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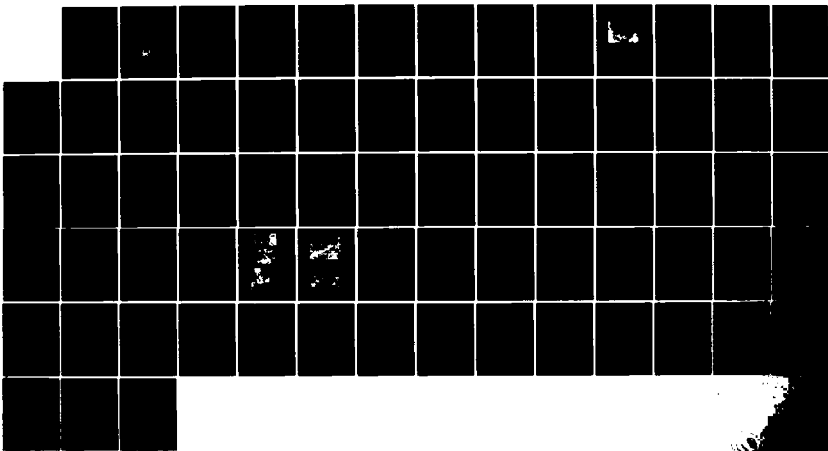

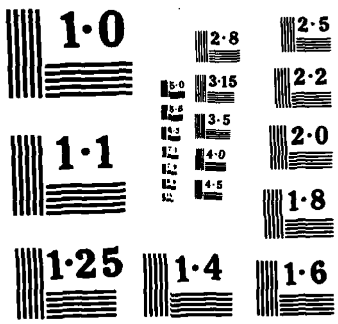
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AD-A156 422

MERRIMACK RIVER BASIN
WASHINGTON, NEW HAMPSHIRE

HIGHLAND LAKE NORTH OUTLET

NH 00238

NHWRB 245.07

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

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

AUGUST 1978

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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

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Merrimack River Basin
Washington, New Hampshire
Contoocook River

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

THe dam is intermediate in size with a low hazard potential. THe hydraulic analyses indicated that the spillway test flood in Highland Lake is 11800 cfs, of which the North Outlet would experience 3950 cfs. It is recommended that the refined hydrological analyses elsewhere recommended for Highland Lake's South Outlet be undertaken.

DISCLAIMER NOTICE

NATIONAL DAM INSPECTION PROGRAM

PHASE I INSPECTION REPORT

Inventory No.:	NH00238
NHWRB	245.07
Name of Dam:	HIGHLAND LAKE NORTH OUTLET
Town:	Washington
County and State:	Shedd Brook, tributary to Contoocook River
Date of Inspection:	14 June 1978

BRIEF ASSESSMENT

The North Outlet is actually the starting point of Shedd Brook and lies on the eastern shore of the lake at a distance of 4.4 miles north of the lake's primary dam, the South Outlet (NH00054). No structure on Shedd Brook can properly be considered as a dam. The original structure at the North Outlet, which served as an emergency spillway for the Highland Lake South Outlet has been covered with earth, rock and debris and has deteriorated to the point where it is indistinguishable from the natural shoreline. Two unpaved road embankments downstream cross the outlet channel, but neither was ever intended to impound water. Nevertheless, the embankment of Tumlin Road 500 feet downstream is the first well-defined control on the outlet stream, and thus becomes the structure of interest. Local residents, in fact, now refer to the road and its 18 inch culvert as the North Outlet.

Highland Lake receives runoff from a 29.7 square mile drainage area which is heavily forested. While Tumlin Road impounds no water at normal lake level, it could impound as much as 2500 acre-feet before overtopping in a major flood. Thus, the potential impoundment places the embankment in the INTERMEDIATE size category. There is little development downstream for over 6 miles, and the hazard potential is LOW.

The hydraulic analyses indicated that the Spillway Test Flood (STF) in Highland Lake is 11,800 cfs, of which the North Outlet would experience 3950 cfs. This flow would overtop the Tumlin Road embankment by more than 4 feet, assuring failure.

It is recommended that the refined hydrological analyses elsewhere recommended for Highland Lake's South Outlet be undertaken, and that the flood flow thus lerived for the North Outlet be the prime design criterion for any structure on the stream. In the meantime, methods of restraining downstream development should be investigated. In view of the character of the outlet's embankments, and of the minimal downstream hazards, it is further recommended that the North Outlet be deleted from the requirement for periodic inspection, until improvements stemming from future studies have been implemented. These studies should be initiated within 1 to 2 years.

Since the North Outlet appears to be the only location on Highland Lake which after improvement will permit substantially increasing the lake's discharge capacity, any future structure on Shedd Brook must be capable of passing very high flows. Since it is impractical to remove the roads which provide access to property owners, they might be replaced by timber trestle bridges or alternatively, by lowered embankments armored with riprap and paving to serve as submerged weirs in flood. However, it would be inadvisable to initiate any modifications until the recommended investigations are complete.

William S. Zoino, PE
New Hampshire Registration 3224

James H. Reynolds, PE
Mass. Registration 8044

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 will be detected.

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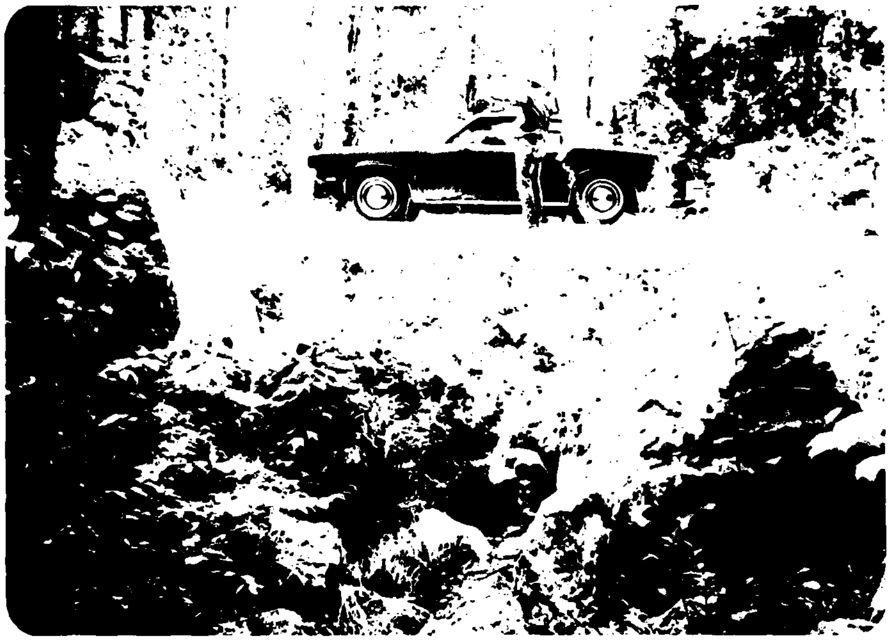
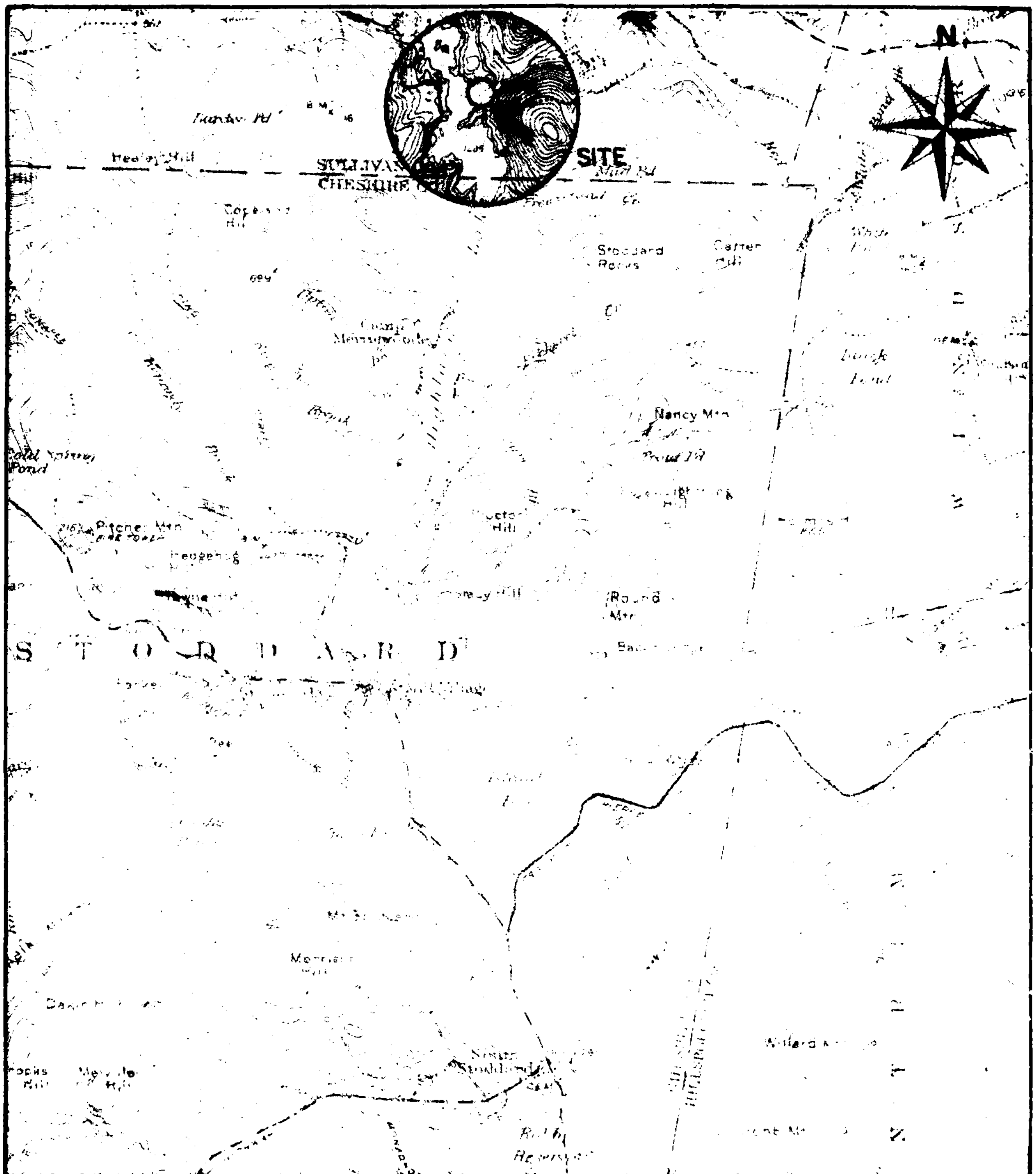


Overview photo of Tumlin Road crossing looking upstream



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FROM: USGS LOVEWELL MOUNTAIN, N.H. QUADRANGLE MAP

GEOTECHNICAL CONSULTANTS

FILE No. 2067

NATIONAL DAM INSPECTION PROGRAM

U.S. ARMY CORPS OF ENGINEERS, NEW ENGLAND DIVISION

HIGHLAND LAKE NORTH OUTLET NH00238

NHWRB 245.07

LOCUS PLAN

JULY 1978

PHASE I INSPECTION REPORT

HIGHLAND LAKE NORTH OUTLET, NH00238

NHWRB 245.07

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 to the responsibility of supervising the inspection of dams within the New England Region. Goldberg, Zoino, Dunnicliff & Associates (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 were issued to GZD under a letter of May 3, 1978 from Ralph T. Garver, Colonel, Corps of Engineers. Contract No. DACW33-78-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 to represent an immediate danger based on condition of the dams.

1.2 Description of Project

(a) Location

The North Outlet is in the Merrimack River Basin and is actually the starting point of Shedd Brook, it lies on the eastern shore of the lake at a distance of 4.4 miles north of the lake's primary dam, the South Outlet (NH00054). The outlet is approximately 1.1 miles from the nearest access off Route 31 and is reached via Bailey Road and Woodpecker Road, which ends at the lake shore approximately 30 feet north of the outlet. Figure 1 in Appendix D presents an enlargement of the appropriate portion of the USGS Lovewell Mountain quadrangle shown previously. Shedd Brook eventually flows into the Contoocook River.

