CONNECTICUT RIVER BASIN
MASTER MANUAL
OF
WATER CONTROL

APPENDIX A

OMPOMPANOOSUC RIVER WATERSHED
UNION VILLAGE DAM
VERMONT

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WATER CONTROL DIVISION
WALTHAM, MASSACHUSETTS

(FEBRUARY 1950)
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ACKNOWLEDGMENTS

The following personnel were involved in the preparation and completion of this Appendix:

Greg Hanlon - Hydraulic Engineer, Reservoir Control Center - prepared the text, tables, and plates.

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Paul Marinelli - Chief, Reservoir Control Center - reviewed the Appendix for style, correctness, and completeness during preparation.

PREFACE

The Ompompanoosuc River watershed, a tributary of the Connecticut River, is located in northeastern Vermont and has a drainage area of 136 square miles. Union Village Dam, a Corps flood control project, is located on the Ompompanoosuc River at Union Village, Vermont. This manual describes the water control plan for Union Village Dam and is considered Appendix A to the Connecticut River Master Water Control Manual, dated November 1983.

This Appendix includes a description of the watershed; hydrologic, climatologic and flood data; project descriptions, and regulation procedures for the reservoir. The Appendix is divided into six chapters: Introduction, Management, Watershed Characteristics, Communications, and Data Collection, Hydrologic Forecasts, and Water Control Plan. The chapter format allows the reader to obtain background on any particular aspect of the project.

Pertinent hydrologic information on the Ompompanoosuc River watershed and Union Village Dam is shown on pages i and ii at the front of this Appendix.

CONNECTICUT RIVER BASIN

MASTER MANUAL OF WATER CONTROL

Appendix	Watershed	Reservoir	Status
Master Manual	Connecticut River	-	Completed 1983
A	Ompompanoosuc River	Union Village	Completed 1950 Revised 1971 Revised 1993
B	Ottaquechee River	North Hartland	Completed 1969 Revised 1985
C	Black River	North Springfield	Completed 1968
D	West River	Ball Mountain Townshend	Completed 1965 Revised 1973
E	Ashuelot River	Surry Mountain Otter Brook	Completed 1962 Revised 1972
F	Millers River	Birch Hill Tully	Completed 1950 Revised 1974
G	Chicopee River	Barre Falls Conant Brook	Completed 1964 Revised 1979
H	Westfield River	Knightville Littleville	Completed 1967 Revised 1978
I	Farmington River	Colebrook Mad River Sucker Brook	Completed 1970 Revised 1990

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MANUAL OF WATER CONTROL
OMPOMPANOOSUC RIVER WATERSHED
VERMONT

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PERTINENT DATA
UNION VILLAGE DAM

LOCATION	Ompompanoosuc River; Union Village, Vermont
DRAINAGE AREA	126 Square Miles
STORAGE USE	Flood Control

RESERVOIR STORAGE

38,000

	Elevation	Stage	Area	Acre-Feet	Runnoff
Inlet Elevation	420.0	-	-	-	-
Spillway Crest	564.0	144.0	740	3,800	5.65
Maximum Surcharge (des. crit.)	579.0	159.0	860	50,000	~~7.4~~ 7.39
Top of Dam	584.0	164.0	900	54,000	~~8.0~~ 8.02

49,640 53,920

EMBANKMENT FEATURES

Type	Rolled earth and rockfill
Length (Feet)	1,100
Top Width (Feet)	30
Top Elevation (Ft. NGVD)	584.0
Maximum Height (Feet)	170
Volume (Cubic yards)	1,619,000

SPILLWAY FEATURES

Location	Right Abutment of Dam
Type	Chute Spillway with Ogee Shaped Weir
Crest Length (Feet)	388.0

SPILLWAY DESIGN FLOOD

Peak Inflow (CFS)	87,500
Peak Outflow	84,900
Volume of Runoff (Acre Feet)	110,600
Maximum Surcharge (Feet above crest)	15.0

OUTLET WORKS

Tunnel	(1) Boston Horseshoe Conduit
Tunnel Size (Feet)	13.0
Length (Feet)	1236
Flood Control Gates	(2) Broome Gates Size: 7'6" wide x 12' high
Downstream Channel Capacity (CFS)	2,400
Maximum Conduit Discharge At Spillway Crest	7,860

LAND ACUISITION

Fee Elevation (Ft. NGVD)	564.0
Easement	4 Acres, No Common Elevation

MAXIMUM POOL	April 1969, Stage = 114.0 Ft., Elevation = 534.0 NGVD, 53% Full
UNIT RUNOFF	6,720 Acre-Feet = 1 Inch of Runoff
OPERATING TIME	10 Minutes, Open/Close Gates at 1 Ft./Min
PROJECT COSTS (THROUGH FY 1991)	5,300,000 O+M 4,950,000 Construction
COMPLETION DATE	June 1950
MAINTAINED BY	New England Division, Corps of Engineers

PERTINENT DATA
OMPOMPANOOSUC RIVER WATERSHED
HYDROLOGIC INFORMATION

DRAINAGE AREA

		Square Miles
Mainstem - Ompompanoosuc River		
	Upstream of Dam	126
	Upstream of USGS Gage	130
	Mouth Of The Ompompanoosuc River	136
Tributaries		
	West Branch	60
	Lake Fairlee Brook	21

PRECIPITATION

	Chelsea Vermont	Union Village Dam, Vermont	Hanover, N H
Mean Annual	36.7	35.4	37.4
Max. Annual	52.5	48.0	56.0
Min. Annual	24.3	23.5	24.9
Years of Record (Through 1988)	40	38	62

WATER EQUIVALENT OF SNOW COVER - Based on Corps of Engineers Surveys

	Mean (inches)	Maximum (inches)	Minimum (inches)
1 February	4.0	6.9	0.1
15 February	4.8	8.3	0.1
1 March	5.6	9.6	0
15 March	5.6	9.5	0
1 April	4.2	10.7	0
15 April	1.6	7.6	0

USGS GAGES

	Drainage Area (sq. mi.)	River	Period of Record
Union Village	130	Ompompanoosuc	1940-present
West Hartford	690	White	1915-present
West Lebanon	4,092	Connecticut	1911-present
North Walpole	5,493	Connecticut	1942-present

PEAK FLOWS

Ompompanoosuc River at Union Village, VT			White River West Hartford, VT			Connecticut River West Lebanon, NH		
Date	CFS	CSM	Date	CFS	CSM	Date	CFS	CSM
11/27	12,000	95*	11/27	120,000	174	11/27	136,000	33
2/67	7,300	58*	9/22	47,600	69	3/36	120,000	29
10/69	7,300	58*	3/36	45,400	66	9/38	82,400	20
3/36	7,300	58*	4/22	35,500	51	6/73	79,100	19

*Estimated from High Water Marks

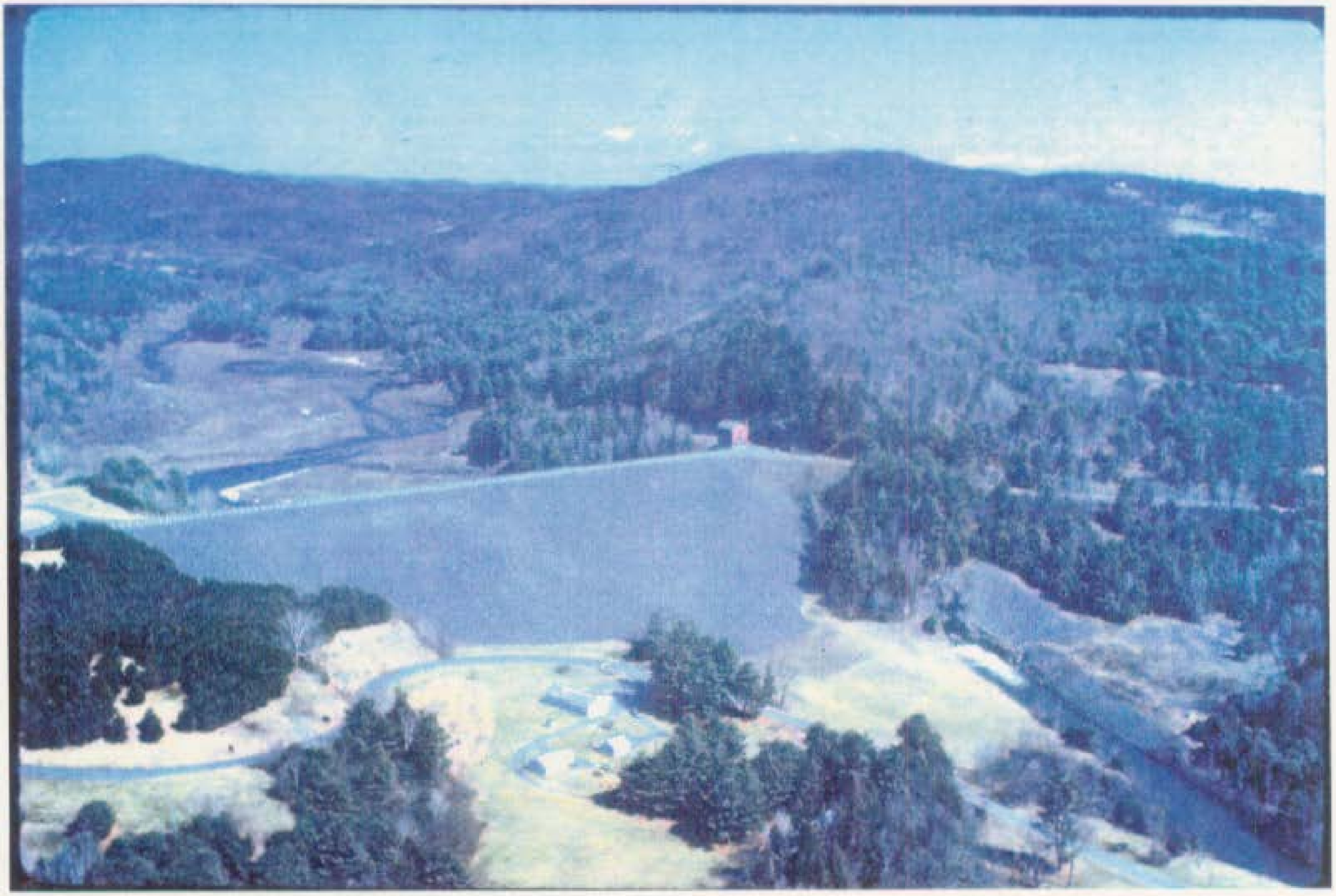
ANNUAL RUNOFF*

	Ompompanoosuc River Union Village, VT			White River West Hartford, VT			Connecticut River West Lebanon, VT		
	CFS	Inches	Year	CFS	Inches	Year	CFS	Inches	Year
Mean	195	20	-	1,176	24	-	7,135	23.8	-
Max.	299	31	1973	1,910	38	1976	10,700	35.8	1928
Min.	74	7.7	1965	494	9.9	1965	4.101	13.7	1965

*Through Water Year 1987

FLOOD ROUTING COEFICIENTS

Reach	3-Hr. Routing Coefficients	River Miles Between Points	High Flow Travel Times (Hours)
Union Village Dam to W. Lebanon	3/2	13.3	6
W. Lebanon to N. Walpole	13/6	32.5	15
N. Walpole to Vernon Dam	13/4	29.5	12
Vernon Dam to Montague City	5/2	18.0	10-12



Union Village Dam and Reservoir Area

APPENDIX A

OMPOMPANOOSUC RIVER WATERSHED, VERMONT
CONNECTICUT RIVER BASIN
MASTER MANUAL OF WATER CONTROL

I - INTRODUCTION

1-01. Regulation Manual

a. Authorization. This report is prepared pursuant to authority contained in ER 1110-2-240, Water Control Management, dated 8 October 1982, and EM 1110-2-3600, Management of Water Control Systems, dated 30 November 1987, which require that manuals be prepared whenever storage allocated to one or more of the functions is the responsibility of the Corps of Engineers. Requirements and format in EC 1110-2-278, Preparation of Water Control Manuals, dated 31 August 1993, were utilized in the preparation of this manual.

This manual supersedes the previous regulation manual prepared for the Ompompanoosuc River Watershed in February 1950, and the May 1971 revision. This revision was necessary due to developments in the watershed affecting regulation, and the necessity to update the format and certain information included in the original manual.

b. Purpose and Scope. This manual serves as a guide and reference source for higher authority, reservoir regulation and maintenance personnel in the New England Division, project managers, and other personnel concerned with or responsible for regulation within the Ompompanoosuc River watershed or Connecticut River Basin. Included in this manual are the following chapters:

Chapter I - Introduction. A description of physical features of Corps and significant non-Federal projects in the watershed. This chapter also includes a history of Corps projects and a discussion of public documents and reports relative to flood control within the Ompompanoosuc and Connecticut River watersheds.

Chapter II - Management. A general description of functional responsibilities of the Corps, relating to regulation of the projects, with a listing of all interagency agreements.

1-02. History of the Project

a. Authorization. Union Village Dam was authorized as a flood control project for the Ompompanoosuc River watershed in the Flood Control Act of 1936 (Public Law 738, 74th Congress, 2d session), and the Flood Control Act of 1938 (Public Law 761, 75th Congress, 1st session).

b. Construction. Construction of Union Village Dam was initiated in March 1947 and completed in June 1950.

1-03. Project Description

a. Location. The Ompompanoosuc River watershed is located in the central Connecticut River Basin on the south eastern slope of the Green Mountains. Plate A-1 shows the Connecticut River Basin and plate A-2, the Ompompanoosuc watershed.

Union Village Dam is located in central Vermont on the Ompompanoosuc River approximately 4 miles upstream of its confluence with the Connecticut River. A vicinity and reservoir map of Union Village Dam is shown on plate A-3 and photograph of the project is shown on page 1-4.

b. Purpose. Union Village Dam, a single purpose dry bed flood control project, is regulated in conjunction with 15 other Corps flood control reservoirs in the Connecticut River Basin to reduce flood stages along the main stem of the Connecticut River. In addition, limited recreation activities are supported at Union Village Dam, and are incidental to the project's primary purpose of flood control.

c. Physical Components. Important physical components consist of a rolled earth dam with rock slope protection, a chute spillway, and outlet works.

At spillway crest elevation 564 feet NGVD, Union Village Dam has a capacity of 38,000 acre-feet, equivalent to 5.65 inches of runoff from the contributing 126-square mile drainage area. When filled to spillway crest, the reservoir has an area of 740 acres and length of 3.5 miles. Area capacity curves are shown on plate A-15. The percent storage curve, and determination of inflow curves are given on plates A-16 and A-29, respectively.

The dam, consisting of a compacted earth embankment with rock slope protection, is approximately 1,100 feet in length, with a maximum height of 170 feet above the riverbed. The top width is 30 feet and top of embankment elevation is 584.0 feet NGVD, which is 20.0 feet above spillway

Chapter III - Watershed Characteristics. A general description of the Ompompanoosuc River watershed and its major tributaries, including meteorological and hydrologic data (i.e. temperature, precipitation, snowfall, snow cover, storms, streamflow and floods), water quality, and economic data. Also included are descriptions of design floods and analysis of experienced major floods, determining the effectiveness of Union Village Dam.

Chapter IV - Communications and Data Collection. Methods of collecting hydrologic data necessary for effective reservoir regulation, and a discussion of the automatic collection of hydrologic data through New England Division's Satellite Data Collection System (NEDSAT) are included, along with descriptions of communication activities between field and office personnel during flood and nonflood periods.

Chapter V - Hydrologic Forecasts. A description of forecasts used by Reservoir Control Center personnel in regulating Union Village Dam and other projects in the Connecticut River Basin. Included are precipitation forecasts from the National Weather Service (NWS) and river stage predictions from the Northeast River Forecast Center in Taunton, Massachusetts.

Chapter VI - Water Control Plan. Includes a summary of objectives associated with operation of Union Village Dam for flood control, hydropower, recreation, water quality, water supply including drought contingency, and other uses.

c. Related Manuals and Reports

(1) Routine Inspection. Routine operation and maintenance activities at all manned, flood control reservoirs are performed by project personnel under supervision of Project Operations Division in Operations Directorate. Operation and Maintenance Manuals prepared for Corps-built projects provide essential instructions to operating personnel for upkeep, repair, maintenance and operation of project facilities. An O&M Manual for Union Village Dam was prepared in November 1983.

(2) Project Inspection Reports. As part of a continuing program to insure structural stability, safety, and operational adequacy of each project, a periodic inspection report is completed for each dam every five years on a rotating basis, as specified by ER 1110-2-100. This field examination includes geotechnical, structural, mechanical, concrete, electrical, and hydrologic/hydraulic features of the project.

Union Village Dam

crest and 5.0 feet above spillway design surcharge. The embankment slopes vary from 1 on 2.5 to 1 on 3 (see general plan plate A-4).

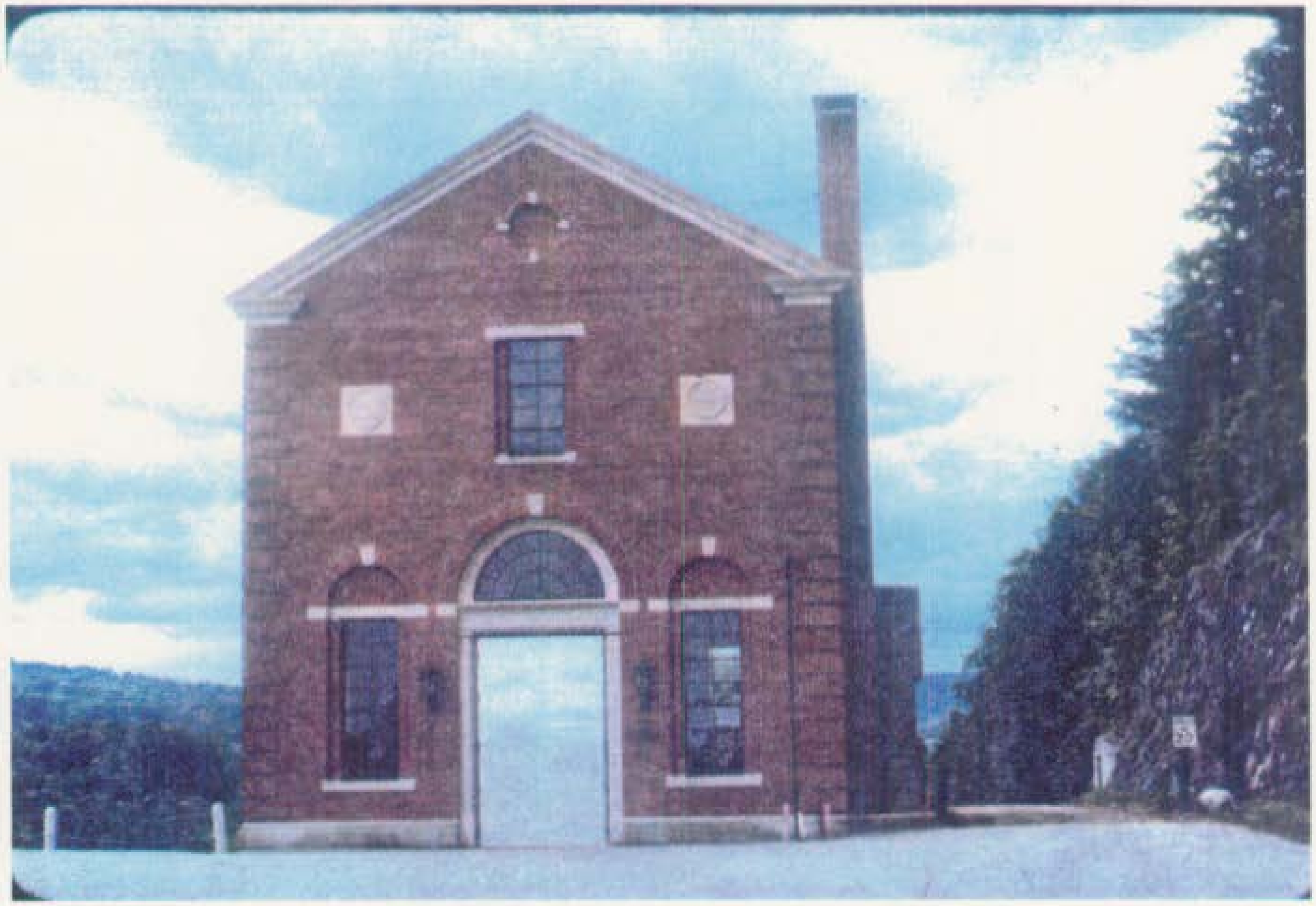
A chute spillway built on rock is located on the right abutment of the dam, with the base of the approach channel at elevation 520 feet NGVD. The ogee-shaped spillway crest is 388 feet in length and has a crest elevation of 564.0 feet NGVD. The discharge channel width varies from 160 to 400 feet, and its bottom slope varies from 7 to 1 percent. Spillway discharge flows are returned to the river via a 1,100-foot channel to Avery Brook, then another 1,100 feet along Avery Brook to the Ompompanoosuc River. Plan, profile, and cross sections of the spillway are shown on plate A-5.

The outlet works, shown on plate A-7, consist of an approach channel, intake structure, discharge conduit, and discharge channel. The intake channel is about 394 feet in length and 23 feet wide. The concrete intake structure houses equipment to operate the two 7 foot 6 inch by 12 foot 0 inch broome gates, with electrically operated gear and drum type cable hoists. A photograph of the gate house is shown on page 1-6. These gates regulate the discharge through the 13-foot diameter, concrete, horseshoe conduit. Total length of the discharge conduit measures 1,167 feet, with entrance invert at elevation 420.0 feet NGVD and exit invert at 418.0 feet NGVD. The rock cut and earth discharge channel is 60 feet wide and approximately 640 feet long. The outlet rating curves are shown on plate A-39.

d. <u>Recreation.</u> Principal recreation activities at Union Village Dam include hiking, picnicking, snowmobiling, fishing, hunting, and cross country skiing.

Pools, rapids, and waterfalls at various locations along both the West Branch and Main Stem Ompompanoosuc River provide an attractive setting for much outdoor activity. White water on the Main Stem Ompompanoosuc, cascading over rocky ledges below the Tucker Hill Road covered bridge in central Vermont, see photo on page 1-7, provides a picturesque setting for one of the few remaining structures of its type. Picnic tables and fireplaces are also provided at various locations along the Ompompanoosuc River, within Union Village project lands.

e. <u>Principal Non-Federal Projects within the Watershed.</u> Lake Fairlee has a drainage area of approximately 20 square miles and water surface area of approximately 500 acres. The stone and concrete-capped dam, privately owned by a lake front property owner, is 40 feet in length and one



Union Village Dam
Gate House

Covered bridge over Ompompanoosuc River
Downstream of Union Village Dam

foot higher than the 30-foot long spillway. The 30-inch outlet conduit has a hand-operated wooden gate.

1-04. Published Documents and Legislative Acts

a. General. Following is a brief summary of pertinent reports, documents, and legislative acts associated with Union Village Dam and the Ompompanoosuc River watershed, which is included for background purposes. Additional documents with broader coverage relating to the Connecticut River Basin, as well as discussion of some of the following, are included in the Connecticut River Basin Master Water Manual, November 1983.

b. House Document 455, 75th Congress. This report, published in 1937, proposed a revised plan for flood control for the Connecticut River and its tributaries which consisted of 20 reservoirs (including Union Village) and seven local protection projects. Authorization of this plan was included in the Flood Control Act of 1938 (Public Law 761, 75th Congress, 1st session) and the Flood Control Act of 1944 (Public Law 534, 78th Congress, 2d session).

c. Connecticut River Flood Control Compact. Union Village Dam and Reservoir were included in the flood control compact adopted by the States of Connecticut, Massachusetts, New Hampshire, and Vermont, and approved on 6 June 1953, Public Law 52, 83rd Congress, 2d session.

d. New England New York Interagency Committee Report. Flood Control on the Ompompanoosuc River was considered in Part Two, Chapter XXI, dated March 1955, and printed as Senate Document 14, 85th Congress. The report consisted of a comprehensive survey of land, water, and related natural resources of the region. This report, prepared by the New England-New York Interagency Committee, was submitted to the President of the United States by the Secretary of the Army on 27 April 1956.

e. Comprehensive Water Related Land Resources, Connecticut River Basin. This study, dated June 1970, recommended the establishment of a summer recreation pool at Union Village Dam. The plan was contingent upon a solution to an existing water quality problem on the West Branch of the Ompompanoosuc River. This problem has not been resolved.

f. Connecticut River Basin Master Manual of Water Control. This manual, completed in November 1983, includes a description of the Connecticut River Basin; statistical, climatologic, flood, and other hydrologic data; required procedures for coordination, communications and data collection; descriptions and pertinent data for reservoirs and local protection projects; and general procedures for reservoir regulation activities.

II - MANAGEMENT

2-01. General

a. Project Owner. Union Village Dam is U.S. Government property, and is managed by the New England Division, Corps of Engineers.

b. Operating Agencies. The New England Division is responsible for operation of Union Village Dam. Staffing is on a normal work week basis--8 hours a day, Monday through Friday. During flood emergency conditions, the project is staffed on a 24-hour basis, or as instructed by the Reservoir Control Center.

c. Regulating Agency. NED is responsible for regulation of the Union Village Dam flood control project.

2-02. Functional Responsibilities

a. New England Division. Reservoir regulation activities are performed by the Reservoir Control Center (RCC), an element of Water Control Division within the Engineering Directorate. RCC's responsibilities are defined in a publication entitled: "Guidance Memorandum, Reservoir Control Center," dated September 1971. Maintenance activities at Corps-owned projects are performed by project personnel under supervision of Project Operations Division of Operations Directorate. During regulation periods, project personnel are responsible to the Reservoir Control Center for operating instructions and information.

Overall administrative functions of each Corps project are the responsibility of basin managers; RCC notifies the basin manager of all RCC activities which could affect administrative functions.

The Water Control Division is comprised of three Branches, namely, Reservoir Control Center, Hydrologic Engineering Branch, and Hydraulics and Water Quality Branch. RCC consists of a staff of hydraulic engineers responsible for all reservoir regulation and hurricane barrier activities at NED. Other RCC responsibilities include:

- Preparing, updating, and revising regulation manuals.

- Continuing studies of regulation procedures.

- Annual reports on regulation activities.

- Data collection and reporting networks.

- Analysis of floods for flood control benefits.

- Training of personnel.

The other two Branches, within Water Control Division, assist Reservoir Control Center during flood operations, and provide technical assistance as requested. An organization chart for reservoir regulation in the New England Division is shown on plate A-8.

b. Other Agencies. No other agency has responsibility of flood control activities at Corps reservoirs in the Connecticut River Basin.

2-03. Interagency Agreements

a. General. The Corps of Engineers has a cooperative working program with the U.S. Geological Survey and a cooperative relationship with the National Weather Service and its Northeast River Forecast Center at Taunton, Massachusetts. NED uses hydrologic and forecasting information from these agencies in flood control regulation.

b. Compacts. The 83d Congress, by the passage of Public Law 52, dated 6 June 1953, granted consent and approval to an Interstate Compact, covering the Connecticut River Basin, which had been previously ratified by the States of New Hampshire, Vermont, Massachusetts, and Connecticut. Principal purposes of the compact are:

(1) Ensuring adequate storage capacity for impounding water in the interest of flood control. Five dams: Union Village, Surry Mountain, Birch Hill, Tully, and Knightville were in operation when the compact was instituted. These dams were endorsed by the compact and are included in a tax sharing clause. Additional locations were agreed upon for future tax reimbursement upon construction.

(2) A system of tax loss reimbursement was set up so that Southern New England States would share tax losses with Northern States from Federal acquisition of lands for any flood control dam and reservoir built in the Connecticut River Basin. Following is a tabulation of this tax reimbursement:

Recipient State	Percent Loss Reimbursed	Reimbursing State
Vermont	40	Connecticut
Vermont	50	Massachusetts
New Hampshire	40	Connecticut
New Hampshire	50	Massachusetts
Massachusetts	40	Connecticut

(3) Providing a joint or common agency through which the signatory States may effectively cooperate in accomplishing the objectives of flood control and water resources utilization in the basin.

(4) Provides for creation of a commission consisting of three representatives from each State. This commission has the authority to enter into contracts and agreements, and make ongoing studies and investigations as required in the interest of flood control and in cooperation with Federal agencies.

c. News Releases. It is the policy of the Corps of Engineers to cooperate with the local press and news media. This cooperation provides local communities with information regarding regulation of Union Village Dam. The primary source of information regarding regulation of the project is the Public Affairs Officer, who is responsible for issuing all communiques to the news media.

Whenever the project manager receives requests for information from local news media or private citizens, he can release information pertinent to his project; however, he cannot make any flood forecasts. For additional information, referrals should be made to RCC or the Public Affairs Office.

III - WATERSHED CHARACTERISTICS

3-01. Description of the Watershed

a. Ompompanoosuc River. The Ompompanoosuc River watershed is located in eastern Vermont, primarily in Orange County, with a small portion in Windsor County. The watershed is fan-shaped with a dendritic drainage pattern. At its confluence with the Connecticut River, the Ompompanoosuc has a watershed area of 136 square miles, of which 126 are up-upstream of Union Village Dam. Because of the steep topography, the watershed is prone to rapid runoff. Elevation of the watershed varies from 2,300 feet NGVD in northwestern headwaters to 385 feet at the mouth in the eastern portion, with an average watershed elevation of about 1,300 feet. Geographic features and the stream system of the basin are shown on plate A-2.

The Ompompanoosuc River originates above the town of Vershire, Vermont, and flows 24 miles to the confluence with the Connecticut River. The main river channel, lying on the easterly side of the watershed, flows in a north-south direction. The river has a fall of 1,020 feet in the first six miles and 430 feet in the remaining 18 miles to the confluence with the Connecticut, with two major tributaries joining along the way. Water surface profiles and other hydrologic features are shown on plate A-9.

b. Tributaries

(1) General. The principal tributary in the watershed is the West Branch Ompompanoosuc River, with a drainage area of 60 square miles.

(2) West Branch Ompompanoosuc River. The largest tributary of the Ompompanoosuc River is located in the western portion of the basin, originating near Hawkins Mountain. Its watershed is oval in shape and it flows in a southeasterly direction. It falls about 1,140 feet in the first 5-1/2 miles, and an additional 540 feet in the remaining 11 miles to its confluence with the Ompompanoosuc River, 5 miles from its mouth.

(3) Lake Fairlee Brook. This tributary, with a 21-square mile drainage area, originates at Lake Fairlee, and flows in a westerly direction for a distance of about 1-1/2 miles to its confluence with the Ompompanoosuc River. Several brooks flow into Lake Fairlee, which has a drainage

area of 20 square miles. The largest, Middle Brook with a drainage area of 11 square miles, originates near Tebbetts Notch and flows in a southerly direction for a distance of about 7 miles, with a fall of about 700 feet, to Lake Fairlee.

(4) Lake Fairlee. The lake has a water surface area of approximately 500 acres. The privately-owned 40-foot long Lake Fairlee dam is made of stone, capped with concrete, and is one foot higher than the 30-foot long spillway. The 30-inch outlet conduit is equipped with a hand-operated wooden gate.

3-02. Climate

a. General. The Ompompanoosuc River watershed has a variable climate characterized by frequent but generally short periods of heavy precipitation in the summer, and longer periods of less intense precipitation in the winter. It lies in the path of the "prevailing westerlies" and cyclonic storms that move across the country from the west or southwest. The area is also exposed to coastal storms, known locally as "northeasters", that travel up the Atlantic seaboard, primarily in the spring and fall. In addition, tropical hurricanes constitute an infrequent but significant potential for flood producing precipitation, particularly from August through October. Thunderstorms may occur over the basin at any time of year, and may be of local origin or associated with a stationary front. Precipitation is fairly evenly distributed throughout the year. Winters are moderately severe with subzero temperatures common; summers are mild with temperatures over 90 degrees occurring infrequently. The climatological station at Chelsea, Vermont, located about 16 miles northwest of Union Village Dam and about 4 miles outside the Ompompanoosuc River watershed, is used to represent the climate of the watershed and is shown on plate A-2.

b. Temperature. The average annual temperature of the Ompompanoosuc River watershed is about 42 degrees Fahrenheit. Average monthly temperatures vary widely throughout the year, from about 15 $^{\circ}$F. in January to about 67 $^{\circ}$F. in July. Temperature extremes range from a high of 100 $^{\circ}$F. to a low of -40 $^{\circ}$F. Mean, maximum, and minimum temperatures recorded over a 100-year period at Chelsea, Vermont, are listed in table A-1.

c. Precipitation. The mean annual precipitation of 35 inches is distributed rather uniformly throughout the year. Average monthly precipitation at Union Village Dam

TABLE A-1

MONTHLY TEMPERATURES (^{o}F)
OMPOMPANOOSUC RIVER WATERSHED AREA

Month	Chelsea, Vermont 91 Years of Record, Through 1989 Maximum Recorded	Minimum Recorded	Mean	Hanover, New Hampshire 104 Years of Record Through, 1889 Maximum Recorded	Minimum Recorded	Mean
January	66	-37	15.0	63	-34	17.9
February	62	-35	16.5	63	-40	19.8
March	82	-32	27.1	82	-22	30.1
April	91	-5	40.2	91	6	43.1
May	93	16	52.2	96	22	55.3
June	95	25	61.1	98	30	64.1
July	98	29	66.5	101	38	69.1
August	100	27	63.8	103	34	66.7
September	93	15	56.1	95	22	59.1
October	87	9	45.4	87	13	47.7
November	77	-17	33.7	79	-12	35.5
December	65	-40	20.0	67	-37	22.3
Annual	100	-40	41.5	103	-40	44.8

ranges from a minimum of 2.28 inches in February to a maximum of 3.45 inches in July. However, precipitation is quite variable, with much of the winter precipitation occurring as snow. Mean, maximum, and minimum monthly precipitation, as recorded at Hanover, New Hampshire, Chelsea, Vermont, and Union Village Dam are listed in table A-2. Plate A-10 lists annual precipitation at Union Village Dam for the 39-year period of record.

d. Snow and Snow Cover. The mean annual snowfall for 92 years of record at Chelsea, Vermont, is 87.2 inches with about 45 percent of this occurring in the months of January and February. Variation in the average monthly snowfall is shown on table A-3.

Snow surveys have been taken by the Corps of Engineers since the early 1950s in the Ompompanoosuc and White River watersheds. Locations of these snow courses are shown on plate A-2 and listed in table A-4. Water content in the snow cover usually reaches a maximum in late March. Since 1951, it has averaged about 6.0 inches, with a maximum of 12.6 inches, and minimum of zero. Moderate springtime discharges commonly occur as a result of melting snow, but runoff from this source alone has not been sufficient, during the period of record, to cause a major flood. However, serious flooding, due to a combination of heavy rain and snowmelt, is a possibility each year. Average, maximum, and minimum water equivalents of snow cover in the Ompompanoosuc and White River watersheds are shown graphically on plates A-11 and A-12.

e. Storms. Generally, three types of storms occur in the Ompompanoosuc River basin: continental, coastal, and those involving thunderstorms which may be of local origin or the result of a stationary front. Continental storms, originating over the western or central part of the United States, move generally in an easterly or northeasterly direction. These storms may be rapidly moving intense cyclones, or stationary storms, not limited to any month, but following one another at more or less regular intervals, with varying intensities throughout the year.

Of the coastal storms, tropical hurricanes are the most important. They originate either in the South Atlantic or in the Western Caribbean Sea, generally moving in a westerly or northwesterly direction, curving to the north near the main land, and then moving northeast when approaching New England. Although the normal path is to the south and east of New England, they may be deflected over this area by continental cyclonic disturbances or by a large, slow-moving,

TABLE A-2

MONTHLY PRECIPITATION
OMPOMPANOOSUC RIVER WATERSHED
(Depth in Inches)

	Hanover, New Hampshire Elevation - 600 ft NGVD (1926 - 1988)			Chelsea, Vermont Elevation - 800 ft NGVD (1948 - 1988)			Union Village Dam, Vermont Elevation - 460 ft NGVD (1950 - 1988)		
	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum
January	2.73	6.62	0.27	2.57	6.67	0.31	2.45	6.07	0.25
February	2.38	5.85	0.09	2.30	6.26	0.23	2.28	7.51	0.10
March	2.74	5.63	0.00	2.65	5.24	0.40	2.48	5.68	0.57
April	2.90	5.31	0.49	2.94	5.48	0.73	2.78	4.66	0.98
May	3.43	10.37	0.88	3.36	8.55	0.79	3.23	9.51	0.53
June	3.10	7.00	0.43	3.04	5.93	0.77	2.76	5.85	0.26
July	3.73	9.71	0.98	3.59	5.63	0.96	3.45	6.66	0.89
August	3.30	10.19	0.66	3.47	8.97	1.19	3.25	8.85	0.57
September	3.30	8.88	0.67	3.27	6.58	0.74	3.30	7.55	0.43
October	2.93	6.66	0.26	3.06	8.07	0.22	2.94	5.80	0.10
November	3.60	8.67	1.00	3.43	8.31	1.29	3.38	7.28	0.98
December	2.99	7.69	0.61	2.95	6.49	1.03	2.84	7.92	0.77
Annual	37.41	56.04	24.88	36.65	52.53	24.25	35.36	47.97	23.52

TABLE A-3

MONTHLY SNOWFALL
OMPOMPANOOSUC RIVER WATERSHED
(Inches)

	Chelsea, Vermont 1898-1989 (Elev = 800 ft NGVD)		Hanover, New Hampshire 1890-1989 (Elev = 600 ft NGVD)	
Month	Mean	Percent of Annual Precip.	Mean	Percent of Annual Precip.
January	20.3	23.3	18.1	25.1
February	18.6	21.3	17.7	24.5
March	15.8	18.1	12.0	16.6
April	6.1	7.0	4.1	5.7
May	0.6	0.7	-	-
June	-	-	-	-
July	-	-	-	-
August	-	-	-	-
September	-	-	-	-
October	0.8	0.9	0.2	0.3
November	8.0	9.2	5.5	7.6
December	17.0	19.5	14.6	20.2
Annual	87.2	100.0	72.2	100.0

TABLE A-4

CORPS OF ENGINEERS
SNOW SURVEY COURSES
OMPOMPANOOSUC RIVER WATERSHED

Station	Elevation (Ft-NGVD)	Location Longitude	Location Latitude	Period of Record
White River Watershed				
Tweed River	900	72°46'40"	43°46'10"	1962-Present
Silver Lake	1500	72°37'30"	43°43'20"	1962-Present
Ompompanoosuc River Watershed				
Union Village Dam	640	72°16'10"	45°48'15"	1951-Present
Post Mills	720	72°15'45"	43°52'35"	1951-Present
Goodhue Ledges	1180	72°17'50"	43°58'05"	1951-Present
Vershire	1920	72°22'25"	43°59'00"	1951-Present
Strafford	1340	72°23'20"	43°53'55"	1951-Present
County Line	1590	72°24'10"	43°49'35"	1951-Present

anticyclonic center located northeast of New England. This latter phenomenon is known as a "blocking" high pressure cell. In general, hurricanes are likely to occur from June through October, with greater incidence of such storms in August and September.

Coastal storms of an extratropical nature differ from hurricanes principally because they originate along the Eastern seaboard. These coastal storms travel northward along the coast, occurring more frequently during autumn, winter, and spring months.

3-03. Streamflow

a. Discharge Records. The USGS currently maintains and publishes streamflow data for over 100 stream gaging stations in the Connecticut River Basin. Periods of record range from only a few years to over 80 years at some stations on the main stem.

The only stream gaging station in the Ompompanoosuc River watershed is located on the Ompompanoosuc River, about 1,600 feet downstream of Union Village Dam. This gage, owned and operated by the U.S. Geological Survey, has provided a continuous record of runoff from its 130-square mile drainage area since 21 September 1940. Runoff data has been adjusted for change in contents at Union Village reservoir since start of operation in October 1949.

b. Streamflow Data. Annual runoff for the 48-year period of record through 1987, at the USGS gaging station at Union Village, has varied from a maximum of 32 inches to a minimum of 7.9, with an average value of 21 inches over the 130-square mile watershed. The mean annual runoff represents about 59 percent of the mean annual precipitation (36 inches), and about 54 percent (11.4 inches) of this runoff occurs in the months of March, April, and May. Average annual discharges, adjusted for change in contents of Union Village reservoir, over the 48 year period of record (1940 - 1987) have varied from a maximum peak of 299 cfs to a minimum of 74 cfs, with an average annual flow of 195 cfs. A summary of maximum, minimum, and average monthly, as well as annual runoff for the Ompompanoosuc River at Union Village and White River at West Hartford, is shown in table A-5. Plate A-13 tabulates annual runoff values for the period of record at these stations, as well as for the Connecticut River at West Lebanon, New Hampshire. Discharge records for the White River at West Hartford and Connecticut River at West Lebanon are included, due to the influence these stations have on regulation activities at Union Village Dam and other Corps reservoirs in the Upper Connecticut Basin.

TABLE A-5

MONTHLY RUNOFF
OMPOMPANOOSUC AND WHITE RIVER WATERSHEDS

	Ompompanoosuc River at Union Village, Vermont D.A. = 130 Square Miles (1940 - 1987)						White River at West Hartford, Vermont D.A. = 690 Square Miles (1915 - 1988)					
	Average		Maximum		Minimum		Average		Maximum		Minimum	
Month	CFS	Inches	CFS	Inches	CFS	Inches	CFS	Inches	CFS	Inches	CFS	Inches
October	98	0.9	389	3.4	9	0.1	639	1.2	2416	4.0	80	0.1
November	160	1.4	425	3.8	23	0.2	980	1.6	2391	3.9	285	0.5
December	167	1.5	593	5.3	29	0.3	994	1.7	3189	5.3	237	0.4
January	130	1.1	288	2.6	38	0.3	814	1.4	2127	3.6	197	0.3
February	140	1.2	507	4.5	32	0.3	788	1.3	3503	5.9	169	0.3
March	295	2.6	667	5.9	73	0.6	1904	3.2	7170	12.0	222	0.4
April	666	5.9	1066	9.5	303	2.7	3926	6.6	7286	12.2	1488	2.5
May	331	2.9	681	6.0	121	1.1	2010	3.4	4734	7.9	634	1.1
June	159	1.4	606	5.4	40	0.3	880	1.5	3459	5.8	224	0.4
July	82	0.7	466	4.1	14	0.1	484	0.8	1742	2.9	108	0.2
August	55	0.5	217	1.9	12	0.1	345	0.6	1822	3.0	91	0.2
September	60	0.5	201	1.8	8	0.1	401	0.7	2774	4.6	78	0.1
Water Year	195	21	299	32	74	7.9	1176	24	1910	38	494	9.9

3-04. Flood History

a. General. Flood history of the Ompompanoosuc River watershed extends back for more than 200 years. Information pertaining to past flood events has been gathered through old newspapers, town history, engineering records, and field investigations. These records concerning early floods, although meager in most cases, mention significant flooding in 1785, 1811, 1824, 1828, 1830, 1867, 1869, 1895, 1913, 1925, 1927, 1936, 1938, and 1947. Most events were caused solely by heavy rainfall, although the flood of 1936 was the result of heavy rain in conjunction with melting snow.

