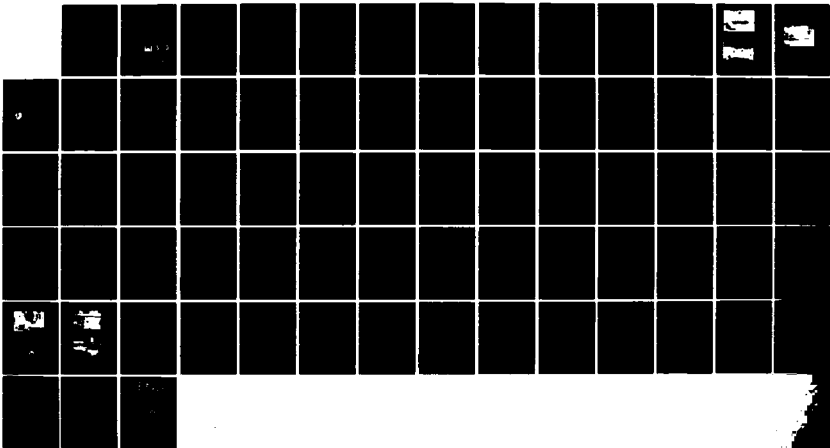
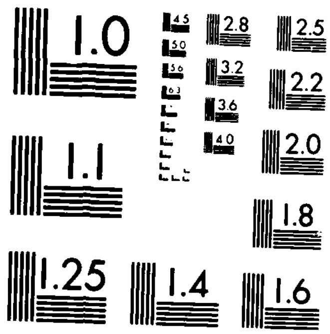
AD-A156 472 NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS AVERY DAM (NH 00465)..(U) CORPS OF ENGINEERS WALTHAM MA NEW ENGLAND DIV NOV 78 1/1

UNCLASSIFIED F/G 13/13 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

MERRIMACK RIVER BASIN
LACONIA, NEW HAMPSHIRE

AVERY DAM

NH 00465

NHWRB 130.02

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

NOVEMBER 1978

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NH 00465	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Avery Dam NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS		5. TYPE OF REPORT & PERIOD COVERED INSPECTION REPORT 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) U.S. ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS DEPT. OF THE ARMY, CORPS OF ENGINEERS NEW ENGLAND DIVISION, NEDED 424 TRAPELO ROAD, WALTHAM, MA. 02254		12. REPORT DATE November 1978 13. NUMBER OF PAGES 53
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVAL FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

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

18. SUPPLEMENTARY NOTES

Cover program reads: Phase I Inspection Report, National Dam Inspection Program; however, the official title of the program is: National Program for Inspection of Non-Federal Dams; use cover date for date of report.

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

DAMS, INSPECTION, DAM SAFETY,

Merrimack River Basin
Laconia, New Hampshire
Winnipesaukee River

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

The dam is a 114 hybid concrete gravity structure with a maximum height of about 20.5 ft. It is intermediate in size with a high hazard potential. The test flood is the PMF. The dam is in good condition at the present time. With the exception of the channel improvements and the repair of one of the sluice gates, only few relatively minor operating and maintentance improvements are necessary. In light of the dam's good condition, periodic technical inspections should be scheduled every two years.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

REPLY TO
ATTENTION OF:

NEDED

JAN 2 6 1979

Honorable Hugh J. Gallen
Governor of the State of New Hampshire
State House
Concord, New Hampshire 03301

Dear Governor Gallen:

I am forwarding to you a copy of the Avery Dam Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Water Resources Board, the cooperating agency for the State of New Hampshire. In addition, a copy of the report has also been furnished the owner, New Hampshire Water Resources Board, Pleasant Street, Concord, New Hampshire 03301.

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Water Resources Board for your cooperation in carrying out this program.

Sincerely yours,

JOHN P. CHANDLER
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

AVERY DAM
NH 00465

MERRIMACK RIVER BASIN
LACONIA, NEW HAMPSHIRE

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

NATIONAL DAM INSPECTION PROGRAM

PHASE I INSPECTION REPORT

Identification No.:	NH 00465
NHWRB No.:	130.02
Name of Dam:	AVERY DAM
Town:	Laconia
County and State:	Belknap, New Hampshire
Stream:	Winnipesaukee River
Date of Inspection	May 31, 1978

BRIEF ASSESSMENT

Avery Dam is a 114 foot long, hybrid concrete gravity structure with a maximum height of approximately 20.5 feet. The dam's primary control features are two 20-foot long ogee spillways with electrically operated, hinged leaf gates, two 25-foot long ogee spillways with flashboards, two 5 foot, 9 inch wide sluiceways with stoplogs and six 5 foot, 9 inch wide openings with timber sluice gates electrically operated in pairs. The dam, which is owned by the New Hampshire Water Resources Board (NHWRB), is founded on bedrock. While a dam of some type has existed at the site since Colonial times, the present concrete structure was built in 1949. Original construction plans are available.

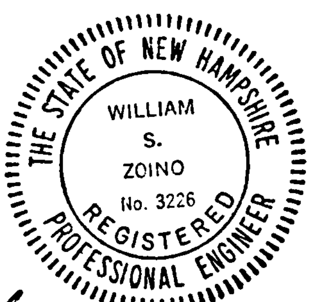
The dam, which lies on the Winnipesaukee River, is used to control the level of Opechee Bay as the discharge from Lake Winnipesaukee through the upstream Lakeport Dam varies. The 374 square mile drainage area of gently to steeply sloping forest includes the 363 square mile Lake Winnipesaukee drainage area. The dam's maximum impoundment of 3700 acre-feet places it in the INTERMEDIATE size category, while its location in heavily populated, downtown Laconia results in a HIGH hazard potential classification.

Based on the size and hazard potential ratings and in accordance with the Corp's guidelines, the Test Flood (TF) is the Probable Maximum Flood (PMF). Because this dam is part of a complex system of dams, lakes and channels which comprise the Winnipesaukee River drainage basin, the PMF cannot be readily determined; two alternatives were therefore considered. For the larger TF, an inflow of 14,000 cfs yields a maximum outflow at the dam of 8000 cfs.

Avery Dam can handle this flow without overtopping; thus, the spillway is considered adequate. Of greater concern, however, is the channel through Laconia, which, due to several obstructions including a road bridge 600 feet downstream of the dam, can pass only 2600 cfs. Therefore, considerable improvement in the capacity of the channel is recommended.

The dam is in GOOD condition at the present time. With the exception of the channel improvements and the repair of one of the sluice gates, only a few relatively minor operating and maintenance improvements are necessary. These improvements include removal or trimming of trees overhanging the channel, repair of eroded slope revetment and any associated undermining of the right training wall's foundation, repair of deteriorated concrete, institution of a formalized maintenance program on the electrical and mechanical gate operating system, provision of a handwheel for manual operation of the hinged leaf gates and training of local officials in dam operation in the event of emergencies. Additionally, the owner should establish a formal written flood and emergency warning system.

The majority of the above recommendations and remedial measures should be implemented within 2 years of receipt of the Phase I inspection Report by the owner. The repair of the inoperative sluice gates and provision of a handwheel for the hinged leaf gates, however, should be accomplished within 6 months. In light of the dam's GOOD condition, periodic technical inspections should be scheduled every two years.



William S Zoino

William S. Zoino
New Hampshire Registration 3226

Nicholas A. Campagna, Jr

Nicholas A. Campagna
California Registration 21006

This Phase I Inspection Report on Avery Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

Richard F. Doherty

RICHARD F. DOHERTY, MEMBER
Water Control Branch
Engineering Division

Carney M. Terzian

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

Joseph A. McElroy

JOSEPH A. MCELROY, CHAIRMAN
Chief, NED Materials Testing Lab.
Foundations & Materials Branch
Engineering Division

APPROVAL RECOMMENDED:

Joe B. Fryar

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

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

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the Test Flood should not be interpreted as necessarily posing a highly inadequate condition. The Test Flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

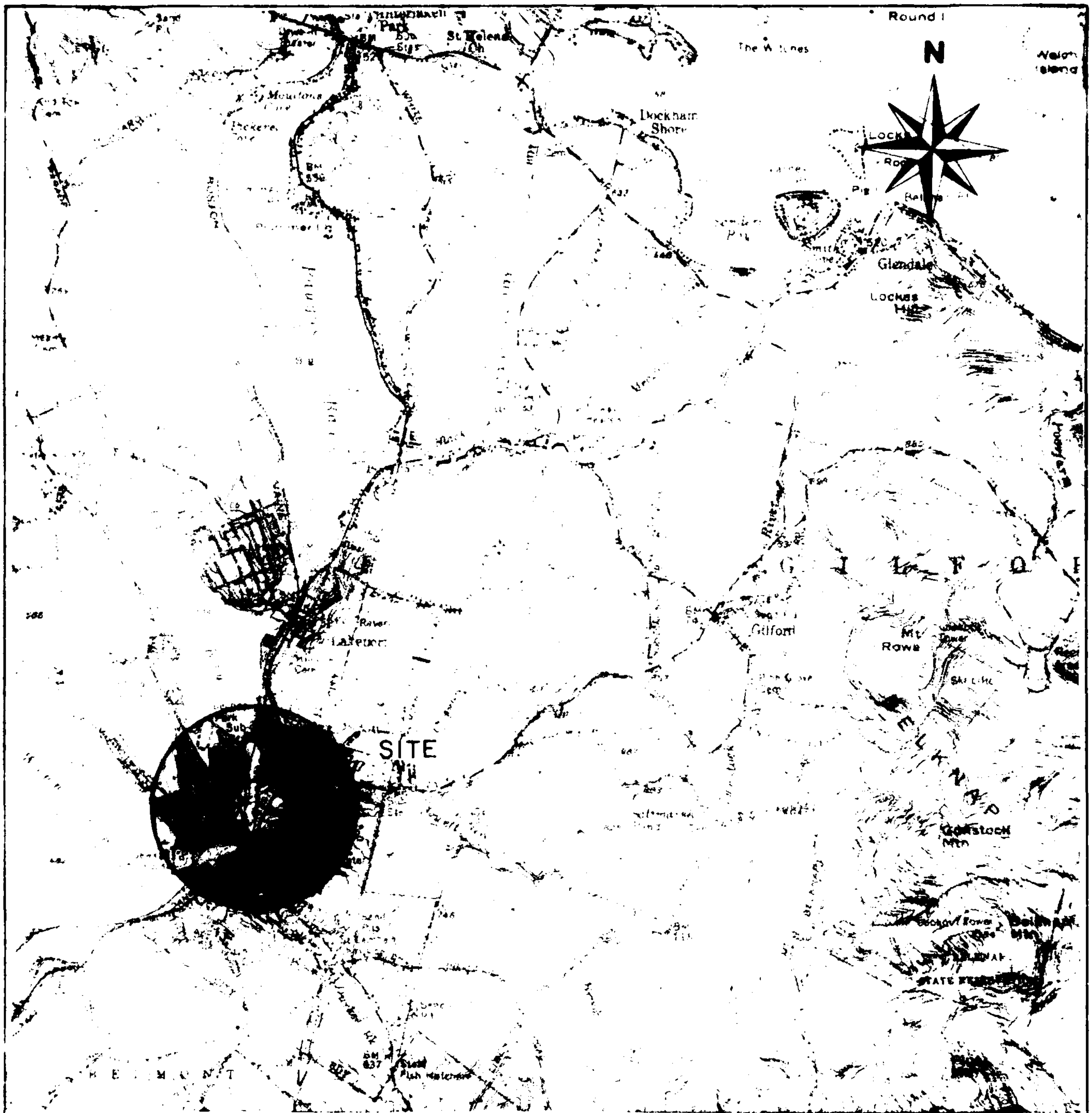
TABLE OF CONTENTS

Table of Contents - cont.

Overview from right side of
downstream foot bridge

Overview from left side of
downs.ream foot bridge

Overview of left side gate structure from right side of downstream channel



- SCALE -

0 1/2 1 2 miles

FROM: USGS WINNIPESAUKEE, N.H. QUADRANGLE MAP

GOLDBERG, ZOINO, DUNNICLIFF & ASSOC, INC.
GEOTECHNICAL CONSULTANTS
NEWTON UPPER FALLS, MASS.

U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS

LOCUS PLAN

AVERY DAM — NEW HAMPSHIRE

FILE No. 2067

SCALE AS NOTED

DATE SEPT 1978

PHASE I INSPECTION REPORT

AVERY DAM

SECTION 1

PROJECT INFORMATION

1.1 General

(a) Authority

Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Goldberg, Zoino, Dunnicliff & Associates, Inc. (GZD) has been retained by the New England Division to inspect and report on selected dams in the State of New Hampshire. Authorization and notice to proceed was issued to GZD under a letter of August 22, 1978 from Colonel Ralph T. Garver, Corps of Engineers. Contract No. DACW 33-78-C-0303 has been assigned by the Corps of Engineers for this work.

