Anderson-Nichols
6 Loudon Road
Concord, New Hampshire 03301
(603) 228-1121

June 19, 1979

NH 69

FEDERAL ENERGY REGULATORY COMMISSION
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John P. Chandler
Colonel, Corps of Engineers
Deputy Division Engineer
Contracting Officer
New England Division
424 Trapelo Road
Waltham, Mass. 02154

SUBJECT: Inspection and Evaluation of
11 New Hampshire Dams
Contract No. DACW33-79-C-0050
Our Job No. 3273

Dear Colonel Chandler:

This letter advises you that one dam in the subject contract appears to have low-hazard potential based on data from our field inspection and the preliminary results of our breach analysis. A brief report, updated inventory sheets, and photos are enclosed for Item 3, Woodsville Hydroelectric Dam.

If you concur with our findings and drop this line item, we would welcome the opportunity to discuss with members of your staff the arrangements for amending our contract to identify a substitute structure.

To expedite resolution of this request, please call Mr. Degen or me and we will arrange to meet in Waltham to execute any contractural changes. Should you require further information or additional documentation we would be pleased to provide same.

Very truly yours,

ANDERSON-NICHOLS & COMPANY, INC.

W. A. Guinan

W. A. Guinan, P. E.
Vice President & Manager
Water Resources Division-Concord

WAG/vm
Enclosure

WOODSVILLE HYDROELECTRIC DAM - Line Item No. 03

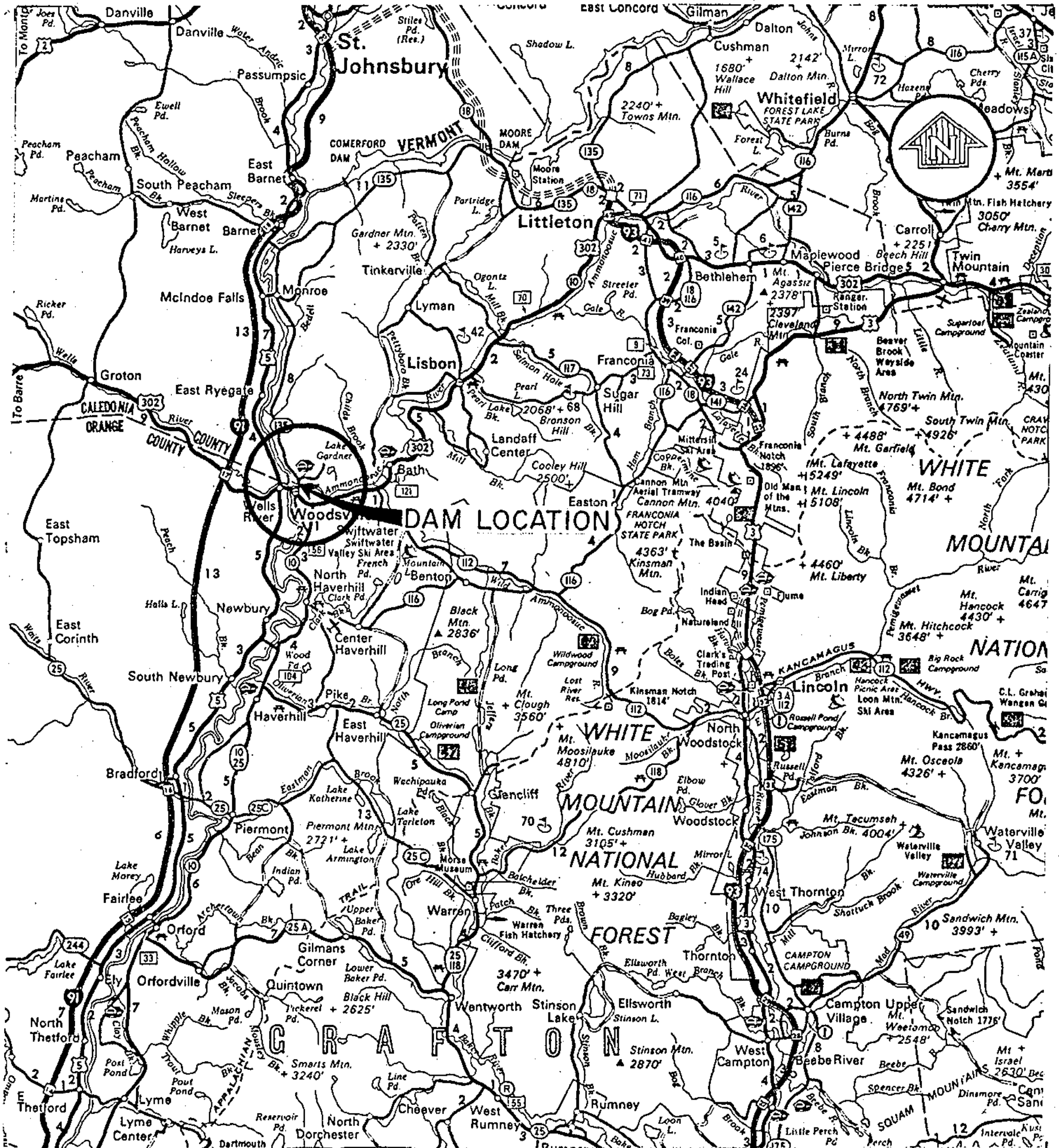
This dam was built in 1936, approximately 500 feet from the point where the Connecticut and Ammonoosuc Rivers become confluent. It is a run-of-the-river concrete gravity dam with a 297 foot spillway built in 4 distinct sections. Its structural height is 23 feet. The height of the spillway crest above the downstream channel bottom is 13 feet (See Figure 1).

