CELRH-EC-WM

05 Jan 2010
Schray/5604

Memorandum for Resource Managers and Water Control Manual holders

Subject: Modification of Huntington District Water Control Reporting Procedures.

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

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

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

Replace the section in its entirety with the following:

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

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

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

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

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

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

CELRH-EC-WM

11 June 2007
Schray/5604

Memorandum for Resource Managers and Water Control Manual holders

Subject: Modification of Huntington District Water Control Reporting Procedures.

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

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

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

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

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

3/16/04
Clu

CELRH-EC-WM

20 January 2004
Schray/5604

Memorandum for Kent Browning, OR Water Management POC.

Subject: Modification of Huntington District Water Control Reporting Procedures.

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

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

The following sections are modified as noted.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

0800 hours.

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

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

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

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

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

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

Instructions to Dam Tender, Schedule for Reading Gages

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

Modify the chart as follows:

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

Modify the footnotes as follows:

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

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

CF:EC-WH

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

Brown/5130

REPLY TO
ATTENTION OF:

CELRH-EC-W (11110-2-1403a)

28 January 2004

MEMORANDUM FOR Commander, Great Lakes and Ohio River Division
ATTN: CELRD-MT-E

SUBJECT: Water Control Manual for Delaware Lake

1. Enclosed herewith are two copies of the subject manual for your retention. There are no changes to the water control plan operating procedure. Changes include changing from the 11 chapter format to the 9 chapter format according to ER 1110-2-8156, modifying the Damtender Section to reflect changes in the reporting procedures and updated water quality information.

2. If you have any questions, please contact Mr. Charles Brown at [redacted].

Encl

JOHN J. JAEGER, Ph.D., P.E.
Chief, Engineering & Construction Division

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

DELAWARE LAKE

OLENTANGY RIVER BASIN

OHIO

PROJECT MANUAL
FOR WATER CONTROL MANAGEMENT
DELAWARE LAKE – OLENTANGY RIVER

PREPARED BY
CORPS OF ENGINEERS
HUNTINGTON DISTRICT
WATER RESOURCES ENGINEERING BRANCH

JANUARY 2004

DELAWARE LAKE

CORPS OF ENGINEERS

U. S. ARMY

DELAWARE F/C 62

OVERALL VIEW, LOOKING UPSTREAM

LOOKING ACROSS AXIS OF DAM

OLENTANGY RIVER

DELAWARE LAKE

DAM AND WALDO LEVEE

PLANS, ELEVATION AND SECTIONS

HUNTINGTON DISTRICT, HUNTINGTON W. VA.

Revised: 30 SEPTEMBER 1986

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
Scioto Area Office,
Circleville, Ohio 43113-1070
[redacted], Area Manager

Normal Work Hours, [redacted]
Night, weekend, Holiday,
Home - [redacted] [redacted]

KEY EMERGENCY CONTACTS

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

Water Resources Engineering Branch
District Personnel Home Telephone
[redacted], P.E.
Chief, Water Management Section [redacted]

[redacted]
Water Management Section [redacted]

[redacted], P.E.
Chief, Hydrology and Hydraulic Section [redacted]

NOTE: All the above numbers can be found on the Corps Intranet plus cell phone numbers at [redacted]

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

Other Agencies

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

National Weather Service
W. S. Forecast Office [redacted]
Hydrology Section, Cleveland, Ohio

U.S.ARMY, CORPS OF ENGINEERS
HUNTINGTON DISTRICT

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PERTINENT DATA

DELAWARE RESERVOIR
OLENTANGY RIVER, OHIO

LOCATION OF PROJECT

Delaware County, Ohio, on Olentangy River, Scioto River Basin, 32.4 miles upstream from confluence with the Scioto River at Columbus, Ohio.

TYPE OF PROJECT

Flood-Control and water-conservation reservoir.

PURPOSE

For reduction of flood damage in the Olentangy, Scioto and Ohio River valleys and water conservation for water-supply, pollution abatement, recreation and conservation of fish and wildlife.

AUTHORITY

Flood Control Act, Public No. 761, Seventy-fifth Congress, third session, dated 28 June 1938.

DRAINAGE AREAS (square miles)

Olentangy River at Delaware dam site	381
Olentangy River at Delaware, Ohio (USGS gage)	387
Olentangy River at mouth	536
Scioto River at Columbus, Ohio (USGS gage)	1,624
Scioto River at mouth	6,510

DAM

Type- Rolled earth fill. Concrete gravity channel section

Maximum height above original bedrock, feet	92
Top length, feet	18,600
Top width, feet	15
Base width	480

SPILLWAY

Type	controlled
Crest length, gross, feet	232
Crest length, net, feet	192
Crest elevation, feet above NGVD	922
Tainter gates, number	6
Tainter gates, size	25' high x 32' long
Spillway design flood, maximum inflow, cfs	148,000
Spillway design flood, maximum outflow, cfs	120,000
Maximum surcharge, spillway design flood, feet	30.2

SCIOTO RIVER
OHIO
PROJECT MANUAL
FOR
WATER CONTROL MANAGEMENT
DELAWARE LAKE – SCIOTO RIVER

SECTION I - INTRODUCTION

1-01. AUTHORIZATION OF WATER CONTROL MANUAL

This manual is prepared in accordance with Engineer Regulation 1110-2-8156, Preparation of Water Control Manuals, dated 31 August 1995; 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; 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 water control management of Delaware 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. Preliminary Examination of Scioto River, Ohio, House Document No. 1792, 64th Congress, 2nd Session	September 1916
2. Report on the Ohio River, House Document No. 306, 74th Congress, 1st Session	August 1935
3. Comprehensive Plan for Flood Control for Ohio and Lower Mississippi Rivers, House Document No. 1, 75th Congress, 1st Session	April 1937
4. Definite Project Report on Delaware Reservoir	May 1940
5. Preliminary Planning Report	October 1945

Title	Date
6. Master Regulation Manual for Reservoirs in the Scioto River Basin	July 1948
7. Instructions to Damtender	June 1952
8. Scioto Basin, Ohio, Comprehensive study	January 1962
9. Report on the 1975 Sedimentation Reconnaissance	March 1976
10. Water Inventory of the Scioto River Basin and Adjacent Ohio River Tributary Area	1968
11. Periodic Inspection, Delaware Dam	
Report No. 1	July 1970
Report No. 2	July 1975
Report No. 3	July 1980
Report No. 4	July 1985
Report No. 5	July 1990
Report No. 6	July 1995
Report No. 7	July 2000

The Delaware Lake project was authorized for construction by the Flood Control Act of 28 June 1938, Public Law 761, Seventy-fifth Congress, 3rd Session.

1-04. PROJECT OWNER

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

1-05. OPERATING AGENCY

The U. S. Army Corps of Engineers, Huntington District, Operations and Readiness Division controls the operation, regulation, and maintenance of the Delaware Lake project. To ensure correct operation Delaware Lake is staffed, all year round, Monday through Friday 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:.....The Damtender is:
Delaware Lake.....[redacted]
3920 U.S. Route 23 N.....Home Number [redacted]
Delaware, Ohio 43015-9708.....Office Number [redacted]

In conformance with the Ohio River Division Regulation 1110-2-27, dated 12 January 1976, the Water Resources Engineering Branch of the Huntington District has the primary responsibility for overall water control management of all Huntington District projects and associated reservoir activities, technical evaluations and performance of operations of these projects, and for developing plans and manuals for the reservoir systems within the District, including the Delaware Lake project.

1-06. REGULATING AGENCY

The regulation of Delaware Lake is under the supervision of the Water Management Section of the Water Resources Engineering Branch of the Huntington District. 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 Reservoir 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: Reservoir 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

Delaware dam is located in Delaware County, Ohio, on the Olentangy River 32.4 miles upstream from confluence with the Scioto River at Columbus, Ohio, and 6 miles above the city of Delaware, Ohio. The Olentangy River drainage area above the dam is 386 square miles.

The lake is located in the north-central portion of Ohio, entirely in Delaware, Morrow, and Marion counties. **Plate Nos. 2-1** and **2-2**, plate section, Drainage Area Map and Project Location, show the location of the project, along with other important features. Whetstone Creek is by far the largest tributary of the Olentangy River and enters the main stream above Delaware Dam. All the other tributaries are very small. The basin is about 57 miles long and the average width varies from about 15 miles above Delaware to less than 5 miles between Delaware and Columbus.

2-02. PROJECT PURPOSES

Delaware Lake was authorized for flood control and allied purposes in a comprehensive plan for both the Scioto and Ohio River Basins. Project purposes include flood control, low-flow augmentation for water supply and pollution abatement, general recreation, and conservation of fish and wildlife. Benefits from specific project purposes serve not only local interests in the Olentangy and Scioto River Basins, but are widespread throughout the Ohio River Basin. Land use for the various project purposes are shown in a later portion of this section. Pertinent data for the Delaware Lake Project is shown as **Exhibit-A**.

