

AD-A063 862

ARMY ENGINEER DISTRICT NEW YORK
NATIONAL DAM SAFETY PROGRAM. LOWER WARWICK RESERVOIR DAM (INVEN--ETC(U)
SEP 78 C H BENN

F/G 13/2

UNCLASSIFIED

NL

1 OF 2
AD
A063 862



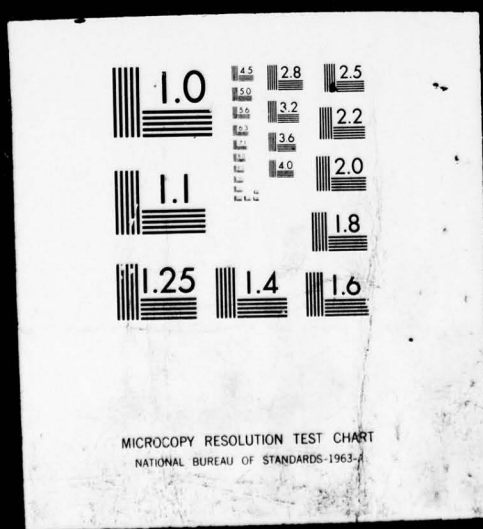
1

OF

2

AD

A063 862



AD A0 63862

WALLKILL RIVER BASIN

8
5c

LOWER WARWICK RESERVOIR DAM
ORANGE COUNTY NEW YORK
INVENTORY NO. 59

LEVEL

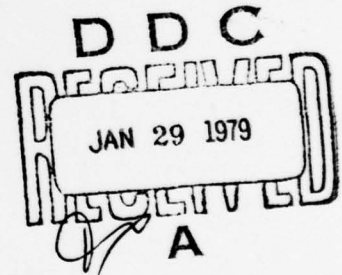
406 959

402 231

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

DDC FILE COPY

THIS DOCUMENT IS BEST QUALITY PRACTICABLE.
THE COPY FURNISHED TO DDC CONTAINED A
SIGNIFICANT NUMBER OF PAGES WHICH DO NOT
REPRODUCE LEGIBLY.



DISTRIBUTION STATEMENT A
Approved for public release
Distribution Unlimited

Prepared by: NEW YORK DISTRICT CORPS OF ENGINEERS
Date: SEPTEMBER 1978

79 01 25 019

DISCLAIMER NOTICE

**THIS DOCUMENT IS BEST QUALITY
PRACTICABLE. THE COPY FURNISHED
TO DDC CONTAINED A SIGNIFICANT
NUMBER OF PAGES WHICH DO NOT
REPRODUCE LEGIBLY.**

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, NEW YORK
26 FEDERAL PLAZA
NEW YORK, NEW YORK 10007

2 OCT 1978

NANEN-F

Honorable Hugh L. Carey
Governor of New York
Albany, New York 12224

Dear Governor Carey:

The purpose of this letter is to inform you of a clarification of the guidelines used by this office in assessing dams under the National Program of Inspection of Dams.

Office of the Chief of Engineers has recently provided a clarification that dams with seriously inadequate spillways are to be assessed as unsafe, non-emergency, until more detailed studies prove otherwise or corrective measures are completed.

The following dams in your state have previously been assessed as having seriously inadequate spillways, with capability to pass safely only the percentage of the probable maximum flood as noted in each report. They are now to be assessed as unsafe:

<u>I.D. NO.</u>	<u>NAME OF DAM</u>
N.Y. 59	Lower Warwick Reservoir Dam
N.Y. 4	Salisbury Mills Dam
N.Y. 45	Amawalk Dam
N.Y. 418	Jamesville Dam
N.Y. 685	Colliersville Dam
N.Y. 6	Delta Dam
N.Y. 421	Oneida City Dam
N.Y. 39	Croton Falls Dam
N.Y. 509	Chadwick Dam (Plattenkill)
N.Y. 66	Boyds Corner Dam
N.Y. 397	Cranberry Lake Dam
N.Y. 708	Seneca Falls Dam
N.Y. 332	Lake Sebago Dam
N.Y. 338	Indian Brook Dam
N.Y. 33	Lower(S) Wiccopee Dam (Lower Hudson W.S. for Peekskill)

NANEN-F
Honorable Hugh L. Carey

<u>I.D. NO.</u>	<u>NAME OF DAM</u>
N.Y. 49	Pocantico Dam
N.Y. 445	Attica Dam
N.Y. 658	Cork Center Dam
N.Y. 153	Jackson Creek Dam
N.Y. 172	Lake Algonquin Dam
N.Y. 318	Sixth Lake Dam
N.Y. 13	Butlet Storage Dam
N.Y. 90	Putnam Lake (Bog Brook Dam)
N.Y. 166	Pecks Lake Dam
N.Y. 674	Bradford Dam
N.Y. 75	Sturgeon Pool Dam
N.Y. 414	Skaneateles Dam
N.Y. 155	Indian Lake Dam
N.Y. 472	Newton Falls Dam
N.Y. 362	Buckhorn Lake Dam

The classification of "unsafe" applied to a dam because of a seriously inadequate spillway is not meant to connote the same degree of emergency as would be associated with an "unsafe" classification applied for a structural deficiency. It does mean, however, that based on an initial screening, and preliminary computations, there appears to be a serious deficiency in spillway capacity so that if a severe storm were to occur, overtopping and failure of the dam would take place, significantly increasing the hazard to loss of life downstream from the dam.

Consequently, it is advisable to implement the recommendations previously furnished in the reports for the above-mentioned dams as soon as practicable.

It is requested that owners of these dams be furnished a copy of this letter and that copies be permanently appended to all reports previously furnished to you.

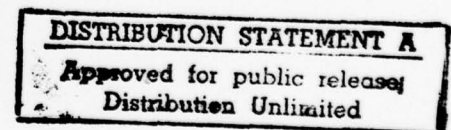
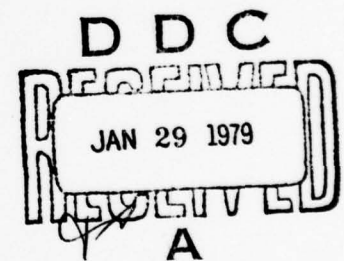
Sincerely yours,

CLARK H. BENN
Colonel, Corps of Engineers
District Engineer

WALLKILL RIVER BASIN

LOWER WARWICK RESERVOIR DAM
ORANGE COUNTY NEW YORK
INVENTORY NO. 59

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM



Prepared by: NEW YORK DISTRICT CORPS OF ENGINEERS
Date: SEPTEMBER 1978

70 01 25 019

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Phase I Inspection Report Lower Warwick Reservoir Dam Wallkill River Basin, Orange County, N.Y. Inventory No. N.Y. 59		5. TYPE OF REPORT & PERIOD COVERED Phase I Inspection Report National Dam Safety Program
7. AUTHOR(s) (10) CLARK H. BENN, Colonel, U.S. Army CofE		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS New York District, Corps of Engineers (NANEN) 26 Federal Plaza New York, New York 10007		8. CONTRACT OR GRANT NUMBER(s)
11. CONTROLLING OFFICE NAME AND ADDRESS Department of the Army 26 Federal Plaza / New York District, CofE New York, New York 10007		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) (12) 81 P1		12. REPORT DATE (11) 27 September 1978
		13. NUMBER OF PAGES
		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; Distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
(6) National Dam Safety Program. Lower Warwick Reservoir Dam (Inventory Number 59), Wallkill River Basin, Orange County, New York. Phase I Inspection Report,		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Dam Safety National Dam Safety Program Visual Inspection Hydrology, Structural Stability Orange County Lower Warwick Reservoir Dam Wallkill River		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report provides information and analysis on the physical condition of the dam as of the report date. Information and analysis are based on visual inspection of the dam by the performing organization. Lower Warwick Reservoir Dam was judged to be unsafe, non-emergency due to a seriously inadequate spillway.		

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

SECURITY CLASSIFICATION OF THIS PAGE When Data Entered)

WALLKILL RIVER BASIN - LOWER WARWICK RESERVOIR DAM
INVENTORY NO. 59

T A B L E O F C O N T E N T S

<u>Paragraph</u>	<u>Description</u>	<u>Page</u>
-	Assessment	i
-	Location Plan - Vicinity Map	ii
-	Photographs	iii - viii
1	PROJECT INFORMATION	1
1.1	GENERAL	1
1.1a	Authority	1
1.1b	Purpose of Inspection	1
1.2	DESCRIPTION OF PROJECT	1
1.2a	Description of Dam	1
1.2b	Location	1
1.2c	Size Classification	1
1.2d	Hazard Classification	1
1.2e	Ownership	1
1.2f	Purpose of Dam	1
1.2g	Design and Construction History	2
1.2h	Normal Operating Procedures	2
1.3	PERTINENT DATA	2
1.3a	Drainage Area	2
1.3b	Discharge at Damsite	2
1.3c	Elevations	2
1.3d	Reservoir	2
1.3e	Storage	2
1.3f	Reservoir Surface	2
1.3g	Dam	2
1.3h	Spillway	2
1.3i	Regulating Outlets	2
2	ENGINEERING DATA	3
2.1	DESIGN	3
2.2	CONSTRUCTION	3
2.3	OPERATION	3
2.4	EVALUATION	3
3	VISUAL INSPECTION	4
3.1	FINDINGS	4
3.1a	Background	4
3.1b	General	4
3.1c	Dam	4
3.1d	Spillway	5
3.1e	Outlet	5
3.1f	Reservoir	5
3.1g	Downstream Channel	5
3.2	EVALUATION	5
4	OPERATIONAL PROCEDURES	6
4.1	PROCEDURES	6
4.2	MAINTENANCE OF THE DAM	6
4.3	WARNING SYSTEM IN EFFECT	6
4.4	EVALUATION	6

TABLE OF CONTENTS (Cont'd)-

<u>Paragraph</u>	<u>Description</u>	<u>Page</u>
5	HYDROLOGY/HYDRAULIC	7
5.1	HYDROLOGIC EVALUATION OF FEATURES	7
5.1a	Design Data	7 - 8
5.1b	Experience Data	8
5.1c	Visual Observations	8
5.1d	Over-topping Potential	8
5.2	HYDRAULIC EVALUATION OF FLOODWAVE	8
5.2a	General	8
6	STRUCTURAL STABILITY	9
6.1	EVALUATION OF STRUCTURAL STABILITY	9
6.1a	Visual Observations	9
6.1b	Design and Construction Data	9
6.1c	Operating Records	9
6.1d	Post Construction Changes	9
6.1e	Seismic Stability	9
7	ASSESSMENT/REMEDIAL MEASURES	10
7.1	DAM ASSESSMENT	10
7.1a	Safety	10
7.1b	Adequacy of Information	10
7.1c	Additional Investigations	10
7.2	REMEDIAL MEASURES	10

APPENDIX

A	AVAILABLE PLANS
B	PERTINENT CORRESPONDENCE
C	FLOODWAVE ANALYSIS
D	HYROLOGY COMPUTATIONS
E	CHECK LISTS

RECEIVED BY
 ENG. WMS. ☐
 DRY D-11 ☐
 FURNISHED
 JUSTIFICATION
 BY _____
 DISTRIBUTION/AVAILABILITY CODES
 ENG. AVAIL. SPECIAL
 A 23

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

LOWER WARWICK RESERVOIR DAM
NEW YORK STATE
ORANGE COUNTY
WALLKILL RIVER BASIN
INSPECTED 9 AUGUST 1978

ASSESSMENT OF GENERAL CONDITIONS

The visual inspection and evaluation of Warwick Dam and its spillway did not reveal conditions which are considered to be unsafe at the present time.

The following non-emergency measures should be implemented prior to the spring season of 1979:


1. The vegetation and debris on the downstream westerly portion of the embankment should be cleared and inspected by a licensed Professional Engineer. The extent of the root systems of large trees should be evaluated prior to indiscriminant cutting.

2. A drainage ditch to collect surface runoff should be constructed on the downstream embankment slope where runoff is presently eroding the slope.