(b) Description of Dam and Appurtenances

As mentioned above the North Outlet is not a formal structure, being merely an overflow from the lake to Shedd Brook (Fig. 1). Prior to the construction of what is now called the South Outlet, Highland Lake was actually three separate, smaller bodies of water. Placement of the dam at the south end resulted in the three smaller ponds consolidating into what is now the larger Highland Lake. At that time, the dam builder, a predecessor company of the Public Service Company of New Hampshire, designated Shedd Brook, which formerly served as the outflow for the original northermost pond, as the emergency spillway for the new dam. While a 1932 New Hampshire Water Resources Board (NHWRB) report indicates that a rock-filled, timber crib dam built to provide a spillway did exist in this area, there is currently no visible control structure of any type at the outlet itself. The outlet is approximately 2.5 feet wide and 1.5 feet deep and its invert is essentially at USGS El.1295±, or only slightly below the lake's normal level. A beaver dam at the lake's shore completely blocks any flow that might occur under normal lake elevation (Figure 1).

Approximately 500 feet downstream of the outlet, Tumlin Road crosses Shedd Brook (Figure 1). The road at this point is basically an earth embankment, 30 feet wide at its base and with a 16 foot wide travelled way. The top of the embankment is at USGS El.1299.5± or 3.5 feet above the normal pond (Figure 2). An 18 inch diameter corrugated metal culvert, with upstream invert at USGS El.1293.3±, or 2.75 feet below normal lake level, carries Shedd Brook under the embankment, but the culvert inlet is completely blocked by beaver placed debris. If the lake rises above El. 1296±, the embankment would impound water to a maximum of 2500 acre-feet since the 18 inch culvert, even if cleared, could only pass a fraction of the flow in Shedd Brook under these conditions. Local residents refer to this structure as the North Outlet and it acts as a hydraulic control on the lake until overtopped.

At a distance of 0.7 miles further downstream, Shedd Brook passes under Bailey Road (Figure 1). The brook flows under the road embankment through two 36 inch diameter culverts placed one on top of the other (Figure 3, Appendix B; Photo 3, Appendix C). Approximately 30 feet upstream of the culverts, a beaver dam completely blocks the brook and impounds approximately 5 acre-feet of water (Photo 4); flow through the culverts is negligible.

As the preceeding discussion indicates, the original North Outlet dam has deteriorated beyond recognition and is no longer distinguishable. The downstream Tumlin Road crossing, referred to by residents as the North Outlet, can, under certain circumstances, impound a reservoir of approximately 2500 acre-feet and could act as a hydraulic control on the lake. For these reasons, the Tumlin Road embankment has, in effect, superceded the original dam as the structure of interest in this area.

(c) Size Classification

As mentioned previously, the embankment at Tumlin Road impounds no water at normal lake level. During the Spillway Test Flood (STF), however, the lake level could rise as much as 7.6 feet. Since the crest elevation of the embankment is 1299.5±, this structure could impound approximately 2500 acre-feet, or the difference between normal lake elevation and the embankment crest elevation times the surface area of the lake, prior to overtopping. This potential impoundment places the embankment in the INTERMEDIATE size category as defined in the "Recommended Guidelines".

(d) Hazard Potential Classification

There is very little permanent development downstream of the embankment for a distance of over 6 miles. This fact, coupled with the significant ponding areas available at some locations, leads to a hazard potential classification of LOW.

(e) Ownership

Mr. Leroy S. Hunter, 329 Woodland Avenue, Hanover, Massachusetts owns the parcel of land which contains both the North Outlet itself and the embankment on Tumlin Road. The road itself is part of his property, but his deed requires that he permit a 50 foot wide right-of-way for his neighbors. His home phone number is 617-878-6480 and his business phone (GSA,Boston) is 617-223-2682. Mr. Hunter has no knowledge of either location being classified as a dam.

(f) Operator

As the description and figures indicate, this dam requires no operator.

(g) Purpose of Dam

The NHWRB considers Shedd Brook as an emergency overflow channel for the Highland Lake South Outlet. Were a dam with suitable outlet works still to exist at the North Outlet proper, it would warrant classification as an emergency spillway. However, as mentioned previously, no such structure exists. The embankment at the Tumlin Road crossing, on the other hand, was intended to serve no other purpose than as an access over Shedd Brook. With the hydrology now under consideration, however, it is obvious that the embankment obstructs the flow of water which Shedd Brook must discharge in the event of a large flood at Highland Lake.

(h) Design and Construction History

The records of the NHWRB indicate a rock-filled timber crib, built in 1876 and rebuilt in 1936, at the North Outlet itself; at the present time, however, this structure is not distinguishable from the shoreline of the lake. Little information exists concerning the history of the Tumlin Road crossing 500 feet downstream from the Lake. Mr. David Titcom of North Branch Builders, Henniker, New Hampshire (603-428-3233 or 603-529-2444) constructed the road in either 1970 or 1971. He had no concern for the embankment as a dam as he never received any indication that it might serve such a purpose; he believed that the 18 inch culvert was sufficient to pass the flow of Shedd Brook. At the time he purchased the land (1966), no dam existed at the North Outlet proper. No earlier information is available as the owner previous to Mr. Titcom is deceased.

(i) Normal Operational Procedure

The three abutters generally clean the culvert each year at the end of the summer.

1.3 Pertinent Data

(a) Drainage Areas

Highland Lake receives runoff from a 29.7 square mile drainage area. Approximately 65% of this area is on the west side of the lake, as the terrain to the east slopes away from the lake at the North Outlet area. Tributaries of the lake include Kennedy, Rice and Upton Brooks to the west, Halfmoon and Philbrick Ponds to the north and Freezeland Creek, Pickerel Creek and Carr Brook to the east. The terrain is heavily forested and steeply sloping, rising approximately 300 feet within one mile of the shoreline on both sides. There is limited year-round development around the lake. The majority of the structures are summer cottages.

(b) Discharge at Damsite

As mentioned previously, the outlet works for the Tumlin Road structure consist of the 18 inch diameter CMP culvert. Neither the NHWRB nor the owner have made any attempt to measure flow or impoundment level at the embankment. Informal observations by the local residents indicate that the water has reached within one foot of the embankment crest (USGS El.1298.5±) at times when the lake was 2.5 feet above normal (USGS El.1298.5±). The residents made these observations since 1973 when they first built homes on the surrounding land.

(c) Elevation (ft. above MSL)

1. Top of Dam: 1299.5±

2. Maximum pool-design surcharge: 1299.5±

3. Full Flood control pool: Not Applicable

4. Recreation pool: Not Applicable

5. Spillway crest: Not Applicable

6. Upstream portal invert diversion tunnel: Not Applicable

7. Streambed at centerline of dam: 1291±

8. Maximum tailwater: Unknown

(d) Reservoir

1. Length of maximum pool: 5.5 miles

2. Length of recreation pool: Not Applicable

3. Length of flood control pool: Not Applicable

(e) Storage (acre-feet)

1. Recreation pool: Not Applicable

2. Flood control pool: Not Applicable

3. Design surcharge: 7800±

4. Top of dam: 7800±

(f) Reservoir Surface (acres)

1. Top dam: Approximately 711

2. Maximum pool: Approximately 715

3. Flood-control pool: Not Applicable

4. Recreation pool: Not Applicable

5. Spillway crest: Not Applicable

(g) Dam

1. Type: Earth embankment

2. Length: 60± feet

3. Height: 8± feet

4. Top Width: 16 feet

5. Side Slopes: Approximately 1:1

6. Zoning: None

7. Impervious Core: None

8. Cutoff: None

9. Grout curtain: None

(h) Regulating Outlets

The only outlet for water impounded by the embankment is an 18 inch diameter CMP culvert. The pipe, which slopes downstream at 1.9% has no control mechanism. Beaver damming at the culvert is a problem, as the last 3 inspections (1967, 1974 and 1978) found the culvert completely blocked.

SECTION 2: ENGINEERING DATA

2.1 Design

Since the intended purpose of the Tumlin Road embankment is to provide access over Shedd Brook, the builder prepared no formal design. The embankment consists entirely of compacted local materials.

A search of available records revealed no hydrological design data which consider the interaction of the North and South Outlet during periods of high lake level.

2.2 Construction

The inspection of the dike revealed no noteworthy construction features. The fact that the embankment has survived at least a few instances of high impoundment indicates that the construction probably involved good compaction and that the embankment material is generally impervious.

2.3 Operation

Not Applicable

2.4 Evaluation

As no information exists as to the fate of the old dam at that North Outlet and as no person or agency has attempted to collect significant information on the present structure which acts in some respects as a replacement, the minimal amount of data available warrants only an unsatisfactory evaluation.

SECTION 3: VISUAL INSPECTION

3.1 Findings

(a) General

For its intended purpose and under normal lake levels, the Tumlin Road embankment is in good condition. As a water retaining structure, however, the structure has serious deficiencies which would probably result in failure during a large flood.

(b) Dam

1. Embankment

The embankment itself shows no evidence of distress in terms of excess settlements or changes in alignment. It has no riprap protection on either slope and, therefore, probably would not withstand prolonged overtopping. At a point near the downstream toe, 10 feet to the left of the culvert's outlet, clear seepage on the order of 0.1gpm flowed out of the embankment. The embankment has no formal abutments, the height of fill merely decreasing gradually to existing grade at both ends. It is evident that construction at the abutments was not sufficient to permit these areas to function as a dam.

2. Upstream Channel

The area between the embankment and the lake is heavily wooded with numerous trees and bushes growing in and over the channel. Medium-size boulders cover the channel bottom. A well constructed beaver dam which has probably existed for as long as 10 years completely blocks the inlet of the culvert. Additionally, the culvert is approximately one-half full of silt at the upstream end.

3. Culvert

The culvert has no headwalls and the downstream end is crushed (Photo 4).

(c) Appurtenant Structures

Bailey Road, located some 0.7 miles downstream, also obstructs Shedd Brook and is of construction similar to Tumlin Road. Although two 36 in. culverts pass through the embankment, they are placed one on top of the other and are thus of reduced hydraulic efficiency.

(d) Reservoir Area

An inspection of the lake shore revealed no evidence of movement or other instability. No sedimentation was evident near the outlet. An examination of the surrounding area revealed no work in progress or recently completed which might increase the flow of sediment into the lake. Additionally, no changes in the surrounding watershed which might adversely affect the runoff characteristics of the basin were evident.

A considerable amount of the development in this area is seasonal in nature and is directly on the lake shore. Were the STF to occur with the lake at normal level, the homes and cottages around the shore would experience significant physical damage.

(e) Downstream Channel

The downstream channel is similar to that upstream as described above. No observed downstream conditions exist which might adversely affect flow through the culvert or which would seriously hinder flow during the STF.

3.2 Evaluation

The visual inspection of the embankment permitted a satisfactory evaluation of those features which affect the safety and stability of this structure. The validity of the evaluation is reinforced by the information available from the local builder of the road.

SECTION 4: OPERATION PROCEDURES

This structure requires no operational procedures other than occasional cleaning of the approach channel and culvert.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

(a) Design Data

As mentioned previously, no design or construction data are available for this structure.

(b) Experience Data

No record of experienced peak floods is available other than the verbal reports described in Section 1.3b.

(c) Visual Observations

As previously noted, the structure carried on the records of the NHWRB is no longer discernible. Debris and vegetation completely obstruct the source of Shedd Brook and under normal conditions only a very limited flow of water leaves the lake by this route. At present, the Tumlin Road embankment acts as a hydraulic control until water overtops the road. The embankment contains an 18 in. CMP culvert with the invert located 2.75 ft. below the normal lake elevation. The top of the road embankment is 3.5 ft. above the normal lake elevation. The road extends across the swampy area that once was a stream, with the level section of the road approximately 100 ft. in length. A beaver dam completely blocks the culvert at present and 2 previous reports (1967, 1974) also mention beaver activity.

(d) Overtopping Potential

The hydrologic conditions of interest in this Phase I investigation are those that are 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 involves investigations to determine how the recommended Spillway Test Flood (STF) compares with dam discharge and storage capacities.

The "Recommended Guidelines" specify Spillway Test Flood (STF) criteria based on the size and hazard potential classifications of the dam. Although the North Outlet merits only a LOW hazard potential classification as discussed in Section 1.2(d), this analysis must consider the STF based on a SIGNIFICANT classification as the STF for the South Outlet establishes the flood for the entire lake. As shown in Table 3 of the "Recommended Guidelines", for a dam classified as INTERMEDIATE in size and SIGNIFICANT in hazard potential, the STF equal to 0.5 to 1 times the probable maximum flood (PMF) is appropriate.

Use of the chart entitled "Maximum Probable Flood Peak Flow Rates" permits an estimate of the PMF. Assigning the drainage area of 30 square miles rolling topography, a maximum probable flow of 39,400 cfs, one-half of which is 19,700 cfs, results.

