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
Clu

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.

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

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.

Instructions to Dam Tender, Section 2 - Precipitation at Ohio River Network Stations

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.

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

This section is rescinded in its entirety and is replaced by sub-section: Historical Files.

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.

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

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.

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

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.

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

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

27 January 2003

REPLY TO
ATTENTION OF:

Engineering & Construction Division
Water Resources Engineering Branch

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Updates for the John W. Flannagan Dam and Reservoir 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: 7-4, 7-5, and 7-6 (main text), Plate Nos. 7-8, 7-9, 7-10, and 7-11 (Plate Section), pages 1-2 and 1-3 (Exhibit B, Instructions to Damtender).

3. Any question 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-JWF (2)
CELRH-OR-BSA
CELRH-EC-WW (2)
CELRH-EC-WH

JOHN W. FLANNAGAN
BIG SANDY RIVER BASIN
KENTUCKY

U.S. ARMY CORPS OF ENGINEERS
GREAT LAKES AND OHIO RIVER DIVISION
HUNTINGTON DISTRICT
HUNTINGTON, WV

PERPARED BY
CORPS OF ENGINEERS
HUNTINGTON DISTRICT
WATER RESOURCES ENGINEERING BRANCH

September 1999

JOHN W. FLANNAGAN DAM & RESERVOIR, VA

NOTICE TO USERS OF THIS MANUAL

Regulations require that this Water Control Manual be published in a hard backed 3-ring binder with the text in loose leaf form. In this way, only those sections or parts thereof requiring changes need be revised and printed. Therefore, this copy should be preserved in good condition in order that single page inserts can be made to keep the manual current. Changes to individual pages must carry the date of revision, which is the Great Lakes and Ohio River Divisions' approval 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 persons:

CORPS OF ENGINEERS

John W. Flannagan Lake Project Office
Rt. 1, P.O. Box 268,
Haysi, VA 24256

Normal Work Hours [redacted]

Person-to-Person, at home [redacted]

Gate Operating Personnel	Home Telephone Number
[redacted]	[redacted]

Big Sandy Area Office
Louisa, Kentucky

Normal Work Hours,
Person-to-Person, at home [redacted]

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]

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BIG SANDY RIVER BASIN
KENTUCKY

PROJECT MANUAL
FOR
WATER CONTROL MANAGEMENT
JOHN W. FLANNAGAN LAKE - POUND RIVER

SECTION 1 - INTRODUCTION

1-01 PROJECT AUTHORIZATION

John W. Flannagan Lake Project, previously titled Pound Reservoir but changed to John W. Flannagan Reservoir by Public Law 86-189 on 25 August 1959, is a substitute for Clintwood Reservoir, included in the comprehensive plan for flood control in the Ohio River Basin. Clintwood Reservoir was one of the reservoirs authorized by the Flood Control Act of 28 June 1938, Public Law No. 761, Seventy-fifth Congress, third session. The project was authorized for flood control, fish and wildlife conservation, water supply, and recreation purposes. A boundary map of the Huntington District showing the John W. Flannagan project location is shown in Plate No. 1-1.

1-02 AUTHORITY, 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 sub-mission 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 ER1110-2-8156 "Preparation of Water Control Manuals" dated 31 August 1995.

The purpose of this manual is to furnish the general plan for the regulation of John W. Flannagan Lake in the Big Sandy 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. The guidelines in EM 1110-2-3600 provide for submission of water control manuals that contain regulation schemes in sufficient detail to establish the basic plan of reservoir operation to be followed under current conditions. This manual supplements the report, subject, "Master Manual for Reservoir Regulation - Big Sandy Basin," in which information required for the coordinated operation of all reservoirs in the Big Sandy Basin is presented.

1-03 RELATED MANUALS AND REPORTS

The following manuals and reports concerning John W. Flannagan Lake or the Big Sandy River projects have been previously completed.

	TITLE	DATE
1.	Report on Big Sandy River and Lower Tug and Levisa Forks (Annual Report of Chief of Engineers)	1875
2.	Report on Levisa Fork Above Pikeville, KY (Annual Report of Chief of Engineers)	1876
3.	Report on Levisa Fork (Annual Report of Chief of Engineers)	1884

4.	Report on Levisa Fork (Annual Report of Chief of Engineers)	1887
5.	Report on Levisa Fork Above Virginia Line (Annual Report of Chief of Engineers)	1888
6.	Report on Big Sandy River and Levisa Fork (Annual Report of Chief of Engineers)	1889
7.	Report on Russell Fork (Annual Report of Chief of Engineers)	1891
8.	Report on Louisa Dam (Annual Report of Chief of Engineers)	1892
9.	Report on Mouth of Big Sandy River (Annual Report of Chief of Engineers)	1893
10.	Report on Big Sandy River and Tug and Levisa Forks (Annual Report of Chief of Engineers)	1898
11.	Report on Levisa Fork Headwaters	1907
12.	Report on Tug and Levisa Forks	1914
13.	Big Sandy River "308" Report	1935
14.	Comprehensive Report on Reservoirs in Mississippi River Basin	1936
15.	Ohio River "308" Report	1936
16.	Comprehensive Flood Control Plan for Ohio and Lower Mississippi Rivers	1937
17.	Report on Preliminary Examination of Big Sandy River and Tributaries, KY and Levisa Fork in the Vicinity of Breaks of Sandy, for Flood Control	July 1937
18.	House Document No. 264, 80th Congress, which considered Clintwood Reservoir.	1948
19.	Interim Survey Report on Big Sandy River and Tug and Levisa Forks, KY, WV, and VA for Flood Control and Applied Purposes	December 1957
20.	Master Regulation Manual for Reservoirs in the Big Sandy River Basin, Including Detailed Regulations Pertaining to John W. Flannagan Reservoir on Pound River(Appendix B)	September 1952 Revised June 1964 Revised January 1969
21.	Interim Survey Report on Big Sandy River and Tributaries, KY, WV, and VA.	October 1964

Design Memorandums:

No. 1. Hydrology	August 1958
No. 2. Access Road	December 1958
No. 3. Geology and Soils	April 1958
No. 4. Diversion Tunnel and Outlet Works	July 1959
No. 5. Spillway and Embankment	June 1959

No. 5A. Supplement to Design Memorandum No.5	June 1960
No. 6. Concrete Aggregates	June 1959
No. 7. Real Estate, Diversion Tunnel	December 1960
No. 8. General Design Memorandum	March 1960
No. 8A. Supplement to Design Memorandum No. 8, Monumentation of Reservation Boundary Lines	July 1966
No. 9. Report on Necessity for Highway Relocations, Commonwealth of Virginia, Dickenson County, VA, (Part I)	July 1960
No. 9A. Report on Necessity for Highway Relocations, Commonwealth of Virginia, Dickenson County, VA,(Part II)	June 1964
No. 10A. Preliminary Master Plan	November 1960
No. 10B. Master Plan	December 1962
No. 10C. Supplement to the Master Plan	December 1963
No. 11. Real Estate - Access Road	March 1960
No. 12. Real Estate - Reservoir Lands (Part I)	December 1960
No. 13. Proposed Acquisition of Highway Easements	February 1961
No. 14. Utility Relocations	June 1962
No. 15. Fallout Protection Facility	August 1961
No. 16. Real Estate - Reservoir Lands (Part II)	October 1962
No. 17. Addition of Storage for Water Quality Control	April 1962
No. 17A. Supplement to Design Memorandum No. 17	November 1962
No. 18. Reservoir Clearing	February 1963
No. 19. Real Estate - Remaining Reservoir Lands (Part III)	October 1963
No. 20. Gated Spillway for Water Quality Control	September 1963
No. 21. Real Estate - Reservoir Lands (Part IV)	November 1964
No. 22. Sediment Range Network Monumentation	April 1975
Supplement No. 1 Report on 1974 Sediment Survey	1975
Supplement No. 2 Report on 1983 Sediment Survey	1984
No. 23. Periodic Inspection and Continuing Evaluation of Completed Civil Works Structures	
Report No. 1	1967
Report No. 2	1969
Report No. 3	1971
Report No. 4	1976
Report No. 5	1981
Report No. 6	1986
Report No. 7	1991

No. 24. Recreation Facilities Report, Supplement to Project Master Plan for Public Use Development and Reservoir Utilization	March 1974
Supplement No. 3	September 1975
Supplement No. 4	April 1976
Supplement No. 5	June 1977
Supplement No. 6	May 1982
No. 25. Dam Failure Inundation Maps for Flood Emergency Plan - John W. Flannagan Dam	February 1983
No. 26. Outdoor Recreation Demand Study for the Levisa Fork of the Big Sandy River	September 1983
No. 27. Dam Safety Training Program Manual, John W. Flannagan Dam	1983
No. 28. John W. Flannagan Lake Master Plan Update	September 1987

1-04 PROJECT OWNER.

The United States Government through the Corps OF Engineers has full title, ownership, and fee control of all Big Sandy Basin Reservoir lands, including John W. Flannagan Lake. The United States Government reimbursed the individual property owners for the surrounding land and now owns the dam and operating structures.

1-05 OPERATING AGENCY.

John W. Flannagan Lake is staffed, attended, and operated continuously by the Huntington District, Corps of Engineers.

The mailing address is:
John W. Flannagan Dam
RR 1, Box 268
Haysi, Va. 24256-9739
Telephone 540-835-8717

The Damtender is:
[redacted]

1-06 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 John W. Flannagan Lake. The locations of various reservoirs within the District are shown on Plate No. 1-1.

Guidelines for routine operations under normal conditions are specified in Exhibit B, "Instructions to Damtenders." 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 Control Section. Operations that deviate from the approved water control plan as presented in this manual are fully coordinated with the Great Lakes and Ohio River Division 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 JOHN W. FLANNAGAN DAM

2-01 LOCATION

John W. Flannagan Dam is located on Pound River, VA, a tributary of Russell Fork, of Levisa Fork of the Big Sandy River 150.0 river miles above the confluence of the Big Sandy and Ohio Rivers and 1.8 miles above the mouth of Pound River. The project is located about 80 air miles south of Huntington, WV, and 4 miles northwest of Haysi, VA in Dickenson County, as shown on Plate No. 2-1. The reservoir also has an upstream tributary lake called North Fork of Pound Lake at Pound, VA. This small lake drains 17.2 square miles and is located 1.1 miles above the forks of Pound River. The drainage areas of both lakes are shown on Plate Nos. 2-2 and 2-3. An aerial view of John W. Flannagan lake is shown on page ii of this report.

2-02 PROJECT PURPOSES

a. General. John W. Flannagan Lake is authorized for flood control, recreation, and fish and wildlife enhancement in a comprehensive plan for the Ohio and Mississippi River Basins. The basic land uses in the John W. Flannagan Lake project area are shown on Plate No. 4-1. Benefits from flood control and water conservation serve not only local interests in the Flannagan Lake Basin, but also the overall Russell Fork, Levisa Fork, Big Sandy and Ohio River Basins.

b. Flood Control. Major flooding can occur at any time of the year in the Big Sandy - Levisa Fork Basin. The upper portion of the basin is subject to headwater flooding, whereas the lower basin is affected by backwater from Ohio River flooding as well as headwater floods. Flood crests on the Big Sandy River resulting from headwater flows generally coincide with high stages on the Ohio River, resulting in greater flooding on the Big Sandy River than would have occurred had the Ohio River been at a lower stage. Conversely, hydrologic studies indicate that high flows from the Big Sandy River significantly increase the stages on the Ohio River during flooding.

Generally, winter-type storms result in flooding on both the Levisa and Tug Forks and the main stream. Summer-type storms usually occur over small tributaries to each of the major Big Sandy Forks, producing severe local "flash" floods without affecting adjacent areas. Floods on the Forks are generally of short duration, seldom remaining above flood stage for more than 24 hours. Because of backwater from the Ohio River, floods in the lower basin are prolonged. The flood control benefits of the John W. Flannagan Lake Project, combined with the other reservoir projects in the Big Sandy Basin, create both local and downstream flood damage reductions to agricultural, industrial, and urban lands.

The flood control storage of John W. Flannagan Lake between the seasonal pool elevation of 1396.0 feet NGVD and the spillway crest elevation of 1446.0 feet NGVD is 78,600 acre-feet, or approximately 7.23 inches of runoff from the 221 square miles of drainage area above the dam. During DEMIA (December to Mid-April), the seasonal pool is normally drawn down to elevation 1380.0 feet, which provides an additional 16,500 acre-feet of flood storage, or another 1.5 inch of runoff from the watershed. Regulation of the storage capacity at John W. Flannagan Lake provides flood protection benefits primarily along Pound River Russell Fork, Levisa Fork, and the Big Sandy River, with incidental benefits to the Ohio and lower Mississippi Rivers.

c. Recreation. Recreation as a project purpose at John W. Flannagan Lake was authorized by the Flood Control Act of 1944 (P.L. 78-534). The Fish and Wildlife Coordination Act of 1958 (P.L. 85-624) provided that fish and wildlife conservation should also be considered as a viable project purpose. The Forest Conservation Act of 1960 (P.L. 86-717) required protection and

sustained yield of the forest resources at reservoir areas.
Prior to the construction of Flannagan Lake, Dickenson County in Virginia did not have a sizable body of water available for recreational use. The area was significantly lacking in non-urban, public recreation facilities, and there was an apparent demand for such facilities. Recreational facilities at Flannagan Lake were designed to provide boating, swimming and fishing waters, along with camping and state park facilities, which were deficient in the area. Access by automobile to Flannagan Lake within the project area is provided by State Routes 63 and 80; U.S. Route 23 and 460; and Interstate 81 and the Mountain and Daniel Boone Parkways are the main access routes to the project area.

An access area is located downstream of the dam on Corps-owned land and provides access to the tailwaters for fishermen. This area also has parking facilities, picnic sites, and a large playground for children.

The Corps of Engineers is responsible for the administration and management of project lands. The State of Virginia was outgranted the forestry, fish and wildlife management of a large portion of these lands. The major recreation attraction at the project, Breaks of Sandy State Park, is managed by the Virginia Department of Parks. Federal rules and regulations governing public use at Flannagan Lake are enforced, along with any State statutes and county ordinances concerning water safety, boating registration, and other items of local jurisdiction which also govern public use. Law enforcement activities at Flannagan Lake are primarily the responsibility of State and local governments. The Virginia Department of Game and Inland Fishery administers state boating, fishing, and hunting regulations on the project water and land areas.

d. Fish and Wildlife. In broad terms, the goals included under this project purpose are the long-term well being of the plant and animal species native to the project area and the maximum sustained enjoyment of these populations by the public. Programs to accomplish these goals were developed in coordination with the U.S. Fish and Wildlife Service and the Virginia Department of Game and Inland Fishery. The recommendations of these two agencies influenced fish and wildlife conservation plans at the project.

The Fisheries Division of the Virginia Department of Game and Inland Fishery, maintains the fisheries in the lake and tailwaters. The Flannagan Lake tailwater fishery consists primarily of rainbow trout that are stocked between April and October on a put-grow-take basis. Based on two cove rotenone studies covering 5.07 surface acres at Flannagan Lake in 1989, pan fishes account for about 53% of the fish stock at Flannagan Lake, followed by forage fishes at 31%, game fishes at 15%, and commercial and food fishes at less than 1% each. Bluegill (51.4%), gizzard shad (21.6%), and white crappie (11.1%), are the most plentiful fish species at Flannagan Lake. The other species present in Flannagan Lake are largemouth bass, spotted bass, channel catfish, green sunfish, longear sunfish, common carp, golden redhorse, bluntnose minnow, brook silverside, brindled madtom, Johnny darter and logperch. The Division of Fish and Wildlife Resources electrofishes and conducts surveys twice a year, and with the help of local sport clubs install fish attractors on a regular basis. In 1988, wildlife clubs used 450 Christmas trees to build fish attractors.

John W. Flannagan Lake project lands support a wide variety of wildlife species. The major game species include ruffed grouse, bobwhite quail, white tail deer, Eastern gray squirrel, Eastern cottontail, and the raccoon. Many nongame birds and mammals, as well as amphibians and reptiles, reside at Flannagan Lake. Flannagan Lake and the surrounding lands in Dickenson County also provide habitat for the bald eagle, peregrine falcon, and the Indiana bat, all 3 of which are on the federally recognized endangered species list. The wildlife management program at Flannagan Lake makes it one of the most popular hunting grounds in Virginia. Edge thinning, forest openings, and food plantings are used to enhance the habitat. Wood duck boxes have aided the nesting of wood ducks.

e. Conservation and Water Quality Storage. Reservoir storage below

minimum pool elevation 1314 has been provided for siltation reserve and general conservation purposes while storage between elevation 1314 and 1380 feet NGVD has been provided for water quality control to provide low-flow augmentation in the Russell and Levisa Fork and Big Sandy River Basin. Based on the recommendations of the U. S. Public Health Service report, dated February 1962, a minimum continuous flow of 190 cfs at Pikeville, KY, and 200 cfs in Levisa Fork at Paintsville would be necessary for proper water supply. This would require an additional water quality storage of 38,900 acre-feet to provide sufficient water to augment normal releases from Flannagan and Fishtrap reservoirs for the downstream cities. Seasonal storage between elevation 1380 and 1396 feet NGVD has been provided for general conservation and recreation purposes, subject to flood control, minimum releases and in an emergency to malarial control requirements.

The U. S. Fish and Wildlife Service, in a report on low-flow requirements, requested that a seasonal pool be provided to maintain minimum downstream flows of 100 cfs during April and May and 75 cfs from June through November. Subsequent studies indicated that, to provide such large flows, the seasonal pool would encroach on the flood control pool to such an extent that there would be many years in which it would be impossible to replenish the pool in the spring to provide the desired flows. The Fish and Wildlife Service subsequently requested that a continuous downstream flow of 50 cfs be generally maintained in accordance with a rule curve during the period April through November and 10 cfs be maintained during the remainder of the year. Operation studies covering the period of record indicated that if the top of the seasonal pool were established at elevation 1350 feet NGVD, a minimum release of 50 cfs could be maintained every year during the period of April through November except during the critical drought year of 1930. After approval of water quality control storage for Flannagan Reservoir, the increment of storage between elevation 1314 and 1350 feet NGVD was added to the water quality pool, elevation 1380 feet NGVD, to establish the new seasonal pool elevation at 1396 feet NGVD. As long as the pool elevation is above the lower limiting rule curve, shown on Plate No. 2-18, a minimum release of 50 cfs will be provided from April through November and 10 cfs from December through March. Releases will be maintained in accordance with the lower limiting rule curve if it is impossible to provide the minimum values of 50 or 10 cfs and remain above the lower limiting rule curve during the designated periods.

The completion of Greenup Locks and Dam project on the Ohio River has created favorable conditions to industrial development in the lower 15 miles of the Big Sandy River. Due to increased industrial activity in this general area, the Public Health Service believed it advisable to estimate the water needs to develop the economic potential of the Big Sandy Basin during the next 50 years. Studies of water needs included municipal and industrial water supply under provisions of the Water Supply Act, Public Law 85-500 and flow regulation for water quality control under Public Law 87-88. For the purpose of evaluation water quality control needs have been developed under the assumption that secondary treatment or its equivalent will be provided by all municipalities and industries in the basin.

Since John W. Flannagan Reservoir was utilizing one of the better dam sites in the basin, additional storage was included in this reservoir to improve downstream water quality. For example, at Paintsville, KY, the minimum monthly flow expected has increased from 11 to 21 cfs. Dewey Reservoir, by releasing a minimum flow of 10 cfs at all times, has greatly improved the minimum flow conditions on Levisa Fork downstream from the confluence of John's Creek. The Public Health Service concluded that while there was an adequate amount of water available for municipal and industrial water supply, there was a definite need for improvement of the quality of the basin water supply. On the basis of this study, the Public Health Service recommended the following:

1. Maintain a minimum assured flow of 190 cfs at Pikeville, 200 cfs at Paintsville, and 232 cfs at Louisa. This would include 8 cfs from uncontrolled area at Pikeville, 125 cfs from summer reservoir releases, and 62 cfs augmented

flow from Flannagan. This augmented flow at Pikeville would normally meet the required minimum flow further downstream at Paintsville and Louisa.

2. Flow augmentation of 300 cfs should be provided at Louisa, KY for water quality control before 1975. This flow of 300 cfs should be in addition to the 79 cfs provided by minimum natural flows and nominal seasonal storage.

On the basis of the recommendations of the Public Health Service, Flannagan Reservoir Design Memorandum No. 17, "Addition of Storage for Water Quality Control," was prepared and transmitted to the Chief of Engineers for review and approval. The Chief of Engineers requested that a supplement to Design Memorandum No. 17 be prepared to fix the most economical location and design of a gated spillway to provide the additional storage for water quality control. The design and cost estimates in DM No.17 were based on operation studies that maintained a continuous minimum flow of 200 cfs in Levisa Fork at Paintsville. In order to maintain this flow of 200 cfs at Paintsville, 38,900 acre-feet of additional storage would be required in Flannagan Reservoir. Detailed low-flow routing studies prepared for the supplement to DM No. 17, using the same water quality storage originally proposed in DM No. 17, indicated that minimum flows could be provided at selected stations as indicated below:

Minimum Daily Average Flow

Station	Natural	Case I	Augment	Case II
Levisa Fork at Pikeville	8	28	8+125+62	184
Levisa Fork at Paintsville	17	57	17+160+62	200
Big Sandy River at Louisa	49(est)	114	49+185+62	226

Case I - Natural flow plus winter releases flow from upstream lakes.
Case II - Natural flow, plus seasonal releases from upstream lakes, plus augmented water from John W. Flannagan and Fishtrap lakes.

3. Water Quality Regulation. The plan of regulation for water quality control augmentation in the Big Sandy River Basin, as used for design purposes, consisted of utilizing the water quality storage in Flannagan Reservoir, in conjunction with nominal releases from Dewey and Fishtrap Reservoirs, to maintain a continuous minimum flow of 206 cfs at Paintsville, KY. Reservoir operation for design purposes was based on hindsight operation, however, after construction of the dam, it became necessary to forecast streamflows in order to operate the reservoir. In order to successfully operate Flannagan Reservoir for water quality augmentation, it becomes necessary to forecast flows at downstream control stations. Due to the long low-flow travel time from Flannagan Reservoir to Paintsville and Louisa, it is impossible to forecast these stations using existing forecast procedures as developed for flood control operation. Until refined forecast procedures can be developed from actual reservoir operation, it is proposed to operate Flannagan and Fishtrap reservoirs for water quality based on the single control station at Pikeville. It has been determined from previous studies that a minimum continuous flow of 190 cfs at Pikeville will provide the necessary water quality requirements at Paintsville and Louisa most of the time. Public Health officials concurred with this proposed plan of operation at a conference with the Corps of Engineers in May 1966, with the provision that a monitoring network be established and more elaborate operation procedures would be developed in the future.

Although the malaria vector, Anopheles quadrimaculatus, is present, the reported incidence of malaria is low and the Pound River Russell Fork areas are considered to be outside the endemic malaria zone. The topography and aquatic plant life in the area are such that little opportunity for significant Anopheles quadrimaculatus breeding is likely to occur, if normal precautions are taken. The narrow flood plains are generally well drained and it is unlikely that ponding of water will result from reservoir drawdown. Should operation of the reservoir reveal any stagnant pools, proper drainage will

prevent mosquito breeding. Reservoir clearing to above seasonal pool level, and proposed maintenance thereof, should be beneficial in prevention of mosquito breeding along the reservoir shores. The reservoir regulation program for malaria control follows:

1. The normal operation for minor rises will result in lake levels high enough to strand driftwood, trash and other spring debris.

2. Since mosquito breeding is considered unlikely to occur to any great degree, it can be controlled by larviciding, if necessary.

3. During seasons in which there are no rises in stream flow, operation under the schedule for low-flow regulation will result in a desirable recession from the summer pool elevation. Considering the above procedures, it is not necessary to provide a regulation program designed for malaria control.

f. Special Purposes. A wide range of people needs involving water flow or stage within the sphere of project influence are often called special purposes. 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 individually evaluated with respect to the hydrometeorological outlook and with respect to the impact on other project purposes. The Water Control Section coordinates minor deviations and FAX'S the results to CELRD; major deviations must be coordinated with the Water Management Branch in the Division Office. After evaluation and coordination, the Chief of the Water Control Section either directs the regulation to the Damtender to answer the need or denies the request. A record of each approved request is recorded on Form ORD 1018R, Record of Deviation from Approved Plan, shown as Plate No. 4-2.

2-03 PHYSICAL COMPONENTS

a. General. The John W. Flannagan Lake project includes a rock-fill clay core dam, outlet works, discharge tunnel, and a concrete-lined, controlled and gated side hill chute-type spillway 0.3 mile from the dam. General details of the dam, spillway, and outlet works are shown on Plate No. 2-3.

b. Dam. The rock-fill dam has an impervious core of clay and clayey sand, protected from leaching by a filter on both sides. Overall length of the structure is 916 feet with top of dam at elevation 1460 feet above NGVD, 250 feet above the streambed. Top of the intake structure is at elevation 1492 feet above NGVD. Top width of the dam is 32 feet and maximum base width is 1030 feet. General plan, profile, elevation, and typical sections are shown as Plate Nos. 2-3, 2-4, and 2-5, respectively.

c. Spillway. The gated spillway structure is located across Cane Branch, adjacent to the right of the dam. The spillway structure consists of six tainter gates, each 42-feet wide and 38-feet high, five piers, each 8-feet wide, one 6-foot wide by 4-foot high sluice gate, gate operating machinery and an access highway bridge across the spillway. Gross spillway width between the downstream abutments is 292 feet while the net spillway width, between the piers and abutments, is 252 feet. Spillway crest elevation is at 1410 feet above NGVD, gate seat elevation is 1409.52 feet NGVD, top of gate elevation, in closed position, is 1448 feet NGVD. The 6-foot wide by 4-foot high sluice gate is located on the upstream face of the right abutment and will normally be opened, except when pool elevation is above 1408 feet NGVD, maintain normal low-flows in Cane Branch. General Layout and spillway plan and profile sections are presented as Plate Nos. 2-6 and 2-7.

d. Outlet works. The outlet works consist of an intake structure,

outlet tunnel and hydraulic jump type stilling basin. The intake structure is an octagonal concrete tower 262 feet high with 22-foot inside dimensions. The gate chamber is located in the lower 53 feet of the tower, and contains two 4-foot by 8.5-foot water passages, each controlled by a high pressure slide gate in tandem with an emergency slide gate. Three high level by-pass conduits for low-flow releases are connected with inlet ports at elevations 1298, 1313 and 1328 feet above NGVD. Each by-pass consists of a 24-inch steel pipe controlled by a motor operated gate valve. The outlet conduit is a 16-foot diameter concrete lined, horseshoe type tunnel 867 feet long and located through a ridge forming the left abutment of the dam. Located at the downstream end of the outlet conduit is a hydraulic jump type energy dissipater. The stilling basin consists of a heavy concrete slab 31 feet wide at the widest portion and 45 feet long. Plan and profile sections of the outlet works and sectional elevations of the intake structure are presented as Plate Nos. 2-8 and 2-9, respectively. Rating curves for the slide gates and the low-flow, by-pass valves are presented in a later section.

e. Tainter gates. The six tainter gates are raised and lowered by the use of individual electric powered rope type hoists. Each hoist consists of a drive end unit and a driven end unit interconnected by a drive shaft supported by bearings attached to the cat walk between piers. The drive end unit is provided with a 5 HP motor, a primary reducer, a brake to hold the gate in any position with power off, a traveling nut limit switch to provide 1-foot incremental control, to prevent overtravel of the gate when raising or overrun of the ropes when lowering, and a gate position indicator. Drive end units are located on the left abutment and on each of the supporting piers. An emergency motor has been installed on the right abutment so that each gate can be operated in an emergency by the drive motor for the adjacent gate on the right. This is accomplished by disengaging the coupling near the normal drive motor and inserting a temporary telescopic coupling near the emergency drive motor. All gate operating machinery has been designed for outdoor installation.

f. Cane Branch sluice gate. The Cane Branch sluice gate is a standard 6-foot wide by 4-foot high gate with a flush bottom for seating pressure. The invert of the gate opening is at elevation 1396 feet NGVD while the motor operated floor stand is installed at elevation 1460 feet NGVD. The floor stand is designed to support the gate by a stem guided by bearings mounted on the concrete face. In addition to operation by the 1½ HP electric motor, the hoist is provided with a handwheel for independent manual operation in event of an emergency condition. Under motor operation, the gate can be raised or lowered at the rate of approximately 1 foot per minute and is capable of being lowered when the pool elevation is at 1446 feet NGVD. The gate is normally fully open when the water surface is below elevation 1408 feet NGVD, however, when the reservoir pool level is rising rapidly start closing the gate as the pool rises above elevation 1406 feet NGVD and have it completely closed when the pool level reaches elevation 1408 feet NGVD.

g. Slide gates. Two slide gates are provided for use in routine operating situations and are designed to operate against a maximum hydrostatic head of 212 feet. Hydraulically operated, vertical lift slide gates close the gate chamber opening of 4 by 8.5 feet. Each gate assembly consists of frames, seal strips, gate leafs, gate leaf stem, leaf nut, gate stem extension, hoist cylinder, hydraulic piston, gate bonnet and cover, gate leaf position indicators, semi-automatic gate hangers and all other accessories necessary for the operation of the gates. The hydraulic hoist cylinders that operate each gate have a maximum working pressure of 1,000 psi with oil being supplied from a central oil pumping station. The hydraulic control system includes two motor driven oil pumps, piping, fittings, valves, gauges and oil storage tank. Motors for the oil pumps are rated at 15 horsepower, 208 volts, 3 phase, 60 cycle. Each slide gate is equipped with a mechanical leaf position indicator graduated to read to the nearest tenth of a foot with numerals opposite each whole foot division. In addition to the mechanical indicators for each slide gate, each of the two service gates is provided with a remote gate position indicator located on the wall above the 4-way valves. The remote gate position

indicators consist of a watertight housing and a stationary dial calibrated from 0 to 8.5 feet in incremental units of feet and tenths of a foot.

h. Emergency slide gates. Each service gate has an exact duplicate gate placed in tandem to act as an emergency gate. Each emergency gate is equipped with a mechanical leaf position indicator.

i. Multiple high level intake valves. By-pass conduits are connected with high-level intakes to provide selective withdrawal and passage of water for downstream low-flow releases. The high level selective withdrawal intakes are at invert elevation 1328, 1313, and 1298 feet NGVD. Each inlet pipe is regulated by an electrically operated, 24-inch, square bottom, non-rising stem gate valve constructed to function at partial openings under various heads. In addition to being motor operated, each service valve is also equipped with a hand operated wheel to be used for emergency operation in the event of a power failure. In addition to a service valve, each inlet pipe also contains an emergency hand operated, 24-inch, square bottom, gate valve placed downstream in tandem with each service valve. Motor operated valves have a gate speed of 6 inches per minute operated by a 208 volt, 60 cycle, 3-phase electrical motor. In addition to a local mechanical valve position indicator on every valve, each service valve is provided with a remote position indicator located on the switchboard and graduated in percentage of valve openings. These high level low-flow valves were intended to function at the original seasonal pool level of 1328 feet NGVD. When the large water quality pool was added to Flannagan Lake, raising the minimum pool to 1380 feet NGVD, the inlets were not raised, hence they are used for low-flow and not for the original intended selective withdrawal and water temperature function.

j. Auxiliary power units. A separate emergency source of power is provided for both the intake structure and the gated spillway structure. [redacted] The generator is driven by a 4-cycle, 6-cylinder diesel engine, which produces 120 percent of the power required by the generator. [redacted] This unit is capable of carrying the estimated demand loads as well as maintaining satisfactory voltage during starting of a tainter gate hoist motor.

2-04 GUIDE TAKING LINE AND LAND ACQUISITION

Project lands at the John W. Flannagan Reservoir site were acquired under the authority of the Flood Control Act of 1938. The guide taking line for acquisition of lands within John W. Flannagan Reservoir was predicated on the inclusion of all land upstream from the dam and below elevation 1451.0 feet NGVD. This elevation was established by routing the winter type Standard Project Flood Series through the reservoir with an initial elevation of 1380.0 feet NGVD, maximum winter seasonal pool elevation, using the present plan of reservoir regulation. The Standard Project Flood Series was routed through the reservoir, utilizing induced surcharge storage and a spillway gate regulation schedule, and reached a maximum pool elevation of 1448.9 feet NGVD, and by the addition of 2 feet for freeboard, the taking line was established at elevation 1451.0 feet NGVD. Real estate planning studies indicated that the increased expenditures necessary to obtain the right to flood the surcharge area would not be excessive, since the additional real estate requirements would be largely confined to the headwater portion of the reservoir, resulting mainly in extending the flowage easement acquisition. Additional areas were acquired in fee where parcels were isolated by the loss of access and costs were prohibitive for alternative access, or where all farmable land and/or buildings were necessary for construction or borrow areas. Coal reserves were acquired below elevation 1450 feet NGVD together with all coal within 200 feet horizontally of that elevation on most tracks. Flowage easements were acquired

over oil and gas reserves below elevation 1450 feet NGVD with drilling restricted below elevation 1410 feet NGVD. The land acquisition program involves approximately 7762 acres of land (400 tracts). As of August 1968, all land tracts had been acquired except one tract on which settlement was pending. Much of this property is leased or licensed for resource management and development by the Virginia Department of Game and Inland Fishery . The limits of the acquired lands at Flannagan Lake are shown on Plate No. 4-1.

2-05 RECREATION AND PUBLIC USE FACILITIES

The general plan of development is shown on Plate No. 2-10. Responsibility for development and management of the dam and reservoir areas is assigned to the Operations and Readiness Division of the Huntington District, U. S. Army Corps of Engineers. All recreation areas were developed in conjunction with a water quality control pool established at elevation 1380.0 feet above NGVD. All proposed and completed recreational layouts for public use and access areas were developed in accordance with EM 1130-2-312. Recreation areas have been located with respect to access and availability of topography suitable for camping, swimming, picnicking, sightseeing and boat launching areas. Construction on initial development areas began in April 1964 and was completed in the fall of 1964. The Corps of Engineers operates and maintains about 400 acres of land and 39 miles of shoreline consisting of all phases of recreation throughout the reservoir area, including patrol activity by reservoir rangers to enforce safety measures for boating and other water and land uses. Operation and maintenance of public use areas will be somewhat different from other Huntington District Reservoirs due to the extremely rugged terrain in and adjacent to the reservoir. Several of these areas may be inaccessible in the early spring and late fall months and will tend to shorten the recreation season for Flannagan Reservoir by about 2 months in comparison with most reservoirs in the Huntington District.

Fishing, boating, camping, hunting, picnicking, hiking, waterskiing, and swimming are among the recreational activities enjoyed at John W. Flannagan Lake. Facilities include 236 campsites, 165 picnic units (including 13 shelters), 7 boat launch lanes, 320 boat slips, 17.9 miles of trails, and 2 public swimming pools. Listed in Table No. 2-1 are recreational sites in operational condition in 1993. Future sites and improvements will be constructed as joint funding is arranged with another governmental agency, such as the Virginia Department of Game and Inland Fishery. Many of the existing facilities have been developed through cost sharing agreements with the State of Virginia. Additional park facilities include a golf course, an outdoor theater, a lodge and park headquarters, and a stable. Recently whitewater rafting has become increasingly popular on the Russell and Levisa Forks. This is expected to increase further in the next few years and is being studied at the present time by the Corps of Engineers for growth potential. In addition to these areas developed for intensive recreation use, most of the remaining federally owned lands are leased to the State for wildlife and forest resources management. Flannagan Lake recreational facilities are shown on Plate No. 4-1.

TABLE No. 2-1

RECREATIONAL SITES AT JOHN W. FLANNAGAN LAKE

Area Name	Status
Operations Area Visitor Center and Overlook	Complete
Tailwater and Hollow Place Area	Complete
Lower Twin Area	Complete
Junction Area and Marina	Complete
Cranenest Launch Ramp and #1, #2, and #3 Area	Complete
Pound River, North & South Brush Creek, Bearpen Areas	Complete

a. Corps-Operated Sites. The Corps of Engineers operates and

maintains the following public use and recreation facilities.

(1) Damsite and Spillway. The damsite and spillway recreational area is comprised of approximately 29 acres which are improved with picnic units, 109 paved parking spaces, 25 stone parking spaces, launching ramps, comfort stations, twenty cookers, trash containers, dusk-to-dawn lighting, picnic shelters, a bulletin board, several benches, drinking fountains, and a sewage treatment plant. Sixteen pieces of playground equipment are available for children's usage. The area is accessible from U.S. Route 23/460 via Virginia State Route 63, or from U.S. Routes 119/23 traveling north through the project from the community of Pound, VA, also via State Route 607 and 614.

(2) Below dam tail-water Hollow Place picnic camping Area. This area is accessible by Route 614 and is located on 84 acres of land below the dam. Eighty-three paved parking spaces are provided as well as 16 additional picnic units, 1 vault-type comfort stations, trash containers, and 3 drinking fountains.

(3) Cranenest River Campground. Access to this 49-acre fee controlled area is gained from Clintwood, VA, by State Route 83 to the Camp Creek access road, then seven miles to the campground. Facilities include 37 tent sites with tables and cookers, 30 camp trailer sites, 3 launching areas, 11 stone parking spaces, 2 comfort stations with pneumatically supplied water and hot water for laundry tubs and showers, drinking fountains, sewage treatment plant, trailer disposal station, dusk-to-dawn lights, bulletin board and benches, picnic tables and cookers, trash containers, bathing area, amphitheater, and playground equipment for children.

(4) Junction Area Marina. This 78-acre site is located near the junction of the two rivers and has 6 free camp trailer sites, picnic units, 4 parking spaces, 81 car trailer spaces, mooring for 64 boats, snack bar, gas station, 1 vault comfort stations, picnic tables and trash containers.

(5) Lower Twin Branch Area. This 86 acre site is accessible from Blowing Rock by State Route 611 and 683, and has 4 parking lots, 32 car spaces, 24 trailer spaces, 32 camp sites, 3 launching ramps, play ground, amphitheater, and 3 hiking trails.

(6) Pound River. This 14 acre site is accessible from Clintwood, Virginia on State Route 631, and has 18 camp sites, 5 trailer spaces, a comfort station, 1 launching ramp, and 1 parking lot.

(7) Bearpen Area. This 8 acre site is along State Route 631 near the Bearpen Creek cove. This area has 9 group picnic, 60 car spaces, snack bar, and a shower building.

(8) Brush Creek Area. This 18 acre site is located on State Route 631 near Pound River, and has 2 parking lot with 109 spaces, snack bar, play ground, and 2 miles of riding trails.

(9) Breaks Interstate Resort Park. This 1,771-acre park is located near the lake, and is accessible from State Route 80, which traverses the length of the park along the shore of the lake. This modern interstate park is a joint venture of the States of Kentucky and Virginia and is not a part of the Flannagan Lake Project or the Jefferson National Forest.

(10) The State of Virginia, Department of Game and Inland Fishery, has a license for forest management purposes that encompasses 7,350 acres. The State renews the boundary of the area with periodic painting, does some selecting thinning, has replanted some areas, and entered into a Forest Fire Protection Service Agreement with the Corps in November 1979.

The Department of Game and Inland Fishery, also has a license that covers approximately 6,378 acres of project lands. This area includes all of the

forest management area and the lake area. Primary objectives include minor habitat manipulation, sharecropping agreements with third parties, regulation of hunting seasons through closure, stocking of forage and game fishes, rotenone and gill net sampling, creel surveys and the establishment of brush fish attractors. Conservation officers patrol and police the areas.

b. Quasi-public Recreational Outgrants. The outgrants for Flannagan Lake area are largely a cooperative program with the Boy Scouts of America. For the last three years the Boy Scouts of America have held their annual fall Council Camporee at Flannagan Lake. This program is part of the Corps of Engineers public support and overall contribution. The camporee was entirely on Flannagan recreation grounds, was a big success, and another is planned for next year.

SECTION III - HISTORY OF PROJECT

3-01 AUTHORIZATION.

The John W. Flannagan 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 four reservoirs in the Big Sandy River Basin. Flannagan Lake (formerly called Pound Lake) was a replacement project for Clintwood Lake, one of the original four projects, and was constructed on Pound River about 122 miles above the junction of Levisa and Tug Forks.

3-02 GENERAL BACKGROUND HISTORY.

The early settlement of the Pound River - Russell and Levisa Fork - Big Sandy River Basin was a part of the general development of the area west of the Appalachian mountains, the state of Kentucky, and the Southwest Territory both before, during and immediately after the Revolutionary War. The first inhabitants of the area were the Fort Ancient, the Adena, and the Hopewell Indian mound builders and later the Cherokee, Delaware, Shawnee, and Tuscarawas Indian tribes, who referred to the area as the "Dark and Bloody Ground". Most of the Indian villages and trails were near a good water supply or portage between rivers; and the main avenue for the Indians was the "Warrior Trail", with a Big Sandy Branch, from Cumberland Gap to the Ohio River. Historical and archeological interest points dating to Indian activity are scattered throughout the basin.

The English Crown incorporated the Virginia Colony with the Second Royal Charter of 1609, which vaguely and broadly stated the colonial boundaries were from Cape Fear to the Hudson River and coast to coast (Atlantic to Pacific). The Virginia Royal Governors were required by the Crown to explore and settle the western frontier. However, the first white European to cross the Big Sandy River is much in doubt with conflicting and unconfirmed claims of discovery and exploration. The Big Sandy River was a major tributary of the Ohio River, which soon became the prize overseas colonial fringe possession of a intermittent century long land struggle and war in Europe between France and England. Basically, the Big Sandy River Basin was an unmapped and uninhabited Indian hunting ground and battlefield. Through a series of treaties and trades, trickery and treachery, rum and raids the English finally pacified the Indians in the treaty of 1744 and eliminated the French in 1763. The only white men west of the mountains, in this huge Fincastle county of Virginia, now Kentucky, had been very rare missionaries, some explorers and trappers, and a tiny few English soldiers for 140 years after the Jamestown settlement. All this would soon change.

The Shenandoah Valley had been rapidly settled in the 1730,s by granting large tracts of land to speculators, developers, and immigrant companies. Following the close of King Georges war in 1744 the English began granting more large tracts of western land to wealthy land promoters and speculators, who contracted to settle and control the frontier for England. Accordingly, on 12 July 1749 the British Board of Trade granted to a prominent Virginia based group, entitled the “Ohio Company”, a large 200,000 acre western land grant. The Royal Grant was located vaguely "between the Ohio and Kanawha rivers" and was soon increased to 500,000 acres with certain reserve clauses. The Virginia Royal Governor was very jealous and quickly countered this grant by granting a

huge 800,000 acre unreserved open tract located "below the Ohio River" to a more favored rival Virginia based group, the "Loyal Land Company". In the spring of 1750 the "Loyal Land Company" hired Dr. Thomas Walker to explore, map, and document their huge grant. Dr. Walker's six man party left Charlottesville on 6 March, went through "Cave Gap", which they renamed the Cumberland Gap to match the Cumberland River; and explored, staked, and mapped in four months the headwaters of several southern Appalachian rivers. On 5-6 June 1750 Dr. Walker staked the Big Sandy Basin at about Paint Creek, spent about two weeks exploring the Big Sandy valley, and named the main fork of the Big Sandy River "Louisa" which became "Levisa" through corrupt translation and writing. In the 1745-55 years the ambitious and generous Virginia Governor's had granted or deeded over four million acres of western land to wealthy speculators. This huge figure appears to be much more land on paper than existed in the forest; and could be based on accidental or real duplicity or on very poor mapping.

The next year the ill fated "Ohio Company" hired the famed explorer Christopher Gist to explore their claim in the western sector of Virginia. On about 1 April 1752 the famed explorer allegedly crossed over to Elkhorn Creek, passed through Pound gap, and completed a seven month tour of the area. Upon his return the Ohio Company realized the future of the Ohio valley and quickly made plans for Gist to make another long tour of their huge grant.

These explorations prompted many pioneers to "go west". Apparently one of the very first was Marthias Harmen, who traveled the area often and built a cabin near the mouth of Johns Creek in 1755. This could be the first cabin in the Big Sandy Basin. About fifteen years later, Americas greatest and most widely publicized hunter (Daniel Boone), with five men spent the winter of 1769 to 1771 traveling to many parts of the basin, beginning at the famous Indian "Warrior trail or Wilderness Road" through Cumberland Gap.

In 1775 Harrodsburg and Boonesbourgh were established and soon the settlers established a "missionary colony" called Translyvainia. The next year this colony petitioned the state of Virginia for membership in the state assembly and was rejected, but all the western Virginia area, below the Big Sandy river, was renamed Kentucky County. The Indians still greatly outnumbered the very few white people in the Big Sandy Basin. Colonial Americans battled the English for seven years from (1775-1782), and aided by the revengeful French, finally won at Yorktown (1782) leaving the colonies in control of all the western land south of the Great Lakes and west of the mountains to the Mississippi River. Soon the Continental Congress chartered this great mass of land below the Ohio River with the Continental Ordinance of 1784 into the vast Southwest Territory. In the same year, 1784, the first state meeting or convention was held at Danville, and by 1 June 1792 Kentucky was the fifteenth state in the Union, the first state west of the mountains. Following the close of the war many new settlers came down the "Wilderness Road" and the Ohio river to the central or Bluegrass section south of the Kentucky and Ohio Rivers, near the Transylvainia Land grant, or present day Lexington and Louisville. However, the first migration to the rugged Big Sandy mountains, called "Kentucky's last frontier" would be a few years later, about 1790 and was fairly slow, even after the 1794 Treaty.

Among those coming to eastern Kentucky, about 1787 or about five years after the war was a group of 20 people lead by the same Marthais Harmen, who had settled 30 years earlier on Johns Creek. The Harmen family resettled on Johns Creek in 1789, located nearby Buffalo Creek, and following several Indian battles, such as the "Jenny Wiley family massacre" decided to build a fort or station at present day Prestonsburg. This first Big Sandy Basin fort was soon

followed by another fort about 40 miles downstream at the forks of the river called Vancovers Fort. The next settlement was to be the Robert Leslie family at Pond Creek or now, South Williamson in the same year, which could be the first cabin on Tug Fork. All three of these tiny settlements were to be short lived, for the next year the Indians harassed the settlers into leaving and Robert Leslie moved to Sycamore Creek and lived for a while in a hollow Sycamore tree. However, within a couple of years the Harman family returned and reestablished Harmans Station and soon John Spurlock built the first permanent home and settlement at Prestons Station, later Prestonsburg.

One of the early legislative assignments for the new state was to settle the border question between Kentucky and Virginia. This was done in 1799 by a joint commission, mostly Kentuckians, meeting at Louisa. According to prevailing land law the border was to be based on the largest fork of the river. The meeting was held inside on a rainy night, with plenty to drink, and the group could not actually see the river, therefore, they decided that the Tug Fork "looked much bigger", and voted that the border would be the Tug. During the night the river flooded and in the morning the Levisa fork was much much bigger, but rather than reverse a late night decision and admit they had not really looked, the men left the border at the Tug. By this rare informal method the new state of Kentucky gained an additional 1,300 square miles of land.

As these self-sufficient hardy settlers extended up the Big Sandy river or came over the mountains from Virginia, the strong need for food, security, protection, transportation, and future access to eastern cities for markets and imports became apparent. This led to the first trail marking, clearing, crude wagon paths, wharfs, ferries, wells, forts, and rare new villages.

From this early settlement, expansion, and growth came the dependance and use of the surface waterways for personal, farm and city consumption, basic transportation, and primitive water power. The early narrow dirt trails followed the Indian trails. When they were widened into crude haul roads they were barely passable for a light horse wagon in warm dry weather, and needed steady maintenance and protection for travel. This was seldom available, hence the only alternative was travel by foot, horseback, or boat. 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 Big Sandy - Levisa Fork valley as the tiny communities grew from a wilderness.

The development of water resources in the Pound - Big Sandy Basin came in four distinct, but overlapping phases. Most of the first improvements in the Big Sandy Basin were for security, survival, protection, and then waterbased projects such as wells, gristmills, wharfs, and boat building. The new and latest two-way boat for the river was called a keelboat and by 1800 there were some 500 keelboats on the Ohio River system drifting downstream and poling upstream. By 1820 the new flat bottomed steamboat had overtaken the oneway flatboat, and the slow poled keelboat was now used mainly as a towed barge or on side streams. By 1833 or so the first steamboat had reached Louisa and about 10 years later the first steamboat skirted the "Hell Gate Shoal" and came on upstream. For the next one hundred years the Levisa Fork - Big Sandy river was the main avenue of transportation for eastern Kentucky; and steamboats, keelboats, and log rafts were seen everywhere on the river.

Many of the settlers and villages along the Big Sandy River were by now using the river for transportation and water supply. The navigability of Tug and Levisa Forks and the Big Sandy River combined with the waterway afforded by the

Ohio River undoubtedly was an important factor. In 1819 the Kentucky Legislature declared the Big Sandy - Levisa Fork navigable all the way to Russell Fork. In 1834 the legislature allocated $6,000 dollars for the first improvements, snagging and clearing on the river; and the next year the allocation was raised to $25,000, but this increase was not fully used.

During the Civil War the isolated self-sufficient Pound - Russell - Levisa Basin was very bitterly divided between the two armies. Very few of the citizens owned slaves, but most had previously lived on the eastern side of the mountains where the slave system was strong in numbers and heavily ingrained. Everyone had very strong feelings on all sides of the struggle. The war caused a complete breakdown of civilian law and order, and guerrilla warfare was very common after night. Colonel James A. Garfield, later General and President, used the river as a supply line for the Union Army in his winter campaign of 1862, and maintained control of the valley most of the time. The Confederate Commander, Humphrey Marshall's line of approach in the mountains was through Pound Gap. Also, vicious Confederate raiding parties swept the valley with Prestonsburg changing hands seven times in the first year of the war.

The earliest activities of the area were trapping, subsistence farming, stock raising, lumbering, and agriculture in succession. These activities continued as the basic economy of pioneer life in the basin for many years. Although extensive deposits of coal were discovered at an early date, the development of the coal mining industry did not begin until the advent of railroads into the coal-bearing areas. The building of railroads in eastern Kentucky was delayed for many years due to the rugged terrain and the culture barriers.

The Pittsburgh Railroad Company built and operated a small line up the Big Sandy River Basin from Ashland to Richardson, KY in the early 1880's. This line was later purchased by the Chesapeake and Ohio Railway Company, and became the basis of that company's present system of lines along the Big Sandy River and in the Levisa Fork Basin. With the extension of the various railway lines into the coal areas, coal production increased rapidly in importance, and since the beginning of development of the industry in 1907, coal mining has been the predominant activity of the basin.

During the period between 1897 and 1910, a total of five navigation locks and dams were completed in the Big Sandy River Basin; three on the Big Sandy River and one each on Tug Fork and Levisa Fork. These five locks and dams were originally designed to provide a 6-foot navigable channel from the Ohio River to points 12.5 and 17.5 miles upstream along Tug and Levisa Forks, respectively. In addition to these structures, a number of small dams were built for operating grist or saw mills, and for impounding water to "splash" timber downstream to nearby saw mills or to deep water, from where it was rafted further downstream to more distant mill locations. However, with the coming of railroads and the depletion of most of the virgin timber, the dams were allowed to disintegrate. The entire navigation system within the basin was discontinued in January 1948, and the structures were removed in the early 1960's, except for Dam No. 3, at Louisa, KY, which was reconstructed for water supply and recreational purposes. Title has been transferred to local interests who have assumed responsibility for maintenance and operation.

The new settlers or the old Indians of the Big Sandy Basin did not cause the annual spring floods or fall droughts. The damaging floods were there long before settlement, but little record was made of these events. The first recorded Ohio River floods were at Fort Pitt or Pittsburgh in 1762 and 1763, and Cincinnati in 1773, 1792, and 1793. The terrible Big Sandy Basin floods of the previous century are recorded in old newspaper stories and military

records; and were all very destructive at Pikeville, Prestonsburg, Paintsville, Louisa, Cattlettsburg, and to agriculture lands all along the valley. The floods usually came about every two or three years with the record flood in February 1862. Lesser floods came in August 1903, March 1913, March 1917, January 1918, December 1926, March 1929, January 1932, January 1946, January 1957, May 1958, April 1977, and November 1985.

Following the disastrous 1913 Ohio Valley flood, the nearby state of Ohio in February 1914 passed the Conservancy Act of Ohio. This was the beginning of modern basin planning, flood control, and water conservation which soon spread to other states.

Water management in the Big Sandy 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 industrial development had to be solved. Although the potential for severe flooding in the Big Sandy and Ohio River Basins had long been recognized, federal investigations made prior to the 1930's were generally concerned with improvements for commercial navigation. In the 1920's and 30's, it became even more apparent that major flooding events were basin-wide problems that could not be controlled by structures built mainly for navigation purposes.

Organized efforts were aided greatly by 1930-31 record drought, one of the most severe in the basin history. Upstream cities, towns, and farms experienced severe water shortages. Low streamflow contributed to pollution problems, stifled navigation, and led to the haunting fear that water shortages might stifle any industrial recovery and regional expansion and growth even more then the 1929-33 world economic depression. All of these fears spurred a basin wide demand for integrated water management by someone.

Later in 1932 the Huntington District, Corps of Engineers, in a "308 Report" came to essentially this conclusion for any basin water project,"The total costs would far exceed local financial resources." The only apparent solution seemed to be massive Federal Aid, which was not readily available.

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 at the time, it did not appear that extensive Federal aid for flood control, other than on the Mississippi River would be possible; 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 1930,31, 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 as a emergency means of combating unemployment.

The Big Sandy River Basin was evaluated in 1935 in the Big Sandy River "308" report (House Document No. 245, Seventy-fourth Congress, first session) with three reservoirs proposed in the Big Sandy River Basin to provide flood control for the Mississippi River. The report concluded that the three reservoirs would be ineffective and unduly expensive in providing Mississippi River flood control. The report also concluded that any further improvements on the Big Sandy River for navigation in connection with power development, flood control, irrigation, or any combination thereof, were not justifiable.

The Big Sandy River was then reconsidered in 1936 (House Document No. 259, Seventy-fourth Congress, first session) in a report on a comprehensive system of reservoirs in the Mississippi River Basin to reduce flood flows on the main stem of the Mississippi River. Three reservoirs in the Big Sandy River Basin were again evaluated, but none were included in the approved plan. During the same congressional session, the Ohio River "308" report (House Document No. 306) presented a plan for controlling floods on the Ohio River and lower Mississippi Valley. None of the Big Sandy River reservoirs were justified and, therefore, were not included in the approved plan of fourteen reservoirs.

As a result of the great flood of January 1937, the Flood Control Committee Document No. 1 of the Seventy-fifth Congress, first session recommended the construction of a system of 45 reservoirs on tributaries of the Ohio River, in conjunction with the 15 projects already under construction and the 14 others previously authorized for construction by the Flood Control Act of 1936. Three of the recommended reservoirs, namely, Fishtrap, Dewey, and Yatesville, were located in the Big Sandy River Basin in Eastern Kentucky below Pound and Cranenest Rivers.

The first report concerning a reservoir on Pound River was a comprehensive plan for flood control in the Ohio River Basin authorized by the Flood Control Act of 1938, H.R. 10618, Public Law No. 761, 75th Congress, third session.

The outbreak and intervention of Pearl Harbor and World War II postponed any further planning or reservoir construction for the duration of the war. World War II consumed all national effort and all federal money went to war plans and production. However, during the intervening war years the preliminary plans for the Big Sandy projects were changed somewhat and updated.

The comprehensive plan for flood control in Committee Document No. 1, as modified in Report No. 2353 that accompanied H.R. 10618 to the House, provided for a flood control reservoir on Pound River, VA, to be formed by a concrete gravity dam located about 17 miles above the mouth. The reservoir, known as the Clintwood Reservoir, controlled a drainage area of 99 square miles and had a storage capacity of 40,000 acre-feet at elevation 1525 feet above NGVD. In House Document No. 264, Eightieth Congress, first session, a reservoir was proposed along the lower reaches of Pound River in the vicinity of the present Flannagan Reservoir site. This reservoir was considered for flood control and hydro-electric power purposes, both as a separate project and as a unit in a system of reservoirs in the Levisa Fork Basin. In this report, the conclusion was reached that none of the studied reservoir plans was economically justified.

3-02 PROJECT FORMULATION AND DESIGN

An Interim Survey Report on Big Sandy River and Tug and Levisa Forks, dated 20 December 1957, concluded that the best plan for comprehensive flood relief in Levisa Fork Basin would consist of a system of four flood control reservoirs to supplement the existing flood control projects. The four reservoirs, as justified by the report, were Fishtrap Reservoir on Levisa Fork, Haysi Reservoir on Russell Fork, North Fork Reservoir on North Fork of Pound River and Pound Reservoir, which was later named John W. Flannagan Reservoir, on Pound River. All four reservoirs were economically justified when considered on a system basis, however, when considered on an incremental basis, all except Haysi Reservoir were economically justified. The report also concluded that the hydro-electric features in a multiple-purpose plan, comprising the same four reservoirs plus hydro-electric features at Pound Reservoir and the Towers

Diversion Project for hydro-electric power were not economically justified. On the basis of this report submitted in 1957, the Secretary of the Army approved on 22 May 1957 the substitution of Pound Reservoir for Clintwood Reservoir on Pound River. The name of Pound Reservoir was changed to John W. Flannagan Reservoir by Public Law 86-189 on 25 August 1959. In this report, further references to John W. Flannagan reservoir will often be made as Flannagan Reservoir. Based on a July 1962 cost basis, the average annual flood control benefits allocated to Flannagan Reservoir were $1,706,000 assuming: (1) that Flannagan and Fishtrap (under construction) Reservoirs have equal status (2) that the two reservoirs are considered as an addition to the completed and under construction reservoirs and local protection projects in the Ohio River Basin and (3) that the benefits of the two reservoirs are allocated in accordance with the effects when each is placed in last position. With the seasonal recreation pool established at elevation 1396, the estimated average annual general recreation benefits in Flannagan Reservoir were $54,000 (July 1962 cost basis). With water quality control storage annual fish and wildlife recreation benefits amount to $43,000 while water quality control benefits are $409,000 (July 1962 basis). The total average annual benefits allocated to Flannagan Reservoir, with water quality control storage, were $2,212,000 (July 1962 basis) which is a benefit to cost ratio of 3.0 to 1.

The John W. Flannagan Lake Project, formerly called Pound Reservoir, was authorized by the Flood Control Act of 1938 (Public Law 75-761), the Flood Control Act of 1944 (P.L. 78-534), the Fish and Wildlife Coordination Act of 1958 (P.L. 85-624), the Federal Water Project Recreation Act of 1965 (P.L. 89-72), and the Forest Conservation Act of 1960 (P.L. 86-717). The lake is an element of the comprehensive flood control plan for the Ohio River Basin. In view of the possibility of early appropriation money, a decision was reached to proceed with the preparation of specific design memoranda in advance of a general design memorandum. Design Memorandum No. 1 on Hydrology presented in detail the basic hydrologic aspects of the project as approved in the Interim Survey Report. Design Memorandum No. 1 was first submitted in August 1958, however, this memorandum was never approved by the Chief of Engineers due to the occurrence of a higher flood of record which had to be used to derive the unit hydrographs presented in the design memorandum. Data for Design Memorandum No. 1 was recomputed, using unit hydrographs taken from the flood of January 1957. Design Memorandum No. 1 was resubmitted in August 1959 after revision of the Spillway Design Flood and redesign of the spillway, and was approved by the Chief of Engineers by 10th Endorsement dated 29 April 1960. Based on studies made for Design Memorandum No. 1, a permanent conservation pool was established at elevation 1314 feet NGVD and a seasonal pool at elevation 1350 feet NGVD. By 2nd Indorsement, dated May 1960, the Chief of Engineers approved General Design Memorandum No. 8 which had been submitted in March 1960. The purpose of Design Memorandum No. 8 was to present all general features of the project, using available data from prior design memoranda, and supplemented by data on lands, relocations, reservoir clearing and public use of the area. Studies in Design Memorandum No. 8 considered several different schemes for adding storage to provide an adequate supply of quality water for augmentation purposes. High level openings in the intake structure were suggested by the U.S. Fish and Wildlife Service for the purpose of regulating water temperatures for warm water fish propagation. Three high-level intakes were subsequently established at elevations 1300, 1315, and 1330 feet above NGVD. The Fish and Wildlife Service also suggested that a seasonal pool be provided to supply minimum downstream flows of 100 cfs during April and May and 75 cfs from June through November, and a minimum release of 50 cfs be maintained at all other times. A report prepared by the U.S. Public Health Service for the Interim Survey Report on Big Sandy River Basin stated that there would be no tangible pollution abatement benefits from increased low

flows from Flannagan Reservoir, but that any increase in low flows would have a distinct, but intangible, beneficial effect on water quality in the Big Sandy and Ohio Rivers. Several schemes were studied in Design Memorandum No. 8 for adding water quality control storage, however, none of these plans were recommended because the costs were more than nominal and the benefits were considered to be of a potential nature with only remote possibility of obtaining firm assurances of local contribution. These studies, made in 1960, were considered sufficient at the time, however, in a letter report dated 8 November 1961, subject, "John W. Flannagan Reservoir, Relocation of State Routes 614 and 619," the Huntington District recommended that bridges and approaches on these two highways be redesigned and constructed to an elevation which would permit ultimate provision of storage for low flow augmentation in Flannagan Reservoir. The Chief of Engineers approved the proposed modification of the two bridges and approaches and in 2nd Indorsement, dated 29 November 1961, OCE requested that a report be initiated covering the necessity and economics of providing storage for water quality control throughout Big Sandy River Basin. In Design Memorandum No. 17, titled "Addition of Storage for Water Quality Control," dated April 1962, the Huntington District recommended that the Flannagan Reservoir Project be modified to include additional storage for low-flow augmentation and water quality control purposes. The recommended plan would consist of a gated control structure located in Cane Branch, adjacent to the dam. In this plan, the top of the dam would be increased about 2 feet from elevation 1460 to 1462 feet NGVD and the top of the intake structure would remain at elevation 1492 feet NGVD. The gated spillway would consist of six 36 by 42 feet tainter gates with spillway crest elevation at 1410 feet above NGVD. Water quality storage can be provided under authority of Section 2 of Public Law 87-88, Federal Water Pollution Control Act, Amendments of 1961. The water quality pool was added by raising the level of the minimum pool from 1314 to 1380 feet NGVD, adding the seasonal pool on top of this to elevation 1396 feet NGVD, and reducing the flood control pool by an equivalent amount. Design Memorandum No. 17 was approved by the Chief of Engineers in 2nd Indorsement dated 17 July 1962, with the recommendation that additional hydraulic design studies be made, and also a comparison made of two separate plans of approach. A supplement to Design Memorandum No. 17, which studied several plans from a hydraulic viewpoint, was completed and submitted to the Chief of Engineers for final approval. The final plan, as recommended in the supplement to Design Memorandum No. 17, consists of a gated spillway structure across Cane Branch with a bridge for the access road. The structure would consist of a 12-foot high concrete weir with six crest gates supported by concrete piers of sufficient height to permit raising the gates above maximum water surface. The size of the gate selected was 42 feet long by 38 feet high with the top of dam to remain at elevation 1460 feet NGVD and top of intake tower at elevation 1492 feet NGVD. The spillway crest elevation was to be at elevation 1410 feet NGVD, and to have a gross width of 292 feet and a net width of 252 feet.

3-04 CONSTRUCTION PHASE

Construction of the project was initiated on 5 February 1960. Construction work on the dam started in November 1960 and closure was effected in September 1961. Construction work on the gated spillway structure was started in the Spring of 1964 and completed in August 1966. The relocation program was initiated 18 August 1961 and consisted of relocating or constructing 21 miles of secondary roads; 2 highway bridges; 1.8 miles of electrical power lines; 0.3 miles telephone lines; one school, and moving 4 cemeteries containing about 70 graves. As of 1 March 1968, all major construction work was complete with only minor miscellaneous work still in progress. The land acquisition program was

started 23 December 1959 and as of 1 March 1968, 393 tracts out of 400 tracts required for project, had been acquired. Later the remaining land was acquired.

The completed project purposes include flood control, recreation, fish and wildlife enhancement, water supply, low flow augmentation, and forest resources conservation which are utilized each day. Benefits from specific project purposes serve not only local interests in the Pound River Basin, but are widespread throughout the Ohio River Basin.

The final phase of development in the Levisa Fork-Russell Fork-Pound River Basin was the solid growth of recreation and vacation resorts near the lakes. This was greatly assisted by the Kentucky Department of Fish and Wildlife Resources who have coordinated with the Corps of Engineers on many water projects in this final phase of water resources and recreation development. This phase was hardly considered when the original four reservoirs were planned, but the Kentucky Department of Fish and Wildlife Resources later built and developed elaborate facilities at Jenney Wiley Park and Breaks of Sandy Park that draw enormous crowds at the lake resorts during the summer. All of this has produced a new industry for the basin called tourism and recreation.

The summary of the Levisa Fork-Pound River water resources development is that many public and private groups now use the multi-purpose water projects of the area that were developed by the COE and Kentucky Department of Fish and Wildlife Resources. Surface water supplies are also used by railroad, coal mining and lumbering industries for producing steam and washing coal. There is little need for irrigation projects within the watershed, as precipitation is generally adequate for agricultural demands.

The first completed Big Sandy Lake (Dewey Dam) was used for the first time in the flood of February 1950 and in the next 49 years (FY 98) accumulated $61.76 MILLION DOLLARS in flood damages prevented. John W. Flannagan Dam was completed in December 1963 and has accumulated benefits amounting to $155.57 MILLION DOLLARS in 35 years (FY 98). North Fork of Pound Lake was completed in January 1966, and has accumulated $5.49 MILLION DOLLARS in benefits for 33 years (FY 98). Fishtrap Lake was completed in October 1968, and has accumulated $290.76 MILLION DOLLARS in benefits for 31 years (FY 98). Yatesville Lake was completed in the fall of 1988, and has accumulated $17.5 MILLION DOLLARS in benefits for 10 years (FY 98). Paintsville Lake was impounded in September 1983, and has accumulated $7.35 MILLION DOLLARS in benefits for 15 years (FY 98). For the five years (FY90-94) the three largest reservoirs alone (Fishtrap, Flannagan, and Dewey) had a combined accumulated flood damages prevented of about $23.15 MILLION DOLLARS. The Levisa Fork - Big Sandy Reservoir system now has six reservoirs, two local protection projects, and a model city with a total storage of 575,000 acre-feet and 1,123 square miles of controlled drainage area or 41 percent of the Big Sandy - Levisa Fork total basin. The Big Sandy Basin projects, including John W. Flannagan Lake have paid for themselves several times over and the grand total of flood control, water supply, recreation, and overall conservation benefits is so enormous that it is difficult to imagine a sum of money equal to the monetary figure of the present day replacement value.

The exploration, settlement, and expansion of the rugged Pound River - Big Sandy River Basin (Kentucky's Last Frontier) began both before and after the American Revolution over 200 years ago. The economic, industrial, and water resources expansion and development of the basin began immediately and continues today. The future of both the Pound River and eastern Kentucky will always be linked with extensive water resources and mineral development.

3-05 RELATED PROJECTS.

During periods of storm runoff, all the Big Sandy reservoirs, including John W. Flannagan, North Fork of Pound, Fishtrap, Dewey, Yatesville, and Paintsville Lakes, are operated to utilize the natural channel capacities by releasing storage at rates not to exceed the designated control stages of the Big Sandy River and tributaries below the reservoirs as listed in Table No. 6-1. Storage of flood flows commences in advance of predicted damage stages at key points, and continues until predicted stages for all control points indicate that releases of stored waters from the reservoirs, with proper allowance for time of travel, will not cause stages in excess of the control stages. Gates are closed and all reservoir inflow stored for partial control of Ohio River floods when a crest stage above 53 feet at Ashland is forecast by the National Weather Service. Operation for reduction of Ohio River floods continues until the Ohio River at Ashland has crested and fallen 1 foot and further recession is indicated. Times of beginning and ending of reservoir operation are based on the estimated time of water travel from the various dam sites to the mouth of the Big Sandy River. At the end of the regulation period, outflows are gradually increased to the bankfull channel capacity below the dams and maintained at that rate until the flood storage is released, or until river stages at key stations require further storage operation.

The storage capacity in John W. Flannagan Lake between the flood control pool and seasonal pool levels is 78,600 acre-feet, or the equivalent of 7.2 inches of runoff from the contributing watershed above the dam. Storage capacity between the flood control pool and minimum pool levels is 95,100 acre-feet, or the equivalent of approximately 8.75 inches of runoff. The principal flood control benefit provided by John W. Flannagan Lake is a reduction in flood crests along the Pound River, Russell and Levisa Forks and the Big Sandy River downstream of the dam. Pertinent data relative to the John W. Flannagan Lake Project are shown on Plate No. 9-2.

A number of studies have been authorized in the Big Sandy Basin with no current activity. Most of these studies are non-structural in nature, consisting of floodproofing, floodplain evacuation, or floodsafe redevelopment measures. All of these studies have been authorized under Section 202 of the 1981 Water and Energy Appropriations Act (P.L. 96-367). The city of Grundy, VA, has been studied under this program most often.

SECTION IV - WATERSHED CHARACTERISTICS

4-01 GENERAL CHARACTERISTICS

Pound River lies entirely in the State of Virginia in Dickenson and Wise Counties as shown on Plate No. 4-1. It has a drainage area of 225 square miles. It is bounded on the north by Elkhorn Creek, a tributary of Russell Fork, and by North Fork of Kentucky River; on the south by Powell and Clinch Rivers, tributaries of the Tennessee River; and on the east by McClure River, a tributary of Russell Fork. The basin is generally mountainous and well dissected. It is roughly triangular in shape being wide in the headwaters (southern part) and gradually narrowing to a point at the stream mouth (northern part). The greatest length is 27 miles and the greatest width is 17 miles. The Pound River is formed by the North and South Forks which combine at the town of Pound VA, in southwest Virginia. From the town of Pound, the river flows generally northwest in a deep narrow valley parallel to and along the foot of the southern slopes of Pine Mountain to its junction with Russell Fork. From the source of the South Fork, elevation 3765 feet NGVD to the town of Pound, the stream falls about 2,230 feet or 200 feet per mile. Between Pound and the mouth, the stream falls about 350 feet in 35 miles, or an average of 10 feet per mile. In the reservoir area the stream channel averages about 200 feet in width with practically no flood plain. The Pound River drainage area is 225 square miles; Flannagan dam is located 1.8 miles upstream of the Pound River and Russell Fork confluence with a drainage area of 221 square miles (203.8 square miles net area excluding North Fork of Pound River drainage area). The Pound River drainage area is shown on Plate No. 4-1.

Pound River is the main stream in the John W. Flannagan Lake drainage basin. Principal tributaries above the Flannagan Lake dam include Cranenest River, Holly Creek, Camp Creek, Bearpen Creek, Georges Fork, Cane Creek, and Cane Branch. Cranenest River drains 40 percent of the Pound River Basin, and flows northwest to its confluence with the main stream 6.5 miles above the mouth. The total length of Pound River is 35 miles and that of Cranenest River is 24 miles. The valley floor along Pound River averages 400 feet in width except for the lower 5 miles where the stream cuts through a gorge to Russell Fork. The valley width along Cranenest River averages between 300 and 400 feet. The stream profile is shown on Plate No. 4-2. Drainage areas of Pound River and principal tributaries above Flannagan Lake are shown in Table No. 4-1 found on the next page.

4-02 TOPOGRAPHY

Flannagan Lake is located in the deeply dissected, unglaciated Cumberland Mountain Section of the Appalachian Plateau physiographic province. This physical section is described as a mature plateau of fine texture drainage with moderate to strong relief. Elevations within the Flannagan Lake Basin vary from elevation 1210 feet NGVD below the dam to 2000 feet NGVD on the surrounding ridge tops. The narrow Pound River valley averages slightly less than 400 feet in width and follows a winding course bounded by steeply sloping walls that rise 700 to 800 feet above the stream. Streambanks heights above the dam vary from 10 feet to 25 feet above low water. The Pound River Basin is shown on Plate No. 4-1.

TABLE NO. 4-1

DRAINAGE AREAS OF POUND RIVER AND TRIBUTARIES

Stream	Point	Area (Sq. Mi.)
Pound River	At mouth	225
Pound River	At dam	221
Pound River	Below Cranenest River	213
Cranenest River	At mouth	91
Pound River	Above Cranenest Run	122
Pound River	Above Georges Fork (Inflow)	82.5
Cranenest River	Near Clintwood (Inflow)	66.5
Pound River	Confluence of Forks	36.5

4-03 GEOLOGY AND SOILS

The consolidated rocks now appearing at the surface in the Pound River Basin are of Pennsylvanian age, except for a narrow belt of Mississippian, and possibly Devonian rocks, which have been exposed along Pine Mountain by a thrust fault of major proportions. The structure of the rocks of the region are, generally speaking, a great down-fold or trough extending northeasterly across Eastern Kentucky into West Virginia. The regional dip of the strata is to the northwest or north, and at low angles. This dip is interrupted, however, by a number of broad, low-folds. The Pennsylvanian rocks, ranging from Pottsville to Conemaugh in age, measure approximately 3,000 feet of sandstones and shales containing numerous beds of coal and a few thin beds of limestone and clay. The Conemaugh rocks, the youngest rocks of the area, are confined to the lower or north end of the basin. The Allegheny series of rocks underlies the Conemaugh in the lower portion of the region, whereas in other sections of the basin only thin remnants of this series remain on the higher ridges or they have been entirely removed by erosion. The Pottsville series ranging in thickness from 2,500 to 500 feet, comprise most of the exposed rocks throughout the basin. It contains more than 20 coal seams that are of commercial thickness at certain locations.

The unconsolidated materials in the watershed are river deposited silts, clays, sand and residual materials formed by the disintegration of the country rock. The valley fill materials are generally fine to medium grained and consist of river deposited sand, silt, clay, and gravel. The higher elevations are blanketed with residual sandy clay which generally passes into bedrock at a shallow depth.

The Pound River Basin lies wholly within the physiographic province known as the Appalachian Plateaus. All of the rocks that now outcrop in the region are of sedimentary origin, that is they were deposited in or by the action of water. With few exceptions, the beds were accumulated in the sea or in extensive marshes during a period of subsidence or sinking of the area. Following this accumulation, crustal movements caused the area to be slowly lifted above the sea; and erosion agencies then reduced the surface to base level. These processes of uplift and erosion were repeated several times. Although the topography and drainage lines of portions of this province have been modified by continental ice sheets, Pound River watershed was not affected by glaciation. The agencies of erosion are now reducing the area to base level or to a low-lying plain. The present streams generally follow the meandering courses cut by an earlier drainage cycle.

4-04 LAKE SEDIMENTATION AND EROSION

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 lands 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 Flannagan Lake Basin lies in an area of steep topography, and combined with the surface mining for coal in the basin, creates the potential for high erosion and sedimentation in the basin. However, the Surface Mining Control and Reclamation Act passed by Congress in 1977 imposed more stringent regulations on surface mining than had previously existed. As the result of strip-mining reclamation measures and replanting programs required by this Act, erosion of slopes and siltation in the Flannagan Lake Basin are reduced.

Over 80 percent of the Pound River drainage basin is wooded. There are no major portions that are farmed due to the topography of the area. Logging of the wooded portion of the basin is actively practiced. Coal production in the drainage area is low due to the current economic situation. The immediate prospect for further commercial development of the coal seams is doubtful, even though the area has large areas of coal seams.

In the past, Pound River has appeared to carry a heavy sediment load. In 1974 and 1983; samples were taken to determine the amount of sediment carried. A summary of reservoir sediment deposition surveys made in the United States through 1960 was published by the United States Department of Agriculture in "Miscellaneous Publication No. 946." The information contained in this publication was used to estimate the amount of sedimentation that might be expected to occur in Flannagan Lake. Utilizing the data relative to the reservoirs in the Tennessee Valley Authority adjacent to the Pound River Basin, it appeared that a sedimentation rate of 0.376 acre-foot per square mile of controlled drainage area per year would be a representative value for Flannagan Lake. Therefore during the construction of the dam the original network of 15 sediment ranges was established and recorded.

A total of 12,006 acre-feet of storage is provided in the minimum pool area, below elevation 1314.0 feet NGVD, for fish and wildlife conservation and sedimentation reserve. Assuming that sedimentation occurred at an annual rate of 0.376 acre-foot per square mile of contributing drainage area, or 75.3 acre-feet per year, and all the material were deposited in the minimum pool area the minimum pool would have a life of about 159 years.

Visual indication that sedimentation problems existed at Flannagan Lake occurred when the lake was drawn down to water quality pool level in the fall of 1971. A field inspection by representatives of several Federal and Virginia state agencies was conducted at Flannagan Lake in January 1972. Following this a cooperative sediment monitoring program between the U.S.G.S. and the Huntington District was initiated in 1973 to obtain data concerning the sedimentation problem. Next, a resurvey of the original 15 sediment ranges was conducted in 1974. The contributing drainage area was taken as the 200.5 square miles of upstream of the John W. Flannagan flood control pool and downstream of the North Fork of Pound Lake. This 1974 resurvey indicated that during the 15 years of project operation, 1187 acre-feet of sediment had been deposited in the lake. This represents about 9.9 percent of the minimum pool storage capacity, for an annual rate of sedimentation of 0.45 acre-feet per square mile of contributing area, which is slightly above the index rate from the Tennessee Valley quoted above. The results of the 1974 resurvey of sediment ranges indicated that the accumulation of sediment in Flannagan Lake was at an excessive rate and a matter of concern in regard to the effective operation and management of the project for authorized purposes.

The next sedimentation survey of Flannagan Lake was made in 1983, and it

indicated that the rate of sedimentation for the 9-year period between August 1974 and the August 1983 had increased. The increase in the sedimentation rate was apparently the result of hydrologic conditions and increased sediment producing surface mining activities in the basin during the latest period between surveys.

Flood control storage capacity remains essentially as originally allocated. At the end of the project's economic life, year 2068, the minimum pool would absorb the accumulation of sediment. The amount of flood control storage capacity would be not be reduced. This loss of minimum pool storage was anticipated during the design of the project. Therefore, potential loss of flood control storage was not regarded as a major problem.

Storage capacity and facilities at Flannagan Lake are adequate for meeting established streamflow regulation requirements. However, streamflow regulation capability will deteriorate significantly by year 2000 and the capability will be lost by year 2030.

Recreation development at the project includes several Corps-operated public use areas covering 93 acres and two acres under commercial lease. Recreational development has been limited by physical constraints, environmental degradation and absence of a qualified cost-sharing sponsor. Problems include floating debris, excessive sedimentation, safety problems relating to mining activities and lack of developable areas. Visitation exceeded 700,000 in 1975 and is expected to continue to rise until project services are lost or severely degraded. Water based recreational activities will be limited by year 2000 and eliminated by year 2025.

Problems associated with fish and wildlife are related to habitat limitations. Mining has taken a toll in decreased wildlife habitat. While fishery habitat has decreased due to loss of storage capacity, angling success remains remarkably good. Progressive loss of winter storage will cause a significant decline in harvestable size game fish and most fishery will be lost by year 2020.

Increasing energy needs and increasing emphasis on coal production to fill those needs could result in future mining in the drainage basin. An increase in sediment producing activities in the drainage basin above Flannagan Lake could increase the rate of sedimentation in the lake. The methods used in mining the coal and reclaiming the land after mining will affect the quantities of sediment reaching Flannagan Lake.

4-05 CLIMATE

a. General. The Flannagan Lake Basin lies beyond the immediate climatic effect of the Atlantic Ocean, and thus its climate is essentially continental in nature. The basin lies near the average path of extra tropical cyclones that move in a general easterly direction during the cooler months of the year. In the warmer months, the area is affected by moisture-bearing, low pressure systems which move from southwest to northeast from the western Gulf of Mexico. Summers are hot and sultry, marked by showery weather, with extreme summer temperatures occasionally reaching 100 degrees or higher. The basin experiences moderately severe winters with frequent changes of weather. Severe thunderstorms frequently cause local flash floods during the late spring and summer months. None of the National Oceanic and Atmospheric Administration (N.O.A.A.) climatological stations within the Flannagan Lake Basin have collected 30 years of data necessary to develop climatological means data. Climatological data for four representative locations near the Flannagan Lake Basin (Pikeville, Meta, and Paintsville, KY and Burkes Garden, VA) are presented in Table No. 4-2.

b. Temperature. N.O.A.A. temperature data is collected in eastern Kentucky at Pikeville, northwest of the Flannagan Lake Basin; and in south

western Virginia at Burkes Garden, east of the Flannagan Basin. The normal annual temperature at Pikeville is 58.2°F, and at Burkes Garden the normal temperature is somewhat less at 49.2°F. Normal monthly temperatures range from 30.°F in January at Burkes Garden to 77.°F in July at Pikeville. The length of the growing season is approximately 180 days at Pikeville, extending from mid-April to mid-October.

c. Precipitation. N.O.A.A. precipitation data is collected at Meta, Paintsville, Pikeville and Burkes Garden located adjacent to the Flannagan Lake Basin. Normal annual precipitation for these 4 stations ranges from 43.67 inches at Burkes Garden to 44.60 inches at Meta. Normal monthly precipitation ranges from 2.47 inches in October at Pikeville and Paintsville to 5.00 inches in July at Paintsville. Seasonal snowfall averages 16.0 inches at Pikeville and 17.3 inches at Paintsville.

d. Evaporation and Wind. For most Big Sandy 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 Flannagan Lake is approximately 33 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 11 inches per year. Lake evaporation for the Flannagan Lake area appears in Table No. 4-3.

