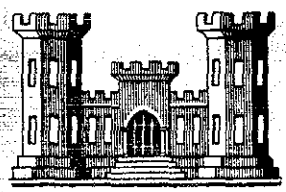
CONNECTICUT RIVER BASIN

MASTER MANUAL OF RESERVOIR REGULATION

APPENDIX C
BLACK RIVER WATERSHED

VERMONT



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

OCTOBER 1968

CONNECTICUT RIVER FLOOD CONTROL

MASTER MANUAL

OF

RESERVOIR REGULATION

APPENDIX "C"

BLACK RIVER WATERSHED

Department of the Army
New England Division, Corps of Engineers
Waltham, Massachusetts

October 1968

CONNECTICUT RIVER FLOOD CONTROL

MASTER MANUAL
OF
RESERVOIR REGULATION

Appendix	Watershed	Reservoirs	Status
Master Manual	Connecticut River	-	Not Started
A	Ompompanoosuc River	Union Village	Completed 1950
B	Ottauquechee River	North Hartland	Started
C	Black River	North Springfield	Completed 1968
D	West River	Ball Mountain	Completed 1965
		Townshend	Completed 1965
E	Ashuelot River	Surry Mountain	Completed 1962
		Otter Brook	Completed 1962
F	Millers River	Birch Hill	Completed 1950
		Tully	Completed 1950
G	Chicopee River	Barre Falls	Completed 1964
		Conant Brook	Completed 1964
H	Westfield River	Knightville	Completed 1967
		Littleville	Completed 1967
I	Farmington River	Colebrook River	Started
		Mad River	Started
		Sucker Brook	Started

P R E F A C E

The Black River basin comprises an area of 204 square miles and is located in southern Vermont. The flood control plan for the basin, described in the manual, consists of a dam and reservoir.

This Appendix of the Connecticut River Master Regulation Manual includes a description of the basin; statistical, climatological and flood data; project descriptions and regulation procedures for the flood control project. The manual, in addition to setting forth a method of reservoir regulation, will serve as a reference source for future studies. Pertinent data and detailed information on reservoirs and local protection projects are contained in the main appendix. Detailed procedures for regulation of the reservoir are contained in Attachment I. Attachment II contains information on the maintenance of hydrologic equipment.

This manual is organized in a manner that enables the reader to obtain desired general and background information in the main appendix. The attachments contain the pertinent information and detailed procedures necessary for actually regulating the protective works.

MANUAL OF RESERVOIR REGULATION
BLACK RIVER BASIN
VERMONT

APPENDIX "C"

LIST OF TABLES

LIST OF PLATES

MANUAL OF RESERVOIR REGULATION
BLACK RIVER BASIN
VERMONT

AUTHORITY AND SCOPE

1. AUTHORITY

This report is submitted pursuant to authority contained in ER 1110-2-240, dated 25 March 1963, and EM 1110-2-3600, dated 25 May 1959, which requires that manuals of reservoir regulation for flood control, navigation or multipurpose reservoirs be prepared whenever storage allocated to one or more of the functions is the responsibility of the Corps of Engineers.

2. PURPOSE AND SCOPE

This manual will serve as a guide and reference source for higher authority, reservoir regulation and maintenance personnel in the New England Division office, respective flood control dam operators, and for personnel who will be concerned with or responsible for regulation of the North Springfield Reservoir in the Black River basin. Included in this appendix are:

a. A brief history of flood problems in the basin and the subsequent studies which led to Congressional authorization of the Black River flood control plan and later modifications.

b. A general description of the drainage basin including topographic features and statistical data relative to population, industry and agriculture.

c. A general coverage of the hydrometeorological data for the basin which includes temperature, precipitation, snowfall, snow cover, storms, streamflow and floods.

d. A description of the basin plan of improvement consisting of a flood control dam with reservoir.

e. Effectiveness of regulation on floods of record and standard project flood.

f. Design criteria.

g. Detailed regulation procedures.

h. Maintenance of hydrologic equipment.

3. GENERAL

The Black River watershed has a long history of flooding, particularly within the communities of Springfield and Ludlow, Vermont. First studies by the Corps of Engineers were reported in 1937 in which two flood control reservoirs, North Springfield and Ludlow, were authorized. Further studies and later reports resulted in enlarging the storage capacity of the North Springfield Reservoir due to the subsequent elimination of the Ludlow project.

4. PUBLISHED REPORTS

Recommendations for flood control of the Black River have been presented in the following reports:

a. The Black River basin was included in a Report on Survey and Comprehensive Plan for Protection of the Connecticut River Valley which was submitted 20 March 1937. The plan, authorized by Public Law 761, 75th Congress, called for a second reservoir on the Black River above Ludlow, Vermont which would act with the North Springfield Reservoir for control of the Black River watershed above North Springfield.

b. The Review of Reports on Flood Control, submitted 20 February 1940, included both North Springfield and Ludlow Reservoirs. The capacity of the North Springfield Reservoir was increased from 26,500 to 33,400 acre-feet and the spillway crest was raised from elevation 519.0 to 528.5. This review was the basis of the Second Interim Report submitted to Congress as House Document 724, 76th Congress, 3rd session. The revised plan for protection as recommended in the report was authorized by Public Law 228, 77th Congress, 1st session. The North Springfield and Ludlow projects were included in the revised plan.

c. A modification of the project was recommended by letter, dated 14 June 1950, subject: "Review of Estimates, River and Harbor and Flood Control Projects." The modification provided a reservoir with spillway crest at elevation 541.5. The change was requested to compensate for elimination of the Ludlow Reservoir which was considered advisable due to local opposition. The State of Vermont concurred in the construction of the project by letter dated 10 February 1956.

d. Flood control of the Black River was also considered in Part Two, Chapter XXI of "The Resources of the New England-New York Region," dated 1957 and printed in Senate Document 14, 85th Congress. It consisted of a comprehensive survey of land, water and related natural resources of the region. The 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.

5. BLACK RIVER BASIN

The Black River basin, shown on plates C-1 and C-2, is located in southern Vermont primarily in Windsor County with a small portion extending westward into Rutland County. The watershed, which drains in a general southeasterly direction, is elongated in shape with a length of about 22 miles and maximum width of 12 miles. It has a drainage area of 204 square miles of which 158 lie upstream of the North Springfield dam. The topography of the basin is hilly with steep wooded slopes. There are a few ponds in the northern headwaters but in general the watershed is conducive to rapid runoff. The elevation varies from 3,700 feet msl at Shrewsbury Peak in the northernmost headwaters to about 280 feet msl at its confluence with the Connecticut River in Springfield, Vermont.

6. BLACK RIVER

The Black River originates in the northwestern part of the basin at Black Pond in the town of Plymouth, Vermont. The river then follows a southerly course for about 12 miles, of which 4 miles pass through Echo and Rescue Lakes to Ludlow, Vermont where it changes course to an easterly direction for 14 miles. North of Perkinsville, the river takes a more southerly course to its mouth where it empties into the headwater pool of the Bellows Falls Power dam on the Connecticut River. The entire length of the river is about 39 miles with a rather uniform drop of 950 feet. Profiles of the Black River and its tributaries are shown on plate C-3.

7. TRIBUTARIES

a. General. The three largest tributaries of the Black River watershed are the North Branch, Great Brook and Twentymile Stream, with respective drainage areas of 33, 20 and 15 square miles.

b. North Branch. The North Branch, located along the northeast section of the watershed, has its origin in South Reading and flows in a southerly direction for approximately 10 miles to its confluence with the main river, about 3 miles upstream of the North Springfield dam. The river has a total fall of about 780 feet.

c. Great Brook. Great Brook, located in the southern portion of the basin, has its origin in Duttonsville Gulf where it flows in an easterly direction and enters the Black River in the town of North Springfield, a short distance downstream of the North Springfield dam. The brook falls about 680 feet in its 8.5 mile length.

d. Twentymile Stream. Twentymile Stream, located in the central part of the watershed, has its source in the hills just east of Plymouth

Kingdom where it flows in a southerly direction and joins the Black River in Whitesville, about 12 miles above the dam. The stream falls about 820 feet in its 8.5 mile length.

DEVELOPMENT IN THE BLACK RIVER BASIN

8. GENERAL

The basin has shown a moderate growth in its economic activity over the past decade and it is expected this area of Vermont will continue to grow at a moderate rate.

9. POPULATION

There are approximately 20,000 inhabitants in the Black River basin of which more than 50 percent are living in the towns of Springfield and Ludlow. According to the 1960 U. S. Census, the population of Springfield was 9,934 an increase of about 8 percent over the 1950 figure of 9,190. Ludlow has shown a slight decrease from 2,428 to 2,386 during the same decade.

10. ECONOMIC DEVELOPMENT

Employment in agriculture has declined from 25 percent of the basin's work force in the 1930's to a present value of about 8 percent. Tillable land is generally scarce in the area and agricultural activity is largely restricted to dairying and the production of poultry and eggs, with hay as the principal field crop.

Approximately 30 percent of the area's work force is employed in manufacturing with approximately half of these in large machine tool firms located in and around Springfield. Another 5 percent is employed in the lumber and wood industry, with the remaining work force associated with service related businesses.

The region's scenic uplands, with good stream fishing, hunting and skiing, make tourism an increasingly important factor in the economic life of the basin.

HYDROLOGY

11. CLIMATOLOGY

a. General. The Black River basin has a variable climate characterized by frequent but short periods of heavy precipitation. It lies in the belt of the "prevailing westerlies" and is exposed to the cyclonic disturbances that cross the country from the west or southwest, producing

frequent weather changes. The area is also exposed to coastal storms, occasionally of tropical origin (hurricanes), that travel up the Atlantic seaboard. Winters are moderately severe with subzero temperatures being common and summers are mild with temperatures over 90° Fahrenheit being infrequent. Precipitation is fairly well distributed throughout the year. Climatological stations within or adjacent to the Black River watershed are shown on plate C-2.

b. Temperature. The average annual temperature of the Black River basin is about 53° Fahrenheit. Average monthly temperatures vary widely throughout the year from 18° F. in January to 68° F. in July. Extremes in temperature range from occasional highs slightly in excess of 100° F. to infrequent lows in the minus 40's. A record of temperatures has been maintained at Cavendish, Vermont for the past 63 years through 1966. Extremes and average values for the months of the year are shown in table C-1 and illustrated on plate C-4.

c. Precipitation. The mean annual precipitation over the basin is about 40 inches distributed rather uniformly throughout the year. Average monthly rainfall at Cavendish ranges from a minimum recorded value of 0.0 inch in March to a maximum value of 11.30 inches in July. The range between maximum and minimum monthly values and average values are shown in table C-2 and illustrated on plate C-5.

d. Snowfall and snow cover. The annual mean snowfall for 61 years of record at Cavendish, Vermont (elevation 800 feet), in the middle of the Black River basin, is 84.2 inches with approximately 50 percent occurring in the months of January and February. The average monthly snowfall is shown in table C-3. Snow surveys have been taken in the watershed by the Corps of Engineers since 1958 and locations of these courses are shown on plate C-2. Water content in the snow cover reaches a maximum about the middle of March, and since 1958 has averaged about 6.5 inches with a maximum of 10.8 and a minimum of 3.7 inches. Moderately high springtime discharges frequently occur as the result of melting snow, but runoff from this source alone has been insufficient to cause a major flood during the period of record. However, due to a combination of heavy rain and snowmelt, serious flooding is a possibility every year.

e. Storms. The Black River basin experiences three general types of storms, namely, continental, coastal and those associated with thunderstorms which may be of local origin or the result of a stationary front. Continental storms originate over the western or central part of the United States and move in a general easterly or northeasterly direction. These storms may be rapidly moving intense cyclones, or the stationary type and are not limited to any season or month but follow one another at more or less regular intervals with varying intensities throughout the year.

Tropical hurricanes, the most severe of the coastal storms, originate in the South Atlantic or Western Caribbean Sea. They generally move

TABLE C-1

MONTHLY TEMPERATURES
AT CAVENDISH, VERMONT
1903 - 1966

Month	Mean	Maximum	Minimum
January	18	65	-38
February	19	63	-40
March	30	82	-27
April	42	93	- 2
May	55	94	17
June	63	100	27
July	68	102	33
August	65	99	30
September	67	97	17
October	47	89	9
November	35	80	-17
December	22	61	-42
ANNUAL	53		

TABLE C-2

MONTHLY PRECIPITATION
AT CAVENDISH, VERMONT
1902 - 1966

Month	Mean	Maximum	Minimum
January	3.09	6.24	1.05
February	2.81	5.17	.83
March	3.28	9.47	.00
April	3.37	6.78	.25
May	3.39	7.33	.47
June	3.73	8.24	.58
July	4.03	11.30	1.52
August	3.26	7.82	.67
September	3.53	10.76	.62
October	3.19	8.28	.49
November	3.54	10.96	.69
December	3.01	6.36	.69
ANNUAL	40.23		

TABLE C-3

MONTHLY SNOWFALL AT
CAVENDISH, VERMONT
(Average Depth in Inches)
1905 - 1966

January	19.9
February	20.8
March	15.8
April	6.0
May	0.3
June	0
July	0
August	0
September	0
October	0.3
November	6.1
December	15.3

Average Annual Snowfall = 84.2

in a westerly direction, recurving to a more northerly path near the mainland and then northeast approaching New England. Although the normal path is to the south and east, they may be drawn over this area by continental cyclonic disturbances or deflected by a large slow moving anticyclone center located to the east of New England. The latter is known as a "blocking high." Hurricanes have occurred during the late summer or fall months with a higher coincidence in August and September.

Extratropical coastal storms generally originate near the Middle Atlantic States and then travel northward along the coastline. These storms occur most frequently during the autumn, winter and spring months. Thunderstorms can be produced by local convective activity or be the frontal type associated with summer months.

12. STREAMFLOW

a. Discharge records. The only stream gaging station in the Black River basin is located on the Black River a short distance downstream of the North Springfield dam. The station, which measures runoff from a drainage area of 158 square miles, was established in October 1929 and has furnished a continuous record to date. Runoff data has been adjusted for storage in North Springfield dam since operation began in 1960. Hydrographs at the North Springfield gage through 1953 are shown on plates C-6 through C-8.

b. Streamflow data. Annual runoff for the period of record through September 1965 has varied from 10.29 inches in 1965 to 36.40 in 1960 with an average of 23.58. The mean annual runoff represents about 60 percent of the mean annual precipitation. About 60 percent of the annual runoff occurs in the months of March, April and May. Discharges for the 36-year period of record have varied from a maximum peak of 15,500 cfs in September 1938 to a minimum daily flow of 8 cfs in July 1962, with an average annual recorded flow of 274 cfs. A summary of the mean, maximum and minimum monthly runoff is shown in table C-4 and illustrated on plate C-9.

13. FLOODS OF RECORD

a. General. Flooding has occurred on the Black River during all seasons of the year. The floods of March 1936 and December 1948 were caused by heavy rains with melting snow. Heavy precipitation during the summer and fall months caused the floods of November 1927, July 1931, September 1938 and June 1952.

b. Historic floods. The flood history of the Black River extends back more than 150 years. Records concerning early events, although meager, indicate the earliest flood to cause widespread damage in the basin occurred in 1801. The February 1824 flood reportedly washed-out all bridges over the Black River. The "great" flood of October 1869 far exceeded any other previous event for which information is available.

c. Recent floods. In recent years four major floods have been experienced in the Black River basin occurring in November 1927, March 1936,

TABLE C-4

MONTHLY RUNOFF - BLACK RIVER
AT NORTH SPRINGFIELD, VERMONT

Month	Mean		Maximum		Minimum	
	CFS	Inches	CFS	Inches	CFS	Inches
January	190	1.38	530	3.86	49	0.36
February	179	1.18	395	2.60	42	0.28
March	440	3.20	1800	13.14	58	0.42
April	984	6.94	1690	11.92	300	2.13
May	423	3.08	1220	8.92	117	0.85
June	198	1.40	582	4.12	45	0.32
July	98	0.71	439	3.21	18	0.13
August	63	0.46	278	2.03	15	0.11
September	88	0.62	875	6.19	16	0.11
October	117	0.85	401	2.92	22	0.16
November	224	1.58	643	4.54	51	0.36
December	216	1.58	596	4.35	70	0.51
ANNUAL	274	23.58	376	32.33	142	12.18

September 1938 and June 1952. A brief description is given in the following paragraphs.

(1) Intense rainfall associated with the storm of 3-4 November 1927 produced the greatest known flood on the Black River. There is no recorded discharge available, but it is estimated from records on the Ottauquechee and West Rivers that the peak discharge approximated 20,000 cfs at the gaging site. Cavendish, Vermont recorded 8.0 inches of rain and greater amounts probably fell over the higher terrain.

(2) The second largest flood occurred on 21-22 September 1938 when a hurricane traveled northward through the Connecticut River valley. Rainfall over the watershed accompanying the hurricane, combined with precipitation for the previous two days, totaled 7.5 inches. The flood at the gaging station peaked at 15,500 cfs with a runoff volume of 5 inches.

(3) Next in size was the flood of March 1936 which consisted of two peaks resulting from separate storms about six days apart. Both were caused by heavy rains and warm temperatures which resulted in rapid melting of extensive snow cover. The first rise peaked on 12 March with a maximum flow of approximately 6,500 cfs and the second, crested on 18 March with a peak flow of 14,700 cfs. The volume of runoff that occurred between 12 and 22 March totaled 10 inches. The rainfall at Cavendish totaled 7.9 inches during the period from 9 to 22 March.

(4) Another major flood occurred on 1 June 1952 when more than 4 inches of rain fell in 24 hours on ground already saturated from an abnormally wet May. A peak discharge of 13,000 cfs was recorded.

d. Flood profiles. High water profiles determined from field surveys following the floods of 1936 and 1938 are shown on plate C-3.

e. Flood frequencies. The frequency (percent chance of occurrence) of discharges was determined for the U. S. Geological Survey gaging station on the Black River in North Springfield. Frequency analyses were made in accordance with procedures described in ER 1110-2-1450, "Hydrologic Frequency Estimates," dated 10 October 1962. Following a regional frequency analysis, a skew coefficient of 1.0 was adopted for all tributaries of the Connecticut River. Discharge-frequency data, based on 36 years of record, are shown in table C-5.

14. ANALYSIS OF FLOODS

a. Black River. Floodflows and precipitation records were analyzed to determine runoff characteristics of the Black River basin such as time of year when floods may occur, effect of topography, relative timing, and flood peak contributions at downstream damage centers on the Connecticut river. The analysis resulted in the following conclusions:

(1) The Black River basin responds quickly to periods of intense

TABLE C-5

NATURAL PEAK DISCHARGE FREQUENCY DATA
BLACK RIVER AT NORTH SPRINGFIELD
(Drainage Area = 158 Square Miles)

Expected Probability		Black River Flows (cfs)
Percent Chance	Years	
0.50	200	31,500
1.0	100	24,000
2.0	50	18,000
4.0	25	13,700
5.0	20	12,600
10.0	10	9,800
20.0	5	8,100
50.0	2	6,600
70.0	1.4	6,100
90.0	1.13	5,700
95.0	1.06	5,600
99.0	1.0[4]	5,500

rainfall which occur in any month and as a result, there is no flood-free season of the year. However, the greatest runoff occurs during March and April and is associated with snowmelt. The spring snowmelt is not of significant damaging magnitude unless augmented by rainfall.

(2) Steep slopes througnout the basin produce rapid runoff.

(3) During minor and moderate floods runoff from the upper 35 square miles, which drains into a series of lakes, is delayed considerably and does not contribute significantly to the flood peak at the gaging station. However, during major floods such as 1936 or 1938 when large volumes of runoff are involved the upper area contributes to the flood peak.

b. Connecticut River. Flooding along the Connecticut River is caused by excessive rainfall, melting snow or a combination of both factors. Analysis of floods of record reveal that Connecticut River floods have originated generally in the following manner: (1) as a general basin wide flood (usually with snowmelt), (2) in the northern portion upstream of White River Junction, (3) in the central portion between White River Junction and Montague City, and (4) in the southern portion downstream of Montague City.

The March 1936 event was basin wide, the September 1938 flood originated in the lower and central portions, the June 1947 flood occurred in the upper basin and the August 1955 flood was a lower basin event.

During floods originating in the northern part of the basin, peak flows at the mouth of the Black River occur earlier than Connecticut River peak discharges at White River Junction. With basin wide floods and those originating in the central portion, the Black River discharge synchronizes with the Connecticut River crest. During floods originating in the southern part of the basin, flood discharges from the Black River occur on the receding side of the Connecticut River hydrographs. Contributions from the Black River to the main river depends considerably on the location of the storm and flood in the Connecticut River basin. Relative timing of the 1936 and 1938 flood peaks at selected locations on the Black and Connecticut Rivers is shown in table C-6.

Contributions of the Black River to the major floods of March 1936 and September 1938 at key locations on the Connecticut River are listed in table C-7. Plate C-10 shows the effect of the reservoir on 1936 and 1938 events at the dam and also effect of the reservoir system on Connecticut River discharges at North Walpole for these floods.

15. DESIGN FLOODS

a. Standard project flood. A standard project flood for the Black River, Vermont was developed from standard project storm rainfall, as described in Civil Engineer Bulletin 52-8 and a unit hydrograph derived from analyzing the recorded floods of record in the river. The adopted

TABLE C-6

RELATIVE TIMING OF FLOOD PEAKS
BLACK AND CONNECTICUT RIVERS

Location	River Miles**	Drainage Area (sq.mi.)	Timing of Peak* March 1936	Timing of Peak* Sept. 1938
Black River at Mouth	183.1	204	0	0
Connecticut River				
at White River Junction, Vt.	215.0	4,092	13	5
at North Walpole, New Hampshire	172.5	5,493	15	10
at Vernon, Vermont	141.9	6,266	17	6
at Montague City, Massachusetts	119.0	7,865	19	10

* Time in hours after peak flow of Black River at mouth

** Above mouth of Connecticut River

TABLE C-7

BLACK RIVER CONTRIBUTIONS TO CONNECTICUT RIVER PEAK DISCHARGES DURING MAJOR FLOODS

	March 1936 Flood (cfs)	September 1938 Flood (cfs)
Black River at Gage	14,700	15,500
Connecticut River at North Walpole		
Observed peak flow	-	-
Computed peak flow	157,600	123,300
Black River contribution to computed Connecticut River peak	15,900	14,300
Percent contribution	10.1	11.6
Percent drainage area	3.8	3.8
TCI* (Percent contribution) / (Percent drainage area)	2.7	3.0
Connecticut River at Vernon		
Observed peak flow	176,000	132,500
Computed peak flow	171,000	148,300
Black River contribution to computed Connecticut River peak	11,900	11,200
Percent contribution	7.0	7.6
Percent drainage area	3.2	3.2
TCI*	2.2	2.4
Connecticut River at Montague City		
Observed peak flow	236,000	195,000
Computed peak flow	231,400	207,600
Black River contribution to computed Connecticut River peak	9,300	9,600
Percent contribution	4.0	4.6
Percent drainage area	2.6	2.6
TCI*	1.5	1.8

* Tributary Contribution Index

unit hydrograph is shown on plate C-11.

The 24-hour storm rainfall over the area averaged 9.44 inches and losses totaled 1.60 inches yielding a rainfall excess volume of 7.84 inches. The resulting flood hydrograph has a peak inflow to the reservoir pool of 48,000 cfs and a spillway discharge of 10,000 cfs as shown on plate C-12. In the town of Springfield, a peak discharge of about 15,000 cfs would occur resulting from the uncontrolled drainage area downstream of the North Springfield Reservoir.

b. Spillway design flood. A spillway design flood for the project was developed from probable maximum precipitation as described in Hydrometeorological Report 33. The reservoir was assumed full to spillway crest at the beginning of the flood with a peak inflow of 157,000 cfs, equivalent to about 1,000 csm from the 158 square mile drainage area. The spillway design flood is shown on plate C-13.

16. FLOOD DAMAGES

a. Experienced flood damage. The most damaging flood of record in the Black River basin, November 1927, caused damages estimated at $700,000. Most of the losses were sustained in the towns of Ludlow and Springfield, with $200,000 industrial and $370,000 highway and bridge damages. The following tabulation shows major losses by type in other large floods.

Date	Type of Loss ($1,000)				
	Urban	Industrial	Highway	Other	Total
Sept. 1938	135	50	100	50	335
March 1936*	70	35	80	20	205

* Record flood on lower Connecticut River

b. Recurring flood damages. A recurrence of November 1927 record flood stages in the basin would cause damages estimated at $6.6 million. Losses would be incurred by urban, rural, highway, railroad, utility and industrial properties in the basin. The major item of damage would be $5 million to industrial properties.

The stage-damage curve, shown on plate C-14, is intended to provide a quick estimate of flood losses along the Black River. The index site is located at Gear Shaper dam 1 in Springfield, Vermont. Additional detailed surveys following a flood event will supplement damage data as required.

17. GENERAL

The flood control plan for the Black River basin consists of a dam and reservoir constructed on the Black River upstream of North Springfield. The reservoir will prevent flooding in North Springfield and Springfield and reduce flows on the Connecticut River.

18. NORTH SPRINGFIELD DAM AND RESERVOIR

a. General. North Springfield Dam and Reservoir, placed in operation in September 1960, is located in east-central Vermont on the Black River at North Springfield, Windsor County. It is about 8.5 miles upstream of the confluence of the Black and Connecticut Rivers and 3 miles northwest of Springfield, Vermont. A general plan and vicinity map of the dam and reservoir area are shown on plate C-15.

Important physical components of the project consist of a rolled earth fill dam with rock slope protection, side channel spillway, outlet works, relocated town road 22 embankment, facilities for recreational purposes, and storage for both flood control and recreation. Pertinent data for the project is summarized in table C-8.

b. Dam. The dam consists of compacted random earth and rock fill approximately 2,940 feet long with a maximum height of 120 feet above the riverbed. The top width is 30 feet and the elevation for top of embankment is 570 feet msl, which is 24.5 feet above spillway crest and 5.2 feet above the design surcharge. The embankment slopes vary from 1 on 2 to 1 on 4.

c. Spillway. A conventional side channel spillway built in rock is located at the left abutment of the dam with the approach channel floor at elevation 535. The 384-foot long crest, having an ogee shape, is at elevation 545.5 feet. The discharge channel converges in width from 60 to 51 feet, and varies in slope from 6.25 to 1 percent. After discharging into a 200-foot long stilling basin, the flows are returned through a 1500-foot channel to the Black River. The plan and profile of the spillway are shown on plates C-16 and C-17.

d. Outlet works. The outlet works, also shown on plates C-16 and C-17, consist of an approach channel, intake structure, discharge conduit and discharge channel. The intake channel is about 735 feet long with invert at elevation 452. It is 20 feet wide except for the last hundred feet where it flares from 20 to 35 feet. A U-shaped concrete weir just upstream of the center gate maintains a 15-foot permanent pool. The concrete intake structure houses the necessary equipment to operate the three 5 x 12 foot slide gates with hydraulic hoists. These gates regulate the discharge through the 12.75 foot diameter horseshoe conduit.

The concrete conduit is 659 feet long with entrance invert at elevation 452 feet and exit invert at elevation 449. A rock-cut channel directs the discharge into the spillway channel.

e. Relocated Town Road 22 embankment. Relocation of Town Road 22 consisted of raising the road as it crossed the North Branch valley in the reservoir area. The road embankment and appurtenant structures provide a 20-foot deep permanent pool (North Branch recreation pool). Pertinent data for this subfeature of the project are shown on plates C-19 and C-20 and also summarized in table C-8.

f. Recreational facilities. The North Springfield Reservoir was authorized as a single-purpose flood control reservoir. However, section 4 of the Flood Control Act, approved 22 December 1944, as amended, provides for the development and use of reservoir areas for public, recreational and other purposes. Two recreation areas (North Branch and Black River) have been established at the project in which the following facilities have been provided: picnic areas with fireplaces, roads and parking areas, beaches, change houses with toilets, and boat ramp. These recreation areas are shown on plate C-18. The recreational facilities are being managed by the State of Vermont under a long term license agreement.

