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WOODWARD RESERVOIR DAM

VT 00209

PLYMOUTH, VERMONT

PHASE I INSPECTION REPORT NATIONAL DAM INSPECTION PROGRAM

NATIONAL DAM INSPECTION PROGRAM

PHASE I INSPECTION REPORT

Identification No:VT 00209Name of Dam:Woodward ReservoirTown:PlymouthCounty and State:Windsor County, VermontStream:Reservoir BrookDate of Inspection:April 23, 1979

BRIEF ASSESSMENT

The Woodward Reservoir Dam is a stone-earth fill dam with a concrete emergency spillway. The dam is approximately 150 feet long with a maximum height of 30 feet and a crest width of 48 feet. The downstream face is vertical, made of stone; while the upstream face has a slope of approximately 1 on 2 with a concrete slab along the top of the slope for embankment protection. The dam and impoundment are part of The Farm and Wilderness Camps, used solely for recreation. The reservoir surface area is approximately 101 acres while the drainage area comprises 2.87 square miles.

The gate house located immediately ahead of the concrete spillway provides control of a 2-foot by 2-foot stone box low-level outlet.

Based on intermediate size and significant hazard classification, in accordance with "Recommended Guidelines for Safety Inspection of Dams, Department of the Army, November 1976," the test flood for this dam is one-half the probable maximum flood (PMF). The test flood inflow was found to be 4732 CFS (1649 CSM) which after routing is reduced to an outflow of 2554 CFS (890 CSM). The routed test flood outflow based on no stop logs in place overtops the embankment by approximately 2.8 feet. The combined low-level outlet and spillway capacity, without embankment overtopping, is 564 CFS which is 22 percent of the test flood.

The following significant conditions were observed:

- 1. Erosion has occurred at both upstream abutments and sloughing of the impoundment shoreline has started.
- 2. Small trees have been allowed to grow from the masonry on the downstream face.
- 3. An area of leakage estimated at 7 to 8 GPM was found downstream of the left abutment.
- 4. The downstream vertical face of the spillway is in very poor condition. Severe spalling for the full height has exposed the reinforcing.

5. Erosion at the downstream toe of the dam has undermined the outlet conduit.

The Woodward Reservoir Dam is in poor condition and subject to continued deterioration when water flows through the spillway. A detailed assessment and recommendations for remedial action are contained in Section 7 of this report. In summary, it is recommended that the following actions be instituted under the guidance of a qualified engineer within one year of the receipt of this report:

- 1. Design plans to repair the undermining at the toe of the spillway and to prevent future undermining.
- 2. Design and reconstruction of the downstream face of the spillway and the training walls.
- 3. Assess the spillway capacity.
- 4. Prepare a formal warning system.

In addition the dam should be continuously monitored during high flows and the gate opened as necessary to minimize flows over the spillway. Normal lake level should be lowered until the recommended repairs can be accomplished.

Following the repairs listed above, institute an annual safety technical inspection program, to include monitoring the seep to the left of the spillway.





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 there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway 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.

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OVERVIEW OF WOODWARD RESERVOIR DAM PLYMOUTH, VERMONT

f. Dam Failure Analysis

In the event the Woodward Reservoir Dam failed with the water elevation level at the top of the dam an initial wave of approximately 20 feet high would be released. The discharge would be approximately 10,500 CFS. Due to the steep mountain side slopes, this wave would continue down the valley. Approximately 1200 feet downstream Route 100 would be overtopped by 2 feet of water, surcharging the culvert there, and because of the steep channel gradient, this section of highway would be destroyed. About 5200 feet downstream of the dam, a house which sits on the bank of the Reservoir Brook, 11 feet above the streambed, would be undermined and destroyed. Further downstream, approximately 6200 feet from the dam, five or six homes are situated in a field near the brook. At this point the water would be 2 feet deep surrounding the homes, two of which are approximately 14 feet above the streambed. Thus much damage and possible loss of lives would result if the Woodward Reservoir Dam failed.

SECTION 5 - HYDRAULIC AND HYDROLOGIC EVALUATION

5.1 Evaluation of Features

a. General

The Woodward Reservoir Dam is an earth fill masonry dam with a concrete spillway which acts as a broad crested weir. The impoundment is used solely for recreation.

b. Design Data

There is no existing design data available for this dam. The hydraulic/hydrologic calculations were based on field measurements.

c. Experience Data

There are no records available for Woodward Reservoir. However, according to the Plant Manager, Bruce Nelson, the dam was slightly overtopped during the 1973 flood. Water during the June-July 1973 flood flowed over the dam at each of the abutments.

d. Visual Observation

The visual inspection of the dam revealed erosion at both right and left upstream abutments, caused by the 1973 flood. Also observed was the severely scoured downstream face, with only remnants for training walls. One major seep was found on the downstream left abutment approximately 3 feet higher in elevation than the low-level outlet. This leakage was believed to be coming either through the mass of the dam or around the entire abutment.

e. Test Flood Analysis

Based on a size classification of intermediate and a hazard classification of significant, the test flood was selected to be one-half the probable maximum flood (1/2 PMF). The test flood was developed using the computer program HEC-1 from the U. S. Army Corps of Engineers. The peak inflow was found to be 4732 CFS (1649 CSM) and after routing through surcharge storage, the routed test flood outflow is 2554 CFS. During the test flood the Woodward Reservoir Dam would be overtopped by approximately 2.8 feet of water, assuming that the spillway stop logs were not in place and that neither the left abutment nor Route 100 were eroded first. The combined capacity of the low-level outlet and the spillway is 564 CFS which is 22 percent of the test flood.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures

The established operational procedures for the Woodward Reservoir Dam consist of regulation of the water level. In the fall the level is lowered by opening the low-level outlet, and in the spring the level is allowed to rise and is maintained throughout the summer by the placement of stop logs.

4.2 Maintenance of Dam

There is no maintenance being performed on this dam.

4.3 Maintenance of Operating Facilities

The maintenance of the operating facilities consists of periodic inspection, operation and necessary repair of the gate and gate house controlling the low-level outlet. According to the Plant Manager, Bruce Nelson, the valve stem had to be repaired in April of 1978.

4.4 Description of Warning System

None exists for the Woodward Reservoir Dam

4.5 Evaluation

The maintenance of the gate house and valve is adequate. The maintenance program should be extended to include the clearing of brush and a few trees immediately downstream of the dam.

In addition, a plan for spillway and low-level outlet flow control should be initiated and maintained during periods of flooding and heavy rains.

spillway is in very poor condition. As Photo 8 indicates, the concrete facing has been completely scoured, exposing reinforcing rods and large cobbles which were used as aggregate. The photograph also shows the remains of two training walls which have been completely worn away.

Upstream of the spillway sits a gate house elevated above the spillway floor slab by two concrete supporting walls (Photo 3). The gate house provides control of a 2-foot square stone lowlevel outlet. According to the Plant Manager, the low-level outlet has a log bar screen on the intake. The inlet was under water and not visible during the inspection. The gate is in good working condition and was operated easily during the inspection. The stem had to be repaired in April of 1978. The downstream end of the low-level outlet has been severely scoured (see Photo 6) and with the added effect from the emergency spillway directly above, has started to undermine the dam.

d. Reservoir Area

The reservoir area consists of approximately 101 acres and is used solely for recreational purposes. The upstream banks have trees growing on them with roots being exposed, indicating slight sloughing of the banks. Some sedimentation has occurred directly upstream of the dam.

e. Downstream Channel

The channel downstream of the Woodward Reservoir is a natural streambed. Several trees have grown immediately downstream of the dam, and some debris has collected. The remainder of the channel is very rough filled with many boulders (see Photo 7).

3.2 Evaluation

The dam was found to be in poor condition based on the visual inspection. Some erosion and sloughing have occurred on the upstream abutments. The gate house and service gate are in good condition. However, the downstream spillway face has completely deteriorated including the training walls. Further deterioration is likely to continue when water flows through the spillway. Along with the scouring effect, undermining of the dam has started and is endangering the stability of the dam. A seep of 7 to 8 GPM was discovered at the left abutment, thought to be flowing through the dam. The trees growing on the downstream masonry wall can accelerate deterioration of the wall.