When the "Recommended Guidelines" suggests a range of STF, it permits selection of the individual magnitude that most closely correlates to the involved risk. On this basis, since the risk is most probably at the lower end of the SIGNIFICANT category, an STF of one-half the PMF, or approximately 20,000 cfs, is reasonable. Applying the procedure suggested by the NED for "Estimating the Effect of Surcharge Storage on Maximum Probably Discharges" results in a final STF of 11,800 cfs.

Attenuation of the STF used a storage-stage curve based on a lake area of 711 acres and simple linear storage, this relationship being the product of the lake area times the depth over the spillway. Appendix D includes this curve.

The discharge capacity of Highland Lake depends on the outlet characteristics and on the water level in the lake. Under most flow conditions, the dam at the South Outlet controls the discharge. If the lake level overtops the spillway abutments, the overall dam crest characteristics then control.

As the lake level continues to rise, two additional outlets come into play. The first of these is Shedd Brook, or the North Outlet, which is the subject of this report. While the brook no longer contains a formal dam, the Tumlin Road embankment acts as a hydraulic control on the lake level until it's overtopping and therefore merits consideration. The crest of the road is level for approximately 100 feet at an elevation 3.5 feet above the spillway at the South Outlet.

The second overflow is a rock and earth dike located 150 feet west of the right abutment of the

South Outlet. The remainder of this report will refer to this structure as the South Dike. The dike is 57 feet long with a crest elevation 3.7 feet above the spillway at the main dam.

The analysis contained in Appendix D uses the following assumptions concerning the behavior of these structures under severe flood conditions:

1. Beaver debris completely blocks the 18 inch culvert at Tumlin Road as it has during the 3 most recent inspections (1967, 1974, 1978).

2. Breaching of the Tumlin Road embankment occurs shortly after overtopping and results in a gap 40 feet wide and 4 feet deep. As the discharge-stage curve in Appendix D indicates, the analysis assumes little flow at 6 in. of overtopping, but a complete breach when the overtopping reaches one foot.

3. Breach of the South Dike occurs once the lake elevation rises 0.8 feet above the crest of the dike. The resulting gap is 20 feet wide and 3.7 feet deep, equal to the elevation of the spillway at the South Outlet.

4. All stop-logs are in place at the time of the STF. The discharge-stage curve illustrates the outflow from each location plus the total overflow from the lake for any given stage. It is obvious that the STF of 11,800 cfs will result in significant overtopping at all three locations.

5.2 Hydraulic/Hydrologic Evaluations

The results of the analysis indicate that the South Outlet can pass only 2000 cfs before overtopping of the Tumlin Road embankment occurs. This quantity is considerably less than the 11,800 cfs anticipated during the STF. Construction of the embankment itself is in no way sufficient to resist severe overtopping. Once breached, the flow released downstream would undoubtedly washed out the crossing at Bailey Road.

Discharge of this STF will result in lake levels approximately 8.6 feet above the spillway at the South Outlet. At that stage, the North Outlet would experience flows of 3,950 cfs while the remaining 7,850 would discharge at the South Outlet and breached South Dike. The 3,950 cfs at the

Tumlin Road crossing indicates a flow 4.1 feet over the top of the embankment, a quantity more than sufficient to wash out the embankment with its deficient discharge capacity.

5.3 Downstream Dam Failure Hazard Estimates

The flood hazards in downstream areas that would result from a failure of the dam were estimated through the use of the procedure set forth in "Rule of Thumb Guidelines for Estimating Downstream Dam Failure Hydrographs, Corps of Engineers, New England Division, April 1978. This procedure allows the attenuation of dam failure hydrographs to be accounted for in computing flows and flooding depths in downstream areas. These calculations take into account the hydraulic and storage characteristics of the stream reaches downstream of the dam.

For the purposes of these calculations, the roadway embankment with the 18 inch culvert located about 1000 feet inland of the lake is taken as the North Outlet subject to failure. It was assumed that this earthen embankment would fail shortly after stages in the lake become sufficiently high to overtop it. This crest height is estimated to be at about elevation 1299.5 feet, corresponding to a lake level 3.5 feet over the main dam (South Outlet) spillway crest, and a depth of about 8.3 feet above the North Outlet stream bed.

Shedd Brook downstream of the dam was divided into two reaches for consideration. The first reach extends about 2100 feet between the dam and a second roadway crossing as shown on the USGS topo map. The second reach covers about 9000 feet between this location and the downstream point where Shedd Brook crosses under Route 31.

The results of the calculations indicate an approximate flood wave depth of 4.5 feet in the first reach. The available topographic maps show no buildings located within the flood hazard area that would result. This depth of flooding could be expected to overtop the roadway crossing between reaches one and two, and to cause that embankment to fail.

In reach two, the average predicted flood depth increases to 5.7 feet. Again, no structures are shown within the resulting flood hazard area in reach two.

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

(a) Visual Observations

Field investigations and findings do not indicate any extensive displacement or distress which would warrant detailed stability analyses.

(b) Design and Construction Data

No aspect of the design or construction of this road involved any consideration of structural stability other than being able to carry light, seasonal traffic.

(c) Operating Records: Not Applicable

(d) Post Construction Changes: None

(e) Seismic Stability

The apparent lack of stability problems and its location in seismic zone 2 permits an evaluation of no earthquake hazard according to paragraph 3.6.4 of the "Recommended Guidelines".

SECTION 7 - ASSESSMENT

RECOMMENDATIONS/REMEDIAL MEASURES

7.1 Dam Assessment

(a) Condition

None of the three embankments on Shedd Brook can properly be considered as a dam. As shown, the former structure at the actual outlet is now completely buried and is indistinguishable from the natural shore line. Neither Tumlin Road nor Bailey Road, both poorly served by inadequate culverts, were ever intended to impound water or to pass more than minimum flows. In any event, a flood caused failure of any or all of the three works would have no material impact downstream and it would be misleading to assign a formal condition rating to any of them. Any downstream damage expected during the STF would occur whether or not these embankments were present.

(b) Adequacy of Inspection

An adequate assessment of the structures consistent with the scope of a Phase I investigation is possible based upon the visual inspection and information supplied by the builder and local residents.

(c) Urgency

There is no urgency associated with the North Outlet, and, in fact, no work whatever should be undertaken until completion of refined hydrological analyses proposed elsewhere.

(d) Need for Additional Information

There is a need for refined hydrological analyses to establish the flows to be accomodated by the North Outlet, and thus to determine the hydraulic characteristics required of in-stream structures.

7.2 Recommendations

It is recommended that: (a) the refined hydrological analyses recommended in the report for Highland Lake's South Outlet (NH00054) be undertaken, and that the flood flow thus derived for the North Outlet be the prime design criterion for any structure on the stream: (b) no work should be put in hand until completion of such analyses; and (c) until that time, methods of restraining downstream development should be investigated. It is further recommended that due to the character of the structures and minimal associated hazard, the North Outlet be deleted from the requirement for periodic inspection, until improvements stemming from future studies have been implemented.

7.3 Remedial Measures

(a) Alternatives

Since the North Outlet appears to be the only location which after improvement will substantially increase Highland Lake's discharge capacity, any future structure must be capable of passing very high flows. Since it is impractical to deny vehicular access to the private properties, the roads could be replaced by timber trestle bridges, or alternatively, by lowered embankments armored with riprap and paving to serve as submerged weirs in flood.

(b) Operation and Maintenance Procedures

Until such time as the refined hydrological analyses and engineering studies on Highland Lake are complete, the owners should institute a regular program of culvert cleaning and repair.

APPENDIX A

VISUAL INSPECTION CHECKLIST

INSPECTION TEAM ORGANIZATION

Date:	14 June 1978 - 11:30 AM
Project:	NH00238 Highland Lake North Outlet Washington, New Hampshire Shedd Brook NHWRB 245.07
Weather:	Sunny, warm

Inspection Team

James H. Reynolds	Goldberg, Zoino, Dunnicliff & Associates, Inc. (GZDA)	Team Captain
William S. Zoino	GZDA	Soils
Nicholas A. Campagna	GZDA	Soils
Robert Minutoli	GZDA	Soils
Paul Razgha	Andrew Christo Engineers, Inc.	Structural & Mech.
Richard L. Laramie	Resource Analysis, Inc.	Hydrology

Highland Lake North Outlet
Washington, New Hampshire

June 14, 1978
NH00238

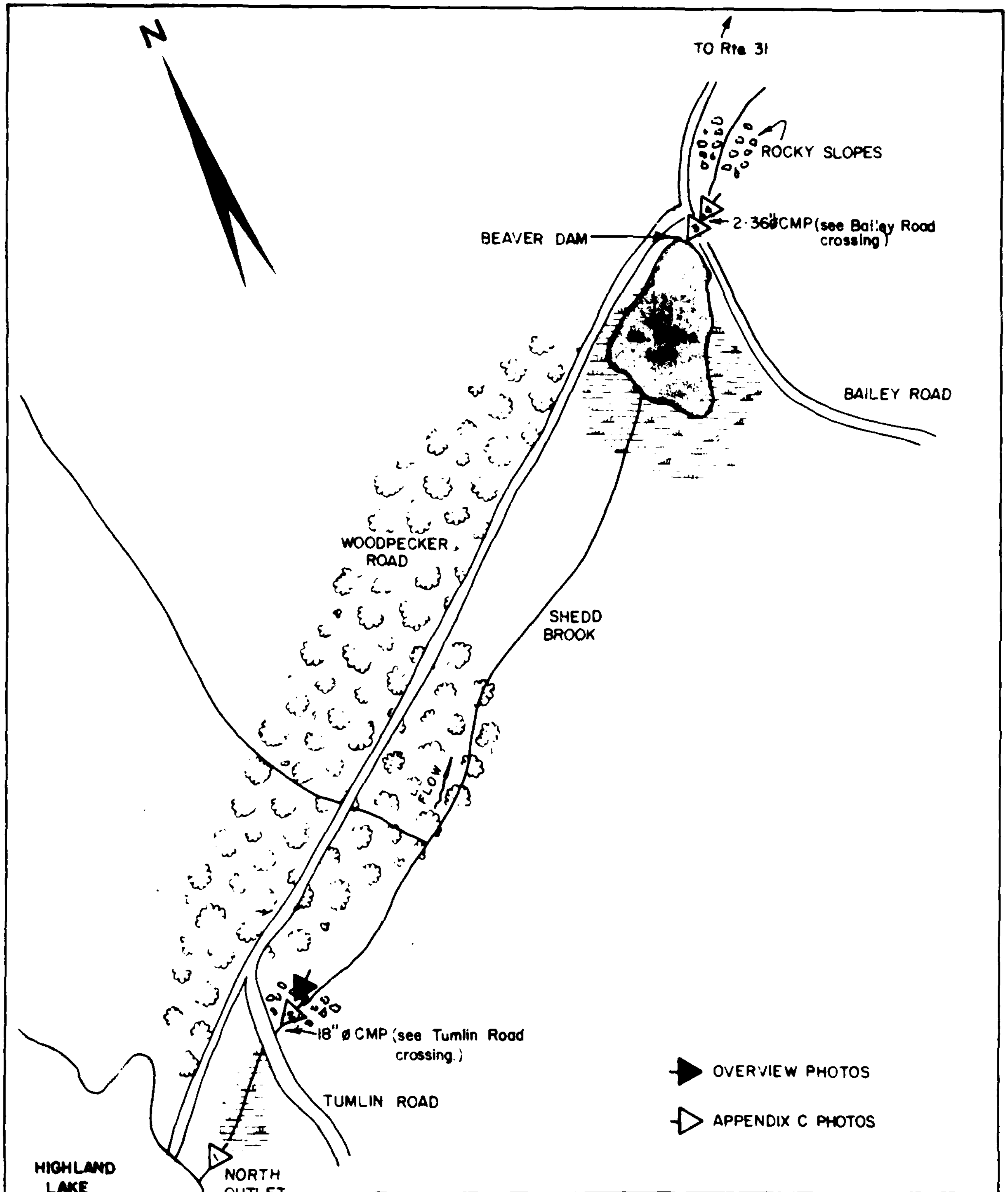
TEAM MEMBERS CHECK LISTS FOR VISUAL INSPECTION		
AREA EVALUATED	BY	CONDITION & REMARKS
EMBANKMENT		
Vertical alignment and movement		No movements noted
Horizontal alignment and movement		No movements noted
Surface cracks		None
Condition of travelled way		Surface well compacted by traffic
Sloughing or erosion of slopes		None
Riprap slope protection		None
Unusual movement or cracking at or near toe		None
Seepage		Very small seepage on left downstream abutment near culvert under head of water created by beaver dam
Piping or boils		None
Foundation drainage features		None
OUTLET WORKS		
Approach Channel		
Bottom conditions		Channel blocked by beaver dam
Debris		Large amount of brush and debris near culvert inlet
Trees overhanging channel		Channel heavily overgrown
Outlet Pipe		
Condition		Pipe bent on downstream side
Leakage		None
Control of debris		Neighbors clean each fall

Highland Lake North Outlet
Washington, New Hampshire

June 14, 1978
NH00238

TEAM MEMBERS CHECK LISTS FOR VISUAL INSPECTION		
AREA EVALUATED	BY	CONDITION & REMARKS
Outlet channel (immediate area)		
Slope conditions		Steep, rocky slopes on both sides
Debris		None
Trees overhanging channel		Channel heavily overgrown
Other obstructions		Large boulders in channel
Erosion at discharge point		None
RESERVOIR		
Shoreline		Shoreline stable to 500 feet each side
Evidence of slides or potential for slides		No slides noted or impending
Sedimentation		Heavy sedimentation around culvert due to beaver dam
Upstream hazard areas in the event of backflooding		Beachfront homes on Highland Lake subject to inundation if lake rises 2-3 feet
Changes in the nature of watershed (agriculture, logging, construction, etc.)		No changes in watershed noted-primarily forest
DOWNSTREAM CHANNEL		
Restraints on dam operation		No restraints on dam noted
Potential flooded areas		No development on Shedd Brook for several miles Damage to Route 31 possible
MAINTENANCE FEATURES		No maintenance being performed other than residents occasionally breaking up beaver dams.

