

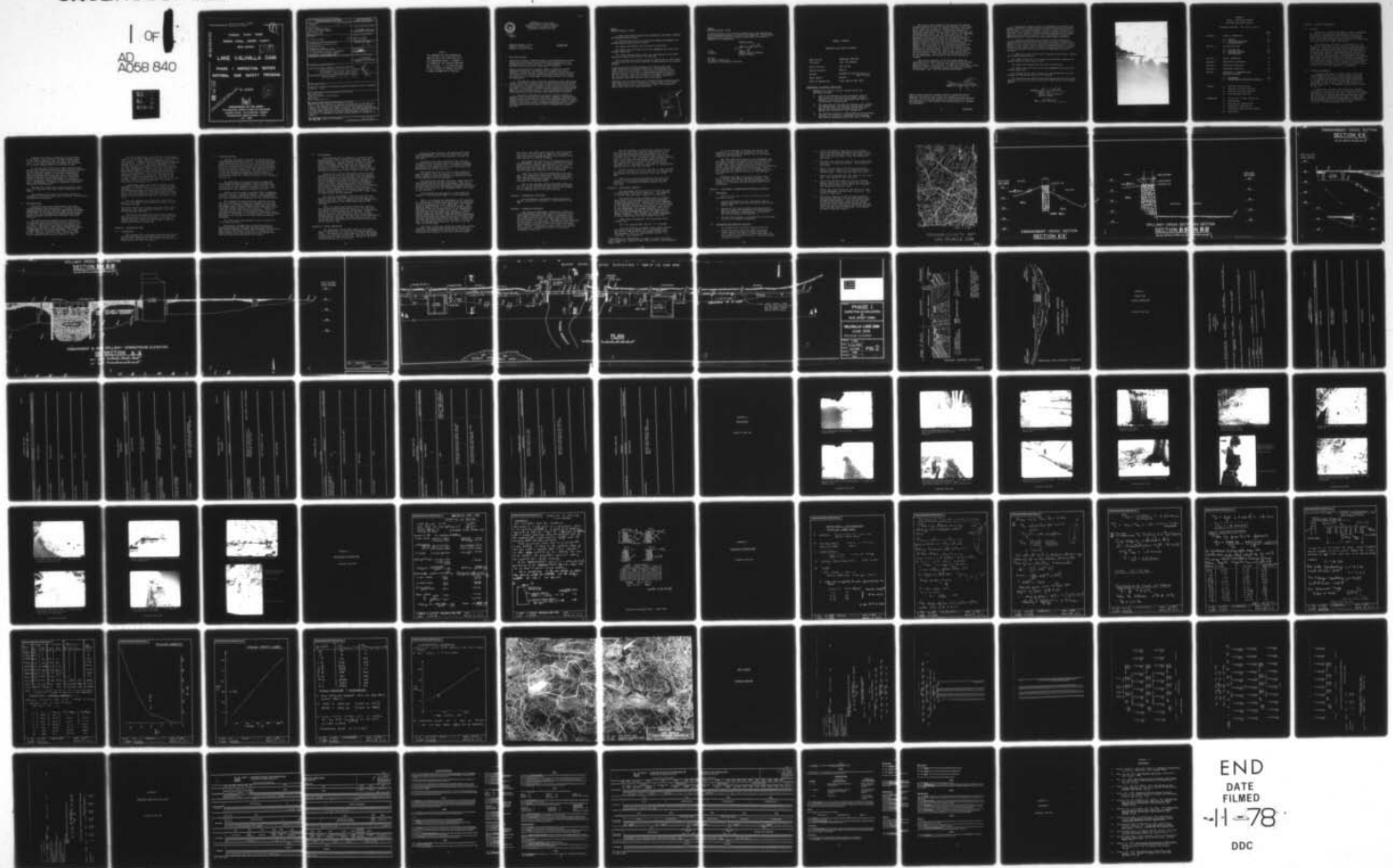
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NEW JERSEY STATE DEPT OF ENVIRONMENTAL PROTECTION TRENTON F/6 13/2  
NATIONAL DAM SAFETY PROGRAM. LAKE VALHALLA DAM (NJ00330), PASSA--ETC(U)  
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PASSAIC RIVER BASIN

MORRIS CANAL, MORRIS COUNTY

NEW JERSEY

LEVEL

# LAKE VALHALLA DAM

## PHASE I INSPECTION REPORT

## NATIONAL DAM SAFETY PROGRAM

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PHILADELPHIA, PENNSYLVANIA 19106

JULY 1978

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.		

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IN REPLY REFER TO

NAPEN-D

Honorable Brendan T. Byrne  
Governor of New Jersey  
Trenton, New Jersey 08621

25 AUG 1978

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Lake Valhalla Dam in Morris County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given on the first three pages of the report.

Based on visual inspection, available records, calculations and past operational performance, Lake Valhalla Dam is judged to be in fair condition. However, the dam's spillway is considered seriously inadequate as 17 percent of the Probable Maximum Flood (PMF) would overtop the dam. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by more sophisticated methods, procedures and studies within six months from the date of approval of this report. Any remedial measures necessary to insure the adequacy of the spillway and to prevent overtopping should be initiated within calendar year 1979. In the interim, a detailed emergency operation plan and warning system should be promptly developed. Also, during periods of unusually heavy precipitation, around-the-clock surveillance should be provided.

b. Engineering investigations and studies to better ascertain the stability of the dam and spillway with respect to seepage, overturning and sliding should be completed by the owner within nine months from the date of approval of this report. Borings, probes and piezometers should be utilized as part of these investigations. Remedial measures, indicated as a result of these investigations and studies, should be implemented in calendar year 1979.

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NAPEN-D

Honorable Brendan T. Byrne

c. Within four months from the date of approval of this report, complete the following remedial actions:

(1) Repair eroded areas of the upstream and downstream embankment and provide protection against future erosion.

(2) Repair and strengthen the side walls of the spillway.

(3) Remove trees and brush from the dam's embankment and replace with suitable ground cover.

(4) Prevent floating debris, boats, etc. from plugging the free space between the footbridge and the top of the spillway.

(5) The outlet pipe should be located and checked and the outlet valves repaired so the lake level may be drawn down to make repairs or for emergency purposes.

A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congresswoman Millicent Fenwick of the Fifth District. Under the provisions of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, thirty days after the date of this letter.

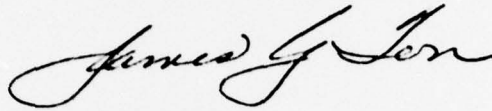
Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia, 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

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NAPEN-D  
Honorable Brendan T. Byrne

An important aspect of the Dam Safety Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely yours,



JAMES G. TON  
Colonel, Corps of Engineers  
District Engineer

1 Incl  
As stated

Cy furn:  
Mr. Dirk C. Hofman, P.E.  
Department of Environmental Protection

PHASE 1 REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam: VALHALLA LAKE DAM  
ID Number Fed. ID NJ00330  
State Located: New Jersey  
County Located: Morris  
Stream: Unnamed Stream Tributary to  
Morris Canal  
River Basin: Passaic  
Date of Inspection: 7, 15, and 19 June 1978

ASSESSMENT OF GENERAL CONDITIONS

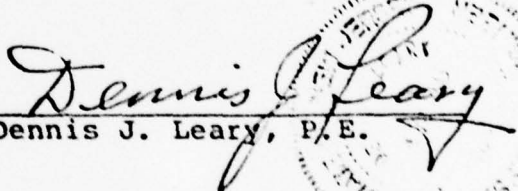
Valhalla Lake Dam is in fair condition for the following reasons:

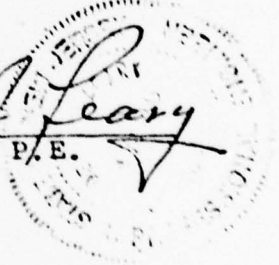
1. Lack of maintenance of the structures such as the erosion of the downstream slope, vegetal growth in the spillway side walls, and lack of a functional bottom outlet;
2. The stability of the dam and spillway with respect to underseepage, overturning, and sliding cannot be reliably evaluated because of the lack of design and construction and information;
3. The spillway capacity as determined by CE screening criteria is seriously inadequate. We estimate the dam can adequately pass only 16% of the PMF.



The outlet pipe should be located and the outlet valves repaired so that the outlet system is functional. It is urgent to be able to control and lower the lake water level when necessary. Piezometers should be installed upstream of the spillway, and in the upstream and downstream slopes at the cross section corresponding to the marshy areas, and, in the marshy areas. If necessary, relief wells should be installed and their locations determined by means of borings and probes and the results obtained from the piezometers. Erosion damage should be repaired and protection provided against future erosion of the upstream and downstream slopes. The side walls of the spillway should be repaired and strengthened. Provisions should be made to prevent floating debris, boats, etc., from plugging the free space between the foot bridge and the top of the spillway. Trees located on and within the area of the embankment and spillway side walls should be removed.

The actual capacity of the spillway should be determined using more precise and sophisticated methods and procedures. The need for the type of mitigating measures should be determined. Around the clock surveillance during periods of unusually heavy precipitation should be provided, and a warning system established.

  
Dennis J. Leary, P.E.



Based on visual inspection, available records, calculations and past operational performance, Lake Valhalla Dam is judged to be in fair condition. However, the dam's spillway is considered seriously inadequate as 17 percent of the Probable Maximum Flood (PMF) would overtop the dam. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by more sophisticated methods, procedures and studies within six months from the date of approval of this report. Any remedial measures necessary to insure the adequacy of the spillway and to prevent overtopping, should be initiated within calendar year 1979. In the interim, a detailed emergency operation plan and warning system should be promptly developed. Also, during periods of unusually heavy precipitation, around-the-clock surveillance should be provided.

b. Engineering investigations and studies to better ascertain the stability of the dam and spillway with respect to seepage, overturning and sliding should be completed by the owner within nine months from the date of approval of this report. Borings, probes and piezometers should be utilized as part of these investigations. Remedial measures, indicated as a result of these investigations and studies, should be implemented in calendar year 1979.

c. Within four months from the date of approval of this report, complete the following remedial actions:

(1) Repair eroded areas of the upstream and downstream embankment and provide protection against future erosion.

(2) Repair and strengthen the side walls of the spillway.

(3) Remove trees and brush from the dam's embankment and replace with suitable ground cover.

(4) Prevent floating debris, boats, etc. from plugging the free space between the footbridge and the top of the spillway.

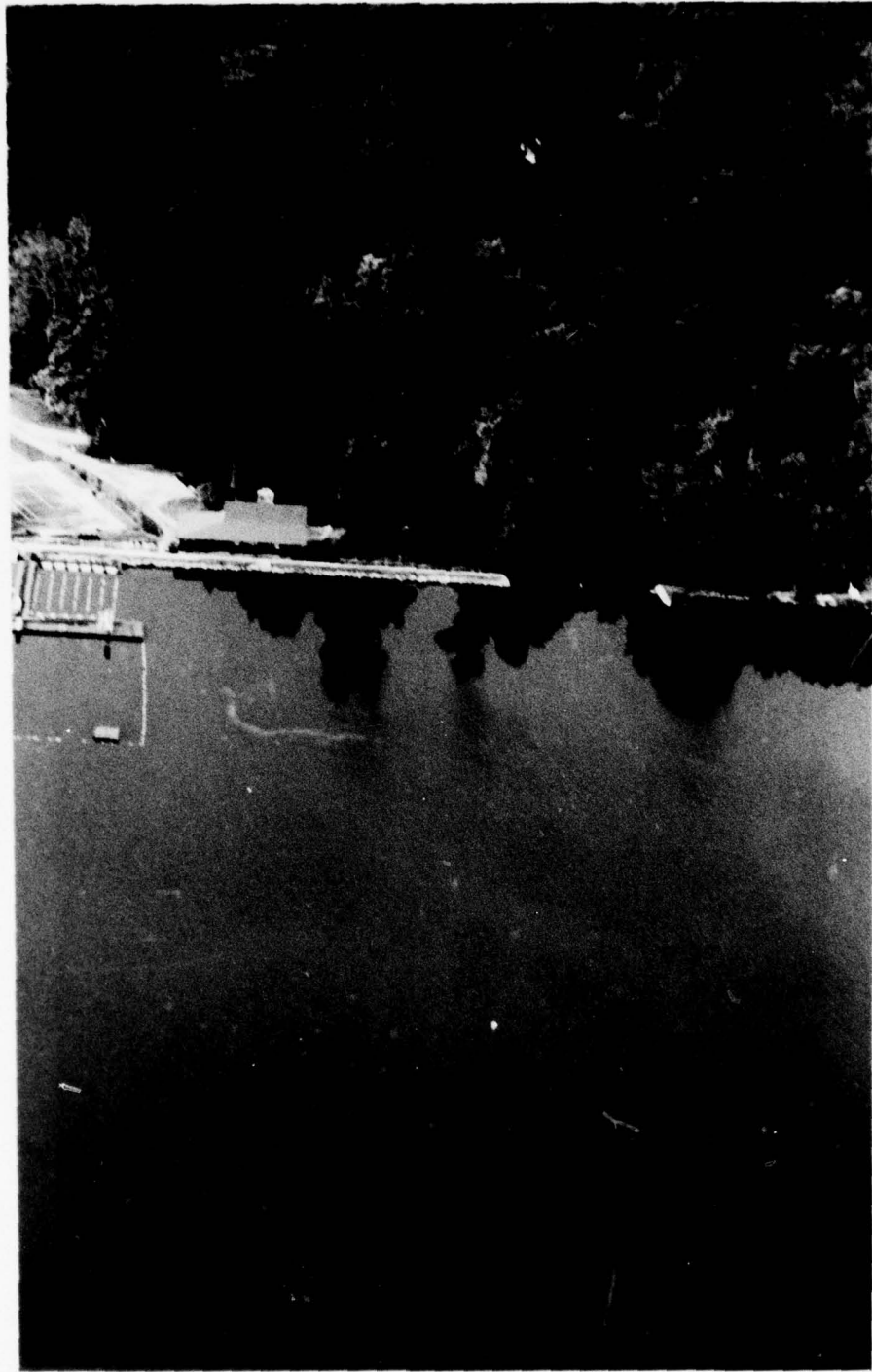
(5) The outlet pipe should be located and checked and the outlet valves repaired so the lake level may be drawn down to make repairs or for emergency purposes.

APPROVED: \_\_\_\_\_

*James G. Ton*  
JAMES G. TON  
Colonel, Corps of Engineers  
District Engineer

DATE: \_\_\_\_\_

*25 Aug 78*



OVER VIEW  
VALHALLA LAKE DAM  
21 June 1978

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NATIONAL DAM SAFETY REPORT

VALHALLA LAKE DAM    FED ID NO. NJ00330

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## SECTION 1 PROJECT INFORMATION

### 1.1 General

Authority to perform the Phase I safety inspection of Valhalla Lake Dam was received from the State of New Jersey, Department of Environmental Protection, Division of Water Resources by letter dated 26 May 1978. This Authority was given pursuant to the National Dam Inspection Act, Public Law 92-367.

The purpose of the Phase I investigation is to develop an assessment of the general conditions with respect to safety of Valhalla Lake Dam and appurtenances based upon available data and visual inspection and, determine any need for emergency measures and conclude if additional studies, investigations and analyses are necessary and warranted. The assessment has been made using screening criteria established in Recommended Guidelines for Safety Inspection of Dams prepared by the Department of Army, Office of the Chief of Engineers. It is not the purpose of the inspection to imply that a dam meeting or failing to meet the screening criteria is, per se, certainly adequate or inadequate.

### 1.2 Project Description

Valhalla Lake Dam is a 620-ft-long, 18-ft-high earth embankment with a 3-ft-wide masonry core and a 78-ft-long, 17-ft-high freefall masonry spillway. It is reported to have been constructed in 1930 and is located at 40° 55' 40" latitude and 74° 22' 36" longitude, at the southern end of Lake Valhalla in Morris County, N.J. A regional vicinity map is given in Fig. 1.

The dam has an outlet structure with a manual valve that is not in use and is reported to have been intended for drawdown of the lake. The valve is rusted and could not be turned and the discharge pipe could not be located. Maintenance personnel did not know where discharge pipe was located and our inspection of the downstream area of the dam did not disclose its location. It may be plugged and covered.

Valhalla Lake Dam is classified as being small on the basis of its reservoir storage volume, which is less than 1,000-acre feet, but more than 50-acre feet. It is also classified as "Small" on the basis of its total height, which is less than 25 feet.

In the National Inventory of Dams, Valhalla Lake Dam has been classified as having "High Hazard Potential" on the basis that failure of the dam would cause excessive property damage to residences downstream, and could potentially cause more than a few deaths. Visual inspection of the downstream area shows that breach of the dam would cause damage to residences and be hazardous to people utilizing a low lying picnic area. Accordingly, no change is proposed concerning the Hazard Classification.

The dam and reservoir are owned by Valhalla Lake Club, P.O. Box 586, Lake Shore Drive, Montville, N.J. 07045.

The purpose of the dam is recreation and no information is available concerning its design, construction, maintenance or operation.

### 1.3 Pertinent Data

Elevations have been established on the basis of USGS Pompton Plains Quadrangle, 7.5 Minute Series, topographic maps and an arbitrary approximate benchmark. Measurements at the dam site were made using surveyors transit and rod, and should be considered approximate. Essential project features and elevations are given in Fig. 2.

The Valhalla Lake drainage area is 1500 acres. The drainage area is in general long and narrow with a length of approximately 3 miles and a width of 1/2 to 1 mile. The area is essentially undeveloped and wooded with scattered single family residential houses in approximately 10% of the watershed. The ground surface slope is in general about 10% but as steep as 25%. The lake area is 85 acres and at the time of our inspection the lake level was at el 398.

