CELRH-EC-WM

05 Jan 2010
Schray/5604

Memorandum for Resource Managers and Water Control Manual holders

Subject: Modification of Huntington District Water Control Reporting Procedures.

1. Reference CELRH-EC-WM Memorandum to Kent Browning, dated 20 January 2004, Subject: Modification of Huntington District Water Control Reporting Procedures.

2. The referenced memorandum modifies certain reporting procedures. Since that memorandum was issued, improvements in technology have resulted in the National Weather Service providing detailed snow analyses data in graphical maps via the internet. This data satisfies Water Managements needs, and therefore an additional modification is necessary.

3. Modify Instructions to Dam Tender, Section 2 – Precipitation at Project, sub-section: Snow Depth and Moisture Content:

Replace the section in its entirety with the following:

"Report snow data to Water Management only when directed to do so. Measure and record the water content of the snow at least as often as indicated below.

(1) Each day when rain falls on existing snow cover

(2) Twice a week on Mondays and Thursdays when there is snow cover on the ground if condition (1) does not require more frequent measurement.

4. This change in reporting instructions does not modify the Project's requirement to store this data on site.

5. This memorandum shall be placed in the front of the Water Control Manual to document the change.

Timothy W. Curran, P.E.
Chief, Water Management Section

CELRH-EC-WM

11 June 2007
Schray/5604

Memorandum for Resource Managers and Water Control Manual holders

Subject: Modification of Huntington District Water Control Reporting Procedures.

1. Reference CELRH-EC-WM Memorandum to Kent Browning, dated 20 January 2004, Subject: Modification of Huntington District Water Control Reporting Procedures.

2. The referenced memorandum modifies certain reporting procedures, and this memorandum makes an additional change. Some Water Control Manuals have been revised with the new procedures the "Instructions to Resource Manager" or "Instructions to Dam Tender" section. Manuals that have not been revised should have the referenced memorandum placed in the front of the manual. Make handwritten changes to the memorandum or the Water Control Manual, as appropriate. This memorandum shall be placed in the front of the Water Control Manual to document the change.

3. Modify Instructions to Dam Tender, Section 4 – Regular Reports, sub-section: Weekly Precipitation Report, second and third sentences:

Replace the text "This report must be filled out and transmitted every Monday morning by 0800 hours. If Monday is a holiday, it shall be filled out on the next work day by 0800 hrs." with "This report is no longer required to be completed on a weekly basis. It shall only be filled out and submitted if required by special directive."

Timothy W. Curran, P.E.
Chief, Water Management Section

3/16/04
clk

CELRH-EC-WM

20 January 2004
Schray/5604

Memorandum for Kent Browning, OR Water Management POC.

Subject: Modification of Huntington District Water Control Reporting Procedures.

1. Please distribute this memorandum to all Huntington District Flood Control Project Managers, direct them to place this memorandum in the front of the Water Control Manual, and make notes in the text which has been superseded.

2. As directed by the QC, EC-WM is implementing the recommendations of the Reservoir Reporting Process Action Team. As such, the following changes shall be made to the water control manuals and the associated processes:

The following sections are modified as noted.

<u>Instructions to Dam Tender, Section 2 - Precipitation at Project, sub-section: Snow Depth and Moisture Content</u>

Measure and report to EC-WM by 0900 hours the water content of the snow at least as often as indicated below.
(1) Each day when rain falls on existing snow cover
(2) Twice a week, on Mondays and Thursdays, when there is snow cover on the ground if condition (1) does not require more frequent measurements.

<u>Instructions to Dam Tender, Section 2 - Precipitation at Ohio River Network Stations</u>

Reports to the National Weather Service are carried out by agreement between the Project and the Weather Service and at their direction. The project is not required to gather or submit any additional data to Water Management beyond what is described previously in section 2 and what is detailed in section 4.

Sub-Sections a, b, and c are therefore no longer relevant except as to describe how to gather and provide data to the National Weather Service.

<u>Instructions to Dam Tender, Section 4 - Regular Reports, sub-section: Weekly Report, ORH 14</u>

This section is rescinded in its entirety and is replaced by <u>sub-section: Historical Files</u>.

Projects are required to maintain a permanent hard copy at the project of all water control data required for daily operation. This data shall be comprised of the information the project has historically gathered using the ORH 14 and 13 reports and shall be gathered at 0730 on days when the project is staffed, at other times as directed by the Schedule for Reading Gages and the Project Manager and when data is requested by Water Management Section. It shall include but not be limited to: Precipitation, Current Weather conditions, Lake Stage Levels, Outflow Stage Levels, Gate Settings, Gate Operations and time performed, Snowfall, Snow on the Ground, Total Moisture Content as directed in Section 2, and all Upstream and Downstream gauge readings which are utilized by project personnel for gate operation decision making.

This information may be maintained either on the historical reports or a new project developed format.

<u>Instructions to Dam Tender, Section 4 - Regular Reports, sub-section: Daily Morning Report</u>

This sub-section is modified to note that: Generation and transmission of the daily morning report (also call the intranet report which replaced the ORH-13 Daily report) is only required when requested by the Water Management Section. Automatic daily transmissions are no longer necessary.

Note: Atwood, Bolivar, Clendening, Piedmont, Tappan, and Tom Jenkins are still required to report all gate operations to EC-WM by phone. Extra emphasis will be placed on these phone calls as Water Management will no longer be able to look up the previous day's gate operations every morning.

<u>Instructions to Dam Tender, Section 4 - Regular Reports, sub-section: Gate Operations Report</u>

This sub-section is modified to note that: Generation and transmission of the gate operations report is only required when requested by the Water Management Section. Neither daily transmissions nor transmissions after every gate operation are necessary any longer.

<u>Instructions to Dam Tender, Section 4 - Regular Reports, sub-section: Weekly Precipitation Report</u>

This sub-section shall be added after the Water Quality Report sub-section.

A fourth report available from the Index Page is the Weekly Precipitation Report. This report must be filled out and transmitted every Monday morning by 0800 hours. If Monday is a holiday, it shall be filled out on the next work day by

0800 hours.

Upon accessing the Weekly Precip Report link on the Index Page, fill in the daily precipitation for the past week. When all data for the week is filled in, save the spread sheet and exit. This record will be saved for the entire year and can be viewed through the link used to modify it.

On days when the project is not staffed, place a "NS" in that day's field and report the combined day's precipitation in the next day when the project is staffed. I.e. If the project does not staff the weekend, place a "NS" in the field for Saturday and Sunday and report the 72 hour precipitation record on Monday morning.

Instructions to Dam Tender, Section 4 - Regular Reports, sub-section: Additional Comments

This sub-section shall be added after the Weekly Precipitation Report sub-section.

A fifth link available on the Index Page is the Additional Comments link. It shall be used when ever the Project has special information or questions that it wants to bring to the immediate attention of the Water Management team. Snow Moisture shall be reported using this link.

Upon accessing the Additional Comments link on the Index page, a blank email to the Water Management Team will be generated. Please note in the subject line, the nature of the issue and then provide supplemental data in the text block of the message. After the email has been completed click on the submit/send button to send the message.

Instructions to Dam Tender, Schedule for Reading Gages

The last sentence of the top paragraph "Stream gages and the precipitation gage (all gages) shall be read at least as often as shown in the table below", shall be replaced with: "Reading and recording of gages shall be carried out as defined under Schedule A except when gage levels/precipitation are such that the Resource Manager or their Acting anticipates that problems may result, at which point the relevant schedule B, C, or D shall be followed for reading and recording of all required gages. Transmission of project gage data will be at the request of EC-WM.

Modify the chart as follows:

SL, SO, and DCO shall be read in all schedules monthly as a check

Modify the footnotes as follows:

(1) When any one of the conditions listed under schedule A, B, C is exceeded and problems are anticipated, place the next higher schedule into effect. When conditions are such that would place schedules C or D into effect, notify by phone one of the Water Control personnel.

Timothy W. Curran, P.E.
Chief, Water Management Section

CF:EC-WH

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
502 EIGHTH STREET
HUNTINGTON, WEST VIRGINIA 25701-2070

16 January 2003

REPLY TO
ATTENTION OF:

Engineering & Construction Division
Water Resources Engineering Branch

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Updates for the Sutton Lake Water Control Manual

1. EC-WW has identified outdated information in the referenced Water Control Manual.

2. Please replace the following pages with the attached pages: Plate No. 7-8 (Plate Section), 1-2, 1-3 and Plate No. 4-3 (Exhibit B, Instructions to Damtender).

3. Any questions should be directed to Mr. Charles Brown at [redacted].

4. Place this page in the front of the manual.

Encl

ALFRED L. BRANCH, JR., P.E.
Chief, Engineering & Construction Division

CELRD-ET-W (2)
CELRH-OR
CELRH-OR-SUT (2)
CELRH-OR-KAO
CELRH-EC-WW (2)
CELRH-WH

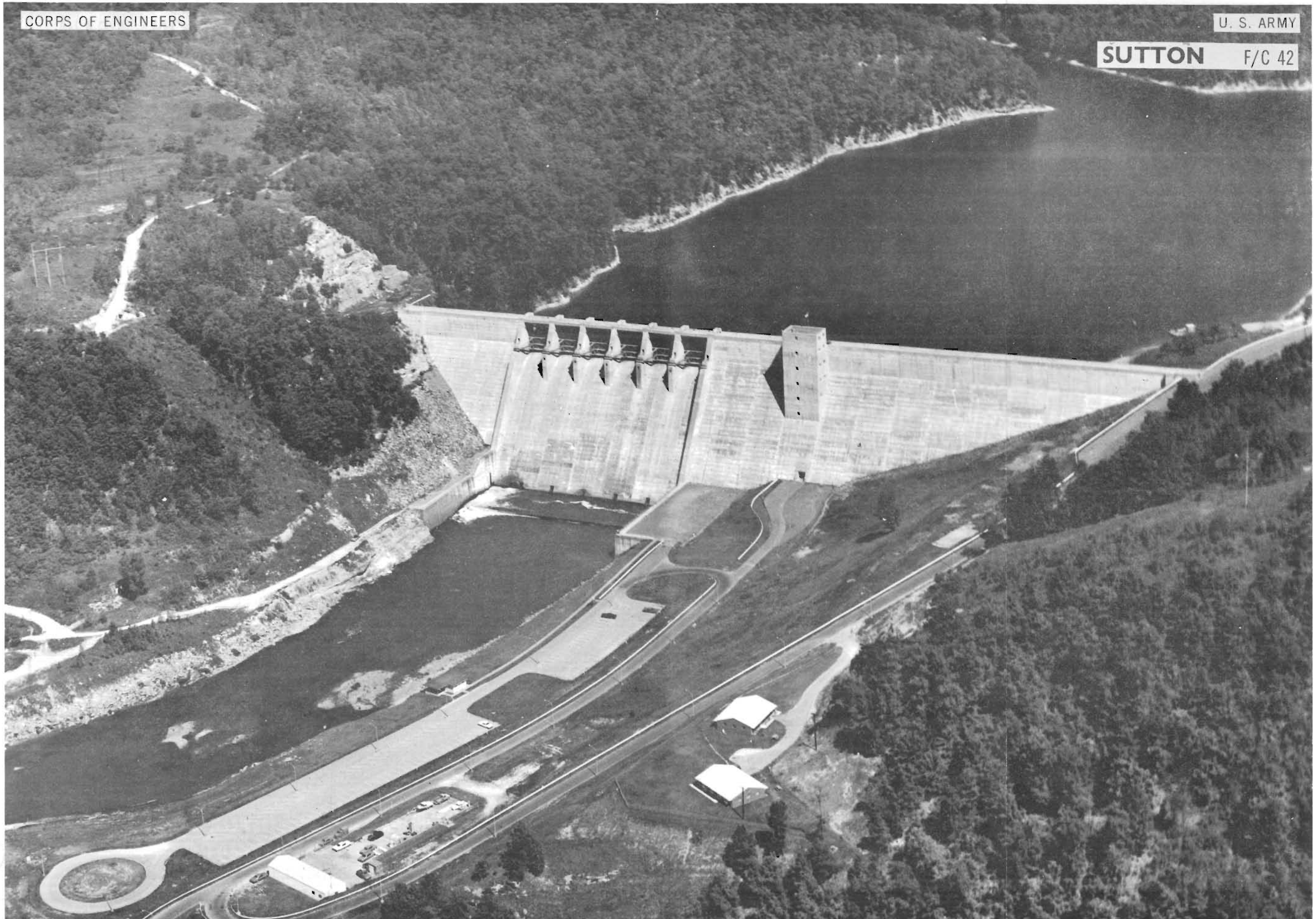
WATER CONTROL MANUAL

SUTTON LAKE - ELK RIVER

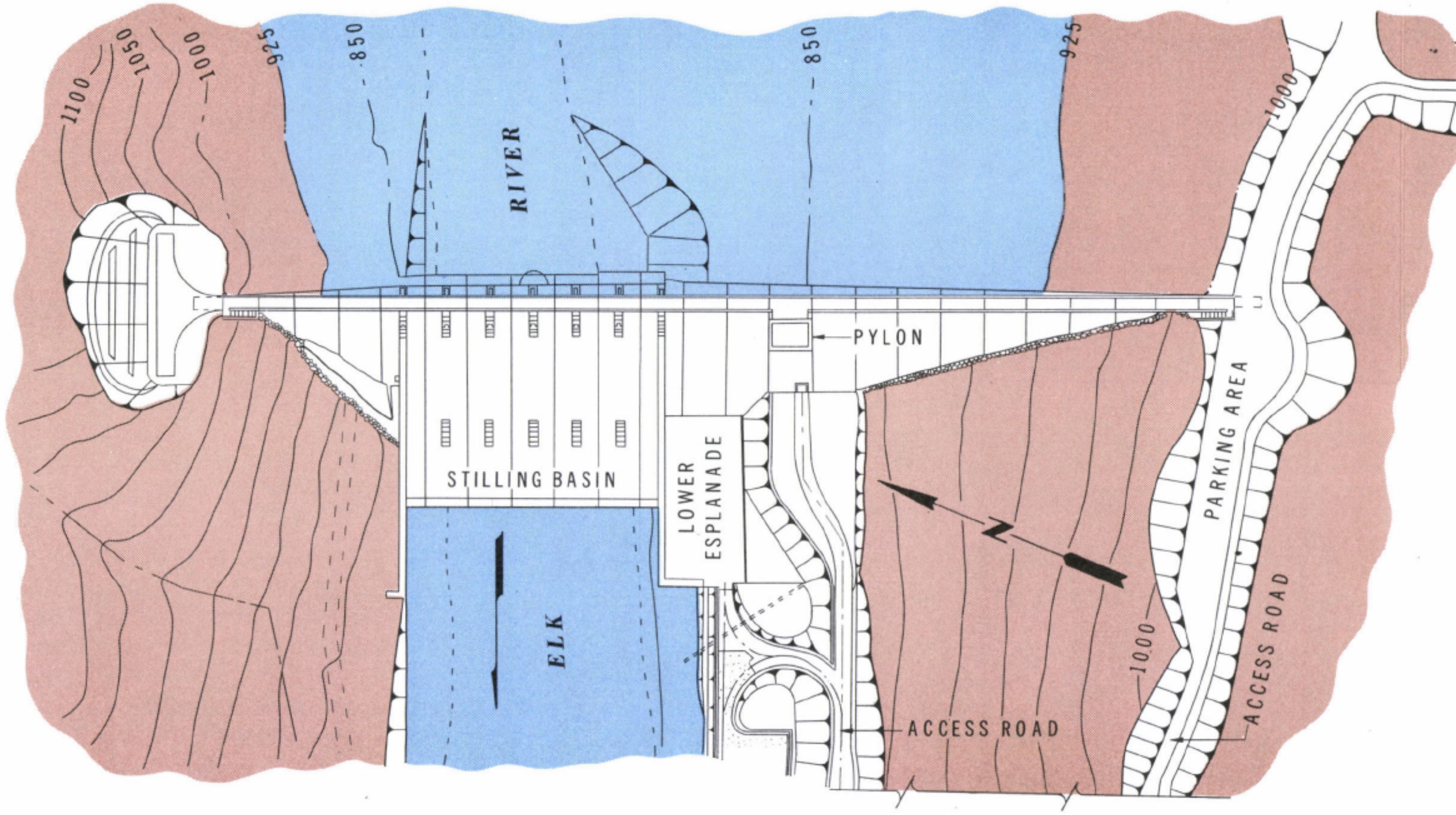
Kanawha River Basin
West Virginia

U.S. ARMY CORPS OF ENGINEERS
HUNTINGTON DISTRICT
HUNTINGTON, WEST VIRGINIA

FERRUARY 1998


CORPS OF ENGINEERS
U. S. ARMY
SUTTON F/C 42

SUTTON F/C 42-A



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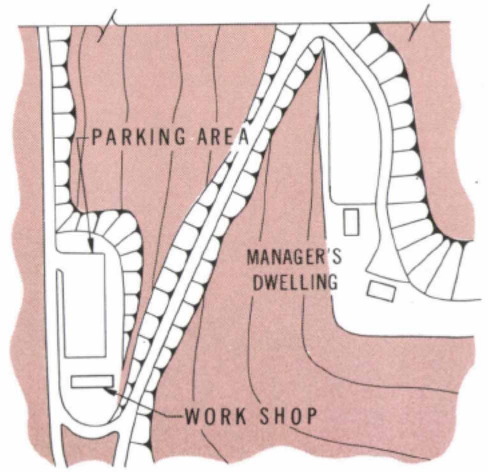
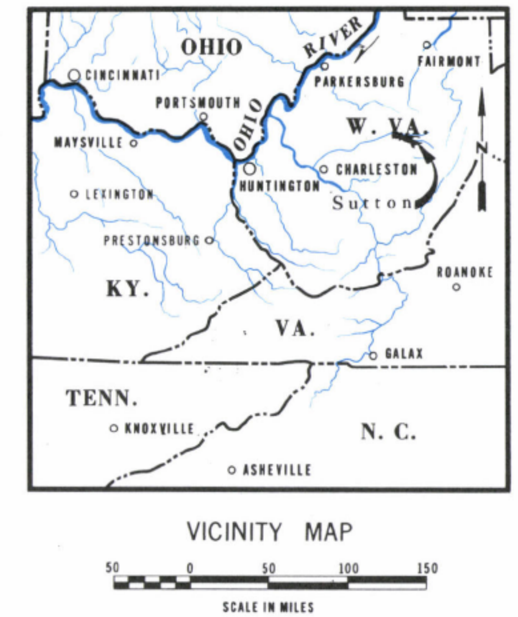




VICINITY MAP

[redacted]

ELK RIVER

SUTTON LAKE

DAM

PLAN, ELEVATION AND SECTION

HUNTINGTON DISTRICT, HUNTINGTON, W. VA.

Revised: 30 SEPTEMBER 1986

NOTICE TO USERS OF THIS MANUAL

Regulations specify that this Water Control Manual be published in a hard copy binder with looseleaf form, and only those sections, or parts thereof, requiring changes will be revised and printed. Therefore, this copy should be current. Changes to individual pages must carry the date of revision, which is the Division's date.

REGULATION ASSISTANCE PROCEDURES

In the event that unusual conditions arise during nonduty hours, communications can be achieved by contacting, in the order listed, one of the following personnel (provide telephone listing).

CORPS OF ENGINEERS

Water Resources Engineering Branch Personnel	Home Telephone Number
[redacted] Chief, Water Control Section	[redacted] unlisted number
[redacted] Water Control Section	[redacted]
[redacted] Water Control Section	[redacted]
[redacted] Chief, Water Resources Engineering Branch	[redacted]

Pertinent telephone numbers which may be of value during flood emergency are listed below:

Huntington District Office, Water Resources Engineering Branch

Normal Work Hours 0700 to 1600 hrs		[redacted]
Nights, Weekend, and Holidays	Additional Extensions	[redacted]

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

VIII. EFFECT OF WATER CONTROL PLAN

IX WATER CONTROL MANAGEMENT

LIST OF TABLES

PLATES

PLATES (Cont'd)

Chapter VIII

Chapter IX

SUTTON LAKE
ELK RIVER

PERTINENT DATA

LOCATION OF DAM: The Dam is located in Braxton County, West Virginia, on the Elk River, a tributary of the Kanawha River, approximately 100.4 miles above the mouth of the Elk River, and 158.9 miles above the mouth of the Kanawha River.

DRAINAGE AREA ABOVE THE DAM: 537 square miles

DAM: TYPE - Concrete gravity, maximum height 210', top length 1,178', top width 20', maximum base width 195'.

SPILLWAY: Gated spillway in channel section of dam with bucket of 50' radius, crest elevation 972, overall length 280', 6 tainter gates 40' long by 31' high supported by 8-foot wide piers. Design discharge 222,240 cfs with surcharge of 38.3' and freeboard of 6.7'.

SEASONAL STORAGE: (Summer)	Surface Elev	Surface Area
Recreation/Low Flow	922 ft	1440 ac
Augmentation	895 ft	870 ac
YEAR ROUND STORAGE: (Winter)		
Augmentation	895 ft	870 ac
Minimum	850 ft	270 ac
FLOOD CONTROL-STORAGE*		
Winter	1000 ft	3875 ac
Summer	1000 ft	3875 ac

*At maximum pool level.

KANAWHA RIVER BASIN
WEST VIRGINIA

PROJECT MANUAL
FOR
WATER CONTROL MANAGEMENT
SUTTON LAKE - ELK RIVER

SECTION 1 - INTRODUCTION

1-01 PROJECT AUTHORIZATION.

The Sutton Lake Project was constructed for flood control, recreation, and fish and wildlife enhancement by authority of an Executive Order of the President on 12 September 1935, and the Flood Control Acts of 22 June 1936 and 28 June 1938.

1-02 PURPOSE AND SCOPE OF WATER CONTROL MANUAL.

This manual is prepared in accordance with ER 1110-2-240, dated 8 October 1982 and ETL 1110-2-251, dated 14 March 1980, which provide for the submission of manuals for reservoir regulation in accordance with instructions contained in "Guide for Preparing Water Control Manuals", as prepared by SWD, dated October 1977 and ER 1110-2-8156 "Preparation of Water Control Manuals" dated 31 August 1995.

The purpose of this manual is to furnish the general plan for the regulation of Sutton Lake in the Kanawha River Basin. The manual serves as documentation of this plan for water control and as a reference source for personnel responsible for water control management throughout the life of the project. The manual also contains background information pertaining to water management schedules, as well as results of optimal simulation of project operation for specific purposes and conditions.

1-03 RELATED MANUALS AND REPORTS.

The following manuals and reports concerning Sutton Lake or the Kanawha River projects have been previously completed.

	TITLE	DATE
1.	Preliminary Report on Summersville and Sutton Reservoir Projects	July 1945
2.	Description and Hydrologic History, Sutton and Summersville Reservoir Projects, Elk and Gauley Basins	January 1946
3.	Definite Project Report on Sutton Reservoir, Elk River, West Virginia	March 1948

4. Necessity for Highway Relocations — May 1953

5. Design Memorandums:

No. 1, Concrete Aggregate	August 1956
No. 2, Necessity for Utility Relocation of the Chesapeake and Potomac Telephone Company of West Virginia	March 1956
No. 3, Plan for Cemetery Relocations, Part I	June 1957
No. 4, Necessity for Relocation of the Monongahela Power Company's Facilities, Construction Area	October 1956
No. 5, Real Estate Purchase of Lands in Lieu of Relocation of Secondary State Road 15/1	November 1956
No. 6, Seasonal Storage	November 1956
No. 7, Necessity for Relocation and Abandonment of the Hope Natural Gas Company's Facilities, Construction Area	November 1956
No. 8, Necessity for Relocation of the Monongahela Power Company's Facilities, Upper Reaches of Sutton Reservoir Project	April 1957
No. 9, Necessity for Relocation of Telephone and Telegraph Facilities Owned by the Western Union Telegraph Company	July 1957
No. 10, Necessity for Highway Relocations, Supplemental Report	February 1958
No. 11, Reservoir Clearing	September 1958
No. 12, Radio Transmitter and Receiving Facilities (Real Estate)	August 1959
No. 13, Master Land Use Plan	January 1959

6. Periodic Inspection, Sutton Lake Dam

Report No. 1	October 1972
Report No. 2	May 1976
Report No. 3	November 1979
Report No. 4	August 1985

7. Kanawha River Comprehensive Basin Study — June 1971

8. Sutton Lake, West Virginia - Project Rehabilitation Study — November 1978

9. Environmental Assessment - Sutton Lake, Elk River, Braxton and Webster Counties — July 1979

10. Utilization Survey Report — 1983

11. Dam Failure Study Report - Sutton Lake — July 1984

12. Dam Safety Training Program for Operations and Maintenance Personnel — 1984

13. Master Plan Update — August 1984

1-04 PROJECT AND SYSTEM OWNER

The United States government gained full title, ownership, and fee control of all three Kanawha basin projects including Sutton Lake project land and all reservoirs sites before the reservoirs were built. The United States Government reimbursed the original property owners for all the surrounding land and now owns the three dams and operating structures.

1-05 OPERATING AND REGULATING RESPONSIBILITY.

The Huntington District Water Resources Engineering Branch has various responsibilities as specified in Ohio River Division Regulation 1110-2-27, dated 12 January 1976. These responsibilities include the primary overall water control management of all District projects, technical evaluations of performance of these projects, and developing plans and manuals for the reservoir systems within the District, such as Sutton Lake. The locations of the reservoir systems within the District are shown on Plate 1-1.

Guidelines for routine operations under normal conditions are specified in the standard operation instructions. Special Directives to provide operating instructions for flood regulation, low flow control, or other situations are issued and signed by the Chief of the Water Resources Engineering Branch. Operations which deviate from the approved water control plan as presented in this manual are coordinated with the Ohio River Water Management Branch.

The operating and regulating responsibility is exercised under the following regulations:

(1) EM 1110-2-3600, 30 November 1987, Subject: Management of Water Control Systems.

(2) ER 1110-2-1400, DAEN-CWE-Y, 24 April 1970, Subject: Reservoir Control Centers.

(3) ER 1110-2-240, DAEN-CWE-Y, 8 October 1982, Subject: Reservoir Control Centers.

(4) ORDR 1110-2-27, 12 January 1976, Subject: Water Control Management Activities.

(5) ER 1130-2-415, DAEN-CWE-Y, 28 October 1976, Subject: Water Quality Data Collection, Interpretation and Application Activities.

(6) ORDR 1110-2-26, 5 February 1979, ORDED-W, Subject: Water Quality Investigations and Control Activities.

(7) ER 1110-2-208, DAEN-CWE-Y, 30 July 1979, Subject: Water Control Management.

SECTION II - DESCRIPTION OF PROJECT

2-01 LOCATION.

The Sutton Lake dam is located in Braxton County, West Virginia on Elk River, a tributary of the Kanawha River, about 1 mile above the town of Sutton, 100.4 miles above the mouth of the Elk River and 158.9 miles above the mouth of the Kanawha River. The dam and lake surface is essentially in Braxton County, with very small tips of the lake extending into Webster Counties in West Virginia.

2-02 PROJECT PURPOSES.

a. General. Sutton Lake is authorized for flood control, recreation, pollution abatement, whitewater activities and fish and wildlife enhancement in a comprehensive plan for the Kanawha and Ohio River Basins. Benefits from flood control and water conservation serve not only local interests in the Elk River Basin, but also the overall Kanawha and Ohio River Basins.

b. Flood Control. Prior to the construction of Sutton Lake and the other Kanawha River Basin projects, flooding was due primarily to the inadequate capacity of the stream channels and the extent of development in the overbank areas. Flood losses were experienced in cities and towns along the streams, in areas of flood plain development, and in agricultural areas.

Major flooding in the basin can occur at any time of the year. Summer rains are often generated by thunderstorm activity, which typically occurs over small areas and produces high intensity rainfalls over a short period of time. Precipitation from late fall to early spring is generally associated with the passage of a low pressure system over the basin. If these systems become stationary or move very slowly, prolonged precipitation is possible. These types of systems can produce flooding conditions over large areas. The principal flood control benefits of Sutton Lake and the other Kanawha Basin flood control projects are general benefits to agricultural areas and urban communities downstream of the dams within the Elk and Kanawha River Basins.

The Flood Control Act of 1938 authorized a study for an alternate reservoir site in the Elk River Basin as a substitute for the Clendenin Reservoir. The investigations resulted in the selection of the Sutton site. The dam was designed to provide flood control storage up to a maximum flood control pool elevation 1000.0, or 9.1 inches of runoff during the winter months and 7.1 inches of runoff during the summer season. Table No. 2-1 summarizes storage data at Sutton Lake for minimum, seasonal, and maximum flood control pools. The general layout, plan, elevation for Sutton Dam is shown on Plate No. 2-1.

Topographic characteristics of the Sutton Lake site precluded the possibility of a side-hill or saddle-type spillway. Preliminary cost estimates indicated that a dam with a controlled overflow spillway would be more economical than a structure with an uncontrolled spillway. As a result of the preliminary cost estimates and detailed foundation exploration studies, the adopted design of the Sutton Lake dam consisted of a concrete gravity-type structure with a gated spillway in the channel section of the dam.

c. Recreation. The recreation purpose is the realization of the full recreational potential for the project. Development and utilization of flood control reservoir areas for recreation were authorized by Section 4 of the Flood Control Act, approved 22 December 1944, as amended by Section 4 of the Flood Control Act, approved 24 July 1946. This Act authorizes the Chief of Engineers to construct, maintain and operate public park and recreational facilities in reservoir areas under the control of the War Department or to permit such activities. It also authorizes the Secretary of War to grant leases of lands, including structures or facilities thereon in reservoir areas for such periods and upon such terms as may be deemed reasonable.

TABLE NO. 2-1

POOL ELEVATIONS, RESERVOIR AREA, AND STORAGE CAPACITY
SUTTON LAKE

Pool	Elevation (Feet, NGVD)	Surface Area (Acres)	Length (Miles)	Gross Storage Capacity (Ac.-Ft.)
Minimum	895	870	13.0	29,100
Seasonal	922	1440	14.5	59,700
Maximum Flood Control	1000	3875	20.5	265,300

Because of topographical limitations and the low population density within easy driving distance of Sutton Lake, a limited development of recreational facilities was contemplated for the project. Areas of concentrated population were located, for the most part, over 100 miles from the reservoir. Preliminary reports indicated that most of the people most likely to visit the site already lived in rural surroundings comparable to those found at Sutton Lake, and therefore would probably not be strongly attracted by the natural scenic resources offered at the reservoir. It was anticipated that the sportsman segment of the population would be most interested in recreational opportunities at Sutton Lake, based on the popularity of the active fish and game associations located in the area.

1. Lake. Prior to the construction of Sutton Lake, the basin did not have a sizeable body of water available for full recreational utilization by the public. The area was significantly lacking in non-urban, public recreation facilities, and there was some demand for boating and fishing facilities. Recreational facilities were designed to provide boating, swimming and fishing waters, and camping and picnicking facilities, which were deficient in the area. Sutton Lake recreational facilities are accessible by automobile from Interstate Route 79, U.S. Route 19 and State Route 15.

2. Downstream. Recreational facilities downstream of Sutton Lake include a 4-acre site below the dam. The area is a popular spot for fishermen and picnickers. The State stocks the area regularly with trout, and facilities include two picnic shelters, 12 picnic units, restrooms, drinking fountains and playground equipment.

3. Management. All recreational facilities at Sutton Lake are operated and maintained by the U.S. Army Corps of Engineers. The Federal government owns 13,154 acres at Sutton Lake, of which the West Virginia Department of Natural Resources has leased 11,725 acres for purposes of fish and wildlife and forest management. This is managed as a part of the State's Elk River Public Hunting Area, which is located south of Sutton Lake. The only concession at the project is a marina, operated as the Sutton Lake Marina, Inc. on 13 leased acres adjacent to the Bee Run day-use area and boat launching ramp.

d. Fish and Wildlife Conservation. In broad terms the goals included under this project purpose are the long-term well being of populations of the plant and animal species native to the project area and the maximum sustained enjoyment of these populations by the public. Programs to promote fulfillment of these goals were developed in coordination with the U.S. Fish and Wildlife Service and the West Virginia Department of Natural Resources. The recommendations of these two agencies influenced fish and wildlife conservation plans put into effect at the project. Hunting, trapping and fishing restrictions are in accordance with annual regulations established by the West Virginia Department of Natural Resources. Hunting rules and regulations for migratory waterfowl are established within guidelines set up by the Department of Interior, Sports Fisheries and Wildlife.

1. Fisheries. Fish management by the Corps of Engineers is very limited. Management by the Corps in most cases is limited to water quality sampling and cooperation with the West Virginia Department of Natural Resources in their management activities. Gamefish in Sutton Lake include largemouth and spotted bass, walleye, white crappy, black crappy, channel catfish, and flathead catfish. Other species include rock bass, sunfish, and a number of rough and forage fish. Upper Elk River gamefish include walleye, smallmouth bass, muskie, and trout. In recent years, annual stockings in Sutton Lake have been limited to walleye.

Prior to the construction of Sutton Lake, the West Virginia Department of Natural Resources investigated the fishing conditions of the Elk River and determined that fishing in Elk River was strongly influenced by river conditions. At that time severe fluctuations in water level and silt loads presented limiting factors to the fish-carrying capacity of the stream. It was estimated that extremes in water temperature, droughts, and muddy conditions adversely affected fishing conditions in the Elk River approximately 85% of the year. It was anticipated that the construction of Sutton Lake would improve fishing conditions in Elk River by regulating the river flow and reducing the wide fluctuations in water levels.

However, the construction of Sutton Lake created other effects downstream of the dam along the Elk River that were considered to be adverse. These effects included depressed downstream water temperatures, increased duration of stream turbidity following storm events, and certain operations during low to moderate runoff periods that resulted in unnatural flows and fluctuations in flow. Furthermore, stockings of muskellunge, northern pike and trout in Sutton Lake by the West Virginia Department of Natural Resources were unsuccessful due to losses through the dam or upstream into tributaries during fall drawdown periods. During the fall of 1979, a high level intake tower was added at the Sutton Lake dam which allows downstream releases from Sutton Lake to be made from the warmer and less turbid waters of the lake. Since temperature is considered to be the single most important parameter affecting activity and distribution of fish downstream of the dam, the release of warmer water has a significant beneficial impact on the fish habitat below Sutton Lake.

2. Wildlife Resources. Numerous game and furbearing mammals are found within the Sutton Lake drainage basin. These include black bear, whitetail deer, gray and fox squirrels, cottontails, snowshoe hares, raccoon, skunk, mink, fisher, weasel, gray and red foxes, bobcat, muskrat, beaver and woodchuck. Other species include mostly nocturnal or fossorial animals.

Gamebirds within the basin include doves, quail, ruffed grouse, turkey, ducks, geese, rails, woodcock and snipe. A variety of warblers nest in the area, and a number of hawks and a few ospreys and bald eagles have been known to frequent the area. Reptiles and amphibians include six turtle, six lizard, 21 snake, 28 salamander, and 13 frog and toad species.

The West Virginia Department of Natural Resources (WVDNR) manages project lands for fish, wildlife, and forest purposes based on an approved Annual Management Plan. The WVDNR maintains wildlife clearings and food plots, 3 fish ponds, supervises the harvesting of a large deer herd, plants and prunes wildlife food trees, constructs waterfowl marshes, and supervises wildfire detection and control. Conservation officers patrol the water and land areas of the project. Parts of the wildlife area are managed by sharecropping agreements with local farmers who leave portions of crops for payment of lands.

e. Whitewater. Legislation contained in the Water Resources Development Act of 1988 (Section 6) specifically authorizes recreation as a Sutton Lake project purpose. In addition to recreation on lands associated with the project, the term "recreation" includes whitewater recreation which is dependent on project operations, recreational fishing, and boating on water at the project.

f. Low-Flow Control. During early planning, the U.S. Public Health Service recommended a 50 cfs minimum flow for water supply purposes. The Service also recommended 50 cfs as a minimum flow for pollution abatement in Elk River so that the river water would be of acceptable quality after no more than primary sewage treatment by bordering towns. In 1958 the Fish and Wildlife Service recommended a minimum release of 200 cfs during spring filling in April and May and 75 cfs at all other times for maintenance of fish habitat below the dam. This has been used for low flow criteria from early operation, with the 200 cfs being scaled down during low inflows.

g. Pollution Abatement. During and after World War II, the Kanawha River was grossly polluted, primarily due to the great concentration of chemical industries in the vicinity of Charleston. Water quality measurements in the river, made by the West Virginia State Water Commission and by industry, indicated a dissolved oxygen content of zero was reached on many occasions. The critical points for dissolved oxygen content in the river appeared to be from river mile 46 to 48 and river mile 36 to 38, both of which are in the pool of Winfield Lock and Dam and below Charleston. The State Water Commission, the coordinating agency for the State in matters pertaining to regulation of reservoirs, during the 1950's and 1960's designated 3 p.p.m. of dissolved oxygen content as the minimum objective value. Allocation of seasonal storage in Sutton and Summersville Reservoirs was made to provide dilution water to augment that in the Elk, Gauley and Kanawha Rivers.

Oxygen dissolved in water is vital for the health of fish and food chain animals, but is less soluble at higher temperatures. Dissolved oxygen is also decreased by industrial and other pollution which has been reduced so dramatically that the Winfield pool in 1990 is used for swimming and fishing. However, under low-flow conditions, high temperature and remaining pollutants can still result in lowered dissolved oxygen. Since water in the Sutton and Summersville Lake pools is much cooler than the river water and is more nearly pure, it is valuable as augmentation on both counts. Temperature is used as a volume criterion.

h. Special Purposes. A wide range of people needs involving water flow or stage within the sphere of project influence become special purposes which are evaluated for translation into regulation. The expressed need may be for a low stage downstream to allow construction work or search for a drowning victim; a medium stage downstream for a sporting event such as white water rafting; a high stage downstream to answer an emergency in the lake area; reservoir drawdown to meet an important construction need; or any of a multitude of other situations generating a request for special operation. Emergency needs are met as quickly as possible; however, requests for deviation from normal regulation must be evaluated with respect to the hydrometeorological outlook and with respect to the impact on other project purposes and must be coordinated with the Water Management Branch in the Division Office. After evaluation and coordination, the Chief of the Water Resources Engineering Branch either directs the regulation to the Resource Manager to answer the need or denies the request. A record of each approved request is shown on Form ORD 1018R, Record of Deviation from Approved Plan.

2-03 PHYSICAL COMPONENTS.

a. General. Flood control structures at Sutton Lake include a concrete gravity dam with a gated spillway located in the channel section of the dam, and the outlet works located through the spillway section. General details of the dam, spillway and outlet works are shown on Plate Nos. 2-2.

b. Embankment. The dam is a concrete gravity structure having an overall length of 1178 feet, consisting of 280 feet of spillway section and 898 feet of non-overflow section. The dam is about 210 feet high with the top at elevation 1017 feet, NGVD. It is made up of twenty one, 48-foot wide concrete gravity monoliths, and five abutment monoliths of varying 20 to 40-foot widths. Six of the monoliths comprise the spillway section of the dam. The topwidth of the dam is 20 feet, which includes a 16-foot wide roadway. General details of the dam are shown on Plate Nos. 2-3 and 2-4.

c. Spillway. The gated spillway is located in the channel section of the dam, with a bucket of 50-foot radius, a crest elevation of 972 feet, and an overall length of 280 feet. Spillway flow is controlled by 6 electronically operated tainter gates, 40 feet long and 31 feet high, supported by 7 piers, each 8 feet wide. Design discharge is 222,240 cfs with a surcharge of 38.3 feet and a freeboard of 6.7 feet. Details of the spillway and crest gates are shown on Plate Nos. 2-5 through 2-9.

d. Outlet Works. The outlet works consists of 5 gated sluices, 5'-8" wide by 10'-0" high and one 36-inch diameter valve-controlled sluice for low flow control, all located through the spillway section and discharging into the spillway bucket. A high-level intake is located at the center sluice. One service gate is provided for each sluice, and each gate is hydraulically operated from a gallery through the dam. Details of the outlet works are shown on Plate Nos. 2-10 and 2-11.

e. Operating Machinery. Operating machinery for the spillway tainter gates consists of 7 hoist assemblies, five for the intermediate piers, and two for the end piers. The units include motors, first reducers, second reducers, pinions and gears, sprockets and chains, brakes, limit switches and gate position indicators. Each gate is operated individually and is controlled from a control cabinet stationed on the pier to the left of the gate. In case of emergency, the gate may operated from the motor located to the right of any one gate by engaging a coupling between the first and second reducers. In case the gate fails to stop when reaching any extreme position due to a failure of the limit switch, the overtravel limit switch will automatically function and stop the hoist motor and set the brake.

The sluice gates are operated by hydraulic cylinders, located over the leaves of the gates, and are supplied with oil from a central oil pumping station. The control system includes two variable volume pumps, one of which is for standby service, oil reservoir tank, relief valves, counterbalance valves, filter, 4-way valves, and the necessary piping to control the oil feed to and from the hydraulic cylinders for raising and lowering the sluice gates. Each sluice gate is equipped with a mechanical leaf-position indicator graduated in tenths of a foot. An emergency sluice bulkhead, 11.2' wide by 19.04' high can be lowered into the slots and removed by means of a rubber-tired motor crane.

[redacted]

2-04 RESERVOIR DESCRIPTION.

Sutton Lake lies in portions of Braxton and Webster Counties in West Virginia. The watershed above Sutton Lake is generally oblong in shape and lies in an east-west direction. The total drainage area above Sutton Lake is 537 square miles. An aerial view of the lake is shown on page ii, and the reservoir and drainage area are shown on Plate No. 2-12.

At the seasonal pool elevation of 922 feet, the reservoir has a surface area of 1440 acres, with a backwater of 14.5 miles along Elk River. The total capacity of the reservoir at the seasonal pool is 59,700 acre-feet, or 2.08 inches of runoff from the watershed. The flood control storage of Sutton Lake between the seasonal pool elevation 922 and spillway crest elevation 1000 feet, NGVD is 201,100 acre-feet, or approximately 7.0 inches of runoff from the uncontrolled drainage area above the dam. At the maximum flood control pool, approximately 3,875 acres are inundated, and backwater extends approximately 20.5 miles upstream along Elk River from the Sutton Lake dam.

During DEMIA (December to mid-April), the seasonal pool is normally drawn down to elevation 895 feet, which provides an additional 30,600 acre-feet of flood storage, or approximately 1.06 inches of additional runoff from the watershed. Regulation of this storage capacity provides flood protection for agricultural areas and the communities of Sutton, Gassaway, Frametown, Clay, Procious, Clendenin, Queen Shoals and Charleston along the Elk River and Point Pleasant on the Kanawha River, with incidental benefits to cities downstream along the Ohio River.

2-05 REAL ESTATE ACQUISITION.

The principal document authorizing acquisition of land at Sutton Lake was the revised version of Appendix V of the Definite Project Report. That report authorized the purchase of 8,520 acres of fee lands, together with all coal, oil and gas interests below elevation 1003 feet, plus all coal within a 200-foot barrier outside of the 1003-foot contour. The initial land acquisition policy was based on the criteria of a close blocked-out fee taking along the 1003-foot contour, but at some locations, sound real estate practices dictated purchases of entire tracts where loss of access and basic economics made it the only practical thing to do. In addition to those lands authorized in Appendix V, another 2036 acres of land were authorized for purchase based on the reports "Lands Required for Sealing Abandoned Mine and Dam Site" (36 acres), "Lands Required for Relocation of Section 1 of the B&O Railroad" (1700 acres), and Design Memorandum No. 5, Real Estate, "Purchase of Lands in Lieu of Relocation of Secondary Route 15/1" (300 acres).

The resulting ownership was an irregular land area which was later determined to be totally inadequate for recreation development. In 1963, the District was authorized to acquire an additional 2,352 acres, generally buffering the north shore of the lake, and required in support of general recreation development. The United States thus acquired 13,473 acres in fee. Of this amount, approximately 319 acres has been disposed, giving a current fee acreage of 13,154 acres. The State of West Virginia owns a 7,000-acre reserve bordering the south shore of the lake, extending from the dam site about half-way up the project.

Flowage easements were acquired in remote areas where flooding is confined generally within the streambed. Present flowage easement holdings by the United States is 208 acres, which includes retained flowage rights to 92.63 acres of land transferred to the Baltimore and Ohio Railroad Company.

2-06 RECREATION AND PUBLIC USE FACILITIES.

Facilities are available at Sutton Lake for camping, boating, picnicking, swimming, hunting and fishing, and woodlands for general browsing and hiking. Most of the project area, more than 13,000 acres, is open to unrestricted hunting. During the recreational season, informational and educational programs are provided in designated campground areas. The West Virginia Regatta Festival is held annually at Sutton Lake, normally in late June, and includes activities such as boat races, ski shows, square dancing, a beauty contest and fireworks displays at the Bee Run Area of the lake. A majority of visits are made to Sutton Lake for sightseeing purposes. Listed in Table No. 2-2 are recreational sites in operational condition in 1990. Future sites and improvements will be constructed as joint funding is arranged with another governmental agency, such as the West Virginia Department of Natural Resources.

a. Corps-Operated Sites.

(1) Below Dam-Site. This popular 4-acre site is reached by an unnumbered road from U.S. Route 19, just south of Sutton. Fishermen and picnickers are the most frequent users of the area. The stilling basin and river below the dam provide good opportunities for fishermen, and the State regularly stocks the area with trout. Facilities include 2 picnic shelters, 12 picnic units, waterborne restrooms, benches, bulletin board, city water, drinking fountains, sewage treatment plant, playground equipment, two parking lots containing a total of 151 spaces, a weather station, and trash containers.

TABLE NO. 2-2

RECREATION SITES AT SUTTON LAKE

Name	Status
Tailwater	Complete
South Abutment	Complete
Bee Run	Complete
Bakers Run - Mill Creek	Complete
Gerald R. Freeman*	Complete

* Originally named Kanawha Run

(2) South Abutment. This 3-acre area provides a parking lot for 71 cars, visitor's access along the top of dam for sightseeing, and a large hand-painted map of the project area with general project information. Past the dam, a lakeshore site provides the nearest boat launch ramp to the town of Sutton and through traffic on I-79 and U.S. Route 119. Besides the two-lane launch ramp and parking lot, there is a picnic shelter, vault-type toilet, four picnic units, docks for the operations boats, and West Virginia Department of Natural Resources boats. This area has also become a popular swimming area for the local bathers.

(3) Mill Creek and Bakers Run Camping Areas. These fee-controlled, side-by-side campgrounds encompass 66 acres, and are reached by travelling south from Sutton on U.S. Route 19, then by State Route 17 to the community of Centralia. Facilities include 130 trailer campsites, parking lot for 63 cars, a one-lane boat launch-ramp, 3 restrooms with showers and waterborne toilets, laundry facilities, drinking fountains, sewage treatment plant, trailer waste disposal station, playground equipment, picnic tables, and trash containers.

(4) Bee Run Area. A 2-acre camping area is located on the access road to the marina and day-use area. It is accessed via U.S. Route 19 and State Route 15 north of Sutton, then by project road. Twelve sites are

provided, along with vault-type comfort stations, picnic tables, cookers, and garbage containers. In the day-use area of 11 acres there is a 3-lane launch ramp, parking lot with 194 spaces, 58 picnic units, a waterborne restroom, drinking fountains, sewage treatment plant, playground and 2 picnic shelters. There is also an area on the lakeshore that attracts large numbers of swimmers and sun bathers.

(5) Gerald R. Freeman Memorial Campground. This campground is located on State Route 15, east of U.S. Route 19. It is a fee-controlled area of 50 acres that can accommodate 157 camp trailers. There are also parking areas totalling 70-spaces, a 2-lane boat launching ramp, 4 waterborne restrooms with shower facilities, laundry facilities and drinking fountains, dusk-to-dawn lights, a bulletin board, benches, and handicapped facilities.

b. Privately-Operated Sites. A marina is operated as the Sutton Lake Marina, Inc. on 13 acres adjacent to the Bee Run day-use area and boat launching ramp. This operation has approximately 98 slips for rent and facilities to handle 9 pontoon or houseboats. They also rent boats, motors, safety equipment and fishing supplies. Other items available include sandwiches, soft drinks, gasoline, oils and other boating supplies. A satellite concession, in conjunction with the marina, was constructed in 1988 at the lower end of the Gerald R. Freeman Memorial Campground.

c. State-Operated Sites. The West Virginia Department of Natural Resources operates 11,725 acres of Corps land under a license agreement for fish and wildlife and forest management purposes. This area is called the Elk River Public Hunting and Fishing Area, and is operated in conjunction with 7,000 acres that the State owns or leases from others. The State maintains vehicular and foot bridges, 26 miles of roads, 30 miles of trails, and informational signs and boundary signs.

SECTION III - GENERAL HISTORY OF PROJECT

3-01 AUTHORIZATION.

The Sutton Lake Project became eligible for selection as a unit in the comprehensive plan for flood control in the Ohio River Basin as a result of the Flood Control Act of 1938, Public Law No. 761, Seventy-fifth Congress, third session. The general comprehensive plan for flood control in the Ohio River Basin proposed the construction of 6 reservoirs in the Kanawha River Basin. One of these reservoirs was Clendenin Reservoir on the Elk River, which was later replaced by the Sutton Lake Project, located about 74 miles upstream of the original Clendenin Reservoir site, at Sutton, WV.

3-02 GENERAL BACKGROUND HISTORY.

The history and development of the water resources of the Elk-Gauley-Kanawha River basin began even before the European explorers discovered America. The Elk-Gauley-Kanawha River Basin was explored and settled by European emigrants soon after the establishment of Colonial America before, during, and following the Revolutionary War. However, the very first travelers through the area were Indian hunters going across the Ohio, Kanawha, and Elk Rivers in pursuit of mammoths, food, and other Indians. Around 9,000 BC the Archaic people occupied the area, and were followed by the Adena, or mound builders (1,000 BC to 1 BC) who created numerous earth works or mounds still visible in the Charleston and South Charleston area. The Adena were absorbed by the Fort Ancient people, who hunted the area until they were destroyed by the Iroquois League about 1670. The Indian villages were rare and scattered but were usually on the established Indian trails near a good water supply. Historical interest points dating to the Indian activity are scattered throughout the basin.

The English Privy Council granted the London Company a second Royal Charter in 1609 to incorporate the new colony called Virginia. The colonial boundaries were broadly stated as Cape Fear to the Hudson River and coast to coast (Atlantic to Pacific) and the Royal Governor was required by the Crown to explore the colonial frontier. The early ships could sail up the James River to the forks and here Col. Abraham Woods in 1641 built a trading post, Ft. Henry, which later became Petersburg. Col. Woods soon heard vague rumors about a large river that flowed west, hence he explored the frontier lands, and in 1654 made the amazing discovery of a large river running northwest towards the Ohio River, and a pass in Floyd county, which he quickly named "Woods River" and "Woods Gap". Several expeditions followed Abraham Woods trail from Ft. Henry. One of these were Batts and Fallam (1671), supplied by Col. Woods, who found Gauley and Greenbrier Rivers, and Peters and Kanawha Falls, and claimed all of the New-Kanawha-Ohio basin for England. Basically, the Elk-Gauley-Greenbrier-Kanawha River Basin was a mountainous unmapped and uninhabited Indian hunting ground and battlefield, rich in furs and timber.

The English Crown had always wanted to control the rich fur trade in the prized Canadian and western provinces surrounding the Great Lakes, all now claimed by France. These provinces had become the prime overseas colonial empire possession of an intermittent century long bitter bloody land struggle and war in Europe between France and England. Following the close of King Georges war in 1744 the Indians forfeited all land claims between the mountains and the Ohio River to the English with the "sweetheart treaty of Lancaster" for the "huge sum" of L400 pounds, some blankets, and a new road to the homeland in the southern mountains. Soon the victorious English began granting large tracts of western land to wealthy land promoters and speculators, who contracted to settle and control the frontier for England. The James Patton Group or "Woods River Co." from nearby Roanoke, Va. was granted 100,000 acres on "Woods River" on 26 April 1745 near present day Montgomery County and Little River. However, the French still held very strongly to the claim of Robert LaSalle (1669) and later Bienville (1748) on the Ohio River. The British Board of Trade granted to the Virginia based "Ohio Company" on 12 July 1748, a 200,000 acre grant, later increased to 500,000 acres, vaguely located between the Ohio, Monogahela, and Kanawha Rivers. The Virginia Royal Governor was very resentful and quickly countered this with a huge Royal Grant of 800,000 acres to another Virginia based "Loyal Company" in the Upper New River Valley, and a second grant to three very wealthy Virginia gentlemen. In 1751 another Royal Grant of 100,000 acres was given to the Lewis families "Greenbrier Company" to settle and develop the Greenbrier River Valley. Very soon the "Loyal Land Co." hired Dr. Thomas Walker to lead a six man party to map and stake there 800,000 acre claim. Leaving Charlottesville on 6 March 1750 the seven months long expedition toured several mountain basins, ending at the New and Greenbrier River on 28 June 1750, near Hinton. Within a short ten year period(1745-55) a few wealthy speculators had gained control of about four million acres of prime western land by Royal Grant, Council Decree, or Colonial Deed. This huge figure would appear to be much more land on paper then really existed in the forest, or to be based on duplicity, faulty bookkeeping, or very poor mapping.

A few months after the grant to the "Woods River Co.", or on 16 October 1745, John Buchanan began surveying and staking the land; and summarily changed the names from "Woods River and Woods River Co." to "New River and New River Company" to match "New Virginia". At the same time John Buchanan discovered that the previous spring Adam Harman and Frederick Starn had settled on New River near the horseshoe bend, along with William Macke's at Max Meadows. This seems to be the very first known German settlers in the New-Kanawha Basin. The next year a group of about 10 settlers followed the old Indian trail to New River. Here at the Little River junction the Ingles family settled "Ingles Ferry" and about 15 miles northeast on a beautiful mountain meadow along the head of Stroubles Creek on 19 March George Draper bought 500 acres and settled "Drapers Meadows". This settlement on Stroubles and Toms Creek, and Prices Fork was the first real settlement on "New-Kanawha River". This early settlement lasted about seven years and was destroyed in the "Drapers Meadow Massacre" on 8 July 1755; Col. Patton was killed and four women from the Ingles and Draper families were captured. The four women were taken to the "Ohio Country", below present day Cincinnati, where Mary Ingles and a Dutch lady escaped and made an heroic 800 mile 6-week return trip on foot back to Ingles Ferry and there families.

The first known white settlers west of the mountains in the Kanawha-Greenbrier River Basin was a cabin established in 1749 by Jacob Marlin and Steven Sewell at the junction of Greenbrier River and Knapps Creek in present Pocahontus County. First called Marlins Bottom, later it became Marlinton, the county seat. Shortly, Steven Sewell became irate over religion, slept in an adjacent hollow tree, and later moved 50 miles further west in the Gauley-Meadow River

basin to live on a mountain so named for him and was soon murdered by the Indians. Here at Marlinton, on the present site of the Mitchell Chevrolet Co., the surveyors of the "Greenbrier Company", John Lewis and his son Andrew, found this small squatters cabin in 1751 when they explored there "Greenbrier land grant". This settlement lingered about 10 years and was destroyed by Chief Cornstalk in 1761 as part of a plan led by Chief Pontiac. During these years most of the lower Kanawha Basin was involved in the long drawn out struggle for control of North America with the French and Indian War, Lord Dunmores War, the battle of Point Pleasant, and the American Revolution. The general index map for the Kanawha River basin is shown as Plate 3-1, and the detailed data are shown as Table 4-1(T4-1), and with individual project data sheets as Plates Nos. 4-1 thru 4-8.
Just before the outbreak of the American Revolution several prominent frontier men including Col. George Washington, Simeon Kenton, Daniel Boone, and the Bullitt family came to the lower Kanawha valley below Elk River junction to stake claims. Col. Washington staked huge claims for both himself and his company. Thomas Bullitt staked a large claim at the mouth of Elk River, but he died in 5 years, leaving his unused land to his brother. Within two years (1773) Walter Kelly built a cabin on Kelly's Creek at Cedar Grove, and about the same time George Strawn built a cabin on the glades near Camden-on-Gauley, both were the first in Kanawha County. However, the next big Indian raid destroyed both the Kellys, the Strawns, and there neighbors. William Morris and his sons then built the first permanent cabin at Brownstown or Cedar Grove. Leonard Morris then settled at the mouth of Lens Creek, John Morris settled on the south side of the Kanawha near the I-77 turnpike interchange, while Herbert Morris built his cabin 80 miles away on a 600 acre tract along Peters Creek near Line Creek. Captain George Fitzwater then settled along Gauley River near Arnett Church and the Cross Lanes. This settlement of the Morris family appears to be the first in the lower Kanawha valley.

Enormous national publicity followed General Washington, his Continental Army, his plantation, and his 33,075 acre claim in the lower Kanawha - Ohio Valley. Following the close of the Revolutionary War the State of Virginia began the previous English process of granting large tracts of interior land to groups of Kanawha-Gauley Basin speculators. The large land groups near the Elk-Gauley River were Warder and Parker granted 16,000 acres, William Henshaw granted 8,000 acres, Robert Morris granted 24,630 acres, Tupper and Pride granted 14,500 acres, William Morris granted 93,000 acres, Skyles Co. granted 32,000 acres; and McClung, Moore, and Welch Co. granted 135,000 acres. The Bullitt claim at Elk River junction was never fully settled and twelve years later a Burgesse delegate in Richmond, George Clendenin, bought the 1030 acre tract of land at the mouth of Elk River on 28 December 1787 from the Bullitt heirs. Four months later in April 1788 he arrived at Elk River one year before George washington was inaugurated President, organized a company of rangers, and in May built a fort near Brooks Street, calling it Mansion House. The nearby blockhouse was called Clendenin's Fort and became Fort Lee in 1792. On 1 October 1789 Kanawha County was formed with a very well known Burgese Delegate at Richmond from 1790-92, America's foremost frontier hunter, Delegate Daniel Boone. The next step came on 16 December 1794 when Mr. Clendenin platted a 40 acre tract as a new city. The next year, on 19 December 1795, the tract was incorporated and named Charleston, the name coming from George Clendenins brother Charles Clendenin. Later on a street, a small creek, and a settlement 21 miles upstream on Elk River were all named for the Clendenin family. Through a century of struggle this small settlement at Elk River junction

(Charleston) miraculously survived the 1861 and 1878 flood, the Civil War to eventually become the Capitol of the new state of West Virginia, the basins largest city, and the center of the great chemical industry.

The beautiful Elk River was named by the Indians for the large Elk herds in the valley. Apparently the first settlements on the Elk River mainstem came in several different places about the same time. About 1783 four families moved into or settled in the lower Elk River Valley between Blue Creek and the mouth. Likewise the Carpenter brothers, Jeremiah and Benjamin, settled about 90 miles upstream on upper Elk River above Holly River about 1784, but were driven out by Indians. Benjamin and his wife were killed but Jeremiah and his wife escaped and lived in a nearby cave where there new baby boy was born. A few miles downstream by 1792 Daniel or John Obrien lived in a tree and became the first settler at present day Sutton, then called Newville. Many years later in 1836, Sutton became the county seat for the new county, Braxton.

As the settlers extended westward over the mountains the strong need for food, security, protection, transportation, and future access to eastern cities for markets and imports became very apparent. This led to the first trail marking, clearing, wagon paths, haul road building, wells, forts, ferries, and new villages. The early explorers generally followed the Indian trails, which had followed the ridges to avoid the many stream crossings. The common path to cross the mountains and go west was the "Kanawha Indian Trail", which followed the New-Kanawha River, soon became the state road, the Midland Trail, later U.S. Rt. 60, and now part of I-64. The trails were later widened into logged haul roads in places but were only passable for a light horse wagon in warm dry weather, and needed steady maintenance and protection for public travel. The only alternatives were walking, horseback, raft, or canoe on Elk, Gauley, or Greenbrier River. With this early settlement, expansion, and growth came the dependance and use of the surface waterways for personal, farm, and village consumption, heavy transportation, and primitive water power. Therefore, the early leaders quickly saw the obvious need for safe water access and supply, flood protection or control, open river channels, and water resource development along all the rivers and floodplains of the Kanawha Basin as the communities grew from a wilderness. The development of water resources in the Elk-Gauley-Kanawha Basin came in four distinct overlapping phases. The first step after settlement and location of a good water supply was the building of water powered grist mills which soon led to the first water projects and industries.

The first great dream project was the famous "James River and Kanawha Canal" project. This project was originated by Thomas Huthchins, Chief Geographer of the Continental Army, and had the support of many men including George Washington. This huge navigation improvement project was to canalize the James and Kanawha Rivers and link them with a canal, tunnel, tramway, or road to develop trade and transportation between the coastal areas and the Ohio river and the west. The project company was chartered in 1785, four years before Washington was inaugurated President, but unlike the other surrounding states, New York and Ohio, western Virginia was too steep and rugged and lacked money and taxpayers for this huge project. Overall, this vast project was dreamed, talked, and planned for a century, but never fully funded or finished as originally conceived.

The first water industries in the Elk River Valley were timbering and coal mining. The obvious method of moving these cargos down river was by raft or flatboat, which stimulated the demand for improved navigation channels and later meant snagging, clearing, and widening of channels. This led to revival or reconsideration of the long dormant "James River - Kanawha Project". This began again in 1812 with a typical state commission headed by none other then Chief Justice John Marshall, who traveled the full length of the river project. By 1820, the state of Virginia had authorized an improvement project, and by 1830 the big sum of $92,000 had been spent. By 1824 the lower Kanawha River had regular steam boat traffic from Point Pleasant to Kanawha Falls, and up the Elk River past Sutton. This steamboat traffic meant that each spring the main river channel had to be cleared, scraped, and prepared for the summer boat traffic, all of which required state money. The obvious strained attitude quickly developed between the Kanawha River water groups and the eastern seaboard government at Richmond. "More money for the western side" versus "Too much money and too many small barges" and "Not enough freight and no big money cargoes". Despite the lack of state money, by 1832 Andrew Donnally had built the first steamboat at Charleston, and the race was on.

Partly in response to these Kanawha River complaints the Virginia State Legislature reorganized the same James River-Kanawha Canal project in 1835 by hiring Benjamin Wright, formerly chief engineer of the Erie Canal Company, who was later to be hailed as the father of American Engineering. To assist Mr. Wright, a brilliant young engineer, Mr. Charles Ellet, JR. was hired and these two men quickly prepared plans for a great engineering feat. The James River Project would have a canal from Richmond to Covington, a railroad from Covington to Kanawha Falls, and several locks and dams for steamboating down the Kanawha to Point Pleasant. The mountain phase of the project had started in 1828 when an army engineer, William G. McNeil, had created a plan for reservoirs on Anthony Creek, Howard Creek, and Meadow River that would store needed water for the mountain canals. Elk River was a part of this huge plan in that it would feed products and water to the lower system. While this system was never fully developed quite as planned, but this was the start of what became a mighty transportation system. The canal opened to Lynchburg by 1840 and reached Buchanan in 1851. Mr. Ellet now went one more step and planned more reservoirs in the headwaters to aid slackwater navigation and even store water and reduce damage during floods. He was a century too soon. The mountain crossing phase took a long time to complete, but after many years the C&O, B&O, and Western Maryland railroad had surpassed the small canalboat, which led to another era.

The great railroad era began at this time by the building of the road connecting Baltimore with the Ohio River in 1853 and marked the beginning of the network of railroads that now cross the Kanawha Basin. The first railroads in Europe had been very slow, short haul, and horse drawn; but now they were steam powered, faster, more powerful, ran in cold or bad weather, uphill or down, and were capable of reaching mountain areas not on a waterway. Many times the rails and ties for the new railroad were hauled by the barge boat it was replacing. The same Mr. Charles Ellet had worked on the Virginia Central R.R.(C&O) which he opened through the Blue Ridge to Staunton in 1854. His big dream in the James River Project was to connect the Ohio and James with rails. Many of the cities and industries along the New, Kanawha, and Elk Rivers were by now using the river for all water supply and transportation. When the Civil War temporarily divided the country, the topography and culture of the Lower Kanawha River seemed to unite the majority of the people of the Lower Kanawha

Valley to the Ohio River and the Union. When voting for the ordinance of Secession the Lower Kanawha counties declared for the Union, while the Upper Kanawha-Elk River-Gauley River-New River counties were more evenly divided, and some even voted for secession. This left the Kanawha river under Union Control and the upper New River in confederate control with a decline in river traffic. Surprisingly, Braxton County supplied more men for the Confederate Army then the Union (300 to 119). During most of the war the Kanawha and Elk River was dominated and controlled by the Union Army, however, the village of Sutton was burned during a Confederate raid on 29 December 1861. This extreme division in the mountains eventually led to full separation and later the new 35th State of West Virginia.

During the Civil War the great Transcontinental Railroad was begun and finished in May 1869. Immediately after the war, one of the big four Union Pacific rail magnates, Collis P. Huntington, declared the time had come to connect the two big eastern rivers by crossing the mountains of Virginia. Accordingly the big project began to extend the railroad through the mountains from Clifton Forge to Lewisburg, down the Greenbrier, New, and Kanawha Rivers to the Ohio. White Sulphur Springs was entered in July 1869, two months after the National dedication at Salt Lake City; the Ohio River was reached in 1873, near Guyandotte, and a new city was founded and named for C.P. Huntington. The James River Project had been partially completed as the old Virginia Central or the new C.& O. Railroad. Part of this plan lead to the building of the B&O Railroad from Weston to Sutton in 1892 and the Coal & Coke R.R. from Charleston to Clarksburg in 1904.

While the C&O R.R. was crossing the mountains the State Capital was moved on 1 April 1870 to Charleston, and the Corps of Engineers began a program of building wing dams and clearing the Kanawha River of 10 years of accumulated snags and boulders all for the great sum of $50,000. When this was completed the big movement came for another revival of the James River Water Project. Many meetings and conferences led to reports and a Congressional Act in 1875 to build a six-foot slackwater navigation project from Cairo all the way to Richmond. Colonel William E. Merrill, the District Engineer at Cincinnati, strongly supported the plan. The first step was to create a Kanawha River Board, grant the board $25,000, and hire Addison C. Scott as Chief Engineer for the project. The plan developed by Scott was a series of 12 locks and dams, later reduced to 10, on the Kanawha River with permanent locks and movable wickets for a temporary dam for low water navigation from the falls to the mouth. No sooner then started the project was nearly wrecked by the record Flood of September 1878. Elk River had a big part in this plan by supplying extra water for the lock system and fresh drinking water for Charleston. The mountain phase was finally discarded, but the 10 locks and dams were built by the Corps of Engineers in 23 years and were completed $100,000 under original budget. This was the big step in completing the great James River Project after 113 years of dreaming, talking, and working. The Kanawha-James River system was ready for eternal prosperity. Eternity was interrupted by an enormous monster in Europe - World War I.

The outbreak of World War I in Europe during August 1914 was one of the earth-shattering events of history. This war changed the lives of many people and cities. When the war began most of Americas supply of chemicals came from Germany. There was some modern industry in the lower Kanawha-Elk Valley, but not much. Charleston had moved from the early salt industry to a regional coal industry center. This brought the first major chemical plant to South Charleston in 1915 to produce chlorine and soda. America entered the war in April 1917, quickly Sec. of War Newton D. Baker came to Charleston and inspected the industrial, material, manpower, and water potential of the valley. Very soon three large war plants were built in the area and the modern water based chemical center explosion had begun. The expansion of Kanawha County and the lower Elk River valley (Queen Shoals-Clendenin-Elk View-Elk Two Mile) into the giant chemical center was so rapid that the county population tripled from 81,457 in 1910 to 231,414 in 1950.

The Indians and early settlers of the Kanawha basin did not cause the annual spring floods or the summer droughts. The damaging floods began long before settlement, but little record was made of these events. The first major Ohio River recorded floods were at Fort Pitt or Pittsburgh in 1762 and 1763, and Cincinnati in 1773, 1792, and 1793. The terrible Elk-Kanawha Basin floods of the previous century are recorded in old newspaper stories and were all very destructive at all villages from Webster Springs to Clendenin, Charleston, and Point Pleasant, and to all farm lands in the valley.

The Elk River appears to have a damaging flood about every three or four years in the previous century with a major flood in September 1861, September 1878, April 1886, February 1897, and March 1899. The present century brought floods in May 1901, December 1901, January 1911, July 1916, March 1918, July 1932, March 1934, October 1937, Feb. 1939, April 1939, Aug. 1940, Jan. 1946, Oct. 1954, Jan. 1957, July 1969, and the disastrous November 1985. Several of the great Ohio Valley floods were not record floods on the Kanawha and Elk River, as a result the pathway for the development of water resources was different for each basin. Furthermore, the Corps of Engineers was still confined to the tradition of only building navigation projects on tributary streams, but, flood control could be an allied purpose of navigation.

After the record 1913 flood, which resulted in nearly $200 million in flood losses and the loss of 415 lives in the Ohio River basin, the Ohio legislature passed the Conservancy Act of Ohio. This was the beginning of modern basin planning, flood control and water conservation in Ohio and the procedure soon spread to other areas.

Water management in the Kanawha-Elk Basin has played a crucial role in economic development. As in most basins, the twin problems of excess water during floods and inadequate water supply in the summer for personal, urban, and chemical industry development had to be solved. Although the potential for severe flooding in the Kanawha and Ohio River basins had long been recognized, Federal investigations made prior to the 1930's were generally concerned with improvements for commercial navigation. By this time the Corps of Engineers had moved to Huntington (1922) and the first big project was the modernization of the Kanawha River navigation system. Before World War I and the Huntington District it became apparent that the six-foot Kanawha River system was somewhat retarded by the partially improved Ohio River system. After World War I the nine-foot Ohio River system was completed from Pittsburgh to Cairo. This now left the Kanawha behind the Ohio and it was soon time to catch up. The first survey report on Kanawha River navigation above Charleston was prepared by the Corps of Engineers and published in 1923 with this conclusion "No big money should be spent on old low-lift wicket dams, all new money should go to modern high lift dams". This report recommended a nine foot channel with two high-lift twin 56x360 locks in place of the four old wicket dams. The Board Of Rivers and Harbors approved this report except with a six foot channel.

On 3 March 1925, Congress directed the Secretary of War, acting through the U.S. Army Corps of Engineers and the Federal Power Commission, to prepare and submit estimates of costs of investigations for improving navigable streams and their tributaries for navigation, power, flood control and irrigation. The estimates were made and published in House Document 308, Sixty-ninth Congress, first session. The River and Harbor Act of 21 January 1927 authorized the Corps of Engineers to undertake the investigations listed in House Document 308.

The same year Congress approved the detailed investigation of a highlift navigation project for the lower Kanawha Basin. In 1930 Congress approved the first high-lift navigation project, the Marmet-London-Kanawha Replacement Project. The project work began in 1931 and was dedicated during the Presidential election campaign of September 1932 with a steamboat parade and Vice-President Charles Curtis presiding. The Corps of Engineers, Charleston sub-district completed Marmet Lock on 7 May 1934 and London Lock and Dam was completed by 25 June 1934.

In the meantime the country found itself in the midst of a very severe stock market crash and worldwide economic depression. Because of the depressed economy, it appeared that only the Mississippi River would receive extensive Federal aid for flood control; however, the election of a president, political party, and congress who were more receptive to proposals for public works programs and water resources development opened the door for the needed assistance. The severe droughts of 1930, 1931, and 1934; the 1926, 27, 29, 30, and 1933 floods; coupled with the national economic and financial recovery crisis; and the 1932 and 1934 elections culminated in a broader public support for Federal Public Works program, which included the adoption of a national flood control policy independent of the policy of navigation improvement. One of the early acts of the new administration in 1933 was to organize the Public Works Administration in order to further combat unemployment.

At the time that Marmet Lock was being dedicated Congress approved the next high-lift navigation project, the Gallipolis-Winfield Replacement Project. The work began late in 1933 and Winfield was finished by 1937. Gallipolis, the biggest roller-dam in the world, was flooded during the record 1937 flood; and both were dedicated by another steamboat parade on 12 June 1938 marshalled by Governor Homer Holt. One of the main features of these navigation locks on the Kanawha River was that each had an electric power generating plant for the Kanawha Power Company. The James River Project was now updated and expanded 150 years after the first edition.

The next year, 1932, another "308" report for the Kanawha Basin emphasized flood control, and combined water power and flood control. Other findings on the report were that there was no great need for irrigation. Another precept was that major flooding events were basin-wide problems that could not be controlled by structures built mainly for navigation purposes. Congress normally did not approve flood control projects unless they were in conjunction with a navigation project. It was also suggested that a private corporation could build a power dam that could be used for flood control.

Fortunately, the study showed that a comprehensive reservoir system would have a measurable effect in improving flows and levels for navigation and reducing flood crests on the Kanawha and Ohio Rivers. These findings had a strong bearing on Congressional support of this project. The study concluded that benefits from a comprehensive program of navigation, flood control and water conservation would accrue not only to individual property owners, corporations, and municipalities, but also to the state and nation.

While this was transpiring two more reports were compiled but one was not published. House Document No. 306, 74th Congress, first session - the unprinted Ohio River "308 Report", and the published "308" report prepared for the Kanawha River (House Document No. 91, 74th Congress, first session), in which 3 possible plans of development for the Kanawha River Basin were presented. The unpublished report planned for a total of 39 flood control reservoirs to be built for the Ohio River Basin and its tributaries as part of flood control plans for the Mississippi River Basin. This report recommended Clendenin Reservoir on Elk River, Summersville Reservoir on Gauley River, Big Bend Reservoir on Greenbrier River, and Bluestone Reservoir on New River.

The Flood Control Act of 1938 was accompanied by House of Representatives Report No. 2353, which included a previous report titled "Comprehensive Flood Control Plan, Ohio River Basin", submitted 12 November 1937 by the Ohio River Division Engineer. Immediately following the record January 1937 Ohio Valley flood, rapid investigations were conducted to modify, enlarge, and publish on 22 February 1937 Flood Control Committee Document No 1 which already included a review of House Document 306. This review of House Document No. 306, had produced a report setting forth a revised and enlarged flood-relief plan which included Clendenin Lake in a revised system of 49 additional Ohio River Basin reservoirs rather then the earlier proposal of 53 additional reservoirs to the then small system.

The November 1937 Flood report No. 2353 proposed a comprehensive flood control plan including Pocatalico Dam, Bluestone Dam, Big Bend Dam, Clendenin Dam, and Summersville Dam. The January 1937 flood was not as severe in the Kanawha Basin as elsewhere, but many people who had previously had strong doubts about flood control projects now became supporters of the Corps Of Engineers and flood control projects. After all these reports the Flood Control Act of 1938, based on the "Comprehensive Flood Control Plan, Ohio River Basin" authorized the construction of six reservoirs, including Clendenin Dam, in the Kanawha River Basin for the control of floods on the Ohio River and on the tributary streams below the reservoirs. Three of these projects, Bluestone Lake on New River, Sutton Lake on Elk River, and Summersville Lake on Gauley River, have been built.

3-03 PROJECT FORMULATION AND DESIGN

The Kanawha River "308" Report listed Clendenin Reservoir, with a flood-control storage capacity of 160,600 acre-feet, as one of a system of 4 reservoirs in the Kanawha River Basin for Ohio River flood control, and as one of another system of 4 reservoirs in the Kanawha River Basin for Mississippi River flood control. Clendenin Reservoir was also one of the reservoirs authorized for the reduction of Ohio River floods by the Flood Control Act of 1936. The Report of

December 1936, indicated that industrial development occurring within the proposed reservoir area would limit the gross storage capacity at the Clendenin site to 108,000 acre-feet, or about 1.8 inches of runoff from the controlled area. Originally 160,600 acre-feet, or about 2.66 inches of runoff, had been proposed for the site. Detailed studies further indicated that the Clendenin project would be unduly expensive. Because of industrial development occurring within the reservoir area, and the excessive costs associated with the project, authorization was made on 20 October 1938 for the study of alternative sites upstream for a flood control reservoir in the Elk River Basin as a substitute for the Clendenin Reservoir.

