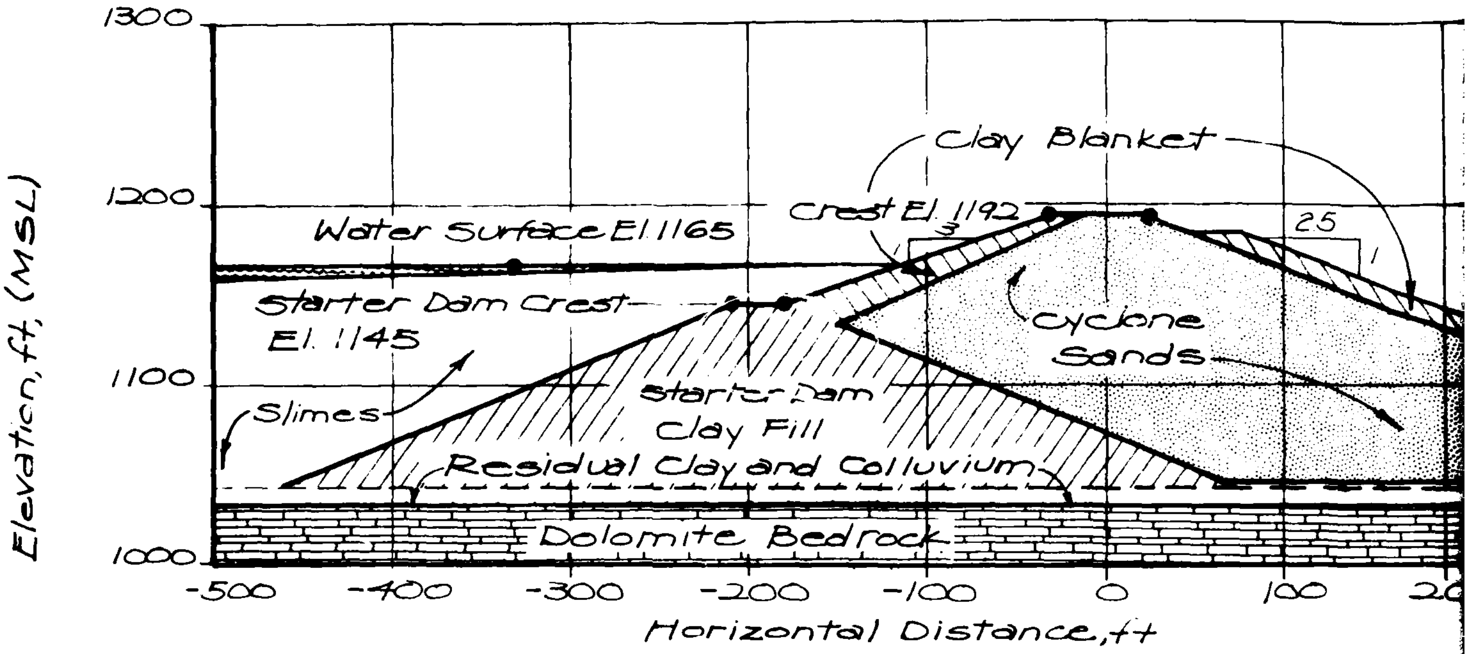
Note:
Permanent Spillway, to be located on the south-east bank of impoundment, not yet constructed at time of inspection.



PLAN AND PROFILE OF DAM

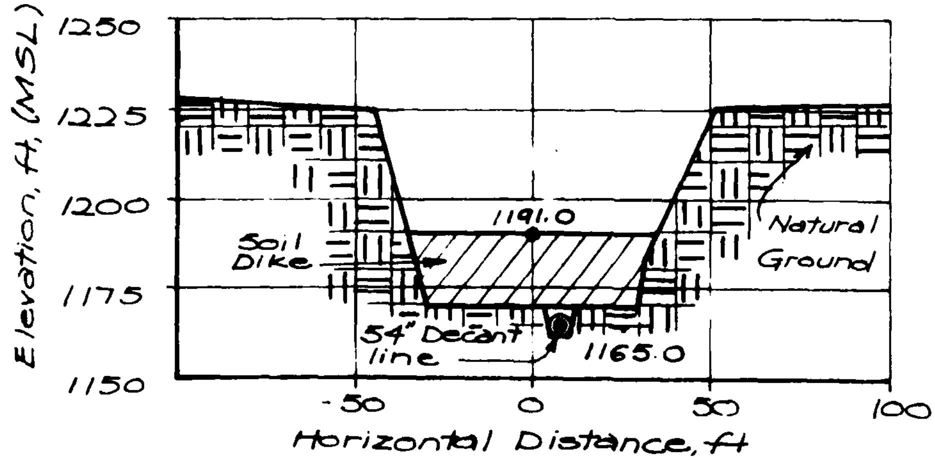
BUICK MINE TAILINGS DAM

MO 30162	Fig. 3-A



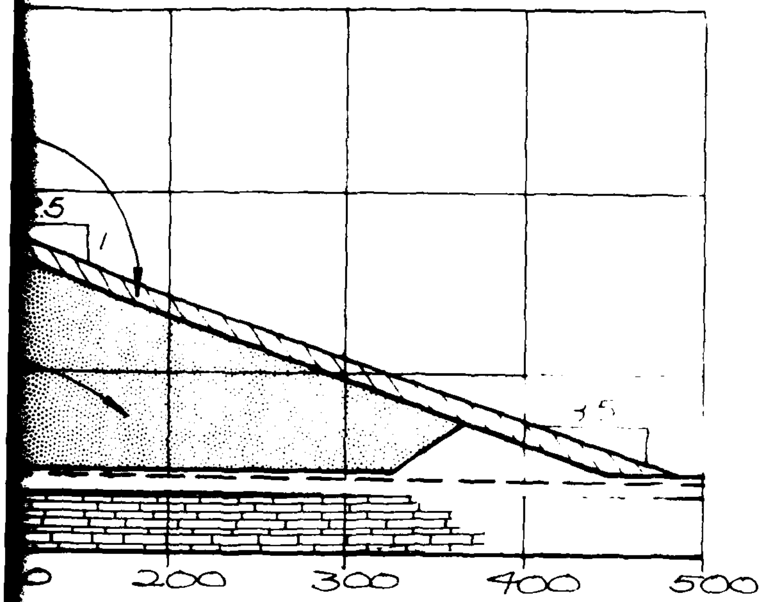
SECTION A-A

Maximum Dam Section
(Note 1)