Prior to 1867, the magnitude of these floods is not known. Subsequent to 1867, the 1927 event is unquestionably the largest. From record high watermarks, the 1927 peak flow was estimated to be approximately 12,000 cfs at the Union Village Dam site. A tabulation of the six largest known flood events in the Ompompanoosuc River Basin follows:

MAXIMUM FLOW AT
UNION VILLAGE DAM
(Dam constructed in 1950)

Date	Discharge (cfs)
November 1927	12,000*
February 1867	7,300*
October 1869	7,300*
March 1936	7,300*
June 1947	4,800**
September 1938	4,750*

* Estimated
** Recorded

b. Recent Floods

(1) General. Several major floods have been experienced in the Ompompanoosuc River watershed, occurring in November 1927, March 1936, September 1938, June 1947, April 1960, March-April 1969, June-July 1973, May-June 1984, and March-April 1987. A brief discussion of observed conditions in the Ompompanoosuc watershed, as a result of each flood, is presented in the following paragraphs. In addition, detailed discussions of the effects of the above floods, with the exception of the 1984 and 1987 events, are

presented in the Master Manual of Water Control for the Connecticut River Basin, dated November 1983. Isohyetal maps for storms associated with the 1927, 1936, 1938, and 1973 events are also included in the Master Manual, along with plates showing the effect of the reservoir system on the floods of 1936, 1938, and 1960.

Due to the significance of the May-June 1984 and March-April 1987 floods in the Connecticut River Basin, and because they occurred after completion of the Master Manual, a detailed narrative of these events, including discussions of flooding on the main stem and some of its tributaries, is included in this manual.

(2) November 1927. In late October 1927, a tropical storm forming over the Caribbean, veered northward on 1 November, and arrived at the lower end of Chesapeake Bay on 3 November. The storm followed a path over western Massachusetts and Vermont, causing the greatest flooding on Vermont tributaries of the Connecticut River, and serious flooding in New Hampshire and western tributaries of Massachusetts. Average precipitation in the Ompompanoosuc River watershed for this storm was estimated to have been about 7.5 inches. A peak discharge estimated to be 12,000 cfs occurred at the Union Village USGS gaging station. This is the largest flood known to have occurred in the Ompompanoosuc River Basin. Property damage in Vermont was estimated to be in excess of $26 million.

(3) March 1936. After the first week of March 1936, temperatures in New England became unseasonably warm and continued so for the remainder of the month. Snow cover throughout most of the Connecticut River Basin was above average as little thawing occurred in January and February. During mid-March, two storm centers with heavy rainfall, passed over New England on 11-12 and 17-18. Although total rainfall during this period amounted to only 5.7 inches at the Chelsea gage, the runoff volume, including snowmelt, was equivalent to approximately 7.6 inches of rainfall. The flood had three peaks, ranging from 4,600 to 7,300 cfs, with a maximum estimated 24-hour average discharge of 6,050 cfs. Record flows were set at many index stations on the main stem of the Connecticut River.

(4) September 1938. On 21 September 1938, after a week of rainfall, a major hurricane travelled northward through the Connecticut River Valley. The combined rainfall totaled 4.99 inches at Chelsea, Vermont. Maximum flow at Union Village was estimated to be 4,750 cfs.

(5) June 1947. The highest recorded discharge at the Union Village gaging station (installed 1940) occurred on 3 June 1947 as a result of heavy rainfall on the previous day. Total rainfall for this event was 3.77 inches at Chelsea, Vermont. This event, combined with an already saturated ground, resulted in heavy runoff and a peak flow of 4,800 cfs at the Union Village gaging station.

(6) April 1960. Heavy snowfall and abnormal cold temperatures in March resulted in thick snow cover in most of New England, with water equivalents up to 10 inches in headwaters of upper tributaries of the Connecticut River Basin. This condition, coupled with eight days of unseasonably warm weather and moderate to heavy rain from 30 March to 6 April, resulted in a 21.2-foot stage on the Connecticut River at White River Junction on 5 April. Runoff totals for April on the White and Ompompanoosuc Rivers were 9.8 and 9.2 inches, respectively. Although no major tributary flooding occurred in the basin, tributary discharges synchronized causing the main stem of the Connecticut River at Hartford to experience a stage of 27.6 feet on 7 April, the highest since August 1955.

(7) March-April 1969. A record snow cover with water equivalents from 8 to 14 inches existed over all watersheds in Vermont, New Hampshire, and central Massachusetts as the spring snowmelt season approached in early March 1969. On 25 March, up to 2.5 inches of rain fell over much of the Connecticut Basin, depleting snow cover in the southern basin and causing flows in Connecticut River tributaries to reach near channel capacity. The following weeks were characterized by frequent shower activity and above normal temperatures, resulting in or near flood stages on the main stem for almost the entire month of April. The total 11.8-inch runoff for the month of April, at the USGS gage on the White River at West Hartford, was 20 percent greater than the previous maximum for the month, based on 50 years of record. On the Ompompanoosuc River at Union Village, the total 10.5-inch runoff volume for the month was also a record, resulting in the maximum flood storage utilized at Union Village Dam, 20,000 acre-feet or 3.0 inches of rainfall over the entire 126-square mile drainage area.

(8) June-July 1973. During the last few days of June 1973, continuous moderate to heavy shower activity occurred over widespread areas of New England, resulting in several inches of rain in the mountainous regions of Vermont and New Hampshire. This storm caused the greatest summer flood, i.e., June, July, and August, in many watersheds in the White Mountains of New Hampshire and Green Mountains of Vermont.

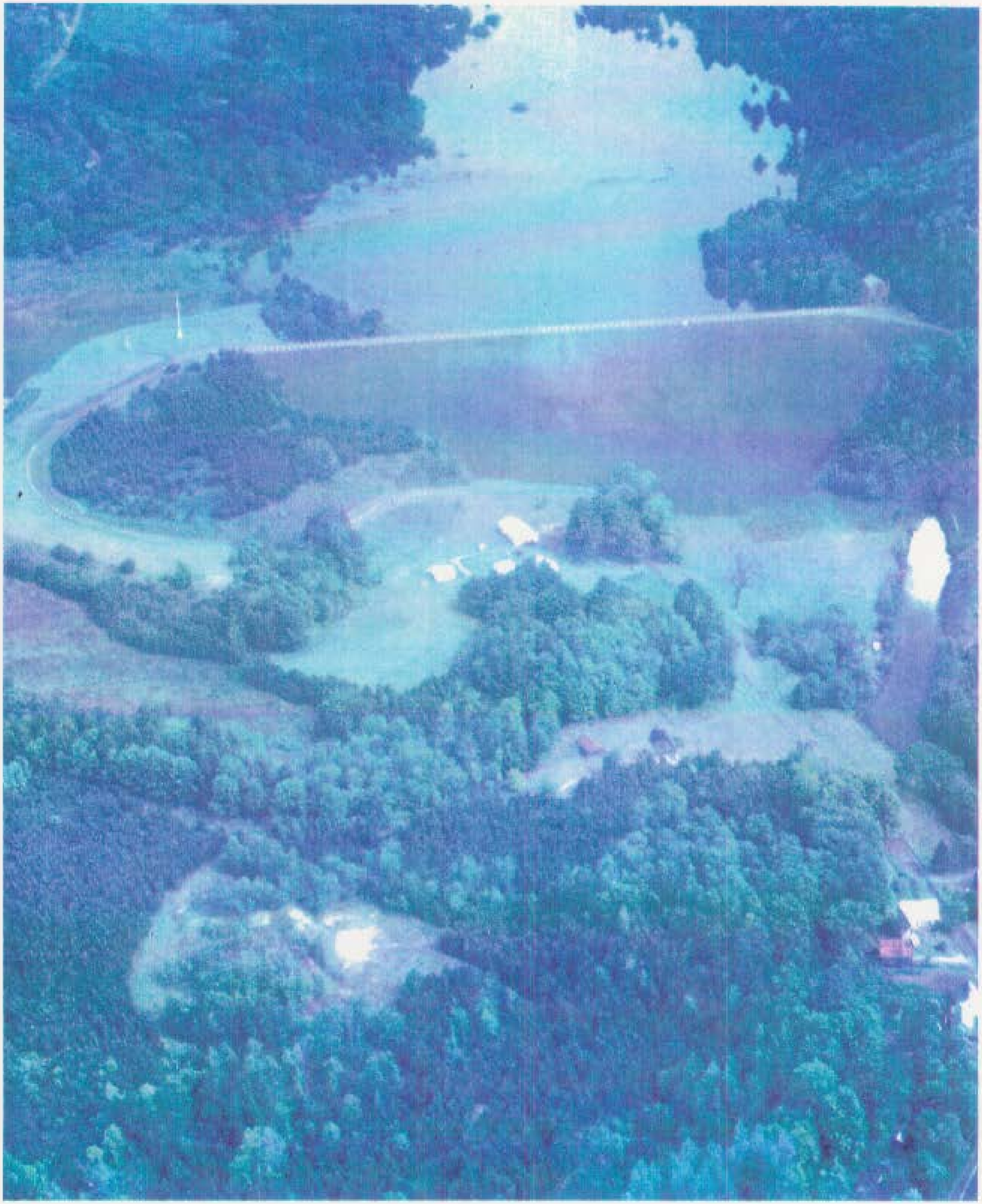
Rainfall totals in the vicinity of the watershed were 2.2, 3.5, and 3.6 inches at Chelsea, Union Village, and Hanover, respectively. As a result of this storm, runoff for the first 10 days of July totaled 3.2 inches at the Union Village USGS gage, and a peak reservoir stage of 96.8 feet, equivalent to 33 percent of flood control storage, was experienced at Union Village Dam.

(9) <u>May-June 1984.</u> In late May 1984, an extensive, slow moving frontal system resulted in a prolonged period of heavy tropical showers over most of New England. By 4 June, rainfall amounts varied from several inches in coastal regions to more than 10 inches in mountainous areas of northern and western Connecticut, Massachusetts, Vermont, and New Hampshire. In the Connecticut River Basin, rainfall amounts for this period were 7.8 inches at Woodstock, Vermont, 9.9 inches at Surry Mountain, New Hampshire, 10.2 inches at Knightville Dam, Massachusetts and 10.9 inches at Hartford, Connecticut. The extended rainfall caused record riverflows in many sections of southern New England, and widespread damage to low lying agricultural lands. At that time it was the greatest flood experienced by the Corps system of 16 reservoirs in the Connecticut Basin. An isohyetal map for New England for this event is shown on plate A-17, and a photo of Union Village Dam during this flood is displayed on page 3-14.

The greatest flooding was experienced on the main stem of the Connecticut River in Massachusetts and Connecticut where stages were the highest since the record floods of 1936 and 1938. A tabulation of peak observed and computed natural discharges on the main stem follows:

<u>CONNECTICUT RIVER</u>
<u>FLOOD OF JUNE 1984</u>
<u>REDUCTION IN FLOW</u>

Location	Experienced Discharge (cfs)	Computed Natural Discharge (cfs)	Reduction in Discharge (percent)
Montague City, MA	142,400	175,000	19
Holyoke, MA	148,000	181,000	18
Springfield, MA	189,000	225,000	16
Hartford, CT	208,400	245,000	15
Middletown, CT	186,800	220,000	15



Union Village Dam and Reservoir
(May, June 1984 Flood Stage=103.8')

In spite of this record flooding, Corps projects in the basin reduced flood stages by about four feet along the Connecticut River from Montague City to Hartford. All 16 Corps reservoirs within the basin were operated during this event, with record amounts of storage being utilized at nine projects.

In the Ompompanoosuc River watershed, rainfall totals amounted to 4.7 inches in Chelsea, Vermont, for the period 27 May to 3 June. At Union Village Dam, flows were throttled back while flows on the main stem of the Connecticut River remained high, resulting in a peak pool stage of 103.8 feet or 40 percent of storage utilized.

(10) March-April 1987. During a one week period beginning the end of March 1987, a pair of intense rainstorms hit New England, causing major flooding in most of Connecticut, Massachusetts, New Hampshire, Vermont, and Maine. These storms, augmented by snowmelt in the mountains and northern areas, resulted in the most widespread flooding in approximately 50 years. The storms created two separate and distinct flood peaks, especially in the southern and central regions of New England. A rainfall isohyetal for the total period is shown on plate A-18. Although this series of events produced severe rainfall and flooding throughout much of New England, total storm precipitation at Union Village, Vermont, was only 2.57 inches, the least recorded at any Corps reservoir during that timeframe. To alleviate downstream flooding along the main stem of the Connecticut River, flows at Union Village were cut back, causing the reservoir to fill to a level of 97.8 feet, utilizing 34 percent of the reservoir's flood storage capacity. The maximum outflow experienced at the Union Village gage during this event was 2,050 cfs.

3-05. Frequency Analysis

a. Natural Peak Discharge Frequency Analysis. Natural discharge-frequency analyses (without the effects of Union Village Dam) have been developed during preparation of the previous Water Control Manual, dated May 1971. Analysis of flow records from the USGS streamflow gaging station, located on the Ompompanoosuc River at Union Village, Vermont, was made in the mid-1960s for the then available 23 years of systematic flow records plus records of historic flood events that occurred in 1927 and 1936. Discharge frequencies were determined using a Log Pearson Type III analysis using these 23 years of systematic records and two historic events. Based on a regional analysis, a skew coefficient of 1.0 was adopted. The lower portion of the previously developed discharge frequency curve was determined by use of a partial duration series in which all peaks above 1,500 cfs were arranged in order of magnitude and plotted, using Weibull plotting positions.

As part of the current studies, this analysis was updated for the now available 51 years of systematic flow data (1928 - 1991), plus the two historic events. The data was also analyzed in a Log Pearson Type III analysis, resulting in a mean log of 3.3572, standard deviation of 0.2412, and a computed skew of 0.9. As in previous studies, a skew coefficient of 1.0 was adopted. A partial duration series was also developed for the lower part of the discharge frequency curve in which all peaks above 1,500 cfs were used. The adopted discharge frequency data, based on the analysis of flow data up to 1991, and adjusted for expected probability, are shown in table A-6.

TABLE A-6

NATURAL PEAK DISCHARGE FREQUENCY
OMPOMPANOOSUC RIVER AT UNION VILLAGE, VT
Drainage Area = 130 Square Miles
(1928 - 1991)

Percent Chance of Occurrence (percent)	Recurrence Interval (years)	Expected Probability Adjustment Discharge (cfs)
1.0	100	13,500
2.0	50	10,100
10.0	10	4,900
50.0	2	2,300

Tabulations of natural peak discharge frequency relationships (i.e., without the effect of existing Corps reservoirs) at USGS streamflow gages within the Connecticut River watershed are included in tables 17 and 18 of the Master Water Control Manual, Connecticut River Basin, dated November 1983.

b. Frequency of Reservoir Filling. The pool stage at Union Village Dam has exceeded 50 feet (approximately

TABLE A-7

SIGNIFICANT STORAGES* AT UNION VILLAGE DAM (1950 - 1991)

Date	Maximum Stage	Storage Utilized Inches	Storage Utilized Acre-feet	Storage Utilized Percent
1950 Apr	53.2	0.4	2,400	7
1951 Apr	66.7	0.6	4,300	11
1952 Jun	74.0	0.9	5,800	15
1953 Mar	101.4	2.1	14,500	38 3
1954 Apr	55.5	0.4	2,700	7
1955 Apr	64.0	0.6	3,900	10
1955 Aug	54.6	0.4	2,600	7
1957 Dec	64.4	0.6	3,900	10
1958 Apr	56.6	0.4	2,900	8
1959 Nov	62.3	0.5	3,600	10
1960 Apr	77.3	0.9	6,600	17
1962 Apr	63.0	0.6	3,700	10
1962 Apr	52.0	0.3	2,300	6
1964 Mar	50.0	0.3	2,100	6
1964 Apr	69.1	0.7	4,800	12
1967 Apr	63.4	0.6	3,800	10
1969 Apr	114.0	3.0	20,000	53
1971 May	69.0	0.7	4,800	13
1972 May	72.0	0.8	5,400	14
1973 Mar	55.5	0.4	2,700	7
1973 Jul	96.8	1.8	12,100	33
1973 Dec	61.4	0.5	3,500	9
1976 Apr	89.1	1.5	9,730	26
1977 Mar	72.0	0.8	5,400	13
1978 Jan	56.3	0.4	2,780	7
1979 Mar	84.4	1.2	8,350	22
1980 Apr	55.5	0.4	2,700	7
1981 Feb	76.8	0.9	6,450	17
1982 Apr	62.1	0.5	3,590	9
1983 Mar	63.9	0.6	3,850	10
1983 Apr	69.4	0.7	4,880	12
1983 Dec	81.9	1.1	7,720	20
1984 Apr	63.2	0.6	3,750	10
1984 Jun	103.8	2.3	15,200	40 2
1986 Feb	59.0	0.5	3,100	8
1987 Apr	97.8	1.9	12,600	34 4
1989 Apr	58.2	0.5	3,037	8
1990 Mar	61.4	0.5	3,478	9

* Stage above 50 feet, 6 percent storage
Elevation at zero stage = 420 ft msl

5 percent of flood control storage capacity and start of significant storage) 40 times since placed in operation in 1950. A frequency of reservoir filling analysis was performed, based on a partial duration series in which all pool stages above 50 feet were arranged in order of magnitude, and plotted using Weibull plotting positions. Pool stages from 1950 through 1991 (42 years of data), tabulated and used in this analysis, are presented in table A-7. Results of this frequency analysis are presented in table A-8. Corresponding area-capacity tables, area-capacity curves, and percent storage curves are shown on plates A-14, A-15, and A-16, respectively.

TABLE A-8

FREQUENCY OF RESERVOIR FILLING
UNION VILLAGE DAM
(1950 - 1991)

Pool			Storage	
Elevation (ft,NGVD)	Stage (ft)	Frequency* (years)	Acre-Feet	Inches
483.0	63	2	3,697	0.56
502.0	82	5	7,753	1.15
514.0	94	10	11,440	1.70
524.0	104	20	15,314	2.28
537.0	117	50	21,485	3.20

* Based on Weibull plotting positions

Spillway Crest: Elevation = 564.0 feet NGVD
Stage = 144 feet
Storage = 38,000 acre-feet; 5.65 inches

3-06. Analysis of Floods

a. Ompompanoosuc River. Floodflows and precipitation records were analyzed to determine runoff characteristics of the Ompompanoosuc River Basin. Table A-9 lists peak observed discharges at the USGS gaging station on the Ompompanoosuc River at Union Village, Vermont. Analysis of time of year

TABLE A-9

PEAK OBSERVED DISCHARGES AT THE USGS GAGING STATION ON THE OMPOMPANOOSUC RIVER AT UNION VILLAGE, VERMONT

Date	Discharge (cfs)	Date	Discharge (cfs)
--	--	18 April 1970	1950
28 July 1941	1260	7 May 1971	1730
15 June 1942	2660	20 April 1972	1700
28 April 1943	1880	30 June 1973	1810
9 Nov 1944	2970	15 April 1974	1840
26 April 1945	3300	19 April 1975	1540
9 March 1946	2200	7 April 1976	2060
3 June 1947	4800	17 March 1977	1920
1 April 1948	3240	14 April 1978	1430
28 March 1949	2310	13 March 1979	1840
20 April 1950	2350	11 April 1980	1400
31 March 1951	1740	13 May 1981	1770
6 April 1952	2000	21 April 1982	1910
31 March 1953	1830	22 March 1983	1760
19 April 1954	1540	8 June 1984	1840
16 Aug 1955	1690	13 March 1985	1070
17 April 1956	1780	31 March 1986	1950
24 Jan 1957	740	11 April 1987	2050
19 April 1958	1840	3 April 1988	1060
5 April 1959	1950	6 May 1989	1860
1 April 1960	1940	-- April 1990	2000
24 April 1961	1340	-- April 1991	1500
10 April 1962	2070		
3 April 1963	1580		
13 April 1964	1870		
13 April 1965	1070		
26 March 1966	1120		
6 April 1967	1830		
22 March 1968	2190		
13 April 1969	2130		

when floods occur, topography, relative timing, and flood peak contributions at downstream damage centers on the Connecticut River resulted in the following conclusions:

(1) Floods develop very rapidly in the watershed. Peak flows occur about four hours after an intense rainfall on principal tributaries of the Ompompanoosuc River.

(2) Moderately high discharges occur frequently as a result of melting snow, but runoff from this source alone has never been sufficient to cause a major flood. However, rainfall in conjunction with snow melt runoff has resulted in floodflows on both the Ompompanoosuc and Connecticut Rivers.

(3) Peak flows from spring runoff are generally of a lesser magnitude than those from intense summer-type storms; however, they are usually associated with greater volumes of runoff.

(4) The watershed responds quickly to periods of heavy rainfall and since this may occur any time of year, there is no flood-free season.

b. Connecticut River. Flooding along the Connecticut River is caused by either excessive rainfall, melting snow, or a combination of both. Analyses of historic floods reveal that Connecticut River floods have generally occurred in the following modes:

(1) As a general rule, basin-wide flooding usually occurs as a combination of rainfall and snowmelt (April 1987).

(2) In the northern portion of the basin, upstream of White River Junction (June 1947).

(3) In the central portion of the basin, between White River Junction and Montague City (November 1927).

(4) In the southern section of the basin, downstream of Montague City (August 1955).

During flood events originating in the northern portion of the basin, peak flows at the mouth of the Ompompanoosuc occur earlier than Connecticut River peak discharges at White River Junction. With basin-wide floods and those originating in the central portion, the Ompompanoosuc River's peak synchronizes with Connecticut River's crest. Discharge contributions to the lower portion of the

Connecticut River from the Ompompanoosuc occur on the receding side of floods, originating in the lower part of the basin. Contributions from the Ompompanoosuc to the Connecticut River depend considerably on the location of the storm. Estimated high flow travel times from Corps reservoirs to selected index stations on the Connecticut River are included in table 13 of the Master Water Control Manual. Plates 48 and 50 of the same manual show contributions of the Ompompanoosuc and all other major tributaries to the great floods of March 1936 and September 1938. The effect Union Village Reservoir would have had on the 1936 and 1938 events is shown on plate A-19 of this manual.

c. Ice Jam Flooding

(1) General. During the spring thaw, many communities along the Connecticut River and its tributaries face an additional threat of flooding from ice jams. This is especially serious in Vermont and New Hampshire where longer periods of cold weather causes thicker ice cover. The origin of ice jams varies somewhat at each location, but the resulting higher river stages are caused by channel cross sections being sufficiently reduced by the piling ice.

(2) Ompompanoosuc River. Downstream of Union Village Dam, particularly in the area of Campbell Flats, ice jamming can be a problem. In the springtime, during periods of increased releases, project personnel must carefully monitor channel conditions between Union Village Dam and the Connecticut River to avoid ice jam flooding.

(3) White River. The earliest recorded major ice jams occurred on the White River in the Hartford, VT, area in 1867 and 1908. In recent years, jams have occurred with increasing frequency. The problems are caused by rock obstructions in the channel, and land projections just downstream of the Hartford Highway bridge which spans the White River. The river stages are raised considerably by the damming effect of ice until a height is reached that releases the jam and pushes the ice downstream. In the record 1964 event, water levels were raised an estimated 10 feet upstream of the bridge, before the jam released with a surge that moved downstream and destroyed the bridge.

(4) Connecticut River. The reach of river where ice jams are an annual threat is between White River Junction and the power pool of New England Power Company's Bellows Falls Dam. However, excessive damages did not occur during the jams of 1942, 1948, and 1964. Jamming initially occurs at bends and constrictions in a 3-mile length of river, just

downstream of the confluence with the Mascoma River. Jams also occur in Windsor, Vermont, in the area between the Cornish Highway bridge, the railroad crossing, and Chase Island, which is located at the upstream end of the Bellows Falls power pool. Further downstream, jams have formed at the Ascutney bridge.

Chapter 4 of the Master Manual of Water Control for the Connecticut River Basin, includes discussions of other locations on the main stem affected by ice jam flooding.

(5) Dynamic Ice Breakup. The Corps of Engineers, Cold Regions Research and Engineering Laboratory, in conjunction with the State of New Hampshire, has been working on the development and testing of methods to prevent formation of destructive ice jams. This is done by controlled dynamic breakup of the river's ice cover through carefully synchronized releases from Corps and New England Power Company's (NEPCO) dams. Releases are coordinated between the Corps Union Village Dam, North Hartland, and North Springfield Lake projects as well as NEPCO projects on the main stem of the Connecticut River.

Three such tests have been performed in the Upper Connecticut River Basin, in 1989, 1990, and 1992. The 1989 test, which involved a below average ice condition, was successful in breaking the ice cover, whereas, the 1990 and 1992 tests, with considerably thicker ice, were unsuccessful. The State of New Hampshire will determine if additional testing is needed. At present, no further testing is anticipated.

3-07. Design Floods

a. Spillway Design Flood (SDF). In the 1944 design of Union Village Dam, spillway design inflow to the reservoir was derived by applying storm rainfall described in Hydrometeorological Report 1. The resulting 30-hour storm rainfall, for the 126-square mile drainage area, was 17.6 inches. Infiltration losses were assumed to be 1.5 inches for a total of 16.1 inches of rainfall excess.

During the original design, the lack of long term streamflow records for the Ompompanoosuc River, required a unit hydrograph to be determined by empirical methods, using topographical and hydrological relationships of the Connecticut River Basin ("The Unit Hydrograph and Flood Routing" by G.T. McCarthy, revised 21 March 1939). The empirically developed unit hydrograph had a rainfall time period of 12 hours, and then was adjusted for a rainfall period of 6 hours. To provide for any nonuniform areal distribution of rainfall, the 6-hour unit hydrograph was increased about 70 percent, resulting in an adopted unit hydrograph with a peak of 8,000 cfs.

The spillway design inflow to Union Village reservoir was derived by applying the rainfall excess of 16.1 inches to the adopted 6-hour unit hydrograph. The pool was assumed to be full to spillway crest at the beginning of the flood, with all sluice gates inoperable. The inflow peaked at 87,500 cfs, resulting in an outflow of 84,900 cfs and a 110,600 acre-foot volume of runoff. This would result in a maximum pool level of 579.0 feet NGVD, which is 5.0 feet below top of the dam. The peak discharges of the SDF are 7.2 and 18.4 times the November 1927 and September 1938 flood peaks, respectively. Pertinent data regarding spillway design flood characteristics are shown in table A-10. Development of the spillway design flood is shown on plate A-20.

b. Review of Design Features of Existing Dams. In 1988, a hydrologic review of the spillway design flood at Union Village Dam was conducted to determine whether the spillway conforms adequately to current criteria and policies, with respect to safety and functional reliability. Current criteria specify 3 feet of freeboard be allowed above maximum surcharge of the SDF, occurring with an antecedent pool filled to spillway crest. A summary of the original and 1988 hydrologic design reviews, using Hydrometeorological Reports 51 and 52, for Union Village Dam is shown in table A-10. The probable maximum storm for Union Village Dam, using HMR 51 (72-hour total = 24.6 inches), was 40 percent greater in volume than the original design storm (30-hour total = 17.6 inches). Applying the current HMR 51 PMP excess (20.1 inches) to the adopted 6-hour unit hydrograph (adjusted slightly from a peak of 8,000 to 8,290 cfs), resulted in a peak inflow of 120,700 cfs or 38 percent greater than the original design. It was determined that with storage at spillway crest and outlet gates operable, the resulting SDF outflow would be 118,200 cfs, resulting in a maximum pool level of 581.1 feet NGVD, which is 2.9 feet below top of the dam. Although current criteria specify that 3 feet of freeboard be allowed above maximum surcharge of the SDF, with an antecedent full pool, 2.9 feet are not considered adequate to pose a critical or emergency situation.

TABLE A-10

SPILLWAY DESIGN CRITERIA
UNION VILLAGE DAM
(D.A. = 126 sq. mi.)

Item	1944 Original Criteria	1988 SDF Review
Spillway Design Storm		
Basis of Design	USWB	HMR 51
Volume of Rainfall	17.2	24.6
Total Losses (in)	1.5	4.5
Excess Rainfall (in)	16.1	20.1
Storm Duration (hr)	30	72
Unit Hydrograph		
Unit Rainfall Duration (hr)	6	6
Peak Flow (cfs)	8,000	8,290
Spillway Design Flood		
Peak Inflow (cfs)	87,500	120,700
Volume of Runoff (acre-feet)	110,600	135,100
Peak Outflow (cfs)	84,900	118,200
SDF Reservoir Regulation Plan		
Initial Pool Elev (ft NGVD)	564.0	564.0
Outlet Gates During Flood	Closed	Operative
Maximum Surcharge Elev (ft NGVD)	579.0	581.1
Top of Dam Elev (ft NGVD)	584.0	584.0
Freeboard (ft)	5.0	2.9
Freeboard Characteristics		
Design Wind Velocity (mph)	60	80
Effective Fetch (miles)	2.5	0.65
Average Depth (ft)	-	100
Wave Runup (ft)	4.6	3.4
Wind Tide (ft)	0.2	-
Adopted Freeboard (ft)	5.0	5.0

c. Standard Project Floods

(1) Ompompanoosuc River. A standard project flood (SPF) for the Ompompanoosuc River was not developed prior to construction.

(2) Connecticut River. A standard project flood for the Connecticut River was developed by the Corps for the "Comprehensive Water and Land Resources Investigation--Connecticut River Basin," dated June 1970. A discussion of this flood is included in chapter 8 of the Connecticut River Basin Master Water Control Manual.

3-08. Flood Damages

a. Damages Prevented

(1) General. Over the last 65 years, six large basin-wide floods have occurred: November 1927, March 1936, September 1938, August 1955, May-June 1984, and March-April 1987. Discussions of the first four events and damages associated with each has been included in the Connecticut River Basin - Master Manual of Water Control. The 1984 and 1987 events have been discussed in detail with regard to their effects on both the Connecticut and Ompompanoosuc River Basins in section 3-04 of this manual. Total damages prevented during the 1984 and 1987 flood events in the Connecticut River Basin, as a result of Corps-built flood control projects, are $595 and $255 million, respectively.

(2) Union Village Dam. Union Village Reservoir is regulated in conjunction with a comprehensive system of reservoirs to reduce flood stages along the main stem of the Connecticut River. Although there is some development along the Ompompanoosuc River, most damages prevented, as a result of the operation of Union Village Dam, have occurred along the main stem of the Connecticut River. Union Village Dam has prevented $265 million in damages through September 1990.

b. Experienced Flood Levels or Discharges. The following tabulation summarizes experienced flood discharges at selected index stations for reference purposes:

MAXIMUM DISCHARGES
DURING FLOOD EVENT

Location	November 1927 (cfs)	March 1936 (cfs)	September 1938 (cfs)	July 1987 (cfs)
Union Village	12,000**	7,300**	4,750**	2,050*
West Hartford	120,000	45,400	47,600	32,600
West Lebanon	136,000	120,000	82,400	68,300*

* Regulated
** Estimated from high watermarks

c. Benefit Analysis. Following each flood event, RCC determines the modifying effects of Corps projects on downstream flooding. Natural or unregulated flows and stages are computed for index zones in the Connecticut River Basin. These stages are then provided to the Economic and Resource Analysis Branch of Planning Directorate to determine the benefits at each zone, associated with reservoirs and local protection projects. A "Damages Prevented" form, used by RCC and ERAB to compute benefits within the Connecticut Basin is included in the Master Water Control Manual.

3-09. Droughts

a. General. The Ompompanoosuc River watershed lies within the general climatic zone classified as humid, and the average annual precipitation is reasonably well distributed throughout the year. In National Weather Service terminology, a drought is considered a period of 14 or more days when less than 0.1 inch of precipitation falls in a 48-hour period. From an agricultural standpoint, a drought is a lack of soil moisture during the growing season. Hydrologically, a drought is a prolonged period of precipitation deficiency, seriously diminishing riverflow as well as surface and groundwater supplies. Periods of deficient precipitation and runoff have occurred in this watershed. As previously mentioned, table A-2 summarizes the monthly and annual precipitation at Chelsea, Vermont, and table A-5 summarizes monthly and annual runoff at the Union Village gaging station.

b. History. Drought history in the watershed extends back more than 100 years. Several periods of below average precipitation have occurred prior to 1960, although no serious impact has resulted on water needs of the area due to sparse population and lack of industry in the region. One of the more pronounced periods of below average precipitation occurred from 1880 to 1883, when a cumulative deficiency of 31.5 inches was experienced at Woodstock, Vermont. Similarly, since establishment of the Union Village gaging station, several periods of low flow have occurred, the most notable in water year 1965 when only 7.70 inches of runoff were recorded.

c. Drought of 1961 - 1966. The longest and most severe drought in the history of the Connecticut River Basin, as well as the Ompompanoosuc River watershed, occurred during the period from 1961 to 1966. During this timeframe, the cumulative rainfall deficiency in the Ompompanoosuc River Basin amounted to 39.3 inches, considerably more than the average annual precipitation of approximately 35 inches. The cumulative runoff deficiency amounted to 39 inches, considerably greater than the average annual runoff of 21 inches. Rarely is a deficiency of groundwater carried over from one growing season to the next in New England, since it is generally replenished during each spring runoff. However, this condition occurred in the winter of 1964-1965, resulting in a record low flow runoff of 7.9 inches in water year 1965, which is about 37 percent of the average yearly runoff.

d. Drought Contingency Planning. Drought contingency planning is covered in section 6-05 of this manual.

3-10. Evaporation. During preparation of "Appendix C--Report of Hydrology of the Connecticut River Basin Comprehensive Water and Related Land Resources Investigation," dated June 1970, studies were undertaken to determine what effect evaporation had on Corps reservoirs. Analysis of available published information indicated that net lake losses of 3 to 8 inches of depth have occurred on area lakes, which is considered a negligible loss.

3-11. Water Quality. Waters of the Ompompanoosuc River are classified as class B by the Vermont Water Resources Board, as described in the Vermont Water Quality Standards (Vermont WRB, 1987). It is important to note that the classification assigned to any specific body of water does not necessarily represent a description of existing conditions or quality of the waters. As described in the Vermont Water Quality Standards, "Class B waters shall be managed to achieve and maintain a high level of quality, which is compatible with the following beneficial values and uses:

Values - Water which is of a quality which consistently exhibits good aesthetic value and provides high quality habitat for aquatic biota, fish and wildlife.

Uses - Public water supply with filtration and disinfection; irrigation and other agricultural uses; swimming and recreation."

Large deposits of copper in the watershed, along with mining activities associated with recovery of this copper, have had a great effect on water quality of the basin. Much copper contamination in the overall water has come from Copperas Brook, which drains the abandoned Elizabeth Mine. If it were not for effects of copper deposits, the water would be of very high quality and good for most any purpose. Even effects of acid rain on the watershed are minor due to limestone deposits in the watershed, which causes the water to be highly buffered.

IV - COMMUNICATIONS AND DATA COLLECTION

4-01. Hydrometeorological Stations

a. Facilities

(1) General. During normal working hours or when NED headquarters are otherwise manned, communications between the project manager and the Reservoir Control Center are made via the NED radio network, as shown on plate A-21. Whenever the radio network is inoperative, communications are made via telephone. During nonworking hours, reports and regulation instructions are issued via telephone to or from homes of RCC personnel. The order of contact within the Reservoir Control Center is updated annually, or as needed, and distributed to all Corps projects (see plate A-22). In the event of failure of the NED radio network and telephone service, the project manager will attempt to communicate through the State Police or Civil Defense radio facilities.

(2) Precipitation Reporting Network. Reports of precipitation data from the Ompompanoosuc River watershed are primarily used for alerting RCC personnel of possible flooding, and for providing a basis for appraising the severity of a given storm. Collection and reporting of precipitation data from Union Village Dam is the responsibility of project personnel.

The Reservoir Control Center periodically reviews precipitation network arrangements to ensure that an adequate reporting network is maintained. The Northeast River Forecast Center in Taunton, Massachusetts, receives precipitation reports from observers in and near the Ompompanoosuc River watershed, which are made available to RCC upon request. In addition, cooperative daily reporting procedures from most Corps dams have been established with the River Forecast Center and have been detailed in memos to each project. Information reported to the River Forecast Center is outlined paragraph 4-01a(5) of this manual.

Through close coordination with the New England Power Company, precipitation reports and hydropower releases are available to either the project personnel or RCC, upon request.

(3) New England Division Satellite Data Collection System (NEDSAT). NEDSAT consists of 49 remote reporting stations, equipped with data collection platforms (DCPs) and

a ground receive station at NED headquarters. The DCPs continuously monitor water levels and rainfall, and the information is converted into an ASCII coded message, transmitted to NOAA's Geostationary Operational Environmental Satellite (GOES) and then back to the NED ground receive station in Waltham, Massachusetts, where the signal is decoded and discharge rates computed and stored. The data are then interpreted by RCC personnel.

A detailed description of all aspects of NEDSAT is included on page 5-3 of the Master Water Control Manual, and a typical computer summary printout of data acquired by satellite relay is shown on plate A-23.

RCC has also prepared an operating manual OPMAN, describing all aspects of NEDSAT, including data collection platforms, ground receive station, computer hardware, software, and other pertinent features. Copies of this manual are available in the Reservoir Control Center.

(4) River Reporting Stations

(a) General. A network of river stage observation stations, shown on plate A-24, which is part of the overall river reporting system for the Connecticut River Basin has been established. This network assists in execution of the reservoir regulation plan by permitting RCC and project personnel to obtain real time flow data at selected key index stations located on tributaries of, or on, the Connecticut River.

(b) Ompompanoosuc River. The only river gaging station currently in the Ompompanoosuc River watershed is located on the right bank at Union Village, about 1,600 feet downstream from Union Village Dam. The gate has been in continuous operation since establishment in September 1940. Its records are used to compute runoff from a 130-square mile drainage area. Plate A-33 shows the rating table for this station.

(c) White River. This river empties into the Connecticut about 9 miles south of the mouth of the Ompompanoosuc River. Due to its large uncontrolled drainage area of 712 square miles, it is important that flows from the White River be considered when regulating Union Village Dam. The USGS gage on the White River at West Hartford has continually monitored flow from the upper 690-square mile drainage area since 1915. It is located about 7.2 miles upstream of the mouth, and is telemark equipped, as well as being part of NEDSAT.

(d) Connecticut River. Primary index stations on the Connecticut River used for determining reservoir release rates in the Upper Connecticut River Basin are the USGS gaging stations at Wells River, VT, West Lebanon, VT, North Walpole, NH, and Montague City, MA. These gages are all part of NEDSAT. Wells River, West Hartford, North Walpole, and Montague City are also telemark equipped.

The USGS gaging station at Wells River is located on the right bank of the Connecticut in the village of Wells River, about 200 feet downstream of the Route 302 bridge, river mile 266. This gage has monitored flow from its 2,644-square mile drainage area since placed in operation in 1940.

The USGS gaging station on the Connecticut River at West Lebanon is located about 500 feet downstream from the mouth of the White River at river mile 215, in the community of West Lebanon. The gage, originally located across the river in White River Junction from 1911 to November 1976, was moved to West Lebanon in November 1978. This gage has provided records for the 4,092-square mile drainage area.

The North Walpole gage, with a drainage area of 5,493 square miles, is located on the left bank of the Connecticut River, just upstream of the Saxtons River at river mile 173. This gage has been in operation since 1942.

The Montague City gage, with a drainage area of 7,865 square miles, is located on the left bank of the Connecticut River about 1,000 feet downstream of the mouth of the Deerfield River, at river mile 119 in Massachusetts. The Montague City gage is an important index station in regulation of Corps reservoirs for floods on the lower Connecticut River.

Locations of river gages in the Connecticut River Basin are shown on plates A-24 and A-32.

b. Reporting

(1) Weekly Reports. All Corps project managers make routine reports via radio or telephone to RCC on Friday mornings. These reports insure continuous contact between regulation personnel, and also serve as a check of the NED radio network. Radio relay coverage is delineated on plate A-21. Weekly reports include the preceding 24-hour precipitation, current weather conditions, reservoir pool stages,

gate settings, outflows, river conditions at index stations, and other miscellaneous data. A sample of a completed NED Form 477, used in logging data, is shown on plate A-25.

(2) Supplemental Flood Alert Reports. Supplemental radio (or telephone) reports to RCC are also required from project personnel if flood conditions might develop from rainfall, melting snow, ice jams, or other climatologic/hydrologic phenomena. Time and frequency of these reports are dependent upon severity of conditions. These reports are entered on NED Form 503; an example is shown on plate A-26.

Normally, supplemental reports will be requested by RCC during regularly scheduled work hours. When off duty reports are necessary, explicit instructions will be given by RCC to project personnel, requesting reports at specific times and indicating the information to be contained in the report. The following information is normally included in a supplemental report to the Reservoir Control Center:

(a) Precipitation at Dam. Total amount of precipitation fallen up to the reporting time, plus several intermediate amounts with time of observation, as requested by RCC.

(b) Reservoir Stage. The pool stage at time of report and, if requested, previous readings with corresponding times to determine rate of rise and to define the inflow hydrograph. Accurate readings of both stage and time are essential to facilitate computation of inflow. A sample NED Form 102, "Computation of Inflow," as well as Union Village inflow guide curves, are shown on plates A-28 and A-29, respectively.

(c) Gate Opening and Tailwater Discharge. Gate opening and discharge at time of reporting. Any change since the previous report should be included with corresponding stage and discharge.

(d) River Stages. River stages from gages at index stations with times of observation.

(e) Snow Cover. General snow cover which may affect runoff conditions throughout the basin.

(f) Miscellaneous Data. Any other pertinent information such as temperature, reports of ice jams in the winter, reports of flooding, etc.

(3) Special Reports. A special report should be submitted by the project manager to RCC whenever unusual

circumstances occur during a flood, or as requested by RCC. The report should include:

(a) Observations at Dam. Project personnel make general observations of conditions at the intake works, and enter in log books. If possible, photographs are taken of any unusual condition, noting date, time, reservoir stage, gate positions, and discharge. Observations reported to RCC should include:

1. Extent and action of eddies, waves, or whirlpools in vicinity of the conduit intake and portal.

2. Extent and action of turbulence or eddies downstream of the spillway and outlet works.

3. Effect on flow through the gates due to accumulation of debris and/or ice at the intake.

4. Pool elevation and position of gates where gate vibration or whirlpools develop.

5. Seepage, noting time, pool stage, and color of discharge. Embankment sloughing which may appear at downstream sides of the dam or dikes should also be reported.

6. Other unusual conditions which might affect the safety of the dam.

(b) Observations at Downstream Control Points. During periods of flooding and also when emptying stored floodwaters, reconnaissance of downstream conditions is made by project personnel, as requested by RCC. This is necessary in obtaining further information at downstream damage areas or index points.