The new study resulted in the selection of the current Sutton Lake site about 74 miles further upstream as the most favorable alternate for the costly Clendenin project. Detailed studies were made in 1945 to determine whether future hydroelectric developments were feasible for Sutton Lake on Elk River and also for Summersville Lake on the neighboring Gauley River watershed. The results of the study indicated that provision for hydro-electric power was not justified, and Sutton Lake was to be constructed for the purposes of flood control, pollution abatement, fish and wildlife conservation, and recreation.

The dam was designed to provide flood control storage up to a maximum flood control pool elevation 1710.0, or 7.0 inches of runoff during the summer months and 8.1 inches of runoff during the winter season. Table No. 3-1 summarizes storage information at Sutton Lake for minimum, seasonal, and maximum flood control pools.

Topographic characteristics of the Sutton Lake site precluded the possibility of a side-hill or saddle-type spillway. Preliminary cost estimates indicated that a dam with a controlled overflow spillway would be more economical than a structure with an uncontrolled spillway. As a result of the preliminary cost estimates and detailed foundation exploration studies, the adopted design of the Sutton Lake dam consisted of a concrete gravity-type structure with gated spillway in the channel section of the dam.

3-04 CONSTRUCTION.

Construction of the project was initiated in October 1949, with the sealing of an abandoned coal mine near the site of the dam. The sealing was completed in April 1950. A contract was then awarded in June 1950 for the first section of railroad relocation. Shortly thereafter, work was curtailed due to the Korean War. Active construction work was resumed in December 1955 by awarding continuing contracts for the remaining grading work for the railroad relocation and the relocation of a State highway at the dam site. A contract for construction of the dam proper was awarded 24 September 1956.

During the process of drilling exploratory holes for the examination of the foundation rock, a geologic fault was discovered in the valley bottom. Because of this fault and the discovery of intensely fractured rock below the fault, dam monolith numbers 11 through 19 were lowered an average of 30 feet below planned grade. During construction of the dam, fly ash was used in the concrete for the first time on a Corps project as a replacement for a part of the portland cement. Closure at Sutton Lake was effected in April 1959, and construction was completed in January 1961.

The project required relocation of 8.6 miles of single track of the Baltimore and Ohio Railroad, including 5 deck plate girder bridges and a tunnel approximately 650 feet long; 14.0 miles of secondary roads, including 3 bridges; 14.2 miles of telephone and telegraph lines; 4.5 miles of powerlines; 0.8 mile of gas pipe line and 18 cemeteries having a total of 700 graves. The relocation program was initiated in July 1950 and completed in December 1960. The cost of construction of the project was approximately $34.9 million.

In the fall of 1979, construction began on a high-level intake to improve water clarity and temperatures downstream of the dam in the Elk River. Dravo Engineers was awarded the contract for construction of the intake, which was completed in three sections. The lower section, weighing about 50 tons, went up first and was anchored to the wall of the dam, about 20 feet from the bottom. It was sealed with 600 yards of concrete, which was poured underwater through a pipe, and then topped with a layer of dry concrete. The second and third sections followed, each welded to the other. A reinforced concrete shell was added to the top 20 feet of the structure to improve flow conditions and aesthetics and reduce maintenance. The construction was completed in May 1980 at a cost of approximately $1,961,000.

The finished dam cost about 34,904,000 MILLION DOLLARS and the partially completed dam was used for the first time in the Kanawha River floods of 1959. Since then Sutton Dam has accrued flood control benefits calculated and estimated to 211,597,000 DOLLARS to FY 95. The Kanawha Reservoir system now has three reservoirs and five local protection projects with a total of 1,309,700 acre-feet of storage and 5905 square miles of controlled drainage area or 48 percent of the total basin. During the last five years the Kanawha River Reservoirs have accumulated average annual benefits of 56,227 million dollars, with Sutton Lake accounting for 7.5 million dollars per year. Sutton Lake and the other Kanawha Lakes have paid for themselves many times over and the grand total of flood control, water supply, recreation, and overall conservation benefits is an enormous figure and the amount of the present day replacement value for Sutton Dam is huge.

The final post war phase of development in the Kanawha-Elk Basin was the solid growth of recreation and vacation resorts at the lakes and rivers in the area. This began with the creation of the West Virginia Department Of Natural Resources in 1949, and they have coordinated with the Corps of Engineers on many water projects in this phase of water resources and recreation development. This phase was not considered when the original James River Project was dreamed or Bluestone Dam was built, but the WVDNR later built and developed elaborate facilities that draw large crowds at the lake resorts during the summer which has produced a new industry for the basin called tourism. In certain mountain counties of the basin like Nicholas, Summers, and Braxton counties, the largest revenue payroll is connected with lake or white-water recreation from a nearby lake or river.

The summary and final phase of Kanawha-Elk water resources development is that many public and private groups now use the multi-purpose water projects of the Kanawha Basin that were developed by the COE and WVDNR. The vital personal and urban water supply of about 179 cities, towns, and units within the basin now come from both underground and surface streams and lakes. The 179 unit municipal water consumption for each day in the basin was about 48mgd or 75 cfs in 1965. This very basic need for municipal water supply, particularly at Charleston, is expected to more then triple to 150mgd or 225cfs by the end of the century. Surface waters used by railroad, coal, mining, manufacturing, and lumbering industries for producing steam, processing material, and washing coal. The total water consumption from the Kanawha Basin in 1965 was about 2230mgd or 3480 cfs, of which 97 percent goes for industrial cooling. Many cities and towns in the Kanawha Basin also have a municipal sewerage treatment plant designed to use a certain amount of public water. The combined effort of safe water treatment and sewerage treatment plants has reduced the number of deaths from Typhoid fever remarkably. The present surface water is usually adequate for agriculture, however, there is still a need for additional water supply during a dry summer for optimum crop growth in the watershed.

The settlement and expansion of the Kanawha-Elk River Basin began with the building of a cabin and settlement on Peters Creek nearly 225 years ago and the James River Project. The economic, industrial, and the water resources expansion and development of the basin began immediately and continues today. The future of the Kanawha Basin and the States of Virginia and West Virginia has always been linked with extensive water resources development. The Kanawha Basin has always been the number one basin in West Virginia in basinwide planning for flood control, water conservation, and water resources development and will always be first in West Virginia for planning the future.

IV - WATERSHED CHARACTERISTICS

4-01 GENERAL CHARACTERISTICS.

The Elk River watershed above Sutton Lake lies in portions of Braxton, Webster, Randolf and Pocahontas Counties in West Virginia, and has a total drainage area of 537 square miles. The Elk River is the second largest tributary of the Kanawha River. It flows in a westerly direction through a narrow, winding valley and drains a long, narrow basin situated in the mountainous section of central West Virginia. Elk River is formed by the confluence of Big Spring Fork and Old Field Fork on the western slopes of the Allegheny Mountains in Pocahontas County, West Virginia, and flows a distance of 172 miles to its junction with the Kanawha River at Charleston, West Virginia. The average fall of the Elk River for its entire length is 12.3 feet per mile. The tributary streams flow through narrow valleys and gorges and are generally short with steep gradients. Drainage areas of the major tributaries in the Elk River Basin above the Sutton Lake damsite are shown in Table No. 4-1. A stream profile of Elk River is shown on Plate 4-1.

TABLE NO. 4-1

DRAINAGE AREAS OF ELK RIVER AND TRIBUTARIES

Stream	Point	Area (Sq.Mi)
Elk River	At mouth	1,533
Elk River	At damsite	537
Holly River	At mouth	148.4
Laurel Creek	At mouth	66.8
Back Fork Elk River	At mouth	69.7
Leatherwood Creek	At mouth	19.4
Big Spring Fork	At mouth	21.4
Old Field Fork	At mouth	24.7

4-02 TOPOGRAPHY.

The Elk River Basin lies wholly within the unglaciated portion of the Appalachian Plateau. The basin has been highly dissected by erosion into a region marked by a succession of nearly level-topped ridges and hills separated by deep, sinuous, narrow V-shaped valleys. Relief in the basin is about 1000 feet in the headwater areas and about 500 feet in the lower portions of the basin. At the Sutton Lake dam site, ridge elevations are near 1,500 feet above mean sea level. Spruce Knob, the highest ridge in the basin, rises to an elevation of 4,710 feet above mean sea level. The stream gradient is very steep in the headwater areas, becoming more gentle in the portions near the mouth. Steep to precipitous hillsides impinge closely on the river's edge on one side or the other, and frequently on both. The river bed consists generally of gravel, boulders, and large rocks, creating bars between which are pools of up to 20 feet in depth.

4-03 GEOLOGY AND SOILS.

Sutton Lake lies wholly within the Kanawha section of the Appalachian Plateau physiographic province. Following uplift during the Permian period, the plateau was level and its surface sloped northwestward. Subsequent stream erosion has altered the area into a highly dissected region marked by a succession of nearly level-topped ridges and hills separated by deep, sinuous, narrow, V-shaped valleys.

The surface rocks of the basin are of Pennsylvanian age and consist principally of sandstone and shale with numerous beds of coal and clay and a few limestone strata. Bedrock pertinent to the foundation for the dam and appurtenant structures consists primarily of Conemaugh and Allegheny series sandstones. In descending stratigraphic order, rock formations at the site include the Upper and Lower Mahoning sandstones, the Upper Freeport shale and coal, the Lower Freeport sandstone, the Upper Freeport shale and coal, and the Upper East Lynn sandstone. Soil cover on the steep valley hillsides is sandy and porous in nature, but it is shallow, as indicated by numerous rock outcroppings. The soils within the project area are residual soils belonging to the Upshur, Belmont, and DeKalb series, all of which have good drainage but poor fertility ratings.

Foundation excavation for the structures at Sutton Lake disclosed a fault near the base of the Lower Freeport sandstone. Zones of intense fracturing were also found associated with the fault. The attitude of the fault was nearly horizontal at elevation 789 across the entire valley bottom, becoming angular before dissipating into the valley walls.

4-04 SEDIMENT.

The amount of sediment generated by a watershed depends on a number of factors including land use, physiography, rainfall and size and shape of the drainage basin. Rainfall dislodges soil particles from the earth, the first step in the erosion-sedimentation process. High intensity rainfalls with large-sized raindrops produce the highest concentrations of sediment. Steep sloping land and land with poor vegetation produce high erosion and sedimentation. Larger drainage basins generally produce less sediment per square mile from a given storm than smaller basins because of the variation in land uses and rainfall rates. And the shape of a drainage basin determines the amount of bottom land available for sediment deposition before it reaches the reservoir.

The Sutton Lake Basin lies in an area of steep topography, thus creating the potential for high erosion and sedimentation in the basin. In addition, strip mining and timbering operations in the basin can produce large non-vegetated areas, which are prone to serious erosion. However, as a result of the combination of strip-mining reclamation measures and replanting programs, soils in the Sutton Lake Basin are being conserved and restored. Erosion of slopes and siltation in the lakes are reduced as a result of these programs.

4-05 CLIMATE.

a. General. The climate of the Elk River Basin is typical of many regions of the north temperate zone. Topographic characteristics of the basin considerably modify the latitudinal control of the climate, with the result that marked variations in temperature and precipitation occur between mountain and plateau areas. The seasons are nearly of equal length and are strongly contrasted. Winters are moderate to rigorous and only occasionally severe. The summers are warm in the low valleys and rather mild in the mountains, where temperatures in excess of 90 degrees occur infrequently. Summer rainfall occurs mostly during thunderstorms or as moderate showers in connection with low pressure areas that pass north of the basin. The thunderstorms are extensive and well developed with sporadic rainfall and, while usually of short duration, are often violent and attended by excessive precipitation, causing local flooding of streams. The heaviest precipitation of late fall and winter months occurs during passage of general storms that move from the southwest northeastward over the Ohio Valley. Occasionally, decadent tropical hurricanes moving northward parallel to the Atlantic Coast will cross the Appalachian Range and deposit enough rain to cause heavy flooding. Climatological data for three representative locations within or near the Sutton Lake Basin are presented in Table No. 4-2.

b. Temperature. The sites selected for Table 4-2 illustrate variations in temperature associated with topographic influences. Webster Springs (at elevation 1540 feet) is located near a ridge within the Sutton Lake Basin, and Gassaway, located below Sutton Lake, is located in a plateau area at elevation 840. Temperatures at the two sites are comparable during the winter months, but temperatures average about 1.4°F warmer in the plateau area at Gassaway during the summer months. Normal monthly temperatures range from 32.7°F in January at both sites to 73.8°F during August at Gassaway. The length of the growing season averages 168 days at Gassaway, normally extending from about the end of April to the middle of October.

c. Precipitation. Precipitation within the Sutton Lake Basin is heavily influenced by topography. For the 3 representative stations shown in Table No. 4-2, normal annual precipitation ranges from 45.68 inches at Gassaway to 49.48 inches at Webster Springs. Pickens, West Virginia, located just east of the basin and at a high elevation of 2770 feet, receives an average annual rainfall of 66.02 inches. Normal monthly precipitation at the 3 representative stations ranges from 3.01 inches during November at Gassaway to 5.98 inches during July at Webster Springs. Seasonal snowfall at Gassaway averages 29.1 inches annually.

d. Evaporation and Wind. For most Kanawha River Basin reservoirs, the amount of water lost by evaporation is quite small. The amount of loss attributable to evaporation from the lake surface is the difference between actual evaporation from the lake surface and the evapotranspiration from that area before the reservoir was constructed. The average annual lake evaporation over Sutton Lake is approximately 28 inches. Comparison of the water surface evaporation with the water loss shows that the average increase in loss, or augmented evaporation due to a reservoir, is about 8 inches per year. Table No. 4-3 shows estimated evaporation losses from Sutton Lake.

Prevailing winds in the area are from the south and southwest for most of the year; from January through March prevailing winds are more westerly. The mean annual wind speed, based on data from the Charleston, West Virginia/Kanawha Airport is 6.5 miles per hour. The maximum mean monthly wind speeds average between 7 and 9 miles per hour during the period November through April; minimum mean monthly wind speed is 4.5 miles per hour in August. Damaging windstorms are mostly associated with heavy thunderstorms, squall lines or intense large-area storms.

TABLE NO. 4-2

CLIMATIC SUMMARY - SUTTON LAKE & VICINITY

Condition	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Normal Monthly and Annual Precipitation (Inches)	Webster Springs*	3.54	3.11	4.20	4.30	4.35	4.83	5.98	4.79	4.08	3.44	3.38	3.48	49.48
	Centralia*	4.12	3.33	4.17	3.98	4.19	4.63	5.71	4.87	3.77	3.26	3.24	3.61	48.88
	Gassaway	3.56	3.12	3.93	3.90	3.88	4.37	5.16	4.49	3.62	3.08	3.01	3.56	45.68
Normal Monthly and Annual Temperature (°F)	Webster Springs*	32.7	35.1	43.7	53.9	62.2	69.0	72.4	71.4	65.7	54.6	44.3	36.0	53.4
	Centralia*													
	Gassaway	32.7	35.1	44.1	54.4	62.9	70.1	73.8	72.8	66.8	55.3	44.9	36.4	54.1
Normal Monthly and Annual Snowfall (Inches)	Webster Springs*													
	Centralia*													
	Gassaway	10.5	7.7	3.7	0.1	-	-	-	-	-	0.1	1.8	5.2	29.1

* Station is within Sutton Lake drainage basin

Base period for climatological normals: 1951-1980

* Operational time prior to crest stage in excess of 45.0 feet.

TABLE NO. 4-3

LAKE EVAPORATION LOSSES - SUMMARY

Maximum Seasonal Evaporation (1966) = 32.31 inches (1)
Average Annual Evaporation = 28 inches
Average Seasonal Evaporation (May-Oct.) = 21 inches

Average Monthly Evaporation Losses

Month	Inches (1)	Acre-feet (2)
April	4.00	477
May	5.03	599
June	5.48	653
July	5.60	667
August	4.94	589
September	3.72	443
October	2.59	309

(1) Coefficient to convert Class A pan evaporation to lake evaporation assumed to be 0.78.

(2) Measured from seasonal pool elevation 922.0 feet.

4-06 STORMS AND FLOODS.

a. General. Most floods on the Kanawha and New River Basins are caused by precipitation of unusual intensity or of unusual duration and extent. Floods may also result from a series of ordinary storms which follow one another in rapid succession or from rain falling at relatively high temperatures on snow-covered areas. At times, though infrequently, flood conditions are caused or aggravated by ice jams, especially in the tributary streams. Severe thunderstorms frequently cause local flash flooding. General flooding in the basin occurs most frequently during the winter or early spring months, but it can occur at any time during the year.

The flooding characteristics of the Elk River Basin can be partially described by comparing the highest annual historical floods. These are shown in Table No. 4-4 for the water years 1940 through 1986 at the Elk River at Sutton, West Virginia gaging station. All flows represent natural flows occurring at the gage without regulation of Sutton Lake. The datum of the gage currently is 800.0 feet above mean sea level. Prior to 5 April 1940, the gage was a non-recording gage, and from 5 April 1940 to 30 September 1960, the water stage recorder was located at a site 150 feet downstream at a datum 8.03 feet higher.

Flooding characteristics of the Elk River Basin can also be described by flow-frequency data. A flow-frequency curve for Elk River below Sutton Lake is shown on Plate 4-2. The plate shows flow-frequency data for natural conditions in the stream and also as modified by Sutton Lake. A discharge rating table for the channel below Sutton Lake is presented in Plate 4-3, and a flow duration curve as affected by regulation of Sutton Lake is shown on Plate 4-4. The historical profiles are shown on Plates 4-5.

TABLE NO. 4-4
ELK RIVER BELOW SUTTON LAKE AT SUTTON, WEST VIRGINIA
MAXIMUM ANNUAL NATURAL FLOWS

Water Year	Discharge (cfs)
1986	42,500
1967	38,000
1957	34,200
1970	32,500
1955	32,300
1972	29,000
1949	26,700
1948	25,000
1951	24,900
1944	24,100
1958	23,700
1978	22,900
1979	22,620
1974	22,300
1945	21,500
1950	21,100
1954	20,400
1942	19,400
1956	18,800
1964	18,300
1946	16,900
1971	16,800
1981	16,000
1959	15,700
1973	15,500
1952	15,500
1940	15,400
1947	14,700
1983	14,300
1943	14,100
1982	14,000
1977	13,900
1985	13,500
1960	13,150
1963	12,700
1968	12,100
1966	11,800
1965	11,700
1962	11,300
1953	11,100
1941	10,700
1975	10,200
1969	10,000
1976	10,000
1984	9,800
1961	9,250
1980	9,000

b. Storm and Flood of September 1861. The flood of September 1861 is the maximum of record on the Elk River. The flood on the Elk River synchronized with one of the greatest floods on the Kanawha River to produce the highest stage of record at Charleston. The storm that caused the flood was hurricane-related and covered a large area from North Carolina to Pennsylvania, including most of West Virginia. Very heavy rainfall occurred over the southern and eastern portions of the Kanawha River watershed, amounting to about 6 inches of rain during a 3-day period. The Kanawha River rose at a rate of 3 to 4 feet per hour during a portion of the storm, and the current out of the Kanawha River at Point Pleasant was so strong that the Ohio River ran upstream as far as 30 miles above the confluence. High water marks along the Elk River indicate that the 1861 flood was several feet higher than any other known flood along the Elk River below Sutton.

c. Storm and Flood of July 1932. The flood of 4-5 July 1932 was the second largest summer flood of record on the Elk River, and the largest summer flood of record on the neighboring Gauley River. The flood was confined to the Elk and Gauley River Basins, and did not cause any flooding along the Kanawha River. The major event of 4-8 July was preceded by thunderstorms on 27 June, which deposited approximately 2.0 to 2.5 inches of rain over the Elk and Gauley River Basins. During the main storm of 4-8 July, a total of 4 to 8 inches of rain fell over the Elk River Basin, with the heaviest rainfall at Clay near the center of the basin, and lesser amounts in the headwater regions. The flood had a comparatively long duration, as the Elk River remained above flood stage at Clay for about 2½ days.

d. Storm and Flood of January 1937. A series of abnormally heavy rains in late December 1936 and most of January 1937 caused a major series of floods in the middle and lower portions of the Ohio River Valley, with record flood heights being measured on the Ohio River below Point Pleasant. During the period 15-25 January, the rainfall over the Elk River watershed averaged 5.25 inches. The flood on the Elk River did not reach extreme heights, but due to the prolonged duration of the storm, the Elk River experienced 5 distinct crests, each increasing in magnitude from 16-25 January. The floodwaters of the Elk River contributed directly to the record-breaking crests on the Ohio River. The flood of January 1937 caused flood damages of approximately $417.6 million in the Ohio and Mississippi River Basins, and the loss of 139 lives.

e. Storm and Flood of January 1957. Frontal activity between strongly contrasting air masses brought excessive rainfall to the southern Appalachian region during the period 27-29 January. Record-breaking floods occurred in southwestern West Virginia on 29-30 January, with significant floods occurring in the headwaters of the Kanawha, Guyandotte, and Big Sandy River Basins. Approximately 7 inches of rain fell in the upper portion of the Big Sandy River Basin, and resulting flood stages along Tug Fork were 2 to 3 feet higher than previous floods of record. In southwestern West Virginia, rainfalls ranged from about 2 to 5 inches. Heavier rainfalls were also recorded in and near the Sutton Lake Basin, with nearly 3 inches of rain falling at Centralia and Webster Springs, and 3.87 inches of rain falling at Pickens. The Elk River exceeded all stages since the start of records in 1939, but was about 6 feet less than the historic flood of March 1918.

f. Storm and Flood of March 1967. Floods of record occurred in many northcentral and southern West Virginia watersheds as a result of heavy rainfalls occurring in early March. As a result of the flooding, over half of the State's 55 counties were declared disaster areas. Hardest hit were areas along the Guyandotte, Greenbrier, West Fork, and Little Kanawha Rivers. Flood damages were estimated at $16 million. The heaviest rains were centered just northeast of the Sutton Lake Basin, as Weston, Buchanan and Rowlesburg all reported more than 5 inches of rain during the period 4-7 March. Average rainfall over the Sutton Lake Basin during this period was approximately 3 inches.

g. Storm and Flood of December 1969. Rainfall combining with snowmelt from a major snowcover produced flooding on smaller streams in West Virginia at the end of December 1969. A coastal low pressure center produced a variety of weather conditions over the Atlantic coastal plain during the period of 25-27 December. Substantial snowfalls occurred in the Appalachian highlands, with more than 30 inches of snow falling over portions of Vermont and the northeastern United States. No snowfall data is available within the Sutton Lake watershed, but Camden-on-Gauley located just south of the basin received approximately 13 inches of snow during the storm. Following this storm, warmer temperatures and a major rainfall on 30-31 December created large volumes of runoff from the combined snowmelt and rain, producing flooding conditions in the basin. The rain began about noon on 29 December and fell nearly continuously until the early morning hours of 31 December, amounting to about 2 inches over the Sutton Lake Basin.

h. Storm and Flood of October 1976. Heavy rains of 4 to 5 inches during the first 10 days of October caused the rivers on the eastern slopes of the central Appalachians to rise to flood stage from interior Georgia to Maryland. In West Virginia, the major portion of the flood-producing storms occurred during the period 7-9 October. The heaviest precipitation fell just south of the Sutton Lake Basin in a band from near Camden-on-Gauley to Bartow. Snowshoe and Bartow each received just over 6 inches of rain during the period. In the Sutton Lake Basin, rainfall totals ranged from 2.99 inches at Centralia to 3.68 inches at Webster Springs. The heaviest rains at Webster Springs occurred during the evening of 8 October, as 1.0 inch of rain fell in a 2-hour period.

i. Storm and Flood of December 1978. Heavy rains associated with the passage of a cold front during 8-9 December caused flooding conditions in parts of Kentucky and West Virginia. In West Virginia, the heaviest rains fell in an east-west band from about Dunlow to Richwood, southwest of the Sutton Lake Basin. During the period 7-9 December, Dunlow received 7.13 inches of precipitation, with more than 6 inches falling in a period of 48 hours. Precipitation over the Sutton Lake Basin averaged just over 3 inches during the storm, with the major portion of the precipitation falling initially as rain, and the latter portion falling in the form of snow.

j. Storm and Flood of November 1985. West Virginia suffered its worst disaster in history as the result of flooding from the remnants of Hurricane Juan. The hurricane initially made landfall near Morgan City, Louisiana on the morning of 29 October. After being downgraded to a tropical storm, Juan moved eastward along the Louisiana coast, made landfall again just west of Pensicola, Florida at midday on 31 October, then curved northward. After bringing tropical downpours northward into the Carolinas and Virginia, a new wave formed along a stationary front located from the Great Lakes to the Gulf of Mexico. This re-energized the precipitation process, bringing deluges of rain to the mountain country of Virginia and West Virginia, to areas already soaked by the remnants of Hurricane Juan. Record high floods were experienced in adjacent parts of western Virginia, eastern West Virginia, western Maryland and southwestern Pennsylvania, affecting headwaters of the Potomac, Monongahela, James, and Little Kanawha Rivers. In West Virginia, 39 lives were lost, thousands were left homeless, and storm losses amounted to nearly $500 million. In West Virginia, the heaviest rain fell at Spruce Knob, where 10.57 inches of rain was recorded during the period 1 thru 6 November. In the Sutton Lake Basin, rainfall totals for the storms ranged from 6.13 inches at Webster Springs to 6.82 inches at Sutton Lake.

4-07 RUNOFF CHARACTERISTICS.

The Elk River watershed lies in an unglaciated section of the Appalachian Plateau, and is characterized by rugged, hilly country with narrow valleys which are conducive to flash floods. Basin runoff is highest during the winter months when storm rainfall may combine with snowmelt and when frozen or saturated ground can result in very low infiltration rates. Runoff is lowest during late summer and early fall when the ground is dry and infiltration losses are high.

Tables 4-5 presents average normal, maximum, and minimum runoff from the watershed just below the Sutton Lake damsite, based on 49 years of record (1939 through 1987) at the USGS gage. The gage is located about 0.9 mile downstream of the Sutton Lake dam and 0.5 mile upstream from the Granny Creek confluence.

TABLE NO. 4-5

MONTHLY AND ANNUAL RUNOFF
ELK RIVER AT SUTTON LAKE DAM

Month	Normal Average Flow (cfs)	Maximum Average Flow (cfs)	Minimum Average Flow (cfs)
January	1,600	18,100	100
February	1,889	18,000	95
March	2,188	15,500	11
April	1,366	20,400	75
May	1,203	9,300	74
June	741	10,800	62
July	665	17,400	24
August	543	10,800	8
September	386	6,370	5
October	612	18,800	1
November	1,099	7,820	7
December	1,520	19,000	32
Annual	1,152	14,358	41

4-08 WATER QUALITY.

Sutton Lake is located on Elk River which is located within the Kanawha River watershed. Basin geology, morphology, and land use determine the quality of water within the basin. Geological considerations are the most important because rock types in the drainage basin determine, to a great extent, the inorganic composition of the water. The Elk River lies wholly within the Kanawha section of the Appalachian Plateaus Physiographic Province. The area consist of high ridges separated by deep V-shaped valleys. All the rocks in the project drainage basin area are of sedimentary origin. They are composed of sandstone, shale, coal, indurated clays, and a few thin layers of limestone. The major uses of land in the basin include coal mining and timber.

Water quality data collected by the Corps of Engineers from 1974 to 1993 indicated that water quality of the basin reflected the above conditions.

4-09 CHANNEL AND FLOODWAY CHARACTERISTICS.

Elk River follows a tortuous course through a rugged mountainous country. The river channel varies from 100 to 300 feet in width, averaging about 200 feet. The average width of the valley floor is hardly more than 600 feet. The narrow strips of bottom land rarely exceed a few hundred feet in width and the amount of tillable land is small. Stream banks range in height from 5 to 10 feet near the source to about 30 feet near the mouth. Time of travel of Sutton Lake discharge along Elk River to Charleston is about 21 hours, and to the Ohio River at Point Pleasant is an additional 12 hours.

a. Population. The Sutton Lake watershed covers portions of Braxton, Webster, Randolf and Pocahontas Counties in West Virginia. Webster Springs is the largest village within the Sutton Lake watershed. The population of Webster Springs in 1980 was 939; in 1970, the population was 1,038. Sutton, the county seat of Braxton County, is the largest village near the Sutton Lake project area. In 1980, the population of Sutton was 1,192; the total population of Braxton County was 13,894.

b. Industry and Agriculture. Within the Sutton Lake watershed, more than 65 percent of the basin is forested, presenting a renewable resource that employs nearly 10 percent of the workforce. The basin is not well adapted for farming due to the rugged terrain and low fertility of the soils; however diversified farming is the principal industry of the basin. The chief crops are corn, small grains and hay. The bottom lands are relatively fertile, but are too narrow for efficient mechanized farming operations. Thus farm production is limited mainly to the subsistence level. Coal mining and lumbering are conducted on a limited scale and are next in importance to farming.

c. Flood Damages. Most of the great floods of record in the Kanawha River Basin occurred quite long ago and damages were slight due to the low value of developments in the basin. If such floods were repeated under present conditions, the destruction of property would be much higher since the flood plain has since been extensively occupied by cities, towns, railroads, industrial plants and highways. Most of the urban developments in the Kanawha

River Basin, including Charleston and its adjacent industrialized areas, are located on the flood plains of the Kanawha River and its major tributaries. Flooding along tributary streams occurs frequently; however, flooding along the industrialized main stem valley occurs only occasionally. The highest flood of record at Charleston, WV occurred in September 1861 and covered most of the city. If the flood of September 1861 should reoccur under present conditions of development, approximately forty percent of the area contained within the Charleston corporate limits would be inundated to depths ranging up to eleven feet.

In 1964, a flood damage survey was performed on the main stem of the Kanawha River from Leon to Gauley Bridge, West Virginia. This survey estimated flood damages which would have resulted in this reach if stages equivalent to those produced by the three greatest floods of record had been produced in 1964. The survey results indicated that damages would have totaled $215 million without any stage modifications associated with current upstream reservoirs such as Sutton Lake.

SECTION V - DATA COLLECTION AND COMMUNICATION NETWORKS

5-01 HYDROMETROLOGICAL STATIONS.

a. Facilities. Numerous stream gaging stations, designed for the collection of hydrologic data, are located at strategic sites in and around the Elk and Kanawha River Basins. Those stations pertinent to Sutton Lake are shown in Table No. 5-1.

The Huntington District water control system consists of a state-of-the-art computer, located in Water Resources Engineering Branch, and many Data Collection Platforms (DCPs) and Hydrologgers located throughout the district at various stream gaging and precipitation stations. Installations at stations in the Elk River Basin are described in Table Nos. 5-1 and 5-2. DCPs collect, store, and transmit data via the Geostationary Operational Environmental Satellite (GOES) to various receive sites. The current hydrologic network system is illustrated in Plate 5-1. Data collected by DCPs in the Huntington District are received by the Ohio River Division (ORD) downlink in Cincinnati, Ohio and disseminated at least hourly to the District water control system via the ORD water control system over a leased line.

Many DCPs, with added "voice" capability, and all Hydrologgers answer human telephone queries by simulated voice with latest or current readings and answer computer queries with stored data.

All daily reservoir reports are now received through the water control system. Each project report is entered into a computer terminal offline and transmitted directly over telephone lines to the district water control system. The district radio network is used as backup, when needed. Data are also received from the National Weather Service (NWS) through the water control system. Reservoir project data are also disseminated back to the NWS from the water control system.

(1) Stream Cooperative Program. The Corps of Engineers participates in the U.S. Geological Survey Federal-State Cooperative Water Resources Program under which the Survey installs, rates and maintains the gages at locations desired by the cooperating entity, except at Corps' projects where the lake and outflow gages are originally installed by the Corps. Under this program, the Survey maintains the stream gaging stations on Elk River below Webster Springs and Sutton Lake, near Frametown, and at Clay and Queen Shoals.

The Corps of Engineers also maintains several gages in the Elk River Basin independent of the stream cooperative program. These installations are described in Table No. 5-1.

(2) Collecting and Reporting Facilities. Strip chart recorders provide a graphical record of stream stage and a backup for Analog-to-Digital Recorder (ADR) devices. Shaft encoders are used to digitally record water levels. The data collection platforms have been installed at basin gages. The platforms store stage and precipitation data and every four hours transmit to the ORD computer downlink via the Geostationary Operational and Environmental Satellite. The Water Resources Engineering Branch water control system receives data automatically from the ORD water control system on an hourly basis. If desired, the District can also access the data at other times by operator control.

TABLE NO. 5-1

SUTTON LAKE
ELK RIVER-KANAWHA RIVER BASIN STREAM GAGING NETWORK - PERTINENT DATA

Stream and Station	Zero Gage Elevation (Feet, m.s.l.)	Drainage Area (Sq. Mi.)	Date Established (Mo./Yr.)	Existing Station Facilities	Method of Obtaining Data
Elk River below Webster Springs*	1020.0	268	10/59 11/82	Recorder. Encoder, DCP.	Sutton report, DCP transmission.
Right Fork Holly River at Guardian	1078.0	51.1	2/74 11/82	Recorder. Hydrologger.	Sutton report.
Left Fork Holly River near Replete		48.1	2/74 11/82	Recorder, electric tape. Encoder, DCP.	Sutton report, DCP transmission.
Elk River at Sutton Lake	m.s.l.	537	1960	Recorder.	Sutton report.
Elk River below Sutton Lake*	800.0	543	2/39	Recorder, electric tape.	Sutton report.
Elk River near Frametown*	775.51	752	11/58	Recorder, electric tape.	Sutton report.
Elk River at Clay*	677.46	994	3/59	Recorder, electric tape.	Sutton report.
Elk River at Queen Shoals	604.09	1145	11/28	Recorder.	Sutton report.

Note: DCP - Data Collection Platform. DCP transmits via satellite to Ohio River Division (ORD) downlink every 4 hours. ORD Water Control System (WCS) receives from downlink and disseminates hourly to Ohio River Huntington (ORH) WCS. Voice DCP's are equipped to respond to telephone calls with electronically synthesized voice.

Encoder: Shaft encoder.
* Included in U.S. Geological Survey Cooperative Water Resources Program.

Some data collection platforms have the capability of reporting in response to a telephone query by computer, terminal or human. The query can be initiated at any time from the water control system, Project Office or the home of a selected individual during off-duty hours. In response to a human caller, the platform will respond with the last recorded information such as stage with a synthesized voice. Information from the DCP's may also be obtained directly by the water control system computer. The DCP's can also dump several readings taken over a period of hours to a computer terminal. These DCP's have been installed at critical locations such as inflow, lake, outflow, and some control point stations.

(3) Reports. Currently, morning reports from the Kanawha watershed projects, containing stage, precipitation, operational and temperature data, are received in the Water Control Section as computer printouts from the water control system. They are received in the same format in which they are input at the Project Office. Stage data are converted to flow and the values are used in the forecasting process. Frequency of reporting, and thus data collection, are dependent on the degree of urgency of weather and/or flooding conditions as specified in Exhibit B, Instructions to Damtender. The frequency ranges from daily (5 days per week) at about 0730 hours under Normal Conditions to hourly under Major Flood Conditions when the lake level approaches or threatens spillway elevation. Project data are submitted to the District water control system in accordance with the schedule for Reading Gages.

b. Precipitation Stations.

(1) ORN Program. The Ohio River Reporting Network, a divisionwide cooperative program with the National Weather Service, involves interchanges of information between the Weather Service and the Corps of Engineers which utilizes the respective installations and experience of the two agencies. The Weather Service recruits, trains, equips, and pays observers at Corps requested locations and receives and records data from them. The Weather Service also provides weather and stream stage data, Ohio River and tributary forecasts, regular and requested special forecasts, radar and other special reports on request. In addition to reimbursing NWS for direct costs incurred on the Corps' behalf, Huntington District provides NWS with all precipitation, snow cover, and stage information received in the Water Resources Engineering Branch from reservoir and other reports, three-day pool and outflow forecasts, and depth reports from the Corps of Engineers' Snow Cover Reconnaissance.

There are numerous precipitation stations within the Elk River watershed. The pertinent data for the stations associated with Sutton lake are shown in Table No. 5-2(T5-1), table section in back.

(2) Collecting and Reporting Facilities. Normal equipment is the 8-inch Standard Rain Gage with a metal support. Most of the reporting stations pertinent to Sutton Lake have this standard gage. Stations at Sharps Knob, Replete, Frametown, Queen Shoals, and the outflow station at Sutton Lake utilize a tipping bucket gage. Other stations utilize both a standard gage and a tipping bucket gage, including those at Webster Springs, Birch River and Clay. At ORN weather stations, the standard 8-inch rain gage is read and reported manually by telephone landline to either the National Weather Service Office in Charleston or to the Sutton Lake Project Office. At the unattended stations, the "tipping bucket" measuring gage is interfaced to a data

collection platform. The platform receives the signal electrically and transmits to the computer downlink via the satellite. Station locations pertinent to the Sutton Lake watershed are shown on the Basin Drainage Map, Plate 2-12, and data collection and communication equipment utilized at each are listed in Table No. 5-2(T5-1), back table section.

(3) Reports. Weather Service observers who report by telephone to the Sutton Lake Project Office include those at Webster Springs, Birch River, Centralia, Big Otter, and Clay. Observers who report to the National Weather Service Office in Charleston include those at Valley Head, Pickens, Hacker Valley, Camden-on-Gauley, Gregory, and Clendenin.

The Water Resources Engineering Branch utilizes platform information, morning report information and Weather Service data in forecasting and computing average precipitation over the Sutton Lake Basin and Kanawha River Basin District. Weather Service information for areas lacking Corps projects, when plotted on the District Isohyetal Map, provides better understanding of storm movement and aerial intensity. This additional coverage contributes to improved water management decisions.

National Weather Service radar also provides valuable information for regulation and forecasting. Radar receivers at NWS display reflected "echoes" of precipitation in the form of a visual readout. These radar echoes show relative intensity and aerial extent of the precipitation. The NWS Hydrologist analyzes the radar information for position, direction and speed of movement, and estimated precipitation amounts and relays this analysis by telephone on request.

5-02 WATER QUALITY STATIONS

a. Facilities. A network of 46 water quality sampling stations were established at the Sutton Lake project. Primary stations located on the lake are shown in Plate 5-1. ALL primary stations within the basin are described in Table No. 5-3.

b. Reporting. Water quality data collected at Sutton Lake is used to meet such objectives as:

(1) Establish baseline conditions and monitor subsequent changes;

(2) Identify water quality environmental problems;

(3) Study special problems or develop criteria for such solutions as modification of reservoir regulation procedures aimed at controlling or enhancing environmental conditions and meeting water quality objectives; and

(4) Provide a data base adequate for understanding project conditions and for coordination with state agencies in regard to implementing any needed watershed pollution control.

TABLE NO. 5-3

Description by Location of Sutton Lake
Primary Water Quality Sampling Stations

Station	Distance From the Dam	
SUT0001	322 Meters	Above
SUT0007	35.5 Kilometers	Above
SUT0008	36.4 Kilometers	Above
SUT0009	37.2 Kilometers	Above
SUT0010	1.6 Kilometers	Below
SUT0012	161 Meters	Below
SUT0017	1.9 Kilometers	Above
SUT0018	3.5 Kilometers	Above
SUT0019	5.1 Kilometers	Above
SUT0020	6.8 Kilometers	Above
SUT0021	8.4 Kilometers	Above
SUT0022	10.0 Kilometers	Above
SUT0023	11.6 Kilometers	Above
SUT0024	13.2 Kilometers	Above
SUT0025	14.8 Kilometers	Above
SUT0026	16.4 Kilometers	Above
SUT0027	18.0 Kilometers	Above
SUT0028	19.6 Kilometers	Above
SUT0038	24.3 Kilometers	Above
SUT0039	3.2 Kilometers	Below
SUT0040	11.1 Kilometers	Below
SUT0041	12.9 Kilometers	Below
SUT0042	41.4 Kilometers	Below
SUT0043	57.8 Kilometers	Below
SUT0045	19.0 Kilometers	Above

Parameters to be measured, frequency of collection, and number of data collection stations at any one time are determined by specific project conditions. The water quality program design for Sutton Lake was structured to describe the various factors which affect water quality over the long term. Data collected are used for applications such as identification of trends which indicate problem conditions and reporting existing conditions. Basic studies consist of 5 essential components:

(1) in-situ measurements to evaluate distribution of various properties

(2) wet chemistry and various types of solids for both immediate and long-term use

(3) indirect but rapidly obtainable indicators of productivity such as chlorophyll and carbon

(4) benthic organisms to monitor long-term quality of inflows and outflow

(5) other biological measurements such as plankton and seston Standard physical/chemical tests and reasons for testing are presented in Table No. 5-4.

c. Maintenance. Sediment and water samples are collected annually from Sutton Lake once every 5 years. Water samples are also collected every 10 years each month from April through September. During emergency or under adverse conditions water quality samples are collected on an as-needed basis. In all cases data are collected for one or more of the following reasons:

(1) long term analysis
(2) problem identification or solution
(3) cause and effect relationships
(4) mathematical modeling
(5) predictive capability

Present sampling programs are oriented toward existing or potential effects and are structured to describe various factors at the project which affect water quality.

TABLE NO. 5-4

Standard Physical/Chemical Tests

Type of Test	Reason for Testing
Calcium (Ca) Magnesium (Mg) Sodium (Na) Potassium (K)	Major Cations - Ionic Balance, ratios and relationships
Sulfate (SO4) Chloride (Cl)	Major Anions - Ionic Balance, ratios and relationships
Nitrogen (N) Nitrate + Nitrite Ammonia Total Kjeldahl Total Organic Carbon	Nutrient
Phosphorous (P) Total Filterable	Nutrient
Solids Total Suspended Dissolved	Equivalent Ambient Values, Correlation with optical measurements
Hardness	Evaluate buffer capacity and Alkalinity characteristics
Metals Iron (Fe) Manganese (Mn)	Important for hypolimnetic and outflow evaluations during stratification
Dissolved Oxygen Temperature pH Specific Conductance	Insitu parameters used to evaluate conditions for project operation

5-03 SEDIMENTATION.

a. Lake. Sedimentation surveys have been completed at Sutton Lake in 1973, 1979, and 1984. A network of sediment ranges was established in the Sutton Lake area between 1959 and 1965. The network consisted of 46 category "A" sediment ranges, all located in the lake area above the dam. In 1979, three additional sediment ranges, category "C", were established downstream of the dam. The current network of sediment ranges is shown on Plate No. 5-2.

For the 1973 study, all of the original 46 sediment ranges upstream of the dam were resurveyed. The detailed study indicated a sedimentation rate of 0.16 acre-foot per year per square mile for the period of February 1960 to January 1973, the mean date of the resurvey. This rate was not considered to be excessive or detrimental to the project.

In August 1979, a reconnaissance scope sedimentation study was conducted at Sutton Lake. As part of this study, 13 of the original 46 sediment ranges were investigated. Lake bottom profiles were obtained by use of a fathometer, at or near the selected sediment ranges. The results of this study did not indicate any significant increase in sedimentation since the 1973 study.

In 1984, another sedimentation reconnaissance of the lake was conducted. During this study, 18 of the original 46 sediment ranges were investigated. The water depth along each range was again obtained by use of a fathometer, but horizontal control was not maintained. Comparison of the data obtained from this study with previous studies indicated that sedimentation in the seasonal pool at Sutton Lake was not excessive. It was recommended that the next sedimentation study at Sutton Lake be of detailed scope and be conducted in FY 1993.

b. Stream. Sedimentation in Elk River within the area inundated by the seasonal pool was analyzed as part of the 1984 sedimentation survey.

5-04 RECORDING HYDROLOGIC DATA.

Each morning a full report of the previous days activities at the project will be made. The morning report will be compiled on ORH Form 13. This report will then be forwarded to the Area Office and to Water Resources Engineering Branch. The Area Office then forwards a combined morning report by WITS to the Huntington District Office, and a copy of the morning report is retained as a part of the permanent file at the project.

5-05 COMMUNICATION NETWORK.

High-quality radios are installed at the District Office, Area Offices, construction field offices, and navigation lock and dam installations. These installations also have commercial telephone service. Data collection DCP's are installed at several stream gaging stations and precipitation stations in the Elk River Basin. The DCP's transmit data (several readings over a period of hours) via the Geostationary Operational Environmental Satellite (GOES) to a computer downlink that is accessed by the Water Resources Engineering Branch water control system. As outlined in Table No. 5-1, voice DCP's have been added to some streamgaging stations. Plate 5-3 graphically illustrates the communication network throughout the Kanawha River Basin.

5-06 COMMUNICATION WITH PROJECTS.

The telephone is utilized for normal communications by the Water Resources Engineering Branch, Kanawha Area Office, and project personnel. District communications are normally made directly to the individual projects. District radio is used for emergency backup communications; standard procedures require radios to be turned on at all times during working hours. During military emergency or national disaster, protected commercial telephone lines with the Kanawha River Basin projects or special radio frequencies may be assigned by the Emergency Operations Manager. The District radio communication network is shown on Plate 5-3. Mobile radio, State Police, couriers, or other available means are utilized during an emergency when neither the telephone nor district radio is operational. The U.S. Postal Service is utilized for letters, reports, or other voluminous information, pictorial material, confirmation of Special Directives and other formal communication. Occasional visits to the projects afford an opportunity for office and project personnel to discuss ideas, problems, new procedures, etc.

5-07 PROJECT REPORTING INSTRUCTIONS.

a. District Staff. Major flood conditions may require daily or more frequent briefings for key staff members. During floods or other disasters when the Emergency Operations Center is in operation, Water Resources Engineering Branch personnel distribute copies of all reports received for critical and adjoining areas to the Center, District Engineer, Chief Engineer, and Executive Officer. Storm analysis, critical situation information and operational data are provided to pertinent key staff as determined to be informational or necessary. The Public Affairs Office is kept advised to ensure proper public notification.

b. Emergency Management Division. The Water Resources Engineering Branch has no regular communication with Emergency Management Division (EMD) except as mentioned above when the Emergency Operations Center is in operation. When storms occur in the district or high precipitation is shown on a NWS Quantitative Precipitation Forecast, the Water Resources Engineering Branch telephones EMD to pass on the information. Frequently EMD personnel will visit the Water Resources Engineering Branch in person for further briefing. When EMD personnel learn of storms in or heading for the district, they visit the Water Resources Engineering Branch for evaluation and determination of impact. During these meetings, participants view Quantitative Precipitation Forecasts, other NWS forecasts and current information, District Isohyetal (precipitation) Maps, morning reports, etc.

c. Ohio River Division Water Management Branch. Telephone land lines and the U.S. Postal Service carry all normal communications between the Water Resources Engineering Branch and the Water Management Branch (WMB). Radio is used as backup in emergency situations. When desired, pictorial, handwritten or printed material can be transmitted in a matter of minutes over land lines by facsimile machine. A file containing observed data, 3-day forecasts of lake and outflow for all reservoir projects and 5-day flow forecasts for Ohio River tributary gage points is generated by the water control system. Subsequent to final modeling and certification, the file is transmitted to WMB by leased line. The Water Resources Engineering Branch briefs WMB personnel who call three times weekly, normally Monday, Wednesday and Friday, for updates on any and all special operations in the district. A Report of Deviation, revised Form ORD 1018R, may be requested by WMB on the occasion of a special purpose operation at Sutton Lake outside the approved plan of regulation.

d. Operations and Readiness Division Area Office. Sutton Lake is, for administrative purposes, included with the Kanawha River Reservoirs under the Kanawha Area Office, at Summersville, West Virginia. Normal communication between Water Resources Engineering Branch and the Area Office is by telephone, mail transfer of disposition forms, reports, maps, drawings, and other pictorial material, and occasional visits by Branch personnel. Emergency communication is by radio.

e. National Weather Service. Communication with National Weather Service (NWS) begins with cooperative arrangements for the ORN program discussed earlier in sub-section 6-02b(1). Precipitation amounts are included in the morning report to the District water control system and to the National Weather Service Office in Charleston, West Virginia.

The Division Office currently has a direct link with the NWS Automated Field Operating System (AFOS) and disseminates data from AFOS to the District water control system at least once an hour. Information formerly received from the NWS Weather Wire is also now received via the AFOS link in the Division Office.

f. U.S. Geological Survey. Communication between the Water Resources Engineering Branch and U.S. Geological Survey (USGS) is varied and affected by the meshing of interests of the two entities. A large portion of the communication surrounds the stream cooperative program discussed in sub-section 6-02a(1) and involves telephone discussions and mailed information on gage location, ratings, and rating extensions. Telephone requests are made by the Water Resources Engineering Branch for the USGS to repair a gage critical to regulation of a reservoir in flood condition. Annual meetings are held with the USGS concerning the cooperative program. Additional meetings are held with the USGS as deemed necessary.

g. State and Local Agencies. Water Resources Engineering Branch coordinates with the West Virginia Division of Natural Resources about recreation and fish and wildlife enhancement in the West Virginia lakes and downstream areas, timing of spring filling and fall drawdown, probable height of a rise and, during emergency, with the Department's representative in West Virginia Office of Emergency Services. Water Quality Section personnel meet with Department fisheries personnel in the winter to seek their input and comments on the proposed District water sampling and testing program for the ensuing season. The Section Chief is an active member of the State Water Quality Advisory Board which advises the Chief of the Department's Division of Water Resources. In certain instances, Water Resources Engineering Branch or the Department confirms telephone conversations or transmits information and data by mail.

Water Quality Section maintains contact during the period of lake stratification with the West Virginia Division of Natural Resources, by mailing to the assigned contact point copies of the weekly Water Quality Assessment for Sutton Lake. If a potentially or currently serious situation develops, the Water Quality Section chief telephones the Department Fisheries Biologist assigned the Kanawha Basin Lakes to advise and discuss the situation. If necessary, Water Quality Section may begin a special study to determine the cause and/or remedy.

Sutton Lake personnel coordinate in person and by telephone with Department personnel concerning the forest fire protection agreement with Forestry Division, stocking of the lake and tailwaters, enforcement of fish and game licensure, and boating safety. Project personnel cooperate with the State Health Department by sampling all drinking water for biological safety factors, mailing to Charleston for analysis and receiving results by mail. The State Highway Department coordinates details of road maintenance with the project office by telephone and in person.

County offices with which project personnel communicate are the Sheriff's Department and Health Department, the first in conjunction with the patrol and law enforcement contract, and the second concerning periodic inspections of the Marina by the Health Department in compliance with provisions of the Corps of Engineers lease.

h. General Public and Commercial Interests. There are no interests downstream of the dam vulnerable to flooding at discharge rates up through respective channel capacities. However, in order to advise recreators below the dam of impending increases in outflow, a discharge warning horn is blown at the pylon whenever the total gate opening is to be increased.

SECTION VI - HYDROLOGIC FORECASTS

6-01 GENERAL.

Hydrologic forecasts of stream flows above and below Sutton Lake are vitally important to Water Control Management. The Water Resources Engineering Branch utilizes all available hydrologic and meteorologic data and the best methods available in preparing stream flow forecasts for the Kanawha River Basin under low flow, normal flow and flood flow conditions for optimal project management.

a. Corps of Engineers.

(1) District Office. In accordance with ORDR 1110-2-27, dated 12 January, 1976, Subject: Water Control Management Activities, the Water Resources Engineering Branch performs water control management activities for multi-purpose projects throughout the Huntington District. These activities include the preparation of forecasts for lake inflows, lake levels, project outflows, water quality, outflow temperature, and flows at downstream stations to insure the safe and efficient operation of the district projects. River forecasts prepared by the Corps of Engineers are generally used for its own responsibilities and are not normally issued to the general public unless the National Weather Service is willing to make the release or agrees to such a release.

(2) Division Office. The Water Management Branch at the Great Lakes and Ohio River Division Office utilizes the 5-day tributary forecasts prepared by the individual districts to derive its own 5-day flow forecasts for stations along the Ohio River.

b. National Weather Service. The National Weather Service (NWS) has the official responsibility for preparing forecasts of Ohio River stages and flows, and for transmitting data, forecasts, watches, and warnings to users and the general public. NWS also collects and evaluates weather data from a variety of sources to prepare short and long-term weather forecasts.

6-02 FLOOD CONDITION FORECASTS.

a. Requirements. The special requirement of flood forecasting is that the forecast be both accurate, usable, and timely. A breakdown or error in any of these areas can lead to a serious mis-operation of one or more reservoirs. The most effective method of forecasting has been to have accurate data for the storm and stream basin and to process or develop the forecast quickly, in order that it may be disseminated and used well before the flood or reservoir crests. A late or inaccurate, or even illegible forecast can often create a very bad or impossible situation for many people.

b. Methods. In order to achieve the most efficient water control management possible, a real-time computer model, developed for Hydrology and Hydraulics Branch by the Hydrologic Engineering Center (HEC) at Davis California, was adapted and calibrated for use in management of the Walhonding-Tuscarawas-Muskingum River Basin. The model, a major part of the District water control system, primarily was real time data form the Corps of Engineers' satellite platform network in and adjacent to the basin, along with existing data bases.

The model forecasts both reservoir inflow and releases and provides project operation based on downstream constraints. In addition to reservoir conditions, the model forecasts streamflows for all downstream control stations under both natural and regulated conditions. Currently, the model is being utilized for flow forecasts and will be expanded later to include water quality and temperature operations and forecasts.

A typical sequence of events leading to water control management decisions is described as follows:

1. Satellite data, both stage and precipitation, are received from the GLD downlink, decoded and added to the resident data base. This is done automatically each hour.

2. Observed precipitation and flow data are reviewed graphically to insure integrity. Any necessary corrections are made and any missing data are added when available from supplementary sources.

3. The precipitation-runoff model is executed based on observed data up to the time of forecast. If precipitation is occurring at the time of forecast then future precipitation is considered in the model execution. If necessary, the model base conditions are adjusted and the model is reexecuted to insure that observed conditions and time-of-forecast conditions in the model agree.

4. The operations model is then executed to obtain suggested project outflows and the downstream results of the suggested outflows.

5. Steps 3 and 4 are repeated to obtain subsequent forecasts that consider any additional precipitation (QPF), special regulation or other hypothetical analyses that may be required.

6. Forecast results are reviewed graphically using the display module of the water control system, after which water control decisions are made and key forecasts are saved in the data base.

6-03 CONSERVATION PURPOSE FORECASTS.

a. Requirements. The requirement for conservation forecasting is that the forecast be both accurate, usable, and timely. A breakdown or error in any of these areas can lead to a serious water crisis for one or more basins. The most effective method of forecasting has been to have accurate data for the area and stream basin and to process or develop the forecast quickly, in order that it may be disseminated and used well before the flood or reservoir crests. A late or inaccurate, or even illegible forecast can often create a very bad or impossible situation for many people. Low-flow conservation forecasts are usually for a longer period then flood forecasts and often are produced with a longer period of lead time.

b. Methods. In order to achieve the most efficient water control management possible, a real-time computer model, developed for Water Resources

Engineering Branch by the Hydrologic Engineering Center (HEC) was adapted and calibrated for use in management of the Elk-Kanawha River Basin. The model, a major part of the District water control system, primarily uses real-time data from the Corps of Engineers' satellite platform network in and adjacent to the basin, along with existing data bases. The model forecasts both reservoir inflow and releases and provides project operation based on downstream constraints. In addition to reservoir conditions, the model forecasts streamflows for all downstream control stations under both natural and regulated conditions. Currently, the model is being utilized for flow forecasts and will be expanded later to include water quality and temperature operations and forecasts.

A typical sequence of events leading to water control management decisions is described as follows:

1. Satellite data, both stage and precipitation, are received from the ORD downlink, decoded and added to the resident data base. This is done automatically each hour.

2. Observed precipitation and flow data are reviewed graphically to insure integrity. Any necessary corrections are made and any missing data are added when available from supplementary sources.

3. The precipitation-runoff model is executed based on observed data up to the time of forecast. If precipitation is occurring at the time of forecast then future precipitation is considered in the model execution. If necessary, the model base conditions are adjusted and the model is reexecuted to insure that observed conditions and time of forecast conditions in the model agree.

4. The operations model is then executed to obtain suggested project outflows and the downstream results of the suggested outflows.

5. Steps 3 and 4 are repeated to obtain subsequent forecasts that consider any additional precipitation (QPF), special regulation or other hypothetical analyses that may be required.

6. Forecast results are reviewed graphically using the display module of the water control system, after which water control decisions are made and key forecasts are saved in the data base.

6-04 LONG-RANGE FORECASTING.

a. Requirements. Long-range forecasts assist the Huntington District in water control management in the Kanawha River Basin. Plate 6-1 shows the forecast area and reaches. A long-range forecast of a dry spring can allow earlier than normal filling during late winter or early spring to reach summer seasonal pool levels in time for the beginning of the recreational season. If a drought is projected for summer, the summer seasonal pool may be raised where possible to store additional water for later release downstream, if not injurious to other project purposes. Where this additional storage is possible, the later releases can supplement low flows in tributaries or downstream in the Ohio River, where abnormally low flow can cut off shipping. Knowledge of an impending drought in the fall could lead to early winter drawdown for downstream benefit.

The long-range forecasts to the Division Headquarters Water Management Branch (WMB) allows the Division to inform the Lower Mississippi River Division (LMRD) of probable future conditions and to suggest specific items of water control management to the districts. LMRD receives a weekly 21-day forecast of flows to assist them in the scheduling of in the Lower Mississippi River.

The 21-day forecast is produced utilizing long-term averages of various stations along the Ohio River and the latest issue of Average Monthly Outlook. For longer range forecasts, WMB utilizes a partial probability method made up of historic average monthly flows in the river and a computer program which projects probable future flows.

b. Methods. The Water Management Branch produces the weekly 21-day forecasts requested by the Lower Mississippi River Division by consulting the record of long-term average flows at various stations on the Ohio River and the latest Average Monthly Outlook for a 60 percent probability of precipitation being higher or lower than normal. The method assumes that normal precipitation produced the long-term average flows in the river, and that variations from the normal precipitation will produce corresponding variations in stream flow.

When districts request longer term forecasts, WMB utilizes flow data for the last available full month, and a computer program projects the flow in the river for one month and two months in advance. For 10-day forecasts, WMB utilizes the regular 5-day forecast and extends it through the use of long-term normals.

6-05 DROUGHT FORECASTING.

a. Requirements. Drought forecasts also assist the Huntington District in water control management in the Kanawha River Basin. Plate No. 6-1 shows the forecast area and reaches. A long-range drought forecast of a dry spring can allow earlier than normal filling during late winter or early spring to reach summer conservation pool levels in time for the beginning of the recreational season. If a drought is projected for summer, the summer conservation pool may be raised where possible to store additional water for later release downstream, if not injurious to other project purposes.

The long-range forecasts to the Division Headquarters Water Management Branch (WMB) allows the Division to inform the Lower Mississippi River Division (LMRD) of probable future conditions and to suggest specific items of water control management to the districts. LMRD receives a weekly 21-day forecast of flows to assist them in the scheduling of dredging in the Lower Mississippi River.

The 21-day forecast is produced utilizing long-term averages of various stations along the Ohio River and the latest issue of Average Monthly Outlook. For longer range forecasts, WMB utilizes a partial probability method made up of historic average monthly flows in the river and a computer program which projects probable future flows.

b. Methods. The Water Management Branch produces the weekly 21-day forecasts requested by the Lower Mississippi River Division by consulting the record of long-term average flows at various stations on the Ohio River and the latest Average Monthly Outlook for a 60 percent probability of precipitation being higher or lower than normal. The method assumes that normal precipitation produced the long-term average flows in the river, and that variations from the normal precipitation will produce corresponding variations in stream flow.

When districts request longer term forecasts, WMB utilizes flow data for the last available full month, and a computer program projects the flow in the river for one month and two months in advance. For 10-day forecasts, WMB utilizes the regular 5-day forecast and extends it through the use of long-term normals.

c. Reference Documents. Many of the basic documents for drought forecast are in the Corps of Engineers Library, Huntington District, Huntington, West Virginia. This library contains records prepared by the Ohio Division of Natural Resources and the Ohio USGS for past drought periods, the Water Inventory of The Muskingum Basin, Water Availability Studies for the Muskingum Basin, and the Ohio River Basin Comprehensive Study, prepared by the Ohio River Division, Cincinnati, Ohio. Also included are the national and state weekly drought forecasts and Palmer Index summaries for the current and preceding drought period.

SECTION VII - WATER CONTROL PLAN

7-01 GENERAL OBJECTIVES.

In accordance with ER 1110-2-240, "Water Control Management," dated 8 October 1982, and ORDR 1110-2-27, "Water Control Management Activities", dated 12 January 1976, the plan of water control management and regulation reflects optimal consideration of each project purpose, namely flood control, lake and downstream recreation, whitewater activities, fish and wildlife conservation, and water quality control. In developing the plan of regulation, the following general requirements were considered and evaluated in relation to the overall effective water control plan for the Sutton Lake Project, the Kanawha River Basin, and the Ohio River Basin.

a. Prevention or reduction of serious damages to communities, crops, properties and industries below the dam along the Elk and Kanawha Rivers to the greatest extent consistent with safe operation of the project.

b. Maximum retention of flows that would add to flood crests on the Ohio River below Point Pleasant, West Virginia.

c. Maintenance of a minimum discharge of 75 cfs, which is designed to be adequate to sustain downstream aquatic populations.

d. Maintenance of a minimum pool elevation 895 feet, subject to minimum discharge, to support fish populations and provide space for sediment storage.

e. Maintenance of a seasonal pool near elevation 925 feet for recreation and fish and wildlife conservation between approximately 1 April and the optimum date to begin drawdown in the fall, considering all hydrometeorological and recreational factors, subject to flood control and minimum discharge purposes.

f. Provision for increases in outflow to insure minimum damaging discharge when there are indications that the available storage will be insufficient to completely control the flood.

g. Establishment of maximum allowable discharge to avoid downstream damage during flood releases.

h. During minor rises when releases are less then downstream channel capacity, limitation of release rates to the maximum flow that would have occurred if the project had not been constructed.

i. Controlling discharge temperature to enhance downstream aquatic communities.

j. Sensitivity to reasonable requests for operational changes from the public or other agencies.

k. Concern for safety and well-being of humans, fish and wildlife, manmade structures and streambanks downstream of the dam, which can be affected by discharge control.

l. Concern for safety of humans and property at recreation sites in the lake area.

m. Limitation of the rate of change of stage at the outflow station to a value no greater than that which would occur naturally.

7-02 MAJOR CONSTRAINTS.

Constraints to regulation of the water control plan at Sutton Lake include interests both upstream and downstream of the dam which are affected by higher than normal pool elevations. Maximum allowable gage heights downstream restrict the total outflow that can be discharged from Sutton Lake during normal operations to protect navigation, electric power production, industry, communities, farming interests, recreation and roads downstream of Sutton Lake. Rising pool levels also affect recreation interests upstream within the flood pool. Camping areas and access roads to the lakeside camping areas are the first areas to be affected by rising pool levels at Sutton Lake. A rise in pool level to elevation 930 affects approximately 81 campsites at Sutton Lake. Prior to inundation of a camping area, all campers must pack and move out, operations personnel occasionally have to move an unoccupied trailer, comfort stations must be secured which requires removal of electric water heaters, hand dryers, and at one station, electric heaters. Compressor motors on sewage treatment plants require removal, as do some items in the water treatment system. Since a major storm event can occur at any time, the time needed to collect and evaluate rainfall data, notify personnel, travel to the given areas, and perform the above described operations necessitates that increased storm inflow at the onset of the storm be passed downstream to the maximum extent possible to limit lake level increases. As the flood pool rises, the proper authorities are notified of the impending high water levels.

7-03 LOW FLOW CONTROL AND POLLUTION ABATEMENT.

a. Requirements. Fish and food chain organisms require a continuous flow of oxygenated water for maintenance of normal vitality. A report prepared by the United States Fish and Wildlife Service in September 1958 recommended a minimum release of 200 cfs during the spring filling period of April and May, and 75 cfs at all other times for fish habitat below the dam. Based on studies of monthly flow records on Elk River, it was determined that regulation of low flows as recommended by the Fish and Wildlife Service would result in only minor and rare adverse effects on low-flow regulation for pollution abatement requirements, and no adverse effects on water supply requirements. Based on these findings, the plan of regulation provides a minimum release which varies between 120 and 200 cfs, as inflow permits, during the spring filling period of April and May, and 75 cfs at all other times.

The plan of regulation for Kanawha River pollution abatement consists of utilizing available seasonal storage of Sutton Lake in conjunction with seasonal storage in Summersville Lake for pollution abatement in the Kanawha River. The seasonal storage at both lakes is utilized for augmentation in the Kanawha River based on the water temperature of the Kanawha River as described on Plate 7-1, Rule Curve for Regulation.

b. Control Plan. Sutton Lake is regulated for low flow control in accordance with the rule curves as presented in Plate 7-1. These curves were derived in order to provide for minimum releases for fish habitat, and maximum utilization of storage for pollution abatement. The upper limiting curve was established for periods of adequate flow in the Elk and Kanawha Rivers, while the lower limiting rule curve was developed for low-flow periods. Releases required for pollution abatement purposes are scheduled from the storage available between the upper and lower limiting rule curves as shown on Plate 7-1.

During April and May, an outflow of 200 cfs will be maintained below Sutton Lake, subject to flood control and filling requirements. During the spring filling period, if the rate of rise falls below the release zone of 200 cfs, releases will be maintained as indicated by the rule curve release zones. Under no circumstances will the release rate fall below 75 cfs.

From 1 June to 30 November, releases in excess of 75 cfs for pollution abatement in the Kanawha River are computed in the district office, and the subsequent operating instructions are transmitted by Special Directive to the Damtender. Until a 69 percent reduction in waste load discharged to the river has been accomplished, an interim method of computing releases is based on the following assumptions:

(1) Water temperatures of the Kanawha River at Charleston and Winfield Dam are known.

(2) Maintenance of the dissolved oxygen content in the Kanawha River is kept at 3 parts per million, as recommended in the original interim plan.

(3) Predicted flows in the Kanawha River are used for determining total dilution water requirements. Releases are scheduled based on 0.286 of the required flow augmentation, and limited to a maximum flow augmentation of 400 cfs.

(4) Releases are computed daily based on Winfield Locks pool temperature data and hydrologic model forecasts.

7-04 STANDING INSTRUCTIONS TO DAMTENDER.

The Sutton Lake Resource Manager and staff operate the project in accordance with general instructions and Special Directives issued by the Water Resources Engineering Branch. This information is provided directly to Sutton Lake project personnel.

a. Regulations. The above-mentioned general instructions and Special Directives are written in accordance with regulations listed under Section 1-03 of this manual, Operating and Regulating Responsibility.

b. General Instructions. General instructions provide for routine reservoir regulation including the discharge limits, details of gate operation technique, collection and transmission of hydrologic and streamflow data, reservoir regulation at the start of a flood before contact can be made with the District Office, and emergency regulation in the event all communications fail during a flood. These instructions are contained in Exhibit B, "Instructions to the Dantender". These instructions also establish the minimum number of observations to be made and are designed to ensure that any necessary gate operations will be promptly executed and that special reports will be initiated by the Resource Manager before reservoir and stream conditions reach critical proportions. The general instructions apply at all times except when instructed by Special Directives from the Water Resources Engineering Branch. If work is required after normal duty hours for the collection and transmission of hydrologic data, and for the execution of necessary gate operations, overtime will be approved by proper authority.

c. Special Directives. Special Directives are issued by the Water Resources Engineering Branch and disseminated to the Resource Manager. These directives are issued by telephone and confirmed by mail, and pertain to water control activities not covered by the general instructions. Special Directives are applicable for a specific operation or period of time and override the general instructions to the Damtender. The following is a list of typical occurrences which could call for the issuance of a Special Directive:

(1) Flood control:

(a) Outflow reduction for Kanawha River Basin streams or Ohio River control.

(b) Release of flood storage and adjustments in rate of release.

(2) Special regulation for:

(a) Construction activities downstream affected by flow.

(b) Stream clean-up activities.

(c) Emergency - Drowning or pollutant spill.

(d) Complete closure for inspection on emergency or periodic basis.

(e) Low flow augmentation for Kanawha River.

(3) Change in general instructions.

(4) Any and all other pertinent operations as deemed necessary by Water Resources Engineering Branch.

7-05 FLOOD CONTROL.

Damages occurring along the Elk and Kanawha Rivers resulting from flooding occur mainly to residences, utilities, highways, commercial establishments, agriculture and industry. The greatest flood damage in the past has occurred to the communities of Sutton and Charleston, and to industries along the Kanawha River between Leon and Gauley Bridge, West Virginia.

a. Requirements. Summer thunderstorms containing heavy rainfall over a short period of time can be destructive and produce areas of localized flooding. Because thunderstorms often affect only localized areas, it may be necessary to operate only individual reservoirs for flood control during these types of storms. Winter or spring-type storms can occur when soil, vegetation or snowcover conditions provide a high percentage or volume of runoff. These storms often cover more extensive areas and produce more generalized flooding conditions in the basin. These types of storms generally require operating several reservoirs for flood control.

b. Normal Plan. Sutton Lake is part of the flood control system of the entire Ohio River Basin as well as of the Elk and Kanawha River Basins. Regulation procedures for the lake are correlated with the operation of the other lakes in the Kanawha River Basin and other Ohio River tributaries to the fullest extent possible while giving due consideration to local concerns and requirements.

Operation for Ohio River control is based on retention of flows that would add to crest stages in excess of 45 feet at Point Pleasant, West Virginia. This stage represents the stage of zero damage for the unprotected communities below the mouth of the Kanawha River.

The maximum stages and flows that can be maintained at points along the channel below the dam are called control flows or regulation channel capacities. During MIANO (Mid April through November) the control stage of 20.5 feet on the outflow gage flow below Sutton Lake, or 7,700 cfs, may be maintained on without causing appreciable damage to crops and the community of Sutton. During DEMIA (December to Mid-April), the control stage is 25.0 feet at the outflow gage, or 12,600 cfs. Control stage at Frametown is 12.5 feet with a flow of 14,700 cfs during MIANO, and 14.0 feet stage or 17,500 cfs during DEMIA. At Clay, the control stage is 18.0 feet, or 31,200 cfs during MIANO and DEMIA. At Queen Shoals, the control stage is 19.0 feet, or a flow of 31,600 cfs during MIANO and DEMIA. And at Charleston, the control stage is 36.0 feet, with a flow of 150,000 cfs during MIANO and DEMIA. The control flows are summarized in Table No. 7-1.

TABLE NO. 7-1
CONTROL STAGES AND FLOWS AT KEY RIVER STATIONS

		MIANO		DEMIA		Time of Travel
Station	Stream	Stage (feet)	Flow (cfs)	Stage (feet)	Flow (cfs)	From Dam (hours)
Sutton	Elk River	20.5	7,700	25.0	12,600	-
Frametown	Elk River	12.5	14,700	14.0	17,500	4
Clay	Elk River	18.0	31,200	18.0	31,200	8
Queen Shoals	Elk River	19.0	31,600	19.0	31,600	12
Charleston	Kanawha River	36.0	150,000	36.0	150,000	15
Point Pleasant	Ohio River	45.0	-	45.0	-	60*

* Operational time prior to crest stage in excess of 45.0 feet.

The plan of operation is based on having adequate flood forecasting and flood warning systems in effect. Streamflow data is obtained from the platform-satellite network and from Sutton Lake reports. Precipitation amounts in and near the Elk and Kanawha River Basins are received through the Corps of Engineer's satellite-platform system, as well as precipitation data from the project reports which contain project gage data, data from observers in the Ohio River Network and from NWS. Water Resources Engineering Branch personnel use current and previous rainfall, soil and foliage conditions, and stream stage data as input to the water control system to forecast lake and downstream stages. Table 7-2(T7-1), table section in back, and Plate 7-2, Area and Capacity Tables, can be used to determine available storage for flood control purposes.

It is desirable to empty the lake of flood storage as quickly as possible, considering any special operations, in view of the possibility of a major flood occurring at a time when the lake is partly filled.

During flood events, the following operation will provide for effective management of the project to meet downstream flood control objectives:

(1) All inflow is to be released at rates up to that causing a stage at the outflow gage not to exceed 20.5 feet (7,700 cfs) during MIANO, and 25.0 feet (12,600 cfs) during DEMIA except when the lake level is being raised or lowered seasonally, when critical flood conditions prevail or are predicted at downstream control points, or when the Water Resources Engineering Branch has directed special operations.

(2) All inflow will be stored, subject to the minimum flow requirements, or the low flow augmentation requirement, if greater, which would contribute to stages in excess of the designated control stages at the key stations along the Elk and Kanawha Rivers as listed in Table No. 7-1.

(3) All inflow will be stored, subject to the minimum flow requirements, or the low flow augmentation requirement, if greater, beginning 60 hours in advance of the predicted time of reaching a forecast crest stage in excess of 45 feet on the Ohio River at Point Pleasant, Ohio. After a complete assessment of Ohio River conditions and trends of continued falling stages, releases will be scheduled so as not to add to actual crests on the Ohio River at Point Pleasant.

(4) If the river stage at Point Pleasant is not indicative of flooding conditions further downstream along the Ohio River, recommendations from LRD Water Management Branch may suggest the storage of inflows in order to provide some benefit to these downstream areas. In such special cases, a complete assessment will be made of all current and anticipated hydrologic conditions in the Elk and Kanawha River Basins to establish an operational scheme that will benefit the downstream Ohio River areas and not prove detrimental to Elk and Kanawha River Basin flood control objectives.

(5) Release of accumulated flood storage will be based on determinations by the Water Resources Engineering Branch after a complete evaluation of all hydrologic conditions that impact effective management of the project for optimal flood control benefits. Each individual flood event will be evaluated and Special Directives issued for the release of stored flood waters.

(6) Gates will be regulated so that the rate of change of stage at the outflow gage will not exceed 0.5 foot per hour when lowering the stage or 1.0 foot per hour when raising the stage, except under emergency conditions.

(7) The water control plan for major floods provides for increases in reservoir outflow when there are indications that the available storage will be insufficient to control the flood completely. In such an event, the Regulation Schedule for Major Floods, as shown on Plate 7-3, is used to determine the necessary increases in outflow. Ordinarily, lake regulation will be based on the forecasted inflow hydrograph predicted from reports of rainfall depths above the dam, the relationship of the inflow unit hydrograph to the updated inflow hydrograph calculated from pool change and outflow values, and the updated inflow hydrograph. After the inflow hydrograph has been predicted, Water Resources Engineering Branch personnel will determine the outflow required to utilize all the storage available. If the required discharge is equal to or greater than the downstream channel capacity, it is imperative that the outflow be increased to the required value as soon as possible in order to avoid the necessity of releasing even greater flows later. If the required discharge is considerably less than channel capacity, it may be desirable to delay releases to avoid synchronization of the outflow with peak flows from uncontrolled areas below the dam. Under the above circumstances, lake regulation will be governed by an analysis of current and forecast rainfall above the reservoir and forecast conditions at key downstream control stations. Full consideration will be given to the effect of increased discharge from the reservoir, which would result from delaying the originally indicated outflow. The Water Resources Engineering Branch will direct these operations by Special Directives.