SECTION B-B

Spillway Section

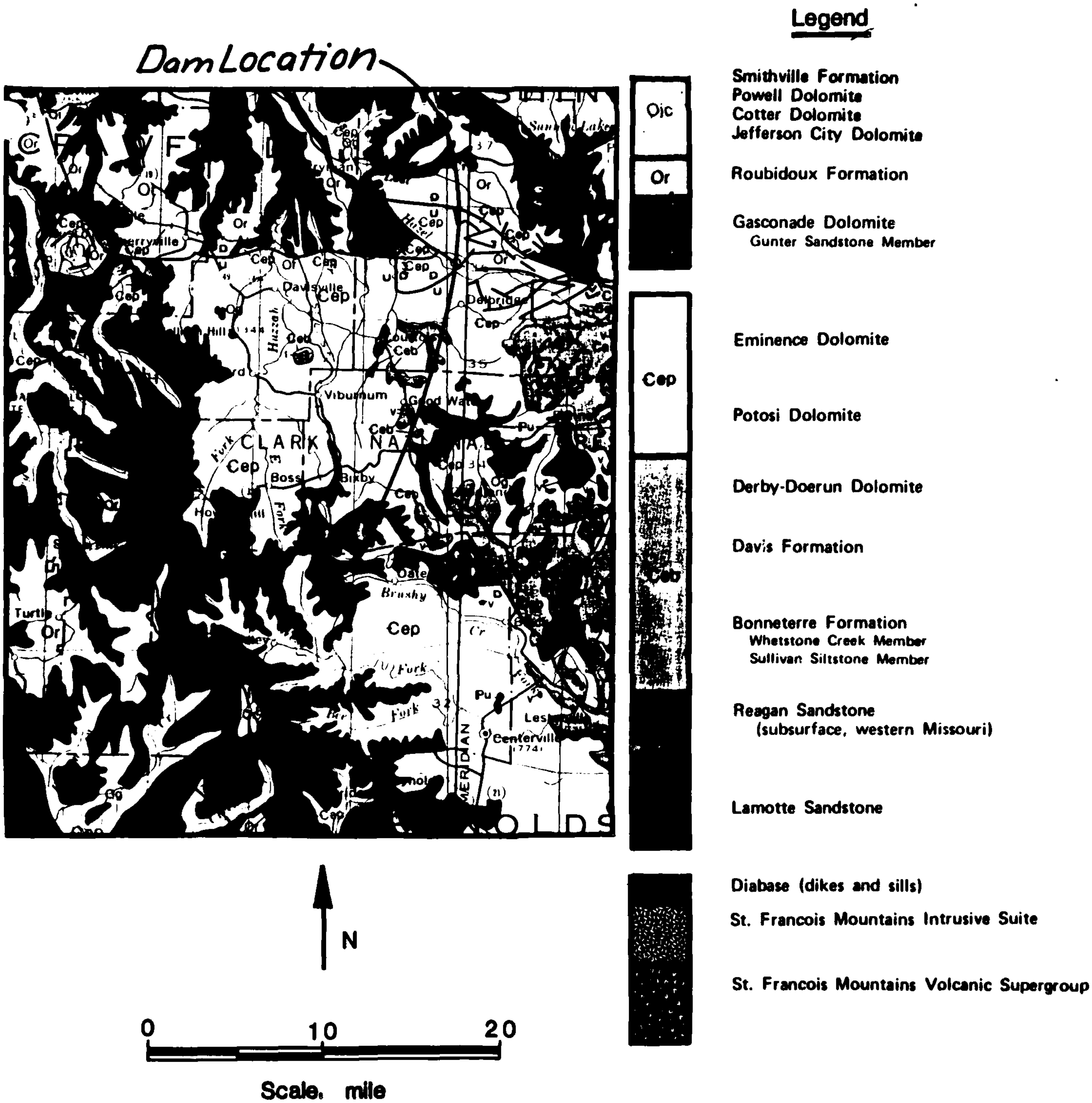


Note:
1. From Barr Emergency Report, Fig. 23
2. Slope inclinations from Visual inspection measurements

DAM AND SPILLWAY CROSS SECTIONS

BUICK MINE TAILINGS DAM

MO 30162 | Fig. 3-B



REGIONAL GEOLOGIC MAP

BUICK MINE TAILINGS DAM

MO 30162 | Fig. 4

APPENDIX A

Photographs

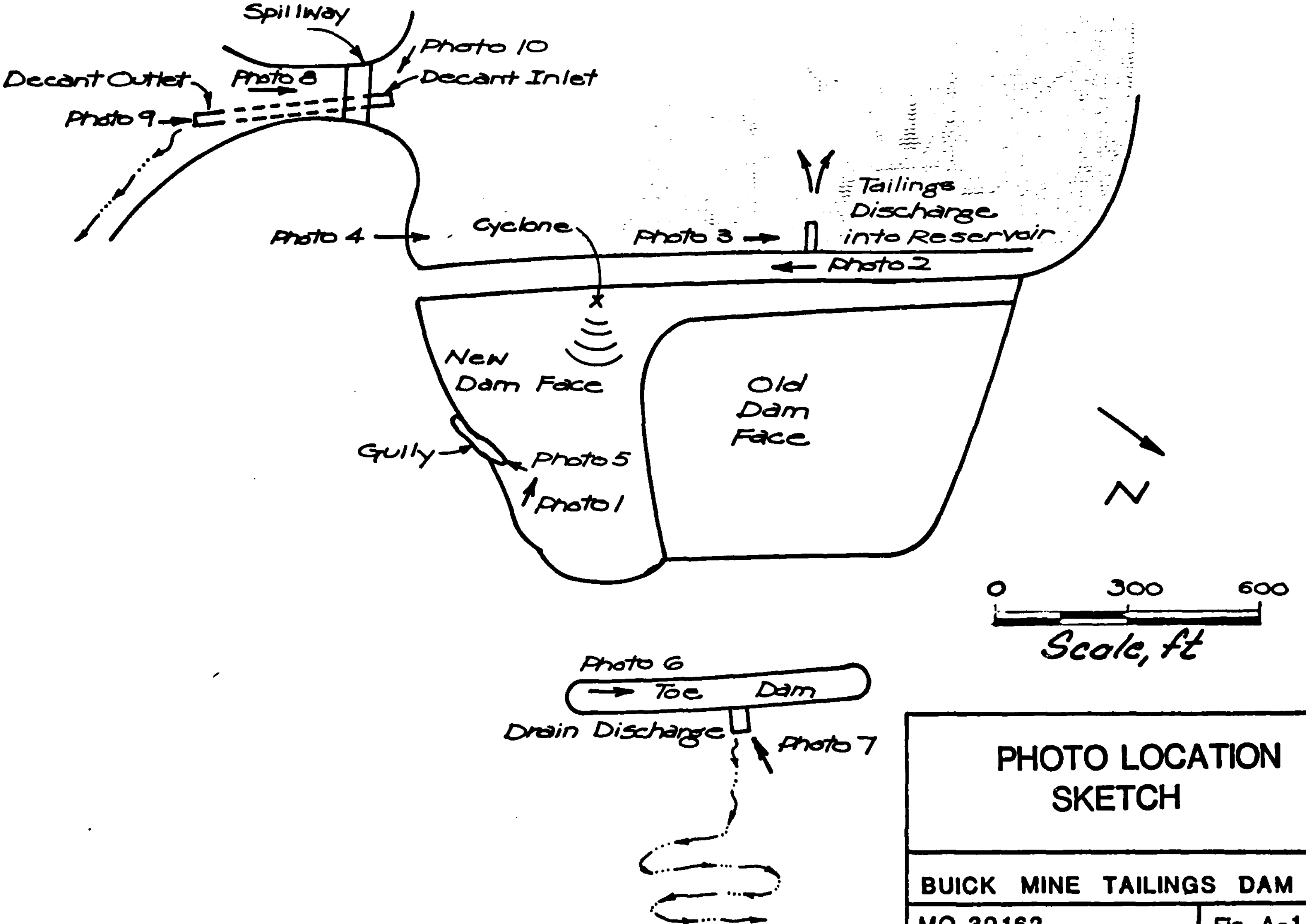
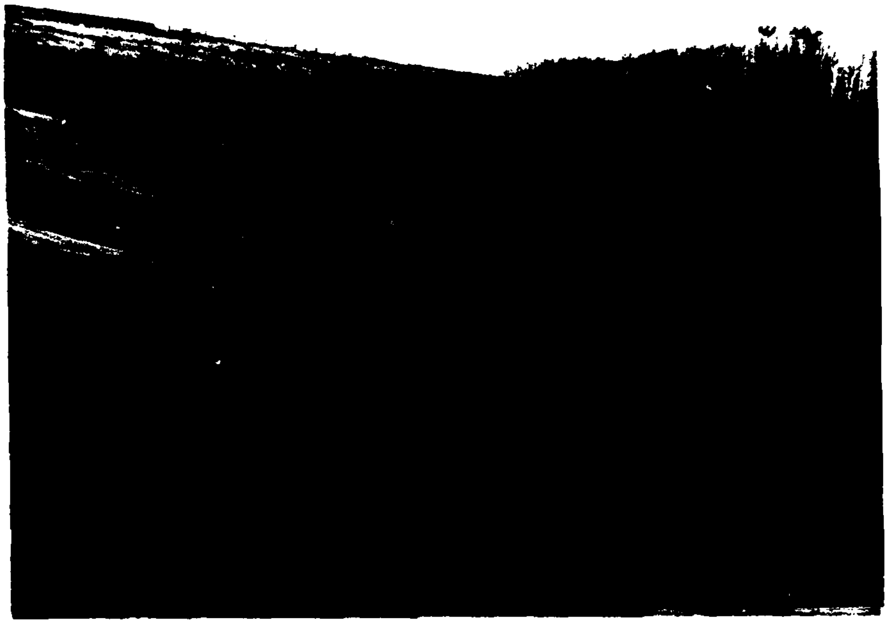