(b) Purpose

(1) Perform technical inspection and evaluation of non-federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-federal interests.

(2) Encourage and prepare the states to initiate quickly effective dam safety programs for non-federal dams.

(3) Update, verify and complete the National Inventory of Dams.

(c) Scope

The program provides for the inspection of non-federal dams in the high hazard potential category based upon location of the dams and those dams in the significant hazard potential category believed to represent an immediate danger based on condition of the dams.

1.2 Description of Project

(a) Location

The Avery Dam lies on the Winnipesaukee River at the outlet of Opechee Bay in downtown Laconia. The site is readily accessible via Routes 11, 106 or 107. The portion of the USGS Winnipesaukee, N.H. quadrangle presented on page viii shows this locus. Figure 1 of Appendix B shows a detail of the site found in the records of the New Hampshire Water Resources Board (NHWRB).

(b) Description of Dam and Appurtenances

The dam is a 114 foot long, hybrid concrete gravity structure consisting of a "U" shaped core configuration with extended wings (Page B-3). Provisions for flow are incorporated in all components of the structure. The main spillway of the structure, located within the "U" section, consists of two 20-foot long ogee sections with electrically operated, hinged leaf gates separated by a buttress pier and two side ogee spillways, both 25 feet in length, equipped with flashboards (Page B-4). The electrically operated hinged leaf gates have a range of 3.25 feet in elevation and have provisions for manual operation. The side sections of the spillway are equipped with flashboards 3.25 feet high. The wing extension to the left abutment, which is approximately 42 feet long, contains six electrically operated (two in tandem) sluice gates. The wing extension to the right abutment, which is approximately 13 feet long, contains a dual sluiceway equipped with stoplogs. The structure has a maximum height above the streambed of approximately 20.5 feet and is founded on bedrock.

Operation of the two hinged leaf gates is through individual Type SMB-O "Limitorque" electrical operators which may also be manually controlled by use of a handwheel. The operator provides power through a shaft to each end of the gate, from which point cables fastened to the gate permit the gate to be raised or lowered as desired. The operator has a gear-head type drive motor, torque limit and gate travel limit switches, reversing starter with over-load relays, open-close-stop position push buttons and indicating lights (red-gate closed, green-gate open). Conversion from electrical to manual operation is accomplished through a lever which mechanically disconnects the motor from the gear train.

The wing extension to the left abutment contains six 5 foot, 9 inch wide openings equipped with timber sluice gates approximately 6 foot, 3 inches wide and 9 feet high. The gates have a 5 foot operational range and are operated in pairs by electrical or manual means.

The wing extension to the right abutment incorporates dual sluiceway openings 5 feet, 9 inches in width with inverts 3.75 feet below the permanent spillway crest. At the time of the visual inspection, stoplogs were set 3.25 feet above the permanent spillway crest.

The right abutment, which is approximately 4 feet thick, is cast in front of and forms an integral part of the foundation for a renovated mill building which is constructed immediately adjacent to the dam. This building has been designated as a National Historic Landmark. The downstream extension of this abutment consists of a double wingwall approximately 100 feet long. The face of the exterior wall is in line with the abutment and the top of the wall was constructed to approximately the permanent spillway crest elevation. The rear wall is set approximately 3.5 feet back from the face of the exterior wall and is approximately 3 feet higher in elevation. Reinforcing rods, acting as tiebacks and spaced at approximately 3 feet O.C., extend from the top of the exterior wall and are embedded in the back wall. Weep holes are located approximately 12 inches below the top of the exterior wall and are spaced 3 to 4 feet apart. Slope revetment consisting of mortar bound rubble stone has been placed in front of the abutment and wingwall.

A reinforced concrete walkway spans over all components of the water control structure. Removable galvanized steel gratings permit access over the dam's various control features.

Approximately 0.25 miles upstream of the dam, an underground concrete conduit known as the Perly Canal carries water from Opechee Bay to a water wheel at the Allen Rogers Corporation some distance west of the dam. The water wheel discharges into a channel which rejoins the river downstream of the dam.

(c) Size Classification

The dam's maximum impoundment of 3700 acre-feet falls within the 1000 acre-feet to 50,000 acre-feet range which defines the INTERMEDIATE size category as outlined in the "Recommended Guidelines."

(d) Hazard Potential Classification

The location of the dam in a heavily populated, urban location with a large number of low-lying buildings immediately downstream warrants a HIGH hazard potential classification.

(e) Ownership

The NHWRB owns this dam. Key officials are: Chairman George McGee, Chief Engineer Vernon Knowlton, Assistant Chief Engineer Donald Rapoza and Staff Engineer Gary Kerr. The Board's telephone number is (603) 271-3406 and it can also be reached through the State Capitol operator at (603) 271-1110.

The Board purchased the dam in 1973 from the Avery Dam Corporation, an association of local residents and businesses having part ownership in the dam and water rights.

(f) Operator

The NHWRB has a permanent dam tender who operates the Lakeport, Avery and Lochmere dams and several smaller structures. All dam operations are directed by the Board and the operator can be contacted through the individuals listed in subparagraph (e) above. The plant engineer for the Allan Rogers Corporation of Laconia, Mr. Adrian Lei, can also operate the dam in the event of an emergency.

(g) Purpose of Dam

The primary purpose of the dam at present is to maintain the level of Opechee Bay within reasonable limits as the discharge from Lake Winnipesaukee through the upstream dam at Lakeport varies with the weather and channel conditions.

(h) Design and Construction History

Page B-6 of Appendix B presents a recent newspaper article by Mr. James P. Rogers of the Allan Rogers Corporation which describes in detail the history of the Avery Dam from Colonial times to the advent of state ownership in 1973. The NHWRB installed the dam's electrical operating facilities in 1976.

(i) Normal Operational Procedures

The NHWRB operator visits the dam at least every other day and reports gage readings back to the Concord office. Engineers at the head office, in turn, direct any gate operations necessitated by the operator's input. The Board does not draw down Opechee Bay in late summer or fall, as is the case with many of their other dams.

1.3 Pertinent Data

(a) Drainage Area

Avery Dam must pass flow from the Lake Winnipesaukee and Opechee Bay drainage areas which cover 374 square miles. In general, the area is forested and gently sloping, although regions of steeply sloping terrain border the lake at some points. The area is a major recreational center and, as such, has considerable development all around it and on the many islands in the lake.

(b) Discharge at Dam Site

(1) Outlet Works

The outlet works at the dam consist of the six electrically operated timber sluice gates and the dual sluiceway with stoplogs. Both the sluice gate and sluiceway openings are 5 feet, 9 inches wide and have inverts at elevation 484.5. The sluiceway stoplogs are installed and removed manually, while the operation of the timber sluice gates is described in subparagraph 1.3(g) below.

(2) Maximum Known Flood at Dam Site

There is no complete record of discharges at Avery Dam, but historical records are maintained upstream at the Lakeport Dam (USGS Gauge #01080500) and downstream at the USGS Gauge #01081000 in Tilton, N.H. The peak recorded flow at Lakeport Dam occurred March 31, 1936 and is 2890 cfs. A peak flow of 3810 cfs was recorded at the Tilton gauge on September 21, 1938.

(3) Spillway capacity at maximum pool elevation (assuming no tailwater): 5860 cfs at elevation 495.5.

(4) Gate capacity at normal pool elevation (assuming no tailwater): 2280 at elevation 491.5.

(5) Gate capacity at maximum pool elevation (assuming no tailwater): 2860 cfs at elevation 495.5

(6) Total discharge capacity at maximum pool elevation: 8720 cfs at elevation 495.5

(c) Elevation (ft. above MSL)

(1) Top of dam: 496.5 (walkway)
495.5 (top of abutment wall)

(2) Maximum pool: 495.5

(3) Recreational pool: 491.5

(4) Spillway crest: 491.5 (gates up)
488.25 (gates down)

(5) Streambed at centerline of dam: 478± (upstream)
476± (downstream)

(6) Maximum tailwater: 492 (calculated for a 500 year flow of 4400 cfs)

(d) Reservoir

(1) Length of recreational pool: 2 miles

(2) Storage of recreational pool: 1900 acre-feet

(3) Storage of maximum pool: 3700 acre-feet

(4) Area of reservoir: 450± acres

(e) Dam

(1) Type: Concrete gravity

(2) Length: 114 feet

(3) Height: 20.5 feet structural
17.5 feet hydraulic

(4) Top width: 7 feet

(5) Side slopes: Upstream - 1:4.8
Downstream - vertical

(6) Cutoff and grout curtain: Unknown

(f) Spillway

(1) Type: Concrete ogee

(2) Length of weir: 90 feet

(3) Crest elevation: 491.5 (gates up)
488.25 (gates down)

(4) Gates: Electrically operated leaf gates on two 20 foot sections
Flashboards on two 25 foot long side sections

(5) U/S channel: 4000 feet of restricted channel from Opechee Bay including 3 bridges

(6) D/S channel: Wide with rubble walls but restricted at bridge 600 feet downstream

(g) Regulating Outlets

Basic information regarding the dam's regulating outlets is discussed in subparagraphs 1.2 and 1.3(b)(1) above. With regard to the sluice gates, adjacent gates are electrically operated in tandem by Type SMB-00 "Limitorque" operators and Rodney Hunt BS-5004 bench stands. The operators include all the major design features of the larger SMB-0 units described in subparagraph 1.2(b) above. Stoplogs can be installed on the upstream side of the sluice gates for maintenance purposes.

SECTION 2 - ENGINEERING DATA

2.1 Design Records

The design of the Avery Dam is innovative and maximizes discharge capacity in a very restricted area. None of the original hydrologic, hydraulic or structural calculations are available. The Limitorque Corp. of King of Prussia, PA designed the electrical operating mechanisms installed in 1976.

2.2 Construction Records

The construction plans for the dam, included at Appendix B, are quite detailed. The plans adequately present most important features of the dam itself. No information regarding the progress of construction, particularly foundation conditions, is available, however. The files of the NHWRB contain considerable information on the installation of the electrical operating mechanisms in 1976.

2.3 Operational Records

The NHWRB operates the dam in a manner consistent with its intended purpose and engineering features and maintains satisfactory records of the dam's operation.

2.4 Evaluation of Data

(a) Availability

Neither design calculations nor as-built drawing are available, if indeed they exist. While the original construction drawings are available and quite detailed, the lack of design data and information on foundation conditions results in a marginal evaluation for availability.

(b) Adequacy

The lack of in-depth engineering data does not permit a definitive review. Therefore, the adequacy of this dam cannot be assessed from the standpoint of reviewing design and construction data. The assessment is thus based primarily on the visual inspection, past performance history and sound engineering judgement.

(c) Validity

Since the observations of the inspection team generally confirm the available written and verbal data, these sources of information warrant a satisfactory evaluation for validity.

SECTION 3 - VISUAL OBSERVATIONS

3.1 Findings

(a) General

The Avery Dam is in GOOD condition at the present time and requires no immediate remedial measures for continued safe operation.

(b) Dam

(1) Right Abutment

Inspection of the right abutment revealed no structural defects except at the transition from the right sluiceway training wall. The interface between these components is open, probably due to shrinkage of mass concrete in the abutment. Superficial cracking of the abutment adjacent to the training wall may be attributable to construction procedures.

(2) Left Abutment (Photo 1)

The left abutment consists of a massive, coarse grained granite outcrop. The concrete forming the sluice gate section is cast directly against the outcrop. The rock itself is moderately jointed. Just downstream of the sluice gate section, three small seepages through joints in the rock are visible. The largest of the three, which is less than one gpm, emanates from a joint open 1/2 to 2 inches.

(3) Hinged Leaf Gated Spillways

The twin spillways equipped with hinged leaf gates are in good condition with the exception of minor spalls on the spillway surface; cracking and efflourescence are not in evidence. However, the top of the buttress pier dividing this spillway is severely spalled immediately below the concrete walkway. In addition, minor erosion is evident on the downstream side of the buttress between 2 to 6 feet above the tailwater level. The two gates operated properly.

At the time of inspection, the structural supporting members and the hinged leaf gate operating mechanism were in good condition. The two hinged leaf gates were opened and closed utilizing electrical power and operated satisfactorily. Neither gate was operated utilizing a handwheel as none was available at the site that is compatible with the operator shaft.

(4) Side Spillways

With the exception of minor surface erosion on their crests, the side spillways are in good condition with no evidence of spalls, cracks or efflourescence. The timber flashboards are in good condition.

(5) Sluice Gate Structure

With the exception of the dividing pier between the sluice gate openings adjacent to the left abutment, the concrete is in good condition with minor exceptions. The base of the most westerly pier was subjected to erosion; however, proper maintenance has arrested further deterioration. The outlet sill of this structure has also suffered minor surface erosion exposing stone aggregate.