Plates 7-4 through 7-6 are useful in determining the discharge that will result from various gate openings for the sluices in the outlet works. Plate 7-7 is the rating curve for the gated spillway, and Plate 7-8 is the rating table for the area just below Sutton Lake.

c. Emergency Plan. During a major flood, all communications between Sutton Lake and the Huntington District may be disrupted. In that event, Water Resources Engineering Branch will utilize all available data (e.g., satellite platform data), to keep informed of project conditions and to be prepared to resume regulation instructions when communication is restored. The Resource Manager will assume regulation of the lake during a communication blackout, following the measures listed below. In addition, the Resource manager will immediately make every effort to reestablish communications with the District Office. Plate 7-3 is the Office Regulation Schedule for Major Floods.

Plate 1-2, Emergency Operation Schedule, found in the Instructions to the Damtender, Exhibit B to this manual, contains rate of rise curves which are used by project personnel to operate the reservoir when communications with the District Office are disrupted. The curves indicate outlet gate openings to be used when the rate of rise in lake levels indicates that the available storage capacity of the project may be inadequate to control a given flood totally. The Instructions to Damtender contain operational procedures to be followed when there is a delay greater than three hours in establishing contact with the Water Resources Engineering Branch and the rate of rise curves indicate gate settings greater than those being maintained from previous instructions.

7-06 RECREATION.

a. Lake

(1) Requirements. Recreational activities can occur during all seasons of the year at Sutton Lake. The peak fishing season at Sutton Lake occurs between mid-March and mid-November. The peak period for hunting in the area occurs from October through December. The most popular area for fishing is in the Elk River just below the Sutton Lake dam.

It is usually advantageous to maintain a constant pool level for recreational purposes. Noticeable variations in pool level can cause concern to visitors if they are not aware of the cause. Changing water levels affect boating safety by changing the normal view of the lake. Disorientation may occur to boaters or fishermen who are not familiar with the lake under variable pool level conditions. This is especially true at Sutton Lake, which has a long winding shoreline and numerous tributary streams. Higher pool levels after rainfalls can increase chances of boaters hitting newly inundated obstructions or grounding themselves in shallow bay areas. Higher lake levels also cause difficulties in launching and retrieving boats. Lower lake levels bring submerged obstructions closer to the surface, creating possible snagging problems for fishermen.

(2) Control Plan. The water control plan at Sutton Lake attempts to maintain the pool level at or near seasonal elevation 925 NGVD during dry recreational seasons, and elevation 922 during wet to normal recreational seasons. Use of the three-foot buffer zone between elevations 922 and 925 NGVD depends upon the hydrologic conditions and anticipated future rainfall. As moisture and hydrologic conditions become more dry, the lake should be maintained closer to elevation 925 NGVD. Under normal conditions, this is accomplished by regulation of the low-flow sluice, high-level intake, or the gates in the outlet works. At times, however, heavy runoff may require utilization of available flood storage at Sutton Lake, causing a rise in the lake level. Part of the plan of regulation includes forecasts of lake level and outflow rates.

b. Downstream.

(1) Requirements. Project personnel must maintain an awareness of downstream usage of Elk River for both recreation and other purposes since safety of these interests is of prime importance to lake regulation. Fishermen and any other interests accustomed to using the stream at low water should be notified of impending high discharges.

(2) Control Plan. In order to be aware of downstream activities, project personnel make occasional surveys, during both low water and high water, to observe potentially hazardous situations. In the interest of downstream safety of life and property and integrity of stream banks, the water control plan limits the rate of increase or decrease of discharge in Elk River at the Sutton Lake outflow gage, except during an emergency. A warning horn is sounded at the dam whenever gate openings are increased below the dam. If a spillway flood should occur, project personnel would evacuate downstream areas and remove any equipment which could be damaged by high discharge.

c. Whitewater. The low gradient of Elk River downstream of the dam is not conducive to Whitewater rafting, However, at other projects the Corps of Engineers receives numerous requests to make project releases in a manner that furthers whitewater rafting. Issues that must be addressed before approval of such releases include the extent of the Corps' responsibility for property damage and public safety, environmental impacts, and the impacts on other project purposes. The Corps has adopted a consistent nationwide policy with respect to whitewater rafting by describing a decision framework to be used by district engineers in evaluating each request.

Authorities for regulation of Corps projects are contained in legislative authorization acts and referenced project documents. Generally, the Corps is not precluded by law from accommodating special uses not specifically envisioned in the project documents but which are part of the general parameters of authorized project purposes, provided that the use does not adversely interfere with authorized project purposes, and is otherwise in the public interest. General policies and procedures governing water control management plans are found in ER-1110-2-240 (33 CFR 222.7). It is within the context of the generic water control management plans that specific requests to adjust project flows for whitewater rafting are considered.

The evaluation of each request to modify project releases to accommodate whitewater rafting considers impacts on project purposes, and impacts associated with modifying releases on water quality, recreation other than whitewater rafting, project and other affected lands, responsibility and potential for personal injuries and property damage, increased costs of operation, comments of interested parties, and any river management plans. Requests for releases for whitewater rafting are accommodated provided the district engineer determines that the releases do not adversely interfere with authorized project purposes and are otherwise in the public interest.

Significant costs incurred for making releases to enhance whitewater rafting are recovered.

Several general operating criteria are applied in implementing requests for whitewater recreation. These include not exceeding downstream channel capacity, keeping downstream water level fluctuations within established limits, and maintaining reservoir water levels within operating limits established for other project purposes.

7-07 WATER QUALITY

Sutton Dam is located in Braxton County on the Elk River, a tributary of the Kanawha River. The concrete dam is 100.4 miles above the mouth of the Elk River and backs water for 14.5 miles at a seasonal pool elevation of 281.0 meters mean sea level (msl). The average annual hydraulic residence time is about 25 days. Lake waters, during periods of higher flows, are released through 5 gated sluices. At lower flows the pool is maintained by the use of a 36 inch diameter valve. A high level intake attached to the center sluice intake provides a means for withdrawing water from high in the pool.

The project was designed for flood control, general recreation, fish and wildlife enhancement, water supply, and low flow augmentation. The outlet structure was not designed with maintenance or improvement of water quality as one of its purposes, therefore the quality of release water could not be regulated. The addition of the high level intake added some capability in regulating water quality downstream.

7-08 FISH AND WILDLIFE CONSERVATION.

a. Requirements.

(l) Lake. In accordance with a 50-year license agreement between the United States and the State of West Virginia/Division of Natural Resources, the Division of Natural Resources has responsibility for conservation of fish and wildlife at Sutton Lake. Conservation requirements in the lake are met by various features of the Department management program which includes stocking of the tailwaters and lake, monitoring populations, general chemical water quality analyses and administering licensing regulations for sport fishermen. Fish and wildlife at Sutton Lake are affected by fluctuating lake levels. A stable or rising pool is required for fish spawning. Rises in pool level can affect groundnesting animals living near the pool. Drawdowns affect waterfowl and furbearing animals through elimination of shallow-area feeding grounds. Drawdowns can affect hunters, especially during duck season, when shallow marsh areas are drained; however, Sutton Lake is only minimally affected due to its steep topography along shoreline areas. Dry weather drawdowns expose muddy lake sides, and boat waves can then produce turbid water conditions an appreciable distance from the bank. This is the fertile littoral area into which fishermen cast. Fishing success suffers under such conditions because the lures are not readily visible.

(2) Downstream. Habitat maintenance, including continuous flow of clean water at proper temperature, constitutes the conservation needs of the downstream aquatic community as to reservoir outflow. Lower food chain members which live on the bottom are dependent on clean rocks, gravel and sand for normal habitat. Since water is generally of high quality, interest is normally in temperature and turbidity of the water for the best fishing conditions.

Changes in rates of outflow, especially cutbacks in outflow, can affect aquatic organisms downstream of the dam. The West Virginia Division of Natural Resources prefers that unnatural changes in outflow from Sutton Lake be kept to a minimum.

b. Control Plan. As explained in subparagraph 7-05 a(1), the normal mode of regulation for both recreation and flood control, with the guiding principle of conserving storage capacity for possible early flood control needs, fosters a stable pool; however, downstream flooding may require gate closure and consequent pool rise. As the risk of summer storms decrease from late spring to late summer, the need for a lake level slightly below seasonal elelvation 925 NGVD also decreases. As this occurs, the actual lake level should rise from near the lower end of the three foot buffer zone to the upper level of the zone. This type of operation minimizes muddy conditions along the shoreline, and increases fish habitat in general. Detailed instructions for operation within the three -foot buffer zone are given in the "Instructions to Damtender", found in Exhibit B of this manual.

Operation of the high level intake, installed during the winter of 1979-1980, is given in the Instructions to Damtender, found in Exhibit B of this manual.

The Water Resources Engineering Branch would make any operation requested by the West Virginia Division of Natural Resources in the interest of fish and wildlife populations, as long as the operation did not interfere with another project purpose.

7-09 WATER SUPPLY.

a. Types. Either an increase or decrease in outflow may be requested by the public or by other governmental agencies, including state and local, or by higher authority within the Corps of Engineers. Two events which require special purpose regulation at Sutton Lake are periodic inspections of the dam and repairs to the dam or appurtenant structures.

b. Requirements. Prior approval of substantive deviations is necessary from the Ohio River Division Water Management Branch before Water Resources Engineering Branch may grant a request except in case of emergency. In order for Water Resources Engineering Branch and the Division Water Management Branch to gage the advisability of compliance with a request, Water Resources Engineering Branch must investigate upstream watershed conditions, potential flood threat, impact on other project purposes, condition of the lake, and possible alternatives.

c. Plan. Under normal conditions, all agencies involved are careful not to authorize actions which would create worse conditions. In the interest of maintaining good public relations, requests for minor deviation may be coordinated by telephone and granted provided there are only minor adverse effects to the overall project. Requests for major deviations may require additional analysis, with cooperation between agencies occurring by letter, telephone, or interagency meetings.

7-10 DROUGHT CONTINGENCY PLAN.

In accordance with ER-1110-2-1941, dated 15 September 1981, titled "Engineering and Design, Drought Contingency Plans," the drought contingency plan covering Sutton Lake is contained in Annex I of this manual.

7-11 FLOOD EMERGENCY ACTION PLAN.

Notification of the public is carried out by the Project, the Water Resources Engineering Branch, the National Weather Service and the District Public Affairs Office. How the public is notified depends on the target of the information and urgency of the situation. Methods available include radio, television, sirens, newspapers, mail, telephone, car loud-speakers, and personal visitations. Daily rainfall and reservoir data are disseminated by Project Office personnel to the National Weather Service via computer terminal. This information appears along with other weather and stage information provided by the Weather Service to mass media and county, state and Federal agencies.

Important public service messages of early significance concerning regulation of the lake for flood control are handled by the Public Affairs Office and disseminated via radio and/or television. Warnings of any unusual releases are transmitted downstream by project personnel in person and by telephone.

7-12 DEVIATIONS FROM NORMAL WATER CONTROL PLAN

a. Emergencies. Examples of some emergencies that can be expected to occur at a project are: drowning and other accidents, failure of the operation facilities, chemical spills, treatment plan failures and other temporary pollution problems. Water control actions necessary to abate the problem are taken immediately unless such action would create equal or worse conditions. Districts must inform their division office as soon as practicable. Prepare written confirmation of the deviation and description of the cause and furnish it to the division water control manager. Divisions may develop forms to facilitate the reporting of emergency deviations.

b. Unplanned Minor Deviations. There are unplanned instances that create a temporary need for minor deviations from the normal regulation plan, although they are not considered emergencies. Construction accounts for the major portion of these incidents and typical examples include utility stream crossings, bridge work, and major construction contracts. Deviations are sometimes necessary to carry out maintenance and inspection of facilities. Requests for changes in release rates generally involve time periods ranging from a few hours to a few days. Each request is evaluated on its own merits. Consideration must be given to upstream watershed conditions, potential flood threat, condition for the lake, and alternative measures that can be taken. In the interest of maintaining good public relations, requests generally are complied with, providing there are no foreseen adverse effects on the overall regulation of the project (or projects) for the authorized purposes. Approval for minor deviations normally will be made at the District level. Written confirmation explaining the deviation and its cause will be furnished to the division water control manager.

c. Planned Deviations. Each condition should be analyzed on its merits. Sufficient data on flood potential, lake and watershed conditions, possible alternative measures, benefits to be expected, and probable effects on other authorized and useful purposes, together with the district recommendation, will be presented by letter or telefacsimile to the division of review and approval.

7-13 RATE OF RELEASE CHANGE.

a. Requirements.

(1) Minimum Pool. Sutton Lake is normally drawn down during DEMIA to control aquatic vegetation and provide certain other benefits. These benefits include reducing ice damage to docks and other shoreline facilities, allowing maintenance of shoreline areas, decreasing shore erosion, and adding flood storage to the reservoir.

(2) Seasonal Pool. In order to provide a maximum of recreational benefits during spring and summer, the minimum pool is raised beginning in early April to the seasonal pool elevation of 925.0 feet NGVD or slightly below, depending upon use of the three-foot buffer zone. The seasonal pool is

then maintained by regulation of the low flow sluice, high level intake, and other sluices in the outlet works.

b. Plan. The seasonal pool level is normally drawn down to a minimum pool level near elevation 895.0 feet. After Labor Day, Water Resources Engineering Branch conducts a hydrological investigation to determine the optimal period for fall drawdown. Short-range, long-range, and low-flow augmentation forecasts are analyzed as part of the process. Typically, drawdown begins about 10 September, with the minimum pool being obtained by 1 December. Spring refilling typically begins on 1 April, normally by utilizing the filling curves until the seasonal pool is reached. Fall drawdown and spring refilling periods, however, may be affected by other operations at Sutton Lake, and therefore be subject to change by the District Engineer.

SECTION VIII - EFFECT OF WATER CONTROL PLAN

8-01 GENERAL.

The results of regulation for the authorized purposes of flood control, low flow augmentation, recreation, whitewater activities, and fish and wildlife enhancement at Sutton Lake are presented in the following paragraphs and referenced plates. Regulation for various hypothetical design floods and for representative actual floods demonstrate the capability of the project to control and pass runoff from the drainage basin. The same capability is described in probability terms by Plate 8-1, Frequency of Filling, and Plate 8-2, Duration of Filling. Plate 8-1 shows that the lake is likely to be filled to pool elevation 985.5 feet once in 100 years. Effects of the water control plan on recreation and fish and wildlife are also presented in later paragraphs.

8-02 FLOOD CONTROL.

Sutton Lake controls 537 square miles, or approximately 35% of the Elk River Basin. The combination of Sutton Lake, Summersville Lake, and Bluestone Lake controls approximately 48% of the total Kanawha River Basin. The chief benefit of these 3 dams is the reduction of flood heights at Charleston and other communities along the Elk, New, Gauley and Kanawha Rivers, with incidental benefits to Gallipolis and other downstream points along the Ohio River. The application of the adopted water control plan to 3 hypothetical floods, 2 historical floods and 4 recent floods as they occurred are discussed in subsequent paragraphs.

a. Hypothetical Floods.

(1) Standard Project Flood. The Standard Project Flood for reservoir design was based on a Pennsylvanian storm of July 1942, as discussed in a Pennsylvania Department of Forests and Waters report the Flood of July 1942 in the Upper Allegheny River and Sinnemahoning Creek Basins. Prior to the design of the Sutton Lake dam, the Hydrometeorological Section of the U.S. Weather Bureau, at the request of the US Army Corps of Engineers, investigated the most intense storms of record in the northeastern United States to determine the maximum possible storm which could be expected to center over the Elk River Basin. It was concluded that the storm of July 1942 could have centered over the Elk River Basin to produce flood runoff far in excess of any previously experienced. Official records for the storm of 17-18 July 1942 indicated record-breaking precipitation amounts for a 24-hour period at a number of U.S. Weather Bureau stations. The largest total officially observed was 8.48 inches, but no regularly maintained gage was located in the area of the heaviest rainfall. Numerous measurements made in favorably located unofficial containers indicated rainfall exceeding 10 inches, with some areas exceeding 20 inches. The maximum amount measured in an unofficial container was 35.2 inches. An area/depth curve prepared for this storm indicated that the maximum average depth of rainfall over an area of 537 square miles (equivalent to the Sutton Lake Basin) amounted to 16.5 inches during a period of 22 hours. Based on stream flow records from the storm, the average runoff was estimated to be 11.1 inches, or 67.3% of the rainfall. A natural hydrograph for this

adopted Standard Project Flood was computed, having a peak flow at the damsite of 129,000 cfs. The discharge hydrograph for this storm and the operation of the Sutton Lake dam are shown on Plate 8-3.

At the onset of the flood, the reservoir would have been regulated to maintain the seasonal pool and so as not to exceed the control stage at the outflow gage or control stages along the Elk River. By noon of the first day, when heavy rainfall and rising river stages would have indicated that control stages at downstream points would be exceeded within a few hours, the gates at the Sutton Lake dam would have been closed sufficiently to limit the outflow to 75 cfs. The 1930 report from the reservoir on the first day would have indicated that the flood control storage available would not be sufficient to completely control the flood. As a result the damtender would have been ordered to report pool elevation and rainfall every hour on the hour commencing at 2100 hours the first day. It is assumed that during the morning, all communication facilities failed except radio, thereby limiting rainfall and runoff data available to that observed and reported by the damtender. The 2400 report from the damtender on the first day would have indicated an outflow on the "Office Regulation Schedule for Major Floods", and the proper gate setting would have been so ordered. This process of hourly reports from the damtender and gate settings ordered by the District office would have been continued until 0300 hours on the fourth day when reservoir drawdown from maximum flood control pool elevation 1000.0 to the seasonal pool level could have been initiated without exceeding the control stage on the outflow gage. The reservoir pool would have reached a crest elevation of 1002.4 feet at 0500 hours on the third day and the maximum outflow from the dam would have been 24,700 cfs.

(2) Spillway Design Flood. At the time of the design of the Sutton Lake dam, the spillway design storm was based on an extensive study of intense storms that had occurred in the general region of the Elk River Basin. Based on these storms, enveloping curves of maximum possible rainfall depth-duration values were produced. The spillway design storm for Sutton Lake was then taken from the preliminary depth-duration values for the Sutton Lake Drainage area of 537 square miles. The Sutton spillway was designed to safely pass the Probable Maximum Flood (PMF) with appropriate freeboard to accommodate potential wind and wave conditions. The reservoir pool would have reached a crest elevation of 1010.3 feet at 0600 hours on the second day and the maximum outflow from the dam would have been 222,240 cfs as shown on Plate No. 8-4.

Current Corps criteria specify that the Spillway Design Flood (SDF) be based on the runoff from the Probable Maximum Precipitation (PMP), or Hydrometeorological Reports 51 and 52. Probable Maximum Precipitation (PMP) is defined as the theoretically greatest depth of precipitation for a given duration that is physically possible over a particular drainage area at a certain time of year. Using current spillway design flood criteria based on HMR 51 and 52, dated June 1978, the existing spillway is not capable of safely passing the Probable Maximum Flood (PMF) with appropriate freeboard to accommodate potential wind and wave conditions. However, the project would not be overtopped during the revised PMF and the hydrologic deficiency is not sufficient for the project to receive priority consideration of modification at this time. It is estimated that after some of the more deficient projects are corrected for hydrologic deficiencies under the Dam Safety Assurance Program, Sutton Lake may be approved for further evaluation of remedial actions to correct the spillway deficiency. Additional information will be provided when it becomes available. After remedial action is approved, a revised Plate 8-4, Spillway Design Flood, Current Criteria, will be issued showing inflow, outflow and pool elevation hydrographs for the approved study design.

b. Representative Floods.

(1) General. The historical floods which were selected for illustration of the water control plan are the floods of September 1861 and January 1937. Also selected were the floods of March 1967, December 1969, December 1978, and November 1985, which illustrate floods actually regulated according to the water control plan. The flood of September 1861 was caused by a hurricane-related storm which affected a large portion of the southeastern United States. The flood of January 1937 was caused a series of storms passing over the Ohio River Basin. The flood of March 1967 was caused by heavy rainfalls occurring over a 4-day period. The flood of December 1969 was caused by a combination of heavy rainfall and snowmelt from a major snowcover. The flood of December 1978 was caused by excessive rainfall falling during a 3-day period. The flood of November 1985 was caused by rainfalls associated with the remnants of Hurricane Juan. Stage reductions for representative floods occurring before Sutton Lake became operational are listed in Table No. 8-1.

(2) Flood of September 1861. The flood of September 1861 is the flood of record on the Elk River and the Kanawha River at Charleston, West Virginia. A hurricane-related storm passed over the southeastern portion of the United States, dropping about 6 inches of rain in a 3-day period over the southern and eastern portions of the Kanawha River Basin. High water marks from the flood along the Elk River indicate that the 1861 flood stages were several feet higher than any known flood along the Elk River below Sutton.

Sutton Lake did not exist at the time of the flood, but the flood has been reconstituted. The peak inflow of approximately 50,000 cfs occurred early on 3 September. In the reconstituted operation of the dam, the gates were closed to pass the minimum allowable outflow of 75 cfs during the evening of 2 September to avoid exceeding down-stream control stages. The gates remained closed until the morning of 4 September, when the gates were reopened to pass the MIANO channel capacity and draw down the flood pool. The maximum pool level calculated for this flood at Sutton Lake was elevation 960.2 on 4 September.

(3) Flood of January 1937. A series of abnormally heavy rains, centered largely in the middle and lower portions of the Ohio River Valley, began in late December 1936 and continued through most of January 1937. These rains caused a series of floods that produced the highest known stages of record along the Ohio and mid-Mississippi Rivers.

The Elk River did not reach extreme heights, but floodwaters of the Elk River contributed directly to the record-breaking flood crests on the Ohio River. During the period 26 December 1936 to 25 January 1937, the Elk River Basin above Sutton received an average of about 9 inches of precipitation, and runoff amounted to approximately 7 inches.

The series of storms produced 5 distinct inflow peaks on the Elk River, with the largest peak of 9,400 cfs occurring during the early morning hours of 21 January. In the reconstituted operation of the dam, the gates would have been operated at the onset of the storm to hold the seasonal pool near elevation 850.0. The gates would have been closed to pass the minimum outflow of 75 cfs during the afternoon of 18 January in response to a forecasted stage in excess of 45 feet on the Ohio River early on 20 January. The gates would have remained closed until the morning of 29 January, when the gates could be reopened without exceeding downstream control stages. Outflow would have been gradually increased to the DEMIA channel capacity to draw down the flood pool. The maximum pool level calculated for this flood was elevation 947.8 on 29 January.

TABLE NO. 8-1

FLOOD REDUCTIONS AT DOWNSTREAM GAGES BY REGULATION OF SUTTON LAKE

	Sutton Gage	Frametown Gage	Clay Gage	Queen Shoals Gage
FLOOD OF SEPTEMBER 1861				
Natural Stage (feet)	848.2	34.8	32.8	35.0
Modified Stage (feet)	820.5	24.1	28.0	33.0
Reduction (feet)	27.7	10.7	4.8	1.7
FLOOD OF SEPTEMBER 1878				
Natural Stage (feet)	837.9	21.8	20.8	24.6
Modified Stage (feet)	820.5	12.4	15.2	21.1
Reduction (feet)	17.4	9.4	5.6	3.5
FLOOD OF MARCH 1918				
Natural Stage (feet)	845.2	32.2	30.8	32.0
Modified Stage (feet)	824.5	21.4	25.8	28.3
Reduction (feet)	20.7	10.8	5.0	3.7
FLOOD OF JULY 1932				
Natural Stage (feet)	842.7	23.7	26.6	31.6
Modified Stage (feet)	820.5	18.5	25.1	30.5
Reduction (feet)	22.2	5.2	1.5	1.1
FLOOD OF MARCH 1936				
Natural Stage (feet)	835.7	18.6	23.1	21.4
Modified Stage (feet)	824.5	11.3	19.0	14.1
Reduction (feet)	11.2	7.3	4.1	7.3
FLOOD OF JANUARY 1937				
Natural Stage (feet)	821.9	10.8	12.8	12.0
Modified Stage (feet)	821.5	9.4	10.5	10.8
Reduction (feet)	0.4	1.4	2.3	1.2
FLOOD OF FEBRUARY 1939				
Natural Stage (feet)	839.2	23.6	24.5	26.8
Modified Stage (feet)	824.5	13.0	20.3	24.7
Reduction (feet)	14.7	10.6	4.2	2.1

(4) Flood of March 1967. The March 1967 flood was the flood of record in many northcentral and southern West Virginia watersheds, resulting in more than half of the State's 55 counties being declared disaster areas. The heaviest rains centered just northeast of the Sutton Lake Basin, with Weston, Buchanan and Rowlesburg all reporting more than 5 inches of rain in a 4-day period from 4-7 March. The Elk River Basin above Sutton Lake received approximately 3 inches of rain during this period.

The maximum peak inflow into the reservoir from this flood was approximately 40,000 cfs during the morning of 7 March. At the onset of the flood, the reservoir was being regulated to maintain the minimum pool level at Sutton Lake. The gates were regulated to maintain the pool level until 6 March, when the gates were gradually closed to pass the minimum required outflow and store the flood runoff. Minimum outflow values were maintained until about midday on 10 March, when the gates were gradually reopened by order of a Special Directive to draw down the flood pool. The maximum pool level observed at Sutton Lake during this flood was elevation 941.93 on 10 March.

(5) Flood of December 1969. Small stream flooding occurred along West Virginia streams as a result of rainfall runoff combining with runoff from a major snowcover at the end of December 1969. A major storm produced substantial snowfalls over the Appalachian highlands and northeastern United States during the period 25-27 December. Approximately 13 inches of snow was recorded at Camden-on-Gauley, the nearest snowfall measuring station to the Sutton Lake basin. Warmer temperatures and a major rainfall of about 2 inches in less than 24 hours on 30-31 December produced large volumes of runoff from the combined snowmelt and rain, producing flooding conditions in the Elk River Basin.

The peak inflow of approximately 36,000 cfs arrived at Sutton Lake at about midnight on 30 December. The minimum pool level was maintained during the early portion of the storm, but rising stages downstream required gradual gate closures beginning during the afternoon of 30 December. Minimum outflow values were maintained at Sutton Lake during 31 December and the morning of 1 January 1970. Gates were gradually opened beginning about noon on 1 January to begin drawing down the flood pool. The maximum pool level observed at Sutton Lake during this flood was elevation 936.87 on 1 January 1970.

(6) Flood of December 1978. A cold front passage on 8-9 December produced heavy rains and flooding conditions in portions of Kentucky and West Virginia. In West Virginia, the heaviest rains fell southwest of the Sutton Lake basin, in an east-west band from about Dunlow to Richwood. Dunlow received 7.13 inches of precipitation during the period 7-9 December, with more than 6 inches falling in a 48-hour period. Precipitation within the Sutton Lake Basin averaged just over 3 inches, with the bulk of the precipitation falling as rain before tapering off to snow towards the end of the storm.

The peak inflow of approximately 23,750 cfs occurred during the late morning of 9 December at Sutton Lake. The gates were regulated at the onset of the flood to pass inflow and maintain the minimum pool level. The gates were then gradually closed beginning during the evening of 8 December to store inflow. The minimum required outflow was maintained at Sutton Lake from the afternoon of 9 December until mid-afternoon on 11 December, when the gates were gradually reopened to draw down the flood pool. The maximum flood elevation observed at

Sutton Lake was elevation 941.21 during the evening of 11 December.

(7) Flood of November 1985. Rainfall from two successive storms associated with the remnants of Hurricane Juan produced record-breaking floods in portions of eastern West Virginia and adjacent states. The flood-producing rains in West Virginia were associated with the second storm during 3-5 November. During the storm period, 39 lives were lost, and storm losses amounted to nearly half a billion dollars. During the period 1-6 November, the heaviest rains in West Virginia were recorded at Spruce Knob, with a total of 10.57 inches. In the Sutton Lake Basin, rainfall during the period averaged approximately 6.5 inches.

The maximum peak inflow of approximately 49,500 cfs arrived at Sutton Lake at about midnight on 4 November. The gates were closed during the late afternoon on 4 November by order of a Special Directive to store inflow and reduce downstream stages. Minimum allowable outflow values were maintained at Sutton Lake until late on 5 November, when the gates were gradually opened to draw down the flood pool. A maximum pool level of elevation 959.51 was observed at Sutton Lake during the late morning of 7 November.

c. Benefits. Most of the great floods in the Kanawha River Basin occurred before the turn of the 20th century, prior to the construction of the Sutton Lake dam and the other flood control dams in the Kanawha River Basin. Damages at that time were slight because of the low value of developments in the valley.

However, current development of the Kanawha River flood plain is varied and extensive. A flood damage survey conducted in 1964 estimated flood damages which would have occurred in the main stem of the Kanawha River from Leon to Gauley Bridge, West Virginia, if stages equivalent to those produced by the 3 greatest floods of record had occurred in the year 1964. The results of this study indicated that damages would have amounted to approximately $215 million without the flood control structures in the Kanawha River Basin. Of this $215 million, it is estimated that residential damages would have been approximately 48% of the total damages, followed by commercial damages at 23% and industrial damages at 17% of the total. The study also concluded that after stage modifications by Sutton, Summersville and Bluestone Lakes, the total damage of $215 million would have been reduced to approximately $13 million.

Flood damages prevented since the construction of the Sutton Lake dam have also been estimated, based on elevation-damage relationships derived from detailed damage surveys for the stream reaches below Sutton Lake. Based on these studies, it is estimated that Sutton Lake has prevented approximately $173.1 million in flood damages through fiscal year 1987.

8-03 RECREATION.

Success of the recreational purpose of the project, as measured by the number of visitors, has been excellent. It is estimated that approximately 600,000 visits are made to the Sutton Lake area each year. Visitation figures for Sutton Lake are shown in Table No. 8-2.

TABLE NO. 8-2
VISITATIONS AT SUTTON LAKE

Year	Visitations
1978	730,300
1979	703,500
1980	642,300
1981	674,100
1982	662,000
1983	658,700
1984	548,200
1985	581,200
1986	571,300
1987	626,400
1988	566,155

Changes in pool level tend to diminish recreational benefits by affecting boating, camping, hunting and fishing interests at Sutton Lake. Public campgrounds, boat launching areas, and local access roads to these areas are the most frequently flooded areas at the project. The recent addition of a high level intake to the outlet works at Sutton Lake has improved fishing and swimming conditions downstream of the dam by introducing warmer and less turbid water to the downstream reaches of the Elk River. The recreation facilities presently in place around Sutton Lake were designed initially for a stable summer pool level at elevation 925 feet msl. Campsites were located at an elevation only slightly above the seasonal pool level, which required maintaining the seasonal pool at a nearly constant elevation, but allowing the Elk River below the dam to fluctuate throughout the summer use season. The recent lowering of the seasonal pool to elevation 922 allows for smaller flow variations and an improved balance between recreation utilization of the lake and stream resources. The lower seasonal pool provides more time for evaluation of storm runoffs and creates a smoother release operation during summer storm events. The additional flood storage capacity improves manageability of the project. Flooding elevations at recreation and other critical sites are shown in Table No. 8-3 with probable frequency of occurrence. Plate 8-1, Frequency of Filling, shows the probable time between occurrences of elevations of the pool, and Plate 8-2 Duration of Filling, shows the probable length of time of each occurrence.

a. Recreational Benefits. Currently, U.S. Water Resources Council "Economic and Environmental Principals and Guidelines for Water and Related Land Resources Implementation Studies", dated March 1983, is used to assign recreational benefit values. The Principles give points of incremental value based on characteristics of recreation possibilities in comparison with the ideal and availability of alternative facilities. Points thus determined for Sutton Lake indicate $3.05/visitor-day for general recreation and $3.70/visitor-day for fishing or hunting.

8-04 WATER QUALITY

a. Special Problems. Sutton Lake had a definite influence to water quality conditions below the impoundment. Prior to the addition of the high level intake at Sutton Dam, cold water releases during the summer months were common and the duration of high stream turbidity following storm events was increased. The quality of the release water nearly reflected inflow conditions.

b. Data Interpretation and Results. An interdisciplinary approach is used to evaluate the physics, chemistry, and biology of inflow streams, the lake, and the outflow. The following interpretations are based on data collected between 1974 and 1993.

(1) Physical/Chemical. The chemical composition of water may be defined by grouping substances which compose the dissolved solids. Relationships among groups of chemicals determine the type of water. In terms of major ions and descriptive parameters, water in the Elk River Basin above Sutton Dam is classified as a calcium-carbonate type. This represents a balanced condition.

Historically, sulfate levels, chloride, specific conductance, and total dissolved solids were low in the watershed, the lake, and in the water released from the lake. The system has a low inherent capacity to resist shifts in pH as indicated by low alkalinity values and water hardness classifications of "soft". This indicates a potential for watershed problems if land use is not managed properly.

TABLE NO. 8-3

FLOODING ELEVATIONS AND FREQUENCIES AT SUTTON LAKE SITES

Area	Item	Flooding Elevation (ft., msl)	Frequency, in years, between occurrences
Bee Run	Marina access road, low point	940.0	1.9
	Roadway to main parking area, low point	943.0	2.2
Baker's Run Campground	Roadway at Site #114	929.0	0.9
	Roadway near Site #62	930.9	1.0
	Lift station	931.0	1.0
	Campground	935.0	1.4
	Mill Creek/Baker's Run access road, low point	937.5	1.7
Mill Creek Campground	Campground	930.0	1.0
	Entrance station	951.0	3.5
Gerald R. Freeman Campground	Stone roadway near Site #155, low point	925.3	0.5
	Roadway near Site #99, low point	926.5	0.7
	Roadway near Site #34, low point	928.7	0.9
	Roadway below wooden bridge, low point	928.75	0.9
	Lift station	930.4	1.0
Damsite, South Abutment Parking Area	West end of parking lot, low point	930.0	1.0
	Parking lot and launch ramp	935.0	1.4

In a freshwater community, algae are the primary producers. They serve as the basis of the food chain and are the primary food source for most aquatic animals. The quantity and types of algae present in a stream or lake is dependent upon many factors, such as temperature, oxygen, light, nutrients and flow. All freshwater algae contain the green pigment chlorophyll. Therefore, the productivity of aquatic habitats can be monitored by measuring chlorophyll.

Algal productivity is low as indicated by chlorophyll A concentrations less than 3 ug/l. Both nitrate/nitrite and phosphate are detectable in low concentrations in the tailwaters during the summer. Phosphorous is considered the limiting nutrient at Sutton Lake. Measurable levels of phosphorous in the tailwaters indicate that there are sufficient nutrients available for the aquatic community.

A lake structure will typically cycle from a mixed condition (Temperature same from top to bottom) to a stratified or layered condition (Temperature changes with depth). This is the result of thermal energy from the atmosphere gained and lost during the year. During the winter, water temperatures are the same from top to bottom and the lake is considered mixed. During Spring as air temperatures start to warm, so do surface water temperatures. This creates a surface layer called the epilimnion. Water temperatures near the bottom remain cool because they are not exposed to the sunlight or warmer air temperatures. This layer is called the hypolimnion. The layer in the middle is referred to as the metalimnion or transition layer. During the Fall season when temperatures start to cool the water temperature in the epilimnion cools until it reaches the same temperature as the hypolimnion and the lake is once again mixed.

Temperature data indicated that seasonal stratification at Sutton lake started as early as April and lasted into October. A typical lake temperature profile during the summer is shown in Plate 8-5. The plate shows a well defined epilimnion between 0 and 3 meters deep, a metalimnion or transition zone between 4 and about 19 meters deep, and a hypolimnion extending from 20 to 31 meters deep.

Dissolved oxygen data indicated that there is not a large demand on available dissolved oxygen in the watershed. A typical dissolved oxygen profile during the summer months is shown in Plate 8-6. A dissolved oxygen spike at about a depth of 3 to 5 meters indicates increased algal activity in that layer. This would not normally be expected since chlorophyll concentrations are so low. This is the result of a low demand on the available dissolved oxygen. Under normal conditions the lake hypolimnion does not become anoxic. This is most likely the result of Sutton being a headwater lake (low demand on oxygen) and a short hydraulic retention time.

The outlet structure at Sutton Lake under normal conditions releases water from the bottom of the lake. Releasing hypolimetic water can causes problems in the downstream area for many miles below the dam. Sutton was no exception from this problem. A project rehabilitation study in 1978 indicated that downstream water temperatures were about 12 fahrenheit degrees cooler than natural stream conditions and that maximum yearly temperatures were postponed for about 2 months. Timbering and coal mining in the watershed resulted in water with high turbidity levels flowing into the lake during storm events. In the summer months when the lake was stratified, the turbid inflows would enter the lake as an underflow moving along the lake bottom. The density current moved through the lake slower than the flood wave. This caused turbid releases to occur long after the flood waters were released.

(2) Biological.

Biological Monitoring. Freshwater macroinvertebrates (aquatic insects and worms, crayfish, mussels, etc.) serve as a useful tool for evaluating environmental impacts that occur over time. Because of their limited mobility and their relatively long life span, these organisms are subjected to the environmental conditions of their immediate aquatic habitat. Macroinvertebrates have been used as an assessment parameter to evaluate the overall water quality conditions of the Elk River at the main inflow station at Clifton Ford (SUT-07) and the outflow station at Sutton (SUT-12). The secondary inflow stations on Right Fork of Holly River at Guardian (SUT-08), Left Fork of Holly River at Hanging Rock (SUT-09), and Laurel Creel at Centralia (SUT-38) have also been monitored using macroinvertebrates.

OVERALL QUALITY RATING: OQR is derived from the BMWP score and the ASPT. The BMWP (Biological Monitoring Working Party) was designed to give a broad indication of the biological condition of rivers and streams. Identification of organisms, from macroinvertebrate samples, is made to the family level. Each family is given a score, between 1 and 10, depending on their susceptibility to pollution. Taxa least tolerant, such as families of mayflies and stoneflies, are given the highest scores. The BMWP score is the sum of the family scores. The BMWP score is then divided by the number of families to produce the Average Score Per Taxon (ASPT). The calculated BMWP score (X) and ASPT (Y) are then give a rating between 1 and 7, depending on whether the site or station is classed as a habitat-rich riffle, or a habitat-poor riffle/pool. The overall quality rating is derived as OQR=X+Y/2.

RESULTS: The results are based on macroinvertebrates samples collected from 1977 through 1989. The OQR and interpretation for the above water quality stations are presented in Plate 8-7. The outflow station SUT-12 had poor to moderate quality, while the inflow stations SUT-07 and SUT-38 had moderate to good quality, and SUT-08 and SUT-09 had good overall quality.

The most common groups of macroinvertebrates collected in the benthic samples from the outflow station were caddisflies (38%), and chironomid midges (32%). Mayflies accounting for only four percent of the total. No stoneflies were collected. The common groups collected at the four inflow stations were: Elk River -- stoneflies (2%), mayflies (28%), caddisflies (10%), and midges (30%); Right Fork of Holly River -- stoneflies (4%), mayflies (28%), caddisflies (13%), and midges (24%); Left Fork of Holly River -- stoneflies (8%), mayflies (37%) caddisflies (15%), and midges (13%); and Laurel Creek -- stoneflies (9%), mayflies (30%), caddisflies (19%), and midges (21%).

8-05 FISH AND WILDLIFE.

Effects of the water control plan on fish and wildlife at Sutton Lake are associated with water turbidity, water temperature and pool level fluctuations. Land use practices of timber harvesting, coal mining, and farming combined with rapid runoff from the Sutton Lake Basin result in turbid water entering Sutton Lake. Stratification of the lake is sufficient to prevent mixing from summer storm runoff, which concentrates colder, turbid water in the bottom lake zone. The initial design of the Sutton Lake outlet works required all outflow to be drawn from this bottom zone, resulting in a significantly changed temperature and turbidity regime downstream of the dam, affecting the fish habitat downstream. In addition, the winter drawdown to a very small minimum pool (elevation 850 feet) during the early years of operation resulted in significant environmental changes which caused the fish to migrate either upstream or downstream. A combination of these factors prevented implementation of a sound fishery management program at Sutton Lake.

In 1978, a project rehabilitation study was undertaken, prompted by public dissatisfaction of water quality on Elk River downstream of Sutton Lake. Operation procedures were reviewed to determine if modifications were advisable to improve the environment of the Elk River. As a result of this study, a number of modifications were instituted including construction of a high level intake on the outlet works, a raising of the minimum pool level, and a lowering of the seasonal pool level.

a. Fish and Wildlife Benefits. Utilization of the high level intake now allows warmer and less turbid waters to be released downstream along the Elk River. The warmer waters downstream of the dam create better spawning conditions for fish and improve the habitat for many species of indigenous benthic invertebrates. The raising of the minimum pool level creates improved conditions for the lake fishery and reduces fish migration to upstream or downstream waters.

Based on data obtained in 1988, the installation of the high level outlet structure has substantially improved downstream fishing conditions. In the Sutton tailwater area, 1988 fishing conditions were rated good (with temperatures greater than 55°F and turbidity of 15 J.T.U. or less) on 125 days, compared to an average of 61 days before the outlet structure was modified. In the Gassaway/Frametown area, there were 157 good fishing days during 1988 compared to a 65-day average before modification of the dam. Good catches of smallmouth bass, walleye and muskellunge, some of which are trophy size, have been reported from the Elk River below the dam each year since the modification.

8-06 WHITEWATER.

At the present time, fishing is the main recreational activity pursued downstream of Sutton Lake on the Elk River, and no special releases are made from Sutton Lake for whitewater activities. Excellent whitewater rafting facilities are available in the adjacent Gauley River watershed, just south of the Elk River watershed.

8-07 WATER QUALITY CONTROL.

Prior to the construction of the high level intake at Sutton Lake, the bottom release discharge from Sutton Lake depressed downstream water temperatures about 12°F from natural stream conditions and postponed maximum yearly temperature about two months. Exploitation of natural resources upstream of the impoundment resulted in high levels of turbidity entering and passing through the lake as an underflow moving along the bottom. Since the density current moved through the lake slower than the flood wave, prolonged turbid outflow was being released from the lake after storm events.

Since the construction of the high level intake, warmer and less turbid water has been released from the lake. In 1988, the maximum water temperature recorded by the West Virginia Water Company at Gassaway, five miles below Sutton, was 75°F during July. Prior to installation of the high level intake at Sutton Lake, the highest recorded temperature was about 70°F. Based on temperature and turbidity data taken in the Sutton Lake tailwater area between 1977 and 1987, there have been about 2.3 times as many good fishing days in the tailwater area since the construction of the high level intake. At the Winfield Locks pool on the Kanawha River, water quality is markedly improved compared to the 1950s and 1960s. The dissolved oxygen concentrations were originally set to be held at 3 parts per million in the interim plan for the Kanawha River; during the drought months of June, July and August of 1988, the dissolved oxygen concentration in the pool at Winfield Locks was above 5 parts per million about one-half of the time.

8-08 EMERGENCY DRAWDOWN.

Since the Sutton Lake Project has been operational, no emergency drawdown has occurred. The time required to draw down the reservoir from the maximum flood control pool is dependent on the maximum allowable discharge assumed from the outlets. With the sluice gates opened to pass the MIANO channel capacity downstream, the maximum flood control pool can be drawn down to the seasonal pool in 14.6 days, to the minimum pool in 16.7 days, and to the sluice invert in a total of 19.6 days. With the gates opened to pass the DEMIA channel capacity downstream, the drawdown times can be reduced to 9.0 days, 10.4 days, and 12.6 days, respectively. With all sluices wide open, the maximum flood control pool can be emptied to the sluice invert in approximately 8.2 days. With all crest gates and sluices open, the emptying time can be reduced to about 6.9 days. Emergency drawdown curves for Sutton Lake are shown on Plate 8-8.

Should emergency drawdown become necessary, various procedures such as surveillance of the dam or notification of key personnel may be placed into effect, depending on the cause and its severity. Detailed information concerning these emergency actions can be found in the Flood Emergency Plan for Sutton Lake.

8-09 SPECIAL PURPOSE RELEASES.

Special purpose regulation at Sutton Lake has been minimal during its period of operation. Relative to the dam itself, the most significant recurring deviations from the water control plan at Sutton Lake are associated with trash and debris removal, periodic maintenance and repairs, and periodic inspections of the dam and appurtenances. These deviations have had only minor impacts on the overall project.

8-10 FREQUENCIES AND DURATIONS.

a. Natural Discharge Frequency and Duration at the Outflow Gage. The natural discharge frequency curve for the Elk River at the Sutton Lake outflow gage was developed on a regional basis in accordance with methods outlined in "Statistical Methods in Hydrology", by Leo R. Beard, dated January 1962, and Bulletin 17A, "Guidelines for Determining Flood Flow Frequency", published by the United States Water Resources Council and dated March 1976. A Log-Pearson Type III distribution was fitted to the annual event series at gaging stations in the Kanawha River Basin.

This enabled generalized relationships to be derived which relate frequency curve characteristics, mean, standard deviation and skew to individual basin factors. These data were utilized to make flow frequency estimates for the project drainage area. Flow values for selected exceedence intervals from 1 year to 100 years are given in Table No. 8-4.

TABLE NO. 8-4

FREQUENCY SUMMARY
ELK RIVER AT SUTTON, WEST VIRGINIA
ALL SEASONS - NATURAL

Exceedence Interval (years)	Natural Discharge (cfs)	Modified Discharge (cfs)
100	56,900	12,400
50	47,700	12,400
20	37,000	12,400
10	30,600	12,400
5	25,300	12,400
2	19,300	12,400
1	15,400	12,400

Since 1949, flows in Elk River have been regulated by Sutton Lake. A computer study of the duration of flow at the outflow gage was conducted using the U.S. Geological Survey record of flow past the gage for the period 1961 through 1989. Percent of total elapsed time during which the flow was at or above certain selected values was calculated. These flow values were then plotted against the percent of time as calculated for the full year to produce the Annual Flow Duration curve for the Elk River below Sutton.

b. Pool Elevation Frequency and Duration. Peak pool elevations for all significant rises experienced during actual operation of the Sutton Lake Project through 1989 have been analyzed using graphical frequency procedures. The annual curve derived from this study is shown on Plate 8-1, Frequency of Filling. Durations of selected pool elevations have been derived from historical pool elevations experienced at the Sutton Lake Project for the same period ending in 1989. Duration curves for average and maximum number of days per year derived from this study are shown on Plate 8-2, Duration of Filling. A frequency summary of Sutton Lake pool elevation deviations is shown on Table No. 8-5.

c. Control Stations - Frametown, Clay, and Queen Shoals, West Virginia. The natural frequencies of the Elk River at the Frametown, Clay and Queen Shoals gaging stations were estimated using nearly the same methods and techniques of data handling and calculation as were used for the Elk River at the damsite. The difference was that long-term records of stream flow existed for these gages, making unnecessary the regional approach used for ungaged areas.

TABLE NO. 8-5

FREQUENCY OF FILLING SUMMARY
SUTTON LAKE POOL ELEVATION DEVIATION - ALL SEASONS

Exceedence Interval (years)	Elevation (feet msl)
100	985.5
50	981.5
20	974.1
10	966.7
5	957.0
2	942.0
1	929.0

Actual peaks occurring at the gages since the Sutton Lake Project went into operation were increased by the routed lake reductions to produce natural flows. Maximum natural flows expected to occur, on the average, once in a certain period of years, which is the exceedence interval, were plotted against the respective intervals to produce the "Natural" curves of Natural and Modified Flow Frequency Curves. Flows for selected exceedence intervals from 1 year to 100 years for each control station are included in Table Nos. 8-6 through 8-8.

TABLE NO. 8-6

FREQUENCY SUMMARY
ELK RIVER AT FRAMETOWN, WEST VIRGINIA
ALL SEASONS

Natural Condition		Modified Condition	
Exceedence Interval (Years)	Discharge (CFS)	Exceedence Interval (Years)	Discharge (CFS)
100	65,700	100	32,000
50	54,200	50	23,700
20	42,000	20	16,300
10	33,900	10	12,300
5	27,800	5	10,100
2	21,700	2	8,400
1	18,000	1	7,700

TABLE NO. 8-7

FREQUENCY SUMMARY
ELK RIVER AT CLAY, WEST VIRGINIA
ALL SEASONS

Natural Condition		Modified Condition	
Exceedence Interval (Years)	Discharge (CFS)	Exceedence Interval (Years)	Discharge (CFS)
100	79,700	100	54,000
50	67,700	50	43,500
20	54,200	20	32,200
10	44,400	10	26,400
5	37,500	5	23,600
2	29,400	2	21,100
1	23,900	1	19,800

TABLE NO. 8-8

FREQUENCY SUMMARY
ELK RIVER AT QUEEN SHOALS, WEST VIRGINIA
ALL SEASONS

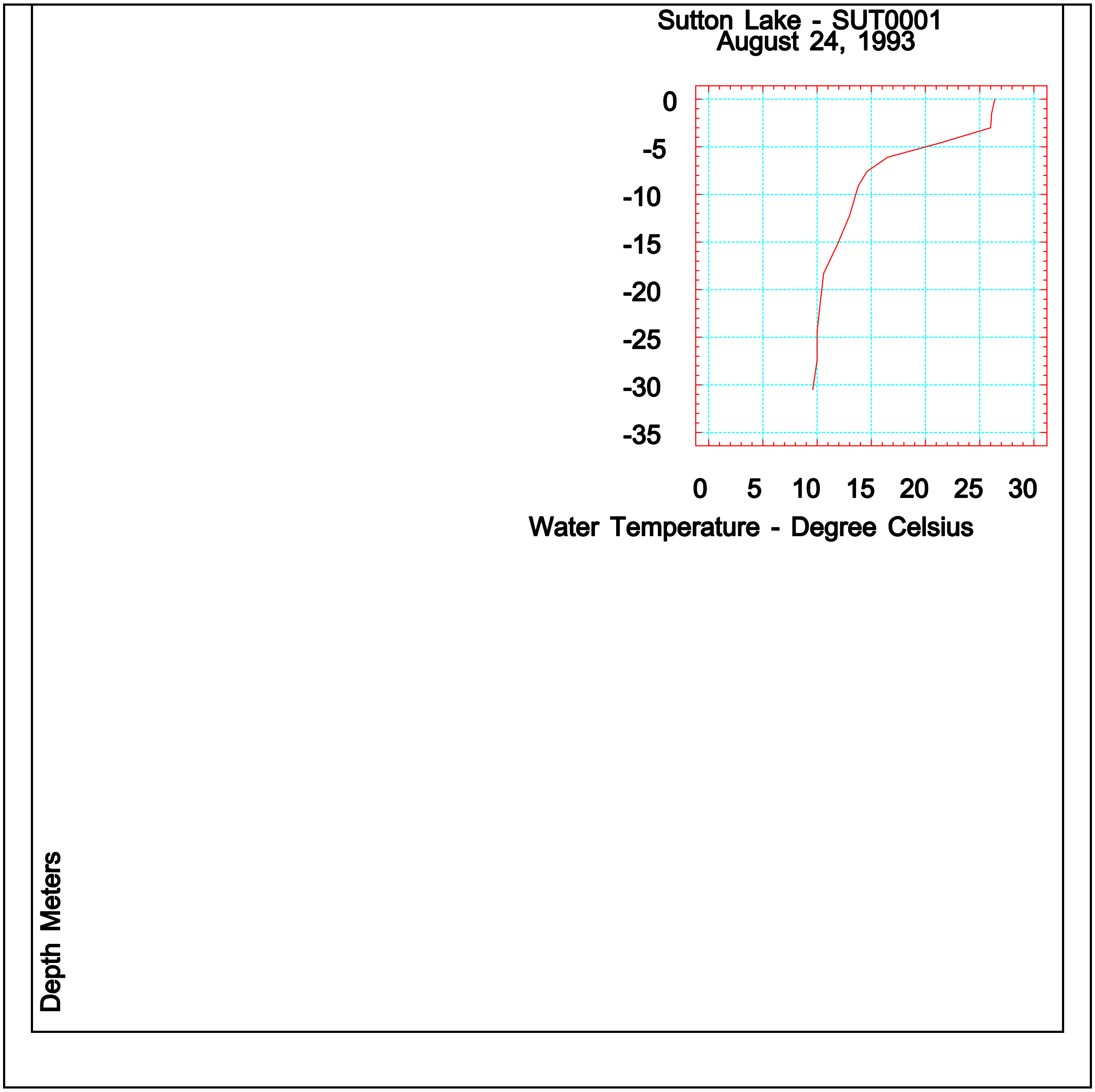
Natural Condition		Modified Condition	
Exceedence Interval (Years)	Discharge (CFS)	Exceedence Interval (Years)	Discharge (CFS)
100	86,600	100	64,500
50	73,400	50	54,300
20	58,600	20	43,200
10	48,100	10	35,800
5	40,600	5	30,800
2	31,800	2	25,500
1	26,000	1	22,200

In order to estimate modified frequencies, representative floods from the record prior to beginning operation of the Sutton Lake Project were routed through the lake and reductions routed to the gaging stations. These were applied to the actual (natural) and the resulting modified peaks noted. Reductions of Elk River flows effected by the Sutton Lake Project since 1960 were routed to the gaging stations and added to the actual (modified) flows to produce the natural. The peak modified flow for each event at each gage was plotted against the peak natural flow for the event. The most representative smooth curve, to be known as the "Correlation Curve", was drawn among the points, the upper end of the curve being defined by the natural and modified by the Standard Project Flood. Any point on the Correlation Curve gives, for the peak natural flow specified, the probable peak flow to be experienced at each gage because of Sutton Lake control of Elk River flows; and exceedence intervals of modified flows are the same as those of the corresponding natural flows. Therefore, intervals of selected natural flows were plotted against their corresponding modified flows to produce the "Modified" Curves.

Studies of the duration of flow at each gage were performed for the period beginning with the commencement of regulation of flow in the Elk River by Sutton Lake in 1960 and ending with the year 1988. Using the USGS record of flow at each gaging station, the percent of total elapsed time during which the flow was at or above certain specified values was calculated by computer. These flow values were then plotted against the respective percent of time as calculated for the entire year to produce the Annual Flow Duration Curves.

8-11 HISTORICAL HYDROGRAPHS.

Regulation of the Sutton Lake Project has been simulated using historical data from the beginning of its operation. Historical hydrographs of inflow, outflow, and pool elevation are shown in Plate 4-5 to facilitate review and understanding of the project regulation during its life.


Sutton Lake - SUT0001
August 24, 1993
0
-5
-10
-15
-20
-25
-30
-35
0
5
10
15
20
25
30
Water Temperature - Degree Celsius
Depth Meters

SECTION IX - WATER CONTROL MANAGEMENT

9-01 RESPONSIBILITIES AND ORGANIZATION FOR CORPS OF ENGINEERS.

(1) General. General authorities for allocation and regulation of reservoir storage in projects owned and operated by the Corps of Engineers are contained in legislative authorization acts and referenced project documents. These public laws and project documents usually contain provisions for development of water control plans, and appropriate revisions thereto, under the discretionary authority of the Chief of Engineers. Some modifications in project operation are permitted under laws passed since the original project authorization. The dam at Sutton Lake is owned and operated by the U.S. Government. The Huntington District, Corps of Engineers is the operating agency for the project, through administrative control by the Kanawha Area Office within Operations and Readiness Division.

(2) OCE Role in Water Control Activities. OCE will establish policies and guidelines applicable to all field offices and for such actions as are necessary to assure a reasonable degree of consistency in basic policies and practices in all Division areas. Assistance will be provided to field offices during emergencies and upon special request.

(3) Great Lakes and Ohio River Division. The Division Engineer has primary responsibility and authority for direct action with respect to all phases of reservoir regulation, including: (a) basic policies, criteria, and concepts that determine operating plans; (b) technical evaluations; (c) field operation; and (d) review and approval of reservoir regulation plans and manuals and related activities. The Division Office will coordinate water control management activities associated with interdistrict, interdivision and interagency water resource needs. As established in accordance with ER 1110-2-1400, the Ohio River Division Water Management Branch is responsible for administration of the Division Engineer's policy for water control management.

(4) Huntington District. District Engineers have the primary responsibility for (a) general management of reservoir regulation activities within their respective areas; (b) technical evaluations and performance of operations associated therewith; and (c) developing plans and manuals required for reservoirs and interrelated systems within their respective district area. The Water Resources Engineering Branch, within the Engineering Division, is the responsible element for all water control activities which include the following reservoir project functions:

(a) Flood control.

(b) Fish and wildlife enhancement.

(c) Recreation.

(d) Pollution abatement.

Water control plans include coordinated reservoir regulation schedules for project/system operation and such additional provisions as may be required to collect, analyze and disseminate basic data, prepare detailed operating instructions, assure project safety and carry out regulation of projects in an appropriate manner. Water control plans are developed to conform with objectives and specific provisions of project authorizing legislation and applicable Corps of Engineers' projects. They include any applicable authorities established after project construction. The water control plans are prepared giving appropriate consideration to all applicable Congressional Acts relating to operation of Federal facilities, i.e., Fish and Wildlife Coordination Act (P.L. 85-624), Federal Water Project Recreation Act - Uniform Policies (P.L. 89-72), National Environmental Policy Act of 1969 (P.L. 91-190), and Clean Water Act of 1977 (P.L. 95-217). Thorough analysis and testing studies are made as necessary to establish the optimum water control plans possible within prevailing constraints.

(5) Water Resources Engineering Branch is delegated the responsibility to coordinate the operation of specific projects with Federal and State agencies, local entities, and the general public. The Division Engineer, ATTN: CEORD-ED-W, is advised, as soon as possible, of any coordination activities which may require a study, public hearing, or revision in operating plans. Districts are required to alert the Division Engineer, ATTN: CELRD-OR-ET-W, of any significant deviations from routine regulation plans. The communication mode for the advisory is commensurate with the urgency of the situation and transmitted before a plan of action is implemented by the district. An organizational chart is shown on Plate 9-1 for Water Control Management at Sutton Lake. As shown on the chart, the Natural-Resource Management Branch and the Kanawha Area Office are responsible for supervision of the operation and maintenance of the dam and operations area at Sutton Lake. The Resource manager at Sutton Lake regulates the project in accordance with general instructions and Special Directives issued by the Water Resources Engineering Branch. General instructions are included in Instructions to Damtender, Exhibit B of this manual, and Special Directives are issued and signed by the Chief, Water Resources Engineering Branch, for dissemination to the Damtender as necessary to efficiently regulate the project for optimal water control management for all project purposes.

During normal operations, the Water Control Section of Water Resources Engineering Branch are involved in the following activities pertaining to water control management:

(a) Routine regulation of the lakes and dissemination of pertinent data.

(b) Investigations and refinement of regulation procedures such as analysis of past floods, channel investigations, improvement of forecasting, and planning programs with other agencies.

(c) Training personnel in flood control duties with visits to projects and instructing Water Resources Engineering Branch personnel from other sections.

(d) Development and application of mathematical modeling to complex reservoir systems.

(e) Operation of the Branch hydrologic data collection and water control management system, including computers and field equipment.

(f) Developing and conducting effective public information programs to inform and educate the public regarding Corps of Engineers' water control management activities.

(g) Preparing and submitting reports on lake regulations such as daily reports, weekly reports, monthly reports, annual reports, weekly briefings, and post-flood reports.

(h) Preparing and updating water control manuals for individual projects and master manuals for basins.

During flood or other emergencies, Water Resources Engineering Branch personnel are responsible for the following activities in regard to water control management:

(a) Evaluation and dissemination of current and forecast hydrologic, hydraulic and meteorologic data.

(b) Presentation of storm and flood analysis to the District Engineer and pertinent staff members.

(c) Providing liaison personnel to support Emergency Operations Center when it is operational.

(d) Regulation of all projects and systems in accordance with approved plans.

(e) Furnishing information to others such as reports to higher authority, status to Emergency Operations Center and data to Public Affairs Office.

Lines of communication between the various office elements are shown on Plate 9-2. Details and responsibilities of other elements are indicated in the overall district plan in the Emergency Operations Center Plan and ER 500-1-1, ER 500-2-1 and all annexes to these two ER's.

During normal non-flood periods, water control management activity is accomplished by personnel of the Water Control Section. During flood conditions and other emergencies, assistance of other Water Resources Engineering Branch personnel may be required to maintain effective water control management within the Huntington District. The area affected and magnitude of the flood determines the number of people engaged in each particular activity and assigned to each sub-basin or major river basin.

The National Weather Service and project personnel are provided with a list of names of Water Resources Engineering Branch personnel and home telephone numbers with instructions to contact them during off-duty hours if unusual conditions occur or a project is in a particular reporting schedule. During emergency conditions or flood regulation, Water Resources Engineering Branch staff are available from 18 to 24 hours daily, depending on the magnitude of a particular event. At each project, responsible personnel are on duty or on call at all times.

The Huntington District also works in cooperation with other Federal, State, local and private organizations and agencies, as has been illustrated throughout this report. A summary of the major relationships is shown on Plate 9-3.

9-02 REPORTS.

Table No. 9-1 at the end of this section contains a listing of the various

Periodic and Special reports provided by Huntington District Water Resources Engineering Branch.

a. Periodic.

(1) Daily. Districts are required to report current hydrologic data daily as prescribed by the Division Office. During normal workdays, a daily report containing observed data, 3-day forecast of lake and outflow for all reservoir projects, and 5-day flow forecasts for Ohio River tributary gage points is automatically generated by the water control system. Subsequent to final modeling and certification, the report is transmitted to the Division Office Water Management Branch via leased line. During weekends and holidays, the report contains only observed district data. Items are prepared in accordance with ORDR 1110-2-20, CEORD-ED-W Ltr, 10 Jul 69, CEORD-ED-W Ltr, 23 Jan 67, and ORDR 1110-2-17.

Daily or more frequent briefings of the District Engineer and Chief Engineer containing pertinent hydrologic and meteorologic information are made during flood or other emergencies.

In carrying out water control activities, Corps of Engineers personnel must recognize and observe the legal responsibility of the National Weather Service (NWS) and the National Oceanic and Atmospheric Administration (NOAA) for issuing weather forecasts and flood warnings, including river discharges and stages. River forecasts prepared by the Corps of Engineers in the execution of its responsibilities are not released to the general public, unless the NWS is willing to make the release or agrees to such dissemination. However, release to interested parties of factual information on current storms or river conditions and properly quoted NWS forecasts is permissible. District offices are encouraged to provide assistance to communities and individuals regarding the impact of forecasted floods. Typical advice would be to provide approximate water surface elevations at locations upstream and downstream of the NWS forecasting stream gages. Announcement of anticipated changes in reservoir release rates as far in advance as possible to the general public is the responsibility of Corps of Engineers' water control managers for projects under their jurisdiction.

(2) Weekly. Each week a list of 24-hour reservoir effects at tributary gage points is transmitted to LRD. The list, which gives flows in cfs held out from or added to the natural flow, shows the data for an entire month ending with the current week. The gage point reported for the Kanawha River Basin is at Charleston, West Virginia, on the Kanawha River.

(3) Monthly. Engineer Regulation No. 1110-2-240, dated 8 October 1982, requires that a monthly record of reservoirs operated by the District be promptly prepared by Water Resources Engineering Branch, according to 33 CFR 208.11, and maintained in tabular form readily available for transmittal to the Chief of Engineers or others on request.

(4) Reservoir Operations. Each District provides a review of meteorological influences and water control management activities to each of the meetings of the Reservoir Operations Coordinating Group. Huntington District personnel of the Water Control Section summarize and compare weather experienced with long-term normals and actual streamflows to mean annual values. They describe seasonal features of operation such as spring filling, summer outflow temperature control or fall drawdown, frozen lakes and effect of river ice on navigation, in addition to any significant flood control

operations and damages prevented.

(5) Annual. The Division Engineer is required by ORDR 1110-2-27 and CEORD-ED-W Ltr, 30 Sep 1977 to submit to OCE for approval an annual report on reservoir regulation activities of significance during the fiscal year ending and programs proposed for the year following. This report summarizes the water control activities throughout the Ohio River Basin. Therefore district input is mandatory. The following documentation of district programs and activities is requested by 1 November of each year:

(a) A brief summary highlighting the significant accomplishments attributed to each reservoir during the preceding fiscal year.

(b) Reservoir regulation manual submission schedule.

(c) Concise report on major accomplishments concerning personnel, training, model application, ADP use, data reporting and analysis, and general improvements in reservoir regulation activities. By Executive Order 12088, the President ordered the head of each Executive Agency to be responsible for ensuring that all necessary actions are taken for prevention, control, and abatement of environmental pollution with respect to Federal facilities and activities under control of the agency. Annual Division Water Quality reports are required by ORDR-2-26. The report is submitted in two parts. The first part addresses the division Water Quality Management plan while the second part presents specific project information. A major objective of this report is to summarize information pertinent to overall water management responsibilities. An Annual Water Quality Report by Districts to ORD includes narrative and tabular summaries of water quality activities and conditions in the Districts. The District report contains a synopsis of activities, specific cases of interest, improvements during the year, and plans for future emphasis. The tabular portion includes an overview of water quality activities, an overview of water quality conditions, specific water quality control actions in coordination with the Reservoir Control Section, special studies aimed at identification or solution of problems and problems requiring special studies with schedules for executing the studies. The annual water quality report is submitted by 1 December of each year.

b. Special Reports.

(1) Reports on Reservoir Operations During Flood Emergencies. Information on reservoir operations to be included in reports submitted to the Chief of Engineers during flood emergencies in accordance with ER 500-1-1 include rate of inflow and outflow in cfs, reservoir levels, predicted maximum level and anticipated date, and percent of flood control storage utilized to date. Maximum use is made of computerized communication facilities in reporting project status to DAEN-CWO-E/CWE-HY in accordance with the requirements of ER 500-1-1.

(2) Post-Flood Report. Information on the operation of the affected reservoirs is gathered in accordance with ER 500-1-1. This report provides details on antecedent meteorologic and hydrologic conditions, description of the performance of the dam and appurtenant works, detailed analysis of the operating procedures, and effects of reservoir operation on the Kanawha River and Ohio River. Reservoir effects include evaluation of the stage reductions at key stations and estimates of damages prevented. Conclusions are discussed with regard to adequacy of operating technique, performance of structures, and benefits derived from operation during the flood.

(3) Fiscal Year Budget Requests. Budget requests for water control management activities are prepared and submitted to the Office of the Chief of Engineers in accordance with requirements established in Engineer Circular on Annual Budget Requests for Civil Works Activities. The total annual costs of all activities and facilities that support the water control functions (excluding physical operation of projects, but including flood control and regulation of navigation projects subject to 33 CFR 208.11) are reported. Information on the Water Control Data Systems and associated Communications Category of the Plant Replacement and Improvement Program is submitted with the annual budget. Reporting is in accordance with an Engineer Regulation and the annual Engineer Circular on Civil Works Operations and Maintenance, General Program.

(4) Snowmelt Runoff and Flood Potential Letter Reports. The Chief of Engineers and staff require information to respond to inquiries from members of Congress and others regarding runoff potentials. Therefore, the Division Engineer submits a snowmelt runoff and flood potential letter report covering the snow accumulation and runoff period, beginning generally in February and continuing monthly, until the potential no longer exists. Dispatch of supplemental reports is determined by the urgencies of situations as they occur. The reports are forwarded as soon as hydrologic data are available, but not later than the 10th of the month. For further information on reporting refer to ER 500-1-1.

(5) Drought Reports. During major drought situations or low-flow conditions, narrative summaries of the situation are furnished to alert the Chief of Engineers regarding the possibility of serious runoff deficiencies that are likely to call for actions associated with Corps of Engineers' reservoirs.

(6) Master Plans for Water Control Data Systems. These plans and significant revisions thereto are prepared by Division water control managers and submitted to HQDA (DAEN-CWE-HY) Washington, DC 20314, for review and approval of engineering aspects. Engineering approval does not constitute funding approval. After engineering approval is obtained, equipment in the master plan is eligible for consideration in the funding processes described in ER 1125-2-301 and Engineering Circulars on the Annual Budget Request for Civil Works Activities. Master plans are maintained current and are updated as necessary to meet needs.

Modified master plans are submitted by 1 February if revisions are required to include equipment not previously approved or for changes in scope or approach. Submittal by the February date allows adequate time for OCE review and approval prior to annual budget submittals.

(7) Other Reports. Any additional or pertinent reports which are required from higher authority are prepared as necessary.

TABLE NO. 9-1

HUNTINGTON DISTRICT REPORTS
BY
WATER RESOURCES ENGINEERING BRANCH

PERIODIC REPORTS - Computer reports keyed to forms formerly completed by hand as follows:

Daily — Computer report of observed and forecast stages and flows including:
- Morning reservoir pool elevation, outflow, outflow temperature and three-day pool and outflow forecast.
- 24-hour rainfall, morning stage, flow and five-day flow forecast at Ohio River tributary gage points.

Weekly — Reservoir effects at Ohio River tributary gage points.

Monthly — Record of District reservoirs available on request.

Annually — Summary of significant reservoir regulation activities for the year and of programs proposed for the following year.

SPECIAL REPORTS

Daily or more frequent briefing of District Engineer and Chief Engineer during flood or other emergencies containing hydrologic, meteorologic, and operational information, when and as requested.

Information relevant to flooded area or situation to the Emergency Operations Center (when functioning) such as pertinent data about the area, copies of reservoir morning and extra reports, relay of any verbal reports, relevant NWS zone forecasts and special bulletins, and computer-generated isohyetal map of the District.

Reports on reservoir operations to OCE during flood emergencies including inflow, outflow, pool elevation, predicted crest, and maximum storage utilization to date.

Post-flood reports.

Budget requests for water control management activities to OCE.
Snow-melt runoff and flood potential letter report to OCE.

Narrative summaries of major drought or lowflow conditions likely to call for regulations of District reservoirs.

Master plans for water control data systems and significant revisions thereto are submitted to HQDA (DAEN-CWE-HY) Washington, DC 20314, for review and approval of engineering.

TABLE NO. 5-2

PRECIPITATION STATIONS IN AND NEAR
ELK RIVER-SUTTON LAKE BASIN - PERTINENT DATA

Record From	Station	Type Station	Equipment	Method of Obtaining Data	Reporting Criteria
1982	Sharps Knob	SP	TBKT and DCP.	DCP transmission.	Data collection interval 60 minutes.
1937	Valley Head	ORN	SRG	Observer, AFOS.	Daily.
1900	Pickens	ORN	SRG	Observer, AFOS.	Daily.
1959	Hacker Valley	ORN	SRG	Observer, AFOS.	0.1 inch collected by 0700.
1933	Webster Springs	ORN	SRG	Observer, Sutton report.	0.5 inch collected by 0700.
1982	Webster Springs	SP	TBKT and DCP.	DCP transmission.	Data collection interval 30 minutes.
1901	Camden-on-Gauley	ORN	SRG	Observer, AFOS.	Daily.
	Camden-on-Gauley	SP	TBKT and DCP.	DCP transmission.	Data collection interval 60 minutes.
1965	Birch River	ORN	SRG	Observer, Sutton report.	0.5 inch collected by 0700.
1988	Birch River	SP	TBKT and DCP.	DCP transmission.	Data collection interval 60 minutes.
1949	Centralia	ORN	SRG	Observer, Sutton report.	0.5 inch collected by 0700.

Note: DCP - Data Collection Platform. DCP transmits via satellite to Ohio River Division (ORD) downlink every 4 hours. ORD Water Control System (WCS) receives from downlink and disseminates hourly to Ohio River Huntington (ORH) WCS. Voice DCP's are equipped to respond to telephone calls with electronically synthesized voice.
TBKT - Tipping bucket rain gage.
SRG - Standard 8" rain gage.
ORN - Ohio River Network.
AFOS - Automated Field Operating Services.

TABLE NO. 5-2 (Cont'd.)

PRECIPITATION STATIONS IN AND NEAR
ELK RIVER-SUTTON LAKE BASIN - PERTINENT DATA

Record From	Station	Type Station	Equipment	Method of Obtaining Data	Reporting Criteria
1984	Replete	SP	TBKT and DCP.	DCP transmission.	Data collection interval 30 minutes.
1975	Gregory	ORN	SRG	Observer, AFOS.	0.1 inch collected by 0700.
1947	Sutton Lake	ORN	SRG	Sutton report.	Daily.
1984	Sutton outflow	SP	TBKT and DCP.	DCP transmission.	Data collection interval 60 minutes.
1984	Frametown	SP	TBKT and DCP.	DCP transmission.	Data collection interval 30 minutes.
1962	Big Otter	ORN	SRG	Observer, Sutton report.	0.5 inch collected by 0700.
1913	Clay	ORN	SRG	Observer, Sutton report	0.1 inch collected by 0700.
1984	Clay	SP	TBKT and DCP.	DCP transmission.	Data collection interval 60 minutes.
1984	Queen Shoals	SP	TBKT and DCP.	DCP transmission.	Data collection interval 60 minutes.
1949	Clendenin	ORN	SRG	Observer, AFOS.	Daily.

Note: DCP - Data Collection Platform. DCP transmits via satellite to Ohio River Division (ORD) downlink every 4 hours. ORD Water Control System (WCS) receives from downlink and disseminates hourly to Ohio River Huntington (ORH) WCS. Voice DCP's are equipped to respond to telephone calls with electronically synthesized voice.
TBKT - Tipping bucket rain gage.
SRG - Standard 8" rain gage.
ORN - Ohio River Network.
AFOS - Automated Field Operating Services.

TABLE No. 7-2

SUTTON LAKE
ELK RIVER
AREA AND CAPACITY TABLES

Drainage Area = 537.0 Sq.Mi. 1" Runoff = 28,640 Ac.Ft.

Pool	Capacity		Area	Pool	Capacity		Area
Elev.	Ac.Ft.	Inches	(Acres)	Elev.	Ac.Ft.	Inches	(Acres)
810	0	0	0	845	2,820	0.10	220
811	0	0	0	846	3,050	0.11	230
812	0	0	0	847	3,280	0.11	240
813	0	0	5	848	3,530	0.12	250
814	0	0	5	849	3,780	0.13	260
815	10	0	5	850	4,050	0.14	270
816	20	0	5	851	4,330	0.15	280
817	20	0	5	852	4,620	0.16	300
818	30	0	10	853	4,920	0.17	310
819	40	0	10	854	5,240	0.18	330
820	50	0	10	855	5,570	0.19	340
821	60	0	15	856	5,920	0.21	350
822	80	0	20	857	6,280	0.22	360
823	100	0	20	858	6,640	0.23	370
824	120	0	30	859	7,020	0.25	380
825	160	0.01	40	860	7,410	0.26	400
826	200	0.01	50	861	7,820	0.27	410
827	250	0.01	60	862	8,230	0.29	420
828	320	0.01	70	863	8,650	0.30	430
829	390	0.01	80	864	9,080	0.32	440
830	480	0.02	100	865	9,530	0.33	450
831	590	0.02	110	866	9,990	0.35	460
832	700	0.02	110	867	10,460	0.36	480
833	810	0.03	120	868	10,940	0.38	490
834	940	0.03	130	869	11,440	0.40	500
835	1,070	0.04	140	870	11,950	0.42	520
836	1,210	0.04	140	871	12,470	0.44	530
837	1,350	0.05	150	872	13,010	0.45	550
838	1,510	0.05	160	873	13,570	0.47	560
839	1,670	0.06	160	874	14,130	0.49	570
840	1,840	0.06	170	875	14,650	0.51	590
841	2,010	0.07	180	876	15,310	0.53	600
842	2,200	0.08	190	877	15,920	0.56	610
843	2,400	0.08	200	878	16,540	0.58	630
844	2,600	0.09	210	879	17,170	0.60	640

SUTTON LAKE
ELK RIVER
AREA AND CAPACITY TABLES

Drainage Area = 537.0 Sq.Mi. 1" Runoff = 28,640 Ac.Ft.