A covered bridge crosses the crest of the dam (See Figure 2). The north abutment of the dam is immediately upstream of the bridge while the south abutment is just downstream of the bridge (See Figures 3 and 4). The center pier of the bridge is founded on a bedrock knob near the center of the dam. A small leak through the joints in the rock beneath the bridge pier indicates some structural weakness in the rock and a possibility that the rock may be deteriorating with time due to the physical action of freezing and thawing, and other factors (See Figure 5). Sand and gravel have accumulated in the channel almost up to the level of the crest of the dam.

In 1974 the equipment used for the generation of electricity at Woodsville Dam was removed, including the main turbine. The two 8'w x 10'h headgates adjoining the second abutment are presently being operated. The storage capacity for the dam at spillway crest is 179 acre-feet, the maximum capacity being 226 acre-feet. These storages correspond to surface area of 27 and 30 acres; respectively. It is the maximum storage capacity of 226 acre-feet combined with a hydraulic height of 15 feet that classifies Woodsville Hydroelectric Dam as a small dam, as given in Recommended Guidelines for Safety Inspection of Dams based on height ($<$ 40') and storage ($\geq$ 50 and $<$ 1000 acre-feet).

The hazard downstream is virtually none. Woodsville Dam is located approximately 500 feet from the Connecticut River, there being only 1 inhabited structure before the confluence. This house is located just downstream from the northerly abutment of the bridge crossing the dam, and is approximately at the same elevation as the spillway (417' msl). Based on a rating curve developed for the short reach of river below the dam, it was determined that a breach at top of dam would result in a discharge of 17,000 cfs and subsequently, raise the water surface elevation in the reach to 410' msl; thereby, resulting in no hazard.

Another developed area investigated for potential hazard exists on the Connecticut River just downstream of its confluence with the Ammonoosuc River, consisting of about 14 inhabited structures (415' msl) and the National Guard Armory located on the east bank in Woodsville, New Hampshire, and 7 inhabited structures (420' msl) on the west bank in Wells River, Vermont. Assuming a normal flow condition on the Connecticut River, a breach at top of dam would increase the stage in the area of interest by only 5 feet (408 msl) above normal flow; and would not create any hazard to the shoreline structures (see attached calculations).



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SCALE IN MILES

0 5 10

MAP BASED ON STATE OF NEW HAMPSHIRE OFFICIAL HIGHWAY MAP.