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SECTION 3 - VISUAL INSPECTION

3.1 Findings

a. <u>General</u>

The Woodward Reservoir Dam is judged to be in poor condition based on the visual inspection. The downstream face of the emergency spillway has scoured badly and leakage was found near the left abutment.

b. Dam

The dam is an earth fill stone masonry dam located on the northern end of the reservoir adjacent to Route 100. The dam is approximately 150 feet long with a top width of 48 feet and a maximum height of 30 feet. The upstream face of the dam is protected by a concrete slab and concrete wall as shown in Photos 1 and 2.

The condition of the concrete is fair with spalling occurring particularly at construction joints. Some erosion has occurred at the left and right abutments as shown in Photos 1 and 5. According to the Plant Manager, Bruce Nelson, this happened during the 1973 flood.

The downstream vertical face is constructed of stone masonry and is in fair condition. Some small trees have been allowed to grow from the masonry (see Fhoto 7). Photos 9 and 10 show leakage from the left abutment. The cardboard box shown in Photo 9 can also be seen in Photo 8 and indicates the location of the seep in relation to the left abutment. The leakage was found to be 3 feet higher in elevation than the low-level outlet which would indicate the flow is coming through the dam or possibly around the left abutment. The flow was estimated at 7 or 8 gallons per minute.

c. Appurtenant Structures

The concrete emergency spillway is located in the center of the dam and is 13.9 feet wide (Photos 2 and 3). Over it sits an access bridge (See Photo 4). The distance between the spillway floor and the I-beams of the bridge is 3.5 feet. The spillway floor and walls are in good condition. One crack has developed in the right spillway wall and spalling has occurred along the top of the walls and several other locations. On the upstream end of the spillway are two concrete abutments which allow for the placement of 2-feet of stop logs. The stop logs are placed diagonally between the end of the spillway and the back of the gate house. The downstream vertical face of the

SECTION 2 - ENGINEERING DATA

2.1 Design Data

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There is no design information available for this dam.

2.2 Construction Data

There is no significant construction data available other than a builder's plaque set into the concrete wall at the dam site, and some correspondence on file with the Vermont Department of Water Resources. The plaque indicates that the dam was constructed in 1922 by Barry, Cashman & Company, Inc., Engineers and Constructors, Boston. According to the correspondence, the spillway walls and floor slab were replaced in May of 1966. Mention was made of leakage discovered during the spillway replacement, yet no remedial measures were recorded. 1

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2.3 Operation Data

Operational procedures have been assigned to Mr. Bruce Nelson, Plant Manager, by Mr. Rich Satterthwaite (telephone 802-422-3445). Mr. Nelson's duties involve installation and removal of stop logs, operation of the valve controlling the low-level outlet, and general supervision of the dam site. The water level of the reservoir is lowered in the fall to prevent ice damage to the gate house during the winter. In the spring the level is allowed to rise and is maintained during the summer months with the placement of stop logs for recreational purposes.

2.4 Evaluation of Data

a. Availability

The design and construction records for this dam are not available.

b. Adequacy

The structural and hydraulic adequacy of this dam could not be determined based on original design calculations and plans, but rather on visual inspection, past performance history and sound engineering judgment.

c. Validity

Not applicable.

(10) Other

Not applicable.

h. Diversion and Regulating Tunnel

Not applicable.

i. Spillway

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(1) <u>Type</u>

Concrete spillway, acting as a broad crested weir/orifice controlled by 2 feet of stop logs.

(2) Length of Weir

13.9.

(3) <u>Crest Elevation</u>

1344.

(4) <u>Gates</u>

None.

(5) Upstream Channel

Reservoir approach channel.

(6) Downstream Channel

Natural streambed.

(7) General

Vehicle access bridge across spillway - entrance to The Farm and Wilderness Camps.

j. <u>Regulating Outlets</u>

The only control of the water level other than the placement or removal of the 2 feet of stop logs, is the low-level outlet. The low-level outlet has a log bar screen at the intake, measures 2-feet by 2-feet, and is made from stone. Control of the outlet is provided at the gate house with a gate and stem. Capacity for the low-level outlet at normal pool elevation is 119 CFS and at the test flood elevation is 133 CFS. (3) Spillway Crest

101 acres.

(4) <u>Test Flood Pool</u>

102 acres.

(5) <u>Top of Dam</u>

102 acres.

- g. Dam
 - (1) <u>Type</u>

Masonry-earth fill with concrete lined spillway.

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(2) Length

Overall: 158 feet. Spillway: 13.9 feet.

(3) <u>Height</u>

Maximum 30 feet.

(4) <u>Top Width</u>

48 feet.

(5) <u>Side Slopes</u>

Upstream: Approximately 1 on 2. Downstream: Vertical.

(6) Zoning

None known.

(7) <u>Impervious Core</u>

None known.

(8) <u>Cutoff</u>

None known.

(9) Grout Curtain

None known.

- (8) <u>Top of Dam</u> 1349.
- (9) <u>Test Flood Surcharge</u> 1351.8.
- d. <u>Reservoir Data</u>

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- Length of Maximum Pool
 5650 feet.
- (2) <u>Length of Recreation Pool</u> 5600 feet.
- (3) Length of Flood Control Pool Not applicable.
- e. Storage Data
 - (1) <u>Recreation Pool</u> 1122 acre-feet.
 - (2) <u>Flood Control Pool</u> Not applicable.
 - (3) <u>Spillway Crest Pool</u>918 acre-feet.
 - (4) Top of Dam

1428 acre-feet.

- (5) <u>Test Flood Pool</u>1714 acre-feet.
- f. <u>Reservoir Surface Area</u>
 - <u>Recreation Pool</u>
 101 acres.
 - (2) Flood Control Pool

Not applicable.

- (4) <u>Ungated Spillway Capacity at Test Flood Elevation</u>
 587 CFS at elevation 1351.8.
- (5) <u>Gated Spillway Capacity at Normal Pool Elevation</u> Not applicable.
- (6) <u>Gated Spillway Capacity at Test Flood Elevation</u> Not applicable.
- (7) Total Spillway Capacity at Test Flood Elevation
 587 CFS at elevation 1351.8 (stop logs out).
- (8) <u>Total Project Discharge at Test Flood Elevation</u> 2554 CFS at elevation 1351.8.
- c. Elevation Data
 - (1) <u>Streambed at Centerline of Dam</u> 1319.-
 - (2) <u>Maximum Tailwater</u>
 - Not applicable.
 - (3) <u>Upstream Portal Invert Diversion Tunnel</u> Not applicable.

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- (4) <u>Recreation Pool (Normal)</u>1346 (includes 2' of stop logs).
- (5) <u>Full Flood Control Pool</u> Not applicable.
- (6) <u>Spillway Crest</u> 1344.
- (7) <u>Design Surcharge (Original Design)</u>Unknown.

g. <u>Purpose</u>

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The dam was originally built to act as storage and to regulate stream flow for power plants located downstream. Currently the reservoir is used solely for recreational purposes associated with The Farm and Wilderness Camps.

h. Design and Construction History

According to a bronze plaque set into the left abutment, the original dam was built in 1922. No design or construction data are available.

i. Normal Operating Procedures

There are no routine operations involved with this dam other than opening the low-level outlet in the fall and closing it and installing stop logs in the spring. The water level is lowered for the winter duration to prevent ice damage to the gate house, and is allowed to rise in the spring for summer recreational purposes.

1.3 Pertinent Data

a. Drainage Area

The total drainage area for the Woodward Reservoir includes 2.87 square miles of moderate to steep forested land. One mountain stream drains approximately 40 percent of the basin and enters the reservoir on the southwestern section. The soils within the drainage area are well drained loamy soils with mostly shallow hardpan or bedrock.

b. Discharge at the Dam Site

(1) Outlet Works

The spillway, which is 13.9 feet wide, is spanned by an access road bridge. The only other discharge is from a low-level 2-foot square stone outlet which can be controlled at the gate house.

(2) Maximum Known Flood at Dam Site

There are no flow records available for the Woodward Reservoir.

