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NATIONAL DAM SAFETY PROGRAM, CADET NUMBER 2 DAM (MO 30707), MIS--ETC(U)
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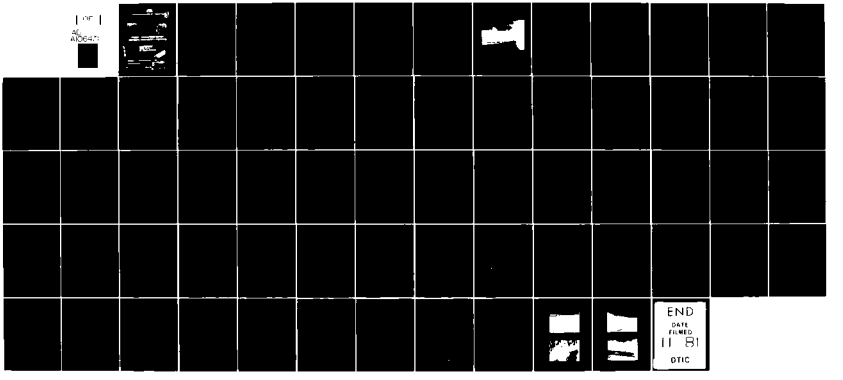

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A106471	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Phase I Dam Inspection Report National Dam Safety Program Cadet #2 Dam (MO 30707) Washington County, Missouri		5. TYPE OF REPORT & PERIOD COVERED Final Report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) International Engineering Company, Inc.		8. CONTRACT OR GRANT NUMBER(s) DACW43-79-C-0037
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101		12. REPORT DATE August 1979
		13. NUMBER OF PAGES Approximately 60
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

National Dam Safety Program. Cadet Number 2 Dam (MO 30707), Mississippi - Kaskaskia - St. Louis Basin, Washington County, Missouri. Phase I Inspection Report.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

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.

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

REPLY TO ATTENTION OF

LMSED-P

27 February 1980

SUBJECT: Cadet No. 2 Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Cadet No. 2 Dam (MO 30707).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, emergency by the St. Louis District as a result of the application of the following criteria:

1) The dam has no spillway and the dam cannot contain a 10-year frequency flood without overtopping of the dam.

2) Overtopping could result in dam failure.

3) Dam failure significantly increases the hazard to life and property downstream.

Also, unsafe conditions were observed on the steep downstream slope consisting of a slide between stations 44+00 and 46+45 and ponding of seepage at various locations along the toe, which threaten its stability.

For Phase I reports, the extent of the downstream damage zone has been determined assuming that all materials contained by the tailings dam are in a liquid state.

SUBMITTED BY: SIGNED
Chief, Engineering Division

28 FEB 1980
Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer

28 FEB 1980
Date

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CADET NO. 2 DAM
WASHINGTON COUNTY, MISSOURI

MISSOURI INVENTORY NO. 30707

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY
INTERNATIONAL ENGINEERING COMPANY, INC.
CONSULTING ENGINEERS
SAN FRANCISCO, CALIFORNIA

UNDER DIRECTION OF
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
FOR
GOVERNOR OF MISSOURI

AUGUST 1979

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam	Cadet No. 2 Dam
State Located	Missouri
County Located	Washington
Stream	Offstream from Tributary of Mill Creek
Date of Inspection	14 April 1979

Cadet No. 2 Dam, I.D. No. 30707, owned by Baroid Division of N. L. Industries, Potosi, Mo., was inspected by two civil engineers and an engineering geologist from International Engineering Company, Inc., of San Francisco, California. The purpose of the inspection was to assess the general condition of the dam with respect to safety. The assessment is based upon an evaluation of the available data, a visual inspection, and an evaluation of the hydrology and hydraulics of the site in order to determine if the dam poses hazards to human life or property. The dam provides impoundment for barite ore tailings.

Cadet No. 2 Dam was inspected using the "Recommended Guidelines for Safety Inspection of Dams" furnished by the Department of the Army, Office of the Chief of Engineers. Based on these guidelines, this dam is classified as being of intermediate size. The St. Louis District Corps of Engineers has classified this dam to have a high downstream hazard potential. Failure of this dam could threaten life and property. The estimated damage zone provided by the St. Louis District Corps of Engineers extends approximately four miles downstream of the dam. There are 25 dwellings, a dam, and two bridges within this damage zone.

The results of the inspection and evaluation indicate that the dam does not meet the criteria given in the Guidelines for a dam with the size and hazard potential of Cadet No. 2 Dam. As an intermediate size dam with a high hazard potential, the Guidelines specify that the discharge capacity and/or storage capacity should be capable of safely handling the Probable Maximum Flood (PMF) without overtopping the crest. The PMF is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

It has been calculated that the dam cannot handle a 100-year flood (a flood having a 1 percent chance of being equalled or exceeded in any 1 year) or a 10 year flood (a flood having a 10 percent chance of being equalled or exceeded in any year) without overtopping the dam. It was also estimated that the dam could retain 3 percent of the PMF without overtopping the dam and without significant erosion of the embankment; however, the dam cannot handle 50 percent of the PMF without overtopping and significant erosion.

No detrimental settlement, depressions, sinkholes, or animal burrows were observed at the damsite. The embankment gravels are probably near their angle of repose on the downstream slope. The developing slope failure on the embankment should be repaired, and seepage drained away to reduce weakening of foundation materials by saturation. A spillway should be constructed and adequate freeboard provided to safely pass the PMF.

Seepage and stability analyses of this dam are not available. These studies should be performed by a professional engineer experienced in the design and construction of tailings dams and should be made a matter of record. The effects of the present tailings disposal method on dam stability should be carefully evaluated. Based on the results of these analyses, remedial measures may become necessary. Remedial work should be performed under the direction of an engineer experienced in the design and construction of tailings dams.

An inspection and maintenance program should be initiated. Periodic inspections should be made and documented by qualified personnel to observe the performance of the dam and spillway.

It is recommended that the owner take action to correct the deficiencies described.

Kenneth B. King, P.E.

James H. Gray, P.E.

Donald E. Westcott

OVERVIEW OF CADET NO. 2
DAM (ID NO. 30707) AND TAILINGS DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
CADET NO. 2 DAM
ID NO. 30707

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APPENDIX A

HYDROLOGIC AND HYDRAULIC ANALYSES

APPENDIX B

INFORMATION SUPPLIED BY OTHERS

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4	Dam Profile
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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
CADET NO. 2 DAM - ID NO. 30707

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection of Cadet No. 2 Dam be made.

b. Purpose of Inspection. The purpose of the inspection was to assess the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams". 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.

(1) Type of dam - Cadet No. 2 Dam is an earthfill dam that is used to impound barite ore tailings. The impoundment is formed by a semi-circular cross-valley dam downstream from the mill site.

(2) Spillways - A decant pipe of unknown dimensions passes water through the embankment. No operable spillway was found. Overflow passes over the dam crest at the right abutment of the dam.

b. Location. The dam is located in Washington County, Missouri, as shown in Plate 1. The dam is shown in Plate 2 and is located in Section 21, Township 38 North, Range 3 East.

c. Size Classification. Cadet No. 2 Dam is greater than 40 feet but less than 100 feet high and therefore is classified as an intermediate size dam in accordance with "Recommended Guidelines for the Safety Inspection of Dams".

d. Hazard Classification. This dam is classified as having a high hazard potential by the St. Louis District Corps of Engineers. The estimated damage zone, as provided by the St. Louis District Corps of Engineers, extends approximately four miles downstream. There are 25 dwellings, a dam, and two bridges within this damage zone.

e. Ownership. This dam is owned by:

Baroid Division
N. L. Industries
P.O. Box 8
Potosi, Missouri 63664

f. Purpose of Dam. The dam impounds tailings resulting from a barite separation and benefication process. Tailings are being conveyed to the impoundment.

g. Design and Construction History. No written design or construction records are known to exist. The starter dam was built around 1966. The impoundment is active, and the dam is being enlarged to provide further storage capacity.

h. Normal Operating Procedures. No operating records are known to exist. Runoff and water from the tailings slurry is removed from the tailings pond by seepage and a decant line into an adjacent water pond. Water for the mill is pumped from this pond.

1.3 PERTINENT DATA

a. General. Field surveys were made by Booker Associates, Inc., of St. Louis, Missouri on 20 April 1979. Measurements are valid as of the date of the survey.

b. Drainage Area. - 64 acres. (Surdex airphoto enlargement 4-185, 6/14/78.)

c. Discharge at Damsite.

(1) Outlet Pipe - Not estimated.

(2) Total Spillway Discharge at Maximum Pool Elevation - Not applicable.

d. Elevation (Feet Above M.S.L.)[1/]

1/ Elevations are based on an arbitrary reference of 873.9 feet M.S.L. at the temporary bench mark. This datum was estimated from topographic data presented in the Iiff 7.5 minute USGS quadrangle sheet.

(1) Top of Dam - Varies from El. 866.5 to El. 861.0 feet.

(2) Impoundment Level 20 April 1979 - El. 860.7 to 860.9 feet.

(3) Low Point on Crest at Sta. 48+00 - El. 861.0.

(4) Decant Pipe (Invert) - No measurement of pipe invert was possible.

(5) Intake Structure - El. 860.5 feet ± (for decant structure at Sta. 43+64 - estimated only; not surveyed).

e. Reservoir.

(1) Length of Pool - 1200 feet ± (20 April 1979).

(2) Length of Impoundment Pool - 1000 feet ±.

f. Storage Capacity above Tailings Surface - 17 acre-feet.

g. Reservoir Surface Area.

(1) Top of Dam - 28 acres at El. 861.0.

(2) Impoundment Level - 26 acres at El. 860.7.

(3) Spillway Crest - Not applicable.

h. Dam.

(1) Type - Earthfill.

(2) Length of Crest - 3340 feet for the Main Dam.
485 feet for the Wing Dam.

(3) Maximum Height of Main Dam - 77 feet.
Maximum Height of Wing Dam - 7 feet.

(4) Width of crest - approximately 25 feet at the main dam and approximately 20 feet at the wing dam.

(5) Side Slopes -

(a) Downstream slopes - 1.5(H) to 1(V)

(b) Upstream slopes - Unknown.

(6) Zoning - The dam appears to be constructed consistent with the prevailing barite dam construction practice. This consists of a clay starter dam enlarged using -7/8-inch gravel.

(7) Cutoff - No written information exists to indicate that a cutoff was designed or constructed.

i. Spillway - Not applicable.

j. Outlets. There are no regulating outlets that lead out of the impoundment. The information below pertains to the decant structure that is located at Station 4364.

(1) Length - 40 feet ±.

(2) Invert of Intake at Impoundment - El. 860.5 feet. (estimated)

(3) Invert of Pipe at Downstream End - Could not be determined. Outlet is under water in the mill water pond.

(4) Type of Outlet - Submerged culvert.

(5) Slope - Unknown.

(6) Flow at Time of Inspection - Could not be determined.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

No design drawings or data are known to exist.

2.2 CONSTRUCTION

a. Information. According to Mr. Clarence Houk, General Superintendent of Baroid Division of N. L. Industries, the starter dam was built in 1966 and the dam was enlarged during operations which are continuing. There are no written records concerning construction methods.

According to Mr. Houk, the foundation for the starter dam was stripped and a core trench was excavated with scrapers to a depth of 10 feet and then refilled with residual clay soil. Residual clay soil was compacted in lifts of unknown thickness with sheepsfoot rollers to construct the starter dam. The dam was raised by dumping gravel in windrows on the crest and spreading the gravel to raise the crest approximately 6 inches at a time. Gravel ravelled down upstream and downstream slopes. Residual clay soil was placed against the upstream slope to seal the dam against seepage. The starter dam was also extended along the abutments as the operation progressed.

Reports by J. H. Williams of the Missouri Geological Survey dated September 30, 1975 and October 21, 1975 entitled "Engineering Geologic Report on Baroid (NL) Industries Tailings Pond" and "NL Industries Baroid Division Tailings Pond" indicate that previous stability problems were encountered at this dam. A downstream berm was built in 1975 to improve the stability of the structure. No design or construction information pertaining to this berm was located. These reports are contained in Appendix B.

b. Assessment of Construction Method and Materials. Procedures used to build this dam were developed by local miners using trial and error techniques over the last 60 years. After construction of the starter dam, sand and angular gravels (finer than 7/8-inch) were hauled to the crest of the dam, end-dumped, and spread; and excess material was pushed over the upstream and downstream faces of the dam. The sands and gravels placed in this manner are in a loose state and are at their natural angle of repose on the downstream face. The material pushed over the upstream side rests on the tailings. The centerline of the dam remains approximately at the same position as the embankment is raised. Compaction of the material on the crest was by construction equipment.

The barite gravels (-7/8-inch) were used to enlarge this tailings dam. They are free draining, angular and relatively well-graded through the gravel and coarse sand range. The gravel appears to function well as a drain material, and it also functions fairly well as erosion protection from rainfall; however, it is inadequate to prevent erosion from

channeled surface flow with a velocity greater than 4 to 6 feet per second.

2.3 OPERATION

No records of operation are known to exist.

2.4 EVALUATION

a. Availability. No design or construction records were available. The only information made available to the inspection team was provided during conversations with Mr. Clarence Houk, General Superintendent of Baroid Division of N. L. Industries, owner of the facility.

b. Adequacy. The field surveys and visual inspections documented herein are considered adequate to support the conclusions of this report. Seepage and stability analyses comparable to the requirements of "Recommended Guidelines for the Safety Inspection of Dams" are not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions, including earthquake loads, and made a matter of record.

c. Validity. Not applicable.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. The inspection team consisted of a civil engineer and an engineering geologist from International Engineering Company, Inc. Clarence Houk, general superintendent for Baroid, met the inspection team at Baroid's office near the site. A Baroid employee escorted the team to the damsite. The facility is an active barite tailings impoundment. Photographs taken during the inspection are included in this report; locations are shown on Plate 7.

b. Project Geology. Bedrock in the area and underlying the dam at depth is composed of the gray dolomite of the Cambrian Age Potosi formation. Isolated outcrops are found over much of the surrounding area; these outcrops have been exposed by mining activities. Soil cover ranges from about 10 to 15 feet in thickness. The residual overburden soil consists of dark red and brown barite-rich clays derived from weathering of the dolomite. Intermixed with the clays are rock fragments consisting of barite, quartz, chert and dolomite which grade from fine gravel to boulders.

c. Dam. The plan of the dam is shown on Plate 3. Profile and cross-sections are shown on Plates 4, 5, and 6. No vegetation was growing on the slopes of the dam. No detrimental settlement, depressions, sinkholes, or animal burrows were observed. Gravel placed on the downstream slope is probably near the angle of repose for the material. One to two inch wide cracks on the downstream edge of the embankment crest were observed between Stations 44+00 and 46+45. A slope failure into the mill water pond appears to be developing. Embankment height in this vicinity is approximately 10 feet or less, and the water level at the downstream side was approximately 4.5 feet below the crest.

The downstream toe is composed of soft, wet residual soils. In some areas, particularly between Stations 35+00 and 42+00, the foundation area has a downstream slope of 15 percent.

A rock and gravel berm was placed at the dam toe approximately between Stations 20+00 to 30+00.

Seepage was noted in many areas at the dam toe. One spring at Station 39+41 was observed flowing turbid at 20 gpm. Seepage was generally less than 1 gpm and turbid.

Freeboard, defined here as the difference in height between the crest roadway and the adjacent mud elevation, varies between 0.3 feet at Station 48+65 to greater than 5 feet.

The low area on the dam crest is at the right abutment between Stations 47+50 and 48+65. Some evidence of recent overtopping was observed on the date of inspection at Station 48+65. The roadway had washed out and residual soil had been pushed into the road to fill in the washout.

Active erosion by surface runoff was noted at the dam toe near the wing dam. No erosion protection is present on the dam slopes. Residual soil had been dumped on some areas on the upstream slope to reduce seepage through the pervious embankment gravels.

Both abutments of the semi-circular shaped main dam and the abutment of the wing dam are composed of residual soil.

d. Appurtenant Structures. A decant pipe at Station 43+64 passes water from the tailings impoundment to the adjacent mill water pond. The only part of this structure that was visible was part of the debris grate over the inlet. No information pertaining to the pipe size was obtained. An abandoned 12-inch water line was observed passing into the embankment at Station 30+22. No intake for this line was observed in the pond.

No functioning spillway for the main dam was found; overflow apparently passes over the dam at the right abutment near Station 48+00 into the mill water pond adjacent to the main dam.

A spillway for the wing dam was located at the right abutment of that dam. This spillway is a low spot at the end of the dam (Station 4+50) which passes outflow from the mill water pond into an overland downstream drainage.

The wing dam is constructed of residual soil. Some tree limbs and other vegetation were observed in this fill. The height of this embankment was less than 10 feet, and crest width averaged at 15 feet. Side slopes were approximately 1.5(H) to 1(V).

e. Reservoir Area. No landslide activity or excessive erosion was observed in the reservoir area. Little natural sedimentation occurs at this site because of the small drainage basin, and there are no upstream hazards that might be subject to backwater flooding.

The impoundment consists of red silty clays being deposited by hydraulic methods during active mine operations. The tailings flow into the impoundment from the southwest corner of the pond. This results in the coarse portion of the tailings to be deposited at the upstream end of the pond, causing the finer materials to settle out next to the dam.

Approximately 83 percent of the watershed area consists of tailings and mud. Strip mining is occurring on 5 percent of the watershed, and 12 percent is undisturbed forest land.

f. Downstream Channels. Discharges from the tailings impoundment would pass through the mill water pond spillway into a heavily forested overland drainage. This drainage feeds the unnamed tributary to Mill

Creek approximately 0.4 mile downstream from the dam. This area is not normally flood prone.