In December 1967 approval was received to increase the depth of the Black River pool from 15 to 23 feet during the recreation season. As this portion of the year, late spring to early autumn, has floodflows which are less prevalent, there is no significant effect on the flood control benefits of the project. Trial pools were held at various elevations along with field inspections in conjunction with State of Vermont officials. The 23-foot depth offered the best combination of water and developable lands and resulted in a maximization of recreational benefits. It is anticipated the recreational facilities for the 23-foot pool will be operational for the 1970 summer season.

g. Reservoir storage

(1) General. The reservoir when filled to spillway crest elevation 545.5 has a total capacity of 51,100 acre-feet, a surface area of 1,200 acres and is about 5.4 miles long.

(2) Permanent pool. A small permanent pool was originally provided to facilitate gate operations during the winter months. This 100-acre pool at elevation 467 feet msl has a water depth of 15 feet at the dam and about 500 acre-feet of storage.

(3) Recreation pool - Black River. Recreation pool will be maintained at elevation 475 during the summer months. It will have a maximum depth of about 23 feet, an area of 290 acres and utilize a net storage of 1,500 acre-feet.

(4) Recreation pool - North Branch. This 20-foot deep permanent recreation pool (elevation 502 feet), located on the North Branch and

TABLE C-8

PERTINENT DATA
NORTH SPRINGFIELD DAM AND RESERVOIR

LOCATION	Black River, Springfield, Vermont			
DRAINAGE AREA	158 square miles			
RESERVOIR STORAGES				
	Permanent Pool	Recreation Pool Areas		Flood Control Pool
		Black River	North Branch	
Full pool elevation (ft,msl)	467	475	502	545.5
Capacity - acre-feet (net)	500	1,500	600	48,500 to 50,000
- inches (net)	0.06	0.18	0.07	5.75 to 5.93
Full pool area (acres)	100	290	65	1,200

EMBANKMENT FEATURES		
	Main Dam	Relocated Town Road 22 (North Branch)
Type	Rolled earth and rockfill	Rolled earth and rock fill
Length (ft)	2,940	900
Top elevation (ft,msl)	570	552
Maximum height	120	75
Top width	30	28
Slopes	1 on 2 to 1 on 4	1 on $2\frac{1}{4}$ to 1 on $2\frac{1}{2}$

SPILLWAY FEATURES		
Type	Conventional side channel with ogee weir	Broad Crested (Town Road 22 roadway)
Length (ft)	384	200
Crest elevation (ft,msl)	545.5	550

SPILLWAY DESIGN FLOOD		
Inflow (cfs)	157,000	8,200 (project design flood)
Total outflow	125,500	2,440
spillway	117,200	1,600
conduit	8,300	840
Maximum surcharge (ft,msl)	564.8	551.5
feet above crest	19.3	1.5

OUTLET WORKS		
Type	Horseshoe conduit	Cir. corrugated metal
Size (ft, diameter)	12.75	8
Length (ft)	659	300
Invert elevation (ft,msl)	452	497
Capacity at spillway crest (cfs)	11,900	1,800
Gate type	Three 5'x12' slide	-

LAND ACQUISITION	
Fee taking elevation (ft,msl)	520
Flowage easement	550
PROJECT COST	$6,654,000 (dam and appurtenant facilities)
PLACED IN OPERATION	September 1960
MAINTAINED BY	New England Division

impounded by Town Road 22 embankment, has a storage of about 600 acre-feet and covers 65 acres.

(5) Flood control. During the late fall, winter and spring months there is a net storage of 50,000 acre-feet set aside for flood control purposes, which is equivalent to 5.93 inches of runoff from the 158 square mile drainage area. By raising the recreation pool to elevation 475, the net storage is slightly reduced to 48,500 acre-feet, equivalent to 5.75 inches of runoff.

19. FREQUENCY OF RESERVOIR FILLING

The following tabulation denotes the estimated frequency of filling relationship for the North Springfield Reservoir:

TABLE C-9

FREQUENCY OF RESERVOIR FILLING

Pool Elevation (ft,msl)	Estimated Frequency (years)
500	1
510	2
520	5
530	10
540	20
545.5	35

20. REGULATION PROCEDURES

Regulation procedures for North Springfield dam are contained in attachment I. There are no major deviations from the previously established SOP, dated January 1961.

21. EFFECTIVENESS OF PROJECT

Since 1961 when the North Springfield Dam and Reservoir reached operational status, there have been five significant operations. An estimated $730,000 in damages to properties in the Connecticut River basin have been prevented.

22. AUTOMATIC HYDROLOGIC RADIO REPORTING NETWORK

The effective regulation of flood control projects in New England, consisting of 35 flood control dams and 2 hurricane barriers require an efficient, reliable and rapid means of both collecting and coordinating

hydrologic data by the Reservoir Regulation Section. The installation of an automatic hydrologic radio reporting network has been undertaken recently.

Radio gaging stations are being established at the following locations in the Connecticut River basin:

Passumpsic River at Passumpsic, Vermont
Connecticut River at Wells River, Vermont
White River at West Hartford, Vermont
Connecticut River at White River Junction, Vermont
Connecticut River at North Walpole, New Hampshire

Deerfield River at West Deerfield, Massachusetts
Connecticut River at Montague City, Massachusetts
Chicopee River at Indian Orchard, Massachusetts
Westfield River at Westfield, Massachusetts

Connecticut River at Springfield, Massachusetts
Farmington River at Collinsville, Connecticut
Farmington River at Rainbow, Connecticut
Connecticut River at Hartford, Connecticut

Radio gages will also be installed at Mad River and Conant Brook Reservoirs (see plate C-1 for locations of radio gages).

The network is scheduled for completion by the end of fiscal year 1969. Details of the radio hydrologic reporting network will be covered in the Connecticut River Master Manual of Reservoir Regulation.

23. IMPROVEMENTS BY OTHER FEDERAL AGENCIES

The Soil Conservation Service (SCS) of the U. S. Department of Agriculture has developed a work plan for the Jewell Brook watershed (dated April 1964) which affords protection to the community of Ludlow, Vermont from Jewell Brook floodflows. This plan includes 4 small floodwater retarding reservoirs in the headwaters and a diversion channel in Ludlow and is shown on plate C-21. Pertinent data are contained in table C-10.

TABLE C-10

PERTINENT DATA - SCS PROJECTS

A. FLOOD RETARDING STRUCTURES*

Reservoir Site	Drainage Area (sq.mi.)	Reservoir Area and Storage at Emergency Spillway Elevation		Outlet Discharge at Emergency Spillway		Conduit Size
		Area (acres)	Storage (inches)	CFS	CSM	
1 - Upper Jewell Brook	2.09	26	3.0	136	65	30" Diameter
2 - Grant Brook	1.74	18	3.0	148	85	30" Diameter
3 - Parker Brook**	1.31	20	3.0	144	110	30" Diameter
5 - Sanders Brook	1.74	8.2	2.0	164	25	30" Diameter

* Site 1 is scheduled for completion in 1968, site 2 in 1969, with the work plan completed by 1972

** Multiple-purpose project, recreation and flood control

B. DIVERSION CHANNEL

Stream	Location	Length (ft)	Design Capacity (cfs)	Scheduled Completion Date
South Hill Brook	Town of Ludlow	665	175	Completed

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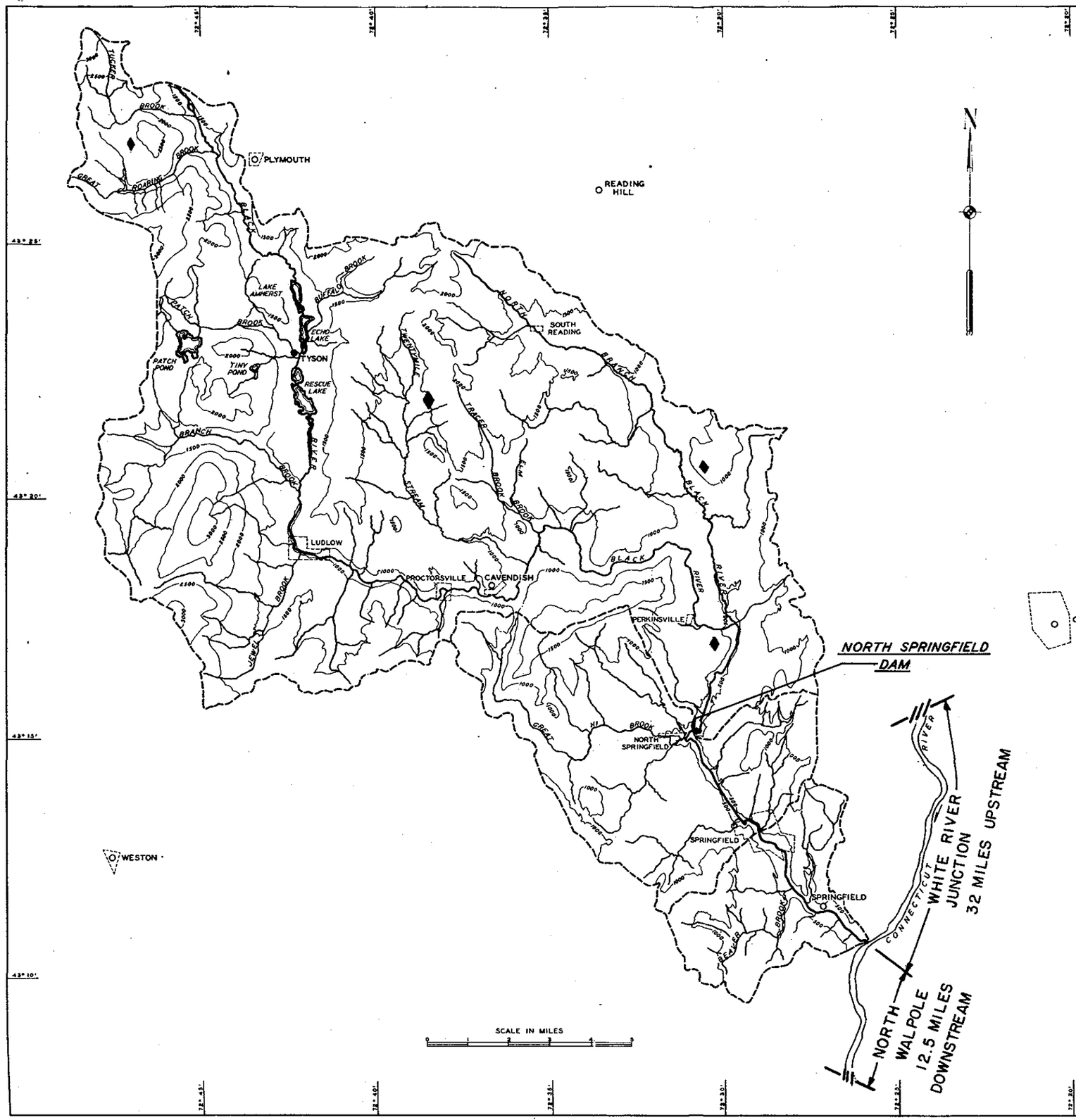

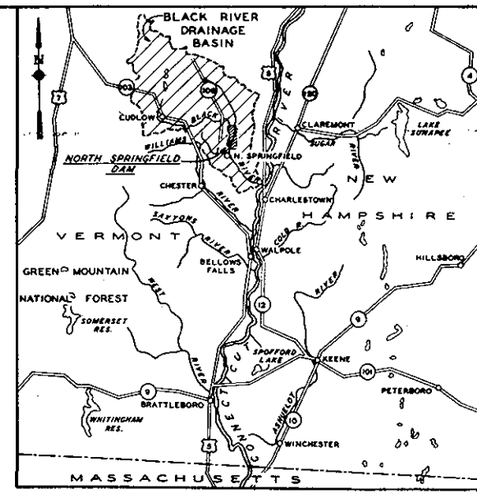

VICINITY MAP

SCALE IN MILES

0 6 10

LEGEND

- PRECIPITATION STATION - RECORDER TYPE
- PRECIPITATION STATION - NON-RECORDER TYPE
- STREAM GAGING STATION
- SNOW COURSES

THIS DRAWING HAS BEEN REDUCED TO THREE EIGHTHS THE ORIGINAL SCALE

DATE	REVISIONS DESCRIPTION	MADE	APPRD

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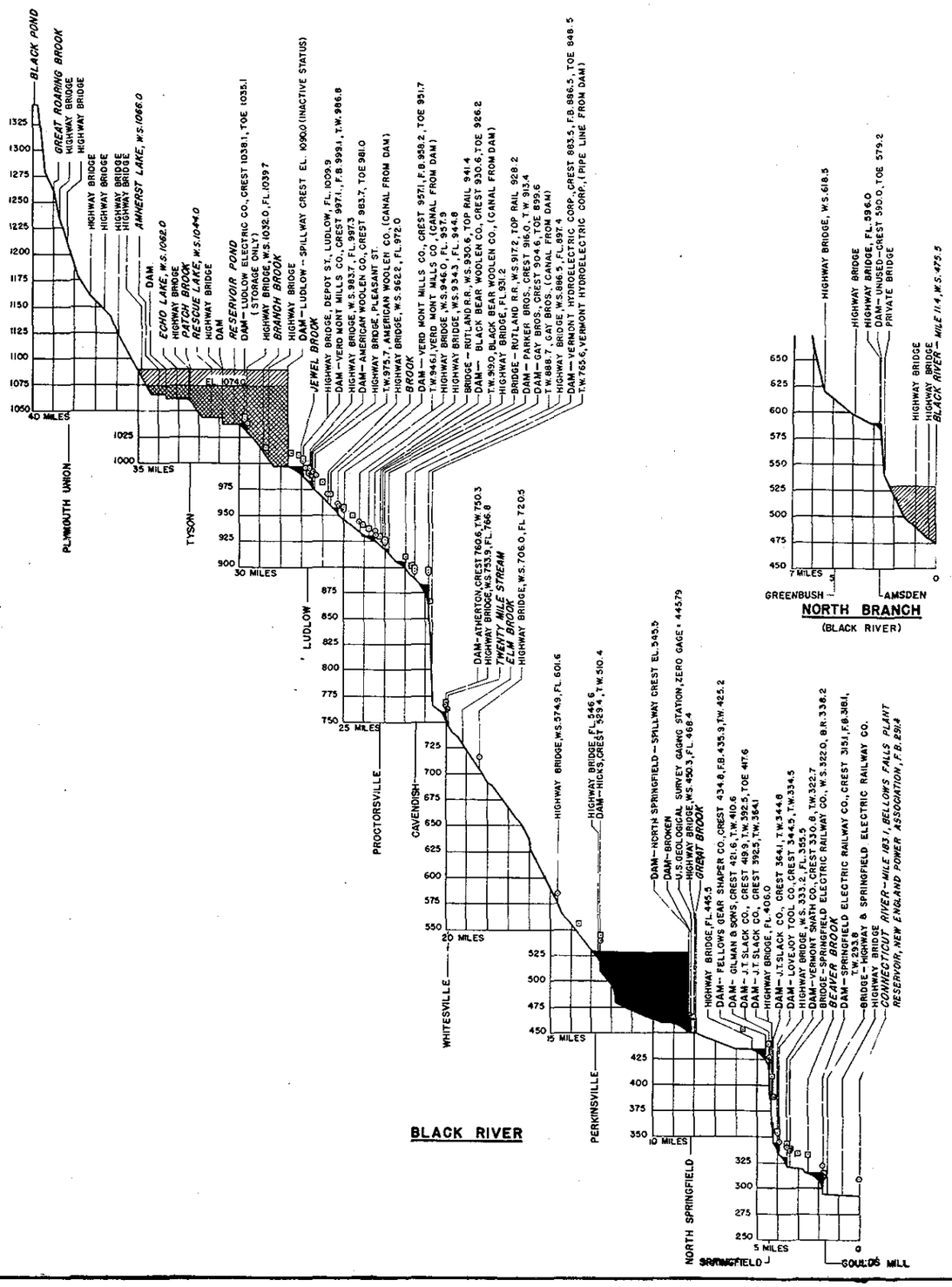
OFFICE OF THE DISTRICT ENGINEER
OMAHA DISTRICT
OMAHA, NEBRASKA

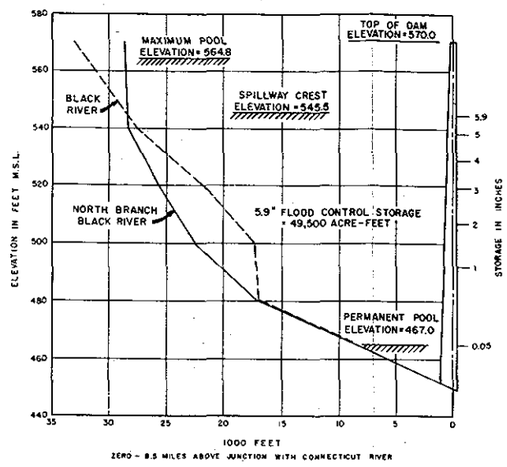
DESIGNED BY: C. J. A.
DRAWN BY: C. F. W.
TRACED BY: C. F. W.
CHECKED BY: C. F. T.
SUBMITTED BY:
CHIEF SECTION
APPROVED:
CHIEF BRANCH
APPROVED:
COL. C. E. DISTRICT ENGINEER

CONNECTICUT RIVER FLOOD CONTROL
NORTH SPRINGFIELD DAM AND RESERVOIR
BASIN MAP
BLACK RIVER VERMONT

APPROVED: CHIEF ENGINEERING DIVISION
DATE: AUGUST 1936
SCALE: AS SHOWN
SPEC. NO.
DRAWING NUMBER
SHEET OF

PLATE NO. C-2





LEGEND

- EXISTING DEVELOPMENT
- PROPOSED FLOOD CONTROL DEVELOPMENT
- PROPOSED CONSERVATION STORAGE FOR POWER
- PROPOSED FLOOD CONTROL DEVELOPMENT
- O --INDICATES HIGH WATER MARKS OF MAR. 1936
- □ --INDICATES HIGH WATER MARKS OF NOV. 1927

FL.--FLOOR
W.S.--WATER SURFACE
T.W.--TAIL WATER

NOTES

ELEVATION IN FEET ABOVE MEAN SEA LEVEL
DISTANCES IN MILES FROM CONNECTICUT AND BLACK RIVERS

CONNECTICUT RIVER FLOOD CONTROL

NORTH SPRINGFIELD RESERVOIR AND DAM

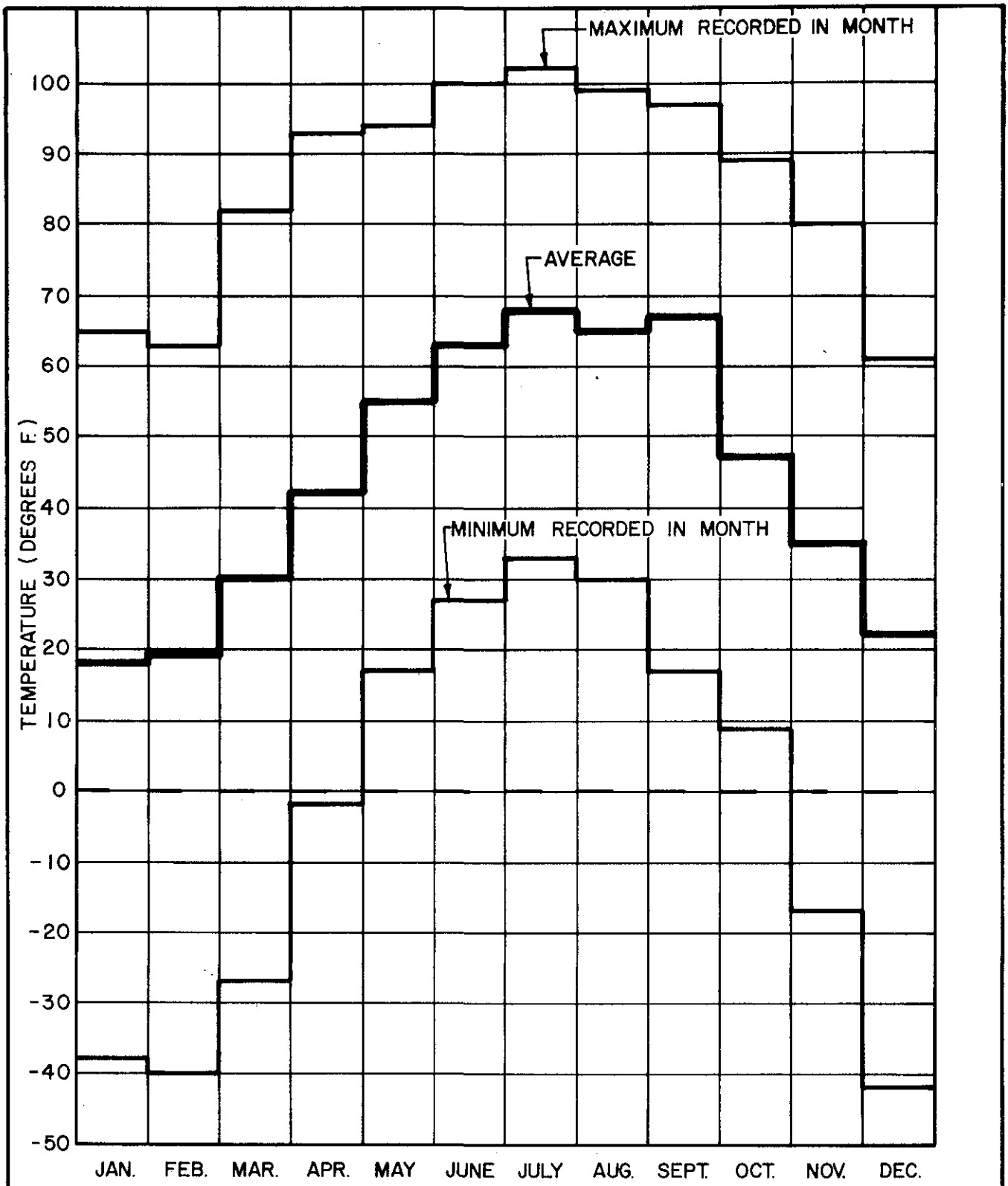
BLACK RIVER, VERMONT

PROFILES

NEW ENGLAND DIVISION, WALTHAM, MASS.

JUNE 1967

PLATE NO. C-3



CONNECTICUT RIVER FLOOD CONTROL

NORTH SPRINGFIELD RESERVOIR

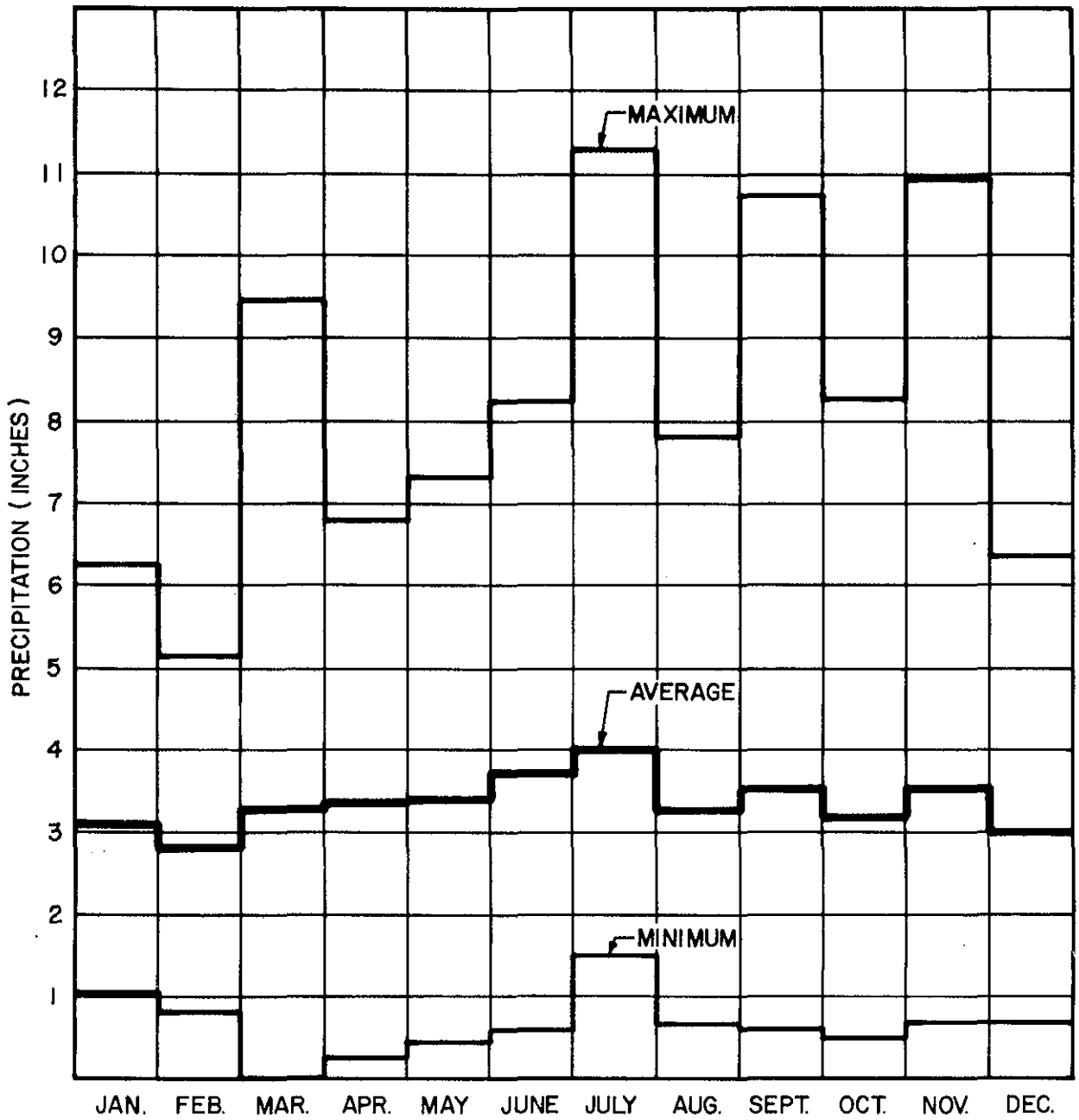
BLACK RIVER, VERMONT

MONTHLY TEMP. VARIATION

NEW ENGLAND DIVISION, WALTHAM, MASS.

JUNE, 1967

PLATE NO. C-4



CONNECTICUT RIVER FLOOD CONTROL

NORTH SPRINGFIELD RESERVOIR

BLACK RIVER, VERMONT

MONTHLY PRECIP. VARIATION

NEW ENGLAND DIVISION, WALTHAM, MASS.

