Crystal Lake Brook
Mascoma River Watershed
Connecticut River Basin
Enfield, New Hampshire

Crystal Lake

Dam-Break Flood Analysis

January 1989

US Army Corps of Engineers
New England Division

Preface

This investigation was performed under the Corps of Engineers' Flood Plain Management Services Authority at the request of the State of New Hampshire. The Flood Plain Management Authority is contained in Section 206 of the Flood Control Act of 1960 which authorizes the U.S. Army Corps of Engineers "...to compile and disseminate information on floods and flood damages...and to provide engineering advice to local interests for their use in planning to ameliorate the flood hazard."

The Dam-Break Analysis study presented in this report was prepared under contract by Storch Associates of Boston, Massachusetts and Manchester, New Hampshire. Any questions concerning this report should be addressed to the the Chief of the Hydrology Engineering Section of the Corps of Engineers, New England Division.

CRYSTAL LAKE DAM

ENFIELD, NEW HAMPSHIRE

DAM-BREAK FLOOD ANALYSIS

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CRYSTAL LAKE DAM

DAM-BREAK FLOOD ANALYSIS

1. INTRODUCTION AND PURPOSE

This report presents the findings of a dam-break flood analysis performed for Crystal Lake Dam. Its purpose is to provide quantitative information for emergency planning use. The dam is owned, operated and maintained by the Water Resources Board of New Hampshire. Included in this report is a description of the pertinent features of the dam, the procedure used for the analysis, the assumed dam-break conditions and the resulting effects on downstream flooded areas. This study was not performed because of any known likelihood of a dam-break at Crystal Lake Dam.

2. DAM DESCRIPTION

Identification No.	NH00269
Name of Dam:	Crystal Lake Dam
Town:	Enfield
County and State:	Grafton County, New Hampshire
Stream:	Crystal Lake Brook
Watershed:	Mascoma River
Basin:	Connecticut River

Crystal Lake Dam is located on Crystal Brook and creates an impoundment primarily used for recreational purposes. During the winter months, the pool is lowered to provide some control over snow melt and stormwater runoff. Crystal Lake Dam is a 170 linear foot long earth dam with concrete abutment walls and a stone spillway with concrete facing upstream. There are timber flashboards on the spillway crest. The principal spillway is 50 linear feet long, 16.5 feet high and has 5.5 feet of low level outlet. The outlet works structure consists of a mechanically operated timber gate. The dam is classified as being intermediate in size with a maximum storage of 4,840 acre-feet and significant in hazard classification. The dam has been restored as recommended in the Phase I Inspection Report dated November 1978.

3. PERTINENT DATA

a. Drainage Area The drainage area above the Crystal Lake Dam consists of approximately 13.2 square miles of rolling, heavily wooded hills. The periphery of Crystal Lake is comprised of wooded area with some residences located near the reservoir. Elevations in the watershed range from 2,020 to 890 feet MSL.

The major tributary draining into Crystal Lake is Bicknell Brook which is approximately 5 miles long with a vertical drop over its length of about 500 feet.

b. Elevation (ft. above MSL) based on elevation of 892.0 for the spillway crest as obtained from existing data.

(1)	Streambed at centerline of dam:	875.5
(2)	Maximum tailwater:	Unknown
(3)	Diversion tunnel:	None
(4)	Recreation pool:	892.0
(5)	Normal winter pool:	884.0
(6)	Spillway crest:	892.0
(7)	Design surcharge:	Unknown
(8)	Top dam:	897.5

c. Spillway

(1)	Type:	Broad crested vertical drop spillway
(2)	Length of weir:	50 ft.
(3)	Crest elevation:	892.0
(4)	Gates:	None
(5)	Upstream channel:	Crystal Lake
(6)	Downstream channel:	The downstream channel is a boulder strewn stream bed with many small diameter trees on each bank. Approximately 300 feet downstream from the dam, the channel has a debris dam consisting of washed down trees and branches.

d. Reservoir (miles)

(1)	Length of maximum pool:	1.50
(2)	Length of recreational pool:	1.50
(3)	Length of winter pool:	1.45

e. Storage (Acre-Feet)

(1)	Recreation pool:	2,720
(2)	Winter pool:	1,300
(3)	Spillway crest pool:	2,720
(4)	Top of dam:	4,840

f. Reservoir Surface (acres)

(1)	Recreation pool:	378
(2)	Winter pool:	340
(3)	Spillway crest:	372

g. Discharge at Dam Site

(1)	Spillway capacity with water at top of dam (with flashboards):	1,850 cfs
(2)	Spillway capacity with water at top of dam (without flashboards):	1,950 cfs

(3) The maximum discharge at this dam site is unknown.

h. Dam

(1)	Type:	stone, earth, concrete
(2)	Length:	170 ft. (overall)
(3)	Height:	22 ft. (maximum)
(4)	Top width:	10" wall, 21 foot earth fill section
(5)	Side slopes:	US = vertical; DS = variable
(6)	Zoning:	unknown
(7)	Impervious core:	concrete retaining wall
(8)	Cutoff:	concrete wall
(9)	Grout curtain:	none

i. Diversion and Regulating Tunnel - None

j. Regulatory Outlets

The regulating outlet consists of a wooden, mechanically operated, control gate having an effective opening of 4.0 feet by 4.0 feet. The invert of the gate opening (884.0) is such that the water level of Crystal Lake may be lowered 8 feet from its spillway crest elevation (892.0) which is about 3 feet above the original channel bed.

4. VALLEY DESCRIPTION

Crystal Lake Dam is located in the Town of Enfield, New Hampshire, approximately six and one-half miles upstream from the headwaters of Mascoma Lake. Below Crystal Lake Dam, Crystal Lake Brook flows in a generally northerly direction for approximately three miles to its confluence with the Mascoma River in Canaan, New Hampshire.

The 3± miles of valley downstream of the dam consist of meadows of varying widths adjacent to the stream edge. Immediately downstream of the dam is a settlement of new homes, built after the 1978 Phase I Report, which are in close proximity of the brook. The channel slope is moderate to moderately flat.

At the 2.8 mile mark at the Town of West Canaan, which is a significant population center in this area, the channel snakes along a railroad bed and enters a corrugated metal pipe culvert located in the railroad embankment. This creates a damming effect which will result in a back-up of water into the upstream meadow area.

The channel, having merged with the Mascoma River, passes under a series of three bridges at the 4.1 mile mark. At this point, the right overbank is a cultivated/residential area, while the left bank consists predominantly of meadows. The oversized bridges and overbank meadow conditions do not create significant damming effects at this location.

Between the 4.1 mile mark and the point at which the river empties into Mascoma Lake (6.5 miles downstream of the dam), the valley consists of meadows until the Town of Enfield, a large population center, where cultivated/residential areas are located on each overbank. The channel in this area has been modified and rebuilt several times.

5. MODEL DESCRIPTION

The Crystal Lake Dam dam-break analysis was performed using the Microcomputer Version 9-86 of "DAMBRK": The National Weather Service DAM-BREAK Flood Forecasting Model 7-18-84. This microcomputer version is a transference from Dr. D.L. Fread's main frame version. The analysis option utilized was "Subcritical Dynamic Routing" for a single dam and input consisted of:

(a) Storage characteristics of the reservoir

(b) Selected dam breach geometry, and duration

(c) Surveyed geometry and observed characteristics of downstream valley presented in cross-sections and by selected Mannings "n" coefficients along with initial inflows.

(d) Active and inactive flow regions of the study reach. Based on the input data, the model computes the dam-break outflow hydrograph and routes it downstream. Dynamic routing of outflow hydrograph through entire reach of downstream valley is performed by a "honing" iterative attenuation process governed by the requirements of both the principles of conversation of mass and momentum. The analysis provides output on the attenuation of the flood hydrograph, resulting flood stages, and timing of the flood wave as it progresses downstream.

6. ASSUMED DAM-BREAK CONDITIONS

The magnitude of a flood resulting from the hypothetical failure of Crystal Lake Dam is a function of many different parameters including size of breach, initial pool level and storage, rate of breach formation, channel and overbank roughness, and antecedent flow conditions. Engineering assumptions of conditions which could be reasonably expected to exist prior to a failure of Crystal Lake Dam, were used in the flood analysis as presented below:

(1) Initial Pool Level: 896.5 feet MSL, 4.5 feet above top of spillway crest and 1.0 foot below top of dam.

(2) Breach Invert: 878.0 feet MSL.

(3) Breach Base Width: 57 feet; vertical side slopes (1.0 vert: 0.0 Horiz.)

(4) Time to Complete Formation of Breach: 0.8 hour

(5) Downstream Channel Roughness Coefficient: Manning's "n" = 0.04 to 0.06.

(6) Pre-Breach Flow: The pre-breach river flow was assumed equal to the March 1936 flood of record. Inflow into Crystal Lake was estimated to be 1,650 cfs (125 cms). With an outflow of 1,487 cfs. At the confluence of Crystal Lake Brook and Mascoma River an inflow of 8,000 cfs was added.

7. RESULTS

The resulting peak stage flood profiles, timing of the peak stage and leading edge of the flood wave are shown on plate no. 2. Because of the scarcity of good topographic mapping in the area, profiles are shown in feet above normal summertime (July - August) low water (NLW). Users of the information can establish depth of flooding at particular properties by establishing its relative elevation with respect to the adjacent stream level. Variations in depth above NLW progressing downstream, are attributable to changes in natural stream hydraulic capacity as well as changes in peak discharge.

The maximum dam-break water surface stages and maximum flows vs. time from start of dam failure are presented on plates 3 and 4 for selected stations of interest at mile 1.0, 2.8 and 6.5 downstream from Crystal Lake Dam.

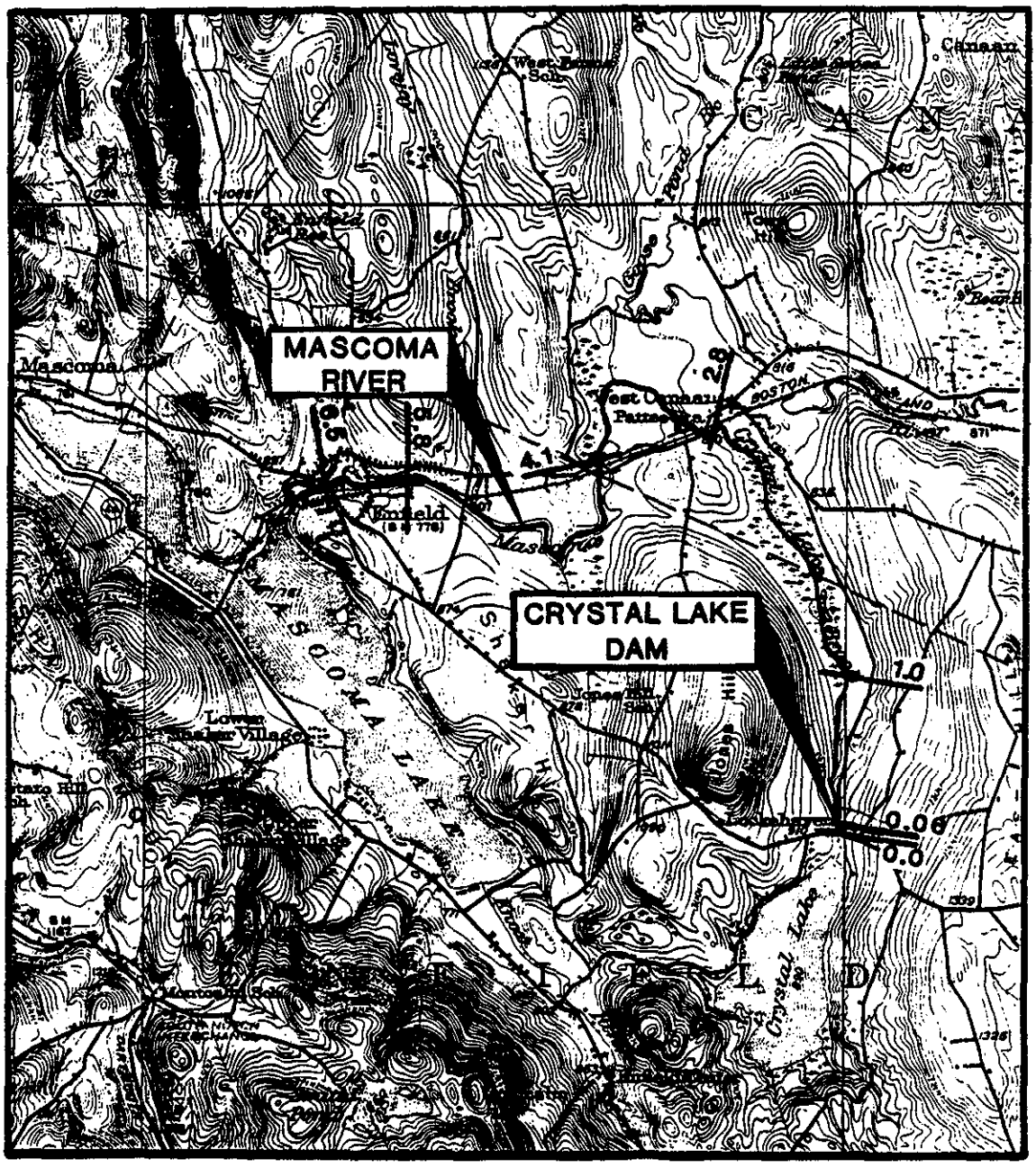
The breach and pre-breach peak flows throughout the study reach resulting from Crystal Lake Dam breach are shown on plate no. 5.