2-03. PHYSICAL COMPONENTS

a. General. Delaware Dam consists of an 18,600 feet long rolled embankment, 92 feet high, with an ogee spillway controlled by six radial gates. The outlet works consist of five conduits which are hydraulically controlled by vertical lift sluice gates. Also, part of the Delaware Lake project is a 6,500 foot long levee which protects the village of Waldo 9 miles upstream of the dam. The Delaware Lake General Site Plan is shown in **Plate No. 2-3**, plate section.

b. Embankment. The embankment portion of Delaware Dam is a rolled fill embankment with an impervious core and random fill shells. The upstream slopes of the higher sections were protected with rock paving, while the remainder of the upstream slope was seeded. The downstream slope was protected against high tailwater by rock fill and rock paving, and above that the slopes were seeded. The embankment slopes at the right bank of the river were filleted in order to minimize seepage along the abutment slope, and the right bank upstream

from the dam is protected against sudden draw-down by a rolled fill blanket placed on and against the original ground. A General Site Plan is given in **Plate No. 2-3** and the Embankment and Channel Protection Plan is shown in **Plate 2-4**, plate section. Plans, elevations and sections of the East and West abutments are shown in **Plate No. 2-5** and **Plate No. 2-6**, plate section. The Village of Waldo, located 9 miles upstream from the dam on the right bank, is protected by a rolled earth levee approximately 6,500 feet long, with two pump stations and appurtenant structures. The crest elevation of the levee is 954 feet, NGVD. Typical sections profiles, and plan views of the Waldo Levee are shown in **Plate No. 2-7** and **Plate No. 2-8**, plate section. General site plans for the South Draw and Tomahawk pump stations are found in **Plate No. 2-9** and **Plate No. 2-10**, plate section.

c. Spillway. The concrete spillway monolith with a controlled ogee crest is located on the left bank of the original river channel as shown in **Plate No. 2-11**, plate section. The valley floor to be occupied by this work was excavated and cleared of overburden with sufficient rock removed to secure a good foundation. Training walls are provided at the ends of the spillway to retain the earth fill of the embankment and to prevent the overflowing water from spreading outside the stilling basin. The fixed crest of the spillway is at elevation 922 feet NGVD, with the top of the crest gates at elevation 947 feet NGVD. The spillway is controlled by means of six radial tainter gates, each 32 feet long by 25 feet high. Five piers, 8 feet wide, surmount the crest and support the gate control machinery. Spillway section and details are shown in **Plate No. 2-12**, plate section.

d. Outlet Works. The outlet works consist of five hydraulically controlled, gated conduits which discharge into a stilling basin. The conduits are 6.5 feet square and are located in each of the five pier sections. The entrance invert of conduits the is at elevation 881.0 feet NGVD. Discharge through the conduits is controlled by vertical lift gates having their operating mechanism at the top of the piers. The five conduits have a discharge capacity of 11,100 cubic feet per second (cfs) with the reservoir at elevation 947 feet NGVD. When the reservoir pool reaches elevation 945.0 feet NGVD, the damtender shifts the outflow control from the sluice gates to the crest gates, raising all the crest gates enough to discharge the required flow. This provides a certain amount of freeboard between the water surface and the top of the gates by the time the pool reaches elevation 947.0 feet NGVD. During prolonged general floods, it may be necessary to maintain the reservoir level at elevation 947.0 NGVD for a considerable period of time. During such periods the damtender will endeavor to hold the pool at this level by manipulating the spillway crest gates.

e. Operating Machinery. Operating machinery for Delaware Dam consists of crest gates, sluice gates, and associated mechanisms.

(1) Crest Gates. The six radial spillway tainter gates are 32 feet long and 25 feet high, each operated by means of individual electric hoists. Emergency gate operation is by a traveling electric hoist. The location and general arrangement of the crest gates is shown on **Plate No. 2-13**, plate section.

(2) Sluice Gates. The five sluice gates that control the flow in the 6.5 feet square conduits are hydraulically controlled vertical lift gates. The hydraulic machinery to lift the sluice gates is located in the operating gallery inside the masonry dam section, under the spillway. The sluice gates are shown in **Plate No. 2-14**, **Plate No. 2-15**, and **Plate No. 2-16**, plate section.

(3) Auxiliary Power Unit. A gasoline-driven generator is provided at the dam for general auxiliary use. Detailed pertinent data for the Delaware Lake Project is shown as **Exhibit–A**.

2-04. RELATED CONTROL FACILITIES

Delaware Dam is one of four Corps operated multi-purpose lakes in the Scioto River Basin. Alum Creek Lake on a tributary of Big Walnut Creek is the nearest Corps lake. Paint Creek and Deer Creek Lakes are about 50 miles below Delaware Lake in the basin near Chillicothe.

2-05. REAL ESTATE ACQUISITION

The acquisition of lands and easements for the Delaware Project were performed in accordance with the departmental policy current at that time. The taking line for the acquisition of land and for the relocation of roads and utilities were based on a pool elevation of 947.0 feet NGVD, the top of the spillway gates. Real estate planning studies determined that the damages resulting from the one surcharge operation that may be experienced during the life expectancy of the project would not justify the greatly increased expenditures which would be required to obtain the legal right to flood up to elevation 950.0 feet NGVD. Fee title was acquired in the dam site and in the reservoir properties which were completely affected, or so seriously affected as to have little, if any, value remaining in the residual area. The final decision as to the acquisition of the fee title in, or easement over, any property not so seriously affected was based upon a comparison of the cost of either, with due consideration given to the projected frequency of flooding, the effect upon access roads, the location of buildings thereon, and with the view of consolidating all fee acquisitions into a fairly compact boundary, thereby making it easier to control. Lands acquired were 7,703 acres in fee and 2,424 acres in easement.

There are no known outstanding water or mineral rights, nor known minerals of commercial importance, within the project area. The State of Ohio, however, holds an easement in narrow strips of land abutting the Olentangy River for public fishing rights over certain of the

tracts required for the project. In this connection, the State of Ohio, by appropriate instrument, has released all such rights in the tracts here-to-fore authorized for acquisition.

2-06. RECREATION AND PUBLIC USE FACILITIES

Listed in **Table No. 2-1**, below are recreational sites in operational condition in December 1984. Future sites will be constructed as joint funding is arranged with another governmental agency, such as the Ohio Department of Natural Resources. Site locations are shown in the Land Use Plan, **Plate No. 2-17**, plate section.

TABLE NO. 2-1

RECREATION SITES AT DELAWARE LAKE

Damsite Picnic Area and Fishing Access
Hickory Grove Picnic Area
Elmwood Grove Picnic Area
Beach Area
Cardinal Grove Picnic Area
Walnut Grove Picnic Area
Buckeye Grove Picnic Area
Sweet Gum Grove Picnic Area
Camping Area
Boating Marina
Fish and Wildlife Area

a. Corps Operated Sites. The Corps of Engineers operates and maintains the recreation facilities for public use at the dam site. Access to the top of the dam is restricted to pedestrian traffic and official vehicles since the road comes to a dead end at the project utility building. Two benches are provided along the roadway overlook on top of the dam. Persons fishing at the dam site may park in the area provided below the dam. Other recreational facilities include 18 picnic units, a picnic shelter, a waterborne comfort station with handicap facilities, playground equipment, drinking fountain, and two bulletin boards. Below dam fishing access has been improved by the construction of a stone based foot path.

b. State Operated Sites. The State of Ohio Department of Natural Resources maintains the following sites.

(1) Hickory Grove Picnic Area. This site consists of 20 developed acres with one group picnic site, 18 picnic units, 15 parking spaces, and a vault-type comfort station. Also included in this area is a landing strip or field 1950 feet long with an isolated group camp area for "fly-in campers".

(2) Elmwood Grove. The 20 developed acres have 30 picnic units, 69 car parking spaces, 22 trailer parking spaces, two boat launching lanes, 72 boat slips, and a vault-type comfort station.

(3) Cardinal Grove. Adjacent to Elmwood Grove, this 20 acre overflow area provides an additional 4 picnic sites, 20 car parking spaces and 55 trailer parking spaces.

(4) Beach Area. There are 15 developed acres with a bathing beach, bathhouse with showers, etc., two waterborne comfort stations, 51 picnic units, 900 parking spaces, dusk-to-dawn lights, four bathhouses, and playground equipment.

(5) Walnut Grove. This area has 5 developed acres with 10 picnic units, 36 parking spaces, and a vault-type comfort station.

(6) Buckeye Grove. There are 13 developed acres with 37 picnic units, 102 parking spaces, and a vault-type comfort station.

(7) Sweet Gum Grove. This site consists of 12 developed acres with 34 picnic units, 2 vault toilets, and 43 car parking spaces.

(8) Camping Area. The camping area comprises 50 developed acres with 213 campsites, 44 parking spaces, 4 waterborne comfort stations, 2 foot trails, 5 playgrounds, dusk-to-dawn lights, public pier with 18 boat tie-ups, drinking fountains, benches, and bulletin boards.

(9) Boat Marina. The Marina is a third-party concession, with two boat launching lanes, 220 boat slips, 56 picnic units, 54 car parking spaces, 110 trailer parking spaces, two waterborne comfort stations, two foot trails, dusk-to-dawn lights, four bathhouses, and playground equipment.

On site observation and visitation figures indicate that the State Park Areas receive optimum utilization. The areas are managed in such a manner so as to divert usage to an alternate site as needed to give relief to a site reflecting excess wear.

In addition to the above, a grass airstrip is available for small aircraft, with accommodations for fly-in camping. The State has also designated an area along the shore near Elmwood Grove and Cardinal Grove for boat access, swimming, and tent camping.

(10) Fish and Wildlife Area. The Fish and Wildlife Division manages 4,661 acres for fish and wildlife purposes. Hunting areas and fishing access points are provided. Facilities include parking areas, launching ramps, vault comfort stations, and a shooting range. The area is managed under an approved Fish and Wildlife Management Plan.

SECTION III – GENERAL HISTORY OF THE DELAWARE LAKE PROJECT

3-01. AUTHORIZATION

The Delaware Lake project was authorized for construction by the Flood Control Act of 28 June 1938, Public Law 761, Seventy-fifth Congress, 3rd session. The project was authorized for flood control, general recreation, fish and wildlife conservation, water supply, and low-flow augmentation for pollution abatement.

Additional Legislative authority includes the authorizing act; the Flood Control Act of 1944, as amended; the Fish and Wildlife Coordination Act of 1958; the Forest Conservation Act, as amended; the Federal Water Project Recreation Act; and the Water Resources Planning Act.

3-02. PLANNING AND DESIGN

Water supply and management in the Scioto-Olentangy River Basin has always played a crucial role in economic development. As in most basins, the twin problems of excess water during floods and inadequate water supply in the summer for personal, urban, and industrial development had to be solved. By the turn of the century, it was clear that the main source of Columbus water supply, the Scioto River, only marginally adequate for now, had to be expanded to accommodate long term future growth. Therefore, a five-year improvement program was initiated in 1904 to provide a safe and abundant water supply. By 1908, Griggs Reservoir on the Scioto River had been constructed, and water was treated by a 30-MGD facility at the site of Columbus, Dublin Road plant, then the largest lime-soda water softening plant in the world.

Following the record 1913 flood, which resulted in nearly $200 million in flood losses and the loss of 415 lives in the Ohio River Basin (145 lives in the Scioto Basin), the state legislature on 18 February 1914 passed the Conservancy Act of Ohio (Vol. 104-1914, Laws of Ohio). This Act initiated the third phase of Water Resources development, authorizing the creation of conservancy districts. They would have the power to plan, construct, administer flood control and conservation projects, to issue bonds, purchase land, levy assessments and enter into joint contracts with the state and Federal Government for any necessary work. The Conservancy Act, though originally conceived as flood control legislation, provided for the first state institutions with broad water management powers to conserve and develop water supplies, improve drainage, plan waste disposal and irrigation. This was the beginning of modern basin planning, flood control, and water conservation.