The top of the dam is at el 401 and the spillway crest is at el 397.9. The central 18 ft of the spillway crest is 0.6 ft lower than the remaining portion of the spillway. Tailwater was at el 383 and the discharge channel is at el 382.2. The left embankment is 350-ft-long and varies in downstream height from zero at the left abutment beach area to 16 ft at the spillway. The right embankment is 190-ft long and varies in downstream height from zero at the right abutment to 15 ft at the spillway. The 3-ft-thick core in the embankment appears to be vertical. The downstream side of the core is unsupported for a height of 10 ft and a length of 40 ft at the location of a one story building along the right embankment. The width of the crest of the dam is 6 ft.

Downstream slopes vary from horizontal at the abutments to essentially 1.5 hor to 1 vert near the spillway to 1 hor to 1 vert at the spillway abutments. The downstream slopes are grass covered with small trees. The free board is 3 ft and the upstream slope below lake level appears to be about 20 hor to 1 vert. There is upstream rip-rap about one foot below crest level.

The core appears to be impervious and no information is available concerning the presence of a cut-off below the dam.

The outlet valves are located in a valve house 20 ft upstream of the right spillway abutment at the end of the spillway side wall.

The bed of the downstream channel has boulders that vary in size from 1 ft to 8 ft. A one foot high masonry walk way crosses the channel about 300 ft downstream and a light vehicular bridge crosses the channel about 400 ft downstream.

## SECTION 2 ENGINEERING DATA

### 2.1 Introduction

No information is available concerning the design, construction, operation and maintenance of the dam. We have been informed that the outlet valves have not been used for at least ten years.

## 2.2 Regional Geology

Valhalla Lake Dam is located in the New Jersey Highlands physiographic province. The New Jersey Highlands extend across the state in a northeast-southwest direction from the border of New York to the Delaware River and includes the northwest portions of Hunterdon, Passaic and Morris Counties and the southeastern parts of Warren and Sussex Counties. This province is part of the New England Physiographic Province and lies between the Appalachian Ridge and Valley Province to the northwest and the Piedmont Province to the southeast. See Fig. 3.

The Highlands are characterized by rounded and flat-topped northeast-southwest ridges and mountains up to 1,400 ft high separated by narrow valleys. The orientation of the valleys are usually, but not always controlled by the underlying geologic structure.

Bedrock of the region is predominantly Precambrian gneisses, schists, and metasediments. Some sedimentary strata, typically sandstones, shales and conglomerate have been infolded and infaulted into the valley bottoms.

The regional geologic structure reflects the very old age of bedrock. A number of regional faults cross the area in a northeast southwest direction, including the Ramapo Fault; the more than 30 mile long fault scarp forms the eastern border of the province. Faults control many of the river valley orientations. The relatively uniform slope of the mountain elevations, from northwest to southeast, is a direct result of the faulting. The entire area is part of the now dissected Schooley Peneplain.

The Pleistocene Age Wisconsin glacier covered all of the dam site area.

The glacier stripped most of the existing overburden and weathered rock and uncovered the numerous hard bedrock knobs and ridges seen throughout the province. Most of the side-slopes in the area are covered with heavy boulder tills (ground moraine), and glacial outwash and recent alluvium cover the valleys.



### 2.3 Site Geology

Lake Valhalla Dam is located in a valley between Turkey Mountain and a southeast extension ridge of Waughaw Mountain, near the eastern boundary of the New Jersey Highlands. Waughaw Mountain is the up thrown side of the Ramapo Fault and forms the fault scarp between the Highlands and the adjacent Piedmont Physiographic Province. The lake lies at about elevation 400 with the mountains rising to 800 ft on either side.

Examination of aerial photographs and an on-site inspection of the dam site indicates that the dam has been constructed on relatively deep, heavily bouldered, glacial ground moraine and, depending on the depth of the dam foundation, possibly on glacial outwash or recent alluvium. Stratified alluvium stream deposits occupy the stream bottom downstream of the spillway and includes well rounded boulders up to 8 ft in diameter. No evidence of bedrock was seen at either abutment. However, the steepness of the slopes suggest that relatively shallow bedrock, ie. less than 20 ft deep, could be found further up the abutment.

The overall topography in the dam site area indicates relatively pervious zones of overburden could underlie the dam. This is supported by the swampy areas located downstream of the dam on both sides of the spillway.

There are unverified reports that water wells in the area have encountered more than 50 ft of sand above the bedrock and the valley was occupied by a much smaller lake prior to the construction of the dam. A good quality gneissic rock reportedly from a large quarry located east of the lake, has been used in the construction of the vertical spillway. No deterioration of the rock was noted, but, some erosion of the mortar between rock blocks could be seen.

### SECTION 3 VISUAL INSPECTION

The embankment and spillway appear to be stable with no indications of failure of the dam and appurtenances. The masonry core wall appears intact and without vertical or horizontal deflection. The earth embankment on both sides of the core wall has settled one to three inches below the top of the wall.

There are small trees in the upstream and downstream embankment. The roots of these trees could cause piping problems if they penetrate through the core wall.

Erosion of the earth upstream of the wall has occurred at three locations along the right embankment to depths of one to three feet. In addition, erosion has occurred to a depth of one to four feet below the downstream side of the core wall.

The downstream vertical face of the spillway is made of masonry stone and appears in good condition. Minor seepage is occurring through the downstream face of the spillway near the abutments.

The downstream abutment side walls slope away from the spillway and are in poor condition. They act as retaining walls for the downstream backfilling behind the core wall and there are signs of movement and erosion by rain in that part of the embankment where the height is the greatest.

The upstream rip-rap appears in good condition except in a few locations where it has disappeared.

There is no downstream embankment at the location of a one story building constructed directly downstream of the core wall in the right embankment. The ground level is approximately 10 ft. below the crest. The building itself is not in a good state of maintenance. Portions of the wall perpendicular to and immediately downstream of the core wall are cracked. It appears the core wall and the downstream embankment are on stable foundation material. Whereas further downstream the building walls are supported on the existing ground and have suffered differential settlement. Within the building the inside face of the core wall is perfectly dry. No seepage was observed at the wall or on the floor of the building.

The outlet valves are rusted and could not be moved manually. The outlet pipe could not be located and no one at the Valhalla Club could provide information concerning its location or the last time the valves

were used. The outlet gate could be seen below water from the valve house and it appears to be rusting. This outlet valve system may have been abandoned many years ago and is possibly plugged.

No leakage was observed at the downstream toe of the embankment. However, further downstream, on both banks of the stream and approximately 1 to 2 ft above downstream water level there are wet marshy areas. The water may come from the slope itself, or more probably through the foundation of the embankment.

There are two structures downstream of the core wall. One immediately downstream and the other about four feet downstream of the wall. These structures offer minimal downstream support of the embankment in the event of an extreme flood.

Two of the spillway concrete capstone slabs are missing and the concrete has deteriorated and broken up. It appears that at one time the full 78 ft width of the spillway was at the same elevation.

#### SECTION 4 OPERATIONAL PROCEDURES

No information is available concerning past or present operational procedures or maintenance of the dam.

#### SECTION 5 HYDRAULIC/HYDROLOGIC

The hydraulic/hydrologic evaluation is based on a spillway design flood (SDF) equal to one half to the full probable maximum flood (PMF) in accordance with the evaluation guidelines for dams classified as high hazard and small in size. The hydrologic design data for this dam is not available. The PMF has been determined by developing a synthetic hydrograph based on the maximum probable precipitation of 22.5 inches (200 square mile - 24 hour). Hydrologic computations are presented in Appendix 4. The PMF determined for the subject watershed is 6652 cfs.

The main spillway is essentially a broad crested weir with an effective length of approximately 65 ft and a maximum flow depth of approximately two feet although the distance from the spillway crest to dam crest is 3.0 ft. This is because a foot bridge traverses over the spillway and wood beams impede the outlet flow. The spillway is divided into 6 area ways by the supports for the walkway. The capacity of the spillway to the underside of the walkway is approximately 680 cfs which is less than the SDF.

Flood routing for both the PMF and 1/2 PMF indicates the dam will overtop, by 2.6 ft and 1.4 ft respectively. We estimate the dam can adequately pass 16% of the PMF.

There is no specific information available with regard to the size and function of the outlet pipe. Therefore, a preliminary drawdown analyses has not been made.

## SECTION 6 STRUCTURAL STABILITY

The embankment and spillway do not show any sign of instability from visual inspection. The stability of the spillway side walls appears to be marginal.

The stability of the spillway itself is unknown since there is no available information concerning the upstream slope of the masonry, and watertightness of the upstream backfill. An analysis of the stability of the spillway section has been made for a water level of 3 ft above the crest of the spillway (crest level of the embankment), an assumed slope of 1 hor to 2.5 vert for the upstream face of the spillway, and no uplift pressure inside the wall (i.e. impervious upstream backfill). For sliding the masonry/foundation friction coefficient has been assumed to be 0.8.

Under these assumptions, the Calculated safety factors are:

FS = 1.8 (overturning) and FS = 1.5 (sliding)

It is of interest to compare these safety factors with those given by Healy\* for a rectangular wall, but with no indication of the height of water over the spillway. FS = 1.4 (overturning) and FS = 1.3 (sliding). See Appendix 3.

\* Ref: Healy K.A. "Evaluation of repair of stone wall-Earth dams; Proceedings, Safety of small dams, Hennifer, New Hampshire, August 1974.



It is not possible to decide from visual site inspection, if the assumed conditions used in the stability computations, or another set of equivalent conditions are fulfilled.

The same limitations apply to the embankment and core wall. Nothing is known concerning the core wall, its upstream slope, foundation level and quality of foundation or the existence and effectiveness of a cutoff. The quality and characteristics of the foundation of the downstream backfill are also unknown. This makes any sort of computation for the embankment even more hypothetical than in the case of the spillway section.

Valhalla Lake Dam is located in Seismic Zone 1 of the Seismic Zone Map of Contiguous States. The degree of stability of the dam and appurtenances are assumed to be marginal and may present hazard from earthquakes.

## SECTION 7 ASSESSMENT, RECOMMENDATIONS/REMEDIAL MEASURES

### 7.1 Assessment

Valhalla Lake Dam is in fair condition for the following reasons:

1. Lack of maintenance of the structures such as downstream slope, spillway side walls, and bottom outlet; and
2. Because of the lack of design and construction data the degree of stability of the dam and spillway with respect to underseepage, overturning, and sliding cannot be determined.
3. The spillway capacity as determined by CE screening criteria is seriously inadequate.

### 7.2 Recommendations/Remedial Measures

We recommend the following remedial measures:

1. Locate the outlet pipe and repair the outlet valves so that the outlet system functional. It is urgent to be able to control and lower the lake water level when necessary. This work should be done very soon.

2. Install Piezometers upstream of the spillway, and in the upstream and downstream slopes at the cross section corresponding to the marshy areas, and in the marshy areas. This work should be done soon.
3. Determine the upstream slope of the spillway wall by means of borings and probes. This should be done soon.
4. Repair erosion damage and provide protection against future erosion of the upstream and downstream slopes. This should be done very soon.
5. Repair and strengthen the side walls of the spillway. This should be done very soon.
6. Provisions should be made to prevent floating debris, boats, etc. from plugging the free space between the bridge and the top of the spillway. This should be done very soon.
7. Remove any trees located on and within the area of the embankment and spillway side walls. This should be done soon.
8. The actual capacity of the spillway should be determined using more precise and sophisticated methods and procedures. The need for and type of mitigating measures should be determined. Around the clock surveillance during periods of unusually heavy precipitation should be provided, and a warning system established. This should be done in the near future.



REGIONAL VICINITY MAP  
LAKE VALHALLA DAM

Fig. 1

ELEV. IN FEET  
USGS DATUM

Upstream

400

16 June  $\nabla$  398.13

Rip-Rap

395

SOIL

3'-0"

CONCRETE CAP

Downstream

6'

1  
2

390

SOIL

390

MASONRY

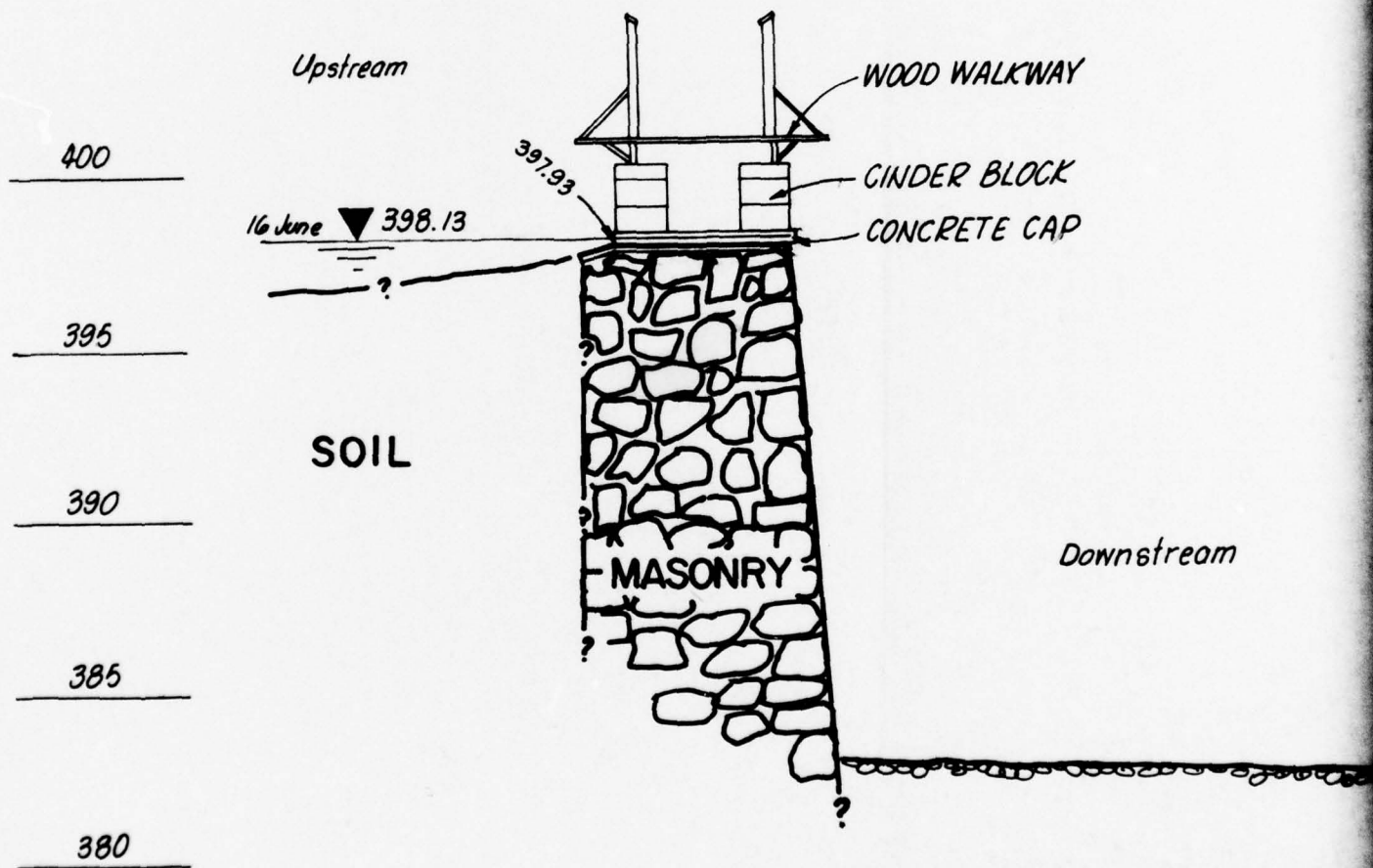
CORE WALL

385

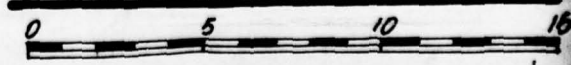
380

EMBANKMENT - CROSS SECTION  
SECTION C-C'





SPILLWAY - CROSS SECTION  
**SECTION B-B'**



390

2

ELEV. IN FEET  
USGS DATUM

400

395

390

385

380

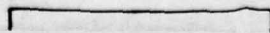
downstream

382.23

CROSS SECTION  
ON B-B'