(c) Observations at Upstream Control Points. Several small communities located upstream of the reservoir on the Ompompanoosuc River, or the West Branch, have been prone to flooding. During flood periods, RCC will consider having project personnel make reconnaissance visits to these areas in order to anticipate and/or evaluate possible flooding.

(4) Alerting Reports

(a) Scheduled Working Hours (Monday Through Friday). The project manager will make an alerting report to RCC by radio or telephone according to the following instructions:

1. Precipitation. Occurrence of 1.0 inch of rainfall or other amount during a 24-hour period at Union Village Dam, as indicated by RCC.

2. Reservoir Stage. The reservoir reaching a stage of 10 feet and rising in the summer, or 25 feet and rising in the winter, when a winter pool is being held.

3. River Stages. Whenever stages on the Connecticut River at Wells River reach 7.5 feet (18,700 cfs) and rising.

4. Unusual Conditions. Project personnel will survey local conditions and report any unusual problem such as difficulty with gate functions, ice jams, excessive debris, bridge failures, etc.

(b) Nonscheduled Working Hours (Nights, Weekends, Holidays). When weather forecasts or expected runoff conditions pose a threat of possible flood problems in downstream areas affected by Corps reservoirs, RCC will issue prior instructions to project personnel, requesting an alerting report at a specific time, e.g., 2200 hours on Wednesday evening, 1500 hours on Sunday afternoon, etc. If additional reporting is considered necessary by RCC during nonscheduled working hours, a specific time will be given for the report.

(c) Other. Project personnel are a vital element of reservoir regulation activities as they are the "eyes and ears" of the Corps. Whenever project managers are home or in the watershed area during nonscheduled working hours and unexpected hydrologic conditions such as heavy rainfall, rising pool levels, high downstream river stages, unusual or emergency conditions occur, RCC encourages them to make an alerting report, which includes available pertinent hydrologic data.

(5) Snow Survey Reports. Snow courses have been established at selected locations within both the Ompompanoosuc and Connecticut River watersheds. Weekly surveys are made by project personnel during winter and early spring to determine snow depths and water equivalent. Survey dates are determined each year by RCC so as to correspond with bimonthly surveys by the New England Power Company, and supplemental data from other State agencies and power companies. Reports contain name of the station, snow depth, and water equivalent. Weekly reports are distributed by RCC to various interested parties. An example snow report is shown on plate A-30.

(6) Northeast River Forecast Center Reports. When on duty, project personnel at Union Village Dam will make a daily telephone call between 7 a.m. and 8 a.m. to the National Weather Service, ROSA (Remote Observation System Automation) computer system, located in Burlington, Vermont. This system allows weather observers to input their observations directly into the Weather Service computer system, using a memory telephone. The following parameters are reported on a daily basis:

Dam
Date and time of observation
Temperature - maximum and minimum (24 hours)
Temperature - current
Precipitation amount and form (24 Hours)
Present weather
Depth of new snow and total depth

The above data are used to prepare flood statements by the NWS. Additional information on these statements is included in Chapter V of this appendix.

(7) Special Advisories. In accordance with regulations set forth in EM 550-1-1, "Domestic Emergency Operations," and "Guidance Memorandum, Reservoir Control Center," RCC submits special advisories to the Commander, and Engineering and Operations Directorates, on the progress of any storm, with possible flood potential, which could significantly impact New England. Flood reports for OCE are also prepared by the Reservoir Control Center.

(8) Maintenance of Log. All reports, instructions, records of unusual circumstances at the project, and information pertinent to regulation of the reservoirs are entered in log books, maintained by project managers and the Reservoir Control Center.

(9) Gate Operation and Daily Record. All daily observations and gate operations are carefully noted on NED Form 90 (plate A-27), and submitted monthly to RCC. All operations are noted, regardless of the amount or duration of change in gate position. The report includes date, time of day, reservoir stage, outflow, precipitation, gate settings, and remarks.

NED Form 90 data are entered into a computer file, and used by RCC in preparing monthly and annual reservoir summaries. These summaries are discussed in paragraph 5-02g of the Master Water Control Manual.

c. Maintenance of Equipment

(1) Precipitation Gages. A standard weighing and recording National Weather Service (NWS) precipitation gage is located at Union Village Dam. This gage serves as a supplement to other rainfall stations in the vicinity. Charts from the Union Village gage are forwarded to the National Weather Service. If the gage becomes inoperable, the NWS is notified.

(2) Reservoir Stage Recorders. The water level recorder at Union Village Dam monitors water stages in the reservoir at all times. This equipment should be checked each workday morning, to assure that the clock is keeping correct time and the pen is tracing water levels properly. Any discrepancy, as evidenced by pen time or gage height, should be corrected and the pen reset. During periods of reservoir storage, the outside tile staff gage should be read periodically to check accuracy of the chart. If the recorder become inoperable, RCC should be notified and arrangements made for immediate repair by the USGS.

Pool charts are kept for permanent filing at the project. Charts should be changed the first working day of each month except during periods of significant impoundments. The following information should be noted in ink at the beginning and end of each chart:

Outside tile gage reading
Pen gage height reading
Date
Watch time
Pen time

(3) Tailwater Gaging Station. The USGS gaging station at Union Village provides a continuous official record of releases from the dam. It is equipped with a digital-type water stage recorder, and operated and maintained by the USGS under the cooperative stream gaging program. It is essential that the gage be checked frequently to assure proper operation. If inspection indicates a need for repair, RCC should be notified immediately and arrangements will be made with the USGS to have the equipment serviced.

(4) Telemarks and Talk-A-Marks. These stage detection devices, equipped with telephone voice modems, obtain current river stages and aid in regulating releases from the dam. They are in operation on the Connecticut River at Wells River, Vermont; North Walpole, New Hampshire;

Montague City and Holyoke, Massachusetts; and Thompsonville, Hartford, and Bodkin Rock, Connecticut. Should the telemark at Wells River become inoperative, the Union Village project manager will visit the gage to ascertain the source of difficulty. If the trouble cannot be determined and corrected at the gage by project personnel, the telephone company should be requested to check out their circuit in presence of the project manager, and make necessary repairs. If the telemark or talk-a-mark still is not functioning by this time, RCC should be notified, and NED or USGS personnel will inspect and repair the gaging station.

(5) Snow Sampling Set. Depending on conditions, snow surveys are performed from approximately January to April by Union Village project personnel. Procedures for obtaining snow survey data should follow instructions in the "Snow Sampling Guide, Department of Agriculture, Handbook No. 169." The snow sampling set, which consists of a sampling tube and water equivalent scale, will only require occasional replacement of wornout cutterheads if provided proper care.

4-02. Water Quality Sampling

a. General. Explanation of Corps Water Quality Sampling objectives is included in chapter V of the Master Water Control Manual. This manual also includes locations, parameters, and other specifics related to Corps Water Quality activities in the Connecticut River Basin.

b. Union Village Dam. Water quality monitoring stations have been established at several location throughout the Ompompanoosuc River Basin. These stations, depicted on plate A-30, have been used to measure water quality parameters throughout the basin. Water quality data from station UV05 was collected via an automatic water quality monitor (AWQM), from the late 1970s to the mid-1980s, when it was decided that acquired data was not variable enough to warrant the expense associated with this method of collection. Data collected under the (AWQM) program, is stored in the Environmental Protection Agency's STORET computer system. The Hydraulics and Water Quality Branch (HAWQB) of Water Control Division retrieves data as needed, and provides analysis and interpretation on request for study purposes. A report entitled: "Union Village Dam Water Quality Evaluation," prepared by HAWQB, June 1989, includes summaries and evaluations of water quality data collected by NED. This report and those for other Corps reservoirs are updated when necessary.

4-03. Sedimentation. In accordance with ER 1110-2-4001, sedimentation ranges and monuments have been installed. However, operating experience has shown that, in most dry bed reservoirs of New England, sedimentation accumulated during flood filling and emptying, has not had any significant impact on the project; therefore, sedimentation is not considered a problem.

V - HYDROLOGIC FORECASTS

5-01. National Weather Service

a. Weather Forecasts. National Weather Service offices in Boston, Massachusetts, Albany, New York, and Portland, Maine, are responsible for issuing daily weather forecasts for public dissemination through the news media. These reports are received at the Reservoir Control Center approximately four times daily via "CONTEL" Weather Wire Service. Special advisories, forecasts, and updates are also issued for approaching storm systems and during adverse weather conditions.

b. Precipitation Forecasts. In addition to normal weather reports and forecasts, quantitative precipitation forecasts (QPFs), prepared by the National Weather Service, are received daily by RCC via computer request. These QPF reports indicate the maximum anticipated 24-hour rainfall for New England. Supplemental weather information and forecasts, prior to or during floods, are available upon request.

c. Flood Forecasts. Flood forecasts are prepared by the Northeast River Forecast Center (NERFC). These reports are transmitted to Weather Service stations (Boston, Albany, and Portland), and then issued to the public for the following locations within the Connecticut River Basin.

Connecticut River at North Stratford, VT
Connecticut River at Dalton, NH
Connecticut River at Wells River, VT
Connecticut River at West Lebanon, NH
Connecticut River at North Walpole, NH
Connecticut River at Montague City, MA

Connecticut River at Holyoke, MA
Connecticut River at Springfield, MA
Connecticut River at Thompsonville, CT
Connecticut River at Hartford, CT
Connecticut River at Bodkin Rock, CT

Passumpsic River at Passumpsic, VT
White River at West Hartford, VT
Chicopee River at Indian Orchard, MA
Westfield River at Westfield, MA
Farmington River at Simsbury, CT
Farmington River at Rainbow, CT

d. Coordination with the NERFC. The NERFC also prepares biweekly headwater statements, indicating the amount of 6-hour rainfall necessary to produce watershed runoff into Corps reservoirs, varying from 0.25 to 5 inches. These statements also include the amounts of rainfall required to produce one-half flood, flood, and twice flood conditions on selected tributaries below Corps projects.

These statements were initiated in 1973 when project personnel from 18 NED reservoirs, including Union Village, began telephoning climatologic and hydrologic data to the National Weather Service on a daily basis.

5-02. Corps of Engineers

a. Ompompanoosuc River Watershed. During flood periods in the Ompompansoouc River watershed and Upper Connecticut River Basin, Union Village Dam is regulated along with other Corps projects in the basin to desynchronize flows along the main stem of the Connecticut River. Nearly all the Ompompansoouc River watershed lies upstream of Union Village Dam, and since there are no significant damage areas on the Ompompanoosuc downstream of the project, it is not necessary to develop flood forecast procedures for this watershed.

b. Connecticut River. Corps plans for flood forecasting activities, associated with flood control procedures within the Connecticut River Basin, are included in paragraph 6-02 of the Master Water Control Manual.

VI - WATER CONTROL PLAN

6-01. General Objective. The general objective of regulation procedures for the Ompompanoosuc River watershed is to provide a comprehensive tool for guiding personnel responsible for operating Union Village Dam, in accomplishing the missions for which the project was authorized. This plan, along with those prepared for fifteen other Corps projects in the Connecticut River Basin, provides the most effective protection for downstream communities along the Connecticut River, while also considering impacts of the short reach of the Ompompanoosuc River downstream of Union Village Dam.

6-02. Flood Control

a. Normal Pool and Gate Setting

(1) Winter Season. A 20-foot pool surface elevation of 440 feet NGVD, with an approximate storage volume of 440 acre-feet, is maintained throughout the winter months to prevent ice buildup on the gate slides, thereby, facilitating gate operation. The 20-foot pool level is maintained normally by leaving one gate fully closed and controlling the pool with the second gate. Care should be taken during lowering of the reservoir in springtime so reservoir ice does not break the log boom.

(2) Nonfreezing Season. Normal gate settings for the nonfreezing season are 2.0 and 2.0 feet with the reservoir empty. Approval will be obtained from the Reservoir Control Center if water is to be stored for any reason. Any reservoir impoundment will then be emptied as rapidly as possible, maintaining safe downstream channel capacity, in accordance with directions from RCC.

b. Flood Control Regulation

(1) Objective. Flood control is the primary purpose of Union Village Dam and will take precedence over all other activities pertaining to the project.

(a) Flowage Easements in the Reservoir Area. Four acres of flowage easement were acquired at various elevations at Union Village Dam. It is possible that adjacent lands could be inundated during a rare flood. Observation will be made periodically by project personnel to determine if any development has occurred in these areas which could be affected by reservoir impoundments; if so, RCC should be notified.

(b) Ice Jam Flooding. When an ice jam occurs on the Ompompanoosuc or Connecticut Rivers, observations should be made to determine if releases from the project are adversely affecting downstream ice jams. In the past, ice jams have occurred on the Connecticut River between White River Junction and the Bellows Falls power pool, and on the Ompompanoosuc River at Campbell's Flats. Paragraph 3-05c of this manual includes a more extensive discussion on ice jam flooding.

(c) Downstream Developments or Constrictions. Project personnel should periodically reconnoiter downstream conditions to determine if there are any developments, debris, or other physical restrictions which might reduce nondamaging channel capacity along the Ompompanoosuc River downstream of Union Village Dam.

(2) Flood Period

(a) General. Regulation of flows from Union Village Dam are initiated for heavy rainfall over the Ompompanoosuc River watershed, Upper Connecticut River Basin, and also for specific river stages at key stations along the Connecticut River. These stations are discussed in paragraph 4-01. Regulation may be considered in three phases during the course of a flood:

Phase I - The appraisal of storm and river conditions during development of the flood leading to initial regulation.

Phase II - Regulation of the project while Connecticut River floodflows crest and move downstream.

Phase III - Emptying the reservoir following downstream recession of the flood.

The standard operating procedure (SOP) for regulating Union Village Dam is shown on plate A-32.

(b) Phase I - Appraisal, Initial Regulation. During this phase, data collection is vital. Rainfall and discharge data are compiled in order to appraise the development and magnitude of a flood within the basin.

Gate operations at Union Village Dam will be initiated to restrict reservoir discharge. Consideration will be given to partial closure of gates for any of the following conditions:

1. Whenever rainfall of 2.0 inches on snow-covered frozen ground or ground wet from previous rainfall, or 3.0 inches on dry ground occurs within a 24-hour period.

2. Whenever the stage at the USGS North Walpole gage reaches 24 feet and rising.

3. Whenever the stage at the USGS gage at Montague City reaches 25 feet and rising.

(c) Phase II - Continuation of Regulation. An important regulation activity during Phase II is the collection of hydrologic data such as:

1. Precipitation amounts throughout the watershed as well as surrounding areas.

2. Snow cover and water content in case of snowmelt floods.

3. Stage and discharge values at downstream control points.

4. Other streamflow data which may assist in regulation.

During Phase II, reservoir discharge is regulated to reduce downstream flooding along the Connecticut River.

As a flood develops, considerable judgment and experience are necessary to vary the regulation in accordance with the amount of residual reservoir storage at Union Village Dam, river stages, water content of remaining snow in the watershed, and weather forecasts. In general, consideration will be given to complete closure of the flood control gates for any of the following rising river stages:

Location	Stage (ft)	Discharge CFS	Discharge CFS/Sq.Mi.
Wells River, NH	10.0	30,400	11.5
West Lebanon, NH	17.0	41,300	10.1
North Walpole, NH	26.0	75,920	13.8
Montague City, MA	25.0	64,090	8.2

There are three hydroelectric plants on the main stem Connecticut River operated by the New England Power Company (NEPCO), namely, Wilder, Bellows Falls, and Vernon Dams (see plate A-32 for locations) that are affected by releases from Corps flood control reservoirs. Only Wilder is capable of releasing large amounts of water from storage that could adversely affect our operations. Releases will be coordinated with NEPCO during flood periods.

(d) <u>Phase III - Emptying the Reservoirs.</u> Following the recession of the flood peak at downstream communities along the Ompompanoosuc and Connecticut Rivers, Union Village reservoir will be emptied as rapidly as possible, in accordance with instructions issued by RCC. Releases will normally be made in a manner that will not cause stages downstream to exceed conditions listed below.

<u>FLOOD STAGES AT INDEX STATIONS</u>
<u>DOWNSTREAM OF CORPS DAMS</u>

Location	Stage (ft)	Discharge CFS	Discharge CFS/Sq.Mi.
West Lebanon, NH	22.0	63,300	15.5
North Walpole, NH	30.0	95,210	17.3
Montague City, MA	30.0	89,460	11.4
Thompsonville, CT	9.2	154,000	15.9

Rating tables for USGS gages in regulation of Union Village Dam are shown on plates A-33 through A-37.

Other Phase III considerations include:

<u>1</u>. The rate of increase in discharges from Union Village Dam should not exceed 300 cfs/hour to 1,800 cfs, and then at a reduced rate of 100 cfs/hour. Also, the rate of reservoir drawdown shall not exceed 15 feet in 24 hours.

<u>2</u>. Discharges will be coordinated with releases from other reservoirs in the system, in a manner that will normally allow Connecticut River flood crests to continue receding, or remain below flood stage.

3. The nondamaging channel capacity immediately downstream of Union Village Dam is about 2,400 cfs. This rate of discharge should be considered by RCC whenever peak inflows exceed these values, and climatologic and hydrologic conditions permit. Outlet rating curves for the flood control gates are shown on plate A-39.

4. Secondary river rises during Phase III, due to either additional rainfall or snowmelt, may result in regulation procedures reverting to Phase II.

5. With Union Village reservoir filled to spillway crest (elevation 564 feet NGVD; stage 144 feet) and 5 csm inflow, it would take 11 days to lower the reservoir to a 20-foot stage (elevation 440 feet NGVD) using a release rate of 2,400 cfs. With two gates fully open, it would take 3.5 days to lower the pool. This would not be within regulation guidelines as flows would exceed channel capacity; however, it could be considered if emergency conditions warranted.

6. Discharges should be made in a manner that balances flows through each gate, thereby reducing turbulence within the conduit, eddy effects, whirlpools, and scouring.

7. Emptying the reservoir will not begin until the flood peak has passed White River Junction. Guide Curves for evacuating flood storage are shown on plate A-40.

(e) Regulation for Snowmelt. Moderately high springtime discharges can occur as a result of melting snow, but runoff from this source alone has not caused major flooding. Snow cover in lower elevations of Massachusetts and Connecticut usually diminishes before melting takes place in northern areas of Vermont and New Hampshire; however, the potential snowmelt flood threat period on the Connecticut River and its tributaries is prolonged, generally occurring in March and April due to high riverflows and saturated ground conditions.

Active snowmelt begins when density of the snowpack becomes "ripe" and rises above 30 percent, i.e., a 10-inch depth of snow having a 3-inch water equivalent. RCC has not developed precise correlations regarding high temperatures, snow density, and peak runoff relationships for each tributary. However, operating experience has indicated that after the snowpack becomes "ripe", several days of prolonged temperatures in the fifties and sixties would result in flows of 8 to 10 csm on the main stem Ompompanoosuc River and discharges up to 20 csm from the smaller, steeper tributaries in the watershed. Runoff from snowmelt alone is diurnal, orderly, and gradual, and regulation by RCC will not necessarily follow release guides established for runoff from rainfall. Regulation during periods of snowmelt, with no rainfall occurring or expected to occur, will generally be based on releases consistent with maintaining full downstream channel capacities.

(f) Spillway Discharge. During a major flood event, gates will not ordinarily be opened to avoid spillway discharge. Surcharge storage above the spillway crest will be utilized if downstream channel capacities continue to be exceeded by runoff from uncontrolled areas.

If stored floodwaters in the reservoir continue rising above spillway crest, with the possibility of the pool exceeding the maximum design surcharge, the following schedule will be used as a guide for gate openings during spillway discharges. This schedule will result in both gates being fully open when the pool has reached about one-half the spillway design flood surcharge.

UNION VILLAGE DAM

Pool Stage (feet)	Pool Elevation (feet NGVD)	Flood Control Gates (feet)	Spillway & Outlet Discharges (cfs)
148	568	0 - 0	10,000
149	569	3 - 3	18,300
150	570	6 - 6	26,200
151	571	6 - F	35,100
152	572	F - F	38,800

F - Fully Open

Spillway crest elevation 564 feet NGVD (pool stage 144 feet); top of dam elevation 584 feet NGVD.

It should be emphasized that the spillway design flood maximum surcharge would result from an extremely rare event, i.e., more than 24 inches of rainfall in 24 hours, with the reservoir full or nearly full at the beginning of the storm event. The spillway rating curve is shown on plate A-41.

(g) Alerting Flood Affected Populace. Whenever it is anticipated that the pool will rise above spillway crest elevation along the Ompompanoosuc and Connecticut Rivers, police and other local community officials must be notified of the situation. These officials will then inform the affected populace of the potential flood conditions.

(h) Effect of Regulation on Roads within the Reservoir. Union Village--Thetford Center (East access) and River Roads (West access), shown on plate A-3, pass through the reservoir area and are subject to inundation during storage of floodwaters. Road barriers have been installed at locations where these roads pass into the reservoir area. These barriers consist of gates limiting access to the reservoir. The two barriers on the Union Village-Thetford Center Road will be closed by project personnel when the reservoir stage is expected to rise over 40 feet (460 feet NGVD). The two barriers on River Road will be closed when the reservoir stage is expected to rise above 64 feet (484 feet NGVD). Signs will be placed on the barriers when closed. Project personnel will notify local authorities when barriers are required. Names of officials to contact are updated periodically in the RCC telephone directory.

(3) Extraordinary Regulation Conditions. It is conceivable that extraordinary circumstances or unpredictable flood conditions may arise such as a possible drowning, dam or bridge failures, highway or railroad washouts, ice jams, or debris deposits. Regulation during such unusual conditions may not follow previously described rules but will be governed by the urgency of the situation. During these conditions, the project manager has full authority to act immediately in the public interest. RCC will be notified as soon as possible of any unusual incident so additional action may be taken to provide maximum protection.

(4) Regulation with Failure of Communications. If the Union Village project manager is unable to contact RCC, he has full authority to act promptly in accordance with instructions contained in the Emergency Operating Procedures, and will direct regulation of the reservoir until communications with RCC are reestablished (refer to plate A-32 and the following paragraph). Whenever communications fail, and due to lack of adequate reports when it is difficult to fully appraise runoff conditions from an intense storm, it is preferable for the project manager to completely stop reservoir discharges rather than contribute to downstream flood conditions by delaying regulation.

In cases of extreme emergency, the project manager shall attempt to communicate with RCC through radio network with the State Police and the office of Civil Defense Mobilization.

Releases for emptying the reservoir will not be made until contact has been established with RCC. Instructions contained in this manual do not relieve the project manager of his responsibility for continued efforts to communicate with RCC.

(5) Emergency Operating Procedures (EOP). If the project manager is unable to contact RCC, and flood conditions develop, he has full authority to completely restrict outflow, exclusive of minimum flows, for any of the following conditions:

If 3-inch precipitation occurs at the project in a 24-hour period.

If the Connecticut River at North Walpole reaches a stage of 26 feet.

If the Connecticut River at Wells River reaches a stage of 10 feet.

Gate Settings for restricting flows to a minimum are 0'- 0.1' (see plate A-32 for standard and emergency operating procedures).

(6) Cooperation With Downstream Water Users. It is Corps policy to cooperate with downstream water users and other interested parties or agencies. The project manager may be requested by downstream users to deviate from normal regulation for short periods of time. Whenever a request for such modification is received, he shall ascertain its validity and require the individual making the request, to obtain verbal assurances from other downstream water users that they are agreeable to the proposed operation. The project manager will then relay the information to RCC and request instructions.

(7) Absence from Dam. RCC and the basin manager are notified whenever the project will not be staffed daily during the normal work week or for an extended period.

(8) Future Studies. Significant post-flood studies will be made by RCC personnel, after all reservoir regulation periods, to determine the following:

- Efficiency of communication and reporting networks.

- Applicability of regulation guides, including stage-discharge relationships and discharge correlations.

- Flood reductions at damage centers.

c. Flood Emergency Plans. A program requiring preparation of dam safety plans for all Corps reservoirs was instituted in May 1978 with the issuance of ER 1130-2-419, and plans include the following:

- Emergency notification procedures.

- List of conditions leading to emergencies such as dam breaks and spillway discharge, and ways of dealing with such conditions.

- Reservoir dewatering procedure.

- Dam failure inundation maps.

- Listing of emergency repair materials and equipment.

- Outline of responsibilities for inspection and emergency repairs.

- List of nearby contractors.

Preparation of a "Flood Emergency Plan" for Union Village Dam was completed by the Corps in June 1985. Copies are located in the Emergency Operations Center, New England Division.

6-03. Recreation. A recreation resources program has been undertaken by the Corps to provide an increased level of recreational opportunities, and to effectively manage natural resources available at Corps projects. In response to this program, Recreation Resources Development Plans have been prepared for all Corps reservoirs, including Union Village Dam. Recreational facilities for swimming, picnicking, hiking, camping, fishing, hunting, and boating have been furnished by the Corps. Related facilities for public safety, health and protection, and conservation of natural resources are also provided at the projects.

6-04. Water Quality Activities

a. General. Executive Order 12088 establishes the head of each executive agency with responsibility for prevention, control, and abatement of environmental pollution at

Federal facilities and activities, and requires compliance with applicable pollution control standards. In consonance with this directive and the requirements of ER 1130-2-415 concerning water quality data collection, interpretation, and application activities, the NED Water Quality Management Program has been established. The goals and objectives of this program are:

- Meet State water quality standards at existing projects through maintenance or improvement of existing water quality conditions.

- Provide the quality of water required to support the assigned uses of each project.

- Consider water quality in all aspects of planning, engineering, design, construction, and operation and maintenance activities.

In support of these goals as they pertain to existing reservoirs, the water quality program is designed to define existing water quality conditions, identify any subsequent change, identify and quantify any water quality problems, and provide information useful to reservoir regulation activities. Water quality control engineering is performed by the Hydraulics and Water Quality Branch, Water Control Division. Field measurement, sampling and laboratory analysis services are provided by the NED Materials and Water Quality Laboratory. A report, summarizing all water quality management activities, is submitted annually to OCE, as required by ER 1130-2-334. Sampling and analysis of water quality are also performed in the interest of public health, associated with water supply and recreation activities at NED projects, in accordance with ER 1130-2-407 and other existing guidance.

In the event an emergency water quality condition exists, either in the upstream watershed or within project lands, which may affect use of the reservoir or that of downstream users (e.g., chemical spill, algae bloom condition, failure of an upstream treatment plant) the RCC will be notified immediately. In turn, coordination will be made with members of the Hydraulics and Water Quality Branch and Operations Directorate to determine an acceptable solution of the problem.

b. <u>Specific Water Quality Activities.</u> There is no storage allocated specifically to water quality control at Union Village Dam. Water quality activities at the project are currently limited to only monitoring. Data from stations upstream and downstream of the dam are analyzed on a periodic basis. Plate A-31 shows the location of water quality monitoring stations at Union Village Dam.

c. Hazardous Substance Emergencies. When a real or potential discharge of hazardous substances occurs, e.g., chemicals, oil, etc.) into waters or other environment, the owner or operator of the facility or vessel from where the release occurs should notify the United States Government immediately. In order to facilitate reporting, the United States provides a National Response Center in Washington, D.C., staffed 24 hours a day, for coordination of reports; the telephone number is 800-424-8802.

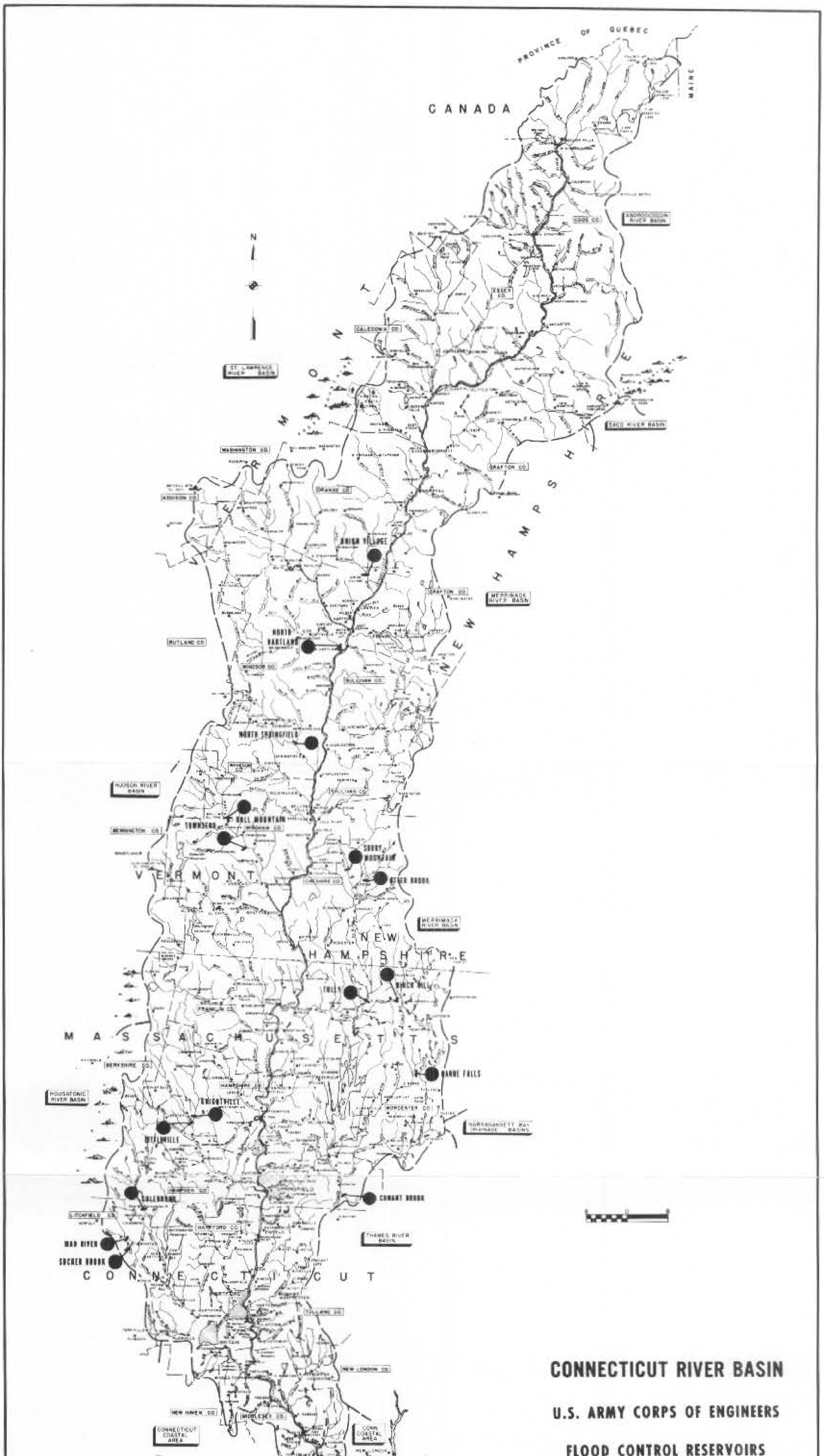
Although the Center is the official and recommended point of contact for use, emergency numbers for other United States agencies have been provided to all Corps projects in the event that the Center cannot be reached. In addition, any emergencies at Union Village Dam should be reported to the Vermont Department of Water Resources and Environmental Engineering, Montpelier, Vermont.

6-05. Water Supply

a. Union Village Dam. There is no storage provided for water supply at Union Village Dam.

b. Drought Contingency. ER 1110-2-1941, Drought Contingency Plans, dated 15 September 1981, states that all water control plans will be continually reviewed, and where appropriate, adjusted in accordance with public needs. Therefore, in November 1981, a drought contingency planning team was formed by the New England Division. This team evaluated each project, and established limits of flexibility, under existing authorities, to modify project regulation and use existing storage to respond to periods of water shortages.

The Drought Contingency Plan for Union Village Dam, completed in September 1987, concluded that drought contingency storage could not take place without significant degradation of the water quality, the environment, and aquatic life. Therefore, drought contingency planning will not be implemented at the project. A copy of the Drought Contingency Plan for Union Village Dam is on file in the Reservoir Control Center. For information purposes only, climatologic and hydrologic indicators, used in recognizing the onset of a drought within New England Division, are presented in attachment 1 of this manual.



CONNECTICUT RIVER BASIN

U.S. ARMY CORPS OF ENGINEERS

FLOOD CONTROL RESERVOIRS

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

PLATE A-1

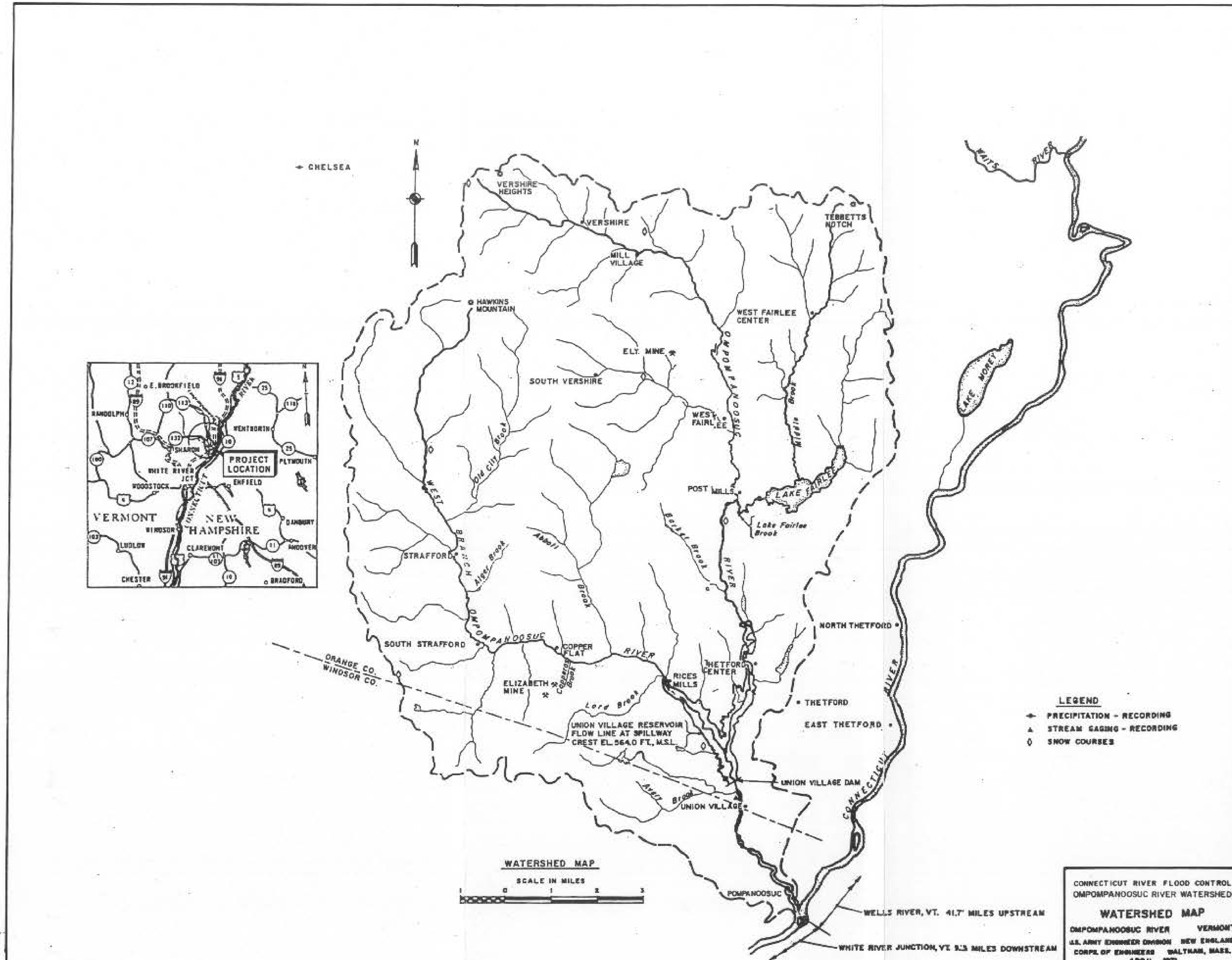

CHELSEA
N
VERSHIRE HEIGHTS
VERSHIRE
MILL VILLAGE
TEBBETTS NOTCH
WAITS RIVER
HAWKINS MOUNTAIN
WEST FAIRLEE CENTER
ELY MINE
SOUTH VERSHIRE
OMPOMPANOOSUC
WEST FAIRLEE
Middle Brook
LAKE MOREY
Old City Brook
WEST BRANCH
POST MILLS
LAKE FAIRLEE
Lake Fairlee Brook
Abbott Brook
Blood Brook
Alger Brook
STRAFFORD
RIVER
NORTH THETFORD
SOUTH STRAFFORD
OMPOMPANOOSUC
COPPER FLAT
RIVER
ORANGE CO.
WINDSOR CO.
ELIZABETH MINE
Copperas Brook
RICES MILLS
THETFORD CENTER
THETFORD
EAST THETFORD
Lord Brook
UNION VILLAGE RESERVOIR FLOW LINE AT SPILLWAY CREST EL. 564.0 FT., M.S.L.
CONNECTICUT RIVER
UNION VILLAGE DAM
Ayers Brook
UNION VILLAGE
LEGEND
PRECIPITATION - RECORDING
STREAM GAGING - RECORDING
SNOW COURSES
WATERSHED MAP
SCALE IN MILES
1 0 1 2 3
POMPANOOSUC
WELLS RIVER, VT. 41.7 MILES UPSTREAM
WHITE RIVER JUNCTION, VT. 9.3 MILES DOWNSTREAM
E. BROOKFIELD
RANDOLPH
SHARON
WENTWORTH
PLYMOUTH
PROJECT LOCATION
WHITE RIVER JCT
ENFIELD
WOODSTOCK
VERMONT
NEW HAMPSHIRE
WINDSOR
DANBURY
LUDLOW
CLAREMONT
ANDOVER
CHESTER
BRADFORD
CONNECTICUT RIVER FLOOD CONTROL
OMPOMPANOOSUC RIVER WATERSHED
WATERSHED MAP
OMPOMPANOOSUC RIVER VERMONT
U.S. ARMY ENGINEER DIVISION NEW ENGLAND
CORPS OF ENGINEERS WALTHAM, MASS.
APRIL 1971