JUNE, 1967

PLATE NO. C-5

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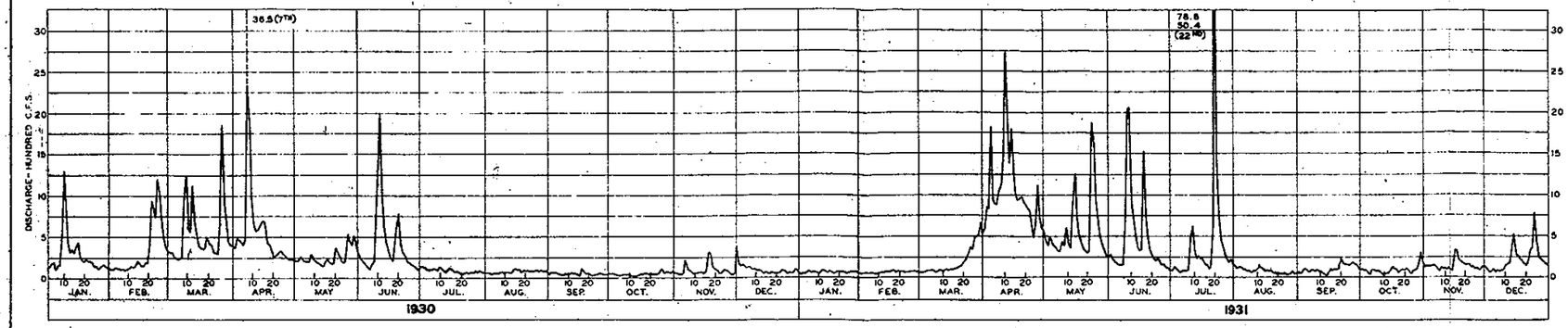

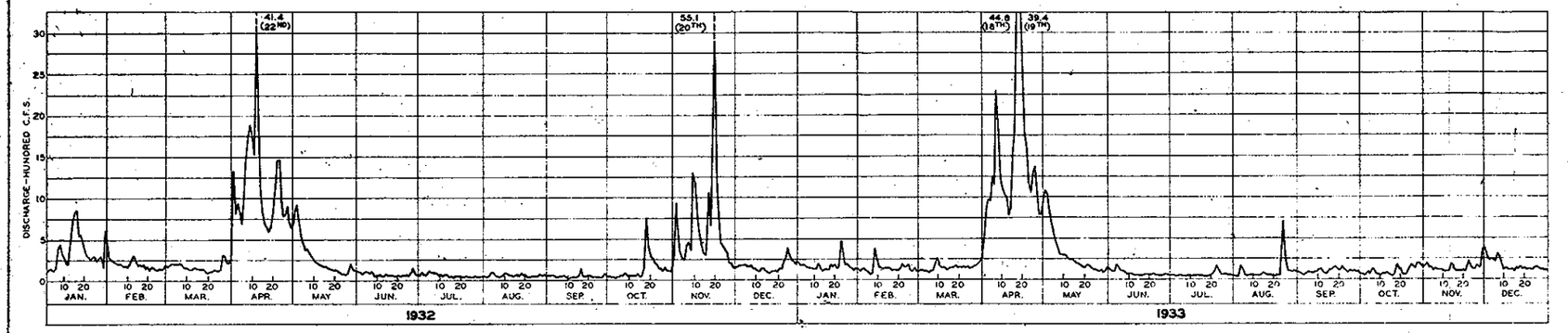

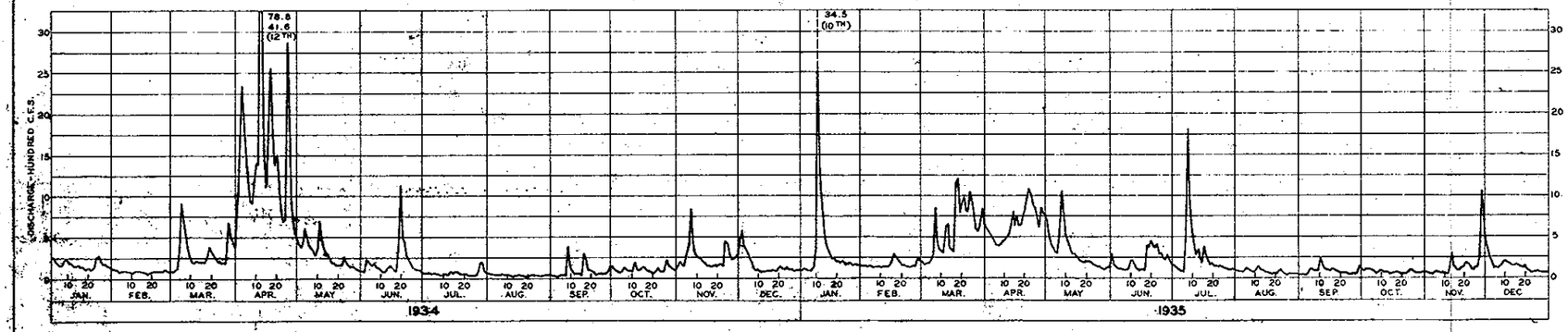

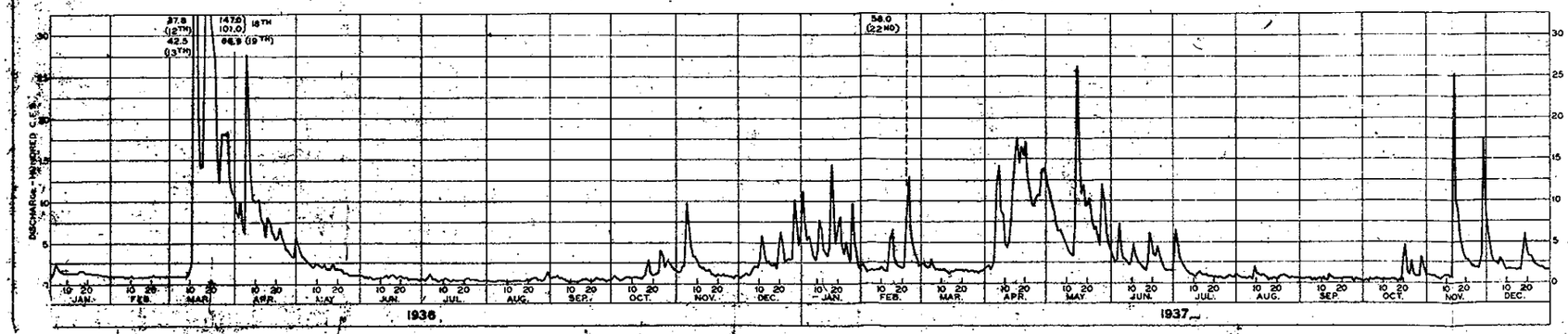

DATE	DESCRIPTION	MADE	APPR'D

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OMAHA NEBRASKA

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TRACED BY
CHECKED BY
SUBMITTED BY
CHIEF SECTION
APPROVED
CHIEF BRANCH
APPROVED
COL. C. E. DISTRICT ENGINEER

CONNECTICUT RIVER FLOOD CONTROL

NORTH SPRINGFIELD DAM AND RESERVOIR HYDROGRAPHS 1930-1937

BLACK RIVER VERMONT

APPROVED CHIEF ENGINEERING DIVISION

DATE AUGUST 1938

SCALE: SPEC NO

DRAWING NUMBER

SHEET OF

PLATE NO. C-6

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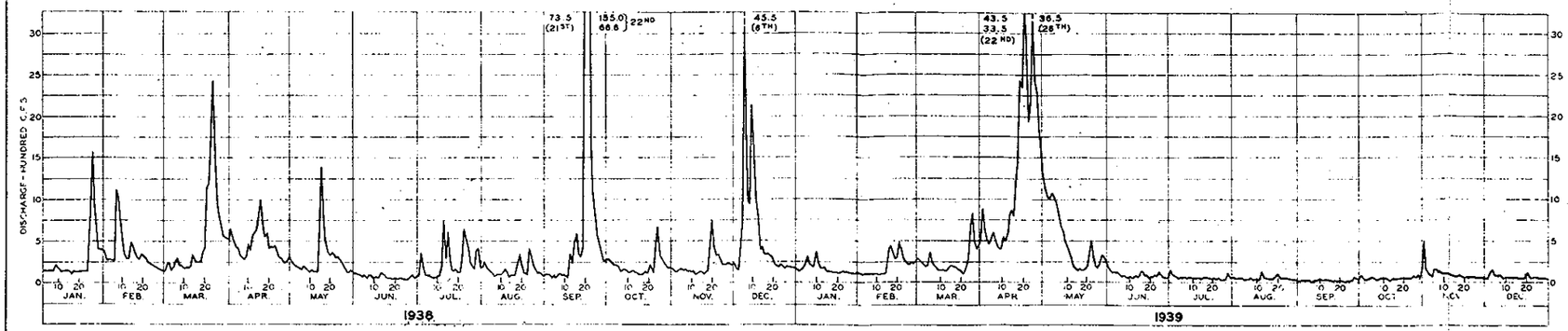

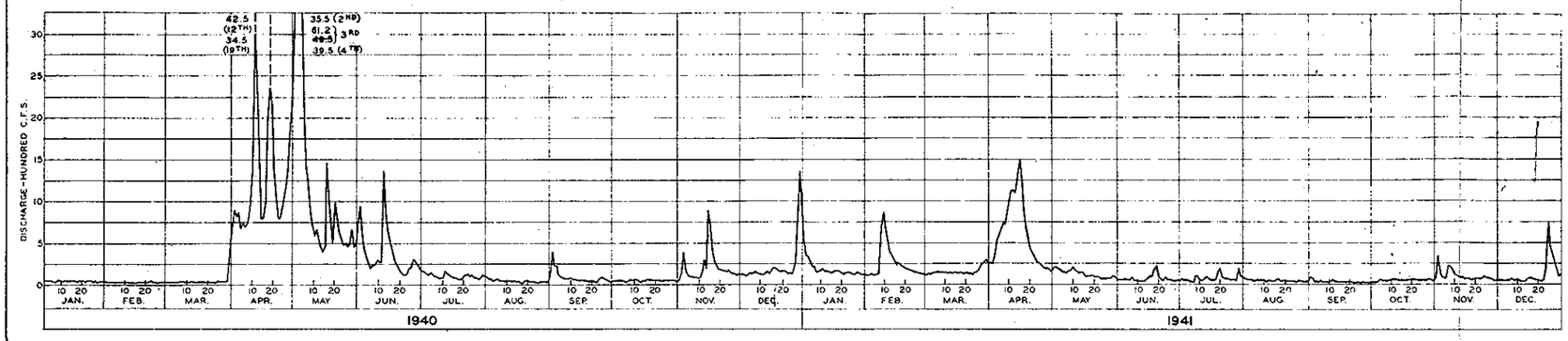

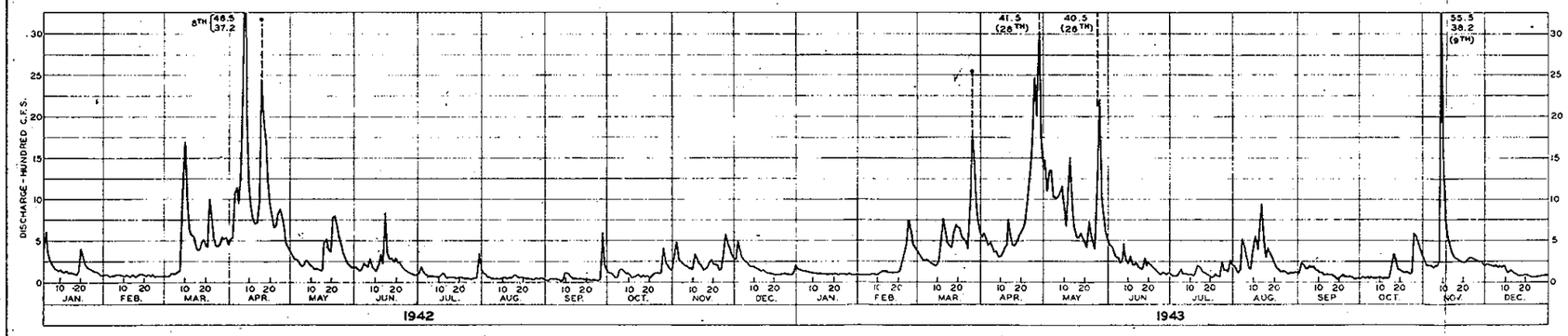

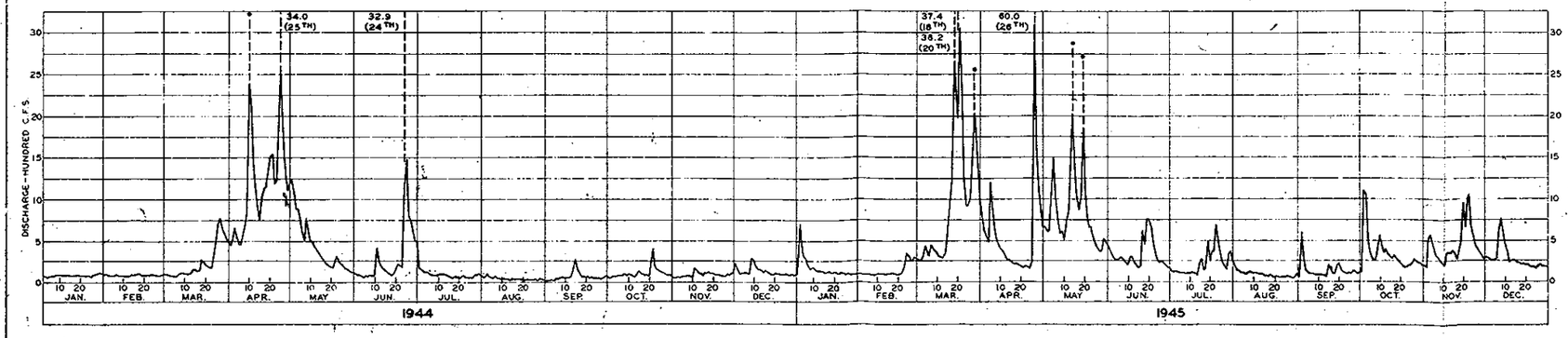

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CHIEF BRANCH
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CONNECTICUT RIVER FLOOD CONTROL

NORTH SPRINGFIELD DAM AND RESERVOIR HYDROGRAPHS 1938-1945

BLACK RIVER VERMONT

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DATE AUGUST 1958

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PLATE NO. C-7

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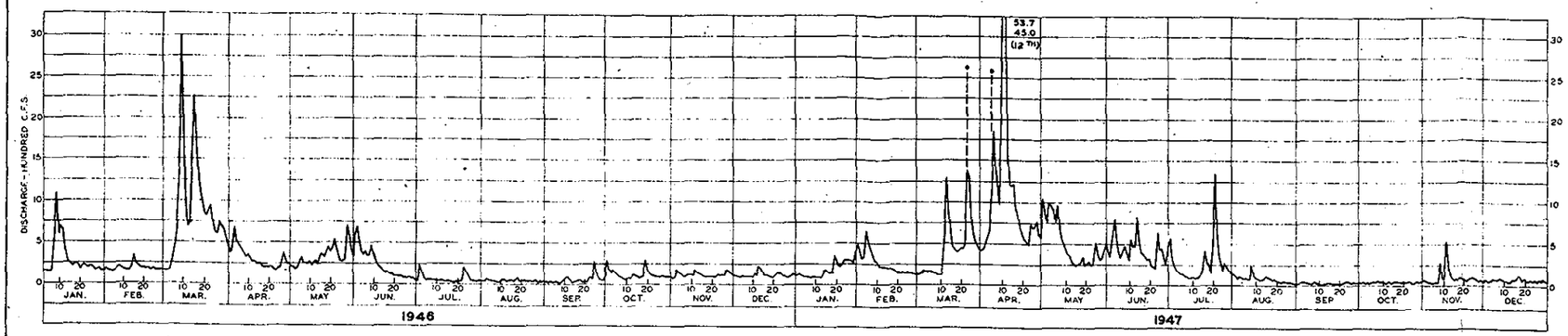

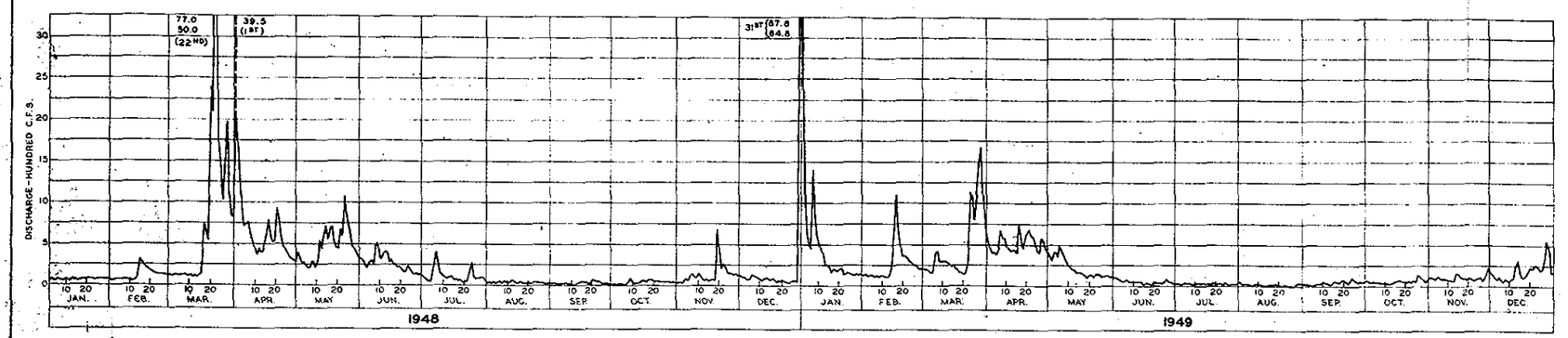

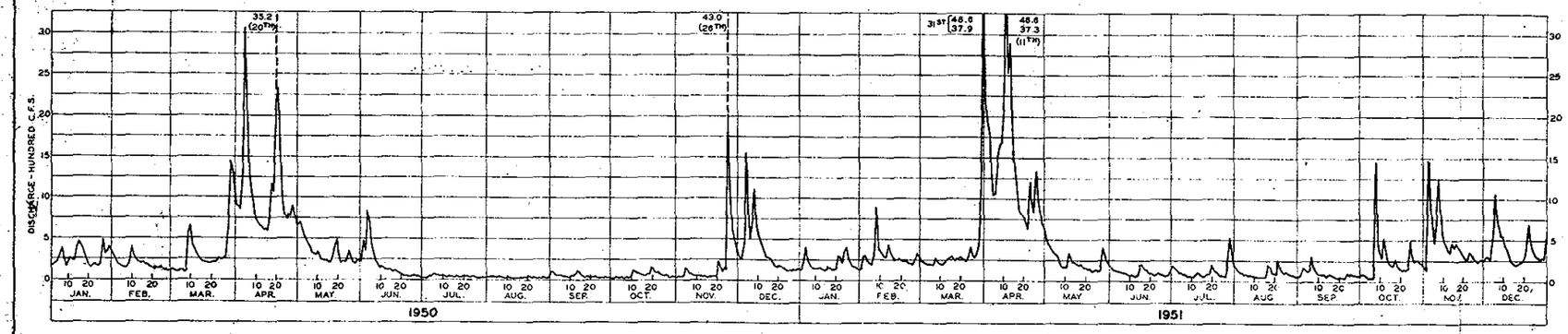

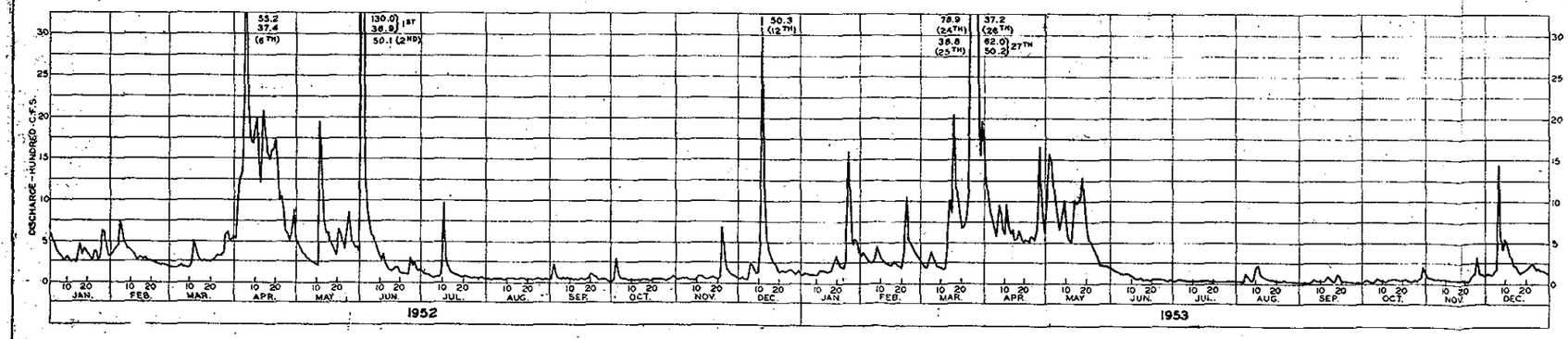

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APPROVED
CHIEF BRANCH

CONNECTICUT RIVER FLOOD CONTROL
NORTH SPRINGFIELD DAM AND RESERVOIR
HYDROGRAPHS
1946-1953
BLACK RIVER VERMONT

APPROVED
CHIEF ENGINEERING DIVISION
DATE AUGUST 1955

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SPEC NO
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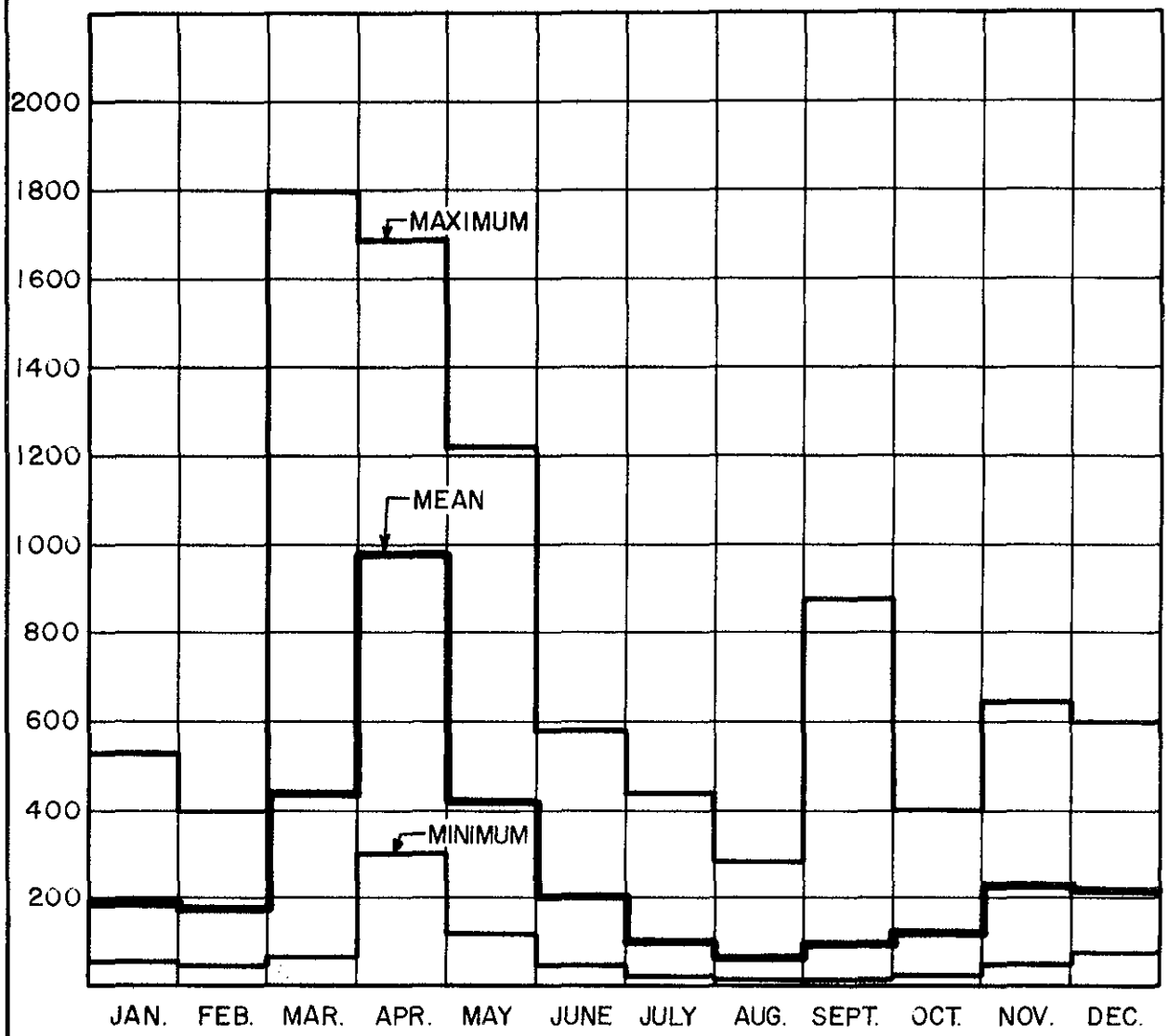
PLATE NO. C-8



CONNECTICUT RIVER FLOOD CONTROL

NORTH SPRINGFIELD RESERVOIR

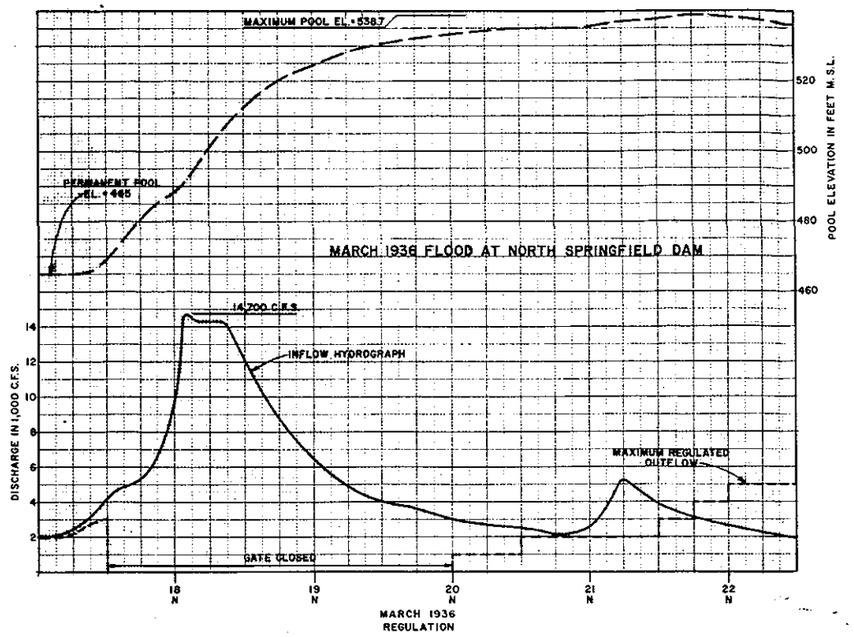
BLACK RIVER, VERMONT

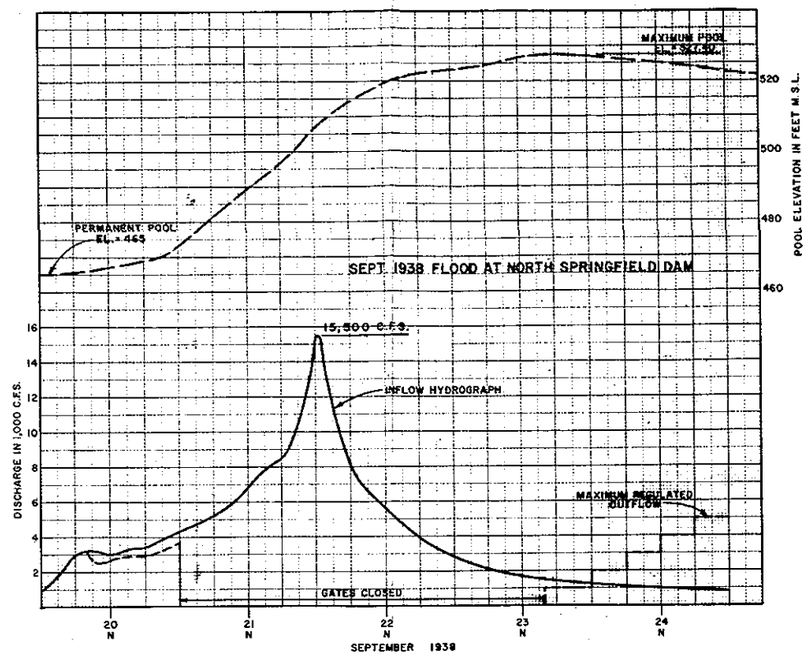
AVERAGE MONTHLY DISCHARGE

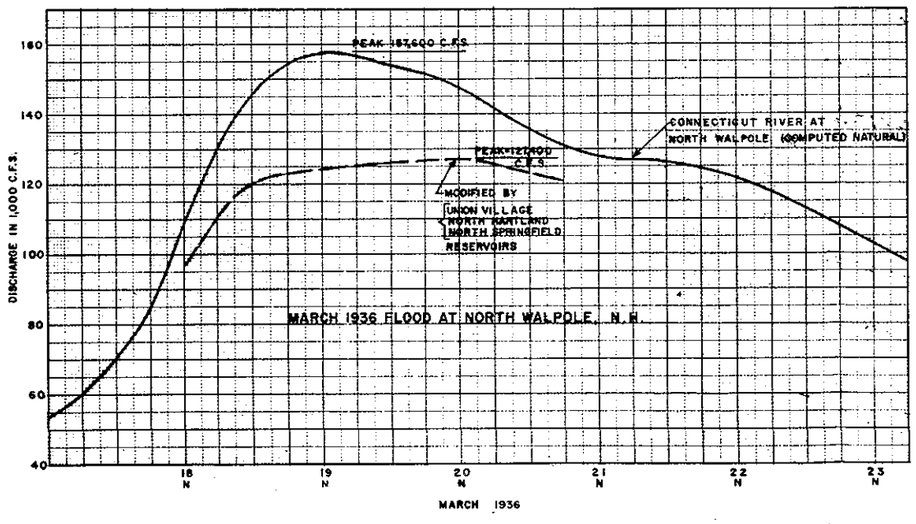
NEW ENGLAND DIVISION, WALTHAM, MASS.