10 16 ft

1 3



380

# EMBANKMENT - CROSS SECTION SECTION C-C'



ELEV. IN FEET  
USGS DATUM

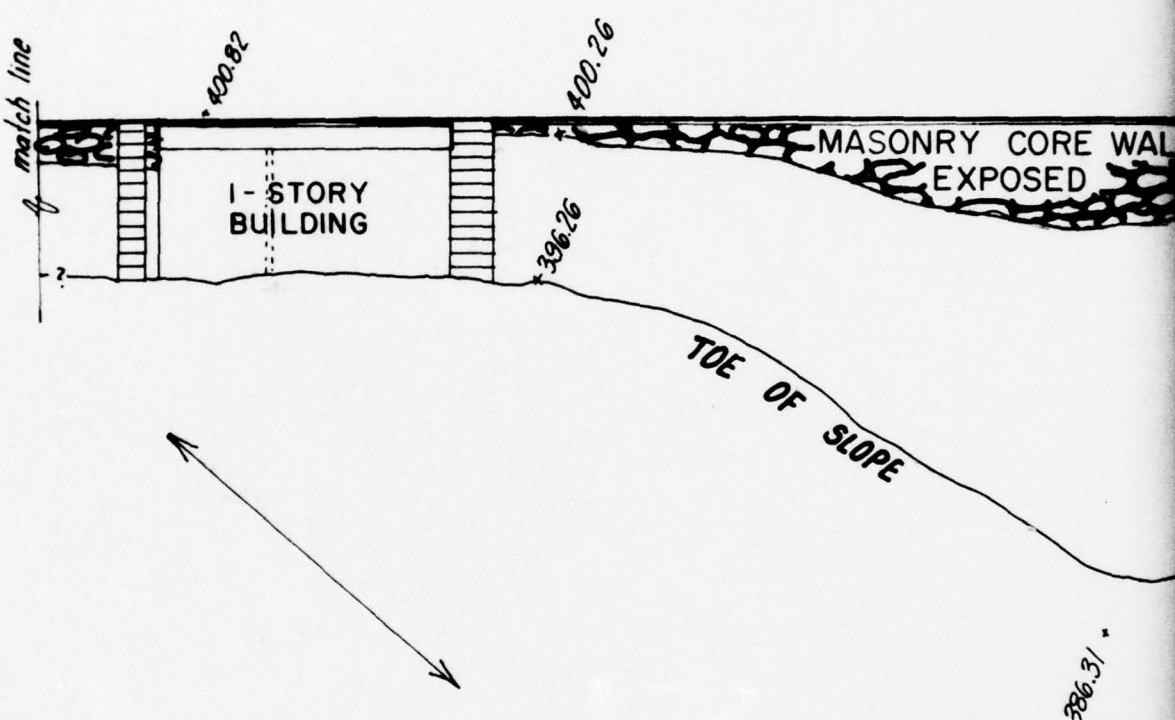
405

400

395

390

385



405

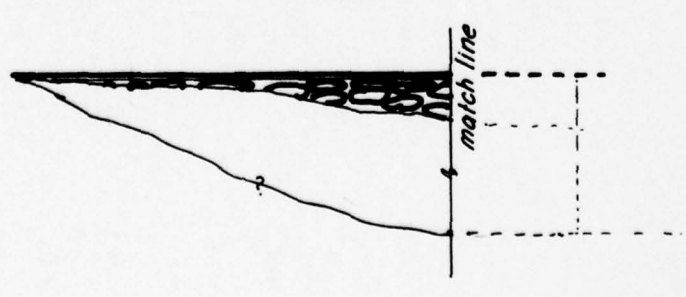
405

400

400

395

395

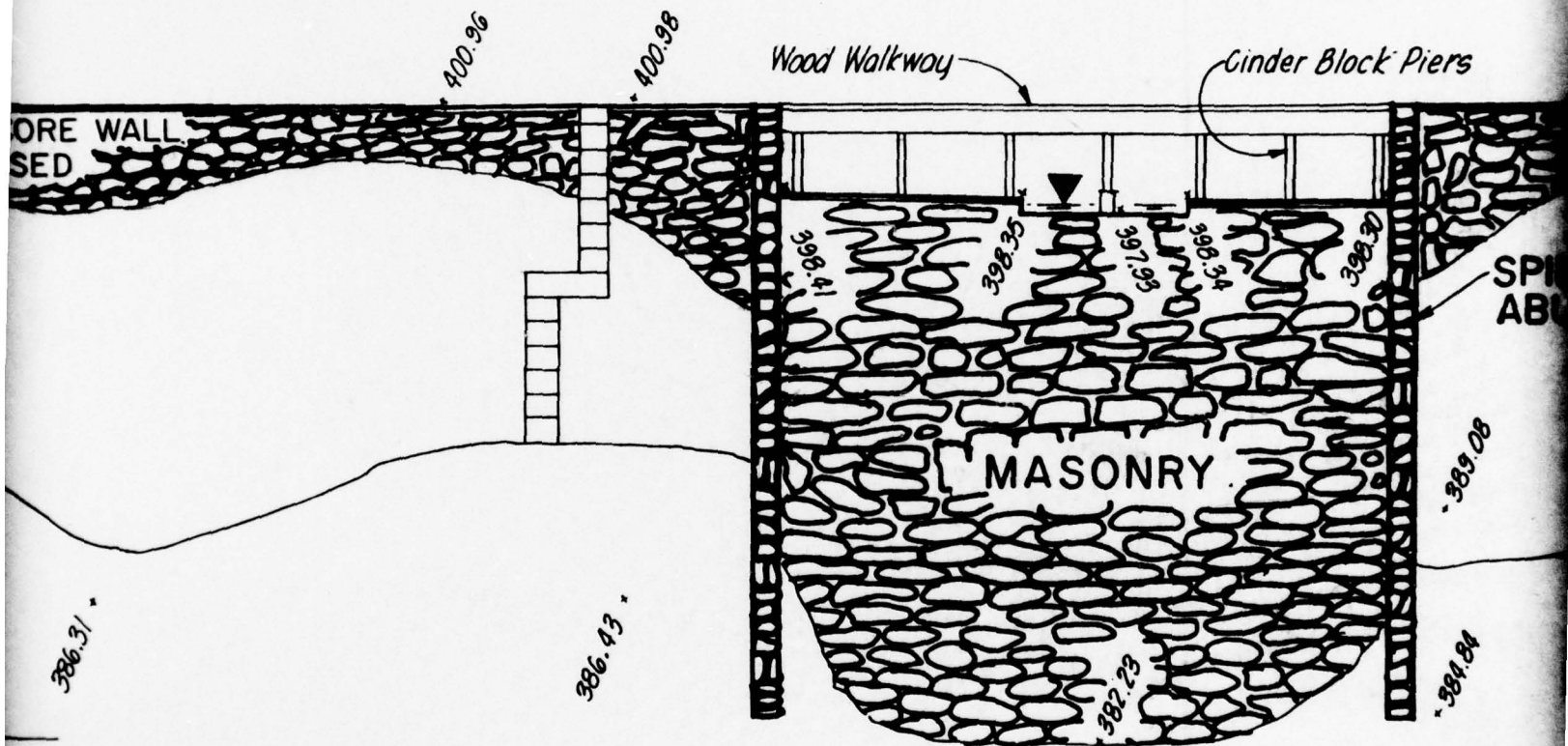
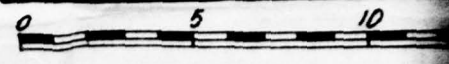


4

380

# SPILLWAY - CROSS SECTION II

2



## EMBANKMENT & SPILLWAY SECTION

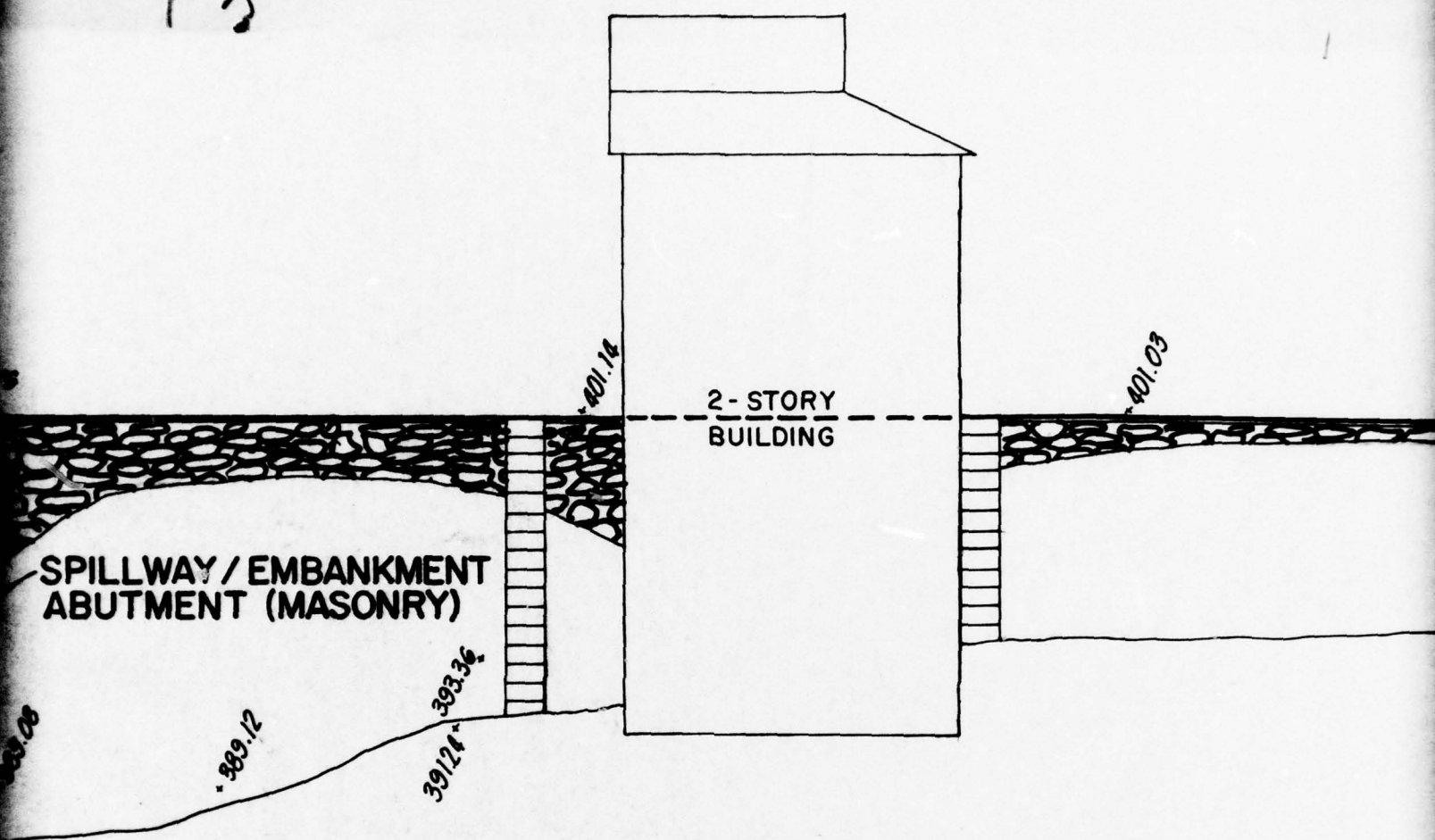
Horiz: 0  
Vert: 0

5

I A K F

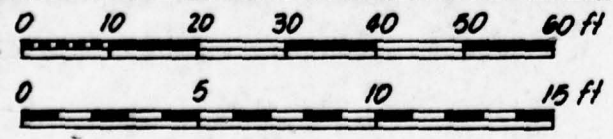


S SECTION  
N B-B'



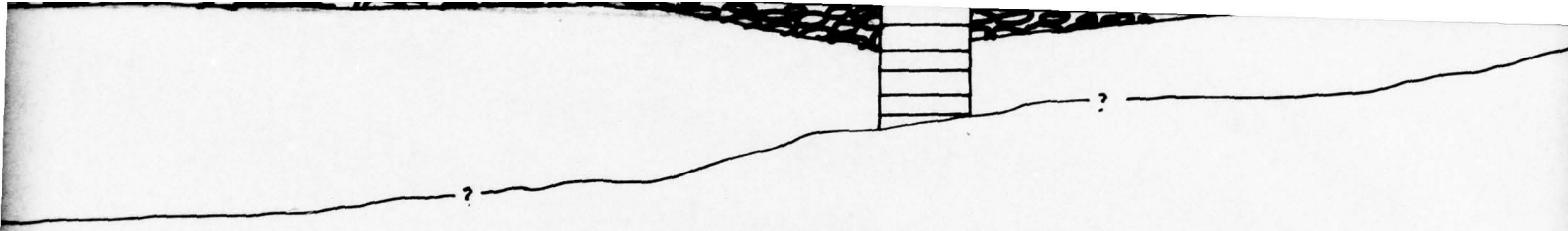
SPILLWAY - DOWNSTREAM ELEVATION

SECTION A-A'



6

V A I H A L



L 7 L A



ELEV. IN FEET  
USGS DATUM

405

400.10

400

400

395

390

385

8

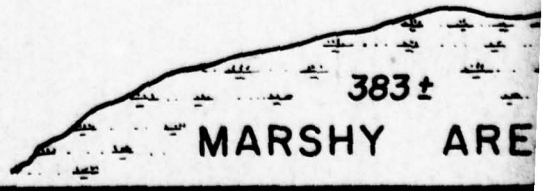
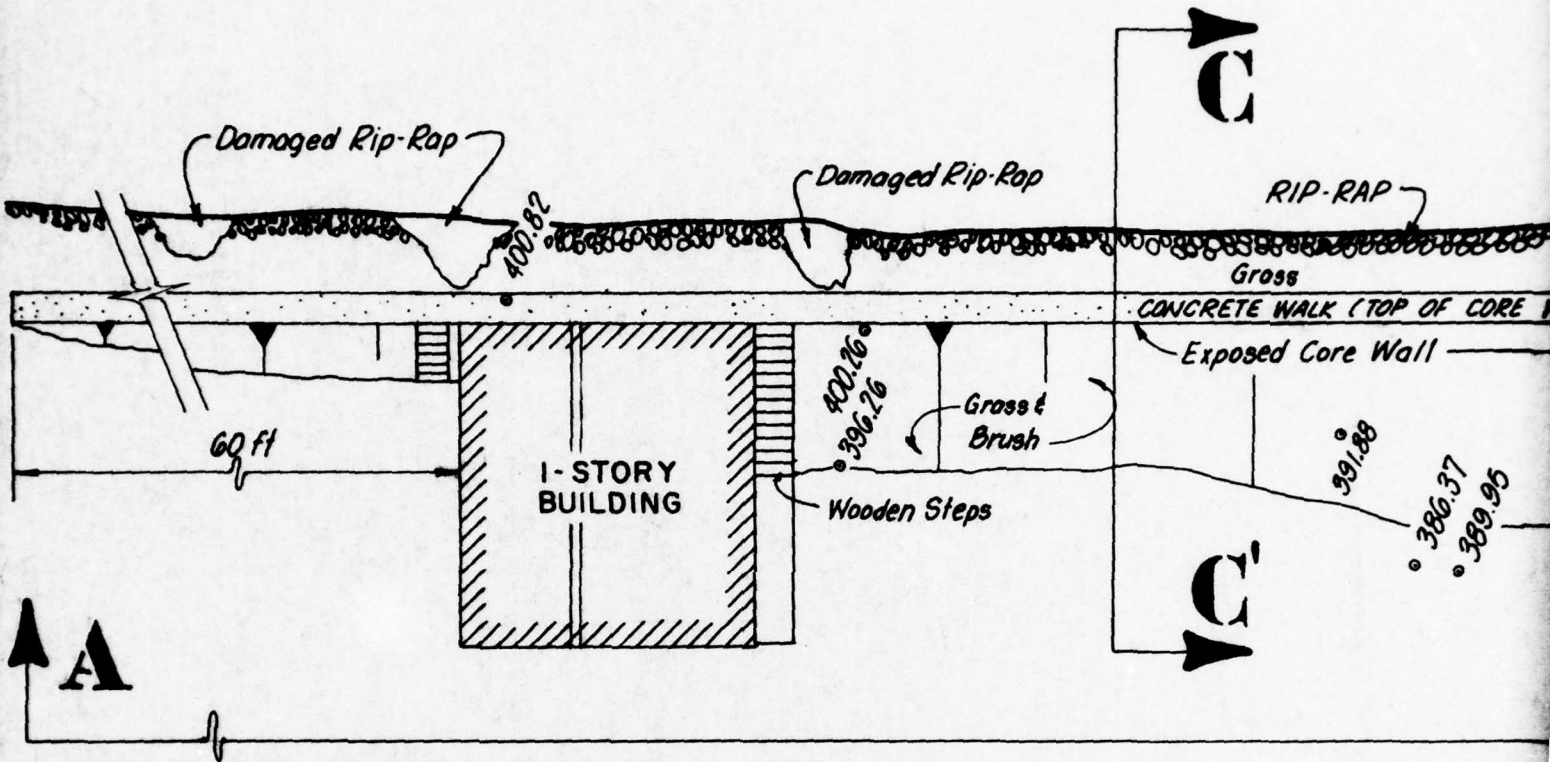
DATE

DESCRIPTION

NO.