Pool	Capacity		Area	Pool	Capacity		Area
Elev.	Ac.Ft.	Inches	(Acres)	Elev.	Ac.Ft.	Inches	(Acres)
880	17,820	0.62	650	915	50,230	1.75	1270
881	18,470	0.64	660	916	51,510	1.80	1290
882	19,140	0.67	670	917	52,810	1.84	1320
883	19,820	0.69	680	918	54,140	1.89	1340
884	20,510	0.72	700	919	55,490	1.94	1370
885	21,210	0.74	710	920	56,870	1.98	1390
886	21,930	0.77	730	921	58,270	2.03	1420
887	22,670	0.79	740	922	59,700	2.08	1440
888	23,420	0.82	760	923	61,160	2.14	1470
889	24,180	0.84	780	924	62,640	2.19	1490
890	24,970	0.87	790	925	64,140	2.24	1520
891	25,770	0.90	810	926	65,670	2.29	1540
892	26,590	0.93	830	927	67,230	2.35	1570
893	27,420	0.96	840	928	68,820	2.40	1600
894	28,270	0.99	860	929	70,430	2.46	1620
895	29,140	1.02	870	930	72,070	2.52	1650
896	30,020	1.05	890	931	73,730	2.57	1680
897	30,920	1.08	900	932	75,430	2.63	1710
898	31,830	1.11	920	933	77,160	2.69	1750
899	32,760	1.14	940	934	78,920	2.76	1780
900	33,700	1.17	950	935	80,720	2.82	1810
901	34,660	1.21	970	936	82,540	2.88	1840
902	35,640	1.24	990	937	84,400	2.95	1870
903	36,640	1.28	1010	938	86,290	3.01	1900
904	37,660	1.31	1030	939	88,210	3.08	1930
905	38,690	1.35	1050	940	90,160	3.15	1960
906	39,750	1.39	1070	941	92,130	3.22	1990
907	40,830	1.42	1090	942	94,130	3.29	2010
908	41,930	1.46	1110	943	96,160	3.36	2040
909	43,050	1.50	1130	944	98,200	3.43	2060
910	44,190	1.54	1150	945	100,280	3.50	2080
911	45,350	1.58	1170	946	102,370	3.57	2110
912	46,540	1.62	1200	947	104,490	3.65	2130
913	47,740	1.67	1220	948	106,630	3.72	2150
914	48,980	1.71	1240	949	108,790	3.80	2180

SUTTON LAKE
ELK RIVER
AREA AND CAPACITY TABLES

Drainage Area = 537.0 Sq.Mi.   1" Runoff = 28,640 Ac.Ft.

Pool Elev.	Capacity Ac.Ft.	Capacity Inches	Area (Acres)	Pool Elev.	Capacity Ac.Ft.	Capacity Inches	Area (Acres)
950	110,990	3.88	2210	985	210,270	7.34	3440
951	113,210	3.95	2240	986	213,730	7.46	3470
952	115,460	4.03	2270	987	217,220	7.58	3510
953	117,760	4.11	2310	988	220,740	7.71	3540
954	120,090	4.19	2350	989	224,300	7.83	3570
955	122,450	4.28	2390	990	227,880	7.96	3600
956	124,860	4.36	2430	991	231,500	8.08	3630
957	127,310	4.44	2470	992	235,140	8.21	3660
958	129,800	4.53	2510	993	238,810	8.34	3690
959	132,330	4.62	2550	994	242,510	8.47	3710
960	134,900	4.71	2590	995	246,240	8.60	3740
961	137,510	4.80	2630	996	249,990	8.73	3770
962	140,150	4.89	2660	997	253,770	8.86	3790
963	142,820	4.97	2690	998	257,580	8.99	3820
964	145,530	5.08	2730	999	261,410	9.13	3850
965	148,270	5.18	2760	1000	265,270	9.26	3880
966	151,050	5.27	2790	1001	269,160	9.40	3910
967	153,860	5.37	2830	1002	273,090	9.54	3940
968	156,700	5.47	2860	1003	277,060	9.67	3980
969	159,580	5.57	2890	1004	281,060	9.81	4020
970	162,490	5.67	2930	1005	285,100	9.95	4060
971	165,430	5.78	2960	1006	289,180	10.08	4100
972	168,410	5.88	3000	1007	293,300	10.24	4150
973	171,430	5.98	3030	1008	297,470	10.39	4190
974	174,480	6.09	3070	1009	301,680	10.53	4240
975	177,560	6.20	3100	1010	305,940	10.68	4280
976	180,680	6.31	3130	1011	310,250	10.83	4330
977	183,830	6.42	3170				
978	187,010	6.53	3200				
979	190,230	6.64	3240				
980	193,490	6.76	3270				
981	196,770	6.87	3310				
982	200,100	6.99	3340				
983	203,450	7.10	3370				
984	206,850	7.22	3410				

SUTTON LAKE
ELK RIVER

PERTINENT DATA

LOCATION

The dam is located in Braxton County, West Virginia, on the Elk River, a tributary of the Kanawha River, approximately 100.4 miles above the mouth of the Elk River, and 158.9 miles above the mouth of the Kanawha River.

TYPE OF PROJECT

Multi-purpose; flood control, pollution abatement, recreation, and fish and wildlife conservation.

AUTHORITY

Sutton Lake was authorized by the Flood Control Act of 28 June 1938, H.R. 10618, Public Law No. 761, 75th Congress, third session, as a unit in the comprehensive flood control plan for the Ohio River Basin.

PURPOSES

The project was initially authorized as a flood control project for reduction of flood damages on the Elk, Kanawha, Ohio and Mississippi Rivers. In addition to flood control, current project purposes include general recreation, pollution abatement, and fish and wildlife conservation.

DRAINAGE AREAS (Square Miles)

Elk River at dam site	537
Elk River at Sutton	542
Elk River near Frametown	751
Elk River at Clay	992
Elk River at Queen Shoals	1,145
Elk River at mouth	1,536
Kanawha River at Charleston	10,419
Kanawha River at Poca	11,435
Kanawha River at Winfield Dam	11,809
Kanawha River at mouth	12,300
Ohio River at Point Pleasant	52,760

SUTTON LAKE
ELK RIVER

PERTINENT DATA (Cont'd)

STREAMFLOW DATA (Cubic feet per second)

Average annual flow just below Damsite(1939-1987)	1,152
Maximum peak discharge at Damsite (September 1861)	50,000
(March 1918)	49,000
Maximum Discharge below Damsite (11 March 1967)Regulated	13,200
Minimum discharge below Damsite (1 October 1959)Regulated	9
Minimum Discharge below Damsite (Oct 1953)pre-regulation	0.4

RESERVOIR DATA

Elevations (Feet above m.s.l.)

Streambed at Damsite	807
Mimimum Pool	850
Winter Pool	895
Seasonal Pool	922
Flood Control Pool	1000
Spillway Design Flood Crest	1010.3

	Acre-Feet		Inches Runoff	
Capacities	Net	Gross	Net	Gross
Minimum Pool	4,050	4,050	0.14	0.14
Winter Pool	29,100	29,100	0.88	1.02
Seasonal Pool	30,600	59,700	1.06	2.08
Flood Control Pool				
Above Minimum	236,200	265,300	8.2	9.2
Above Seasonal	205,600	265,300	7.1	9.2
Total Storage		265,300		9.2

Surface Area (Acres)

Minimum Pool - 850	270
Winter Pool - 895	870
Seasonal Pool - 922	1,440
Flood Control Pool - 1000	3,875

Backwater Along Main Stream (Miles)

Minimum Pool	6.6
Winter Pool	12.6
Seasonal Pool	14.5
Flood Control Pool	20.5

SUTTON LAKE
ELK RIVER

PERTINENT DATA (Cont'd)

DAM

Type-concrete gravity	
Maximum height, feet	210
Top length, feet	1,178
Top width, feet	20
Base width, feet	195

SPILLWAY

Type-gated concrete spillway in channel section of dam	
Bucket radius, feet	50
Crest length, feet	280
Crest elevation, feet above m.s.l.	972
Number of tainter gates	6
Size of tainter gates	40'x31'
Design discharge, cubic feet per second	222,240
Surcharge, feet	38.3
Freeboard, feet	6.7

OUTLET WORKS

Type-gated sluices and valve-controlled low flow sluice located in spillway section and discharging into spillway bucket. High level intake at center sluice.	
Number of gated sluices	5
Size of gated sluices	5'-8"x10'-0"
Size of low flow sluice, diameter in inches	36

U. S. ARMY ENGINEER DISTRICT, HUNTINGTON
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

KANAWHA RIVER BASIN
WEST VIRGINIA

PROJECT MANUAL
FOR
WATER CONTROL MANAGEMENT
SUTTON LAKE - WEST VIRGINIA

FEBRUARY 1998

INSTRUCTIONS TO DAMTENDER

SUTTON LAKE

Exhibit B

TABLE OF CONTENTS

Section I - General Operation Instructions

Section II - Collection of Hydrometeorologic Data

Section III - Collection of Streamflow Data

TABLE OF CONTENTS (Cont'd)

Section IV - Instructions for Completion and Transmission of Reports

LIST OF TABLES

LIST OF PLATES

INSTRUCTIONS TO THE RESOURCE MANAGER

SUTTON LAKE

SECTION I - GENERAL OPERATION INSTRUCTIONS

1-01 GENERAL.

Follow instructions given in this section under one or more of the sub-sections listed below at all times, except when other operations are required by Special Directive issued by Water Resources Engineering Branch of the Huntington District Office. Water Resources Engineering Branch personnel will normally issue Special Directives directly to the project.

a. The project is to be operated to maintain a minimum flow of 75 cfs, or 811.1 feet on the 'O' gage, for downstream aquatic environments.

b. Instructions contained in a Special Directives will be applicable for a specific operation or for a stated period of time. After the instructions specified have been executed, resume operation in accordance with the following general instructions.

1-02 GATE REGULATION TECHNIQUE

a. General. Facilities provided for water control include five sluice gates, one 36-inch low-flow gate, a high-level riser, and six spillway gates. Speed of movement of the gates is controlled by the mechanism in all cases. Sequence and manner of operation, where applicable, appear in subsequent paragraphs. Gates are to be opened or closed in such a manner as to prevent the stage at the outflow gage from rising more then 1.0 foot per hour or falling more than 0.5 foot per hour.

b. Sluice gate. The five sluice gates are 5'-8" x 10'-0", hydraulically controlled, and have sills at elevation 825.0 feet msl. The gates are numbered 1-5 starting at north or right abutment. Hydraulic cylinders located over the gate leaves, and pressurized by a central oil pumping station, operate the gates. Each gate is equipped with a mechanical leaf position indicator graduated in tenths of a foot. The high-level riser is installed upstream of sluice-gate number three.

(1) Reservoir level below elevation 1000.0. When the required outflow stage is 813.0 or below, one sluice gate, preferably number(3), will be operated to control the flow. For stages greater than 813.0, when the intended operation is to maintain an outflow stage of 814.0 or greater, gradually transition to gates 1, 2, and 4 over a three hour or longer period, and close gate (3). When the lake level is not high enough to keep the high-level by-pass filled with water, use gates 1, 2, 4, or 5 for additional flows as necessary. When the intended operation is to maintain an outflow stage between 813.0 and 814.0, it is not necessary to close gate 3 after gradually opening gates 1, 2, 4, and 5. Plate 1-2 tabulates the approximate outflow stage and flow by lake elevation and gate opening.

(2) Reservoir level above elevation 1000.0. The lake level is above

the spillway crest at this elevation. The sluice gates will be fully closed and the spillway gates will be used for reservoir regulation. Under extreme conditions, once the spillway gates are lifted clear of the water surface, the sluice gates will be opened completely to augment discharge.

c. Spillway gates. The six spillway gates are 31'-0" x 40'-0" tainter gates, electrically operated and have a crest elevation of 972.0 feet msl. The gates are numbered 1-6 starting with the north or right abutment. The gates will be opened equally as closely as possible. The gates are operated individually from control boxes on the pier to the left of each gate. In an emergency, the gate may be operated from the pier to the right of the gate by engaging a coupling between the first and second speed reducer. Each pressing of the "Raise" or the "Lower" buttons changes the opening by a one foot increment. However, the final increment is between 24' and the maximum opening of 28.94 feet. The gate may be stopped inside an increment by pressing the "Stop" button at the desired opening. An automatic overtravel limit switch stops the gate at either extreme of opening should the limit switch fail.

To prevent the collection of rain, snow, etc. behind the tainter gates, the gates will be open one foot as long as the lake elevation is below 965.0 feet. For lake levels above 965.0 feet, the gates will be closed except for operations under Special Directives or the "Damtenders Emergency Operations Schedule".

d. 36 inch low flow valves. The low flow system has two valves. The gate is manually operated to open or close the conduit. The gate is operated by a rising stem by a power wrench through spur gears. The variable butterfly valve is operated by a power wrench from a operating stand. A vertical travel indicator in the stand is graduated in hundredths of opening and reads the percentage of 90 degrees the gate angles away from the centerline of the conduit, 0 being fully open and 1.0 fully closed. The centerline of the conduit is at 838.5 feet msl. The low flow valve is operated only for lake elevations between 890.0 and 926.0 feet and the required outflow stage is 811.5 feet or less, Plate 1-1. Outside of these conditions the low flow valves are to opened only for tests. Plate 1-2 tabulates the "O" gage stage for various lake elevations and valve openings. The operation of these 2 valves has been superseded by the high-level riser system.

1-03 ROUTINE OPERATION.

Under normal conditions, (See "Schedule of Reading Gages", Plate 3-1 for specified conditions) the lake is regulated by the sluice gate.

Regulation may be determined by Kanawha Area Office staff, however releases under normal conditions (not under Special Directive) shall not exceed a stage at the outflow gage of 816.4 feet (4,025 cfs) in MIANO* or 818.8 feet (6,300 cfs) in DEMIA* unless specifically directed by the Water Resources Engineering Branch. After rainfall or when there is a general stream rise, guidance presented in the following paragraphs shall be used to maintain proper project conditions.

*MIANO: Mid-April through end of November.
*DEMIA: December through mid-April.

1-04 REGULATION FOR ELK RIVER, KANAWHA RIVER, AND OHIO RIVER.

During reservoir regulation activity, a maximum MIANO stage of 820.5 feet at the outflow gage, equivalent discharge 8,500 cfs, or a DEMIA stage of 825.0 feet, 12,600 cfs, can be maintained during light to medium rainfall without causing any appreciable damage along Elk River, or Kanawha Rivers. These stages must be authorized by Special Directive from Water Resources Engineering Branch. When significant rainfall occurs over the uncontrolled drainage areas along Elk River or Kanawha River below Elk River, discharges will be regulated from Sutton Lake so as not to add to or cause flooding at downstream control stations.

Operation for the Ohio River at Point Pleasant is based on stage forecasts by National Weather Service and water travel time from the project to Point Pleasant. Dam Special Directives are issued by the Water Resources Engineering Branch for operation of Sutton Lake for Ohio River control. Releases are timed so as not to add to the crest at Point Pleasant or at other stations downstream along the Ohio River.

1-05 EMERGENCY OPERATION DURING COMMUNICATION FAILURE.

During flood periods, make every effort to contact personnel of the Water Resources Engineering Branch. Possibly other projects can help reach the District Office. If both telephone and radio facilities fail, solicit the cooperation of the local radio and TV stations, amateur and citizens band radio operators, or the State Police. The emergency procedure outlined below shall be followed during periods when the Water Resources Engineering Branch cannot be contacted.

a. If a Special Directive from the Water Resources Engineering Branch was in effect prior to the communications failure, follow the operating instructions contained in the Special Directive until:

(1) the specific operation given in the directive has been completed, or

(2) twenty-four hours have elapsed since last contact with Water Resources Engineering Branch, or

(3) sufficient rainfall or snowmelt occurs which causes the lake or streams in the vicinity to rise rapidly.

b. Whenever any of the foregoing conditions, (1), (2) or (3) occurs or if not under Special Directive and either of conditions (2) or (3) applies, follow operating instructions contained in sub-sections 1-03, 1-04, or 1-05c whichever is applicable.

c. Instructions contained herein involve the Emergency Operation Schedule, Plates 1-5 and 1-6 and take precedence over all preceding instructions. The Emergency Operations Schedule is provided for use by the Damtender for flood control operation during complete failure of communication with Water Resources Engineering Branch.

Whenever the lake level is above elevation 960.0 feet and rising, a constant check shall be made on the rate of rise of the lake level. Read the lake gage every hour on the hour and calculate the rise in lake level for the previous hour. Enter the rate-of-rise curves of the Emergency Operations Schedule Plate 1-5 and 1-6 with the rise and current lake level and read the Sluice Gate Position at the bottom of the Schedule. Look in the table above the curves for necessary sluice gate settings opposite the Sluice Gate Position. Should the required settings be greater than the current gate settings, contact the Water Resources Engineering Branch immediately for operating instructions. In the event of failure of normal means of communication (radio and telephone), continuous and vigorous effort shall be made to contact the Water Resources Engineering Branch as described above.

Authorization is hereby given to operate the project in accordance with the Emergency Operation Schedule when there is a three-hour or greater delay in establishing contact with the Water Resources Engineering Branch, from the time that the curves indicate gate settings greater than those being maintained in accordance with other instructions. In such an emergency situation, follow the procedures described below, continuing efforts to contact Water Resources Engineering Branch before and after each operation for guidance in use of the rate-of-rise curves.

(1) Emergency operation shall be based on the last readings taken and no attempt shall be made to make up for any missed operation steps. The required gate settings shall be executed as soon as they have been determined from the Emergency Operation Schedule, Plates 1-5 and 1-6.

(2) One hour after the previous reading, the lake gage shall be read again, the new rate of rise computed and the required gate settings executed as determined from the Emergency Operation Schedule.

a. If the lake elevation is between 960.0 and 972.0 feet, use Plate 1-3 to determine the sluice gate openings. As stated earlier, all sluice gates are to be opened equally to spread outflow evenly across spillway bucket.

b. If the lake elevation is between 972.0 and 1,000.0 feet, use Plate 1-4 to determine the spillway gate openings. Close all sluice gates and raise all spillway gates uniformly. Do not open any crest gates until the sluice gates have been opened fully.

c. If the lake elevation exceeds 1,000.0 feet, close all sluice gates, open all spillway gates uniformly to opening set in Plate 1-3. After the spillway gates are clear of the water, open the sluice gates.

(3) Continue the hourly computations and gate settings until the lake level crests.

(4) If the lake level crests above spillway elevation 779.0, maintain the current gate settings until the lake level recedes to elevation 972.0; then gradually close the gates as necessary to maintain the lake level at that elevation until ordered by Special Directive to begin drawdown operation.

(5) If the lake level crests below spillway elevation of 972.0, gradually close the gates as necessary to maintain the crest lake level until ordered by Special Directive to being drawdown operation.

(6) If a second rise occurs while out of communication with Water

Resources Engineering Branch, resume operation in accordance with rate-of-rise curves and instructions printed in the Emergency Schedule.

1-06 PUBLIC NOTIFICATION OF UNUSUAL RELEASES.

Operation of reservoir projects during major floods has on occasion resulted in water releases being made which damaged privately-owned equipment or facilities located downstream, and caused claims or damage suits to be filed against the Government. To minimize the possibility of such claims or suits, the Damtender must stay informed and inform the Water Resources Engineering Branch of all developments along Elk River between the dam and the end of such development below the community of Sutton.

Constraints should be located and documented as to degree of constraint that might affect stages at the outflow gage. A file of pictures, dates of construction, of flooding with outflow gage readings, records of conversations with owners, and any other documentation should be kept in the project office, updated as necessary, and copies provided to the Area Office and Water Resources Engineering Branch.

If required by unusual release patterns, obtain directions from Water Resources Engineering Branch which will coordinate the release with Public Affairs Office for public notification procedures. Unusual release patterns include closure for maintenance purposes, special increases or decreases for down-stream requests and requirements, and emergency, above channel capacity, discharges. Notification of large releases is to afford those likely to be affected an opportunity to take remedial measures in advance of the arrival of the release as so to prevent damage to or loss of their property.

1-07 BUFFER ZONE OPERATION.

The seasonal buffer zone between elevation 922 and 925 is intended to lengthen the time available to warn campers of an impending rise in lake level, and to lower the magnitude of increases in outflow to maintain the lake level at seasonal pool.

More attention to stream flow and weather conditions is required when the lake level is near the top of the buffer zone as compared to when the lake level is near the bottom of the buffer zone.

a. The upper elevation of the buffer zone is 925 feet and every effort should be made to limit the pool rises to that elevation when light to moderate rainfall occurs over the drainage area. The critical elevation for recreation interests is 926.5 feet and when heavy rainfall occurs it may become necessary to release substantial outflow rates (5,000 cfs or more) as the pool elevation approaches elevation 925. When rainfall begins, project personnel must maintain close surveillance over the rise in pool level, increasers in inflow rates, amounts of precipitation, and weather forecasts. Close contact should be maintained with the Water Control Section, Water Resources Engineering Branch for guidance.

b. When rainfall is light to moderate with average precipitation over the basin at or below 0.50 inch with the pool level at or below elevation 923.5, the outflow rate will probably need no change to maintain the lake level within the buffer zone; however, if the pool elevation is above 924 feet, it may become necessary to increase the outflow to prevent the pool rising above 925 feet.

c. When rainfall is moderate the with average precipitation over the basin between 0.5 and 1.00 inch with the pool level at or below 923 feet, the outflow rate will probably need no increase to maintain the lake level within the buffer zone; however, if the pool elevation is above 923.5 feet, it may become necessary to increase the outflow to prevent the pool rising above 925 feet .

d. When rainfall is moderate to heavy with average precipitation above the project over 1.0 inch, it will probably become necessary to increase the outflow rate to stay within the upper limits of the buffer zone. The amount of outflow increase will depend upon the current pool elevation. The higher the pool elevation level at the beginning of the storm the greater the outflow increase.

1-08 HIGH LEVEL INTAKE BULKHEAD OPERATION

The high-level intake tower is used to release a small continuous rate of fresh water from the top layer of the lake through sluice gate three. During the recreational season the release is through the screened open top at elevation 910 with the 5' x 10' bulkhead panel at elevation 878 closed. When the lake level is lowered in the fall the daily winter flow is maintained by temporarily closing sluice gate three, thereby stabilizing the lake level and raising the bulkhead panel to the open position. The maximum release of the intake tower will be somewhat lower during the winter season.

During the spring when the lake is raised to summer level the high-level intake bulkhead is returned to the closed position and fresh water release continues through the top opening. When the bulkhead panel is to be moved the lake level should be stabilized between elevation 909.0 and 910.0 for operational safety.

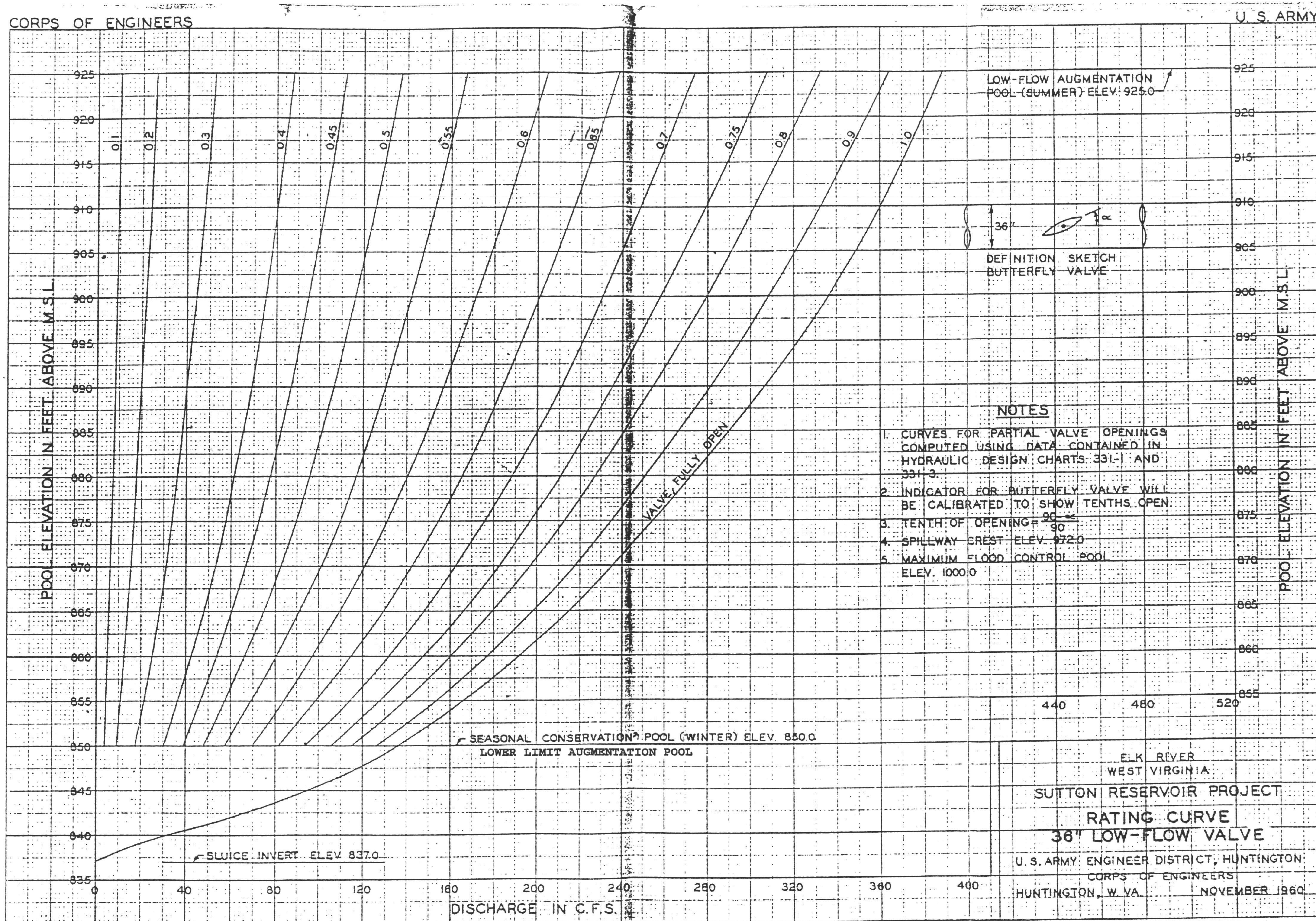
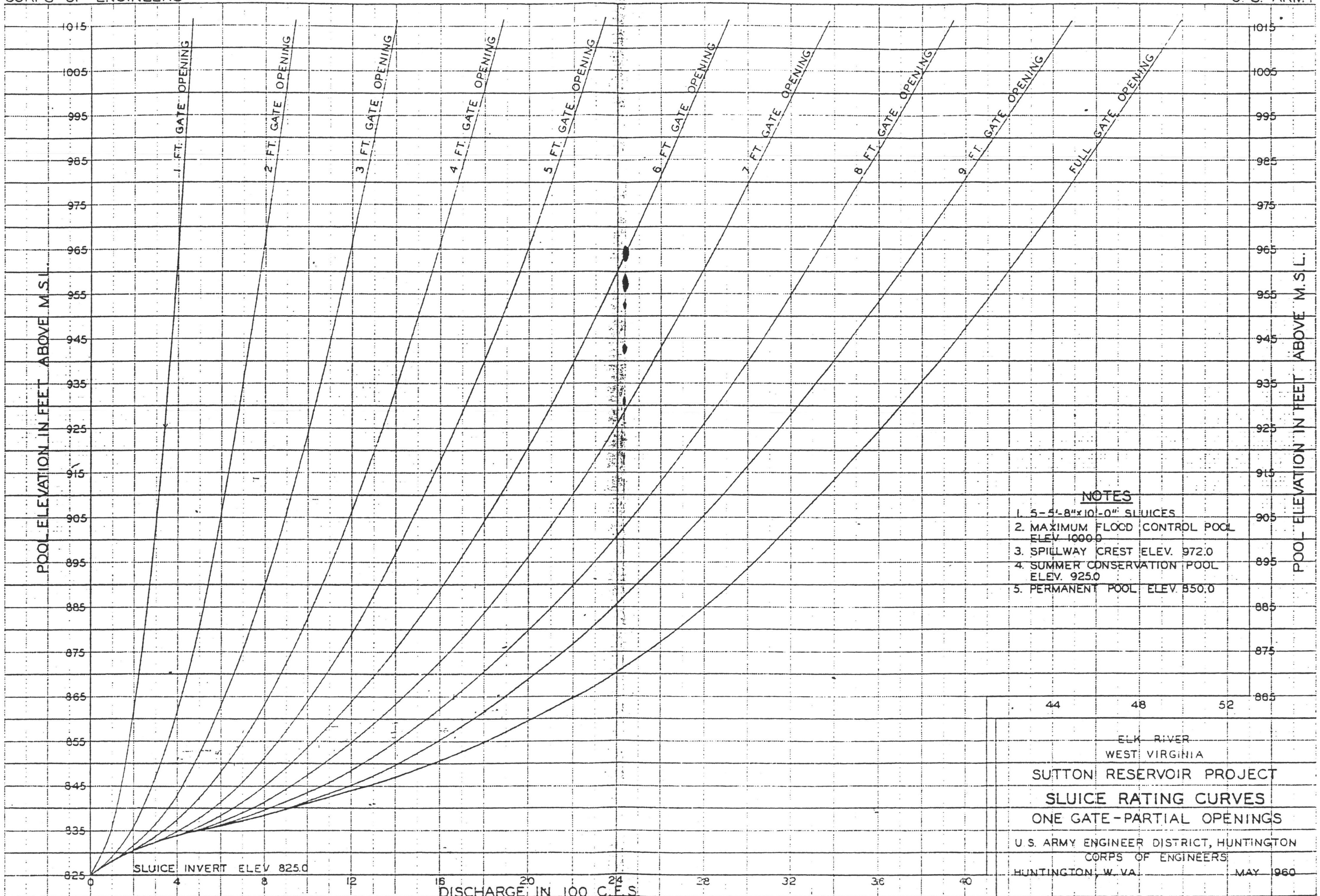
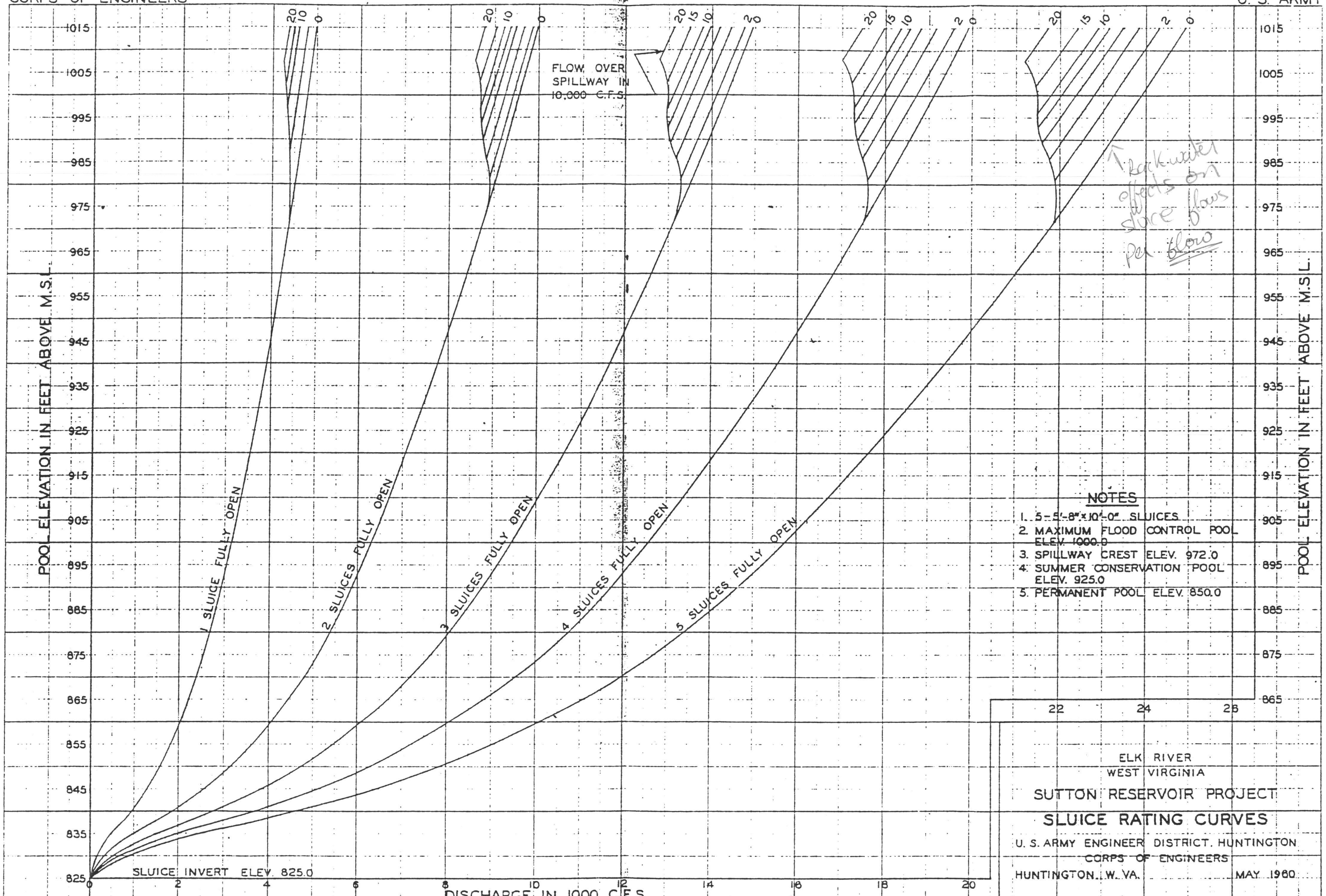
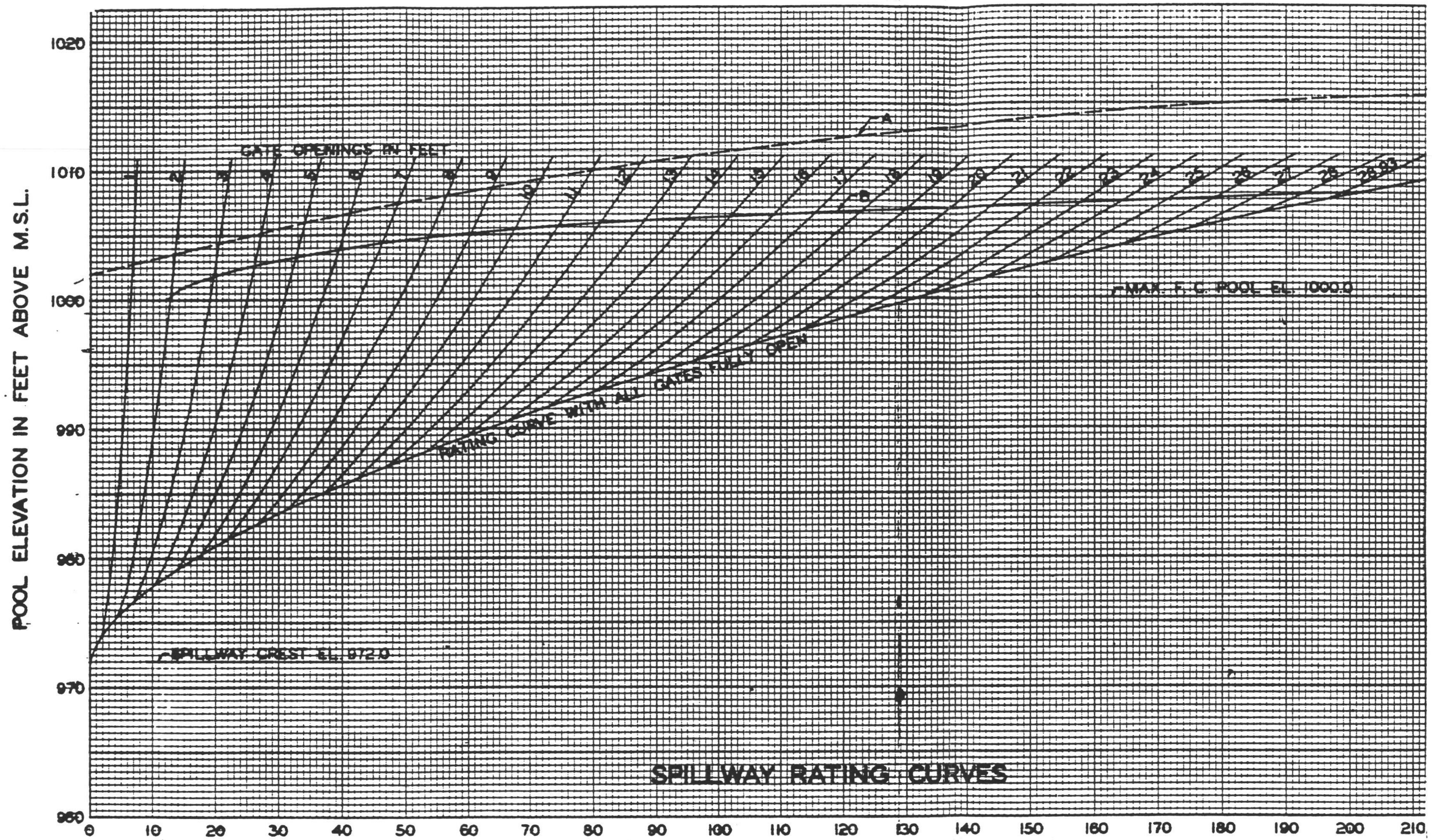

CORPS OF ENGINEERS
U. S. ARMY
LOW-FLOW AUGMENTATION POOL (SUMMER) ELEV. 925.0
0.1
0.2
0.3
0.4
0.45
0.5
0.55
0.6
0.65
0.7
0.75
0.8
0.9
1.0
36"
α
DEFINITION SKETCH BUTTERFLY VALVE
VALVE FULLY OPEN
NOTES
1. CURVES FOR PARTIAL VALVE OPENINGS COMPUTED USING DATA CONTAINED IN HYDRAULIC DESIGN CHARTS 331-1 AND 331-3.
2. INDICATOR FOR BUTTERFLY VALVE WILL BE CALIBRATED TO SHOW TENTHS OPEN.
3. TENTH OF OPENING = (90 − α)/90
4. SPILLWAY CREST ELEV. 972.0
5. MAXIMUM FLOOD CONTROL POOL ELEV. 1000.0
POOL ELEVATION IN FEET ABOVE M.S.L.
SEASONAL CONSERVATION POOL (WINTER) ELEV. 850.0
LOWER LIMIT AUGMENTATION POOL
SLUICE INVERT ELEV. 837.0
DISCHARGE IN C.F.S.
0
40
80
120
160
200
240
280
320
360
400
440
480
520
835
840
845
850
855
860
865
870
875
880
885
890
895
900
905
910
915
920
925
ELK RIVER
WEST VIRGINIA
SUTTON RESERVOIR PROJECT
RATING CURVE
36" LOW-FLOW VALVE
U. S. ARMY ENGINEER DISTRICT, HUNTINGTON
CORPS OF ENGINEERS
HUNTINGTON, W. VA.
NOVEMBER 1960

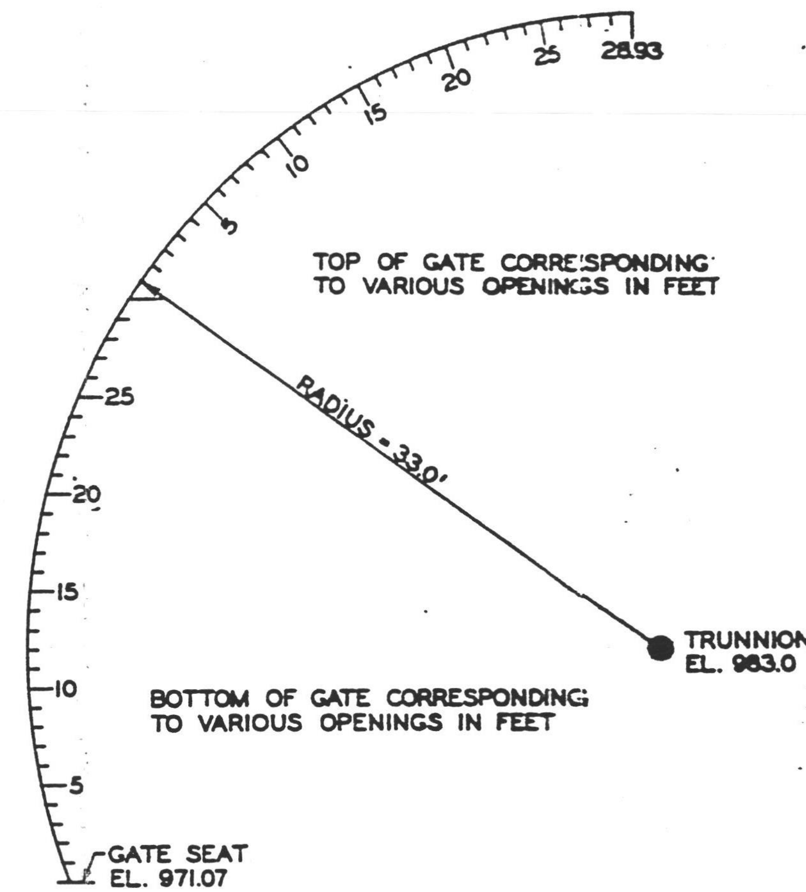
PLATE NO. 1-1


POOL ELEVATION IN FEET ABOVE M.S.L.
1015
1005
995
985
975
965
955
945
935
925
915
905
895
885
875
865
855
845
835
825
1 FT. GATE OPENING
2 FT. GATE OPENING
3 FT. GATE OPENING
4 FT. GATE OPENING
5 FT. GATE OPENING
6 FT. GATE OPENING
7 FT. GATE OPENING
8 FT. GATE OPENING
9 FT. GATE OPENING
FULL GATE OPENING
SLUICE INVERT ELEV 825.0
0
4
8
12
16
20
24
28
32
36
40
44
48
52
DISCHARGE IN 100 C.F.S.
NOTES
1. 5-5'-8"x10'-0" SLUICES
2. MAXIMUM FLOOD CONTROL POOL ELEV. 1000.0
3. SPILLWAY CREST ELEV. 972.0
4. SUMMER CONSERVATION POOL ELEV. 925.0
5. PERMANENT POOL ELEV. 850.0
ELK RIVER
WEST VIRGINIA
SUTTON RESERVOIR PROJECT
SLUICE RATING CURVES
ONE GATE-PARTIAL OPENINGS
U.S. ARMY ENGINEER DISTRICT, HUNTINGTON
CORPS OF ENGINEERS
HUNTINGTON, W. VA.
MAY 1960


POOL ELEVATION IN FEET ABOVE M.S.L.
DISCHARGE IN 1000 C.F.S.
FLOW OVER SPILLWAY IN 10,000 C.F.S.
1 SLUICE FULLY OPEN
2 SLUICES FULLY OPEN
3 SLUICES FULLY OPEN
4 SLUICES FULLY OPEN
5 SLUICES FULLY OPEN
SLUICE INVERT ELEV. 825.0
NOTES
1. 5-5'-8"x10'-0" SLUICES
2. MAXIMUM FLOOD CONTROL POOL ELEV. 1000.0
3. SPILLWAY CREST ELEV. 972.0
4. SUMMER CONSERVATION POOL ELEV. 925.0
5. PERMANENT POOL ELEV. 850.0
ELK RIVER
WEST VIRGINIA
SUTTON RESERVOIR PROJECT
SLUICE RATING CURVES
U. S. ARMY ENGINEER DISTRICT, HUNTINGTON
CORPS OF ENGINEERS
HUNTINGTON, W. VA.
MAY 1960



SPILLWAY RATING CURVES



TAINTER GATE DIAGRAM

NOTES

SPILLWAY CONTROLLED BY 6-40'×28' TAINTER GATES. (2 FT. FREEBOARD)

ALL GATES ARE ASSUMED TO OPEN UNIFORMLY.

GATE OPENINGS REPRESENT VERTICAL DISTANCE OF LOWER EDGE OF GATE ABOVE GATE SEAT.

CURVES OF PARTIAL GATE OPENINGS WERE COMPUTED USING HYDRAULIC DESIGN CHARTS 311-1 TO 311-5, INCLUSIVE.

CURVE "A" REPRESENTS THE TOP OF GATES AT VARIOUS OPENINGS.

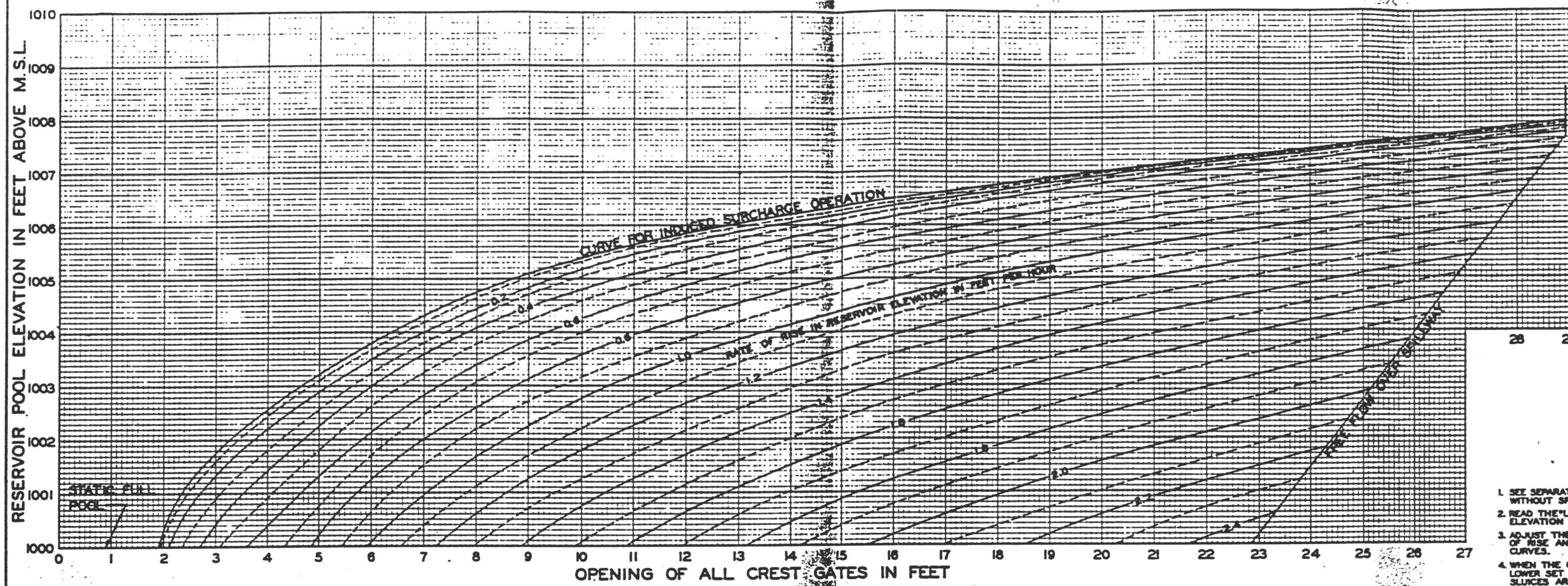
CURVE "B" REPRESENTS A LIMITING RELATION OF GATE OPENING AND RESERVOIR LEVEL.

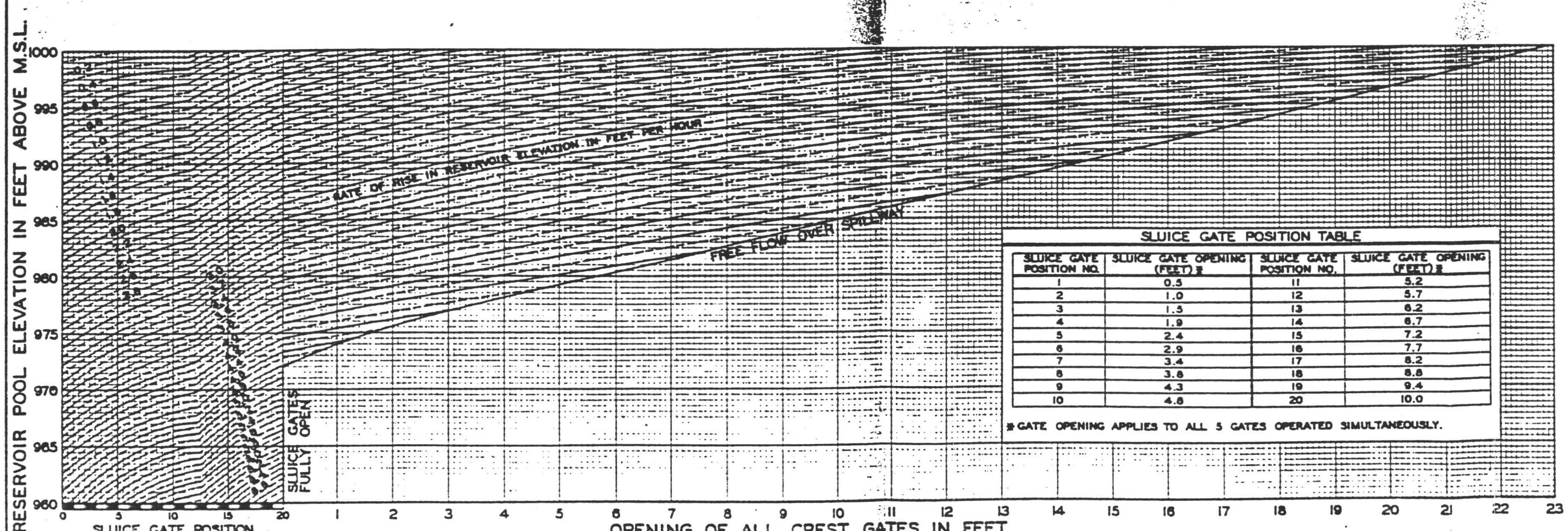
ELK RIVER
WEST VIRGINIA

SUTTON RESERVOIR PROJECT

RATING CURVES
GATED SPILLWAY

U. S. ARMY ENGINEER DISTRICT, HUNTINGTON
CORPS OF ENGINEERS
HUNTINGTON, W. VA. MAY 1960





SLUICE GATE POSITION TABLE

SLUICE GATE POSITION NO.	SLUICE GATE OPENING (FEET) *	SLUICE GATE POSITION NO.	SLUICE GATE OPENING (FEET) *
1	0.5	11	5.2
2	1.0	12	5.7
3	1.5	13	6.2
4	1.9	14	6.7
5	2.4	15	7.2
6	2.9	16	7.7
7	3.4	17	8.2
8	3.8	18	8.8
9	4.3	19	9.4
10	4.8	20	10.0

* GATE OPENING APPLIES TO ALL 5 GATES OPERATED SIMULTANEOUSLY.

OPERATION INSTRUCTIONS

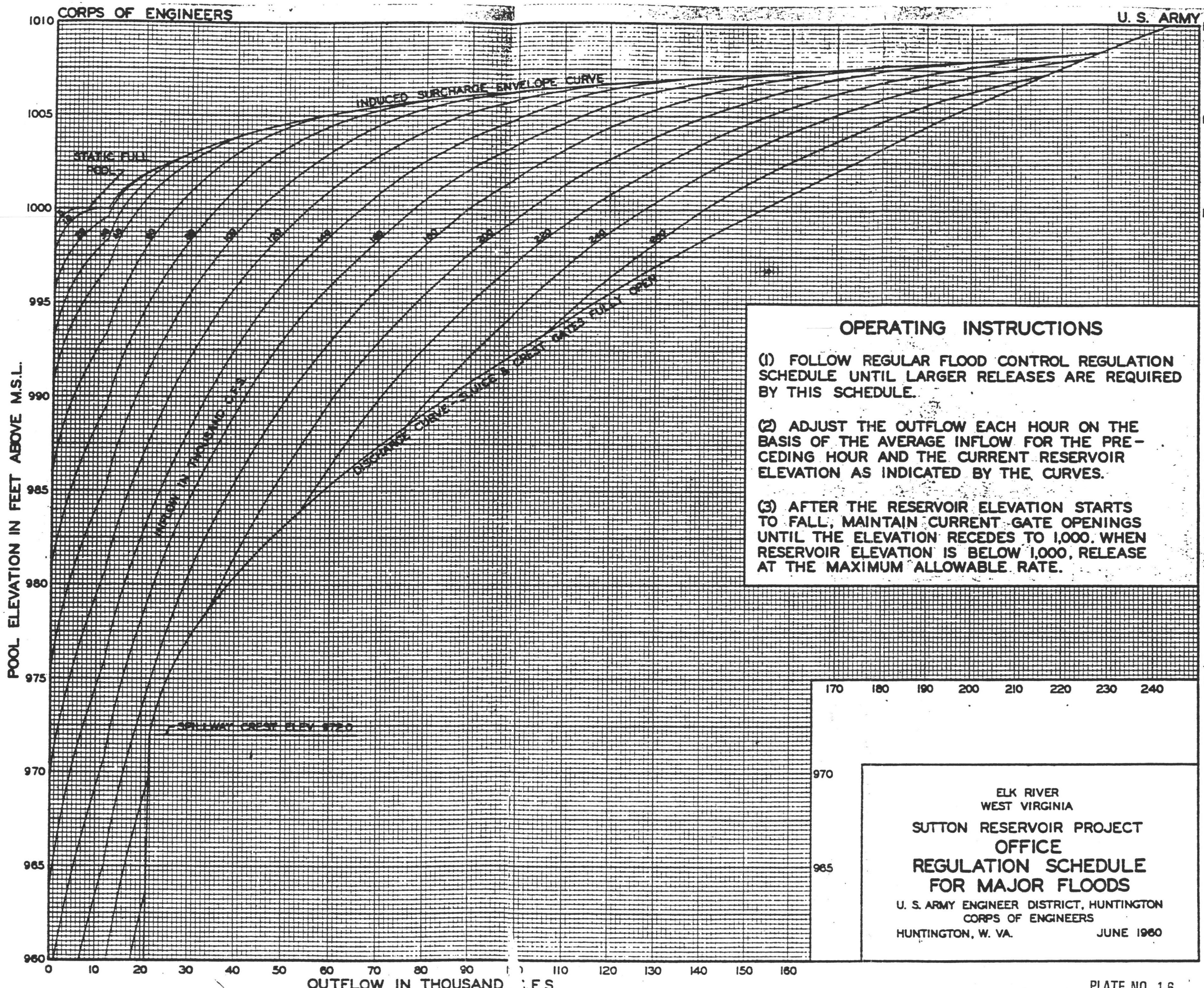
1. SEE SEPARATE INSTRUCTIONS AS TO WHEN RESERVOIR MAY BE OPERATED WITHOUT SPECIFIC INSTRUCTIONS FROM DISTRICT OFFICE.
2. READ THE "LAKE" GAGE EVERY HOUR AND COMPUTE THE RISE IN POOL ELEVATION DURING THE PRECEEDING HOUR.
3. ADJUST THE GATE SETTINGS EACH HOUR ON THE BASIS OF THE RATE OF RISE AND THE CURRENT RESERVOIR ELEVATION AS INDICATED BY THE CURVES.
4. WHEN THE CURRENT RESERVOIR ELEVATION IS BELOW 1000.0, USE THE LOWER SET OF CURVES. DO NOT RAISE THE CREST GATES UNTIL ALL SLUICES ARE OPEN. RAISE ALL CREST GATES AS UNIFORMLY AS POSSIBLE
5. WHEN THE HOURLY RESERVOIR LEVEL READING FIRST EXCEEDS ELEVATION 1000.0 CLOSE ALL SLUICES AND RAISE ALL CREST GATES AS UNIFORMLY AS POSSIBLE TO THE OPENING INDICATED BY THE UPPER SET OF CURVES USE THE UPPER SET OF CURVES AS LONG AS THE POOL EXCEEDS 1000.0. OPEN THE SLUICE GATES WHEN THE CREST GATES HAVE BEEN LIFTED CLEAR OF THE WATER SURFACE.
6. AFTER THE RESERVOIR LEVEL STARTS TO FALL, MAINTAIN THE CURRENT GATE SETTINGS UNTIL THE POOL RECEDES TO ELEVATION 1000.0, THEN CLOSE THE SLUICE GATES IF THEY ARE OPEN, AND CLOSE THE CREST GATES AS REQUIRED TO MAINTAIN RESERVOIR ELEVATION AT 1000.0.
7. HOLD THE POOL AT ELEVATION 1000.0 OR AT MAXIMUM LEVEL ATTAINED, IF BELOW 1000.0, UNTIL ORDERED BY SPECIAL DIRECTIVE TO BEGIN DRAW-DOWN OPERATION.
8. IF A SECOND RISE OCCURS WHILE THE POOL IS BEING HELD AT ELEVATION 1000.0 FEET, FOLLOW THE "CURVE FOR INDUCED SURCHARGE OPERATION". IF THE CREST GATES ARE OPEN MORE THAN 1.9 FT. WHEN THE SECOND RISE OCCURS, MAINTAIN THE CURRENT GATE SETTINGS UNTIL THE RESERVOIR LEVEL RISES TO THE ELEVATION CORRESPONDING TO THE GATE SETTING ON THE "CURVE FOR INDUCED SURCHARGE OPERATION", THEN FOLLOW THE CURVE UNTIL THE POOL CEASES TO RISE, WHEN THE POOL STARTS TO FALL, OPERATE IN ACCORDANCE WITH INSTRUCTION NO. 6, ABOVE.

ELK RIVER
WEST VIRGINIA

SUTTON RESERVOIR PROJECT

DAMTENDER'S EMERGENCY OPERATION SCHEDULE

U. S. ARMY ENGINEER DISTRICT, HUNTINGTON
CORPS OF ENGINEERS
HUNTINGTON, W. VA. JULY 1960



CORPS OF ENGINEERS
U. S. ARMY
INDUCED SURCHARGE ENVELOPE CURVE
STATIC FULL POOL
INFLOW IN THOUSAND C.F.S.
DISCHARGE CURVE- SLUICE & CREST GATES FULLY OPEN
SPILLWAY CREST ELEV. 972.0
POOL ELEVATION IN FEET ABOVE M.S.L.
OUTFLOW IN THOUSAND C.F.S.
OPERATING INSTRUCTIONS
(1) FOLLOW REGULAR FLOOD CONTROL REGULATION SCHEDULE UNTIL LARGER RELEASES ARE REQUIRED BY THIS SCHEDULE.
(2) ADJUST THE OUTFLOW EACH HOUR ON THE BASIS OF THE AVERAGE INFLOW FOR THE PRECEDING HOUR AND THE CURRENT RESERVOIR ELEVATION AS INDICATED BY THE CURVES.
(3) AFTER THE RESERVOIR ELEVATION STARTS TO FALL, MAINTAIN CURRENT GATE OPENINGS UNTIL THE ELEVATION RECEDES TO 1,000. WHEN RESERVOIR ELEVATION IS BELOW 1,000, RELEASE AT THE MAXIMUM ALLOWABLE RATE.
ELK RIVER
WEST VIRGINIA
SUTTON RESERVOIR PROJECT
OFFICE
REGULATION SCHEDULE
FOR MAJOR FLOODS
U. S. ARMY ENGINEER DISTRICT, HUNTINGTON
CORPS OF ENGINEERS
HUNTINGTON, W. VA.
JUNE 1960

SECTION II - COLLECTION OF HYDROMETEOROLOGIC DATA

2-01 PRECIPITATION AT SUTTON LAKE.

a. General. Obtain precipitation data by direct observation of the rain gage at the damsite. Instructions for preparation and transmission of hydrologic reports are contained in Section IV.

b. Official Precipitation Gage. The standard National Weather Service (non-recording) rain gage at the damsite is designated as the gage for official use.

c. Regular Readings. Measure and discard precipitation contained in the standard gage about 0730 hours daily. Observe and record the times of beginning and ending of precipitation. The times of beginning and ending may be read from the recorder chart of the recording precipitation gage when "unknown" or "during night." Instructions for the preparation and transmission of precipitation reports are contained in Section IV. These instructions are for Corps of Engineers purposes and are not be considered as superseding observation instructions received from the National Weather Service.

d. Special and Extra Readings. Take special readings of the precipitation gage when requested by Water Resources Engineering Branch through the Kanawha Area Office and extra readings whenever required by the Schedule for Reading Gages, Plate 3-1. When taking these readings, do not empty the gage at any time except the regular time. Report the total which has fallen since the regular time of reading even though a portion of it may have been reported in a previous extra reading. The regular reading on the morning following any extra readings should always include the amounts reported in the extra readings. Instructions pertaining to the transmission of extra and special precipitation readings are contained in Section IV.

e. Satellite Platform Stations. Five precipitation stations, Webster Springs, Replete, Frametown, Clay, Queen Shoals are equipped with a data collection platform which has a voice modem. It answers a telephone caller by synthetic voice. After a few seconds of high pitched tone, the voice gives the latest reading and time of reading of each parameter reported by the platform. Precipitation is called "rain" and stream stage, "level". The message ends with battery voltage and time of reading. One should note that the time given by the platform is Greenwich Mean Time (GMT). To convert to Eastern Daylight or Eastern Standard Time, subtract 4 or 5 hours, respectively.

Reporting information on satellite precipitation stations in the Elk River Basin is listed on the next page.

f. Snow Depth and Moisture Content. During the winter, make regular measurement of snowfall and snow depth about 0730 hours daily. Measurements of the water content of the snow on the ground are needed in order to determine the amount of water which may run off during a warm spell or with any wind and rainfall which may occur. To determine the water content of the snow, obtain a representative snow sample at an undisturbed location by forcing the outside container of the rain gage through the snow to the ground surface.

TABLE NO. 2-1
PRECIPITATION PLATFORM COMMUNICATION INFORMATION

Location/ Gage	Equipment	Voice	Channel No.	Update Interval	Data Trans-mitted	Frequency of Transmission
Birch River	1/		23	60 min.	P	4 Hours
Clay	1/	v	55	60 min.	P,S	4 Hours
Frametown	1/	v	55	60 min.	P,S	4 Hours
Queen Shoals	1/	v	55	60 min.	P,S	4 Hours
Replete	1/	v	67	60 min.	P,S	4 Hours
Sharps Knob	1/		35	60 min.	P	4 Hours
Webster Springs	1/	v	35	60 min.	P,S	4 Hours

1/ Precipitation equipment same at all platform reported stations: Tipping-bucket gage and platform.
P - precipitation in inches
E - elevation in feet above mean sea level
S - streamstage in feet above gage zero
V - Voice platform answers telephone query with electronically synthesized voice in addition to transmitting via satellite.

Then, using a shovel or thin sheet of metal to hold the snow cover within the container, remove the container from the ground. The water content of the sample can be measured by placing the outside container in a vessel of warm water, and then pouring the melted snow into the inside container of the gage for a reading with the measuring stick. On no account should the vessel containing the snow be exposed to extreme heat because of the possibility of loss by evaporation. Measure water content of the snow at least as often as indicated below:

(1) Each day when any new snowfall occurs.

(2) Each day when rain falls on existing snow cover.

(3) Twice a week when there is snow cover if neither condition (1) nor (2) requires more frequent measurements.

(4) By special request from Water Resources Engineering Branch.

2-02 PRECIPITATION AT OHIO RIVER NETWORK STATIONS.

a. Ohio River Network Stations. The Ohio River Network, abbreviated ORN, includes precipitation stations and stations reporting both precipitation and stage. There are five ORN stations in or near the Elk River drainage basin. They are listed in Table No. 2-2 below with reporting criteria and code symbols which include coordinates for location on the District Isohyetal Map.

b. Reporting Criteria. Big Otter, Birch River, Centralia and Webster Springs are all on 1/2" criterion. Each of the observers report only if and when 1/2" or more of precipitation has occurred and been collected in the station rain gage during the 24 hours prior to the time for measuring and reporting.

TABLE NO. 2-2

OHIO RIVER NETWORK STATIONS

Station	Code Symbol	Precipitation Criterion	Observer	Telephone
Big Otter	BI0K6	0.5	Rosco Boggs	286-3842
Birch River	BIRL7	0.5	Mrs. Tina Baughman	
Centralia	CENK7	0.5	Mrs. Elizabeth Skidmore	765-2322
Webster Springs	WBSL8	0.5	Wayne L. Bright	

c. Method of Reporting. Big Otter, Birch River, Centralia and Webster Springs observers report to the NWS in Charleston by 1-800 telephone number.

2-03 OUTFLOW TEMPERATURE AND TEMPERATURE-DISSOLVED OXYGEN PROFILES.

Tailwater temperature is remoted to the project office and is read and recorded from the dial to the approximate nearest 0.1 degree celsius. Weekly temperature and dissolved oxygen profiles are to be taken in the lake on Monday during periods of stratification. Water Resources Engineering Branch will issue Special Directives each year concerning the location and the time periods for the profiles. Project personnel have been provided with instrumentation necessary and Water Quality field personnel have given instruction in the use of the equipment.

Send profile data in a supplemental report to the daily WITS report. Soon after receipt of the data it is incorporated into a Water Quality Assessment. The daily outflow temperature, along with the Assessment and target temperature from Outflow Temperature Regulation Curves, Plate 1-4, is used by Water Resources Engineering Branch in determining proper operation of the high-level by-pass for outflow temperature control. Special directives are issued for these operations.

SECTION III - COLLECTION OF STREAMFLOW DATA

3-01 GENERAL.

Obtain river and lake stage data by visiting the lake and outflow gages to read stage values from the recorder charts and by interrogating the surrounding telemetered gages. The necessary frequency for reading the gages at the project and for obtaining reports from the telemetered stations is set forth in the Schedule for Reading Gages, Plate 3-1, which appears at the end of this section. Instructions regarding the transmission of regular, extra and special reports of gage readings are contained in Section IV.

3-02 GAGES PERTINENT TO REGULATION OF SUTTON LAKE.

a. Gage Listing. Information about gages of importance to operation of the project appears in Table No. 3-1.

b. Reading and Recording Gage Heights. List all gage readings in the records in order that complete data on the effect of the lake on natural flows will be available. Record lake gage readings in terms of elevation above mean sea level but record all other gages in feet above gage datum, or zero of the gage. Gage datums are listed in Table No. 3-1.

3-03 TELEPHONIC GAGES.

In order to facilitate collection of stage information, data collection platforms having the additional capability of responding to telephone calls were installed at Clay, Frametown, Queen Shoals, Replete, Webster Springs. To obtain reports from the gaging stations via telephone, call the station telephone number. After a few seconds of high-pitched tone, the platform will repeat, by synthesized voice, the platform identification, and then the most recent reading and time of reading of each parameter reported by the platform. Stage and elevation are called "level" and precipitation, "rain." The message ends with battery voltage, time of the reading, and repetition of the identification. One should note that the time given by the platform is Greenwich Mean Time (GMT). To convert to Eastern Daylight or Eastern Standard Time, subtract four or five hours, respectively.

The telephone numbers of these gages are classified as "Restricted" in order to avoid indiscriminate calls by unauthorized persons. The necessary frequency for obtaining reports from the "voice" gages is set forth in "Schedule for Reading Gages," Plate 3-1, at the end of this section. Instructions pertaining to transmission of regular, extra and special reports of gage readings are contained in Section IV. Telephone numbers and code symbols assigned to the gages important to regulation of Elk River appear in Table No. 3-2.

Table 3-1

PERTINENT GAGE DATA

Gage	Location	Symbol	Eqpt	Staff	Other	Recorder	Datum
Lake	Dam	SUEK7	DCP-H	S	F	D	M.S.L.
Outflow	0.9 mile below dam	SUEOF	DCP-H	W	F	D,C	M.S.L.
Clay	Highway bridge in Clay WV	CYEL6	V	S,W	T	D,C	677.46
Frametown	Swinging bridge	FREK7	V	S	T	D,C	775.51
Queen Shoals	100 feet below bridge	QSEL6	V	S	T	D	604.09
Replete	Highway bridge in Poling	REPK7	V	S	T	D	1180.
Webster Springs	bridge 6.5 miles upstream from Centralia	WBEL7	V	S	F	D,C	1020.0
Guardian	50 feet upstream	GARK7	H	S		D	1078.0

DCP-H-satellite platform V-voice in addition to satellite platform H-Hydrolloger, S-staff, W-wire, T-electronic tape, F-float D-digital, C-continuous graph.

TABLE NO. 3-2

STREAM GAGE TELEPHONE NUMBERS

Gage	Code* Symbol	Telephone Number	Type of Device
Elk River at Clay	CYEL6	[redacted]	Voice Platform
Elk River near Frametown	FREK7	[redacted]	Voice Platform
Elk River near Queen Shoals	QSEL6	[redacted]	Voice Platform
Left Fork Holly near Replete	REPK7	[redacted]	Voice Platform
Elk River near Webster Springs	WBEK7	[redacted]	Voice Platform
Right Fork Holly at Guardian	GARK7	[redacted]	Voice Platform

3-04 DATA COLLECTION

Project personnel read the lake gage and outflow gage and telephone the voice platforms reporting the Elk and Holly Rivers stage at Clay, Frametown, Guardian, Queen Shoals, Replete, Webster Springs. All the values are recorded in the daily log, morning and extra reports. Gate positions and operations are noted in the log and on Form 14 and the positions are included in morning and extra reports to the Area Office. Supplemental lake and outflow data, discussed in 4-01.c below, are taken along with regular readings or soon after.

Data are given by Sutton Lake personnel as detailed in Section IV below and as shown in Plate 4-2 at the end of Section IV.

Supplemental data, when required, are transmitted in the same sequence immediately after sending the regular data to Water Resources Engineering Branch. Plate 4-2 is an example of Supplemental Data or GOES as furnished to Water Resources Engineering Branch. Data collection platforms report stage data at all the locations (plus precipitation at some stations) listed in Table No. 3-2. They transmit the data by electronic signal to the LRD downlink via satellite each four hours. The LRD Water Control System retrieves from the downlink and disseminates hourly to Water Resources Engineering Branch WCS data base. GOES data is available through WITS.

SCHEDULE FOR READING GAGES

SUTTON DAM

The regular stream gages SL or VL and SO or VO must always be read and recorded immediately before each gate operation except when they have been read in the last hour with no intervening gate operation. They must also be read within one hour after completion of any operation. However, when the gates are being operated practically continuously, the gages need not be read before and after each individual operation, but readings at one-hour intervals including the readings before the first and after the last operation will be sufficient. If the recorders are operating properly, the above gage heights may be read from the charts at the time of the next reading. Stream gages and the precipitation gage shall be read at least as often as shown in the following table.

Conditions	SCHEDULE A Normal conditions		SCHEDULE B(1) Flood threat		SCHEDULE C(1) Flood condition		SCHEDULE D(1) Major flood condition	
	Crop season	Noncrop season	Crop season	Noncrop season	Crop season	Noncrop season	Crop season	Noncrop season
Reservoir elevation	below 930.0	below 860.0	930.0 - 950.0	860.0 - 925.0	950.0 - 972.0(2)	925.0 - 972.0(2)	above 972.0(2)	above 972.0(2)
"O" gage elevation	below 816.0	below 818.0	816.0 - 818.0	818.0 - 820.5	818.0 - 820.5	820.5 - 824.5	above 820.5	above 824.5
Frametown USGS	below 8.0	below 9.0	8.0 - 12.5	9.0 - 14.0	12.5 - 20.0	14.0 - 20.0	above 20.0	above 20.0
Precipitation within 24 hours	less than 1.00	less than 0.75	1.00 - 2.00	0.75 - 2.00	2.00 - 3.00	2.00 - 3.00	above 3.00	above 3.00

Read gages	Schedule A	Schedule B	Schedule C	Schedule D
VL, VO and Frametown gages(3)	Twice daily (4)	At 0730, 1330 and 1930	At 0730, 1330, 1930 and 0130	At 3-hour intervals
VL, SL, RL, TL, VO, SO, RO and TO	Twice weekly (as check)	Twice weekly (as check)	Twice weekly (as check)	Twice weekly (as check)
Clay U.S.G.S. gage	Monday and Thursday (as check)	At 0730 and 1930 (5)	At 0730, 1330, 1930 and 0130(5)	At 0730, 1330, 1930 and 0130(5)
Queen Shoals U.S.G.S. gage	Monday and Thursday (as check)	At 1930	At 1330, 1930 and 0130	At 1330, 1930 and 0130
Precipitation gage	At 0730	At 0730, 1330 and 1930	At 0730, 1330, 1930 and 0130	At 0730, 1330, 1930 and 0130

(1) When any one of the conditions listed under these schedules are met, place the higher schedule into effect immediately.
(2) Whenever the reservoir level is between elevation 960.0 and 1000.0 and rising or at elevation 1000.0 or above, a constant check shall be kept on the rate-of-rise in pool level. Whenever the rate of rise approaches a value which indicates a gate opening on the "Damtenders Emergency Operation Schedule" (for example: 4.0 feet per hour at elevation 966.5), readings of the "Lake" gage shall be taken every hour, on the hour.
(3) When the tape gages, counters, or Frametown telemark are not operating properly read the staff gages.
(4) When the change in stage is slight and uniform, and the recorders are working properly, the Saturday and Sunday readings may be taken from the recorder charts at the time of the next regular reading.
(5) Make direct readings of the Clay telemark except when you are sure that the ORN observer will furnish the scheduled reading.

Once a particular schedule is in effect, follow that schedule for a minimum of 24 hours before placing a lower schedule into effect or until such time that conditions require the use of a higher schedule. The foregoing table lists the minimum number of gage readings required. All gage readings made in addition to those required by the foregoing table must be recorded.

SECTION IV - INSTRUCTIONS FOR COMPLETION AND TRANSMISSION OF REPORTS

4-01 REGULAR REPORTS

a. Weekly Report, ORH Form 14. To reduce the probability of error in transcribing data from other forms, enter gage readings through the week on a copy of Form 14. Obtain lake gage elevation and outflow gage readings for every six hours (0130, 0730, 1330, and 1930) during periods when the project is attended and record on the form. When gate changes are made, record them on the form immediately. The Schedule for Reading Gages, Plate 4-1, defines conditions for taking more frequent readings of gages. After each time of entering a reading on the form, check the correctness of the reading as recorded. If doubt arises, investigate to the extent necessary to be certain of the reading. During normal conditions, the 1930 and 0130 readings will not have been recorded on the form; therefore, take them from the recorder charts at the time of taking the 0730 readings. After any period when the project was not attended, obtain all missed readings from the recorder charts and record on Form 14. If it is necessary to turn the charts back in order to obtain readings, use instructions contained in Plate 1-2 for doing so and resetting properly after recording readings. On Monday morning, or Tuesday if the project was not attended on Monday, after recording any missed readings and the 0730 readings, enter the data on Form 14 and check for accuracy. Make a copy for project files and mail to the District Office marked "Attention Water Resources Engineering Branch." A sample Form 14, Plate 4-2, is included at the end of this section.

b. Daily WITS Report. The regular morning readings at the project, including precipitation, readings of the lake "L" gage, outflow "O" gage, gate positions, river stages, gate operations and supplemental data shall be transmitted via computer terminal to the Water Resources Engineering Branch by approximately 0800 hours each day on which the project is attended. The proper manner of reporting these data is shown in a printout of a WITS report at the end of this section as Plate 4-2. Further information concerning the WITS system is found in the WITS software package manual developed and published in May 1990, by Paul E. Cook and Lee Adkins of the Water Resources Engineering Branch, Huntington District Office. This system is computerized menu driven with a convenient auto-prompt feature. The system was further revised in May 1993 and has been installed at the dam.