The peak dam-break discharge from Crystal Lake Dam was computed to be 15,667 cfs producing a rise of 11.01 feet and peak flow of 14,963 cfs at a point 1.0 mile downstream from the dam.

The peak discharge decreases to 8,662 cfs with an attendant rise of stage of 20.04 feet at mile 2.8 below dam just upstream from the confluence with Mascoma River, which is contributing with a peak flow of 8,000 cfs. The combined peak flow at 4.10 miles was computed to be 15,476 cfs, which produces a rise of 18.79 feet.

At mile 6.5 below the dam the discharge is 15,273 cfs producing a rise of 9.36 feet over NLW stage. This rise will be during a storm condition assuming peak stage at Mascoma Lake W.S. Elevation 759.0.

The natural valley storage above miles 2.8 and 4.1 has a significant effect on reducing the peak dam-break flood discharges.



MAP BASED UPON U.S.G.S. MASCOMA, N.H. QUADRANGLE, (1927)

CROSS-SECTION LOCATION

IN MILES BELOW DAM

CROSS-SECTION 1.0 MILES-INTERPOLATED

1000 0 4000

SCALE IN FEET

1 1/2 0 1

SCALE IN MILES

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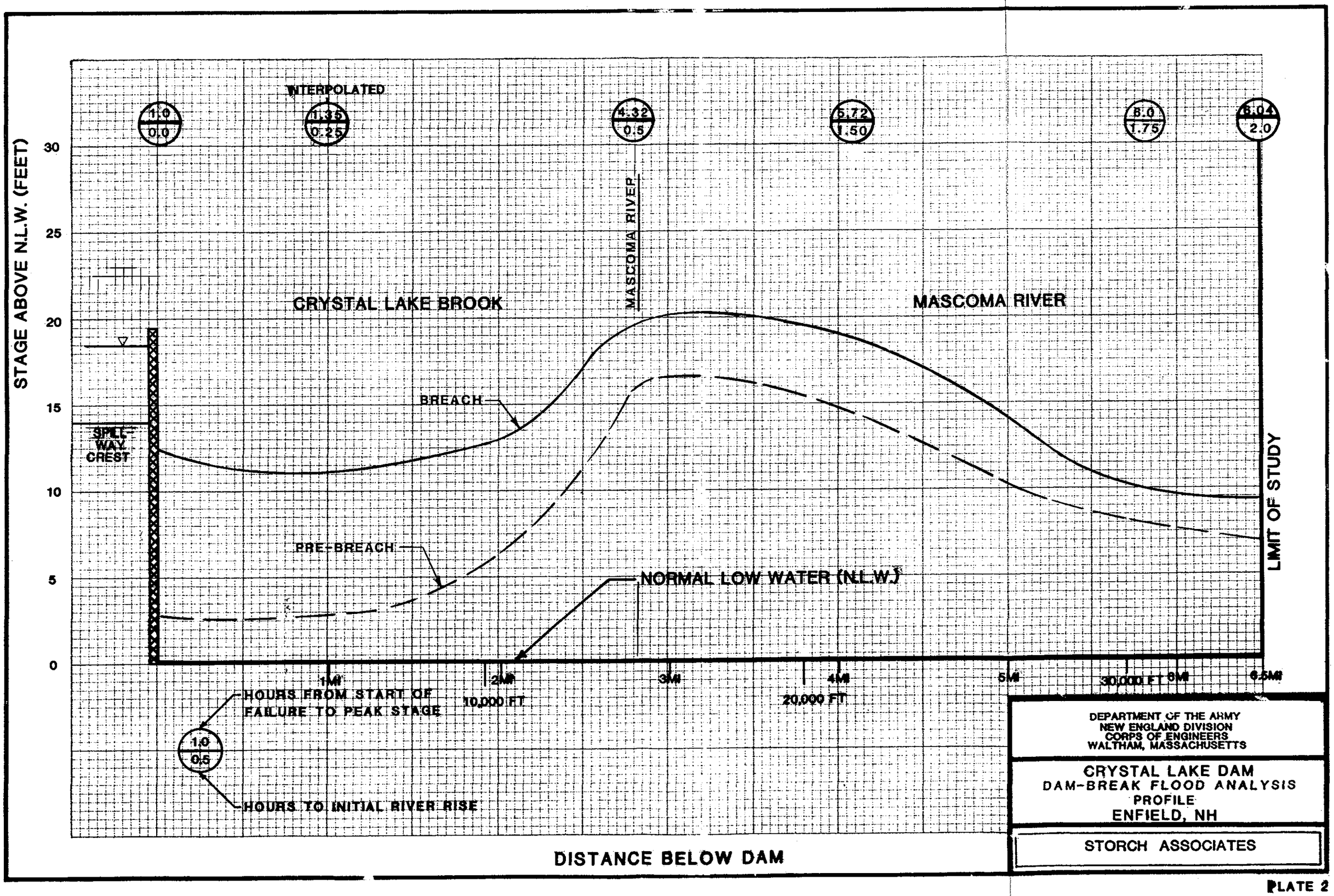
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASSACHUSETTS

CRYSTAL LAKE DAM
DAM-BREAK FLOOD ANALYSIS

INDEX MAP

ENFIELD,NH

STORCH ASSOCIATES



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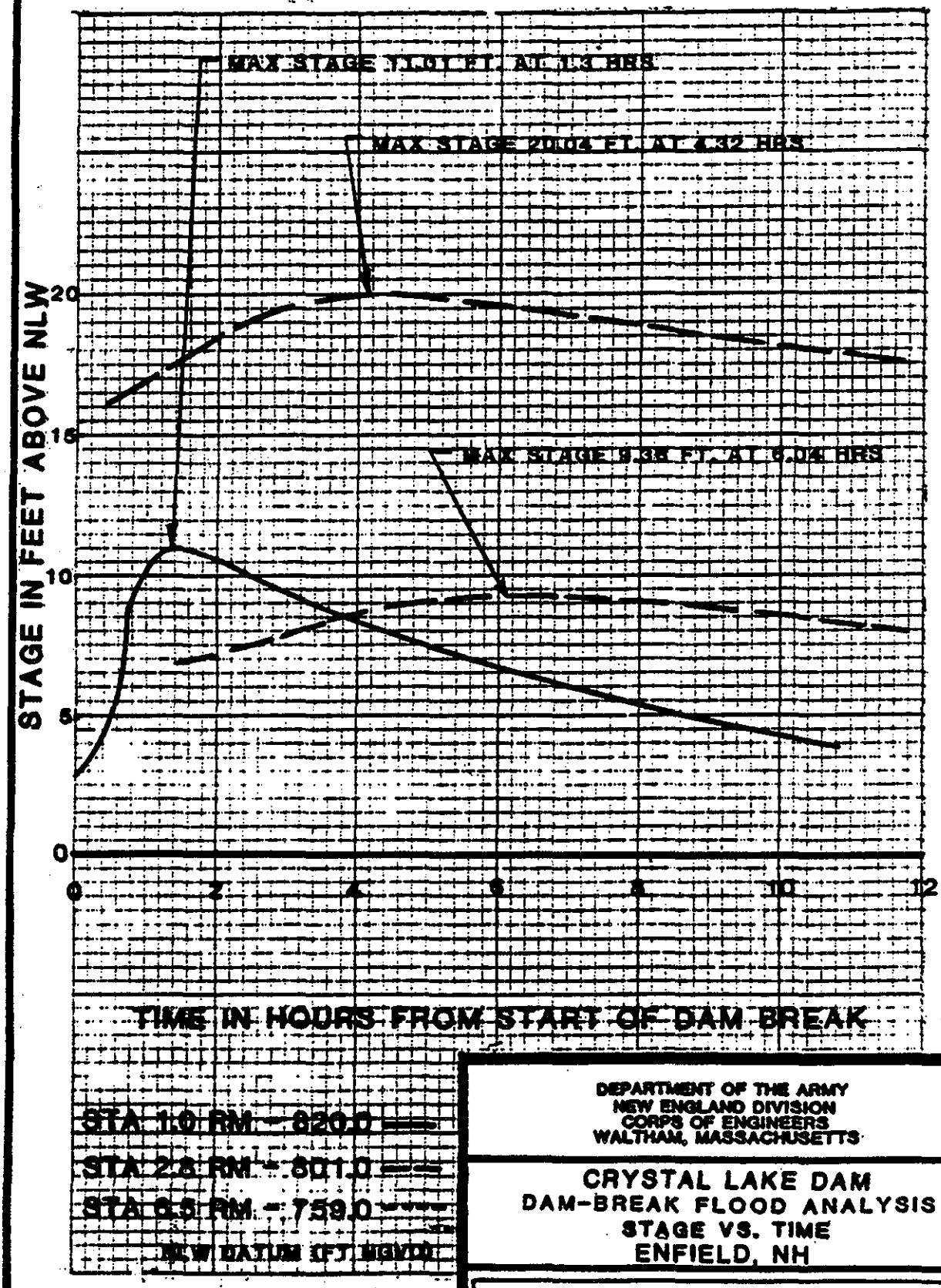
CRYSTAL LAKE DAM
DAM-BREAK FLOOD ANALYSIS
PROFILE
ENFIELD, NH

STORCH ASSOCIATES

PLATE 2



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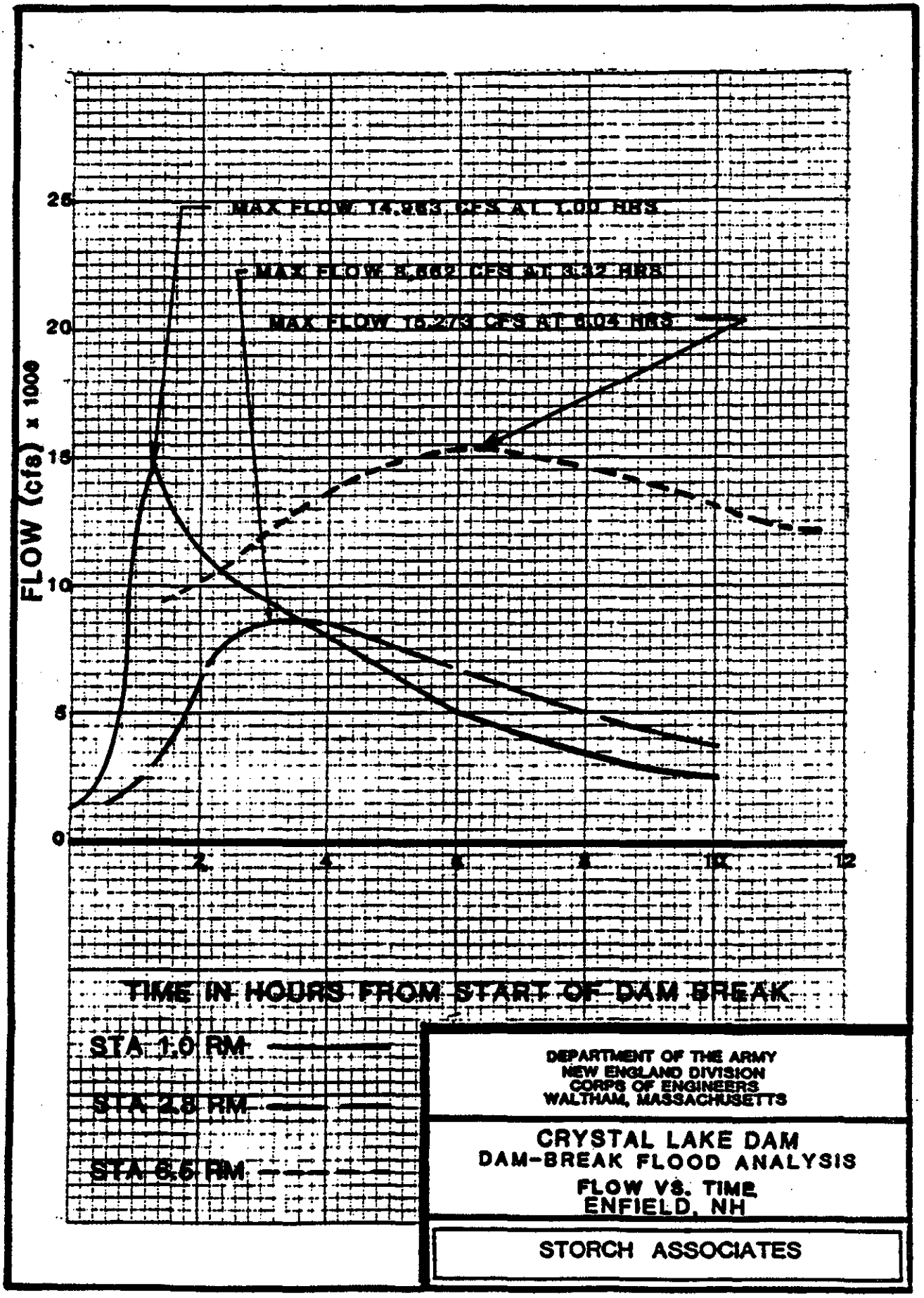
WALTHAM, MASSACHUSETTS