REVISIONS

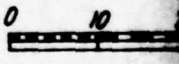
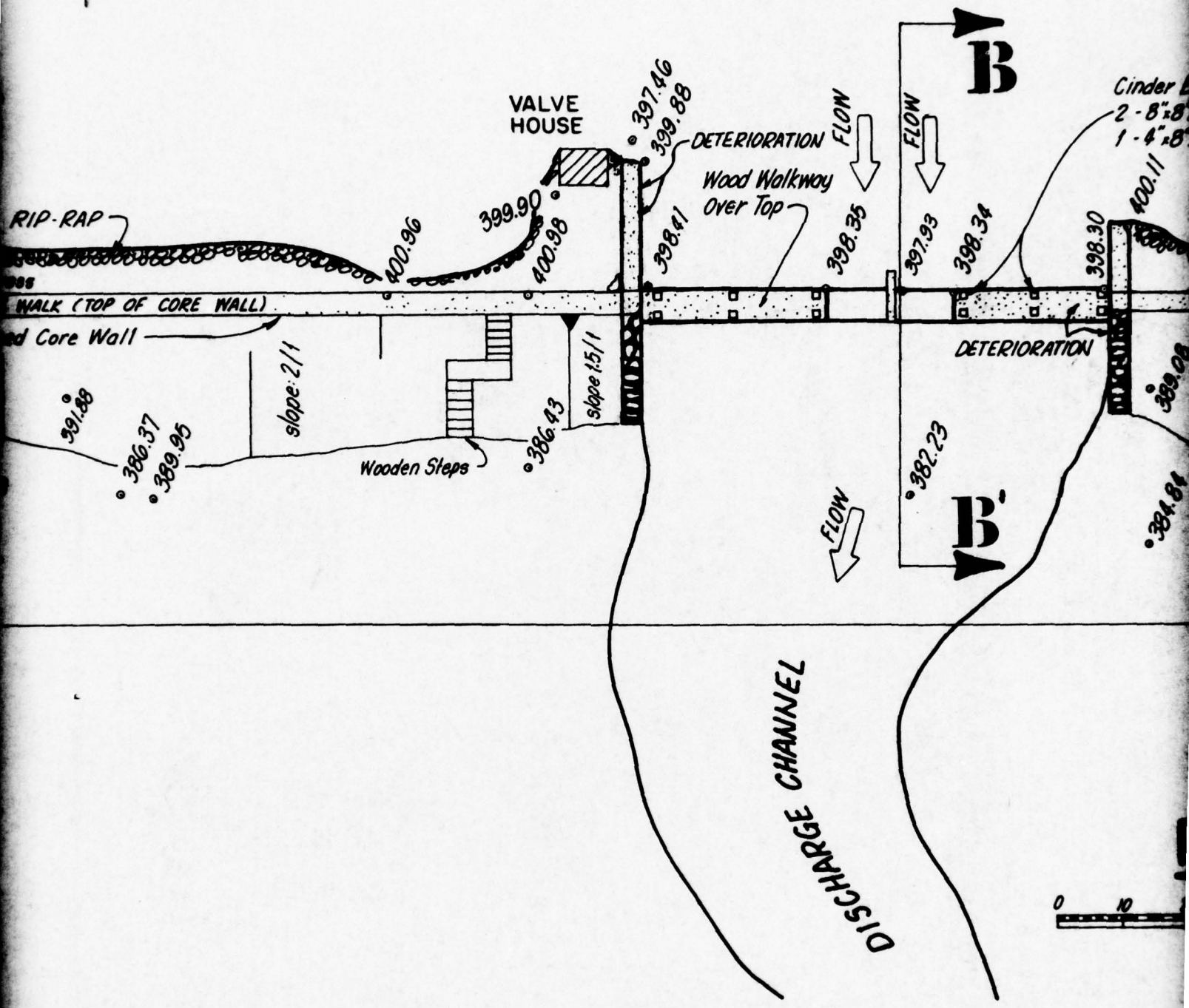
9



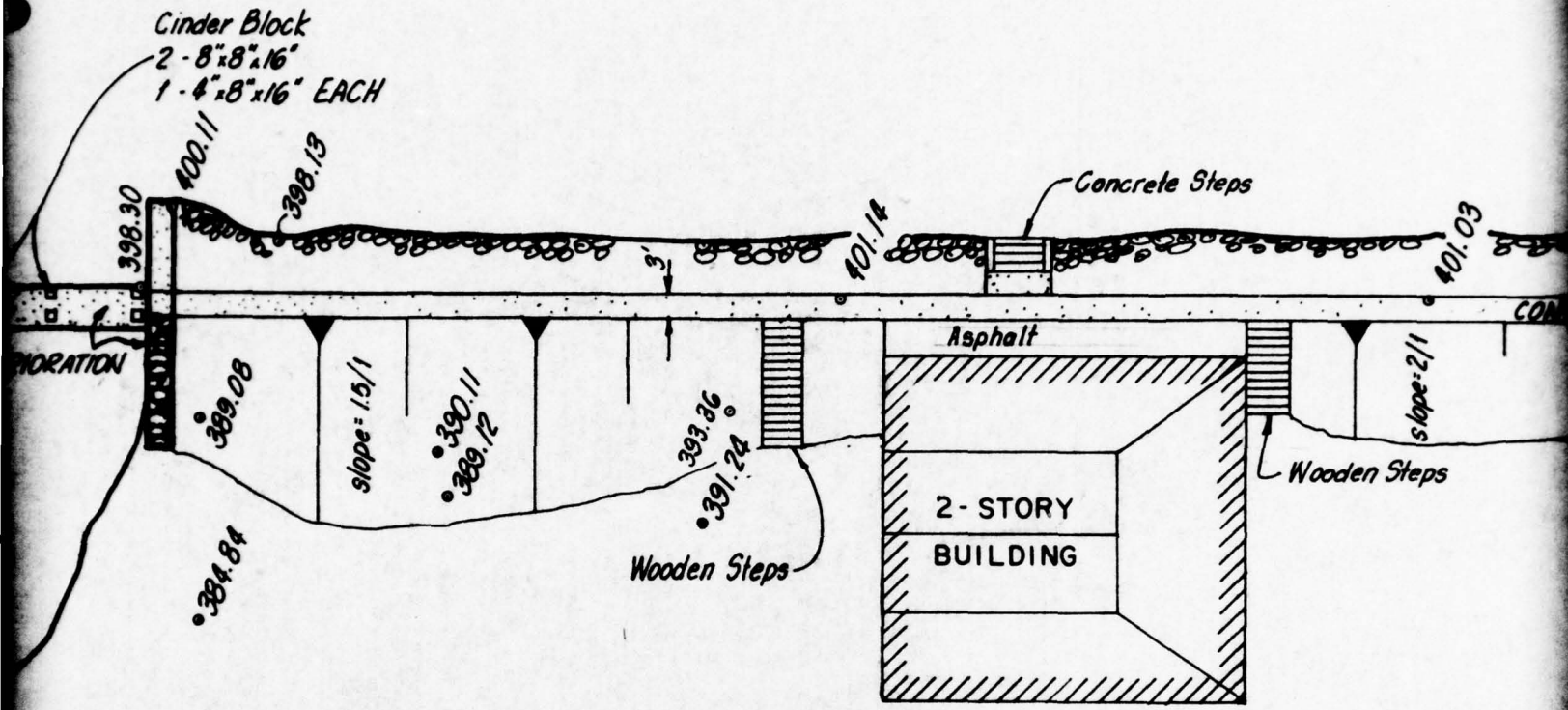


10

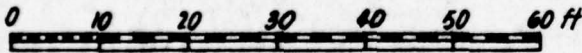
# WATER LEVEL



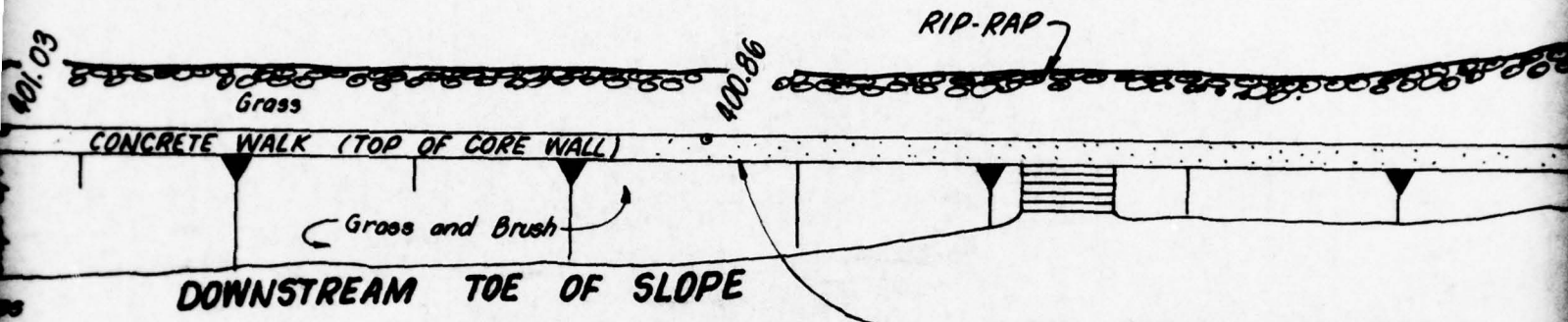
LEVEL ELEVATION = 398.13 (16 JUNE 1978)



**PLAN**

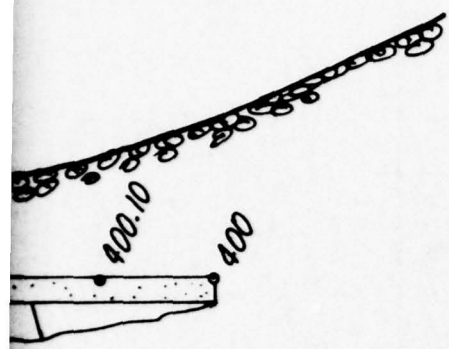


11

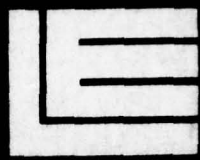


NOTE: EARTH ON BOTH SIDES OF CONC. WALL HAS SETTLED ONE TO THREE INCHES BELOW TOP OF WALL.

12



13



PROJECT

# PHASE I

INSPECTION & EVALUATION  
of  
NEW JERSEY DAMS

## VALHALLA LAKE DAM

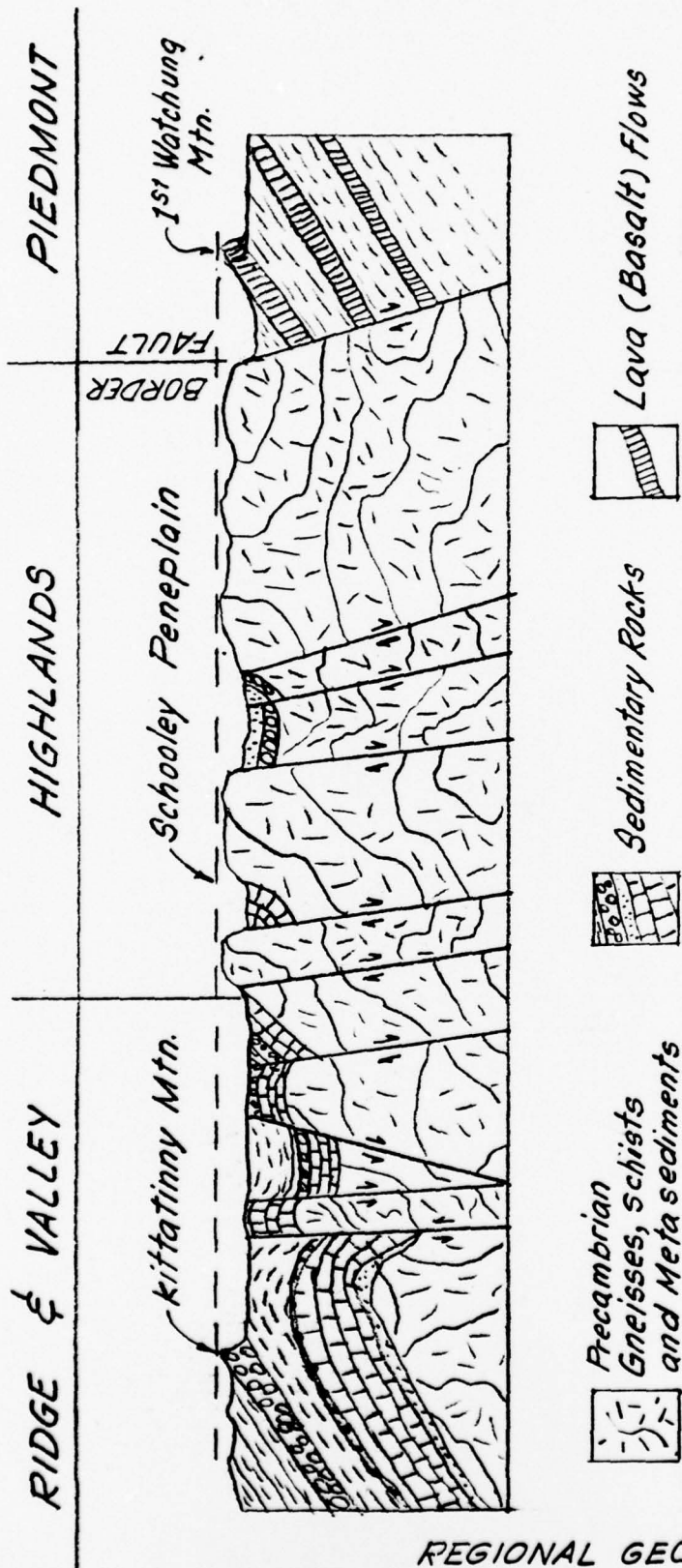
JUNE 1978

FED. ID. No. NJ00330

JOB NO.	J783
DATE	5 July 1978
SCALE	as noted
DRN. BY	JMR
CHKD. BY	DJL

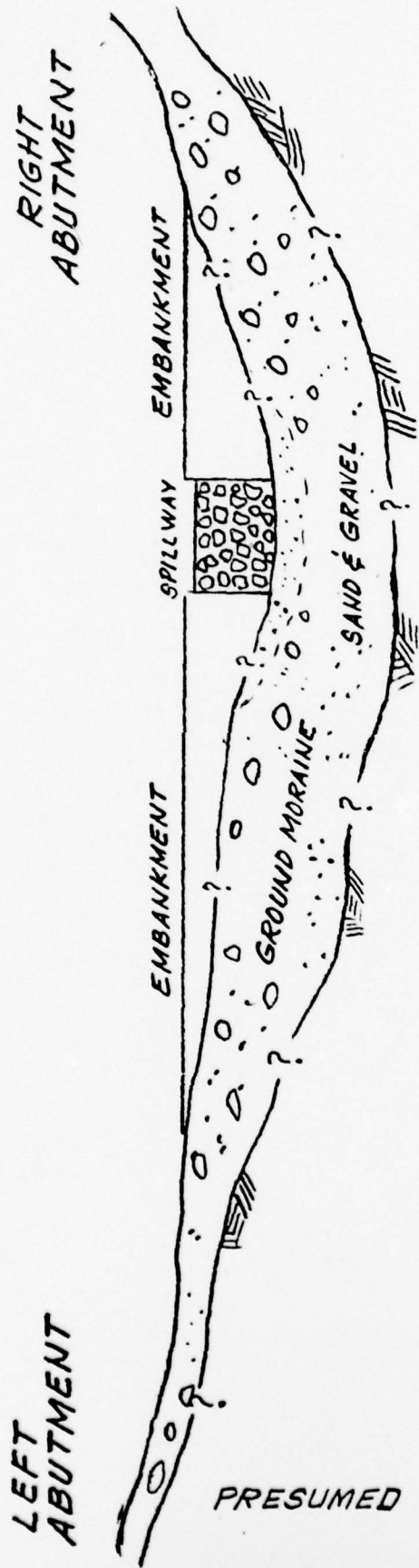
# FIG. 2





REGIONAL GEOLOGIC FEATURES

Schematic Cross-section of  
New Jersey Highlands  
Physiographic Province  
(After Wolfe, 1977)



DIAGRAMMATIC SKETCH  
 LAKE VALHALLA DAM  
 (NO SCALE)

PRESUMED SITE GEOLOGIC FEATURES

APPENDIX 1

CHECK LIST

VISUAL INSPECTION

VALHALLA LAKE DAM

VALHALLA LAKE DAM

Check List  
Visual Inspection  
Phase 1

Name Dam Valhalla Lake Dam County Morris State New Jersey Coordinators N J DEP

Date(s) Inspection 7, 15 & 19 June 1978 Weather Sunny Temperature 70 - 80°F

Pool Elevation at Time of Inspection El 398 M.S.L. Tailwater at Time of Inspection El 383 M.S.L.

Inspection Personnel:

- D. Leary \_\_\_\_\_
- A. Puyo \_\_\_\_\_
- C. Campbell \_\_\_\_\_
- A. Puyo \_\_\_\_\_ Recorder
- D. Lachel \_\_\_\_\_



11/15/64

VALHALLA LAKE DAM  
~~CONCRETE~~/MASONRY CORE

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SEE PAGE ON LEAKAGE	NONE OBSERVED	
STRUCTURE TO ADJUTMENT/EMBANKMENT JUNCTIONS	CORE FOUNDATION LEVEL UNKNOWN	
DRAINS	NONE OBSERVED	
WATER PASSAGES	NONE OBSERVED	
FOUNDATION	UNKNOWN	

VALHALLA LAKE DAM  
CONCRETE/MASONRY DAMS CORE

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS ON CONCRETE SURFACES	NONE OBSERVED	
STRUCTURAL CRACKING	NONE OBSERVED	
VERTICAL AND HORIZONTAL ALIGNMENT	GOOD	
MONOLITH JOINTS	N.A.	
CONSTRUCTION JOINTS	N.A.	

VALHALLA LAKE DAM  
EMBANKMENT

USUAL EXAMINATION OF OBSERVATIONS REMARKS OR RECOMMENDATIONS

URFACE CRACKS

NONE OBSERVED

UNUSUAL MOVEMENT OR  
CRACKING AT OR BEYOND  
THE TOE

NONE OBSERVED

SLOUGHING OR EROSION OF  
EMBANKMENT AND ABUTMENT  
SLOPES

EROSION NEAR THE SIDE WALLS  
OF SPILLWAY DOWNSTREAM.

VERTICAL AND HORIZONTAL  
ALIGNMENT OF THE CREST

GOOD

RIPRAP FAILURES

AT THREE LOCATIONS ON EMBANKMENT  
ON RIGHT SIDE OF SPILLWAY, UPSTREAM OF

VALHALLA LAKE DAM  
EMBANKMENT

Sheet 2

USUAL EXAMINATION OF

OBSERVATIONS

REMARKS OR RECOMMENDATIONS

JUNCTION OF EMBANKMENT  
AND ABUTMENT, SPILLWAY  
AND DAM

Masonry of side walls of  
spillway in poor condition  
downstream of spillway.

Need repair and strengthen

ANY NOTICEABLE SEEPAGE

Left abutment 0.1 gpm

STAFF GAGE AND RECORDER

NONE OBSERVED



VALHALLA LAKE DAM

OUTLET WORKS

VISUAL EXAMINATION OF

CRACKING AND SPALLING OF  
CONCRETE SURFACES IN  
OUTLET CONDUIT

N.A.

OBSERVATIONS

INTAKE STRUCTURE

Rusted valve and gate not used.