Reports for Saturdays, Sundays, and holidays on which the project is attended will be transmitted as on regular work days. Reports for unattended days will be transmitted after submission of the current report for the first working day which follows. Each regular WITS report shall also include any gage readings obtained visually or by telephone since the previous report. If conditions are such that the daily report cannot be transmitted to WITS by 0830 hours, transmit via radio to the Water Resources Engineering Branch at that time. Instructions relative to arrangement and transmission of the WITS report are as follows:

(1) Logging On. Give WITS the qualifier and user number prescribed for Sutton Lake.

(2) Column 1 - Station Abbreviation. This column identifies the station. The first three letters comprise the abbreviation of the station name and the last letter and figure are a key to its location on the District

Isohyetal Map. The entire five member group constitutes the abbreviation for the station and should always be used when asked by the menu. Follow the example shown on Plate 3-1 or refer to the WITS handbook.

(3) Column 2 - Precipitation, Beginning and Ending. Report the amount of precipitation at the time of observation in this column. Include the time of beginning and ending if it is available. When either the time of beginning or ending is unknown, read it from the recorder.

(4) Column 3 - Lake Elevation. Use this column for reporting the lake "L" gage, in feet above mean sea level, to the nearest hundredth foot, in a six digit group and for reporting stream gage readings, also to the nearest hundredth foot. Please include decimal points as asked by the menu.

(5) Column 4 - Outflow Stage. Use this column for reporting the reading at the "O" gage, in elevation to the nearest hundredth foot, in a six digit group. For example, record and report 12.29 feet as 812.29 and 14.00 feet as 814.00. This is done by adding the zero elevation of 800.00 to the stage reading. See the example shown in Plate 4-2 or follow the WITS handbook.

(6) Column 6 and 7 - Snow and Amount. Report the amounts of snow and the water content in these columns. Where a station does not make this report or no precipitation has been reported, send NIL in place of this group. The first three figures give the snow since the last 073 report, but not to exceed a period of 24 hours. This will be in inches and hundredths. Indicate a trace by 00T. The fourth figure in this group is the amount of snow to the nearest whole inch which has fallen since the last 0730 report. The last figure in this group is the total depth of snow cover on the ground to the nearest whole inch. If there are ten inches or more of precipitation, snowfall or snow cover, report the amounts in a supplementary message. Always report the figures for snowfall and snow since the last report. In summer and at other seasons when there is zero snowfall and snow cover both at the time of the current and previous observations, omit the fourth and fifth figures in this group.

(7) Column 8,9 - Weather Description. The last two columns in this group are used to report the weather code and indicate the state of the weather at the time of observation, in accordance with the following code:

MM - missing or unknown DR - drizzle or fine rain HS - heavy snow
FA - fair or clear LR - light to moderate rain MI - mist of fog
CL - cloudy HR - heavy rain LS - light to moderate
snow PC - partly cloudy SL - sleet or hail

When there has been no precipitation to report, show this whole group as NIL.

(8) Sluice Gate Settings - Column 1 through 5. Use these columns for reporting the amount of opening of the sluice gates, starting with the number one gate on the left at the time of observation. The menu requests gate opening to the nearest tenth of a foot in four-digit notation. For example, record 2.5 feet as 2.50, 6 feet as 6.00 and closed as .00. In the WITS report, transmit gate openings in four-digit groups including decimal points.

(9) Gate Operation. Record all gate operations since the previous report and transmit with each regular, extra, or special report, listing them in chronological order. There is no selective withdrawal system at Sutton

Lake, therefore there is no selective withdrawal data. Enter the data on the form in the following manner. Use column one for the gate designation and columns two through six, successively for initial gate opening, final gate opening, date, beginning time, and ending time.

c. Supplementary Messages. Report additional data in message form at the end of the WITS report. Include any or all of the following, as appropriate, in such messages:

(1) Precipitation and snow cover amounts when either is ten (10) inches or more.

(2) Moisture content of snow cover, when requested.

(3) Precipitation at the dam during the past 24 hours, when greater than one (1) inch, by 6-hour periods.

4-02 EXTRA REPORTS

Extra reports, as indicated by Schedule for Reading Gages, Plate 1-1, should always be transmitted to WITS via computer in the same way as the regular morning WITS report. If some circumstance prohibits, such as for example, malfunction of the computer or lack of computer competency by personnel on duty, attempt to fax the report to Water Resources Engineering Branch in the District Office. Failing this attempt, telephone the report to one of the Water Resources Engineering Branch personnel in the order listed below in paragraph 4-03c.

4-03 SPECIAL REPORTS

a. Reporting Criteria. Special reports include any report not regularly scheduled. A special report should be made when an event occurs concerning the project that Water Resources Engineering Branch should have knowledge of or when requested by the Branch.

b. Special Report Data. The following types of occurrences or information are examples of occasions for or subjects of special reports.

(1) Heavy precipitation after 0730 hours.

(2) Extraordinary meteorological event such as a tornado or blizzard.

(3) Gate positions and/or operations.

(4) Flooding upstream or downstream.

(5) Request for special operation.

(6) Catastrophe such as drowning.

(7) Moisture content of snow.

(8) Air temperature at times other than 0730 hours if significant.

(9) Local weather forecast.

c. Transmission of Special Reports. All special reports should be made at any time of day or night, including weekends and holidays, or when requested by Water Resources Engineering Branch. During office hours, submit them by telephone; however, if it is impossible by telephone, utilize the District radio network. When making telephone calls after hours or during weekends or holidays, unless advised that the Water Resources Engineering Branch will be on duty, place a person-to-person call to one of the following Water Resources Engineering Branch personnel, in the order listed:

CORPS OF ENGINEERS

Water Resources Engineering Branch Personnel	Home Telephone Number
[redacted] Chief, Water Control Section	[redacted]
[redacted] Water Control Section	[redacted]
[redacted] Chief, Water Resources Engineering Branch	[redacted]

Pertinent telephone numbers which may be of value during a flood emergency are listed below:

Huntington District Office, Water Resources Engineering Branch

Normal Work Hours, Nights, Weekends, and Holidays [redacted]

Nights, Weekends, and Holidays — Additional Extensions [redacted]

Kanawha Area Office, Summersville, W.Va.

Normal Work Hours, [redacted]

Night, weekend Holiday, NWS observers [redacted]

Person-to-person, at home [redacted]

Sutton Lake Project Office
South Stonewall Street
PO Box 426
Sutton, WV 26601-1426
[redacted]
Project Supervisor
[redacted]

Gate Operating Personnel
[redacted]

Other Agencies

U. S. Geological Survey
Charleston, W. Va. [redacted]

Night, Weekend, Holidays
[redacted] [redacted]

National Weather Service
W. S. Forecast Office
Charleston, W. Va. [redacted]

4-04 RADIO AS BACKUP COMMUNICATION

Keep the radio turned on at all times when anyone is on duty at the project office, including overtime periods, since Area Office and District Office operators are sometimes on duty outside of regular office hours. Also, messages may be relayed through other projects. When there is difficulty in transmitting reports to the Area Office via radio or telephone, attempt to transmit by radio either direct to the District Office or by relay through another project which has contact with the District Office. Failing the above, telephone Corps of Engineers listings in 4-03c as appropriate.

If the radio is used for a morning report the data must be ready for radio transmission by 0800 when the Kanawha Area Office begin calling the projects for these reports. The regular morning data at the dam include precipitation, water levels at lake and outflow gages, gate positions, depth of snow cover, if any, beginning and ending times of precipitation with current weather, and water content of snow if previously requested. After transmitting reports, projects must monitor the radio in order to receive any special instruction until given the "Clear" signal. An example of special instruction would be to be prepared to make extra reports, and if so, whether water content of snow would be required. In order to simplify and expedite transmission and copying the data in the Area Office, it is directed that the normal sequences or groupings be observed.

4-05 LETTER REPORTS

a. General. All letter reports pertaining to water control management will be addressed to the District Engineer, Attention: Water Resources Engineering Branch (CEORH-ED-H).

b. Downstream Channel Conditions. At the request of Water Resources Engineering Branch, inspection of critical areas downstream from the dam will be made for conditions listed below:

(1) Channel encroachment and/or indiscrete utilization of low-lying areas during moderate rainfall when project discharge is at minimum for the season.

(2) If complaints of flooding are received, notify EC-W and Area Office immediately; then make any inspection requested by Area Office of the specific area as soon as practicable.

(3) At any other times, as requested by Water Resources Engineering Branch, and under (2) above, the essential items to note and report are: (a) persons or communities involved, (b) nature of complaint or encroachment, and (c) extent and depth of flooding. Make a letter report, containing pictures, cross sections or sketches of the findings as soon as practicable if required after a brief initial report via telephone to Area Office or Water Resources Engineering Branch.

(4) The Water Resources Engineering Branch should be informed concerning applications of chemicals to the water or to surrounding land. This includes fertilizers and pesticides.

c. Low Flow Releases. During periods of low flow release, downstream observations shall be made of stream depth, fish and wildlife, water odor, and discoloration, if any, as directed by the Water Resources Engineering Branch. Stream gages, rain gages and temperature equipment shall be periodically checked for proper functioning and performance or when directed by the Water Resources Engineering Branch. During periods of stratification, outflow temperature requirements will be maintained according to directives issued by the Water Resources Engineering Branch.

d. Functioning of the Dam. Functioning of the dam shall be observed at all times, including performance of gates, valves, machinery and outlet structure and the presence of any leakage. During flood storage periods when the lake level reaches or exceeds the Alert Elevation, 958 feet msl, for Sutton Lake, daily observations are made and reported under provisions of the Dam Operations Management Policy in addition to the normal weekly and monthly observations made under the Policy. At these times, or other times requested by Water Resources Engineering Branch for a particular use, forward a copy of such observations as soon as practicable to Water Resources Engineering Branch as a letter report.

e. Water Quality Reports. Any unusual water conditions should be reported to the Water Resources Engineering Branch, particularly:

(1) Floating debris, oil, scum and other floating materials from municipal, industrial, or other discharges such as from agricultural practices in such amounts that they are unsightly or detrimental to wildlife or public health.

(2) Unusual color, odor or other conditions in such degree as to be a nuisance.

(3) Any fish kills, plankton blooms or insects to the degree that they are a nuisance should be reported.

(4) The Water Resources Engineering Branch should be informed concerning applications of chemicals to the water or to surrounding land. This includes fertilizers and pesticides.

U. S. ARMY ENGINEER DISTRICT, HUNTINGTON

SAMPLE COPY

DAMTENDER'S WEEKLY REPORT

Reports Control Symbol OVDGW-1

DATE Sutton

WEEK ENDING Monday, 15 February 196_

GAGE RECORDS						GATE OPERATING RECORD			
DATE	TIME START	TIME END	GAGES VL	GAGES VO	GAGES FREK 7	GATE NO.	AMT. OF OPENING INITIAL	AMT. OF OPENING FINAL	PURPOSE
8	1630		850.42	811.44	2.79				
9	0730		850.31	811.44	2.76				
	0740	0741				3	019	018	Maint. cons. pool
	0830		850.31	811.37	2.73				
	1630		850.29	811.37	2.72				
10	0730		850.25	811.37	2.71				
	0735	0736				3	018	012	Maint. cons. pool
	0830		850.25	811.11	2.70				
	1630		850.23	811.11	2.56				
11	0730		850.19	811.11	2.55				
	0745					3	012	009	Maint. cons. pool
	0845		850.19	810.92	2.54				
	1630		850.18	810.92	2.38				
12	0730		850.16	810.92	2.38				
	1630		850.15	810.92	2.37				
13	0730		850.13*	810.91*	2.37*				
	1630		850.12*	810.91*	2.37*				
14	0730		850.10*	810.91*	2.37*				
	1630		850.09*	810.91*	2.36*				
15	0730		850.07	810.91	2.36				

*Readings taken from recorder charts.

CHECK READINGS

Date	Time	SL	TL	RL	VL
9	1047	850.29	850.30	850.30	850.30
11	1350	850.16	850.19	850.18	850.18
		SO	TO	RO	VO
9	1055	811.37	811.36	811.36	811.37
11	1400	810.92	810.92	810.93	810.92

FINAL POSITION OF GATES

Gates #1-2-4-5 closed.
Gate #3 open 009
All crest gates open 010.
Low-flow valve closed.

/s/ Warren F. Daily
DAMTENDER

OVH Form
5 Jul 1945

```
FILE=97050907.SUE           SUTTON          FRI    09 May 9   1215 HRS

.B  COESUE 050997  E 0730/PPP/HG/QR/HP/HT/QT/SD/SW
:
:  PROJECT REPORT FOR SUTTON LAKE                            FRI    9 MAY 97
:
:STANDARD PROJECT DATA -------------------------------------------------------
:                         POOL      TAILWATER     SNOW WATER   WEATHER
:    ID        PRECIP     ELEV     STAGE     FLOW   DEPTH EQIV CODE DESCRIPTION
:  COE/SHEF     (IN)   (FT-MSL)   (FT)     (KCFS)  (IN)  (IN)
:SUEK7:SUTW2   .75/// 922.89/ 813.47/        M/   .00/   .0: 3 CLOUDY
:
:GATE SETTINGS ---------------------------------------------------------------
:S1=.10        /S2=.60       /S3=2.00      /S4=.60       /S5=.10       /LFV=.00
:C1=1.00       /C2=1.00      /C3=1.00      /C4=1.00      /C5=1.00      /C6=1.00
:
:STATION DATA ----------------------------------------------------------------
:                                                SNOW  WATER WEATHER
:    ID              PRECIP  STAGE    FLOW      DEPTH  EQIV CODE     LOCATION
:  COE/SHEF            (IN)   (FT)   (KCFS)      (IN)  (IN)
:CYEL6:CLYW2  0730/     M/    5.42/        M////  .00/   .00:     CLAY
:FREK7:FRMW2  0730/---  M/----4.11/     -  M////---.00/-  .00:--- FRAMETOWN
:QSEL6:QUSW2  0730/     M/    6.88/        M////  .00/   .00:     QUEEN SHOALS
:WBEK8:WEBW2  0730/     M/    5.36/        M////  .00/   .00:     WEBSTER SPGS
:REPK7:REPW2  0730/     M/    6.46/        M////  .00/   .00:     REPLETE
:GARK7:GUAW2  0730/     M/    5.05/        M////  .00/   .00:     GUARDIAN
:
:COMMENTS --------------------------------------------------------------------
: OUTFLOW TEMP 55
: HIGH 77
: LOW 47
: PRESENT 56
: CFS 1380
: a little late this morning....sorry
:
.END
```

UPON APPROVAL OF NEPA DOCUMENTATION, THE DROUGHT CONTINGENCY PLAN WILL BE FURNISHED FOR ENCLOSURE IN THE WATER CONTROL MANUALS.

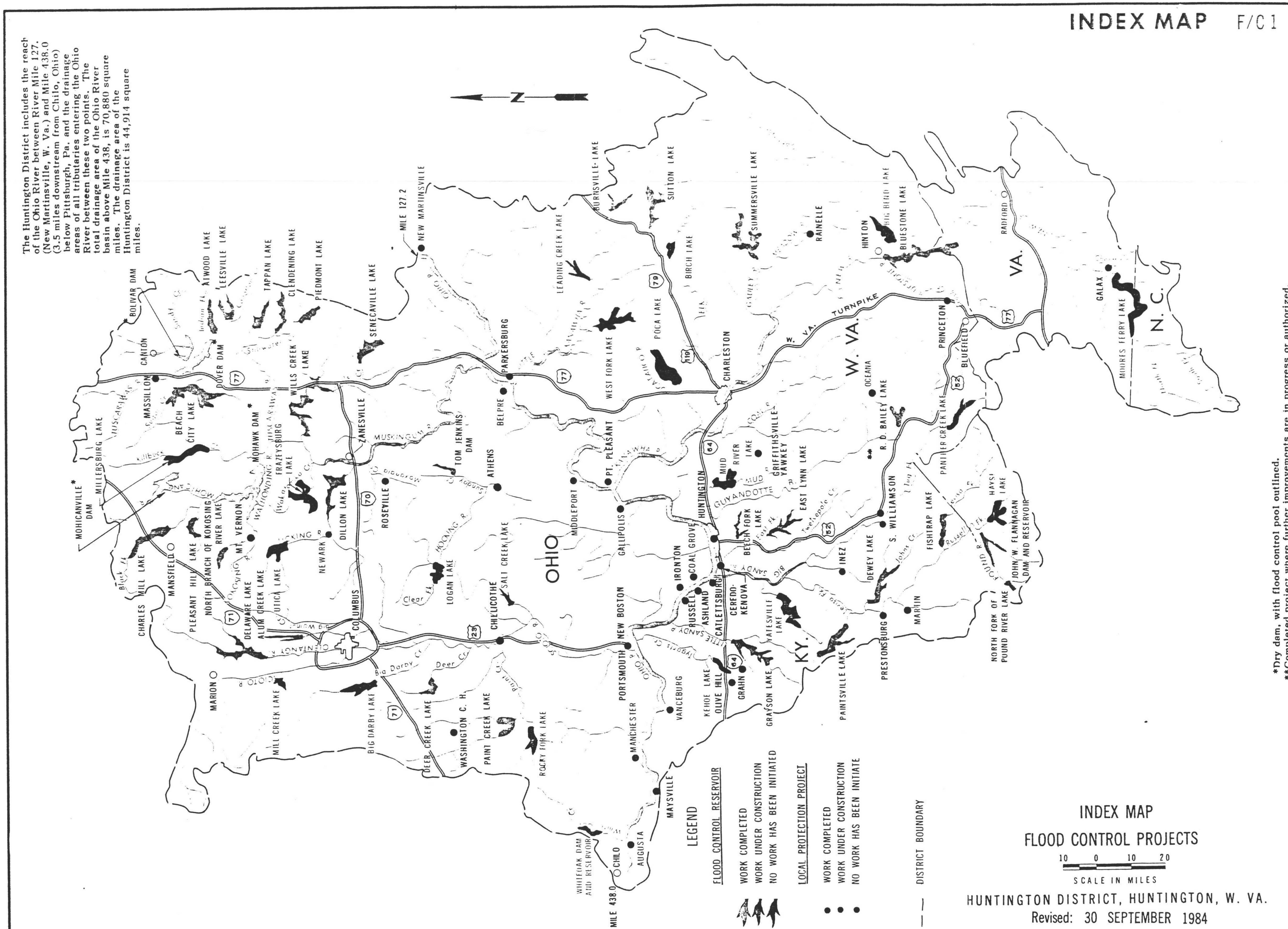

INDEX MAP F/C1
The Huntington District includes the reach of the Ohio River between River Mile 127.2 (New Martinsville, W. Va.) and Mile 438.0 (3.5 miles downstream from Chilo, Ohio) below Pittsburgh, Pa. and the drainage areas of all tributaries entering the Ohio River between these two points. The total drainage area of the Ohio River basin above Mile 438, is 70,880 square miles. The drainage area of the Huntington District is 44,914 square miles.
N
MILE 127.2
NEW MARTINSVILLE
BOLIVAR DAM
ATWOOD LAKE
LEESVILLE LAKE
TAPPAN LAKE
CLENDENING LAKE
PIEDMONT LAKE
SENECAVILLE LAKE
CANTON
MASSILLON
DOVER DAM
BEACH CITY LAKE
MOHAWK DAM
FRAZEYSBURG
WILLS CREEK LAKE
ZANESVILLE
MILLERSBURG LAKE
MOHICANVILLE DAM
DILLON LAKE
NEWARK
ROSEVILLE
TOM JENKINS DAM
ATHENS
PARKERSBURG
BELPRE
BURNSVILLE LAKE
SUTTON LAKE
SUMMERSVILLE LAKE
RAINELLE
LEADING CREEK LAKE
BIRCH LAKE
POCA LAKE
WEST FORK LAKE
CHARLESTON
PT. PLEASANT
MIDDLEPORT
GALLIPOLIS
HUNTINGTON
MUD RIVER LAKE
GRIFFITHSVILLE
YAWKEY
EAST LYNN LAKE
BEECH FORK LAKE
HINTON
BIG BEND LAKE
BLUESTONE LAKE
RADFORD
PRINCETON
BLUEFIELD
W. VA. TURNPIKE
OCEANA
R. D. BAILEY LAKE
PANTHER CREEK LAKE
WILLIAMSON
S. WILLIAMSON
HAYSI LAKE
JOHN W. FLANNAGAN DAM AND RESERVOIR
FISHTRAP LAKE
DEWEY LAKE
INEZ
MARTIN
NORTH FORK OF POUND RIVER LAKE
PRESTONSBURG
PAINTSVILLE LAKE
GALAX
MOORES FERRY LAKE
VA.
N. C.
W. VA.
OHIO
KY.
MANSFIELD
CHARLES MILL LAKE
PLEASANT HILL LAKE
NORTH BRANCH OF KOKOSING RIVER LAKE
MT. VERNON
DELAWARE LAKE
ALUM CREEK LAKE
UTICA LAKE
COLUMBUS
MARION
MILL CREEK LAKE
BIG DARBY LAKE
DEER CREEK LAKE
WASHINGTON C. H.
PAINT CREEK LAKE
ROCKY FORK LAKE
LOGAN LAKE
CHILLICOTHE
SALT CREEK LAKE
NEW BOSTON
PORTSMOUTH
IRONTON
COAL GROVE
RUSSELL
ASHLAND
CATLETTSBURG
CEREDO-KENOVA
YATESVILLE LAKE
GRAYSON LAKE
KEHOE LAKE
OLIVE HILL
GRAHN
VANCEBURG
MANCHESTER
MAYSVILLE
AUGUSTA
CHILO
MILE 438.0
WHITEOAK DAM AND RESERVOIR
LEGEND
FLOOD CONTROL RESERVOIR
WORK COMPLETED
WORK UNDER CONSTRUCTION
NO WORK HAS BEEN INITIATED
LOCAL PROTECTION PROJECT
WORK COMPLETED
WORK UNDER CONSTRUCTION
NO WORK HAS BEEN INITIATE
DISTRICT BOUNDARY
*Dry dam, with flood control pool outlined.
**Completed project where further improvements are in progress or authorized.
INDEX MAP
FLOOD CONTROL PROJECTS
10 0 10 20
SCALE IN MILES
HUNTINGTON DISTRICT, HUNTINGTON, W. VA.
Revised: 30 SEPTEMBER 1984

PLATE NO. 1-1

[redacted]

ELK RIVER
W. VA.
SUTTON RESERVOIR PROJECT

GENERAL DRAWINGS
ELEVATIONS AND SECTIONS

SCALE : N.T.S.

U.S. ARMY CORPS OF ENGINEERS

HUNTINGTON DISTRICT - HUNTINGTON, W. VA.
SEPT. 30, 1979
REDRAWN AUG., 1998

ELK RIVER
W. VA.
SUTTON RESERVOIR PROJECT

GENERAL DRAWINGS
ELEVATIONS AND SECTIONS

SCALE : N.T.S.

U.S. ARMY CORPS OF ENGINEERS

HUNTINGTON DISTRICT - HUNTINGTON, W. VA.
JULY 1963
REDRAWN AUG., 1998

PLATE NO. 2-2

ELK RIVER
W. VA.
SUTTON RESERVOIR PROJECT

DAM
GENERAL DRAWINGS-TYPICAL SECTIONS

SCALE: N-T-S

U.S. ARMY CORPS OF ENGINEERS
HUNTINGTON DISTRICT - HUNTINGTON, W. VA.
REDRAWN AUG., 1998

PLATE NO. 2-3

ELK RIVER
W. VA.
SUTTON RESERVOIR PROJECT

DAM
SPILLWAY
TYPICAL SECTION & DETAILS

NOT TO SCALE

U.S. ARMY CORPS OF ENGINEERS

HUNTINGTON DISTRICT - HUNTINGTON, W. VA.

REDRAWN AUG., 1998

ELK RIVER
W. VA.
SUTTON RESERVOIR PROJECT

DAM
SPILLWAY
BUCKET-PLAN & DETAILS

NOT TO SCALE

U.S. ARMY CORPS OF ENGINEERS

HUNTINGTON DISTRICT - HUNTINGTON, W. VA.
REDRAWN AUG., 1998

PLATE NO. 2-5

[redacted]

ELK RIVER
W. VA.
SUTTON RESERVOIR PROJECT

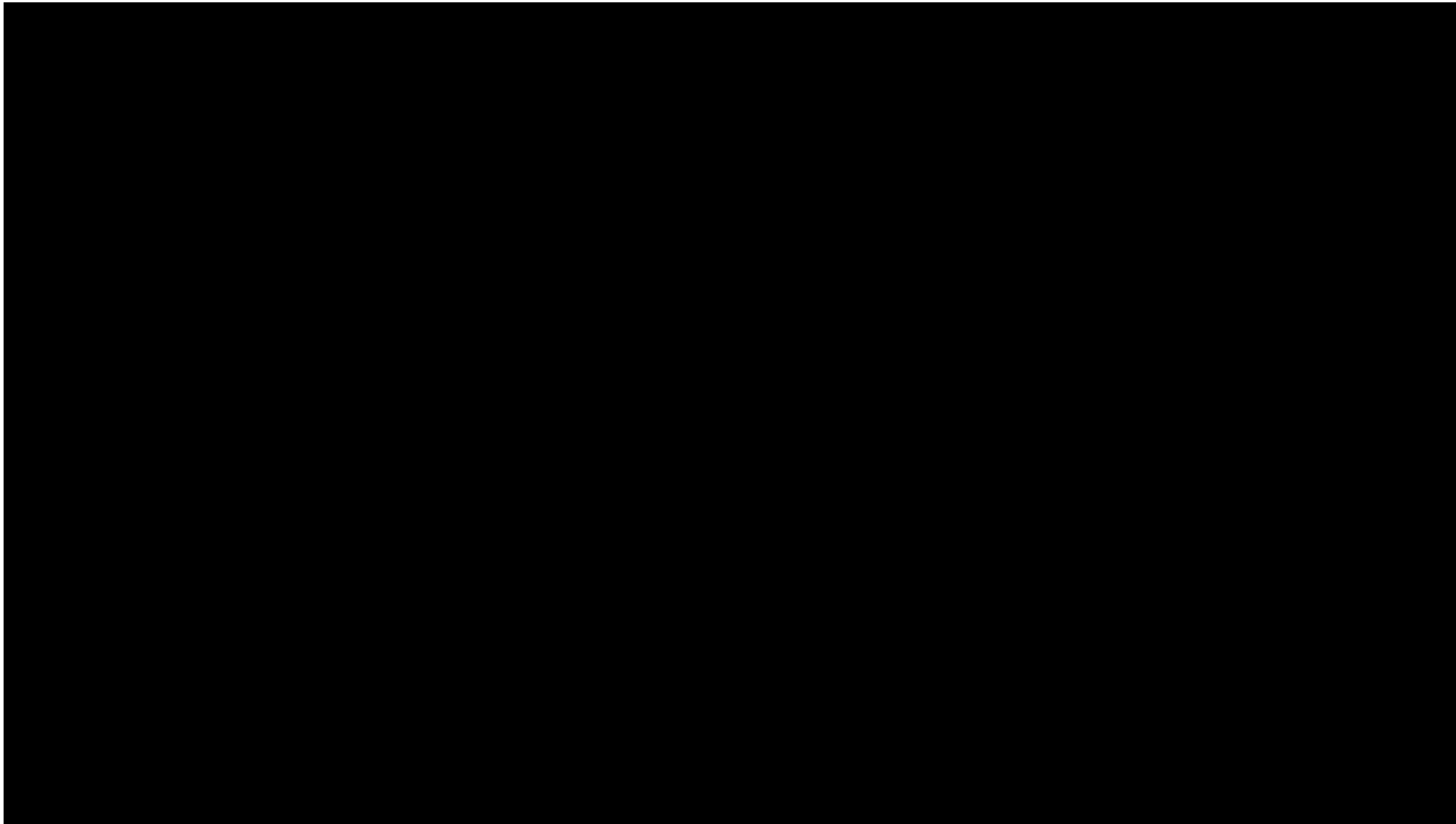
DAM
SPILLWAY
SPRAY WALL & TRAINING WALL-NORTH

NOT TO SCALE

U.S. ARMY CORPS OF ENGINEERS

HUNTINGTON DISTRICT - HUNTINGTON, W. VA.

REDRAWN AUG., 1998



ELK RIVER
W. VA.
SUTTON RESERVOIR PROJECT

DAM
SPILLWAY
SPRAY WALL & TRAINING WALL-SOUTH

NOT TO SCALE

U.S. ARMY CORPS OF ENGINEERS

HUNTINGTON DISTRICT - HUNTINGTON, W. VA.

REDRAWN AUG., 1998

ELK RIVER
W. VA.
SUTTON RESERVOIR PROJECT

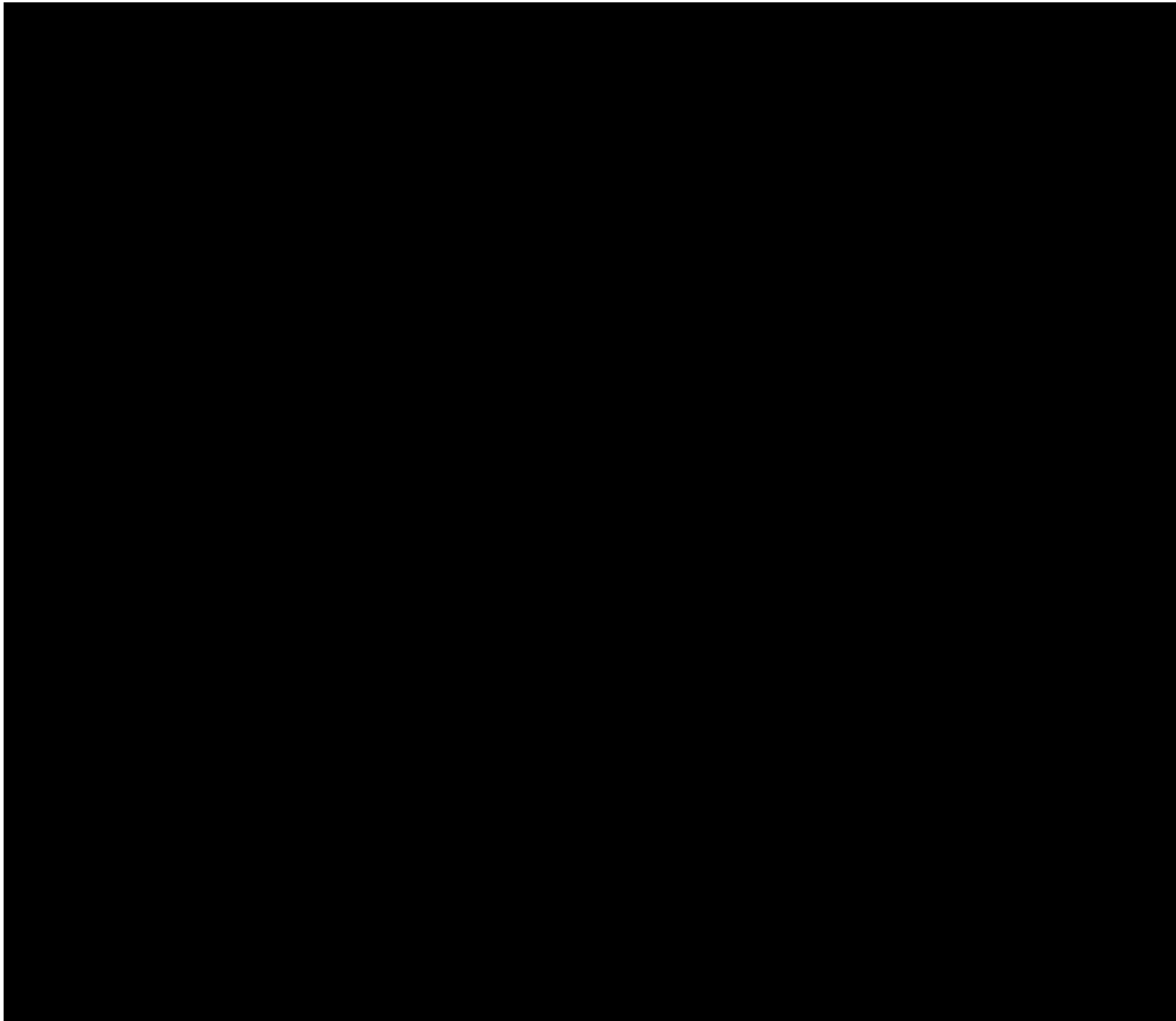
DAM
TAINTER GATES
GENERAL ARANGEMENT

NOT TO SCALE

U.S. ARMY CORPS OF ENGINEERS

HUNTINGTON DISTRICT - HUNTINGTON, W. VA.

REDRAWN AUG., 1998



ELK RIVER
W. VA.
SUTTON RESERVOIR PROJECT

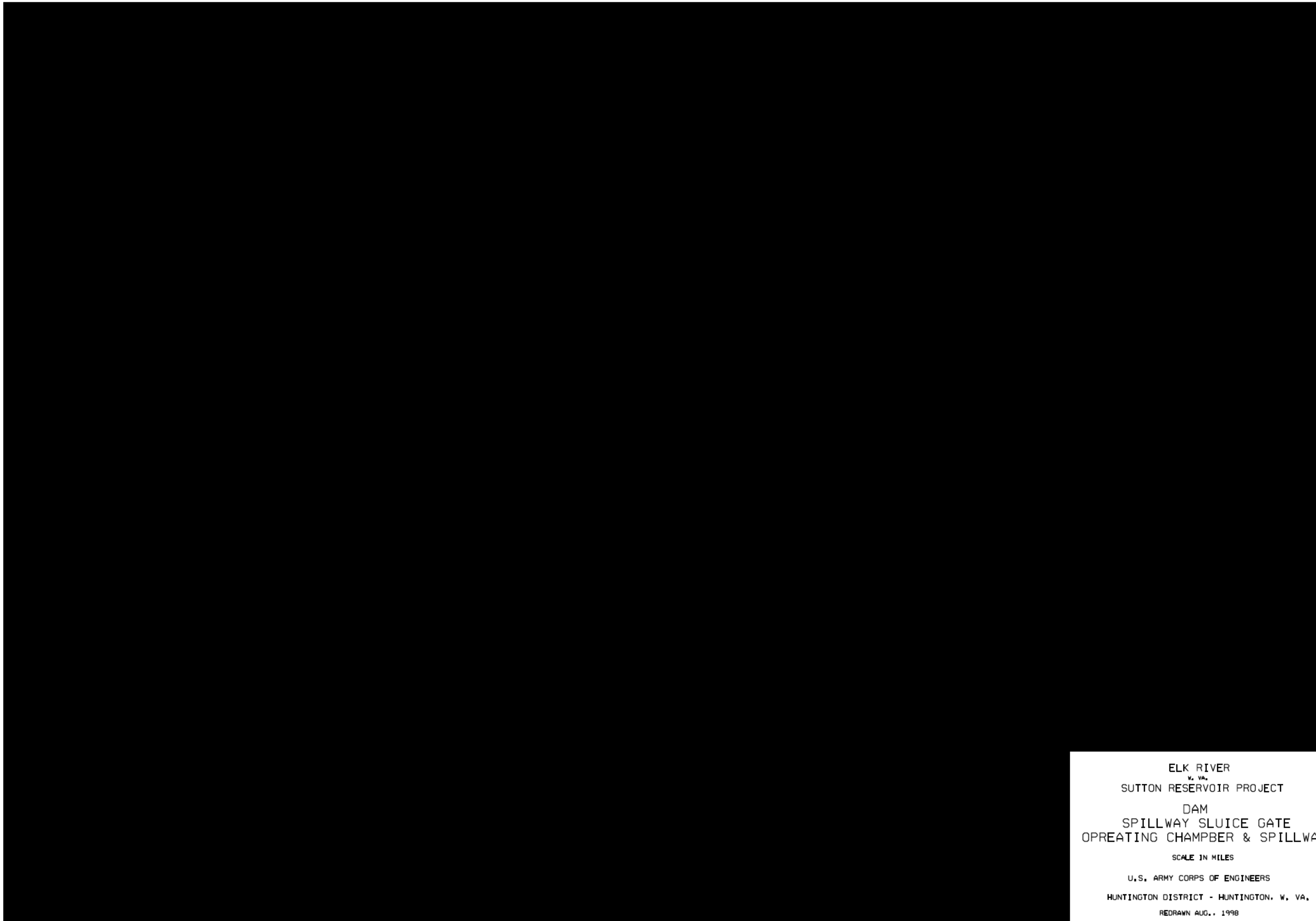
TAINTER GATES
OPERATING MACHINERY-
SECTIONS & ELEVATIONS

SCALE : N.T.S.

U.S. ARMY CORPS OF ENGINEERS

HUNTINGTON DISTRICT - HUNTINGTON, W. VA.

REDRAWN AUG., 1998



ELK RIVER
W. VA.
SUTTON RESERVOIR PROJECT

DAM
SPILLWAY SLUICE GATE
OPREATING CHAMPBER & SPILLWAY

SCALE IN MILES

U.S. ARMY CORPS OF ENGINEERS

HUNTINGTON DISTRICT - HUNTINGTON, W. VA.

REDRAWN AUG., 1998

PLATE NO. 2-10

[redacted]

ELK RIVER
W. VA.
SUTTON RESERVOIR PROJECT
DAM

CONTROL GATES
LOW FLOW SLUICE & DETAILS

SCALE : N.T.S.

U.S. ARMY CORPS OF ENGINEERS

HUNTINGTON DISTRICT - HUNTINGTON, W. VA.

REDRAWN AUG., 1998

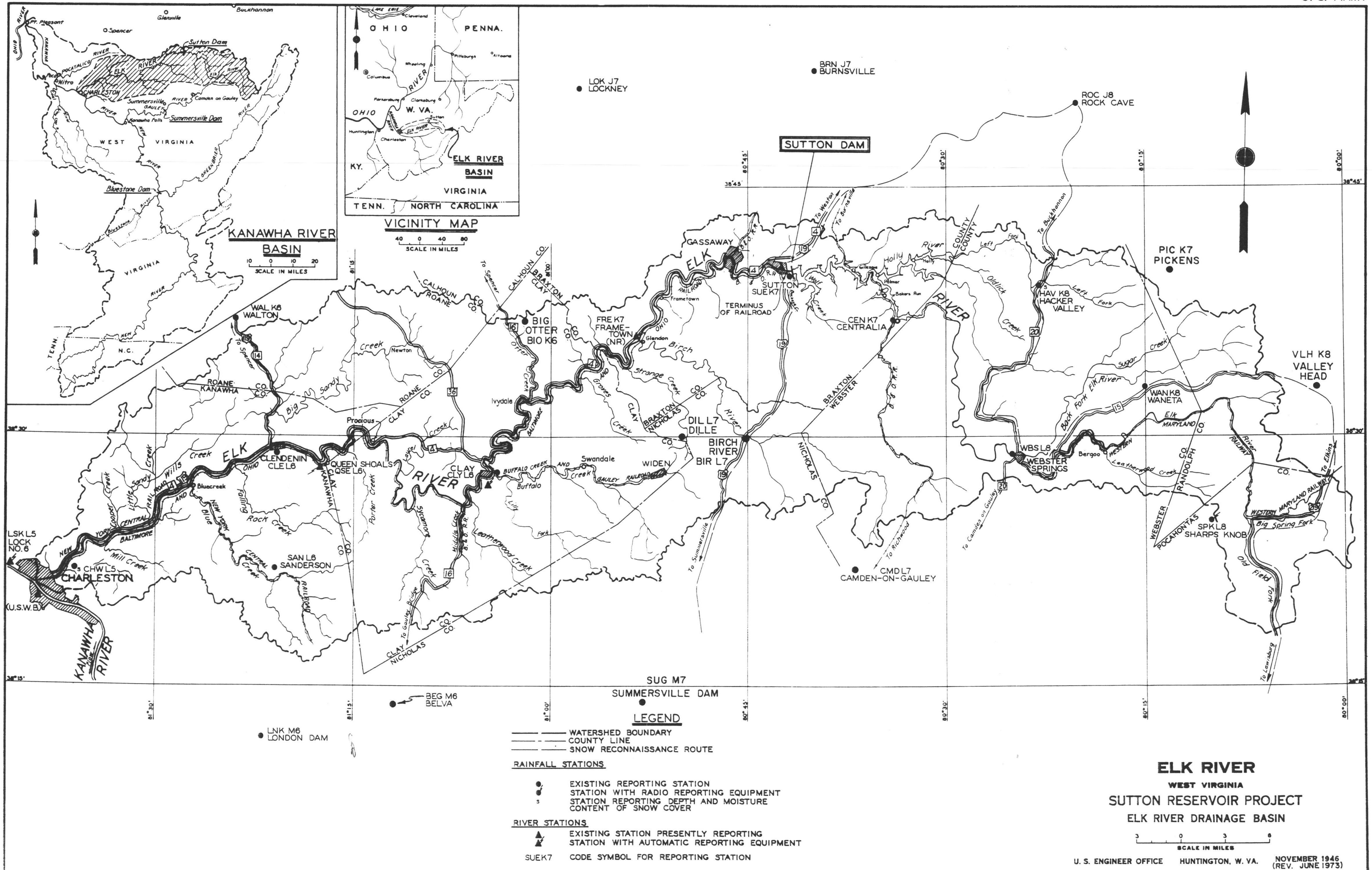
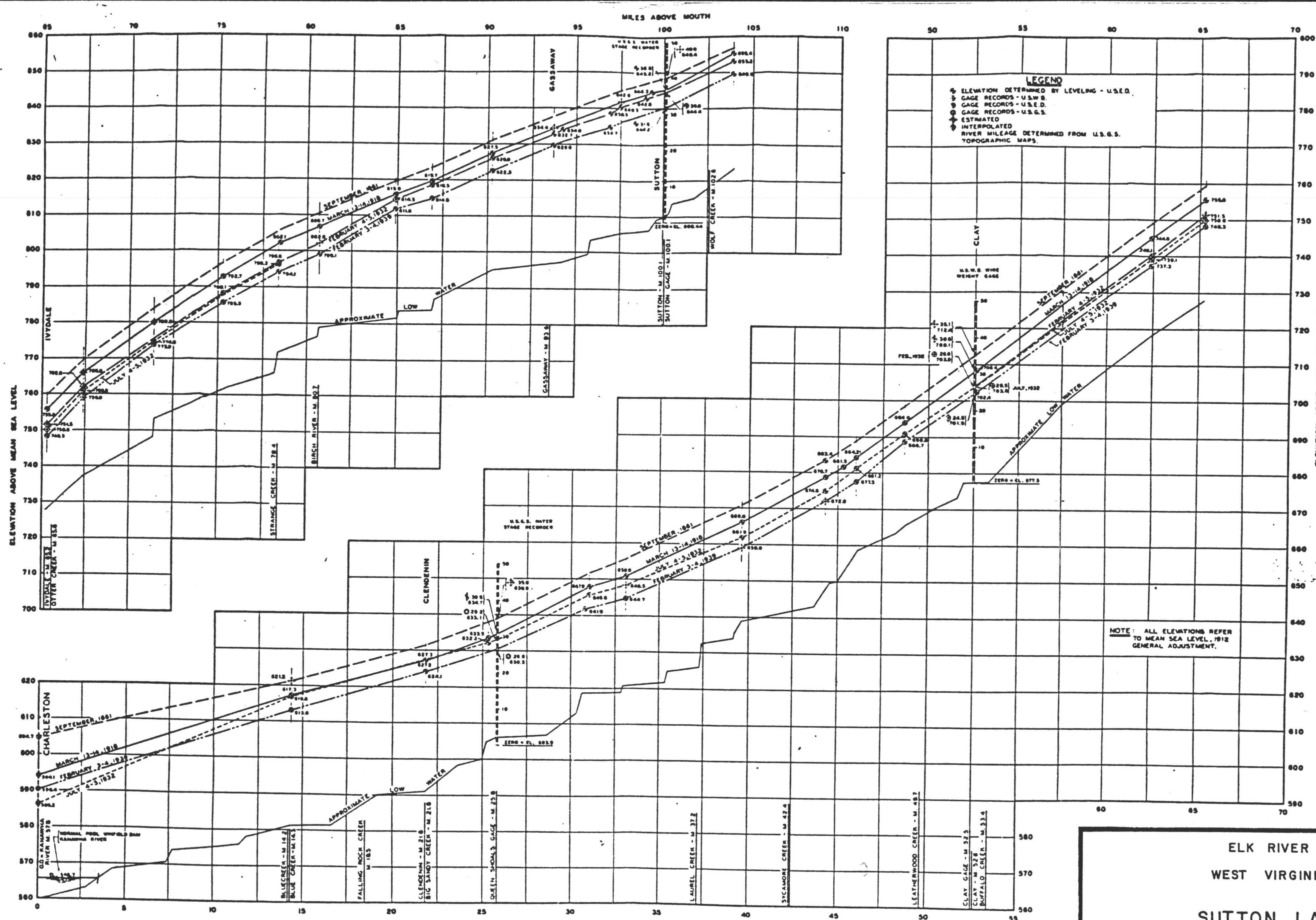

KANAWHA RIVER BASIN
SCALE IN MILES
VICINITY MAP
SCALE IN MILES
OHIO
PENNA.
W. VA.
KY.
VIRGINIA
TENN.
NORTH CAROLINA
ELK RIVER BASIN
Sutton Dam
Summersville Dam
Bluestone Dam
SUTTON DAM
LOK J7 LOCKNEY
BRN J7 BURNSVILLE
ROC J8 ROCK CAVE
PIC K7 PICKENS
GASSAWAY
SUTTON SUE K7
TERMINUS OF RAILROAD
CEN K7 CENTRALIA
HAV K8 HACKER VALLEY
VLH K8 VALLEY HEAD
WAN K8 WANETA
WAL K6 WALTON
BIG OTTER BIO K6
FRE K7 FRAME-TOWN (NR)
DIL L7 DILLE
BIRCH RIVER BIR L7
WBS L8 WEBSTER SPRINGS
SPK L8 SHARPS KNOB
CLENDENIN CLE L6
QUEEN SHOALS QSE L6
CLAY CLY L6
LSK L5 LOCK NO. 6
CHW L5 CHARLESTON
(U.S.W.B.)
SAN L8 SANDERSON
CMD L7 CAMDEN-ON-GAULEY
SUG M7 SUMMERSVILLE DAM
BEG M6 BELVA
LNK M6 LONDON DAM
ELK RIVER
KANAWHA RIVER
LEGEND
WATERSHED BOUNDARY
COUNTY LINE
SNOW RECONNAISSANCE ROUTE
RAINFALL STATIONS
EXISTING REPORTING STATION
STATION WITH RADIO REPORTING EQUIPMENT
STATION REPORTING DEPTH AND MOISTURE CONTENT OF SNOW COVER
RIVER STATIONS
EXISTING STATION PRESENTLY REPORTING
STATION WITH AUTOMATIC REPORTING EQUIPMENT
SUEK7 CODE SYMBOL FOR REPORTING STATION
ELK RIVER
WEST VIRGINIA
SUTTON RESERVOIR PROJECT
ELK RIVER DRAINAGE BASIN
SCALE IN MILES
U. S. ENGINEER OFFICE HUNTINGTON, W. VA.
NOVEMBER 1946 (REV. JUNE 1973)

PLATE NO. 2-12



ELK RIVER

WEST VIRGINIA

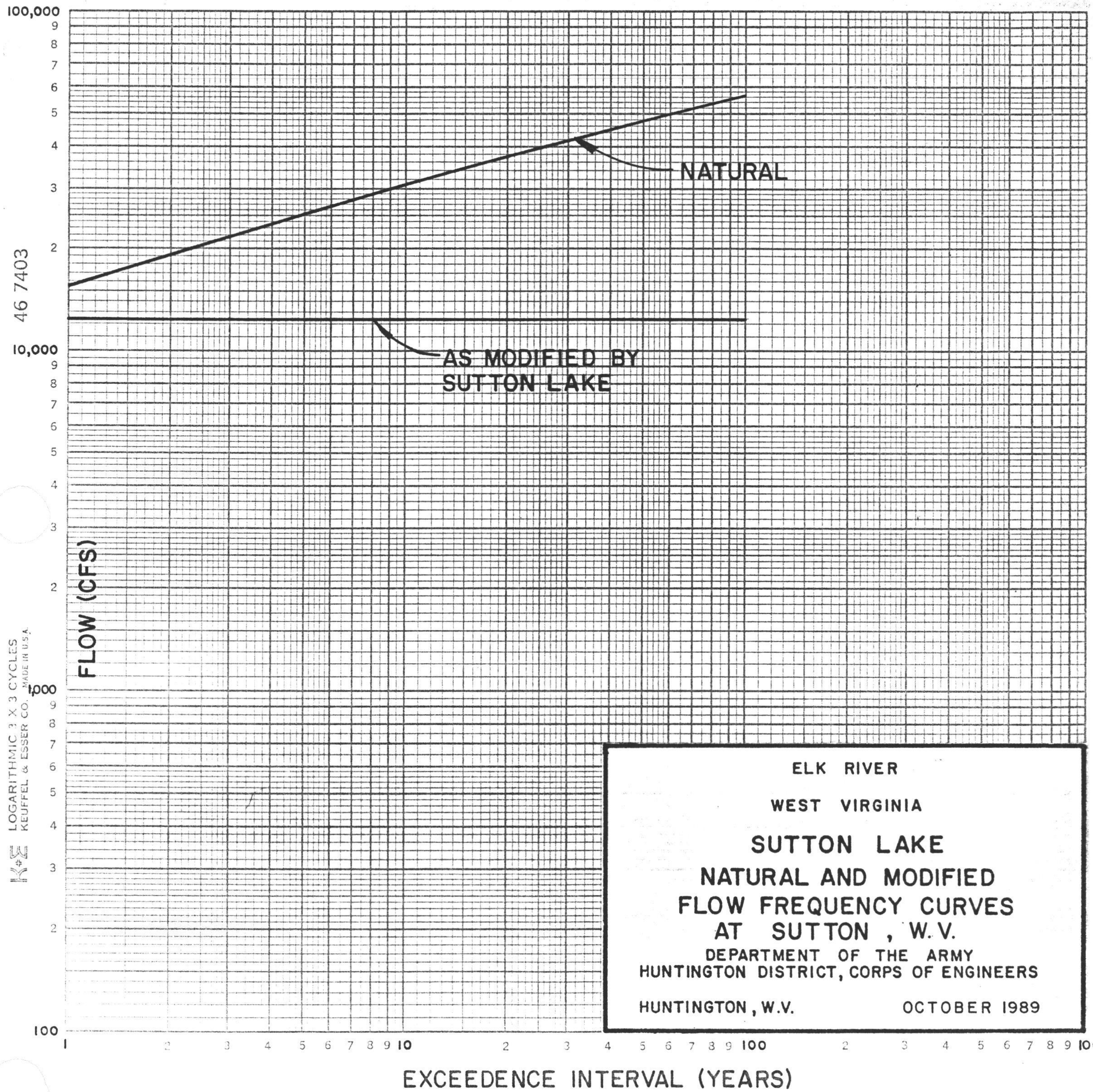
SUTTON LAKE

HIGH WATER PROFILES

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. OCTOBER 1989

PLATE NO. 4-1



ELK RIVER

WEST VIRGINIA

SUTTON LAKE

NATURAL AND MODIFIED FLOW FREQUENCY CURVES AT SUTTON, W.V.

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. OCTOBER 1989

/KANAWHA/SUEOF/ELEV-FLOW/RES OUT/04MAR92/USGS TABLE NO.40 adj/

810	25	815	2650	820	7100
810.1	25	815.1	2730	820.1	7210
810.2	25	815.2	2820	820.2	7320
810.3	25	815.3	2900	820.3	7430
810.4	25.5	815.4	2990	820.4	7540
810.5	26	815.5	3070	820.5	7650
810.6	30.5	815.6	3160	820.6	7760
810.7	35	815.7	3240	820.7	7870
810.8	41	815.8	3330	820.8	7980
810.9	47	815.9	3410	820.9	8090
811	55	816	3500	821	8200
811.1	75	816.1	3580	821.1	8310
811.2	105	816.2	3670	821.2	8420
811.3	125	816.3	3750	821.3	8530
811.4	150	816.4	3840	821.4	8640
811.5	180	816.5	3920	821.5	8750
811.6	220	816.6	4010	821.6	8860
811.7	260	816.7	4090	821.7	8970
811.8	300	816.8	4180	821.8	9080
811.9	345	816.9	4260	821.9	9190
812	395	817	4350	822	9300
812.1	445	817.1	4430	822.1	9410
812.2	500	817.2	4520	822.2	9520
812.3	565	817.3	4600	822.3	9630
812.4	630	817.4	4690	822.4	9740
812.5	695	817.5	4770	822.5	9850
812.6	760	817.6	4860	822.6	9960
812.7	820	817.7	4940	822.7	10100
812.8	880	817.8	5030	822.8	10200
812.9	950	817.9	5110	822.9	10300
813	1020	818	5200	823	10400
813.1	1090	818.1	5290	823.1	10500
813.2	1160	818.2	5380	823.2	10600
813.3	1240	818.3	5470	823.3	10700
813.4	1320	818.4	5560	823.4	10800
813.5	1400	818.5	5650	823.5	10900
813.6	1480	818.6	5740	823.6	11100
813.7	1560	818.7	5830	823.7	11200
813.8	1640	818.8	5920	823.8	11300
813.9	1720	818.9	6010	823.9	11400
814	1800	819	6100	824	11500
814.1	1880	819.1	6200	824.1	11600
814.2	1970	819.2	6300	824.2	11700
814.3	2050	819.3	6400	824.3	11800
814.4	2140	819.4	6500	824.4	12000
814.5	2220	819.5	6600	824.5	12100
814.6	2310	819.6	6700	824.6	12200
814.7	2390	819.7	6800	824.7	12300
814.8	2480	819.8	6900	824.8	12400
814.9	2560	819.9	7000	825	12600

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SU[illegible]- WATER RESOURCES DIVISION

EXPANDED RATING TABLE

TYPE: LOG

DATE PROCESSED: 04-03-[illegible]2 @ 13:15 BY smward

03194700
ELK RIVER BELOW WEBSTER SPRINGS, WV
OFFSET: 1.9 BREAK,OFFSET: (2.9,2.5)

DD: 6 TYPE: 001 RATING NO: 0026
START DATE/TIME: 02-15-2001 (1800)

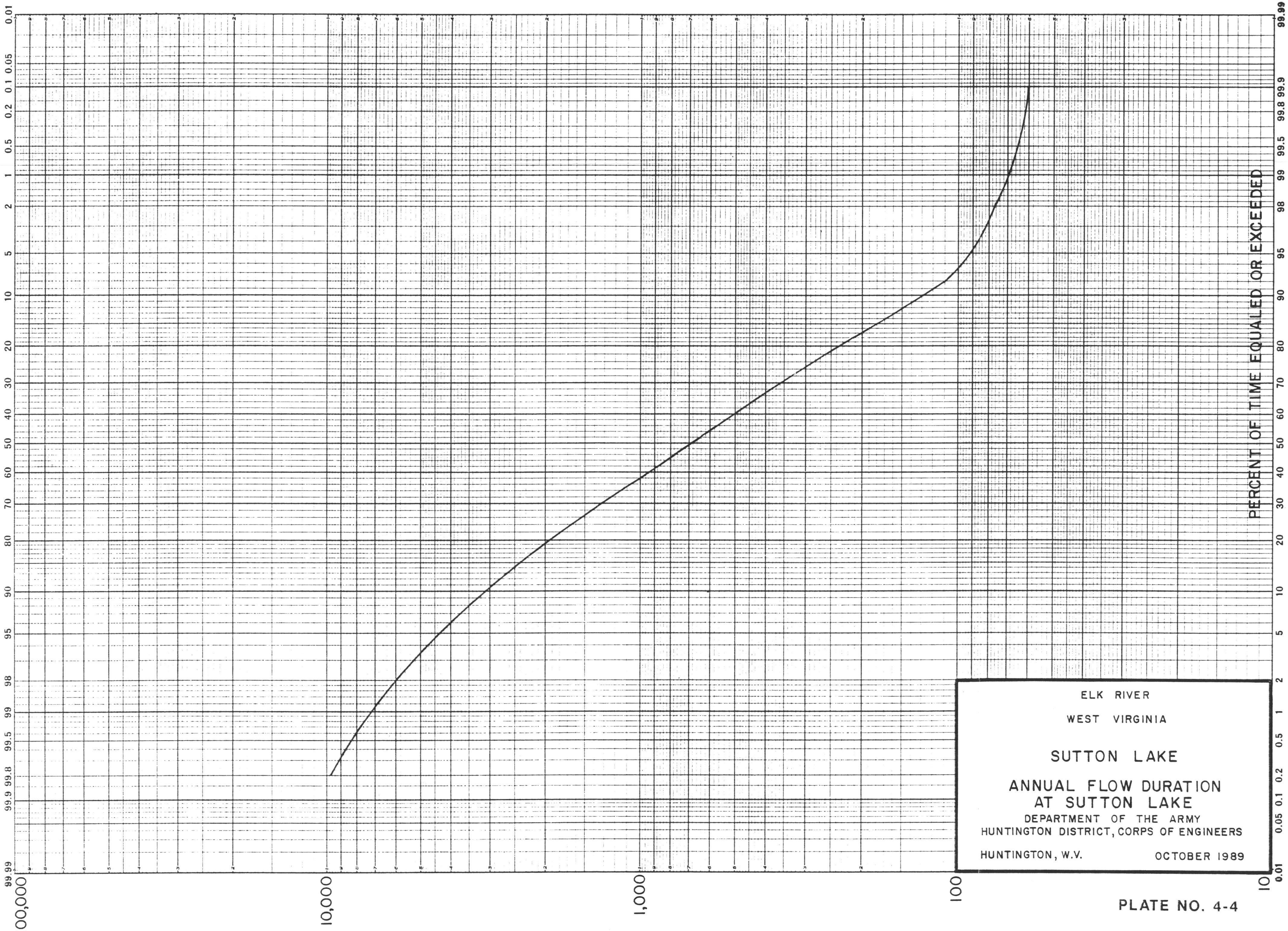
BASED ON _______ DISCHARGE MEASUREMENTS, NOS ________, AND ________, AND IS ______ WELL DEFINED BETWEEN ______ AND ______ CFS
COMP BY _____ DATE _________ CHK. BY _____ DATE _________

SAME AS RATING 25 BOLOW 2.7 FT AND ABOVE 5.5 FT

DISCHARGE IN CUBIC FEET PER SECOND (STANDARD PRECISION)

GAGE HEIGHT (FEET)	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	DIFF IN Q PER FOOT
2.0	.00*	.50*	1.0*	1.5*	2.5*	3.5*	5.0*	7.3*	11.5*	16.5*	23.0
3.0	23.0*	30.5*	39.5*	50.0*	63.0*	78.0*	95.0*	116	140*	167	174
4.0	197	230*	267	308	352	400*	456	517	583	654	533
5.0	730*	809	894	984	1080	1180*	1280	1380	1480	1590	980
6.0	1710*	1830	1960	2100	2240	2380*	2520	2660	2810	2960*	1410
7.0	3120	3280*	3450	3630	3810	4000*	4190	4380	4580	4790	1880
8.0	5000*	5220	5450	5680	5910	6160	6400	6660	6920	7180	2450
9.0	7450	7730	8020	8300	8600	8900*	9160	9430	9700	9980	2850
10.0	10300	10500	10800	11100	11400	11700	12000	12300	12600	13000	3000
11.0	13300	13600	13900	14300	14600	14900	15300	15600	16000	16300	3400
12.0	16700*	17000	17400	17700	18000	18400	18700	19100	19400	19800	3500
13.0	20200	20500	20900	21300	21600	22000	22400	22800	23100	23500	3700
14.0	23900	24300	24700	25100	25500	25900	26300	26700	27100	27600	4100
15.0	28000	28400	28800	29300	29700	30100	30600	31000	31500	31900	4300
16.0	32300	32800	33300	33700	34200	34600	35100	35600	36000	36500	4700
17.0	37000*	37500	38000	38500	39000	39500	40000	40500	41000	41500	5000*
18.0	42000*										

added



ELK RIVER

WEST VIRGINIA

SUTTON LAKE

ANNUAL FLOW DURATION
AT SUTTON LAKE

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. OCTOBER 1989

PLATE NO. 4-4

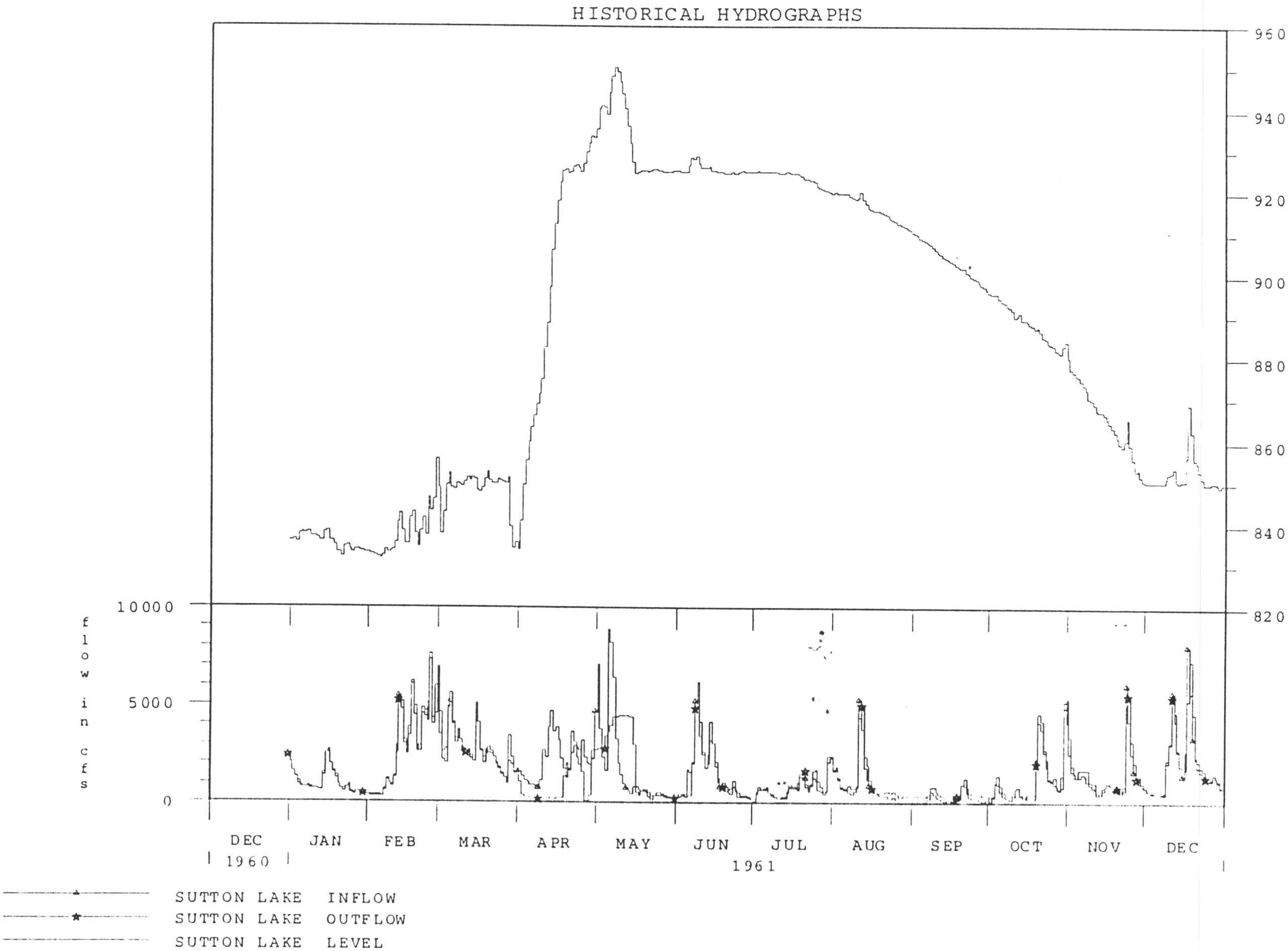
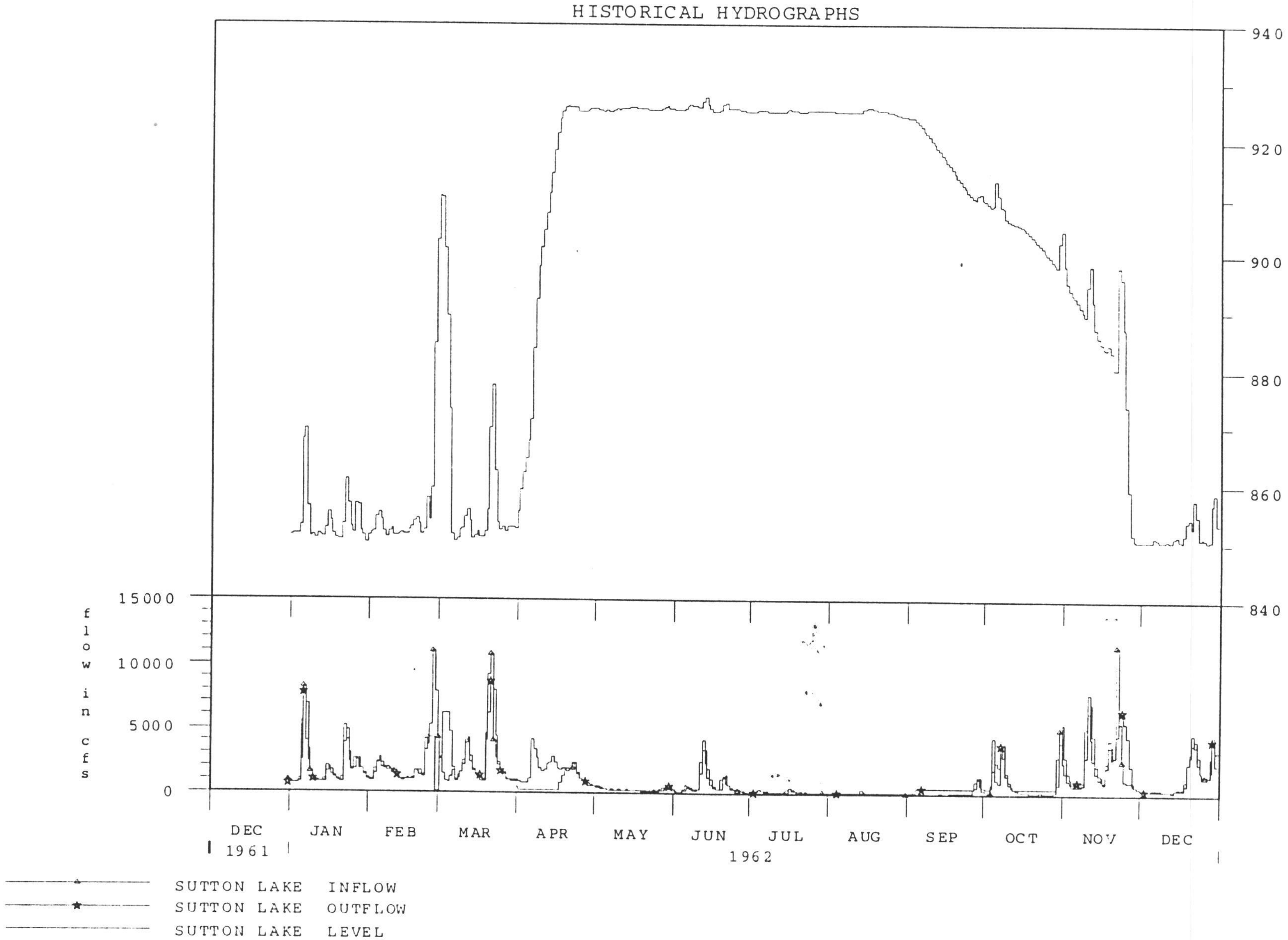


Plate No. 4-5
Sheet 1 of 35


HISTORICAL HYDROGRAPHS
940
920
900
880
860
840
level in feet - msl
15000
10000
5000
0
flow in cfs
DEC
1961
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1962
SUTTON LAKE INFLOW
SUTTON LAKE OUTFLOW
SUTTON LAKE LEVEL

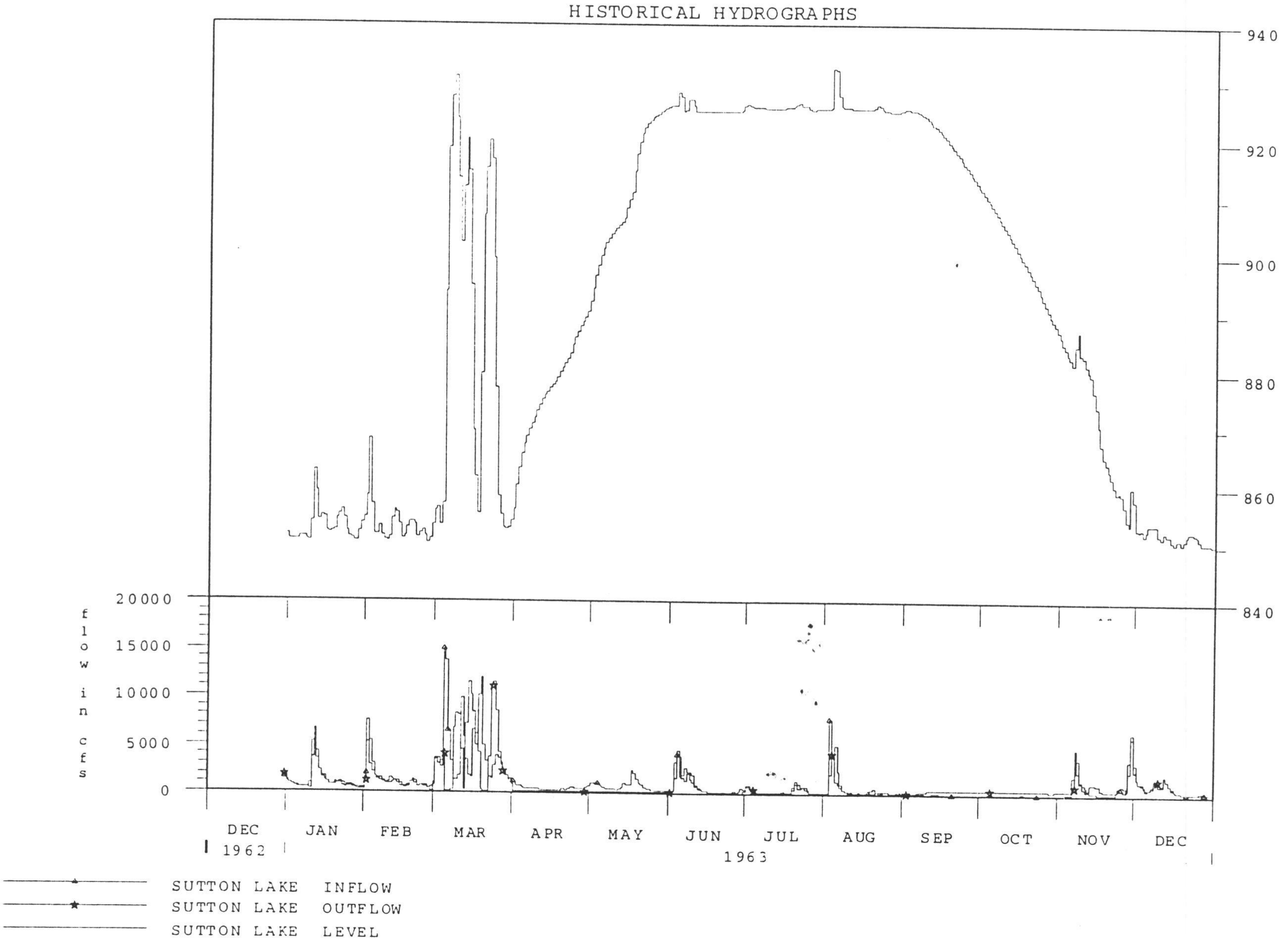
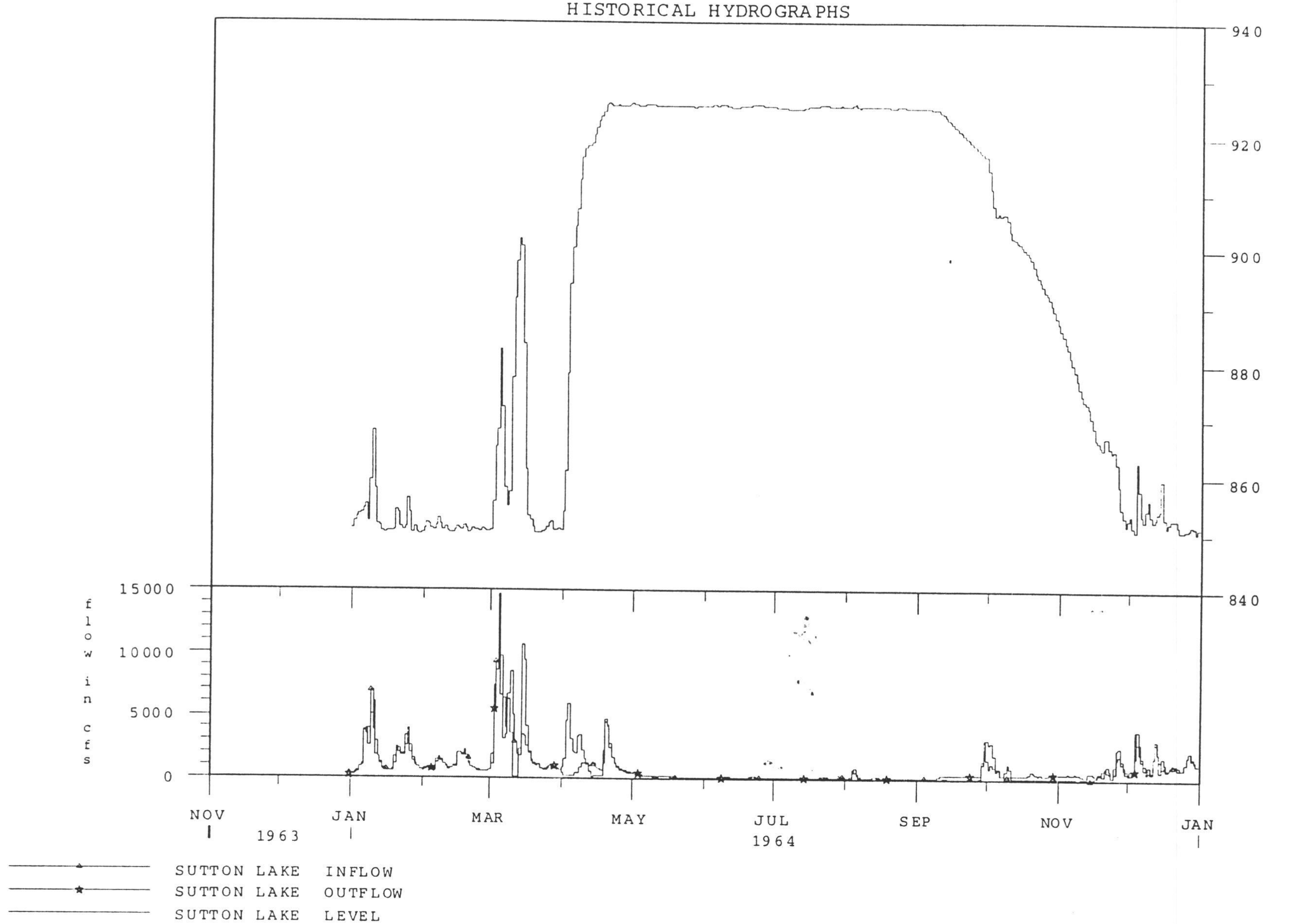
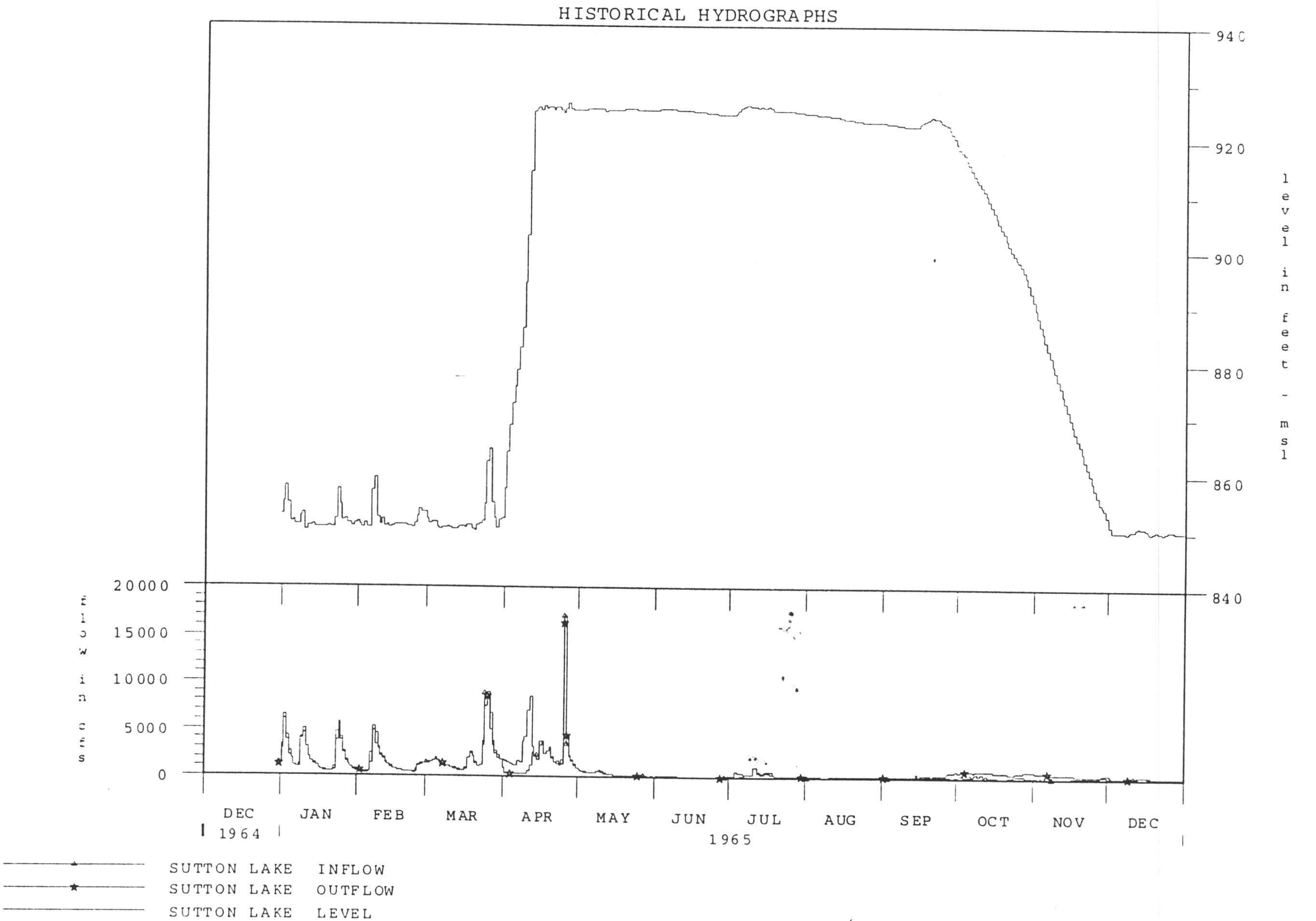