At the time of inspection the structural supporting members, sluice gates and operating gate mechanisms appeared to be in good condition. An attempt was made to open and close all six sluice gates utilizing electrical power and the three operators. The two right hand tandem units were raised and lowered and operated satisfactorily. The left hand tandem unit would not open utilizing electrical power and "blew" fuses. An attempt to open this unit by manual operation was to no avail.

(6) Dual Sluiceway Openings (Photo 2)

The sluiceway openings adjacent to the right abutment exhibit superficial erosion, particularly on the outlet apron. More serious erosion is evident at the base of the training wall adjacent to the side spillway. The base of this wall, though not a structural encumberance, is completely eroded from approximately 12 inches above the concrete outlet apron to an estimated depth of 6 inches into the apron.

Additionally, the construction joint between this wall and the adjacent buttress is open with minor evidence of efflourescence. The stoplogs contained within this structure are in good condition.

(c) Appurtenant Structures

(1) Concrete Walkway (Photo 3)

The concrete walkway is in fair condition. The walkway suffers from extensive cracking, spalling and efflourescence over the buttress dividing the hinged leaf gated spillways. Minor hairline cracking and associated efflourescence is also evident at the four reentrant corners of the walkway. The removable galvanized steel service gratings are in good condition.

(2) Downstream Training Wall (Photo 4)

The concrete in both the front and back walls is in good condition. However, the slope revetment placed as toe protection adjacent to the front wall has been seriously eroded. Probings reveal that voids up to 6 feet in depth occur under the foundation of the front wall; approximately 6 feet of the front wall footing are exposed.

(3) Pipe Rail Fences

The pipe rail fences around the perimeters of the walkways are in good condition and do not exhibit any signs of corrosion or deterioration.

(4) Abandoned Intake Channel

A short distance upstream of the right abutment is an intake channel which permitted the diversion of water into the building constructed on the right abutment of the dam; this structure, formerly a mill, has since been converted into an office building. The channel itself is now blocked by concrete and warrants no further consideration.

(d) Reservoir

An inspection of the reservoir shore revealed no evidence of movement or other instability. No significant sedimentation exists behind the spillway, although minor sedimentation was observed along much of the 4000 foot long channel immediately upstream of the dam. Observation of the surrounding area revealed no work in progress or recently completed which might increase the flow of sediment into the bay. On the other hand, improvements made on the upstream right bank by the Bureau of Recreation, U.S. Department of Interior, will significantly decrease any erosion from this area. Additionally, there were no major changes to the surrounding watershed which might adversely affect the runoff characteristics of the basin. As will be discussed in Section 5, there are three bridges across the approach channel to the dam which do create some degree of flow restriction in the Winnipesaukee River. As the dam lies in downtown Laconia, there is heavy development all around Opechee Bay and the channel leading from the bay to the dam.

(e) Downstream Channel (Photo 4)

There are no downstream conditions which adversely affect the operation of the dam or which pose a hazard to the safety of the structure.

The effects of the constriction created by the Main Street bridge some 600 feet downstream of the dam are discussed in detail in Section 5. Basically, the presence of the bridge will create tailwater levels in the event of the Test Flood (TF) sufficient to cause the dam to operate in the deep submergence mode. From a stability point of view, the existence of a high tailwater is beneficial to the structure.

The erosion of the slope revetment along the right training wall presents no hazard to the dam, but requires attention to prevent potential undermining of the building foundations.

3.2 Evaluation

Because this dam is of basically straightforward design and because most of its major components are accessible for examination, the visual inspection permitted an overall satisfactory evaluation of those items which affect the safety of the structure.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures

As mentioned previously, the NHWRB's dam tender visits the dam at least every other day and reports gage readings back to the Board's engineering section. The engineering section, in turn, directs any operations deemed necessary. The Board does not draw this dam down in the late summer or early fall, as is the case with many of its other dams.

4.2 Maintenance of Dam

The dam operator also inspects the condition of the dam during his visits and periodically files a written report with the Board. The engineering section then initiates whatever actions are necessary to effect repairs. Additionally, engineers from the Board inspect the dam periodically.

4.3 Maintenance of Operating Facilities

The procedures outlined in section 4.2 also apply to all operating facilities.

4.4 Description of Any Warning System in Effect

No formal warning system exists for this structure.

4.5 Evaluation

The operation and maintenance of this dam are well organized and accomplished satisfactorily. Because of the dam's HIGH hazard potential classification, the lack of a formal, written flood and emergency warning system is a significant deficiency. Section 7 includes some recommdations concerning the maintenance of the electric gate operating mechanisms.

SECTION 5 - HYDROLOGIC/HYDRAULIC

5.1 Evaluation of Features

(a) Design Data

The available data relevant to Avery Dam comes from three primary sources: (1) the New Hampshire Water Resources Board (NHWRB) files on the dam, which include 1947 drawings by Roland S. Burlingame for a reconstruction in that year and an approximate discharge rating table for the new sluice gates installed in 1976, (2) the backup file for the Flood Insurance Study of Laconia, N.H. prepared for the Federal Insurance Administration by Anderson-Nichols & Company, Inc. of Concord, N.H. and (3) a flood control report on the Winnipesaukee River, prepared by Fenton G. Keyes Associates for the Corps of Engineers, New England Division, in 1957.

No design flow data were available in any of these references. The 1957 Keyes report determined that the maximum safe capacity of the Winnipesaukee River through Laconia was 2600 cfs. This capacity was, in general, reconfirmed by the Flood Insurance Study evaluation. The NHWRB file contains an estimated discharge rating for each of the new (1976) underflow sluice gates. The capacities determined appear to be somewhat optimistic and the associated assumptions are not available. For this study, more conservative assumptions were made when determining the capacity of those gates.

(b) Experience Data

Experience data for Avery Dam is discussed in subparagraph 1.3 (b)(2).

(c) Visual Observation

The dam is well maintained and operated on a continual basis by the NHWRB. The banks of the river upstream of the dam are at basically the same elevation as the top of the dam and, thus, if the dam was overtopped, the flow would immediately spread out over the surrounding area. Downstream and adjacent to the dam is the central commercial area of Laconia.

The Main Street bridge is a severe restriction downstream with a maximum capacity of approximately 2600 cfs. The constraint on flows in Laconia is therefore the bridge and not Avery Dam, which is equipped with sufficient spillways and gates to handle substantially higher flows.

(d) Overtopping Potential

The hydrologic conditions of interest in this Phase I investigation are those required to assess the adequacy of the dam in terms of its overtopping potential and its ability to safely allow an appropriately large flood to pass. This includes the determination of a Test Flood (TF) and a comparison of that peak flow to the discharge and storage capacities of the structure.

The Corps of Engineers' (COE) "Recommended Guidelines" for the Dam Safety Inspection Program provides guidance on the selection of a Test Flood (TF) based on the hazard and size classifications of the structure. For a structure classified as INTERMEDIATE in size and HIGH in hazard, the recommended TF inflow to the reservoir above the dam is the Probable Maximum Flood (PMF). For New England, a PMF resulting from 19" of runoff is to be assumed. A chart of "Maximum Probable Flood Peak Flow Rates" as a function of drainage area and general topography was provided by the New England Division, Corps of Engineers.

The PMF cannot be directly determined for Avery Dam in a convenient manner. The dam is part of a complex hydrologic and hydraulic system consisting of the various dams, lakes, and channels that comprise the Winnipesaukee River drainage basin. The drainage area at Avery Dam is 374 square miles; but, of that total, 363 square miles are located upstream of Lakeport Dam, which controls Lake Winnipesaukee during normal conditions. During periods of high flow the narrow channel and bridge at the Weirs becomes the hydraulic control for Lake Winnipesaukee. The area upstream of that constriction is 351 square miles. The surface area of Lake Winnipesaukee is 72 square miles, the area of Paugus Bay which lies between Lakeport Dam and the Weirs is 2.0 square miles, and the area of Opechee Bay between Avery Dam and Lakeport Dam is 0.7 square miles.

Between Avery Dam and Opechee Bay there are three constrictive bridges and sufficient head losses to cause an approximate two foot rise in water surface during flood flows.

When considering the behavior of this system during an extreme rainfall event, or combined rainfall-snowmelt event, it is necessary to consider the relative timing of the peak flows through each major constriction. A complete analysis would include a detailed hydrologic or hydraulic routing of an assumed rainfall distribution through the system with time; but that degree of detail is beyond the scope of a Phase I investigation. For this study, two alternative cases are considered.

The first estimate would result from direct runoff from the area below Lakeport Dam, but above Avery Dam, added to a base flow from Lakeport. For the 11 square mile drainage area below Lakeport, a runoff rate of 1000 csm would be feasible based on the COE PMF runoff curve. Normal operations at Lakeport seek to limit flow to about 2600 cfs to minimize downstream flooding. For this case, an assumed baseflow of 3000 cfs is used. Thus, the total peak inflow to Opechee Bay and the section of river above Avery Dam would be 14000 cfs.

The second case considered would occur later in time when Lake Winnipesaukee rises to its maximum elevation and thus produces a peak flow through the Weirs and Lakeport Dam. This flow must then be combined with the residual runoff from the falling limb of the runoff hydrograph for the incremental area below Lakeport. Based on an assumed rise of five feet on Lake Winnipesaukee as a result of a 19 inch runoff, discharge of 6200 cfs at the Weirs is estimated. For the incremental area downstream of Lakeport, a runoff rate of 300 csm is estimated for the falling side of the hydrograph. Thus, a peak inflow to Opechee Bay of 9,500 cfs results.

The greater inflow estimate of 14000 cfs was then selected for development of the Test Flood. This flow would then be attenuated by the surcharge storage available on Opechee Bay due to backwater effects from Avery Dam and the three bridges upstream of the dam. An exact computation of this attenuation would again require a complete routing starting with an assumed runoff hydrograph for the entire storm.

After considering the capacities of the structures and surface area of the bay, a Test Flood of 8000 cfs for the Avery Dam site was selected as a reasonable estimate of the peak flow at the structure.

This peak flow is then compared to the capacity of the dam's outlet works. The dam, if considered independent of backwater conditions, could handle the Test Flood without overtopping the abutments. The necessary headwater to pass 8000 cfs is approximately 495 feet (MSL), or 0.5 feet below the abutment walls at the sides of the dam. This assumes, however, that the dam is functioning as a combined free overflowing spillway and sluice gate without significant tailwater. In reality, these conditions could not exist as long as the Main Street bridge remained in place. The Flood Insurance Study for Laconia produced backwater profiles for the Winnipesaukee River using the HEC-2 program and surveyed cross-sections. For a peak flow of approximately 4400 cfs (500-year flood), this study shows a tailwater elevation of 492 feet (MSL) below the dam. This is 4-feet above the spillway crest and 2.5 feet above the top of the sluice gate openings. Given that the test flood is nearly twice the 500-year flow used for the Flood Insurance Study, it is apparent that the dam will be overtopped from the backwater and, thus, will operate in a deep submergence mode. Since the water surfaces above and below the dam would be expected to be approximately the same, the danger to the dam relative to failure of the structure from high hydrostatic pressures is less than when a more moderate flow is occurring with the pond full, but without a significant tailwater. If, during the course of a PMF magnitude flood, the Main Street bridge was to wash out, the dam would be left to stand independently. It could, however, pass the given flow assuming that all the sluice gates are wide open, the top three feet of stoplogs are removed, the leaf gates are completely lowered and the flashboards wash out.

The normal pool elevation behind the dam is 491.5 feet (MSL). If all the gates are open and no tailwater exists, the discharge capacity of the dam at 492 feet (MSL), or 0.5' above normal, is 4544 cfs. This analysis concurs with previous studies of the Winnipesaukee River which conclude that Avery Dam itself has sufficient capacity to handle most floods, but that the channel above and below the dam cannot pass equivalent flows.

5.2 Hydrologic/Hydraulic Evaluation

The results of the hydrologic and hydraulic assessment indicate that Avery Dam as an isolated structure has sufficient capacity to handle any historic flood and even the estimated Test Flood. However, the dam would not function as an isolated structure as long as the severe constriction to flow at Main Street exists. At present, the dam is partially protected from the possibility of even greater flows by the constrictions in the upstream channel and any plans to improve upstream channel capacity must consider the maximum capacity of the dam.

5.3 Downstream Dam Failure Hazard Analysis

The downstream flood hazards that would result from a failure of the dam were estimated using the procedure set forth in "Rule of Thumb Guidelines for Estimating Downstream Dam Failure Hydrographs," Corps of Engineers, New England Division, April 1978.

The assumed failure condition is that the water surface upstream of the dam is at the normal pond elevation of 491.5 feet (MSL) and that the flow over the spillways and through the sluice gates is 2000 cfs. The assumed flow is less than the 10-year flood flow of 2600 cfs and represents a significant runoff, but not a major flood condition. The design drawings of the dam indicate that the stream bed above the dam is at 478 feet (MSL). Thus, the total head on the dam at the time of failure would be 13.5'. The failure is assumed to result in an average gap width of 30 feet in the dam. The resulting increment in flow would be 2500 cfs which, when added to the initial flow of 2000 cfs, yields a maximum of 4500 cfs in the downstream reach.