APPENDIX B



FILE No. 2067

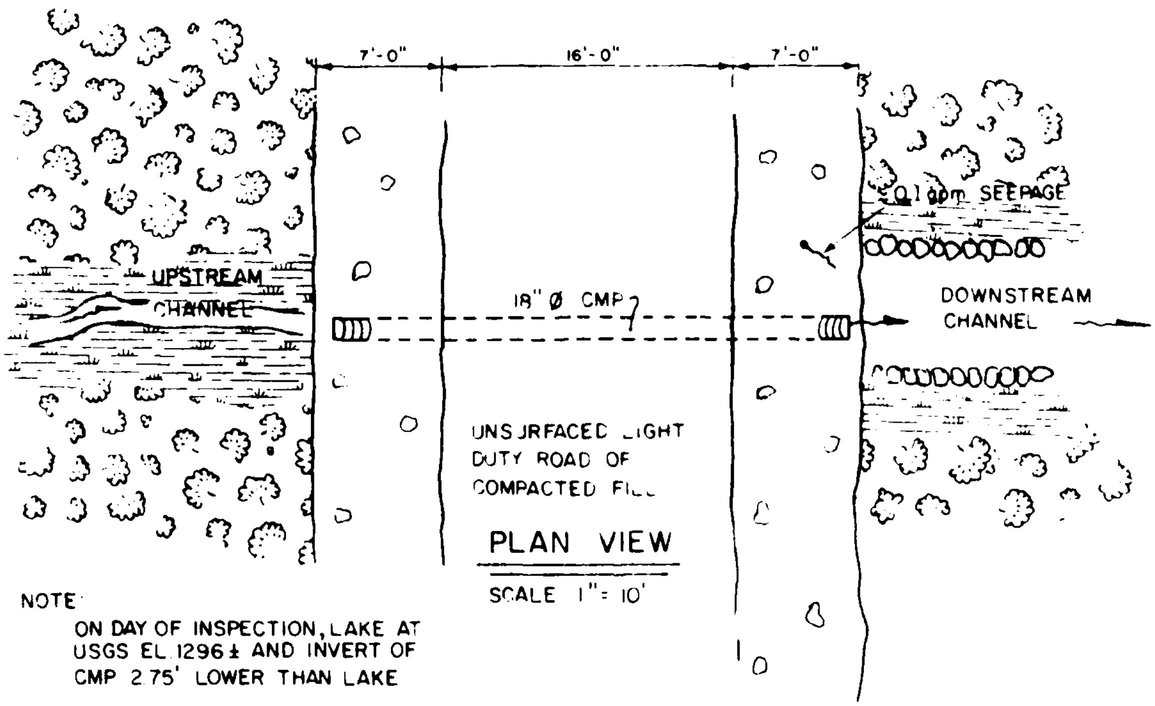
GEOTECHNICAL CONSULTANTS

NATIONAL DAM INSPECTION PROGRAM
U.S. ARMY CORPS OF ENGINEERS, NEW ENGLAND DIVISION

HIGHLAND LAKE NORTH OUTLET AREA NH 00238
NHWRB 245.07

SITE PLAN

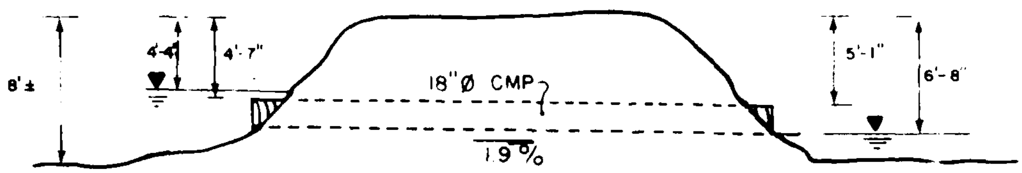
JULY 1978 | SCALE: 1" ≈ 0.1 mi | FIG. 1



PLAN VIEW

SCALE 1" = 10'

NOTE:
ON DAY OF INSPECTION, LAKE AT USGS EL 1296± AND INVERT OF CMP 2.75' LOWER THAN LAKE



CROSS SECTION

SCALE: 1" = 10'

NOTE: INLET OBSTRUCTED BY BEAVER DAM AND HEAVY SILTATION

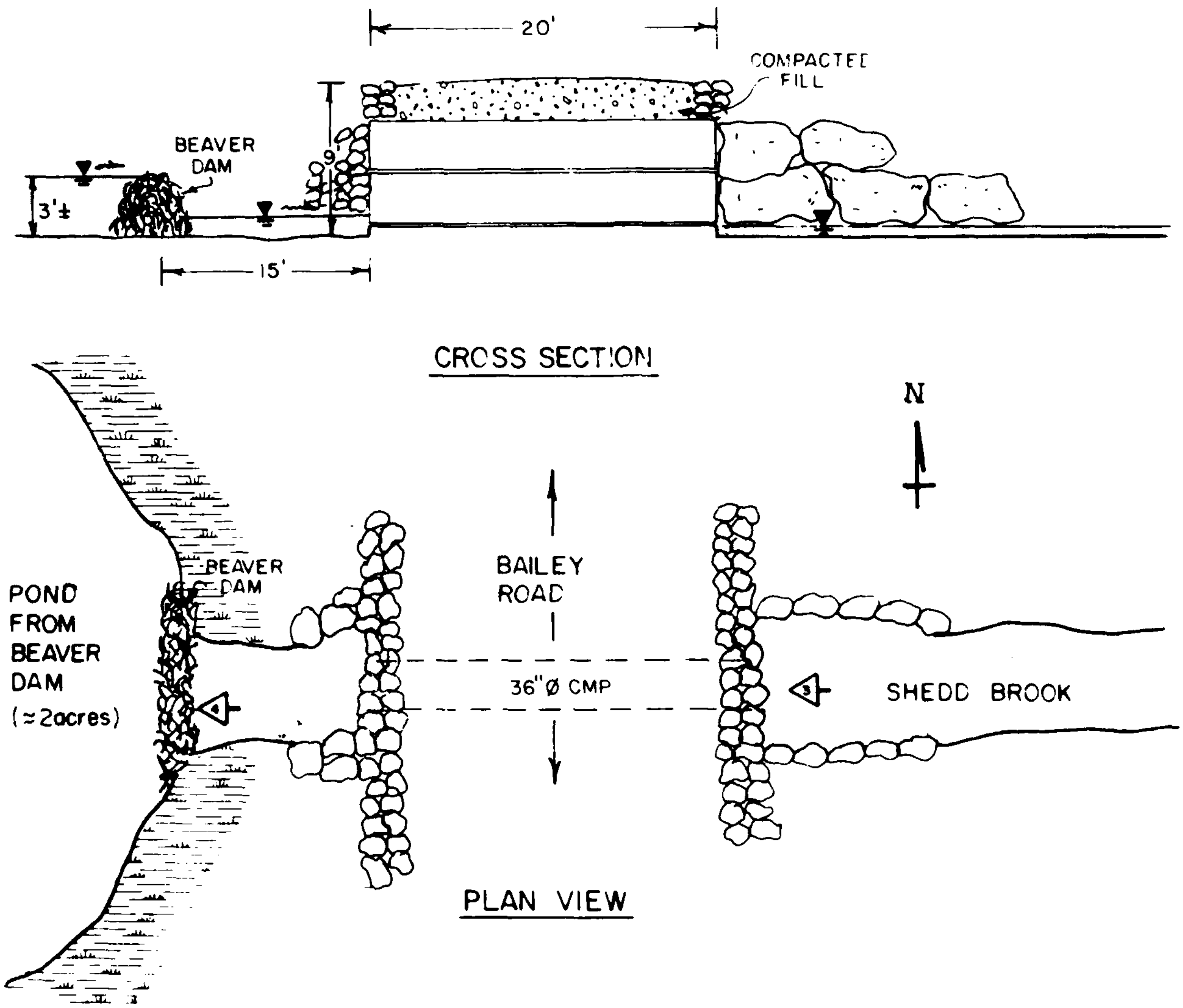
TUMLIN ROAD CROSSING

GEOTECHNICAL CONSULTANTS

NATIONAL DAM INSPECTION PROGRAM
U.S. ARMY CORPS OF ENGINEERS, NEW ENGLAND DIVISION

HIGHLAND LAKE NORTH OUTLET NH00238
NHWRB 245.07
TUMLIN ROAD CROSSING

JULY 1978 | SCALE AS NOTED | FIG. 2



NOTE
WATER LEVELS MEASURED
14 JUNE 78

▷ APPENDIX C PHOTOS

FILE No 2067

GEOTECHNICAL CONSULTANTS

NATIONAL DAM INSPECTION PROGRAM
U.S. ARMY CORPS OF ENGINEERS, NEW ENGLAND DIVISION

HIGHLAND LAKE NORTH OUTLET NH00238
NHWRB 245.07

BAILEY ROAD CROSSING

JULY 1978 | SCALE: 1" = 10' | FIG. 3

The NHWRB holds all available records on the North Outlet. Included in these are:

(a) A 1939 report by the New Hampshire Water Control Commission entitled " Data on Dams in New Hampshire."

(b) A 1939 report by the same agency entitled " Data on Reservoirs and Ponds in New Hampshire."

(c) A 1937 report by the NHWRB entitled " Inventory of Dams and Water Power Developments."

The NHWRB has offices at the State Capitol in Concord, New Hampshire.