PLATE A-2

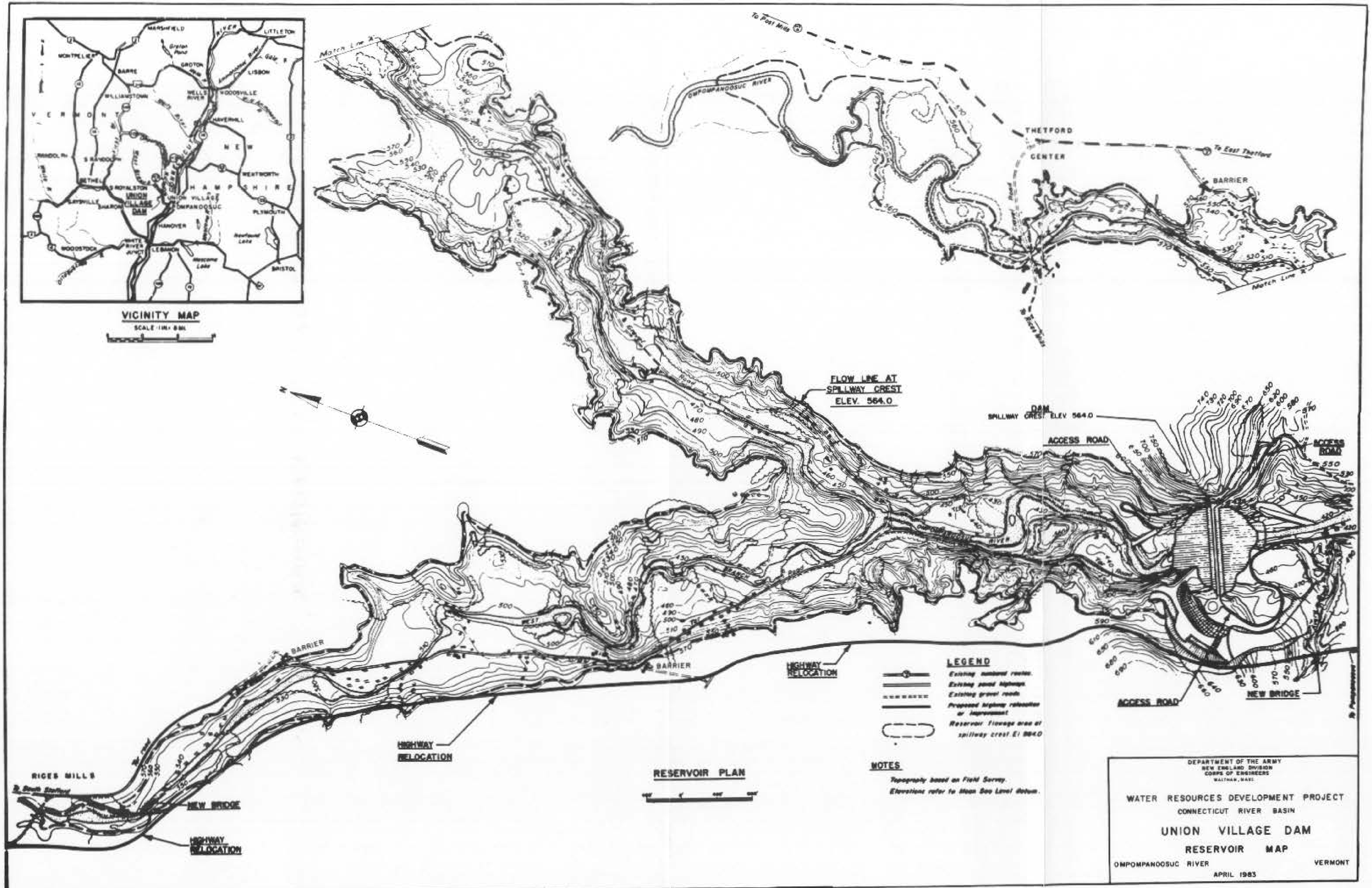
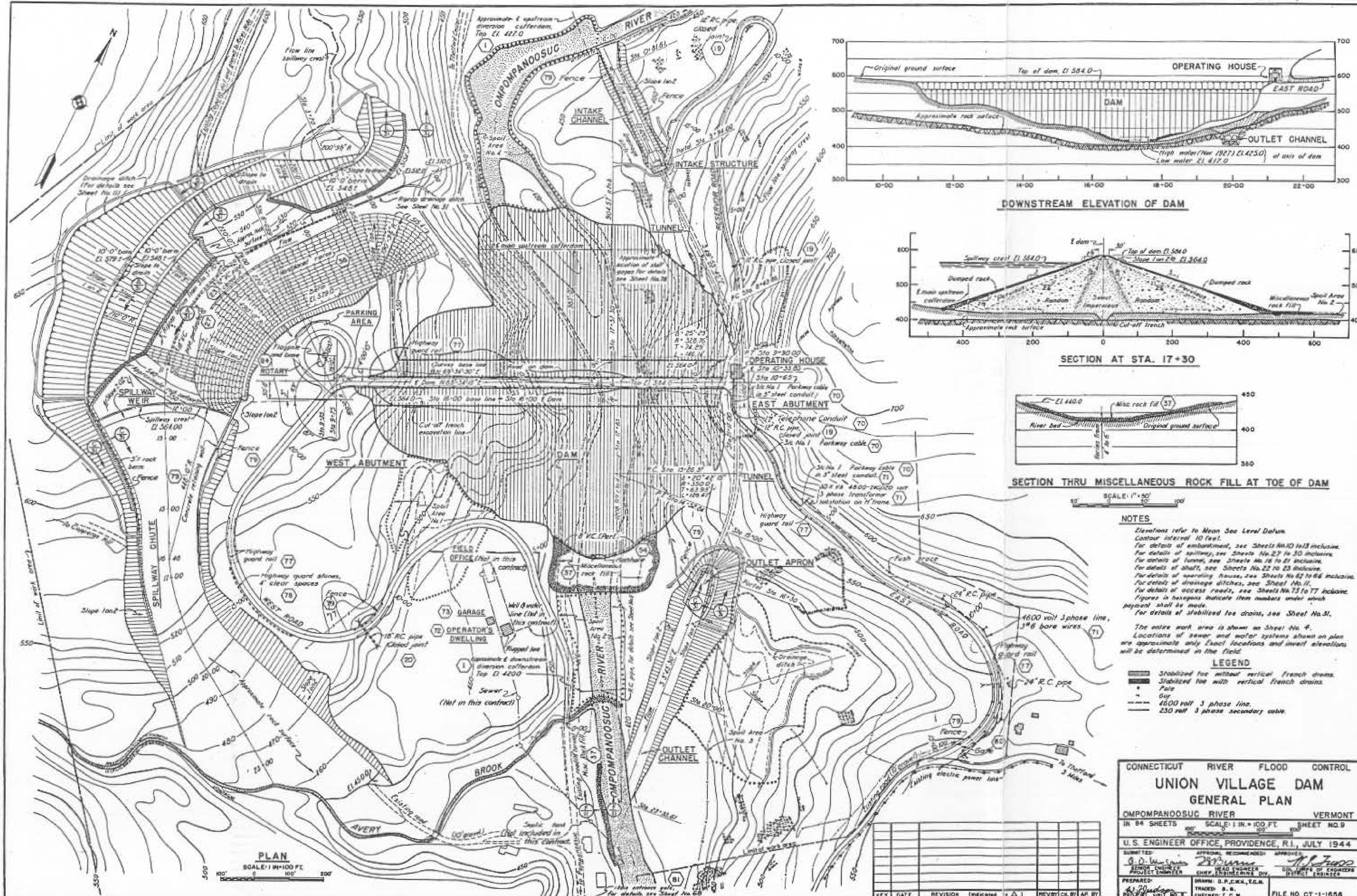
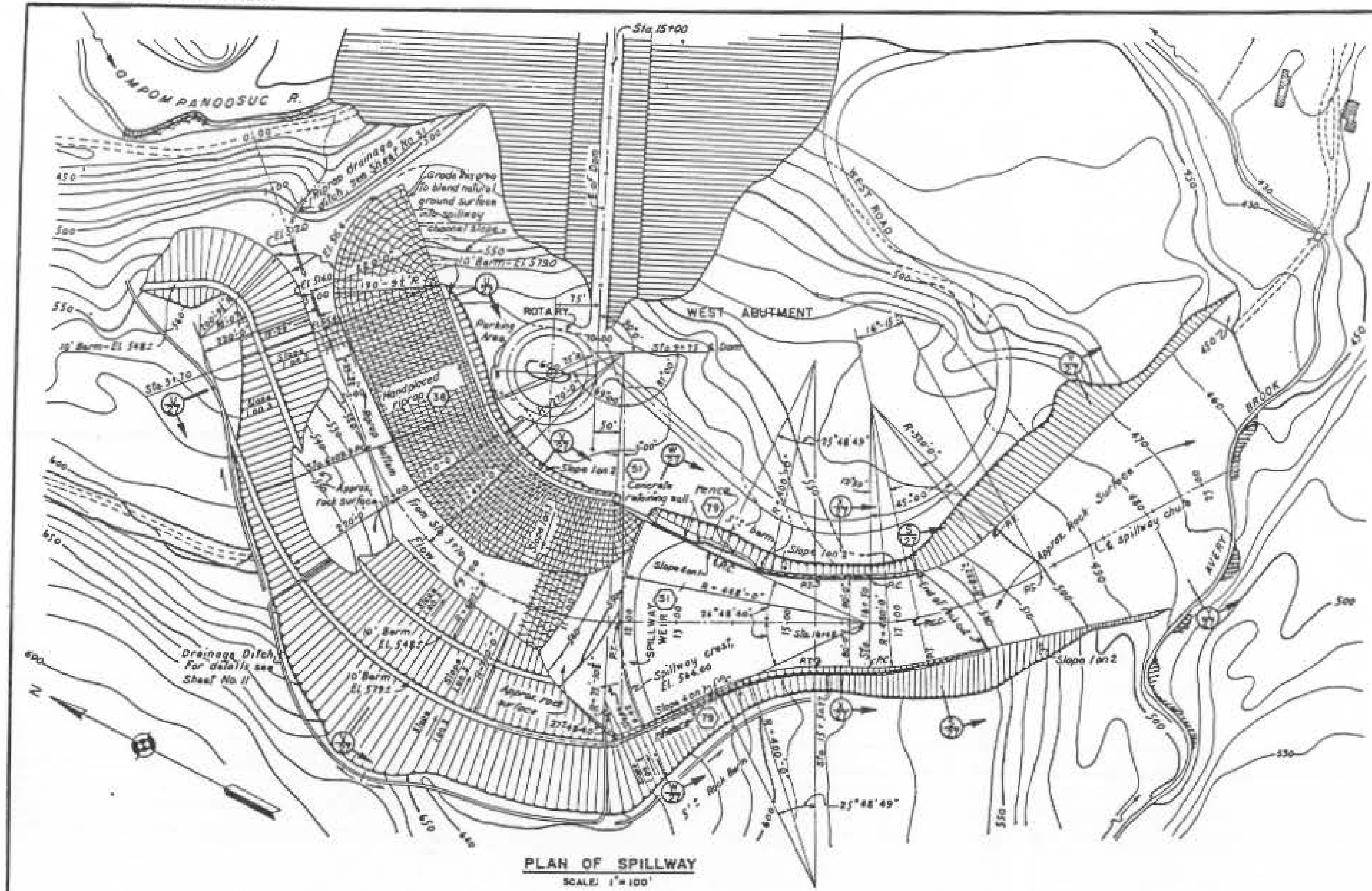
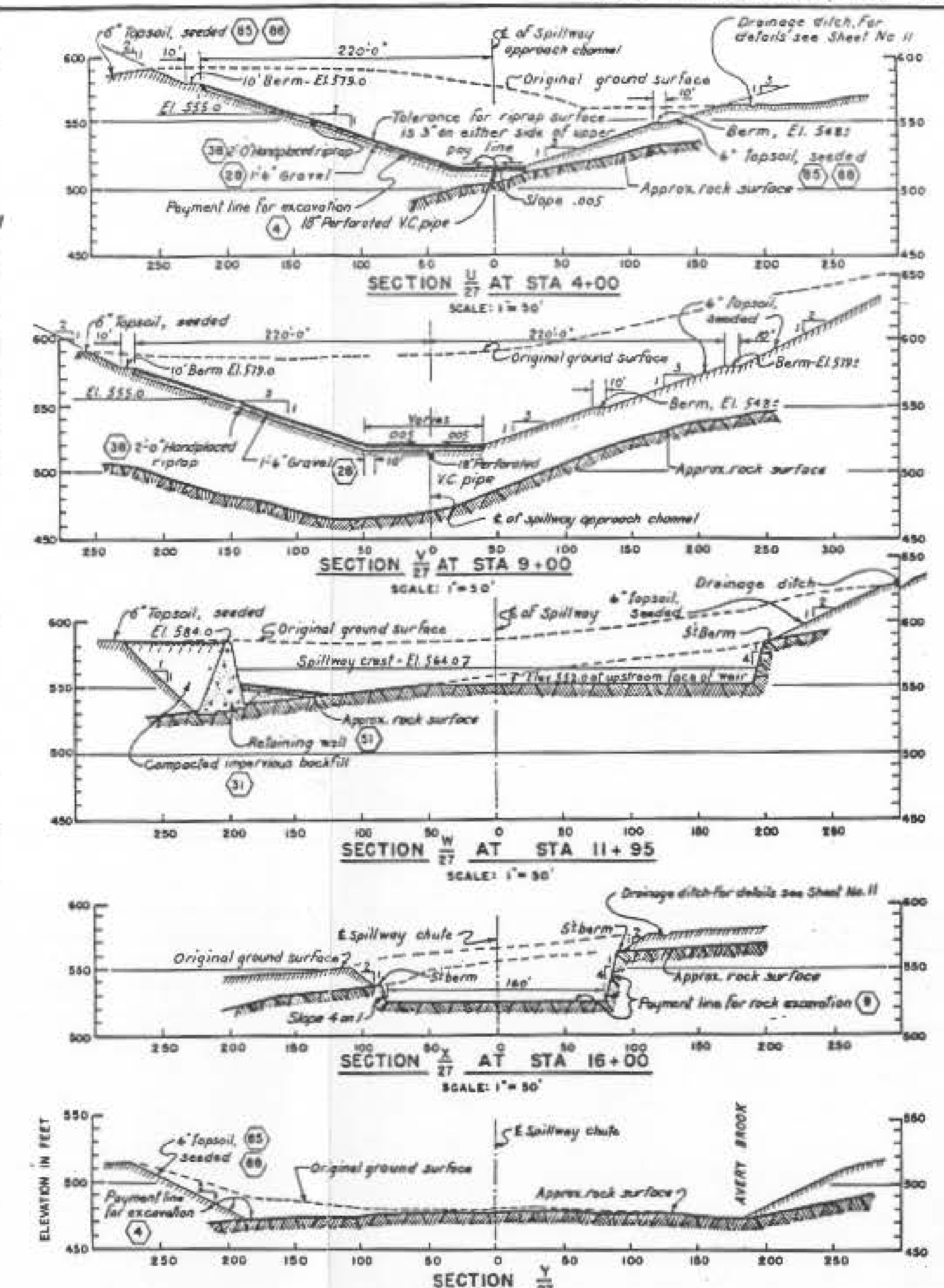

VICINITY MAP
MONTPELIER
MARSHFIELD
LITTLETON
BARRE
GROTON
LISBON
WILLIAMSTOWN
WELLS RIVER
WOODSVILLE
HAVERHILL
V E R M O N T
N E W
H A M P S H I R E
WENTWORTH
BETHEL
UNION VILLAGE DAM
UNION VILLAGE
OMPANOOSUC
SHARON
HANOVER
PLYMOUTH
LEBANON
WOODSTOCK
BRISTOL
RESERVOIR PLAN
THETFORD
CENTER
BARRIER
OMPOMPANOOSUC RIVER
FLOW LINE AT SPILLWAY CREST ELEV. 564.0
DAM
SPILLWAY CREST ELEV 564.0
ACCESS ROAD
HIGHWAY RELOCATION
NEW BRIDGE
RICES MILLS
LEGEND
Existing numbered routes
Existing paved highways
Existing gravel roads
Proposed highway relocation or improvement
Reservoir flowage area at spillway crest El 564.0
NOTES
Topography based on Field Survey.
Elevations refer to Mean Sea Level datum.
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.
WATER RESOURCES DEVELOPMENT PROJECT
CONNECTICUT RIVER BASIN
UNION VILLAGE DAM
RESERVOIR MAP
OMPOMPANOOSUC RIVER
VERMONT
APRIL 1983

PLATE A-3


DOWNSTREAM ELEVATION OF DAM
Original ground surface
Top of dam El. 584.0
OPERATING HOUSE
EAST ROAD
DAM
Approximate rock surface
OUTLET CHANNEL
High water (Nov. 1927) El. 425.0
Low water El. 417.0
at axis of dam
SECTION AT STA. 17+30
Spillway crest El. 564.0
Top of dam El. 584.0
Dumped rock
Random
Select impervious
Cut-off trench
Approximate rock surface
Miscellaneous rock fill
Spoil Area No. 2
SECTION THRU MISCELLANEOUS ROCK FILL AT TOE OF DAM
SCALE: 1" = 50'
El. 440.0
Misc. rock fill
River bed
Original ground surface
NOTES
Elevations refer to Mean Sea Level Datum.
Contour interval 10 feet.
For details of embankment, see Sheets No. 10 to 13 inclusive.
For details of spillway, see Sheets No. 27 to 30 inclusive.
For details of tunnel, see Sheets No. 16 to 21 inclusive.
For details of shaft, see Sheets No. 22 to 23 inclusive.
For details of operating house, see Sheets No. 62 to 66 inclusive.
For details of drainage ditches, see Sheet No. 11.
For details of access roads, see Sheets No. 73 to 77 inclusive.
Figures in hexagons indicate item numbers under which payment shall be made.
For details of stabilized toe drains, see Sheet No. 31.
The entire work area is shown on Sheet No. 4.
Locations of sewer and water systems shown on plan are approximate only. Exact locations and invert elevations will be determined in the field.
LEGEND
Stabilized toe without vertical French drains.
Stabilized toe with vertical French drains.
Pole
Guy
4600 volt 3 phase line.
230 volt 3 phase secondary cable.
OMPOMPANOOSUC RIVER
INTAKE CHANNEL
INTAKE STRUCTURE
TUNNEL
OPERATING HOUSE
EAST ABUTMENT
WEST ABUTMENT
DAM
SPILLWAY WEIR
SPILLWAY CHUTE
PARKING AREA
ROTARY
FIELD OFFICE (Not in this contract)
GARAGE
OPERATOR'S DWELLING
OUTLET APRON
OUTLET CHANNEL
WEST ROAD
EAST ROAD
BROOK
AVERY
To Thetford 3 Miles
PLAN
SCALE: 1 IN. = 100 FT.
CONNECTICUT RIVER FLOOD CONTROL
UNION VILLAGE DAM
GENERAL PLAN
OMPOMPANOOSUC RIVER VERMONT
IN 84 SHEETS
SCALE: 1 IN. = 100 FT.
SHEET NO. 9
U. S. ENGINEER OFFICE, PROVIDENCE, R.I., JULY 1944
SUBMITTED:
SENIOR ENGINEER PROJECT ENGINEER
APPROVAL RECOMMENDED:
HEAD ENGINEER CHIEF, ENGINEERING DIV.
APPROVED:
CORPS OF ENGINEERS DISTRICT ENGINEER
PREPARED:
PROJECT UNIT NO. 2
TRACED: S. S.
CHECKED: T. C. M.
FILE NO. CT-1-1656
KEY
DATE
REVISION
CK. BY
AP. BY



PLAN OF SPILLWAY
SCALE: 1" = 100'



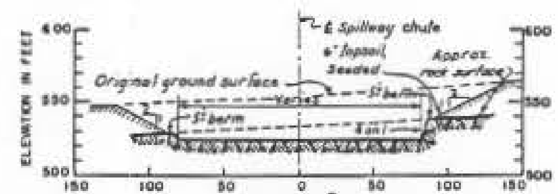
SECTION $\frac{U}{27}$ AT STA 4+00
SCALE: 1" = 50'

SECTION $\frac{V}{27}$ AT STA 9+00
SCALE: 1" = 50'

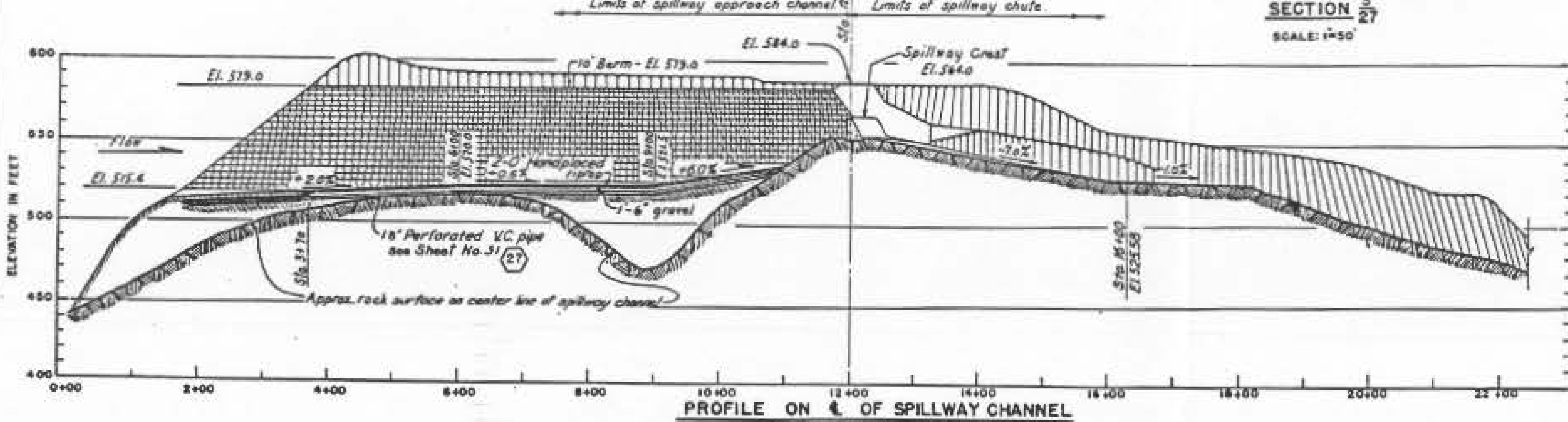
SECTION $\frac{W}{27}$ AT STA 11+95
SCALE: 1" = 50'

SECTION $\frac{X}{27}$ AT STA 16+00
SCALE: 1" = 50'

SECTION $\frac{Y}{27}$
SCALE: 1" = 50'



SECTION $\frac{S}{27}$
SCALE: 1" = 50'



PROFILE ON ℄ OF SPILLWAY CHANNEL
SCALE: HOR. 1" = 100' VERT. 1" = 40'

NOTES:

All sections are taken looking downstream.
Elevations refer to Mean Sea Level Datum.
Contour interval is ten feet.
For spillway weir and retaining wall details, see Sheets No. 28, 29, and 30.
For drainage details of spillway approach channel, see Sheets No. 9 and 31.
Figures in hexagons indicate item numbers under which payment will be made.

KEY	DATE	REVISION (Indicated by △)	REV'D BY	CK. BY	AP. BY

CONNECTICUT RIVER FLOOD CONTROL

UNION VILLAGE DAM

SPILLWAY—PLAN AND SECTIONS

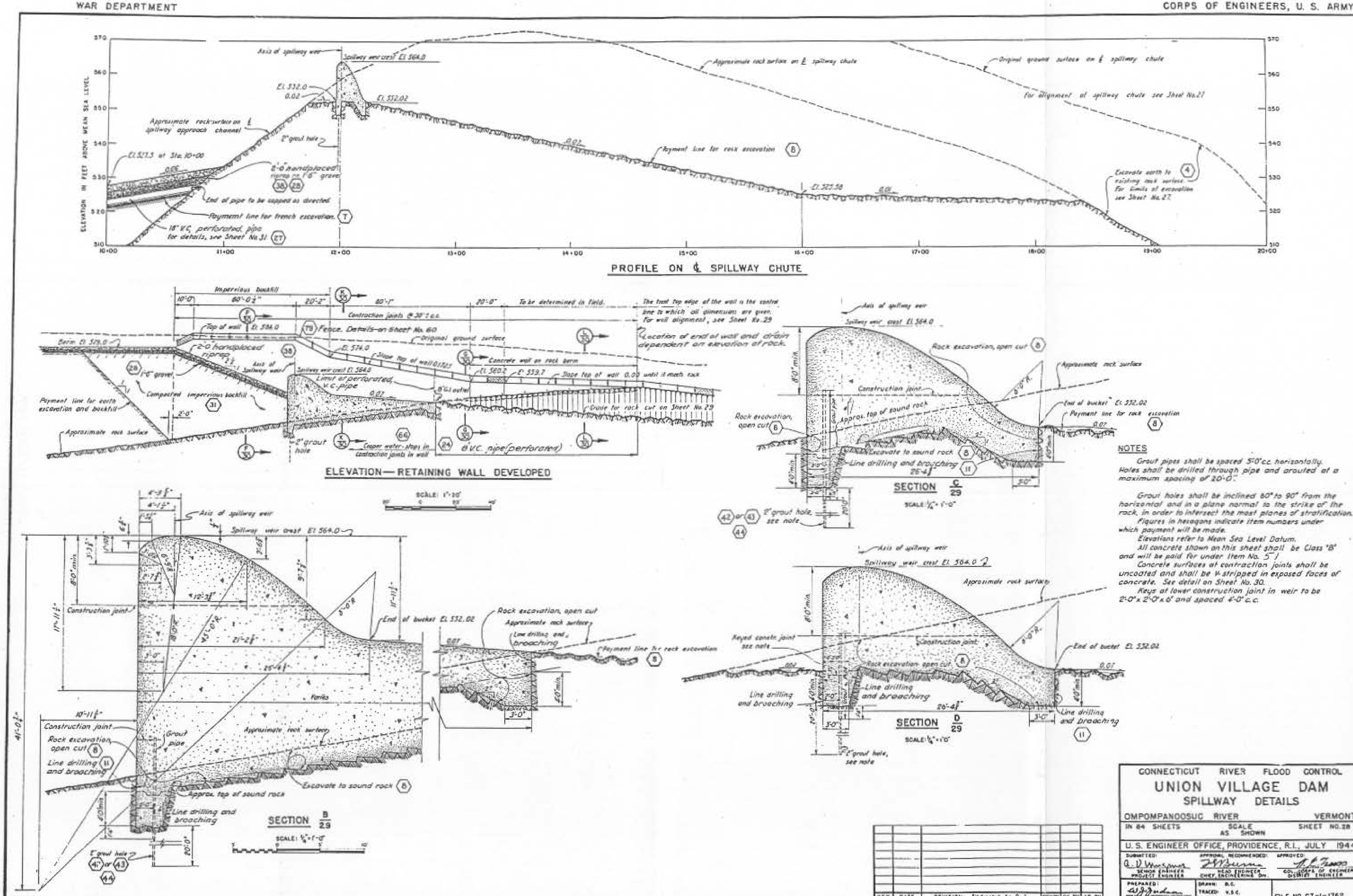
OMPOMPANOOSUC RIVER VERMONT

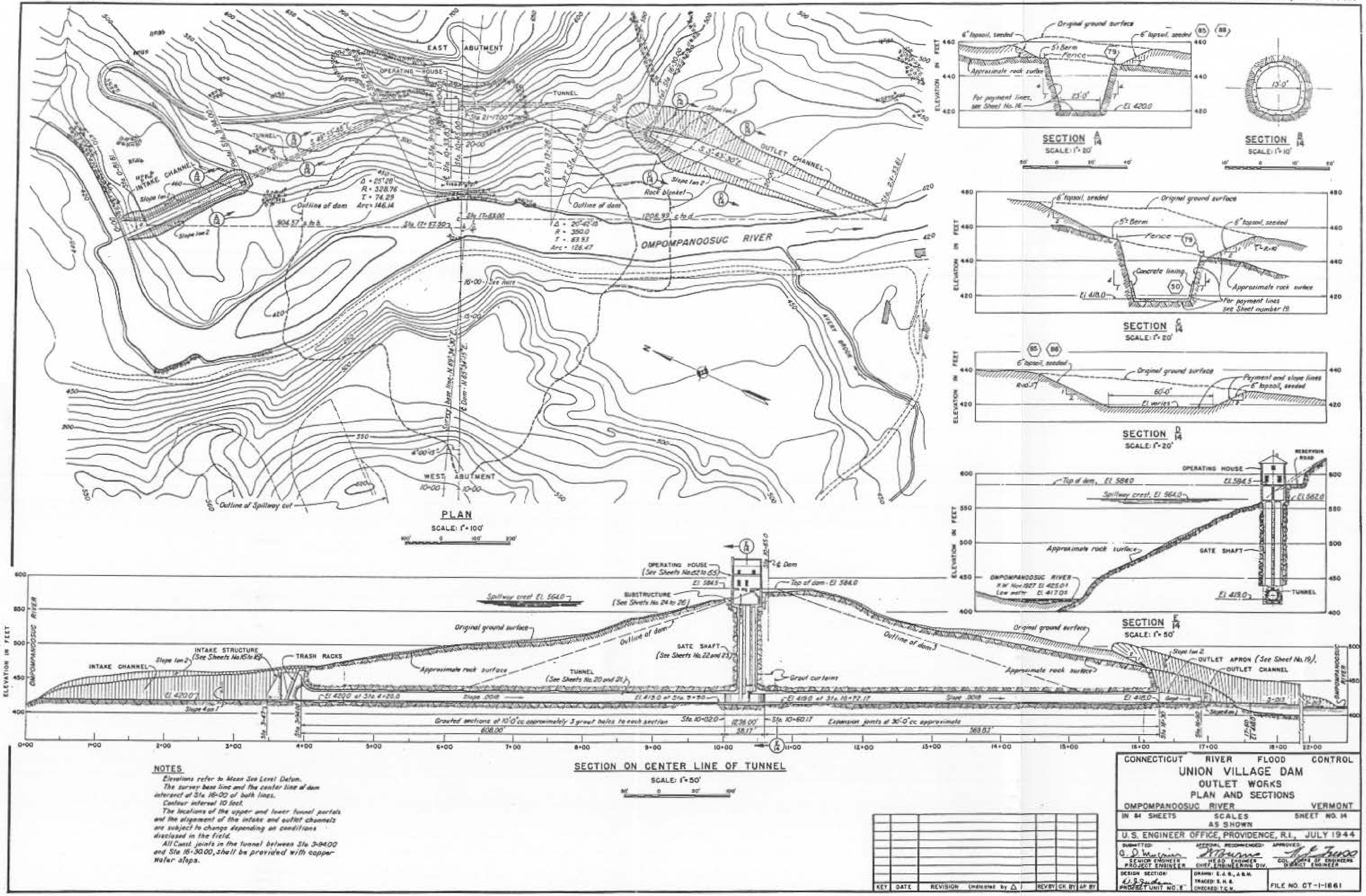
IN 84 SHEETS SCALE: 1 IN. = 100 FT. SHEET NO. 27

U.S. ENGINEER OFFICE, PROVIDENCE, R.I., JULY 1944

SUBMITTED: SENIOR ENGINEER PROJECT ENGINEER — APPROVAL RECOMMENDED: HEAD ENGINEER CHIEF, ENGINEERING DIV. — APPROVED: COL., CORPS OF ENGINEERS DISTRICT ENGINEER

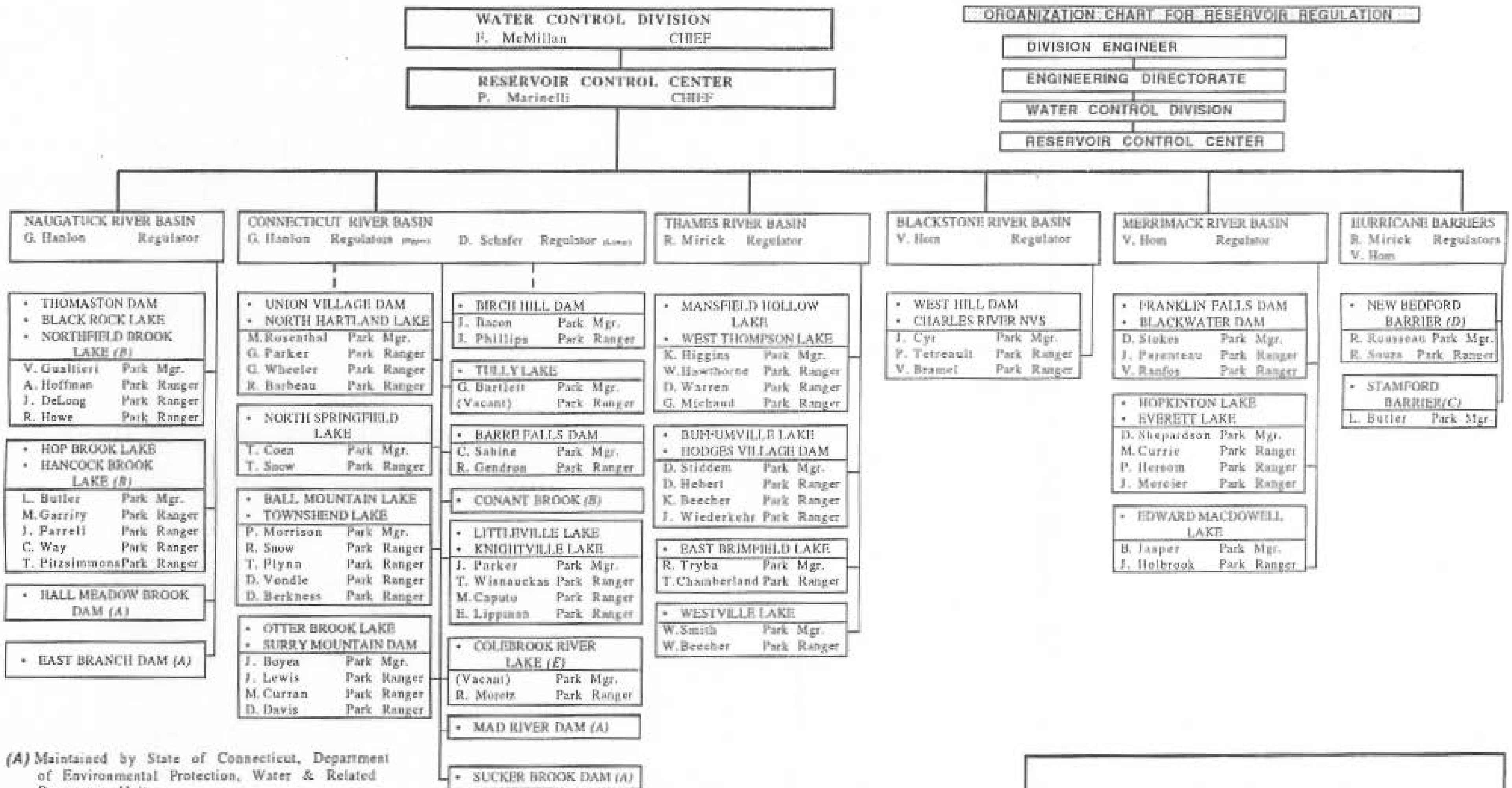
PREPARED: PROJECT UNIT NO. 1 — DRAWN: TRACED: CHECKED: — FILE NO. CT-1-1674


PROFILE ON ℄ SPILLWAY CHUTE
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
Axis of spillway weir
Spillway weir crest El. 564.0
Approximate rock surface on ℄ spillway chute
Original ground surface on ℄ spillway chute
For alignment of spillway chute see Sheet No. 27
Payment line for rock excavation
Payment line for trench excavation
18" V.C. perforated pipe for details, see Sheet No. 31
End of pipe to be capped as directed
2'-0" handplaced riprap on 1'-6" gravel
Excavate earth to existing rock surface. For limits of excavation see Sheet No. 27.
ELEVATION—RETAINING WALL DEVELOPED
Impervious backfill
Contraction joints @ 30' c.c.
To be determined in field.
The front top edge of the wall is the control line to which all dimensions are given. For wall alignment, see Sheet No. 29
Location of end of wall and drain dependent on elevation of rock.
Fence. Details on Sheet No. 60
Original ground surface
Concrete wall on rock berm
Compacted impervious backfill
Payment line for earth excavation and backfill
Approximate rock surface
Copper water-stops in contraction joints in wall
8" V.C. pipe (perforated)
SCALE: 1"=20'
SECTION B/29
SCALE: 1/4"=1'-0"
SECTION C/29
SCALE: 1/4"=1'-0"
SECTION D/29
SCALE: 1/4"=1'-0"
Construction joint
Rock excavation, open cut
Line drilling and broaching
Approx. top of sound rock
Excavate to sound rock
End of bucket El. 532.02
Grout pipe
2" grout hole, see note
Keyed constr. joint see note
NOTES
Grout pipes shall be spaced 5'-0" c.c. horizontally. Holes shall be drilled through pipe and grouted at a maximum spacing of 20'-0".
Grout holes shall be inclined 60° to 90° from the horizontal and in a plane normal to the strike of the rock, in order to intersect the most planes of stratification.
Figures in hexagons indicate item numbers under which payment will be made.
Elevations refer to Mean Sea Level Datum.
All concrete shown on this sheet shall be Class "B" and will be paid for under Item No. 5
Concrete surfaces at contraction joints shall be uncoated and shall be V-stripped in exposed faces of concrete. See detail on Sheet No. 30.
Keys at lower construction joint in weir to be 2'-0" x 2'-0" x 6" and spaced 4'-0" c.c.
KEY | DATE | REVISION (Indicated by △) | REV BY | CK BY | AP BY
CONNECTICUT RIVER FLOOD CONTROL
UNION VILLAGE DAM
SPILLWAY DETAILS
OMPOMPANOOSUC RIVER
VERMONT
IN 84 SHEETS
SCALE AS SHOWN
SHEET NO. 28
U. S. ENGINEER OFFICE, PROVIDENCE, R.I., JULY 1944
SUBMITTED:
SENIOR ENGINEER PROJECT ENGINEER
APPROVAL RECOMMENDED:
HEAD ENGINEER CHIEF, ENGINEERING DIV.
APPROVED:
COL. CORPS OF ENGINEERS DISTRICT ENGINEER
PREPARED:
PROJECT UNIT NO. 1
DRAWN: B.C.
TRACED: V.B.C.
CHECKED: G.H.H.
FILE NO CT-1-1762



EAST ABUTMENT
OPERATING HOUSE
TUNNEL
INTAKE CHANNEL
OUTLET CHANNEL
Outline of dam
Rock blanket
OMPOMPANOOSUC RIVER
AVERY BROOK
WEST ABUTMENT
Outline of Spillway cut
PLAN
SCALE: 1" = 100'
SECTION A/14
SCALE: 1" = 20'
SECTION B/14
SCALE: 1" = 10'
SECTION C/14
SCALE: 1" = 20'
SECTION D/14
SCALE: 1" = 20'
SECTION E/14
SCALE: 1" = 50'
Original ground surface
6" topsoil, seeded
Approximate rock surface
Top of dam, El. 584.0
Spillway crest, El. 564.0
GATE SHAFT
INTAKE STRUCTURE (See Sheets No. 16 to 18)
TRASH RACKS
SUBSTRUCTURE (See Sheets No. 24 to 26)
GATE SHAFT (See Sheets No. 22 and 23)
TUNNEL (See Sheets No. 20 and 21)
Grout curtains
OUTLET APRON (See Sheet No. 19)
SECTION ON CENTER LINE OF TUNNEL
SCALE: 1" = 50'
NOTES
Elevations refer to Mean Sea Level Datum.
The survey base line and the center line of dam intersect at Sta. 16+00 of both lines.
Contour interval 10 feet.
The locations of the upper and lower tunnel portals and the alignment of the intake and outlet channels are subject to change depending on conditions disclosed in the field.
All Const. joints in the tunnel between Sta. 3+94.00 and Sta. 16+30.00, shall be provided with copper water stops.
KEY DATE REVISION (indicated by △) REV. BY CK. BY AP. BY
CONNECTICUT RIVER FLOOD CONTROL
UNION VILLAGE DAM
OUTLET WORKS
PLAN AND SECTIONS
OMPOMPANOOSUC RIVER VERMONT
IN 84 SHEETS
SCALES AS SHOWN
SHEET NO. 14
U.S. ENGINEER OFFICE, PROVIDENCE, R.I., JULY 1944
SUBMITTED: SENIOR ENGINEER PROJECT ENGINEER
APPROVAL RECOMMENDED: HEAD ENGINEER CHIEF, ENGINEERING DIV.
APPROVED: COL. CORPS OF ENGINEERS DISTRICT ENGINEER
DESIGN SECTION: PROJECT UNIT NO. 3
DRAWN: E.J.B., J.B.M.
TRACED: E.H.B.
CHECKED: T.C.N.
FILE NO. CT-1-1661

PLATE A-7



(A) Maintained by State of Connecticut, Department of Environmental Protection, Water & Related Resources Unit.

(B) Unstaffed project maintained by the Corps.

(C) Maintained and operated by Hop Brook Lake Personnel.

(D) Maintained and operated by Cape Cod Canal Regulation for hurricanes by R.C.C.

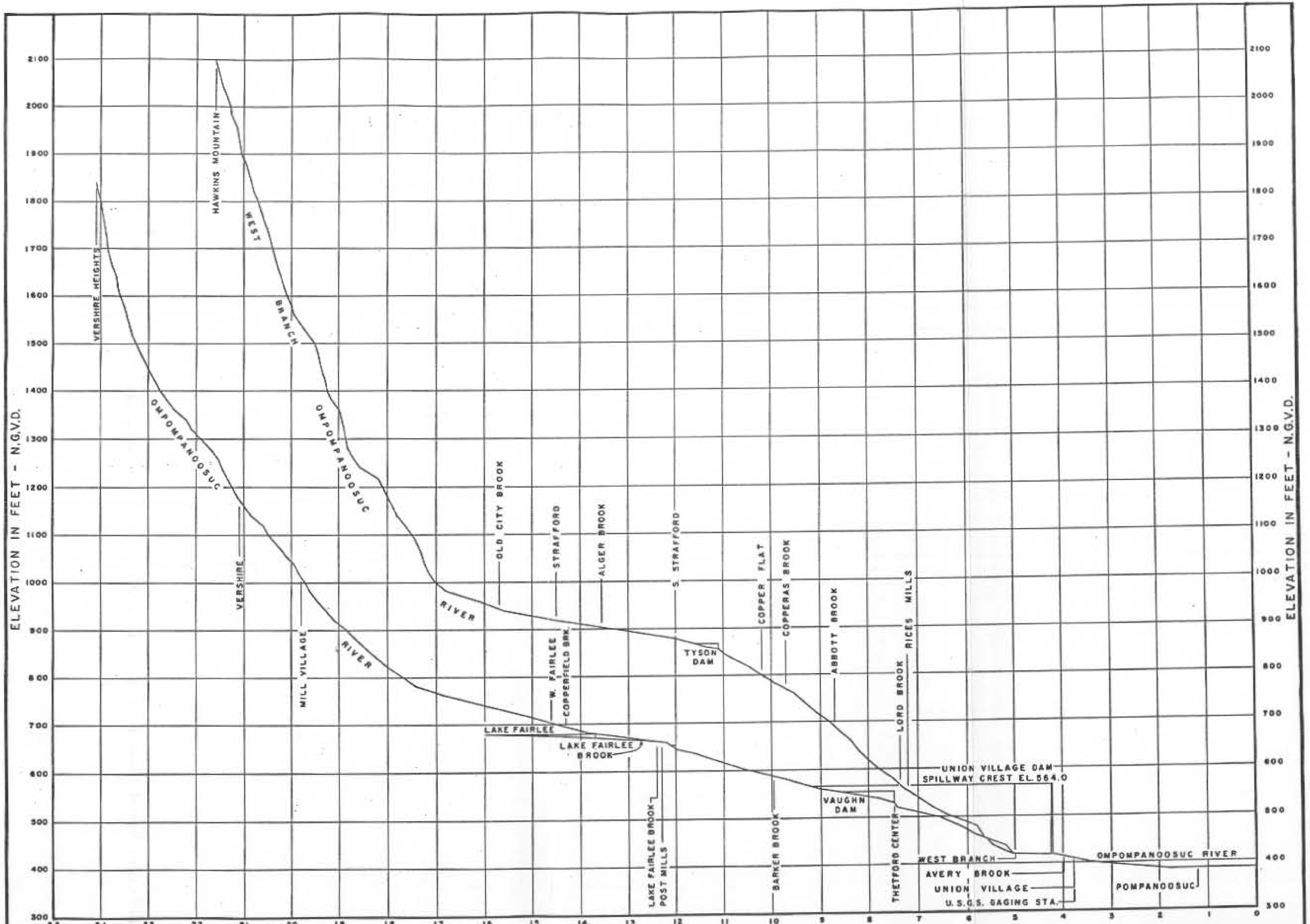
(E) Will continue to be regulated by R. Mirick.