As a part of this movement, various organizations such as the Scioto-Sandusky Conservancy District, the Muskingum-Tuscarawas Improvement Association, the Miami Conservancy District, and the Franklin County Conservancy District, were formed and they began talking and promoting water resources management programs for the entire state. The first area to plan and complete any basin wide flood control program and project was the Miami Conservancy District, organized in 1915. This

pioneer conservancy district planned and built five flood control reservoirs or retarding basins in the Miami River Basin by 1922.

Along with these groups the city of Columbus engaged private engineering consultants to investigate methods of preventing destructive flooding in that city. One of the plans considered for this purpose involved the construction of a detention reservoir on the Olentangy River in the vicinity of Delaware. The reservoir plan was discarded, however, in favor of a plan for local relief consisting of channel rectification and levees within the city limits. Also, in 1916, the Franklin County Conservancy District using the same firm of consulting engineers, completed an investigation of the entire Scioto Basin. Their report recommended, among other things, the construction of a detention reservoir on the Olentangy River at substantially the same location as the present project. No action was taken, on this aspect of the flood-control program.

Since the flood problem in the Scioto – Olentangy River Basin was not confined to the main stream entirely nor to any one individual local area, the consideration of flood control measures needed to include the entire basin. And, through all these studies it was found that the most desirable and practical method of flood control in the basin was by reservoirs since the effected area is so extensive.

Certain local protection measures had already been completed at Delaware, Columbus and Chillicothe, but were generally inadequate. Even adequately protecting the cities alone would not entirely solve the problem since little relief would be afforded to the agricultural areas. It became apparent that the construction of levees or other such works for the protection of extensive agricultural areas was impractical. Consequently, the practical methods of flood control for these areas were confined to reducing the flood flows which could be accomplished best by the use of reservoirs. Large reservoirs would not only protect Delaware, but, also provide benefits downstream for the cities of Columbus and Chillicothe and the agricultural areas between Delaware and the mouth of the Scioto River at Portsmouth.

While the potential for severe flooding in the Scioto – Olentangy River Basin has long been recognized, and has been strongly considered, reviewed, and debated; nearly all Federal investigations made prior to the 1930's were generally concerned with improvements for commercial navigation, only; flood control was a secondary function, except on the lower Mississippi River. Water supply, recreation, and conservation were always considered local issues, and water quality, sedimentation, and environmental protection were unknown vague fields.

Unfortunately, since, the Scioto - Olentangy River Basin was no longer used for navigation, this basic formula for any Federal funding of any water control project was a huge obstacle that blocked most of the early project planning.

Locally the main concern was that the Scioto River could not always supply water for the growing Columbus area, especially in a severe drought. These nagging worries resulted in the building of a second water supply project, O'Shaunessy Dam in 1925. The Scioto – Olentangy Basin Drainage Map is shown on **Plate No. 3-1**, plate section.

These concerns were magnified by the 1930-31 record drought, which returned in 1934, the most extreme in the modern basin history. Major cities, towns, and farms all had severe water shortages. The Olentangy River had a tiny flow of 0.1 cfs at Delaware for 20 August 1930, and one month later the Scioto River at Columbus had flows below 50 cfs. Four years later, during the last half of September 1934 the Scioto River at Columbus had the same low-flow, less than 50 cfs, with a very small 1934 average annual water year flow of only 305 cfs.

At the same time the country found itself in the midst of a very severe stock market crash and worldwide economic depression. Low stream flow contributed to pollution, and led to the haunting fear that water shortages might stifle industrial recovery and regional expansion and growth even more than the 1929-33 world economic depression. All of these fears spurred a demand throughout the basin, especially in Columbus, for overall water management by someone.

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

As mentioned, Federal aid for flood control, other than on the Mississippi River, did not seem possible, and the depressed economy in the 1930's magnified the crisis. However, the election of a president, political party, and congress much more receptive to proposals for public works programs and water resources development opened the door for the needed assistance. The severe droughts of 1930, 1931, and 1934; the 1926, 27, 29, 30, and 1933 floods, coupled with the national economic and financial recovery crisis fueled the 1930, 1932, and 1934 elections. This culminated in a broader public support for Federal Public Works program, which included the adoption of a national flood control policy independent of the policy of navigation improvement.

One of the early acts of the new administration in 1933 was to organize the Public Works Administration(PWA) as an emergency means of combating unemployment. The near-by adjacent Muskingum Conservancy District was formed on June 3, 1933, one of the very first to request Federal Aid for water management. PWA officials encouraged the Muskingum project, but advised that to approve any projects, the PWA would require some legally constituted authority with contract authority for construction and operation of the project.

As a result of this 1933 expanded Federal Public Works program, state conservancy districts has been entwined with the U.S. Army Corps of Engineers. Flood protection and prevention on the Scioto River and its tributaries were now under consideration by the Federal Government. The Ohio River Basin was first evaluated in 1933 in the "308" report (House Document No. 245, Seventy-fourth Congress, first session) with 39 reservoirs proposed in the Ohio River Basin to provide flood control for the Mississippi River. While this was transpiring another report was submitted by the Chief of Engineers - the 1935 "308" report for the Scioto River Basin. This report supported seven flood control reservoirs in the Scioto Basin. Unfortunately, congress did not recommend any of these sites for construction,

however, all seven sites were recommended in later reports. Fortunately, the Delaware Lake project was included in the system of reservoirs proposed in a comprehensive plan for the control of floods on the Ohio River and tributary streams presented in the Report on the Ohio River (House Document No. 306, 74th Congress, 1st Session). But, the Delaware Lake project was not included in the portion of the plan considered justified and recommended for immediate construction.

The Report of the Chief of Engineers, contained in Document Number 1, House Committee on Flood Control, 75th Congress, 1st Session, and Report 2353, 75th Congress, 3rd Session, reviewed and revised previous reports and presented a comprehensive flood-control plan for the Ohio and lower Mississippi Rivers. These reports outlined the basic principles of the Flood Control Act of 28 June 1938 under which Delaware Lake, and four other projects in the Scioto Basin, as revised following the 1937 flood in the Ohio and Mississippi Basins, were selected for construction.

Meanwhile, the official plan of the Scioto-Sandusky Conservancy District, which was organized in 1934, endorsed the five Corps Projects and strongly recommended construction of a flood control reservoir on Mill Creek. The established need for control of a larger portion of the drainage area for both Scioto and Ohio River flood control prompted the search for additional sites in the basin.

Regardless of the extensive detailed study plans during the late 1930's, no ground was ever broken for any project based on this study. All construction work was delayed for several years and when it came it was based on later, more modern, much reviewed design plans.

The outbreak and intervention of Pearl Harbor and World War II postponed any further action for the duration of the war. Construction of any large flood control project or any local protection project was deferred until peacetime, with all national effort and money going to war production. During the war years the design plans for several dams were changed somewhat by changes in design criteria and by a severe water shortage at Columbus during the fall and winter of 1944 and 1945. For 25 September 1944 Mill Creek above Columbus reported no flow, while further downstream at Chillicothe, on 27 September, the Scioto River flow was only 165 cfs. That summer Delaware had an average flow only 4.4 cfs for August 1944, and Stratford reported 6.6 cfs for the same month. That winter the water level in Griggs Dam was down to 38 acre-feet on 24 January 1945, and three weeks later, on 11 February, the water level in O'Shaughnessy Dam was down to 42 acre-feet. By now, the city of Columbus was really concerned for more and more water. If water was scarce now, what would it be when all the War Veterans came home from Europe. This severe water crisis really aroused many agencies in Columbus to search for a better water supply, the sooner the better.

Following World War II the Corps of Engineers and the Ohio State Capital city of Columbus were deeply involved with the planning of Delaware Lake. The Corps actively pursued and finally constructed Delaware Reservoir, the first Scioto River Basin flood control project on the Olentangy River in 1951. The recommended size and scope of the Delaware Lake Project was determined by maximization, where applicable, of the net benefits of joint operation with the five

additional authorized reservoir projects in the Scioto River Basin. The combined output of the six reservoirs is important in the flood control function, significant in maximizing the recreational uses of the projects, and critical in meeting water quality and water supply objectives. Strong conflicts between purposes within the project as a result of multiple-purpose formulation was resolved by economic efficiency criteria methods. The recommended plan maximizes the net benefits of the system. As the State of Ohio indicated a willingness to participate financially in the project plan, formulation studies proceeded with close city-state-federal coordination to meet indicated requirements and to increase the overall efficiency of the project.

Demand analysis for the beneficial purposes, or output of the reservoir, was initiated by deriving benefits resulting from control of the floods of record. Recreation demand was predicated on studies of the Huntington District and the report of the Fish and Wildlife Service projected to include the general range of possible project development. The Federal Water Pollution Control Administration's evaluation of water supply needs, as well as the indicated intent of non-Federal interests to reimburse the costs allocated for water supply were used to determine the storage required for municipal and industrial water supply.

The recommended allocation of flood control storage is that required to store the floods of record and to maximize net benefits. Flood control benefits were adjusted to distribute joint benefits with the five other authorized reservoirs in areas of common influence. With this base, the scope of the project was altered to accommodate additional purposes and the effect on net benefits was evaluated to determine optimal use of the site.

The reservoir was originally designed to have a capacity of 360 acre-feet or 0.02 inches of runoff at conduit invert elevation 890 feet NGVD, and a capacity of 132,000 acre-feet or 6.5 inches of runoff at controlled spillway elevation 947 feet NGVD. The design specified that a permanent pool be maintained at or somewhat above the conduit invert elevation of 890 feet NGVD. However, some aspects of the original design were revised or improved. The conservation pool was raised from elevation 890.0 feet NGVD to elevation 910.0 feet NGVD with provision for additional conservation storage up to elevation 915.0 feet NGVD during the summer season for increased low-flow releases. A summary of pool elevations and storages for Delaware Lake is shown for Delaware Lake on **Table No. 3-1**, next page. At approximately the same time the Corps of Engineers was investigating the possibility of other water conservation projects in central Ohio.