Anderson-Nichols & Co., Inc. CONCORD NEW HAMPSHIRE	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

WOODSVILLE HYDROELECTRIC DAM LOCATION MAP

AMMONOOSUC RIVER NEW HAMPSHIRE

SCALE: SEE BAR SCALE

DATE: JUNE, 1979

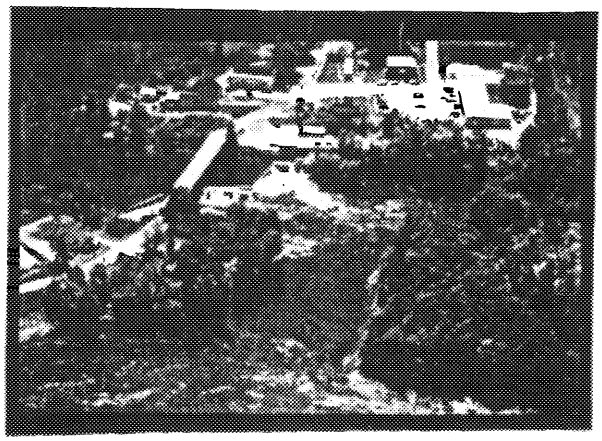

Figure 1

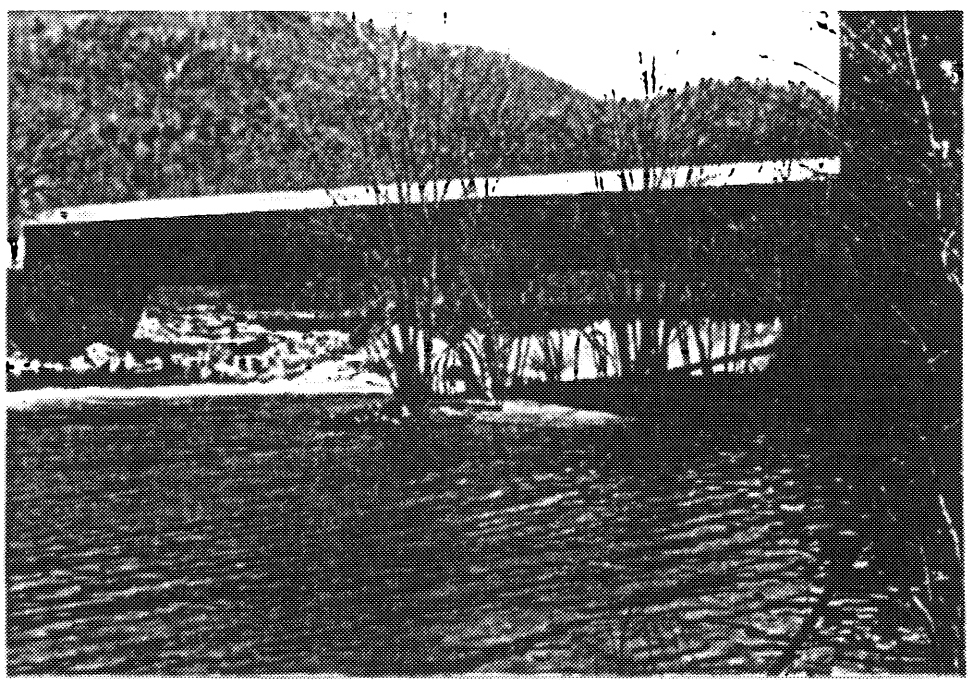

Figure 2

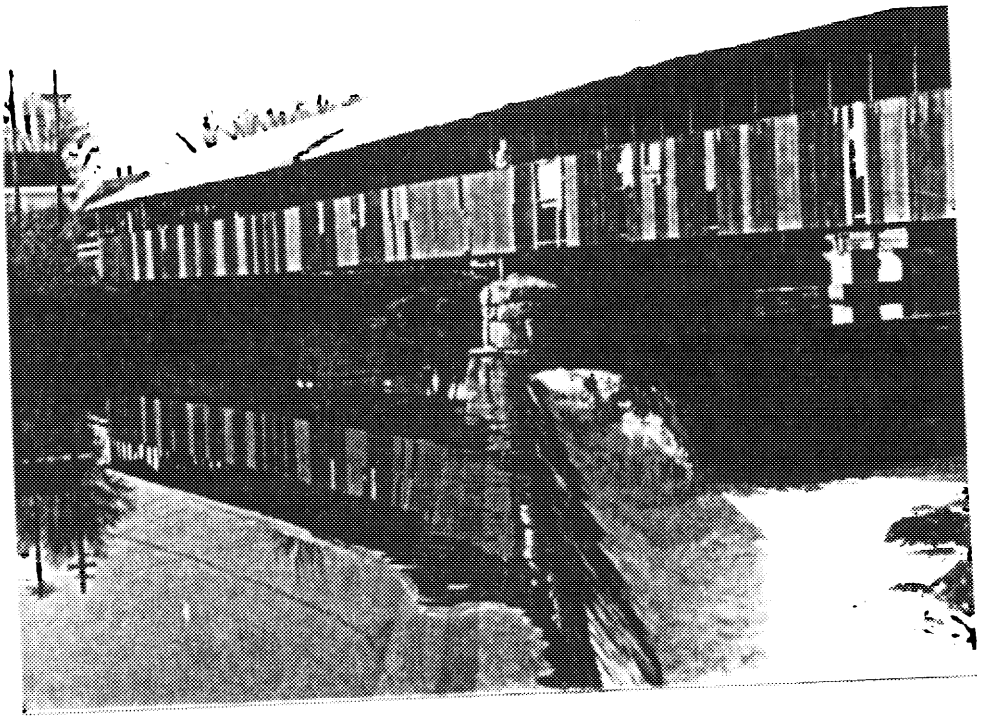

Figure 3

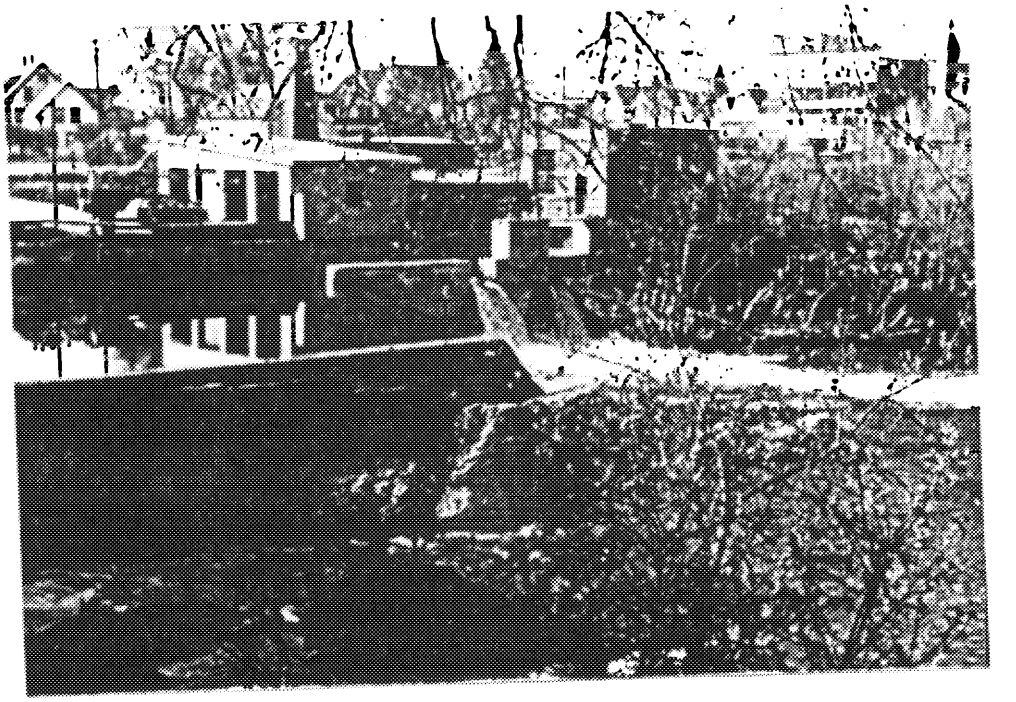

Figure 4

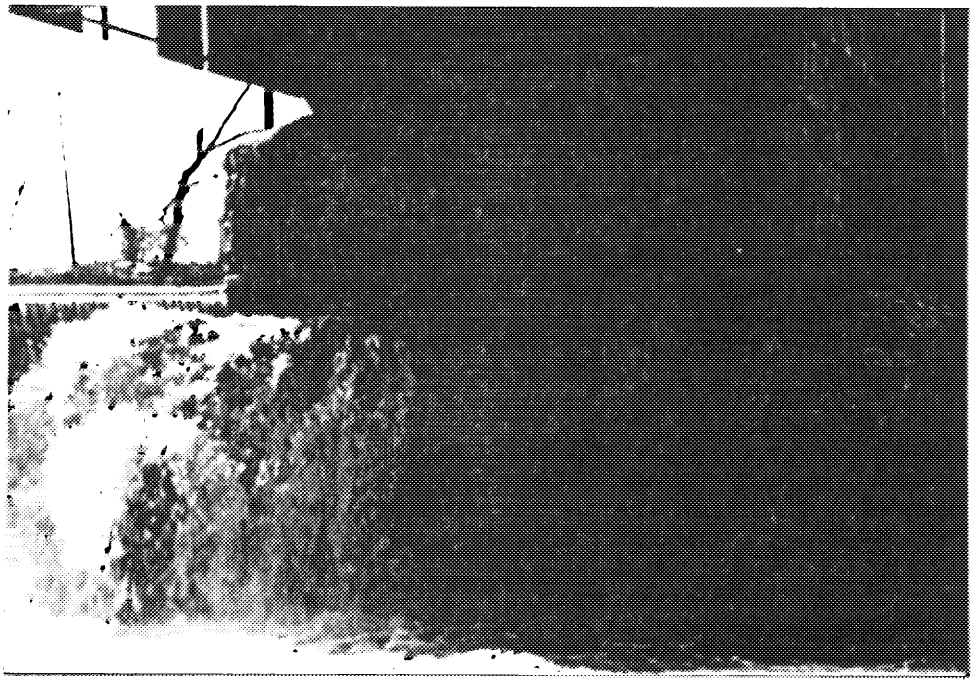

Figure 5

ASSUMPTION: FROM HISTORIC RECORDS OF CONNECTICUT R. & AMONOOSUC R., THE 2 RIVERS APPEAR TO PEAK AT THE SAME TIME DURING MAJOR FLOOD EVENTS.

THE BREACH ANALYSIS WILL BE FIRST TESTED UNDER THE ASSUMPTION OF NON-CONCURRENT PEAKS WHEN THE BREACH FLOW OCCURS.

$$Q_P = 8/27\,(W_b)(\sqrt{g})(y_o)^{3/2}$$

WHERE: W_b = breach width
$g = 32.2$ ft/sec^2