3. Toe drainage facility should be inspected and flow noted at frequent intervals.

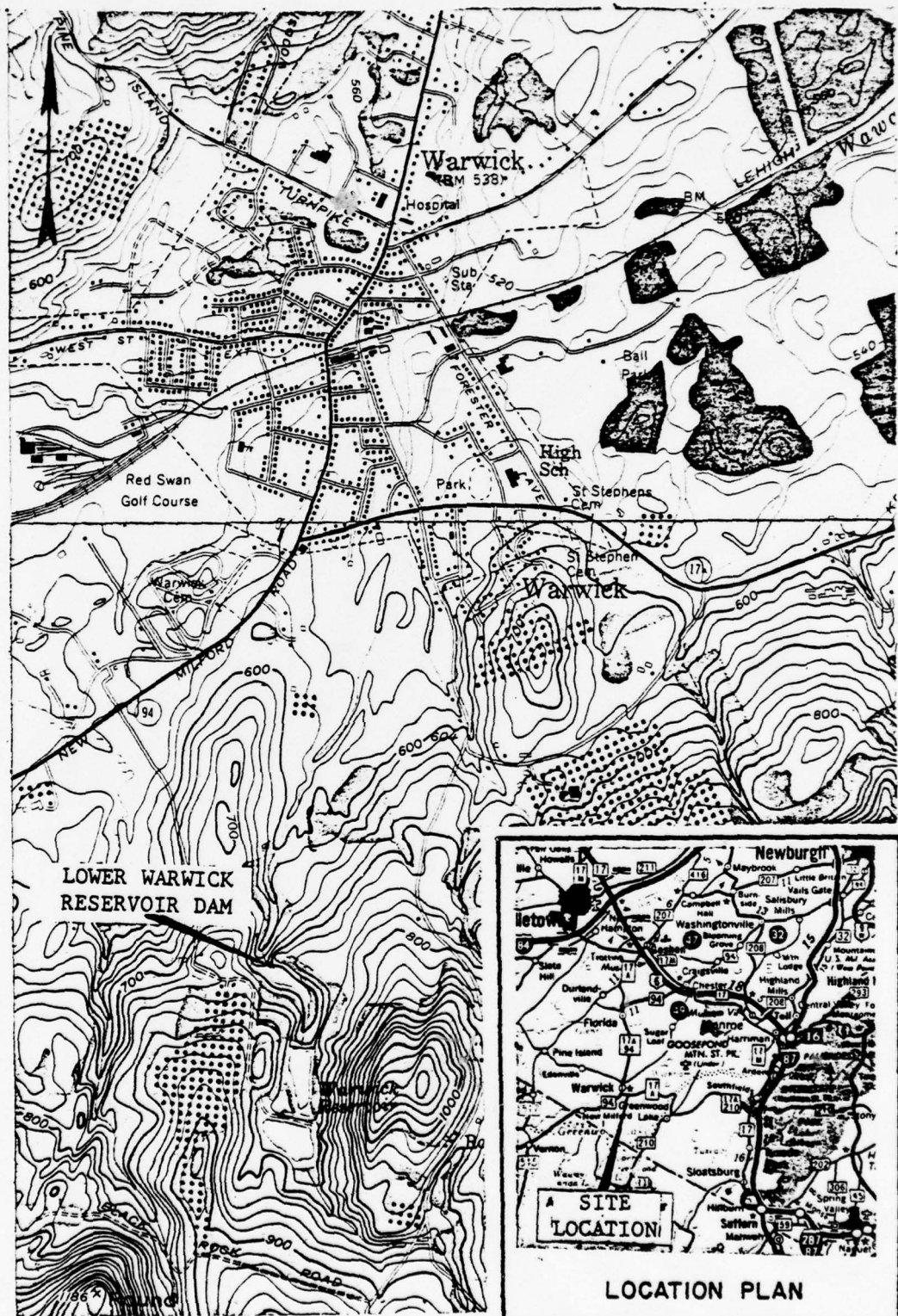
4. A piezometer should be installed in the embankment and read periodically to evaluate changes in water level within the embankment.

The hydrologic analysis indicates that the spillway is capable of passing approximately 20 percent of the Probable Maximum Flood. Since the spillway is not capable of passing the Standard Project Flood, considered as one-half the Probable Maximum Flood, without overtopping the earth embankment and possibly causing failure, the spillway is therefore considered to be seriously inadequate in accordance with Corps of Engineers Screening Criteria. The hydrologic aspects of the dam should be further investigated and the Probable Maximum Flood computations refined. In the interim around the clock surveillance should be provided during periods of high flow, and a contingency plan initiated for implementation in the event of overtopping.

Approved by: 

CLARK H. BENN
Colonel, Corps of Engineers
District Engineer

DATE: 27 September 1978





**VIEW ALONG CREST OF DAM LOOKING EAST
(NOTE ABANDONED OUTLET STRUCTURE)**



DOWNSTREAM FACE OF NEW EMBANKMENT SLOPE



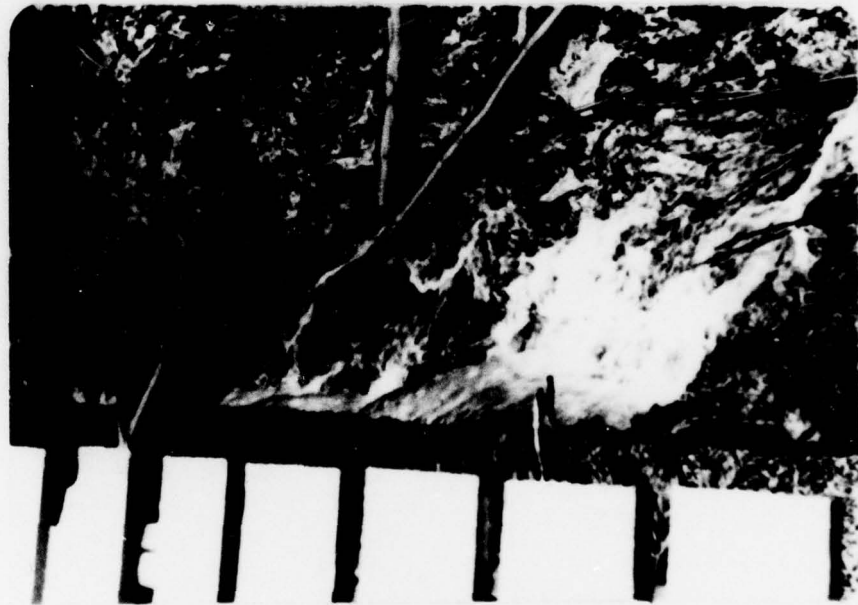
EROSION ON DOWNSTREAM EMBANKMENT SLOPE



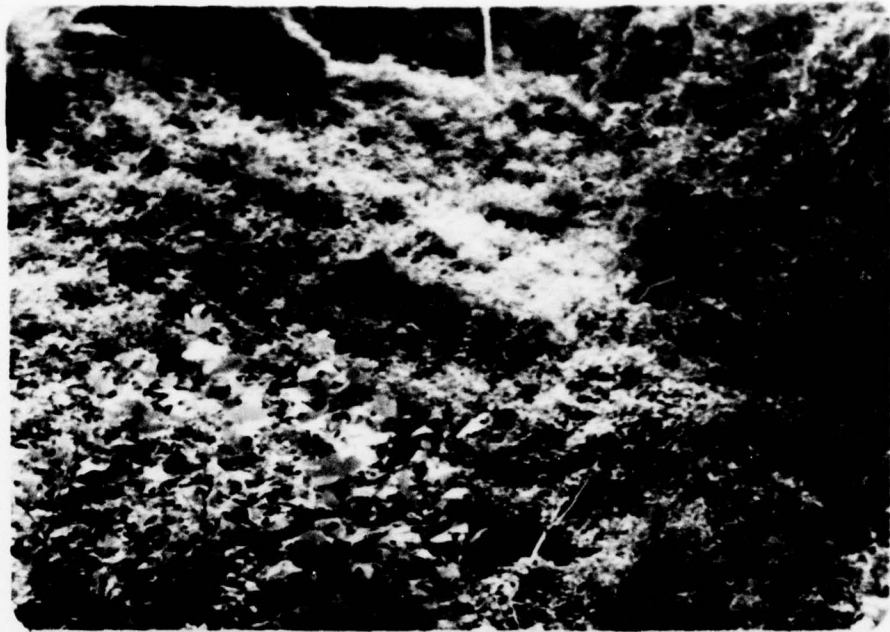
OUTLET PIPE FOR TOE DRAINAGE



OVERVIEW OF SPILLWAY



DOWNSTREAM FACE OF SPILLWAY AND
ROCK CHANNEL



WESTERLY PORTION OF DOWNSTREAM EMBANKMENT SLOPE



DOWNSTREAM CHANNEL BELOW SPILLWAY



CLORINATION AND PUMP BUILDING



**UPSTREAM SLOPE OF DAM DURING LOWERING
(SPRING 1978)**



PLACEMENT OF DRAINAGE LAYER
(SPRING 1978)

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
LOWER WARWICK RESERVOIR DAM I.D. NO. 59

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL:

a. Authority. Authority for this report is provided by the National Dam Inspection Act, Public Law 92-367, 1972.

b. Purpose of Inspection. The purpose of this report and inspection is to identify deficiencies and hazardous conditions; determine if they constitute hazards to human life or property; make recommendations for remedial measures where necessary and thus permit correction in a timely manner by non-Federal interests.

1.2 DESCRIPTION OF PROJECT:

a. Description of Dam. The Lower Warwick Reservoir Dam was built in approximately 1887 to supply water to the Village of Warwick, New York. It is the lowest of a system of three reservoirs used for the water supply of the Village. The dam is 210 feet in length; 185 feet being earth embankment possibly with a concrete core wall, and a 25 feet concrete gravity uncontrolled spillway. The dam crest is 3.3 feet above the spillway sill elevation of 679.8. The dam as originally constructed has a berm width of 12 feet and upstream and downstream slopes $1\frac{1}{2}$ horizontal on 1 vertical. A 20 inch cast iron pipe serves as the outlet works for the reservoir. It runs through the embankment just west of center and terminates in the downstream channel at invert elevation 651.12. The outlet pipe is controlled by a manual gate valve at the downstream toe of the dam. The lower dam forms the most downstream impoundment of a pumped storage system, supplying water to the Village of Warwick. Water is pumped via an eight inch diameter cast iron pipe; an offshoot from the 20 inch outlet pipe; to the upper reservoir for eventual distribution, by gravity, to the village.

b. Location. The Lower Warwick Reservoir Dam, I.D. No. 59, is located approximately $1\frac{1}{2}$ miles above the Village of Warwick, Orange County, New York. The latitude is $41^{\circ}-14.1'$ and the longitude is $74^{\circ}-21.7'$.

c. Size Classification. The available storage is approximately 12 million gallons or 36.8 acre feet at normal pool elevation (crest of spillway) with a pool area of 3.4 acres. The crest of the dam is approximately 25 feet above the existing grade. Based upon the above the dam is classified as small.

d. Hazard Classification. The dam is classified as Hazard Category I based upon floodwave analysis and the proximity of downstream habitable development.

e. Ownership. The Lower Warwick Reservoir Dam is owned by the Village of Warwick.

f. Purpose of Dam. The Lower Warwick Reservoir Dam forms the lowest of three reservoirs supplying water to the Village of Warwick. Water released from the lower reservoir is pumped to the highest of the three reservoir systems for eventual release to consumers in the village via gravity flow.

g. Design and Construction History. The dam was constructed in 1887. Design data, plans, and construction information are not available.

h. Normal Operating Procedures. Formal operating procedures are not available.

1.3 PERTINENT DATA:

- a. Drainage Area 1.3 square miles
- b. Discharge at Damsite
Maximum known flood Unknown
Ungated spillway at maximum pool 386 C.F.S.
- c. Elevations (above M.S.L.)
Top of dam 683.1 feet
Spillway crest 679.8 feet
Streambed at centerline of dam Approx. 650.0 feet
Maximum tailwater Approx. 652.0 feet
- d. Reservoir
Length of maximum pool Approx. 800 feet
Length of recreation pool Approx. 700 feet
Length of flood control pool Approx. 700 feet
- e. Storage
Recreation pool 36.8 acre feet
Flood control pool 36.8 acre feet
Top of Dam 48.0 acre feet
- f. Reservoir Surface
Recreation pool 3.4 acres
Spillway crest 3.4 acres
Top of dam Not available
- g. Dam
Type: Earth Fill (compacted)
Length: 130 feet
Height: Approx. 25 feet
Width: Approx. 12 feet
Side Slopes: 1½H on IV (upstream and downstream)
Zoning: None
Impervious Core: None
Grout Curtain: None
Cut-Off ?
- h. Spillway
Type: Broad crested weir
Length of weir: 24 feet
Crest elevation: 679.8 feet
Gates: None
Downstream Channel: Concrete spillway discharges into rock channel. (No stilling basin)
- i. Regulating Outlets - There is a 20 inch outlet pipe at elevation 651.12 feet M.S.L. used for water supply.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

There is no original design information available. During December 1977 the New York District inspected the Lower Warwick Dam at the request of Mr. Carl Quackenbush, Supt. of Public Works for the Village of Warwick. The purpose of the inspection was to provide technical advice regarding seepage through the earth dam. Recommendations made by the New York District were implemented by the Village during the spring of 1978. Construction plans were prepared by Wehran Engineering of Middletown, New York and included the following items:

- a. Immediate drawdown of the impoundment.
- b. Clear the downstream slope of debris.
- c. Construct an inclined drainage system with appropriate filter on the downstream face.
- d. Line the upstream face with bentonite .

Construction plans are included as Appendix A of this report.

2.2 CONSTRUCTION:

Original construction records are not available for review.

2.3 OPERATION:

There are no formal records of operation or discharge available.

2.4 EVALUATION:

Detail information is not available, however, sufficient information is available for a Phase I investigation.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS:

a. Background. On 21 and 23 December 1977 representatives of the New York District, Corps of Engineers visited the Lower Warwick Reservoir Dam at the request of Mr. Carl Quackenbush, Supt. of Public Works for the Village of Warwick, to investigate thru seepage in the earth dam which had raised the concern of the village officials as to the integrity of the structure. The inspection was performed under the authority of Public Law 84-99 which authorizes the Corps of Engineers to lend technical assistance to non-federal public interests during emergency situations.

Visual observations at the time revealed thru seepage in the vicinity of the right abutment from approximately half-way down the downstream embankment slope to the base of the dam, seeping at several locations. Some piping was occurring at the seep locations and serious sloughing of the downstream face had occurred.

On 22 December 1977 the Supt. of Public Works, Village of Warwick was notified of a "potentially hazardous situation requiring immediate remedial action". On 23 December 1977 Governor Carey was notified of the distressed condition of the dam. On 6 January 1978 the State was advised to require the owner of the dam to take immediate action to: (a) drawdown the reservoir immediately (b) clear the downstream slope (c) construct an inclined drainage system on the downstream slope (d) provide a pipe weir at the drainage discharge (e) construct a stabilizing berm on the downstream slope (f) treat the upstream face with bentonite (g) install a piezometer on the embankment to monitor pore pressures.