This flow level is very similar to the 4400 cfs used as the 500-year flow for the Flood Insurance Study. Thus, the 500-year delineation can be utilized to estimate the level of probable damages due to a dam failure under the assumed conditions. Both banks of the river below Avery Dam as far as Winnisquam Lake would be subject to flooding. The greatest depth of flooding would be upstream of the Main Street bridge where the flow would surcharge the bridge and back up into the various commercial structures located along the river. Below Main Street and above Fair Street, the flooding would extend over a greater area but at a lesser depth. The flood elevation above Main Street would be approximately 492 feet (MSL) and above Fair Street the elevation would be approximately 488 feet (MSL) . Property damage in both reaches would be significant and the loss of life a real possibility depending on the amount of warning, if any, prior to the failure.

SECTION 6 - STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

(a) Visual Observations

The extensive field investigations of the dam revealed no significant displacements and/or distress which would warrant the preparation of structural stability calculations based on assumed sectional properties and engineering factors.

(b) Design and Construction Data

While no original computations are available, the existing plans would facilitate the preparation of a stability analysis were such an action deemed necessary.

(c) Operating Records

The operating records on file with the NHWRB for this dam reveal no evidence of past instability or changing conditions which might influence stability in the future.

(d) Post Construction Changes

The only changes to the dam since construction involve the installation of motorized sluice gates on the left side and the provision of motors for the existing leaf gates on the center spillway. These changes would be expected to improve the dam's overall stability by improving its ability to pass high water levels.

(e) Seismic Stability

The dam is located in Seismic Zone No. 2 and, in accordance with recommended Phase I guidelines, does not warrant seismic analyses.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

(a) Condition

The Avery Dam is in GOOD condition at the present time.

(b) Adequacy of Information

The lack of in-depth engineering data does not permit a definitive review. Therefore, the adequacy of this dam cannot be assessed from the standpoint of reviewing design and construction data. The assessment is thus based primarily on the visual inspection, past performance history and sound engineering judgement.

(c) Urgency

With the exception of items 7.3(d) and 7.3(e) below, the improvements described herein should be implemented by the owner within 2 years of receipt of the Phase I Inspection Report. The two excepted remedial measures warrant action within six months.

(d) Need for Additional Investigation

No additional investigations are deemed necessary at this time.

7.2 Recommendations

As discussed in Section 5, the discharge capacity of the Avery Dam exceeds the capacity of the downstream channel, primarily due to the constriction created by the Main Street bridge. As a result, in the event of the Test Flood, the dam would probably operate as a submerged weir instead of as a free overfall spillway. While this situation presents no particular hazard from a structural stability point of view, it is nonetheless undesirable. Thus, the NHWRB should consider implementing the necessary improvements to upgrade the capacity of the downstream channel.

Additionally, technical inspections of the dam should continue on a two year basis.

7.3 Remedial Measures

The Avery Dam requires only normal operating and maintenance improvements. Implementation of the following measures will assist the NHWRB in assuring the long-term safety of the dam:

(a) Remove or trim all trees which overhang the upstream channel near the right abutment to limit the potential for these objects becoming obstructions during a severe storm.

(b) Repair the eroded slope revetment along the right training wall and monitor this area for future deterioration.

(c) Repair all areas of cracked, spalled or eroded concrete, paying particular attention to the proper filling and sealing of joints and cracks.

(d) Repair the inoperative gate mechanism.

(e) Provide a suitable handwheel to permit manual operation of the hinged leaf gates in the event of an emergency and store the device at the site.

(f) Perform routine operating and maintenance procedures on the hinged leaf gates and sluice gates including:

(1) Inspect the oil level in all gearhead housings every six months and record.

(2) Operate all gates through their full travel every six months and record.

(3) Grease all exposed fittings and bearings at recommended intervals and record.

(4) Insure any other service and maintenance operations recommended by the service manual are performed and recorded.

(5) Maintain an adequate supply of spare fuses at the site.

(g) Closely monitor the seepage through the left abutment, noting any change in quantity.

(h) Instruct local municipal officials such as the police and fire chiefs in the proper operation of the dam and arrange for their access to operating equipment in the event of an emergency. Such a program might decrease response time in the event of unforseen circumstances.

(i) Institute a formal, written flood and emergency warning system.

7.4 Alternatives

With regard to the recommended improvements in the capacity of the downstream channel, the owner could leave the channel as is and accept and flooding that might occur in the event of a severe storm. A storm of this magnitude has not occurred in the area of the dam since 1938.

There are no meaningful alternatives to the operating and maintenance improvements outlined above.

APPENDIX A

VISUAL INSPECTION CHECKLIST

INSPECTION TEAM ORGANIZATION

Date: 31 May 1978

NH 00465
AVERY DAM
Laconia, New Hampshire
Winnipesaukee River
NHWRB 130.02

Weather: Sunny and warm

INSPECTION TEAM

James H. Reynolds	Goldberg, Zoino, Dunnicliff & Associates, Inc. (GZD)	Team Captain
William S. Zoino	GZD	Soils
Nicholas Campagna	GZD	Soils
Andrew Christo	Andrew Christo Engineers (ACE)	Structural
Paul Razgha	ACE	Structural
Donald Adamson	Engineers, Incorporated	Electrical
David Duncan	Bethel, Duncan and O'Rourke, Inc.	Mechanical
Guillermo Vicens	Resource Analysis, Inc.	Hydrology

Mr. Robert Vay, dam tender for the NHWRB, accompanied the inspection team.

Avery Dam
Laconia, N.H.

May 31, 1978
NH 00465

CHECK LISTS FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITION & REMARKS
DAM SUPERSTRUCTURE		
Settlement of crest	MAC	None noted
Vertical alignment		No deficiencies noted
Horizontal alignment		No deficiencies noted
Condition at abutments		Left abutment is massive, moderately jointed granite; approximately 1 gpm seepage through joints in rock. Right abutment consists of a concrete wall which is part of the foundation for an old mill building, since converted to an office, built immediately adjacent to the dam; interface of right sluiceway training wall and concrete wall forming right abutment open due to shrinkage of mass concrete; some surficial cracking due to construction procedures.
Unusual downstream seepage		None other than that discussed above
Foundation drainage features		Unknown
OUTLET WORKS		
(a) Approach Channel		
Slope conditions		No evidence of instability along 4000 feet of restricted channel from Opechee Bay
Bottom conditions	MAC	Some siltation along entire channel

CHECK LISTS FOR VISUAL INSPECTION		
AREA EVALUATED	BY	CONDITION & REMARKS
Log boom	mac	Not required
Debris		None
Trees overhanging channel	mac	Small number of overhanging trees which form a park area near right abutment
(b) Hinged Leaf Gated Spillways	PC	
General condition of concrete		Good
Rusting or staining		None noted
Spalling		None noted
Erosion or cavitation		Minor surface erosion on spillways and on buttress separating spillways
Visible reinforcing		None noted
Seepage or efflourescence		None noted
Cracking		None noted
Condition of leaf gates and operating mechanisms		Good when operated electrically No handwheel available for manual operation
Junctions with side spillway wiers		No deficiencies noted
(c) Side Spillways		
General condition of concrete		Good
Rusting or staining	PC	None noted

Avery Dam
Laconia, NH

May 31, 1978
NH 00465

CHECK LISTS FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITION & REMARKS
Spalling	PE	None noted
Erosion or cavitation		Minor surface erosion
Visible reinforcing		None noted
Seepage or efflourescence		None noted
Cracking		None noted
Condition of flashboards and stanchions		Good
Junctions with left and right end walls		No deficiencies noted
(d) Dual Sluiceway Structure		
General condition of concrete		Good
Rusting or staining		None noted
Spalling		None noted
Erosion or cavitation		Complete erosion under training wall adjacent to side spillway; minor surface erosion on outlet sill
Visible reinforcing		None noted
Seepage or efflourescence		Minor efflourescence and opening of construction joint between wall with eroded base and adjacent buttress
Cracking		None noted
Condition of stoplogs	PE	Good

CHECK LISTS FOR VISUAL INSPECTION		
AREA EVALUATED	BY	CONDITION & REMARKS
(e) Sluice Gate Structure	RL	
General condition of concrete		Good
Rusting or staining		None noted
Spalling		None noted
Erosion or cavitation		Some erosion at base of westernmost dividing pier; superficial erosion on outlet sill
Visible reinforcing		None noted
Seepage or efflourescence		None noted
Cracking		None noted
Condition of leaf gates		Good
Mechanical condition of operating mechanism		Two right hand tandem units operated satisfactorily; left hand unit would not open electrically and blew fuse; left hand unit could not be opened manually either
(f) Electrical Operating Mechanisms		
General condition		Good
Lightning protection system		None
Emergency power system		None , but not necessary as all electrical features have manual operational capability
(g) Service Bridge		
Bearing	RL	Severe spalling of supporting buttress just below walkway

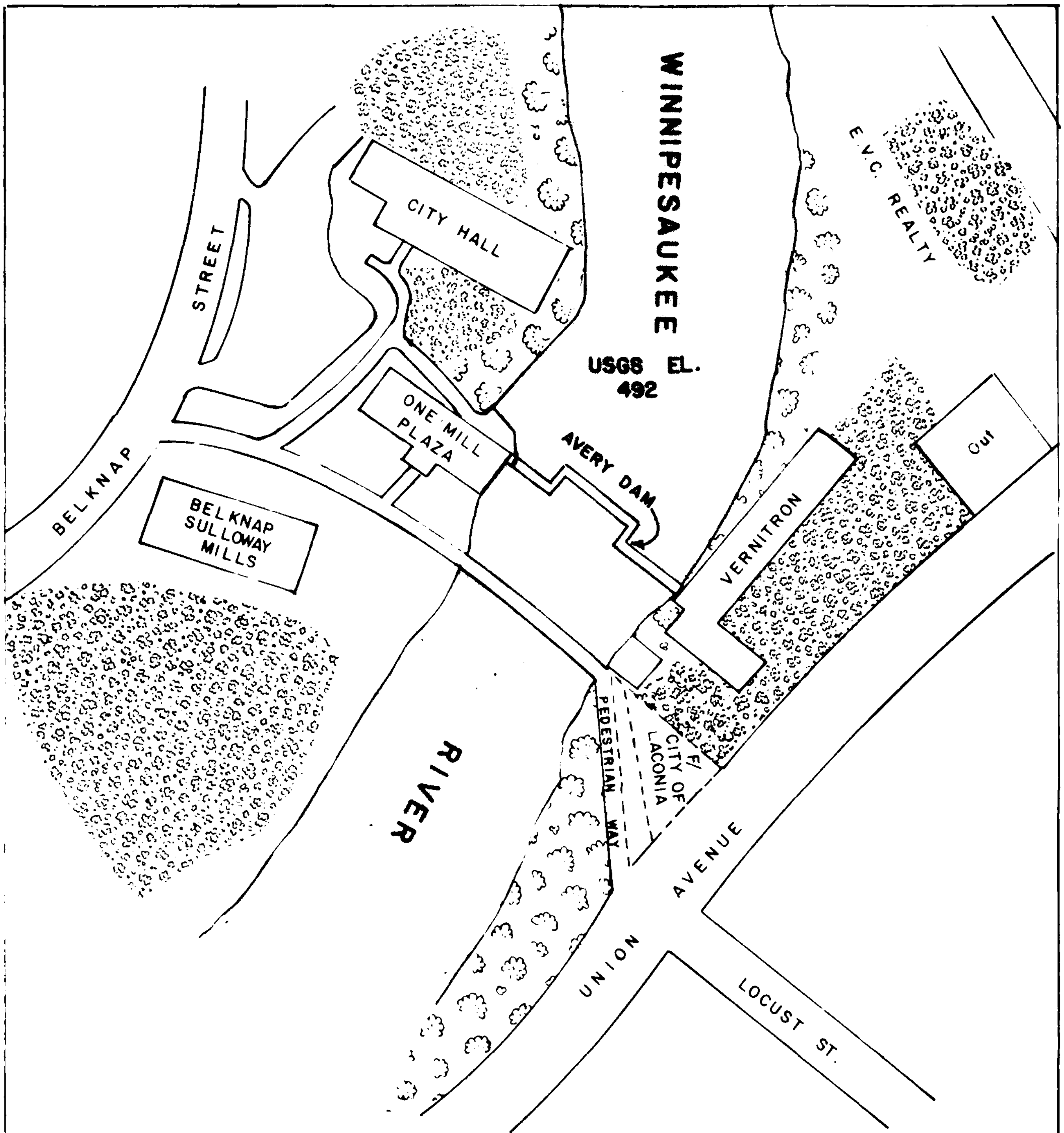
CHECK LISTS FOR VISUAL INSPECTION		
AREA EVALUATED	BY	CONDITION & REMARKS
General condition of concrete	PR	Extensive cracking, spalling and efflourescence
Expansion joints		Open joint immediately over buttress dividing two spill-ways with leaf gates
Drainage system		Good
Handrails		Good condition
Removable steel gratings	PR	Good condition
(h) Outlet Channel		
General condition	nac	Good
Trees overhanging channel		None of note
Floor of channel		Considerable erosion under slope revetment placed as toe protection adjacent to right downstream training wall/ abutment; approximately 6 feet of wall footing exposed
Other obstructions		Significant hyraulic constriction at Main Street bridge 600 feet downstream
(i) Existence of gages		NHWRB gage at dam plus USGS gages upstream and downstream
RESERVOIR		
(a) Shoreline		
Evidence of slides	nac	None