In addition to providing recreation and conservation facilities, the proposed reservoir would serve as a source of additional water supply for the city of Delaware. The city had previously obtained its supply from the natural flow of the Olentangy River, and the river flow was inadequate to meet the demands of the city during abnormally dry years. Therefore, the city requested that the project include facilities to insure additional water supply. Its pumping plant and intake were located about one mile below the proposed dam, and water was pumped from a small pool maintained for that purpose. It was estimated that a minimum continuous release of 5 cubic feet per second (cfs) from Delaware Lake would satisfy the water requirements of the

city of Delaware and other water users on the Olentangy River, and would also provide water for pollution abatement and for maintenance of the fishery habitat in the Olentangy River. The analysis of the city's requirements indicated that the proposed permanent pool would be of ample capacity to permit its use for this purpose and that no additional storage would be required. Consequently no additional expense would be incurred by the United States and there would be no cost to the City of Delaware.

TABLE NO. 3-1

DELAWARE LAKE
POOL ELEVATIONS AND STORAGES

Pool	Surface Elevation	Area Acres	Storage Acre-feet Net	Storage Acre-feet Gross	Inches runoff Net	Inches runoff Gross
Winter	910.0	950	8,400	8,400	0.4	0.4
Summer	915.0	1,270	5,600	14,000	0.3	0.7
Flood Control:						
Winter	947.0	8,550	123,600	132,000	6.1	6.5
Summer	947.0	8,550	118,000	132,000	5.8	6.5
TOTAL	947.0	8,500		132,000		6.5

3-03. CONSTRUCTION OF DELAWARE DAM

Construction of the Delaware Lake project began in April 1946, dam closure was made in December 1947, and construction of the dam was completed in July 1948 at a cost of $7,632,000 dollars. The entire project was completed in October 1951.

3-04. RELATED PROJECTS

The Columbus water supply system now includes Griggs Dam built on the Scioto River in 1908; O'Shaughnessy Reservoir, also on the Scioto River, constructed in 1925; Hoover Reservoir, constructed in 1955 on Big Walnut Creek; and Alum Creek Reservoir, constructed in 1975.

Although Griggs, O'Shaughnessy, and Hoover Reservoirs were constructed for the primary purpose of providing a water supply, these reservoirs have always been utilized for recreational purposes. They represent the only extensive stream impoundment for the express primary purpose of public water supply development in central Ohio.

The last phase of resource development with environmental enhancement, began with the formation of the Ohio Department of Natural Resources in 1949. As the role of conservancy districts in the Scioto River Basin declined and become virtually nonexistent, the department's role and partnership function with the Corps of Engineers has increased.

When the Corps of Engineers was designing Delaware Lake, the role of recreation was hardly considered. Considerably more emphasis is now being placed on recreational development as a full share partner in reservoirs where federal money is involved. Today Delaware Lake provides enormous recreation benefits for the 1,300,000 people in the Columbus-Franklin County Metropolitan area.

The settlement and expansion of the Scioto – Olentangy River Basin began with the exploration of Christopher Gist for the "Ohio Company" and the post Revolutionary War land expansion over 200 years ago. The economic and industrial expansion began immediately and the water resources development of the basin is ongoing. The future of the Scioto Basin and the State of Ohio has always been linked with extensive water resources development and will always be part of Ohio's planning for the future.

3-05. MODIFICATIONS TO REGULATION PLAN

Downstream of Delaware Dam the basin is quite narrow, the tributary streams are very small, which creates a rapid flashy type of flooding, that quickly adds to the main stream crest. The only way this can be prevented would be to reduce the outflow from Delaware Dam just as the rainfall begins.

3-06. REGULATION PROBLEMS

No regulation problems have occurred to date.

SECTION IV - WATERSHED CHARACTERISTICS

4-01. GENERAL CHARACTERISTICS

a. Olentangy River Basin. Rising in Crawford County, the Olentangy River flows generally southward about 90 miles to enter the Scioto River at Columbus, about 132 miles above the mouth of the Ohio River at Portsmouth. The principal tributaries of the Olentangy River all enter the main stream at or above Delaware village. As a result, the upper and lower portions of the gourd-shaped Olentangy River Basin are distinctively different in shape. From Columbus up to Delaware the basin is an extremely long exceedingly narrow valley, with no tributaries of any consequence entering the main stream within this reach. In contrast, the upper portion of the basin, above Delaware village, is comparatively broad and the tributaries are arranged in the shape of a modified fan; and Whetstone Creek is the largest tributary. Therefore, the overall basin shape is much like an old fashion hand fan or gourd. The entire basin contains 536 square miles and includes parts of four counties. The length of the entire Olentangy River Basin is about 57 miles while its average width varies from about 15 miles to less than 5 miles between Delaware and Columbus. Olentangy River drainage areas and principal tributaries are given in **Table No. 4-1**, next page.

b. Delaware Dam Basin. The dam that forms Delaware Lake is located in Delaware County, Ohio, on the Olentangy River, a tributary of the Scioto River, about 32 miles above the mouth of the Olentangy River and about 6 miles above Delaware above the City of Delaware. The drainage area above Delaware Dam lies in Delaware, Marion, Morrow, and Crawford Counties, Ohio, and covers 381 square miles, with approximately 67 percent of the area in Delaware County, 25 percent in Marion County, and 8 percent in Morrow County. The upper portion of the drainage basin above Delaware Dam is comparatively broad and the arrangement of the tributaries presents the shape of a modified fan, while the lower part, below the dam, is rather long and narrow, giving the overall appearance of a panhandle to the upper fan part. The drainage is part of the glacial drift plain of northern Ohio and has a relief generally less than 100 feet. Land use in the basin is predominantly agricultural with some mining and quarrying as shown on **Plate No. 2-17**, plate section, the Land Use Map for Delaware Lake.

The reservoir at the maximum flood control pool level, elevation 947.0 feet NGVD, extends approximately 16.7 miles up the Olentangy River above the dam site, and extends 8.8 miles up Whetstone Creek, the principal tributary. At this level the reservoir inundates approximately 8,550 acres. The summer conservation pool, elevation 915.0 feet NGVD inundates 1,270 acres, and the winter conservation pool, elevation 910.0 feet NGVD, permanently inundates 950 acres. Delaware Lake project pertinent data appear in **Exhibit–A**.

TABLE NO. 4-1
DRAINAGE AREAS OF OLENTANGY RIVER
AND PRINCIPAL TRIBUTARIES

Stream	Location	Drainage Area (sq. mi.)
Olentangy River	At mouth	536
Olentangy River	Near Delaware, Ohio	393
Olentangy River	At dam site	386
Olentangy River	At Claridon, Ohio	157
Whetstone Creek	At mouth	114
Grave Creek	At mouth	28.5
Flat Run	At mouth	41

4-02. TOPOGRAPHY

The topography of the basin is generally rolling. The river occupies a shallow, rather narrow valley throughout its course. In the upper basin above Delaware, the relief is less than 100 feet and the valley walls are topped with broad, relatively flat uplands. Below the dam, between Delaware and Columbus, the valley becomes more narrow and valley walls are more steep than the upper basin. Overall, the basin is essentially rural and agricultural.

Rising at an elevation of about 1260 feet NGVD the slope of the Olentangy River averages about 6.2 feet per mile throughout its course, varying from 7.3 feet per mile in the upper reaches to 3.5 feet per mile in the lower reaches.

4-03. GEOLOGY AND SOILS

The bedrock topography of the area is nearly everywhere concealed by glacial deposits. In general, the drift does not exceed 80 feet in thickness. Along pre-glacial drainage lines, thickness of drift considerably greater than 80 feet may be present, although widely scattered bedrock determinations in this section of Ohio indicate that the pre-glacial relief was not great. The Olentangy River valley is formed in these glacial deposits. Except in places where the stream may cross or coincide with the pre-glacial drainage lines, it has cut essentially through the glacial deposits and in places has exposed the bedrock. At the dam site only 7 or 8 feet of overburden is present below the streambed.

The Olentangy watershed is located on the east limb of the Cincinnati anticline, a great up-fold that extends in a northerly direction through the state. The course of the river is roughly parallel to the axis of the anticline. The bedrock formations therefore dip to the east, their inclination from the horizontal being about 20 to 30 feet per mile. If the glacial deposits were removed, the outcrops of the

bedrock formations would form a series of roughly parallel, north-south strips, appearing in series, from the oldest to the youngest, traveling across the watershed from west to east. All of the formations which come to the surface in the watershed are of Devonian Age. Beginning with the oldest they are, the Columbus limestone, the Delaware limestone, the Olentangy shale, and the Ohio shale.

The unconsolidated materials that cover the bedrock formations consist of till, moranic deposits, water-lain sands and gravel of glacial origin, and alluvium. In the upland areas the prevailing overburden material is till or boulder clay. It is a hetero-generous mixture of clay, silt, sand, gravel and boulders. Being composed largely of clay and silt, and having been compacted under a heavy load of ice, it is for the most part a highly impervious material, although scattered lenses of water-bearing sand are found in it.

4-04. EROSION AND SEDIMENT YIELD

Erosion from a watershed depends on a number of factors, including precipitation, physiographic, land use, and size and shape of the drainage basin. Precipitation loosens the soil particles from the earth, the first process in the erosion-sedimentation process. The highest concentrations of sediment are created by high-intensity rainfalls with large-sized raindrops. Steep sloping land produces more erosion than gently sloping land. Greater sediment production occurs from land with poor vegetative cover. Large drainage basins generally produce less sediment per square mile from a given storm than a small basin produces because of the variability of slopes and rainfall in the large basin. The shape of the drainage basin is an indicator of sediment production, as sedimentation can occur in available bottom lands before it reaches the reservoir.

The Olentangy River Basin is predominantly generally rolling terrain. The river occupies a shallow, rather narrow valley throughout its course. In the upper basin above Delaware, the relief is less than 100 feet and the valley walls are topped with broad, relatively flat uplands. And approximately 90 percent of the Olentangy River above Delaware is rural farmland; the remaining 10 percent is wooded. Forested areas are limited to areas along streams and numerous wood lots ranging in size from five to fifty acres; a few cover more than fifty acres.

In the past, the stream has not appeared to carry a heavy sediment load. An increase in sediment-producing activities in the drainage basin above Delaware Lake could increase the rate of sedimentation in the lake. However, drastic changes in land use or the rate of urbanization is not foreseen for the drainage basin.

A network of 58 sediment ranges was established in the reservoir area prior to impoundment of the minimum pool. In 1960, 28 of the original 58 ranges were resurveyed, including all ranges in the seasonal pool.