3.2 EVALUATION

The decant line is inadequate to pass runoff from the tailings impoundment and appeared to be prone to clogging. The lack of a spillway and inadequate freeboard present at the damsite increases the likelyhood of overtopping.

The primary effect of overtopping would be a greatly increased flow of water into the mill water pond, and out through the mill pond spillway. Significant erosion of the millpond spillway could be expected during high sustained flows.

Evidence of a developing slope failure was noted on the downstream slope between Stations 44+00 and 46+45. Some loss of crest width will result, and breaching will occur eventually if this slide is not stabilized and repaired.

Extensive seepage and soft, mushy foundation conditions were observed in many areas at the dam toe. Continued expansion of the dam over these areas, if untreated, could adversely affect the stability of the dam.

The tailings disposal method used at this site is not typical of practices used in the area. Normally tailings are discharged near the dam and allowed to flow back into the blocked drainage area used for tailings disposal. In this instance, the tailings are deposited from the upstream end of the pond allowing the finer portions to accumulate next to the dam. This increases the lateral pressure against the dam because the fine tailings are less pervious, and increases the amount of fine material piped through the dam since the coarser tailings are generally not present to act as a filter medium. This method of tailings disposal presents a higher hazard to embankment stability than the prevailing practice.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

No regulating procedures are in effect for this dam.

4.2 MAINTENANCE OF DAM

The dam is under construction at present, and maintenance consists in part of enlarging the dam while it remains active. According to the general superintendent for Baroid, erosion on the access roads and at the abutments is repaired as necessary and the decant line is cleared of debris and maintained. The dam is inspected each working day by the shift foremen.

4.3 MAINTENANCE OF OPERATING FACILITIES

The intake structure at the decant pipe is cleared of debris when required. The 12-inch water supply line into the dam was plugged and abandoned sometime around 1976, and it is estimated that the pipe invert is approximately 5 feet below the present crest elevation.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no warning system in effect at this dam.

4.5 EVALUATION

A periodic inspection program should be established so that indications of instability, such as cracks in the dam, sloughing, sudden settlement, erosion of the dam, or an increase in the volume or turbidity of water from the seeps, can be monitored. This inspection program should be carried out in conjunction with the daily inspection, and records of the inspections should be maintained.

SECTION 5 - HYDRAULIC AND HYDROLOGIC ANALYSES

5.1 EVALUATION OF FEATURES

a. Design Data. The significant dimensions of the dam are presented in Section 1 - Project Information, and also presented in the accompanying field survey drawings, Plates 3 through 7. Hydrologic or hydraulic design information are not available.

For this evaluation, the watershed drainage area and reservoir area-elevation data were measured using 1978 Surdex airphoto enlargements and survey data.

The total drainage area (including the reservoir) at Cadet No. 2 Tailings Dam, I.D. No. 30707, is primarily enclosed by the embankment and is approximately 64 acres (0.1 square miles). The watershed location and drainage boundary are shown on Plate 2. About 83% of the entire drainage area boundary was occupied by disposed tailings from barite mining, 5% disturbed by mining activities, and the remaining 12% of the area was undisturbed original topography. In order to obtain the active storage capacity, the spot surveys of the tailings elevations were transferred to an aerial photograph and used as a guide to develop reservoir contours on the tailings surface.

There is a berm separating the tailings pond into two sections. Field observations indicated that the water and slurry inside the pond was slowly flowing from the slightly higher ponded water surface elevation on the western side through two gaps in this berm and to the lower eastern side of the pond. Data on the dimension and elevation of the berm are not available. It was assumed that this berm does not retard the flood flows nor separate the enclosed area into two separate ponds.

A small wing dike is located adjacent to and downstream of the main embankment. This wing dike is connected to the main embankment at Sta. 42+40 (see Plate 3). Together with part of the main embankment, the wing dike forms a small enclosure that serves as a mill water pond. Water inside the Cadet No. 2 main embankment is discharged through a decant pipe, located at Sta. 43+64, into the mill water pond. A spillway is located for the wing dike near its right abutment (see Plates 3 and 5). This pond is limited in storage capacity and is used as a retention pond. On the date of the survey, the pond water surface elevation was at El. 857.5, slightly above the mill pond spillway crest elevation (see Plate 5). This wing dike is considered not part of the present overtopping analysis since it is very small in size and less than 6 feet in embankment height, and has limited storage capacity.

Another tailings dam, Cadet No. 1 Dam, I.D. No. 30704, is located about 200 feet south from Station 0+00. Separate analysis of the upstream dam indicated that approximately 45% of the probable maximum flood would overtop the upstream dam. The flood outflows from the upstream dam would probably be diverted away by a roadside drainage ditch and not into Cadet No. 2. However, the possibility exists that if the upstream

dam is overtopped, outbursts could flow into the Cadet No. 2 pond. For this analysis, it was assumed that Cadet No. 2 is an enclosed system and flood outflows from the upstream dam would not discharge into the project drainage area and pond (see description presented in Section 1.3).

Due to the small watershed size and the fact that the impoundment is essentially a closed system, a lag time of 0.1 hour and a runoff curve number (CN) of 100 were assumed for the computations of flood runoff for the watershed, the tailings and water within the pond.

The input data and computed parameters, such as basin lag time, unit hydrograph, probable maximum precipitation, and the reservoir elevation-area-capacity data are in Appendix A. As shown in the computer printouts, the reservoir surface areas are actual surface areas corresponding to the elevations shown. The capacities shown, as computer in the computer program by the Conic Method, are the active capacities at the given elevation adjusted for the tailings.

The lowest point of the embankment is at El. 861.0 and is located at about Sta. 48+60. There is a small diameter outlet pipe. This outlet pipe has limited discharge capacity and was assumed to be clogged during floods in the analysis.

Computations of the discharge rating curve for flows over the dam crest were made by using the weir flow formula with a weir coefficient of C=2.7 for the dam crest. The discharge rating curve for flows over the dam crest is in Appendix A, under the input data listing on the Y4 and Y5 cards. The overtopping analysis was based on the effective crest elevations as surveyed on the dam crest at El. 861.0, the lowest point along the dam crest at about Sta. 48+00.

b. Experience Data. Rainfall, streamflow and flood data for the entire watershed are not available.

c. Visual Observations. Visual observations are discussed in Section 3 - Visual Observations.

During the field inspection, it was observed that the low points of the tailings were submerged in water. The pond water surface elevation averaged about El. 860.8 (see Plate 3). Also, evidence of overtopping of the embankment by Station 48+65 was observed. The crest was eroded and soil had been pushed over the spot to fill the eroded areas. This erosion was probably the result of the 11 April 1979 rainstorm.

d. Overtopping Potential. The probable maximum flood (PMF), and floods expressed as a percentage of PMF were computed and routed into and through the reservoir. The probable maximum flood is defined as the hypothetical flood event that would result from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible at a particular location or region.

The computed floods were routed through the project reservoir using the Modified Puls Method of flood routing. For all cases of the reservoir flood routing, the starting water surface elevation was set at El. 860.8, the observed average water surface elevation. Results of the overtopping indicate that the dam cannot pass the 50% PMF without overtopping the minimum dam crest.

The 100-year flood and 10-year flood were computed and routed through the reservoir in the same manner as discussed above. Results of the overtopping analyses show that the dam cannot pass the 100-year flood or the 10-year flood without overtopping the effective dam crest. The primary overtopping location is at about Sta. 47+50 to Sta. 48+65 near the right abutment and at the lowest point of the main embankment. Large embankment overtopping discharges from the Cadet No. 2 pond will cause significant erosion of the mill pond spillway and possible overtopping of the dam and the wing dike.

Results of the overtopping analyses are reported in Appendix A and are summarized below.

Flood	Peak Inflow (cfs)	Peak Outflow (cfs)	Max WS Elev (ft)	Max Depth Over Min. Dam Crest (ft)	Duration Overtopped (hrs)
10-Year	279	87	861.3*	0.3	13.3
100-Year	401	127	861.5*	0.5	14.8
3% PMF	43	0	861.0	0	-
50% PMF	723	317	861.7*	0.7	16.6
PMF	1446	809	862.2*	1.2	18.0

* Dam overtopped (Minimum Dam Crest El. 861.0)

Note: Water surface elevations include the velocity heads corresponding to the velocities computed for the various flow depths for the overtopping section.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which adversely affect the structural stability of the dam are discussed in Section 3.

b. Design and Construction Data. No design, construction data, pertaining to the structural stability of the dam were available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, and lack of this information is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions, including earthquake loads, and made a matter of record.

c. Operating Records. No appurtenant structures are operable at this dam; no records of operations were located.

d. Post Construction Changes. Not applicable. The dam is presently being raised.

e. Seismic Stability. The dam is located in Seismic Zone 2, to which the 1976 Uniform Building Code assign a "moderate" damage potential. There appears to be a potential for instability caused by ground shaking during earthquakes where the dam overlies soft saturated clay foundation soil. Some ravelling of the embankment gravels could also occur during seismic shaking because the downstream slope is at or near the gravels' natural angle of repose. Crest settlement could also occur because the gravels are in a loose state.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. Several deficient conditions at the dam should be corrected to improve the margin of safety. The absence of an operable spillway to remove storm runoff is the most serious deficiency. Other deficiencies noted are: a landslide on the downstream slope, soft foundation materials resulting from ponded seepage and springs at the dam toe, and the method of tailings disposal. The developing slope failure, the soft foundation conditions caused by seepage and the tailings disposal method could adversely affect the stability of the dam. Seepage and stability analyses meeting the requirements of "Recommended Guidelines for the Safety Inspection of Dams" were not available, which is considered a deficiency. Suggested remedial measures are discussed in Section 7.2 REMEDIAL MEASURES.

b. Adequacy of Information. No design or construction data were available. Seepage and stability analyses meeting the requirements of "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

Topographic data for this dam is inadequate. This is due primarily to the fact that the dam enlargement activity occurred subsequent to the publication of USGS 7.5' quadrangle map. The drainage area measurement was made after locating the dam on the original topography. Reservoir area-capacity data and slopes were developed using survey measurements and constructing topographic contours on a 1" = 1000' air photo enlargement showing the reservoir and watershed areas. This data is considered adequate for a Phase I analysis; however, the estimate of overtopping potential is approximate.

c. Urgency. The deficiencies described in this report are serious. Corrective measures described in Section 7.2 should be initiated without delay. The item recommended in Section 7.2a should be pursued on a high priority basis.

d. Necessity for Phase II. No Phase II investigation is recommended; however, additional studies are recommended to evaluate the method of tailings disposal used and perform seepage and stability analyses as described in Section 7.2. These studies should be undertaken by a professional engineer experienced in the design and construction of tailings dams.

7.2 REMEDIAL MEASURES

a. Spillway. A spillway should be designed and adequate freeboard provided to safely pass the PMF without causing erosion of the embankment under the Guidelines established by the Corps of Engineers. An engineer experienced in the design of dam spillways should be retained for the design and supervision of construction of the spillway.

b. Repair of Slope Failure. The slide observed between Stations 44+00 and 46+45 should be repaired to prevent loss of embankment material. This work should be performed under the direction of an engineer experienced in the design and construction of tailings dams.

c. Drainage of Seepage. Seepage that presently ponds at the dam toe in various locations should be drained to remove water which saturates and weakens foundation soil.

d. Inspection Program. The dam should be inspected periodically by an engineer who will observe and record the performance of the dam. The springs and seeps should be monitored as part of the inspection program. Records of these inspections should be maintained, and all maintenance or remedial measures performed at the site should be documented.

e. Seepage and Stability Analyses. These analyses should be performed by an engineer experienced in the design and construction of tailings dams. Seepage and stability computations should be included in these analyses and performed with the reservoir water surface set at the top of the dam. The effects on stability of flow through the pervious embankment gravels should also be evaluated. The tailings disposal method used at this impoundment should be carefully evaluated with regard to the effects on stability of the dam. Based on the results of these analyses, remedial measures may become necessary. Remedial work should be done under the direction of an engineer experienced in tailings dam design and construction.

APPENDIX A

HYDROLOGIC AND HYDRAULIC ANALYSES

The hydrologic and hydraulic analyses were accomplished by using the computer program "Flood Hydrograph Package, HEC-1, Dam Safety Investigations Version, July 1978". This program was developed by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California. The criteria and methodology used are briefly discussed below:

- Probable Maximum Precipitation (PMP) - The 24-hour PMP was obtained from Hydrometeorological Report No. 33. The 6-hour and the 1-hour depth-duration distributions followed Corps of Engineers EM 1110-2-1411 criteria.

- 100-year and/or 10-year storms - The 24-hour storm amounts and distributions were supplied by Corps of Engineers, St. Louis District, Missouri.

- Reservoir Area-Capacity - Areas were measured from U.S.G.S. topographic maps and/or from aerial photographs. Reservoir elevations and corresponding surface areas were input into the computer program, which determined the reservoir capacities by the Conic Method.

- Flood Routing - The Modified Puls Method was used for all flood routing and dam overtopping analyses.

The following pages present the input data listing, the computer program version and its last modification date, together with pertinent computer printouts of results. Definitions of all input and output variable names are presented in the September 1978 computer program "Users Manual", and are not explained herein.

```
A1          CADET NO. 2 TAILINGS DAM MO. NO. 30707
A2          HEC-1  PHASE 1  DAM SAFETY INVESTIGATIONS
A3          RATIO OF PMF ROUTED THROUGH CLOSED SYSTEM
B     288                 5
B1      5
J       1        6        1
J1    .03      .04      .05      .10      .50      1.0
K       0  INFLOW                          1        1
K1    PMF INFLOW TO CLOSED SYSTEM
M       1        2       .1                         1                         1
P       0     25.8      102      120      130
T                                                          -1     -100
W2              .1
X    -.01     -.01      1.0
K       1   LAKE                           1        1        1
K1 ROUTING THROUGH CLOSED SYSTEM
Y                                   1        1
Y1      1                                                -860.8       -1
Y4 861.0    861.5    862.0    862.5    863.0    863.5    864.0
Y5   0.0     140.     510.    1360.    3000.    5000.    7600.
$A   0.0      4.6     26.3     27.5     30.5     33.7     36.9     40.0     43.0     46.3
$E  856.     860.    860.8    861.0    861.5    862.0    862.5    863.0    863.5    864.0
$$ 861.0
$D  861.
K      99
A
A
A
A
A
```