y_o = max. pool elev. before overtopping − u/s river bed elevation

$W_b = 0.4(145+65+87) = 118.8$, say 119
$y_o = 418.4 - 403.2 = 15.2$

$$Q_P = 8/27\,(119)(\sqrt{32.2})(15.2)^{3/2}$$

$Q_P = 11{,}857$ CFS

FLOW OVER DAM NOT BREACHED:

(1) $Q = CLH^{3/2}$

Rest of weir

WHERE: $L = (297 - 119) = 178'$
$H = (418.4 - 416.6) = 1.8'$
C = from King & Brater Table 5-3
Breadth = 3.7'
Head ≈ 1.8' @ DAM failure
$C = 2.7$ Broad crested

− Broad crested w/ corner rounding and slightly inclined upstream/downstream

— Table 5-4
C = 2.92

∴ use C = 2.85

$Q = CLH^{3/2}$
$Q = 2.85(178)(1.8)^{3/2}$
$Q = 1225$ CFS — over rest of weir

(2) GATE
$Q = CA\sqrt{2gh}$

$A = 6 \times 8 = 48$ □
$h = 418.4 - 405.2 = 13.2'$

401.7
d
405.2

$C = 0.7$ — King & Brater Table 4-9 Submerged Gates

$Q = 0.7(48)\sqrt{2(32.2)(13.2)}$
$Q = 980$ CFS

(3) 2 - 8'W X 10'H
$Q = 2 \times CA\sqrt{2gh}$