PHOTO LOCATION SKETCH

BUICK MINE TAILINGS DAM

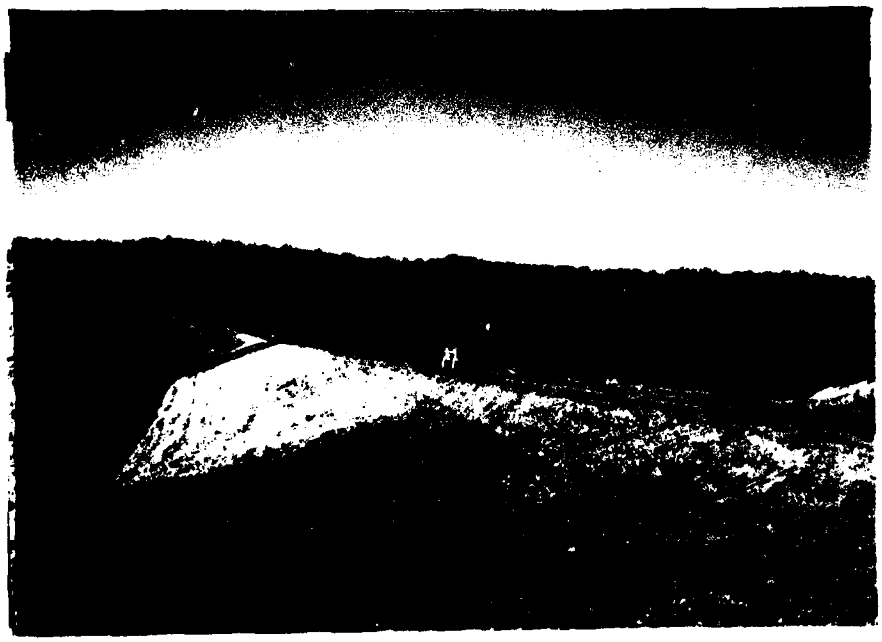
MO 30162	Fig. A-1



1. Downstream face of dam showing newly deposited tailings in the foreground and earth cover to earlier tailings portion of the dam in background. Looking northwest.

2. Cyclone depositing tailings on the downstream face of the dam. Pipes in the foreground carry unsorted tailings from the mill to the cyclone, and fine tailings from the cyclone to be discharged into the reservoir. Looking southeast along crest of dam.

3. Pipe discharging fine tailings from the cyclone into the reservoir area. Reservoir to the left, dam crest to the right. Looking northwest.



4. View along crest of dam from right abutment. Looking northwest.

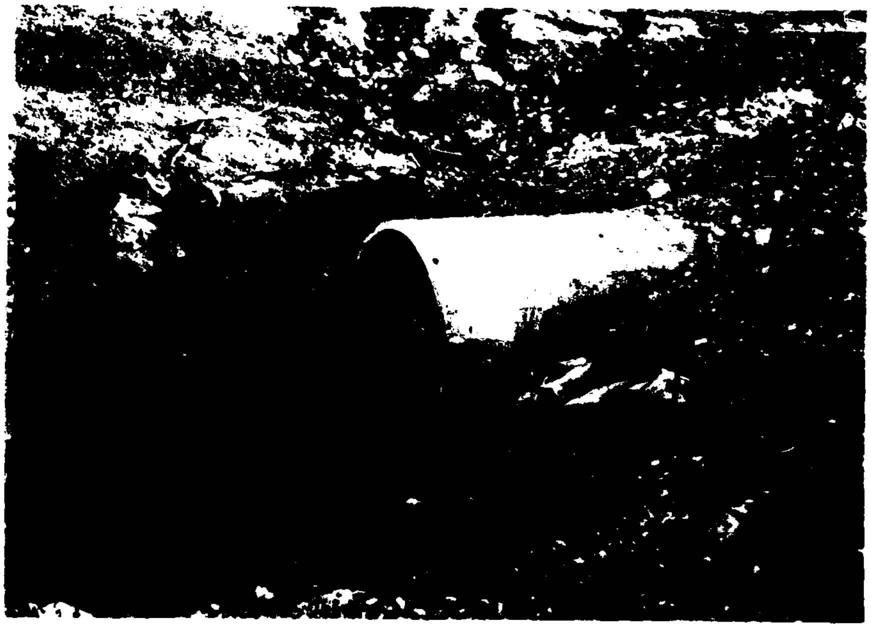
5. Erosion gully at junction of embankment and right abutment. Appears to be the result of slopewash from the abutment. Looking southwest.

6. Crest and downstream face of toe dam below Buick Mine Tailings Dam. Upstream slope covered by pushed up tailings. Looking northwest.

7. Outlet for drainfield at base of toe dam. Flow estimated at 100 gal/min at time of inspection. Looking southwest.

8. Spillway cut through hillside to the south of the dam and reservoir. Soil embankment at far end of (upstream) is 1 ft lower than crest of dam. Decant line runs beneath the fill placed on the floor of this cut. Looking northwest (upstream in spillway channel).

9. Outlet for decant discharge. Concrete post (right foreground) and riprap are for energy dissipation. Looking northwest (upstream) in spillway discharge channel.



10. Trash rack at inlet to decant line. Looking east.

APPENDIX B

Hydraulic/Hydrologic Data and Analyses

APPENDIX B
Hydraulic/Hydrologic Data and Analyses

B.1 Procedures

a. General. The hydraulic/hydrologic analyses were performed using the "HEC-1, Dam Safety Version (1 Apr 80)" computer program. The inflow hydrographs were developed for various precipitation events by applying them to a synthetic unit hydrograph. The inflow hydrographs were subsequently routed through the reservoir and appurtenant structures by the modified Puls reservoir routing option.

b. Precipitation events. The Probable Maximum Precipitation (PMP) and the 1 and 10 percent probability-of-occurrence events were used in the analyses. The total rainfall and corresponding distributions for the 1 and 10 percent probability events were provided by the St. Louis District, Corps of Engineers. The Probable Maximum Precipitation was determined from regional curves prepared by the US Weather Bureau (Hydrometeorological Report Number 33, 1956).

c. Unit hydrograph. The Soil Conservation Services (SCS) Dimensionless Unit Hydrograph method (National Engineering Handbook, Section 4, Hydrology, 1971) was used in the analysis. This method was selected because of its simplicity, applicability to drainage areas less than 10 mi^2, and its easy availability within the HEC-1 computer program.

The watershed lag time was computed using the SCS "curve number method" by an empirical relationship as follows:

$$L = \frac{\ell^{0.8} (s+1)^{0.7}}{1900\ Y^{0.5}} \qquad \text{(Equation 15-4)}$$

where:
- L = lag in hours
- ℓ = hydraulic length of the watershed in feet = 11,000
- $s = \frac{1000}{CN} - 10 = 3.2$
- CN = hydrologic soil curve number as indicated in Section B.2e.
- Y = average watershed land slope in percent = 4.2.

This empirical relationship accounts for the soil cover, average watershed slope and hydraulic length.

With the lag time thus computed, another empirical relationship is used to compute the time of concentration as follows:

$$T_c = \frac{L}{0.6} \qquad \text{(Equation 15-3)}$$

where: T_c = time of concentration in hours

L = lag in hours.

Subsequent to the computation of the time of concentration, the unit hydrograph duration was estimated utilizing the following relationship:

$$\Delta D = 0.133T_c \qquad \text{(Equation 16-12)}$$

where: ΔD = duration of unit excess rainfall
T_c = time of concentration in hours.