The annual sedimentation rate was estimated after the 1960 resurvey as 56.56 acre-feet for the 386 square miles of contributing drainage area, or 0.1475 acre-feet per square mile, for the 9.14 year period from March 1951 to May 1960.

A total of 8,400 acre-feet of storage was provided in the minimum pool area of Delaware Lake below elevation 910 feet NGVD for fish and wildlife conservation and sedimentation reserve. Assuming that sedimentation would occur at an annual rate of 0.1475 acre-feet per square mile of contributing drainage area, or 56.56 acre-feet per year, and all the material were deposited in the minimum pool area, the minimum pool was assumed to have a life of about 148 years. All subsequent sediment resurveys have been near similar to these results.

4-05. CLIMATE

a. General. The Delaware Lake Basin demonstrates considerable seasonal variations in temperature, precipitation and wind that are typical of temperate climate regions. The area is affected by frontal air-mass activity, and is subject to continental polar and maritime tropical air masses. Frequent and rapid changes in weather are caused by the passage of fronts associated with general low-pressure areas. The prevailing wind direction is from the southwest.

b. Temperature. The temperature in the basin has varied from a minimum of -32 degrees at Columbus, during January to a maximum of 110 degrees at Delaware during July. 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 the end of April to mid-October. **Table No. 4-2**, page 4-16, presents a temperature summary for three representative stations in and near the Olentangy River Basin.

c. Precipitation. The normal annual precipitation recorded on the Olentangy River Basin, 37 inches, is comparatively uniform throughout the entire watershed area. Normal monthly, maximum monthly, minimum monthly and maximum 24-hour precipitation as well as normal monthly snowfall are listed in **Table No. 4-3**, page 4-16, for three representative stations of the Olentangy River Basin. The Olentangy River 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 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 northeastward.

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 Olentangy River Basin is about 26 inches and represents only a minor portion of the total average annual precipitation. Average monthly and annual snowfall is listed in **Table No. 4-3**, page 4-16, for three stations representative of the Olentangy River Basin.

d. Droughts. The most severe modern droughts for the central Ohio - Olentangy River Basin occurred in 1930, 1931, and 1934. Since the construction of Delaware Dam the inflow station at Claridon, Ohio, reported no flow from 2-26 October, 1953, and the same for September 14-22, 1955. On 7-8 October, 1989 the Claridon station reported a flow of 1.8 cfs.

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

Annual average wind direction over the Olentangy River Basin is from the southwest. Southerly winds, prevalent from October through December, change to northwesterly during January through April, and become southwesterly in May through September except during August when the average wind direction is northwesterly again. During the seasonal period of maximum evaporation, the lowest average wind speed, 6 mph, occurs in July through September and the highest, 8 mph, in May. Wind direction and speed data 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
DELAWARE LAKE EVAPORATION

Average Annual Evaporation - inches* 33.0
Average Seasonal Evaporation (May-October) - inches* 24.4
Average Monthly Evaporation Losses

Month	Inches*	Ac-ft**
May	4.16	440.3
June	4.98	527.0
July	5.12	541.9
August	4.52	478.4
September	3.27	346.1
October	2.34	247.6
Seasonal Total	24.39	2581.3

* Vertical distance
** 1-inch loss from summer water supply pool (elevation 915.0 surface area 1,270 acres) = 105.83 acre-feet.

4-06. STORMS AND FLOODS

a. General. The period of observed storms and floods in the Scioto River Basin is considered to begin with the establishment of the Columbus gage on 1 August 1898. The maximum flood of record in the Scioto River Basin occurred at Chillicothe in March 1913. No other flood in the Scioto watershed has equaled this flood for peak flow and resultant damages. High water profiles, for two of the major floods that have occurred in the drainage basin, are given in **Plate No. 4-1**, plate section. The flooding characteristics of the basin are illustrated by the list of peak natural discharges at Delaware, Ohio on the Olentangy River, from 1911 to 2001 presented in **Table No. 4-5**, next page.

TABLE NO. 4-5
OLENTANGY RIVER NEAR DELAWARE, OHIO
PEAK NATURAL DISCHARGE

Water Year	Discharge - cfs	Water Year	Discharge - cfs
1911	4,500	1960	3,700
1912	7,520	1961	4,325
1913	41,600	1962	9,700
1914	2,920	1963	13,750
1915	12,200	1964	12,900
1916	9,850	1965	3,050
1917	6,240	1966	4,800
1918	6,680	1967	5,300
1919	6,240	1968	7,700
1920	10,700	1969	10,700
1921	10,700	1970	9,800
1922	9,720	1971	5,100
1923	9,460	1972	9,200
1924	7,770	1973	5,200
1925	4,990	1974	6,400
1926	5,650	1975	12,300
1927	14,100	1976	7,000
1928	12,000	1977	6,700
1929	13,200	1978	8,350
1930	9,670	1979	7,700
1931	4,860	1980	13,340
1932	4,450	1981	12,730
1933	12,400	1982	5,500
1934	2,360	1983	4,750
1935	3,810	1984	8,150
1938	6,240	1985	12,200
1939	13,000	1986	6,700
1940	6,350	1987	23,373
1941	5,910	1988	6,700
1942	7,520	1989	8,350
1943	8,240	1990	7,700
1944	5,360	1991	13,340
1945	7,400	1992	6,600
1946	5,840	1993	6,520
1947	9,100	1994	8,400
1948	6,400	1995	8,320
1949	5,700	1996	9,900
1950	7,350	1997	7,910
1951	7,850	1998	4,800
1952	12,400	1999	5,930
1953	4,300	2000	8,120
1954	4,000	2001	3,340
1955	6,200		
1956	8,680		
1957	8,500		
1958	3,000		
1959	33,000		

Flow frequency and flow duration curves for the outflow gage at the dam, and flow frequency curves for Worthington on the Olentangy River, are also useful to describe the flooding characteristics of the Delaware Lake drainage basin and are given in **Plate Nos. 4-2**, **4-3**, and **4-4**, plate section, respectively. Historical hydrographs from 1962 to present for inflow and outflow and corresponding pool elevations for Delaware Lake are kept in the files of the Water Management Section.

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 state of Ohio. 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 preliminary storms of 14 March and 19-20 March. 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 about 9.0 inches above Columbus.

The maximum flood of record occurred on practically all major streams in the Scioto Basin, and in the few cases where it had been exceeded, the margin is very small. The crest at Columbus on the Scioto River was about 113,000 cfs, while on the Olentangy River it was about 41,600 cfs. This deadly flood had 92 reported deaths in Columbus, and 13 in Delaware. Record stages were reached on the Ohio River which still stand today from New Martinsville to Point Pleasant.

c. Storm and Flood of March 1933. The weather during the month of March is characterized by its unpredictability, variety, and frequent change. This March was no exception. There were five distinct cool spells and six distinct warm spells. Two of the warm spells ended in severe thunderstorms. The first storm was from the 13th to the 15th and deposited approximately 2.22 inches of precipitation over the Delaware Basin. The second storm, from the 18th to the 21st, placed about 1.72 inches of additional precipitation into the basin. These storms caused flooding throughout the Scioto basin. If Delaware Lake had been in operation during this flood the peak natural discharge of 7,081 cubic feet per second (cfs)(stage 11.7 feet) would have been reduced to 4,500 cfs(stage 8.0 feet). The flow at Worthington would have been reduced from 9,050 cfs (stage 11.27 feet) to 3,960 cfs (stage 6.79 feet).

d. Storm and Flood of June 1947. The storm and flood of June 1947 was a succession of storms from the 1st to the 14th. Three separate storms occurred during this 2 week period that resulted in damages to crops planted near the creeks and rivers and a delayed planting over most of the state because of wet conditions. During the first storm between 1 June and 3 June approximately 2.8 inches of rain fell over the Delaware Lake Basin. Between 6 June and 9 June an additional 2 inches fell. The third storm occurred on the 13th and

14th of June with another 2 inches of precipitation falling on the basin. The peak natural flow on the Olentangy at Delaware Dam was 9,100 cfs(stage 13.4 feet). If the lake had been in operation at the time, the natural peak would have been reduced to 4,500 cfs(stage 8.0 feet). The Olentangy River at Worthington had a peak flow of 13,000 cfs(stage 13.7 feet) that would have been reduced to 8,800 cfs(stage 11.06 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 Scioto 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 approximately 0.78 inches of precipitation over the Delaware Lake Basin in the form of snow and rain. Prior to the generalized rains which began during the night of 20 January, the ground was saturated, frozen, and covered with 3 to 5 inches 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 20th and began to travel rapidly northeastward. A sharp trough of low pressure moved across northwestern Ohio on the 21st and encountered a warm air mass already extending over southern Ohio. Approximately 4.83 inches of precipitation fell in the Delaware Basin between the 20th and the 22nd of January.

Surface temperatures were well above freezing and increased the snow melt, which in turn contributed to the flood producing runoff. Operation of Delaware Lake decreased the peak of the Olentangy River from 32,600 cfs to 6,015 cfs, and a stage of 23.3 feet to a stage of 9.11 feet at the dam; while at Worthington the crest of 33,200 cfs would reduce to 16,880 cfs, and a stage of 19.0 feet to 15.5 feet.

f. Storm and Flood of March 1984. Between the 1st and 19th of March snow covered the Delaware Basin. A few days before the rains of 20 March to 25 March the temperature increased and the snow cover melted and saturated the soil. Because the soil was saturated, the 2.25 inches of precipitation that fell between 20 March and 25 March increased the stages in the rivers to a greater degree than if the soil had not been saturated. Operation of Delaware Lake decreased the stage on the Olentangy River at the dam from 9.6 feet (7,500 cfs) to 6.17 feet (3,069 cfs). The stage at Worthington was reduced from 10.76 feet (8,420 cfs) to 6.98 feet (4,160 cfs).

g. Storm and Flood of June - July 1987. Between the 29th of June and the 3rd of July approximately 5.1 inches of precipitation fell on the Delaware Basin. Eighty percent of the rain fell on the 1st and 2nd of July creating flooding conditions in the basin. Operation of Delaware Lake decreased the stage of the Olentangy River

at the dam from 19.8 feet (23,550 cfs) to 7.3 feet (4,497 cfs). The stage at Worthington was reduced from 17.0 feet (23,750 cfs) to 10.25 feet (7,800 cfs).