(3) Ungated Spillway Capacity at Top of Dam

438 CFS at elevation 1349.

b. Description of Dam and Appurtenances

The Woodward Reservoir Dam is 150 feet long with a maximum height of 30 feet and a top width of 48 feet. It is an earth fill masonry dam with a vertical stone downstream wall. The exposed upstream face of the dam consists of a vertical concrete face with a height of 3.7 feet and a lower part sloping 1 vertical to 2 horizontal. Dimensions of the slab are unknown.

The gate house sits above an extended concrete slab which also serves as the floor of the emergency spillway, and provides control for a 2-foot square stone low-level outlet. A log bar screen is located on the intake of the low-level outlet.

The concrete spillway is approximately 14 feet wide by 3-1/2 feet high. A bridge spans the spillway providing access to the Farm and Wilderness Camps.

Diagonally between the gate house and upstream corners of the spillway is provision for the placement of stop logs.

c. Size Classification

The dam has a maximum height of 30 feet and an impoundment of 1428 acre-feet. The United States Corps of Engineers' guidelines place dams with impoundments more than 1000 acre-feet in the intermediate classification. The Woodward Reservoir is therefore classified as intermediate.

d. Hazard Classification

A failure of the Woodward Reservoir Dam would release an initial flood wave of approximately 20 feet in height. Due to the steep mountain slopes below the dam the wave would <u>not</u> dissipate very quickly. Several homes are located downstream along the banks of the brook. At least three houses would receive major damage. One house sits approximately 11 feet above the stream bed, while two other homes are 14 feet above the stream bed. Therefore, the hazard classification of this dam is significant.

e. Ownership

The Woodward Reservoir and dam are currently owned by:

The Farm and Wilderness Foundation, Inc. Plymouth Union, Vermont 05056

f. Operator

The dam is currently being maintained by the Farm and Wilderness Foundation, Inc. The contract is Mr. Rich Datterthwaite, telephone 802-422-3445. The Plant Manager is Mr. Bruce Nelson.

NATIONAL DAM INSPECTION PROGRAM PHASE I INSPECTION REPORT NAME OF DAM: WOODWARD RESERVOIR

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. Dufresne-Henry Engineering Corporation has been retained by the New England Division to inspect and report on selected dams in the State of Vermont. Authorization and notice to proceed were issued to Dufresne-Henry Engineering Corporation under a letter of November 20, 1978 from Max B. Scheider, Colonel, Corps of Engineers. Contract No. DACW33-79-C-0010 has been assigned by the Corps of Engineers for this work.

- b. Purpose
 - Perform technical inspection and evaluation of nonfederal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by nonfederal increasts.
 - (2) Encourage and prepare the states to initiate quickly effective dam safety programs for nonfederal dams.
 - (3) To update, verify and complete the National Inventory of Dams.

1.2 Description of Project

a. Location

The Woodward Reservoir is located in the Town of Plymouth, Windsor County, Vermont, in the south central section of the State, at $43^{\circ}34.5'$ N latitude and $72^{\circ}45.7'$ W longitude.

The dam is located immediately adjacent to Route 100, approximately 2 miles south of West Bridgewater, Vermont. The stream below the dam, called Reservoir Brook, is a tributary of the Ottauquechce River.



SECTION 6 - STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

The visual inspection did not disclose any signs of immediate instability. However, the spalling, exposed reinforcement and undermining of the downstream face of the spillway significantly reduce the degree of stability of the dam.

b. Design and Construction Data

There is practically no design or construction data available and thus, the stability of the dam cannot be formally analyzed.

c. Operating Records

Available records indicate scour of spillway channel and that repairs to the channel were made. There are no other records available which are of significance with respect to stability.

d. Post-Construction Changes

There are no records of post-construction changes.

e. Seismic Stability

The dam is located in Seismic Zone 2, and in accordance with the recommended Phase I guidelines does not warrant seismic analysis.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS/ REMEDIAL MEASURES

7.1 Dam Assessment

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a. Condition

Based on the visual inspection, the condition of the Woodward Reservoir Dam was judged as poor. The considerable spalling and erosion of the downstream face of the spillway and the undermining of its foundation endangers the safety of the dam, particularly when water flows through the spillway.

b. Adequacy of Information

Due to very limited design and construction data, the assessment of the condition of the dam is based solely on the visual inspection and engineering judgment.

c. Urgency

The recommendations presented in Sections 7.2 and 7.3 should be carried out within one year of receipt of this report by the owner.

d. Need for Additional Investigations

There is no need for additional investigations beyond those recommended in Section 7.2

7.2 Recommendations

Plans should be prepared by a qualified engineer for the following:

- a. Repairs of the undermining at toe of the spillway and design of measures to prevent future undermining.
- b. Repair of downstream face of spillway and reconstruction of training walls.
- c. Assessment of the spillway capacity.
- d. Inspection of the outlet conduit and repairs as necessary.

The lake level should be lowered a few feet below the spillway crest without stop logs along with providing continuous monitoring during high flows and operation of the gate to minimize flows over the spillway until the recommended repairs can be implemented.

7.3 Remedial Measures

- a. Operation and Maintenance Procedures
 - An annual safety technical inspection program should be instituted. It should include monitoring of the seep to the left of the spillway.
 - 2. The routine maintenance of the dam should include repair of eroded areas, patching of minor spalling in concrete and removal of trees growing on the downstream face of the dam and from the discharge channel.

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3. A formal warning plan should be prepared.

APPENDIX A

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VISUAL INSPECTION CHECK LIST

VISUAL INSPECTION CHECK LIST PARTY ORGANIZATION

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| PARTY: Walter A. Henry D-H 6 Sherward G. Farnsworth D-H 7 G. Gonzalo Castro GEI 8 | 5 7 |
|--|----------------------|
| Gonzalo Castro GEI | • |
| Bruce Nelson, Plant Manager, Farm & Wilderness Foundation | 3 9 0 |
| PROJECT FEATURE | INSPECTED BY REMARKS |
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| PERIODIC INSPECTION (| CHECK | LIST |
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| PROJECTWOODWARD_RESERVOIR | DATE <u>April 23, 1979</u> |
|---------------------------|----------------------------|
| PROJECT FEATURE | NAME |
| DISCIPLINE | NAME |

