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
cllr

CELRH-EC-WM

20 January 2004
Schray/5604

Memorandum for Kent Browning, OR Water Management POC.

Subject: Modification of Huntington District Water Control Reporting Procedures.

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them to place this memorandum in the front of the Water Control Manual, and make notes in the text which has been superseded.

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

The following sections are modified as noted.

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

Measure and report to EC-WM by 0900 hours the water content of the snow at least as often as indicated below.

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

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

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

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

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

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

This section is rescinded in its entirety and is replaced by 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

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

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

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

17 December 2002

REPLY TO ATTENTION OF:

Engineering & Construction Division
Water Resources Engineering Branch

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Updates for the Wills Creek Lake Water Control Manual

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

2. Please replace the following pages with the attached pages: 7-2, 7-6, and 7-7 (main text), 1-2 (Exhibit B), and Plate No. 4-9 and 7-4.

3. 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-MUR
CELRH-OR-WCW (2)
CELRH-EC-WW (2)
CELRH-EC-WH

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

REPLY TO
ATTENTION OF
Engineering & Construction Division
Water Resources Engineering Branch

3 June 2002

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Water Control Manual for Wills Creek Lake

1. Please replace the existing Plate in subject manual with the revised Plate (attached).

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

Encl

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

DISTRIBUTION:
CELRD-ET-W (2)
CELRH-OR
CELRH-OR-WCW (2)
CELRH-OR-MUR
CELRH-EC-WW (2)
CELRH-EC-WH

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

REPLY TO
ATTENTION OF
CELRH-EC-W (1110-2-1403a)

25 April 2002
Brown/5530

MEMORANDUM FOR: Commander, Great Lakes and Ohio River Division,
ATTN: CELRD-ET-W

SUBJECT: Water Control Manual for Wills Creek Lake

Forwarded herewith are two copies of the subject manual for your retention.

2 Encl

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

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

WILLS CREEK DAM

WILLS CREEK BASIN

OHIO

PROJECT MANUAL
FOR WATER CONTROL MANAGEMENT
WILLS CREEK LAKE – WILLS CREEK

PREPARED BY
CORPS OF ENGINEERS
HUNTINGTON DISTRICT
WATER RESOURCES ENGINEERING BRANCH

April 2002

WILLS CREEK LAKE

[redacted]

MUSKINGUM RIVER

WILLS CREEK LAKE

DAM AND SPILLWAY

PLAN, PROFILE AND SECTION

HUNTINGTON DISTRICT, HUNTINGTON, W. VA.

Revised : 30 SEPTEMBER 1984

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 non-duty hours, communications can be achieved by contacting, in the order listed, one of the following.

CORPS OF ENGINEERS
Muskingum Area Office,
Dover, Ohio
[redacted], Area Manager

Normal Work Hours, [redacted]
Night, weekend, Holiday, NWS observers
Person-to-Person, at home
[redacted] [redacted]

KEY EMERGENCY CONTACTS

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

DISTRICT PERSONNEL	Office Assignment	Telephone Residence
Water Resources Engineering Branch		
[redacted]	Chief, Water Control Section	[redacted]*
[redacted],	Water Control Section	[redacted]
[redacted] Chief, Water Resources Engineering Branch		[redacted]*

*Unlisted numbers

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

Other Agencies

U. S. Geological Survey
New Philadelphia, Ohio [redacted]

Night, Weekend, Holidays
[redacted] [redacted]

National Weather Service
W. S. Forecast Office
Hydrology Section FTS [redacted]
Pittsburgh, Penn.

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LIST OF PLATES (continued)

TABLE 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, meteorological, 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.

SUPPLEMENTARY PERTINENT DATA

LOCATION OF PROJECT

Wills Creek Lake is located in Coshocton, Muskingum and Guernsey Counties, on Wills Creek, a tributary of the Muskingum River. The dam site is 108.2 miles above the mouth of the Muskingum River and 5.0 miles above the mouth of Wills Creek.

TYPE OF PROJECT

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

DAM

Type: rolled earth fill embankment with impervious core	
Maximum height, feet	87
Top length, feet	1,950
Top width, feet	30
Base width, feet	240+

SPILLWAY

Type: uncontrolled saddle spillway at right (east) abutment	
Crest length, feet	204.5
Crest elevation, feet NGVD	779
Design discharge, cfs	45,800
Surcharge, feet	18

OUTLET WORKS

Type: Intake structure with control weir, tunnel and stilling basin

Intake Structure: Reinforced concrete with two semi-circular 20 foot arch conduits and control gates

Control weir - equipped with two stop log gates for maintaining minimum pool elevation

Number of control gates	6
Size of control gates in feet	7x15
Invert elevation of control gates, NGVD	733
Maximum outlet discharge at spillway elevation, all gates open (cfs)	25,000
Tunnel	
Number of tunnels	2
Type, semi-circular, concrete lined	
Size, diameter in feet	20
Length in feet	179.5
Stilling Basin	
Type, conventional jump type with a stepped apron discharging onto a baffle sill	
Width in feet	85
Length in feet, including outlet transition	190

WILLS CREEK OHIO
PROJECT MANUAL
FOR
WATER CONTROL MANAGEMENT
WILLS CREEK - MUSKINGUM RIVER

SECTION I - INTRODUCTION

1-01. AUTHORIZATION

This manual is prepared in accordance with Engineer Regulation 1110-2-240, Water Control Management, dated 30 April 1987; Engineer Manual 1110-2-3600, Management of Water Control Systems, dated 30 November 1987; Engineer Regulation 1110-2-8156, Preparation of Water Control Manuals, dated 31 August 1995; and ETL 1110-2-251, dated 14 March 1980, which provides for submission of regulation manuals in accordance with instructions contained in "Guide for Preparing Water Control Manuals" as prepared by SWD, dated October 1977.

1-02. PURPOSE AND SCOPE OF WATER CONTROL MANUAL

The purpose of this manual is to furnish detailed schedules for the regulation of Wills Creek Lake. The manual will function as documentation of the plan for water control and as a reference source for higher authority and office and field personnel responsible for water control management throughout the life of the project. The manual also contains background information necessary for under standing the objectives and application of the water management schedules, as well as results of optimal simulation of project operation for specific purposes and conditions.

1-03. RELATED MANUALS AND REPORTS

	Title	Date
1.	Report on main river in vicinity of mouth (Navigation)	1879
2.	Report on main river, (Navigation)	1884
3.	Report on main river, (Navigation)	1886
4.	Report on main river, Zanesville to Dresden (Navigation)	1889
5.	Report on main river, Zanesville to Dresden (Navigation)	1895

	Title	Date
6.	Report on main river, Zanesville to Coshocton (Navigation)	1902
7.	Report on main river in vicinity of the mouth (Navigation)	1905
8.	Report on Muskingum River and all tributaries. House Document No. 1792, 64th Congress, 2nd Session.	September 1916
9.	Official Plan for the Muskingum Watershed Conservancy District. 2 volumes.	November 1934 Revised June 1935
10.	Comprehensive Report on Reservoirs in the Mississippi River Basin. House Document No. 259, 74th Congress, 1st Session.	August 1935
11.	Report on the Ohio River, House Document No. 306, 74th Congress, 1st Session.	August 1935
12.	Comprehensive Plan for Flood Control for Ohio and Lower Mississippi Rivers, House Document No. 1, 75th Congress, 1st Session.	April 1937
13.	Analysis of Design - Wills Creek Dam. Revised	1938
14.	Major Dams and Hydro-Projects in the Huntington, West Virginia and Zanesville, Ohio Engineer Districts	November 1937
15.	History and Development of the Muskingum Watershed Conservancy District Projects	March 1938 Revised March 1939 Revised July 1952
16.	Analysis of Hydrologic Data for Index Areas - Muskingum River Basin, Ohio	April 1942
17.	Flood Control Operation - Flood of December 1942 - January 1943 - Muskingum River Reservoirs, Ohio.	February 1943
18.	Channel Capacity Investigation - Muskingum River Reservoir System.	May 1944
19.	Instructions to the Damtender, Wills Creek Dam	April 1951
20.	An Experience History of the Muskingum River Reservoir System.	October 1951
21.	Water Inventory of the Muskingum River Basin and Adjacent Ohio River Tributary Area	1968

Title	Date
22. Muskingum Area, Emergency Operation Plan	March 1970
23. Post Flood Report, Muskingum River Basin, Ohio - Flood of July 1969.	April 1970
24. Periodic Inspection, Wills Creek Dam	
Report No. 1	April 1971
Report No. 2	August 1976
Report No. 3	August 1981
Report No. 4	August 1986
Report No. 5	August 1991
Report No. 6	August 1996
Report No. 7	August 2001
25. Muskingum River Basin, Ohio - Basin Report	September 1973
26. Report on the 1973 Sedimentation Reconnaissance	August 1974
27. Muskingum River Basin, Ohio, Spillway Adequacy Study	April 1975
28. Muskingum River Basin, Ohio - Interim Feasibility Report for Water Resources Development.	November 1975 Revised March 1976 Revised February 1977
29. Operations and Maintenance Manual Wills Creek Lake.	November 1977

1-04. PROJECT OWNER

The United States Government has full title, ownership, and fee control of all Huntington District, Corps of Engineers reservoir and lake lands, including Wills Creek Dam and operating structures. The Corps of Engineers boundary map showing the location of all the district flood control projects is shown as Plate No. 1-1.

1-05. OPERATING AGENCY

The U. S. Army Corps of Engineers, Huntington District, Operations and Readiness Division controls the operation and maintenance of the Wills Creek Lake project. To ensure correct operation Wills Creek Lake is staffed, all year round between the hours of 0700 and 1530, and the project is monitored during non-duty hours when conditions warrant it, and, if necessary, operations will be made during non-duty hours.

The Mailing Address is:
Wills Creek Lake
49320 County Road 497
Coshocton, Ohio 43812-9496

The Damtender is;
Victor R. Grewell
Office phone (740)829-2425

1-06. REGULATING AGENCY

The Water Control Section, of the Huntington District, Corps of Engineers, Water Resources Engineering Branch is primarily responsible for the regulation of Wills Creek Lake. Any operations which might deviate from the approved water control plan, as presented in this manual must be coordinated with the Great Lakes and Ohio River Division Water Control Center.

The operating and regulating responsibility is exercised under 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: Water Control Centers;

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

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

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

(6) ER 1110-2-208, DAEN-CWE-Y, 30 July 1979, Subject: Water Control Management; and

(7) ER 1110-2-240, DAEN-CWE-Y, 8 October 1982, Subject: Water Control Management.

SECTION II - DESCRIPTION OF PROJECT

2-01. LOCATION

Wills Creek dam is located in Coshocton County, Ohio, on Wills Creek, a tributary of the Muskingum River, 6.0 miles above the mouth of Wills Creek and 108.2 miles above the mouth of the Muskingum River, a tributary of the Ohio River. Wills Creek Dam is 2 miles upstream of the town of Wills Creek, Ohio. **Plate No. 1-1** shows the location of all the Huntington District flood control projects, and **Plate No. 2-1** shows the Wills Creek Basin and the upstream tributary projects for Wills Creek lake.

2-02. PROJECT PURPOSES

Wills Creek Lake was authorized for flood control and allied purposes in a comprehensive plan for the Muskingum River Basin and the Ohio River Basin. Project purposes are: flood control, general recreation, and fish and wildlife conservation. Benefits from specific project purposes serve not only local interests in the Wills Creek Basin, but are widespread throughout the Muskingum and Ohio River Basins. Land use for the various project purposes are shown in a later portion of this section.

2-03. PHYSICAL COMPONENTS

a. Embankment. The embankment for Wills Creek Lake consists of rolled earth fill about 1,950 feet long, with an impervious core. The top of dam has a generally symmetrical section about 30 feet wide with a varying bottom width of about 240 feet, rising about 87 feet above streambed. A panoramic photograph of the dam and lower portion of the lake is given in **Plate No. 2-2,** and a plan and elevation of the dam are given in **Plate No. 2-3,** with the cross section of the embankment shown on **Plate No. 2-4.** The valley fill material, consisting in general of fine sands with some silt and clay, is relatively impervious and offered a suitable foundation for an earth dam. Suitable borrow pits adjacent to the site offered ample materials of a character suitable for rolled fill embankment. The embankment was designed according to proven past experience; combined with a method of detailed stability analysis of the embankment design very similar to that developed by the Swedish Geotechnical Commission.

Embankment slopes vary from 1:2.25 at the top of the dam to 1:3 at the toe. The impervious core has a slope of 1:1 and was designed to be fully stable without the restraining forces of the outer shell. Undisturbed samples were taken from the embankment as construction progressed, and the samples were tested for in-situ shear strengths. An upstream impervious blanket is provided with a minimum thickness of 2 feet. A rock fill trench was constructed at the downstream toe to provide an outlet for seepage and to add stability to the embankment.

Embankment foundation treatment included the stripping of all soft, organic top soils. A key trench was excavated across the dam centerline at depths of 5 to 17 feet and refilled with impervious material. A concrete keywall was constructed from Station 24+20 to the outlet conduits. The keywall extends from the conduits into the west abutment to approximate station 25+50. Curtain grouting was performed through the keywall into the underlying silt-shale foundation with hole depths ranging from 12 to 16 feet.

b. Spillway. The uncontrolled chute spillway is located approximately 150 feet east of the east abutment of the dam. The spillway is a trapezoidal open cut in rock with a bottom width of 204.5 feet, at the crest. The channel reduces to a width of 96.5 feet approximately 200 feet downstream of the crest. The entire bottom and west bank of this section are lined with reinforced concrete. The west bank lining extends downstream 360 feet. The foundation below the slab is drained to prevent uplift. The total length of the spillway is about 1100 feet. Details of the spillway are shown on **Plate No. 2-5**, and listed later on pertinent data sheets.

The concrete slab in the spillway floor is founded on fine to coarse grained, medium-hard, gray sandstone. The west retaining wall is anchored in sandstone, sandy silt-shale, and clayey silt, with the sandstone and shale dipping below the cut to the north.

c. Outlet Works. The outlet works, located in the west abutment, consist of an approach channel, intake structure, twin concrete conduits, stilling basin, and outlet channel. General arrangement of the outlet works is shown in **Plate No. 2-6**. An ogee type control weir is provided at the entrance of the intake structure to maintain conservation storage, with a crest elevation of 741 feet NGVD. Details of the weir are shown on **Plate No. 2-7**.

The intake structure consists of a reinforced concrete substructure and brick and stone superstructure which houses the gate operating machinery. Details of the intake structure are shown in **Plate Nos. 2-8** and **2-9**. The intake structure contains six 7'X15' caterpillar gates. Access to the intake structure is by means of a steel and reinforced concrete service bridge from the west abutment. Details of the service bridge are shown in **Plate No. 2-10**.

The twin 20 foot diameter conduits are joined to the intake structure through a 67 foot transition section as shown in **Plate Nos. 2-11**. The section is lined with cast iron to prevent cavitation and damage at high velocities due to partial gate opening operation.

A conduit section with a semi-circular top, vertical side walls and flat bottom was selected for hydraulic efficiency and arch strength. The total length of the conduits is 176.5 feet. Three concrete collars are provided to prevent contact seepage along the conduits. Plan and profile views of the conduits are on **Plate No. 2-12**, and typical sections are shown on **Plate No. 2-13**.

The stilling basin, at the downstream end of the conduits, is a reinforced concrete structure of stair step design. The abutment side of the basin is protected by a reinforced concrete liner wall anchored to the bedrock face. Maximum height of the wall is 29 feet. The embankment side is protected by a gravity section retaining wall with a maximum height of 32 feet. The bottom is paved with a heavy concrete slab anchored in rock. Uplift pressures are relieved by pre-formed, gravel filled floor and wall drains discharging through 3-inch weep holes. A baffle sill is provided at the toe of the stair step slab for energy dissipation. The stilling basin plan and sections are on **Plate Nos. 2-14**.

The foundation material for the approach slab, retaining walls, control weir, intake structure, transition section and conduits is a medium hard to hard, medium grained, weathered sandstone. The foundation of the stilling basin varies from a medium hard, medium grained sandstone to a sandy silt-shale underlain by weathered, silty clay-shale. Toward the eastern edge of the structure, the rock line falls rapidly and the footers of the east retaining wall rest partly on steps cut into the clay-shale. The footer of the service bridge abutment is founded on fine to medium grained, weathered sandstone at elevation 787 feet NGVD.

e. Operating Machinery. Operating machinery for water control purposes consists of control gates and associated mechanisms located in the operating house shown in **Plate No. 2-15**.

(1) Control Gates. The six control gates are of the self closing or tractor type and are designed structurally to withstand and operate under the head of the maximum flood control pool at 779 feet NGVD without exceeding normal design stresses. The gates are operated by electrically driven hoists mounted at operating floor level (799.0 feet NGVD) in the gate house. The gates are also equipped for manual operation. A single emergency gate, designed for insertion in front of any of the service gates, is provided. This gate is used to close off a service gate bay to allow repairs to that service gate if needed. The emergency gate is of the self-closing tractor type and is raised or lowered by an electrically driven crane in the operating house superstructure. Due to the number and size of the gate openings and conduit sections, no trash racks are provided.

(2) Auxiliary Power Unit. The standby power unit consists of a six-cylinder gasoline engine connected directly to an alternating current generator, both mounted on a common base. The engine is a liquid-cooled, cold-starting type and is easily started by its battery. The generator is rated at 31 KVA and is sufficient for emergency operation of the control gates and other essential equipment.

2-04. RELATED CONTROL FACILITIES

Wills Creek Lake has two upstream tributary reservoirs that modify the inflow into Wills Creek lake. Senecaville Lake is a small Muskingum River Basin project on Seneca Fork of Wills Creek controlling a 118 square mile drainage area. The other is Salt Fork Lake a state owned and operated project just above Cambridge. These upstream lakes are shown on **Plate No. 2-16.**

2-05. REAL ESTATE ACQUISITION

After the official plan for the original 14 reservoir system was prepared by the Corps of Engineers and approved by the Muskingum Watershed Conservancy District, the Conservancy District began acquiring lands, rights-of-way and flood easements. Fee title for the lands required specifically for the construction of the 14 dams and appurtenant structures was conveyed to the United States. The Attorney General of Ohio determined that the Muskingum Watershed Conservancy District could not convey fee simple title of reservoir lands to the United States, so the United States accepted flowage easements over lands acquired in fee by the Conservancy District for purposes other than construction. The Conservancy District acquired the remaining properties in fee simple title and conveyed flowage easements to the United States. The United States acquired flowage easements directly from the remaining property owners where easements only were required. The land acquisition program was not completed until June 1953.

2-06. RECREATION AND PUBLIC USE FACILITIES

Wills Creek Lake was developed as a multi-purpose project and general recreation is one of the project purposes. The Muskingum Watershed Conservancy District is responsible for the management of public use facilities at Wills Creek Lake. At the time of this writing (August 1986), the only recreation facilities available on Wills Creek Lake are a boat launch ramp and picnic area with parking, located on the north side of the lake near State Route 83. The Conservancy District is working with local interests to upgrade the facilities and increase public use of the lake. The Land Use map for Wills Creek lake is shown on **Plate No. 2-16**.

All pertinent data for the Wills Creek Lake project is shown on Supplementary Data, **Exhibit–A**, pages 1, 2, and 3.

SECTION III - HISTORY OF PROJECT

3-01. AUTHORIZATION

The original fourteen Muskingum Reservoir system, including Wills Creek Lake, was authorized for flood control and allied purposes by the Official Plan for the Muskingum Reservoir System prepared by the Corps of Engineers, and approved on 19 November 1934 by the Muskingum Watershed Conservancy District. The Public Works Administration approved the general project plan developed by the Muskingum Conservancy District and allocated funds to the Corps of Engineers to aid in financing the construction of the project. **Plate No. 1-1** shows all the flood control projects in the Huntington District including the 16 Muskingum Reservoir locations.

The Flood Control Act of 1939 contained a provision that the Muskingum River Basin dams and reservoirs, then owned by the Muskingum Watershed Conservancy District, be included in the comprehensive flood control plan for the Ohio River Basin. Since that date the operation and maintenance of the Muskingum Reservoir system has been the responsibility of the Corps of Engineers.

3-02. PROJECT PLANNING AND DESIGN

The recommended size and scope of the Wills Creek Lake Project was determined by maximization, where applicable, of the net benefits of joint operation with the thirteen additional authorized reservoir projects in the Muskingum River Basin. Joint output of the thirteen reservoirs is critical in the flood control function and significant in maximizing the recreational uses of the projects.

Because of the large amount of uncontrolled area between Coshocton and Zanesville, it was considered desirable, during the planning stage of the Muskingum River reservoir projects, to control as much as possible of the Wills Creek drainage area. Three sites were studied as likely locations for the dam, with the present site being chosen for its good foundation conditions, ability to control over 98 percent of the basin, and adequate flood control storage.

The recommended allocation of flood control storage is that required to store the floods of record and to maximize net benefits. Wills Creek Lake was designed primarily for flood control, with only a small permanent conservation pool, thus all routine inflow is always passed through the stop-log weir.

A summary of pool elevations and storage is shown on **Table No. 3-1** next page, and the area-capacity curves are shown with a later section. Wills Creek Lake pertinent data is shown on **Exhibit–A**.

TABLE No. 3-1

WILLS CREEK LAKE
POOL ELEVATIONS AND STORAGE

Pool	Surface Elevation	Area Acres	Storage Acre-feet Net	Storage Acre-feet Gross	Inches runoff Net	Inches runoff Gross
Minimum	742.0	900	6,000	6,000	0.2	0.2
Flood Control	779.0	11,450	190,000	196,000	4.9	5.1
TOTAL	779.0	11,450	196,000		5.1	

3-03. CONSTRUCTION

Construction on the Wills Creek Dam project began on 25 February 1935, and closure of the dam was accomplished on 14 June 1936. The project construction was completed 13 October 1937. During this period, construction of the dam and appurtenant works, reservoir clearing, and construction of recreational facilities were completed. The principal contractor was Edward J. Eiff Co., Quincy, Illinois.

Cemetery removals and road and utilities relocation were started 29 August 1935 and completed 9 December 1936. The relocation program consisted of relocating 3.5 miles of single track railroad and attendant construction of one steel bridge, one concrete pile trestle, one highway underpass, and a 757 foot tunnel for the Penn Central Railroad, the tunnel reducing the length of the relocation by several miles. It was also necessary to relocate 16.2 miles of telephone and telegraph wires, 4.8 miles of electric power lines, 1.7 miles of state highway, 5.4 miles of secondary road, and 2.4 miles of oil and gas lines, including one pump station.

The total cost of the project was $2,842,200. This total cost included $1,234,700 for the construction of the dam and attendant works, $885,000 for land and rights-of-way acquisition, and $722,500 for the relocations described above.

During construction of the outlet works, Wills Creek was maintained in the existing channel. Embankment was placed to elevation 770 feet NGVD from station 18+00 to station 6+00. Subsequent to diversion of the stream through the outlet works, the embankment was completed.

Concrete for the control weir, intake structure, conduits and stilling basin was placed between 22 July 1935 and 19 May 1936. Concrete for the spillway was poured during the period of 30 April to 10 July 1937. The single monolith pour for the service bridge abutment was made on 30 October 1936.

The early construction process was interrupted by the enormous summer cloudburst of 8 August 1935. Later, near the end of the construction period the near completed project was operated for the Ohio Valley flood of January 1937. There is no report of any other problems encountered during the construction of the dam and appurtenant works.

3-04. RELATED PROJECTS

The Muskingum Watershed Conservancy District was created for the purpose of developing a plan for flood control, water conservation, and water use in the Muskingum River Basin. The official plan was prepared by the Corps of Engineers and was approved by the Conservancy District on 19 November 1934. The system as constructed included 14 reservoirs; with five lakes on the Walhonding River, seven on the Tuscarawas River, and Wills Creek Lake with Senecaville Lake as an upstream tributary above Cambridge.

Ten of the fourteen Muskingum River Basin reservoirs create lakes with a total surface area of 16,000 acres. These lakes and adjacent lands in excess of 35,000 acres are managed for public use by the Muskingum Watershed Conservancy District in cooperation with the State of Ohio and the Corps of Engineers. Individual lakes range from 420 to 3,350 acres, and recreational facilities are diversified, ranging from primitive tent camping to the deluxe accommodations provided by Atwood Lake Lodge.

Four of the original fourteen reservoirs projects; Bolivar, Dover, Mohicanville, and Mohawk, were designed and built to have little or no conservation pool, with all storage allocated for flood control. Consideration has been given to establishing conservation pools at these reservoirs, primarily for recreational purposes, but, the strong flood control purpose has always prevailed, hence, there has been no pool elevation changes. In addition, Beach City and Wills Creek Lakes have a small minimum year-round pool that is not raised in the summer, and all normal inflow is passed. Therefore, six of the 14 original Muskingum lakes are basically for flood control only.

Water supply considerations have been given to both Charles Mill Lake and Atwood Lake. These reservoirs are viewed as possible alternate water supplies for the surrounding areas.

The Muskingum Reservoir system now has sixteen reservoirs and five local protection projects with a total of 1,604,000 acre-feet of storage and 5,020 square miles of controlled drainage area or 62.5 percent of the total basin. The partially completed dams were used for the first time in the great Ohio valley flood of 1937 and in the next 61 years the system prevented or were credited with about $2.068 BILLION FLOOD CONTROL BENEFIT DOLLARS. This is an accumulated figure and the process of benefit allocations to individual reservoirs is often ambiguous and misleading.

Individual flood control benefits are usually not compiled each project, but, they may be roughly estimated. During the last five years the combined system accumulated damages prevented has been $630 million dollars. This would mean $126 million benefit dollars per year for the system, and with a 11.8 percent allocation for Wills Creek Lake the annual benefits for the last five years would be about 15 million dollars per year. This figure is very close to the 1983 benefit survey for the Muskingum Basin.

The final post war phase of development in the Muskingum Basin was the solid growth of recreation and vacation resorts at the lakes and rivers in the area. This phase was only lightly considered when the original Muskingum Reservoirs were built, but the Muskingum Water Conservancy District later built and developed elaborate facilities that draw enormous crowds at the near-by Dillon Lake during the summer which has produced a new industry for the basin called tourism and recreation.

Before the recreational phase of the Muskingum River Basin was initiated, the National Park Service assisted the Muskingum Watershed Conservancy District in the 1940's in estimating the recreational value of the Muskingum River Basin projects. The value was estimated to be $807,000 per year.

Recreational development was provided under authority of the 1944 Flood Control Act and in accordance with paragraph 3, Category d, of ENGCW-Y letter of 5 August 1965, subject "Implementation of the Federal Water Project Recreation Act (PL 89-72) in Previously Authorized Projects."

All this led to the creation of the ODNR in 1949 and they have coordinated with the Corps of Engineers on many water projects in this final phase of water resources and recreation development. Thirty years later, in 1975, conservative estimates placed the annual recreational values in excess of 5 million dollars. The present day value of these recreation benefits would be about $26 million dollars per year. Wills Creek Lake has many visitors during the summer, and the boating activities usually consist of pontoon boat fishing.

The summary and final phase of Muskingum River Basin water resources development is that many public and private groups now depend on the multi-purpose water projects that were developed by the Corps of Engineers. The vital personal water supply of several villages, towns, and many homes within the Muskingum Basin now come from both underground and surface streams and lakes. This very basic need for water supply is expected to more than triple by the end of the century. The state of Ohio has built Salt Fork Lake. Surface waters are also used by railroad, coal, mining, manufacturing, and lumbering industries for producing steam, processing material, and washing coal. In addition, several villages in the Wills Creek Basin also have a municipal sewerage treatment plant. This amount or capacity is expected to more than triple by the year 2020. However, there is still a strong need for additional water supply each summer for optimum crop growth in the watershed. The wide and divergent uses of the land by various groups is shown on **Plate No. 2-16**.

3-05. MODIFICATIONS TO REGULATIONS

Since the opening of Wills Creek Lake there has been little or no changes to the original regulation plan.

The U. S. Government provided for all initial development, and the State of Ohio will provide all further development of the initial facilities and any new areas.

Hydrologic studies in connection with the siltation pool show that at the end of approximately 50 years the minimum pool may be filled to such a point that less than a 5-foot average depth of water will be available for recreational use. Therefore, the economic life of the recreation facilities provided is assumed to be 50 years. This 50 year life span has already elapsed.

3-06. REGULATION PROBLEMS

Wills Creek Lake is rather unique in that little or no regulation problems have occurred during the life of the project. The lake is virtually self-regulating at the year–round pool elevation of 742 feet NGVD. However, during one very dry summer the inflow was so small that the damtender was planning to pull the top stop-log in the inflow weir to create enough outflow to keep the stream flowing below the dam.

SECTION IV - WATERSHED CHARACTERISTICS

4-01. GENERAL CHARACTERISTICS

Wills Creek, a major tributary of the Muskingum River, is located in eastern Ohio and extends in a general northwesterly direction from its headwaters in northwestern Monroe County and northeastern Noble County to its junction with the Muskingum River below Coshocton, Ohio. The Wills Creek drainage basin is roughly oval in shape and is about 44 miles along the major axis and 24 miles along the minor axis. The principal axis of the basin lies in the northwest-southeast direction. The basin includes portions of Coshocton, Guernsey, Noble, Belmont, Monroe, and Muskingum counties. The flood plain width averages one-half mile. The river banks average approximately 10 feet in height, and the stream width varies from 30 to 100 feet. Drainage areas and stream flows of Wills Creek and principal tributaries above the dam site are given in **Table No. 4-1**, next page.

Wills Creek Dam is located about 6 miles upstream from the junction with the Muskingum River, therefore the general dimensions for the basin and the lake drainage area are very similar. **Plate No. 4-1** shows Wills Creek having a long fairly flat stream profile.

4-02. TOPOGRAPHY

The Wills Creek drainage basin lies within the Kanawha section of the Great Appalachian Plateau Province. The region is characterized by a hilly maturely dissected countryside with broad flat bottomed valleys in which flood plains and terraces are prominent. The total relief for the basin is approximately 685 feet, with the uplands rising to a maximum elevation of about 1,400 feet above NGVD.

At the dam site, the valley bottom is approximately 1,300 feet wide. The stream has entrenched itself 35 feet into the valley fill and flows close to the left or west abutment. The portion of the valley fill to the east of the stream occurs as a wide terrace 35 feet above the comparatively narrow flood plain.

4-03. GEOLOGY

Wills Creek valley is a winding, terraced, deeply filled pre-glacial valley with steep walls that rise some 275 feet to the surrounding well dissected upland. The deep valley fill consists of unsorted coarse sand, sandy silt and gravel blanketed throughout most of the site area, with 3-7 feet of alluvial silt. The old bedrock floor is buried more than 150 feet below the present flood plain.

At the site, the valley bottom is approximately 1300 feet wide. The Wills Creek channel flowing close to the left or west valley wall, is entrenched about 35 feet below a wide terrace that occurs on the east bank of the stream at approximate elevation 760 feet NGVD. The right or east bank is formed by a narrow flood plain at elevation 735 feet NGVD.

TABLE NO. 4-1

DRAINAGE AREAS AND STREAM FLOWS OF WILLS CREEK AND PRINCIPAL TRIBUTARIES ABOVE DAM SITE

Location	Miles Above Mouth	Drainage Area (sq.mi.)	Period of Record	Maximum Flow CFS	Minimum Flow CFS	Mean Flow CFS
Seneca Fork At Senecaville Lake	86	118	1938-1999	985	0	44
Wills Creek at Cambridge	62	406	1937-1999	8,500	0.7	451
Salt Fork nr Cambridge	-	55.6	1956-1967	3,890	0	53
Salt Fork at Salt Fork Dam	-	161				
Wills Creek at Wills Creek Lake	**6.2**	**842**	**1938-1999**	**6,930**	**1.0**	**939**

The bedrock of the valley belongs to the Pottsville and Allegheny series of Pennsylvanian age. It consists of essentially horizontal shale, sandstone, limestone, and coal, with 95% of the thickness being sandstone and shale.

4-04. EROSION AND SEDIMENT YIELD

At the time of the original design in the early 1930’s, there was no data available to establish the amount of sediment being carried by Wills Creek. Studies of sedimentation rates at other lakes in the Muskingum River Basin had not been completed, however, other studies in the eastern United States indicated that sedimentation in Wills Creek Lake would not be a serious problem and little depletion of flood control storage was expected during a 50-year economic life.

When the first sedimentation reconnaissance survey was accomplished on, 1 September 1973, the sediment volume estimated to have been deposited below minimum pool elevation 742 feet NGVD during the 37.2 year period, 14 June 1936 to 1 September 1973 was 2,750 acre-feet. The sedimentation rate in the minimum pool was then estimated to be 73.9 acre-feet per year. The average sediment contributing area, adjusted for the period of operation and for the area controlled by Senecaville and Salt Fork Dams, was determined to be about 700 square miles. The sedimentation rate was estimated to be 0.11 acre-foot per year per square mile of contributing drainage area. The 1973 Sedimentation Reconnaissance Report concluded that the amount of sedimentation did not indicate a need for a detailed sedimentation survey at that time.

The second sedimentation reconnaissance was conducted by the Huntington District in 1981. During this survey partial lake bottom profiles were obtained using a fathometer at or near the original sediment range locations, and no horizontal control was maintained on the profiles. A close comparison of the data from the 1981 sedimentation reconnaissance with previous data indicated that there had been an increase in the rate of sedimentation in Wills Creek Lake since the 1973 sedimentation survey. At the time of the 1973 survey, the Wills Creek Lake drainage basin was primarily farmlands. Since that time, surface mining activity had rapidly increased. The increase in sediment producing surface mining in the basin has strongly contributed to the apparent increase in the sedimentation rate in the lake.

A total of 6,000 acre-feet of storage is provided in the minimum pool area, below elevation 742 feet NGVD. Assuming that sedimentation into the minimum pool continues at an annual rate of 0.11 acre-foot per square mile of contributing drainage area, or 62.2 acre-feet per year, the minimum pool would have a life of about 90 years. Even with the slight increase in the rate of sedimentation at Wills Creek Lake that was indicated by the 1981 sedimentation reconnaissance, sedimentation did not appear to be detrimental to the effective operation of the project for authorized purposes at that time. A future sediment reconnaissance was recommended for FY 1986 and each ensuing five year period.

A third sedimentation reconnaissance was conducted by the Huntington District in October 1986. A close comparison of the data from the 1986 sedimentation reconnaissance with previous data indicated that there had been a decrease in the rate of sedimentation in Wills Creek Lake since the 1981 sedimentation survey. At the time of the 1973 survey, the Wills Creek Lake drainage basin was primarily farmlands. For the next several years it became an area of major surface mining activity. However, this surface mining activity and the amount of inflow water gradually decreased during the 1980's, causing an apparent decline in the sedimentation rate in the lake.

4-05. CLIMATE

a. General. The climate of the Wills Creek Basin is typical of the central temperate zone, having highly variable temperatures between the summer and winter seasons and non-seasonal precipitation. Rainfall is generally ample for all needs during normal years. During extended droughts, which are infrequent, depletion of ground water storage exhausts the water resources of the basin to the extent that the stream-flow becomes very low. The entire basin is affected by frontal air-mass activity and is subject to both continental polar and maritime tropical air-masses. Frequent and rapid changes in weather occur due to the passage of fronts associated with general low-pressure areas. The prevailing wind direction is from the southwest, at an average wind speed of 10 to 12 mph. Winds of a destructive nature are relatively rare, but have been known to occur as adjuncts to severe thunderstorms or intense large area storms.

b. Temperature. There are several stations within the Wills Creek Basin in 1985 that are equipped with thermometers. These stations and other stations adjacent to the basin have temperature records that extend over as many as 73 years. The mean annual temperature for the entire basin is about 51.5 degrees. The growing season, or the period between the last killing frost of spring to the first killing frost of autumn, usually runs from mid-April to mid-October. **Table No. 4-2,** next page presents a temperature summary for three representative stations for the Wills Creek Basin.

c. Droughts. The most extreme modern droughts for the Wills Creek Basin and central Ohio occurred in 1930, 1931, and 1934.

d. Precipitation. The normal annual precipitation of approximately 39 inches is nearly uniform over the Wills Creek Basin. Average monthly, maximum monthly, minimum monthly and maximum 24-hour precipitation are listed in **Table No. 4-3,** page 4-6 for three representative stations. The Wills Creek Basin lies directly in the path of extensive meteorological disturbances, which in winter and spring generally travel from southwest to northeast. Storms likely to produce major flooding in the basin can be classified in two types: the summer-type and the winter-type. The summer-type storm usually occurs during the period from May to October, inclusive, with the greatest probability of occurrence during June and July. Winter-type storms, which can occur in the period between December and April, are most likely to occur in March and April.

Summer-type rains usually result from thunderstorms of conventional frontal activity with convectional or orographic origins. They are characterized by rainfall of high intensity, short duration, and relatively small areal extent.

Winter-type storms are differentiated from the summer-type storm by their less intensive and more evenly distributed rainfall of longer duration and wider areal extent. These storms are generally caused by cold air-masses, originating in the region of Alaska, which interact with warm moist air masses sweeping northward from the Gulf of Mexico and southern Atlantic Ocean. Occasional stagnation and stationary development produces prolonged precipitation. Snow cover, saturated or frozen ground, or combinations thereof, may greatly increase runoff rates and volume. The direction of travel of the storm system is usually north-eastward.

Meteorological studies indicate that the summer-type storm has possibilities of producing the maximum flood. However, meteorological records show that winter-type storms occur more frequently and produce more major floods than the summer-type storms. Average annual snowfall over the Wills Creek Basin is about 25 inches and represents only a minor portion of the total average annual precipitation. Average monthly and annual snowfall are listed in **Table No. 4-3,** page 4-6 for three representative stations.

TABLE NO. 4-2

TEMPERATURE SUMMARY - WILLS CREEK BASIN

Station	Period	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Mean Monthly and Annual Temperature, Degrees Fahrenheit														
Barnesville,	1951-80	25.3	27.5	37.3	48.3	58.1	66.6	70.4	69.2	62.8	50.6	40.0	30.2	48.9
Caldwell,	1951-80	28.3	31.0	40.8	52.2	61.2	68.9	72.4	71.4	65.3	54.0	42.7	32.8	51.8
Cambridge,	1951-80	28.4	31.1	40.6	51.6	61.1	69.2	72.7	71.7	65.4	53.6	42.6	32.9	51.7
Coshocton,	1951-80	27.1	29.8	39.5	50.6	60.6	69.1	72.4	71.1	64.8	52.8	41.7	31.7	50.9
Senecaville,	1951-80	26.9	28.8	38.8	50.2	59.7	68.1	71.7	70.2	64.1	52.2	41.4	31.7	50.3
Mean Daily Maximum Temperature, Degrees Fahrenheit														
Barnesville,	1951-80	35.5	38.2	48.7	60.8	71.2	79.4	82.9	81.9	76.4	64.3	51.0	39.6	60.8
Caldwell,	1951-80	37.6	41.3	52.3	64.9	74.2	81.6	84.5	83.7	78.2	66.8	52.7	41.8	63.3
Cambridge,	1951-80	37.8	41.3	52.0	64.7	74.7	82.1	85.1	84.2	78.5	66.9	53.0	41.9	63.5
Coshocton,	1951-80	36.3	39.9	50.6	63.4	73.8	82.0	84.9	83.6	77.7	66.0	52.1	40.7	62.6
Senecaville,	1951-80	36.6	39.3	50.0	62.4	72.5	80.4	83.7	82.4	77.1	65.4	52.0	40.6	61.9
Mean Daily Minimum Temperature, Degrees Fahrenheit														
Barnesville,	1951-80	15.1	16.7	26.0	35.7	44.9	53.8	57.9	56.4	49.1	36.8	29.0	20.7	36.8
Caldwell,	1951-80	19.0	20.7	29.4	39.5	48.1	56.1	60.2	59.1	52.4	41.1	32.6	23.7	40.2
Cambridge,	1951-80	19.1	20.9	29.1	38.5	47.5	56.2	60.3	59.1	52.4	40.3	32.2	23.9	40.0
Coshocton,	1951-80	17.7	19.7	28.3	37.8	47.4	56.1	59.9	58.5	51.8	39.6	31.2	22.8	39.2
Senecaville,	1951-80	17.2	18.2	27.5	37.8	46.8	55.9	59.8	57.9	51.0	38.9	30.7	22.7	38.7

d. Evaporation and Wind. Evaporation losses occurring at Wills Creek Lake were calculated from NOAA Technical Report NWS 33, published by the National Weather Service from data obtained jointly by the Weather Service, Corps of Engineers and other organizations. Average values for monthly, seasonal, and annual evaporation losses from the lake are shown in **Table No. 4-4**, page 4-7, Lake Evaporation Losses - Summary. The evaporation records at Wooster Experimental Station, Ohio, were used to determine the maximum seasonal (May-October) evaporation losses.

TABLE NO. 4-3

PRECIPITATION SUMMARY - WILLS CREEK BASIN

Station	Period	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Mean Monthly and Annual Precipitation, Inches														
Barnesville,	1951-80	2.98	2.65	3.77	3.97	4.07	4.22	4.50	3.79	3.18	2.66	2.74	2.94	41.47
Caldwell,	1951-80	2.68	2.24	3.27	3.33	3.79	4.20	4.42	3.80	3.00	2.43	2.51	2.45	38.12
Cambridge,	1951-80	2.77	2.54	3.69	3.51	3.83	4.40	4.07	3.60	2.74	2.45	2.66	2.65	38.91
Coshocton,	1951-80	2.76	2.39	3.57	3.98	3.65	3.88	4.57	3.64	2.98	2.48	2.86	2.80	39.56
Wills Creek,	1936-74	2.88	2.44	3.72	3.89	4.36	4.23	4.21	3.23	2.82	2.29	2.88	2.51	39.46
Senecaville,	1936-70	2.93	2.52	3.61	3.68	4.02	4.54	4.39	3.36	2.48	2.32	2.71	2.48	39.04
Maximum Monthly Precipitation, Inches														
Barnesville,	1951-80	5.85	5.47	7.94	8.36	8.30	8.43	11.59	12.33	7.53	6.06	4.98	6.02	12.33
Caldwell,	1951-80	5.80	5.28	7.78	6.16	9.60	6.92	8.51	8.75	8.85	5.18	6.26	4.98	9.60
Cambridge,	1951-80	5.35	4.89	9.50	7.36	7.73	10.53	9.02	11.39	6.56	6.62	5.57	5.49	11.39
Coshocton,	1951-80	7.03	5.80	8.49	6.53	7.30	8.67	8.03	12.38	7.03	6.40	5.54	5.29	12.38
Wills Creek,	1936-74	9.75	5.95	9.67	7.16	7.44	9.21	9.10	7.16	8.18	6.22	5.66	6.42	9.75
Senecaville,	1936-70	9.48	5.15	7.71	6.77	7.95	9.09	7.40	7.65	6.33	5.67	4.85	4.36	9.48
Maximum 24-Hour Precipitation, Inches														
Barnesville,	1951-80	2.00	1.94	2.45	2.25	3.04	3.39	3.07	5.12	2.22	2.75	1.82	2.09	5.12
Caldwell, OH	1951-80	1.60	2.20	2.60	1.72	2.40	3.70	3.84	3.10	2.25	2.75	2.10	1.75	3.84
Cambridge,	1951-80	1.69	2.67	3.71	2.20	2.57	7.18	2.74	5.45	2.44	2.32	2.36	1.68	7.18
Coshocton,	1951-80	2.99	2.70	3.50	2.07	2.15	3.00	2.87	2.85	2.81	2.24	2.60	1.56	3.50
Mean Monthly and Annual Snowfall, Inches														
Barnesville,	1951-80	10.1	7.4	5.4	1.0	.0	.0	.0	.0	.0	.1	2.2	6.2	32.4
Caldwell,	1951-80	8.2	5.2	4.9	.6	.0	.0	.0	.0	.0	.0	2.0	4.7	25.6
Cambridge,	1951-80	8.2	6.0	4.6	.7	.0	.0	.0	.0	.0	.1	1.7	4.7	26.0
Coshocton,	1951-80	9.1	7.1	5.0	.3	.0	.0	.0	.0	.0	.0	1.8	5.8	29.1
Wills Creek,	1950-70	7.3	7.5	5.6	.5	.0	.0	.0	.0	.0	.0	2.1	6.2	29.2
Senecaville,	1940-70	7.5	5.8	4.8	.7	.0	.0	.0	.0	.0	.0	2.7	6.3	27.8
Maximum Monthly Snowfall, Inches														
Barnesville,	1951-80	43.7	21.4	13.6	5.5	.0	.0	.0	.0	.0	2.5	8.0	18.5	43.7
Caldwell,	1951-80	37.0	14.0	13.5	6.0	.0	.0	.0	.0	.0	.0	7.4	16.6	37.0
Cambridge,	1951-80	32.3	25.7	14.3	5.2	.0	.0	.0	.0	.0	2.8	8.2	14.2	32.3
Coshocton,	1951-80	33.9	19.0	16.3	3.5	.0	.0	.0	.0	.0	.0	8.0	15.8	33.9
Wills Creek,	1950-70	24.0	18.0	14.0	3.0	.0	.0	.0	.0	.0	.0	14.0	15.0	24.0
Senecaville,	1940-70	17.0	17.0	14.0	7.0	.0	.0	.0	.0	.0	1.0	8.0	23.0	23.0

Annual average wind direction over the Wills Creek Basin is southwesterly. Southerly winds, prevalent from July through October, change to southwesterly during November and December, and become near-westerly in January and February. The direction then gradually becomes and remains southwesterly during March, April, May and June.

Information on wind direction is taken from "Climatic Atlas of the United States," June 1968, published by Environmental Science Services Administration of the U.S Department of Commerce.

TABLE NO. 4-4

LAKE EVAPORATION LOSSES - SUMMARY

Average Annual Evaporation - inches* 31.5
Average Seasonal Evaporation (May-October) - inches* 23.3
Average Monthly Evaporation Losses

Month	Inches*	Ac-ft**
May	3.97	297.8
June	4.76	357.0
July	4.88	366.0
August	4.32	324.0
September	3.12	234.0
October	2.24	168.0
Seasonal Total	23.29	1,746.8

* Vertical distance
** 1-inch loss from summer water supply pool (elevation 742.0, surface area 900 acres) = 75 acre-feet.

4-06. STORMS AND FLOODS

a. General. Floods in the basin are not limited to any specific month, although winter and spring floods are more frequent than summer floods. The occurrence of summer-type storms over the basin has produced local floods without affecting adjacent areas. Ohio River floods are generally caused by winter-type storms that occur between December and April; these storms are more widespread and of longer duration.

The basin is characterized by winding, terraced, and flat bottomed valleys with steep valley walls and well dissected uplands and concentration of runoff is rather quick. Floods on Wills Creek above the dam site are generally of relatively short duration and seldom remain above flood stage more than 24 to 36 hours. The flooding characteristics of the basin are illustrated by the list of high-water data, the top twenty-one floods at Cambridge, Ohio on Wills Creek presented in **Table No. 4-5**, below.

High water profiles for Wills Creek above the damsite are shown on **Plate No. 4-1**. Flow frequency curves for the lake outflow gage, Dresden, Zanesville, McConnelsville, and Marietta, are useful to describe the flooding characteristics of Wills Creek and the Muskingum River as shown on **Plate Nos. 4-2** and **4-6**. Flow Duration Curves for the outflow gage and Dresden are shown as **Plate Nos. 4-7** and **4-8**. Discharge rating tables curves for McConnelsville and Zanesville are given on **Plate Nos. 4-9** and **4-10.**

TABLE NO. 4-5

WILLS CREEK AT CAMBRIDGE, OHIO
HIGH-WATER DATA

Date	Gage Height feet*	Natural Discharge cfs**
13 August 1980	29.5	13,680
7 March 1945	24.0	12,700
6 June 1963	24.9	12,225
11 March 1964	24.9	12,250
21 April 1940	24.3	11,800
March 1913		11,700 est.
8 August 1935	25.4	11,000 est.
25 January 1937	--	10,500 est.
27 February 1979	25.9	10,320
25 February 1975	22.6	9,200
8 November 1985	24.4	8,770
29 May 1956	22.07	8,665
23 January 1959	21.98	8,580
26 May 1968	21.49	8,090
15 April 1948	21.28	7,725
15 February 1966	18.53	7,200
28 January 1952	20.79	7,350
6 March 1955	20.38	7,060
16 March 1978	20.31	7,000
16 January 1951	19.87	6,590
8 January 1950	19.40	6,450

* Present site and datum. ** Flow regulated by Senecaville Lake since 1936. Computed natural discharge and stages shown for floods after 1937.

b. Storm and flood of March 1913. The flood of March 1913 was caused solely by excessive precipitation over a comparatively large area which enabled great volumes of water to be literally dumped into the streams throughout the Muskingum Basin. The rain was exceptionally heavy in the northern section of Ohio, amounting to 10 inches or more, and since the winter had been mild, the ground was without snow, not frozen and was already saturated with water from the heavy rains of January and the first portion of March. In the Muskingum River Basin, the main storm commenced just before noon on 23 March, with the rain becoming increasingly heavy the next two days, and then continued on the 26th and in some portions of the basin on the 27th. Total rainfall during the five days, most of which occurred in a period of 96 hours or less at individual points, averaged 6.94 inches over the entire Muskingum Basin, 6.55 inches over the Tuscarawas Basin, and 9.17 inches over the Walhonding Basin.

The maximum flood of record occurred on practically all major streams in the Muskingum Basin and in the few cases where it had been exceeded, the margin is very small. The crest at Zanesville on the Muskingum River lower Lock No. 10 Weather Bureau gage occurred from 9 pm on the 27th to 3 pm on the 28th at a stage of 51.2 feet. This flood attained record stages on the Ohio River which still stand today from 50 miles above the mouth of the Muskingum River at Marietta to the mouth of the Kanawha River at Point Pleasant, WV.

c. Storm and flood of August 1935. Following a period of light to moderate rains over the Muskingum Basin on the first four days of August 1935, the most severe summer storm on record in the Muskingum Basin and one of the most severe storms experienced in the central United States occurred in a 12-hour period on August 6-7. Extreme rainfall intensities were recorded in the vicinity of Newcomerstown, Ohio, just outside of the Wills Creek Basin. A total of 8.7 inches of rainfall was recorded at the Weather Bureau station in Newcomerstown during the main storm, and an unofficial measurement near the storm center indicated total precipitation of 12.8 inches, all of which fell in a 12-hour period. As a result of this storm, the maximum stages of record were experienced on practically all of the smaller streams in the storm area, major floods occurred in practically all parts of the Muskingum River Basin, and the main stream itself rose to a crest stage at Zanesville of 33.6 feet with an estimated peak discharge of around 100,000 cfs.

d. Storm and flood of January 1937. A series of abnormally heavy rains beginning late in December 1936 and continuing nearly through January 1937, centered largely in the middle and lower portions of the Ohio River valley, caused a series of floods that were greater than any known since the time of settlement. Stages higher than any previously recorded occurred on the Ohio River from Point Pleasant, West Virginia, to its mouth at Cairo, Illinois, a distance of some 700 miles. The Muskingum Basin which lies to the north and east of the center of maximum precipitation, experienced the second highest flood of record at many stations throughout the basin. Tributary streams experienced a succession of flood rises which were timed such that accumulating flood waters in the major river basins produced increasingly higher stages and discharges after each storm. The heavy general rainfall continued for about a month and concluded with the heaviest period in the storm of 14 to 25 January in which 7.93 inches of rain fell on the Muskingum Basin and produced outstanding floods, particularly on the tributaries in the southern and western portions of the basin. The peak stage at Zanesville, Ohio, was 37.6 feet, which is equivalent to a discharge of approximately 120,000 cfs. The partially completed flood control reservoirs, including Wills Creek, helped to decrease peak stages and discharges downstream by acting as retarding basins. Stage reductions at Zanesville due to the retarding action of the reservoirs were estimated to be approximately 2 feet.

e. Storm and flood of January 1959. The storm and flood of January 1959 is generally regarded as one of the major floods of record throughout most of the Muskingum River Basin. Conditions prior to the generalized rains on the 20th and 21st of January contributed greatly to the magnitude of flood stages throughout the basin. Severe cold weather during the previous December froze the ground, ranging in depth from 6 to 18 inches. A storm occurring between the 14th and 17th of January deposited 0.5 to 1.84 inches over the basin in the form of snow in the northern section and rain changing to snow in the southern section. Prior to the generalized rains which began during the night of 20 January, the ground was saturated, frozen, and covered with varying amounts of snow, all of which greatly contributed to the high percentage of runoff encountered after the 20th. The storm of the 20th and 21st was due to the large mass of warm moist air which moved onto the Ohio Valley from the Gulf of Mexico. The storm center located over northern Arkansas became well established about midnight of the 19th and began to travel rapidly northeastward. A sharp trough of low pressure moved across northwestern Ohio on the 20th and encountered a warm air mass already extending over southern Ohio and early on the 21st thunderstorms broke out as far north as Columbus.

Most of the flood producing rains fell between midnight on the 20th and noon on the 21st. Surface temperatures were well above freezing and increased the snow melt, which in turn contributed to the flood producing runoff. Operation of the flood control reservoirs in the Muskingum River Basin reduced the stage at Zanesville by 11.1 feet and at McConnelsville by 7.8 feet.

f. Storm and flood of July 1969. The storm of July 4-5, 1969, in north central Ohio was an unprecedented event. Never before had such intense and widespread precipitation been recorded for a summer storm in Ohio. More than 14 inches of rainfall in less than 24 hours were observed at several places. More than 4 inches fell over an area of 6,000 square miles in the northern and eastern parts of Ohio. Flooding in the Muskingum River Basin was greatest on the Muskingum tributaries upstream of Coshocton. Although rainfall in the Wills Creek Basin occurred mostly after the main storm, on the 6th and 8th of July, and did not approach the intensities of that in other portions of the Muskingum River Basin, the operation of Wills Creek Lake reduced the stage at the outflow gage by more than six feet. The Muskingum Flood Control Reservoir System was effective in reducing flood heights on the Walhonding, Tuscarawas, and Muskingum Rivers. Specifically, the stages at Dresden and Zanesville were reduced by more than 10 feet, and the stage at McConnelsville was reduced nearly 8 feet.

g. Storm and flood of February-March 1979. Cold temperatures in the first three weeks of February combined with over 2 inches of precipitation to produce a covering of snow over the Wills Creek Basin that averaged 18 inches deep on 20 February. A warming trend beginning on the 20th melted the snow cover so that only traces were left by the 25th. This melting caused the streams in the basin to rise sharply beginning on 21 February. Another winter storm hit the

Muskingum River Basin beginning in the afternoon of 25 February, this time dumping over 1.5 inches of rain over the already saturated Wills Creek Basin. The inflow to Wills Creek Lake peaked at more than 12,500 cfs around noon on 26 February, and the pool crested at elevation 771.56 feet NGVD a week later on 5 March. Operation of Wills Creek Lake reduced the peak stage at the outflow gage by more than 10 feet. The peak flows occurred at Dresden and Zanesville in the afternoon of 26 February and were 16.5 feet and 18.2 feet respectively. Operation of the Muskingum Flood Control Reservoir System, including Wills Creek Lake, reduced the stage at Dresden by 10.1 feet, at Zanesville by 11.8 feet.

h. Storm and flood of August 1980. The flood of August 1980 was caused by two separate events. First, a series of small, mostly localized storms occurred in the Wills Creek Basin in the latter part of July and the first part of August 1980. These storms saturated the soils in the basin and set the stage for the large storm event of 11 August. This storm was localized over the Wills Creek Basin, but the effects in the basin were widespread. Over 6 inches of rain fell on the basin in a 24-hour period of time beginning late on 10 August. This heavy rainfall, combined with the already saturated soils, caused very steep rises in the stream levels in the basin. The rainfall continued, and more than 1 inch fell over much of the basin on the 12th, thus keeping basin streams at their high levels for a longer period of time. Inflow at Wills Creek Lake peaked late on 11 August, at about 19,000 cfs, with a natural flow of about 16,400 cfs. This flood produced the record computed natural crest at Cambridge of 13,680 cfs on 13 August. The pool crested on 23 August at elevation 773.14 feet NGVD. Operation of Wills Creek Lake reduced the outflow stage by 10.5 feet and this in combination with other Muskingum Flood Control Reservoirs reduced the stage at Dresden from 21.18 feet to 18.86 feet.

i. Storm and flood of June and July 1998. The flood of June – July 1998 was caused by a series of localized storms that occurred in the Wills Creek Basin in the latter part of June 1998. The storms were localized over the Wills Creek Basin, but the effects were widespread, especially in the upper part of the basin. The two upstream tributary lakes both reached pools of record during this flood. Senecaville Lake on Seneca Fork reached a record pool crest of elevation 842.33 feet NGVD, one inch below the spillway; while Salt Fork had considerable spillway flow. Basically a 8 inch block of rainfall spread over the last 36 hours of June created the storm that led to the near pool of record at all three lakes. The first 0.22 inches on 26 June saturated the soils in the basin and set the stage for the large storm event of 3.78 inches the next two days. This heavy rainfall, combined with the already saturated soils, caused very steep rises in the stream levels in the basin. The rainfall continued with about 0.30 inches on the last day of the month, thus keeping basin streams at their high levels for a few more days. Inflow at Wills Creek Lake peaked late on 30 June at about 16,300 cfs; the pool crested on 6 July at elevation 774.45 feet NGVD.

4-07. RUNOFF CHARACTERISTICS

Wills Creek Basin is characterized by rugged hilly country with broad flat valleys along the major streams. Infiltration losses are generally low due to the relatively shallow depth and the sandy clay composition of the upland soils. Basin runoff is highest during the late winter and early spring months. During this period, snow cover, saturated or frozen ground in combination with rainfall, may greatly increase runoff rates and volumes. The runoff is lowest in the late summer and early fall when the ground is dry and infiltration rates are high. During the late summer and early fall periods stream flows in the basin drop to very low levels; for example, the natural minimum low-flow was down to zero during the very severe 1930-31 drought. However, precipitation during these seasons may be quite heavy and of sufficient intensity to more than make up for the higher infiltration rates. Since the time of construction Wills Creek Lake has always had a minimum inflow, which in-turn was used to supply a daily minimum low-flow for the channel below the dam. The record modified low-flow for Wills Creek Lake hovered between 13 and 18 cfs during the summer and fall of 1954. If, in the event of another very severe drought, Wills Creek Lake inflow would still be aided by Senecaville and Salt Fork Lakes outflow. Should the Wills Creek pool drop below the weir elevation of 741 feet NGVD, one of the stop logs could be withdrawn to release enough water for minimum outflow. **Table No. 4-6** below, presents natural and modified monthly and annual average runoff for the Wills Creek watershed below the dam.

TABLE NO. 4-6
MONTHLY AND ANNUAL AVERAGE RUNOFF
WILLS CREEK AT WILLS CREEK DAM SITE
BASED ON GAGE RECORDS*

	Average Mean flow		Average Maximum flow		Average Minimum flow	
Month	Natural	Modified	Natural	Modified	Natural	Modified
January	1,292	1,223	3,714	3,518	246	116
February	1,716	1,735	3,125	3,638	90	93
March	2,242	2,128	5,539	5,234	728	708
April	1,726	1,736	2,016	3,307	364	393
May	1,145	1,146	2,576	2,685	151	147
June	733	853	3,161	3,193	98	133
July	370	384	1,162	1,175	44	43
August	193	232	951	1,001	0	18
September	137	142	452	480	0	18
October	109	132	312	379	0	13
November	333	343	1,043	969	10	16
December	709	680	2,291	1,371	32	33
Annual	892	894	2,120	2,329	147	144

* Based on 48 years of record at U.S.G.S gage on Wills Creek at Wills Creek Lake, Ohio.

4-08. WATER QUALITY

a. Geology. The Wills Creek Basin lies in the Kanawha section of the Appalachian Plateau Province. The region is characterized by a hilly, maturely dissected topography with broad flat valleys in which flood plains and terraces are prominent features. The total relief for the basin is approximately 685 feet, with the uplands rising to a maximum elevation of about 1,400 feet NGVD. Strata within the basin belong to the Pottsville Group and Allegheny Formation of the Pennsylvania system. These strata consist of essentially horizontal shale, sandstone, limestone, and coal, with about 95 percent of the lithologic units being sandstone and shale. Land use in the basin was mostly farming, but, recently, surface mining has become very prominent in the Wills Creek Basin.

Soils in the area are components of the Western Allegheny Plateau and are formed over sandstone and shale. These acidic soils have a high erosion potential when disturbed, and are low in natural fertility and organic matter. Geological considerations are most important because rock type in the drainage basin determines, to a great extent, the inorganic composition of inflow and (ultimately) lake water.

b. Chemical. Inflow water is characteristic of the calcareous nature of the watershed. In terms of the major ions and descriptive parameters, inflow water is classified as a calcium-sulfate type, which is an unbalanced condition. Ionic concentrations and buffering capacity (alkalinities) are high. Nutrient levels are fairly high but over-productivity seems to be kept in check by pollution sources. Wills Creek receives domestic pollution from the City of Cambridge where most of the collection system is combined sewers into which the river backs up when the water is high. Local industries, and active and inactive mining operations are other sources of pollution which might influence water quality in the Wills Creek drainage basin.

c. Temperature. 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 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 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 fall 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. Wills Creek Lake remains nearly isothermal during the winter months. In the spring the lake starts to stratify. The three layers described above do not develop because of the short hydraulic retention time. **Plate No. 4-11**, shows a typical temperature profile.

d. Retention. The calculated average retention time of 3 days is very short and should affect the stratification pattern. It is not expected that any stratification would exist with such a short retention time, but the design of the outflow structure allows for only the release of surface waters during non-flood conditions. The deeper water remains in the lake for longer periods of time.

e. 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. Specific conductance, alkalinity and hardness are all relatively high. Water hardness in the basin is 209 ml/l Calcium Carbonate, which is classified as hard (Durfor and Becker, 1964, pg. 23), it has high concentrations of dissolved materials, and has good inherent capacity to resist shifts in pH.

f. Dissolved Oxygen. Dissolved oxygen levels are extremely important in water quality characterization. Oxygen levels in man-made and natural are directly dependent on the physical, chemical, and biological activities that occur in the water. A strong interplay occurs between temperature and dissolved oxygen levels. Thermal stratification can result in zones which exhibit greatly different physical, chemical, and biological characteristics. In well-mixed epilimnetic water, relatively high levels of oxygen occur, and water is of acceptable quality or at least of a quality comparable to that of inflowing streams. Water in the hypolimnion may become deprived of oxygen as a consequence of various oxygen demanding materials and processes. Therefore, a concomitant decrease in water quality can occur after stratification becomes established. Because Wills Creek is a shallow lake, twenty feet at its deepest point, it does not become strongly thermally stratified. The lake stays almost isothermal until early summer with a weak thermocline developing at about 5 feet deep in late summer. Dissolved oxygen concentrations remain fairly constant throughout the water column during the winter period, but decrease as a function of depth during the summer months. See **Plate No. 4-12**.

Throughout the epilimnion, dissolved concentrations remain greater than or equal to 5.0 mg/l. As temperature decreases through the thermocline region, dissolved oxygen disappears rapidly, resulting in anoxic conditions near the bottom of the downstream section of the main lake during late summer. Streams entering the project contain dissolved oxygen at concentrations greater than 5.0 mg/l. This is also true of the discharge, despite dissolved oxygen depletion within the reservoir in the late summer. The concentrations of nutrients in a lake is an indicator of productivity. Low productivity results in fewer littoral plants and low density of phytoplankton, whereas highly productive lakes tend to be characterized by littoral vegetation and abundant phytoplankton populations. The amount of productivity is important in fishery considerations and plankton bloom problems. Production at Wills Creek Lake has the potential to be high, but is probably limited by high siltation and acid mine discharge.

g. Nutrient Load. Concentrations of nutrients in a lake are an indicator of productivity. Low productivity results in fewer littoral plants and low density of phytoplankton, whereas littoral plants and abundant phytoplankton populations characterize highly productive lakes. The amount of productivity is directly related to the lake fishery. Sufficient quantities of phosphorous, nitrogen, and carbon are needed to have a productive lake such as Wills Creek Lake. Phosphorous is the limiting nutrient. As long as there is available phosphorous, the food supply is not limiting productivity.

Nutrients are transported with sediments. As water enters a lake, its velocity decreases and the sediments settle to the bottom. Because of this phenomenon, it is common to see algal blooms at the upper end of a lake. Phosphorous concentrations averaged 0.09 mg/l at the inflow and 0.08 mg/l in the outflow which indicated that there was available phosphorous in the tail waters.

h. Phosphorous. Inflowing streams and the outflow contain total phosphorus less than the 1 mg/l (1000 ug/l) recommended by the Ohio Water Quality Standards. Because of the higher total phosphorus than dissolved phosphorus values, phosphorus is probably linked to the sediment and thus overproduction is not stimulated. In the lake, total phosphorus reached a maximum of 135ug/l, well within the state standard. Distributions are erratic and no definite pattern can be linked to the formation of a thermocline.

i. Ph. The highest value for nitrate plus nitrite was 2.0 mg/l and the average value was 0.7 mg/l. A relatively uniform distribution with depth was observed in most cases. No significance of nitrate plus nitrite concentrations can be associated with reservoir operations. Nitrogen is not felt to be a limiting nutrient for biological productivity. Streams entering the project have a pH range of about 6.3 to 8.7. In the pool, pH decreased below the thermocline during periods of thermal stratification. Values of pH in the non-stratified periods were normally around 7. At the outflow, pH ranges from 6.5 to 8.7, which is within the Ohio state standard.

j. Iron Concentrations. Total iron at major inflow stations exceeds the Ohio state standard recommended maximum of 1.0 mg/l. Iron also occurs in high concentrations within the lake, with total iron in excess of 2.0 g/l common throughout the water column. Dissolved iron in inflows and the epilimnion constitute a small percentage of the total content, thereby indicating that suspended solids from active and inactive strip mines are the primary source of iron within the lake. During months when the lake is thermally stratified, increases occur at the outflow as a consequence of hypolimnic discharges. Periods of mixing, such as in spring prior to stratification and fall after overturn, also result in increased outflow concentrations. See **Plate No. 4-13**.

k. Manganese Concentrations. Manganese exists in both the lake and watershed throughout the year, which is probably indicative of the strip mining area. Unlike iron and phosphorus, most of the manganese is not tied up in the sediment, but instead is dissolved in the water. This could cause problems to down-stream users of the water if the levels were excessive. Thus far, the data collected show most levels are 1 mg/l. See **Plate No. 4-14.**

l. Biological. Very few biological samples have been collected at Wills Creek Lake by Huntington District. The data obtained correlates well with samples taken throughout the basin by the Ohio EPA in 1976 and samples taken in 1967 by the Federal Water Pollution Control Administration. Biological data of benthic macro invertebrate and plankton are summarized from all three sources.

The benthic macro invertebrate samples reflect, for the most part, a dominance of tolerant forms. Above the lake the major components of the benthic community were chironomids, mayflies, and oligochaetes with moderate sample diversities, equitabilities, and low densities. Below the dam, the community was dominated by chironomidae and caddisflies. The moderate diversities and equitabilities and low densities both above and below the lake is probably due to the active and abandoned strip mines located in the area, and the domestic pollution from Cambridge.

All plankton samples collected were dominated by diatoms (Bacillario-phyceae). Blue green algae (chlorophyta), and flagellates (Mastigo-phora) were the other major components of the community. The environ-mental stress is reflected by the low diversities but moderate production. Productivity and number of taxa would probably be higher, but seems to be kept in check by the high total suspended solids.

Chlorophyll a has been used to monitor and evaluate plankton production(algal biomass). Chlorophyll a concentrations greater than 8.0 milligrams per cubic meter (mg/m3) indicate a potential for overproduction, while concentrations in excess of 20 mg/m3 exist during algae blooms and indicate eutrophic conditions. The physiological state of an algal population may also be determined by the ratio of the chlorophyll a concentration to the pheophytin a concentration. Pheophytin a, a degradation product of chlorophyll a, characterizes non-viable cells. It is also possible to project a calculated biomass from chlorophyll data. Biomass of the major algal types may estimated by comparison of the relative concentrations or the three principle chlorophyll pigments.

Only six chlorophyll samples, collected in the summer of 1977, have been processed. These samples show that the streams entering the Wills Creek lake have high chlorophyll concentrations, generally over 8.0 mg/m3which indicate a potential for over production. These high counts are probably due to the domestic pollution from the town of Cambridge, while the high total suspended solids from coal mining operations seems to keep the overproduction in check. Productivity from the outflow is slightly less than the inflow, indicating possible production loss in the lake.

4-09. CHANNEL AND FLOODWAY CHARACTERISTICS

Wills Creek follows a meandering course over the 6.0 mile length between the dam site and its junction with the Muskingum River. Wills Creek valley is a winding, terraced, and flat-bottomed topographic feature whose walls rise on rather steep slopes to a well dissected upland. The stream has entrenched itself into a wide flood plain and the streambed is mostly sand and gravel and varies in width from about 30 feet above Wills Creek Lake to 100 feet at the mouth. The valley width averages around 1,500 feet from the dam site to the mouth. The slope of the channel is relatively constant at about 1.4 feet per mile from the dam site down to the mouth of Wills Creek, as shown on **Plate No. 4-1**, High-water Profiles.

Travel times from Wills Creek Lake to the gage at Dresden, Zanesville, and McConnelsville, Ohio and to the mouth of the Muskingum River at Marietta, Ohio are estimated at 12, 16, 22, and 48 hours respectively. These travel times are shown on **Table No. 3-1**, page 3-2 of the Instructions to Damtender.

4-10. UPSTREAM STRUCTURES

Two upstream structures in the Wills Creek Basin are the Corps of Engineers tributary project, Senecaville Lake on Seneca Fork of Wills Creek with a 118 square mile drainage area, and the State of Ohio owned dam on Salt Fork.