The final interval was selected to provide at least three discharge ordinates prior to the peak discharge ordinate of the unit hydrograph. For this dam, a time interval of 15 minutes was used.

d. Infiltration losses. The infiltration losses were computed by the HEC-1 computer program internally using the SCS curve number method. The curve numbers were established taking into consideration the variables of: (a) antecedent moisture condition, (b) hydrologic soil group classification, (c) degree of development, (d) vegetative cover and (e) present land usage in the watershed.

Antecedent moisture condition III (AMC III) was used for the PMF events and AMC II was used for the 1 and 10 percent probability events, in accordance with the guidelines. The remaining variables are defined in the SCS procedure and judgements in their selection were made on the basis of visual field inspection.

e. Starting elevations. Reservoir starting water surface elevations for this dam were set as follows:

(1) 1 and 10 percent probability events - decant pipe elevation

(2) Probable Maximum Storm - fixed by antecedent storm

f. Spillway Rating Curve. The basic weir equation was utilized to compute the spillway rating curve. The weir equation is as follows:

$$Q = CLH^{3/2}$$

where Q = discharge in cubic feet per second
L = effective length of spillway in feet = 70
C = coefficient of discharge = 2.8
H = total head over spillway in feet

The flow through the decant pipe outlet was calculated and compared to the discharge rating curve provided by AMAX. The two capacities were in relatively close agreement, with the AMAX capacity being smaller. For reasons of conservatism, the smaller AMAX discharge capacity was used.

B.2 Pertinent Data

a. Drainage area. 3.8 mi^2

b. Storm duration. A unit hydrograph was developed by the SCS method option of HEC-1 program. The design storm of 48 hours duration was divided into 15-minute intervals in order to develop the inflow hydrograph.

c. Lag time. 1.2 hrs

d. Hydrologic soil group. C & D

e. SCS curve numbers.

1. For PMF- AMC III - Curve Number 89
2. For 1 and 10 percent probability-of-occurrence events - AMC II - Curve Number 76

f. Storage. Elevation-area data were developed by planimetering areas at various elevation contours on the AMAX Lead Co. topographic map. The data were entered on the $A and $E cards so that the HEC-1 program could compute storage volumes.

(Storage volume calculated by HEC-1 did not include dead storage between elevation 1051 (zero storage) and elevation 1141. Storage figures in text of report include 6300 ac-ft storage between elevations 1051 and 1141. This change in dead storage volume does not affect overtopping or flood routing analyses.)

g. Outflow over dam crest. As the profile of the dam crest is level, flow over the crest was computed within the HEC-1 program. The crest length-elevation data and hydraulic constants were entered on the $D card.

h. Outflow capacity. A combined rating curve was obtained by combining decant pipe outflow and flow over the spillway.

The results of the above were entered on the Y4 and Y5 cards of the HEC-1 program.

i. Reservoir elevations. For the 50 and 100 percent of the PMF events, the starting reservoir elevations were fixed by the antecedent storm at 1173.7 and 1177.5, respectively. For the 1 and 10 percent probability-of-occurrence events, the starting reservoir elevation was 1165 ft, the decant pipe elevation.

B.3 Results

The results of the analyses as well as the input values to the HEC-1 program follow in this Appendix. Only the result summaries are included, not the intermediate output. Complete copies of the HEC-1 output are available in the project files.

```
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
********************************
    1               A1     DAM NO. 30162 BUICK MINE (AMAX LEAD CO.)
    2               A2     WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB 80C224
    3               A3     PROBABLE MAXIMUM FLOOD (PMF)
    4               B     200       0      15       0       0       0       0       0       0       0
    5               B1      5
    6               J       1       1       1
    7               J1    1.0
    8               K       0    LAKE                                        1
    9               K1     PROBABLE MAXIMUM FLOOD INFLOW HYDROGRAPH CALCULATION
   10               M       1       2     3.8                       1.0
   11               P       0    26.0     102     120     130     140
   12               T                                                       -1     -89             .11
   13               W2            1.2
   14               X      -1    -.05       5
   15               K       1     DAM                                        1
   16               K1     PMF ROUTING AND OVERTOPPING ANALYSIS
   17               Y                               1       1
   18               Y1      1                                          -1177.5      -1
   19               Y41170.0  1172.0  1174.0  1176.0  1178.0  1179.0  1180.0  1190.0  1191.0  1191.5
   20               Y41192.0  1193.0
   21               Y5     0.    30.0   120.0   225.0   280.0   295.0   300.0   380.0   390.0   465.0
   22               Y5 600.0   950.0
   23               $A 140.0   170.0   210.0   270.0   330.0   390.0   404.0   460.0
   24               $E1141.0  1150.0  1160.0  1170.0  1180.0  1190.0  1192.0  1200.0
   25               $$1191.0
   26               $D1192.0     2.8     1.5  2480.0
   27               K      99
```

Input Data
Various PMF Events
Buick Mine Tailings Dam
MO 30162
B4

Output Summary
Various PMF Events
Buick Mine Tailings Dam
MO 30162
B5

```
**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION       JULY 1978
 LAST MODIFICATION  26 FEB 79
**********************************

RUN  DATE? 81/02/04.
     TIME? 15.48.40.

                   DAM NO. 30162 BUICK MINE (AMAX LEAD CO.)
                   WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB 80C224
                   PROBABLE MAXIMUM FLOOD (PMF)

                                 JOB SPECIFICATION
          NO     NHR    NMIN    IDAY     IHR    IMIN   METRC    IPLT    IPRT   NSTAN
         200       0      15       0       0       0       0       0       0       0
                               JOPER     NWT   LROPT   TRACE
                                   5       0       0       0

                            MULTI-PLAN ANALYSES TO BE PERFORMED
                                NPLAN= 1 NRTIO= 1 LRTIO= 1
          RTIOS=   1.00

      **********      **********      **********      **********      **********

                               SUB-AREA RUNOFF COMPUTATION

                   PROBABLE MAXIMUM FLOOD INFLOW HYDROGRAPH CALCULATION

                       ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                        LAKE       0       0       0       0       0       1       0       0

                                      HYDROGRAPH DATA
          IHYDG    IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
              1       2    3.80    0.00    3.80    1.00   0.000       0       0       0

                                        PRECIP DATA
                      SPFE     PNS      R6     R12     R24     R48     R72     R96
                      0.00   26.00  102.00  120.00  130.00  140.00    0.00    0.00

                                         LOSS DATA
        LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
            0    0.00    0.00    1.00    0.00    0.00    1.00   -1.00  -89.00    0.00     .11

          CURVE NO =  -89.00  WETNESS =   -1.00  EFFECT CN =   89.00

                                    UNIT HYDROGRAPH DATA
                                  TC=  0.00    LAG=  1.20

                                       RECESSION DATA
                            STRTQ=   -1.00    ORCSN=    -.05    RTIOR= 5.00

             UNIT HYDROGRAPH 26 END OF PERIOD ORDINATES, TC=    0.00 HOURS, LAG=   1.20  VOL= 1.00
        129.      392.      825.     1220.     1378.     1345.     1169.      927.      640.      468.
        350.      260.      189.      140.      102.       74.       55.       40.       30.       22.
```