CRYSTAL LAKE DAM
DAM-BREAK FLOOD ANALYSIS
STAGE VS. TIME
ENFIELD, NH

STORCH ASSOCIATES

PLATE 3



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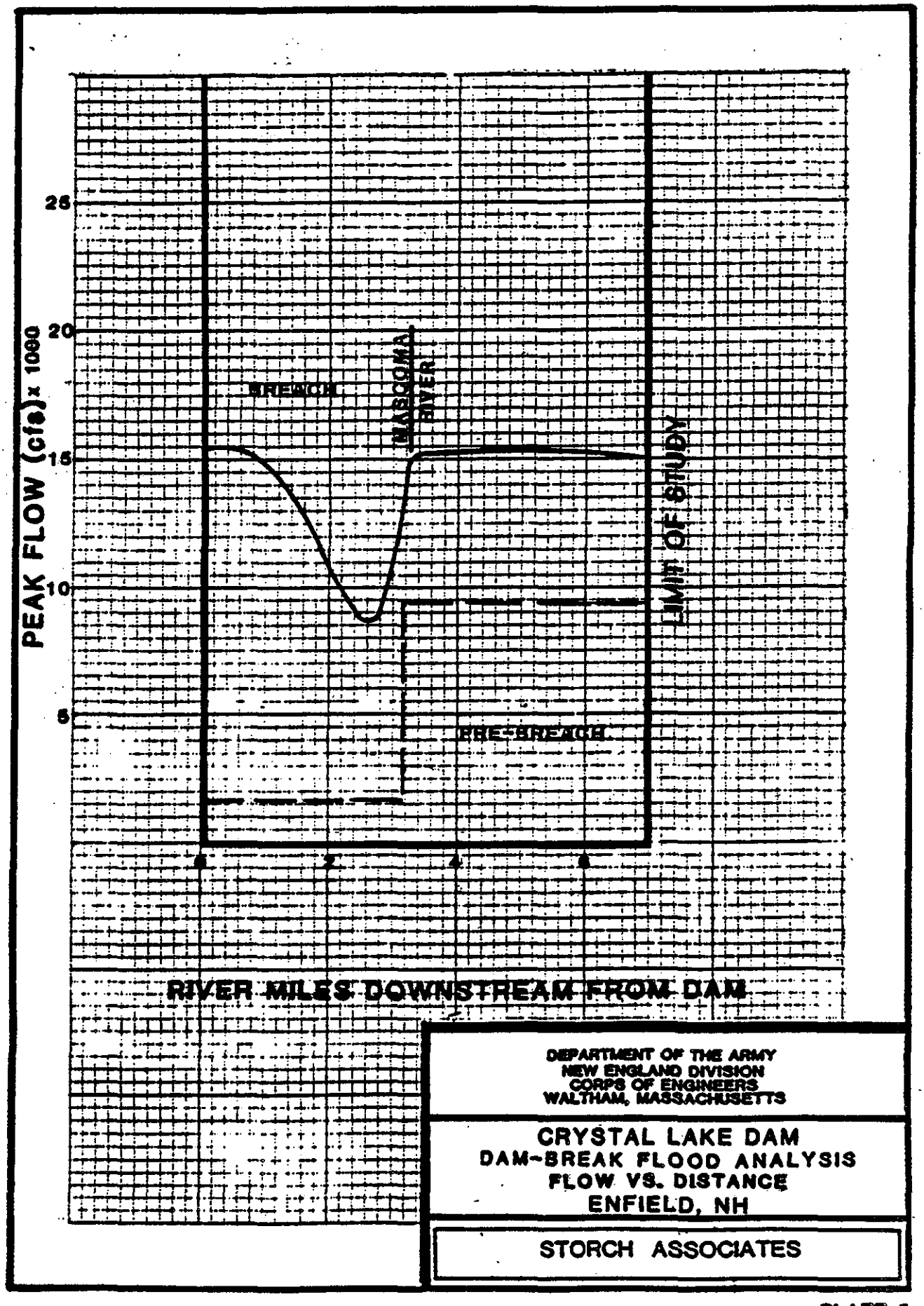
CRYSTAL LAKE DAM
DAM-BREAK FLOOD ANALYSIS
FLOW VS. TIME
ENFIELD, NH

STORCH ASSOCIATES

PLATE 4



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CRYSTAL LAKE DAM
DAM-BREAK FLOOD ANALYSIS
FLOW VS. DISTANCE
ENFIELD, NH

STORCH ASSOCIATES

PLATE 5

APPENDIX A

INPUT DATA FILE

```
CRYSTAL LAKE DAM      CRYSTAL LAKE BROOK  STORCH ASSOCIATES
1616 SOLDIERS FIELD ROAD                  BOSTON, MA 02135
        1        0        0        5        2
         00 0
398.     393.     388.     372.     0.
904.     900.     896.     892.     878.
1.5      896.5    0.0      878.0    57.0     0.8      878.     0.0
896.5    897.5    892.     0.0      0.       0.0      442.     27.
154.     433.     793.     1216.    1949.    2270.
1.       2.       3.       4.       5.5      6.
0.       12.
1650.    1650.
0.       12.
        6        8        6        0        0        0        1        0
        1        2        3        4        5        6
0.01
878.     883.     886.75   887.75   892.     895.     899.     900.
80.      80.      115.     115.     115.     115.     115.     115.
0.       0.       0.       50.      82.      97.      140.     228.
1.0
819.5    820.     821.     823.     825.     827.     828.     830.
175.     200.0    200.0    200.0    200.0    200.0    200.0    200.0
0.0      0.0      100.0    105.0    190.0    260.0    300.0    385.0
2.8
801.0    805.0    812.75   815.0    820.0    830.0    835.0    840.0
80.0     80.0     80.0     180.0    180.0    180.0    180.0    180.0
0.0      0.0      0.0      1450.0   1910.0   2435.0   2698.0   3310.0
4.1
795.5    796.0    798.0    800.0    805.0    810.5    815.0    820.0
125.     125.0    125.0    140.0    155.0    155.0    155.0    155.0
0.0      0.0      0.0      0.0      0.0      0.0      810.0    1850.0
5.8
792.8    796.0    798.0    799.     800.     805.     810.     815.
100.     103.     103.0    138.     138.     138.     138.     138.
0.0      0.0      0.0      0.0      200.     300.     500.     600.
6.5
759.     760.0    766.0    774.0    780.0    785.0    790.0    800.0
75.0     82.0     115.0    115.0    115.0    115.0    115.0    115.0
0.0      0.0      0.0      20.0     115.0    175.0    190.0    215.0
0.06     0.06     0.06     0.06     0.06     0.06     0.06     0.06
0.05     0.05     0.05     0.05     0.05     0.05     0.05     0.05
0.04     0.04     0.04     0.04     0.04     0.04     0.04     0.04
0.04     0.04     0.04     0.04     0.04     0.04     0.04     0.04
0.05     0.05     0.05     0.05     0.05     0.05     0.05     0.05
0.033    0.18     0.05     0.085    0.07
0.0      0.0      0.0      0.0      0.0
0.0      0.0      0.1      0.5      59.0                       1.
        3
8000.    8000.
```

APPENDIX B

OUTPUT DATA FILE

PROGRAM DAMBRK---VERSION-07/18/84
MICROCOMPUTER VERSION - R.G. TRAVER

ANALYSIS OF THE DOWNSTREAM FLOOD HYDROGRAPH

PRODUCED BY THE DAM BREAK OF

CRYSTAL LAKE DAM

ON

CRYSTAL LAKE BROOK

ANALYSIS BY

STORCH ASSOCIATES
1616 SOLDIERS FIELD ROAD
BOSTON, MA 02135

BASED ON PROCEDURE DEVELOPED BY

DANNY L. FREAD, PH.D., RESEARCH HYDROLOGIST
HYDROLOGIC RESEARCH LABORATORY
W23, OFFICE OF HYDROLOGY
NOAA, NATIONAL WEATHER SERVICE
SILVER SPRING, MARYLAND 20910

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*****************************
*****************************
***                       ***
***  SUMMARY OF INPUT DATA  ***
***                       ***
*****************************
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```

INPUT CONTROL PARAMETERS FOR CRYSTAL LAKE DAM

PARAMETER	VARIABLE	VALUE
NUMBER OF DYNAMIC ROUTING REACHES	KKM	1
TYPE OF RESERVOIR ROUTING	KUI	0
MULTIPLE DAM INDICATOR	MULDAM	0
PRINTING INSTRUCTIONS FOR INPUT SUMMARY	KDMP	5
NO. OF RESERVOIR INFLOW HYDROGRAPH POINTS	ITEH	2
INTERVAL OF CROSS-SECTION INFO PRINTED OUT WHEN JNK=9	NPRT	0
FLOOD-PLAIN MODEL PARAMETER	KFLP	0
LANDSLIDE PARAMETER	KSL	0

IOPUT= 0 0 0 0 0 0 0 0 0 0 0 0

CRYSTAL LAKE DAM RESERVOIR

TABLE OF ELEVATION VS SURFACE AREA

SURFACE AREA (ACRES) SA(K)	ELEVATION (FT) HSA(K)
398.0	904.00
393.0	900.00
388.0	896.00
372.0	892.00
.0	878.00
.0	.00
.0	.00
.0	.00

CRYSTAL LAKE DAM RESERVOIR AND BREACH PARAMETERS

PARAMETER	UNITS	VARIABLE	VALUE
LENGTH OF RESERVOIR	MI	RLM	1.50
ELEVATION OF WATER SURFACE	FT	YO	896.50
SIDE SLOPE OF BREACH		Z	.00
ELEVATION OF BOTTOM OF BREACH	FT	YBMIN	878.00
WIDTH OF BASE OF BREACH	FT	BB	57.00
TIME TO MAXIMUM BREACH SIZE	HR	TFH	.80
ELEVATION (MSL) OF BOTTOM OF DAM	FT	DATUM	878.00
VOLUME-SURFACE AREA PARAMETER		VOL	.00
ELEVATION OF WATER WHEN BREACHED	FT	HF	896.50
ELEVATION OF TOP OF DAM	FT	HD	897.50
ELEVATION OF UNCONTROLLED SPILLWAY CREST	FT	HSP	892.00
ELEVATION OF CENTER OF GATE OPENINGS	FT	HGT	.00
DISCHARGE COEF. FOR UNCONTROLLED SPILLWAY		CS	.00
DISCHARGE COEF. FOR GATE FLOW		CG	.00
DISCHARGE COEF. FOR UNCONTROLLED WEIR FLOW		CDO	442.00
DISCHARGE THRU TURBINES	CFS	QT	27.00

QSPILL(K,1)	HEAD(K,1)
154.	1.0
433.	2.0
793.	3.0
1216.	4.0
1949.	5.5
2270.	6.0
0.	.0
0.	.0

DHF(INTERVAL BETWEEN INPUT HYDROGRAPH ORDINATES) = .00 HRS.

TEH(TIME AT WHICH COMPUTATIONS TERMINATE) = 12.0000 HRS.

INFLOW HYDROGRAPH TO CRYSTAL LAKE DAM
****

1650.00 1650.00

TIME OF INFLOW HYDROGRAPH ORDINATES

.0000 12.0000

CROSS-SECTIONAL PARAMETERS FOR CRYSTAL LAKE BROOK
BELOW CRYSTAL LAKE DAM

PARAMETER	VARIABLE	VALUE
NUMBER OF CROSS-SECTIONS	NS	6
MAXIMUM NUMBER OF TOP WIDTHS	NCS	8
NUMBER OF CROSS-SECTIONAL HYDROGRAPHS TO PLOT	NTT	6
TYPE OF OUTPUT OTHER THAN HYDROGRAPH PLOTS	JNK	0
CROSS-SECTIONAL SMOOTHING PARAMETER	KSA	0
DOWNSTREAM SUPERCRITICAL OR NOT	KSUPC	0
NO. OF LATERAL INFLOW HYDROGRAPHS	LQ	1
NO. OF POINTS IN GATE CONTROL CURVE	KCG	0

NUMBER OF CROSS-SECTION WHERE HYDROGRAPH DESIRED
(MAX NUMBER OF HYDROGRAPHS = 6)

1 2 3 4 5 6

CROSS-SECTIONAL VARIABLES FOR CRYSTAL LAKE BROOK
BELOW CRYSTAL LAKE DAM

PARAMETER	UNITS	VARIABLE
LOCATION OF CROSS-SECTION	MI	XS(I)
ELEVATION (MSL) OF FLOODING AT CROSS-SECTION	FT	FSTG(I)
ELEV CORRESPONDING TO EACH TOP WIDTH	FT	HS(K,I)
TOP WIDTH CORRESPONDING TO EACH ELEV (ACTIVE FLOW PORTION)	FT	BS(K,I)
TOP WIDTH CORRESPONDING TO EACH ELEV (OFF-CHANNEL PORTION)	FT	BSS(K,I)
SURFACE AREA CORRESPONDING TO EACH ELEV (ACTIVE FLOW PORTION)	ACRES	DSA(K,I)
SURFACE AREA CORRESPONDING TO EACH ELEV (OFF-CHANNEL PORTION)	ACRES	SSA(K,I)
NUMBER OF CROSS-SECTION		I
NUMBER OF ELEVATION LEVEL		K

CROSS-SECTION NUMBER 1
****

XS(I) = .010 FSTG(I) = .00 XSL(I) = .0 XSR(I) = .0

HS ...	878.0	883.0	886.8	887.8	892.0	895.0	899.0	900.0
BS ...	80.0	80.0	115.0	115.0	115.0	115.0	115.0	115.0
BSS ...	.0	.0	.0	50.0	82.0	97.0	140.0	228.0

CROSS-SECTION NUMBER 2
****

XS(I) = 1.000 FSTG(I) = .00 XSL(I) = .0 XSR(I) = .0

HS ...	819.5	820.0	821.0	823.0	825.0	827.0	828.0	830.0
BS ...	175.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0
BSS ...	.0	.0	100.0	105.0	190.0	260.0	300.0	385.0