| AREA EVALUATED | CONDITION |
|--|--|
| DAM EMBANKMENT (Earth and stone | |
| Crest Elevation | 1348.5 to 1350. |
| Current Pool Elevation | 1342.5 |
| Maximum Impoundment to Date | |
| Surface Cracks | Minor cracking, upstream face. |
| Pavement Condition | Gravel road. |
| Movement of Settlement of Crest | None apparent. |
| Lateral Movement | None apparent. |
| Vertical Alignment | None apparent. |
| Horizontal Alignment | Upstream face - none apparent. Down- stream face - too irregular to judge. |
| Condition at Abutment and at Concrete Structures | Erosion at both right and left upstream abutments. |
| Indications of Movement of Structural • Items on Slopes | Not applicable. |
| Trespassing on Slopes | Not applicable. |
| Sloughing or Erosion of Slopes or Abutments | Erosion at both right and left upstream abutments. |
| Rock Slope Protection - Riprap Failures | Not applicable. |
| Unusual Movement or Cracking at or Near Toes | Not applicable. |
| Unusual Embankment or Downstream Seepage | Seepage at left side embankment, 10+ feet from spillway, 3 feet above outlet. |
| Piping or Boils | None observed. |
| Foundation Drainage Features | None known. |
| Toe Drains | None known. |
| Instrumentation System | None known. |
| Vegetation | None |
| | |
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| PROJECT WOODWARD RESERVOIR | | DATE April 23, 1970 |
|--|----------|---------------------|
| PRO IFCT FFATURE | | NAME |
| | | |
| DISCIPLINE | <u> </u> | NAME |
| | | |
| AREA EVALUATED | | CONDITION |
| IKE EMBANKMENT | NONE. | |
| rest Elevation | | • |
| urrent Pool Elevation | | |
| faximum Impoundment to Date | | |
| Surface Cracks | | |
| Pavement Condition | | |
| ovement or Settlement of Crest | | |
| ateral Movement | | |
| ertical Alignment | | |
| orizontal Alignment | | |
| condition at Abutment and at Concrete Structures | | |
| Indications of Movement of Structural Items on Slopes | | |
| respassing on Slopes | | |
| loughing or Erosion of Slopes or Abutments | | |
| ock Slope Protection - Riprap Failures | | |
| Jnusual Movement or Cracking at or Near Toes | | |
| Jnusual Embankment or Downstream Seepage | | |
| iping or Boils | | |
| oundation Drainage Features | | |
| oe Drains | | |
| nstrumentation System | | |
| Vegetation | | |
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| PROJECT WOODWARD_RESERVOIR | DATE <u>April 23, 1979</u> | |
|--|--|--|
| PROJECT FEATURE | NAME | |
| DISCIPLINE | NAME | |
| AREA EVALUATED | CONDITION | |
| OUTLET WORKS - INTAKE STRUCTURE | | |
| a. Approach Channel Slope Conditions Bottom Conditions Rock Slides or Falls Log Boom Debris Condition of Concrete Lining Drains or Weep Holes | Below water surface, unable to pass judgment. | |
| b. Intake Structure Condition of Concrete Stop Logs and Slots | Below water surface, unable to pass judgment | |
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| PROJECT WOODWARD RESERVOIR | DATE APRIL 23, 1979 | |
|---|---|------------|
| PROJECT FEATURE | NAME | • |
| DISCIPLINE | NAME | |
| | | |
| AREA EVALUATED | CONDITION | |
| OUTLET WORKS - CONTROL TOWER | | |
| a. Concrete and Structural | | |
| General Condition | Good condition. | |
| Condition of Joints | None visible, below water level if any exist. | |
| Spalling | Minor spalling. | - - |
| Visible Reinforcing | Left corner, ice has chipped off corner, minor to total structure. | |
| Rusting or Staining of Concrete | None observed. | |
| Any Seepage or Efflorescence | None observed. | |
| Joint Alignment | Not applicable. | |
| Unusual Seepage or Leaks in Gate Chamber | None observed. Gate was shut at time of inspection. | |
| Cracks | None observed. | • |
| Rusting or Corrosion of Steel | Not applicable. | |
| b. Mechanical and Electrical | | |
| Air Vents | None observed. | |
| Float Wells | None observed. | |
| Crane Hoist | None observed. | |
| Elevator | None observed. | |
| Hydraulic System | None observed. | |
| Service Gates | Good working condition. Repaired April 1978. Hand operated. | |
| Emergency Gates | Not applicable. | |
| Lightning Protection System | Not applicable. | |
| Emergency Power System | Not applicable. | • |
| Wiring and Lighting System | Not applicable. | |
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| PROJECT WOODWARD RESERVOIR | DATE April 23, 1979 | |
|---------------------------------------|---------------------|-------|
| PROJECT FEATURE | NAME | |
| DISCIPLINE | NAME | |
| AREA EVALUATED | CONDITION | |
| OUTLET WORKS - TRANSITION AND CONDUIT | Not Applicable. | |
| General Condition of Concrete | | |
| Rust or Staining on Concrete | | |
| Spalling Erosion or Cavitation | | |
| Cracking | | |
| Alignment of Monoliths | | |
| Alignment of Joints | | |
| Numbering of Monoritins | | |
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| PROJECT WOODWARD RESERVOIR | DATE April 23, 1979 | |
|---|---------------------|--|
| PROJECT FEATURE | NAME | |
| DISCIPLINE | NAME | |
| AREA EVALUATED | CONDITION | |
| OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL | Not Applicable. | |
| General Condition of Concrete Rust or Staining | | |
| Spalling Frosion or Cavitation | | |
| Visible Reinforcing | | |
| Any Seepage or Efflorescence | | |
| Condition at Joints | | |
| Drain Holes | | |
| Channel Loose Rock or Trees Overhanging Channel | | |
| Condition of Discharge Channel | | |
| | | |
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| | PERIODIC INSPECTIO | DN CHECK LIST | : |
|-----|--|--|----------|
| PRO | JECTWOODWARD RESERVOIR | DATE <u>April 23, 1979</u> | |
| PRO | JECT FEATURE | NAME | |
| DIS | CIPLINE | NAME | |
| | | | Ī |
| | AREA EVALUATED | CONDITION | |
| | 'LET WORKS - PRINCIPAL SPILLWAY EIR. APPROACH AND DISCHARGE CHANNEL | | . , . |
| ı. | Approach Channel | Under water. | . , |
| | General Condition | Good condition. | · • |
| | Loose Rock Overhanging Channel | Not applicable. | |
| | Trees Overhanging Channel | Yes. | . |
| | Floor of Approach Channel | Lake bed with some sediment. | |
| 5. | Weir | | • |
| | General Condition of Concrete | Good. | |
| | Rust or Staining | None observed. | - |
| | Spalling | Minimal. | |
| | Any Visible Reinforcing | None. | |
| | Any Seepage or Efflorescence | None. | |
| | Drain Holes | None. | |
| 2. | Discharge Channel | Natural river bed. | |
| | General Condition | Good. | |
| | Loose Rock Overhanging Channel | Very steep slopes 1:1-1/2 (V-H). | |
| | Trees Overhanging Channel | Several. | i I |
| | Floor of Channel | Boulders. | |
| | Other Obstructions | None. | ļ |
| d. | Spillway (Downstream Face) | Concrete Structures . | |
| | General Condition of Concrete | Very poor condition for full height. | - |
| | Rust or Staining | Very poor condition for full height. | |
| | Any Visible Reinforcing | Very poor condition for full height. | |
| | Drain Holes | None. | 1 |
| | Training Walls | Very poor condition, training walls partly all gone, severe undermining. | |
| | | | 1 |
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| PERIODIC INSPECTI | ION CHECK LIST | |
|----------------------------------|---|-----------|
| PROJECT WOODWARD RESERVOIR | DATE April 23, 1979 | |
| PROJECT FEATURE | NAME | |
| DISCIPLINE | NAME | |
| ΑΡΕΑ ΕΥΔΙ ΠΑΤΈΡ | CONDITION | |
| OUTTIET LOOPES - SEDU ICE BDIDCE | | |
| COTELT WORKS SERVICE BRIDGE | Not applicable. | |
| a. Super Structure | | |
| Bearings | | |
| Anchor Bolts | | |
| bridge Seat | · · | |
| Longitudinal Nembers | | |
| Socondary Presing | | |
| Deck | | |
| Drainage System | | |
| Pailinge | | |
| Expansion loints | | |
| Paint | | |
| b. Abutment & Piers | | |
| General Condition of Concrete | | |
| Alignment of Abutment | | |
| Approach to Bridge | | |
| Condition of Seat & Backwall | | |
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| PROJECT | DATEApri1_23, 1979 | |
|--|--|----------|
| PROJECT FEATURE | NAME | |
| | | |
| DISCIPLINE | NAME | |
| AREA EVALUATED | CONDITION | |
| RESERVOIR AREA | | |
| Stability of Shoreline | Some erosion. | |
| Sedimentation | Not observable. | |
| Changes in Watershed Runoff Potential | Minimum. | |
| Upstream Hazards | Possibly a few homes are reached by high flows over dam crest. | |
| Downstream Hazards | Several homes. | |
| Alert Facilities | None known. | |
| Hydrometeorological Gauges | None known. | |
| Operational and Maintenance Regulations | None. | |
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" WATER RENOURCES

OFFICE MEMORANDUM

DATE April 6, 1966

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for the Record

Donald W. Webster

ICT: Woodward Reservoir Spillway Dimensions

On April 6, 1966, the writer measured the spillway section of Woodward Reservoir and found the following:

Width of spillway 14 feet 1 inch Height of spillway walls above spillway floor West side 3 feet 5½ inches East side 3 feet 4½ inches

This gives a capacity flow based on a coefficient C = 3.3of 247 cubic feet per second.



- (2) Installation of a suitable apron below the overflow channel to check scour at the base, and
- (3) possibly, some relief of the congestion at the entrance to the overflow channel.

BY Stiplin H. Haybrook HYDRAULIC ENGINEER

ublic Fervice Commission ecember 9, 1952 orizontal slope.