Output Summary
Various PMF Events
Buick Mine Tailings Dam
MO 30162
B6

END-OF-PERIOD FLOW

O NO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.15	1	.00	.00	.00	3.	1.02	1.15	101	.04	.04	.00	180.
1.01	.30	2	.00	.00	.00	3.	1.02	1.30	102	.04	.04	.00	226.
1.01	.45	3	.00	.00	.00	3.	1.02	1.45	103	.04	.04	.00	267.
1.01	1.00	4	.00	.00	.00	3.	1.02	2.00	104	.04	.04	.00	299.
1.01	1.15	5	.00	.00	.00	3.	1.02	2.15	105	.04	.04	.00	322.
1.01	1.30	6	.00	.00	.00	3.	1.02	2.30	106	.04	.04	.00	339.
1.01	1.45	7	.00	.00	.00	4.	1.02	2.45	107	.04	.04	.00	352.
1.01	2.00	8	.00	.00	.00	4.	1.02	3.00	108	.04	.04	.00	362.
1.01	2.15	9	.00	.00	.00	4.	1.02	3.15	109	.04	.04	.00	369.
1.01	2.30	10	.00	.00	.00	4.	1.02	3.30	110	.04	.04	.00	374.
1.01	2.45	11	.00	.00	.00	4.	1.02	3.45	111	.04	.04	.00	379.
1.01	3.00	12	.00	.00	.00	4.	1.02	4.00	112	.04	.04	.00	382.
1.01	3.15	13	.00	.00	.00	4.	1.02	4.15	113	.04	.04	.00	385.
1.01	3.30	14	.00	.00	.00	4.	1.02	4.30	114	.04	.04	.00	387.
1.01	3.45	15	.00	.00	.00	4.	1.02	4.45	115	.04	.04	.00	388.
1.01	4.00	16	.00	.00	.00	4.	1.02	5.00	116	.04	.04	.00	390.
1.01	4.15	17	.00	.00	.00	4.	1.02	5.15	117	.04	.04	.00	391.
1.01	4.30	18	.00	.00	.00	4.	1.02	5.30	118	.04	.04	.00	392.
1.01	4.45	19	.00	.00	.00	4.	1.02	5.45	119	.04	.04	.00	393.
1.01	5.00	20	.00	.00	.00	4.	1.02	6.00	120	.04	.04	.00	394.
1.01	5.15	21	.00	.00	.00	4.	1.02	6.15	121	.20	.18	.01	413.
1.01	5.30	22	.00	.00	.00	4.	1.02	6.30	122	.20	.18	.01	470.
1.01	5.45	23	.00	.00	.00	4.	1.02	6.45	123	.20	.19	.01	599.
1.01	6.00	24	.00	.00	.00	4.	1.02	7.00	124	.20	.19	.01	784.
1.01	6.15	25	.02	.00	.01	4.	1.02	7.15	125	.20	.19	.01	963.
1.01	6.30	26	.02	.00	.01	4.	1.02	7.30	126	.20	.19	.01	1158.
1.01	6.45	27	.02	.00	.01	5.	1.02	7.45	127	.20	.19	.01	1329.
1.01	7.00	28	.02	.00	.01	7.	1.02	8.00	128	.20	.19	.01	1466.
1.01	7.15	29	.02	.00	.01	9.	1.02	8.15	129	.20	.19	.01	1582.
1.01	7.30	30	.02	.00	.01	10.	1.02	8.30	130	.20	.19	.01	1634.
1.01	7.45	31	.02	.00	.01	12.	1.02	8.45	131	.20	.19	.01	1689.
1.01	8.00	32	.02	.00	.01	13.	1.02	9.00	132	.20	.19	.01	1731.
1.01	8.15	33	.02	.00	.01	14.	1.02	9.15	133	.20	.19	.01	1769.
1.01	8.30	34	.02	.00	.01	15.	1.02	9.30	134	.20	.19	.01	1787.
1.01	8.45	35	.02	.00	.01	15.	1.02	9.45	135	.20	.19	.00	1808.
1.01	9.00	36	.02	.00	.01	15.	1.02	10.00	136	.20	.19	.00	1820.
1.01	9.15	37	.02	.00	.01	16.	1.02	10.15	137	.20	.19	.00	1832.
1.01	9.30	38	.02	.00	.01	16.	1.02	10.30	138	.20	.19	.00	1841.
1.01	9.45	39	.02	.00	.01	17.	1.02	10.45	139	.20	.19	.00	1848.
1.01	10.00	40	.02	.00	.01	18.	1.02	11.00	140	.20	.19	.00	1854.
1.01	10.15	41	.02	.00	.01	19.	1.02	11.15	141	.20	.19	.00	1859.
1.01	10.30	42	.02	.00	.01	21.	1.02	11.30	142	.20	.19	.00	1863.
1.01	10.45	43	.02	.00	.01	23.	1.02	11.45	143	.20	.19	.00	1867.
1.01	11.00	44	.02	.00	.01	25.	1.02	12.00	144	.20	.19	.00	1870.
1.01	11.15	45	.02	.00	.01	27.	1.02	12.15	145	.66	.65	.01	1931.
1.01	11.30	46	.02	.00	.01	30.	1.02	12.30	146	.66	.65	.01	2114.
1.01	11.45	47	.02	.00	.01	32.	1.02	12.45	147	.66	.66	.01	2497.
1.01	12.00	48	.02	.00	.01	35.	1.02	13.00	148	.66	.66	.01	3063.
1.01	12.15	49	.05	.02	.03	39.	1.02	13.15	149	.80	.79	.01	3719.
1.01	12.30	50	.05	.02	.03	46.	1.02	13.30	150	.80	.79	.01	4396.
1.01	12.45	51	.05	.02	.03	60.	1.02	13.45	151	.80	.79	.01	5049.
1.01	13.00	52	.05	.02	.03	81.	1.02	14.00	152	.80	.79	.00	5644.
1.01	13.15	53	.06	.03	.03	107.	1.02	14.15	153	.99	.99	.01	6152.
1.01	13.30	54	.06	.03	.03	136.	1.02	14.30	154	.99	.99	.00	6629.
1.01	13.45	55	.06	.04	.03	166.	1.02	14.45	155	.99	.99	.00	7114.
1.01	14.00	56	.06	.04	.02	198.	1.02	15.00	156	.99	.99	.00	7603.
1.01	14.15	57	.08	.05	.03	230.	1.02	15.15	157	1.01	1.00	.00	8099.
1.01	14.30	58	.08	.05	.03	262.	1.02	15.30	158	2.02	2.01	.01	9586.
1.01	14.45	59	.08	.05	.02	297.	1.02	15.45	159	5.64	5.63	.01	9789.
1.01	15.00	60	.08	.05	.02	334.	1.02	16.00	160	1.41	1.41	.00	11766.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.02	16.15	161	.93	.93	.00	14463.