Prevailing winds in the area are from the south or south-southwest. The mean annual wind speed, based on data from Lexington, KY is 9.7 miles per hour. The maximum mean monthly wind speeds average between 11 and 12 miles per hour during the period of December through April; minimum mean monthly wind speed is 7.0 miles per hour during August. Damaging windstorms are mostly associated with heavy thunderstorms, squall lines, or intense large-area storms.

TABLE NO. 4-3

JOHN W.FLANNAGAN LAKE EVAPORATION LOSSES - SUMMARY

Maximum Seasonal Evaporation 1930 = 29.0 inches
Average Annual Evaporation = 29 inches.
Average Seasonal Evaporation (May-October) = 21 inches.

Flannagan Lake Average Monthly Evaporation Losses

Month	Inches (1)	Acre-feet (2)
May	4.71	409
June	5.29	459
July	5.61	487
August	4.82	418
September	3.63	315
October	2.39	207

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

(2) Measured from seasonal pool elevation 1396.0 feet NGVD.

4-06 STORMS AND FLOODS

a. General. Most floods in eastern Kentucky are caused by precipitation of unusual intensity or of unusual duration and extent. Floods may also result from a series of ordinary storms that 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 often during the winter or early spring months, but it can occur at any time during the year.

The flooding characteristics of the Pound River Basin can be partially described by comparing the 40 highest historical floods. These floods are shown in Table No. 4-4 for the water years 1927 through 1987 at the Pound River near Haysi, VA U.S.G.S. gaging station. All flows represent natural flows occurring at the gage without regulation of Flannagan Lake. The datum of the gage currently is 1200.0 feet NGVD. Prior to December 20, 1939 a nonrecording gage was at a site 3.8 miles upstream at a higher datum. From December 20, 1939, to September 30, 1963, a water stage recorder was at a site 4.6 miles upstream at a datum of 1279.91 feet NGVD.

Flooding characteristics of the Pound River Basin can also be described by flow frequency data. A flow frequency curve for Pound River below Flannagan Lake that shows flow frequency data for both natural conditions in the stream and as modified by Flannagan Lake is shown as Plate No. 4-3. A discharge rating curve for the channel below Flannagan Lake, and an all season duration of discharge curve for Flannagan Lake are shown in a later section.

b. Storm and Flood of February 1862. The flood of February 1862 is the third highest of record in the Levisa Fork Basin. Inhabitants of the valley who remember the flood suggest that the flood was caused by heavy rainfall on accumulated snow. The flood on Levisa Fork at Pikeville reached a stage of 51.9 feet, which is about 0.7 foot lower than the January 1957 flood of record. The crest stages at Prestonsburg, Paintsville and Louisa for the flood were 50.0, 46.6 feet and 52.6 feet, respectively. The average runoff from the Levisa Fork Basin was estimated to be approximately 3.2 inches. The Cincinnati newspapers indicate that the flood was localized in the Big Sandy valley with no Ohio River flood. Information obtained from residents of the Pound River Valley indicates that the flood of February 1862 was of major proportions on that stream, but no high water marks from the flood were preserved. The Civil War was in progress and the mountain area of Virginia and Kentucky was in turmoil, however the military records have left a few scraps of data for this flood. The overall sentiment of the Russell Fork, Levisa Fork, and Pound River area was for the Union, with a large amount of confederate support when any Rebel troops were in the area. The Confederate Army entered the area through Pound Gap and was defeated in January 1862 at Middle Creek, near Prestonsburg. Following this victory General James Garfield, later President, brought his freight and supplies to Pikeville, and stored them 10 feet above the highest known flood level. The torrential rains during the night of 22 February caused the river to rise 12 feet in one hour, and over 50 feet in one night. General Garfield not only lost his supplies, but two of the Union Steamboats were left stranded on the main street of Pikeville. General Garfield and the Union Army held Eastern Kentucky despite the rebels, high water, and supply problems.

c. Storm and Flood of January 1918. The storm which caused this flood was preceded by snow, sleet, and temperatures below freezing, all of which were instrumental in causing excessive runoff. Snowfalls at Pikeville and Weeksbury in the Levisa Fork Basin were the heaviest known to that time for the month of January, amounting to 20.2 and 13.0 inches, respectively. Precipitation, generally in the form of snow, was almost a daily occurrence during the first 3 weeks of January. On 26 January, a minor low pressure center passed near the headwaters of the Levisa Fork Basin, producing minor amounts of rainfall, which was absorbed by the snowcover. On 27 January, a large storm passed over the Levisa Fork-Russell Fork-Pound River Basin, producing warm temperatures and heavy rainfall, with more than 2 inches of rain falling over a large portion of the basin in a 12-hour period. The heavy precipitation in conjunction with melted snow combined to produce a stage of 44.7 feet at Pikeville on 28 January, the highest stage recorded since February 1862. The next day a crest of 44.2 feet was reached at Prestonsburg, a crest of 41.5 was reached at Paintsville, and a crest stage of 47.0 feet was reached at the Louisa gage, 3

feet below the maximum known stage there. The flood waters reached the mouth of Big Sandy River late on 29 January, and along with floods from other tributaries, began breaking up ice in the Ohio River, resulting in ice gorges which caused enormous damage to river craft.

d. Storm and Flood of March 1929. The flood of March 1929 reached major proportions throughout the Levisa Fork watershed and was the highest of record on Pound River near Haysi, VA. The flood was preceded by the periods of unusually high temperatures. The flood was caused by heavy rainfall on the 23rd with 3.21 inches recorded at Jenkins, KY, and 2.93 inches at Dante, VA None of the present reservoirs were built at the time, however the flood has been reconstituted from the available data and routed downstream. The volume of runoff from Pound River was approximately 3.00 inches and the pool crest would have been about 1411 feet NGVD. On Pound River near Haysi on 23 March an estimated crest stage of 18.9 feet and a published flow of 30,000 cfs was reached. The Levisa Fork gage at Pikeville crested at 44.6 feet or 60,000 cfs with about 12,000 cfs in computed reductions for John W. Flannagan Lake.

e. Storm and Flood of January 1937. The flood of January 1937 was the greatest of record on the Ohio River below Point Pleasant, WV. It resulted from excessive rains during January which followed moderate rains occurring in the latter part of December over the entire Ohio River watershed. During the period 15 to 25 January 1937, the rainfall in the Big Sandy River Basin averaged more than 6 inches. The resulting flood on Pound River did not reach extreme heights, but the prolonged duration of the storm produced large volumes of runoff. The same resulting flood on Levisa and Tug Forks did not exceed flood stages but at Louisa the crest stage was 49.0 feet, 4.0 feet above flood stage. The estimated runoff volumes from Levisa Fork and Tug Fork were approximately 5.1 and 3.5 inches, respectively. The flood rises of 18 January, 25 January, and 9 February produced crests of 12.7 ft., 12.1 ft., and 13.6 ft, respectively on Pound River near Haysi. None of the present reservoirs were built at the time, however the flood and operation has been reconstituted with an estimated pool crest of about 1416.feet NGVD. On the lower 22 miles of the Big Sandy River, the flood of January 1937 was the maximum of record due to backwater from the Ohio River. The hydrographs shown in this and subsequent exhibits labeled "natural" represent the flow conditions that would exist without the Flannagan Lake Project, and those labeled "modified" represent the inflow conditions that exist with the project. The outflow hydrograph represents the regulated outflow from Flannagan Lake.

f. Storm and Flood of February 1939. The flood of February 1939 reached major proportions throughout the Big Sandy River Basin, and was caused from two distinct storms, with the heaviest amounts reported over the lower portion of the basin. On 30 January the first storm released between 1.0 and 1.2 inches over the basin, which saturated the ground and started the streams to rise. The second storm occurred on the 1st to 3rd of February and resulted in rainfall over the basin varying from 2.0 to 4.0 inches with the heavier rainfall over the lower Levisa Fork Basin below Pikeville. The volume of runoff on Pound River near Haysi was approximately 1.9 inches. Maximum stages of record were reached on many of the upper and lower tributaries, and the stages at Paintsville and Louisa were the greatest since before 1900. The crest flow of 47,800 cfs was recorded early on 4 February at Pikeville, and a crest stage of 51.6 feet was reached at Louisa on 5 February. The estimated crest stage at Pound River near Haysi, VA was 15.8 ft. with a flow of about 18,200.cfs.

g. Storm and Flood of July 1942. This storm occurred in the early morning hours of 8 July, and although the intensities were not very great throughout the basin, the high runoff was probably due to the saturated conditions of the soil from previous rains. For the period 7-11 July at Haysi, VA, the total rainfall was 3.29 inches with 1.73 inches occurring on the 8th; at Jenkins, KY, the total was 4.43 inches with 2.71 inches occurring on the 8th. The storm centered on North Fork of Kentucky River near Quicksand, where a total of 8.13 inches fell with 5.1 inches on the 8th. On Pound River near

Haysi a crest stage of 15.55 feet was reached with a flow of about 17,700 cfs. This flood is the maximum recorded summer flood for the upper Levisa Fork and Pound River prior to the construction of Flannagan Dam.

h. Storm and Flood of February-March 1955. The storm period began on 26 February and was characterized by unseasonable warmth, thunderstorms, and general rains while the area was under the influence of warm, moist air masses. Extremely heavy rains, averaging 3.0 inches, from 4-6 March followed earlier rains of approximately 3.8 inches, which fell during the last three days of February. The flood on Levisa Fork reached a stage at Pikeville of 39.1 feet, thirteenth highest of record. The multiple rises of 1 March, 6 March, and 16 March 1955 caused flood crests of 12.0 feet., 12.4 feet., and 13.2 feet., respectively on the Pound River near Haysi. At Paintsville, the stage reached 41.3 feet, seventh highest of record. On Tug Fork at Williamson and Kermit the crest stages were 37.4 and 43.5 feet, respectively, fifth highest of record. The crest stage of the Big Sandy River at Louisa was 52.6 feet, third highest of record. The Ohio River reached a crest stage of 63.2 feet at Lock No. 29. It is estimated that the regulation of Flannagan Reservoir would have resulted in crest stage reductions of 2.5 feet at Pikeville and in conjunction with existing reservoirs above the confluence of Big Sandy and Ohio Rivers, would have reduced the stage at Louisa 2.5 feet and 3.0 feet at Lock No. 29. The volume of runoff from the series of storms amounted to approximately 5.5 inches from each of the Forks of the Big Sandy River.

i. Storm and Flood of January 1957. Frontal activity between strongly contrasting air masses brought excessive rainfall to the southern Appalachian region during the period of 27 to 29 January 1957. Rainfall from 27 January to 1 February averaged 5.0 inches over the basin, varying from 2.8 inches in the lower basin to 7.0 inches in the upper basin. The streams were at average flows and the ground was saturated from antecedent rainfall at the onset of the storm. On upper Levisa Fork and along most of Tug Fork, the flood exceeded the previously known maximum. The flood on Levisa Fork reached a stage at Pikeville of 52.7 feet, 0.8 foot higher than the previous maximum of 1862, while at Paintsville the stage reached 46.0 feet, 0.6 foot lower than the maximum of 1862. The crest stage on Tug Fork at Williamson was 43.6 feet, 0.4 foot higher than the previous maximum of 1875 and about 1 foot below the present maximum of March 1963; while at Kermit, the stage was 46.0 feet, or 0.9 foot lower than the maximum of 1875. The Big Sandy River at Louisa reached a crest stage of 50.8 feet. It is estimated that regulation of Flannagan Reservoir would have resulted in crest stage reductions of 6.9 feet at Pikeville and in conjunction with existing reservoirs above the confluence of Big Sandy and Ohio Rivers, 1.9 feet at Louisa. The volume of runoff from the drainage areas of Levisa Fork and Tug Fork amounted to approximately 3.4 and 3.0 inches, respectively. The flood of 29 January 1957 produces a near record crest and flow on Pound River of 18.7 ft. and 27,300 cfs.

j. Storm and Flood of March 1963. In March 1963, three separate periods of severe flooding occurred in the Big Sandy River Basin due to an above average amount of precipitation after three previous months of cold dry weather. The first rise occurred between March 5th and 9th, the second between the 11th and 16th and the third between the 16th and 21st. Monthly precipitation ranged from slightly more than 2 inches above normal in the west to almost 4 inches above normal in the eastern section of Kentucky. On Tug Fork, the stage at Williamson, WV, crested at 44.5 feet, 0.9 feet above the previous flood of record January 1957. John W. Flannagan reservoir was under construction at the time of the flood and was partially regulated for all three rises during the month of March in order to reduce down stream damage.

The highest of the three rises for Pound River was on 12 March with an estimated crest of 18.0 feet and an estimated flow of 25,000 cfs. The gage was obscured backwater from the dam and the flow through the diversion tunnel was estimated to be 10,820 cfs.

The Levisa Fork crested at Pikeville, KY with a modified level of 45.8 feet and

a flow of 76,000 cfs. It has been estimated that the Flannagan Lake reduced the crest at Pikeville by about 6.2 feet.

k. Storm and Flood of March 1967. Heavy general precipitation fell over Kentucky and adjacent states during the period 4-7 March 1967, causing floods of record in many northcentral and southern West Virginia watersheds, and headwater flooding in areas of eastern Kentucky. In northwestern Kentucky, much of the precipitation of 6-7 March fell in the form of snow, with some areas receiving record snowfalls in a 24-hour period. In the area of the Flannagan Lake watershed, rainfall totals for the period of 4-7 March averaged about 3 inches. The bulk of the rain fell on 6 March, with Flannagan Lake receiving 2.52 inches and nearby Meta receiving 2.71 inches during a 24-hour period. Nearly 1 inch of rain fell during a 4-hour period during the early evening of 6 March. This flood produced actual crests on the Levisa Fork of 41.06, 40.06, and 37.85 feet at Pikeville, Paintsville, and Prestonsburg. Russell Fork had actual crests of 18.9 and 17.2 feet at Bartlick and Elkhorn City. John W. Flannagn reservoir was fully operated for this flood and the intense storm produced a regulated outflow of 4500 cfs with a record computed crest at the outflow gage of 21.0 feet and a record computed natural flow of 38,000 cfs.

l. Storm and Flood of January 1974. Heavy rains fell over eastern Kentucky during 8-11 January 1974, causing flooding conditions in the Levisa Fork basin. Within the Flannagan Lake Basin there was about 2.7 inches of runoff during the 9-13 January period; with nearby Meta receiving 4.5 inches of precipitation during the 4-day period, 3.6 inches of which fell in a 27-hour period on 9-10 January. Pikeville, located just northwest and downstream of the Flannagan Lake Basin, received 5.23 inches of precipitation during the 4-day period, including 4.08 inches in a 24-hour period. This heavy rainfall produced an observed modified crest at Pikeville of 34,200 cfs. John W. Flannagan Reservoir was fully operated for this flood with a peak outflow of 3900 cfs, a computed inflow crest of 14,000 cfs, a pool crest of 1403.98 feet NGVD, and a computed natural crest of 11,000 cfs at the reservoir outflow gage.

m. Storm and Flood of April 1977. Heavy rains fell over the Appalachian region of Eastern Kentucky during the period of 2-5 April 1977, causing record flooding. Flood discharges in the upper Levisa and Tug Forks exceeded all previous records. The most significant periods of precipitation during the month began on the evening of the 2nd of April. The post flood frequency study revealed the level of flooding to exceed the 100 year level at 29 stream gaging stations. Although there was an 18-24 hour break in the rainfall on Sunday the 3rd, this set the stage for greater runoff when the rain began again on Sunday evening. A series of disturbances moved from the southern plains into the Appalachians on Monday 4 April. Heavy thunderstorms formed ahead of the disturbances in the lower Mississippi Valley and moved rapidly north eastward along a stationary front into the Southern Appalachians. Three bursts of heavy rainfall occurred over Southern West Virginia, Southeastern Kentucky, and Western Virginia during the 4th. The first heavy rain fell between midnight and 5 AM; the next around midday; and the last around sunset. Measured rainfall ranged from 1.31 inches at Louisa, KY, to 9.44 inches at Flat Gap, VA, in the head water area of the Pound River. High intensity rainfall was also recorded at Tiny, VA, in the headwaters of the Russell Fork measuring 8.65. Darwin on Cranenest River recorded 7.32 inches, Burdine, KY. just over the basin rim had 5.27 inches, and Hurley on Knox Creek in the Tug Fork Basin recorded 6.69 inches. The center of the storm seemed to be in the head waters of Slate Creek and near Jalo in the Tug Fork where over 15.5 inches fell in 30 hours at the storm center. This intense rain fall resulted in a rapid concentration of runoff for many streams in the Pound River, Russell Fork and upper Levisa Fork Basin. Storm runoff from the area above Pikeville was 5.8 inches, with Pound River runoff averaging about 5.1 inches. This would indicate that average basin rainfall above Pikeville exceeded 6.5 inches.

The April 1977 flood was the greatest known flood on Levisa Fork above Pikeville and produced a record computed natural flow of 150,000 cfs at

Pikeville. Substantial reductions in peak discharges were accomplished as a result of reservoir storage in North Fork of Pound Lake and Flannagan Lake on the Pound River and Fishtrap Lake on the Levisa Fork. Operation of Flannagan lake for this flood of record in the upper Levisa Fork and Pikeville is shown in a later section. At the start of the flood, Flannagan was refilling to seasonal pool level of 1396 feet NGVD., by storing inflow. After a series of disturbances moved over this region, it became apparent that Flannagan Lake would have to prepare for a flood. Because the flood occurred during the refilling period the crest of the Flannagan Lake pool reached a record level of 1430.77 feet NGVD at 1300 hours on 7 April. This record flood had a computed natural crest of 17,000 cfs, a regulated crest at the outflow gage of 4540 cfs on 8 April, and overall reductions at Pikeville for Flannagan Lake of about 4.4 feet.

n. Storm and Flood of May 1984. Heavy rains falling on saturated ground created flash flooding conditions in Eastern Kentucky during early May 1984. The upper part of the Levisa Fork Basin received the heaviest part of the storms causing severe crop damage to the freshly plowed fields. Isolated storms occurring on 3 and 4 May dropped up to about 2 inches of rain over the Flannagan Lake Basin during the period 3-4 May, saturating the soil prior to the heavy rainfalls of 6-8 May. During the following days of 6-8 May, more than 4 inches of rain fell over portions of the Flannagan Basin. Pikeville, KY, had a recorded crest of 45.48 feet, a corresponding flow of 38,400 cfs, and a computed natural crest of 83,500 cfs late on the 7th of May. The Birch Gap station reported a rainfall of 4.02 inches by 0800 on the 7th of May, with 2.39 falling on the 7th; with the nearby station of Meta having approximately 4.2 inches of rainfall in the 3-day period of 6-8 May, including 2.2 inches on the 7th. The total storm was about 6.93 inches over the Pound River Basin with a runoff of 2.87 inches. This flood produced a regulated outflow of 4,000 cfs on 7 May with a computed natural crest of 15,000 cfs at the outflow gage. Pikeville, KY had an observed crest of 45.48 feet for this flood and John W. Flannagan Lake was credited with about 3.1 feet of reductions at Pikeville for this flood.

4-07 RUNOFF CHARACTERISTICS

The Pound 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.

Table No. 4-5 presents average normal, maximum, and minimum runoff from the watershed just below the Flannagan Lake damsite, based on 28 years of record (1965 through 1992) at the U.S.G.S. gage. The gage is located about 1700 feet downstream of the Flannagan Lake dam and 1100 feet upstream from Backlog Branch. Flow frequency curves are given on Plate No. 4-3 and the annual flow duration curve is shown in a later section.

TABLE NO. 4-5
MONTHLY AND ANNUAL RUNOFF
POUND RIVER BELOW FLANNAGAN LAKE DAM

Month	Normal Average Flow (cfs)	Maximum Average Flow (cfs)	Minimum Average Flow (cfs)
January	442	1,171	31.8
February	469	898	92.3
March	487	1,181	110
April	281	1,004	49
May	356	1,074	47.4

June	185	756	9.66
July	116	320	5.49
August	105	243	7.13
September	104	405	32.5
October	254	927	48.9
November	314	679	24.8
December	349	1003	16.1
Annual	288	481	120

Statistics for water years 1965-1992 (regulated, unadjusted)

4-08 WATER QUALITY.

John W. Flannagan Reservoir is located on Pound River in Dickenson County, VA. The dam is located 3.5 miles northwest of Haysi, VA, 1.8 miles upstream from the mouth of Pound River and about 150 miles upstream from the Ohio River as measured along the Big Sandy River, Levisa Fork, Russell Fork, and Pound River. The reservoir controls a drainage area of 221 square miles.

The Pound River Basin is located in the Appalachian Plateau Physiographic province of the United States. The area is underlain by sedimentary strata of Pennsylvanian Age. These strata, which consist of sandstone, shale, and coal, were deposited in large inland seas about 200 to 300 million years ago. They were greatly stressed and uplifted by crustal movements at the close of the Paleozoic Era. The resultant folding inclined the strata and formed anticlines and synclines. Active erosion in the area following the disturbance formed the high ridges and narrow, deep valleys now predominating the topography of the area.

Iron levels are not present at problematic concentrations, but manganese concentrations are. Levels of nitrogen are high in the watershed, and phosphorus appears to be the biologically limiting factor. In terms of major ions and descriptive parameters, water in the Pound River Basin above Flannagan is classified as a magnesium sulfate type. This represents an unbalanced condition. Normally the classification would be calcium carbonate.

Water quality data collected by the Corps of Engineers from 1974 to 1996 indicated that water quality of the basin has improved, but it is still closely related to the fortunes of the coal industry.

4-09 CHANNEL AND FLOODWAY CHARACTERISTICS

Pound River follows a tortuous course from its source in the eastern portion of Wise County to its confluence with Russell Fork below Haysi, VA. The stream flows between steep hills and over its 43-mile length has an average valley width of slightly less than 500 feet. At the Flannagan Lake damsite, the valley is narrow and steep sloped with a bottom width of about 400 feet. Pound River at this point is about 100 feet wide with banks about 20 feet high. Time of travel of Flannagan Lake discharge along Pound River, Russell Fork, and Levisa Fork to Pikeville is approximately 15.8 hours.

4-10 UPSTREAM STRUCTURES

Upstream of Flannagan Lake located just above Pound, VA is located another multipurpose Corps of Engineers Lake, North Fork of Pound Lake. This small lake has a 17.2 square mile drainage area and is used for flood control, recreation, fish and wildlife; and also as a water supply source for the city of Pound, VA and as an inflow structure for Flannagan Lake. The location and uses of most of the upstream structures are shown on Plate No. 4-4.

4-11 ECONOMIC DATA

a. Population. There are no major population centers within the Flannagan Lake drainage basin. The closest upstream community to Flannagan Lake is Clintwood, VA, the county seat of Dickenson County, population 1369, located about 8 miles upstream on state route 607. Another nearby village is Haysi, VA, population 371, located about 4 miles east on Russell Fork. The closest major community to Flannagan Lake is Pikeville, the county seat of Pike County, KY, population 4,756, located about 25 miles northwest of the dam on U.S. Route 23. Pike County, KY had a 1980 census population of 81,123. The other nearby communities are Elkhorn City, KY, population 1,446, Jenkins, KY, population 3,271, and Grundy, VA population 1,699.

b. Industry and Agriculture. In the Flannagan Lake watershed, habitations, roads, and cleared and cultivated lands are largely confined to the narrow bottoms of the larger streams. Some lower slopes are also cleared and used for pasture and hay crops. Coal, however, has dominated the economy of the area since the early portion of the 20th century. In general, those who live in the area have not prospered in proportion to the wealth they have helped to provide. Absentee ownership of a large portion of minerals and production facilities causes a large portion of profits generated by the coal industry to leave the area. Deposits of low-sulfur coal are extensive in the basin, and the area is part of the Big Sandy gas field.

c. Flood Damages. Areas subject to flooding downstream of Flannagan Lake along Pound River and Russell and Levisa Forks are mainly agricultural in nature. Crops are planted to within a few feet of the low water line along Pound River and Russell Fork, but much of the cultivated land is located on higher ground. Downstream along Levisa Fork, flood damages occur to agricultural areas and also to the communities of Elkhorn City, Pikeville, Paintsville, Prestonsburg, and Louisa, KY.

The project benefits for Flannagan Lake can best be defined in terms of average annual flood control benefits for a period of record. If it is assumed that the flood experience from the year 1950 through 1995 is representative of the long-term average and that the accumulated benefits are a conservative estimate of the damages prevented, the computed average annual flood control benefits for Flannagan Lake would be about $4,875,166. per year based on the 30-year life of the dam. However, it should be noted that no escalation of past benefits has been made for inflation; the 1964 dollars are added directly to the 1993 dollars. Another method would be to use the ENR average national construction cost index system for escalation. The average yearly index cost figure for the 31 year period rose from 936 to 5336, with an average of 2977. The 1994 level of 5336 was 179% above the 31 year average. The same increase to the annual benefits would give a present day worth of $8,726,540. per year for John W. Flannagan Lake.

Sometimes the total benefits for the last five years are used as a base for average annual benefits. The last five year benefits could not be used for the Levisa Fork - Pound River Basin, because there has been no large floods in this time period. The figures were very much below average and not revealing. For the last five years (FY90-94) the three largest reservoirs alone (Fishtrap, Flannagan, and Dewey) had a combined accumulated flood damages prevented of about $23.15 MILLION DOLLARS. John W. Flannagan Lake has about 94,700 acre-feet of flood control storage, which combines with the other two large lakes to give a 3 lake total of 329,000 acre feet for flood control storage. By using this ratio of 28.7 percent for Flannagan the computed benefits for the last five years would be about $6.644 million dollars. This would be only $1.3 million dollars per year.

TABLE 4-4

POUND RIVER BELOW FLANNAGAN LAKE NEAR HAYSI, VIRGINIA
MAXIMUM FLOOD CREST DATA 1927-1967

Date	Gage height feet (1)	Discharge c.f.s.	Duration days (2)
7 Mar 1967	21.0*	38,000*	-
23 Mar 1929	18.9	30,000	1.1
29 Jan 1957	18.7	27,300	1.6
12 Mar 1963	18.0	25,000	-
21 Dec 1926	16.3	19,900	0.8
3 Feb 1939	15.8	18,200	1.0
8 Jul 1942	15.6	17,700	0.9
8 Jan 1946	15.5	17,400	1.3
5 Apr 1977	15.4	17,000	1.1
18 Feb 1944	14.7	15,100	0.9
7 May 1884	14.6	15,000	0.9
29 Jan 1932	13.8	12,700	1.3
16 Apr 1956	13.7	12,300	1.2
9 Feb 1937	13.6	12,100	0.9
24 Mar 1936	13.4	11,600	l.0
11 Jan 1974	13.2	11,000	0.8
16 Mar 1955	13.2	11,000	0.8
14 Feb 1948	13.1	10,800	1.7
19 May 1953	13.0	10,500	1.4
22 Oct 1929	13.0	10,400	0.5
14 Jul 1938	12.8	10,000	1.1
19 Apr 1943	12.8	10,000	0.8
28 Feb 1962	12.8	10,000	-
6 May 1958	12.7	9,880	1.6
18 Jan 1937	12.7	9,760	0.9
6 Apr 1936	12.6	9,550	0.9
30 Jan 1950	12.6	9,520	1.3
6 Mar 1955	12.4	9,040	1.3
7 Dec 1936	12.4	8,980	0.6
30 May 1927	12.3	8,800	0.8
28 Dec 1932	12.3	8,800	0.6
3 Mar 1934	12.3	8,800	1.1
17 Feb 1945	12.3	8,800	0.8
25 Jan 1937	12.1	8,320	0.7
29 Feb 1944	12.1	8,320	0.7
2 Feb 1950	12.1	8,320	1.3
1 Mar 1955	12.0	8,080	3.1
22 Apr 1927	11.9	8,020	0.7
31 Mar 1935	11.9	8,000	l.0
30 Apr 1928	11.8	7,800	0.8
18 Mar 1949	11.7	7,620	0.7
7 Dec 1950	11.7	7,620	0.6
22 Jan 1952	11.7	7,620	0.6

(1) Present site, datum and conditions
(2) Duration above damage stage of 9.2 feet
* Computed natural crests

SECTION V - DATA COLLECTION AND COMMUNICATION NETWORKS

5-01 General

The Huntington District water control system consists of an up to date computer, located in the Water Resources Engineering Branch, and many Data Collection Platforms (DCP's) and Hydrologgers located throughout the district at various stream gaging and precipitation stations. Installations at stations in the Pound River, Russell and Levisa Fork Basins are described in Table Nos. 5-1 and 5-2, (T5-3 and T5-4,table section). DCP's collect, store, and transmit data via the Geostationary Operational Environmental Satellite (GOES) to various receiver sites. The current hydrologic network system is illustrated in Plate No. 5-1. Data collected by DCP's in the Huntington District are received by the Great Lakes and Ohio River Division (LRD) downlink in Cincinnati, Ohio and disseminated at least hourly to the District water control system via the LRD water control system over a leased line.

Many DCP's, 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 via INTRANET. Each project morning report is entered into a computer terminal offline and transmitted directly over telephone lines to the district water control system via the new Intranet format. The district radio network is used as an emergency backup, when needed as shown on Plate No. 5-2. Data are also received from the National Weather Service (NWS) through the water control system, and reservoir project data are also disseminated back to the NWS with the water control system.

5-02 HYDROMETEOROLOGICAL STATIONS

a. Streamflow Stations. Numerous stream gaging stations, designed for the collection of hydrologic data, are located at strategic sites in and around the North Fork of Pound, Pound River and Russell and Levisa Fork Basins. Those stations pertinent to John W. Flannagan Lake are shown in Table No. 5-1(Table Section).

(1) Stream Cooperative Program. The Corps of Engineers and the U.S. Geological Survey began the Federal-State Cooperative Water Resources Program about 1940. The U.S.G.S. 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 U.S.G.S. maintains the following stream gaging stations: North Fork Pound River at North Fork Lake, VA; North Fork Pound River below North Fork Lake; Pound River above Pound, VA; Pound River below Pound, VA; Russell Fork near Haysi, VA; Russell Fork at Bartlick, VA; Russell Fork at Elkhorn City, KY; Pound River above Indian Fork; Pound River below Bold Camp Creek; Pound River below Georges Fork, VA.; Cranesnest River near Clintwood, VA; John W. Flannagan Reservoir near Haysi, VA; Pound River below Flannagan Dam near Haysi, VA; Levisa Fork at Pikeville, KY; Levisa Fork at Prestonsburg, KY; Levisa Fork at Paintsville, KY; and Big Sandy River at Fullers, KY. The Corps of Engineers also maintains the lake gage at John W. Flannagan Lake independent of the stream cooperative program.

(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 now being used to digitally record water levels. The data collection platforms mentioned earlier, in sub-section 5-01, have been installed at basin gages as listed in Table No. 5-1(Table Section). The platforms store stage and precipitation data and transmit every four hours to the LRD computer downlink via the Geostationary Operational and Environmental Satellite (GOES). The Water Resources Engineering Branch water

control system receives data automatically from the LRD water control system on an hourly basis. If desired, the District can also access the data at other times by operator control. The Huntington District Hydrologic Network is shown on Plate No. 5-1 and the District Radio Network is shown on Plate No. 5-2.

Some data collection platforms and Hydrologgers 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 John W. Flannagan, Pound River, Russell Fork, Levisa Fork and Big Sandy River 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. 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.

(4) Maintenance. Routine daily first level maintenance for all the mechanical stream gaging equipment for the Big Sandy River Basin, including John W. Flannagan Lake will be performed by the assigned personnel at each lake. Advanced maintenance, particularly for a mechanical breakdown, for the electronic gaging equipment will be performed by the Corps trained technicians.

b. Precipitation Stations.

(1) ORN Program. The Ohio River Reporting Network, a division wide 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 National 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 level and outflow forecasts, and depth reports from the Corps of Engineers, Snow Cover Reconnaissance.

Precipitation stations in and near the John W. Flannagan Lake watershed include Pound, John W. Flannagan Lake, Clintwood, North Fork of Pound Lake, Grundy, Pilgrim Knob, Davenport, Haysi, Bartlick, Elkhorn City, Paintsville, Pikeville, Pound River below Bold Camp Creek, Georges Creek, and Williamson.

(2) Collecting and Reporting. Normal equipment is the 8-inch Standard Rain Gage with a metal support. At most locations within the Levisa Fork Basin, a tipping bucket precipitation gage is interfaced to a data collection platform. The platform receives precipitation data from the gage electrically and transmits the data to the computer downlink via satellite. The standard gage is thus read and reported electronically to the National Weather Service and the Huntington District Water Control System. John W. Flannagan Lake utilizes both the standard gage and tipping bucket gage. Station locations within the Pound River Basin are shown on the Basin Drainage Map,

Plate No. 2-1, and data collection and communication equipment utilized at all stations are listed in Table No. 5-2 (T5-5 Table Section).

The Corps personnel at John W. Flannagan, Fishtrap, Dewey, North Fork of Pound, Paintsville, and Yatesville Lake report any precipitation or sudden abrupt changes in weather on the computerized morning report by telephone to the District water control system. The District water control system also relays the data to NWS in Charleston, WV. Usage of data from these reports and data exchanged with the NWS is described below.

The Water Control Section utilizes platform information, morning report information and Weather Service data in forecasting and computing average precipitation over the Pound River Basin and the Big Sandy 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.

A large portion of the total precipitation information received by NWS comes through the cooperative ORN program. Complete district morning report data accessed from the Water Resources Engineering Branch mini-computer (water control system) are reorganized by NWS personnel into downstream format and inserted into the NWS Eastern data bank. The data are widely used by NWS elements such as those producing infiltration indices and short, medium and long-range forecasts, and by the River Forecast Center in Wilmington which produces Ohio River and tributary stage and flow forecasts. The Charleston office utilizes the data early in their mid-morning weather report including any updating of forecasts which may be indicated.

(3) Maintenance. Routine daily first level maintenance for all the mechanical precipitation recording equipment for the Big Sandy River Basin, including John W. Flannagan Lake will be performed by the individual weather observer. Advanced maintenance, particularly for a mechanical breakdown, for the electronic recording equipment will be performed by the Huntington District trained technicians.

5-03 WATER QUALITY STATIONS

a. Facilities. A network of twenty-three water quality sampling stations was established at John W. Flannagan Reservoir. Primary stations located on the lake are shown on Plate No. 5-3. All primary stations within the basin are described in Table No. 5-3. Standard physical/chemical tests and reasons for testing are presented in Table No. 5-4(Next Page). The water quality standards for the state of Virginia are shown on Plate No. 5-4.

b. Reporting. Water quality data collected at John W. Flannagan Reservoir 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, modification of reservoir regulation procedures aimed at controlling or enhancing environmental conditions, and meeting water quality objectives; and

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

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 John W. Flannagan Reservoir was structured to describe the various factors affecting water quality over the long term. Data collected are used for applications such as identification of trends indicating problem conditions and reporting existing conditions. Basic studies consist of 5 essential components:

TABLE NO. 5-3

Description by Location of John W. Flannagan Reservoir
Primary Water Quality Sampling Stations

Station	Distance From the Dam		
JWF0001	0.5	Kilometers	Below
JWF0002	33.8	Kilometers	Above
JWF0003	28.0	Kilometers	Above
JWF0004	0.5	Kilometers	Above
JWF0005	2.6	Kilometers	Above
JWF0006	4.0	Kilometers	Above
JWF0007	5.8	Kilometers	Above
JWF0008	7.4	Kilometers	Above
JWF0009	8.8	Kilometers	Above
JWF0010	10.6	Kilometers	Above
JWF0011	12.2	Kilometers	Above
JWF0012	14.0	Kilometers	Above
JWF0013	15.8	Kilometers	Above
JWF0014	16.9	Kilometers	Above
JWF0015	19.0	Kilometers	Above
JWF0016	20.0	Kilometers	Above
JWF0017	7.0	Kilometers	Above

(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

c. Maintenance. Sediment and water samples are collected from John W. Flannagan Reservoir once every 5 years. Water samples are also collected every 10 years each month for the months 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 that 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	Nutrient
Total Organic Carbon (TOC)	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

5-04 SEDIMENT STATIONS

a. General. In order to monitor and assist in carrying out the authorized purposes of flood control, recreation, and fish and wildlife conservation at John W. Flannagan Lake, a sediment monitoring program has been established at Flannagan Lake.

The program designed for John W. Flannagan Lake has been structured to measure describe, either separately or in combination, the various factors which affect sedimentation. Results are used for project regulation activities, and to safeguard the integrity of project purposes. The program is described as follows.

b. Facilities. A network of sediment ranges was established at John W. Flannagan Lake with concrete monuments to mark the ends of each range, sediment range monitoring stations are listed below in Table No. 5-5(Next Page). The original 15 ranges were approved by the Chief of Engineers in 1958 and are shown on Sediment Range Network, Plate No. 5-5. Three additional category "A" sediment ranges, numbers 16-A, 17-A, and 18-A, and two category "C" or downstream ranges, 1-C and 2-C were established and profiled in 1983.

c. Reporting. In order to monitor the rate of deposition of sediment in the lake, reconnaissance scope survey of selected ranges are conducted every five years unless an earlier survey is indicated by natural causes, such as a major flood or by increased sediment producing activities in the basin. Sedimentation surveys were completed at Flannagan Lake in 1974, 1983, and 1994. The original network of 15 sediment ranges at Flannagan Lake was approved by the Chief of Engineers in 1958; ground profiles along the ranges were taken during the period January through February 1959. The first re-survey of the 15 sediment ranges, was completed in 1974. The next re-survey of 12 selected ranges was completed in 1983, and the latest re-survey of the 18 ranges was in September 1994. The original minimum elevation profile for John W. Flannagan Lake at each sediment range is shown on Plate No. 5-6. Also included on Plate No. 5-6 are the minimum sediment range elevation profiles for each succeeding re-survey.

TABLE NO. 5-5

LOCATION OF
JOHN W. FLANNAGAN LAKE
SEDIMENT RANGE MONITORING STATIONS

Station	Mile Point	Distance Above or Below Dam
1JWFCP001	0.80	1.0 Mile Below
2JWFCP002	1.30	0.5 Mile Below
1JWFAP003	1.90	500. Feet Above
2JWFAP004	2.80	1.0 Mile Above
3JWFAP005	3.80	2.0 Mile Above
4JWFAP006	4.90	3.1 Mile Above
5JWFAP007	6.00	4.2 Mile Above
6JWFAP008	7.70	5.9 Mile Above
7JWFAP009	8.80	7.0 Mile Above
8JWFAP010	10.50	8.7 Mile Above
9JWFAP011	12.80	11.0 Mile Above
10JWFAP12	15.50	13.7 Mile Above
11JWFACN13	7.55	5.75 Mile Above
12JWFACN14	9.90	8.10 Mile Above
13JWFACN15	11.90	10.1 Mile Above
14JWFACN16	13.50	11.7 Mile Above
15JWFACN17	15.70	13.9 Mile Above
16JWFATB18	5.70	3.9 Mile Above
17JWFALTB19	6.20	4.4 Mile Above
18JWFAUTB20	6.30	4.5 Mile Above

The results of the sedimentation surveys indicate an average sedimentation rate of 90.2 acre-feet per year or 0.45 acre-foot per year per square mile of contributing drainage area for the 15-year period from 1959 to 1974. The 1983 resurvey indicated an increase in sedimentation rates for the 9-year period between 1974 and 1983. The higher rates in these periods have been attributed to increased annual precipitation and streamflows along with greater surface mining activities during these periods. The 1983 study recommended that a detailed sedimentation study at Flannagan Lake of all sediment ranges to be accomplished in FY 1988. This survey was postponed due to lack of funding, and was finally accomplished in September 1994. The results of the September 1994 sedimentation surveys indicate an average sedimentation rate of 84.4 acre-feet per year or 0.44 acre-foot per year per square mile of contributing drainage area for the 20-year period from 1974 to 1994.

d. Maintenance. The sediment range markers should be regularly and periodically checked by the project personnel and the survey party so that damaged and missing markers can be replaced and undergrowth that may obscure the markers can be removed.

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 North Fork of Pound, Pound River, Russell and Levisa Forks and Big Sandy River Basins. 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. Operation of the DCP-satellite network is discussed in more detail in sub-sections 5-01 and 5-02. Plate No. 5-2 graphically illustrates the communication network throughout the Big Sandy River Basin.

5-06 COMMUNICATION WITH PROJECTS

The telephone is utilized for normal communications by the Water Resources Engineering Branch, Big Sandy 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 Big Sandy River Basin projects or special radio frequencies may be assigned by the Emergency Operations Manager. District radio communications network is shown on Plate No. 5-2. 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 COMMUNICATION WITH OTHERS

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. Operations and Readiness Division. The Water Resources Engineering Branch has no regular communication with Operations and Readiness Division (OR) 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 OR to pass on the information. Frequently OR personnel will visit the Water Resources Engineering Branch in person for further briefing. When OR personnel learn of storms in or near 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. Great Lakes and 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. 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 GLWMB on the occasion of a special purpose operation at Flannagan Lake outside the approved plan of regulation. A copy of Form ORD 1018R is included as Plate No.4-2.

d. Operations and Readiness Division Area Office. John W. Flannagan Lake is, for administrative purposes, included with the Big Sandy Reservoirs under the Big Sandy Area Office, at Louisa, KY. 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 Water Control Section 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 5-02b(1). Precipitation amounts are included in the morning report to the District water control system and to the National Weather Service Offices in Charleston, WV.

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 Control Section and U.S. Geological Survey (U.S.G.S.) 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 5-02a(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 U.S.G.S. to repair a gage critical to regulation of a reservoir in flood condition. Annual meetings are held with the U.S.G.S. concerning the cooperative program. Additional meetings are held with the U.S.G.S. as deemed necessary.

g. State and Local Agencies. Water Resources Engineering Branch communicates through Resource Managers with the Virginia Department of Game and Inland Fishery concerning fish and wildlife enhancement in the Corps of Engineers' Virginia lakes and downstream areas and probable height of a rise. The Department's management program includes stocking of turkey and deer, leasing of land for agricultural sharecropping, water quality checks, fish inventories, and habitat management. Water Quality Section maintains contact during the period of lake stratification with the Fisheries Division by mailing to the assigned contact point copies of the weekly Water Quality Assessment for Flannagan Lake. If a potentially or currently serious situation develops, the Water Quality Section chief may telephone the Division Fisheries Biologist assigned to Flannagan Lake to advise and discuss the situation. Anytime an unusual water quality situation occurs, an investigation is made into causes and ramifications to the extent warranted by the situation and the availability of manpower. In certain instances, Water Resources Engineering Branch or the Division confirms telephone conversations or transmits information and data by mail. Special and routine test results are inserted into the water control system and, depending on the use, the long term storage. Later results are inserted into the Storet system where they are computer accessible to all agencies.

During flood emergencies, the District Emergency Operations Center, EOC, maintains close contact by telephone and/or radio with the Division of Disaster and Emergency Services which is under Virginia Department of Military Affairs. Water Resources Engineering Branch furnishes hydrologic and operational information to EOC for the exchange by face-to-face and telephone conversations and by providing copies of all relevant reservoir and weather service reports.

h. General Public and Commercial Interest. The Project Office answers calls on such subjects as fishing success, requests for camping and swimming information. Others concern locations of picnic and other recreational areas, or downstream flooding potential.

Neither the project nor Water Resources Engineering Branch receives or accepts any official calls from commercial interests (except that the project does advise the Marina operator of probable height of a rise and parking lot flooding). The NWS should disseminate information to commercial companies.

There are no interests downstream from Flannagan Lake vulnerable to flooding at discharge rates up to channel capacity. However, in order to advise recreators below the dam of impending increases in outflow, a discharge warning horn is blown at the outlet works whenever the total gate opening is to be increased.

SECTION VI - HYDROLOGIC FORECASTS

6-01 GENERAL

Hydrologic forecasts of stream flows above and below John W. Flannagan Lake are vitally important to Water Control Management. The Water Control Section utilizes all available hydrologic and meteorologic data and the best methods available in preparing stream flow forecasts for the Levisa Fork and Big Sandy River Basins under low flow, normal flow and flood flow conditions for optimal project management.

a. Role of Corps.

(1) District Office. In accordance with ORDR 1110-2-27, dated 12 January 1976, Subject: Water Control Management Activities, the Water Control Section performs water control management activities for multi-purpose projects throughout 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 ensure the safe and efficient operation of the district projects. River forecasts prepared by the Corps of Engineers are generally used internally, 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 and Other Agencies. 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 for 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 the Water Resources Engineering Branch by the Hydrologic Engineering Center (HEC) at Davis, California, was adapted and calibrated for use in management of the Pound River-Russell Fork-Levisa Fork-Big Sandy 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. Plates No. 6-3 thru 6-12 show examples of the

computerized data produced by the Water Control Section.
A typical sequence of events leading to water control management decisions is described as follows:

l. Satellite data, both stage and precipitation, are received from the LRD 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 forecast model is then executed to obtain computed project outflows and the downstream results of the computed 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 than flood forecasts and often are produced with a longer period of lead time. The amount of anguish from an unusable or misleading low flow forecast can be the same as the anguish from a poor flood forecast.

b. Methods. In order to achieve the most efficient water control management possible, the same real-time computer model, developed for the Water Resources Engineering Branch by the Hydrologic Engineering Center (HEC) was adapted and calibrated for use in conservation forecasting of the Pound-Russell-Levisa-Big Sandy 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 flood and conservation 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 the same as for a flood forecast:

l. Satellite data, both stage and precipitation, are received from the LRD 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 forecast model is then executed to obtain computed project outflows and the downstream results of the computed 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 FORECASTS.

a. Requirements. Long range forecasts assist the Huntington District in water control management in the Big Sandy River Basin. Plate No. 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 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. 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 Mississippi Valley Division (MVD) of probable future conditions and to suggest specific items of water control management to the districts. MVD 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 historical 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 Mississippi Valley 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 FORECASTS.

a. Requirements. Drought forecasts also assist the Huntington District in water control management in the Big Sandy 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. Where this additional storage is possible, the later releases can supplement low-flow 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.

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c. Reference Documents. Many of the basic documents for drought forecast are in the Water Resources Engineering Branch, Huntington District, Huntington, WV. These are records prepared by the West Virginia Department of Natural Resources, Virginia Department of Game and Inland Fishery, and Kentucky Department of Fish and Wildlife Resources and the West Virginia, Virginia, and Kentucky U.S.G.S. for past drought periods, and the Ohio River Basin Comprehensive Study, prepared by the Great Lakes and 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.

U.S. ARMY ENGINEER DISTRICT, HUNTINGTON

CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

BIG SANDY RIVER BASIN
KENTUCKY

CHAPTER 7 OF JOHN W. FLANNAGAN WATER CONTROL MANUAL

WATER CONTROL PLAN
FOR
JOHN W. FLANNAGAN LAKE – BIG SANDY RIVER

2001

INSTRUCTIONS TO DAMTENDER

JOHN W. FLANNAGAN LAKE – POUND RIVER, VIRGINIA

U.S. ARMY CORPS OF ENGINEERS
HUNTINGTON DISTRICT
JULY 2001

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SECTION VII - WATER CONTROL PLAN

7-01 GENERAL OBJECTIVES

In accordance with ER 1110-2-8156 dated 31 August 1995, 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 the primary project purpose of flood control. In developing the plan of regulation, the following general requirements were considered and evaluated in preparing an overall effective water control plan for the John W. Flannagan Lake Project:

a. Prevention or reduction of serious damages to communities and crops below the dam along the Pound River, Russell Fork, Levisa Fork, and the Big Sandy River 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 Ashland, Kentucky.

c. Subject to flood control and low-flow augmentation requirements, reservoir outflow should be regulated to maintain the pool level at or near the elevations designated on the upper limiting rule curve **Plate 7-1** (See John W. Flannagan Water Control Manual).

d. Maintenance of a minimum discharge of 50 cfs summer and 10 cfs winter, which is designed to be adequate to sustain downstream aquatic populations. During periods of low-flow in the Big Sandy River Basin, the seasonal water quality storage will be utilized, in conjunction with releases from Dewey and Fishtrap Reservoirs to augment flows for downstream water supply.

e. Maintenance of a minimum pool elevation of 1314 feet NGVD and a water quality pool elevation of 1380 feet NGVD, subject to minimum discharge, to support fish populations and provide space for sediment storage.

f. Maintenance of a seasonal pool elevation of 1396 feet NGVD for recreation and fish and wildlife conservation between approximately 1 April and the optimum date to begin drawdown in the fall, normally 1 October, considering all hydrometeorological and recreational factors, subject to flood control and minimum discharge purposes. Drawdown subject to low-flow or minimum releases should be complete by 1 December.

g. Provision for gradual opening of the spillway gates, during great floods, to avoid creation of disastrous flood waves and to reduce inflow peaks as much as possible. Establishment of a maximum allowable discharge to avoid downstream damage during flood releases. The natural crest stages which are below the incipient damage stage will be exceeded only during unusual circumstances.

h. During general floods that portion of the reservoir inflow, in excess of the minimum release, should be stored which would contribute to stages in excess of designated control stages at downstream control stations.

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

j. If forecast above the dam or if the rate of rise in pool elevation indicates that the reservoir cannot completely control the flood, reservoir outflow should be scheduled for the minimum damaging discharges which will require full utilization of the available storage.

k. If the flood is of such a magnitude as to require the release of flows greater than downstream channel capacity on Pound River, the normal storage capacity of the reservoir will be temporarily augmented by a small amount of “induced surcharge” storage, which will be utilized to regulate outflows to safer rates of increase during these emergencies.

l. Sensitivity to reasonable requests for operational changes from state agencies.

m. Flood control in tandem with North Fork, Yatesville, Paintsville, Fishtrap and Dewey Lakes for optimum control of flows in the Big Sandy River Basin. Monitor and promptly enact all applicable directives from the Water Control Section to John W. Flannagan.

n. Concern for safety and well-being of humans, fish and wildlife, manmade structures, channels, and streambanks, which can be affected by discharge control.

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

7-02 MAJOR CONSTRAINTS.

Constraints to regulation of the water control plan at John W. Flannagan Lake include interests both upstream and downstream of the dam, which is affected by higher than normal pool elevations. Maximum allowable gage heights downstream restrict the total outflow that can be discharged from Flannagan Lake during normal operations to protect communities, farming interests, recreation and roads downstream of Flannagan 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 Flannagan Lake. Downstream of Flannagan Lake, high water levels can affect portions of the camping areas. As the flood pool rises, the proper authorities are notified of the impending high water levels. 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.

Operational limitations concerning flood control, recreation, water supply, low-flow and water quality, and fish and wildlife conservation are listed on **Table 7-1** below.

Table 7-1
Operational Limitations for Flood Control

	Pool Level Elevation NGVD	**Capacity Acre-feet - Gross**
Streambed	1210.0	zero
Minimum pool	1314.0	12,000
Winter Water Supply	1314.0	12,400
Water Quality Control	1380.0	51,000
Summer Recreation	1396.0	67,500
Maximum Flood Control Pool	1446.0	145,700
Maximum Surcharge Level	1450.0	
Top of Dam	1460.0	

Gate Change Maximum Rate – 1.0 foot per hour on Outflow gage.
Spillway maximum flow – 1450.0 NGVD Outflow – 206,000 cfs
Min. Winter Outflow - 10 cfs continuous or stage 1.8 ft on “O” gage
Min. Summer Outflow - 50 cfs continuous or stage 2.15 ft on “O” gage
Maximum low-flow system rate – 440 cfs

Summer/Winter release rate w/out directive - 2025 cfs, 5.8 ft on “O” gage
Year Round Maximum outflow with a SPECIAL DIRECTIVE
Maximum Outflow - 4000 cfs or 7.8 feet on “O” gage

7-03 OVERALL PLAN FOR WATER CONTROL.

The overall plan for effective water control was developed for the optimum use of all available storage for the primary purpose of John W. Flannagan Lake, namely flood control. The overall operation of Flannagan Lake is correlated with the other lakes in the Levisa Fork Basin. The plan was developed from a detailed study of other similar near-by lakes and from OCE doctrine on Flood Control Operation. The plan provides 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 detail in Exhibit B, “Instructions to the Damtender.” These instructions also establish the minimum number of observations to be made and are designed to insure that any necessary gate operations will be promptly executed and that special reports will be initiated by the Damtender before reservoir and stream conditions reach critical proportions. The general instructions apply at all times

except when instructed by Special Directives, which will be applicable for a specific operation or period of time. During the course of any flood control operation at Flannagan Lake, if it becomes apparent that the assigned job cannot be finished in the normal workday, the job must and will be finished on an overtime basis.

7-04 STANDING INSTRUCTIONS TO DAMTENDER.

The John W. Flannagan Lake Damtender and staff operate the project in accordance with general instructions and Special Directives issued by the Water Control Section.

a. General Instructions. The general instructions apply at all times except when instructed by Special Directives, which will be applicable for a specific operation or period of time. 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 "Instructions to the Damtender." These instructions also establish the minimum number of observations to be made and are designed to insure that any necessary gate operations will be promptly executed and that special reports will be initiated by the Damtender before reservoir and stream conditions reach critical proportions. 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.

b. Special Directives. Special Directives are issued by telephone and confirmed by mail by the Water Control Section to record all substantive guidance to the project pertaining to water control activities not covered by the general instructions. The following list of subjects or purposes of Special Directives is representative of types issued.

(1) Flood control

(a) Outflow reduction for Pound River, Russell Fork, Levisa Fork, Big Sandy River Basin streams or Ohio River control.

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

(c) Above channel capacity discharge when inflow hydrograph is greater than available storage capacity.

(2) Low-Flow release less than minimum flow to avoid loss of pool in extremely dry weather.

(3) Special regulations for:

(a) Construction activities downstream affected by flow.

(b) Stream cleanup activities.

(c) Emergency drowning or pollutant spill.

(d) Special pool levels for fish spawning.

(e) Above seasonal pool levels for drought relief in summer and fall.

(f) Stocking tailwaters stable flow 24-48 hours.

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

(4) Temperature control inlet gate operations and low-flow valve adjustments.

(5) Spring filling, fall drawdown beginning and adjustments to discharge rate in order to control rate of rise or fall in lake level.

(6) Begin and terminate temperature dissolved oxygen profiles in the lake.

(7) Change in general instructions.

(8) Any and all other pertinent operations as deemed necessary by Water Control Section.

c. Regulations. The above-mentioned general instructions and Special Directives are written in accordance with the following regulations:

(1) EM 1110-2-3600, 25 May 1959, Subject: Reservoir Regulation.

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

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

(4) ER 1110-2-240, DAEN-CWE-Y, 24 April 1970, Subject: Reservoir Control Centers.

(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.

7-05 FLOOD CONTROL

The primary objective of John W. Flannagan Lake is to reduce downstream flood damage by storing excessive runoff from major storms. Major flood damages occurring along Pound River, Russell Fork, Levisa Fork and the Big Sandy River resulting from flooding occur mainly to residences, utilities, highways, commercial establishments, agriculture and industry. The greatest flood damages in the past have occurred to the communities of Bartlick, VA, Elkhorn City, Pikeville, Prestonsburg, Paintsville and Louisa, KY.

a. Requirements. The operation of John W. Flannagan Lake is best accomplished by not exceeding the control stages on Pound River, Russell Fork, Levisa Fork and the Big Sandy River, shown in **Table 7-2**, below. Control stages were established by close correlation with damage survey curves and result in only minimal damage in the control areas.

TABLE NO. 7-2

CONTROL STAGES AND FLOWS AT KEY RIVER STATIONS

Station	Stream	MIANO		DEMIA		Travel Time from Dam (hours)
		Stage (feet)	Flow (cfs)	Stage (feet)	Flow (cfs)	
J.W. Flannagan outflow gage	Pound River	7.8	4,000	7.8	4,000	-
Bartlick, Va	Russell Fork	14.0	8,955	14.0	8,955	0.2
Elkhorn City	Russell Fork	12.5	10,990	12.5	10,990	6.3
Pikeville	Levisa Fork	23.0	13,859	31.6	26,980	15.8
Prestonsburg	Levisa Fork	21.0	14,800	33.0	28,220	31.8
Paintsville	Levisa Fork	20.0	15,100	29.0	24,800	40.0
Louisa (Fullers)	Big Sandy River	45.0		45.0		57.0
Ashland	Ohio River	53.0		53.0		72.0(*)

(*) Operational time prior to crest stage in excess of 53.0 feet.

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. John W. Flannagan Lake is part of the flood control system of the entire Ohio River Basin as well as of the Levisa Fork and Big Sandy River Basins. Regulation procedures for the lake are correlated with the operation of the other lakes in the Big Sandy River Basin and other Ohio River tributaries to the fullest extent possible while giving due consideration to local concerns and requirements.

The proposed plan of regulation provides that, unless flood control, low-flow augmentation or minimum releases are required, normal outflow from the reservoir will be regulated to maintain the pool at levels governed by the upper limiting rule curve as shown on **Plate 7-1** (see WCM). This plan provides that the pool elevation will be held as close as possible to the upper limiting rule curve but never allowed to fall below the lower limiting rule curve.

Operation for Ohio River control is based on retention of flows that would add to crest stages in excess of 53 feet at Ashland, KY. This stage represents the point at which damage begins in the unprotected communities in the Ohio Valley below the mouth of the Big Sandy River. When required by unusual circumstances, adjustment of the reservoir regulation schedule may be directed by the Great Lakes and Ohio River Division Engineer for control of floods on the Ohio River below Ashland, KY.

The maximum flows (or stages) that can be maintained at points along the channel below the dam are called control flows or regulation channel capacities. The year round control flow below John W. Flannagan Lake is 4,000 cfs, or a stage of 7.8 feet on the USGS gage during both MIANO (Mid-April through November) and during DEMIA (December to Mid-April), when a SPECIAL DIRECTIVIE from the Water Control Section so orders. The maximum control stage below the dam without a directive is 2,025 cfs or 5.8 feet on the U.S.G.S. gage. Recent field investigations and natural channel capacity studies indicate that the no-damage flow in Pound River below the dam is considerably greater than 4,000 cfs. However, if the outflow were held at 7.8 feet when there was significant rainfall over the uncontrolled area above the Bartlick USGS gage, the combined flow could cause damage on Russell Fork; or the combined flows could also cause backwater damage on Pound River below the dam. Therefore, this value of 4,000 cfs is still retained as the maximum allowable summer and winter channel capacity along Pound River.

Two stations on Russell Fork are used as control points for the operation of Flannagan Lake. Stage damage curves were prepared based on damage surveys of 1955 and January 1957 flood evaluations. These stage damage curves were reevaluated following the March 1963 flood.

The no-damage or initial flooding stage along Russell Fork was determined to be approximately 12.5 feet on the USGS gage (10,990 cfs) at Elkhorn City, KY and 11.75 feet on the U.S.G.S. gage at Haysi, VA, on Russell Fork above the mouth of Pound River. Stage damage information is not available for the area around Russell Fork at Bartlick, VA U.S.G.S. gage, however, the year round control flow of 8,955 cfs (14.0 ft) has been adopted. In order to effectively control flood stages along Russell Fork, it is proposed to store all reservoir inflow, which would contribute to stages in excess of the control stages at the key stations along Russell Fork, listed in **Table 7-2**, above.

The regulation plan provides for the storage of all inflow into the reservoir, except minimum flow releases for water control and fishery habitat purposes, when designated control stages are exceeded at downstream Russell and Levisa Fork key control stations. It is proposed to regulate Flannagan Lake with the other existing reservoirs in the Levisa Fork and Big Sandy River Basins to limit downstream stages to those designated at key control stations as shown on **Table 7-2**, above. Control flows downstream on Levisa Fork at Pikeville, KY are 13,859 cfs (23.0 feet stage) during MIANO, and 26,980 cfs (31.6 feet stage) during DEMIA. Control flows further downstream on Levisa Fork at Prestonsburg, KY are 14,800 cfs (21.0 feet stage) during MIANO, and 28,220 cfs (33.0 feet stage) during DEMIA. The control flows for the last station on Levisa Fork at Paintsville, KY are 15,100 cfs (20.0 feet) at MIANO and 24,800 cfs (29.0 FEET) DEMIA. Control flows are shown in **Table 7-2**, above.

The plan of operation is based on having adequate flood forecasting and flood warning systems in effect. Reservoir regulation will ordinarily be based on a forecast inflow hydrograph as predicted from reports of rainfall depths above the dam. After the inflow hydrograph has been computed, the necessary outflow will be determined in order to use all the available storage. If the required outflow release discharge is equal to or greater than the downstream channel capacity, it is imperative that the outflow be increased, if possible, to the required value as soon as possible in order to avoid the necessity of releasing even greater flows at a later time. Under the above circumstances, regulation of the reservoir will be governed by an analysis of current and forecast rainfall above the reservoir, and forecast conditions at downstream control stations. Full consideration will be given to the effect of increased discharge from the reservoir, which would result from delaying the indicated outflow. Streamflow data is obtained from the platform-satellite network and from Flannagan Lake reports. Precipitation amounts in and near the Pound River, Russell Fork, Levisa Fork and Big Sandy River Basins are received through the Corps of Engineers' satellite platform system and from the project reports, which contain project gage data, data from observers in the Ohio River Network, and from NWS. Water Control Section 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. **Plate 7-2**, Area and Capacity Curves (see WCM) and Percent Storage Utilization, can be used to determine available storage for flood control.

Discharge from the reservoir will be governed by a given setting of the high level by-pass valves, slide gates, spillway gates and by prescribed control stages at the outflow gage located 2,000 feet below the dam. A remote reporting indicator for this gage is located in the control room at the dam. Discharge rating curves for the spillway gates; sluices, high-level valves and outflow station are presented as **Plates 7-6, 7-4, 7-5**, and **7-8**, respectively (see WCM). The rate of change on the outflow gage should be limited to one foot per hour when opening the sluice gates or the high-level, by-pass valves.

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.

Operations at John W. Flannagan Lake are based on control stages listed in **Table 7-2**. Since the control stages are dependent on the season of the year, operations at Flannagan Lake are also dependent on the season. In addition, backwater conditions from Russell Fork may affect outflow from Flannagan Lake.

For flood events during DEMIA (December to Mid-April), the following operation will provide for effective management of the project to meet downstream flood control objectives:

(1) When the reservoir pool is above elevation 1380.0 feet NGVD and rising, and when Ohio River control is not necessary, maintain the control outflow stage of 5.8 feet or Directive control stage of 7.8 feet by using the chart shown as **Plate 7-3** (see WCM), reducing the outflow as much as necessary when backwater from Russell Fork tends to raise the outflow elevation above that stage.

(2) When the reservoir pool is or has been above elevation 1380.0 feet NGVD and is falling, and when Ohio River control is not necessary, maintain outflow at the highest stage reached while the reservoir was rising or at a stage of 7.8 feet, whichever is the lower, but not lower than a stage of 5.8 feet, until the reservoir returns to the minimum pool level.

(3) When a crest of 53.0 feet or higher on the Ohio River at Ashland is forecast to occur within 72 hours, maintain an outflow of 10 cfs until the Ohio River has crested and fallen one foot and continued recession is predicted.

(4) When forecasts indicate that the reservoir will exceed an elevation of 1446.0 feet NGVD, regardless of conditions at downstream control points, maintain the control outflow of 4,000 cfs through the gates and spillway combined, until the reservoir has crested or until the spillway flow alone exceeds that rate.

For flood events during MIANO (Mid-April through November), the following operation will provide for effective management of the project to meet downstream flood control objectives:

(1) When the reservoir is above elevation 1396.0 feet NGVD and rising, and when Russell Fork, Levisa Fork, Big Sandy or Ohio River control is not necessary, maintain the control outflow stage of 5.8 feet or the Directive control stage of 7.8 feet (4,000 cfs).

(2) When the reservoir elevation is or has been above elevation 1396.0 feet NGVD and is falling, and when Russell Fork, Levisa Fork, Big Sandy or Ohio River control is not necessary, maintain the outflow at the highest elevation reached while the reservoir was rising, or at a stage of 7.8 feet, whichever is the lower, but not lower than 5.8 feet, until the reservoir falls to the seasonal pool level.

(3) When a stage above 23.0 feet on Levisa Fork at Pikeville, KY occurs or is forecast to occur within 16.8 hours, reduce the outflow as much as necessary to prevent the Pikeville gage from exceeding 23.0 feet.

(4) When a stage above 21.0 feet on Levisa Fork at Prestonsburg, KY occurs or is forecast to occur within 32.8 hours, reduce the outflow as much as necessary to prevent the Prestonsburg gage from exceeding 21.0 feet.

(5) When a stage above 20.0 feet on Levisa Fork at Paintsville, KY occurs or is forecast to occur within 41 hours, reduce the outflow as much as necessary to prevent the Paintsville gage from exceeding 20.0 feet.

(6) When a stage above 12.5 feet on Russell Fork at Elkhorn City, KY occurs or is forecast to occur within 7 hours, reduce the outflow as much as necessary to prevent the Elkhorn City gage from exceeding 12.5 feet.

(7) When a crest above 53.0 feet on the Ohio River at Ashland is forecast to occur within 72 hours, maintain outflow at 50 cfs until the Ohio River has crested and fallen one foot and further recession is predicted.

(8) When forecasts indicate that the reservoir pool will exceed elevation 1446.0 feet NGVD, regardless of conditions at downstream control points, an outflow of 4,000 cfs shall be maintained through the gates or through the gates and spillway combined until the reservoir has crested or until the spillway flow alone exceeds that rate.

In addition to the above regulations, the following operations are applicable for both DEMIA and MIANO floods:

(1) Gates will be regulated at all times in such a manner that the rate of change of stage at the outflow gage will not exceed that of one foot per hour except when closing for flood control.

(2) If the river stage at Ashland 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 on Pound River, Russell Fork, Levisa Fork and Big Sandy River Basins to establish an operational scheme that will benefit the downstream Ohio River areas and not prove detrimental to the Big Sandy River Basin flood control objectives.

(3) Release of accumulated flood storage will be based on determinations by the Water Control Section 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.

(4) 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. 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 Control Section 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 Control Section will direct these operations by Special Directives.

c. Emergency Plan. During a major flood, all communications between John W. Flannagan 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 Damtender will assume regulation of the lake during a communication blackout, following the measures in Section I of “Instructions to Damtender”, John W. Flannagan Lake, which appears in Exhibit B of this manual. In addition, the Damtender will immediately make full and complete effort to reestablish communications with the District Office. **Plate 7-7** (see WCM), Spillway Gate Regulation Schedule, may be used to determine discharge amounts.

(1) Emergency operations shall be based on the last lake level reading taken, and no attempt shall be made to make up for any lost or missed operation steps. The required tainter gate settings shall be executed as soon as they have been determined from the Emergency Operation Schedule.

(2) One hour after previous reading, the lake gage shall be read again, the new rate of rise computed and the required gate settings executed immediately.

(3) Continue the one hour interval of computations and gate settings until the lake crests.

(4) If the lake level crests above maximum flood control elevation of 1446 feet NGVD, maintain the current tainter gate settings until the lake level recedes to maximum flood control elevation of 1446 feet NGVD; then, gradually close the tainter gates as necessary to maintain the lake level at maximum flood control elevation until ordered by Special Directive to begin drawdown operation.

(5) If the lake level crests below maximum flood control elevation of 1446 feet NGVD, gradually close the tainter gates as necessary to maintain the crest lake level until ordered by Special Directive to begin drawdown operation.

(6) If the lake level is at or above the maximum flood control elevation of 1446 feet NGVD and a second rise occurs, the operations required by the Curve for Induced Surcharge Operation, which is the upper limiting curve of the Emergency Operation Schedule, shall be implemented immediately. If the lake level reaches 1456 feet NGVD, all tainter gates shall be lifted clear of the water, and all sluice gates shall be fully opened. Current gate settings shall be maintained on recession until elevation 1451.0 feet NGVD, when the sluice gates shall be closed. When the lake level recedes to maximum flood control elevation of 1446 feet NGVD, the tainter gates shall be gradually closed to hold the lake at that level until a Special Directive is issued to begin drawdown.

a. Lake.

(1) Requirements. Recreational development objectives at Flannagan Lake include providing high quality recreation and boating facilities to meet current and future demands, providing a trail system to satisfy the unmet demand for hiking facilities in the area, providing landscape screening where necessary to improve visitor privacy, and providing safe and sanitary swimming facilities for visitors to Flannagan Lake. The Breaks of Sandy Interstate Park adjacent to the John W. Flannagan Lake Project area is classified as a State Resort Park within the Virginia State Park System. Resort parks are typically designed for year-round use and include a lodge, dining facilities, and a wide variety of recreational opportunities. The Breaks Interstate Park operates independently of and is not connected with Flannagan Lake recreation.

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 Flannagan 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 and boater hazards.

A water use plan has been developed for John W. Flannagan Lake in order to minimize conflicts between lake users and to maximize recreational use. Three water use categories have been delineated at Flannagan Lake: Unlimited Speed Zone, Controlled Use Zone, and Boat Exclusion zone. The Unlimited Speed Zone comprises 850 acres of the seasonal pool area, and is useable for water skiing, power boating, sailing and fishing. This area runs from 1/2 mile above the dam to just above Mill Creek on Pound River and to just above Persimmon Branch on Cranenest River. The Controlled Use Zone restricts boating in two ways. A “No Ski Zone” is designated between Mill Creek and Little Laurel Creek on Pound River and between Persimmon Branch and Honeycamp Branch on Cranenest River. The “No Wake Zone” restricts boating use to that which will not produce a damaging or unsafe wake or waves. Waters designated as “No Wake Zones” at Flannagan Lake include the small area near the dam, Skeetrock cove, Upper and Lower Twin Branch coves, Mill Creeks cove, Cane Creek cove, Pound River above Little Laurel Branch cove, Junction Area marina, and Cranenest River above Honeycamp Branch. A total of 250 acres of the seasonal pool area is allocated to this Controlled Use Zone. The Boat

Exclusion Zone comprises 43 acres of the seasonal pool area in which boating use is prohibited. The water adjacent to the inlet tower/outlet works and waters near the dam and pump station are included in this category. Buoys delimit waters included in the Boat Exclusion Zone.

(2) Control Plan. The water control plan at John W. Flannagan Lake attempts to maintain the pool level at or near seasonal elevation 1396 feet NGVD during the recreational season. Under normal conditions, this is accomplished by regulation of the selective withdrawal system and the sluice gates in the outlet works. At times, however, heavy runoff may require utilization of available flood storage at Flannagan Lake, causing a rise in the lake level. Part of the plan of regulation includes forecasts of lake level and outflow rates. In order to accommodate the normal recreation requirements a gradual rise to the seasonal pool elevation, in accordance with the upper limiting rule curve, should be anticipated by recreators. At other times, augmented flow releases for Pikeville, Ky may lower the seasonal pool level.

b. Downstream.

(1) Requirements. Project personnel must maintain an awareness of downstream usage of Pound River and Russell and Levisa Forks 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 Pound River at the Flannagan Lake outflow gage, except during an emergency. 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 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.

Authority for regulation of Corps projects is 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 may be recovered in other areas.

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.

During the summer season, the operational zone for Flannagan Lake used for daily flow management is usually between the summer pool level of 1396.0 and elevation 1396.5 feet NGVD. During the month of October the winter drawdown period begins and the normal schedule, once winter drawdown begins, is about two feet a week for eight weeks to lower the pool the required sixteen feet. If the drawdown pool release is continuous and uniform the outflow is only slightly increased. However, if the outflow is greatly increased on the weekends, and accordingly reduced during the weekdays, the pool level is still dropped two feet a week, but a much higher weekend flow is necessary. This higher, weekend only, rate is sometimes used to accommodate white-water rafting requests, during the month of October, when the pool storage is available. The October Whitewater plan, developed by the Water Resources Engineering Branch and approved by LRD, is to lower the pool one foot each weekend at the high rate, if the storage is available, and one foot at the low rate for the remaining five weekdays, for the four weeks of October. If the storage is not available the outflow is adjusted accordingly.

During the recent past several studies were made to evaluate the potential of increased whitewater rafting on the Russell Fork. The latest study appears to indicate that good whitewater potential

exists on the Russell Fork if the proposed Haysi Dam is used to augment the Flannagan outflow in October.

7-07 WATER QUALITY AND LOW-FLOW CONTROL

a. Requirements. Prior to construction of John W. Flannagan Lake, flows in the Pound River at the dam site sometimes decreased to less than 2 cfs, and remained there for several days or more, creating stagnant or near stagnant conditions that were harmful to fish life. Stream fisheries need flowing, oxygenated water at normal temperatures and it was to fill this need that the U.S. Fish and Wildlife Service recommended provision for increasing flows below the dam and regulation of temperatures for fisheries benefit.

In accordance with the new national environmental policy objectives, water quality evaluation and reporting of water quality control activities are a required part of the overall water quality control management activity at John W. Flannagan Lake. Responsibility for quality of impounded waters was assigned to the corps of engineers by public health Law 87-88, enacted by congress on the 20 July 1961. The chief of engineers delegated this responsibility to the various divisions as an ongoing function. Guidelines for water quality activities associated with water control management were established and described in ER 1130-2-415.

Stream fisheries need flowing, oxygenated water at normal temperatures. In order to fill this need provisions were made to increase flows below the dam and regulate outflow temperatures for fisheries benefit. The discharge rate was selected after a study to determine the maximum rate that does not exceed the maximum acceptable drawdown in the driest year. The Virginia Department of Game and Inland Fishery, has worked with corps to develop optimum outflow temperatures and allowable ranges of variation for use at John W. Flannagan Lake. These guidelines have been correlated with natural stream temperatures.

b. Water Quality Plan. Water quality control has two major aspects: flow augmentation for downstream needs and low-flow temperature adjustments. Water quality augmentation needs for John W. Flannagan were evaluated by the Federal Water Pollution Control Administration (later changed to EPA).

(1) Selective Withdrawal System. The low flow selective withdrawal system was designed for a lake that stratifies during the summer, with warm, oxygenated water in the epilimnion and colder water with little or no oxygen in the hypolimnion. The low-flow selective withdrawal system is normally used to maintain the designated minimum flow, but, it may also be used as a fine-tuning control on the quantity of discharge from the slide gate system. The selective withdrawal system further provides a wide range of water temperatures downstream, and adequate control of volume and quality of discharged water up to the capacity of the control valves. The

low-flow system dimensions are discussed in Section II of the WCM. As previously mentioned, inlets provided in the selective withdrawal system, at elevations 1328, 1313, and 1298 feet NGVD, in the seasonal pool are used to release water through the inlet most likely to produce the highest quality water as indicated by weekly temperature dissolved oxygen profiles in the lake. The selective withdrawal system was originally designed for a much lower seasonal pool; as a result the present system does not function in the manner it was originally intended. The maximum capacity of the low-flow control system with all three inlets open is approximately 440 cfs, but varies with pool elevation.

(2) Low-Flow Release. Low-flow augmentation meets the need of downstream aquatic communities or normal habitat, particularly with regard to temperature, dissolved oxygen, and chemical sediment. John W. Flannagan Lake is regulated for low-flow in accordance with the rule curves of Storage and Release Schedule **Plate 7-1** (see WCM). These curves were derived in order to provide for minimum releases for fish habitat and maximum utilization of storage for water quality control. The upper limiting rule curve, derived in cooperation with the U.S. Fish and Wildlife Service, was established for periods of adequate flow in Russell and Levisa Forks and the Big Sandy River. The intermediate and lower limiting curves, delineating release zones of 50 cfs and 10 cfs were determined by simulation routings of critical low flow periods of record through the reservoir and adopting an envelope curve of the pool elevations for these periods using a design plan. The design plan of operation is to provide a continuous minimum release of 50 cfs at all times, except for the winter period of December until the end of March when 10 cfs will be released. In addition, a continuous minimum flow of 190 cfs at Pikeville and 206 cfs at Paintsville will be maintained for water quality control. These discharges are to be maintained at all times, even during closure for flood control. Low-flow control and control of minor storms are accomplished by the operation of the selective withdrawal system and sluices in the outlet works at Flannagan Lake. Releases are held to a maximum of 2,025 cfs (5.8 feet on the outflow gage) during both MIANO and DEMIA, unless specifically directed by Water Control Section to discharge at a higher rate.

(3) Temperature Profiling. Outflow water temperature regulation is possible through the use of the selective withdrawal system. The Virginia Department of Game and Inland Fishery, has worked with the Corps to develop optimum outflow temperatures and allowable ranges of variation for use at John W. Flannagan Lake. These guidelines have been correlated with natural stream temperatures. Regulation of outflow temperature requires a current assessment of lake temperatures and levels of dissolved oxygen available for withdrawal. Weekly temperature and dissolved oxygen profiles must be taken in the lake during the seasonal stratification period. Visual reference to the appropriate profile and the temperature regulation curve will frequently indicate an

obvious choice of one level for withdrawal. At times, however, mixing water from more than one level will be necessary to release outflow water near the natural water temperature. Consideration of dissolved oxygen levels may also affect proper gate selection.

Project personnel take data on Monday for a temperature dissolved oxygen profile of the lake, which includes temperature and dissolved oxygen concentration at the surface and at 2-foot depth intervals to the bottom. This data is transmitted to the Water Control Section where it is computer plotted to produce the Water quality Assessment. Water Quality Personnel use this assessment in conjunction with daily outflow temperature and Outflow Temperature Objective to determine which combination of the selective withdrawal inlets to use to obtain the desired temperature downstream. If the bottom water has a dissolved oxygen concentration of 1.0 milligrams per liter or greater, it may be carefully metered through a slide gate into the outflow. At these times, the discharge must be monitored in the stilling basin for the possible appearance of red-iron hydroxide color in the water and/or the smell of hydrogen sulfide. The regulation scheme is transmitted to the project as a Special Directive.

7-8 FISH AND WILDLIFE CONSERVATION

a. Requirements.

(1) Lake. In accordance with a license from the federal government, the Virginia Department of Game and Inland Fishery manages the John W. Flannagan Lake area for fish and wildlife resources. The Department shares the Corps conservation goal of the long-term well being of the populations of water and land species of plant and animal life common to the area and the maximum sustained enjoyment of these populations by the public. Lake area conservation requirements are met by various features of the Department management program. This includes stocking of the lake; imposing size limits as necessary; monitoring populations, reproductive success, and size distribution within species; maintaining a conservation officer at the lake to conduct creel surveys and fisherman interviews; and administering licensing regulations for sport fishermen.

A 1982 creel survey estimated that Flannagan Lake received approximately 53,000 hours of fishing pressure between 1 April and 31 October, with an overall success rate of 22.5 percent. Several brush fish attractor structures have been installed at Flannagan Lake in past years in an attempt to provide cover for fish and to concentrate their numbers for anglers. In addition, tiger muskies have been stocked in the lake in an attempt to improve the fishery.

Most of the hunting at Flannagan Lake is concerned with Virginia White Tail Deer season, which is largely concentrated on project lands on the North Side of Pound River. Access roads are provided to project lands on all sides of the lake; however, some visitors use

boats to gain access certain portions of the project. In some areas and locations the U.S. Government property for John W. Flannagan Lake and the U.S. National Forest are separated by only a few short yards. This allows some hunters access from one area to another rather easily.

No hunting is permitted in Breaks of Sandy State Park or within 3 mile of any recreation or camping area. Management of wildlife resources at Flannagan Lake is largely limited to regulation of hunting seasons. Fish and wildlife management objectives include increasing access to project lands for use by hunters and increasing the wildlife carrying capacity and species diversity of the area by improving the habitat.

Fish and wildlife at Flannagan Lake are affected by fluctuating lake levels. A stable or rising pool is required for fish spawning. Rises in pool level can affect ground-nesting animals living near the pool. Drawdowns affect waterfowl and fur bearing animals through elimination of shallow area feeding grounds. Drawdowns can affect hunters, especially during duck season, when shallow marsh areas are drained; however, Flannagan Lake is only minimally affected due to its steep topography along shoreline areas. Dry weather drawdowns expose muddy lakesides, 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. Needs of the downstream aquatic community for habitat maintenance, i.e., the continuous flow of clean water at proper temperature, constitutes the conservation needs related to reservoir outflow. The selective withdrawal system provides a wide range of released water temperatures downstream, and adequate control of volume and quality of discharged water that meet these conservation needs.

Lower food chain members which live on the bottom are dependent on clean rocks, gravel and sand for normal habitat. Silt and iron hydroxide, particularly under summer low flow conditions, can coat this habitat making it unsuitable. This suppresses that basic portion of the food chain and depresses populations of higher members until the habitat is improved, as by flushing, and populations of lower members reestablished. Water in lower zones of the lake, subject to reducing conditions common during stratification, contains iron which is soluble in the reduced state. When this water is released and aerated in the stilling basin, the iron is changed to insoluble oxide by oxidation and hydrolyzed to the hydroxide mentioned above.

b. Control Plan. As explained previously, 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.

Water Control Section exhibits flexibility in spring filling on behalf of fish spawning. When the Virginia Department of Game and Inland Fishery requests maintenance of a special pool level during spawn, Water Control Section will normally honor the request if it does not interfere with other project purposes. A minimum discharge of 10 cfs during the DEMIA and an outflow of 50 cfs during the MIANO is maintained for the benefit of fish downstream of Flannagan Lake.

7-9 WATER SUPPLY

John W. Flannagan Lake is required to provide water for low-flow augmentation. No water supply is provided.

a. Low-Flow Augmentation.

(1) Requirements. Prior to construction of John W. Flannagan Lake, flows in the Pound River at the dam site sometimes decreased to less than 2 cfs, and remained there for several days or more, creating stagnant or near stagnant conditions that were harmful to fish and food chain organisms. Modern new environmental policies were developed to resolve these severe problems.