Directly underneath is a low level, regulated outlet. It is 3 ft. dia. conduit equiped with gates and trash rack at the upstream end. The gate house sits at the entrance to the overflow shannel.

ments on inspection

The dam was more recently inspected on Nov. 16, 1952 at a time on the reservoir was well drawn down. Observations were as follows:

- (1) On the downstream side, the stone masonry wall shows a localized weakened condition in the vicinity of the overflow. A concrete lining below the overflow channel to provide a water face down the vertical wall is deeply scoured from the action of water. Also, there is some foundation scour at the base because of the uncontrolled vertical 25 ft. drop of any water passing through the overflow.
- (2) The concrete lining on the upstream face shows spalling and cracking mainly in the upper portions.
- (3) The overflow channel also shows a surface condition.
- (4) There is congestion at the entrance to the overflow channel due to the location of the gate house directly in line and in close proximity.
- (5) The structure has a massive section which enhances its stability in general.

<u>iclus!ons</u>:

In the writer's summary report on dams, this structure was satisfied in Group II as being capable of some damage in the event 'ailure. As such, it should be maintained in a reasonable condition. 'ticular attention may be directed to:

(1) Maintenance repairs,

2 -



Dame: Nydio-ilec Bridgewale Ofice.

Woodward Reservoir dam is owned and operated by a group of water power operators, among which are two electric utilities. Because of this connection the dam is reported to this Commission.

Pertinent data

| 1. | Location | of | Dam | - | Tributary of | Ottauquechee | River, | town |
|----|----------|----|-----|---|--------------|--------------|--------|------|
| | | | | | of Plymouth. | | | |

- 2. ^Uwners of dam Bridgewater Woolen Co., Woodstock Electric Company, Harris Emery Co., and A. G. Dewey Co. - combined to form the Woodward Reservoir Corp.
- 3. Purpose of dam Storage for stream flow regulation for power plants downstream.
- 4. Size of reservoir -Surface area is given as 100 acres, volume is estimated at 40,000,000 cu. ft.

5. Drainage area About 2 sq. mi.

Description of the dam

This dam is essentially an embankment retained by an unpaved mesonry wall on the downstream side. It measures about 150 ft. long and 30 ft. high at the maximum section. It has a top width of about 50 ft. While the downstream face is vertical, the upstream face slopes at about 1 on 1. The latter is protected by a concrete slab which also serves as a flow retarding element. The dam is on a hard pan foundation.

A rectangular, concrete-lined overflow channel is provided near the west end. It is 4 ft. deep and 14.5 ft. wide and has a practically

Kames: Nylo-skeetries

June 9, 1953

Mr. Carl Bennett, Supt. Woodstock Electric Company Woodstock, Vermont

Dear Mr. Bennett:

I understand that your company has an interest in the Woodward Reservoir dam located in the town of Flymouth. For this reason I am sending you a copy of my report on the structure as submitted to the Commission after an inspection last fall.

I have again inspected this dam in May and found, for additional comments, the overflow cluttered with debris, a minor seepage condition, and insufficient freeboard.

Your attention is invited to my appraisal of the fitness of this dam.

Very truly yours,

STEPHEN H. HAYBROOK HYDRAULIC ENGINEER

· SHH/ef

Enc.

Manie): Vydro-electric

Mr. R. M. Sharpe, Vice Pres. Bridgewater Electric Company Bridgewater, Vermont

Dear Mr. Sharpe:

I understand that your company has an interest in the Woodward Reservoir dam located in the town of Plymouth. For this reason I am sending you a copy of my report on the structure as submitted to the Commission after an inspection last fall.

I have again inspected this dam in May and found, for additional comments, the overflow cluttered with debris, a minor seepage condition, and insufficient freeboard.

Your attention is invited to my appraisal of the fitness of this dam.

Yours very truly,

June 9, 1953

STEPHEN H. HAYBROOK HYDRAULIC ENGINEER

SHH/of

Enc.

MENT OF WATER RESOURCES

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OFFICE MEMORANDUM

For the Record

Andre J. Rouleau

IE_ECT: Woodward Reservoir (Plymouth Pond), Plymouth, Vermont

December 30, 1970

Received a telephone call from Mr. Earl Cram on December 28, 1970, who has a camp on the pond. He was concerned about the procedure for registering concern about the management of water levels of the pond. I had suggested to a colleague of his that he should write a letter outlining the problem.

In general, the lake is drawn down in a 2 to 3 week period, to about 12 to 15 feet below normal summer level. There is more than 20 acres left when the lake is drained to the bottom of the dam.

In 1969, drawdown commenced in mid-August in order to repair docks at the Webb's. Actual repair started in early November.

In 1970, drawdown commenced in mid-August to repair the dam. Actual repair started in early November.

The point that Mr. Cram makes is that these objectives could still be attained without an early drawdown which adversely affects the other landowners on the pond and also the general public who views the lake and use the Fish and Game Department access.

He also wished to alert us about a building foundation on the lakeshore in the vicinity of an island which is about 2 feet above the water level (southerly of the fishing access). The reported price paid is \$25,000. for $1\frac{1}{2}$ acres, which leads him to expect a major use of that land with no apparent solution to pollution.

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| FILE | Martin Contractor | , e |

VERMONT DEPARTMENT OF MATER RESOURCES

INFORMATION SUCET

Name of Dam Configured Aug. Town Manuel Owner <u>Kunneth With</u> Name of Stream <u>Othernether Ruin Tail</u> Former Withformers Compro Sure Address <u>Hypourch Classification</u> Comment 05051 U.S.G.S. Coordinates: Lat. <u>13' 24' :4"</u> Long. <u>77' 15' 42"</u> U.S.G.S. Map Kilmin Parts (15) Aerial Photos A worth 16-124,25 U.S.G.S. Elev. 2 Spillway 1346 Total Length of Dam 148133 Crest Width of Emergency X' 13-7' Spillwav Width of Ton 417 Maximum Height 28.5' Spillway Capacity: Principal______Fmergency_____ Pond Area 100 deares Prainage Area 200 deares Pond Volume: Normal Water Level ____ Design High Water Level_____ Maximum Water Depth: Mormal Water Level ____ Design High Water 10' Level Storage Before Emergency Spillway is Used_____ Use of Reservoir dignational Description of Dam: Some mariny and sant fill Description of Spillwav(s): Cincula nea Designed by _____Year Built _____ Hearing Date_____Order Date_____ Additional Remarks:







| Remarks The above questions are framed for a pond TO BE CONSTRUCTED. This is a repair job which doesn't need doing now, but is more conventiont now because the Town is put in a new bridge over the spillway with I-beams! We propose to re-surface the floor of spillway h-6 deep erhaps 2" would be ficient; we'll be glad of your counselser to set up new side walls just inside for even to cracking walls, probably 8" thick () if you think less would do). Since the men and equipment are about thru working at the Camps, we would like to catch them. | ir - sti sf ti le: he |
|---|-----------------------------------|
| now, to save expense. Please let us (owner) | |
| And Donald Webster, Name of Engineer, if any | |
| Wote No. 1: for close with Unstapplication thereiting. KEW. | · |
| and Specifications. | |

Note No. 2: Enclose copy of letter of notice to selectmen of the town in which such dam is to be located.