4-11. DOWNSTREAM STRUCTURES – N.A.

4-12. ECONOMIC DATA

a. Population. The Wills Creek Basin above Wills Creek Dam had an estimated 2000 population of about 39-40,000 persons in a predominantly rural environment. Population centers are small, most of them numbering less than 100 persons, except for the city of Cambridge which had a 1999 population of about 11,790 people. Guernsey County, which comprises the majority of the Wills Creek Basin, experienced a loss of about 3 percent in population for the decade ending in 2000.

a. Industry and Agriculture. The Muskingum River Basin is rich in mineral resources. Coal is the most important mineral resource in the Wills Creek Basin and deposits are located throughout the basin. Tuscarawas County, which contains a small portion of the basin, is one of the leading producers in the area. Much of the land surrounding Wills Creek Lake has been mined for coal using strip mining techniques. Mining and agriculture employed approximately 10 percent of the labor force in the basin in 1977.

Between 40 and 50 percent of the basin is used for agricultural purposes, mainly cropland and pasture. The average farm size is around 170 acres. In recent years there has been a steady conversion of agricultural lands to forests and industrial-urban development, but agricultural development is still occurring, primarily in the wide stream valleys.

b. Flood Damages. Areas subject to flooding downstream of Wills Creek Dam along Wills Creek and the Muskingum River consist of some farms and rural residences along with several larger communities, including Dresden, Zanesville, Philo, McConnelsville, and Marietta. Average annual damages prevented by the existing flood control projects, in the Muskingum Flood Control Reservoir System have been estimated at various times with a wide range of answers. They were estimated to be $27.5 million in July 1971 and were updated to $105 in December 1999, assuming that the 1971 level of development in the flood plain remained at a fairly constant level due to zoning and flood insurance regulations. Actual average annual flood damages for various reaches along the Muskingum River are shown in **Table No. 4-7,** next page, and the estimated flood damages prevented by the original 14 Muskingum Reservoirs for the eight years ending 30 September 1998 are shown in **Table No. 4-8,** next page. The estimated average annual damages prevented for the eight years from 1991 to 1998 is about 87 million dollars per year.

Damages were updated to December 1999 by considering escalation of construction costs between July 1971 and December 1999. Table values can be updated by applying an appropriate ratio of "U.S. 20 Cities Average" construction cost index from Engineering News Record. The updating formula is as follows:

ENR for month desired
ENR for December 1999 (6060)

X Table Value
= Updated Damage Value

Where ENR is the "U.S. 20 Cities Average" monthly index of construction costs.

TABLE NO. 4-7

AVERAGE ANNUAL DAMAGES
ALONG MUSKINGUM RIVER

Reach	Communities	Average Annual Damages*
Wills Creek to Dresden	Dresden, Adams Mills, Trinway	$772,810
Dresden to McConnelsville	Duncan Falls, Philo, Zanesville	$11,128,760
At McConnelsville	Stockport, Malta, McConnelsville	$2,101,516
McConnelsville to Lock No. 2	Lowell, Beverly, Waterford	$22,962,126

*Based on December 1999 prices and July 1971 level of development.

TABLE NO. 4-8

FLOOD DAMAGES PREVENTED BY
ORIGINAL 14 MUSKINGUM RESERVOIRS
(8 years ending 30 September 1998)

	Damages Prevented ($1,000)	
Year	During Year	Cumulative*
1991	112,601	1,376,719
1992	1,930	1,378,649
1993	60,410	1,439,059
1994	164,371	1,603,430
1995	17,145	1,620,575
1996	240.370	1,860,945
1997	54,061	1,915,006
1998	153,775	2,068,781

* Since 1936

SECTION V - DATA COLLECTION AND COMMUNICATION NETWORKS

5-01. HYDROMETEROLOGICAL STATIONS

a. Facilities. Data Collection Platforms (DCP's) and Hydrologgers have been installed at various stream gaging and precipitation stations in the Wills Creek Basin. Installations at stations in the Wills Creek Basin are described in **Table Nos. 5-1** (Table Section). Early-model stage detection devices, i.e. staff sections and wire weight gages, are now used as primary references for setting modern measuring and recording instruments. 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.

Some stream gaging stations have voice DCP's, capable of answering a telephonic call and responding with the current updated information by synthesized voice.

Another type of DCP is now available that has the capability of reporting in response to a telephone query from a computer or terminal. The query can be initiated any time from the Water Control System, project office or the home of a selected individual during off-duty hours. The voice synthesizer gives stage as "level" to 0.1 feet when dialed. These DCP's can also dump to a computer terminal giving several readings over a period of hours. These DCP's are being installed at critical locations such as inflow, lake and outflow stations, along with some control point stations.

Stream Gaging Stations in the Wills Creek Basin include: Wills Creek at both Derwent and Cambridge; both Wills Creek Lake Gage and Outflow Gage; Seneca Fork of Wills Creek below Senecaville Lake, Salt Fork Lake, and Muskingum River at Dresden. ORN precipitation stations in and near the Wills Creek Basin have been combined with the DCP’s until all precipitation is collected and reported by INTRANET computer. Gage locations are shown in **Plate No. 5-1,** Hydrologic Network; and pertinent data about them is listed in **Table Nos. 5-1** and **5-2,** Table Section. Discharge Rating Tables for Dresden, Zanesville, and McConnelsville are shown on **Plate Nos. 4-9,** and **10.**

b. Reporting. The DCP platforms store stage and precipitation data and, every four hours, transmit to the LRD computer downlink via the GOES satellite. The water Resources Engineering Branch Water Control System receives data automatically from the LRD water control system on an hourly basis.

c. Maintenance. Routine daily first level maintenance for all mechanical stream gaging equipment in the Wills Creek Basin will be performed by the assigned project personnel. Advanced higher level maintenance, particularly for any electronic equipment malfunction, will be performed by a Corps trained technician or a U.S.G.S. technician. The Water Control Section should be contacted if a malfunction has occurred, and they in-turn will then contact the appropriate personnel. The Corps trained electronic technician for the state of Ohio is located at Alum Creek Lake on Alum Creek Drive, Ohio.

Numerous changes have been made in the methods of data collection with anticipated future improvements to take place as to data collection, analysis, and use.

The Corps of Engineers and NWS cooperatively exchange stage information along with weather information as delineated in 5-01d.

5-02 WATER QUALITY STATIONS

a. Facilities. A network of eight water-quality-sampling stations was established at Wills Creek Lake. Primary stations located on the lake are shown in **Plate No. 5-2**. All primary stations within the basin are described in **Table No. 5-3,** below.

TABLE NO. 5-3

Description by Location of Wills Creek Lake
Primary Water Quality Sampling Stations

Station	Distance From the Dam
1WCW0001	0.1 Miles Below
1WCW0002	0.1 Miles Above
1WCW0003	23.9 Miles Above
1WCW0004	10.0 Miles Above
1WCW0005	8.5 Miles Above
1WCW0006	9.5 Miles Above
1WCW0007	10.5 Miles Above
1WCW0008	11.7 Miles Above

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

(1) Establish baseline conditions and monitor subsequent changes

(2) Identify water quality environmental problems

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

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

Parameters measured, frequency of collection, and numbers of data-collection-stations are determined by specific project conditions. The water quality program design for Wills Creek Lake was structured to describe 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:

(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 streams

(5) Other biological measurements such as plankton and seston

Standard physical/chemical tests and reasons for testing are presented in **Table No. 5-4,** next page.

c. Maintenance. Sediment and water samples are collected from Wills Creek Lake once every 5 years. Water samples are also collected each month for the months April through September every 10 years. 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

5-03. SEDIMENT STATIONS

(1) Facilities. A network of sediment ranges was established at Wills Creek Lake as part of an aerial photography, ground control, and mapping contract during the summer of 1973. Sediment range monuments for 7 sediment ranges were established at Wills Creek Lake, in the minimum pool area, upstream of the dam site. The 1936 or original ground profiles were obtained using a spud to estimate the sediment depth along each range. Each range consists of

two concrete monuments placed at the end of each range. The ground profile of each range was measured at that time and several years later the sediment range was adopted by the Chief of Engineers. The first sediment range reconnaissance at Wills Creek Lake was completed in 1973. A second sedimentation reconnaissance at Wills Creek Lake was conducted in 1981, and a third reconnaissance was conducted in 1986. The sediment range network is shown on **Plate No. 5-2,** with the location and description data shown on **Table No. 5-5,** next page.

(2) Reporting and Maintenance. In order to monitor the rate of deposition of sediment in the lake, reconnaissance scope surveys of selected ranges are conducted every five years unless the requirement for an earlier survey is indicated by natural causes, such as a major flood or by increased sediment producing activities in the basin. Detailed resurveys of all ranges will be conducted as deemed necessary by reconnaissance scope surveys. Reports have been published for the 1973, 1981, and 1986 sediment reconnaissance. A description of sediment yield, as calculated from the 1981 reconnaissance, is given in paragraph No. 5-04. A sedimentation profile of the lake obtained during the 1981 and 1986 reconnaissance, along with the original and 1973 profiles, is shown in **Plate No. 5-3**.

b. Downstream.

(1) Facilities. After a multi-purpose dam has been constructed and placed in operation, flow characteristics downstream are different from the natural pre-impoundment characteristics and the discharge carries generally less silt than did the natural stream. These factors together can cause unpredictable channel changes due to both degradation and aggradation and the changes can cause anxiety in downstream property owners where they occur. In order to monitor any such changes which may occur, the Corps normally installs and surveys sediment ranges along the stream below the dam and designates them category "C" ranges. No downstream “C” ranges, have been established at Wills Creek Lake.

(2) Reporting and Maintenance. In order to determine the character and extent of any channel changes below the dam, monitoring of the downstream ranges is carried out by field survey methods on a selective basis at the time of a sedimentation reconnaissance or during a detailed survey. A detailed survey may be performed when recommended by a reconnaissance scope effort or in the event of the lodging of a complaint about a channel change. The report on the 1981 sediment reconnaissance recommended that a reconnaissance scope sediment survey take place in FY 1986. And in turn, the 1986 survey recommended that a sedimentation survey be conducted every five years, however, this was postponed due to lack of funds. All computations for the sediment report were performed by computers.

c. Maintenance. Project personnel and the survey party members regularly and periodically check the sediment range markers so the damaged monuments can be replaced and any obscuring undergrowth can be removed.

TABLE NO. 5-5

DESCRIPTION AND LOCATION OF
WILLS CREEK LAKE
SEDIMENT RANGES

	Range	Wills Creek Mile Point	Distance Above or Below Dam
	DAM	7.31	0.0
1.	1 WCS 1-A	7.52	0.21 Miles Above
2.	1 WCS 2-A	8.18	0.87 Miles Above
3.	1 WCS 3-A	9.37	2.06 Miles Above
4.	1 WCS 4-A	10.45	3.14 Miles Above
5.	1 WCS 5-A	12.16	4.85 Miles Above
6.	1 WCS 6-A	12.69	5.38 Miles Above
7.	1 WCS 7-A	13.58	6.27 Miles Above

5-04. RECORDING HYDROLOGIC DATA

All data entered into the water control system are stored in a database. Stream and precipitation data is stored in one hour increments. Project information along with being stored in one hour increments is also processed in one day average values and stored.

The data is stored in water year files and in period of record files for each basin. As the data is useful for historic studies it is to be maintained indefinitely, or until further notice arrives from LRD.

5-05. COMMUNICATION NETWORK

Communication between Wills Creek Lake, the Muskingum Area Office, the District Office, etc., is carried out primarily by telephone, although the morning report from Wills Creek Lake is transmitted to the Area Office via INTRANET. High-quality Cell Phones are now available at the District office, Area offices, lake project offices, construction field offices, and navigation lock and dam installations. The Cell Phones provide a backup when telephone service is interrupted. In the Muskingum reservoir system, data collection platforms (DCP's) are installed at all lake projects, at all key stream gaging control stations, and at several precipitation stations for collection of hydrometerological data. At Wills Creek Lake, there is a DCP at both the lake and at the outflow gage. Operation of the DCP-satellite network is discussed in more detail in 5-01 and 5-02. **Plate No. 5-4** graphically illustrates the communication network throughout the Muskingum River Basin.

5-06. COMMUNICATION WITH PROJECTS

Telephone is the primary mode for most communication between the Water Control Section and the multipurpose projects, such as Wills Creek, and the Muskingum Area Office and between projects and the Area Office. Lines of communication for the Wills Creek-Muskingum River Basin are illustrated in **Plate No. 5-4**. Cell Phones are used for secondary backup communication, while mobile radio, State Police, courier, etc. is utilized during an emergency when neither the telephone or Cell Phone is operational. Inter-project communication is mostly by Cell Phone with some telephone communications when privacy is essential.

Water Control Section personnel use the telephone to request and receive additional operations information and weather information and to give operational guidance and directives. The U.S. Postal Service is utilized for letter reports from projects to the Water Control Section, other voluminous or detailed information, pictorial material, confirmation of Special Directives, and any other formal communication between the Water Resources Engineering Branch and the projects.

Occasional visits to the projects afford an opportunity for office and project personnel to discuss ideas, problems, new procedures, etc.

5-07. PROJECT REPORTING INSTRUCTIONS

Project personnel will report hydrometeorologic and water quality data to the Water Resources Engineering Branch as described in "Instructions to Damtender", Exhibit B, chapter 4. The project will report any operational problems by telephone to the Water Resources Engineering Branch and the Technical Support Branch of Operations.

5-08. WARNINGS

Project personnel are required to sound a horn to warn the users of the downstream recreation area that the volume of outflow is expected to rapidly increase. The National Weather Service is responsible for issuing public flood watches and warnings in the Muskingum – Wills Creek Basin. If the situation is grave or serious enough, the Dam Safety Emergency Action Plan lists individuals to contact and warm of an impending crisis.

Project personnel communicate with the County Sheriff's Department in conjunction with law enforcement assistance. Although there are no public use areas around the lake that need to be notified of rising pool elevations, several state and county roads are affected by pool elevations above 750 feet above NGVD. The roads affected and the agencies notified are given in **Table No. 5-6**, next page.

TABLE NO. 5-6

WILLS CREEK LAKE
WATER LEVEL WARNINGS

Elevation	Road	Description	Agency Notified
	STATE ROADS		
760+	SR 271	Coshocton -Kimbolton	State Highway Dept.
765+	SR 75	Zanesville -Plainfield	
765+	SR 76	New Concord-Coshocton	
	COUNTY ROADS		
750+	Co-Mu 2,8	Wills Creek - Marquand Mills	Coshocton or Muskingum County Road Departments
750+	Co-Mu 10,12	Marquand Mills - Plainfield	Coshocton or Muskingum County Road Departments
750+	Co-Mu 9,11	Maysville–Plainfield	Coshocton or Muskingum County Road Departments
750+	Co 112	North of Ostego	Coshocton County Road Department
750+	Co 15	Plainfield west	Coshocton County Road Department
750+	Gu 20	Kimbolton north	Guernsey County Road Department
750+	Gu 68	North of Kimbolton	Guernsey County Road Department
750+	Gu 70	North of Kimbolton	Guernsey County Road Department

SECTION VI - HYDROLOGIC FORECASTS

6-01. GENERAL

Hydrologic forecasts of lake elevations and stream flows in Wills Creek Basin are vitally important for Water Control Management as these forecast provide information, which enable the optimal regulation of the projects. The Water Control Section uses all available hydrologic and meteorological data in forecasting efforts for the Wills Creek - Muskingum River Basin. These forecast are conducted under low-flow, normal flow, and flood conditions and are primarily developed by the Corps of Engineers and the National Weather Service on a daily basis.

a. Corps of Engineers.

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

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

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

6-02. FLOOD CONDITION FORECASTS

a. Requirements. Whenever "flood threat" conditions approach, as defined by the Schedule for Reading Gages, forecasting effort primarily focuses on area rainfall, downstream flood control points, and the lake elevation. The basin forecast is computed using one-hour data and it normally takes one hour to complete the forecast of the Wills Creek Basin. The model is executed repeatedly during the flood event as additional data becomes available.

The forecast data is used to predict the anticipated pool crest, downstream flood crests, necessary storage releases, and probable duration of flood period. The reservoir storage data used in the forecast model program is summarized in **Table No. 6-1** below.

The control stages and flows for the Wills Creek Basin are summarized in **Table No. 6-2,** next page. The detailed drainage areas for the Wills Creek Basin are listed in **Table No. 6-3,** on page 6-4 and shown on the Basin Forecast Map, **Plate No. 6-1**.

TABLE NO. 6-1

WILLS CREEK LAKE POOL ELEVATIONS AND STORAGES

Pool	Surface Elevation NGVD	Area Acres	Backwater Stream Miles	Storage Acre-feet Net	Storage Acre-feet Gross	Storage Inches runoff Net	Storage Inches runoff Gross
Year-Round Storage:							
Minimum	742	900	20.9	6,000	6,000	0.2	0.2
Flood Control Storage							
Year Round	779*	11,450	60.6	190K+	196K	4.90+	5.10
Total	779*	11,450	60.6	196K*	196K	5.10*	5.10

* At maximum pool elevation
+ Between elevations 742 and 779

A basin forecaster assigned to the Muskingum River Basin, utilizes the Water Control System computer model for each day and couples the results from the model with past records, knowledge, and experience with the basin to produce the required daily forecasts. The adjusted computerized forecast is then made available for distribution to interested parties and groups. A typical sequence of modeling events leading to water control management decisions is described as follows:

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

2. Observed precipitation and stage 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 at the request of Division.

4. The small basin hydrograph forecasts are then reviewed and modified if necessary. The second part of the model is then executed to route, blend and combine flows. The flows are reviewed, the lake outflows modified if necessary, and the second part of the model is recomputed.

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

TABLE NO. 6-2

WILLS CREEK LAKE
CONTROL STAGES AND TRAVEL TIMES

Station	Stream	Summer Stage	Summer Flow	Winter Stage	Winter Flow	Time of Travel Hours
Wills Creek Dam	Wills Creek	15.0	5,880	*15.4	6,100	0
Dresden	Muskingum River	16.0	23,450	18.5	32,000	12
Zanesville	Muskingum River	19.5	38,200	21.5	48,000	16
McConnelsville	Muskingum River	10.0	35,600	11.0	41,600	24
Marietta	Ohio River	35.0		35.0		48

*Water Control Section has authority to use 16.2 ft in winter emergency.

The real time modeling program makes extensive use of small-area unit hydrographs, infiltration rates, discharge rating tables, routing coefficients, and graphical review of flood hydrographs and profiles. The computer program assimilates the total precipitation over a 3-day time period and analyzes the storm in detail. By using predetermined basin rainfall infiltration rates and runoff percentages the program computes the antecedent rainfall, base flow, and storm runoff.

By applying the computed storm runoff to the appropriate unit-hydrographs a computed hydrograph is developed. The computer then uses routing coefficients with routing and combining methods to route the flood downstream and through Wills Creek Lake. With this computer program and practical experience the Water Control Section is able to produce a reliable forecast for the Wills Creek Basin.

Table No. 6-3, next page is an example of the various small areas above and below Wills Creek Dam which small-area unit hydrographs are developed. **Plate No. 6-1** shows the basic forecast areas for the Wills Creek Basin, while **Plate No. 6-2** shows the Wills Creek network configuration.

The small area six-hour adopted unit-hydrographs for the various Wills Creek forecast areas are shown on **Table No. 6-4**, page 6-5. The unit hydrograph data was derived by the 1975 Dodson Lindbloom Muskingum study, and is based on the uncontrolled area above Wills Creek Dam yet below Senecaville and Salt Fork Dams. The Discharge Rating Tables for the key points in the Wills Creek Basin are shown on **Plate Nos. 4-9,** and **4-10.**

TABLE NO. 6-3

DRAINAGE AREAS AND STREAM FLOWS OF WILLS CREEK
AND PRINCIPAL TRIBUTARIES ABOVE DAM SITE

Location	Miles Above Mouth	Drainage Area (sq.mi.)	Period of Record	Maximum Flow CFS	Minimum Flow CFS	Mean Flow CFS
Seneca Fork At Senecaville Lake	86	118	1938-1999	985	0	132
Wills Creek at Cambridge	62	406	1937-1999	8,500	0.7	451
Salt Fork nr Cambridge	-	55.6	1956-1967	3,890	0	53
Salt Fork at Salt Fork Lake	-	161				
Wills Creek at Wills Creek Lake	**6.2**	**842**	**1938-1999**	**6,930**	**1.0**	**939**

6-03. CONSERVATION PURPOSE FORECASTS

a. Requirements. Conservation forecasts are executed in conjunction with the flood control forecast. They are executed on a daily basis for the next five days and on a weekly basis for the next 30 days. The main focus of the conservation forecast is to maintain seasonal pool at Wills Creek Lake in order to provide fish and wildlife habitat, recreation, and water supply. At the present time, operations for water temperature and quality are based on observations rather than forecast.

b. Methods. The methods and procedures for nonflood streamflow projection are the same as mentioned previously for the flood forecasting except the concern of the modeler is the low-flow analysis. The repetitive process is utilized to operate the reservoir in order to provide downstream low-flow requirements and then to evaluate their impact on the lake pool.

6-04. LONG RANGE FORECASTING

a. Requirements. Long-range forecasts assist the Huntington District and the Great Lakes and Ohio River Division in water control management in the Wills Creek Basin. 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, conservation pool may be raised to store additional water for later release downstream. Long-range forecasts are required by the Division Headquarters Water Management Branch (WMB) as they utilize it to inform the Mississippi Valley Division (MVD) of probable future conditions and to suggest specific items of water control management to the districts.

b. Methods. The Water Control Section produces a weekly forecast for the next 30-days utilizing the same method as used for flood forecast. This forecast assumes no future rain. Lower than normal precipitation forecast are produced by the National Weather Service.

6-05. DROUGHT FORECASTS

a. Requirements. The Huntington District now uses the drought forecast of the National Weather Service. The Corps summer drought forecast was discontinued in lieu of the regular NWS forecast.

b. Methods. The long range and conservation forecast address all forecasting concerns that would be raised by a drought. No extra forecast activities are planned for this time.

c. Reference Documents. Many of the basic documents for drought forecast are in Water Resources Engineering Branch files for the Huntington District, Huntington, West Virginia. These files contain records prepared by the Ohio Department of Natural Resources and the Ohio USGS for past drought periods, Water Availability Studies for the Wills Creek Basin, and the Ohio River Basin Comprehensive Study, prepared by the Great Lakes and Ohio River Division, Cincinnati, Ohio. The national and state weekly drought forecasts are included with the Palmer Index summaries for the current and preceding drought periods. During a drought period the low-flow records and reference books are used to prepare a weekly drought information bulletin for distribution to all concerned groups.

TABLE NO. 6-4

ADOPTED SIX-HOUR UNIT-HYDROGRAPHS FOR
PRINCIPAL POINTS FOR WILLS CREEK LAKE
(Excluding Senecaville and Salt Fork Lakes)

Time Hours 6-hours	Natural Unit Graph 563.0	Inflow Unit Graph 563.0	1-A Pool Head 375.0	#2 Around Pool 170.0	#3 Pool Area 18.0
.0	0	0	0	0	0
6	500	800	440	450	1920
12	1075	1600	1010	960	
18	1720	2550	1800	1510	
24	2400	3400	2610	1990	
30	2955	4000	3220	2260	
36	3283	4450	3680	2065	
42	3455	4600	3905	1785	
48	3540	4600	3740	1485	
54	3565	4500	3350	1170	
60	3510	4100	2910	925	
66	3350	3500	2440	745	
72	3130	3030	2050	610	
78	2950	2630	1710	500	
84	2795	2330	1430	410	
90	2635	2000	1180	335	
96	2410	1750	970	260	
102	2210	1500	790	210	
108	2003	1250	640	165	
114	1800	1100	515	120	
120	1600	930	400	90	
126	1450	750	315	65	
132	1260	600	245	35	
138	1150	480	190	20	
144	980	390	150		
150	825	250	110		
156	740	190	80		
162	630	100	55		
168	530	50	35		
174	435	0	20		
180	360		10		
186	280				
192	210				
198	150				
204	100				
210	70				
216	40				
222	20				

SECTION VII - WATER CONTROL PLAN

7-01. GENERAL OBJECTIVES

In accordance with ER 1110-2-240, Water Control Management, 8 October 1982 and ORDR 1110-2-27, Water Control Management Activities, 12 January 1976, the plan of water control management and regulation as discussed in the subsequent paragraphs reflect optimal consideration of each project purpose, namely flood control, lake and downstream recreation, and fish and wildlife conservation. In developing the plan of regulation, the following general requirements were considered and evaluated in relation to the overall effective water control management plan for the project, the Wills Creek Basin, the Muskingum and the Ohio River Basins.

a. Prevention or reduction of serious flood damages to communities, crops, and properties below the dam along Wills Creek and the Muskingum River to the greatest extent consistent with safe operation of the project.

b. Reduction of flood damages along the Ohio River below the mouth of the Muskingum River at Marietta, Ohio.

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

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

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

f. Maintenance of minimum conservation pool elevation 742 feet above NGVD to support fish populations and for sediment reserve.

g. Sensitivity to reasonable requests for operational changes from other agencies.

h. Concern for safety and well-being of humans, fish and wildlife, man-made structures and stream banks downstream of dam, which can be affected by discharge control.

7-02. MAJOR CONSTRAINTS

The various project purposes may at times strongly conflict, therefore the following priorities have been established. Flood control is the primary project purpose followed by the fish and wild life conservation, and recreation.

Operational limitations concerning flood control, recreation, low-flow and water quality, and fish and wildlife conservation are listed in **Table No. 7-1**, below.

Table No. 7-1

Operational Limitations

Pool Level Elevation NGVD	- Streambed	716.0	zero storage	
Minimum Pool		742.0	900	acre-feet - Gross
Maximum Flood Control Pool		779.0	11,450	acre-feet - Gross
Maximum Surcharge Level		797.0	475,000	acre-feet - Gross
	Top of Dam	799.0	NGVD	

Gate Change Maximum Rate - 1.0 feet per hour at Outflow gage except for emergencies

Spillway flow at
Max flood control pool - 779.0 NGVD Outflow - Zero
Spillway Maximum Flow – 797.0 NGVD Outflow - 45,800 cfs
Maximum Flow for

Six Caterpillar Sluice Gates - Elev. 779 feet NGVD - 25,000 cfs

Max. Winter flow without a directive	2,480 cfs, 10.2 ft. @ "O" gage
Max. Summer flow without a directive	2,600 cfs, 10.5 ft. @ "O" gage
Max. Winter flow by SPECIAL DIRECTIVE	6,100 cfs,*15.4 ft. @ "O" gage
Max. Summer flow by SPECIAL DIRECTIVE	5,880 cfs, 15.0 ft. @ "O" gage

* Water Control Section has authority to go to 16.2 ft in winter emergency, seldom used due to low level housing below dam.

The major constraint to operation for flood control is the buildup of housing that has occurred along Wills Creek below the dam since it was constructed. Two cottages are located at an elevation at which water is dangerously close to the thresholds at a stage of 15.4 feet (equivalent discharge 5,880 cfs) at the outflow (K) gage. Due to this fact, the winter operational control stage has been reduced from 16.2 feet (6,570 cfs) to 15.4 feet at the K gage for all but major floods. The criterion for use of the higher discharge during a flood is based on the pool level reaching elevation 769 feet NGVD, the level when approximately 50% of the available flood storage in Wills Creek Lake has been utilized.

Other constraints to regulation are those affecting fulfillment of the project purpose of flood control. Exercise of the flood control function can be inhibited by restrictions on storage of the design volume of water such as construction in the lake area and/or by inability to discharge storage as quickly as planned because of floodplain encroachment.

Compliance with a requested deviation as outlined in subsection 7-02 may become a constraint to regulation if some assumed factor, such as weather, developed differently from the way assumed.

7-03. OVERALL WATER CONTROL PLAN

Wills Creek Lake operates to reduce flooding on the Muskingum and Ohio Rivers, provide consistent low-flow releases, provide habitat for fish and wildlife conservation, and provide recreation in and below the lake

Wills Creek Lake is one of 16 flood control reservoirs in the Muskingum system. During a flood on either the Muskingum or Ohio Rivers flood regulation procedures for Wills Creek are closely coordinated with all other nearby lakes that affect the Ohio River. Coordination of regulation is toward maintenance of rough equivalence of degree of utilization of flood control storage capacity between the projects to maximize the ability of the reservoir system to meet potential flood threats in the basin and along the Ohio River below Marietta.

Historically, flood damages occurring along the Muskingum to Marietta primarily involve residences, utilities, highways, and commercial and extractive industries; with lesser amounts to agriculture. Greatest flood damages in the past have occurred to residences in the communities of Dresden, Zanesville, McConnelsville, Beverly, and Philo; as well as individual residences along the river and to small villages of less than 200 people. The most valuable agricultural products are from livestock, which sustain only slight damage from flooding.

Most of the conflicting interests and purposes are resolved by practical planning and allocation of the lake storage volume into pools as listed on **Table No. 7-2**, below.

TABLE NO. 7-2

WILLS CREEK LAKE POOL ELEVATIONS AND STORAGES

Pool	Surface Elev. NGVD	Backwater Area Acres	Backwater Stream Miles	Storage Acre - feet Net	Storage Acre - feet Gross	Storage Inches runoff Net	Storage Inches runoff Gross
Year-Round							
Minimum	742	900	20.9	6,000	6,000	0.15	0.15
Flood Control Storage*							
Winter	779	11,450	60.6	190K+	196K*	4.91	5.06
Summer	779	11,450	60.6	190K+	196K*	4.91	5.06
TOTAL	779	11,450		190K+	196K*	4.91	5.06

* At maximum pool elevation
+ Between elevations 742 and 779

The Wills Creek Lake inlet weir supports the sediment storage and fish habitat with a year-round minimum pool of about 742 feet NGVD.

NOTE: The minimum pool was designed to contain 50 years of sediment storage. The 1981 sediment survey indicates that under the current sedimentation rate the minimum pool will contain 90 years of sediment storage.

7-04. STANDING INSTRUCTIONS TO THE DAMTENDER

The Wills Creek Lake Project Damtender and staff operate the project in accordance with general instructions and Special Directives issued by the Water Control Section through the Muskingum Area Office.

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

b. General Instructions. The general instructions apply at all times except when instructed by Special Directives that will be applicable for a specific operation or period of time. General instructions provide for routine reservoir regulation including discharge limit at project initiation, details of gate operation techniques, collection and transmission of hydrologic and stream flow data, reservoir regulation at the start of a flood before contact can be made with the Area Office, and emergency regulation in the event that all communications fail during a flood. These instructions are contained in Exhibit B, "Instructions to the Damtender", Wills Creek Lake," along with plates and schedules pertaining to their use. The Schedule for Reading Gages, **Plate No. 3-1**, Exhibit B, in addition to establishing the minimum number of observations to be made, is designed to ensure that any necessary gate operation will be promptly executed and that special reports will be initiated by the damtender before reservoir and stream conditions reach critical limits. If work is required after normal duty hours for the collection and transmission of hydrologic data, and for the execution of necessary gate operations, overtime will be approved by proper authority.

c. Special Directives. Special Directives are issued by telephone and confirmed by mail to record all substantive guidance given to the project by the Water Control Section, through the Muskingum Area Office, 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 Muskingum 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.

(d) Decrease outflow to prevent flooding due to ice jams downstream.

(2) Special regulations for:

(a) Construction activities downstream affected by flow.

(b) Stream clean-up activities.

(c) Emergency - drowning or pollutant spill.

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

(3) Change in general instructions.

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

7-05. FLOOD CONTROL

Damages occurring along the 6.3 mile reach from the Wills Creek dam down to the mouth of Wills Creek on the Muskingum River resulting from flooding are primarily to rural residential and some farms with damages also occurring to crops and stored crops. Major damage centers along the Muskingum River, below the mouth of Wills Creek, are at Dresden, Zanesville, and McConnelsville.

a. Requirements. Summer-type storms, even though of relatively small areal extent, can be destructive and result in local flooding due to the intensity of the rainfall associated with them. Winter-type storms often occur when vegetation and soil conditions lead to high percentage runoff. They are usually of wide extent, necessitating the operation of several reservoirs. Both headwater flooding and backwater flooding from the Muskingum River are likely from these winter-type storms, as opposed to the highly localized flooding associated with summer-type storms. It should be noted that it is possible for storms with either winter or summer characteristics to occur at any time during the year. The descriptions of winter-type and summer-type only indicate the period of highest probability of that type of storm.

Control stages on Wills Creek and the Muskingum River, shown in **Table No. 7-3**, next page, are of such value that only nominal damages would occur at downstream points, considering safe and effective operation of the lake. Control stages were established by correlation with damage survey curves for minimum damage.

b. Normal Plan. Wills Creek Lake is part of the flood control system of the entire Ohio River Basin as well as of the Muskingum River Basin. Regulation procedures must therefore be correlated with the operation of reservoirs on other tributaries of the Muskingum and Ohio Rivers to the fullest extent possible. Due consideration must also be given to local concerns and requirements.

Control stages at the outflow gage were established by a channel capacity investigation. The original winter stage of 16.2 feet, later revised down to 15.4 feet, for discharges occurring between 1 December and 15 April, at the "O" gage, does not endanger any buildings, other structures or access roads, whereas higher stages were deemed potentially dangerous during release of flood waters. Summer control stage at the "O" gage has been set at 15.0 feet for discharges between 16 April and 30 November. These stages can be maintained during moderate rises without causing damage in Dresden, Zanesville, and further downstream. **Plate Nos. 7-1** and **7-2**, Area and Capacity Curves and Percent Storage Utilization, can be used to determine available storage for flood control purposes.

The plan of operation is based on having adequate flood forecasting and flood warning systems in effect. Stream flow data is obtained from the data collection platform network and from the Wills Creek Lake morning report. Precipitation amounts in and near the Wills Creek Basin are received through the Corps of Engineer's platform-satellite system, along with supplemental precipitation data on the morning report from the project gages and from observers in the Ohio River Network and from NWS in Cleveland. Water Control Section personnel use real time precipitation and stream stage data and future precipitation and operation alternatives, when required, as input to the Muskingum River Basin Model, in order to forecast lake and downstream stages.

TABLE NO. 7-3

CONTROL FLOWS AND STAGES AND TRAVEL TIMES
FOR KEY POINTS BELOW WILLS CREEK LAKE

Station	Stream	Winter Stage	Winter Flow	Summer Stage	Summer Flow	Time of Travel Hr
Wills Creek Dam	Wills Creek	*15.4	6,100	15.0	5,880	0
Dresden	Muskingum River	16.0	23,450	18.5	32,000	12
Zanesville	Muskingum River	19.5	38,200	21.5	48,000	16
McConnelsville	Muskingum River	10.0	35,600	11.0	41,600	24
Marietta	Ohio River	35.0		35.0		48

*Water Control Section has authority to go to 16.2 ft in a major winter flood.

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.

Operation for Wills Creek and the Muskingum River is based on stages at the outflow gage and downstream stations in relation to the control stages listed in **Table No. 7-3**, previous page. Consideration of other projects in the Muskingum River Basin may result in adjusting operation of Wills Creek to maintain a balance of flood control storage. Operation for Ohio River control is based on retention of flows that would add to crest stages in excess of 35 feet at Marietta, Ohio. This stage represents the point at which damage begins in unprotected communities of the Ohio River Valley below the Muskingum River.

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

(1) All inflow is to be released up to that causing a stage at the outflow gage not to exceed 15.0 (5,140 cfs) in the summer or 15.4 feet (5,410 cfs) in the winter; except when critical flood conditions prevail or are predicted at downstream control points, or when the Water Control Section has directed special operations.

(2) All inflow will be stored which would contribute to stages in excess of the designated control stages at the key stations along Wills Creek and the Muskingum River, as listed in **Table No. 7-3**, previous page.

(3) All inflow will be stored beginning at a time 48 hours in advance of the predicted time of reaching a forecast crest stage in excess of 35 feet on the Ohio River at Marietta, Ohio. After a complete assessment of Ohio River conditions and trends of continued falling stages, releases will be scheduled so as not to add to actual crests above 35 feet on the Ohio River at Marietta.

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

(5) 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 including consideration of

percent storage utilization by other reservoirs in the Muskingum Basin and special directives issued for the release of stored waters.

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

(7) The water control plan for major floods provides for increases in reservoir outflow when there are indications that the available storage will be insufficient to control the flood completely.

Ordinarily, lake regulation will be based on the forecast 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 that are issued through the Muskingum Area Office.

The Spillway Discharge Rating Curve, **Plate No. 7-3** is used to determine the discharge from a particular pool elevation that is above the spillway crest. **Plate No. 7-4** is the rating table that applies to the outflow station below Wills Creek Dam, and **Plate No. 7-5** is the Reservoir Utilization curve.

c. Emergency Plan. During a major flood, all communications between the Muskingum Area Office and the Huntington District may be disrupted. In that event, Water Control Section 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 Area Office Manager, in Dover, Ohio, will assume regulation in the interim if communications exist between the Area and Project Offices. Otherwise, the Damtender will assume regulation of the lake during a communication blackout, following the measures listed below. In addition, the Damtender will immediately make every effort to reestablish communications with the District Office.

(1) Rate-of-rise curves from Exhibit B, "Instructions to the Damtender", will be used in determining correct operations of the project.

(2) If a special directive was not in effect prior to the failure of communications, project personnel shall operate the reservoir in accordance with the operating instructions for either summer or winter storms as contained in Section I of "Instructions to Damtender" found in Exhibit B, to this manual.

(3) If the reservoir was being operated in accordance with a special directive when communications failed, the instructions of the special directive should be followed until the specific operation given in the directive has been executed, twenty-four hours have elapsed since the last contact with the Muskingum Area Office, or additional heavy rainfall occurs. Whenever any of these conditions occur, project personnel shall operate the reservoir in accordance with the operating instructions for either summer or winter storms as contained in Section I of "Instructions to Damtender" in Exhibit B.

7-06. RECREATION

a. Lake.

(1) Requirements. Recreational activities in the lake area are limited mainly to fishing which begins in March and continues through summer and fall.

For all water related recreational purposes it is desirable to maintain a constant minimum pool as much as possible. Visitors can become anxious and concerned when the pool level fluctuates rapidly since there is no information available to them regarding the cause or impact of the fluctuations. Instability of banks and hillsides can cause failure and slippage upon rapid drawdown of lakes during release of flood storage, although any bank slippage during drawdown from spillway elevation to minimum pool elevation would probably be minimal at the maximum channel capacity rate of discharge with zero inflow.

High water levels change the view from normal and cause anxiety to boat operators due to danger from newly inundated obstacles or potential snags near lake edges and cove areas. High levels can also cause difficulty in launching and retrieving boats.

The inlet weir maintains a minimum pool at about elevation of 742 feet NGVD, even during dry years. During a very severe drought one stop log could be lifted to maintain downstream flow. But, if this occurs, lowered pool levels may cause snagging problems because previously well covered objects are closer to the surface.

(2) Control Plan. The optimum control plan for lake area recreation is to hold the pool level as close as possible to the minimum year-round elevation of 742 feet NGVD. The overflow inlet

weir at Wills Creek Lake fosters a fairly stable pool because their design, while preventing lowering of the pool below the minimum elevation, at the same time permits release of all inflow up to the discharge allowed by the current gate settings. Only when heavy rains occur, creating inflow to Wills Creek Lake that would cause downstream flooding if discharged without regulation will there be a significant rise in lake level. Such a reduction in outflow during the recreation season may infrequently be required due to an Ohio River flood or an emergency downstream. Part of the plan of regulation is the daily determination of a 3-day forecast of lake elevation and outflow rate. This information is available to project personnel for their use and for dissemination to the general public.

b. Downstream.

(1) Requirements. Fishing occurs at the tailwaters all year long, and is heaviest in the winter. Fishing may be affected by regulation because of the high velocity of large discharges through the narrow outflow channel. Channel capacity discharge does not pose any threat to visitors or property along the bank of the tailwaters.

Project personnel must maintain an awareness of downstream use of Wills Creek for both recreation and other purposes since safety of these interests is of prime importance to lake regulation. Any interest accustomed to using the stream at low water should be notified of impending high discharge.

(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 to a change in stage at the outflow gage of 1.0 foot per hour. Emergency measures may exceed this rate of change. If a spillway flood should occur during which the discharge rate will be greater than the channel capacity, project personnel would evacuate the tailwater area.

7-07. WATER QUALITY

a. Corps Role. Many years after Wills Creek Lake was completed the responsibility for quality of impounded waters was assigned to the Corps of Engineers by Public Law 87-88, enacted by Congress on 20 July 1961. The Chief of Engineers delegated the 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.

b. Water Quality Plan. Water Quality control normally has two major aspects: flow augmentation for downstream needs, and control of the temperature and quality of the releases for these purposes. However, during the design and construction of the original Muskingum Reservoirs there was no provision at Wills Creek lake for a guaranteed minimum flow or for any adjusted temperature control.

(1) Flow Augmentation. There is no flow augmentation at Wills Creel Lake. All normal inflow into the lake is routinely passed over a stop log weir at elevation 741 feet NGVD.

(2) Temperature and Water Quality Operation. The State of Ohio Division of Natural Resources, division of Fish and Game, has worked with the Corps to develop optimum outflow temperatures and allowable ranges of variation at Wills Creek Lake. Standards also define the dissolved oxygen levels required and the maximum amount of harmful solids and gases. Weekly temperature and dissolved oxygen profiles are taken in the lake during the seasonal stratification period. The discharge is also monitored in the stilling basin for the possible appearance of red-iron hydroxide(see section 7-07b) color in the water and/or the smell of hydrogen sulfide.

When passing high summer inflows from the lake below elevation 747 feet NGVD or when discharging flood storage both the sluice gates and the weir are utilized to maximum capacity. The purpose of this operating procedure is to maximize the use and benefit of the upper level water. Due to the likelihood of high concentrations of iron in bottom slide gate discharge when the dissolved oxygen concentration in lower levels of the lake is less than 1.0 mg/l, this water is not highly desirable for the downstream flow.

7-08. FISH AND WILDLIFE CONSERVATION

a. Requirements. Muskingum Watershed Conservancy District (MWCD) owns the land and water areas associated with the Wills Creek Lake Project, except for the 131 acres of the damsite and adjacent areas owned by the Corps of Engineers. MWCD has interest in fish and wildlife in the lake area and leases the land and water areas to the Wildlife Division of the Ohio Department of Natural Resources for their administration for conservation aims. The conservation aims coincide with the Corps project purpose of wildlife enhancement.

(1) Lake. The Fishery Section of Wildlife Division of ODNR has responsibility for the lake fishery, but does not actively manage it at this time. Wills Creek Lake does not meet their criteria for management of the fishery because of the effects of strip mine silt and pool level fluctuations which suppress the fishery except for some catfish and carp. The lake is also very shallow, averaging 13 feet. The ODNR is active in administering licensing regulations for sport fishermen.

Land areas around the lake are managed as a public hunting area by the ODNR Division of Wildlife. Although the area supports normal populations of typical forest animals such as grouse, squirrels and deer, the Division of Wildlife does not have any currently active programs to maintain or enhance the habitat or populations.

(2) Downstream. Needs of the downstream aquatic community for habitat maintenance, i.e., the continuous flow of clean water, constitutes the conservation needs related to reservoir outflow. Fishing occurs in the tail water area during the entire year, with the heaviest pressure in the winter. Many large black crappy, saugeye, and walleye are taken in the tailwaters in the winter. Fishing in the tailwaters is good for the remainder of the year, with species taken including blue gill, white bass, small-mouth and large-mouth bass.

b. Control Plan. Because the outflow from Wills Creek Lake is controlled by a weir at elevation 741.0 feet NGVD, the control of normal flows is very limited in scope. This type of inlet weir does avoid the pool drawdown that might otherwise occur in dry periods, but, the pool varies slightly according to the inflow, therefore, a perfectly stable pool desired for fish spawning or other reasons is seldom achieved. The outlet also provides water to the downstream fishery that is very close to the natural stream temperatures. Downstream flooding will require a rise in pool elevation as Wills Creek Lake is operated for its flood control purpose.

7-09. WATER SUPPLY

Wills Creek Lake does not have a seasonal pool, it has a year-round minimum pool. The minimum pool storage capacity allocation in the lake includes year round equivalent storage volume for sediment accumulation and year-round habitat for the fish population. At the time of the original design, there was no data available to establish the amount of sediment being carried by Wills Creek. Studies of sedimentation rates at other lakes in the Muskingum River Basin had not been completed, however, other studies in the eastern United States indicated that sedimentation in the lake would not be a serious problem and little depletion of flood control storage was expected during a 50 year economic life. Minimum pool was established at elevation 742.0 feet NGVD, and contains 6,000 acre-feet of storage which covers 900 acres. This minimum year round pool is maintained at all times by a weir and all normal inflow is passed over the weir.

7-10. HYDROELECTRIC POWER - N.A.

7-11. NAVIGATION - N.A.

7-12. DROUGHT CONTINGENCY PLAN – See ANNEX I

7-13. FLOOD EMERGENCY ACTION PLANS

Although the Huntington District does not have a specific Flood Emergency Action Plan for Wills Creek Lake, inundation maps have been published for spillway floods and there are standard responses to floods in the District. These responses are dependent on whether or not the integrity of the Dam is threatened.

a. Inundation Mapping. Inundation Maps have been prepared to Wills Creek Lake for the upstream and downstream spillway design flood with and without Dam failure. The maps were prepared in accordance with ER 1130-2-419 and show the time associated with the hypothetical flood wave. The inundation maps can be found in the Dam Safety Emergency Action Plan copies of which are located in OR-E-EC-GD, and the individual maps are stored in EC-W.

b. Floods Without Dam Integrity Problems. In the course of a flood, which does not threaten the integrity of the dam, the lake operations will be governed as described in 7-05. The Emergency Operations Center(EOC) will respond, based on the Commanders initiative, to the situation as described in the Policies contained in Natural Disaster Procedures, ER 500-1-1, 11 March 1991, which can be found in the EOC. The EOC may ask for periodic updates of the river situation from the Water Control Section or this briefing may be carried out during the briefing for the Commander.

c. Floods With Dam Integrity Problems. When a condition occurs which requires the project to operate to protect the integrity of the Dam and has the potential to be or is a significant hazard to life and property, the observing personnel will elevate the awareness of the situation to the appropriate individuals and take the actions as described in 7-05-a-8 or in Exhibit B, section 1-07. Project personnel shall use the Wills Creek Lake Dam Safety Emergency Action Plan to determine what events will initiate this action and which individuals to contact.

The Water Control Section will be kept informed of the situation as a result of the reporting requirements as defined in Exhibit B, **Plate No. 3-1**. Water Control Personnel will contact the Dam Safety officer when the lake rise indicates that the 772 elevation NGVD alert pool will be achieved or exceeded and will keep the National Weather Service informed of any abnormal operations of the project. The Dam safety Officer is responsible for convening the Dam Safety Committee who is responsible for convening the Crisis Management Team. The District Engineer, the head of the Crisis Management Team, will open the EOC if he determines it is necessary.

7-14. OTHER PLANS

Emergency drawdown procedures are graphically illustrated on **Plate No. 7-6**. In the event of drawdown the directory of key Emergency Personnel is located preceding the Table of contents of this book.

Wills Creek Lake does not require an operational change to handle mosquitoes, debris, ice jams, or the local ground water table. If necessary these and other issues are addressed in paragraph 7-15, below.

7-15. DEVIATION FROM NORMAL REGULATION

The Huntington District Engineer is occasionally requested to deviate from the normal regulation of Wills Creek 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. Definitions

Major Deviation: Change the normal operation of the project for a period of time greater than 5 days or and elevation change greater than two feet. A Major Deviation is approved at the Branch and Division levels.

Minor Deviation: A change of the normal operation that does not meet the Major Deviation criteria. A minor deviation approved at the Branch level based on the authority of the Division.

b. Types

1. Emergencies. Emergencies may fall under Major or Minor Deviations. Normally they begin as minor deviations and if necessary are elevated to Major Deviations. The most common emergency that can be expected to occur at a project is a downstream drowning; decreased flow may be needed while searching for the victim, or increased flow may be needed to dislodge the body. Other common accidents occurring at the project are failure of the operation facilities, chemical spills, treatment plan failures and other temporary pollution problems. Water control actions necessary to abate the problem are taken immediately unless such action would create equal or worse conditions.

2. Minor Deviations. There are instances that create a temporary need for minor deviations from the normal regulation plan, although they are not considered emergencies. The following list contains most of the types of special regulations commonly requested: Legitimate interests, such as family to travel to and from home and burial processions on a road which traverses the Wills Creek streambed may require reduction of flow for safe crossing. Construction work, major or minor, including pipeline changes or repair, boat dock work, or testing of a finished facility may have various and changing flow requirements.

3. Major Deviations. Either 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.

Each condition should be analyzed on its merits. Required data on flood potential, lake and watershed conditions, possible alternative measures, benefits to be expected and probable effects on other authorized and useful purposes, as mentioned above, shall be analyzed and presented by letter, telephone or fax to either the Great Lakes and Ohio River Division office, along with recommendations for review and approval. Except in case of emergency, confirmation is necessary before the Water Control Section may grant a request.

The types of major deviations commonly requested might be special pool levels for fishery enhancement, etc. 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; Anticipated drought periods may require maintenance of additional storage in the lake for later release into the river system for downstream benefit. 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; Slow drawdown from rises during annually designated 2-week to 3-week period in May in behalf of bass spawn, and special lake drawdown in fall for species adjustment.

7-16. RATE OF RELEASE CHANGE

The Wills Creek 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 feet per hour.

7-17. PUBLIC NOTIFICATION AND WARNING

News of impending gate opening operations is transmitted to persons downstream, primarily anglers, by means of the Below-Project Warning System which consists of a horn. At Wills Creek Lake, the horn is installed approximately 1,000 feet below the dam and is audible within a one mile radius. The horn is remotely controlled from the project office. Important public service messages of early significance concerning regulation of the lake are handled by Public Affairs Office and disseminated via radio and/or television. Warnings of any unusual releases will be transmitted downstream by project personnel in person and by telephone.

Notification of the public is enacted by the project, the Water Control Section, the 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 Control Section. 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 transmitted to the Weather Service via telephone lines with the aid of computers and other data-handling equipment. This information appears along with other weather and stage information provided by the Weather Service to mass media and, county, State, and Federal agencies.

SECTION VIII - RESULTS OF WATER CONTROL PLAN

8-01. GENERAL

The effects of regulation for the authorized purposes of flood control, recreation, and fish and wildlife conservation are presented in the following paragraphs and plates mentioned. Flood control benefits are discussed in subsection 8-03 and stage and flow reductions for major floods are listed in **Table No. 8-1**, next page. Regulations for various hypothetical design floods and for representative actual floods have demonstrated the capability of the project to control and pass runoff from the drainage basin. The results of a study of historical hydrographs are presented as a series of hydrographs that show inflow and outflow in Wills Creek Lake. These hydrographs are now on file with the Water Resources Engineering Branch.

8-02. FLOOD CONTROL

Wills Creek dam and spillway was designed to control large hypothetical floods used during the 1930 building period. These design floods will be discussed, as well as application of several post construction modern design floods; and the water control plan for three historical floods, and five current floods, as they occurred.

a. Hypothetical Floods. Two hypothetical floods used in the design of Wills Creek Dam consist of the following:

1. Spillway Design Flood.

(a) Spillway Design Flood (1930). The Wills Creek dam spillway design flood was the basis for determination of the spillway capacity required to provide dam safety during the largest recorded area storm and the most critical basin wide flooding. Three general criteria for fixing spillway capacities were adopted by the Board of Consulting Engineers for spillway design at the time Wills Creek Dam was planned. Spillways were to be of sufficient capacity to meet the requirements of whichever criterion proved to be the most severe in each individual case. The criteria follow and their hydrographs are shown in **Plate No. 8-1**.

(1) Criterion I. Reservoir assumed to be at or slightly above conservation elevation, 741 feet above NGVD, at the beginning of the flood as it was intended to keep the reservoir at this elevation at all times except when flood retention is required. A freeboard of 5 feet must be maintained below the top of the dam. The outlets were assumed to be entirely closed throughout the flood. This is to provide for the possibility of all the gates being immovable in the closed position, of drift or debris entirely plugging them if they were all open, or the conduits being completely blocked. However, the outlets at Senecaville Lake, situated upstream, are assumed to

function, since their inability to do so would be a very remote possibility.

TABLE NO. 8-1

REDUCTIONS EFFECTED DURING SELECTED FLOODS AT GAGES ON WILLS CREEK AND THE MUSKINGUM RIVER

Flood	Natural Stage (feet)	Modified stage due to Muskingum Lakes (feet)	Reduction attributed to Wills Creek Lake (feet)
March 1913			
Wills Creek Lake	28.2	16.2	12.0
Dresden	46.0	29.8	3.0
Zanesville	52.4	29.9	2.4
McConnelsville	33.2	18.2	2.0
August 1935			
Wills Creek Lake	29.6	16.2	13.4
Dresden	31.8	21.0	3.7
Zanesville	33.6	17.7	5.7
McConnelsville	19.2	10.7	3.8
January 1937			
Wills Creek Lake	28.0	16.4	11.6
Dresden	32.4	21.3	2.4
Zanesville	38.0	21.5	2.5
McConnelsville	22.5	13.1	2.3
January 1959			
Wills Creek Lake	20.3	16.5	3.7
Dresden	33.5	20.5	1.0
Zanesville	39.2	30.7	0.8
McConnelsville	22.2	14.4	0.7
July 1969			
Wills Creek Lake	18.2	12.3	5.9
Dresden	33.0	20.1	0.9
Zanesville	35.0	19.0	0.7
McConnelsville	19.9	10.1	0.5
February-March 1979			
Wills Creek Lake	25.1	15.0	10.1
Dresden	26.6	16.5	-
Zanesville	30.0	18.2	-
McConnelsville	17.7	11.5	-
July-August 1980			
Wills Creek Lake	25.7	15.1	10.6
Dresden	21.2	18.9	2.3
Zanesville	21.3	18.8	2.5
McConnelsville	13.6	12.8	0.8

The peak flow of the design flood at the Damsite was determined from the adopted envelope curve of 1913 peak flows in the Miami Basin plotted against drainage area. This storm creates for the Wills Creek area of 844 square miles, a peak flow of 183 cfs per square mile or 154,500 cfs. The duration of the natural inflow was arbitrarily set at 3 days. The total volume of the flood is equivalent to 10.7 inches of depth uniformly distributed over the entire drainage area above the damsite, or 482,200 acre feet. A flood amounting to 10.7 inches of runoff was also routed through Senecaville Lake, starting from conservation pool. The outlets at Senecaville were operated as for the Official Plan Flood until spillway crest was reached and then were fully opened.

(2) Criterion II. This criterion was used to insure sufficient spillway capacity to provide for the possibility of a great flood occurring with the reservoir already filled to the spillway crest elevation 779 feet NGVD. It differs from Criterion I only as follows:

The lakes were assumed to be already filled to spillway crest elevations at the beginning of the flood. Thus, Senecaville Lake was already filled, and the outlets were opened fully as the flood came into the lake. A freeboard of 2 feet must be maintained below the top of the dam.

(3) Criterion III. This criterion was used to insure that an enormous flood could come upon the lake at conservation elevation, and by operating the outlets, could be passed through the lake without reaching within 5 feet of the top of the dam. It differs from Criterion I only as follows:

Outlets assumed to be operated as for Official Plan Flood until spillway crest is reached and then fully opened. The total volume of runoff from the curve of total runoff versus drainage area adopted for this criterion, gives a total runoff of 14.6 inches or 658,000 acre feet. Curves showing the discharge relations required by the spillway design floods and conditions of the three criteria are shown on **Plate No. 8-2**. The Wills Creek Lake spillway rating curve is also shown on **Plate No. 8-3**. It may be noted that Criterion II is most critical, the flood raising the water surface to elevation 796.9 feet NGVD, leaving a 2.1 foot freeboard below the top of the dam, with a maximum discharge is 45,800 cfs.

Criterion I raises the water surface to elevation 791.2 feet NGVD, with a maximum discharge is 24,500 cfs, and a 7.8 foot freeboard; but it does not govern since only a 5 foot freeboard is required for this criterion. Criterion III raises the pool elevation to 793.9 feet above NGVD, with a maximum discharge of 34,000 cfs.

(4) Modern Spillway Design Floods. At the time of construction of Wills Creek Dam the present day concept of a Spillway Design Flood (SDF) or a Standard Project Flood (SPF) had not yet been developed. As previously mentioned, during the 1930's, Wills Creek Dam

was designed for a storm based on 10.7 inches of rainfall. The natural hydrograph crested at about 154,500 cfs and was placed on a full spillway pool of 779.0 NGVD. This flood produced a crest of about 796.9 feet NGVD with 2.1 feet of freeboard. Several years later, when the modern program or concept of the Spillway Design Storm (SDS) was developed and 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, the criteria was informally applied, on an after the fact basis, to Wills Creek Dam, and the spillway was adequate.

Later still, the contract for an evaluation and study of the entire Muskingum System for Spillway Adequacy and Replacement was awarded to the Dodson-Lindbloom Co. of Columbus, Ohio. This detailed study was undertaken in 1975 with the overall plan of evaluating and comparing the original Muskingum System of 14 reservoirs, plus 2 added, by current 1975 criteria. The 1975 study was based on Hydromet Bulletin No. 33, defined as the theoretically greatest depth of precipitation or probable maximum 48 hour storm or SDS over a particular drainage area at a certain time of year in the eastern United States. Detailed unit hydrographs were developed from individual storms and the SDS rainfall was applied, with the storm centered over the uncontrolled area above Wills Creek Dam. The pool routings were natural conditions, no dam; followed by a full pool elevation 779 routing, and the third routing on a 50% half pool for all lakes. The Spillway Design Storm had 20.70 inches of rain, with 17.85 inches of runoff, with a natural hydrograph peak of 114,300 cfs, and the "A" inflow hydrograph peaks at 166,000 cfs with all upstream reservoirs full. The pool crest for the full pool was 796.5 feet NGVD with a peak outflow of 72,350 cfs, while the half pool crest was 795.0 feet NGVD with a peak outflow of 72,350 cfs. Since the existing top of dam was elevation 799.0 feet NGVD, the two floods left a freeboard of 2.5 and 4 feet, respectively. Based on this study the original Wills Creek Dam and spillway was capable of safely passing 100 percent of the Hydromet No. 33 (SDF) on both a full pool, and a half-pool; however, the recommended freeboard was still 0.5 foot short on the full pool and 1.0 foot short on the half pool. This Spillway Design Flood operation is shown on **Plate No. 8-4**.

When the Dam Safety Assurance program was initiated for the Huntington District in 1982 Wills Creek Lake spillway was again informally evaluated by using the SDF reviewed in the previous paragraph using probable maximum rainfall shown in Hydrometerological Report No. 33. Later in 1982, the same Dodson-Lindbloom Associates of Columbus performed a dam break study for Wills Creek Dam. Flood waves were determined for failure of the dam during the 1975 Spillway Design Flood (SDF) and with the reservoir level at elevation 779.0 feet NGVD. Flood waves were also determined for the SDF without failure. The study provided estimated wave heights and arrival times at several locations downstream of Wills Creek Dam as well as maps of the areas inundated during the SDF with and without failure.

All these previous studies have shown the spillway design at Wills Creek to be slightly inadequate by modern design criteria. Current Corps criteria specify that the Spillway Design Flood (SDF) be based on the runoff from the Probable Maximum Precipitation (PMP), as indicated in Hydromet Reports 51 and 52. The CELRD further requires that this PMP be used with an antecedent storm of 39%(PMP) for 72 hours followed by a 120 hour dry period. Wills Creek Dam has never been computer operated for this storm, however, it is currently on a list of dams to be tested for hydrologic deficiency using the current Hydrometerological 51 and 52 under the Dam Safety Assurance Program.

Further detailed study will determine the necessary changes in dam elevation and spillway capacity, and the efforts required to remedy the deficiency. When this operation is completed the operational hydrograph will be forwarded to all concerned parties.

2. Official Plan Flood. The Official Plan Flood was used during the design stage for the purposes of determining the various pool and spillway levels. The Official Plan Flood is based on a storm about 36% greater than the 1913 storm above Zanesville. This represents a total of 10 inches of rainfall in 5 days, assumed to yield 90% or 9 inches of runoff. Every portion of the drainage area was assumed to receive the rainfall at the same rates and at the same time as every other portion. The distribution of the 10 inches of rainfall among the 5 days was made in the same proportion as the average of the rainfall that actually occurred above Coshocton during the March 1913 storm.

The maximum capacity of the outlets to the reservoir was fixed by the rate of flow that was required to be passed when operating the reservoir under the Official Plan Flood. The hydrograph of the Official Plan Flood at the dam site, along with the reservoir operation and pool elevation curves, is shown on **Plate No. 8-5**. The outflow operation was the optimum operation for the Official Plan Flood, i.e. coordinated with the operation of Dover Dam on the Tuscarawas River, Mohawk Dam on the Walhonding River, and Senecaville Lake on Seneca Fork to secure the flattest combined hydrograph of the Muskingum River at Zanesville. Under this operation, the gates remain fully open until the outflow attains a rate of 9,200 cfs and the water surface in the lake has risen to elevation 751.7 feet NGVD after which the gates are operated to reduce the outflow. Since there is a possibility of one gate becoming obstructed with debris, one gate was considered closed, and additional capacity was allowed to accommodate that possibility. This resulted in an outlet design discharge at flood control pool elevation 779 feet NGVD of about 25,000 cfs.

3. Standard Project Flood. The standard project flood is a modern replacement for the original 1930 Official Plan Flood, and 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.

This theoretical flood would result from a storm probably in July or August designed to equal the worst combination of meteorological and hydrologic conditions considered reasonably characteristic of the area. It was determined from generalized rainfall criteria and procedures outlined in EM 1110-2-1411. A review of summer-type storms indicated that a minimum infiltration rate of 0.05 inch per hour might be experienced and this value was adopted in determining the rainfall excess. Based on studies of stream flow records for the Muskingum River, a base flow of 1 cfs per square mile was adopted. The total excess rainfall for this flood would be about 11.0 inches, and the sluice gates must be used for the rising pool levels above elevation 769 feet NGVD. Spillway and sluice discharge would rise concurrently with hourly gate adjustments to the maximum outflow. The sluice gate settings would be maintained until the pool crested and receded to maximum flood control pool elevation 779 feet NGVD, and then would be regulated to maintain that pool level. As soon as downstream conditions permitted, the Water Control Section would direct discharge of flood storage. Releases would be made through the sluice gates until the lake level receded to elevation 742 feet NGVD, at which time normal operations would be resumed. Wills Creek Dam appears to adequately control the Standard Project Flood, however, the operational hydrograph for this SPF flood is not shown.

b. Other Floods.

(1) General. The three pre-impoundment floods chosen to illustrate the results of the water control plan were the floods of March 1913, August 1935, and January 1937. Also selected were the floods of January 1959, July 1969, February-March 1979, July-August 1980, and June-July 1998, since they were regulated according to the water control plan, for large floods as they occurred. Reductions at gages on Wills Creek and the Muskingum River for representative floods are listed on **Table No. 8-1**, page 8-2. These table values indicate that regulation of the lake has helped reduce major flooding in the reach of Wills Creek below Wills Creek Lake and in the Muskingum River for most floods.

(2) Flood of March 1913. The flood of March 1913 was caused by heavy precipitation over a large area in the Muskingum River Basin. The ground was not frozen at the time of the storm, but was already saturated from the rains occurring in January and the first part of March. Total rainfall during the 5 days beginning on 23 March, most of which occurred in a 96-hour period, averaged 6.94 inches over the Wills Creek drainage area. The resulting flood attained record stages it many sites in the Muskingum River Basin.

Wills Creek Dam and the other flood control dams in the Muskingum Basin were not built at the time of the storm, but the flood has been reconstituted with the hypothetical operation of the flood control lakes. The operation of Wills Creek Lake during the flood is described below and on **Plate No. 8-6**. As the storm began, the outflow would have followed the natural flow curve until 1800 hours on 24

March at which time the outflow would have slowly been reduced to zero by midnight on 24 March. The outflow would have been held at zero until well after the peak of the storm had passed and then would be increased incrementally to 5,750 cfs on the morning of 31 March. The peak inflow of 23,200 cfs, to Wills Creek Lake, would have occurred at 1800 hours on 28 March and the pool elevation would have peaked at 779.0 feet NGVD on 31 March before beginning to drop. The operation of Wills Creek Lake during the flood would have reduced the discharge from the natural peak flow of 22,270 cfs to the winter channel capacity of 5,750 cfs. Flood hydrographs for the downstream control points on the Muskingum River are on **Plate Nos. 8-7, 8-8,** and **8-9**.

(3) Flood of August 1935. The flood of August 1935 came as a result of one of the most severe summer storms ever recorded in the Muskingum River and Wills Creek Basins. This storm, which occurred on the 6th and 7th of August, followed a period of light to moderate rains that had saturated the ground in the basin. A total of 8.7 inches of rainfall was recorded in Newcomerstown, just outside of the northern edge of the Wills Creek Basin.

If this storm had occurred after Wills Creek Lake was in operation, the operation would have been as follows and as shown in **Plate No. 8-10**. The outflow from Wills Creek would have been equal to inflow during the storms of the first part of August and would have continued until the inflow from the severe storm began late on 6 August. At that time the outflow from Wills Creek Lake would have been reduced to zero where it would remain until a Special Directive would be sent from the Muskingum Area Office to slowly raise the outflow to channel capacity, beginning in the afternoon of the 13th.

This operation of Wills Creek Lake would greatly reduce the stages at the outflow gage and at points downstream on the Muskingum River.

The pool at Wills Creek Lake would reach a peak of 782.1 feet NGVD, assuming that the pool began the storm at conservation elevation. The peak stage at the outflow gage would be 16.2 feet, coinciding with a channel capacity of 5,400 cfs as opposed to the natural peak of 29.6 feet and 20,200 cfs. Flood hydrographs for downstream control points are shown in **Plate Nos. 8-11, 8-12,** and **8-13**.

(4) Flood of January 1937. The flood of January 1937 was a result of a series of abnormally heavy rains that began late in December 1936 and continued through nearly the entire month of January 1937. Although the Muskingum River Basin lies to the north and east of the center of maximum precipitation, it still experienced the second highest flood of record at many stations in the basin. The peak stage at Zanesville was 37.6 feet or about 120,000 cfs.

The magnitude of the flood was increased by the timing of the succession of storm rises that occurred through the month of January, culminating with the heaviest period of the storm, during which 7.93 inches of rain fell on the Muskingum River Basin in the period of 14 to 25 January. The Muskingum River Flood Control Reservoirs were still under construction at the time of this storm, but the partially completed reservoirs, including Wills Creek, helped to decrease peak stages and discharges downstream by acting as retarding basins.

The operation of Wills Creek Lake for this flood has been simulated and is presented below and in **Plate No. 8-14**. At the beginning of the flood, the outflow from Wills Creek Lake would have been reduced to zero due to previous flooding conditions. The outflow would have been raised to around 5,700 cfs on 15 January and then would have been gradually reduced over the next 7 days as the inflows to the lake increased. On 22 January a Special Directive would have been issued to reduce the outflow from Wills Creek Lake to zero, for Muskingum and Ohio River control, where it would remain until a directive would be issued on 25 January to increase the outflow to the winter channel capacity. The peak natural, unregulated flow at the dam site was 17,500 cfs and the peak regulated outflow would have been 5,700 cfs. The pool elevation would have peaked at 782.6 feet NGVD on 29 January before beginning to drop. Hydrographs, showing the unregulated and regulated flows at downstream control points, are shown on **Plate Nos. 8-15, 8-16,** and **8-17**.

(5) Flood of January 1959. The flood of January 1959 is one of the major floods of record throughout most of the Muskingum River Basin. It was caused by generalized rains that took place on 20 and 21 January, but the flooding was greatly augmented by the conditions that existed prior to the 20th. Severe cold weather during December 1958 caused the ground to freeze to depths ranging from 6 to 18 inches. In addition, a storm deposited nearly 2 inches of precipitation, in the form of snow, during the period of 14 to 17 January. The saturated, frozen, and snow covered ground contributed to the runoff that occurred during the widespread rains of 20 to 24 January.

Before the beginning of the storm late on 20 January, the outflow from Wills Creek Lake was larger than the inflow in order to lower the pool to conservation elevation of 742 feet NGVD. As the inflow began to increase on 21 January, the outflow was also increased until a Special Directive directing the decrease of outflow to zero for Muskingum River control was received and put into effect at 1800 hours on the 21st. The outflow remained at zero until the notice to increase was given early in the morning of the 25th. It was increased throughout the day, to stabilize at around 5,400 cfs. The pool level peaked at an elevation of 763.7 feet NGVD on 26 January at around 1200 hours and then began to fall as outflow exceeded inflow for the first time in six days. The operation hydrograph and the results of regulation for this flood at Wills Creek Lake and downstream are given in **Plate Nos. 8-18, 8-19, 8-20,** and **8-21.**

(6) Flood of July 1969. Beginning on the evening of 4 July 1969 and continuing through the 5th, severe thunderstorms with intense rainfall moved across northern and central Ohio. This intense rainfall and runoff resulted in the rapid and severe inundation of much of the Muskingum River Basin. The rainfall in the Wills Creek

Basin occurred mostly after the main storm front had passed, on 6 and 8 July, and did not approach the intensities of the precipitation in other portions of the Muskingum River Basin. The operation of Wills Creek Lake, described in **Plate No. 8-22**, was still effective in reducing the stage at the outflow gage from 18.2 feet to 12.1 feet.