Stream fisheries need flowing, oxygenated water at normal temperatures. In order to fill this need provisions were made to increase flows below the dam and regulate outflow temperatures for fisheries benefit. The discharge rate was selected after a study to determine the maximum rate that does not exceed the maximum acceptable drawdown in the driest year.

(2) Control Plan. The minimum continuous flow rate selected by the Virginia Department of Game and Inland Fishery in cooperation with the U.S. Fish and Wildlife Service was 50 cfs in the summer and 10 cfs in winter. One of these discharges is to be maintained at all times, even during closure for flood control. The discharge rate was selected after a study to determine the maximum rate that does not exceed the maximum acceptable pool drawdown in the driest year.

b. Storage Allotments. The total storage capacity of John W. Flannagan Lake is estimated to be 145,700 acre-feet. This storage was divided and allocated for various purposes during the planning phase of the project.

1. Requirements.

(a) Minimum Pool. Storage capacity allocation in the lake for minimum pool includes year-round equivalent storage volume for sediment accumulation, provision of minimum flow during an unusually dry winter, and satisfactory winter habitat for the large population of fish. Sediment storage was estimated to contain 92 years accumulation of sediment based on data from other

reservoirs in the basins adjacent to John W. Flannagan. The minimum pool was established at elevation 1314.0 feet NGVD, containing 12,000 acre-feet of storage and covering 310 acres. The remainder of the allocated pool storage, or the difference between maximum flood control pool storage, elevation 1446.0 feet NGVD, and the minimum pool storage, elevation 1314.0 feet NGVD, is 133,700 acre-feet. This large volume of storage is equivalent to 13.4 inches of runoff from the drainage area above the dam. It was divided into year round water supply and low-flow augmentation at elevation 1314.0 NGVD, summer Recreation Pool at elevation 1396.0 NGVD, and the remainder to elevation 1446.0 feet NGVD is for flood control.

John W. Flannagan 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 capacity to the reservoir during the most flood prone season.

(b) Summer Water Supply and Recreation Pool. In order to provide for maximum recreation during late spring, summer and early fall, the summer recreation and water supply pool was established at elevation 1396.0 feet NGVD and covering 1,145 acres. This pool contains 67,500 acre-feet of water, which supports aquatic life, recreational activities high in monetary benefits, and provides the 50 cfs minimum flow during dry periods. The storage volume between the maximum flood control elevation 1446 feet NGVD and the Summer Recreation/Water Supply pool elevation 1396 feet NGVD, volume is 78,200 acre-feet, which is equivalent to 7.2 inches of rainfall and runoff over the entire drainage basin above the dam. Minimum temperature and quality requirements of discharge for downstream fishery habitat are met through use of the multilevel release capability of the outlet work.

(c) Winter Recreation Pool. During the winter months of December through March, John W. Flannagan Lake is maintained at elevation 1380.0 feet NGVD. The winter water supply and recreation pool covers 318 acres and contains 50,558 acre-feet of storage, which supports aquatic life, winter recreational activities high in monetary benefits, and provides the 10 cfs minimum flow during winter dry periods. The difference between maximum flood control elevation 1446 feet NGVD and the winter water supply pool volume is 94,700 acre-feet, which is equivalent to 8.7 inches of rainfall over the entire drainage basin above the dam.

2. Control Plan. On or about 1 April, when the normal flood season has passed, the Water Control Section directs the beginning of filling. It is desirable for the lake level to reach 1396.0 feet NGVD soon as possible after 1 April in order to maximize recreation benefits and to facilitate activities of early spawning fish. These benefits would be quickly produced by reducing outflow to a minimum discharge of 50 cfs; however, the Special Directive for filling specifies a stage at the outflow gage equivalent to 50 cfs

to fully support the downstream fishery. In a dry season, the filling directive specifies the minimum flow required at the outflow gage. During an exceptional dry season the Virginia Department of Game and Inland Fishery may report to the Water Control Section that the outflow is inadequate for the spawning season and request more water. The request is fulfilled by retarding the filling rate or holding the pool temporarily at some elevation between 1314.0 and 1396.0 feet NGVD. Special Directives from the Water Control Section supply guidance to the project for these water control actions.

When pool elevation 1396 feet NGVD is reached, it is maintained, subject to flood control and minimum flow requirements, throughout the recreation season. If suggested by CELRD, the Water Control Section may direct storage of water above elevation 1396 feet NGVD for later release to augment flows in the Ohio River or Mississippi River.

Around 1 September, the Water Control Section assesses all hydrometeorological and recreational factors and determines whether to maintain the pool at seasonal level for continued recreation benefit or to begin releasing water for downstream beneficial use. In any case, drawdown is begun by 1 October and completed by 30 November. The Water Control Section issues appropriate directives to the Damtender for beginning drawdown including initial "O" gage setting with equivalent discharge value and as frequently as necessary thereafter to maintain the desired schedule for pool elevations, all subject to maximum allowable discharge and flood control operation. Winter water supply pool level at elevation 1380.0 feet NGVD is maintained through the flood season until 1 April, subject to regulation for flood control and minimum flow requirements.

7-10 HYDROELECTRIC POWER - NA

7-11 NAVIGATION - NA

7-12 DROUGHT CONTINGENCY PLANS – SEE ANNEX I – WATER CONTROL MANUAL

7-13 FLOOD EMERGENCY ACTION PLANS

Extremely high lake levels and/or sudden release of large volumes of water or any emergency condition affecting operation of John W. Flannagan Lake could result in a hazard to life and/or nearby property. Early identification of the existence or potential for occurrence of such conditions is essential as a basis for initiating emergency operations and/or repairs and for issuing appropriate notifications to higher authority and potentially affected parties.

a. Definitions.

(1) Pre-Emergency. A Pre-Emergency condition occurs when some impending or existing threat to the safe operation of the dam or lake is identified, but no significant hazard to life or

property is expected to occur. Pre-Emergency declaration is internal to the Corps of Engineers and does not require notification of other parties or warnings to evacuate.

(2) Emergency. An Emergency condition occurs when a significant hazard to life and/or property is possible or certain to occur. Conditions justifying declaration of an Emergency condition may be imminent or longer term. An Emergency condition declaration requires notification of others and issuance of warnings to evacuate potentially hazardous areas.

b. Declaration of Pre-Emergency and Emergency Conditions. Pre-Emergency and Emergency declarations will be made by the District Engineer. The Chiefs of the Engineering-Construction Division, Water Resources Engineering Branch, Geotechnical Branch, Design Branch, Operational and Readiness Division and the Emergency Management Branch will provide input onto the decision making process.

(1) Responsibility. The District is responsible for the declaration of “Pre-Emergency” or “Emergency” conditions in all but extreme cases where the loss of communications or the speed of onset of a situation prevents the Damtender from conferring with the District.

(2) Conditions Warranting Declaration. Not every situation requiring the declaration of a Pre-Emergency or an Emergency condition can be specified. All personnel must exercise proper initiative and judgment, and each situation is evaluated individually on the basis of all relevant factors.

c. Pre-Emergency. Examples of circumstances warranting declaration of a Pre-Emergency condition include:

(1) Malfunction of flood control gate system during flood operations, which impedes release of water and creates potential for spillway flow.

(2) Minor seepage problems including: unexplained increases or decreases in amount, cloudy appearance of seepage or presence of fines, development of new seepage areas as indicated by soft, boggy areas or new or lush vegetation, and substantial unexplained fluctuation in piezometer readings.

(3) Minor slope failures including: tension cracks at crest or in slopes of embankment, small bulges in slopes or in foundation near toe of slope, small depressions or sags in crest or slopes, changes in horizontal crest alignment, and gullies forming in or near embankment or junction of the embankment or abutments.

(4) Threats of sabotage or occurrence of sabotage of non-critical project features.

d. Emergency. Examples of conditions warranting declaration of an Emergency condition include:

(1) Emergency Drawdown. Extremely high lake levels and/or sudden release of large volumes of water or any emergency condition affecting operation of John W. Flannagan Lake could result in a hazard to life and/or nearby property. Early identification of the existence or potential for occurrence of such conditions is essential as a basis for initiating emergency drawdown operations and/or repairs and for issuing appropriate notifications to higher authority and potentially affected parties.

(2) Major seepage problems including: large increases in piezometer readings movement of large amounts of material in existing or new seeps, pipes in embankment or foundation materials, slippage at higher elevations on downstream face of dam or in abutment areas, and substantial increases in normal seepage amounts (especially when associated with movement of material from embankment or foundation).

(3) Major slope failures including: appreciable depressions or sloughs in the crest or slopes of the dam or bulges in the slopes or foundation, large gullies developing and continuing to erode in the embankment or at the junction of the embankment and abutments, displacement of structures or instrumentation on the dam and continuing expansion of tension cracks after their appearance on the dam crest or slope.

(4) Threats of sabotage or occurrence of sabotage to critical project features.

e. Action upon declaration

(1) Project Damtender

(i) Monitor telephones on 24-hour basis;

(ii) Notify key personnel in Big Sandy Area Office;

(iii) Notify District Dam Safety Officer (Chief of Engineering-Construction Division);

(iv) Maintain 24-hour monitoring surveillance of situation responsible for declaration;

(v) Perform non-routine observations and tasks as directed by District; and

(vi) If Area Office personnel cannot be contacted, notify key personnel in **Table 7-3**, page 7-27.

(2) Big Sandy River Basin Area Manager

(i) Monitor telephones on 24-hour basis;

(ii) Notify key personnel - see **Table 7-3**, page 7-27;

(iii) Place all personnel on standby for emergency duty.

(3) District

(i) Activate Emergency Operations Center;

(ii) Monitor telephones on 24-hour basis;

(iii) Test radio communications;

(iv) Place key staff on emergency duty;

(v) Provide detailed instructions to Damtender for any needed non-routine observations and tests;

(vi) Dispatch personnel to dam site as required to provide expert evaluation of situation and to assist Damtender as needed; and

(vii) Make any necessary notifications concerning declared situation.

f. Communications System.

(1) Normal. Communications between the District, Damtender (Resource Manager), and Big Sandy Area Office will be by telephone. Telephones at the project office, Big Sandy Area Office and District Emergency Operations Center will be manned on a 24-hour basis whenever a Pre-Emergency or Emergency condition is in effect at John W. Flannagan or at another site that can be affected by operation of John W. Flannagan Lake. Office and home phone numbers of key Huntington District, John W. Flannagan, Big Sandy Area Office and other federal agency personnel are listed in **Table 7-3**, page 7-27.

(2) Alternate. The radio communications network between the District Office, project office, and Big Sandy Area Office will be used to backup telephone communications. Radios at the project office, Big Sandy Area Office and District Emergency Operations Center will be manned on a 24-hour basis whenever telephone service is disrupted while a Pre-Emergency or Emergency condition is in effect at John W. Flannagan Lake or at another site that can be affected by operation of John W. Flannagan Lake. Radio frequencies and call letters for pertinent parties are listed in **Table 7-3**, page 7-27.

(3) Disaster Blackout. During a situation when both radio and telephone communications between the District Office and the Big Sandy Area Office or project office is lost, others equipped with radio or telephone facilities will be called on for assistance. Those to whom application for assistance may be made are listed in

Table 7-3, page 7-27, along with information for telephone and radio contacts.

g. Notification Plan.

Extreme conditions affecting operation of John W. Flannagan Lake could result in a hazard to life and/or property due to high lake levels and/or sudden release of large volumes of water.

Notification of the public of an enormous water release is carried out by the project, the Water Resources Engineering Branch, National Weather Service and by the District's Public Affairs Office. These units utilize various types of mass media, telephone, radio, personal visitation, and the Weather Service dissemination system, depending on the type, urgency and target of the information. Information on planned additions to or changes in lake regulation such as for recreation or fishery enhancement are disseminated by the Public Affairs Office from detailed statements by the Water Resources Engineering Branch. Information of interest primarily to anglers, such as water condition of the lake and outflow, are disseminated by the project via an automatic telephone answering machine tape that is updated as necessary by project personnel. Daily reservoir and rainfall data are disseminated to the Weather Service via the District Water Control System. This information appears along with other weather and stage information provided by the Weather Service to mass media and County, State, and Federal agencies.

TABLE NO. 7-3
DIRECTORY OF KEY PERSONNEL

Party	Telephone		Radio
DISTRICT PERSONNEL	OFFICE	RESIDENCE	CALL LETTERS
Water Resources Engineering Branch			WUE4
[redacted] Chief, Water Control Section	[redacted]	[redacted] - unlisted	
[redacted] Water Control Section	[redacted]	[redacted]	
[redacted] Water Control Section	[redacted]	[redacted]	
[redacted] Chief, Water Resources Engineering Branch	[redacted]	[redacted] - unlisted	

Huntington District Office, Water Resources Engineering Branch	
Normal Work Hours, [redacted]	[redacted]
Nights, Weekends, and Holidays Additional Extensions	[redacted],

NOTE: All the above numbers can be found on the C of E Intranet, including cell phone numbers. Located at [redacted]

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

John W. Flannagan Lake Project Office		
[redacted] - Damtender		Telephone No.
[redacted]	Commercial	[redacted]
[redacted]	Home	[redacted]

Gate Operating Personnel	Telephone No.
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

Other Agencies		
U. S. Geological Survey Richmond, Virginia Nights, weekends, Holidays	Commercial	[redacted]
[redacted]	Commercial	[redacted]
[redacted]	Commercial	[redacted]
National Weather Service Jackson, KY	Commercial	[redacted]

Big Sandy Area Office, Louisa, Kentucky		
[redacted] - Area Manager		Telephone No.
	Commercial	[redacted]

7-14 OTHER PLANS

a. Types. Either an increase or decrease in outflow may be requested by other governmental agencies, including state and local, or by higher authority within the Corps of Engineers. Typical recurring events which require special purpose regulation at John W. Flannagan Lake include periodic inspections and repairs of the dam and appurtenances, and stocking of fish in the tailwaters. Other types of special purpose regulation that have occurred in the past at Flannagan Lake include a reduction of flow for emergency aid to a drowning victim, maintenance of a minimum flow to inspect riprap below the dam and for downstream construction work, a closing of the gates to prevent a drowning victim from being drawn into the intake structure, a closure of the gates to aid in inspection of seepage past the gates, and a reduction in outflow to aid in the recovery of a wrecked vehicle below the dam.

b. Requirements. Prior approval of substantive deviations is necessary from the Great Lakes and 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.

7-15 DEVIATIONS FROM NORMAL REGULATION

The Huntington District Engineer is occasionally requested to deviate from the normal regulation of John W. Flannagan Lake. Approval and notification procedures are required when deviations from the normal water control plan are necessary. Prior approval for major deviations is required from the Division Engineer except as noted below. Deviation requests normally fall into the following categories:

a. Emergencies. The most common emergency requiring special regulation is a drowning downstream; decreased flow may be needed while searching for the victim or increased flow to dislodge the body. Other common emergencies occurring at a project are accidental insertion of a pollutant into a stream that requires flushing, 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 and prepare written confirmation of the deviation and description of the cause and furnish it to the division Water Control Manager. Division may develop forms to facilitate the reporting of emergency deviations.

b. Minor Deviations. There are instances that create a temporary need for minor deviations from the normal regulation plan, although they are not considered emergencies. Construction work, major or minor, accounts for the major portion of these incidents and typical examples include bridge work, and major construction contracts, pipeline changes or repair, utility stream crossings, boat dock work, or testing of a finished facility that may have various and changing flow requirements. 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 for minor deviation is evaluated on its own merits. Consideration must be given to upstream watershed conditions, potential flood threat, condition of 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 is normally coordinated at the project and District level, with a post operation written report showing the deviation and conditions on ORD Form l0l8-R revised. 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 tele-facsimile to the division for review and approval by the division water control manager.

c. Major Deviations. Prior approval for major deviations is required from the Division Engineer except as noted below. Either increase or decrease in outflow may be requested by other government agencies, including State and local, or by higher authority within the Corps of Engineers.

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 tele-facsimile to the division for review and approval. Except in case of emergency, confirmation of a major deviation is necessary from the Great Lakes and Ohio River Water Control Center before the Water Control Section may grant a request. In order for the Water Resources Engineering

Branch and Division Office to gage the advisability of compliance with a request, the Water Control Section must investigate upstream watershed conditions, potential flood threat, impact on other project purposes, condition of the lake, and possible alternatives. The following list contains most of the types of major deviations commonly requested.

(1) Anticipated drought periods may require additional water storage in the lake for later release into the river system for downstream benefit.

(2) Special pool level for fishery enhancement. Measures such as holding a specific higher pool level during and after the spawning period to foster recruitment may be requested by State Fisheries Biologists to benefit populations of certain species or the entire fishery.

(3) All requests for special releases from Corps lakes for recreation such as canoeing, whitewater, or other special releases will be referred to the Huntington District, Water Control Section of the Engineering-Construction Division for evaluation.

7-16 RATE OF RELEASE CHANGE

The John W. Flannagan Lake outflow is to be regulated in such a manner that the rate of release and the resulting stream level does not change more than 1.0 foot per hour on the “O” gage.

7-20 PUBLIC NOTIFICATION AND WARNING

Notification of the public of an enormous water release is carried out by the project, the Water Resources Engineering Branch, National Weather Service and by the district Public Affairs Office. These units utilize various types of mass media, telephone, radio, personal visitation, and the Weather Service dissemination system, depending on the type, urgency and target of the information. Information on planned additions to or changes in lake regulation such as for recreation or fishery enhancement are disseminated by the Public Affairs Office from detailed statements by the Water Resources Engineering Branch. Information of interest primarily to anglers, such as water condition of the lake and outflow, are disseminated by the project via an automatic telephone answering machine tape that is updated as necessary by project personnel. Daily reservoir and rainfall data are disseminated to the Weather Service via the District Water Control System. This information appears along with other weather and stage information provided by the Weather Service to mass media and county, State, and Federal agencies.

The Damtender (Resource Manager) at John W. Flannagan Lake will keep informed and inform the Water Resources Engineering Branch of all developments upstream and downstream along John W. Flannagan. Arrangements should be made with the Water Resources Engineering

Branch for public notification of water release operations that are of an unusual nature or substantially different from the established release pattern whenever such releases might cause damage to equipment or facilities located downstream. The objective of this program is to afford those likely to be affected an opportunity to take appropriate remedial action in advance of the arrival of the releases to prevent damage to or loss of property. Warnings of any unusual releases will be transmitted downstream by project personnel in person and by telephone.

News of impending gate opening operations is transmitted to persons downstream, primarily anglers, by means of the Below Project Warning System. Important public service messages concerning regulation of the lake are handled by the Public Affairs Office and disseminated via radio, newspapers, and television.

SECTION VIII - RESULTS OF WATER CONTROL PLAN

8-01 GENERAL

The results of regulation for the authorized purposes of flood control, recreation, and fish and wildlife enhancement at John W. Flannagan 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 No. 8-1, Frequency of Filling, and Plate No. 8-2, Duration of Filling. Plate No. 8-1 shows that the lake is likely to be filled to spillway elevation 1446.0 feet NGVD once in nearly 100 years. Effects of the water control plan on recreation and fish and wildlife are also presented in later paragraphs.

8-02 FLOOD CONTROL

Flannagan Lake controls 221 square miles, or approximately 98% of the Pound River drainage basin. Flannagan Lake has a tributary lake, North Fork of Pound Lake, which controls 17.2 square miles. The net controlled area of Flannagan Lake is 203.8 square miles. The combination of John W. Flannagan Lake, Yatesville, Paintsville Lake, Fishtrap Lake and Dewey Lake controls 1121.5 square miles, or approximately 48% of the Levisa Fork drainage basin. The chief benefit of these dams is the reduction of flood heights on Russell and Levisa Forks and the Big Sandy River, with additional benefits to Ashland and other communities downstream along the Ohio River. The application of the adopted water control plan to 3 hypothetical floods, 4 historical floods and 7 recent floods as they occurred are discussed in subsequent paragraphs.

a. Hypothetical Floods.

Two hypothetical floods, developed in Hydrology Design Memorandum No.1 (August 1958), consist of the following:

1. Spillway Design Flood.

2. Standard Project Flood.

The spillway design flood is the basis for determination of the spillway capacity required to provide safety for the most critical flood runoff over the basin. The standard project flood constitutes a standard for design of structures that will provide a high degree of protection as determined by flood potentialities of the drainage area involved, without regard to economic or physical limitations. The summer-type reservoir design flood, equal to 61.0 percent of the standard project flood, represents the limit of conditions against which flood protection can be provided within limits of economic and physical limitations.

(1) Spillway Design Flood. Current Corps criteria specify that the Spillway Design Flood (SDF) be based on the runoff from the Probable Maximum Precipitation (PMP), as indicated in Hydrometeorological Reports 51 and 52. Probable Maximum Precipitation 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. Hydrometerological Report No. 33, prepared by the U.S. Weather Bureau, dated April 1956, presents estimates of the seasonal variations of the probable maximum precipitation east of the 105th meridian for areas up to 1,000 square miles and durations up to 48 hours. This report was the basis for the determination of the spillway design storm and flood for the reservoir. Operation for Flannagan Reservoir for the spillway design flood is shown on Plate No. 8-3. At the start of the flood, it was assumed that the pool would be at elevation 1446.0 feet NGVD, maximum flood control pool, and that the reservoir would be regulated to pass inflow without

exceeding downstream channel capacity. By manipulating the slide gates, the pool would was held at this elevation until hour 11, at which time, conditions would have required operations to be performed in accordance with the induced surcharge envelope curve shown on Plate No. 1-3, Exhibit B, "Instruction to Damtender", Flannagan Dam. In following the induced surcharge curve, the slide gates were operated until fully opened after which the crest gates were used for additional operation. By hour 29, the pool would have reached a maximum elevation of 1455.0 feet NGVD with a maximum discharge of 253,500 cfs, 7,100 cfs through the outlets and 246,500 cfs over the spillway. The pool level would have receded to elevation 1446.0 by hour 34 and outflow would have been maintained at channel capacity of 4,000.cfs in order to draw down the pool elevation to 1396.0 feet NGVD. The effect of North Fork of Pound Reservoir was determined by applying the above rules of operation to the spillway design flood modified by North Fork Reservoir. The pool would have reached a maximum elevation of 1454.9 feet NGVD with a maximum discharge of 252,500 cfs.

(2) Standard Project Flood. The Standard Project Storm and Flood for Flannagan Lake was developed in accordance with Chief of Engineers memorandum dated 5 June 1950, subject "Standard Project Storm Determinations for Small Drainage Basins Located East of 105 Degrees Longitude", and Civil Engineers Bulletin No. 52-8. Operation of Flannagan Reservoir for the standard project flood is shown on Plate No. 8-4. At the start of the flood, the reservoir would have been regulated to maintain the seasonal pool at elevation 1396.0 feet NGVD without exceeding channel capacity of 4,000 cfs along Pound River. By hour 8, special instructions would have been issued by the Water Control Section to reduce the reservoir discharges to minimum value of 50 cfs due to rising downstream stages. Early rainfall and stream flow reports would have indicated that the flood control storage available would be insufficient to completely control the flood. As a result of this anticipated additional storage, the damtender would have been instructed to report pool elevation and rainfall every hour on the hour commencing at hour 30. In order to create the most critical situation, it is assumed that all communication would fail, except radio, thereby limiting rainfall and runoff data to that observed and reported by the damtender. The hour 33 report from the damtender would have indicated an outflow on the "Office Regulation Schedule for Major Floods", and the proper gate settings would have been ordered by the Water Control Section. This process of hourly reports and gate operations would have been continued until hour 66 when reservoir drawdown from maximum flood control pool elevation 1446.0 feet NGVD to seasonal pool elevation 1396.0 feet NGVD could have been initiated without exceeding the down stream channel capacity of 4,000 cfs. The maximum pool elevation attained would have been 1448.5 feet at hour 39 and the maximum outflow from the dam would have been 51,900 cfs.

b. Representative Floods.

(1) General. The early historical floods which were selected for illustration of the water control plan are the floods of March 1929, January 1937, February 1939, and July 1942. The more recent historical floods of February/March 1955 and February 1957 were also chosen. Also selected were the modern regulated floods of March 1963, March 1967, January 1974, April 1977, and May 1984, all of which illustrate floods actually regulated according to the water control plan. The historical floods of February 1862 and January 1918 were not reconstituted due to lack of details and scanty records. The record flood of November 1985 was not particularly damaging in the Levisa Fork and Pound River Basin and was not discussed. The historical floods of January 1937 and February 1939 were both caused by generalized heavy rainfalls occurring on saturated ground. The flood of February/March 1955 was caused by a series of storms occurring over the basin between 26 February and 6 March. The floods of March 1967, January 1974, April 1977, and May 1984 were all caused by heavy rains falling on saturated or frozen ground. Reductions at Bartlick for representative floods occurring before Flannagan Lake became operational are listed in Table No. 8-1(Table Section). Reductions for floods on the Ohio River at Ashland are shown in Table No. 8-2.

TABLE NO. 8-2

REDUCTIONS EFFECTED DURING SELECTED FLOODS
ON OHIO RIVER AT ASHLAND, KENTUCKY

Flood	Natural Stage (ft.)	Modified Stage (ft.)	Reductions For Flannagan Lake (ft.)
January 1937	73.3	73.1	0.2
January 1939	60.5	60.3	0.2
December 1942	63.4	63.3	0.1
March 1945	63.0	62.8	0.2
February 1948	54.6	54.3	0.3
April 1948	65.2	65.1	0.1
December 1950	56.7	56.5	0.2
March 1955	63.2	62.7	0.5

* Natural stages include Dewey reductions after 1948.

(2) Storm and Flood of March 1929. The flood of March 1929 reached major proportions throughout the Levisa Fork watershed and was the highest of record on Pound River near Haysi, VA. The flood was preceded by the periods of unusually high temperatures. The flood was caused by heavy rainfall on the 23rd with 3.21 inches recorded at Jenkins, KY, and 2.93 inches at Dante, VA. None of the present reservoirs were built at the time, however the flood has been reconstituted from the available data and routed downstream. The volume of runoff from Pound River was approximately 3.00 inches and the pool crest would have been about 1411 feet NGVD. On Pound River near Haysi on 23 March an estimated crest stage of 18.9 feet with a published flow 30,000 cfs was reached. The Levisa Fork gage at Pikeville crested at 44.6 feet or 60,000 cfs with about 12,000 cfs in reductions for Flannagan Lake.

(3) Storm and Flood of January 1937. The flood of January 1937 was the greatest of record on the Ohio River below Point Pleasant, WV. It resulted from excessive rains during January which followed moderate rains occurring in the latter part of December over the entire Ohio River watershed. During the period 15 to 25 January 1937, the rainfall in the Big Sandy River Basin averaged more than 6 inches. The resulting flood on Pound River did not reach extreme heights, but the prolonged duration of the storm produced large volumes of runoff. The same resulting flood on Levisa and Tug Forks did not exceed flood stages but at Louisa the crest stage was 49.0 feet, 4.0 feet above flood stage. The estimated runoff volumes from Levisa Fork and Tug Fork were about 5.1 and 3.5 inches, respectively. On the lower 22 miles of the Big Sandy River, the January 1937 flood was the maximum of record due to backwater from the Ohio River.

Neither Flannagan Lake nor any of the other Big Sandy River Basin flood control dams were built at the time, but the flood has been reconstituted. Prior to the morning of 18 January 1937, Flannagan Lake would have been operated to maintain the water quality pool and to pass the inflow as nearly as possible up to the limitations of gate capacity. At that time, a forecast would have been made that the Ohio River, already above flood stage, would reach a crest on the night of 19 January. Flannagan Lake dam would have been closed at 10 PM on 16 January to control the crest on the Ohio River, although Levisa Fork was not high enough to require control. Because of additional rainfall, the Ohio River did not crest until noon on 27 January, and sluices at Flannagan Lake would have been opened to channel capacity outflow beginning at 8 PM on 28 January after the Ohio River stage had dropped one foot and upstream stations were showing continued falling stages. The maximum pool elevation calculated at Flannagan Lake for this flood would have been about elevation 1418.0 feet NGVD on 28 January.

The hydrographs shown in this and subsequent plates labeled "natural" represent the flow conditions that would exist without the Flannagan Lake Project, and those labeled "modified" represent the inflow conditions that exist with the project in operation. The outflow hydrograph represents the regulated outflow from Flannagan Lake.

(4) Storm and Flood of February 1939. The flood of February 1939 reached major proportions throughout the Big Sandy River Basin, and was caused from two distinct storms, with the heaviest amounts reported over the lower portion of the basin. On 30 January the first storm released between 1.0 and 1.2 inches over the basin, which saturated the ground and started the streams to rise. The second storm occurred on the 1st to 3rd of February and resulted in rainfall over the basin varying from 2.0 to 4.0 inches with the heavier rainfall over the lower Levisa Fork Basin below Pikeville. The volume of runoff on Pound River near Haysi was approximately 1.9 inches. Maximum stages of record were reached on many of the upper and lower tributaries, and the stages at Paintsville and Louisa were the greatest since before 1900. The crest stage of 51.6 feet was reached at Louisa on 5 February. The estimated crest stage at Pound River near Haysi, VA was 15.8 ft with a flow of about 18,200.cfs.

None of the Big Sandy River flood control structures were built at the time, but the flood has been reconstituted. Outflow from Flannagan Lake would have been operated to maintain and control the water quality pool and to control the stage at Elkhorn City beginning at 0900 on 3 February. Forecasts of a crest on the Ohio River for 5 February would have been received from the Weather Bureau about this same time and would have indicated the necessity for closing the dam. About noon of 6 February, the stage at Dam 29 had fallen one foot and the reservoir would have been opened to channel capacity outflow at 2pm, since Levisa Fork at Paintsville had fallen enough that operation for its control was no longer necessary. The maximum pool level calculated for this flood was about elevation 1400.0 feet NGVD on 6 February.

(5) Storm and Flood of July 1942. This storm occurred in the early morning hours of 8 July, and although the intensities were not very great throughout the basin, the high runoff was probably due to the saturated conditions of the soil from previous rains. For the period 7-11 July at Haysi, Virginia, the total rainfall was 3.29 inches with 1.73 inches occurring on the 8th; at Jenkins, KY, the total was 4.43 inches with 2.71 inches occurring on the 8th. The storm centered on North Fork of Kentucky River near Quicksand, where a total of 8.13 inches fell with 5.1 inches on the 8th. On Pound River near Haysi a crest stage of 15.55 feet was reached with a flow of about 17,700 cfs. This is the highest recorded summer flood for the Levisa Fork - Pound River Basin prior to the construction of Flannagan Dam.

None of the Levisa Fork reservoirs were built at the time, however the flood has been reconstituted and operated. The estimated pool crest for this flood would be about elevation 1409 feet NGVD.

(6) Storm and Flood of February/March 1955. The flood of February-March 1955 was general throughout the basin and was characterized by extremely heavy rains from 4th to 6th of March. Rainfall over the basin averaged about 6.8 inches while the average runoff for all rises amounted to approximately 5.5 inches. Flannagan dam was not built at the time but the flood has been reconstituted. Operation of Flannagan Reservoir for the flood of February-March 1955 is shown on Plate No. 8-5. At the start of the flood, the reservoir would have been operated to maintain the water quality control pool at or near elevation 1380 feet NGVD, until the morning of 27 February. The outflow would have been reduced to a minimum flow of 10 cfs at 0900 hours on the 27th to reduce flooding at the control station at the USGS gage on Russell Fork at Bartlick, VA. By the morning of 2 March, the reservoir could have been opened in accordance with regulation for Russell and Levisa Forks, however, the Ohio River was rising and special instructions would have been issued to continue

releasing the minimum flow of 10 cfs until further instructions were received. By 0900 hours on 4 March, the Ohio River had crested and fallen one foot and continued recession was indicated, special instructions would have been issued by the Water Control Section to increase the outflow in increments of 1,000 cfs per hour until the channel capacity of 4,000 cfs was reached and to hold this outflow until the pool receded to elevation 1380.0 feet NGVD or regulation was required for downstream control at key stations. General rains, averaging between 2.0 and 2.5 inches, from the 4th to 6th of March contributed more runoff to existing moderately high stages which had resulted from heavy rains during the latter days of February. Due to this additional rain, rising streams and a USWB forecast of a crest stage in excess of 53 feet at Ashland on the Ohio River, special instructions would have been issued to the damtender to reduce the outflow to the minimum flow 10 cfs at 1000 hours on 5 March. By the morning of 9 March, after the Ohio River had crested, fallen 1 foot and continued recession was indicated, instructions would have been issued to the damtender to increase the outflow by increments of 1,000 cfs per hour until the channel capacity of 4,000 cfs was reached and to hold this outflow until the pool receded to water quality pool level of 1380 feet NGVD or regulation was required for downstream control at key stations. Channel capacity of 4,000 cfs would have been released until the afternoon of 15 March when local streams in the Big Sandy Basin would have started to rise again due to additional rainfall. Instructions would have been issued to the damtender to reduce the reservoir outflow to the minimum value of 10 cfs at 1500 hours on hours on 15 March. By 1500 hours on 17 March, downstream stations along Russell and Levisa Forks would have receded below control stages and instructions would have been issued to increase the outflow to downstream channel capacity of 4,000 cfs and hold this outflow until the pool level receded to elevation 1380 feet NGVD sometime early on the morning of 27 March. Plate No. 8-6 shows the natural and modified hydrographs on Russell Fork at Bartlick, VA. Plate Nos. 8-7 and 8-8 show the natural and modified hydrographs at Elkhorn City and Pikeville, KY, due to the operation of Flannagan and North Fork of Pound Reservoirs.

(7) Storm and Flood of January 1957. Frontal activity between strongly contrasting air masses brought excessive rainfall to the region during the period of 27 through 29 January 1957. Rainfall averaged approximately 5.0 inches over the basin, varying from 2.8 inches in the lower basin to 7.0 inches in the upper basin. On the upper Levisa and Tug Forks, the flood exceeded the previously known maximums. The volume of runoff amounted to an average of approximately 3.4 inches over Levisa Fork and 3.0 inches over Tug Fork. At Pikeville, Levisa Fork reached a stage of 52.7 feet, which is 0.8 feet higher than the previous known maximum of 1862, while at Williamson, Tug Fork reached a stage of 43.6 feet, 0.4 feet higher than the previous maximum of 1875. Flannagan dam was not built at the time, but the flood has been reconstituted. Operation of Flannagan Reservoir for the flood of January 1957 is shown on Plate No. 8-9. This flood was caused by frontal activity between strongly contrasting air masses, which brought excessive rainfall to the Big Sandy River Basin during the period of 27 to 29 January 1957. Streams were at average flow levels and the ground was thoroughly saturated from antecedent rainfall at the onset of the storm which averaged about 4.9 inches of rainfall over Pound River Basin. At the start of this flood, the reservoir would have been operated to maintain the pool level at water quality pool level of 1380 feet above NGVD. At 0800 hours on the morning of 29 January, the damtender would have reduced the outflow to the minimum release of 10 cfs to maintain the control stage at the gage on Russell Fork at Bartlick, VA. Special instructions would have been issued to the damtender to keep the reservoir closed and continue to release the minimum flow of 10 cfs until further instructions. By early morning of 31 January, all downstream control stations would have receded below flood stages and no additional rain was forecast; therefore, instructions would have been issued to start releases from Flannagan Reservoir. Upon receiving instructions from the Water Control Section, the damtender at Flannagan reservoir would have increased the outflow, by increments of 1,000 cfs per hour, beginning at 0800 hours on 31 January. By 1100 hours on 31 January, the maximum release rate of 4,000 cfs would have been reached and the outflow would have been held until 1700 hour on 1 February when the damtender would have reduced the outflow to

2,000 cfs to prevent flooding at Bartlick gage. The reduced flow of 2,000 cfs would have been held until the morning of 2 February when the outflow could again be increased to the maximum allowable channel capacity of 4,000 cfs. This release rate of 4000 cfs would have been maintained until the pool level had receded to elevation 1380 feet NGVD, at which time operation would be resumed in accordance with standing operation instructions. Plate Nos. 8-10, 8-11, and 8-12 show the natural and modified hydrographs for Russell Fork at Bartlick, VA, Elkhorn City, KY, and Levisa Fork at Pikeville, KY, due to the operation of Flannagan and North Fork of Pound Reservoirs. The recorded crest for Pound River at Haysi was the third highest, 18.7 feet with a flow of 27,300 cfs at the U.S.G.S. gage.

Flannagan Reservoir operation has been performed in conjunction with North Fork of Pound Reservoir for the floods described in the following paragraphs.

Table No. 8-2 shows the effect of Flannagan Reservoir operation on downstream control stations for four representative floods, including those used for illustration of reservoir operation.

(8) Storm and Flood of March 1963. In March 1963, three separate periods of severe flooding occurred in the Big Sandy River Basin due to an excessive amount of precipitation after three previous months of cold dry weather. The first rise occurred between March 5th and 9th, the second between the 11th and 16th and the third between the 16th and 21st. Monthly precipitation ranged from slightly more than 2 inches above normal in the west to almost 4 inches above normal in the eastern section of Kentucky. On Tug Fork, the stage at Williamson, WV, crested at 44.5 feet, 0.9 feet above the previous flood of record January 1957. John W. Flannagan reservoir was under construction at the time of the flood and was partially regulated with a rainfall of about 6.0 inches for the month of March, with 2.71 inches of rainfall on the 11-12th of March producing a computed natural crest of 25,000 cfs at the outflow gage under present day conditions. The partial operation produced a pool crest of 1315.0 feet NGVD and a computed diversion tunnel outflow of 10,825 cfs. The reconstituted operation of Flannagan Reservoir for the flood of March 1963 is shown on Plate No. 8-13. The excessive precipitation over the Big Sandy River Basin produced three separate periods of severe flooding on basin streams and also on the Ohio River at Ashland. At the start of the flood, the reservoir would have been operated to maintain the water quality pool level at or near elevation 1380 feet NGVD and to provide the necessary releases for downstream minimum flow requirements. By 1100 hours on 5 March, the damtender would have reduced the outflow to the minimum release of 10 cfs due to rising stages at the control station on Russell Fork at Bartlick, VA. On the afternoon of 5 March, based on forecasts by the National Weather Service for the Ohio River at Ashland, KY, special instructions would have been issued to the damtender to keep the Flannagan Dam closed for Ohio River flood control until further instructions. Only the minimum flow of 10 cfs would have been released, until the Ohio River had crested, fallen 1 foot and continued recession was indicated. At about 1500 hours on 9 March, special instructions would have been issued to the damtender to increase the outflow by increments of 1,000 cfs per hour until the channel capacity of 4,000 cfs would be reached. This release rate would continue until the pool level receded to elevation 1380 feet NGVD, or additional regulation was necessary for downstream flood conditions. Additional rains on the 10th, 11th and 12th of March caused rain swollen streams to start another rise; and based on NWS forecasts for the Ohio River, instructions would have been issued at 0900 hours on 11 March to close the reservoir for Ohio River control. For this second and largest rise, the Flannagan sluice gates would have been kept closed, except the minimum flow of 10 cfs would have been released. About 1500 hours on 14 March special instructions would have been issued to start drawdown procedures by increasing the outflow to 4,000 cfs, by increments of 1,000 cfs per hour. Maximum channel capacity of 4,000 cfs would have been released until 0800 hours on 17 March at which time it would have become necessary to again close the gates for control of flood water throughout the Big Sandy River Basin. Flannagan Dam would have been kept closed with, only the minimum flow of 10 cfs being released, until

0800 hours on 18 March. At this time the damtender would have been directed to increase the outflow, by increments of 1,000 cfs per hour, until reaching the maximum allowable channel capacity of 4,000 cfs. This outflow of 4,000 cfs would have been maintained until the morning of 19 March. At this time special instructions would have been issued to reduce the discharge to the minimum value of 10 cfs, based on a NWS forecast of crest flood stage, above 53 feet, being reached on the Ohio River at Ashland, KY. The minimum release rate of 10 cfs would have been maintained until the morning of 23 March when special instructions would have been issued, based on the Ohio River at Ashland having crested, fallen 1 foot and indications of continued recession, to increase the outflow by increments of 1,000 cfs per hour until channel capacity of 4,000 cfs was reached. By 1100 hours on 23 March, the channel capacity of 4,000 cfs would have been reached and would have been held until the pool level receded to elevation 1380 feet NGVD or had intersected with the upper limiting rule curve on the "Low-Flow Regulation Schedule." Operation of the reservoir would have been continued in accordance with the upper limiting rule curve in order to raise the pool level to elevation 1396 feet NGVD, by 15 April. Plate Nos. 8-14, 8-15, and 8-16 show the natural and modified hydrographs for Russell Fork at Bartlick, VA, and Elkhorn City, KY, and Levisa Fork at Pikeville, KY, due to the operation of Flannagan and North Fork of Pound Reservoirs.

(9) Storm and Flood of March 1967. Floods of record occurred in many northcentral and southern West Virginia watersheds in early March 1967. Headwater flooding occurred in areas of eastern Kentucky and record 24-hour snowfalls occurred in some areas of northwestern Kentucky during the storm of 6-7 March. In the near-by Dewey Lake Basin, rainfall totals during the period 4-7 March averaged about 3 inches, with a large portion of the rain occurring on 6 March. Dewey Lake and Meta received 2.52 and 2.71 inches of rain, respectively, during a 24-hour period, with about 1 inch of that total falling in a 4-hour period. Pound River rainfall was about the same amount.

In the operation of the dam, the gates were regulated at the onset of the storm to maintain the minimum pool elevation. Partial DEMIA channel capacity discharge of 1100 cfs was reached late on 6 March, and then reduced to minimum flow on the morning of 7 March to store inflow. The gates remained closed except for minimum flow until early afternoon on 10 March, when the gates were reopened to begin drawing down the flood pool. The maximum instantaneous inflow occurred about midnight on 6 March with a peak near 16,500 cfs with a computed natural crest of 13,000 cfs. The maximum pool level observed during this flood was elevation 1407.76 feet NGVD on 10 March. Crest reductions for Flannagan Lake for Bartlick on Russell Fork were about 3.5 feet. Results of regulation of this flood at Flannagan Lake and downstream at Levisa Fork at Pikeville are not available at the time of publication.

(10) Storm and Flood of January 1974. Eastern Kentucky experienced flooding as a result of heavy rains which fell during the period 8-11 January. Pikeville, located northwest of the Flannagan Lake Basin received more than 4 inches of rain in a 24-hour period, and a total of 5.23 inches of rain over a 4-day period. Meta, located in the nearby Dewey Lake Basin, received a total of 4.5 inches over the 4-day period, including 3.6 inches which fell in a 27-hour period on 9-10 January. The Flannagan Basin received comparable rainfall and had about 2.7 inches of runoff for the days of 9 to 13 January.

In the operation of the dam, the gates were initially operated to maintain the minimum pool level. The instantaneous peak inflow of approximately 14,000 cfs reached the dam about noon of 11 January, and the gates were closed to store inflow from the flood on the afternoon of 10 January. A minimum outflow of 10 cfs was maintained from the dam for benefit of fish habitat during the flood, and the gates were reopened on 14 January to begin drawing down the flood pool. The maximum pool level observed for the flood was elevation 1403.98 feet NGVD on 14 January with a computed natural crest of 11,000 cfs and a regulated outflow of 3900 cfs. Results of regulation of this flood at Flannagan Lake are shown on Plate No. 8-17.

(11) Storm and Flood of April 1977. Heavy rains fell over the Appalachian region during the 2-5 April 1977, causing record flooding. Flood discharges along the upper Tug and Levisa Forks exceeded all records. Recurrence interval of observed flood discharges were greater than those of 100 years at 29 stream-flow stations. The most significant periods of precipitation during the month began on the evening of the 2nd of April. Although there was an 18-24 hour break in the rainfall on Sunday the 3rd, this set the stage for greater runoff when the rain began again on Sunday evening. A series of disturbances moved from the southern plains states into the Appalachians on Monday 4 April. Heavy thunderstorms formed ahead of the disturbances in the lower Mississippi Valley and moved rapidly northeastward along a stationary front into the Southern Appalachians. Three bursts of heavy rainfall occurred over Southern WV, Southeastern KY, and Western VA during the 4th. The first heavy rain fell between midnight and 5 AM; the next around midday; and the last around sunset. Measured rainfall ranged from 1.31 inches at Louisa, KY, to 9.44 inches at Flat Gap, VA, in the head water area of the Pound River. High intensity rainfall was also recorded at Tiny, VA, in the headwaters of the Russell Fork measuring 8.65. Darwin on Cranenest River recorded 7.32 inches, Burdine, KY near the basin rim had 5.27 inches, and Hurley on Knox Creek in the Tug Fork Basin recorded 6.69 inches. The storm centered in the head waters of the Slate Creek Basin and near Jalo in the Tug Fork Basin where over 15.5 inches of rainfall fell in 30 hours at the storm center. This record intense rain fall resulted in a rapid concentration of runoff for many streams in the Pound River, Russell Fork and upper Levisa Fork Basin. Storm runoff from the area above Pikeville amounted to 5.8 inches, with runoff from the Pound River averaging about 5.1 inches. This indicates that Levisa Fork rainfall above Pikeville exceeded 6.5 inches and Pound River Basin rainfall was nearly the same.

In the upper Tug and Levisa Forks the April 1977 flood was the greatest of record. Substantial reductions were accomplished as a result of reservoir storage in the North Fork of Pound Lake and Flannagan Lake on the Pound River and Fishtrap Lake on the Levisa Fork. Flannagan flood control operations reduced peak stages at Elkhorn City on the Russell Fork and Pikeville on the Levisa Fork by 1.2 feet and 4.4 feet, respectively. The actual crest at Pikeville was observed at 51.46 feet, with a record computed natural crest of 65.1 feet with a corresponding computed flow of 150,000 cfs. Operation of Flannagan lake for this flood of record in the upper Levisa Fork and Pikeville is shown on Plate No. 8-18. At the start of the flood, Flannagan was refilling to seasonal pool level of 1396 feet NGVD, by storing inflow. After a series of disturbances moved over this region, it became apparent that Flannagan would have to prepare for a flood. At 1900 hours, 4 April special instructions were given to the damtender to store all inflow above the minimum flow of 50 cfs due to rapidly rising stages at the down stream control stations. This discharge was maintained until 1300 hours 7 April. Because the flood occurred during the refilling period the crest of the Flannagan Lake pool reached a record level of 1430.77 feet NGVD at 1300 hours on 7 April. The crest at Ashland, KY on the Ohio River was just 0.4 of a foot above flood stage of 53 feet; therefore, special instructions were issued to the damtender to gradually begin opening to the maximum discharge of 4,000 cfs at 1300 hours 7 April. This release was maintained until Flannagan Lake receded to the seasonal pool of 1396 feet NGVD. This record flood produced a computed natural crest of 17,000 cfs and a record regulated outflow of 4540 cfs at the outflow gage. Results of regulation of this flood at Levisa Fork at Pikeville is shown for both Flannagan Lake and the upper Levisa system on Plate Nos. 8-19 and 8-20.

(12) Storm and Flood of May 1984. Flash flood conditions resulted from a series of storms occurring during 2-4 May and again on 6-8 May. Isolated storms dropped up to 2 inches of rain over portions of the Flannagan Lake Basin during 2-4 May, saturating soils. The storms came after the spring plowing and planting causing heavy crop damage. During the following storms of 6-8 May, more than 4 inches of rain fell over portions of the Flannagan Lake Basin. Of that total, about 2.5 inches of rain fell on 7 May, creating the flashflood conditions. The heavy part of the storm was in the upper end of the basin,

especially the Pound River and Russell Fork areas. The total rainfall for the storm over Pound River was 6.93 inches with about 2.87 inches of runoff. The Birch Gap station reported 4.02 inches of rainfall by 0800 on the 7th of May with 2.39 inches falling early on the 7th. The nearby station of Meta had approximately 4.2 inches of rainfall in the 3 day period of 6-8 May with 2.2 inches falling early on the 7th.

In the operation of the dam, the gates were operated at the onset of the storm to maintain the seasonal pool elevation. The gates were closed late during the night of 5 May to store the bulk of the flood runoff, and a minimum flow of 50 cfs was maintained below the dam for fishery benefit. The instantaneous peak inflow of near 20,000 cfs arrived at noon on 7 May, and gates were reopened to pass the MIANO channel capacity and draw down the flood pool in the afternoon of 9 May. The maximum pool for this flood was 1421.81 feet NGVD, on 9 May, partially because the lake was in the refilling period when the flood began. This damaging flood produced a computed natural crest of 15,000 cfs and a full channel capacity outflow of 4,000 cfs. Results of regulation of this flood at Flannagan Lake and on Levisa Fork at Pikeville are shown on Plate Nos. 8-21 and 8-22.

c. Flood Damage and Benefits. The primary purpose of the Big Sandy Reservoir system, including John W. Flannagan was for flood control and reduction of flood damages. This area has been even more successful than originally conceived, however, the process of allocating benefits to individual reservoirs is sometimes vague and misleading. Placing a monetary value on saving human lives is also very difficult. Flood damages in the areas below the John W. Flannagan Lake dam site along Pound River and Russell and Levisa Forks consist principally of agricultural losses and of extensive damages in the immediate vicinity of Elkhorn City and Pikeville, KY, where as much as 80 percent of the area of the town has been flooded in the past. Crops are sometimes planted to within a few feet of the low water line along Pound River and Russell Fork, but much of the cultivated land is located on higher ground. Downstream along Levisa Fork, flood damages occur to agricultural areas and also to the communities of Elkhorn City, Pikeville, Paintsville, Prestonsburg, and Louisa, KY. Flood losses along the Big Sandy River result more often as result of backwater from Ohio River floods than from headwater floods, but when high flows from the headwaters coincide with floods on the Ohio River they serve to increase the flood damages. The losses along Big Sandy River are confined to damages to crops and rural properties except in the developed areas near the mouth. Serious bank erosion and caving along the lower parts of the stream result from major floods.

Flood damages prevented since the construction of the Flannagan Lake dam have been estimated, based on elevation damage relationships derived from detailed damage surveys for the stream reaches below Flannagan Lake. The present project benefits for Flannagan Lake can best be defined in terms of average annual flood damages prevented for a given period of record. If, it is assumed that the flood experience from the year 1963 through 1995 is representative of the long term average and that the accumulated damages and damages prevented are a reliable conservative estimate, the average annual flood control benefits for Flannagan Lake may then be calculated as the total damages prevented divided by the given period of record. Based on these studies, it is estimated that Flannagan Lake has prevented approximately $147.6 million in flood damages through fiscal year 1995, or approximately $4,612,500 per year based on the 32-year period of record since construction of John W. Flannagan dam. However, it should be noted, there has been no escalation or updating of property values and new building costs, and no adjustment for new building, renovation, or depreciation. The 1964 dollars are added directly to the 1993 dollars.

The various methods and procedures of computing and allocating flood control benefits for each Big Sandy Lake have been strongly debated, often doubted and misunderstood, and the debate will probably continue for the life of the project.

8-03 RECREATION

Success of the recreational purpose of the project, as measured by the number of visitors, has been excellent. Attendance was strong in the early years, then slightly declined in the years 1988-1990, however recent visitation at Flannagan Lake has now increased to approximately 300,000 visits per year. Visitation figures for John W. Flannagan Lake are shown in Table No. 8-3. 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 Flannagan Lake indicate $3.00/visitor-day for general recreation and $3.60/visitor-day for fishing or hunting.

Changes in pool level tend to diminish recreational benefits by affecting boating, camping, hunting and fishing interests at Flannagan Lake. Public campgrounds, boat launching areas, and local access roads to these areas are the most frequently flooded areas at the project. Flooding elevations at recreational and other critical sites are shown in Table No. 8-4 with probable frequency of occurrence. Plate No. 8-1, Frequency of Filling, shows the probable time between occurrences of elevations of the pool, and Plate No.8-2, Duration of Filling, shows the probable length of time for each occurrence.

TABLE NO. 8-3
VISITATIONS AT FLANNAGAN LAKE

Year	Visitations
1978	532,000
1979	510,200
1980	513,100
1981	519,500
1982	484,200
1983	380,300
1984	285,700
1985	246,300
1986	223,500
1987	227,500
1988	211,100
1989	210,000
1990	220,000
1991	223,000
1992	312,000
1993	306,400

TABLE NO. 8-4

FLOODING ELEVATIONS AND FREQUENCIES
AT FLANNAGAN LAKE SITES

Area	Item	Flooding Elevation (Feet NGVD)	Frequency, in Years, between Occurrences
Summer Pool Elevation		1396.0	0.6
Lower Twin Launch Parking Lot		1397.6	0.7
Cranenest Launch Ramp		1400.0	0.9
Spillway Launch Ramp		1403.0	1.1
Pound River Launch Ramp		1404.0	1.2
Cranenest Low Water Ramp		1410.0	2.3

Lower End Pound River Toilets	1410.0	2.3
Marina Launch Ramp	1413.0	3.3
Marina Parking Lot	1413.0	3.3
Cranenest Camping Area No. 1&3	1415.0	4.0
Cranenest Camping Area No. 2	1420.0	7.0
Cranenest Washhouse	1422.5	9.5
Lower Twin Washhouse	1430.0	21.5
Lower Twin Sewage Treatment Plant	1444.7	94.0
Top of Spillway Tainter Gates	1446.0	103.0
Marina Comfort Station	1446.5	108.0

8-04 WATER QUALITY

a. Special Problems. Water quality problems at John W. Flannagan Dam and Reservoir are related to coal mining and logging operations within the watershed. Raw sewage discharges are also a common problem, but population densities are low within the basin. Major ions; calcium, magnesium, sodium, potassium, sulfate, and chloride, are out of balance. This is most likely the result of coal mining. Acid mine drainage from the headwaters should be monitored to evaluate buffer capacity of the lake. Lake iron and manganese values are important for hypolimnetic and outflow evaluations during stratification periods.

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 1996.

(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 John W. Flannagan Basin is classified as a calcium-sulfate type. This represents an unbalanced condition. Normally this classification would be calcium carbonate.

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 air temperatures start to cool the surface water temperature also cools and mixes with water below at the same temperature. This process continues until water temperature in the epilimnion is the same as the hypolimnion and the lake is once again mixed.

John W. Flannagan Reservoir remains nearly isothermal during the winter months. In the spring the lake stratifies and remains so until September. At that time the lake mixes and becomes isothermal again. The lake has a long average retention time of 114 days, which directly affects the stratification pattern. As shown in Plate No. 8-23, there is a strong thermal stratification pattern. Specific conductance does not indicate any density layers in the lake resulting in interflows through the lake during the summer months. Thus water entering the lake remains there for close to 4 months before it is released to the downstream area.

Concentrations of dissolved oxygen remain constant throughout the water column after fall mixing in October and remain so until around April after the lake has stratified. At that time dissolved oxygen levels in the hypolimnion decline rapidly until anoxic conditions are reached. Throughout the epilimnion and the metalimnion dissolved oxygen remains above 5.0 mg/l, which

includes about 92% of the lake. Since dissolved oxygen is one of the key parameters for fishing, this represents the maximum amount of lake available for fishing during most of the stratification season. During fall turnover in September and October, dissolved oxygen remains above 5.0 mg/l in the epilimnion, which includes about 36% of the lake. Plate No. 8-24 shows typical dissolved oxygen concentrations during the summer months.

North Fork of Pound River and Cranesnest River are the two major streams flowing into John W. Flannagan Dam and Reservoir. Dissolved oxygen concentrations in the two inflow streams and the outflow average 99% saturation. Originally there was a system of three bypass conduits used to make releases during low-flow and two sluice gates for higher flows. This system was designed to allow some regulation of the quality of the water during low flow conditions. After the summer pool elevation was raised, the three inlets were all located within the hypolimnion. Thus regulating the quality of the releases was hampered. The very bottom of the lake becomes anoxic during the stratification season, but this is most likely due to the long residence time rather than a high demand on oxygen. During fall turnover a much larger part of the lake turns anoxic. Tailwater re-aeration is considered excellent since dissolved oxygen concentrations are so high.

Sufficient quantities of phosphorous, nitrogen, and carbon are needed to have a productive lake. John W. Flannagan Reservoir is considered productive with phosphorous as the limiting nutrient. Nutrients are transported along with the sediments. As water enters a lake, its velocity decreases and the sediments settle to the bottom. Because of this phenomena it is not uncommon to see algal blooms at the upper end of a lake. Phosphorous concentrations were usually just above detection in the inflow, lake and outflow.

Mean pH values were around 7.7 in the headwaters and 7.7 in the tailwaters. Both are slightly above neutral on the basic side. Long-term trends indicate no significant pattern in pH values over the entire watershed. Average alkalinity, a factor buffering pH, was around 93 mg/l CaCO3 in the headwaters and 59 mg/l CaCO3 in the tailwaters. Hardness at all stations was classified as very hard (ASTM).

Concentrations of iron remained below a 1.0 mg/l standard in the headwaters, and tailwaters. During the stratification season, iron levels also remained below a 1.0 mg/l standard in the lake hypolimnion and below 0.1 in the epilimnion and metalimnion (Plate No. 8-25). This implies a minimal effect on the lake fishery from iron. Long-term trends indicate no significant changes in iron concentrations.

Concentrations of manganese remain below a standard of 1.0 mg/l in the headwaters. During lake stratification manganese exceeded 6.0 mg/l in the hypolimnion, but remained below 0.1 mg/l in the epilimnion (Plate 8-26). The high concentrations of manganese in the hypolimnion are reflected in tailwater readings, which exceed 2 mg/l during late summer and fall. Long term trends indicate no significant change in manganese concentrations.

(2) Biological. 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, measuring chlorophyll can monitor the productivity of aquatic habitats. Algal productivity was low in headwaters with average chlorophyll concentration less than 2 ug/l. Productivity on the lake was not much better with average chlorophyll concentrations around 4 ug/l.

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 for two inflow stations JWF0002 (Pound River) and JWF0003 (Cranes Nest River), and the outflow station JWF0001 below John W. Flannagan dam.

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 OQR and interpretation for the above water quality stations are presented in Plate No. 8-27. Data is based on benthic samples collected from 1975 through 1986. The two inflow stations JWF0002 and JWF0003 had **moderate** quality, while the outflow station JWF0001 had **poor** overall quality.

The most common groups of macroinvertebrates collected in the benthic samples from the outflow station were black flies (61%) and chironomid midges (22%). Mayflies, stoneflies, and caddisflies accounted for only 10 percent of the total. The common groups collected at the two inflow stations were: JWF0002 (Pound River) -- mayflies (30%), stoneflies (13%), caddisflies (24%), and midges (20%); and JWF0003 (Cranes Nest River) -- mayflies (22%), stoneflies (9%), caddisflies (40%), and midges (14%).

8-05 FISH AND WILDLIFE

Effects of the water control plan on fish and wildlife at Flannagan Lake are associated mainly with pool fluctuations in the lake, and outflow from the outlet works.

Requirements of a constant or rising pool for fish spawning are incorporated into the water control plan at Flannagan Lake. The seasonal pool level at Flannagan Lake is normally reached before or during the spawning periods of the fish at Flannagan Lake. The water plan at Flannagan Lake will therefore normally provide adequate pool conditions for fish spawning.

With construction of the project, there was a reduction in wildlife habitat as a result of inundation by the conservation pool, and additional habitat within the flood pool was reduced in value due to periodic flooding. Lands acquired in fee contiguous with the pool area were then outgranted to other agencies for management. The outgranting of 9,751 acres to the Virginia Department of Game and Inland Fishery has improved the original habitat by the elimination of overgrazing and soil erosion. Allowing cropland, pasture and homesites to revert to forest provides a long-term benefit for wildlife and forest conservation.

Recent fishing success at Flannagan Lake can be shown by results of a roving creel survey conducted at Flannagan Lake during the period 1 March through 31 October 1988. During that period it is estimated that 26,015 fishing trips resulted in the harvest of 35,340 fish that weighed an estimated 9,151 pounds. Approximately 57% of the fishing trips were in pursuit of black bass, with an additional 12.5% of the trips for crappie. Out of the total harvest there were an estimated 659 largemouth bass averaging 16.2 inches, and 10,941 crappie averaging 7.5 inches. The catch rate of 0.86 fish per hour was nearly three times the harvest rate of 0.3 fish per hour. The total fishing pressure during the period was estimated at 112,919 man-hours, and bluegill was the most

harvested species in the lake.

8-06 EMERGENCY DRAWDOWN

Since the Flannagan Lake project has been operational, no emergency drawdown has occurred. The time required to draw down the reservoir from the maximum flood control pool level of elevation 1446 feet NGVD is dependent on the maximum discharge allowed through the outlets. Assuming channel capacity discharge during MIANO, it would require approximately 25 days to draw down the flood pool from the maximum flood control pool elevation 1446 feet NGVD to the seasonal pool elevation 1396 feet NGVD. It would take an additional 7 days to empty the seasonal pool down to the low-flow sluice invert at elevation 1318.5 feet NGVD. Assuming channel capacity discharge during DEMIA, the maximum flood control pool could be drawn down to the seasonal pool level in approximately 17.5 days, to the minimum pool level in approximately 19 days, and to the low flow sluice invert elevation in a total of approximately 23.5 days. With all gates fully open, the maximum flood control pool level could be drawn down to the seasonal pool level in about 11.5 days or emptied to the low-flow sluice invert in about 15.5 days. 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 Flannagan Lake.

8-07 SPECIAL PURPOSE RELEASES

There have been a number of special purpose releases and closures at the Flannagan Lake Project, but the deviations from the water control plan have had only minor impacts on the overall project. Relative to the dam itself, the most significant deviations from the water control plan have been associated with trash and debris removal, periodic maintenance and repairs, and periodic inspections of the dam and appurtenances. In December 1990 the winter pool was lowered to elevation 1350 feet NGVD for 10 days, in order to make special repairs on the equipment. In addition to these deviations, emergency closures have been made at the dam for swimming and boating accidents, and for recovery of a wrecked vehicle below the dam. Flows have also been adjusted during periods of fish stocking below the dam.

8-08 FREQUENCIES AND DURATIONS

a. Natural Frequency and Duration at the Outflow Gage. The natural discharge frequency curve for Pound River at the Flannagan 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 Big Sandy 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 1000 years are given in Table No. 8-5.

Since 1963, flows in Pound River have been regulated by Flannagan Lake. A computerized frequency 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 1938 through 1987. 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 Pound River below Flannagan Lake.

TABLE NO. 8-5

FREQUENCY SUMMARY
POUND RIVER NEAR HAYSI, VIRGINIA

ALL SEASONS - NATURAL

Exceedence Interval (years)	Natural Discharge (cfs)	Modified Discharge (cfs)
1000	55,000	
500	49,400	
200	41,400	
100	35,800	4,000
50	30,500	4,000
20	23,800	4,000
10	19,200	4,000
5	14,900	4,000
2	10,400	4,000
1	7,800	860

b. Pool Elevation Frequency and Duration. Peak pool elevations for all significant rises experienced during actual operation of the Flannagan Lake Project through 1987 have been analyzed using graphical frequency procedures. Duration of selected pool elevations have been derived from historical pool elevations experienced at the Flannagan Lake Project for the same period ending in 1987. A frequency summary of Flannagan Lake pool elevation deviations is shown on Table No. 8-6.

TABLE NO. 8-6
FREQUENCY SUMMARY
FLANNAGAN LAKE POOL ELEVATION DEVIATION - ALL SEASONS

Exceedence Interval (years)	Elevation (feet NGVD)
100	1446.0
50	1438.4
20	1429.4
10	1423.0
5	1416.8
2	1408.8
1	1401.8

c. Control Station - Pikeville, Kentucky. The natural frequencies of Levisa Fork at the Pikeville gaging station were estimated using nearly the same methods and techniques of data handling and calculations as were used for Pound River at the damsite.

Actual peaks occurring at the gage since the Flannagan Lake, Fishtrap Lake, and North Fork of Pound Lake projects 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 the natural and modified flow frequency curves. Flows for selected exceedence intervals from year 1 to 100 for the Pikeville control station are included in Table No. 8-7.

TABLE NO. 8-7

FREQUENCY SUMMARY

LEVISA FORK AT PIKEVILLE, KENTUCKY
ALL SEASONS - NATURAL

Exceedence Interval (years)	Natural Discharge (cfs)	Flannagan, Fishtrap, NFP Modified Discharge (cfs)
1000	190,000	101,000
500	168,000	88,000
200	140,000	71,600
100	121,000	60,900
50	103,500	51,100
20	80,500	39,900
10	64,900	32,700
5	50,000	27,360
2	35,000	21,600
1	25,000	18,100

SECTION IX - WATER CONTROL MANAGEMENT

9-01 RESPONSIBILITIES AND ORGANIZATION

a. Corps of Engineers. 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 John W. Flannagan 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 Big Sandy Area Office within Operations and Readiness Division.

b. 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.

c. 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 Great Lakes and Ohio River Division Water Management Branch is responsible for administration of the Division Engineer's policy for water control management.

d. Huntington District. The District Engineer has 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.

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.

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:

(1) Flood control
(2) Fish and wildlife enhancement
(3) Recreation

(4) Water Supply

The 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: CELRD-EC-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-EC-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 No. 9-1 for Water Control Management at John W. Flannagan Lake. As shown on the chart, the Natural Resource Management Branch and the Big Sandy Area Office are responsible for supervision of the operation and maintenance of the dam and operations area at Flannagan Lake. The Damtender at John W. Flannagan Lake regulates the project in accordance with general instructions and Special Directives issued by the Water Control Section. General instructions are included in Exhibit B, "Instructions to Damtender", of this manual, and Special Directives are issued and signed by the Chief, Water Control Section, 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 the Water Resources Engineering Branch are involved in the following activities pertaining to water control management:

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

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

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

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

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

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

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

(8) 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:

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

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

(3) Providing liaison personnel to support Emergency

Operations Center when it is operational.

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

(5) 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 No. 9-1. 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 Control Section 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 Control Section 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 No. 9-2.

9-02 INTERAGENCY COORDINATION.

a. Local Press and Corps Bulletins.

b. National Weather Service.

c. U.S. Geological Service.

d. Power Marketing Agencies.

e. Other Federal, State, or Local Agencies.

9-03 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 level 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 the current week. The gage point reported for the Big Sandy River Basin is at Fullers, Kentucky on the Big Sandy 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 Control Section, 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 l977 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 LRD 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 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 Russell Fork, Levisa Fork, Big Sandy River, and the 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. Flood reductions at John W. Flannagan Lake are shown in Plate No. 9-3.

(3) Fiscal year 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) 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 day of the month. For further reporting information refer to ER 500-1-1.

(5) 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 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) Any additional or pertinent reports which are required from higher authority.

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 low flow 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. 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 - Created by current developments or district request.

Daily or more frequent briefing of District Engineer and Chief Engineer during flood or other emergencies contains 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 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
POUND RIVER - FLANNAGAN LAKE BASIN - PERTINENT DATA

Record From	Station	Type Station	Equipment	Method of Obtaining Data	Reporting Criteria
1969	North Fork of Pound Lake, VA	SP	SRG	North Fork of Pound report	Daily.
1963	Clintwood, VA	SP	SRG	NWS Charleston,	Daily.
1984		SP	TBKT and DCP	AFOS, DCP transmission	Data collection interval 30 minutes.
1969	Flannagan Lake	SP	SRG	Flannagan Report	Daily.
1951	Grundy, VA	SP	SRG	NWS Charleston, AFOS	Daily.
1939	Ivel, KY	SP	SRG	Dewey report	0.01 inch collected by 0700.
1981	Pikeville, KY		SRG	AFOS	0.01 inch collected by 0700.
1983	Pikeville, KY	SP	TBKT and DCP	DCP transmission	Data collection interval 30 minutes.
1977	Feds Creek, KY	SP	SRG	Fishtrap extra report	0.01 inch collected by 0700.
1978	Virgie, KY	SP	SRG	NWS Louisville, AFOS	0.01 inch collected by 0700. Data collection interval 60 minutes.
1971	Meta, KY	ORN	SRG	Dewey report.	0.01 inch collected by 0700.
1984		SP	TBKT and DCP	DCP Transmission	Data collection interval 30 minutes.

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

TABLE NO. 5-2 (cont.)

PRECIPITATION STATIONS IN AND NEAR
POUND RIVER - FLANNAGAN LAKE BASIN - PERTINENT DATA

Record From	Station	Type Station	Equipment	Method of Obtaining Data	Reporting Criteria
1988	Pilgrim Knob	SP	TBKT and DCP.	DCP transmission.	Data collection interval 60 minutes.
1986	North Fork of Pound Lake O.F.	SP	TBKT and DCP.	DCP transmission.	Data collection interval 60 minutes.
1986	Pound River below Bold Camp	SP	TBKT and DCP.	DCP transmission.	Data collection interval 30 minutes.
1984	Georges Fork	SP	TBKT and DCP.	DCP transmission.	Data collection interval 30 minutes.
1985	Flannagan Lake	SP	TBKT and DCP.	DCP transmission.	Data collection interval 30 minutes.
1984	Haysi, VA	SP	TBKT and DCP.	DCP transmission.	Data collection interval 30 minutes.
1984	Bartlick, VA	SP	TBKT and DCP.	DCP transmission.	Data collection interval 30 minutes.
1984	Elkhorn City, KY	SP	TBKT and DCP.	DCP transmission.	Data collection interval 30 minutes.
1963	Flat Gap, KY	SP	SRG	North Fork of Pound rept. DCP Transmission	0.5 inch. Data collection interval 60 minutes.
1895	Burkes Garden, Virginia	SP	TBKT and DCP.	DCP transmission.	Data collection interval 60 minutes.
1983	Prestonsburg, KY	SP	SRG	NWS Louisville, AFOS.	0.01 inch collected by 0700.
1933	Paintsville, KY	SP	SRG	Dewey report.	0.01 inch.

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

TABLE NO. 6-1
JOHN W. FLANNAGAN LAKE-POUND RIVER - LEVISA FORK BASIN STREAM GAGING NETWORK

Stream and Station	Zero Gage Elevation (Feet, NGVD)	Drainage Area (Sq. Mi.)	Date Established (Mo./Yr.)	Existing Station Facilities	Method of Obtaining Data
North Fork of Pound River at North Fork Lake, VA	NGVD	17.5	10/60	Hydrologger/DCP	North Fork report, DCP transmission.
North Fork of Pound below North North Fork Lake, VA	1500.00	18.5	10/61	Hydrologger, ADR	North Fork report, DCP transmission.
Pound River above Indian Fork, VA	1535.64	37.7	9/65	ADR/ DCP	North Fork report, DCP transmission.
Pound River below Bold Camp Creek, VA	1527.36	61.2	9/65	Voice DCP	North Fork report, DCP transmission.
Pound River near Georges Fork, VA	1490.39	84.9	10/63	ADR, Voice DCP	Flannagan report, DCP transmission.
Cranenest River report, near Clintwood, VA	1440.31	66.5	10/63	ADR, Voice DCP	Flannagan DCP transmission.
Pound River at Flannagan Lake, VA	NGVD	220	10/62	Hydrologger, DCP	Flannagan report, DCP transmission.

Note: ADR - Analog to Digital Recorder.
DCP - Data Collection Platform. DCP transmits via satellite to Great Lakes and Ohio River Division (LRD) downlink every 4-hrs. LRD Water Control System (WCS) receives from downlink and disseminates hourly to Ohio River Huntington (LRH) WCS. Voice DCPs are equipped to respond to telephone calls with electronically synthesized voice.
Encoder - Shaft encoder.
Wire wt - Wire weight gage.
Bubbler - Bubbler gage. Tape - Electric Tape Gage

TABLE NO. 6-1 (cont.)
JOHN W. FLANNAGAN LAKE
POUND RIVER - LEVISA FORK BASIN STREAM GAGING NETWORK

Stream and Station	Zero Gage Elevation (Feet, NGVD)	Drainage Area (Sq. Mi.)	Date Established (Mo./Yr.)	Existing Station Facilities	Method of Obtaining Data
Pound River below Flannagan Lake, VA	1200.00	221	10/63	Hydrologger, ADR, DCP	Flannagan report, DCP transmission.
Russell Fork near Haysi, VA	1237.45	286	7/26	ADR, Voice DCP	Flannagan report, DCP transmission.
Russell Fork at Bartlick, VA	1165.00	526	10/62	ADR, Voice DCP	Flannagan report, DCP transmission.
Russell Fork at Elkhorn, City, KY	773.00	554	3/57	Voice DCP	Flannagan report, DCP transmission.
Levisa Fork at Pikeville, KY	631.98	392	9/79	Manometer, ADR, Voice DCP	Fishtrap report, DCP transmission.
Levisa Fork at Prestonsburg, KY	588.12	1702	3/60	Manometer, ADR, Voice DCP	Dewey report, DCP transmission.
Levisa Fork at Paintsville, KY	566.84	2144	12/28	ADR, Voice DCP	Dewey report, DCP transmission.

Note: ADR - Analog to Digital Recorder.
DCP - Data Collection Platform. DCP transmits via satellite to Great Lakes and Ohio River Division (LRD) downlink every 4-hrs. LRD Water Control System (WCS) receives from downlink and disseminates hourly to Ohio River Huntington (LRH) WCS. Voice DCPs are equipped to respond to telephone calls with electronically synthesized voice.
Encoder - Shaft encoder.
Wire wt - Wire weight gage.
Bubbler - Bubbler gage.
Tape - Electric tape gage.
* - Included in U.S. Geological Survey Cooperative Water Resources Program.

JOHN W. FLANNAGAN DAM AND RESERVOIR

PERTINENT DATA

LOCATION OF DAM: In Dickenson County, Virginia. On Pound River, a tributary of Russell Fork of Levisa Fork of Big Sandy River; 1.8 miles above the mouth of Pound River and 150.0 miles above the mouth of Big Sandy.

AUTHORITY: Flood Control Act of 28 June 1938, PL 75-761, Federal Water Pollution Control Act, Amendments of 1961 (PL 87-88).

PURPOSES SERVED: Flood reduction, low-flow augmentation, fish and wildlife betterment, recreation and water supply.

DAM: Type-rockfill with central impervious core, maximum height 250', top length 916', top width 32', maximum base width 1,030'.

SPILLWAY: Controlled spillway 0.3 mile south of dam with 6-42'x38' tainter gates. Crest elevation 1410, length of crest 252 net feet, design discharge 246,700 cfs, with surcharge of 9.0' freeboard of 5.0'.

OUTLET WORKS: Intake structure with two 4'-0" x 8'6" water passages controlled by slide gates and discharging into a 16' horseshoe tunnel through the left abutment. Three by pass conduits with 24-inch valves control inlets at invert elevations 1328, 1313 and 1298 for low-flow control.

OTHER STRUCTURES: None.

RELOCATIONS: 21 Miles of secondary roads, 3 highway bridges, 1.8 miles of power lines, 0.3 mile of telephone lines, 1 school and 11 cemeteries with 73 graves.

DRAINAGE AREA ABOVE DAM: 221 Miles square miles. (203.8 sq. mi. net area excluding North Fork of Pound drainage area).

MAXIMUM FLOW OF RECORD AT DAMSITE: 28,800 cfs (January 1957).

RESERVOIR DESIGN FLOOD PEAK FLOW: 70,000 cfs.

RESERVOIR DATA: Streambed elevation at dam: 1,210 feet NGVD

JOHN W. FLANNAGAN DAM AND RESERVOIR

PERTINENT DATA (Cont'd)

Pool	Surface Elevation (Ft above Sea level)	Surface Area (Acres)	Backwater along Main Stream (Miles)	Capacity Ac Ft (Thousands) Net	Capacity Ac Ft (Thousands) Gross	Capacity Inches of runoff Net	Capacity Inches of runoff Gross
Year Round Storage:							
Minimum	1314	310	6.0	12.0	12.0	1.1	1.1
Water Supply	1314	318	6.1	0.4	12.4	0.1	1.1
Water Quality Control	1380	933	11.6	38.6	51.0	3.6	4.7
Seasonal Storage (Summer):							
Low-Flow Augmentation/ Recreation	1396	1145	13.6	16.5	67.5	1.5	6.2
Flood Control Stage*							
Winter	1446	2098	18.5	94.7	145.7	8.7	13.4
Summer	1446	2098	18.5	78.2	145.7	7.2	13.4
Total	1446	2098	18.5	145.7	145.7	13.4	13.4

*At maximum pool level.
+Between elevations 1380 and 1446.
**Between elevations 1396 and 1446.

NET LAND OWNED: Fee 8,273.3 acres; easement-92 acres.

STATUS: All construction work is complete. The dam was placed in operation in December 1993.

COST:		
	Construction	$19,998,400
	Estimated recreation (code 711) funds	443,200
	Expended through 30 Sep 1984	443,200
	Operation and maintenance 30 Sep 1988	11,076,400

U.S. ARMY ENGINEER DISTRICT, HUNTINGTON

CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

BIG SANDY RIVER BASIN
KENTUCKY

PROJECT MANUAL
FOR
WATER CONTROL MANAGEMENT
JOHN W. FLANNAGAN LAKE – POUND RIVER, VIRGINIA

INSTRUCTIONS TO DAMTENDER
JOHN W. FLANNAGAN LAKE

2001

INSTRUCTIONS TO DAMTENDER

JOHN W. FLANNAGAN LAKE – POUND RIVER, VIRGINIA

U.S. ARMY CORPS OF ENGINEERS
HUNTINGTON DISTRICT
JULY 2001

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INSTRUCTIONS TO DAMTENDER

JOHN W. FLANNAGAN LAKE

SECTION I - GENERAL OPERATION INSTRUCTIONS

1-01 GENERAL

The instructions given in this section shall be followed at all times, except when other operations are required by Special Directives issued by the Water Control Section of the Huntington District Office.

a. In order to support downstream aquatic environment maintain an outflow of at least 10 cfs (1.80 feet on the "O" gage) from December through mid-April (DEMIA) or winter and 50 cfs (2.15 feet on the "O" gage) from mid-April through November (MIANO) or summer, including periods of closure for flood control.

b. Instructions contained in Special Directive will apply for a specific operation or for a stated period of time. When the order or specified instructions have been executed, resume operations in accordance with the following general instructions.

1-02 GATE REGULATION TECHNIQUE

a. General. Facilities provided for water control include a concrete gravity spillway with crest at elevation 1410 NGVD, with six 42′ x 38′ tainter gates, with a net crest length of 252 feet, and a 6′ x 4′ sluice gate, located 0.3 miles south of the dam for passing extreme high flows; an intake tower with two rectangular 4′ x 8.5′ conduits controlled by slide-type gates for passing the normal flood flows through the tunnel; and three by-pass conduits for selective withdrawal.

The two slide gates are numbered 1 and 2 with No. 1 being on the left side and No. 2 on the right side facing the downstream from the intake structure. The six spillway crest gates are numbered consecutively, beginning with No. 1 nearest the left abutment, facing downstream in Cane Branch. The three high level, by-pass valves are designated H1, H2 and H3. H1 refers to the valve with the inlet elevation at 1328.0 feet, NGVD; H2 to the valve with inlet elevation at 1313.0 feet, NGVD; and H3 to the valve with inlet elevation at 1298.0 feet, NGVD. The by-pass valves shall never be opened at the same time as either the slide gates and/or the spillway tainter gates. The Cane Branch Sluice Gate shall be designated as CBS and shall be maintained in either the fully opened or completely closed position depending on the pool elevation.

b. Slide Gates. **Plate 1-1** is a tabulation of the approximate stages which will be reached on the outflow "O" gage under various conditions of reservoir level and gate openings. Using these tables as a guide, the approximate gate openings required to maintain a

designated control stage at the “O” gage can be determined. When the flow at the “O” gage has stabilized, after making the gate settings as determined by the tables, only a minor adjustment of the gates should be necessary to maintain the designated control stage. Either slide gate No. 1 or No. 2 shall be operated until fully opened after which the other gate shall be used for any additional operation. In order to equalize wear, the slide gates shall be alternated for routine operations. The gates shall be operated at such a rate that the stage on the outflow “O” gage does not change more than one foot per hour. The slide gates shall be used for all flood control operation below reservoir pool elevation 1410.0 feet NGVD. Above elevation 1410.0 feet NGVD, the slide gates shall continue to be used until fully opened, after which the crest gates will be used for any additional operation. **Plate 7-4** (see John W. Flannagan Water Control Manual) is a series of curves for partial gate openings for one gate at rising pool elevations.

c. High-level, By-pass Valves. The three, 24-inch, by-pass valves are to be used to release water from various zones of the pool. Before water quality storage was added, these valves could be used to maintain various down stream water temperatures. Since the seasonal pool has been increased from elevation 1350.0 to 1396.0 NGVD, these temperatures can no longer be maintained as provided in the original design. In order to utilize the valves, they shall be used to maintain minimum required releases, less than elevation 1202.3 feet NGVD at the outflow “O” gage. To provide equalized wear on the by-pass valves and their operating equipment, they shall be alternated in their use for routine operation. **Plate 1-2** is a tabulation of the various valve openings based on the pool elevation and the required downstream stage at the “O” gage. **Plate 7-5** (see WCM) is a three sheet series of curves for partial openings of the three High - Level - Valves with rising pool elevations.

d. Spillway Crest Gates. In order to prevent collection of rain water and snow or ice between the gates and the lip of the spillway, when the reservoir level is below elevation 1400.0 feet NGVD, keep all crest gates open approximately one foot. When the reservoir level is above elevation 1400.0 feet NGVD, all spillway crest gates shall be maintained in the fully closed position, except when testing, operating in accordance with special directives or with the “Damtender’s Emergency Operation Schedule.” Whenever crest gate operation is necessary, all six gates shall be operated so as to maintain equal openings on all gates insofar as possible. Gates are to be opened or closed in such a manner as to prevent the stage at the outflow gage from changing more than 1.0 foot per hour unless directed by the Water Control Section or under emergency procedure. **Plate 7-6** (see WCM) is a series of curves for the operation of the spillway crest gates with various openings at rising pool elevations. **Plate 7-7** (see WCM) is a family of curves for the required gate openings for various inflows and outflow at rising pool elevations.

e. Cane Branch Sluice Gate. When the reservoir elevation is below 1408.0 feet NGVD, Cane Branch Sluice Gate shall be fully opened. Above this elevation, the sluice gate shall be closed and remain closed until the pool recedes below elevation 1408.0 feet NGVD.