$A = 8 \times 10 = 80$
$h = (418.4 - 407.7) = 10.7$

Assumption: ~~Small~~ Negligible loss in C due to ~~gate~~ seperation between gates

$Q = 2 \times (0.7)(80)\sqrt{2(32.2)(10.7)}$

$Q = 2940$ CFS

(4) TRASH WEIRS
$Q = CLH^{3/2}$
$Q = 3.0(5)(418.4 - 412.1)^{3/2} + 3(2)(418.4 - 414.6)^{3/2}$

King & Brater pg. 5-46

$Q = 237 + 44 = 281$ CFS

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Subject H & H BREACH ANALYSIS

Sheet No. 3 of 7
Date 5/31/79
Computed
Checked

JOB NO. 3273-03
WOODSVILLE HYDRO DAM

SQUARES 1/4 IN. SCALE

$$Q_{TOTAL} = Q_{breach} + Q_{non\text{-}breach}$$

$$= 11{,}857 + (1225 + 980 + 2940 + 281)$$

$$Q_{TOTAL} = 11{,}857 + (5426) = 17{,}283 \text{ CFS}$$

QUARES /4 IN. SCALE

- CHECK DOWNSTREAM HAZARD ON CONNECTICUT
  - HOUSES ACROSS FROM USGS GAGE

Assume: No effect of attenuation due to confluent hydraulics w/ Conn. R.