REMARKS OR RECOMMENDATIONS

OUTLET STRUCTURE

Not known.

OUTLET CHANNEL

N.A.

VALHALLA LAKE DAM

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	NONE OBSERVED	
APPROACH CHANNEL	GOOD	Check upstream slope of masonry. Need piezometer thru upstream backfill.
DISCHARGE CHANNEL	Stream bed contains boulders and very low masonry foot path across stream	
BRIDGE AND PIERS	Wood Bridge over spillway and light vehicular bridge over stream.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF OBSERVATIONS REMARKS OR RECOMMENDATIONS

CONDITION  
(OBSTRUCTIONS,  
DEBRIS, ETC.)

Boulders up to 8 ft. dia.  
Condition generally good.

SLOPES

Side slopes 10 to 20 hor to  
1 vert.

APPROXIMATE NO.  
OF HOMES AND  
POPULATION

Montville reported to be nearest  
D/S city with population of 1,000.

VALHALLA LAKE DAM

RESERVOIR

REMARKS OR RECOMMENDATIONS

OBSERVATIONS

VISUAL EXAMINATION OF

SATISFACTORY

SLOPES

SEDIMENTATION

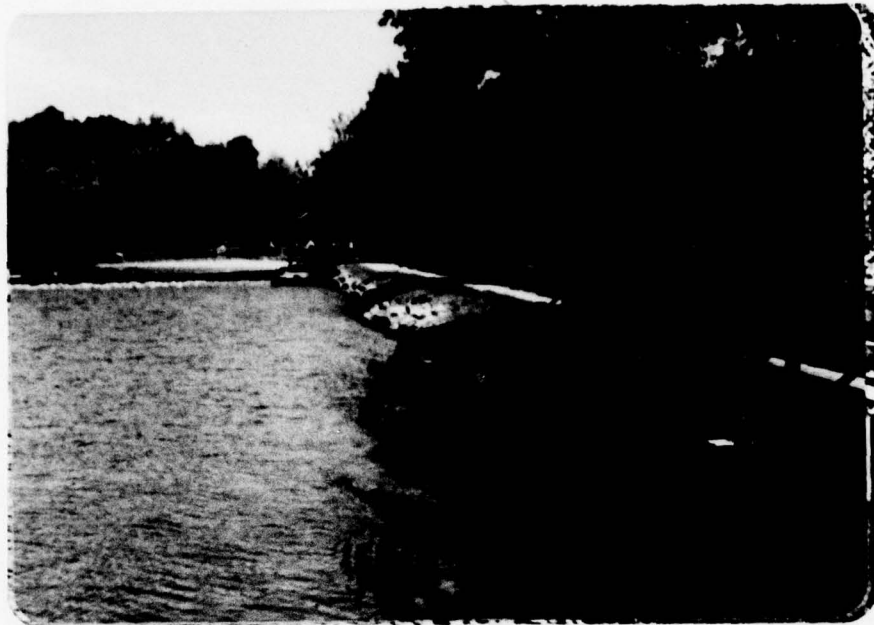
Unknown and probably small  
due to heavy foliage surrounding  
lake.



APPENDIX 2

PHOTOGRAPHS

VALHALLA LAKE DAM



Left embankment and spillway  
looking east

15 June 1978



Top of core wall in left embankment  
looking east

15 June 1978

VALHALLA LAKE DAM

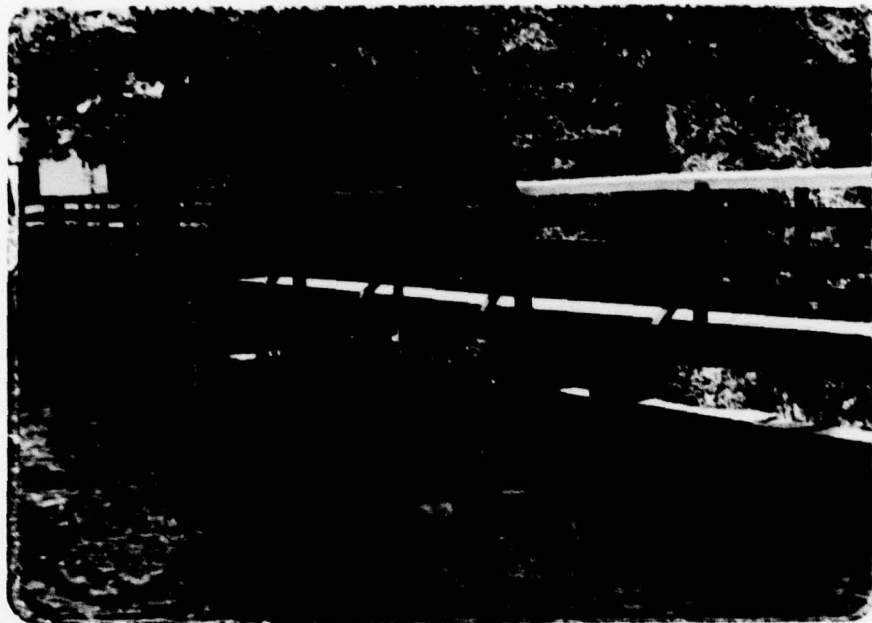


Erosion downstream of Core Wall in Right Embankment looking upstream 15 June 1978



Top of Core wall and one story building downstream of wall. Note upstream erosion at right of wall looking west. 15 June 1978

VALHALLA LAKE DAM



Top of Spillway Looking  
Downstream

15 June 1978

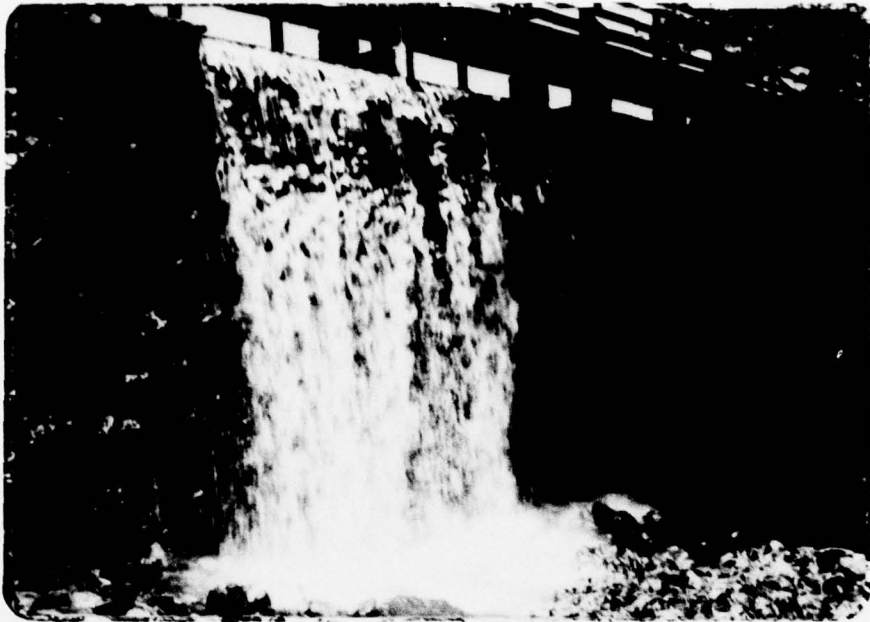


Deterioration of concrete and  
Spillway Capstones

15 June 1978

VALHALLA LAKE DAM





Free Fall Spillway  
Looking Upstream

15 June 1978



Rocks at bottom of Spillway

15 June 1978

VALHALLA LAKE DAM



Downstream Spillway  
Right Sidewall. Note  
vegetation in masonry.

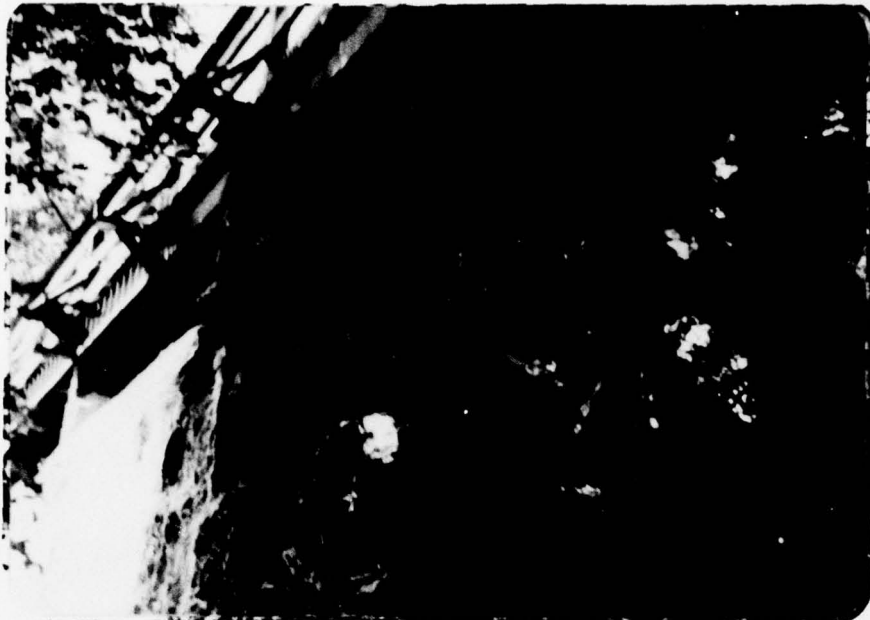
15 June 1978



Deterioration of  
upstream spillway  
right sidewall.

15 June 1978

VALHALLA LAKE DAM



Minor seepage at left face of spillway 15 June 1978



Minor seepage and absence of mortar in spillway masonry and right side wall. 15 June 1978



Erosion of upstream right  
embankment and rip-rap.

15 June 1978



Erosion of upstream right  
embankment and rip-rap. Note  
tree roots in embankment.

15 June 1978

VALHALLA LAKE DAM



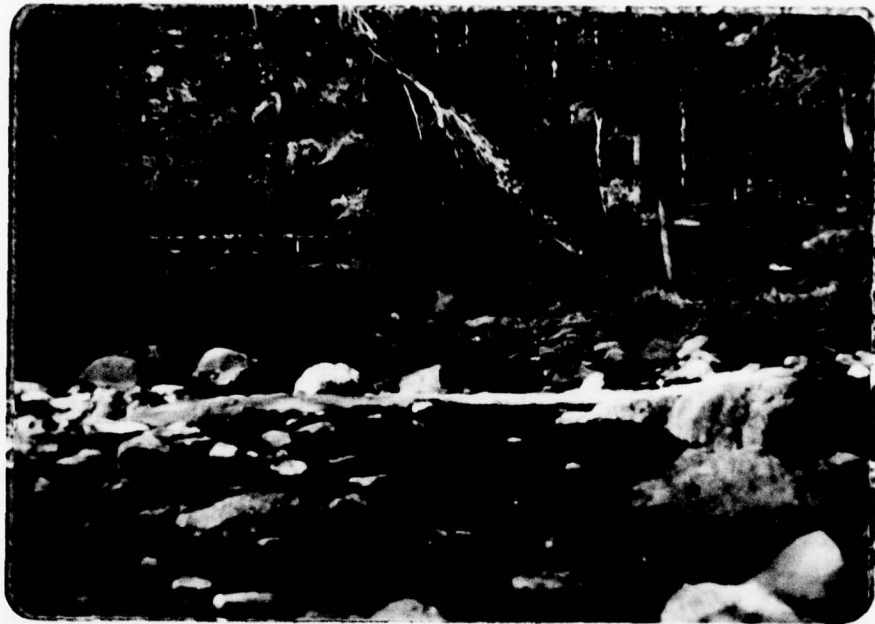


Outlet valve house upstream of right embankment. 15 June 1978



Deterioration of spillway upstream right side wall. 15 June 1978

VALHALLA LAKE DAM



Low masonry footpath across discharge channel. 15 June 1978



Discharge channel looking downstream from spillway.

15 June 1978

VALHALLA LAKE DAM

APPENDIX 3

ENGINEERING COMPUTATIONS

VALHALLA LAKE DAM

STABILITY OF SPILLWAY

width of crest 5.5 ft  
 water level 3 ft above spillway crest  
 Friction coefficient .8  
 Masonry 144 lb/ft<sup>3</sup>



UPSTREAM SLOPE ASSUMED 0.4/1

ASSUMPTION (A) No upstream backfilling

1) WALL WEIGHT  $144 \times 5.5 \times 17 = 13464$   
 $+ 17^2 \times 0.2 \times 144 = 8340$   
 $13464 \times \frac{5.5}{3} = 37026$   
 $8340 \left( \frac{5.5 + 6.8}{3} \right) = 64774$

2) WATER WEIGHT  
 below crest  $\frac{6.8}{2} \times 17 \times 62.5 = 3620$   
 above crest  $(6.8 + 5.5) \times 3 \times 62.5 = 2306$   
 $3620 \left( \frac{5.5 + 6.8 \times 2}{3} \right) = 36320$   
 $2306 \times 12.3 \times 0.5 = 14182$

3) uplift  $12.3 \times 62.5 \times \frac{20}{2} = 7687$   
 $7687 \times \frac{12.3 \times 2}{3} = 63033$

4) horizontal force  $62.5 \times \frac{20^2}{2} = 12500$   
 $- 62.5 \times \frac{3^2}{2} = -280$   
 $- 12220$   
 $\left. \begin{array}{l} \\ \\ \end{array} \right\} -77960$

Sliding SF =  $\frac{0.8 [20045]}{12220} = 1.31$

overturning  $\frac{152302}{141000} = 1.08$

ASSUMPTION (B) upstream backfilling

1) WALL WEIGHT  $13464$   
 $8340$

2) WATER WEIGHT  $3620$   
 $2306$

3) SOIL WEIGHT  
 BELOW CREST  $3620$

HORIZ. FORCE WATER  $12220$

4) SOIL  $\frac{17^2}{2} \times 0.5 \times 62.5 = 4515$

Sliding SF =  $\frac{0.8 \times 31350}{16735} = 1.50$

Active pressure coefficient 0.5  
 immersed unit weight of soil 62.5 lb/ft<sup>3</sup>

$37026$   
 $64774$

$36320$   
 $14182$

$36320$

$77960$

$25590$

OVERT. SF =  $\frac{188682}{103000} = 1.83$



STABILITY OF SPILLWAY  
(CONTINUED)

COMMENTS

Two assumptions have been considered.

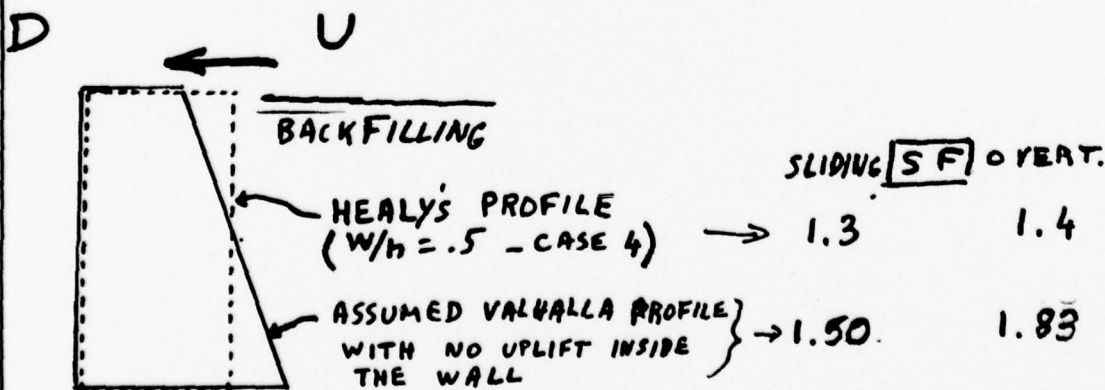
Assumption A is only given as a comparison: there is an upstream backfilling in front of the spillway.

Assumption B take into account an impervious backfilling with a perfect drainage along the upstream face of the masonry wall: in that case no uplift under the masonry wall has been considered.

These computation show that it is not possible to get stability as long as the upstream slope of the core wall is greater than 0.4/1. Besides an other ~~criteria~~ condition of the stability has also to be checked: the piezometric pressure along the upstream face of the masonry.

If the ~~max~~ piezometric pressure is a relatively high percentage of the ~~upstream~~ head at the 0.4/1 slope will be too steep to provide enough stability.