1-03 ROUTINE OPERATION

Curves shown on **Plates 1-3** and **1-4** (at the end of this section) shall be used as an aid for maintaining the water quality control and seasonal pool elevations of 1380.0 and 1396.0 feet NGVD, respectively. After rainfall or when there is a general stream rise, use the operation charts and schedules described in the following paragraphs. Special instructions will be issued for raising the pool to seasonal level in the spring and for lowering the pool to water quality control level in the fall. Day to day operation instructions will be issued in regard to water quality control releases when necessary.

Routine regulation under normal conditions (not under Special Directive) may be determined by the Damtender (Resource Manager); however, releases shall not exceed 2025 cfs (5.8 feet on the "O" gage) MIANO or DEMIA unless SPECIFICALLY DIRECTED by the Water Control Section. After rainfall or when there is a general stream rise, guidance presented in the following paragraphs shall be used to maintain proper project conditions.

1-04 REGULATION FOR DOWNSTREAM CONTROL

Downstream control regulation of John W. Flannagan for the Ohio River at Ashland, KY, is based on forecasts by the National Weather Service based on stage forecasts and water travel time from the project to the Ohio River. Accordingly the Water Control Section will issue Special Directives for regulation of Flannagan Lake for Ohio River control. All inflow is stored, subject to minimum flow requirements, from 48 hours in advance of the predicted time of reaching a forecast crest stage of 53 feet on the Ohio River at Ashland, KY. Flannagan Lake is also operated integrally with Fishtrap, Dewey, North Fork of Pound, Paintsville, and Yatesville Lakes when they are operated for regulation of Levisa Fork, Big Sandy River, and the Ohio River. Discharges from Flannagan Lake are to be coordinated with all other Big Sandy Basin projects to prevent adding to flow crests on the Levisa Fork, Big Sandy and Ohio Rivers. Control stages on the Levisa Fork at Pikeville, Prestonsburg, and Paintsville are listed in **Table 1-1**, next page. Control stage at the Louisa (Fullers) gage is 45.0 feet, and at the Ashland gage is 53.0 feet at all times.

Table 1-1

Control Stages And Flows At Key River Stations

Station	River	MIANO		DEMIA		Travel Time from dam (hrs)
		Stage (feet)	Flow (cfs)	Stage (feet)	Flow (cfs)	
J.W. Flannagan Outflow gage	Pound River	7.8	4,000	7.8	4,000	-
Bartlick, VA	Russell Fork	14.0	8,955	14.0	8,955	0.2
Elkhorn City	Russell Fork	12.5	10,990	12.5	10,990	6.3
Pikeville	Levisa Fork	23.0	13,859	31.6	26,980	15.8
Prestonsburg	Levisa Fork	21.0	14,800	33.0	28,220	31.8
Paintsville	Levisa Fork	20.0	15,100	29.0	24,800	40.0
Louisa (Fullers)	Big Sandy River	45.0	-	45.0	-	57.0
Ashland	Ohio River	53.0	-	53.0	-	72.0 (*)
(*) Operational time prior to crest stage in excess of 53.0 feet						

1-05 REGULATION FOR POUND RIVER AND RUSSELL FORK CONTROL

During reservoir regulation activity, light to medium rainfall, and emptying of the reservoir, the “O” gage can be held at stage 7.8 feet without causing any appreciable damage along Pound River downstream from the dam, providing there is no backwater from Russell Fork. However, if the outflow were held at stage 7.8 feet when there was significant rain all over the uncontrolled drainage area above Bartlick U.S.G.S. gage, or with Russell Fork backwater, the combined flows could cause flooding along Russell Fork or possible backwater damage on Pound River below the dam. In order to minimize such flooding, the outflow from the dam will be reduced sufficiently to maintain a control stage of 14.0 feet on the Bartlick gage and 12.5 feet on the Elkhorn City gage. The previously listed maximum allowable discharge of 4000 cfs MIANO or DEMIA can only be maintained during light to medium rainfall when authorized by a SPECIAL DIRECTIVE from the Water Control Section.

As mentioned above the maximum outflow releases shall not exceed 2025 cfs (5.8 feet on the “O” gage) MIANO or DEMIA unless SPECIFICALLY DIRECTED by the Water Control Section. Curves shown on **Plate 1-3** and **1-4** shall be used as an aid for determining the permissible stage on the “O” gage to maintain a control stage of 14.0 feet on the Bartlick U.S.G.S. gage.

When conditions are such that either the curves for maintaining the pool (**Plates 1-3** or **1-4**) or downstream control stages at Bartlick (**Plates 1-5** and **1-6**) may apply, use the schedule which results in the lowest stage at the “O” gage. Special directives will always

take precedence over these schedules. When the reservoir is above elevation 1400.0 feet NGVD, the "Damtender's Emergency Operation Schedule" (**Plate 1-7**) shall be consulted and when it indicates a higher outflow, it will take precedence over all other operation charts and schedules, including any special directives.

1-06 OPERATION DURING COMMUNICATION FAILURE

During flood periods, every effort shall be made to contact personnel of the Water Resources Engineering Branch. If both radio and telephone facilities fail, solicit the cooperation of 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 Control Section cannot be contacted.

a. If a Special Directive was in effect prior to 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 the Water Control Section, or

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

c. Whenever any of the foregoing conditions occur, follow the operating instructions contained in sub-sections 1-03, 1-04, 1-05 or 1-07, whichever is applicable.

1-07 EMERGENCY OPERATION

a. General. The rate of rise curves are on **Plate 1-7**, "Emergency Operation Schedule," shall be used to operate the reservoir in cases where the rate of rise in the lake level indicate that the available storage of the lake may be insufficient to completely control a given flood. **Plate 1-7**, mentioned above, will be used by both the Water Control Section and by the project personnel in the rare event that contact with the Water Control Section has been lost for three-hours or more, and a gate movement is required. Project personnel are hereby authorized in this emergency situation to consult the rate of rise curves and make any required gate movements, without special directive from the Water Control Section.

b. Rate of Rise Curves. The "Damtender's Emergency Operation Schedule," **Plate 1-7**, provides for increases in reservoir outflow when the rate of rise in pool level indicates that the available storage capacity is insufficient to completely control the flood.

Whenever the reservoir level is above elevation 1400.0 feet NGVD, and rising, a constant check shall be made on the rate of rise in the reservoir level. Read the “Lake” gage every hour, on the hour and compute the rise in pool elevation during the preceding hour.

Enter the “Damtender’s Emergency Operation Schedule” with the current pool elevation and the computed rate of rise for the previous hour to determine the required gate settings for the next hour. If the current pool elevation is between elevation 1400.0 and 1410.0 feet NGVD, determine the slide gate position and enter the “Slide Gate Position Curve” to determine the amount of slide gate opening. If the current pool elevation is between elevation 1410.0 feet NGVD and 1446.0 feet NGVD, and the rate of rise curves indicate an opening of all crest gates (after both slide gates are fully open) the amount of opening can be read directly from the bottom scale. Should the rate of rise approach a value which indicates a gate opening on the “Damtender’s Emergency Operation Schedule,” contact the District Office immediately and each hour thereafter for instructions.

In the event of failure of normal means of communication, continuous and vigorous efforts shall be made to contact the District Office as described in paragraph 1-06. The damtender is authorized to operate the reservoir in accordance with the Emergency Operation Schedule when there is a delay of three hours in establishing contact with the District Office from the time that the curves indicate gate openings greater than those being maintained in accordance with any other instructions. In such an event, follow the emergency procedures described below.

(1) Emergency operation shall be based on the last readings taken and no attempt shall be made to make up for missed operation steps. The required gate operation shall be executed as soon as it has been determined from the emergency schedule. Crest gates shall not be opened until both slide gates have been fully opened.

(2) One hour after the previous reading, the “Lake gage” shall be read again and the required operation determined for the succeeding hour.

(3) If the pool level crests below elevation 1446.0 feet NGVD, gradually close the crest gates and then the slide gates as may be necessary to maintain the reservoir level at the maximum height attained. If the pool crests at or above elevation 1446.0 feet NGVD, maintain the current gate settings until the pool recedes to elevation 1446.0 feet NGVD. After elevation 1446.0 feet NGVD is reached, gradually close the crest gates and then the slide gates as may be necessary to maintain the reservoir level at that elevation. Hold the reservoir level at elevation 1446.0 feet NGVD or at the maximum level attained, if below elevation 1446.0 feet NGVD, until ordered by special directive to begin drawdown operation.

(4) If the reservoir level is at or above elevation 1446.0 feet NGVD and a second rise occurs, the instructions outlined in the following paragraph, “Induced Surcharge Curve Operation,” shall be followed.

c. Induced Surcharge Curve Operation. The “Curve for Induced Surcharge Operation” which is shown as the upper limiting curve of the “Damtender’s Emergency Operation Schedule”, **Plate 1-7** provides for utilizing some 7 feet of additional storage above elevation 1446.0 feet NGVD when required to regulate outflow to safe rates of increase during emergencies. Factors considered in developing the induced surcharge envelope curve were as follows:

(1) Non-damaging flood control release of 4,000 cfs.

(2) Limiting induced surcharge level to 7 feet.

(3) Providing a minimum of two feet of freeboard below the top of the spillway gates at all times.

During periods when the reservoir level is at or above elevation 1446.0 feet NGVD and a second rise occurs, the instructions outlined below shall be followed.

(1) The operation required by the “Curve for Induced Surcharge Operation” shall be executed without delay and as often as necessary to conform to the rule curve. The District Office shall be contacted immediately and each hour thereafter, for consultation relative to operations undertaken and anticipated.

(2) When the slide gate position is less than 11.5, endeavor to hold the reservoir level at elevation 1446.0 feet NGVD by manipulating the slide gates. If the pool continues to rise after gate position 11.5 is reached, continue to raise the slide gates until fully open then follow with the crest gates in conformance with the “Curve for Induced Surcharge Operation.”

(3) When the slide gate position is greater than 11.5 or the crest gates are open, maintain the current gate settings. If the pool rises to the elevation corresponding to the current gate setting on the “Curve for Induced Surcharge Operation” then increase the opening of the gates in conformance with the rule curve.

(4) When the reservoir level ceases to rise under the conditions described in paragraph (2) or (3) above, maintain the current gate setting until the reservoir level recedes to elevation 1446.0 feet NGVD, then gradually close the crest gates and then the slide gates as may be necessary to maintain the pool at elevation 1446.0 feet NGVD until ordered by special directive to begin drawdown operation.

1-08 PUBLIC NOTIFICATION OF UNUSUAL RELEASES

Operation of reservoir projects 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 Flannagan Damtender must keep informed of all developments along Pound River below the dam, and downstream along Russell Fork between the mouth of Pound River and Elkhorn City, Kentucky. Formal arrangements must be made for public notification of water release operations, which are of an unusual nature or are substantially different from the established release pattern whenever such releases might be likely to cause damage to equipment or facilities located downstream.

The objective of this program is to afford those likely to be affected, an opportunity to take appropriate remedial measures in advance of the arrival of the releases so as to prevent damage to or loss of their property. Confirmation of suitable arrangements to accomplish the objective will be made to the Huntington District office by letter reports.

JOHN W. FLANNAGAN RESERVOIR

STAGES AT "O" GAGE AND CORRESPONDING SLIDE GATE SETTING

FOR ONE GATE

Reservoir Pool Elevation - Feet above NGVD

"O" Gage Stage-feet	1310	1320	1330	1340	1350	1360	1370	1380
1202.00	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
1202.20	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2
1202.40	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4
1202.60	0.8	0.7	0.7	0.6	0.6	0.6	0.6	0.6
1202.80	1.0	1.0	0.9	0.9	0.8	0.8	0.8	0.7
1203.00	1.3	1.2	1.2	1.1	1.1	1.0	1.0	0.9
1203.50	2.2	2.1	2.0	1.9	1.8	1.7	1.6	1.6
1204.00	3.4	3.2	3.0	2.9	2.8	2.7	2.6	2.5
1204.50	4.8	4.5	4.3	4.1	3.9	3.7	3.6	3.5
1205.00	6.4	6.1	5.8	5.5	5.3	5.1	4.9	4.7
1205.50	8.4	8.0	7.6	7.3	7.0	6.7	6.5	6.3
1206.00	-	-	-	8.4	8.2	8.1	8.0	7.8
1206.50	-	-	-	-	-	-	-	-
1207.00	-	-	-	-	-	-	-	-

Reservoir Pool Elevation - Feet above NGVD

"O" Gage Stage-feet	1390	1400	1410	1420	1430	1440	1450	
1202.00	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
1202.20	0.2	0.2	0.2	0.2	0.2	0.2	0.2	
1202.40	0.4	0.4	0.3	0.3	0.3	0.3	0.3	
1202.60	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
1202.80	0.7	0.7	0.7	0.7	0.7	0.6	0.6	
1203.00	0.9	0.9	0.9	0.8	0.8	0.8	0.8	
1203.50	1.5	1.5	1.5	1.4	1.4	1.4	1.3	
1204.00	2.4	2.3	2.3	2.2	2.2	2.1	2.1	
1204.50	3.4	3.3	3.2	3.1	3.0	2.9	2.9	
1205.00	4.6	4.4	4.3	4.2	4.1	4.0	3.9	
1205.50	6.1	5.9	5.7	5.5	5.4	5.3	5.2	
1206.00	7.6	7.4	7.2	7.0	6.8	6.7	6.5	
1206.50	8.4	8.3	8.2	8.2	8.1	8.0	7.9	
1207.00	-	-	-	-	-	-	8.5	

PLATE NO. 1-1

JOHN W. FLANNAGAN RESERVOIR

STAGES AT "O" GAGE AND CORRESPONDING SLIDE GATE SETTING

ONE GATE FULLY OPEN PLUS OPENING FOR OTHER GATE

Reservoir Pool Elevation - Feet above NGVD

"O" Gage Stage-feet	1310	2320	1330	1340	1350	1360	1370	1380
1206.00	1.5	0.7	0.1	-	-	-	-	-
1206.50	4.1	3.2	2.5	1.9	1.3	0.9	0.5	0.1
1207.00	6.6	5.6	4.8	4.1	3.5	3.0	2.5	2.1
1207.45	8.3	7.8	6.9	6.2	5.5	4.9	4.4	3.9

Reservoir Pool Elevation - Feet above NGVD

"O" Gage Stage-feet	1390	1400	1410	1420	1430	1440	1450	
1206.00	-	-	-	-	-	-	-	
1206.50	-	-	-	-	-	-	-	
1207.00	1.7	1.3	1.0	0.7	0.4	0.1	-	
1207.45	3.5	3.0	2.6	2.3	2.0	1.6	1.4	

JOHN W. FLANNAGAN RESERVOIR
STAGES AT "O" GAGE AND CORRESPONDINGTTING
HIGH-LEVEL VALVE SETTINGS

Valve No. H-1
Reservoir Pool Elevation - Feet above NGVD

"O" Gage Stage-feet	1330	1340	1350	1360	1370	1380	1390	1400
1201.4	01	01	01	01	01	01	01	01
1201.5	02	02	02	01	01	01	01	01
1201.6	02	02	02	02	02	02	02	02
1201.7	04	04	04	04	04	03	03	03
1201.8	06	06	06	06	05	05	05	05
1201.9	14	14	13	12	11	11	11	10
1202.0	23	22	21	20	19	18	18	18
1202.1	-	29	27	26	26	25	24	23
1202.2	-	37	35	34	33	32	31	30
1202.3	-	49	46	44	42	40	39	38
1202.4	-	84	69	63	58	54	51	49

Valve No. H-2
Reservoir Pool Elevation - Feet above NGVD

"O" Gage Stage-feet	1315	1320	1330	1340	1350	1360	1370	1380
1201.4	01	01	01	01	01	01	01	01
1201.5	02	02	02	01	01	01	01	01
1201.6	03	03	02	02	02	02	02	02
1201.7	06	05	05	04	04	04	04	04
1201.8	09	08	07	06	06	06	06	05
1201.9	17	15	15	14	13	13	12	12
1202.0	26	25	24	23	22	21	20	20
1202.1	-	33	32	30	29	27	26	25
1202.2	-	43	41	38	36	35	34	33
1202.3	-	58	52	49	46	44	42	41
1202.4	-	-	90	73	65	59	55	52

Valve No. H-3
Reservoir Pool Elevation - Feet above NGVD

"O" Gage Stage-feet	1314	1320	1330	1340	1350	1360	1370	1380
1201.4	01	01	01	01	01	01	01	01
1201.5	02	02	02	02	02	01	01	01
1201.6	03	03	02	02	02	02	02	02
1201.7	06	05	05	04	04	04	04	04
1201.8	08	08	07	07	06	06	06	06
1201.9	18	16	15	14	13	13	12	12
1202.0	26	25	24	23	22	21	20	19
1202.1	35	33	31	30	28	27	26	25
1202.2	45	42	40	38	36	34	33	32
1202.3	60	56	52	48	46	44	42	40
1202.4	-	-	83	69	62	58	54	51

PLATE NO. 1-2

OUTFLOW GAGE ELEVATION IN FEET ABOVE NGVD

1200 1201 1202 1203 1204 1205 1206 1207 1208 1209 1210

POOL ELEVATION IN FEET ABOVE NGVD

1387 1386 1385 1384 1383 1382 1381 1380 1379

MAXIMUM ELEVATION 1207.45

MINIMUM ELEVATION 1201.80

CURVE NO. 2

CURVE NO. 1

WATER QUALITY CONTROL POOL - 1380

INSTRUCTIONS

1. AT 0700, ENTER CURVE NO. 1 WITH CURRENT POOL ELEVATION TO DETERMINE REQUIRED ELEVATION TO BE MAINTAINED AT OUTFLOW GAGE.

2. AT 1600, ENTER CURVE NO. 2 WITH CURRENT POOL ELEVATION TO DETERMINE REQUIRED ELEVATION TO BE MAINTAINED AT OUTFLOW GAGE.

3. ADJUST GATES TO MAINTAIN REQUIRED ELEVATION AT OUTFLOW GAGE.

NOTE

ALL OTHER OPERATION CHARTS AND SCHEDULES TAKE PRECEDENCE OVER THIS CURVE.

POUND RIVER
VIRGINIA

JOHN W. FLANNAGAN
RESERVOIR PROJECT

CURVES TO MAINTAIN WATER QUALITY CONTROL POOL ELEVATION AT 1380

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V. REDRAWN JULY 2001

PLATE NO. 1-3

OUTFLOW GAGE ELEVATION IN FEET ABOVE NGVD

1200 1201 1202 1203 1204 1205 1206 1207 1208 1209 1210

POOL ELEVATION IN FEET ABOVE NGVD

1403 1402 1401 1400 1399 1398 1397 1396 1395

MAXIMUM ELEVATION 1207.45

MINIMUM ELEVATION 1202.10

CURVE NO. 2

CURVE NO. 1

SEASONAL POOL ELEVATION - 1396

INSTRUCTIONS

1. AT 0700, ENTER CURVE NO. 1 WITH CURRENT POOL ELEVATION TO DETERMINE REQUIRED ELEVATION TO BE MAINTAINED AT OUTFLOW GAGE.

2. AT 1600, ENTER CURVE NO. 2 WITH CURRENT POOL ELEVATION TO DETERMINE REQUIRED ELEVATION TO BE MAINTAINED AT OUTFLOW GAGE.

3. ADJUST GATES TO MAINTAIN REQUIRED ELEVATION AT OUTFLOW GAGE.

NOTE

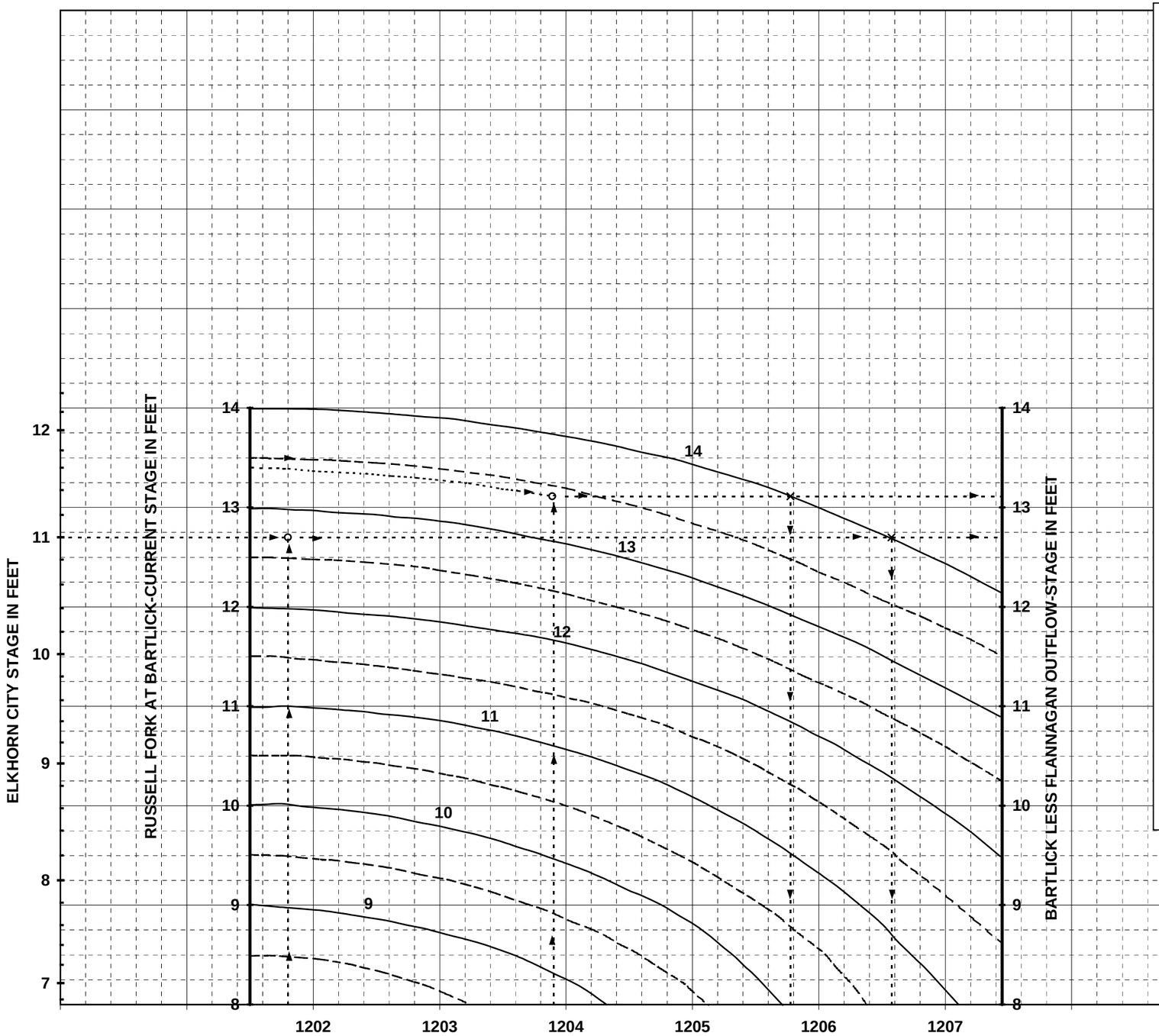
ALL OTHER OPERATION CHARTS AND SCHEDULES TAKE PRECEDENCE OVER THIS CURVE.

POUND RIVER
VIRGINIA

JOHN W. FLANNAGAN
RESERVOIR PROJECT

CURVES TO MAINTAIN SEASONAL POOL ELEVATION AT 1396

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V. REDRAWN JULY 2001



NOTES

WHEN RUSSELL FORK AT HAYSI AND BARTLICK STAGES ARE RISING USE PLATE 1-6.
WHEN THE BARTLICK LESS FLANNAGAN OUTFLOW STAGE IS BELOW 12.17 FEET AND FALLING. THE ALLOWABLE OUTFLOW GAGE ELEVATION IS 1207.45 FEET.
MINIMUM ALLOWABLE OUTFLOW ELEVATIONS.
1201.8 1 DECEMBER THROUGH 31 MARCH.
1202.1 1 APRIL THROUGH 30 NOVEMBER.

INSTRUCTIONS

1. **ENTER CHART ON LEFT SIDE WITH CURRENT BARTLICK STAGE.**
2. **WHEN CURRENT ELKHORN CITY STAGE GIVES A HIGHER EQUIVALENT BARTLICK STAGE USE THIS HIGHER STAGE.**
3. **FOLLOW THE APPROPRIATE CURVE TO CURRENT OUTFLOW GAGE READING.**
4. **READ BARTLICK LESS FLANNAGAN OUTFLOW STAGE ON RIGHT HAND SCALE.**
5. **THE MAXIMUM ALLOWABLE OUTFLOW GAGE ELEVATION IS DETERMINED FROM THE 14.0 FOOT BARTLICK STAGE CURVE AND THE STAGE AS FOUND IN STEP 4.**

EXAMPLE #1

BARTLICK STAGE - 13.40 FEET.
ELKHORN CITY STAGE - 11.25 FEET.
OUTFLOW GAGE ELEVATION - 1203.90 FEET.
FIND:
BARTLICK LESS FLANNAGAN OUTFLOW STAGE. - 13.11 FEET.
ALLOWABLE OUTFLOW GAGE ELEVATION - 1205.78 FEET.

EXAMPLE #2

BARTLICK STAGE - 12.50 FEET.
ELKHORN CITY - 11.00 FEET.
OUTFLOW GAGE ELEVATION - 1201.80 FEET.
USING EQUIVALENT BARTLICK STAGE - 12.70 FEET.
FIND:
BARTLICK LESS FLANNAGAN OUTFLOW STAGE - 12.69 FEET.
ALLOWABLE OUTFLOW GAGE ELEVATION - 1206.58 FEET.

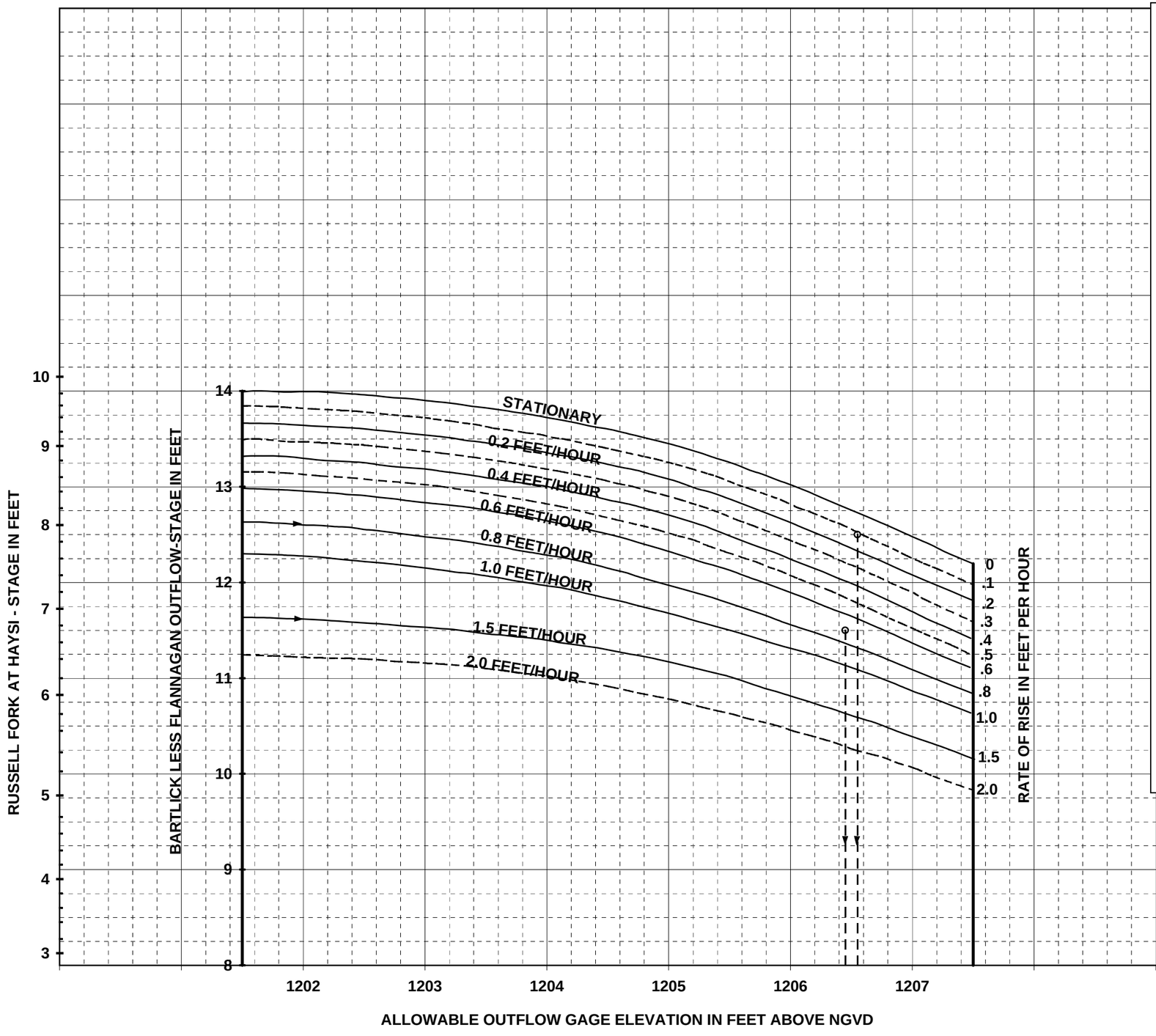
POUND RIVER
VIRGINIA

JOHN W. FLANNAGAN RESERVOIR PROJECT

MAXIMUM ALLOWABLE OUTFLOW RUSSELL FORK AT BARTLICK STAGE FALLING

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V. REDRAWN JULY 2001

PLATE NO. 1-5



NOTES

WHEN RUSSELL FORK AT HAYSI AND BARTLICK STAGES ARE FALLING USE PLATE 1-5.

WHEN USING THIS CHART TO MAINTAIN 14.0 FEET ON THE BARTLICK GAGE, HOURLY READINGS ARE REQUIRED.

MINIMUM ALLOWABLE OUTFLOW ELEVATIONS

1201.8 1 DECEMBER THROUGH 31 MARCH.

1202.1 1 APRIL THROUGH 30 NOVEMBER.

INSTRUCTIONS

1. **ENTER CHART ON LEFT SIDE WITH BARTLICK LESS FLANNAGAN OUTFLOW STAGE FROM PLATE 1-5.**
2. **WHEN RUSSELL FORK AT HAYSI STAGE GIVES A HIGHER EQUIVALENT STAGE, USE THIS HIGHER STAGE.**
3. **PROCEED HORIZONTALLY TO THE APPROPRIATE RATE OF RISE PER HOUR.**
4. **READ DIRECTLY BELOW THIS POINT THE MAXIMUM ALLOWABLE OUTFLOW GAGE ELEVATION FOR THE NEXT HOUR.**

EXAMPLE #1

BARTLICK LESS FLANNAGAN OUTFLOW PLATE 1-5) - 11.50 FEET.
RUSSELL FORK AT HAYSI - 6.60 FEET.
RATE OF RISE (BARTLICK LESS FLANNAGAN OUTFLOW) -0.70 FEET PER HOUR.
FIND:
ALLOWABLE OUTFLOW GAGE ELEVATION - 1206.45 FEET.

EXAMPLE #2

BARTLICK LESS FLANNAGAN OUTFLOW PLATE I-5) -12.25 FEET.
RUSSELL FORK AT HAYSI - 7.90 FEET.
RATE OF RISE (BARTLICK LESS FLANNAGAN OUTFLOW) -0.10 FEET PER HOUR.
USING EQUIVALENT STAGE - 12.50 FEET.
FIND:
ALLOWABLE OUTFLOW GAGE ELEVATION - 1206.55 FEET.

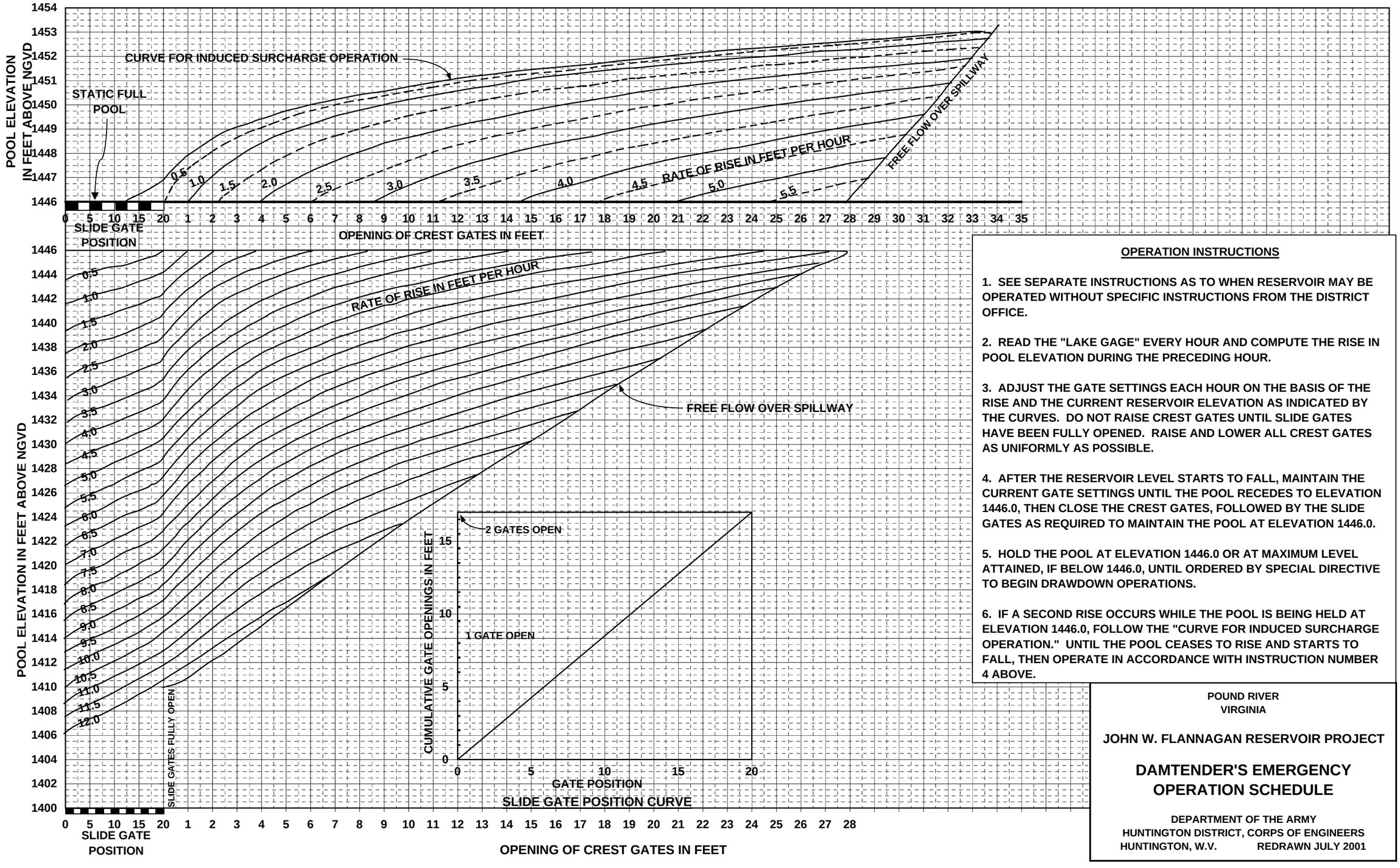
POUND RIVER
VIRGINIA

JOHN W. FLANNAGAN RESERVOIR PROJECT

MAXIMUM ALLOWABLE OUTFLOW
RUSSELL FORK AT BARTLICK
STAGE RISING

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V. REDRAWN JULY 2001

PLATE NO. 1-6



OPERATION INSTRUCTIONS

1. SEE SEPARATE INSTRUCTIONS AS TO WHEN RESERVOIR MAY BE OPERATED WITHOUT SPECIFIC INSTRUCTIONS FROM THE DISTRICT OFFICE.

2. READ THE "LAKE GAGE" EVERY HOUR AND COMPUTE THE RISE IN POOL ELEVATION DURING THE PRECEDING HOUR.

3. ADJUST THE GATE SETTINGS EACH HOUR ON THE BASIS OF THE RISE AND THE CURRENT RESERVOIR ELEVATION AS INDICATED BY THE CURVES. DO NOT RAISE CREST GATES UNTIL SLIDE GATES HAVE BEEN FULLY OPENED. RAISE AND LOWER ALL CREST GATES AS UNIFORMLY AS POSSIBLE.

4. AFTER THE RESERVOIR LEVEL STARTS TO FALL, MAINTAIN THE CURRENT GATE SETTINGS UNTIL THE POOL RECEDES TO ELEVATION 1446.0, THEN CLOSE THE CREST GATES, FOLLOWED BY THE SLIDE GATES AS REQUIRED TO MAINTAIN THE POOL AT ELEVATION 1446.0.

5. HOLD THE POOL AT ELEVATION 1446.0 OR AT MAXIMUM LEVEL ATTAINED, IF BELOW 1446.0, UNTIL ORDERED BY SPECIAL DIRECTIVE TO BEGIN DRAWDOWN OPERATIONS.

6. IF A SECOND RISE OCCURS WHILE THE POOL IS BEING HELD AT ELEVATION 1446.0, FOLLOW THE "CURVE FOR INDUCED SURCHARGE OPERATION." UNTIL THE POOL CEASES TO RISE AND STARTS TO FALL, THEN OPERATE IN ACCORDANCE WITH INSTRUCTION NUMBER 4 ABOVE.

POUND RIVER
VIRGINIA

JOHN W. FLANNAGAN RESERVOIR PROJECT

DAMTENDER'S EMERGENCY OPERATION SCHEDULE

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V. REDRAWN JULY 2001

PLATE NO. 1-7

SECTION II - COLLECTION OF HYDROMETEOROLOGIC DATA

2-01 PRECIPITATION AT JOHN W. FLANNAGAN 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 0700 hours or 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 to be considered as superseding observation instructions received from the National Weather Service.

d. Extra and Special Readings. Take special readings of the precipitation gage when requested by Water Resources Engineering Branch or 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. Data collection platforms (DCPs) and tipping bucket rain gages are installed at seven precipitation station locations in or near the drainage area, see **Table 2-1**, next page. The platforms collect, store, and transmit the precipitation data via the Geostationary Operational Environmental Satellite to the LRD downlink in Cincinnati, Ohio.

LRD Water Control System retrieves the data and automatically transmits it hourly to the District Water Control System, located in Water Resources Engineering Branch, for use in water control management and dissemination.

This data is stored in a database and can be accessed by project personnel. Data from one or more stations, for the most recent readings, can be obtained by use of the portable computer terminal assigned to the project. After signing on the Water Control System,

the command "SCAN" will create a list of the most recent readings at all stations pertinent to the project.

Several platforms are equipped with voice modems. This allows one to obtain the most recent data value by simply calling the station and listening to a synthesized voice, see **Table 2-1** below.

Reporting information on satellite precipitation stations in and near the Big Sandy River Basin is listed on the below.

Table 2-1

Precipitation Platform Communication Information

Location/ Gage	Equip	Voice	Channel No.	Update Interval	Data Transmitted	Frequency of Transmission
Flannagan	1/			30 min	P	4 Hours
Dewey				60 min	P	4 hours
Fishtrap				60 min	P, S	4 Hours
Paintsville		v		30 min	P	4 Hours
Yatesville				60 min	P	4 Hours
Meta	1/			30 min	P	4 Hours
Fullers		v		60 min	P	4 Hours

1/ Precipitation equipment same at all platform reported stations: Tipping-bucket gage and platform.
P Precipitation in inches
E Elevation in feet NGVD
S Stream stage in feet above gage zero
T Temperature in degrees Fahrenheit
V "Voice platform answers telephone query with synthesized voice in addition to transmitting via satellite

f. Snow Depth and Moisture Content. During the winter, make regular measurement of snowfall and snow depth about 0700 or 0730 hours daily. Measurements of the water content of the snow on the ground are required 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. 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(l) nor (2) requires more frequent measurements.

(4) By special request from the Water Resources Engineering Branch, Water Control Section.

Instructions for the preparation and transmission of reports pertaining to snowfall, snow depth, and moisture content of snow cover are contained in Section IV.

2-02 PRECIPITATION AT O.R.N. STATIONS

a. O.R.N. Stations. The Ohio River Network includes precipitation stations and river stage stations operated by the National Weather Service in cooperation with the Corps Of Engineers. All of the stations located in or near Pound River Basin are satellite platforms that report to the Huntington District Water Information network. The damtender also reports precipitation information to the Huntington District Office in accordance with instructions contained in Section IV. These stations and their code symbols are listed on **Table 5-2** (see WCM).

b. Reporting Criteria. The Elkhorn City station makes special river stage reports in addition to precipitation while the other 12 stations report only precipitation. All of the platform stations make an electronic report downlink CELRD. The CELRD water control system (WCS) receives and disseminates hourly to the data base of District Water Control System. The Elkhorn City station also reports river stages at the request of the National Weather Service. When the Flannagan Dam gage readings are being made in accordance with schedules C or D of the “Schedule for Reading Gages”, **Plate 3-1**, they are transmitted to the system.

c. Method of reporting. Satellite Platform stations make their reports electronically every four hours to downlink CELRD. CELRD in turn transmits hourly to the district water control system, as shown on **Table 5-2** (see WCM).

2-03 EVAPORATION AT JOHN W. FLANNAGAN RESERVOIR

Evaporation observations for Flannagan Lake will be made and reports submitted as prescribed by the National Weather Service.

2-04 WATER TEMPERATURE AT JOHN W. FLANNAGAN RESERVOIR

The water temperature profile and other parameters are recorded each week during the summer season as part of the water quality-sampling program of the Water Quality Section.

SECTION III - COLLECTION OF STREAMFLOW DATA

3-01 GENERAL

River and reservoir stage data will be obtained by direct observation of the gages in the vicinity of the dam site and by telephonic reports from the surrounding telemark stations. Obtain lake and outflow gage readings by telephoning the Hydrologger at each station and recording the value in the logbook. The zero of the lake gage is based on NGVD, and lake readings are read direct as elevation when recording. The outflow gage is read in stage. The necessary frequency for reading the gages at the project 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 FLANNAGAN LAKE

a. Gage Listing. Information about gages of importance to operation of the project appears in **Table 3-1**, page 3-3.

b. Reading and Recording Gage Heights. All gage readings must be listed 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 in feet above NGVD, but record the gages in feet above gage datum, or zero of the gage. Gage datums are listed in **Table 3-1**, page 3-3.

3-03 TELEPHONIC GAGES

In order to facilitate collection of stage information, a data collection platform was installed at the lake station to transmit lake levels to LRD downlink via satellite for dissemination to LRH Water Resources Engineering Branch. A Hydrologger was installed at the outflow station and one was later installed at the lake station to allow personal or computer interrogation for stage information by telephone line. To obtain reports from a Hydrologger, call the station telephone number. After a few seconds of high-pitched tone, the Hydrologger will repeat by synthesized voice the unit identification, the time and current reading of the gage. Elevation and stage are called “level”. The message ends with a short pause and notification to “Enter command” which is to be ignored. One should note that the time given by the Hydrologger is Greenwich Mean Time (GMT). To convert to Eastern Daylight or Eastern Standard Time, subtract four or five hours, respectively. When interrogated by computer, a Hydrologger will give any portion or all of the stored readings specified.

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 telephonic 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 lake and outflow gages appear in **Table 3-2**, page 3-4.

3-04 DATA COLLECTION

Lake and outflow readings are taken from the respective readouts in the project office. The readings may be obtained by telephoning the voice platform at the lake station and the Hydrologger at the outflow or by visiting the stations if question arises. Haysi, Bartlick, Elkhorn City, Pikeville, Prestonsburg, Paintsville, Fullers, and Ashland stages are obtained by calling the voice platform at each gage.

As listed in **Table 3-2** page 3-4, standard data collection platforms (without voice modules) report stage at the outflow and precipitation at Meta. All the platforms relating to the project update readings each 60 minutes except Pikeville, Prestonsburg, and Paintsville, which are on 30-minute schedules. All district platforms report by electronic transmission via satellite to the LRD downlink every four hours. LRD water control system (WCS) retrieves from the downlink and disseminates the data hourly via dedicated telephone line to Huntington District WCS in Water Resources Engineering Branch.

Project data for morning and extra reports are entered into the terminal offline and checked for accuracy. Then the reports are transmitted electronically by telephone to the District Water Control System via INTRANET. By use of the portable terminal from office or home location, selected personnel can access the most recent reading or a series of recent readings for desired stations that are reported by platform by using the "SCAN" command.

TABLE NO. 3-1
PERTINENT GAGE DATA

Gage	Location	Code Symbol	Equipment	Reference Gages		Recorder	Datum of gage
				Staff	Other		
Lake	Gate House	JFPQ4	DCP, H	SL	TL	RL	NGVD
	Outflow 700 ft below dam	JFPOF	DCP, H, ADR	SO	TO	RO, PO	1200.0
N. Fork Pound	Outflow 1600 ft below dam	O	H, ADR	SO	TO	RO, PO	1500.0
Clintwood	1,000 ft below Rush Ck.	CLCQ4	ADR, V, DCP	SC	TC	RC	1440.3
Haysi, Va.	180 ft below Rt.63 Br.	ARQ4	ADR, V, DCP	SH	TH	RH	1237.6
Bartlick	0.2 mile below Pound R.	BLRQ4	ADR, V, DCP	SB	TB	RB	1165.0
Elkhorn City	10 ft below Rt.80 Br.	ECRP4	ADR, V, DCP	RE	TE	RE	773.00
Pikeville	2 miles above Harold's Branch	PKVP3	ADR, V, DCP	SP	TP	RP	631.98
Prestonsburg	50 ft below Rt.114 Br.	PRL03	ADR, V, DCP	SP	TP	RP	588.12
Paintsville	900 ft below Paint Creek	PTLN3	ADR, V, DCP	SP	TP	RP	566.84
Fullers, Ky	1.6 mile above Blaine Creek	FSSM3	ADR, V, DCP	SF	TF	RF	568.02
Ashland, Ky	1700 ft. above Ashland-Coal Grove Bridge	ASOL3	TM, DCP	SA	TA	RA	481.03

S - Staff
T - Electric tape
DCP - Data collection platform
H - Hydrologger, device answers query stage by voice
R - Strip chart recorder
SB - Stilling Basin
W - Wire Weight
V - Voice module with data collection platform to answer telephone as the Hydrologger above
P - ADR or Punch-tape type stage recorder

TABLE NO. 3-2
STREAM GAGE TELEPHONE NUMBERS

Gage	Code* Symbol	Telephone Number	Type of Gage
NFP Outflow	NFPOF	[redacted]	Hydrologger
NFP Lake	NFPQ3	[redacted]	Hydrologger
Pound Upper	PUPQ3	[redacted]	Voice platform
Pound Lower	PLPQ3	[redacted]	Voice Platform
JFP Lake	JFPQ4	[redacted]	Hydrologger
JFP Outflow	JFPOF	[redacted]	Hydrologger
Haysi	HARQ4	[redacted]	Voice Platform
Bartlick	BLRQ4	[redacted]	Voice Platform
Elkhorn City	ECRP4	[redacted]	Voice Platform
Pikeville	PKVP3	[redacted]	Voice Platform
Paintsville	PTLN3	[redacted]	Voice Platform
Fullers	FSSM3	[redacted]	Voice Platform
Ashland	ASOL3	[redacted]	Hydrologger

* Project abbreviation plus location on District Isohyetal Map

SCHEDULE FOR READING GAGES
JOHN W. FLANNAGAN DAM

The regular stream gages VL or SL and VO or SO 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 reading 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 height 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.

	Schedule A		Schedule B (1)		Schedule C (1)		Schedule D (1)	
	Normal conditions		Flood threat		Flood conditions			
Conditions	Crop* season	Non-crop* season	Crop* season	Non-crop* season	Crop* season	Non-crop* season	Crop* season	Non-crop* season
Reservoir elevation	Below 1399	Below 1382	1399-1411	1382-1401	144-1420(6)	1401-1420(6)	Above 1420(6)	Above 1420(6)
"O" gage elevation	Below 1205.6	Below 1205.6	1205.6-1206.6	1205.6-1206.6	1206.6-1207.4	1206.6-1207.4	Above 1207.4	Above 1207.4
Bartlick U.S.G.S. stage	Below 12.0	Below 12.0	12.0-14.0	12.0-14.0	14.0-25.0	14.0-25.0	Above 25.0	Above 25.0
Precipitation within 24 hrs.	Less than 0.75	Less than 0.60	0.75-1.50	0.60-1.50	1.50-3.00	1.50-2.50	Above 3.00	Above 2.5
Read gages								
VL and VO (2)	Twice daily (3)		At 0730, 1330 & 1930		At 0730, 1330, 1930 & 0130		At 3-hour intervals	
Georges Fork telemark (inflow)	Daily at 0730		At 0730		At 0730, 1330 & 1930		At 3-hour intervals	
Clintwood telemark (inflow)	Daily at 0730		At 0730		At 0730, 1330, & 1930		At 3-hour intervals	
Bartlick telemark	Daily at 0730		At 0730, 1330, 1930		At 0730, 1330, 1930 & 0130		At 3-hour intervals	
SL, TL, RL, SO, TO, RO and Haysi telemark (5)	Twice weekly (as check)		Twice weekly (as check)		Twice weekly (as check)		Twice weekly (as check)	
Elkhorn City telemark	Twice weekly (as check)		At 0730 & 1330 (4)		At 0730, 1330, & 1930 (4)		At 0730, 1330, 1930, & 0130 (4)	
Precipitation gage	At 0730		At 0730, 1330, & 1930		At 0730, 1330, 1930 & 0130		At 0730, 1330, 1930 & 0130	

(1) When any one of the conditions listed under these schedules is met, place the higher schedule into effect, immediately.
(2) When the tape gages or counters are not operating properly, read the staff gages.
(3) 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.
(4) Make direct reading of the ELKHORN CITY telemark except when you are sure that the ORN observer will furnish the scheduled reading.
(5) When the BARTLICK telemark is not operating, read and report the HAYSI telemark in accordance with the required schedule for the BARTLICK gage.
(6) Whenever the reservoir level is between elevation 1410 and 1446 and rising or at elevation 1446 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 "Damtender's Emergency Operation Schedule", readings of the "Lake" gage shall be taken every hour, on the hour.

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 reading required. All gage reading made in addition to those require by the foregoing table must be recorded.

*Crop season – 16 April through 30 November
**Non-crop season – 1 December through 15 April

PLATE NO. 3-1

CHART HANDLING INSTRUCTIONS

Obtaining Weekend and Holiday Readings
From Stevens Strip Chart Recorders

STEVENS TYPE AP, TYPE A-71 OR A-35 RECORDER

1. First lift the lid or remove dust cover.
2. Lift pen from chart and secure pen in holder off paper position.
3. Facing Stevens recorder grasp knurled knob on the take up roll located in the rear of the recorder and to the left of the recorder paper. Turn knurled knob clockwise until enough paper is showing to obtain sufficient readings being careful paper does not come in contact with pen.
4. Record weekend and Holiday readings.
5. After sufficient readings have been obtained, grasp knurled knob, turn counterclockwise until slack is out of paper. Lower pen back on chart. If pen is off more than 1 hour, reset for correct time. To reset, grasp the knurled disc which is located on the right-hand side of the recorder just beneath the knurled knob of the supply cylinder. Pull the disc out to the right and rotate it until the paper is free. Advance paper until chart shows the correct time. Rotate the knurled disc to its normal location and push back in place to the left.
6. If you reset for time, make notation on chart.

STEVENS PAV-C OR CAV-C RECORDER

1. Face recorder and open recorder door.
2. Remove pen from chart by turning pen arm positioning screw clockwise.
3. Run the chart upward by moving and turning the knurled disk on the right end of the take up roller, upward, until enough record is showing to obtain readings. Be careful paper doesn’t come in contact with pen.
4. Record weekend and Holiday readings.
5. After readings are obtained, run the chart downward by turning the knurled disk on the right end of the take up roll, downward, until paper slack is removed and pen time is correct. Hold the chart in place; at the same time place a finger under the spiral belt, lift outward from the wall slightly stretching the belt, then release. Paper will stay taut.
6. Place pen back on the chart by turning pen arm positioning screw counter clockwise.
7. If pen is off more than I hour, reset for time. To reset, run chart downward until pen shows correct time on the chart. Holding chart in place, lift outward spiral spring belt, stretching slightly, then release belt.
8. If you reset for time, make a notation on chart. Include in notation time, date, stage from counter, etc.

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. Take daily readings at 0730 of the Russell Fork gage at Bartlick, Va.; and obtain lake 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.

The Schedule for Reading Gages, **Plate 3-1**, defines conditions for taking more frequent readings of gages. After each time of entering readings on the form, check the correctness of the readings as recorded. If doubt arises, investigate to the extent necessary to be certain of the readings. During normal conditions, if the 1930 and 0130 readings have not been recorded on the form, 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 3-2** 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, type the data on a fresh Form 14 with a carbon for project files. Check the date on the typed original to be the same as on the handwritten form and mail to the District Office marked “Attention Water Resources Engineering Branch.” A sample Form 14, **Plate 4-1**, is included at the end of this section.

b. Daily Morning 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 through the District Intranet System 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 Project Data Input Form shown at the end of this section as **Plate 4-2**.

This new reporting program was installed at the dam in May 1998, as a fully computerized three page, menu driven master data sheet that is virtually self explanatory, with a convenient auto prompt feature easily completed by filling the empty data boxes.

Transmit reports for Saturdays, Sundays, and Holidays on which the project is attended as on regular work days. Transmit reports for unattended days after transmission of the current report for the first working day, which follows.

In each regular or extra Daily Morning Report, also include any telephonic readings made since the previous Project Information report.

If conditions are such that the daily report cannot be transmitted to the District Intranet System by 0830 hours, transmit the report by telephone or fax to Water Resources Engineering Branch, then enter the data into the computerized report form when it becomes available.

There is a water quality function at John Flannagan Lake. During periods of lake stratification the weekly temperature-dissolved oxygen profile and water quality data are included in a separate report. Instructions relative to recording and transmission of the report are as follows:

(1) Logging On. Open the web browser (Microsoft Internet Explorer or Netscape Navigator) to the address [redacted]. This index page contains information pertaining to only John Flannagan Lake. The Data Submission Reports vary for each project, and report Forms for one project cannot be substituted for another project. When submitting data for gate operations follow the link for Gate Operations. There is a water quality stratification function at John Flannagan Lake, hence there is a water quality data report. When the data submission page has been accessed, indicate if this is a new or a revised report and then check the date/time group. The John Flannagan Lake assigned PASSWORD is required for submission. Follow the example on **Plate 4-2**.

(2) Three reports can be accessed from the Index Page: The Daily Project Report (also called the Morning Report), the Gate Operations Report and the Water Quality Report. Click on the picture or on the Report name to access a report.

(3) When the Project Report Page has been accessed, indicate if this is a new or a revised report. Check the date/time group.

(4) The first table, Current Project Info, is used to record general information about the project at the time of the report.

(5) 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-digit group constitutes the abbreviation for the station and should always be used. These station names have been coded into the web page and cannot be changed at the project. If there are any difficulties in relation to this, please contact the Water Control Section.

(6) Column 2 - Precipitation. Record the amount of precipitation (to the nearest 1/100 inch) since the last report.

(7) Column 3 - Lake Elevation. Use this column for reporting the lake "I" gage, in feet above NGVD, to the nearest hundredth foot. Please include decimal points.

(8) Column 4 - Outflow Stage. Use this column for reporting the stage at the "O" gage, to the nearest hundredth foot. This is the stage reading of the gage.

(9) Column 5 - Flow. This column can be used for recording the outflow if it becomes necessary. At this point, this field is unavailable.

(10) Columns 6 and 7 - Snow and Water Equivalent. Report the depth of snow cover and its water content in these columns. Where a station does not make this report or no precipitation has been reported, send 0.00. Record the snow depth in inches to the nearest hundredth. Indicate a trace by OOT. Report the figures for snowfall and snow cover since the previous report.

(11) Columns 8 - Weather Description. The last column in this group is used to report the state of the weather at the time of observation, in accordance with the code on the drop down menu. When there has been no precipitation to report, show this group as NIL.

(12) The second table, current gate settings, is used to record gate settings at the time of the report.

(13) Slide Gate Settings - Column l and 2. Use these columns for reporting the amount of opening of the slide gates, starting with the number one gate on the left and then number two 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 0.00. In the Daily Morning Report, transmit gate openings in four-digit groups including decimal points.

(14) Selective Withdrawal Settings - Column 3, 4, and 5. There is a water quality selective withdrawal system and a Cane Branch spillway sluice at Flannagan Lake, therefore stratification and gate data are required for both. Follow the example in Plate No. 4-2. Enter the data for upper window 1 as Hl, window 2 as H2, lower window 3 as H3. Enter the position of the Cane Branch Sluice CBS in column six.

(15) The third table, Additional Station Information, is used to record data from downstream gages Bartlick (BRLQ4), Elkhorn City (ECRP4), Haysi (HARQ4), Clintwood (CLCQ4) and Georges Fork (GFPO4) for permanent record. Record any and all the stage and precipitation in such messages. Data are entered in the SHEF box. Follow the example in **Plate 4-2**.

(16) The fourth table, Additional Comments, gives an unlimited field to record any comments relevant to the Project Report which have not been covered in the previous tables.

(17) Password. Each project has a unique password needed to submit the report the WCDS-A system. If this password is missing or incorrect, attempts to submit the Project Report will be unsuccessful. Use the 'back arrow' on the browser to get back to the Project Report Page to attempt to submit the form with the correct password. While the information being submitted is not classified, the password should be protected to keep unauthorized personnel from gaining access to mil computer systems. Questions about the password should be directed to the Water Control Section.

(18) After all the project information has been recorded, click on the 'Submit' button to send the report to WCDS-A or "Clear Form" to clear all the information out of the form and start over.

(19) If the password was correct, a SHEF compatible report will be sent back to the computer terminal. Information can be checked before the final submission. If there is any incorrect data on the report, use the browser's 'back button' to return to the Project Report Page to correct the information. If the information is correct, click the 'correct' button at the top of the page. At this point, the report is sent to the WCDS-A computer for permanent storage.

This report can be accessed through the Flannagan Lake web page [redacted] under Project Reports or through a link to 'Project Reports' on the Index Page. The reports are stored as ASCII text and may be printed to keep as a hard copy.

(20) The second report accessed from the Index Page is the Gate Operations Report. This report is used to record information about gate operations. Each gate operation should be recorded at the time it occurs. If several gate operations are performed within a short period of time, up to 6 (six) gate operations may be reported on a single form. Choose the Gate ID from a drop down menu. Enter the data on the report in the following manner with the first entry for a new report. Use column one through six, successively for gate designation, the beginning and ending values of the gate opening, the Date of gate operation, and the beginning and ending time of the Gate operation. An unlimited field is also provided to make any additional comments. Transmit all gate valve operations since the previous report and transmit with each morning or extra report.

As in the Project Report, a password is necessary to submit the gate Operation Report to the WCDS-A computer. The same password is used for both the Project Report and the Gate Operations Report (see Para. 4.01.17). If the report is submitted with the proper password,

a confirmation screen will be transmitted back to the terminal. If the information is correct, click on the 'Correct' button at the top of the page. The information will be entered into a permanent record. This record can be viewed through the Flannagan web page at ().

(22) The third report available from the Index Page is the Water Quality Report. This report is used during the seasons in which the lake is subject to stratification. Monitoring begins when a special directive is sent by Water Control Section at the request of Water Quality Section. Report Water Quality data in accordance with the special directive. Monitoring ends when the lake is no longer stratified. Water Quality Section will request Water Control Section issue a special directive ending monitoring when it is no longer necessary.

(23) The first table in the Water Quality Report has fields referring to conditions at the time the water quality sampling was performed. Record the date and time, the lake elevation in feet to the nearest hundredth, and the weather conditions.

(24) The second table is used to record water quality data at the outflow gage on the surface. Record the water temperature in degrees Celsius, the Dissolved Oxygen (D.O.) content in mg/ml, the water condition, turbidity in n.tu and pH.

(25) The third table is used to record water quality at various depths. The first column records the depth water depth, from the surface, in meters. This field is populated for the convenience of the data transcriber, but can be changed if conditions warrant. The second column records the water temperature in degrees Celsius. The third records the Dissolve Oxygen (D.O.) content in mg/ml. The fourth column records the water condition. The fifth column records turbidity in n.tu. The sixth column records the pH. Not all of these readings will be taken at every recording session at every depth.

(26) Below the table recording the water conditions, there is an unlimited field to provide additional comments.

(27) As in the Project Report, a password is necessary to submit the Water Quality Report to the WCDS-A computer. The same password is used to the Project Report and the Water Quality Report (see Para. 4.01.17). If the report is submitted with the proper password, a confirmation screen will be transmitted back to the terminal. If the password was correct, a SHEF compatible report will be sent back to the computer terminal. If there is any incorrect data on the report, use the browser's 'back button' to return to the Project Report Page to correct the information. If the information is correct, click on the 'Correct' button at the top of the page. The information will be entered into a permanent record.

This record can be viewed through the Flannagan Lake web page at .

This arrangement is illustrated in **Plate 4-3** at the end of this section.

4-02 EXTRA REPORTS

Always transmit extra reports, as indicated by the Schedule for Reading Gages, **Plate 3-1**, to INTRANET over the project computer terminal in the same way as the regular Project Information Report. If project personnel are unable to transmit the report over the computer terminal, telephone the report in to Water Control Section. 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 or called for by the Schedule for Reading Gages. 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) Extraordinary meteorological event such as a tornado or blizzard, or heavy precipitation after 0730 hours.

(2) Gate positions and/or operations.

(3) Flooding upstream or downstream.

(4) Request for special operation.

(5) Catastrophe such as drowning.

(6) Unusual or abnormal water quality condition in the lake, inflow streams or downstream a reasonable distance from the dam.

(7) Moisture content of snow.

(8) Outflow temperature and/or air temperature at time other than 0730 hours.

(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 radio, email or fax.

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 on **Table 4-1**, next page.

TABLE NO. 4-1

DIRECTORY OF KEY PERSONNEL

Party	Telephone		Radio
DISTRICT PERSONNEL	OFFICE	RESIDENCE	CALL LETTERS
Water Resources Engineering Branch			WUE4
[redacted] Chief, Water Control Section	[redacted]	[redacted] - unlisted	
[redacted] Water Control Section	[redacted]	[redacted]	
[redacted] Water Control Section	[redacted]	[redacted]	
[redacted] Chief, Water Resources Engineering Branch	[redacted]	[redacted] - unlisted	

Huntington District Office, Water Resources Engineering Branch

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

Additional Extensions [redacted]

NOTE: All the above numbers can be found on the C of E Intranet, including cell phone numbers. Located at [redacted]

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

John W. Flannagan Lake Project Office

[redacted] - Damtender		Telephone No.
[redacted]	Commercial	[redacted]
[redacted]	Home	[redacted]

Gate Operating Personnel	Telephone No.
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

Other Agencies

U. S. Geological Survey Richmond, Virginia Nights, weekends, Holidays	Commercial	[redacted]
[redacted]	Commercial	[redacted]
[redacted]	Commercial	[redacted]
National Weather Service Jackson, KY	Commercial	[redacted]

Big Sandy Area Office, Louisa, Kentucky

[redacted] - Area Manager		Telephone No.
	Commercial	[redacted]

4-04 CELL PHONE AS BACKUP COMMUNICATION

Keep the cell phone turned on at all times when anyone is on duty at the project office, including overtime periods, since a District Office operator is 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 Intranet or via telephone, attempt to transmit by cell phone, email or fax either direct to the District Office or by relay through another project, which has contact with the District Office.

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 (CELRH-EC-W).

b. Downstream Channel Conditions. At the request of the Water Resources Engineering Branch, inspection of critical areas downstream from the dam will be made for conditions listed below to observe encroachment on the channel, indiscreet utilization of low-lying areas, and flooding conditions, as follows:

(1) During flood periods when maintaining the maximum allowable (for the season) stage on the “O” gage, downstream to Russell Fork.

(2) As workload permits during or immediately following periods of unusual storage releases, along the Russell Fork to Elkhorn City.

(3) If complaints of flooding are received, notify the Water Resources Engineering Branch immediately, then make an inspection of the specific area as soon as practicable.

(4) At any other times, as requested by the Water Resources Engineering Branch, and under (3) above, the essential items to note and report are: (a) persons or communities involved, (b) nature of complaint, and (c) extent and depth of flooding. A letter report, containing pictures, cross sections or sketches, will be made of the findings as soon as practicable. If immediate action appears necessary, a brief initial report will be made via telephone to the Water Resources Engineering Branch.

c. Lake Area Conditions. During periods of lake storage above seasonal pool elevation, inspections shall be made within the lake area. Essential items to look for and observe are bank slippage and effects of wind and wave erosion.

d. 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 Control Section. Stream gages, rain gages and temperature

equipment shall be periodically checked for proper functioning and performance or when directed by the Water Control Section. During periods of stratification, outflow temperature requirements will be maintained according to directives issued by the Water Control Section.

e. 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, 1425 feet NGVD, for John Flannagan 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.

f. 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.

RESERVOIR WEEKLY REPORT						*REPORTS CONTROL SYMBOL ORHED-H-2*			
						STATION JOHN W. FLANNAGAN DAM & RESERVOIR			
						WEEK ENDING 02 AUGUST 1999			
GAGE RECORDS						GATE OPERATING RECORD			
	TIME		GAGES			GATE	AMT OF OPENINGS		PURPOSE
DATE	START	END	VL	VO	BLRQ4	NO.	INITIAL	FINAL	
	1330		139479	120214					
	1930		139476	120214					
07/27	0130		139479	120214					
	0730		139476	120212	0739				
	1330		139475	120212					
	1930		139474	120212					
07/28	0130		139472	120212					
	0730		139472	120212	0728				
	0815	0816	139472	120212		S1	0.1	0.2	SD 678
	0915		139472	120228					CHECK READING
	1330		139469	120228					
	1930		139467	120232					
07/29	0130		139466	120232					
	0730		139466	120232	0753				
	1330		139462	120232					
	1930		139460	120232					
07/30	0130		139459	120232					
	0730		139457	120232	0759				
	1330		139454	120232					
	1930		139453	120232					
07/31	0130		139451	120232					
	0730		139450	120232	0766				
	1330		139446	120232					
	1930		139444	120232					
08/01	0130		139442	120232					
	0730		139439	120232	0758				
	1330		139437	120232					
	1930		139436	120232					
CHECK READINGS						FINAL POSITION OF GATES			
08/02	0130		139436	120232		S1 0.2 S2 0 H1 0 H2 0 H3 0			
	0730		139435	120232	0767				
						HAROLD E. MILLER, JR. CELRH-OR-JWF			
						SIGNATURE			

CEORH Form 14-E 1 Dec 76 *EDITION OF 1 NOV 72 MAY BE USED*

PLATE NO. 4-1

J. W. FLANNAGAN LAKE

PROJECT INFORMATION

★ ★ ★

ADDITIONAL COMMENTS

PLEASE ENTER THE J. W. FLANNAGAN PASSWORD:

You submitted the following information for this New report:

If this is correct, please click here

```
.B COEJFP E 0730/PPP/HG/QR/HP/HT/QT/SD/SW
:
: PROJECT REPORT FOR J. W. FLANNAGAN LAKE                    TUE 09
Mar 1999 1044
:
:STANDARD PROJECT
DATA----------------------------------------------------------------------------------------------
:     ID                PRECIP      POOL      TAILWATER            SNOW
WATER          WEATHER
:COE/SHEF               (IN)        ELEV       STAGE       FLOW   DEPTH
EQUIV      CODE/DESCRIPTION
:JFPQ4:FLAV2       0///          1380/          1200/          M/       0.0/          0.0:
      0 Unchanged
:
:GATE
SETTINGS-------------------------------------------------------------------------------------------

: S1=.00     /S2=.00     /H1=.00     /H2=.00     /H3=.00     /CBS=Open
/C1=1.0      /C2=1.0     /C3=1.0     /C4=1.0     /C5=1.0     /C6=1.0
:
:STATION
DATA----------------------------------------------------------------------------------------------

:     ID                      PRECIP     TAILWATER
:COE/SHEF                     (IN)         ELEV
:BLRQ4:BLKV2      0730/       0///         0.0/                BARTLICK VA
:ECRP4:ELKK2      0730/       0///         0.0/                ELKHORN
CITY KY
:HARQ4:HAYV2      0730/       0///         0.0/                HAYSI VA
:CLCQ4:CLWV2      0730/       0///         0.0/                CLINTWOOD
VA
:GFPQ4:GFKV2      0730/       0///         0.0/                GEORGES
FORK
.END
```

J. W. FLANNAGAN LAKE

GATE OPERATIONS

★ ★ ★

J. W. FLANNAGAN LAKE

Lake Quality Report

★ ★

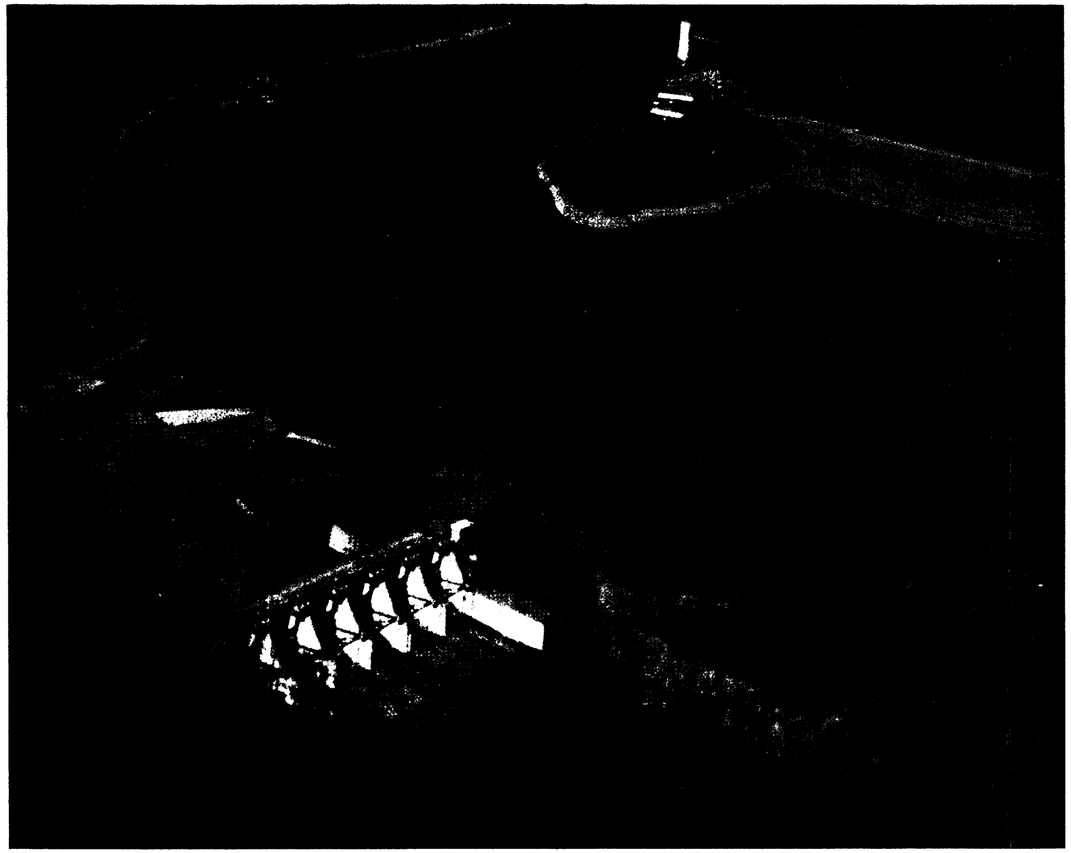
USE THE MOUSE OR TAB TO MOVE BETWEEN FIELDS
THE ENTER KEY WILL SUBMIT THE DATA

This file is a New submission.

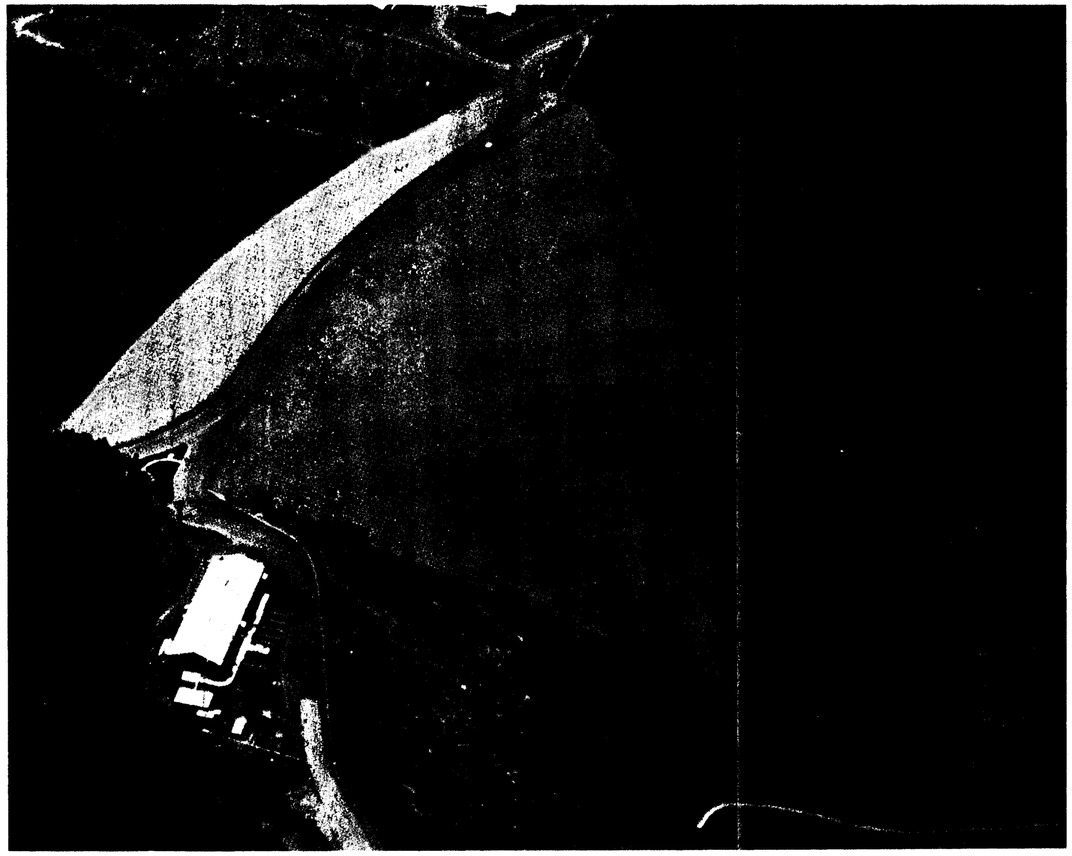
DATE	TIME	LAKE ELEV (FT)	WEATHER
9 Mar 99	0730	885.00	0 Unchanged

DEPTH (M)	TEMP (C)	D.O.	COND	TURB	pH
OUTFLOW	20.0	7.0	00350	10	8.00
SURFACE	20.0	7.0	00350	10	8.00
1.0	20.0	7.0	00350	10	8.00
2.0	20.0	7.0	00350	10	8.00
3.0	20.0	7.0	00350	10	8.00
4.0	20.0	7.0	00350	10	8.00
5.0	20.0	7.0	00350	10	8.00
6.0	20.0	7.0	00350	10	8.00
7.0	20.0	7.0	00350	10	8.00
8.0	20.0	7.0	00350	10	8.00
9.0	20.0	7.0	00350	10	8.00
10.0	20.0	7.0	00350	10	8.00
12.0	20.0	7.0	00350	10	8.00
14.0	20.0	7.0	00350	10	8.00

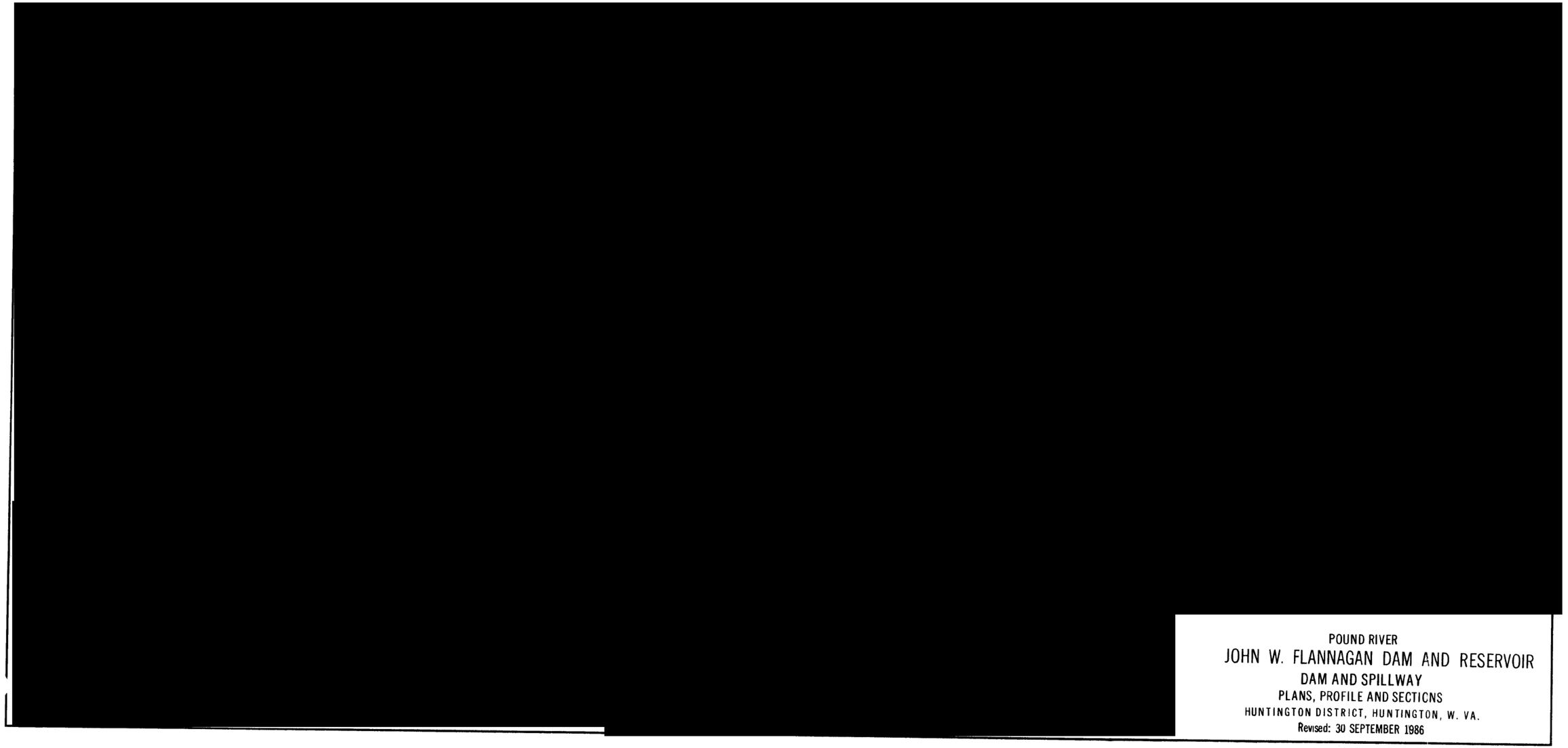
UPON APPROVAL OF NEPA DOCUMENTATION, THE DROUGHT CONTINGENCY PLAN WILL BE FURNISHED FOR ENCLOSURE IN THE WATER CONTROL MANUALS.