The outflow at Wills Creek Lake was already being held below the inflow when the first runoff from the storm began late on 5 July. Although the outflow was never reduced to zero, it was held substantially below the inflow to help alleviate the flooding on the Muskingum River. The peak natural flow would have been 6,900 cfs, but the peak outflow from the lake was held to 3,400 cfs, which is well below the channel capacity below the dam. Hydrographs illustrating the flood history, downstream of Wills Creek Lake on the Muskingum River, are found on **Plate Nos. 8-23, 8-24**, and **8-25**.

(7) Flood of February-March 1979. Low temperatures and a major snow cover persisted over the Wills Creek and Muskingum River Basins during most of January and February 1979. Rising temperatures and light rainfall on 21-22 February created thawing conditions which caused streams to rise and persisted until moderate rainfall on 25-26 February, combined with rapid snowmelt, created flooding conditions in the basin.

Operations of Wills Creek Lake for the period of 22 February to 6 March 1979 are shown in **Plate No. 8-26** and the flood hydrographs for other stations downstream of Wills Creek Lake are shown in **Plate Nos. 8-27, 8-28,** and **8-29**. The outflow from Wills Creek Lake was being regulated at a rate that was following increasing inflow into the lake but was less than the inflow at the beginning of the storm on 22 February. This trend continued through the 23rd and 24th until it was reduced to discharges below 1,000 cfs late on 24 February. These discharges, designed to alleviate flooding on the Muskingum, were held until 28 February when the outflow was increased to 10.8 on the "K" gage, or 3,000 cfs. Outflows were increased again on 2 March and were increased to a final level of 5,000 or 15.0 feet on 3 March. The pool elevation began rising in 20 February and reached a peak of 771.6 feet NGVD on 5 March before the inflow to the lake decreased to a level less than the outflow and the lake level began to drop.

(8) Flood of July-August 1980. The flood of August 1980 was caused by two separate events. First, a series of small, mostly localized storms with heavier than normal rainfall fell over the Muskingum River Basin during June and July of 1980 created saturated soil conditions in many areas. The rainfall continued the first part of August and kept the soils in the basin saturated thus setting the stage for the large storm event of 10-11 August. This storm was centered over the Wills Creek Basin which received over 6 inches of rain in a 24-hour period beginning late on the 10th. The Cambridge area received approximately 8 inches in 18 hours. The rainfall continued into the 12th when more than an inch of precipitation fell on the basin.

Operation of Wills Creek Lake for the flood of August 1980 Operation of Wills Creek Lake reduced the outflow stage by 10.5 feet and this in combination with other Muskingum Flood Control Reservoirs reduced the stage at Dresden from 21.18 feet to 18.86 feet. The operation is described in the following paragraph and on **Plate No. 8-30.** Outflow from the project was equal to the inflow until the heavy rainfall began in the basin on the night of 10 August. Inflow began to exceed outflow at that time. The Project Supervisor was directed to decrease outflow, to prevent flooding downstream of the dam, around noon on 13 August, and the stage at the outflow gage was gradually reduced to 4.9 feet or 630 cfs. On 15 August the stage was increased to 15.6 feet or 5,400 which is a little over the summer control stage of 15.0 feet. The outflow stage was again reduced on the 18th to help with downstream flooding and then was again raised to around 3500 cfs on the 19th. Inflow at Wills Creek Lake peaked late on 11 August, at about 19,000 cfs, with a natural flow of about 14,600 cfs. This flood produced the record computed natural crest at Cambridge of 13,680 cfs on 13 August; and the pool crested at elevation 773.14 feet NGVD, 10 days later on 23 August. Flood hydrographs for Wills Creek Lake and downstream control points are given in **Plate Nos. 8-31, 8-32** and **8-33**.

(9) Storm and flood of June and July 1998. The flood of June–July 1998 was caused by a series of localized storms that occurred in the Wills Creek Basin in the latter part of June 1998. The storms were localized over the Wills Creek Basin, but the effects were widespread, especially in the upper part of the basin. The two upstream tributary lakes both reached pools of record during this flood. Senecaville Lake on Seneca Fork reached a record pool crest of elevation 842.33 feet NGVD, one inch below the spillway; while Salt Fork had considerable spillway flow. A huge block of rainfall spread over the last five days of June created the near pool of record at all three lakes. The first 0.22 inches on 26 June saturated the soils in the basin and set the stage for the large storm event of 3.78 inches the next day, followed by another larger 4.7 inch block on the 28th. This heavy rainfall, combined with the already saturated soils, caused very steep rises in the stream levels in the basin. The rainfall continued with about 0.30 inches on the last day of the month, thus keeping basin streams at their high levels for a few more days. Inflow at Wills Creek Lake peaked late on 30 June at about 16,300 cfs; a week later the pool of record crested at elevation 774.45 feet NGVD.

c. Benefits. Financial results, or annual monetary benefits of operation of the lake for the project purposes are updated as necessary. Updating of flood control benefits, in the Muskingum River Basin, is described in paragraph 4-10c and **Table Nos. 4-7** and **4-8,** page 4-18. A typical hydrograph for flood reductions, used to compute flood damages at the Wills Creek outflow gage and on down the stream is shown on **Plate No. 8-34**. The total accumulated flood control damage values in the Muskingum River Basin for the years 1937 to 1998 is $2.07 billion dollars, or about $105 million dollars per year, or $88 million dollars per year from 1991 to 1998. This constitutes damages that would have occurred in the Muskingum River Basin if the flood control projects were not operating. A study conducted during the preparation of the Muskingum Basin Comprehensive Report calculated the percentage of flood control benefits that can be attributed to Wills Creek Lake at 3.84 percent. This is less than the 17 percent determined by previous studies, but still represents annual flood control benefits for Wills Creek Lake of $4.0 million per year based on the $105 million annual total benefits for the system.

8-03. RECREATION

Success of the recreational purpose of the project, is measured by the number of visitors. **Table No. 8-2,** below shows the annual visitation numbers for the years 1981-1998. It can be seen from the table that recreation is not a major purpose of the project. The drop in visitation at the project after 1981 coincides with the closing of the marina that was in operation at the lake. The marina was closed because the additional visits to the lake due to the marina were not sufficient to justify its existence.

TABLE NO. 8-2

VISITATION AT WILLS CREEK LAKE

Year	Visitation
1981	40,100
1982	30,200
1983	31,700
1984	31,900
1985	32,100
1986	32,200
1987	32,200
1988	32,200
1989	21,000
1990	23,627
1991	23,387
1992	34,767
1993	34,767
1994	30,600
1995	30,707
1996	31,023
1997	31,300
1998	31,600
1999	31,851

The U.S. Water Resources Council "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies", dated March 1983, is used to assign 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 Wills Creek Lake indicate $2.35/visitor-day for general recreation and $3.10/day for fishing or hunting. The portion of total 1999 visitation in **Table No. 8-2**, above, calculated for general recreation was 19,550. Therefore, the value of general recreation benefits for calendar year 1999 is $45,900.

8-04. WATER QUALITY

Because of the nature of a large body of water as described in section 4-08 there are a number of problems with the water quality of the lake. The temperature cycle results in lake stratification with low dissolved oxygen, high iron and manganese concentration in the bottom of the lake as shown on **Plate Nos. 4-12, 13,** and **14;** and higher than designed temperatures in the top of the lake on **Plate No. 4-11**. The nutrient load also causes algae blooms in the head waters. All of these problems negatively impact the lake fishery as only part of the storage during the summer is habitable.

The lack of a low-flow system prevents the lake from releasing the higher quality water, high dissolved oxygen, natural temperature, and low iron manganese, needed to sustain downstream fishery. The lake itself improves the quality of water downstream as it provides a steady volume of the low-flows and insures the river will not drop below a flow that is not habitable. The Overall Quality Rating for Wills Creek Lake is poor to moderate.

8-05. FISH AND WILDLIFE

Effects of water control management on fish and wildlife are those associated with pool level fluctuations in the lake area and those of the outflow on downstream fisheries. The weir-type outlet works enhance the long-term stability of the pool level, but may cause small fluctuations in pool elevations during increased inflow events. Usually the pool in Wills Creek Lake will remain very close to the conservation pool elevation of 742 feet NGVD. It is only when the inflow into the lake exceeds the capacity of the weir, or the control gates below the weir are closed that the pool elevation rises appreciably. It is possible to lower the pool elevation below 741 feet NGVD only by removing stop logs in the weir.

Major benefits to wildlife of Muskingum Watershed Conservancy District and Corps occupancy of lands purchased, but not submerged, were claimed for fire control efforts and the vegetation changes occurring during reversion of farm lands to forest. The range appears to be healthy for forest animals.

The eggs and young of the year of ground-nesting birds, small mammals and reptiles are lost during a rise of 10-15 feet, and those closest to the lake during smaller rises. Such a rise also kills the herbaceous vegetation which is the food source of small mammals; however, losses of these animals are not as critical due to their fecundity. Although these rises do reduce the carrying capacity, there has been little observable adverse effect of flood regulation on wildlife near the pool.

Extremes of high and low-flows downstream from the dam are not as great as before the project (1 year frequency natural flow at the damsite is 8,200 cfs from **Plate No. 5-2**); but the lesser flushing action of channel capacity discharge, 4,860 cfs, for several days while releasing flood storage has similar effects. In either case, temporarily, fish populations are displaced and flood supplies diminished.

Wills Creek Lake fishing and hunting opportunities were analyzed according to the U.S. Water Resources Council "Principles" of March 1983 (See paragraph 9-04a) and the analysis yielded points indicating $3.10/visitor-day benefits for fishing or hunting at the project. The portion of total recreation visitation at Wills Creek Lake in calendar year 1985 determined to be involved in fishing or hunting was 12,343. Therefore, the fish and wildlife benefit for the year 1985 was $38,260.

8-06. WATER SUPPLY

Wills Creek Lake is essentially a flood control reservoir that normally passes all routine inflow with little or no weir regulation. However, because of the regulated outflow from Senecaville and Salt Fork Lakes there is now a steady year–round inflow, which gives a steady small summer outflow at Wills Creek Lake. This minimum flow has a two fold effect on Wills Creek Lake. It significantly improves both downstream flows and/or fish and wildlife habitats during extreme low-flow times, and also maintains the lake level which improves lake recreation and fisheries.

8-07. HYDROELECTRIC POWER - N.A.

8-08. NAVIGATION - N.A.

8-09. DROUGHT CONTINGENCY PLANS - N.A.

8-10. FLOOD EMERGENCY ACTION PLANS - N.A.

8-11. FREQUENCIES AND DURATIONS

a. Natural Discharge Frequency and Duration for Outflow Gage. The natural discharge-frequency curve for Wills Creek at the Wills Creek Lake outflow gage was developed in accordance with methods outlined in "Statistical Methods in Hydrology," by Leo R. Beard dated January 1962 and Bulletin 17B, "Guidelines for Determining Flood Flow Frequency," published by the United States Water Resources Council and dated September 1981.

The curve derived by plotting probable maximum flow to be expected at the dam site against exceedence interval in years, is shown as **Plate No. 5-2**. Flow values for certain exceedence intervals from 1 year to 1000 years are given in **Table No. 8-3**, next page, Frequency Summary, Wills Creek at Wills Creek Lake Outflow Gage, All Season, Natural.

b. Pool Elevation Frequency and Duration. The records of pool elevation from beginning of operation of Wills Creek Lake in 1937 to April 1976 were analyzed statistically to obtain the pool elevation frequency and duration. The pool elevation frequency is shown in **Plate No. 8-35**, Frequency of Filling. Selected exceedence intervals with the respective maximum pool elevation expected to occur (on the average), once in that interval are listed in **Table No. 8-4**, next page, Frequency Summary, Wills Creek Lake Pool Elevation.

Pool elevation hydrographs from the period 1937 to 1976 were measured for amplitude (duration in days) at certain specified elevations and these tabulated by elevation. The total number of days tallied for each are presented for all the floods of the period of record was divided by the 40 years of record, to obtain average number of days per year at or above the elevation.

TABLE NO. 8-3

FREQUENCY SUMMARY
WILLS CREEK AT WILLS CREEK LAKE OUTFLOW GAGE
ALL SEASONS

Exceedence Interval Years	Natural		Modified	
	Stage Feet	Flow cfs	Stage Feet	Flow cfs
100	31.5	23,200	15.4	5,090
50	30.2	21,200	15.4	5,090
20	28.3	18,000	15.4	5,090
10	26.6	15,700	15.4	5,090
5	25.1	13,600	15.4	5,090
2	22.3	10,500	15.4	5,090
1	19.7	8,200	15.4	5,090

TABLE NO. 8-4

FREQUENCY SUMMARY WILLS CREEK LAKE
POOL ELEVATION

Exceedence Interval Years	Elevation Feet NGVD
100	779.0
50	775.9
20	772.5
10	769.5
5	766.5
2	761.3
1	755.3

The "Average" curve in Duration of Filling, **Plate No. 8-36** was derived by plotting these average number of days values against the respective elevations. Amplitude at specific elevations of the curve with the highest peak were plotted against the elevations to obtain the "Maximum Number of Days for Period of Record."

c. Control Stations. - Dresden, Zanesville, and McConnelsville, Ohio. The natural frequencies of the Muskingum River at Dresden, Zanesville, and McConnelsville were estimated using nearly the same methods and techniques of data handling and calculation as were used for Wills Creek at the damsite.

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 Flow Frequency for the Wills Creek outflow gage and the Muskingum River gages at Dresden, Zanesville, and McConnelsville, **Plate Nos. 5-2, 5-3, 5-4,** and **5-5**, respectively. Flows for selected exceedence intervals from 1 year to 1,000 years at the Muskingum River gages at Dresden, Zanesville, and McConnelsville are included respectively in **Table No. 8-5**, below**, Table No. 8-6,** and **Table No. 8-7**, next page.

TABLE NO. 8-5

STAGE AND DISCHARGE FREQUENCIES
MUSKINGUM RIVER AT DRESDEN, OHIO

Exceedence Interval Years	Natural Stage Feet	Natural Flow cfs	Natural Modified by Muskingum Basin Flood Control Reservoirs Stage Feet	Natural Modified by Muskingum Basin Flood Control Reservoirs Flow cfs
1000	51.5	310,000	35.3	131,400
500	48.0	265,000	31.6	101,000
200	43.7	212,000	28.2	78,000
100	40.5	178,000	26.0	64,500
50	37.4	148,000	23.8	53,700
20	33.2	112,000	21.2	43,100
10	30.4	92,400	19.9	38,000
5	27.7	74,000	18.8	34,000
2	24.1	55,000	17.9	30,800
1	21.2	43,000	17.4	29,100

TABLE NO. 8-6

STAGE AND DISCHARGE FREQUENCIES
MUSKINGUM RIVER AT ZANESVILLE, OHIO

Exceedence Interval Years	Natural Stage Feet	Natural Flow cfs	Natural Modified by Muskingum Basin Flood Control Reservoirs Stage Feet	Natural Modified by Muskingum Basin Flood Control Reservoirs Flow cfs
1000	59.0	320,000	36.5	122,000
500	54.8	274,000	32.7	97,700
200	49.6	222,000	29.0	78,000
100	45.6	188,000	26.4	68,000
50	41.8	158,000	24.1	59,500
20	36.9	124,000	21.9	50,500
10	33.1	100,000	20.8	45,400
5	29.7	81,000	20.3	43,400
2	24.2	60,000	20.3	43,400
1	21.4	48,000	20.3	43,400

TABLE NO. 8-7

STAGE AND DISCHARGE FREQUENCIES
MUSKINGUM RIVER AT McCONNELSVILLE, OHIO

Exceedence Interval Years	Natural Stage Feet	Natural Flow cfs	Natural Modified by Muskingum Basin Flood Control Reservoirs Stage Feet	Natural Modified by Muskingum Basin Flood Control Reservoirs Flow cfs
1000	37.8	345,000	23.5	148,000
500	34.8	297,000	20.3	115,100
200	31.0	243,000	17.7	91,200
100	28.4	207,000	16.1	77,700
50	25.7	175,000	14.6	65,500
20	22.3	137,000	12.9	54,100
10	19.8	111,000	11.9	47,500
5	17.6	90,000	11.5	45,000
2	14.6	66,000	11.5	45,000
1	12.5	51,500	11.5	45,000

SECTION IX - WATER CONTROL MANAGEMENT

9-01. RESPONIBILITIES and ORGANIZATION

a. Corps of Engineers

(1) General. General authorities for allocation and regulation of reservoir storage in projects owned and operated by the Corps of Engineers are contained in legislative authorization Acts and referenced project documents. These public laws and project documents usually contain provisions for development of water control plans, and appropriate revisions thereto, as shown on the Organization Chart **Plate No. 9-1**, under the discretionary authority of the Chief of Engineers. Some modifications in project operation are permitted under congressional enactments subsequent to original project authorization; regardless, Wills Creek Lake is fully owned and operated by the U.S. Government. The Huntington District, Corps of Engineers is the operating agency under administrative control of the Muskingum Area office within Operations Division.

An organizational chart is shown on **Plate No. 9-1,** for Water Control Management in the Wills Creek Basin. As shown on the chart, the Recreation-Resource Management Branch and the Muskingum River Area Office are responsible for supervision of the operation and maintenance of the dam and operations area at Wills Creek Lake. The Damtender (Resource Manager) at Wills Creek Dam regulates the Wills Creek project in accordance with general instructions and Special Directives issued by the Water Control Section. Special Directives are issued and signed by the Chief, Water Control Section, for dissemination to the Wills Creek Damtender as necessary to efficiently regulate the project for optimal water control management for all project purposes.

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

(3) Great Lakes and Ohio River Division. The Division Engineer has primary responsibility and authority for direct action with respect to all phases of reservoir regulation, including: (a) basic policies, criteria, and concepts that determine operating plans; (b) technical evaluations; (c) field operation; and (d) review and approval of reservoir regulation plans and manuals and related activities. The Great Lakes and Ohio River Division Office(LRD) 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 Control Center is responsible for

administration of the Division Engineer's policy for water control management.

(4) 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. The Water Control Section is the responsible element for all water control activities, which include the following reservoir project functions.

(a) Flood Control;

(b) Regulation of flows for water supply and water quality control;

(c) Navigation stage regulation;

(d) Hydropower;

(e) Recreation;

(f) Fish and Wildlife enhancement;

(g) Alleviation of sediment and erosion problems affected by reservoirs.

(5) Water Control Section is further 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 is transmitted before the district implements a plan of action. All water control plans will be prepared with appropriate consideration to all applicable congressional acts relating to operation of Federal facilities. Included are the 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 will be made as necessary to establish the optimum water control plans possible within prevailing constraints.

During normal operations, the Water Control Section of the Water Resources Engineering Branch are involved in the following activities pertaining to water control management as shown on **Plate No. 9-1**:

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

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

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

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

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

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

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

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

During flood or other emergencies, Water Resources Engineering Branch personnel are responsible for the following activities in regard to water control management as shown on **Plate No. 9-2:**

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

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

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

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

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

a. Instructions to Damtender. During a FLOOD EMERGENCY SITUATION, Exhibit B of the manual describes the responsibilities of the Corps of Engineers on site project personnel. The lines of communication between the various office elements are shown on **Plate No. 9-2**. Details and responsibilities of other elements are indicated on **Plate No. 9-3**, and 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.

b. Other Federal Agencies. The National Weather Service and the U.S. Geological Survey cooperate and coordinate activity with the Water Control Section in regard to accumulation of rainfall and streamflow data, as well as river forecasts and discharge measurements. The Corps of Engineers is required by the Fish and Wildlife Coordination Act (48 Stat. as amended) to coordinate all plans affecting Fish and Wildlife with the U.S. Fish and Wildlife Service. The service is required to present the plans to the relevant State Agency, in this case, the Ohio Department of Natural Resources, for their comments and recommendations. The Service then presents a combined report to the Corps including its comments and recommendations and those of the Ohio Department of Natural Resources.

c. Local and State Agencies. No local or state agency has funding or operational responsibilities in the Huntington District multipurpose reservoirs except in leased recreational areas. The State of Ohio constitutionally holds in trust all wild animal life in the state on both public and private lands, and all aquatic life in public waters. The State Department of Natural Resources, as mandated by State Code, has the responsibility for conservation of fish and wildlife and for boating safety at the project lakes. The Game Protection Division of the Department of Natural Resources enforces hunting regulations and licenses on the reservoir lands. The State has undertaken fish management at the project lakes and the Corps of Engineers cooperates in the lake level manipulation and maintenance of downstream flow requirements to enhance fisheries management.

d. Private Organizations. There are no private interests presently involved with Wills Creek Lake.

9-02. INTERAGENCY COORDINATION AND COOPERATION

a. Local Press and Corps Bulletins. Huntington District Office and the National Weather Service, coordinate in forecasting flood stages. Local press is provided with information of flood forecasts as furnished by the National Weather Services (officially responsible for issuing flood warnings). This information will be supplemented by the Corps with available information on observed conditions and with technical advise to enable local interests, within the limits of their capabilities, to obtain optimum flood protection, and to perform rescue and relief functions.

The Public Affairs Office in the Huntington District Office releases various other items to the press for public dissemination. Some of these are in the public interest such as drawdown announcements or notification of a change in or opening of a new facility or service at a reservoir. Some releases are to enlist public cooperation and some, such as reports of flood damages saved by regulation of certain reservoirs, are to inform the public of the benefits derived from

Corps-built projects. Many such varied articles are printed in Castle Comments, the District newspaper; and Engineer Update, the newspaper from the Corps of Engineers. Both are unofficial monthly publications for Corps' employees and retirees of all ages.

b. National Weather Service. An agreement between the National Weather Service (NWS) and the Corps of Engineers provides for collection and dissemination of current precipitation data for the Ohio River Basin. By joint agreement, the NWS installs, maintains and operates all stations in the Ohio River Network, except those operated by the Corps of Engineer personnel at flood-control and navigation projects. Where there is a mutual need for the data, station costs are shared by both the NWS and the Corps of Engineers. Costs of stations required for reservoir regulation are borne entirely by the Corps of Engineers. In either case, an annual transfer of funds from the Corps of Engineers to NWS is made to cover the required expenditures. As described in paragraph 6-01b, NWS provides a range of tributary stage information and forecasts. The Corps reciprocates, providing NWS with all precipitation, snow cover, and stage information from reservoir and other reports, pool level and outflow forecasts, and depth reports from the District Snow Cover Reconnaissance.

c. U.S. Geological Survey. The Cooperative Stream Gaging Program was established about 1940 through cooperative arrangements between the Corps of Engineers and the USGS in order that sufficient stream flow water would be available to meet special needs in connection with the Corps water resources responsibilities. This is in keeping with the Chief of Engineers policy of fully utilizing the facilities and services of other Federal Agencies in obtaining many types of basic data. Accordingly, arrangements were made for the Geological Survey to operate specific stations for the Corps on an advance of funds basis. Although the Corps of Engineers requires the basic data, many other Federal, State, and private agencies and individuals interested use the water data. The data are published by the survey assuring maximum availability and use of all data.

The annual program is formulated by the Water Resources Engineering Branch in collaboration with appropriate District Chiefs of the Geological Survey. The Corps of Engineers and the local representative of the U.S. Geological Survey determine the necessary stations to provide the data for publication and the Corps is requested to furnish an estimate of the costs of installing and/or operating each station. The District Engineer forwards the selected program through the Division Engineer to the Chief of Engineers. Any new supplemental instructions required for preparation of the report are issued annually by the Chief of Engineers.

The Geological Survey coordination and cooperation with the Corps, described in paragraph 5-01a, provides the Water Control Section with a system for obtaining reliable stage and flow information, which is necessary for efficient water control management.

d. Ohio Department of Natural Resources. The Huntington District Water Control Section cooperates fully with the Ohio Department of Natural Resources about fish and wildlife enhancement in the Ohio lakes and downstream areas, by making special efforts to maintain constant pool elevations during April, May, and June for spawning benefit. Additional coordination is used for proper timing of spring filling and fall drawdown, and probable height of both lake level manipulation during flooding and expected project outflow.

The Ohio Department of Natural Resources maintains an Office of Corps Liaison for the purpose of coordinating special releases from Corps Lakes for recreational or other purposes. This office receives all requests for special regulation and, after examining the request and appending to it any ODNR comments, sends the request to the Division Office. Using the Corps based guidance policies and criteria a determination is then made, and this decision is then sent back to the ODNR to coordinate with the organization making the request.

Functional agreements, meetings, and contacts with various divisions of the Department of Natural Resources are discussed below. They are important to operation of the project in accordance with project purposes and with the recommendations of the Ohio Department of Natural Resources and the U.S. Fish and Wildlife Service.

The Ohio Division of Forestry at Columbus, all project lake Corps Personnel, and project lake state park personnel cooperate in fire-fighting activities to suppress fires that threaten or are burning on project lands. Project personnel cooperate by taking training in fire suppression techniques, reporting such fires to the ODNR District Forester, fighting the fires before State personnel arrive and by assisting their suppression efforts after arrival.

The Parks and Recreation Division will enforce the Boating safety and water regulations, while hunting and fishing licensure procedure enforcement is by the Division of Wildlife. There is frequent day-to-day contact between project personnel and Ohio Department of Natural Resources personnel through much of the year.

e. Other State, Federal, Local or Private Agencies. The Corps of Engineers receives requests for information, aid, or cooperation from many parties or groups. All legitimate responsible requests from Federal, State, local, or private organizations or from groups that coordinate with ODNR receive appropriate attention and consideration. Accuracy of information transmitted and the proper level or amount of aid or cooperation given is commanded by District policy. Huntington District reacts quickly in disaster situations, allocating material and man power when needs are in Corps areas of responsibility and expertise.

In certain cases, such as potential downstream flooding concerns or emergency complications involving regulation of Wills Creek Lake, the District Emergency Operations Manager coordinates with the Ohio Disaster Services Agency. An example of cooperation with a State entity is an occasion when the Corps studies damages and reconstruction costs due to a flood or other disaster for the office of the Governor to use in applying for Federal assistance.

In accord with the Corps of Engineers statutory responsibility for operation of its reservoirs in the public interest, the Great Lakes and Ohio River Division Engineer organized the Reservoir Operation Coordinating Group for the Ohio River Basin as a vehicle for perceiving, interpreting, and prioritizing that interest. The Group is composed of the twelve basin states, the Tennessee Valley Authority, six Federal Agencies, and two regional commissions, which are Ohio River Oriented. The Group meets three times yearly and provides a mechanism for a two-way communication through various levels of government and among various agencies of government and other organizations, which serve the public. Meetings of the Group have the stated mission of bringing focus to the publics varied interests in reservoir regulation and accordingly perfecting that regulation to the maximum extent possible.

Water Control Section personnel sends to each meeting a report which summarizes hydrologic and meteorologic situations in the district for the preceding three month or six month period highlighting pertinent events, flood control activity, and special operations by each project.

9-03. INTERAGENCY AGREEMENTS, MEETINGS AND ORGANIZATIONS

Agreements among the Corps of Engineers, the U.S. Geological Survey, and the National Weather Service are mentioned and outlined in paragraphs 6-02a and b. An annual meeting is held with each of the State branches of the Geological Survey cooperating in the Stream Gaging Program. The Corps and Weather Service mutually agree upon scheduling of meetings concerning the Ohio River Network on an as-needed basis.

In the interest of fire protection for visitors, employees, property and animal and plant life, the District executed a memorandum of understanding covering all Corps reservoir projects in Ohio with the Ohio Department of Natural Resources to be administered by the Division of Forestry. The understanding includes cooperative warning and suppression of fires on or threatening Corps owned lands, Ohio Department of Natural Resources maintenance of a standard cache of fire-fighting tools at the project, and payment by the Corps of extinguishment costs incurred by the Ohio Department of Natural Resources.

The Great Lakes and Ohio River Division Water Management Division holds a quarterly meeting of the Reservoir Operations Coordinating Group. The meeting is normally attended by representatives of Federal, Regional, and State agencies and commissions; along with Corps representatives of District and Division reservoir regulation elements. The purpose of the meeting is to exchange information and views on regional water recourse concerns.

9-04. COMMISSIONS, RIVER AUTHORITIES, COMPACTS, AND COMMITTEES

a. Ohio River Basin Commission(ORBC). This commission has an active interest in the operation of Wills Creek Lake and acts in a consultative capacity to both governmental and private interests in the basin. The commission members are representatives of Federal and State leaders in Water Resources. The commissions purpose is to provide a forum for the Ohio River border states to study, discuss, and develop regional policies and positions on common interstate issues concerning water and related land issues.

b. Ohio River Valley Water Sanitation Commission(ORSANCO). This commission, created in 1948, coordinates the water quality programs of member states, and promulgates regulations to prevent and mitigate water quality problems on the Ohio River and its tributaries. The states of New York, Ohio, Indiana, Illinois, Pennsylvania ,West Virginia, Kentucky, and Virginia are represented on this commission.

c. Ohio Fish and Wildlife Service(PFBC). This commission has interest in water related issues as they affect fishery resources and boating opportunities in the state.

d. Ohio Department of Natural Resources(ODNR). Through its several divisions, the ODNR regulates water appropriation and all activities with direct impact on public streams and lakes in the state of Ohio.

e. District Drought Monitoring Committee(DDMC). This is an existing committee consisting of Huntington District Corps of Engineers personnel from the Planning, Operation and Readiness, and Engineering and Construction divisions; the Office of Councel; and the Public Affairs Office. The purpose of this committee is to review guidelines, develop and implement functional drought contingency plans, and to keep the CDMC informed on drought status and drought related topics and issues.

f. Corps Drought Management Committee(CDMC). The CDMC is composed of personnel from the Planning, Operation and Readiness, and Engineering and Construction divisions; the Office of Counsel; and the Public Affairs Office. The purpose of the committee is to represent the broad range of Federal interests and to establish and direct the water management policy for the Huntington District during a drought. Where possible, the Chief of the Engineering Division uses guidelines from this committee in developing and justifying deviations from approved water management plans and procedures.

g. Interagency Drought Management Committee(IDMC). The IDMC is composed of local, state, and Federal agency directors that have the authority to represent all user water needs within the Muskingum

River Basin. Federal members include the Huntington District Commander who serves as the Chairmen, and agency heads or their designees from the Federal Emergency Management Committee Agency, U.S. Fish and Wild Life Service, Environmental Protection Agency, National Weather Service, U.S. Geological Survey, and Soil Conservation Service. State members include department heads or their designees from the Ohio Department of Environmental Protection and the Ohio Emergency Management Agency. Local members include representatives from the area counties. The purpose of the committee is to review the status of Districts lake storage and operations, review drought related water needs and requests, develop proposed action plans for meeting consolidated and coordinated user needs, and set priorities and define actions on these needs.

9-05. NON-FEDERAL HYDROPOWER – Not Applicable

9-06. HUNTINGTON DISTRICT REPORTS

Table No. 9-1, back of section, contains a listing of the various Periodic and Special reports provided by the District Water Control Section.

a. Periodic.

(1) Daily. Districts are required to report current hydrologic data daily as prescribed by the Division Office. A daily report is prepared five days per week by the Water Control Section and, when staffing is provided, as under flooding conditions, on Saturdays, Sundays and holidays. It is prepared as detailed in sub-section 5-01 and inserted into a computer file. After review, the report is sent over a leased line to the Great Lakes and Ohio River Division water control system. The transmission includes morning lake elevation, rate and temperature of outflow, and 3-day forecast of lake and outflow for all reservoir projects. Ohio River morning stages and 24-hour rainfall, morning stage and flow and 5-day flow forecast for Ohio River tributary gage points complete the transmission and the report. The report items are prepared in accordance with ORDER 1110-2-20, CHORD-ED-W lt, 10 Jul 69, CHORD-ED-W lt, 23 Jan 67, and ORDER 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 should not be 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 are permissible. District offices are encouraged to provide assistance to communities and individuals regarding the impact of forecasted floods. Typical advice would be to provide approximate water surface elevations at locations upstream and downstream of the NWS forecasting stream gages. Announcement of anticipated changes in reservoir release rates as far in advance as possible to the general public is the responsibility of Corps of Engineers water control managers for projects under their jurisdiction.

(2) Weekly. Each week a list of 24-hour reservoir effects at tributary gage points is transmitted to LRD. The list, which gives flows in cfs held out from or added to the natural flow, shows the data for an entire week. All of the key gage points are reported for Wills Creek, Muskingum River, and Ohio River Basin. The main stem points are located at Cambridge, Dresden, Zanesville, and Marietta, Ohio.

During any flood, drought or other emergency involving reservoirs, the Ohio River or other streams in the District, the Water resources Engineering Branch provides all available information to the District Engineer, Chief of Engineers and interested elements as frequently as necessary.

(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 the 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) Quarterly Reservoir Operations. Each District provides a quarterly review of meteorological influences and water control management activities to each of the four yearly 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 September 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 reports 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. An annual Division Water Quality report is required by ORDR-2-26. The report is submitted in two parts. The first part addresses the divisions 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 the Water Control Section, 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 should be 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 of Reservoir Effects. 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 Wills Creek, the Muskingum, and the Ohio River. Reservoir effects include evaluation of the stage reductions at key stations, estimates of damages

prevented by the projects, and precipitation maps will be included in the post-flood reports required by ER 500-1-1. Conclusions are discussed with regard to adequacy of operating technique, performance of structures, and benefits derived from operations during the flood. **Plate No. 8-34** shows the tabular and graphic data used to calculate stage reductions at the following gaging stations pertinent to Wills Creek Dam: Wills Creek at Cambridge, Wills Creek at Derwent, Wills Creek at Birds Run, and Muskingum River at Zanesville. The outline of a typical post flood report is given below.

I- Authority, Purpose And Scope

II- Basin Description
Basin Flood Control works
Impact of Flood

III- General Precipitation
Storms and Reservoirs

IV- Damages and Flooding

V- Antecedent Rainfall
Storm Rainfall and Runoff

VI- General Method of Operation
Emergency and Standing Instructions
Flood Control Operations during Storms
Special Operations
Operations during Release Period
Results of Operation
Flood Damages Eliminated

VII- Computer Programs Utilized
Special Flood Activity

(3) Fiscal year budget requests. 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. 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, if necessary. Dispatch of supplemental reports is determined by the urgencies of situations as they occur. The reports are forwarded as soon as hydrologic data are available, but not later than the 10th of the month. For further information on reporting refer to ER 500-1-1.

(5) Major droughts. During major droughts or extreme low-flow conditions, narrative summaries of the situation should be furnished to alert the Chief of Engineers regarding the possibility of serious runoff deficiencies that are likely to precipitate actions associated with Corps of Engineers reservoirs.

(6) Master Plans. Division water control managers will develop Master plans for water control data systems and significant revisions thereto. They are 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) Miscellaneous. Any additional or pertinent reports required from higher authority will be promptly compiled and transmitted.

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 reports 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 forecasts at Ohio River tributary gage points.

Weekly Reservoir effects at Ohio River tributary gage points.

Monthly Records 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 maps 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.

Snowmelt runoff and flood potential reports to OCE.

Narrative summaries of major drought or low-flow conditions likely to require special regulation of District reservoirs.

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

TABLE NO. 5-1
WILLS CREEK BASIN
STREAMGAGING NETWORK - PERTINENT DATA

Stream and Station	Gage Datum Ft. NGVD.	Drainage Area Sq. Mi.	Date Mo./Yr.	Existing Facilities	Method of Obtaining Data
Seneca Fork of Wills Creek below Senecaville Lake, H gage (outflow)	799.0	118	9/38	DCP, E, strip chart, tape, and staff gage.	Senecaville lake project personnel read tape and include in regular and extra reports. DCP transmits via GOES satellite to LRD downlink every 4 hours. LRD WCS disseminates
				data hourly to ORH WCS.	
Wills Creek at Derwent	782.0	272	9/38	Voice DCP, E, Tipping bucket with heater (TBGH), strip chart, wire weight (WW), tape, and staff gage.	Project personnel call DCP and include in regular and extra reports. DCP transmits via GOES satellite to LRD downlink every 4 hours. LRD WCS disseminates data hourly to LRH WCS. DCP can also be accessed directly by WCS via phone lines.
Salt Fork Lake	700.0	159	9/68	DCP, E, and TBGH.	DCP transmits via GOES satellite to LRD downlink every 4 hours. LRD WCS disseminates data hourly to LRH WCS.
Wills Creek at Cambridge	772.34	406	6/26	Voice DCP, E, TBGH, WW, Analog-to-Digital Recorder (ADR), tape, and WW.	Muskingum Area Office calls DCP and include in regular and extra reports. DCP transmits via GOES satellite to LRD downlink every 4 hours. LRD WCS disseminates data hourly to LRH WCS. DCP can also be accessed directly by WCS via phone lines.
Wills Creek at Wills Creek Lake A gage (Lake)	733.0	842	4/38	DCP, E, TBGH*, strip chart, tape, and staff gage.	Project personnel read strip chart and include in regular and extra reports. DCP transmits via GOES satellite to LRD downlink every 4 hours. LRD WCS disseminates data hourly to LRH WCS.

TABLE NO. 5-1
PAINT CREEK BASIN
STREAMGAGING NETWORK - PERTINENT DATA
(Continued)

Stream and Station	Gage Datum Ft. NGVD	Drainage Area Sq. Mi.	Date Mo./Yr.	Existing Facilities	Method of Obtaining Data
Wills Ck below Wills Creek Lake, I gage, (outflow)	717.0	842	10/38	DCP, E, strip chart, and tape.	Project personnel read strip chart and include in regular and extra reports. DCP transmits via GOES satellite to LRD downlink every 4 hours. LRD WCS disseminates data hourly to LRH WCS.
Muskingum R. at Dresden	693.15	5993	9/21	Voice DCP, ADR, E, TBGH* and tape.	Dillon Project personnel call DCP and include in regular and extra reports. DCP transmits via GOES satellite to LRD downlink every 4 hours. LRD WCS disseminates data hourly to LRH WCS. DCP can also be accessed directly by WCS via phone lines.
Muskingum R. at Zanesville	667.0	6844	10/60	Voice DCP, E, TBGH, strip chart, manometer, and staff gage.	Dillon Project personnel call DCP and include in regular and extra reports. DCP transmits via GOES satellite to LRD downlink every 4 hours. LRD WCS disseminates data hourly to LRH WCS. DCP can also be accessed directly by WCS via phone lines.
Muskingum River t McConnelsville	650.31	7422	10/21	Voice DCP, E, TBGH, ADR, manometer, and WW.	Dillon Project personnel call DCP and include in regular and extra reports. DCP transmits via GOES satellite to LRD downlink every 4 hours. LRD WCS disseminates data hourly to LRH WCS. DCP can also be accessed directly by WCS via phone lines.
Ohio River at Marietta, Ohio, 2 miles below mouth of Muskingum River	567.12	35600	10/68	Voice DCP, E, TBGH, ADR, staff gage, Telemark, and tape.	Willow Isl. L&D personnel call Telemark and include in regular and extra reports. DCP transmits via GOES satellite to LRD downlink every 4 hours. LRD WCS disseminates data hourly to LRH WCS. DCP can also be accessed directly by WCS via phone lines.

* Future Equipment

TABLE NO. 5-2

PRECIPITATION STATIONS IN AND NEAR
WILLS CREEK BASIN - PERTINENT DATA

RECORD FROM	STATION	EQUIPMENT	METHOD OF OBTAINING DATA	REPORTING CRITERIA
1938	Wills Creek Lake	(2) 8-inch raingage (SRG)	Project personnel gage collector and report to Muskingum Area Office (MAO). MAO reports to LRH WCS via computer terminal.	Daily at 0700 for previous 24 hours precipitation.
		(2) Voice DCP, TBGH*	DCP transmits via GOES satellite to LRD downlink every 4 hours. LRD WCS disseminates hourly to LRH WCS. DCP can be accessed directly by phone line	Data collection interval 60 min.
1938	Senecaville	(2) 8-inch SRG	Project personnel gage collector and report to MAO. MAO reports to LRH WCS using computer terminal.	Daily at 0700 for previous 24 hours precipitation.
		(2) DCP, TBGH	DCP transmits via GOES satellite to LRD downlink every 4 hours. LRD WCS disseminates hourly to LRH WCS.	Data collection interval 60 minutes.
1937	Barnesville	(1) 8-inch SRG	Observer calls MAO about 0730 plus follow ups as required.	0.01 inch precipitation in 24 hours prior to 0700. LRN Type 'C' follow ups(ORN Type 'C'-report if 0.5 inch additional precipitation by 1300 or 1900 hours)

TABLE NO. 5-2
PRECIPITATION STATIONS IN AND NEAR
WILLS CREEK BASIN - PERTINENT DATA
(Continued)

RECORD FROM	STATION	EQUIPMENT	METHOD OF OBTAINING DATA	REPORTING CRITERIA
1955	Caldwell	(1) 8-inch SRG	Observer calls MAO about 0730 plus follow ups as required.	0.5 inch precipitation in 24 hours prior to 0700. ORN Type 'C' follow ups
		(2) DCP, TBG	DCP transmits via GOES satellite to LRD downlink every 4 hours. LRD WCS disseminates hourly to LRH WCS.	Data collection interval 60 minutes.
1959	Cambridge	(1) 8-inch SRG, F-P punch tape.	Observer calls MAO about 0730 plus follow ups as required.	0.01 inch precipitation in 24 hours prior to 0700. ORN Type 'C' follow ups
		(2) Voice DCP, TBGH	DCP transmits via GOES satellite to LRD downlink every 4 hours. LRD WCS disseminates hourly to LRH WCS. DCP can be accessed directly by phone line.	Data collection interval 60 minutes.
1985	Coshocton	(2) Voice DCP, TBGH	DCP transmits via GOES satellite to LRD downlink every 4 hours. LRD WCS disseminates hourly to ORH WCS. DCP can be accessed directly by phone line.	Data collection interval 30 minutes.
1985	Derwent	(2) Voice DCP, TBGH	DCP transmits via GOES satellite to LRD downlink every 4 hours. LRD WCS disseminates hourly to LRH WCS. DCP can be accessed directly by phone line.	Data collection interval 60 minutes.

TABLE NO. 5-2
PRECIPITATION STATIONS IN AND NEAR
WILLS CREEK BASIN - PERTINENT DATA
(Continued)

RECORD FROM	STATION	EQUIPMENT	METHOD OF OBTAINING DATA	REPORTING CRITERIA
	Dresden	(2) Future Installation		
1985	Newcomerstown	(1) 8-inch SRG	Observer calls MAO about 0730 plus follow ups as required.	0.5 inch precipitation in 24 hours prior to 0700. ORN Type 'C' follow ups
		(2) Voice DCP, TBG	DCP transmits via GOES satellite to LRD downlink every 4 hours. LRD WCS disseminates hourly to LRH WCS. DCP can be accessed directly by phone line.	Data collection interval 60 minutes.
1949	Norwich	(1) 8-inch SRG	Observer calls MAO about 0730 plus follow ups as required.	0.5 inch precipitation in 24 hours prior to 0700. ORN Type 'C' follow ups
1946	Summerfield	(1) 8-inch SRG	Observer calls MAO about 0730 plus follow ups as required.	0.5 inch precipitation in 24 hours prior to 0700. ORN Type 'C' follow ups
		(2) DCP, TBG	DCP transmits via GOES satellite to LRD downlink every 4 hours. LRD WCS disseminates hourly to LRH WCS.	Data collection interval 60 minutes.

(1) Ohio River Network, cooperative with National Weather Service.
(2) Installation, maintenance, and ownership by Corps of Engineers.
* Future installation.

SUPPLEMENTARY PERTINENT DATA

LOCATION OF PROJECT

Wills Creek Lake is located in Coshocton, Muskingum and Guernsey Counties, on Wills Creek, a tributary of the Muskingum River. The dam site is 108.2 miles above the mouth of the Muskingum River and 5.0 miles above the mouth of Wills Creek.

TYPE OF PROJECT

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

AUTHORITY

Official Plan for the Muskingum Watershed Conservancy District, 19 November 1934 and the Flood Control Act of 1939.

PURPOSES

The purposes of the project are principally to reduce flood damages along the Muskingum and Ohio Rivers and secondarily to provide water conservation for recreation and management of fish and wildlife.

DRAINAGE AREAS (Square Miles)

Seneca Fork at Senecaville Lake	118
Seneca Fork at mouth	151
Wills Creek above Seneca Fork	124
Wills Creek at Derwent	275
Wills Creek at Cambridge	406
Salt Fork at Salt Fork Lake	159
Salt Fork at mouth	160
Wills Creek above Salt Fork	494
Wills Creek at Wills Creek Lake	844
Wills Creek at mouth	853
Muskingum River above Wills Creek	4,886
Muskingum River at mouth	8,051

STREAMFLOW DATA (Cubic feet per second)

Average annual flow at dam site	939
Maximum peak discharge at dam site, (1913 computed)	22,000
Minimum discharge at dam site	1

RESERVOIR DATA

Capacities	Acre Feet	Inches Runoff
Minimum Conservation Pool	6,000	0.2
Flood Control Pool	190,000	4.9
Total Storage	196,000	5.1

Surface Areas (Acres)

Minimum Pool	900
Flood Control Pool	11,450

Elevations (Feet above NGVD)

Top of dam	799
Maximum water surface (Spillway Design Flood)	-
Flood Control Pool	779
Minimum Conservation Pool	742
Streambed at dam site	725

Backwater along Main Stem (Miles)

Minimum Pool	20.9
Flood Control Pool	60.6

DAM

Type: rolled earth fill embankment with impervious core	
Maximum height, feet	87
Top length, feet	1,950
Top width, feet	30
Base width, feet	240+

SPILLWAY

Type: uncontrolled saddle spillway at right (east) abutment	
Crest length, feet	204.5
Crest elevation, feet NGVD	779
Design discharge, cfs	45,800
Surcharge, feet	18

OUTLET WORKS

Type: Intake structure with control weir, tunnel and stilling basin

Intake Structure: Reinforced concrete with two semi-circular 20 foot arch conduits and control gates

Control weir - equipped with two stop log gates for maintaining minimum pool elevation

Number of control gates	6
Size of control gates in feet	7x15
Invert elevation of control gates, NGVD	733
Maximum outlet discharge at spillway elevation, all gates open (cfs)	25,000

Tunnel

Number of tunnels	2
Type, semi-circular, concrete lined	
Size, diameter in feet	20
Length in feet	179.5

Stilling Basin

Type, conventional jump type with a stepped apron discharging onto a baffle sill	
Width in feet	85
Length in feet, including outlet transition	190

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

WILLS CREEK BASIN
OHIO

INSTRUCTIONS TO DAMTENDER
WILLS CREEK LAKE

PROJECT MANUAL
FOR
WATER CONTROL MANAGEMENT
WILLS CREEK LAKE - WILLS CREEK

April 2002

EXHIBIT B

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Section II - Collection of Hydrometeorological Data

Section III - Collection of Stream flow Data

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WILLS CREEK LAKE

SECTION I - GENERAL OPERATION INSTRUCTIONS

1-01. GENERAL

Follow instructions given in this section under one or more of the sub-sections listed below at all times, except when other operations are required by Special Directive issued by the Water Control Section of the Huntington District Office and normally transmitted through the Muskingum Area Office. In the event contact cannot be made with proper personnel of the Area Office, the Water Control Section personnel will issue Special Directives directly to the project.

The project is to be operated to pass inflow at all times except when flow restriction or complete closure is necessary for downstream flood control.

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

1-02. GATE OPERATION TECHNIQUE

a. General. Facilities provided for water control include the weir with two stop log gates for maintaining the 742 feet NGVD year around pool level, six caterpillar gates for flood control, and an uncontrolled saddle spillway for passing major floods. The caterpillar gates are controlled by electronic operating machinery, in all cases. Sequence, speed, and manner of operation, where applicable, appear in subsequent paragraphs. Gates are to be opened or closed in such a manner as to prevent the stage at the outflow gage from changing more then 1.0 foot per hour unless directed by the Water Control Section or under emergency procedure of 1-05 below.

b. Caterpillar Gates. The six tractor gates, 7'X15' in size, are electric hoist driven, operating from sills at elevation 733.0 feet NGVD. They are numbered 1 through 6 from the left facing downstream. Under normal conditions these gates are maintained about half open as explained in 1-03 below, to allow nearly free flow of Wills Creek. They are closed as necessary for downstream control in the following order: Gate No. 6 on the right first, then Nos. 1, 5, 2, 4, and finally No. 3 for complete closure. They are to be opened in the reversed order of closing.

1-03. ROUTINE OPERATION

Under normal conditions, (See "Schedule of Reading Gages", **Plate No. 3-1** for specified conditions) the lake is regulated by the stationary weir to pass inflow. The broad notch in the weir at elevation 741 feet NGVD maintains the conservation pool at about elevation 742 feet NGVD varying with the volume rate of inflow in Wills Creek. Therefore, there is no water quality and outflow temperature regulation.

Regulation under normal conditions (not under Special Directive) may be determined by Muskingum Area Office staff; however releases shall not exceed a stage at the outflow gage of 10.2 feet (2,480 cfs) in MIANO* or 10.5 feet 2,600 cfs) in 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

During reservoir regulation activity, a maximum MIANO stage of 15.0 feet at the outflow gage, equivalent discharge 5,880 cfs, or a DEMIA stage of 16.2 feet, 6,580 cfs, can be maintained during light to medium rainfall without causing any appreciable damage along Wills Creek from the dam to the Muskingum River. Control stages are listed below on **Table No. 1-1**, and must be authorized by a Special Directive from the Water Control Section.

The official control stage at the outflow station is 16.2 feet, or 6,580 cfs. However, construction of houses along Wills Creek below the project at low elevations required the reduction of the normal maximum DEMIA outflow stage to the 15.4 feet shown below. Present practice is to restrict discharge to the lower 15.4 ft value unless the pool elevation rises to the 50% capacity, 769.0 feet NGVD. When significant rainfall occurs over the uncontrolled drainage areas along Wills Creek or Muskingum River below Wills Creek, discharges will be regulated from Wills Creek Lake so as not to add to or cause flooding at downstream control stations.

TABLE NO. 1-1

WILLS CREEK LAKE
CONTROL STAGES AND TRAVEL TIMES

Station	Stream	Summer Stage	Summer Flow	Winter Stage	Winter Flow	Travel Time Hours
Wills Creek Dam-	Wills Creek	15.0	5,880	15.4	6,100	0
Dresden-	Muskingum River	16.0	23,450	18.5	32,000	12
Zanesville	Muskingum River	19.5	38,200	21.5	48,000	16
McConnelsville	Muskingum River	10.0	35,600	11.0	41,600	24
Marietta	Ohio River	35.0		35.0		48

* DEMIA is December to mid-April; MIANO is from mid-April to November.

Operation for the Ohio River at Marietta, Ohio is based on stage forecasts by National Weather Service and water travel time from the project to Marietta. Special Directives are issued by the Water Control Section for operation of Wills Creek Lake for Ohio River control. Releases are timed so as not to add to the crest at Marietta or at other stations downstream along the Ohio River.

1-05. OPERATION DURING COMMUNICATION FAILURE

During flood periods, make every effort to contact personnel of the Area Office and failing that, the Water Control Section. Possibly other projects can help reach the District Office. If the facilities fail, solicit the cooperation of the local radio and T.V. 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 either through the Area Office or otherwise.

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

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

(2) twenty-four hours have elapsed since last contact with the Water Control Section either through the Area Office or otherwise, or

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

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

1-06. EMERGENCY OPERATIONS

a. General. Instructions contained herein involve the Emergency Operation Schedule, **Plate No. 1-1,** and take precedence over all preceding instructions. The Emergency Operations Schedule is provided for use by the Project Supervisor for flood control operation during complete failure of communication with the Water Control Section either through the Area Office or otherwise.

Whenever the lake level is above elevation 768.0 feet NGVD and rising, a constant check shall be made on the rate of rise of the lake level. Read the lake gage every hour on the hour and calculate the rise in lake level for the previous hour.

Enter the rate-of-rise curves of the Emergency Operations Schedule with the rise and current lake level and read the Sluice Gate Position at the bottom of the Schedule. Look in the table above the curves for necessary sluice gate settings opposite the Sluice Gate Position. Should the required settings be greater than the current gate settings, contact the Water Control Section immediately for operating instructions. In the event of failure of normal means of communication (cell phone and telephone), continuous and vigorous effort shall be made to contact the Water Control Section as described above.

Authorization is hereby given to operate the project in accordance with the Emergency Operation Schedule (**Plate No. 1-1**) when there is a three-hour or greater delay in establishing contact with the Water Control Section, from the time that the curves indicate gate settings greater than those being maintained in accordance with other instructions.

In such an emergency situation, follow the procedures described below, continuing efforts to contact the Water Control Section before and after each operation for guidance in use of the rate-of-rise curves.

(1) Emergency operation shall be based on the last readings taken and no attempt shall be made to make up for any missed operation steps. The required gate settings shall be executed as soon as they have been determined from the Emergency Operation Schedule, **Plate No. 1-3**.

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

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

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

(5) If the lake level crests below spillway elevation of 779.0 feet, NGVD, gradually close the gates as necessary to maintain the crest lake level until ordered by Special Directive to being drawdown operation.

(6) If a second rise occurs while out of communication with the Water Control Section, resume operation in accordance with rate-of-rise curves and instructions printed in the Emergency Schedule.

1-06. PUBLIC NOTIFICATION OF UNUSUAL RELEASES

Operation of reservoir projects during major floods has on occasion resulted in water releases being made which damaged privately owned equipment or facilities located downstream, and caused claims or damage suits to be filed against the Government.

To minimize the possibility of such claims or suits, the Wills Creek Project Supervisor must stay informed and inform the Water Control Section of all developments along Wills Creek between the dam and the end of such development below the community of Wills Creek.

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

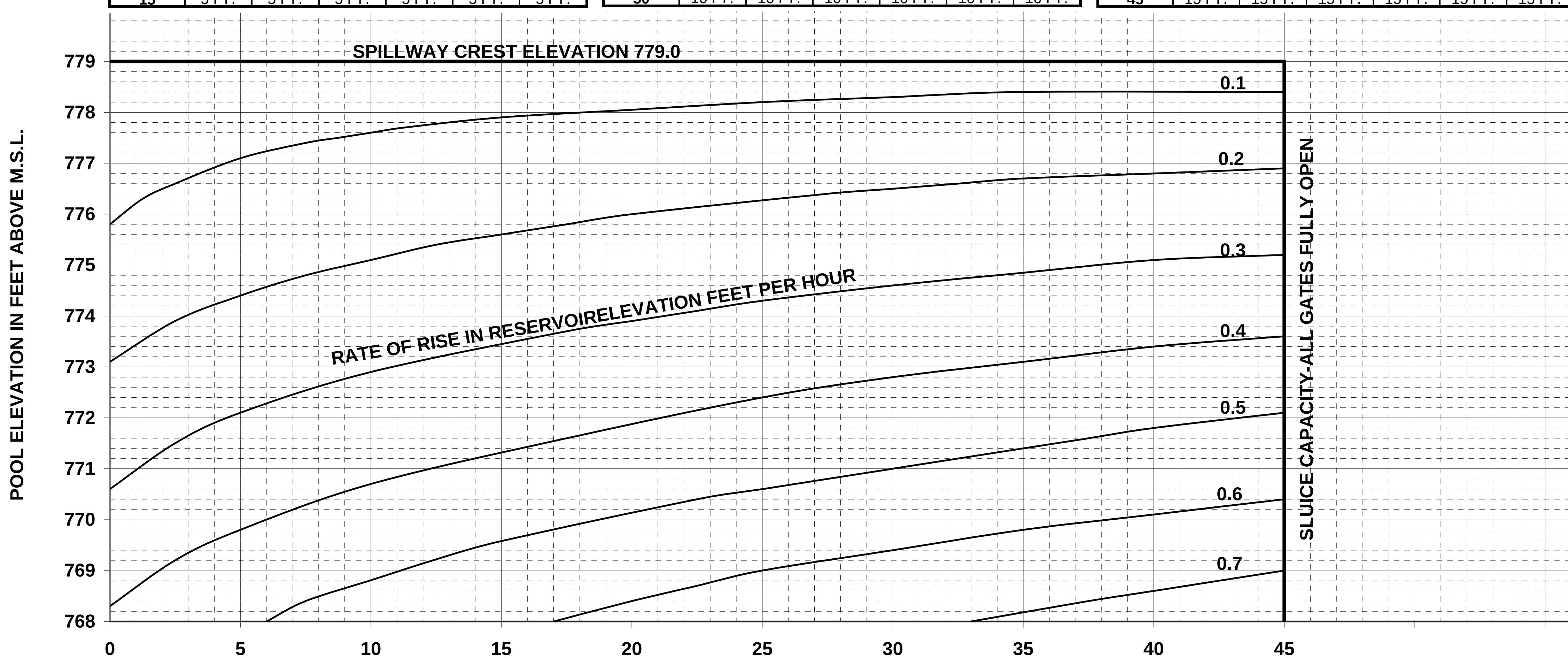
If required by unusual release patterns, obtain directions from the Water Control Section which will coordinate the release with Public Affairs Office for public notification procedures.

Unusual release patterns include closure for maintenance purposes, special increases or decreases for downstream requests and requirements, and emergency, above channel capacity, discharges. Notification of large releases is to afford those likely to be affected an opportunity to take remedial measures in advance of the arrival of the release as so to prevent damage to or loss of their property.

SLUICE GATE POSTION NO.	SLUICE GATE NO. 1	SLUICE GATE NO. 2	SLUICE GATE NO. 3	SLUICE GATE NO. 4	SLUICE GATE NO. 5	SLUICE GATE NO. 6
1	0 FT.	1 FT.	0 FT.	0 FT.	1 FT.	0 FT.
2	0 FT.	1 FT.	1 FT.	1 FT.	1 FT.	0 FT.
3	1 FT.	1 FT.	1 FT.	1 FT.	1 FT.	1 FT.
4	1 FT.	2 FT.	1 FT.	1 FT.	2 FT.	1 FT.
5	1 FT.	2 FT.	2 FT.	2 FT.	2 FT.	1 FT.
6	2 FT.	2 FT.	2 FT.	2 FT.	2 FT.	2 FT.
7	2 FT.	3 FT.	2 FT.	2 FT.	3 FT.	2 FT.
8	2 FT.	3 FT.	3 FT.	3 FT.	3 FT.	2 FT.
9	3 FT.	3 FT.	3 FT.	3 FT.	3 FT.	3 FT.
10	3 FT.	4 FT.	3 FT.	3 FT.	4 FT.	3 FT.
11	3 FT.	4 FT.	4 FT.	4 FT.	4 FT.	3 FT.
12	4 FT.	4 FT.	4 FT.	4 FT.	4 FT.	4 FT.
13	4 FT.	5 FT.	4 FT.	4 FT.	5 FT.	4 FT.
14	4 FT.	5 FT.	5 FT.	5 FT.	5 FT.	4 FT.
15	5 FT.	5 FT.	5 FT.	5 FT.	5 FT.	5 FT.

SLUICE GATE POSTION NO.	SLUICE GATE NO. 1	SLUICE GATE NO. 2	SLUICE GATE NO. 3	SLUICE GATE NO. 4	SLUICE GATE NO. 5	SLUICE GATE NO. 6
16	5 FT.	6 FT.	5 FT.	5 FT.	6 FT.	5 FT.
17	5 FT.	6 FT.	6 FT.	6 FT.	6 FT.	5 FT.
18	6 FT.	6 FT.	6 FT.	6 FT.	6 FT.	6 FT.
19	6 FT.	7 FT.	6 FT.	6 FT.	7 FT.	6 FT.
20	6 FT.	7 FT.	7 FT.	7 FT.	7 FT.	6 FT.
21	7 FT.	7 FT.	7 FT.	7 FT.	7 FT.	7 FT.
22	7 FT.	8 FT.	7 FT.	7 FT.	8 FT.	7 FT.
23	7 FT.	8 FT.	8 FT.	8 FT.	8 FT.	7 FT.
24	8 FT.	8 FT.	8 FT.	8 FT.	8 FT.	8 FT.
25	8 FT.	9 FT.	8 FT.	8 FT.	9 FT.	8 FT.
26	8 FT.	9 FT.	9 FT.	9 FT.	9 FT.	8 FT.
27	9 FT.	9 FT.	9 FT.	9 FT.	9 FT.	9 FT.
28	9 FT.	10 FT.	9 FT.	9 FT.	10 FT.	9 FT.
29	9 FT.	10 FT.	10 FT.	10 FT.	10 FT.	9 FT.
30	10 FT.	10 FT.	10 FT.	10 FT.	10 FT.	10 FT.

SLUICE GATE POSTION NO.	SLUICE GATE NO. 1	SLUICE GATE NO. 2	SLUICE GATE NO. 3	SLUICE GATE NO. 4	SLUICE GATE NO. 5	SLUICE GATE NO. 6
31	10 FT.	11 FT.	10 FT.	10 FT.	11 FT.	10 FT.
32	10 FT.	11 FT.	11 FT.	11 FT.	11 FT.	10 FT.
33	11 FT.	11 FT.	11 FT.	11 FT.	11 FT.	11 FT.
34	11 FT.	12 FT.	11 FT.	11 FT.	12 FT.	11 FT.
35	11 FT.	12 FT.	12 FT.	12 FT.	12 FT.	11 FT.
36	12 FT.	12 FT.	12 FT.	12 FT.	12 FT.	12 FT.
37	12 FT.	13 FT.	12 FT.	12 FT.	13 FT.	12 FT.
38	12 FT.	13 FT.	13 FT.	13 FT.	13 FT.	12 FT.
39	13 FT.	13 FT.	13 FT.	13 FT.	13 FT.	13 FT.
40	13 FT.	14 FT.	13 FT.	13 FT.	14 FT.	13 FT.
41	13 FT.	14 FT.	14 FT.	14 FT.	14 FT.	13 FT.
42	14 FT.	14 FT.	14 FT.	14 FT.	14 FT.	14 FT.
43	14 FT.	15 FT.	14 FT.	14 FT.	15 FT.	14 FT.
44	14 FT.	15 FT.	15 FT.	15 FT.	15 FT.	14 FT.
45	15 FT.	15 FT.	15 FT.	15 FT.	15 FT.	15 FT.



SLUICE GATE POSITION (SEE TABLE)

OPERATING INSTRUCTIONS

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

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

3. ADJUST THE GATE SETTINGS EACH HOUR ON THE BASIS OF THE RATE OF RISE AND THE CURRENT RESERVOIR ELEVATION AS INDICATED BY THE CURVES. OBTAIN THE SLUICE GATE POSITION FROM THE SET OF CURVES AND OBTAIN SLUICE GATE OPENINGS FROM THE TABLE.

4. WHEN THE RESERVOIR LEVEL EXCEEDS SPILLWAY ELEVATION AND THEN STARTS TO FALL, MAINTAIN THE CURRENT GATE SETTINGS UNTIL THE POOL RECEDES TO SPILLWAY ELEVATION 779.0.

5. HOLD THE POOL AT SPILLWAY ELEVATION 779.0 OR AT MAXIMUM LEVEL ATTAINED, IF BELOW SPILLWAY ELEVATION, UNTIL ORDERED BY SPECIAL DIRECTIVE TO BEGIN DRAWDOWN OPERATION.

6. IF A SECOND RISE OCCURS WHILE THE POOL IS BEING HELD AT MAXIMUM LEVEL, RESUME OPERATION IN ACCORDANCE WITH RATE OF RISE CURVES AND ABOVE INSTRUCTIONS.

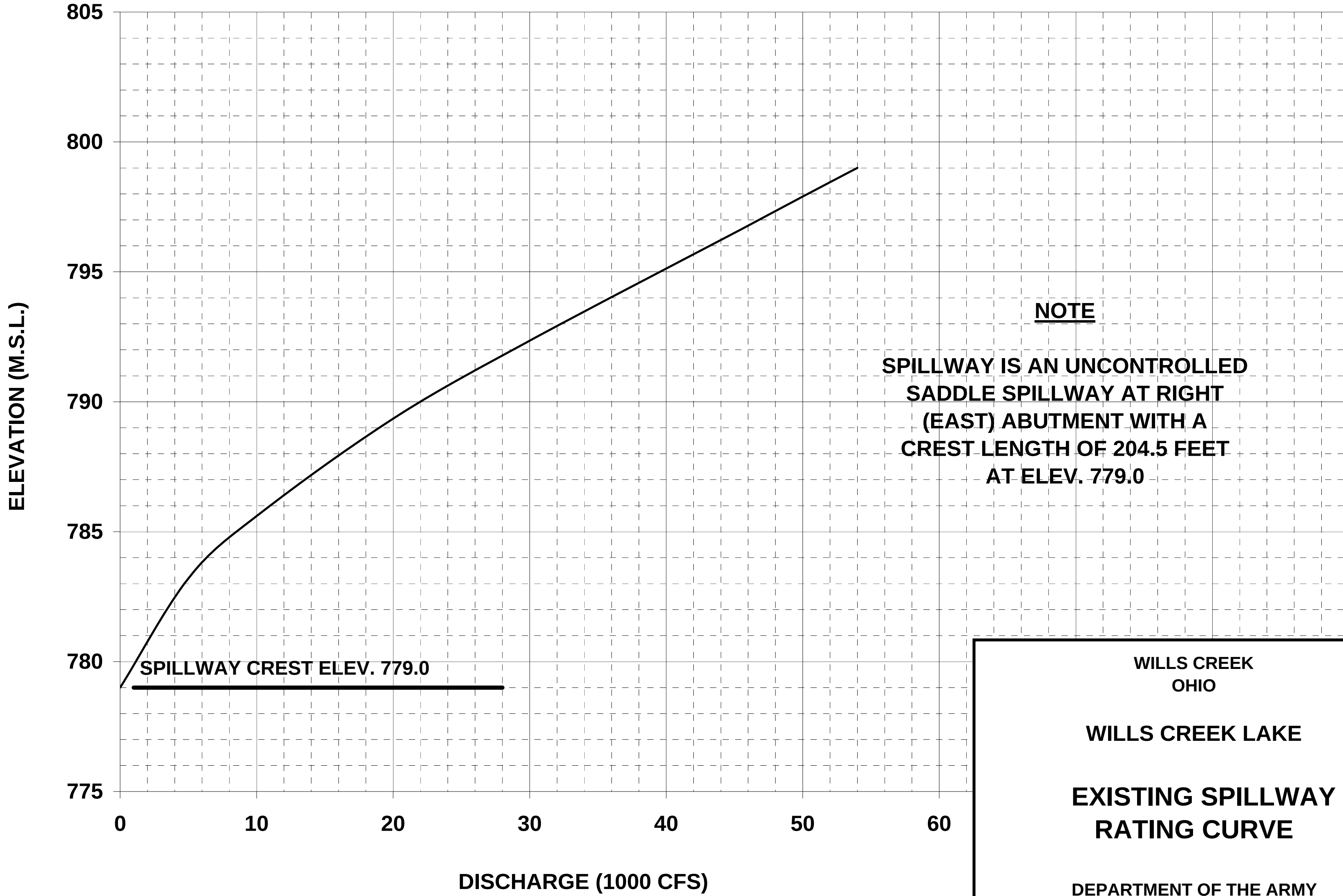
WILLS CREEK
OHIO

WILLS CREEK RESERVOIR PROJECT

EMERGENCY OPERATION SCHEDULE

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



WILLS CREEK
OHIO

WILLS CREEK LAKE

EXISTING SPILLWAY RATING CURVE

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V.   REDRAWN OCTOBER 1999

SECTION II - COLLECTION OF HYDROMETEOROLOGIC DATA

2-01. PRECIPITATION AT WILLS CREEK LAKE

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

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

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

d. Recording Precipitation Gage. Check the recording Precipitation gage about 0730 hours daily. Remove punched tape record monthly, marking record and unused portions with date and time and mail the record to National Weather Service, Columbus in the envelope provided. Install new roll of tape as needed. Empty collector bucket as needed after between 10 and 15 inches has been collected and add two quarts of antifreeze oil if between 1 October and 1 May.

e. Special and Extra Readings. Take special readings of the precipitation gage when requested by the Water Control Section through the Muskingum Area Office and extra readings whenever required by the Schedule for Reading Gages, **Plate No. 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.

f. Satellite Platform Stations. Three precipitation stations, Cambridge, Newcomerstown and Coshocton are equipped with a data collection platform which has a voice modem. It answers a telephone caller by synthetic voice. After a few seconds of high pitched tone, the voice gives the latest reading and time of reading of each parameter reported by the platform. Precipitation is called "rain" and stream stage, "level". The message ends with battery voltage and time of reading.

One should note that the time given by the platform is Greenwich Mean Time (GMT). To convert to Eastern Daylight or Eastern Standard Time, subtract 4 or 5 hours, respectively. Reporting information on satellite precipitation stations in the Wills Creek Basin is listed below in **Table No. 2-1**.

TABLE NO. 2-1

PRECIPITATION PLATFORM COMMUNICATION INFORMATION

Location/ of Gage	Equipment	Frequency Channel Voice	Frequency Channel No	Update Interval	Trans - mitted	Data Trans- mission
Senecaville Lk	1/		35	60 min.	P,E	4 Hours
Derwent	1/		35	30 min.	P,S	4 Hours
Cambridge	1/	v	55	60 min.	P,S	4 Hours
Salt Fork Lk	1/		23	60 min.	P,S	4 Hours
Newcomerstown	1/	v	35	60 min.	P,S	4 Hours
Coshocton	1/	v	35	30 min.	P,S	4 Hours

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

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

(1) Each day when any new snowfall occurs

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

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

(4) By special request from the Water Control Section

2-02. PRECIPITATION FOR NATIONAL WEATHER SERVICE

The Ohio River Network, abbreviated ORN, formerly includes precipitation stations and stations reporting both precipitation and stage. The ORN stations in or near the Wills Creek drainage basin have been combined with the Satellite Platform Stations, and now report electronically by INTRANET.