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

RUN  DATE= 79/06/02.
     TIME= 10.32.10.
```

LADET NO. 2 TAILINGS DAM NO. NO. 30707
HEC-1 PHASE 1 DAM SAFETY INVESTIGATIONS
RATIO OF PMF ROUTED THROUGH CLOSED SYSTEM

JOB SPECIFICATION

NO.	NHR	NMIN	IDAY	IHR	IMIN	METRIC	IPLT	IPRT	NSTAN
288	0	5	0	0	0	0	0	0	0
			JOPER	NWT	LROPT	TRACE			
			5	0	0	0			

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 6 LRTIO= 1

RTIOS= .03 .04 .05 .10 .50 1.00

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

SUB-AREA RUNOFF COMPUTATION

PMF INFLOW TO CLOSED SYSTEM

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

HYDROGRAPH DATA

IHYDG	IUNG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	.10	0.00	.10	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	25.80	102.00	120.00	130.00	0.00	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	-100.00	0.00	0.00

CURVE NO = -100.00 WETNESS = -1.00 EFFECT CN = 100.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .10

RECESSION DATA
STRTQ= -.01 QRCSN= -.01 RTIOR= 1.00

TIME INCREMENT TOO LARGE--(NMO IS GT LAG/2)

UNIT HYDROGRAPH 8 END-OF-PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .10 VOL= 1.00

	219.	324.	142.	55.	21.	4.	3.	1.				
					END-OF-PERIOD FLOW							
HO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	HO. A	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	.01	0.00	3.	1.01	12.05	145	.22	.22	-.00	84.
1.01	.10	2	.01	.01	.00	8.	1.01	12.10	146	.22	.22	-.00	134.
1.01	.15	3	.01	.01	.00	10.	1.01	12.15	147	.22	.22	-.00	156.
1.01	.20	4	.01	.01	-.00	11.	1.01	12.20	148	.22	.22	-.00	165.
1.01	.25	5	.01	.01	.00	11.	1.01	12.25	149	.22	.22	-.00	168.
1.01	.30	6	.01	.01	.00	11.	1.01	12.30	150	.22	.22	.00	169.
1.01	.35	7	.01	.01	.00	11.	1.01	12.35	151	.22	.22	-.00	170.
1.01	.40	8	.01	.01	-.00	11.	1.01	12.40	152	.22	.22	.00	170.
1.01	.45	9	.01	.01	.00	11.	1.01	12.45	153	.22	.22	-.00	170.
1.01	.50	10	.01	.01	.00	11.	1.01	12.50	154	.22	.22	-.00	170.
1.01	.55	11	.01	.01	.00	11.	1.01	12.55	155	.22	.22	.00	170.
1.01	1.00	12	.01	.01	.00	11.	1.01	13.00	156	.22	.22	.00	170.
1.01	1.05	13	.01	.01	.00	11.	1.01	13.05	157	.26	.26	-.00	179.
1.01	1.10	14	.01	.01	.00	11.	1.01	13.10	158	.26	.26	-.00	194.
1.01	1.15	15	.01	.01	.00	11.	1.01	13.15	159	.26	.26	-.00	200.
1.01	1.20	16	.01	.01	.00	11.	1.01	13.20	160	.26	.26	-.00	202.
1.01	1.25	17	.01	.01	.00	11.	1.01	13.25	161	.26	.26	-.00	203.
1.01	1.30	18	.01	.01	.00	11.	1.01	13.30	162	.26	.26	.00	203.
1.01	1.35	19	.01	.01	.00	11.	1.01	13.35	163	.26	.26	-.00	204.
1.01	1.40	20	.01	.01	.00	11.	1.01	13.40	164	.26	.26	-.00	204.
1.01	1.45	21	.01	.01	-.00	11.	1.01	13.45	165	.26	.26	-.00	204.
1.01	1.50	22	.01	.01	.00	11.	1.01	13.50	166	.26	.26	-.00	204.
1.01	1.55	23	.01	.01	.00	11.	1.01	13.55	167	.26	.26	-.00	204.
1.01	2.00	24	.01	.01	.00	11.	1.01	14.00	168	.26	.26	-.00	204.
1.01	2.05	25	.01	.01	-.00	11.	1.01	14.05	169	.33	.33	-.00	218.
1.01	2.10	26	.01	.01	.00	11.	1.01	14.10	170	.33	.33	-.00	239.
1.01	2.15	27	.01	.01	.00	11.	1.01	14.15	171	.33	.33	.00	249.
1.01	2.20	28	.01	.01	.00	11.	1.01	14.20	172	.33	.33	-.00	252.
1.01	2.25	29	.01	.01	.00	11.	1.01	14.25	173	.33	.33	.00	254.
1.01	2.30	30	.01	.01	-.00	11.	1.01	14.30	174	.33	.33	-.00	254.
1.01	2.35	31	.01	.01	.00	11.	1.01	14.35	175	.33	.33	.00	255.
1.01	2.40	32	.01	.01	.00	11.	1.01	14.40	176	.33	.33	-.00	255.
1.01	2.45	33	.01	.01	-.00	11.	1.01	14.45	177	.33	.33	-.00	255.
1.01	2.50	34	.01	.01	.00	11.	1.01	14.50	178	.33	.33	.00	255.
1.01	2.55	35	.01	.01	.00	11.	1.01	14.55	179	.33	.33	-.00	255.
1.01	3.00	36	.01	.01	.00	11.	1.01	15.00	180	.33	.33	-.00	255.
1.01	3.05	37	.01	.01	.00	11.	1.01	15.05	181	.20	.20	-.00	226.
1.01	3.10	38	.01	.01	.00	11.	1.01	15.10	182	.40	.40	.00	228.
1.01	3.15	39	.01	.01	.00	11.	1.01	15.15	183	.40	.40	-.00	275.
1.01	3.20	40	.01	.01	.00	11.	1.01	15.20	184	.60	.60	.00	340.
1.01	3.25	41	.01	.01	-.00	11.	1.01	15.25	185	.70	.70	.00	455.
1.01	3.30	42	.01	.01	.00	11.	1.01	15.30	186	1.70	1.70	-.00	718.
1.01	3.35	43	.01	.01	.00	11.	1.01	15.35	187	2.80	2.80	.00	1309.
1.01	3.40	44	.01	.01	.00	11.	1.01	15.40	188	1.10	1.10	.00	1446.
1.01	3.45	45	.01	.01	.00	11.	1.01	15.45	189	.70	.70	-.00	1023.
1.01	3.50	46	.01	.01	.00	11.	1.01	15.50	190	.60	.60	.00	713.
1.01	3.55	47	.01	.01	.00	11.	1.01	15.55	191	.40	.40	-.00	518.
1.01	4.00	48	.01	.01	.00	11.	1.01	16.00	192	.40	.40	-.00	394.
1.01	4.05	49	.01	.01	-.00	11.	1.01	16.05	193	.31	.31	.00	322.
1.01	4.10	50	.01	.01	.00	11.	1.01	16.10	194	.31	.31	-.00	271.
1.01	4.15	51	.01	.01	.00	11.	1.01	16.15	195	.31	.31	.00	249.
1.01	4.20	52	.01	.01	-.00	11.	1.01	16.20	196	.31	.31	-.00	242.
1.01	4.25	53	.01	.01	.00	11.	1.01	16.25	197	.31	.31	.00	239.
1.01	4.30	54	.01	.01	-.00	11.	1.01	16.30	198	.31	.31	.00	238.
1.01	4.35	55	.01	.01	.00	11.	1.01	16.35	199	.31	.31	-.00	238.

1.01	[illegible]	56	.01	.01	.00	11.	1.01	16.40	200	.31	.31	.00	238.
1.01	[illegible]	57	.01	.01	.00	11.	1.01	16.45	201	.31	.31	-.00	238.
1.01	[illegible]	58	.01	.01	.00	11.	1.01	16.50	202	.31	.31	.00	238.
1.01	4.55	59	.01	.01	.00	11.	1.01	16.55	203	.31	.31	.00	238.
1.01	5.00	60	.01	.01	-.00	11.	1.01	17.00	204	.31	.31	-.00	238.
1.01	5.05	61	.01	.01	.00	11.	1.01	17.05	205	.24	.24	.00	223.
1.01	5.10	62	.01	.01	.00	11.	1.01	17.10	206	.24	.24	.00	202.
1.01	5.15	63	.01	.01	.00	11.	1.01	17.15	207	.24	.24	-.00	193.
1.01	5.20	64	.01	.01	.00	11.	1.01	17.20	208	.24	.24	.00	189.
1.01	5.25	65	.01	.01	-.00	11.	1.01	17.25	209	.24	.24	.00	188.
1.01	5.30	66	.01	.01	.00	11.	1.01	17.30	210	.24	.24	.00	187.
1.01	5.35	67	.01	.01	.00	11.	1.01	17.35	211	.24	.24	.00	187.
1.01	5.40	68	.01	.01	.00	11.	1.01	17.40	212	.24	.24	.00	187.
1.01	5.45	69	.01	.01	-.00	11.	1.01	17.45	213	.24	.24	.00	187.
1.01	5.50	70	.01	.01	.00	11.	1.01	17.50	214	.24	.24	.00	187.
1.01	5.55	71	.01	.01	.00	11.	1.01	17.55	215	.24	.24	.00	187.
1.01	6.00	72	.01	.01	-.00	11.	1.01	18.00	216	.24	.24	.00	187.
1.01	6.05	73	.06	.06	.00	22.	1.01	18.05	217	.02	.02	.00	159.
1.01	6.10	74	.06	.06	-.00	38.	1.01	18.10	218	.02	.02	-.00	67.
1.01	6.15	75	.06	.06	-.00	45.	1.01	18.15	219	.02	.02	-.00	36.
1.01	6.20	76	.06	.06	-.00	48.	1.01	18.20	220	.02	.02	-.00	24.
1.01	6.25	77	.06	.06	-.00	49.	1.01	18.25	221	.02	.02	-.00	19.
1.01	6.30	78	.06	.06	.00	50.	1.01	18.30	222	.02	.02	-.00	18.
1.01	6.35	79	.06	.06	-.00	50.	1.01	18.35	223	.02	.02	-.00	17.
1.01	6.40	80	.06	.06	.00	50.	1.01	18.40	224	.02	.02	-.00	17.
1.01	6.45	81	.06	.06	-.00	50.	1.01	18.45	225	.02	.02	-.00	17.
1.01	6.50	82	.06	.06	-.00	50.	1.01	18.50	226	.02	.02	.00	17.
1.01	6.55	83	.06	.06	.00	50.	1.01	18.55	227	.02	.02	-.00	17.
1.01	7.00	84	.06	.06	-.00	50.	1.01	19.00	228	.02	.02	-.00	17.
1.01	7.05	85	.06	.06	-.00	50.	1.01	19.05	229	.02	.02	-.00	17.
1.01	7.10	86	.06	.06	.00	50.	1.01	19.10	230	.02	.02	-.00	17.
1.01	7.15	87	.06	.06	-.00	50.	1.01	19.15	231	.02	.02	-.00	17.
1.01	7.20	88	.06	.06	.00	50.	1.01	19.20	232	.02	.02	-.00	17.
1.01	7.25	89	.06	.06	.00	50.	1.01	19.25	233	.02	.02	-.00	17.
1.01	7.30	90	.06	.06	.00	50.	1.01	19.30	234	.02	.02	-.00	17.
1.01	7.35	91	.06	.06	.00	50.	1.01	19.35	235	.02	.02	-.00	17.
1.01	7.40	92	.06	.06	.00	50.	1.01	19.40	236	.02	.02	-.00	17.
1.01	7.45	93	.06	.06	.00	50.	1.01	19.45	237	.02	.02	-.00	17.
1.01	7.50	94	.06	.06	.00	50.	1.01	19.50	238	.02	.02	-.00	17.
1.01	7.55	95	.06	.06	.00	50.	1.01	19.55	239	.02	.02	-.00	17.
1.01	8.00	96	.06	.06	.00	50.	1.01	20.00	240	.02	.02	-.00	17.
1.01	8.05	97	.06	.06	-.00	50.	1.01	20.05	241	.02	.02	-.00	17.
1.01	8.10	98	.06	.06	.00	50.	1.01	20.10	242	.02	.02	-.00	17.
1.01	8.15	99	.06	.06	.00	50.	1.01	20.15	243	.02	.02	-.00	17.
1.01	8.20	100	.06	.06	.00	50.	1.01	20.20	244	.02	.02	.00	17.
1.01	8.25	101	.06	.06	.00	50.	1.01	20.25	245	.02	.02	-.00	17.
1.01	8.30	102	.06	.06	.00	50.	1.01	20.30	246	.02	.02	-.00	17.
1.01	8.35	103	.06	.06	-.00	50.	1.01	20.35	247	.02	.02	.00	17.
1.01	8.40	104	.06	.06	.00	50.	1.01	20.40	248	.02	.02	-.00	17.
1.01	8.45	105	.06	.06	.00	50.	1.01	20.45	249	.02	.02	-.00	17.
1.01	8.50	106	.06	.06	.00	50.	1.01	20.50	250	.02	.02	-.00	17.
1.01	8.55	107	.06	.06	.00	50.	1.01	20.55	251	.02	.02	-.00	17.
1.01	9.00	108	.06	.06	.00	50.	1.01	21.00	252	.02	.02	-.00	17.
1.01	9.05	109	.06	.06	.00	50.	1.01	21.05	253	.02	.02	-.00	17.
1.01	9.10	110	.06	.06	.00	50.	1.01	21.10	254	.02	.02	-.00	17.
1.01	9.15	111	.06	.06	-.00	50.	1.01	21.15	255	.02	.02	.00	17.
1.01	9.20	112	.06	.06	.00	50.	1.01	21.20	256	.02	.02	-.00	17.
1.01	9.25	113	.06	.06	.00	50.	1.01	21.25	257	.02	.02	-.00	17.
1.01	9.30	114	.06	.06	.00	50.	1.01	21.30	258	.02	.02	.00	17.
1.01	9.35	115	.06	.06	.00	50.	1.01	21.35	259	.02	.02	-.00	17.

1.01	9.40	116	.06	.06	-.00	50.	1.01	21.40	260	.02	.02	-.00	17.
1.01	9.45	117	.06	.06	.00	50.	1.01	21.45	261	.02	.02	-.00	17.
1.01	9.50	118	.06	.06	.00	50.	1.01	21.50	262	.02	.02	-.00	17.
1.01	9.55	119	.06	.06	.00	50.	1.01	21.55	263	.02	.02	-.00	17.
1.01	10.00	120	.06	.06	-.00	50.	1.01	22.00	264	.02	.02	-.00	17.
1.01	10.05	121	.06	.06	-.00	50.	1.01	22.05	265	.02	.02	-.00	17.
1.01	10.10	122	.06	.06	-.00	50.	1.01	22.10	266	.02	.02	-.00	17.
1.01	10.15	123	.06	.06	-.00	50.	1.01	22.15	267	.02	.02	-.00	17.
1.01	10.20	124	.06	.06	-.00	50.	1.01	22.20	268	.02	.02	-.00	17.
1.01	10.25	125	.06	.06	-.00	50.	1.01	22.25	269	.02	.02	-.00	17.
1.01	10.30	126	.06	.06	.00	50.	1.01	22.30	270	.02	.02	-.00	17.
1.01	10.35	127	.06	.06	-.00	50.	1.01	22.35	271	.02	.02	-.00	17.
1.01	10.40	128	.06	.06	-.00	50.	1.01	22.40	272	.02	.02	-.00	17.
1.01	10.45	129	.06	.06	-.00	50.	1.01	22.45	273	.02	.02	-.00	17.
1.01	10.50	130	.06	.06	.00	50.	1.01	22.50	274	.02	.02	-.00	17.
1.01	10.55	131	.06	.06	-.00	50.	1.01	22.55	275	.02	.02	.00	17.
1.01	11.00	132	.06	.06	-.00	50.	1.01	23.00	276	.02	.02	-.00	17.
1.01	11.05	133	.06	.06	-.00	50.	1.01	23.05	277	.02	.02	-.00	17.
1.01	11.10	134	.06	.06	.00	50.	1.01	23.10	278	.02	.02	-.00	17.
1.01	11.15	135	.06	.06	-.00	50.	1.01	23.15	279	.02	.02	-.00	17.
1.01	11.20	136	.06	.06	-.00	50.	1.01	23.20	280	.02	.02	-.00	17.
1.01	11.25	137	.06	.06	-.00	50.	1.01	23.25	281	.02	.02	-.00	17.
1.01	11.30	138	.06	.06	-.00	50.	1.01	23.30	282	.02	.02	-.00	17.
1.01	11.35	139	.06	.06	-.00	50.	1.01	23.35	283	.02	.02	-.00	17.
1.01	11.40	140	.06	.06	-.00	50.	1.01	23.40	284	.02	.02	-.00	17.
1.01	11.45	141	.06	.06	-.00	50.	1.01	23.45	285	.02	.02	-.00	17.
1.01	11.50	142	.06	.06	-.00	50.	1.01	23.50	286	.02	.02	-.00	17.
1.01	11.55	143	.06	.06	-.00	50.	1.01	23.55	287	.02	.02	-.00	17.
1.01	12.00	144	.06	.06	.00	50.	1.02	0.00	288	.02	.02	-.00	17.
									SUM	33.54	33.54	.00	25972.
										(852.)(	852.)(	0.)(	735.45)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1446.	281.	90.	90.	25936.
CMS	41.	8.	3.	3.	734.
INCHES		26.14	33.50	33.50	33.50
MM		663.95	850.95	850.95	850.95
AC-FT		139.	179.	179.	179.
THOUS CU M		172.	220.	220.	220.

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HYDROGRAPH ROUTING

ROUTING THROUGH CLOSED SYSTEM

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

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-861.	-1

STAGE	861.00	861.50	862.00	862.50	863.00	863.50	864.00			
FLOW	0.00	140.00	510.00	1360.00	3000.00	5000.00	7000.00			
SURFACE AREA=	0.	5.	26.	28.	31.	34.	37.	40.	43.	46.
CAPACITY=	0.	6.	17.	23.	37.	53.	71.	90.	111.	133.
ELEVATION=	856.	860.	861.	861.	862.	862.	863.	863.	864.	864.

CREL	SPWID	COQW	EXPW	FLEVL	COQL	CAREA	EXPL
861.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
861.0	0.0	0.0	0.

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)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 .03	RATIO 2 .04	RATIO 3 .05	RATIO 4 .10	RATIO 5 .50	RATIO 6 1.00
HYDROGRAPH AT	INFLOW	.10	1	43.	58.	72.	145.	723.	1446.
	(	.26)	(	1.23)(	1.64)(	2.05)(	4.09)(	20.47)(	40.95)(
ROUTED TO	LAKE	.10	1	0.	6.	11.	44.	317.	809.
	(	.26)	(	0.00)(	.18)(	.31)(	1.26)(	8.99)(	22.90)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	860.80	861.00	861.00
STORAGE	17.	23.	23.
OUTFLOW	0.	0.	0.

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
.03	861.00	0.00	23.	0.	0.00	0.00	0.00
.04	861.02	.02	23.	6.	7.83	16.08	0.00
.05	861.04	.04	24.	11.	8.33	17.08	0.00
.10	861.16	.16	27.	44.	10.25	16.00	0.00
.50	861.74	.74	45.	317.	16.58	15.83	0.00
1.00	862.18	1.18	59.	809.	18.00	15.83	0.00