4-07. RUNOFF CHARACTERISTICS

The rolling topography of the upper basin and the relatively steep gradient of the Olentangy River above Delaware Dam, together with the general arrangement of the tributaries, are conducive to rapid concentrations of runoff, resulting in high peak flows at Delaware Dam. Infiltration losses are generally low due to the relatively shallow depth and high clay content of the 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. Precipitation during these seasons may be quite heavy and of sufficient intensity to more than make up for the higher infiltration rates. It is during the late summer and early fall periods when streamflows in the basin drop to very low levels. **Table No. 4-6**, below, shows the average monthly and yearly flows below Delaware Dam before and after construction of the dam. The average monthly and yearly flows are very close, as expected, but, the big difference before and after construction is very obvious for both the maximum month of January, June, September and October; and the dry minimum months of July to November.

TABLE NO. 4-6
MONTHLY AND ANNUAL RUNOFF
OLENTANGY RIVER BELOW DELAWARE DAM
Natural Flow from 1924-'34, '38-1950
*Regulated Flow from 1951 to 2001

	Normal Average		Maximum Average		Minimum Average	
Month	NatQ	*RegQ	NatQ	*RegQ	NatQ	*RegQ
January	681	483	2774	1790	13.7	20.5
February	650	651	1455	2073	20.6	18.4
March	757	743	1533	2087	225	117
April	572	561	1179	1537	68.3	16.3
May	325	400	1070	1618	23.6	33.1
June	307	304	1688	1247	22.2	8.2
July	119	246	426	1723	5.6	12.6
August	79.5	115	524	1259	0.9	18.2
September	94.3	64.4	1130	538	0.54	13.9
October	103	74.9	1100	560	7.6	10.8
November	199	272	728	1442	7.9	6.5
December	431	432	1570	1683	10.1	7.8
Annual	358	361	550	609	74.6	137

4-08. WATER QUALITY

The 386 square mile drainage area above Delaware dam lies in Delaware, Morrow and Marion counties and is situated within the glacial till plains section of central Ohio. In the vicinity of the dam, the valley of the Olentangy River is comparatively narrow, while the remainder of the reservoir lies in a rather broad, flat area. Geologic considerations are very important because rock type in the drainage basin determines, to a great extent, the inorganic composition of inflow and lake water.

Delaware Lake has two major inflows: the Olentangy River and Whetstone Creek. The Olentangy River Basin is primarily an agricultural area. The basin is impacted by wastewater treatment plant discharges and non-point agricultural runoff. Industrial and municipal pollution also affects Delaware Lake. The Olentangy River is designated as warm-water habitat and listed as impaired. Sources of known or suspected impact in the basin are agriculture, crop production, livestock pasture/feedlots, pasture, storm sewers, construction sites, surface runoff, channel restrictions, dam construction, industrial land treatment, and on-site wastewater treatment systems.

Whetstone Creek, an upper tributary of the Olentangy River, is affected by municipal discharges, oil wells, and non-point source pollution. Whetstone Creek is also designated as warm-water habitat, but it is listed as attaining use. The influence of extensive and widespread agricultural practices results in sediment loads and heavy nutrient loads to the watershed. In turn, the discharge of these materials, especially evident during periods of high runoff, creates lake conditions conducive to high turbidity and high plankton production.

Delaware Lake will typically cycle from a near uniform mixed condition (temperature same from top to bottom) in winter, to a stratified or layered summer condition (temperature changes with depth). This is the result of thermal energy from the atmosphere gained and lost during the year. During the winter, water temperatures are the same from top to bottom and the lake is considered mixed. During spring as air temperatures start to warm, so do surface water temperatures, and 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, and this layer is called the hypolimnion. The layer in the middle is referred to as the metalimnion or transition layer, thusly, there is a well defined thermal stratification pattern. During the fall season when air temperatures start to cool, surface water 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 near homogenous or mixed.

The lake has an average retention time of 20 days, which directly affects the stratification pattern. Specific conductance does not indicate any density layers in the lake resulting in interflows

through the lake during the summer months. Thus water entering the lake remains there for about one month before it is released to the downstream area. This is an average number, with water remaining in the lake longer in the summer during times of low-flow, and less time in the spring during times of high-flow.

The chemical composition of water may be defined by grouping substances, which compose the dissolved solids. Relationships among groups of chemicals determine the type of water. In terms of major ions and descriptive parameters, water in Delaware Lake is classified as a borderline calcium-carbonate type. This represents a balanced condition, but it could easily change. Water hardness in the basin is 261 mg/l Calcium Carbonate which is classified as very hard according to USGS classifications. Water quality data collected by the Corps of Engineers from 1980 to 1999 indicate that water quality in the basin reflects watershed conditions.

EPA requires the States to assign a designated use to streams within the state. Those streams not meeting their designated use are listed as impaired waters. Survey data collected by the United States Environmental Protection Agency (EPA) during 1973 indicated a eutrophic stat and high concentrations of plant nutrients in Delaware Lake (Ohio EPA, 1979). Sufficient quantities of phosphorous, nitrogen, and carbon are needed to have a productive lake. Delaware Lake is considered productive with phosphorous as the limiting nutrient. The nutrient contribution (phosphorus and nitrates) from point sources was about one-fifth of the total load to Delaware Lake. The greatest influx of these substances was from agricultural runoff and non-point sources.

Concentrations of dissolved oxygen remain constant throughout the water column after fall mixing has completed, sometime in October, and remain so until around April after the lake has stratified. At that time dissolved oxygen levels in the hypolimnion decline rapidly until anoxic conditions are reached.

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

Freshwater macroinvertebrates (aquatic insects and worms, crayfish, mussels, etc.) serve as a useful tool for evaluating environmental impacts that occur over time. Because of their limited mobility and their relatively long life span, these organisms are subjected to the environmental conditions of their immediate aquatic habitat. Macro-invertebrates have been used as an assessment parameter to evaluate the overall water quality conditions for the outflow stations.

To date, no serious water quality problems affecting Delaware Lake have been caused by energy exploration or extraction in the watershed, but increased resource exploitation has several potential consequences.

4-09. CHANNEL AND FLOODWAY CHARACTERISTICS

The regulation channel capacity, or control flow in the Olentangy River below Delaware Dam is 4,282 cfs. Travel time from Delaware Dam to the gage at Columbus, Ohio is about 12 hours. The control flow in the Scioto River at Columbus is 8,100 cfs in the summer and 19,000 cfs in the winter.

The Olentangy River rises in Crawford County, Ohio, and flows generally southward about 90 miles to enter the Scioto River at Columbus. The principal tributaries of the Olentangy River all enter the main stream above Delaware Village, Whetstone Creek being the largest. Below Delaware Dam the river occupies a shallow and rather narrow valley through its course to Columbus.

The stage-discharge ratings at the Delaware Dam outflow gage are determined from a man-made concrete control channel, with sloping V-notch, downstream of the gage, and are very stable with around ten percent variation between 1964 and 1982 for channel control flow. Ratings are checked frequently by U.S.G.S. personnel so that regulations personnel always have up-to-date ratings. The discharge rating table for Worthington is shown as **Plate No. 4-5**, plate section, while the Delaware Outflow table is shown in Section VII. Flood time of travel of Delaware Lake discharge to Columbus, on the Scioto River, is 12 hours and to Portsmouth on the Ohio River, 93 hours (i.e., operational time prior to crest in excess of 50 feet at Portsmouth). Mean velocities at the gage at Delaware range from around 0.8 feet per second (fps) for a low-flow of 50 cfs to 3.2 fps for a flow of 5,000 cfs. Natural and modified flow frequencies for the gages at the lake outflow and at Worthington are shown in **Plate No. 4-2** and **Plate No. 4-4**, plate section, respectively. The 100 year flood discharge at Worthington will be reduced from 38,500 cfs to 15,700 by Delaware Lake operation.

4-10. UPSTREAM STRUCTURES – The only upstream structure is Waldo Levee.

4-11. DOWNSTREAM STRUCTURES – N.A.

4-12. ECONOMIC DATA

a. Population. The Olentangy River Basin above Delaware Dam has an estimated 2001 population of 119,752 persons in a predominantly rural environment. Population centers are small, most of them numbering less than 100 persons, with the exception of large

towns such as Marion, Norton, and Galion which account for over one-half of the basin population. The area, especially Delaware and Morrow Counties, experienced over 20 percent population growth. in the decade ending in 1980. From 1980 to 2001 these two counties grew from about 80,320 to 152,476 people.

b. Industry and Agriculture. Approximately 85 percent of the basin is cleared and currently supports an active agricultural industry with an average farm size of around 190 acres. All the highlands, as well as most of the bottom-lands are cleared for farm use. The principal products are dairy products, hogs, poultry, nursery products, corn, wheat, and soybeans. No major industry is located within the basin, although a variety of support services are available. The remaining members of the work force commute to one of the metropolitan areas outside of the basin, Bucyrus, Marion, Delaware the county seat, or the Capitol of the State of Ohio, Columbus.

c. Flood Damages. Flooding in the Olentangy River Basin is not an uncommon occurrence. Major floods have caused severe damage to the urban communities of Delaware and Columbus, whereas the damage resulting from the more frequent minor floods is confined almost wholly to agricultural areas. The areas which sustain the most flood damage in the Scioto River Basin are located in the Olentangy and Scioto River valleys below Delaware Lake. The flood of March 1913 was by far the greatest and most damaging flood which has ever occurred in the basin. The floods of March 1927 and January 1937 were of smaller magnitude than the 1913 flood. Due to channel improvements and other works completed after the 1913 flood only minor urban damages occurred. Because these floods occurred in the winter the damage to agricultural areas was minimal. Although the stages of the July 1915 flood were less than the floods of 1927 and 1937 the agricultural damages that resulted were extensive because it occurred during the growing season.

Field studies conducted in 1940, of the Scioto River flood damages indicate that a recurrence of the 1913 flood would result in damages at Delaware of $3.6 million and at Columbus of $48.6 million. These damages were updated to March 1987 by considering escalation of construction costs between 1940 and March 1987.