1.01	15.15	61	.08	.06	.02	370.	1.02	16.15	161	.93	.93	.00	14463.
1.01	15.30	62	.16	.12	.04	413.	1.02	16.30	162	.93	.93	.00	16743.
1.01	15.45	63	.43	.35	.09	497.	1.02	16.45	163	.93	.93	.00	17652.
1.01	16.00	64	.11	.09	.02	632.	1.02	17.00	164	.93	.93	.00	17378.
1.01	16.15	65	.07	.06	.01	814.	1.02	17.15	165	.73	.73	.00	16235.
1.01	16.30	66	.07	.06	.01	973.	1.02	17.30	166	.73	.73	.00	14619.
1.01	16.45	67	.07	.06	.01	1045.	1.02	17.45	167	.73	.73	.00	12809.
1.01	17.00	68	.07	.06	.01	1049.	1.02	18.00	168	.73	.73	.00	11484.
1.01	17.15	69	.06	.05	.01	994.	1.02	18.15	169	.07	.06	.00	10386.
1.01	17.30	70	.06	.05	.01	907.	1.02	18.30	170	.07	.06	.00	9301.
1.01	17.45	71	.06	.05	.01	805.	1.02	18.45	171	.07	.06	.00	8069.
1.01	18.00	72	.06	.05	.01	731.	1.02	19.00	172	.07	.06	.00	6787.
1.01	18.15	73	.00	.00	.00	668.	1.02	19.15	173	.07	.06	.00	5519.
1.01	18.30	74	.00	.00	.00	604.	1.02	19.30	174	.07	.06	.00	4357.
1.01	18.45	75	.00	.00	.00	529.	1.02	19.45	175	.07	.06	.00	3391.
1.01	19.00	76	.00	.00	.00	446.	1.02	20.00	176	.07	.06	.00	2635.
1.01	19.15	77	.00	.00	.00	364.	1.02	20.15	177	.07	.06	.00	2107.
1.01	19.30	78	.00	.00	.00	288.	1.02	20.30	178	.07	.06	.00	1719.
1.01	19.45	79	.00	.00	.00	225.	1.02	20.45	179	.07	.06	.00	1432.
1.01	20.00	80	.00	.00	.00	175.	1.02	21.00	180	.07	.06	.00	1221.
1.01	20.15	81	.00	.00	.00	140.	1.02	21.15	181	.07	.06	.00	1064.
1.01	20.30	82	.00	.00	.00	115.	1.02	21.30	182	.07	.06	.00	945.
1.01	20.45	83	.00	.00	.00	96.	1.02	21.45	183	.07	.06	.00	854.
1.01	21.00	84	.00	.00	.00	82.	1.02	22.00	184	.07	.06	.00	786.
1.01	21.15	85	.00	.00	.00	72.	1.02	22.15	185	.07	.06	.00	739.
1.01	21.30	86	.00	.00	.00	64.	1.02	22.30	186	.07	.06	.00	709.
1.01	21.45	87	.00	.00	.00	58.	1.02	22.45	187	.07	.06	.00	687.
1.01	22.00	88	.00	.00	.00	54.	1.02	23.00	188	.07	.06	.00	671.
1.01	22.15	89	.00	.00	.00	51.	1.02	23.15	189	.07	.06	.00	660.
1.01	22.30	90	.00	.00	.00	49.	1.02	23.30	190	.07	.06	.00	651.
1.01	22.45	91	.00	.00	.00	47.	1.02	23.45	191	.07	.06	.00	644.
1.01	23.00	92	.00	.00	.00	46.	1.03	0.00	192	.07	.06	.00	640.
1.01	23.15	93	.00	.00	.00	45.	1.03	.15	193	0.00	0.00	0.00	629.
1.01	23.30	94	.00	.00	.00	45.	1.03	.30	194	0.00	0.00	0.00	603.
1.01	23.45	95	.00	.00	.00	44.	1.03	.45	195	0.00	0.00	0.00	549.
1.02	0.00	96	.00	.00	.00	44.	1.03	1.00	196	0.00	0.00	0.00	470.
1.02	.15	97	.04	.04	.00	48.	1.03	1.15	197	0.00	0.00	0.00	400.
1.02	.30	98	.04	.04	.00	62.	1.03	1.30	198	0.00	0.00	0.00	341.
1.02	.45	99	.04	.04	.00	90.	1.03	1.45	199	0.00	0.00	0.00	290.
1.02	1.00	100	.04	.04	.00	132.	1.03	2.00	200	0.00	0.00	0.00	247.
									SUM	36.40	35.12	1.28	344108.
										(925.)(	892.)(	33.)(	9744.05)

Output Summary
Various PMF Events
Buick Mine Tailings Dam
MO 30162
B7

Output Summary
Various PMF Events
Buick Mine Tailings Dam
MO 30162
B8

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

OPERATION	STATION	AREA	PLAN	RATIO 1 1.00
HYDROGRAPH AT	LAKE	3.80 (9.84)	1	17652. (499.84)(
ROUTED TO	DAM	3.80 (9.84)	1	3918. (110.95)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1177.50	1191.00	1192.00
STORAGE	7873.	12667.	13068.
OUTFLOW	200.	390.	600.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	1192.59	.59	13306.	3918.	7.25	43.50	0.00

Output Summary
Various PMF Events
Buick Mine Tailings Dam
MO 30162
B9

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

OPERATION	STATION	AREA	PLAN	RATIO 1 .50
HYDROGRAPH AT	LAKE	3.80	1	8826.
		(9.84)		(249.92)(
ROUTED TO	DAM	3.80	1	323.
		(9.84)		(9.15)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1173.70	1191.00	1192.00
STORAGE	6722.	12667.	13068.
OUTFLOW	106.	390.	600.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	1182.88	0.00	9653.	323.	0.00	47.75	0.00

Output Summary
Various PMF Events
Buick Mine Tailings Dam
MO 30162
B10

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

OPERATION	STATION	AREA	PLAN	RATIO 1 .95
HYDROGRAPH AT	LAKE	3.80	1	16769.
		(9.84)		(474.85)(
ROUTED TO	DAM	3.80	1	1008.
		(9.84)		(28.53)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1176.70	1191.00	1192.00
STORAGE	7623.	12667.	13068.
OUTFLOW	244.	390.	600.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.95	1192.14	.14	13124.	1008.	5.50	45.25	0.00

```
***********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
***********************************
A1       DAM NO. 30162 BUICK MINE (AMAX LEAD CO.)
A2       WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB 80C224
A3       PROBABILISTIC FLOOD  100-YEAR
B      192       0      15       0       0       0       0       0       0       0
B1       3
K        0    LAKE                                     1
K1    RAIN STA--18=LESTRVL -- FREQ=10.0: -- INTERVAL=  15MIN -- DURATION=  48HR
M        0       2     3.8                     1.0
O      192   8.838                  DA =    5.00
O1    .016    .016    .016    .016    .016    .016    .016    .016    .016    .016
O1    .016    .016    .016    .016    .016    .016    .016    .016    .016    .016
O1    .016    .016    .016    .016    .016    .016    .016    .016    .016    .016
O1    .016    .016    .016    .016    .016    .016    .016    .016    .016    .016
O1    .016    .016    .016    .016    .016    .016    .016    .016    .016    .016
O1    .016    .016    .016    .016    .016    .016    .016    .016    .016    .016
O1    .016    .016    .016    .016    .016    .016    .016    .016    .016    .016
O1    .016    .016    .016    .016    .016    .016    .016    .016    .016    .016
O1    .016    .016    .016    .016    .016    .016    .016    .016    .016    .016
O1    .016    .016    .016    .016    .016    .016    .021    .021    .021    .021
O1    .021    .021    .021    .021    .021    .021    .021    .021    .021    .021
O1    .021    .021    .021    .021    .021    .021    .021    .021    .021    .021
O1    .041    .041    .041    .041    .042    .042    .042    .042    .042    .042
O1    .042    .042    .042    .042    .042    .042    .042    .042    .042    .042
O1    .042    .041    .041    .041    .075    .076    .076    .076    .076    .076
O1    .102    .102    .178    .180    .424    .769   1.685    .431    .181    .179
O1    .102    .102    .076    .076    .076    .076    .076    .076    .021    .021
O1    .021    .021    .021    .021    .021    .021    .021    .021    .021    .021
O1    .021    .021    .021    .021    .021    .021    .021    .021    .021    .021
O1    .021    .021
T                                                     -1     -76             .11
W2             1.2
X       -1    -.05       5
K        1     DAM                                     1
K1       100-YEAR FLOOD ROUTING AND OVERTOPPING ANALYSIS
Y                                1
Y1       1                                       -1170.0      -1
Y41170.0  1172.0  1174.0  1176.0  1178.0  1179.0  1180.0  1190.0  1191.0  1191.5
Y41192.0  1193.0
Y5    0.    30.0   120.0   225.0   280.0   295.0   300.0   380.0   390.0   465.0
Y5 600.0   950.0
$A 140.0   170.0   210.0   270.0   330.0   390.0   404.0   460.0
$E1141.0  1150.0  1160.0  1170.0  1180.0  1190.0  1192.0  1200.0
$S1191.0
$D1192.0     2.8     1.5  2480.0
K       99
```

Input Data
1% Probability Event
Buick Mine Tailings Dam
MO 30162
B11

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*********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
*********************************

RUN  DATE? 81/02/04.
     TIME? 15.18.15.