Wehran Engineering of Middletown, New York, under contract to the Village of Warwick prepared a contract plan incorporating most of the above recommended actions. The work was completed during the spring of 1978 by Village personnel after approval of the plan by NYS DEC.

b. General. The Lower Warwick Reservoir Dam was inspected by Corps of Engineers personnel on 9 August 1978 as part of the National Dam Inspection Program. At the time of the inspection water was spilling approximately two to three inches above the spillway crest. The weather was sunny with a temperature of approximately 90°F.

c. Dam. The dam, built in approximately 1887, exhibited no signs of sloughing of the embankment slopes. The embankment and drainage system, constructed in the spring of 1978, as recommended by the New York District, was in excellent condition. A grass cover had been established on the new downstream embankment and the surface was well maintained. Surface drainage had eroded a shallow swale at the downstream embankment slope in the area of the eastern terminus of new construction. No evidence of seepage was noted on the downstream face and no water was evident in the toe drainage system. Numerous rock outcroppings were noted in the area, indicative of the earth section being founded on bedrock. It is questionable whether a concrete core wall, shown on an old drawing furnished by Mr. Quackenbush, actually exists. Areas of heavy bentonite concentrations were noted on the upstream slope, just below the water line. The abutment/embankment contact showed no evidence of distress.

Heavy growth on the entire western half of the downstream embankment slope prevented examination of this area. The above paragraph does not apply to this area.

d. Spillway. The spillway, located at the west abutment is a concrete gravity section 25 feet in width. Two to three inches of water was flowing over the spillway at the time of inspection. The concrete appeared to be in good condition with minor surface scaling. There is no evidence of structural cracking. The spillway is cut into bedrock and the west abutment contact is in rock. No evidence of distress was evident.

e. Outlet. A 20 inch cast iron outlet pipe extends through the embankment just west of the center of the dam. The outlet is controlled by a manual gate valve located in a valve pit at the downstream toe. The outlet control structure, located on the upstream embankment, and previously utilized to draw water from different levels, is not operable and is not utilized. The outlet pipe was extended upstream from the old control structure and presently draws water at elevation 659.6. The gate valve is maintained in a closed position except when drawdown of the reservoir is necessary. It is fully operational.

f. Reservoir. There was no noticeable signs of sloughing or erosion in the reservoir area.

g. Downstream Channel. The outlet channel is bedrock. A small amount of debris (tree limbs, etc.) was in the channel at the time of inspection.

3.2 EVALUATION OF OBSERVATIONS:

Visual observations did not reveal any conditions which would adversely affect the safety of the dam. However, the west downstream slope of the earth embankment could not be examined due to heavy growth and brush. The drainage collection system constructed on the downstream slope in the spring of 1978 is presently not passing any seepage, apparently due to the lining of the upstream face with bentonite.

SECTION 4 - OPERATION AND MAINTENANCE PROCEDURES

4.1 PROCEDURES:

The Lower Warwick Reservoir is the lowest of three reservoirs supplying water to the Village of Warwick. Water is normally discharged through the 20 inch cast iron outlet pipe, the gate valve at the downstream toe remaining in a closed position. The water is then pumped via an eight inch pipe to the upper reservoir for distribution to the village by gravity. The chlorination facilities are located just downstream from the lower dam.

4.2 MAINTENANCE OF DAM:

Heavy brush and growth on approximately one-half of the downstream slope made this area inaccessible. The remainder of the embankment and spillway are maintained in satisfactory condition by village personnel.

4.3 WARNING SYSTEM IN EFFECT:

No warning system is in effect.

4.4 EVALUATION:

Mr. Quackenbush, Supt. of Public Works for the Village of Warwick, informed the inspection team that the western half of the downstream slope will be cleared during the winter of 1978-79. The remainder of the dam is maintained in satisfactory condition.

SECTION 5: HYDROLOGY/HUDRAULIC

5.1 HYDROLOGIC EVALUATION OF FEATURES:

a. Design Data. Warwick Dam No. 1, is the most downstream dam of a series of three dams on a headwater tributary of Wawayanda Creek. Wawayanda Creek flows into Pochuck Creek, which is a tributary of the Wallkill River. The reservoirs formed by the dams are used for water supply for the village of Warwick. The dam is an earthen structure approximately 185 feet long and 25 feet high. The dam has a 24 foot concrete spillway cut out of rock and a 20 inch outlet pipe at its base for water supply.

Warwick Dam No. 1 was designed to function primarily as a water supply facility, not a flood detention structure. However, for the purpose of this investigation, the design features were analyzed with respect to their flood control potential. This potential was investigated through the application of the probable maximum flood (PMF) to the contributing basin. The PMF is that hypothetical flow induced by the most critical combination of precipitation, minimum infiltration losses, and concentration of run-off at a specific location, that is considered reasonably possible for a particular drainage area.

The contributing drainage area to the lower Warwick Dam is 1.3 square miles as shown on Appendix D. The main stream is relatively steep with an average slope of 350 feet per mile. Since this stream is typical of the fairly mountainous Appalachian Highlands, average Snyder parameters of $640 C_p = 400$ and $C_t = 2$ were used for the determination of the unit hydrograph, the basic hydrologic working tool. Based on a C_t of 2, the lag time was developed as 2.7 hours. The lag time was increased by one hour to account for the time of travel through the system of three reservoirs for an estimated total lag time of 3.7 hours to the lowest reservoir site.

The probable maximum precipitation was developed through procedures in Hydro-meteorological Report No. 33. The PMP index rainfall was determined to be 22 inches for a 24 hour storm duration over 200 square miles. The percentages of the index rainfall applied to other durations over the study basin were developed. Because of the critical nature of this storm, a fully saturated soil condition was assumed with minimum infiltration rates of 0.1 inch/hour. The peak discharge associated with the PMF as developed by the inclosed HEC I computer output is 1979 C.F.S. For purposes of this study, the standard project flood is taken as $\frac{1}{2}$ the PMF or approximately 990 C.F.S.

The 24 foot spillway on the left bank of the dam was analyzed as a broad crested weir with a "C" coefficient of discharge of 2.65, using the formula $Q = CLH^{3/2}$. The maximum discharge capacity of the spillway with a head of 3.33 feet to the top of the dam was determined to be 386 C.F.S.

Based on a storage capacity of 12 million gallons, provided by Mr. Carl Quackenbush, the Warwick Supt. of Public Works, equivalent to 36.8 acre feet at spillway crest and a estimated surface area of 3.4 acres, a stage storage relationship was developed, as shown in Appendix D.

The lag time, C_p , drainage area, PMP index rain and percentages, loss rates and the reservoir storage versus discharge information was input into the HEC I program, "Flood Hydrograph Package". This program developed the unit hydrograph, the PMP rain data, applied the loss rates and developed the flood hydrograph. The PMF and a series of ratioed flood hydrographs were routed through the reservoir. An assumption of a full pool was made at the start of the routing. The technical computations are shown in Appendix D.

b. Experience Data. Warwick Dam has been operational since approximately 1890. As far as can be determined, it has safely passed all floods which have occurred since it was built.

c. Visual Observations: At the time of the on-site inspection, a few inches of water was flowing over the spillway, and there were no indications of any major problems.

d. Overtopping Potential. As far as can be determined, no actual storm event has had sufficient magnitude and duration to overtop the dam since it was built. However, the hypothetical probable maximum and standard project floods would cause overtopping of this dam. It is estimated that the spillway is capable of passing only 20 percent of the Probable Maximum Flood.

5.2 HYDRAULIC EVALUATION OF FLOODWAVE:

a. General. Since the lower Warwick Reservoir Dam is an earth embankment a condition of total failure was utilized in floodwave computations.

b. The downstream channel was investigated on 23 December 1977. The resulting floodwave analysis employed approximations as to stream cross-sections. The first critical location in the event of a dam failure is 3600 feet downstream from the dam, where there is a residential home development. At this location the resulting floodwave would overtop the stream banks by approximately 4 feet. At the most downstream location (8000 feet downstream from the dam, in the center of the village of Warwick) the resulting floodwave would be approximately one foot above stream bank elevation.

c. It is considered that there is a potential for damage and loss of life caused by a failure of the dam and the resulting floodwave.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY:

a. Visual Observations. Visual inspection of the lower Warwick Reservoir Dam did not reveal any areas which would represent a potential hazard due to instability. The western half of the earth embankment could not be inspected due to heavy brush growth on the downstream slope. The spillway is cut in rock and did not exhibit any serious signs of distress.

b. Design and Construction Data. No design computations or other data regarding the structural stability of the dam or spillway are available.

c. Operating Records. No major operational problems which would affect the stability of the dam or spillway were reported.

d. Post Construction Changes. Repairs on the western portion of the downstream embankment slope were completed in the spring of 1978. The recently placed toe drainage facility is not passing water, indicative that the impervious blanket placed on the upstream slope in this area is functioning as anticipated.

e. Seismic Stability. The dam is located in Seismic Zone No. 1, therefore no seismic analysis are warranted in accordance with Corps of Engineers guidelines.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT:

a. Safety. The portion of the Lower Warwick Reservoir Dam, which was able to be inspected, did not exhibit any problems which would require an unsafe assessment. No evidence of seepage or unusual settlement was observed at the time of inspection, however, due to the presence of heavy brush growth, the entire western half of the embankment was neither observed nor inspected. Preliminary hydrologic evaluations performed indicate that the dam would be topped by the Standard Project Flood. It is estimated that the spillway is capable of passing 20 percent of the Probable Maximum Flood. Therefore, since the spillway is not capable of passing the Standard Project Flood, considered as one-half of the Probable Maximum Flood, without overtopping the dam and causing failure, it is considered to be seriously inadequate.

b. Adequacy of Information. No reliable information was available regarding the dam section. This report is primarily based upon visual observations.

c. Additional Investigations. Additional investigations to assess the safety of that portion of the dam and spillway observed are not necessary.

7.2 REMEDIAL MEASURES:

The following remedial measures should be accomplished prior to the spring of 1979:

1. The western half of the downstream embankment should be cleared of all vegetation and debris and inspected by a licensed professional engineer. The extent of the root system of large trees should be evaluated prior to indiscriminant cutting.

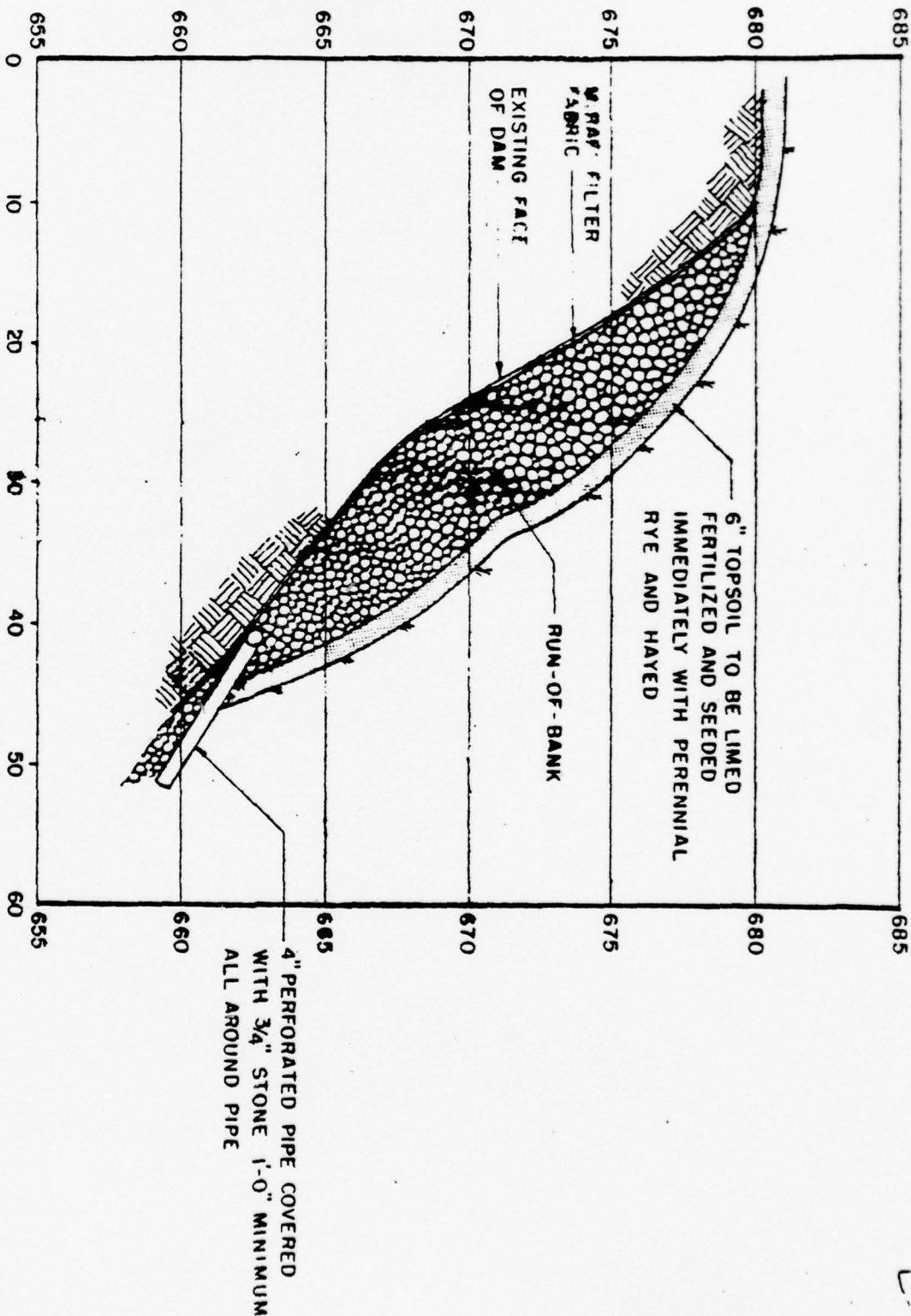
2. A drainage ditch to collect surface runoff should be constructed on the downstream slope in the area where runoff is eroding the downstream slope. A crushed gravel ditch lined with filter cloth should be provided.

3. A piezometer should be installed in the embankment and read periodically to evaluate water levels in the embankment soils.

4. The toe drainage facilities should be inspected and flow noted at weekly intervals.

5. During periods of high flows around-the-clock surveillance of the dam should be provided and a contingency plan should be initiated for implementation in the event of overtopping.