As a comparison on the same stretch are shown the assumed profile for Valhalla and the Healy's profile for case 4 and  $w/h = 0.5$

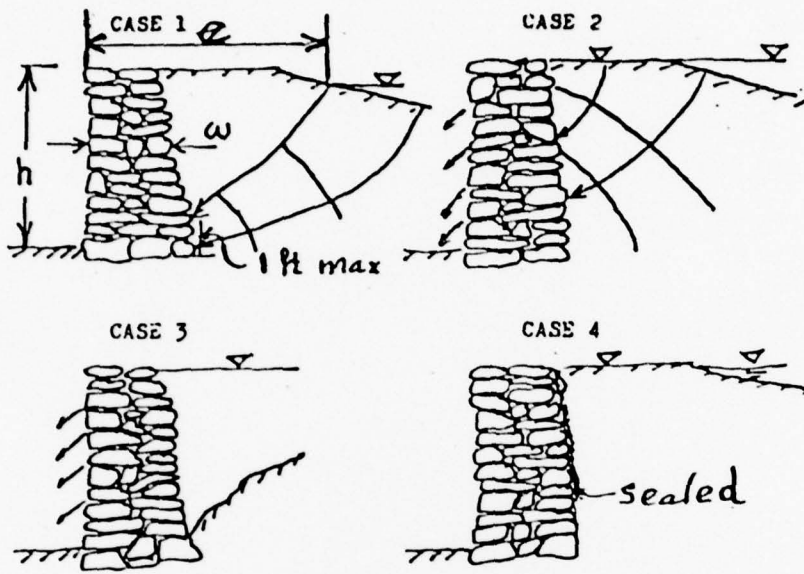


BY JMAP DATE 6-19-78 VALHALLA LAKE DAM

JOB NO. \_\_\_\_\_

CKD JC DATE 6-7-78

SHEET NO. 2 OF 3



$e > \frac{h}{2}$

FACTOR OF SAFETY

w/h	CASE 1		CASE 2		CASE 3		CASE 4	
	over turn	slide	over turn	slide	over turn	slide	over turn	slide
0.2	0.6	1.9	0.5	1.5	0.3	0.6	0.2	0.6
0.3	1.4	2.6	1.1	2.1	0.6	0.9	0.5	0.8
0.4	2.4	3.3	1.9	2.7	1.1	1.2	0.9	1.0
0.5	3.8	4.0	3.1	3.6	1.8	1.5	1.4	1.3

$\mu_{\text{stone}} = 0.7$        $\gamma_{\text{stone}} = 150 \text{ pcf}$   
 $\gamma_{\text{soil}} = 130 \text{ pcf}$        $\phi_{\text{soil}} = 35^\circ$

(After K.A. Healy)

APPENDIX 4

HYDROLOGIC COMPUTATIONS

VALHALLA LAKE DAM

HYDROLOGIC COMPUTATIONS  
VALHALLA LAKE DAM

A. Location Morris County N.J within the Passaic River Basin

B. Drainage Basin 1518 ac or 2.37 sq mi  
Area of Lake 85 ac

C. Classification  
size - small < 1000 acft storage  
Hazard - High

D. Spillway Design Flood (SDF) 1/2 PMF to PMF

E PMP

1. Dam located in Zone G

PMP = 22.5 inches (200 sq mi - 24 hr)

2. PMF must be adjusted for basin size by following the factors

Duration-hr	% 24hr (for 10 sq miles)	Reduction Factor*
0-6	112	.8 for all hrs
0-12	123	
0-24	132	
0-48	142	

\* page 48 "Small Dams"



DETERMINE TIME OF CONCENTRATION

There is a stream running through the Valhalla water shed

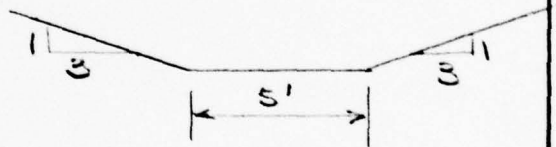
From a site inspection the ground cover is "Forest with Heavy Ground Litter & Meadow"

The stream has irregular side slopes and bottom, & this section is filled with large growth

∴ take Mannings  $n = 0.06$

Cross section of the stream will

be approximated as



Slope of the stream

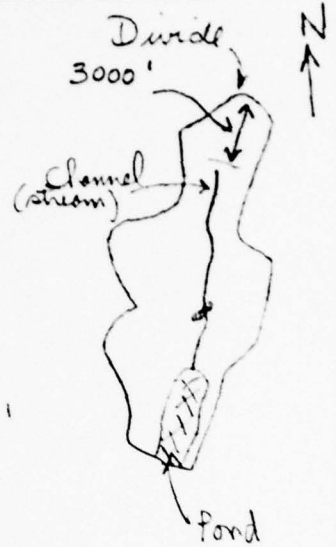
$$= \frac{H}{L}$$

$$H = 700 - 400 = 300'$$

$$L \approx 10,000'$$

$$\therefore S = \frac{300}{10,000} = .03$$

The slope of the north portion of the water shed is  $\approx 4.3\%$



From SCS Tech Rel #55

A  $T_{AB}$  calculated from overland flow

Fig 3-1,  $vel = 0.5 \text{ ft/sec}$

$$T_{AB} = \frac{\text{length}}{\text{velocity}} = \frac{3000}{(0.5)(3600)}$$

$$= 1.66 \text{ hr.}$$



We estimate that an approximate average value of  $Q$  in the stream during the time of concentration = 2000 cfs

$$Q = \frac{1.49}{n} AR^{2/3} S^{1/2}$$

$$2000 = \frac{1.49}{.06} AR^{2/3} (.03)^{1/2}$$

$$\therefore AR^{2/3} = 465$$

for the given cross section the depth of flow  $y \cong 7 \text{ ft}$

$$\therefore \text{Area of flow} = 5(7) + 2 \left( 7 \frac{(21)}{2} \right) = 182 \text{ ft}^2$$

$$\text{velocity} = \frac{2000 \text{ cfs}}{182 \text{ ft}^2} = 10.98 \text{ ft/sec}$$

BY JC DATE 8/5 Valhalla

JOB NO. J-783

CKD QED DATE 8.8.78

SHEET NO. 3 OF 11

$$T_{BC} = \frac{10000}{10.98(3600)} = 0.25 \text{ hours}$$

$$T_c = T_{AB} + T_{BC} = 1.66 + 0.25 = \underline{\underline{1.91 \text{ hr}}}$$

B Determine  $T_c$  by Fig 3.3 Tech Rel #55

Avg slope of watershed = 8%

$l$  = Greatest flow length = 13,200 ft

Lag Time = 1.5 hours

$$\therefore T_c = \frac{1.5}{0.6} = \underline{\underline{2.5 \text{ hours}}}$$

CHOOSE  $T_c = 2.5 \text{ hrs}$

### DETERMINE TIME OF PEAK

$$T_p = \frac{D}{2} + 0.6 T_c$$

Take  $D$  between  $.2 T_c$  &  $.3 T_c$

$$\therefore D = 0.6 \text{ hr}$$

BY JC DATE 5/5 Valhalla

JOB NO. J-783

CKD LER DATE 8.8.78  
REV 8.16.78

SHEET NO. 4 OF 11

$$T_p = \frac{0.6}{2} + 0.6(2.5) = 1.8 \text{ hours}$$

$$\therefore \boxed{T_p = 1.8 \text{ HOURS}}$$

UNIT HYDROGRAPH

Take  $q_p$  from SCS formula

$$q_p = \frac{484 A}{T_p} = \frac{484(2.37)}{1.8} = \underline{\underline{637 \text{ cfs}}}$$

A curvilinear hydrograph may be constructed from the values of  $q_p$  and  $T_p$  by using ratios tabulated in "Design of Small Dams", Pg 74. Take the Time increments = D

HOURS	T/T <sub>p</sub>	q/q <sub>p</sub>	UNIT HYDROGRAPH q <sub>p</sub> cfs
0.6	0.33	0.18	114
1.2	0.67	0.74	472
1.8	1.00	1.00	637
2.4	1.33	0.83	529
3.0	1.67	0.51	325
3.6	2.00	0.32	204
4.2	2.33	0.20	127
4.8	2.67	0.12	76
5.4	3.00	0.075	48
6.0	3.33	0.044	28
6.6	3.67	0.024	15
7.2	4.00	0.018	12
7.8	4.33	0.016	10

$$\Sigma q = 2597 \text{ cfs}$$

BY JC DATE 5/5 Valhalla

JOB NO. J-783

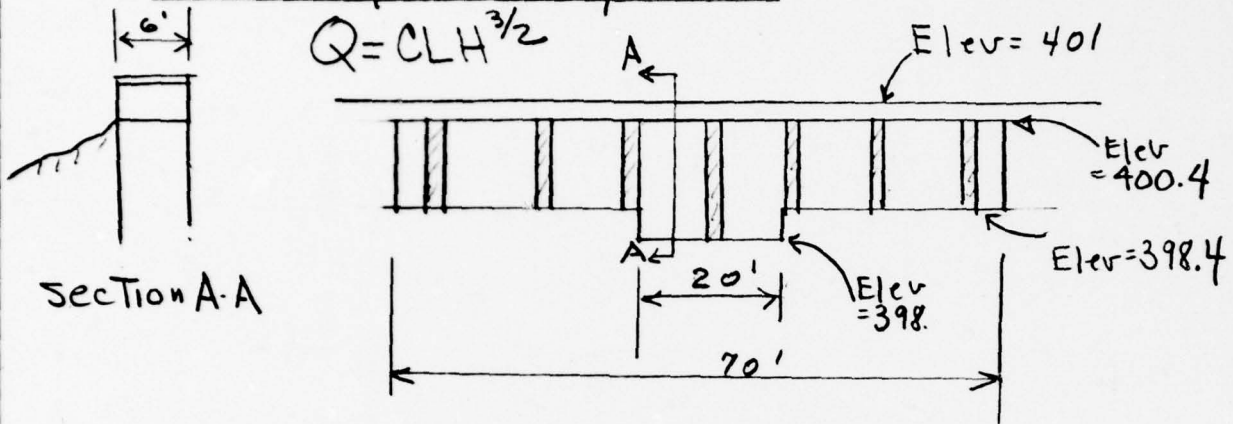
CKD QED DATE 8.8.78

SHEET NO. 5 OF 11



$$\text{Area Under Unit Graph (in)} = \frac{2597(.6 \text{ hr}) 3600(12)}{(1518 \text{ Acres}) 43560} = 1.02''$$

### SPILLWAY CAPACITY



Shape of weir is similar to those shown in "Handbook of Hydraulics, King & Brater, Fig 5-10, & 5-12. Tables for C values presented on page 5-50. Dam has similar shape as spillway.

choose

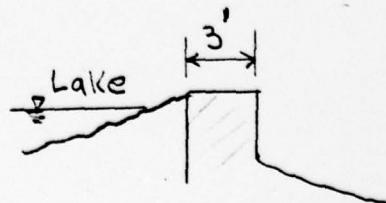
$$C = 3.39$$

For Center Spillway  $L = 19.2 \text{ ft}$   
Crest at Elev = 398

$$C = 3.39$$

For Flange Spillway  $L = 45 \text{ ft}$   
Crest at Elev = 398.7'

For Reservoir Top  
Elev = 400'



Reser. cross section

∴ Take  $C = 3.39$

Elev (ft)	Center		Flanges		Reservoir			Q TOTAL (cfs)
	H (ft)	Q <sub>c</sub> (cfs)	H (ft)	Q <sub>f</sub> (cfs)	H (ft)	L (ft)	Q(cfs)	
398.0	0	0						0
398.2	0.2	6						6
398.4	0.4	16	0	0				16
399.0	1.0	66	0.6	72				138
399.4	1.4	108	1.0	155				263
400.0	2.0	182	1.6	323				505
400.4	2.4	241	2.0	440				680
401.0	3.0	270	2.6	491	0			761
402.0	4.0	416	3.6	802	1	300	1017	2235
404.0	6.0	765	5.6	1557	3	300	5284	7606
406.0	8.0	1178	7.6	3196	5	300	11370	15744

NOTE Flows for walkway adjusted for flow blocked by walkway in proportion to area of walkway to total spillway area

RESERVOIR STORAGE CAPACITY

1 Assume embankment slopes up at 1 vertical vs 5 horiz

2. Equivalent square for area = 85 acres

$$\sqrt{85 \times 43560} = 1924' = L_e$$

3.

H	L <sub>e</sub>	Area <sub>ac</sub>	Incr. Storage	Σ Storage
0	1924	85	0	0
1	1934	85.87	85.43	85.43
2	1944	86.76	86.26	171.69
3	1954	87.65	87.21	258.9
4	1964	88.55	88.10	347.00
6	1984	90.36	178.91	525.0
8	2004	92.2	182.50	707

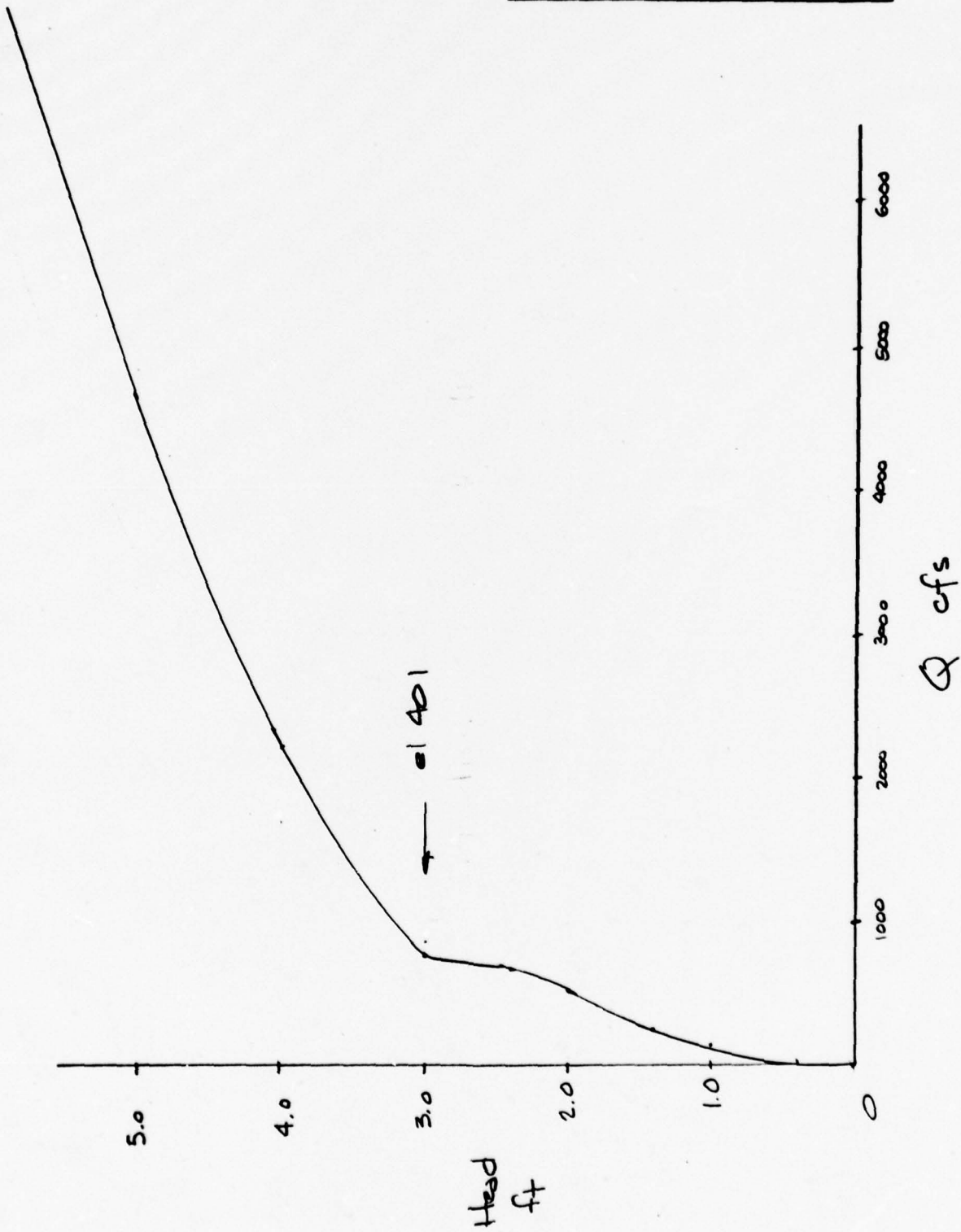
BY JC DATE 8/5 Valhalla

JOB NO. J-783

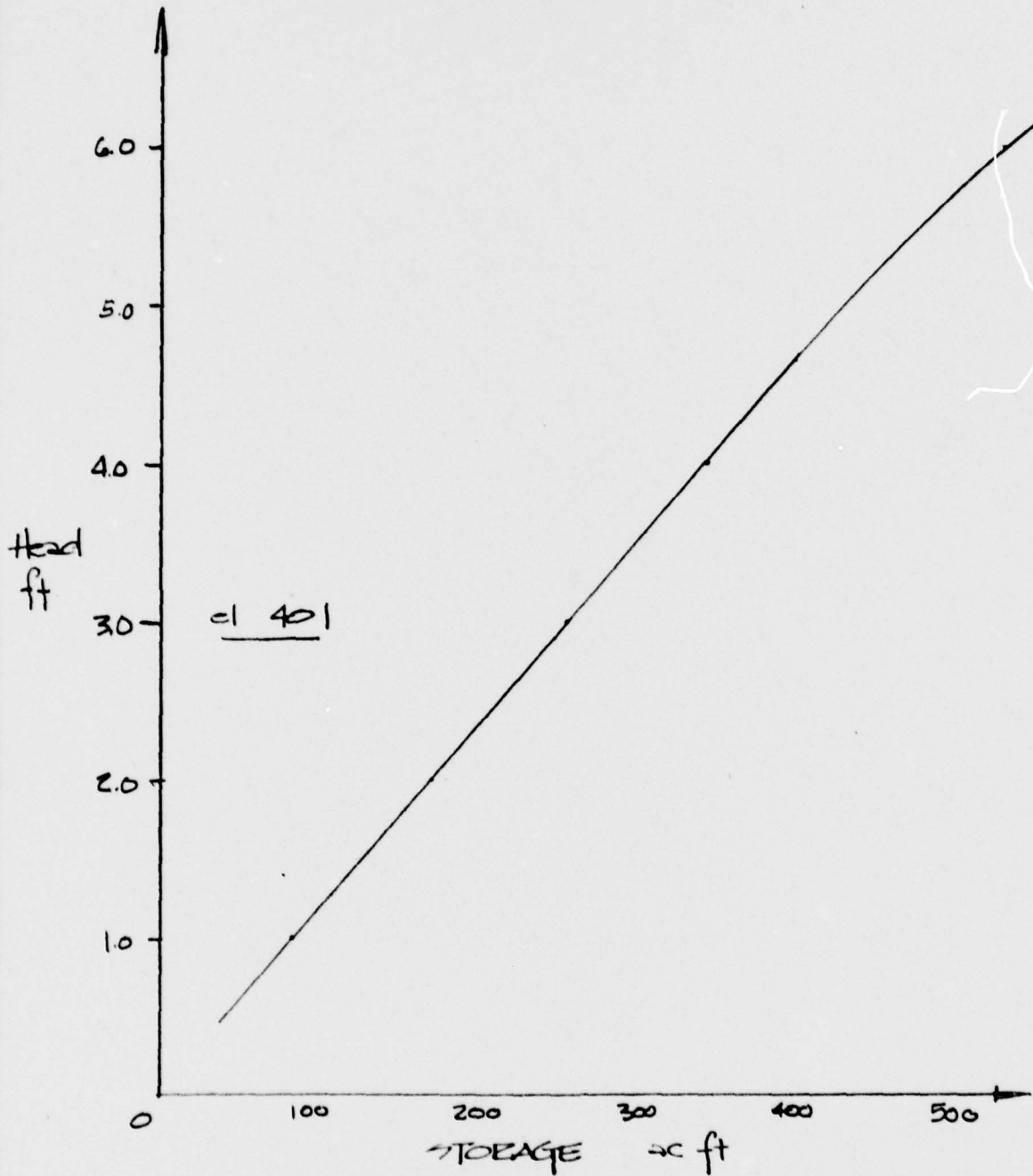
CKD PED DATE 8.8.78  
Rev. 8.15.78

SHEET NO. 7 OF 11

SPILLWAY CAPACITY



STORAGE CAPACITY CURVE



BY JC DATE            Yalhalla JOB NO. J-783  
CKD GED DATE 8-8-78 SHEET NO. 9 OF 11  
Rev 8.15.78