                         DAM NO. 30162 BUICK MINE (AMAX LEAD CO.)
                         WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB 80C224
                         PROBABILISTIC FLOOD  100-YEAR

                                        JOB SPECIFICATION
               NQ     NHR    NMIN    IDAY     IHR    IMIN   METRC    IPLT    IPRT   NSTAN
              192       0      15       0       0       0       0       0       0       0
                                    JOPER     NWT   LROPT   TRACE
                                        3       0       0       0

          **********      **********      **********      **********      **********

                                    SUB-AREA RUNOFF COMPUTATION

              RAIN STA--18-LESTRV  -- FREQ=10.0: -- INTERVAL=  15MIN -- DURATION=  48HR

                            ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                             LAKE       0       0       0       0       0       1       0       0

                                        HYDROGRAPH DATA
              IHYDG    IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
                  0       2    3.80    0.00    3.80    1.00   0.000       0       0       0

                                          PRECIP DATA
                                   NP   STORM     DAJ     DAK
                                  192    8.84    0.00    0.00
                                        PRECIP PATTERN
             .02     .02     .02     .02     .02     .02     .02     .02     .02     .02
             .02     .02     .02     .02     .02     .02     .02     .02     .02     .02
             .02     .02     .02     .02     .02     .02     .02     .02     .02     .02
             .02     .02     .02     .02     .02     .02     .02     .02     .02     .02
             .02     .02     .02     .02     .02     .02     .02     .02     .02     .02
             .02     .02     .02     .02     .02     .02     .02     .02     .02     .02
             .02     .02     .02     .02     .02     .02     .02     .02     .02     .02
             .02     .02     .02     .02     .02     .02     .02     .02     .02     .02
             .02     .02     .02     .02     .02     .02     .02     .02     .02     .02
             .02     .02     .02     .02     .02     .02     .02     .02     .02     .02
             .02     .02     .02     .02     .02     .02     .02     .02     .02     .02
             .02     .02     .02     .02     .02     .02     .02     .02     .02     .02
             .04     .04     .04     .04     .04     .04     .04     .04     .04     .04
             .04     .04     .04     .04     .04     .04     .04     .04     .04     .04
             .04     .04     .04     .04     .09     .08     .09     .08     .09     .08
             .10     .10     .18     .18     .42     .77    1.69     .43     .18     .19
             .10     .10     .09     .08     .09     .08     .09     .08     .02     .02
             .02     .02     .02     .02     .02     .02     .02     .02     .02     .02
             .02     .02     .02     .02     .02     .02     .02     .02     .02     .02
```

Output Summary
1% Probability Event
Buick Mine Tailings Dam
MO 30162
B12

Output Summary
1% Probability Event
Buick Mine Tailings Dam
MO 30162
B13

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-76.00	0.00	.11

CURVE NO = -76.00 WETNESS = -1.00 EFFECT CN = 76.00

UNIT HYDROGRAPH DATA

TC= 0.00 LAG= 1.20

RECESSION DATA

STRTQ= -1.00 QRCSN= -.05 RTIOR= 5.00

UNIT HYDROGRAPH 26 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= 1.20 VOL= 1.00

128.	392.	825.	1220.	1378.	1345.	1169.	927.	640.	468.
350.	260.	189.	140.	102.	74.	55.	40.	30.	22.
16.	13.	10.	7.	4.	1.				

0

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.15	1	.02	.00	.01	3.	1.02	.15	97	.02	.01	.01	68.
1.01	.30	2	.02	.00	.01	4.	1.02	.30	98	.02	.01	.01	70.
1.01	.45	3	.02	.00	.01	5.	1.02	.45	99	.02	.01	.01	73.
1.01	1.00	4	.02	.00	.01	6.	1.02	1.00	100	.02	.01	.01	76.
1.01	1.15	5	.02	.00	.01	9.	1.02	1.15	101	.02	.01	.01	80.
1.01	1.30	6	.02	.00	.01	11.	1.02	1.30	102	.02	.01	.01	84.
1.01	1.45	7	.02	.00	.01	13.	1.02	1.45	103	.02	.01	.01	87.
1.01	2.00	8	.02	.00	.01	14.	1.02	2.00	104	.02	.01	.01	91.
1.01	2.15	9	.02	.00	.01	15.	1.02	2.15	105	.02	.01	.01	93.
1.01	2.30	10	.02	.00	.01	16.	1.02	2.30	106	.02	.01	.01	95.
1.01	2.45	11	.02	.00	.01	16.	1.02	2.45	107	.02	.01	.01	97.
1.01	3.00	12	.02	.00	.01	16.	1.02	3.00	108	.02	.01	.01	99.
1.01	3.15	13	.02	.00	.01	17.	1.02	3.15	109	.02	.01	.01	100.
1.01	3.30	14	.02	.00	.01	17.	1.02	3.30	110	.02	.01	.01	101.
1.01	3.45	15	.02	.00	.01	17.	1.02	3.45	111	.02	.01	.01	103.
1.01	4.00	16	.02	.00	.01	17.	1.02	4.00	112	.02	.01	.01	104.
1.01	4.15	17	.02	.00	.01	17.	1.02	4.15	113	.02	.01	.01	105.
1.01	4.30	18	.02	.00	.01	17.	1.02	4.30	114	.02	.01	.01	106.
1.01	4.45	19	.02	.00	.01	17.	1.02	4.45	115	.02	.01	.01	107.
1.01	5.00	20	.02	.00	.01	17.	1.02	5.00	116	.02	.01	.01	108.
1.01	5.15	21	.02	.00	.01	17.	1.02	5.15	117	.02	.01	.01	109.
1.01	5.30	22	.02	.00	.01	17.	1.02	5.30	118	.02	.01	.01	110.
1.01	5.45	23	.02	.00	.01	17.	1.02	5.45	119	.02	.01	.01	111.
1.01	6.00	24	.02	.00	.01	17.	1.02	6.00	120	.02	.01	.01	112.
1.01	6.15	25	.02	.00	.01	17.	1.02	6.15	121	.04	.02	.02	114.
1.01	6.30	26	.02	.00	.01	17.	1.02	6.30	122	.04	.02	.02	119.
1.01	6.45	27	.02	.00	.01	17.	1.02	6.45	123	.04	.02	.02	130.
1.01	7.00	28	.02	.00	.01	17.	1.02	7.00	124	.04	.02	.02	145.
1.01	7.15	29	.02	.00	.01	17.	1.02	7.15	125	.04	.03	.02	162.
1.01	7.30	30	.02	.00	.01	17.	1.02	7.30	126	.04	.03	.02	180.
1.01	7.45	31	.02	.00	.01	17.	1.02	7.45	127	.04	.03	.02	195.
1.01	8.00	32	.02	.00	.01	17.	1.02	8.00	128	.04	.03	.02	209.
1.01	8.15	33	.02	.00	.01	17.	1.02	8.15	129	.04	.03	.02	220.
1.01	8.30	34	.02	.00	.01	17.	1.02	8.30	130	.04	.03	.02	228.
1.01	8.45	35	.02	.00	.01	17.	1.02	8.45	131	.04	.03	.01	235.
1.01	9.00	36	.02	.00	.01	17.	1.02	9.00	132	.04	.03	.01	241.
1.01	9.15	37	.02	.00	.01	17.	1.02	9.15	133	.04	.03	.01	247.
1.01	9.30	38	.02	.00	.01	17.	1.02	9.30	134	.04	.03	.01	251.
1.01	9.45	39	.02	.00	.01	17.	1.02	9.45	135	.04	.03	.01	255.