M E M O R A N D U M

DATE: November 1, 1974

FROM: Pattu D. Kesavan, Water Resources Engineer

SUBJECT: Highland Lake - North Outlet in Washington - #245.07

TO: Vernon A. Knowlton, Chief Water Resources Engineer

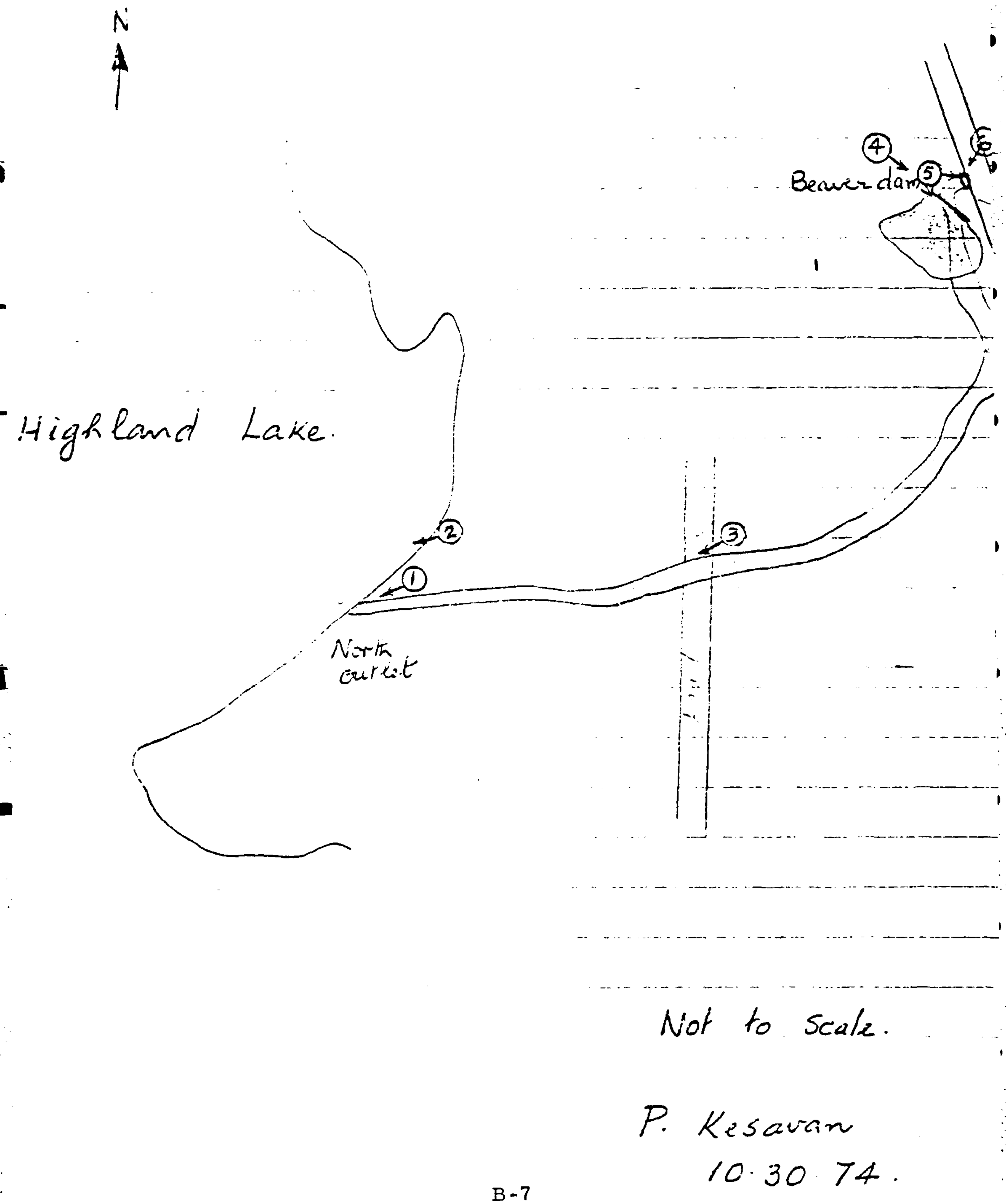
On October 30, 1974, I inspected the north outlet of the Highland Lake in Washington.

The sketch showing number 1 - 6 are the areas that have been photographed.

Picture 1 shows the outlet being obstructed and prevents flow. It could pass a very limited amount of water at full pond if the channel were cleared to its original dimensions. A stoplog control section at the entrance to the outlet could be constructed.

About 1/4 mile downstream of the outlet is a beaver dam. (See pictures 4 & 6.) Picture 5 shows the road culvert which originally might have been built with the intention of impounding water. Two pipes are placed vertically, one on top of the other.

pdk:js


N
Highland Lake
Beaver dam
1
2
3
4
5
6
North outlet
Not to Scale.
P. Kesavan
10.30.74.

WASHINGTON

Highland Lake - #245.07

1.

2.

3.

P.D.K.
10/30/74

Highland Lake - #245.07

4.

5.

6.

P.D.K.
10/30/74

M E M O R A N D U M

To: Vernon A. Knowlton

Re: North Outlet of Highland Lake, Washington

Date: September 19, 1967

The North Outlet is shown on the USGS Quadrangle sheet at Lovewells Mountain. It is located about 1000 feet north of a camp road which runs north from the end of that shown on the USGS sheet.

This outlet structure is essentially an emergency spillway of very limited capacity. (There is a 36" BCCM pipe culvert under Bailey Road about 0.8 mile downstream.) The channel and inlet is now obstructed and prevents flow at full pond. It could pass a limited amount of water at full pond if the inlet and channel were cleared to its original dimensions.

The channel narrows to 1 1/2' wide with vertical rock sides. Water would have to be about two feet over full to pass any considerable flow as it is now. About 0.2 miles below the North Outlet, there is a natural or beaver induced barrier at the head of the brook which from there runs down an appreciable grade. If this barrier were opened about ten feet wide and to the depth of the original channel, appreciable flow would result.

My recommendations to activate this emergency spillway include:

(1) Removing the natural or man-made obstructions at the entrance to the Outlet. This would require shovels and crow bar to remove wood, earth and cobbles - possible 1/2 to 1 cubic yard as the opening is 2 1/2' wide and 1 1/2' deep.

(2) The channel from the Outlet should be cleared of debris, wood and some stones to the originally dug depth. This would be mainly shovel work for a distance of 1000±' but only a fraction of it may have to be deepened. It may be advisable to blast a few stones by mudcapping.

(3) The barrier of cobbles, larger rocks and earth at the start of the sloping brook channel should be removed. This could be accomplished by dynamiting or barring out the rocks.

(4) A very simple control structure at the entrance to the outlet could be constructed. This should be three feet wide and 2 1/2' deep opening with provision for stoplogs for the botton 18". The top of this structure should be 12" over full pond.

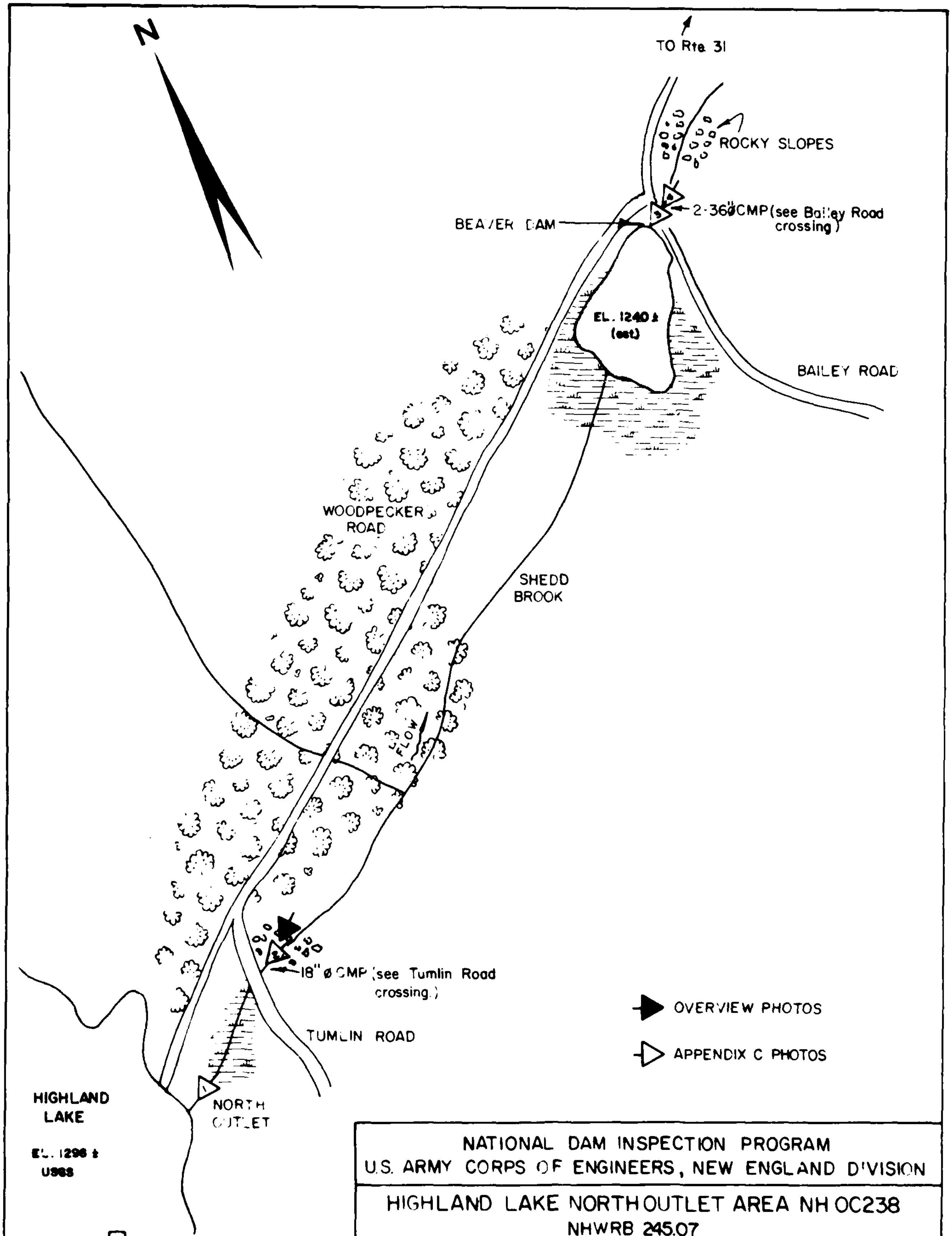
The above is based upon a field trip taken September 14, 1967.