BASIN MANAGERS	
R. Morgan	HOUSATONIC R. BASIN
M. Curran	CONN. R. BASIN (upper)
J. Faloretti	CONN. R. BASIN (lower)
R. Hanacek	THAMES R. BASIN
W. Irwin	MERRIMACK R. BASIN

ORGANIZATION CHART

RESERVOIR REGULATION

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MA
SEPTEMBER 1993



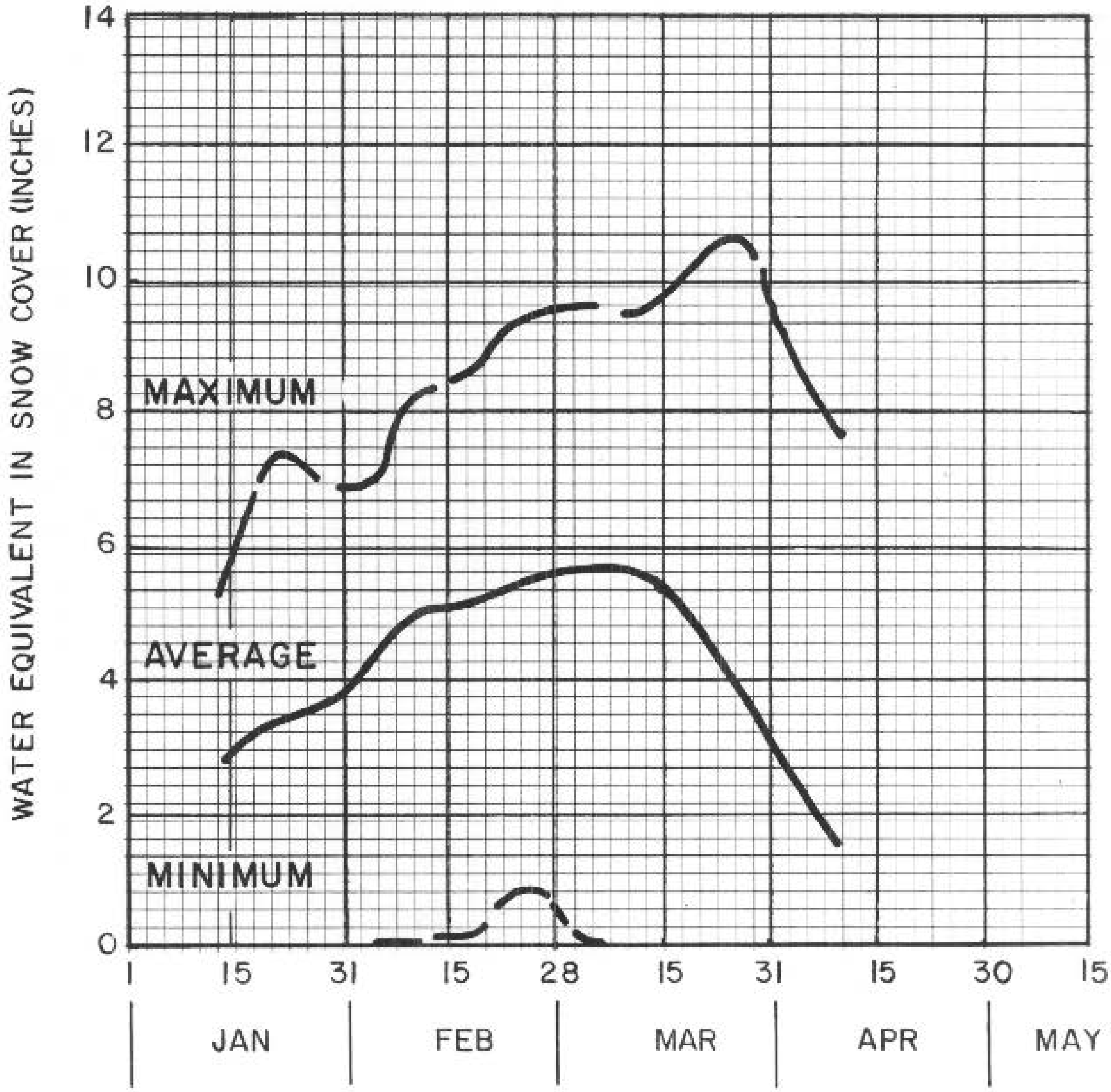
CONNECTICUT RIVER FLOOD CONTROL
OMPOMPANOOSUC RIVER WATERSHED
RIVER PROFILES
NEW ENGLAND DIVISION WALTHAM, MA
FEBRUARY 1971

PLATE A-9

ANNUAL PRECIPITATION
AT CHELSEA VERMONT
(Elevation 750 Ft. NGVD)

1886 - 1989

Calendar Year	Precip. (inches)	Calendar Year	Precip. (inches)	Calendar Year	Precip. (inches)
--	--	1920	41.31	1960	38.39
--	--	1921	32.39	1961	31.77
--	--	1922	38.63	1962	36.09
--	--	1923	36.23	1963	24.25
--	--	1924	34.45	1964	31.36
--	--	1925	39.11	1965	26.58
1886	34.36	1926	36.95	1966	35.55
1887	46.70	1927	44.21	1967	34.63
1888	43.68	1928	36.42	1968	36.06
1889	46.34	1929	37.14	1969	38.23
1890	45.61	1930	--	1970	30.97
1891	37.46	1931	35.70	1971	36.01
1892	38.85	1932	37.33	1972	40.75
1893	34.71	1933	34.46	1973	47.42
1894	38.30	1934	32.63	1974	39.17
1895	33.88	1934	34.08	1975	38.26
1896	30.54	1936	45.55	1976	47.42
1897	48.06	1937	40.25	1977	36.44
1898	37.53	1938	39.77	1978	35.83
1899	27.06	1939	33.37	1979	35.39
1900	36.48	1940	34.87	1980	29.47
1901	29.37	1941	28.04	1981	42.51
1902	38.77	1942	37.53	1982	30.93
1903	29.65	1943	39.31	1983	52.53
1904	29.40	1944	34.70	1984	37.59
1905	30.48	1945	49.11	1985	32.74
1906	35.67	1946	39.59	1986	38.72
1907	41.66	1947	39.92	1987	35.89
1908	27.45	1948	35.20	1988	30.83
1909	33.10	1949	--	1989	38.75
1910	33.13	1950	34.23	AVERAGE	36.66 in.
1911	35.14	1951	38.00		
1912	35.16	1952	34.91		
1913	31.90	1953	39.42		
1914	29.36	1954	47.52		
1915	30.08	1955	35.55		
1916	32.69	1956	37.43		
1917	32.49	1957	33.93		
1918	33.75	1958	40.56		
1919	33.87	1959	42.78		

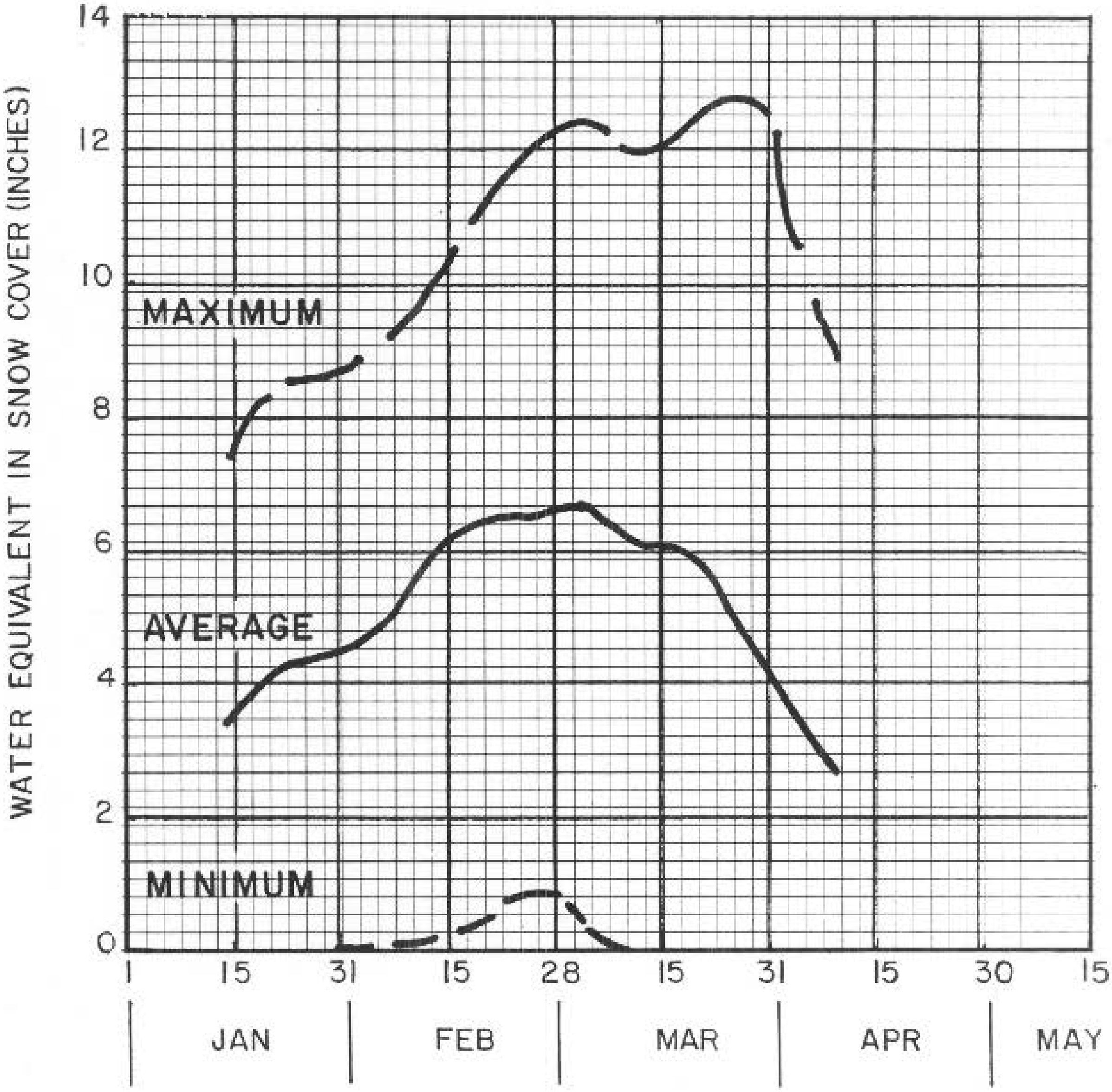


PERIOD OF RECORD: 1951 - 1989

WATER RESOURCES DEVELOPMENT PROJECT
CONNECTICUT RIVER BASIN
OMPOMPANOOSUC RIVER

WATER EQUIVALENT OF SNOW COVER

NEW ENGLAND DIVISION, WALTHAM, MASS.
MAY 1991



PERIOD OF RECORD: 1962-1989

WATER RESOURCES DEVELOPMENT PROJECT
CONNECTICUT RIVER BASIN
WHITE RIVER
WATER EQUIVALENT
OF SNOW COVER
NEW ENGLAND DIVISION, WALTHAM, MASS.
MAY 1991

PLATE A-12

ANNUAL RUNOFF

SELECTED GAGING STATIONS

WATER YEAR	Ompompanoosuc R. at Union Village, Vt. D.A. = 130 sq. mi.		White River at West Hartford, Vt. D.A. = 690 sq. mi.		Connecticut River* at West Lebanon, N.H. D.A. = 4092 sq. mi.	
	CFS	Inches	CFS	Inches	CFS	Inches
1930	--	--	1070	21.2	6014	20.1
1931	--	--	936	18.6	4884	16.4
1932	--	--	969	19.2	6593	22.1
1933	--	--	1144	22.7	7221	24.2
1934	--	--	928	18.4	6053	20.3
1935	--	--	1066	21.2	6683	22.4
1936	--	--	1390	27.6	8018	26.8
1937	--	--	1529	30.4	8493	28.4
1938	--	--	1247	24.8	7043	23.6
1939	--	--	1339	26.6	7839	26.2
1940	--	--	1108	22.0	6419	21.5
1941	121	12.6	711	14.1	5040	16.9
1942	169	17.6	1015	20.2	6244	20.9
1943	211	22.0	1318	26.2	7523	25.2
1944	197	20.6	1127	22.4	6566	22.0
1945	253	26.4	1443	28.7	8499	28.5
1946	246	25.7	1364	27.1	7938	26.6
1947	268	28.0	1595	31.7	9212	30.8
1948	155	16.2	948	18.8	5216	17.5
1949	153	16.0	970	19.3	5525	18.5
1950	164	17.1	996	19.8	6236	20.9
1951	207	21.6	1251	24.8	7151	23.9
1952	251	26.2	1453	28.8	7711	25.8
1953	208	21.7	1236	24.5	6740	22.6
1954	231	24.1	1329	26.4	8864	29.7
1955	213	22.2	1226	24.3	7948	26.6
1956	206	21.5	1140	22.6	6158	20.6
1957	131	13.7	825	16.4	5057	16.9
1958	235	24.5	1267	25.2	8032	26.9
1959	148	15.5	917	18.2	5608	18.8
1960	276	28.8	1589	31.5	8782	29.4
1961	170	17.8	978	19.4	6014	20.1
1962	125	13.1	796	15.8	5426	18.2
1963	157	16.4	914	18.1	6765	22.6
1964	131	13.7	808	16.0	5624	18.8
1965	74	7.7	494	9.8	4101	13.7
1966	163	17.0	1012	20.1	6552	21.9
1967	166	13.9	996	19.8	5875	19.7
1968	189	19.7	1026	20.4	6477	21.7
1969	213	22.2	1280	25.4	7761	26.0
1970	198	20.7	1181	23.4	7297	24.4
1971	164	17.1	1005	20.0	6132	20.5
1972	228	23.8	1299	25.8	7223	24.2
1973	299	31.2	1777	35.3	10060	33.7
1974	249	26.0	1487	29.5	9773	32.7
1975	179	18.7	1192	23.7	6403	21.4
1976	283	29.6	1910	37.9	10460	35.0
1977	177	18.5	1173	23.3	--	--
1978	218	22.8	1480	29.4	--	--
1979	169	17.6	1230	24.4	--	--
1980	119	12.4	832	16.5	4754	15.9
1981	195	20.4	1146	22.8	7956	26.6
1982	225	23.5	1321	26.2	8025	26.9
1983	197	20.6	1245	24.7	7543	25.3
1984	287	30.0	1605	31.9	9533	31.6
1985	124	12.9	878	17.3	5513	18.3
1986	225	23.5	1452	28.6	7152	23.7
1987	183	19.1	1208	23.8	6082	20.2
1988	169	17.6	1164	22.9	6071	20.1
1989	155	16.3	1204	23.7	6591	21.9
AVERAGE**	195	20.4	1185	23.3	7242	24.0

* Formally located at White River Junction, Vermont (1911-1976).
** Period of record.

UNION VILLAGE RESERVOIR
AREA / CAPACITY
(DA = 126 square miles)

Elevation (ft.,msl)	Stage (ft)	Area (acres)	Capacity (ac/ft)	Capacity (inches)	Full Percent
420	0	0	0	0.00	0.0
425	5	12	100	0.01	0.3
430	10	22	200	0.03	0.5
435	15	33	300	0.04	0.8
440	20	45	400	0.06	1.1
445	25	58	500	0.07	1.3
450	30	72	650	0.10	1.7
455	35	86	800	0.12	2.1
460	40	97	1,200	0.18	3.2
465	45	115	1,600	0.24	4.2
470	50	132	2,100	0.31	5.5
475	55	148	2,600	0.39	6.8
480	60	168	3,300	0.49	8.7
485	65	188	4,000	0.60	10.5
490	70	208	5,000	0.74	13.2
495	75	232	6,000	0.89	15.8
500	80	255	7,250	1.08	19.1
505	85	280	8,500	1.26	22.4
510	90	307	10,000	1.49	26.3
515	95	338	11,800	1.76	31.1
520	100	372	13,700	2.04	36.1
525	105	406	15,700	2.34	41.3
530	110	444	18,000	2.68	47.4
535	115	483	20,500	3.05	53.9
540	120	530	23,000	3.42	60.5
545	125	575	26,000	3.87	68.4
550	130	622	29,000	4.32	76.3
555	135	666	32,300	4.81	85.0
560	140	707	35,200	5.24	92.6
564	144	740	38,000	5.65	100.0
Spillway Crest Elevation = 564.0 ft., msl					
565	145	748	38,700	5.76	
570	150	785	42,500	6.32	
575	155	823	46,600	6.93	
579	159	853	49,640	7.39	
Maximum Surcharge Elevation = 579.0 ft., msl					
580	160	860	50,400	7.50	
584	164	896	53,920	8.02	
Top of Dam Elevation = 584.0 ft., msl					

1 - inch runoff = 6,720 acre-feet

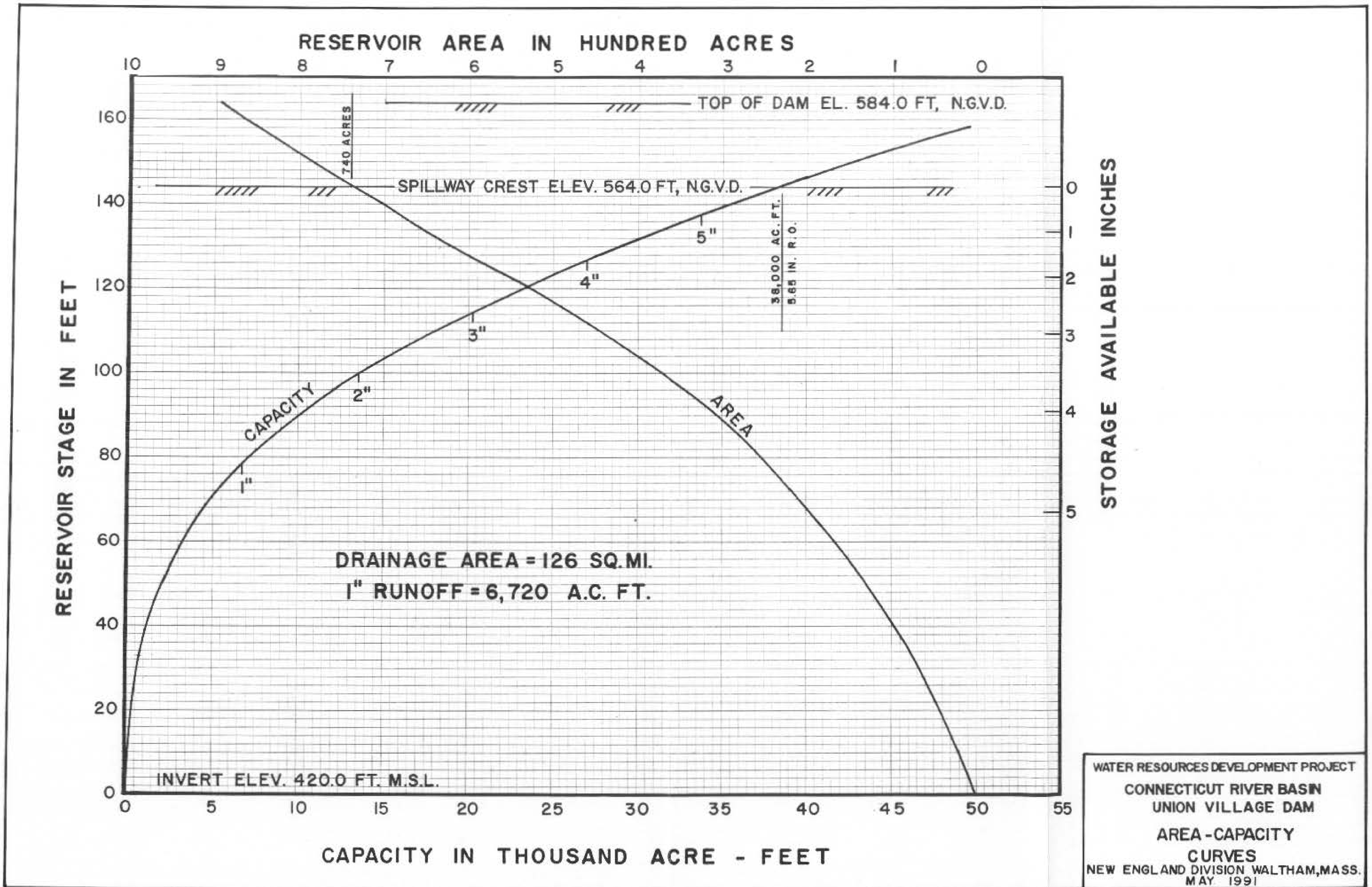
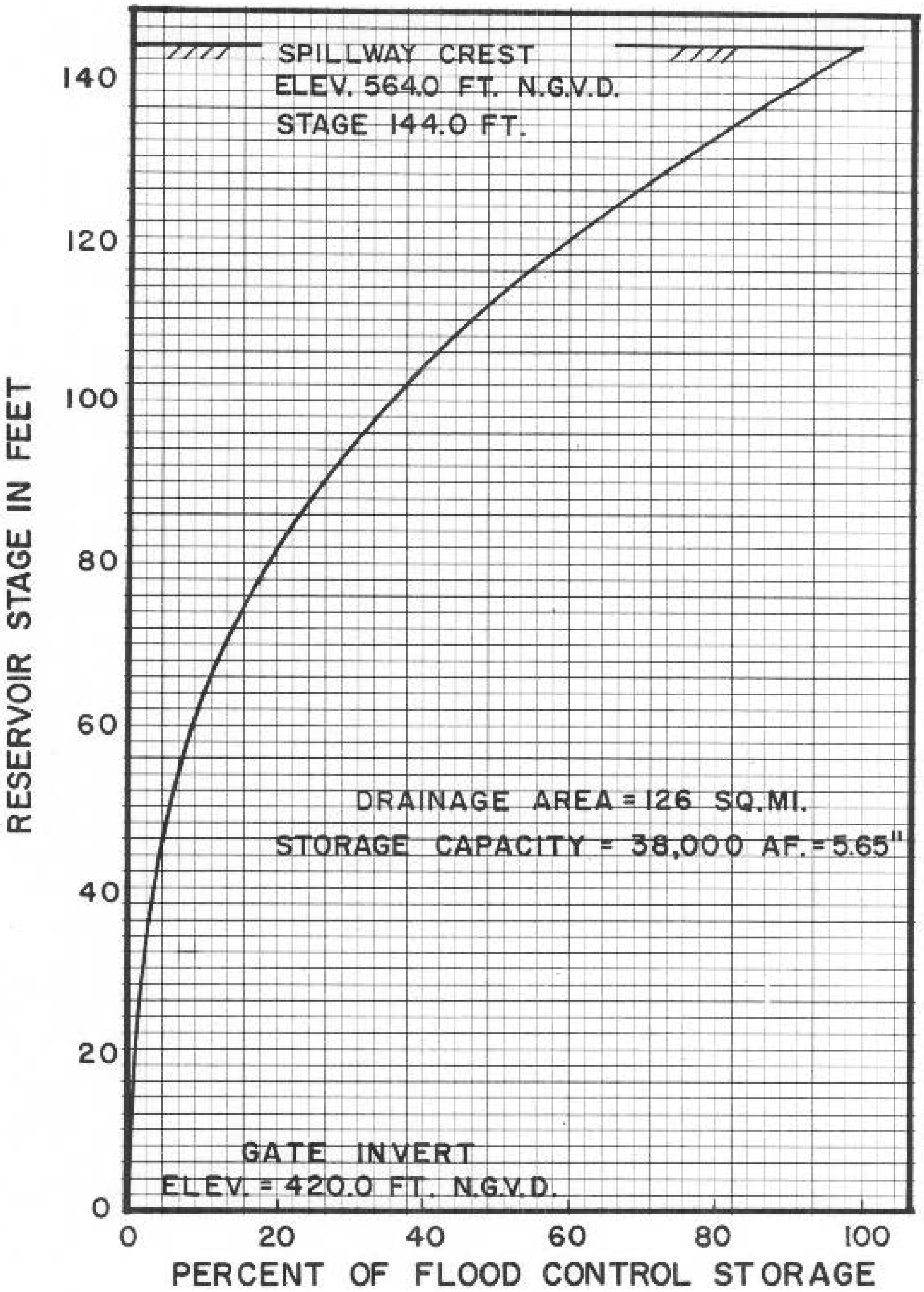

RESERVOIR AREA IN HUNDRED ACRES
10 9 8 7 6 5 4 3 2 1 0
TOP OF DAM EL. 584.0 FT, N.G.V.D.
740 ACRES
SPILLWAY CREST ELEV. 564.0 FT, N.G.V.D.
38,000 AC. FT.
5.65 IN. R.O.
RESERVOIR STAGE IN FEET
0 20 40 60 80 100 120 140 160
STORAGE AVAILABLE INCHES
0 1 2 3 4 5
1"
2"
3"
4"
5"
CAPACITY
AREA
DRAINAGE AREA = 126 SQ. MI.
1" RUNOFF = 6,720 A.C. FT.
INVERT ELEV. 420.0 FT. M.S.L.
0 5 10 15 20 25 30 35 40 45 50 55
CAPACITY IN THOUSAND ACRE - FEET
WATER RESOURCES DEVELOPMENT PROJECT
CONNECTICUT RIVER BASIN
UNION VILLAGE DAM
AREA - CAPACITY
CURVES
NEW ENGLAND DIVISION WALTHAM, MASS.
MAY 1991

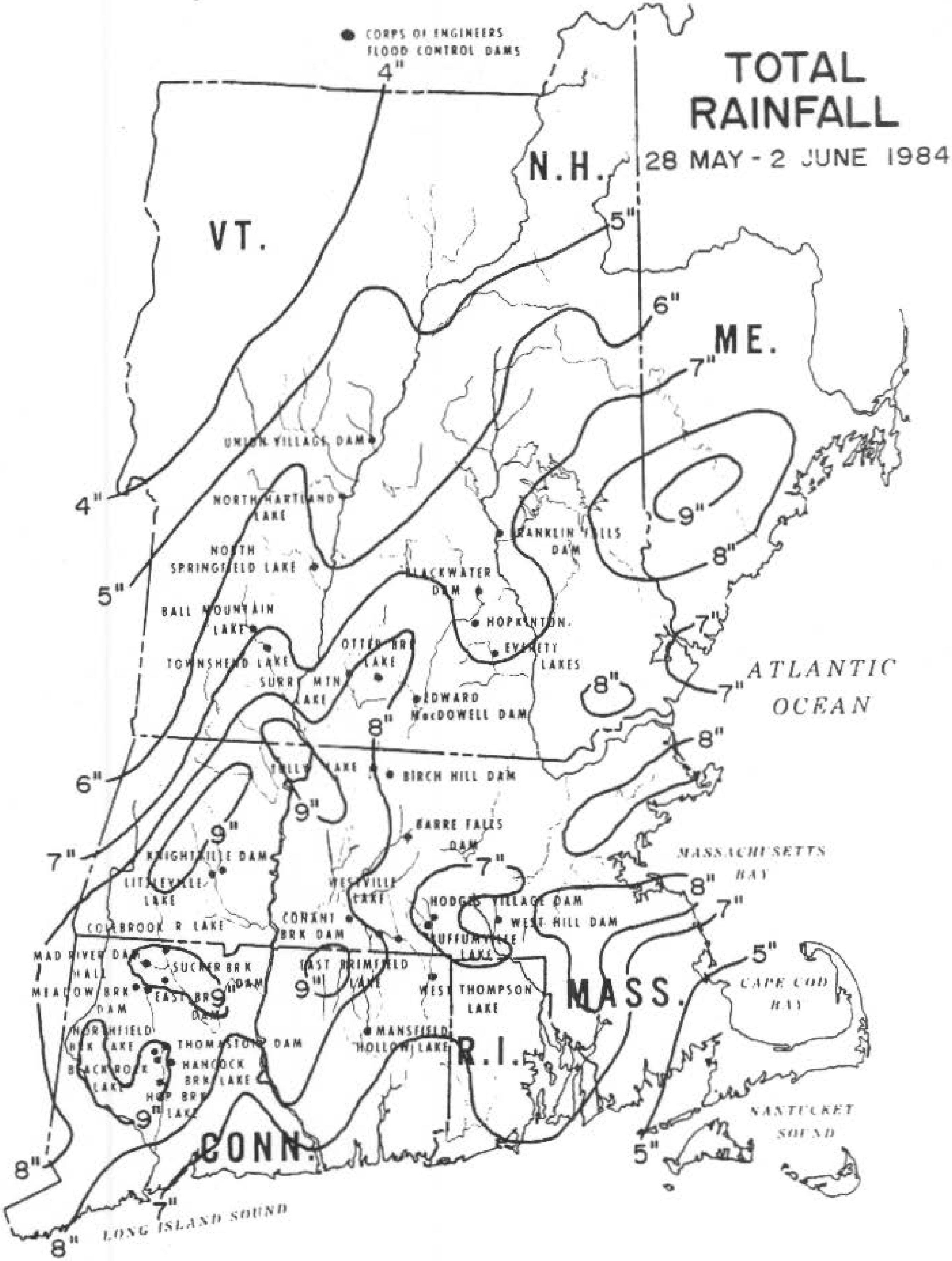
PLATE A-15



WATER RESOURCES DEVELOPMENT PROJECT
CONNECTICUT RIVER BASIN
UNION VILLAGE DAM

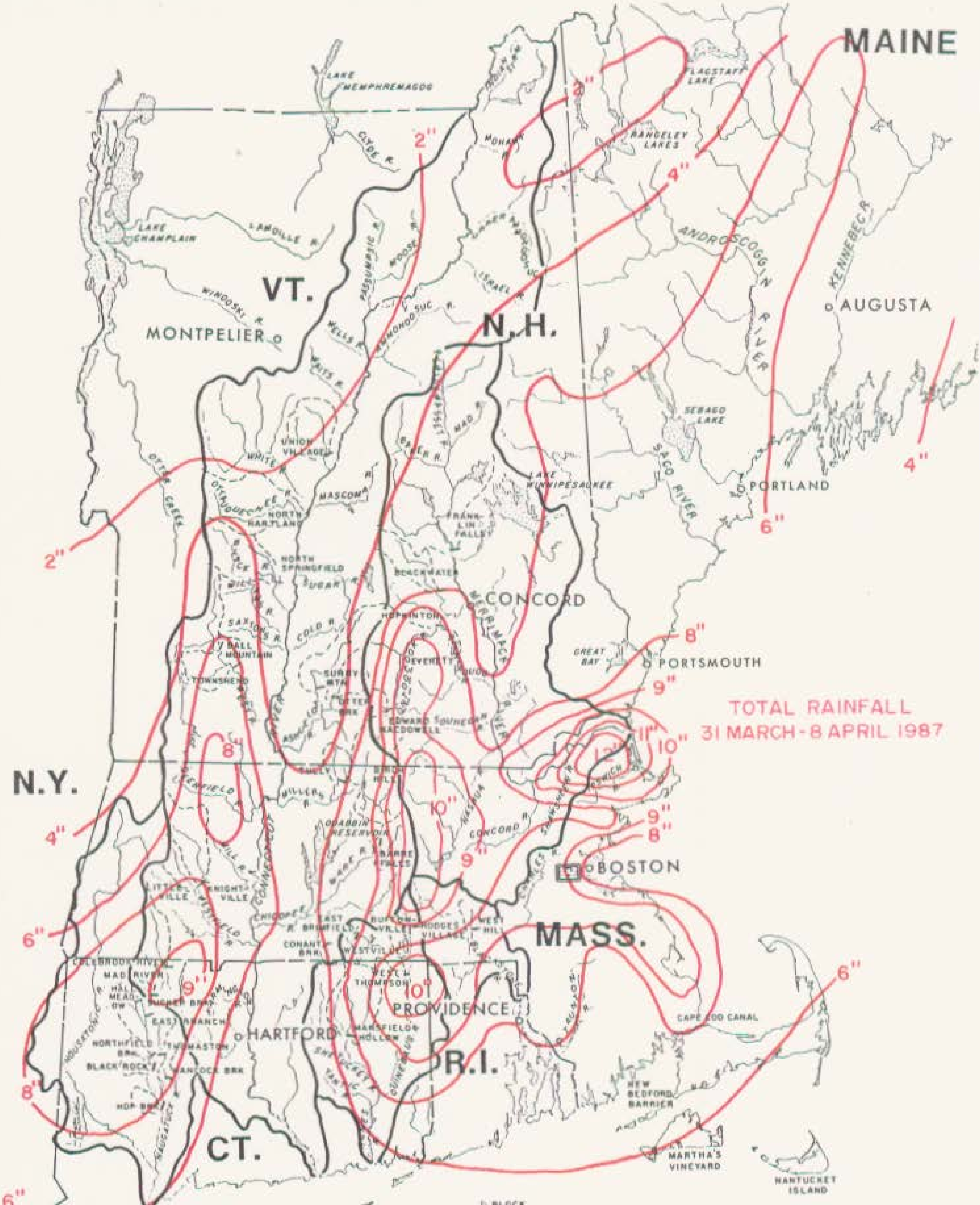
PERCENT STORAGE CURVE

NEW ENGLAND DIVISION WALTHAM, MASS.
MAY 1991



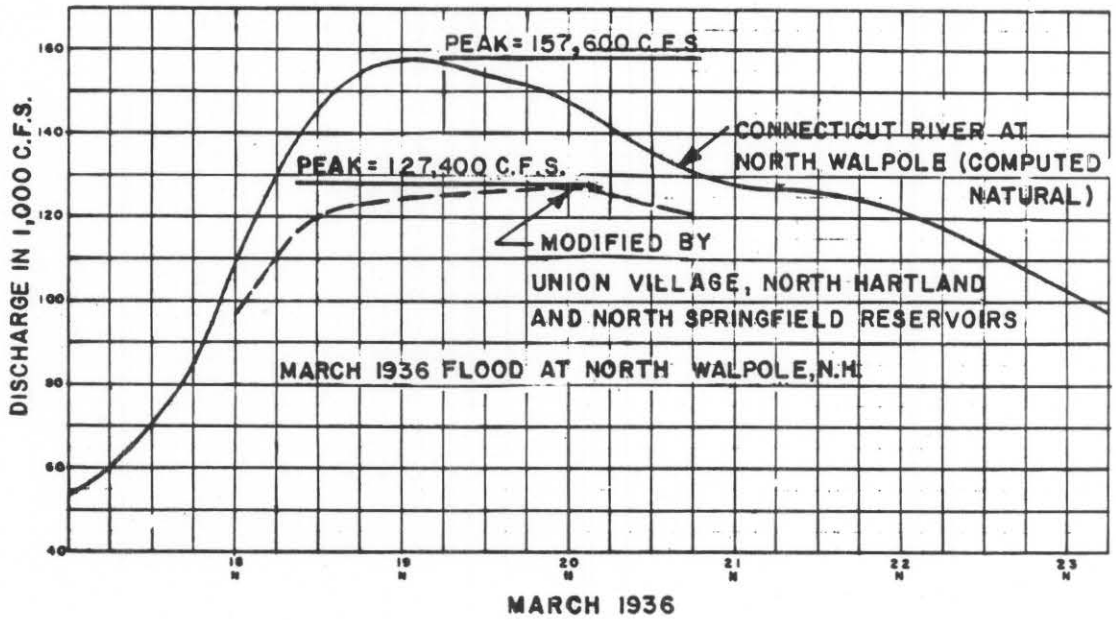
ISOHYETES BY R. LAUTZENHEISER
STATE CLIMATOLOGIST
NEW ENGLAND CLIMATIC SERVICE

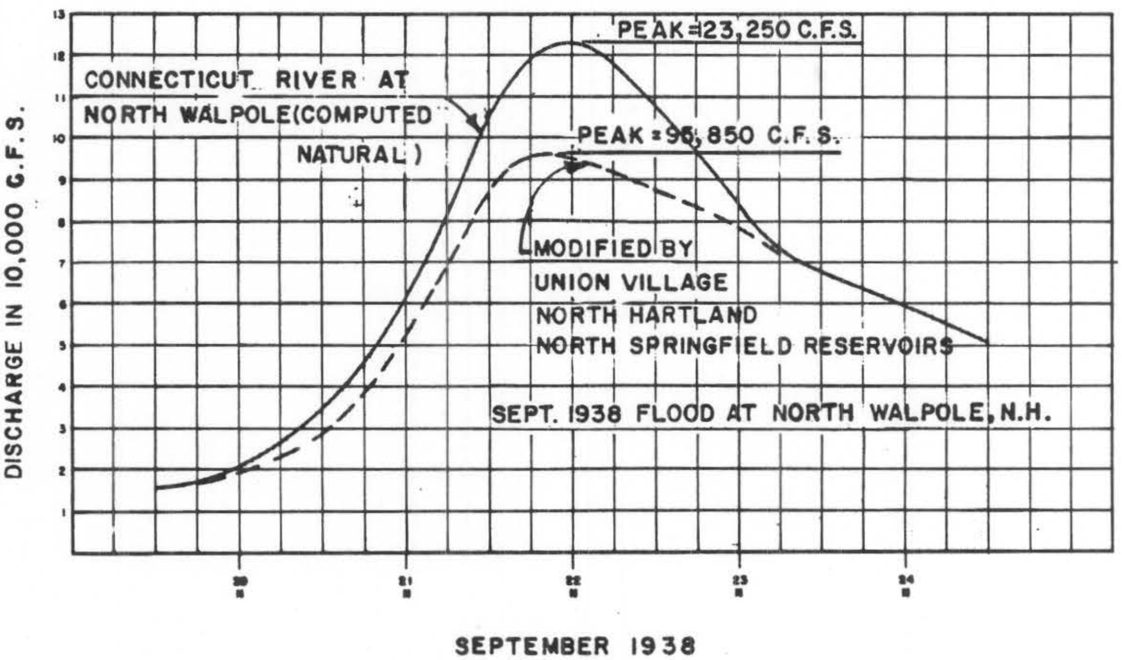
PLATE A-17



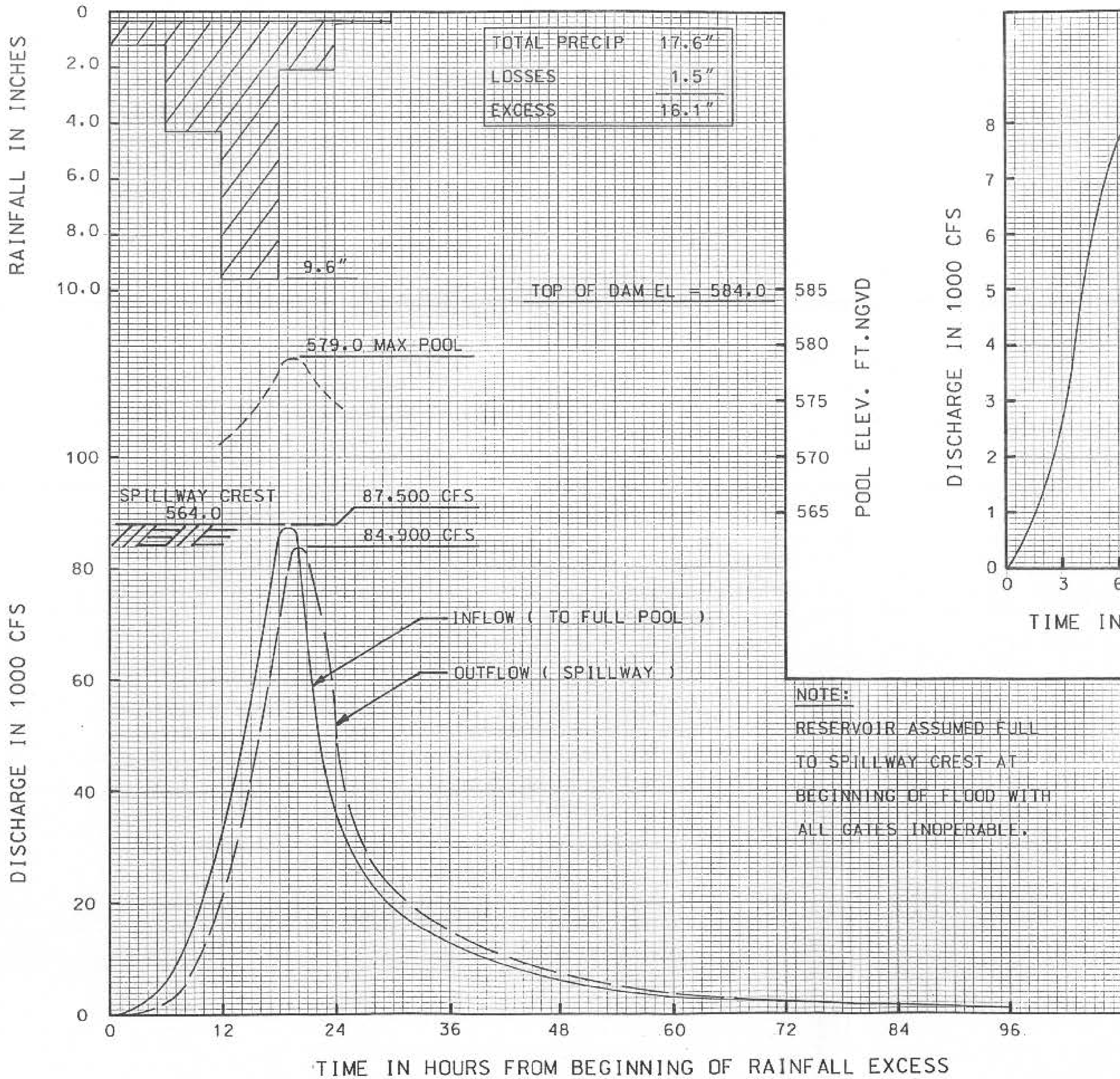
ISOHYETES BY R. LAUTZENHEISER
STATE CLIMATOLOGIST
NEW ENGLAND CLIMATIC SERVICE

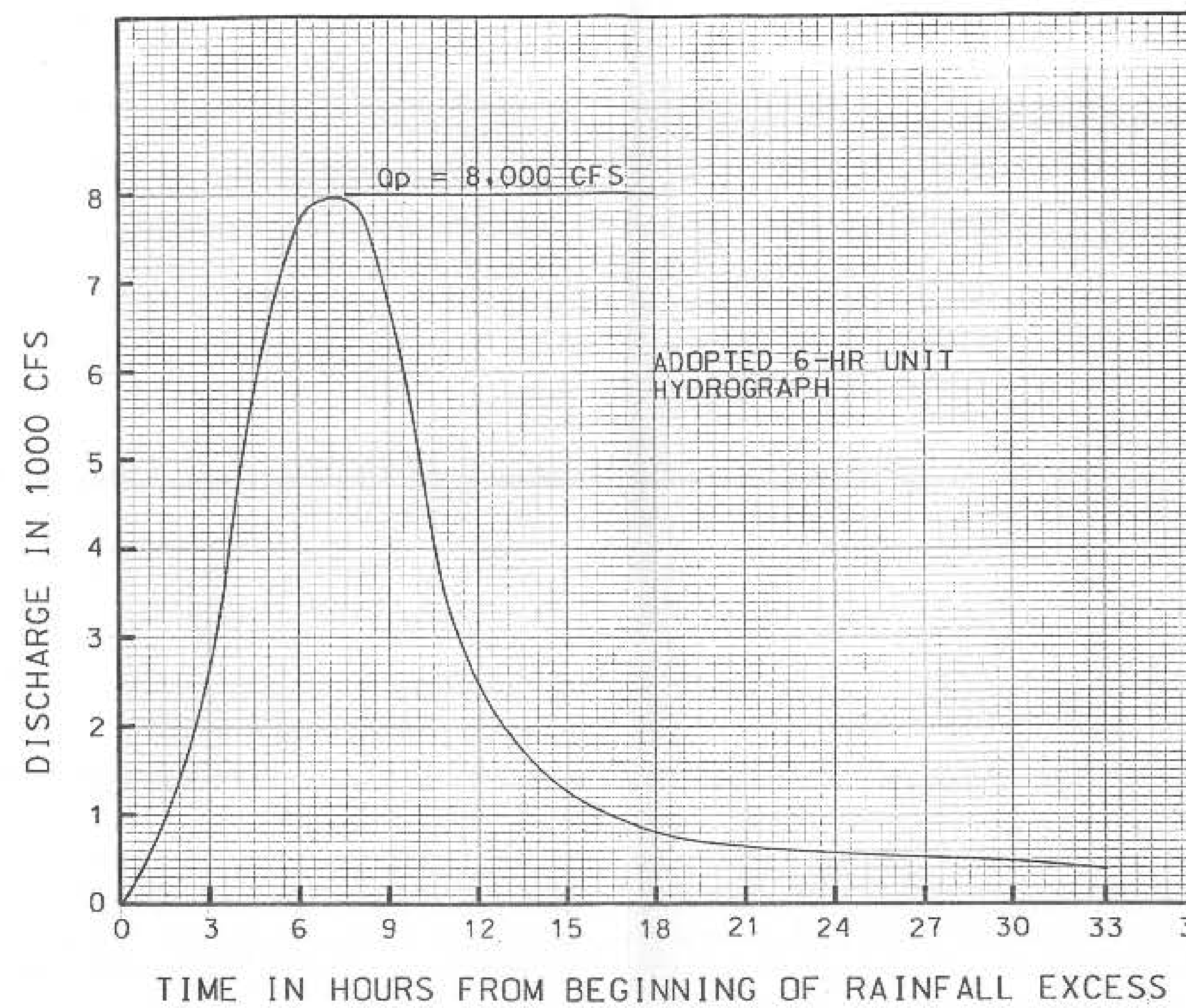
PLATE A-18





CONNECTICUT RIVER FLOOD CONTROL
OMPOMPANOOSUC RIVER, VERMONT
UNION VILLAGE DAM AND RESERVOIR
EFFECT OF RESERVOIR SYSTEM ON 1936 AND 1938 FLOODS
NEW ENGLAND DIVISION WALTHAM, MASS
JAN., 1992





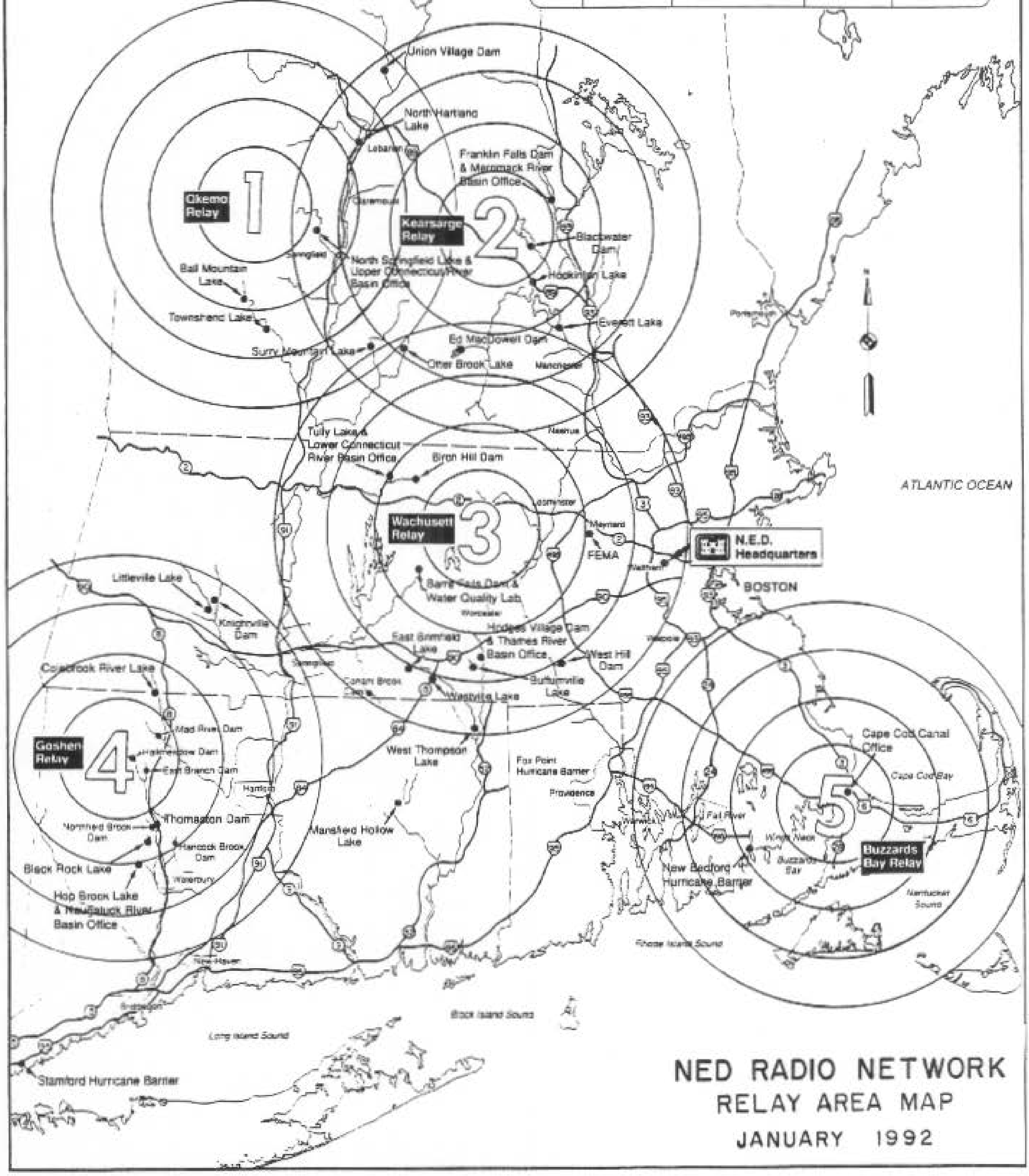
CONNECTICUT RIVER FLOOD CONTROL
UNION VILLAGE DAM
OMPOMPANOOSUC RIVER, VT
(DA = 126 SQ. MI.)
SPILLWAY DESIGN FLOOD

AUG. 1991 N.E.D.