CROSS-SECTION NUMBER 3
****

XS(I) = 2.800 FSTG(I) = .00 XSL(I) = .0 XSR(I) = .0

HS ...	801.0	805.0	812.8	815.0	820.0	830.0	835.0	840.0
BS ...	80.0	80.0	80.0	180.0	180.0	180.0	180.0	180.0
BSS ...	.0	.0	.0	1450.0	1910.0	2435.0	2698.0	3310.0

CROSS-SECTION NUMBER 4
****

XS(I) = 4.100 FSTG(I) = .00 XSL(I) = .0 XSR(I) = .0

HS ...	795.5	796.0	798.0	800.0	805.0	810.5	815.0	820.0
BS ...	125.0	125.0	125.0	140.0	155.0	155.0	155.0	155.0
BSS ...	.0	.0	.0	.0	.0	.0	810.0	1850.0

CROSS-SECTION NUMBER 5
****

XS(I) = 5.800 FSTG(I) = .00 XSL(I) = .0 XSR(I) = .0

HS ...	792.8	796.0	798.0	799.0	800.0	805.0	810.0	815.0
BS ...	100.0	103.0	103.0	138.0	138.0	138.0	138.0	138.0
BSS ...	.0	.0	.0	.0	200.0	300.0	500.0	600.0

CROSS-SECTION NUMBER 6
****

XS(I) = 6.500 FSTG(I) = .00 XSL(I) = .0 XSR(I) = .0

HS ...	759.0	760.0	766.0	774.0	780.0	785.0	790.0	800.0
BS ...	75.0	82.0	115.0	115.0	115.0	115.0	115.0	115.0
BSS ...	.0	.0	.0	20.0	115.0	175.0	190.0	215.0

MANNING N ROUGHNESS COEFFICIENTS FOR THE GIVEN REACHES
(CM(K,I),K=1,NCS) WHERE I = REACH NUMBER
****

REACH	1 ...	.060	.060	.060	.060	.060	.060	.060	.060
REACH	2 ...	.050	.050	.050	.050	.050	.050	.050	.050
REACH	3 ...	.040	.040	.040	.040	.040	.040	.040	.040
REACH	4 ...	.040	.040	.040	.040	.040	.040	.040	.040
REACH	5 ...	.050	.050	.050	.050	.050	.050	.050	.050

CROSS-SECTIONAL VARIABLES FOR CRYSTAL LAKE BROOK
BELOW CRYSTAL LAKE DAM

PARAMETER	UNITS	VARIABLE
MINIMUM COMPUTATIONAL DISTANCE USED BETWEEN CROSS-SECTIONS	MI	DXM(I)
CONTRACTION - EXPANSION COEFFICIENTS BETWEEN CROSS-SECTIONS		FKC(I)

REACH NUMBER	DXM(I)	FKC(I)
1	.033	.000
2	.180	.000
3	.050	.000
4	.085	.000
5	.070	.000

DOWNSTREAM FLOW PARAMETERS FOR CRYSTAL LAKE BROOK
BELOW CRYSTAL LAKE DAM

PARAMETER	UNITS	VARIABLE	VALUE
MAX DISCHARGE AT DOWNSTREAM EXTREMITY	CFS	QMAXD	.0
MAX LATERAL OUTFLOW PRODUCING LOSSES	CFS/FT	QLL	.000
INITIAL SIZE OF TIME STEP	HR	DTHM	.1000
INITIAL WATER SURFACE ELEVATION DOWNSTREAM	FT	YDN	.50
SLOPE OF CHANNEL DOWNSTREAM OF DAM	FT/MI	SOM	59.00
THETA WEIGHTING FACTOR		THETA	.00
CONVERGENCE CRITERION FOR STAGE	FT	EPSY	.000
TIME AT WHICH DAM STARTS TO FAIL	HR	TFI	1.00

LATERAL INFLOW REACH NUMBER

LQX(I)

3

(QL(L, 1),L=1,ITEH)
8000. 8000.

TOTAL NUMBER OF CROSS SECTIONS (ORIGINAL+INTERPOLATED) (N) = 97 (MAXIMUM ALLOWABLE = 200

TOTAL VOLUME IN RESERVOIR BEHIND
CRYSTAL LAKE DAM = 4318.2 ACRE-FEET

DEFINITION OF VARIABLES IN RESERVOIR DEPLETION TABLE

PARAMETER	UNITS	VARIABLE
TIME STEP FROM START OF ANALYSIS		I
ITERATIONS NECESSARY TO SOLVE FLOW EQUATIONS		K

ELAPSED TIME FROM START OF ANALYSIS	HRS	TTP(I)
TOTAL OUTFLOW FROM DAM	CFS	Q(I)
ELEVATION OF WATER SURFACE AT DAM	FT	H2
ELEVATION OF BOTTOM OF BREACH	FT	YB
EST DEPTH OF FLOW IMMEDIATELY DOWNSTREAM	FT	D
SUBMERGENCE COEFFICIENT		SUB
VELOCITY CORRECTION		VCOR
TOTAL VOLUME DISCHARGED FROM TIME OF BREACH	AC-FT	OUTVOL
BREACH WIDTH	FT	BB
RECTANGULAR BREACH DISCHARGE COEFFICIENT		COFR
INFLOW TO RESERVOIR	CFS	QI(I)
BREACH OUTFLOW	CFS	QBRECH
SPILLWAY OUTFLOW	CFS	QSPIL

RESERVOIR DEPLETION TABLE

I	K	TTP(I)	Q(I)	HZ	YB	D	SUB	VCOR	OUTVOL	BB	COFR	QI(I)	QBRECH	QSPIL
***	**	******	********	*******	*******	*******	****	****	*********	****	****	*****	******	*****
1	0	.000	1487	896.50	897.50	881.24	1.00	1.00	.0	.0	3.10	1650.	0.	1487.
2	1	.016	1487	896.50	897.11	881.24	1.00	.98	2.0	1.1	3.10	1650.	0.	1488.
3	1	.032	1487	896.50	896.72	881.24	1.00	.93	3.9	2.3	3.10	1650.	0.	1488.
4	1	.048	1488	896.50	896.33	881.24	1.00	1.08	5.9	3.4	3.10	1650.	1.	1488.
5	1	.064	1494	896.50	895.94	881.25	1.00	1.03	7.9	4.6	3.10	1650.	6.	1488.
6	1	.080	1505	896.50	895.55	881.26	1.00	1.02	9.9	5.7	3.10	1650.	17.	1489.
7	1	.096	1522	896.50	895.16	881.28	1.00	1.01	11.9	6.8	3.10	1650.	34.	1489.
8	1	.112	1546	896.50	894.77	881.31	1.00	1.01	13.9	8.0	3.10	1650.	57.	1489.
9	1	.128	1577	896.50	894.38	881.35	1.00	1.01	16.0	9.1	3.10	1650.	88.	1489.
10	1	.144	1617	896.50	893.99	881.40	1.00	1.01	18.1	10.3	3.10	1650.	128.	1489.
11	1	.160	1665	896.50	893.60	881.46	1.00	1.01	20.2	11.4	3.10	1650.	176.	1489.
12	1	.176	1723	896.50	893.21	881.53	1.00	1.01	22.5	12.5	3.10	1650.	234.	1489.
13	1	.192	1790	896.50	892.82	881.62	1.00	1.01	24.8	13.7	3.10	1650.	302.	1489.
14	1	.208	1867	896.50	892.43	881.71	1.00	1.01	27.2	14.8	3.10	1650.	380.	1488.
15	1	.224	1954	896.50	892.04	881.81	1.00	1.01	29.7	16.0	3.10	1650.	469.	1485.
16	1	.240	2051	896.50	891.65	881.93	1.00	1.01	32.4	17.1	3.10	1650.	569.	1482.
17	1	.256	2161	896.50	891.26	882.05	1.00	1.01	35.2	18.2	3.10	1650.	682.	1479.
18	1	.272	2282	896.50	890.87	882.18	1.00	1.01	38.1	19.4	3.10	1650.	807.	1476.
19	1	.288	2417	896.49	890.48	882.33	1.00	1.01	41.2	20.5	3.10	1650.	944.	1473.
20	1	.304	2563	896.49	890.09	882.49	1.00	1.01	44.5	21.7	3.10	1650.	1095.	1469.
21	1	.320	2724	896.49	889.70	882.65	1.00	1.01	48.0	22.8	3.10	1650.	1259.	1466.
22	1	.336	2897	896.48	889.31	882.83	1.00	1.01	51.7	23.9	3.10	1650.	1436.	1462.
23	1	.352	3085	896.48	888.92	883.02	1.00	1.01	55.7	25.1	3.10	1650.	1628.	1457.
24	1	.368	3287	896.47	888.53	883.27	1.00	1.01	59.9	26.2	3.10	1650.	1835.	1452.
25	1	.384	3504	896.47	888.14	883.53	1.00	1.01	64.4	27.4	3.10	1650.	2057.	1447.
26	1	.400	3735	896.46	887.75	883.79	1.00	1.01	69.2	28.5	3.10	1650.	2294.	1442.
27	1	.416	3984	896.45	887.36	884.06	1.00	1.01	74.3	29.6	3.10	1650.	2546.	1438.
28	1	.432	4249	896.45	886.97	884.33	1.00	1.01	79.7	30.8	3.10	1650.	2815.	1434.
29	1	.448	4529	896.44	886.58	884.61	1.00	1.01	85.5	31.9	3.10	1650.	3100.	1430.
30	1	.464	4826	896.43	886.19	884.89	1.00	1.01	91.7	33.1	3.10	1650.	3402.	1425.
31	1	.480	5140	896.42	885.80	885.18	1.00	1.02	98.3	34.2	3.10	1650.	3721.	1419.
32	1	.496	5470	896.40	885.41	885.47	1.00	1.02	105.3	35.3	3.10	1650.	4058.	1413.
33	1	.512	5818	896.39	885.02	885.76	1.00	1.02	112.8	36.5	3.10	1650.	4413.	1406.
34	1	.528	6184	896.37	884.63	886.05	1.00	1.02	120.7	37.6	3.10	1650.	4785.	1399.
35	1	.544	6568	896.36	884.24	886.35	1.00	1.02	129.2	38.8	3.10	1650.	5177.	1391.
36	1	.560	6970	896.34	883.85	886.65	1.00	1.03	138.1	39.9	3.10	1650.	5588.	1383.
37	1	.576	7392	896.32	883.46	886.90	1.00	1.03	147.6	41.0	3.10	1650.	6019.	1373.
38	1	.592	7833	896.30	883.07	887.15	1.00	1.03	157.7	42.2	3.10	1650.	6470.	1364.
39	1	.608	8295	896.28	882.68	887.39	1.00	1.03	168.3	43.3	3.10	1650.	6942.	1353.
40	1	.624	8776	896.26	882.29	887.64	1.00	1.04	179.6	44.5	3.10	1650.	7436.	1341.
41	1	.640	9280	896.23	881.90	887.90	1.00	1.04	191.6	45.6	3.10	1650.	7951.	1329.
42	1	.656	9805	896.20	881.51	888.16	1.00	1.04	204.2	46.7	3.10	1650.	8489.	1316.
43	1	.672	10353	896.18	881.12	888.43	1.00	1.05	217.5	47.9	3.10	1650.	9051.	1302.
44	1	.688	10924	896.15	880.73	888.70	1.00	1.05	231.6	49.0	3.10	1650.	9638.	1287.
45	1	.704	11520	896.11	880.34	888.98	1.00	1.06	246.4	50.2	3.10	1650.	10249.	1271.
46	1	.720	12141	896.08	879.95	889.27	1.00	1.06	262.1	51.3	3.10	1650.	10888.	1254.
47	1	.736	12789	896.04	879.56	889.56	1.00	1.07	278.5	52.4	3.10	1650.	11554.	1236.
48	1	.752	13465	896.00	879.17	889.85	1.00	1.07	295.9	53.6	3.10	1650.	12249.	1217.
49	1	.768	14173	895.96	878.78	890.16	1.00	1.08	314.2	54.7	3.10	1650.	12974.	1199.
50	1	.784	14910	895.92	878.39	890.47	1.00	1.09	333.4	55.9	3.10	1650.	13729.	1181.