VIEW OF SPILLWAY



VIEW AT DOWNSTREAM SIDE OF DAM



POUND RIVER

JOHN W. FLANNAGAN DAM AND RESERVOIR

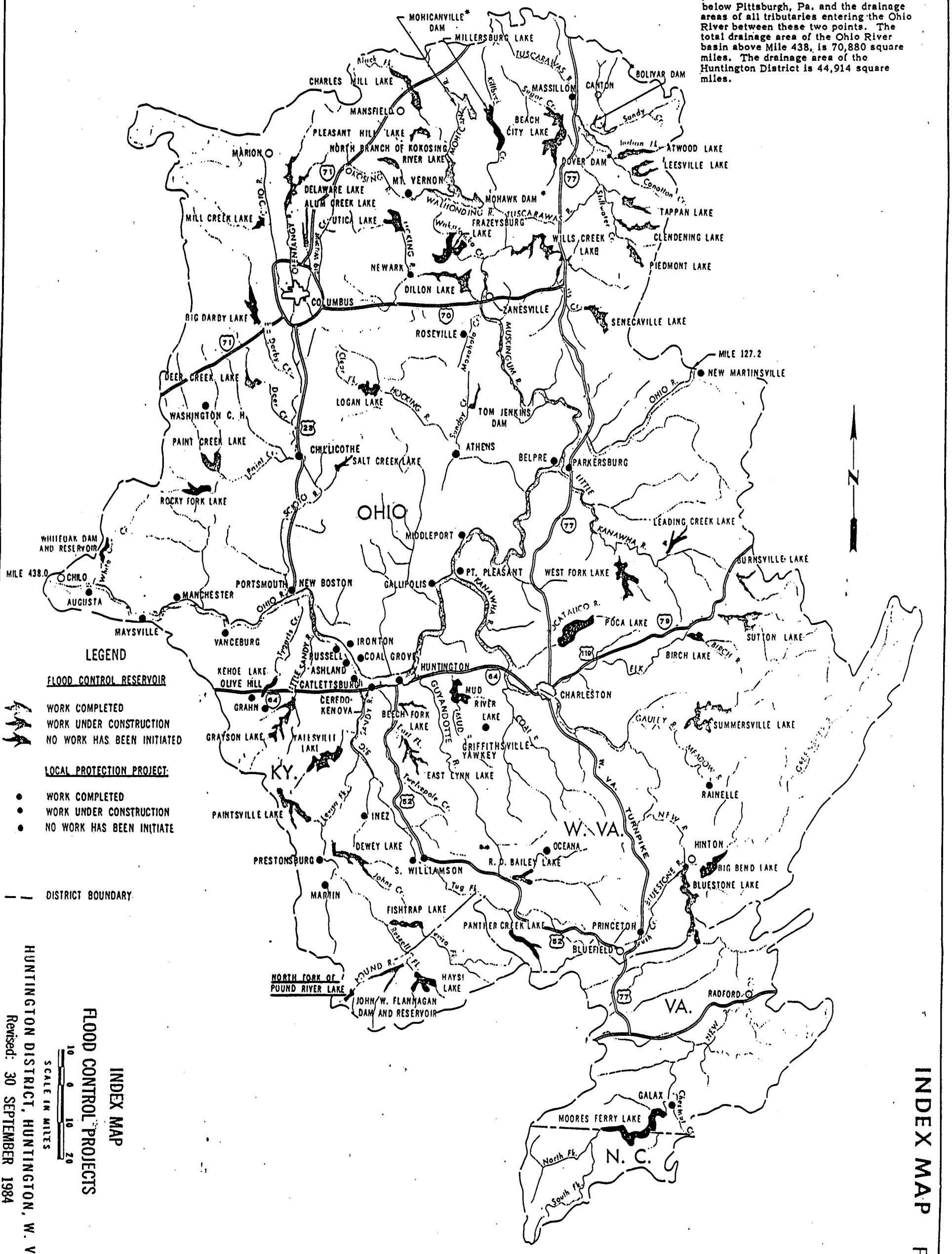
DAM AND SPILLWAY

PLANS, PROFILE AND SECTIONS

HUNTINGTON DISTRICT, HUNTINGTON, W. VA.

Revised: 30 SEPTEMBER 1986

The Huntington District includes the reach of the Ohio River between River Mile 127. (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.



INDEX MAP

FLOOD CONTROL PROJECTS

HUNTINGTON DISTRICT, HUNTINGTON, W. VA.

Revised: 30 SEPTEMBER 1984

INDEX MAP F/C 1

*Dry dam, with flood control pool outlined.

**Completed project where further improvements are in progress or authorized.

CORPS OF ENGINEERS

U.S. ARMY

ELKHORN CITY

ASHCAMP

POUND DAM NEAR HAYSI

PERMANENT CONSERVATION POOL EL. 814

MAX. FLOOD CONTROL POOL EL. 1425

R BURDINE

HAYSI

CLINCHCO

RUSSELL FORK

RIVER

KENTUCKY VIRGINIA

JENKINS

POUND

CLINTWOOD

CRANESNEST

MACCLURE

LICK CREEK

NORTH FORK OF POUND DAM

NORTH FORK

SOUTH FORK

POUND

DICKENSON CO.

FORAKER

DARWIN

CANEY CREEK

BIRCHFIELD CREEK

SOLOMON CREEK

WISE

SANTE

DUNBAR

37°15'

37°10'

37°05'

37°00'

82°45'

82°40'

82°35'

82°30'

82°25'

82°20'

82°15'

VICINITY MAP

VA. TENN. KINGSPORT BRISTOL

SCALE IN MILES

LEGEND

- STATE LINE
- COUNTY LINE
- DRAINAGE AREA
- U.S. HIGHWAY
- STATE HIGHWAY
- RAINFALL
- DISCHARGE
- R RECORDING GAGE

POUND RIVER
JOHN W. FLANNAGAN RESERVOIR PROJECT
GENERAL MAP OF DRAINAGE AREA

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

HUNTINGTON W. VA.

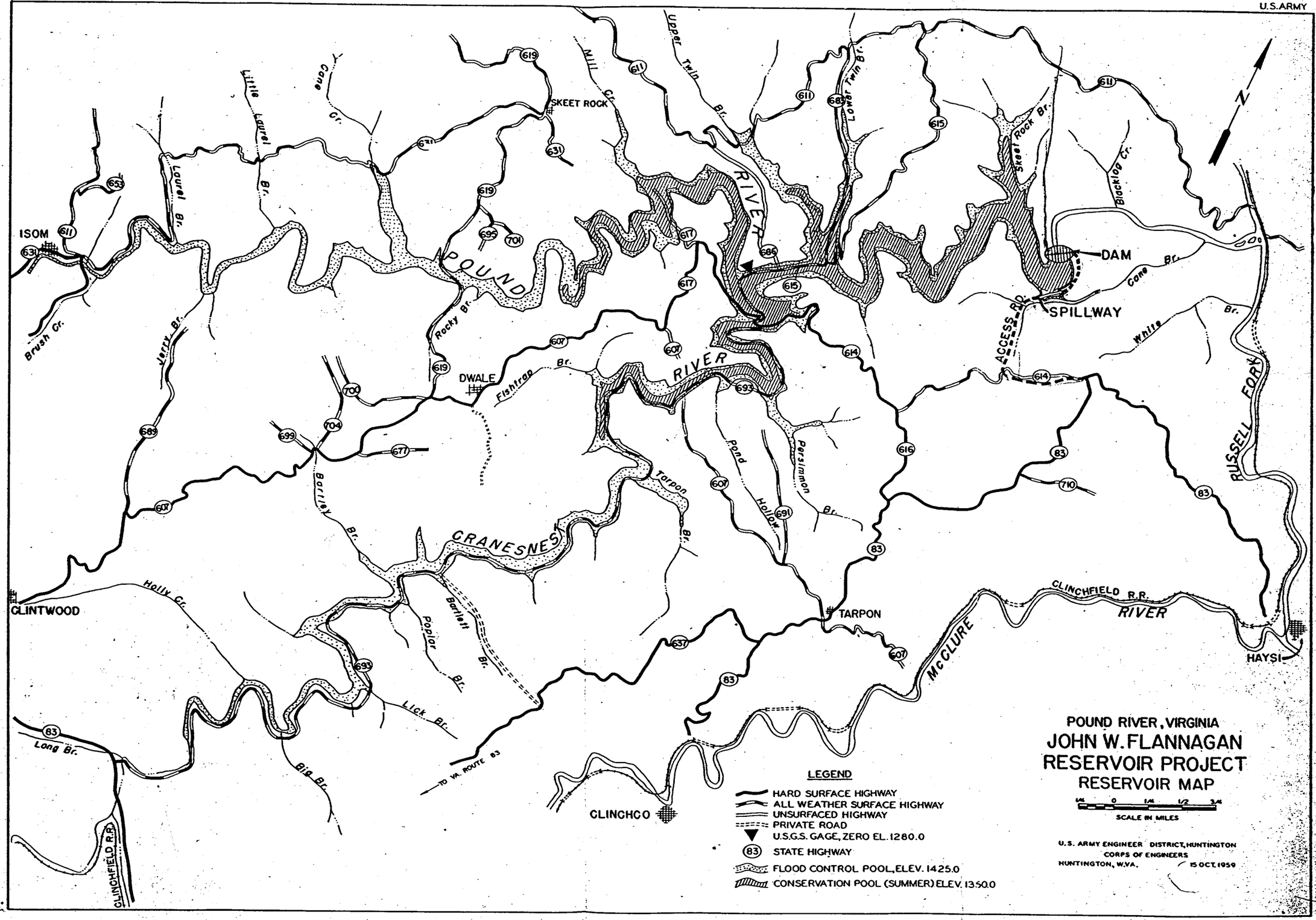
REVISED AUGUST 1950

SCALE IN MILES

Plate No. 2-1

CORPS OF ENGINEERS

U.S.ARMY



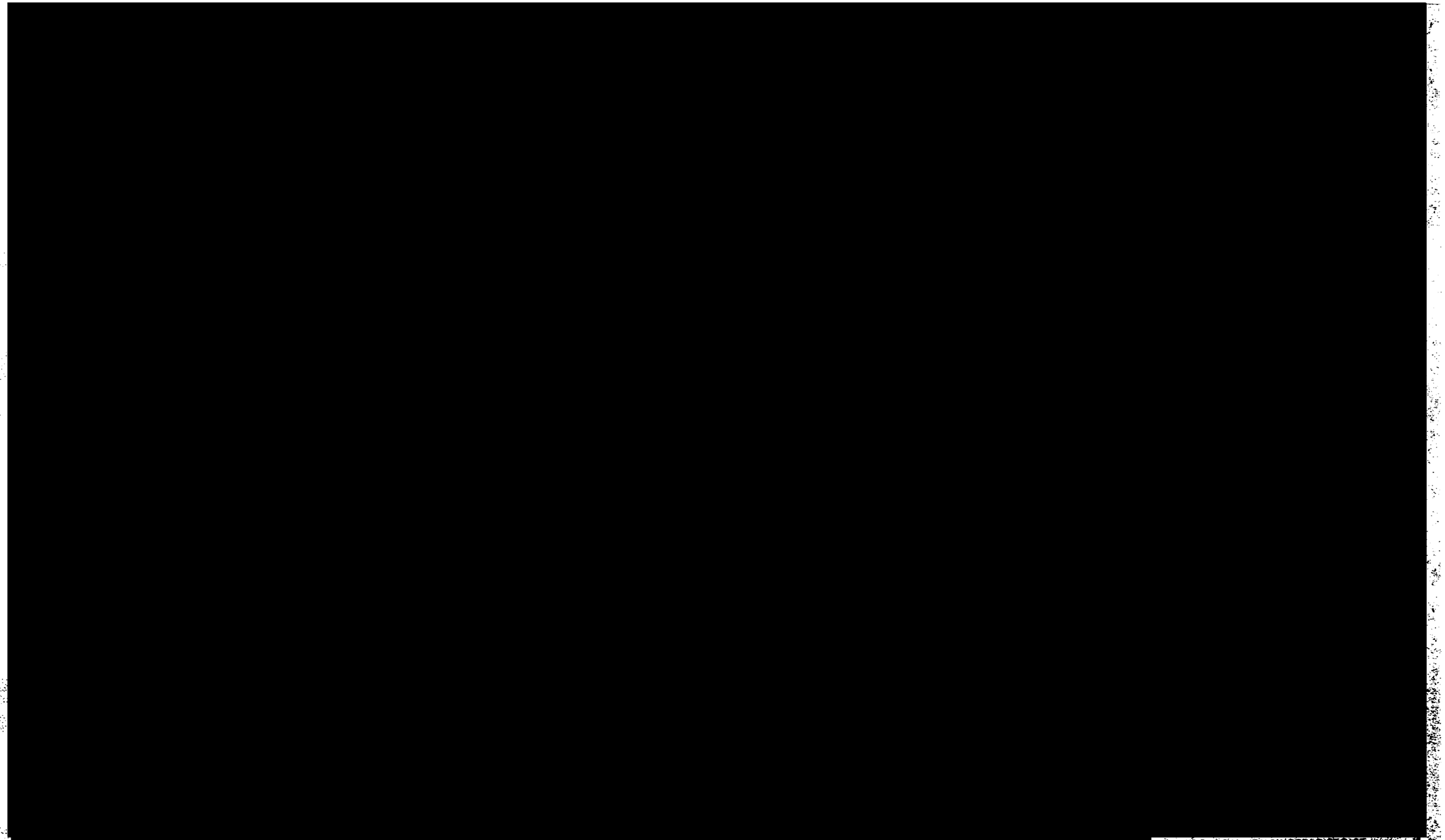
POUND RIVER, VIRGINIA

JOHN W. FLANNAGAN RESERVOIR PROJECT

RESERVOIR MAP

U.S. ARMY ENGINEER DISTRICT, HUNTINGTON
CORPS OF ENGINEERS
HUNTINGTON, W.VA. 15 OCT. 1959

Plate No. 2-2



U.S. ARMY ENGINEER DISTRICT
HUNTINGTON, W. VA.

JOHN W. FLANNAGAN RESERVOIR
PLAN OF DAM AND OUTLET WORKS WITH CONTROL TOWER

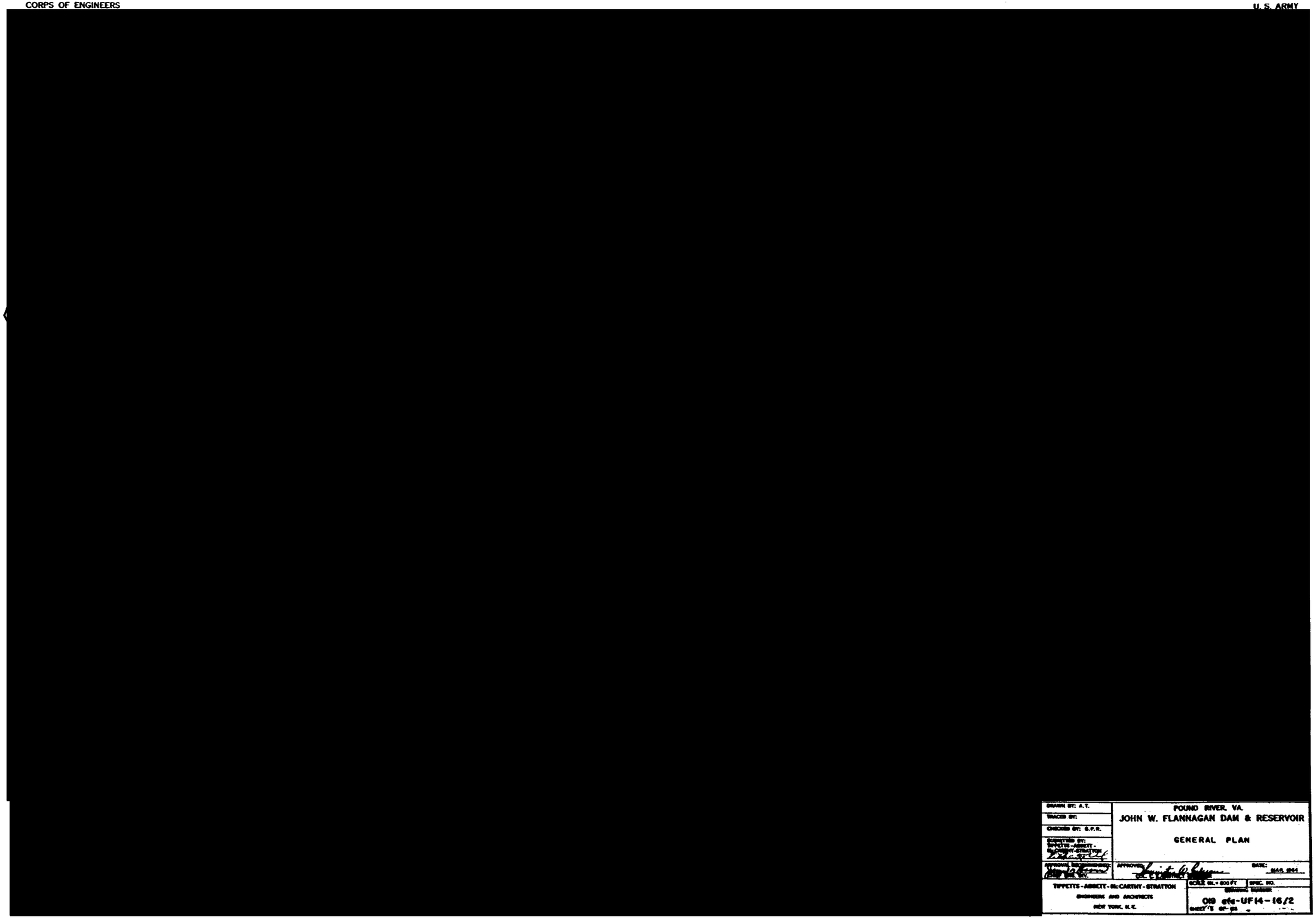
TIPPETTS-ABBETT-McCARTHY-STRATTON
ENGINEERS NEW YORK

DES. J.W.B. DRAWN R.G. CHECKED J.W.B.	SCALE: AS SHOWN	PLATE NO. 4-3
	DATE JULY, 1959	

Plate No. 2-3

CORPS OF ENGINEERS

U.S. ARMY



DRAWN BY: A.T.	POUND RIVER, VA.
TRACED BY:	JOHN W. FLANNAGAN DAM & RESERVOIR
CHECKED BY: E.P.R.	GENERAL PLAN
SUBMITTED BY: TIPPETTS-ABBETT-McCARTHY-STRATTON	APPROVED: Chief, Engineering Division DATE: MAR 1964
APPROVED RECOMMENDED: Lt. Col. Corps of Engineers	
TIPPETTS - ABBETT - McCARTHY - STRATTON ENGINEERS AND ARCHITECTS NEW YORK, N.Y.	SCALE IN. = 200 FT. SPEC. NO. DRAWING NUMBER 019 efa-UF14-16/2 SHEET 16 OF 28

Plate No. 2-4

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

JOHN W. FLANNAGAN RESERVOIR
PROPOSED EMBANKMENT
PLAN, PROFILE AND SECTIONS

TIPPETTS - ABBETT - McCARTHY - STRATTON
ENGINEERS NEW YORK

DES: T.C.J. DRAWN: H.N.S. CHECKED: P.F.Z.	SCALE: AS SHOWN DATE: MARCH 1959	PLATE NO. 5-11

REVISION	DATE	DESCRIPTION	BY
1	1-30-64	Revised in accordance with Amendment No. 3	ADKIN

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

DRAWN BY: A. T.
TRACED BY:
CHECKED BY: A. Z. K.
SUBMITTED BY: TIPPETTS - ABBETT - McCARTHY - STRATTON

POUND RIVER, VA.

JOHN W. FLANNAGAN DAM & RESERVOIR
GATED SPILLWAY
GENERAL ARRANGEMENT
PLAN, ELEVATION AND SECTIONS

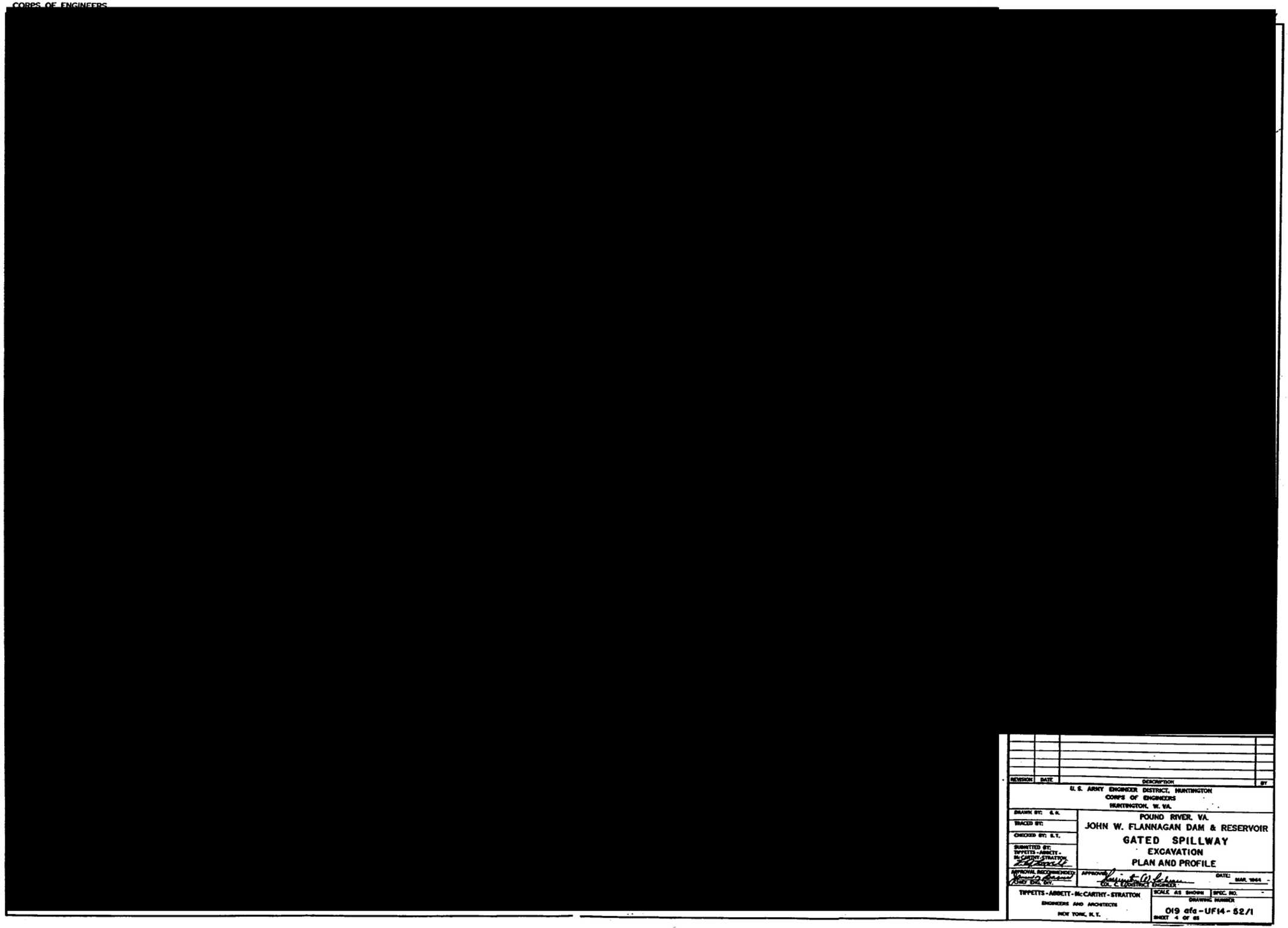
APPROVAL RECOMMENDED: Chief, Engr. Div.
APPROVED: Col. C. E. Branch, District Engineer
DATE: MAR 1964

TIPPETTS - ABBETT - McCARTHY - STRATTON
ENGINEERS AND ARCHITECTS
NEW YORK, N. Y.

SCALE 1IN. = 50 FT | SPEC. NO.
DRAWING NUMBER
019 eta-UF14-52.1/1
SHEET 11 OF 65

Plate No. 2-6

CORPS OF ENGINEERS



REVISION	DATE	DESCRIPTION	BY

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

DRAWN BY: G.K.
TRACED BY:
CHECKED BY: E.T.
SUBMITTED BY: TIPPETTS-ABBETT-McCARTHY-STRATTON
APPROVAL RECOMMENDED: Chief, Eng. Div.

POUND RIVER, VA.
JOHN W. FLANNAGAN DAM & RESERVOIR
GATED SPILLWAY
EXCAVATION
PLAN AND PROFILE

APPROVED: Col. C. L. District Engineer
DATE: MAR. 1964

TIPPETTS-ABBETT-McCARTHY-STRATTON
ENGINEERS AND ARCHITECTS
NEW YORK, N. Y.

SCALE AS SHOWN
SPEC. NO.
DRAWING NUMBER
019 afa-UF14-52/1
SHEET 4 OF 65

Plate No. 2-7

CORPS OF ENGINEERS

[redacted]

REVISION	DATE	
	12-21-62	DELETED SERVICE BRIDGE PIER
	7-15-57	[redacted]

U.S. ARMY ENGINEER DISTRICT, WASHINGTON
CORPS OF ENGINEERS
WASHINGTON, D. C.

DRAWN BY: H.M.T.
TRACED BY: H.M.T.
CHECKED BY: J.W.S
SUBMITTED BY: [redacted]
RECOMMENDED BY: [redacted]
APPROVED BY: [redacted]
DATE: SEPT. 1960

POUND RIVER, VA.
JOHN W. FLANNAGAN DAM & RESERVOIR
INTAKE STRUCTURE
GENERAL
GENERAL PLAN AND PROFILE

TIPPETTS - ABBETT - McCARTHY - STRATTON
ENGINEERS AND ARCHITECTS
NEW YORK, N.Y.

SCALE: 1 IN. = 20 FT
DRAWING NUMBER
018 ofa - UF4 - 16/3
SHEET 1 OF 70

Plate No. 2-8

CORPS OF ENGINEERS

U.S. ARMY

[redacted]

REVERSION	DATE	DESCRIPTION	BY
◊	1-15-61	[illegible]	F.J.F.

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

DRAWN BY: E.A.W.
TRACED BY:
CHECKED BY: J.T.McT. E.M.K. - G.A.F. - F.J.F.
SUBMITTED BY: TIPPETTS - ABBETT - McCARTHY - STRATTON
APPROVAL RECOMMENDED: Chief Engr. Div.

POUND RIVER, VA.
JOHN W. FLANNAGAN DAM & RESERVOIR
INTAKE STRUCTURE
GENERAL
GENERAL SECTIONS

APPROVED: Steven Melanich, COL. C. E. DISTRICT ENGINEER
DATE: SEPT. 1960

TIPPETTS - ABBETT - McCARTHY - STRATTON
ENGINEERS AND ARCHITECTS
NEW YORK, N. Y.

SCALE 1/8 IN. = 1 FT. | SPEC. NO.
DRAWING NUMBER
019 efa-UF4-62.1/2
SHEET 8 OF 20

Plate No. 2-9

U.S. ARMY ENGINEER DISTRICT
HUNTINGTON, W. VA.

JOHN W. FLANNAGAN RESERVOIR
CONTROL TOWER SUPERSTRUCTURE
ELEVATION AND SECTIONS

TIPPETTS – ABBETT – McCARTHY – STRATTON
ENGINEERS
NEW YORK

DES: J.W.B. DRAWN: J.L. CHECKED: J.W.B.	SCALE: AS SHOWN DATE: JULY, 1939	PLATE NO. 4-12

U.S. ARMY ENGINEER DISTRICT
HUNTINGTON, W. VA.

JOHN W. FLANNAGAN RESERVOIR
CONTROL TOWER GATE CHAMBER
ELEVATION AND SECTIONS

TIPPETTS - ABBETT - McCARTHY - STRATTON
ENGINEERS — NEW YORK

DES: J.W.B. DRAWN: H.H.S. CHECKED: J.W.B	SCALE: AS SHOWN	PLATE NO. 4-13
	DATE: JULY, 1959	

[redacted]

U.S. ARMY ENGINEER DISTRICT
HUNTINGTON, W. VA.

JOHN W. FLANNAGAN RESERVOIR
PROPOSED OUTLET WORKS
TYPICAL TUNNEL SECTIONS

TIPPETTS - ABBETT - McCARTHY - STRATTON
ENGINEERS — NEW YORK

DES.: A.V. DRAWN: S.L.-W.J.B. CHECKED: J.W.B.	SCALE: AS SHOWN DATE: JULY, 1959	PLATE NO. 4-5

[redacted]

U.S. ARMY ENGINEER DISTRICT
HUNTINGTON, W. VA.

JOHN W. FLANNAGAN RESERVOIR
OUTLET WORKS-CONTROL TOWER
ELEVATION AND PROFILE

TIPPETTS-ABBETT-McCARTHY-STRATTON
ENGINEERS
NEW YORK

DES: J.W.B. DRAWN: J.L. CHECKED: J.W.B	SCALE: 1 IN. = 50 FT. DATE: JULY, 1959	PLATE NO. 4-11

[redacted]

1150

PROFILE ALONG TUNNEL

U.S. ARMY ENGINEER DISTRICT
HUNTINGTON, W. VA.

JOHN W. FLANNAGAN RESERVOIR
OUTLET WORKS-CONTROL TOWER
ELEVATION AND PROFILE

TIPPETTS-ABBETT-McCARTHY-STRATTON
ENGINEERS
NEW YORK

DES: J.W.B. DRAWN: J.L. CHECKED: J.W.B	SCALE: 1 IN. = 50 FT. DATE: JULY, 1959	PLATE NO. 4-11

[redacted]

U.S. ARMY ENGINEER DISTRICT
HUNTINGTON, W. VA.

JOHN W. FLANNAGAN RESERVOIR
PROPOSED OUTLET WORKS
OUTLET STRUCTURE

TIPPETTS - ABBETT - MCCARTHY - STRATTON
ENGINEERS
NEW YORK

DES: E. B. DRAWN: J.F.R. CHECKED: S.T.	SCALE: AS SHOWN DATE: JULY, 1959	PLATE NO. 4-14

JOHN W. FLANNAGAN DAM AND RESERVOIR

PERTINENT DATA

LOCATION OF DAM: In Dickenson County, Virginia. On Pound River, a tributary of Russell Fork of Levisa Fork of Big Sandy River; 1.8 miles above the mouth of Pound River and 150.0 miles above the mouth of Big Sandy.

AUTHORITY: Flood Control Act of 28 June 1938, PL 75-761, Federal Water Pollution Control Act, Amendments of 1961 (PL 87-88).

PURPOSES SERVED: Flood reduction, low-flow augmentation, fish and wildlife betterment, recreation and water supply.

DAM: Type-rockfill with central impervious core, maximum height 250', top length 916', top width 32', maximum base width 1,030'.

SPILLWAY: Controlled spillway 0.3 mile south of dam with 6-42'x38' tainter gates. Crest elevation 1410, length of crest 252 net feet, design discharge 246,700 cfs, with surcharge of 9.0' freeboard of 5.0'.

OUTLET WORKS: Intake structure with two 4'-0" x 8'6" water passages controlled by slide gates and discharging into a 16' horseshoe tunnel through the left abutment. Three by pass conduits with 24-inch valves control inlets at invert elevations 1328, 1313 and 1298 for low flow control.

OTHER STRUCTURES: None.

RELOCATIONS: 21 Miles of secondary roads, 3 highway bridges, 1.8 miles of power lines, 0.3 mile of telephone lines, 1 school and 11 cemeteries with 73 graves.

DRAINAGE AREA ABOVE DAM: 221 Miles square miles. (203.8 sq. mi. net area excluding North Fork of Pound drainage area).

MAXIMUM FLOW OF RECORD AT DAMSITE: 28,800 cfs (January 1957).

RESERVOIR DESIGN FLOOD PEAK FLOW: 70,000 cfs.

RESERVOIR DATA: Streambed elevation at dam:

JOHN W. FLANNAGAN DAM AND RESERVOIR

PERTINENT DATA (Cont'd)

Pool	Surface Elevation (Ft above Sea level)	Surface Area (Acres)	Backwater along Main Stream (Miles)	Capacity Ac Ft (Thousands) Net	Capacity Ac Ft (Thousands) Gross	Capacity Inches of runoff Net	Capacity Inches of runoff Gross
Year Round Storage:							
Minimum	1314	310	6.0	12.0	12.0	1.1	1.1
Water Supply	1314	318	6.1	0.4	12.4	0.1	1.1
Water Quality Control	1380	933	11.6	38.6	51.0	3.6	4.7
Seasonal Storage (Summer):							
Low-Flow Augmentation/ Recreation	1396	1145	13.6	16.5	67.5	1.5	6.2
Flood Control Stage*							
Winter	1446	2098	18.5	94.7	145.7	8.7	13.4
Summer	1446	2098	18.5	78.2	145.7	7.2	13.4
Total	1446	2098	18.5	145.7	145.7	13.4	13.4

*At maximum pool level.
+Between elevations 1380 and 1446.
**Between elevations 1396 and 1446.

NET LAND OWNED: Fee 8,273.3 acres; easement-92 acres.

STATUS: All construction work is complete. The dam was placed in operation in December 1993. Earlier

COST:		
	Construction	$19,998,400
	Estimated recreation (code 711) funds	443,200
	Expended through 30 Sep 1984	443,200
	Operation and maintenance 30 Sep 1988	11,076,400

CORPS OF ENGINEERS

U.S. ARMY

BIG SANDY RIVER
TUG & LEVISA FORKS - KY., W.VA. & VA.
DRAINAGE MAP

SCALES AS SHOWN

CORPS OF ENGINEERS U.S. ARMY
HUNTINGTON DISTRICT
JANUARY 1964

LOCATION MAP

VICINITY MAP

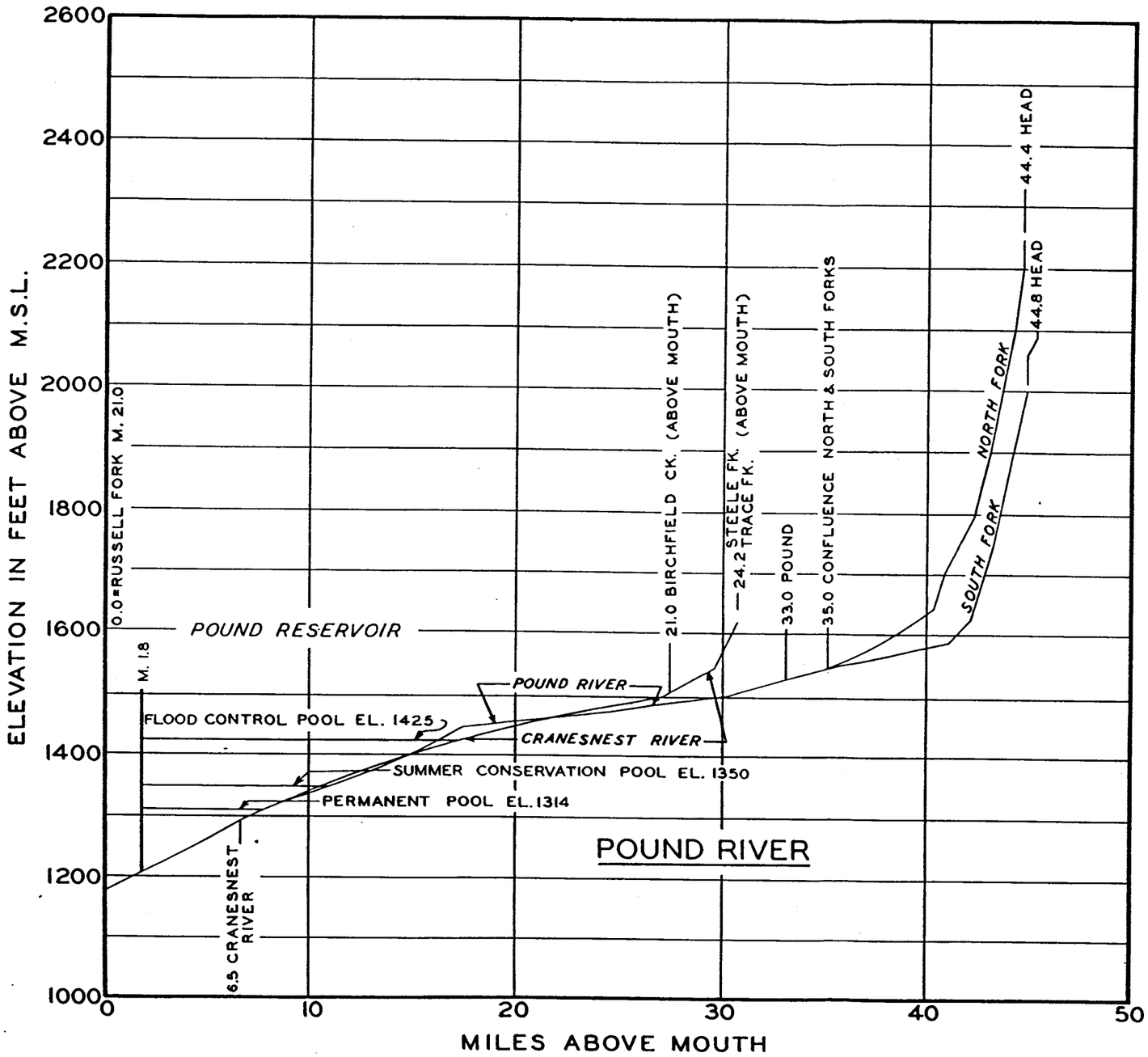
LEGEND

WATERSHED LINE
STATE LINE
COUNTY LINE
RAINFALL STATION - U.S.E.D.
RAINFALL STATION - U.S.W.B.
GAGE HEIGHT STATION - U.S.E.D.
GAGE HEIGHT STATION - U.S.W.B.
GAGE HEIGHT STATION - U.S.E.D. & U.S.W.B.
DISCHARGE STATION - U.S.E.D.
DISCHARGE STATION - U.S.G.S.
RECORDING GAGE
STATION DISCONTINUED

Plate No. 4-1

CORPS OF ENGINEERS

U. S. ARMY



POUND RIVER, VIRGINIA

POUND RESERVOIR PROJECT
STREAM PROFILES

SCALES AS SHOWN

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

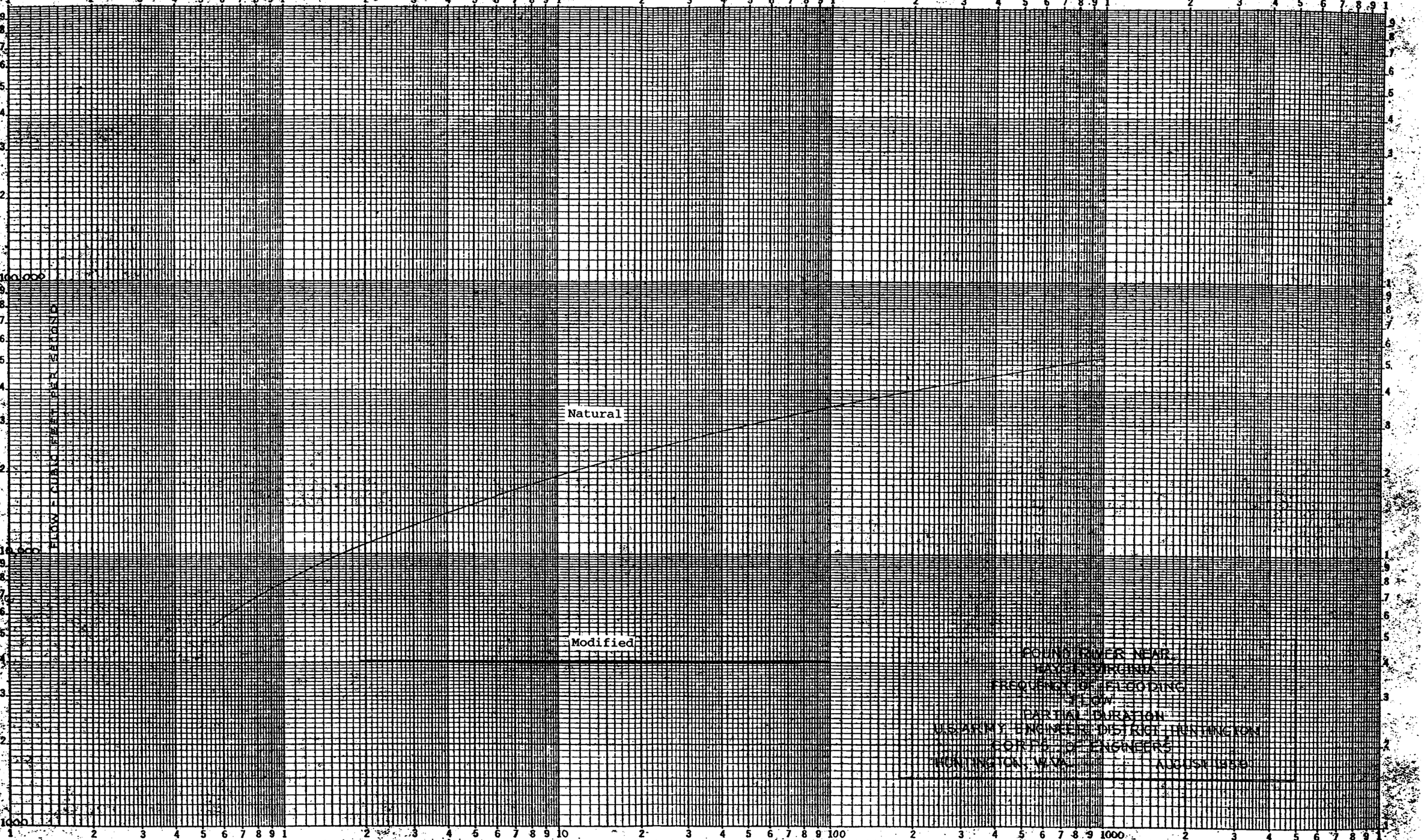
JULY 1958

REVISED: AUGUST 1959

Plate No. 4-2

CORPS OF ENGINEERS

U.S. ARMY



COLUMBIA RIVER NEAR
WAYNE, WEST VIRGINIA
FREQUENCY OF FLOODING
BELOW
PARTIAL DURATION

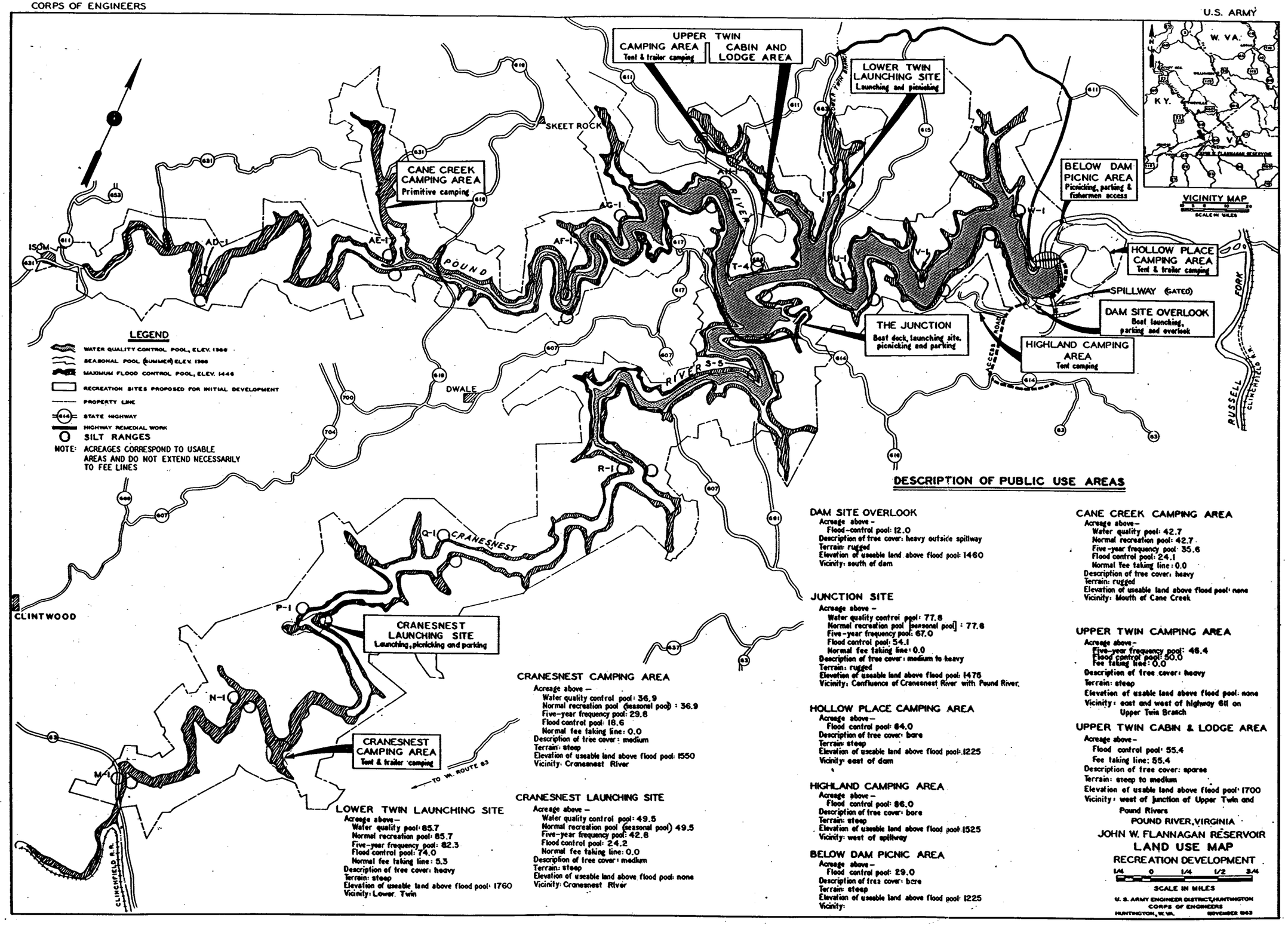
U.S. ARMY ENGINEER DISTRICT, HUNTINGTON
CORPS OF ENGINEERS
HUNTINGTON, W.VA.

AUGUST 1958

Plate No. 4-3

CORPS OF ENGINEERS

U.S. ARMY



DESCRIPTION OF PUBLIC USE AREAS

DAM SITE OVERLOOK
Acreage above –
Flood-control pool: 12.0
Description of tree cover: heavy outside spillway
Terrain: rugged
Elevation of useable land above flood pool: 1460
Vicinity: south of dam

JUNCTION SITE
Acreage above –
Water quality control pool: 77.8
Normal recreation pool [seasonal pool] : 77.8
Five-year frequency pool: 67.0
Flood control pool: 54.1
Normal fee taking line: 0.0
Description of tree cover: medium to heavy
Terrain: rugged
Elevation of useable land above flood pool: 1476
Vicinity: Confluence of Cranesnest River with Pound River.

HOLLOW PLACE CAMPING AREA
Acreage above –
Flood control pool: 84.0
Description of tree cover: bare
Terrain: steep
Elevation of useable land above flood pool: 1225
Vicinity: east of dam

HIGHLAND CAMPING AREA
Acreage above –
Flood control pool: 86.0
Description of tree cover: bare
Terrain: steep
Elevation of useable land above flood pool: 1525
Vicinity: west of spillway

BELOW DAM PICNIC AREA
Acreage above –
Flood control pool: 29.0
Description of tree cover: bare
Terrain: steep
Elevation of useable land above flood pool: 1225
Vicinity:

CANE CREEK CAMPING AREA
Acreage above –
Water quality pool: 42.7
Normal recreation pool: 42.7
Five-year frequency pool: 35.6
Flood control pool: 24.1
Normal fee taking line: 0.0
Description of tree cover: heavy
Terrain: rugged
Elevation of useable land above flood pool: none
Vicinity: Mouth of Cane Creek

UPPER TWIN CAMPING AREA
Acreage above –
Five-year frequency pool: 46.4
Flood control pool: 50.0
Fee taking line: 0.0
Description of tree cover: heavy
Terrain: steep
Elevation of useable land above flood pool: none
Vicinity: east and west of highway 611 on Upper Twin Branch

UPPER TWIN CABIN & LODGE AREA
Acreage above –
Flood control pool: 55.4
Fee taking line: 55.4
Description of tree cover: sparse
Terrain: steep to medium
Elevation of useable land above flood pool: 1700
Vicinity: west of junction of Upper Twin and Pound Rivers

CRANESNEST CAMPING AREA
Acreage above –
Water quality control pool: 36.9
Normal recreation pool (seasonal pool) : 36.9
Five-year frequency pool: 29.8
Flood control pool: 18.6
Normal fee taking line: 0.0
Description of tree cover: medium
Terrain: steep
Elevation of useable land above flood pool: 1550
Vicinity: Cranesnest River

CRANESNEST LAUNCHING SITE
Acreage above –
Water quality control pool: 49.5
Normal recreation pool (seasonal pool) 49.5
Five-year frequency pool: 42.6
Flood control pool: 24.2
Normal fee taking line: 0.0
Description of tree cover: medium
Terrain: steep
Elevation of useable land above flood pool: none
Vicinity: Cranesnest River

LOWER TWIN LAUNCHING SITE
Acreage above –
Water quality pool: 85.7
Normal recreation pool: 85.7
Five-year frequency pool: 82.3
Flood control pool: 74.0
Normal fee taking line: 5.3
Description of tree cover: heavy
Terrain: steep
Elevation of useable land above flood pool: 1760
Vicinity: Lower Twin

POUND RIVER, VIRGINIA
JOHN W. FLANNAGAN RESERVOIR
LAND USE MAP
RECREATION DEVELOPMENT

1/4 0 1/4 1/2 3/4
SCALE IN MILES

U. S. ARMY ENGINEER DISTRICT, HUNTINGTON
CORPS OF ENGINEERS
HUNTINGTON, W. VA. NOVEMBER 1963

Plate No. 4-4

CORPS OF ENGINEERS

U.S. ARMY

BIG SANDY RIVER
TUG & LEVISA FORKS - KY., W.VA. & VA.
DRAINAGE MAP

SCALES AS SHOWN

CORPS OF ENGINEERS U.S. ARMY
HUNTINGTON DISTRICT
JANUARY 1964

LOCATION MAP

VICINITY MAP

LEGEND

- WATERSHED LINE
- STATE LINE
- COUNTY LINE
- RAINFALL STATION - U.S.E.D.
- RAINFALL STATION - U.S.W.B.
- GAGE HEIGHT STATION - U.S.E.A.
- GAGE HEIGHT STATION - U.S.W.B.
- GAGE HEIGHT STATION - U.S.E.D.A. U.S.W.B.
- DISCHARGE STATION - U.S.E.D.
- DISCHARGE STATION - U.S.G.S.
- RECORDING GAGE
- STATION DISCONTINUED

HUNTINGTON DISTRICT OFFICE

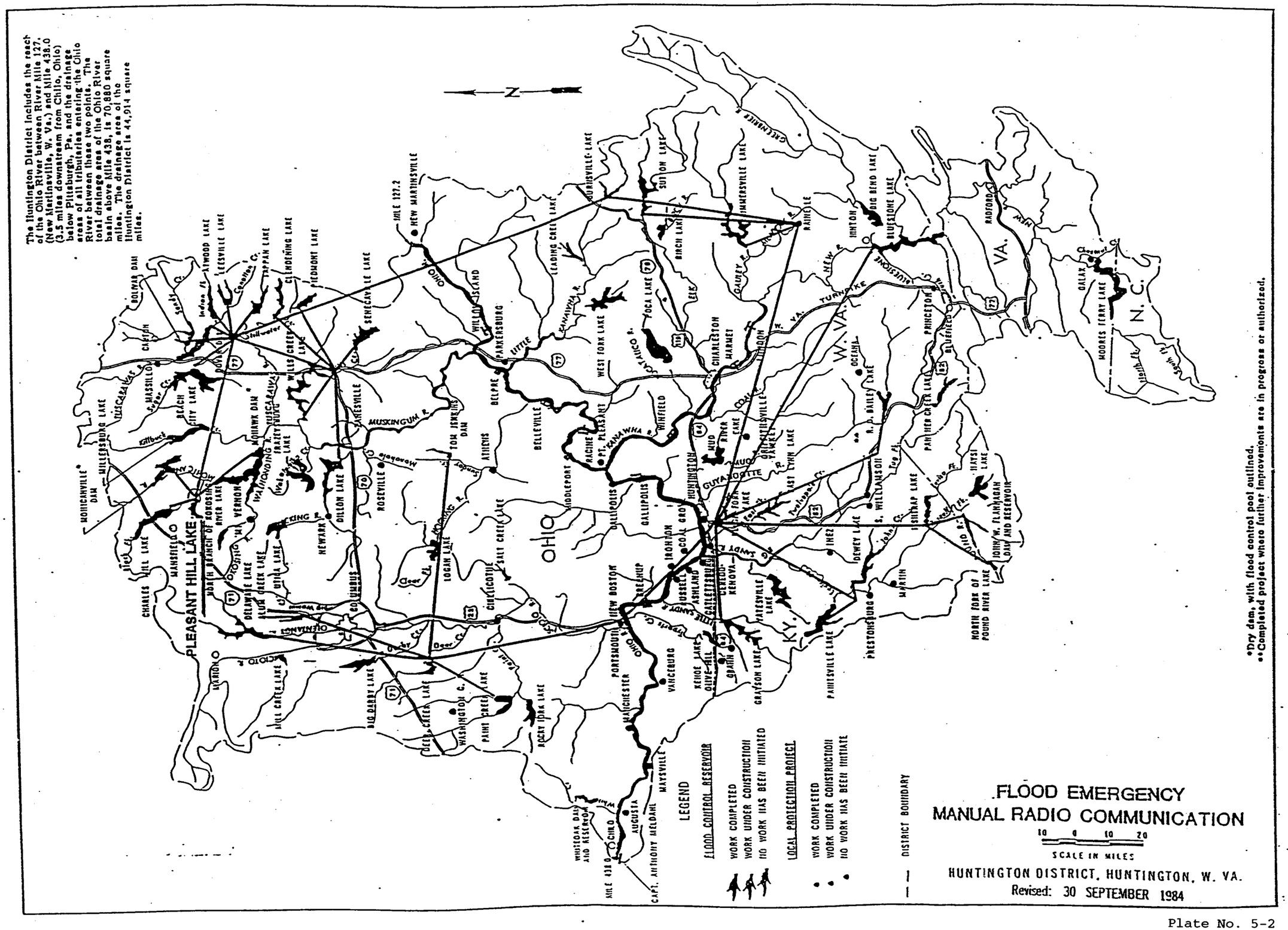
SATELLITE DATA FROM GRD DOWNLINK

HYDROLOGIC NETWORK

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.VA. JUNE 1989

Plate No. 5-1

The Huntington District includes the reach of the Ohio River between River Mile 127. (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.



*Dry dam, with flood control pool outlined.
**Completed project where further improvements are in progress or authorized.

Plate No. 5-2

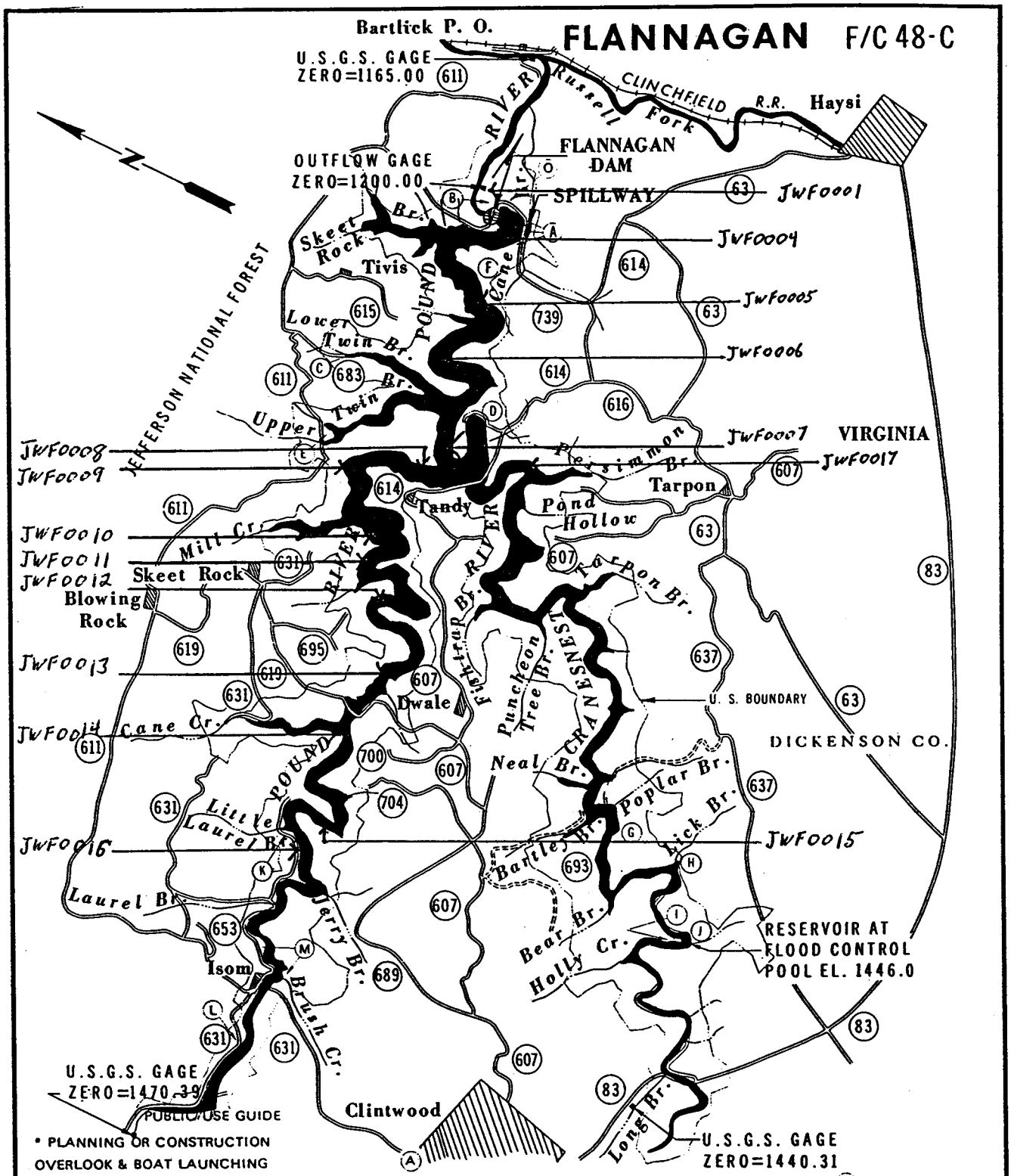

FLANNAGAN F/C 48-C
Bartlick P. O.
U.S.G.S. GAGE ZERO=1165.00
Russell Fork
CLINCHFIELD R.R.
Haysi
RIVER
FLANNAGAN DAM
OUTFLOW GAGE ZERO=1200.00
SPILLWAY
JWF0001
JWF0004
JWF0005
JWF0006
JWF0007
JWF0008
JWF0009
JWF0010
JWF0011
JWF0012
JWF0013
JWF0014
JWF0015
JWF0016
JWF0017
JEFFERSON NATIONAL FOREST
POUND
Skeet Rock Br.
Tivis
Cane
Lower Twin Br.
Upper Twin Br.
Persimmon Br.
Tarpon
Tandy
Pond Hollow
Tarpon Br.
Milt Cr.
Skeet Rock
Blowing Rock
Fighter Br.
Puncheon Tree Br.
Dwale
Cane Cr.
Neal Br.
Poplar Br.
Little Laurel Br.
Laurel Br.
Jerry Br.
Brush Cr.
Isom
Clintwood
Bartley Br.
Bear Br.
Holly Cr.
Long Br.
U. S. BOUNDARY
VIRGINIA
DICKENSON CO.
RESERVOIR AT FLOOD CONTROL POOL EL. 1446.0
U.S.G.S. GAGE ZERO=1440.31
U.S.G.S. GAGE ZERO=1470.39
PUBLIC USE GUIDE
• PLANNING OR CONSTRUCTION
OVERLOOK & BOAT LAUNCHING (A)
PARKING, REST ROOMS, PICNIC AREA & FISHERMAN ACCESS (B)
PARKING, REST ROOMS, SHOWERS, PICNIC AREA, BOAT LAUNCHING & CAMPING AREA (C)
PARKING, REST ROOMS, FISHERMAN ACCESS, MARINA & LAUNCHING (D)
FISHERMAN ACCESS (E)
• CAMPING AREA (F)
PARKING & BOAT LAUNCHING (G)
CAMPING AREA & REST ROOMS (H)
PICNIC AREA & REST ROOMS (I)
REST ROOMS, SHOWER & CAMPING AREA (J)
PARKING, REST ROOMS, PICNIC AREA, PRIMITIVE CAMPING AREA & FISHERMAN ACCESS (K)
SWIMMING POOL, PICNIC AREA (L)
RIDING RING, SOFTBALL FIELD (M)
LITTLE LEAGUE FIELD (O)
BIG SANDY RIVER BASIN
POUND RIVER
JOHN W. FLANNAGAN DAM AND RESERVOIR
Scale In Miles
1 0 1 2
HUNTINGTON DISTRICT, HUNTINGTON, W. VA.
Revised: 30 SEPTEMBER 1988

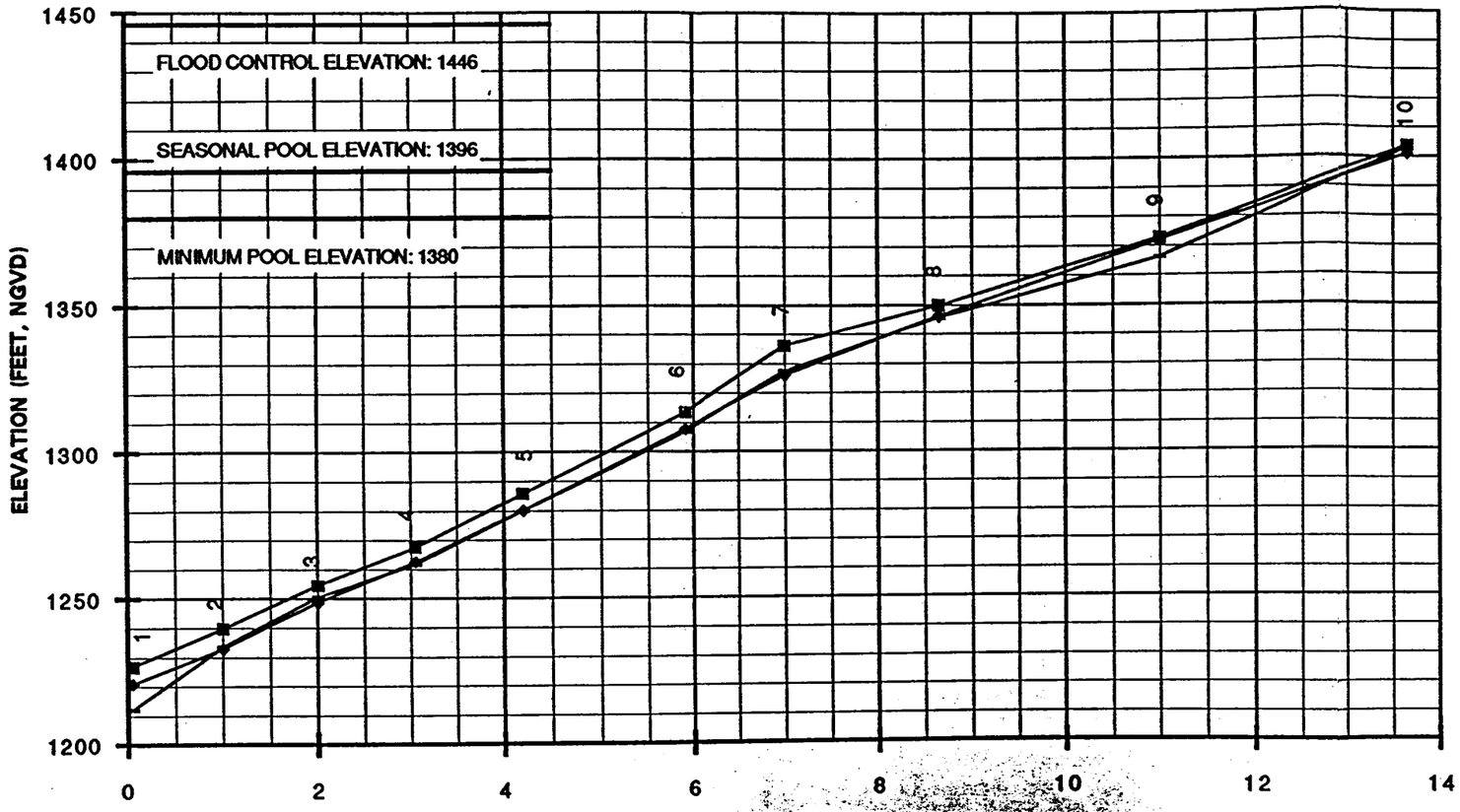
Plate No. 5-3

VIRGINIA WATER QUALITY STANDARDS FOR AQUATIC LIFE

Parameter	Acute Toxicity[1] µg/l	Chronic Toxicity[2] µg/l
Aldrin	3.0	0.3
Arsenic (III)	360	190
Cadmium	$e^{(1.128[\ln(\text{hardness})]-3.828)}$	$e^{(0.7852[\ln(\text{hardness})]3.490)}$
Chlordane	2.4	0.0043
Chloride	860,000	230,000
Chlorpyrifos	0.083	0.041
Chromium (III)	$e^{(0.8190[\ln(\text{hardness})]+3.688)}$	$e^{(0.8190[\ln(\text{hardness})]+1.561)}$
Chromium (IV)	16	11
Copper	$e^{(0.9422[\ln(\text{hardness})]-1.464)}$	$e^{(0.8545[\ln(\text{hardness})]-1.465)}$
Cyanide	22	5.2
DDT	1.1	0.0010
Demeton	---	0.1
Dieldrin	2.5	0.0019
Dissolved oxygen	(See Table 3.2)	(See Table 3.2)
Endosulfan	0.22	0.056
Endrin	0.18	0.0023
Guthion	---	0.01
Heptachlor	0.52	0.0038
Hexachlorocyclohexane	2.0	0.080
Hydrogen sulfide	---	2.0
Iron (soluble)	---	---
Kepone	---	0
Lead	$e^{(1.273[\ln(\text{hardness})]+1.460)}$	$e^{(1.273[\ln(\text{hardness})]-4.705)}$
Manganese	---	---
Mercury	2.4	0.012
Nickel	$e^{(0.8460[\ln(\text{hardness})]+3.3612)}$	$e^{(0.8460[\ln(\text{hardness})]+1.1645)}$
Parathion	0.065	0.013
PCB's (each)	---	0.014
Pentachlorophenol	$e^{(1.005[\ln(\text{hardness})]-4.830)}$	$e^{(1.005[\ln(\text{hardness})]-5.290)}$
pH	(See Table 3.2)	(See Table 3.2)
Selenium	20	5.0
Silver	$e^{(1.72[\ln(\text{hardness})]-6.52)}$	---
Temperature	(See Table 3.2)	(See Table 3.2)
Toxaphene	0.73	0.0002
Zinc	$e^{(0.8473[\ln(\text{hardness})]0.8604)}$	$e^{(0.8473[\ln(\text{hardness})]+0.7614)}$

[1] An adverse effect that usually occurs shortly after the introduction of a pollutant. Lethality to an organism is the usual measure of acute toxicity. Where death is not easily detected, immobilization is considered equivalent to death.

[2] An adverse effect that is irreversible or progressive or occurs because the rate of injury is greater than the rate of growth.



POUND RIVER

ORIG. GROUND 1959 ▬

RESURVEY - 1974 ◆

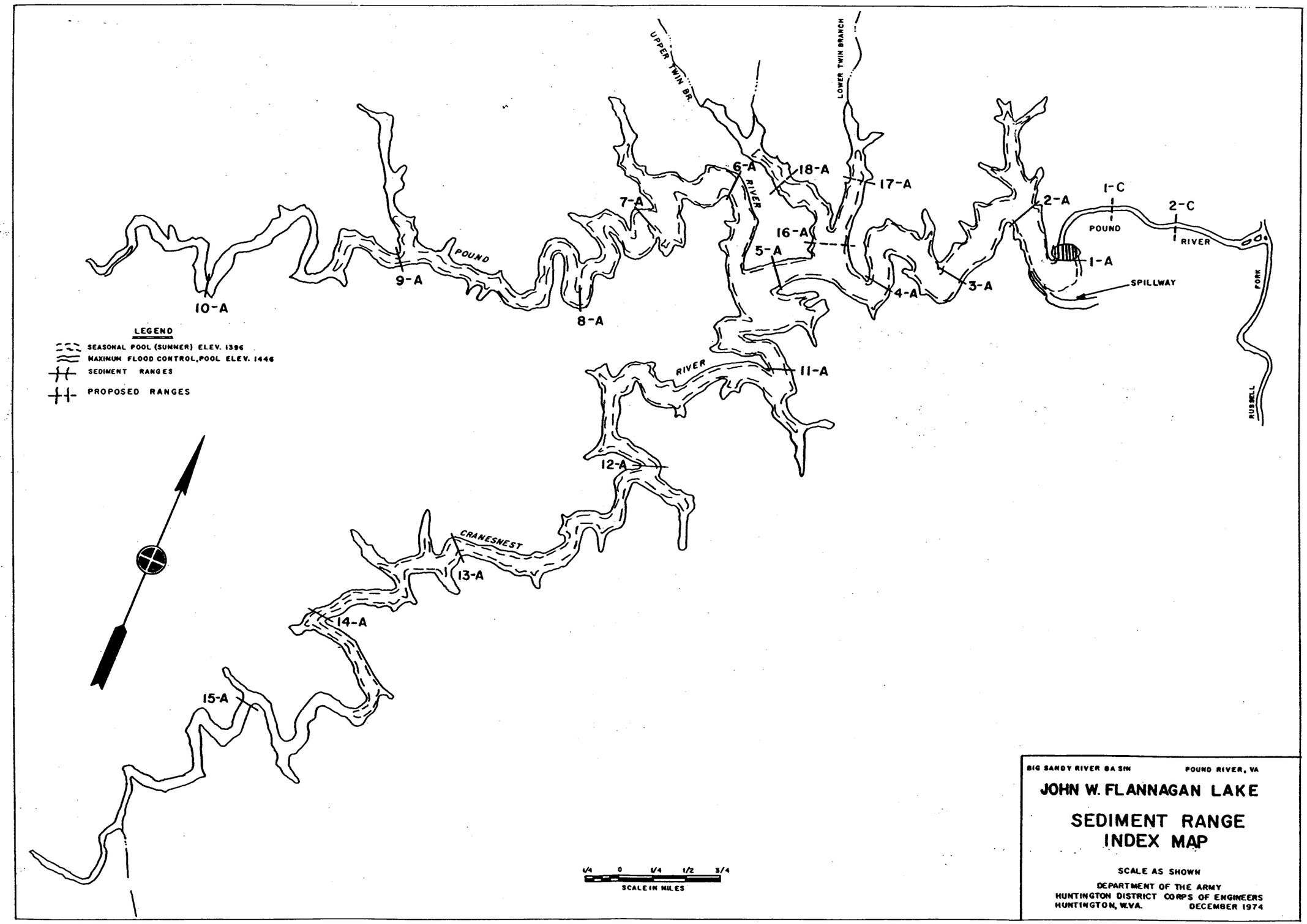
RESURVEY - 1994 ■

BIG SANDY RIVER BASIN
POUND RIVER, VIRGINIA

J.W. FLANNAGAN LAKE
SEDIMENT RANGE
BOTTOM PROFILE

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT CORPS. OF ENGINEERS
HUNTINGTON, WV AUGUST 1995

Plate No. 5-5



BIG SANDY RIVER BASIN POUND RIVER, VA

JOHN W. FLANNAGAN LAKE

SEDIMENT RANGE INDEX MAP

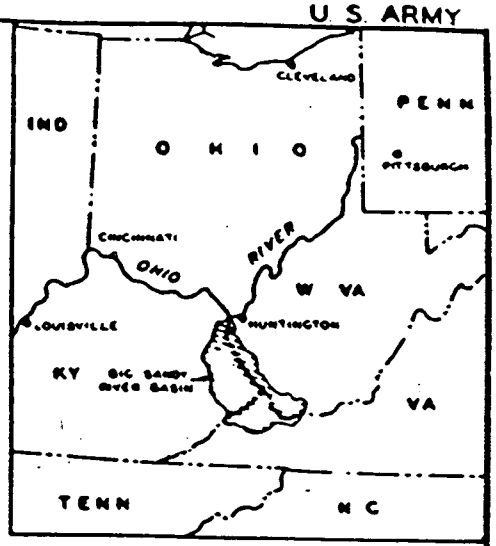
SCALE AS SHOWN

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT CORPS OF ENGINEERS
HUNTINGTON, W.VA. DECEMBER 1974

Plate No. 5-6

CORPS OF ENGINEERS

U S ARMY



VICINITY MAP

SCALE IN MILES

YATESVILLE RESERVOIR

PAINTSVILLE RESERVOIR

PRESTONSBURG LOCAL BACKWATER PROTECTION PROJECT

DEWEY RESERVOIR

WILLIAMSON LOCAL PROTECTION PROJECT

FISHTRAP RESERVOIR

NORTH FORK RESERVOIR

JOHN W. FLANNAGAN (POUND) RESERVOIR

HAYSI RESERVOIR INACTIVE

HAYSI ALTERNATE RESERVOIR SITE

LEGEND

- EXISTING RESERVOIR
- COMPLETED PROJECTS
- PROPOSED PROJECTS
- AUTHORIZED PROJECTS

BIG SANDY RIVER

TUG AND LEVISA FORKS - KY, W VA, VA

FORECAST AREA AND REACHES

SCALE IN MILES

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

JUNE 1986

Plate No. 6-1

NORTH FORK OF POUND LAKE - POUND RIVER BASIN

RUSSELL FORK - UPPER LEVISA FORK

BASIN CONFIGURATION

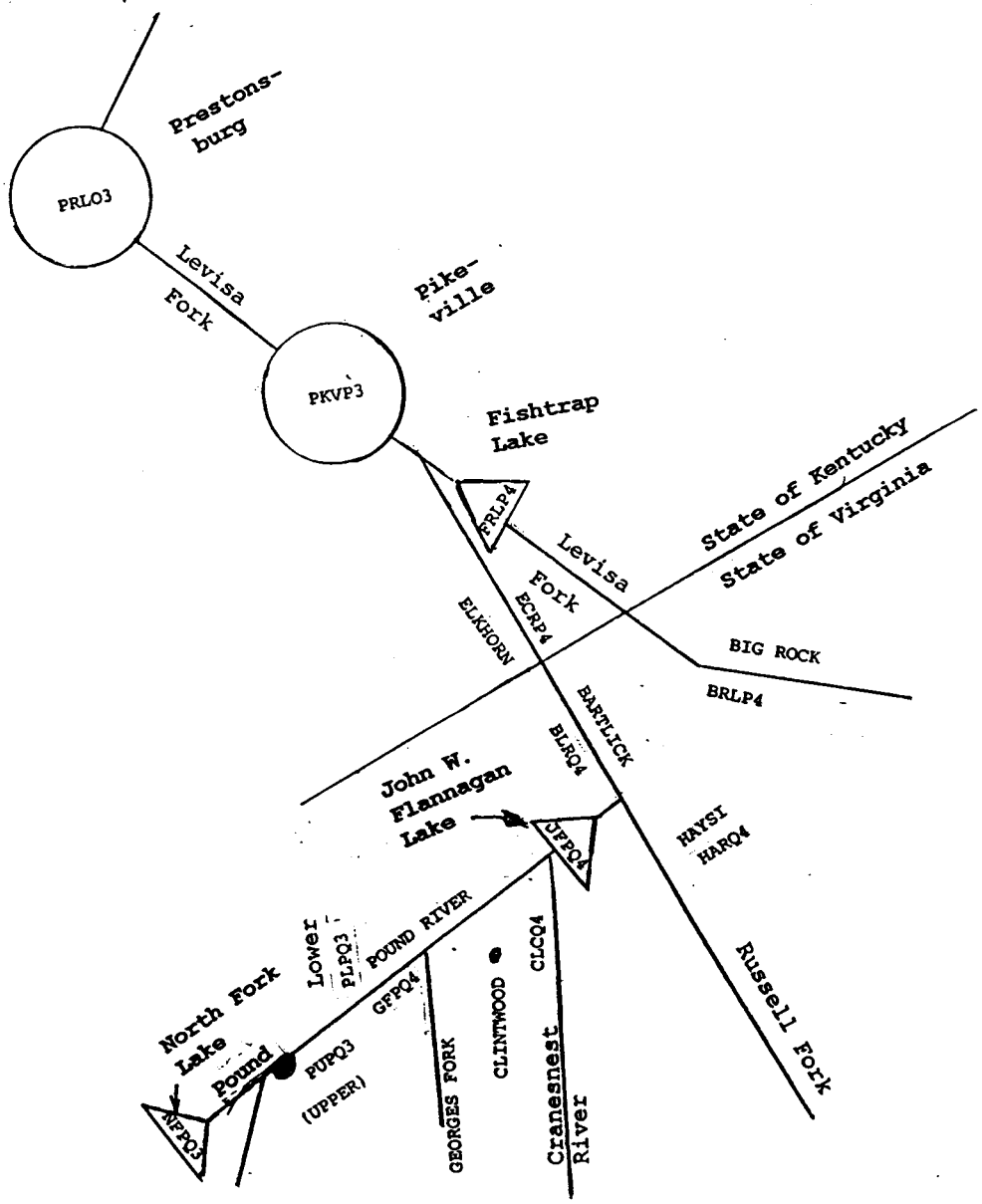
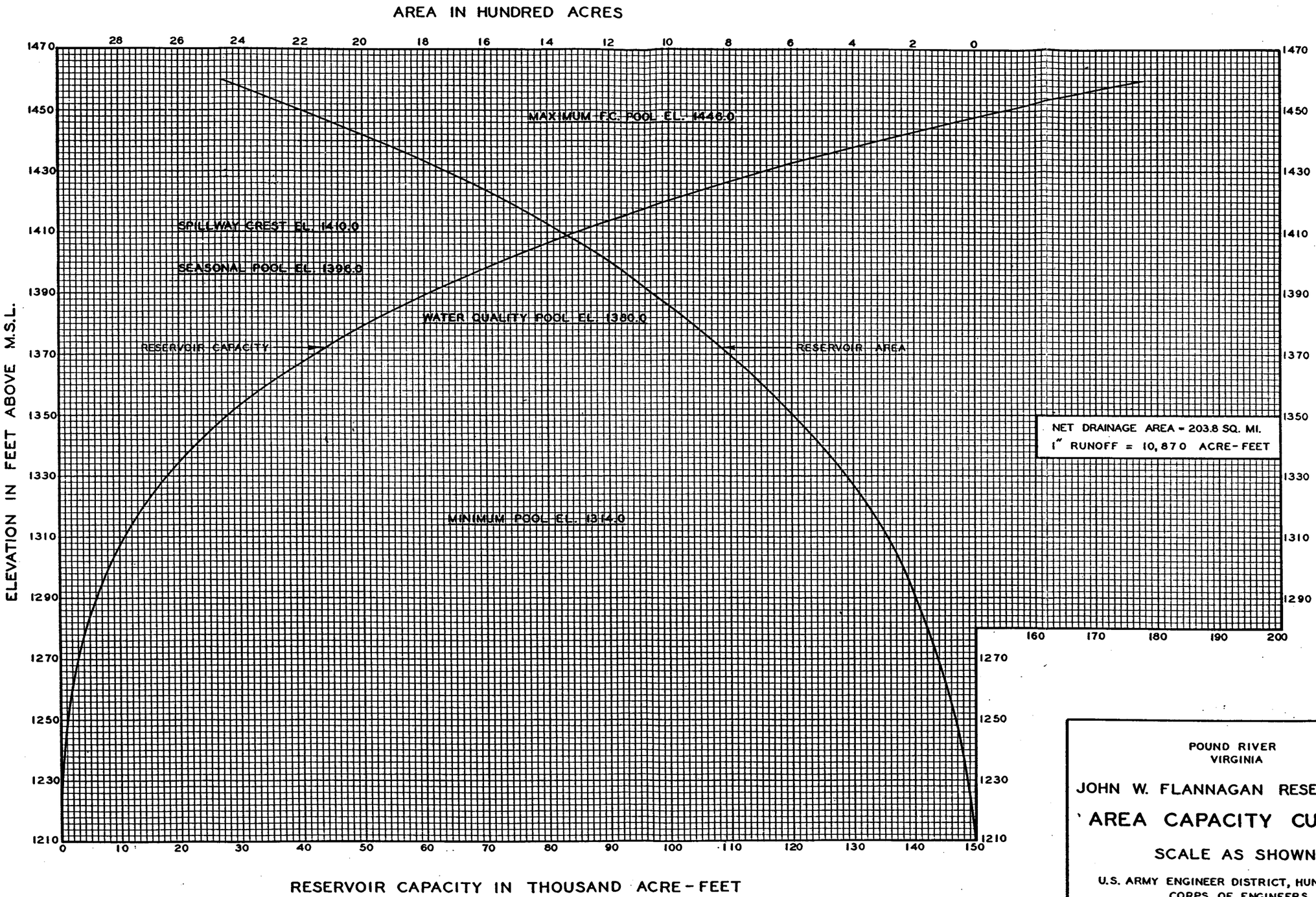


Plate No. 6-2

CORPS OF ENGINEERS

U.S. ARMY



POUND RIVER
VIRGINIA

JOHN W. FLANNAGAN RESERVOIR

AREA CAPACITY CURVES

SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, HUNTINGTON
CORPS OF ENGINEERS
HUNTINGTON, W.VA. MARCH 1964
REVISED NOV. 1967

Plate No. 7-2

JOHN W. FLANNAGAN RESERVOIR
POUND RIVER
AREA AND CAPACITY TABLES

NET DRAINAGE AREA = 203.8 SQ. MI. 1 IN. RUNOFF = 10,870 AC. FT.