CHECK LISTS FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITION & REMARKS
Potential for slides	NOC	Shoreline stable
(b) Sedimentation		Minor along entire restricted channel
(c) Upstream hazard areas in the event of back flooding		Many residences and businesses subject to backflooding; storm drains already back up when Opechee Bay too high
(d) Changes in nature of watershed (agriculture logging, construction, etc.)		None noted
DOWNSTREAM CHANNEL		
Restraints on dam operation		Main Street bridge 600 feet downstream is significant hydraulic construction
Potential flooded areas		Many homes and businesses potentially subject to flooding
OPERATION AND MAINTENANCE FEATURES		
(a) Reservoir regulation plan		
Normal procedures		Regulate Opechee Bay as Lake Winnipesaukee discharges vary
Emergency procedures		Minimize flooding through Laconia
Compliance with designated plan	NAC	Satisfactory

CHECK LISTS FOR VISUAL INSPECTION		
AREA EVALUATED	BY	CONDITION & REMARKS
(b) Maintenance		
Quality	MLC	Satisfactory
Adequacy	MLC	Satisfactory, but maintenance of electrical and operating systems should comply with manufacturer's guidelines and be formally recorded

APPENDIX B



GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC.
GEOTECHNICAL CONSULTANTS
NEWTON UPPER FALLS, MASS.

U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

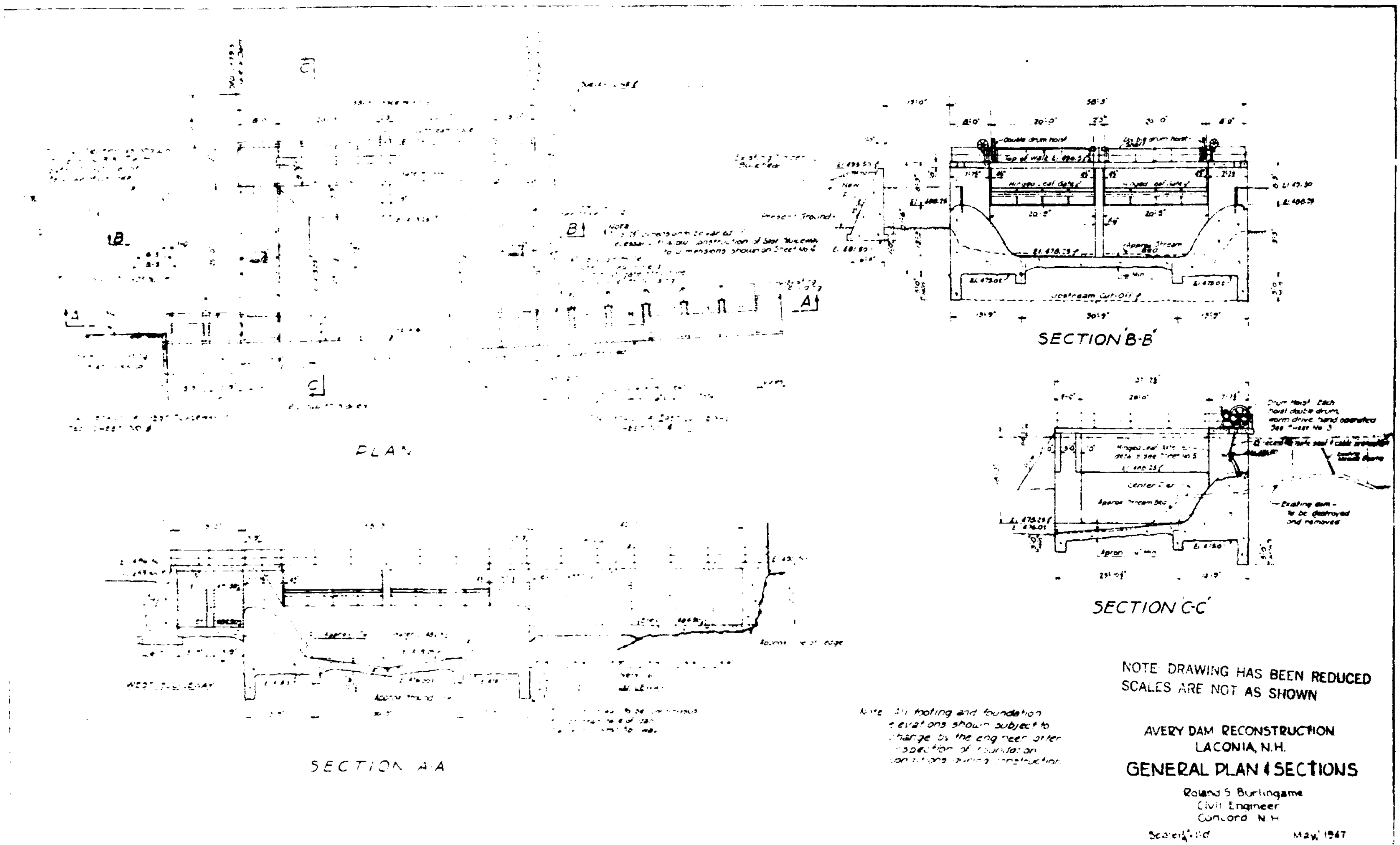
FIGURE 1

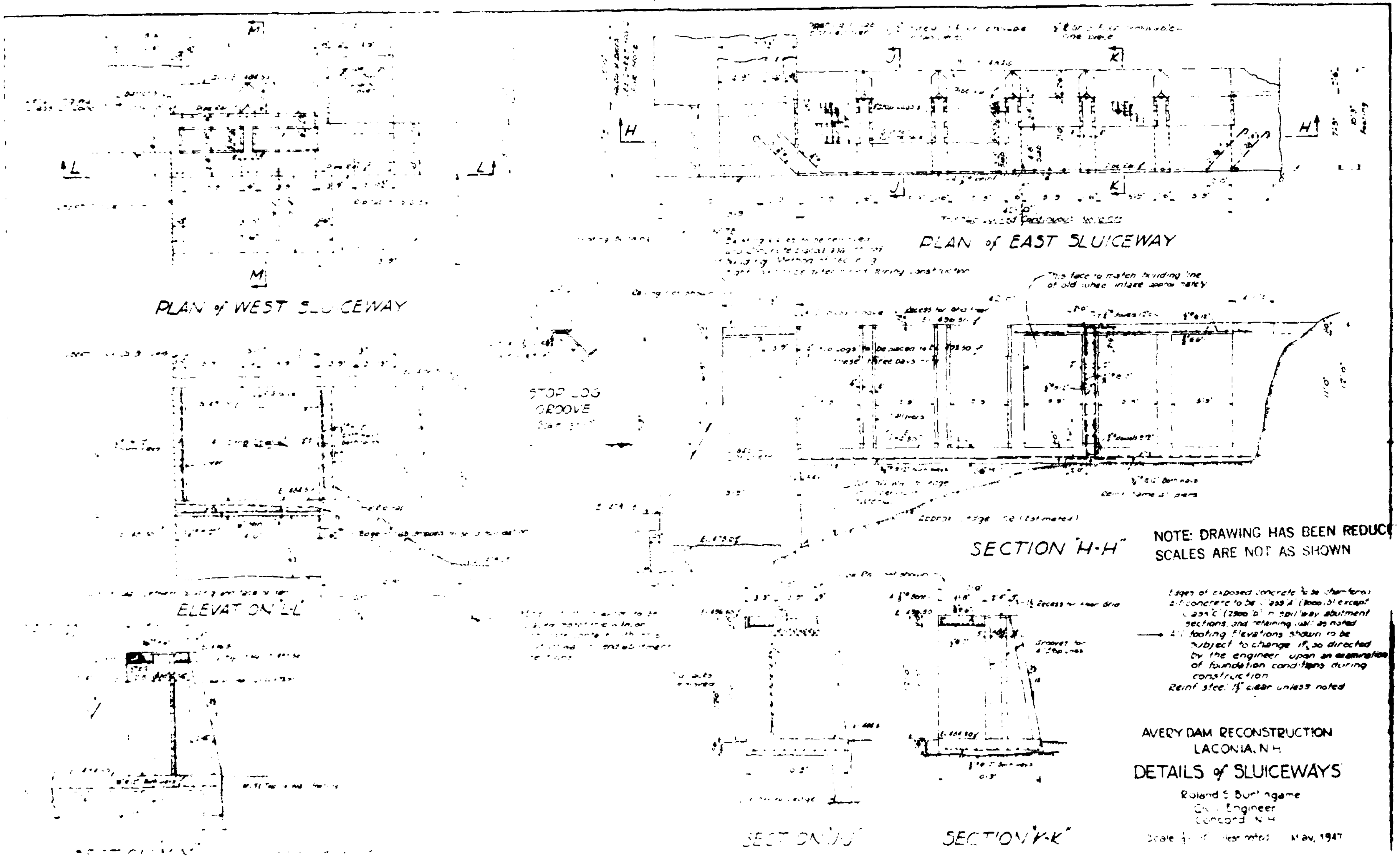
SITE PLAN

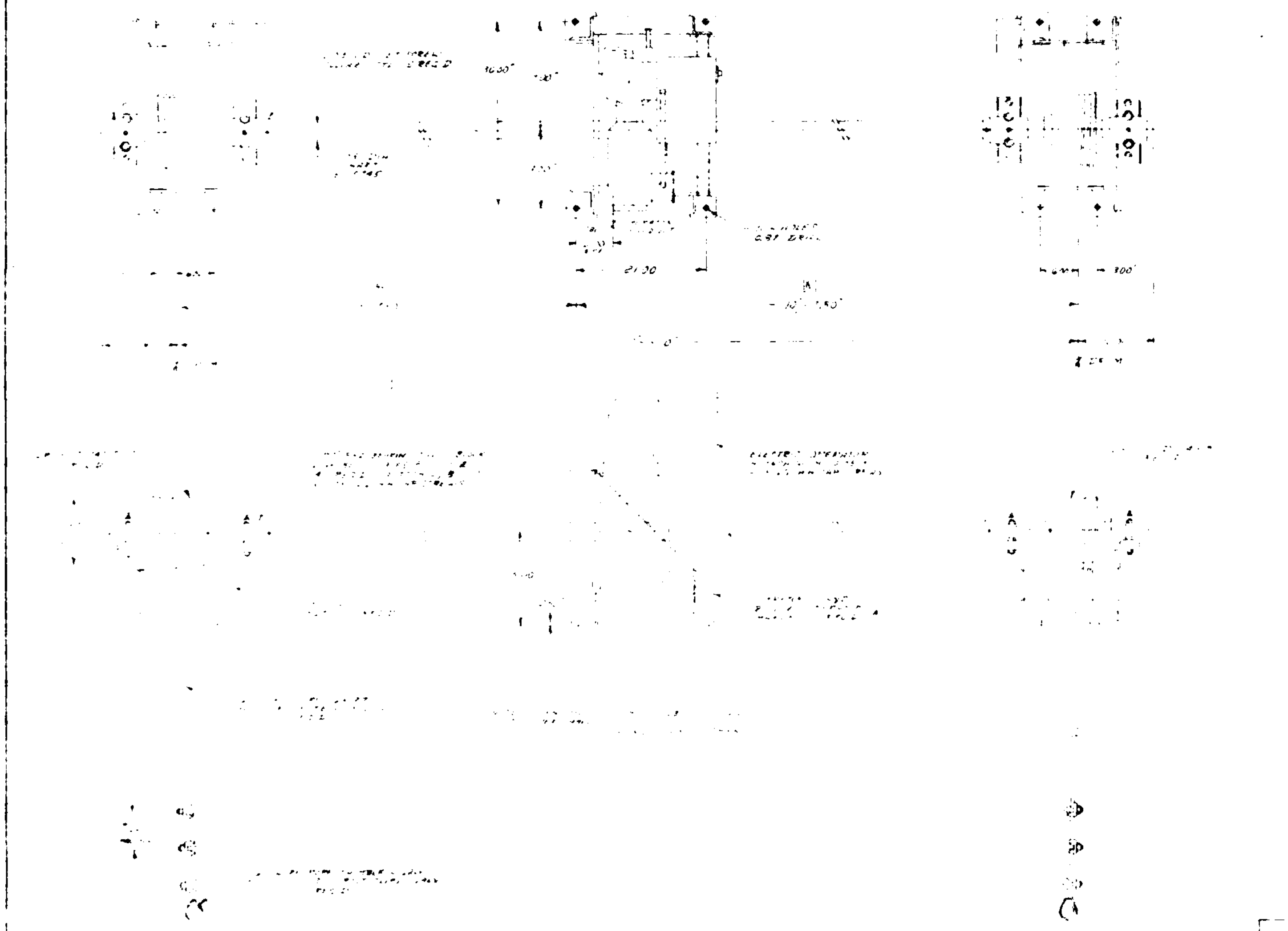
AVERY DAM — NEW HAMPSHIRE

SCALE: NO SCALE
DATE: SEPT 1978

FILE No. 2067


PLAN
SECTION A-A
SECTION B-B
SECTION C-C
Note: All footing and foundation elevations shown subject to change by the engineer after inspection of foundation conditions during construction.
NOTE: DRAWING HAS BEEN REDUCED
SCALES ARE NOT AS SHOWN
AVERY DAM RECONSTRUCTION
LACONIA, N.H.
GENERAL PLAN & SECTIONS
Roland S. Burlingame
Civil Engineer
Concord N.H.
May, 1947