Francis C. Moore
Civil Engineer

FCM:p

APPENDIX C

SELECTED PHOTOGRAPHS



GEOTECHNICAL CONSULTANTS

NATIONAL DAM INSPECTION PROGRAM
U.S. ARMY CORPS OF ENGINEERS, NEW ENGLAND DIVISION

HIGHLAND LAKE NORTH OUTLET AREA NH 00238
NHWRB 245.07

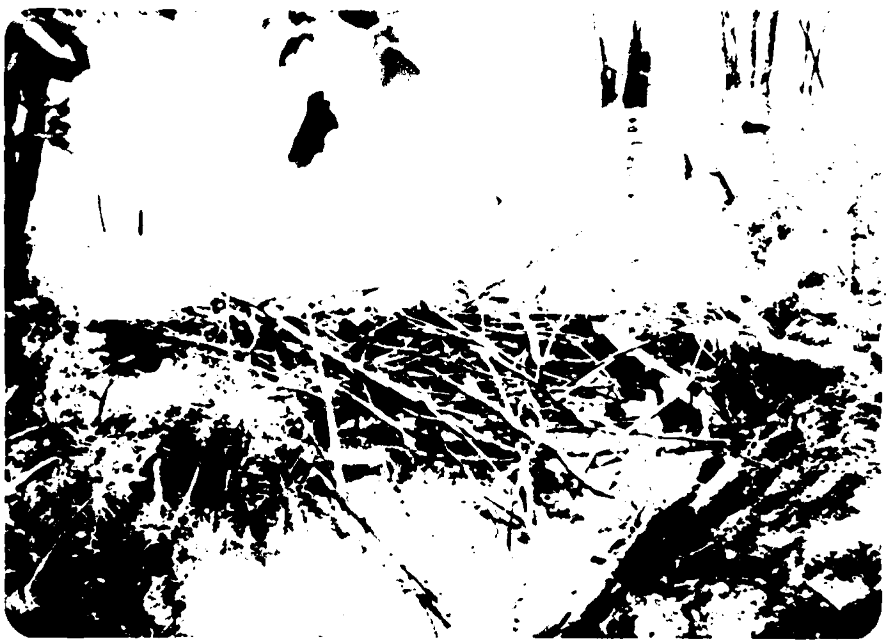
LOCATION AND ORIENTATION OF PHOTOS

JULY 1978 SCALE: 1" ≈ 0.1 mi

1. View looking upstream of North Outlet blocked by debris

2. Downstream outlet of 18" CMP culvert under Tumlin Road

3. Outlet area for 2-36" CMP culverts under Bailey Road



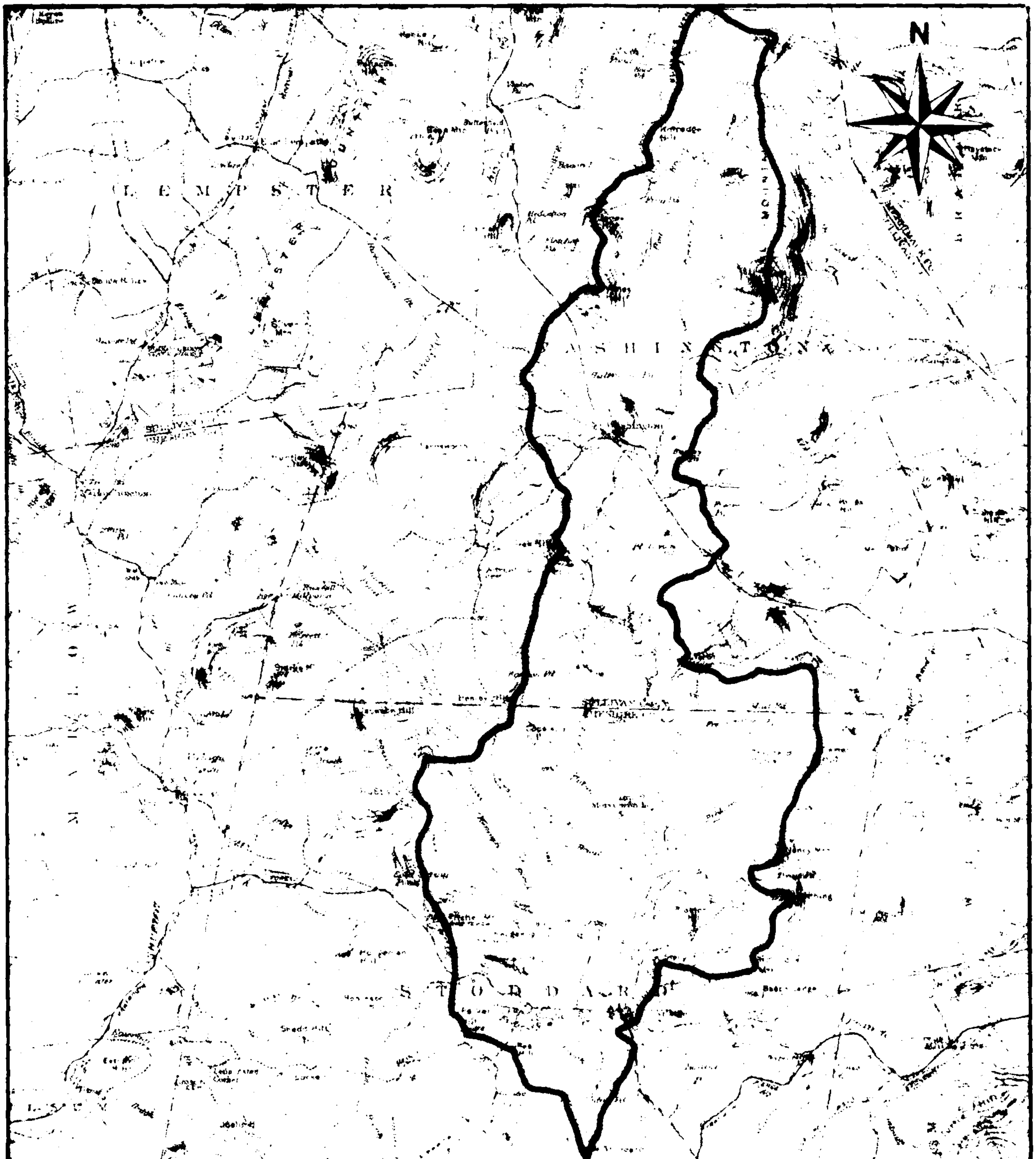
4. View looking upstream of beaver dam blocking flow into culverts under Bailey Road

APPENDIX D

HYDROLOGIC & HYDRAULIC COMPUTATIONS

FOR

HIGHLAND LAKE NORTH OUTLET



- ESTIMATED -
0 1/2 1 2 3 (miles)

FILE No. 2067

GEOTECHNICAL CONSULTANTS

NATIONAL DAM INSPECTION PROGRAM
U.S. ARMY CORPS OF ENGINEERS, NEW ENGLAND DIVISION

HIGHLAND LAKE NORTH OUTLET NH00238
NHWRB 245.07
DRAINAGE AREA

JULY 1978

SIZE CLASSIFICATION: INTERMEDIATE

HAZARD CLASSIFICATION: SIGNIFICANT

Downstream homes [illegible]
[illegible]
South [illegible]
Significant [illegible]

SPILLWAY TEST FLOOD

½ PMF → PMF

From [illegible] curve [illegible]

⇒ 1325 cfs/mi²

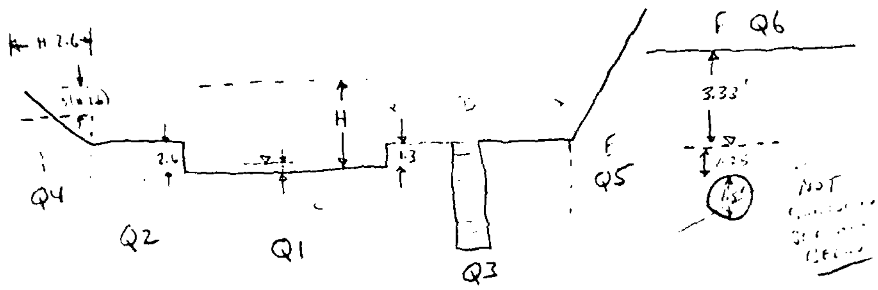
PMF = 29.7(1325) = 39353 cfs

GIVEN THE UNCERTAINTY OF [illegible] THIS DAM SHOULD BE "LOW" OR SIGNIFICANT HAZARD, WE'LL USE THE ½ PMF VALUE

STF = 20,000 cfs

DAMS 148 HIGHLAND LAKE DWood 6-19-78 2 of 4

FOR THE STAGE DISCHARGE RATING CURVE WE HAVE THE COMBINATION OF FLOW OVER THE SOUTH OUTLET SPILLWAY, THE SOUTH OUTLET STOPLOG SLUICE IF REMOVED AND THE NORTH OUTLET CULVERT.



ASSUME STOPLOGS AT SOUTH OUTLET ARE IN PLACE.
ASSUME LAKE [illegible] FLAT ON [illegible] FIRST [illegible] [illegible] AT [illegible]. "H" WILL BE MEASURED AS DISTANCE ABOVE PRIMARY SPILLWAY AT [illegible]

[illegible] BY [illegible] SECTION

C: $Q_C = C_C L_C H^{3/2} = C_C (51.25) H^{3/2}$ $C_C = 3.0$

B: $Q_B = C_B L_B (H-2.6)^{3/2} = C_B (14.3)(H-2.6)^{3/2}$ $C_B = 3.0$

A: $Q_A = C_A L_A [.5(H-2.6)]^{3/2} = C_A [H-2.6][.5(H-2.6)]^{3/2}$ $C_A = 2.8$

D: $Q_D = C_D L_D [H-1.3]^{3/2} = C_D [41.25][H-1.3]^{3/2}$ $C_D = 3.0$

E: $Q_E = C_E L_E [.5(H-1.3)]^{3/2} = C_E [H-1.3][.5(H-1.3)]^{3/2}$ $C_E = 2.8$

F: ASSUME FLAT ROAD 100' LONG

ASSUME CULVERT (18") IS BLOCKED SINCE IT HAS BEEN BLOCKED FOR EACH FIELD TRIP.

ASSUME ROAD IS BREACHED ONCE IT IS OVERTOPPED* ASSUME BREACH IS 40'x4'.

$H \leq 4.0 \qquad Q_F = C_F(100)(H-3.5)^{3/2}$

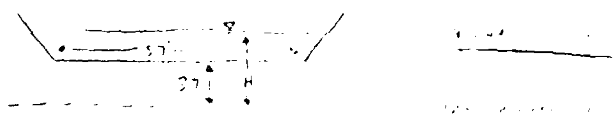
$H > 4.0 \qquad Q_F = C_F(60)(H-3.5)^{3/2} + C_F(40)(H+.5)^{3/2}$

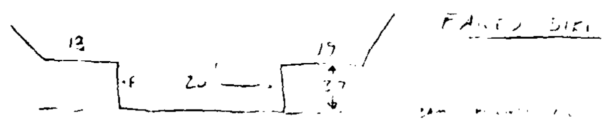
* OVERTOPPED BY 0.5'

DAMS 148 6-28-78 4 of 24

$H > 4.0$

FAILS





IN THE

STAGE CURVE

$$H \le 4.0 \quad Q_G = C_G(57)(H-3.7)^{3/2}$$

$$H > 4.0 \quad Q_G = C_G(37)(H-3.7)^{3/2} + C_G(20)(H)^{3/2}$$

SIDES: $$Q_H = 2.8\left[2(H-3.7)\right]\left[.5(H-3.7)\right]^{3/2}$$

DAMS 148 | HIGHLAND LAKE #1 F#1 | DWood 6-19-78 5 of 24

STORAGE / STAGE RELATIONSHIP

SURFACE AREA OF LAKE AS SHOWN ON NJWRB DATA

711 ACRES

I'LL ASSUME NO S[illegible] AS THE WATER SURFACE [illegible] EVERY FOOT THE [illegible]

DRAINAGE AREA = 29.7 SQMI

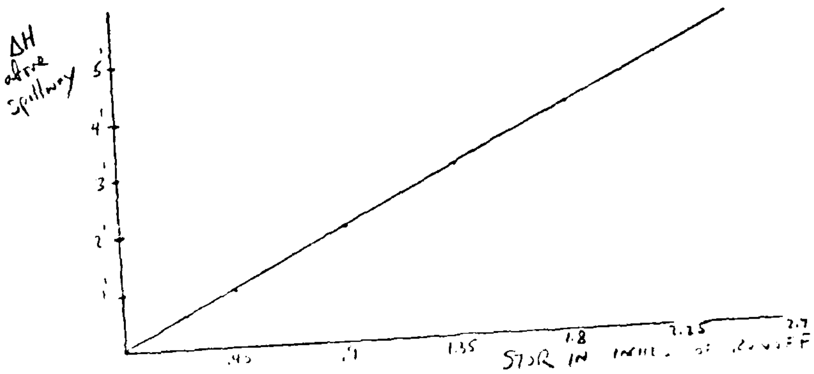
1 inch of runoff would cause

$\frac{29.7(640)}{711}$ = 26.73" rise in water surface

1 foot of rise = .449" of runoff ~ .45"

2 feet of rise .898" of runoff ~ .9"

5 feet of rise 2.245" of runoff ~ 2.25"



DAM: 142 HIGHLAND LAKE 1/4 6-19-78 [illegible] 6 of 14

EFFECT OF SURCHARGE ON MAX. PROBABLE DISCHARGES

For 20,000 cfs, $H \approx 10.2$ FT

10.2' of HEAD EQUATES TO $10.2 \times (.45) = 4.59''$ OF RUNOFF

STOR$_1$ = 4.6

$$Q_{P2} = Q_{P1} \times \left(1 - \frac{STOR}{9.5}\right)$$

$$Q_{P2} = 20,000 \times \left(1 - \frac{4.6}{9.5}\right)$$

$$Q_{P2} = 10337$$

For 10337 cfs, $H \approx 7.1'$

$STOR_2 = 7.1 \times .45'' = 3.2''$

AVG STOR $= \frac{4.6 + 3.2}{2} = 3.9''$

$$Q_{P3} = 20000 \times \left(1 - \frac{3.9}{9.5}\right) = 11789 \approx 11800 \text{ cfs}$$

Thus THE STF RESULTS IN A DISCHARGE OF ≈ 11800 CFS TOTAL AND A HEAD ABOVE THE [illegible] SPILLWAY OF 7.6'. THIS REPRESENTS A TOTAL FLOW OF ≈ 3950 CFS OUT THE NORTH OUTLET, 5850 CFS OVER THE [illegible] DAM, AND 2000 CFS THROUGH THE BREACHED SOUTH DIKE.

COMMENTS ON RESULTS:

THE SPILLWAY OF 51.25 HAS A MAX. OF 1.3' OF FREEBOARD BEFORE THE EAST ABUTMENT IS OVERTOPPED. THIS REPRESENTS A CAPACITY OF 228 CFS. THE VICINITY OF THE DAM INCLUDING OVERFLOW OVER THE ABUTMENTS — HAS A MAX. CAPACITY OF 1700 cfs AT A HEAD OF 3.7' ABOVE THE SPILLWAY. ABOVE 3.7' THE SOUTH DIKE BEGINS TO BE OVERTOPPED. ABOVE 3.5' THE NORTH OUTLET ROAD EMBANKMENT IS OVERTOPPED. THE ANALYSIS ASSUMES THAT BOTH OF THESE AREAS FAIL WITH A 20' WIDE AND 3.7' DEEP GAP AT THE SOUTH DIKE, AND A 40' WIDE, 4' DEEP GAP AT THE NORTH OUTLET. WHEN THE DIKES FAIL IT IS IMPOSSIBLE TO PREDICT EXACTLY HOW WIDE A GAP WILL RESULT. IN ADDITION THE BREAKS MAY BECOME SURCHARGED [illegible] FROM DOWNSTREAM BACKWATERS AND THUS THE USE OF THE WEIR EQUATION IS GENEROUS FROM AN OUTFLOW CONSIDERATION, SINCE ANY TAILWATER ON A CHANNEL FLOW ANALYSIS WOULD REDUCE THE OUTFLOW.