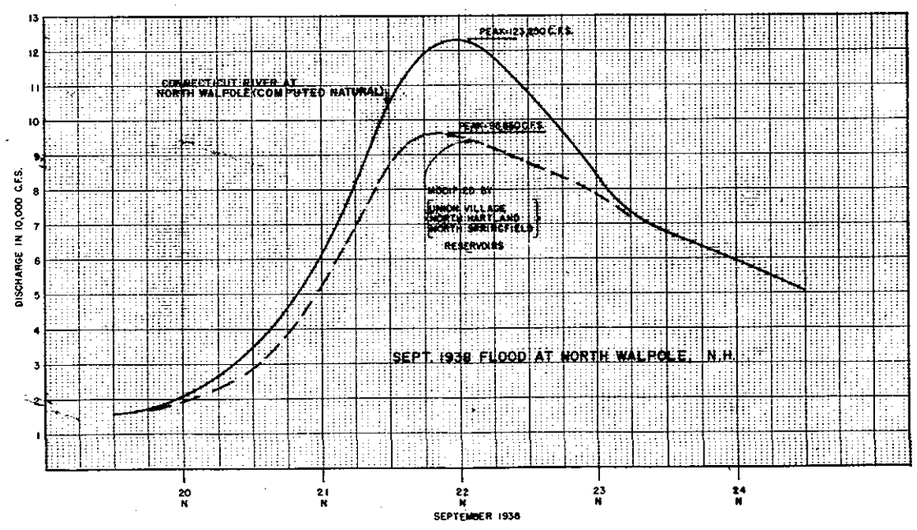
JUNE, 1967

PLATE NO. C-9









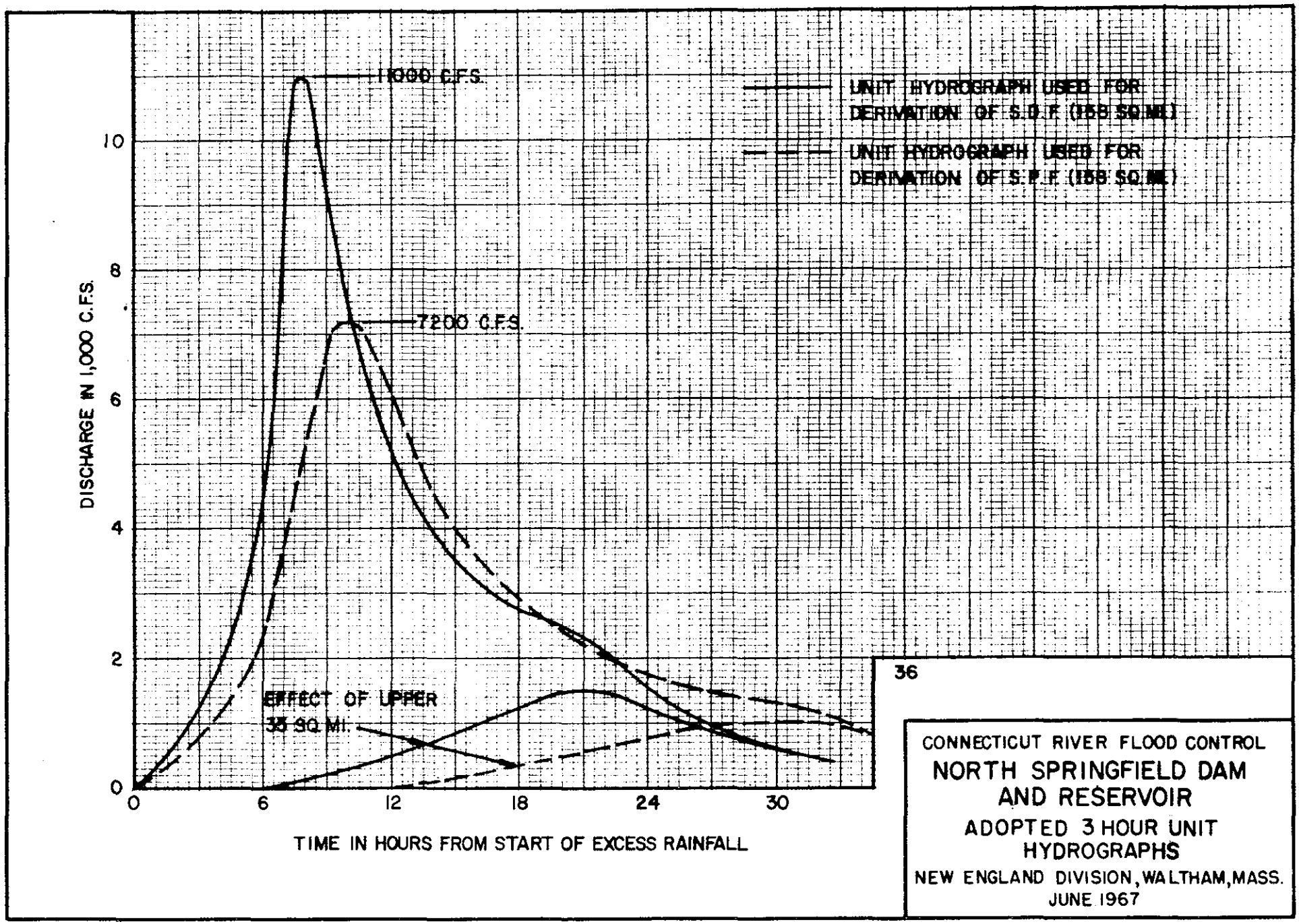
CONNECTICUT RIVER FLOOD CONTROL
BLACK RIVER, VERMONT

NORTH SPRINGFIELD DAM AND RESERVOIR

EFFECT OF RESERVOIR ON 1936 AND 1938 FLOODS

NEW ENGLAND DIVISION WALTHAM, MASS.
NOVEMBER, 1967

PLATE NO. C-10



36

CONNECTICUT RIVER FLOOD CONTROL

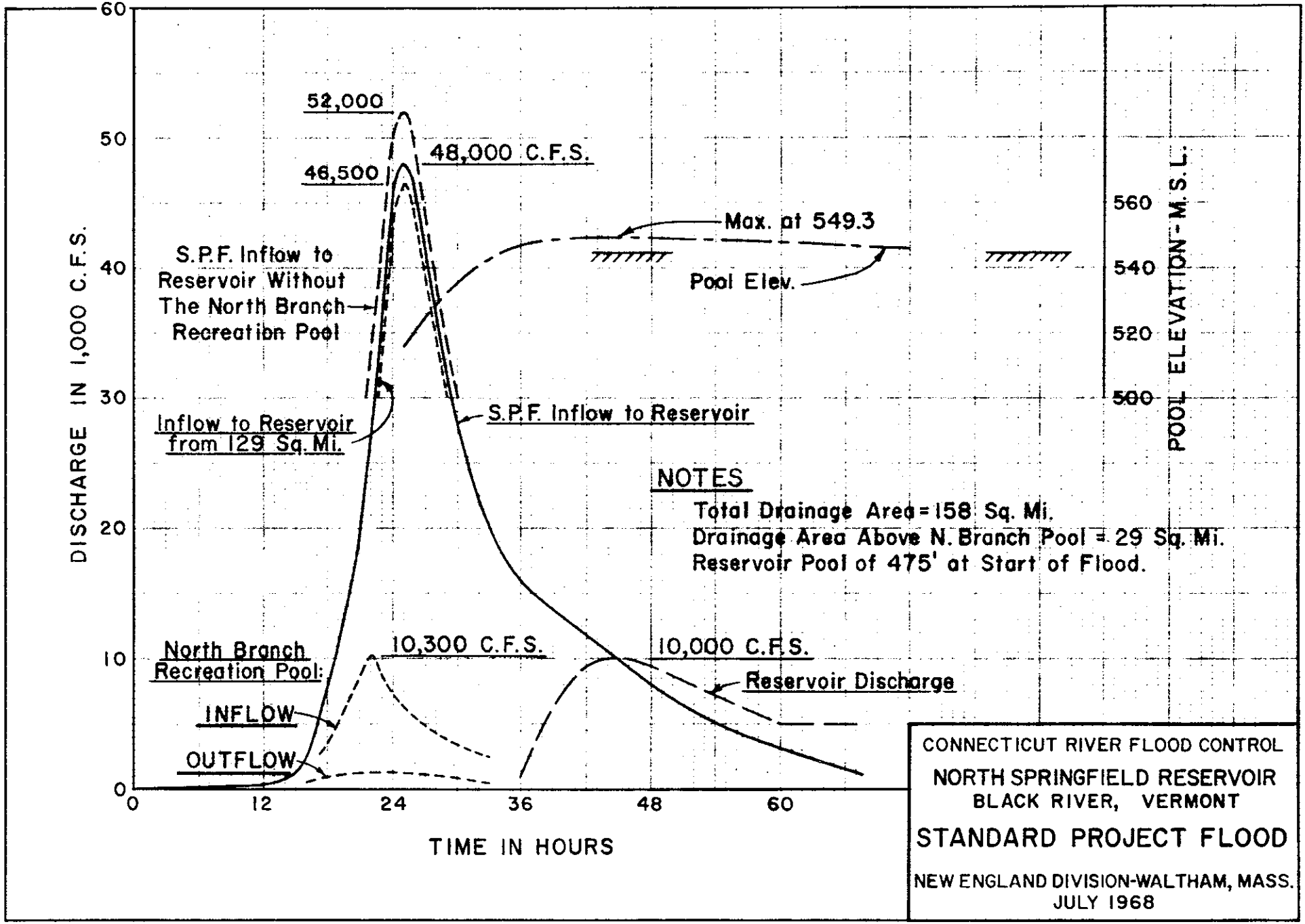
NORTH SPRINGFIELD DAM AND RESERVOIR

ADOPTED 3 HOUR UNIT HYDROGRAPHS

NEW ENGLAND DIVISION, WALTHAM, MASS.

JUNE 1967

PLATE NO. C-11



CONNECTICUT RIVER FLOOD CONTROL

NORTH SPRINGFIELD RESERVOIR
BLACK RIVER, VERMONT

STANDARD PROJECT FLOOD

NEW ENGLAND DIVISION-WALTHAM, MASS.
JULY 1968

PLATE NO. C-12

CORPS OF ENGINEERS

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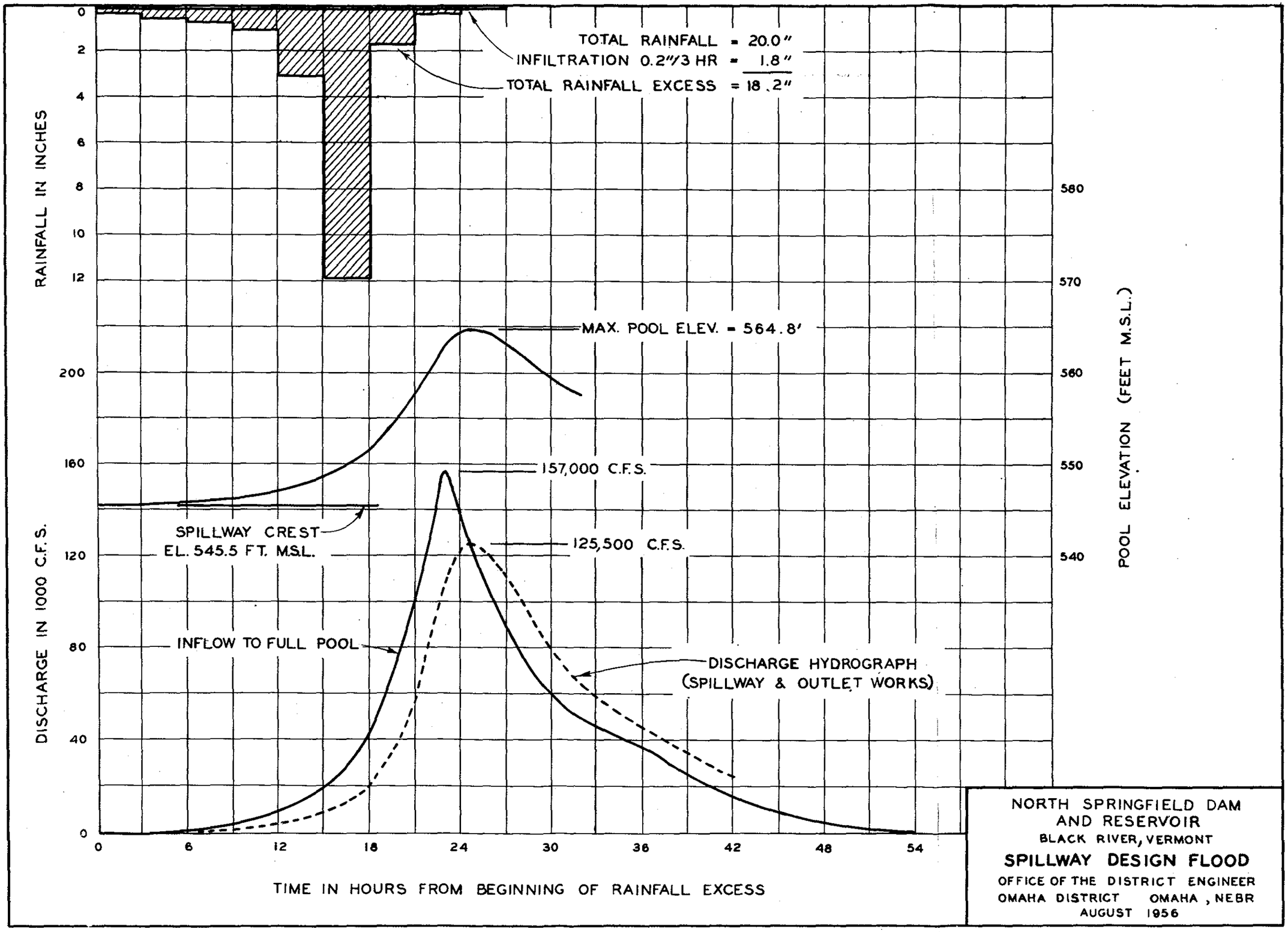
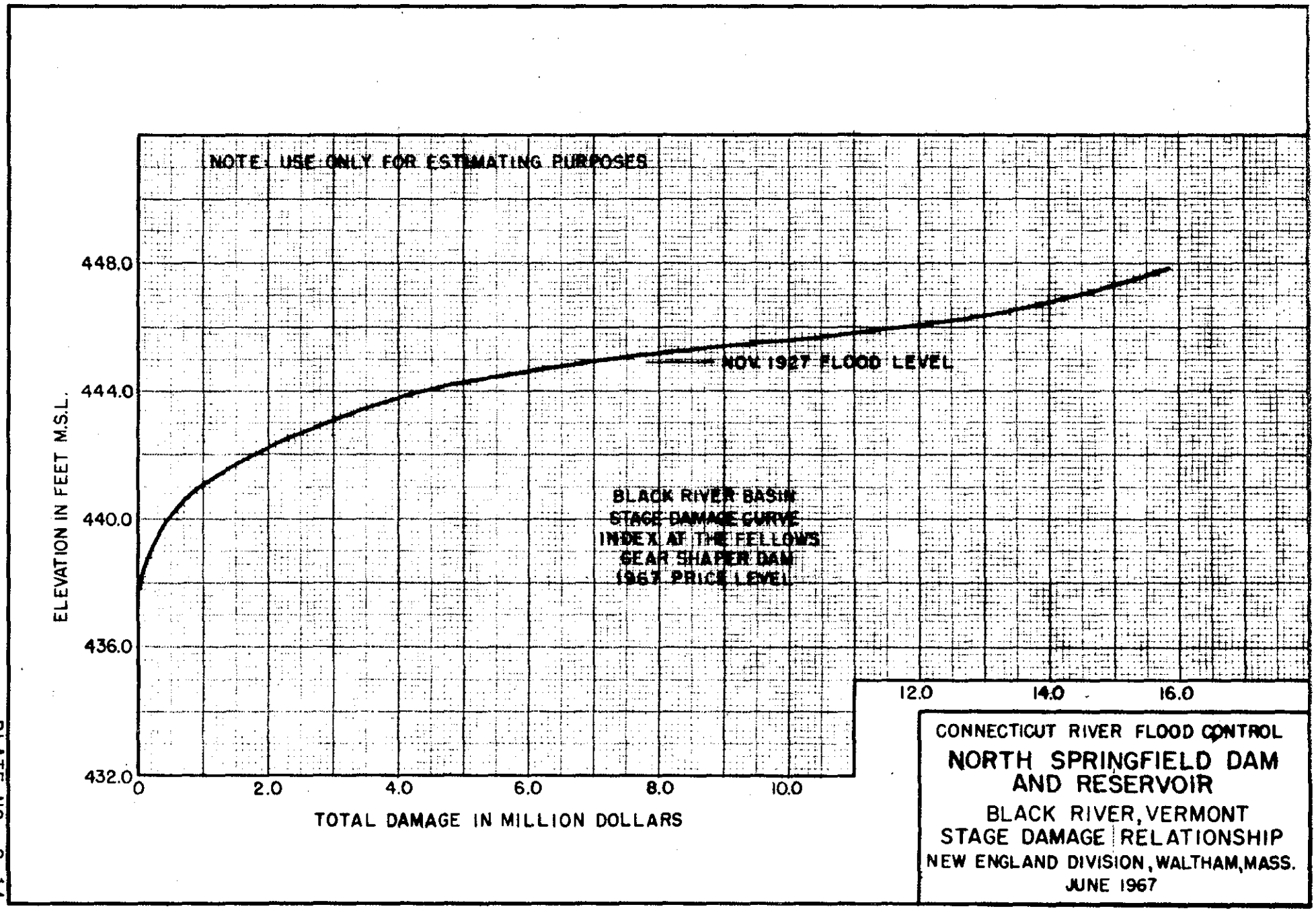


NORTH SPRINGFIELD DAM
AND RESERVOIR
BLACK RIVER, VERMONT

SPILLWAY DESIGN FLOOD

OFFICE OF THE DISTRICT ENGINEER
OMAHA DISTRICT OMAHA, NEBR
AUGUST 1956

PLATE NO. C-13



CONNECTICUT RIVER FLOOD CONTROL

NORTH SPRINGFIELD DAM AND RESERVOIR

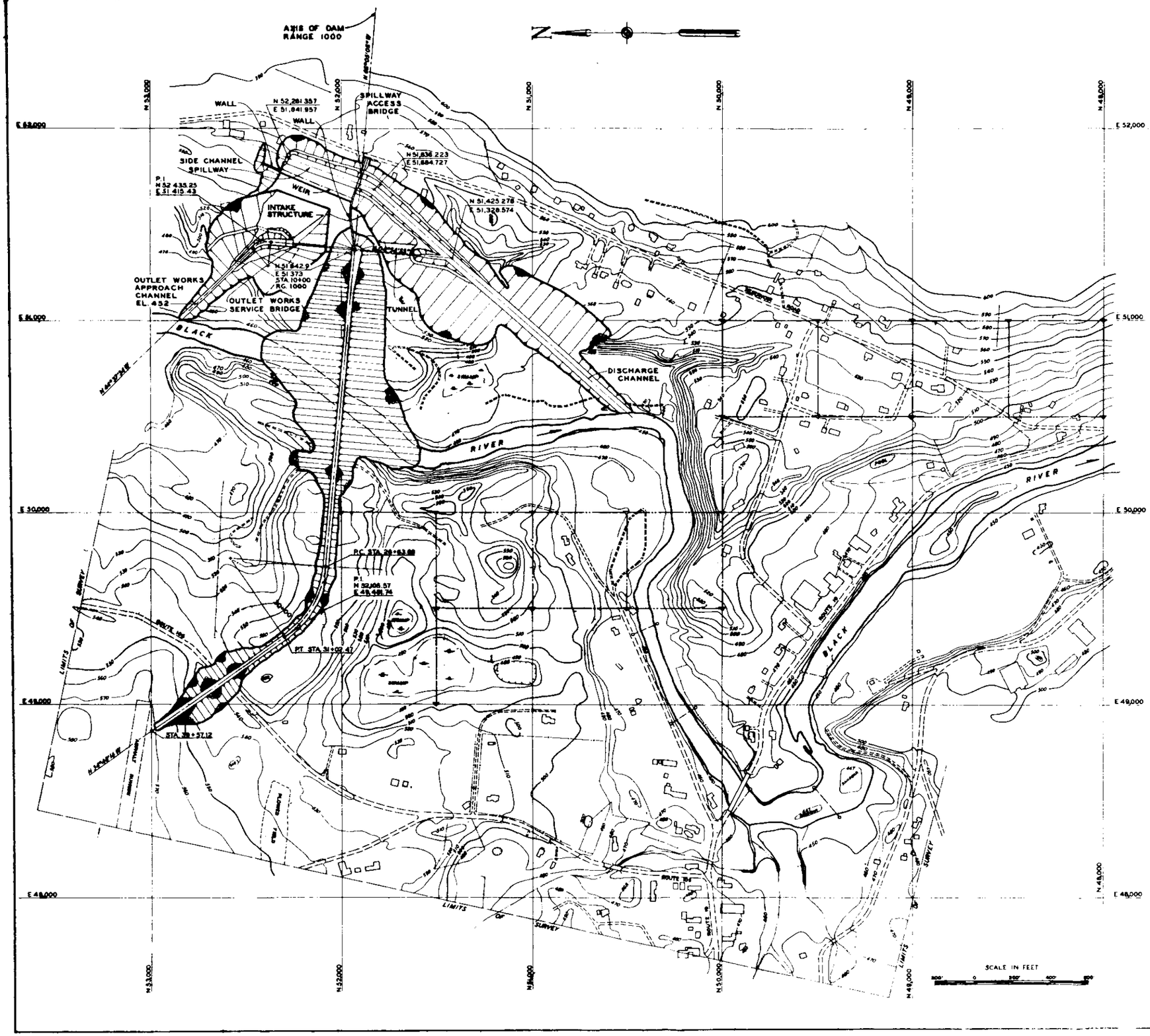
BLACK RIVER, VERMONT

STAGE DAMAGE RELATIONSHIP

NEW ENGLAND DIVISION, WALTHAM, MASS.

JUNE 1967

PLATE NO. C-14



NOTE:

1. *All elevations refer to M.S.L., 1929 Gen. Adj.*

THIS DRAWING HAS BEEN REDUCED TO THREE EIGHTHS THE ORIGINAL SCALE

DATE	REV.	DESCRIPTION	MADE	APPR'D
		REVISIONS		

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OFFICE OF THE DISTRICT ENGINEER
OMAHA DISTRICT
OMAHA, NEBRASKA

DESIGNED BY:
DRAWN BY:
TRACED BY:
CHECKED BY:
SUBMITTED BY:
PROJECT ENGINEER
APPROVED
CHIEF, CIV. DESIGN BRANCH
APPROVED

CONNECTICUT RIVER FLOOD CONTROL
NORTH SPRINGFIELD DAM AND RESERVOIR
GENERAL PLAN
BLACK RIVER

APPROVED
CHIEF ENGINEERING DIVISION

DATE: JUNE 61

SCALE AS SHOWN

SPEC. NO.

DRAWING NUMBER

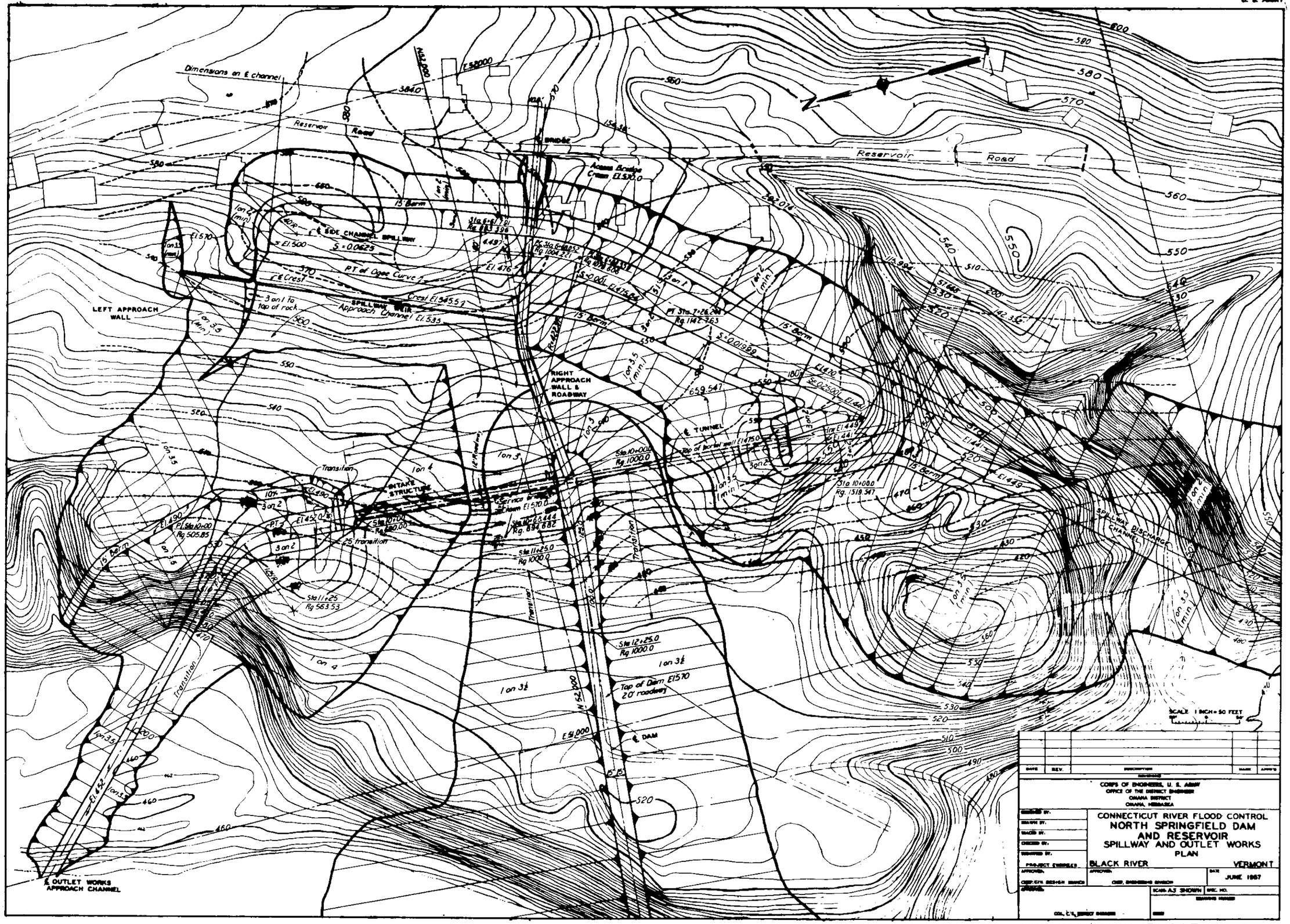
COL. C. E. DISTRICT ENGINEER

SHEET

DESIGN MEMORANDUM NO. 4 PLATE NO. C-15

CORPS OF ENGINEERS

U. S. ARMY



DATE	REV.	DESCRIPTION	BASIC	APPR'D
		REVISIONS		

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DISTRICT ENGINEER
OMAHA DISTRICT
OMAHA, NEBRASKA

DESIGNED BY
DRAWN BY
TRACED BY
CHECKED BY
SUBMITTED BY
PROJECT ENGINEER
APPROVED
CHIEF, DESIGN BRANCH

CONNECTICUT RIVER FLOOD CONTROL
NORTH SPRINGFIELD DAM AND RESERVOIR
SPILLWAY AND OUTLET WORKS
PLAN
BLACK RIVER VERMONT

APPROVED: CHIEF, ENGINEERING DIVISION
DATE: JUNE 1967

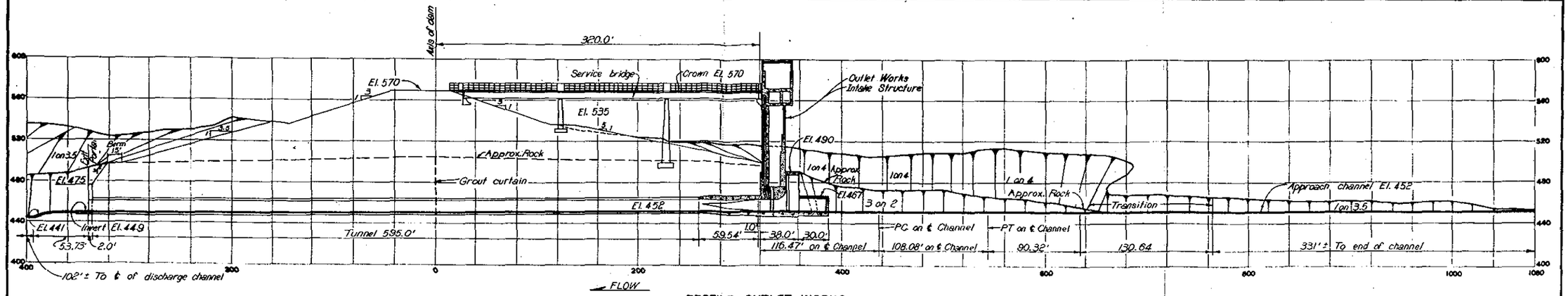
DRAWING NUMBER
SCALE AS SHOWN | ENG. NO.