PLAN of WEST SLU…CEWAY
ELEVATION "L-L"
STOP LOG GROOVE
PLAN of EAST SLUICEWAY
This face to match building line of old wheel intake approximately
SECTION "H-H"
SECTION "J-J"
SECTION "K-K"
NOTE: DRAWING HAS BEEN REDUC
SCALES ARE NOT AS SHOWN
Edges of exposed concrete to be chamfered
All concrete to be Class A (3000#) except Class C (2500#) in spillway abutment sections and retaining wall as noted
All footing elevations shown to be subject to change if so directed by the engineer upon an examination of foundation conditions during construction
Reinf. steel 1½" clear unless noted
AVERY DAM RECONSTRUCTION
LACONIA, N.H.
DETAILS of SLUICEWAYS
Roland S. Burlingame
Civil Engineer
Concord, N.H.
May, 1947



NOTE: DRAWING HAS BEEN REDUCED
SCALES ARE NOT AS SHOWN

REVISED

APR 30 1975

RODNEY HUNT COMPANY, ORANGE, MASS. 01364

The NHWRB, 37 Pleasant Street, Concord, New Hampshire, 03301 maintains the following records on this dam:

(a) Letter dated 11 January 1978 from the NHWRB to the Peter Dutile Fuel Company concerning drainage problems in Laconia when Opechee Bay is above normal levels.

(b) Letter dated 20 May 1976 from the NHWRB to the Allen Rogers Company discussing discharges for the six new gates.

(c) Memorandum dated 3 July 1956 by the NHWRB discussing flood flows out of Lake Winnipesaukee.

(d) Operating records for periods both before and after the state's takeover of the dam.

(e) Two reports, one prepared by the Department of Housing and Urban Development and one prepared by the Corps of Engineers concerning the hydrology of the Winnipesaukee River.

The Board's telephone numbers are (603) 271-3406 or (603) 271-1110.

Dam Has Played Key Role in City's History

Editor's Note: Improvements on Avery Dam which were started in late March are being completed today. The N.H. Water Resources Board sent a crew to install six new motorized gates and equipment for electric operation of the two main leaf gates. The following article, researched and written by James P. Rogers, chairman of the *board of Allen-Rogers Corp.*, describes Avery dam since Colonial times.

The Water Resources Board owns over 100 dams in the state and is responsible for their operation including control of the flow of water. *The 1973 legislature* authorized the board to acquire title to the Avery Dam and to spend $35,000 of state funds for its improvements, provided $25,000 of matching funds were provided by Avery Dam Corp.

Allen-Rogers Corp., *being* the only one of the local mills presently using the water impounded by this dam, contributed the $25,000 and received a guarantee to ten years' use of water through *the Perley Canal. This canal, which is now almost entirely* enclosed in concrete, was originally an open brook which left the river about one-quarter mile above the dam and ran from there under a *narrow bridge to the present* location of a turbine generator at the easterly end *of the Allen-Rogers plant.* The generator was installed by Laconia Car Company about 50 years ago and has been completely overhauled during the past year.

At the time of the Revolutionary War the present area comprising the Main St. business and industrial area was divided by the Winnipesaukee River between the towns of Gilmanton and Meredith. The easterly side was later to become part of Gilford and the settlement on both sides of the river came to be known as Meredith Bridge.

Samuel Jewett settled on the Gilmanton side in 1777 and after a few years moved on to build a house about one-half mile upstream. He sold land and water rights to Col. Samuel Ladd and together they built the first log dam where several mills were soon operating. The early attempts at dam construction *were thwarted by occasional* flooding.

About 1790 Daniel Avery moved from Stratham to Meredith Bridge and opened up a store in a small building near the bridge at Mill St. Avery also had other business interests and he replaced the original log dam with a more durable structure. *However*, on numerous occasions during the 19th century high *water caused severe damage.* As time went on various industries on both sides of the river utilized water power and managed to make repairs to the dam necessary *to keep their mills running.*

In 1852, the owners of water rights at Meredith Bridge entered into an agreement with "Winnipissiogee" Lake Cotton and Woolen Manufacturing Company, which owned various rights upstream (at Lake Village, *later Lakeport* and on a good portion of the shore line of the big lake itself). The agreement, in effect, defined the level of water to be maintained at Avery Dam, and guaranteed a minimum flow of water throughout the year.

In recent years the water Resources Board has acquired the dams at both Lakeport and Laconia and, in spite *of certain riparian* rights still in private ownership, controls the flow of water from Lake Winnipesaukee, primarily for the benefit and protection of the public. Certain conditions resulting from natural causes such as silt in the river *channel at various locations, and occasional heavy rainfall* or spring run-off, sometimes causes high water in the lakes and rivers.

Soon after the end of World War II, the owners of the Avery Dam and water rights realized that major repairs were needed in order to properly control the flow of water. They engaged Roland S. Burlingame, a qualified hydraulic engineer, to make studies and recommendations. He found that the various flumes and water wheels were in some cases in bad repair and in general had capacity in excess of the amount of water available. An attempt was made to apportion the water according to the several fractions allotted by existing agreements, but without much success.

In July, 1949 the N.H. Water Control Commission found the old dam to be in a state of *disrepair, and after a public* hearing, ordered that it be repaired or rebuilt according to plans and specifications approved by the commission. The Avery Dam Corporation was *organized with the following directors:* A.O. Cormier, L.W. Guild, K.A. Killam, J.P. Rogers and W.B. Weissblatt. Rogers was elected president; Weissblatt as vice-president; Earle Kinsman, treasurer and Arthur Nighswander, clerk.

Plans and specifications for the new dam, provided by Roland Burlingame, were approved and put out for bids. The contract was awarded to W.M. Bisson and Son and work was commenced on Aug. 30, 1949, with only four months allowed for completion. Actually the construction was completed on Nov. 28 and the first power was delivered to the Belknap Mill Dec. 12, 1949. In addition to the Bissons ("Bill" and "Reg") some credit is due "Simmy" Clement, foreman *for the Bissons, and Henry Erickson, well-known architect-engineer,* who acted as clerk of the works.

Belknap Mills Corporation, later known as Belknap-Sulloway Mills, was sold to a New York concern, but continued using the water power until 1969. Meanwhile, a new corporation, Belknap Industries, Inc., acquired most of the knitting machines and moved to the former ski factory on New Salem St. This marked the end of an era lasting about 175 years during which the Avery Dam supplied at least part of the power for a succession of nearby mills located near the bridge at Mill St.

It is not generally un*derstood that the main* purpose of the Avery Dam is to maintain the level of Lake Opechee within reasonable limits as the discharge of water from Lake Winnipesaukee varies according to weather and channel *conditions.* Perley Canal has rights to at least one-fifth of the water flowing in the river, but does not have the capacity to draw even that amount during periods of heavy rainfall and spring *run-off. It is expected that* with the new equipment installed at the dam it will be possible to regulate the flow more economically and to the satisfaction of everybody concerned.

J. P. Rogers

January 27, 1970

Mr. [illegible] P. Davis
Davis T[illegible]l Company, Inc.
23 Arch Street
Laconia, New Hampshire 032[illegible]6

Dear Mr. Davis:

In response to your request, the New Hampshire Water Resources Board has made a preliminary study of the effects of sealing off the gate sections leading to the Belknap-Sulloway Mill power plant.

Due to the power wheel in this system, the present discharge capacity of these gates is limited to about 225 cubic feet per second (cfs). However, the potential for much greater capacity exists if the wheels did not restrict flow.

At the present time, the river channel restricts flow through Laconia to about 2600 cfs. It is the opinion of the Water Resources Board that a discharge capacity of 4,275 cfs is necessary to substantially [illegible] the possibility of severe high water on Lake Winnipesaukee. The Corps of Engineers' Report of January 1957 on the Winnipesaukee River describes the overall improvements necessary to attain this capacity in the river. Present usable discharge capacity of the Avery Dam at normal pond level is about 2700 cfs.

It would appear that reducing the capacity of the Winnipesaukee River through Laconia would cause a somewhat greater threat of high water damage on Opechee Bay since the dam capacity would be reduced by about 8%. However, modifications could be made to the penstock in the future which would help achieve the desired capacity.

In conclusion, the New Hampshire Water Resources Board is of the opinion that any reduction in discharge capacity at the Avery Dam or the adjacent Belknap-Sulloway canal would be detrimental at the present time.

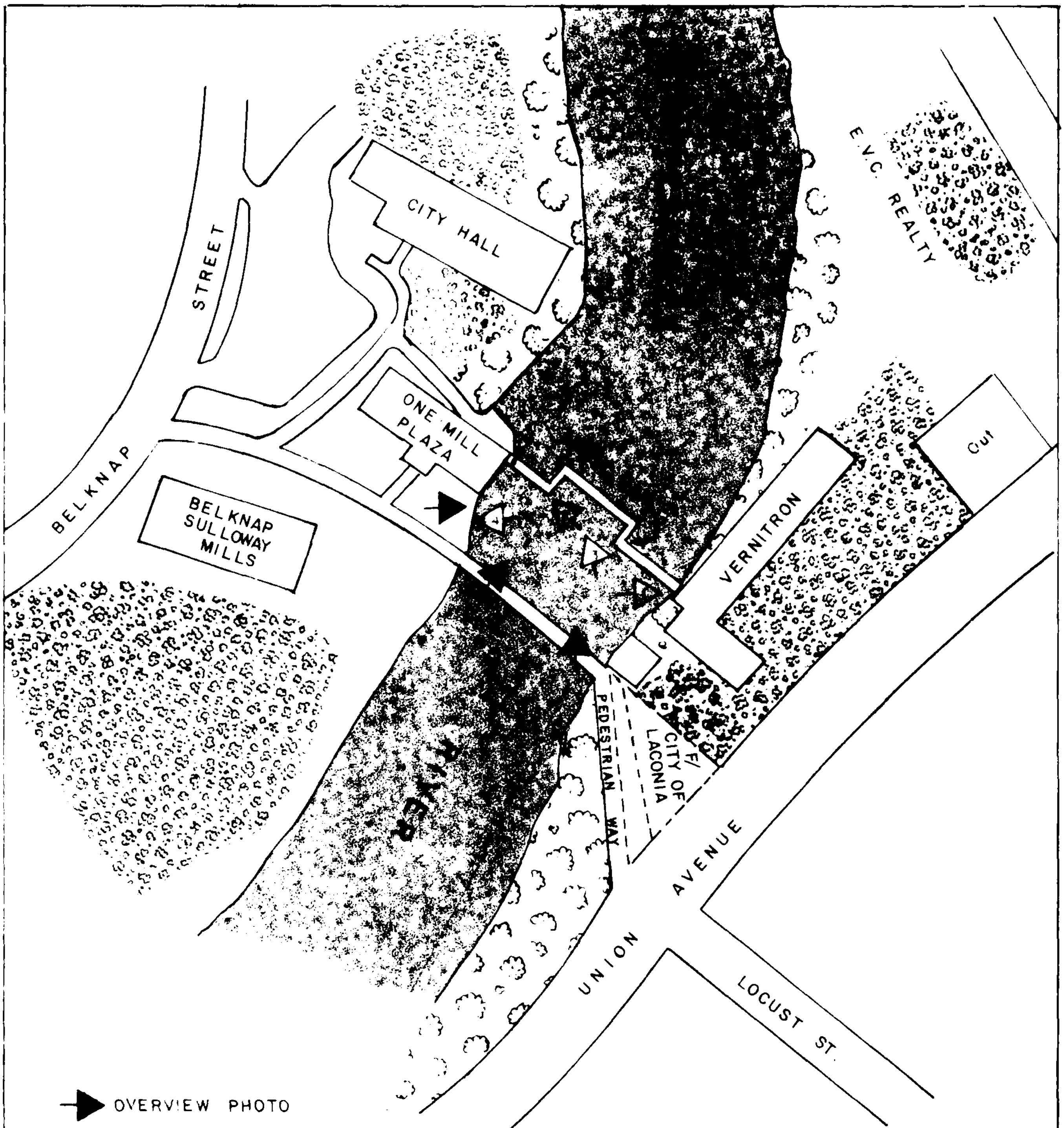
Very truly yours,

Robert [illegible]. Livingston, P.E.
Water Resources Engineer

[illegible]