Conn. R. AT normal stage when breach occurs.

- FROM FIELD INSPECTION 5-17-79
  ≈ W.S. @ GAGE = 403
  FROM RATING TABLE: 403 − 399.75 = 3.25 gage ht.

  3.25 gage ht = 3590 CFS

- CONN. R. HT DUE TO BREACH AT WOODSVILLE HYDROELECTRIC DAM

  Q = 3590 + 17,283 = 20,873

  FROM RATING TABLE:
  20,873 ≈ 7.76' gage height

  ELEV. = 399.75 ("0" gage in MSL) + 7.76
  = 407.51 say
  408

- HAZARD – LOWEST ELEV. NEAR HOUSES (14) is 415 (ROADWAY)

  408 < 415

- WAVE (r) – 2/3 (15') = 10'
  403 (Antecedent – normal flow) + 10 = 413

  413 < 415

∴ NO HAZARD

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Subject H.H.
BREACH ANALYSIS

Sheet No. 5 of 7
Date 5/31/79
Computed
Checked

JOB NO. 3273-03
WOODSVILLE DAM

- CHECK HAZARD AT HOUSES, DOWNSTREAM RT. BANK, BELOW WOODSVILLE HYDRO DAM.

- SECTION - SEE NEXT SHT.

- $Q = \frac{1.49}{n} R^{2/3} S^{1/2} A$

$S = 404.3 - 403.2 = 1.10'/162 = 0.007$ ft/ft

$S^{1/2} = 0.0824$

ELEV.	A	WP	R=A/WP	$R^{2/3}$	$n_{comp.}$	Q (CFS)
403.2	315	210.5	1.50	1.31	0.05	1013
405	707	219.5	3.22	2.18	0.049	3862
416	3375	274.4	12.30	5.33	0.046	48,013
400.2						0

- SEE RATING CURVE

∴ w/ $Q_{BREACH} = 17,283$ CFS

DOWNSTREAM ELEV. = 410.1

410.1 < 417

- WAVE (✓) - 2/3 (H) = 2/3 (15) = 10'

403 + 10 = 413 < 417

∴ NO HAZARD

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JOB NO. 3273-03 WOODSVILLE HYDRO DAM