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Form WR-33

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| • | r, Vermont | |
|---|--|---|
| | | RMIT FOR DAM |
| Owner FARM AND WILDEPRESS CAMPS | | Date APRIL 1st, 1966 |
| P. O. Address Plymouth Union | | |
| | | Tel. No. 457-2141 (Wdstk) |
| Location of Structure: | | |
| Town Plymouth | Shown or | USGS Quadrangle |
| Name of Stream Lake: Woodward Reservoir | at | inches south of Lat. north |
| | and | inches east of Long |
| • This is an application for: (New Construction) (A | Iteration) | Repair) (Removal) |
| This pond is to be used for: swimming, cance: | ing, fish | ing, etc. |
| This pond is to be used for: swimming, cance: | ing, fish 1 1 miles | ing, etc. area Somebody.said 100.acres. |
| This pond is to be used for: swimming, cance: Dimensions of Pond: width = mile length : Maximum depth of water immediately above dam: | ing, fish 1 ¹ / ₂ miles c. 10 fea | above) ing, etc. area Somebody.said 100.acres |
| This pond is to be used for: swimming, cance: Dimensions of Pond: width 1 mile length Maximum depth of water immediately above dam: Volume of water in cubic feetover 500,000 | ing, fish 1 ¹ / ₂ miles c. 10 fea | area Somebody.said 100 acres. |
| This pond is to be used for: swimming, cance: Dimensions of Pond: width 1 mile length Maximum depth of water immediately above dam: Volume of water in cubic feetover 500,000 Total length of dam: 145 | ing, fish 1 ¹ / ₂ miles c. 10 fe | ing, etc. area Somebody.said.100.acres. |
| This pond is to be used for: swimming, cance: Dimensions of Pond: width 1 mile length Maximum depth of water immediately above dam: Volume of water in cubic feetover 500,000 Total length of dam: 148 for the Crest width of spillway: 14 | ing, fish l ¹ / ₂ miles c. 10 fea | area Somebody.said 100.acres. |
| This pond is to be used for: swimming, cance: Dimensions of Pond: width $\frac{1}{2}$ mile length Maximum depth of water immediately above dam: Volume of water in cubic feetover 500,000 Total length of dam: 143 | ing, fish 1 ¹ / ₂ miles c. 10 fe | area Somebody said 100 acres. |
| This pond is to be used for: swimming, cance: Dimensions of Pond: width $\frac{1}{2}$ mile length Maximum depth of water immediately above dam: Volume of water in cubic feetover 500,000 Total length of dam: 148 mile Crest width of spillway: 14 Height of dam: 248 mile Width of top: 48 mile | ing, fish 1 ¹ / ₂ miles c. 10 fe | area Somebody said 100 acres. |
| This pond is to be used for: swimming, cance: Dimensions of Pond: width $\frac{1}{2}$ mile length Maximum depth of water immediately above dam: Volume of water in cubic feetover 500,000 Total length of dam: 113 met Crest width of spillway: 14 Height of dam: 143 met Width of top: 433 met Width of base: -3232 methods. | ing, fish 1 ¹ / ₂ miles c. 10 fe | area Somebodysaid 100acreset |
| This pond is to be used for: swimming, cance: Dimensions of Pond: width $\frac{1}{2}$ mile length Maximum depth of water immediately above dam: Volume of water in cubic feetover 500,000 Total length of dam: 113 | ing, fish 1 ¹ / ₂ miles c. 10 fe | ing, etc. area Somebody.said 100.acres. et |
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APPENDIX B

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PROJECT RECORDS AND PLANS

RTMENT OF WATER RESOURCES MONTPELIER, VERMONT

OFFICE MEMORANDUM

DATE May 10, 1966

TO: For the Record

FROM: Donald W. Webster

-SUBJECT: Woodward Reservoir Dam

On May 10, 1966, the writer went to the Woodward Reservoir to inspect the status of the outlet structure in accordance with instructions from the Commissioner's office. The contractor was on the scene and in conjunction with the writer, looked over the conditions at the outlet. The concrete wingwalls and sidewalls of the spillway had been removed preparatory to replacement. The floor slab of the spillway was still in place. A readily apparent leakage under the spillway was visible from the area where the sidewalls were formally located. The holes under the slab apparently extend throughout most of the dam. However, the full extent is not visible so long as the slab remains in place. The contractor wanted advise as to repair and was instructed that the Department of Water Resources was not going to supply such technical assistance but that Mr. Webb, the owner, had promised in October of 1965, that he would contact Peter Gratiot of Woodstock for engineering assistance. The contractor was told by the writer that the State of Vermont would suggest to Mr. Webb that the services of a professional engineer, Peter Gratiot et al, be obtained and that the spillway floor be removed in order that a full visual inspection could be made by the engineer in preparing a method of repair. He promised to convey this to Mr. Webb.

The other two items that Mr. Webb wis concerned about; the septic tank situation and the filling of the lake, were checked into by the writer. It does appear that two new camps have been constructed on Woodward Reservoir at which septic tanks are being installed with no leaching field and in fact, direct discharge from the tank to the reservoir. This matter should be looked into by our Water Pollution Control Inspector. The second problem of filling into the reservoir concerns an area perhaps 100 feet square about one-quarter mile south of the outlet structure. The contractor was told that there is no State statute inforceable by this Department which can prevent such occurances. Indeed, there would be some question as to this Department's responsibility even if the "Lands under Public Waters" Bill had been enacted by the last session of the Legislature as an determination would have to be made as to whether this is initially a public water of the State of Vermont or whether if a probably artificial reservoir falls in the realm of private property.



FARM AND WILDERNESS CAMPS

Timberlake • Indian Brook • Tamarack Farm • Saltash Mountain • Flying Cloud

PLYMOUTH UNION, VERMONT 05057 WINTER ADDRESS: Woodstock, Vermont 05091

October 22, 1965

Mr. Rheinhold Thieme Commissioner, Department of Water Resources Montpelier, Vermont

Dear Lr. Thieme:

I am still awaiting a reply to my letter of some time ago to you about inspection by a competent engineer of the dam on the Woodward Reservcir.

Personally, I am not in the least concerned about the condition of the dam, for I think it is all right, and that the small loss of water has been going on for years, probably, and presents no danger of anything more. However, if we have got to let down the water, I want to do it before cold weather, since we have to close the dam by the time the water starts to freeze in order to get a good head for another year.

Will you please let us know, therefore, whether to forght about this, or to expect a visit from your engineer. If the latter, I should be glad to know when, so I can get a chance to go out there with him and open the gatehouse, and also discuss the whole thing with him. After Friday of this week, I shall be in Woodstock.

Sincerely,

Germeth B. Webt

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Kenneth B. Webb

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FARM AND WILDERNESS CAMPS

Timberlake • Indian Brook • Tamarack Farm • Saltash Mountain • Flying Cloud

PLYMOUTH UNION, VERMONT 05057 WINTER ADDRESS: Woodstock, Vermont 05091

October 11, 1965

Mr. Rheinhold Thieme Department of Water Resources Montpelier, Vermont

Dear Mr. Thieme:

You may remember our little talk at the spring meeting of the Vernont Camping Association.

We have a problem here about which Rex Jillson may possible have written you. We have been losing a little water through our dam on Plymouth Pond (Woodward Reservoir). It is not a bad leak, and it has probably been going on for years, but we should like to have it inspected by some competent engineer. Since the lake has a capacity of over 500,000 gallons, Rex Said that you people should be brought in on this.

I should be happy to know of when such an engineer might come, so that I could be there and talk with him. Of course we are very anxious to save any large bill at the present time, since we have not budgeted it, but I suppose we will have to do what is immediately essential for the safety of the dam.

Sincerely,

Kenneth B. Webb

Kenneth B. Webb

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OFFICE MEMORANDUM

DATE October 26, 1965

For the Record

🗅 Donald W. Webster

BJECT: Woodward Reservoir

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The writer contacted Mr. Kenneth B. Webb of Farm and Wilderness Camps, Woodstock, Vermont, in regard to the leak at the dam on Woodward Reservoir. It appears that although there has been surface deterioration of the masonry face of the dam over the years, the problem involved at the present time, however, is that of a leak around the gate structure. After discussion with Mr. Webb, he was advised that this probably would fall in the nature of repair rather than of reconstruction of the dam. However, he was further advised that should an investigation show that the dam or a portion would have to be reconstructed then it would not be either ethical or legally possible for the Department or representatives thereof to take an active part in the design of any improvements.

Mr. Webb stated he was cognizant of this and the reasons for it, and agreed that he would contact Mr. Peter Gratiot for advise, and if the matter was simple repair or maintenance then there would be no further need for action by this Department. If, however, it should necessitate reconstruction or other involved work, then this Department will be advised and the necessary legal requirements will be met.

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FARM AND WILDERNESS CAMPS

Timberlake · Indian Brook · Tamarack Farm · Saltash Mountain · Flying Cloud

PLYMOUTH UNION, VERMONT 05057 WINTER ADDRESS: Woodstock, Vermont 05091

Npril 1st, 1966

Messrs. Dola Datis, Chm. Hervey Gray Donald K. Martin

Der Friends:

This is just to inform you in compliance with the law that we are going to make the minor repairs on the spillway at Woodward before you put in the new bridge. We are applying to the Waver Resources Board for permission to make these repairs, since they are required to assure the safety of any dam impounding more than 500,000 callons of water.