At the end of every month, the project at the request of the National Weather Service, faxes the daily precipitation report for the Project.

SECTION III - COLLECTION OF STREAMFLOW DATA

3-01. GENERAL

Obtain river and lake stage data by visiting the lake and outflow gages to read stage values from the recorder charts and by interrogating the surrounding telemeter gages. The necessary frequency for reading the gages at the project and for obtaining reports from the telemeter stations is set forth in the Schedule for Reading Gages, **Plate No. 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 WILLS CREEK LAKE

Information about gages of importance to operation of the project appears in **Table No. 3-1**, next page. List all gage readings in the records in order that complete data on the effect of the lake on natural flows will be available. Record lake gage readings in terms of elevation above NGVD but record all other gages in feet above gage datum, or zero of the gage. Gage datum is listed in **Table No. 3-1**, next page.

3-03. TELEPHONIC GAGES

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

The telephone numbers of these gages are classified as "Restricted" in order to avoid indiscriminate calls by unauthorized persons. The necessary frequency for obtaining reports from the "voice" gages is set forth in "Schedule for Reading Gages," **Plate No. 3-1**, at the end of this section.

Instructions pertaining to transmission of regular, extra and special reports of gage readings are contained in Section IV. Telephone numbers and code symbols assigned to the gages important to regulation of Wills Creek appear in **Table No. 3-2, page 3-3**.

TABLE NO. 3-1

PERTINENT GAGE DATA

Gage	Location	Code Symbol	Eqpt	Reference Gages Staff	Gages Other	Recorder	Datum of Gage
Lake	Dam	WCWE5	DCP-H	SA	TA	*RA	NGVD.
Outflow	1200 ft bel Dam	WCWOF	DCP-H	--	TK	RK	717.00
Cambridge	Campbell Ave bridge	CAWE5	v	WC	TC	*RC	722.34
Coshocton	Highway bridge 2 mi bel Walhonding-Tuscarawas junction	COMD5	v	SCo	TCo	*RCo	725.00
Dresden	70 ft bel Highway 280 bridge	DRME4	v	SDr	TDr	*RDr	693.15

* - ADR (Analog-to-Digital Recorder)

S - staff

T - electric tape

W - wire weight on bridge

DCP - data collection platform

v - "voice" platform answers telephone query with electronically synthesized voice in addition to transmitting via satellite.

G - Hydrologger, device answers telephone query giving stage by synthesized voice.

R - Strip chart recorder

TABLE NO. 3-2

STREAM GAGE TELEPHONE NUMBERS

Gage	Code* Symbol	Telephone Number	Type of Device
Wills Creek near Derwent	DRWF5	[redacted]	Voice Platform
Wills Creek at Cambridge	CAWE5		Voice Platform
Muskingum R. nr Coshocton	COMD5		Voice Platform
Muskingum R. at Dresden	DRME4		Voice Platform
Muskingum R.@ McConnelsville	MCMG5		Voice Platform

* Project abbreviation plus location on District Isohyetal Map

3-04. DATA COLLECTION

Project personnel read the lake gage and outflow gage and telephone the voice platform reporting the Muskingum River stage at Coshocton. All the values are recorded in the daily morning report and given to the District Data System, EC-WW, by INTRANET. If Coshocton stage is 12.00 feet or above, telephone the Dresden gage and record the stage in the log. Gate positions and operations are noted in the log and on Form 14 and the positions are included in morning and extra reports to the Area Office. Supplemental lake and outflow data, discussed in next section, are taken along with regular readings or soon after.

The Morning Report data are given by Wills Creek personnel as detailed in Section IV, and as shown in **Plate No. No. 4-2** at the end of Section IV. Supplemental data, when required, are called for by Area Office in the same sequence immediately after sending the regular data to the Water Control Section. Page 2 and 4 of **Plate No. 4-2** are examples of Supplemental Data as furnished to the Water Control Section. Data collection platforms report stage data at all the locations (plus precipitation at some stations) listed above in **Table No. 3-2**. They transmit the data by electronic signal to the LRD downlink via satellite each four hours. The LRD Water Control System retrieves from the downlink and disseminates hourly to the Water Control Section WCS data base. By use of the "SCAN" command with the portable terminal assigned, Area Office personnel can access the most recent readings from area stations that are reported by platform, as previously mentioned in 3-03.

3-05 OUTFLOW TEMPERATURE AND DISSOLVED OXYGEN PROFILES. – N.A.

SCHEDULE FOR READING GAGES
WILLS CREEK LAKE

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

	SCHEDULE A(1) Normal Conditions		SCHEDULE B(1) Flood Threat		SCHEDULE C(1) Flood Condition		SCHEDULE D Major Flood Condition	
CONDITIONS	MIANO*	DEMIA**	MIANO*	DEMIA**	MIANO*	DEMIA**	MIANO*	DEMIA**
Lake Gage elevation	Below 745	Below 745	745-761	745-761	761-769	761-769	Above 769	Above 769
Stage at Outflow gage	Below 13.0(8)	Below 14.0(8)	13-14.0(8)	14-15.4(8)	14.0-15.0(8)	15.4-16.2(8)	Above 15.0(8)	Above 16.2(8)
Coshocton Stage	Below 12.0	Below 13.0	12-13	13-14	13-15.5	14-18.0	Above 15.5	Above 18.0
Dresden Stage	Below 12.0	Below 13.0	12-14	13-15	14-16	15-18.5	Above 16.0	Above 18.5
Precipitation within 24 hours (6)	Less than 0.75	Less than 0.50	0.75-1.25	0.50-1.00	1.25-2.50	1.00-2.50	More than 2.50	More than 2.50
READ GAGES								
RA and RK	At 0730 & 1330(2)		At 0730 & 1330		At 0730, 1330, 1930 & 0130		At 3 hour intervals (3)	
RA and RK take from Charts	Readings for 0730, 1330, 1930 & 0130(4)		Readings for 0730, 1330, 1930 & 0130(4)		Readings for 0730, 1330, 1930 & 0130(4)		Readings for 0730, 1330, 1930 & 0130(4)	
Precipitation Gage	Daily at 0730 (6)		Daily at 0730 & 1330		At 0730, 1330, 1930 & 0130		At 3-hour intervals	
Coshocton Voice	At 0730		At 0730 & 1330(5)		At 3-hour intervals(7)		At 3-hour intervals(7)	
Dresden Voice			At 0730		At 3-hour intervals(7)		At 3-hour intervals(7)	
SA, TA, and TK	Twice Weekly (as check)		Twice weekly (as check)		Twice weekly (as check)		Twice weekly (as check)	

(1) When any one of the conditions listed under schedule A, B or C is exceeded, place the next higher schedule into effect immediately and notify designated personnel of the Muskingum Area Office by person to person telephone call. If unable to reach either of them, similarly call personnel of H&H Branch as listed in 4-03c below, persisting (within reason) until message has been delivered.
(2) Take readings on week days regularly and on weekends and holidays by special arrangement.
(3) Whenever the water level at the lake gage is between elevation 774 and 779 and rising, or at elevation 779 or above, read A gage and K gage hourly.
(4) The 1330, 1930, and 0130 readings on weekdays and all readings for weekends and holidays may be obtained from the chart at the time of the next scheduled reading of visual gages. If necessary to obtain the readings desired, roll the chart back and, after taking readings, return to the proper position--all according to instructions contained in Exhibit No. III-2.
(5) If instructed to report.
(6) If precipitation has occurred since the morning reading and amounted to 0.20" in winter or 0.50" in summer, or if snowmelt has occurred sufficiently to cause a rise in stream or inflow, read the lake gage, outflow gage, and rain gage at 1330 hours and transmit the information to the Muskingum Area Office.
(7) While Coshocton stage above 13.0 feet.
(8) All stages at the outflow gage above 10.2 feet in MIANO or 10.5 feet in DEMIA must be authorized by Hydrology and Hydraulics Branch.

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

* MIANO - 16 April through 30 November
** DEMIA - 1 December through 15 April

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 week end 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 spring 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 1 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 - 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. Lake and outflow gage readings will be obtained for every six hours (0130, 0730, 1330 and 1930) during periods when the project is attended and recorded on the form.

The Schedule for Reading Gages, **Plate No. 3-1**, defines conditions for taking more frequent readings of gages. After entering each of the readings on the form, check the accuracy 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 when taking the 0730 Project Report readings. After any period in which the project was not attended, obtain all missing readings from the recorder charts and record on Form 14. See **Plate 3-2** for instructions on how to turn back charts to obtain missed readings and the proper method to reset the gage after doing so. On Monday morning, or Tuesday if the project was not attended on Monday, record any missed readings along with the 0730 readings. Check the accuracy of the data on the typed original compared to the handwritten form. Mail the original typed form to the District Office marked “Attention Water Resources Engineering Branch.” Begin a new Form 14. A sample Form 14, **Plate No. 4-1** is included at the end of this section.

b. Daily Morning Report. Use of the ORH–13 form has been discontinued. An all new reporting program was installed at the dam in May 1998. The program is a fully computerized three page, menu-driven master data sheet which is virtually self-explanatory, with a convenient auto-prompt feature, easily completed by filling the empty data boxes. This form is used to record the regular morning report at Wills Creek Lake, and then used to transmit the data to EC-WW.

The regular morning readings at the project, including precipitation, readings of the lake “L” gage, outflow “O” gage, gate positions, river stages and gate operations shall be recorded each day. After recording, the data will be transmitted via the District INTRANET System for the Water Resources Engineering Branch by approximately 0800 hours on each day in which the project is attended.

An example of this report is shown at the end of this section as Project Data Input Form, **Plate No. 4-2**. The proper manner of reporting the data and completing the data in detail are shown in a printout of project reporting instructions found at the end of this section as **Plate No. 4-3**.

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.

c. Gate Operations Report. 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 and all gate operations are reported by the INTRANET SYSTEM. Choose the Gate ID from a drop down menu. 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. Transmit all gate valve operations since the previous report and transmit with each morning or extra report. List them in chronological order after project report data. See the example in **Plate No. 4-2**. An unlimited field is also provided to make any additional comments.

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 to the Project Report and the Gate Operations Report (see Para. 4.01.b).

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 at the Wills Creek Lake web page at(http://wcds-a.orh.usace.army.mil/dbases/WCW/reports/gateop.txt).

4-02. EXTRA REPORTS

Always transmit extra reports, as indicated by the Schedule for Reading gages, **Plate No. 3-1** to INTRANET over the project computer terminal in the same way as the regular MORNING report. If some circumstance prohibits, such as for example, malfunction of the terminal or lack of terminal competency by personnel on duty, attempt to telephone the report to Water Resources Engineering Branch in the District Office.

Failing this attempt, telephone the report to one of the Water Resources Engineering Branch personnel in the order listed below in paragraph 4-03c.

4-03. SPECIAL REPORTS

a. Reporting Criteria. Special reports include any report not regularly scheduled 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 Water Control Section.

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) A catastrophe such as drowning.

(6) Unusual or abnormal water quality condition in the lake, inflow streams, or downstream reasonably close to 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 the District radio network.

When making telephone calls after hours or during weekends or holidays, unless advised that the Water Resources Engineering Branch will be on duty, place a person-to-person call to one of the following Water Resources Engineering Branch personnel, in the order listed: Plate 4-3, page 6 of 6.

4-04. CELL PHONE AS BACKUP COMMUNICATION

Backup communication is provided by the Cell Phone. The Cell Phone with beeper at the project office should be turned on at all times, including overtime periods. The District Office is sometimes on duty outside of regular office hours. Messages may be relayed through other projects when there is difficulty in transmitting reports to INTRANET or via telephone. Transmit by Cell Phone 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 outflow stage on the “H” gage, inspections will be made along Wills Creek to Dresden, Ohio.

(2) Inspections will be made downstream to McConnelsville, Ohio, during or immediately after periods of unusual storage releases.

(3) If complaints of flooding are received, notify the Water Control Section immediately, then make an inspection of the specific areas 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. Make a letter report, containing pictures, cross sections or sketches of the findings as soon as practicable. If immediate action appears necessary, make a brief initial report via telephone to the Water Resources Engineering Branch.

c. Lake Area Conditions. During periods of lake storage above minimum pool elevation 742 feet NGVD, 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 the Water Control Section Special Directives.

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, 772 feet NGVD for Wills Creek Lake, daily and hourly observations are made and reported under provisions of the Dam Operations Management Policy in addition to the normal weekly observations made under the policy. At these 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 condition 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 condition 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 application of chemicals to the water or to surrounding land. This includes fertilizers and pesticides.

RESERVOIR WEEKLY REPORT

REPORTS CONTROL SYMBOL ORRED-R-3

STATION: Wills Creek Lake

WEEK ENDING: 0730 Mon. 7 March, 1988

GAGE RECORDS

DATE	TIME START	TIME END	GAGES A	GAGES K	
	1330		743.20	721.25	
	1930		743.18	721.20	
3/1	0130		743.15	721.14	
	0730		743.13	721.08	
	1330		743.09	721.02	
	1930		743.07	720.97	
3/2	0130		743.05	720.93	
	0730		743.03	720.89	
	1330		743.00	720.85	
	1930		742.99	720.84	
3/3	0130		742.98	720.82	
	0730		742.97	720.81	
	1330		743.01	720.88	
	1930		743.07	721.05	
3/4	0130		743.21	721.25	
	0730		743.44	721.68	
	1330		743.70	722.20	
	1930		744.00	722.75	
3/5	0130		744.40	723.50	
	0730		744.82	724.34	
	1330		745.17	724.98	
	1930		745.47	725.59	
3/6	0130		745.78	726.09	
	0730		746.03	726.66	
	1330		746.21	727.05	
	1930		746.36	727.37	
3/7	0130		746.48	727.60	
	0730		746.59	727.88	

GATE OPERATING RECORD

GATE NO.	AMT. OF OPENING INITIAL	AMT. OF OPENING FINAL	PURPOSE

CHECK READINGS

			RA	SA	TA
3/4	0730		743.44	743.45	743.47
3/7	0730		746.59	746.40	746.57
			RK	VK	TK
3/4	0730		721.68	721.73	721.74
3/7	0730		727.88	727.93	727.91

FINAL POSITION OF GATES

All gates 080

SIGNATURE: Victor R. Griswell

ORH FORM 14
1 DEC 78

EDITION OF 1 NOV 72 MAY BE USED

WILLS CREEK LAKE

PROJECT INFORMATION

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

This file is a New submission.

DATE	TIME
17 Jan 2002	0730

CURRENT PROJECT INFO

COE ID	PRECIP (IN)	POOL ELEV (FT-MSL)	TAIL WATER STAGE (FT)	FLOW (KCFS)	SNOW DEPTH (IN)	WATER EQUIVILENT (IN)	W CC
WCWE5	0	750.0	725.0	0	0.0	0.0	0 Uncha

CURRENT GATE SETTINGS

GATE	S01	S02	S03	S04	S05	S06
SETTING	.00	.00	.00	.00	.00	.00

ADDITIONAL STATION INFORMATION

COE ID	PRECIP (IN)	STAGE (FT)
COMD5	0	0.0
NECD5	0	0.0

ADDITIONAL COMMENTS

PLEASE ENTER THE WILLS CREEK PASSWORD:

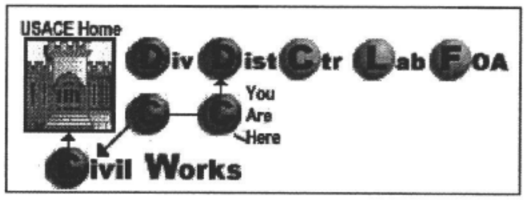
SUBMIT REPORT

CLEAR FORM


CLICK HERE TO RETURN TO WILLS CREEK LAKE HOME PAGE (WILL NOT SAVE DATA)

The POC for this page:

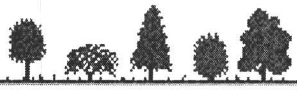
[redacted] CELRH-EC-WW
Huntington, WV
Send Email to Water Resources



Date last modified: 7 Sep 2001 at 0916

WILLS CREEK LAKE

GATE OPERATIONS



This file is a New submission.

GATE ID	VALUE		DATE	TIME	
	Start	End		Start	End
S01	0.0	0.0	17 Jan 2002	0700	0705

ADDITIONAL COMMENTS

PLEASE ENTER THE WILLS CREEK PASSWORD:

Submit These Gate Operations

Clear Form

CLICK HERE TO RETURN TO WILLS CREEK LAKE HOME PAGE (WILL NOT SAVE DATA)

WILLS CREEK 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
17 Jan 2002	0730	885.00	0 Unchanged

DEPTH (M)	TEMP (C)	D.O.	COND	TURB	pH
OUTFLOW					

DEPTH (M)	TEMP (C)	D.O.	COND	TURB	pH
0.0					
1.0					
2.0					
3.0					
4.0					
5.0					
6.0					
8.0					
9.0					

10.0					
12.0					
14.0					

ADDITIONAL COMMENTS

PLEASE ENTER THE WILLS CREEK PASSWORD:

SUBMIT DATA

CLEAR FORM

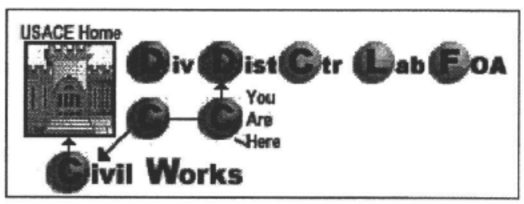
CLICK HERE TO RETURN TO WILLS CREEK LAKE HOME PAGE (WILL NOT SAVE DATA)

The POC for this page:

[redacted] *CELRH-EC-WW*

Huntington, WV

Send Email to Water Resources



Date last modified: 7 Sep 2001 at 0823

INTRANET REPORTING SYSTEM INSTRUCTIONS

LOGGING ON. Open the web browser or the (Microsoft (Internet Explorer or Netscape Navigator) to the following address: http://wcds-a.orh.usace.army.mil/WCW/index.htm). This Index Page contains links to information pertaining to Wills Creel 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.

PASSWORD. Each project has a unique password needed to submit the report the WCDS-A system. The same password is used to the Morning Report and the Gate Operations Report (see Para. 4.02.15). 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.

SUBMISSION. 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. 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”, return to the Project Report Page to correct the information.

If the report was correct, click on the “Correct” button at the top of the page, the SHEF confirmation screen will be transmitted back to the terminal. The information will be entered into a permanent record. If this password is missing or incorrect, attempts to submit the Project Report will be unsuccessful.

REPORTS. Three reports can be accessed from the Index Page: (1) The Daily Project Report (also called the Morning Report); (2) the Gate Operations Report; and (3) the Water Quality Report. Click on the picture or on the Report name to access a report.

DAILY PROJECT REPORT (MORNING REPORT)

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

CURRENT PROJECT INFO. The first table is used to record general information about the project at the time of the report.

Column 1 - Station Abbreviation. This column identifies the lake 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. This five-digit group (WCWE5) is 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. In completing this form prior to transmitting the data, list the stations in the following order: Coshocton(COMD5), and Newcomerstown(NECD5). Follow the example shown on **Plate No. 4-2**.

If there are any difficulties in relation to this, please contact the Water Control Section.

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

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

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 in feet above NGVD.

Column 5 - Flow. This column can be used for recording the outflow if it becomes necessary.

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.

Columns 8 - Weather Description. The drop down menu in this column is used to report the weather conditions by code at the time of the Project Report observation. When there has been no precipitation to report, show this group as NIL.

CURRENT GATE SETTINGS. The second table, Current Gate Settings, is used to record gate settings at the time of the Report. The table is a seven section–two row box. Column 1 is written Gate Settings.

Gate Settings – Column 2 through 7. These six columns are used for recording the openings of the slide gates. Column 2 is used for the left slide gate SO1, column 3 is used for the next slide gate SO2, and each succeeding column is used for the next slide gate until column 7 is used for the right slide gate SO6. Each gate opening is reported to the nearest tenth of a foot. For example, 4.8 feet is reported as 048 and 6.0 feet as 060. The gates usually remain open with the same setting during normal operations. When all gates are fully open, instead of listing each gate separately, the word “open” will be transmitted in column 4. When all gates are partially open, an equal amount, instead of listing each gate separately, the word “all” will be transmitted in column 4 and the amount of opening in column 5. When all the gates are fully closed, the word “closed “ is entered in column 4. When the gate settings are not uniform the individual columns from 2 through 7 are used to report the various openings. Transmission of the openings for each gate shall consist of a 3-digit number, and if the gate is closed, 000 is reported.

Low-Flow Control. There is no low-flow control function at Wills Creek Lake. During normal operations all inflow is passed over a weir. When all gates are closed there will be a very small seepage at the sills. And, one of the gates may be cracked just enough for a small flow, this is the only low-flow control at Wills Creek Lake.

Additional Station Information - Report additional precipitation and stage information for COSHOCTON(COMD5) and NEWCOMERSTOWN(NECD5) are entered in the SHEF box. Follow the example in **Plate No. 4-2.** Include any or all of the stage and precipitation in such messages: There is no water supply function at Wills Creek Dam.

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.

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. 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 on 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 record can be viewed through the Wills Creek lake web page at (http://wcds-a.orh.usace.army.mil/dbases/briefing/WCW.txt). See the example in **Plate No. 4-2**.

GATE OPERATIONS REPORT

The second report accessed from the Index Page is the Gate Operations Report. When the Gate Operations Report has been accessed, indicate if this is a new or a revised report. Check the date/time group.

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. Transmit all gate valve operations since the previous report and transmit with each morning or extra report. List them in chronological order after project report data. 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, initial gate opening, final gate opening, date, beginning time, and ending time. See the example in **Plate No. 4-2**.

In the second table, Additional Comments, an unlimited field is also provided to make any additional comments pertaining to the Gate Operations Report which have not been previously covered.

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 to the Project Report and the Gate Operations Report (see Para. 4.02.15).

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 at the Wills Creek Lake web page at(http://wcds-a.orh.usace.army.mil/dbases/WCW/reports/gateop.txt).

WATER QUALITY REPORT

When the Water Quality Report has been accessed, indicate if this is a new or a revised report. Check the date/time group.

This report is used during the rare time the lake is subject stratification. Monitoring begins when a special directive is sent by the Water Control Section at the request of the Water Quality Section. Water Quality Section will request the Water Control Section to issue a special directive ending monitoring when it is no longer necessary.

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.

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. The third table is used to record water quality at various depths. (a) 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. (b) The second column records the water temperature in degrees Celsius. (c) The third records the Dissolve Oxygen (D.O.) content in mg/ml. (d) The fourth column records the water condition. (e) The fifth column records turbidity in n.tu. (f) The sixth column records the pH. Not all of these readings will be taken at every recording session at every depth.

Supplementary Data - Below the table recording the water conditions, there is an unlimited field to provide additional comments. (a) Precipitation and snow cover amounts when either is ten (10) inches or more. (b) Moisture content of snow cover. (c) Precipitation at the dam during the past 24 hours, when greater than one (1) inch, by 6-hour period.

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. 4.02.15). 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 Wills Creek Lake Dam web page at (http://wcds-a.orh.usace.army.mil/dbases/WCW/reports/waterqual.txt). This arrangement is illustrated in **Plate No. 4-3** at the end of this section.

DIRECTORY OF KEY PERSONNEL

Huntington District Office - Water Resources Engineering Branch

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

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

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

Muskingum Area Office

[redacted]	[redacted]

Wills Creek Lake Project Office

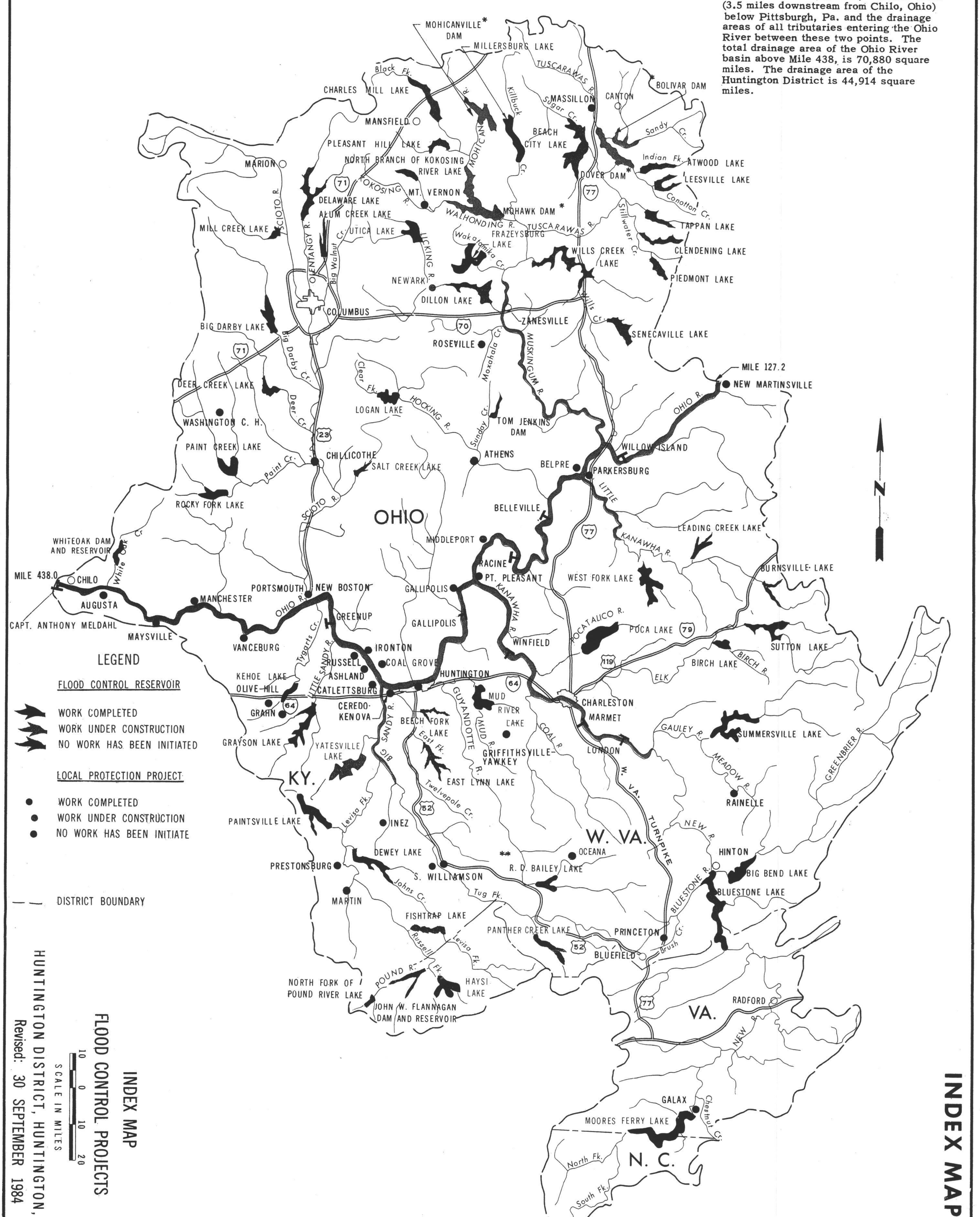
	Commercial	[redacted]
Gate Operating Personnel		Home Telephone No.
[redacted]	Commercial Commercial Commercial	[redacted]

Other Agencies

U. S. Geological Survey New Philadelphia, Ohio	Commercial FTS	[redacted]
Nights, Weekends, Holidays [redacted]	Commercial Commercial	[redacted]
National Weather Service Forecast Office, Hydrology Section Pittsburg, PA	Commercial Commercial FTS Commercial from HDQ	[redacted]

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

The Huntington District includes the reach of the Ohio River between River Mile 127.2 (New Martinsville, W. Va.) and Mile 438.0 (3.5 miles downstream from Chilo, Ohio) below Pittsburgh, Pa. and the drainage areas of all tributaries entering the Ohio River between these two points. The total drainage area of the Ohio River basin above Mile 438, is 70,880 square miles. The drainage area of the Huntington District is 44,914 square miles.



*Dry dam, with flood control pool outlined.
**Completed project where further improvements are in progress or authorized.

INDEX MAP F/C1

INDEX MAP
FLOOD CONTROL PROJECTS
HUNTINGTON DISTRICT, HUNTINGTON, W. VA.
Revised: 30 SEPTEMBER 1984

Plate No. 1-1

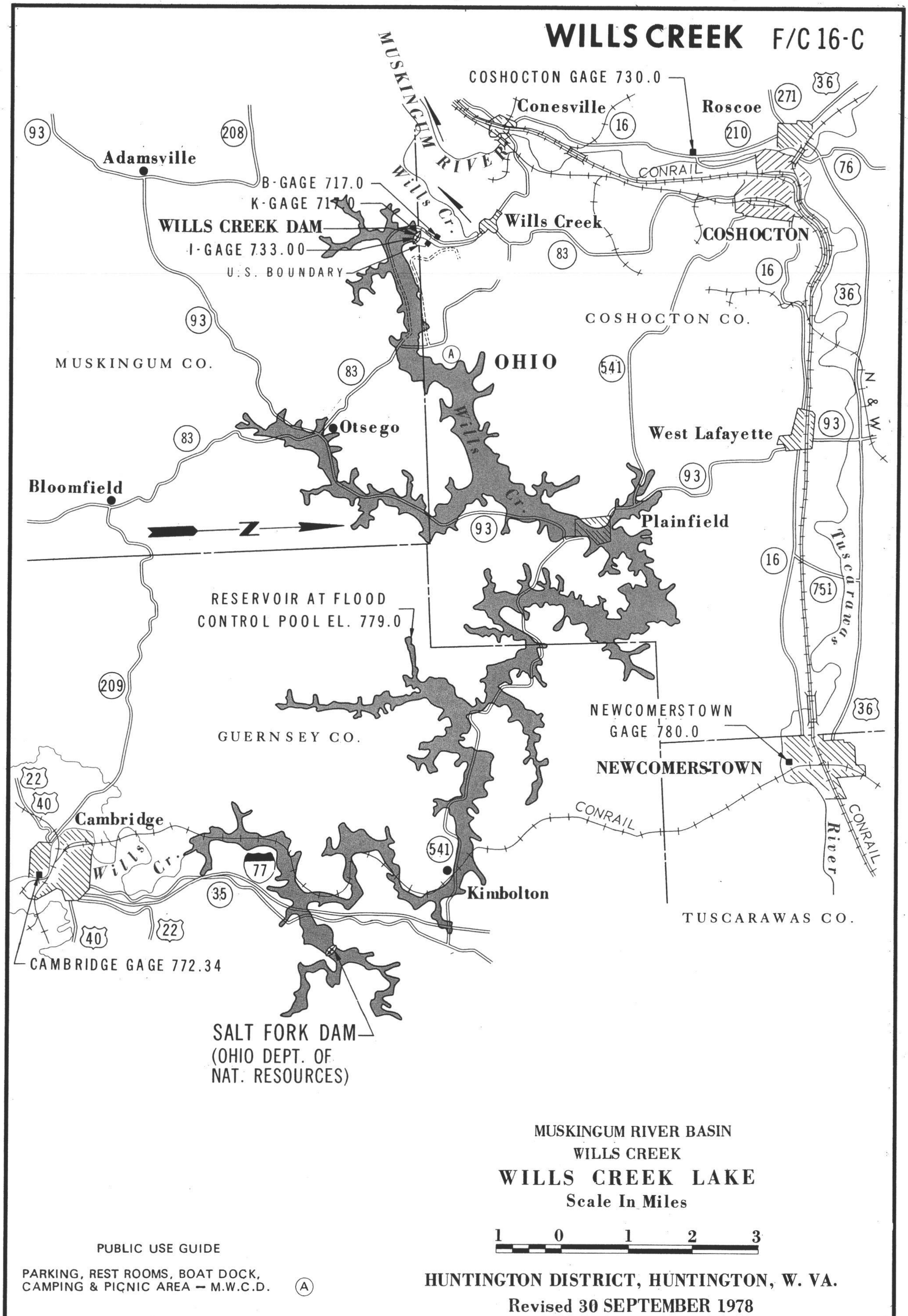
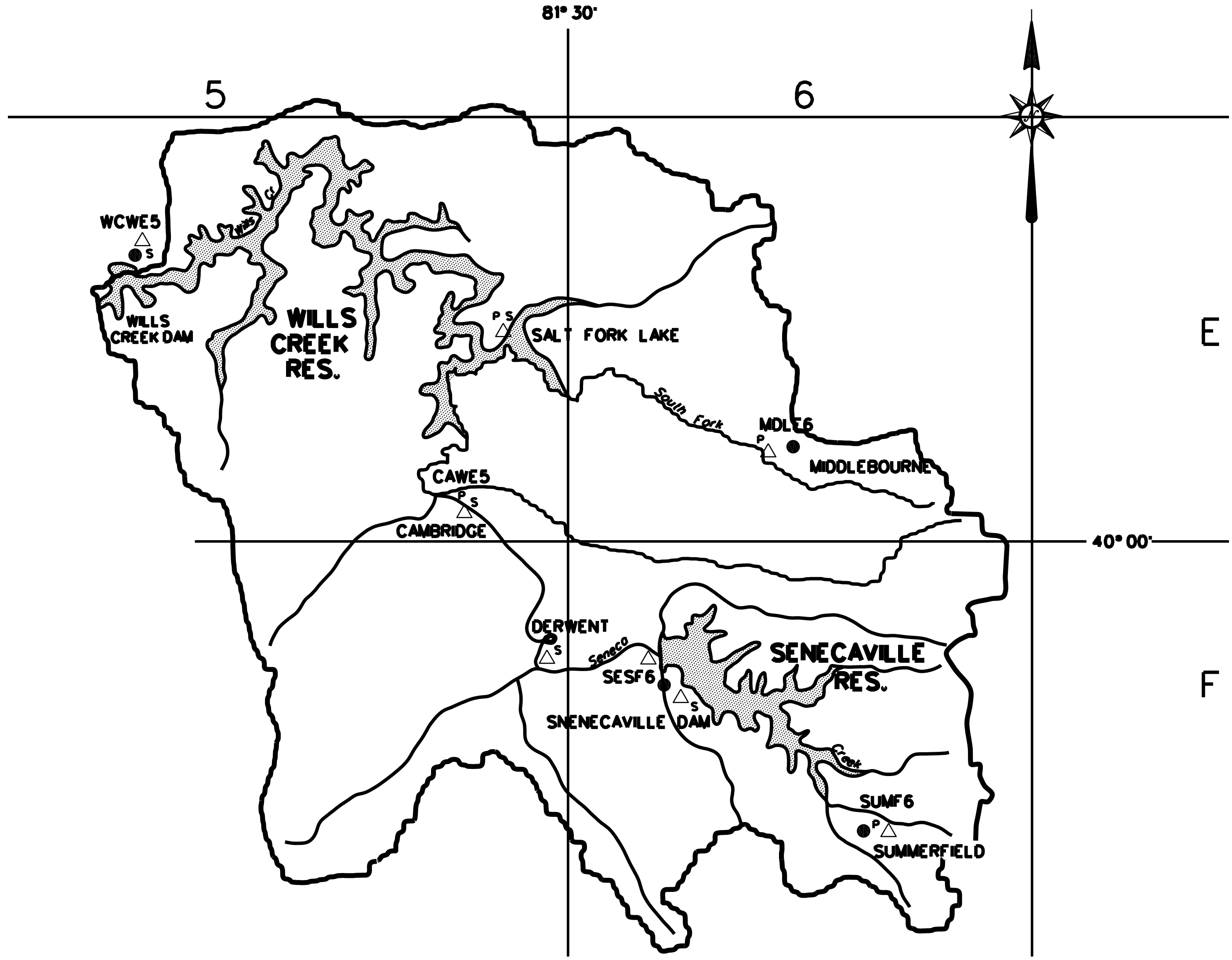

WILLS CREEK F/C 16-C
COSHOCTON GAGE 730.0
Conesville
Roscoe
MUSKINGUM RIVER
Wills Cr.
Adamsville
B-GAGE 717.0
K-GAGE 717.0
WILLS CREEK DAM
I-GAGE 733.00
U.S. BOUNDARY
Wills Creek
CONRAIL
COSHOCTON
COSHOCTON CO.
MUSKINGUM CO.
OHIO
Otsego
West Lafayette
N & W
Bloomfield
Plainfield
Tuscarawas
Wills Cr.
RESERVOIR AT FLOOD
CONTROL POOL EL. 779.0
NEWCOMERSTOWN
GAGE 780.0
NEWCOMERSTOWN
GUERNSEY CO.
Cambridge
CONRAIL
Wills Cr.
Kimbolton
River
TUSCARAWAS CO.
CAMBRIDGE GAGE 772.34
SALT FORK DAM
(OHIO DEPT. OF
NAT. RESOURCES)
MUSKINGUM RIVER BASIN
WILLS CREEK
WILLS CREEK LAKE
Scale In Miles
1 0 1 2 3
PUBLIC USE GUIDE
PARKING, REST ROOMS, BOAT DOCK,
CAMPING & PICNIC AREA — M.W.C.D.
HUNTINGTON DISTRICT, HUNTINGTON, W. VA.
Revised 30 SEPTEMBER 1978

Plate No. 2-1



LEGEND

WATERSHED BOUNDARY LINE

RESERVOIR, SPILLWAY ELEVATION

● REPORTING PRECIPITATION STATION

P PRECIPITATION

S STAGE

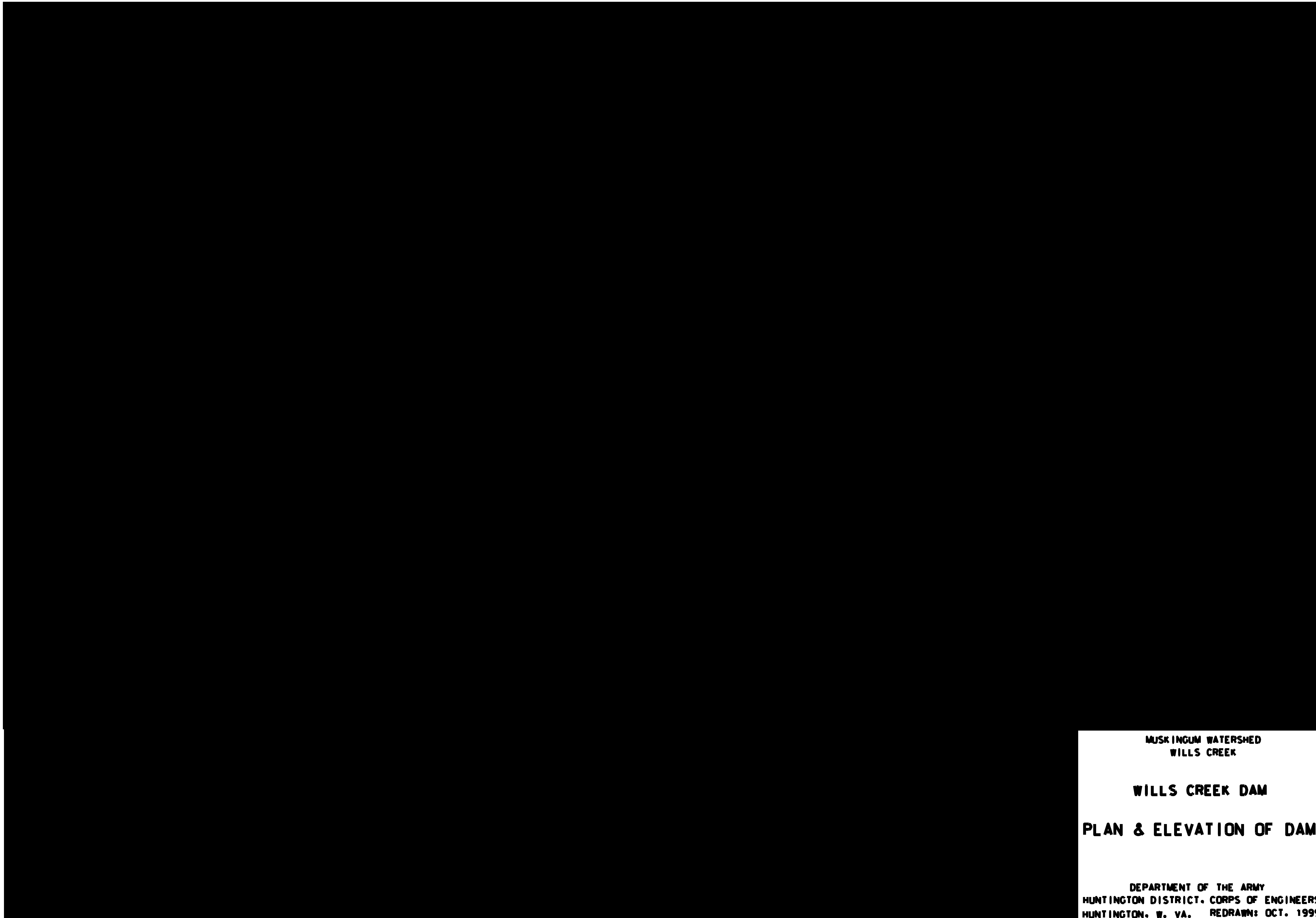
△ SATELLITE DATA PLATFORM

WILLS CREEK
OHIO

WILLS CREEK LAKE

DRAINAGE AREA MAP

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W. VA. REDRAWN: OCT. 1999



MUSKINGUM WATERSHED
WILLS CREEK

WILLS CREEK DAM

PLAN & ELEVATION OF DAM

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W. VA. REDRAWN: OCT. 1999

[redacted]

MUSKINGUM WATERSHED
TUSCARAWAS RIVER

WILLS CREEK DAM

EMBANKMENT DETAILS

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W. VA. REDRAWN: OCT. 1999

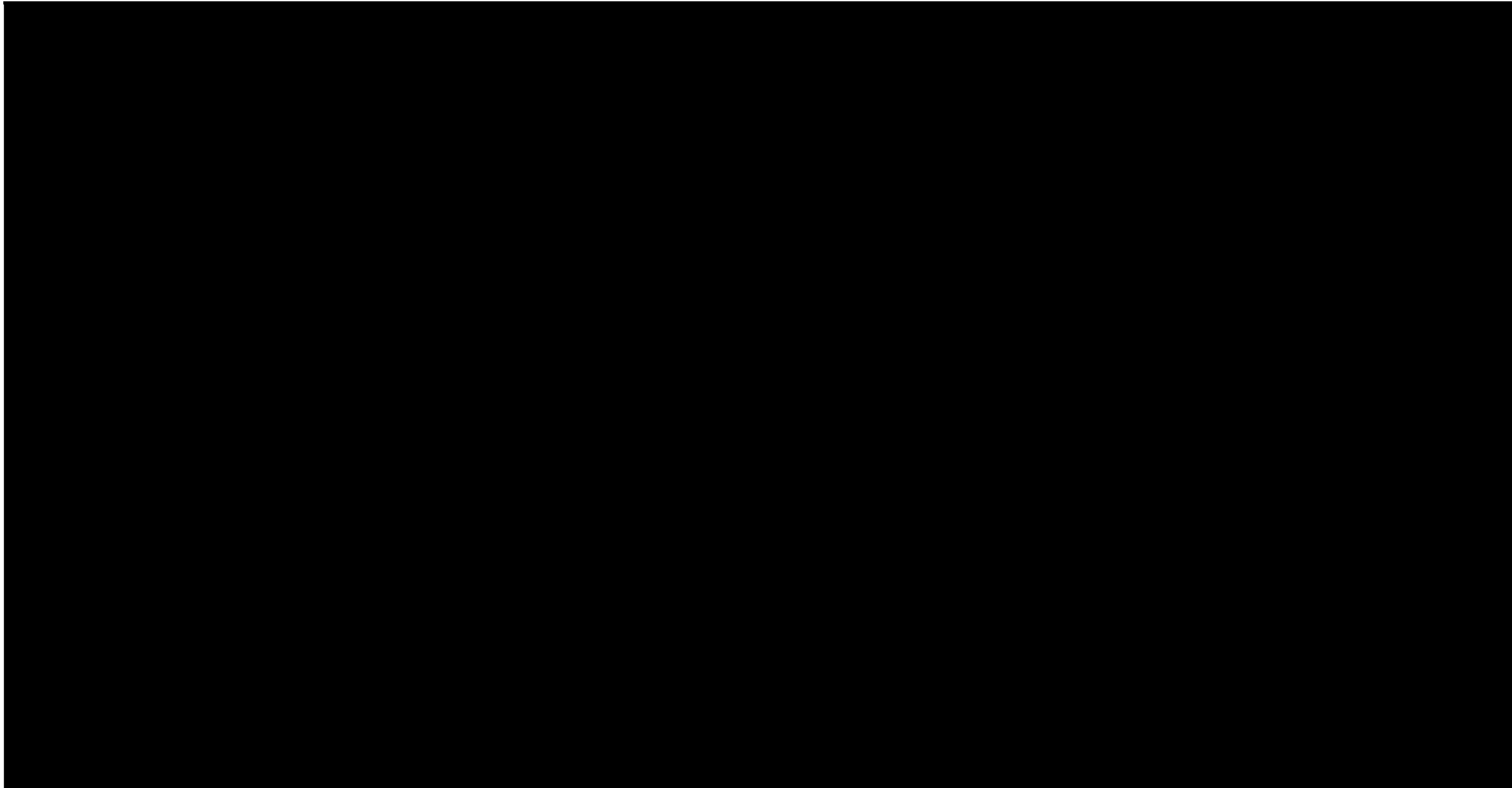
MUSKINGUM WATERSHED
WALHONDING RIVER

WILLS CREEK DAM

SPILLWAY-
PLAN AND PROFILE

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W. VA. REDRAWN: OCT. 1999

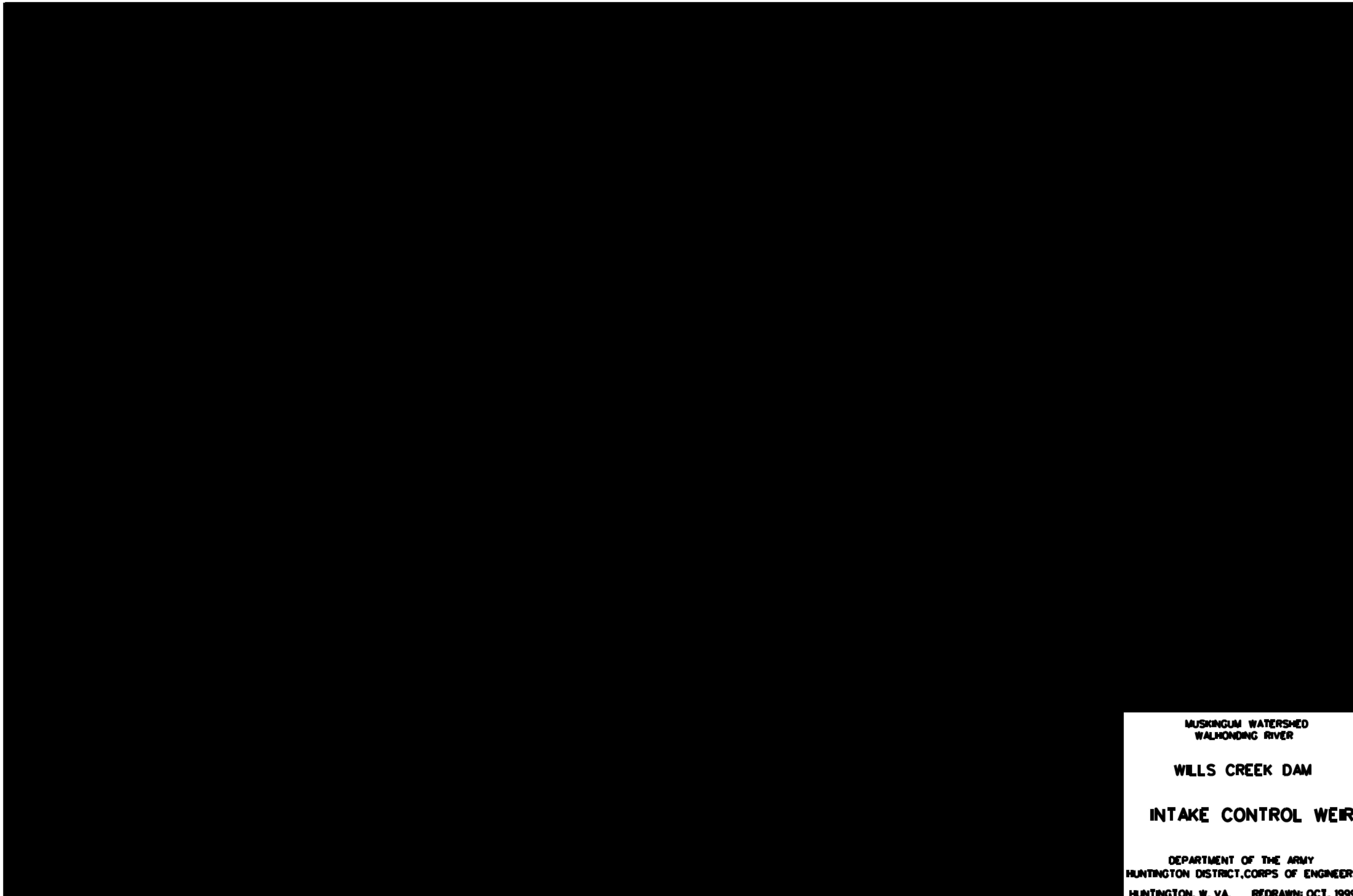


MUSKINGUM WATERSHED
WILLS CREEK

WILLS CREEK DAM

APPROACH & OUTLET CHANNELS

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W. VA. REDRAWN: OCT. 1999

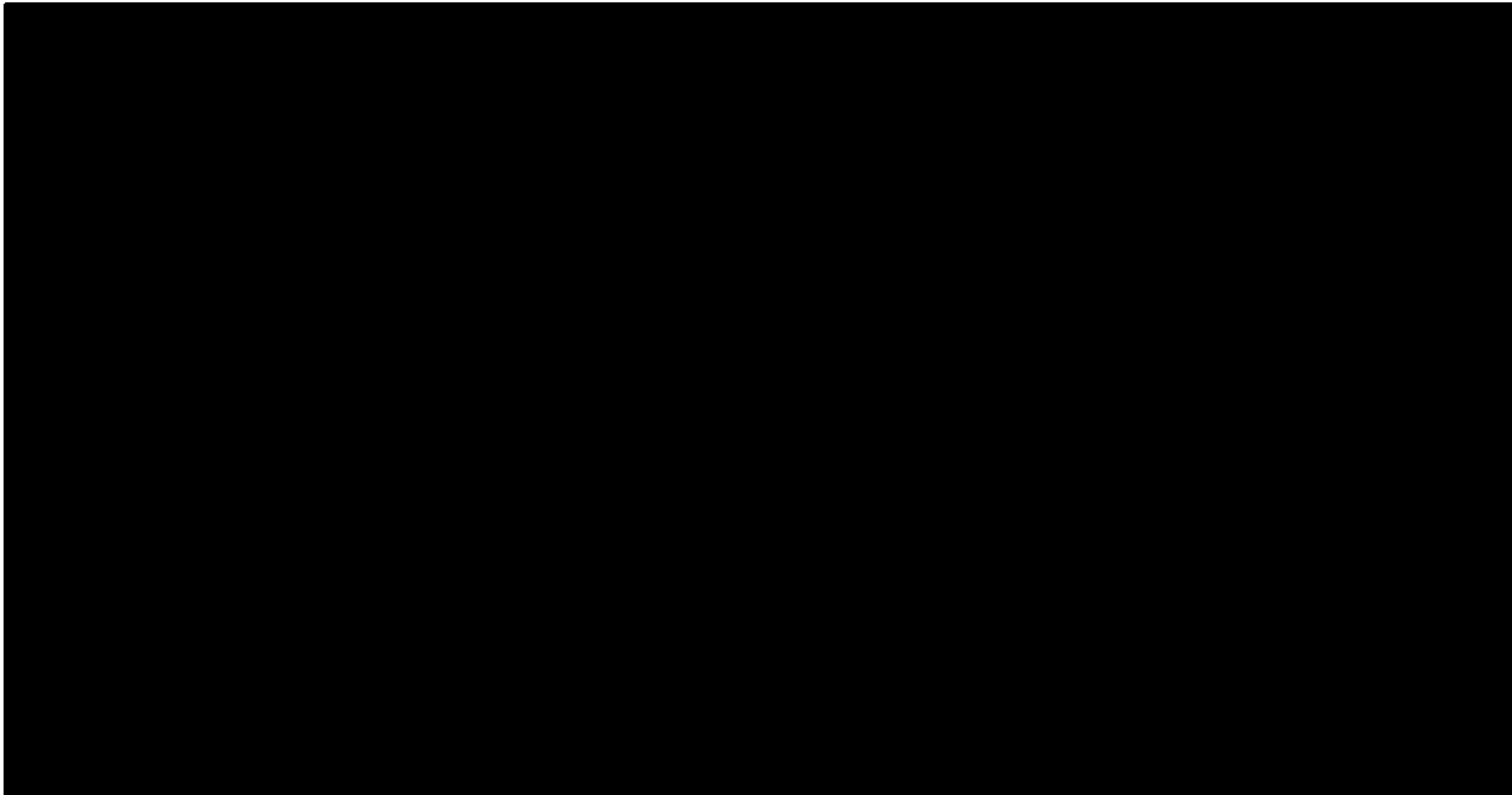


MUSKINGUM WATERSHED
WALHONDING RIVER

WILLS CREEK DAM

INTAKE CONTROL WEIR

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W. VA. REDRAWN: OCT. 1999

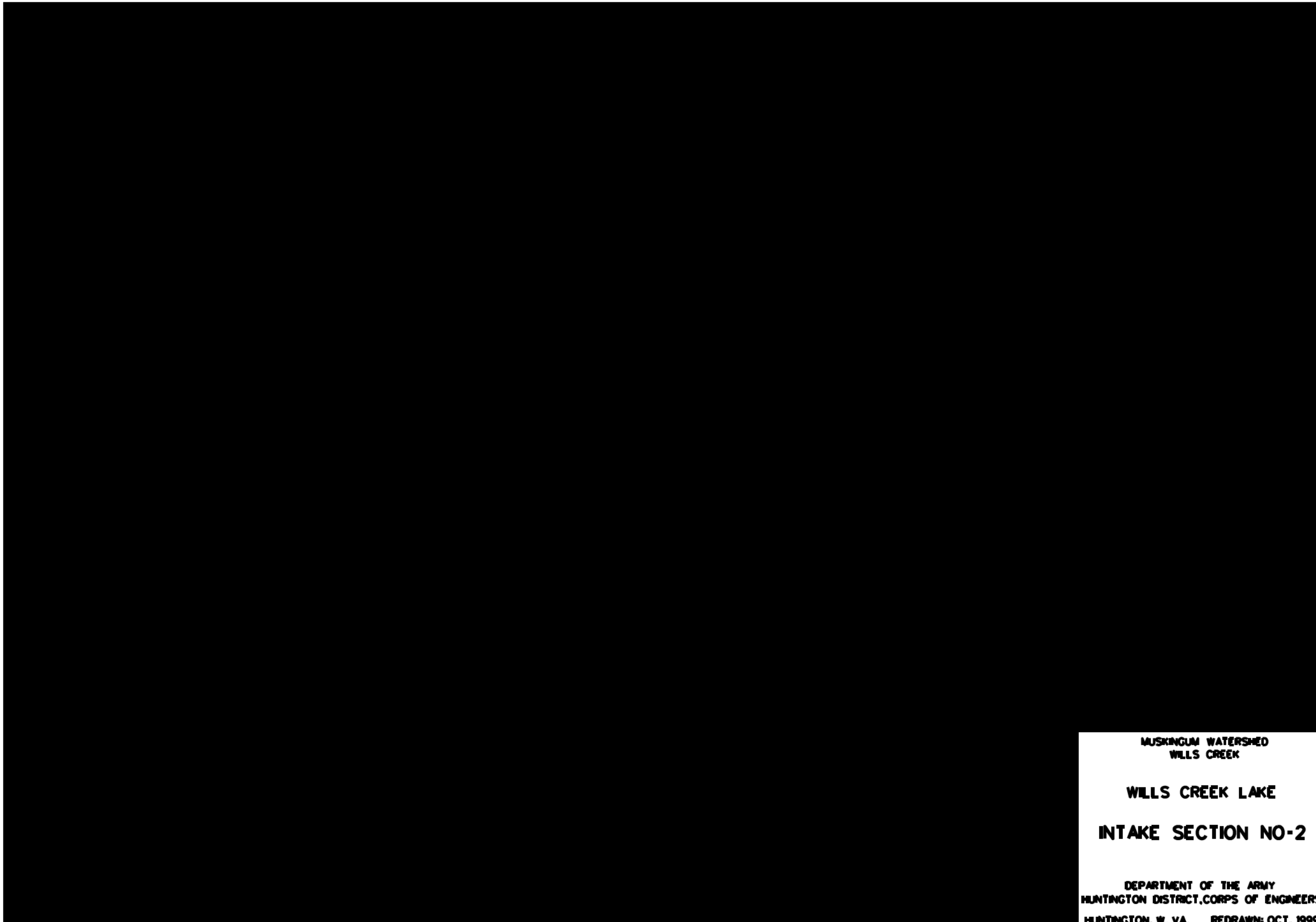


MUSKINGUM WATERSHED
WILLS CREEK

WILLS CREEK DAM

INTAKE SECTION NO-1

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W. VA. REDRAWN: OCT. 1999



MUSKINGUM WATERSHED
WILLS CREEK

WILLS CREEK LAKE

INTAKE SECTION NO-2

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W. VA. REDRAWN: OCT. 1999

WILLS CREEK
OHIO

WILLS CREEK LAKE

SERVICE BRIDGE

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W. VA. REDRAWN: OCT. 1999

[redacted]

MUSKINGUM WATERSHED
WILLS CREEK

WILLS CREEK DAM

OUTLET WORKS

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W. VA. REDRAWN: OCT. 1999

MUSKINGUM WATERSHED
TUSCARAWAS RIVER

WILLS CREEK DAM

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W. VA. REDRAWN: OCT. 1999

MUSKINGUM WATERSHED
WILLS CREEK

WILLS CREEK DAM

CONDUITS- SECTIONS

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W. VA. REDRAWN: OCT. 1999

[redacted]

WILLS CREEK
OHIO

WILLS CREEK DAM

STILLING BASIN- SECTIONS

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT CORPS OF ENGINEERS
HUNTINGTON, W. VA. REDRAWN: OCT. 1999

MUSKINGUM WATERSHED
WILLS CREEK

WILLS CREEK DAM

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W. VA. REDRAWN: OCT. 1999

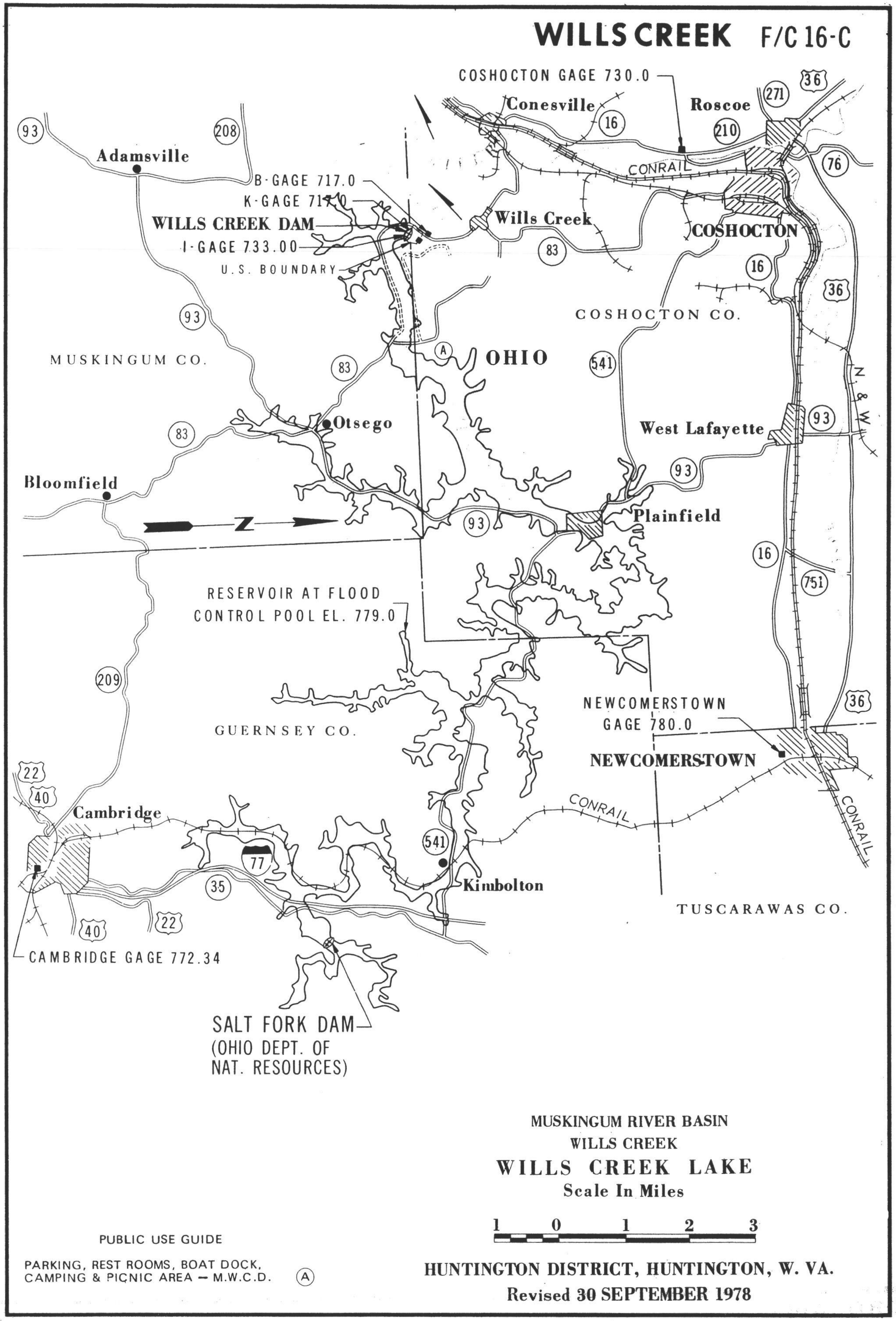
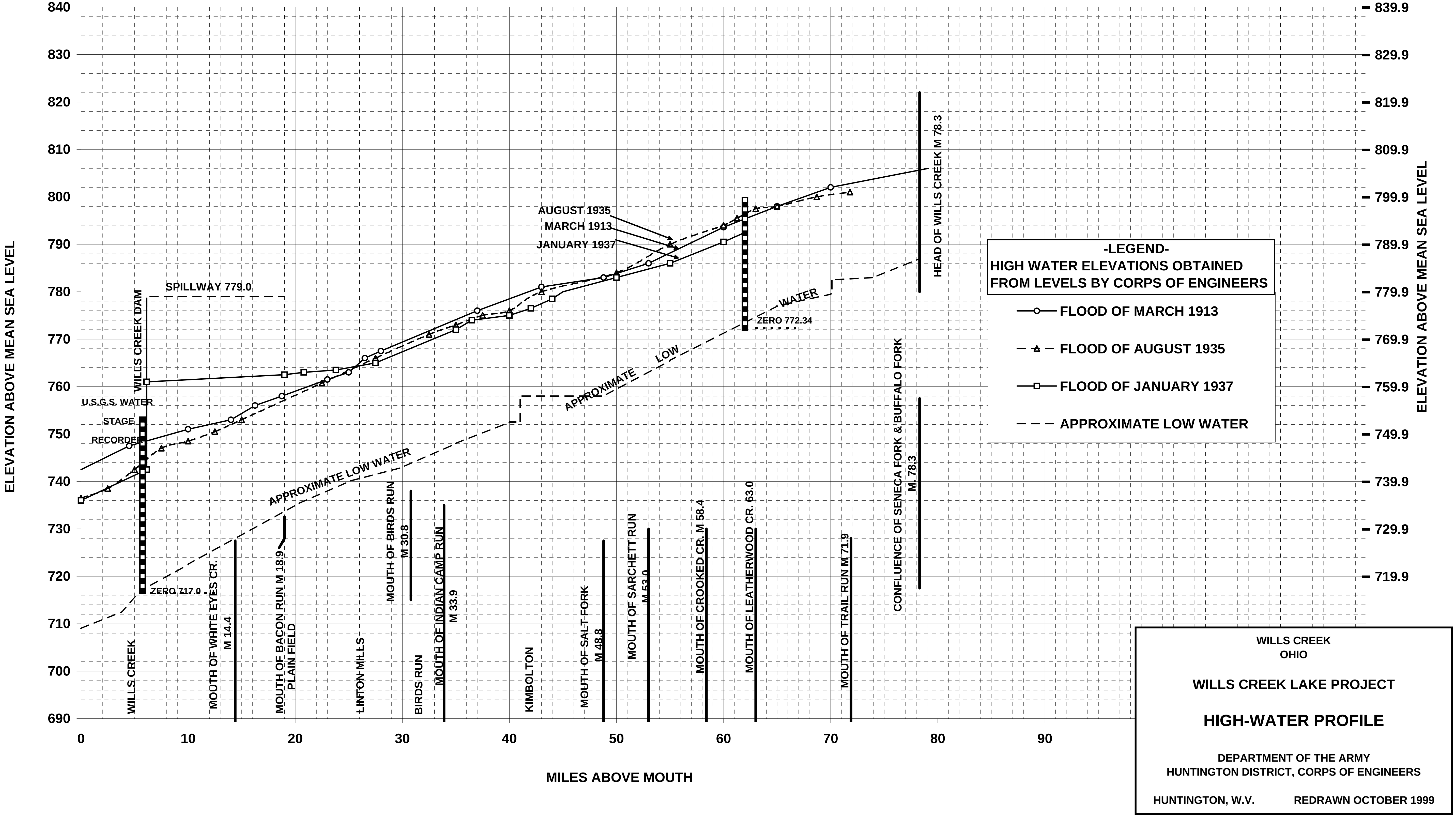
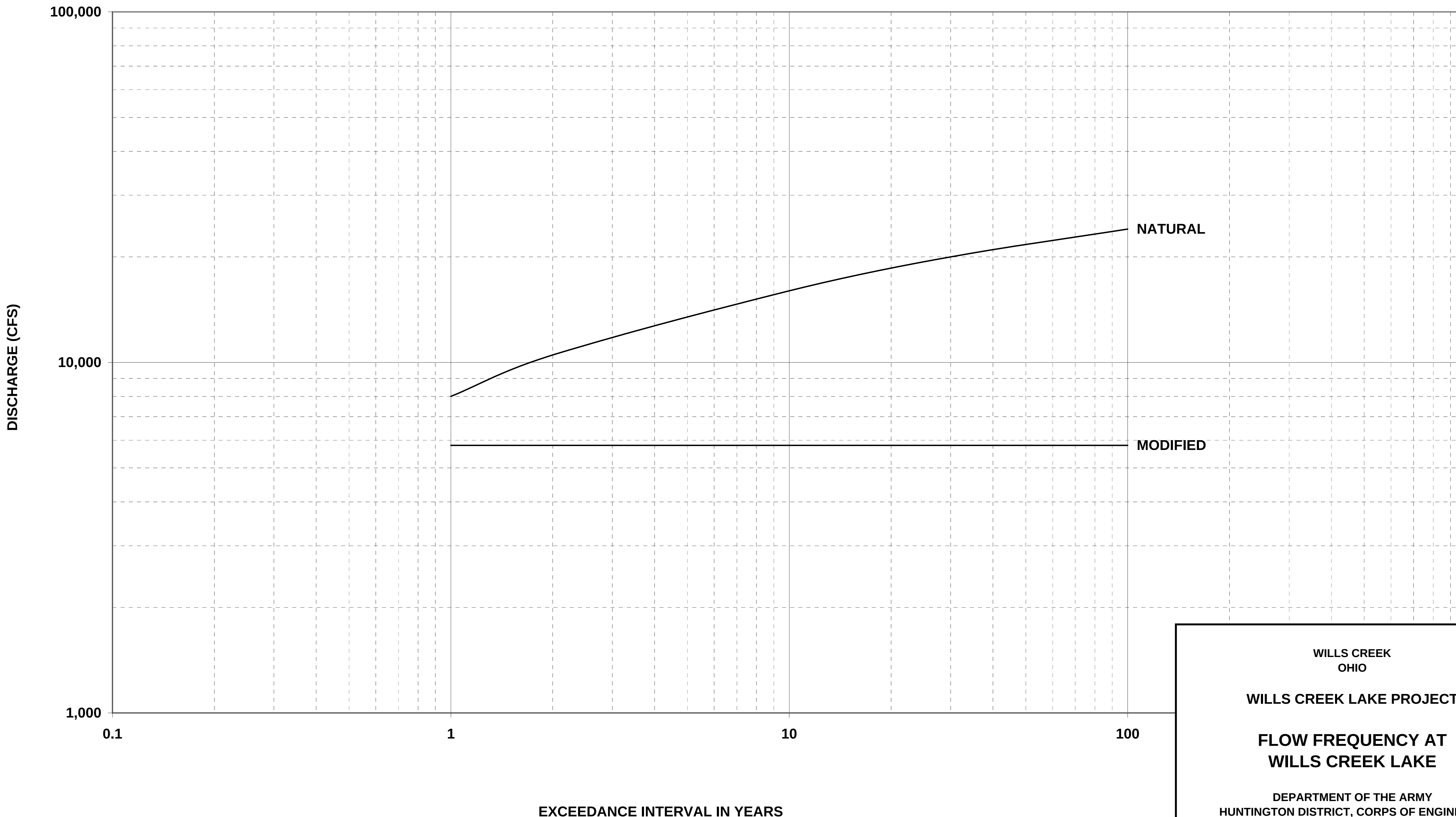