RESERVOIR DEPLETION TABLE

I	K	TTP(I)	Q(I)	H2	YB	D	SUB	VCOR	OUTVOL	BB	COFR	QI(I)	QBRECH	QSPIL
***	**	******	********	*******	*******	*******	****	****	*********	****	****	*****	******	*****
51	1	.800	15648	895.87	878.00	890.77	1.00	1.10	353.6	57.0	3.10	1650.	14487.	1161.
52	1	.816	15667	895.82	878.00	890.78	1.00	1.10	374.3	57.0	3.10	1650.	14526.	1141.
53	1	.832	15600	895.77	878.00	890.75	1.00	1.10	395.0	57.0	3.10	1650.	14480.	1121.
54	1	.848	15522	895.73	878.00	890.72	1.00	1.10	415.6	57.0	3.10	1650.	14422.	1101.
55	1	.864	15443	895.68	878.00	890.69	1.00	1.10	436.0	57.0	3.10	1650.	14362.	1081.
56	1	.880	15363	895.63	878.00	890.66	1.00	1.10	456.4	57.0	3.10	1650.	14303.	1061.
57	1	.896	15284	895.59	878.00	890.62	1.00	1.10	476.7	57.0	3.10	1650.	14244.	1041.
58	1	.912	15206	895.54	878.00	890.59	1.00	1.10	496.8	57.0	3.10	1650.	14185.	1021.
59	1	.928	15128	895.49	878.00	890.56	1.00	1.10	516.9	57.0	3.10	1650.	14127.	1002.
60	1	.944	15051	895.45	878.00	890.53	1.00	1.10	536.8	57.0	3.10	1650.	14069.	982.
61	1	.960	14974	895.40	878.00	890.49	1.00	1.10	556.7	57.0	3.10	1650.	14012.	963.
62	1	.976	14897	895.36	878.00	890.46	1.00	1.10	576.4	57.0	3.10	1650.	13955.	943.
63	1	.992	14822	895.31	878.00	890.43	1.00	1.10	596.1	57.0	3.10	1650.	13898.	924.
64	1	1.008	14746	895.27	878.00	890.40	1.00	1.10	615.6	57.0	3.10	1650.	13841.	905.
65	1	1.024	14671	895.22	878.00	890.37	1.00	1.09	635.1	57.0	3.10	1650.	13785.	886.
66	1	1.040	14597	895.18	878.00	890.34	1.00	1.09	654.4	57.0	3.10	1650.	13730.	867.
67	1	1.056	14523	895.13	878.00	890.30	1.00	1.09	673.7	57.0	3.10	1650.	13674.	849.
68	1	1.072	14449	895.09	878.00	890.27	1.00	1.09	692.8	57.0	3.10	1650.	13620.	830.
69	1	1.088	14376	895.04	878.00	890.24	1.00	1.09	711.9	57.0	3.10	1650.	13565.	811.
70	1	1.104	14303	895.00	878.00	890.21	1.00	1.09	730.9	57.0	3.10	1650.	13511.	793.
71	1	1.120	14233	894.96	878.00	890.18	1.00	1.09	749.7	57.0	3.10	1650.	13457.	777.
72	1	1.136	14165	894.91	878.00	890.15	1.00	1.09	768.5	57.0	3.10	1650.	13403.	762.
73	1	1.152	14096	894.87	878.00	890.12	1.00	1.09	787.2	57.0	3.10	1650.	13351.	746.
74	1	1.168	14028	894.83	878.00	890.09	1.00	1.09	805.8	57.0	3.10	1650.	13298.	731.
75	1	1.184	13961	894.78	878.00	890.07	1.00	1.09	824.3	57.0	3.10	1650.	13246.	715.
76	1	1.200	13894	894.74	878.00	890.04	1.00	1.09	842.7	57.0	3.10	1650.	13194.	700.
77	1	1.216	13827	894.70	878.00	890.01	1.00	1.09	861.0	57.0	3.10	1650.	13142.	685.
78	1	1.232	13760	894.66	878.00	889.98	1.00	1.09	879.3	57.0	3.10	1650.	13091.	670.
79	1	1.248	13694	894.62	878.00	889.95	1.00	1.09	897.4	57.0	3.10	1650.	13040.	655.
80	1	1.264	13629	894.57	878.00	889.92	1.00	1.09	915.5	57.0	3.10	1650.	12989.	640.
81	1	1.280	13564	894.53	878.00	889.89	1.00	1.09	933.5	57.0	3.10	1650.	12939.	625.
82	1	1.296	13499	894.49	878.00	889.87	1.00	1.09	951.4	57.0	3.10	1650.	12889.	610.
83	1	1.312	13434	894.45	878.00	889.84	1.00	1.09	969.2	57.0	3.10	1650.	12840.	595.
84	1	1.328	13370	894.41	878.00	889.81	1.00	1.09	986.9	57.0	3.10	1650.	12790.	581.
85	1	1.344	13307	894.37	878.00	889.78	1.00	1.09	1004.5	57.0	3.10	1650.	12741.	566.
86	1	1.360	13244	894.33	878.00	889.76	1.00	1.09	1022.1	57.0	3.10	1650.	12692.	552.
87	1	1.376	13181	894.29	878.00	889.73	1.00	1.09	1039.6	57.0	3.10	1650.	12644.	537.
88	1	1.392	13118	894.25	878.00	889.70	1.00	1.09	1057.0	57.0	3.10	1650.	12596.	523.
89	1	1.408	13056	894.21	878.00	889.67	1.00	1.09	1074.3	57.0	3.10	1650.	12548.	509.
90	1	1.424	12994	894.17	878.00	889.65	1.00	1.09	1091.5	57.0	3.10	1650.	12500.	494.
91	1	1.440	12933	894.13	878.00	889.62	1.00	1.09	1108.6	57.0	3.10	1650.	12453.	480.
92	1	1.456	12872	894.09	878.00	889.59	1.00	1.09	1125.7	57.0	3.10	1650.	12406.	466.
93	1	1.472	12811	894.05	878.00	889.56	1.00	1.09	1142.7	57.0	3.10	1650.	12359.	452.
94	1	1.488	12751	894.01	878.00	889.54	1.00	1.09	1159.6	57.0	3.10	1650.	12313.	438.
95	1	1.504	12693	893.98	878.00	889.51	1.00	1.09	1176.4	57.0	3.10	1650.	12267.	426.
96	1	1.520	12636	893.94	878.00	889.49	1.00	1.09	1193.1	57.0	3.10	1650.	12221.	416.
97	1	1.536	12580	893.90	878.00	889.46	1.00	1.09	1209.8	57.0	3.10	1650.	12176.	405.
98	1	1.552	12525	893.86	878.00	889.44	1.00	1.09	1226.4	57.0	3.10	1650.	12131.	394.
99	1	1.568	12469	893.82	878.00	889.41	1.00	1.09	1242.9	57.0	3.10	1650.	12086.	384.
100	1	1.584	12414	893.79	878.00	889.39	1.00	1.09	1259.4	57.0	3.10	1650.	12042.	373.

RESERVOIR DEPLETION TABLE

I	K	TTP(I)	Q(I)	H2	YB	D	SUB	VCOR	OUTVOL	BB	COFR	QI(I)	QBRECH	QSPIL
***	**	******	********	*******	*******	*******	****	****	*********	****	****	*****	******	*****
101	1	1.600	12360	893.75	878.00	889.36	1.00	1.09	1275.8	57.0	3.10	1650.	11997.	363.
102	1	1.618	12300	893.71	878.00	889.34	1.00	1.09	1293.7	57.0	3.10	1650.	11949.	351.
103	1	1.637	12235	893.66	878.00	889.31	1.00	1.09	1313.3	57.0	3.10	1650.	11897.	339.
104	1	1.658	12164	893.61	878.00	889.28	1.00	1.09	1334.8	57.0	3.10	1650.	11839.	325.
105	1	1.682	12086	893.56	878.00	889.24	1.00	1.09	1358.3	57.0	3.10	1650.	11776.	310.
106	1	1.707	12001	893.50	878.00	889.20	1.00	1.09	1383.9	57.0	3.10	1650.	11708.	294.
107	1	1.736	11909	893.44	878.00	889.16	1.00	1.09	1411.9	57.0	3.10	1650.	11633.	276.
108	1	1.767	11808	893.37	878.00	889.12	1.00	1.09	1442.5	57.0	3.10	1650.	11552.	257.
109	1	1.801	11699	893.29	878.00	889.07	1.00	1.09	1475.8	57.0	3.10	1650.	11464.	235.
110	1	1.839	11580	893.21	878.00	889.01	1.00	1.09	1512.1	57.0	3.10	1650.	11368.	212.
111	1	1.880	11451	893.12	878.00	888.95	1.00	1.09	1551.6	57.0	3.10	1650.	11264.	187.
112	1	1.926	11312	893.02	878.00	888.89	1.00	1.09	1594.5	57.0	3.10	1650.	11152.	160.
113	1	1.976	11161	892.92	878.00	888.82	1.00	1.09	1641.2	57.0	3.10	1650.	11031.	131.
114	1	2.032	10997	892.80	878.00	888.74	1.00	1.09	1691.8	57.0	3.10	1650.	10899.	99.
115	1	2.092	10822	892.68	878.00	888.66	1.00	1.09	1746.5	57.0	3.10	1650.	10758.	64.
116	1	2.159	10632	892.54	878.00	888.57	1.00	1.09	1805.8	57.0	3.10	1650.	10606.	27.
117	2	2.233	10427	892.40	878.00	888.47	.99	1.09	1869.8	57.0	3.10	1650.	10441.	-14.
118	2	2.314	10204	892.24	878.00	888.38	.99	1.09	1938.7	57.0	3.10	1650.	10262.	-57.
119	2	2.403	9965	892.08	878.00	888.29	.99	1.09	2012.9	57.0	3.10	1650.	10070.	-104.
120	2	2.500	9863	891.90	878.00	888.19	.99	1.09	2093.0	57.0	3.10	1650.	9863.	0.
121	2	2.608	9659	891.70	878.00	888.09	.99	1.09	2179.9	57.0	3.10	1650.	9660.	0.
122	2	2.726	9427	891.49	878.00	887.97	.99	1.09	2273.3	57.0	3.10	1650.	9428.	0.
123	2	2.857	9174	891.25	878.00	887.85	.99	1.09	2373.4	57.0	3.10	1650.	9175.	0.
124	2	3.000	8906	891.00	878.00	887.71	.99	1.09	2480.4	57.0	3.10	1650.	8906.	0.
125	2	3.158	8614	890.73	878.00	887.56	.99	1.09	2594.5	57.0	3.10	1650.	8615.	0.
126	2	3.331	8302	890.44	878.00	887.39	.98	1.09	2715.7	57.0	3.10	1650.	8302.	0.
127	2	3.522	7968	890.13	878.00	887.22	.98	1.09	2843.9	57.0	3.10	1650.	7968.	0.
128	2	3.731	7613	889.79	878.00	887.03	.98	1.09	2979.0	57.0	3.10	1650.	7614.	0.
129	2	3.962	7238	889.43	878.00	886.82	.97	1.09	3120.6	57.0	3.10	1650.	7239.	0.
130	2	4.216	6862	889.06	878.00	886.57	.97	1.09	3268.5	57.0	3.10	1650.	6862.	0.
131	2	4.495	6481	888.65	878.00	886.28	.97	1.09	3422.4	57.0	3.10	1650.	6481.	0.
132	2	4.802	6090	888.23	878.00	885.98	.96	1.10	3582.0	57.0	3.10	1650.	6090.	0.
133	2	5.140	5691	887.78	878.00	885.65	.96	1.10	3746.4	57.0	3.10	1650.	5691.	0.
134	2	5.512	5288	887.32	878.00	885.31	.96	1.10	3915.0	57.0	3.10	1650.	5288.	0.
135	2	5.920	4885	886.84	878.00	884.95	.96	1.10	4086.9	57.0	3.10	1650.	4886.	0.
136	2	6.370	4481	886.34	878.00	884.57	.95	1.11	4260.9	57.0	3.10	1650.	4482.	0.
137	1	6.865	4099	885.84	878.00	884.19	.95	1.11	4436.3	57.0	3.10	1650.	4099.	0.
138	1	7.409	3726	885.34	878.00	883.78	.95	1.12	4612.3	57.0	3.10	1650.	3726.	0.
139	1	8.007	3373	884.84	878.00	883.37	.96	1.12	4787.8	57.0	3.10	1650.	3373.	0.
140	2	8.665	3046	884.36	878.00	882.97	.96	1.13	4962.5	57.0	3.10	1650.	3047.	0.
141	2	9.390	2722	883.90	878.00	882.65	.95	1.13	5135.1	57.0	3.10	1650.	2722.	0.
142	2	10.186	2438	883.50	878.00	882.35	.95	1.13	5304.9	57.0	3.10	1650.	2438.	0.
143	2	11.062	2203	883.15	878.00	882.09	.95	1.13	5473.0	57.0	3.10	1650.	2204.	0.
144	2	12.026	2020	882.88	878.00	881.89	.94	1.13	5641.3	57.0	3.10	1650.	2020.	0.

PARAMETER	UNITS	VARIABLE	VALUE
INITIAL FLOW	CFS	Q(1)	1487.
MAX FLOW	CFS	QM	15667.
FINAL FLOW	CFS	Q(NU)	2020.
TIME TO MAX FLOW	HRS	TP	.82
NUMBER OF TIME STEPS		NNU	144
TOTAL VOLUME DISCHARGED FROM RESERVOIR	AC-FT	DISVOL	5641.