Plate No. 4-5
Sheet 3 of 35

HISTORICAL HYDROGRAPHS




HISTORICAL HYDROGRAPHS
940
920
900
880
860
840
level in feet - msl
20000
15000
10000
5000
0
flow in cfs
DEC
1964
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1965
SUTTON LAKE INFLOW
SUTTON LAKE OUTFLOW
SUTTON LAKE LEVEL

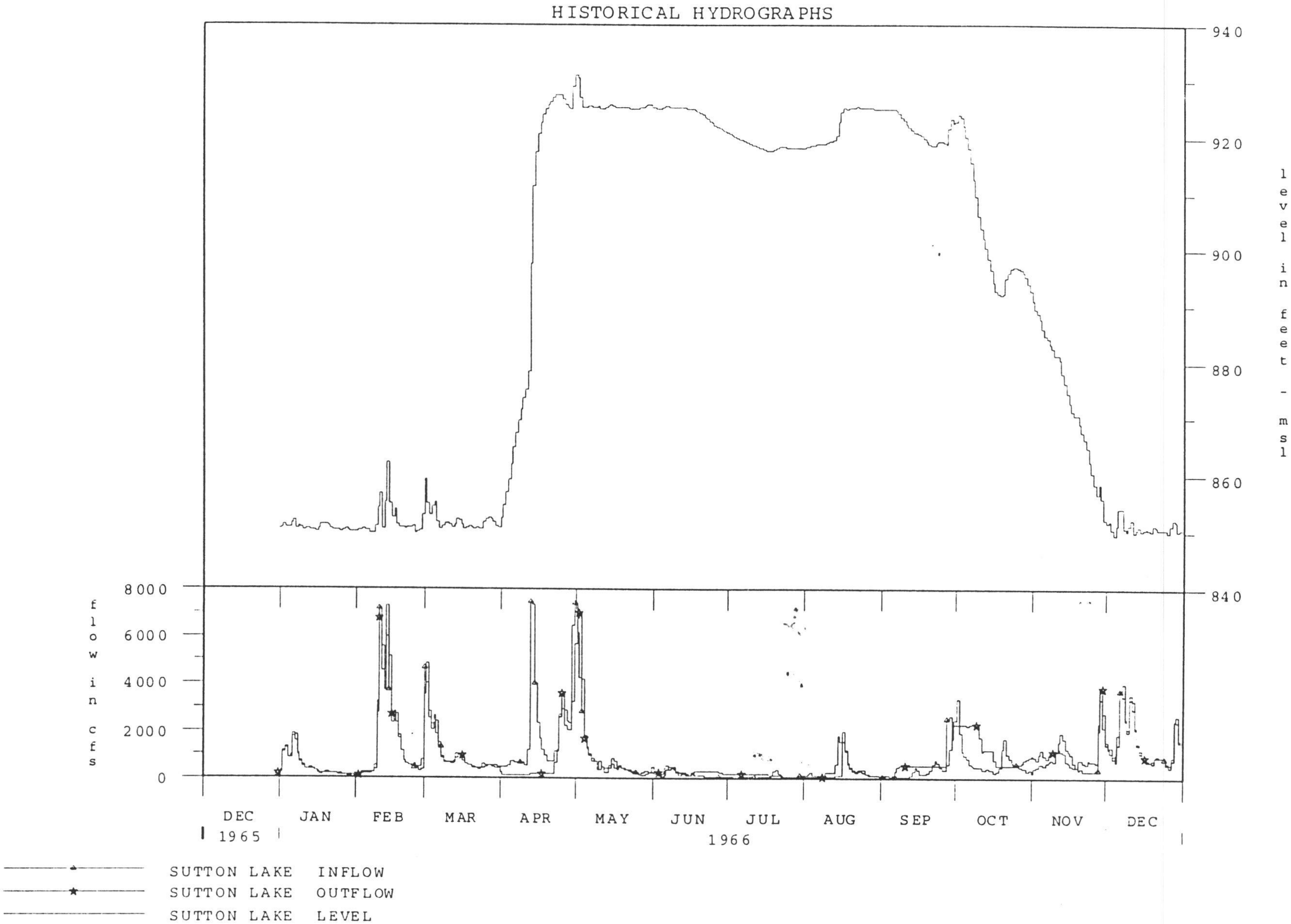
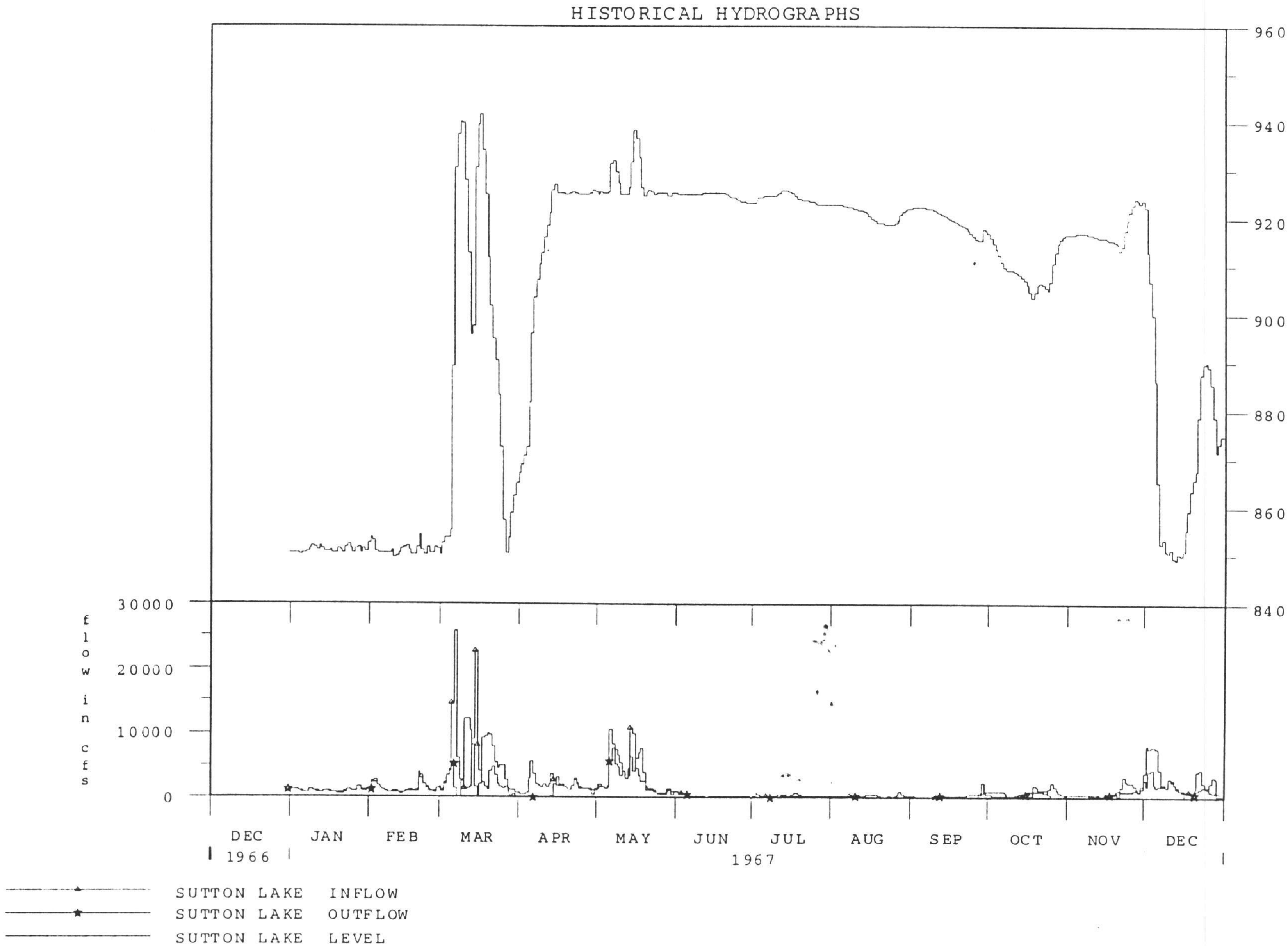


Plate No. 4-5
Sheet 6 of 35



HISTORICAL HYDROGRAPHS
960
940
920
900
880
860
840
level in feet - msl
30000
20000
10000
0
flow in cfs
DEC
1966
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1967
SUTTON LAKE INFLOW
SUTTON LAKE OUTFLOW
SUTTON LAKE LEVEL

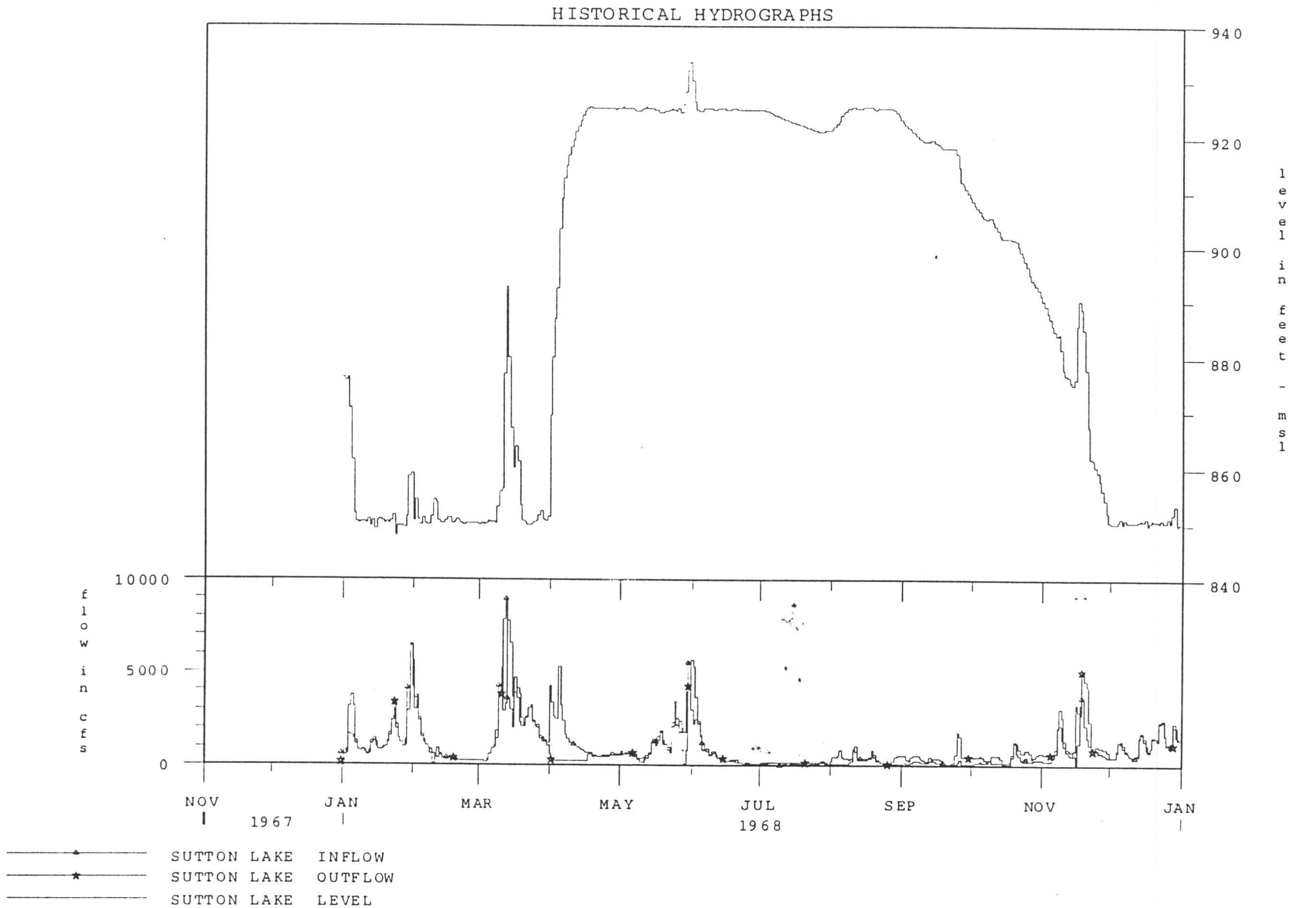


Plate No. 4-5
Sheet 8 of 35

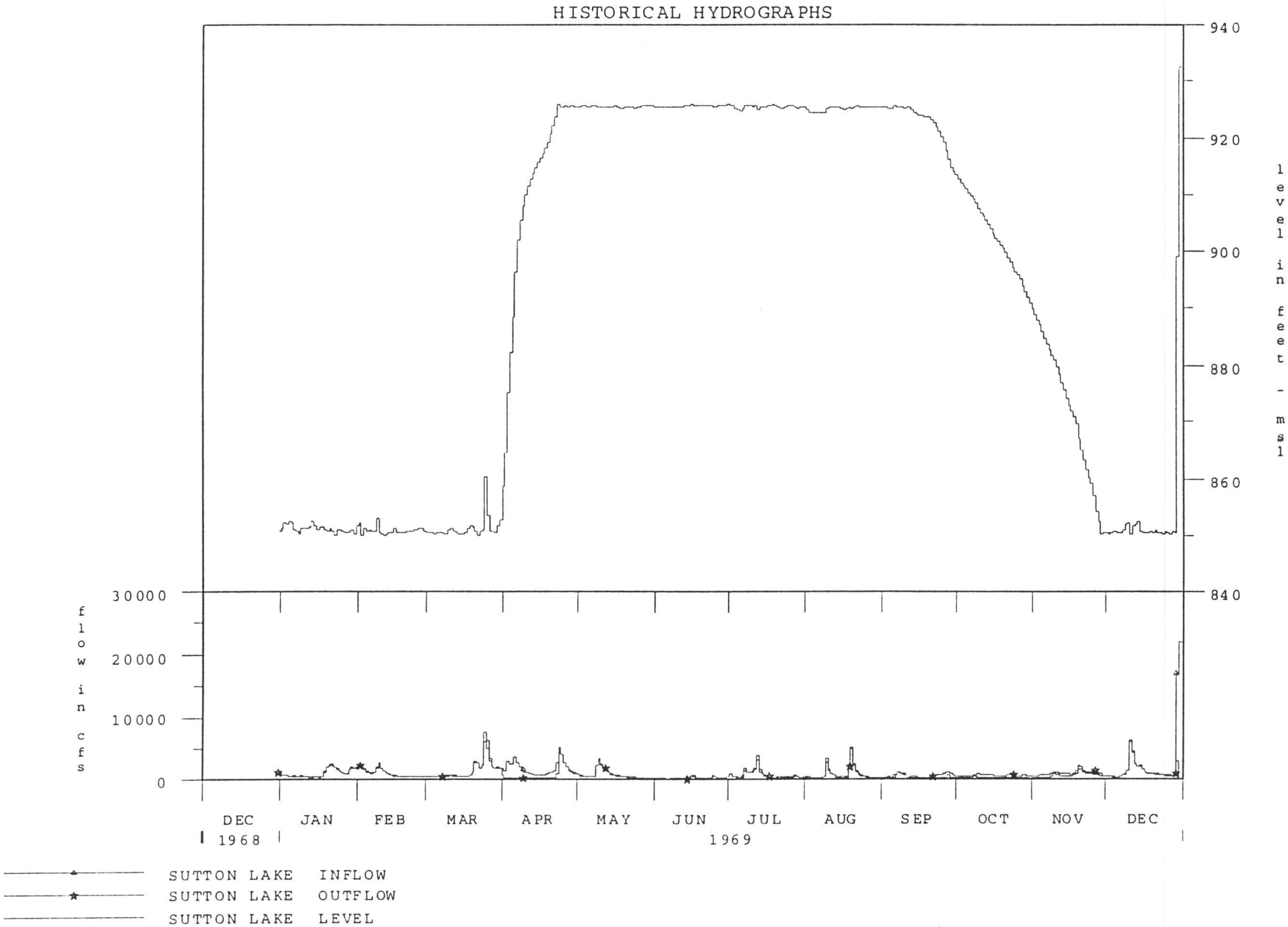


Plate No. 4-5
Sheet 9 of 35

HISTORICAL HYDROGRAPHS

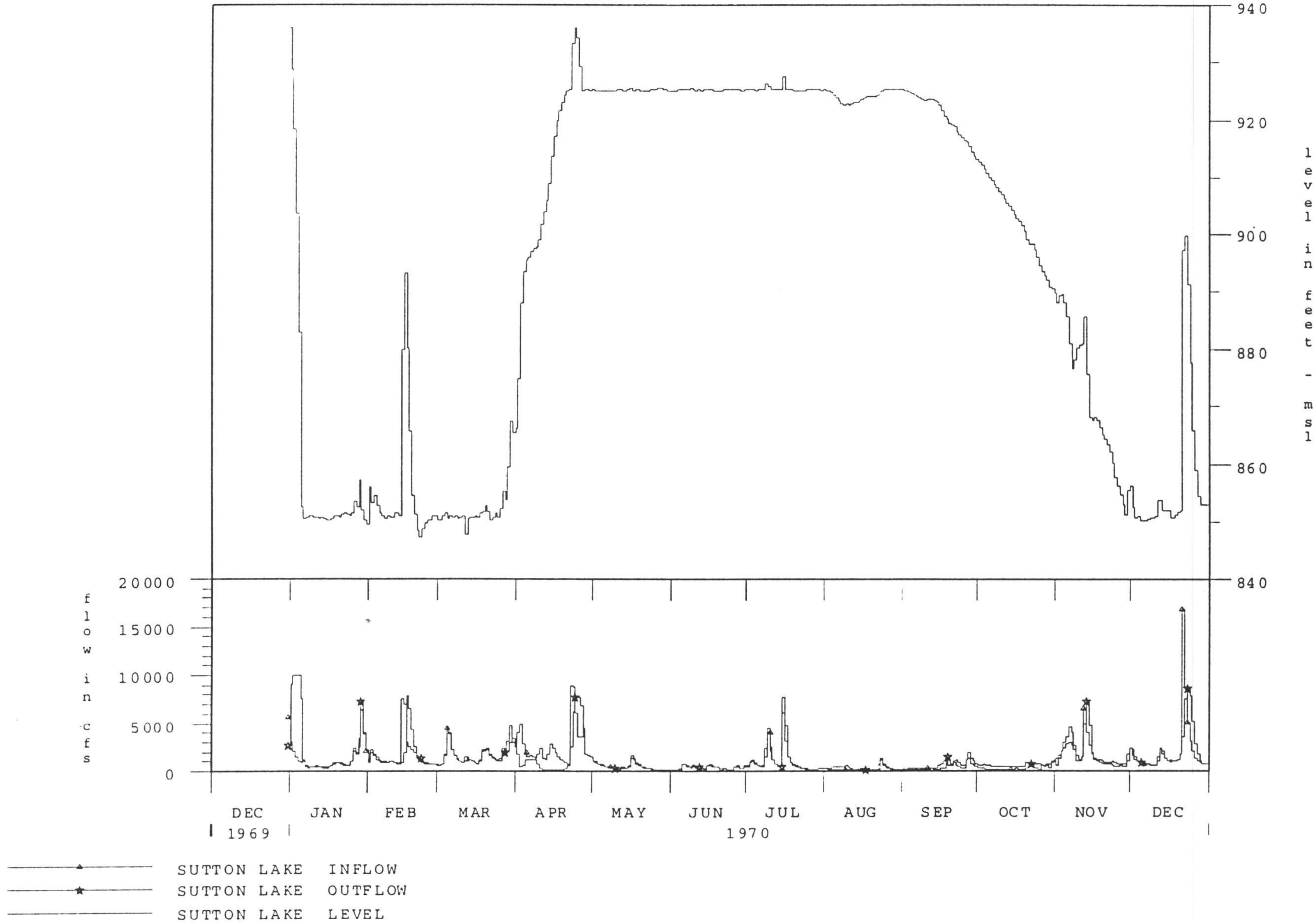
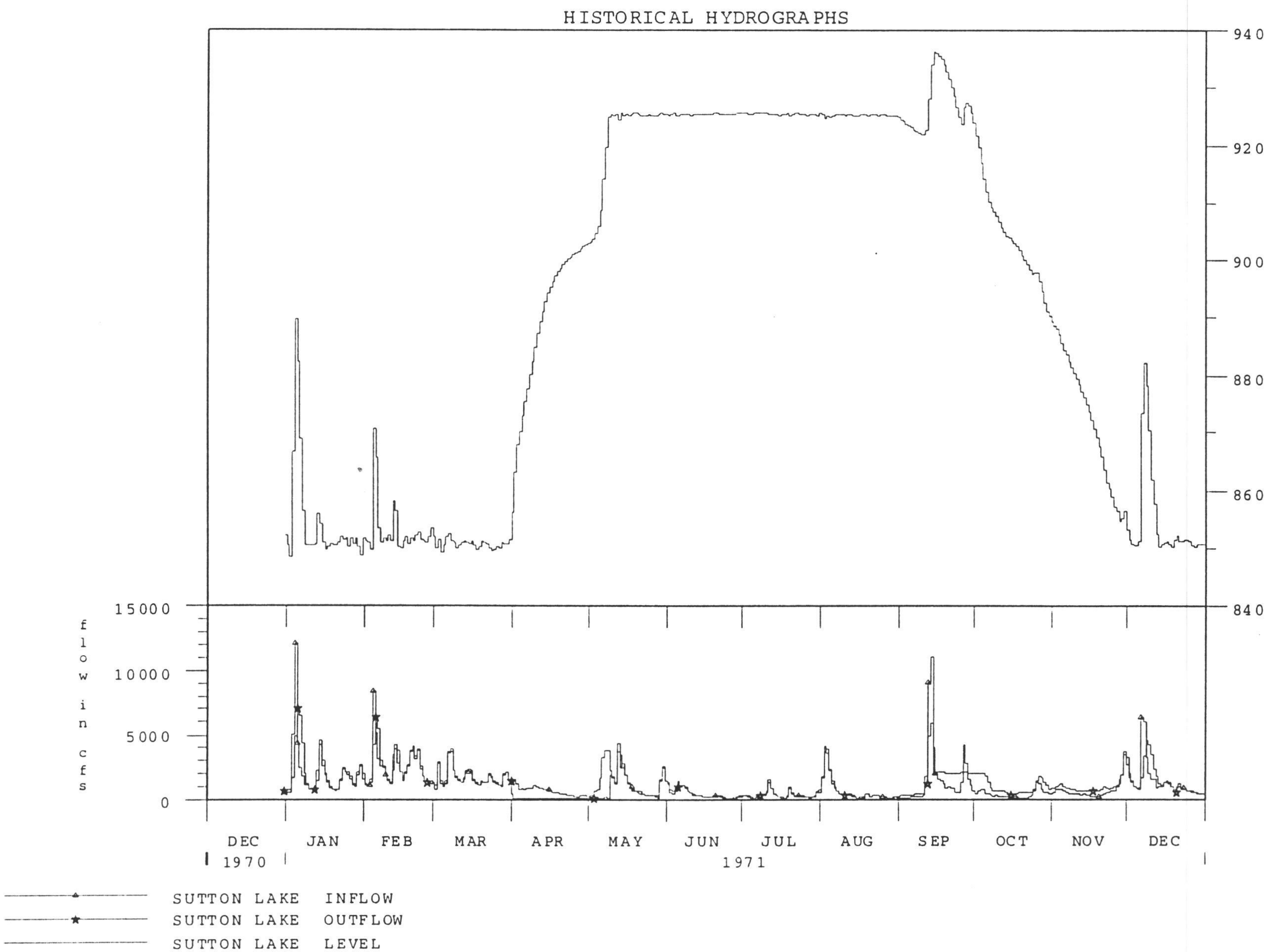


Plate No. 4-5
Sheet 10 of 35


HISTORICAL HYDROGRAPHS
940
920
900
880
860
840
level in feet - msl
15000
10000
5000
0
flow in cfs
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1970
1971
SUTTON LAKE INFLOW
SUTTON LAKE OUTFLOW
SUTTON LAKE LEVEL

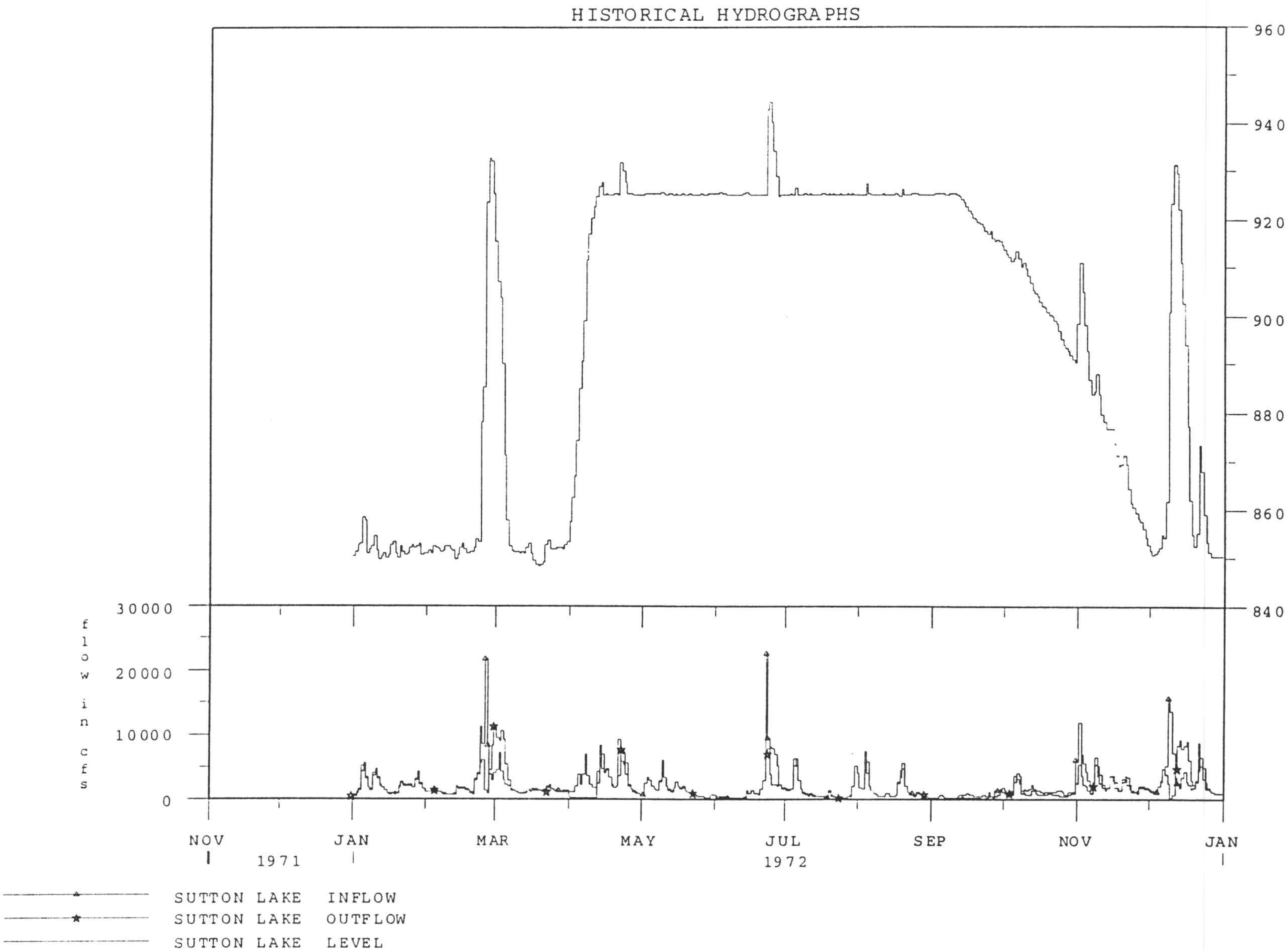


Plate No. 4-5
Sheet 12 of 35

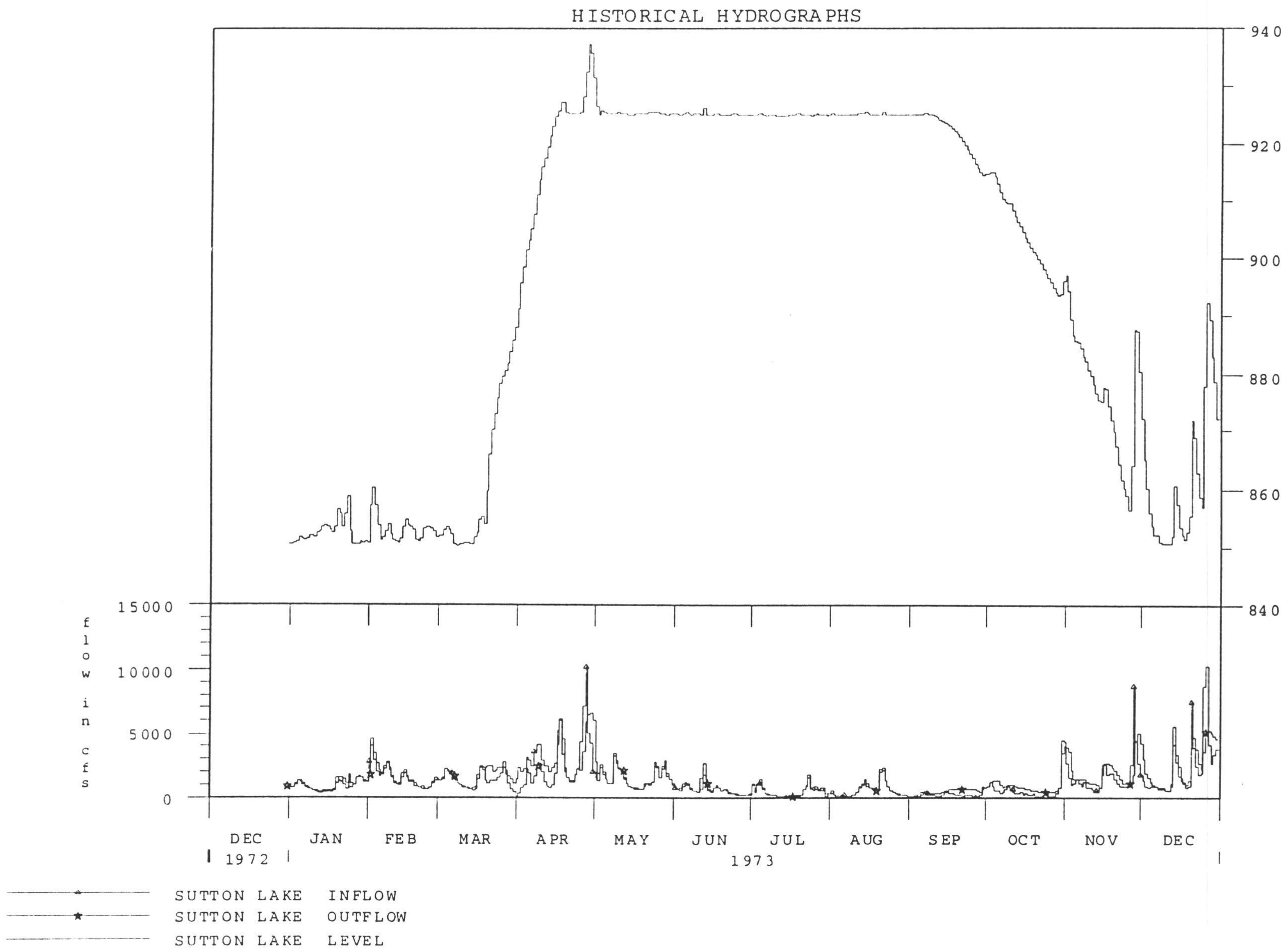
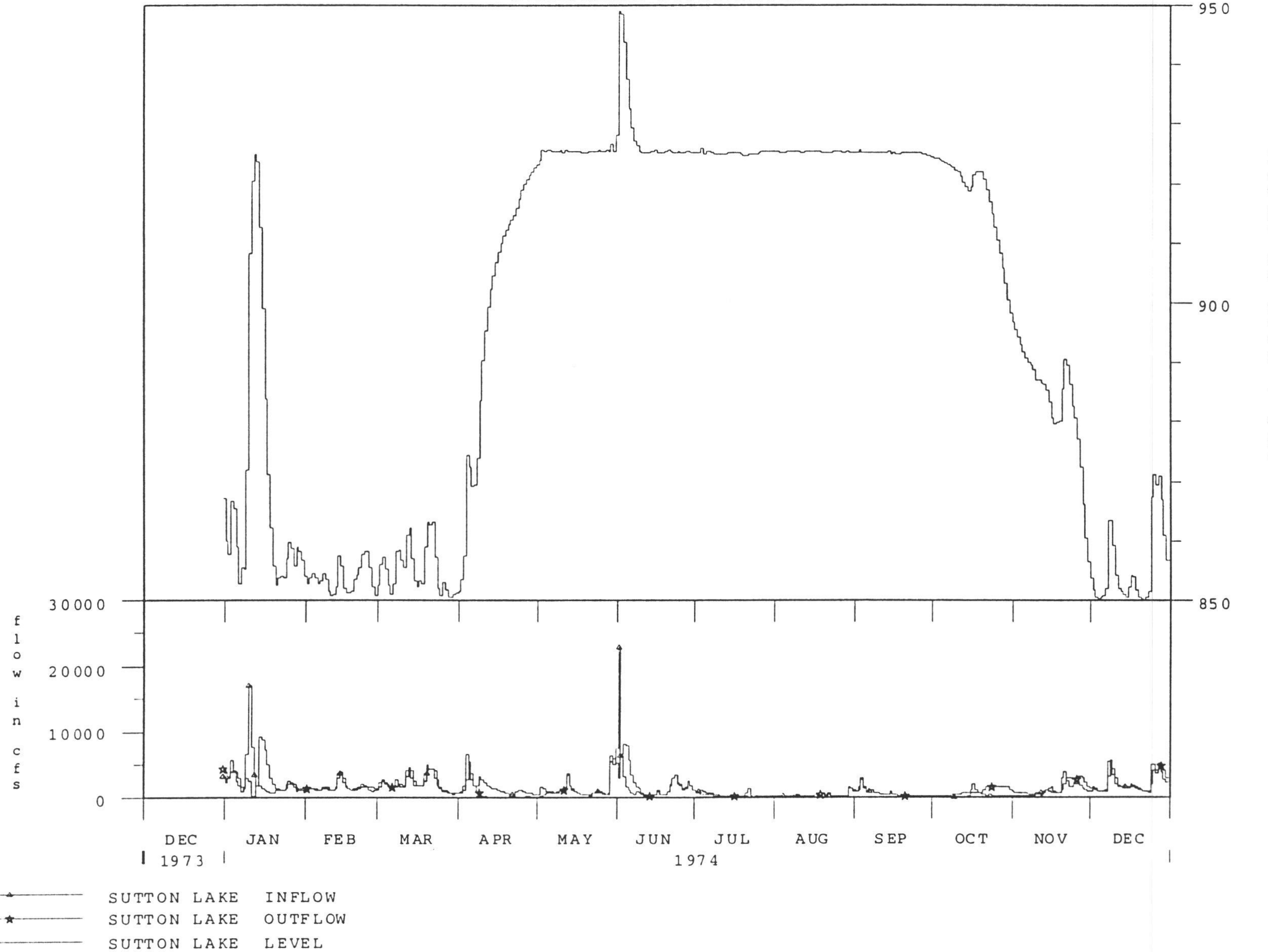


Plate No. 4-5
Sheet 13 of 35

HISTORICAL HYDROGRAPHS



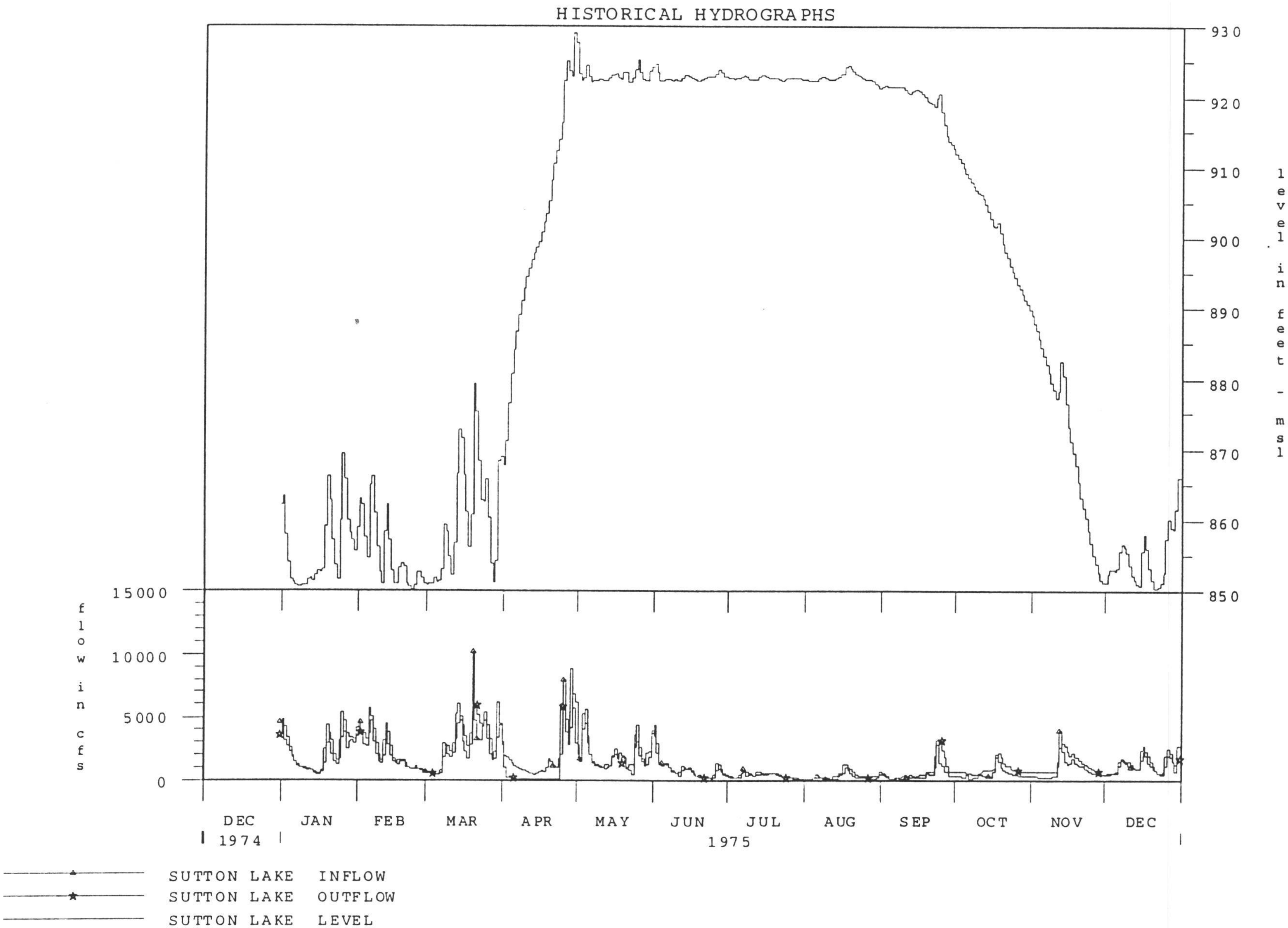
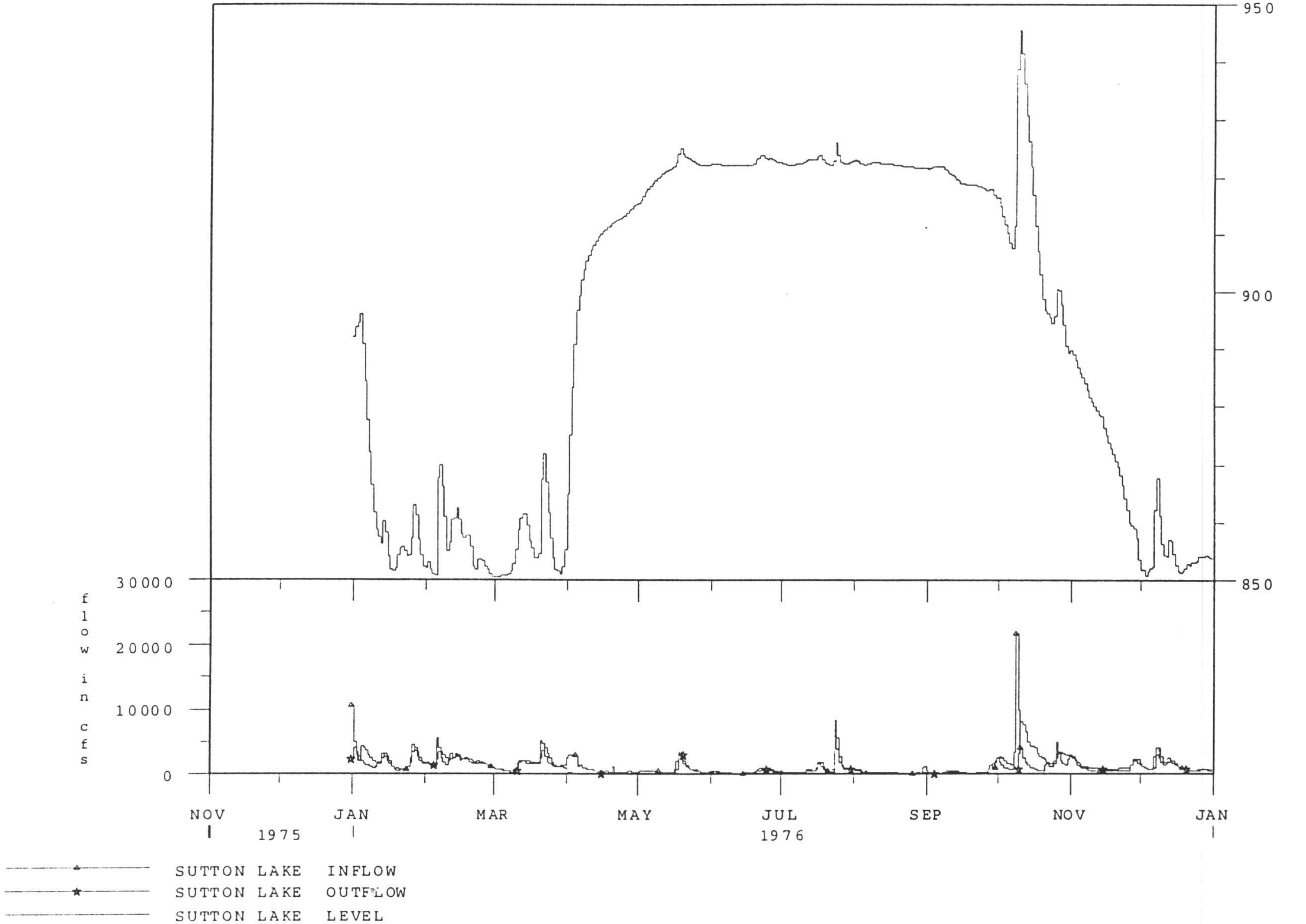
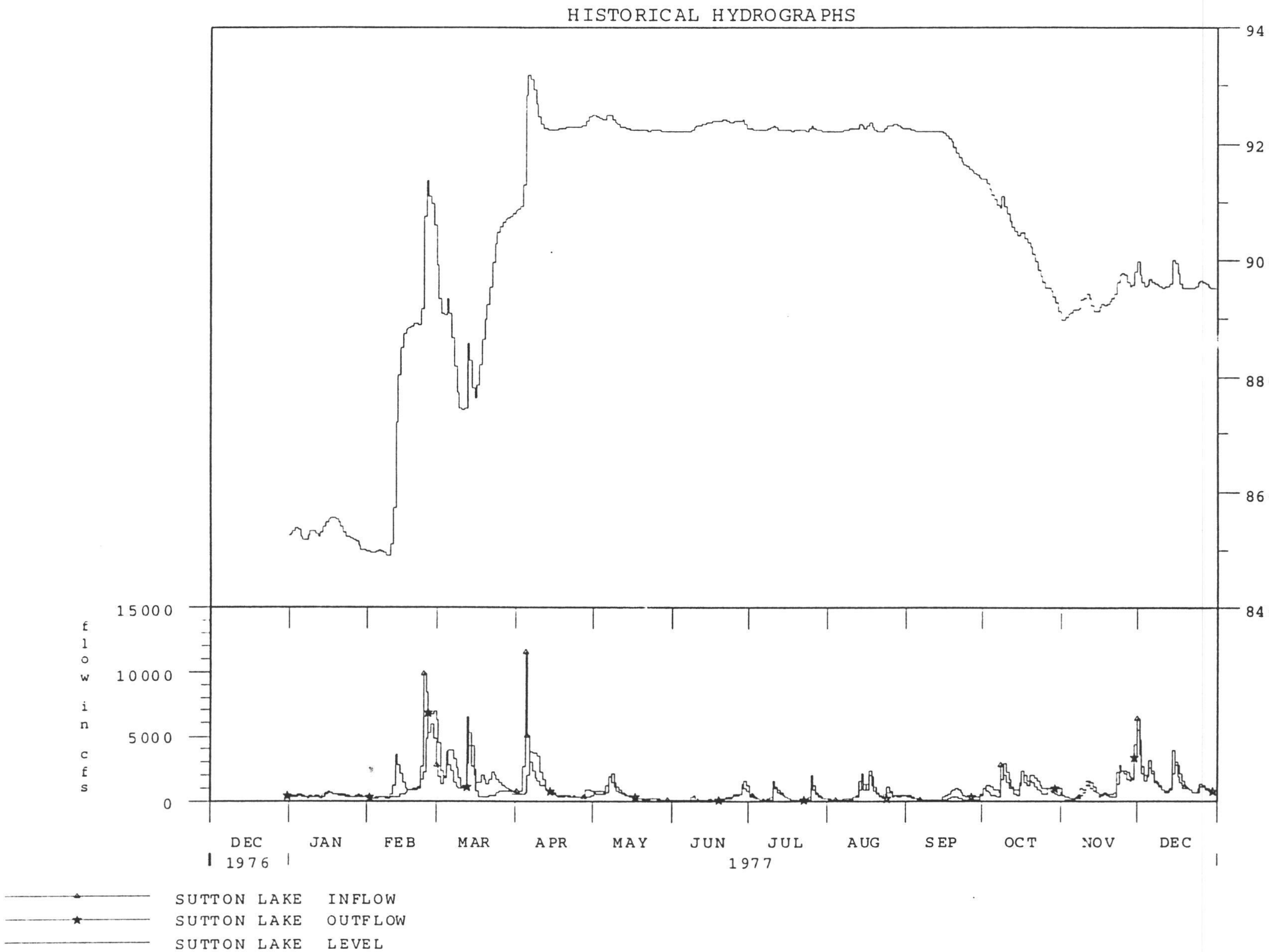


Plate No. 4-5
Sheet 15 of 35

HISTORICAL HYDROGRAPHS




HISTORICAL HYDROGRAPHS
940
920
900
880
860
840
level in feet - msl
15000
10000
5000
0
flow in cfs
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1976
1977
SUTTON LAKE INFLOW
SUTTON LAKE OUTFLOW
SUTTON LAKE LEVEL

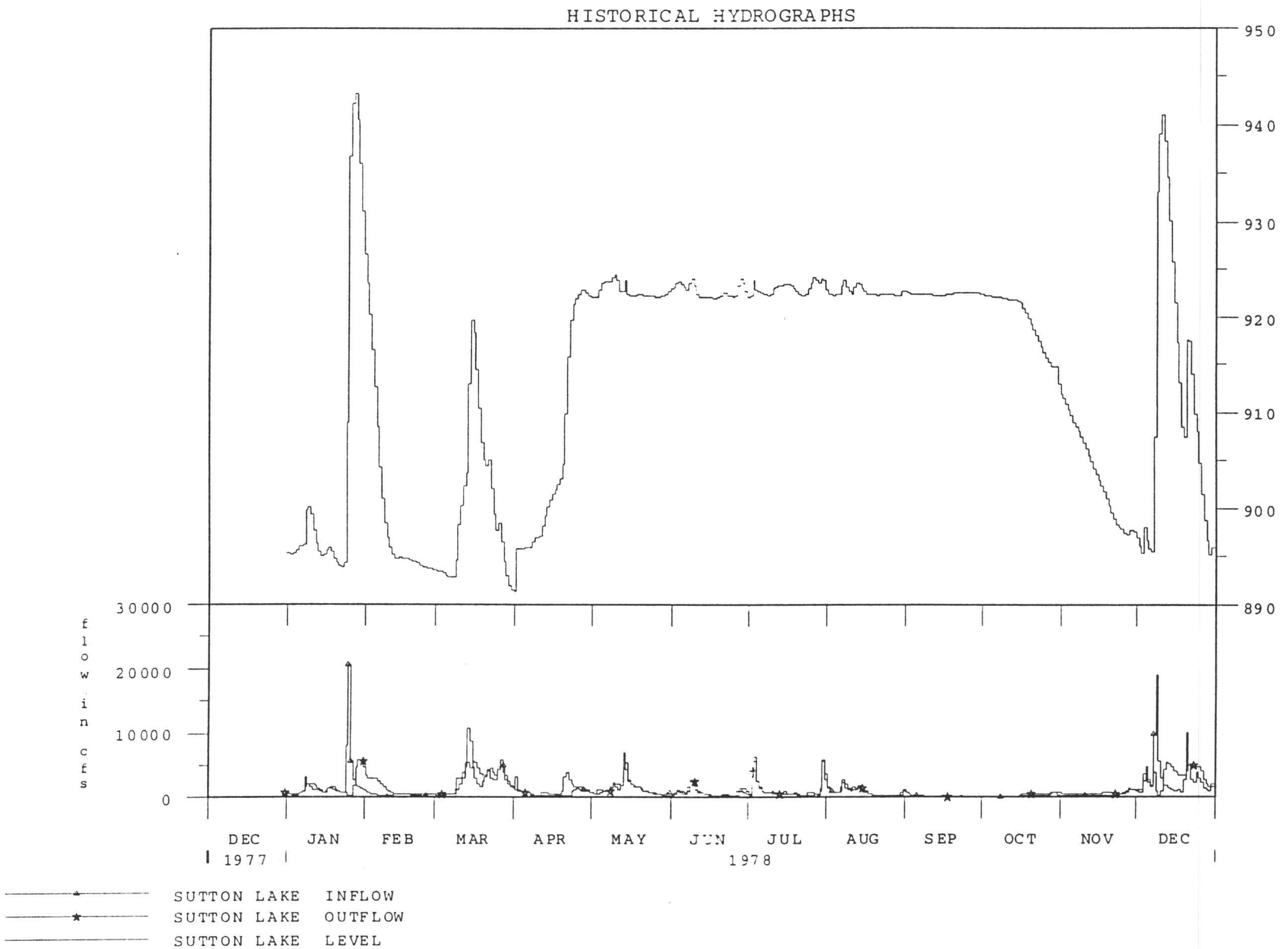
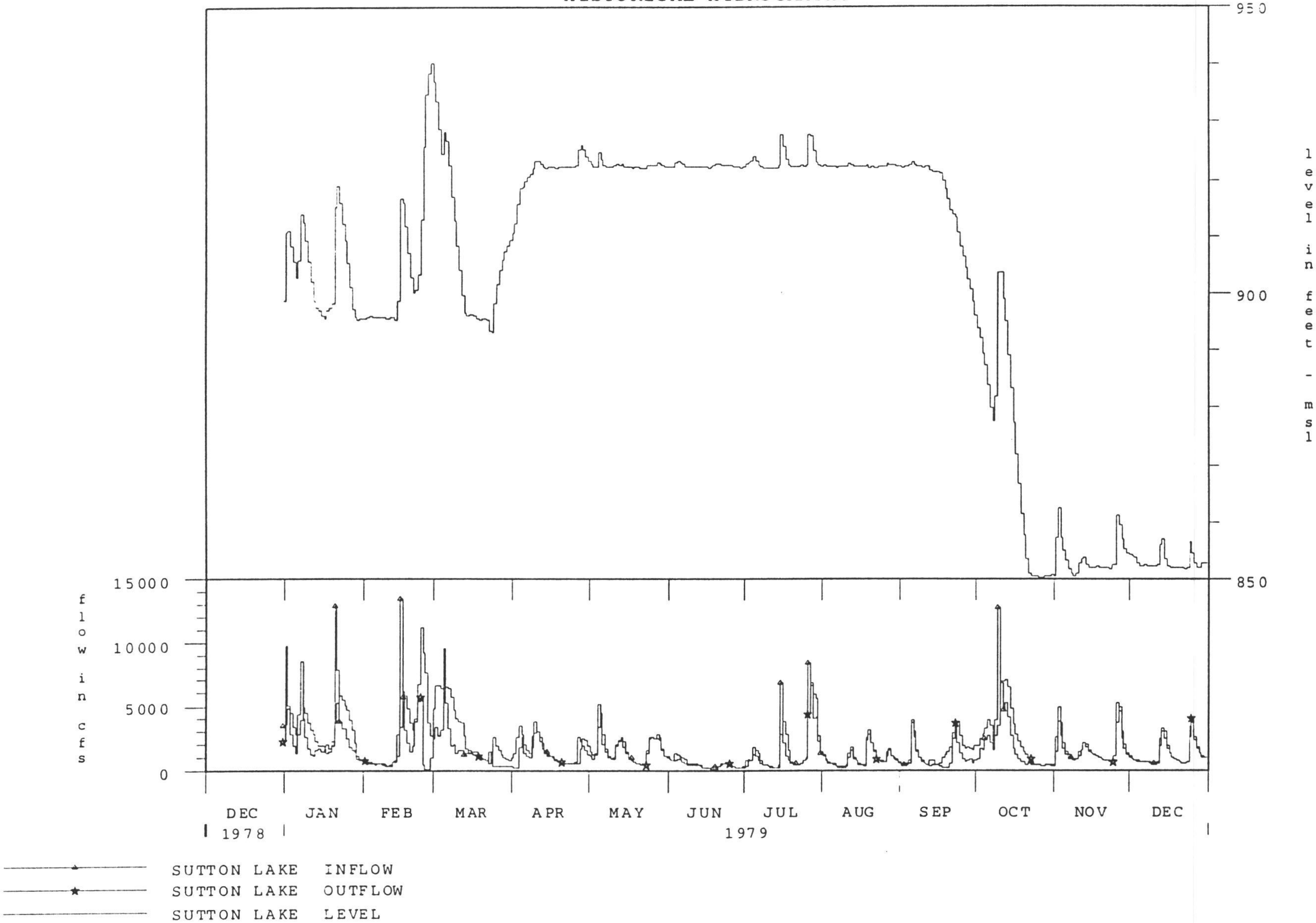


Plate No. 4-5
Sheet 18 of 35

HISTORICAL HYDROGRAPHS



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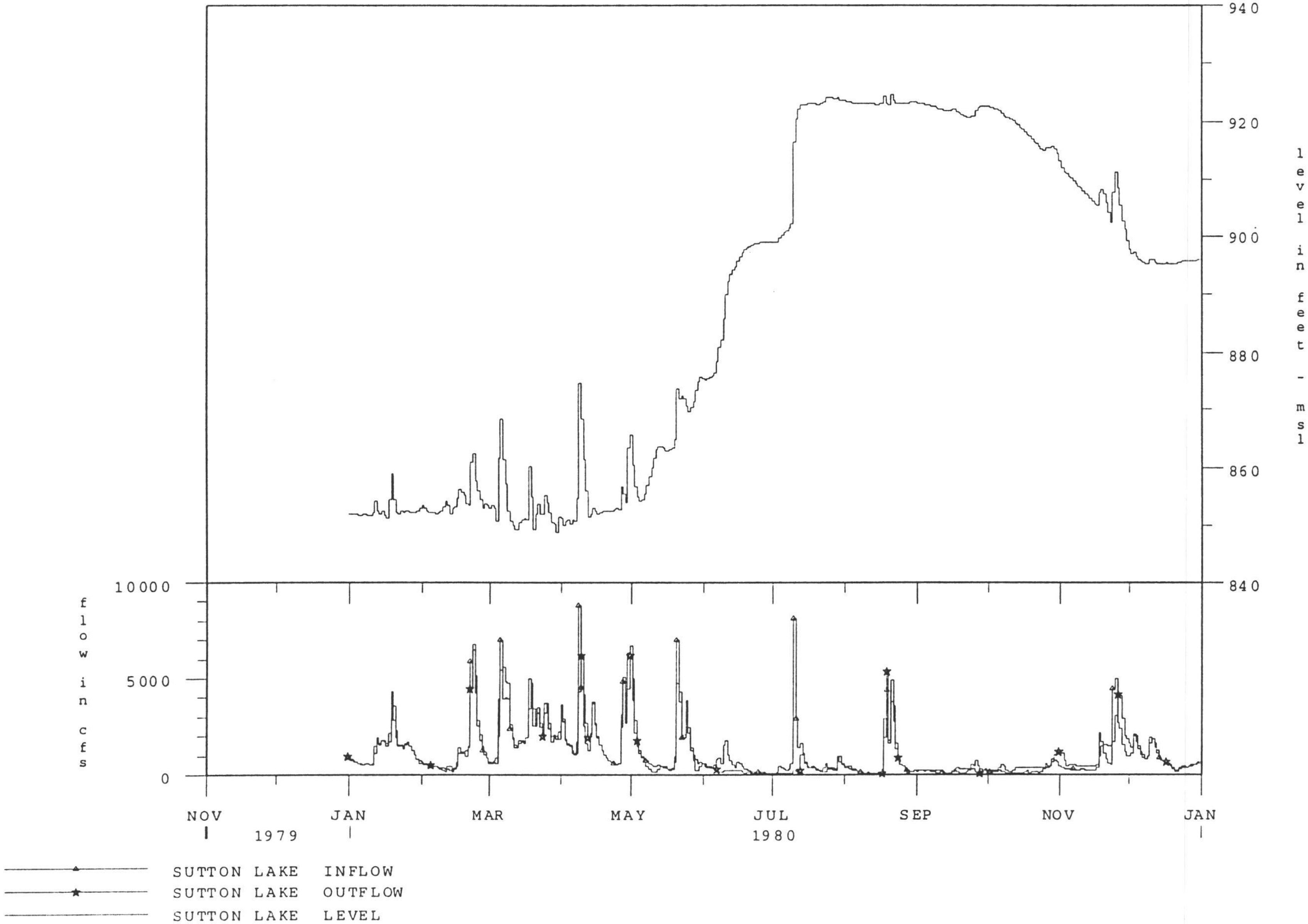


Plate No. 4-5
Sheet 20 of 35

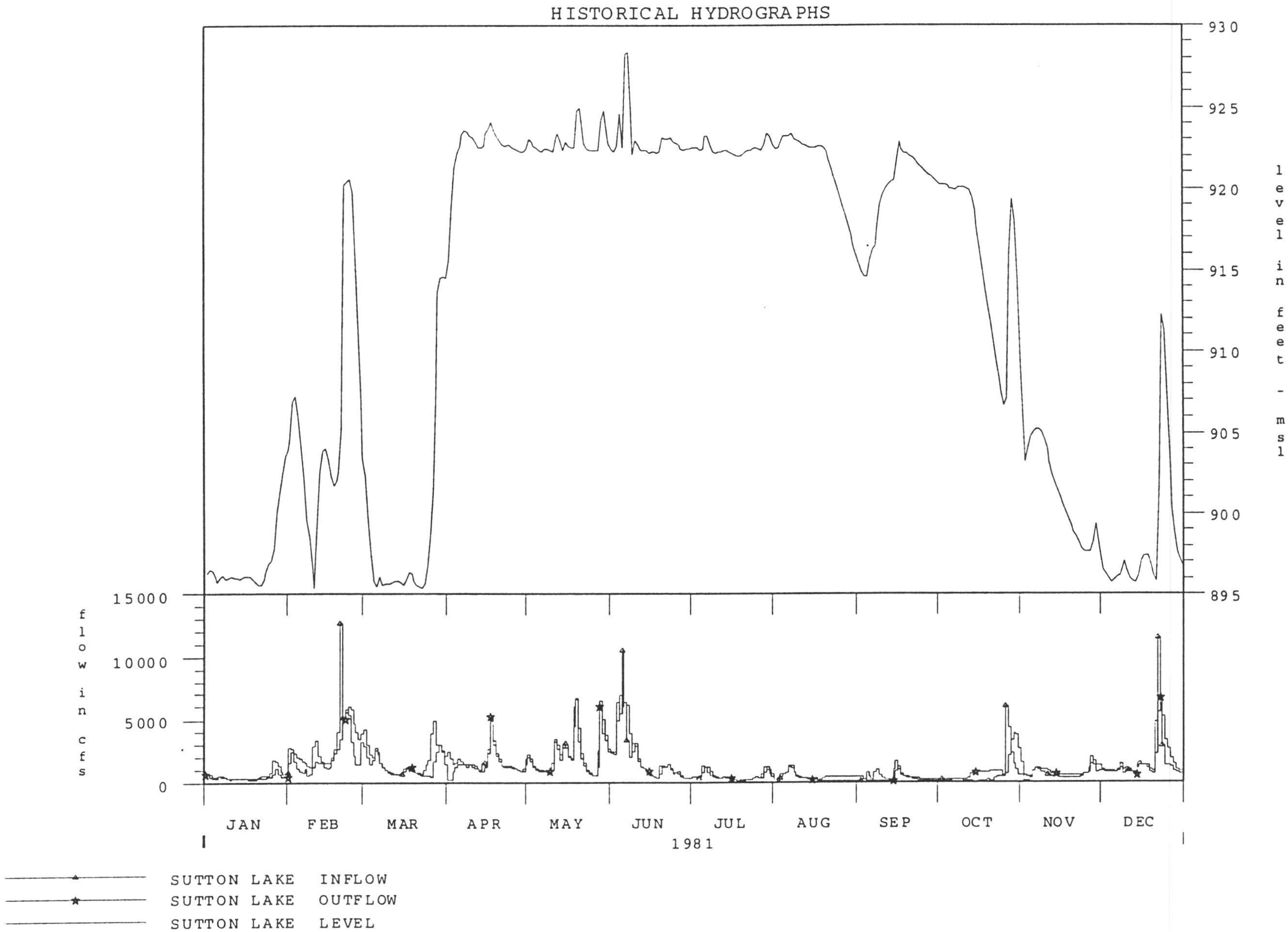
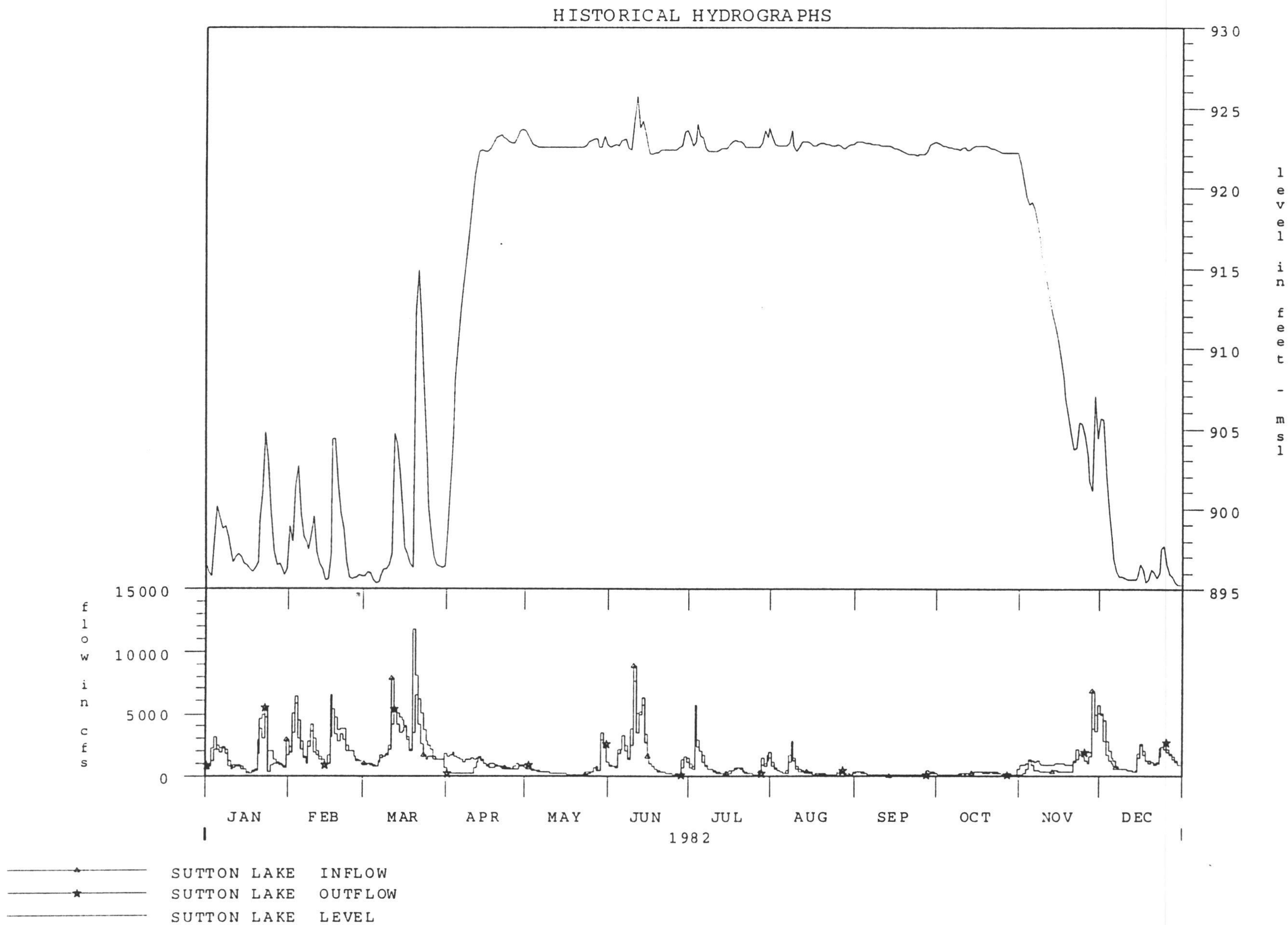


Plate No. 4-5
Sheet 21 of 35


HISTORICAL HYDROGRAPHS
930
925
920
915
910
905
900
895
level in feet - msl
15000
10000
5000
0
flow in cfs
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1982
SUTTON LAKE INFLOW
SUTTON LAKE OUTFLOW
SUTTON LAKE LEVEL