WILLS CREEK F/C 16-C
COSHOCTON GAGE 730.0
Conesville
Roscoe
Adamsville
B-GAGE 717.0
K-GAGE 717.0
WILLS CREEK DAM
I-GAGE 733.00
U.S. BOUNDARY
Wills Creek
COSHOCTON
CONRAIL
COSHOCTON CO.
MUSKINGUM CO.
OHIO
Otsego
West Lafayette
N & W
Bloomfield
Plainfield
Z
RESERVOIR AT FLOOD
CONTROL POOL EL. 779.0
GUERNSEY CO.
NEWCOMERSTOWN
GAGE 780.0
NEWCOMERSTOWN
Cambridge
CONRAIL
Kimbolton
TUSCARAWAS CO.
CAMBRIDGE GAGE 772.34
SALT FORK DAM
(OHIO DEPT. OF
NAT. RESOURCES)
MUSKINGUM RIVER BASIN
WILLS CREEK
WILLS CREEK LAKE
Scale In Miles
1 0 1 2 3
PUBLIC USE GUIDE
PARKING, REST ROOMS, BOAT DOCK,
CAMPING & PICNIC AREA – M.W.C.D. (A)
HUNTINGTON DISTRICT, HUNTINGTON, W. VA.
Revised 30 SEPTEMBER 1978

Plate No. 2-16


ELEVATION ABOVE MEAN SEA LEVEL
840
830
820
810
800
790
780
770
760
750
740
730
720
710
700
690
839.9
829.9
819.9
809.9
799.9
789.9
779.9
769.9
759.9
749.9
739.9
729.9
719.9
0
10
20
30
40
50
60
70
80
90
MILES ABOVE MOUTH
SPILLWAY 779.0
WILLS CREEK DAM
U.S.G.S. WATER
STAGE
RECORDER
ZERO 717.0
APPROXIMATE LOW WATER
APPROXIMATE LOW WATER
ZERO 772.34
AUGUST 1935
MARCH 1913
JANUARY 1937
HEAD OF WILLS CREEK M 78.3
CONFLUENCE OF SENECA FORK & BUFFALO FORK
M. 78.3
WILLS CREEK
MOUTH OF WHITE EYES CR.
M 14.4
MOUTH OF BACON RUN M 18.9
PLAIN FIELD
LINTON MILLS
MOUTH OF BIRDS RUN
M 30.8
BIRDS RUN
MOUTH OF INDIAN CAMP RUN
M 33.9
KIMBOLTON
MOUTH OF SALT FORK
M 48.8
MOUTH OF SARCHETT RUN
M 53.0
MOUTH OF CROOKED CR. M 58.4
MOUTH OF LEATHERWOOD CR. 63.0
MOUTH OF TRAIL RUN M 71.9
-LEGEND-
HIGH WATER ELEVATIONS OBTAINED
FROM LEVELS BY CORPS OF ENGINEERS
FLOOD OF MARCH 1913
FLOOD OF AUGUST 1935
FLOOD OF JANUARY 1937
APPROXIMATE LOW WATER
WILLS CREEK
OHIO
WILLS CREEK LAKE PROJECT
HIGH-WATER PROFILE
DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V.
REDRAWN OCTOBER 1999



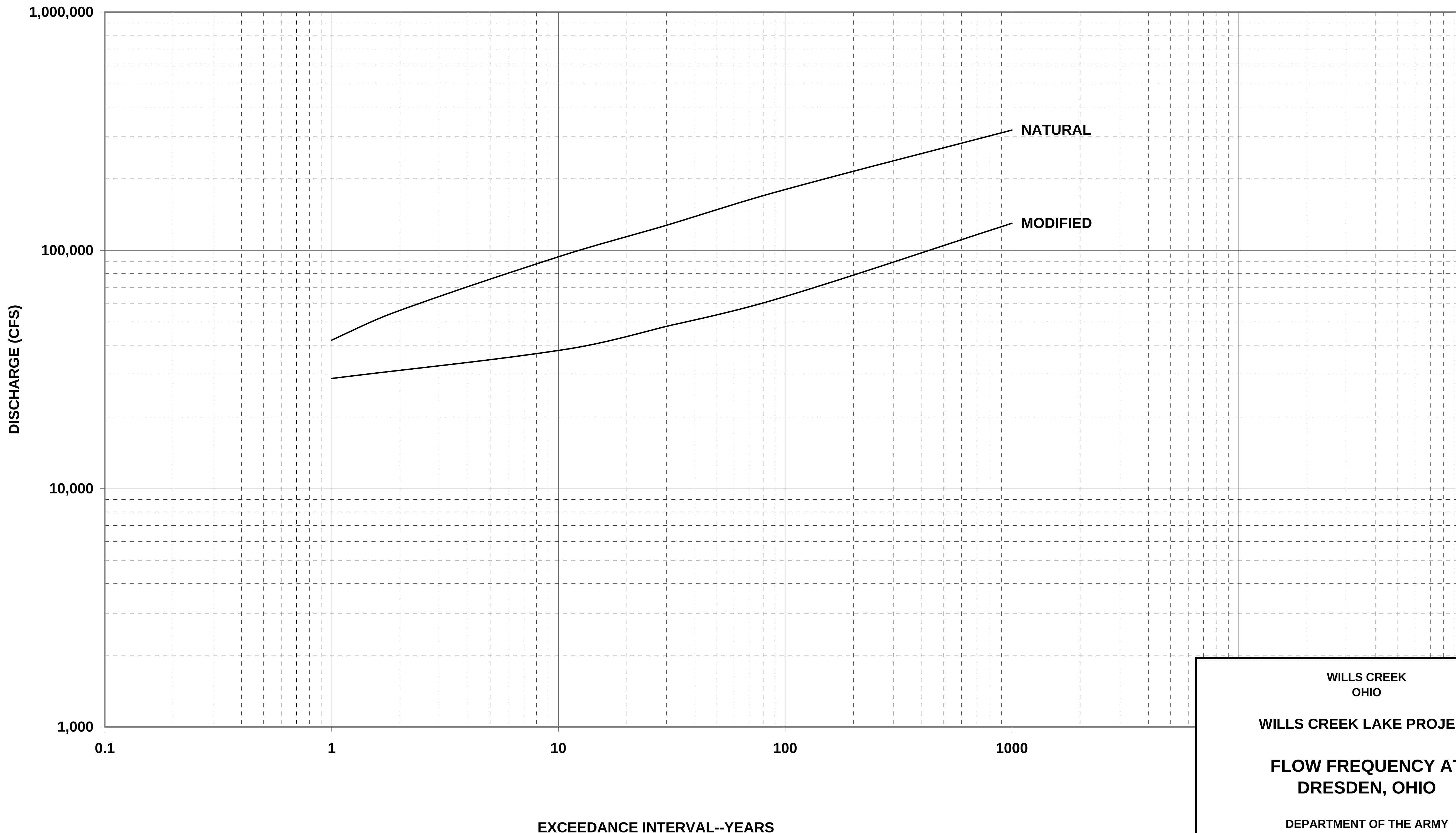
WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

FLOW FREQUENCY AT WILLS CREEK LAKE

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



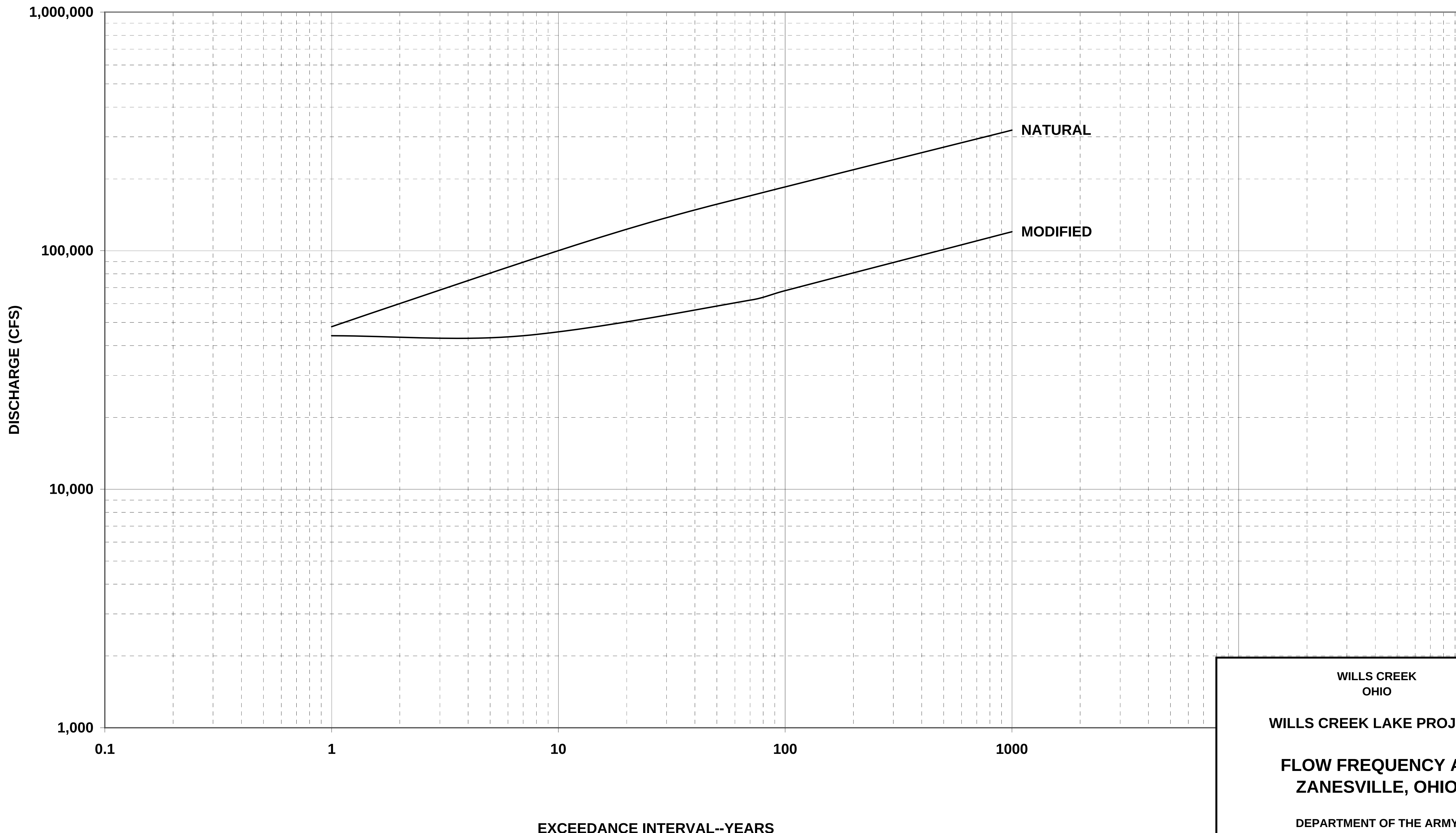
WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

**FLOW FREQUENCY AT
DRESDEN, OHIO**

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



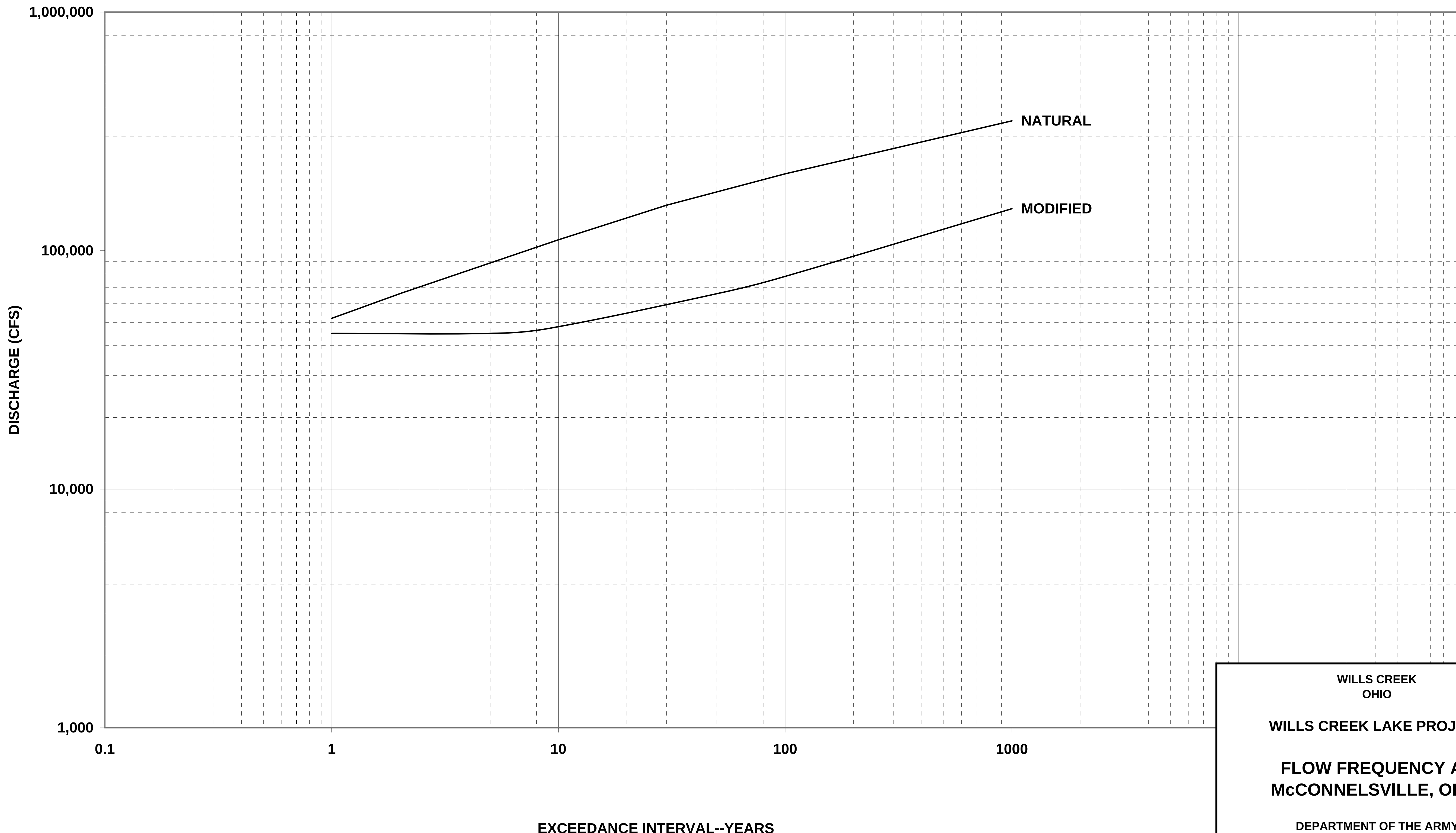
WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

FLOW FREQUENCY AT ZANESVILLE, OHIO

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



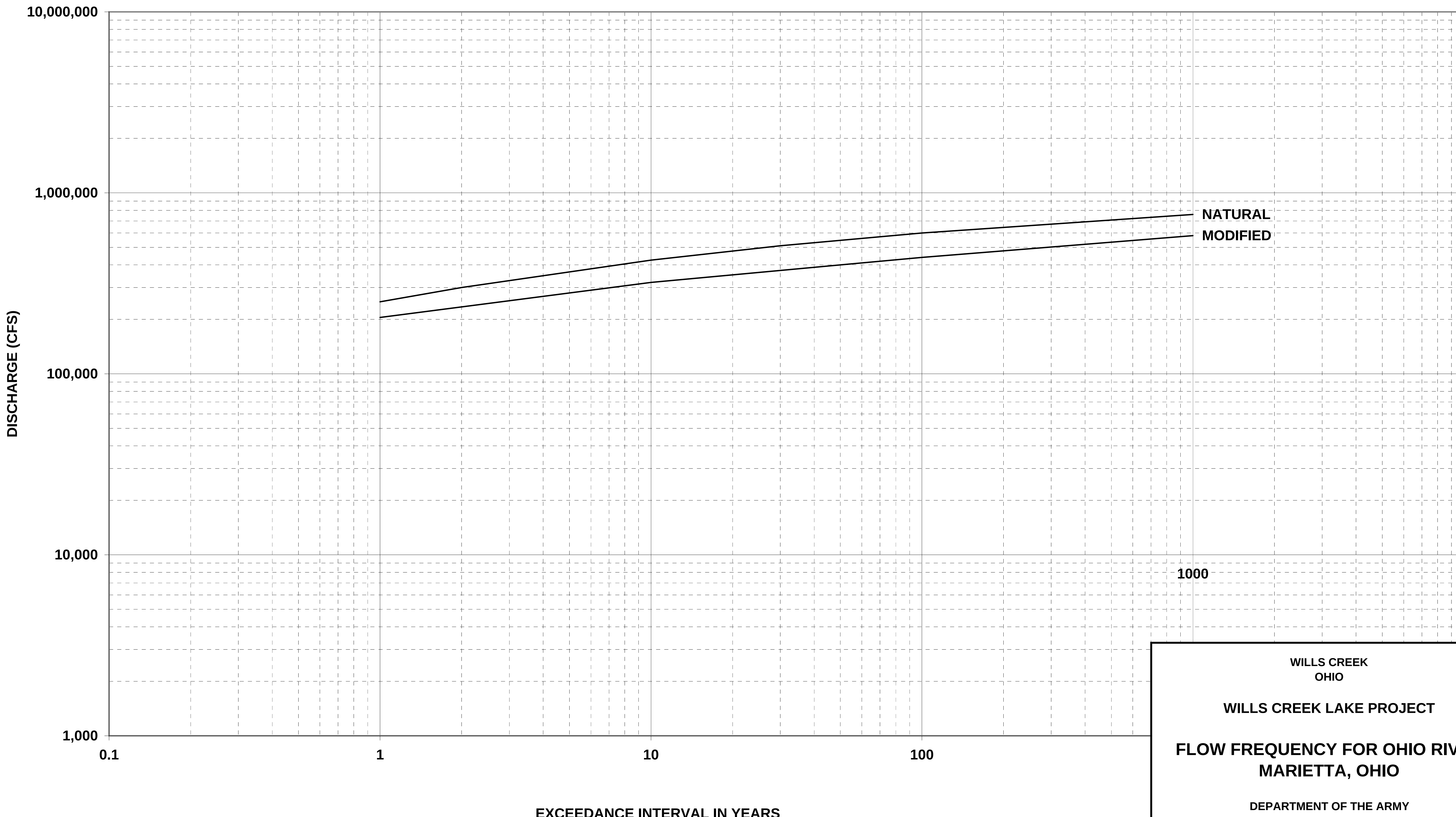
WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

FLOW FREQUENCY AT
McCONNELSVILLE, OHIO

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



WILLS CREEK
OHIO

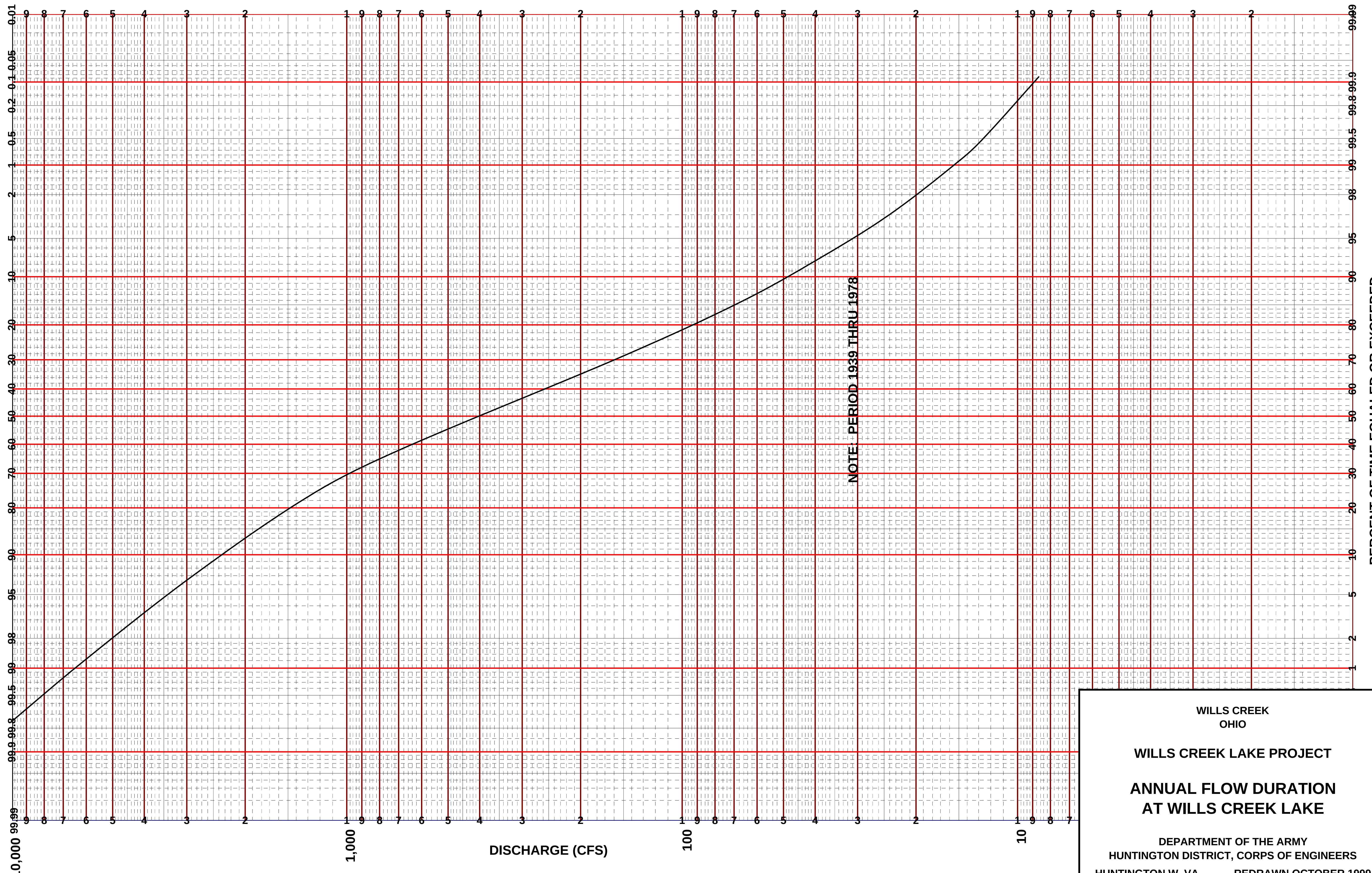
WILLS CREEK LAKE PROJECT

FLOW FREQUENCY FOR OHIO RIVER
MARIETTA, OHIO

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999

PROBABILITY X FOUR 3½ INCH LOGARITHMIC CYCLES



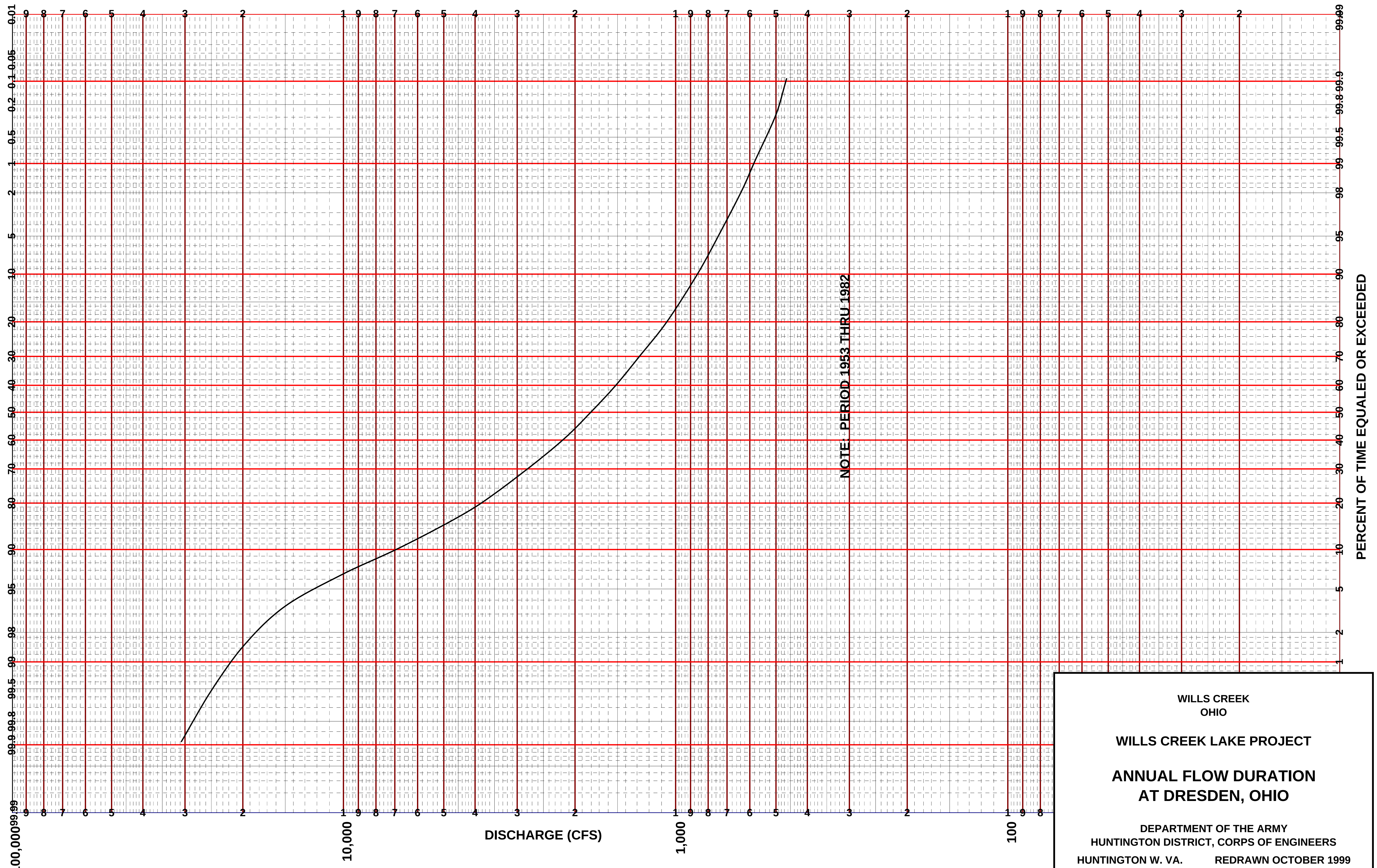
WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

ANNUAL FLOW DURATION AT WILLS CREEK LAKE

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON W. VA. REDRAWN OCTOBER 1999

PROBABILITY X FOUR 3½ INCH LOGARITHMIC CYCLES



WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

ANNUAL FLOW DURATION AT DRESDEN, OHIO

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON W. VA. REDRAWN OCTOBER 1999

/MUSKINGUM/MCMG5/STAGE-FLOW//01JAN72/USGS TABLE NO.09A/

FLOW IN CFS

NO	STAGE	FLOW
1	1.000	500.000
2	1.200	721.000
3	1.400	956.800
4	1.600	1210.000
5	1.800	1497.000
6	2.000	1819.000
7	2.200	2180.000
8	2.400	2580.000
9	2.600	3020.000
10	2.800	3580.000
11	3.000	4114.000
12	3.200	4600.000
13	3.400	5183.000
14	3.600	5800.000
15	3.800	6434.000
16	4.000	7100.000
17	4.200	7756.000
18	4.400	8438.000
19	4.600	9146.000
20	4.800	9879.000
21	5.000	10640.000
22	5.200	11420.000
23	5.400	12230.000
24	5.600	13060.000
25	5.800	13920.000
26	6.000	14800.000
27	6.200	15640.000
28	6.400	16500.000
29	6.600	17380.000
30	6.800	18280.000
31	7.000	19200.000
32	7.200	20130.000
33	7.400	21070.000
34	7.600	22030.000
35	7.800	23010.000
36	8.000	24000.000
37	8.200	25030.000
38	8.400	26080.000
39	8.600	27150.000
40	8.800	28230.000
41	9.000	29330.000
42	9.200	30450.000
43	9.400	31590.000
44	9.600	32740.000
45	9.800	33910.000
46	10.000	35100.000
47	10.200	36310.000
48	10.400	37530.000
49	10.600	38760.000
50	10.800	40020.000
51	11.000	41290.000
52	11.200	42580.000
53	11.400	43880.000
54	11.600	45200.000
55	11.800	46520.000
56	12.000	47860.000
57	12.250	49220.000
58	12.440	50590.000
59	12.640	51970.000
60	12.830	53370.000
61	13.040	54790.000
62	13.270	56220.000
63	13.490	57660.000
64	13.720	59120.000

65	13.950	60600.000
66	15.190	69600.000
67	16.250	78600.000
68	18.000	93000.000
69	20.000	111000.000
70	25.000	165000.000
71	30.000	225000.000
72	35.000	300000.000
73	37.000	340000.000

/MUSKINGUM/ZANF5/STAGE-FLOW//05NOV69/USGS TABLE NO.00MODIFIED/

FLOW IN CFS

NO	STAGE	FLOW
1	7.800	500.000
2	8.200	910.000
3	8.400	1140.000
4	8.600	1440.000
5	8.800	1780.000
6	9.000	2170.000
7	9.200	2590.000
8	9.400	3050.000
9	9.600	3540.000
10	9.800	4040.000
11	10.000	4570.000
12	10.200	5100.000
13	10.400	5650.000
14	10.600	6220.000
15	10.800	6770.000
16	11.000	7380.000
17	11.200	7980.000
18	11.400	8650.000
19	11.600	9330.000
20	11.800	10030.000
21	12.000	10800.000
22	12.200	11600.000
23	12.400	12400.000
24	12.600	13200.000
25	12.800	14000.000
26	13.000	14700.000
27	13.200	15500.000
28	13.400	16400.000
29	13.600	17200.000
30	13.800	18000.000
31	14.000	18800.000
32	14.200	19600.000
33	14.400	20400.000
34	14.600	21100.000
35	14.800	21900.000
36	15.000	22700.000
37	15.200	23300.000
38	15.400	24100.000
39	15.600	24900.000
40	15.800	25500.000
41	16.000	26200.000
42	16.200	26900.000
43	16.400	27700.000
44	16.600	28500.000
45	16.800	29200.000
46	17.000	29800.000
47	17.200	30600.000
48	17.400	31300.000
49	17.600	31900.000
50	17.800	32600.000
51	18.000	33400.000
52	18.200	34000.000
53	18.400	34600.000
54	18.600	35300.000
55	18.800	35900.000
56	19.000	36500.000
57	19.100	36900.000
58	19.200	37200.000
59	19.300	37500.000
60	19.400	37900.000
61	19.500	38200.000
62	20.800	44300.000
63	21.600	47650.000
64	22.300	50800.000

65	23.200	55000.000
66	24.200	59200.000
67	25.100	63500.000
68	26.000	67332.000
69	27.800	75000.000
70	30.200	85000.000
71	35.000	110000.000
72	40.000	145000.000
73	45.000	185000.000
74	50.000	228000.000
75	57.000	310000.000

/MUSKINGUM/ZANF5/STAGE-FLOW//05NOV69/USGS TABLE NO.00MODIFIED/

FLOW IN CFS

NO	STAGE	FLOW
1	7.800	500.000
2	8.200	910.000
3	8.400	1140.000
4	8.600	1440.000
5	8.800	1780.000
6	9.000	2170.000
7	9.200	2590.000
8	9.400	3050.000
9	9.600	3540.000
10	9.800	4040.000
11	10.000	4570.000
12	10.200	5100.000
13	10.400	5650.000
14	10.600	6220.000
15	10.800	6770.000
16	11.000	7380.000
17	11.200	7980.000
18	11.400	8650.000
19	11.600	9330.000
20	11.800	10030.000
21	12.000	10800.000
22	12.200	11600.000
23	12.400	12400.000
24	12.600	13200.000
25	12.800	14000.000
26	13.000	14700.000
27	13.200	15500.000
28	13.400	16400.000
29	13.600	17200.000
30	13.800	18000.000
31	14.000	18800.000
32	14.200	19600.000
33	14.400	20400.000
34	14.600	21100.000
35	14.800	21900.000
36	15.000	22700.000
37	15.200	23300.000
38	15.400	24100.000
39	15.600	24900.000
40	15.800	25500.000
41	16.000	26200.000
42	16.200	26900.000
43	16.400	27700.000
44	16.600	28500.000
45	16.800	29200.000
46	17.000	29800.000
47	17.200	30600.000
48	17.400	31300.000
49	17.600	31900.000
50	17.800	32600.000
51	18.000	33400.000
52	18.200	34000.000
53	18.400	34600.000
54	18.600	35300.000
55	18.800	35900.000
56	19.000	36500.000
57	19.100	36900.000
58	19.200	37200.000
59	19.300	37500.000
60	19.400	37900.000
61	19.500	38200.000
62	20.800	44300.000

63	21.600	47650.000
64	22.300	50800.000
65	23.200	55000.000
66	24.200	59200.000
67	25.100	63500.000
68	26.000	67332.000
69	27.800	75000.000
70	30.200	85000.000
71	35.000	110000.000
72	40.000	145000.000
73	45.000	185000.000
74	50.000	228000.000
75	57.000	310000.000

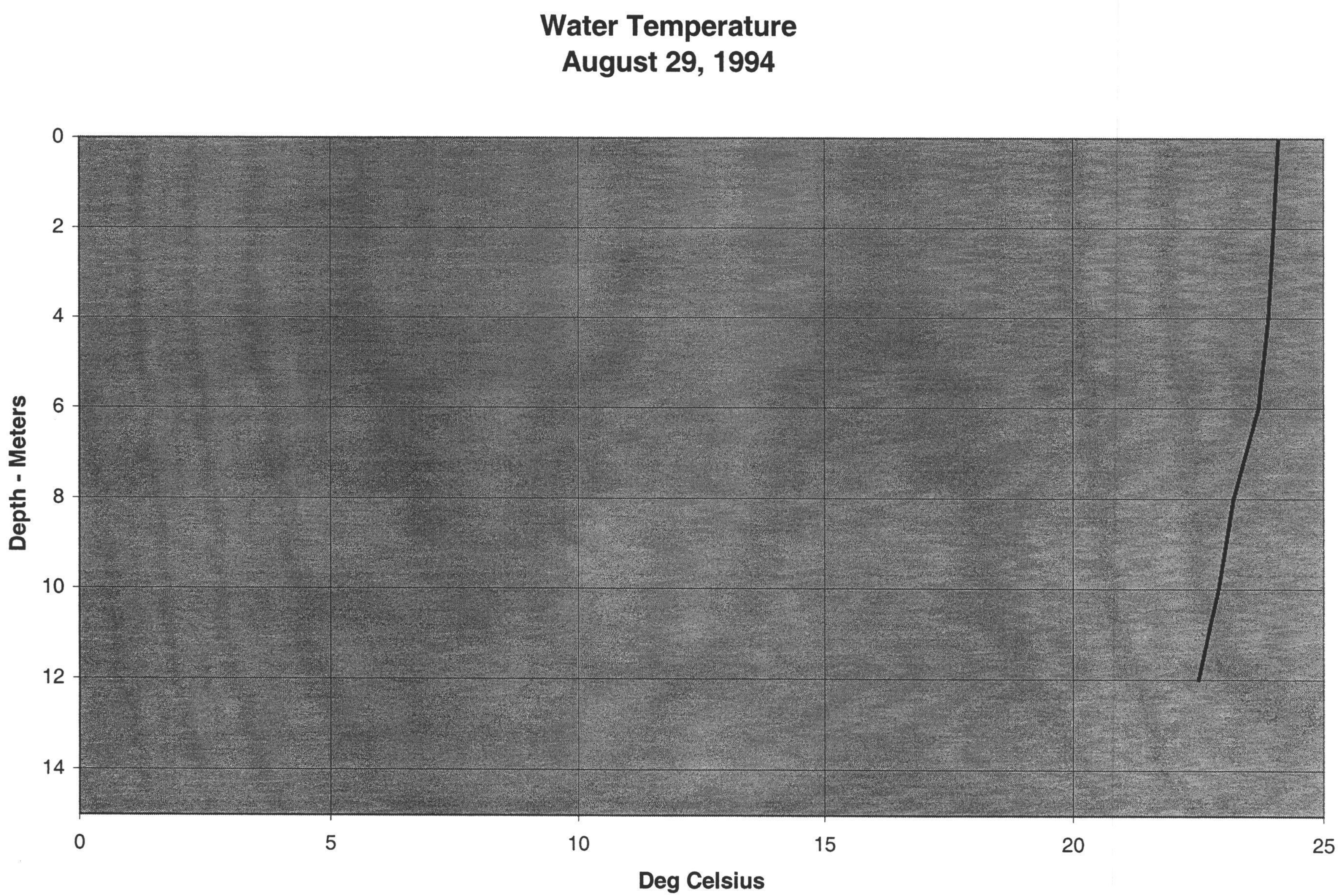
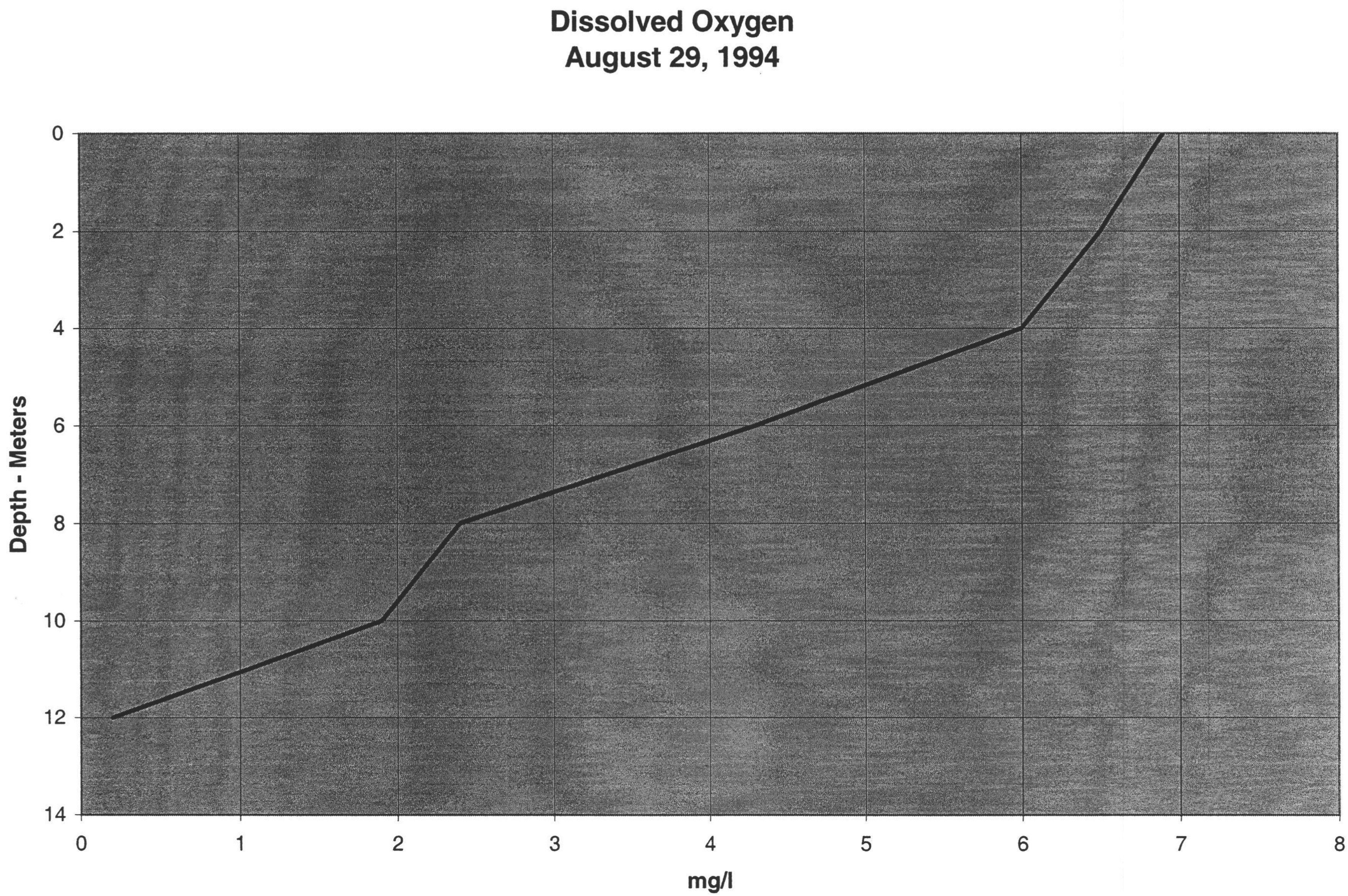
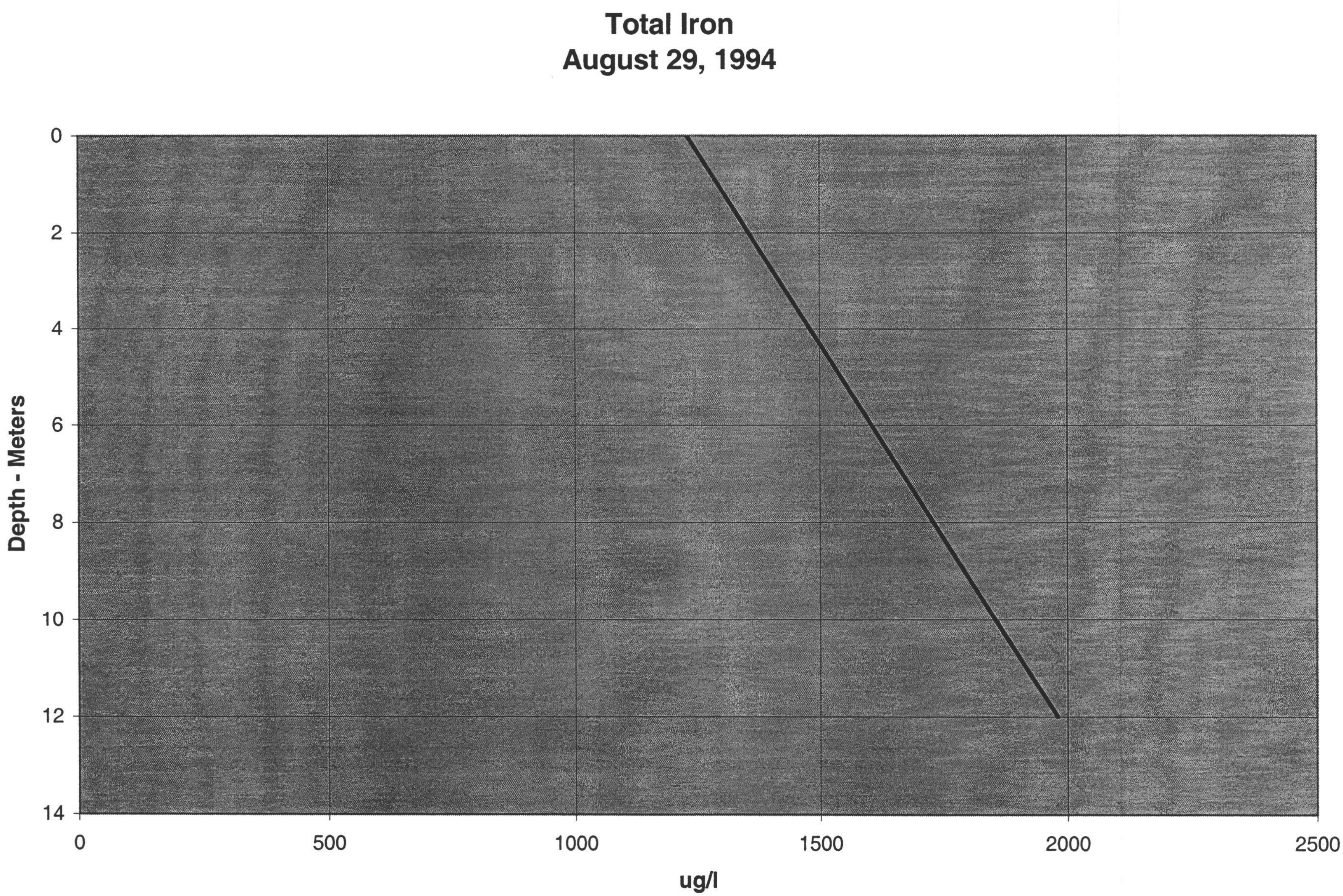

Water Temperature
August 29, 1994
Depth - Meters
0
2
4
6
8
10
12
14
0
5
10
15
20
25
Deg Celsius

Plate No. 4-11



Dissolved Oxygen
August 29, 1994
Depth - Meters
0
2
4
6
8
10
12
14
0
1
2
3
4
5
6
7
8
mg/l

Plate No. 4-12



Total Iron
August 29, 1994
Depth - Meters
0
2
4
6
8
10
12
14
0
500
1000
1500
2000
2500
ug/l

Plate No. 4-13

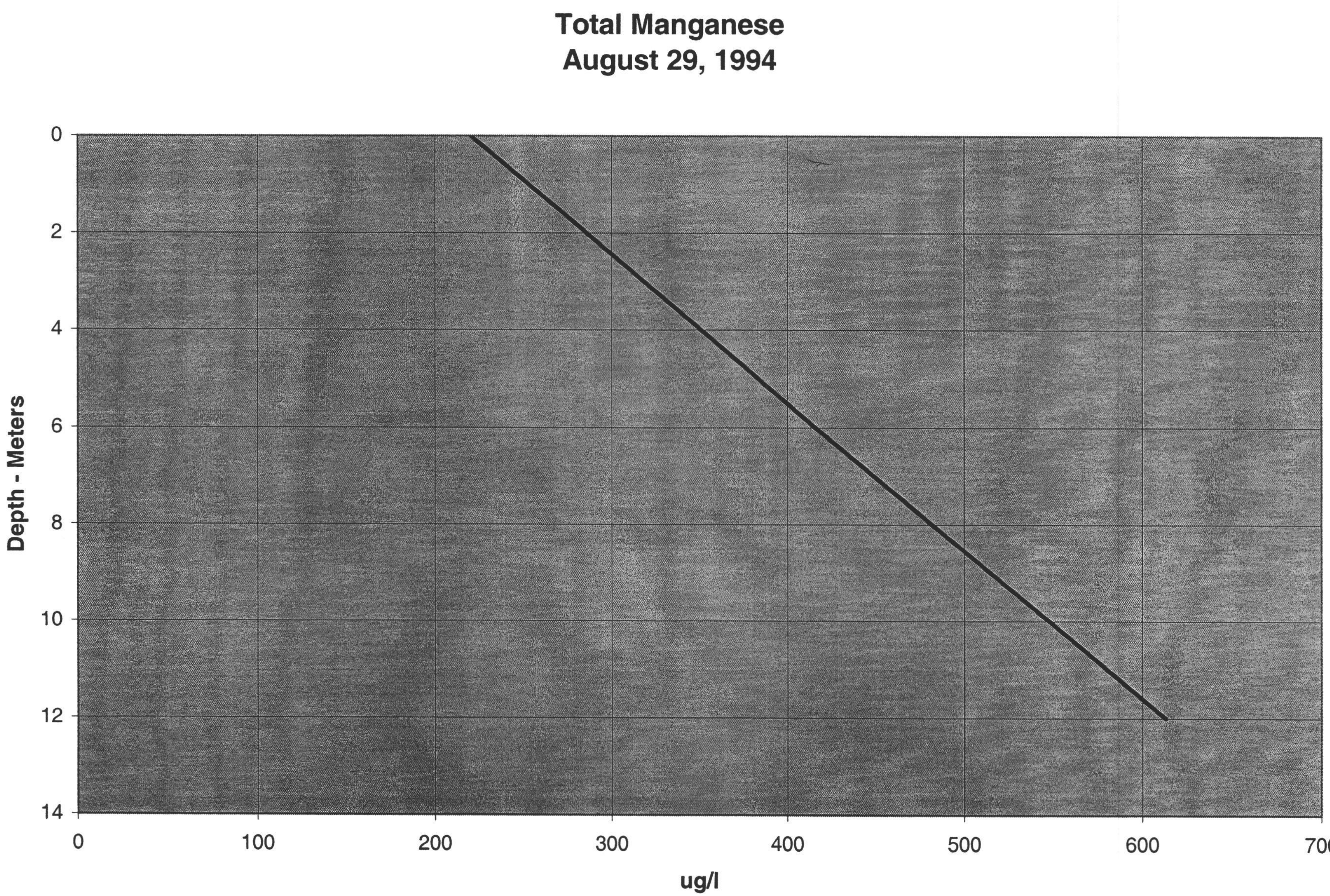
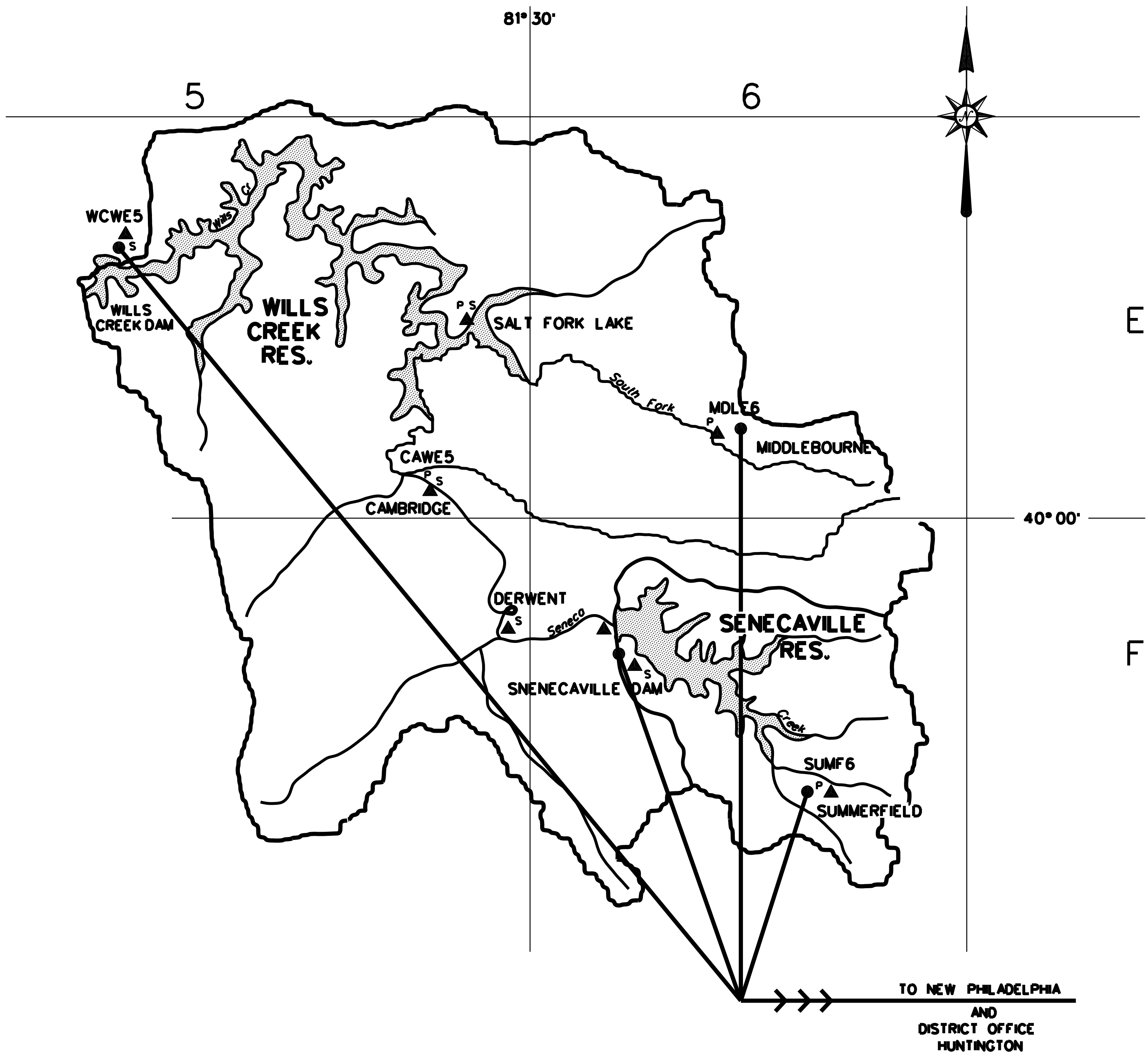


Plate No. 4-14

4-14



LEGEND

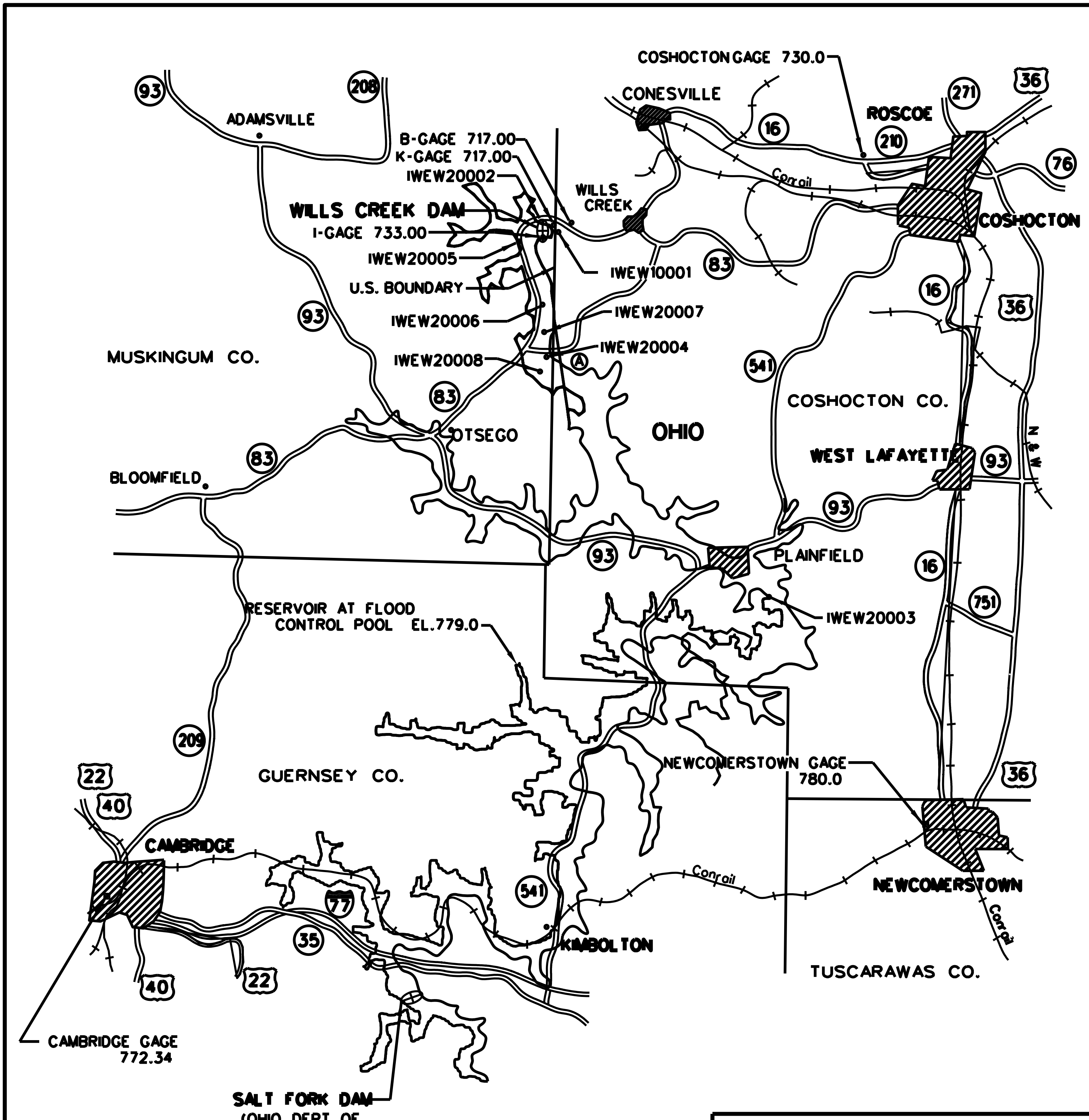
- WATERSHED BOUNDARY LINE
- RESERVOIR, SPILLWAY ELEVATION
- ● REPORTING PRECIPITATION STATION
- P PRECIPITATION
- S STAGE
- ▲ SATELLITE DATA PLATFORM
- TELEPHONE AND RADIO BACKUP
- TELEPHONE OBSERVERS

WILLS CREEK
OHIO

WILLS CREEK LAKE

HYDROLOGIC NETWORK

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W. VA. REDRAWN: OCT. 1999



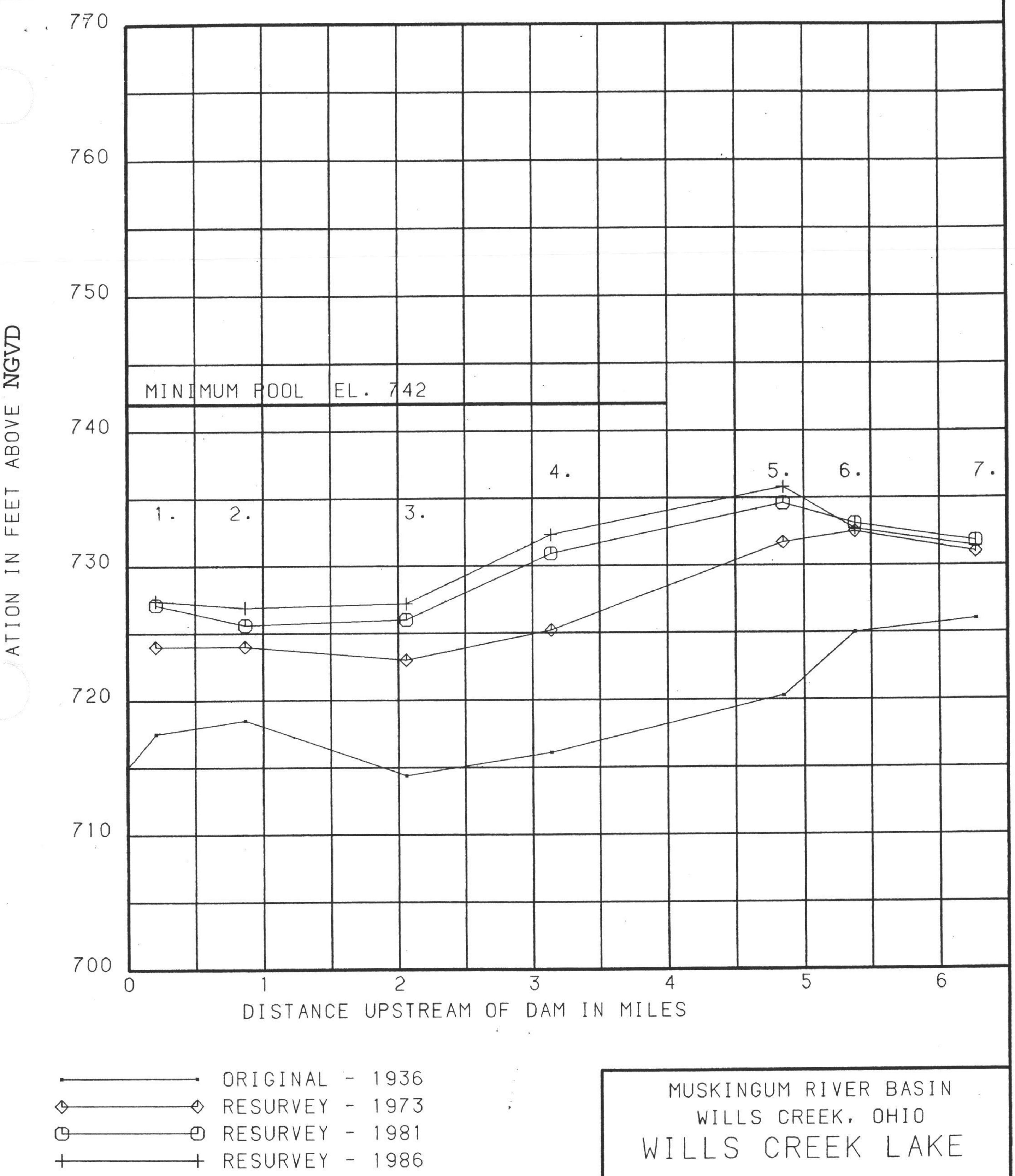
MUSKINGUM RIVER BASIN
WILLS CREEK

WILLS CREEK LAKE

SEDIMENT RANGES AND WATER QUALITY SAMPLING STATIONS

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT CORPS OF ENGINEERS

HUNTINGTON, W. VA. REDRAWN: OCT. 1999

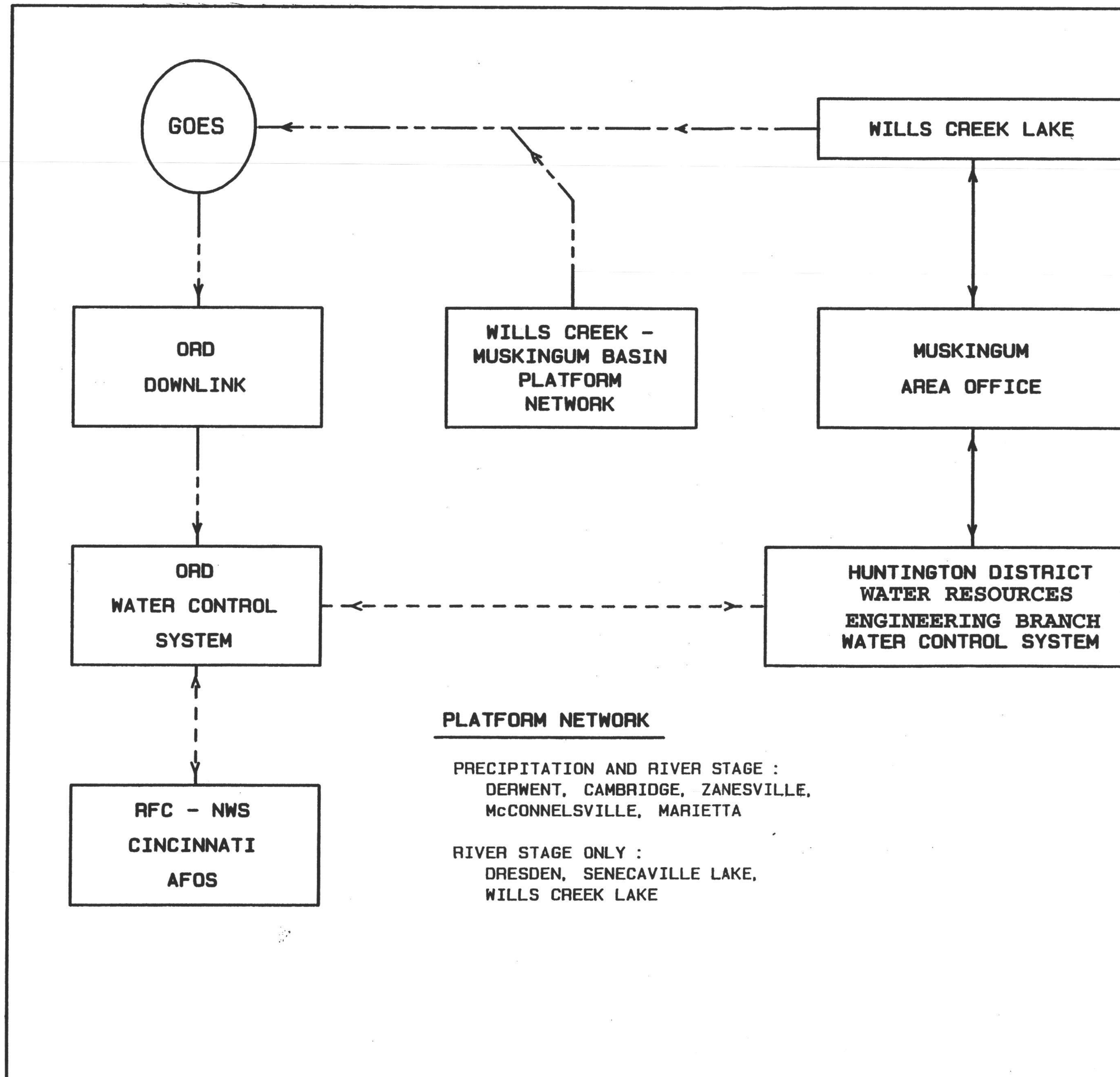


MUSKINGUM RIVER BASIN
WILLS CREEK, OHIO

WILLS CREEK LAKE

SEDIMENT RANGE BOTTOM PROFILE

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT CORPS OF ENGINEERS
HUNTINGTON, W. VA. AUGUST 1992

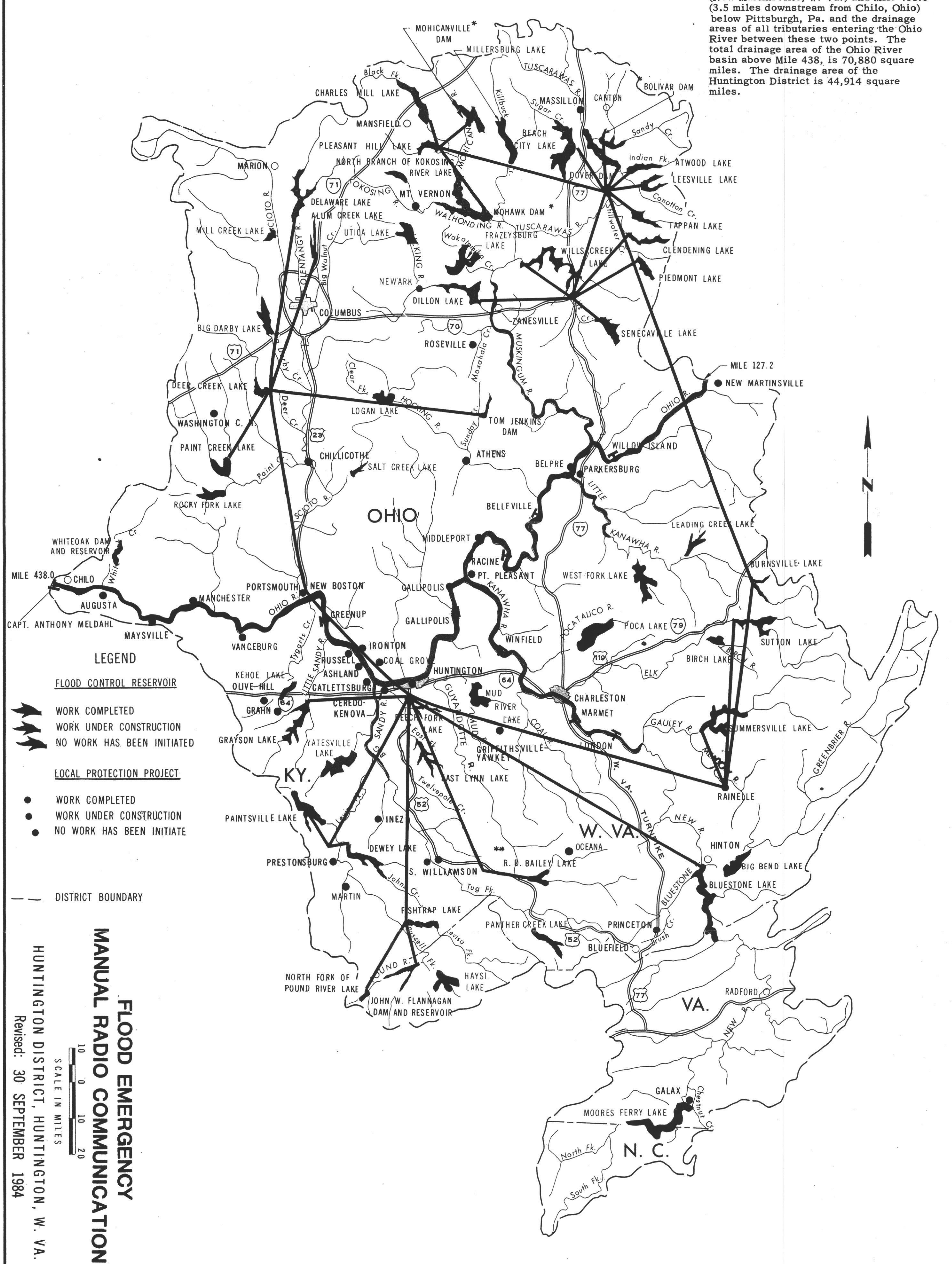


LINES OF COMMUNICATION

WILLS CREEK - MUSKINGUM RIVER BASINS

WILLS CREEK LAKE

The Huntington District includes the reach of the Ohio River between River Mile 127.2 (New Martinsville, W. Va.) and Mile 438.0 (3.5 miles downstream from Chilo, Ohio) below Pittsburgh, Pa. and the drainage areas of all tributaries entering the Ohio River between these two points. The total drainage area of the Ohio River basin above Mile 438, is 70,880 square miles. The drainage area of the Huntington District is 44,914 square miles.