TIME PARAMETERS OF OUTFLOW HYDROGRAPH IMMEDIATELY DOWNSTREAM OF DAM

PARAMETER	UNITS	VARIABLE	VALUE
TIME TO FAILURE	HR	TFH	.800
TIME TO START OF RISING LIMB OF HYDROGRAPH	HR	TFO	.016
TIME TO PEAK	HR	TP	.816
TIME STEP SIZE	HR	DTHI	.040

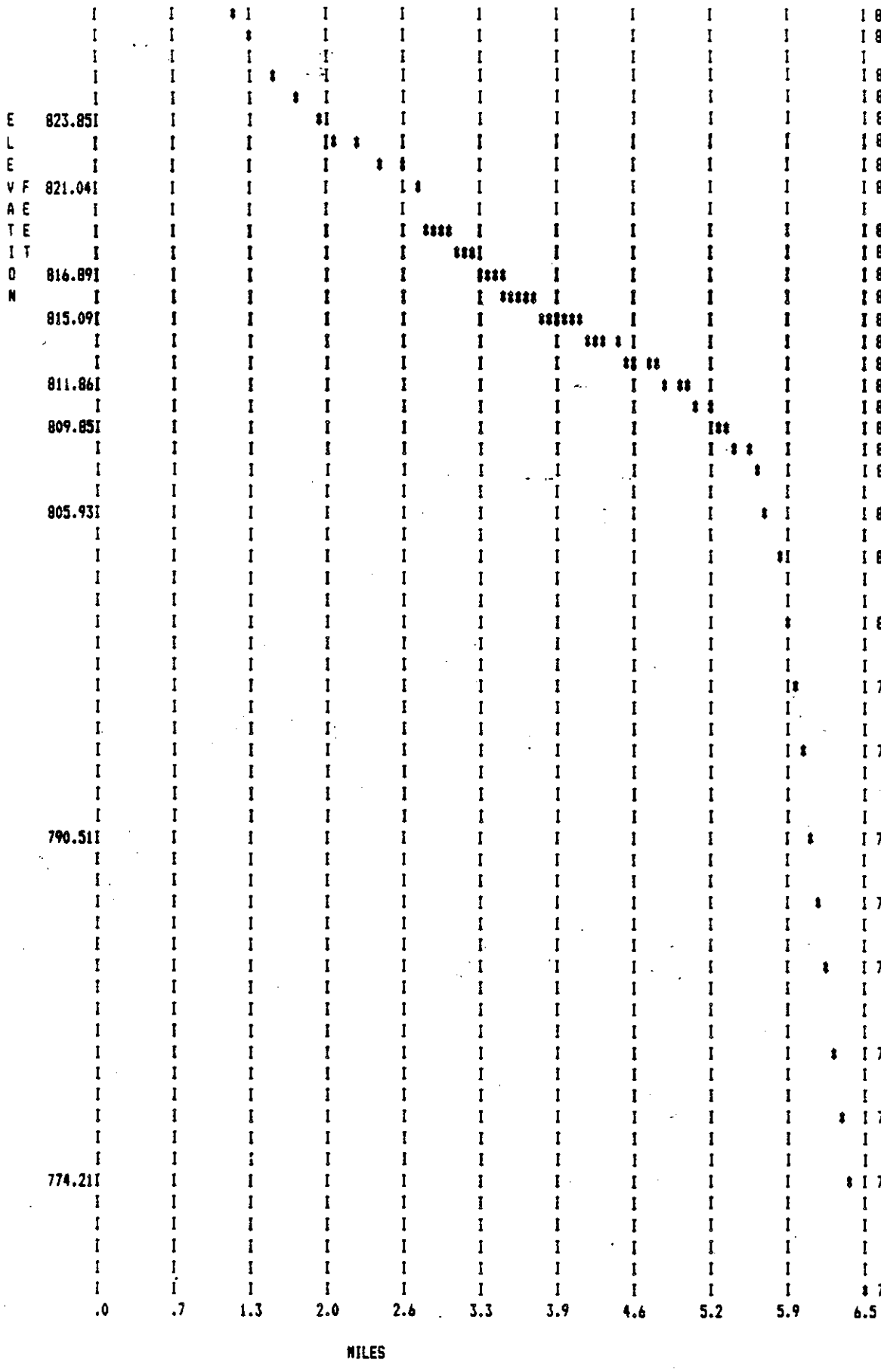
ROUTING COMPLETED.

KTIME=301 ALLOWABLE KTIME= 698 TT= 12.0

PEAK ELEVATION PROFILE

MILES

	.0	.7	1.3	2.0	2.6	3.3	3.9	4.6	5.2	5.9	6.5	ELEV FEET	MILE
890.25	*											890.2	.0
	*											888.0	.0
	*											885.8	.1
	*											883.6	.1
	*											881.4	.1
879.19	*											879.2	.2
	*											877.0	.2
	*											874.9	.2
	*											872.7	.3
	*											870.6	.3
868.43	*											868.4	.3
	*											866.3	.4
	*											864.2	.4
	*											862.1	.4
	*											860.0	.5
857.85	*											857.9	.5
	*											855.8	.5
	*											853.7	.6
	*											851.6	.6
	*											849.5	.6
847.44	*											847.4	.7
	*											845.4	.7
	*											843.3	.7
	*											841.3	.8
	*											839.2	.8
837.15	*											837.2	.8
	*											835.1	.9
	*											833.1	.9
	*											831.6	.9
	**											830.9	1.0

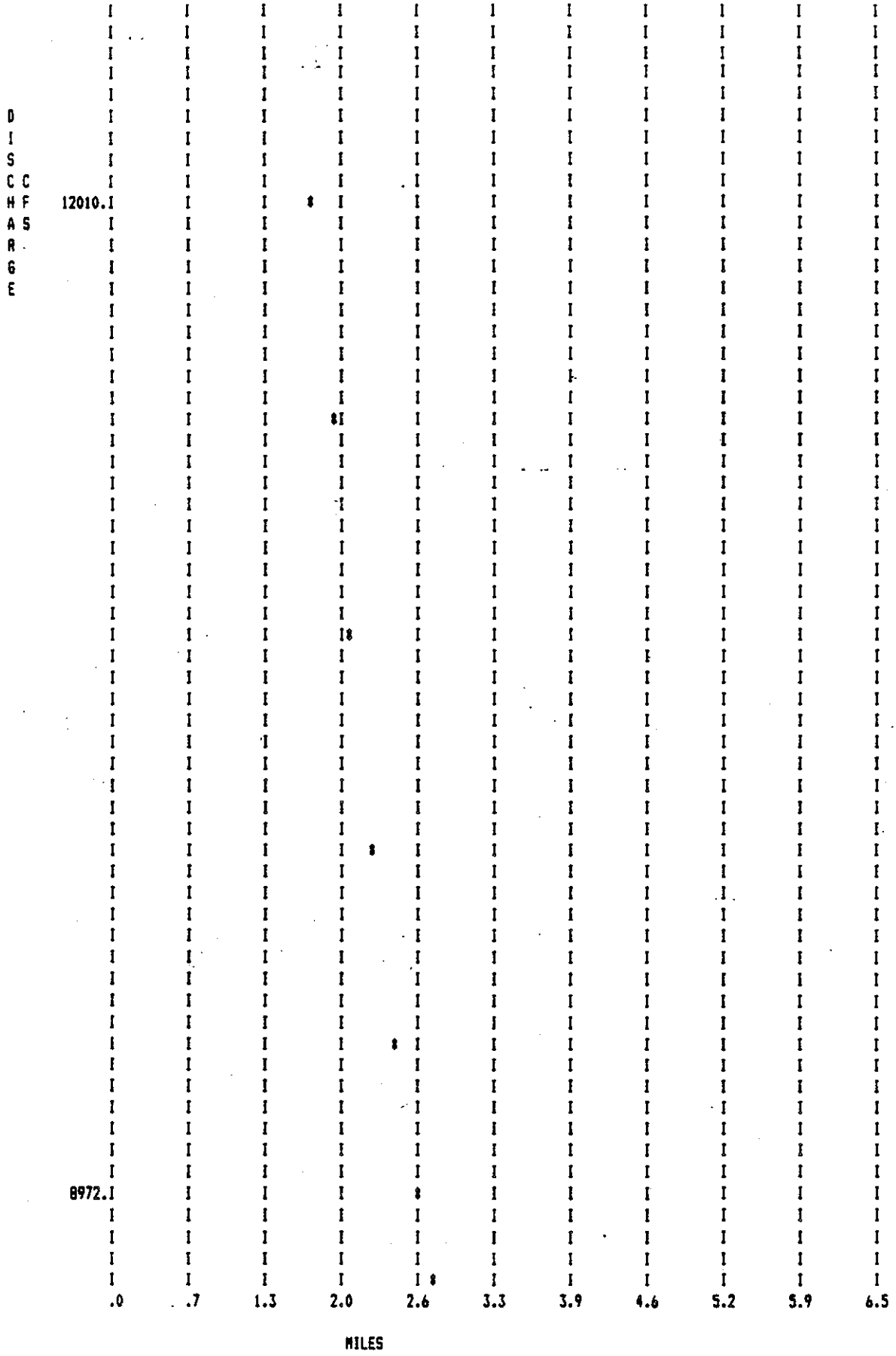

ELEVATION
823.85
821.04
816.89
815.09
811.86
809.85
805.93
790.51
774.21
828.8 1.2
827.3 1.4
825.9 1.5
824.8 1.7
823.8 1.9
823.1 2.1
822.0 2.4
821.0 2.8
819.3 2.8
817.9 3.1
816.9 3.3
816.1 3.5
815.1 3.8
814.1 4.2
813.1 4.5
811.9 4.9
810.8 5.1
809.9 5.3
808.7 5.5
807.1 5.6
805.9 5.7
803.5 5.8
800.3 5.9
797.0 5.9
793.8 6.0
790.5 6.1
787.2 6.2
783.8 6.2
780.4 6.3
777.0 6.4
774.2 6.4
768.4 6.5
.0 .7 1.3 2.0 2.6 3.3 3.9 4.6 5.2 5.9 6.5
MILES

PEAK DISCHARGE PROFILE

MILES

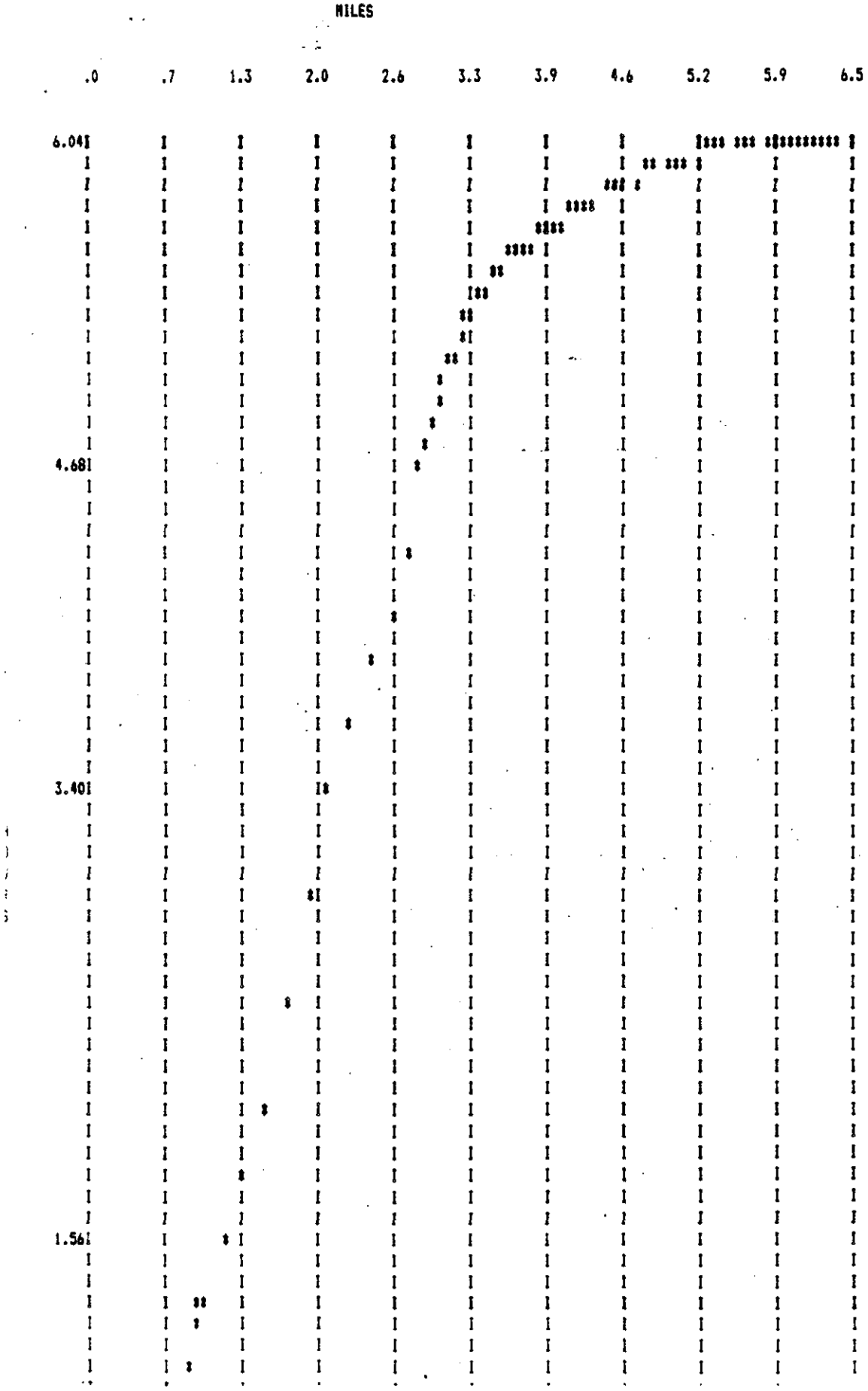
.0 .7 1.3 2.0 2.6 3.3 3.9 4.6 5.2 5.9 6.5

	DISCHARGE CFS	MILE
16582.	16582.	2.85
	16497.	2.90
	16414.	2.95
	16333.	3.00
	16255.	3.05
16181.	16181.	3.10
	16111.	3.15
	16046.	3.20
	15984.	3.25
15876.	15876.	3.35
	15828.	3.40
	15784.	3.45
	15709.	3.55
	15658.	.08
15591.	15591.	.21
	15520.	.27
15448.	15448.	4.18
	15380.	4.44
	15322.	4.78
	15225.	.93
15123.	15123.	.97
	14963.	1.00
	14122.	1.18
	13369.	1.36


DISCHARGE
12010.
12010.
1.72
11359.
1.90
10696.
2.08
10022.
2.26
9419.
2.44
8972.
8972.
2.62
8662.
2.80
.0
.7
1.3
2.0
2.6
3.3
3.9
4.6
5.2
5.9
6.5
MILES