H (ft)	Q TOTAL (cfs)	Storage (Acre-ft)
0	0	0
.2	6	17
.4	16	34
1.0	132	85
1.4	263	119
2.0	505	171
2.4	680	205
3.0	761	259
4.0	2235	347
6.0	7606	525
8.0	15744	707

FLOOD ROUTING + HYDROGRAPH

1. Flood routing and hydrograph determined using HEC 1. Output attached

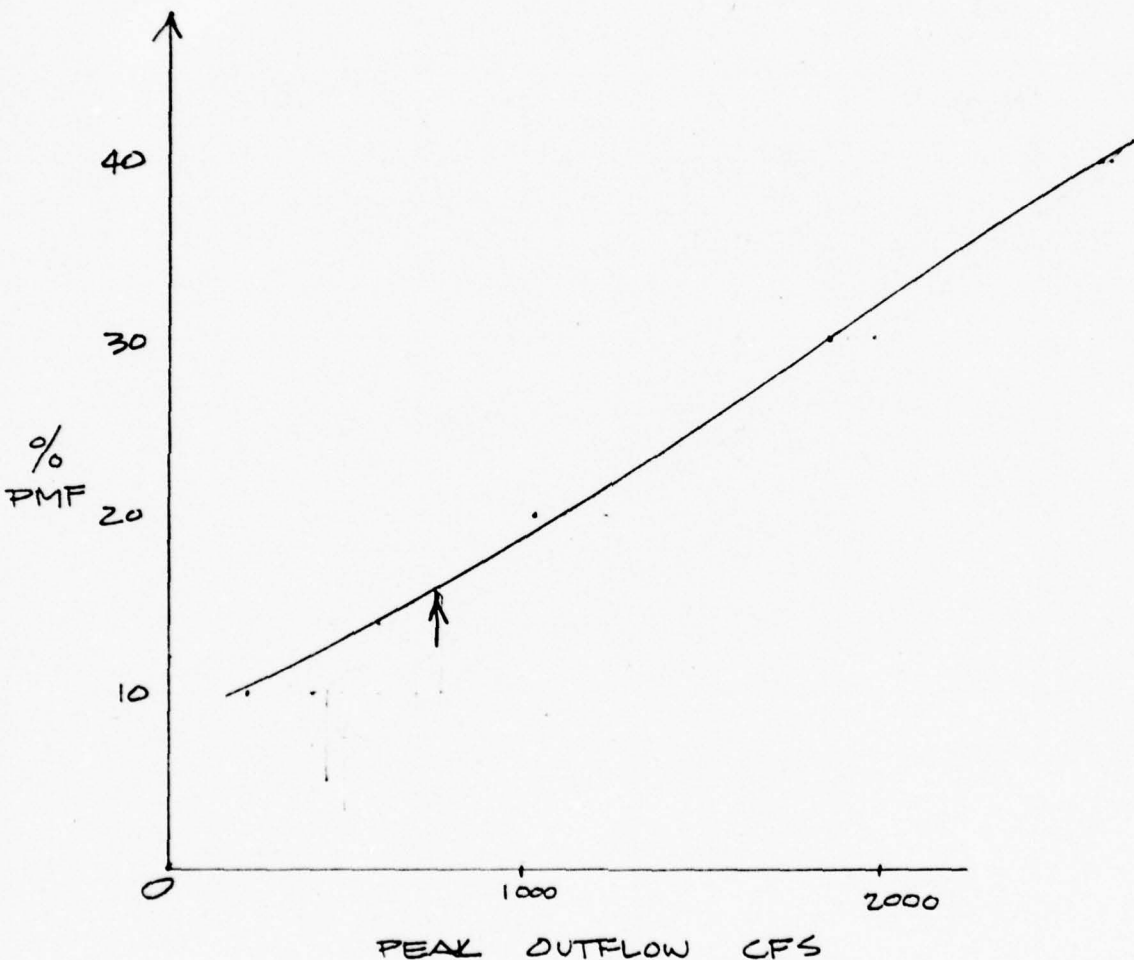
2. PMF = 6652 cfs (routed to 6577.)  
 $\frac{1}{2}$  PMF = 3326 cfs (routed to 3288)

3. Flood routing indicates dam will overtop for the PMF by 2.6 ft and the  $\frac{1}{2}$  PMF by 1.4 ft (el 402.4)

(OVERTOPPING OCCURS AT  $\approx$  el 401)

OVERTOPPING POTENTIAL

1. Rating for various %PMF performed using HEC 1; output attached
2. Peak outflow vs % DMF plotted



3. OVERTOPPING OCCURS AT EI 40' or 760 cfs  
 $\therefore$  DAM CAN PASS APPROX 16% OF PMF W/O OVERTOPPING







**DRAINAGE BASIN  
LAKE VALHALLA**

**LANGAN ENGINEERING ASSOCIATES, INC.**

270 CLIFTON AVE. SUITE 201, NEWTON, MA 02459

MAP SOURCE USGS  
BOONTON & POMPTON PLAINS  
SCALE 1" = 2000'

2 DITCH



HEC-1 OUTPUT

VALHALLA LAKE DAM

listcf vout8 'breakdown'-  
 VOUT8 12:53 AUG 15,'78  
 AMDS09 JOB 6558 (LANG0314) IN BREAKDOWN FT06F001 10.50.30 15 AUG 78 GBD  
 CDC1B 6558

\*\*\*\*\*  
 HEC-1 VERSION DATED JAN 1973  
 UPDATED AUG 74  
 CHANGE NO. 01  
 \*\*\*\*\*

\*\*\*\*\*  
 HEC-1 VERSION DATED JAN 1973  
 UPDATED AUG 74  
 CHANGE NO. 01  
 \*\*\*\*\*

VALHALLA DAM  
 DETERMINE INFLOW HYDROGRAPH FOR PMF AND .5PMF AND ROUT  
 N.J. DAM INSPECTION

JOE SPECIFICATION  
 NO NHR NMIN IDAY IRR IMIN METRC IPLT IPRT NSTAN  
 90 0 36 0 0 0 0 0 0 0  
 JOPER 0 NWT  
 5 0

MULTI-PLAN ANALYSES TO BE PERFORMED  
 NPLAN# 1 NRTIO# 2 LRTIO# 1

RTIOS# 1.00 0.50

\*\*\*\*\*

SUB-AREA RUNOFF COMPUTATION

COMPUTE HYDROGRAPH

ISTAQ ICOMP IECON ITAPE JPLT JPRT INAME  
 1 0 0 0 0 0 1

HYDROGRAPH DATA

IHYDG IUHG TAREA SNAP TRSDA TRSPC RATIO ISNOW ISAME LOCAL  
 1 -1 2.37 0.0 2.37 0.80 0.0 0 0 0

PRECIP DATA

SPPE PMS R6 R12 R24 R48 R72 R96  
 . . . . .

114. 472. 637. 529. 325. 204. 127. 76. 48. 28.  
 15. 12. 10.

UNIT GRAPH TOTALS 2597. CFS OR 1.02 INCHES OVER THE AREA

STRTQ# -2.00 QRCNS# 0.0 RTIOR# 1.00

RECESSION DATA

END-OF-PERIOD FLOW

TIME	RAIN	EXCS	COMP	Q
1	0.00	0.00	5.	5.
2	0.00	0.00	5.	5.
3	0.00	0.00	5.	5.
4	0.00	0.00	5.	5.
5	0.00	0.00	5.	5.
6	0.00	0.00	5.	5.
7	0.00	0.00	5.	5.
8	0.00	0.00	5.	5.
9	0.00	0.00	5.	5.
10	0.00	0.00	5.	5.
11	0.01	0.00	5.	5.
12	0.01	0.00	5.	5.
13	0.01	0.00	5.	5.
14	0.01	0.00	5.	5.
15	0.01	0.00	5.	5.
16	0.01	0.00	5.	5.
17	0.01	0.00	5.	5.
18	0.01	0.00	5.	5.
19	0.01	0.00	5.	5.
20	0.01	0.00	5.	5.
21	0.09	0.00	5.	5.
22	0.11	0.00	5.	5.
23	0.14	0.00	5.	5.
24	0.35	0.00	5.	5.
25	0.13	0.00	5.	5.
26	0.10	0.00	5.	5.
27	0.23	0.11	18.	70.
28	0.23	0.11	140.	198.
29	0.23	0.11	221.	191.
30	0.23	0.11	135.	85.
31	0.01	0.00	55.	..
32	0.01	0.00	..	..
33	0.01	0.00	..	..
34	0.01	0.00	..	..
35	0.01	0.00	..	..

LOSS DATA  
 STRKR DLTR RTIOL ERAIN STRMS RTIOK STRTL CNSTL ALSMX RTIMP  
 0.0 0.0 1.00 1.00 0.0 0.0 1.00 0.20 0.0 0.0

GIVEN UNIT GRAPH, NUHGO# 13

STRTQ# -2.00 QRCNS# 0.0 RTIOR# 1.00

37	0.01	0.00	23.
38	0.01	0.00	16.
39	0.01	0.00	12.
40	0.01	0.00	9.
41	0.06	0.00	7.
42	0.06	0.00	6.
43	0.06	0.00	5.
44	0.06	0.00	5.
45	0.06	0.00	5.
46	0.06	0.00	5.
47	0.06	0.00	5.
48	0.06	0.00	5.
49	0.06	0.00	5.
50	0.06	0.00	5.
51	0.20	0.08	14.
52	0.20	0.08	50.
53	0.20	0.08	100.
54	0.20	0.08	141.
55	0.20	0.08	167.
56	0.20	0.08	183.
57	0.20	0.08	193.
58	0.20	0.08	198.
59	0.20	0.08	202.
60	0.20	0.08	204.
61	1.21	1.09	321.
62	1.45	1.33	827.
63	1.81	1.69	1628.
64	4.60	4.48	2805.
65	1.69	1.57	4475.
66	1.33	1.21	5313.
67	3.04	2.92	5254.
68	3.04	2.92	5378.
69	3.04	2.92	6010.
70	3.04	2.92	6622.
71	0.10	0.00	6652.
72	0.10	0.00	5517.
73	0.10	0.00	3805.
74	0.10	0.00	2342.
75	0.10	0.00	1460.
76	0.10	0.00	900.
77	0.10	0.00	522.
78	0.10	0.00	317.
79	0.10	0.00	194.
80	0.10	0.00	113.
81	0.0	0.0	69.
82	0.0	0.0	34.
83	0.0	0.0	5.
84	0.0	0.0	5.
85	0.0	0.0	5.
86	0.0	0.0	5.



87 0.0 0.0 5.  
 88 0.0 0.0 5.  
 89 0.0 0.0 5.  
 90 0.0 0.0 5.  
 SUM 29.89 24.29 63441.

PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
6652.	5183.	1551.	705.	63430.
	20.34	24.35	24.90	24.90
	2571.	3078.	3147.	3147.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 1

	5.	5.	5.	5.	5.	5.	5.	5.	5.
5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
221.	191.	135.	85.	55.	35.	23.	16.	12.	9.
7.	6.	5.	5.	5.	5.	5.	5.	5.	5.
14.	50.	100.	141.	167.	183.	193.	198.	202.	204.
321.	827.	1628.	2805.	4475.	5313.	5254.	5378.	6010.	6622.
6652.	5517.	3805.	2342.	1460.	900.	522.	317.	194.	113.
69.	34.	5.	5.	5.	5.	5.	5.	5.	5.

PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
6652.	5183.	1551.	705.	63430.
	20.34	24.35	24.90	24.90
	2571.	3078.	3147.	3147.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 2

	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
110.	96.	68.	43.	27.	18.	12.	8.	6.	4.
4.	3.	2.	2.	2.	2.	2.	2.	2.	2.
7.	25.	50.	71.	83.	91.	96.	99.	101.	102.
160.	413.	814.	1403.	2238.	2656.	2627.	2689.	3005.	3311.
3326.	2758.	1903.	1171.	730.	450.	261.	159.	97.	56.
34.	17.	2.	2.	2.	2.	2.	2.	2.	2.

PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
3326.	2592.	776.	352.	31715.
	10.17	12.18	12.45	12.45
	1286.	1539.	1573.	1573.

\*\*\*\*\*

HYDROGRAPH ROUTING

ROUTING COMPUTATIONS



0.	1.	2.	3.	21.	27.	24.	51.	382.	149.	0.	1.	2.	3.	28.	25.	31.	62.	375.	132.	0.	1.	2.	3.	28.	25.	34.	197.	292.	97.	106.	3288.	3234.	9.16	1158.	3288.	2334.	755.	11.86	1499.	338.	30436.	11.95	1510.	1.	2.	7.	28.	24.	44.	365.	192.	70.	1.	2.	7.	28.	24.	44.	376.	169.	66.
----	----	----	----	-----	-----	-----	-----	------	------	----	----	----	----	-----	-----	-----	-----	------	------	----	----	----	----	-----	-----	-----	------	------	-----	------	-------	-------	------	-------	-------	-------	------	-------	-------	------	--------	-------	-------	----	----	----	-----	-----	-----	------	------	-----	----	----	----	-----	-----	-----	------	------	-----

PEAK 6-HOUR 24-HOUR 72-HOUR TOTAL VOLUME  
 CFS 3288. 755. 338. 30436.  
 INCHES 9.16 11.86 11.95  
 AC-FT 1158. 1499. 1510.

\*\*\*\*\* \*\*\*\*\* \*\*\*\*\* \*\*\*\*\* \*\*\*\*\*

PEAK FLOW SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS

OPERATION	STATION	PLAN	1.00	0.50	RATIOS APPLIED TO FLOWS
HYDROGRAPH AT	1	1	6652.	3326.	
	2	0.	0.	0.	
ROUTED TO	1	1	6577.	3288.	
	2	0.	0.	0.	

MCDONNELL DOUGLAS AUTOMATION COMPANY -- ST. LOUIS  
 OS/MVT RELEASE 21.7 COMPUTER SYSTEM SYO

ASP JOB NO. = 6558 JOBNAME = LANG0314 START TIME = 10.5  
 B-5

\*\*\*\*\* 'breakdown' -

W0077 13:07 AUG 15, '78

AM009 JOB 6546 (LANG0322) IN BREAKDOWN  
C0C18 LANG0322 FT06P001 10.50.11 15 AUG 78 GED

\*\*\*\*\*  
REC-1 VERSION DATED JAN 1973  
UPDATED AUG 74  
CHANGE NO. 01  
\*\*\*\*\*

THIS CARD SLOUGHED LOOKING FOR LTRA --/3

\*\*\*\*\*  
REC-1 VERSION DATED JAN 1973  
UPDATED AUG 74  
CHANGE NO. 01  
\*\*\*\*\*

VALHALLA DAM  
DETERMINE INFLOW HYDROGRAPH FOR PMF AND .5PMF AND ROUT  
# PMF

JOB SPECIFICATION									
NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	INSTAN
90	0	36	0	0	0	0	0	40	0
				JOPER	NWT				
				5	0				

PEAK FLOW SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS

OPERATION	STATION	PLAN	1.00	0.50	0.40	0.30	0.20	0.10
HYDROGRAPH AT	1	1	6652.	3326.	2661.	1996.	1330.	665.
	2	2	0.	0.	0.	0.	0.	0.
ROUTED TO	1	1	6577.	3288.	2615.	1862.	1075.	458.
	2	2	0.	0.	0.	0.	0.	0.



APPENDIX 5

INVENTORY FORMS 4474 and 4474A

VALHALLA LAKE DAM



**PART I - INVENTORY OF DAMS IN THE UNITED STATES**  
 (PURSUANT TO PUBLIC LAW 92-367)

See reverse side for instructions.