Subject H & H BREACH ANALYSIS

Sheet No. 6 of 9

Date 5/31/79

Computed

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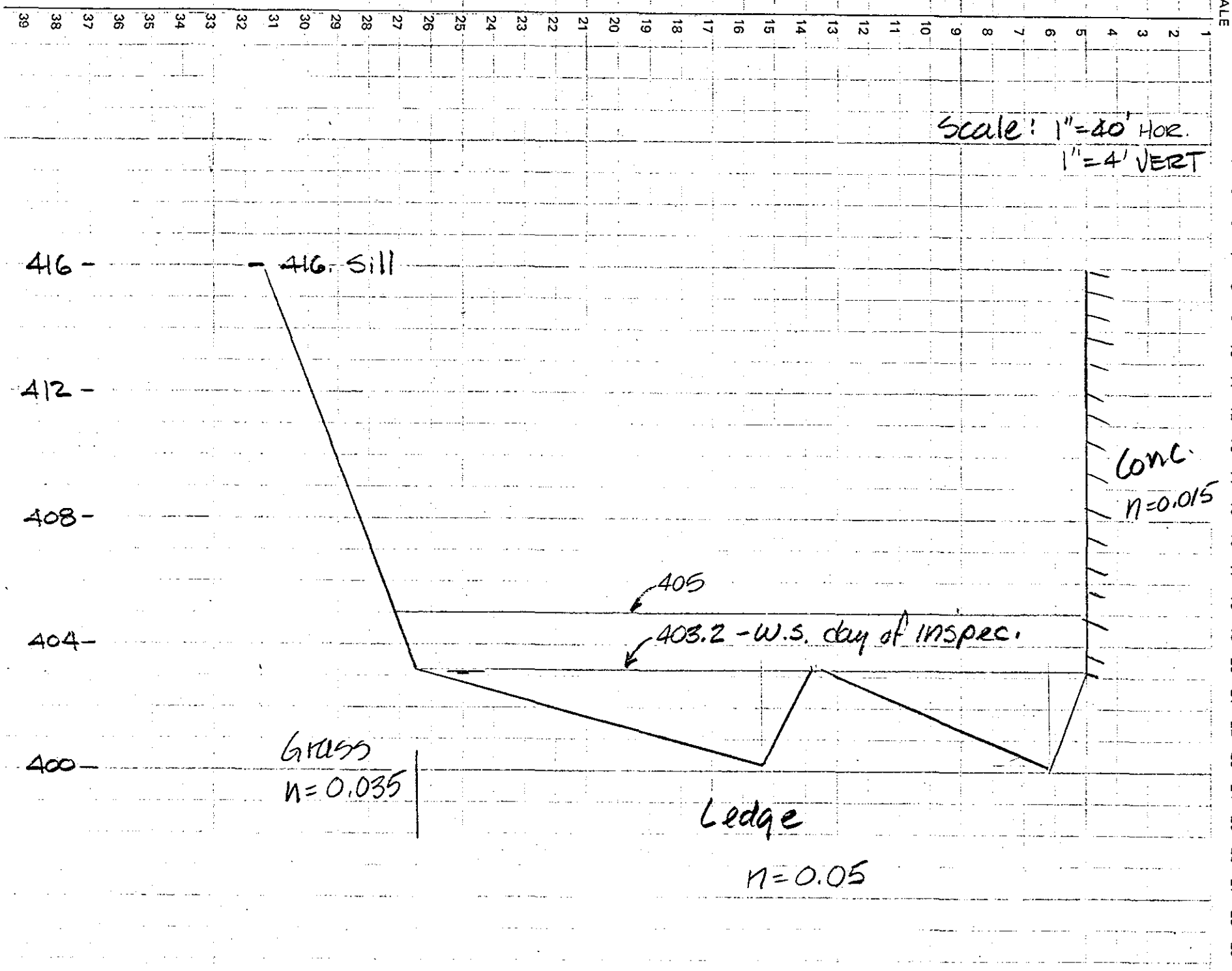