APPENDIX C

SELECTED PHOTOGRAPHS



OVERVIEW PHOTO

APPENDIX C PHOTOS

GOLDBERG, ZOINO, DUNNICLIFF & ASSOC, INC. GEOTECHNICAL CONSULTANTS NEWTON UPPER FALLS, MASS.	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOCATION AND ORIENTATION OF PHOTOS

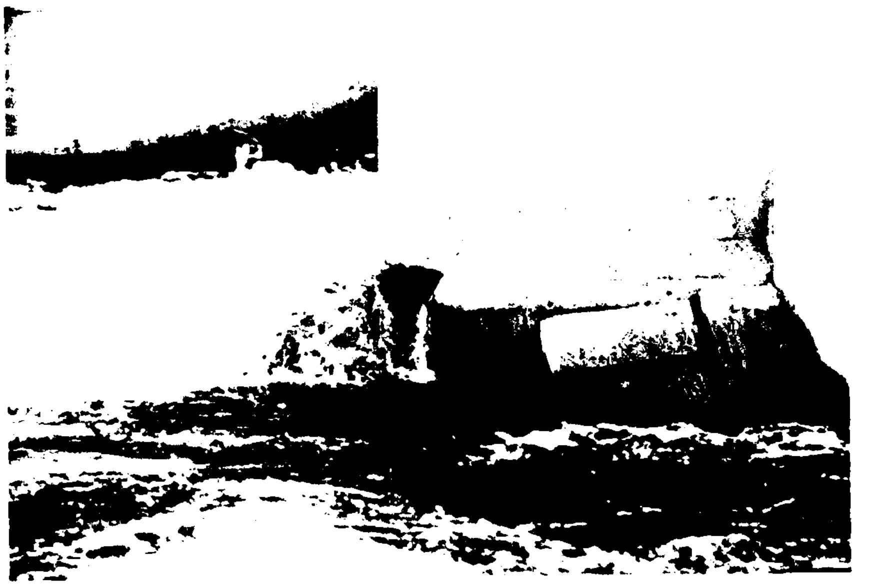
AVERY DAM — NEW HAMPSHIRE

FILE No. 2067

SCALE: NO SCALE

DATE: SEPT 1978

1. View of seepage near downstream side of left abutment



2. View of erosion under junction of spillway and right side gate structure

3. View from downstream of open joint in concrete service bridge

4. View from dam of erosion on right side of downstream channel

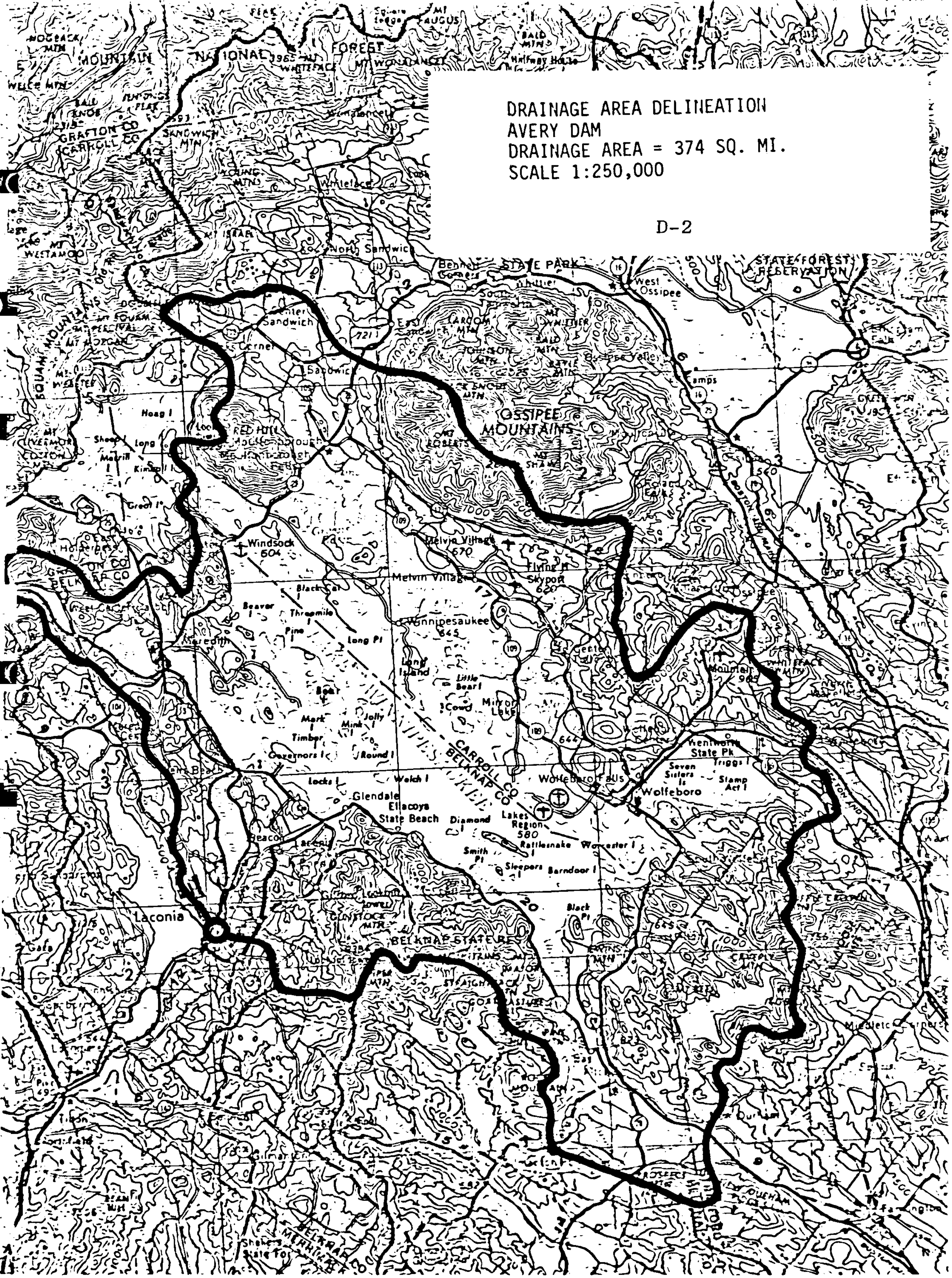
APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

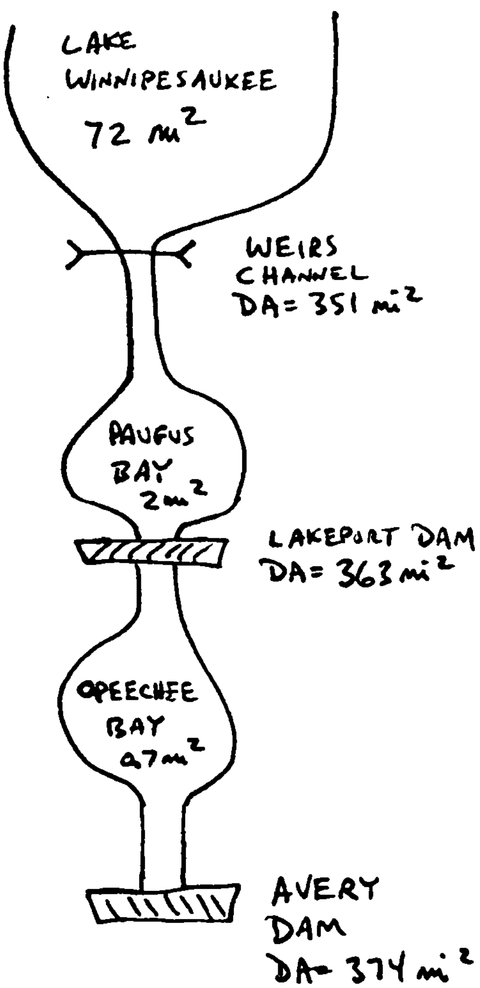
AVERY DAM

DRAINAGE AREA DELINEATION
AVERY DAM
DRAINAGE AREA = 374 SQ. MI.
SCALE 1:250,000

D-2



AVERY DAM HAS A TOTAL DRAINAGE AREA OF 374 SQMI. BUT THERE ARE TWO SIGNIFICANT RESTRICTIONS PLUS SEVERAL BRIDGES UPSTREAM OF THE DAM IN ADDITION TO LAKE WINNIPESAUKEE, WHICH WITH 72 SQMI OF SURFACE AREA (PLUS 2.0 SQMI IN PAUGUS BAY, 0.7 SQMI IN OPEECHEE) PROVIDES SIGNIFICANT SURCHARGE STORAGE CAPACITY.



IF A PMF RUNOFF OF 19" WERE TO OCCUR ON THE 363 mi^2 UPSTREAM OF LAKEPORT DAM, AND NO SPREADING OF THE LAKE IS CONSIDERED AND NO DISCHARGE AT LAKEPORT DAM ACCOUNTED FOR, THE MAX. POSSIBLE RISE ON WINNIPESAUKEE WOULD BE ≈ 7.8 FEET

$$\frac{363\ mi^2}{\underbrace{74.\ mi^2}_{72+2}} \times \frac{19"}{12"/ft} = 7.8'$$

WHEN DETERMINING THE PEAK FLOW TO USE AS A TEST FLOOD AT AVERY DAM IT IS NECESSARY TO SELECT A FLOW IN ACCORDANCE WITH THE COE GUIDELINES FOR THE GIVEN SIZE AND HAZARD CLASSIFICATION, AND WITH DUE CONSIDERATION

GIVEN TO THE UPSTREAM STORAGE CAPACITY AND FLOW RESTRICTIONS.

THE SIZE CLASSIFICATION OF AVERY DAM IS INTERMEDIATE BASED ON THE STORAGE CAPACITY OF OPEECHEE BAY.

THE HAZARD CLASSIFICATION WAS DETERMINED TO BE HIGH BASED ON THE LOCATION OF THE DAM IN THE CENTER OF LACONIA, NH. AND THE HIGH DEGREE OF DEVELOPMENT IN THE IMMEDIATE DOWNSTREAM FLOOD PLAIN.

FOR AN INTERMEDIATE SIZE AND HIGH HAZARD DAM THE COE GUIDELINES CALL FOR A TEST FLOOD BETWEEN 1/2 AND 1 TIMES THE PMF (PROBABLE MAX. FLOOD). THE PROBABLE MAX. FLOOD IS BASED ON AN ASSUMED RUNOFF OF 19" FOR NEW ENGLAND.

FOR AVERY DAM WE MUST CONSIDER TWO ALTERNATIVE PEAK FLOWS AT THE DAM SITE. THE FIRST PEAK WOULD RESULT FROM THE RUNOFF DOWNSTREAM OF THE LAKEPORT DAM WITH A BASEFLOW FROM LAKE WINNIPESAUKEE. FOR THE 11 SQMI INCREMENTAL DRAINAGE AREA BETWEEN THE DAMS A RUNOFF OF 1000 CSM IS

PLAUSIBLE BASED ON THE COE/NED CURVE.
A BASEFLOW OF 3000 CFS WILL BE ASSUMED AT LAKEPORT DAM. THUS THE TOTAL INFLOW WITHOUT CONSIDERATION OF SURCHARGE STORAGE IS $Q_1 = 11(1000) + 3000 = 14000$ CFS.