APPENDIX A
AVAILABLE PLANS



A-2

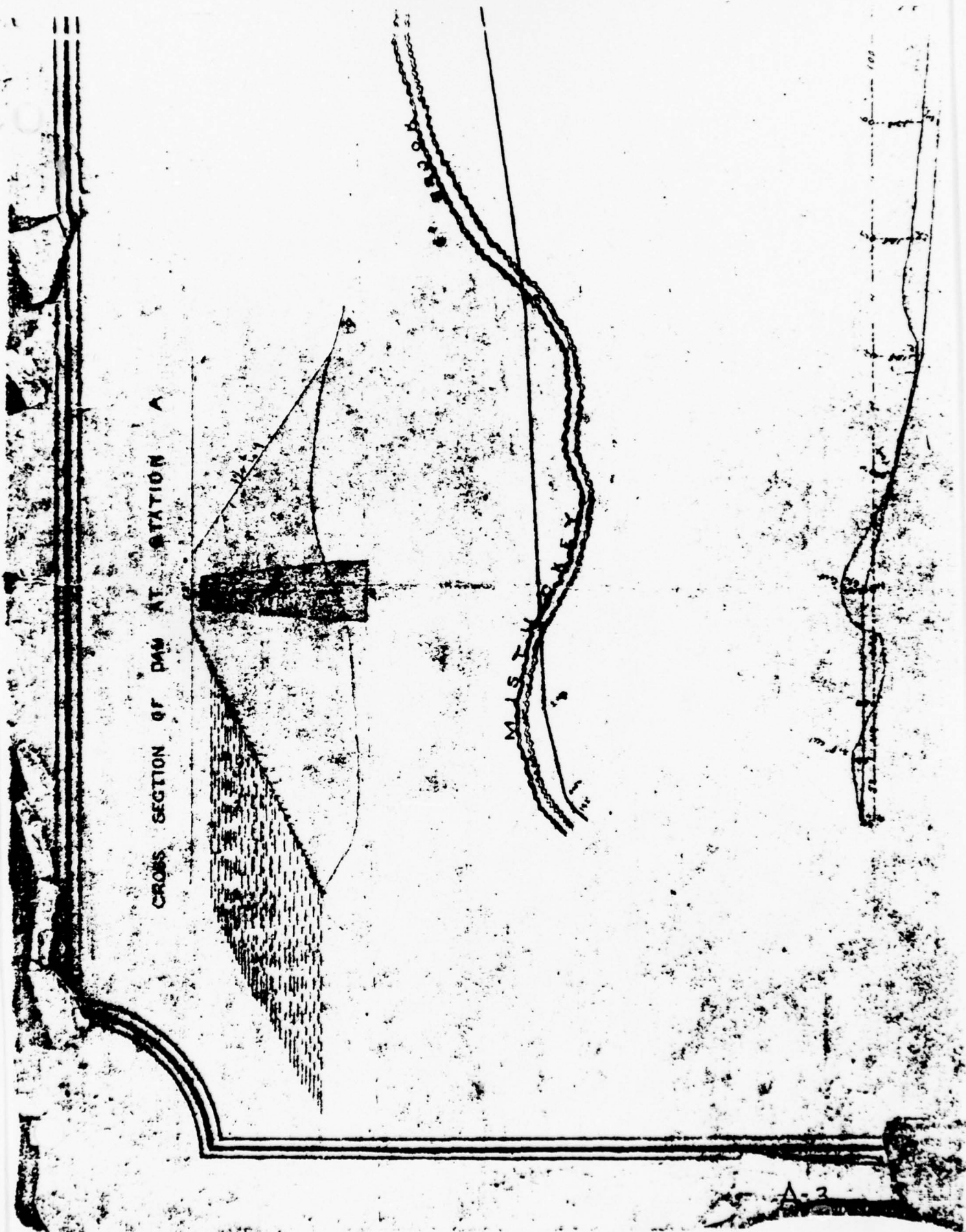
Sec

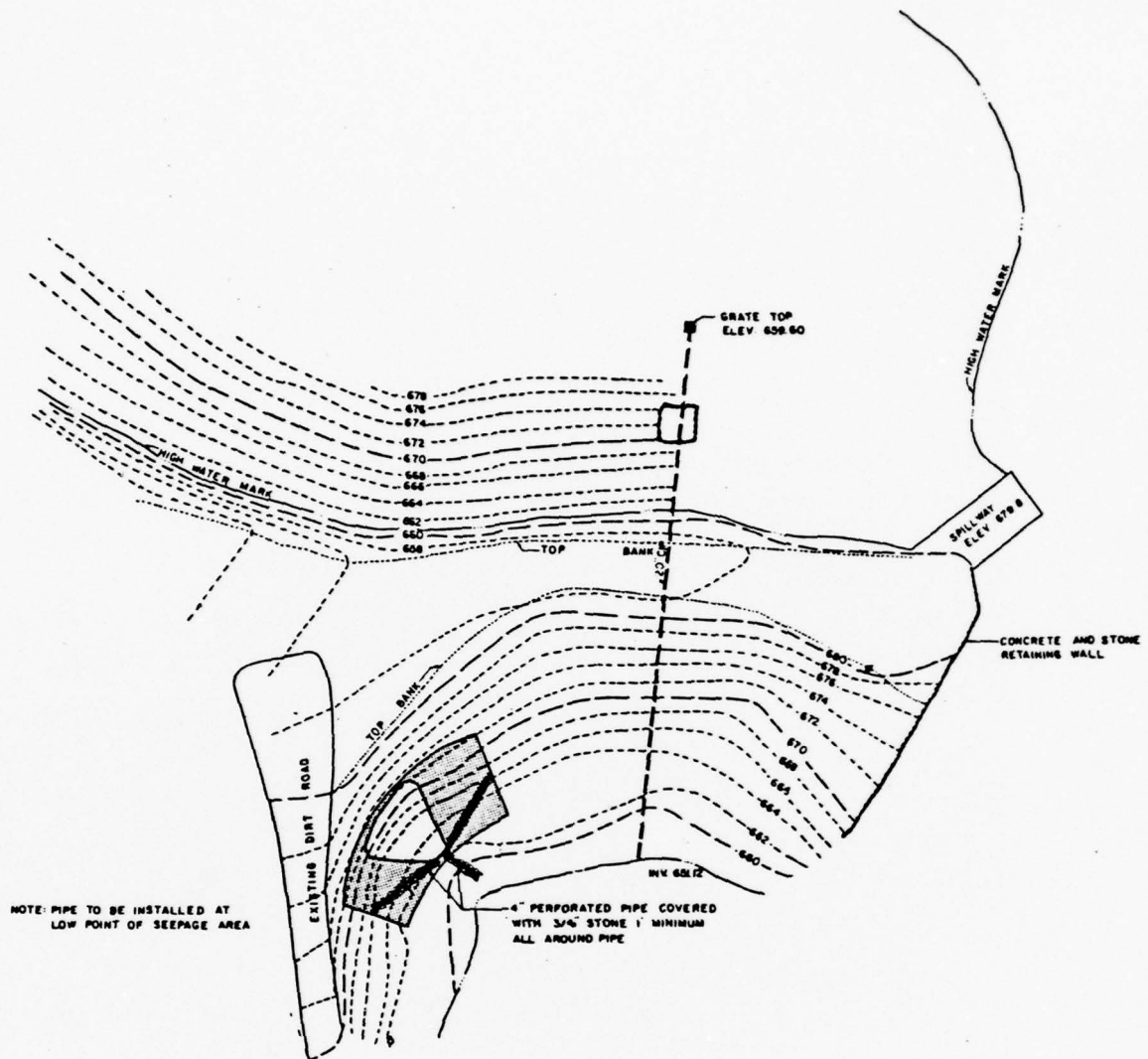
RICHARD A. PELUSO, P.E.

VILLAGE OF WARV

Remedial Slope Stabilization
& Drainage (April 78)

CROSS SECTION OF DAM AT STATION A





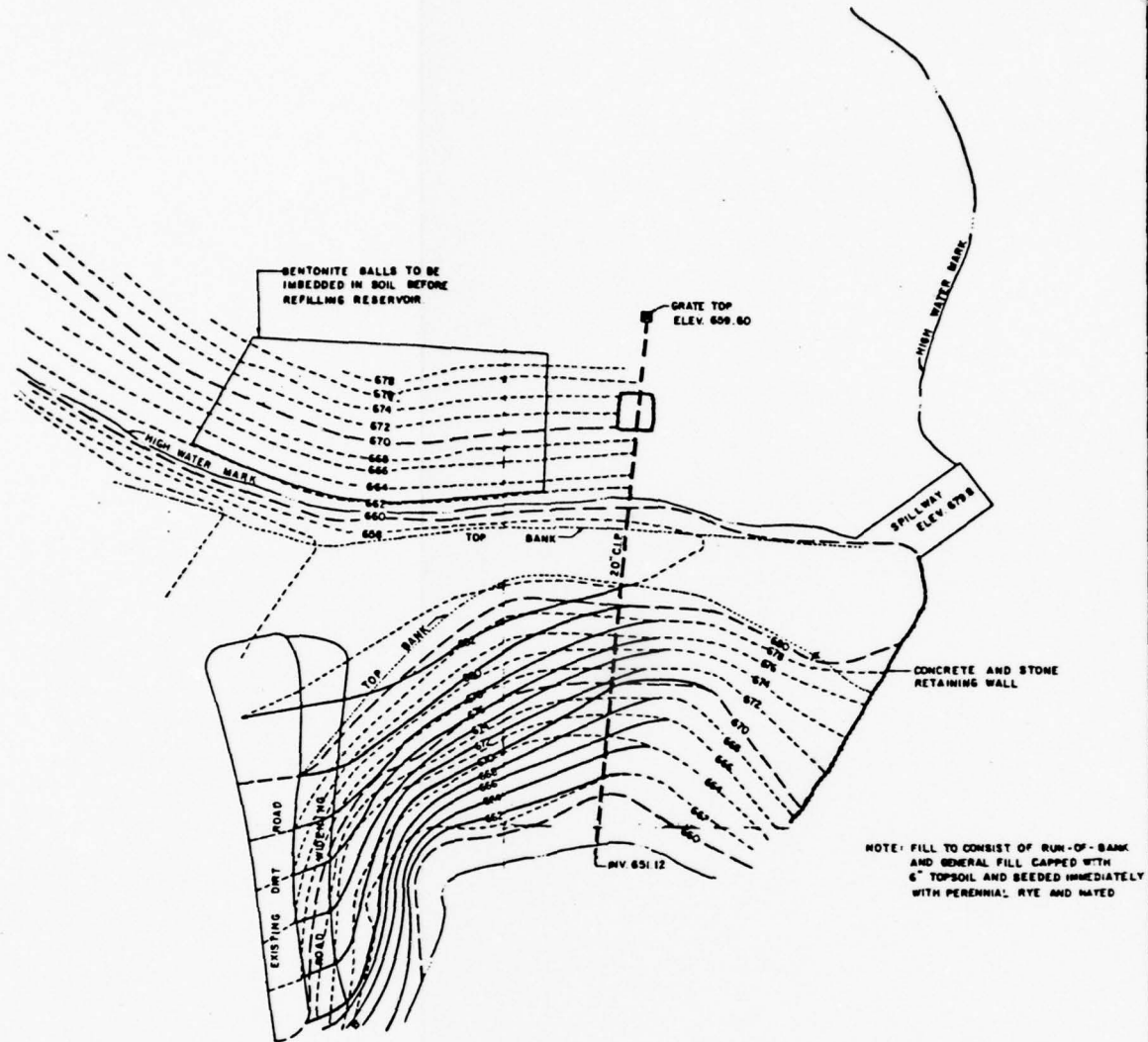
TOPOGRAPHY OF DAM NO. 1
WITH CONTROL MEASURES FOR SEEPAGE

WE WEHRAN ENGINEERING
CONSULTING ENGINEERS

Drawn by: S.W.W.
Checked by: R.A.P.
Date: 5/2/78

Scale:
1" = 20'

RICHARD A. PELUSO, PE
Richard A. Peluso
N.Y. Lic. No. 48021 Date:



FINAL GRADING PLAN

VILLAGE OF WARWICK
WARWICK, NEW YORK

REMEDIAL MEASURES
RESERVOIR NO. 1
DAM SEEPAGE

Sheet	of
1	1
Project No.	
01214032	

APPENDIX B

PERTINENT CORRESPONDENCE

CHRONOLOGY OF EVENTS
VILLAGE OF WARWICK, NEW YORK
DAM (I.D. No. 59)

<u>DATE</u>	<u>EVENT</u>
21 December 1977	Physical inspection of dam by John Dioguardi, NAN
22 December 1977	Letter from J.A. Weiss to Supt. of Public Works, Village of Warwick alerting him to "potentially hazardous situation requiring immediate action."
23 December 1977	Letter from Col. Benn to Governor Carey indicating "sufficient evidence of distress as to warrant immediate remedial action to preclude to possibility of failure."
23 December 1977	Physical inspection by Hydraulics Section of dam to determine the effects of a possible dam failure on the downstream population .
23 December 1977	Letter from J.A. Weiss to NAD alerting them to all the above.
30 December 1977	Letter from George Koch, N.Y.S. DEC, to Supt. of Public Works instructing him to: (a) Lower reservoir, (b) cut and remove trees and brush on downstream slope of dam for more complete visual observation.
30 December 1977	Letter from Secretary to Governor to Col. Benn acknowledging Col. Benn's letter of 23 Dec 77 (above).
6 January 1978	Letter from Col. Benn to George Koch advising him of Warwick problem and calling for various "immediate actions" to be taken to include: (a) immediate drawdown, (b) clearing of downstream slope, (c) construction of inclined drain system, (d) provide pipe weir, (e) construct stabilizing berm, (f) bentonite treatment of upstream fall, (g) installation of piezometer on downstream embankment.
12 January 1978	Internal DF from Chief, Design Branch evaluating downstream effects should total failure occur.