TIME TO PEAK ELEVATION PROFILE

MILES



HOUR	MILE	ELEV
6.0	6.5	768.4
5.9	5.2	810.3
5.8	4.7	812.5
5.8	4.4	813.6
5.7	4.0	814.4
5.6	3.8	815.1
5.5	3.5	815.9
5.4	3.4	816.5
5.3	3.3	816.9
5.2	3.2	817.4
5.2	3.1	817.6
5.0	3.0	818.2
5.0	3.0	818.5
4.9	2.9	818.8
4.8	2.9	819.2
4.7	2.8	819.5
4.3	2.8	821.0
4.1	2.6	821.5
3.9	2.4	822.0
3.7	2.3	822.5
3.4	2.1	823.1
3.0	1.9	823.8
2.5	1.7	824.8
2.1	1.5	825.9
1.8	1.4	827.3
1.6	1.2	828.8
1.3	1.0	830.5
1.2	.9	831.6
1.0	.9	833.1

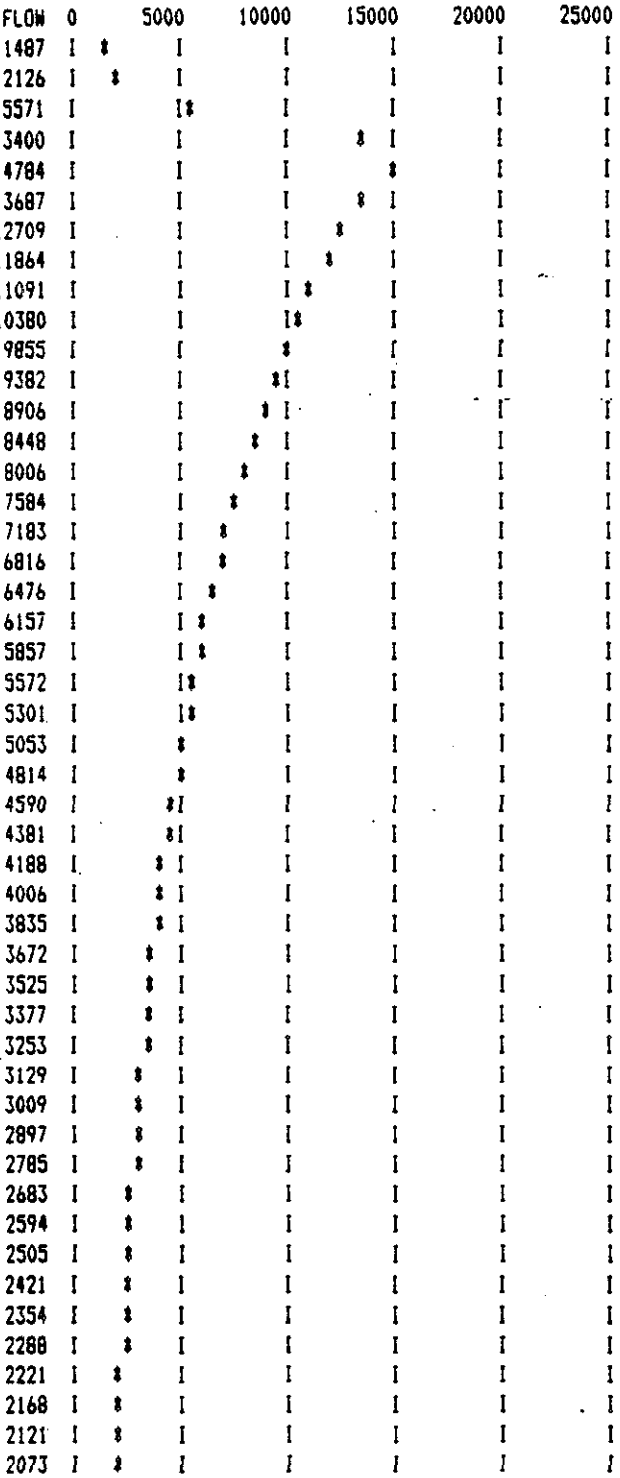
```
I ########I      I      I      I      I      I      I      I      I      I   .9   .6  851.6
###      I      I      I      I      I      I      I      I      I      I   .8   .2  879.2
.0      .7     1.3    2.0    2.6    3.3    3.9    4.6    5.2    5.9    6.5

                                MILES
```

DISCHARGE HYDROGRAPH FOR CRYSTAL LAKE BROOK ... STATION NUMBER 1
BELOW CRYSTAL LAKE DAM AT MILE .01

GAGE ZERO = 878.00 MAX ELEVATION REACHED BY FLOOD WAVE = 890.25
FLOOD STAGE NOT AVAILABLE
MAX STAGE = 12.25 AT TIME = .840 HOURS
MAX FLOW = 15648 AT TIME = .800 HOURS

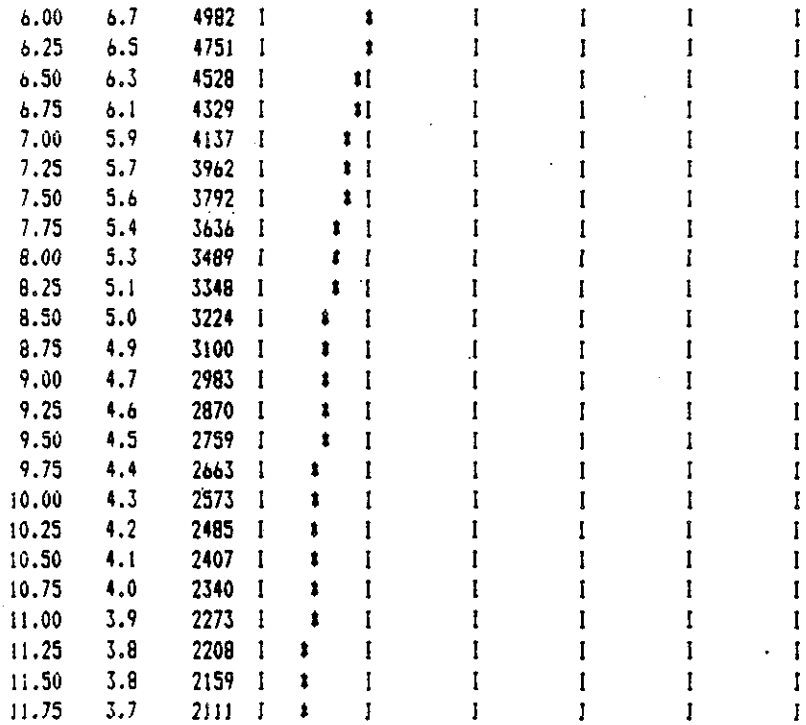
HR	STAGE	FLOW
.00	3.2	1487
.25	3.9	2126
.50	7.2	5571
.75	11.3	13400
1.00	11.9	14784
1.25	11.5	13687
1.50	11.1	12709
1.75	10.8	11864
2.00	10.4	11091
2.25	10.1	10380
2.50	9.9	9855
2.75	9.6	9382
3.00	9.4	8906
3.25	9.2	8448
3.50	9.0	8006
3.75	8.7	7584
4.00	8.5	7183
4.25	8.2	6816
4.50	8.0	6476
4.75	7.7	6157
5.00	7.5	5857
5.25	7.3	5572
5.50	7.1	5301
5.75	6.9	5053
6.00	6.7	4814
6.25	6.5	4590
6.50	6.3	4381
6.75	6.1	4188
7.00	5.9	4006
7.25	5.7	3835
7.50	5.5	3672
7.75	5.4	3525
8.00	5.2	3377
8.25	5.1	3253
8.50	4.9	3129
8.75	4.8	3009
9.00	4.7	2897
9.25	4.6	2785
9.50	4.5	2683
9.75	4.4	2594
10.00	4.3	2505
10.25	4.3	2421
10.50	4.2	2354
10.75	4.1	2288
11.00	4.0	2221
11.25	4.0	2168
11.50	3.9	2121
11.75	3.9	2073



DISCHARGE HYDROGRAPH FOR CRYSTAL LAKE BROOK ... STATION NUMBER 31
BELOW CRYSTAL LAKE DAM AT MILE 1.00

GAGE ZERO = 819.50 MAX ELEVATION REACHED BY FLOOD WAVE = 830.51
FLOOD STAGE NOT AVAILABLE
MAX STAGE = 11.01 AT TIME = 1.320 HOURS
MAX FLOW = 14963 AT TIME = 1.000 HOURS

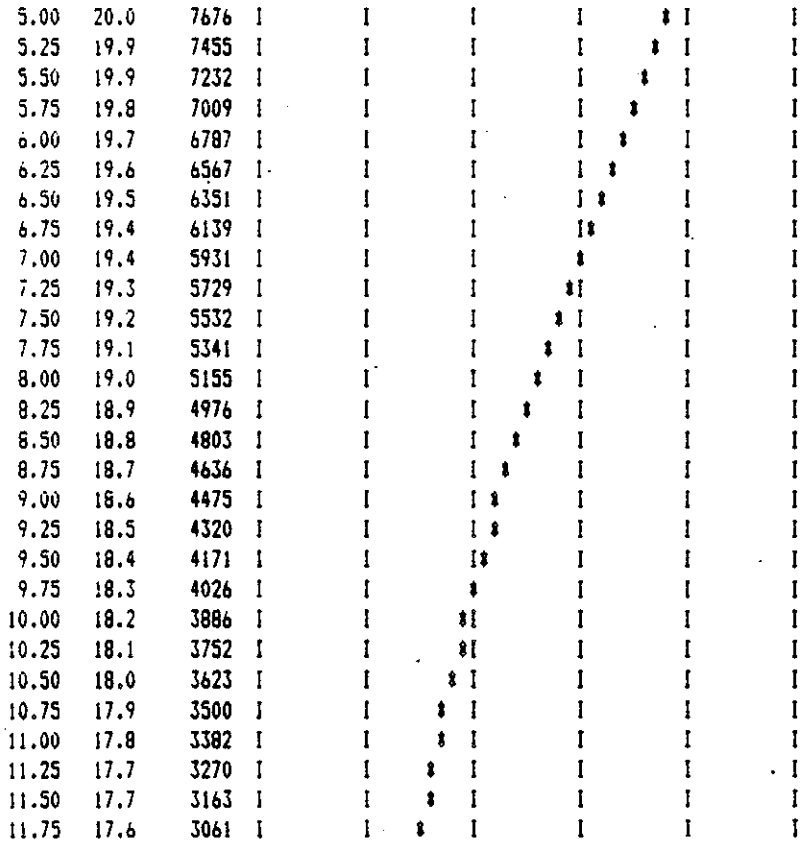
HR	STAGE	FLOW
.00	2.9	1487
.25	3.0	1510
.50	3.9	2758
.75	7.0	8200
1.00	10.4	14963
1.25	11.0	14196
1.50	11.0	13228
1.75	10.8	12341
2.00	10.5	11544
2.25	10.2	10809
2.50	9.9	10132
2.75	9.7	9686
3.00	9.5	9202
3.25	9.2	8734
3.50	9.0	8282
3.75	8.7	7848
4.00	8.5	7437
4.25	8.2	7054
4.50	8.0	6701
4.75	7.7	6371
5.00	7.5	6059
5.25	7.3	5765
5.50	7.1	5490
5.75	6.9	5227
6.00	6.7	4982
6.25	6.5	4751
6.50	6.3	4528
6.75	6.1	4329
7.00	5.9	4137
7.25	5.7	3962
7.50	5.6	3792
7.75	5.4	3636
8.00	5.3	3489
8.25	5.1	3348
8.50	5.0	3224
8.75	4.9	3100
9.00	4.7	2983
9.25	4.6	2870
9.50	4.5	2759
9.75	4.4	2663
10.00	4.3	2573
10.25	4.2	2485
10.50	4.1	2407
10.75	4.0	2340
11.00	3.9	2273
11.25	3.8	2208
11.50	3.8	2159
11.75	3.7	2111



DISCHARGE HYDROGRAPH FOR CRYSTAL LAKE BROOK ... STATION NUMBER 41
BELOW CRYSTAL LAKE DAM AT MILE 2.80

GAGE ZERO = 801.00 MAX ELEVATION REACHED BY FLOOD WAVE = 821.04
FLOOD STAGE NOT AVAILABLE
MAX STAGE = 20.04 AT TIME = 4.320 HOURS
MAX FLOW = 8662 AT TIME = 3.320 HOURS

HR	STAGE	FLOW
.00	16.3	1487
.25	16.3	1487
.50	16.3	1487
.75	16.3	1513
1.00	16.4	1745
1.25	16.6	2415
1.50	17.1	3744
1.75	17.7	5207
2.00	18.3	6454
2.25	18.7	7377
2.50	19.1	7999
2.75	19.4	8378
3.00	19.6	8579
3.25	19.8	8657
3.50	19.9	8646
3.75	20.0	8569
4.00	20.0	8443
4.25	20.0	8282
4.50	20.0	8095
4.75	20.0	7890
5.00	20.0	7676
5.25	19.9	7455
5.50	19.9	7232
5.75	19.8	7009
6.00	19.7	6787
6.25	19.6	6567
6.50	19.5	6351
6.75	19.4	6139
7.00	19.4	5931
7.25	19.3	5729
7.50	19.2	5532
7.75	19.1	5341
8.00	19.0	5155
8.25	18.9	4976
8.50	18.8	4803
8.75	18.7	4636
9.00	18.6	4475
9.25	18.5	4320
9.50	18.4	4171
9.75	18.3	4026
10.00	18.2	3886
10.25	18.1	3752
10.50	18.0	3623
10.75	17.9	3500
11.00	17.8	3382
11.25	17.7	3270
11.50	17.7	3163
11.75	17.6	3061