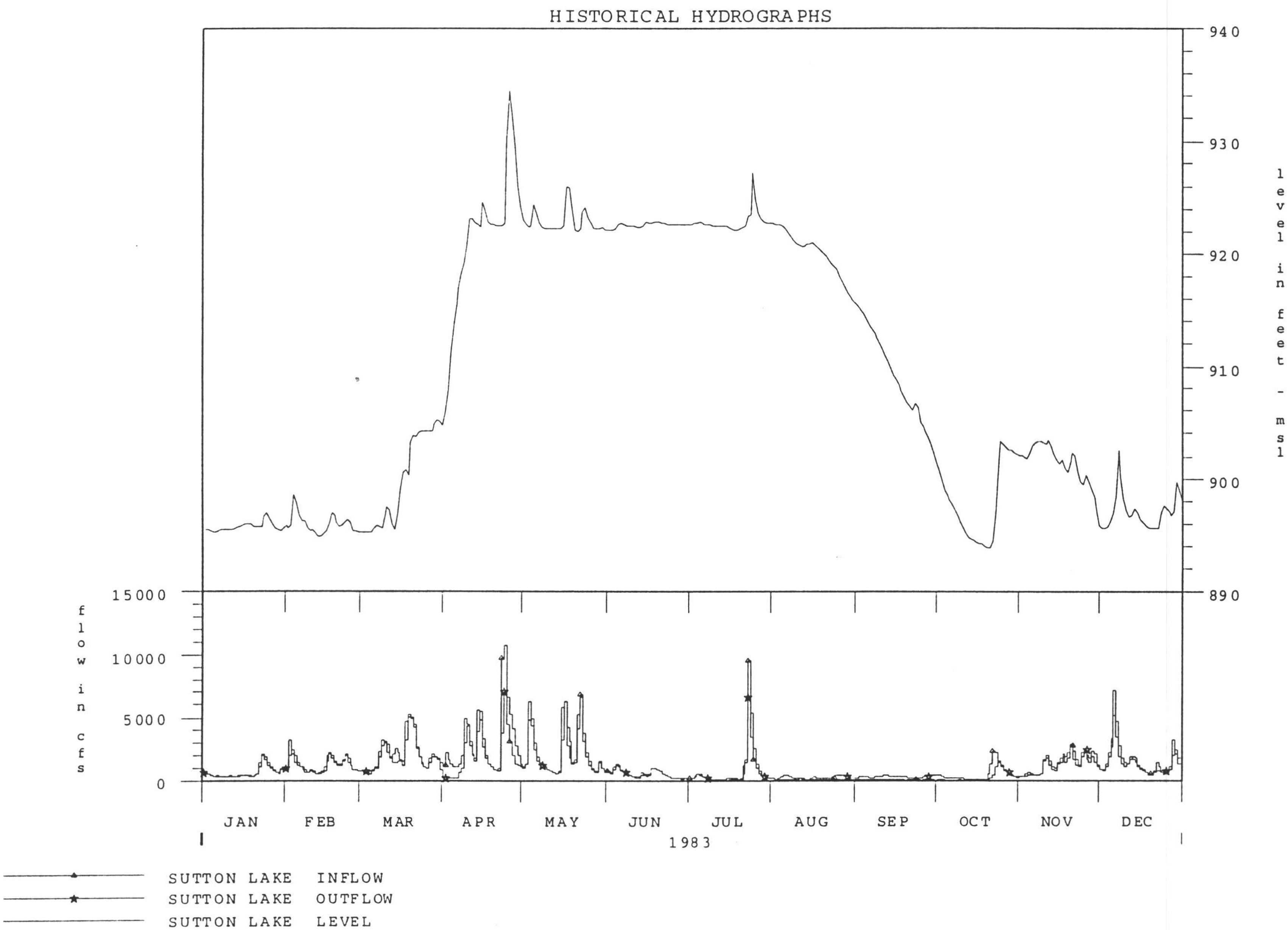


Plate No. 4-5
Sheet 23 of 35

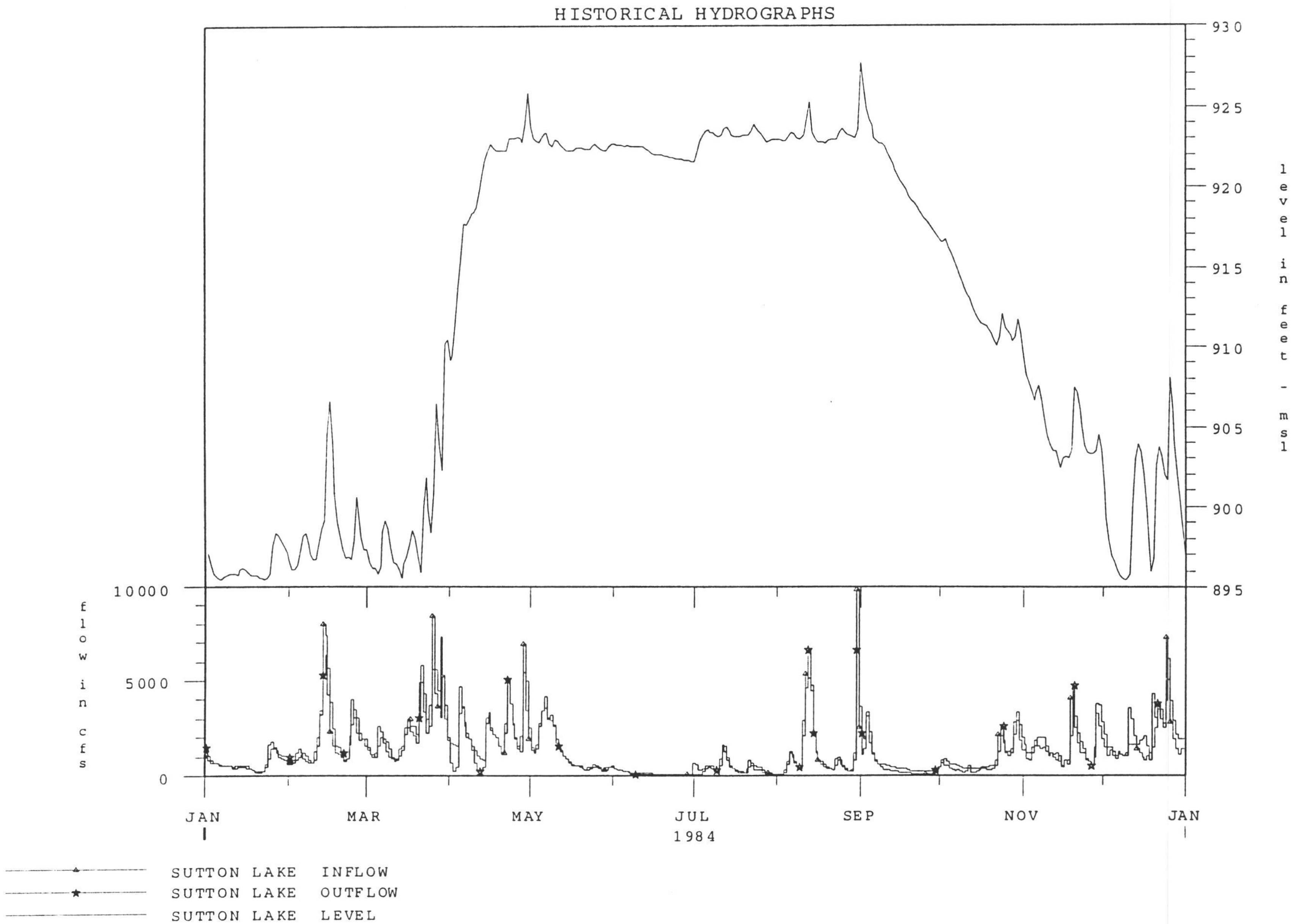


Plate No. 4-5
Sheet 24 of 35

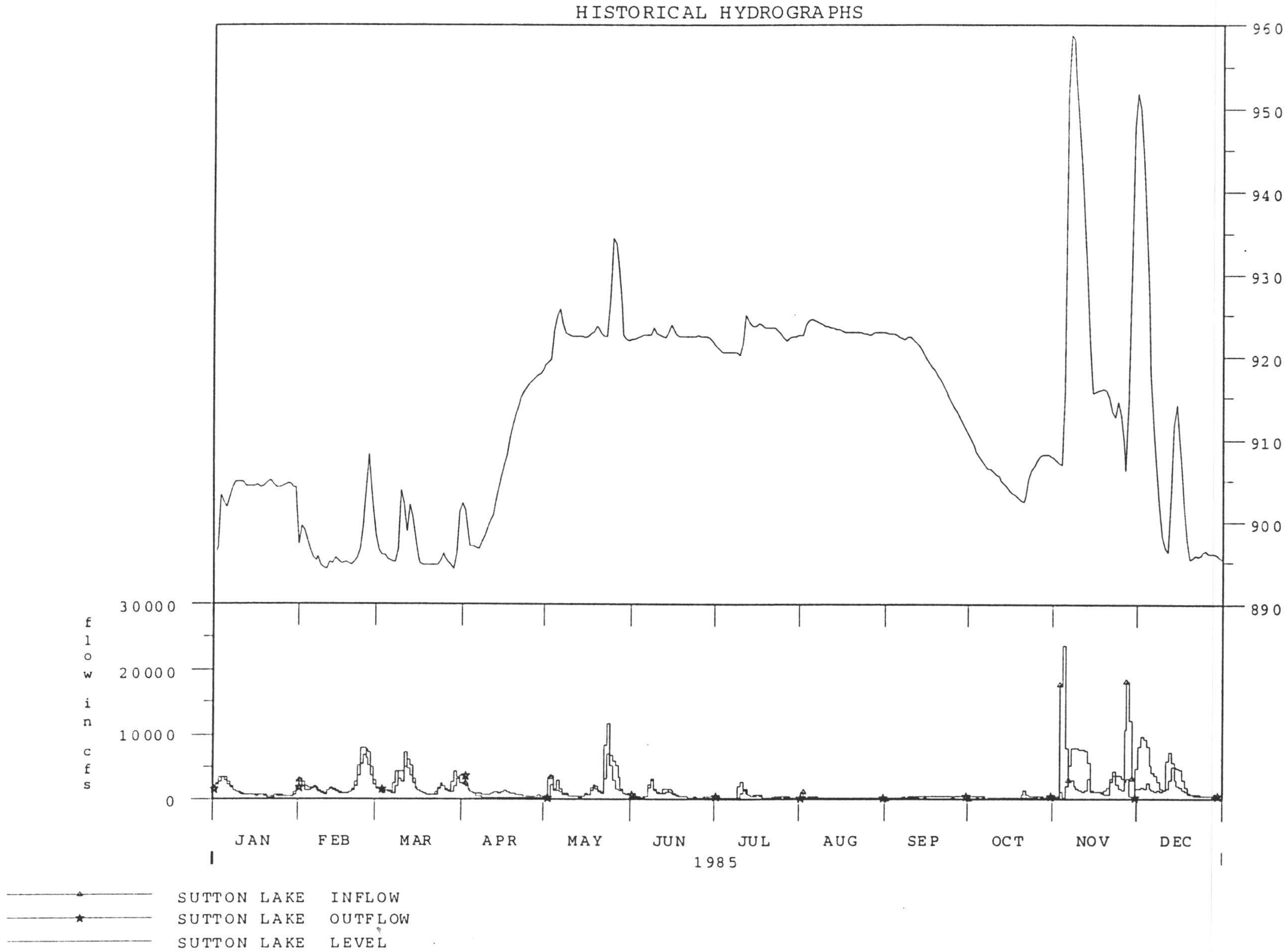
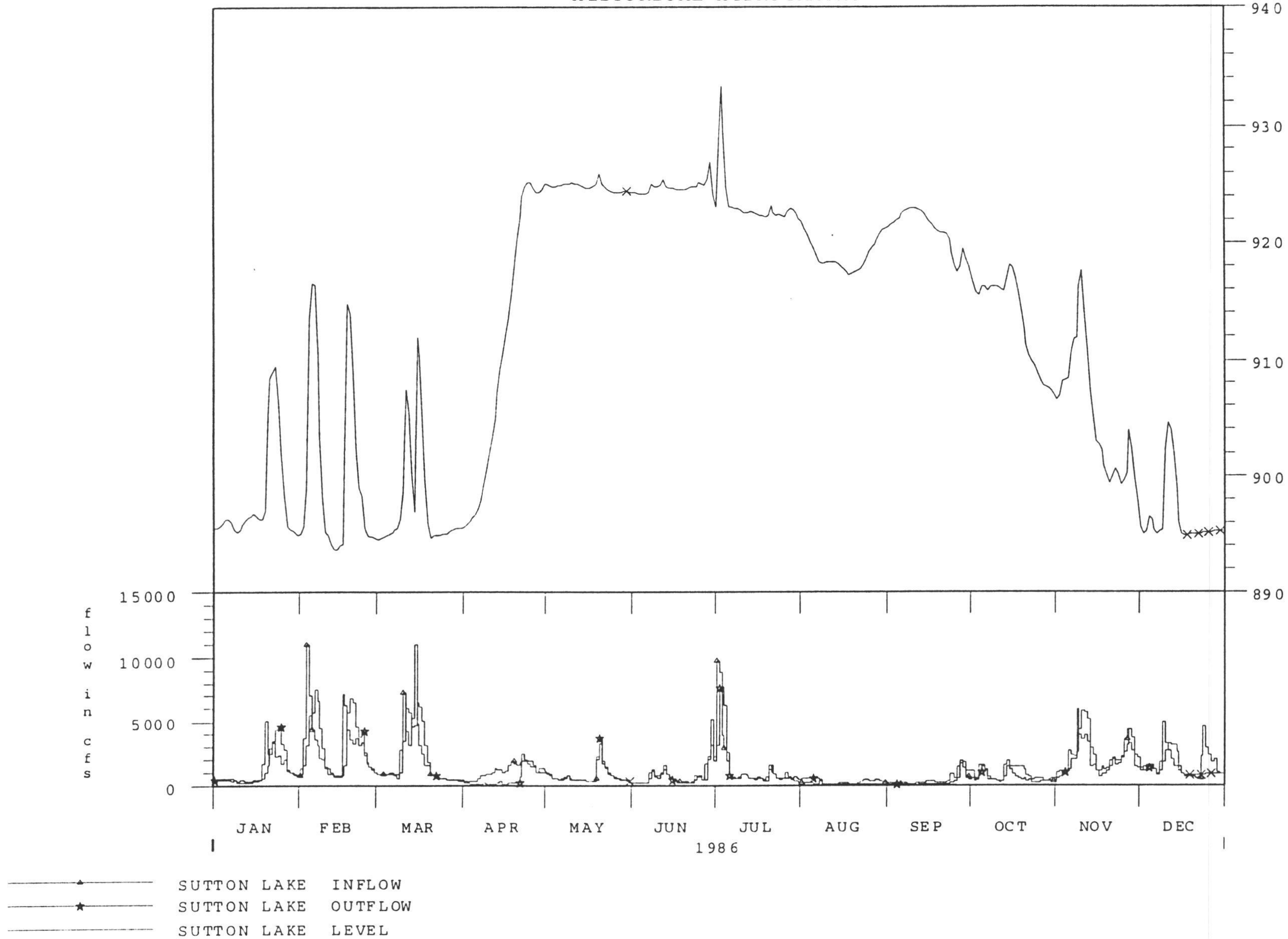


Plate No. 4-5
Sheet 25 of 35

HISTORICAL HYDROGRAPHS



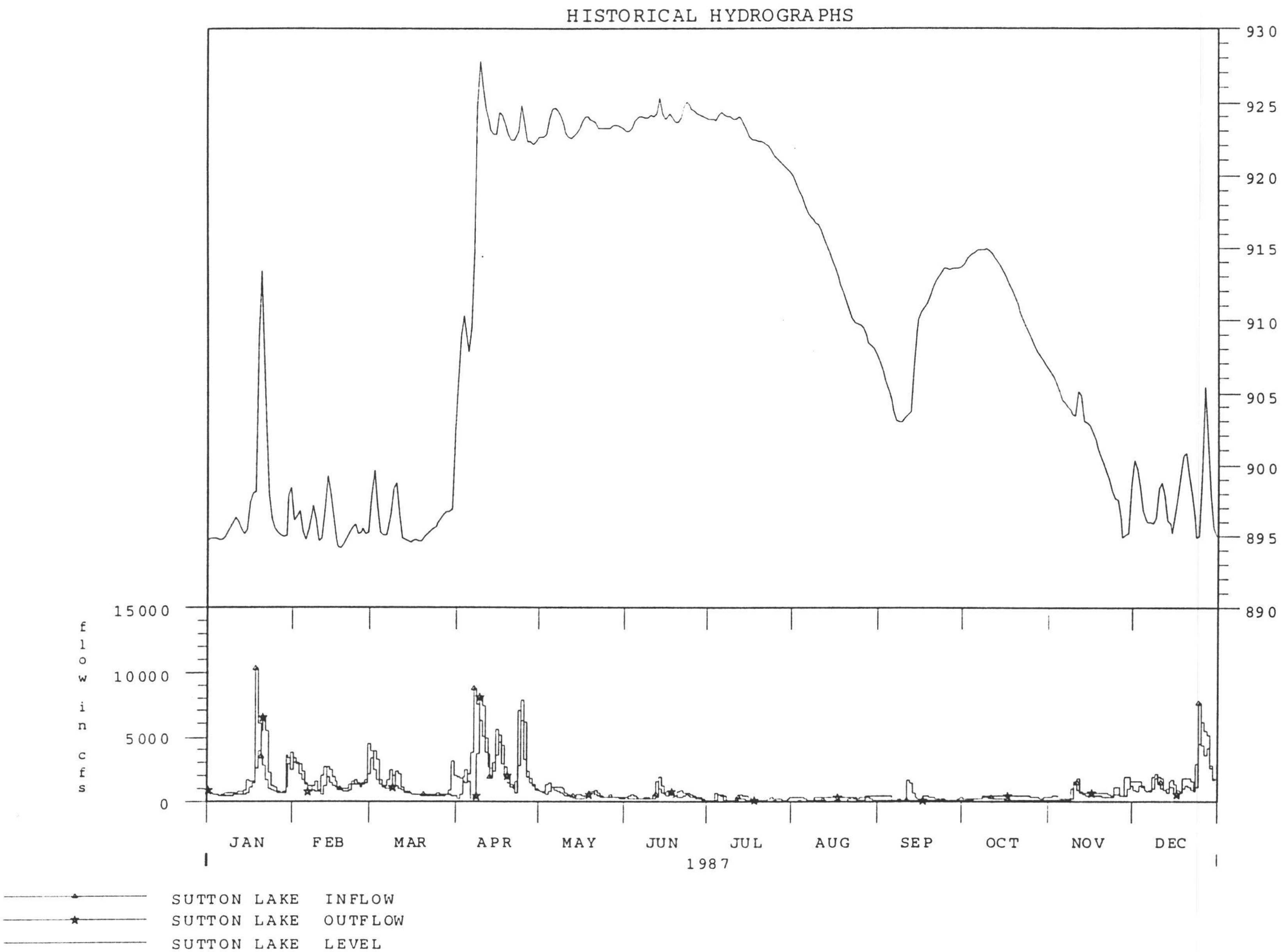
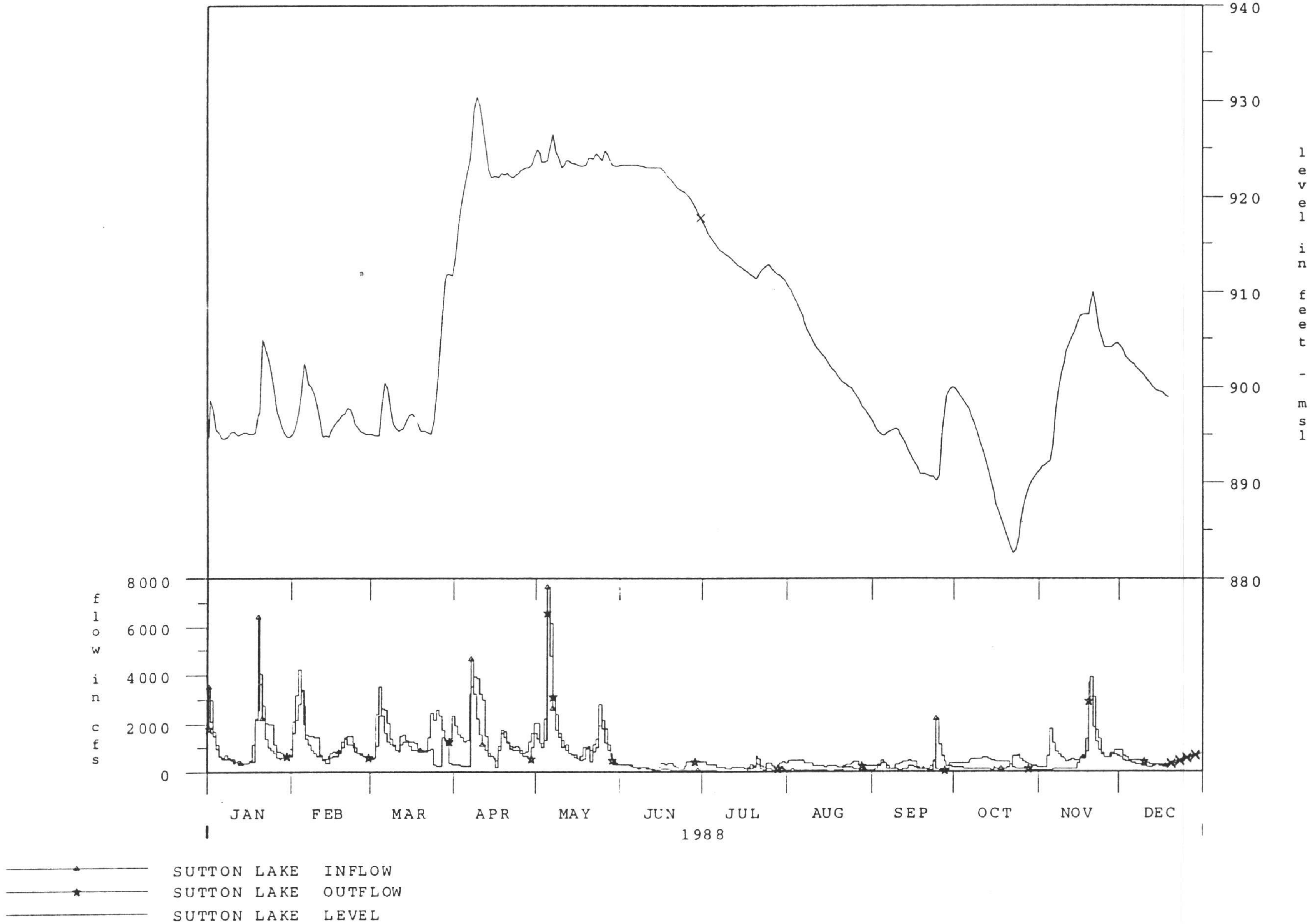
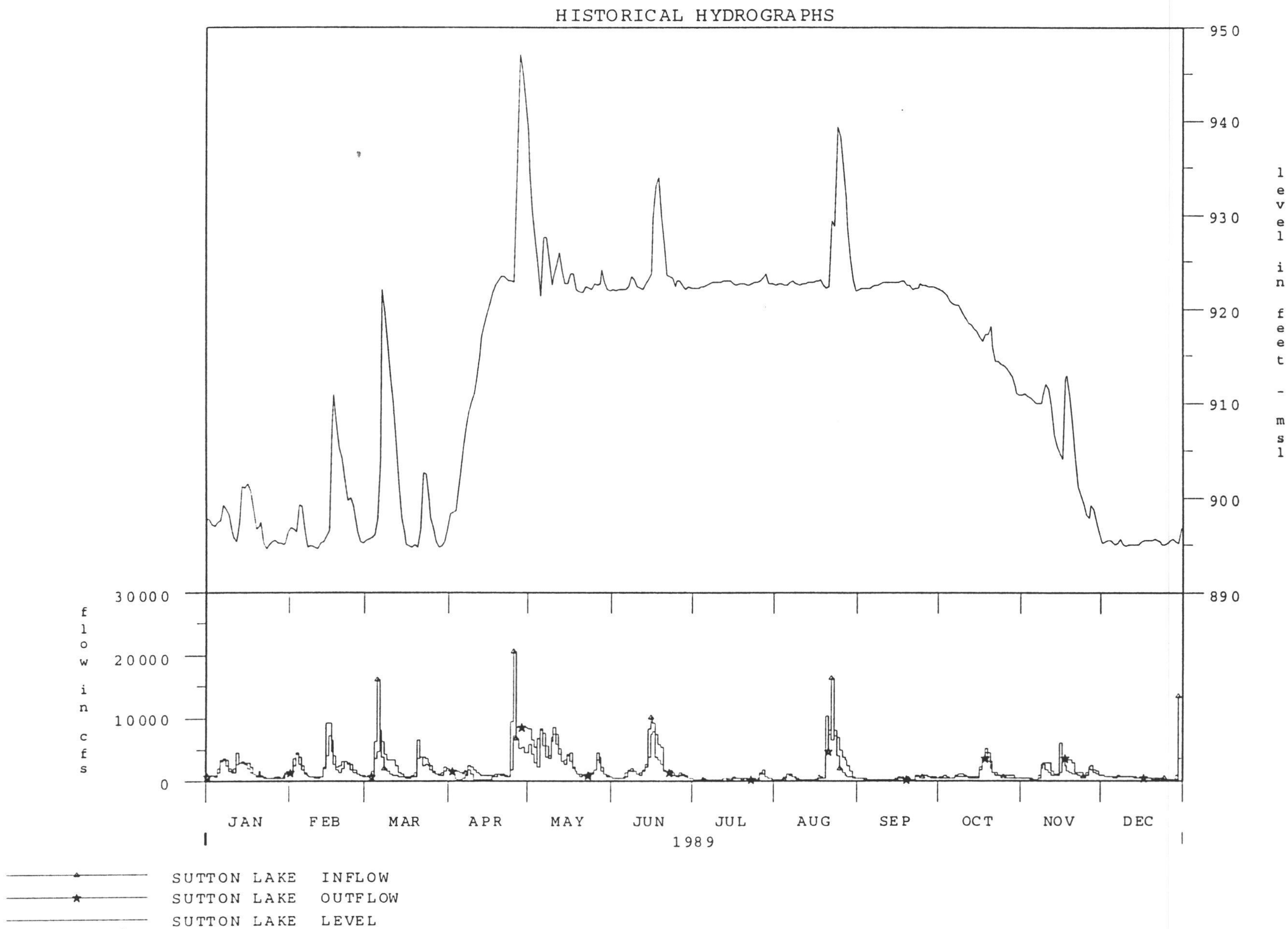


Plate No. 4-5
Sheet 27 of 35

HISTORICAL HYDROGRAPHS




HISTORICAL HYDROGRAPHS
950
940
930
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900
890
level in feet - msl
30000
20000
10000
0
flow in cfs
JAN
FEB
MAR
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1989
SUTTON LAKE INFLOW
SUTTON LAKE OUTFLOW
SUTTON LAKE LEVEL

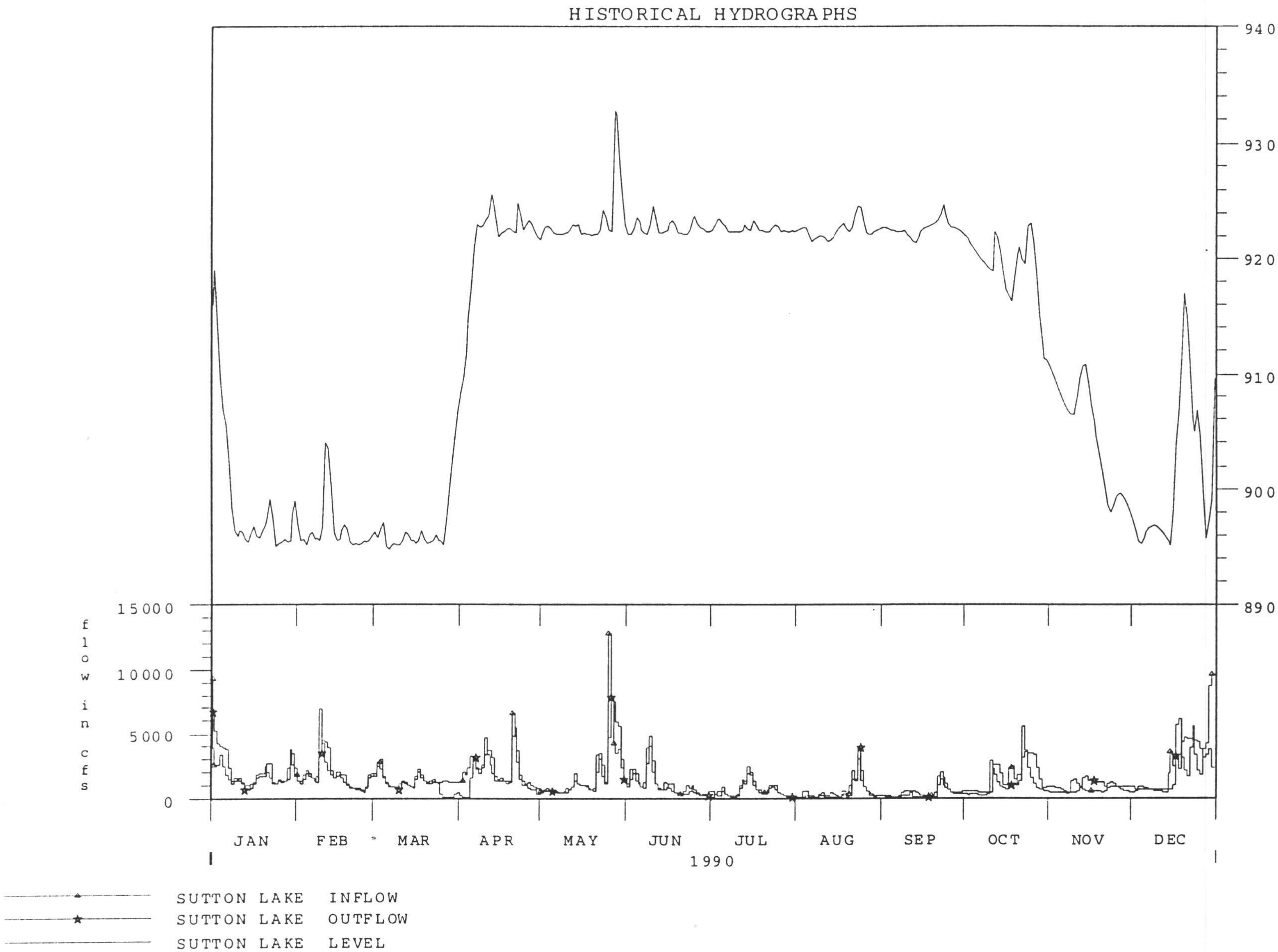
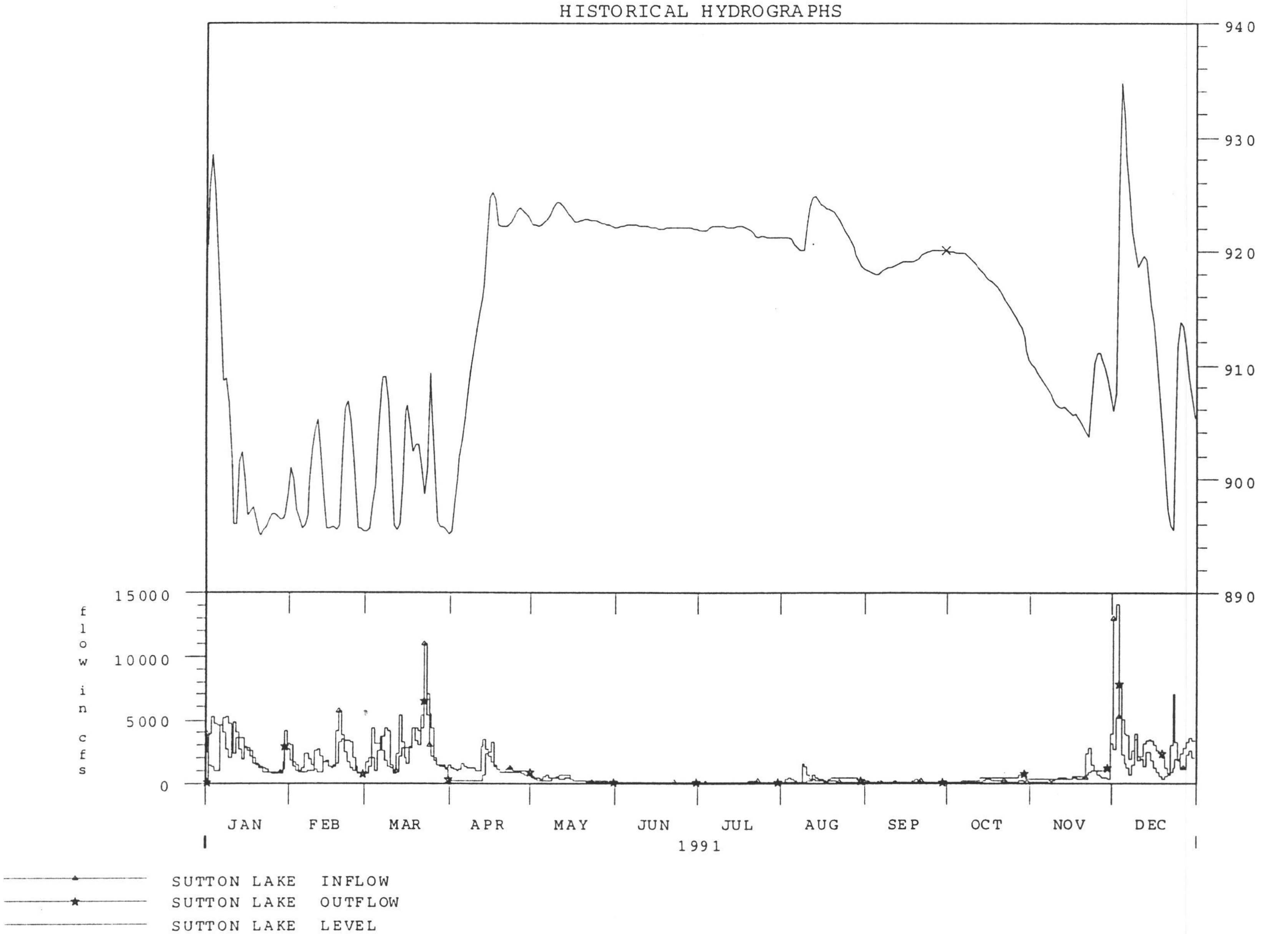


Plate No. 4-5
Sheet 30 of 35


HISTORICAL HYDROGRAPHS
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JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
1991
SUTTON LAKE INFLOW
SUTTON LAKE OUTFLOW
SUTTON LAKE LEVEL

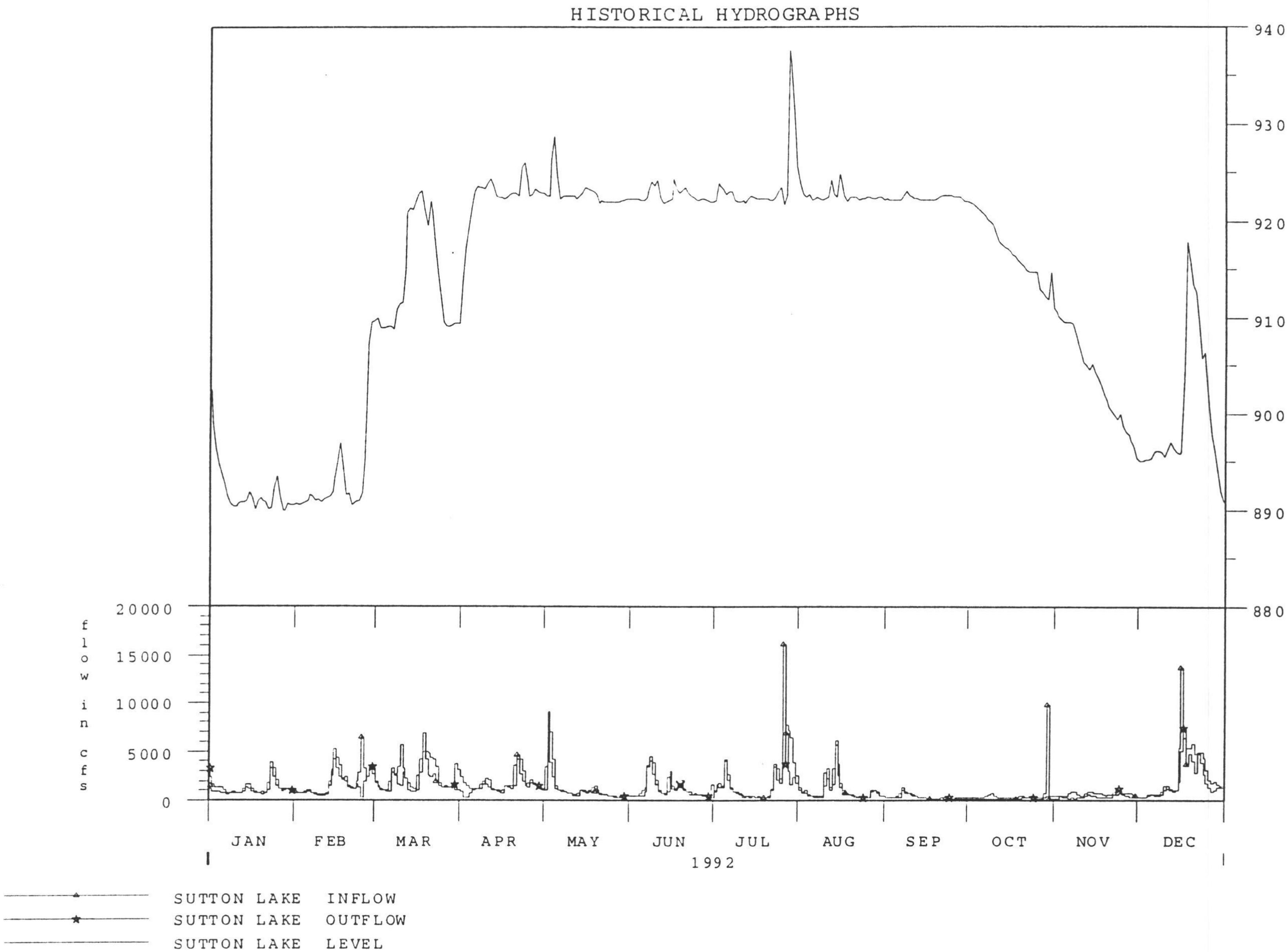
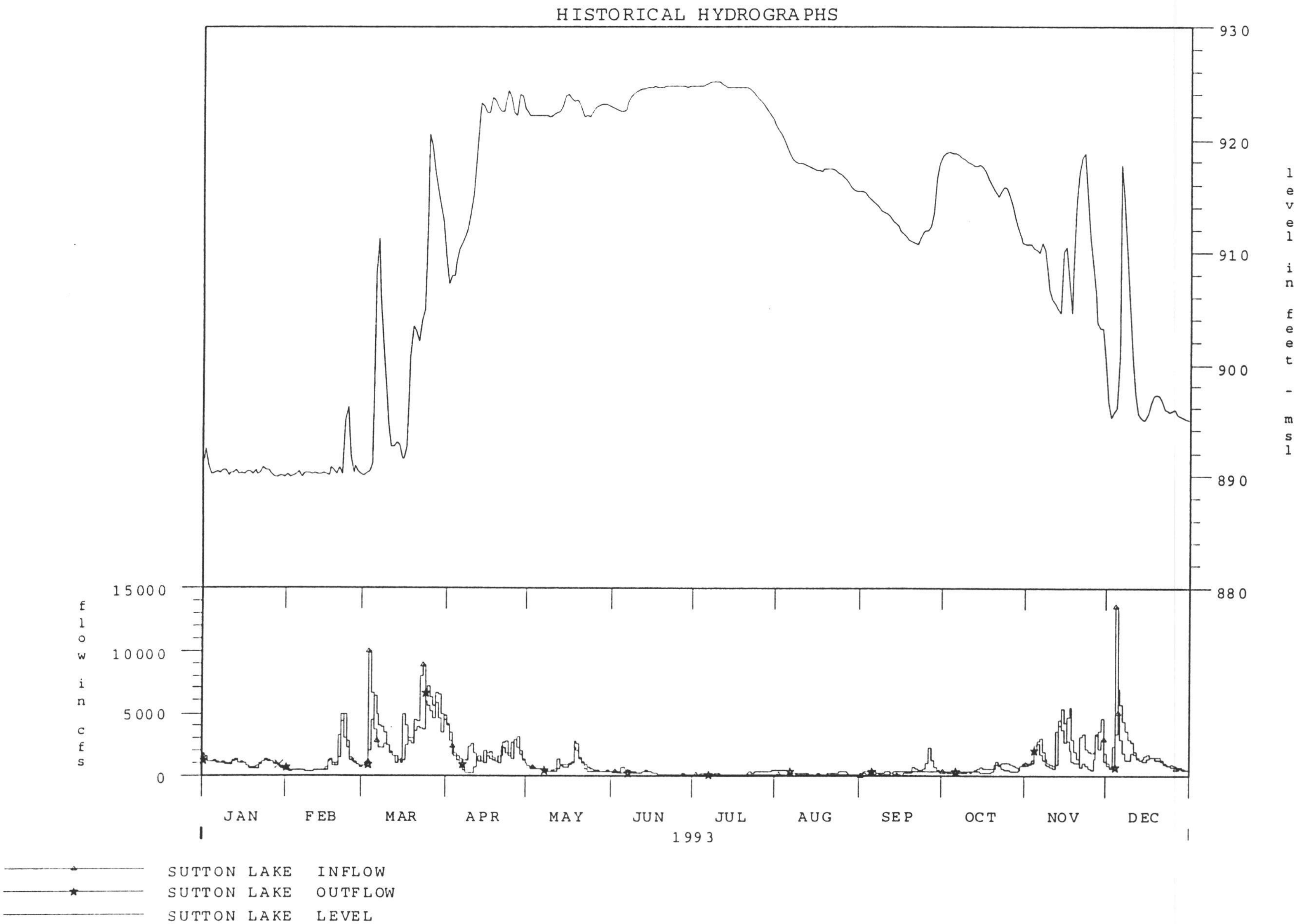


Plate No. 4-5
Sheet 32 of 35


HISTORICAL HYDROGRAPHS
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level in feet - msl
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flow in cfs
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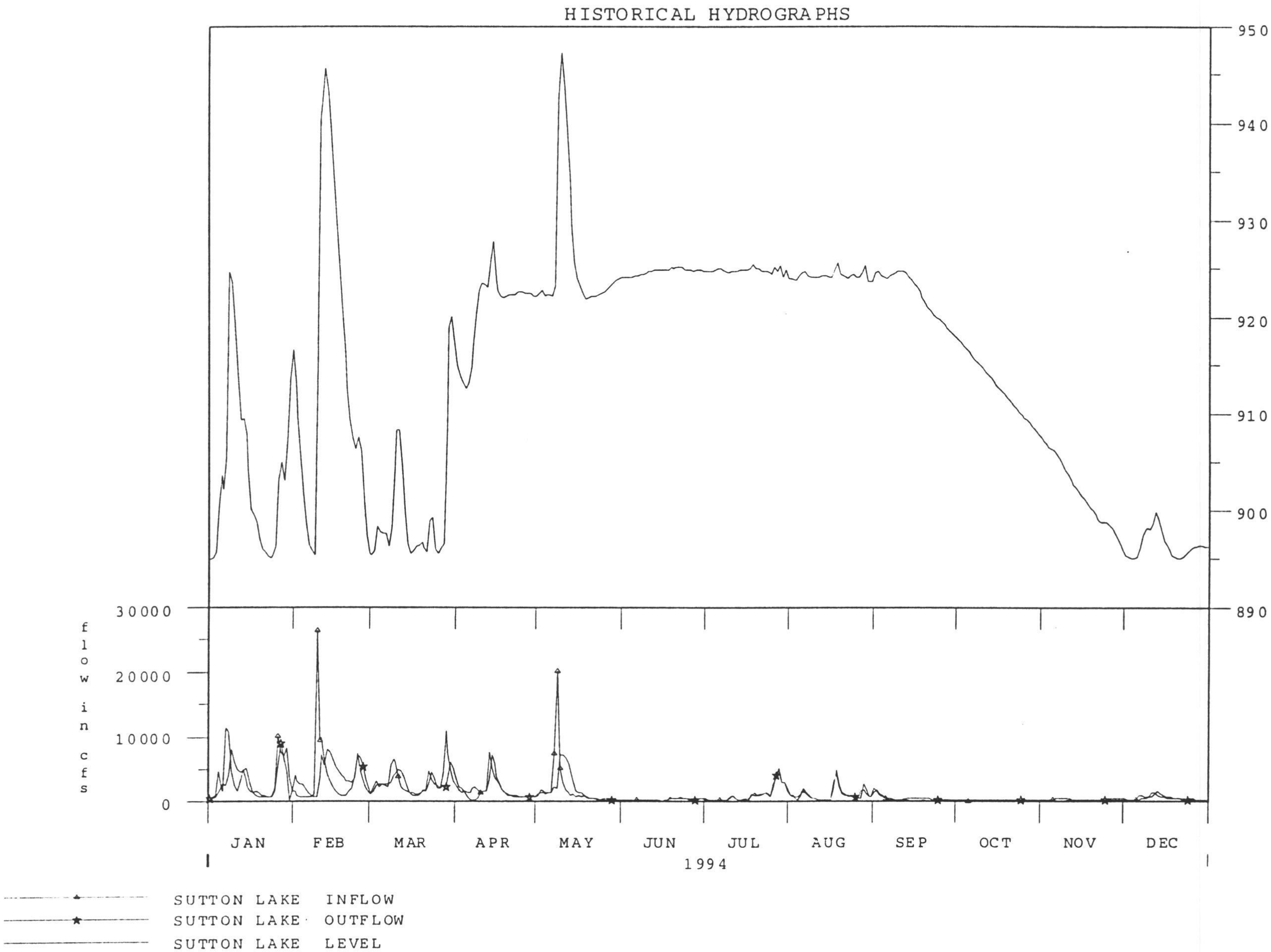
DEC
1993
SUTTON LAKE INFLOW
SUTTON LAKE OUTFLOW
SUTTON LAKE LEVEL


HISTORICAL HYDROGRAPHS
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level in feet - msl
30000
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flow in cfs
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FEB
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APR
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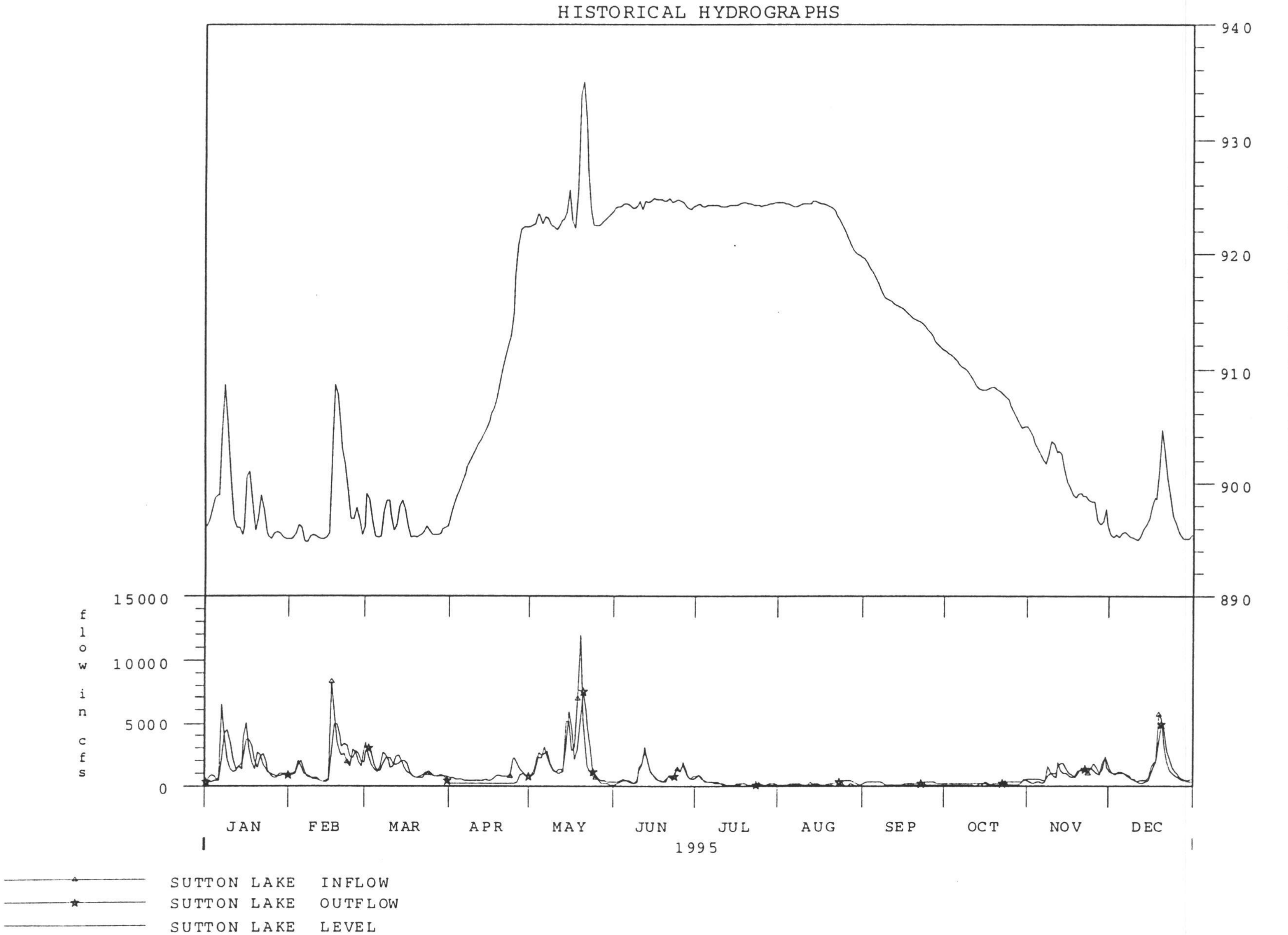
1994
SUTTON LAKE INFLOW
SUTTON LAKE OUTFLOW
SUTTON LAKE LEVEL


HISTORICAL HYDROGRAPHS
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level in feet - msl
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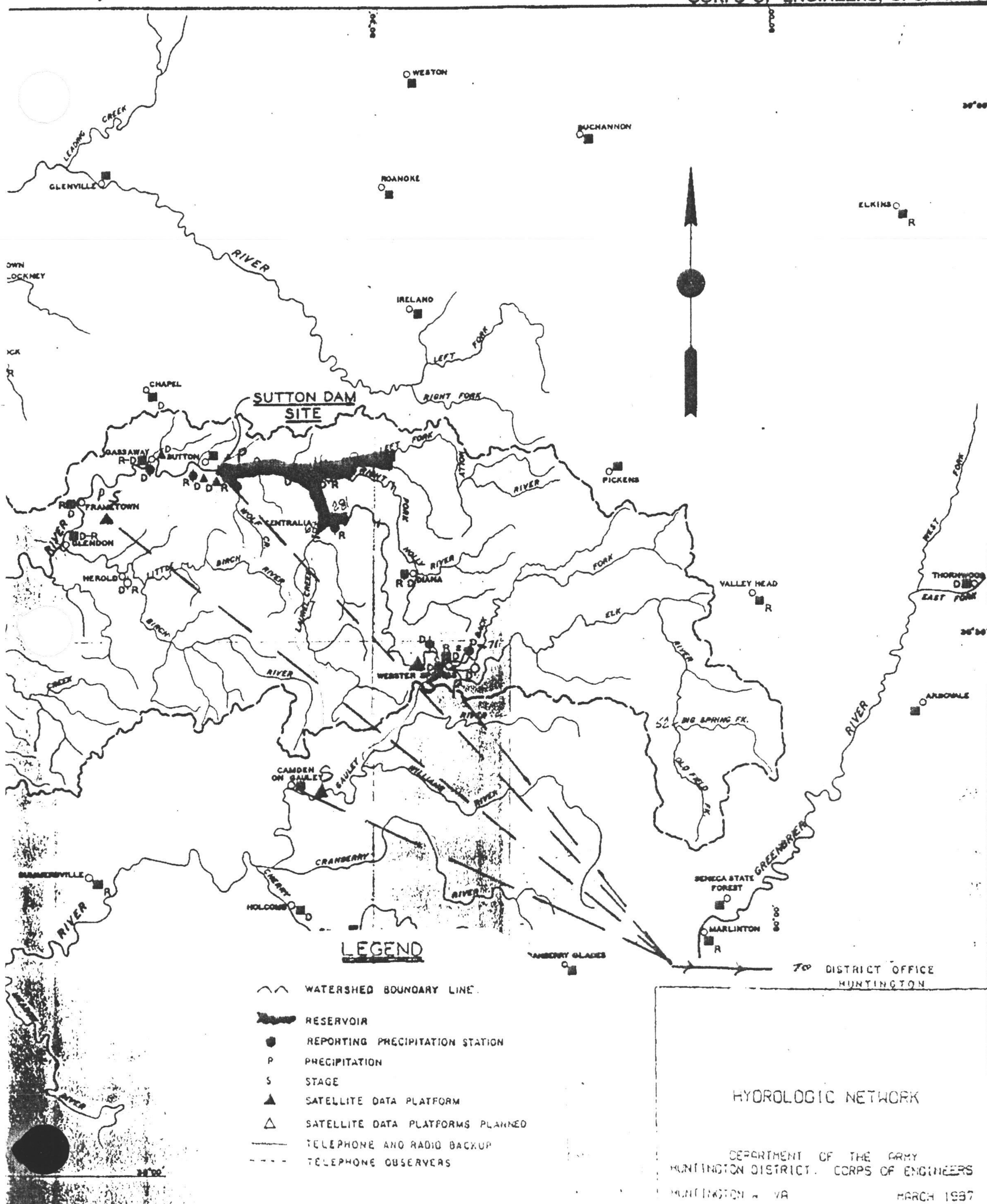
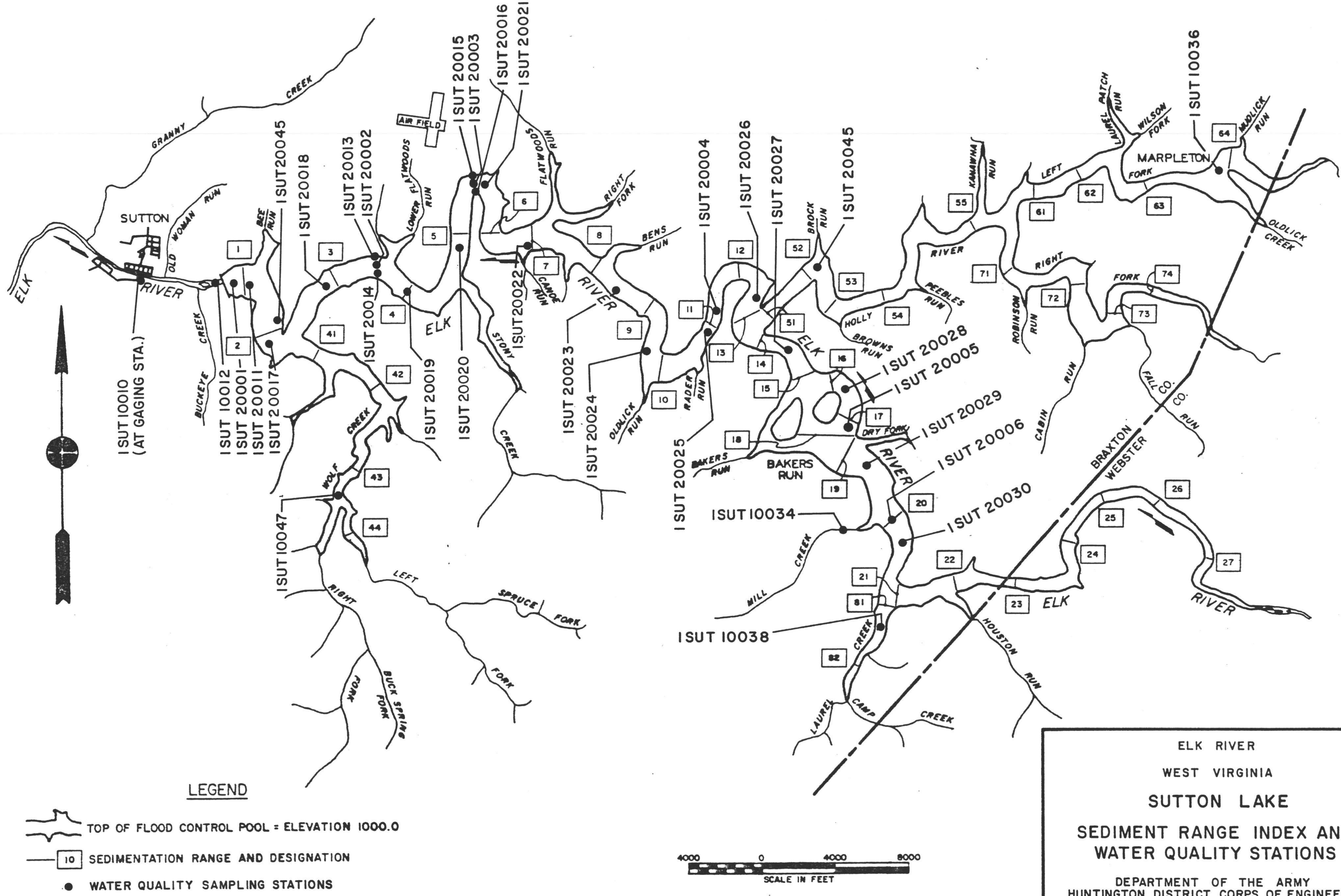
SUTTON LAKE INFLOW
SUTTON LAKE OUTFLOW
SUTTON LAKE LEVEL



HYDROLOGIC NETWORK

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W. VA MARCH 1987

PLATE NO. 5-1



LEGEND

- TOP OF FLOOD CONTROL POOL = ELEVATION 1000.0
- 10 SEDIMENTATION RANGE AND DESIGNATION
- ● WATER QUALITY SAMPLING STATIONS

ELK RIVER

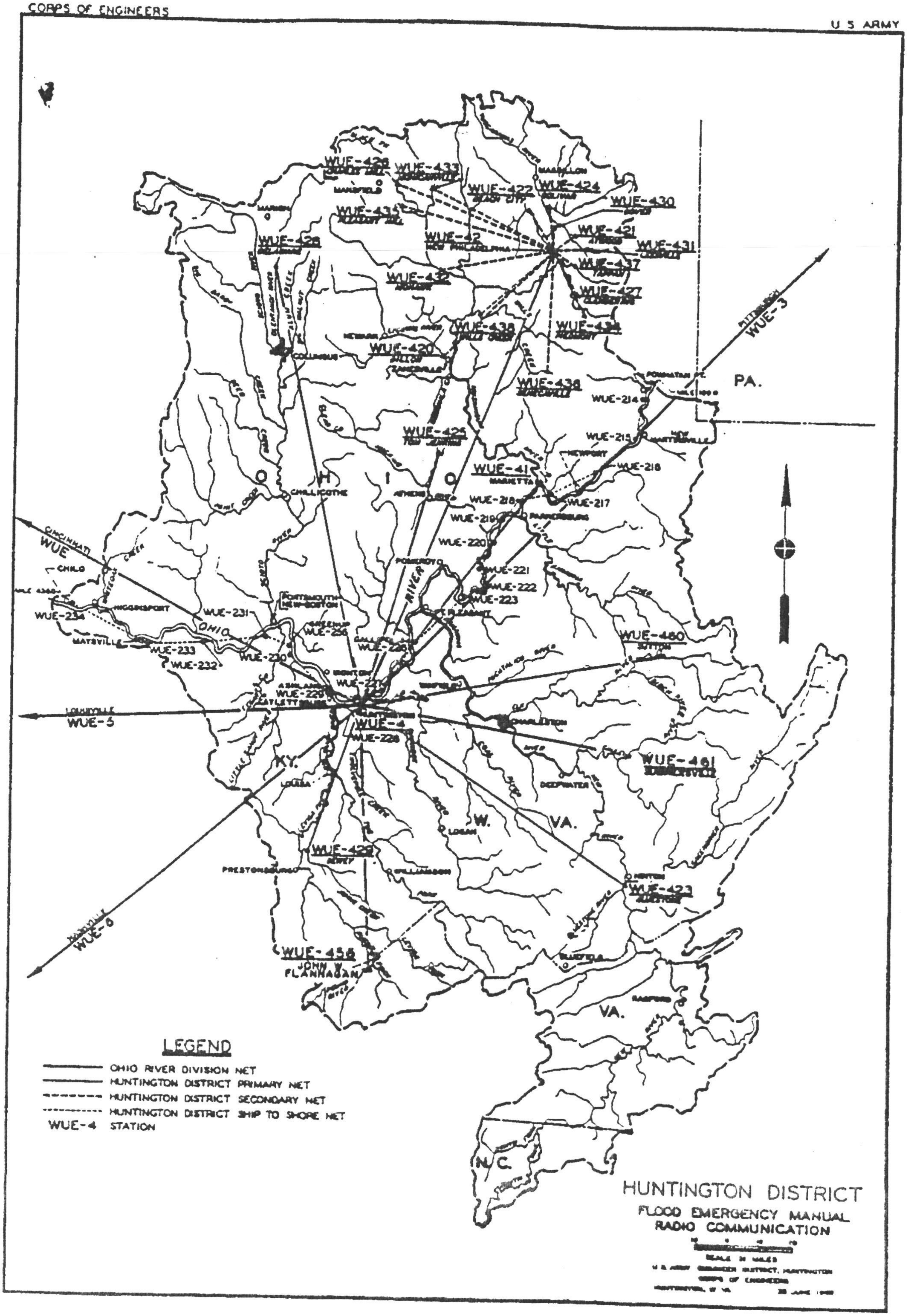
WEST VIRGINIA

SUTTON LAKE

SEDIMENT RANGE INDEX AND WATER QUALITY STATIONS

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. OCTOBER 1989


PA.
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KY.
W. VA.
VA.
N.C.
WUE-4
WUE-3
WUE-5
WUE-6
WUE-41
WUE-42
WUE-420
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WUE-438
WUE-456
JOHN W. FLANNAGAN
WUE-460
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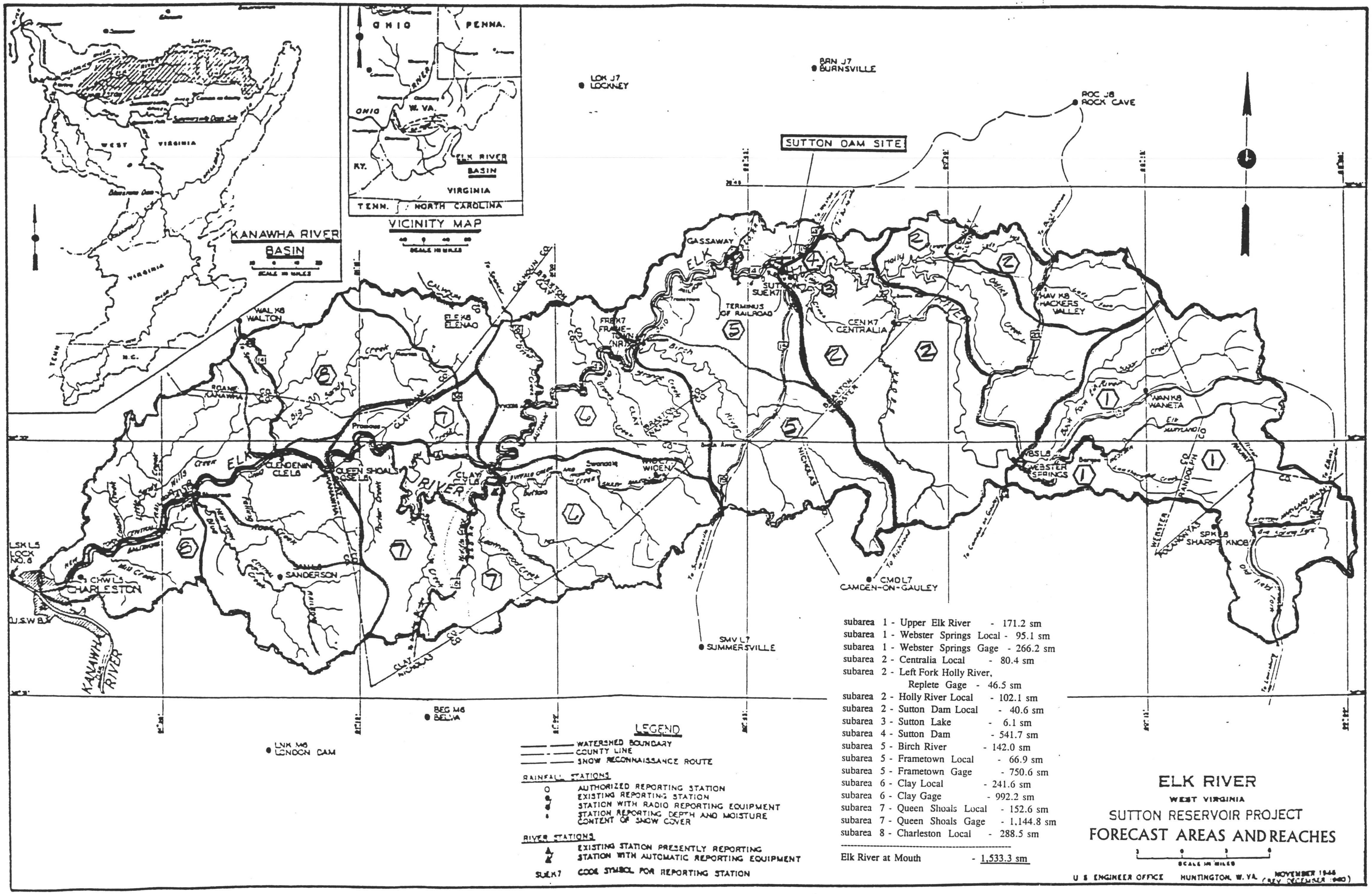
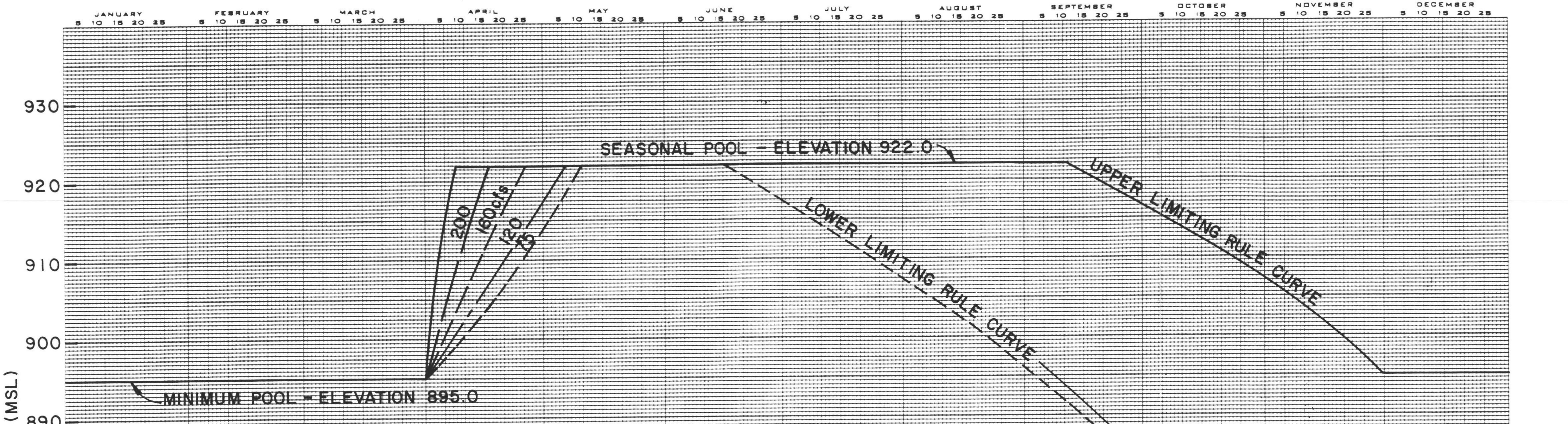
WUE-234
CHILLICOTHE
COLUMBUS
MARIETTA
PARKERSBURG
POMEROY
PT. PLEASANT
PORTSMOUTH-NEW BOSTON
ASHLAND
CATLETTSBURG
CHARLESTON
LOGAN
WILLIAMSON
PRESTONSBURG
MAYSVILLE
HIGGINSPORT
CHILO
DEEPWATER
OHIO
RIVER
LEGEND
OHIO RIVER DIVISION NET
HUNTINGTON DISTRICT PRIMARY NET
HUNTINGTON DISTRICT SECONDARY NET
HUNTINGTON DISTRICT SHIP TO SHORE NET
WUE-4 STATION
HUNTINGTON DISTRICT
FLOOD EMERGENCY MANUAL
RADIO COMMUNICATION



subarea 1 -	Upper Elk River	- 171.2 sm
subarea 1 -	Webster Springs Local	- 95.1 sm
subarea 1 -	Webster Springs Gage	- 266.2 sm
subarea 2 -	Centralia Local	- 80.4 sm
subarea 2 -	Left Fork Holly River, Replete Gage	- 46.5 sm
subarea 2 -	Holly River Local	- 102.1 sm
subarea 2 -	Sutton Dam Local	- 40.6 sm
subarea 3 -	Sutton Lake	- 6.1 sm
subarea 4 -	Sutton Dam	- 541.7 sm
subarea 5 -	Birch River	- 142.0 sm
subarea 5 -	Frametown Local	- 66.9 sm
subarea 5 -	Frametown Gage	- 750.6 sm
subarea 6 -	Clay Local	- 241.6 sm
subarea 6 -	Clay Gage	- 992.2 sm
subarea 7 -	Queen Shoals Local	- 152.6 sm
subarea 7 -	Queen Shoals Gage	- 1,144.8 sm
subarea 8 -	Charleston Local	- 288.5 sm
Elk River at Mouth		- 1,533.3 sm



OPERATION INSTRUCTIONS

1. MIMIMUM OUTFLOW OF 75 C.F.S. WILL BE MAINTAINED AT ALL TIMES.
2. 1 DEC. TO 31 MAR. MAINTAIN POOL AT ELEVATION 895.0, SUBJECT TO FLOOD CONTROL AND LOW-FLOW REQUIREMENTS.
3. BEGIN RAISING POOL ON 1 APR. IN ACCORDANCE WITH RULE CURVES.
4. SUBJECT TO FLOOD CONTROL AND FILLING REQUIREMENTS, AN OUTFLOW OF 200 C.F.S. WILL BE MAINTAINED DURING APR. AND MAY. IF POOL ELEVATION FALLS BELOW RELEASE ZONE OF 200 C.F.S., MAINTAIN RELEASE INDICATED BY RULE CURVES.
5. 16 APR. TO 10 SEPT. MAINTAIN POOL AT ELEVATION 922.0, SUBJECT TO FLOOD CONTROL, FILLING, AND LOW-FLOW REQUIREMENTS.
6. 1 JUN. TO 30 NOV. RELEASES IN EXCESS OF 75 C.F.S., FOR FLOW AUGMENTATION PURPOSES, WILL BE SCHEDULED FROM STORAGE AVAILABLE ABOVE LOWER LIMITING RULE CURVE.
7. FLOW AUGMENTATION WILL BE BASED ON THE DIFFERENCE BETWEEN DILUTION WATER REQUIRED BY THE FOLLOWING TABLE AND PREDICTED FLOWS IN KANAWHA RIVER, EXCLUSIVE OF EXISTING FLOW AUGMENTATION.

EXAMPLE

GIVEN

(1) AUG. 10, SUTTON POOL AT EL. 920.5, INFLOW 45 C.F.S. AND OUTFLOW = 75 C.F.S.

(2) FLOW AT MOUTH OF ELK RIVER = 150 C.F.S.

(3) FLOW AT KANAWHA FALLS = 2,000 C.F.S.

(4) TEMPERATURE OF KANAWHA RIVER = 90°

FIND

REQUIRED OUTFLOW FROM SUTTON FOR AUGMENTATION.

SOLUTION

(A) DILUTION WATER (EX.) = (2)+(3) = 2150 C.F.S.

(B) PRESENT AUGMENTATION (OUTFLOW - INFLOW) = 75 - 45 = 30 C.F.S.

(C) DILUTION WATER (EX.) W/O AUGMENTATION = 2120 C.F.S.

(D) REQUIRED TOTAL DILUTION WATER (FROM TABLE) = 3750 C.F.S.

(E) DILUTION WATER FROM RESERVOIRS = (D) - (C) = 1630 C.F.S.

(F) AUGMENTATION FROM SUTTON = 0.286(E) = 466 C.F.S.

(G) MAXIMUM ALLOWABLE AUGMENTATION IS 400 C.F.S.

(H) NEW OUTFLOW AT SUTTON = (G) + INFLOW = 400 + 45 = 445 C.F.S.

KANAWHA RIVER

WATER TEMPERATURE (°F)	TOTAL DILUTION WATER REQUIRED (C.F.S.)
40	1,630
50	1,970
60	2,330
70	2,750
80	3,220
90	3,750
100	4,300

RELEASES WILL BE SCHEDULED BASED ON 0.286 OF REQUIRED FLOW AUGMENTATION AND LIMITED TO A MAXIMUM FLOW AUGMENTATION OF 400 C.F.S.

ELK RIVER
WEST VIRGINIA

SUTTON LAKE

RULE CURVE
FOR REGULATION

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. OCTOBER 1989

SUTTON LAKE
ELK RIVER
AREA AND CAPACITY TABLES

Drainage Area = 537.0 Sq.Mi. 1" Runoff = 28,640 Ac.Ft.

Pool Elev.	Capacity Ac.Ft.	Capacity Inches	Area (Acres)	Pool Elev.	Capacity Ac.Ft.	Capacity Inches	Area (Acres)
810	0	0	0	845	2,820	0.10	220
811	0	0	0	846	3,050	0.11	230
812	0	0	0	847	3,280	0.11	240
813	0	0	5	848	3,530	0.12	250
814	0	0	5	849	3,780	0.13	260
815	10	0	5	850	4,050	0.14	270
816	20	0	5	851	4,330	0.15	280
817	20	0	5	852	4,620	0.16	300
818	30	0	10	853	4,920	0.17	310
819	40	0	10	854	5,240	0.18	330
820	50	0	10	855	5,570	0.19	340
821	60	0	15	856	5,920	0.21	350
822	80	0	20	857	6,280	0.22	360
823	100	0	20	858	6,640	0.23	370
824	120	0	30	859	7,020	0.25	380
825	160	0.01	40	860	7,410	0.26	400
826	200	0.01	50	861	7,820	0.27	410
827	250	0.01	60	862	8,230	0.29	420
828	320	0.01	70	863	8,650	0.30	430
829	390	0.01	80	864	9,080	0.32	440
830	480	0.02	100	865	9,530	0.33	450
831	590	0.02	110	866	9,990	0.35	460
832	700	0.02	110	867	10,460	0.36	480
833	810	0.03	120	868	10,940	0.38	490
834	940	0.03	130	869	11,440	0.40	500
835	1,070	0.04	140	870	11,950	0.42	520
836	1,210	0.04	140	871	12,470	0.44	530
837	1,350	0.05	150	872	13,010	0.45	550
838	1,510	0.05	160	873	13,570	0.47	560
839	1,670	0.06	160	874	14,130	0.49	570
840	1,840	0.06	170	875	14,650	0.51	590
841	2,010	0.07	180	876	15,310	0.53	600
842	2,200	0.08	190	877	15,920	0.56	610
843	2,400	0.08	200	878	16,540	0.58	630
844	2,600	0.09	210	879	17,170	0.60	640

SUTTON LAKE
ELK RIVER
AREA AND CAPACITY TABLES

Drainage Area = 537.0 Sq.Mi. 1" Runoff = 28,640 Ac.Ft.

Pool Elev.	Capacity Ac.Ft.	Capacity Inches	Area (Acres)	Pool Elev.	Capacity Ac.Ft.	Capacity Inches	Area (Acres)
880	17,820	0.62	650	915	50,230	1.75	1270
881	18,470	0.64	660	916	51,510	1.80	1290
882	19,140	0.67	670	917	52,810	1.84	1320
883	19,820	0.69	680	918	54,140	1.89	1340
884	20,510	0.72	700	919	55,490	1.94	1370
885	21,210	0.74	710	920	56,870	1.98	1390
886	21,930	0.77	730	921	58,270	2.03	1420
887	22,670	0.79	740	922	59,700	2.08	1440
888	23,420	0.82	760	923	61,160	2.14	1470
889	24,180	0.84	780	924	62,640	2.19	1490
890	24,970	0.87	790	925	64,140	2.24	1520
891	25,770	0.90	810	926	65,670	2.29	1540
892	26,590	0.93	830	927	67,230	2.35	1570
893	27,420	0.96	840	928	68,820	2.40	1600
894	28,270	0.99	860	929	70,430	2.46	1620
895	29,140	1.02	870	930	72,070	2.52	1650
896	30,020	1.05	890	931	73,730	2.57	1680
897	30,920	1.08	900	932	75,430	2.63	1710
898	31,830	1.11	920	933	77,160	2.69	1750
899	32,760	1.14	940	934	78,920	2.76	1780
900	33,700	1.17	950	935	80,720	2.82	1810
901	34,660	1.21	970	936	82,540	2.88	1840
902	35,640	1.24	990	937	84,400	2.95	1870
903	36,640	1.28	1010	938	86,290	3.01	1900
904	37,660	1.31	1030	939	88,210	3.08	1930
905	38,690	1.35	1050	940	90,160	3.15	1960
906	39,750	1.39	1070	941	92,130	3.22	1990
907	40,830	1.42	1090	942	94,130	3.29	2010
908	41,930	1.46	1110	943	96,160	3.36	2040
909	43,050	1.50	1130	944	98,200	3.43	2060
910	44,190	1.54	1150	945	100,280	3.50	2080
911	45,350	1.58	1170	946	102,370	3.57	2110
912	46,540	1.62	1200	947	104,490	3.65	2130
913	47,740	1.67	1220	948	106,630	3.72	2150
914	48,980	1.71	1240	949	108,790	3.80	2180

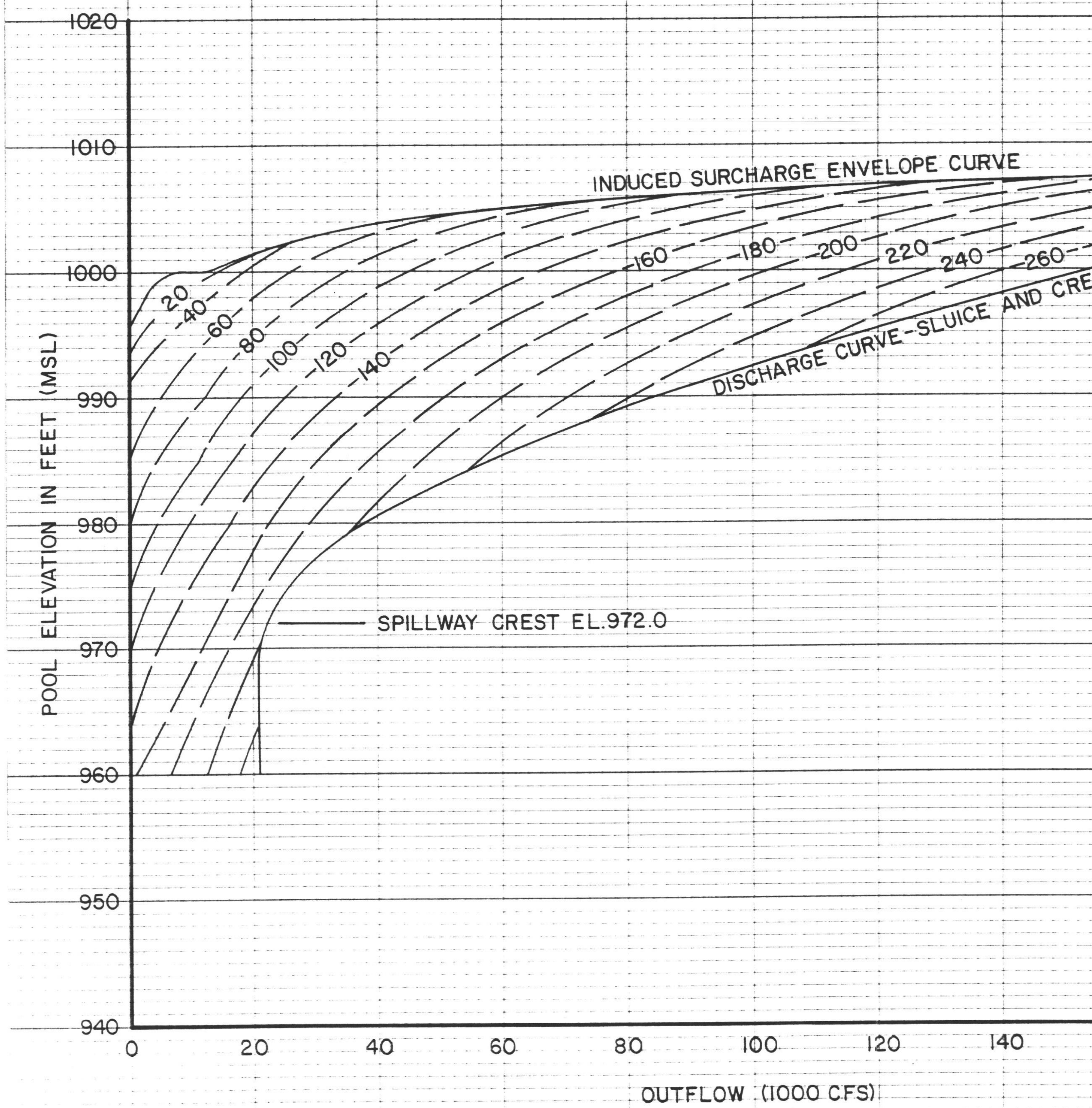
SUTTON LAKE
ELK RIVER
AREA AND CAPACITY TABLES

Drainage Area = 537.0 Sq.Mi. 1" Runoff = 28,640 Ac.Ft.