Incidentally, we find that the loke is regarded as "private", since it was formed orignally by building the dam. This is nows to us, and interesting, since if some of those throttle-happy water-skiers who prefer to infest small lakes rather than going to Bomoseen or Champlain become too dangerous to our canceists from the three camps on the Peserveir, we may be able to do something about it.

We certainly are glad to have the I-bdams going in (and us hopers slightly wider bridge) for it was sometimes hard to persuade a new driver of one of the big busses at the start of camp that he should go over that old wooden bridge. Mur only talking-point use that the bridge hadn't gone thru yet!

Sincorely,

11-05 10,266

P.S. Morriam is just waiting for the above permission from the WEB to get started on this job. KH



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APPENDIX C

PHOTOGRAPHS

- 1. View from right abutment showing gate house.
- 2. View showing left abutment, gate house, spillway and access bridge.
- 3. View showing gate house, spillway and bridge.
- 4. Close-up of spillway and access bridge.
- 5. View of right abutment.
- 6. Downstream view of low-level outlet.
- 7. View of downstream channel and downstream masonry face.
- 8. Close-up of downstream face showing exposed reinforcing and remains of training walls.
- 9. View showing seep downstream of dam.

10. Close-up of seep.

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#1. VIEW FROM RIGHT ABUTMENT SHOWING GATE HOUSE



#2. VIEW SHOWING LEFT ABUTMENT, GATE HOUSE, SPILLWAY AND ACCESS BRIDGE



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#3. VIEW SHOWING GATE HOUSE, SPILLWAY AND BRIDGE

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#4. CLOSE-UP OF SPILLWAY AND ACCESS BRIDGE

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#5. VIEW OF RIGHT ABUTMENT



#6. DOWNSTREAM VIEW OF LOW-LEVEL OUTLET

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#7. VIEW OF DOWNSTREAM CHANNEL AND DOWNSTREAM MASONRY FACE



#8. CLOSE-UP OF DOWNSTREAM FACE SHOWING EXPOSED REINFORCING AND REMAINS OF TRAINING WALLS

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APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS



#9. VIEW SHOWING SEEP DOWNSTREAM OF DAM. NOTE CARDBOARD BOX LOCATION IN THIS PHOTO AND IN PHOTO #8.



#10. CLOSE-UP OF SEEP

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| DUFRESNE-HENRY ENGINEERING CORPORATION | <u></u> |
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| INALEONINGD SUBJECT MODINICO RECEIVOIR SHEET NO. 2 OF 33 ATE 3-29-78 TEST FLOOD JOB NO. 04-0090 | |
| FOR SMALL DAM WITH SIGNIFICANT HAZARD - TEST FLOOD 100 yr - 1/2 P.11.F. | |
| FOR 100 YR FLOOD - FROM SOILS CONSEEVATION SERVICE 100 YR RAINFALL = 5.6" (47-3) DOMINANT SOIL TYPE "C" CURVE NO 73 SLOPE MODERATE | |
| 12'41 ES -1027 100 YE PEAR DISCHAREGE = 1150 CF.S. TRIMTABLE 2.2; (.75)(1150) = <u>663 CFS</u> | |
| FOR V2 P.M.F - FROM CORIS DE ENGLINEERS MAXIMUM PROBASLE DISCHMUGETS INI PHASE I DAM SAFETY INVESTIGAT FROM GRAPH USING 2.87 39 MI V2 PMT = 05 (2450)(2.87) = 3516 CFS -75(3516) = 2637 C.C.S. | |
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| DUFRESNE-HENRY ENGINEERING CORPORATION | |
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| DATE 3-29-79 HEC-1 COMPUTER INPUT DATA JOB NO. 04-0090 | |
| Soil Hydrzologic GROUP "C" EUNOFF CUIZVE NO. 73 | |
| INITIAL RAINTE <u>SOMETES</u> INITIAL RAINTENLL COSSES <u>SOMENES</u> INFILTRATION RATE <u>12 INICHES</u> | |
| $\frac{AVERAGE}{EVENEGE} = \frac{3000 - 1580}{VERAGE} $ $EVENEGE = \frac{3000 - 1580}{VERAGE} $ | |
| $\frac{1}{12} = 2.2 \left(\frac{L}{15} \right)^{.37} = 2.2 \left[\frac{2.84(.6)(2.54)}{15} \right]^{.37} = 1.18$ | |
| BOND STORAGE ASSUME STORAGE INCREMSES BY 102 AC-FT PER FOOT OF RISE | |
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DUFRESNE-HENRY ENGINEERING CORPORATION SUBJECT KODWARD RECERVOIR SHEET NO. 1 OF 33 XWAL. DATE ______79 DRAINAGE AREA - CLASSIFICATIONI JOB NO. 04. 0090 DRAINAGE AREA PLANIMETER READING - 20.01 Scale 1: 24,000 FACTOR .14348 SFMI/ D.A. = (20.01)(.14348) = <u>2.87 sami</u> POND SUPFACE APEL PLANIMETER READING - 1,10 Scale 1: 24,000 FACTOR . 14-34-8 Spani/SUIN (1.10)(.14348)(640) = 101 Acces1: 640 No/Sqmi VOLUME ESTIMATED IN 1952 AS 40,000,000 CUFT 2 918 ANE-ET LASSIMMANTONI SIZE MEIGHT 28,5 STORAGE 918 AC-FT AT TOP OF DAM STORAGE 1428 AC-FT - INTERMEDIAT HARAS SEVERIL PERCES DOUNSINGING AGUT 1 MILE SIGNIFICANT

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DUFRESNE-HENRY ENGINEERING CORPORATION

| , KI. A. LEONARD | SUBJECT KLOODWARD RESERVOIR | SHEET NO. 27 OF 33 |
|------------------|-----------------------------|--------------------|
| TE 4-4-79 | X-SECT #1 CALS (CONT.) | JOB NO. 04-0090 |

$$A = 8.91 (80) = 712.80 \text{ ft}^{2}$$

$$NP = 63.43 + 3.61 + 30 + 28.18 + 1.53 + 2.83 = 138.58$$

$$QB = \frac{1485}{.05} (712.8) \left[\frac{712.8}{136.58} \right]^{2/3} (.03)^{1/2} = \frac{10.993 \text{ cfs}}{136.58}$$

:

$$A = 12.15 (80) = 972 F7^{2}$$

$$NP = 138.558 + 3.61 + 2.63 = 145.02'$$

$$QS = \frac{1.4916}{.05} (972) \left[\frac{972}{.45.02} \right]^{2} 3 (.03)^{2} = \frac{17,900 \text{ cFS}}{.03}$$

ITH DAM FAILURE WITH WSEL @ SPILLWAY (7,986 CFS) WATER WOULD BE APPROX 1' ABOVE ECOND

LITH DAM FAILURE WITH WELL & TOP OF DAM (10,498 CFS) WATER WOULD BE Z'ABOVE ROAD



| DU | RESNE-HENRY ENGINEERING CORPORATION | | |
|---------|-------------------------------------|--------------------|--|
| L. | SUBJECT WOOD WARD RESERVOIR | SHEET NO. 25 OF 33 | |
| 3-29-79 | DAM FAILURE ANALYSIS | JOB NO. 04-0090 | |

$$Q = \frac{8}{27} \text{ Wb } \sqrt{\frac{9}{9}} \sqrt{\frac{3}{2}} = \frac{7986 \text{ c.f.s.}}{7986 \text{ c.f.s.}}$$

 $\frac{1}{Q} = \frac{1}{27} \text{ WSCL } \oplus \frac{1}{70} \text{ or Plandur Hy} = \frac{1}{249} \text{ BLEY } \frac{1349}{7} \text{ CLEY } \frac{1}{7} \frac{1}{7}$

DUE TO THE STEEP SLOPE OF THE DISCHARGE CHANNEL THE "RULE OF THUMB" ROUTING IS <u>NOT</u> PRACICABLE. THEREFORE USE THE PEAK FAILURE OUTFLOW