DATE

EVENT

23 January 1978

Letter to George Koch from J.A. Weiss advising him of results of hydraulics investigation.

14 February 1978

Telecon between John Dioguardi and George Koch, re: Village of Warwick Dam basically indicating that brush and debris had been removed from downstream slope but that water level had not been lowered by owners.

21 February 1978

Letter from J.A. Weiss to George Koch reiterating potential danger this dam poses to downstream inhabitants and calling again for lowering the water level and use by N.Y.S. of its enforcement authority to do so.

3 March 1978

Letter from Mr. George Koch to Mr. Quackenbush relative to dewatering procedures.

22 March 1978

Letter from Mr. George Koch to Mr. Quackenbush giving permission to drain reservoir.

27 March 1978

Letter from Mr. Carl Quackenbush, Supt. of Public Works, Village of Warwick to Mr. George Koch, NYS DEC giving status of reservoir lowering.

MC GRATH

TRUSTEES

BANK LACALAMITA
EDWARD R. CUMMISKEY, JR.
WILLIAM WENDEL, SR.
EDMUND H. BROWN, JR.



OFFICE OF THE CORPORATION
MEETINGS HELD SECOND MONDAY OF EACH MONTH

Village of Warwick

77 MAIN STREET 10930

Orange County, N. Y.

AREA CODE 914 986-2031

CLERK

MARTHA PAFER
TREASURER
CARL QUACKENBUSH
SUPT. OF PUB.
ALVIN GOLDBERG
POLICE JUST.
HARRY C. SAYRE
HEALTH OFFIC.
WARREN MC FAR
CHIEF OF POL.
BERNARD L. KUN
ATTORNEY

November 18, 1977

Daniel G. Parrillo:
North Atlantic Division
U.S. Army Corp. Engineers
NADEN-TC
90 Church St.
New York, New York 10007

Dear Mr. Parrillo:

After my telephone conversation with you on November 15th, I was speaking with my water plant operator about our conversation. He asked if I had mentioned to you the leak we have in the dam of the lowest reservoir, which we have been aware of for the past couple of years. Why I didn't think to tell you of this during our conversation I can't explain. We have been involved in many different projects for the past few months and things have been somewhat hectic. I guess I was not thinking straight.

I thought I would make you aware of this by letter, in hopes you might be able to arrange for one of your personnel to look at this and inform us if there might be a temporary correction we might be able to make.

I am not sure which I.D number applies to this dam. Following are our I.D. numbers you gave me: #0059, #0062 and #0063.

Thanking you in advance.

Very truly yours,

Carl Quackenbush

Carl Quackenbush
Supt. of Public Works
Village of Warwick
Box 369
Warwick, New York 10990

nee

B-3

Engs. Div.
77

DIOGUARDI/dms/9111

NANEN-F

22 DEC 1977

Mr. Carl Quackenbush
Supt. of Public Works
Village of Warwick
Box 369
Warwick, New York 10990

Dear Mr. Quackenbush:

Reference is made to your telephone conversation with Mr. John Dioguardi of my staff concerning a reported "leak in the dam of the lowest reservoir in the Village of Warwick."

An inspection of the dam under the authority of Public Law 99 has been scheduled for Wednesday, 21 December 1977 in your office. Any plans and/or design or construction records you may have available would be most beneficial.

Sincerely yours,

cc:w/incl:
Casper
Lawska (Oper Div)
Mr. George Koch
50 Wolf Road
Albany, N.Y. 12233

CLARK H. BENN
Colonel, Corps of Engineers
District Engineer

JH CASPE/NANEN-F
JH FAFINSKI/NANEN
WEISS/NANEN *cto*
~~PAO/NANEN~~
EA/NANEX *Dr.*
DDE/CW *W*
DE *CW*

B-4

NANEN-F

22 December 1977

Mr. Carl Quackenbush
Supt. of Public Works
Village of Warwick
77 Main Street
Warwick, New York 10990

Dear Mr. Quackenbush:

On 21 December 1977 an on-site inspection of the lowest of the three (3) earth dams, inventory I.D. No. 59, Hazard Category 2, in the Village of Warwick, Orange Co., N.Y. was made at your request.

Visual observations revealed through seepage in the vicinity of the right abutment from approximately half-way down the slope which has caused considerable sloughing and softening of the downstream embankment. We consider this to be a potentially hazardous situation requiring immediate action to alleviate the condition. A copy of the above has been forwarded to the Governor of the State and the State regulating agency charged with dam safety.

Sincerely yours,

J CASPE/NANEN-F

J.A. WEISS
Chief, Engineering Division

FAFINSKI/NANE N

WEISS/NANEN *to*

B-5

23 DEC 1977

NANEN-F

Honorable Hugh L. Carey
Governor of New York
Albany, New York 12224

Dear Governor Carey:

New York District Corps of Engineers inspection performed on 21 December 1977 of dam in the Village of Warwick, Orange County, New York (I.D. No. 59, Hazard Category 2) revealed the dam to have sufficient evidence of distress as to warrant immediate remedial action to preclude the possibility of failure. Pursuant to this a joint Corps-State inspection to determine the effects of a possible dam failure on the downstream population is scheduled for Friday, 23 December 1977.

Sincerely yours,

Incl
Letter Supt Public Works,
Warwick, N.Y.

CLARK H. BENN
Colonel, Corps of Engineers
District Engineer

cc: G. Koch, NYS DEC
Supervisor of Dam Safety

ll
FAFINSKI/NANEN

WEISS/NANEN *to*

PAO

AA

DDE

DE *CW*

B-6

JK
CASPE/dms/9111

NANEN-P

23 December 1977

SUBJECT: Dam Inspection in the Village of Warwick, New York

Division Engineer, North Atlantic
ATTN: NADEN-TF

1. Inspection performed on 21 December 1977 by NAN of dam in the Village of Warwick, Orange County, N.Y. (I.D. No. 59, Hazard Category II) revealed the dam to have sufficient evidence of distress as to warrant immediate remedial action to preclude the possibility of failure.
2. Inclosed is correspondence transmitted to Village officials relative to the above. The Governor's Office and State Regulating Authority responsible for dam safety have been advised. Consequently, a joint NAN-STATE inspection is scheduled for Friday, 23 December 1977 to evaluate the effects of a possible dam failure on the downstream population.

Incl
Letter Supt. Public Works
Warwick, N.Y. 22 DEC 77

J.A. WEISS
Chief, Engineering Division

CCW/ind: Rosen
C, Design Br

JK
FAFINSKI/NANEN
WEISS/NANEN *JK*

December 30, 1977

Mr. Carl Quackenbush
Supt. of Public Works
Village of Warwick
77 Main St.
Warwick, NY 10990

RE: Dam #397, Lower Hudson Basin

Dear Mr. Quackenbush:

Reference is made to the inspections of December 21, 1977 and December 23, 1977 of the lower earth dam in the Village of Warwick. The inspections were made by the NY District Corps of Engineers and New York State. Reference is also made to the letter of December 22, 1977 from the Corps of Engineers. This letter indicates that the seepage has caused considerable sloughing and softening of the downstream embankment. In order to remove the hazard to the downstream residents, the following remedial work should be performed immediately:

1. The water surface of the reservoir should be lowered below the seep. The seep appears about 6 feet below the existing water surface, therefore, the water surface should be lowered about 8 feet by opening the drain pipe.
2. At the time of the inspections, the trees and brush on the downstream slope of the dam prevented a thorough inspection of the earth embankment. The trees and brush along the entire downstream earth embankment should be cut and removed. This will enable us to observe the seepage area as well as the rest of the embankment.

When you have lowered the water surface and removed the trees and brush, please inform me. If you have any questions, please call at (518) 457-1216.

Yours truly,

George Koch
Supv. Dam Safety Section

cc: J. Caspe



STATE OF NEW YORK
EXECUTIVE CHAMBER
ALBANY 12224

ROBERT J. MORGADO
SECRETARY TO THE GOVERNOR

December 30, 1977

Dear Colonel Benn:

On behalf of Governor Carey, I acknowledge your letter of December 23 advising on a joint Corps-State inspection to determine effects of a possible dam failure on the downstream population of the Village of Warwick.

Sincerely,

A handwritten signature in dark ink, appearing to read "Robert J. Morgado", written in a cursive style.

Colonel Clark H. Benn
New York District, Corps of Engineers
Department of the Army
26 Federal Plaza
New York, New York 10007

NANEN-F

6 JAN 1978

New York State Department of
Environmental Conservation
ATTN: Mr. George Koch
50 Wolf Road
Albany, New York 12233

Dear Mr. Koch:

On 21 and 23 December 1977 members of my staff met with Village of Warwick, New York representatives regarding a Village request to investigate and evaluate an earth dam which was reportedly leaking at the base of the dam. As a result of these field inspections, it was determined that one of three earth dams forming part of a pumped storage water supply project for the Village was in fact experiencing through seepage in the vicinity of the right abutment. The dam, the lowest in both elevation and height of the three is an arched earth dam approximately 25 ft. high, 150 ft. long impounding approximately (12) million gallons of water. It has a 20-25 ft. wide uncontrolled overflow spillway at the left abutment at an elevation of approximately 5 ft. below the top of dam and a 20" blow-off pipe extending through and at the base of the dam controlled by a sluice gate on the downstream side. Operational procedures for the three dam system call for pumping of water from this lowest reservoir to the highest from which point the water would flow by gravity to a chlorination plant and subsequently for distribution into the water supply system of the Village.

Visual observations by field inspection teams revealed through seepage in the vicinity of the right abutment from approximately half-way down the dam embankment slope of the downstream face to the base of the dam seeping at several locations. Although flow measurements could not be made due to the fact that no quantitative instrumentation

NANEN-F
Mr. George Koch

50
DIOGUARDI/dms/9110

was available, this type of seepage poses a definite threat to the integrity of the structure which requires that immediate remedial actions be taken. In addition, a field inspection of downstream development revealed that the first of a row of one-family houses was only approximately 600 ft downstream with the Village's main population located further downstream. An evaluation of downstream impact should dam failure occur is presently being made.

In order to remove the immediate threat and insure that the seepage forces created by this through seepage do not cause dam failure the following immediate actions are recommended:

- a. Immediate drawdown of the reservoir. During drawdown observations should be made at the seeps to determine their relation to reservoir stage.
- b. The entire downstream slope should be cleared of debris and inspected in order to determine if additional seeps are present.
- c. Construct an inclined drain system with appropriate filter and collector pipes to collect and channelize seepage.
- d. Provide a pipe weir to measure and monitor discharge through the drain pipes.
- e. Construct a stabilizing berm on the downstream embankment with a minimum slope of 2½ horizontal and 1 vertical.
- f. After drawdown, the upstream face of dam should be examined and treated with bentonite in an attempt to seal the seep at its source.
- g. Install a piezometer on the downstream embankment to measure pore pressure fluctuations as a means of determining the effectiveness of the drain.

Sincerely yours,

He.
CASPE/NANEN-F

cc:
Mayor John P. McGrath
P.O. Box 369
Warwick, New York 10990

Lawska (Oper. Div.)
Caspe

CLARK H. BENN
Colonel, Corps of Engineers
District Engineer

FAFINSKI/NANEN
WEISS/NANEN

PAO

EA

DDE

DE

JD

DIOGUARDI/dms/91

NANEN-F

23 January 1978

Mr. George Koch
New York State Department of
Environmental Conservation
50 Wolf Road
Albany, New York 12233

Dear Mr. Koch:

Reference is made to letter dated 6 January 1978, concerning our inspections of the Village of Warwick's lower dam in Warwick, New York.

The results of the joint 23 December 1977 inspection with members of your staff and my Hydraulics Section regarding downstream effects revealed a potential for damage caused by a flood wave should total dam failure occur. The analysis employed approximations as to structural dimensions and stream cross sections. It was determined that the flood wave depth would be several feet above the banks at both the first critical location (3600 feet downstream of the dam) and the most downstream location (8000 feet below the dam or the middle of the Village).

Sincerely yours,

cc:
Lawska (Oper. Div.)
Rosen (Hydraulics Sect.)
Barbero

Mr. Carl Quackenbush
Supt. of Public Works
Village of Warwick
77 Main Street
Warwick, New York 10990

J.A. WEISS
Chief, Engineering Division

File
BARBERO/NANEN-F
[Signature]
ROSEN/NANEN-DH
[Signature]
FAFINSKI/NANEN
WEISS/NANEN *[Signature]*

NANEN-F
Village of Warwick Dam; I.D. No. 59

21 February 1978

Mr. George Koch
New York State Department of
Environmental Conservation
50 Wolf Road
Albany, New York 12233

Dear Mr. Koch:

Reference is made to the following:

- a. Letter dated 30 December 1977 from your office to Mr. Carl Quackenbush, Supt. of Public Works, Village of Warwick regarding the downstream hazard subject dam poses, and your request to immediately lower the water surface of the reservoir.
- b. Letter dated 6 January 1978 from Col. Clark H. Benn, District Engineer, New York District advising you of the definite threat caused by the seepage mentioned in this letter and calling for remedial measures to include immediate drawdown of the impoundment.
- c. Letter dated 23 January 1978 from the undersigned describing the downstream effects should total failure of subject dam occur.
- d. Telephone conversation between Mr. John Dioguardi of my staff and yourself on 14 February 1978 in which you indicated that the Village of Warwick had initiated the cutting of brush on the downstream slope to further observe this seepage condition but had not as of yet lowered the reservoir stage as requested in references a and b, above.

This office still considers the reported seepage in the vicinity of the right abutment to be a definite threat to the integrity of the structure requiring the immediate drawdown of the reservoir. To date no such action by the owner has been taken as indicated in reference d., above.

21 February 1978

NANEN-F
Village of Warwick Dam; I.D. No. 59

It is requested that your office exercise its enforcement authority in insuring that the initial step of the recommended remedial measures outlined in reference b., be implemented immediately to obviate the possibility of dam failure with its associated downstream damage potential.