CDR., U.S. DISTRICT ENGINEER

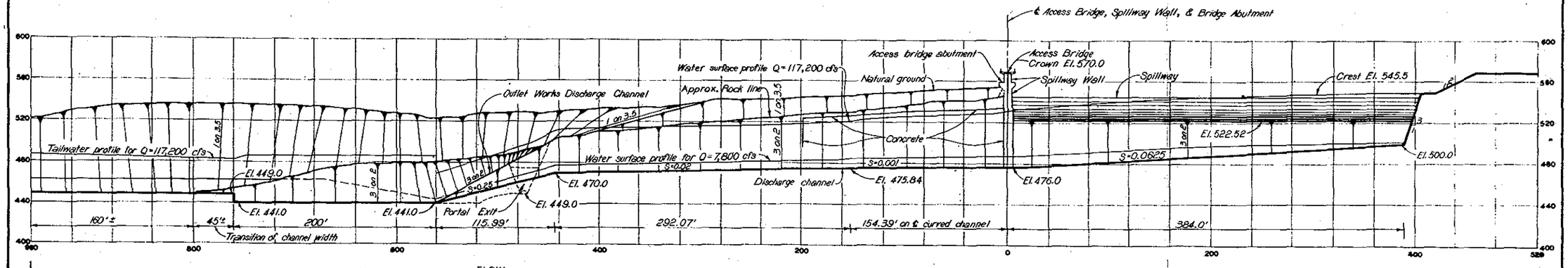
DESIGN MEMORANDUM NO. 4 PLATE NO. C-16

CORPS OF ENGINEERS

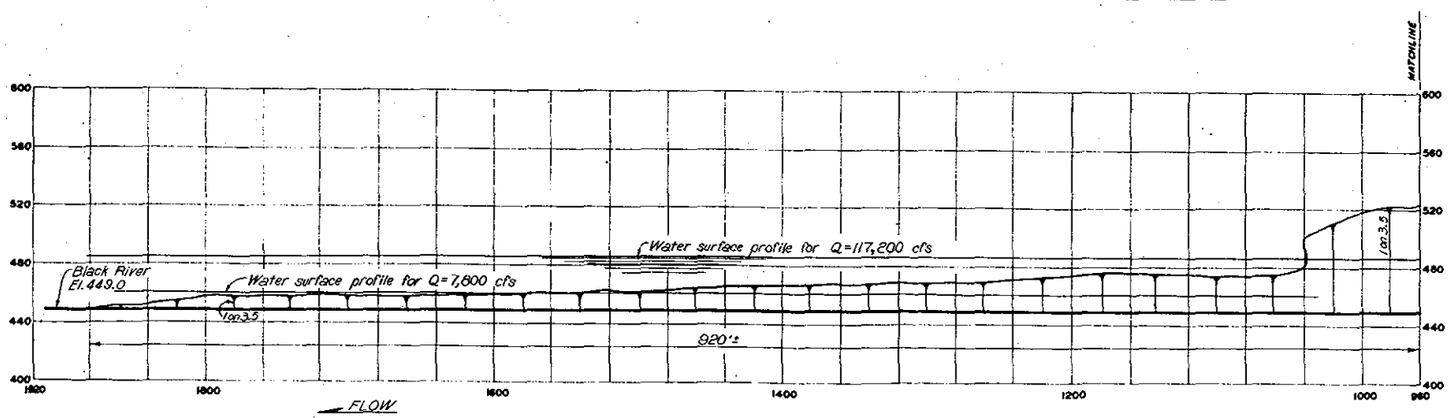
U. S. ARMY



PROFILE - OUTLET WORKS



SECTIONAL ELEVATION - SPILLWAY DISCHARGE CHANNEL



SECTIONAL ELEVATION - SPILLWAY DISCHARGE CHANNEL

SCALES: HORIZ: 1 INCH = 40 FEET
VERT: 1 INCH = 40 FEET

THIS DRAWING HAS BEEN REDUCED TO THREE EIGHTHS THE ORIGINAL SCALE

DATE	REV	DESCRIPTION	MADE	APPVD

REVISIONS

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DISTRICT ENGINEER
OMAHA DISTRICT
OMAHA, NEBRASKA

DESIGNED BY:
DRAWN BY: L.M.G.
TRACED BY: L.M.G.
CHECKED BY:
SUBMITTED BY: PROJECT ENGINEER
APPROVED: CHIEF ENGINEERING BRANCH

CONNECTICUT RIVER FLOOD CONTROL
NORTH SPRINGFIELD DAM AND RESERVOIR
SPILLWAY AND OUTLET WORKS
SECTIONS AND PROFILE
BLACK RIVER, VERMONT

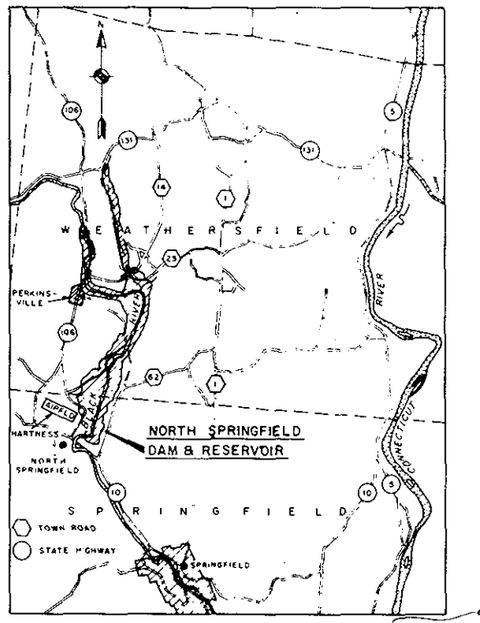
APPROVED: CHIEF, ENGINEERING DIVISION
DATE: JUNE 1957

APPROVED: COL, C. E., DISTRICT ENGINEER
SCALE: AS SHOWN
SPEC. NO.
DRAWING NUMBER
SHEET

DESIGN MEMORANDUM NO. 4 PLATE NO. C-17

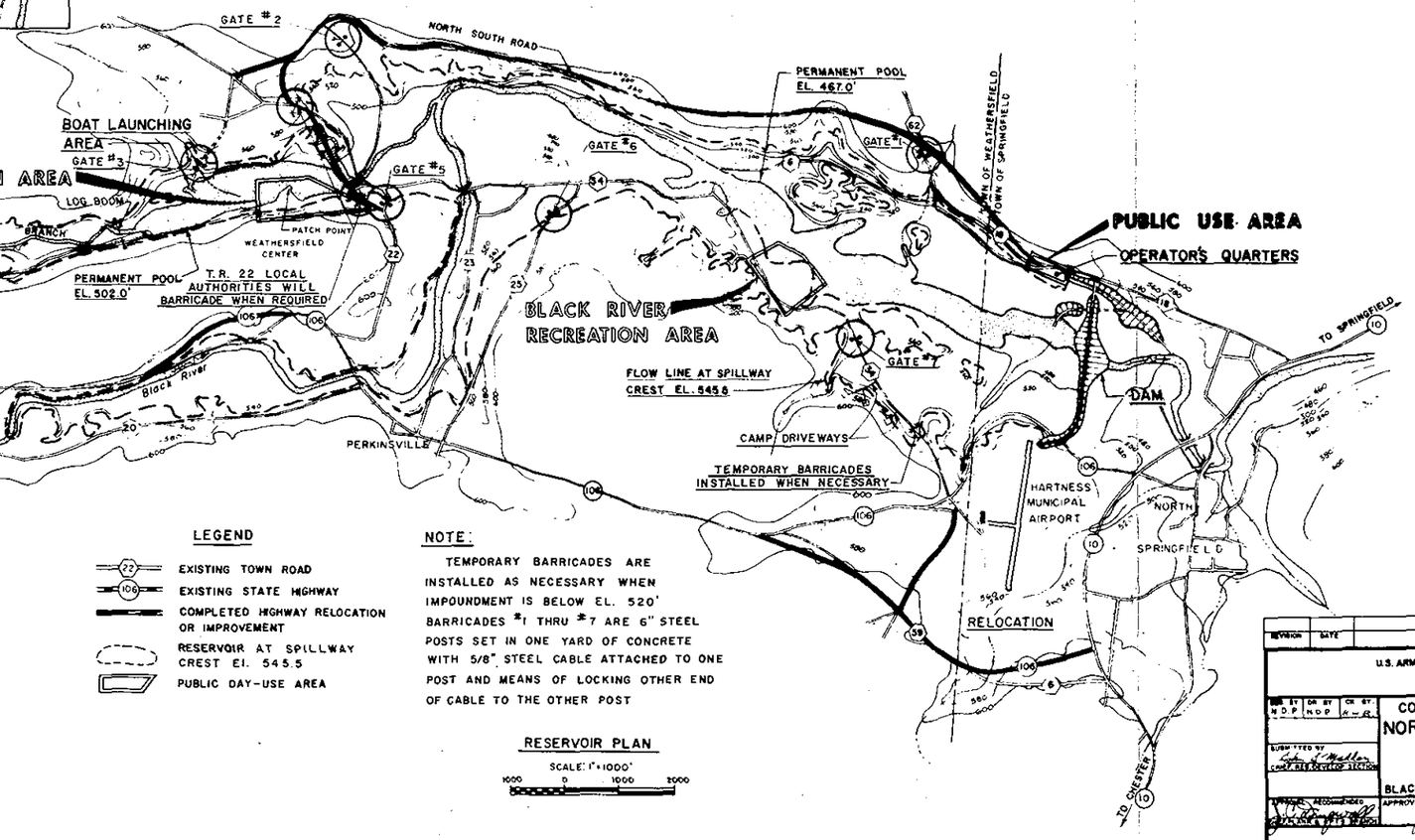
CORPS OF ENGINEERS

U S. ARMY



LOCATION MAP

SCALE 1" = 1 MI.



LEGEND

- EXISTING TOWN ROAD
- EXISTING STATE HIGHWAY
- COMPLETED HIGHWAY RELOCATION OR IMPROVEMENT
- RESERVOIR AT SPILLWAY CREST El. 545.5
- PUBLIC DAY-USE AREA

NOTE:

TEMPORARY BARRICADES ARE INSTALLED AS NECESSARY WHEN IMPOUNDMENT IS BELOW EL. 520' BARRICADES #1 THRU #7 ARE 6" STEEL POSTS SET IN ONE YARD OF CONCRETE WITH 5/8" STEEL CABLE ATTACHED TO ONE POST AND MEANS OF LOCKING OTHER END OF CABLE TO THE OTHER POST

RESERVOIR PLAN

SCALE: 1" = 1000'

1000 0 1000 2000

REVISION	DATE	DESCRIPTION

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

DES. BY	DR. BY	CH. BY
N.D.P.	N.D.P.	R.W.G.

SUBMITTED BY: Chief, Res. Control Section

CONNECTICUT RIVER FLOOD CONTROL

NORTH SPRINGFIELD RESERVOIR MASTER PLAN

GENERAL DEVELOPMENT PLAN

BLACK RIVER VERMONT

APPROVED: John W. Leslie Jr. Chief, Engineering Division

DATE MAY 1961

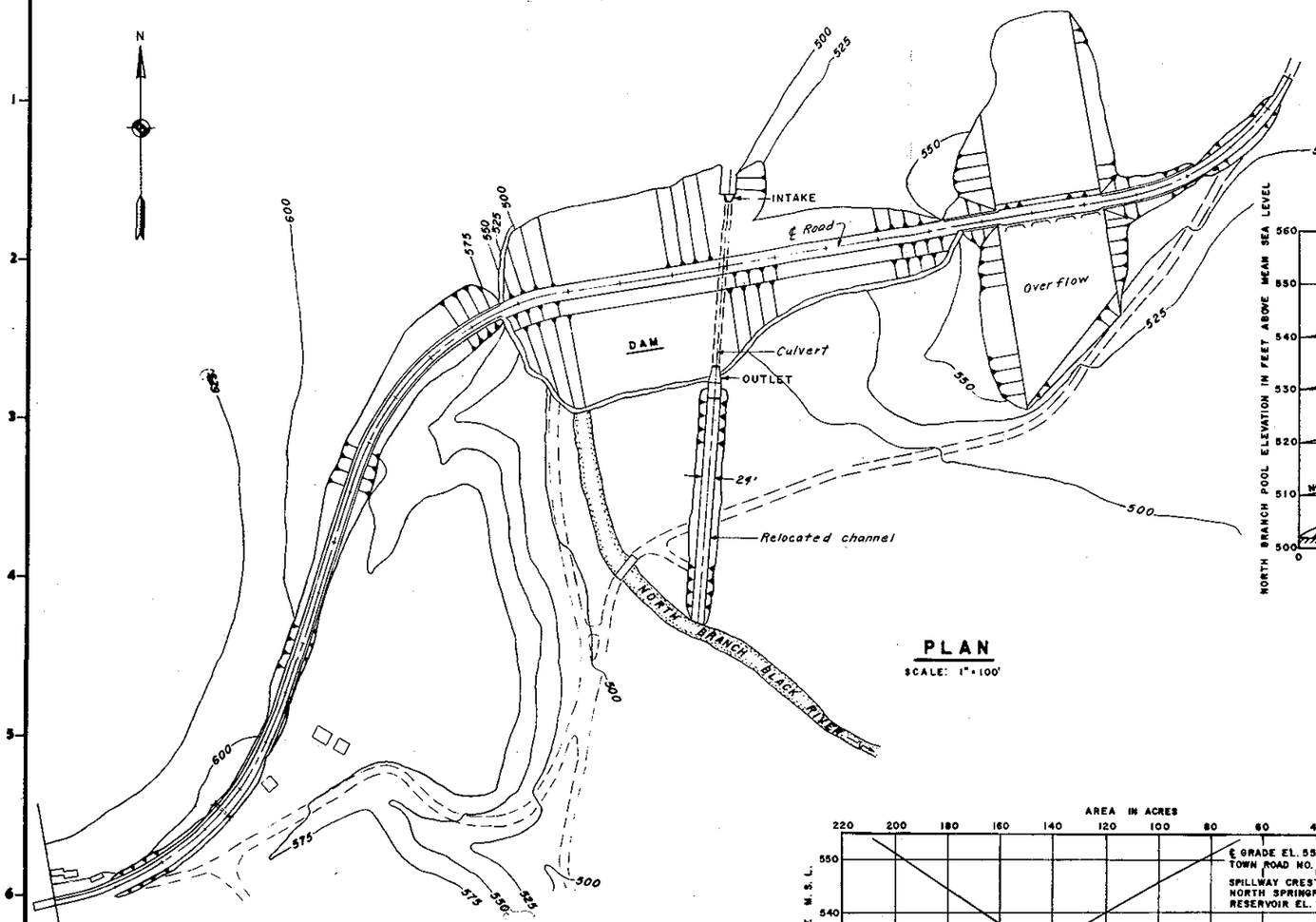
SCALE

DRAWING NUMBER CT-1-5685

SHEET 3 OF 13

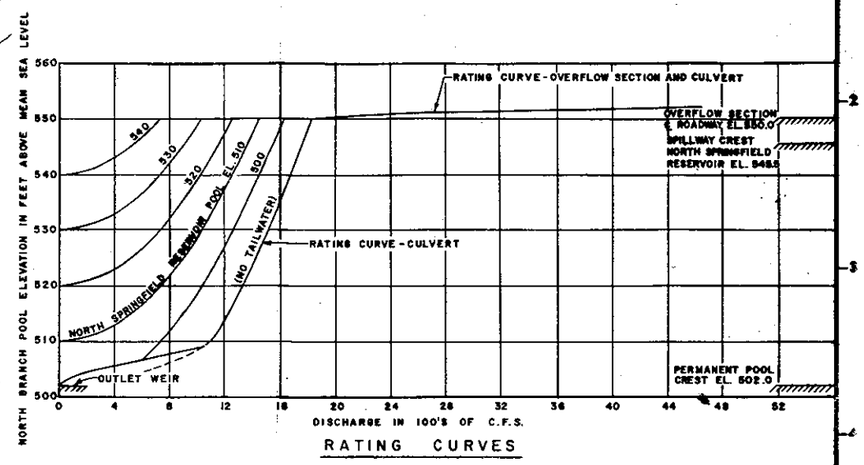
PLATE NO. C-18

CORPS OF ENGINEERS — U. S. ARMY

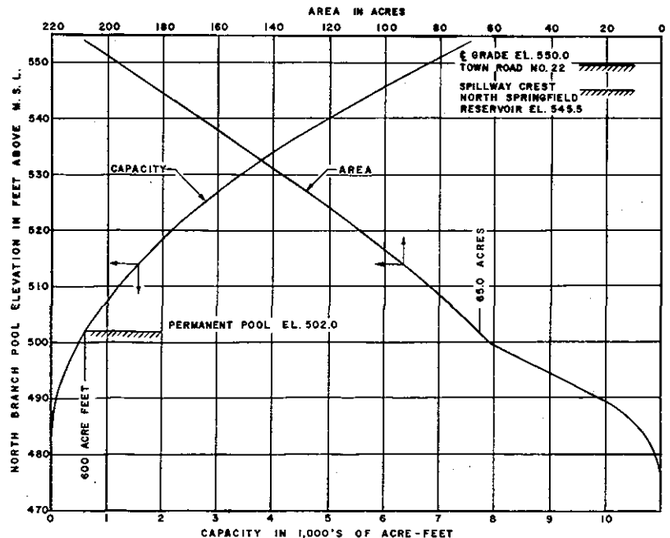


PLAN

SCALE: 1" = 100'



RATING CURVES



AREA - CAPACITY CURVES

GRAPHIC SCALE

1"=100'

SAFETY PAYS

REVISION	DATE	DESCRIPTION	BY

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

DES. BY | DR. BY | CK. BY

SUBMITTED:

CHIEF, SECTION

APPROVAL RECOMMENDED:

CHIEF, TECH. ENG. BRANCH

REVIEWED:

PROJECT ENGINEER

APPROVAL RECOMMENDED:

CONNECTICUT RIVER FLOOD CONTROL
NORTH SPRINGFIELD DAM & RESERVOIR
RELOCATED TOWN ROAD NO. 22 EMBANKMENT
(NORTH BRANCH RECREATION POOL)
GENERAL PLAN AND PERTINENT DATA
BLACK RIVER VERMONT

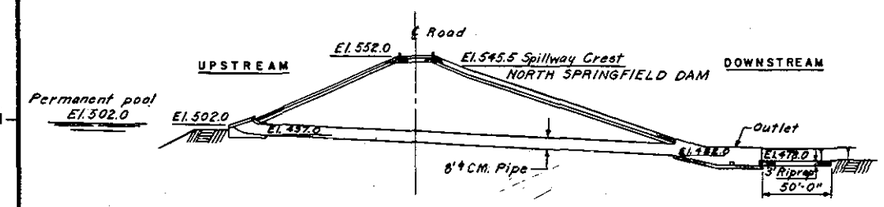
APPROVED DATE

CHIEF, ENGINEERING DIVISION

SCALE | SPEC. NO. | DRAWING NUMBER

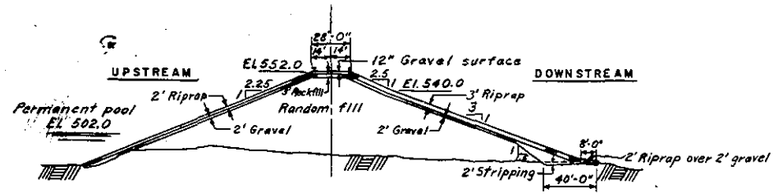
PLATE NO. C-19

CORPS OF ENGINEERS — U. S. ARMY



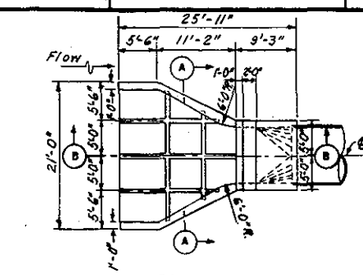
EMBANKMENT-SECTION ALONG CULVERT

SCALE: 1" = 40'



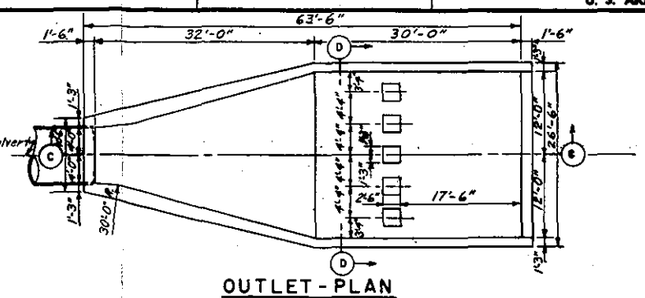
EMBANKMENT - TYPICAL SECTION

SCALE: 1" = 40'



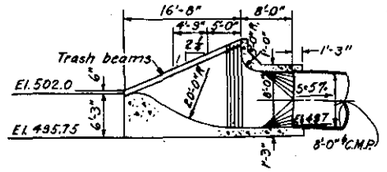
INTAKE - PLAN

SCALE: 1/8" = 1'-0"



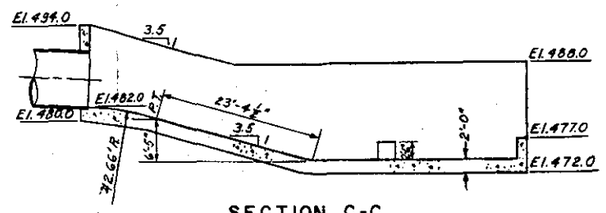
OUTLET - PLAN

SCALE: 1/8" = 1'-0"



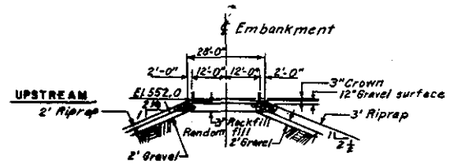
SECTION B-B

SCALE: 1/8" = 1'-0"



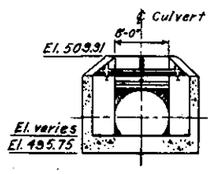
SECTION C-C

SCALE: 1/8" = 1'-0"



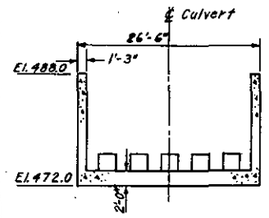
SECTION - TOP OF EMBANKMENT

SCALE: 1" = 20'



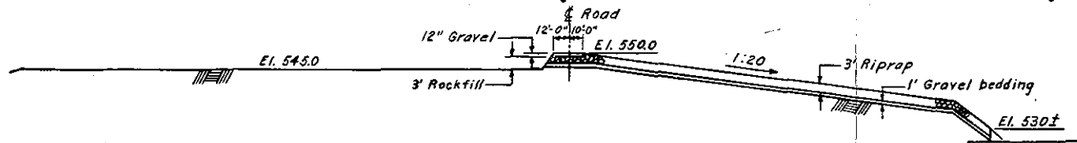
SECTION A-A

SCALE: 1/8" = 1'-0"



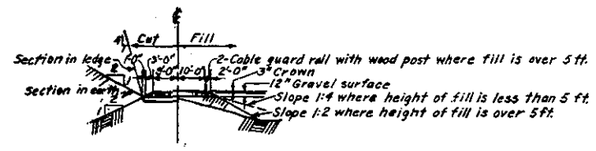
SECTION D-D

SCALE: 1/8" = 1'-0"



PROFILE ON ℄ OVERFLOW

SCALE: VERT. 1" = 20'
HOR. 1" = 40'



ROADWAY - TYPICAL SECTION

SCALE: 1" = 20'

GRAPHIC SCALES

1" = 1'-0" — 4' 0 4' 8' 12' 16' 20'
1" = 20' — 20' 0 20' 40'
1" = 40' — 40' 0 40' 80'

SAFETY PAYS

NO.	DATE	DESCRIPTION	BY

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

DES. BY	DR. BY	CK. BY

SUBMITTED
CHIEF, SECTION
APPROVAL RECOMMENDED
CHIEF, ENGR. DIV. BRANCH
REVIEWED
PROJECT ENGINEER
APPROVAL RECOMMENDED:

CONNECTICUT RIVER FLOOD CONTROL
NORTH SPRINGFIELD DAM & RESERVOIR
RELOCATED TOWN ROAD NO. 22 EMBANKMENT
(NORTH BRANCH RECREATION POOL)
SECTIONS AND PROFILES
BLACK RIVER — VERMONT

APPROVED — DATE
CHIEF, ENGINEERING DIVISION

SCALE AS SHOWN | SPEC. NO.
DRAWING NUMBER

PLATE NO. C-20

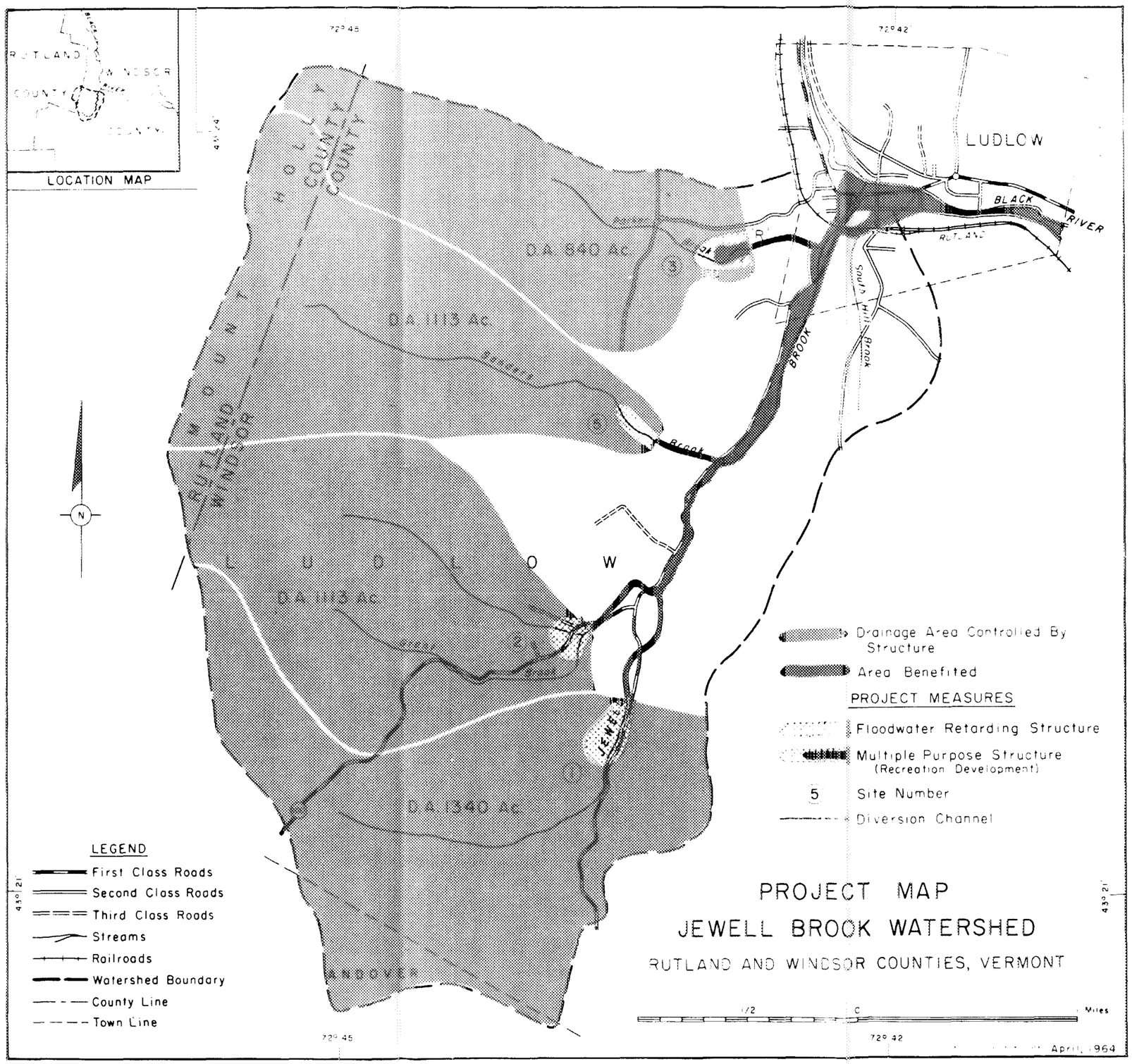

LOCATION MAP
RUTLAND
WINDSOR
COUNTY
COUNTY
72°45
72°42
43°24'
43°21'
HOLLY
RUTLAND
WINDSOR
COUNTY
COUNTY
D.A. 540 AC.
D.A. 1113 AC.
D.A. 1340 AC.
LUDLOW
BLACK
RIVER
RUTLAND
BROOK
South Hill Brook
Brook
JEWELL
BROOK
LUDLOW
WINDSOR
N
LEGEND
First Class Roads
Second Class Roads
Third Class Roads
Streams
Railroads
Watershed Boundary
County Line
Town Line
Drainage Area Controlled By Structure
Area Benefited
PROJECT MEASURES
Floodwater Retarding Structure
Multiple Purpose Structure (Recreation Development)
5 Site Number
Diversion Channel
PROJECT MAP
JEWELL BROOK WATERSHED
RUTLAND AND WINDSOR COUNTIES, VERMONT
1/2
0
Miles
April, 1964

PLATE NO. C-21

A T T A C H M E N T I

RESERVOIR REGULATION

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ATTACHMENT I
RESERVOIR REGULATION

1. ORGANIZATION

The Reservoir Regulation Section is responsible for regulation of the flood control reservoirs in the New England area. In the New England Division, the Hydrology & Hydraulics Branch of the Engineering Division functions also as the Reservoir Regulation Section (RRS). In addition to its regular flood control duties, RRS is responsible for: (a) monthly reports on reservoir regulation, (b) continuing studies of regulation procedures, (c) analyses of actual flood operations, (d) training of personnel, (e) the establishment of a data gathering and reporting network, and (f) maintenance of hydrologic equipment. The supervision of routine operations and maintenance activities comes under the jurisdiction of the Reservoir Branch of the Operations Division. An organization chart for reservoir regulation in the New England Division is shown on plate C-I-1.