GIVEN THESE COMBINATIONS OF DISCHARGE CONDITIONS AND SURCHARGE STORAGE A PEAK INFLOW OF 7,000 CFS COULD RESULT IN A DISCHARGE OF 11,800 CFS AND A LAKE ELEVATION 7.6' ABOVE THE DAM SPILLWAY CREST.

TOTAL DISCHARGE FROM HIGHLAND LAKE AS FUNC OF HEAD

HEAD	DISCHARGE			
	TOTAL	DAM	SOUTH DIKE	NORTH OUTLET
0.5	54	54	0	0
1.0	154	154	0	0
1.5	294	294	0	0
2.0	508	508	0	0
2.5	772	772	0	0
3.0	1088	1088	0	0
3.5	1455	1455	0	0
4.0	1990	1864	26	99
4.5	4342	2311	610	1420
5.0	5331	2794	783	1753
5.5	6413	3310	981	2121
6.0	7578	3858	1200	2520
6.5	8823	4437	1439	2947
7.0	10142	5044	1697	3400
7.5	11533	5681	1973	3878
8.0	12992	6346	2267	4379
8.5	14517	7037	2577	4902
9.0	16106	7755	2904	5446
9.5	17758	8500	3247	6011
10.0	19471	9270	3606	6595
10.5	21243	10065	3981	7197
11.0	23075	10885	4371	7818
11.5	24964	11729	4777	8457
12.0	26909	12598	5198	9113
12.5	28910	13490	5634	9786
13.0	30967	14407	6085	10475
13.5	33077	15346	6551	11180
14.0	35242	16309	7032	11900

8 of 24

Summary file

```
LIST
100 REM STAGE DISCHARGE CALC FOR HIGHLAND LAKE DAM JOB 148LIST
110 PAGE
120 C1=3
130 C2=2.8
140 E=1.5
150 PRINT "TOTAL DISCHARGE FROM HIGHLAND LAKE AS FUNC OF HEAD"
160 PRINT USING 170:
170 IMAGE // 2T"HEAD"30T"DISCHARGE"
180 PRINT USING 190:
190 IMAGE 10T"TOTAL    DAM   SOUTH DIKE   NORTH OUTLET"
200 FOR H=0.5 TO 14 STEP 0.5
210 Q1=C1*51.25*H↑E
220 Q2=0
230 Q4=0
240 IF H<=2.6 THEN 270
250 Q2=C1*14.3*(H-2.6)↑E
260 Q4=C2*(H-2.6)*(0.5*(H-2.6))↑E
270 Q3=0
280 Q5=0
290 IF H<=1.3 THEN 320
300 Q3=C1*41.25*(H-1.3)↑E
310 Q5=C2*(H-1.3)*(0.5*(H-1.3))↑E
320 Q6=0
330 IF H<=3.5 THEN 350
340 Q6=C2*100*(H-3.5)↑E
350 Q8=0
360 Q9=0
370 IF H<=3.7 THEN 430
380 Q8=C2*57*(H-3.7)↑E
390 Q9=C2*(2*(H-3.7))*(0.5*(H-3.7))↑E
400 IF H<=4 THEN 430
410 Q8=C2*37*(H-3.7)↑E+C2*20*H↑E
420 Q6=C2*60*(H-3.5)↑E+C2*40*(H+0.5)↑E
430 Q7=Q1+Q2+Q3+Q4+Q5+Q6+Q8+Q9
```

9/24

```
431 F1=Q1+Q2+Q3+Q4+Q5
432 F2=Q8+Q9
440 PRINT USING 450:H,Q7,F1,F2,Q6
450 IMAGE 1T,2D.1D,8D,9D,11D,11D
460 NEXT H
470 END
```

TOTAL DISCHARGE FROM HIGHLAND LAKE AS FUNC OF HEAD

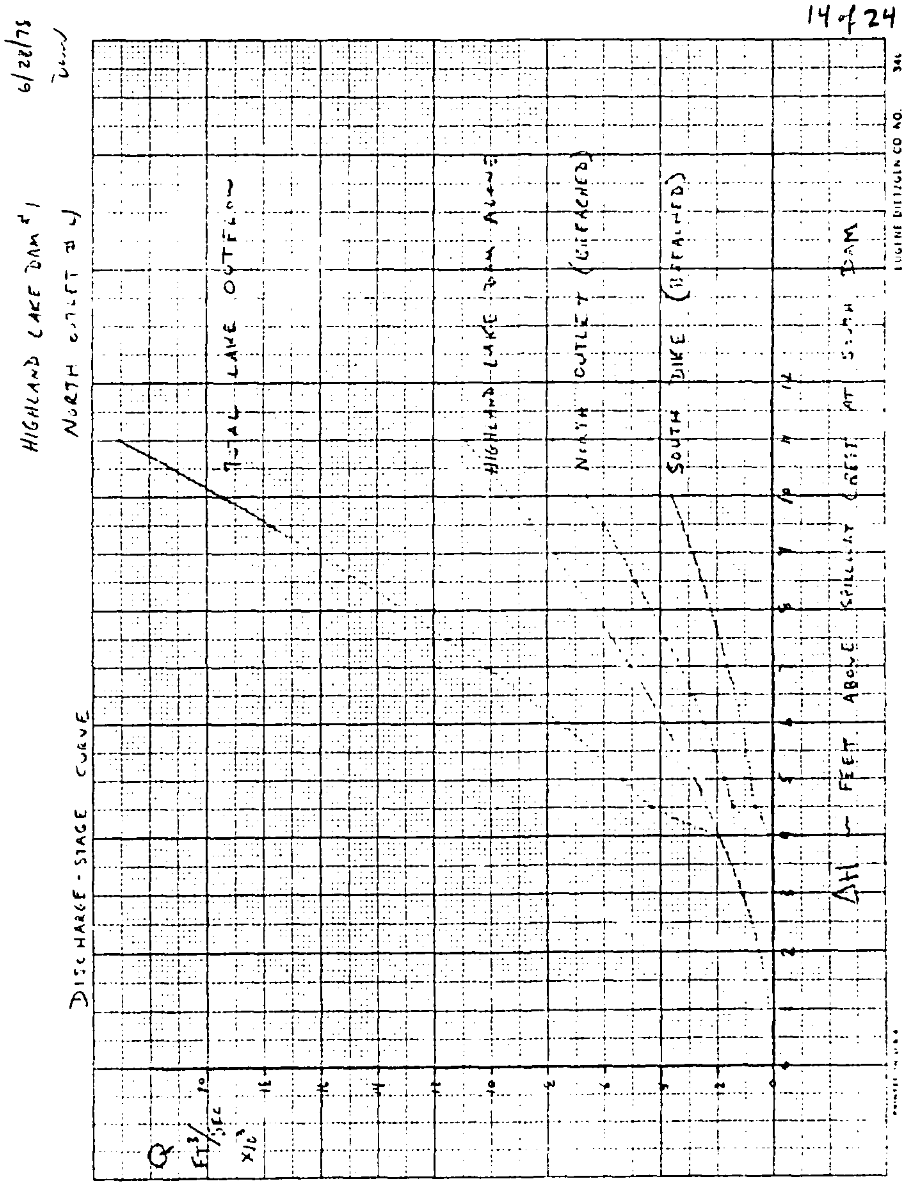
HEAD				DISCHARGE					
	TOTAL	Q1	Q2	Q3	Q4	Q5	Q6	Q8	Q9
0.5	54	54	0	0	0	0	0	0	0
1.0	154	154	0	0	0	0	0	0	0
1.5	294	282	0	11	0	0	0	0	0
2.0	508	435	0	72	0	0	0	0	0
2.5	772	608	0	163	0	2	0	0	0
3.0	1088	799	11	274	0	4	0	0	0
3.5	1455	1007	37	404	1	7	0	0	0
4.0	1990	1230	71	549	2	12	99	26	0
4.5	4342	1468	112	708	5	18	1420	609	1
5.0	5331	1719	160	881	9	26	1753	780	4
5.5	6413	1983	212	1065	14	36	2121	973	9
6.0	7578	2260	269	1261	21	47	2520	1184	16
6.5	8823	2548	330	1467	30	61	2947	1413	26
7.0	10142	2847	396	1684	40	77	3400	1658	39
7.5	11533	3158	465	1910	53	95	3878	1918	56
8.0	12992	3479	538	2146	67	115	4379	2191	76
8.5	14517	3810	615	2391	84	138	4902	2477	100
9.0	16106	4151	695	2644	103	163	5446	2776	128
9.5	17758	4502	778	2906	124	191	6011	3087	160
10.0	19471	4862	864	3176	147	221	6595	3409	197
10.5	21243	5231	953	3453	174	254	7197	3742	239
11.0	23075	5609	1044	3739	202	290	7818	4086	285
11.5	24964	5996	1139	4031	234	329	8457	4441	336
12.0	26909	6391	1236	4331	268	371	9113	4805	393
12.5	28910	6795	1336	4638	305	416	9786	5179	455
13.0	30967	7207	1439	4952	345	464	10475	5563	522
13.5	33077	7626	1544	5273	388	515	11180	5956	595
14.0	35242	8054	1651	5601	434	569	11900	6358	674

```
LIST
100 REM STAGE DISCHARGE CALC FOR HIGHLAND LAKE DAM JOB 148LIST
110 PAGE
120 C1=3
130 C2=2.8
140 E=1.5
150 PRINT "TOTAL DISCHARGE FROM HIGHLAND LAKE AS FUNC OF HEAD"
160 PRINT USING 170:
170 IMAGE // 2T"HEAD"30T"DISCHARGE"
180 PRINT USING 190:
190 IMAGE  8T"TOTAL     Q1     Q2     Q3    Q4    Q5     Q6     Q8    Q9"
200 FOR H=0.5 TO 14 STEP 0.5
210 Q1=C1*51.25*H↑E
220 Q2=0
230 Q4=0
240 IF H<=2.6 THEN 270
250 Q2=C1*14.3*(H-2.6)↑E
260 Q4=C2*(H-2.6)*(0.5*(H-2.6))↑E
270 Q3=0
280 Q5=0
290 IF H<=1.3 THEN 320
300 Q3=C1*41.25*(H-1.3)↑E
310 Q5=C2*(H-1.3)*(0.5*(H-1.3))↑E
320 Q6=0
330 IF H<=3.5 THEN 350
340 Q6=C2*100*(H-3.5)↑E
350 Q8=0
360 Q9=0
370 IF H<=3.7 THEN 430
380 Q8=C2*57*(H-3.7)↑E
390 Q9=C2*(2*(H-3.7))*(0.5*(H-3.7))↑E
400 IF H<=4 THEN 430
410 Q8=C2*37*(H-3.7)↑E+C2*20*H↑E
420 Q6=C2*60*(H-3.5)↑E+C2*40*(H+0.5)↑E
430 Q7=Q1+Q2+Q3+Q4+Q5+Q6+Q8+Q9
```