Sincerely yours,

BARBERO/NANEN-F

cc
Mr. Carl Quackenbush
Supt. of Public Works
Village of Warwick
77 Main Street
Warwick, New York 10990

J.A. WEISS
Chief, Engineering Division

FAFINSKI/NANEN

WEISS/NANEN

Messrs: Lawska (Oper. Div.)
PAO ATTN: Campbell

March 3, 1978

Mr. Carl Quackenbush
Supt. of Public Works
Village of Warwick
Box 369
Warwick, New York 10990

Re: Warwick Dam #397 L.H.
Reservoir #1 (Lower Reservoir)

Dear Mr. Quackenbush:

This letter will confirm the remedial work that we discussed during our field inspection of the dam on March 2, 1978. The initial remedial work that we agreed upon involves lowering of the reservoir water surface and will be accomplished as follows:

1. On March 3, 1978 you will begin lowering the water surface by pumping water to your upper reservoir.
2. On Monday, March 6, 1978 you will continue lowering the water surface of the lower reservoir by opening the sluice gate on the 20-inch diameter drain. Gravity drainage will continue until the water surface has been lowered just below the elevation of the seep. The water surface will be lowered about 8 feet.
3. During your dewatering operation, consideration will be given to providing enough cover over the existing water pipe in the reservoir to prevent freezing. However, the water surface will be lowered at least 6 feet.
4. The water surface will be kept at the lowered elevation until permanent remedial work has been completed at the downstream portion of the earth embankment.

3/3/78

Field inspection at the site on March 3, 1978 indicated that there was about 12 inches of snow on the frozen ice surface. About a half-inch of water was flowing over the masonry spillway. In the vicinity of the seepage area there was less snow cover than on the rest of the earth embankment and the ground surface was frozen.

Lowering the water surface is the first step in the remedial work that is required at this dam. Later, when weather conditions are favorable for construction work, additional remedial work will be necessary. This work will include placing a stone filter blanket on the downstream slope of the earth embankment.

Please keep Ken Harmer informed of your progress in dewatering the reservoir.

Very truly yours,

George Koch
Supervisor, Dam Safety Section

cc: J. Caspe ✓
Army Corps of Engineers

March 22, 1978

Mr. Carl Quackenbush
Supt. of Public Works
Village of Warwick
Box 369
Warwick, NY 10990

Re: Warwick Dam #397
Lower Hudson

Dear Mr. Quackenbush:

This letter will confirm our telephone conversation on the above date. You have our permission to drain the entire reservoir.

Because of the spring runoff and snow melt, you have indicated that it will take from four to six weeks before you will begin remedial work on the earth embankments. Please have your engineer submit a drawing on the planned corrective work in order that we can review your proposal.

Yours truly,

George Koch, Supervisor
Dam Safety Section

GK/jb

cc: Mr. Jerome Caspe, Army Corps of Engineers

MAYOR
JOHN P. MC GRATH

TRUSTEES

TANK LACALAMITA
EDWARD R. CUMMISKEY, JR.
WILLIAM WENDEL, SR.
EDMUND H. BROWN, JR.



OFFICE OF THE CORPORATION
MEETINGS HELD SECOND MONDAY OF EACH MONTH

Village of Warwick

77 MAIN STREET 10990

Orange County, N. Y.

AREA CODE 914 986-2031

CAROLE PAFFENROTH
CLERK
MARTHA PAFFENROTH
TREASURER
CARL QUACKENBUSH
SUPT. OF PUBLIC WORKS
ALVIN GOLDSTEIN
POLICE JUSTICE
HARRY C. SAYRE, JR.,
HEALTH OFFICER
WARREN MC FARLAND
CHIEF OF POLICE
BERNARD I. KUNERT
ATTORNEY

March 27, 1978

Mr. George Koch
N.Y.S. Dept. of
Environmental Conservation
50 Wolf Rd.
Albany, New York 12233

Dear Mr. Koch:

After our meeting and discussion on Friday, March 3, 1978, we came to the agreement we would proceed to lower the #1 Reservoir. Following are the procedures we took and the effects of these procedures.

We began the lowering by using our 40 H.P. recirculating pump and ran it through the weekend.

3/6/78- Monday A.M.- The water had lowered 10". Just after noon that same day, we discontinued the pumping and opened a 8" gate valve to proceed with the lowering.

3/7/78- Tuesday A.M.- The water had lowered 2" more. This same day I conversed with Mr. Ken Harmer of your office and explained what was being done.

3/8/78- Wed. The water had lowered 1' more, which made the level 2' below normal.

3/9/78- Thurs.- The level had lowered 8" more and the ice was all cracked loose from the shore line and lowering with the water, which we were happy to see.

3/10/78- Fri. - Water level was down 1' more.

3/13 - Monday- After the weekend the level had been lowered 5'4". The ice was still lowering with the water.

3/14- Tuesday- We had the water level down 6' and was making adjustments with the 8" valve to try and hold this level. It rained off and on during the day.

cont'd page 2

B-18

3/15- Wed. - Water level, due to the 1.41" of rain and snow melt, came up 2'6".

3/16- Thurs.- Warm weather and continued run-off raised the level 6" more.

3/17- Fri.- Level was holding.

3/20- Monday- Changed from the 8" gate and opened the 20" gate.

3/21- Tuesday- As of today, we had the level backdown 3'6".

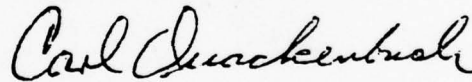
3/22- Wed.- I called your office and asked if you had any objections to the draining completely of this reservoir and you did not.

We found due to warm weather, we could not control any level, so this is why we decided to lower it completely.

We devoted from 3/22 till 3/24 and almost had the mission accomplished, but Saturday and Sunday we got 2.9" of rain again and the rain is still continueing today, 3/27. We are in hopes that when the rain ends and we once get the water drained, we will be able to open the 20" gate fully and it will keep the level down, without any effects of some lower area downstream.

Just as a matter of information, there was no change visually in the so called leak.

Very truly yours,



Carl Quackenbush
Supt. of Public Works

CQ:ms

cc: R.A. Peluso, Wehran Engineering
Jerome Caspe, Army Corps of Engineers

APPENDIX C

FLOODWAVE ANALYSIS

Warwick Reservoir

"Dam Break Analysis"

Flood Wave Determination

Dec 1977-Jan 1978

Refer to ASCE Paper No. 3915, dated May 1964, "Hydrology of Spillway Design," by A.F. Snyder for the method used in determining the flood wave.

Calculations by R.L. ALPERN
C-1

General steps required in order to perform the calculations of flood wave depths

- ① Volume of reservoir must be determined.
- ② Representative downstream sections must be chosen.
- ③ Compute the value of Q at the time of breach
- ④ Using the steps outlined in ASCE paper No. 3915, compute the downstream flood wave depths.

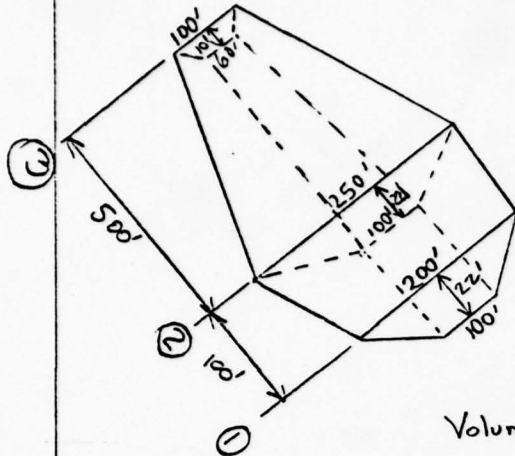
Findings

Knowing the depths at the downstream sections and the locations of the houses it was found that if the dam broke, the first set of houses at station 35+50 would have about 9 feet of water overflowing the banks. From station 35+50 to the town line there are no further houses in the flooded area. Once in the town limits, around station 60+00, the depth decreases to $5\frac{1}{2}$ feet above the banks but the area is more highly populated. The depth in the middle of the town, station 80+00 decreases to 2.8 feet above the banks.

To conclude, there is a potential for damage to occur by the dam breaking.



The volume of the reservoir must be found in Acre-feet



Using the average end area method.

$$A① = \frac{1}{2}(22)(200+100) = 3300 \text{ ft}^2$$

$$A② = \frac{1}{2}(22)(250+100) = 3850 \text{ ft}^2$$

$$A③ = \frac{1}{2}(10)(100+60) = 800 \text{ ft}^2$$

$$\text{Volume} = \left(\frac{3300+3850}{2} \right) 100 + \left(\frac{3850+800}{2} \right) 500 = 1,520,000 \text{ ft}^3$$

$$\text{Volume Acre-ft} = \frac{1,520,000}{43560} = 34.9 \text{ say } \underline{35 \text{ Acre-ft}}$$

The peak discharge at time of full breach using the W.E.S. equation is $Q_{\max} = \frac{8}{27} \sqrt{g} K^{.28} W_b D_b^{1.5}$

$$\text{where } K = \frac{W_d \cdot Y_o}{W_b \cdot D_b}$$

W_d = width of dam

W_b = width of breach

Y_o = overall depth of dam

D_b = depth of breach

For full breach $K=1$

$$Q_{\max} = \frac{8}{27} \sqrt{32.2} (200)(22)^{1.5} = 34,699$$

width of breach = 200'
depth = 22

Say 34,700 cfs

The steps used to calculate the flood wave depth are as follows:

Reach A - From dam to section #2

① Compute shape index, S_i , in hours

$$S_i = \frac{12V_b}{Q_{\max}}$$

V_b is reservoir storage

$$S_i = \frac{12(35)}{34,700} = .01210$$

$$\frac{12(1,520,000)}{34,700(3600)} = .1460$$

We know the depth at the dam (Upstream section) = 22'
 From the dam to section 2 is 300' in length

The average depth between the two sections must be used in the calculation: Where $D_{avg} = D_{Ds} + \frac{1}{3} (D_{Us} - D_{Ds})$
 DOWNSTREAM UPSTREAM

- ② In order to get D_{avg} , we must assume a downstream depth

We can try 15' as our first guess

$$D_{Ds} = 15' \quad D_{Us} = 22' \quad D_{avg} = 15 + \frac{1}{3}(22 - 15) = 20.7'$$

we now go to figure 2, Valley storage index, t_s ,
 and for a depth of 20.7' get a value of .125

- ③ We are now able to compute T_s , the index of valley storage where $T_s = L t_s$ L is in miles

$$T_s = \left(\frac{300}{5280} \right) (.125) = .0071$$

We now have the ratio $\frac{T_s}{S_i} = \frac{.0071}{.0421} = .587$
 .1460 .049

- ④ We go to Fig 2., the attenuation of discharge from a breached dam. enter the bottom with $T_s/S_i = .587$
 this yields a % of $Q_{max} = 57\% \rightarrow 93\%$

$$\text{Attenuated } Q_{max} = \frac{.57}{.93} (34,700) = \frac{19,432}{32,270}$$

- ⑤ We must check to see if the attenuated Q_{max} , 19,432
 32,270 can equal the maximum discharge at that section.

$$Q_{max} = \frac{8}{27} \sqrt{g} (W) (D_{Ds})^{1.5}$$

W = width of the water surface at depth D_{Ds}

$$Q_{max} = \frac{8}{27} (\sqrt{32.2}) (173') (15')^{1.5} = 16900 \text{ cfs} < \frac{19,432}{32,270}$$

- ⑥ Go to step ② and choose a greater depth C-5

to increase Q_{max} . If Q_{max} was greater than the attenuated Q_{max} , we must choose a lesser depth.

$$\text{Try } D_{os} = \frac{20.5}{16.3} \quad D_{ave} = \frac{20.5}{16.3} + \frac{1}{3}(22 - \frac{20.5}{16.3}) = 18.2'$$

$$w = 130 \quad 20.5$$

$$\Rightarrow t_s = .152 \quad .120$$

$$T_s = \left(\frac{300}{5280} \right) (.120) = .0075 \quad .0068$$

$$T_s/S_i = \frac{.0075}{.0131} = .57 \Rightarrow \% Q = 50\frac{1}{2}\% \quad 93\%$$

$$\text{Att. } Q_{max} = \frac{.505}{.93} (34700) = 19005$$

$$Q_{max} = 8/27 \sqrt{32.2} \left(\frac{180}{20.5} \times \frac{16.3}{20.5} \right)^{1.5} = \frac{19916}{32000} \approx \frac{19005}{32270}$$

We can say its close enough

$$\therefore D_{os} = \frac{16.3}{20.5} \quad Q = \frac{19000}{32270} \quad @ \text{ section 2}$$

We now go to the next reach

Reach B - section 2 to 4

$$D_{os} = \frac{20.5}{16.3} \quad Q = 19000 \quad L = 2500'$$

$$\text{Try } D_{os} = 12' \quad w = 126'$$

$$D_{ave} = 12 + \frac{1}{3} \left(\frac{20.5}{16.3} - 12 \right) = 13.43' \Rightarrow t_s = .14$$

$$T_s = \left(\frac{2500}{5280} \right) (.14) = .0734 \quad .0663$$

$$S_i = \frac{12(35)}{19000} = .0211 \quad 1.57 \quad T_s/S_i = 3.43 \quad \frac{.0663}{.157} = .423 \Rightarrow 64\%$$

$$\Rightarrow \text{Att } Q_{max} = \frac{24\%}{.64} (19000) = 716 \text{ cfs}$$

$$Q_{max} = 8/27 (\sqrt{32.2}) (126 \times 12)^{1.5} = 8800 \text{ cfs} \Rightarrow 4116 < 20650$$

N.G.