The Reservoir Regulation Section is subdivided into basin units, each responsible for receiving routine hydrometeorological reports and directing reservoir regulation within an assigned river basin. Each unit consists of a regulator in charge of the overall operation in the basin, and project regulators who receive reports and issue instructions to individual dams either from NED headquarters during working hours or from their homes during nonworking hours. Whenever emergency conditions so require, the RRS staffs NED headquarters and the regulation units are organized to assure 24-hour operation as long as the emergency exists.

2. INSTRUCTIONS TO OPERATORS

All instructions to operators for regulation of the flood control reservoirs are given directly by the RRS with advisories forwarded to the Operations Division. When the North Springfield dam operator is unable to communicate with RRS and circumstances require immediate action, the operator has full authority and responsibility to operate the flood control gates and regulate discharges in accordance with Emergency Operation Procedures (EOP) described in paragraph 15. Standard Operating Procedures and Operating Guide Curves are shown on plates C-I-2 through C-I-4.

3. COMMUNICATIONS

All communications between the dam operator and RRS are made via the NED radio network during normal working hours or when NED headquarters is otherwise manned. Whenever the radio network is inoperative, communications are made by telephone. During nonworking hours, reports and regulation instructions are issued by telephone to or from the homes of RRS personnel. A telephone directory is maintained and issued by RRS for its

specific use during flood operations. In the event of failure of the NED radio network and telephone service, emergency communications are attempted through State Police and Civil Defense radio facilities.

4. PRECIPITATION REPORTING NETWORK

Reports of precipitation data from the Black River basin are used primarily for the purpose of alerting regulation personnel and providing a basis for appraising the severity of the storm. The collection and reporting of precipitation data from the North Springfield dam, as well as from voluntary observers at Cavendish and Tyson, are the responsibility of the North Springfield dam operator. He should periodically review the network arrangements with voluntary observers as well as trying to increase the number of reporting stations to insure that a complete reporting network is established. The River Forecast Center at Hartford, Connecticut receives precipitation reports from USWB observer stations in and near the Black River basin which are available to RRS upon request. Locations of the NED and USWB precipitation stations are shown on plate C-I-2.

5. RIVER REPORTING NETWORK

a. General. A network of river stage observation stations has been established downstream of the North Springfield dam which is part of an overall river reporting system for the Connecticut River basin. This network assists in the execution of the reservoir regulation plan by permitting personnel in RRS or at the dams to obtain river stages at selected locations either on tributaries or the Connecticut River. Immediately downstream of the dam, the USGS maintains a gaging station which provides a continuous record of releases from the dam.

b. Black River. An index staff gage is located on the left bank of the Black River at the bridge entrance to Fellows Gear Shaper Company, about 1,000 feet downstream of dam 1, in Springfield, Vermont. The gage, established by NED during the construction of North Springfield dam, indicates runoff from a drainage area of approximately 188 square miles, of which 158 lie upstream of North Springfield dam. River stages can be obtained 24 hours a day by telephoning plant personnel. A provisional discharge rating curve has been established for the index gage and is shown on plate C-I-11. (Recently a staff gage has been installed about 100 feet upstream of Gear Shaper dam 1 and is anticipated to be used in future operations. A provisional rating curve also is shown on plate C-I-11).

c. Connecticut River. The USGS gaging station at North Walpole, New Hampshire, located about 100 feet upstream of the Saxtons River between the communities of Bellows Falls, Vermont and North Walpole, New Hampshire, is the primary index station for determining reservoir flood releases on the Connecticut River. This gage measures runoff from 5,493 square miles and has been in operation since 1942. A telemark

system (telephone transmitting equipment) has been installed at this location. Other index stations also used as guides are the USGS gaging stations at White River Junction, Vermont (D.A. = 6,266 square miles) and Montague City, Massachusetts (D.A. = 7,865 square miles), both of which have telemark systems. These three gages on the Connecticut River are included in the automatic hydrologic radio reporting network and are shown on plate C-I-2.

6. WEATHER AND RIVER FORECASTS

a. Precipitation forecasts. In addition to normal periodic weather forecasts, quantitative precipitation forecasts prepared by the U. S. Weather Bureau are received daily over the Massachusetts Weather Teletype Network by the Reservoir Regulation Section. Supplemental weather information and forecasts prior to or during floods are made available upon request from the USWB office at Boston, Massachusetts.

b. USWB river forecasts. The River Forecast Center of the Weather Bureau at Hartford, Connecticut is responsible for preparing and disseminating flood forecasts for the Connecticut River and some of its principal tributaries. Biweekly forecasts, indicating the amount of 12-hour rainfall necessary to produce flood conditions on tributaries are prepared by the Center and transmitted by teletype to RRS. Although flood forecasts are not given specifically for the Black River, they are indicative of conditions existing in the basin.

c. Corps of Engineers flood forecasts. Guide curves, shown on plate C-I-3, have been developed for estimating rainfall-runoff relationships for Corps of Engineers use only. Curves of rainfall versus estimated peak discharges into the reservoir have been determined from available information. The curves will be checked with future data and modified, if necessary, to improve the correlation.

7. REPORTS

a. Weekly reports. The dam operator makes a routine report by radio (or telephone) to RRS each Friday morning which insures continuous contact between the operating personnel and RRS and also serves as a check on the communications network. The report includes the preceding 24-hour precipitation, current weather conditions, reservoir pool stage, regulation data, river conditions at index stations and other miscellaneous data. A sample of the completed form is shown on sheet C-I-1.

b. Alerting reports. An alerting report is promptly made and includes available pertinent data together with a general appraisal of local conditions (data from all the precipitation or flood index stations may not be available). Whenever any of the following conditions occur, the dam operator will immediately notify RRS:

(1) Precipitation. Occurrence of 1 inch of precipitation during

a 24-hour period at the dam or any reporting station within the network.

(2) Reservoir stage. Whenever a rising pool reaches a stage of 18 feet during the nonrecreation season or reaches a stage of 25.5 feet during the recreation season.

(3) River stages. Whenever the Black River at Fellows Gear Shaper Company index gage in Springfield reaches 2.0 feet and is rising or the Connecticut River at North Walpole reaches 24.0 feet and is rising.

(4) Unusual conditions. Unusual local conditions such as difficulty with the gates, ice jams, excessive debris, bridge failures, etc. will be reported.

c. Supplemental reports. Supplemental radio (or telephone) reports are made to RRS by the dam operator either with instructions from RRS or if it appears that flood conditions might develop in the basin as the result of melting snow, ice jams, dam failures or heavy localized rainfall. The time and frequency of these reports are dependent upon the severity of conditions and specific instructions from RRS. Flood reports are transmitted at minimum 3-hour intervals. Sheet C-I-2 shows a typical reporting log indicating data to be included in reports by the dam operator during flood periods. Insofar as practicable, the following information should be included in the flood report:

(1) Precipitation at dam. The total amount of precipitation which has fallen up to the time of reporting and several intermediate amounts with times of observation.

(2) Reservoir stage. The pool stage at time of reporting and several previous readings with the corresponding times to determine the rate of rise and define the inflow hydrograph (accurate readings of stage and time are essential to facilitate computations made by RRS).

(3) Gate positions. Gate openings and discharges at time of reporting and beginning of storm.

(4) Precipitation reports from observers. Rainfall data received from cooperative observers.

(5) River stages. River stages with times of observations from gages at Springfield and North Walpole and other stations as requested by RRS.

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

(7) Miscellaneous data. Any other information which might be pertinent.

d. Special reports. A special report is submitted by the dam operator to RRS whenever unusual circumstances occur during a flood or if requested. The report may be written in longhand and should describe the subjects outlined below if appropriate.

(1) Observations at dam. The dam operator makes general observations of conditions occurring at the outlet works as listed below. The observations are entered in the log book at the dam. If possible, photographs are taken of any unusual conditions noting date, time, reservoir gage heights and position of the gates.

(a) Intake and portal. Extent and action of eddies and waves in the vicinity of the conduit intakes and portals.

(b) Outlet and spillway discharge channels. Extent and action of turbulence or eddies downstream of the spillway and outlet works.

(c) Ice and debris. Effect on flow through the gates due to an accumulation of ice or debris at the intake.

(d) Gates. The pool elevation and position of the gates at which vibration may develop.

(e) Other. Any other unusual hydraulic phenomena that may occur.

(2) Observations at control points. During periods of reservoir regulation, particularly while emptying the reservoir, reconnaissance of the river is made by the dam operator upon specific authorization from RRS to obtain further data on the safe channel capacity of the Black River through principal damage areas. Critical stages at damage points are correlated with concurrent stage at the nearest gaging station to obtain the corresponding discharge.

8. SPECIAL ADVISORIES

In accordance with regulations set forth in EM 500-1-1, Domestic Emergency Operations, special advisories from RRS on flood potential and progress of all threatening storms are submitted to the Division Engineer, Chief, Engineering and Operations Divisions. Flood reports also are made to OCE by Reservoir Regulation Section.

9. MAINTENANCE OF LOG

All reports, instructions, records of unusual circumstances at the dam, and information pertinent to regulation of the reservoir are entered in the log. A log is maintained by both the dam operator and the Reservoir Regulation Section.

10. GATE OPERATION RECORD

All gate operations are carefully noted on NED Form 90, a sample of which is shown on sheet C-I-3, and submitted monthly with recorder charts of reservoir stages. All operations are noted regardless of the duration of change in gate position. The report includes date and time of day, gate opening, reservoir gage height and reason for operation.

11. RESERVOIR REGULATION - NORMAL PERIODS

a. Nonrecreation season. The permanent pool is maintained at a stage of about 15 feet which is the crest of the concrete U-shaped weir just upstream of the center gate (elevation 467). The two outside gates are closed and the middle gate fully open. No gate operation is required during minor pool rises. Based on limited operating experience at the project, formation of ice at the intake works during the winter months is not a problem. However, if icing problems do occur, RRS should be notified immediately.

b. Recreation season. During the month of May, and following the spring runoff period, the pool will be raised to elevation 475, equivalent to a stage of 23 feet. Two gates will be completely closed, and the third throttled to maintain the pool. In order to minimize pool stage fluctuations during minor rises, the third gate will be automatically operated by a selsyn controlled motor. In this automatic condition, the gate opening will range from 0.1 to 5 feet, the discharges from 15 to 700 cfs, and pool stages from 23 to 25.5 feet. When the pool rises to 25.5 feet, an alarm will sound alerting the operator. RRS will be notified at this time for further instructions.

c. Cooperation with downstream water users. The policy of the Corps of Engineers is to cooperate whenever possible with downstream water users, police authorities and other interested parties and agencies. The operator of the dam may be requested by downstream water users to modify the river-flow for short periods of time. Whenever a request for such modification is received, the operator shall ascertain the validity of the request and obtain assurances from all other downstream water users that they are agreeable with the proposed operation. The operator will then relay the information to RRS and request instructions. Under no circumstances will the reservoir releases be less than 15 cfs as this amount of discharge is required for maintenance of fish life downstream.

12. RESERVOIR REGULATION - FLOOD PERIODS

a. General. Regulation of flow from North Springfield Reservoir is initiated for specific river stages on the Black and Connecticut Rivers or for heavy rainfall over the basin. Regulation may be considered in three phases during the course of a flood: Phase I - appraisal of storm or river conditions during development of the flood and initial regulation, Phase II - regulation during the flood period, and Phase III - emptying the

reservoir following downstream recession of the flood. The Standard Operating Procedure is shown on plate C-I-2.

b. Phase I - Initial regulation of flow. This phase is important as it is necessary to collect rainfall and discharge data and appraise the development of the storm and magnitude of the flood in a short period of time. Gate operations at North Springfield dam will be initiated for the following conditions:

(1) Black River. Regulation of the reservoir for Black River stages will be in accordance with guide curves shown on plate C-I-4. At all times regulation will be undertaken to keep the river stage at the Gear Shaper index gage less than 3.0 feet. Average travel time from the dam to the index gage is about 1 hour.

(2) Connecticut River. Regulation of the reservoir for Connecticut River stages will be based on origin of the flood and in accordance with the following schedule:

Flood Origin		Regulation Required
Upstream	(North of White River Junction)	No regulation until White River Junction stage exceeds 20 feet.
Central	(White River Junction to Montague City)	Restrict outflow at dam and be prepared to close to minimum openings. A regulation schedule based on the North Walpole index station follows:

North Walpole Stage for Initiating Regulation	Restrict Outflow to:
24.0 feet (66,700 cfs), rising	1,500 cfs
25.0 feet (71,200 cfs), rising	750 cfs
26.0 feet (75,700 cfs), and higher	15 cfs*

* Minimum required for maintenance of fish life (15 cfs)

Flood Origin	Regulation Required
Downstream (South of Montague City)	Restrict outflow based on local conditions and be prepared to close to minimum openings according to the following schedule:

Index Location	Stage for Closing Gates to Minimum Openings
Montague City	25.0 feet (65,800 cfs) and rising
Springfield	12.0 feet (65,000 cfs) and rising

Table C-I-1 consists of warning and flood stages at key index stations along the Connecticut River, average peak travel times and maximum recorded stages. Average travel time from the dam to the North Walpole gage is approximately 5 hours.

(3) Rainfall. Depending on antecedent condtions, past experience has indicated that 2-3 inches of rainfall over the Black River basin in 24 hours produces a moderate rise in river stages. Therefore, initial regulation of the reservoir is also considered necessary whenever the following precipitation has been recorded at the dam within a 24-hour period.

Rainfall-Inches (24-hour period)	Maximum Reservoir Release (cfs)
Less than 2	Gates in normal position
2-3	1,500
3-4	750
More than 4	15 (minimum opening)

c. Phase II - Continuation of regulation. During this phase of a flood,outflow from the reservoir is regulated to alleviate, or reduce as far as practicable, downstream flood damages on the Black and Connecticut Rivers. If the gates are completely closed, they remain in that position until the final phase of operation is initiated. If they are not completely closed, it will be necessary to follow schedule listed in Phase I.

(1) Black River. The reservoir discharges will be regulated to maintain safe channel capacities on the Black River. If the gates are partially open and reservoir stages continue to rise, further gate operations may be necessary to maintain nondamaging flows.

TABLE C-I-1

CONNECTICUT RIVER
WARNING AND FLOOD STAGES

Index Station	Warning Stage Gage Height (feet)	Flood Stage & Discharge Gage Height (feet)	Flood Stage & Discharge CFS	Average Peak Travel Time (hours)	Maximum Recorded Stage Gage Height (feet)	Maximum Recorded Stage Date
White River Junction	17.0 (38,300)	20.0	51,000		35.0	11/ 4/27
North Walpole	26.0 (75,700)	30.0	95,000	9	43.8	3/19/36
Montague City	25.0 (65,800)	28.0	80,000	20	49.2	3/19/36
Holyoke	7.0 (60,000)	9.0	92,000	12	16.8	3/19/36
Springfield	12.0 (65,000)	20.0	151,000	6	28.6	3/20/36
Thompsonville	8.0 (120,000)	10.3	161,700	6	16.6	3/20/36
Hartford	16.0 (66,000)	22.0	114,000	7	37.6	3/21/36

(2) Connecticut River. The dam is regulated in coordination with other reservoirs in the system to provide optimum flood reductions to communities along the Connecticut River.

Another important regulation activity during this period is the collection of hydrologic and hydraulic data such as: (a) precipitation amounts throughout the entire Black River basin, (b) snow cover and water content in case of spring floods, (c) stage and discharge values at downstream control points on the Black River, and (d) any other pertinent rainfall and runoff information which will assist in regulation of the reservoirs. Discharge data along the main Connecticut River and principal tributaries above and below the mouth of the Black River are received by RRS in order to coordinate the regulation of North Springfield Reservoir with all other reservoirs in the Connecticut River basin.

d. Phase III - Emptying the reservoirs

(1) General. The runoff hydrograph of each flood has its own characteristics, and as a result the operating procedures will vary, but in general Phase III usually is based on conditions in the Connecticut River. During recession of the flood on the Black or Connecticut Rivers, the reservoir is emptied as rapidly as possible. The rate of increase in discharges is not to exceed 500 cfs per hour. Following emptying of the reservoir the gates will be set at their normal openings.

(2) Black River. Evacuation discharges from the reservoir will not exceed Black River channel capacities. The channel capacity in Springfield is about 5,000 cfs.

(3) Connecticut River. Evacuation of the reservoir will not be initiated until the flood crest has passed North Walpole. Guide curves for reservoir releases are shown on plate C-I-4.

Evacuating discharges from the North Springfield Reservoir will be coordinated with releases from other projects in the system in a manner that will allow Connecticut River flood crests to continue receding. This subject will be described in detail in the Master Regulation Manual for the Connecticut River basin.

Secondary river rises during Phase III, due to either additional rainfall or snowmelt, may result in the regulation procedure reverting to Phases I or II.

e. Spillway discharge. Ordinarily during a major flood the gates will be closed to induce surcharge storage whenever downstream channel capacity continues to be exceeded by the runoff from uncontrolled areas. However, gates at the dam will be immediately operated with or without instructions from RRS, when the pool rises to the following levels.

Stage Above Spillway Crest	Gate 1	Gate 2	Gate 3
4'	0	0	0
5'	0	6'	0
6'	0	F	0
7'	6'	F	0
8'	6'	F	6'
9'	F	F	6'
10'	F	F	F

F - Fully Open

f. Alerting of flood affected populace. Whenever it is anticipated that the pool will rise above spillway crest elevation during an extreme flood, police and/or officials of communities downstream that may be affected will be advised immediately of impending conditions. Whenever the pool is expected to rise above the flowage easement line of 550 feet msl (4.5 feet above spillway crest), affected residents within the reservoir area will be notified.

g. Effect of regulation on roads within the reservoir area. Several roads that pass through the reservoir area (shown on plate C-18 of the appendix) are subject to inundation during the storage of floodwaters. If the pool is expected to rise above a stage of 30 feet, the 7 permanent barricades (steel posts with cables) on roads leading to the reservoir area will be closed.

Town Road 22 will be inundated when the reservoir reaches a stage of 98 feet, elevation 550.0 feet msl which is 4.5 feet above the spillway crest. If spillway discharge is anticipated, barricades are necessary at the westerly end of the embankment of Town Road 22 crossing and at the junction of Town Road 22 and North-South Road east of the spillway section. Local authorities will be notified by the operator when barricades are required.

13. EXTRAORDINARY FLOOD CONDITIONS

It is conceivable that extraordinary and unpredictable flood conditions may arise, such as dam or bridge failures, highway or railroad washouts, ice jams or debris deposits. Since the prime purpose of the reservoir is to prevent further damage, regulation during such unusual conditions may not follow previously described rules but will be governed by the urgency of the circumstances. If time permits, RRS will be notified immediately of any unusual incident so that the emergency can be weighed with respect to conditions at other locations. The gates will be operated to provide maximum protection.

14. REGULATION WITH FAILURE OF COMMUNICATIONS

If the operator is unable to communicate with RRS by normal or emergency methods and conditions develop which appear to warrant regulation, he will operate the gates in accordance with instructions contained in paragraph 15, Emergency Operating Procedure. However, possession of the instructions contained in this manual does not relieve the operator of his responsibility for continued efforts to communicate with the Reservoir Regulation Section. In cases of emergency, the operator shall attempt to communicate with RRS through the Vermont State Police and Office of Civil Defense Mobilization radio networks. It should be emphasized that whenever communications fail, or due to lack of adequate reports which make it impossible to fully appraise the runoff from an intense storm, it is preferable to restrict immediately or completely stop the reservoir discharge than delay regulation and actually contribute to downstream flood conditions.

15. EMERGENCY OPERATING PROCEDURE (EOP)

When unable to contact the RRS and flood conditions develop, the operator has full authority to act promptly in accordance with instructions contained herein regarding the partial closure of gates. However, the gate openings will not be increased until contact has been established with RRS. During such an operation, if any of the following stages are reached, there will be no partial gate closures and the operator will close the gates to the minimum opening.

EMERGENCY OPERATION PROCEDURE
STAGES FOR COMPLETE CLOSURE OF GATES

Location	Stage (feet)
Black River at Springfield, Vt. (Fellows Gear Shaper gage)	3.0
Connecticut River at North Walpole (USGS gage)	26.0

RAINFALL FOR COMPLETE CLOSURE OF GATES

North Springfield dam will be closed whenever 3 inches of rainfall has fallen in the Black River basin in a 24-hour period.

Emptying the reservoir will not be initiated until contact has been established with RRS.

16. SNOW SURVEYS

Snow courses have been established at selected locations within the reservoir watershed and are shown on plate C-2 of the main report. Weekly surveys are made by the operator during the winter and early spring to determine the depth of snow and its equivalent water content. Dates for surveys are determined each year by RRS so as to correspond with monthly bulletins of the U. S. Geological Survey.

17. ABSENCE FROM DAM

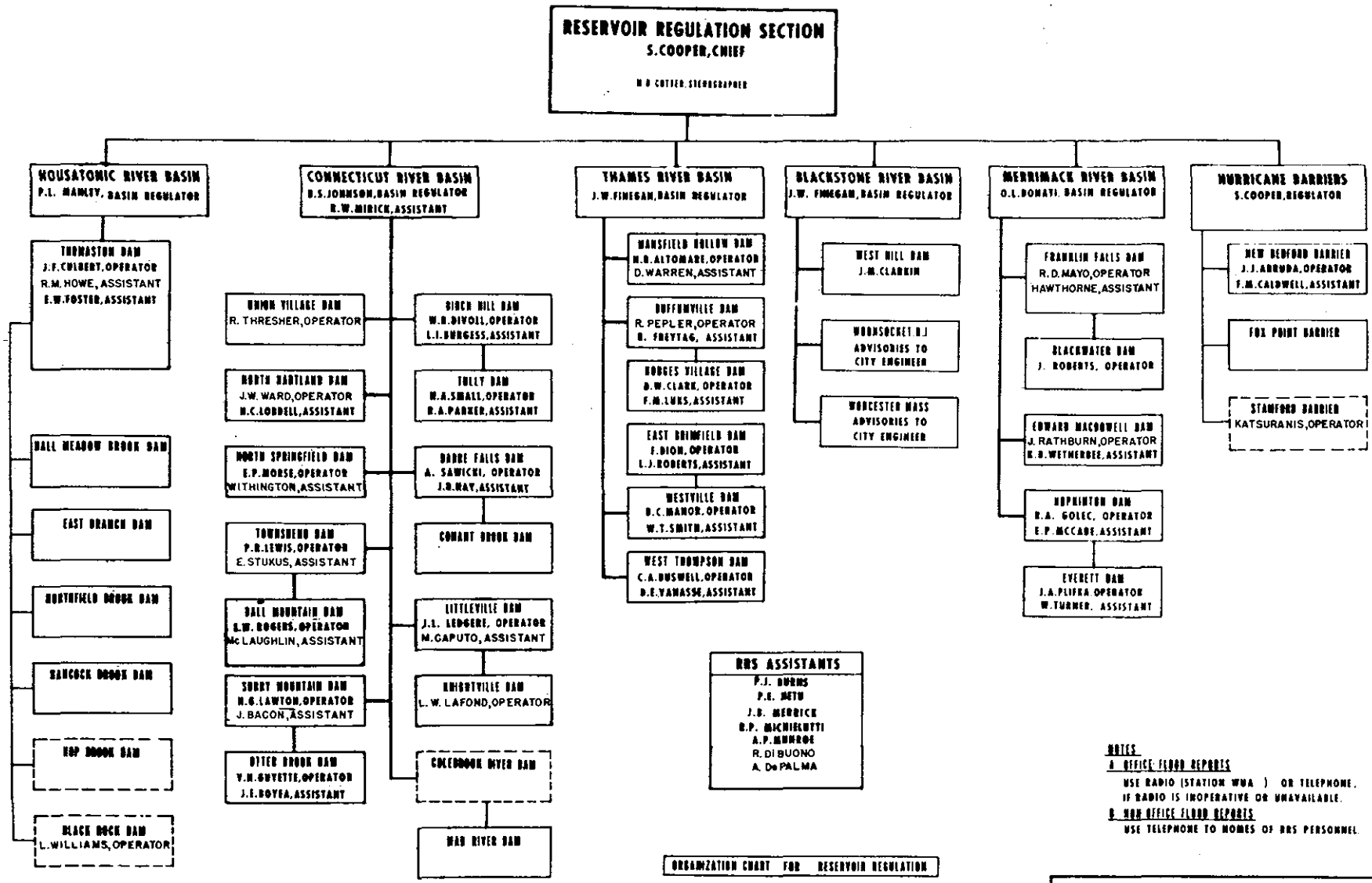
Whenever the Head Operator expects to be absent overnight from the dam, the Reservoir Regulation Section will be notified.

18. SEDIMENTATION

Sedimentation ranges and monuments have not been installed in the reservoir area. Experience from other reservoir projects in New England has shown that only minimal amounts of sediment deposition have taken place. Based on readings of existing ranges at other reservoirs, no sedimentation surveys will be made until some evidence of their need is demonstrated.

19. FUTURE STUDIES

Post flood studies will be made for each period of reservoir regulation to determine efficiency of the communications and reporting networks, applicability of regulation guides including stage discharge relationships, discharge correlations and flood reductions at damage centers.



ORGANIZATION CHART
RESERVOIR REGULATION SECTION

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

OCTOBER 1968

PLATE NO. CI-1

STANDARD OPERATING PROCEDURE (S.O.P.)