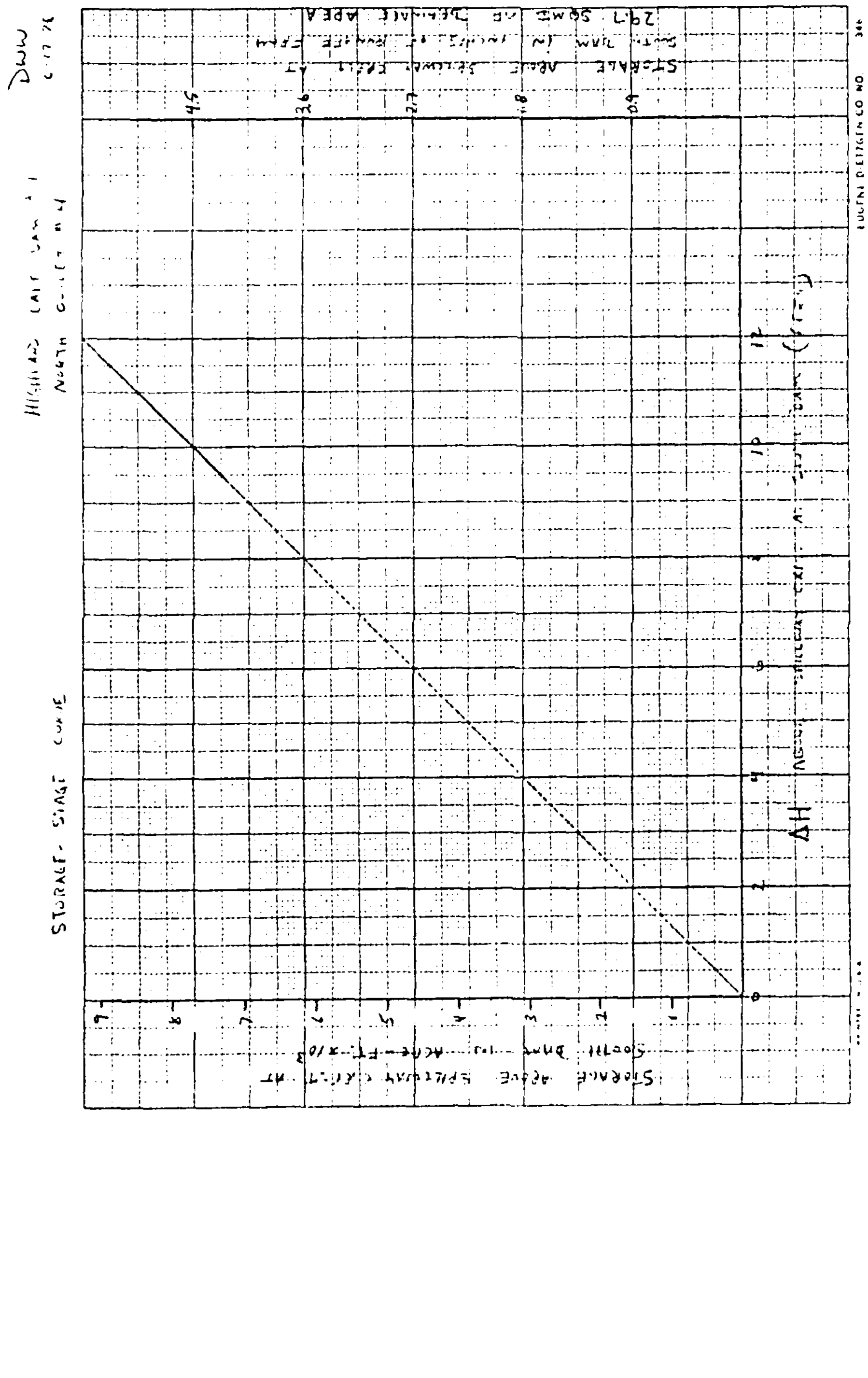
12-124

```
440 PRINT USING 450:H,Q7,Q1,Q2,Q3,Q4,Q5,Q6,Q8,Q9
450 IMAGE 1T,2D.1D,7D,7D,6D,7D,6D,6D,7D,7D,6D
460 NEXT H
470 END
```

13-f24


HIGHLAND LAKE DAM #1
NORTH OUTLET
6/28/75
DISCHARGE - STAGE CURVE
TOTAL LAKE OUTFLOW
HIGHLAND LAKE DAM ALONE
NORTH OUTLET (BREACHED)
SOUTH DIKE (BREACHED)
ΔH — FEET ABOVE SPILLWAY CREST AT SOUTH DAM
Q FT³/SEC x10³

15 of 24



HIGHLAND LAKE —
NORTH OUTLET

2LL
5 JULY 78 Page 17 of 22

CALCULATION OF ESTIMATED DOWNSTREAM FLOOD STAGES
— BASED ON COE "RULE OF THUMB" GUIDANCE, APRIL 1972.

STEP 1 RESERVOIR STORAGE (S) AT TIME OF FAILURE

ASSUME: FAILURE WHEN EARTHFILL ROADWAY EMBANKMENT AT ELEV. 1299.5' IS OVERTOPPED

ALSO STORAGE AT FAILURE IS ONLY THAT VOLUME ABOVE OUTLET INVERT AT LAKE SHORE AT ABOUT ELEV 1295'

S = (1299.5' − 1295') × 711 AC ≈ 3200 AF

STEP 2 PEAK FAILURE OUTFLOW (QPI)

$$QPI = \frac{8}{27} W_b \sqrt{g}\, Y_0^{3/2}$$

WHERE W_b = BREACH WIDTH ≈ 40% OF LENGTH

= 0.4(100') = 40'

g = 32.2

Y_0 = HEIGHT ABOVE STREAMBED AT FAILURE

= 1299.5 − 1291.2 = 8.3'

$$\therefore\ QPI = \frac{8}{27}(40)\sqrt{32.2}\,(8.3)^{3/2} = 1610 \text{ cfs}$$

STEP 3 STAGE DISCHARGE RATINGS FOR DOWNSTREAM REACHES:

ASSUMED CROSS SECTIONS FOR D.S. REACHES SHOWN ON USGS TOPO MAP ARE PLOTTED ON THE ATTACHED SHEET.

COMPUTER PRINTOUT TABLE OF STAGE - DISCHARGE RELATIONSHIPS ARE ATTACHED

STEP 4 CALCULATIONS

REACH 1 QP1 = 1610 cfs

H = f(QP1) = 4.5'

AREA @ 4.5' = 200 S.F.

V1 = L × AREA = 2100 × 200/43560 = 9.6 AF (≤ 25)

QP2T = QP1(1 − V1/S) = 1610(1 − 9.64/3200) = 1605 cfs

QP2 = 1605 cfs

REACH 2 QP1 = 1605

H = f(QP1) = 5.8'

AREA @ 5.8 = 98 SF

V1 = L × AREA = 9000 × 98 / 43560 = 20.2 AF

QP2T = QP1(1 − V1/S) = 1605(1 − 20.2/3200) = 1594 cfs

H = f(QP2T) = 5.7'

QP2 = 1600 cfs

HIGHLAND LAKE —
NORTH OUTLET

RLL
29 JUNE 78

REACH 1 — NORTH OUTLET TO LAKE SHORE ROAD

L = 2100

$S = \frac{1250-1210}{2100} = .019$

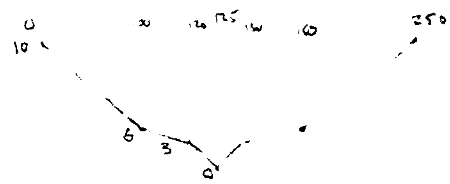
n = .025

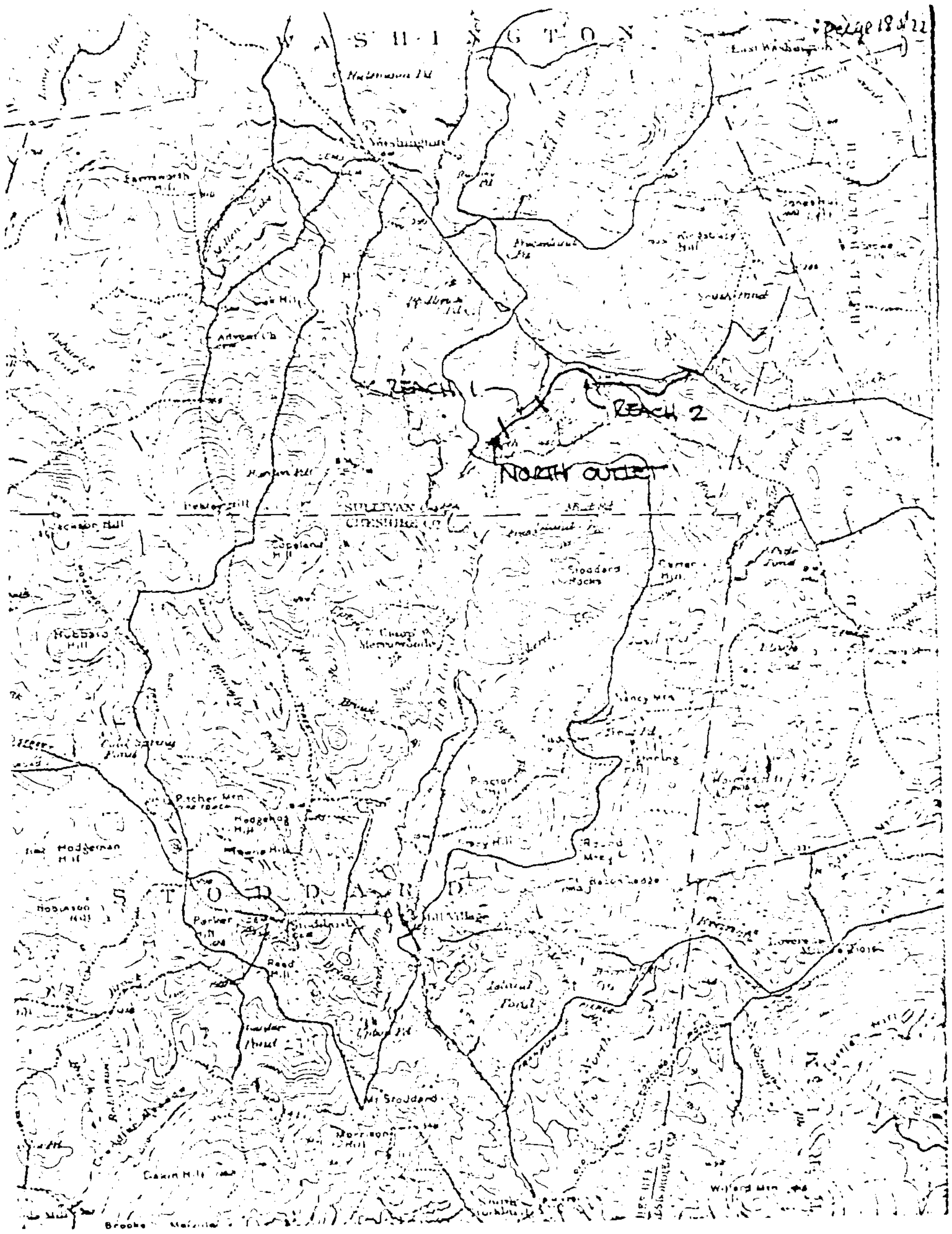
REACH 2 — SHORE ROAD TO ROUTE 31

L = 9000

$S = \frac{1210-1005}{9000} = .023$

n = .020




W A S H I N G T O N
REACH 1
REACH 2
NORTH OUTLET
SULLIVAN CO
CHESHIRE CO
S T O D D A R D
Pitcher Mtn
Hedgehog Hill
Hodgeman Hill
Robinson Hill
Parker Hill
Reed Hill
Mt Stoddard
Stoddard Rocks
Copeland Hill
Proctor
Round Mtn
Gilson Hill

DEPTH	ELEV	AREA	WPER	HYD-R	AR2/3	Q
0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	1.0	1.7	3.9	0.4	0.9	7.8
2.0	2.0	6.7	7.8	0.9	6.0	49.4
3.0	3.0	15.0	11.7	1.3	17.7	145.8
4.0	4.0	93.3	148.3	0.6	68.5	562.9
5.0	5.0	308.3	285.0	1.1	324.9	2669.4
6.0	6.0	660.0	421.7	1.6	889.8	7310.1
7.0	7.0	1090.0	441.8	2.5	1990.8	16354.7
8.0	8.0	1540.0	461.9	3.3	3438.3	28246.4
9.0	9.0	2010.0	482.0	4.2	5209.9	42801.2
10.0	10.0	2500.0	502.1	5.0	7293.5	59918.3

HIGHLAND LAKE NORTH OUTLET - REACH 1

DEPTH	ELEV	AREA	WPER	HYD-R	AR2/3	Q
0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	1.0	1.7	3.9	0.4	0.9	10.7
2.0	2.0	6.7	7.8	0.9	6.0	68.0
3.0	3.0	15.0	11.7	1.3	17.7	200.5
4.0	4.0	31.7	25.1	1.3	36.9	417.3
5.0	5.0	61.7	38.6	1.6	84.2	951.9
6.0	6.0	105.0	52.1	2.0	167.5	1893.0
7.0	7.0	180.0	102.1	1.8	262.7	2967.6
8.0	8.0	305.0	152.2	2.0	484.9	5479.0
9.0	9.0	480.0	202.2	2.4	854.3	9652.8
10.0	10.0	705.0	252.3	2.8	1399.2	15809.1

HIGHLAND LAKE NORTH OUTLET - REACH 2

APPENDIX E

REVISED INVENTORY FORMS

END

FILMED

8-85

DTIC