$$\text{Try } D_{os} = \frac{17.2}{8.5'} \quad W = 94'$$

$$D_{ave} = \frac{17.2}{8.5} + \frac{1}{3} (20.5 - 8.5) = 17.7$$

$$T_s = \frac{2500}{5280} \left(\frac{1.126}{.106} \right) = .0736 \quad .060$$

$$T_s/S_i = \frac{.0736}{.157} = 3.67 \Rightarrow 66\%$$

$$A+Q = \frac{19.7\% (19000)}{.66} = \frac{3760}{32270} \quad 21290$$

$$Q_{max} = \frac{8}{27} (5.67 \times 8.5)^{1.5} \left(\frac{94}{17.2} \right) = \frac{3913}{20870} \approx 3860 \approx 21290$$

Say O.K.

$$\therefore D_{os} = \frac{17.2}{8.5'} \quad Q = 3900 \quad @ \text{ section 4}$$

Reach C - section 4 to 5

$$D_{os} = \frac{17.2}{8.5'} \quad Q = 3900 \quad L = 750'$$

$$\text{Try } D_{os} = \frac{10}{6'} \quad W = 270 \quad D_{ave} = \frac{12.4}{6.83} \quad S_i = \frac{12(35)}{3900} = .11 \quad .23$$

$$T_s = \frac{750}{5280} \left(\frac{1.152}{.215} \right) = .022$$

$$T_s/S_i = \frac{.022}{.1236} = .22 \quad .091$$

$$A+Q = \frac{.66(3900)}{.87} = \frac{2575}{21290} \quad 18520$$

$$Q_{max} = \frac{8}{27} (5.67 \times 6)^{1.5} \left(\frac{270}{10} \right) = \frac{6067}{25570} \gg 2535 \text{ N.G.}$$

$$\text{Try } D_{os} = \frac{8.8}{4.2'} \quad W = 180 \quad D_{ave} = \frac{11.6}{5.63}$$

$$T_s = \frac{750}{5280} \left(\frac{1.157}{.236} \right) = .022 \quad \frac{T_s}{S_i} = .32 \quad .094$$

$$A+Q = \frac{.65\% (3900)}{.87} = \frac{2535}{21290} \quad 18520$$

$$Q_{max} = \frac{8}{27} (5.67 \times 4.2)^{1.5} \left(\frac{180}{8.8} \right) = \frac{2600}{18435} \approx 2535 \text{ OK}$$

$$D_{os} = \frac{8.8}{4.2'} \quad Q = 2550 \quad @ \text{ section 5}$$

C-7

Reach D - section 5 to 6

$$D_{os} = 4.1' \quad Q = 2550 \quad L = 1150$$

$$\text{Try } D_{os} = 2' \quad W = 340' \quad D_{ave} = 5.6$$

$$S_i = \frac{13(35)}{19500(3000)} = .000277 \quad T_s = \left(\frac{1150}{5280}\right)(.34) = .07 \quad .05$$

$$T_s/S_i = .75 \quad .18$$

$$\text{Att } Q = .62(2550) = 1580 \text{ cfs}$$

$$Q_{max} = \frac{8}{27} (5.67)(2)^{1.5} (340) = 1010 \text{ cfs} \approx 1580 \text{ OK}$$

$$\text{Try } 4.7' \quad D_{ave} = 6.06 \quad T_s = \frac{1150}{5280} (.216) = .047 \quad T_s/S_i = .173 \Rightarrow 78\% \quad Q = 14430$$

$$Q_{max} = \frac{8}{27} (5.67)(4.7)^{1.5} (825) = 14130 \approx 14430$$

Reach E section 6 to 7 $\therefore D = 4.7' \quad Q = 14430$

$$D_{os} = 4.7' \quad Q = 1580 \quad L = 1300$$

$$\text{Try } D_{os} = 2' \quad W = 210' \quad D_{ave} = 4.23$$

$$S_i = \frac{35(175)}{14430(3000)} = .000277$$

$$T_s = \left(\frac{1300}{5280}\right)(.25) = .106 \quad \frac{T_s}{S_i} = \frac{.106}{.000277} = 382.31$$

$$\text{Att } Q_{max} = .63(1580) = 1000$$

$$Q_{max} = \frac{8}{27} (5.67)(2)^{1.5} (210) = 998 \quad 5380 < 11250$$

~~$D_{os} = 2' \quad Q = 1000$ @ section 7~~

$$\text{Try } 5.5' \quad Q = 14430 \quad W = 520 \quad D_{ave} = 5.23$$

$$T_s = \left(\frac{1300}{5280}\right)(.222) = .06 \quad \frac{T_s}{S_i} = .163 \Rightarrow 77\%$$

$$Q = .79(14430) = 11400$$

$$Q_{max} = \frac{8}{27} (5.67)(5.5)^{1.5} (520) = 11280 \approx 11400$$

$$D = 5.5' \quad Q = 11400$$

Reach (F) sections 7 to 8

$$D_{us} = 2.5' \quad Q = \frac{1000}{11400} \quad L = 2000'$$

Try $D_{os} = 2.1' \quad w = \frac{860}{620} \quad D_{ave} = \frac{3.17}{1.33}$

$$T_s = \frac{2000}{5280} (.49) = .19$$

$$S_i = \frac{12(35)}{1000} = .420 \quad \frac{T_s}{S_i} = .45 \quad \frac{.11}{.44} = .26$$

$$Att \quad Q_{max} = .63(1000) = 630 \text{ cfs}$$

$$73\% (11400) = 8320$$

$$Q_{max} = 8/27 (5.67)(1)^{1.5} (620) = 1080 \quad 2430$$

Try $D_{os} = 2.8' \quad w = 1070 \quad D_{ave} = \frac{3.70}{1.17}$

$$T_s = \frac{2000}{5280} (.52) = .19 \quad \frac{T_s}{S_i} = .46 \Rightarrow 630\%$$

$$Q = 630 \text{ cfs} \quad 8440$$

$$q = 8/27 (5.67)(.75)^{1.5} (550) = 600$$

$$D = 2.8' \quad Q = 600 \text{ cfs}$$

$$2.8' \quad 8440$$

40 SHEETS 3 SQUARE
40 SHEETS 3 SQUARE
NATIONAL

APPENDIX D
HYDROLOGY COMPUTATIONS



WARWICK RESERVOIR - PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

DRAINAGE AREA = 1.3 SQ. MI.

PROBABLE MAXIMUM PRECIPITATION

INDEX RAINFALL = 22 IN. - 200 SQ. MI. - 24 HOURS (PLATE 1)
HYDROMET NO 33

FOR 10 SQ. MI (CONSIDERED AS POINT RAINFALL)

6 HR % = 111 (PLATE 2)
12 HR % = 123
24 HR % = 133
48 HR % = 142

TRANSPOSITION FACTOR: TO OBTAIN BASIN PRECIPITATION FROM STORM PRECIP

$$1 - \frac{.3008}{(TRSDA)} \cdot .17718$$

$$1 - \frac{.3008}{(1.3)} \cdot .17718 = 1 - \frac{.3008}{1.05} = 1 - .286 = .714$$

UNIT HYDROGRAPH DETERMINATION

L = LONGEST LENGTH OF TRAVEL = 2.3 MI.

LCA = LENGTH TO CENTROID OF BASIN = 1.17 MI.

$$\text{SLOPE} = \frac{1480 \text{ FT} - 680 \text{ FT}}{2.3 \text{ MI.}} = \frac{800 \text{ FT}}{2.3} \approx 350 \frac{\text{FT}}{\text{MI.}}$$

STEEP MOUNTAINOUS STREAM

USE C_t = 2 (AVG. APPALACHIAN STREAM) 640 CP = 400

$$\begin{aligned} t_p &= C_t (L LCA)^{0.3} \\ &= 2 (2.3 \times 1.17)^{0.3} \\ &= 2 (1.35) = 2.7 \text{ HRS} \end{aligned}$$

$$t_n = t_p / 5.5 = 2.7 / 5.5 = .49 \quad \text{USE } t_R = \text{UNIT DURATION} = 0.5$$

$$\text{LAG} = t_{PR} = t_p + 0.25(t_R - t_n) = 2.7 \text{ HRS}$$

INCREASE LAG TIME BY 1 HOUR TO ACCOUNT FOR TRAVEL THROUGH RESERVOIRS.

$$\text{LAG} = t_{PR} + 1 = 2.7 + 1 = \underline{3.7 \text{ HOURS}}$$

PMF PEAK = 1979 CFS SEE HEC 1 OUTPUT

PHYSICALLY SIMILAR
RECENT HYDROLOGIC WORK ON E. BRANCH SHELDRAKE R - D.P. = 1.87 PMF = 2730
 $(\frac{1.87}{1.3})^{0.75} = (1.438)^{0.75} = 1.313$ $\frac{2730}{1.313} = 2080 \text{ C.F.S.}$ 6000 CHECK
D-2 T.S 8178

SPILLWAY RATING RELATION

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

BROAD CRESTED WEIR $C=2.65$

L = LENGTH OF SPILLWAY

SEE TABLE 5.3 KING'S HANDBOOK OF HYDRAULICS H = HEAD OVER SPILLWAY

$$CL = 63.6$$

EL. FT. M.S.L.	HEAD	$H^{3/2}$	$CLH^{3/2}$ Q [C.F.S.]	Δ STOR	TOTAL STORAGE ACRE FT
SPILLWAY CREST 679.8	0	0		-	36.8
680	.2	.09	5.7	.68	37.48
681	1.2	1.315	83.6	3.4	40.88
682	2.2	3.263	208	3.4	44.28
683	3.2	5.724	364	3.4	47.68
684	4.2	8.607	547	3.4	51.08

NOTE: SPILLWAY RATING ONLY APPLICABLE TO TOP OF DAM.

* STORAGE CAPACITY = 12,000,000 GAL = 1,604,278 FT³
= 36.8 ACRE-FT.

$$7.48 \text{ GAL/FT}^3$$

$$43,560 \frac{\text{SQ. FT}}{\text{ACRE}}$$

APPROX. SURFACE AREA = 3.4 ACRES - "CALDWELL SURVEY"
NEWBURN, N.Y. NOV 1870.

Q AT MAXIMUM HEAD OF 3.33 FT

$$Q = 2.65 \times 24 \times \frac{(3.33)^{3/2}}{6.077} = \underline{386 \text{ C.F.S.}}$$

* - PROVIDED BY MR. CARL QUACKENBUSH, WARWICK SUPT. OF PUBLIC WORKS

 MEC-1 VERSION DATED JAN 1973

 WATERS RESERVOIR
 RESERVOIR ROUTING OF PMF
 24 FOOT SPILLWAY

JOB SPECIFICATION
 NO NHD NWIN IDAY IWR IWIN METPC IPLT IPRT NSTAN
 150 0 0 0 30 0 0 0 0 0 0 0 0
 JOBER NWT
 5 0

MULTI-PLAN ANALYSES TO BE PERFORMED
 NPLANS 1 NSTIME 9 LRTIME 1
 RTIME .10 .20 .30 .40 .50 .60 .70 .80 1.00

 SUB-AREA RUNOFF COMPUTATION

COMPUTE PMF
 ISTAR ICONR IECOR ITAPE JPLT JPRT INAME
 1 0 0 0 0 0 1

HYDROGRAPH DATA
 IWRG IWRG TAREA SNAP TRSPA TRSFC RATIO ISNOW ISAME LOCAL
 1 1 1.50 0.00 1.50 0.00 0.00 0.00 0 1 0

PRECIP DATA
 SPCF PVS R4 P12 P24 R68 R72 R96
 0.00 22.00 111.00 123.00 133.00 142.00 0.00 0.00
 TRSFC COMPUTED BY THE PROGRAM IS .713

UNIT HYDROGRAPH DATA
 TPE 3.70 CPE .63 NTAKE 0

 RECESSION DATA
 STEPS 1.00
 APPROXIMATE FLASK COEFFICIENTS FROM GIVEN SNOWDR CP AND TP ARE TCE 6.53 AND RE 6.74 INTERVALS

UNIT HYDROGRAPH DATA
 FUND-OF-DEPTON OBSERVATIONS, LACS 3.70 HOURS, CPE .63 VOLE 1.00
 6.57 24.24 49.45 75.72 103.28 125.76 139.55 148.22 156.79 120.46
 103.83 89.69 77.14 66.49 57.31 48.39 42.57 34.69 27.26
 23.50 20.25 17.46 15.05 12.97 11.18 9.63 8.30 7.16 6.17
 5.32 4.54 3.95 3.40 2.93 2.53 2.18 1.88 1.62 1.40
 1.20

END-OF-PERIOD FLOW
 TIME GAIN EXCS COMP 2
 1 .00 0.00 3.00

2	.00	0.00	3.00
3	.00	0.00	3.00
4	.00	0.00	3.00
5	.00	0.00	3.00
6	.00	0.00	3.00
7	.00	0.00	3.00
8	.00	0.00	3.00
9	.00	0.00	3.00
10	.00	0.00	3.00
11	.00	0.00	3.00
12	.00	0.00	3.00
13	.01	0.00	3.00
14	.01	0.00	3.00
15	.01	0.00	3.00
16	.01	0.00	3.00
17	.01	0.00	3.00
18	.01	0.00	3.00
19	.01	0.00	3.00
20	.01	0.00	3.00
21	.01	0.00	3.00
22	.01	0.00	3.00
23	.01	0.00	3.00
24	.01	0.00	3.00
25	.06	.01	3.06
26	.07	.02	3.78
27	.07	.02	4.74
28	.09	.04	6.35
29	.09	.04	6.79
30	.12	.17	12.99
31	.22	.17	20.36
32	.22	.17	30.70
33	.08	.03	40.52
34	.08	.03	54.55
35	.06	.01	65.22
36	.06	.01	72.90
37	.01	0.00	76.74
38	.01	0.00	78.25
39	.01	0.00	78.25
40	.01	0.00	71.65
41	.01	0.00	60.60
42	.01	0.00	57.57
43	.01	0.00	50.44
44	.01	0.00	40.30
45	.01	0.00	38.63
46	.01	0.00	35.71
47	.01	0.00	29.47
48	.01	0.00	25.82
49	.05	.00	22.48
50	.05	.00	20.02
51	.05	.00	17.79
52	.05	.00	15.95
53	.05	.00	14.64
54	.05	.00	13.23
55	.05	.00	12.26
56	.05	.00	11.47
57	.05	.00	10.82
58	.05	.00	10.27
59	.05	.00	9.79
60	.05	.00	9.34
61	.16	.11	9.71