Pool Elev.	Capacity Ac.Ft.	Capacity Inches	Area (Acres)	Pool Elev.	Capacity Ac.Ft.	Capacity Inches	Area (Acres)
950	110,990	3.88	2210	985	210,270	7.34	3440
951	113,210	3.95	2240	986	213,730	7.46	3470
952	115,460	4.03	2270	987	217,220	7.58	3510
953	117,760	4.11	2310	988	220,740	7.71	3540
954	120,090	4.19	2350	989	224,300	7.83	3570
955	122,450	4.28	2390	990	227,880	7.96	3600
956	124,860	4.36	2430	991	231,500	8.08	3630
957	127,310	4.44	2470	992	235,140	8.21	3660
958	129,800	4.53	2510	993	238,810	8.34	3690
959	132,330	4.62	2550	994	242,510	8.47	3710
960	134,900	4.71	2590	995	246,240	8.60	3740
961	137,510	4.80	2630	996	249,990	8.73	3770
962	140,150	4.89	2660	997	253,770	8.86	3790
963	142,820	4.97	2690	998	257,580	8.99	3820
964	145,530	5.08	2730	999	261,410	9.13	3850
965	148,270	5.18	2760	1000	265,270	9.26	3880
966	151,050	5.27	2790	1001	269,160	9.40	3910
967	153,860	5.37	2830	1002	273,090	9.54	3940
968	156,700	5.47	2860	1003	277,060	9.67	3980
969	159,580	5.57	2890	1004	281,060	9.81	4020
970	162,490	5.67	2930	1005	285,100	9.95	4060
971	165,430	5.78	2960	1006	289,180	10.08	4100
972	168,410	5.88	3000	1007	293,300	10.24	4150
973	171,430	5.98	3030	1008	297,470	10.39	4190
974	174,480	6.09	3070	1009	301,680	10.53	4240
975	177,560	6.20	3100	1010	305,940	10.68	4280
976	180,680	6.31	3130	1011	310,250	10.83	4330
977	183,830	6.42	3170				
978	187,010	6.53	3200				
979	190,230	6.64	3240				
980	193,490	6.76	3270				
981	196,770	6.87	3310				
982	200,100	6.99	3340				
983	203,450	7.10	3370				
984	206,850	7.22	3410				

4295

1010.3 307233



OPERATING INSTRUCTIONS

1. FOLLOW REGULAR FLOOD CONTROL REGULATION SCHEDULE UNTIL LARGER RELEASES ARE REQUIRED BY THIS SCHEDULE.
2. ADJUST THE OUTFLOW EACH HOUR ON THE BASIS OF THE AVERAGE INFLOW FOR THE PRECEDING HOUR AND THE CURRENT RESERVOIR ELEVATION AS INDICATED BY THE CURVES.
3. AFTER THE RESERVOIR ELEVATION STARTS TO FALL, MAINTAIN CURRENT GATE OPENINGS UNTIL THE ELEV. RECEDES TO 1,000. WHEN RESERVOIR ELEVATION IS BELOW 1,000, RELEASE AT THE MAX. ALLOWABLE RATE.

ELK RIVER

WEST VIRGINIA

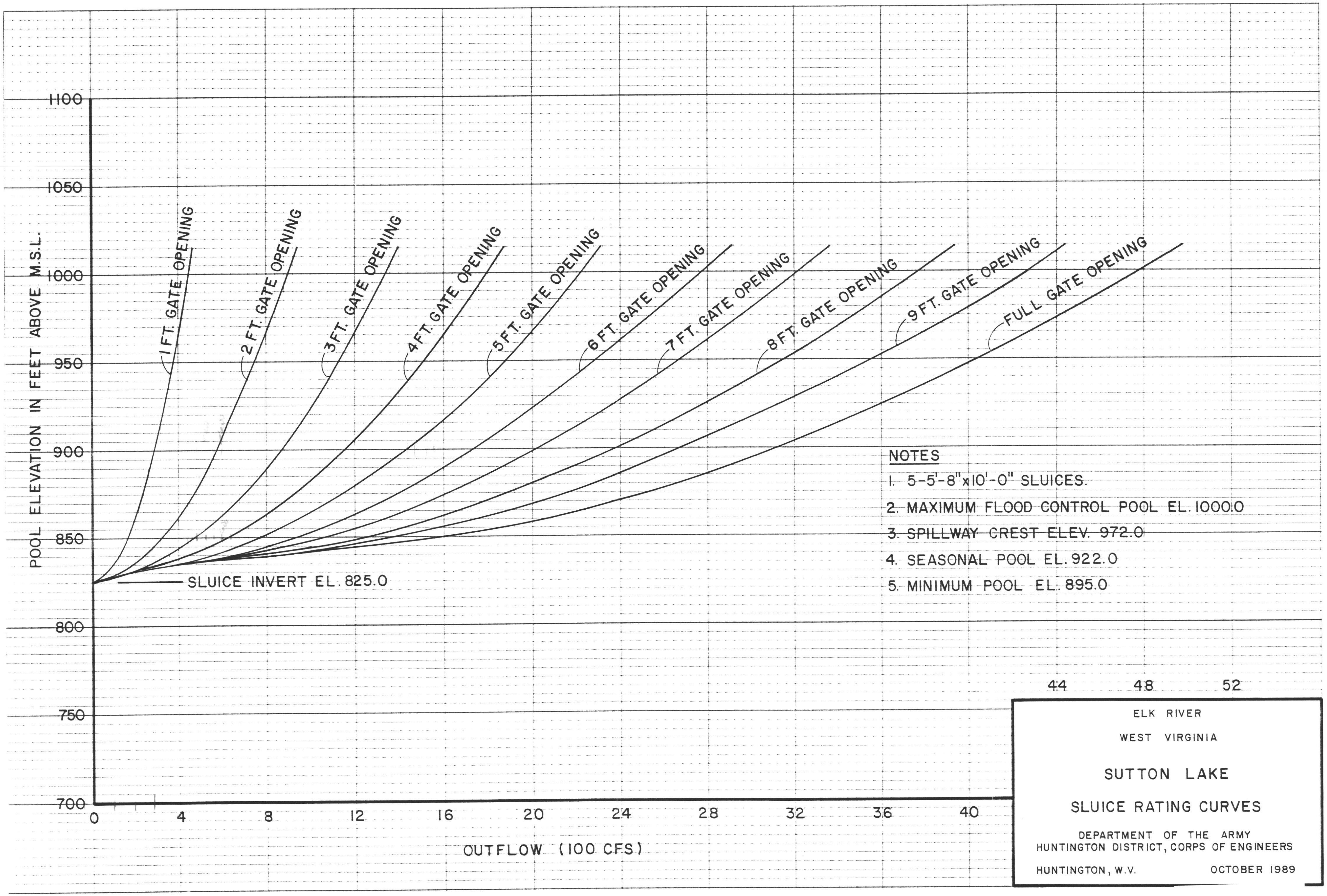
SUTTON LAKE

REGULATION SCHEDULE FOR MAJOR FLOODS

DEPARTMENT OF THE ARMY

HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. JUNE 1960



ELK RIVER

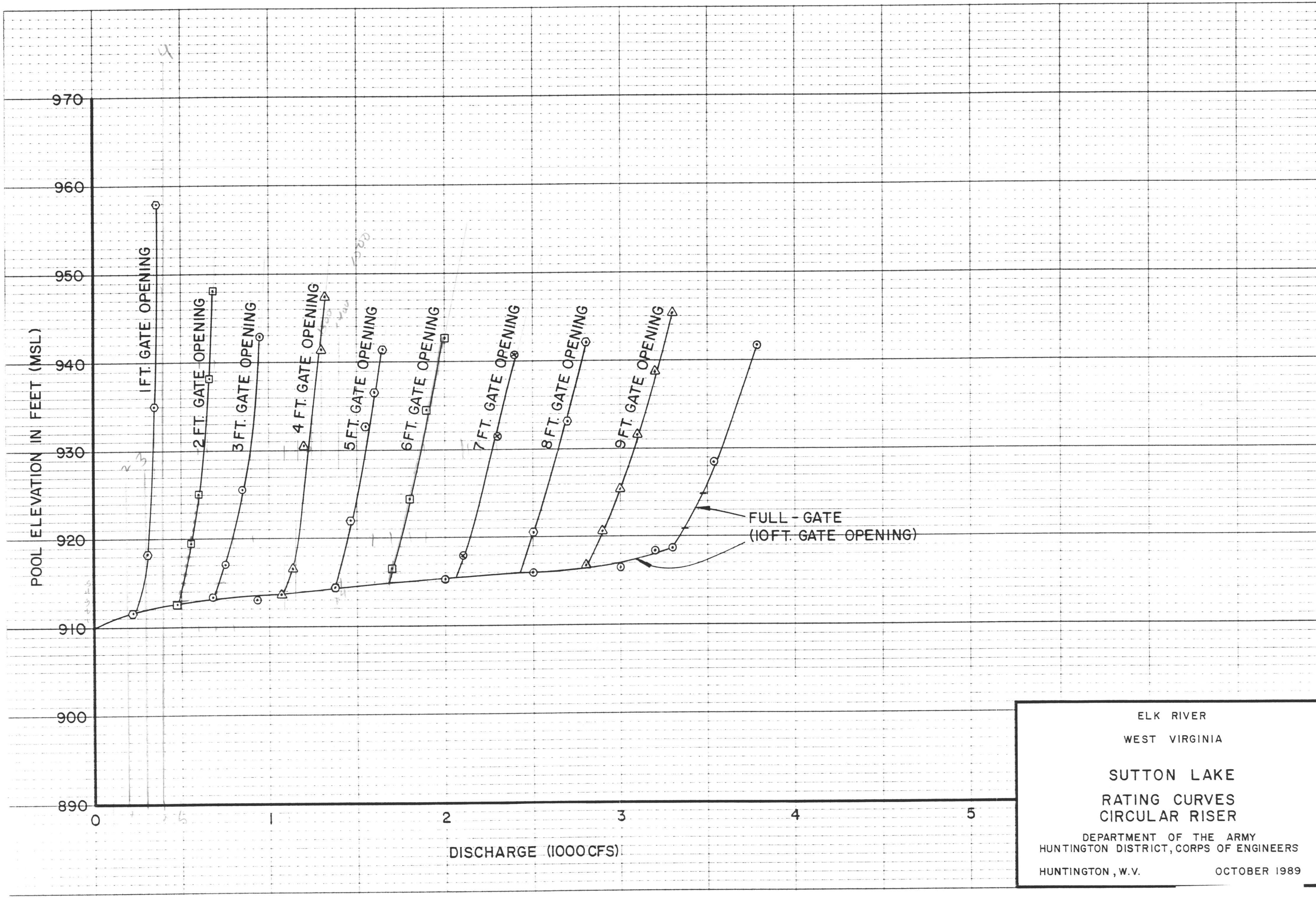
WEST VIRGINIA

SUTTON LAKE

SLUICE RATING CURVES

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. OCTOBER 1989



ELK RIVER

WEST VIRGINIA

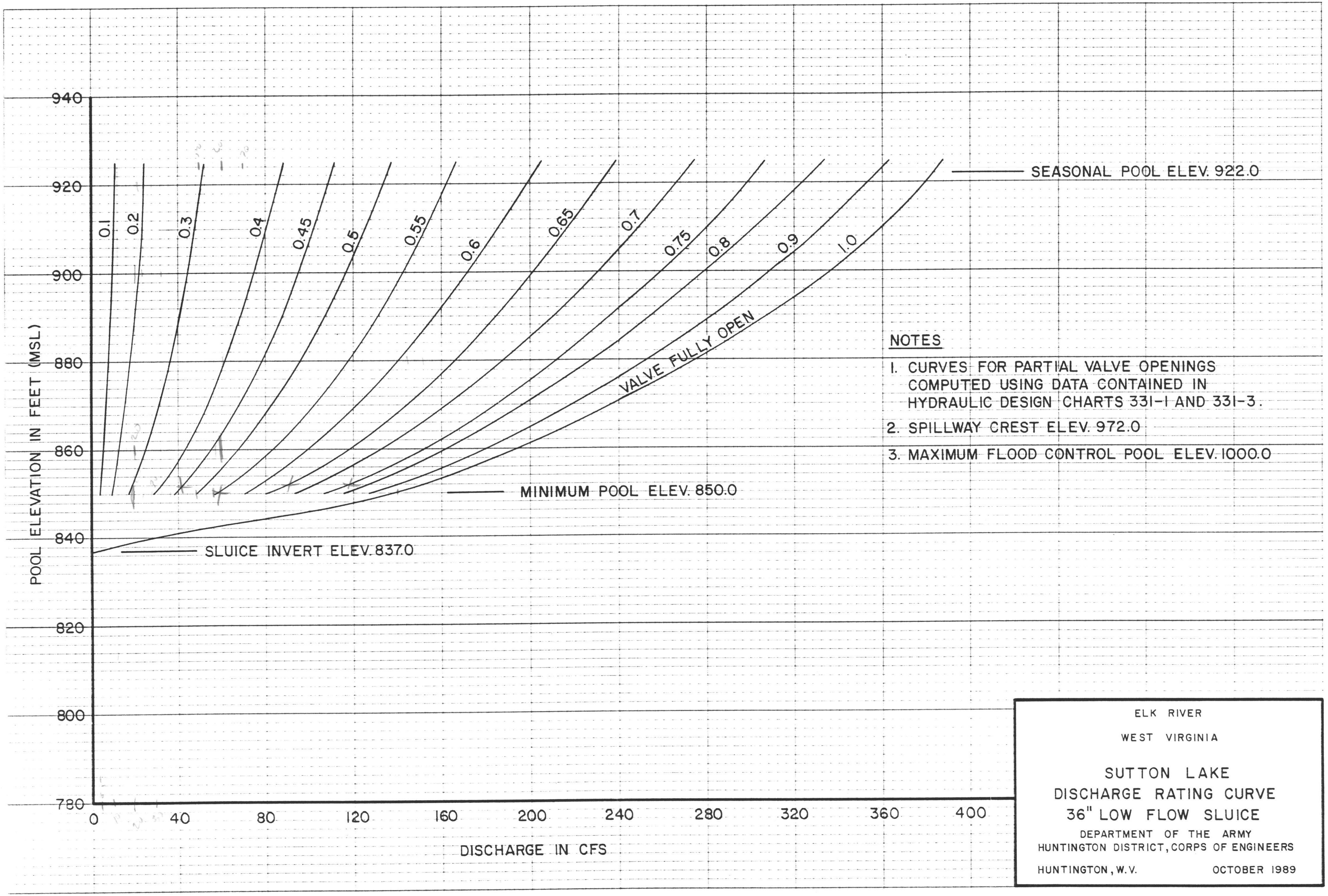
SUTTON LAKE

RATING CURVES
CIRCULAR RISER

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. OCTOBER 1989

PLATE NO. 7-5



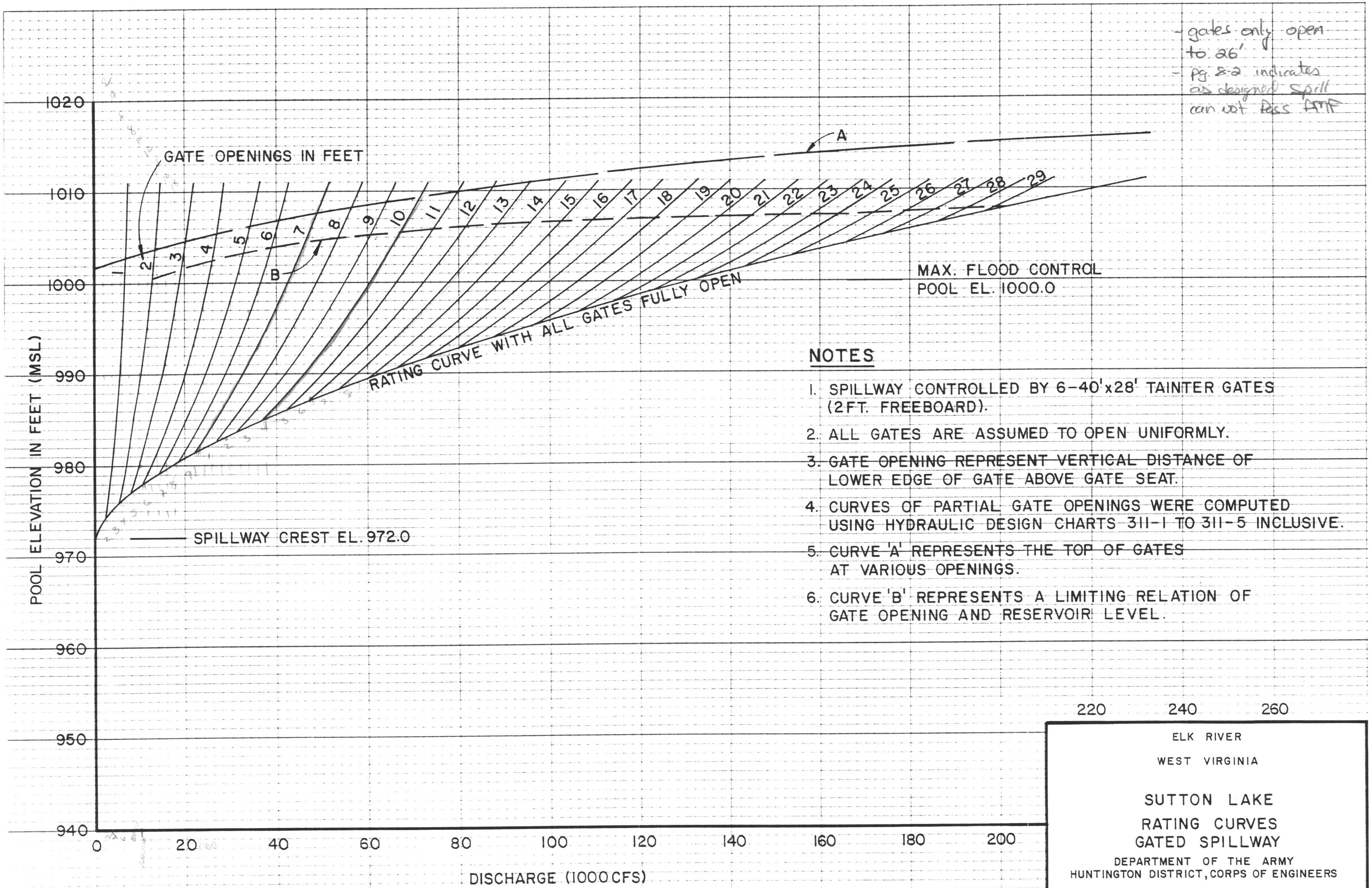
ELK RIVER

WEST VIRGINIA

SUTTON LAKE
DISCHARGE RATING CURVE
36" LOW FLOW SLUICE

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. OCTOBER 1989



NOTES

1. SPILLWAY CONTROLLED BY 6-40'x28' TAINTER GATES (2FT. FREEBOARD).
2. ALL GATES ARE ASSUMED TO OPEN UNIFORMLY.
3. GATE OPENING REPRESENT VERTICAL DISTANCE OF LOWER EDGE OF GATE ABOVE GATE SEAT.
4. CURVES OF PARTIAL GATE OPENINGS WERE COMPUTED USING HYDRAULIC DESIGN CHARTS 311-1 TO 311-5 INCLUSIVE.
5. CURVE 'A' REPRESENTS THE TOP OF GATES AT VARIOUS OPENINGS.
6. CURVE 'B' REPRESENTS A LIMITING RELATION OF GATE OPENING AND RESERVOIR LEVEL.

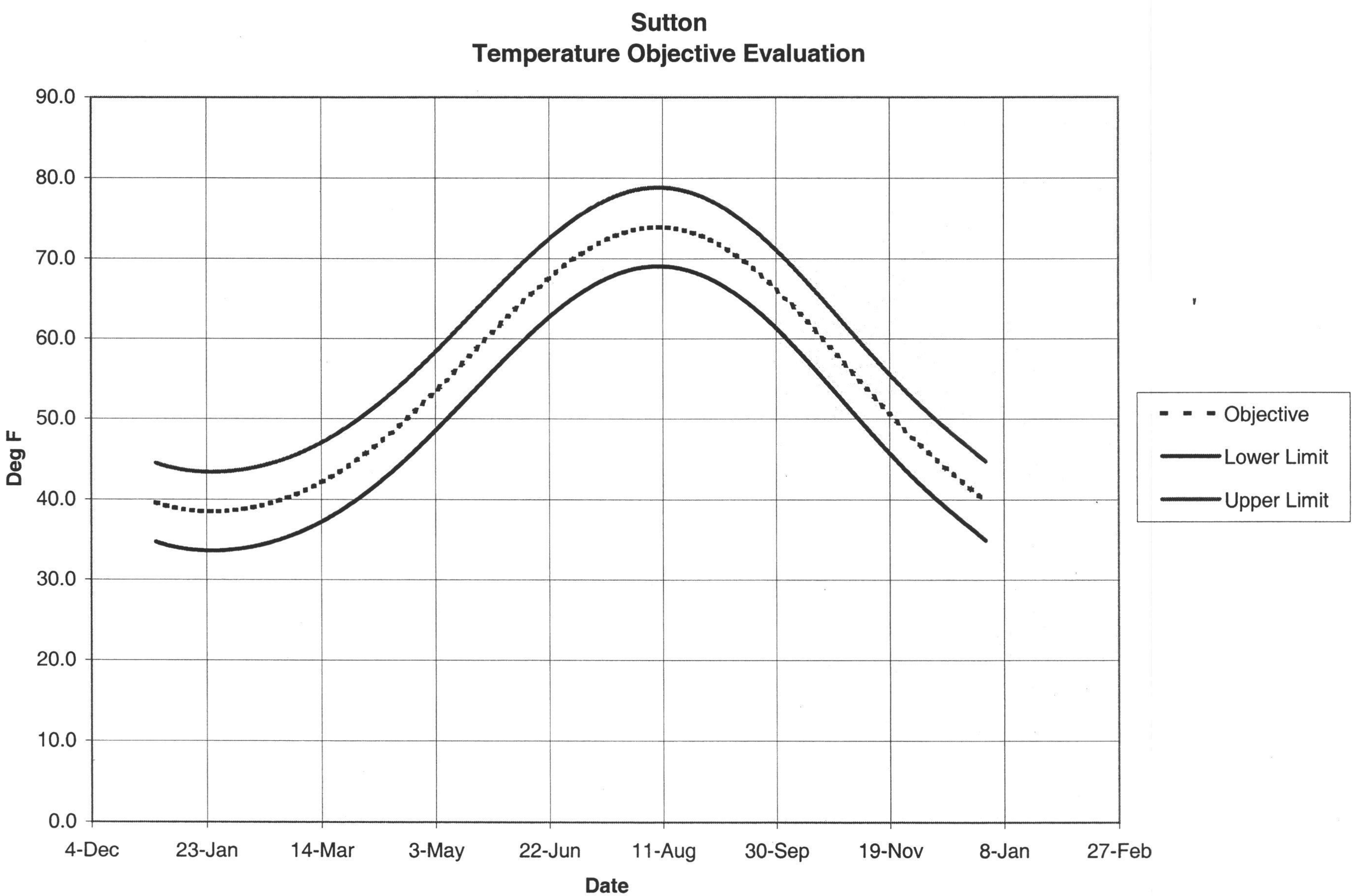
ELK RIVER
WEST VIRGINIA

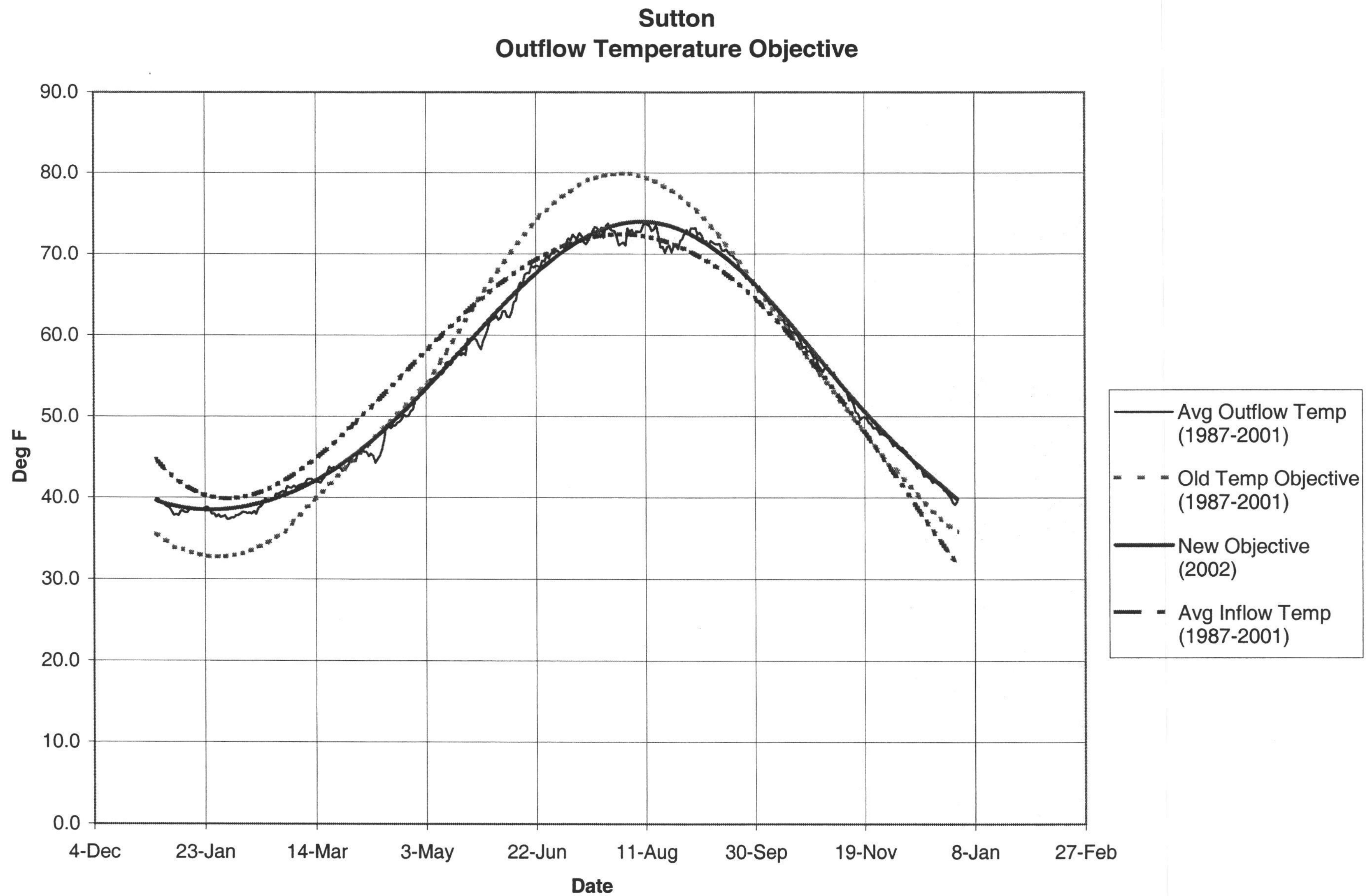
SUTTON LAKE
RATING CURVES
GATED SPILLWAY

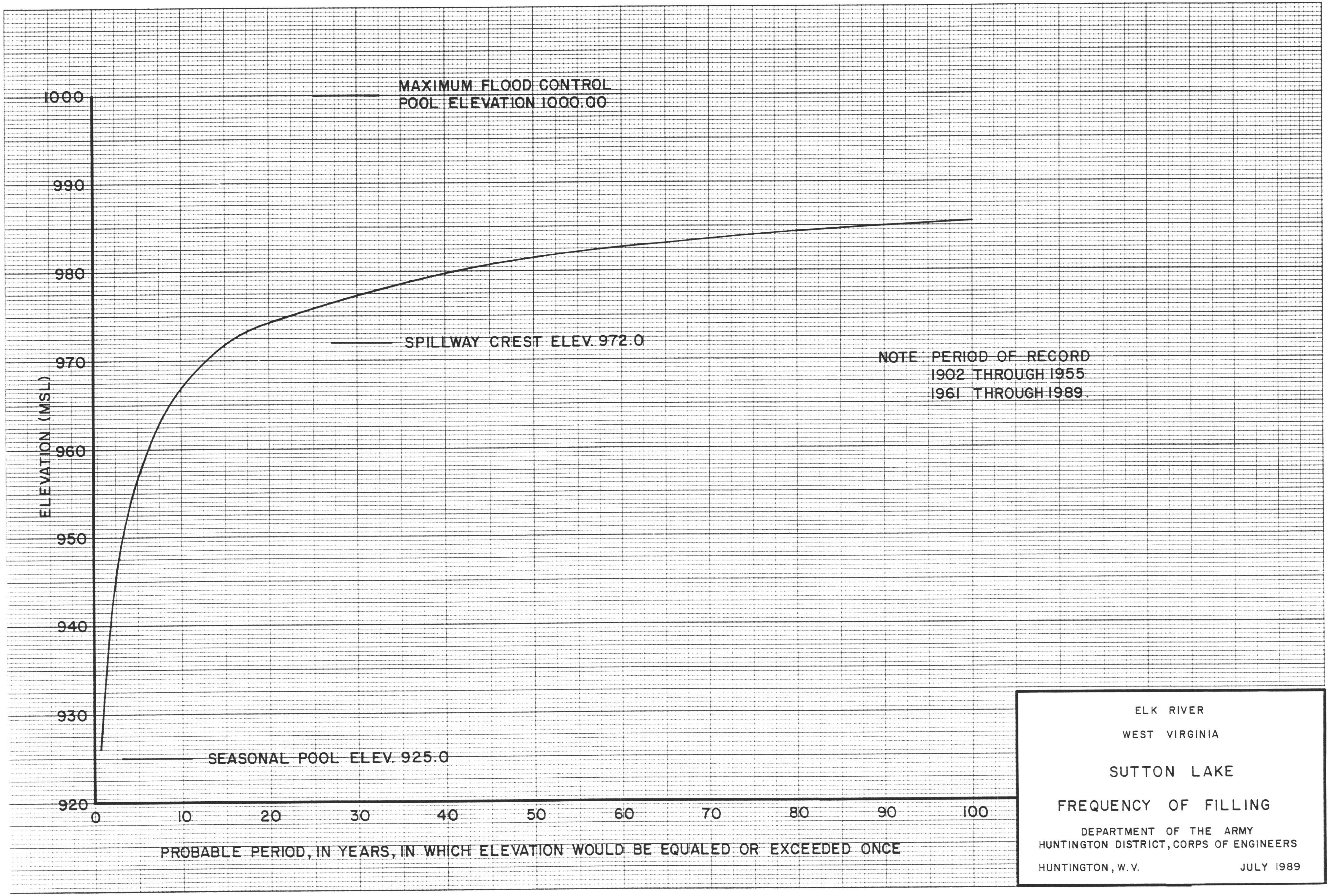
DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W. V. OCTOBER 1989

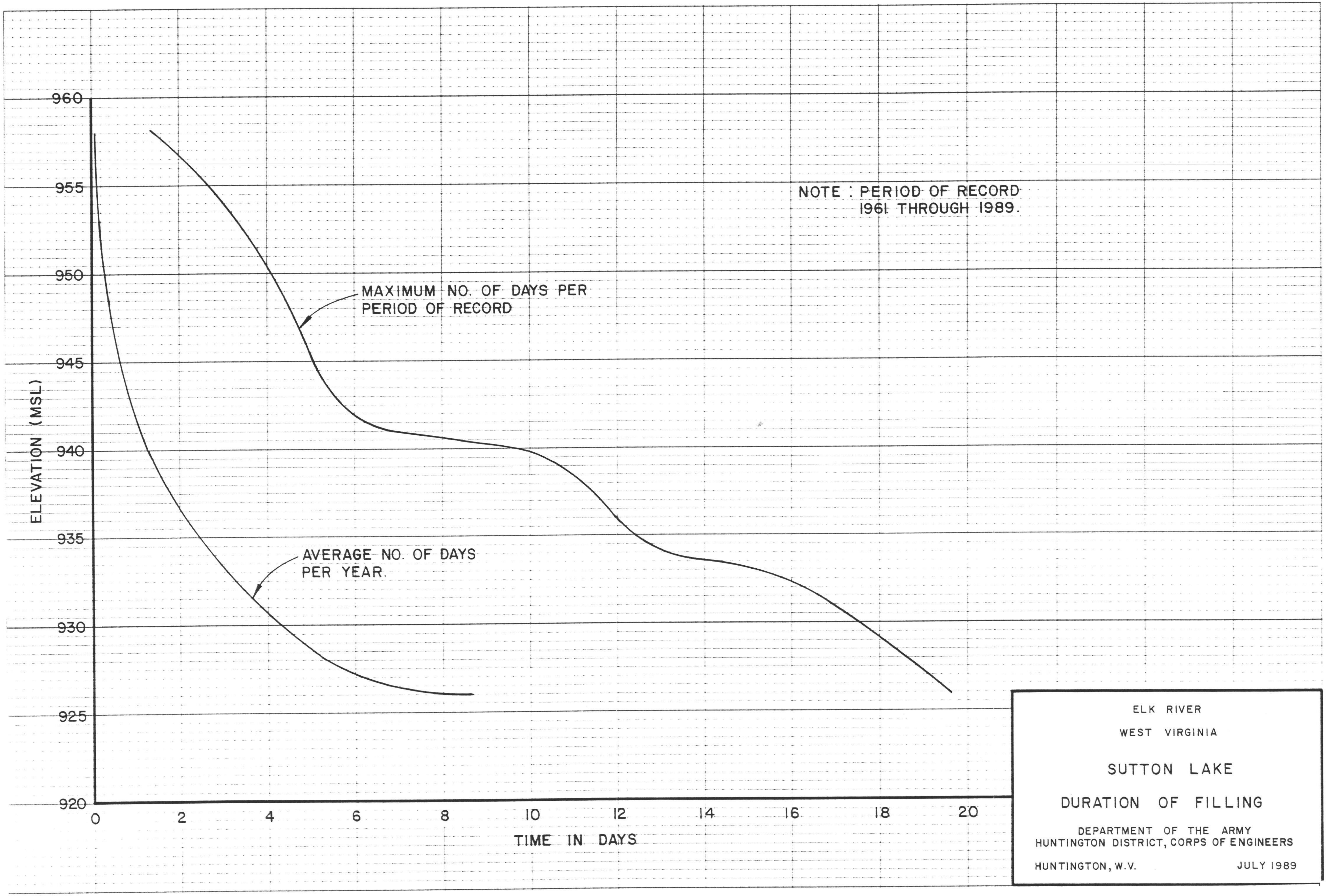
/KANAWHA/SUEOF/ELEV-FLOW/RES OUT/04MAR92/USGS TABLE NO.40 adj/

810	25	815	2650	820	7100
810.1	25	815.1	2730	820.1	7210
810.2	25	815.2	2820	820.2	7320
810.3	25	815.3	2900	820.3	7430
810.4	25.5	815.4	2990	820.4	7540
810.5	26	815.5	3070	820.5	7650
810.6	30.5	815.6	3160	820.6	7760
810.7	35	815.7	3240	820.7	7870
810.8	41	815.8	3330	820.8	7980
810.9	47	815.9	3410	820.9	8090
811	55	816	3500	821	8200
811.1	75	816.1	3580	821.1	8310
811.2	105	816.2	3670	821.2	8420
811.3	125	816.3	3750	821.3	8530
811.4	150	816.4	3840	821.4	8640
811.5	180	816.5	3920	821.5	8750
811.6	220	816.6	4010	821.6	8860
811.7	260	816.7	4090	821.7	8970
811.8	300	816.8	4180	821.8	9080
811.9	345	816.9	4260	821.9	9190
812	395	817	4350	822	9300
812.1	445	817.1	4430	822.1	9410
812.2	500	817.2	4520	822.2	9520
812.3	565	817.3	4600	822.3	9630
812.4	630	817.4	4690	822.4	9740
812.5	695	817.5	4770	822.5	9850
812.6	760	817.6	4860	822.6	9960
812.7	820	817.7	4940	822.7	10100
812.8	880	817.8	5030	822.8	10200
812.9	950	817.9	5110	822.9	10300
813	1020	818	5200	823	10400
813.1	1090	818.1	5290	823.1	10500
813.2	1160	818.2	5380	823.2	10600
813.3	1240	818.3	5470	823.3	10700
813.4	1320	818.4	5560	823.4	10800
813.5	1400	818.5	5650	823.5	10900
813.6	1480	818.6	5740	823.6	11100
813.7	1560	818.7	5830	823.7	11200
813.8	1640	818.8	5920	823.8	11300
813.9	1720	818.9	6010	823.9	11400
814	1800	819	6100	824	11500
814.1	1880	819.1	6200	824.1	11600
814.2	1970	819.2	6300	824.2	11700
814.3	2050	819.3	6400	824.3	11800
814.4	2140	819.4	6500	824.4	12000
814.5	2220	819.5	6600	824.5	12100
814.6	2310	819.6	6700	824.6	12200
814.7	2390	819.7	6800	824.7	12300
814.8	2480	819.8	6900	824.8	12400
814.9	2560	819.9	7000	825	12600


Sutton
Temperature Objective Evaluation
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Deg F
4-Dec
23-Jan
14-Mar
3-May
22-Jun
11-Aug
30-Sep
19-Nov
8-Jan
27-Feb
Date
Objective
Lower Limit
Upper Limit


Sutton
Outflow Temperature Objective
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Deg F
4-Dec
23-Jan
14-Mar
3-May
22-Jun
11-Aug
30-Sep
19-Nov
8-Jan
27-Feb
Date
Avg Outflow Temp (1987-2001)
Old Temp Objective (1987-2001)
New Objective (2002)
Avg Inflow Temp (1987-2001)


MAXIMUM FLOOD CONTROL
POOL ELEVATION 1000.00
SPILLWAY CREST ELEV. 972.0
SEASONAL POOL ELEV. 925.0
NOTE: PERIOD OF RECORD
1902 THROUGH 1955
1961 THROUGH 1989.
ELEVATION (MSL)
1000
990
980
970
960
950
940
930
920
0
10
20
30
40
50
60
70
80
90
100
PROBABLE PERIOD, IN YEARS, IN WHICH ELEVATION WOULD BE EQUALED OR EXCEEDED ONCE
ELK RIVER
WEST VIRGINIA
SUTTON LAKE
FREQUENCY OF FILLING
DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W. V.
JULY 1989



ELK RIVER

WEST VIRGINIA

SUTTON LAKE

DURATION OF FILLING

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. JULY 1989

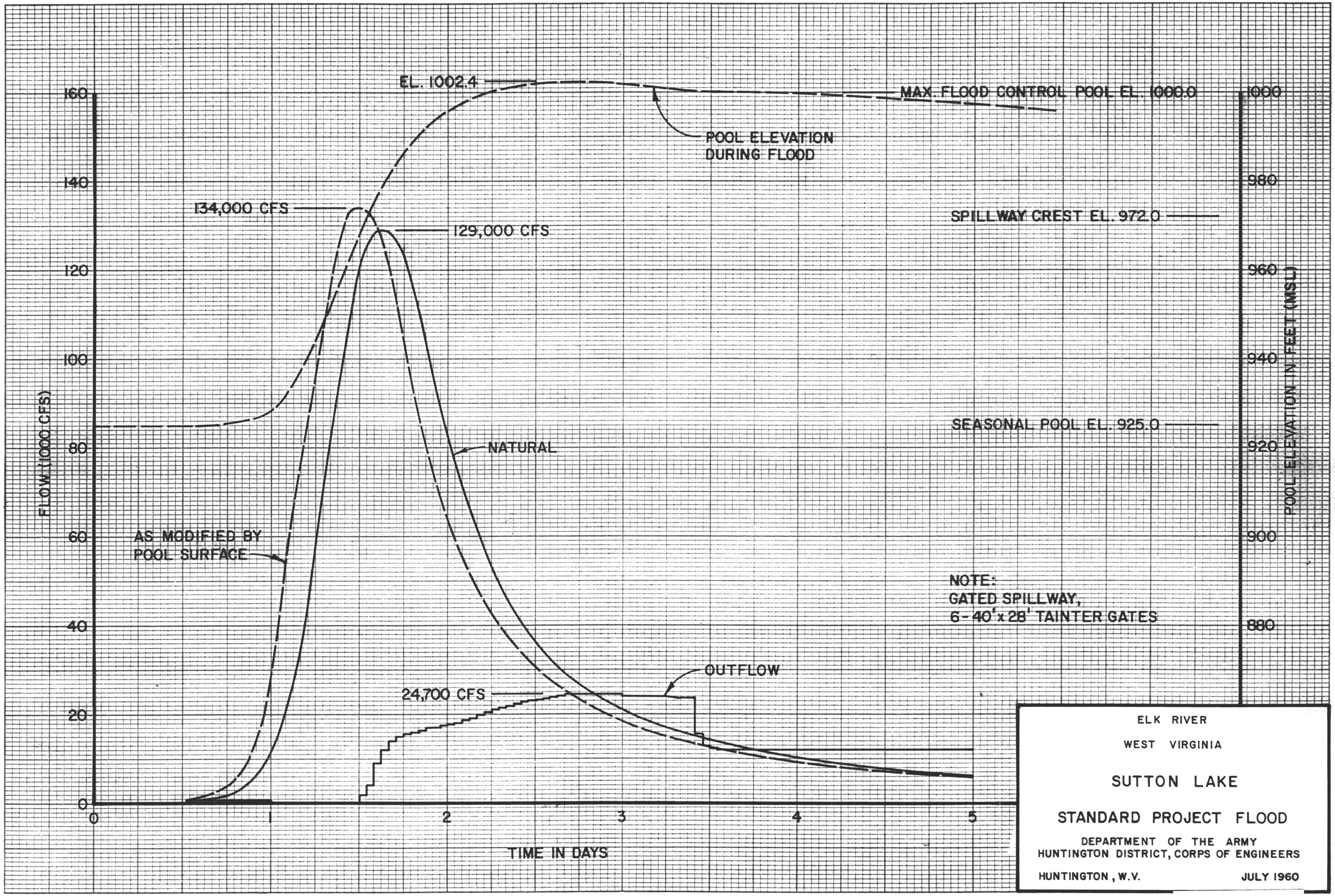
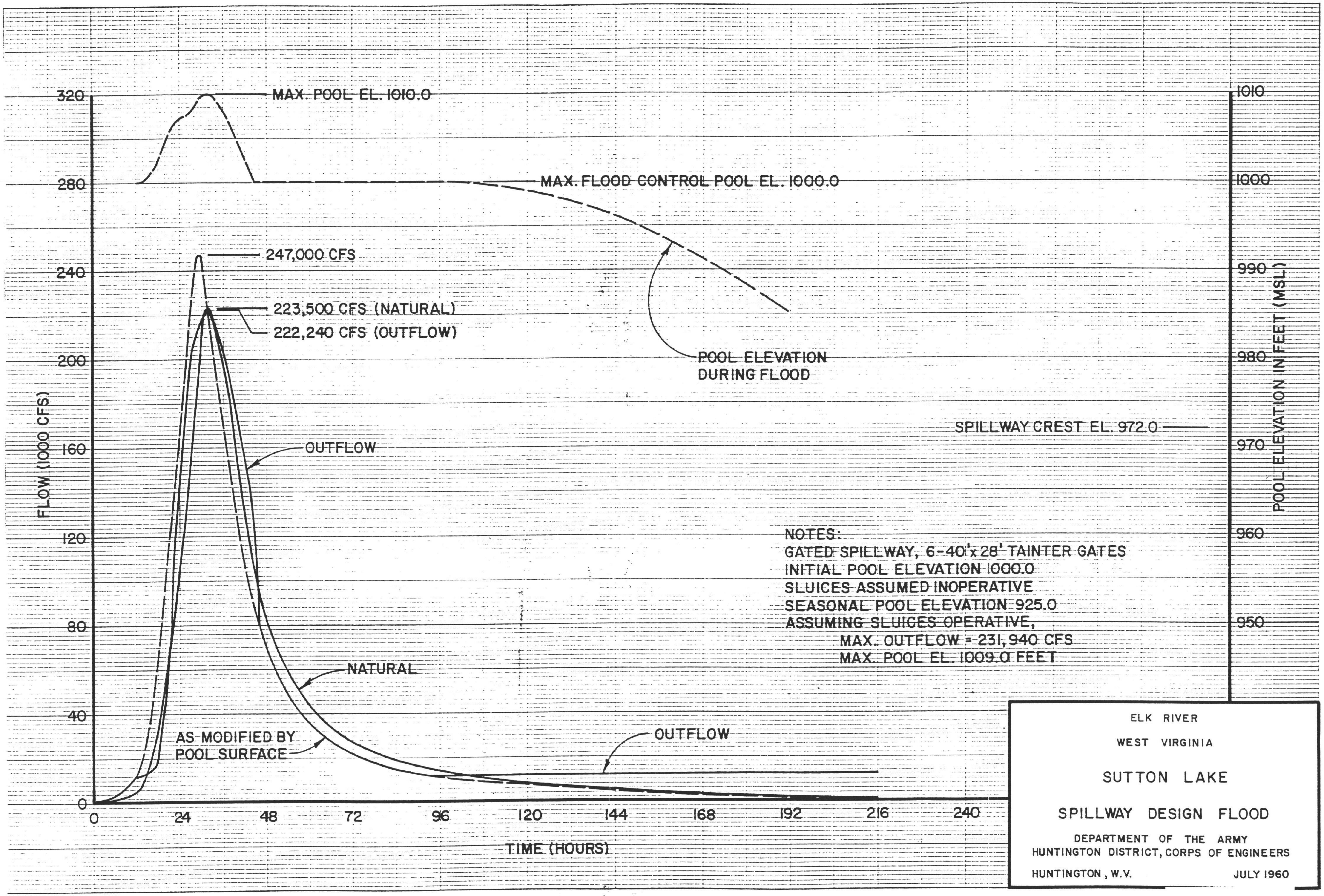

EL. 1002.4
MAX. FLOOD CONTROL POOL EL. 1000.0
POOL ELEVATION DURING FLOOD
134,000 CFS
129,000 CFS
SPILLWAY CREST EL. 972.0
SEASONAL POOL EL. 925.0
NATURAL
AS MODIFIED BY POOL SURFACE
NOTE:
GATED SPILLWAY,
6-40'x28' TAINTER GATES
OUTFLOW
24,700 CFS
FLOW (1000 CFS)
POOL ELEVATION IN FEET (MSL)
TIME IN DAYS
0
20
40
60
80
100
120
140
160
1
2
3
4
5
880
900
920
940
960
980
1000
ELK RIVER
WEST VIRGINIA
SUTTON LAKE
STANDARD PROJECT FLOOD
DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V.
JULY 1960

PLATE NO. 8-3


MAX. POOL EL. 1010.0
MAX. FLOOD CONTROL POOL EL. 1000.0
247,000 CFS
223,500 CFS (NATURAL)
222,240 CFS (OUTFLOW)
POOL ELEVATION DURING FLOOD
SPILLWAY CREST EL. 972.0
OUTFLOW
NATURAL
AS MODIFIED BY POOL SURFACE
OUTFLOW
NOTES:
GATED SPILLWAY, 6-40'x 28' TAINTER GATES
INITIAL POOL ELEVATION 1000.0
SLUICES ASSUMED INOPERATIVE
SEASONAL POOL ELEVATION 925.0
ASSUMING SLUICES OPERATIVE,
MAX. OUTFLOW = 231,940 CFS
MAX. POOL EL. 1009.0 FEET
FLOW (1000 CFS)
POOL ELEVATION IN FEET (MSL)
TIME (HOURS)
0
24
48
72
96
120
144
168
192
216
240
40
80
120
160
200
240
280
320
950
960
970
980
990
1000
1010
ELK RIVER
WEST VIRGINIA
SUTTON LAKE
SPILLWAY DESIGN FLOOD
DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V.
JULY 1960

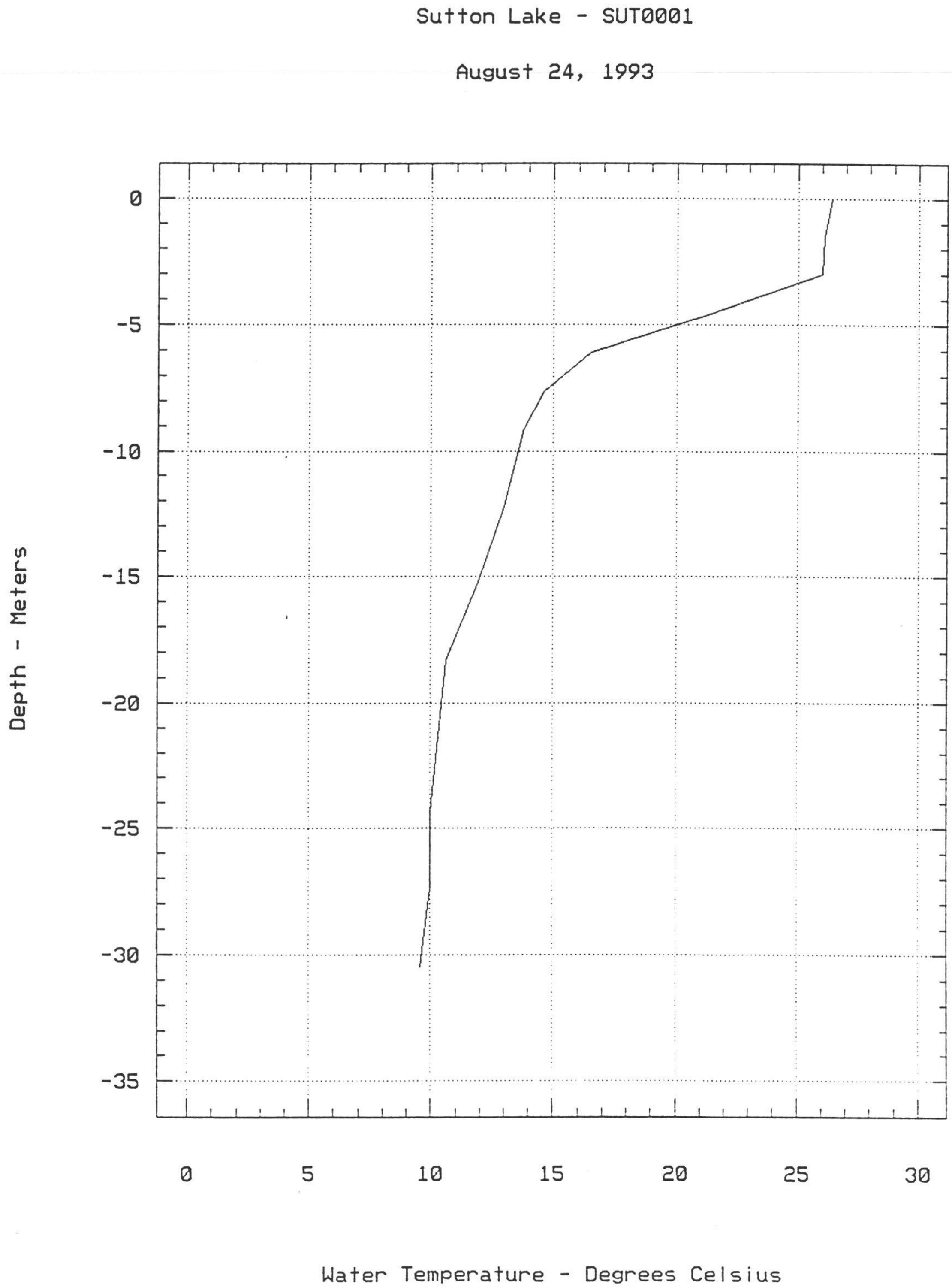

Sutton Lake - SUT0001
August 24, 1993
Depth - Meters
0
-5
-10
-15
-20
-25
-30
-35
0
5
10
15
20
25
30
Water Temperature - Degrees Celsius

PLATE NO. 8-5

Sutton Lake - SUT0001

August 24, 1993

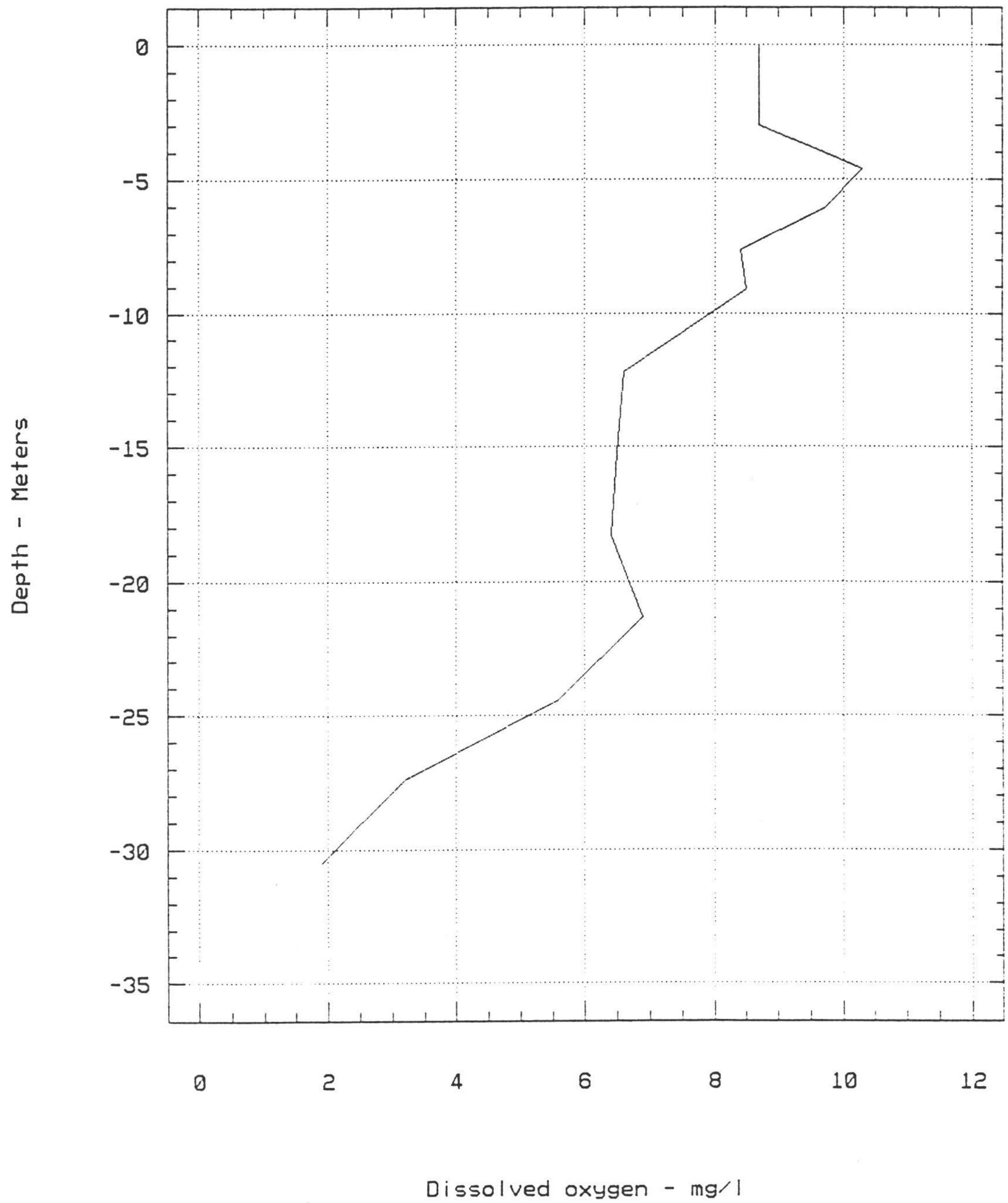
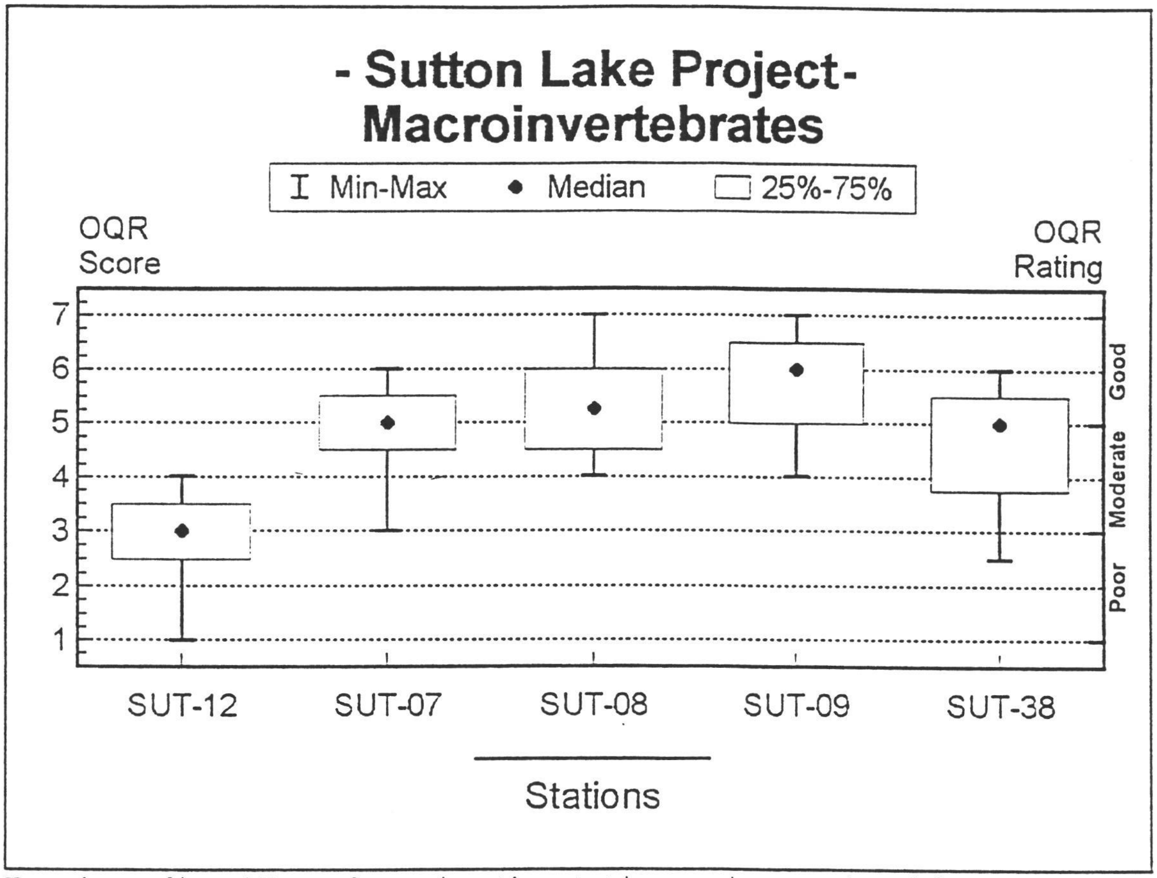
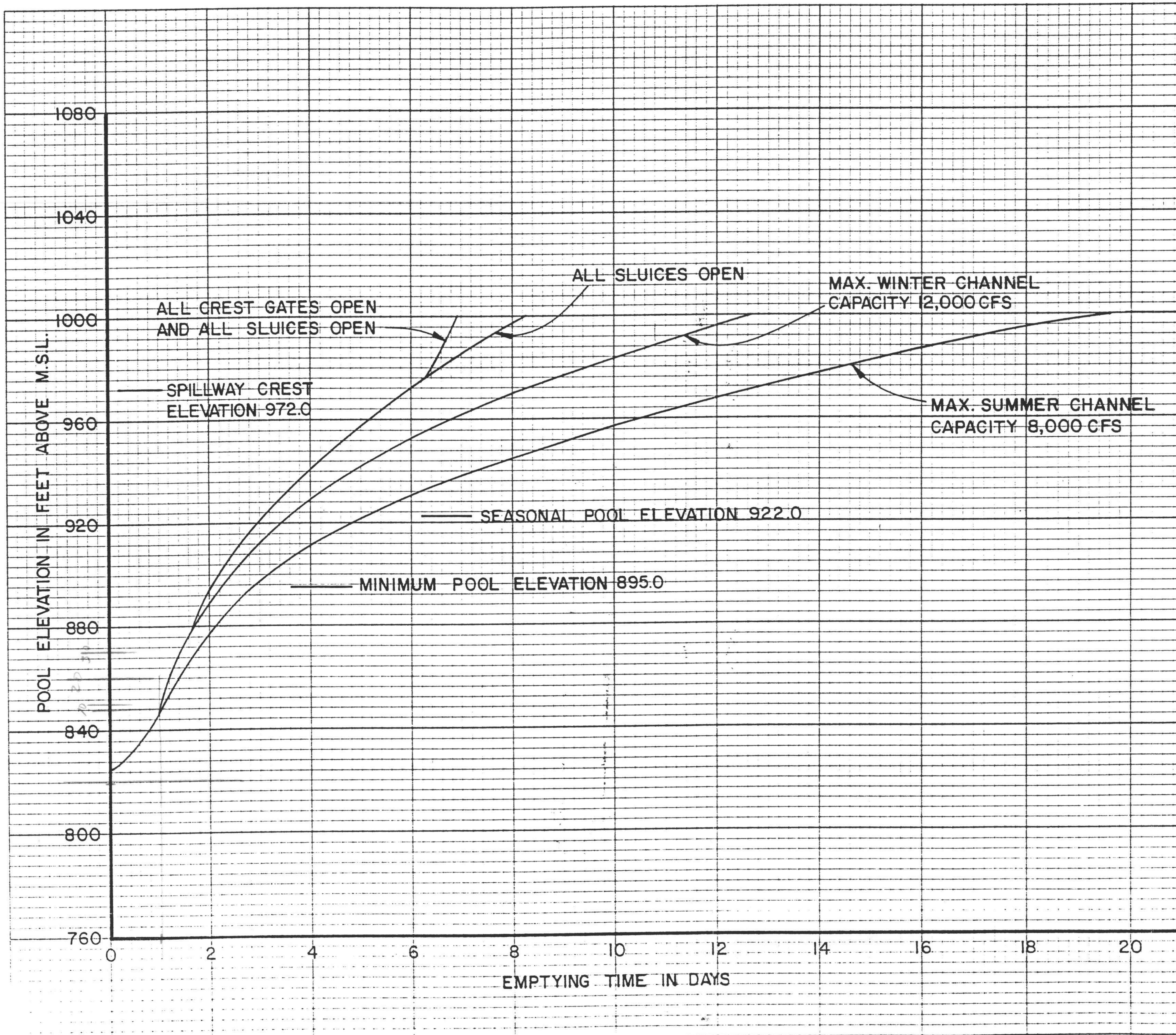


PLATE NO. 8-6



Use the median (●) to determine the station rating on the right. For example, SUT-12 is poor to moderate, while SUT-09 is good.



ELK RIVER

WEST VIRGINIA

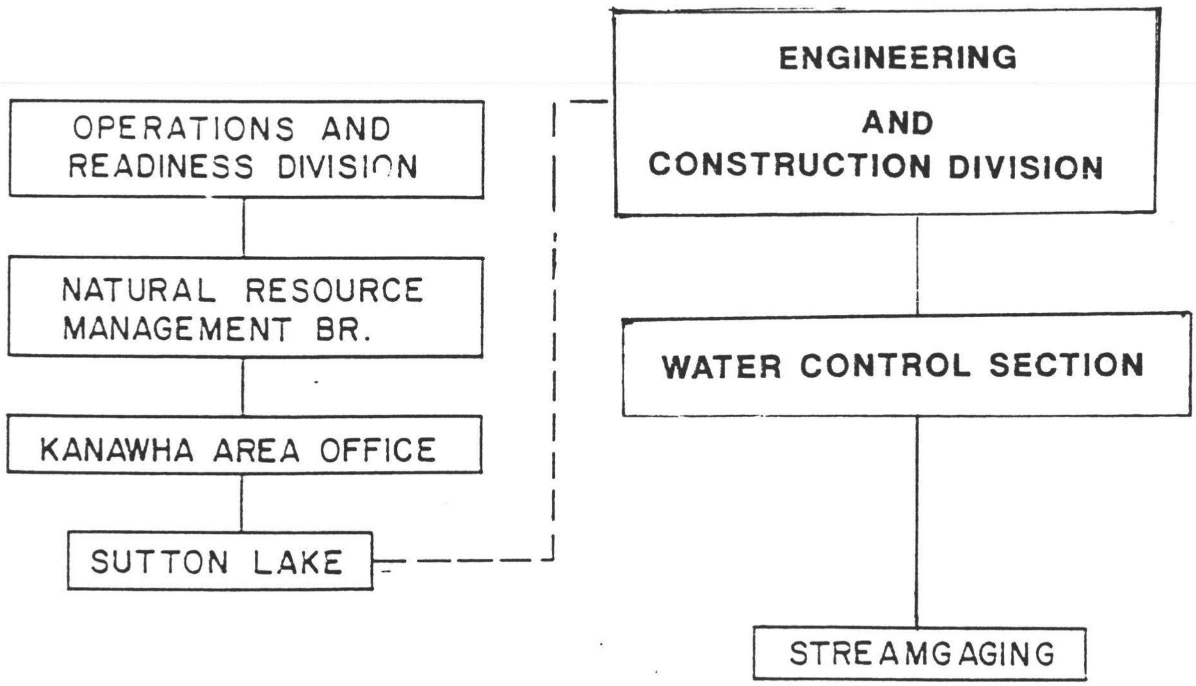
SUTTON LAKE

EMERGENCY DRAWDOWN CURVES

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. OCTOBER 1989

WATER CONTROL MANAGEMENT
SUTTON LAKE BASIN
NORMAL ORGANIZATION



--- WATER CONTROL MANAGEMENT INSTRUCTIONS GIVEN TO PROJECT BY **WATER RESOURCES ENGINEERING BRANCH**

ELK RIVER

WEST VIRGINIA

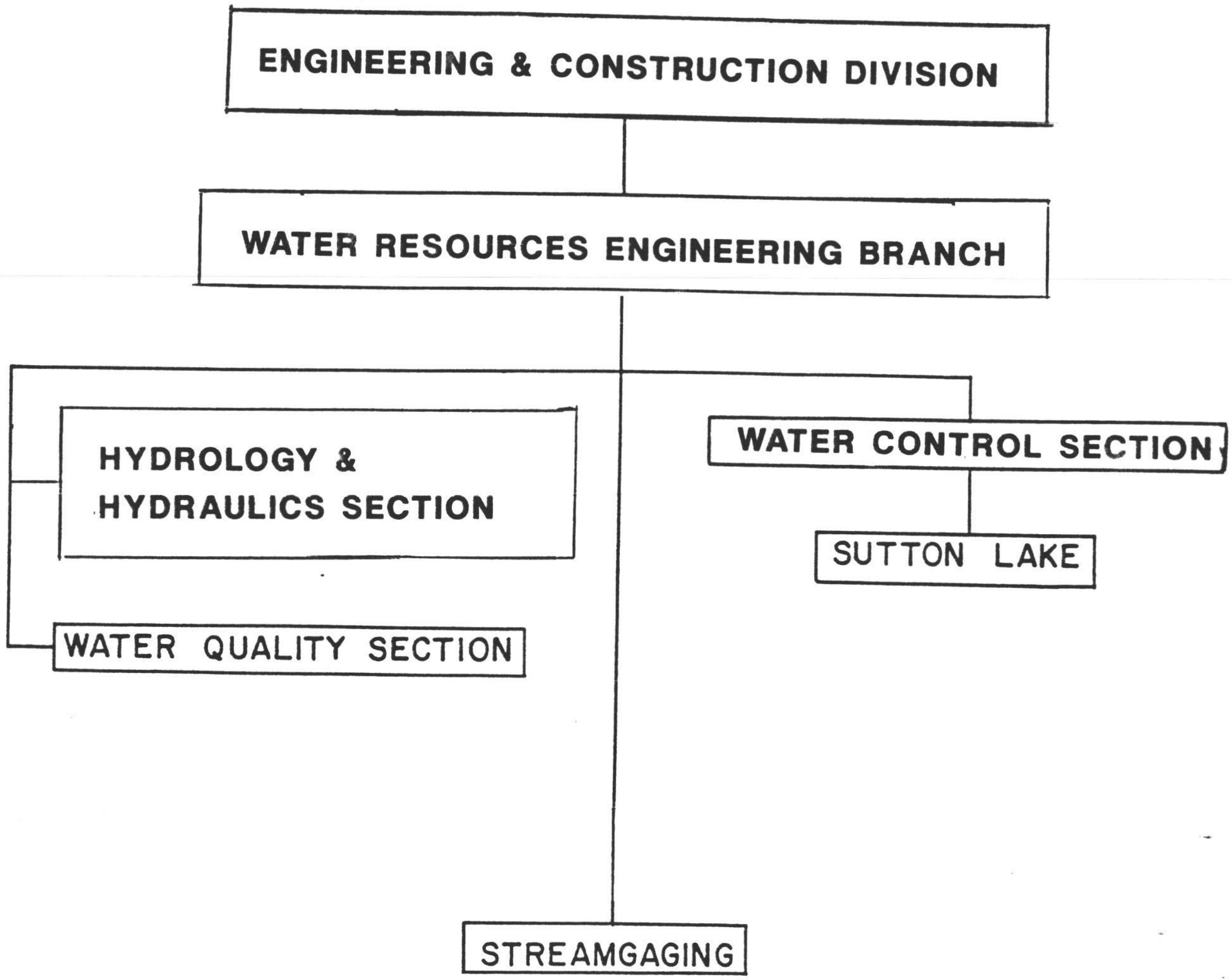
SUTTON LAKE

WATER CONTROL MANAGEMENT
NORMAL ORGANIZATION

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. OCTOBER 1989

PLATE NO. 9-1



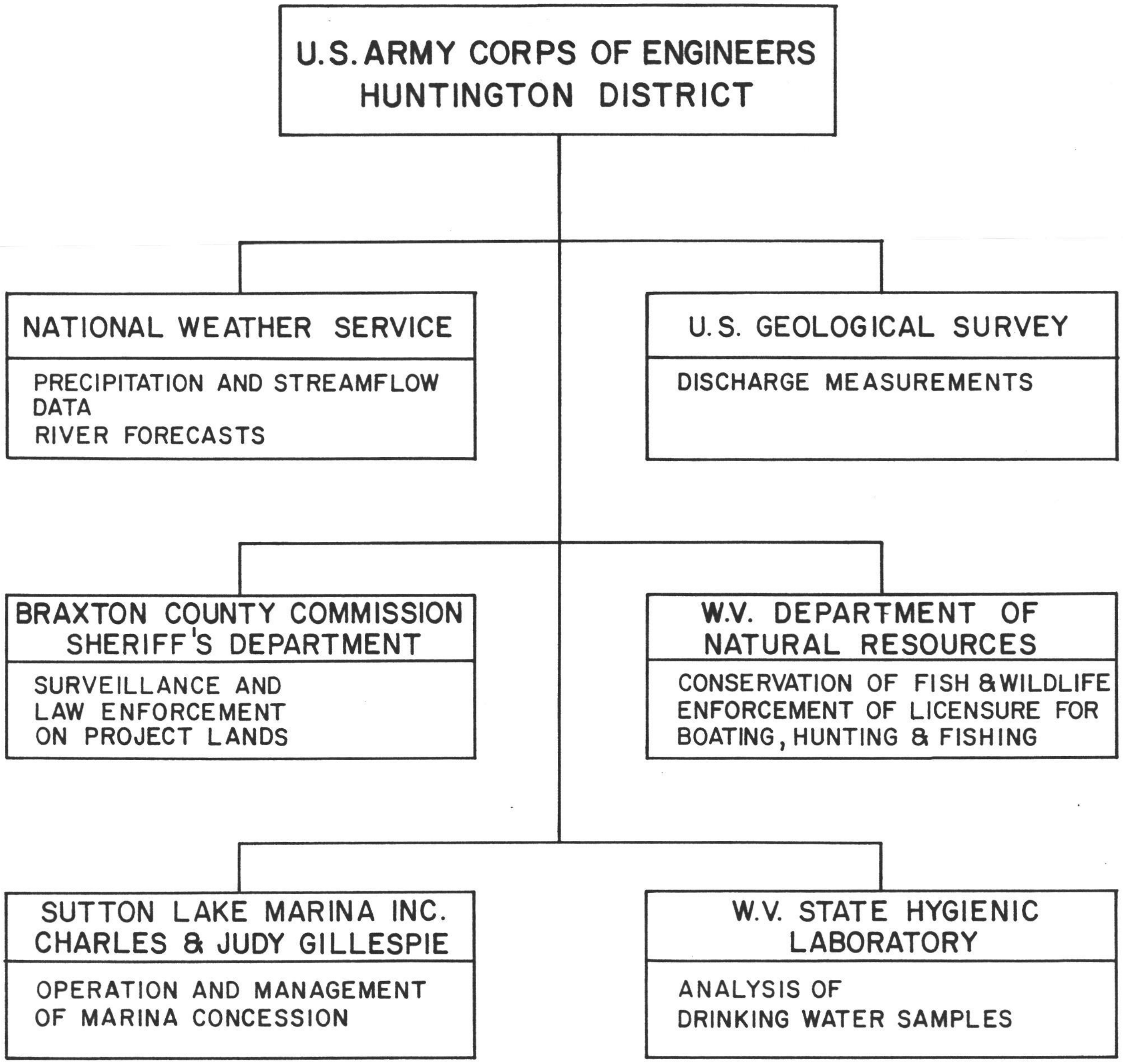
ELK RIVER

WEST VIRGINIA

SUTTON LAKE
WATER CONTROL MANAGEMENT
FLOOD EMERGENCY ORGANIZATION

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. OCTOBER 1989



ELK RIVER

WEST VIRGINIA

SUTTON LAKE

DISTRICT RELATIONS WITH OTHER AGENCIES

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. OCTOBER 1989

PLATE NO. 9-3