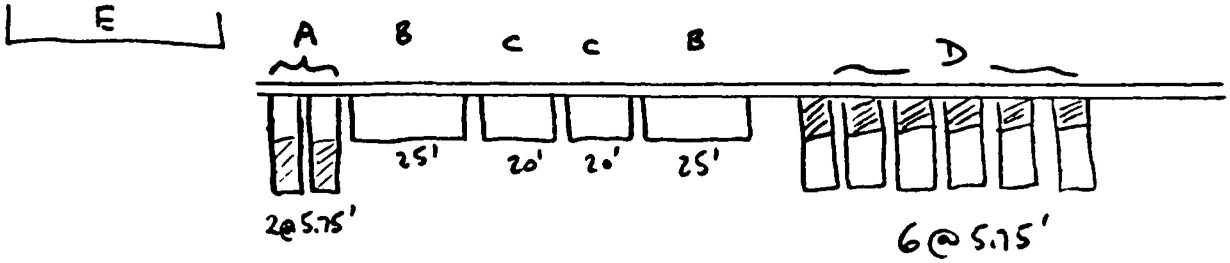
THE SECOND PEAK TO CONSIDER WOULD BE WHEN THE PEAK OUTFLOW FROM THE WEIRS PASSES THROUGH OPEECHEE BAY AND DOWN TO AVERY DAM. A REPORT BY CHARLES T. MAIN, INC. FOR NHWRB DETERMINED A PEAK DISCHARGE AT LAKEPORT DAM OF APPROX. 10,000 CFS. THIS MUST BE ADDED TO AN ASSUMED RUNOFF ON THE FALLING SIDE OF THE RUNOFF HYDROGRAPH FOR THE AREA BETWEEN DAMS. AN ASSUMED RUNOFF OF 300 CSM WOULD YIELD A TOTAL INFLOW OF $Q_2 = 11(300) + 10000 = 13300$ CFS. BY CHANCE THIS IS CLOSE TO Q_1. TO DETERMINE THE FLOW AT AVERY DAM CONSIDERATION MUST BE GIVEN TO THE AVAILABLE SURCHARGE STORAGE ON OPEECHEE BAY. FOR THE Q_1 CASE OPEECHEE BAY WOULD BE ASSUMED TO BE AT NORMAL ELEVATION BUT FOR CASE 2, Q_2, OPEECHEE BAY WOULD ALREADY BE SEVERAL FEET ABOVE ITS NORMAL STAGE. A COMPLETE

ANALYSIS OF THIS COMPLEX SYSTEM WOULD REQUIRE THAT HYDROGRAPH SHAPES ARE ASSUMED FOR BOTH THE LOCAL INFLOW AND LAKE WINNIPESAUKEE DISCHARGE AND THEN A ROUTING PERFORMED TO ACCOUNT FOR THE CHANGES IN STORAGE AND DISCHARGE WITH TIME. TO COMPLICATE MATTERS AVERY DAM DOES NOT DETERMINE THE ELEVATION OF OPEECHEE BAY DIRECTLY. THERE ARE THREE UPSTREAM BRIDGES AND A SILTED CHANNEL WHICH RESULTS IN THE ELEVATION OF OPEECHEE BEING ≏ 2 FEET ABOVE THE WATER SURFACE AT AVERY DAM DURING MAJOR FLOODS.

GIVEN THE COMPLEXITY OF THE SYSTEM AND THE SCOPE OF THIS STUDY IT WAS DECIDED THAT A TEST FLOOD ~~AT~~ OF 8000 CFS WOULD BE ASSUMED AT AVERY DAM.

TO DETERMINE OVERTOPPING POTENTIAL A RATING CURVE OF AVERY DAM MUST BE ESTABLISHED FOR HIGH FLOWS.

THE DAM IS CONFIGURED AS FOLLOWS:



A: TWO STOPLOG BAYS 5.75' WIDE WITH INVERT AT 484.5 MSL AND MAX. OPENING OF 11.0 FT. NORMALLY STOPLOGS ARE IN PLACE TO ELEV. 491.5 BUT SINCE DAM IS WELL TENDED AND IN CENTRAL ACCESSIBLE LOCATION WE ASSUME THAT THE TOP 3.0 FEET OF STOPLOGS ARE REMOVED DURING TEST FLOOD. THUS CREST WILL BE AT 488.5

B. TWO SPILLWAY CRESTS 25.0' LONG. NORMALLY RIGGED WITH FLASHBOARDS WHICH ARE ASSUMED TO BREAK FOR TEST FLOOD. CREST AT 488.25'

C. TWO SPILLWAYS WITH HINGED LEAF GATES IN CREST. GATES ASSUMED TO BE DOWN WHICH RESULTS IN CREST ELEVATION OF 488.25' LENGTH OF EACH SPILLWAY IS 20.0'

D. SIX UNDERFLOW SLUICE GATES WITH ELECTRIC AND MANUAL LIFTING STEMS. MAX. OPENING IS 5.0' HIGH, 5.75' WIDE. INVERT OF GATES IS 484.5

E. LOW AREA ON WEST BANK OF RIVER, ≈ 400' UPSTREAM OF DAM. ASSUME A WEIR 200' LONG AT ELEVATION 495'.

THERE IS A CONSTRICTION AT THE MAIN ST BRIDGE DOWNSTREAM OF THE DAM THAT IS LIKELY TO CAUSE A SIGNIFICANT TAILWATER AT THE DAM.

THE FLOOD INSURANCE STUDY USING HEC-2 INDICATES A TAILWATER ELEVATION OF 492' FOR A FLOW OF ≈ 4400 CFS. GIVEN THAT OUR SELECTED TEST FLOOD IS 8000 CFS IT IS APPARENT THAT THE DAM WOULD NO LONGER FUNCTION AS A WEIR OF SIMPLE SLUICE GATE AND SEVERE TAILWATER CONDITIONS WOULD DEVELOP. THE DAM WOULD THEN BE IN A DEEP SUBMERGENCE MODE OF OPERATION AND THE NET FORCE ON THE DAM RELATIVE TO STRUCTURAL FAILURE WOULD BE REDUCED BY THE BACK PRESSURE FROM THE TAILWATER. THUS IT APPEARS THAT AVERY DAM WOULD NOT BE THE PRIMARY CONTROL DURING A PMF FLOOD, INSTEAD THEN MAIN STREET BRIDGE WOULD BE.

IF THE MAIN STREET BRIDGE WAS TO WASH AWAY AND THUS RELIEVE THE TAILWATER CONDITION WE CAN DETERMINE THE CAPACITY OF THE DAM UNDER FREE FLOWING CONDITIONS.

THE DISCHARGE CAPACITY CALCULATION CAN BE SIMPLIFIED BY COMBINING Q_A, Q_B, AND Q_C ASSUMING THAT THE CREST AT A, ALSO IS AT 488.25'

THE TOTAL WEIR LENGTH WOULD BE 101.5'. ALLOWING FOR THE CONTRACTION FROM THE FIVE INTERMEDIATE PIERS WE WILL USE A WEIR LENGTH = 100', AND A COEFFICIENT OF 3.0. FOR THE SIX SLUICE GATES THE TOTAL MAXIMUM OPENING AREA WOULD BE 6 × 6' × 5.75' = 207 SQ FT. BASED ON A MAXIMUM HEAD OF 11 FEET AND A HEIGHT OF 5 FEET, THE C_d SELECTED FROM ROUSE (PG 50) IS .52

$Q_{TOTAL} = Q_{WEIR} + Q_{SLUICE}$

$$Q_T = CLH^{3/2} + C_d A\sqrt{2gH}$$

ASSUME MAX HEADWATER WITHOUT OVERTOPPING IS 495.5

$$Q_T = 3.0(100)(495.5-488.25)^{3/2} + .52(207)\sqrt{2(32.2)(495.5-484.5)}$$

$$Q_T = 300(7.25)^{3/2} + 107.64\sqrt{64.4 \times 11}$$

$$Q_T = 5856 + 2864.$$

$$Q_T = 8720 \text{ cfs}$$

THUS THE DAM ITSELF HAS THE CAPACITY TO CARRY THE TEST FLOOD IF THE DOWNSTREAM REACH DID NOT CAUSE A SEVERE TAILWATER.

THE CAPACITY OF THE DAM ALONE FOR A HEADWATER OF 492.0, WHICH IS JUST ABOVE THE NORMAL POOL ELEVATION OF 491.5', WOULD BE :

$$Q_T = 3.0(100)(492-488.25)^{3/2} + .52(207)\sqrt{2(32.2)(492-484.5)}$$

$$Q_T = 2178 + 2366$$

$$Q_T = 4544.$$

DAM FAILURE ANALYSIS

FOR DAM FAILURE ASSUME THAT THE POOL BEHIND THE DAM IS AT THE NORMAL ELEVATION OF 491.5' AND A COMBINATION OF GATES AND SPILLWAY DISCHARGE SUFFICIENT TO PASS 2000 CFS IS OPEN. THE 2000 CFS IS REASONABLY UNDER THE ESTABLISHED DOWNSTREAM CAPACITY OF 2600 CFS. ASSUME A 30' GAP IN THE DAM OPENS UPON FAILURE.

(491.5-478)

$$Q_{P1} = \frac{8}{27} W_b \sqrt{g}\, Y_0^{1.5} = \frac{8}{27}(30)\sqrt{32.2}\,(13.5)^{1.5}$$

$$Q_{P1} = 2502 \text{ cfs}$$

THUS A TOTAL OF ≈ 5000 CFS WOULD REPRESENT THE DAM BREAK WAVE DOWNSTREAM OF AVERY DAM. THIS FLOW VALUE IS

SLIGHTLY ABOVE THE 500 YEAR FLOW USED IN THE FLOOD INSURANCE STUDY (4400 cfs) BUT THE DELINEATION OF THE 500 YEAR FLOOD PROVIDES A REASONABLE ESTIMATE OF DOWNSTREAM DAMAGES BETWEEN AVERY DAM AND WINNISQUAM LAKE, FOR IN THAT REACH NO SIGNIFICANT STORAGE IS AVAILABLE TO ATTENUATE THE FLOW. BELOW WINNISQUAM LAKE THE DAM FAILURE FLOOD WAVE WOULD BE SIGNIFICANTLY ATTENUATED BY SURCHARGE STORAGE ON WINNISQUAM AND THUS NO SIGNIFICANT DAMAGES ARE ANTICIPATED. BELOW WINNISQUAM. THE SEVERE DAMAGE AREA WOULD BE ON BOTH BANKS OF THE RIVER AS FAR AS THE FAIR ST BRIDGE. BETWEEN THE DAM AND MAIN STREET THE FLOODING WOULD INUNDATE THE BACKS OF ALL THE BUILDINGS THAT LINE THE STREAM, COMPOUNDED BY THE BACKWATER EFFECT FROM MAIN ST. BRIDGE.

BELOW MAIN ST. THE FLOODING WOULD SPREAD OUT RESULTING IN LESSER DEPTHS BUT OVER A GREATER AREA. DAMAGE TO PROPERTY IN BOTH REACHES WOULD BE SIGNIFICANT AND THERE IS A REAL POTENTIAL FOR LOSS OF LIFE IF THE DAM BREAK OCCURED WITHOUT WARNING.

APPENDIX E

INFORMATION AS CONTAINED IN
THE NATIONAL INVENTORY OF DAMS

INVENTORY OF DAMS IN THE UNITED STATES

STATE	IDENTITY NUMBER	DIVISION	STATE	COUNTY	CONGR. DIST.	STATE	COUNTY	CONGR. DIST.	NAME	LATITUDE (NORTH)	LONGITUDE (WEST)	REPORT DATE DAY MO YR
NH	465	NED	NH	001	01				AVERY DAM	4331.7	7128.1	13NOV78

POPULAR NAME	NAME OF IMPOUNDMENT
	OPECHEE BAY

REGION	BASIN	RIVER OR STREAM	NEAREST DOWNSTREAM CITY-TOWN-VILLAGE	DIST FROM DAM (MI.)	POPULATION
01	05	WINNIPESAUKEE RIVER	LACONIA	0	15000

TYPE OF DAM	YEAR COMPLETED	PURPOSES	STRUCTURAL HEIGHT (FT.)	HYDRAULIC HEIGHT (FT.)	IMPOUNDING CAPACITIES MAXIMUM (ACRE-FT.)	IMPOUNDING CAPACITIES NORMAL (ACRE-FT.)	DIST	OWN	FED	R	PRV/FED	SCS	A	VER/DATE
CTPG	1949	CRH	21	18	3700	1900	NED	N	N		N	N		13DEC78

REMARKS
23-ONLY 250 CFS FOR HYDROELECTRIC

D/S HAS	SPILLWAY CREST LENGTH	SPILLWAY TYPE	SPILLWAY WIDTH (FT.)	MAXIMUM DISCHARGE (FT.)	VOLUME OF DAM (CY)	POWER CAPACITY INSTALLED (MW)	POWER CAPACITY PROPOSED (MW)	NAVIGATION LOCKS NO.	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)
1	114	C	90	5860												

OWNER	ENGINEERING BY	CONSTRUCTION BY
NH WATER RESOURCES BOARD	ROLAND S BURLINGAME	W.M.BISSON AND SON

REGULATORY AGENCY DESIGN	CONSTRUCTION	OPERATION	MAINTENANCE
NONE	NONE	NONE	NONE

INSPECTION BY	INSPECTION DATE DAY MO YR	AUTHORITY FOR INSPECTION
GOLDBERG ZOINO DUNNICLIFF + ASSOC	31MAY78	PUBLIC LAW 92-367

REMARKS
47-1976 GATE MECHANISMS BY NHWRB AND LIMITORQUE CORP

END

FILMED

8-85

DTIC