Damages can be further 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 March 1987
X Damage Value
= Updated Damage Value

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

TABLE No. 4-2

TEMPERATURE SUMMARY
OLENTANGY RIVER BASIN

Station	Yrs. of Record	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
	Normal Monthly and Annual Temperature. Degrees Fahrenheit													
Columbus, Ohio-USWB	86	30.1	31.4	40.2	51.4	62.3	71.3	75.5	73.5	67.2	55.6	42.7	32.6	52.8 UI
Marion, Ohio	72	28.1	29.4	39.5	50.2	61.0	70.1	74.0	72.3	66.2	54.6	41.7	30.9	51.5
Delaware, Ohio	79	27.2	31.6	38.8	51.6	61.1	69.8	73.7	72.3	65.4	54.2	41.2	31.7	51.0
	Average Maximum Temperature. Degree* Fahrenheit													
Columbus, Ohio-USWB	86	37.2	39.0	48.7	60.9	72.1	81.2	85.4	83.3	77.2	65.3	50.3	39.3	61.7
Marion, Ohio	67	36.7	38.4	49.9	61.8	73.3	82.0	86.3	84.5	78.8	67.0	51.4	38.7	62.4
Delaware, Ohio	29	34.2	37.5	48.4	61.8	2.3	81.2	84.6	83.1	77.0	65.1	50.7	38.7	61.2
	Average Minimum Temperature. Degrees Fahrenheit													
Columbus, Ohio-USWB	86	22.7	23.9	31.7	41.8	52.5	61.4	65.5	63.5	57.1	46.0	35.0	25.8	43.9
Marion, Ohio	67	20.3	20.7	29.3	38.5	49.0	58.1	62.0	60.0	53.7	43.0	32.5	23.0	40.8
Delaware, Ohio	29	16.4	18.5	27.4	37.8	47.4	56.7	60.5	58.8	51.6	39.6	31.0	21.9	39.0

TABLE No. 4-3
PRECIPITATION SUMMARY - OLENTANGY RIVER BASIN

Station	Yrs. of Record	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Annual
		Normal Monthly and Annual Precipitation, Inches												
Columbus, Ohio-USWB	86	2.89	2.51	3.37	3.08	3.45	3.49	3.60	3.03	2.42	2.19	2.56	2.52	35.11
Marion, Ohio	88	2.88	2.31	3.54	3.32	3.60	4.13	3.80	3.06	3.00	2.55	2.56	2.51	37.62
Delaware, Ohio	80	2.81	2.18	3.48	3.39	3.67	3.93	3.94	3.23	2.78	2.27	2.55	2.58	36.81
		Maximum Monthly and Annual Precipitation, Inches												
Columbus, Ohio-USWB	86	10.64	7.65	10.14	7.05	9.59	10.30	10.07	7.40	7.13	8.64	7.54	6.12	51.30
Marion, Ohio	88	10.80	6.35	12.58	8.11	8.83	8.86	9.63	7.95	11.35	7.94	7.85	6.14	54.03
Delaware, Ohio	29	7.22	4.80	8.87	7.70	7.55	8.49	8.90	8.30	5.45	5.23	5.09	5.43	--
		Minimum Monthly and Annual Precipitation, Inches												
Columbus, Ohio-USWB	86	0.57	0.43	0.28	0.83	0.95	0.96	0.66	0.24	0.42	0.08	0.18	0.46	21.60
Marion, Ohio	88	0.38	0.30	0.42	0.26	0.53	1.16	0.86	1.05	0.18	T	0.23	0.22	21.84
Delaware, Ohio	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Maximum 24-Hour Precipitation, Inches												
Columbus, Ohio-USWB	86	4.21	2.54	3.70	3.33	2.74	3.97	3.87	3.71	3.91	3.18	2.81	2.05	--
Marion, Ohio	88	2.87	1.86	4.39	2.60	3.86	5.40	3.50	3.18	3.00	3.25	2.45	1.96	--
Delaware, Ohio	29	2.59	2.16	2.82	2.19	2.60	2.53	3.13	3.80	3.90	1.41	3.17	1.74	--
		Normal Monthly and Annual Snowfall, Inches												
Columbus, Ohio-USWB	80	6.5	5.3	3.4	0.8	T	T	T	0	0	0.1	1.7	4.5	22.3
Marion, Ohio	67	8.1	7.1	4.3	0.8	T	0	0	0	0	0.1	1.6	6.1	28.1
Delaware, Ohio	29	7.9	5.8	4.0	0.5	0	0	0	0	0	0	1.6	5.8	25.6

SECTION V - DATA COLLECTION AND COMMUNICATION NETWORKS

5-01. HYDROMETEROLOGICAL STATIONS

a. Facilities. Data Collection Platforms (DCPs) and Hydrologgers have been installed at various stream gaging and precipitation stations in and near the Olentangy River Basin. Installations at stations in the Olentangy River Basin are described in **Table No. 5-1** next page, and **Table No. 5-2** page 5-3. 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 and near the Olentangy River Basin include: Olentangy River at Claridon, and Worthington; both Delaware Lake Gage and Outflow Gage; Scioto River at Prospect; and Little Scioto River near Marion. ORN precipitation stations in and near the Olentangy River are located at Delaware Lake, Worthington, Claridon, Waldo, Galion, Marion, Prospect, and Mt. Gilead. Gage locations are shown in **Plate No. 5-1**, plate section, Hydrologic Network; and pertinent data about them is listed in **Table No. 5-1**, next page, and **Table No. 5-2**, page 5-3. **Plate Nos. 4-5** and **4-6**, plate section, are Stage–Discharge Curves for Olentangy River at Delaware Dam and at Worthington, Ohio.

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 Management Sections 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 Olentangy River 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 Management Section should be contacted if a malfunction has occurred, and they in-turn will then contact the appropriate personnel.

TABLE NO. 5-1
OLENTANGY RIVER BASIN - PERTINENT DATA
STREAMGAGING PLATFORM COMMUNICATION INFORMATION

Location of Gage	Gage Symbol	Zero	Drainage Area	Date Install.	Station Equipment And Facilities
Olentangy R. at Claridon	CLOD3	961.72	157	10/46	Shaft Encoder, ADR, tipping bucket, DCP
Delaware Lake	DDOD2	NGVD	387	12/47	Shaft Encoder, DCP
Olentangy River at Delaware"O"	DDOOF	799.58	393	10/51	Shaft Encoder, ADR DCP
Olentangy River At Worthington	WOOE2	743.20	493	10/55	Voice DCP, ADR wire wt gage
Scioto River at Prospect	PRSD2	886.9	567	10/39	ADR, DCP Shaft Encoder,
Scioto River at Dublin	DUSE2	755.0	980	4/21	Shaft Encoder, ADR, DCP
Scioto River at Columbus	CLSF2	680.0	1629	10/24	Shaft Encoder, ADR, DCP

1/ Precipitation equipment same at all platform reported stations: Tipping-bucket gage and platform.
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.
(1) Ohio River Network, cooperative with National Weather Service.
(2) Installation, maintenance, and ownership by Corps of Engineers.
* At USGS gaging station on Olentangy River at Claridon.

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.

Data collection installations at stations in the Olentangy River Basin are described in **Table No. 5-1**, above, and**, Table No. 5-2**, next page. The DCP's transmit hydrometeorological data, via the Geostationary Operational Environmental Satellite(GOES), to various receive sites such as the one operated by Ohio River Division in Cincinnati, Ohio. Satellite data from the LRD receive site is automatically sent to the District Water Control System via leased line from LRD Water Control System at least once per hour. The District Water Control System also has the capability of initiating a retrieval of satellite data from the LRD Water Control System. All the data entered into the Water Control System is stored in a data base and used by water control software programs, allowing more timely and efficient water management decisions and generation of required reports.

Cell Phones are now the primary mode of emergency backup communication between the District Office and the Area Office or projects. Standard procedures require Cell Phone to be turned on during working hours. During military emergency or national disaster, protected commercial telephone lines with Scioto River Basin projects or special radio frequencies may be assigned by the Emergency Operations Manager.

The Corps of Engineers and the National Weather Service cooperatively exchange stage information along with weather information as delineated in 5-02b. A partial summary of the Scioto Area morning report is also available via National Weather Service AFOS. NWS data is received over leased line via the LRD Water Control System. NWS also dials the District Water Control System directly for some data entry. Data from Corps of Engineers projects is disseminated to the National Weather Service by the District Water Control System.

TABLE NO. 5-2

OLENTANGY RIVER BASIN - PERTINENT DATA
PRECIPITATION PLATFORM COMMUNICATION INFORMATION

Location of Gage	Symbol	Frequency Equip	Voice	Channel No.	Update Interval	Data Trans - mitted	Trans-mission
Delaware Lake	DDOD2	1/		35	60 min.	P,E	4 Hours
Delaware	DEOD2	1/		35	30 min.	P,S,T	4 Hours
Prospect	PRSD2	1/	V	55	60 min.	P	4 Hours
Galion Water Works	GALC3.....					P	
Worthington							

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.
X Synthesized voice in addition to transmitting via satellite.
(1) Ohio River Network, cooperative with National Weather Service.
(2) Installation, maintenance, and ownership by Corps of Engineers.
* At USGS gaging station on Olentangy River at Claridon.

5-02. WATER QUALITY STATIONS

a. Facilities. A network of nine water sampling stations has been established at Delaware Lake Project. These stations are shown in **Plate No. 5-2** plate section, and described as to location in **Table No. 5-3,** next page.

TABLE NO. 5-3

DESCRIPTION BY LOCATION OF
DELAWARE LAKE
WATER QUALITY SAMPLING STATIONS

Station Number	Olentangy River Mile	Miles above or Below Delaware Dam
1DEO10001	31.5	0.6 Below
1DEO20002	32.28	0.1 Above
1DEO20005	33.10	0.92 Above
1DEO20006	34.00	1.82 Above
1DEO20007	35.00	2.82 Above
1DEO20008	36.10	3.92 Above
1DEO20009	37.10	4.92 Above
1DEO10003	43.33	11.15 Above
1DEO10004	Whetstone Creek 6.86	12.28 Above

b. Reporting. Except for special studies, sampling is conducted only on the lake and immediate environs; i.e., the inflows, lake, and outflow. This prevents possible duplication of effort with programs of other agencies, and provides for detection of pertinent variations in quality of inflow, lake, outflow, and downstream waters.

Water quality data is collected at Delaware Lake to meet such objectives as:

(1) Establish base-line conditions and monitor subsequent changes:

(2) Identify water quality environmental problems; and

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

c. Sampling. Parameters to be measured, frequency of collection, and number of data collection stations at any one time are determined by specific project conditions. The water quality program design for Delaware Lake was structured to describe various factors affecting water quality over the long term. Present sampling programs are oriented toward existing or potential effects and are structured to describe various factors that affect water quality.