```
A1          CADET NO. 2 TAILINGS DAM MO. NO. 30707
A2          HEC-1  PHASE 1  DAM SAFETY INVESTIGATIONS
A3          100  YEAR FLOOD
B     144                10
B1      3
K       0  100-YR                                  1       1
K1100-YR INFLOW FLOOD  BASED ON SULLIVAN PRECIP.  10-MINUTE INCREMENTS
M       0        2       .1
O     144
O1   .014     .014     .014     .014     .014     .014     .014     .014     .014     .014
O1   .014     .014     .014     .014     .014     .014     .014     .014     .014     .014
O1   .014     .014     .014     .014     .014     .014     .014     .014     .014     .014
O1   .014     .014     .014     .014     .014     .014     .028     .028     .028     .028
O1   .028     .028     .028     .028     .028     .028     .028     .028     .028     .028
O1   .028     .028     .028     .028     .044     .044     .044     .044     .044     .044
O1   .044     .044     .044     .062     .062     .062     .122     .122     .122     .264
O1   .384     .801    1.205     .384     .264     .122     .122     .122     .062     .062
O1   .062     .044     .044     .044     .044     .044     .044     .044     .044     .044
O1   .028     .028     .028     .028     .028     .028     .028     .028     .028     .028
O1   .028     .028     .028     .028     .028     .028     .028     .028     .014     .014
O1   .014     .014     .014     .014     .014     .014     .014     .014     .014     .014
O1   .014     .014     .014     .014     .014     .014     .014     .014     .014     .014
O1   .014     .014     .014     .014     .014     .014     .014     .014     .014     .014
O1   .014     .014     .014     .014
T                                                        -1     -100
W2              .1
X    -.01     -.01      1.0
K       1   LAKE                                   1       1
K1 ROUTING THROUGH CLOSED SYSTEM
Y                                 1
Y1      1                                          -860.8      -1
Y4 861.0    861.5    862.0    862.5    863.0    863.5    864.0
Y5   0.0     140.     510.    1360.    3000.    5000.    7600.
$A   0.0      4.6     26.3     27.5     30.5     33.7     36.9     40.0     43.0     46.3
$E  856.     860.    860.8    861.0    861.5    862.0    862.5    863.0    863.5    864.0
$$ 861.0
$D  861.
K      99
A
```

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

RUN DATE= 79/[illegible]/01.
TIME= 16.[illegible].13.

CADET NO. 2 TAILINGS DAM MO, NO. 50707
HEC-1 PHASE 1 DAM SAFETY INVESTIGATIONS
100 YEAR FLOOD

JOB SPECIFICATION

NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
144	0	10	0	0	0	0	0	0	0
			JOPER	NMI	LROPT	TRACE			
			3	0	0	0			

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SUB-AREA RUNOFF COMPUTATION

100-YR INFLOW FLOOD BASED ON SULLIVAN PRECIP, 10-MINUTE INCREMENTS

	ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
	100-YR	0	0	0	0	1	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
0	2	.10	0.00	.10	0.00	0.000	0	0	0

PRECIP DATA

NP	STORM	DAJ	DAK
144	0.00	0.00	0.00

PRECIP PATTERN

.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.03	.03	.03	.03
.03	.03	.03	.03	.03	.03	.03	.03	.03	.03
.03	.03	.03	.03	.04	.04	.04	.04	.04	.04
.04	.04	.04	.06	.06	.06	.12	.12	.12	.26
.38	.80	1.21	.38	.26	.12	.12	.12	.06	.06
.06	.04	.04	.04	.04	.04	.04	.04	.04	.04
.03	.03	.03	.03	.03	.03	.03	.03	.03	.03
.03	.03	.03	.03	.03	.03	.03	.03	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01						

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	-100.00	0.00	0.00

CURVE NO = -100.00 WETNESS = -1.00 EFFECT CN = 100.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .10

RECESSION DATA
STRTQ= -.01 QRCSN= -.01 RTIOR= 1.00

TIME INCREMENT TOO LARGE--(NMO IS GT LAG/2)

UNIT HYDROGRAPH 5 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .10 VOL= 1.00
259. 99. 23. 5. 1.

C MO,DA	HR,MN	PERIOD	RAIN	EXCS	LOSS	END-OF-PERIOD FLOW COMP Q	MO,DA	HR,MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.10	1	.01	.01	.00	4.	1.01	12.10	73	1.21	1.21	.00	401.
1.01	.20	2	.01	.01	.00	5.	1.01	12.20	74	.38	.38	-.00	239.
1.01	.30	3	.01	.01	0.00	5.	1.01	12.30	75	.26	.26	-.00	139.
1.01	.40	4	.01	.01	.00	5.	1.01	12.40	76	.12	.12	-.00	74.
1.01	.50	5	.01	.01	.00	5.	1.01	12.50	77	.12	.12	-.00	53.
1.01	1.00	6	.01	.01	-.00	5.	1.01	13.00	78	.12	.12	-.00	48.
1.01	1.10	7	.01	.01	-.00	5.	1.01	13.10	79	.06	.06	-.00	32.
1.01	1.20	8	.01	.01	-.00	5.	1.01	13.20	80	.06	.06	.00	26.
1.01	1.30	9	.01	.01	.00	5.	1.01	13.30	81	.06	.06	-.00	24.
1.01	1.40	10	.01	.01	-.00	5.	1.01	13.40	82	.04	.04	.00	19.
1.01	1.50	11	.01	.01	-.00	5.	1.01	13.50	83	.04	.04	-.00	18.
1.01	2.00	12	.01	.01	-.00	5.	1.01	14.00	84	.04	.04	-.00	17.
1.01	2.10	13	.01	.01	.00	5.	1.01	14.10	85	.04	.04	.00	17.
1.01	2.20	14	.01	.01	-.00	5.	1.01	14.20	86	.04	.04	-.00	17.
1.01	2.30	15	.01	.01	-.00	5.	1.01	14.30	87	.04	.04	.00	17.
1.01	2.40	16	.01	.01	-.00	5.	1.01	14.40	88	.04	.04	-.00	17.
1.01	2.50	17	.01	.01	-.00	5.	1.01	14.50	89	.04	.04	-.00	17.
1.01	3.00	18	.01	.01	.00	5.	1.01	15.00	90	.04	.04	.00	17.
1.01	3.10	19	.01	.01	.00	5.	1.01	15.10	91	.03	.03	-.00	13.
1.01	3.20	20	.01	.01	.00	5.	1.01	15.20	92	.03	.03	.00	11.
1.01	3.30	21	.01	.01	.00	5.	1.01	15.30	93	.03	.03	.00	11.
1.01	3.40	22	.01	.01	.00	5.	1.01	15.40	94	.03	.03	-.00	11.
1.01	3.50	23	.01	.01	.00	5.	1.01	15.50	95	.03	.03	.00	11.
1.01	4.00	24	.01	.01	.00	5.	1.01	16.00	96	.03	.03	.00	11.
1.01	4.10	25	.01	.01	.00	5.	1.01	16.10	97	.03	.03	-.00	11.
1.01	4.20	26	.01	.01	.00	5.	1.01	16.20	98	.03	.03	.00	11.
1.01	4.30	27	.01	.01	.00	5.	1.01	16.30	99	.03	.03	-.00	11.
1.01	4.40	28	.01	.01	.00	5.	1.01	16.40	100	.03	.03	.00	11.
1.01	4.50	29	.01	.01	.00	5.	1.01	16.50	101	.03	.03	.00	11.
1.01	5.00	30	.01	.01	-.00	5.	1.01	17.00	102	.03	.03	.00	11.
1.01	5.10	31	.01	.01	.00	5.	1.01	17.10	103	.03	.03	.00	11.
1.01	5.20	32	.01	.01	-.00	5.	1.01	17.20	104	.03	.03	.00	11.
1.01	5.30	33	.01	.01	.00	5.	1.01	17.30	105	.03	.03	.00	11.
1.01	5.40	34	.01	.01	-.00	5.	1.01	17.40	106	.03	.03	.00	11.
1.01	5.50	35	.01	.01	.00	5.	1.01	17.50	107	.03	.03	-.00	11.
1.01	6.00	36	.01	.01	.00	5.	1.01	18.00	108	.03	.03	.00	11.
1.01	6.10	37	.03	.03	.00	9.	1.01	18.10	109	.01	.01	-.00	7.
1.01	6.20	38	.03	.03	.00	10.	1.01	18.20	110	.01	.01	-.00	6.
1.01	6.30	39	.03	.03	.00	11.	1.01	18.30	111	.01	.01	-.00	6.
1.01	6.40	40	.03	.03	.00	11.	1.01	18.40	112	.01	.01	-.00	5.
1.01	6.50	41	.03	.03	.00	11.	1.01	18.50	113	.01	.01	-.00	5.
1.01	7.00	42	.03	.03	.00	11.	1.01	19.00	114	.01	.01	.00	5.
1.01	7.10	43	.03	.03	.00	11.	1.01	19.10	115	.01	.01	-.00	5.
1.01	7.20	44	.03	.03	.00	11.	1.01	19.20	116	.01	.01	-.00	5.

1.01	7.30	45	.03	.03	.00	11.	1.01	19.30	117	.01	.01	-.00	5.
1.01	7.40	46	.03	.03	-.00	11.	1.01	19.40	118	.01	.01	-.00	5.
1.01	7.50	47	.03	.03	.00	11.	1.01	19.50	119	.01	.01	-.00	5.
1.01	8.00	48	.03	.03	.00	11.	1.01	20.00	120	.01	.01	.00	5.
1.01	8.10	49	.03	.03	.00	11.	1.01	20.10	121	.01	.01	-.00	5.
1.01	8.20	50	.03	.03	-.00	11.	1.01	20.20	122	.01	.01	.00	5.
1.01	8.30	51	.03	.03	.00	11.	1.01	20.30	123	.01	.01	-.00	5.
1.01	8.40	52	.03	.03	.00	11.	1.01	20.40	124	.01	.01	-.00	5.
1.01	8.50	53	.03	.03	.00	11.	1.01	20.50	125	.01	.01	.00	5.
1.01	9.00	54	.03	.03	.00	11.	1.01	21.00	126	.01	.01	-.00	5.
1.01	9.10	55	.04	.04	.00	15.	1.01	21.10	127	.01	.01	-.00	5.
1.01	9.20	56	.04	.04	.00	17.	1.01	21.20	128	.01	.01	.00	5.
1.01	9.30	57	.04	.04	.00	17.	1.01	21.30	129	.01	.01	-.00	5.
1.01	9.40	58	.04	.04	.00	17.	1.01	21.40	130	.01	.01	-.00	5.
1.01	9.50	59	.04	.04	.00	17.	1.01	21.50	131	.01	.01	-.00	5.
1.01	10.00	60	.04	.04	.00	17.	1.01	22.00	132	.01	.01	-.00	5.
1.01	10.10	61	.04	.04	.00	17.	1.01	22.10	133	.01	.01	.00	5.
1.01	10.20	62	.04	.04	.00	17.	1.01	22.20	134	.01	.01	-.00	5.
1.01	10.30	63	.04	.04	.00	17.	1.01	22.30	135	.01	.01	-.00	5.
1.01	10.40	64	.06	.06	.00	22.	1.01	22.40	136	.01	.01	-.00	5.
1.01	10.50	65	.06	.06	-.00	23.	1.01	22.50	137	.01	.01	-.00	5.
1.01	11.00	66	.06	.06	.00	24.	1.01	23.00	138	.01	.01	.00	5.
1.01	11.10	67	.12	.12	0.00	39.	1.01	23.10	139	.01	.01	-.00	5.
1.01	11.20	68	.12	.12	0.00	45.	1.01	23.20	140	.01	.01	-.00	5.
1.01	11.30	69	.12	.12	.00	47.	1.01	23.30	141	.01	.01	.00	5.
1.01	11.40	70	.26	.26	.00	84.	1.01	23.40	142	.01	.01	-.00	5.
1.01	11.50	71	.38	.38	-.00	129.	1.01	23.50	143	.01	.01	-.00	5.
1.01	12.00	72	.80	.80	-.00	252.	1.02	0.00	144	.01	.01	.00	5.
									SUM	7.21	7.21	.00	2766.
										(183.)(	183.)(	0.)(	78.32)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	401.	56.	19.	19.	2785.
CMS	11.	2.	1.	1.	79.
INCHES		5.19	7.20	7.20	7.20
MM		131.79	182.80	182.80	182.80
AC-FT		28.	38.	38.	38.
THOUS CU M		34.	47.	47.	47.

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HYDROGRAPH ROUTING

ROUTING THROUGH CLOSED SYSTEM

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

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	0	0	0	0

NSTPS	NSTOL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-861.	-1

STAGE	861.00	861.50	862.00	862.50	863.00	863.50	864.00			
FLOW	0.00	140.00	510.00	1360.00	3000.00	5000.00	7600.00			
SURFACE AREA=	0.	5.	26.	28.	31.	34.	37.	40.	43.	46.
CAPACITY=	0.	6.	17.	23.	37.	53.	71.	90.	111.	133.
ELEVATION=	856.	860.	861.	861.	862.	862.	863.	863.	864.	864.

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
861.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
861.0	0.0	0.0	0.

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	100-YR	401.	56.	19.	19.	.10
		(11.36)(	1.58)(	.55)(	.55)(	.26)
ROUTED TO	LAKE	127.	54.	16.	16.	.10
		(3.01)(	1.52)(	.47)(	.47)(	.26)

SUMMARY OF DAM SAFETY ANALYSIS

100-year

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	860.80	861.00	861.00
STORAGE	17.	23.	23.
OUTFLOW	0.	0.	0.

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
861.06	.06	36.	127.	14.83	12.50	0.00