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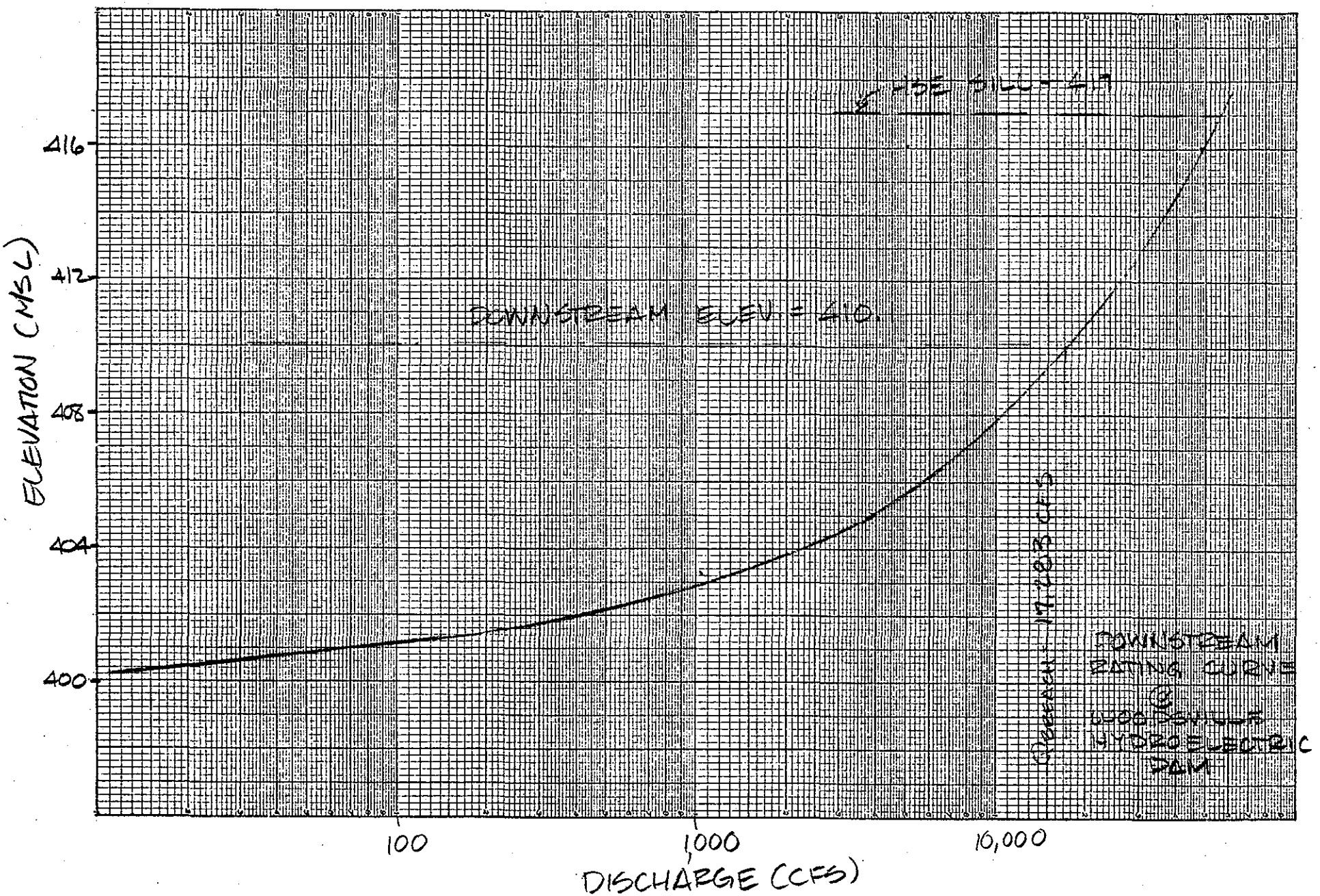
Job # 3273-03
WOODSVILLE
HYDRO DAM

HAH
BREACH ANALYSIS

1 of 9
5/31/79



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Subject: BREACH ANALYSIS

Sheet No. 5 of

Date 5/31/79

Computed

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JOB NO. 3273-03

WOODSVILLE HYDRO DAM

Elev 403.2

$\frac{1}{2}(126)(3) + \frac{1}{2}(84)(3)$

$\frac{1}{2}(3)(126+84) = 315 \text{ ft}^2 = A$

$W.P. = \sqrt{(3)^2+(110)^2} + \sqrt{(3)^2+(16)^2} + \sqrt{(3)^2+(72)^2} + \sqrt{(3)^2+(12)^2}$

110.04 16.28 72.06 12.12

W.P. = 210.50

Elev. 405

$A = A_{add'l} + A_{403.2}$

$A_{add'l} = (405-403.2)\left(\frac{221+214}{2}\right) = 392$

$A = 392 + 315 = 707 \text{ ft}^2$

$W.P = WP_{403.2} + WP_{add'l}$

$WP_{add'l} = 1.8 + \sqrt{7^2+(1.8)^2} = 9.03$

W.P. = 210.50 + 9.03 = 219.5

$n_{comp} = \frac{210.5}{219.5}(0.05) + \frac{1.8}{219.5}(0.015) + \frac{7.23}{219.5}(0.055)$

$n_{comp} = 0.049$

Elev 416

$A = A_{405} + A_{add'l}$

$A_{add'l} = (416-405)\left(\frac{221+264}{2}\right) = 2668$

$A = 707 + 2668 = 3375 \text{ ft}^2$

$WP = WP_{405} + WP_{add'l}$

$WP_{add'l} = 11 + \sqrt{(43)^2+(11)^2} = 11 + 44.4 = 55.4$

$WP = 219.5 + 55.4 = 274.4$

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Subject BREACH ANALYSIS

Sheet No. 9 of

Date 5/31/79

Computed

Checked

JOB NO. 3273-03
WOODSVILLE HYDRO

$$n_{comp} = \frac{210.5}{274.4}(0.05) + \frac{51.6}{274.4}(0.035) + \frac{12.8}{274.4}(0.015)$$

$$n_{comp} = 0.046$$