US Army Corps of Engineers
New England Division

Relay Chart

Relay #	Relay Location	Relay River Basin Coverage	Radio Channel Frequency	Relay Telephone Extension
1	Okemo	Upper Connecticut	3	7842
2	Kearsarge	Merrimack	2	7840
3	Wachusett	Lower Conn. & Thames	1	7841
4	Goshen	Naugatuck	2	7839
5	Buzzards Bay	Cape Cod Canal	2	7843



NED RADIO NETWORK
RELAY AREA MAP
JANUARY 1992

CENED-ED-WR

21 October 1993
Mr. Marinelli/mbc/7630

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Schedule for Contacting Reservoir Control Center Personnel at Home

1. Mr. Dave Schafer, who recently joined the RCC staff, has been assigned regulation duties for the Lower Connecticut River Basin. Effective 1 November 1993, the following schedule supersedes the previous one submitted 11 February 1993. Revisions have been kept to a minimum, with changes only in the Lower Connecticut and Blackstone River Basins.

River Basins	#1	#2	#3	#4
Upper Connecticut	Hanlon	Hom	Mirick	Marinelli
Lower Connecticut*	Schafer	Mirick	Hanlon	Marinelli
Merrimack	Hom	Mirick	Hanlon	Marinelli
Naugatuck	Hanlon	Mirick	Hom	Marinelli
Thames	Mirick	Hom	Hanlon	Marinelli
Blackstone	Hom	Mirick	Hanlon	Marinelli

* Colebrook Lake reports to Mirick

Hurricane Barriers

Stamford	All RCC Personnel
New Bedford (hurricanes only)	Marinelli and Mirick

2. Home telephone numbers for RCC personnel are:

Paul Marinelli	508-460-9567	Marlboro, MA
Bob Mirick	508-369-5259	Concord, MA
Victor Hom	508-791-8044	Worcester, MA
Greg Hanlon	508-667-1108	Billerica, MA*
Dave Schafer	517-232-4954	Brookline, MA

* Temporary residence until Dec/Jan

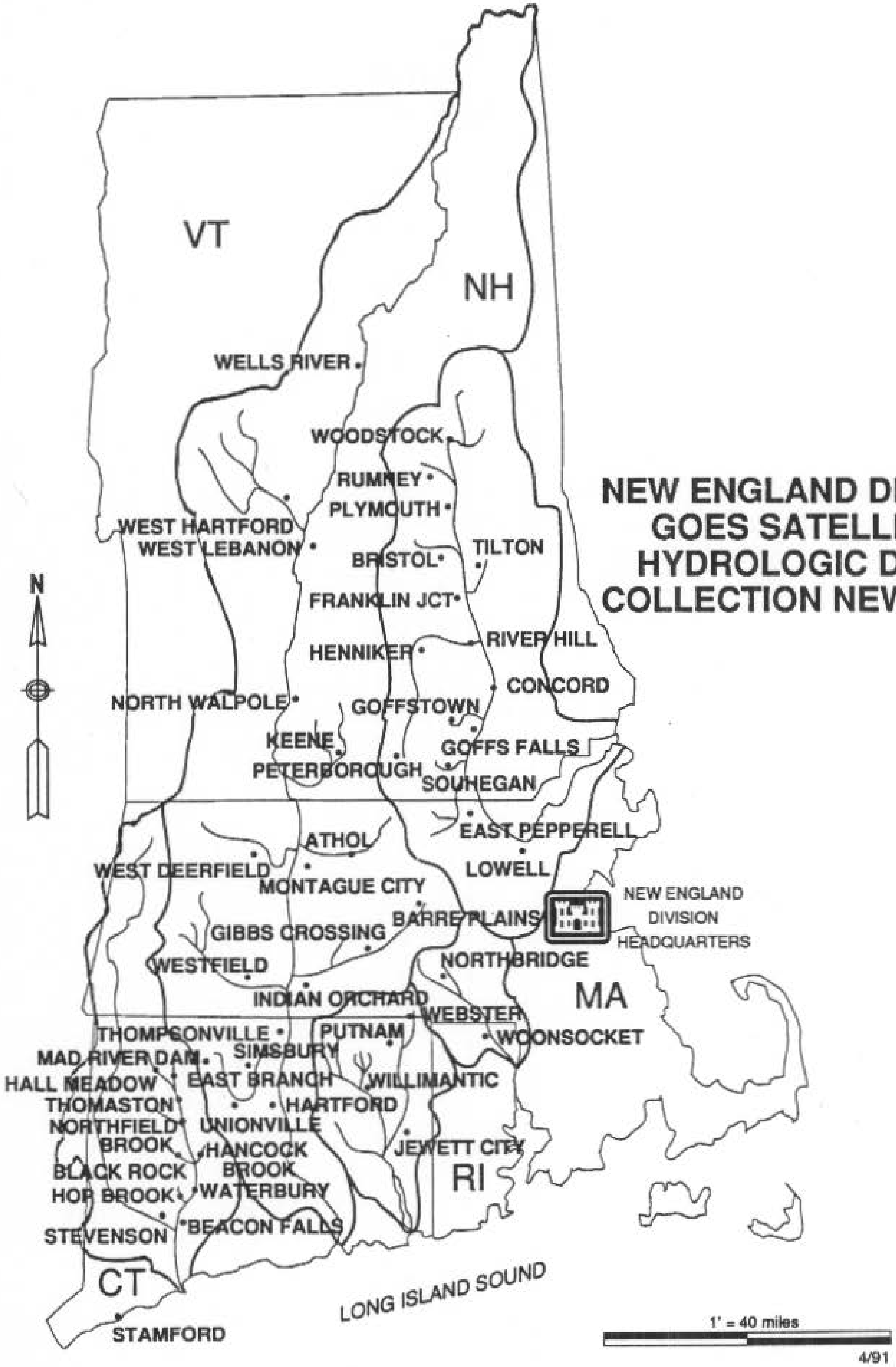
H. Farrell McMillan
H. FARRELL MC MILLAN
Chief, Water Control Division

DISTRIBUTION:
RCC PERSONNEL
OPERATIONS DIRECTORATE
BASIN MANAGERS
PARK MANAGERS

LATEST GOES RRDCS READINGS DATE: 7/19/91 TIME 8:45

NO.	NAME	D.A. SQ MI	M/D	TIME HR:MIN	DT HRS	STAGE FT	+/- FT/HR	Q CFS	+/- Q/HR	CSM Q/DA
38	WELLS RIVER	2644	7/19	7:51	1.0	2.38	.10	1421.	123.	.5
36	WEST HARTFORD	690	7/19	8:09	2.1	2.86	.00	161.	0.	.2
35	WEST LEBANON	4092	7/19	6:18	.7	3.41	.00	781.	0.	.2
37	NORTH WALPOLE	5493	7/19	5:25	2.4	5.61	.04	1700.	62.	.3
15	KEENE	214	7/19	5:23	3.0	66.07	.00	0.	0.	.0
48	ATHOL	280	7/19	7:51	2.1	-4.57	.00	102.	0.	.4
6	MONTAGUE CITY	7865	7/19	5:14	.9	6.50	.00	2940.	0.	.4
46	BARRE PLAINS	115	7/19	6:22	.4	.74	.00	169.	0.	1.5
5	GIBBS CROSSING	199	7/19	7:26	.3	2.10	.00	69.	0.	.3
17	INDIAN ORCHARD	688	7/19	8:33	4.5	4.02	.22	226.	42.	.3
18	WESTFIELD	497	7/19	7:29	.9	3.01	.00	142.	0.	.3
16	THOMPSONVILLE	9661	7/19	7:00	1.8	-.70	.00	4831	0.	.5
27	MAD RIVER DAM	18	7/19	8:07	2.9	17.03	.00	0.	0.	.0
24	UNIONVILLE	378	7/19	8:13	.9	5.04	-.01	287.	-6.	.8
20	SIMSBURY *	497	7/19	5:56	3.5	1.72	.00	268.	0.	.5
19	HARTFORD (NWS)	10480	7/19	7:39	1.7	2.09	.59	5315.	3060.	.5
33	WOODSTOCK	193	7/19	2:24	11.1	2.23	.00	83.	0.	.4
34	RUMNEY	143	7/19	4:29	6.6	.37	.00	13.	0.	.1
32	PLYMOUTH	622	7/19	7:06	.9	.09	.00	182.	0.	.3
40	BRISTOL	86	7/19	2:13	3.7	1.27	.00	10.	0.	.1
39	TILTON	471	7/19	2:42	1.7	2.50	.00	262.	0.	.6
47	FRANKLIN JCT	1507	7/19	3:00	6.3	3.89	.00	717.	0.	.5
44	PETERBOROUGH	68	7/19	8:13	.4	1.17	.00	19.	0.	.3
3	HENNIKER	368	7/19	1:50	7.7	4.55	.00	71.	0.	.2
10	RIVER HILL	760	7/19	4:17	5.1	10.83	.02	369.	8.	.5
11	CONCORD	2385	7/19	7:19	1.8	5.72	.06	7106.	143.	3.0
8	GOFFSTOWN	202	7/19	6:08	3.6	3.18	.00	33.	0.	.2
9	GOFFS FALLS	3092	7/19	7:03	7.2	4.19	.00	2823.	-3.	.9
41	SOUHEGAN	171	7/19	8:18	2.7	2.34	.00	54.	0.	.3
42	EAST PEPPERELL	316	7/19	7:26	1.7	2.17	.38	198.	92.	.6
14	LOWELL	4635	7/19	8.00	.8	41.70	.00	4172	0.	.9
28	HALL MEADOW DAM	17	7/19	1:00	8.3	1.29	.00	14.	0.	.8
30	EAST BRANCH DAM	9	7/19	6:02	4.8	.29	.00	3.	0.	.3
26	THOMASTON DAM	99	7/19	6:35	2.0	.83	.04	29.	2.	.3
31	NORTHFIELD BRK LK	6	7/19	6:40	3.5	21.60	.00	0.	0.	.0
25	BLACK ROCK LAKE	23	7/19	8:14	4.3	25.83	-.01	0.	0.	.0
23	HANCOCK BRK LAKE	12	7/19	3:35	6.4	6.64	.00	0.	0.	.0
29	HOP BROOK LAKE	16	7/19	7:59	1.6	18.16	-.01	3.	-1.	.2
43	WATERBURY	180	7/19	8:12	.9	6.70	-.14	58.	-20.	.3
22	BEACON FALLS	259	7/19	7:40	7.0	1.42	.00	76.	0.	.3
21	STEVENSON	1545	7/19	8:34	5.0	1.12	.00	85.	0.	.1
2	WEBSTER	85	7/19	3:37	2.5	4.34	.00	10.	0.	.1
45	PUTNAM	331	7/19	5:13	4.2	1.99	.00	67.	0.	.2
4	JEWETT CITY	715	7/19	6:45	7.6	4.19	.00	118.	0.	.2
1	WILLIMANTIC	401	7/19	6:19	8.0	1.52	.00	42.	0.	.1
13	NORTHBRIDGE	139	7/19	0:35	9.0	2.81	.00	84.	1.	.6
12	WOONSOCKET	416	7/18	22:16	13.7	1.00	.00	112.	0.	.3
50	STAMFORD BARRIER	2	7/19	8:45	.9	1.91	-1.22	1141.	-1.	86.0

NEW ENGLAND DIVISON GOES SATELLETE HYDROLOGIC DATA COLLECTION NEWTORK



LOG OF RADIO REPORTS - FLOOD CONTROL DAMS

Date 22 APRIL 91

V. HOM

		GOSHEN RELAY				KEARSARGE RELAY					OKEMO RELAY						
		70	72	73	74	44	40	41	42	43	35	36	34	33	30	32	31
	ITEM	THOMAS-TON	BLACK ROCK	HOP BROOK	STAMFORD	MAC DOWELL	FRANKLIN FALLS	BLACK WATER	HOPKINTON	EVERETT	SURRY MT.	OTTER BROOK	TOWNS-HEND	BALL MT.	NORTH SPRINGFIELD	NORTH HARTLAND	UNION VILLAGE
1	Time of Observation										1100	1100	1045	1045	1100	1100	1100
2	Precipitation (last 24 hrs.)										.07	.10	.14	.11	.08	.05/1.15	–
3	Form of Precipitation										R	R	R	R	R	R	–
4	Present Weather										L.R.	L.R.	M.R.	L.R.	L.R.	mist	Cldy.
5	Pool Stage										17.4	20.15	45.2	115.1	28.33	50.3	26.0
6	Tendency										R	F	F	R	R.S.	R	F
7	Gate Openings										3'-3'	3'-3'-3'	5'-8'-5'	3'-3'-3'	5'-8'-5'	10'-10'-10'	4'-4'
8	Tailwater Gage										6.63	7.95	–	–	–	6.75	5.88
9	Outflow										372	421	5,130	2,775	2,700	3,246	880
10	INDEX POINTS											Ashuelot R. @ Keene 468.3	West R. @ Newfane 6.68		Conn. R. @ N. Walp. 17.19	White R. @ W. Har. 9.73	Conn R. @ Wells R 6.16
11													2,550		38,360	8,922	12,976
12																VEC 3"	
13																44°	
14																	
15																	
	REMARKS										No Change	Go to 3½'-3'-3½'	Go to 7'-8'-7'	Go to 4'-4'-4'	Go to 7'-8'-7'	No Change	No Change
	Call @										1430	1430	1430	1430	1430	1430	1430
											4/22	4/22	4/22	4/22	4/22	4/22	4/22

NED Form 477(B)
Oct. 75

NED FORM APR 65 503

REGULATION OF AND RESERVOIRS

RCS NEDED-3

LOG OF REPORTS AND INSTRUCTIONS

DATE AND TIME OF REPORT	Union Village RES. — RES POOL: HOUR	STAGE	GATE OPENING: 1	2	3	4	5	6	7	8	OUTFLOW: T.W.	C.F.S.	RES. — RES POOL: HOUR	STAGE	GATE OPENING: 1	2	3	OUTFLOW: T.W.	C.F.S.	Union Village — PRECIPITATION: LOCATION	HOUR	INCHES: INC	ACC.	Connecticut RIVER AT Wells River: HOUR	STAGE	C.F.S	RIVER AT: HOUR	STAGE	C.F.S	RIVER AT: HOUR	STAGE	C.F.S	HOUR	STAGE	C.F.S
3/16/91	0700	31.2	3	0							5.65	765																							
	0730	31.3	3	2							6.50	1250																							
	1350	27.9	3	3							6.75	1419																							
3/17	840	26.8	3	3							6.79	1,447																							
	1730	30.2	1	0							4.20	247																							
3/18	0745	50.6	1	0							4.70	392								U.V.	0700	.2		0700	10.7	33,400									
3/19	0700	60.2	1	0							4.70	392								U.V.	0700	.2		0700	8.96	26,292									
	0830		1	1								800																							
	1130	61.3	1.5	1.5							5.20	575																							
	1300	61.4	1.5	1.5							6.30	1,120																							
3/20	0700	59.0	1.5	1.5							6.25	1,090								U.V.	0700	.4		0700	7.81	21,226									
	0800	58.9	2	2							6.25	1,090																							
	1400	57.1	2	2							6.90	1520												1400	8.67	25048									
3/21	0700	52.1	2	2							6.80	1,454								U.V.	0700	.8		0700	9.06	26,712									
	0730	52.0	2.5	2							7.0	1639																							
	1300	50.2	2.5	2.5							7.2	1800																							
	1400		2.5	2.5							7.25	1800												1400	8.75	25,400									
3/22	0700	41.1	2.5	2.5							7.0	1600												0700	7.00	18,288									
	1400	36.0	2.5	2.5							6.8	1,454												1400	6.6	15,660									
3/23	0700	25.7	2.5	2.5							6.35	1,152																							

GATE OPERATION RECORD

Union Village **RESERVOIR** June **MONTH** 91 **YEAR**

OPERATOR

I.D.	DAY	HOUR	RES. STAGE	OUTFLOW	PRECIP.	T. W.	GATE SETTING		REMARKS
41	01	0700	9.3	140	.25	382	OUT	4.0	PC
	02	0600	8.3	121	.	372	OUT	4.0	Fog
	03	0700	7.9	111	.	370	OUT	4.0	Clr
	04	0700	7.4	98	.	364	OUT	4.0	PC
41	05	0700	7.3	102	.	366	OUT	4.0	Cldy
	06	0700	7.1	92	.	362	OUT	4.0	Fog
	07	0700	6.8	90	.	360	OUT	4.0	Clr
	08	0600	7.0	90	.	360	OUT	4.0	Clr
41	09	0600	6.8	78	.	350	OUT	4.0	Clr
	10	0700	6.8	78	.	350	OUT	4.0	Clr
	11	0700	6.8	59	.	340	OUT	4.0	PC
	12	0700	6.9	66	.10	350	OUT	4.0	Cldy
41	13	0700	6.7	66	.13	350	OUT	4.0	Cldy
	14	0700	6.5	59	.	342	OUT	4.0	Clr
	15	0700	6.1	55	.	340	OUT	4.0	PC
	16	0800	6.2	55	.10	346	OUT	4.0	Cldy
41	17	0700	6.5	65	.30	345	OUT	4.0	Cldy
	18	0700	6.7	90	.	360	OUT	4.0	PC
	19	0700	5.8	65	.	345	OUT	4.0	Fog
	20	0700	6.5	55	.	340	OUT	4.0	Fog
41	21	0700	6.1	44	.	334	OUT	4.0	PC
	22	0840	6.0	41	.	331	OUT	4.0	PC
	23	0820	5.7	40	.	330	OUT	4.0	Clr
	24	0700	5.7	40	.	330	OUT	4.0	Clr
41	25	0700	6.5	35	.	326	OUT	4.0	Clr
	26	0700	6.2	34	.	325	OUT	4.0	Clr
	27	0700	6.1	31	.	323	OUT	4.0	Hzy
	28	0700	6.3	30	.	321	OUT	4.0	Hzy
41	29	0600	6.3	30	.10	321	OUT	4.0	Hzy
	30	0600	6.2	28	.	320	OUT	4.0	Lt Rain

NED FORM SEP 70 90 REPLACES EDITION OF MAR 62 WHICH IS OBSOLETE

NED FORM 102
15 Nov. 1951

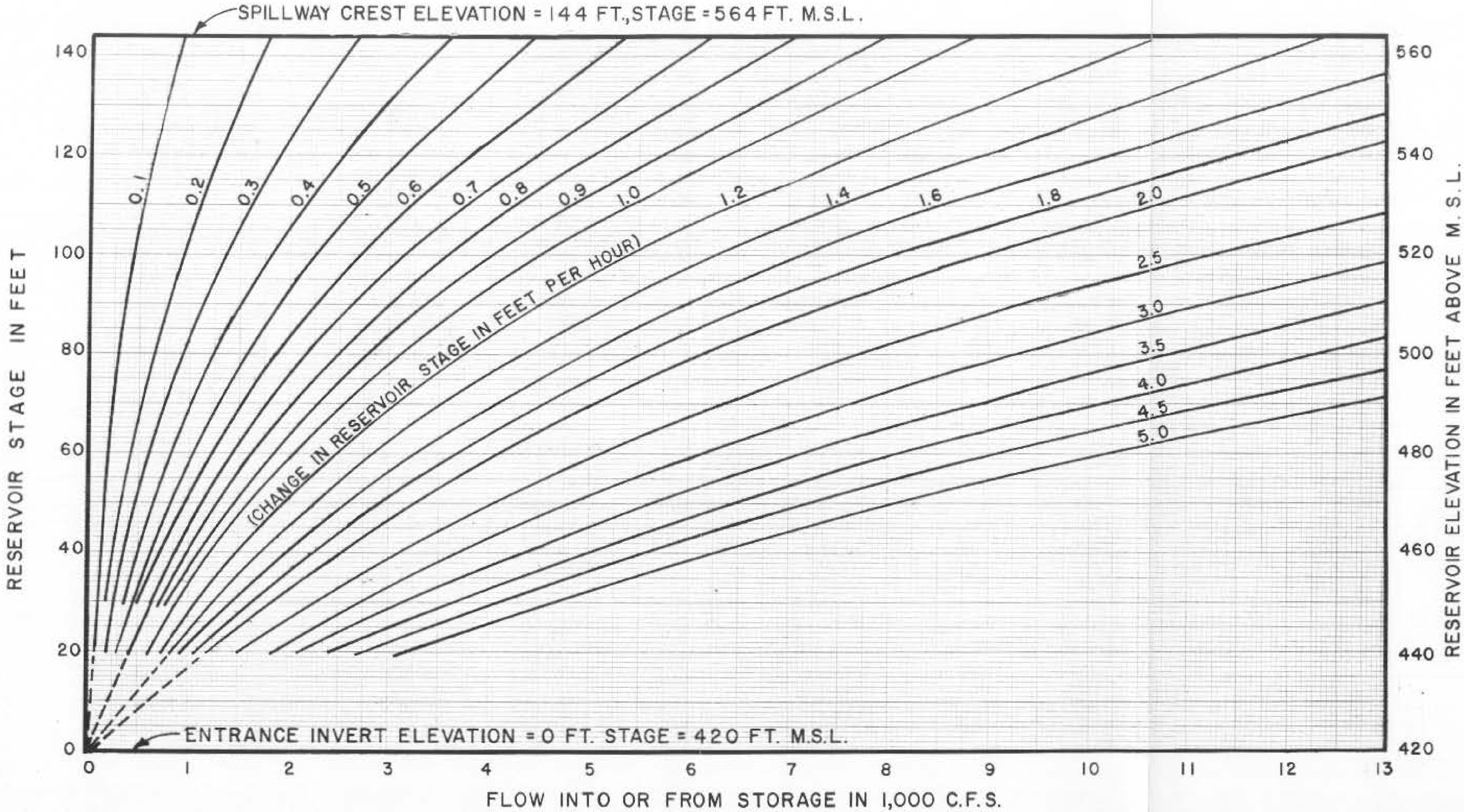
* RESERVOIR REGULATION
COMPUTATION OF INFLOW

Flood of March-April 1987

Reservoir Union Village By ______ Date ______

TIME	RES. STAGE Feet	CHANGE IN RES. STAGE Feet per hour Observed	Adjusted	FLOW into/from STORAGE c. f. s.	OUTFLOW c. f. s.	TOTAL INFLOW (5) ≠ (6) c. f. s.	REMARKS
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
3/31/87							
0700	43.00						
		1.0	1.0	970	640	1,610	
1000	45.90						
		1.6	1.6	1920	390	2,310	
1400	52.40						
		2.4	2.4	3,900	150	4,050	
1800	62.10						
4/1/91		1.8	1.8	4,660	100	4,760	
0700	85.10						
		0.9	0.9	3,120	370	3,490	
1000	87.80						
		0.4	0.4	1,430	380	1,810	
1400	89.30						
		0.4	0.4	1,650	380	2030	
1800	91.00						
		0.3	0.3	1,290	390	1,680	
2200	92.30						

* ALL VALUES ESTIMATED



CONNECTICUT RIVER FLOOD CONTROL
OMPOMPANOOSUC RIVER WATERSHED

UNION VILLAGE RESERVOIR

INFLOW CURVES

U.S ARMY ENGINEER DIVISION NEW ENGLAND
CORPS OF ENGINEER WALTHAM, MASS.
FEBRUARY 1992

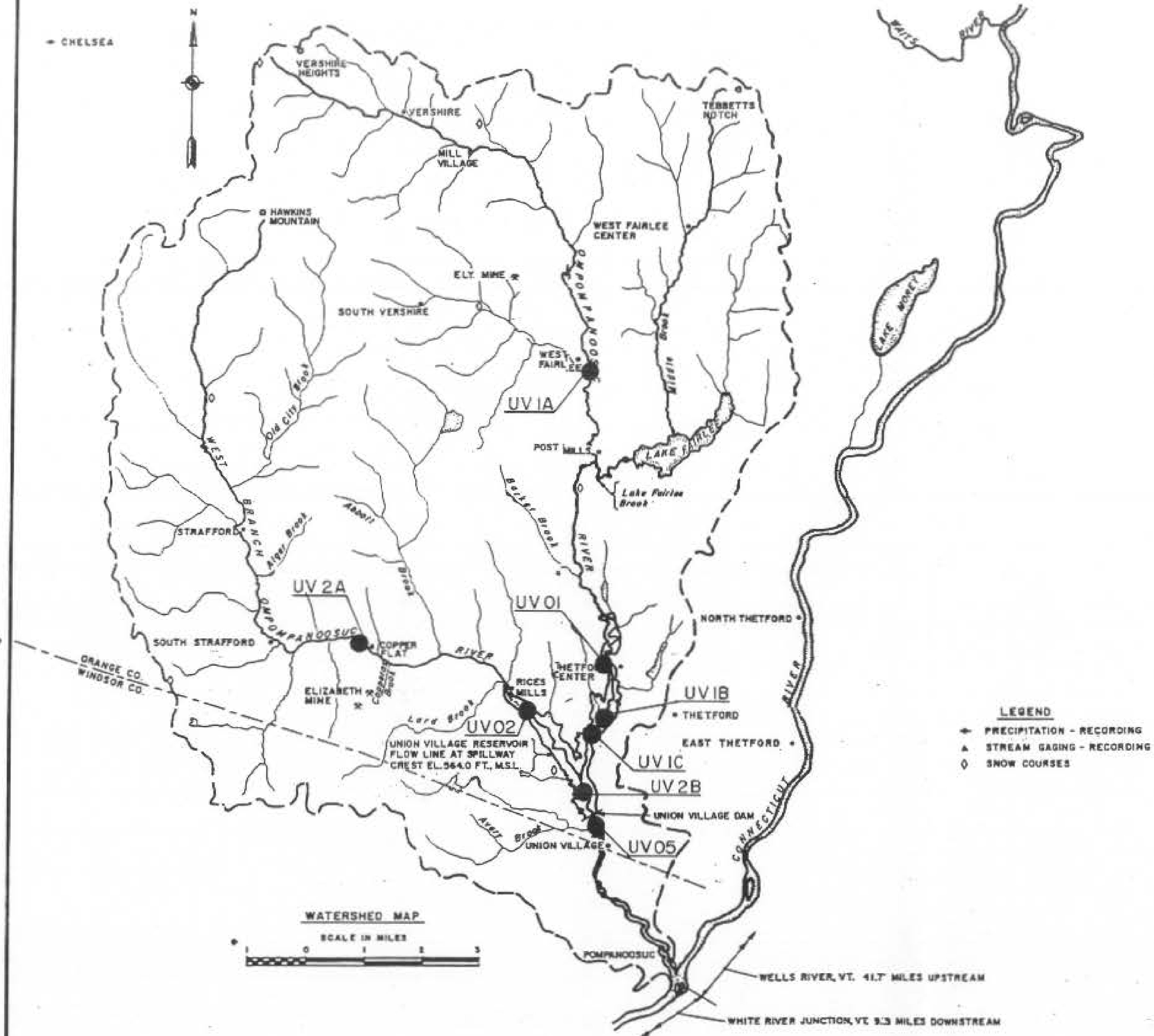
PLATE A-29

SNOW BULLETIN 92 - 4

TABULATION OF SNOW DATA FOR 10 FEBRUARY 1992

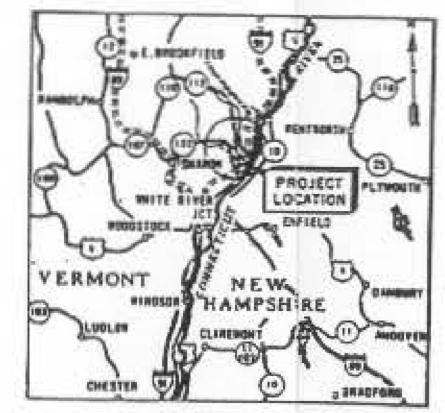
LOCATION	EXISTING CONDITIONS				PERIOD OF RECORD			
	DEPTH IN INCHES(1) SNOW	WATER	PERCENT OF AVERAGE(2)	DENSITY %	YEARS	WATER EQUIVALENT MAXIMUM	MINIMUM	AVERAGE
CONNECTICUT RIVER BASIN								
OMPOMPANOOSUC RIVER	7	2.0	45	29	41	7.6	.1	4.5
OTTAUQUECHEE RIVER	7	1.7	31	25	30	9.6	.1	5.4
BLACK RIVER	6	1.7	35	28	31	8.5	.1	4.8
WEST RIVER	9	2.1	39	23	34	9.9	.3	5.3
ASHUELOT RIVER		NO SNOW			42	8.0	.0	3.3
MILLERS RIVER		NO SNOW			42	5.8	.0	2.5
CHICOPEE RIVER		NO SNOW			35	5.6	.0	2.4
WESTFIELD RIVER		PATCHES			42	8.0	.0	3.5
FARMINGTON RIVER		PATCHES			35	5.4	.0	2.1
MERRIMACK RIVER BASIN								
PEMIGEWASSET RIVER	7	2.0	38	28	51	9.1	.0	5.2
CONTOOCOOK RIVER		PATCHES			41	8.9	.0	4.0
PISCATAQUOG RIVER		PATCHES			29	7.9	.0	4.2
THAMES RIVER BASIN								
SHETUCKET RIVER		NO SNOW			34	5.8	.0	1.3
QUINEBAUG RIVER		NO SNOW			34	5.5	.0	1.7
HOUSATONIC RIVER BASIN								
NAUGATUCK RIVER		NO SNOW			35	5.8	.0	1.7
BLACKSTONE RIVER BASIN								
BLACKSTONE RIVER		NO SNOW			35	6.0	.0	1.7

(1) BASED ON OBSERVATIONS AND MEASUREMENTS
(2) COMPARISON OF EXISTING WATER EQUIVALENTS TO AVERAGE
WATER EQUIVALENT ON THIS DATE FOR PERIOD OF RECORD



UNION VILLAGE DAM STATION LOCATIONS

UV01	Located on the East Branch of the Ompompanoosuc River at the Covered bridge on Tucker Hill Road, Thetford Center, VT
UV1A	Located on the East Branch of the Ompompanoosuc River in West Fairlee, VT.
UV1B	Located on the East Branch of the Ompompanoosuc River below the confluence with an unnamed stream 1 mile below the Thetford Center bridge.
UV1C	Located on the East Branch of the Ompompanoosuc River one quarter mile below station UV1B.
UV02	Located on the West Branch of the Ompompanoosuc River at the bridge where Route 132 intersects Tucker Hill Road, Thetford, VT.
UV2A	Located on the West Branch of the Ompompanoosuc River in South Stratford, VT.
UV2B	Located on the main stem of the Ompompanoosuc River about 2 tenths of a mile below the confluence of the East and West Branches.
UV05	Located on the Ompompanoosuc River below Union Village Dam but above Avery Brook, Union Village, VT.



CONNECTICUT RIVER FLOOD CONTROL
OMPOMPANOOSUC RIVER WATERSHED
BASELINE
WATER QUALITY STATIONS
FEBRUARY 1992
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

STANDARD OPERATING PROCEDURE (SOP)
FLOOD CONTROL REGULATION

UNION VILLAGE DAM

PHASE	STORM RAINFALL (WITHIN 24-HOUR PERIOD) ANTECEDENT CONDITIONS		POOL STAGE FEET	RIVER INDEX STATIONS					REGULATION INSTRUCTIONS
				WHITE RIVER AT	CONNECTICUT RIVER AT				
	SNOW-COVERED, WET OR FROZEN GROUND	DRY GROUND		WEST HARTFORD 690 SQ.MI.	WELLS RIVER 2,644 SQ.MI.	WEST LEBANON 4,092 SQ.MI.	NORTH WALPOLE 5,493 SQ.MI.	MONTAGUE CITY 7,865 SQ.MI.	
I - APPRAISAL INITIAL ALERT	1.0"	1.0"	SUMMER 10' (Rising) WINTER 25' (Rising)	10.0' (9,580 CFS)	7.5' (18,700 CFS)	14.0' (29,300 CFS)	24.0' (66,740 CFS)	25.0' (64,090 CFS)	NORMAL GATE SETTINGS
INITIAL REGULATION	2.0"	3.0"	N\A	10.0' (9,580 CFS)	7.5' (18,700 CFS)	14.0' (29,300 CFS)	24.0' (66,740 CFS)	25.0' (64,090 CFS)	N\A
II CONTINUATION OF REGULATION	3.0"	4.0"	N\A	N\A	10.0' (30,400 CFS)	17.0' (41,300 CFS)	26.0' (75,920 CFS)	25.0' (64,090 CFS)	RESTRICT OUTFLOW TO 10 CFS
III EVACUATION OF POOL	STORM AND/OR FLOOD HAS ABATED		NON-DAMAGING CHANNEL CAPACITY AT UNION VILLAGE DAM IS ABOUT 2400 CFS. **ALL GATE SETTINGS AND ALERT CONDITIONS SUBJECT TO CHANGE BY RCC.**						

EMERGENCY OPERATION PROCEDURE

(DURING COMMUNICATIONS FAILURE WITH RCC)

	COMPLETE CLOSURE
GATE SETTINGS	(0.0' - 0.1')
RAINFALL IN 24 HOURS	3.0"

RISING RIVER STAGES

CONNECTICUT RIVER AT:	
WELLS RIVER	10.0'
WEST LEBANON	17.0
NORTH WALPOLE	26.0'
MONTAGUE CITY	25.0'

NOTES:

1. EMPTYING THE RESERVOIR SHALL NOT BE INITIATED UNTIL CONTACT HAS BEEN ESTABLISHED WITH RCC.
2. THE RATE OF INCREASE IN RESERVOIR DISCHARGE SHALL NOT EXCEED 300 CFS/HOUR TO 1800 CFS THEN 100 CFS/HOUR TO 2400 CFS.
3. THE MAXIMUM RATE OF RESERVOIR DRAWDOWN SHOULD NOT EXCEED 15 FEET IN 24 HOURS.
4. MAXIMUM NON-DAMAGING CHANNEL CAPACITIES AT ABOVE INDEX STATIONS ARE AS FOLLOW:

CONNECTICUT RIVER AT:	WELLS RIVER -	13.0	FEET	= 41,000 CFS
	WEST LEBANON -	22.0	FEET	= 63,000 CFS
	NORTH WALPOLE -	30.0	FEET	= 95,000 CFS
	MONTAGUE CITY -	30.0	FEET	= 89,000 CFS
WHITE RIVER AT:	WEST HARTFORD -	18.0	FEET	= 37,000 CFS

5. RELEASES FROM STORAGE WILL BE COORDINATED WITH NEW ENGLAND POWER CO., DURING FLOOD PERIODS.
6. CLOSE THE TWO BARRIERS ON THE EAST ACCESS ROAD WHEN THE RESERVIOR STAGE IS EXPECTED TO RISE ABOVE 40'.
7. CLOSE THE TWO BARRIERS ON THE WEST ACCESS ROAD WHEN THE RESERVOIR STAGE IS EXPECTED TO RISE ABOVE 64'.

DUTIES DURING EACH PHASE

FLOOD CONTROL PROJECT MANAGER

PHASE I

1. COLLECT AND REPORT RAINFALL AND STAGE DATA TO RCC.
2. OPERATE ACCORDING TO INSTRUCTIONS FROM RCC.

PHASE II

1. OPERATE ACCORDING TO INSTRUCTIONS FROM RCC.
2. NOTE ANY UNUSUAL CONDITIONS AT DAM, IN DOWNSTREAM CHANNEL OR AT INDEX STATIONS.
3. COLLECT AND RELAY RAINFALL, STAGE AND FLOW DATA AS DIRECTED BY RCC.

PHASE III

1. CONTINUE PHASE II, STEP 3.
2. RECONNOITER DOWNSTREAM CHANNELS AND POTENTIAL DAMAGE AREAS.
3. REPORT TO RCC FOR FURTHER INSTRUCTIONS.

BASIN REGULATOR

PHASE I

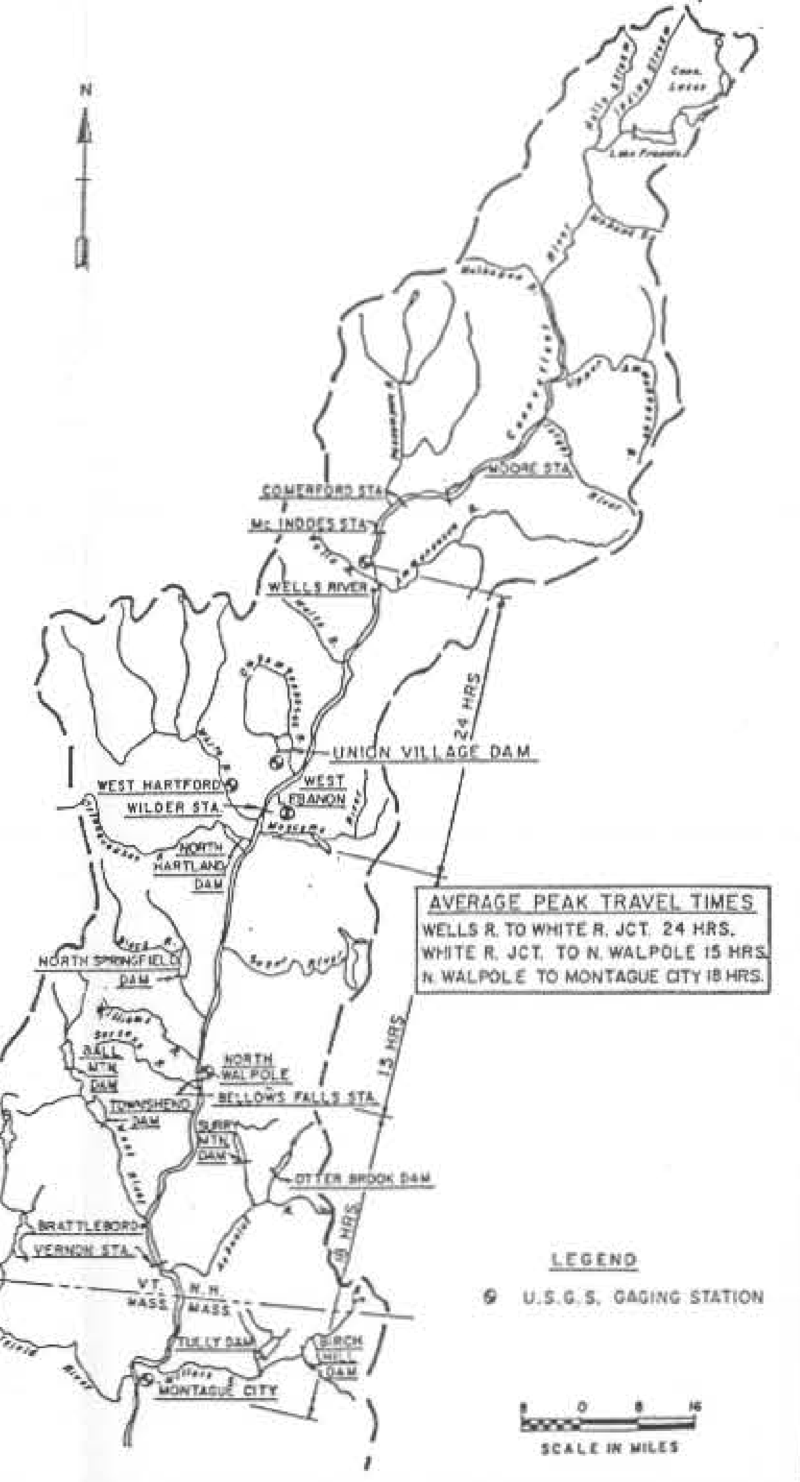
1. COMPILE DATA.
2. PLAN AND COORDINATE NEXT INSTRUCTIONS TO PROJECT MANAGERS.
3. RESTRICT OUTFLOW TO MAINTAIN SAFE DOWNSTREAM CHANNEL CAPACITES.
4. INFORM CHIEF OF RCC OF ACTIONS TAKEN.