POOL EL.	CAPACITY		AREA ACRES	POOL EL.	CAPACITY		AREA ACRES
	AC. FT.	INCHES			AC. FT.	INCHES	
1,210	0	0	0	1,250	1,131	0.10	64
1,211	0	0	0	1,251	1,196	0.11	67
1,212	0	0	0	1,252	1,264	0.12	69
1,213	14	0	1	1,253	1,335	0.12	72
1,214	25	0	2	1,254	1,408	0.13	74
1,215	38	0	4	1,255	1,483	0.14	77
1,216	49	0	5	1,256	1,562	0.14	80
1,217	61	0.01	6	1,257	1,642	0.15	82
1,218	73	0.01	7	1,258	1,726	0.16	85
1,219	85	0.01	9	1,259	1,812	0.17	88
1,220	97	0.01	10	1,260	1,901	0.17	90
1,221	109	0.01	11	1,261	1,993	0.18	93
1,222	123	0.01	13	1,262	2,088	0.19	96
1,223	137	0.01	14	1,263	2,186	0.20	99
1,224	153	0.01	16	1,264	2,286	0.21	102
1,225	169	0.02	17	1,265	2,390	0.22	105
1,226	187	0.02	18	1,266	2,497	0.23	108
1,227	206	0.02	20	1,267	2,606	0.24	111
1,228	227	0.02	21	1,268	2,719	0.25	114
1,229	249	0.02	23	1,269	2,835	0.26	117
1,230	273	0.03	24	1,270	2,954	0.27	121
1,231	298	0.03	26	1,271	3,076	0.28	124
1,232	324	0.03	27	1,272	3,202	0.29	127
1,233	353	0.03	29	1,273	3,331	0.31	131
1,234	383	0.04	31	1,274	3,463	0.32	134
1,235	414	0.04	33	1,275	3,599	0.33	137
1,236	448	0.04	34	1,276	3,738	0.34	141
1,237	483	0.04	36	1,277	3,881	0.36	144
1,238	520	0.05	38	1,278	4,027	0.37	148
1,239	560	0.05	40	1,279	4,176	0.38	151
1,240	601	0.06	42	1,280	4,329	0.40	155
1,241	644	0.06	44	1,281	4,485	0.41	158
1,242	689	0.06	46	1,282	4,646	0.43	162
1,243	737	0.07	48	1,283	4,809	0.44	166
1,244	786	0.07	51	1,284	4,977	0.46	169
1,245	838	0.08	53	1,285	5,148	0.47	173
1,246	892	0.08	55	1,286	5,323	0.49	177
1,247	948	0.09	57	1,287	5,501	0.51	181
1,248	1,007	0.09	60	1,288	5,684	0.52	184
1,249	1,067	0.10	62	1,289	5,870	0.54	188

JOHN W. FLANNAGAN RESERVOIR
POUND RIVER
AREA AND CAPACITY TABLES

NET DRAINAGE AREA = 203.8 SQ. MI. 1 IN. RUNOFF = 10,870 AC. FT.

POOL EL.	CAPACITY		AREA ACRES	POOL EL.	CAPACITY		AREA ACRES
	AC. FT.	INCHES			AC. FT.	INCHES	
1,290	6,061	0.56	192	1,330	17,789	1.64	419
1,291	6,255	0.58	196	1,331	18,212	1.68	427
1,292	6,454	0.59	201	1,332	18,642	1.72	435
1,293	6,656	0.61	205	1,333	19,082	1.76	443
1,294	6,863	0.63	209	1,334	19,529	1.80	452
1,295	7,075	0.65	213	1,335	19,985	1.84	460
1,296	7,291	0.67	218	1,336	20,450	1.88	469
1,297	7,511	0.69	222	1,337	20,923	1.92	478
1,298	7,735	0.71	227	1,338	21,405	1.97	486
1,299	7,965	0.73	232	1,339	21,896	2.01	495
1,300	8,199	0.75	236	1,340	22,396	2.06	504
1,301	8,438	0.78	241	1,341	22,905	2.11	513
1,302	8,681	0.80	246	1,342	23,423	2.15	523
1,303	8,930	0.82	251	1,343	23,950	2.20	532
1,304	9,183	0.84	256	1,344	24,486	2.25	541
1,305	9,442	0.87	261	1,345	25,032	2.30	551
1,306	9,705	0.89	266	1,346	25,588	2.35	560
1,307	9,974	0.92	271	1,347	26,153	2.41	570
1,308	10,248	0.94	277	1,348	26,727	2.46	579
1,309	10,527	0.97	282	1,349	27,311	2.51	589
1,310	10,812	0.99	287	1,350	27,905	2.57	599
1,311	11,102	1.02	293	1,351	28,509	2.62	609
1,312	11,398	1.05	299	1,352	29,122	2.68	618
1,313	11,699	1.08	304	1,353	29,746	2.74	628
1,314	12,006	1.10	310	1,354	30,379	2.79	638
1,315	12,319	1.13	316	1,355	31,021	2.85	648
1,316	12,638	1.16	322	1,356	31,674	2.91	658
1,317	12,963	1.19	328	1,357	32,337	2.98	668
1,318	13,294	1.22	334	1,358	33,010	3.04	678
1,319	13,631	1.25	340	1,359	33,693	3.10	688
1,320	13,974	1.29	347	1,360	34,387	3.16	699
1,321	14,324	1.32	353	1,361	35,091	3.23	709
1,322	14,681	1.35	360	1,362	35,805	3.29	720
1,323	15,044	1.38	367	1,363	36,530	3.36	730
1,324	15,414	1.42	374	1,364	37,265	3.43	741
1,325	15,791	1.45	381	1,365	38,011	3.50	751
1,326	16,176	1.49	388	1,366	38,768	3.57	762
1,327	16,567	1.52	396	1,367	39,536	3.64	773
1,328	16,967	1.56	403	1,368	40,315	3.71	785
1,329	17,374	1.60	411	1,369	41,105	3.78	796

JOHN W. FLANNAGAN RESERVOIR
POUND RIVER
AREA AND CAPACITY TABLES

NET DRAINAGE AREA = 203.8 SQ. MI. 1 IN. RUNOFF = 10,870 AC. FT.

POOL EL.	CAPACITY		AREA ACRES	POOL EL.	CAPACITY		AREA ACRES
	AC. FT.	INCHES			AC. FT.	INCHES	
1,370	41,907	3.86	807	1,410	84,566	7.78	1,356
1,371	42,720	3.93	819	1,411	85,930	7.91	1,372
1,372	43,544	4.01	830	1,412	87,310	8.03	1,388
1,373	44,380	4.08	842	1,413	88,706	8.16	1,404
1,374	45,228	4.16	854	1,414	90,118	8.29	1,421
1,375	46,087	4.24	865	1,415	91,548	8.42	1,437
1,376	46,959	4.32	878	1,416	92,993	8.56	1,454
1,377	47,842	4.40	890	1,417	94,456	8.69	1,472
1,378	48,738	4.48	902	1,418	95,937	8.83	1,489
1,379	49,646	4.57	915	1,419	97,435	8.96	1,507
WP 1,380	50,567	4.65	927	1,420	98,951	9.10	1,525
1,381	51,501	4.74	940	1,421	100,485	9.24	1,543
1,382	52,447	4.83	953	1,422	102,038	9.39	1,562
1,383	53,406	4.91	965	1,423	103,609	9.53	1,581
1,384	54,378	5.00	978	1,424	105,199	9.68	1,600
1,385	55,363	5.09	991	1,425	106,809	9.83	1,619
1,386	56,361	5.19	1,005	1,426	108,438	9.98	1,639
1,387	57,372	5.28	1,018	1,427	110,087	10.13	1,660
1,388	58,397	5.37	1,031	1,428	111,758	10.28	1,681
1,389	59,435	5.47	1,045	1,429	113,449	10.44	1,702
1,390	60,487	5.56	1,059	1,430	115,162	10.59	1,724
1,391	61,553	5.66	1,073	1,431	116,897	10.75	1,745
1,392	62,632	5.76	1,086	1,432	118,653	10.92	1,767
1,393	63,726	5.86	1,100	1,433	120,432	11.08	1,790
1,394	64,833	5.96	1,115	1,434	122,233	11.25	1,812
1,395	65,955	6.07	1,129	1,435	124,056	11.41	1,835
SP 1,396	67,091	6.17	1,143	1,436	125,902	11.58	1,858
1,397	68,242	6.28	1,158	1,437	127,772	11.76	1,881
1,398	69,408	6.39	1,173	1,438	129,665	11.93	1,905
1,399	70,588	6.49	1,188	1,439	131,582	12.11	1,929
1,400	71,783	6.60	1,203	1,440	133,522	12.28	1,953
1,401	72,993	6.72	1,217	1,441	135,487	12.46	1,977
1,402	74,218	6.83	1,232	1,442	137,475	12.65	2,001
1,403	75,458	6.94	1,247	1,443	139,488	12.83	2,025
1,404	76,713	7.06	1,262	1,444	141,525	13.02	2,049
1,405	77,983	7.17	1,278	1,445	143,587	13.21	2,074
1,406	79,268	7.29	1,293	1,446	145,673 FSP	13.40	2,098
1,407	80,569	7.41	1,309	1,447	147,784	13.60	2,123
1,408	81,886	7.53	1,324	1,448	149,919	13.79	2,148
1,409	83,218	7.66	1,340	1,449	152,080	13.99	2,173

JOHN W. FLANNAGAN RESERVOIR
POUND RIVER
AREA AND CAPACITY TABLES

NET DRAINAGE AREA = 203.8 SQ. MI. 1 IN. RUNOFF = 10,870 AC. FT.

POOL EL.	CAPACITY		AREA ACRES	POOL EL.	CAPACITY		AREA ACRES
	AC. FT.	INCHES			AC. FT.	INCHES	
1,450	154,266	14.19	2,198				
1,451	156,477	14.40	2,224				
1,452	158,714	14.60	2,249				
1,453	160,976	14.81	2,275				
1,454	163,263	15.02	2,300				
1,455	165,576	15.23	2,324				
1,456	167,915	15.45	2,352				
1,457	170,280	15.67	2,378				
1,458	172,670	15.89	2,404				
1,459	175,088	16.11	2,430				
1,460	177,532	16.33	2,457				

Plate No. 7-3

DISCHARGE IN HUNDRED C.F.S.

0 4 8 12 16 20 24 28 32 36

1460 1440 1420 1400 1380 1360 1340 1320 1300

POOL ELEVATION IN FEET ABOVE M.S.L.

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
FULL GATE OPENING

TOP OF DAM - ELEVATION 1460.0

SPILLWAY CREST ELEVATION 1410.0

SEASONAL POOL ELEVATION 1396.0

WATER QUALITY POOL ELEVATION 1380.0

MINIMUM POOL ELEVATION 1314.0

NOTES:
1. 2-4'X8.5' GATES
2. DISCHARGES SHOWN REPRESENT FLOW FOR ONE GATE. IF TWO GATES ARE OPEN, DOUBLE THE DISCHARGES SHOWN

DISCHARGE IN HUNDRED C.F.S.

POUND RIVER
VIRGINIA

JOHN W. FLANNAGAN
RESERVOIR PROJECT

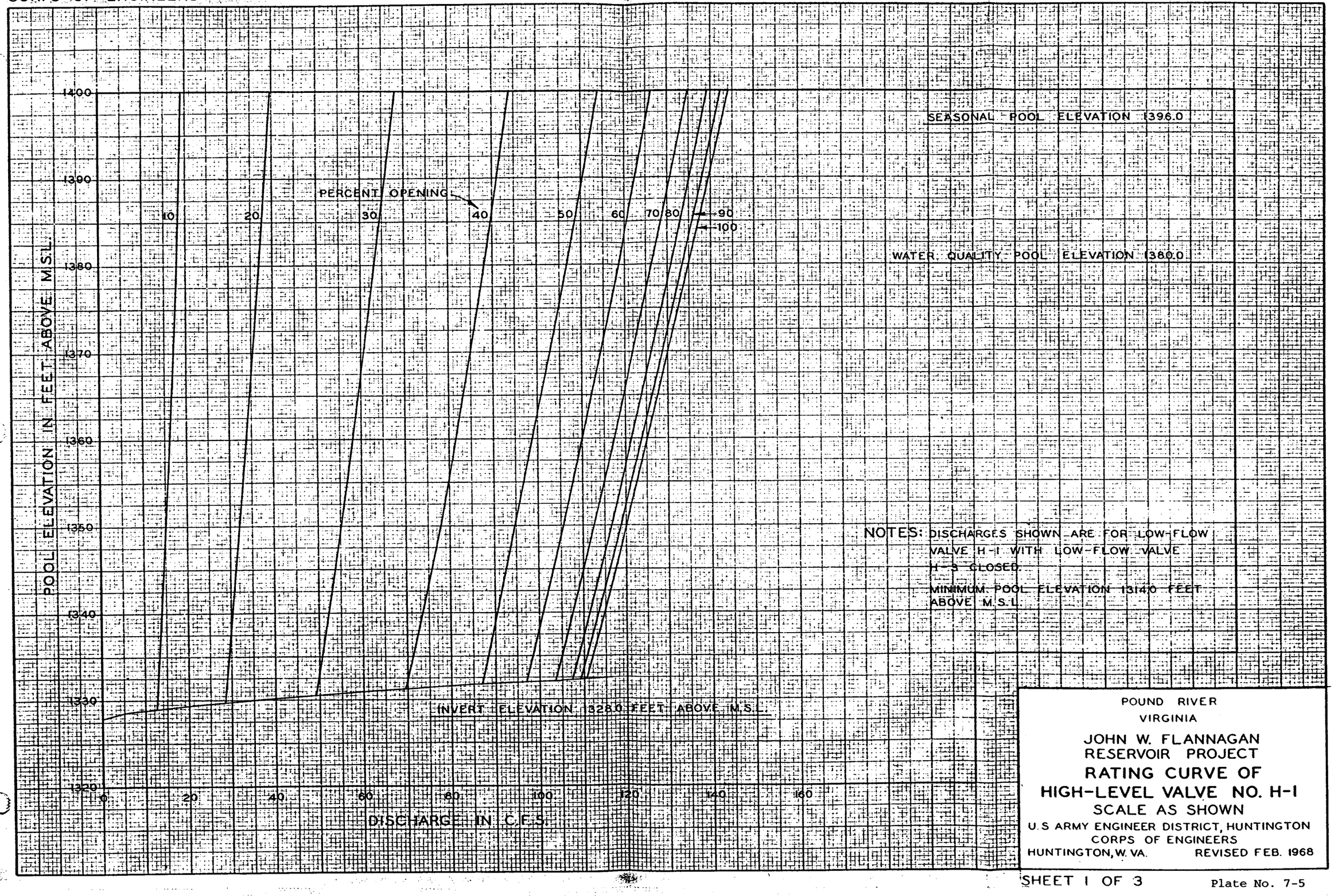
SLIDE GATE RATING CURVES ONE GATE - PARTIAL OPENINGS

SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, HUNTINGTON
CORPS OF ENGINEERS
HUNTINGTON, W. VA. REVISED JAN. 1968

Plate No. 7-4

CORPS OF ENGINEERS U.S. ARMY



NOTES: DISCHARGES SHOWN ARE FOR LOW-FLOW VALVE H-1 WITH LOW-FLOW VALVE H-3 CLOSED.

MINIMUM POOL ELEVATION 1314.0 FEET ABOVE M.S.L.

POUND RIVER
VIRGINIA

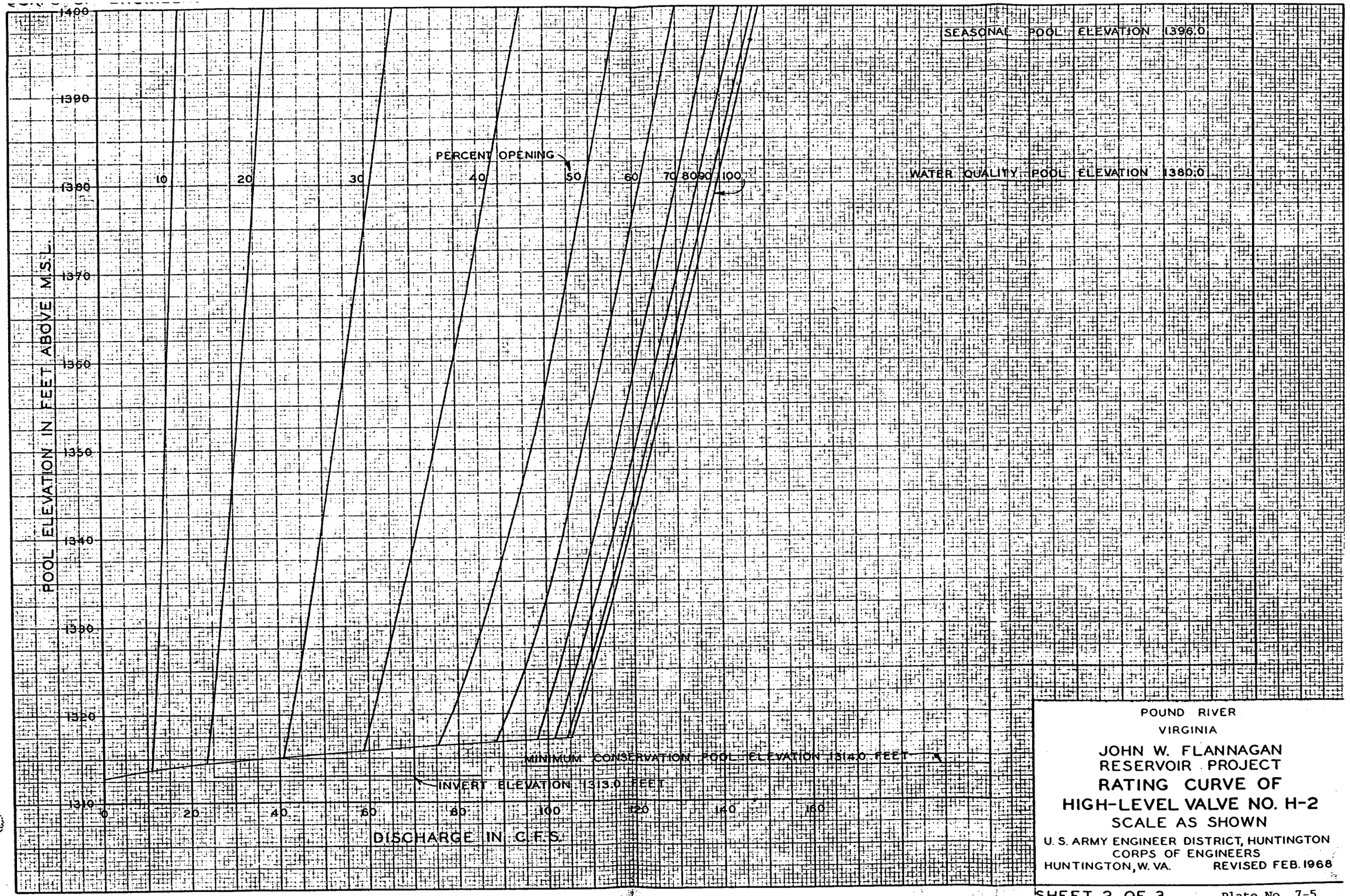
JOHN W. FLANNAGAN
RESERVOIR PROJECT

RATING CURVE OF HIGH-LEVEL VALVE NO. H-1

SCALE AS SHOWN

U.S ARMY ENGINEER DISTRICT, HUNTINGTON
CORPS OF ENGINEERS
HUNTINGTON, W. VA. REVISED FEB. 1968

SHEET 1 OF 3 Plate No. 7-5



POUND RIVER

VIRGINIA

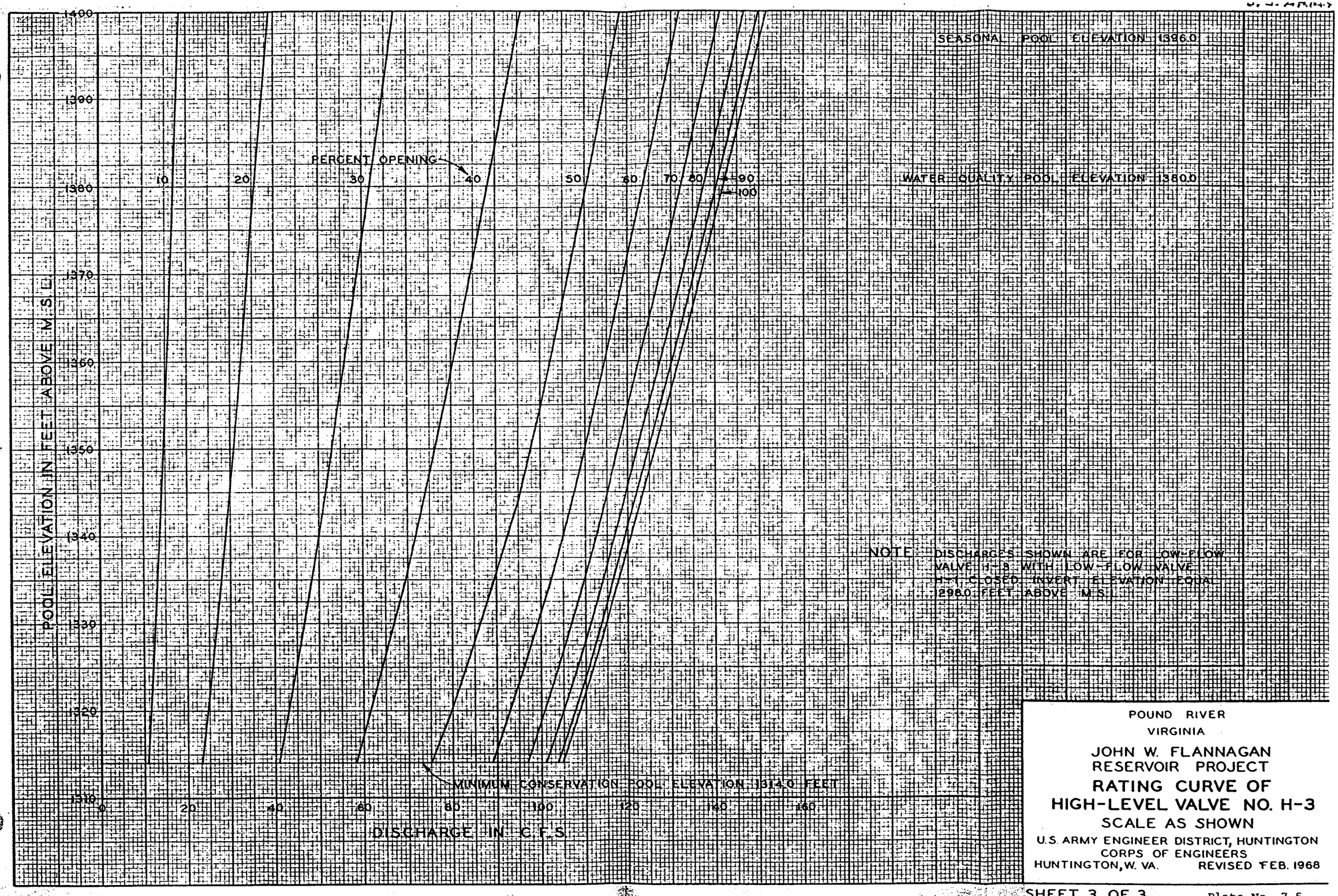
JOHN W. FLANNAGAN
RESERVOIR PROJECT

RATING CURVE OF HIGH-LEVEL VALVE NO. H-2

SCALE AS SHOWN

U. S. ARMY ENGINEER DISTRICT, HUNTINGTON
CORPS OF ENGINEERS
HUNTINGTON, W. VA. REVISED FEB. 1968

SHEET 2 OF 3 Plate No. 7-5



POUND RIVER
VIRGINIA

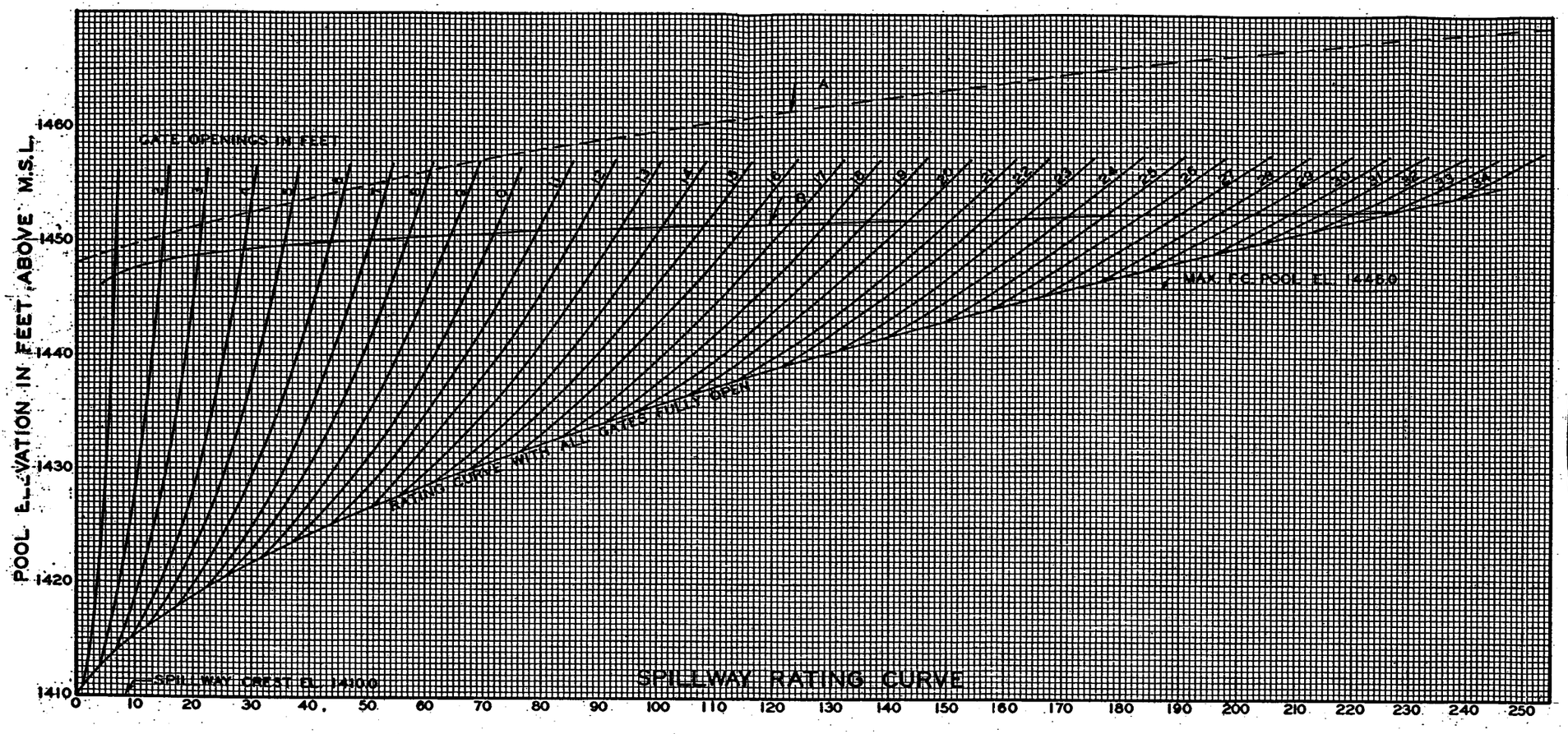
JOHN W. FLANNAGAN
RESERVOIR PROJECT

RATING CURVE OF HIGH-LEVEL VALVE NO. H-3

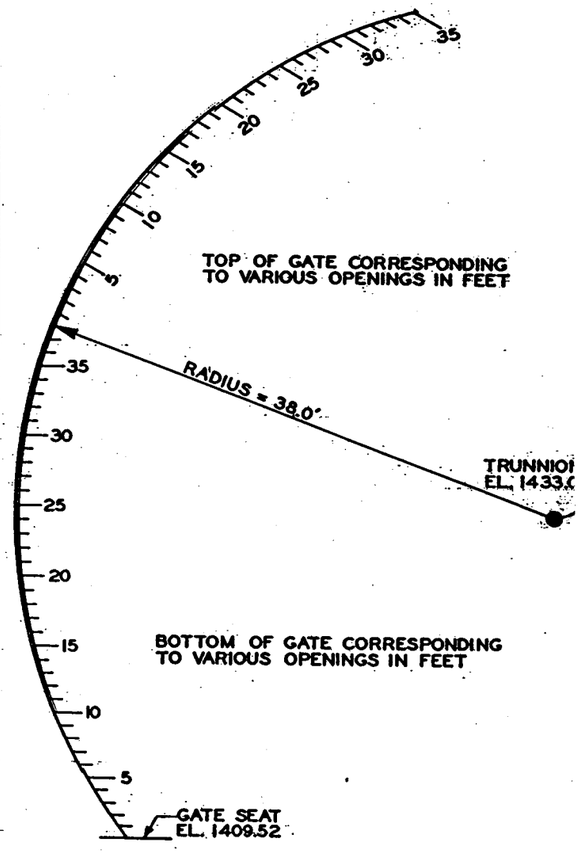
SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, HUNTINGTON
CORPS OF ENGINEERS
HUNTINGTON, W. VA. REVISED FEB. 1968

SHEET 3 OF 3 Plate No. 7-5



SPILLWAY RATING CURVE



TAINTER GATE DIAGRAM

NOTES

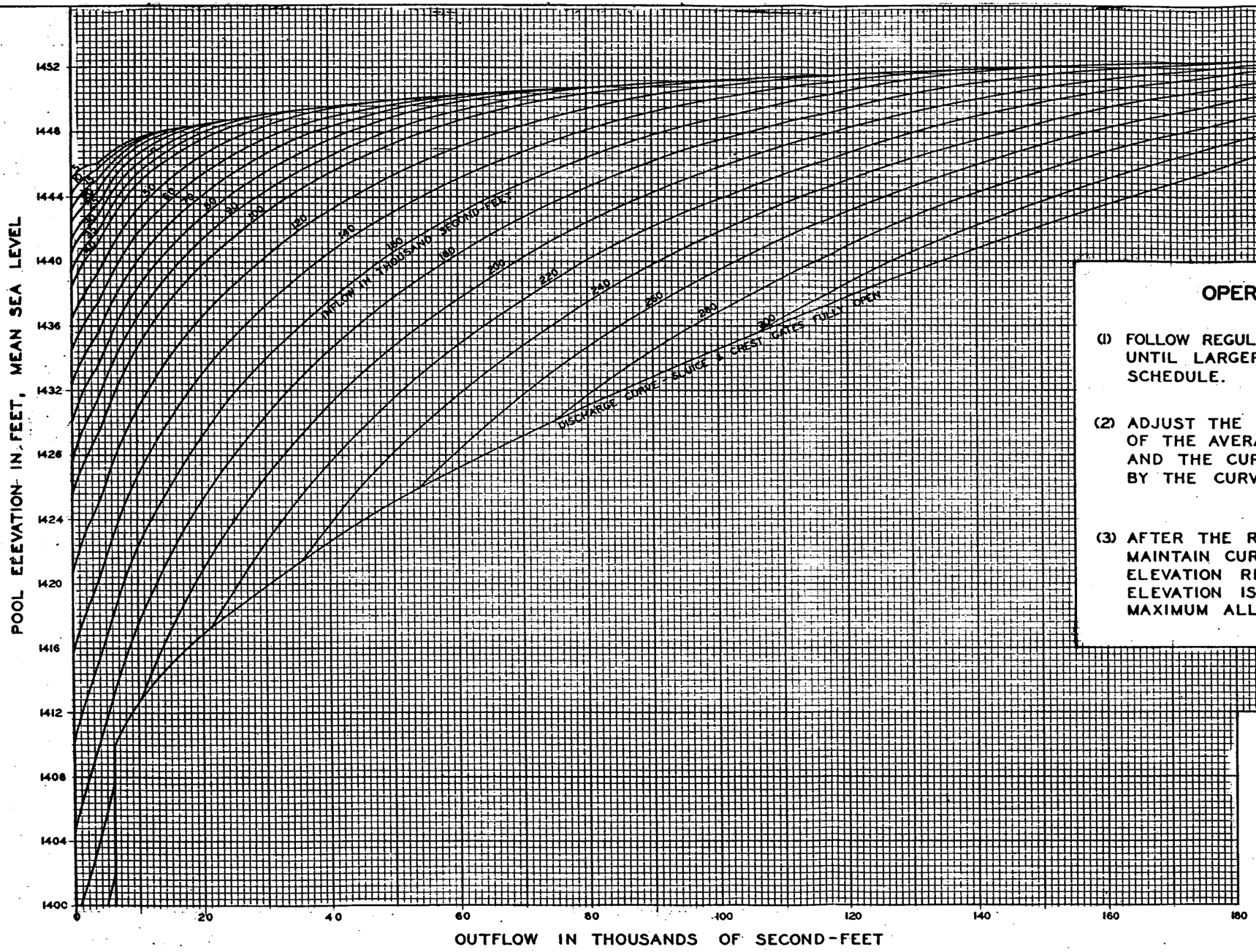
SPILLWAY CONTROLLED BY 6 - 42' X 38' TAINTER GATES. (2 FT. FREEBOARD)
ALL GATES ARE ASSUMED TO OPEN UNIFORMLY.
CURVE "A" REPRESENTS THE TOP OF GATES AT VARIOUS OPENINGS
CURVE "B" REPRESENTS A LIMITING RELATION OF GATE OPENING AND RESERVOIR LEVEL.
CURVES OF PARTIAL GATE OPENINGS WERE COMPUTED USING HYDRAULIC DESIGN CHARTS 311-1 TO 311-5, INCLUSIVE. WITH APPLICABLE FLOWS MODIFIED DUE TO HIGH TAILWATER. ADDITIONAL FRICTION AND BEND LOSSES BETWEEN SPILLWAY STRUCTURE AND POOL HAVE BEEN ADDED.

POUND RIVER
VIRGINIA

FLANNAGAN RESERVOIR PROJECT

RATING CURVES
GATED SPILLWAY

U. S. ARMY ENGINEER DISTRICT, HUNTINGTON
CORPS OF ENGINEERS
HUNTINGTON, W. VA. SEPTEMBER 1963



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 1,446. WHEN RESERVOIR ELEVATION IS BELOW 1,446, RELEASE AT THE MAXIMUM ALLOWABLE RATE.

POUND RIVER
VIRGINIA

JOHN W. FLANNAGAN RESERVOIR PROJECT

SPILLWAY GATE REGULATION SCHEDULE

SCALE AS SHOWN

U. S. ARMY ENGINEER DISTRICT, HUNTINGTON
CORPS OF ENGINEERS
HUNTINGTON, W.VA. MAY 1968

Plate No. 7-7

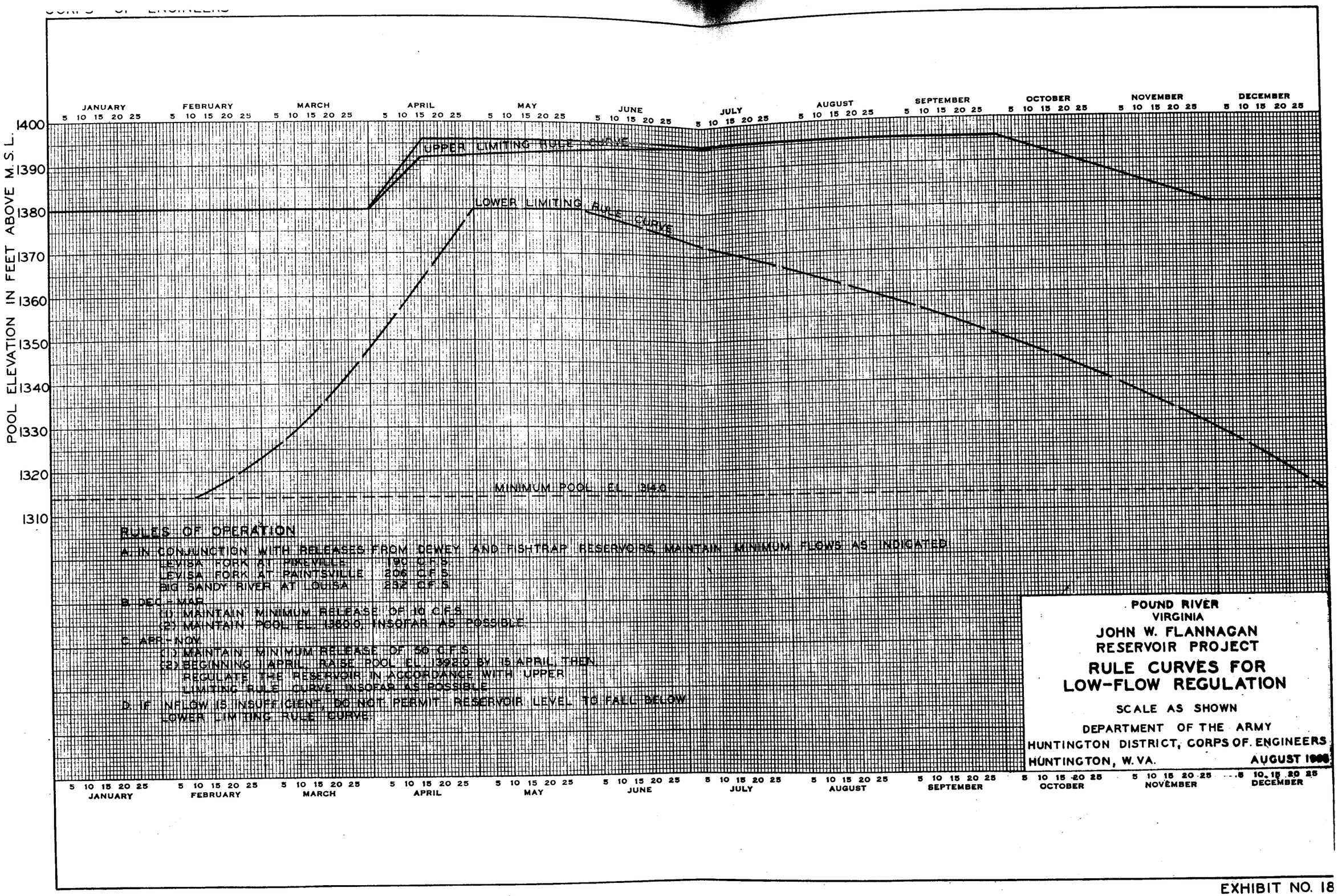


EXHIBIT NO. 18

MAXIMUM PROBABLE STORM RAINFALL - 48 HR. DURATION

JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
12.5"	12.2"	13.4"	15.4"	17.9"	21.0"	25.4"	25.5"	24.9"	23.9"	18.9"	14.6"

MAXIMUM FLOOD CONTROL POOL EL. 1446.9 - 13.40" RUNOFF

SEASONAL POOL EL. 1396.0 + 6.17" RUNOFF

UPPER LIMITING RULE CURVE

LOWER LIMITING RULE CURVE

WATER - QUALITY CONTROL POOL - EL. 1380.0 + 4.65" RUNOFF

MINIMUM POOL - EL. 1340 + 1.10" RUNOFF

POOL ELEVATION IN FEET ABOVE M.S.L.

1440, 1430, 1420, 1410, 1400, 1390, 1380, 1370, 1360, 1350, 1340, 1330, 1320, 1310

5 10 15 20 25 JANUARY | FEBRUARY | MARCH | APRIL | MAY | JUNE | JULY | AUGUST | SEPTEMBER

NOTES:

(1) (NET) DRAINAGE AREA = 263.6 SQUARE MILES

(2) 1" RUNOFF = 10,570 ACRE FEET

(3) POOL ELEVATIONS COMPUTED FROM OBSERVED DATA FROM JULY 1928 TO OCTOBER 1958 ADJUSTED FOR EFFECT OF NORTH FORK OF POUND RESERVOIR

(4) ⊕55 - CREST POOL ELEVATION OF A RISE AND YEAR (1955) IN WHICH IT OCCURRED

POUND RIVER
VIRGINIA

JOHN W. FLANNAGAN
RESERVOIR PROJECT

RESERVOIR UTILIZATION ENVELOPE FLOOD CONTROL, LOW FLOW AND SEASONAL POOL

SCALE AS SHOWN

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.VA. MARCH 1968

EXHIBIT NO. 19

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

03209000 JEBK

EXPANDED RATING TABLE

TYPE: LOG

POUND RIVER BELOW FLANNAGAN DAM NEAR HAYSI, VA

DATE PROCESSED: 03-14-1994 @ 09:55 BY HDWILLIA

OFFSET: 1.30

DD: 2 TYPE: 001 RATING NO: 8.0

START DATE/TIME: 12-02-85 (0001)

BASED ON ___4___ DISCHARGE MEASUREMENTS, NOS 2/8 220-222, AND Previous Curve, AND IS _____ WELL DEFINED BETWEEN __10__ AND 4000 CFS

COMP BY WEH DATE 2-18-87 CHK. BY HGH DATE 2-14-87

1200

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
1.40	.060*	.082	.109	.141	.180	.225	.278	.338	.407	.486	.514
1.50	.574	.673	.784	.906	1.041	1.189	1.351	1.528	1.720	1.928	1.580
1.60	2.154	2.397	2.658	2.938	3.238	3.559	3.901	4.266	4.653	5.064	3.346
1.70	5.500*	5.968	6.463	6.985	7.537	8.118	8.730	9.373	10.05	10.76	6.000
1.80	11.50*	12.28	13.09	13.94	14.83	15.75	16.72	17.73	18.78	19.87	9.500
1.90	21.00*	22.04	23.12	24.23	25.37	26.55	27.77	29.02	30.31	31.64	12.00
2.00	33.00*	34.34	35.71	37.12	38.57	40.05	41.57	43.12	44.71	46.34	15.00
2.10	48.00*	49.56	51.15	52.77	54.42	56.11	57.82	59.57	61.35	63.16	17.00
2.20	65.00*	66.69	68.40	70.14	71.90	73.69	75.50	77.34	79.20	81.09	18.00
2.30	83.00*	84.81	86.63	88.48	90.35	92.24	94.15	96.08	98.03	100.0	19.00
2.40	102.0*	104.1	106.2	108.3	110.5	112.7	114.9	117.1	119.4	121.7	22.00
2.50	124.0*	126.3	128.6	131.0	133.3	135.7	138.1	140.6	143.0	145.5	24.00
2.60	148.0*	150.5	153.0	155.6	158.1	160.7	163.3	166.0	168.6	171.3	26.00
2.70	174.0*	176.5	179.1	181.6	184.2	186.8	189.4	192.0	194.7	197.3	26.00
2.80	200.0*	203.0	206.0	209.0	212.1	215.2	218.3	221.4	224.6	227.8	31.00
2.90	231.0	234.2	237.5	240.7	244.1	247.4	250.7	254.1	257.5	261.0	33.40
3.00	264.4	267.9	271.4	275.0	278.5	282.1	285.7	289.3	293.0	296.7	36.00
3.10	300.4	304.1	307.9	311.7	315.5	319.3	323.2	327.1	331.0	334.9	38.50
3.20	338.9	342.9	346.9	351.0	355.0	359.1	363.3	367.4	371.6	375.8	41.10
3.30	380.0*	383.9	387.8	391.8	395.8	399.7	403.8	407.8	411.8	415.9	40.00
3.40	420.0*	424.2	428.5	432.7	437.0	441.3	445.7	450.0	454.4	458.8	43.20
3.50	463.2	467.7	472.1	476.6	481.1	485.7	490.2	494.8	499.4	504.0	45.50
3.60	508.7	513.3	518.0	522.7	527.5	532.2	537.0	541.8	546.6	551.5	47.70
3.70	556.4	561.2	566.2	571.1	576.1	581.0	586.0	591.1	596.1	601.2	49.90
3.80	606.3	611.4	616.5	621.7	626.9	632.1	637.3	642.6	647.9	653.2	52.20
3.90	658.5	663.8	669.2	674.6	680.0	685.4	690.9	696.4	701.9	707.4	54.40
4.00	712.9	718.5	724.1	729.7	735.4	741.0	746.7	752.4	758.1	763.9	56.80
4.10	769.7	775.5	781.3	787.1	793.0	798.9	804.8	810.7	816.7	822.7	59.00
4.20	828.7	834.7	840.8	846.8	852.9	859.1	865.2	871.4	877.6	883.8	61.30
4.30	890.0*	895.9	901.8	907.8	913.8	919.8	925.8	931.8	937.8	943.9	60.00
4.40	950.0	956.1	962.2	968.4	974.5	980.7	986.9	993.2	999.4	1006	62.00
4.50	1012	1018	1025	1031	1037	1044	1050	1056	1063	1069	64.00
4.60	1076	1082	1089	1095	1102	1109	1115	1122	1128	1135	66.00
4.70	1142	1148	1155	1162	1169	1175	1182	1189	1196	1203	67.00
4.80	1209	1216	1223	1230	1237	1244	1251	1258	1265	1272	70.00
4.90	1279	1286	1293	1300	1308	1315	1322	1329	1336	1344	72.00
5.00	1351	1358	1365	1373	1380	1387	1395	1402	1410	1417	73.00

PLATE NO. 7-8(1 OF 2)

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

03209000
POUND RIVER BELOW FLANNAGAN DAM NEAR HAYSI, VA
OFFSET: 1.30

EXPANDED RATING TABLE
DATE PROCESSED: 03-14-1994 @ 09:55 BY HDWILLIA

PAGE
TYPE: LOG

DD: 2 TYPE: 001 RATING NO: 8.0
START DATE/TIME: 12-02-85 (0001)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
5.10	1424	1432	1439	1447	1454	1462	1470	1477	1485	1492	76.00
5.20	1500*	1508	1516	1524	1532	1540	1548	1556	1564	1572	80.00
5.30	1580	1588	1596	1604	1613	1621	1629	1637	1646	1654	82.00
5.40	1662	1670	1679	1687	1696	1704	1712	1721	1729	1738	84.00
5.50	1746	1755	1764	1772	1781	1789	1798	1807	1815	1824	87.00
5.60	1833	1842	1850	1859	1868	1877	1886	1895	1904	1912	88.00
5.70	1921	1930	1939	1948	1957	1967	1976	1985	1994	2003	91.00
5.80	2012	2021	2031	2040	2049	2058	2068	2077	2086	2096	93.00
5.90	2105	2114	2124	2133	2143	2152	2162	2171	2181	2190	95.00
6.00	2200*	2209	2218	2226	2235	2244	2253	2262	2271	2280	89.00
6.10	2289	2298	2307	2316	2325	2334	2343	2352	2361	2370	90.00
6.20	2379	2388	2397	2406	2416	2425	2434	2443	2452	2462	92.00
6.30	2471	2480	2490	2499	2508	2517	2527	2536	2546	2555	93.00
6.40	2564	2574	2583	2593	2602	2612	2621	2631	2641	2650	96.00
6.50	2660	2669	2679	2689	2698	2708	2718	2727	2737	2747	96.00
6.60	2756	2766	2776	2786	2796	2805	2815	2825	2835	2845	99.00
6.70	2855	2865	2875	2885	2895	2905	2915	2925	2935	2945	100.0
6.80	2955	2965	2975	2985	2995	3006	3016	3026	3036	3046	102.0
6.90	3057	3067	3077	3087	3098	3108	3118	3129	3139	3149	103.0
7.00	3160	3170	3181	3191	3202	3212	3223	3233	3244	3254	105.0
7.10	3265	3275	3286	3296	3307	3318	3328	3339	3350	3360	106.0
7.20	3371	3382	3393	3403	3414	3425	3436	3447	3457	3468	108.0
7.30	3479	3490	3501	3512	3523	3534	3545	3556	3567	3578	110.0
7.40	3589	3600	3611	3622	3633	3644	3655	3666	3678	3689	111.0
7.50	3700*	3711	3723	3734	3745	3757	3768	3780	3791	3803	114.0
7.60	3814	3826	3837	3849	3860	3872	3884	3895	3907	3918	116.0
7.70	3930	3942	3954	3965	3977	3989	4000	4012	4024	4036	118.0
7.80	4048	4060	4071	4083	4095	4107	4119	4131	4143	4155	119.0
7.90	4167	4179	4191	4203	4215	4227	4239	4251	4263	4276	121.0
8.00	4288	4300	4312	4324	4336	4349	4361	4373	4386	4398	122.0
8.10	4410	4423	4435	4447	4460	4472	4484	4497	4509	4522	124.0
8.20	4534	4547	4559	4572	4584	4597	4610	4622	4635	4647	126.0*
8.30	4660*										

PLATE NO. 7-8(2 OF 2)

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

EXPANDED RATING TABLE TYPE: LOG

03208500
DATE PROCESSED: 03-05-1999 @ 09:29 BY bghender

RUSSELL FORK AT HAYSI, VA DD: 3 TYPE: 001 RATING NO: 20.0

OFFSET: 1.10 START DATE/TIME: 04-14-1994 (0001)

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

COMP BY _____ DATE _____ CHK. BY _____ DATE _____

SAME AS RATING NO. 19 ABOVE 3.40 FT.

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
1.80	7.800*	8.300	8.824	9.374	9.950	10.55	11.18	11.84	12.53	13.25	6.200
1.90	14.00*	14.73	15.49	16.28	17.11	17.96	18.84	19.76	20.71	21.69	8.710
2.00	22.71	23.76	24.85	25.98	27.15	28.35	29.60	30.89	32.21	33.58	12.29
2.10	35.00*	36.30	37.64	39.01	40.42	41.86	43.35	44.87	46.42	48.02	14.66
2.20	49.66	51.33	53.05	54.81	56.61	58.46	60.34	62.27	64.25	66.27	18.68
2.30	68.34	70.45	72.61	74.82	77.08	79.38	81.74	84.15	86.60	89.11	23.33
2.40	91.67	94.29	96.96	99.68	102.5	105.3	108.2	111.1	114.1	117.2	28.63
2.50	120.3	123.5	126.8	130.1	133.4	136.9	140.4	143.9	147.5	151.2	34.70
2.60	155.0*	158.8	162.7	166.6	170.7	174.8	178.9	183.1	187.4	191.8	41.30
2.70	196.3	200.8	205.4	210.1	214.8	219.7	224.6	229.6	234.6	239.8	48.70
2.80	245.0*	249.5	254.0	258.6	263.2	267.9	272.6	277.4	282.2	287.2	47.10
2.90	292.1	297.1	302.2	307.4	312.6	317.8	323.1	328.5	333.9	339.4	52.90
3.00	345.0*	350.2	355.5	360.9	366.3	371.7	377.3	382.8	388.4	394.1	54.80
3.10	399.8	405.6	411.4	417.3	423.2	429.2	435.3	441.4	447.5	453.7	60.20
3.20	460.0*	465.4	470.9	476.4	482.0	487.6	493.2	498.8	504.5	510.3	56.10
3.30	516.1	521.9	527.7	533.6	539.6	545.5	551.6	557.6	563.7	569.8	59.90
3.40	576.0*	582.2	588.5	594.8	601.1	607.5	613.9	620.4	626.9	633.5	64.00
3.50	640.0	646.7	653.3	660.0	666.8	673.6	680.4	687.3	694.2	701.1	68.10
3.60	708.1	715.2	722.3	729.4	736.5	743.7	751.0	758.3	765.6	773.0	72.30
3.70	780.4	787.8	795.3	802.9	810.5	818.1	825.8	833.5	841.2	849.0	76.50
3.80	856.9	864.7	872.7	880.6	888.6	896.7	904.8	912.9	921.1	929.3	80.70
3.90	937.6	945.9	954.3	962.7	971.1	979.6	988.2	996.8	1005	1014	85.40
4.00	1023	1032	1040	1049	1058	1067	1076	1085	1094	1103	89.00
4.10	1112	1122	1131	1140	1149	1159	1168	1178	1187	1197	94.00
4.20	1206	1216	1226	1236	1245	1255	1265	1275	1285	1295	99.00
4.30	1305	1315	1325	1336	1346	1356	1367	1377	1387	1398	104.0
4.40	1409	1419	1430	1440	1451	1462	1473	1484	1495	1506	108.0
4.50	1517	1528	1539	1550	1561	1572	1584	1595	1607	1618	113.0
4.60	1630	1641	1653	1664	1676	1688	1700	1711	1723	1735	117.0
4.70	1747	1759	1771	1784	1796	1808	1820	1833	1845	1858	123.0
4.80	1870*	1881	1892	1904	1915	1926	1937	1949	1960	1972	113.0
4.90	1983	1995	2006	2018	2029	2041	2053	2064	2076	2088	117.0
5.00	2100	2112	2123	2135	2147	2159	2171	2184	2196	2208	120.0
5.10	2220*	2232	2243	2255	2267	2278	2290	2302	2314	2326	118.0
5.20	2338	2350	2362	2374	2386	2398	2410	2422	2434	2446	120.0
5.30	2458	2471	2483	2495	2508	2520	2532	2545	2557	2570	124.0
5.40	2582	2595	2608	2620	2633	2646	2658	2671	2684	2697	127.0

PLATE NO. 7-9(1 OF 8)

EXPANDED RATING TABLE TYPE: LOG

03208500 DATE PROCESSED: 03-05-1999 @ 09:29 BY hghender

RUSSELL FORK AT HAYSI, VA DD: 3 TYPE: 001 RATING NO: 20.0

OFFSET: 1.10 START DATE/TIME: 04-14-1994 (0001)

SAME AS RATING NO. 19 ABOVE 3.40 FT.

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION)										DIFF IN Q PER TENTH FT
	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	
5.50	2709	2722	2735	2748	2761	2774	2787	2800	2813	2827	131.0
5.60	2840	2853	2866	2880	2893	2906	2920	2933	2946	2960	133.0
5.70	2973	2987	3000	3014	3028	3041	3055	3069	3082	3096	137.0
5.80	3110	3124	3138	3152	3166	3180	3194	3208	3222	3236	140.0
5.90	3250*	3263	3277	3291	3304	3318	3331	3345	3359	3372	136.0
6.00	3386	3400	3414	3427	3441	3455	3469	3483	3497	3511	139.0
6.10	3525	3539	3553	3567	3581	3596	3610	3624	3638	3652	142.0
6.20	3667	3681	3695	3710	3724	3739	3753	3768	3782	3797	144.0
6.30	3811	3826	3840	3855	3870	3884	3899	3914	3929	3944	147.0
6.40	3958	3973	3988	4003	4018	4033	4048	4063	4078	4093	150.0
6.50	4108	4124	4139	4154	4169	4184	4200	4215	4230	4246	153.0
6.60	4261	4277	4292	4308	4323	4339	4354	4370	4385	4401	156.0
6.70	4417	4432	4448	4464	4480	4496	4511	4527	4543	4559	158.0
6.80	4575	4591	4607	4623	4639	4655	4671	4688	4704	4720	161.0
6.90	4736	4752	4769	4785	4801	4818	4834	4851	4867	4883	164.0
7.00	4900*	4914	4929	4943	4957	4972	4986	5001	5015	5029	144.0
7.10	5044	5058	5073	5087	5102	5116	5131	5146	5160	5175	145.0
7.20	5189	5204	5219	5234	5248	5263	5278	5292	5307	5322	148.0
7.30	5337	5352	5367	5381	5396	5411	5426	5441	5456	5471	149.0
7.40	5486	5501	5516	5531	5546	5561	5576	5591	5606	5622	151.0
7.50	5637	5652	5667	5682	5698	5713	5728	5743	5759	5774	152.0
7.60	5789	5805	5820	5835	5851	5866	5882	5897	5912	5928	154.0
7.70	5943	5959	5974	5990	6006	6021	6037	6052	6068	6084	156.0
7.80	6099	6115	6131	6146	6162	6178	6194	6209	6225	6241	158.0
7.90	6257	6273	6289	6305	6320	6336	6352	6368	6384	6400	159.0
8.00	6416	6432	6448	6464	6480	6496	6513	6529	6545	6561	161.0
8.10	6577	6593	6610	6626	6642	6658	6675	6691	6707	6723	163.0
8.20	6740	6756	6772	6789	6805	6822	6838	6855	6871	6888	164.0
8.30	6904	6921	6937	6954	6970	6987	7003	7020	7037	7053	166.0
8.40	7070	7087	7103	7120	7137	7154	7170	7187	7204	7221	168.0
8.50	7238	7254	7271	7288	7305	7322	7339	7356	7373	7390	169.0
8.60	7407	7424	7441	7458	7475	7492	7509	7526	7543	7560	171.0
8.70	7578	7595	7612	7629	7646	7664	7681	7698	7716	7733	172.0
8.80	7750	7767	7785	7802	7820	7837	7854	7872	7889	7907	174.0
8.90	7924	7942	7959	7977	7994	8012	8030	8047	8065	8082	176.0
9.00	8100*	8116	8132	8148	8164	8180	8196	8212	8228	8244	160.0
9.10	8260	8276	8292	8308	8324	8340	8356	8372	8388	8405	161.0
9.20	8421	8437	8453	8469	8485	8502	8518	8534	8550	8566	162.0

PLATE NO. 7-9(2 OF 8)

EXPANDED RATING TABLE TYPE: LOG

03208500
DATE PROCESSED: 03-05-1999 @ 09:29 BY bghender

RUSSELL FORK AT HAYSI, VA DD: 3 TYPE: 001 RATING NO: 20.0

OFFSET: 1.10 START DATE/TIME: 04-14-1994 (0001)

SAME AS RATING NO. 19 ABOVE 3.40 FT.

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
9.30	8583	8599	8615	8632	8648	8664	8680	8697	8713	8729	163.0
9.40	8746	8762	8779	8795	8811	8828	8844	8861	8877	8894	164.0
9.50	8910	8926	8943	8959	8976	8992	9009	9026	9042	9059	165.0
9.60	9075	9092	9108	9125	9142	9158	9175	9192	9208	9225	167.0
9.70	9242	9258	9275	9292	9308	9325	9342	9359	9375	9392	167.0
9.80	9409	9426	9443	9459	9476	9493	9510	9527	9544	9561	169.0
9.90	9578	9594	9611	9628	9645	9662	9679	9696	9713	9730	169.0
10.00	9747	9764	9781	9798	9815	9832	9849	9866	9884	9901	171.0
10.10	9918	9935	9952	9969	9986	10000	10020	10040	10050	10070	172.0
10.20	10090	10110	10120	10140	10160	10180	10190	10210	10230	10240	170.0
10.30	10260	10280	10300	10310	10330	10350	10370	10380	10400	10420	180.0
10.40	10440	10450	10470	10490	10510	10520	10540	10560	10580	10590	170.0
10.50	10610	10630	10650	10660	10680	10700	10720	10730	10750	10770	180.0
10.60	10790	10800	10820	10840	10860	10870	10890	10910	10930	10950	170.0
10.70	10960	10980	11000	11020	11030	11050	11070	11090	11110	11120	180.0
10.80	11140	11160	11180	11190	11210	11230	11250	11270	11280	11300	180.0
10.90	11320	11340	11360	11370	11390	11410	11430	11450	11460	11480	180.0
11.00	11500*	11520	11540	11550	11570	11590	11610	11620	11640	11660	180.0
11.10	11680	11690	11710	11730	11750	11770	11780	11800	11820	11840	170.0
11.20	11850	11870	11890	11910	11930	11940	11960	11980	12000	12010	180.0
11.30	12030	12050	12070	12090	12100	12120	12140	12160	12180	12190	180.0
11.40	12210	12230	12250	12270	12280	12300	12320	12340	12360	12370	180.0
11.50	12390	12410	12430	12450	12460	12480	12500	12520	12540	12550	180.0
11.60	12570	12590	12610	12630	12650	12660	12680	12700	12720	12740	180.0
11.70	12750	12770	12790	12810	12830	12850	12860	12880	12900	12920	190.0
11.80	12940	12960	12970	12990	13010	13030	13050	13070	13080	13100	180.0
11.90	13120	13140	13160	13180	13200	13210	13230	13250	13270	13290	190.0
12.00	13310	13320	13340	13360	13380	13400	13420	13440	13450	13470	180.0
12.10	13490	13510	13530	13550	13570	13580	13600	13620	13640	13660	190.0
12.20	13680	13700	13720	13730	13750	13770	13790	13810	13830	13850	190.0
12.30	13870	13880	13900	13920	13940	13960	13980	14000	14020	14030	180.0
12.40	14050	14070	14090	14110	14130	14150	14170	14190	14200	14220	190.0
12.50	14240	14260	14280	14300	14320	14340	14360	14380	14390	14410	190.0
12.60	14430	14450	14470	14490	14510	14530	14550	14570	14580	14600	190.0
12.70	14620	14640	14660	14680	14700	14720	14740	14760	14780	14800	190.0
12.80	14810	14830	14850	14870	14890	14910	14930	14950	14970	14990	200.0
12.90	15010	15030	15050	15060	15080	15100	15120	15140	15160	15180	190.0

EXPANDED RATING TABLE TYPE: LOG

03208500
DATE PROCESSED: 03-05-1999 @ 09:29 BY hghender
RUSSELL FORK AT HAYSI, VA DD: 3 TYPE: 001 RATING NO: 20.0
OFFSET: 1.10 START DATE/TIME: 04-14-1994 (0001)

SAME AS RATING NO. 19 ABOVE 3.40 FT.

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION)										DIFF IN Q PER TENTH FT
	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	
13.00	15200*	15220	15240	15260	15280	15300	15320	15340	15360	15380	200.0
13.10	15400	15420	15440	15460	15480	15500	15520	15540	15560	15580	200.0
13.20	15600	15620	15640	15660	15680	15700	15720	15740	15760	15780	200.0
13.30	15800	15820	15840	15860	15880	15900	15920	15940	15960	15980	200.0
13.40	16000	16020	16040	16060	16080	16100	16120	16140	16160	16180	200.0
13.50	16200	16220	16240	16260	16280	16300	16320	16340	16360	16380	200.0
13.60	16400	16420	16440	16460	16480	16500	16520	16540	16560	16590	210.0
13.70	16610	16630	16650	16670	16690	16710	16730	16750	16770	16790	200.0
13.80	16810	16830	16850	16870	16890	16910	16930	16950	16970	16990	210.0
13.90	17020	17040	17060	17080	17100	17120	17140	17160	17180	17200	200.0
14.00	17220	17240	17260	17280	17300	17320	17350	17370	17390	17410	210.0
14.10	17430	17450	17470	17490	17510	17530	17550	17570	17590	17620	210.0
14.20	17640	17660	17680	17700	17720	17740	17760	17780	17800	17820	200.0
14.30	17840	17870	17890	17910	17930	17950	17970	17990	18010	18030	210.0
14.40	18050	18080	18100	18120	18140	18160	18180	18200	18220	18240	220.0
14.50	18270	18290	18310	18330	18350	18370	18390	18410	18430	18460	210.0
14.60	18480	18500	18520	18540	18560	18580	18600	18620	18650	18670	210.0
14.70	18690	18710	18730	18750	18770	18800	18820	18840	18860	18880	210.0
14.80	18900	18920	18940	18970	18990	19010	19030	19050	19070	19090	220.0
14.90	19120	19140	19160	19180	19200	19220	19240	19270	19290	19310	210.0
15.00	19330	19350	19370	19390	19420	19440	19460	19480	19500	19520	220.0
15.10	19550	19570	19590	19610	19630	19650	19680	19700	19720	19740	210.0
15.20	19760	19780	19810	19830	19850	19870	19890	19910	19940	19960	220.0
15.30	19980	20000	20020	20050	20070	20090	20110	20130	20150	20180	220.0
15.40	20200	20220	20240	20260	20290	20310	20330	20350	20370	20390	220.0
15.50	20420	20440	20460	20480	20500	20530	20550	20570	20590	20610	220.0
15.60	20640	20660	20680	20700	20720	20750	20770	20790	20810	20840	220.0
15.70	20860	20880	20900	20920	20950	20970	20990	21010	21030	21060	220.0
15.80	21080	21100	21120	21150	21170	21190	21210	21230	21260	21280	220.0
15.90	21300	21320	21350	21370	21390	21410	21430	21460	21480	21500	220.0
16.00	21520	21550	21570	21590	21610	21640	21660	21680	21700	21730	230.0
16.10	21750	21770	21790	21820	21840	21860	21880	21910	21930	21950	220.0
16.20	21970	22000	22020	22040	22060	22090	22110	22130	22150	22180	230.0
16.30	22200	22220	22240	22270	22290	22310	22330	22360	22380	22400	220.0
16.40	22420	22450	22470	22490	22520	22540	22560	22580	22610	22630	230.0
16.50	22650	22670	22700	22720	22740	22770	22790	22810	22830	22860	230.0
16.60	22880	22900	22930	22950	22970	22990	23020	23040	23060	23090	230.0
16.70	23110	23130	23150	23180	23200	23220	23250	23270	23290	23320	230.0

EXPANDED RATING TABLE TYPE: LOG

03208500
DATE PROCESSED: 03-05-1999 @ 09:29 BY hghender
RUSSELL FORK AT HAYSI, VA DD: 3 TYPE: 001 RATING NO: 20.0
OFFSET: 1.10 START DATE/TIME: 04-14-1994 (0001)

SAME AS RATING NO. 19 ABOVE 3.40 FT.

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
16.80	23340	23360	23380	23410	23430	23450	23480	23500	23520	23550	230.0
16.90	23570	23590	23610	23640	23660	23680	23710	23730	23750	23780	230.0
17.00	23800*	23820	23850	23870	23890	23910	23940	23960	23980	24010	230.0
17.10	24030	24050	24080	24100	24120	24140	24170	24190	24210	24240	230.0
17.20	24260	24280	24310	24330	24350	24370	24400	24420	24440	24470	230.0
17.30	24490	24510	24540	24560	24580	24610	24630	24650	24680	24700	230.0
17.40	24720	24740	24770	24790	24810	24840	24860	24880	24910	24930	230.0
17.50	24950	24980	25000	25020	25050	25070	25090	25120	25140	25160	240.0
17.60	25190	25210	25230	25260	25280	25300	25330	25350	25370	25400	230.0
17.70	25420	25440	25470	25490	25510	25540	25560	25580	25610	25630	240.0
17.80	25660	25680	25700	25730	25750	25770	25800	25820	25840	25870	230.0
17.90	25890	25910	25940	25960	25980	26010	26030	26060	26080	26100	240.0
18.00	26130	26150	26170	26200	26220	26240	26270	26290	26320	26340	230.0
18.10	26360	26390	26410	26430	26460	26480	26510	26530	26550	26580	240.0
18.20	26600	26620	26650	26670	26700	26720	26740	26770	26790	26820	240.0
18.30	26840	26860	26890	26910	26930	26960	26980	27010	27030	27050	240.0
18.40	27080	27100	27130	27150	27170	27200	27220	27250	27270	27290	240.0
18.50	27320	27340	27370	27390	27410	27440	27460	27490	27510	27530	240.0
18.60	27560	27580	27610	27630	27650	27680	27700	27730	27750	27780	240.0
18.70	27800	27820	27850	27870	27900	27920	27940	27970	27990	28020	240.0
18.80	28040	28070	28090	28110	28140	28160	28190	28210	28240	28260	240.0
18.90	28280	28310	28330	28360	28380	28410	28430	28450	28480	28500	250.0
19.00	28530	28550	28580	28600	28620	28650	28670	28700	28720	28750	240.0
19.10	28770	28800	28820	28840	28870	28890	28920	28940	28970	28990	250.0
19.20	29020	29040	29070	29090	29110	29140	29160	29190	29210	29240	240.0
19.30	29260	29290	29310	29340	29360	29380	29410	29430	29460	29480	250.0
19.40	29510	29530	29560	29580	29610	29630	29660	29680	29710	29730	240.0
19.50	29750	29780	29800	29830	29850	29880	29900	29930	29950	29980	250.0
19.60	30000	30030	30050	30080	30100	30130	30150	30180	30200	30230	250.0
19.70	30250	30280	30300	30330	30350	30380	30400	30420	30450	30470	250.0
19.80	30500	30520	30550	30570	30600	30620	30650	30670	30700	30720	250.0
19.90	30750	30770	30800	30820	30850	30870	30900	30920	30950	30970	250.0
20.00	31000*	31030	31060	31080	31110	31140	31170	31200	31220	31250	280.0
20.10	31280	31310	31340	31360	31390	31420	31450	31480	31500	31530	280.0
20.20	31560	31590	31620	31650	31670	31700	31730	31760	31790	31820	280.0
20.30	31840	31870	31900	31930	31960	31980	32010	32040	32070	32100	290.0
20.40	32130	32150	32180	32210	32240	32270	32300	32330	32350	32380	280.0

EXPANDED RATING TABLE TYPE: LOG

03208500
DATE PROCESSED: 03-05-1999 @ 09:29 BY hghender
RUSSELL FORK AT HAYSI, VA DD: 3 TYPE: 001 RATING NO: 20.0
OFFSET: 1.10 START DATE/TIME: 04-14-1994 (0001)

SAME AS RATING NO. 19 ABOVE 3.40 FT.

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
20.50	32410	32440	32470	32500	32520	32550	32580	32610	32640	32670	290.0
20.60	32700	32720	32750	32780	32810	32840	32870	32900	32930	32950	280.0
20.70	32980	33010	33040	33070	33100	33130	33150	33180	33210	33240	290.0
20.80	33270	33300	33330	33360	33380	33410	33440	33470	33500	33530	290.0
20.90	33560	33590	33620	33640	33670	33700	33730	33760	33790	33820	290.0
21.00	33850	33880	33910	33930	33960	33990	34020	34050	34080	34110	290.0
21.10	34140	34170	34200	34230	34250	34280	34310	34340	34370	34400	290.0
21.20	34430	34460	34490	34520	34550	34580	34600	34630	34660	34690	290.0
21.30	34720	34750	34780	34810	34840	34870	34900	34930	34960	34990	300.0
21.40	35020	35040	35070	35100	35130	35160	35190	35220	35250	35280	290.0
21.50	35310	35340	35370	35400	35430	35460	35490	35520	35550	35580	300.0
21.60	35610	35630	35660	35690	35720	35750	35780	35810	35840	35870	290.0
21.70	35900	35930	35960	35990	36020	36050	36080	36110	36140	36170	300.0
21.80	36200	36230	36260	36290	36320	36350	36380	36410	36440	36470	300.0
21.90	36500	36530	36560	36590	36620	36650	36680	36710	36740	36770	300.0
22.00	36800	36830	36860	36890	36920	36950	36980	37010	37040	37070	300.0
22.10	37100	37130	37160	37190	37220	37250	37280	37310	37340	37370	300.0
22.20	37400	37430	37460	37490	37520	37550	37580	37610	37640	37670	300.0
22.30	37700	37730	37760	37790	37820	37850	37880	37910	37950	37980	310.0
22.40	38010	38040	38070	38100	38130	38160	38190	38220	38250	38280	300.0
22.50	38310	38340	38370	38400	38430	38460	38490	38520	38560	38590	310.0
22.60	38620	38650	38680	38710	38740	38770	38800	38830	38860	38890	300.0
22.70	38920	38950	38980	39020	39050	39080	39110	39140	39170	39200	310.0
22.80	39230	39260	39290	39320	39350	39380	39420	39450	39480	39510	310.0
22.90	39540	39570	39600	39630	39660	39690	39720	39760	39790	39820	310.0
23.00	39850	39880	39910	39940	39970	40000	40040	40070	40100	40130	310.0
23.10	40160	40190	40220	40250	40280	40320	40350	40380	40410	40440	310.0
23.20	40470	40500	40530	40560	40600	40630	40660	40690	40720	40750	310.0
23.30	40780	40820	40850	40880	40910	40940	40970	41000	41030	41070	320.0
23.40	41100	41130	41160	41190	41220	41250	41290	41320	41350	41380	310.0
23.50	41410	41440	41480	41510	41540	41570	41600	41630	41660	41700	320.0
23.60	41730	41760	41790	41820	41850	41890	41920	41950	41980	42010	310.0
23.70	42040	42080	42110	42140	42170	42200	42230	42270	42300	42330	320.0
23.80	42360	42390	42430	42460	42490	42520	42550	42580	42620	42650	320.0
23.90	42680	42710	42740	42780	42810	42840	42870	42900	42940	42970	320.0
24.00	43000*	43030	43070	43100	43140	43170	43200	43240	43270	43300	340.0
24.10	43340	43370	43410	43440	43470	43510	43540	43580	43610	43640	340.0
24.20	43680	43710	43750	43780	43820	43850	43880	43920	43950	43990	340.0

EXPANDED RATING TABLE TYPE: LOG

03208500
DATE PROCESSED: 03-05-1999 @ 09:29 BY hghender

RUSSELL FORK AT HAYSI, VA DD: 3 TYPE: 001 RATING NO: 20.0

OFFSET: 1.10 START DATE/TIME: 04-14-1994 (0001)

SAME AS RATING NO. 19 ABOVE 3.40 FT.

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
24.30	44020	44050	44090	44120	44160	44190	44230	44260	44290	44330	340.0
24.40	44360	44400	44430	44470	44500	44530	44570	44600	44640	44670	350.0
24.50	44710	44740	44770	44810	44840	44880	44910	44950	44980	45020	340.0
24.60	45050	45090	45120	45150	45190	45220	45260	45290	45330	45360	350.0
24.70	45400	45430	45470	45500	45540	45570	45600	45640	45670	45710	340.0
24.80	45740	45780	45810	45850	45880	45920	45950	45990	46020	46060	350.0
24.90	46090	46130	46160	46200	46230	46270	46300	46340	46370	46410	350.0
25.00	46440	46480	46510	46550	46580	46620	46650	46690	46720	46760	350.0
25.10	46790	46830	46860	46900	46930	46970	47000	47040	47070	47110	350.0
25.20	47140	47180	47210	47250	47280	47320	47360	47390	47430	47460	360.0
25.30	47500	47530	47570	47600	47640	47670	47710	47740	47780	47820	350.0
25.40	47850	47890	47920	47960	47990	48030	48060	48100	48130	48170	360.0
25.50	48210	48240	48280	48310	48350	48380	48420	48460	48490	48530	350.0
25.60	48560	48600	48630	48670	48710	48740	48780	48810	48850	48880	360.0
25.70	48920	48960	48990	49030	49060	49100	49140	49170	49210	49240	360.0
25.80	49280	49310	49350	49390	49420	49460	49490	49530	49570	49600	360.0
25.90	49640	49670	49710	49750	49780	49820	49860	49890	49930	49960	360.0
26.00	50000*	50040	50080	50120	50150	50190	50230	50270	50310	50350	380.0
26.10	50380	50420	50460	50500	50540	50580	50620	50650	50690	50730	390.0
26.20	50770	50810	50850	50890	50930	50960	51000	51040	51080	51120	390.0
26.30	51160	51200	51240	51270	51310	51350	51390	51430	51470	51510	390.0
26.40	51550	51590	51620	51660	51700	51740	51780	51820	51860	51900	390.0
26.50	51940	51980	52020	52050	52090	52130	52170	52210	52250	52290	390.0
26.60	52330	52370	52410	52450	52490	52520	52560	52600	52640	52680	390.0
26.70	52720	52760	52800	52840	52880	52920	52960	53000	53040	53080	400.0
26.80	53120	53160	53190	53230	53270	53310	53350	53390	53430	53470	390.0
26.90	53510	53550	53590	53630	53670	53710	53750	53790	53830	53870	400.0
27.00	53910	53950	53990	54030	54070	54110	54150	54190	54230	54270	400.0
27.10	54310	54350	54390	54430	54470	54510	54550	54590	54630	54670	400.0
27.20	54710	54750	54790	54830	54870	54910	54950	54990	55030	55070	400.0
27.30	55110	55150	55190	55230	55270	55310	55350	55390	55430	55470	400.0
27.40	55510	55550	55590	55630	55670	55710	55750	55790	55840	55880	410.0
27.50	55920	55960	56000	56040	56080	56120	56160	56200	56240	56280	400.0
27.60	56320	56360	56400	56440	56480	56520	56570	56610	56650	56690	410.0
27.70	56730	56770	56810	56850	56890	56930	56970	57010	57060	57100	410.0
27.80	57140	57180	57220	57260	57300	57340	57380	57420	57460	57510	410.0
27.90	57550	57590	57630	57670	57710	57750	57790	57830	57880	57920	410.0

EXPANDED RATING TABLE TYPE: LOG

03208500
DATE PROCESSED: 03-05-1999 @ 09:29 BY hghender
RUSSELL FORK AT HAYSI, VA DD: 3 TYPE: 001 RATING NO: 20.0
OFFSET: 1.10 START DATE/TIME: 04-14-1994 (0001)

SAME AS RATING NO. 19 ABOVE 3.40 FT.