DISCHARGE HYDROGRAPH FOR CRYSTAL LAKE BROOK ... STATION NUMBER 67
BELOW CRYSTAL LAKE DAM AT MILE 4.10

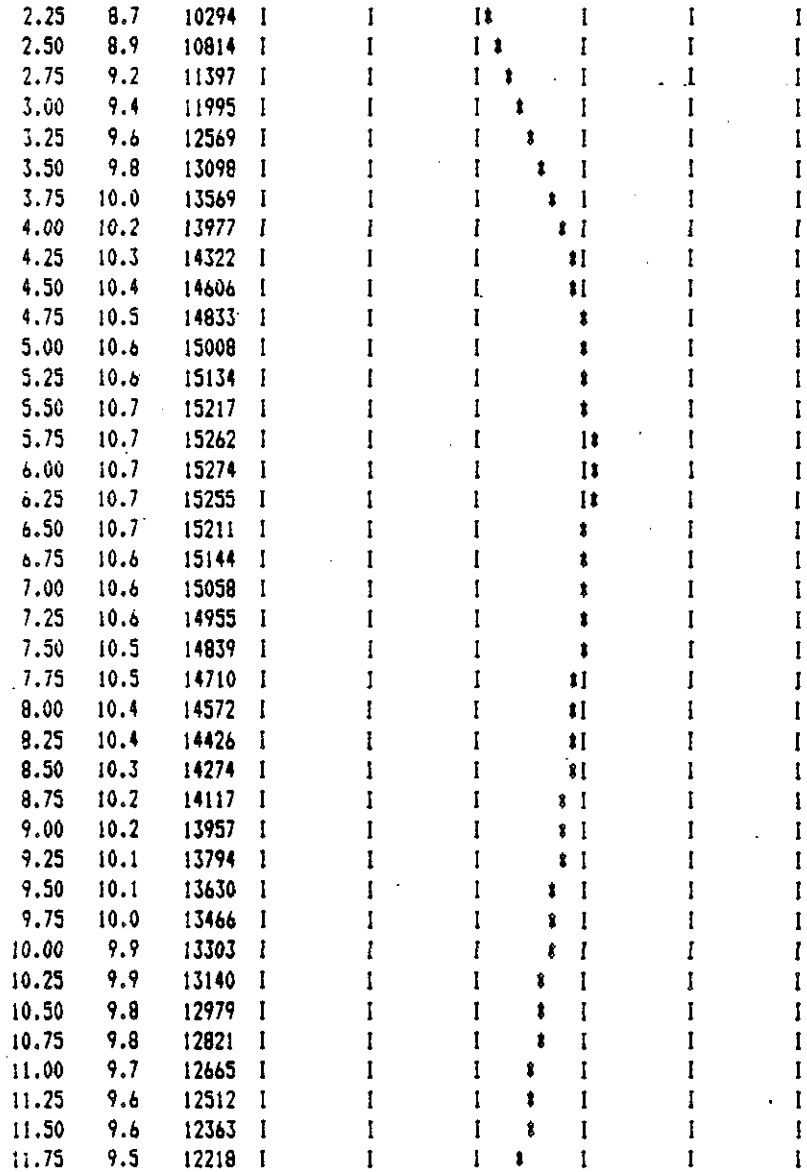
GAGE ZERO = 795.50 MAX ELEVATION REACHED BY FLOOD WAVE = 814.29
FLOOD STAGE NOT AVAILABLE
MAX STAGE = 18.79 AT TIME = 5.720 HOURS
MAX FLOW = 15476 AT TIME = 4.920 HOURS

HR	STAGE	FLOW	0	5000	10000	15000	20000	25000
.00	14.9	9487	I	I	*I	I	I	I
.25	14.9	9487	I	I	*I	I	I	I
.50	14.9	9487	I	I	*I	I	I	I
.75	14.9	9487	I	I	*I	I	I	I
1.00	14.9	9491	I	I	*I	I	I	I
1.25	14.9	9542	I	I	*I	I	I	I
1.50	15.0	9715	I	I	*I	I	I	I
1.75	15.2	10110	I	I	*	I	I	I
2.00	15.5	10729	I	I	I*	I	I	I
2.25	15.9	11490	I	I	I *	I	I	I
2.50	16.3	12282	I	I	I *	I	I	I
2.75	16.7	13021	I	I	I *	I	I	I
3.00	17.1	13661	I	I	I *	I	I	I
3.25	17.4	14187	I	I	I *	I	I	I
3.50	17.7	14602	I	I	I *I	I	I	I
3.75	18.0	14921	I	I	I *	I	I	I
4.00	18.2	15154	I	I	I *	I	I	I
4.25	18.4	15315	I	I	I I*	I	I	I
4.50	18.5	15416	I	I	I I*	I	I	I
4.75	18.6	15466	I	I	I I*	I	I	I
5.00	18.7	15474	I	I	I I*	I	I	I
5.25	18.8	15448	I	I	I I*	I	I	I
5.50	18.8	15393	I	I	I I*	I	I	I
5.75	18.8	15314	I	I	I I*	I	I	I
6.00	18.8	15217	I	I	I *	I	I	I
6.25	18.8	15104	I	I	I *	I	I	I
6.50	18.7	14979	I	I	I *	I	I	I
6.75	18.7	14843	I	I	I *	I	I	I
7.00	18.6	14699	I	I	I *I	I	I	I
7.25	18.5	14548	I	I	I *I	I	I	I
7.50	18.4	14392	I	I	I *I	I	I	I
7.75	18.4	14233	I	I	I * I	I	I	I
8.00	18.3	14072	I	I	I * I	I	I	I
8.25	18.2	13909	I	I	I * I	I	I	I
8.50	18.1	13746	I	I	I * I	I	I	I
8.75	18.0	13583	I	I	I * I	I	I	I
9.00	17.9	13421	I	I	I * I	I	I	I
9.25	17.8	13260	I	I	I * I	I	I	I
9.50	17.7	13102	I	I	I * I	I	I	I
9.75	17.6	12946	I	I	I * I	I	I	I
10.00	17.5	12792	I	I	I * I	I	I	I
10.25	17.4	12642	I	I	I * I	I	I	I
10.50	17.2	12494	I	I	I * I	I	I	I
10.75	17.1	12350	I	I	I * I	I	I	I
11.00	17.0	12210	I	I	I * I	I	I	I
11.25	16.9	12074	I	I	I * I	I	I	I
11.50	16.8	11942	I	I	I * I	I	I	I
11.75	16.8	11814	I	I	I * I	I	I	I

DISCHARGE HYDROGRAPH FOR CRYSTAL LAKE BROOK ... STATION NUMBER 87
BELOW CRYSTAL LAKE DAM AT MILE 5.80

GAGE ZERO = 792.80 MAX ELEVATION REACHED BY FLOOD WAVE = 803.47
FLOOD STAGE NOT AVAILABLE
MAX STAGE = 10.67 AT TIME = 6.000 HOURS
MAX FLOW = 15274 AT TIME = 5.960 HOURS

HR	STAGE	FLOW
.00	8.4	9487
.25	8.4	9487
.50	8.4	9487
.75	8.4	9487
1.00	8.4	9487
1.25	8.4	9490
1.50	8.4	9526
1.75	8.4	9640
2.00	8.5	9892
2.25	8.7	10294
2.50	8.9	10814
2.75	9.2	11397
3.00	9.4	11995
3.25	9.6	12569
3.50	9.8	13098
3.75	10.0	13569
4.00	10.2	13977
4.25	10.3	14322
4.50	10.4	14606
4.75	10.5	14833
5.00	10.6	15008
5.25	10.6	15134
5.50	10.7	15217
5.75	10.7	15262
6.00	10.7	15274
6.25	10.7	15255
6.50	10.7	15211
6.75	10.6	15144
7.00	10.6	15058
7.25	10.6	14955
7.50	10.5	14839
7.75	10.5	14710
8.00	10.4	14572
8.25	10.4	14426
8.50	10.3	14274
8.75	10.2	14117
9.00	10.2	13957
9.25	10.1	13794
9.50	10.1	13630
9.75	10.0	13466
10.00	9.9	13303
10.25	9.9	13140
10.50	9.8	12979
10.75	9.8	12821
11.00	9.7	12665
11.25	9.6	12512
11.50	9.6	12363
11.75	9.5	12218



DISCHARGE HYDROGRAPH FOR CRYSTAL LAKE BROOK ... STATION NUMBER 97
BELOW CRYSTAL LAKE DAM AT MILE 6.50

GAGE ZERO = 759.00 MAX ELEVATION REACHED BY FLOOD WAVE = 768.36
FLOOD STAGE NOT AVAILABLE
MAX STAGE = 9.36 AT TIME = 6.040 HOURS
MAX FLOW = 15273 AT TIME = 6.040 HOURS

HR	STAGE	FLOW	0	5000	10000	15000	20000	25000
.00	7.1	9518	I	I	*I	I	I	I
.25	7.1	9518	I	I	*I	I	I	I
.50	7.1	9518	I	I	*I	I	I	I
.75	7.1	9518	I	I	*I	I	I	I
1.00	7.1	9518	I	I	*I	I	I	I
1.25	7.1	9518	I	I	*I	I	I	I
1.50	7.1	9507	I	I	*I	I	I	I
1.75	7.2	9592	I	I	*I	I	I	I
2.00	7.3	9796	I	I	*	I	I	I
2.25	7.4	10152	I	I	*	I	I	I
2.50	7.6	10638	I	I	I*	I	I	I
2.75	7.8	11204	I	I	I *	I	I	I
3.00	8.1	11801	I	I	I *	I	I	I
3.25	8.3	12383	I	I	I *	I	I	I
3.50	8.5	12927	I	I	I *	I	I	I
3.75	8.7	13417	I	I	I *	I	I	I
4.00	8.8	13847	I	I	I *	I	I	I
4.25	9.0	14212	I	I	I *	I	I	I
4.50	9.1	14516	I	I	I *I	I	I	I
4.75	9.2	14762	I	I	I *	I	I	I
5.00	9.3	14953	I	I	I *	I	I	I
5.25	9.3	15095	I	I	I *	I	I	I
5.50	9.3	15193	I	I	I *	I	I	I
5.75	9.4	15250	I	I	I I*	I	I	I
6.00	9.4	15273	I	I	I I*	I	I	I
6.25	9.4	15264	I	I	I I*	I	I	I
6.50	9.3	15228	I	I	I *	I	I	I
6.75	9.3	15169	I	I	I *	I	I	I
7.00	9.3	15089	I	I	I *	I	I	I
7.25	9.3	14992	I	I	I *	I	I	I
7.50	9.2	14879	I	I	I *	I	I	I
7.75	9.2	14755	I	I	I *	I	I	I
8.00	9.1	14620	I	I	I *I	I	I	I
8.25	9.1	14476	I	I	I *I	I	I	I
8.50	9.0	14326	I	I	I *I	I	I	I
8.75	9.0	14170	I	I	I * I	I	I	I
9.00	8.9	14011	I	I	I * I	I	I	I
9.25	8.8	13849	I	I	I * I	I	I	I
9.50	8.8	13685	I	I	I * I	I	I	I
9.75	8.7	13521	I	I	I * I	I	I	I
10.00	8.7	13357	I	I	I * I	I	I	I
10.25	8.6	13194	I	I	I * I	I	I	I
10.50	8.5	13033	I	I	I * I	I	I	I
10.75	8.5	12873	I	I	I * I	I	I	I
11.00	8.4	12717	I	I	I * I	I	I	I
11.25	8.4	12563	I	I	I * I	I	I	I
11.50	8.3	12412	I	I	I * I	I	I	I
11.75	8.3	12265	I	I	I * I	I	I	I

APPENDIX C

BREACH FORMATION AND SIZING CALCULATION

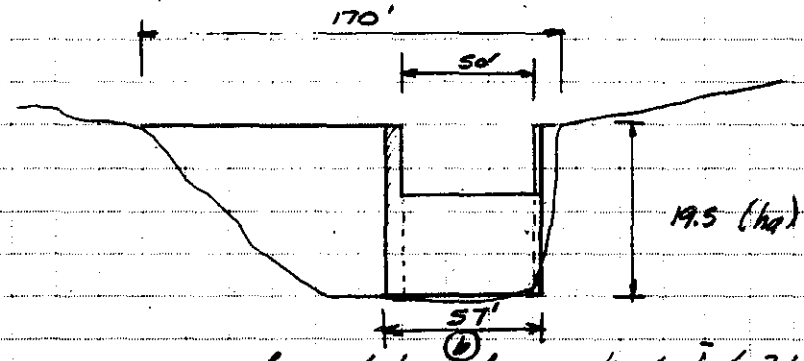
STORCH ASSOCIATES
Engineers - Surveyors - Planners
Landscape Architects
Environmental Scientists

JOB 6389 - NH DAMS - Crystal Lake Enfield
SHEET NO. ____ OF ____
CALCULATED BY JH DATE 12-12-87
CHECKED BY ____ DATE ____
SCALE ~~x~~ 3 Breach Sizing

Breach formation and sizing

Crystal Lake is an earthen embankment with a vertical concrete facing on upstream site and with a concrete spillway having 170 LF overall length

L_d = 120 LF (top of dam) EL. 897.5
L_s = 50 LF (spillway) EL. 892.0
d/s invert EL. 878.0



average formed breach $h_d < \bar{b} < 3h_d$

earthen portion 120 LF $b = 20' - 60'$
concrete portion 50 LF $b = 50'$
upstream concrete facing = 1/3 of length

use $b = 57'$ $z = 0$ vertical side slope

Reservoir length 1.5 Mi
W.S. 892.0
test flood 1/2 PMF 5,400 cfs W.S. 900.2

PRODUCT 204-1 NEBS Inc. Groton, Mass. 01471