PHASE II

1. CONTINUE REGULATION INSTRUCTIONS TO PROJECT MANAGERS.
2. INFORM RCC CHIEF AS TO SEVERITY OF FLOOD AND ACTIONS TAKEN.

PHASE III

1. COLLECT DATA FROM PROJECT MANAGERS.
2. TRANSMIT INSTRUCTIONS TO PROJECT MANAGERS UNTIL FLOOD HAS ABATED.



EXPANDED RATING TABLE TYPE: LOG

01141500 DATE PROCESSED: 08-20-1991 @ 13:11 BY KTOPRIN

OMPOMPANOOSUC RIVER AT UNION VILLAGE, VT DD: 2 TYPE: 001 RATING NO: 29.0

OFFSET: 2.30 BREAK,OFFSET: (4.20,1.60) START DATE/TIME: 10-20-89 (1000)

BASED ON ______ DISCHARGE MEASUREMENTS, NOS ______, AND ______, AND IS ______ WELL DEFINED BETWEEN ______ AND ______ CFS

COMP BY ____ DATE ______ CHK. BY ____ DATE ______

RATING 29 SAME AS RATING 24

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND					(STANDARD PRECISION)					DIFF IN Q PER TENTH FT
	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	
2.70						6.0*	6.3	6.6	7.0	7.3	3.4
2.80	7.7	8.0	8.4	8.8	9.2	9.6	10.0*	10.5	10.9	11.4	4.2
2.90	11.9	12.5	13.0*	13.6	14.2	14.8	15.4	16.0	16.7	17.3	6.1
3.00	18.0*	18.7	19.5	20.2	21.0	21.8	22.6	23.4	24.2	25.1	8.0
3.10	26.0*	27.1	28.2	29.3	30.4	31.6	32.8	34.1	35.3	36.7	12.0
3.20	38.0*	39.1	40.2	41.4	42.6	43.7	45.0	46.2	47.4	48.7	12.0
3.30	50.0*	51.9	53.8	55.8	57.9	60.0*	61.9	63.9	65.9	67.9	20.0
3.40	70.0*	71.9	73.9	75.9	77.9	80.0*	81.9	83.9	85.9	87.9	20.0
3.50	90.0*	91.9	93.9	95.9	97.9	100*	102	104	106	108	20.0
3.60	110	111	113	115	117	120	122	124	126	128	20.0
3.70	130*	132	134	136	138	140	142	144	146	148	20.0
3.80	150*	152	155	157	159	162	164	167	169	171	24.0
3.90	174	176	179	182	184	187	189	192	195	197	26.0
4.00	200*	202	204	207	209	211	214	216	218	221	23.0
4.10	223	225	228	230	232	235	237	240	242	245	24.0
4.20	247*	250	252	255	258	261	264	266	269	272	28.0
4.30	275	278	281	284	287	290	293	296	299	302	30.0
4.40	305*	308	310	313	316	318	321	324	326	329	27.0
4.50	332	335	337	340	343	346	349	351	354	357	28.0
4.60	360*	363	366	369	372	376	379	382	385	388	32.0
4.70	392	395	398	401	405	408	411	415	418	422	33.0
4.80	425*	429	432	436	440	444	447	451	455	459	38.0
4.90	463	467	471	475	479	483	487	491	495	499	40.0
5.00	503	507	511	515	519	524	528	532	536	541	42.0
5.10	545*	548	551	554	557	560	563	566	569	572	30.0
5.20	575	578	581	584	587	590	593	596	599	602	30.0
5.30	605*	609	614	618	622	626	631	635	640	644	43.0
5.40	648	653	657	662	666	671	675	680	685	689	46.0
5.50	694	698	703	708	712	717	722	727	731	736	47.0
5.60	741	746	751	755	760	765	770	775	780	785	49.0
5.70	790*	795	800	805	810	815	820	825	830	835	50.0
5.80	840	845	850	855	860	865	870	876	881	886	51.0
5.90	891	897	902	907	912	918	923	928	934	939	54.0
6.00	945	950	956	961	967	972	978	983	989	994	55.0
6.10	1000*	1010	1010	1020	1020	1030	1040	1040	1050	1050	60.0
6.20	1060	1070	1070	1080	1080	1090	1100	1100	1110	1110	60.0
6.30	1120	1130	1130	1140	1150	1150	1160	1160	1170	1180	60.0
6.40	1180	1190	1200	1200	1210	1220	1220	1230	1240	1240	70.0

PLATE A-33 a

EXPANDED RATING TABLE TYPE: LOG

01141500 DATE PROCESSED: 08-20-1991 @ 13:11 BY KTOPRIN

OMPOMPANOOSUC RIVER AT UNION VILLAGE, VT DD: 2 TYPE: 001 RATING NO: 29.0

OFFSET: 2.30 BREAK,OFFSET: (4.20,1.60) START DATE/TIME: 10-20-89 (1000)

RATING 29 SAME AS RATING 24

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (STANDARD PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
6.50	1250*	1260	1260	1270	1280	1280	1290	1300	1300	1310	70.0
6.60	1320	1320	1330	1340	1340	1350	1360	1360	1370	1380	60.0
6.70	1380	1390	1400	1400	1410	1420	1430	1430	1440	1450	70.0
6.80	1450	1460	1470	1480	1480	1490	1500	1500	1510	1520	80.0
6.90	1530	1530	1540	1550	1560	1560	1570	1580	1580	1590	70.0
7.00	1600*	1610	1620	1620	1630	1640	1650	1650	1660	1670	80.0
7.10	1680	1690	1690	1700	1710	1720	1730	1730	1740	1750	80.0
7.20	1760	1770	1770	1780	1790	1800	1810	1810	1820	1830	80.0
7.30	1840	1850	1860	1860	1870	1880	1890	1900	1910	1920	80.0
7.40	1920	1930	1940	1950	1960	1970	1980	1980	1990	2000	90.0
7.50	2010	2020	2030	2040	2050	2060	2060	2070	2080	2090	90.0
7.60	2100*	2110	2120	2130	2130	2140	2150	2160	2170	2180	90.0
7.70	2190	2200	2200	2210	2220	2230	2240	2250	2260	2270	90.0
7.80	2280	2280	2290	2300	2310	2320	2330	2340	2350	2360	90.0
7.90	2370	2380	2390	2390	2400	2410	2420	2430	2440	2450	90.0*
8.00	2460*										

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY - WATER RESOURCES DIVISION

EXPANDED RATING TABLE DATE PRINTED 08-17-83

01144000 WHITE RIVER AT WEST HARTFORD, VT TYPE LOG(SCALE OFFSET = 1.50) RATING NO 37

BASED ON _______ DISCHARGE MEASUREMENTS, NO.__________, AND ______, AND IS _____ WELL DEFINED BETWEEN _____ AND _____

FROM _________ TO _________, FROM _________ TO _________ *COMP BY _____ DATE _____ *CKD. BY _____ DATE _____

GAGE HEIGHT IN FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	DIFF IN Q PER FOOT GH
	DISCHARGE IN CUBIC FEET PER SECOND (STANDARD PRECISION)										
2.00						72	91	114	139	167	
3.00	197	229	264	302	342	385	432	481	533	587	448
4.00	645	706	771	839	910	982	1060	1140	1220	1300	745
5.00	1390	1480	1570	1670	1770	1870	1970	2080	2190	2300	1030
6.00	2420	2540	2660	2780	2910	3040	3170	3310	3450	3590	1320
7.00	3740	3880	4040	4190	4350	4510	4670	4840	5010	5180	1620
8.00	5360	5540	5720	5900	6090	6280	6480	6670	6880	7080	1930
9.00	7290	7500	7720	7930	8160	8380	8610	8850	9090	9330	2290
10.00	9580	9830	10100	10300	10600	10900	11100	11400	11700	12000	2720
11.00	12300	12500	12800	13100	13300	13600	13900	14200	14500	14800	2700
12.00	15000	15300	15600	15900	16200	16600	16900	17200	17500	17800	3100
13.00	18100	18400	18800	19100	19400	19800	20100	20400	20700	21100	3300
14.00	21400	21700	22100	22400	22700	23100	23400	23800	24100	24500	3500
15.00	24900	25200	25600	26000	26300	26700	27100	27500	27900	28300	3800
16.00	28700	29100	29500	29900	30300	30700	31100	31500	32000	32400	4100
17.00	32800	33200	33700	34100	34600	35000	35400	35900	36300	36800	4400
18.00	37200	37700	38100	38600	39000	39500	39900	40400	40800	41300	4500
19.00	41700	42200	42650								

1 UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY - WATER RESOURCES DIVISION PAGE 1

EXPANDED RATING TABLE TYPE: LOG

01138500 DATE PROCESSED: 08-20-1991 @ 16:46 BY KTOPPIN

CONNECTICUT RIVER AT WELLS RIVER, VT DD: 4 TYPE: 001 RATING NO: 24.0

OFFSET: -.90 BREAK,OFFSET: (4.00,1.90) (10.00,-3.30) START DATE/TIME: 11-17-89 (0330)

BASED ON _______ DISCHARGE MEASUREMENTS, NOS ________, AND ________, AND IS ______ WELL DEFINED BETWEEN ______ AND ______ CFS

COMP BY _____ DATE ________ CHK. BY _____ DATE ________

SAME AS RT. 23 BELOW 1.50 FT AND ABOVE 6.00 FT.

GAGE HEIGHT (FEET)	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
	DISCHARGE IN CUBIC FEET PER SECOND (STANDARD PRECISION)										
.20	47.0*	48.2	49.4	50.7	52.0	53.2	54.6	55.9	57.2	58.6	13.0
.30	60.0*	61.6	63.2	64.8	66.4	68.1	69.8	71.6	73.3	75.1	16.9
.40	76.9	78.8	80.7	82.6	84.5	86.5	88.5	90.5	92.6	94.7	20.0
.50	96.9	99.0	101	103	106	108	110	113	115	118	23.1
.60	120*	123	125	128	131	134	137	140	143	146	29.0
.70	149	152	155	158	161	165	168	171	175	178	33.0
.80	182	185	189	193	196	200*	204	207	211	215	37.0
.90	219	223	227	231	235	239	243	248	252	256	42.0
1.00	261	265	270	274	279	283	288	293	298	303	47.0
1.10	308	313	318	323	328	333	338	344	349	355	52.0
1.20	360*	365	371	376	381	387	392	398	403	409	55.0
1.30	415	420	426	432	438	444	450	456	462	468	60.0
1.40	475	481	487	494	500	507	513	520	526	533	65.0
1.50	540*	547	554	562	569	576	584	591	599	606	74.0
1.60	614	622	630	638	646	654	662	670	678	686	81.0
1.70	695	703	712	720	729	738	747	755	764	773	88.0
1.80	783	792	801	810	820	829	839	848	858	868	94.0
1.90	877	887	897	907	918	928	938	948	959	969	103
2.00	980*	992	1000	1020	1030	1040	1050	1060	1080	1090	120
2.10	1100	1110	1130	1140	1150	1170	1180	1190	1210	1220	130
2.20	1230	1250	1260	1280	1290	1300	1320	1330	1350	1360	150
2.30	1380	1390	1410	1420	1440	1450	1470	1490	1500	1520	150
2.40	1530	1550	1570	1580	1600	1610	1630	1650	1670	1680	170
2.50	1700*	1720	1730	1750	1760	1780	1790	1810	1830	1840	160
2.60	1860	1880	1890	1910	1930	1940	1960	1980	1990	2010	170
2.70	2030	2050	2060	2080	2100	2120	2140	2150	2170	2190	180
2.80	2210	2230	2250	2260	2280	2300	2320	2340	2360	2380	190
2.90	2400	2420	2440	2460	2480	2500	2520	2540	2560	2580	200
3.00	2600*	2620	2640	2670	2690	2710	2730	2750	2780	2800	220
3.10	2820	2850	2870	2890	2920	2940	2960	2990	3010	3040	240
3.20	3060	3080	3110	3130	3160	3180	3210	3230	3260	3280	250
3.30	3310	3330	3360	3390	3410	3440	3470	3490	3520	3550	260
3.40	3570	3600	3630	3650	3680	3710	3740	3770	3790	3820	280
3.50	3850*	3870	3900	3920	3950	3970	4000	4020	4050	4070	250
3.60	4100	4120	4150	4180	4200	4230	4250	4280	4310	4330	260
3.70	4360	4390	4410	4440	4470	4490	4520	4550	4570	4600	270
3.80	4630	4660	4680	4710	4740	4770	4800	4820	4850	4880	280
3.90	4910	4940	4970	5000	5020	5050	5080	5110	5140	5170	290

EXPANDED RATING TABLE TYPE: LOG

01138500 DATE PROCESSED: 08-20-1991 @ 16:46 BY KTOPPIN

CONNECTICUT RIVER AT WELLS RIVER, VT DD: 4 TYPE: 001 RATING NO: 24.0

OFFSET: -.90 BREAK,OFFSET: (4.00,1.90) (10.00,-3.30) START DATE/TIME: 11-17-89 (0330)

SAME AS RT. 23 BELOW 1.50 FT AND ABOVE 6.00 FT.

GAGE HEIGHT (FEET)	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
	DISCHARGE IN CUBIC FEET PER SECOND					(STANDARD PRECISION)					
4.00	5200*	5230	5270	5300	5340	5370	5410	5440	5480	5510	350
4.10	5550	5580	5620	5650	5690	5720	5760	5800	5830	5870	350
4.20	5900	5940	5970	6010	6050	6080	6120	6150	6190	6230	360
4.30	6260	6300	6330	6370	6410	6440	6480	6520	6550	6590	370
4.40	6630	6670	6700	6740	6780	6810	6850	6890	6930	6960	370
4.50	7000*	7040	7070	7110	7140	7180	7210	7250	7280	7320	350
4.60	7350	7390	7420	7460	7490	7530	7570	7600	7640	7670	360
4.70	7710	7740	7780	7820	7850	7890	7920	7960	8000	8030	360
4.80	8070	8100	8140	8180	8210	8250	8290	8320	8360	8400	360
4.90	8430	8470	8510	8540	8580	8620	8650	8690	8730	8760	370
5.00	8800*	8830	8870	8900	8930	8970	9000	9030	9070	9100	340
5.10	9140	9170	9200	9240	9270	9300	9340	9370	9400	9440	330
5.20	9470	9510	9540	9570	9610	9640	9680	9710	9740	9780	340
5.30	9810	9840	9880	9910	9950	9980	10000	10000	10100	10100	390
5.40	10200	10200	10200	10300	10300	10300	10400	10400	10400	10500	300
5.50	10500	10500	10600	10600	10600	10700	10700	10700	10800	10800	300
5.60	10800	10900	10900	10900	11000	11000	11000	11100	11100	11100	400
5.70	11200	11200	11300	11300	11300	11400	11400	11400	11500	11500	300
5.80	11500	11600	11600	11600	11700	11700	11700	11800	11800	11800	400
5.90	11900	11900	11900	12000	12000	12100	12100	12100	12200	12200	300
6.00	12200*	12300	12300	12400	12400	12400	12500	12500	12600	12600	500
6.10	12700	12700	12800	12800	12800	12900	12900	13000	13000	13100	400
6.20	13100	13100	13200	13200	13300	13300	13400	13400	13500	13500	500
6.30	13600	13600	13600	13700	13700	13800	13800	13900	13900	14000	400
6.40	14000*	14000	14100	14100	14200	14200	14300	14300	14400	14400	400
6.50	14400	14500	14500	14600	14600	14700	14700	14800	14800	14800	500
6.60	14900	14900	15000	15000	15100	15100	15200	15200	15300	15300	400
6.70	15300	15400	15400	15500	15500	15600	15600	15700	15700	15800	500
6.80	15800*	15800	15900	15900	16000	16000	16000	16100	16100	16200	400
6.90	16200	16200	16300	16300	16400	16400	16400	16500	16500	16600	400
7.00	16600	16600	16700	16700	16800	16800	16800	16900	16900	17000	400
7.10	17000	17000	17100	17100	17200	17200	17200	17300	17300	17400	400
7.20	17400*	17400	17500	17500	17600	17600	17700	17700	17700	17800	400
7.30	17800	17900	17900	18000	18000	18100	18100	18100	18200	18200	500
7.40	18300	18300	18400	18400	18500	18500	18500	18600	18600	18700	400
7.50	18700	18800	18800	18800	18900	18900	19000	19000	19100	19100	500
7.60	19200*	19200	19300	19300	19300	19400	19400	19500	19500	19600	400
7.70	19600	19700	19700	19800	19800	19800	19900	19900	20000	20000	500

EXPANDED RATING TABLE TYPE: LOG

01138500 DATE PROCESSED: 08-20-1991 @ 16:46 BY KTOPPIN

CONNECTICUT RIVER AT WELLS RIVER, VT DD: 4 TYPE: 001 RATING NO: 24.0

OFFSET: -.90 BREAK,OFFSET: (4.00,1.90) (10.00,-3.30) START DATE/TIME: 11-17-89 (0330)

SAME AS RT. 23 BELOW 1.50 FT AND ABOVE 6.00 FT.

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND .00	.01	.02	.03	.04	(STANDARD PRECISION) .05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
7.80	20100	20100	20200	20200	20300	20300	20400	20400	20400	20500	400
7.90	20500	20600	20600	20700	20700	20800	20800	20900	20900	21000	500
8.00	21000*	21100	21100	21200	21200	21300	21300	21400	21400	21500	500
8.10	21500	21600	21600	21700	21700	21800	21800	21900	21900	22000	500
8.20	22000	22100	22100	22200	22200	22300	22300	22400	22400	22500	500
8.30	22500	22600	22600	22700	22700	22800	22800	22900	22900	23000	500
8.40	23000	23100	23200	23200	23300	23300	23400	23400	23500	23500	600
8.50	23600*	23600	23700	23700	23800	23800	23900	23900	24000	24100	500
8.60	24100	24200	24200	24300	24300	24400	24400	24500	24500	24600	500
8.70	24600	24700	24800	24800	24900	24900	25000	25000	25100	25100	600
8.80	25200	25300	25300	25400	25400	25500	25500	25600	25600	25700	500
8.90	25700	25800	25900	25900	26000	26000	26100	26100	26200	26200	600
9.00	26300*	26300	26400	26400	26500	26500	26500	26600	26600	26700	400
9.10	26700	26700	26800	26800	26900	26900	26900	27000	27000	27100	400
9.20	27100	27100	27200	27200	27300	27300	27300	27400	27400	27500	400
9.30	27500	27600	27600	27600	27700	27700	27800	27800	27800	27900	400
9.40	27900	28000	28000	28000	28100	28100	28200	28200	28200	28300	400
9.50	28300*	28400	28400	28400	28500	28500	28600	28600	28700	28700	400
9.60	28700	28800	28800	28900	28900	28900	29000	29000	29100	29100	500
9.70	29200	29200	29200	29300	29300	29400	29400	29400	29500	29500	400
9.80	29600	29600	29600	29700	29700	29800	29800	29900	29900	29900	400
9.90	30000	30000	30100	30100	30100	30200	30200	30300	30300	30400	400
10.00	30400*	30400	30500	30500	30500	30600	30600	30600	30700	30700	300
10.10	30700	30800	30800	30800	30900	30900	31000	31000	31000	31100	400
10.20	31100	31100	31200	31200	31200	31300	31300	31300	31400	31400	300
10.30	31400	31500	31500	31500	31600	31600	31600	31700	31700	31800	400
10.40	31800	31800	31900	31900	31900	32000	32000	32000	32100	32100	300
10.50	32100*	32200	32200	32200	32300	32300	32300	32400	32400	32500	400
10.60	32500	32500	32600	32600	32600	32700	32700	32700	32800	32800	300
10.70	32800	32900	32900	32900	33000	33000	33100	33100	33100	33200	400
10.80	33200	33200	33300	33300	33300	33400	33400	33400	33500	33500	300
10.90	33500	33600	33600	33700	33700	33700	33800	33800	33800	33900	400
11.00	33900*	33900	34000	34000	34000	34100	34100	34100	34200	34200	300
11.10	34200	34300	34300	34300	34400	34400	34400	34500	34500	34500	400
11.20	34600	34600	34600	34700	34700	34700	34800	34800	34800	34900	300
11.30	34900	35000	35000	35000	35100	35100	35100	35200	35200	35200	400
11.40	35300	35300	35300	35400	35400	35400	35500	35500	35500	35600	300

EXPANDED RATING TABLE TYPE: LOG
01138500 DATE PROCESSED: 08-20-1991 @ 16:46 BY KTOPPIN
CONNECTICUT RIVER AT WELLS RIVER, VT DD: 4 TYPE: 001 RATING NO: 24.0
OFFSET: -.90 BREAK,OFFSET: (4.00,1.90) (10.00,-3.30) START DATE/TIME: 11-17-89 (0330)
SAME AS RT. 23 BELOW 1.50 FT AND ABOVE 6.00 FT.

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (STANDARD PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
11.50	35600	35600	35700	35700	35700	35800	35800	35800	35900	35900	300
11.60	35900	36000	36000	36000	36100	36100	36200	36200	36200	36300	400
11.70	36300	36300	36400	36400	36400	36500	36500	36500	36600	36600	300
11.80	36600	36700	36700	36700	36800	36800	36800	36900	36900	36900	400
11.90	37000	37000	37000	37100	37100	37200	37200	37200	37300	37300	300
12.00	37300	37400	37400	37400	37500	37500	37500	37600	37600	37600	400
12.10	37700	37700	37700	37800	37800	37800	37900	37900	38000	38000	300
12.20	38000	38100	38100	38100	38200	38200	38200	38300	38300	38300	400
12.30	38400	38400	38400	38500	38500	38500	38600	38600	38700	38700	300
12.40	38700	38800	38800	38800	38900	38900	38900	39000	39000	39000	400
12.50	39100	39100	39100	39200	39200	39300	39300	39300	39400	39400	300
12.60	39400	39500	39500	39500	39600	39600	39600	39700	39700	39700	400
12.70	39800	39800	39900	39900	39900	40000	40000	40000	40100	40100	300
12.80	40100	40200	40200	40200	40300	40300	40400	40400	40400	40500	400
12.90	40500	40500	40600	40600	40600	40700	40700	40700	40800	40800	300
13.00	40800	40900	40900	41000	41000	41000	41100	41100	41100	41200	400
13.10	41200	41200	41300	41300	41300	41400	41400	41500	41500	41500	400
13.20	41600	41600	41600	41700	41700	41700	41800	41800	41900	41900	300
13.30	41900	42000	42000	42000	42100	42100	42100	42200	42200	42200	400
13.40	42300	42300	42400	42400	42400	42500	42500	42500	42600	42600	300
13.50	42600	42700	42700	42800	42800	42800	42900	42900	42900	43000	400
13.60	43000	43000	43100	43100	43200	43200	43200	43300	43300	43300	400
13.70	43400	43400	43400	43500	43500	43600	43600	43600	43700	43700	300
13.80	43700	43800	43800	43800	43900	43900	44000	44000	44000	44100	400
13.90	44100	44100	44200	44200	44200	44300	44300	44400	44400	44400	400
14.00	44500	44500	44500	44600	44600	44600	44700	44700	44800	44800	300
14.10	44800	44900	44900	44900	45000	45000	45100	45100	45100	45200	400
14.20	45200	45200	45300	45300	45300	45400	45400	45500	45500	45500	400
14.30	45600	45600	45600	45700	45700	45800	45800	45800	45900	45900	300
14.40	45900	46000	46000	46000	46100	46100	46200	46200	46200	46300	400
14.50	46300	46300	46400	46400	46500	46500	46500	46600	46600	46600	400
14.60	46700	46700	46800	46800	46800	46900	46900	46900	47000	47000	300
14.70	47000	47100	47100	47200	47200	47200	47300	47300	47300	47400	400
14.80	47400	47500	47500	47500	47600	47600	47600	47700	47700	47800	400
14.90	47800	47800	47900	47900	47900	48000	48000	48100	48100	48100	400
15.00	48200	48200	48200	48300	48300	48400	48400	48400	48500	48500	300
15.10	48500	48600	48600	48700	48700	48700	48800	48800	48800	48900	400
15.20	48900	49000	49000	49000	49100	49100	49100	49200	49200	49300	400

EXPANDED RATING TABLE TYPE: LOG

01138500 DATE PROCESSED: 08-20-1991 @ 16:46 BY KTOPPIN

CONNECTICUT RIVER AT WELLS RIVER, VT DD: 4 TYPE: 001 RATING NO: 24.0

OFFSET: -.90 BREAK,OFFSET: (4.00,1.90) (10.00,-3.30) START DATE/TIME: 11-17-89 (0330)

SAME AS RT. 23 BELOW 1.50 FT AND ABOVE 6.00 FT.

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (STANDARD PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
15.30	49300	49300	49400	49400	49500	49500	49500	49600	49600	49600	400
15.40	49700	49700	49800	49800	49800	49900	49900	49900	50000	50000	400
15.50	50100	50100	50100	50200	50200	50200	50300	50300	50400	50400	300
15.60	50400	50500	50500	50600	50600	50600	50700	50700	50700	50800	400
15.70	50800	50900	50900	50900	51000	51000	51000	51100	51100	51200	400
15.80	51200	51200	51300	51300	51400	51400	51400	51500	51500	51500	400
15.90	51600	51600	51700	51700	51700	51800	51800	51800	51900	51900	400
16.00	52000	52000	52000	52100	52100	52200	52200	52200	52300	52300	300
16.10	52300	52400	52400	52500	52500	52500	52600	52600	52700	52700	400
16.20	52700	52800	52800	52800	52900	52900	53000	53000	53000	53100	400
16.30	53100	53200	53200	53200	53300	53300	53300	53400	53400	53500	400
16.40	53500	53500	53600	53600	53700	53700	53700	53800	53800	53900	400
16.50	53900	53900	54000	54000	54000	54100	54100	54200	54200	54200	400
16.60	54300	54300	54400	54400	54400	54500	54500	54600	54600	54600	400
16.70	54700	54700	54700	54800	54800	54900	54900	54900	55000	55000	400
16.80	55100	55100	55100	55200	55200	55300	55300	55300	55400	55400	300
16.90	55400	55500	55500	55600	55600	55600	55700	55700	55800	55800	400
17.00	55800	55900	55900	56000	56000	56000	56100	56100	56200	56200	400
17.10	56200	56300	56300	56400	56400	56400	56500	56500	56500	56600	400
17.20	56600	56700	56700	56700	56800	56800	56900	56900	56900	57000	400
17.30	57000	57100	57100	57100	57200	57200	57300	57300	57300	57400	400
17.40	57400	57500	57500	57500	57600	57600	57700	57700	57700	57800	400
17.50	57800	57800	57900	57900	58000	58000	58000	58100	58100	58200	400
17.60	58200	58200	58300	58300	58400	58400	58400	58500	58500	58600	400
17.70	58600	58600	58700	58700	58800	58800	58800	58900	58900	59000	400
17.80	59000	59000	59100	59100	59200	59200	59200	59300	59300	59400	400
17.90	59400	59400	59500	59500	59600	59600	59600	59700	59700	59800	400*
18.00	59800*										

PLATE A-35 e

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY - WATER RESOURCES DIVISION

EXPANDED RATING TABLE   DATE PRINTED 08-16-83

01144500   CONNECTICUT RIVER AT WEST LEBANON, NH   TYPE LOG(SCALE OFFSET = 1.00) RATING NO 35

BASED ON _______ DISCHARGE MEASUREMENTS, NO.__________, AND ______, AND IS _____ WELL DEFINED BETWEEN _____ AND _____
*COMP BY _____ DATE _____
FROM _________ TO _________, FROM _________ TO _________   *CKD. BY _____ DATE _____

GAGE HEIGHT IN FEET	DISCHARGE IN CUBIC FEET PER SECOND (STANDARD PRECISION) .0	.1	.2	.3	.4	.5	.6	.7	.8	.9	DIFF IN Q PER FOOT GH
2.00						230	271	317	367	421	
3.00	480	542	610	681	758	840	923	1010	1100	1200	820
4.00	1300	1410	1530	1650	1770	1900	2040	2180	2330	2490	1350
5.00	2650	2810	2980	3160	3340	3530	3720	3920	4130	4340	1910
6.00	4560	4760	4970	5180	5400	5620	5850	6080	6310	6550	2240
7.00	6830	7060	7320	7580	7860	8130	8420	8700	9000	9300	2800
8.00	9600	9860	10100	10400	10700	11000	11200	11500	11800	12100	2800
9.00	12400	12700	13000	13300	13600	13900	14200	14500	14800	15100	3000
10.00	15400	15700	16000	16300	16600	17000	17300	17600	17900	18200	3200
11.00	18600	18900	19200	19600	19900	20300	20600	20900	21300	21600	3400
12.00	22000	22300	22700	23000	23400	23700	24100	24500	24800	25200	3500
13.00	25500	25900	26300	26600	27000	27400	27800	28100	28500	28900	3800
14.00	29300	29700	30000	30400	30800	31200	31600	32000	32300	32700	3800
15.00	33100	33500	33900	34300	34700	35100	35500	35900	36300	36700	4000
16.00	37100	37500	37900	38400	38800	39200	39600	40000	40500	40900	4200
17.00	41300	41700	42100	42500	42900	43400	43800	44200	44600	45000	4200
18.00	45500	45900	46300	46700	47200	47600	48000	48500	48900	49300	4300
19.00	49800	50200	50600	51100	51500	52000	52400	52900	53300	53700	4400
20.00	54200	54600	55100	55500	56000	56400	56900	57300	57800	58300	4500
21.00	58700	59200	59600	60100	60500	61000	61500	61900	62400	62900	4600
22.00	63300	63800	64300	64800	65200	65700	66200	66700	67100	67600	4800
23.00	68100	68600	69000	69500	70000	70500	70900	71400	71900	72400	4700
24.00	72800	73300	73800	74300	74700	75200	75700	76200	76700	77200	4900
25.00	77700	78200	78600	79100	79600	80100	80600	81100	81600	82100	4900
26.00	82600	83100	83600	84100	84600	85100	85600	86100	86600	87200	5100
27.00	87700	88200	88700	89200	89700	90200	90800	91300	91800	92300	5100
28.00	92800	93400	93900	94400	94900	95500	96000	96500	97000	97600	5300
29.00	98100	98700	99300	99800	100000	101000	102000	102000	103000	103000	5900
30.00	104000	105000	105000	106000	106000	107000	108000	108000	109000	109000	6000
31.00	110000	111000	111000	112000	112000	113000	114000	114000	115000	115000	6000
32.00	116000	117000	117000	118000	119000	119000	120000	121000	121000	122000	7000
33.00	123000	123000	124000	125000	125000	126000	127000	127000	128000	129000	6000
34.00	129000	130000	131000	131000	132000	133000	133000	134000	135000	135000	7000
35.00	136000										

PLATE A-36

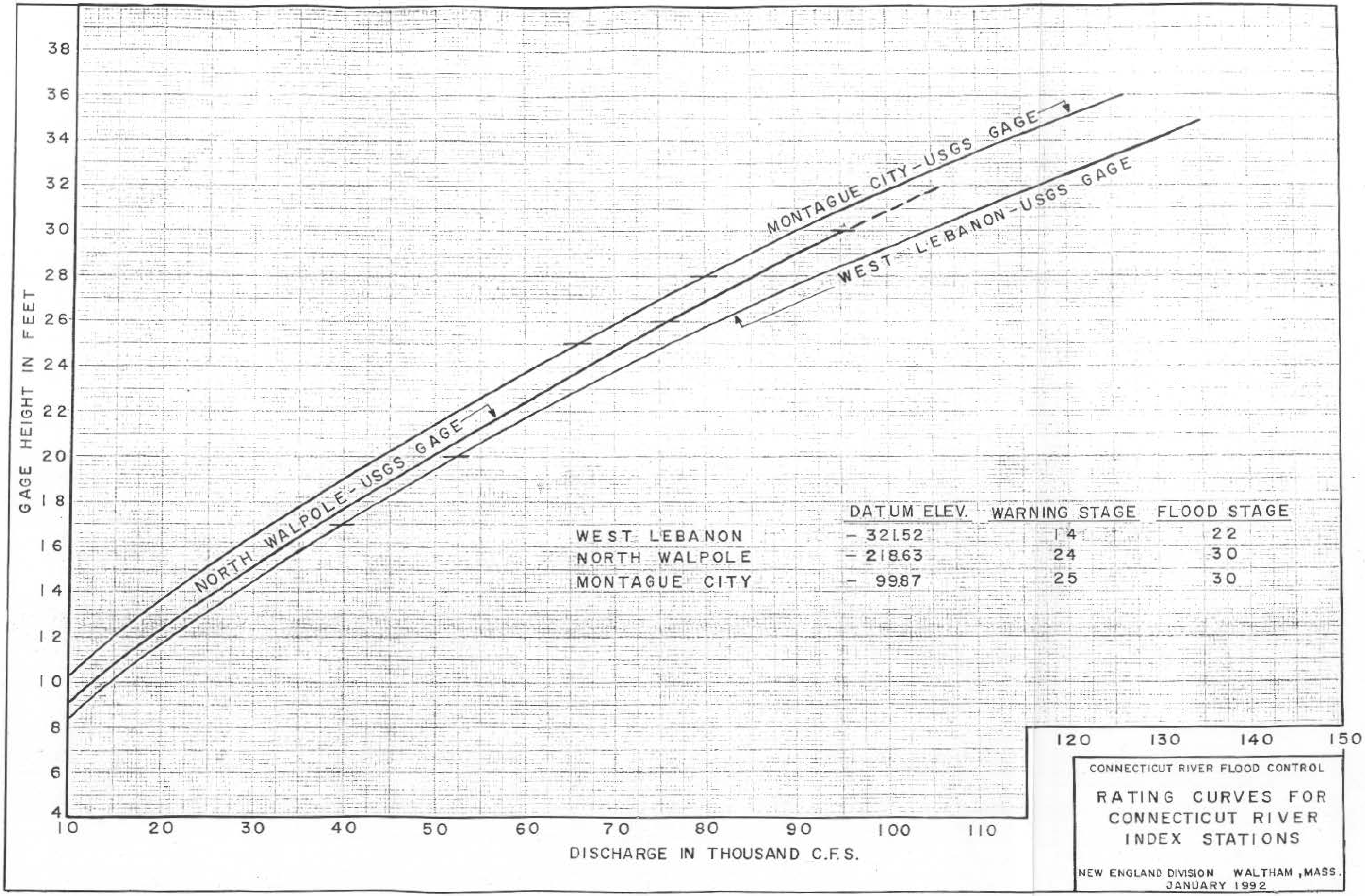
EXPANDED RATING TABLE TYPE: LOG

01170500 DATE PROCESSED: 01-13-1994 @ 13:44 BY RGADOURY

CONNECTICUT RIVER AT MONTAGUE CITY, MA DD: 2 TYPE: 001 RATING NO: 21

OFFSET: 3.0 START DATE/TIME: 10-01-92 (0001)

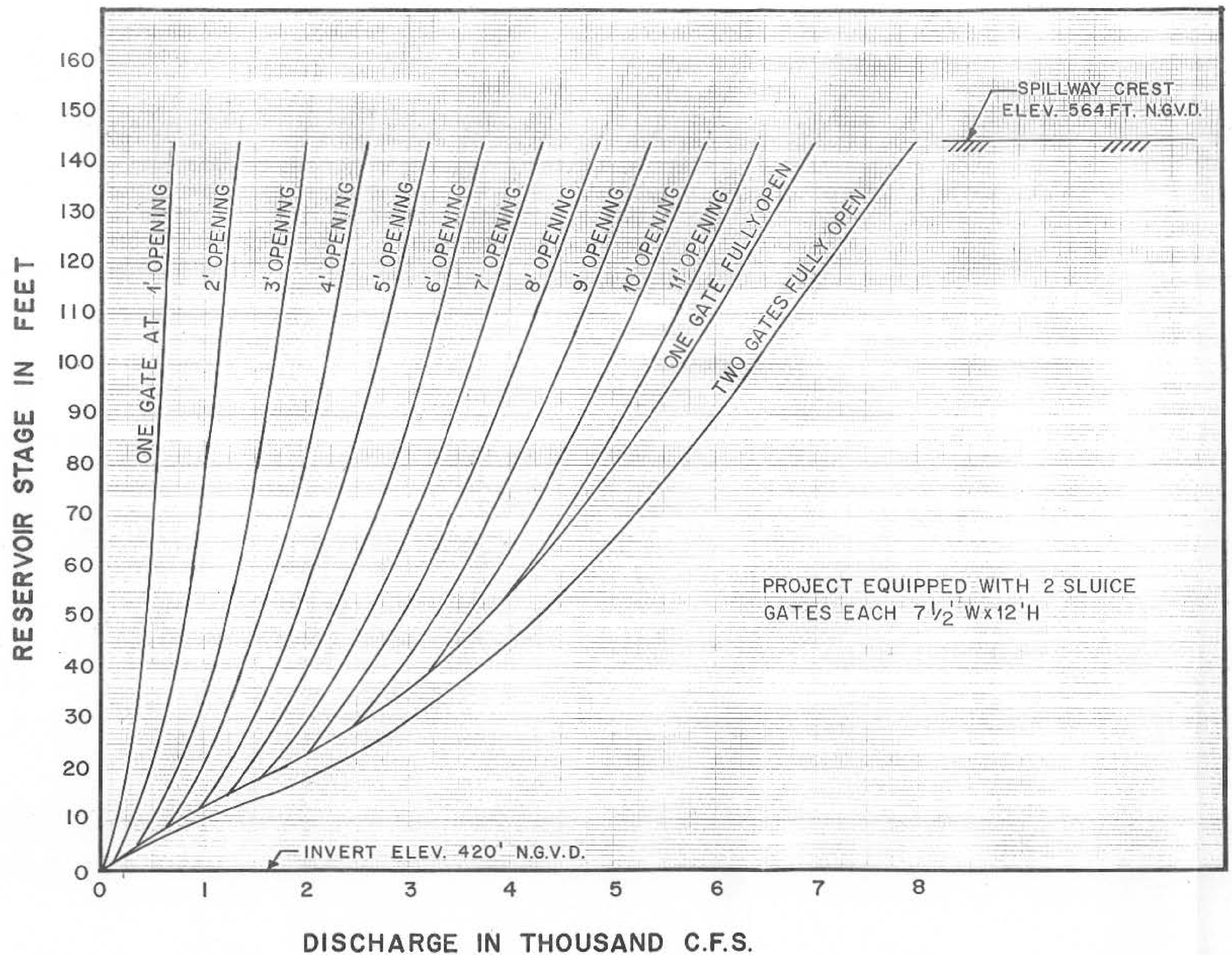
GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (STANDARD PRECISION) .0	.1	.2	.3	.4	.5	.6	.7	.8	.9	DIFF IN Q PER FOOT
4.0						400*	454	510	570	634	600
5.0	700*	770	844	921	1000	1080	1170	1260	1350	1450	850
6.0	1550*	1650	1760	1860	1970	2090	2200	2320	2450	2570	1150
7.0	2700*	2840	2970	3120	3260	3410	3560	3720	3870	4040	1500
8.0	4200*	4380	4570	4760	4950	5150	5350	5560	5770	5980	2000
9.0	6200*	6420	6650	6880	7110	7350	7590	7840	8090	8340	2400
10.0	8600*	8850	9110	9370	9630	9900	10200	10500	10700	11000	2700
11.0	11300*	11600	11900	12100	12400	12700	13000	13300	13600	13900	2900
12.0	14200*	14500	14800	15200	15500	15800	16100	16500	16800	17200	3300
13.0	17500*	17800	18200	18500	18900	19200	19600	19900	20300	20600	3500
14.0	21000*	21300	21700	22000	22300	22700	23000	23400	23700	24100	3400
15.0	24400*	24700	25100	25400	25800	26100	26500	26800	27200	27500	3500
16.0	27900*	28200	28600	29000	29300	29700	30000	30400	30700	31100	3600
17.0	31500	31800	32200	32600	32900	33300	33700	34100	34400	34800	3700
18.0	35200*	35600	35900	36300	36700	37000	37400	37800	38200	38500	3700
19.0	38900	39300	39700	40100	40400	40800	41200	41600	42000	42400	3900
20.0	42800	43200	43600	44000	44400	44800	45200	45600	46000	46400	4000
21.0	46800	47200	47600	48000	48400	48800	49200	49600	50000	50500	4100
22.0	50900	51300	51700	52100	52500	53000	53400	53800	54200	54700	4200
23.0	55100*	55500	56000	56400	56900	57300	57800	58200	58700	59100	4500
24.0	59600	60000	60500	60900	61400	61900	62300	62800	63200	63700	4600
25.0	64200	64600	65100	65600	66000	66500	67000	67500	67900	68400	4700
26.0	68900*	69400	69900	70400	70900	71400	71800	72300	72800	73300	4900
27.0	73800	74300	74800	75300	75800	76400	76900	77400	77900	78400	5100
28.0	78900*	79400	80000	80500	81000	81600	82100	82600	83200	83700	5300
29.0	84200	84800	85300	85900	86400	87000	87500	88100	88600	89200	5500
30.0	89700	90300	90800	91400	92000	92500	93100	93600	94200	94800	5600
31.0	95300	95900	96500	97100	97600	98200	98800	99400	99900	101000	5700
32.0	101000	102000	102000	103000	103000	104000	105000	105000	106000	106000	6000
33.0	107000*	108000	108000	109000	110000	110000	111000	112000	112000	113000	7000
34.0	114000	114000	115000	116000	116000	117000	118000	118000	119000	120000	6000
35.0	120000	121000	122000	122000	123000	124000	125000	125000	126000	127000	7000
36.0	127000	128000	129000	129000	130000	131000	132000	132000	133000	134000	7000
37.0	134000	135000	136000	137000	137000	138000	139000	140000	140000	141000	8000
38.0	142000	143000	143000	144000	145000	146000	146000	147000	148000	149000	7000
39.0	149000	150000	151000	152000	152000	153000	154000	155000	155000	156000	8000
40.0	157000	158000	159000	159000	160000	161000	162000	162000	163000	164000	8000
41.0	165000	166000	166000	167000	168000	169000	170000	170000	171000	172000	8000
42.0	173000	174000	174000	175000	176000	177000	178000	179000	179000	180000	8000
43.0	181000*	182000	183000	184000	184000	185000	186000	187000	188000	189000	8000
44.0	189000	190000	191000	192000	193000	194000	195000	195000	196000	197000	9000
45.0	198000	199000	200000	201000	202000	202000	203000	204000	205000	206000	9000
46.0	207000	208000	209000	210000	210000	211000	212000	213000	214000	215000	9000
47.0	216000	217000	218000	219000	219000	220000	221000	222000	223000	224000	9000
48.0	225000*	226000	227000	228000	229000	230000	230000	231000	232000	233000	9000
49.0	234000	235000	236000*								



CONNECTICUT RIVER FLOOD CONTROL

RATING CURVES FOR CONNECTICUT RIVER INDEX STATIONS

NEW ENGLAND DIVISION WALTHAM, MASS.
JANUARY 1992



CONNECTICUT RIVER FLOOD CONTROL

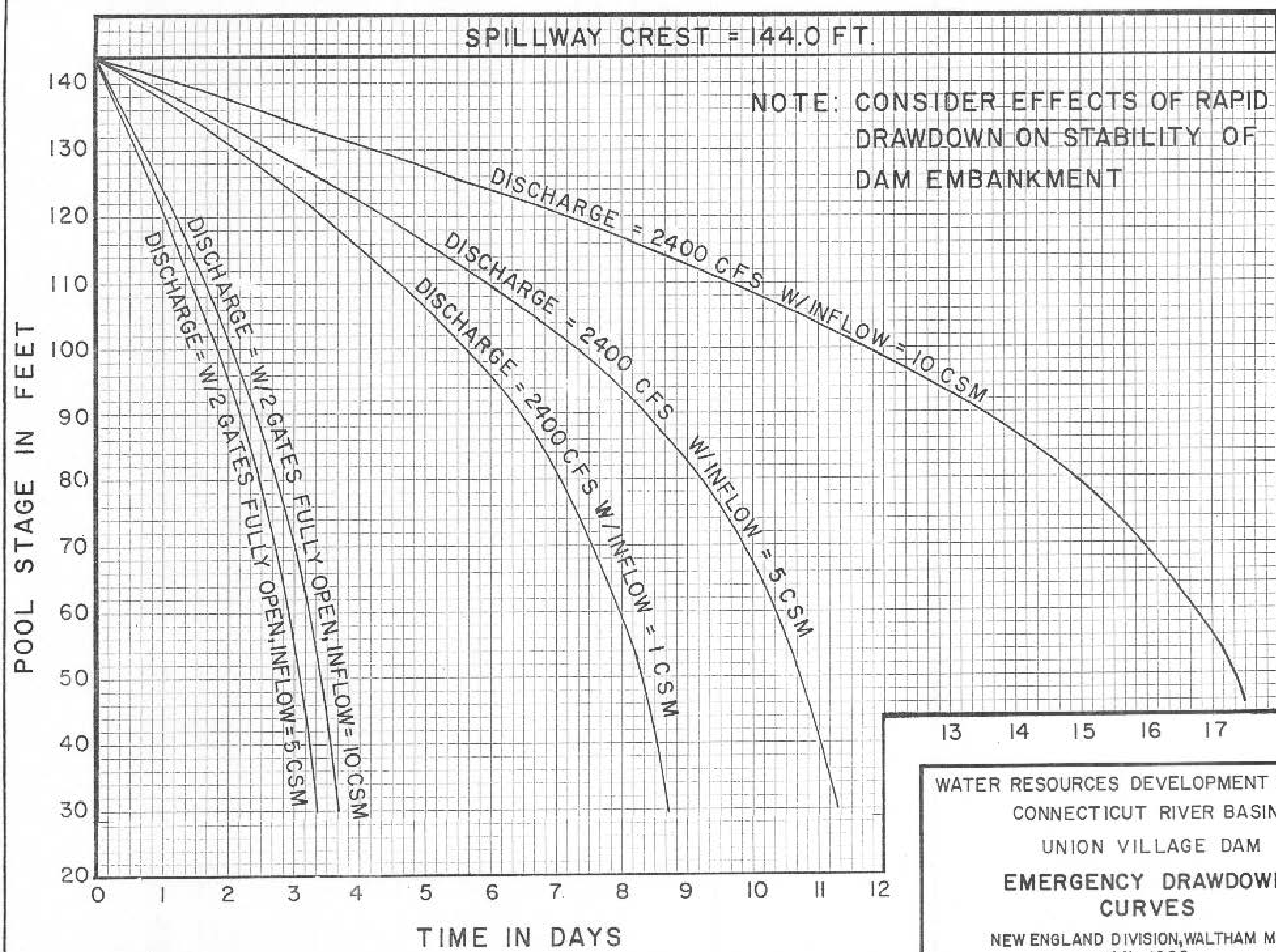
UNION VILLAGE DAM
& RESERVOIR

OMPOMPANOOSUC RIVER, VT.