```
A1          CADET NO. 2 TAILINGS DAM MO. NO. 30707
A2          HEC-1  PHASE 1  DAM SAFETY INVESTIGATIONS
A3           10  YEAR FLOOD
B     144                10                                  0
B1      3
K       0 RUNOFF                                      1       1
K1   10-YEAR FLOOD BASED ON SULLIVAN PRECIP. AT 10 MIN INTERVAL
M       0        2       .1
O     144
O1   .010     .010     .010     .010     .010     .010     .010     .010     .010     .010
O1   .010     .010     .010     .010     .010     .010     .010     .010     .010     .010
O1   .010     .010     .010     .010     .010     .010     .010     .010     .010     .010
O1   .010     .010     .010     .010     .010     .010     .020     .020     .020     .020
O1   .020     .020     .020     .020     .020     .020     .020     .020     .020     .020
O1   .020     .020     .020     .020     .030     .030     .030     .030     .030     .030
O1   .030     .030     .030     .062     .062     .062     .098     .098     .098     .172
O1   .249     .538     .846     .249     .172     .098     .098     .098     .062     .062
O1   .062     .030     .030     .030     .030     .030     .030     .030     .030     .030
O1   .020     .020     .020     .020     .020     .020     .020     .020     .020     .020
O1   .020     .020     .020     .020     .020     .020     .020     .020     .010     .010
O1   .010     .010     .010     .010     .010     .010     .010     .010     .010     .010
O1   .010     .010     .010     .010     .010     .010     .010     .010     .010     .010
O1   .010     .010     .010     .010     .010     .010     .010     .010     .010     .010
O1   .010     .010     .010     .010
T                                                          -1     -100
W2            0.10
X    -.01     -.01       1.
K       1 ROUTING                                     1       1
K1    ROUTING THROUGH CLOSED SYSTEM
Y                                  1
Y1      1                                             -860.8      -1
Y4  861.0    861.5    862.0    862.5    863.0    863.5    864.0
Y5    0.0     140.     510.    1360.    3000.    5000.    7600.
$A    0.0      4.6     26.3     27.5     30.5     33.7     36.9     40.0     43.0     46.3
$E   856.     860.    860.8    861.0    861.5    862.0    862.5    863.0    863.5    864.0
$$  861.0
$D   861.
K      99
A
```

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

RUN DATE= 79/12/01.
TIME= 14.39.37.

CADET NO. 2 TAILINGS DAM NO. NO. 30707
HEC-1 PHASE 1 DAM SAFETY INVESTIGATIONS
10 YEAR FLOOD

JOB SPECIFICATION

NQ	NMIN	IDAY	IHR	IMIN	METRIC	IPLT	IPRT	NSTAN
144	0	10	0	0	0	0	0	0
		JOPER	NAT	LROPT	TRACE			
		3	0	0	0			

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SUB-AREA RUNOFF COMPUTATION

10-YEAR FLOOD BASED ON SULLIVAN PRECIP. AT 10 MIN INTERVAL

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

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
0	2	.10	0.00	.10	0.00	0.000	0	0	0

PRECIP DATA

NP	STORM	DAJ	DAK
144	0.00	0.00	0.00

PRECIP PATTERN

.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.02	.02	.02	.02
.02	.02	.02	.02	.02	.02	.02	.02	.02	.02
.02	.02	.02	.02	.03	.03	.03	.03	.03	.03
.03	.03	.03	.06	.06	.06	.11	.11	.11	.17
.25	.54	.85	.25	.17	.10	.10	.11	.06	.06
.06	.03	.03	.03	.03	.03	.03	.03	.03	.03
.02	.02	.02	.02	.02	.02	.02	.02	.02	.02
.02	.02	.02	.02	.02	.02	.02	.02	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01						

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	-100.00	0.00	0.00

CURVE NO = -100.00 RETNESS = -1.00 EFFECT CN = 100.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .10

RECESSION DATA
STRTQ= -.01 QRCSN= -.01 RTIOR= 1.00

TIME INCREMENT TOO LARGE--(NMG IS GT LAG/2)

UNIT HYDROGRAPH 5 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .10 VOL= 1.00
259. 99. 23. 5. 1.

Q MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	END-OF-PERIOD FLOW COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.10	1	.01	.01	0.00	3.	1.01	12.10	73	.05	.05	-.00	279.
1.01	.20	2	.01	.01	0.00	4.	1.01	12.20	74	.25	.25	-.00	162.
1.01	.30	3	.01	.01	0.00	4.	1.01	12.30	75	.17	.17	.00	92.
1.01	.40	4	.01	.01	0.00	4.	1.01	12.40	76	.10	.10	.00	53.
1.01	.50	5	.01	.01	0.00	4.	1.01	12.50	77	.10	.10	.00	41.
1.01	1.00	6	.01	.01	0.00	4.	1.01	13.00	78	.10	.10	.00	38.
1.01	1.10	7	.01	.01	.00	4.	1.01	13.10	79	.06	.06	.00	29.
1.01	1.20	8	.01	.01	-.00	4.	1.01	13.20	80	.06	.06	-.00	25.
1.01	1.30	9	.01	.01	-.00	4.	1.01	13.30	81	.06	.06	-.00	24.