NORTH SPRINGFIELD DAM & RESERVOIR

PHASE	STORM PRECIPITATION RAINFALL - INCHES ANTECEDENT CONDITIONS		NORTH SPRINGFIELD RESERVOIR	FELLOWS GEAR SHAPER GAGE SPRINGFIELD, VT.	RIVER INDEX STATIONS (STAGE IN FEET) CONNECTICUT RIVER AT			REGULATION INSTRUCTIONS
	SNOW COVERED WET OR FROZEN	DRY	STAGE IN FEET		NO. WALPOLE	MONTAGUE CITY	SPRINGFIELD	GATE SETTINGS
PHASE I - APPRAISAL								
1 st Alert	1.0	1.0	18 -(Winter) 25.5-(Summer)	2.0	24.0 (66,700 c.f.s.)	—	—	NORMAL SETTING O - F - O
2 nd Alert	1.5 (Or As Instructed)	2.0	As Instructed	As Instructed	—	—	—	
Initial Regulation	2.0 (Or As Instructed)	3.0	As Instructed	2.5 (Or As Instructed)	24.0 (66,700 c.f.s.)	25.0 (65,800 c.f.s.)	12.0 (65,000 c.f.s.)	Restrict Outflow (Par. 12)
PHASE II CONTINUATION OF REGULATION	3.0 (Or As Instructed)	4.0	As Instructed	3.0	26.0 (75,700 c.f.s.)	—	—	Restrict Outflow To 15 c.f.s.
PHASE III - EVACUATION	STORM HAS ABATED		FOR ALLOWABLE RELEASES FROM DAM CONSULT GUIDE CURVES ON PLATES C-I-3 AND C-I-4 MAX. ALLOWABLE DISCHARGE FROM DAM = 5000 C.F.S.					

EMERGENCY OPERATION PROCEDURE (E.O.P.)

(DURING COMMUNICATION FAILURE WITH RRS)

1. The operator is responsible for regulation of releases from the dams during loss of contact with RRS.
2. The operator will operate according to Phase I Guide Curves when conditions do not necessitate complete closure of gates.
3. The operator is responsible for complete closure of gates (minimum opening 15 cfs) in accordance with the following:
   a. Rainfall - 2.5 inches have fallen in basin within 24 hours
   b. Stages - Location
      Fellows Gear Shaper Index Gage 3.0'
      Connecticut River at North Walpole 26.0'

   Discharge from the reservoir storage is not to be increased until contact has been re-established with RRS

DUTIES DURING EACH PHASE

FLOOD CONTROL DAM OPERATOR

PHASE I

1. Collect and transmit to RRS rainfall and stage data.
2. Operate according to instructions from RRS.

PHASE II

1. Close to minimum settings upon instructions from RRS.
2. Note all unusual conditions at dam, downstream channels and index stations.
3. Collect and transmit rainfall and stage data at minimum 3-hour intervals or as directed by RRS.

PHASE III

1. See Phase II, step 3.
2. Reconnoiter flood plain as instructed by RRS and note conditions.
3. Report to RRS for further instructions.

PROJECT REGULATOR

PHASE I

1. Compile data.
2. Coordinate next transmission.
3. Restrict outflow to maintain safe channel capacity on the Black and Connecticut Rivers.
4. Inform Basin Regulator of actions.

PHASE II

1. Continue regulation instructions to operator.
2. Consult with Basin Regulator to analyze severity of flood.
3. Relay to operator any special instructions recommended by Basin Regulator.

PHASE III

1. Collect data from operator.
2. Check guide curves for allowable releases
3. Consult with Basin Regulator.
4. Relay instructions to operator.

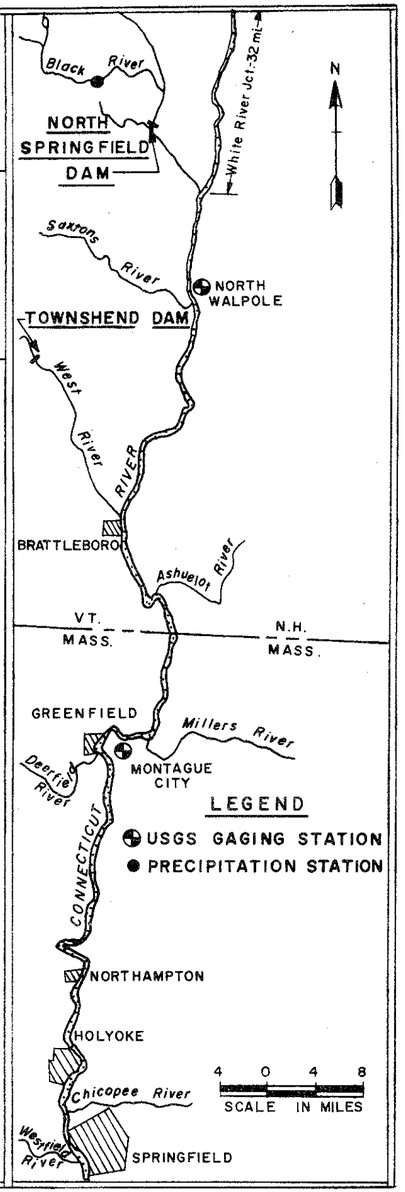
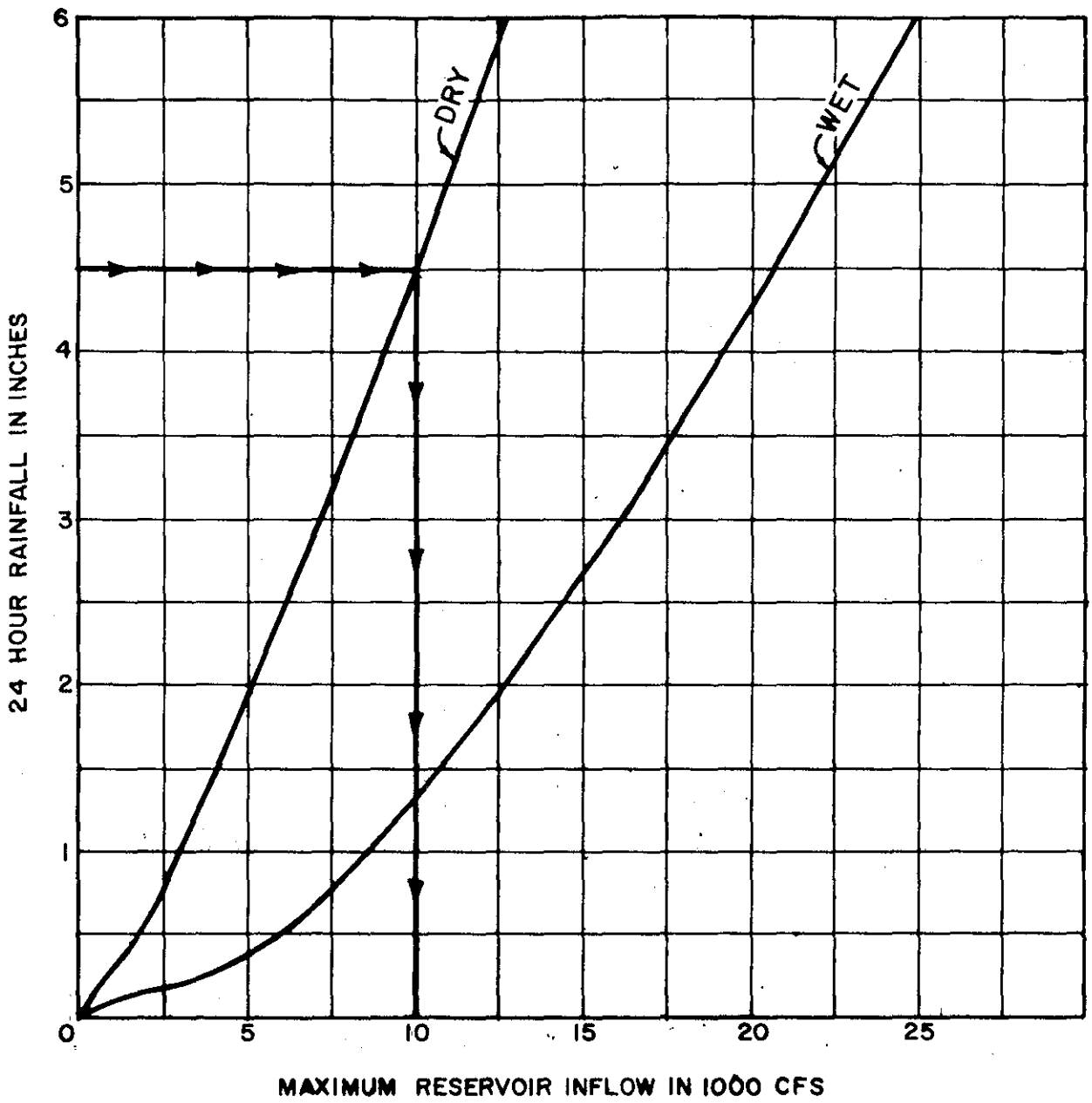


PLATE NO. C-I-2



EXAMPLE:

24 Hour rainfall of 4.5" occurring with dry antecedent conditions. Maximum reservoir inflow of 10,000 cfs is possible.

CONNECTICUT RIVER FLOOD CONTROL
BLACK RIVER, VERMONT
NORTH SPRINGFIELD RESERVOIR
RAINFALL - RUNOFF
RELATIONSHIP
NEW ENGLAND DIV., WALTHAM, MASS.
JULY 1968

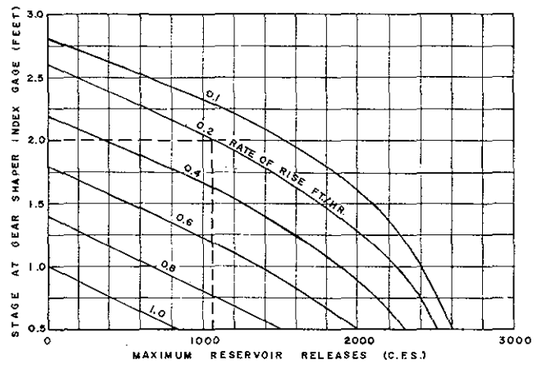
PLATE NO. C-I-3

RELEASE GUIDES FOR PHASES I & II

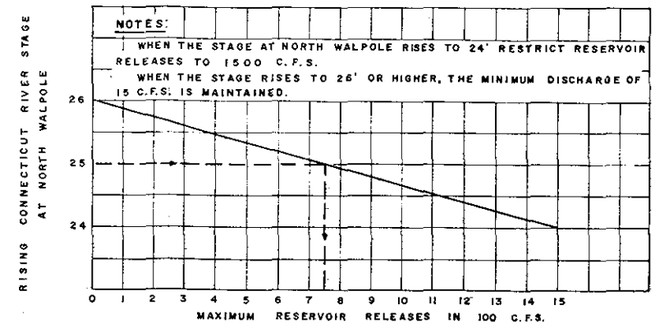
GUIDE NO. 1 - STORM RAINFALL

RAINFALL - INCHES (24-HOUR PERIOD)	MAXIMUM RESERVOIR RELEASE (C.F.S.)
LESS THAN 2	GATES IN NORMAL POSITION
2-3	1,500
3-4	750
MORE THAN 4	15 (MINIMUM OPENING)

GUIDE NO. 2 - BLACK RIVER STAGES



GUIDE NO. 3 - CONNECTICUT RIVER STAGES

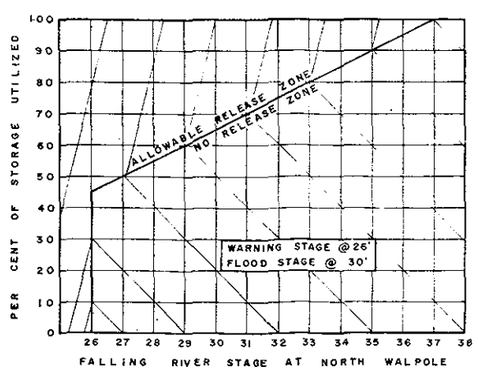


RELEASE GUIDES — PHASES III

GUIDE NO. 4 - BLACK RIVER STAGES

If the regulation during Phase III is based upon Black River conditions, the reservoir discharges can be determined by using the index station rating curve (plate C-1-11) in conjunction with the rate of recession (feet per hour) at the index station.

GUIDE NO. 5 - CONNECTICUT RIVER STAGES



NOTES:

1. Travel time from dam to the Gear Shaper gage is about 1 hour.
2. Travel time from dam to North Walpole gage is about 5 hours.
3. The rate of increase in discharges is not to exceed 500 c.f.s. per hour.
4. The channel capacity in Springfield, Vermont is about 5000 c.f.s.
5. These relationships have been established as guides in determining the regulation procedures. However during an extraordinary or unpredictable flood conditions, the regulation may not be in accordance with the guide, but will be governed by the urgency of the circumstances.

CONNECTICUT RIVER FLOOD CONTROL

BLACK RIVER, VERMONT

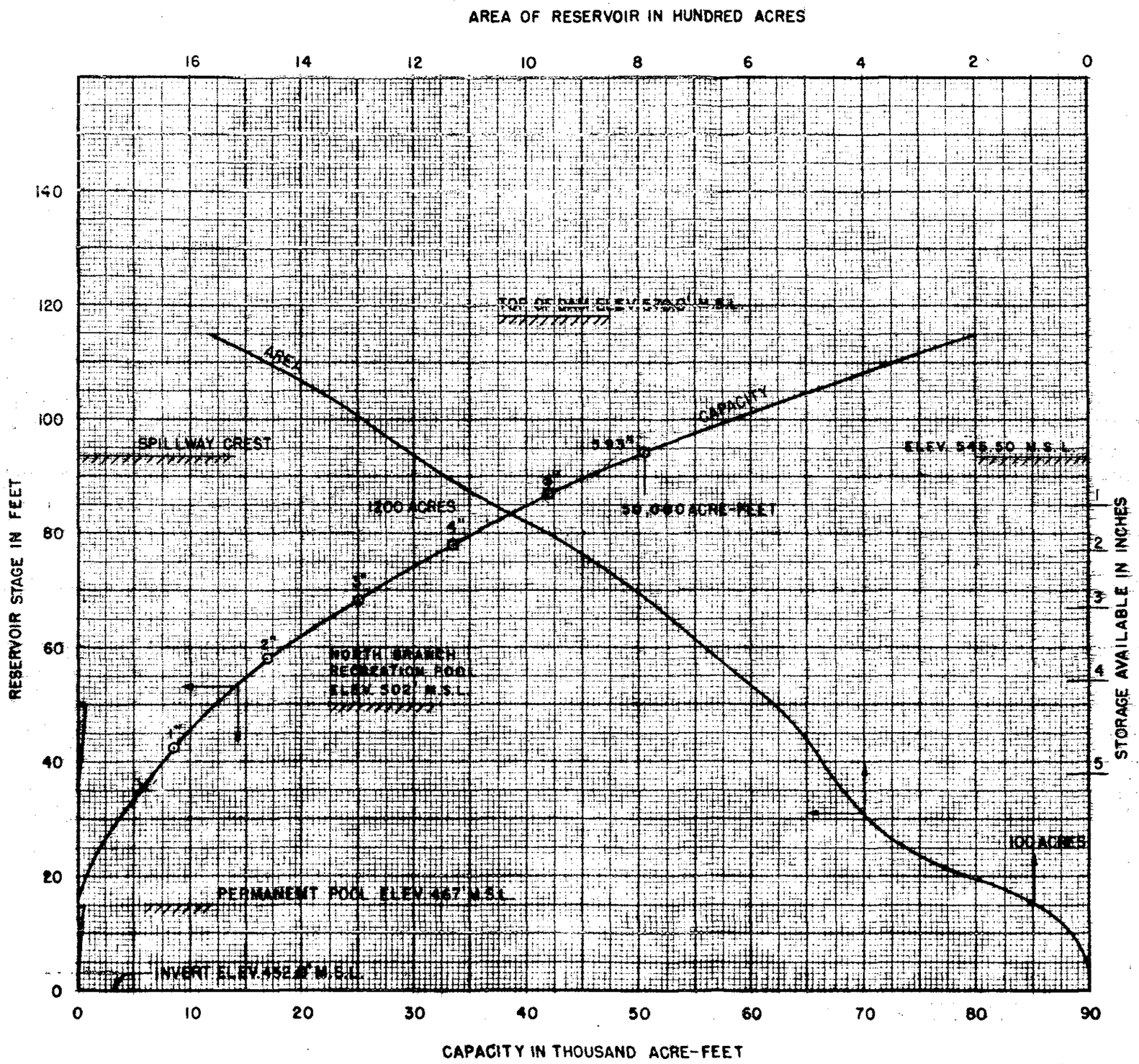
NORTH SPRINGFIELD RESERVOIR

RESERVOIR REGULATION GUIDES

NEW ENGLAND DIVISION WALTHAM, MASS.

JULY 1968

PLATE NO. C-I-4



DRAINAGE AREA = 158 SQ. MI.
1" RUNOFF = 8425 AC. FT.

CONNECTICUT RIVER FLOOD CONTROL
NORTH SPRINGFIELD
RESERVOIR
BLACK RIVER, VERMONT
AREA-CAPACITY CURVES
NEW ENGLAND DIVISION, WALTHAM, MASS.
JULY 1960

PLATE NO. C-I-5

NORTH SPRINGFIELD RESERVOIR
AREA AND CAPACITY
(DA = 158 square miles)

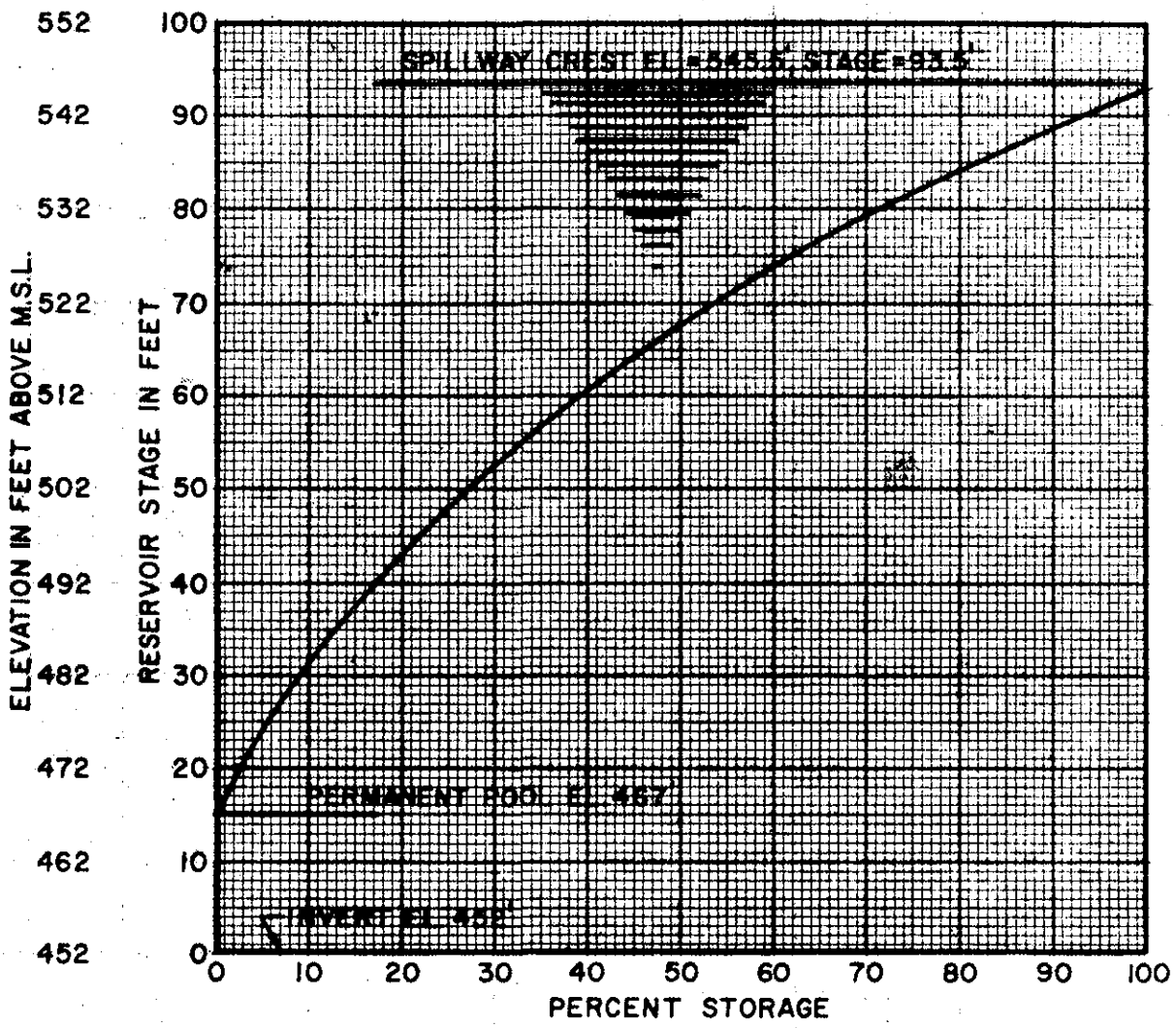
Elevation (msl)	Stage (ft)	Area (acres)	Capacity Ac/Ft	Capacity Inches	Recreation Season* Ac/Ft	Recreation Season* Inches
452	0	Gate Invert Elevation				
467	15	100	500	0.06		
Permanent Pool Elevation = 467						
467	15	100	0	0.0	-	-
475	23	290	1,500	0.18	0	0
477	25	325	2,000	0.24	500	0.06
479	27	360	2,650	0.31	1,150	0.13
481	29	380	3,400	0.40	1,900	0.22
483	31	400	4,000	0.47	2,500	0.29
485	33	420	4,800	0.57	3,300	0.39
487	35	440	5,600	0.66	4,100	0.48
489	37	455	6,400	0.76	4,900	0.58
491	39	470	7,200	0.85	5,700	0.67
493	41	480	8,000	0.95	6,500	0.77
495	43	495	8,900	1.06	7,400	0.88
497	45	510	9,600	1.14	8,100	0.96
499	47	530	10,600	1.26	9,100	1.08
501	49	550	11,700	1.39	10,200	1.21
503	51	570	12,750	1.51	11,250	1.33
505	53	595	14,000	1.66	13,500	1.48
507	55	620	15,000	1.78	14,500	1.60
509	57	650	16,500	1.96	16,000	1.78
511	59	675	17,700	2.10	17,200	1.92

* Recreation Pool at 475 feet
1-inch runoff = 8,425 acre-feet

PLATE NO. C-I-6

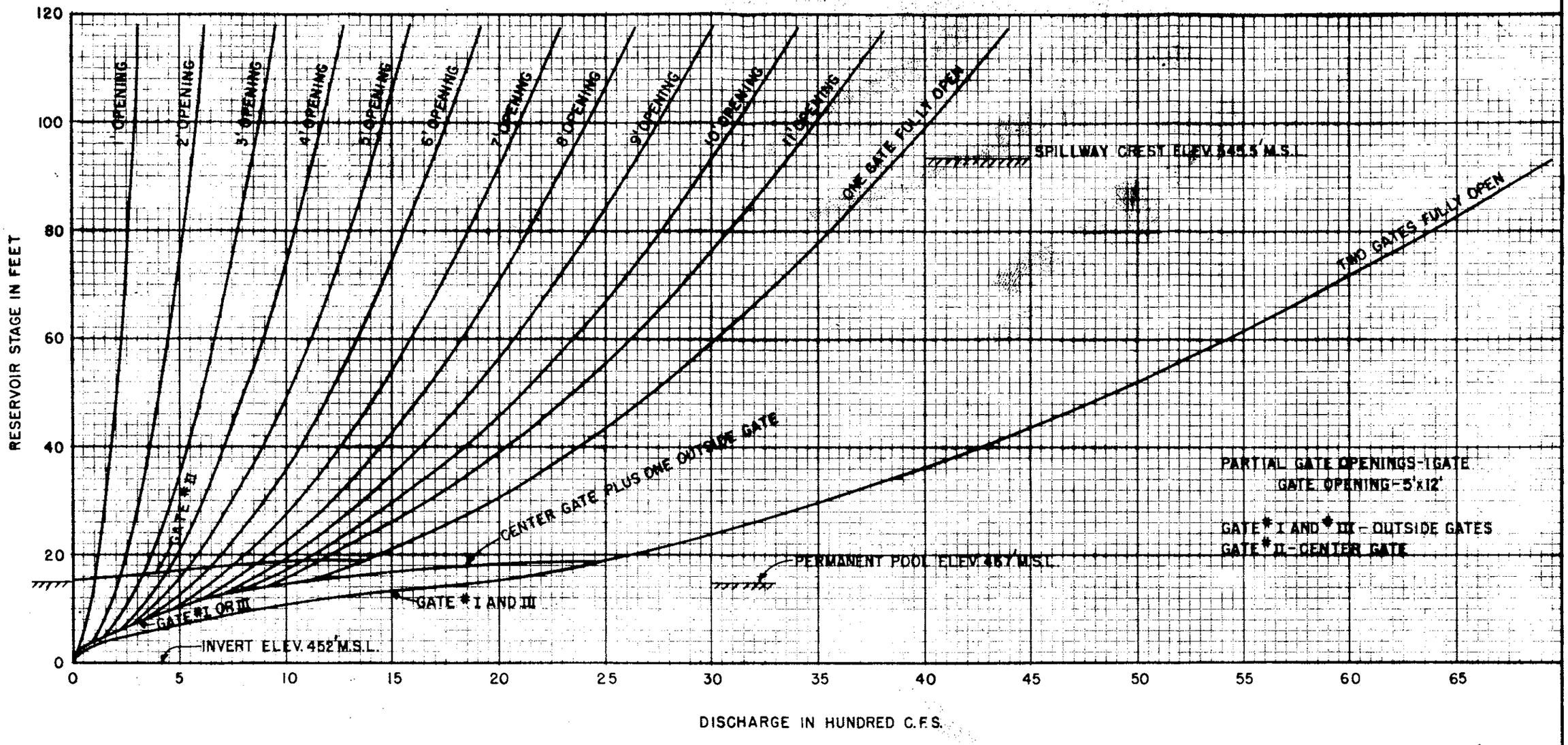
Elevation (msl)	Stage (ft)	Area (acres)	Capacity Ac/Ft	Capacity Inches	Recreation Season* Ac/Ft	Recreation Season* Inches
513	61	695	19,200	2.28	17,700	2.10
515	63	720	20,700	2.46	19,200	2.28
517	65	745	22,300	2.65	20,800	2.47
519	67	770	24,000	2.85	22,500	2.67
521	69	795	25,600	3.04	24,100	2.86
523	71	820	27,200	3.23	25,700	3.05
525	73	850	29,000	3.44	27,500	3.26
527	75	880	30,600	3.63	29,100	3.45
529	77	910	32,500	3.86	31,000	3.68
531	79	945	34,500	4.09	33,000	3.91
533	81	980	36,100	4.28	34,600	4.10
535	83	1,020	38,100	4.52	36,600	4.34
537	85	1,060	40,100	4.76	38,600	4.58
539	87	1,095	42,100	5.00	40,600	4.82
541	89	1,125	44,200	5.25	42,700	5.07
543	91	1,160	46,200	5.48	44,700	5.30
545.5	93.5	1,200	50,000	5.93	48,500	5.75
	Spillway Crest Elevation = 545.5					
547	95.0	1,220	51,200	6.08	49,700	5.90
549	97.0	1,250	54,000	6.41	52,500	6.23
551	99.0	1,280	57,000	6.77	55,500	6.59

D.A. = 158 SQ. MI.
R.O. = 5.9 INCHES



CONNECTICUT RIVER FLOOD CONTROL
NORTH SPRINGFIELD RESERVOIR
BLACK RIVER, VERMONT
PERCENT STORAGE CURVE
NEW ENGLAND DIVISION, WALTHAM, MASS
NOV. 1960

PLATE NO. C-I-7



CONNECTICUT RIVER FLOOD CONTROL

NORTH SPRINGFIELD DAM & RESERVOIR

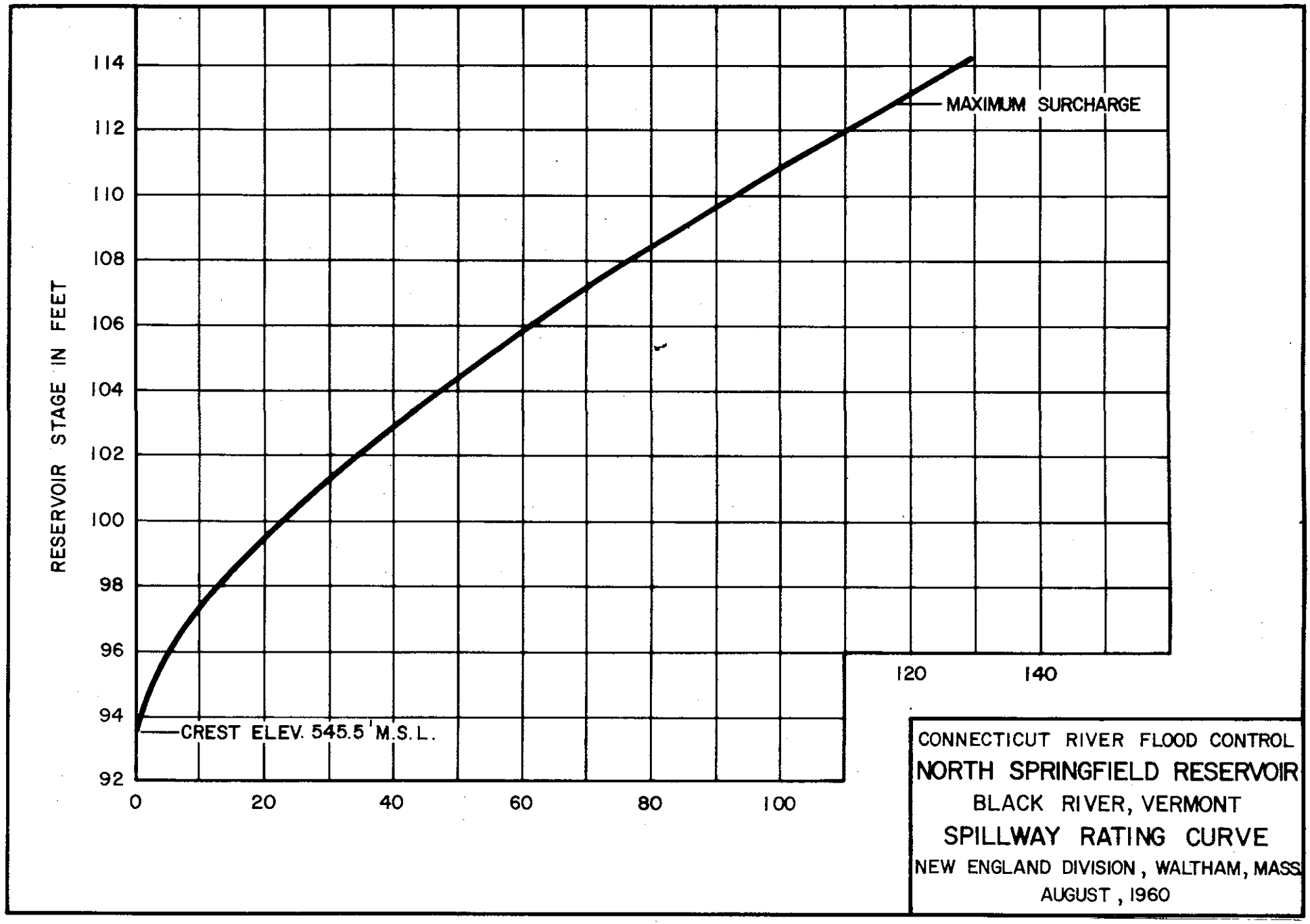
BLACK RIVER, VERMONT

OUTLET RATING CURVES

NEW ENGLAND DIVISION, WALTHAM, MASS.