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
28.00	57960	58000	58040	58080	58120	58160	58210	58250	58290	58330	410.0
28.10	58370	58410	58450	58490	58540	58580	58620	58660	58700	58740	410.0
28.20	58780	58830	58870	58910	58950	58990	59030	59080	59120	59160	420.0*
28.30	59200*										

PLATE NO. 7-9(8 OF 8)

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

EXPANDED RATING TABLE TYPE: LOG

03209200

DATE PROCESSED: 03-05-1999 @ 09:40 BY hghender

RUSSELL FORK AT BARTLICK, VA DD: 2 TYPE: 001 RATING NO: 11.0

OFFSET: 3.00 START DATE/TIME: 03-24-1991 (0001)

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

COMP BY _____ DATE _____ CHK. BY _____ DATE _____

SAME AS RATING NO. 10 BELOW 7.50 AND ABOVE 14.10 F

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION)										DIFF IN Q PER TENTH FT
	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	
5.00	7.000*	7.110	7.222	7.335	7.449	7.564	7.681	7.798	7.917	8.037	1.159
5.10	8.159	8.281	8.405	8.530	8.657	8.784	8.913	9.043	9.175	9.308	1.283
5.20	9.442	9.577	9.714	9.852	9.991	10.13	10.27	10.42	10.56	10.71	1.418
5.30	10.86	11.00	11.15	11.31	11.46	11.61	11.77	11.93	12.09	12.25	1.550
5.40	12.41	12.57	12.74	12.90	13.07	13.24	13.41	13.58	13.75	13.93	1.690
5.50	14.10	14.28	14.46	14.64	14.82	15.01	15.19	15.38	15.57	15.76	1.850
5.60	15.95	16.15	16.34	16.54	16.74	16.94	17.14	17.34	17.54	17.75	2.010
5.70	17.96	18.17	18.38	18.59	18.81	19.02	19.24	19.46	19.68	19.91	2.170
5.80	20.13	20.36	20.59	20.82	21.05	21.28	21.52	21.75	21.99	22.23	2.350
5.90	22.48	22.72	22.97	23.21	23.46	23.72	23.97	24.22	24.48	24.74	2.520
6.00	25.00*	25.25	25.51	25.77	26.03	26.29	26.56	26.82	27.09	27.36	2.630
6.10	27.63	27.90	28.18	28.45	28.73	29.01	29.29	29.58	29.86	30.15	2.810
6.20	30.44	30.73	31.02	31.32	31.61	31.91	32.21	32.51	32.82	33.12	2.990
6.30	33.43	33.74	34.05	34.37	34.68	35.00	35.32	35.64	35.96	36.29	3.190
6.40	36.62	36.95	37.28	37.61	37.95	38.28	38.62	38.96	39.31	39.65	3.380
6.50	40.00*	40.40	40.81	41.22	41.63	42.05	42.47	42.89	43.31	43.74	4.170
6.60	44.17	44.60	45.04	45.48	45.92	46.37	46.82	47.27	47.72	48.18	4.470
6.70	48.64	49.11	49.57	50.04	50.52	50.99	51.47	51.96	52.45	52.94	4.790
6.80	53.43	53.92	54.42	54.93	55.43	55.94	56.46	56.97	57.49	58.02	5.110
6.90	58.54	59.07	59.61	60.14	60.68	61.23	61.78	62.33	62.88	63.44	5.460
7.00	64.00*	64.61	65.22	65.84	66.46	67.08	67.71	68.35	68.99	69.63	6.280
7.10	70.28	70.93	71.58	72.25	72.91	73.58	74.25	74.93	75.62	76.30	6.720
7.20	77.00	77.69	78.39	79.10	79.81	80.53	81.25	81.97	82.70	83.44	7.180
7.30	84.18	84.92	85.67	86.42	87.18	87.95	88.71	89.49	90.27	91.05	7.660
7.40	91.84	92.63	93.43	94.23	95.04	95.85	96.67	97.50	98.33	99.16	8.160
7.50	100.0*	102.6	105.3	108.0	110.8	113.7	116.6	119.6	122.7	125.9	29.10
7.60	129.1	132.4	135.8	139.2	142.7	146.4	150.1	153.8	157.7	161.7	36.60
7.70	165.7	169.9	174.1	178.4	182.9	187.4	192.0	196.8	201.6	206.6	45.90
7.80	211.6	216.8	222.1	227.5	233.0	238.7	244.5	250.4	256.4	262.6	57.30
7.90	268.9	275.3	281.9	288.6	295.5	302.5	309.7	317.0	324.5	332.2	71.10
8.00	340.0*	345.0	350.0	355.1	360.3	365.5	370.8	376.2	381.6	387.1	52.70
8.10	392.7	398.3	404.0	409.8	415.6	421.5	427.5	433.6	439.7	445.9	59.50
8.20	452.2	458.6	465.0	471.5	478.1	484.8	491.6	498.4	505.3	512.3	67.20
8.30	519.4	526.6	533.8	541.2	548.6	556.1	563.7	571.4	579.2	587.1	75.70
8.40	595.1	603.1	611.3	619.5	627.9	636.3	644.8	653.5	662.2	671.1	84.90
8.50	680.0*	687.5	695.1	702.7	710.4	718.2	726.0	734.0	742.0	750.0	78.20
8.60	758.2	766.4	774.7	783.0	791.5	800.0	808.6	817.2	826.0	834.8	85.50
8.70	843.7	852.7	861.7	870.9	880.1	889.4	898.8	908.2	917.8	927.4	93.40

PLATE NO. 7-10(1 OF 7)

EXPANDED RATING TABLE TYPE: LOG

03209200

DATE PROCESSED: 03-05-1999 @ 09:40 BY bghender

RUSSELL FORK AT BARTLICK, VA DD: 2 TYPE: 001 RATING NO: 11.0

OFFSET: 3.00 START DATE/TIME: 03-24-1991 (0001)

SAME AS RATING NO. 10 BELOW 7.50 AND ABOVE 14.10 F

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
8.80	937.1	946.9	956.8	966.8	976.8	987.0	997.2	1008	1018	1028	101.9
8.90	1039	1050	1060	1071	1082	1093	1104	1116	1127	1138	111.0
9.00	1150*	1160	1169	1179	1189	1198	1208	1218	1228	1238	98.00
9.10	1248	1258	1269	1279	1289	1300	1310	1321	1331	1342	105.0
9.20	1353	1364	1375	1386	1397	1408	1419	1430	1442	1453	112.0
9.30	1465	1476	1488	1500	1511	1523	1535	1547	1559	1571	119.0
9.40	1584	1596	1608	1621	1633	1646	1658	1671	1684	1697	126.0
9.50	1710*	1720	1731	1741	1751	1762	1772	1783	1793	1804	104.0
9.60	1814	1825	1836	1847	1857	1868	1879	1890	1901	1912	109.0
9.70	1923	1935	1946	1957	1968	1980	1991	2003	2014	2026	114.0
9.80	2037	2049	2061	2072	2084	2096	2108	2120	2132	2144	119.0
9.90	2156	2168	2181	2193	2205	2217	2230	2242	2255	2267	124.0
10.00	2280*	2291	2302	2313	2324	2335	2346	2357	2368	2379	111.0
10.10	2391	2402	2413	2424	2436	2447	2459	2470	2482	2493	114.0
10.20	2505	2516	2528	2540	2551	2563	2575	2587	2599	2611	118.0
10.30	2623	2635	2647	2659	2671	2683	2695	2708	2720	2732	122.0
10.40	2745	2757	2769	2782	2794	2807	2820	2832	2845	2858	125.0
10.50	2870	2883	2896	2909	2922	2935	2948	2961	2974	2987	130.0
10.60	3000*	3012	3023	3035	3047	3059	3071	3083	3095	3106	118.0
10.70	3118	3130	3143	3155	3167	3179	3191	3203	3215	3228	122.0
10.80	3240*	3252	3264	3275	3287	3299	3311	3323	3335	3347	119.0
10.90	3359	3371	3383	3395	3407	3419	3431	3443	3455	3468	121.0
11.00	3480*	3491	3503	3514	3526	3537	3549	3560	3572	3584	115.0
11.10	3595	3607	3619	3630	3642	3654	3666	3677	3689	3701	118.0
11.20	3713	3725	3737	3749	3761	3773	3785	3797	3809	3821	120.0
11.30	3833	3845	3857	3869	3882	3894	3906	3918	3931	3943	122.0
11.40	3955	3968	3980	3992	4005	4017	4030	4042	4055	4067	125.0
11.50	4080*	4092	4103	4115	4126	4138	4149	4161	4173	4184	116.0
11.60	4196	4208	4220	4231	4243	4255	4267	4279	4290	4302	118.0
11.70	4314	4326	4338	4350	4362	4374	4386	4398	4410	4422	120.0
11.80	4434	4446	4458	4471	4483	4495	4507	4519	4532	4544	122.0
11.90	4556	4568	4581	4593	4605	4618	4630	4643	4655	4668	124.0
12.00	4680*	4692	4703	4715	4727	4738	4750	4762	4773	4785	117.0
12.10	4797	4809	4820	4832	4844	4856	4868	4880	4891	4903	118.0
12.20	4915	4927	4939	4951	4963	4975	4987	4999	5011	5023	120.0
12.30	5035	5047	5059	5072	5084	5096	5108	5120	5132	5145	122.0
12.40	5157	5169	5181	5194	5206	5218	5231	5243	5255	5268	123.0

PLATE NO. 7-10(2 OF 7)

03209200 EXPANDED RATING TABLE TYPE: LOG
RUSSELL FORK AT BARTLICK, VA DATE PROCESSED: 03-05-1999 @ 09:40 BY bghender
OFFSET: 3.00 DD: 2 TYPE: 001 RATING NO: 11.0
START DATE/TIME: 03-24-1991 (0001)

SAME AS RATING NO. 10 BELOW 7.50 AND ABOVE 14.10 F

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
12.50	5280*	5292	5303	5315	5327	5338	5350	5362	5374	5386	117.0
12.60	5397	5409	5421	5433	5445	5456	5468	5480	5492	5504	119.0
12.70	5516	5528	5540	5552	5564	5576	5588	5600	5612	5624	120.0
12.80	5636	5648	5660	5672	5684	5696	5709	5721	5733	5745	121.0
12.90	5757	5770	5782	5794	5806	5818	5831	5843	5855	5868	123.0
13.00	5880*	5892	5904	5916	5929	5941	5953	5965	5977	5990	122.0
13.10	6002	6014	6026	6039	6051	6063	6075	6088	6100	6112	123.0
13.20	6125	6137	6150	6162	6174	6187	6199	6212	6224	6237	124.0
13.30	6249	6262	6274	6287	6299	6312	6324	6337	6350	6362	126.0
13.40	6375	6387	6400	6413	6425	6438	6451	6464	6476	6489	127.0
13.50	6502	6515	6527	6540	6553	6566	6579	6591	6604	6617	128.0
13.60	6630*	6642	6655	6667	6679	6692	6704	6717	6729	6741	124.0
13.70	6754	6766	6779	6791	6804	6816	6829	6841	6854	6866	125.0
13.80	6879	6891	6904	6916	6929	6941	6954	6967	6979	6992	126.0
13.90	7005	7017	7030	7043	7055	7068	7081	7093	7106	7119	127.0
14.00	7132	7145	7157	7170	7183	7196	7209	7221	7234	7247	128.0
14.10	7260*	7277	7293	7310	7327	7344	7360	7377	7394	7411	168.0
14.20	7428	7445	7462	7479	7496	7513	7530	7547	7564	7581	170.0
14.30	7598	7615	7633	7650	7667	7684	7702	7719	7736	7754	173.0
14.40	7771	7788	7806	7823	7841	7858	7876	7893	7911	7928	175.0
14.50	7946	7964	7981	7999	8017	8034	8052	8070	8088	8106	177.0
14.60	8123	8141	8159	8177	8195	8213	8231	8249	8267	8285	180.0
14.70	8303	8321	8339	8358	8376	8394	8412	8431	8449	8467	182.0
14.80	8485	8504	8522	8541	8559	8577	8596	8614	8633	8651	185.0
14.90	8670	8689	8707	8726	8745	8763	8782	8801	8819	8838	187.0
15.00	8857	8876	8895	8914	8933	8951	8970	8989	9008	9027	190.0
15.10	9047	9066	9085	9104	9123	9142	9161	9181	9200	9219	191.0
15.20	9238	9258	9277	9296	9316	9335	9355	9374	9394	9413	195.0
15.30	9433	9452	9472	9492	9511	9531	9551	9570	9590	9610	197.0
15.40	9630	9649	9669	9689	9709	9729	9749	9769	9789	9809	199.0
15.50	9829	9849	9869	9889	9909	9930	9950	9970	9990	10010	201.0
15.60	10030	10050	10070	10090	10110	10130	10150	10170	10190	10210	200.0
15.70	10230	10260	10280	10300	10320	10340	10360	10380	10400	10420	210.0
15.80	10440	10460	10480	10500	10530	10550	10570	10590	10610	10630	210.0
15.90	10650	10670	10690	10710	10740	10760	10780	10800	10820	10840	210.0
16.00	10860	10880	10910	10930	10950	10970	10990	11010	11030	11060	220.0
16.10	11080	11100	11120	11140	11160	11190	11210	11230	11250	11270	210.0
16.20	11290	11320	11340	11360	11380	11400	11430	11450	11470	11490	220.0

PLATE NO. 7-10(3 OF 7)

EXPANDED RATING TABLE TYPE: LOG

03209200
DATE PROCESSED: 03-05-1999 @ 09:40 BY bghender
RUSSELL FORK AT BARTLICK, VA DD: 2 TYPE: 001 RATING NO: 11.0
OFFSET: 3.00 START DATE/TIME: 03-24-1991 (0001)

SAME AS RATING NO. 10 BELOW 7.50 AND ABOVE 14.10 F

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION)										DIFF IN Q PER TENTH FT
	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	
16.30	11510	11540	11560	11580	11600	11620	11650	11670	11690	11710	230.0
16.40	11740	11760	11780	11800	11830	11850	11870	11890	11920	11940	220.0
16.50	11960	11980	12010	12030	12050	12070	12100	12120	12140	12160	230.0
16.60	12190	12210	12230	12260	12280	12300	12330	12350	12370	12390	230.0
16.70	12420	12440	12460	12490	12510	12530	12560	12580	12600	12630	230.0
16.80	12650	12670	12700	12720	12740	12770	12790	12810	12840	12860	240.0
16.90	12890	12910	12930	12960	12980	13000	13030	13050	13080	13100	230.0
17.00	13120	13150	13170	13190	13220	13240	13270	13290	13320	13340	240.0
17.10	13360	13390	13410	13440	13460	13480	13510	13530	13560	13580	250.0
17.20	13610	13630	13660	13680	13700	13730	13750	13780	13800	13830	240.0
17.30	13850	13880	13900	13930	13950	13980	14000	14030	14050	14080	250.0
17.40	14100	14130	14150	14180	14200	14230	14250	14280	14300	14330	250.0
17.50	14350	14380	14400	14430	14450	14480	14500	14530	14550	14580	260.0
17.60	14610	14630	14660	14680	14710	14730	14760	14780	14810	14840	250.0
17.70	14860	14890	14910	14940	14970	14990	15020	15040	15070	15100	260.0
17.80	15120	15150	15170	15200	15230	15250	15280	15300	15330	15360	260.0
17.90	15380	15410	15440	15460	15490	15520	15540	15570	15590	15620	270.0
18.00	15650	15670	15700	15730	15750	15780	15810	15830	15860	15890	270.0
18.10	15920	15940	15970	16000	16020	16050	16080	16100	16130	16160	270.0
18.20	16190	16210	16240	16270	16290	16320	16350	16380	16400	16430	270.0
18.30	16460	16490	16510	16540	16570	16600	16620	16650	16680	16710	270.0
18.40	16730	16760	16790	16820	16850	16870	16900	16930	16960	16980	280.0
18.50	17010	17040	17070	17100	17120	17150	17180	17210	17240	17270	280.0
18.60	17290	17320	17350	17380	17410	17440	17460	17490	17520	17550	290.0
18.70	17580	17610	17640	17660	17690	17720	17750	17780	17810	17840	290.0
18.80	17870	17890	17920	17950	17980	18010	18040	18070	18100	18130	280.0
18.90	18150	18180	18210	18240	18270	18300	18330	18360	18390	18420	300.0
19.00	18450	18480	18510	18540	18570	18590	18620	18650	18680	18710	290.0
19.10	18740	18770	18800	18830	18860	18890	18920	18950	18980	19010	300.0
19.20	19040	19070	19100	19130	19160	19190	19220	19250	19280	19310	300.0
19.30	19340	19370	19400	19430	19460	19490	19520	19560	19590	19620	310.0
19.40	19650	19680	19710	19740	19770	19800	19830	19860	19890	19920	300.0
19.50	19950	19980	20020	20050	20080	20110	20140	20170	20200	20230	310.0
19.60	20260	20290	20330	20360	20390	20420	20450	20480	20510	20540	320.0
19.70	20580	20610	20640	20670	20700	20730	20770	20800	20830	20860	310.0
19.80	20890	20920	20960	20990	21020	21050	21080	21110	21150	21180	320.0
19.90	21210	21240	21270	21310	21340	21370	21400	21440	21470	21500	320.0

EXPANDED RATING TABLE TYPE: LOG

03209200
DATE PROCESSED: 03-05-1999 @ 09:40 BY hgbender
RUSSELL FORK AT BARTLICK, VA DD: 2 TYPE: 001 RATING NO: 11.0
OFFSET: 3.00 START DATE/TIME: 03-24-1991 (0001)

SAME AS RATING NO. 10 BELOW 7.50 AND ABOVE 14.10 F

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
20.00	21530	21560	21600	21630	21660	21690	21730	21760	21790	21820	330.0
20.10	21860	21890	21920	21950	21990	22020	22050	22090	22120	22150	320.0
20.20	22180	22220	22250	22280	22320	22350	22380	22420	22450	22480	330.0
20.30	22510	22550	22580	22610	22650	22680	22710	22750	22780	22810	340.0
20.40	22850	22880	22920	22950	22980	23020	23050	23080	23120	23150	330.0
20.50	23180	23220	23250	23290	23320	23350	23390	23420	23460	23490	340.0
20.60	23520	23560	23590	23630	23660	23690	23730	23760	23800	23830	350.0
20.70	23870	23900	23940	23970	24000	24040	24070	24110	24140	24180	340.0
20.80	24210	24250	24280	24320	24350	24390	24420	24460	24490	24530	350.0
20.90	24560	24600	24630	24670	24700	24740	24770	24810	24840	24880	350.0
21.00	24910	24950	24980	25020	25050	25090	25120	25160	25190	25230	360.0
21.10	25270	25300	25340	25370	25410	25440	25480	25520	25550	25590	350.0
21.20	25620	25660	25700	25730	25770	25800	25840	25880	25910	25950	360.0
21.30	25980	26020	26060	26090	26130	26170	26200	26240	26270	26310	370.0
21.40	26350	26380	26420	26460	26490	26530	26570	26600	26640	26680	360.0
21.50	26710	26750	26790	26830	26860	26900	26940	26970	27010	27050	370.0
21.60	27080	27120	27160	27200	27230	27270	27310	27350	27380	27420	380.0
21.70	27460	27490	27530	27570	27610	27640	27680	27720	27760	27800	370.0
21.80	27830	27870	27910	27950	27980	28020	28060	28100	28140	28170	380.0
21.90	28210	28250	28290	28330	28370	28400	28440	28480	28520	28560	380.0
22.00	28590	28630	28670	28710	28750	28790	28830	28860	28900	28940	390.0
22.10	28980	29020	29060	29100	29140	29170	29210	29250	29290	29330	390.0
22.20	29370	29410	29450	29490	29530	29560	29600	29640	29680	29720	390.0
22.30	29760	29800	29840	29880	29920	29960	30000	30040	30080	30120	400.0
22.40	30160	30200	30230	30270	30310	30350	30390	30430	30470	30510	390.0
22.50	30550	30590	30630	30670	30710	30750	30790	30830	30870	30910	400.0
22.60	30950	30990	31040	31080	31120	31160	31200	31240	31280	31320	410.0
22.70	31360	31400	31440	31480	31520	31560	31600	31640	31680	31730	410.0
22.80	31770	31810	31850	31890	31930	31970	32010	32050	32090	32140	410.0
22.90	32180	32220	32260	32300	32340	32380	32430	32470	32510	32550	410.0
23.00	32590	32630	32670	32720	32760	32800	32840	32880	32920	32970	420.0
23.10	33010	33050	33090	33130	33180	33220	33260	33300	33340	33390	420.0
23.20	33430	33470	33510	33560	33600	33640	33680	33730	33770	33810	420.0
23.30	33850	33900	33940	33980	34020	34070	34110	34150	34190	34240	430.0
23.40	34280	34320	34370	34410	34450	34490	34540	34580	34620	34670	430.0
23.50	34710	34750	34800	34840	34880	34930	34970	35010	35060	35100	430.0
23.60	35140	35190	35230	35270	35320	35360	35400	35450	35490	35540	440.0
23.70	35580	35620	35670	35710	35760	35800	35840	35890	35930	35980	440.0

EXPANDED RATING TABLE TYPE: LOG

03209200
DATE PROCESSED: 03-05-1999 @ 09:40 BY hghender
RUSSELL FORK AT BARTLICK, VA DD: 2 TYPE: 001 RATING NO: 11.0
OFFSET: 3.00 START DATE/TIME: 03-24-1991 (0001)

SAME AS RATING NO. 10 BELOW 7.50 AND ABOVE 14.10 F

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION)										DIFF IN Q PER TENTH FT
	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	
23.80	36020	36060	36110	36150	36200	36240	36290	36330	36370	36420	440.0
23.90	36460	36510	36550	36600	36640	36690	36730	36780	36820	36870	450.0
24.00	36910*	36940	36980	37010	37050	37080	37110	37150	37180	37220	340.0
24.10	37250	37280	37320	37350	37390	37420	37450	37490	37520	37560	340.0
24.20	37590	37630	37660	37690	37730	37760	37800	37830	37870	37900	340.0
24.30	37930	37970	38000	38040	38070	38110	38140	38180	38210	38250	350.0
24.40	38280	38310	38350	38380	38420	38450	38490	38520	38560	38590	350.0
24.50	38630	38660	38700	38730	38760	38800	38830	38870	38900	38940	340.0
24.60	38970	39010	39040	39080	39110	39150	39180	39220	39250	39290	350.0
24.70	39320	39360	39390	39430	39460	39500	39530	39570	39600	39640	350.0
24.80	39670	39710	39740	39780	39810	39850	39880	39920	39950	39990	360.0
24.90	40030	40060	40100	40130	40170	40200	40240	40270	40310	40340	350.0
25.00	40380	40410	40450	40490	40520	40560	40590	40630	40660	40700	350.0
25.10	40730	40770	40810	40840	40880	40910	40950	40980	41020	41060	360.0
25.20	41090	41130	41160	41200	41230	41270	41310	41340	41380	41410	360.0
25.30	41450	41490	41520	41560	41590	41630	41660	41700	41740	41770	360.0
25.40	41810	41840	41880	41920	41950	41990	42030	42060	42100	42130	360.0
25.50	42170	42210	42240	42280	42310	42350	42390	42420	42460	42500	360.0
25.60	42530	42570	42610	42640	42680	42710	42750	42790	42820	42860	370.0
25.70	42900	42930	42970	43010	43040	43080	43120	43150	43190	43230	360.0
25.80	43260	43300	43340	43370	43410	43450	43480	43520	43560	43590	370.0
25.90	43630	43670	43700	43740	43780	43810	43850	43890	43920	43960	370.0
26.00	44000	44040	44070	44110	44150	44180	44220	44260	44290	44330	370.0
26.10	44370	44410	44440	44480	44520	44550	44590	44630	44670	44700	370.0
26.20	44740	44780	44810	44850	44890	44930	44960	45000	45040	45080	370.0
26.30	45110	45150	45190	45230	45260	45300	45340	45380	45410	45450	380.0
26.40	45490	45530	45560	45600	45640	45680	45710	45750	45790	45830	370.0
26.50	45860	45900	45940	45980	46020	46050	46090	46130	46170	46200	380.0
26.60	46240	46280	46320	46360	46390	46430	46470	46510	46540	46580	380.0
26.70	46620	46660	46700	46730	46770	46810	46850	46890	46930	46960	380.0
26.80	47000	47040	47080	47120	47150	47190	47230	47270	47310	47350	380.0
26.90	47380	47420	47460	47500	47540	47580	47610	47650	47690	47730	390.0
27.00	47770	47810	47840	47880	47920	47960	48000	48040	48080	48110	380.0
27.10	48150	48190	48230	48270	48310	48350	48380	48420	48460	48500	390.0
27.20	48540	48580	48620	48660	48690	48730	48770	48810	48850	48890	390.0
27.30	48930	48970	49000	49040	49080	49120	49160	49200	49240	49280	390.0
27.40	49320	49360	49390	49430	49470	49510	49550	49590	49630	49670	390.0

EXPANDED RATING TABLE TYPE: LOG

03209200
DATE PROCESSED: 03-05-1999 @ 09:40 BY hghender

RUSSELL FORK AT BARTLICK, VA DD: 2 TYPE: 001 RATING NO: 11.0

OFFSET: 3.00 START DATE/TIME: 03-24-1991 (0001)

SAME AS RATING NO. 10 BELOW 7.50 AND ABOVE 14.10 F

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION)										DIFF IN Q PER TENTH FT
	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	
27.50	49710	49750	49790	49830	49860	49900	49940	49980	50020	50060	390.0*
27.60	50100*										

PLATE NO. 7-10(7 OF 7)

RT 13.0 UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY - WATER RESOURCES DIVISION

EXPANDED RATING TABLE PROCESS DATE: 19-AUG-85 08:59 SAT RATING NO 13.0

03209300 RUSSELL FORK AT ELKHORN CITY, KY TYPE LOG [OFFSET=(0.00, 5.00)]

BASED ON 990-81 DISCHARGE MEASUREMENTS, NOS ....., AND ....., AND IS ..... WELL DEFINED BETWEEN 6.0... AND 24.0 ft
COMP BY NAM DATE 10-20-81.
CKD. BY ..... DATE .....

RATING TO BE USED STARTING AT: 10/25/80 (0100)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH GH
5.80	50.0*	51.1	52.3	53.5	54.7	55.9	57.1	59.3	59.5	60.7	12.0
5.90	62.0*	63.4	64.9	66.3	67.8	69.3	70.8	72.3	73.9	75.4	15.0
6.00	77.0*	79.6	80.3	81.9	83.6	85.3	87.0	88.7	90.5	92.2	17.0
6.10	94.0*	96.0	98.0	100.0	102.0	104.1	106.2	108.3	110.5	112.6	20.8
6.20	114.8	117.0	119.3	121.5	123.8	126.1	128.4	130.8	133.2	135.6	23.2
6.30	138.0*	140.7	143.4	146.2	149.0	151.8	154.6	157.5	160.4	163.4	29.4
6.40	166.4	169.4	172.4	175.5	178.6	181.8	184.9	188.2	191.4	194.7	31.6
6.50	198.0*	201.6	205.2	208.9	212.6	216.4	220.2	224.1	228.0	231.9	37.9
6.60	235.9	239.9	243.9	248.0	252.2	256.4	260.6	264.9	269.2	273.6	42.1
6.70	278.0*	282.4	286.9	291.4	295.9	300.5	305.1	309.8	314.5	319.3	46.1
6.80	324.1	328.9	333.8	338.3	343.8	349.8	353.9	359.0	364.2	369.4	50.6
6.90	374.7	380.0	385.4	390.9	396.3	401.8	407.3	412.9	418.6	424.3	55.3
7.00	430.0*	435.9	441.9	447.9	454.0	460.1	466.3	472.6	478.9	485.2	61.6
7.10	491.6	498.1	504.6	511.1	517.7	524.4	531.1	537.9	544.7	551.6	66.9
7.20	558.5	565.5	572.6	579.7	586.9	594.1	601.3	608.7	616.1	623.5	72.5
7.30	631.0*	638.6	646.2	653.9	661.7	669.5	677.3	685.3	693.3	701.3	78.4
7.40	709.4	717.6	725.8	734.1	742.4	750.8	759.3	767.8	776.4	785.1	84.4
7.50	793.8	802.5	811.4	820.2	829.2	838.2	847.3	856.4	865.6	874.9	90.4
7.60	884.2	893.6	903.1	912.5	922.2	931.8	941.5	951.3	961.1	971.0	96.8
7.70	981.0*	991.0	1001	1011	1021	1032	1042	1052	1063	1073	103
7.80	1084	1095	1105	1116	1127	1138	1149	1160	1171	1182	109
7.90	1193	1205	1216	1228	1239	1251	1262	1274	1286	1298	117
8.00	1310	1322	1334	1346	1358	1370	1383	1395	1408	1420	123
8.10	1433*	1446	1459	1471	1484	1497	1511	1524	1537	1550	131
8.20	1564	1577	1591	1604	1618	1632	1645	1659	1673	1687	139
8.30	1702	1716	1730	1744	1759	1773	1788	1803	1817	1832	145
8.40	1847	1862	1877	1892	1907	1923	1938	1953	1969	1984	153
8.50	2000	2016	2032	2048	2064	2080	2096	2112	2128	2145	161
8.60	2161	2179	2194	2211	2228	2245	2261	2278	2296	2313	169
8.70	2330*	2347	2365	2382	2400	2418	2435	2453	2471	2489	177
8.80	2507	2525	2544	2562	2581	2599	2618	2636	2655	2674	186
8.90	2693	2712	2731	2750	2770	2789	2808	2828	2848	2867	194
9.00	2887	2907	2927	2947	2967	2987	3008	3028	3049	3069	203
9.10	3090*	3111	3132	3152	3173	3195	3216	3237	3258	3280	211
9.20	3301	3323	3345	3367	3389	3410	3433	3455	3477	3499	221
9.30	3522	3544	3567	3590	3612	3635	3658	3681	3705	3729	229
9.40	3751	3775	3798	3822	3846	3869	3893	3917	3941	3966	238
9.50	3990*	4012	4034	4054	4079	4101	4123	4146	4168	4191	225

PLATE NO. 7-11(1 OF 5)

RT 13.0 UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY - WATER RESOURCES DIVISION

EXPANDED RATING TABLE PROCESS DATE: 19-AUG-85 09:59 SAT RATING NO 13.0

03209300 RUSSELL FORK AT ELKHORN CITY, KY TYPE LOG [OFFSET=(0.00, 5.00)]

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH GH
9.60	4213	4236	4259	4282	4305	4328	4351	4374	4397	4420	231
9.70	4444	4467	4491	4514	4538	4562	4586	4610	4634	4658	238
9.80	4682	4706	4730	4755	4779	4804	4828	4853	4877	4902	245
9.90	4927	4952	4977	5002	5027	5053	5078	5103	5129	5154	253
10.00	5180	5203	5225	5248	5271	5294	5317	5340	5363	5386	229
10.10	5409	5432	5456	5479	5502	5526	5549	5573	5596	5620	235
10.20	5644	5667	5691	5715	5739	5763	5787	5811	5835	5859	240
10.30	5884	5908	5932	5957	5981	6006	6030	6055	6080	6104	245
10.40	6129	6154	6179	6204	6229	6254	6279	6304	6329	6355	251
10.50	6380	6403	6426	6449	6472	6495	6519	6542	6565	6588	232
10.60	6612	6635	6659	6682	6706	6729	6753	6777	6800	6824	236
10.70	6848	6872	6895	6919	6943	6967	6991	7015	7039	7064	240
10.80	7088	7112	7136	7161	7185	7209	7234	7258	7283	7307	244
10.90	7332	7356	7381	7406	7431	7455	7480	7505	7530	7555	249
11.00	7580	7601	7622	7644	7665	7686	7708	7729	7751	7772	213
11.10	7793	7815	7836	7858	7879	7901	7923	7944	7966	7987	216
11.20	8009	8031	8053	8074	8096	8118	8140	8162	8183	8205	218
11.30	8227	8249	8271	8293	8315	8337	8359	8381	8404	8426	221
11.40	8448	8470	8492	8514	8537	8559	8581	8604	8626	8648	223
11.50	8671	8693	8716	8738	8761	8783	8806	8828	8851	8873	225
11.60	8896	8919	8941	8964	8987	9009	9032	9055	9078	9101	227
11.70	9123	9146	9169	9192	9215	9238	9261	9284	9307	9330	230
11.80	9353	9376	9400	9423	9446	9469	9492	9516	9539	9562	233
11.90	9586	9609	9632	9656	9679	9702	9726	9749	9773	9796	234
12.00	9820	9843	9866	9889	9912	9935	9958	9981	10000	10030	230
12.10	10050	10070	10100	10120	10140	10170	10190	10210	10240	10260	230
12.20	10280	10310	10330	10350	10380	10400	10420	10450	10470	10490	240
12.30	10520	10540	10570	10590	10610	10640	10660	10680	10710	10730	240
12.40	10760	10780	10800	10830	10850	10870	10900	10920	10950	10970	230
12.50	10990	11020	11040	11070	11090	11110	11140	11160	11190	11210	250
12.60	11240	11260	11280	11310	11330	11360	11380	11410	11430	11450	240
12.70	11480	11500	11530	11550	11580	11600	11630	11650	11670	11700	240
12.80	11720	11750	11770	11800	11820	11850	11870	11900	11920	11950	250
12.90	11970	12000	12020	12050	12070	12100	12120	12150	12170	12190	240
13.00	12220	12240	12270	12290	12320	12350	12370	12400	12420	12450	250
13.10	12470	12500	12520	12550	12570	12600	12620	12650	12670	12700	250
13.20	12720	12750	12770	12800	12820	12850	12880	12900	12930	12950	250
13.30	12980	13000	13030	13050	13090	13110	13130	13160	13180	13210	260
13.40	13230	13260	13290	13310	13340	13360	13390	13420	13440	13470	260
13.50	13490	13520	13550	13570	13600	13620	13650	13680	13700	13730	260
13.60	13750	13780	13810	13830	13860	13890	13910	13940	13960	13990	270
13.70	14020	14040	14070	14100	14120	14150	14170	14200	14230	14250	260

PLATE NO. 7-11(2 OF 5)

RT 13.0 UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY - WATER RESOURCES DIVISION

EXPANDED RATING TABLE PROCESS DATE: 19-AUG-85 08:59 SAT RATING NO 13.0

03209300 RUSSELL FORK AT ELKHORN CITY, KY TYPE LOG [OFFSET=(0.00, 5.00)]

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION)										DIFF IN Q PER TENTH GH
	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	
13.80	14250	14310	14330	14360	14390	14410	14440	14470	14490	14520	270
13.90	14550	14570	14600	14630	14650	14680	14710	14730	14760	14790	260
14.00	14810	14840	14870	14900	14920	14950	14980	15000	15030	15060	280
14.10	15090	15110	15140	15170	15190	15220	15250	15280	15300	15330	270
14.20	15360	15380	15410	15440	15470	15490	15520	15550	15580	15600	270
14.30	15630	15660	15690	15710	15740	15770	15800	15820	15850	15880	280
14.40	15910	15930	15960	15990	16020	16050	16070	16100	16130	16160	270
14.50	16180	16210	16240	16270	16300	16320	16350	16380	16410	16440	280
14.60	16460	16490	16520	16550	16580	16600	16630	16660	16690	16720	280
14.70	16740	16770	16800	16830	16860	16890	16910	16940	16970	17000	290
14.80	17030	17060	17090	17110	17140	17170	17200	17230	17260	17280	280
14.90	17310	17340	17370	17400	17430	17460	17480	17510	17540	17570	290
15.00	17600	17630	17660	17690	17720	17740	17770	17800	17830	17860	290
15.10	17890	17920	17950	17980	18000	18030	18060	18090	18120	18150	290
15.20	18180	18210	18240	18270	18300	18320	18350	18380	18410	18440	290
15.30	18470	18500	18530	18560	18590	18620	18650	18680	18710	18740	300
15.40	18770	18790	18820	18850	18880	18910	18940	18970	19000	19030	290
15.50	19060	19090	19120	19150	19180	19210	19240	19270	19300	19330	300
15.60	19360	19390	19420	19450	19480	19510	19540	19570	19600	19630	300
15.70	19660	19690	19720	19750	19780	19810	19840	19870	19900	19930	300
15.80	19960	19990	20020	20050	20080	20110	20140	20170	20200	20230	300
15.90	20260	20290	20320	20350	20380	20410	20440	20480	20510	20540	310
16.00	20570	20600	20630	20660	20690	20720	20750	20780	20810	20840	300
16.10	20870	20900	20930	20970	21000	21030	21060	21090	21120	21150	310
16.20	21180	21210	21240	21270	21310	21340	21370	21400	21430	21460	310
16.30	21490	21520	21550	21580	21620	21650	21680	21710	21740	21770	310
16.40	21800	21830	21870	21900	21930	21960	21990	22020	22050	22090	320
16.50	22120	22150	22180	22210	22240	22270	22310	22340	22370	22400	310
16.60	22430	22460	22500	22530	22560	22590	22620	22650	22690	22720	320
16.70	22750	22790	22810	22840	22880	22910	22940	22970	23000	23040	320
16.80	23070	23100	23130	23160	23200	23230	23260	23290	23320	23360	320
16.90	23390	23420	23450	23480	23520	23550	23580	23610	23650	23680	320
17.00	23710	23740	23770	23810	23840	23870	23900	23940	23970	24000	320
17.10	24030	24070	24100	24130	24160	24200	24230	24260	24290	24330	330
17.20	24360	24390	24430	24460	24490	24520	24560	24590	24620	24650	330
17.30	24690	24720	24750	24790	24820	24850	24890	24920	24950	24980	330
17.40	25020	25050	25080	25120	25150	25180	25220	25250	25280	25310	330
17.50	25350	25380	25410	25450	25480	25510	25550	25580	25610	25650	330
17.60	25680	25710	25750	25780	25810	25850	25880	25910	25950	25980	330
17.70	26010	26050	26080	26120	26150	26190	26220	26250	26280	26320	340
17.80	26350	26380	26420	26450	26490	26520	26550	26590	26620	26650	340
17.90	26690	26720	26760	26790	26820	26860	26890	26930	26960	26990	340

PLATE NO. 7-11(3 OF 5)

RT 13.0 UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY - WATER RESOURCES DIVISION

EXPANDED RATING TABLE PROCESS DATE: 19-AUG-85 09:00 SAT RATING NO 13.0

03209300 RUSSELL FORK AT ELKHORN CITY, KY TYPE LOG [OFFSET=(0.00, 5.00)]

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH GH
18.00	27030	27060	27100	27130	27160	27200	27230	27270	27300	27340	340
18.10	27370	27400	27440	27470	27510	27540	27570	27610	27640	27680	340
18.20	27710	27750	27780	27820	27850	27880	27920	27950	27990	28020	350
18.30	28060	28090	28130	28160	28190	28230	28260	28300	28330	28370	340
18.40	28400	28440	28470	28510	28540	28580	28610	28650	28680	28720	350
18.50	28750	28780	28820	28850	28890	28920	28960	28990	29030	29060	350
18.60	29100	29130	29170	29200	29240	29270	29310	29340	29380	29420	350
18.70	29450	29490	29520	29560	29590	29630	29660	29700	29730	29770	350
18.80	29800	29840	29870	29910	29940	29980	30020	30050	30090	30120	360
18.90	30160	30190	30230	30260	30300	30330	30370	30410	30440	30480	350
19.00	30510	30550	30580	30620	30660	30690	30730	30760	30800	30830	360
19.10	30870	30910	30940	30980	31010	31050	31090	31120	31160	31190	360
19.20	31230	31270	31300	31340	31370	31410	31450	31480	31520	31550	360
19.30	31590	31630	31660	31700	31730	31770	31810	31840	31880	31920	360
19.40	31950	31990	32030	32060	32100	32130	32170	32210	32240	32280	370
19.50	32320	32350	32390	32430	32460	32500	32540	32570	32610	32650	360
19.60	32680	32720	32760	32790	32830	32870	32900	32940	32980	33010	370
19.70	33050	33090	33120	33160	33200	33230	33270	33310	33340	33380	370
19.80	33420	33450	33490	33530	33570	33600	33640	33680	33710	33750	370
19.90	33790	33830	33860	33900	33940	33970	34010	34050	34090	34120	370
20.00	34160*	34200	34230	34270	34310	34350	34380	34420	34460	34500	370
20.10	34530	34570	34610	34650	34690	34720	34760	34800	34830	34870	380
20.20	34910	34950	34990	35020	35060	35100	35130	35170	35210	35250	370
20.30	35280	35320	35360	35400	35440	35470	35510	35550	35590	35620	380
20.40	35660	35700	35740	35780	35810	35850	35890	35930	35970	36000	390
20.50	36040	36080	36120	36160	36190	36230	36270	36310	36350	36390	380
20.60	36420	36460	36500	36540	36580	36610	36650	36690	36730	36770	390
20.70	36810	36840	36880	36920	36960	37000	37040	37070	37110	37150	380
20.80	37190	37230	37270	37310	37340	37380	37420	37460	37500	37540	390
20.90	37580	37610	37650	37690	37730	37770	37810	37850	37890	37920	380
21.00	37960	38000	38040	38080	38120	38160	38200	38240	38270	38310	390
21.10	38350	38390	38430	38470	38510	38550	38590	38630	38660	38700	390
21.20	38740	38780	38820	38860	38900	38940	38980	39020	39060	39100	400
21.30	39140	39170	39210	39250	39290	39330	39370	39410	39450	39490	390
21.40	39530	39570	39610	39650	39690	39730	39770	39800	39840	39880	390
21.50	39920	39960	40000	40040	40080	40120	40160	40200	40240	40280	400
21.60	40320	40360	40400	40440	40490	40520	40560	40600	40640	40680	400
21.70	40720	40760	40800	40840	40880	40920	40960	41000	41040	41080	400
21.80	41120	41160	41200	41240	41280	41320	41360	41400	41440	41480	400
21.90	41520	41560	41600	41640	41680	41720	41760	41800	41840	41880	400
22.00	41920	41960	42000	42040	42080	42120	42160	42200	42240	42290	410
22.10	42330	42370	42410	42450	42490	42530	42570	42610	42650	42690	400

PLATE NO. 7-11(4 OF 5)

RT 13.0

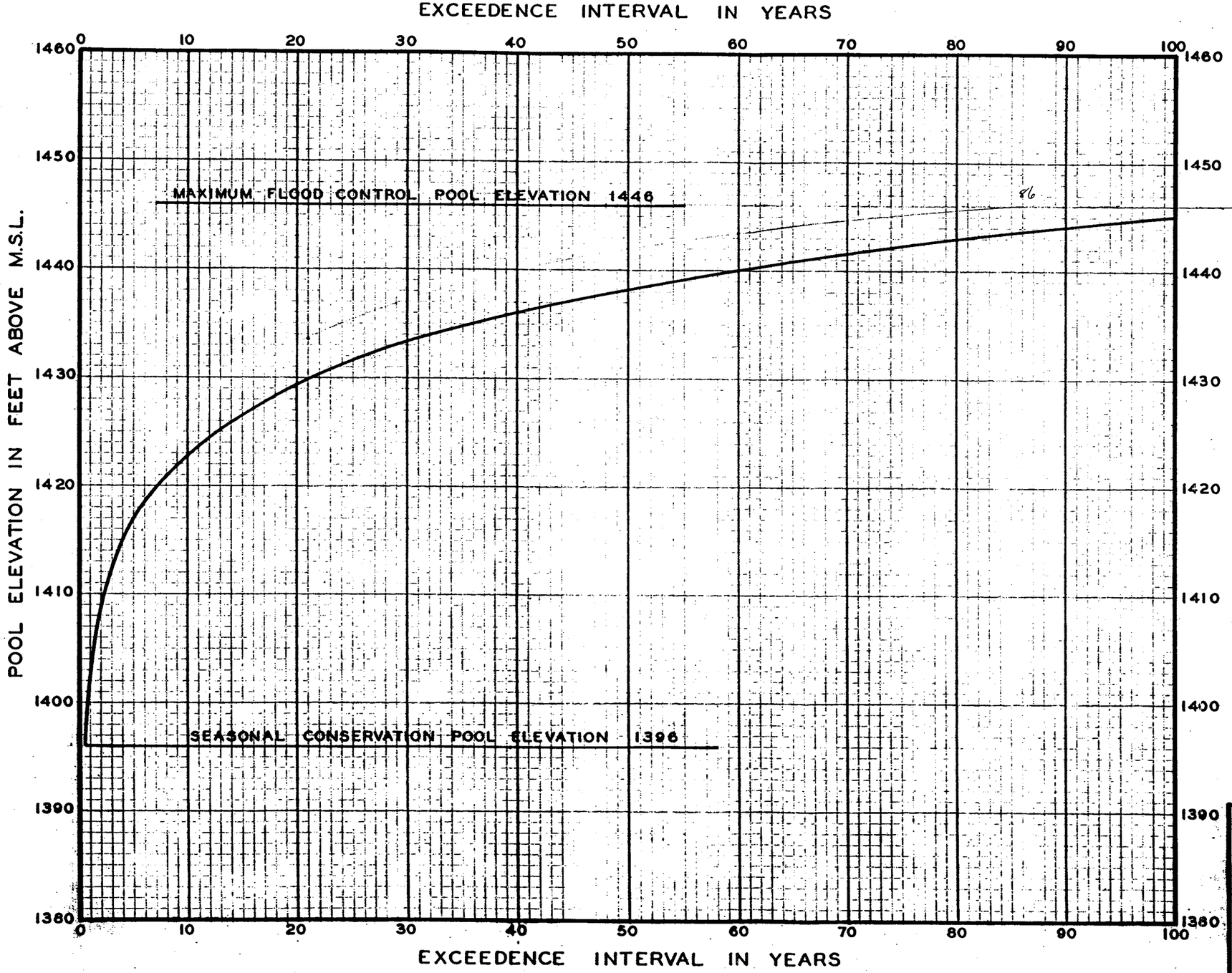
UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY - WATER RESOURCES DIVISION

EXPANDED RATING TABLE — PROCESS DATE: 19-AUG-85 09:00 SAT — RATING NO 13.0

03209300 — RUSSELL FORK AT ELKHORN CITY, KY — TYPE LOG [OFFSET=(0.00, 5.00)]

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION)										DIFF IN Q PER TENTH GH
	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	
22.20	42730	42770	42810	42850	42890	42930	42980	43020	43060	43100	410
22.30	43160	43160	43220	43260	43300	43340	43380	43420	43470	43510	410
22.40	43550	43590	43630	43670	43710	43750	43790	43830	43880	43920	410
22.50	43960	44000	44040	44080	44120	44160	44200	44250	44290	44330	410
22.60	44370	44410	44450	44490	44530	44580	44620	44660	44700	44740	410
22.70	44780	44820	44870	44910	44950	44990	45030	45070	45110	45160	420
22.80	45200	45240	45280	45320	45360	45400	45450	45490	45530	45570	410
22.90	45610	45650	45700	45740	45780	45820	45860	45910	45950	45990	420
23.00	46030	46070	46110	46160	46200	46240	46280	46320	46370	46410	420
23.10	46450	46490	46530	46580	46620	46660	46700	46740	46790	46830	420
23.20	46870	46910	46950	47000	47040	47090	47120	47170	47210	47250	420
23.30	47290	47330	47380	47420	47460	47500	47550	47590	47630	47670	430
23.40	47720	47760	47800	47840	47890	47930	47970	48010	48060	48100	420
23.50	48140	48180	48230	48270	48310	48350	48400	48440	48480	48520	430
23.60	48570	48610	48650	48700	48740	48780	48820	48870	48910	48950	430
23.70	49000	49040	49080	49120	49170	49210	49250	49300	49340	49380	420
23.80	49420	49470	49510	49550	49600	49640	49680	49730	49770	49810	440
23.90	49860	49900	49940	49980	50030	50070	50110	50160	50200	50240	430
24.00	50290	50330	50370	50420	50460	50500	50550	50590	50630	50680	430
24.10	50720	50760	50810	50850	50890	50940	50980	51030	51070	51110	440
24.20	51160	51200*									

PLATE NO. 7-11(5 OF 5)



NOTES:

1. CURVE COMPUTED FROM DATA OBSERVED FROM JULY 1926 TO OCT. 1958.
2. NORTH FORK OF POUND RESERVOIR EFFECTS NOT INCLUDED.

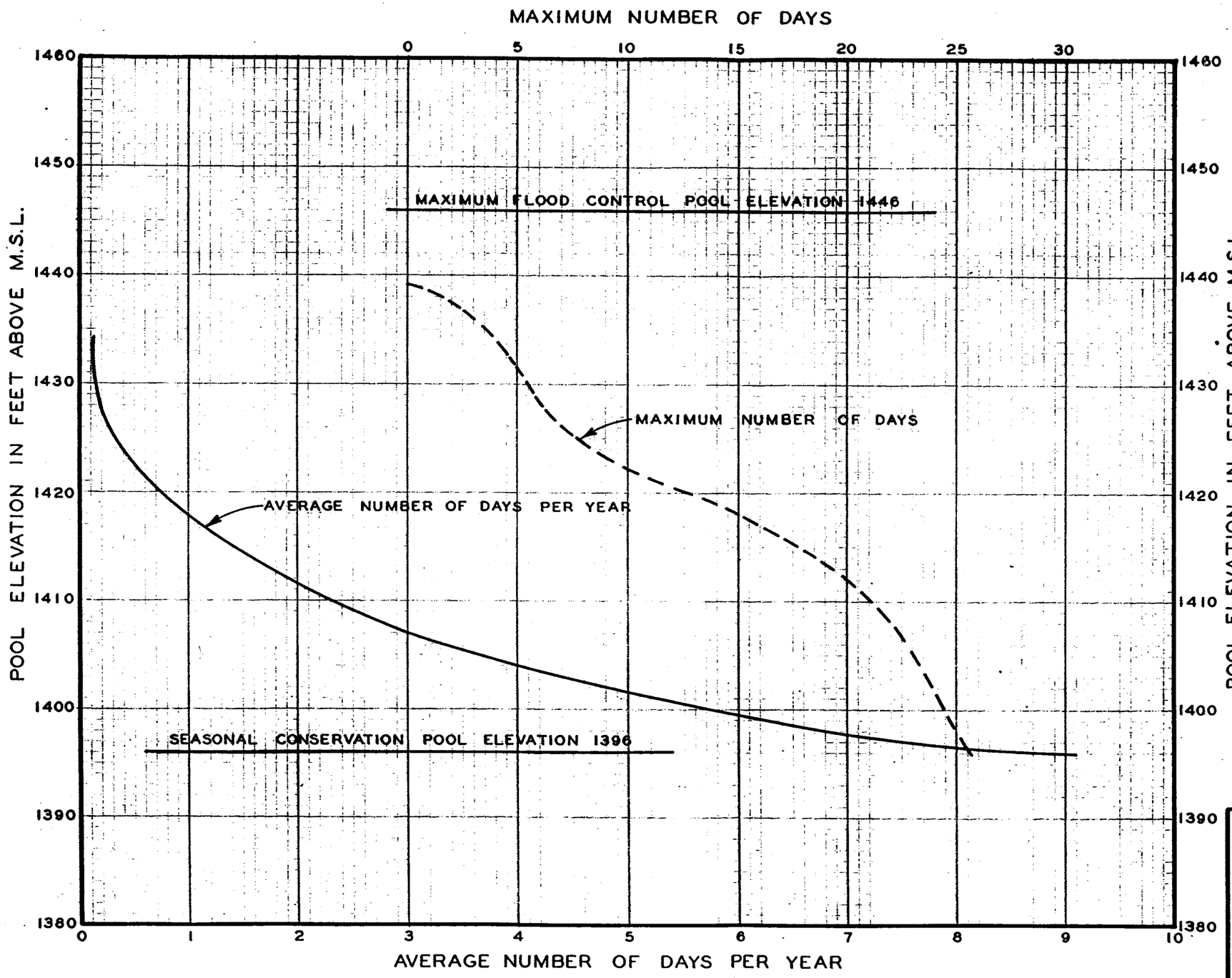
POUND RIVER
VIRGINIA

JOHN W. FLANNAGAN RESERVOIR
FREQUENCY OF FILLING

SCALE AS SHOWN

U.S. ARMY ENGINEER DISTIRCT, HUNTINGTON
CORPS OF ENGINEERS
HUNTINGTON, W. VA. JUNE 1964

Plate No. 8-1



NOTES:

1. 32.25 YEARS OF RECORD JULY 1926 TO OCTOBER 1958
2. NORTH FORK OF POUND RESERVOIR EFFECTS NOT INCLUDED.

POUND RIVER
VIRGINIA

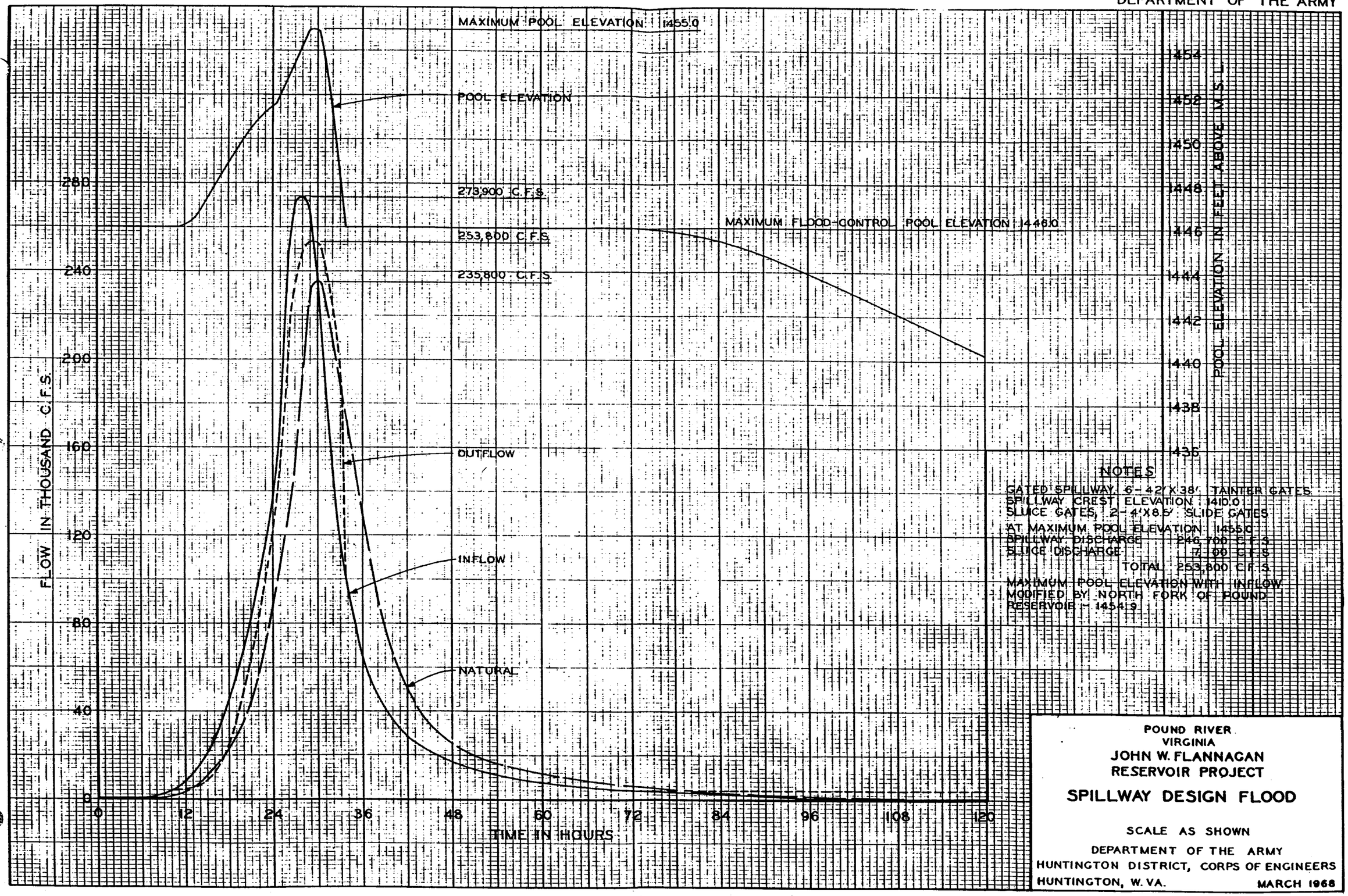
JOHN W. FLANNAGAN RESERVOIR PROJECT
DURATION OF FILLING

SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, HUNTINGTON
CORPS OF ENGINEERS
HUNTINGTON, W. VA. JUNE 1964

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY



NOTES

GATED SPILLWAY, 6-42'X38' TAINTER GATES
SPILLWAY CREST ELEVATION 1410.0
SLUICE GATES, 2-4'X8.5' SLIDE GATES

AT MAXIMUM POOL ELEVATION 1455.0
SPILLWAY DISCHARGE 246,700 C.F.S.
SLUICE DISCHARGE 7,100 C.F.S.
TOTAL 253,800 C.F.S.

MAXIMUM POOL ELEVATION WITH INFLOW MODIFIED BY NORTH FORK OF POUND RESERVOIR = 1454.9

POUND RIVER
VIRGINIA

JOHN W. FLANNAGAN RESERVOIR PROJECT

SPILLWAY DESIGN FLOOD

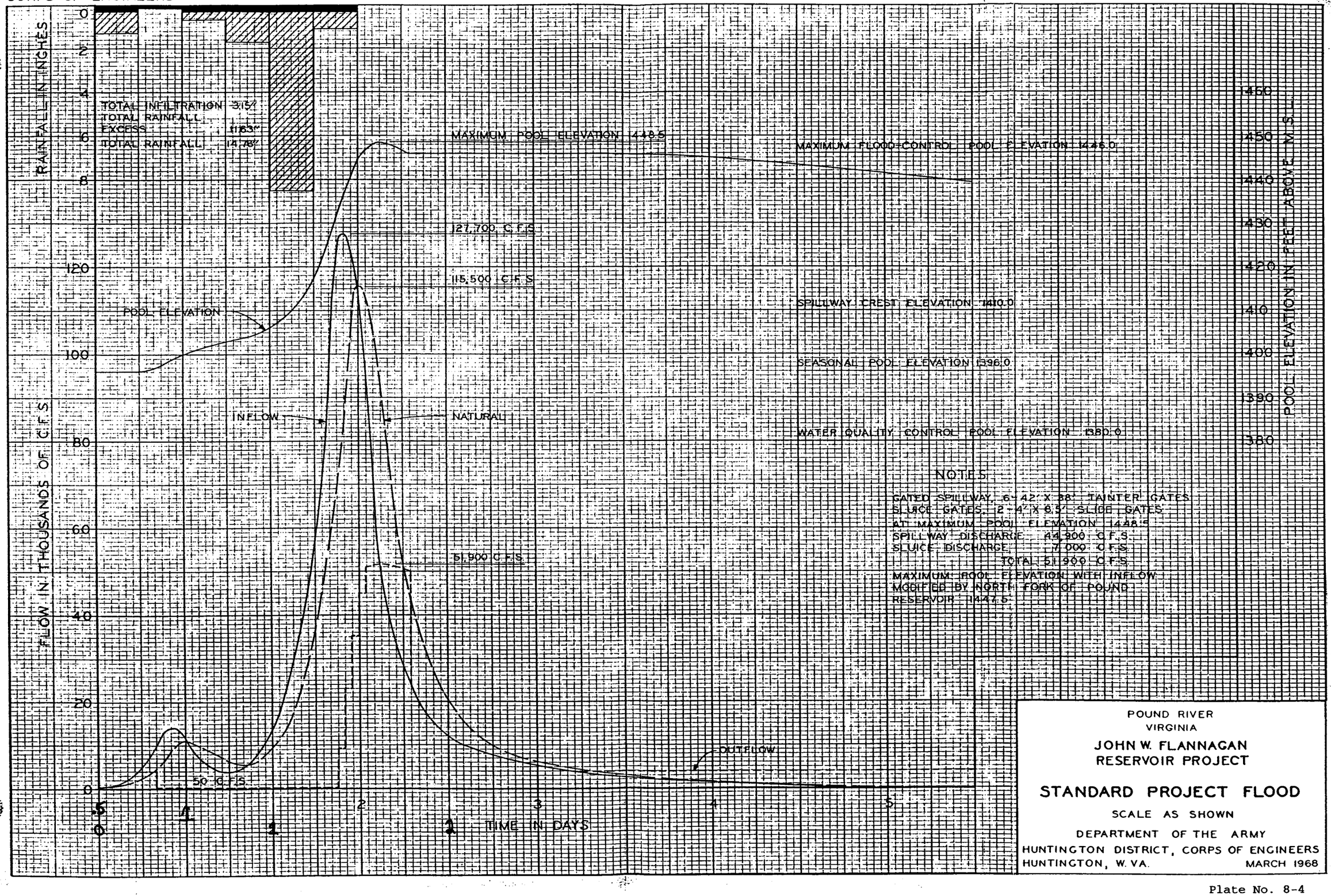
SCALE AS SHOWN

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W. VA. MARCH 1968

Plate NO. 8-3

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY



NOTES

GATED SPILLWAY, 6 - 42' X 38' TAINTER GATES
SLUICE GATES, 2 - 4' X 8.5' SLUICE GATES
AT MAXIMUM POOL ELEVATION 1448.5
SPILLWAY DISCHARGE 44,900 C.F.S.
SLUICE DISCHARGE 7,000 C.F.S.
TOTAL 51,900 C.F.S.
MAXIMUM POOL ELEVATION WITH INFLOW MODIFIED BY NORTH FORK OF POUND RESERVOIR 1447.5

POUND RIVER
VIRGINIA

JOHN W. FLANNAGAN
RESERVOIR PROJECT

STANDARD PROJECT FLOOD

SCALE AS SHOWN

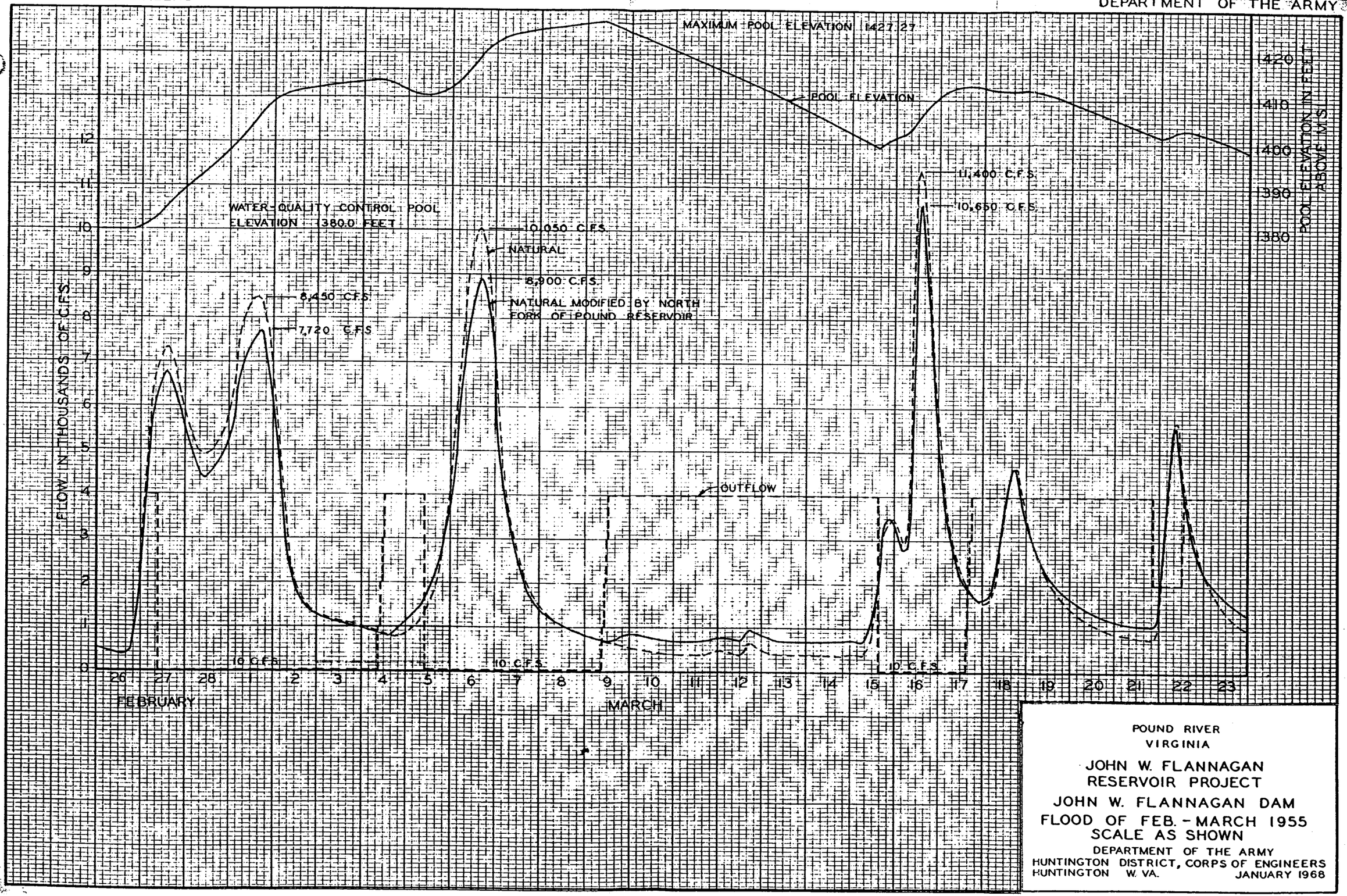
DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W. VA. MARCH 1968

Plate No. 8-4

KEUFFEL & ESSER CO.
10 X 10 TO THE INCH 46 1513
PRINTED IN U.S.A.

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY



POUND RIVER
VIRGINIA

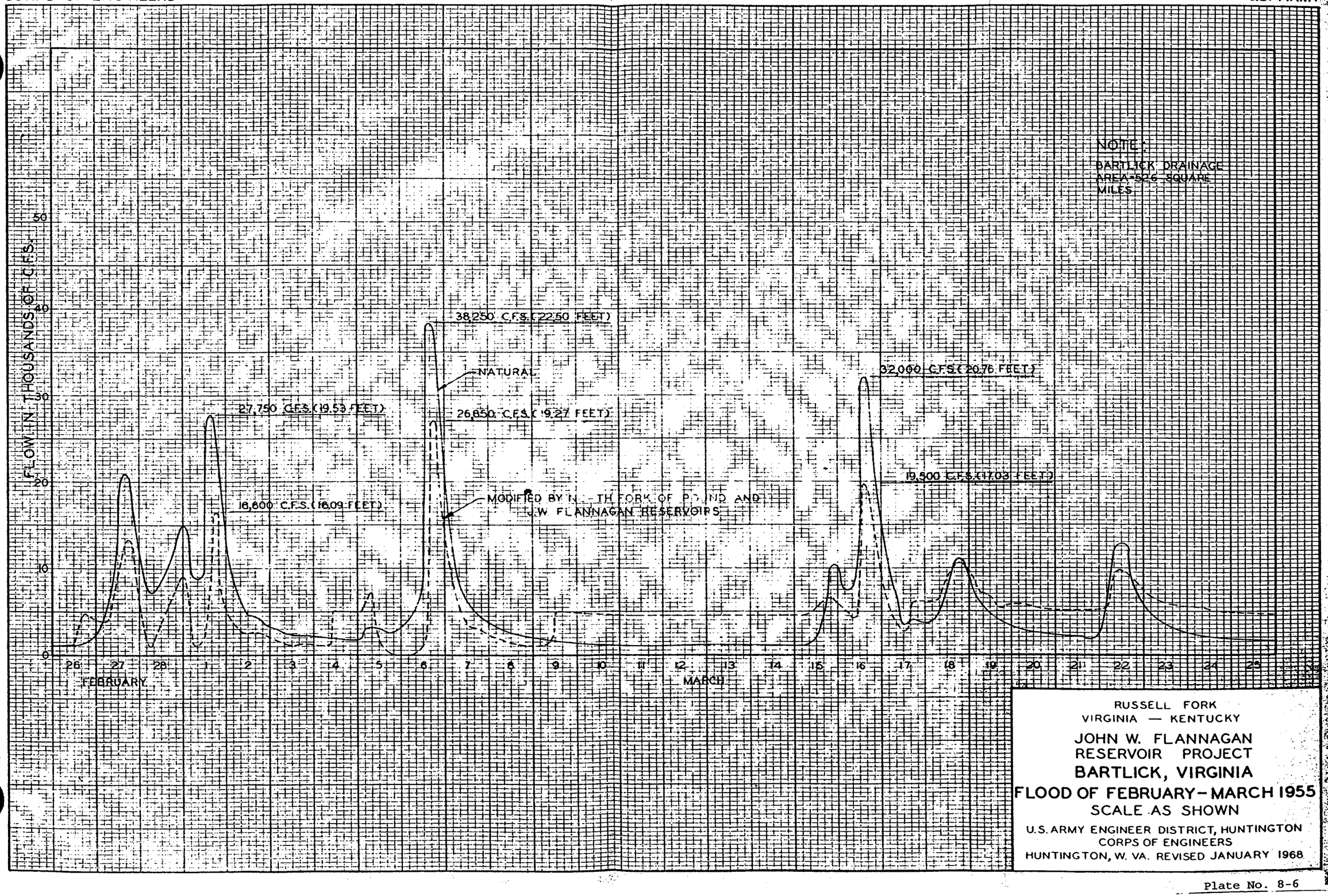
JOHN W. FLANNAGAN
RESERVOIR PROJECT

JOHN W. FLANNAGAN DAM
FLOOD OF FEB.-MARCH 1955
SCALE AS SHOWN

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON W. VA. JANUARY 1968

Plate No. 8-5

CORPS OF ENGINEERS U.S. ARMY



RUSSELL FORK
VIRGINIA — KENTUCKY

JOHN W. FLANNAGAN RESERVOIR PROJECT

BARTLICK, VIRGINIA

FLOOD OF FEBRUARY–MARCH 1955

SCALE AS SHOWN

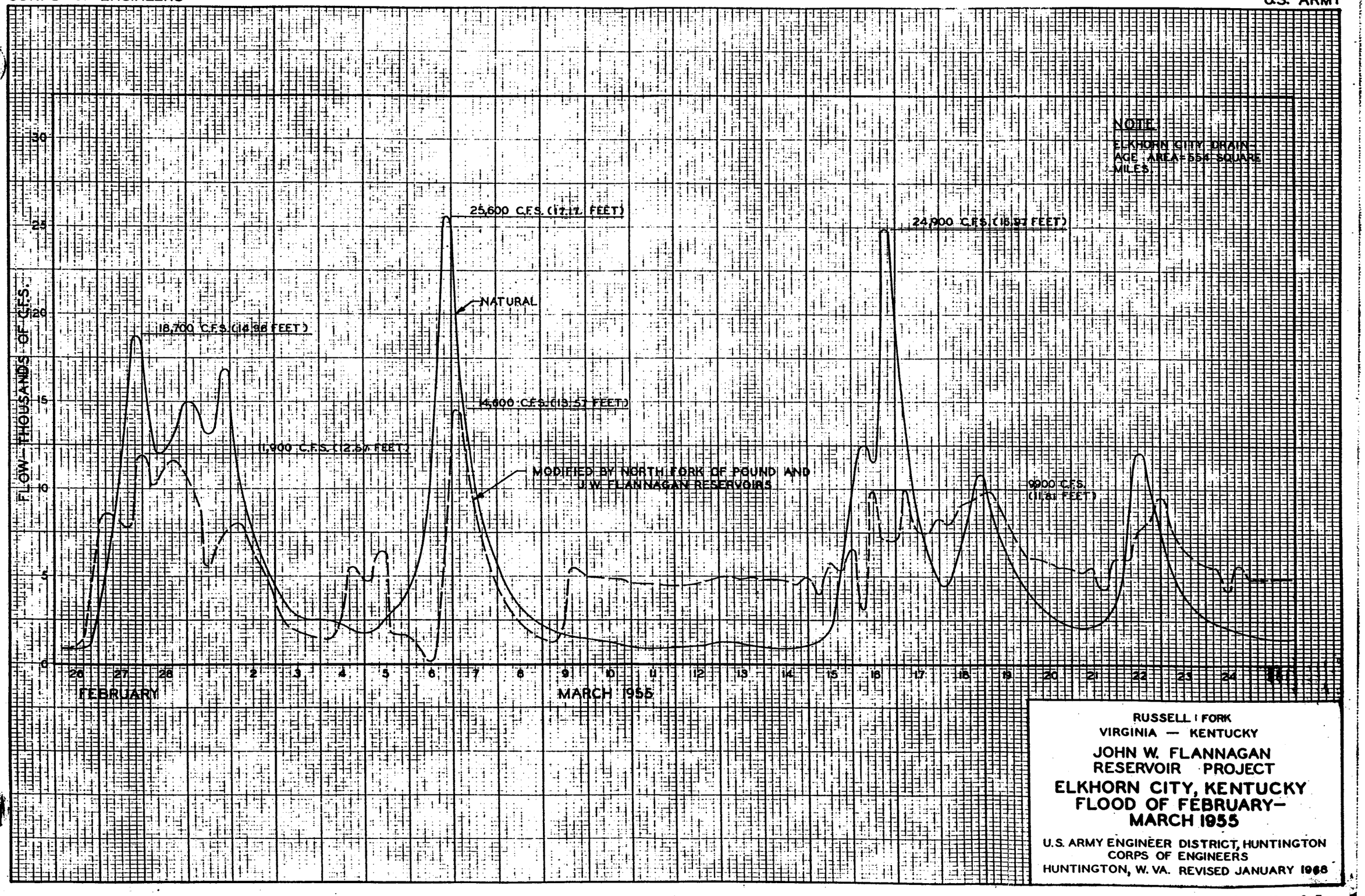
U.S. ARMY ENGINEER DISTRICT, HUNTINGTON
CORPS OF ENGINEERS
HUNTINGTON, W. VA. REVISED JANUARY 1968

Plate No. 8-6

KEUFFEL & ESSER CO. 15 X 20 TO THE INCH 359-11F

CORPS OF ENGINEERS

U.S. ARMY



RUSSELL FORK
VIRGINIA — KENTUCKY

JOHN W. FLANNAGAN RESERVOIR PROJECT

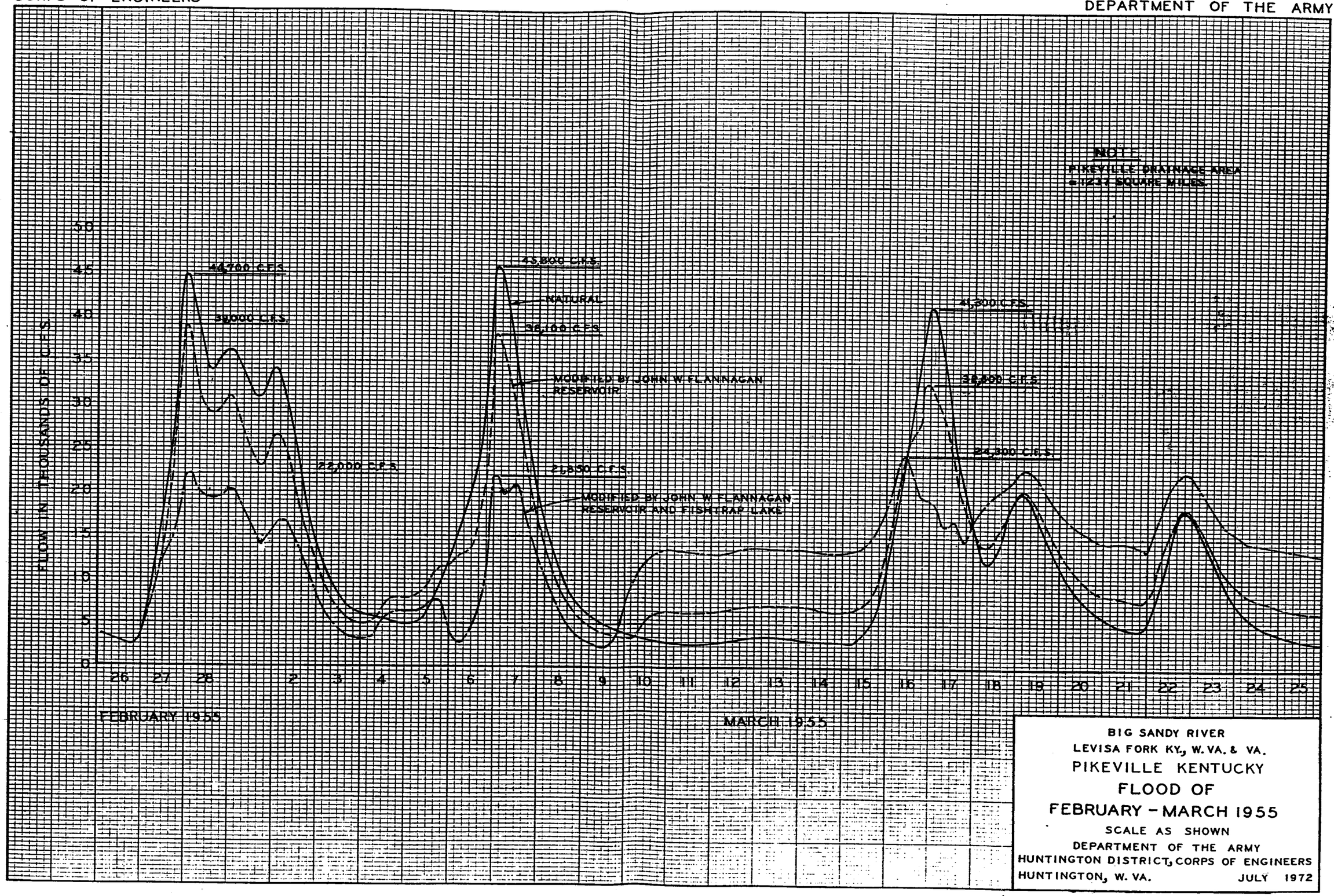
ELKHORN CITY, KENTUCKY FLOOD OF FEBRUARY–MARCH 1955

U.S. ARMY ENGINEER DISTRICT, HUNTINGTON
CORPS OF ENGINEERS
HUNTINGTON, W. VA. REVISED JANUARY 1968

Plate No. 8-7

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY



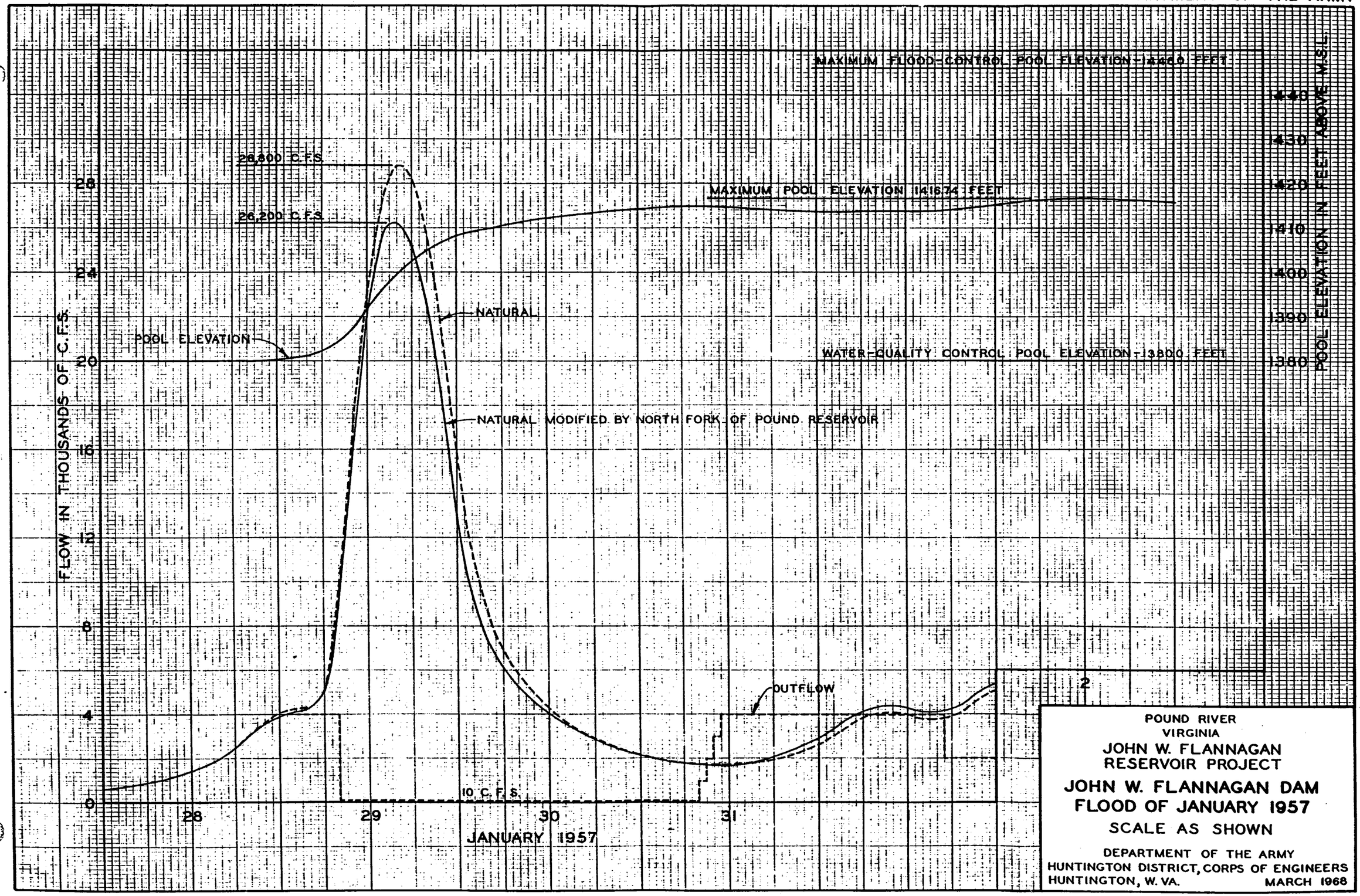
BIG SANDY RIVER
LEVISA FORK KY., W. VA. & VA.
PIKEVILLE KENTUCKY
FLOOD OF
FEBRUARY – MARCH 1955
SCALE AS SHOWN
DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W. VA. JULY 1972

Plate No. 8-8

K+E 12 X 20 TO THE INCH 47 1970
10 X 15 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY



POUND RIVER
VIRGINIA

JOHN W. FLANNAGAN
RESERVOIR PROJECT

JOHN W. FLANNAGAN DAM
FLOOD OF JANUARY 1957

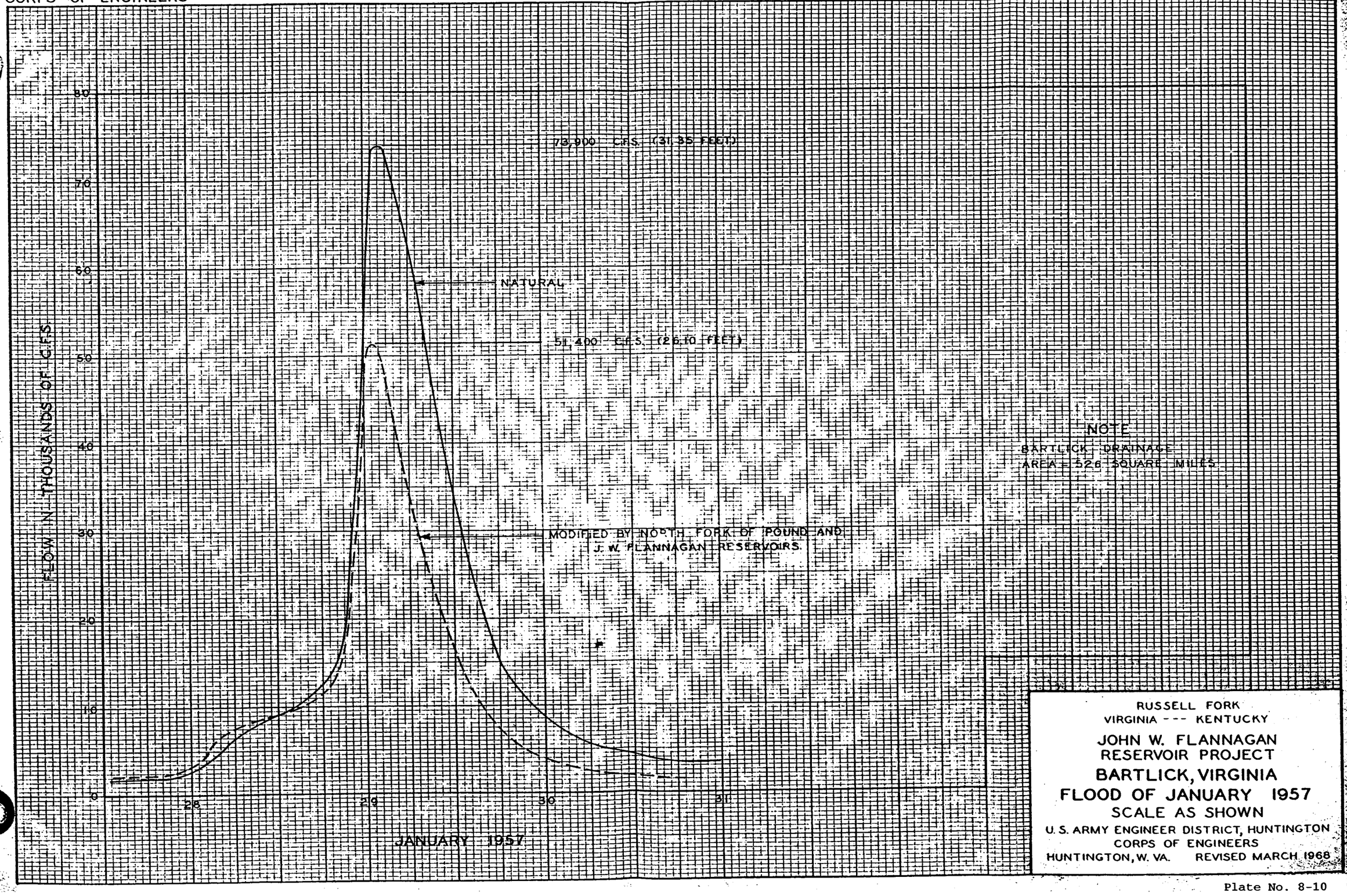
SCALE AS SHOWN

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W. VA. MARCH 1968

Plate No. 8-9

CORPS OF ENGINEERS

U.S. ARMY



NOTE

BARTLICK DRAINAGE AREA = 526 SQUARE MILES

RUSSELL FORK
VIRGINIA --- KENTUCKY

JOHN W. FLANNAGAN RESERVOIR PROJECT

BARTLICK, VIRGINIA

FLOOD OF JANUARY 1957

SCALE AS SHOWN

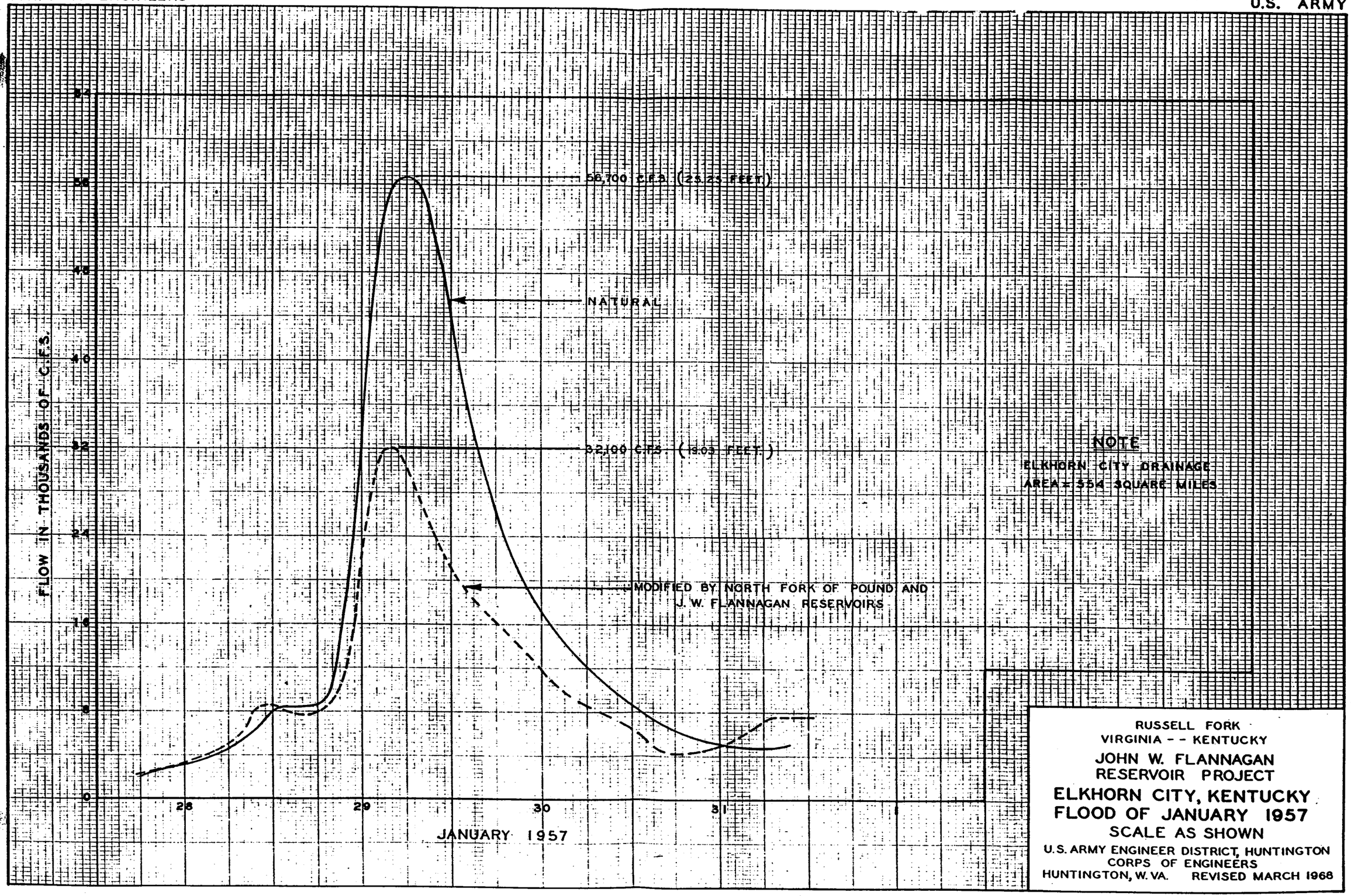
U. S. ARMY ENGINEER DISTRICT, HUNTINGTON
CORPS OF ENGINEERS
HUNTINGTON, W. VA. REVISED MARCH 1968