1.01	1.40	10	.01	.01	-.00	4.	1.01	13.40	82	.03	.03	.00	16.
1.01	1.50	11	.01	.01	-.00	4.	1.01	13.50	83	.03	.03	-.00	13.
1.01	2.00	12	.01	.01	-.00	4.	1.01	14.00	84	.03	.03	-.00	12.
1.01	2.10	13	.01	.01	.00	4.	1.01	14.10	85	.03	.03	-.00	12.
1.01	2.20	14	.01	.01	.00	4.	1.01	14.20	86	.03	.03	-.00	12.
1.01	2.30	15	.01	.01	.00	4.	1.01	14.30	87	.03	.03	-.00	12.
1.01	2.40	16	.01	.01	.00	4.	1.01	14.40	88	.03	.03	-.00	12.
1.01	2.50	17	.01	.01	.00	4.	1.01	14.50	89	.03	.03	-.00	12.
1.01	3.00	18	.01	.01	.00	4.	1.01	15.00	90	.03	.03	-.00	12.
1.01	3.10	19	.01	.01	-.00	4.	1.01	15.10	91	.02	.02	-.00	9.
1.01	3.20	20	.01	.01	.00	4.	1.01	15.20	92	.02	.02	-.00	8.
1.01	3.30	21	.01	.01	-.00	4.	1.01	15.30	93	.02	.02	-.00	8.
1.01	3.40	22	.01	.01	.00	4.	1.01	15.40	94	.02	.02	-.00	8.
1.01	3.50	23	.01	.01	.00	4.	1.01	15.50	95	.02	.02	-.00	8.
1.01	4.00	24	.01	.01	-.00	4.	1.01	16.00	96	.02	.02	-.00	8.
1.01	4.10	25	.01	.01	.00	4.	1.01	16.10	97	.02	.02	-.00	8.
1.01	4.20	26	.01	.01	.00	4.	1.01	16.20	98	.02	.02	.00	8.
1.01	4.30	27	.01	.01	-.00	4.	1.01	16.30	99	.02	.02	-.00	8.
1.01	4.40	28	.01	.01	.00	4.	1.01	16.40	100	.02	.02	-.00	8.
1.01	4.50	29	.01	.01	-.00	4.	1.01	16.50	101	.02	.02	-.00	8.
1.01	5.00	30	.01	.01	.00	4.	1.01	17.00	102	.02	.02	.00	8.
1.01	5.10	31	.01	.01	-.00	4.	1.01	17.10	103	.02	.02	-.00	8.
1.01	5.20	32	.01	.01	.00	4.	1.01	17.20	104	.02	.02	-.00	8.
1.01	5.30	33	.01	.01	.00	4.	1.01	17.30	105	.02	.02	-.00	8.
1.01	5.40	34	.01	.01	.00	4.	1.01	17.40	106	.02	.02	-.00	8.
1.01	5.50	35	.01	.01	.00	4.	1.01	17.50	107	.02	.02	.00	8.
1.01	6.00	36	.01	.01	.00	4.	1.01	18.00	108	.02	.02	-.00	8.
1.01	6.10	37	.02	.02	-.00	6.	1.01	18.10	109	.01	.01	.00	5.
1.01	6.20	38	.02	.02	.00	7.	1.01	18.20	110	.01	.01	.00	4.
1.01	6.30	39	.02	.02	-.00	5.	1.01	18.30	111	.01	.01	.00	4.
1.01	6.40	40	.02	.02	.00	5.	1.01	18.40	112	.01	.01	-.00	4.
1.01	6.50	41	.02	.02	.00	5.	1.01	18.50	113	.01	.01	.00	4.
1.01	7.00	42	.02	.02	.00	5.	1.01	19.00	114	.01	.01	.00	4.
1.01	7.10	43	.02	.02	-.00	5.	1.01	19.10	115	.01	.01	.00	4.
1.01	7.20	44	.02	.02	.00	5.	1.01	19.20	116	.01	.01	.00	4.

1.01	7.30	45	.02	.02	-.00	8.	1.01	19.30	117	.01	.01	.00	0.
1.01	7.40	46	.02	.02	.00	8.	1.01	19.40	118	.01	.01	.00	0.
1.01	7.50	47	.02	.02	.00	8.	1.01	19.50	119	.01	.01	.00	0.
1.01	8.00	48	.02	.02	.00	8.	1.01	20.00	120	.01	.01	.00	0.
1.01	8.10	49	.02	.02	.00	8.	1.01	20.10	121	.01	.01	.00	0.
1.01	8.20	50	.02	.02	.00	8.	1.01	20.20	122	.01	.01	-.00	0.
1.01	8.30	51	.02	.02	.00	8.	1.01	20.30	123	.01	.01	.00	0.
1.01	8.40	52	.02	.02	.00	8.	1.01	20.40	124	.01	.01	-.00	0.
1.01	8.50	53	.02	.02	.00	8.	1.01	20.50	125	.01	.01	.00	0.
1.01	9.00	54	.02	.02	.00	8.	1.01	21.00	126	.01	.01	.00	0.
1.01	9.10	55	.03	.03	.00	10.	1.01	21.10	127	.01	.01	.00	0.
1.01	9.20	56	.03	.03	-.00	11.	1.01	21.20	128	.01	.01	.00	0.
1.01	9.30	57	.03	.03	.00	12.	1.01	21.30	129	.01	.01	.00	0.
1.01	9.40	58	.03	.03	-.00	12.	1.01	21.40	130	.01	.01	.00	0.
1.01	9.50	59	.03	.03	-.00	12.	1.01	21.50	131	.01	.01	.00	0.
1.01	10.00	60	.03	.03	-.00	12.	1.01	22.00	132	.01	.01	.00	0.
1.01	10.10	61	.03	.03	.00	12.	1.01	22.10	133	.01	.01	-.00	0.
1.01	10.20	62	.03	.03	-.00	12.	1.01	22.20	134	.01	.01	.00	0.
1.01	10.30	63	.03	.03	-.00	12.	1.01	22.30	135	.01	.01	.00	0.
1.01	10.40	64	.06	.04	.00	20.	1.01	22.40	136	.01	.01	.00	0.
1.01	10.50	65	.06	.06	.00	23.	1.01	22.50	137	.01	.01	.00	0.
1.01	11.00	66	.06	.06	.00	24.	1.01	23.00	138	.01	.01	.00	0.
1.01	11.10	67	.10	.10	-.00	33.	1.01	23.10	139	.01	.01	.00	0.
1.01	11.20	68	.10	.10	.00	37.	1.01	23.20	140	.01	.01	.00	0.
1.01	11.30	69	.10	.10	.00	38.	1.01	23.30	141	.01	.01	.00	0.
1.01	11.40	70	.17	.17	.00	57.	1.01	23.40	142	.01	.01	.00	0.
1.01	11.50	71	.25	.25	-.00	84.	1.01	23.50	143	.01	.01	.00	0.
1.01	12.00	72	.54	.54	.00	168.	1.02	0.00	144	.01	.01	.00	0.
									SUM	5.17	5.17	.00	2019.
										(131.)(	131.)(	0.)(	57.17)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	279.	40.	14.	14.	1995.
CMS	8.	1.	0.	0.	56.
INCHES		3.72	5.15	5.15	5.15
MM		94.49	130.91	130.91	130.91
AC-FT		20.	27.	27.	27.
THOUS CU M		24.	34.	34.	34.

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HYDROGRAPH ROUTING

ROUTING THROUGH CLOSED SYSTEM

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
OUTING	1	0	0	0	1	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	0	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-861.	-1

STAGE	861.00	861.50	862.00	862.50	863.00	863.50	864.00			
FLOW	0.00	140.00	510.00	1360.00	3000.00	5000.00	7600.00			
SURFACE AREA=	0.	5.	26.	28.	31.	34.	37.	40.	43.	46.