FLOOD EMERGENCY MANUAL RADIO COMMUNICATION

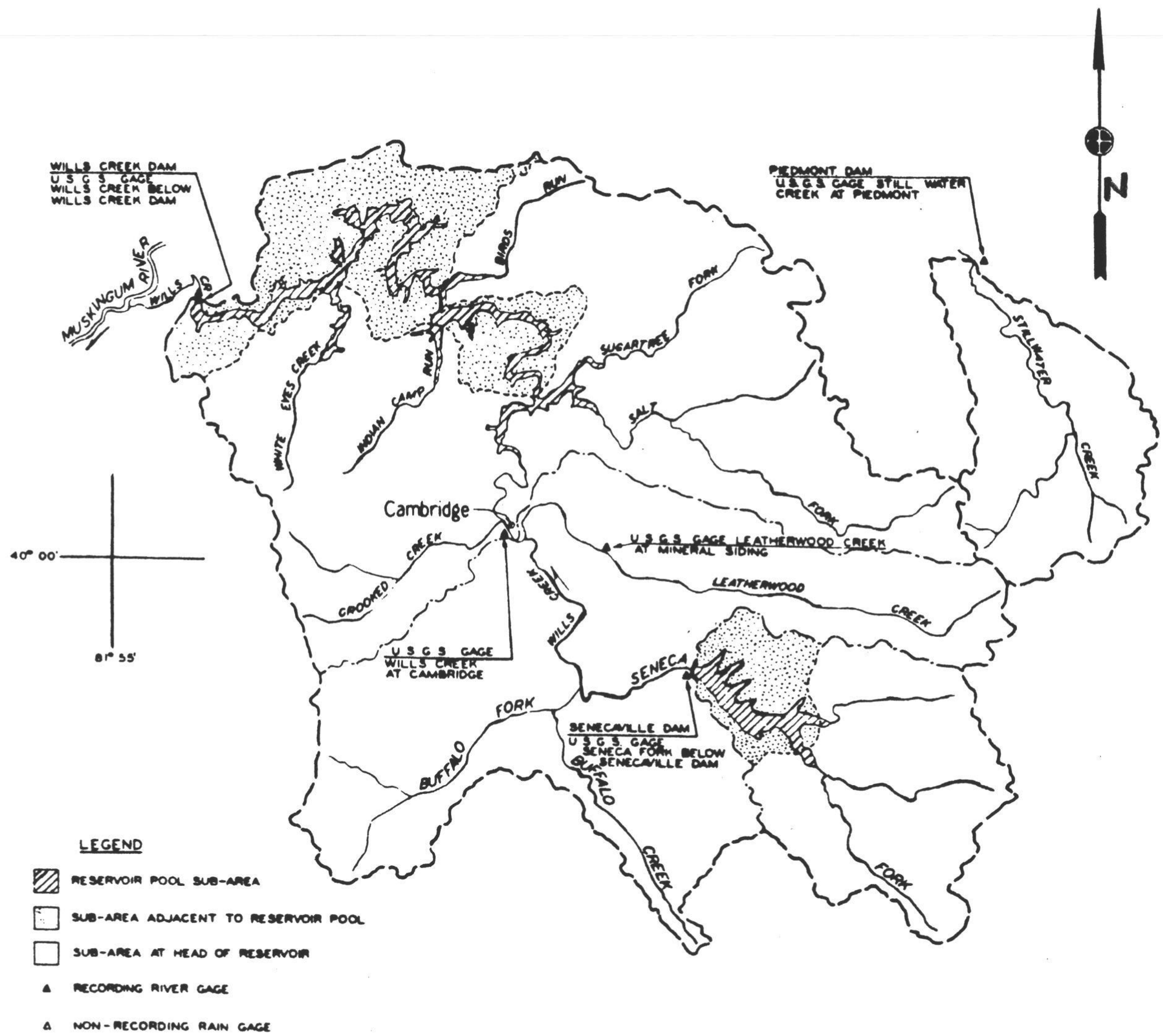
HUNTINGTON DISTRICT, HUNTINGTON, W. VA.

Revised: 30 SEPTEMBER 1984

*Dry dam, with flood control pool outlined.

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

Plate No. 5-5



WILLS CREEK
OHIO

WILLS CREEK LAKE

FORECAST AREA REACHES

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

WILLS CREEK LAKE - MUSKINGUM RIVER BASIN

BASIN CONFIGURATION

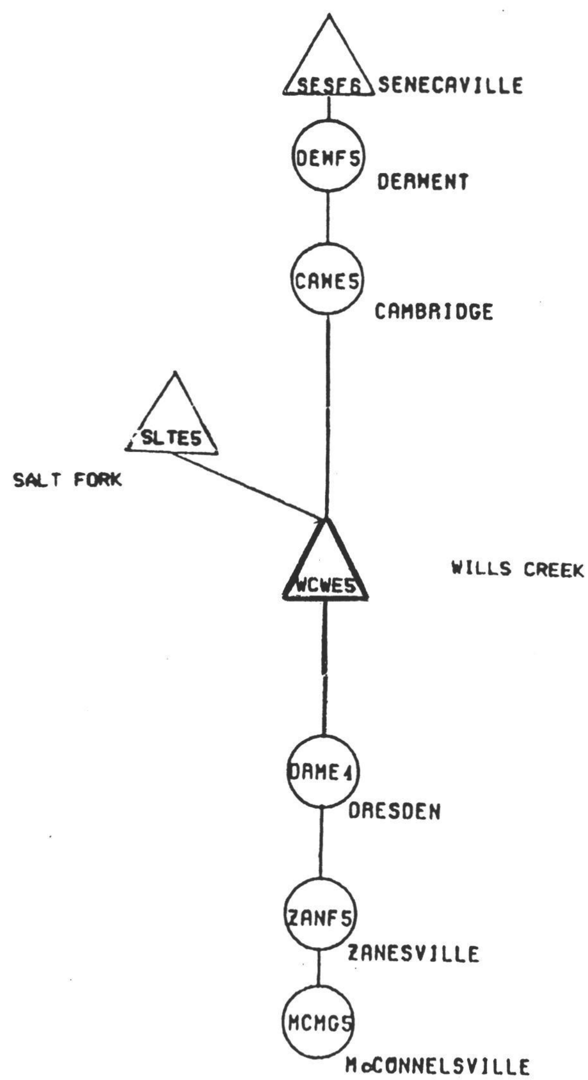


Plate No. 6-2

WILLS CREEK LAKE

WILLS CREEK

AREA AND CAPACITY TABLES

DRAINAGE AREA:

UNCONTROLLED = 726 **SQ. MI.**
CONTROLLED = 118 **SQ. MI.**
TOTAL = 844 **SQ. MI.**

1 IN. RUNOFF = 38,720 **AC. FT.**
(UNCONTROLLED AREA)

POOL ELEV.	CAPACITY AC. FT.	CAPACITY INCHES	AREA IN ACRES	POOL ELEV.	CAPACITY AC. FT.	CAPACITY INCHES	AREA IN ACRES
715	0	0.0	0	735	2,150	0.06	313
716	0	0.0	0	736	2,480	0.06	355
717	2	0.0	3	737	2,870	0.07	408
718	6	0.0	6	738	3,310	0.09	476
719	14	0.0	10	739	3,830	0.10	559
720	26	0.0	14	740	4,440	0.11	659
721	47	0.0	28	741	5,160	0.13	781
722	81	0.0	40	742	6,000	0.15	900
723	127	0.0	52	743	6,980	0.18	1,080
724	185	0.01	65	744	8,140	0.21	1,240
725	256	0.01	77	745	9,470	0.24	1,410
726	344	0.01	99	746	11,000	0.28	1,560
727	452	0.01	116	747	12,600	0.33	1,700
728	576	0.01	131	748	14,400	0.37	1,840
729	721	0.02	159	749	16,300	0.42	1,970
730	896	0.02	191	750	18,300	0.47	2,120
731	1,100	0.03	221	751	20,600	0.53	2,370
732	1,330	0.03	239	752	23,000	0.59	2,600
733	1,580	0.04	257	753	25,800	0.67	2,830
734	1,850	0.05	285	754	28,700	0.74	3,090

WILLS CREEK LAKE

WILLS CREEK

AREA AND CAPACITY TABLES

RAINAGE AREA:

UNCONTROLLED = 726 **SQ. MI.**
CONTROLLED = 118 **SQ. MI.**
TOTAL = 844 **SQ. MI.**

1 IN. RUNOFF = 38,720 **AC. FT.**
(UNCONTROLLED AREA)

POOL ELEV.	CAPACITY		AREA IN ACRES	POOL ELEV.	CAPACITY		AREA IN ACRES
	AC. FT.	INCHES			AC. FT.	INCHES	
755	31,900	0.82	3,320	775	154,000	3.98	9,570
756	35,400	0.91	3,540	776	163,800	4.23	10,000
757	39,000	1.01	3,780	777	174,100	4.50	10,500
758	42,900	1.11	4,030	778	184,800	4.77	11,000
759	47,100	1.22	4,240	779	196,000	5.06	11,450
760	51,400	1.33	4,500	780	207,700	5.36	12,000
761	56,100	1.45	4,810	781	220,000	5.68	12,600
762	61,000	1.58	5,100	782	232,900	6.01	13,200
763	66,300	1.71	5,390				
764	71,800	1.85	5,690				
765	77,700	2.01	5,990				
766	83,800	2.16	6,290				
767	90,300	2.33	6,600				
768	97,000	2.51	6,900				
769	104,100	2.69	7,200				
770	111,400	2.88	7,540				
771	119,100	3.08	7,900				
772	127,200	3.29	8,300				
773	135,800	3.51	8,710				
774	144,700	3.74	9,140				

WILLS CREEK

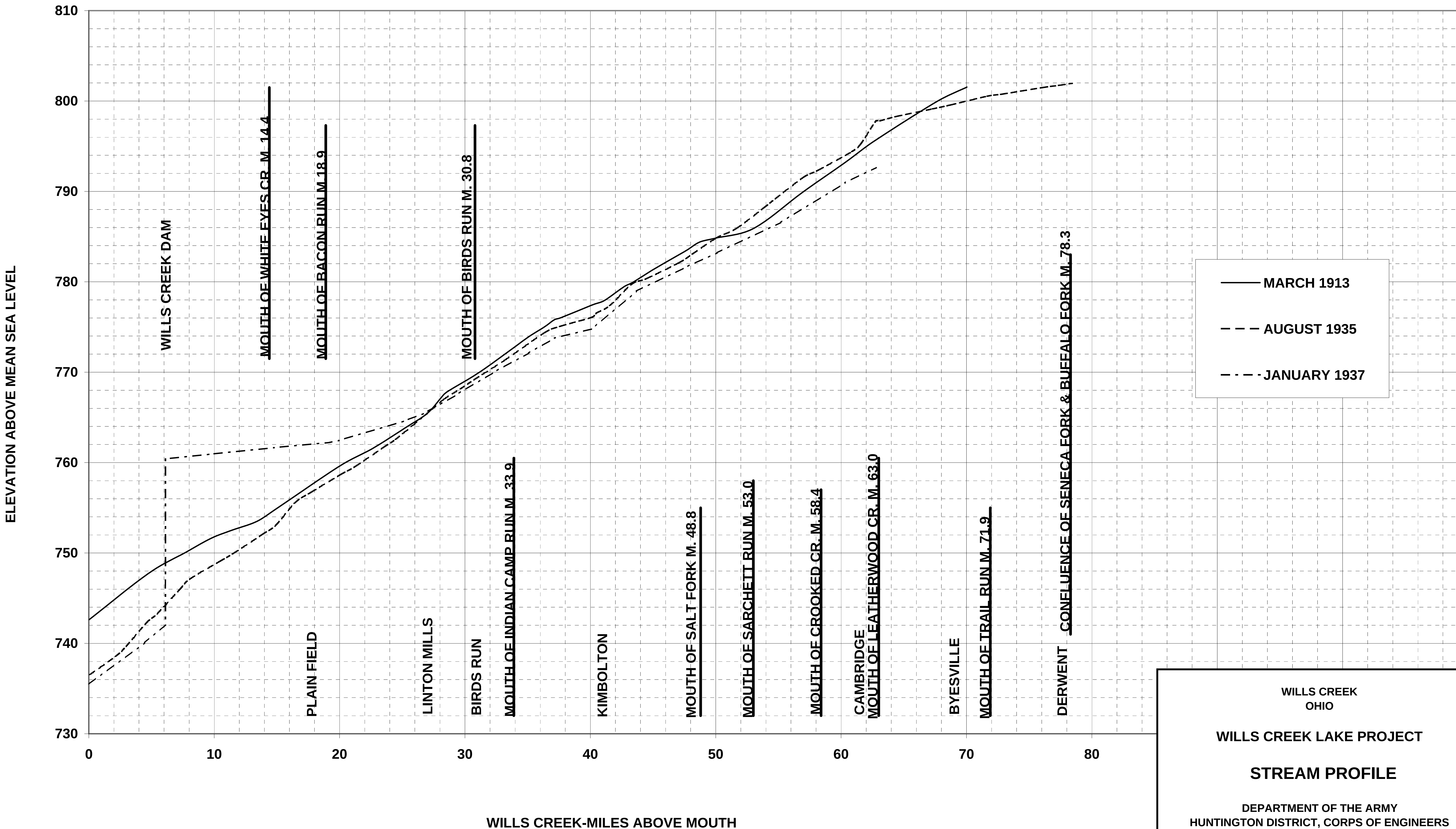
PERCENT STORAGE UTILIZATION - WINTER

ELEV	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
742	0.00	0.05	0.10	0.14	0.19	0.25	0.30	0.35	0.41	0.46
743	0.52	0.57	0.63	0.69	0.75	0.81	0.87	0.93	1.00	1.06
744	1.13	1.19	1.26	1.33	1.39	1.46	1.53	1.61	1.68	1.75
745	1.83	1.91	1.98	2.06	2.14	2.22	2.31	2.39	2.47	2.55
746	2.63	2.71	2.79	2.87	2.96	3.04	3.12	3.21	3.30	3.38
747	3.47	3.57	3.66	3.75	3.85	3.94	4.04	4.13	4.23	4.32
748	4.42	4.52	4.62	4.72	4.81	4.91	5.01	5.12	5.22	5.32
749	5.42	5.52	5.62	5.72	5.82	5.93	6.03	6.14	6.25	6.36
750	6.47	6.59	6.71	6.83	6.95	7.07	7.19	7.32	7.44	7.56
751	7.68	7.80	7.92	8.04	8.16	8.29	8.42	8.55	8.68	8.81
752	8.95	9.09	9.24	9.38	9.53	9.68	9.83	9.97	10.12	10.27
753	10.42	10.57	10.71	10.86	11.01	11.16	11.32	11.47	11.63	11.79
754	11.95	12.11	12.27	12.44	12.60	12.77	12.94	13.11	13.28	13.46
755	13.63	13.81	14.00	14.18	14.36	14.55	14.73	14.92	15.10	15.29
756	15.47	15.66	15.84	16.03	16.21	16.40	16.59	16.78	16.98	17.17
757	17.37	17.57	17.77	17.97	18.17	18.38	18.58	18.79	19.00	19.21
758	19.42	19.64	19.86	20.08	20.30	20.52	20.74	20.96	21.19	21.41
759	21.63	21.85	22.07	22.29	22.51	22.74	22.96	23.19	23.43	23.66
760	23.89	24.14	24.38	24.63	24.87	25.12	25.37	25.62	25.87	26.12
761	26.37	26.62	26.87	27.12	27.37	27.63	27.89	28.15	28.41	28.68
762	28.95	29.22	29.50	29.77	30.05	30.33	30.61	30.89	31.17	31.45
763	31.74	32.02	32.30	32.58	32.87	33.16	33.45	33.74	34.04	34.33
764	34.63	34.94	35.24	35.55	35.86	36.17	36.48	36.79	37.11	37.42
765	37.74	38.05	38.36	38.68	39.00	39.32	39.64	39.96	40.29	40.62
766	40.95	41.29	41.62	41.96	42.30	42.65	42.99	43.33	43.68	44.02
767	44.37	44.71	45.06	45.40	45.75	46.11	46.46	46.82	47.17	47.53
768	47.90	48.26	48.63	49.01	49.38	49.75	50.12	50.50	50.88	51.25
769	51.63	52.01	52.38	52.76	53.14	53.53	53.91	54.30	54.69	55.08
770	55.47	55.87	56.27	56.67	57.07	57.47	57.88	58.29	58.70	59.11
771	59.53	59.94	60.36	60.78	61.20	61.63	62.05	62.48	62.92	63.35
772	63.79	64.24	64.68	65.13	65.58	66.03	66.49	66.94	67.40	67.86
773	68.32	68.78	69.24	69.70	70.16	70.63	71.10	71.57	72.05	72.52
774	73.00	73.48	73.96	74.44	74.93	75.42	75.91	76.40	76.90	77.39
775	77.90	78.40	78.91	79.42	79.93	80.44	80.96	81.48	82.00	82.53
776	83.05	83.59	84.12	84.66	85.20	85.74	86.28	86.83	87.37	87.92
777	88.47	89.03	89.58	90.14	90.70	91.26	91.82	92.39	92.96	93.53
778	94.11	94.68	95.26	95.85	96.43	97.02	97.61	98.20	98.80	99.40
779	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

WILLS C

PERCENT STORAGE UTILIZATION - SUMMER

ELEV	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
742	0.00	0.05	0.10	0.14	0.19	0.25	0.30	0.35	0.41	0.46
743	0.52	0.57	0.63	0.69	0.75	0.81	0.87	0.93	1.00	1.06
744	1.13	1.19	1.26	1.33	1.39	1.46	1.53	1.61	1.68	1.75
745	1.83	1.91	1.98	2.06	2.14	2.22	2.31	2.39	2.47	2.55
746	2.63	2.71	2.79	2.87	2.96	3.04	3.12	3.21	3.30	3.38
747	3.47	3.57	3.66	3.75	3.85	3.94	4.04	4.13	4.23	4.32
748	4.42	4.52	4.62	4.72	4.81	4.91	5.01	5.12	5.22	5.32
749	5.42	5.52	5.62	5.72	5.82	5.93	6.03	6.14	6.25	6.36
750	6.47	6.59	6.71	6.83	6.95	7.07	7.19	7.32	7.44	7.56
751	7.68	7.80	7.92	8.04	8.16	8.29	8.42	8.55	8.68	8.81
752	8.95	9.09	9.24	9.38	9.53	9.68	9.83	9.97	10.12	10.27
753	10.42	10.57	10.71	10.86	11.01	11.16	11.32	11.47	11.63	11.79
754	11.95	12.11	12.27	12.44	12.60	12.77	12.94	13.11	13.28	13.46
755	13.63	13.81	14.00	14.18	14.36	14.55	14.73	14.92	15.10	15.29
756	15.47	15.66	15.84	16.03	16.21	16.40	16.59	16.78	16.98	17.17
757	17.37	17.57	17.77	17.97	18.17	18.38	18.58	18.79	19.00	19.21
758	19.42	19.64	19.86	20.08	20.30	20.52	20.74	20.96	21.19	21.41
759	21.63	21.85	22.07	22.29	22.51	22.74	22.96	23.19	23.43	23.66
760	23.89	24.14	24.38	24.63	24.87	25.12	25.37	25.62	25.87	26.12
761	26.37	26.62	26.87	27.12	27.37	27.63	27.89	28.15	28.41	28.68
762	28.95	29.22	29.50	29.77	30.05	30.33	30.61	30.89	31.17	31.45
763	31.74	32.02	32.30	32.58	32.87	33.16	33.45	33.74	34.04	34.33
764	34.63	34.94	35.24	35.55	35.86	36.17	36.48	36.79	37.11	37.42
765	37.74	38.05	38.36	38.68	39.00	39.32	39.64	39.96	40.29	40.62
766	40.95	41.29	41.62	41.96	42.30	42.65	42.99	43.33	43.68	44.02
767	44.37	44.71	45.06	45.40	45.75	46.11	46.46	46.82	47.17	47.53
768	47.90	48.26	48.63	49.01	49.38	49.75	50.12	50.50	50.88	51.25
769	51.63	52.01	52.38	52.76	53.14	53.53	53.91	54.30	54.69	55.08
770	55.47	55.87	56.27	56.67	57.07	57.47	57.88	58.29	58.70	59.11
771	59.53	59.94	60.36	60.78	61.20	61.63	62.05	62.48	62.92	63.35
772	63.79	64.24	64.68	65.13	65.58	66.03	66.49	66.94	67.40	67.86
773	68.32	68.78	69.24	69.70	70.16	70.63	71.10	71.57	72.05	72.52
774	73.00	73.48	73.96	74.44	74.93	75.42	75.91	76.40	76.90	77.39
775	77.90	78.40	78.91	79.42	79.93	80.44	80.96	81.48	82.00	82.53
776	83.05	83.59	84.12	84.66	85.20	85.74	86.28	86.83	87.37	87.92
777	88.47	89.03	89.58	90.14	90.70	91.26	91.82	92.39	92.96	93.53
778	94.11	94.68	95.26	95.85	96.43	97.02	97.61	98.20	98.80	99.40
779	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00



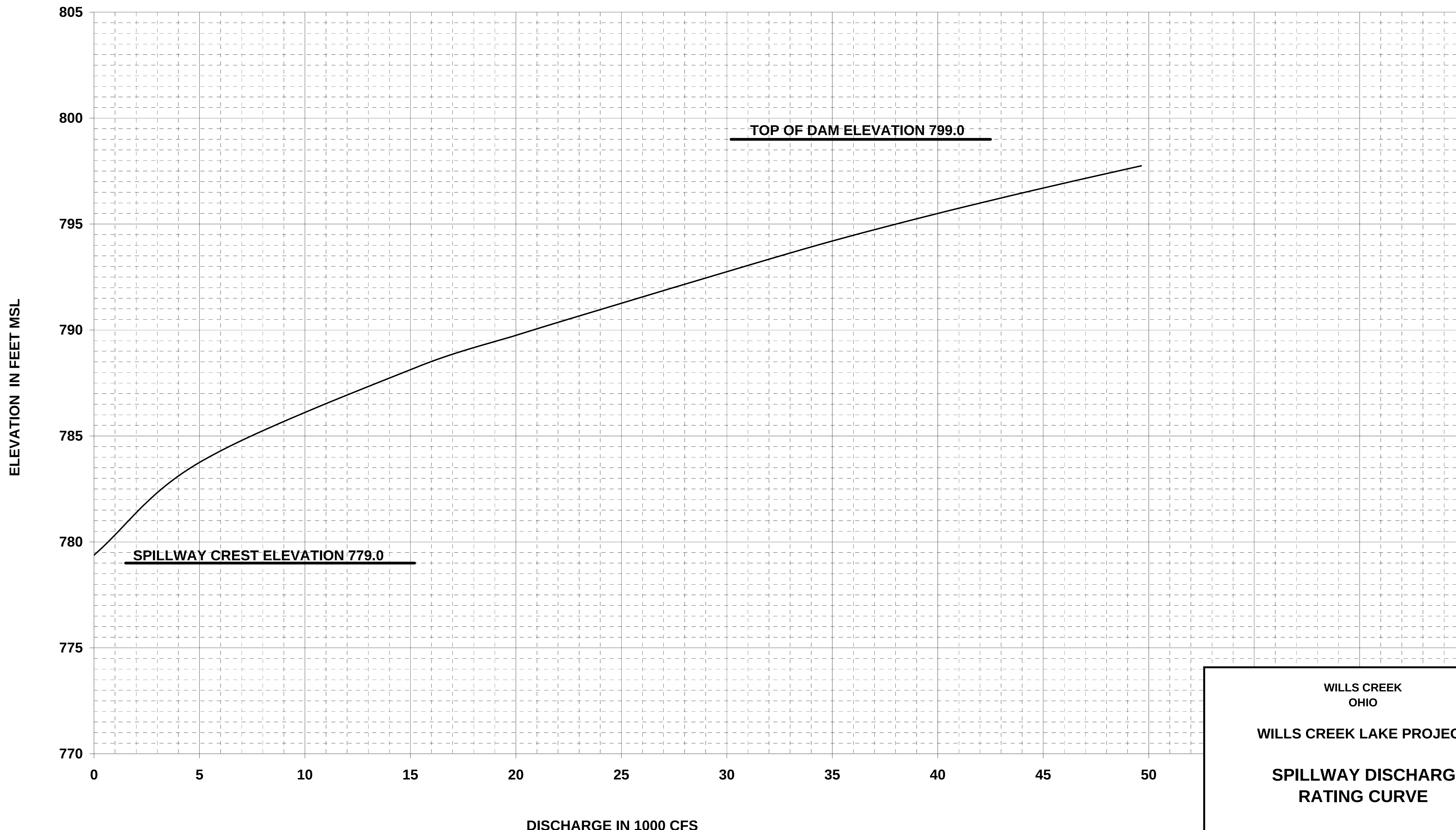
WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

STREAM PROFILE

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

SPILLWAY DISCHARGE RATING CURVE

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY - WATER RESOURCES DIVISION
EXPANDED RATING TABLE
TYPE: LOG

03143500
DATE PROCESSED: 07-15-2002 @ 13:12 BY chawkins
WILLS C BL WILLS C DAM AT WILLS CREEK OH
DD: 2 TYPE: 001 RATING NO: 17
OFFSET: 1.00
START DATE/TIME: 01-05-1990 (2400)

INPUT VALUE	GAGE HEIGHT .00	.01	.02	(EXPANDED PRECISION) .03	.04	.05	.06	.07	.08	.09	DIFF IN Y PER .1 UNITS
1.10	14.100*	14.711	15.293	15.848	16.380	16.891	17.383	17.859	18.320	18.766	5.100
1.20	19.200*	19.923	20.637	21.343	22.042	22.734	23.420	24.099	24.771	25.439	6.900
1.30	26.100*	27.014	27.929	28.846	29.764	30.684	31.604	32.527	33.450	34.374	9.200
1.40	35.300*	36.479	37.667	38.865	40.072	41.288	42.513	43.747	44.989	46.240	12.200
1.50	47.500*	48.791	50.091	51.399	52.717	54.043	55.378	56.721	58.072	59.432	13.300
1.60	60.800*	62.186	63.580	64.982	66.392	67.811	69.237	70.671	72.113	73.563	14.220
1.70	75.020	76.485	77.957	79.437	80.925	82.419	83.921	85.430	86.946	88.470	14.980
1.80	90.000*	91.537	93.081	94.632	96.190	97.755	99.326	100.904	102.488	104.079	15.677
1.90	105.677	107.281	108.891	110.508	112.131	113.760	115.396	117.038	118.686	120.340	16.323
2.00	122.000*	123.604	125.214	126.828	128.448	130.072	131.701	133.335	134.973	136.617	16.265
2.10	138.265	139.918	141.575	143.237	144.904	146.576	148.251	149.932	151.617	153.306	16.735
2.20	155.000*	156.753	158.510	160.273	162.041	163.814	165.592	167.375	169.163	170.956	17.754
2.30	172.754	174.557	176.365	178.177	179.995	181.817	183.644	185.476	187.313	189.154	18.246
2.40	191.000*	192.811	194.627	196.446	198.270	200.098	201.930	203.766	205.606	207.451	18.299
2.50	209.299	211.151	213.007	214.868	216.732	218.600	220.472	222.348	224.228	226.112	18.701
2.60	228.000*	229.958	231.920	233.887	235.859	237.835	239.815	241.800	243.789	245.783	19.781
2.70	247.781	249.783	251.790	253.801	255.817	257.837	259.861	261.889	263.922	265.959	20.219
2.80	268.000*	270.014	272.031	274.053	276.078	278.107	280.140	282.177	284.218	286.262	20.311
2.90	288.311	290.363	292.418	294.478	296.542	298.609	300.680	302.754	304.832	306.914	20.689
3.00	309.000*	311.023	313.049	315.078	317.111	319.146	321.184	323.226	325.270	327.318	20.368
3.10	329.368	331.422	333.479	335.538	337.601	339.666	341.735	343.806	345.881	347.958	20.670
3.20	350.038	352.121	354.208	356.297	358.388	360.483	362.581	364.681	366.785	368.891	20.962
3.30	371.000*	373.246	375.496	377.750	380.007	382.268	384.533	386.802	389.075	391.351	22.631
3.40	393.631	395.915	398.202	400.493	402.788	405.087	407.389	409.695	412.004	414.317	23.003
3.50	416.634	418.954	421.278	423.606	425.937	428.272	430.611	432.953	435.298	437.647	23.366
3.60	440.000*	442.202	444.407	446.614	448.824	451.036	453.251	455.468	457.688	459.910	22.135
3.70	462.135	464.362	466.591	468.824	471.058	473.295	475.535	477.777	480.021	482.268	22.382
3.80	484.517	486.768	489.023	491.279	493.538	495.799	498.062	500.328	502.597	504.868	22.624
3.90	507.141	509.416	511.694	513.974	516.256	518.541	520.828	523.118	525.410	527.704	22.859
4.00	530.000*	532.162	534.326	536.492	538.658	540.827	542.997	545.169	547.342	549.517	21.694
4.10	551.694	553.872	556.051	558.233	560.415	562.600	564.785	566.973	569.162	571.352	21.850
4.20	573.544	575.738	577.933	580.129	582.328	584.527	586.728	588.931	591.135	593.341	22.004
4.30	595.548	597.756	599.967	602.178	604.391	606.606	608.822	611.039	613.258	615.479	22.153
4.40	617.701	619.924	622.149	624.375	626.603	628.832	631.063	633.295	635.529	637.764	22.299
4.50	640.000*	642.354	644.711	647.069	649.429	651.791	654.155	656.520	658.888	661.258	23.629
4.60	663.629	666.002	668.378	670.755	673.134	675.515	677.897	680.282	682.668	685.057	23.818
4.70	687.447	689.839	692.233	694.629	697.026	699.426	701.827	704.230	706.635	709.042	24.004
4.80	711.451	713.861	716.273	718.687	721.103	723.521	725.940	728.361	730.784	733.209	24.185

EXPANDED RATING TABLE TYPE: LOG
DATE PROCESSED: 07-15-2002 @ 13:12 BY chawkins

03143500
WILLS C BL WILLS C DAM AT WILLS CREEK OH DD: 2 TYPE: 001 RATING NO: 17
OFFSET: 1.00 START DATE/TIME: 01-05-1990 (2400)

INPUT VALUE	GAGE HEIGHT .00	.01	.02	(EXPANDED PRECISION) .03	.04	.05	.06	.07	.08	.09	DIFF IN Y PER .1 UNITS
4.90	735.636	738.064	740.495	742.927	745.360	747.796	750.233	752.672	755.113	757.556	24.364
5.00	760.000*	762.366	764.733	767.101	769.471	771.843	774.215	776.590	778.965	781.343	23.721
5.10	783.721	786.101	788.482	790.865	793.249	795.635	798.022	800.410	802.800	805.191	23.863
5.20	807.584	809.978	812.374	814.770	817.169	819.568	821.969	824.371	826.775	829.180	24.002
5.30	831.586	833.994	836.404	838.814	841.226	843.639	846.054	848.470	850.887	853.306	24.140
5.40	855.726	858.148	860.570	862.994	865.420	867.846	870.274	872.704	875.135	877.567	24.274
5.50	880.000*	882.373	884.748	887.123	889.500	891.878	894.256	896.636	899.017	901.399	23.782
5.60	903.782	906.167	908.552	910.939	913.327	915.716	918.105	920.496	922.889	925.282	23.894
5.70	927.676	930.071	932.468	934.865	937.263	939.663	942.064	944.466	946.869	949.272	24.002
5.80	951.678	954.083	956.491	958.899	961.308	963.718	966.130	968.542	970.956	973.371	24.108
5.90	975.786	978.203	980.620	983.039	985.459	987.880	990.302	992.725	995.149	997.574	24.214
6.00	1000.000*	1003.116	1006.236	1009.359	1012.486	1015.616	1018.749	1021.886	1025.026	1028.171	31.318
6.10	1031.318	1034.469	1037.623	1040.781	1043.941	1047.106	1050.273	1053.445	1056.620	1059.798	31.661
6.20	1062.979	1066.164	1069.353	1072.545	1075.740	1078.938	1082.140	1085.346	1088.555	1091.767	32.004
6.30	1094.983	1098.201	1101.424	1104.649	1107.879	1111.111	1114.347	1117.586	1120.828	1124.074	32.341
6.40	1127.324	1130.576	1133.832	1137.091	1140.354	1143.620	1146.890	1150.162	1153.438	1156.717	32.676
6.50	1160.000*	1163.317	1166.636	1169.961	1173.288	1176.618	1179.952	1183.289	1186.630	1189.974	33.321
6.60	1193.321	1196.672	1200.026	1203.384	1206.745	1210.110	1213.478	1216.850	1220.224	1223.603	33.663
6.70	1226.984	1230.369	1233.758	1237.149	1240.545	1243.944	1247.345	1250.750	1254.159	1257.571	34.003
6.80	1260.987	1264.406	1267.828	1271.253	1274.682	1278.114	1281.550	1284.989	1288.431	1291.877	34.339
6.90	1295.326	1298.778	1302.234	1305.693	1309.156	1312.621	1316.090	1319.563	1323.038	1326.518	34.674
7.00	1330.000*	1334.242	1338.491	1342.747	1347.008	1351.276	1355.551	1359.832	1364.120	1368.414	42.714
7.10	1372.714	1377.021	1381.334	1385.654	1389.980	1394.313	1398.651	1402.997	1407.349	1411.708	43.358
7.20	1416.072	1420.443	1424.821	1429.205	1433.596	1437.992	1442.396	1446.805	1451.222	1455.644	44.001
7.30	1460.073	1464.509	1468.951	1473.398	1477.854	1482.315	1486.782	1491.256	1495.736	1500.223	44.643
7.40	1504.716	1509.216	1513.722	1518.234	1522.753	1527.278	1531.810	1536.347	1540.892	1545.443	45.284
7.50	1550.000*	1554.815	1559.638	1564.468	1569.306	1574.152	1579.005	1583.866	1588.734	1593.610	48.493
7.60	1598.493	1603.383	1608.281	1613.187	1618.100	1623.021	1627.950	1632.886	1637.829	1642.780	49.245
7.70	1647.738	1652.704	1657.678	1662.660	1667.648	1672.644	1677.648	1682.659	1687.678	1692.705	50.000
7.80	1697.738	1702.780	1707.829	1712.885	1717.950	1723.021	1728.101	1733.187	1738.282	1743.383	50.755
7.90	1748.493	1753.609	1758.733	1763.866	1769.005	1774.153	1779.307	1784.469	1789.639	1794.816	51.507
8.00	1800.000*	1804.471	1808.945	1813.424	1817.908	1822.397	1826.891	1831.389	1835.891	1840.398	44.910
8.10	1844.910	1849.427	1853.949	1858.475	1863.006	1867.542	1872.082	1876.626	1881.177	1885.730	45.379
8.20	1890.289	1894.854	1899.422	1903.994	1908.572	1913.154	1917.742	1922.333	1926.929	1931.530	45.847
8.30	1936.136	1940.746	1945.361	1949.981	1954.605	1959.233	1963.867	1968.505	1973.148	1977.795	46.311
8.40	1982.447	1987.104	1991.765	1996.431	2001.102	2005.777	2010.457	2015.141	2019.830	2024.524	46.776
8.50	2029.223	2033.927	2038.634	2043.345	2048.062	2052.784	2057.510	2062.241	2066.976	2071.716	47.238

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

EXPANDED RATING TABLE

TYPE: LOG

DATE PROCESSED: 07-15-2002 @ 13:12 BY chawkins

03143500
WILLS C BL WILLS C DAM AT WILLS CREEK OH
OFFSET: 1.00

DD: 2 TYPE: 001 RATING NO: 17
START DATE/TIME: 01-05-1990 (2400)

INPUT VALUE	GAGE HEIGHT .00	.01	.02	(EXPANDED PRECISION) .03	.04	.05	.06	.07	.08	.09	DIFF IN Y PER .1 UNITS
8.60	2076.461	2081.209	2085.963	2090.722	2095.485	2100.252	2105.024	2109.801	2114.582	2119.368	47.697
8.70	2124.158	2128.954	2133.754	2138.557	2143.367	2148.180	2152.998	2157.821	2162.648	2167.479	48.157
8.80	2172.315	2177.156	2182.001	2186.851	2191.707	2196.565	2201.429	2206.298	2211.170	2216.048	48.615
8.90	2220.930	2225.816	2230.708	2235.603	2240.503	2245.408	2250.318	2255.231	2260.150	2265.073	49.070
9.00	2270.000*	2274.880	2279.763	2284.650	2289.543	2294.440	2299.340	2304.245	2309.155	2314.070	48.988
9.10	2318.988	2323.910	2328.837	2333.769	2338.706	2343.645	2348.590	2353.539	2358.492	2363.450	49.423
9.20	2368.411	2373.378	2378.349	2383.324	2388.302	2393.287	2398.275	2403.267	2408.264	2413.266	49.860
9.30	2418.271	2423.281	2428.294	2433.313	2438.335	2443.363	2448.395	2453.429	2458.470	2463.515	50.293
9.40	2468.564	2473.616	2478.674	2483.736	2488.801	2493.872	2498.947	2504.026	2509.108	2514.197	50.725
9.50	2519.289	2524.385	2529.485	2534.589	2539.699	2544.812	2549.930	2555.052	2560.178	2565.310	51.155
9.60	2570.444	2575.583	2580.727	2585.875	2591.026	2596.182	2601.344	2606.508	2611.677	2616.850	51.585
9.70	2622.029	2627.211	2632.398	2637.587	2642.782	2647.982	2653.184	2658.393	2663.604	2668.821	52.013
9.80	2674.042	2679.267	2684.495	2689.728	2694.966	2700.209	2705.453	2710.705	2715.959	2721.217	52.438
9.90	2726.480	2731.749	2737.019	2742.296	2747.576	2752.859	2758.149	2763.443	2768.738	2774.040	52.865
10.00	2779.345	2784.656	2789.969	2795.287	2800.610	2805.937	2811.268	2816.603	2821.943	2827.286	53.289
10.10	2832.634	2837.986	2843.342	2848.703	2854.068	2859.436	2864.809	2870.187	2875.569	2880.953	53.711
10.20	2886.345	2891.740	2897.137	2902.540	2907.948	2913.358	2918.773	2924.193	2929.617	2935.045	54.132
10.30	2940.477	2945.914	2951.354	2956.800	2962.248	2967.700	2973.157	2978.619	2984.084	2989.556	54.552
10.40	2995.029	3000.507	3005.989	3011.478	3016.968	3022.463	3027.962	3033.465	3038.972	3044.484	54.971
10.50	3050.000*	3055.103	3060.209	3065.317	3070.429	3075.546	3080.662	3085.784	3090.909	3096.037	51.169
10.60	3101.169	3106.302	3111.440	3116.581	3121.724	3126.870	3132.021	3137.175	3142.331	3147.489	51.485
10.70	3152.654	3157.817	3162.986	3168.157	3173.331	3178.510	3183.692	3188.876	3194.065	3199.254	51.794
10.80	3204.448	3209.645	3214.846	3220.050	3225.253	3230.465	3235.676	3240.892	3246.110	3251.334	52.109
10.90	3256.557	3261.784	3267.018	3272.253	3277.488	3282.730	3287.972	3293.219	3298.468	3303.722	52.422
11.00	3308.979	3314.237	3319.498	3324.763	3330.034	3335.304	3340.578	3345.855	3351.137	3356.421	52.727
11.10	3361.706	3366.997	3372.290	3377.584	3382.884	3388.186	3393.492	3398.801	3404.114	3409.426	53.037
11.20	3414.743	3420.065	3425.389	3430.715	3436.045	3441.378	3446.715	3452.054	3457.395	3462.740	53.348
11.30	3468.091	3473.443	3478.797	3484.153	3489.513	3494.878	3500.242	3505.614	3510.987	3516.362	53.650
11.40	3521.741	3527.123	3532.509	3537.896	3543.285	3548.679	3554.078	3559.478	3564.879	3570.285	53.956
11.50	3575.697	3581.109	3586.523	3591.941	3597.365	3602.786	3608.215	3613.646	3619.078	3624.514	54.259
11.60	3629.956	3635.398	3640.842	3646.291	3651.744	3657.198	3662.657	3668.117	3673.582	3679.048	54.562
11.70	3684.518	3689.990	3695.462	3700.943	3706.425	3711.911	3717.399	3722.887	3728.380	3733.878	54.862
11.80	3739.380	3744.883	3750.387	3755.895	3761.408	3766.922	3772.441	3777.960	3783.484	3789.012	55.161
11.90	3794.541	3800.071	3805.609	3811.147	3816.690	3822.234	3827.783	3833.332	3838.885	3844.443	55.461
12.00	3850.000*	3855.686	3861.378	3867.068	3872.763	3878.462	3884.167	3889.872	3895.577	3901.292	57.007
12.10	3907.007	3912.723	3918.448	3924.169	3929.899	3935.630	3941.362	3947.102	3952.843	3958.585	57.328
12.20	3964.335	3970.082	3975.837	3981.593	3987.354	3993.115	3998.881	4004.651	4010.426	4016.202	57.647
12.30	4021.982	4027.762	4033.548	4039.337	4045.127	4050.922	4056.721	4062.524	4068.328	4074.137	57.964

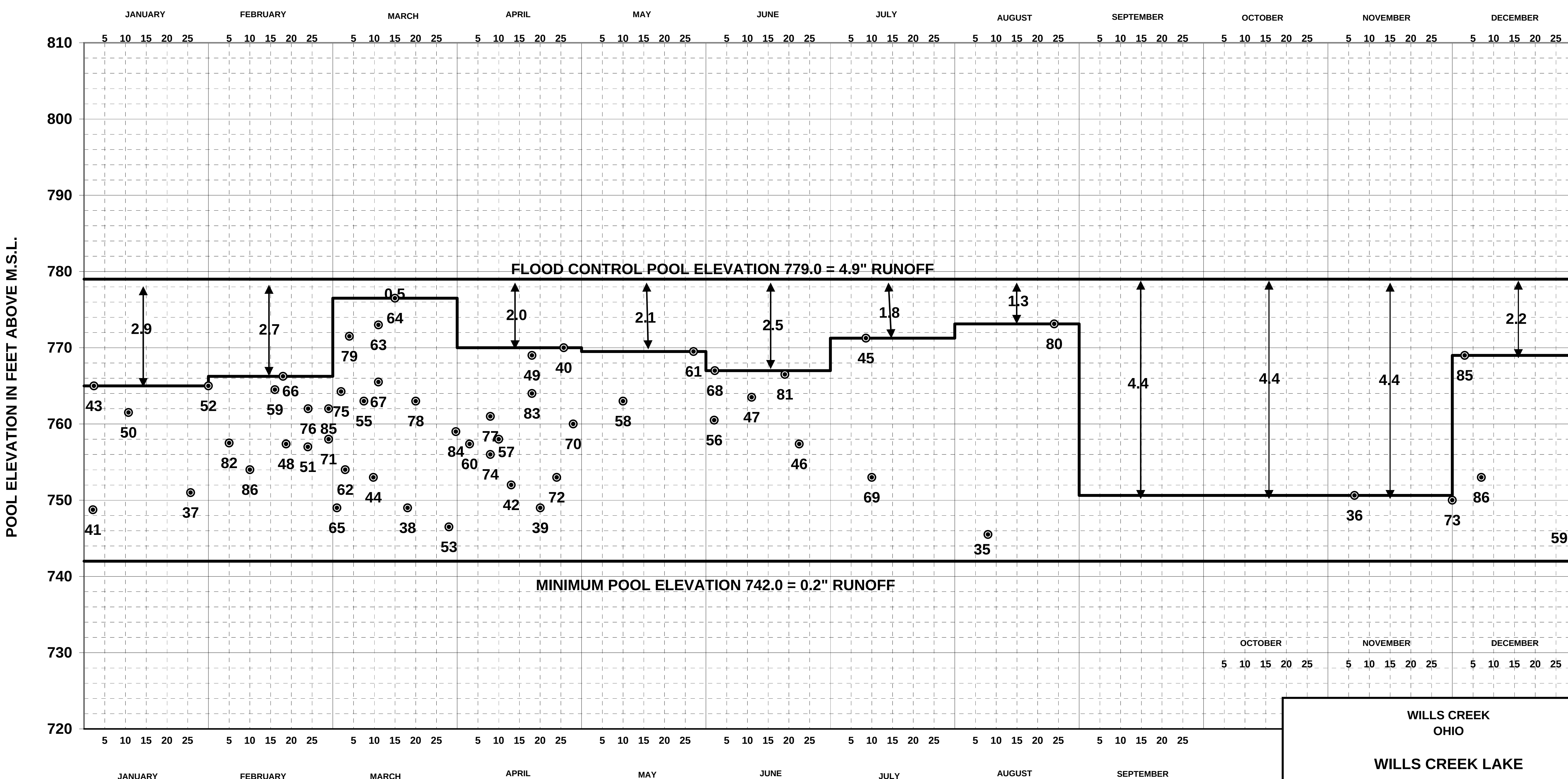
EXPANDED RATING TABLE TYPE: LOG

03143500 DATE PROCESSED: 07-15-2002 @ 13:12 BY chawkins

WILLS C BL WILLS C DAM AT WILLS CREEK OH DD: 2 TYPE: 001 RATING NO: 17

OFFSET: 1.00 START DATE/TIME: 01-05-1990 (2400)

INPUT VALUE	GAGE HEIGHT .00	.01	.02	(EXPANDED PRECISION) .03	.04	.05	.06	.07	.08	.09	DIFF IN Y PER .1 UNITS
12.40	4079.946	4085.759	4091.577	4097.399	4103.221	4109.048	4114.879	4120.711	4126.547	4132.387	58.286
12.50	4138.232	4144.077	4149.926	4155.776	4161.634	4167.492	4173.354	4179.217	4185.088	4190.955	58.599
12.60	4196.831	4202.710	4208.590	4214.474	4220.362	4226.251	4232.144	4238.040	4243.941	4249.842	58.917
12.70	4255.748	4261.661	4267.570	4273.484	4279.406	4285.327	4291.253	4297.179	4303.109	4309.043	59.233
12.80	4314.981	4320.923	4326.865	4332.816	4338.766	4344.716	4350.674	4356.632	4362.594	4368.561	59.549
12.90	4374.530	4380.500	4386.474	4392.456	4398.438	4404.419	4410.409	4416.398	4422.392	4428.389	59.860
13.00	4434.390	4440.395	4446.399	4452.408	4458.420	4464.437	4470.457	4476.476	4482.504	4488.531	60.172
13.10	4494.562	4500.593	4506.632	4512.674	4518.716	4524.766	4530.812	4536.865	4542.922	4548.983	60.481
13.20	4555.043	4561.111	4567.179	4573.250	4579.326	4585.400	4591.482	4597.568	4603.654	4609.748	60.793
13.30	4615.836	4621.937	4628.037	4634.136	4640.243	4646.350	4652.464	4658.578	4664.695	4670.816	61.104
13.40	4676.940	4683.068	4689.200	4695.335	4701.469	4707.607	4713.748	4719.897	4726.045	4732.197	61.412
13.50	4738.352	4744.511	4750.673	4756.834	4763.003	4769.176	4775.347	4781.522	4787.705	4793.886	61.719
13.60	4800.071	4806.260	4812.452	4818.647	4824.846	4831.047	4837.248	4843.457	4849.665	4855.880	62.023
13.70	4862.094	4868.316	4874.537	4880.760	4886.992	4893.223	4899.457	4905.694	4911.934	4918.178	62.330
13.80	4924.424	4930.679	4936.928	4943.184	4949.444	4955.707	4961.973	4968.237	4974.510	4980.785	62.640
13.90	4987.064	4993.341	4999.626	5005.915	5012.201	5018.491	5024.788	5031.089	5037.388	5043.695	62.936
14.00	5050.000*	5056.520	5063.039	5069.562	5076.093	5082.623	5089.156	5095.693	5102.233	5108.782	65.330
14.10	5115.330	5121.880	5128.435	5134.993	5141.554	5148.119	5154.688	5161.259	5167.834	5174.414	65.666
14.20	5180.996	5187.581	5194.170	5200.762	5207.353	5213.958	5220.560	5227.166	5233.771	5240.383	66.003
14.30	5246.999	5253.618	5260.241	5266.867	5273.497	5280.129	5286.765	5293.404	5300.047	5306.692	66.343
14.40	5313.342	5319.994	5326.649	5333.308	5339.976	5346.636	5353.309	5359.981	5366.656	5373.339	66.679
14.50	5380.021	5386.705	5393.397	5400.088	5406.787	5413.484	5420.189	5426.893	5433.604	5440.319	67.011
14.60	5447.032	5453.753	5460.477	5467.204	5473.934	5480.667	5487.403	5494.143	5500.885	5507.630	67.352
14.70	5514.384	5521.135	5527.889	5534.652	5541.412	5548.181	5554.952	5561.721	5568.499	5575.279	67.678
14.80	5582.062	5588.849	5595.638	5602.430	5609.230	5616.028	5622.829	5629.638	5636.450	5643.259	68.014
14.90	5650.076	5656.896	5663.720	5670.546	5677.375	5684.206	5691.046	5697.883	5704.729	5711.577	68.346
15.00	5718.422	5725.276	5732.133	5738.992	5745.854	5752.724	5759.591	5766.467	5773.339	5780.221	68.682
15.10	5787.104	5793.990	5800.879	5807.771	5814.666	5821.568	5828.467	5835.375	5842.285	5849.192	69.010
15.20	5856.114	5863.032	5869.953	5876.875	5883.807	5890.741	5897.678	5904.617	5911.558	5918.502	69.335
15.30	5925.449	5932.404	5939.355	5946.315	5953.277	5960.242	5967.214	5974.184	5981.156	5988.136	69.670
15.40	5995.119	6002.104	6009.091	6016.081	6023.079	6030.074	6037.076	6044.082	6051.089	6058.104	69.998
15.50	6065.117	6072.131	6079.153	6086.178	6093.206	6100.241	6107.272	6114.307	6121.349	6128.393	70.323
15.60	6135.440	6142.489	6149.546	6156.599	6163.661	6170.724	6177.790	6184.864	6191.934	6199.013	70.653
15.70	6206.093	6213.176	6220.261	6227.348	6234.443	6241.540	6248.639	6255.741	6262.850	6269.956	70.976
15.80	6277.069	6284.185	6291.303	6298.429	6305.551	6312.681	6319.812	6326.946	6334.088	6341.227	71.304
15.90	6348.373	6355.521	6362.671	6369.829	6376.989	6384.145	6391.309	6398.481	6405.649	6412.825	71.627*
16.00	6420.000*										



NOTES

(1) DRAINAGE AREA = 844 SQ. MI.

(2) ONE INCH RUNOFF = 45013 AC. FT.

(3) PERIOD OF RECORD: 1935-1936

(4) O CREST POOL ELEVATION OF A RISE AND YEAR (1964) IN WHICH IT OCCURED

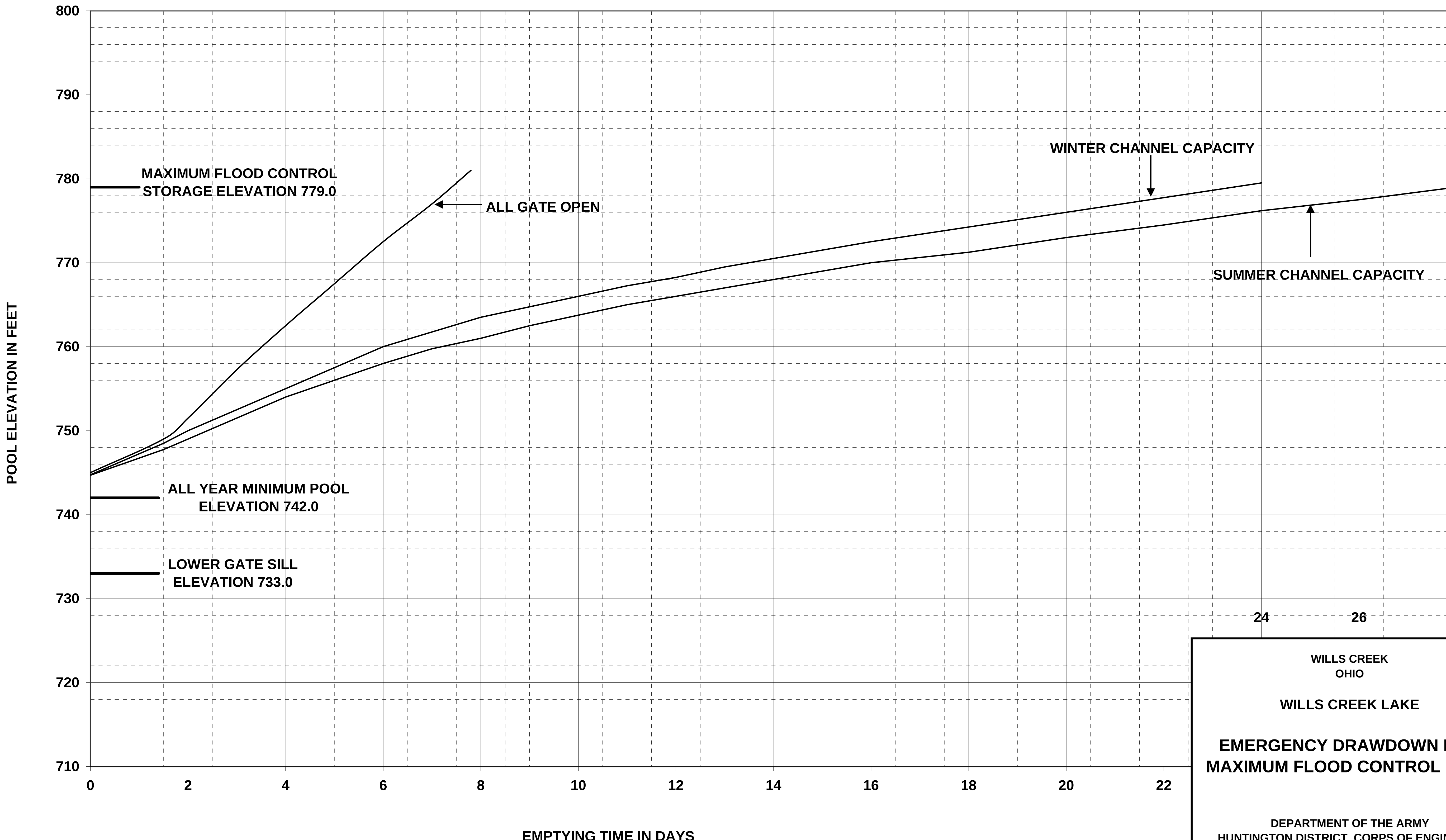
WILLS CREEK
OHIO

WILLS CREEK LAKE

RESERVOIR UTILIZATION FLOOD CONTROL, LOW FLOW AND SEASONAL POOL

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



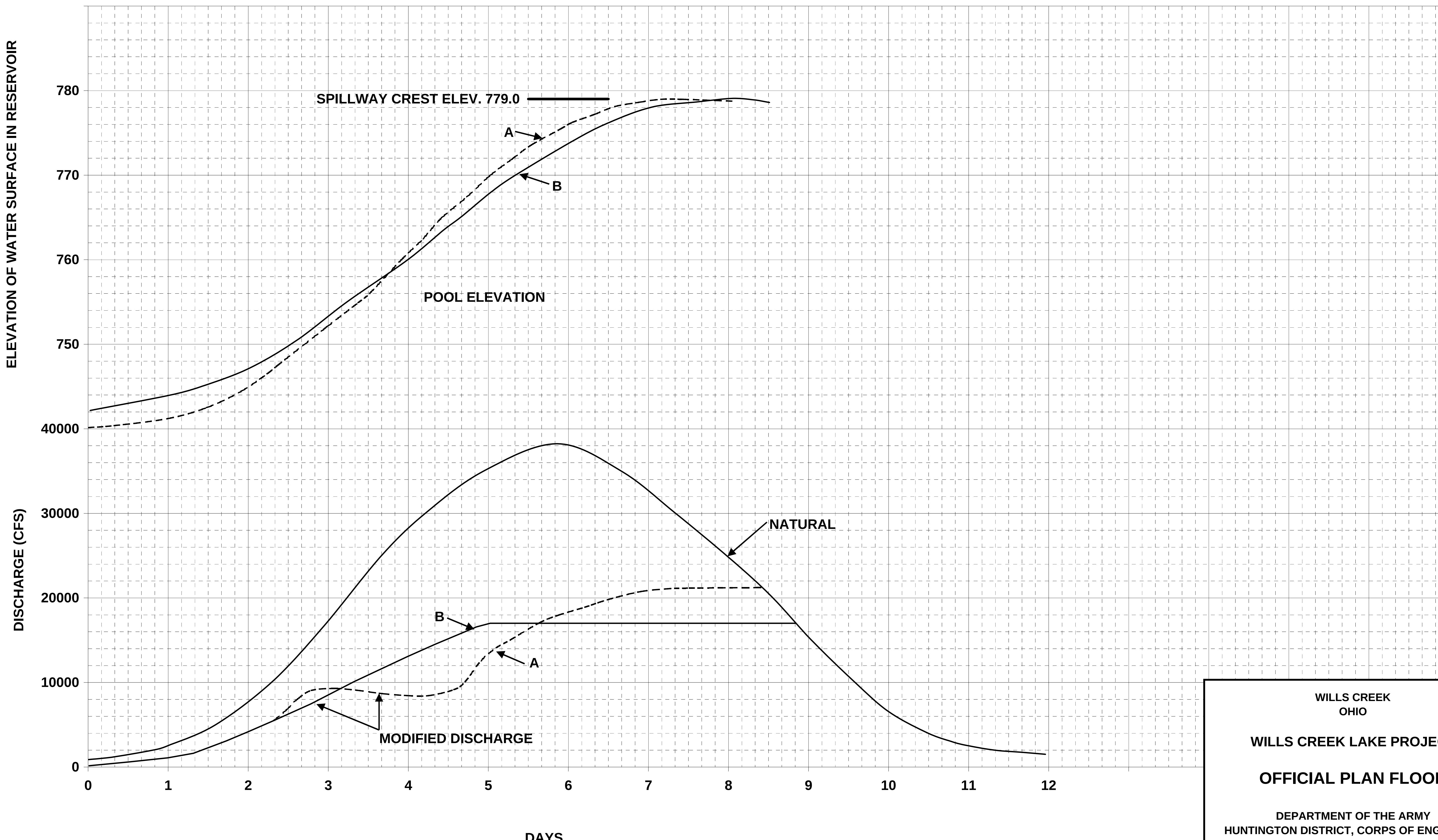
WILLS CREEK
OHIO

WILLS CREEK LAKE

EMERGENCY DRAWDOWN FROM MAXIMUM FLOOD CONTROL POOL

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



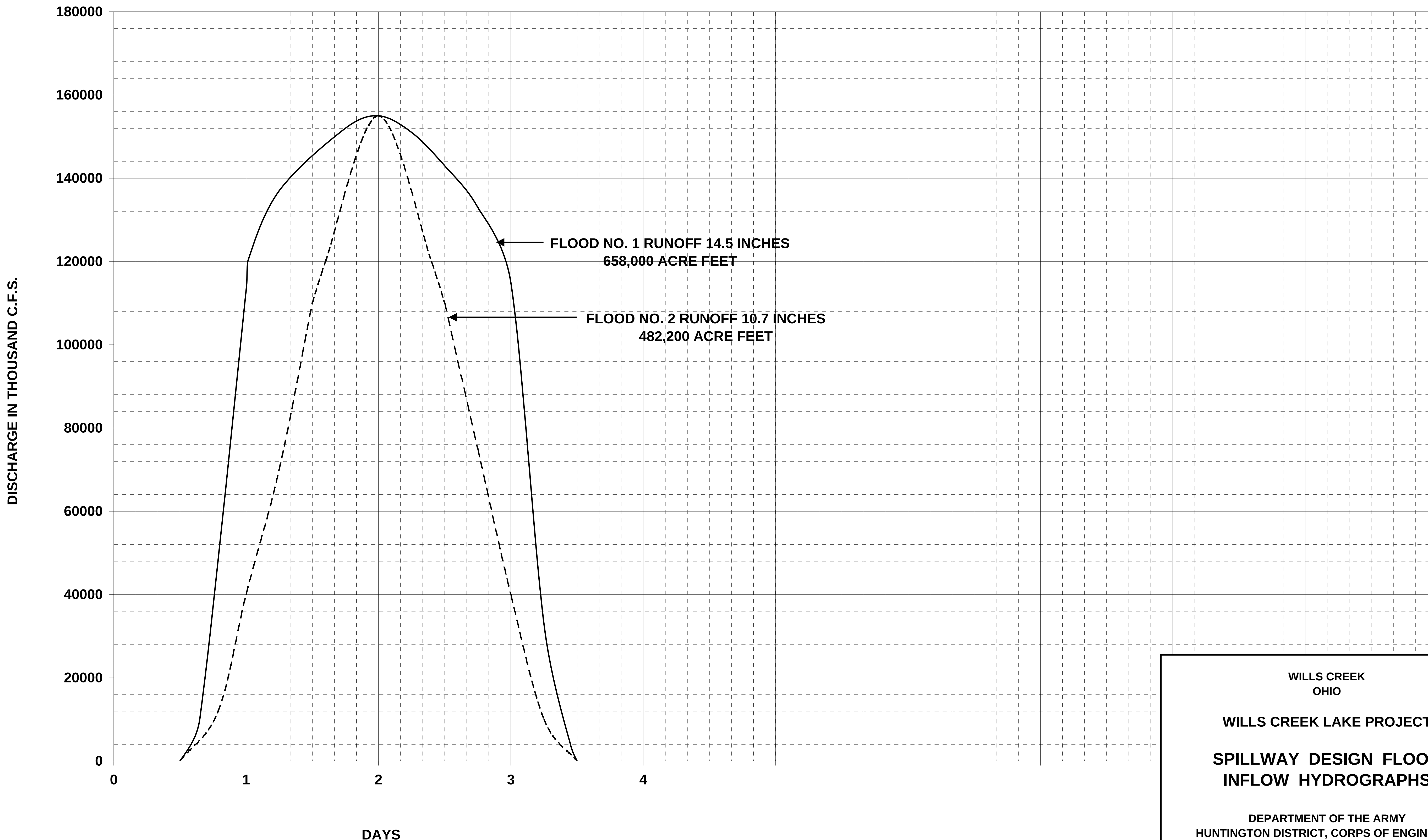
WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

OFFICIAL PLAN FLOOD

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



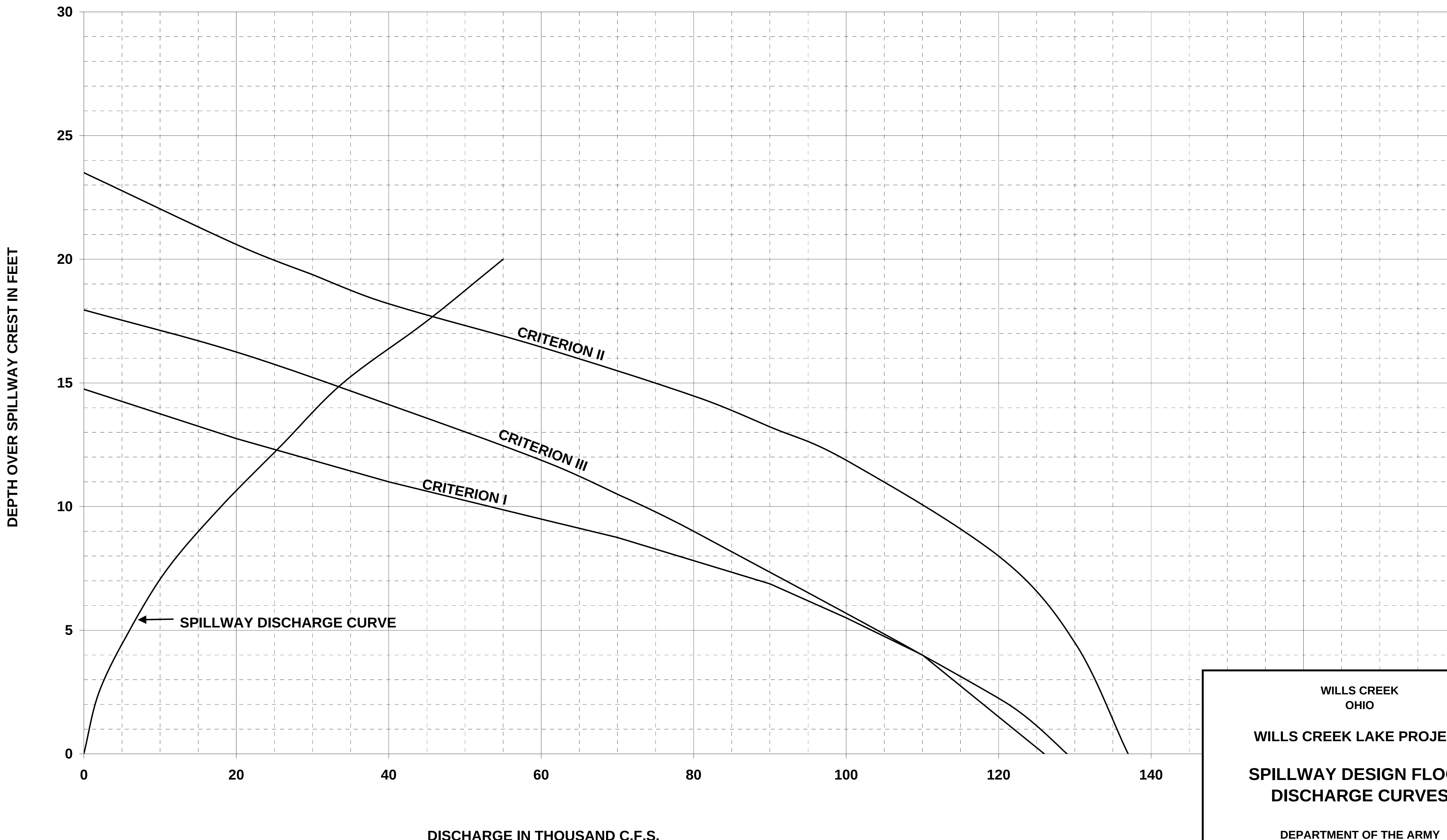
WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

SPILLWAY DESIGN FLOOD
INFLOW HYDROGRAPHS

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



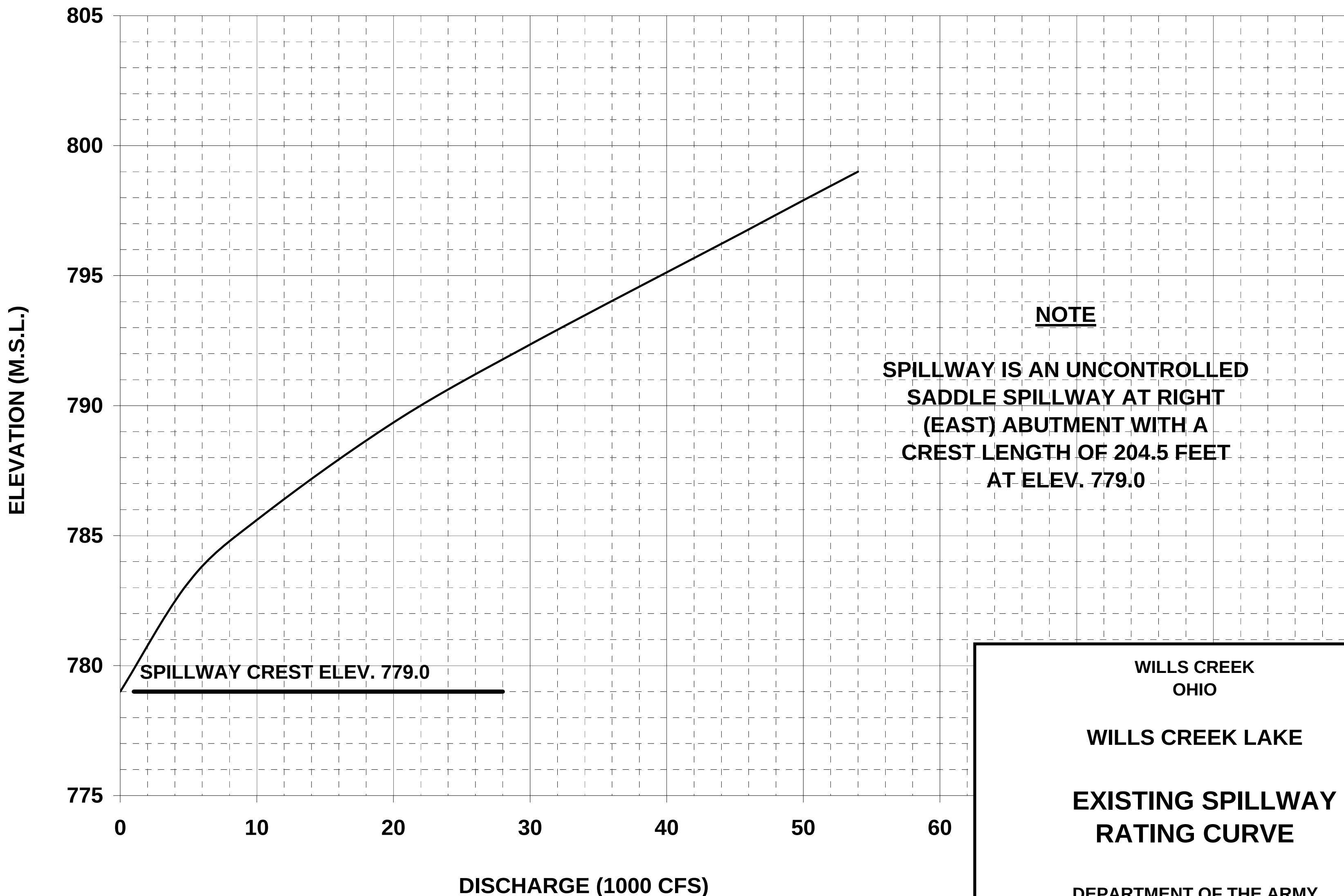
WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

SPILLWAY DESIGN FLOOD DISCHARGE CURVES

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



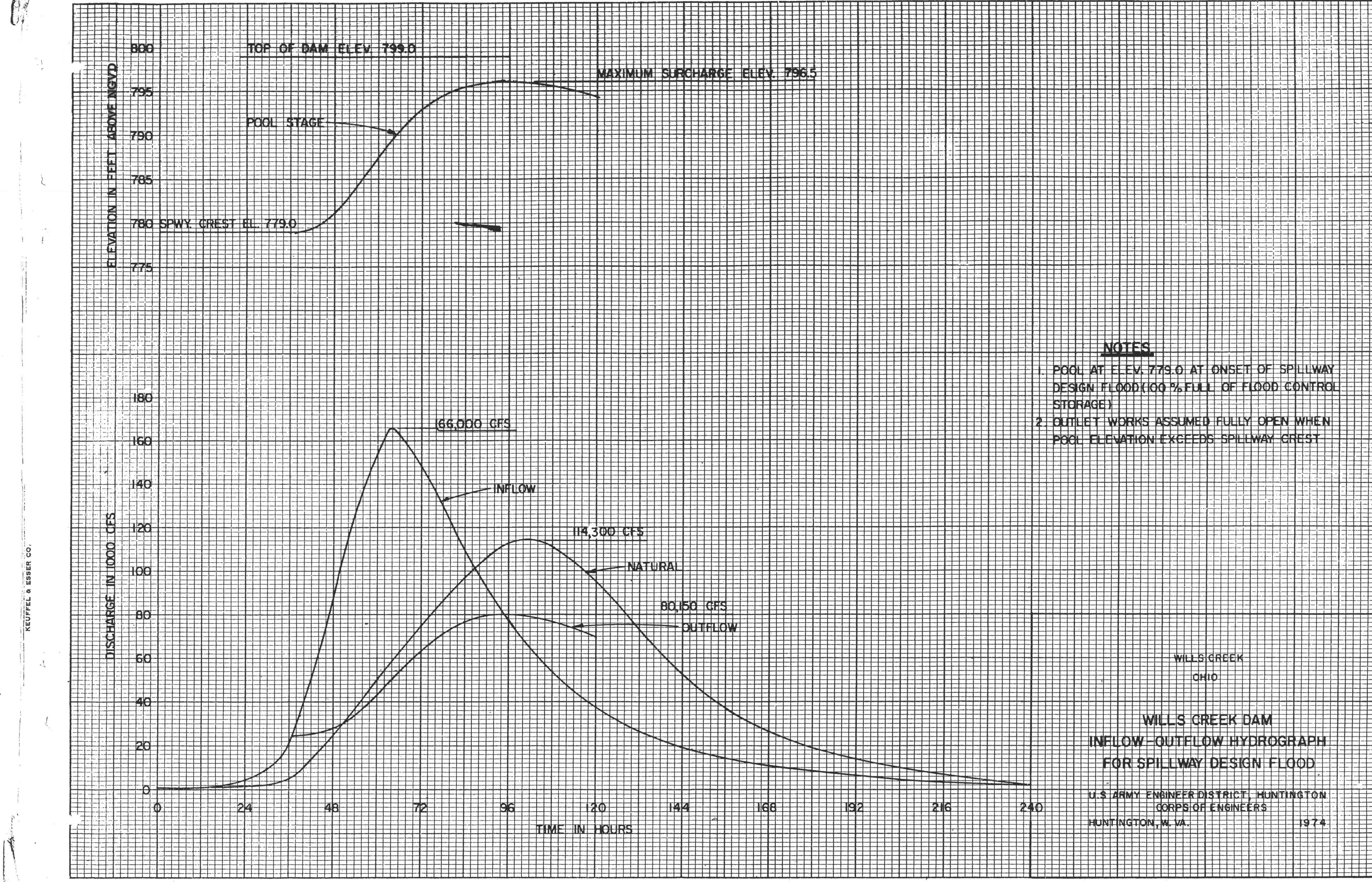
WILLS CREEK
OHIO

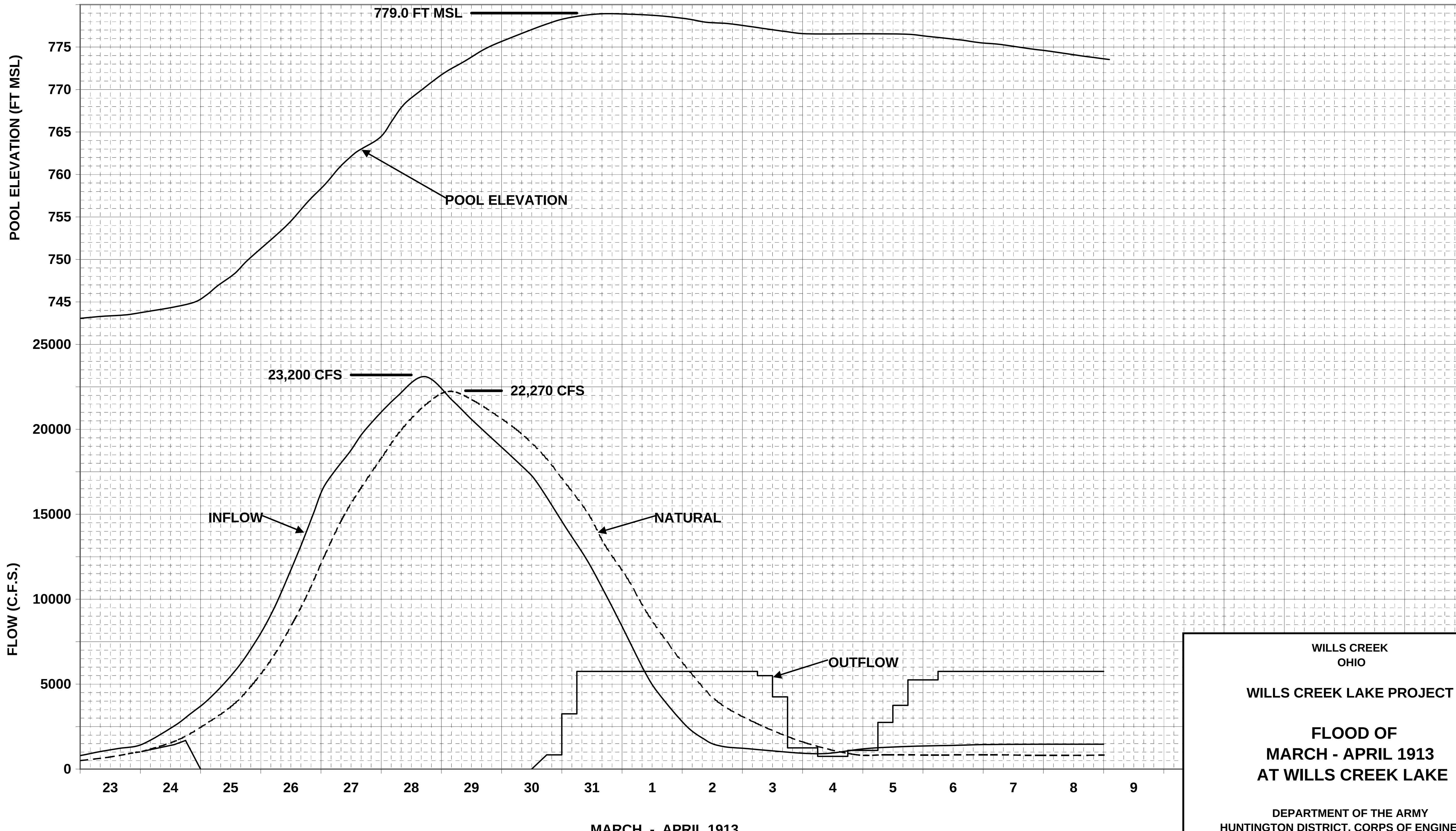
WILLS CREEK LAKE

EXISTING SPILLWAY RATING CURVE

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V.   REDRAWN OCTOBER 1999


TOP OF DAM ELEV. 799.0
MAXIMUM SURCHARGE ELEV. 796.5
POOL STAGE
SPWY. CREST EL. 779.0
ELEVATION IN FEET ABOVE NGVD
800
795
790
785
780
775
166,000 CFS
INFLOW
114,300 CFS
NATURAL
80,150 CFS
OUTFLOW
DISCHARGE IN 1000 CFS
180
160
140
120
100
80
60
40
20
0
0
24
48
72
96
120
144
168
192
216
240
TIME IN HOURS
NOTES
1. POOL AT ELEV. 779.0 AT ONSET OF SPILLWAY DESIGN FLOOD (100 % FULL OF FLOOD CONTROL STORAGE)
2. OUTLET WORKS ASSUMED FULLY OPEN WHEN POOL ELEVATION EXCEEDS SPILLWAY CREST
WILLS CREEK
OHIO
WILLS CREEK DAM
INFLOW - OUTFLOW HYDROGRAPH
FOR SPILLWAY DESIGN FLOOD
U.S. ARMY ENGINEER DISTRICT, HUNTINGTON
CORPS OF ENGINEERS
HUNTINGTON, W. VA.
1974
KEUFFEL & ESSER CO.