62	.16	.11	11.94
63	.16	.11	16.75
64	.16	.11	24.44
65	.16	.11	35.04
66	.16	.11	48.01
67	.16	.11	62.45
68	.16	.11	77.36
69	.16	.11	91.56
70	.16	.11	104.03
71	.16	.11	114.78
72	.16	.11	123.90
73	.16	.11	136.45
74	.16	.11	150.67
75	.16	.11	165.74
76	.16	.11	181.06
77	.16	.11	197.16
78	.16	.11	213.64
79	.16	.11	231.09
80	.16	.11	249.79
81	.16	.11	269.39
82	.16	.11	291.38
83	.16	.11	314.00
84	.16	.11	337.74
85	.16	.11	362.10
86	.16	.11	387.70
87	.16	.11	414.90
88	.16	.11	443.46
89	.16	.11	473.60
90	.16	.11	504.69
91	.16	.11	536.33
92	.16	.11	569.47
93	.16	.11	604.50
94	.16	.11	641.37
95	.16	.11	680.59
96	.16	.11	721.44
97	.16	.11	764.57
98	.16	.11	810.54
99	.16	.11	859.50
100	.16	.11	911.49
101	.16	.11	966.43
102	.16	.11	1024.37
103	.16	.11	1085.22
104	.16	.11	1149.33
105	.16	.11	1217.04
106	.16	.11	1288.94
107	.16	.11	1364.59
108	.16	.11	1444.59
109	.16	.11	1528.54
110	.16	.11	1617.04
111	.16	.11	1710.59
112	.16	.11	1809.59
113	.16	.11	1914.54
114	.16	.11	2026.04
115	.16	.11	2143.59
116	.16	.11	2267.59
117	.16	.11	2398.54
118	.16	.11	2536.04
119	.16	.11	2680.59
120	.16	.11	2832.59
121	.16	.11	2992.54

STATION	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
122	0.00	0.00	0.00	0.79	
123	0.00	0.00	0.00	6.78	
124	0.00	0.00	0.00	5.32	
125	0.00	0.00	0.00	4.06	
126	0.00	0.00	0.00	3.88	
127	0.00	0.00	0.00	3.73	
128	0.00	0.00	0.00	3.68	
129	0.00	0.00	0.00	3.49	
130	0.00	0.00	0.00	3.30	
131	0.00	0.00	0.00	3.31	
132	0.00	0.00	0.00	3.24	
133	0.00	0.00	0.00	3.17	
134	0.00	0.00	0.00	3.12	
135	0.00	0.00	0.00	3.07	
136	0.00	0.00	0.00	3.03	
137	0.00	0.00	0.00	3.00	
138	0.00	0.00	0.00	3.00	
139	0.00	0.00	0.00	3.00	
140	0.00	0.00	0.00	3.00	
141	0.00	0.00	0.00	3.00	
142	0.00	0.00	0.00	3.00	
143	0.00	0.00	0.00	3.00	
144	0.00	0.00	0.00	3.00	
145	0.00	0.00	0.00	3.00	
146	0.00	0.00	0.00	3.00	
147	0.00	0.00	0.00	3.00	
148	0.00	0.00	0.00	3.00	
149	0.00	0.00	0.00	3.00	
150	0.00	0.00	0.00	3.00	
151	0.00	0.00	0.00	3.00	
152	0.00	0.00	0.00	3.00	
153	0.00	0.00	0.00	3.00	
154	0.00	0.00	0.00	3.00	
155	0.00	0.00	0.00	3.00	
156	0.00	0.00	0.00	3.00	
157	0.00	0.00	0.00	3.00	
158	0.00	0.00	0.00	3.00	
159	0.00	0.00	0.00	3.00	
160	0.00	0.00	0.00	3.00	
161	0.00	0.00	0.00	3.00	
162	0.00	0.00	0.00	3.00	
163	0.00	0.00	0.00	3.00	
164	0.00	0.00	0.00	3.00	
165	0.00	0.00	0.00	3.00	
166	0.00	0.00	0.00	3.00	
167	0.00	0.00	0.00	3.00	
168	0.00	0.00	0.00	3.00	
169	0.00	0.00	0.00	3.00	
170	0.00	0.00	0.00	3.00	
171	0.00	0.00	0.00	3.00	
172	0.00	0.00	0.00	3.00	
173	0.00	0.00	0.00	3.00	
174	0.00	0.00	0.00	3.00	
175	0.00	0.00	0.00	3.00	
176	0.00	0.00	0.00	3.00	
177	0.00	0.00	0.00	3.00	
178	0.00	0.00	0.00	3.00	
179	0.00	0.00	0.00	3.00	
180	0.00	0.00	0.00	3.00	
181	0.00	0.00	0.00	3.00	
182	0.00	0.00	0.00	3.00	
183	0.00	0.00	0.00	3.00	
184	0.00	0.00	0.00	3.00	
185	0.00	0.00	0.00	3.00	
186	0.00	0.00	0.00	3.00	
187	0.00	0.00	0.00	3.00	</

[illegible]

D-15

D-16

CFS	1978.01	1908.82	638.29	223.70	32224.26
INCHES		11.51	18.27	19.21	19.22
AC-FT		796.	1267.	1332.	1332.

PEAK FLOW SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS

OPERATION	STATION	PLAN	.10	.20	.30	RATIOS APPLIED TO PLANS				.60	.70	.80	1.00
HYDROGRAPH AT	1	1	198.	396.	594.	791.	989.	1187.	1385.	1583.	1779.	1978.	2176.
		2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MOVED TO	1	1	197.	396.	593.	791.	989.	1187.	1385.	1582.	1778.	1976.	2174.
		2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

S.P.F.

P.M.F.

APPENDIX E
CHECKLISTS

NAME OF DAM Lower Warwick Res. Dam
ID # 59

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

REMARKS

ITEM

AS-BUILT DRAWINGS

N/A

REGIONAL VICINITY MAP

USGS

CONSTRUCTION HISTORY

Built Approx. 1887

TYPICAL SECTIONS OF DAM

yes - No Zoning or Embankment Materials

OUTLETS - PLAN

20" C.I. Pipe -

- DETAILS

- CONSTRAINTS
- DISCHARGE RATINGS

gate valve v/s if dam

RAINFALL/RESERVOIR RECORDS

ITEM REMARKS

DESIGN REPORTS

None

GEOLOGY REPORTS

None

DESIGN COMPUTATIONS
HYDROLOGY & HYDRAULICS
DAM STABILITY
SEEPAGE STUDIES

N/A

MATERIALS INVESTIGATIONS
BORING RECORDS
LABORATORY
FIELD

N/A

POST-CONSTRUCTION SURVEYS OF DAM

1978 WEHMAN CNG

BORROW SOURCES

N/A - 1978 REMAINS - Bank Run from Village Run

ITEM

REMARKS

MONITORING SYSTEMS

MODIFICATIONS

1978 WEIRAN ENG'G

HIGH POOL RECORDS

POST CONSTRUCTION ENGINEERING
STUDIES AND REPORTS

1978 WEIRAN ENG'G

PRIOR ACCIDENTS OR FAILURE OF DAM
DESCRIPTION
REPORTS

None

MAINTENANCE
OPERATION
RECORDS

N/A

ITEM

REMARKS

SPILLWAY PLAN

SECTIONS

DETAILS

OPERATING EQUIPMENT
PLANS & DETAILS

N/A OTHER THAN ELEV.

N/A

CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: AVERAGE MODERATELY STEEP
ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 679.8 FT. A.S.L.
ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): N/A
ELEVATION MAXIMUM DESIGN POOL: N/A
ELEVATION TOP DAM: 683.1

CREST:

a. Elevation 679.8 FT. A.S.L.
b. Type BROAD CRESTED
c. Width 3
d. Length 24 FT.
e. Location Spillover WEST ABOUT
f. Number and Type of Gates NONE

OUTLET WORKS:

a. Type 20" C.I.
b. Location WEST OF CENTER LINE
c. Entrance inverts 659.6 FT. A.S.L.
d. Exit inverts 651.12
e. Emergency draindown facilities 20" PIPE

HYDROMETEOROLOGICAL GAGES:

a. Type NONE
b. Location _____
c. Records _____

MAXIMUM NON-DAMAGING DISCHARGE: (SPILLWAY CAP) 386 CFS.

Check List
Visual Inspection
Phase 1

Name Dam Wainwicks County Orange State NY ID # S9
Type of Dam Earth Hazard Category 2 on inventory should be 1
Date(s) Inspection 9 Aug 1977 Weather Fair Temperature 85°F

Pool Elevation at Time of Inspection 680.05 M.S.L. Tailwater at Time of Inspection _____ M.S.L.

Inspection Personnel:

J. CASPE _____
T. SMYTHE _____

CASPE Recorder

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
-----------------------	--------------	----------------------------

ANY NOTICEABLE SEEPAGE

STRUCTURE TO
RETAINMENT/EMBANKMENT,
FUNCTIONS

RAINS

WATER PASSAGES

FOUNDATION

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
-----------------------	--------------	----------------------------

SURFACE CRACKS CONCRETE SURFACES		
-------------------------------------	--	--

STRUCTURAL CRACKING		
---------------------	--	--

VERTICAL AND HORIZONTAL ALIGNMENT		
--------------------------------------	--	--

MONOLITH JOINTS		
-----------------	--	--

CONSTRUCTION JOINTS		
---------------------	--	--

STAFF GAGE OF RECORDER:

EMBANKMENT

REMARKS OR RECOMMENDATION

OBSERVATIONS

VISUAL EXAMINATION OF

SURFACE CRACKS

None

UNUSUAL MOVEMENT OR
CRACKING AT OR BEYOND
THE TOE

None

SLOUGHING OR EROSION OF
EMBANKMENT AND ADJUTMENT
SLOPES

No EVIDENCE OF THRU SEEPAGE
D/C
Some Minor Surface Erosion on New Embankment Slopes

VERTICAL AND HORIZONTAL
ALIGNMENT OF THE CREST

Good

RIPRAP FAILURES

No RIP RAP

EMBANKMENT

REMARKS OR RECOMMENDATIONS

OBSERVATIONS

USUAL EXAMINATION OF

UNCTION OF EMBANKMENT
ND ABUTMENT, SPILLWAY
ND DAM

No Evidence of Disress

NY NOTICEABLE SEEPAGE

None

TAFF GAGE AND RECORDER

None

DRAINS

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATION
CONCRETE WEIR	Minor Surface Scaling No Structural Cracking	
APPROACH CHANNEL	Concrete Sill Under Water	
DISCHARGE CHANNEL	Rock Cut	
BRIDGE AND PIERS	Wood Bridge Missing Runners -	Does Not Affect Safety of Dam

GATED SPILLWAY

REMARKS OR RECOMMENDATIONS

USUAL EXAMINATION OF

OBSERVATIONS

CONCRETE SILL

APPROACH CHANNEL

DISCHARGE CHANNEL

BRIDGE AND PIERS

GATES AND OPERATION
EQUIPMENT

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	N/A	
INTAKE STRUCTURE	Not in Use Any More 24" CL Pipe THRU EMBANKMENT	MANUAL VALVE P.T. OPERATIONAL
OUTLET STRUCTURE	N/A	
OUTLET CHANNEL	Bed Rock	
EMERGENCY GATE	N/A	

REMARKS OR RECOMMENDATIONS

VISUAL EXAMINATION OF

OBSERVATIONS

CONDITION
(OBSTRUCTIONS,
DEBRIS, ETC.)

Tree Limbs

SECTS

STABLE - ROCK

APPROXIMATE NO.
OF HOMES AND
POPULATION

Approx 3000' D/s Housing Developments
8000' D/s Group of Villages of Warrick

AD-A063 862

ARMY ENGINEER DISTRICT NEW YORK

F/G 13/2

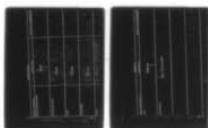
NATIONAL DAM SAFETY PROGRAM. LOWER WARWICK RESERVOIR DAM (INVEN--ETC(U)

SEP 78 C H BENN

UNCLASSIFIED

NL

2 OF 2
AD
A063 862

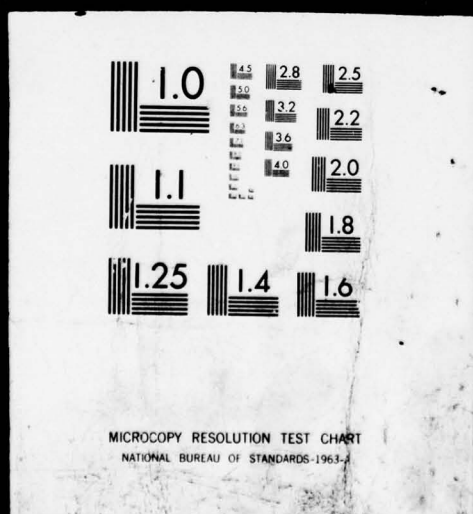


END
DATE
FILMED

3--79
DDC

2 OF 2

AD
4063 862



INSTRUMENTATION		REMARKS OR RECOMMENDATION
VISUAL EXAMINATION	OBSERVATIONS	
MONUMENTATION/SURVEYS	None	
OBSERVATION WELLS	None	
WEIRS	None	
PIEZOMETERS	None	
OTHER		

RESERVOIR

REMARKS OR RECOMMENDATIONS

OBSERVATIONS

USUAL EXAMINATION OF

LOPES

STABLE

REPRESENTATION

Not Investigated