CAPACITY=	0.	6.	17.	23.	37.	53.	71.	90.	111.	133.
ELEVATION=	856.	860.	861.	861.	862.	862.	863.	863.	864.	864.

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
861.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
861.0	0.0	0.0	0.

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	UNOFF	279.	40.	14.	14.	.10
		(7.90)(	1.13)(	.39)(	.39)(	.26)
ROUTED TO	OUTING	87.	37.	11.	11.	.10
		(2.45)(	1.05)(	.31)(	.31)(	.26)

10-year

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	860.80	861.00	861.00
STORAGE	17.	23.	23.
OUTFLOW	0.	0.	0.

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
861.31	.31	31.	87.	13.33	12.50	0.00

APPENDIX B

INFORMATION SUPPLIED BY OTHERS

ENGINEERING GEOLOGIC REPORT ON BAROID (NL) INDUSTRIES TAILINGS POND

Washington County, Mo.

LOCATION: North ½, Sec. 21, T. 38 N., R. 3 E., Mineral Point Quadrangle

GEOLOGIC SITTING:

The area is underlain by the Potosi Dolomite. Soil consists of stony red clay. The dams have been constructed of gravelly material that is generally less than 1 inch in size down to coarse sand. Few fines are present.

The particular dam that is in severe jeopardy has been built perhaps even without a starter dam. Leakage was occurring on the back slope. The front slope of the dam was failing inward into the mud. The dam is presently 70 feet high. Plans call for raising it to 100 feet in height.

MESA has required that the owner dump gravels on the front slope of the dyke in order to stabilize the portions sliding into the mud. There is the opinion expressed that part of the trouble causing the failure of the present dam is the fact that waste from the plant is dumped originally in the upstream portion. Thus, the coarser material which more rapidly is dewatered lies at the upstream end of this structure. Finer materials including water move gradually downslope toward the large dam. Thus, the material at the dam consists primarily of clay material that is supersaturated.

RECOMMENDATIONS:

Several opinions were given as to the need of a berm on the downstream side. However, in view of the fact that the dam is planned to be at least 100 feet in height, it would seem that it would be first most important to explore the characteristics of the material at the downstream toe of the dam. It may be necessary to remove this entirely, and to backfill with compacted coarse rock material. The recommendation was that the berm be raised at least half way up on the original dam. However, there is uncertainty as to the total length of the berm and the total width of the berm.

My recommendation would be that no decisions be made until the downstream portion of the dam is thoroughly explored. In addition, the owner should be required to submit engineering design plans based upon the anticipated final stages of construction and outline in detail the procedures for construction inspection. With the height contemplated, the final slope of the dam may well have to be in the neighborhood of 2½ to possibly 3 to 1 and much of the downstream portion consists of compacted gravelly clay, at least in the lower portion of the dam. This berm should be drained. However, with a toe drain, the remaining portion of the berms could consist of a well graded mixture of clay and stone fragments. Here the essential factors are compaction and a filter deposit between the clay rock and the free draining filter at the base of the berm.

James H. Williams, Chief
Applied Engineering & Urban Geology
Missouri Geological Survey
September 30, 1975

NL INDUSTRIES BARDILL DIVISION TAILINGS POND

Washington County, Mo.

LOCATION: SE¼, NE¼, Sec. 21 & SW¼, NW¼, Sec. 22, T. 39 N., R. 3 W., Tiff Quadrangle

Examination of dam on 16 October 1975, indicates that the owner-operator is beginning to complete repair procedures needed to stabilize the dam. He has initiated the construction of a berm at the downstream toe of the dam. Sod and some of the upper soil materials were scraped away prior to the placement of the coarse gravels and boulders being used in the berm. However, soil was not excavated to bedrock. The subsoil does appear to be relatively firm. No material is being placed on sod, trees, or other unstable debris.

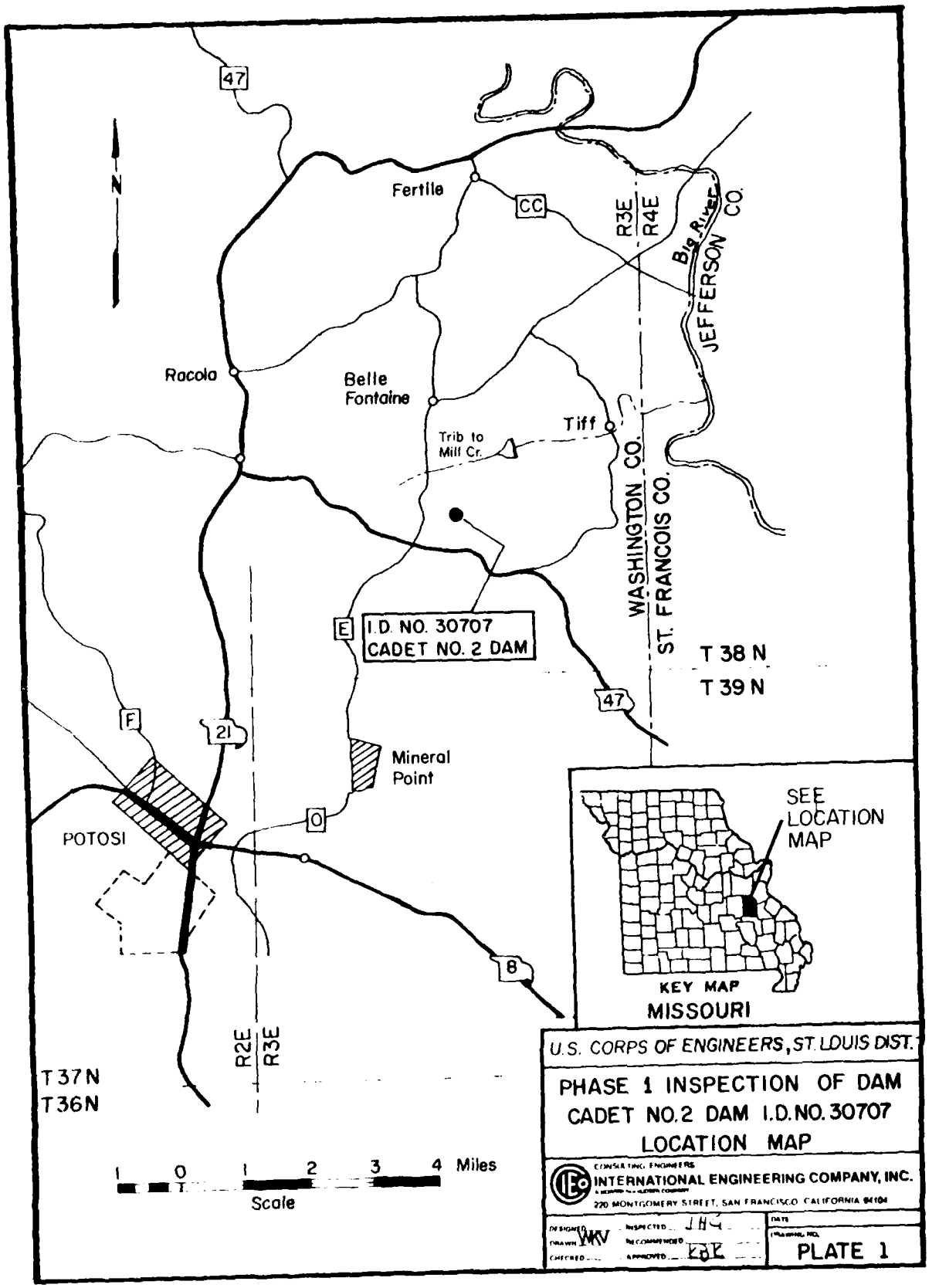