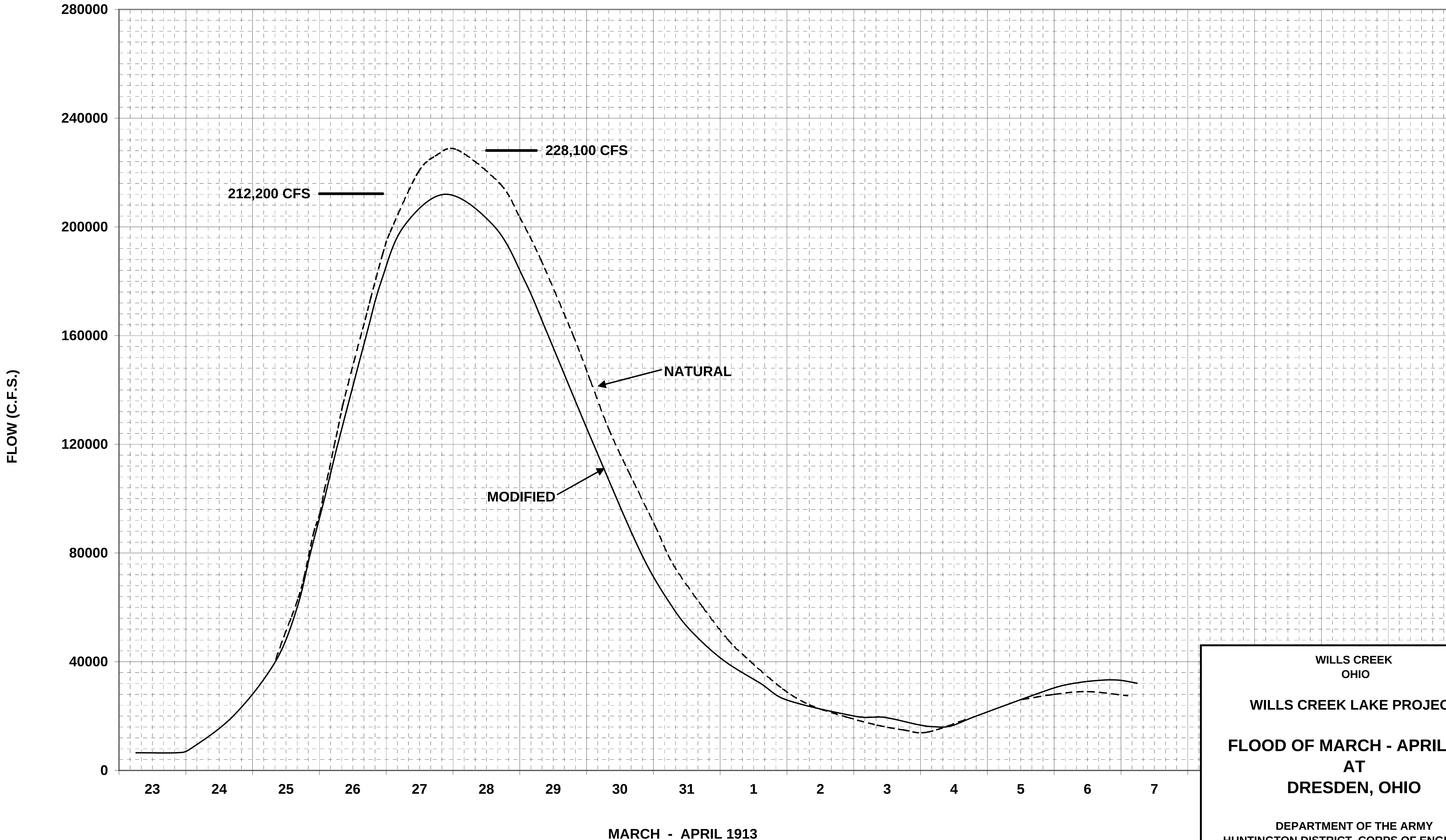
WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

FLOOD OF
MARCH - APRIL 1913
AT WILLS CREEK LAKE

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



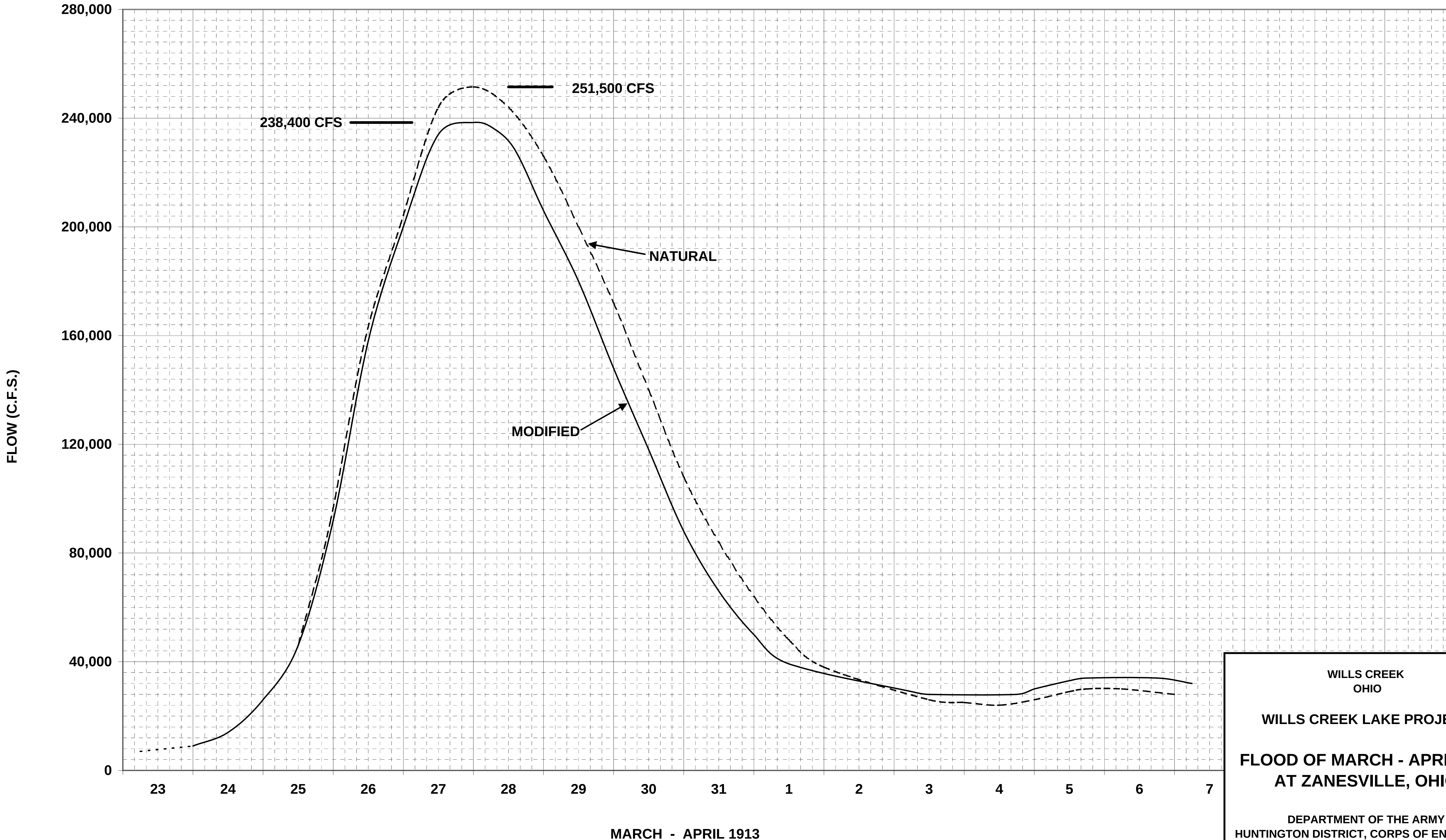
WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

FLOOD OF MARCH - APRIL 1913
AT
DRESDEN, OHIO

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



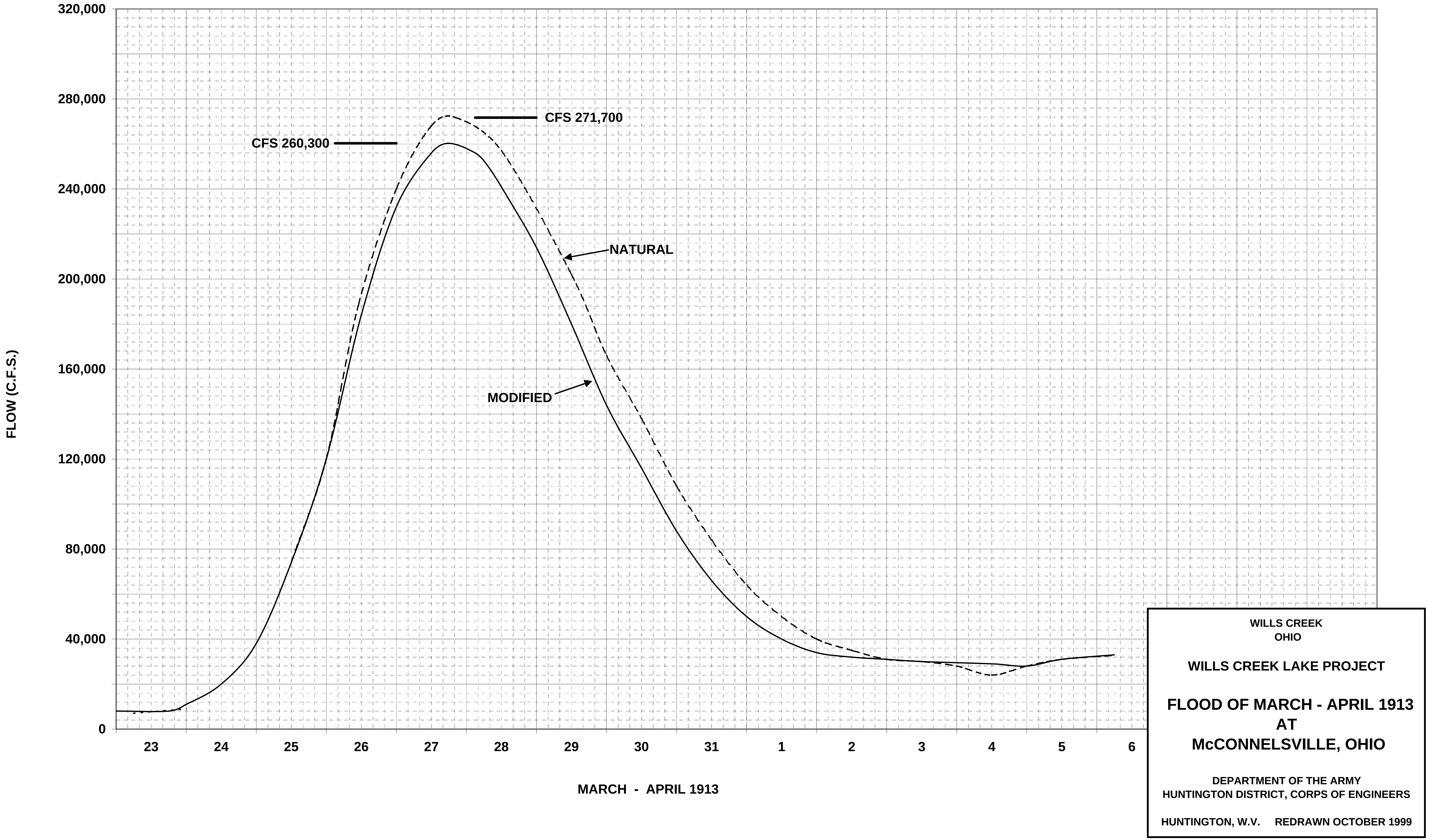
WILLS CREEK
OHIO

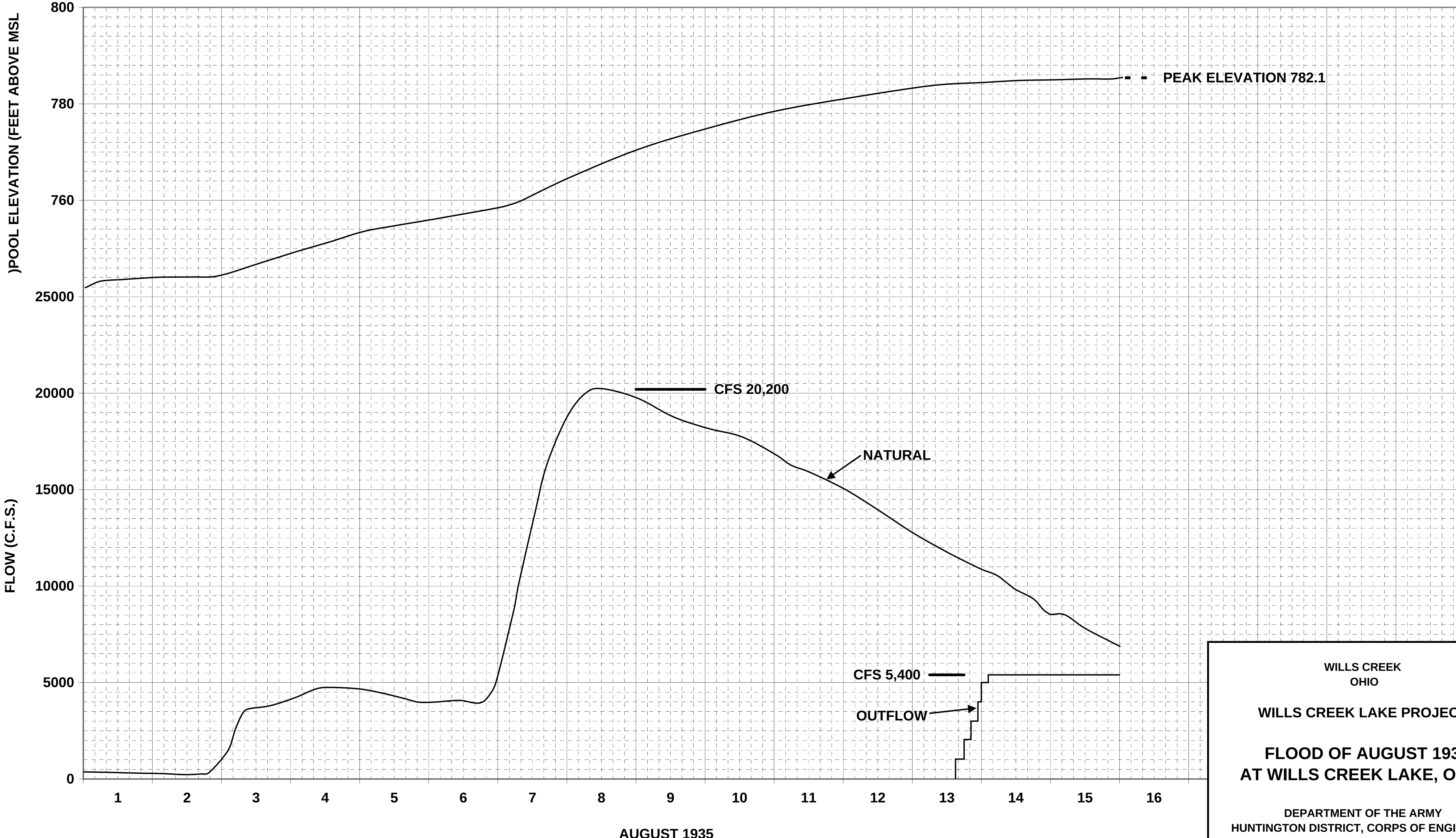
WILLS CREEK LAKE PROJECT

FLOOD OF MARCH - APRIL 1913
AT ZANESVILLE, OHIO

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999


320,000
280,000
240,000
200,000
160,000
120,000
80,000
40,000
0
FLOW (C.F.S.)
CFS 271,700
CFS 260,300
NATURAL
MODIFIED
23
24
25
26
27
28
29
30
31
1
2
3
4
5
6
MARCH - APRIL 1913
WILLS CREEK
OHIO
WILLS CREEK LAKE PROJECT
FLOOD OF MARCH - APRIL 1913
AT
McCONNELSVILLE, OHIO
DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V. REDRAWN OCTOBER 1999



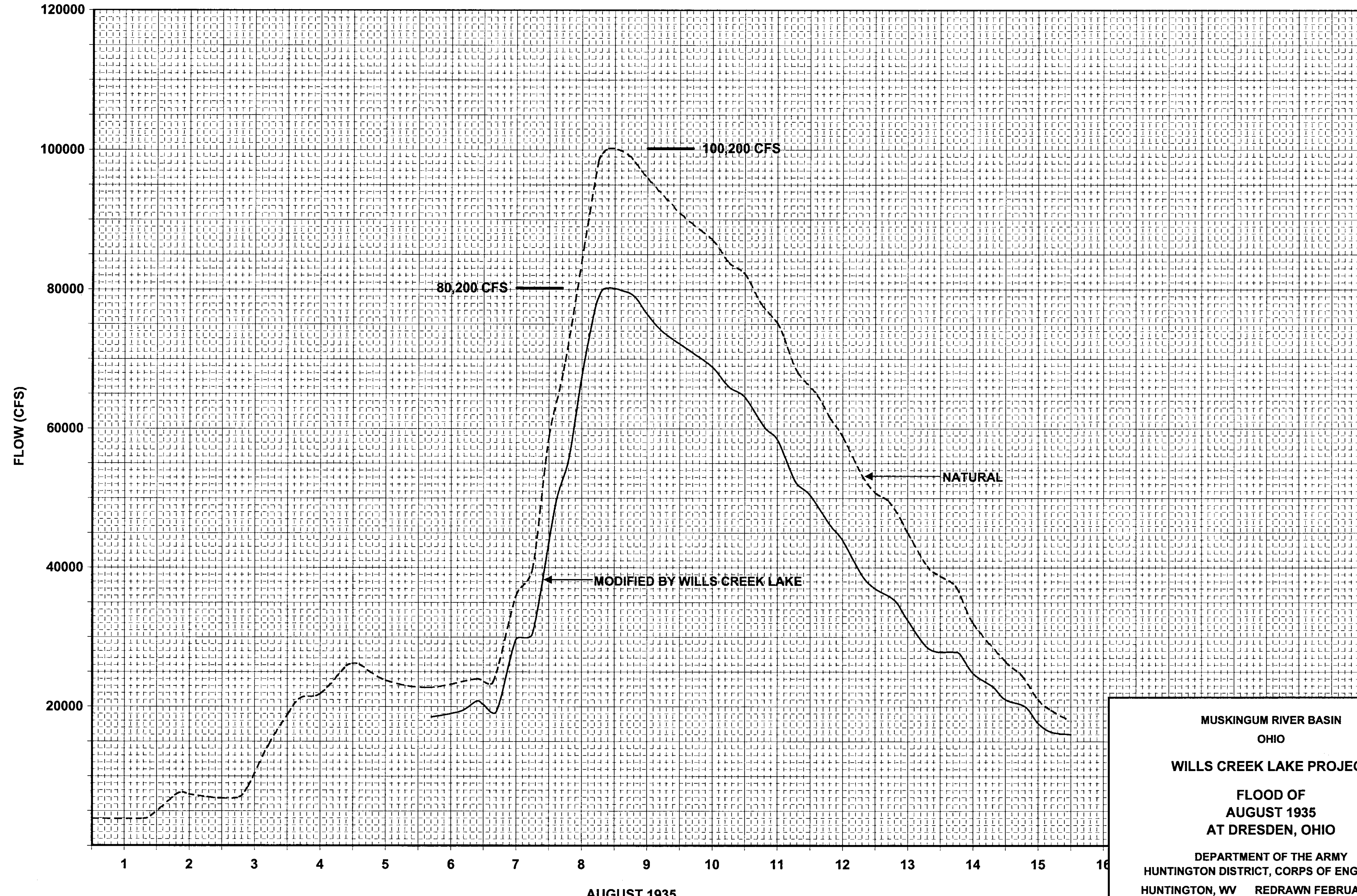
WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

FLOOD OF AUGUST 1935
AT WILLS CREEK LAKE, OHIO

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



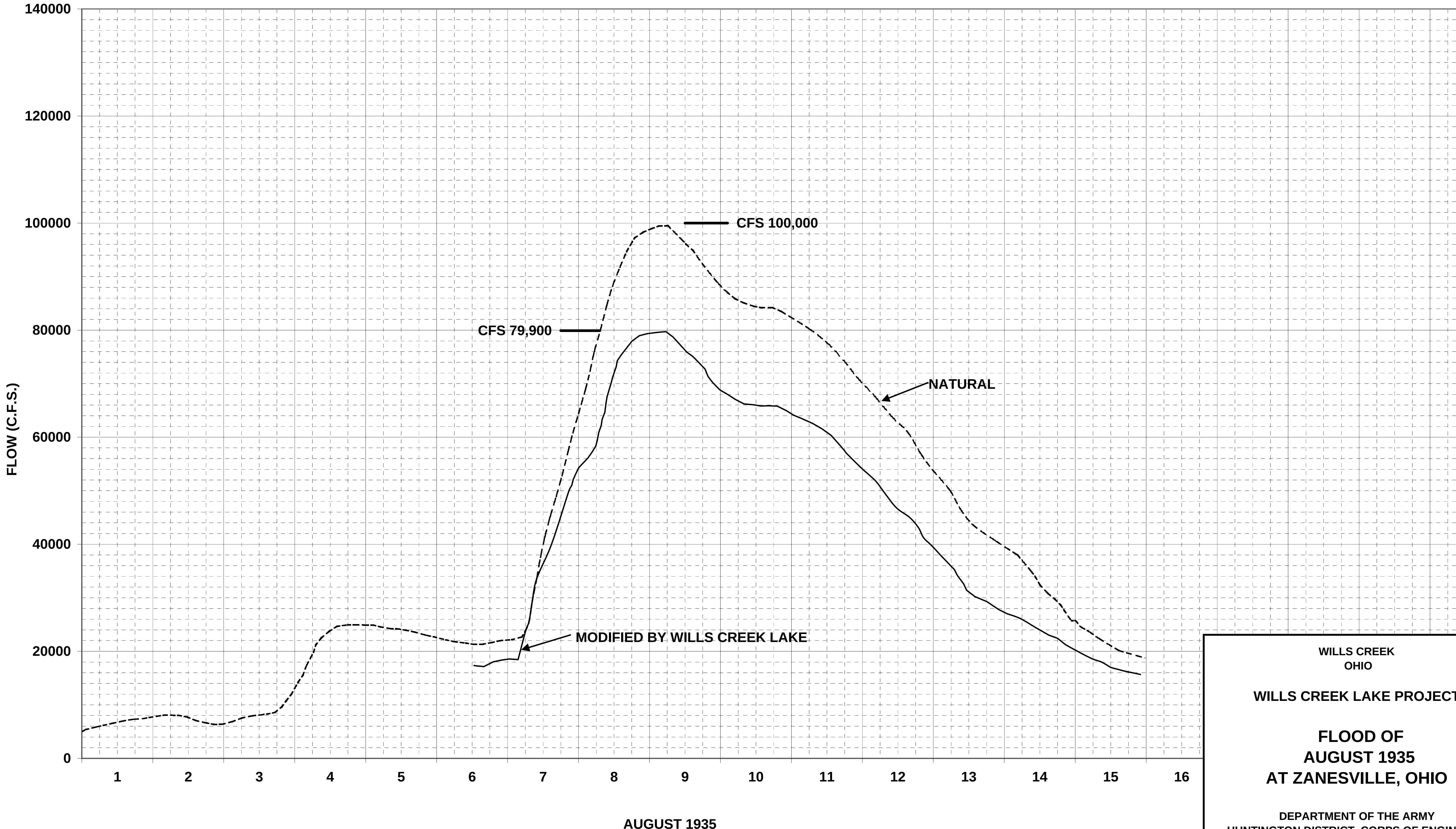
MUSKINGUM RIVER BASIN
OHIO

WILLS CREEK LAKE PROJECT

FLOOD OF
AUGUST 1935
AT DRESDEN, OHIO

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, WV REDRAWN FEBRUARY 2006

PLATE NO. 8-8



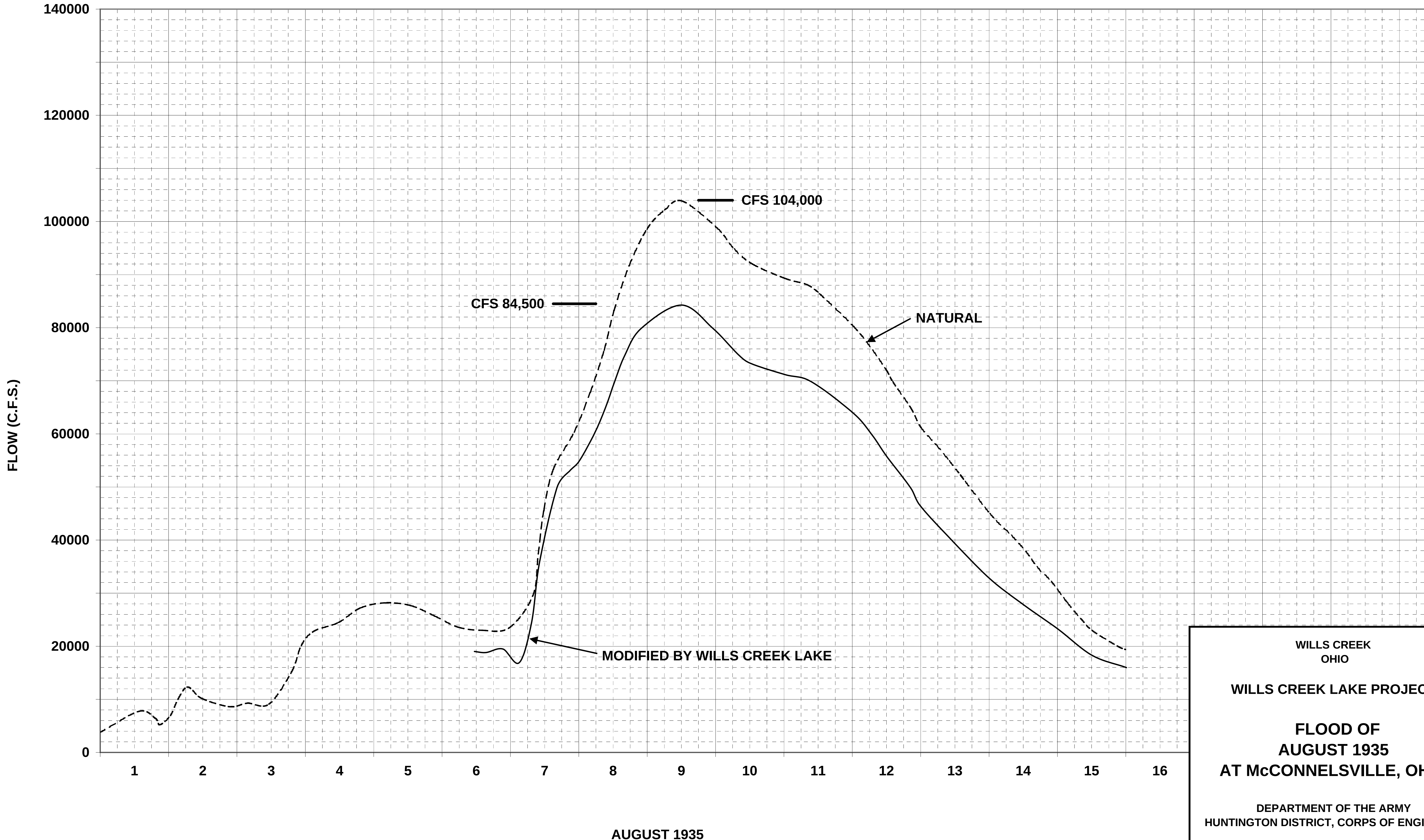
WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

FLOOD OF AUGUST 1935 AT ZANESVILLE, OHIO

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



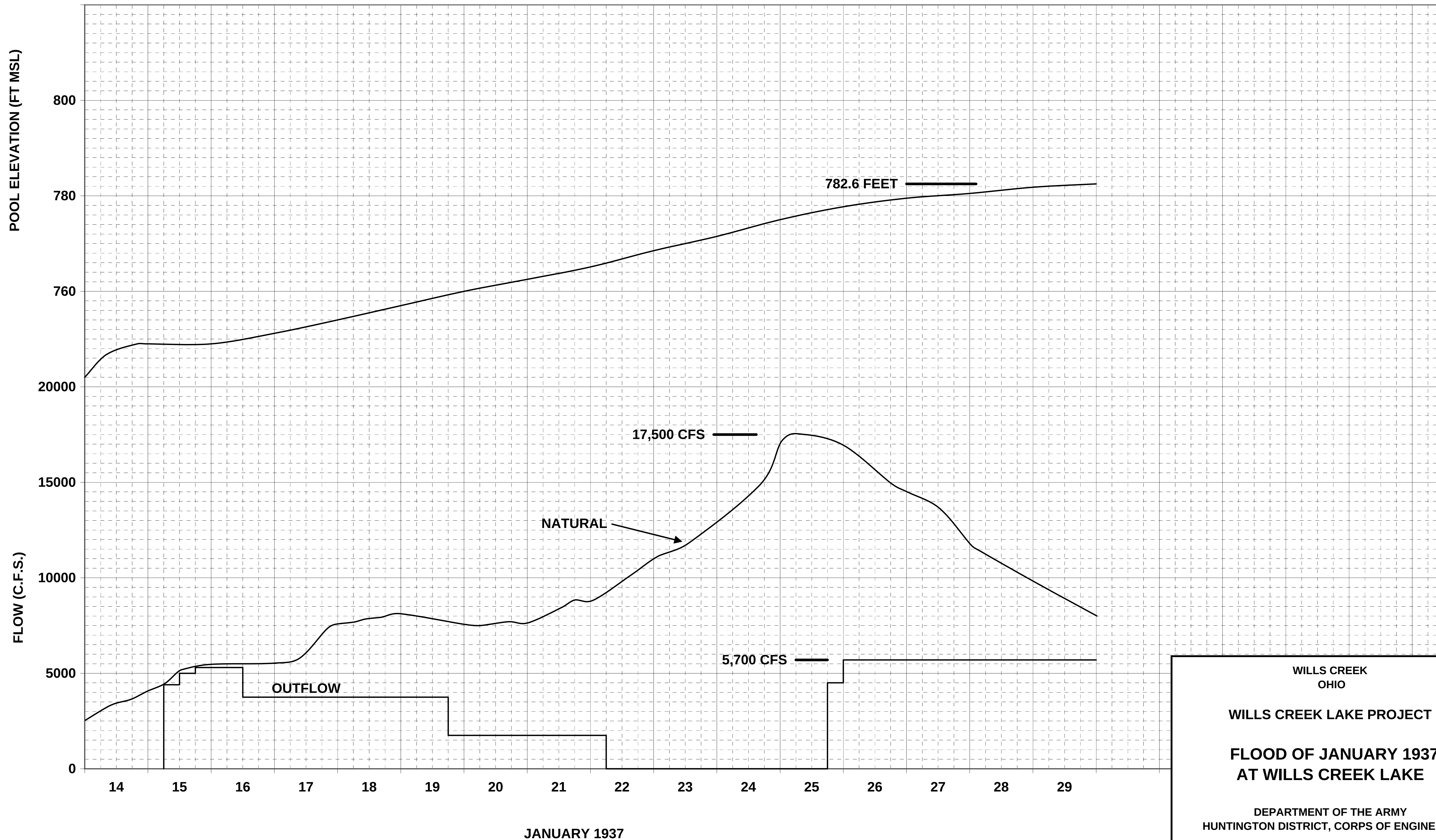
WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

FLOOD OF AUGUST 1935 AT McCONNELSVILLE, OHIO

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



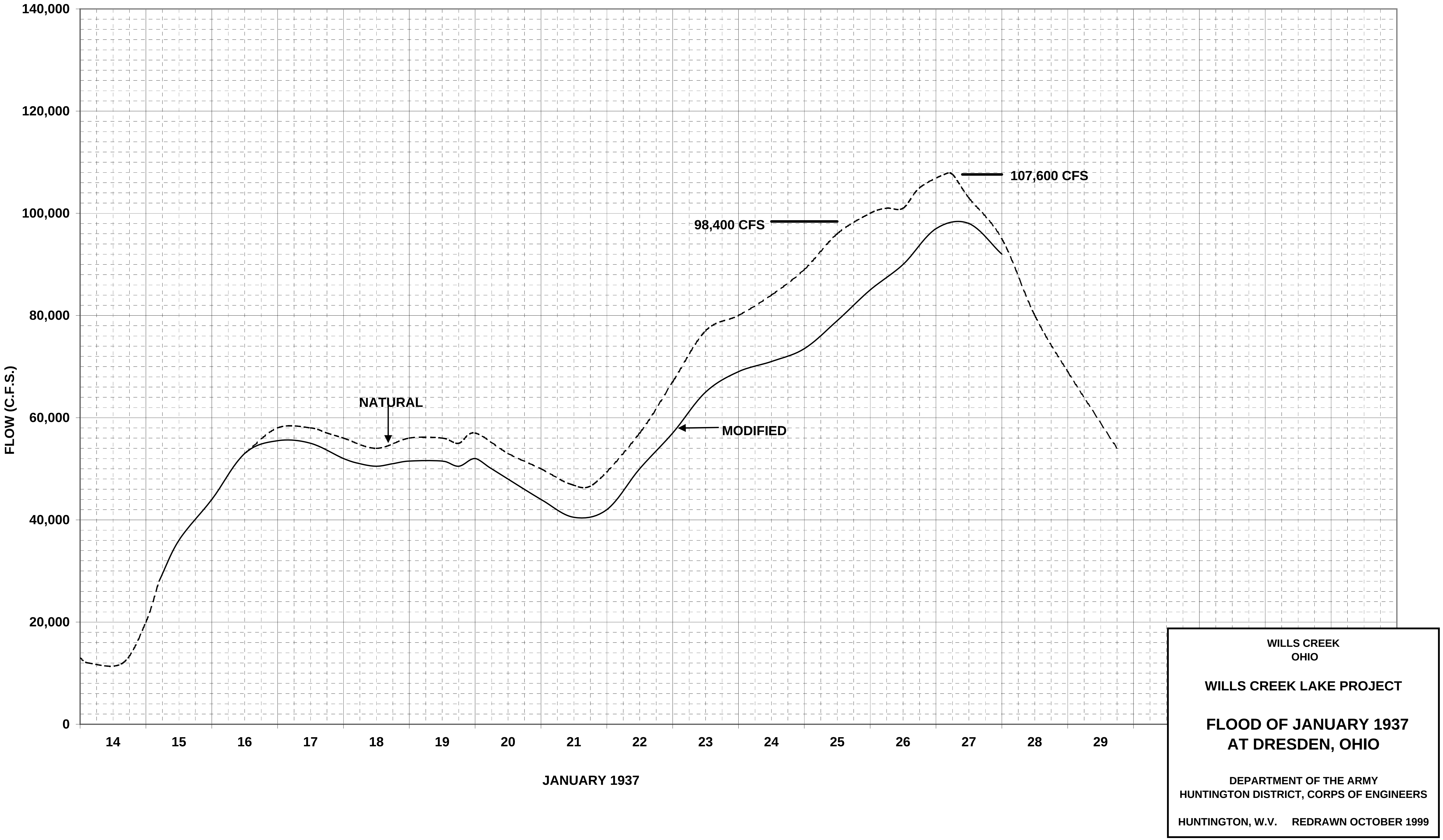
WILLS CREEK
OHIO

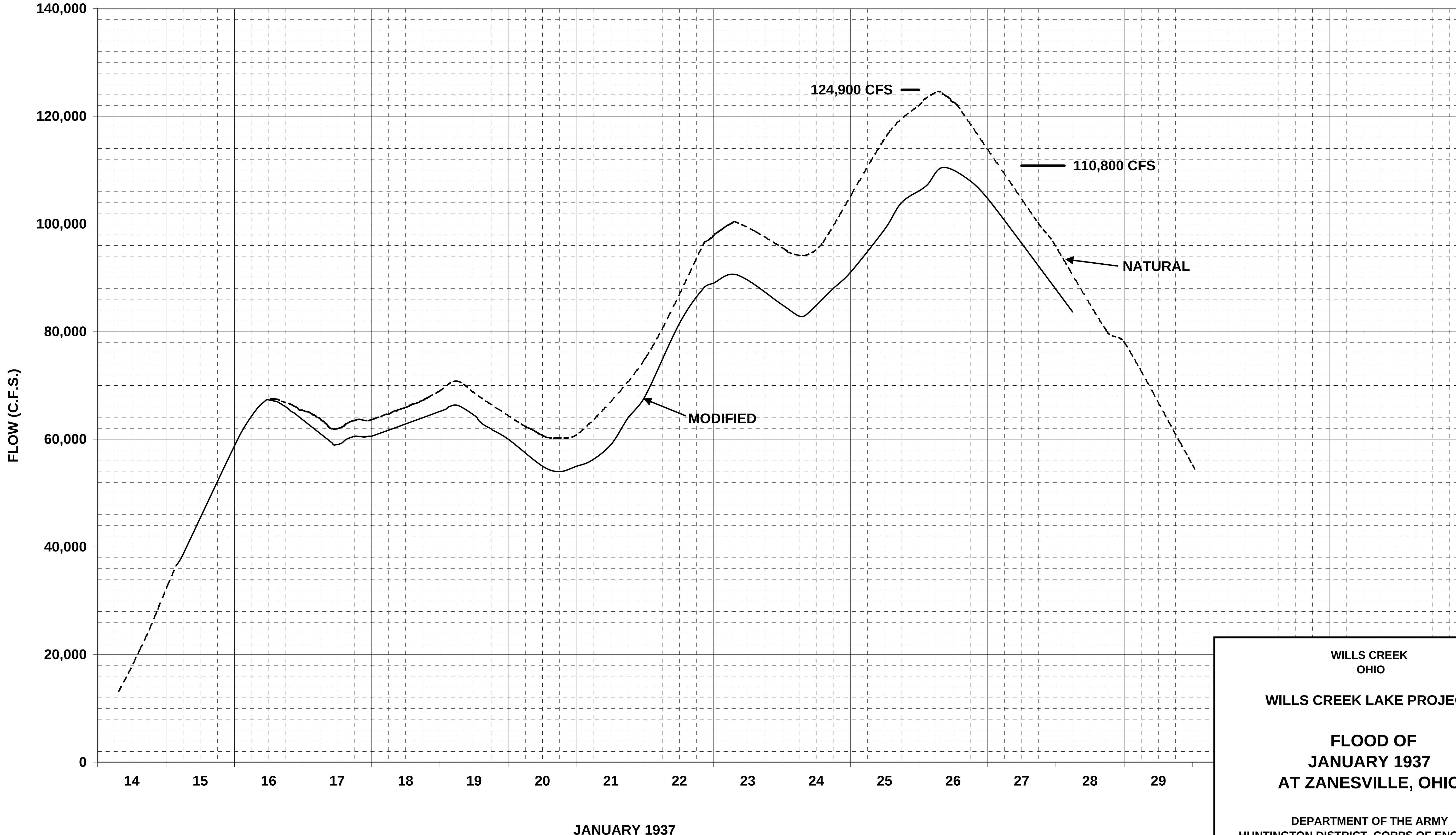
WILLS CREEK LAKE PROJECT

FLOOD OF JANUARY 1937
AT WILLS CREEK LAKE

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V.   REDRAWN OCTOBER 1999


140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
FLOW (C.F.S.)
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
JANUARY 1937
NATURAL
MODIFIED
98,400 CFS
107,600 CFS
WILLS CREEK
OHIO
WILLS CREEK LAKE PROJECT
FLOOD OF JANUARY 1937
AT DRESDEN, OHIO
DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V.
REDRAWN OCTOBER 1999



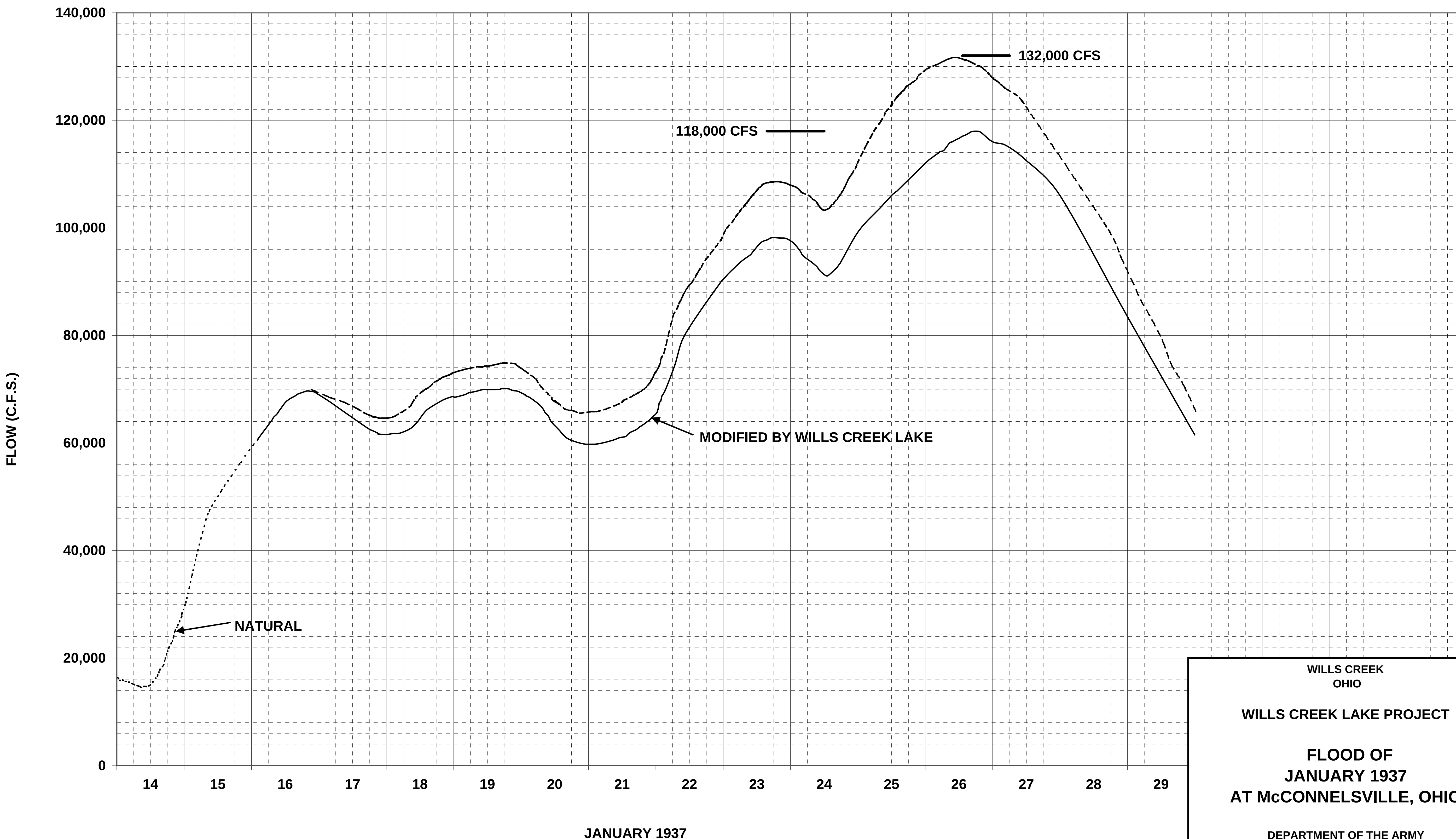
WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

FLOOD OF JANUARY 1937 AT ZANESVILLE, OHIO

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



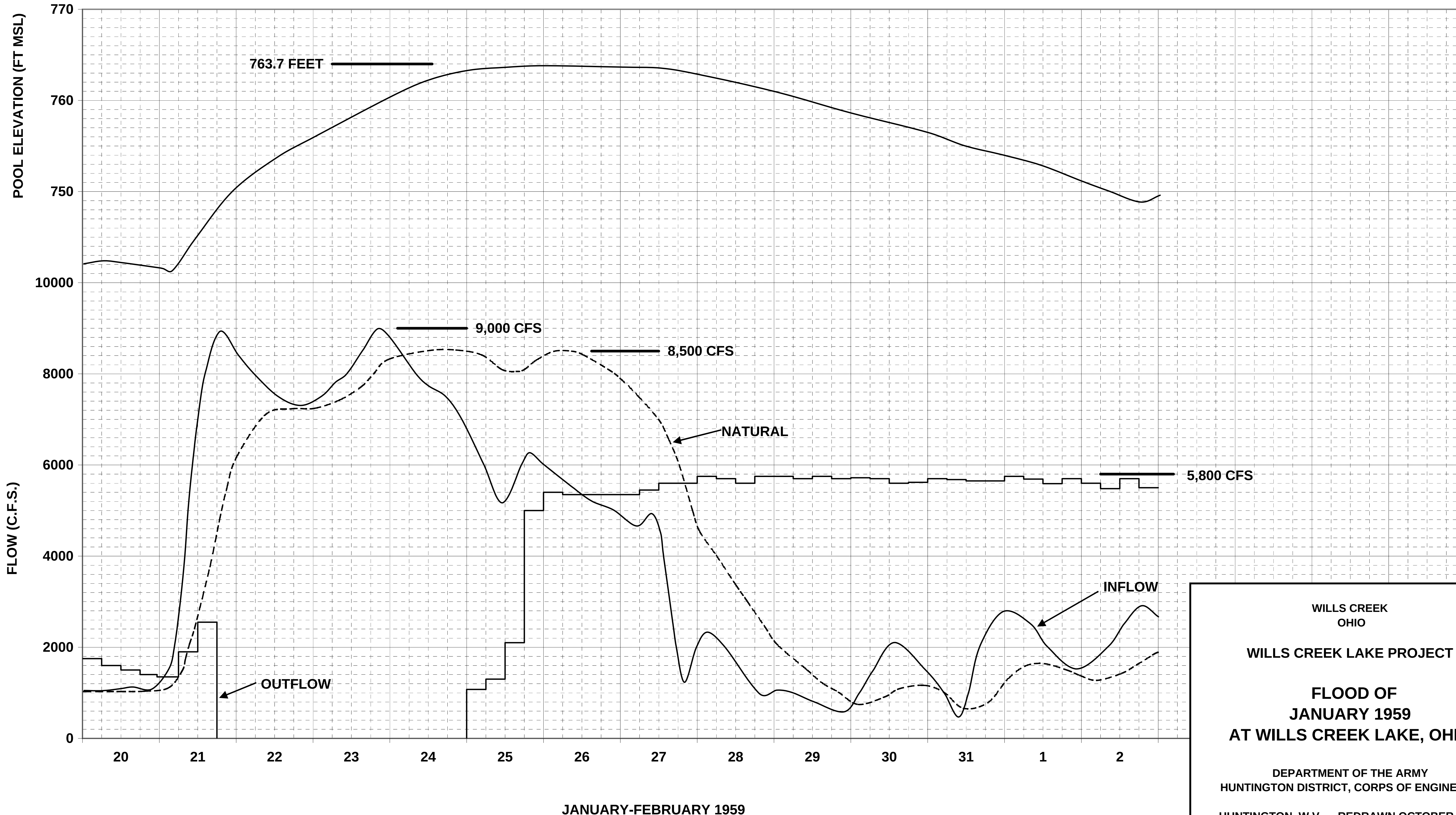
WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

FLOOD OF
JANUARY 1937
AT McCONNELSVILLE, OHIO

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



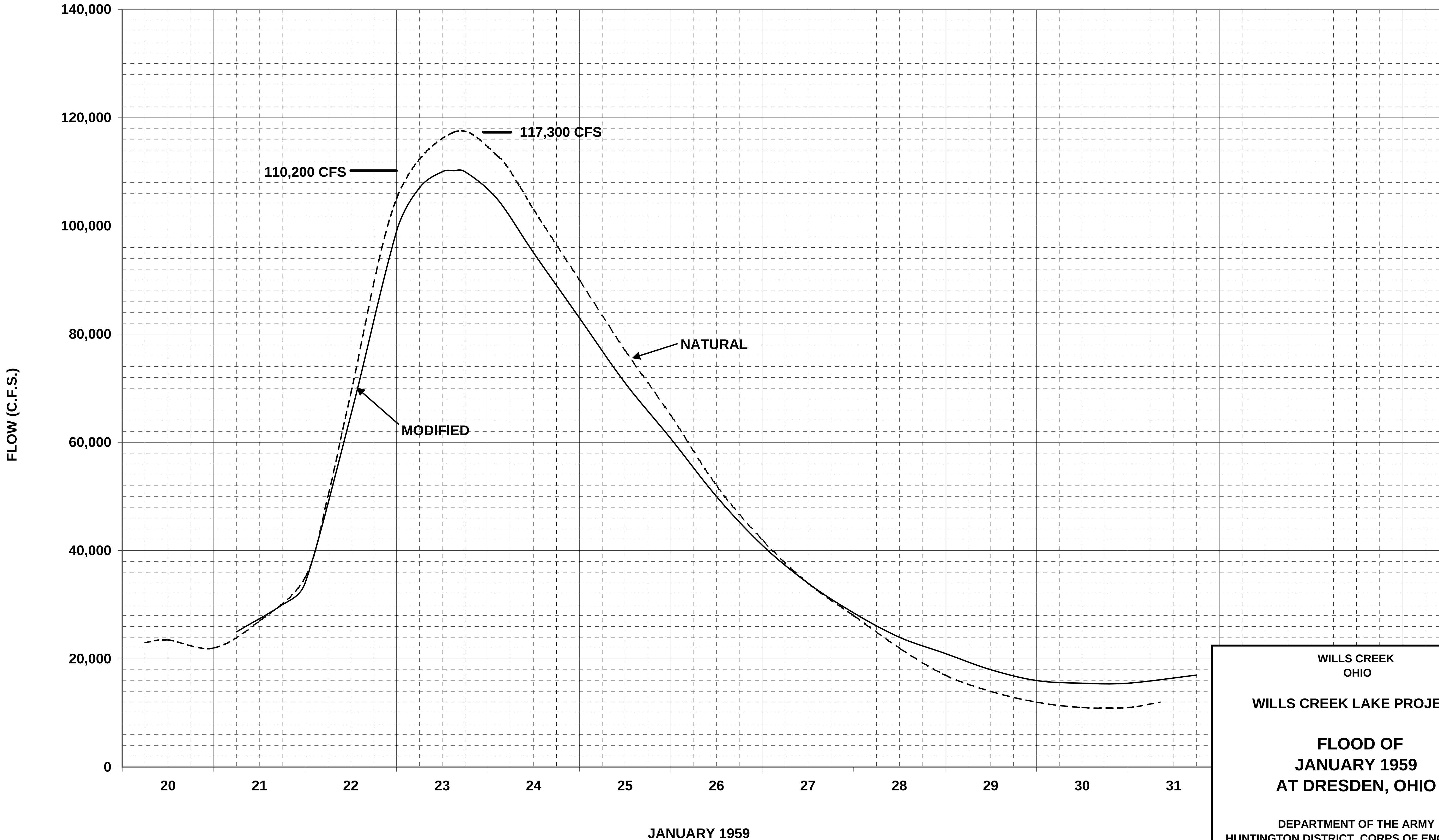
WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

FLOOD OF
JANUARY 1959
AT WILLS CREEK LAKE, OHIO

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



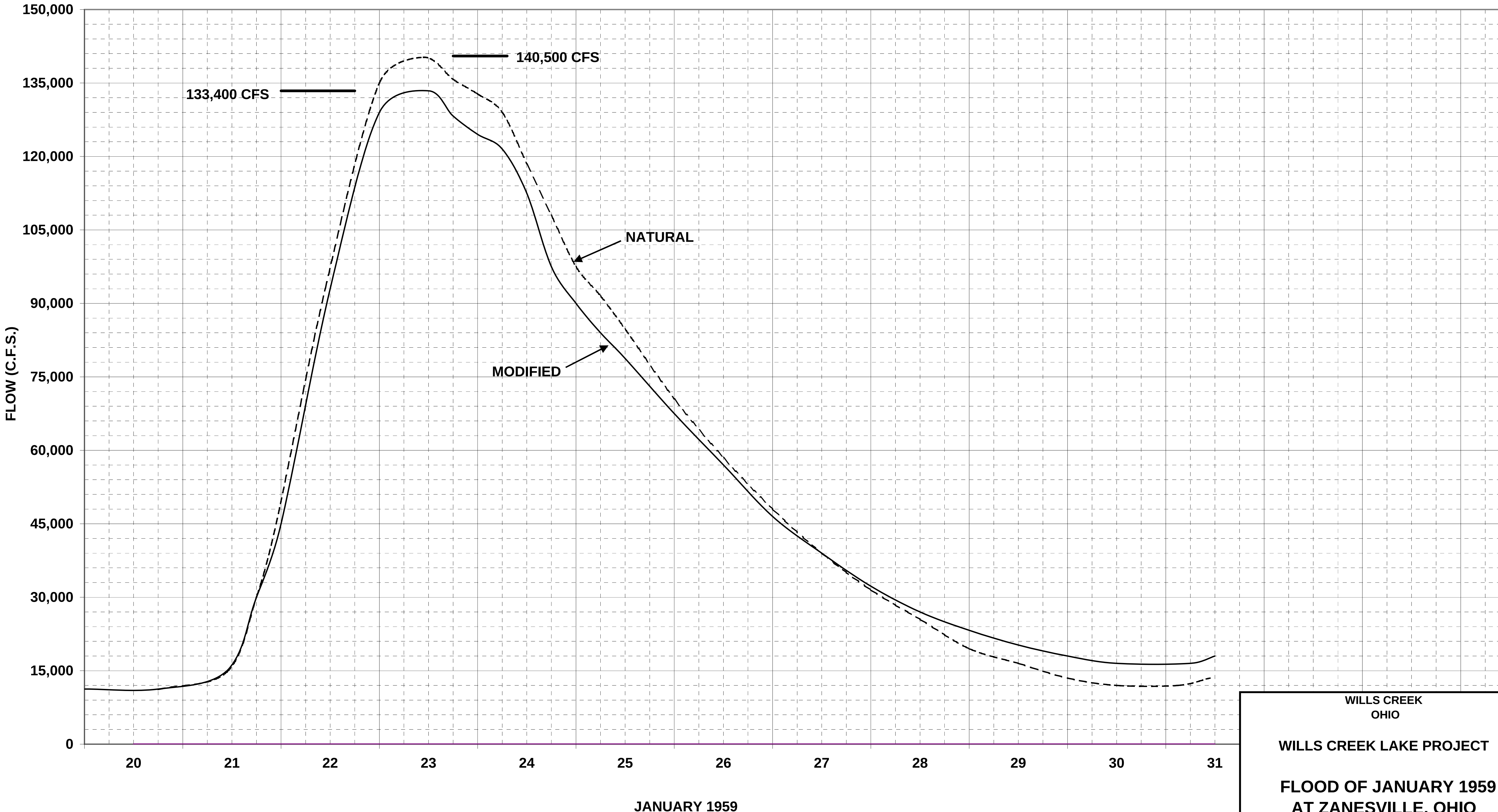
WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

**FLOOD OF
JANUARY 1959
AT DRESDEN, OHIO**

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



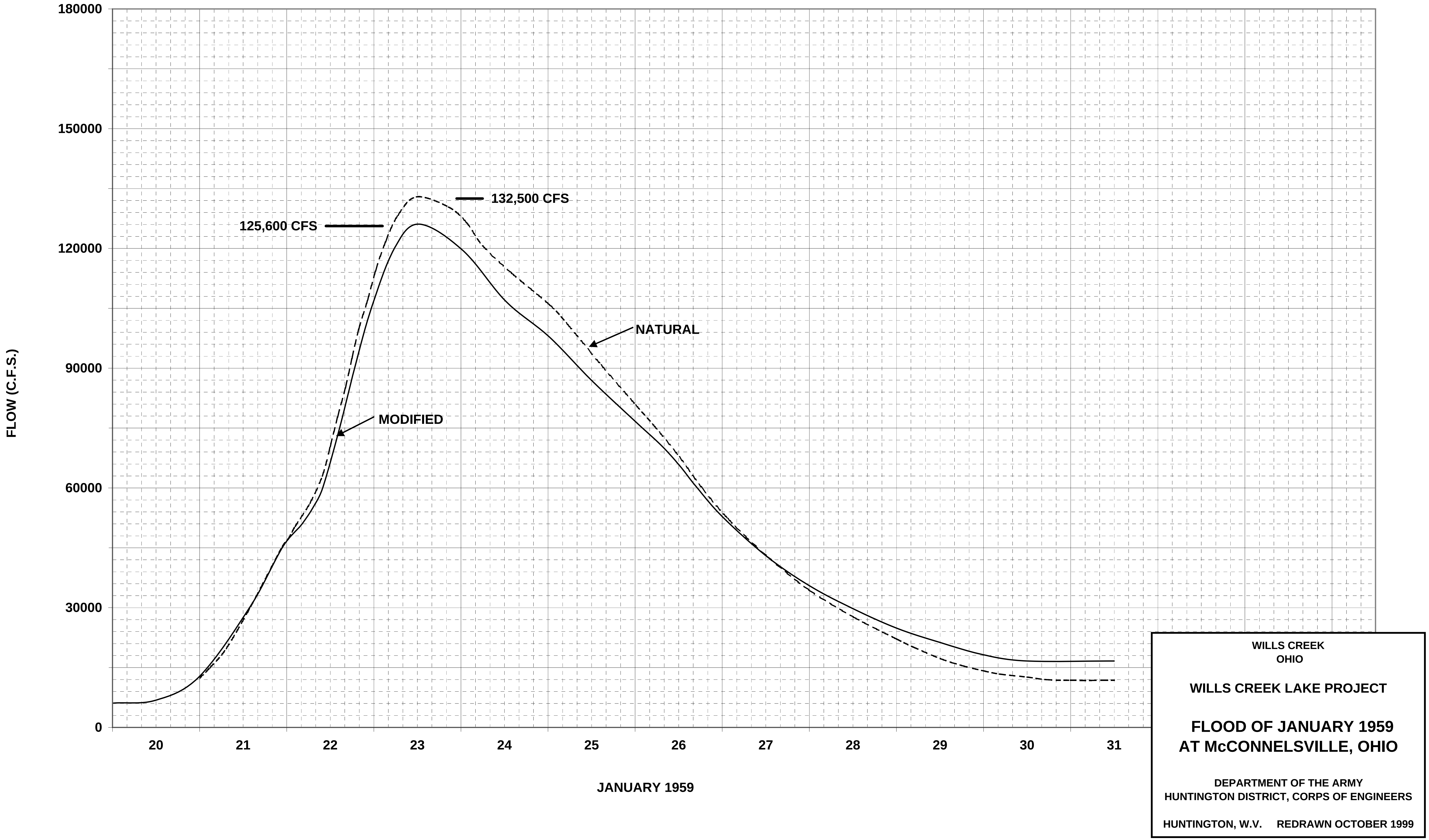
WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

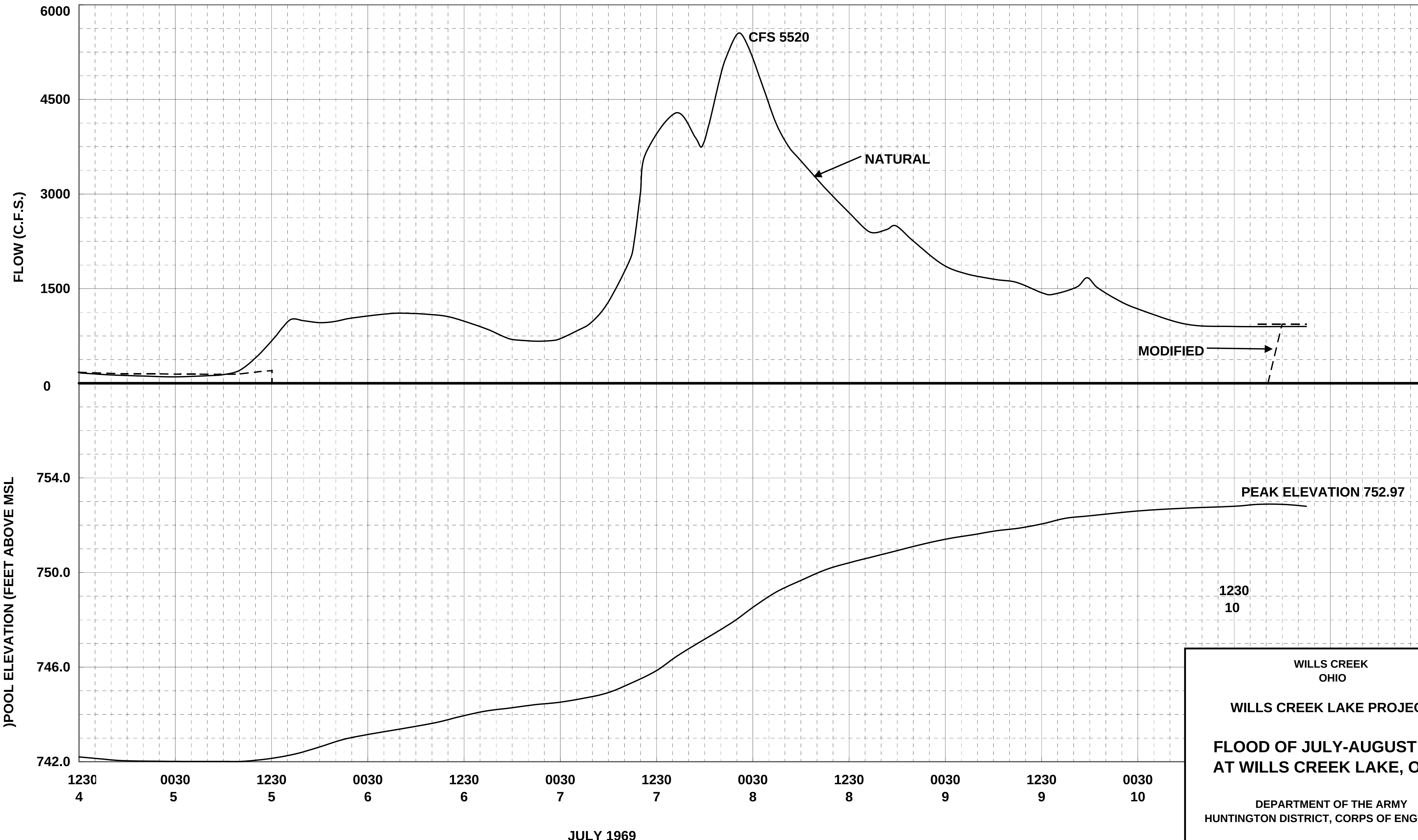
FLOOD OF JANUARY 1959
AT ZANESVILLE, OHIO