[2] [3] [4] [5] [6] [7] [8]																							[19]																								
IDENTIFICATION	DIVISION	STATE	COUNTY	CONGR DIST	STATE	COUNTY	CONGR DIST	NAME																																							
	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51			
	N	A	D	N	J	0	2	7	1	3									L	A	K	E	V	A	L	H	A	L	L	A	D	A	M														

IDENTIFICATION (Continued)	POPULAR NAME																																																			
	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51								

LOCATION	REGION	BASIN	RIVER OR STREAM																																		NEAR CITY													
	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51						
	0	2	0	3	T	R	R	O	C	K	A	W	A	Y	R	I	V	E																																

STATISTICS	TYPE OF DAM														YEAR COMPLETED	PURPOSES														STRUC-TURAL HEIGHT (ft)	HYDRAULIC HEIGHT (ft)	IMPOUNDING CAP														
																																MAXIMUM (acre - ft)														
	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50			
R	E														1	9	3	0	R												1	9											7	2	5	

REMARKS	REMARKS																																																	
	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50							
	2	1	-	2	2	-	2	3	-	2	4	-	2	5	-	2	6	-	2	7	-	E	S	T	I	M	A	T	E	D																				

111

S IN THE UNITED STATES  
IC LAW 92-367)

2

STATE		IDENTITY NUMBER				
1	2	3	4	5	6	7
N	J	0	0	3	3	0

Instructions.

[19] [10] [11] [12]

NAME	LATITUDE (North)	LONGITUDE (West)	REPORT DATE		
			DAY	MO	YR
HALLA DAM	40 55	70 74	26	05	JUL 78

NAME OF IMPOUNDMENT

L	A	K	E	V	A	L	H	A	L	L	A
---	---	---	---	---	---	---	---	---	---	---	---

[18] [19] [20]

NEAREST DOWNSTREAM  
CITY - TOWN - VILLAGE

DIST.  
FROM  
DAM  
(mi)

POPULATION

M	O	N	T	V	I	L	L	E	1	1	3	8	0	0	2
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

[24] [25] [26] [27] [27A] [27B] [27C] [27D] [27E] [27F]

STRUC- TURAL HEIGHT (ft)	HYDRAULIC HEIGHT (ft)	IMPOUNDING CAPACITIES		CORPS ENGR. DIST.	OWN.	FED. R.	PRV/FED.	SCS A.	VERIFICATION DATE			BLANK
		MAXIMUM (acre - ft.)	NORMAL (acre - ft.)						DA	MO	YR	
19	19	725	500						05	JUL	78	

[28]

REMARKS

I	M	A	T	E	D
---	---	---	---	---	---



## GENERAL INSTRUCTIONS

This form is for use in preparing the inventory of dams in the United States under the requirements of the National Program for the Inspection of Dams, P.L. 92-367. All items of Part I and Part II (Lines 0-9) must be completed as instructed below. Print entries distinctly in ink or pencil. For letters o, z, and i, write Ø, Z, and I.

Write only one letter or numeral in each space; do not use more letters than blocks allowed for an item. Do not abbreviate on Part I. Leave one space between words and no space between code letters.

In all letter codes or word entries place first letters in left block of field. In word fields any alphabetic, numeric or special character may be entered. For all numerical entries, use only numerals placing the last digit of number in the right block of field, including trailing zeros. Do not include a decimal point! In fields where decimals are required values are to be placed around a decimal point printed on the form.

Leave blank those spaces where item does not apply, e.g., do not write "N/A", "--", "None", etc., unless instructed to do so by specific instructions. Use the remarks line when additional space is needed for an item, or to clarify an entry. Preface each remark with the item number. (See Item 128 or 156 instructions)

### PART I

**Item 101 IDENTITY:** The Division Engineer will assign and control the identity for dams in the states for which he is responsible. The first two characters of the identity will be the two-letter state abbreviation in accordance with Federal Information Processing Standards Publication, June 15, 1970 (FIPS PUB 6-1). In cases where a dam is physically located in two or more states, one state will be designated as the principal state for the identity. The last five (5) characters of the identity will be a sequential number assigned to identify dams within a state.

#### LINE 0:

**Item 102 DIVISION:** Enter the three (3) letter office symbol for the division making the report in accordance with ABBR Report Code, Appendix B, ER 18-2-1, Civil Works Information System; e.g., NAD, ORD, SWD, etc.

Location:

**Item 103 STATE:** Enter two (2) letter principal state abbreviation in accordance with FIPS PUB 6-1.

**Item 104 COUNTY:** Enter three (3) digit county identification in accordance with FIPS PUB 6-1.

**Item 105 CONG DIST:** Enter one (1) or two (2) digit number for congressional districts in which dam is located.

**Item 106, 107, and 108:** (Use second location for structures situated in more than one state.)

**Item 109 DAM NAME:** Enter official name of dam. Do not abbreviate unless the abbreviation is a part of the official name. For dams that do not have a name, create a name by combining the two (2) letter state abbreviation plus "NO NAME" plus a sequential number, e.g., if two dams in the State of Alabama do not have names, they would be named as ALNONAME 1 and ALNONAME 2.

**Item 110 & 111 LATITUDE AND LONGITUDE:** Enter the latitude and longitude in degrees, minutes and tenths of a minute. All geographical location items pertain to dam as its maximum section.

**Item 112 REPORT DATE:** Enter the one (1) or two (2) digits for day, the first three (3) letters of the month and a two (2) digit year (e.g., 12 JAN74) in which the data has been revised, updated or otherwise changed.

#### LINE 1:

**Item 113 POPULAR NAME OF DAM:** If (other than the official name of the dam) in common use, enter the name in this space. Leave blank if not applicable.

**Item 114 NAME OF IMPOUNDMENT:** Enter official name of lake or reservoir. Leave blank if reservoir does not have a name.

Item 115 & 116 REGION  
ER 18-2-1, Civil Works In  
Item 117 RIVER OR ST  
indicate as tributary to ri  
Item 118 NEAREST DC  
which can be located on a  
Item 119 DISTANCE I  
Item 120 POPULATION

Item 121 TYPE OF DAM  
EARTH - RE  
ROCKHILL - LR  
GRAVITY PG

Item 122 YEAR COMPLETION  
year can be determined,  
Item 123 PURPOSES:  
should indicate the relative

IRRIGATION - I  
HYDROELECTRIC - H  
FLOOD CONTROL - C

Item 124 STRUCTURAL  
vertical distance from the  
Item 125 HYDRAULIC  
height of the dam with re  
at the downstream toe of  
side limit of the barrier to

Impounding Capabilities:

Item 126 MAXIMUM:  
the maximum attainable  
Item 127 NORMAL:  
normal retention level, in

Item 127A) CORPS OF  
the dam is geographically  
SWF, etc.

Item 127B) OWNERSHIP  
Corps of Engineers.

Item 127C) FEDERAL

Item 127D) PRIVATE

Item 127E) ASSISTANCE  
cial Assistance; B for Be

Item 127F) VERIFICATION

Item 128 REMARKS:  
IN 1928, 23-SETTLING



LINE 2:

Item 1151 & 1161 REGION AND BASIN: Enter two (2) digit numbers for Region and Basin in accordance with Appendix C, ER 18-2-1, Civil Works Information System.

Item 1171 RIVER OR STREAM: Enter official name of river or stream on which the dam is built. If stream is without name, indicate as tributary to river named, e.g., TR-COLORADO. If off stream, enter name of river plus "OFF STREAM".

Item 1181 NEAREST DOWNSTREAM CITY-TOWN-VILLAGE: Enter the nearest downstream city-town-village of such size which can be located on a general map.

Item 1191 DISTANCE FROM DAM: Enter distance from dam to nearest downstream city-town-village to the nearest mile.

Item 1201 POPULATION: Enter population of city-town-village given in Item 1181

LINE 3:

Item 1211 TYPE OF DAM: Enter two (2) letter codes, in any order, to describe type of dam.

EARTH - RE  
ROCKHILL - LR  
GRAVITY PG

BUTTRESS - CB  
ARCH - VA  
MULTI-ARCH - MV

OTHER - OT  
(Describe "other" in remarks)

Item 1221 YEAR COMPLETED: Enter year when the main dam structure was completed and ready for use. If only approximate year can be determined, note this in remarks.

Item 1231 PURPOSES: Enter one (1) letter codes that describe the purposes for which the reservoir is used. The order entered should indicate the relative decreasing importance of the project purposes.

IRRIGATION - I  
HYDROELECTRIC - H  
FLOOD CONTROL - C

NAVIGATION - N  
WATER SUPPLY - S  
RECREATION - R

STOCK OR SMALL FARM POND - P  
DEBRIS CONTROL - D  
OTHER - O  
(Describe "other" in remarks)

Item 1241 STRUCTURAL HEIGHT: Enter, to the nearest foot, the structural height of the dam which is defined as: the overall vertical distance from the lowest point of foundation surface to the top of the dam.

Item 1251 HYDRAULIC HEIGHT: Enter, to the nearest foot, the hydraulic height of the dam which is defined as: the effective height of the dam with respect to the maximum storage capacity, measured from the natural bed of the stream or watercourse at the downstream toe of the barrier, or if it is not across a stream or watercourse, the height from the lowest elevation of the outside limit of the barrier to the maximum storage elevation.

Impounding Capabilities:

Item 1261 MAXIMUM: Enter the acre feet for maximum storage which is defined as: the total storage space in a reservoir below the maximum attainable water surface elevation, including any surcharge storage.

Item 1271 NORMAL: Enter the acre feet for normal storage which is defined as: the total storage space in a reservoir below the normal retention level, including dead and inactive storage and excluding any flood control or surcharge storage.

Item 127A1 CORPS OF ENGINEERS DISTRICT: Enter the three character Corps of Engineers ABBR report code in which the dam is geographically located, in accordance with Appendix B, ER 19-2-1, Civil Works Information System, e.g., NAN, ORH, SWF, etc.

Item 127B1 OWNERSHIP: Enter N, for Non-Federal; G, for Federal Gov't. Agencies other than the Corps of Engineers; C for Corps of Engineers.

Item 127C1 FEDERALLY REGULATED: Enter N for No; Enter Y for Yes.

Item 127D1 PRIVATE DAMS ON FEDERAL LAND: Enter N for No; Enter Y for Yes.

Item 127E1 ASSISTANCE BY SOIL CONSERVATION SERVICE: Enter N for None; T for Technical Assistance; F for Financial Assistance; B for Both Technical and Financial Assistance.

Item 127F1 VERIFICATION: Date the data was verified as being complete and correct. Enter date as described in Item 1121

LINE 4:

Item 1281 REMARKS: Preface remarks with the item number to which it pertains, e.g., 22-ORIGINALLY CONSTRUCTED IN 1928, 23-SETTLING

2







PART II:

Item 111 IDENTITY: Enter Identity per GENERAL INSTRUCTIONS on PART I.

LINE 5:

Item 120 D/S HAZ: Enter the digit that most closely represents the hazard potential that could occur to the downstream (D/S) area resulting from failure or mis-operation of the dam or facilities.

HAZARD POTENTIAL

<u>CATEGORY</u>	<u>LOSS OF LIFE</u> (Extent of Development)	<u>ECONOMIC LOSS</u> (Extent of Development)
3 = Low	None expected (No permanent structures for human habitation)	Minimal (Undeveloped to occasional structures or agriculture)
2 = Significant	Few (No urban developments and no more than a small number of inhabitable structures)	Appreciable (Notable agriculture, industry or structures)
1 = High	More than few	Excessive (Extensive community, industry or agriculture)

Item 130 CREST LENGTH: Enter, to the nearest foot, the crest length of the dam which is defined as: the total horizontal distance measured along the axis at the elevation of the top of dam between abutments or ends of dam. Note that this includes spillway width, powerhouse sections, and navigation locks where they form a continuous part of the dam water retaining structure. Detached spillways, locks, and powerhouses shall not be included.

Spillway:

Item 131 TYPE: Enter the one letter code that applies.

CONTROLLED = C                      UNCONTROLLED = U                      NONE = N

Item 132 WIDTH: Enter to the nearest foot, the width of the spillway available for discharge when the reservoir is at its maximum designed water surface elevation.

Item 133 MAXIMUM DISCHARGE: Enter the number of cubic feet per second which the spillway is capable of discharging when the reservoir is at its maximum designed water surface elevation.

Volume of Dam:

Item 134 VOLUME OF DAM: Enter the total number of cubic yards occupied by the materials used in the dam structure. If volume of separate materials is known, enter in remarks. Include portions of powerhouses, locks and spillways only if integral with the dam and required for structural stability.

Power Capacity:

Item 135 INSTALLED: Enter installed capacity to one tenth (1/10) Megawatt as of the report date.

Item 136 PROPOSED: Enter the future additional capacity proposed to one tenth (1/10) Megawatt.

Navigation Locks:

Item 137 NUMBER: Enter

Item 138 LENGTH: Enter

Item 139 WIDTH: Enter

Item 140 thru 145 Enter

Item 146 OWNER: Enter

Item 147 ENGINEERING

Item 148 CONSTRUCTION via as required.

Regulatory Agency:

Item 149 DESIGN: Enter design of the dam. If no one indicate NONE.

Item 150 CONSTRUCTION responsibilities over the construction responsibilities over the

Item 151 OPERATION: control, or surveillance responsibility, operational control

Item 152 MAINTENANCE tion or surveillance responsibility or inspection or

Inspection:

Item 153 BY: Enter the inspection has been performed

Item 154 DATE: Enter when the inspection was performed

Item 155 AUTHORITY cited in Item 153, e.g.,

Item 156 REMARKS: Remarks on earthfill Only one Remark

1



Navigation Locks:

Item 137] NUMBER: Enter the number of existing navigation locks for the project.

Item 138] LENGTH: Enter to the nearest foot the length of the navigation lock.

Item 139] WIDTH: Enter to the nearest foot the width of the navigation lock.

Item 140] thru 145] Enter the lengths and widths of additional locks.

LINE 6:

Item 146] OWNER: Enter name of owner. Abbreviate as necessary.

Item 147] ENGINEERING BY: Enter name of organization that engineered the main dam structure. Abbreviate as required.

Item 148] CONSTRUCTION BY: Enter name of construction agency responsible for construction of main structure. Abbreviate as required.

LINE 7:

Regulatory Agency:

Item 149] DESIGN: Enter the name of the organization other than the owner having regulatory or approval authority over the design of the dam. If no organization other than the owner has regulatory or approval authority over the design of the dam indicate NONE.

Item 150] CONSTRUCTION: Enter the name of the organization other than the owner having regulatory authority or inspection responsibilities over the construction of the dam. If no organization other than the owner has regulatory authority or inspection responsibilities over the construction of the dam indicate NONE.

Item 151] OPERATION: Enter the name of the organization other than the owner having regulatory authority, operational control, or surveillance responsibilities over the operation of the dam. If no organization other than the owner has regulatory authority, operational control or surveillance responsibilities over the operation of the dam indicate NONE.

Item 152] MAINTENANCE: Enter the name of the organization other than the owner having regulatory authority or inspection or surveillance responsibilities over the maintenance of the dam. If no organization other than the owner has regulatory authority or inspection or surveillance responsibilities over the maintenance of the dam indicate NONE.

LINE 8:

Inspection:

Item 153] BY: Enter the name of the organization that performed the last safety inspection. Abbreviate as required. If no inspection has been performed enter NONE.

Item 154] DATE: Enter the one (1) or two (2) digits for day, the first three (3) letters of the month and a two (2) digit year when the inspection was performed. If not applicable, leave blank.

Item 155] AUTHORITY FOR INSPECTION: Enter the legislative or regulatory authority for performing the inspection indicated in Item 153], e.g., P.L. 92-367; Div 3, Water Code, State of Calif; ER 1110-2-100; etc.

LINE 9:

Item 156] REMARKS: Preface remarks with the item number to which it pertains. e.g., 34, 500,000 c.y. conc. 475,000 c.y. earthfill. Only one Remarks line should be used for PART II remarks.

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APPENDIX 6

REFERENCES

VALHALLA LAKE DAM

APPENDIX 6

REFERENCES

1. Brater, Ernest F. and Kings, Horace W. Handbook of Hydraulics 5th Edition, McGraw-Hill Book Company 1963.
2. Chow, Ven Te, Ph.D, Open Channel Hydraulics, McGraw-Hill Book Company, 1959.
3. Eby, C.F., 1976, Soil Survey of Morris County, New Jersey, U.S. Department of Agriculture, Soil Conservation Service, 111 pp.
4. Lewis, J.V., and H.B. Kummel, 1924, The Geology of New Jersey, Bulletin 14, Geological Survey of New Jersey, Trenton, New Jersey, 146 pp.
5. Lucey, C.S., 1972, Geology of Morris County in Brief, State of New Jersey, Bureau of Geology and Topography, Trenton, New Jersey, 13 pp.
6. Minard, J.P., W.W. Holman, A.R. Jumikis, 1953, Engineering Soil Survey of New Jersey, Report No. 9, Morris County, Rutgers University, New Brunswick, New Jersey, 86 pp.
7. Rogers, F.C., D.R. Lueder, and G.H. Obear, 1951 Engineering Soil Survey of New Jersey, Report No. 3, Passaic County, Rutgers University, New Brunswick, New Jersey, 45 pp.
8. United States Dept. of Agriculture, Soil Conservation Service SCS National Engineering Handbook Section 4 Hydrology NEH-Notice 4-102, August 1972.
9. United States Dept of Agriculture, Soil Conservation Service, Somerset, N.J. Urban Hydrology for Small Watersheds, Technical Release No. 55, January 1975.
10. United States Dept. of Commerce Weather Bureau, April 1956 Hydrometeorological Report No. 33, Washington, D.C.
11. United States Dept. of the Interior, Bureau of Reclamation Design of Small Dams, Second Edition 1973, Revised Print 1977.
12. Widmer, K., 1964, The Geology and Geography of New Jersey, Volume 19, The New Jersey Historical Series, D. Van Nostrand Co., Inc., Princeton, New Jersey, 193 pp.
13. Wolfe, P.E., 1977, The Geology and Landscapes of New Jersey, Crane, Russak & Company, Inc., New York, New York, 351 pp.