1.01	10.00	40	.02	.00	.01	17.	1.02	10.00	136	.04	.03	.01	258.
1.01	10.15	41	.02	.00	.01	17.	1.02	10.15	137	.04	.03	.01	261.
1.01	10.30	42	.02	.00	.01	17.	1.02	10.30	138	.04	.03	.01	264.
1.01	10.45	43	.02	.00	.01	17.	1.02	10.45	139	.04	.03	.01	267.

Output Summary
1% Probability Event
Buick Mine Tailings Dam
MO 30162
B14

1.01	11.15	45	.02	.00	.01	18.	1.	11.15	141	.04	.03	.01	272.
1.01	11.30	46	.02	.00	.01	19.	1.02	11.30	142	.04	.03	.01	274.
1.01	11.45	47	.02	.00	.01	20.	1.02	11.45	143	.04	.03	.01	276.
1.01	12.00	48	.02	.00	.01	21.	1.02	12.00	144	.04	.03	.01	278.
1.01	12.15	49	.02	.00	.01	22.	1.02	12.15	145	.07	.05	.02	282.
1.01	12.30	50	.02	.00	.01	23.	1.02	12.30	146	.08	.05	.07	293.
1.01	12.45	51	.02	.00	.01	24.	1.02	12.45	147	.08	.06	.02	314.
1.01	13.00	52	.02	.00	.01	25.	1.02	13.00	148	.08	.06	.02	346.
1.01	13.15	53	.02	.00	.01	26.	1.02	13.15	149	.08	.06	.02	383.
1.01	13.30	54	.02	.00	.01	28.	1.02	13.30	150	.08	.06	.02	419.
1.01	13.45	55	.02	.00	.01	29.	1.02	13.45	151	.10	.08	.02	454.
1.01	14.00	56	.02	.00	.01	30.	1.02	14.00	152	.10	.08	.02	489.
1.01	14.15	57	.02	.00	.01	31.	1.02	14.15	153	.18	.14	.04	533.
1.01	14.30	58	.02	.00	.01	32.	1.02	14.30	154	.18	.14	.04	597.
1.01	14.45	59	.02	.00	.01	34.	1.02	14.45	155	.42	.34	.08	719.
1.01	15.00	60	.02	.00	.01	35.	1.02	15.00	156	.76	.64	.13	942.
1.01	15.15	61	.02	.00	.01	36.	1.02	15.15	157	1.67	1.47	.20	1447.
1.01	15.30	62	.02	.00	.01	37.	1.02	15.30	158	.43	.39	.04	2234.
1.01	15.45	63	.02	.00	.01	38.	1.02	15.45	159	.18	.16	.02	3198.
1.01	16.00	64	.02	.00	.01	39.	1.02	16.00	160	.18	.16	.02	3982.
1.01	16.15	65	.02	.00	.01	40.	1.02	16.15	161	.10	.09	.01	4299.
1.01	16.30	66	.02	.00	.01	41.	1.02	16.30	162	.10	.09	.01	4195.
1.01	16.45	67	.02	.00	.01	42.	1.02	16.45	163	.08	.07	.01	3772.
1.01	17.00	68	.02	.01	.01	43.	1.02	17.00	164	.08	.07	.01	3184.
1.01	17.15	69	.02	.01	.01	44.	1.02	17.15	165	.08	.07	.01	2559.
1.01	17.30	70	.02	.01	.01	45.	1.02	17.30	166	.08	.07	.01	2092.
1.01	17.45	71	.02	.01	.01	46.	1.02	17.45	167	.08	.07	.01	1741.
1.01	18.00	72	.02	.01	.01	47.	1.02	18.00	168	.08	.07	.01	1467.
1.01	18.15	73	.02	.01	.01	48.	1.02	18.15	169	.02	.02	.00	1252.
1.01	18.30	74	.02	.01	.01	49.	1.02	18.30	170	.02	.02	.00	1080.
1.01	18.45	75	.02	.01	.01	50.	1.02	18.45	171	.02	.02	.00	925.
1.01	19.00	76	.02	.01	.01	51.	1.02	19.00	172	.02	.02	.00	781.
1.01	19.15	77	.02	.01	.01	52.	1.02	19.15	173	.02	.02	.00	652.
1.01	19.30	78	.02	.01	.01	53.	1.02	19.30	174	.02	.02	.00	540.
1.01	19.45	79	.02	.01	.01	54.	1.02	19.45	175	.02	.02	.00	449.
1.01	20.00	80	.02	.01	.01	55.	1.02	20.00	176	.02	.02	.00	378.
1.01	20.15	81	.02	.01	.01	56.	1.02	20.15	177	.02	.02	.00	329.
1.01	20.30	82	.02	.01	.01	56.	1.02	20.30	178	.02	.02	.00	293.
1.01	20.45	83	.02	.01	.01	57.	1.02	20.45	179	.02	.02	.00	266.
1.01	21.00	84	.02	.01	.01	58.	1.02	21.00	180	.02	.02	.00	244.
1.01	21.15	85	.02	.01	.01	59.	1.02	21.15	181	.02	.02	.00	227.
1.01	21.30	86	.02	.01	.01	60.	1.02	21.30	182	.02	.02	.00	214.
1.01	21.45	87	.02	.01	.01	60.	1.02	21.45	183	.02	.02	.00	205.
1.01	22.00	88	.02	.01	.01	61.	1.02	22.00	184	.02	.02	.00	201.
1.01	22.15	89	.02	.01	.01	62.	1.02	22.15	185	.02	.02	.00	197.
1.01	22.30	90	.02	.01	.01	63.	1.02	22.30	186	.02	.02	.00	195.
1.01	22.45	91	.02	.01	.01	64.	1.02	22.45	187	.02	.02	.00	194.
1.01	23.00	92	.02	.01	.01	64.	1.02	23.00	188	.02	.02	.00	193.
1.01	23.15	93	.02	.01	.01	65.	1.02	23.15	189	.02	.02	.00	192.
1.01	23.30	94	.02	.01	.01	66.	1.02	23.30	190	.02	.02	.00	191.
1.01	23.45	95	.02	.01	.01	67.	1.02	23.45	191	.02	.02	.00	191.
1.02	0.00	96	.02	.01	.01	67.	1.03	0.00	192	.02	.02	.00	191.
									SUM	8.84	6.25	2.59	60141.
										(224.)(	159.)(	66.)(	1703.00)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	4299.	1797.	595.	313.	60050.
CMS	122.	51.	17.	9.	1700.
INCHES		4.40	5.82	6.13	6.13
MM		111.73	147.9[illegible]	155.58	155.58
AC-FT		891.	1[illegible]	1241.	1241.
THOUS CU M		1099.	[illegible]	[illegible]	[illegible]

Output Summary
1% Probability Event
Buick Mine Tailings Dam
MO 30162
B15

RUNOFF SUMMARY, AVERAGE FLOW IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES(SQUARE KILOMETERS)

		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA
HYDROGRAPH AT	LAKE	4299.	1797.	595.	313.	3.80
		(121.73)(	50.88)(	16.84)(	8.86)(	9.84)
ROUTED TO	DAM	125.	120.	41.	21.	3.80
		(3.55)(	3.39)(	1.18)(	.60)(	9.84)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1170.00	1191.00	1192.00
STORAGE	5683.	12667.	13068.
OUTFLOW	0.	390.	600.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.00	1174.10	0.00	6839.	125.	0.00	48.00	0.00

APPENDIX C

Contents of Barr Engineering Reports on
Buick Mine Tailings Dam Expansion

The Barr Engineering reports supplied to the inspection team following the field inspection are too large to be reproduced in this Appendix. Copies are available in the project file and from Amax Lead Company, Boss, Missouri. The contents of these reports are presented to illustrate the information provided for this Phase I review.

1. Feasibility of Tailing Basin Expansion, Phase II, Preliminary Design Study, Expansion of Existing Tailing Basin, April 1978

TABLE OF CONTENTS

2. <u>Feasibility of Tailing Basin Expansion</u>, Phase II, Appendix A, B & C, April 1978

APPENDIX A

SOIL BORINGS

3. Design and Construction Reports - 1979

TABLE OF CONTENTS

Appendix B - New Decant Line
- Correspondence
- Soil Testing Report
- Plans and Specifications
- Construction Inspection Reports

Appendix C - Drain System
- Correspondence
- Plans and Specifications
- Construction Inspection Reports

Appendix A, Abandonment of Existing Decant Line Correspondence, April 18, 1978, September 10, 1979
Plans
Construction Inspection Reports July 26, 1979, August 17, 1979
Appendix B, New Deacant Line
Corespondence, October 4, 1978, August 23, 1978, August 11, 1979
- Specifications

Special Provisions
- Plans
- Soil Report
- Construction Inspection Reports, August 1, 1979, August 18, 1979

Appendix C, Drain System
- Correspondence, January 30 - July 25, 1979
- Specifications
- Construction Inspection Reports, July 20 - November 16, 1979