JUNE 1967

PLATE NO. C-I-8



CONNECTICUT RIVER FLOOD CONTROL

NORTH SPRINGFIELD RESERVOIR

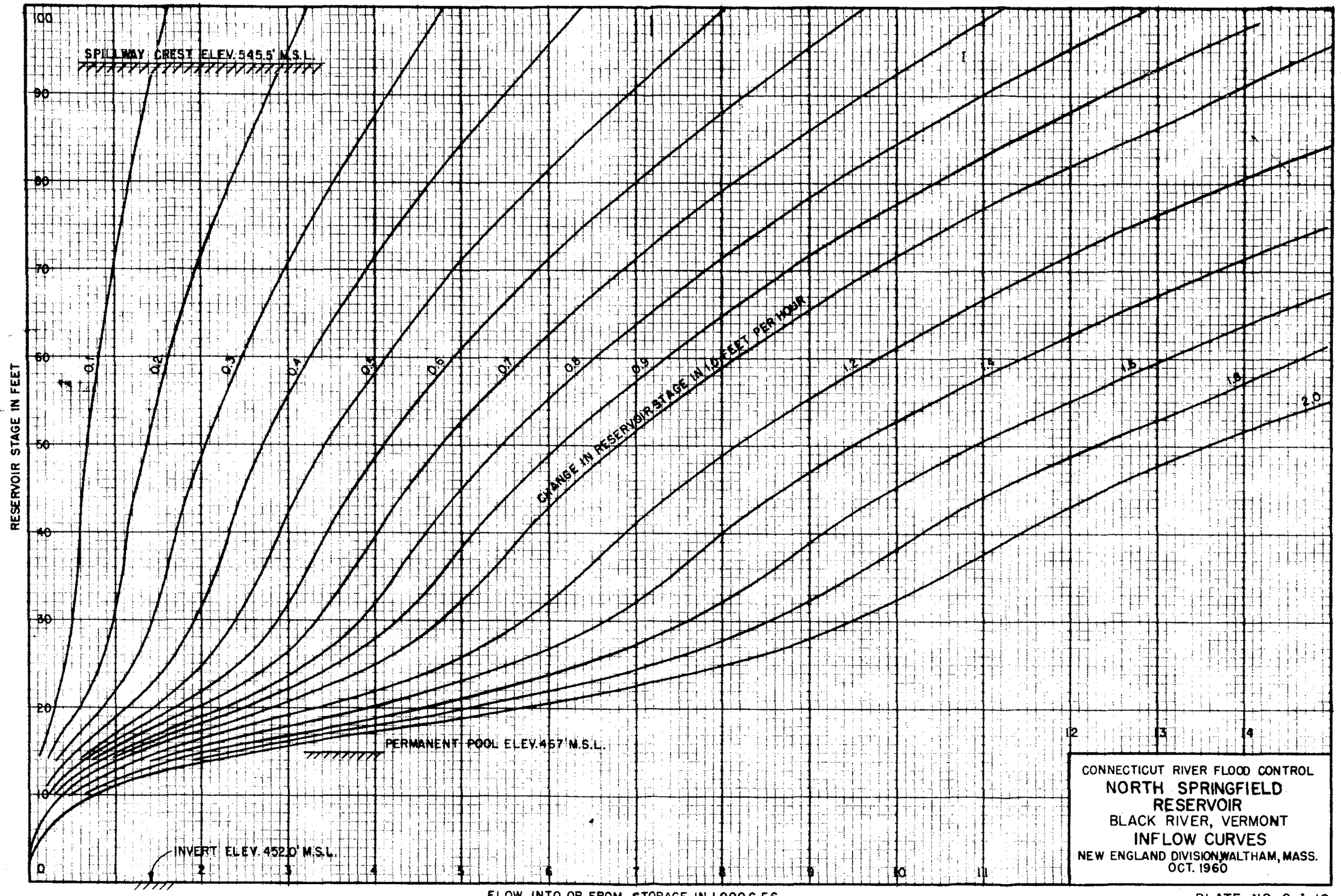
BLACK RIVER, VERMONT

SPILLWAY RATING CURVE

NEW ENGLAND DIVISION, WALTHAM, MASS.

AUGUST, 1960

PLATE NO. C-I-9



CONNECTICUT RIVER FLOOD CONTROL

NORTH SPRINGFIELD RESERVOIR

BLACK RIVER, VERMONT

INFLOW CURVES

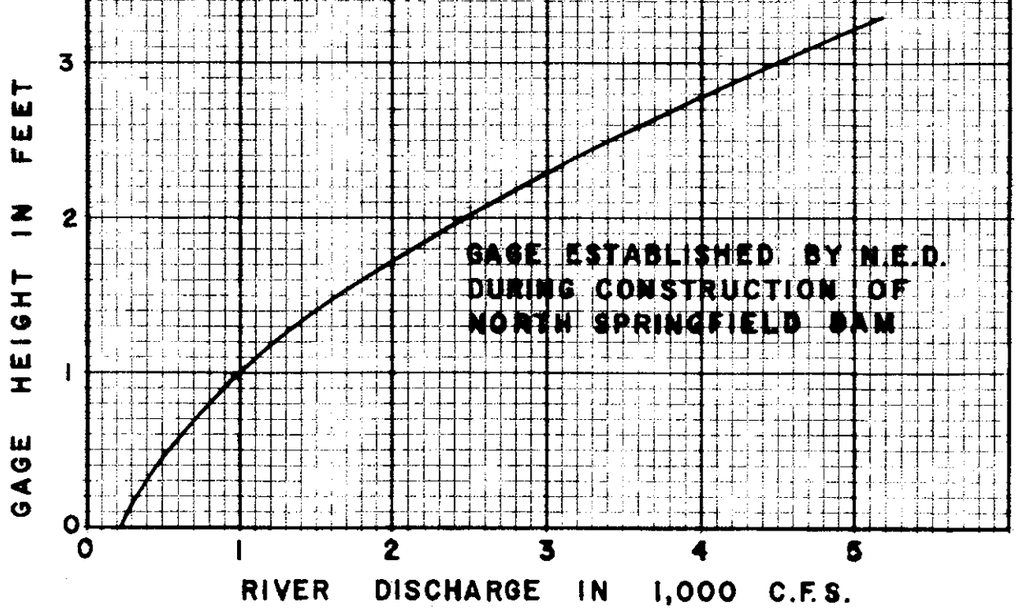
NEW ENGLAND DIVISION, WALTHAM, MASS.
OCT. 1960

PLATE NO. C-I-10

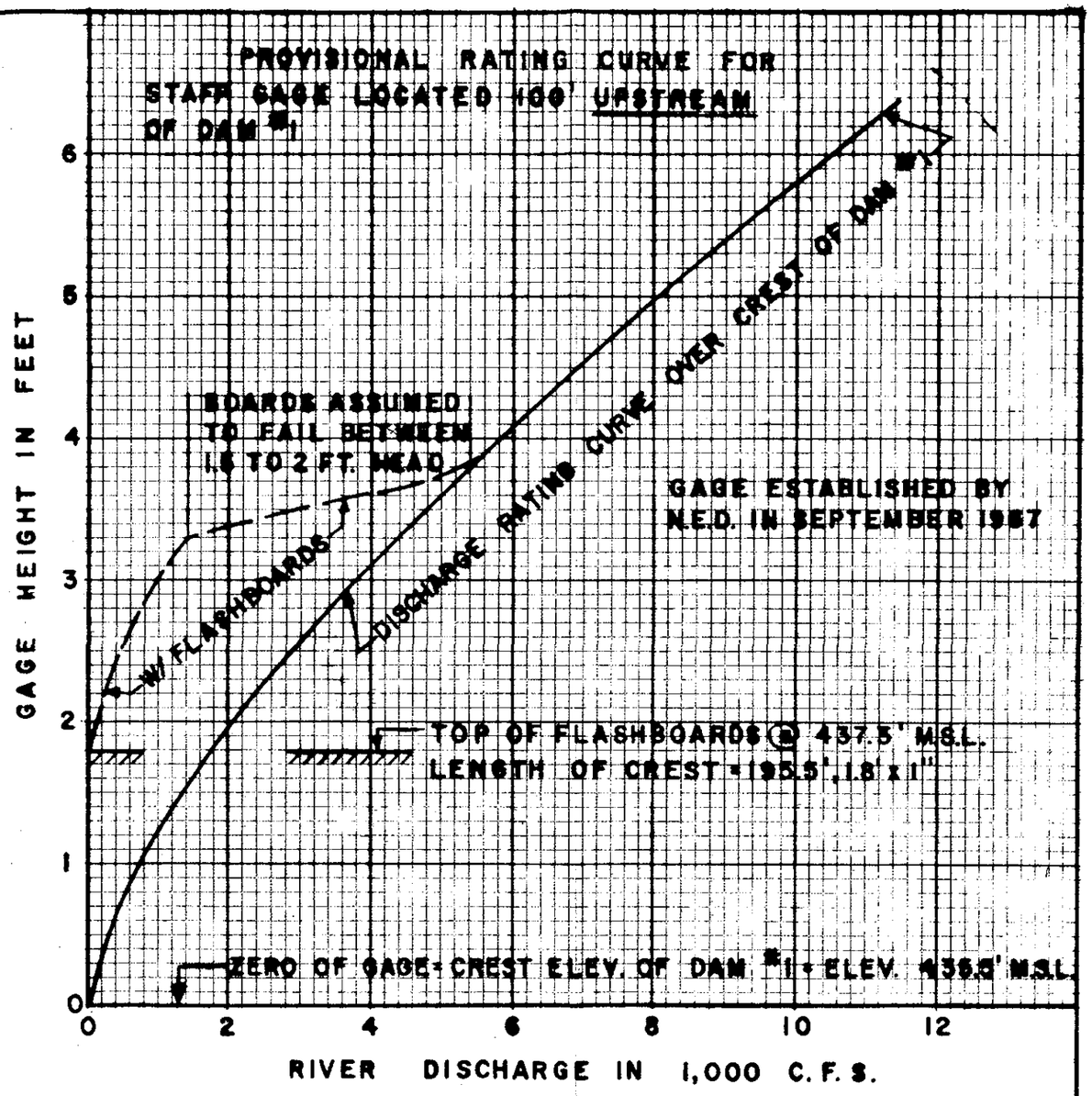
NOTES:

1. CHANNEL CAPACITY = 5000 CFS (EST.)
2. ONE HOUR TRAVEL TIME FROM NORTH SPRINGFIELD DAM TO GAGE

PROVISIONAL RATING CURVE FOR BLACK RIVER INDEX GAGE LOCATED ABOUT 1000 FEET DOWNSTREAM OF DAM #1



PROVISIONAL RATING CURVE FOR STAFF GAGE LOCATED 400' UPSTREAM OF DAM #1



CONNECTICUT RIVER FLOOD CONTROL
BLACK RIVER, VERMONT
NORTH SPRINGFIELD RESERVOIR

BLACK RIVER RATING CURVES
NEW ENGLAND DIV., WALTHAM, MASS.
DECEMBER 1967

PLATE NO. C-I-11

9-9 (Nov.)

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY (WATER RESOURCES DIVISION)

File No. Washington
Field

Rating table for Black River at North Springfield, Vt.
, from Oct. 1, 1961, to , 19 , from , 19 , to , 19

Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference
Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs
1.00			3.00	425	55	5.00	2070	90	7.00	4240	130	.00			.00			.00		
.10	4.0	2.4	.10	480	60	.10	2160		.10	4370		.10			.10			.10		
.20	6.4	3.3	.20	540	65	.20	2250		.20	4500		.20			.20			.20		
.30	9.7	4.3	.30	605	70	.30	2340	90	.30	4630	130	.30			.30			.30		
.40	14	6	.40	675	75	.40	2430	100	.40	4760	140	.40			.40			.40		
.50	20	8	.50	750	80	.50	2530		.50	4900		.50			.50			.50		
.60	28	9	.60	830		.60	2630	100	.60	5040	140	.60			.60			.60		
.70	37	11	.70	910	80	.70	2730	110	.70	5180		.70			.70			.70		
.80	48	14	.80	990	90	.80	2840		.80	5320		.80			.80			.80		
.90	62	17	.90	1080		.90	2950		.90			.90			.90			.90		
2.00	79	19	4.00	1170		6.00	3060		.00			.00			.00			.00		
.10	98	22	.10	1260		.10	3170		.10			.10			.10			.10		
.20	120	26	.20	1350		.20	3280	110	.20			.20			.20			.20		
.30	146	28	.30	1440		.30	3390	120	.30			.30			.30			.30		
.40	174	31	.40	1530		.40	3510		.40			.40			.40			.40		
.50	205	35	.50	1620		.50	3630		.50			.50			.50			.50		
.60	240	40	.60	1710		.60	3750		.60			.60			.60			.60		
.70	280	45	.70	1800		.70	3870		.70			.70			.70			.70		
.80	325	50	.80	1890		.80	3990	120	.80			.80			.80			.80		
.90	375	50	.90	1980	90	.90	4110	130	.90			.90			.90			.90		

This table is applicable for open-channel conditions. It is based on 20 discharge measurements made during 1958(294,295), 1960(311), 1961(326-329), 1962(320-339), 1963(343-345), and is well defined between 40 cfs and 3500 cfs, and is identical with rating 29 between 3.0 and 4.4 ft. Use hundredths throughout.

Comp by DFF date 2-19-
Ckd by RWB date 2-27-63
Table No. 30

GPO 863752

PLATE NO. C-1-12

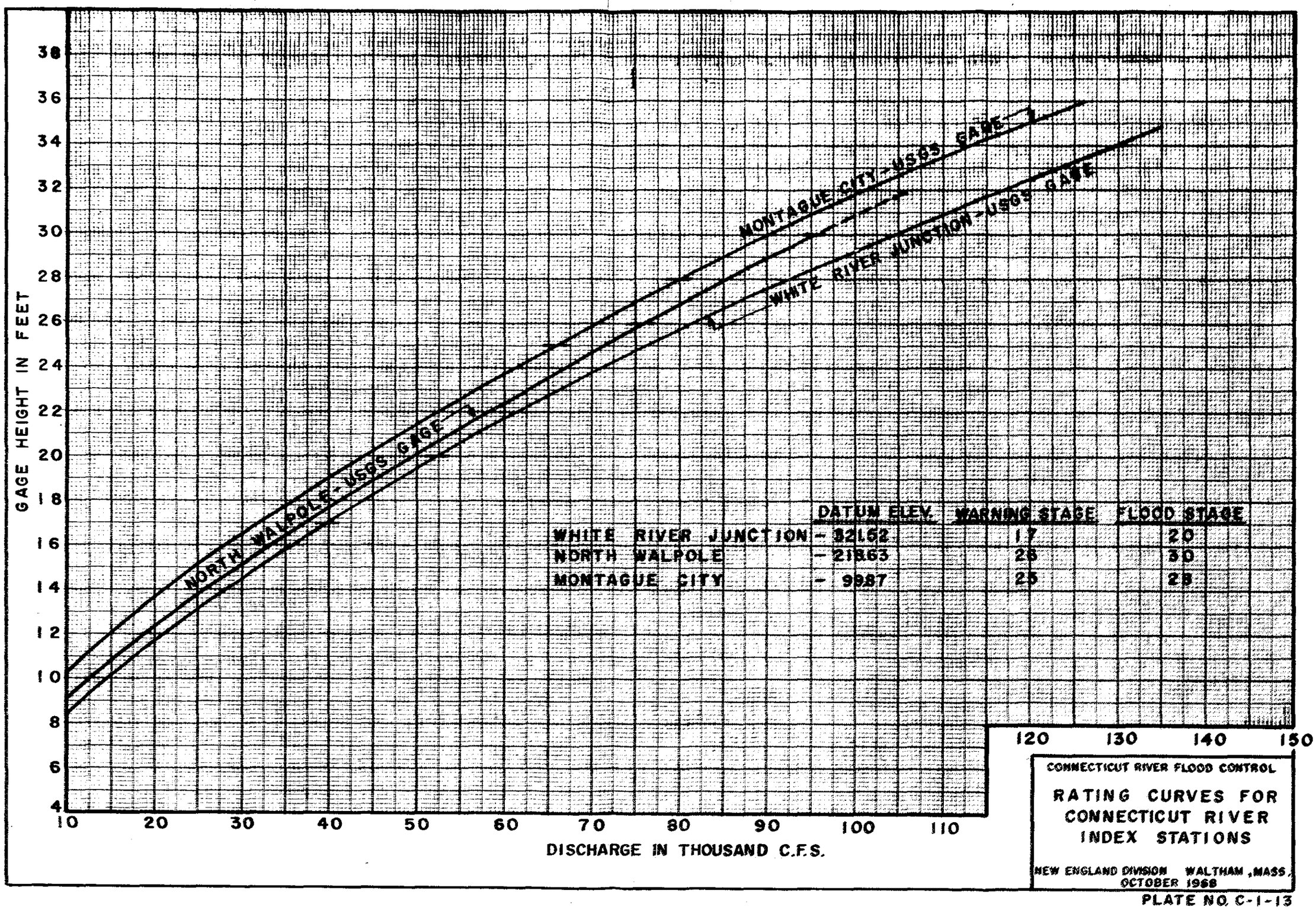


PLATE NO. C-1-13

1 of 2 sht

LOG OF RADIO REPORTS - FLOOD CONTROL DAMS

11 October 1968

Line	ITEM	SURRY MTN	OTTER BRK	MACDOWELL	FRANKLIN FALLS	BLACKWATER	HOPKINTON	EVERETT	BALL MT	TOWNSHEND	NORTH SPRINGFIELD	NORTH HARTLAND	UNION VILLAGE	Line
1	Time of Observation	0800	0800	0800	0800	0800	0800	0800	0800	0800	0800	0800	0800	1
2	Precipitation (last 24 hours)	0.02	0.04	0.01	0.05	0.04	0.02	0	0.03	0	T	0.04	0.05	2
3	Form of Precipitation	R	R	R	R	R	R	–	R	–	R	R	R	3
4	Present Weather	Cldy	Cldy	Cldy	Cldy	Cldy	Cldy	Cldy	Cldy	Cldy	Cldy	Cldy	Cldy	4
5	Pool Stage	8.7	18.79	913.83	306.4	516.5	380.48	340.84	68.68	21.56	15.38	19.79	2.4	5
6	Tendency	R	S		S	S	S	S	R	F	S	S	S	6
7	Gate Openings	0-2.5	0-4.5-0	0-1.0-0	ALL OPEN	ALL 4'	0-0-0-F-F	0-F-0	0-0-0	0-F-0	0-F-0	0-5-0	2'-2'	7
8	Tailwater Gage	5.48	5.96	2.46	2.4		1.75	5.02		3.88		2.21	3.10	8
9	Outflow	91	13	30		80	247	25	–	42	60	76	32	9
10	**INDEX POINTS**	465.4					out of Order	4.14	Small Amount of Leakage				1.02 (446)	10
11											6.09		2.07	11
12					-0.47		1.9 (310)							12
13					1.9									13
14					3.0									14
15					4.4									15
	REMARKS				SAMPLE									

NED FORM APR 61 477

SHEET C-I-1

REGULATION OF NORTH SPRINGFIELD RESERVOIRS

RCS NEDED-3

NED FORM APR 65 503

LOG OF REPORTS AND INSTRUCTIONS

DATE AND TIME OF REPORT	NORTH SPRINGFIELD RES.												RES.						PRECIPITATION				BLACK RIVER AT SPRINGFIELD			CONNECTICUT RIVER AT N. WALPOLE			RIVER AT					
	RES POOL		GATE OPENING								OUTFLOW		RES POOL		GATE OPENING			OUTFLOW																	
	HOUR	STAGE	1	2	3	4	5	6	7	8	T.W.	C.F.S.	HOUR	STAGE	1	2	3	T.W.	C.F.S.	LOCATION	HOUR	INCHES INC	INCHES ACC.	HOUR	STAGE	C.F.S	HOUR	STAGE	C.F.S	HOUR	STAGE	C.F.S	HOUR	STAGE	C.F.S
4/3/62	1130	33.39	5	7	5						5.6	2830												1130	2.7									
	GO TO		5	9	5			CALL			IN	AT	1400 HRS																					
	1400	32.96	5	9	5						6.0	3350												1400	2.8		1400	19.48	46360					
											REMAIN AS IS - CALL IN									AT 0815 TOMORROW														
4/4/62	0800	24.94	5	9	5						5.4	2590												0800	2.4		0800	17.5	38240				Temp = 36°-12°-22°		
	GO To		5	F	5			CALL			IN	AT	1530 HRS																					
	1500	20.85	5	F	5						5.3	2470												1500	2.4		1500	16.9	35900				Temp = 42°		
											REMAIN AS IS - CALL IN									AT 0815 TOMORROW														
4/5/62	0800	15.39	5	F	5						3.9	1080												0800	1.5		0800	15.33	29650				Temp = 44°-18°-28°		
											REMAIN AS IS - CALL IN TOMORROW MORNING																							

SAMPLE

SHEET C-I-2

GATE OPERATION RECORD

N. SPRINGFIELD RESERVOIR APRIL MONTH 61 YEAR

DATE	HOUR	RES. STAGE Feet	GATE OPENING IN FEET*								OUTFLOW C.F.S.		REMARKS
			#1	#2	#3	#4	#5	#6	#7	#8	BEFORE	AFTER	
3/4	1200	37.19	0	4	0						690		
3/4	1200	37.19	0	2	0							345	
4/4	0920	49.80	0	3	0						410	610	
4/4	1000	50.08	0	4	0						610	810	
4/4	1545	51.18	0	6	0						825	1230	
5/4	0945	51.77	1	6	1						1235	1650	
6/4	0900	49.95	2	6	2						1620	2040	
8/4	0900	42.45	3	6	3						1810	2230	
10/4	0840	32.20	0	F	0						1910	2050	
10/4	1600	31.69	0	10	0						2040	1515	
11/4	0845	32.55	0	F	0						1610	2100	

SAMPLE

*Indicate full opened gate by "F"

SIGNED _____
OPERATOR

DATE _____

NED FORM 90 MAR 62 REPLACES EDITION OF FEB 60 WHICH IS OBSOLETE

SHEET C-I-3

A T T A C H M E N T I I

MAINTENANCE OF HYDROLOGIC EQUIPMENT

TABLE OF CONTENTS

ATTACHMENT II
MAINTENANCE OF HYDROLOGIC EQUIPMENT

1. PRECIPITATION GAGE

A standard USWB weighing and recording type precipitation gage, installed at North Springfield dam, serves as a supplement to the USWB rainfall stations at Cavendish and Tyson.

2. RESERVOIR STAGE RECORDER

The float-operated automatic water level recorder at North Springfield traces water level in the reservoir at all times. Each morning the instrument should be checked to assure that the clock is keeping correct time and the pen tracing properly. Any discrepancies in the record as evidenced by pen time or gage height should be noted on the chart and the instrument reset. During periods of reservoir storage, the outside tile or staff gage should be read to check tape readings and chart records. Should the recorder become inoperable, RRS should be notified and arrangements will be made to have the instrument back in operation.

The chart record should be changed the first working day of each month and the following information noted in ink at the beginning and end of each chart:

Outside (tile) gage reading
Pen gage height reading
Watch time
Pen time
Date and name of dam

New charts for monthly recorders should be obtained from the NED warehouse.

3. TAILWATER GAGING STATION

A USGS gaging station, located downstream on the Black River at North Springfield, provides a continuous official record of discharges from the dam. It is equipped with a digital-type water stage recorder and operated and maintained under the cooperative stream gaging program.

4. TELEPHONE TRANSMITTER (TELEMARK)

Telephone transmitters (telemarks) are in operation on the Connecticut River at White River Junction, Vermont; North Walpole, New Hampshire and Montague City, Massachusetts to obtain instantaneous river stages which aid in regulating releases from the dam. The gage at North

Walpole is the primary index on the Connecticut for determining flood releases from North Springfield.

If the telemark becomes inoperative the dam operator should visit the gage to ascertain the source of difficulty. The telephone company should be requested to check out their system in the presence of the damtender. RRS should be notified if the telemark remains inoperative, whereby personnel from the Corps or USGS will inspect the gaging station.

Batteries for the Stevens telemark at North Walpole, New Hampshire will be furnished and installed by the head operator.

In addition to the index stations on the Connecticut River, a staff gage is located on the left bank of the Black River at the bridge entrance to Fellows Gear Shaper Company in Springfield, Vermont. Arrangements have been made with the firm whereby river stages can be obtained 24 hours a day by contacting plant personnel.

5. SNOW SAMPLING SET

A snow sampling set has been assigned to the head operator. Procedures for obtaining snow survey data should follow instructions set forth in Snow Sampling Guide, Department of Agriculture Handbook 169. The only maintenance required would be occasional replacement of worn-out cutterheads if proper care is administered.