Based on the present method of initiating construction of the berm, it appears that the width of the berm will be at least 50 feet. Gravel and boulders are being compacted as they are being placed in the berm. Consequently construction procedures seem to be in order. If this is carried forward with the same procedure as the initation of the project, the berm should be sufficient to stabilize the dam. In addition, gravel being dumped on the backslope has begun to fill in some of the area of slope concavity that existed in the weakest portion of the dam.

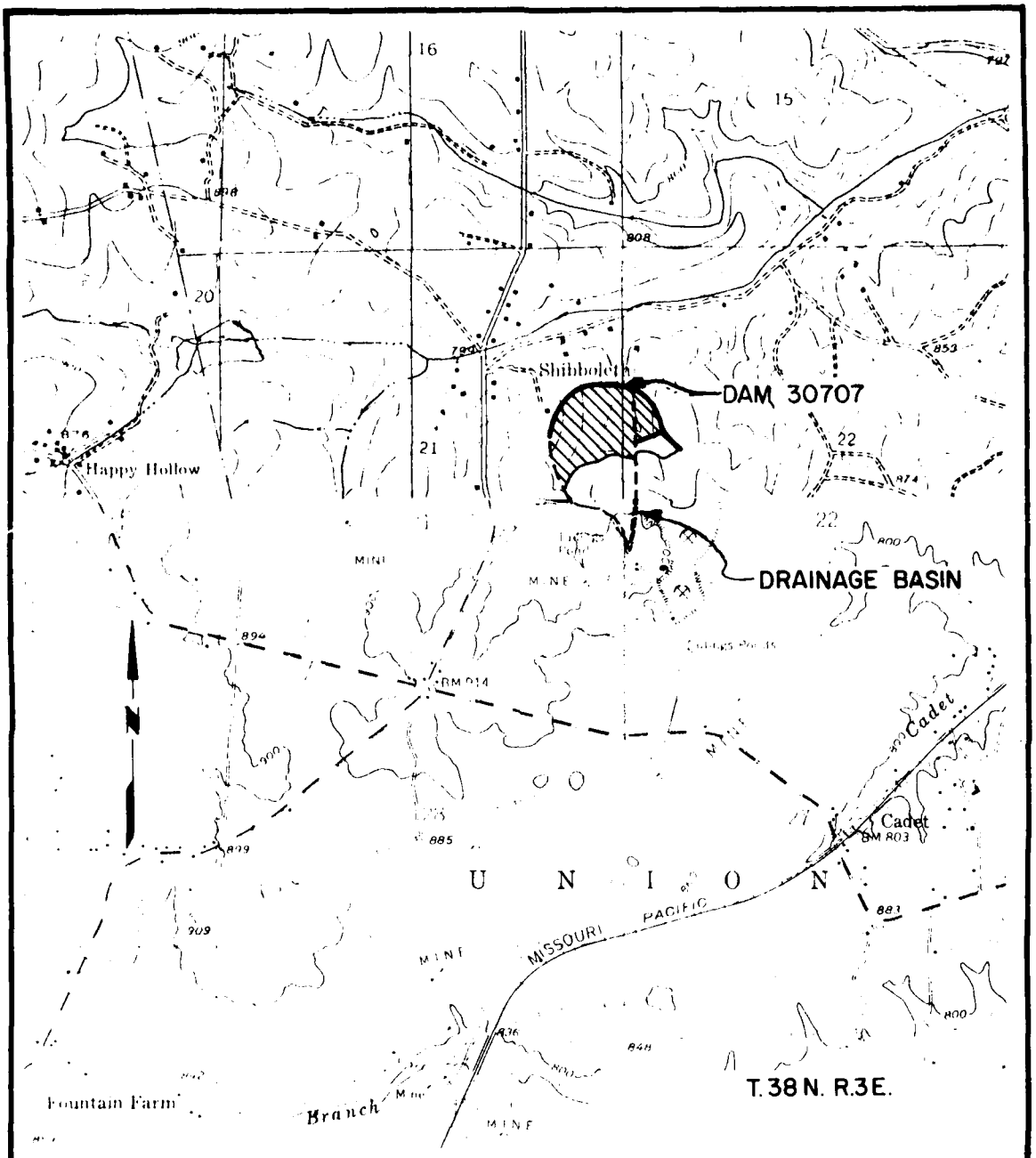
There appears to be at least one permanent resident and perhaps more at Powder Spring lake located approximately 3/4th miles downstream of NL Industries dam. The lake in located in the SE¼, of sec. 15, T. 38 N., R. 3 W., on an unnamed tributary that flows through Tiff.

Dr. J. Hadley Williams, Chief
Applied Engineering & Urban Geology
Missouri Geological Survey
October 21, 1975

cc: Robert Lindholm
Office of Attorney General
Supreme Court Building
Jefferson City, Mo. 65101

Wayne Kanack
MESA
206 Hwy. 63 South
Rolla, Mo. 65401


47
N
Fertile
CC
R3E
R4E
Big River
JEFFERSON CO.
Racola
Belle Fontaine
Tiff
Trib to Mill Cr.
WASHINGTON CO.
ST. FRANCOIS CO.
E
I.D. NO. 30707
CADET NO. 2 DAM
T 38 N
T 39 N
47
F
21
Mineral Point
O
POTOSI
8
R2E
R3E
T37N
T36N
SEE LOCATION MAP
KEY MAP
MISSOURI
0 1 2 3 4 Miles
Scale
U.S. CORPS OF ENGINEERS, ST. LOUIS DIST.
PHASE 1 INSPECTION OF DAM
CADET NO.2 DAM I.D.NO. 30707
LOCATION MAP
CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
220 MONTGOMERY STREET, SAN FRANCISCO, CALIFORNIA 94104
DESIGNED
DRAWN WKV
CHECKED
INSPECTED JHC
RECOMMENDED
APPROVED
DATE
DRAWING NO.
PLATE 1

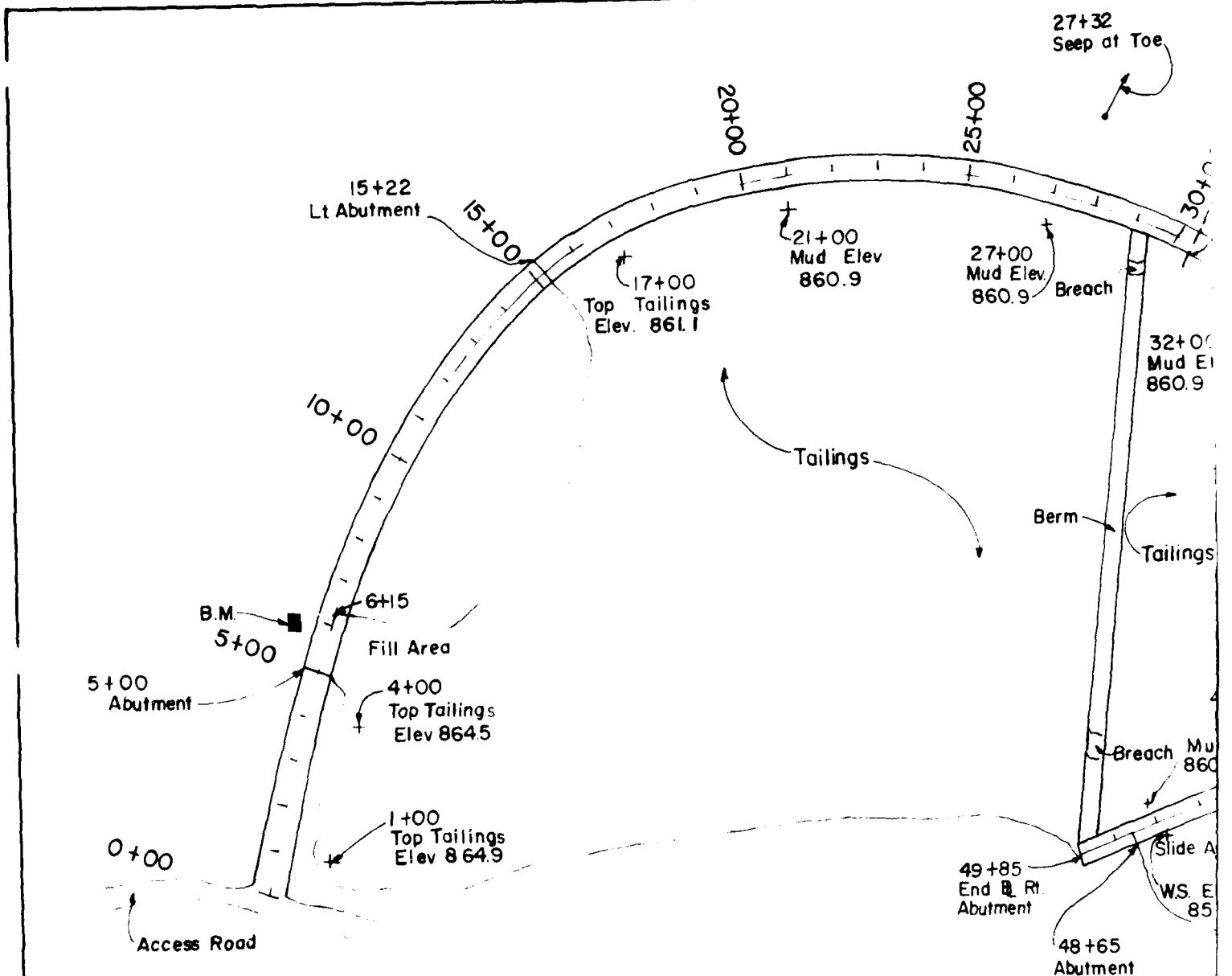


U.S. CORPS OF ENGINEERS, ST. LOUIS DIST.

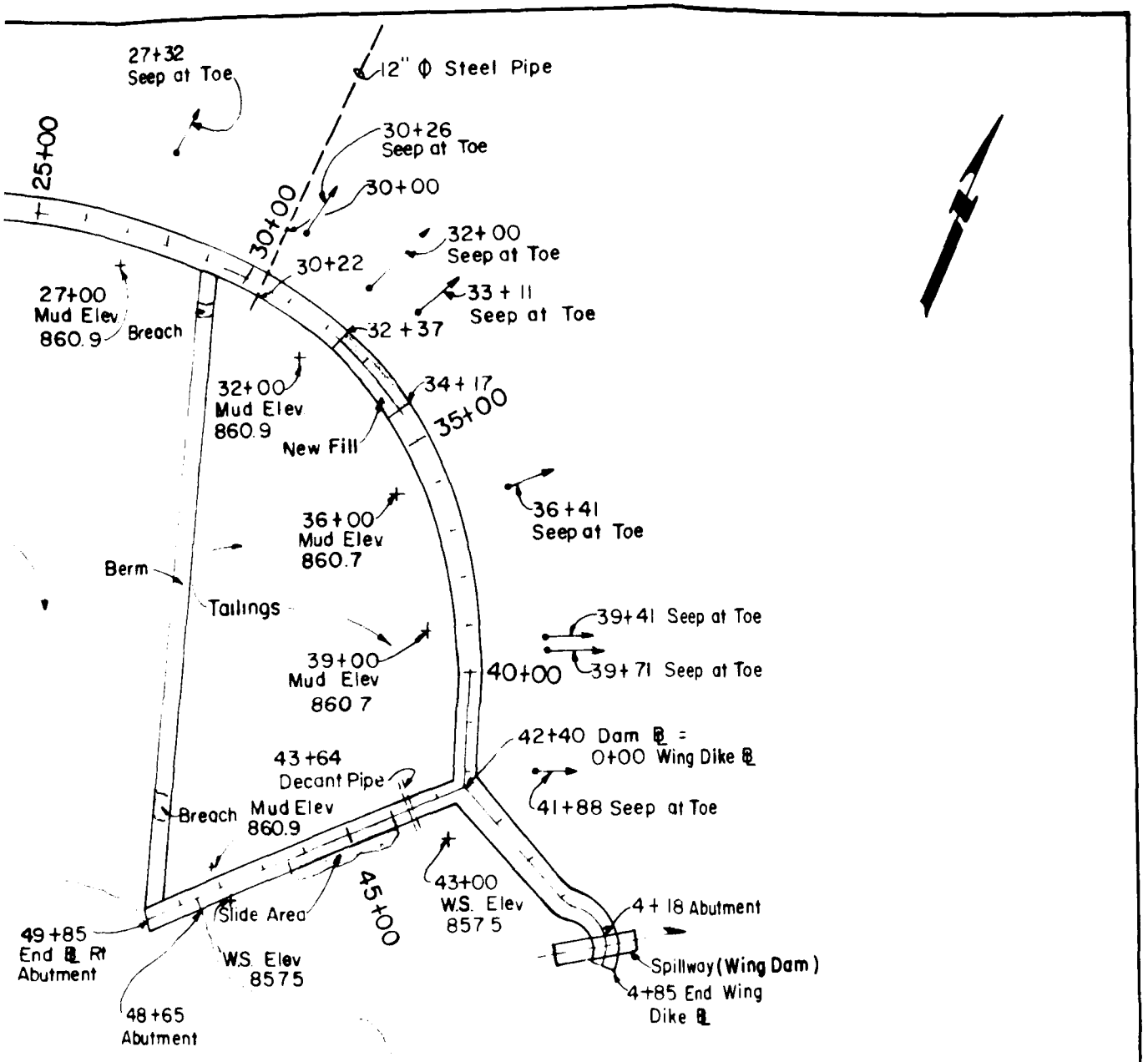
PHASE I INSPECTION OF DAMS
CADET NO. 2 DAM I.D. NO. 30707
VICINITY TOPOGRAPHY

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
220 MONTGOMERY STREET SAN FRANCISCO CALIFORNIA 94104

DESIGNED | INSPECTED JHG | DATE
DRAWN DFEN1 | RECOMMENDED | DRAWING NO.
CHECKED | APPROVED KBK | PLATE 2



B.M. – 80d Spike in 12" Elm
35' Lt. Sta. 6+00 ℄ Dam Elev. 873.8
Date of Survey 4/20/79



DAM I.D.NO. 30707

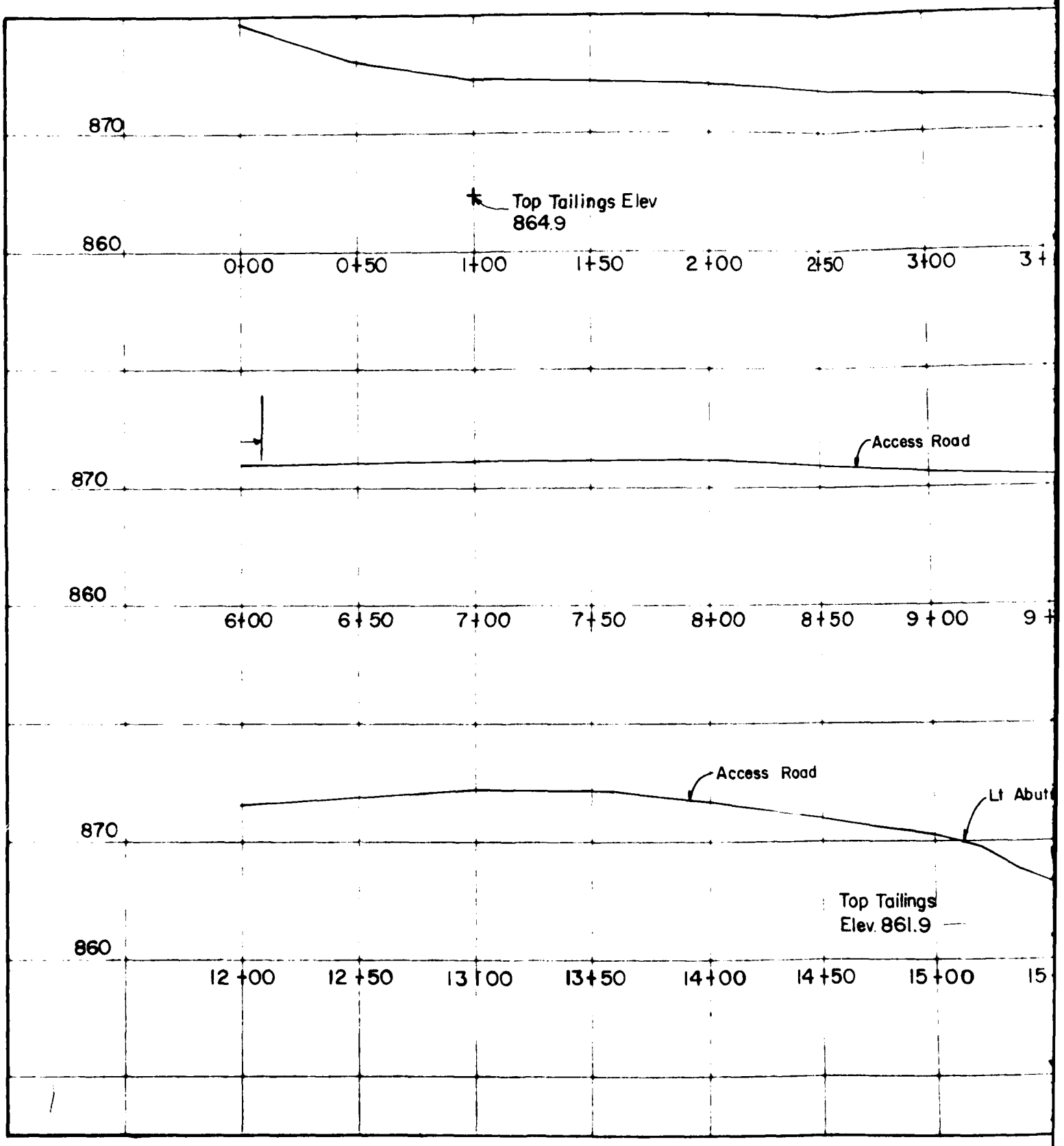
CADET NO.2 DAM

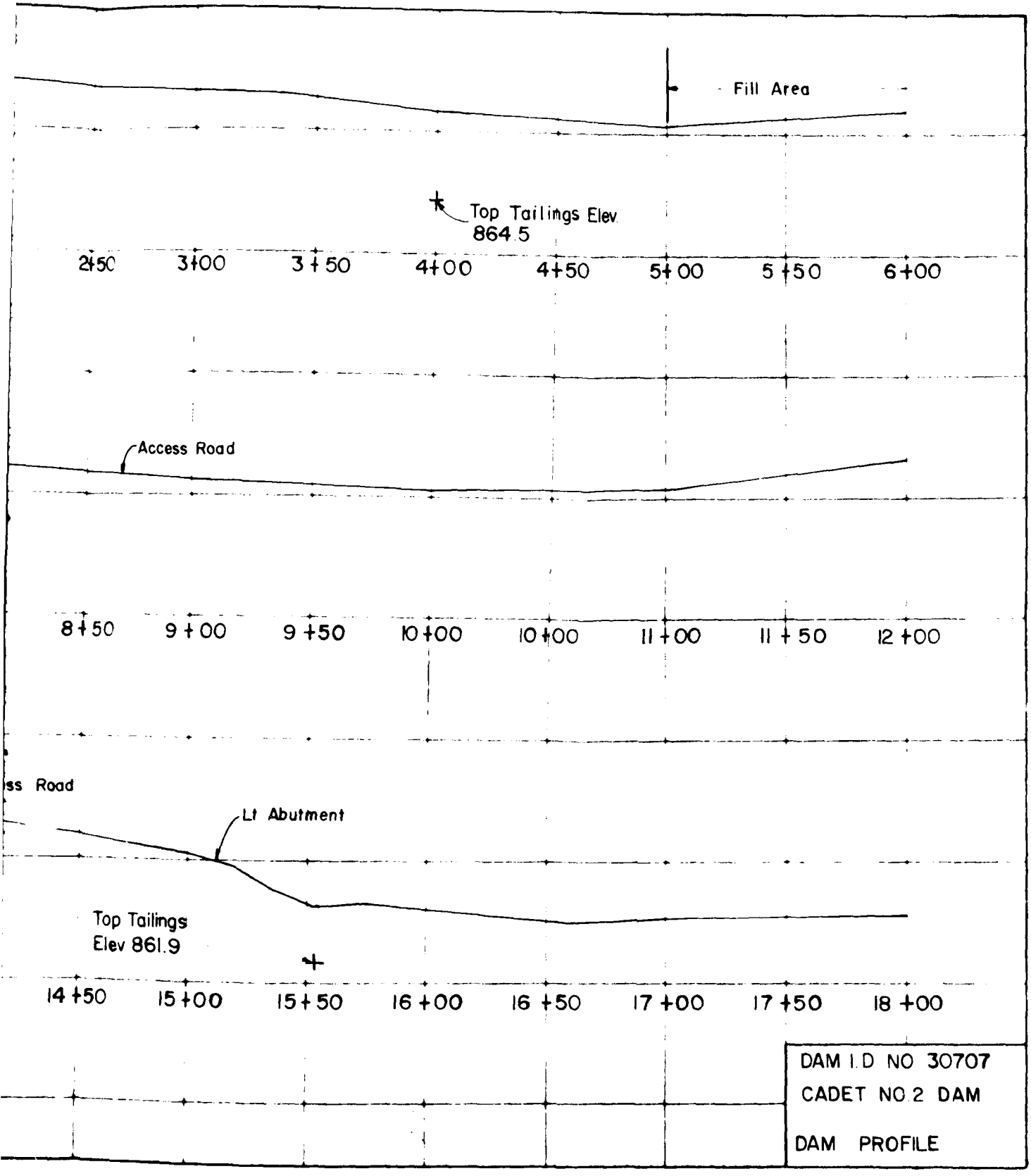
PLAN

SCALE IN FEET

300 200 100 0 300

PLATE 3

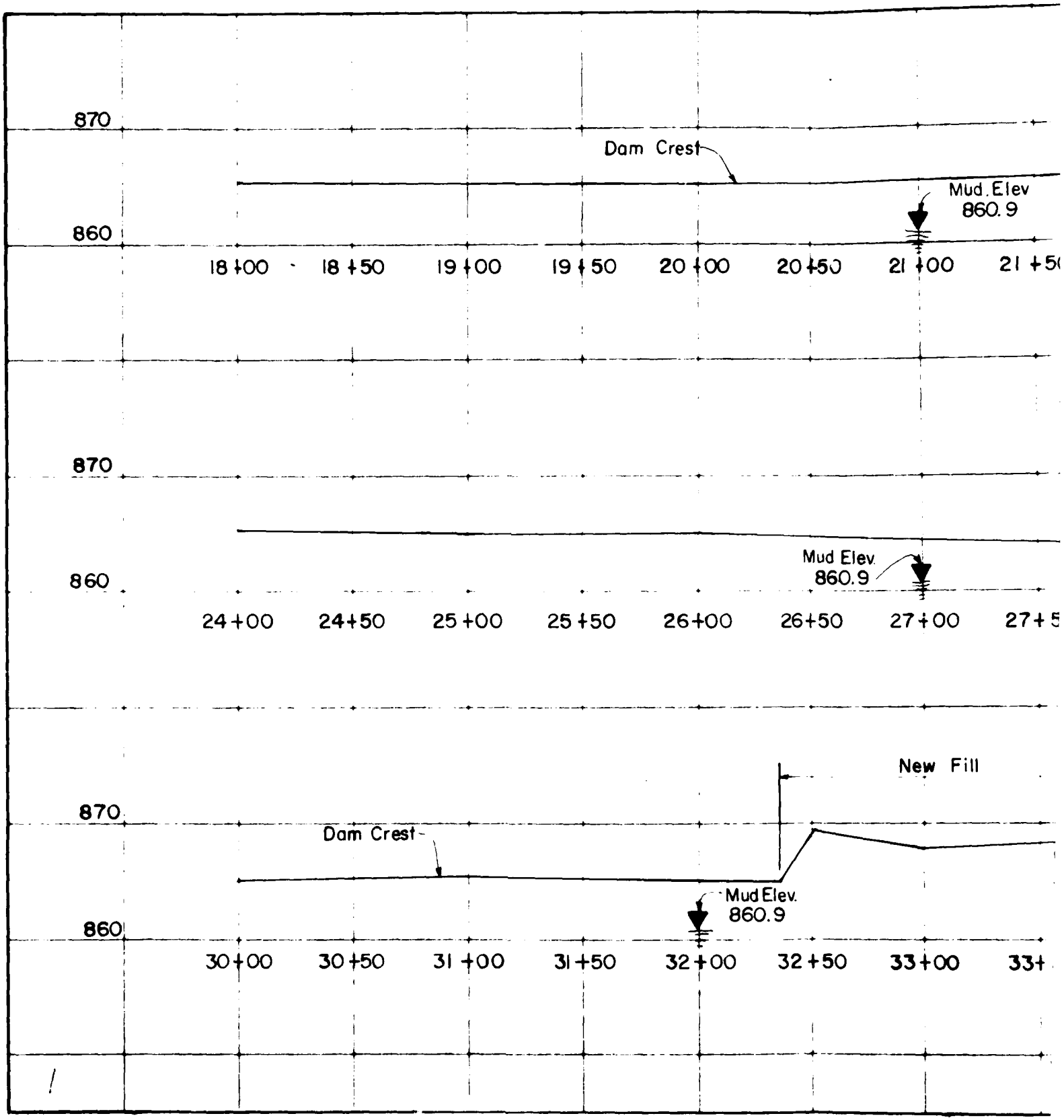

870
860
Top Tailings Elev
864.9
0+00
0+50
1+00
1+50
2+00
2+50
3+00
3+
Access Road
870
860
6+00
6+50
7+00
7+50
8+00
8+50
9+00
9+
Access Road
Lt Abut
870
Top Tailings
Elev. 861.9
860
12+00
12+50
13+00
13+50
14+00
14+50
15+00
15

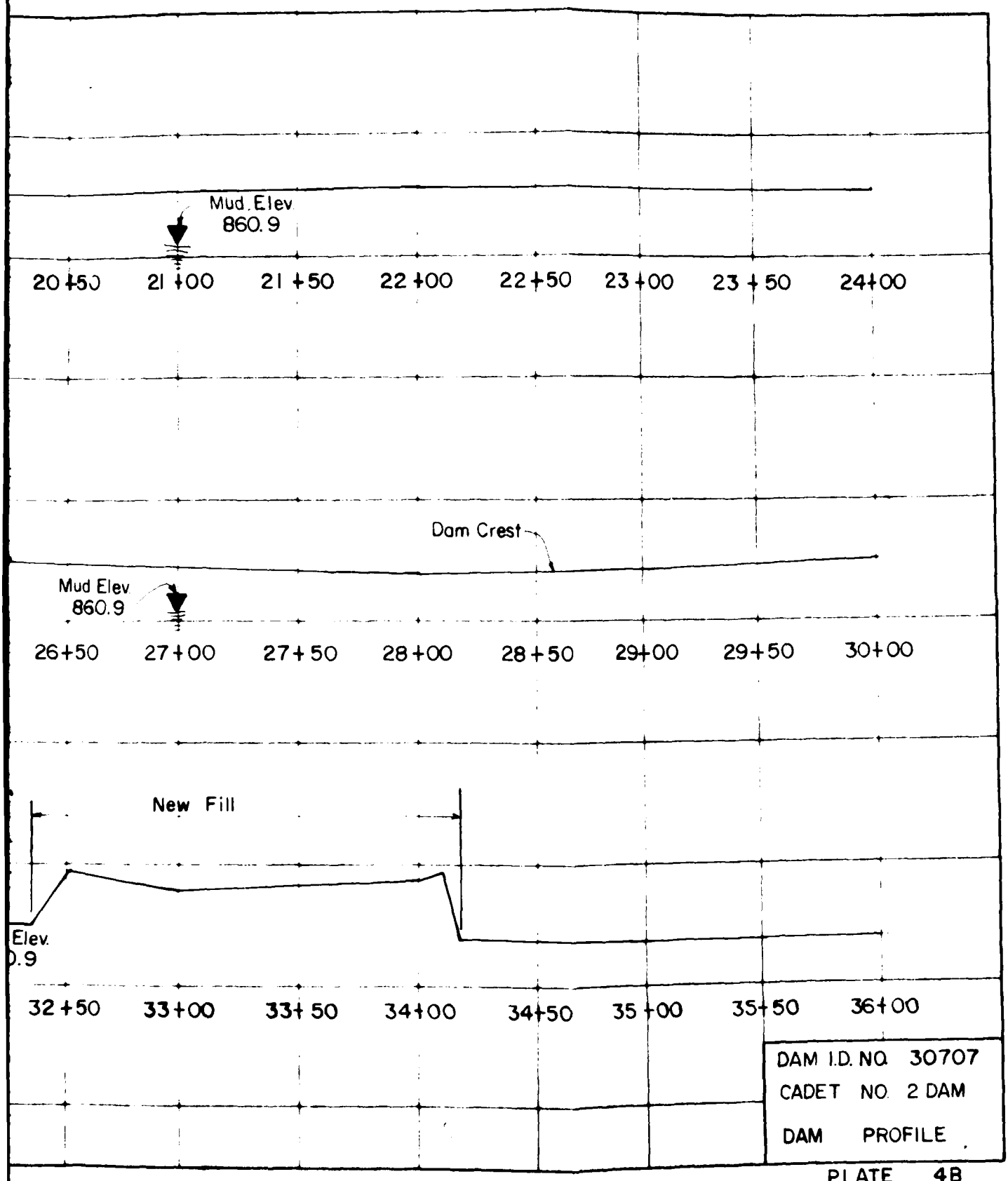


DAM I.D NO 30707
CADET NO.2 DAM

DAM PROFILE

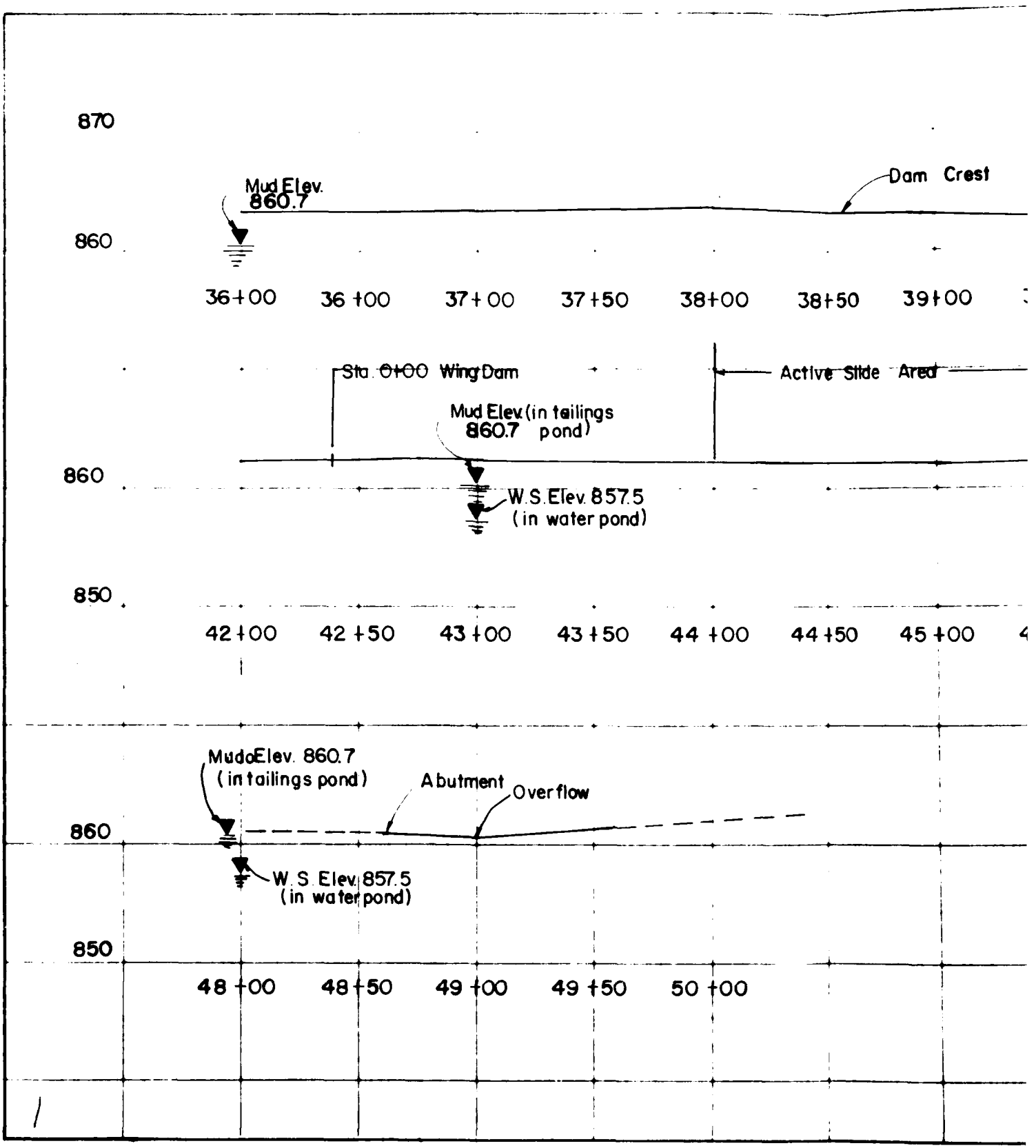
PLATE 4A

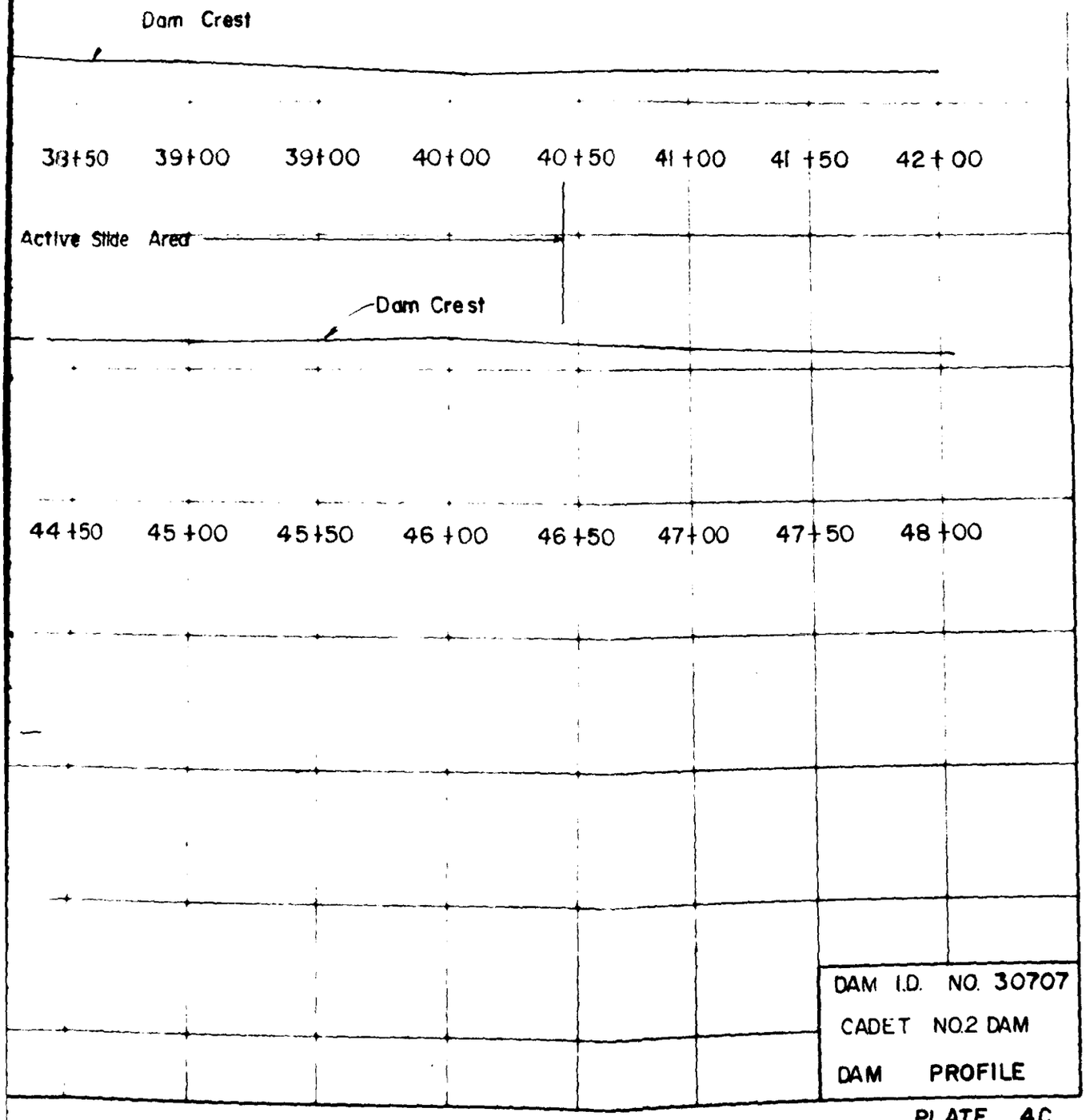

870
860
Dam Crest
Mud Elev
860.9
18+00
18+50
19+00
19+50
20+00
20+50
21+00
21+50
870
860
Mud Elev
860.9
24+00
24+50
25+00
25+50
26+00
26+50
27+00
27+5
New Fill
870
Dam Crest
Mud Elev.
860.9
860
30+00
30+50
31+00
31+50
32+00
32+50
33+00
33+



DAM I.D. NO. 30707
CADET NO. 2 DAM
DAM PROFILE

PLATE 4B


870
860
850
Mud Elev.
860.7
Dam Crest
36+00
36+00
37+00
37+50
38+00
38+50
39+00
Sta. 0+00 Wing Dam
Active Slide Area
Mud Elev. (in tailings
860.7 pond)
W.S. Elev. 857.5
(in water pond)
42+00
42+50
43+00
43+50
44+00
44+50
45+00
Mud Elev. 860.7
(in tailings pond)
Abutment
Overflow
W.S. Elev. 857.5
(in water pond)
48+00
48+50
49+00
49+50
50+00



DAM I.D. NO. 30707

CADET NO.2 DAM

DAM PROFILE

PLATE 4C

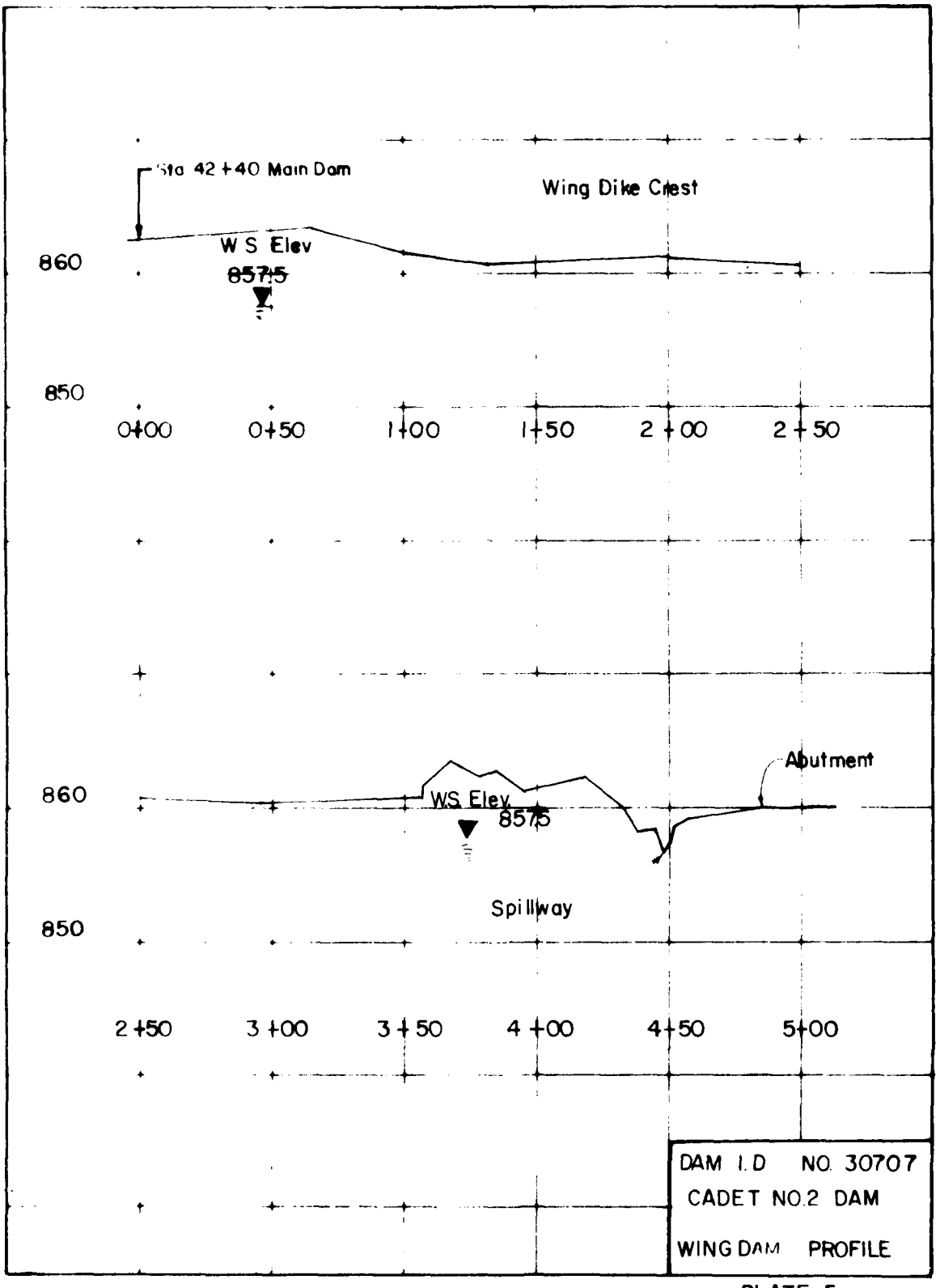

Sta 42+40 Main Dam
Wing Dike Crest
W S Elev
8575
860
850
0+00
0+50
1+00
1+50
2+00
2+50
Abutment
W.S. Elev.
8575
Spillway
2+50
3+00
3+50
4+00
4+50
5+00
DAM I.D NO. 30707
CADET NO.2 DAM
WING DAM PROFILE

PLATE 5

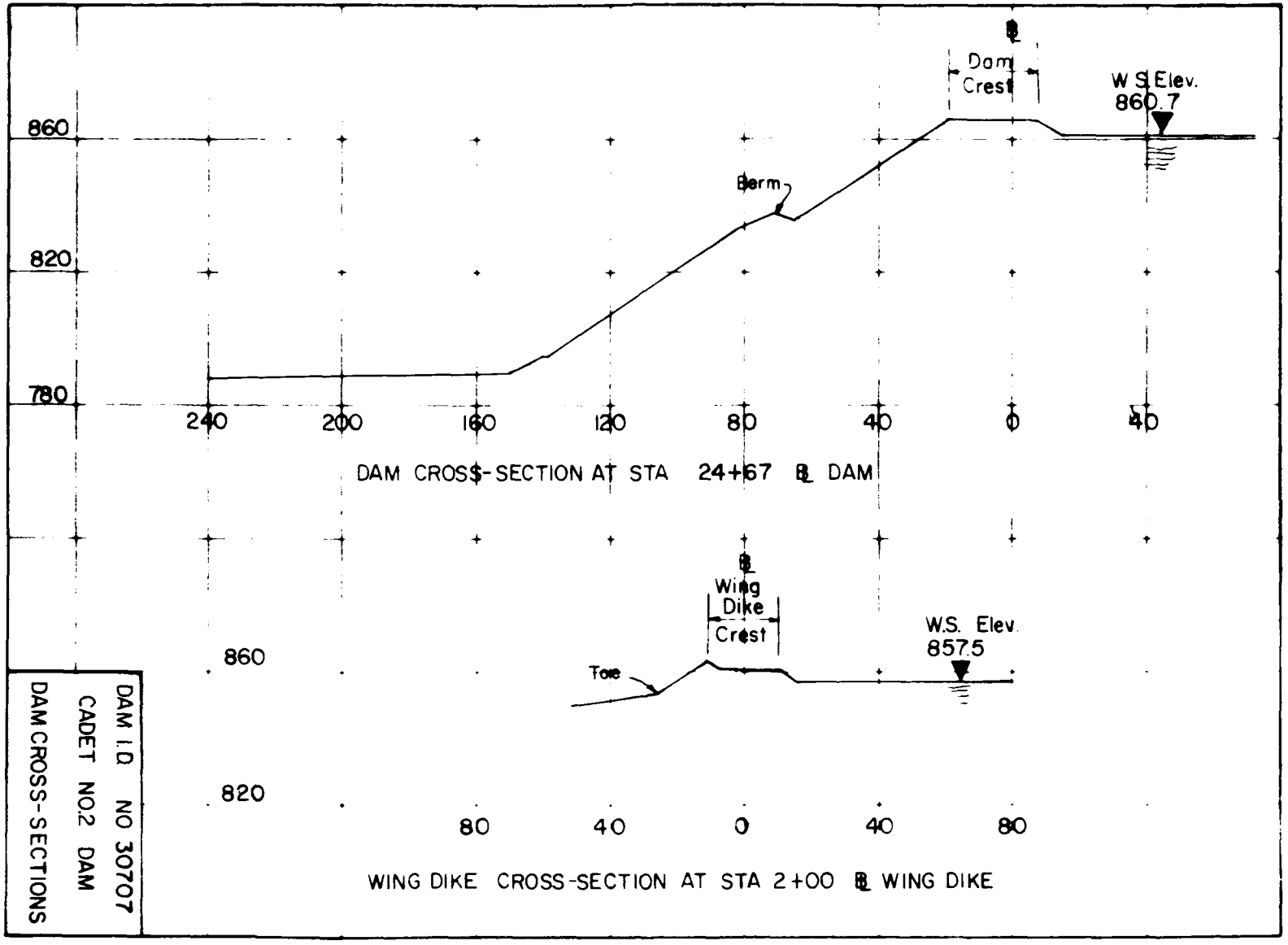
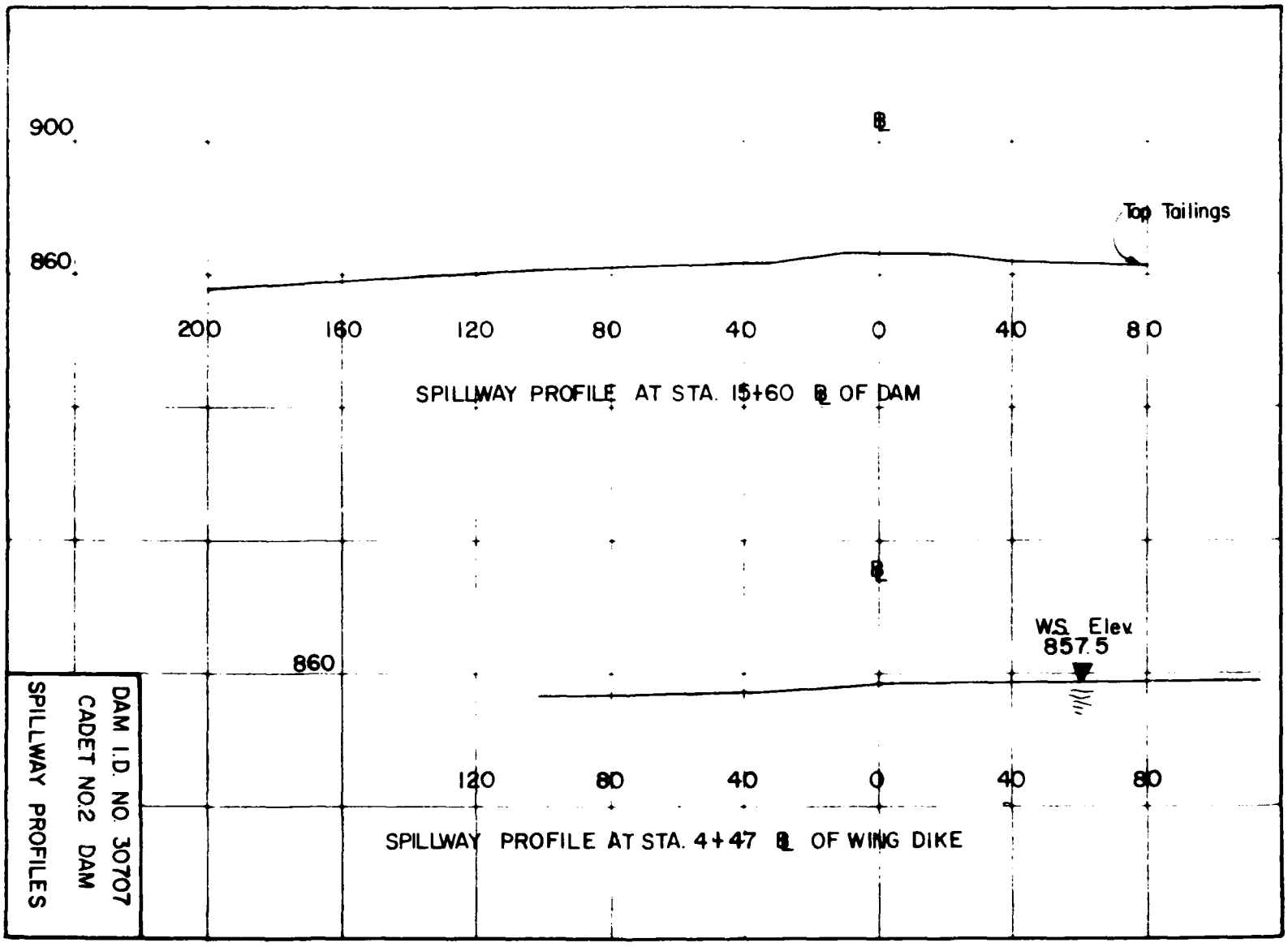


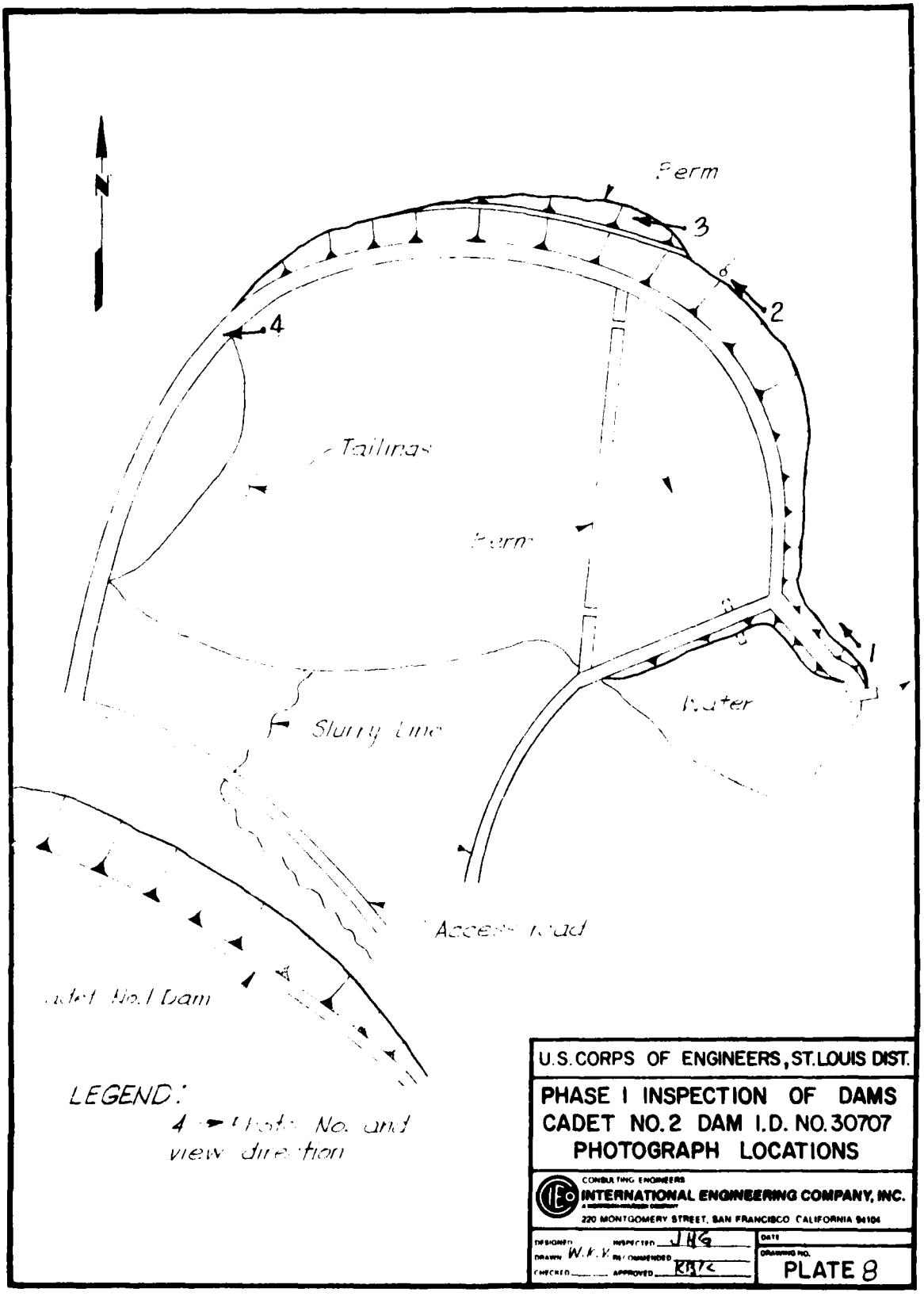
PLATE 6

DAM I.D. NO 30707
CADET NO.2 DAM
DAM CROSS-SECTIONS



DAM I.D. NO. 30707
CADET NO.2 DAM
SPILLWAY PROFILES

PLATE 7



U.S. CORPS OF ENGINEERS, ST. LOUIS DIST.

PHASE I INSPECTION OF DAMS
CADET NO. 2 DAM I.D. NO. 30707
PHOTOGRAPH LOCATIONS

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
220 MONTGOMERY STREET, SAN FRANCISCO CALIFORNIA 94104

DESIGNED — INSPECTED JHG — DATE
DRAWN W.K.V. — RECOMMENDED — DRAWING NO.
CHECKED — APPROVED KBK — PLATE 8

PHOTOGRAPH RECORD

CADET NO. 2 DAM - I.D. NO. 30707

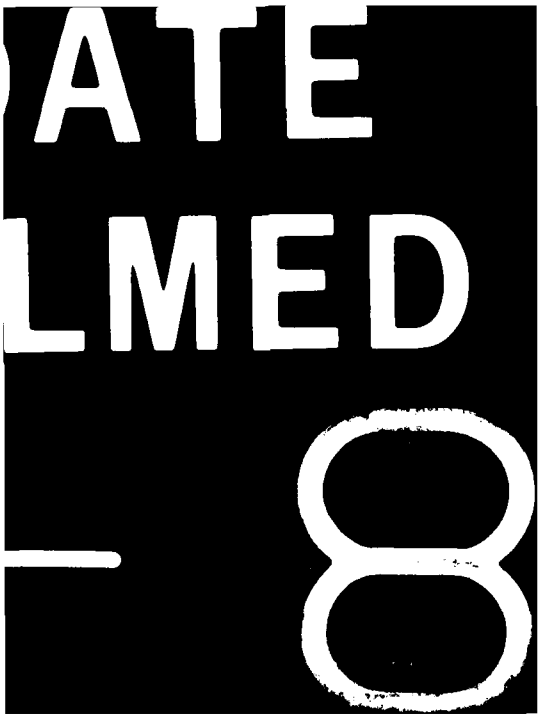
Photo No.	Description
1	View west of dam from wing dike.
2	Ponded seepage at dam toe near Station 30+00.
3	View of berm at dam toe between Stations 20+00 and 30+00.
4	View of left abutment of dam near Station 15+22.

1

2

3

4


ATE
LMED
8