Plate No. 8-10

KEUFFEL & ESSER CO. MADE IN U.S.A. 10 X 10 TO THE INCH 359-51F

CORPS OF ENGINEERS

U.S. ARMY



NOTE

ELKHORN CITY DRAINAGE AREA = 554 SQUARE MILES

RUSSELL FORK
VIRGINIA -- KENTUCKY

JOHN W. FLANNAGAN RESERVOIR PROJECT

ELKHORN CITY, KENTUCKY
FLOOD OF JANUARY 1957

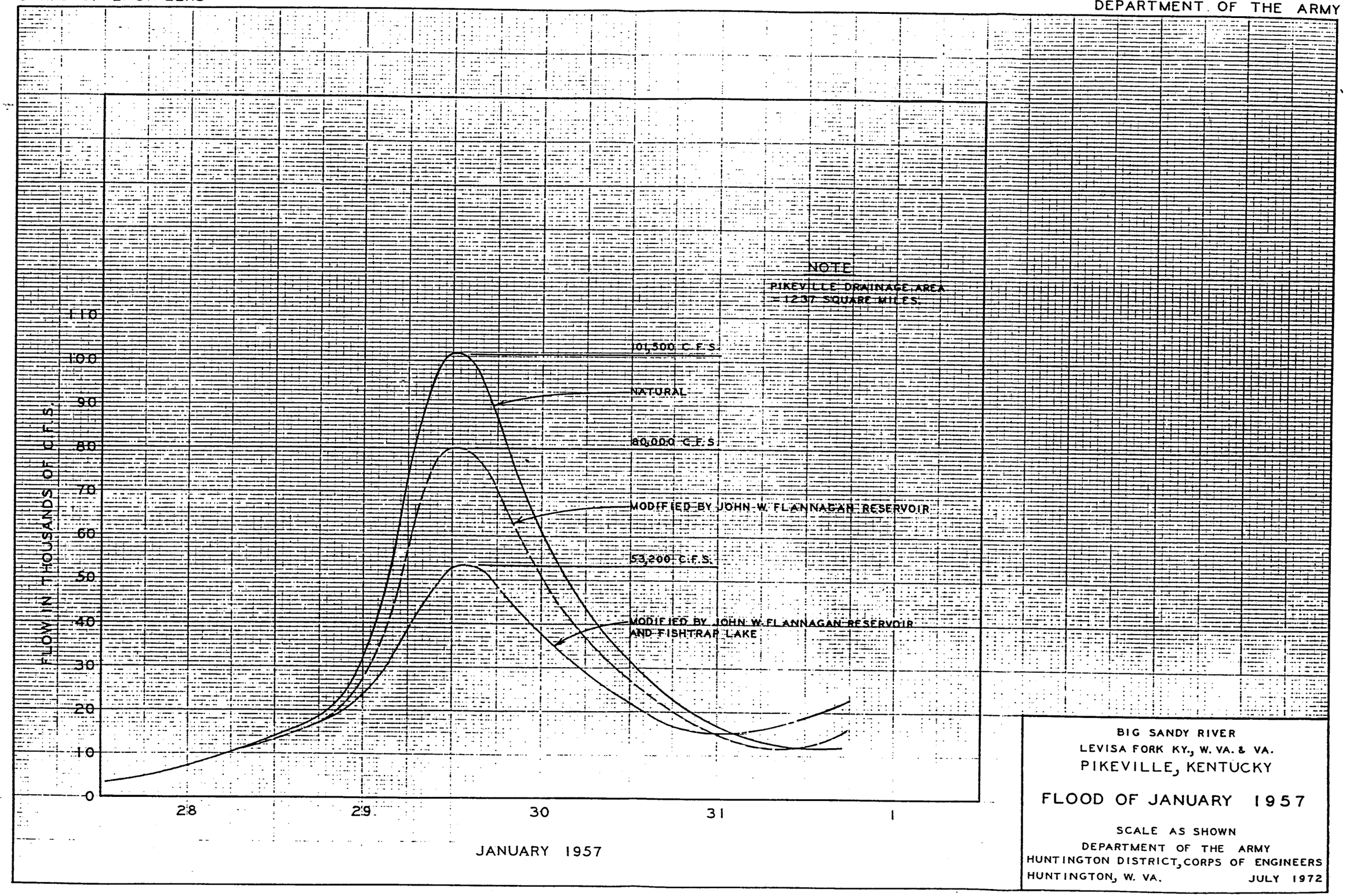
SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, HUNTINGTON
CORPS OF ENGINEERS
HUNTINGTON, W. VA. REVISED MARCH 1968

Plate No. 8-11

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY



BIG SANDY RIVER
LEVISA FORK KY., W. VA. & VA.
PIKEVILLE, KENTUCKY

FLOOD OF JANUARY 1957

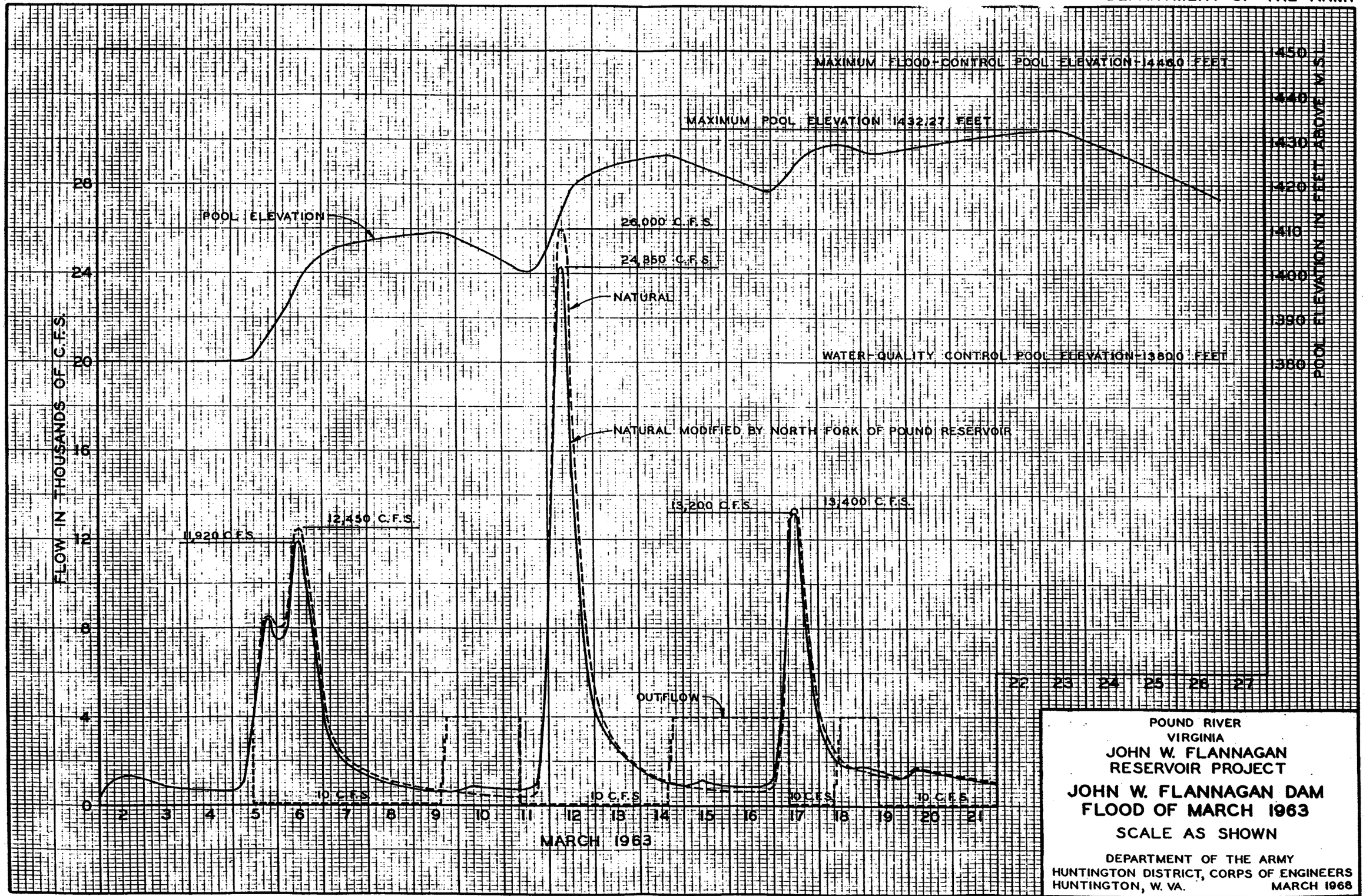
SCALE AS SHOWN
DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W. VA. JULY 1972

Plate No. 8-12

K&E 12 X 20 TO THE INCH 47 1970
10 X 15 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY



POUND RIVER
VIRGINIA

JOHN W. FLANNAGAN
RESERVOIR PROJECT

JOHN W. FLANNAGAN DAM
FLOOD OF MARCH 1963

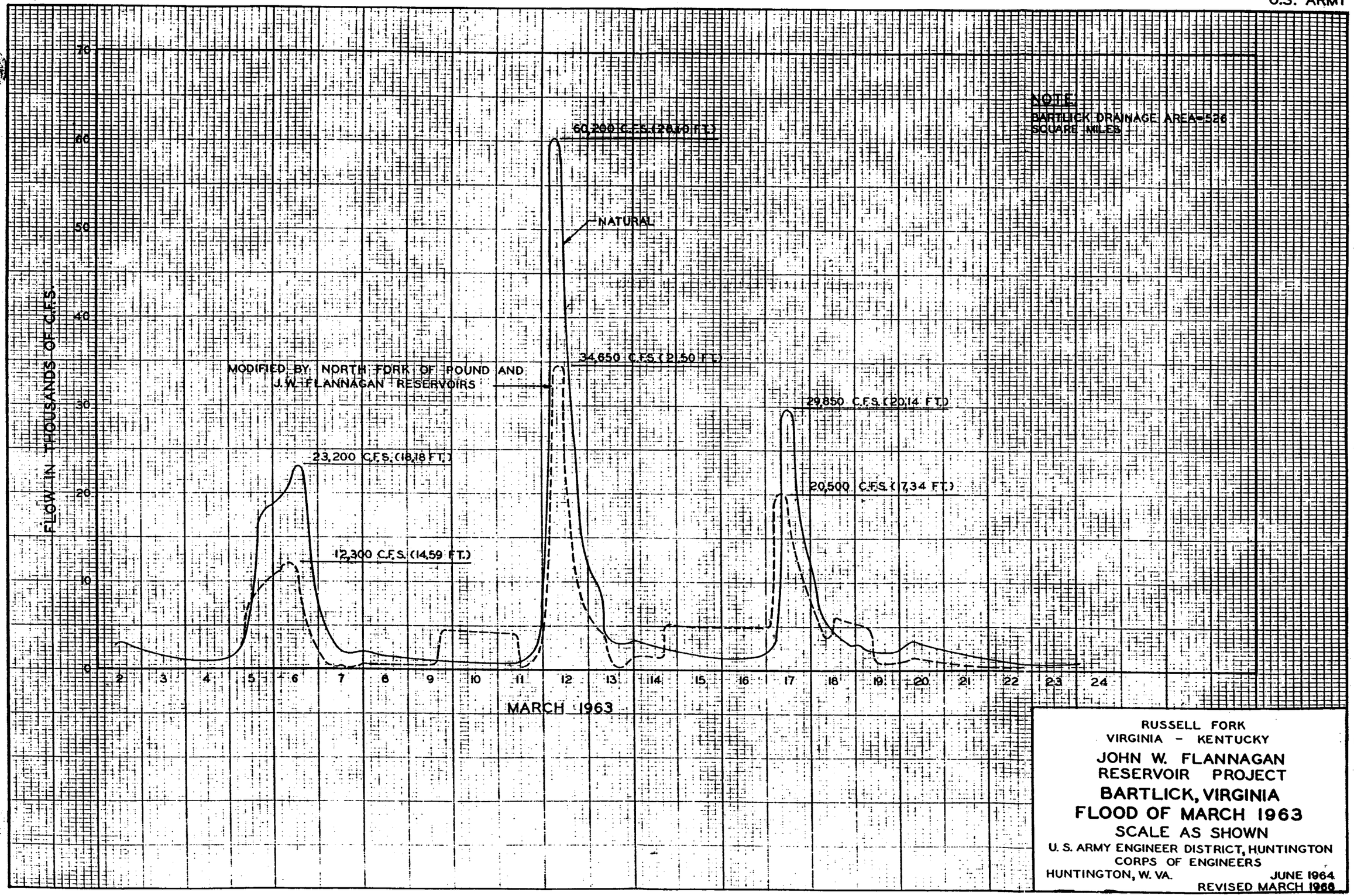
SCALE AS SHOWN

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W. VA. MARCH 1968

Plate No. 8-13

CORPS OF ENGINEERS

U.S. ARMY



RUSSELL FORK
VIRGINIA - KENTUCKY

JOHN W. FLANNAGAN
RESERVOIR PROJECT

BARTLICK, VIRGINIA

FLOOD OF MARCH 1963

SCALE AS SHOWN

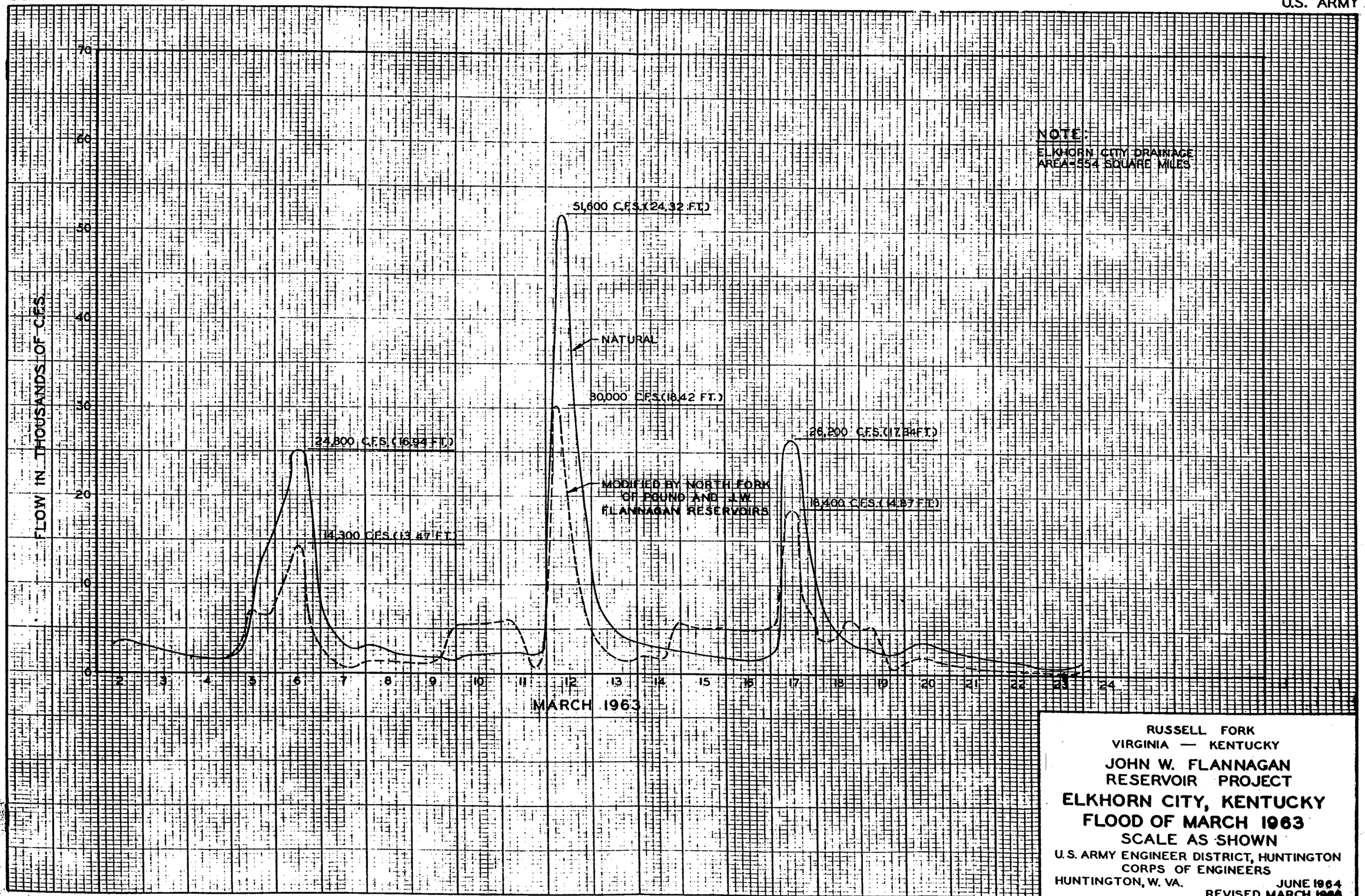
U. S. ARMY ENGINEER DISTRICT, HUNTINGTON
CORPS OF ENGINEERS
HUNTINGTON, W. VA.

JUNE 1964
REVISED MARCH 1968

Plate No. 8-14

CORPS OF ENGINEERS

U.S. ARMY



RUSSELL FORK
VIRGINIA — KENTUCKY

JOHN W. FLANNAGAN
RESERVOIR PROJECT

ELKHORN CITY, KENTUCKY
FLOOD OF MARCH 1963

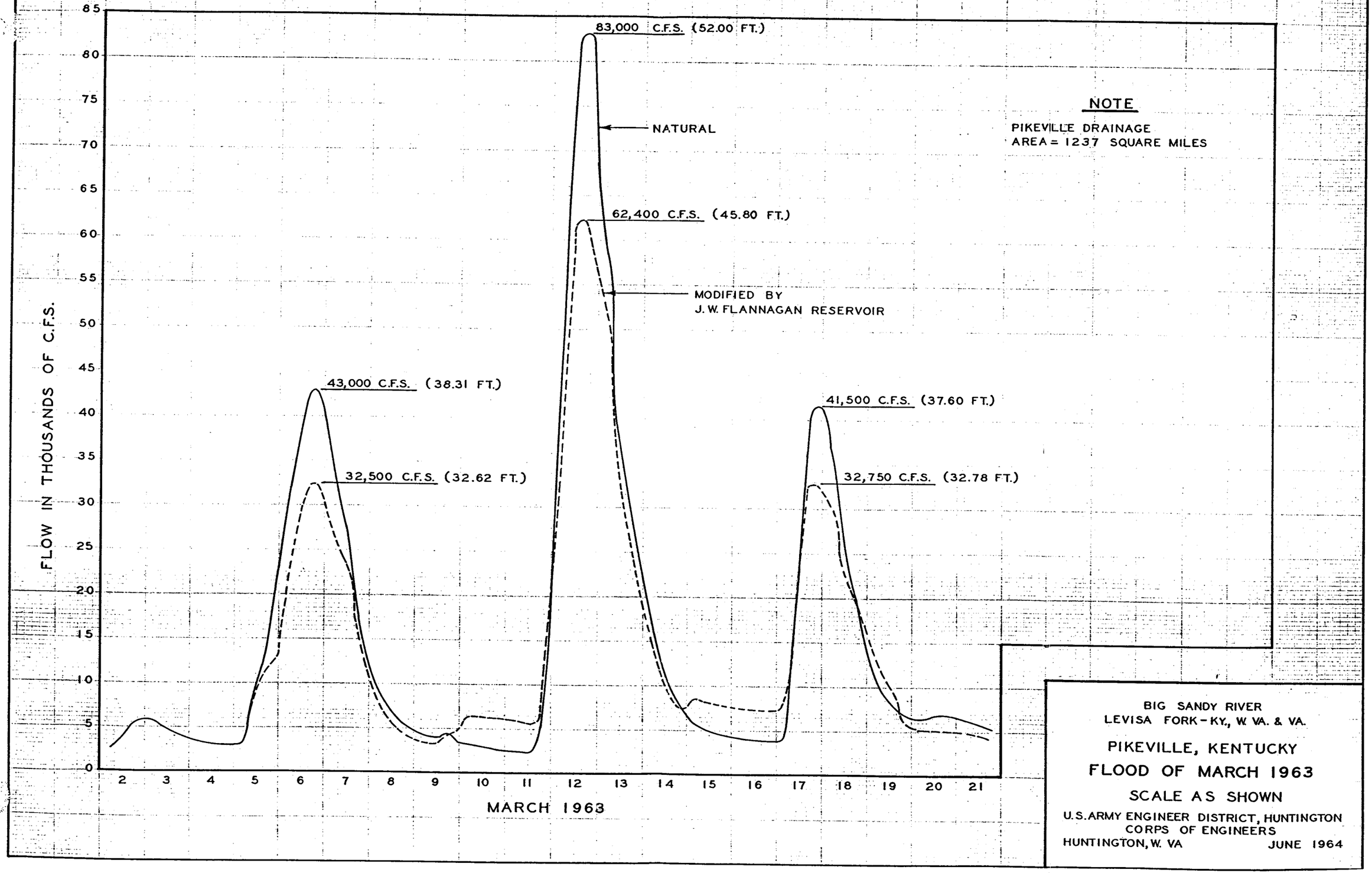
SCALE AS SHOWN

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

JUNE 1964
REVISED MARCH 1968

CORPS OF ENGINEERS

U.S. ARMY



NOTE

PIKEVILLE DRAINAGE
AREA = 1237 SQUARE MILES

BIG SANDY RIVER
LEVISA FORK - KY., W. VA. & VA.

PIKEVILLE, KENTUCKY

FLOOD OF MARCH 1963

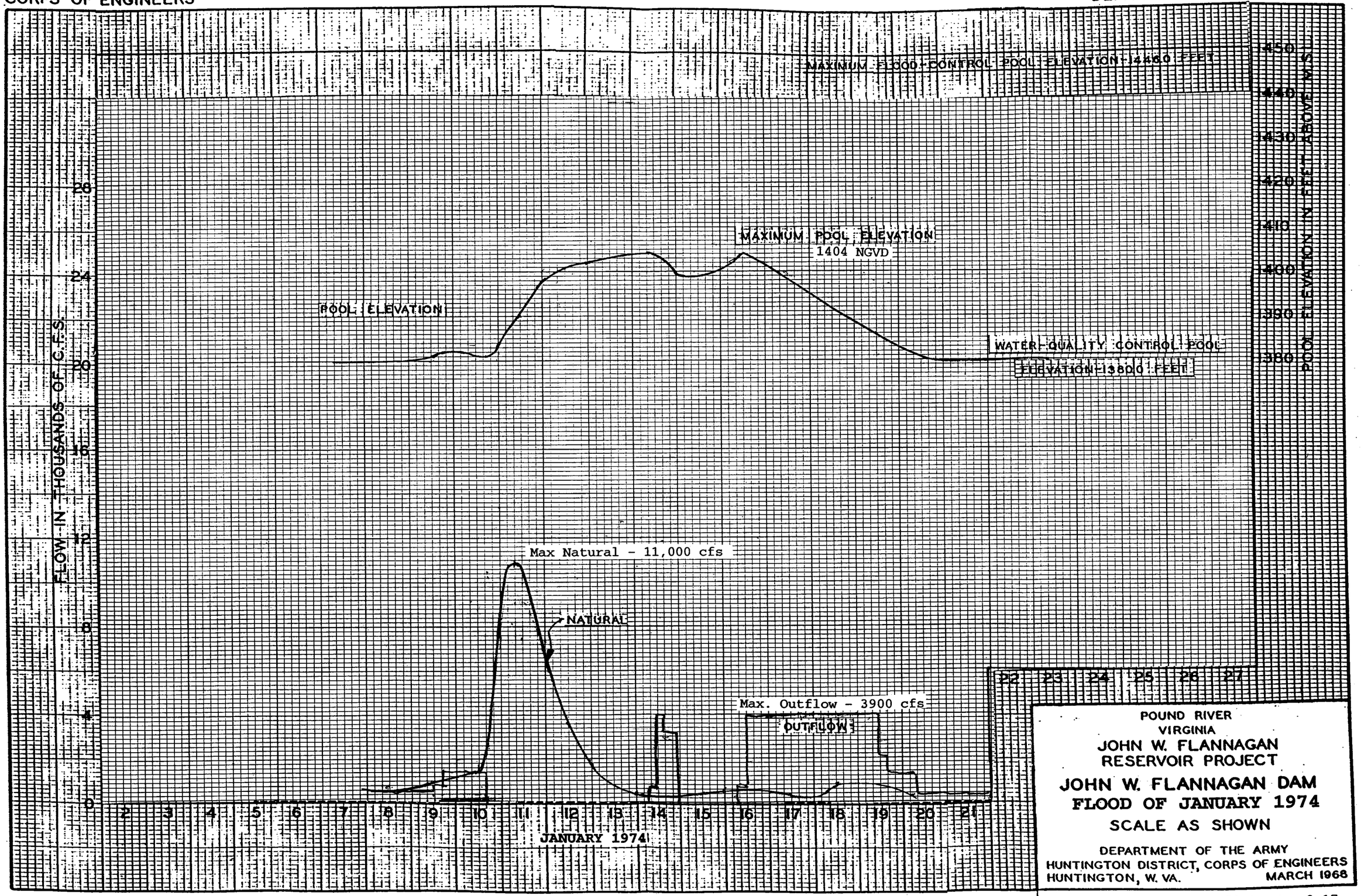
SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, HUNTINGTON
CORPS OF ENGINEERS
HUNTINGTON, W. VA JUNE 1964

Plate No. 8-16

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY



POUND RIVER
VIRGINIA

JOHN W. FLANNAGAN
RESERVOIR PROJECT

JOHN W. FLANNAGAN DAM
FLOOD OF JANUARY 1974

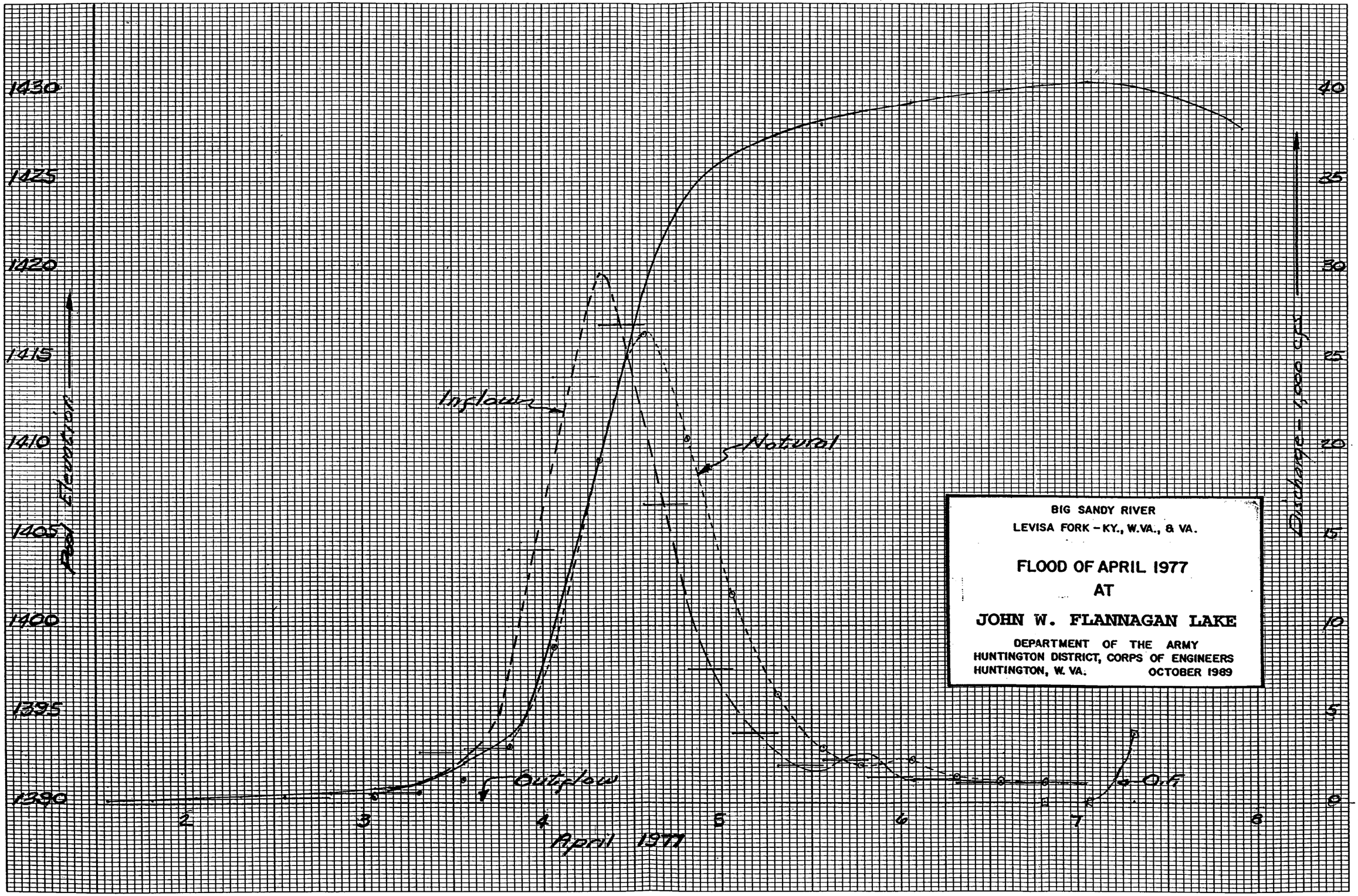
SCALE AS SHOWN

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W. VA. MARCH 1968

Plate No. 8-17

47 1970

K·E 12 x 20 TO THE INCH • 10 x 15 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

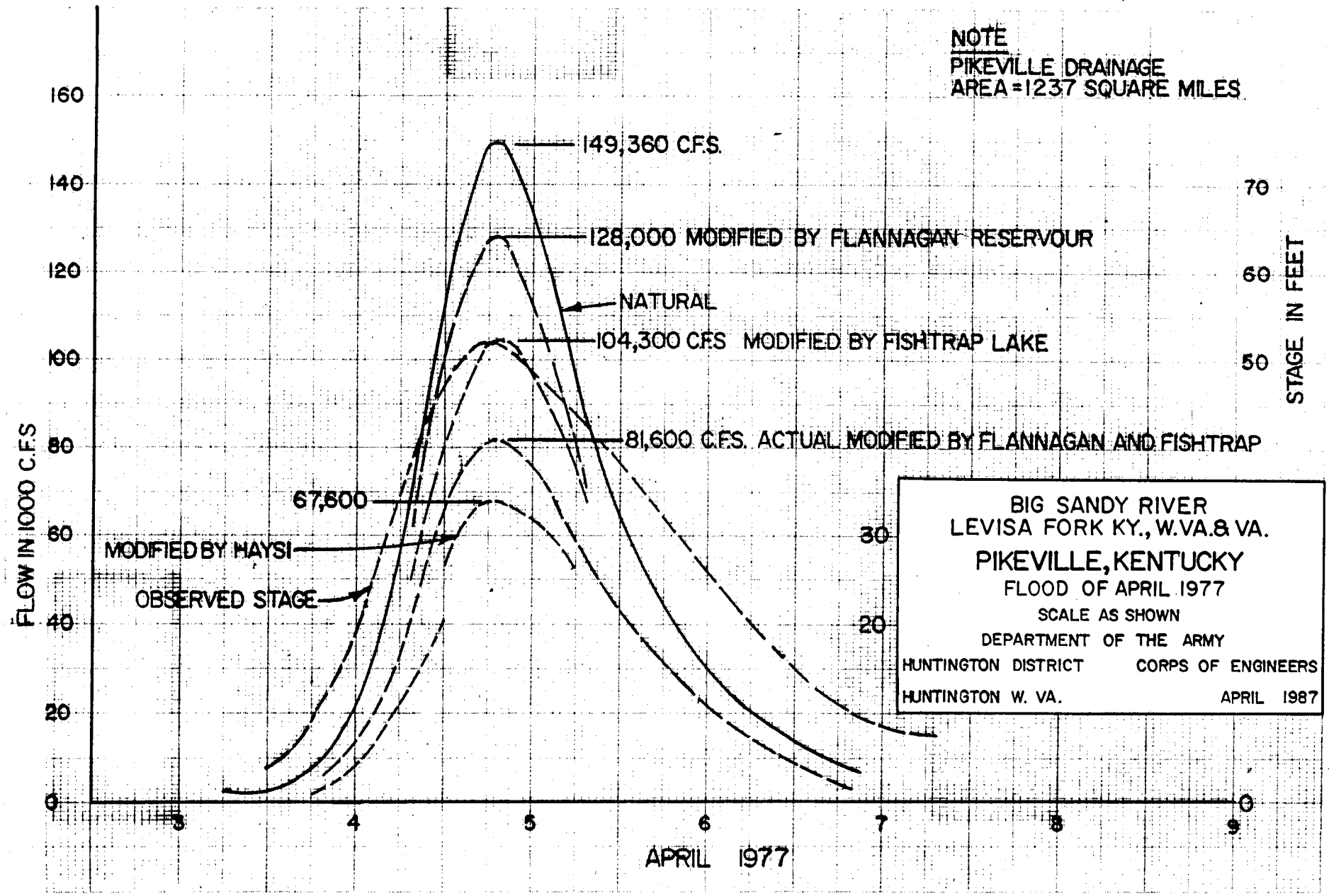


BIG SANDY RIVER
LEVISA FORK – KY., W.VA., & VA.

FLOOD OF APRIL 1977
AT
JOHN W. FLANNAGAN LAKE

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

Plate No. 8-18


NOTE
PIKEVILLE DRAINAGE
AREA = 1237 SQUARE MILES
149,360 C.F.S.
128,000 MODIFIED BY FLANNAGAN RESERVOUR
NATURAL
104,300 C.F.S MODIFIED BY FISHTRAP LAKE
81,600 C.F.S. ACTUAL MODIFIED BY FLANNAGAN AND FISHTRAP
67,600
MODIFIED BY HAYSI
OBSERVED STAGE
FLOW IN 1000 C.F.S
STAGE IN FEET
160
140
120
100
80
60
40
20
0
70
60
50
30
20
0
3
4
5
6
7
8
9
APRIL 1977
BIG SANDY RIVER
LEVISA FORK KY., W.VA.& VA.
PIKEVILLE, KENTUCKY
FLOOD OF APRIL 1977
SCALE AS SHOWN
DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT CORPS OF ENGINEERS
HUNTINGTON W. VA. APRIL 1987

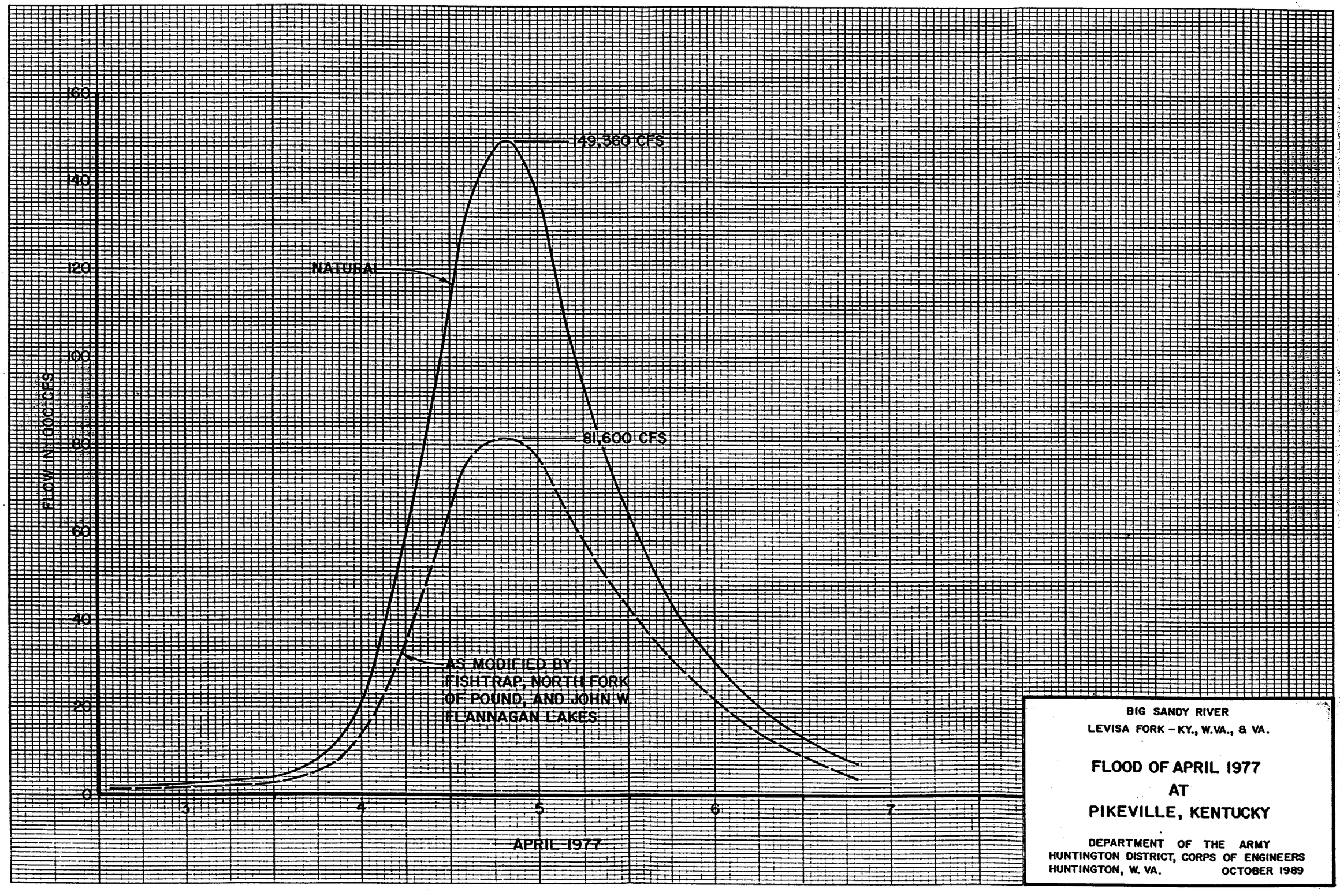
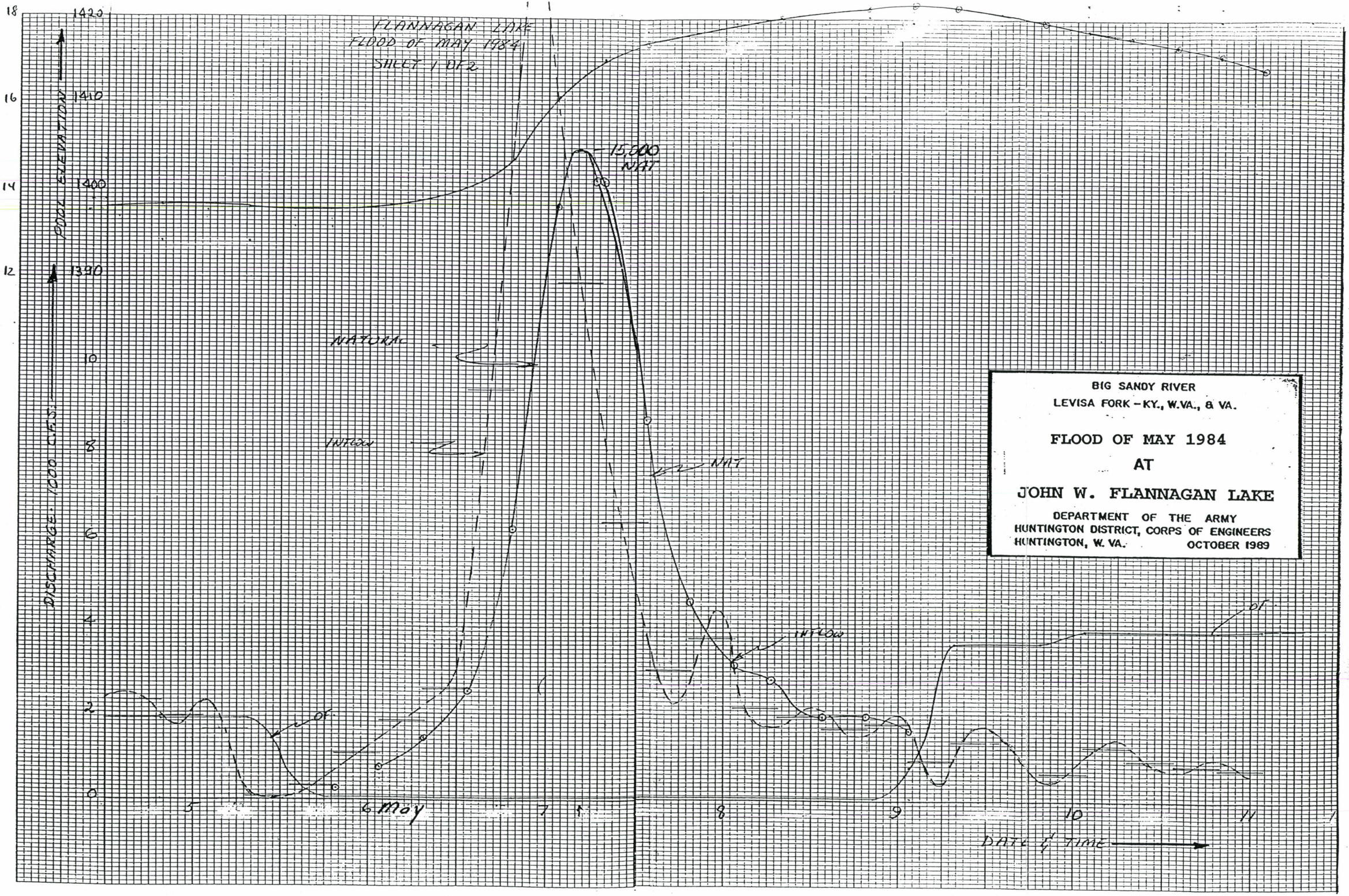

160
140
120
100
80
60
40
20
0
FLOW IN 1000 CFS
149,360 CFS
NATURAL
81,600 CFS
AS MODIFIED BY FISHTRAP, NORTH FORK OF POUND, AND JOHN W. FLANNAGAN LAKES
3
4
5
6
7
APRIL 1977
BIG SANDY RIVER
LEVISA FORK - KY., W.VA., & VA.
FLOOD OF APRIL 1977
AT
PIKEVILLE, KENTUCKY
DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W. VA. OCTOBER 1989

Plate No. 8-20

FLANNAGAN LAKE
FLOOD OF MAY 1984
SHEET 1 OF 2



BIG SANDY RIVER
LEVISA FORK – KY., W.VA., & VA.

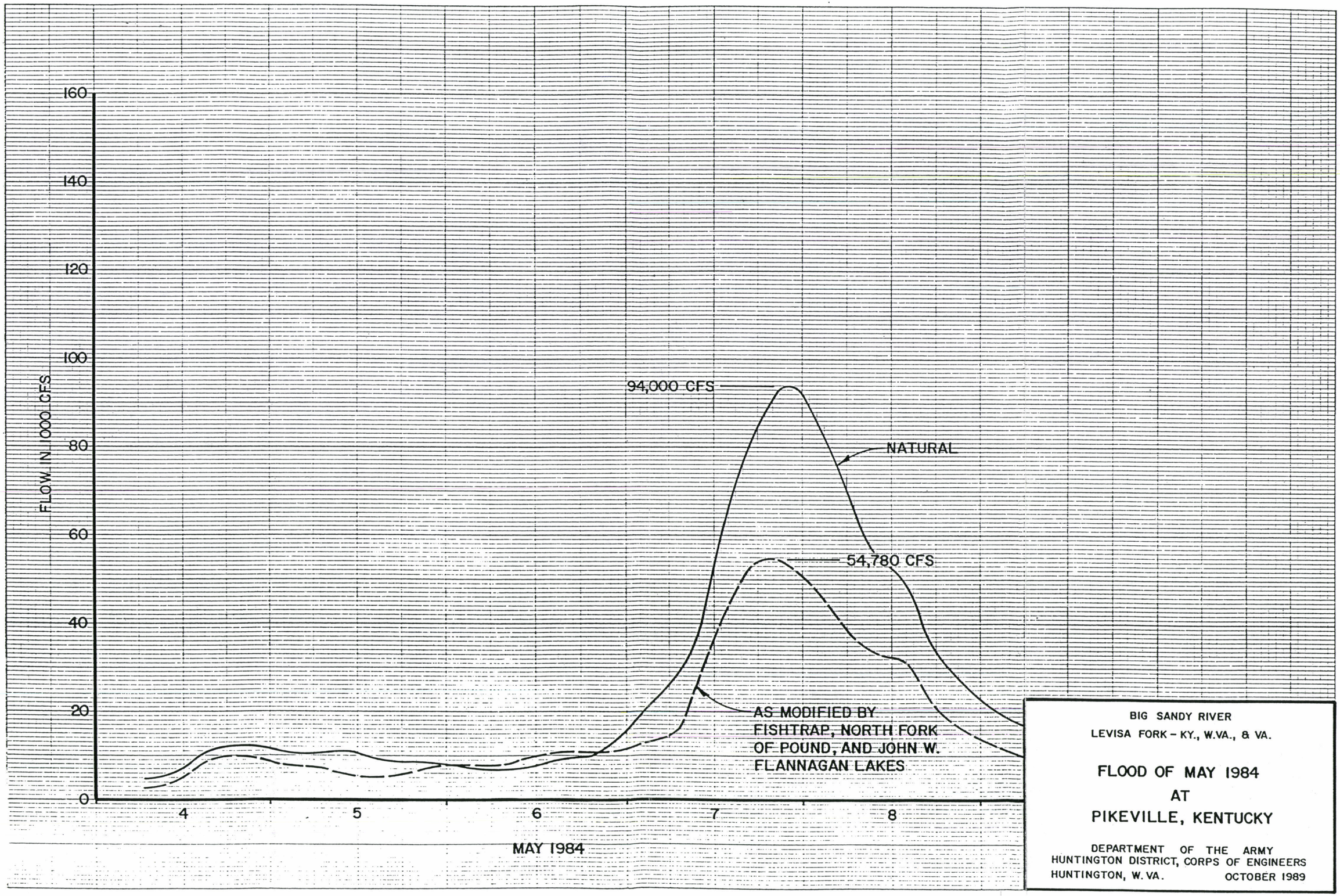
FLOOD OF MAY 1984
AT
JOHN W. FLANNAGAN LAKE

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

47 1970

K&E 12 x 20 TO THE INCH • 10 X 15 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

Plate No. 8-21



BIG SANDY RIVER
LEVISA FORK – KY., W.VA., & VA.

FLOOD OF MAY 1984
AT
PIKEVILLE, KENTUCKY

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

Plate No. 8-22

Water Temperature
July 25, 1995

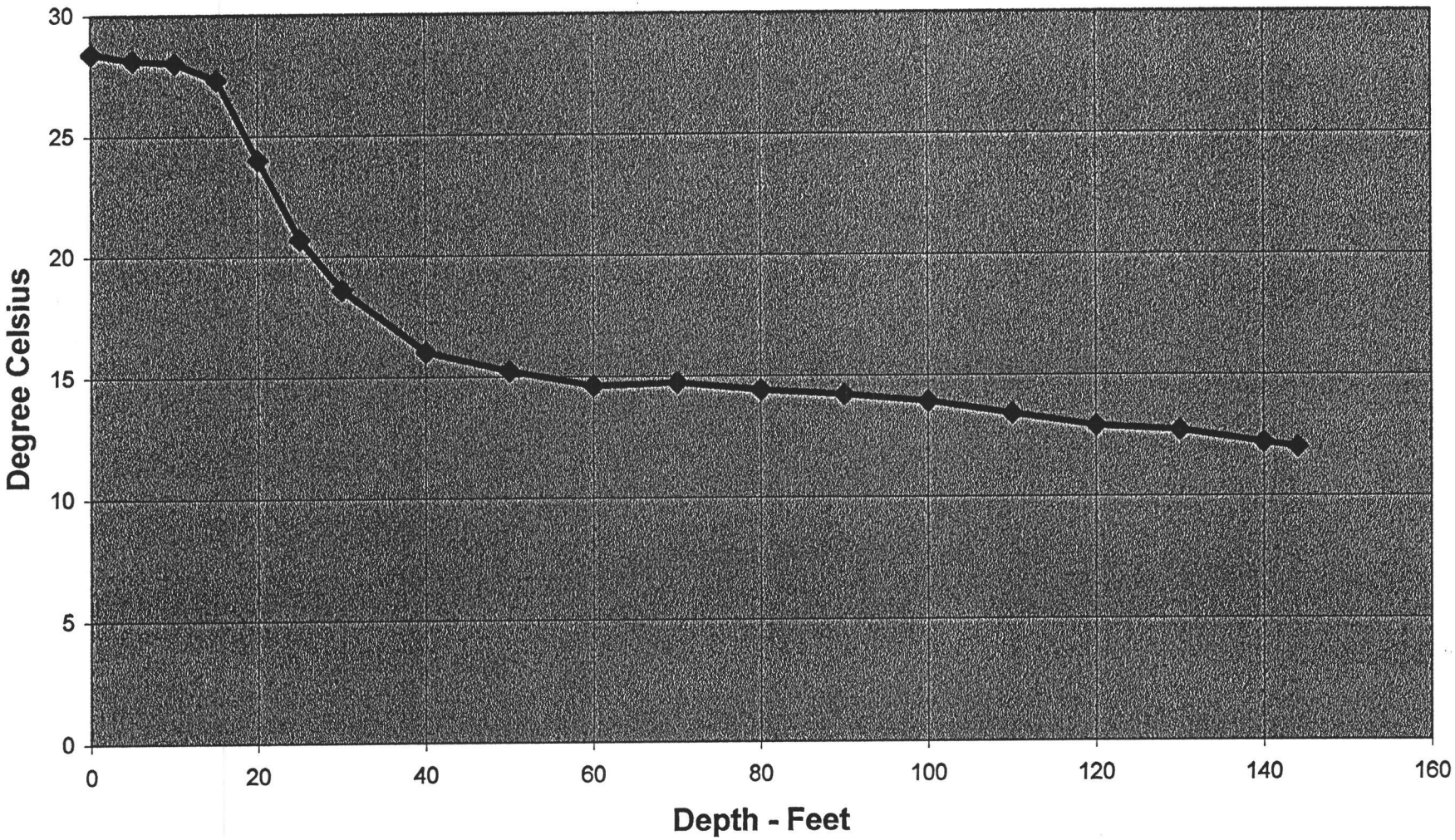


Plate No. 8-23

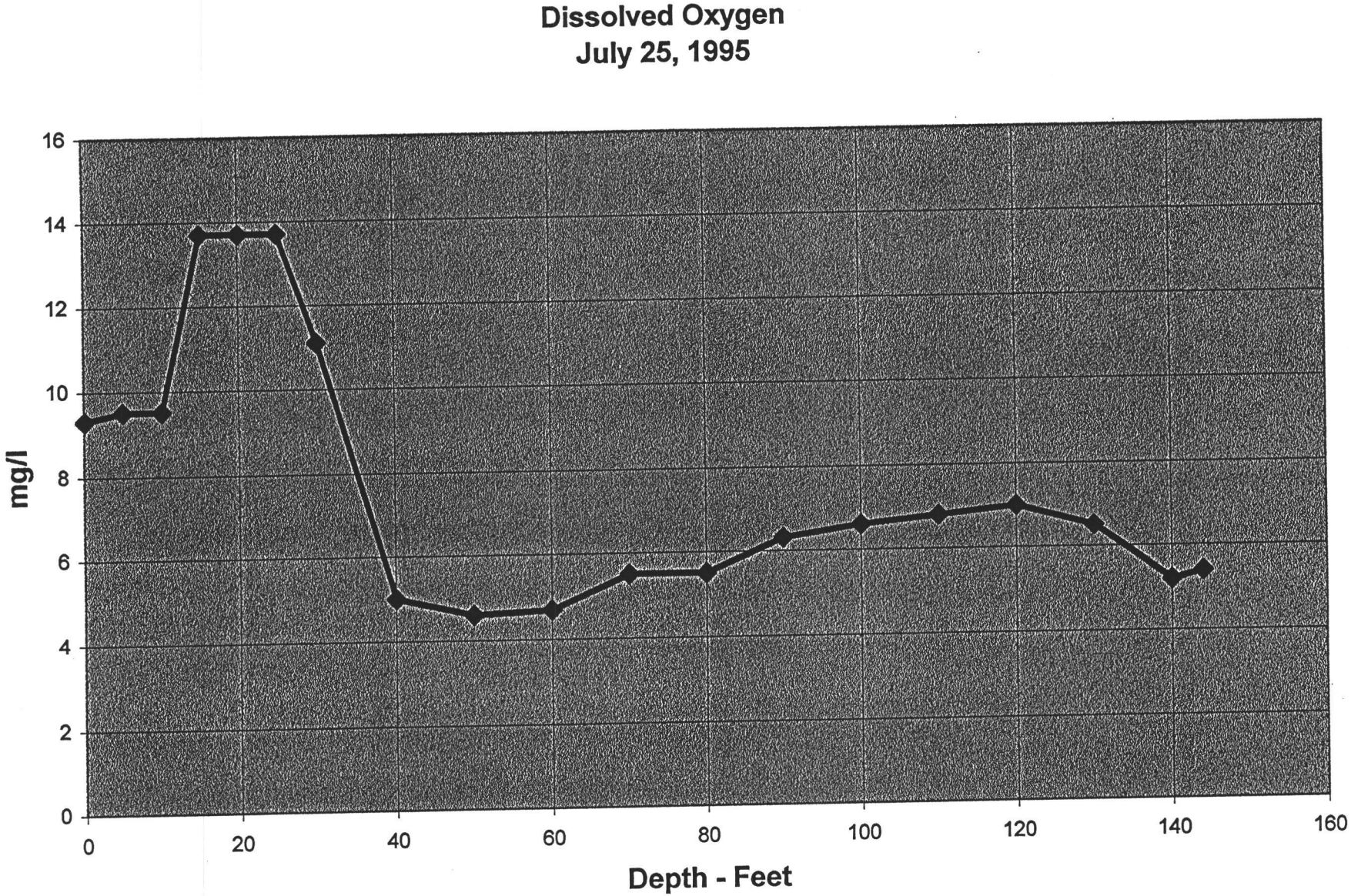

Dissolved Oxygen
July 25, 1995
mg/l
16
14
12
10
8
6
4
2
0
0
20
40
60
80
100
120
140
160
Depth - Feet

Plate No. 8-24

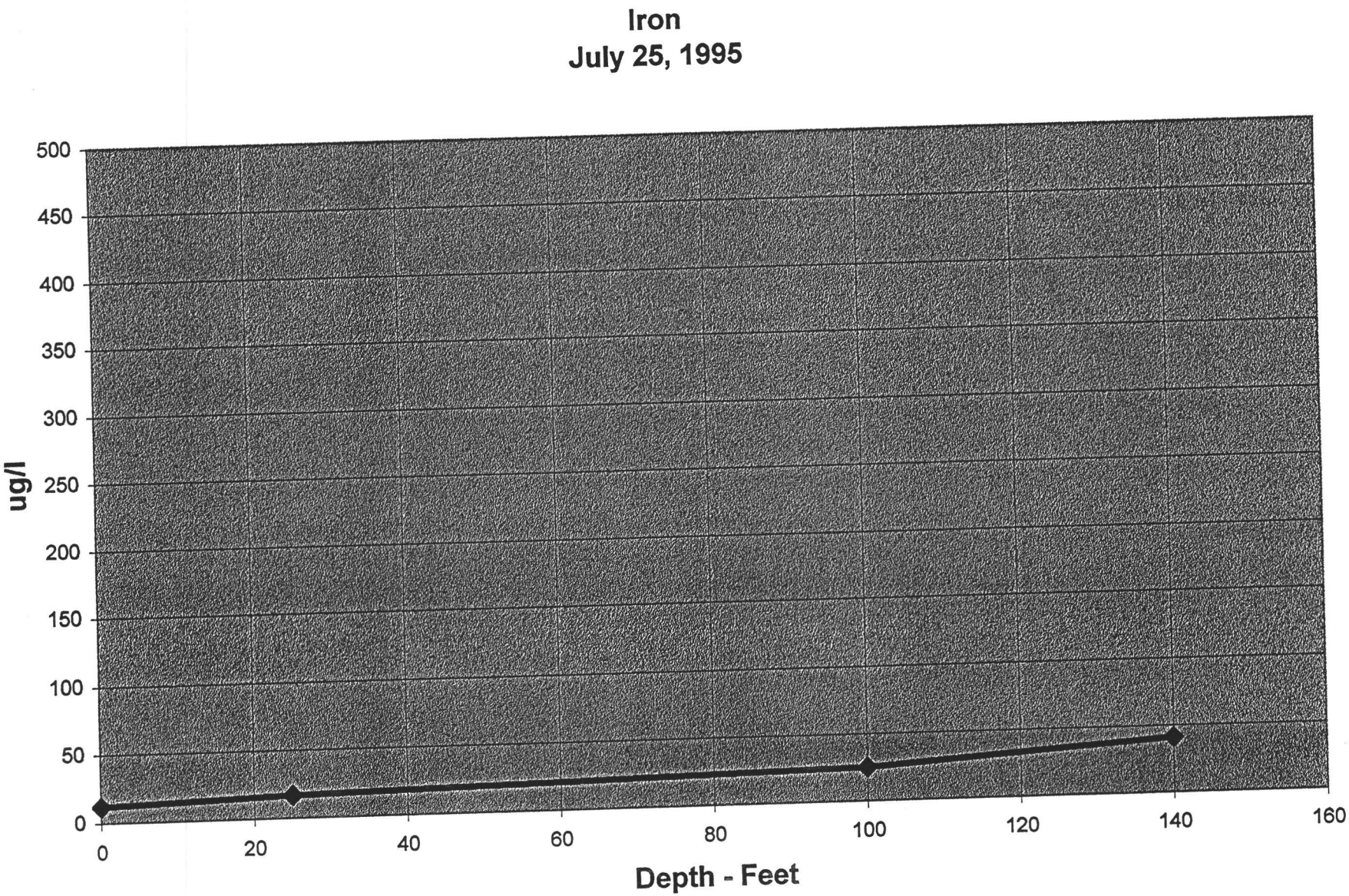

Iron
July 25, 1995
500
450
400
350
300
250
200
150
100
50
0
ug/l
0
20
40
60
80
100
120
140
160
Depth - Feet

Plate No. 8-25

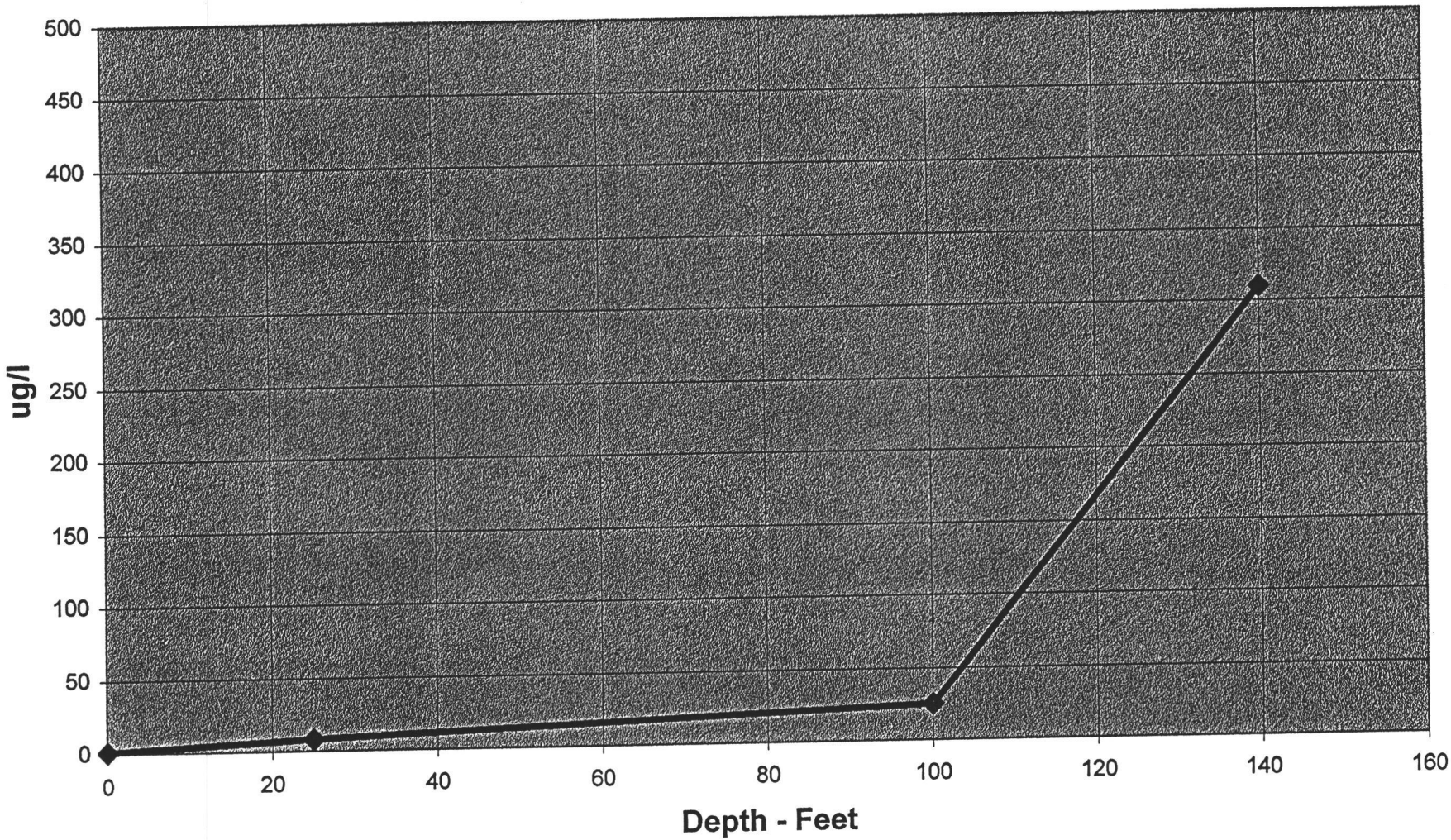
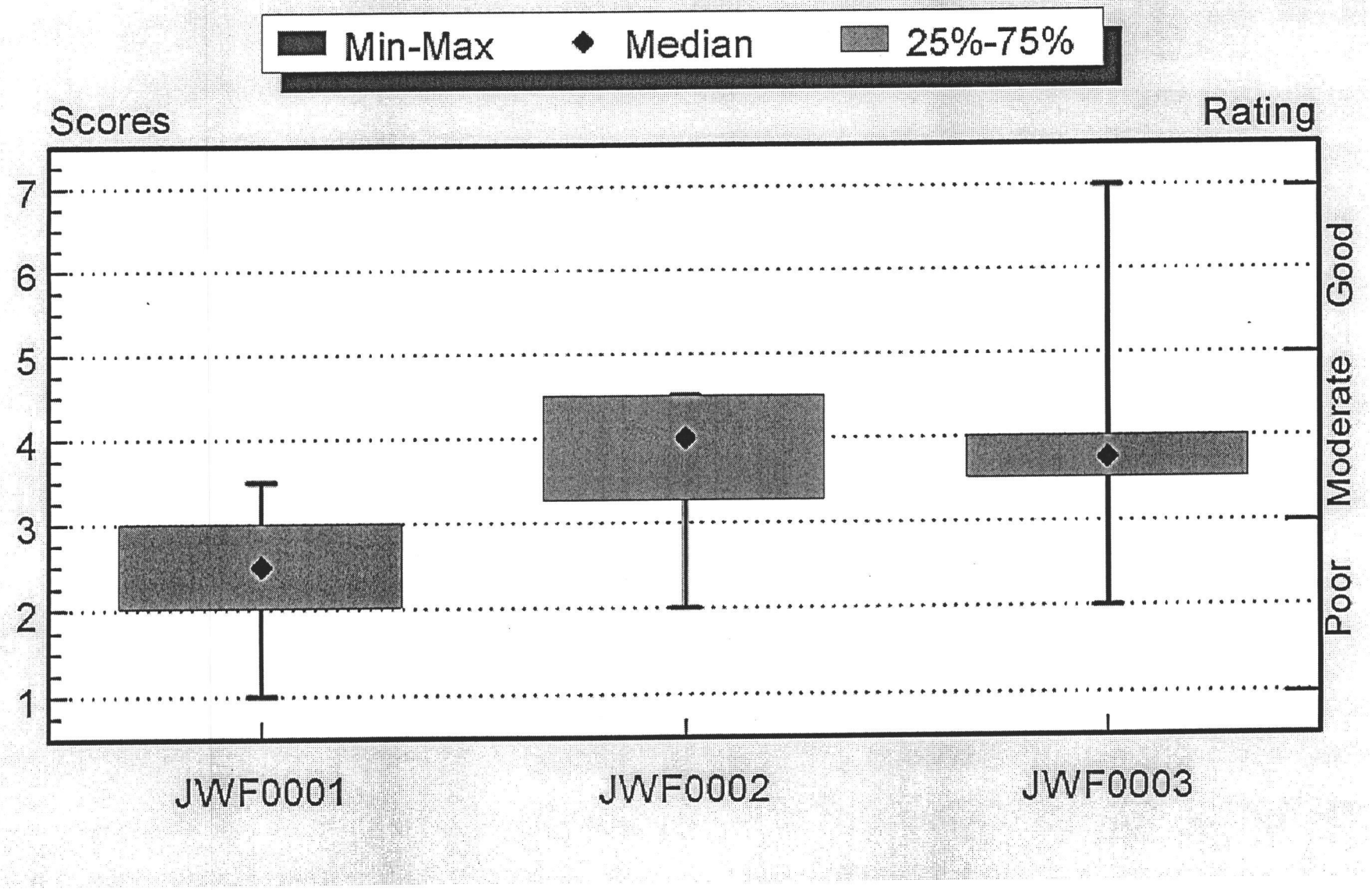
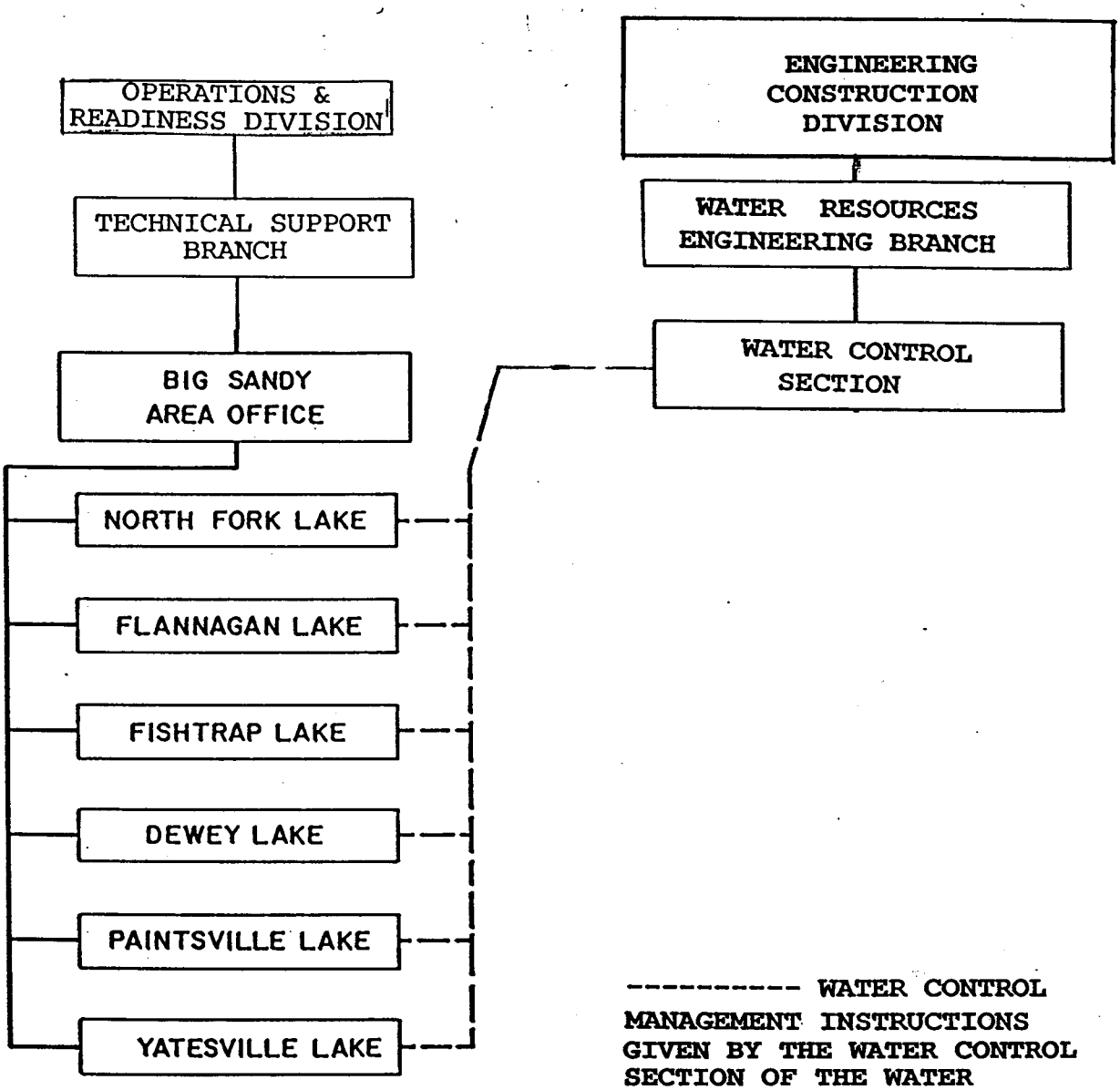

Manganese
July 25,1995
ug/l
500
450
400
350
300
250
200
150
100
50
0
0
20
40
60
80
100
120
140
160
Depth - Feet

Plate No. 8-26

- OVERALL QUALITY RATING - For Macroinvertebrate Stations



WATER CONTROL MANAGEMENT
BIG SANDY RIVER BASIN
NORMAL ORGANIZATION



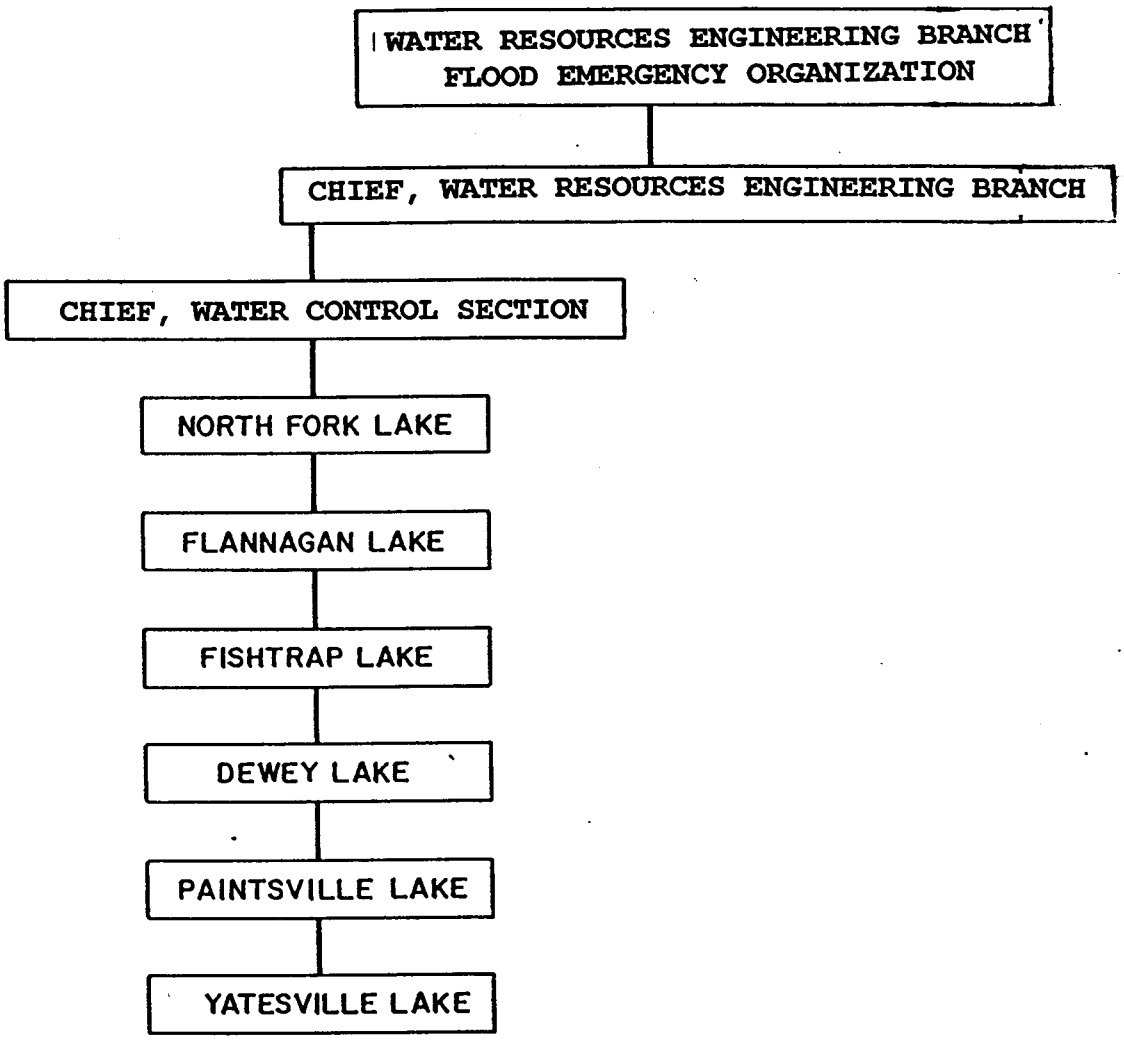
BIG SANDY RIVER
KENTUCKY, WEST VIRGINIA & VIRGINIA
BIG SANDY RIVER BASIN

WATER CONTROL MANAGEMENT
NORMAL ORGANIZATION

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

Plate No. 9.1

WATER CONTROL MANAGEMENT
BIG SANDY RIVER BASIN
FLOOD EMERGENCY ORGANIZATION

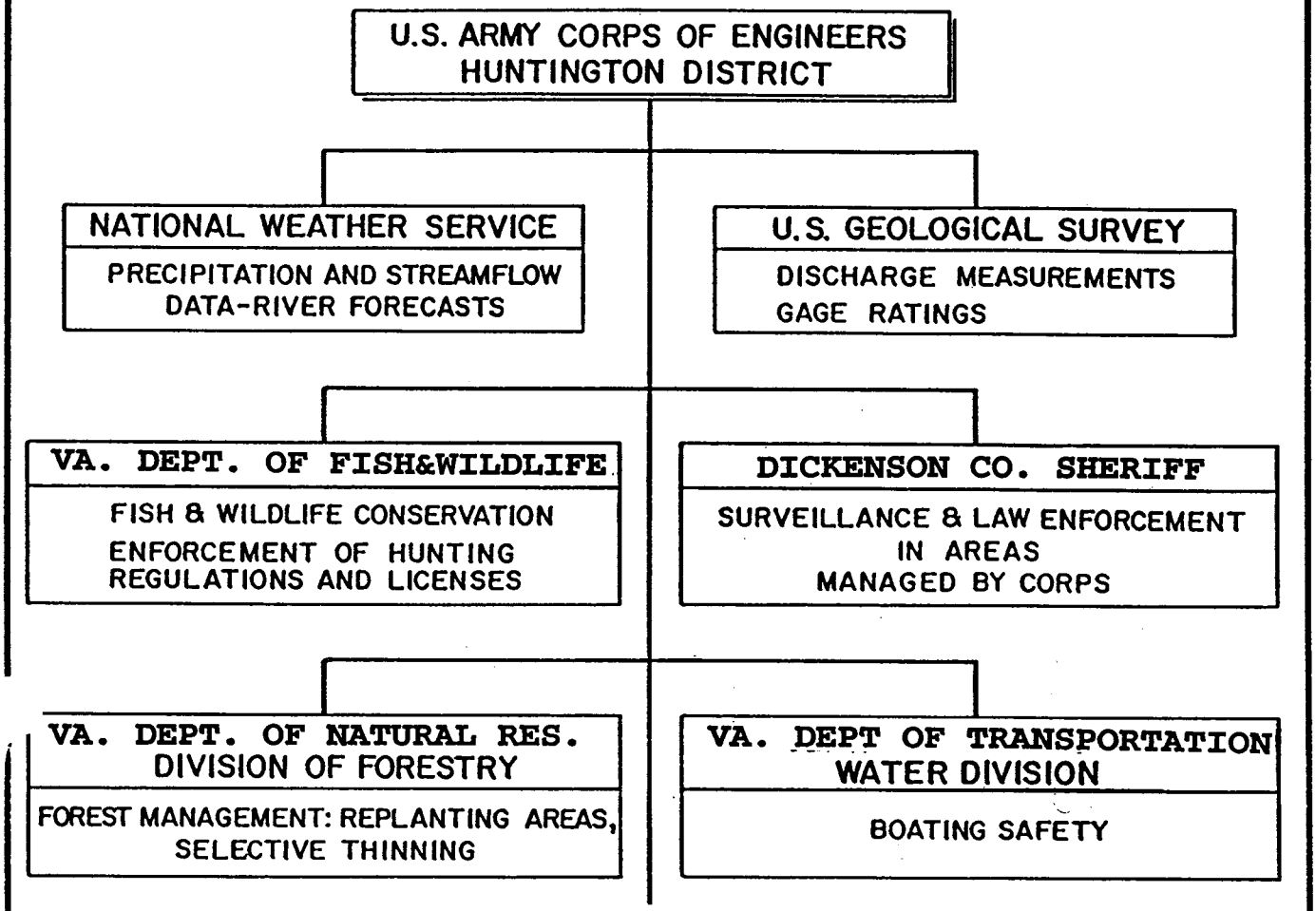


BIG SANDY RIVER
KENTUCKY, WEST VIRGINIA & VIRGINIA
BIG SANDY RIVER BASIN

WATER CONTROL MANAGEMENT
FLOOD EMERGENCY ORGANIZATION

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

Plate No. 9-2



JOHN W. FLANNAGAN LAKE

HUNTINGTON DISTRICT RELATIONS WITH OTHER AGENCIES

PLATE NO. 9-3