OUTLET RATING CURVES

NEW ENGLAND DIVISION, WALTHAM, MASS.

MAY 1991

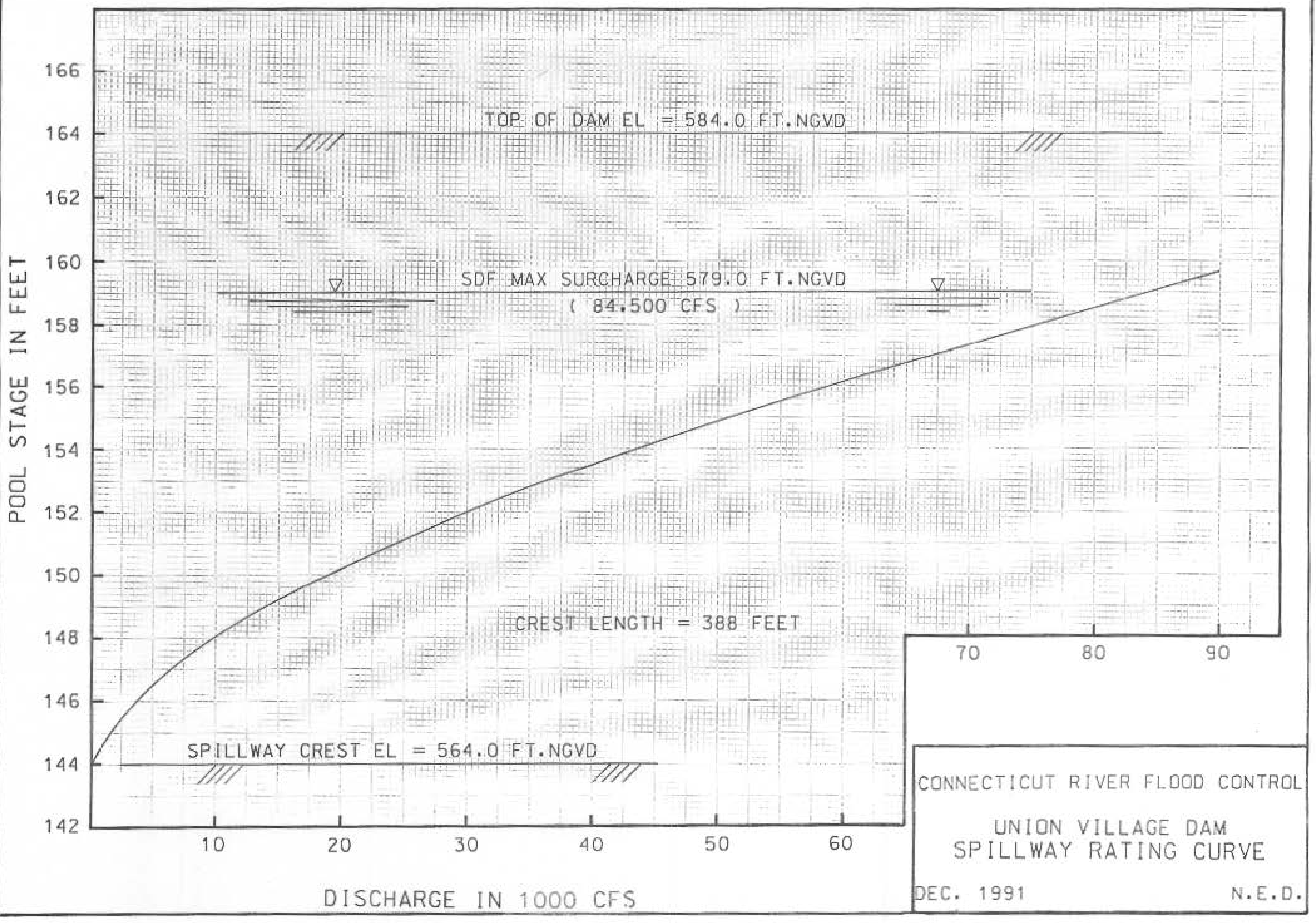


WATER RESOURCES DEVELOPMENT PROJECT
CONNECTICUT RIVER BASIN
UNION VILLAGE DAM

EMERGENCY DRAWDOWN CURVES

NEW ENGLAND DIVISION, WALTHAM MASS.
JAN. 1992

PLATE A-40



CONNECTICUT RIVER FLOOD CONTROL

UNION VILLAGE DAM
SPILLWAY RATING CURVE

DEC. 1991 N.E.D.

DROUGHT CONTINGENCY PLAN
CLIMATOLOGIC AND HYDROLOGIC INDICATORS

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DROUGHT CONTINGENCY PLAN
CLIMATOLOGIC AND HYDROLOGIC INDICATORS

1. INTRODUCTION

This appendix is presented to supplement the developed Drought Contingency Plan with climatological as well as hydrological data that are useful towards identifying and recognizing periods of dry or drought conditions. The analyses presented is not intended to predict a drought, as most drought predicting measures are not considered very accurate or promising. It is however, intended to aid in recognizing the onset of water shortage conditions in an effort to mitigate their impacts prior to severe or emergency conditions prevailing. It is most beneficial to recognize the beginning of a drought rather than to initiate action <u>after</u> the drought's effect become apparent.

The data presented is in the form of "guide curves" and do not serve the purpose of a single "trigger" in which emergency drought storage at Corps reservoirs would be initiated. As stated in the main text of the Drought Contingency Plan, NED's decision to store emergency water supply would be based on a combination of the guide curves as well as information received from various Federal and State agencies.

The data presented is an attempt to show regional indicators of dry or drought periods. While specific index stations were used in developing the guide curves, their use is not to be restricted to that station only. Their application is considered to represent generalized conditions in areas within the region.

Indicators such as rainfall-duration-frequency and minimum surface runoff-duration frequency were developed for various index stations within New England. Index stations selected were based on proximity to Corps drought contingency candidate reservoirs, period of record and reliability of data. The guide curves were developed and compared with historic drought data as a way to "track" current observed conditions with comparable historic conditions. Also presented is the Palmer Drought Severity Index (PDSI) classification chart with available New England historic drought index levels indicated.

2. DROUGHTS

a. <u>General.</u> Hydrologically, drought is defined as a prolonged period of precipitation deficiency which seriously affects riverflow as well as surface and groundwater supplies. The duration, magnitude, severity, frequency and areal extent have been identified as five common characteristics of drought. These characteristics are applicable to drought whether measured by precipitation, streamflow, reservoir levels or by the Palmer index.

b. History. Drought history in New England before 1900 is rather limited. Periods of precipitation deficiencies were experienced, however, records of runoff deficiency are relatively non-existent. Since the establishment of streamflow gaging stations, low flow periods and drought conditions have been observed throughout the New England river basins at various times. Serious droughts occurred within New England during the periods 1924-1927; 1929-1933 and 1961-1967.

c. Drought of Record. The drought of 1961 to 1967 was the longest and most severe in the history of the New England region. It was the most severe in nearly 170 years of precipitation records in Boston, Massachusetts. The 1960's drought followed a period of above normal precipitation which contributed to relaxation on the part of cities and towns during what was really a period of rapidly increasing water demand. In addition, a considerable number of water facilities failed since most had been designed to meet a repetition of the less severe drought of the 1930's.

During the period 1963 through 1966, the cumulative precipitation deficiencies (i.e. total amount below normal) varied from about 40 to 60 inches throughout New England, which is equivalent to 1 to 1.3 years of normal rainfall.

The accumulative deficiency in the average runoff for water years 1962 to 1966 varied from about 25 to 50 inches throughout New England, equivalent to about 1 to 2 years of average annual runoff.

3. CLIMATOLOGIC AND HYDROLOGIC ANALYSIS

a. General. Streamflow, reservoir levels, ground water levels, soil moisture, precipitation and the Palmer Drought Severity Index are some of the indicators used by drought managers for early detection as well as continued tracking of a drought. This analysis focused on three of these indicators: rainfall; runoff and the Palmer Index. Rainfall and runoff were selected due to the large magnitude of available historic as well as current data. The Palmer Index was selected primarily due to its wide acceptance as a reliable drought indicator. While many more parameters are used in the drought identification process, it is believed that for purposes of the Drought Contingency Plans the parameters selected and the analysis performed offer a reasonable approach to drought management at NED reservoirs.

b. Climatological Data. Rainfall frequencies for 1, 3, 6 and 12 month durations were developed for various index stations. The curves were developed using the period of record monthly rainfall data at each index station. Accumulative tabulations were made for 1, 3, 6 and 12 consecutive months, assigning Weibull plotting positions and fitting the curves through the data. Index stations selected, with their corresponding periods of record, as well as the mean, maximum and minimum monthly rainfall, are shown in tables 1 through 3. The computed frequency curves are graphically shown on plates 1 through 3. Historic data, where available, was plotted on the 3, 6 and 12 month duration curves. The historic data was presented to allow comparison with any current data to that which occurred during historic droughts. This comparative analysis allows for a better understanding of the drought or dry period being experienced and provides for a historical perspective during drought tracking procedures.

Although the 1 and 3 month durations are presented, it is suggested that any drought emergency actions or conclusions not be based solely on the data of these short durations. In the New England region, experience has shown that low rainfall amounts for durations of 1 and 3 months do not necessarily constitute a dry or drought condition. For example: During the winter of 1988/1989 rainfall was historically low for a consecutive 3 month duration, measuring 6.5 inches at Storrs, Ct. Applying this rainfall to the 3 month curve identified the frequency to be about a 16 year drought, tracking somewhere between the historic droughts of 1924-1927 and 1980-1981. However, when the 6 month cumulative rainfall, during the same dry period, computed to be 21.5 inches, was applied to the 6 month curve, the frequency became less critical, equivalent to about a 2 year event. On an annual duration, the total 1989 rainfall amounts were considered at or above normal despite record low 3 month durations. Had drought emergency measures been implemented solely on the 3 month duration data it would have been proven to be premature or unnecessary. It is therefore recommended that although 1 and 3 month rainfall amounts should not be ignored, durations greater than 3 months should always be considered prior to any emergency drought plans being implemented.

c. Hydrologic Data. Streamflow data measured and published by the U.S. Geological Survey was used exclusively in all hydrologic analysis performed as part of this appendix. Since this analysis concerned itself with low streamflows, an attempt was made to identify and use streamflow index stations that are not regulated during periods of low flow. While many New England rivers and streams are regulated, to some extent, by mill pond dams, as well as other run of river type dams, it was assumed that any occasional regulation of low flows on the index stations selected would be considered to be minor and have minimal affect on natural low flow conditions. The mean, maximum and minimum monthly flows for four USGS gaging stations used as index stations in this report are presented in tables 4 through 7.

TABLE 1

PRECIPITATION SUMMARY (INCHES)
STORRS, CONNECTICUT
ELEVATION 650 FT. NGVD
(101 Years of Record)

Month	Mean	Maximum	Minimum
January	3.65	13.79	0.64
February	3.25	7.89	0.37
March	3.94	10.65	0.15
April	3.80	10.94	0.55
May	3.76	9.21	0.33
June	3.33	12.79	0.29
July	4.15	12.15	0.78
August	4.19	14.75	0.47
September	3.84	17.00	0.45
October	3.64	8.82	0.15
November	4.00	9.24	0.47
December	3.84	9.97	0.68
ANNUAL	44.90	66.31	29.16

TABLE 2

PRECIPITATION SUMMARY (INCHES)
AMHERST, MASSACHUSETTS
ELEVATION 150 FT. NGVD
(64 Years of Record)

Month	Mean	Maximum	Minimum
January	3.11	8.16	0.49
February	2.81	7.58	0.08
March	3.44	8.24	0.24
April	3.61	8.99	0.55
May	3.75	11.95	0.83
June	3.97	10.25	0.72
July	3.74	10.56	0.00
August	3.73	16.10	0.67
September	3.77	14.55	0.94
October	3.17	8.10	0.32
November	3.84	8.65	0.70
December	3.47	8.77	0.58
ANNUAL	42.55	60.25	29.55

TABLE 3

PRECIPITATION SUMMARY (INCHES)
CONCORD, NEW HAMPSHIRE
ELEVATION 350 FT. NGVD
(69 Years of Record)

Month	Mean	Maximum	Minimum
January	2.69	8.09	0.40
February	2.45	7.77	0.03
March	3.12	10.36	0.55
April	3.11	6.63	0.42
May	3.10	9.52	0.60
June	3.34	10.10	0.64
July	3.38	7.57	0.96
August	3.01	6.88	0.95
September	3.16	10.68	0.41
October	2.85	8.78	0.05
November	3.73	7.59	0.50
December	4.56	10.34	0.58
ANNUAL	38.26	54.29	24.17

TABLE 4

MONTHLY STREAM FLOW
QUINEBAUG RIVER AT JEWETT CITY, CT
DRAINAGE AREA = 713 Sq. Miles
(1919 - 1990)

Month	Mean		Maximum		Minimum	
	cfs	inches	cfs	inches	cfs	inches
January	1566	2.52	5694	9.18	219	0.35
February	1664	2.19	3919	5.16	473	0.62
March	2530	4.08	6930	11.17	1220	1.97
April	2436	3.68	5519	8.33	854	1.29
May	1534	2.47	2842	4.58	620	1.00
June	1033	1.56	4758	7.18	262	0.40
July	578	0.93	4110	6.63	138	0.22
August	498	0.80	3918	6.32	98	0.16
September	532	0.80	3502	5.28	97	0.15
October	630	1.02	3279	5.29	132	0.21
November	1066	1.61	3443	5.19	189	0.29
December	1434	2.31	4125	6.65	281	0.45
ANNUAL	1293	23.54	2015	38.24	598	11.35

TABLE 5

MONTHLY STREAM FLOW
WEST BRANCH WESTFIELD RIVER
AT HUNTINGTON, MA
DRAINAGE AREA = 94 Sq. Miles
(1935 - 1990)

Month	Mean		Maximum		Minimum	
	cfs	inches	cfs	inches	cfs	inches
January	173	2.12	448	5.49	24	0.29
February	185	2.05	712	7.88	35	0.39
March	369	4.52	1098	13.46	112	1.37
April	503	5.97	1069	12.68	116	1.38
May	257	3.15	761	9.33	76	0.93
June	141	1.67	684	8.11	27	0.32
July	66	0.81	307	3.76	10	0.12
August	57	0.69	632	7.75	9	0.11
September	64	0.76	579	6.87	9	0.11
October	102	1.25	1041	12.76	13	0.16
November	173	2.05	544	6.45	25	0.30
December	195	2.39	664	8.14	40	0.49
ANNUAL	190	27.36	296	42.62	74	10.66

TABLE 6

MONTHLY STREAM FLOW
SMITH RIVER NEAR BRISTOL, NH
DRAINAGE AREA = 86 Sq. Miles
(1918 - 1990)

Month	Mean		Maximum		Minimum	
	cfs	inches	cfs	inches	cfs	inches
January	99	1.33	253	3.39	19	0.25
February	99	1.20	578	7.00	21	0.25
March	254	3.41	1242	16.65	30	0.40
April	487	6.33	1077	14.00	183	2.38
May	230	3.08	504	6.76	72	0.97
June	104	1.35	353	4.59	21	0.27
July	52	0.70	387	5.19	9	0.12
August	34	0.46	168	2.25	5	0.07
September	41	0.53	457	5.94	8	0.10
October	68	0.91	267	3.58	9	0.12
November	127	1.65	379	4.93	25	0.33
December	131	1.76	393	5.27	22	0.29
ANNUAL	143	22.57	223	35.19	65	10.26

TABLE 7

MONTHLY STREAM FLOW
WEST RIVER AT NEWFANE, VT
DRAINAGE AREA = 308 Sq. Miles
(1919 - 1990)

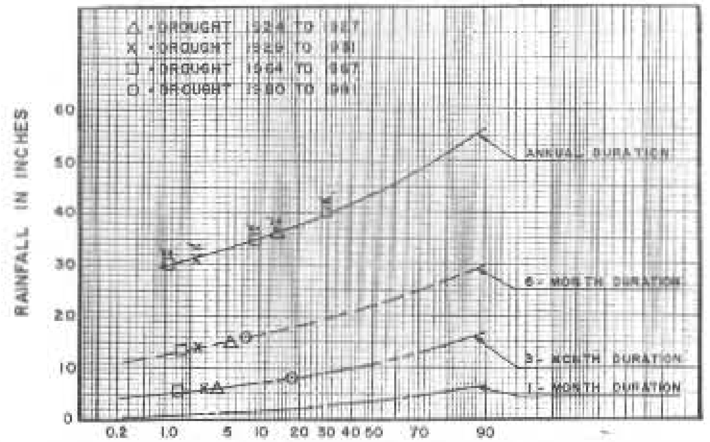
Month	Mean		Maximum		Minimum	
	cfs	inches	cfs	inches	cfs	inches
January	452	1.69	1515	5.67	95	0.36
February	444	1.50	1497	5.06	109	0.37
March	1090	4.08	3712	13.89	184	0.69
April	2199	7.92	4411	15.88	589	2.12
May	1010	3.78	2733	10.23	249	0.93
June	403	1.45	1439	5.18	64	0.23
July	205	0.77	1321	4.94	29	0.11
August	159	0.60	1539	5.76	36	0.13
September	200	0.72	1667	6.00	22	0.08
October	337	1.26	1768	6.61	33	0.12
November	567	2.04	1437	5.17	91	0.33
December	556	2.08	1578	5.91	137	0.51
ANNUAL	636	28.02	1084	47.77	272	11.98

An annual low flow frequency analysis was made of the historical low flow data for each selected USGS gaging station. Low flows were determined for durations of 1, 3, 14, 30, 60, 90, 183 and 365 consecutive days for each climatological year (1 April to 31 March) using the USGS "WATSTORE" data storage and retrieval computer system. The annual low flows for each duration were fitted to a Log Pearson Type III distribution. The fitting technique involves transforming annual low flow values to logarithmic values and finding the mean, standard deviation and skew coefficient of the logarithms. The computed low flow frequency duration curves are shown graphically on plates 1 through 3. Historical data, where available, was plotted for each index station. It is noted that low flow duration curves are not shown less than a 30 day period. Within New England, low streamflow data, over a consecutive period of less than 30 days, is considered to be inconclusive when assessing drought conditions.

d. Palmer Drought Severity Index (PDSI). The Palmer Drought Severity Index is a widely used indicator of drought conditions. It is published in the following: "Weekly Weather and Crop Bulletin" prepared jointly by the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Department of Agriculture (USDA); "Weekly Climate Bulletin" of the NOAA, Climate Analysis Center; and monthly "National Water Conditions" report of the U.S. Geological Survey. The National Climate Center computes the PDSI for all climate divisions in the contiguous United States.

The PDSI is a meteorological index that reflects estimates of departure of soil moisture from normal. Normal moisture conditions are derived from period of record data including monthly averages of evapotranspiration, soil water recharge, runoff and water loss from the soil. The index is standardized so that it has a consistent meaning in different climate areas and from month to month. The classification system translates the numerical value of the index to a descriptive measure of drought or wetness. The dry periods on the index are classified as extreme drought and assigned a numerical value of -4.0. The region on the PDSI graph between extreme drought and near normal conditions was subdivided into three additional drought categories: Severe (PDSI = -3.0): Moderate (PDSI = -2.0); and Mild (PDSI = -1.0). The current PDSI classification system is shown graphically on plates 1 through 3. Also shown on the PDSI graphs are the classifications assigned by others to some historic droughts data that occurred throughout New England.

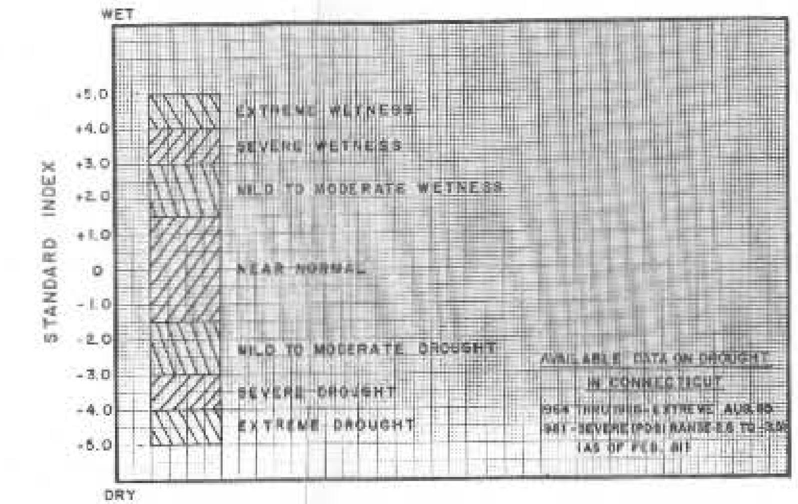
The PDSI is presented as a tool in assessing current wet or dry conditions only and should be used in conjunction with other hydrological and climatological data for effective drought management. The PDSI should not be used for drought planning or hydrologic drought forecasting.



RAINFALL DURATION CURVES

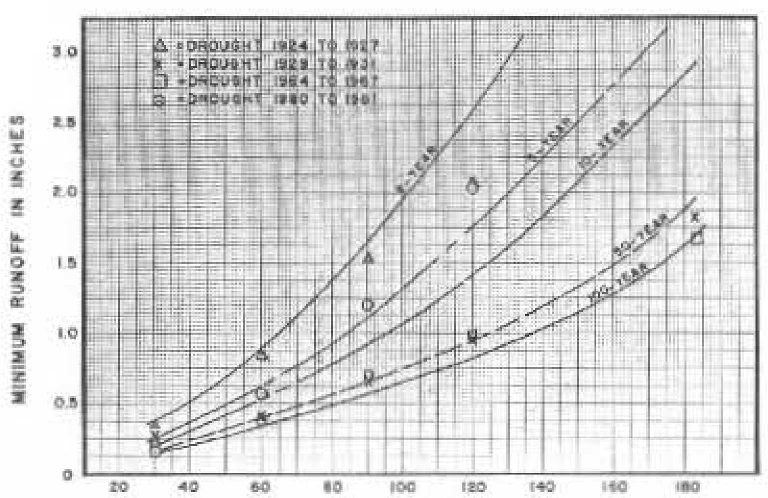
STORRS, CONNECTICUT (EL. = 650.0 FT. N.G.V.D.)

PERIOD OF RECORD 101 YRS.



PALMER DROUGHT SEVERITY INDEX (PDSI)

STANDARD CLASSIFICATION INDEX OF WET AND DRY PERIODS

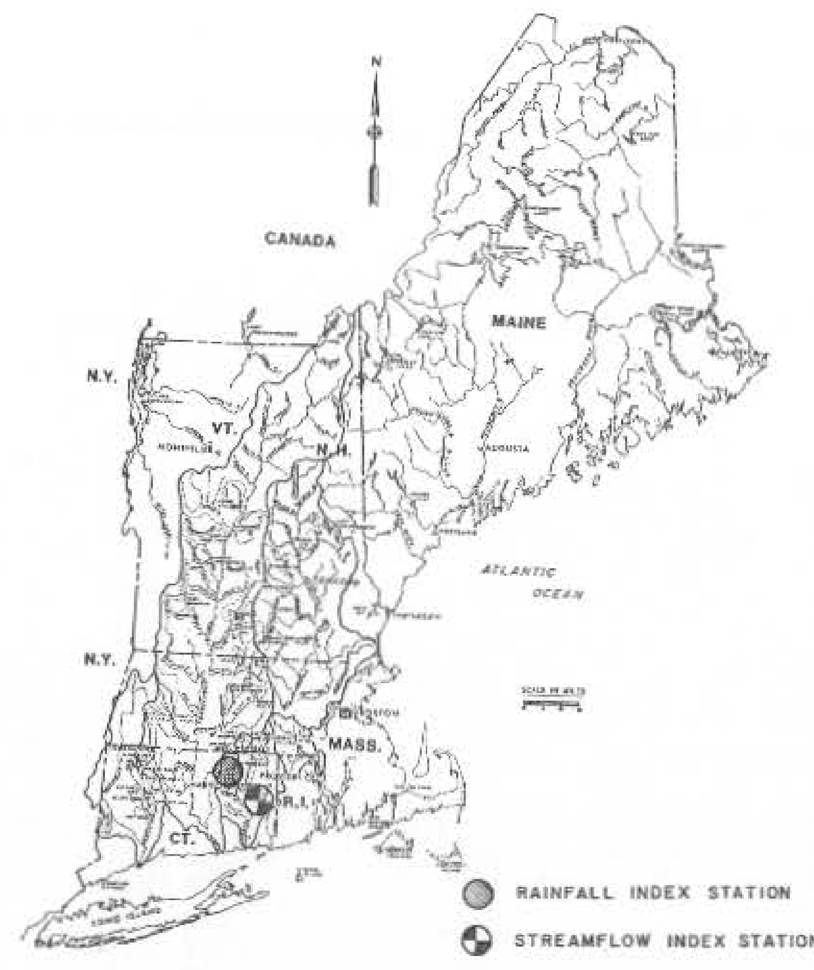


MINIMUM RUNOFF - FREQUENCY CURVES

QUINEBAUG RIVER AT JEWETT CITY, CONNECTICUT

D.A. = 713 SQ. MI.

PERIOD OF RECORD 73 YRS.



RAINFALL AND STREAMFLOW LOCATION MAP

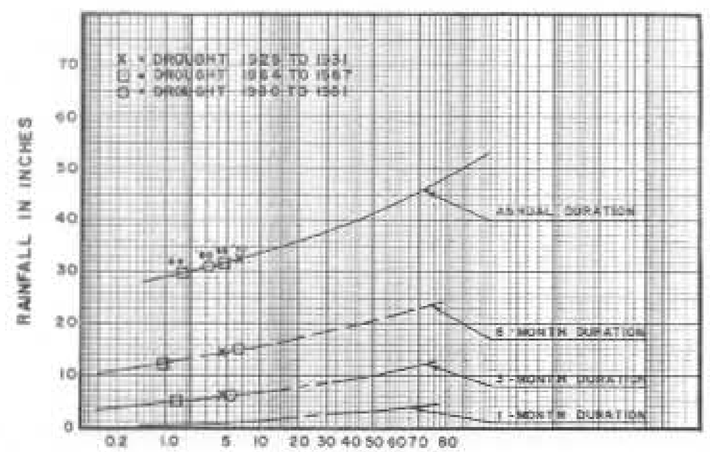
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DROUGHT CONTINGENCY PLAN

RAINFALL AND RUNOFF

GUIDE CURVES FOR

SOUTHERN NEW ENGLAND

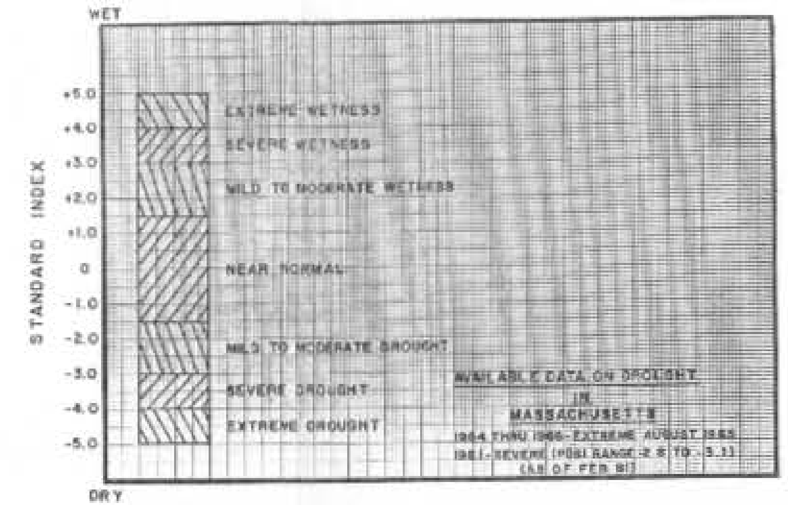


PERCENT CHANCE OF OCURENCE IN ANY GIVEN YEAR

RAINFALL DURATION CURVES

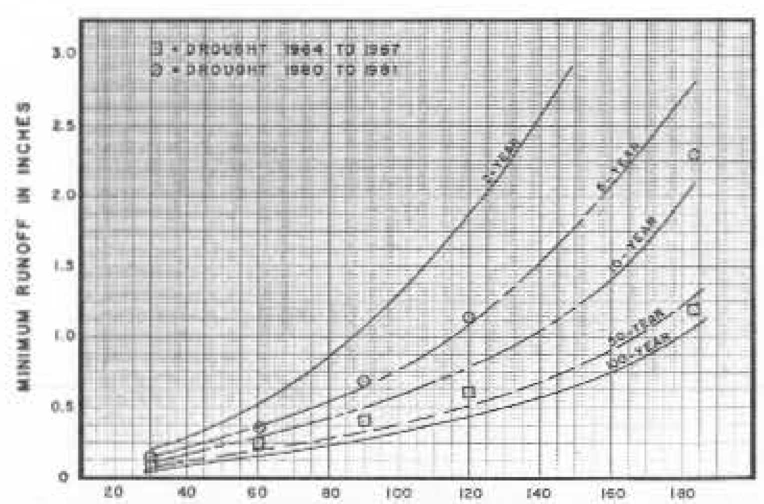
AMHERST, MASSACHUSETTS (EL. = 150.0 FT. N.G.V.D.)

PERIOD OF RECORD 64 YRS.



PALMER DROUGHT SEVERITY INDEX (PDSI)

STANDARD CLASSIFICATION INDEX OF WET AND DRY PERIODS



DURATION IN DAYS

MINIMUM RUNOFF-FREQUENCY CURVES

WEST BRANCH WESTFIELD RIVER AT

HUNTINGTON, MASSACHUSETTS

D.A. = 94 SQ. MI.

PERIOD OF RECORD 54 YRS.

RAINFALL AND STREAMFLOW LOCATION MAP

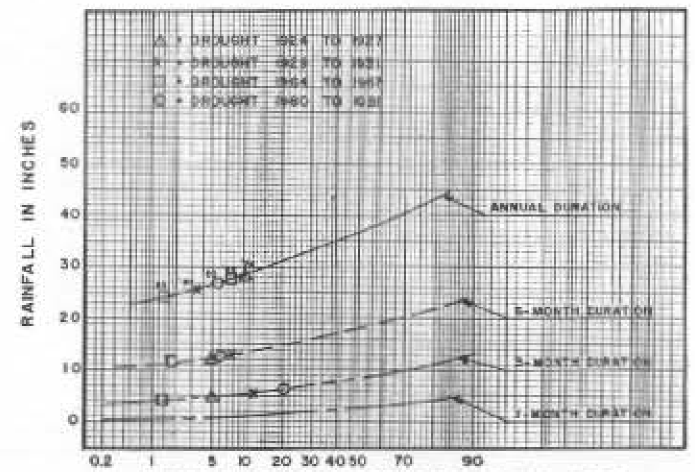
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DROUGHT CONTINGENCY PLAN

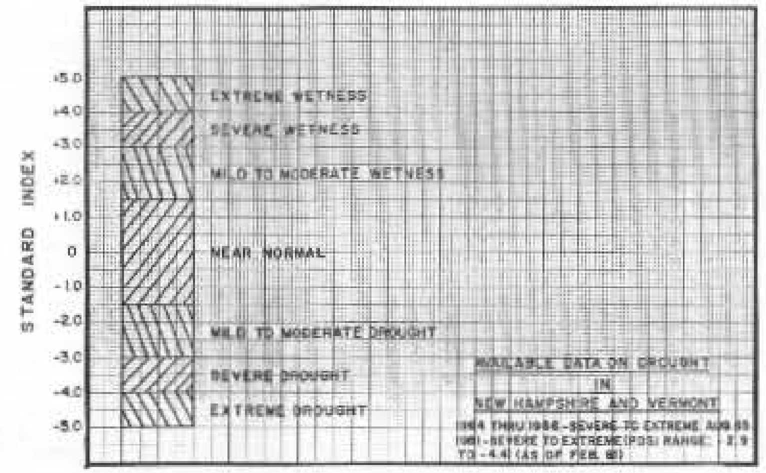
RAINFALL AND RUNOFF

GUIDE CURVES FOR

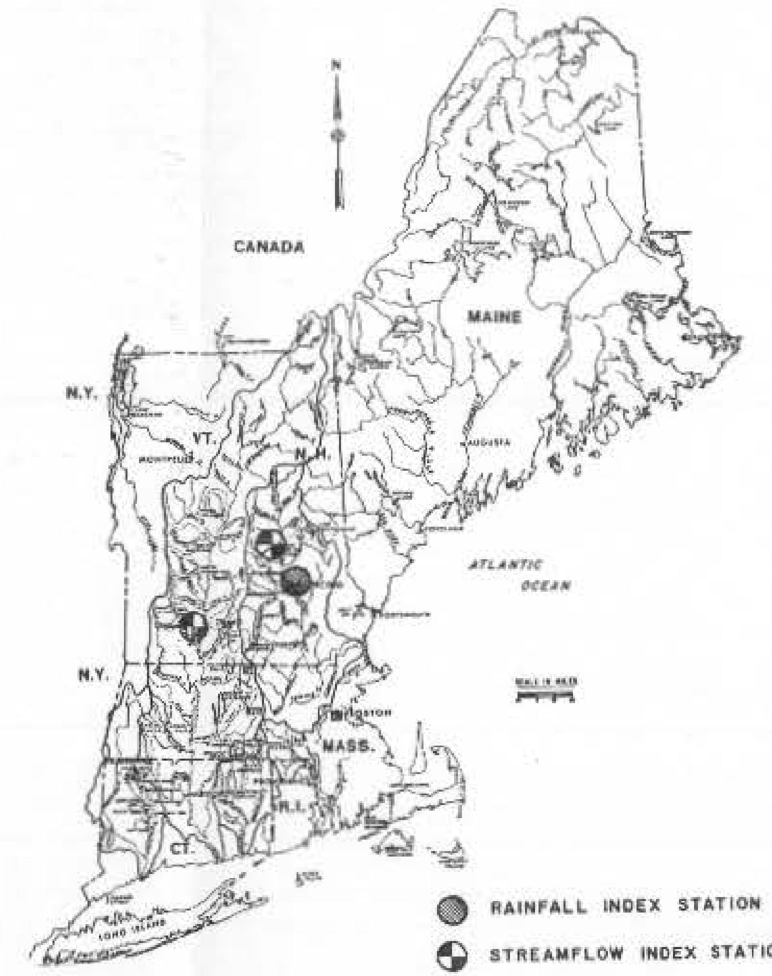
MASSACHUSETTS AND SOUTHERN N.H.



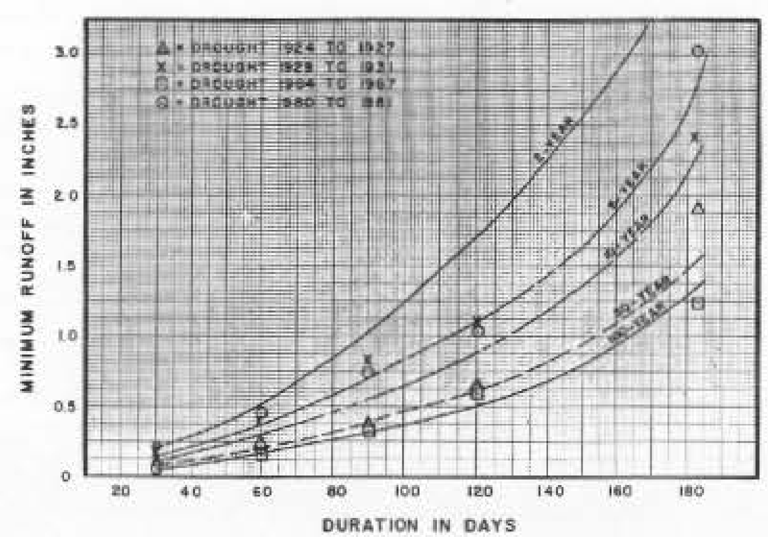
RAINFALL DURATION CURVES
CONCORD, NEW HAMPSHIRE (EL. = 350.0 FT. N.G.V.D.)
PERIOD OF RECORD 69 YRS.



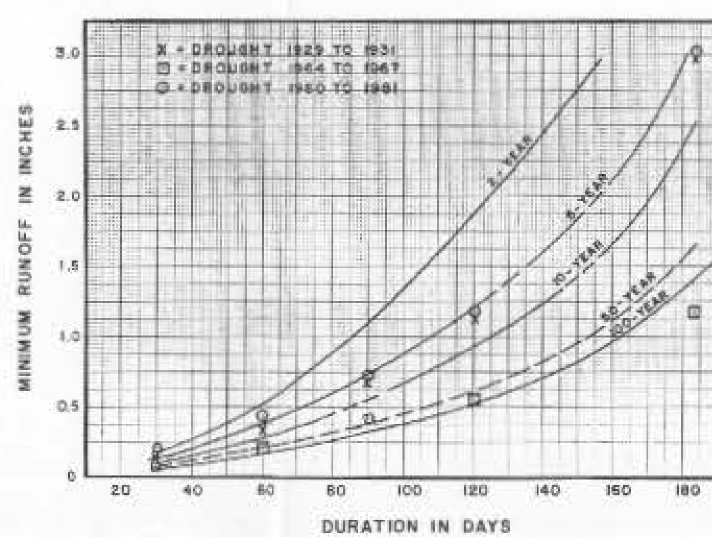
PALMER DROUGHT SEVERITY INDEX (PDSI)
STANDARD CLASSIFICATION INDEX OF WET AND DRY PERIODS



RAINFALL AND STREAMFLOW LOCATION MAP



MINIMUM RUNOFF-FREQUENCY CURVES
SMITH RIVER NEAR BRISTOL NEW HAMPSHIRE
D.A. = 85.8 SQ. MI.
PERIOD OF RECORD 71 YRS.



MINIMUM RUNOFF FREQUENCY CURVES
WEST RIVER AT NEWFANE, VERMONT
D.A. = 308 SQ. MI.
PERIOD OF RECORD 63 YRS.

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

DROUGHT CONTINGENCY PLAN

RAINFALL AND RUNOFF

GUIDE CURVES FOR

NEW HAMPSHIRE AND VERMONT