DUFRESNE-HENRY ENGINEERING CORPORATION

| LEUNARD | SUBJECT KOODLARD RESERVOIC | SHEET NO. 29 OF 33 |
|---------|----------------------------|--------------------|
| 4-4-79 | X-SECT #2 FLOW CALCS | JOB NO. 04-0090 |

ASSUME N= .05, 5=.03

 $A = 0.88(160) = 140.8 \text{ FT}^{2}$ WP = 20 + 1.5 + 15 + 5.53 + 7.21 = 49.3' $Q_{D} = \frac{1.486}{.05} (140.8) \begin{bmatrix} 140.8}{.49.3} \end{bmatrix}^{2/3} (.03)^{1/2} = \frac{1464}{.49.3} \text{ C.F.S.}$

 $A = 5.58(160) = 872.8 \pi^{2}$ $WP = 49.3 + 12.3 + 49 + 1.2 + 1 + 26 + 13.2 = 153.8^{1}$ $Q_{\text{ED}} = \frac{1.486}{.05} (892.8) \left[\frac{692.8}{.153.6} \right]^{\frac{12}{3}} (.03)^{\frac{1}{2}} = \frac{14.932}{.149.32} \text{ GeV}$

$$A = 7.13 (16c) = 1140.8 m^{2}$$

$$wl^{2} = 153.8 + 3.35 + 29.04 = 186.19^{1}$$

$$Q_{2} = \frac{1.486}{.05} (1140.8) \left[\frac{1140.8}{166.19} \right]^{\frac{7}{3}} (.03)^{\frac{16}{2}} = \frac{19.782 \text{ cFs}}{166.19}$$

. CHANNEL WOULD EASILY HOLD WATERS FROM A DAM FAILURE AT THIS POINT





MICROCOPY RESOLUTION TEST CHART

DUFRESNE-HENRY ENGINEERING CORPORATION BY W.A. LEONARD SUBJECT KIND ETSERVAIR SHEET NO. 20 OF 3 3 A SECT N 3 5200 TRANSFER ADOB NO. 04-0090 -DATE 4-4-79 -154 W = 120 54 FT KANK HORIZONTAL SCALF VERTICAL ELEV 0 الد JJ15 HOUSE HARD DO DONK 2082 30 1 SLIZ 2 ____ 18 61 ž.

| | DUFRESNE-HENRY ENGINEERING CORPORATION | |
|------------------|--|--|
| DATE | 4. LEONARD SUBJECT KLOUDINARD RESERVOIR SHEET NO. 29 OF 33 4-4-79 X-SECT #2 FLOW CALCS JOB NO. 04-0090 | |
| ۔ دی: | A = 0.88(160) = 140.8 FT ² WP = 20 + 1.5 + 15 + 5.53 + 7.21 = 49.3' Q = <u>1.486</u> (140.8) $\int \frac{140.8}{(03)^{1/2}} = \frac{1464}{($ | |
| ् _छ : | $A = 5.58(160) = 892.8 m^{2}$ $NP = 49.3 + 12.3 + 49 + 1 + 24 + 13.2 = 153.8'$ $Q_{(2)} = \frac{1.486}{.05} (892.8) \left[\frac{892.8}{.53.8} \right]^{\frac{2}{3}} (.03)^{\frac{1}{2}} = \frac{14.932}{.05} \text{ cf.s.}$ | |
| (3) | $A = 7.13 (160) = 1140.8 \text{ s}^{2}$ $WP = 153.8 + 3.35 + 29.04 = 186.19'$ $Q_{3} = \frac{1.486}{105} (1140.8) \left[\frac{1140.8}{166.19} \right]^{2/3} (.03)^{1/2} = \frac{19.782 \text{ cf.s.}}{166.19}$ | |
| | · CHANNEL WOULD EASILY HULD WATERS FROM A DAM FAILURE AT THIS PUNT. | |
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$$DUFRESNE-HENRY ENGINEERING CORPORATION$$

$$FH.A.LECNARD SUBJECT MODELARD RESERVENTE SHEET NO. 31 OF 33
DATE 4-4-'(9) X-SECT #3 FLOW CALCULATIONS JOB NO. 04-0090
TOP OF BANK A = 7/2 (120) = 854.4 FT2
WP = 19.83 + 15 + 2.75 + 30 + .75 + 29.97 = 98.3'
Q = 1.480 (854.4) $\left[\frac{854.4}{98.3}\right]^{23}$ (.03)^{1/2} = 18.727 crs
TOP BANK - 3'
(HOUSE SILL CLEV) A = 5.01 (120) = 601.2 FT²
WP = 98.3 - 5.41 - 6.92 = 85.97$$

$$Q = \frac{1.486}{.05} (601.2) \left[\frac{601.2}{.03} \right]^{\frac{2}{3}} (.03)^{\frac{1}{2}} = \frac{11.390 \text{ cfs}}{.03}$$

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$$A = 4.39(120) = 526.8 \text{ ft}^2$$

 $k!P. = 85.97 - 1.80 - 2.31 = 81.86'$

 $Q = \frac{1.486}{.05} (526.8) \left[\frac{526.8}{81.86} \right]^{2/3} (.03)^{1/2} =$ 9,440 CF.S

FOR DAM FAILURE WITH WSEL AT TOP OF DAM (10,498 CFS) AT THIS CROSS SECTION WOULD BE UNDERMINED THE HOUSE & DESTROYED AS THE BASEMENTLEVEL IS EXPOSED & SITS ON THE BROOK BANK.

DUPRESME-HENRY ENGINEERING CORPORATION
WHAL EXAMPLE DEBUG MARCH LARGE ACCOUNT SHEET NO. 33 or 33
DATE
$$4+5+73$$
 SUBJECT MARCH LARGE ACCOUNT NOB NO. CHEERED
WE $4+5+73$ N= 505.6 m²
NP = $630+20+20+3.5+20+1.5+13.65+65.01$
G = $1486_{10}(305.6) \left[\frac{375.6}{65.01}\right]^{\frac{3}{2}}(0.3)^{\frac{1}{2}} = \frac{4437}{4437}\frac{45.5}{55.5}$
is IF DAM FRUED, WATCH KOULD BE ACCOUNT FIELD
NSTO ADJACENT FIELD
NSTOME WATCH JUST CREATING ROAD & INTO FIELD
1 G:
A = $(264+20)(40) + 250(1) = 625.6 m2$
NFC $65.01 + 31+11.41+110.62+250+224 = 376.28 m2$
Q = $1.465(1 + 65.6) \left[\frac{625.12}{576.28}\right]^{\frac{1}{2}}(0.5)^{\frac{1}{2}} = \frac{46.49}{449}\frac{1}{55}$
RESUME WATCH I' ACCU ROAD
A = $12.46(40) + 502(1) = 1003.2 m2$
RESUME WATCH I' ACCU ROAD
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NF WATCH I' ACCU ROAD
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NF WATCH I' ACCU ROAD
A = $12.46(40) + 502(1) = 1003.2 m2$
A = $900(40) = 322.4$
MP = $316.25 + 224 + 1.41 = 573.93 m2$
Q = $1.955(...(1003.1) \left[\frac{1003.2}{2370.3}\right]^{\frac{1}{2}}(...5)^{\frac{1}{2}} = \frac{9097}{9097}\frac{1}{100}$
THIS WADULD MEAN 2' OF WATCH AROUND
HOUSES
TOETON IF FROM IN CHANGLE WATCH STORE I' ADD
A = $1.461(20.20) \left[\frac{322.4}{2370.75}\right]^{\frac{1}{2}}(...5)^{\frac{1}{2}} = \frac{9027}{9097}\frac{1}{100}$
Function IF FROM IN CHANGLE WATCH STORE I' FADA
MP = $316.23 + 224.4$
MP = $144.(20.20) \left[\frac{322.4}{2370.75}\right]^{\frac{1}{2}}(...5)^{\frac{1}{2}} = \frac{51571}{100}$
FUNCTION IF FROM IN CHANGLE WATCH I' AND I' AND





APPENDIX E

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