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



180000
150000
120000
90000
60000
30000
0
FLOW (C.F.S.)
132,500 CFS
125,600 CFS
NATURAL
MODIFIED
20
21
22
23
24
25
26
27
28
29
30
31
JANUARY 1959
WILLS CREEK
OHIO
WILLS CREEK LAKE PROJECT
FLOOD OF JANUARY 1959
AT McCONNELSVILLE, OHIO
DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V.
REDRAWN OCTOBER 1999



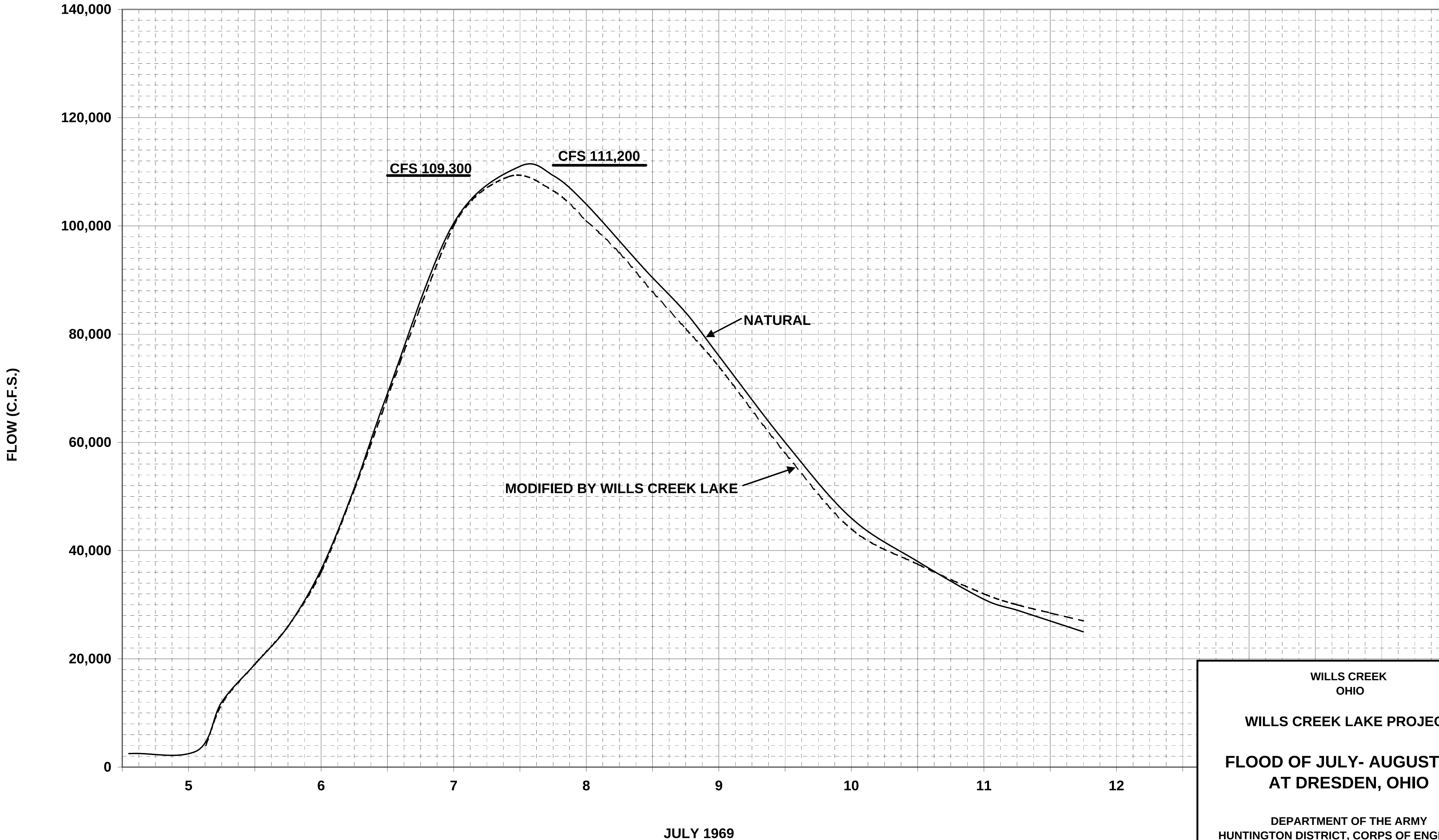
WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

FLOOD OF JULY-AUGUST 1969
AT WILLS CREEK LAKE, OHIO

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



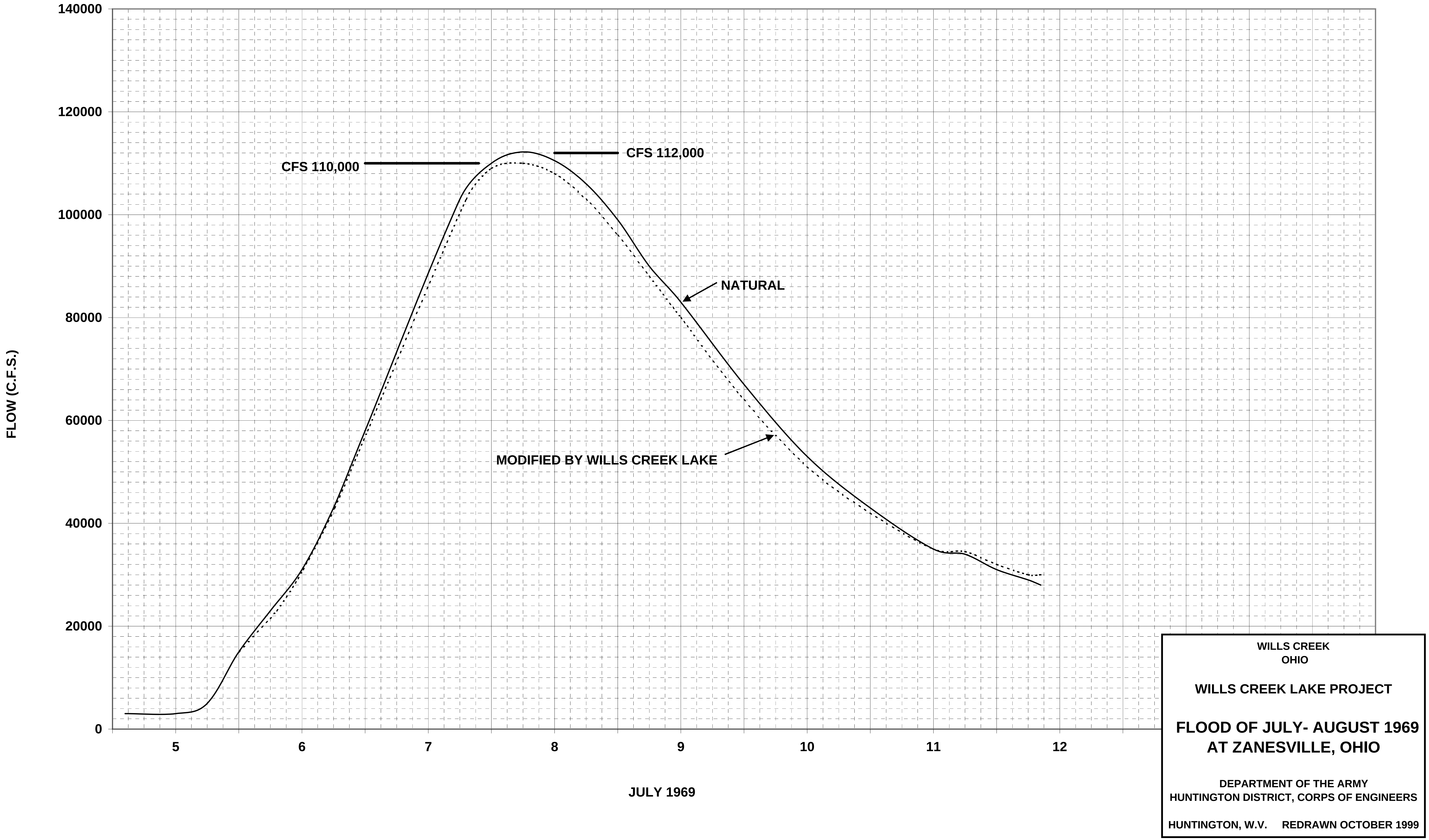
WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

FLOOD OF JULY- AUGUST 1969
AT DRESDEN, OHIO

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



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80000
60000
40000
20000
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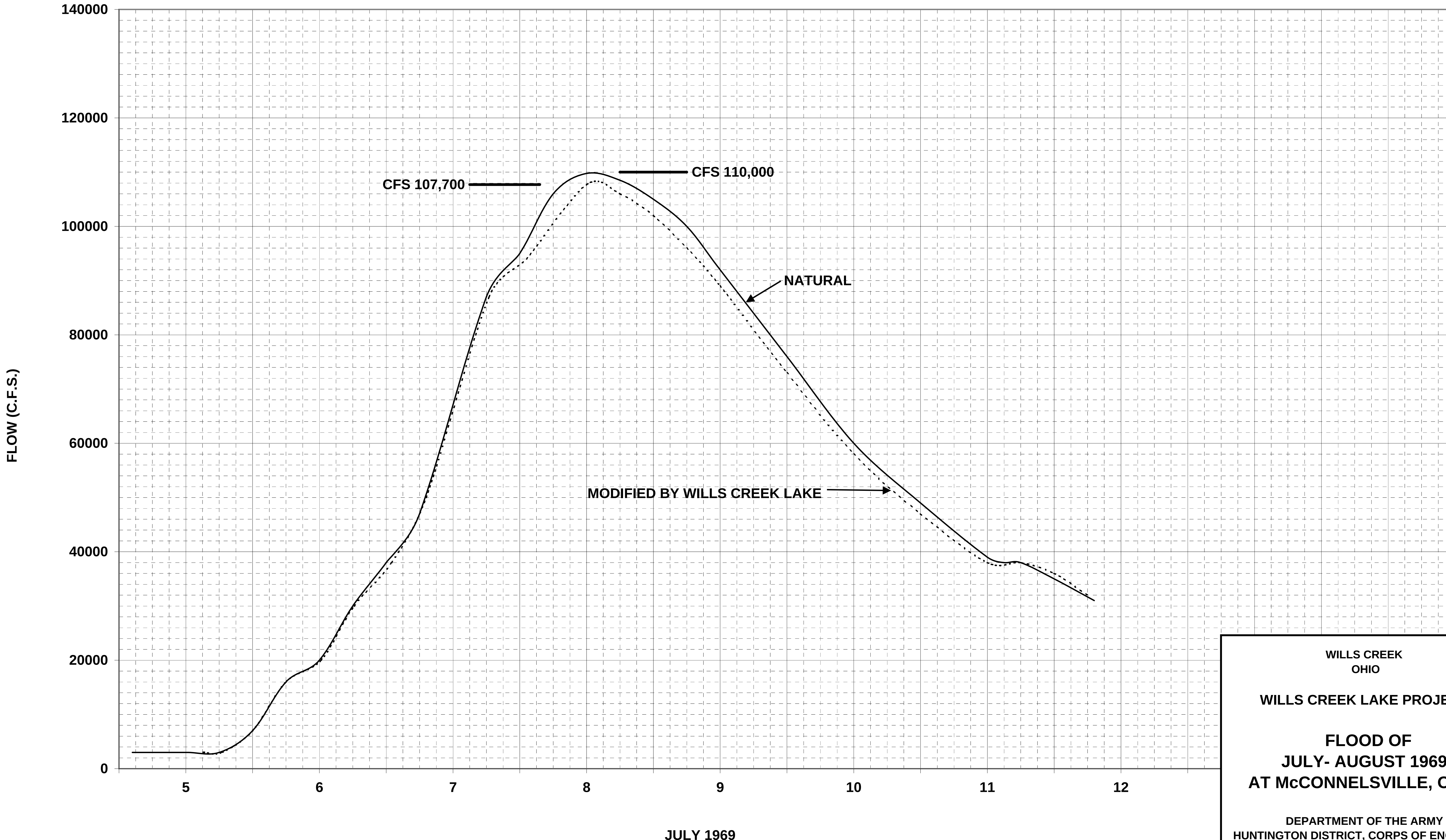
FLOW (C.F.S.)
CFS 110,000
CFS 112,000
NATURAL
MODIFIED BY WILLS CREEK LAKE
5
6
7
8
9
10
11
12
JULY 1969
WILLS CREEK
OHIO
WILLS CREEK LAKE PROJECT
FLOOD OF JULY- AUGUST 1969
AT ZANESVILLE, OHIO
DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V. REDRAWN OCTOBER 1999



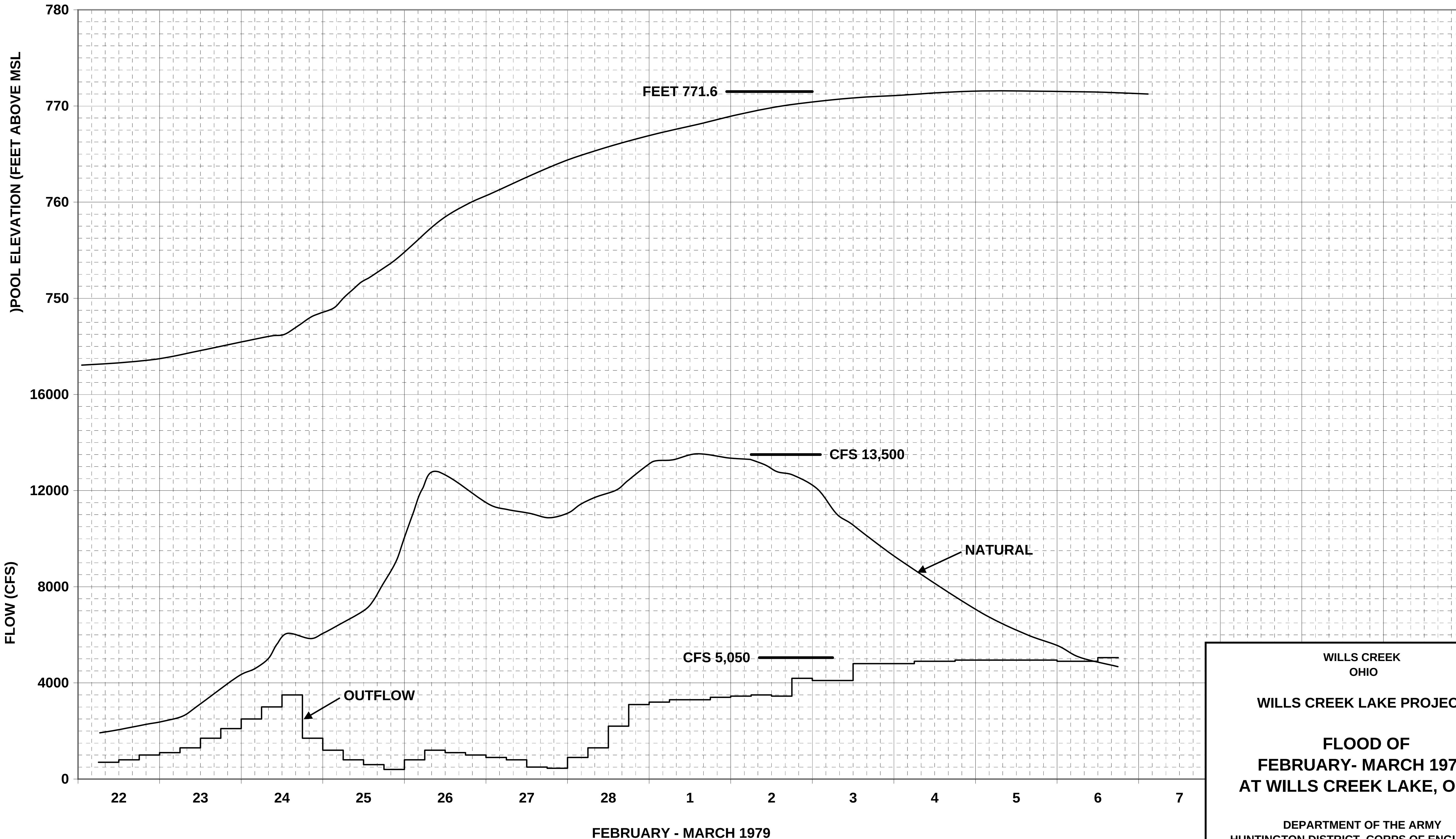
WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

FLOOD OF
JULY- AUGUST 1969
AT McCONNELSVILLE, OHIO

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



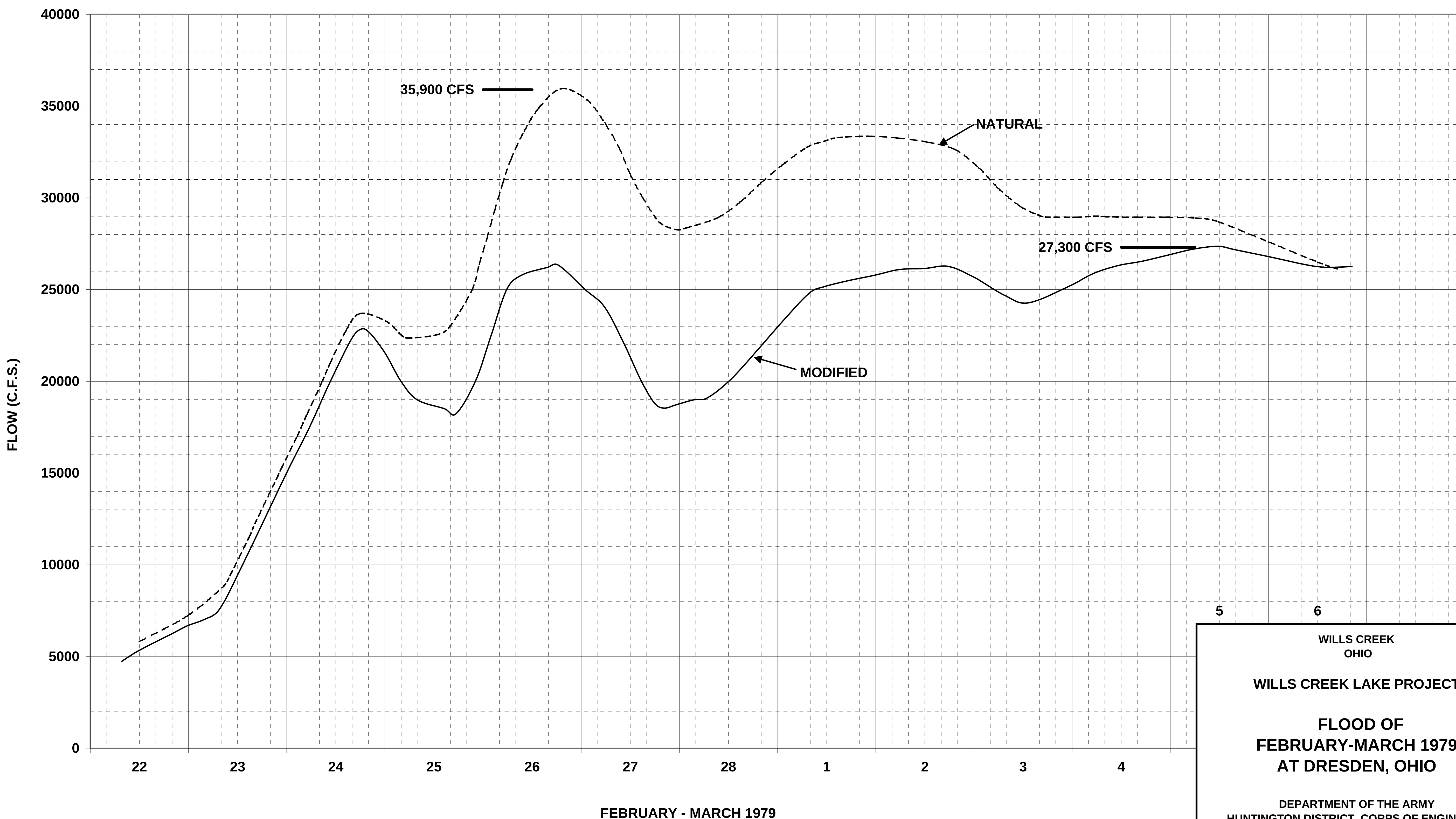
WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

FLOOD OF
FEBRUARY- MARCH 1979
AT WILLS CREEK LAKE, OHIO

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



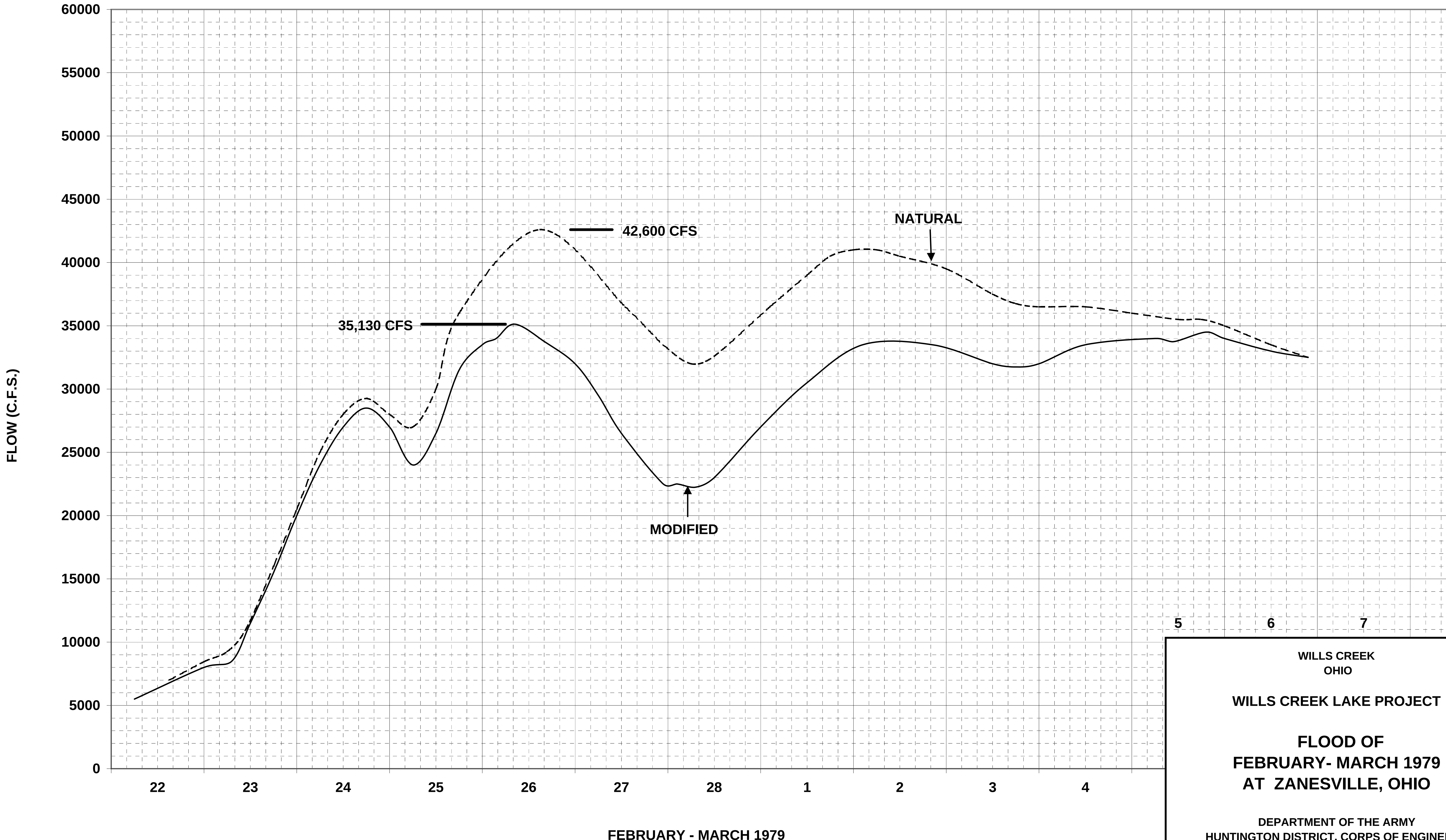
WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

FLOOD OF FEBRUARY-MARCH 1979 AT DRESDEN, OHIO

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

FLOOD OF FEBRUARY- MARCH 1979 AT ZANESVILLE, OHIO

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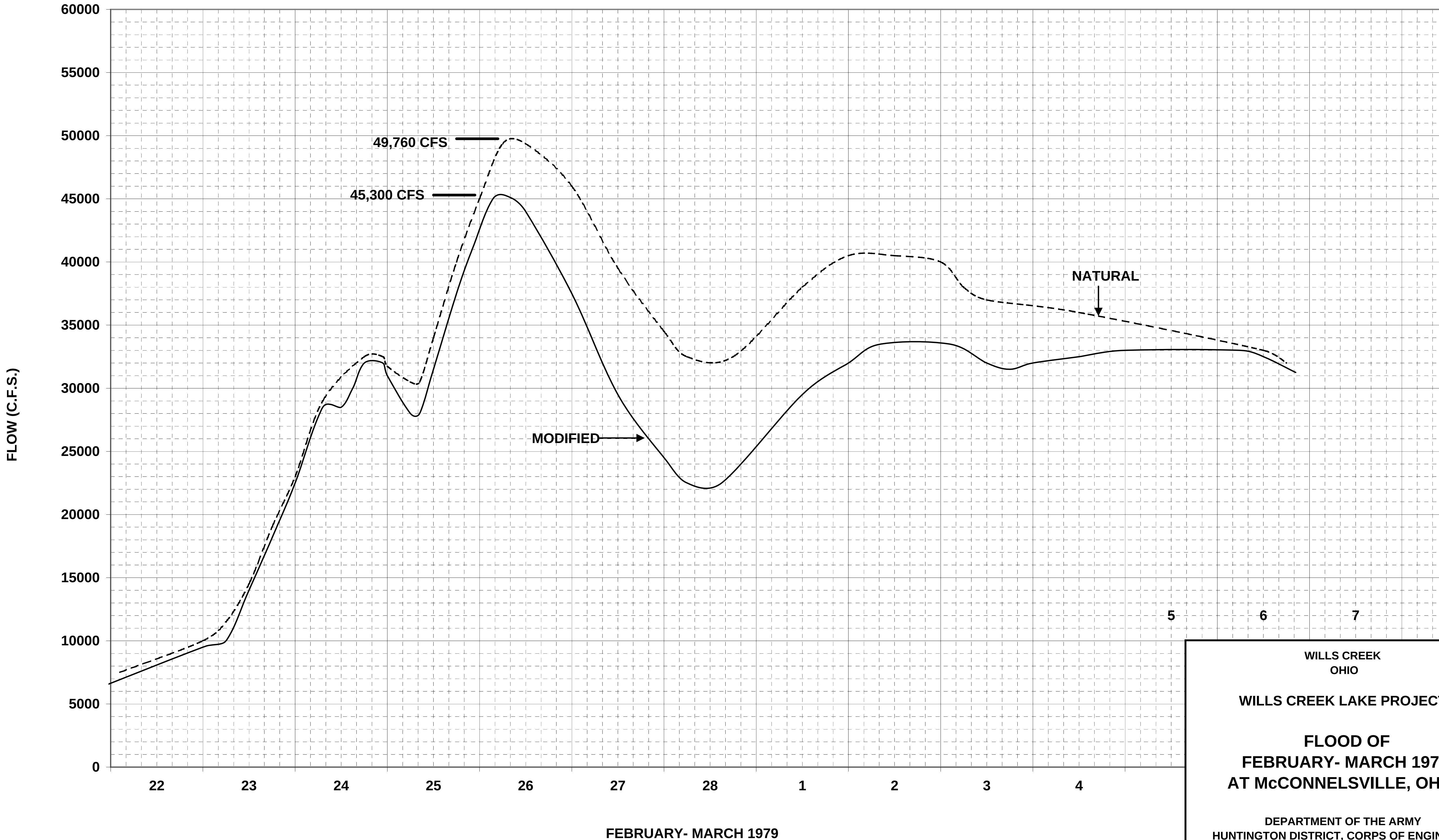
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V.   REDRAWN OCTOBER 1999



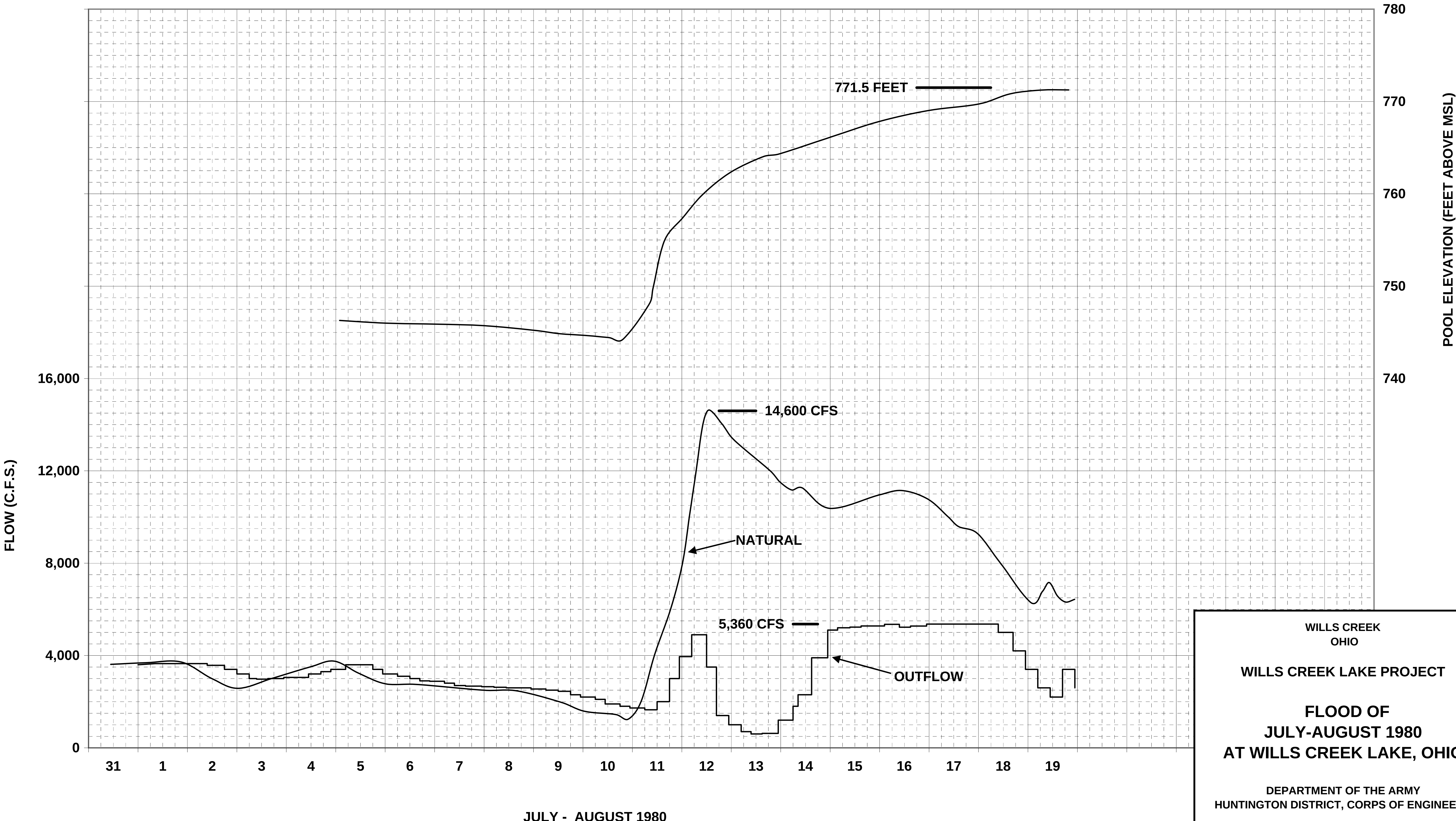
WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

FLOOD OF
FEBRUARY- MARCH 1979
AT McCONNELSVILLE, OHIO

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V.   REDRAWN OCTOBER 1999



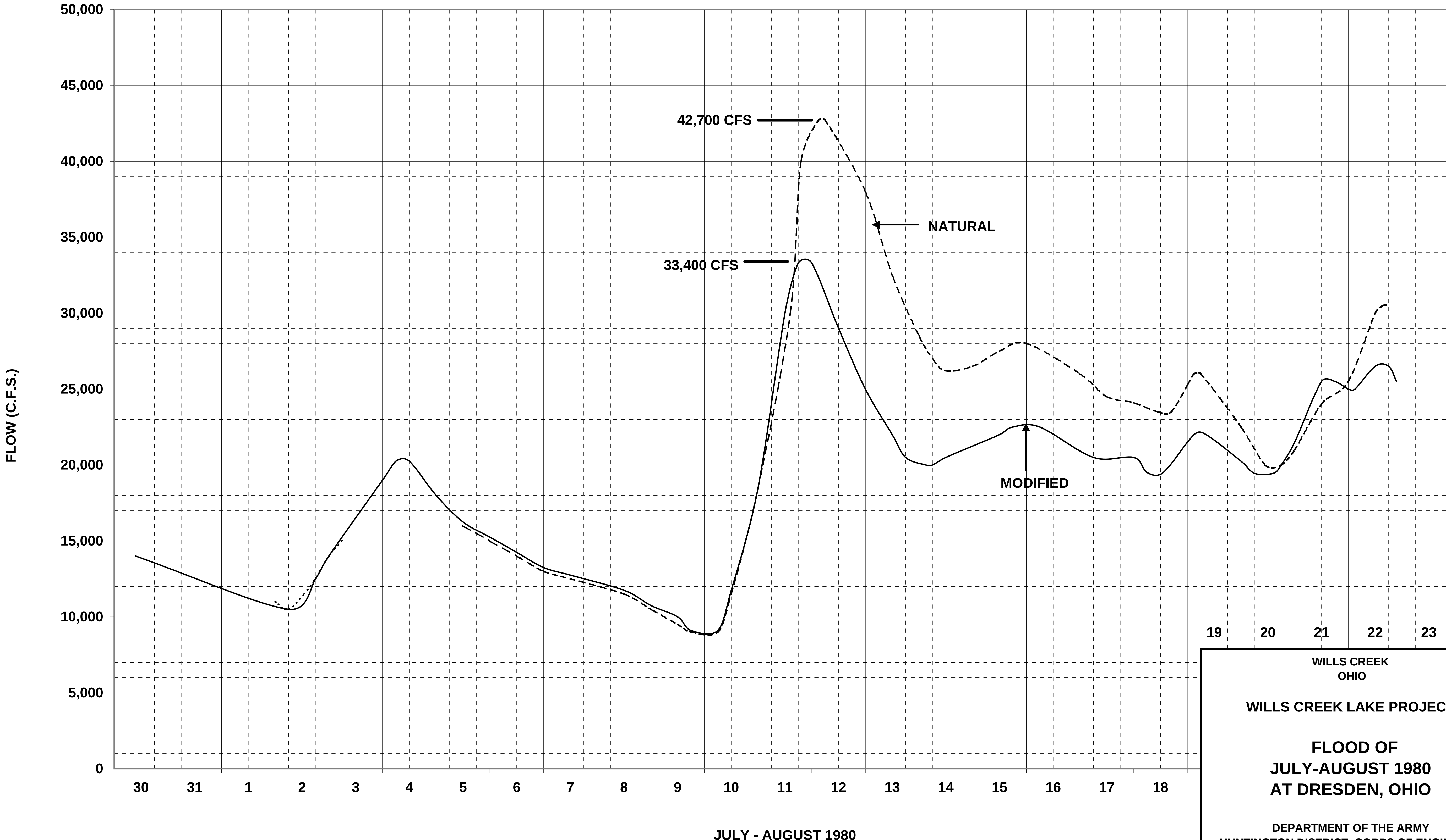
WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

FLOOD OF
JULY-AUGUST 1980
AT WILLS CREEK LAKE, OHIO

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



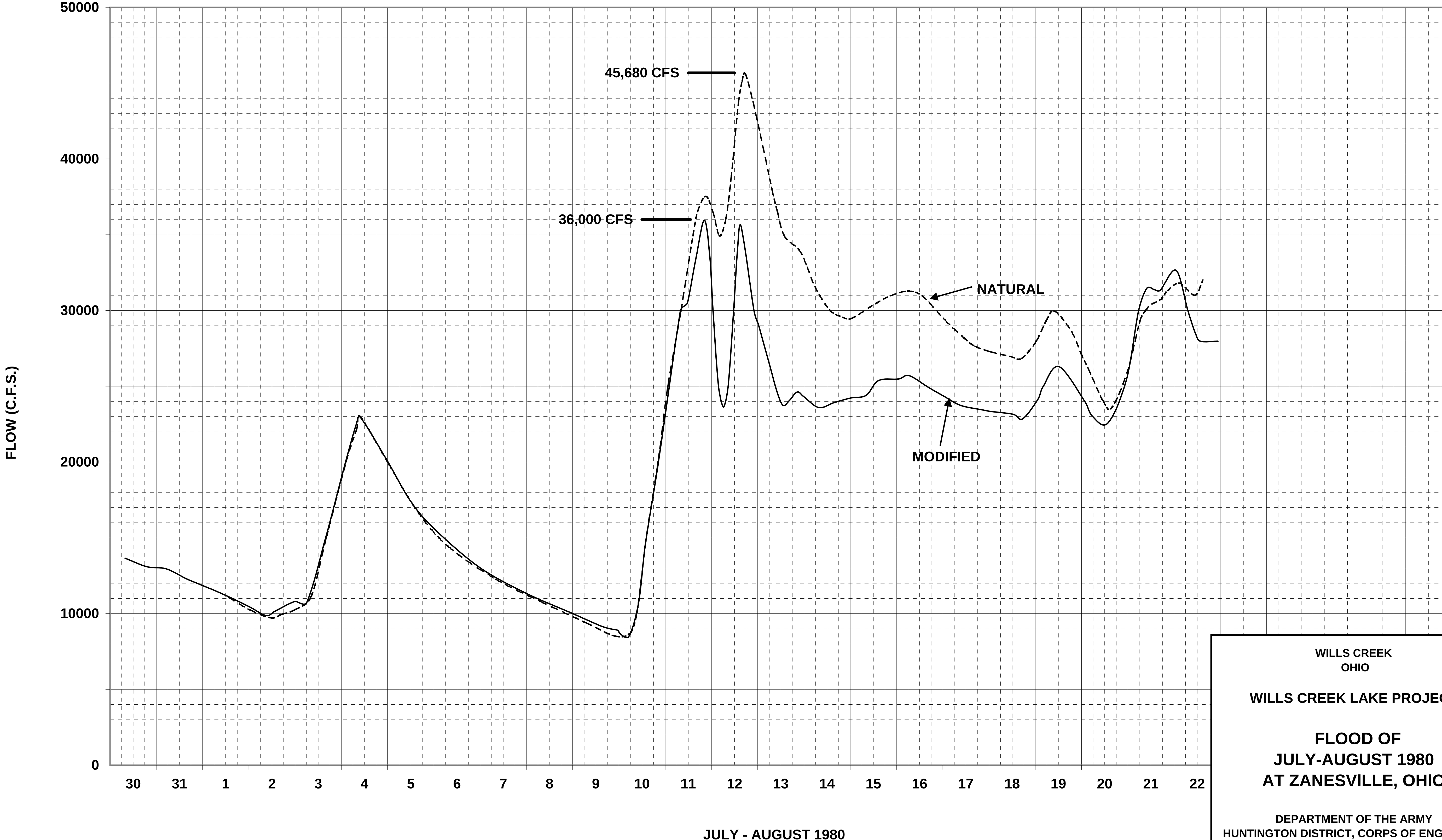
WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

FLOOD OF
JULY-AUGUST 1980
AT DRESDEN, OHIO

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



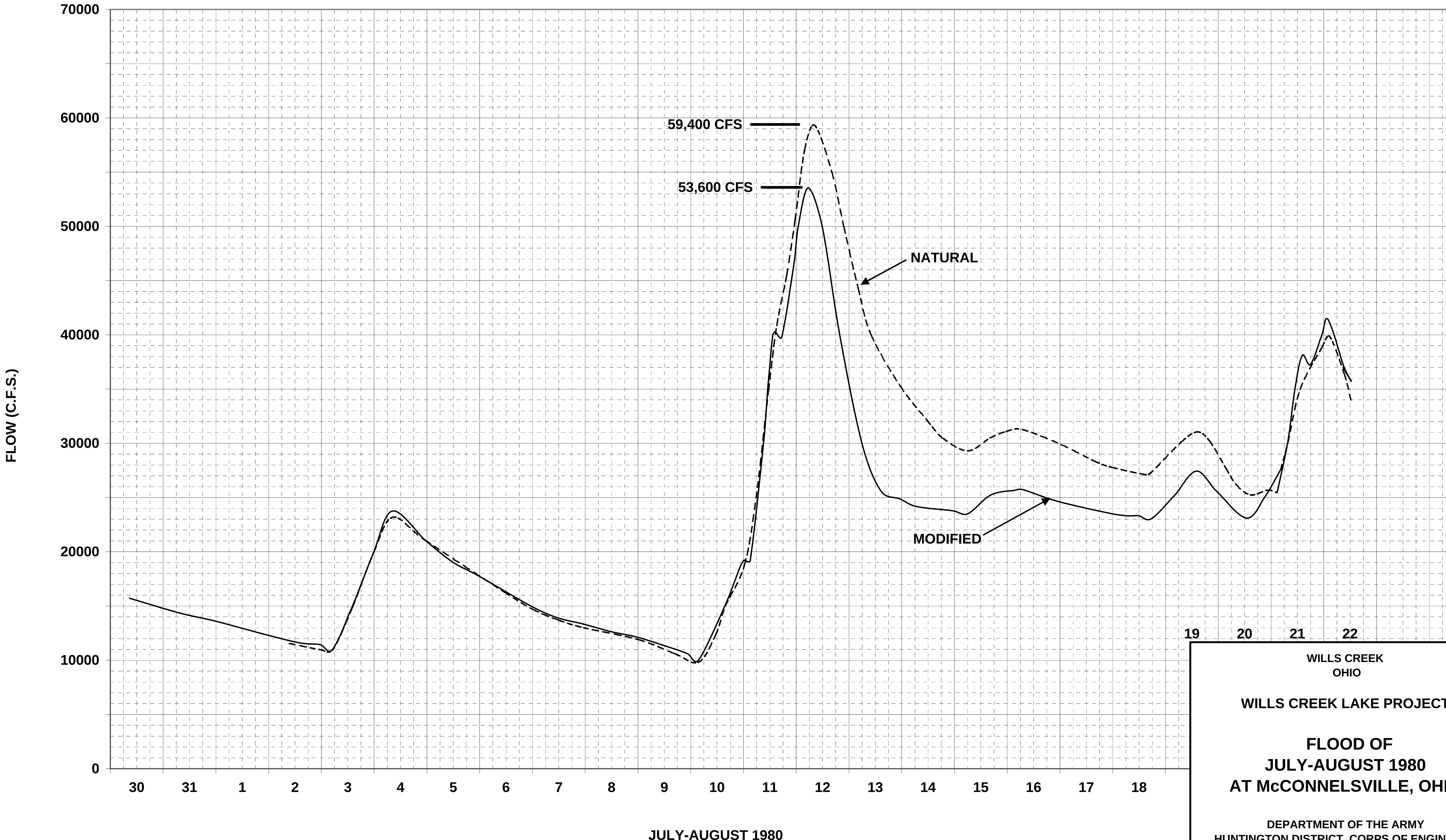
WILLS CREEK
OHIO

WILLS CREEK LAKE PROJECT

FLOOD OF JULY-AUGUST 1980 AT ZANESVILLE, OHIO

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



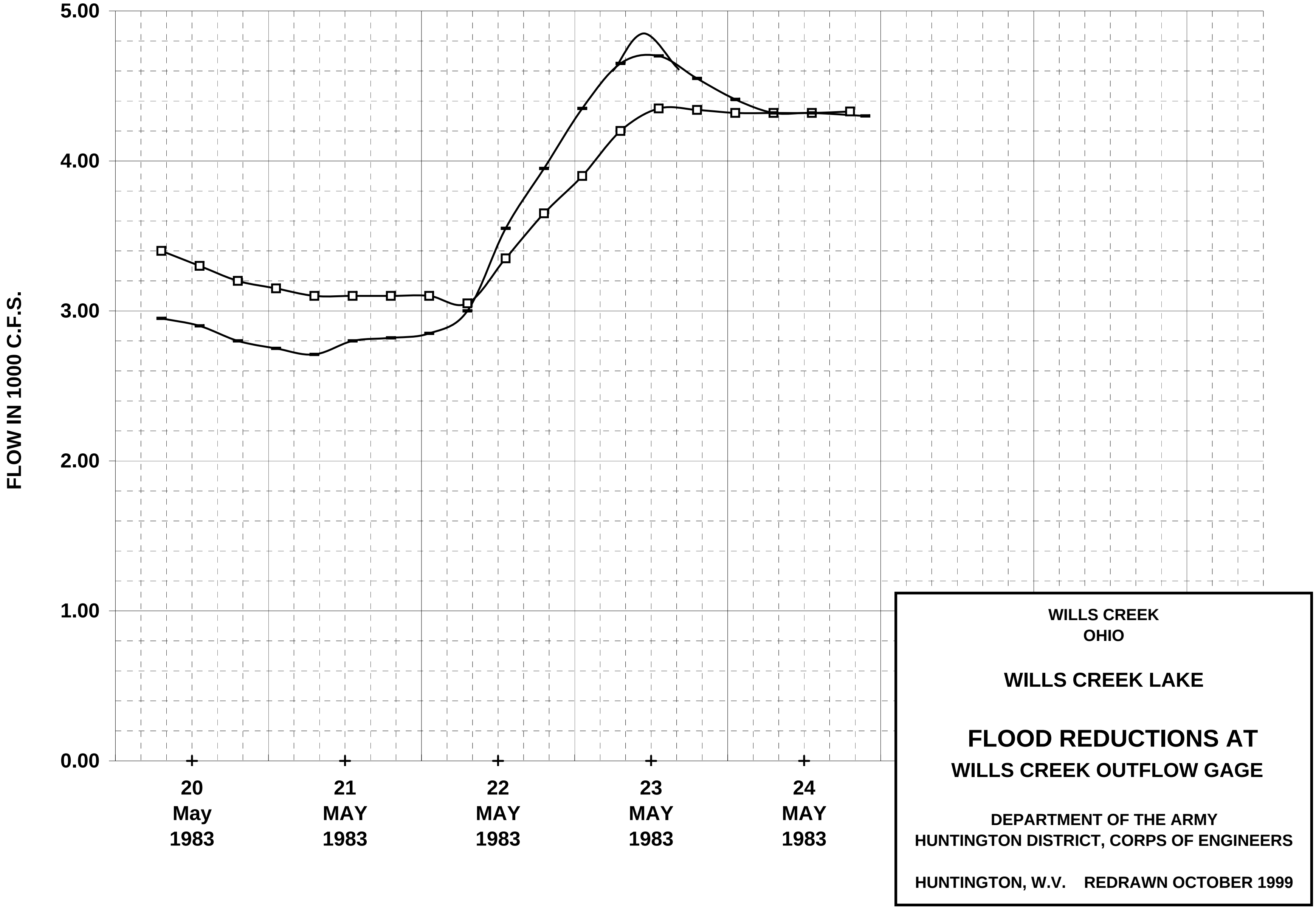
WILLS CREEK
OHIO

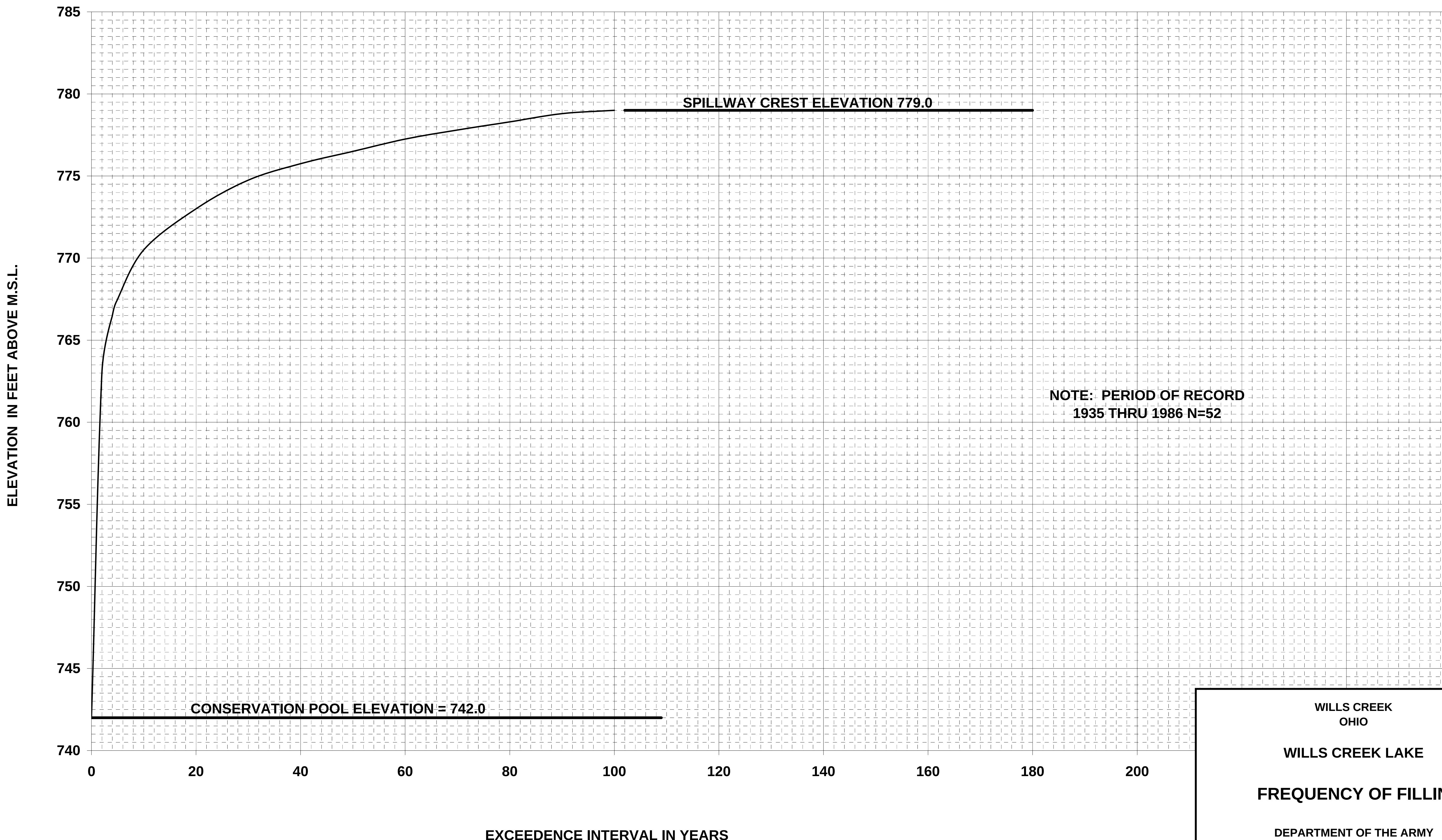
WILLS CREEK LAKE PROJECT

FLOOD OF JULY-AUGUST 1980 AT McCONNELSVILLE, OHIO

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999


5.00
4.00
3.00
2.00
1.00
0.00
FLOW IN 1000 C.F.S.
20 May 1983
21 MAY 1983
22 MAY 1983
23 MAY 1983
24 MAY 1983
WILLS CREEK
OHIO
WILLS CREEK LAKE
FLOOD REDUCTIONS AT
WILLS CREEK OUTFLOW GAGE
DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V. REDRAWN OCTOBER 1999



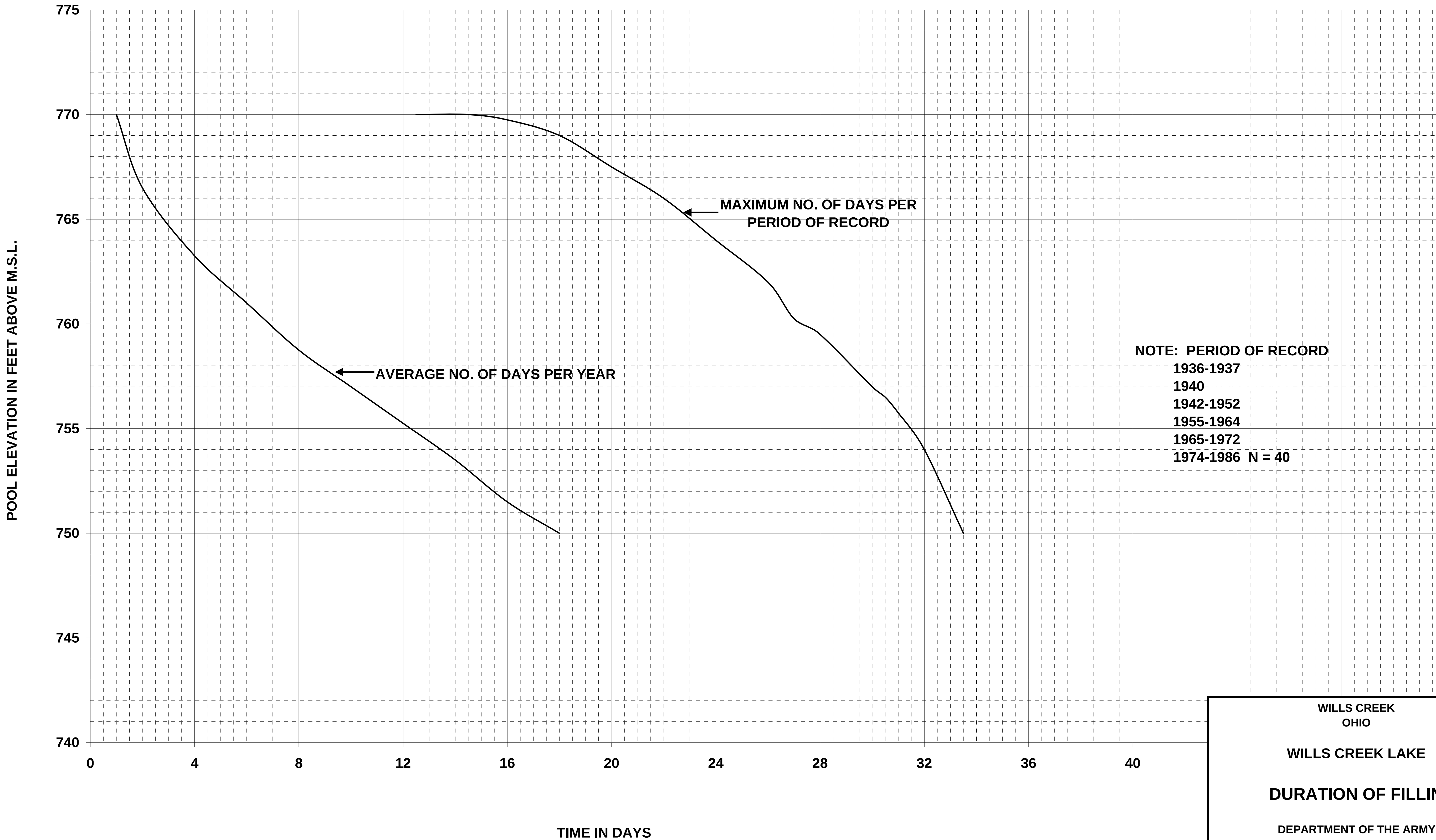
WILLS CREEK
OHIO

WILLS CREEK LAKE

FREQUENCY OF FILLING

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



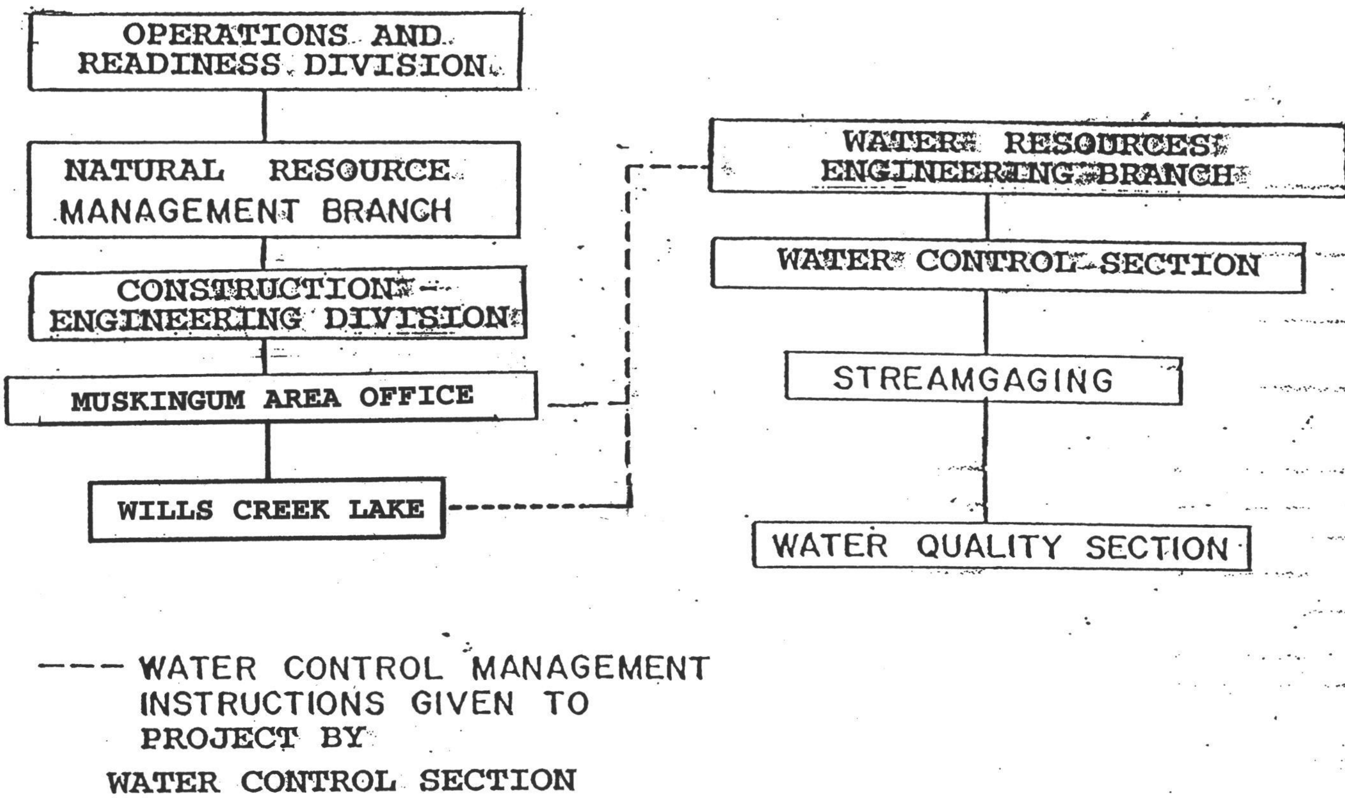
WILLS CREEK
OHIO

WILLS CREEK LAKE

DURATION OF FILLING

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. REDRAWN OCTOBER 1999



WILLS CREEK
OHIO

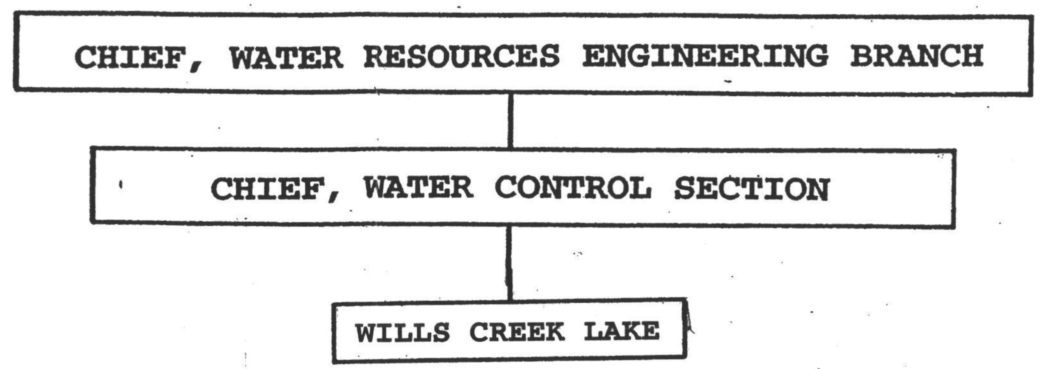
WILLS CREEK LAKE

WATER CONTROL MANAGEMENT
NORMAL ORGANIZATION

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

Plate No. 9-1

WATER RESOURCES ENGINEERING BRANCH FLOOD EMERGENCY ORGANIZATION



WATER RESOURCES ENGINEERING BRANCH
FLOOD EMERGENCY ORGANIZATION

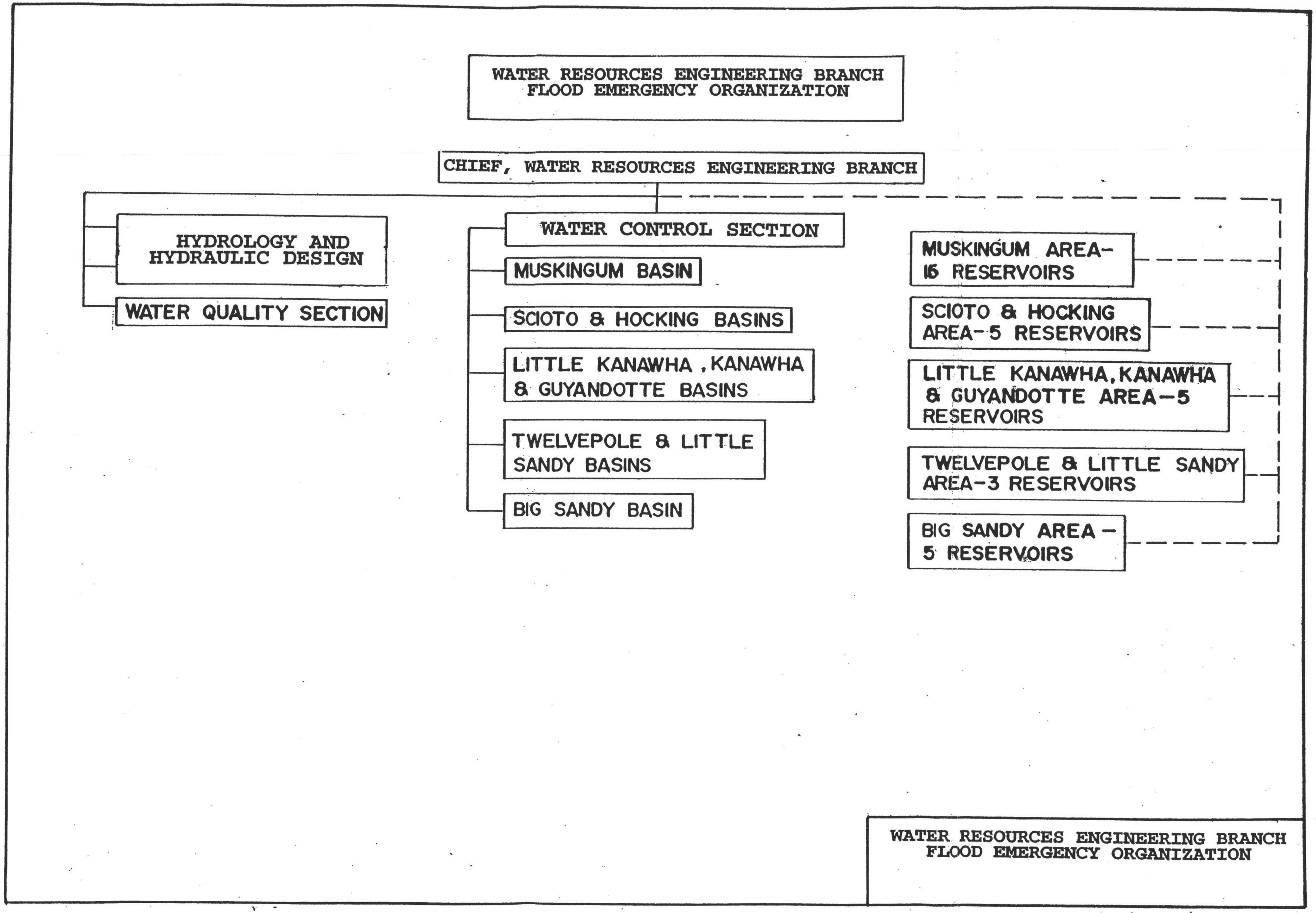
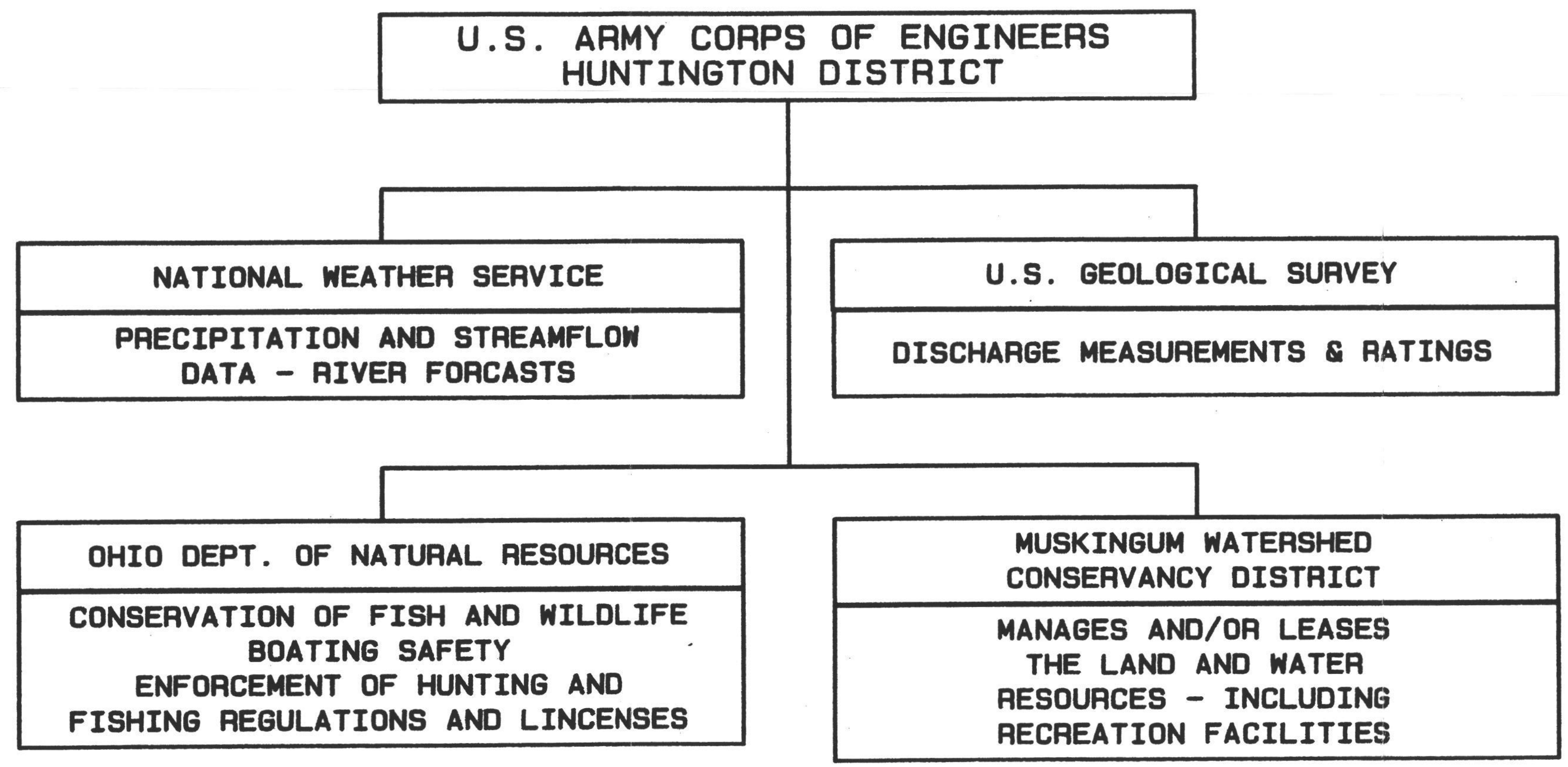


Plate No. 9-2
Sheet 2 of 2



DISTRICT RELATIONS WITH
OTHER AGENCIES
WILLS CREEK LAKE

Plate No. 9-3