Once every five years, the Water Quality Team dedicates one day to sampling Delaware Lake for the parameters presented in **Table No. 5-4,** next page.

TABLE NO. 5-4
Standard Physical/Chemical Tests

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

Present sampling programs are oriented toward existing or potential effects and are structured to describe various factors that affect water quality. 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) Fish and benthic organisms to monitor long-term quality of streams
(5) Other biological measurements such as plankton and seston

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

5-03. SEDIMENT STATIONS

a. Facilities. Prior to dam closure and the impoundment of water in Delaware Lake, the sediment ranges network was planned and submitted by the Huntington District on 5 March 1947, and approved by the Chief of Engineers on 11 June 1947. The sediment range network was established as part of an aerial photography, ground control, and mapping contract during the period of 1948-49; and the original ground profile of each range was measured at that time. The sediment range network consisted of 58 designated category ”A” ranges and they were marked with monuments referenced to the existing triangulation control system or to permanent land marks. The enlarged 58 ranges, with 28 within the seasonal pool are shown on **Table No. 5-5**, next page. The Delaware Lake sediment range network map is on **Plate No. 5-3**, and the sediment range bottom profile plot is shown on **Plate No. 5-4**, plate section. There were no downstream sediment ranges established and designated as category ”C” ranges.

In the past, the stream has not appeared to carry a heavy sediment load. However, an increase in sediment-producing activities in the drainage basin above Delaware Lake could increase the rate of sedimentation in the lake. However, drastic changes in land use or the rate of urbanization is not foreseen for the drainage basin.

In 1960, all 28 of the original ranges in the seasonal pool were resurveyed. In April and May 1975 eight of the 28 sediment ranges surveyed in 1960 were resurveyed.

The annual sedimentation rate was estimated after the 1960 resurvey as 56.56 acre-feet, or 0.1475 acre-feet per square mile of contributing drainage area, for the 9.14 year period from March 1951 to May 1960. A total of 8,400 acre-feet of storage was provided in the minimum pool area of Delaware Lake below elevation 910 feet NGVD for fish and wildlife conservation and sedimentation reserve. The net sediment contributing area was taken as the 386 square miles of drainage area above Delaware Dam, less the lake area at seasonal pool elevation 915 feet NGVD of 2 square miles, or 384 square miles. If all the material were deposited in the minimum pool area, the minimum pool was assumed to have a life of about 148 years.

TABLE No. 5-5

DESCRIPTION AND LOCATION OF DELAWARE LAKE SEDIMENT RANGES

	Range	Mile Point	Bearing
	DAM	32.4	
1.	1 DEL 1-A	Olentangy R.	N87 59′10″W
2.	1 DEL 2-A		N88 03′58″W
3.	1 DEL 3-A		S85 02′17″E
3-A	1 DEL 3-A-A	Tributary	N53 44′13″E
4.	1 DEL 4-A	34.3	N83 42′40″W
5.	1 DEL 5-A		N83 53′02″W
6.	1 DEL 6-A		N82 22′ - W
7.	1 DEL 7-A		S84 16′ - E
7-A.	1 DEL 7-A-A	Tributary	N74 08′ - E
7-B.	1 DEL 7-B-A	″ ″	N54 35′ - E
8.	1 DEL 8-A		N87 39′ - E
9.	1 DEL 9-A	36.73	N89 17′ - W
10.	1 DEL 10-A		S88 31′ - W
11.	1 DEL 11-A		N87 59′ - W
12.	1 DEL 12-A	37.84	S68 30′ - W
13.	1 DEL 13-A		S65 41′ - W
14.	1 DEL 14-A		S64 16′ - W
15.	1 DEL 15-A	38.94	S71 23′ - W
		Brondige Run	
15-A.	1 DEL 15-A-A	″ ″	N85 12′ - E
15-B.	1 DEL 15-B-A	″ ″	S08 18′ - E
15-C.	1 DEL 15-C-A	″ ″	N76 18′ - E
15-D.	1 DEL 15-D-A	″ ″	N82 14′ - E
16.	1 DEL 16-A		N82 24′ - W
16-A.	1 DEL 16-A-A	Tributary	N74 07′ - W
16-B.	1 DEL 16-B-A	″ ″	N03 50′ - E
17.	1 DEL 17-A	40.20	N88 39′ - W
18.	1 DEL 18-A		N88 28′ - W
19.	1 DEL 19-A	41.10	N72 08′ - W
20.	1 DEL 20-A		S82 26′ - E
		Cauguaw Creek	
20-A.	1 DEL 20-A-A	″ ″	N82 45′ - E
20-B.	1 DEL 20-B-A	″ ″	S89 51′10″E
20-C.	1 DEL 20-C-A	″ ″	S88 35′ - W
21.	1 DEL 21-A	Olentangy R.	S52 11′ - E
22.	1 DEL 22-A		S60 10′ - E
23.	1 DEL 23-A		S86 58′ - E
24.	1 DEL 24-A		S83 05′ - E
25.	1 DEL 25-A		N73 52′ - E
26.	1 DEL 26-A		S83 30′30″W
27.	1 DEL 27-A		S55 07′ - E
28.	1 DEL 28-A		S29 03′ - W
29.	1 DEL 29-A		S05 45′ - W
30.	1 DEL 30-A		S25 06′40″E
		Whetstone Creek	
31.	1 DEL 31-A	″ ″	N37 37′ – W
32.	1 DEL 32-A	″ ″	S42 35′ - E
33.	1 DEL 33-A	″ ″	S36 31′ - E
33.	1 DEL 33-A-A	″ ″	N38 28′ - E
		Claypole Run	
34.	1 DEL 34-A	″ ″	S28 35′ - E
34-A	1 DEL 34-A-A	″ ″	S45 40′ - W
34-B.	1 DEL 34-B-A	″ ″	S30 28′ - E
34-C.	1 DEL 34-C-A	″ ″	N88 39′ - E
		Whetstone Creek	
35.	1 DEL 35-A	″ ″	S28 11′ - E
36.	1 DEL 36-A	″ ″	S42 52′ - E
37.	1 DEL 37-A	″ ″	N47 52′ – W
38.	1 DEL 38-A	″ ″	N50 50′ - W
39.	1 DEL 39-A	″ ″	S51 06′ - E
40.	1 DEL 40-A	″ ″	S63 15′ - E
41.	1 DEL 41-A	″ ″	S75 38′ – W
42.	1 DEL 42-A	″ ″	S07 33′ - W

The volume of sediment estimated to be deposited in Delaware Lake below seasonal pool elevation 915 feet NGVD at the time of the 1975 sedimentation reconnaissance was 1,118 acre-feet. The period in which the sediment was deposited was taken as the 24.13 year period between the time of lake impoundment in March 1951 and the mean date of the May 1975 resurvey.

The average annual rate of sedimentation was then computed to be 46.33 acre-feet. The annual rate of sedimentation, below seasonal pool elevation 915 feet NGVD, indicated by the 1975 resurvey, was 0.12 acre-foot per square mile of contributing drainage area. Assuming that sedimentation would continue to occur at an annual rate of 0.12 acre-foot per square mile of contributing drainage area, or 46.33 acre-feet per year, and all the material were deposited in the minimum pool area, the minimum pool would have a life of over 181 years.

A resurvey of twelve sediment ranges was performed in August 1984. However, horizontal control was not maintained during the survey. The survey indicated that the sedimentation rate for Delaware Lake had not changed significantly since the 1975 survey.

The October 1998 resurvey at Delaware Lake consisted of a resurvey by the ODNR, Division of Wildlife, Inland Fisheries Research Unit of the lake bed. Based on the Range Survey/End Area Method the 1998 resurvey estimated that 6,840 acre-feet of sediment had been deposited below summer pool between March 1951 and October 1998. This is equivalent to a 48.6 percent loss in lake storage capacity. The rate of sedimentation between the 1975 and 1998 resurveys was 0.63 acre-feet per year per square mile of contributing drainage area.

The DTM/Bed Contour Method, produced a different sedimentation rate. Based on the DTM/Bed Contour Method the 1998 resurvey estimated that 5,070 acre-feet of sediment had been deposited below summer pool between March 1951 and October 1998. This is equivalent to a 34.7 percent loss in lake storage capacity. The rate of sedimentation between the 1975 and 1998 resurveys was 0.28 acre-feet per year per square mile of contributing drainage area.

Both of these 1998 surveys appeared to be excessively high, so, a new sediment survey was planned. The Natural Resources Conservation Service (NRCS) performed a reconnaissance scope survey during October 2000 at Delaware Lake. Based on the Range Survey/End Area Method the 2000 resurvey estimated that 2,740 acre-feet of sediment had been deposited below summer pool between March 1951 and October 2000. This is equivalent to a 20 percent loss in lake storage capacity. The rate of sedimentation between 1951 and the 2000 was 0.14 acre-feet per year per square mile of contributing drainage area.

In the summer of 2002 a detailed sediment resurvey was made for all 28 ranges in the Delaware Lake seasonal pool. This survey used both the traditional Range Survey/End Area Method employed by the Corps of Engineers and the new HEC-Digital Terrain Method(DTM)electronic bed model process developed at the HEC Engineering center at Davis,

California. The volume of sediment estimated to be deposited in Delaware Lake below seasonal pool elevation 915 feet NGVD at the time of the 2002 sedimentation reconnaissance was 3,710 acre-feet.

The period in which the sediment was deposited was taken as the 41.3 year period between the time impoundment of the minimum pool began in March 1951 and the mean date of the sediment range resurvey in July 2002. The total sediment for the 41.3 years by the Range Survey/End Area was estimated to be 3,990 acre feet. This is equivalent to a 28 percent loss of the lake storage capacity below summer pool. The total sediment for the 41.3 years by the DTM/Bed Contour Method was estimated to be 3,710 acre feet. This is equivalent to a 25 percent loss of the lake storage capacity below summer pool. The two methods correlate very closely, and support each other with similar calculations.

b. Reporting. In order to monitor the rate of deposition of sediment in the lake, reconnaissance scope survey of selected ranges are conducted every five years unless an earlier survey is indicated by natural causes, such as a major flood or by increased sediment producing activities in the basin.

The fathometer consisted of a series of recorded lake bottom elevations with horizontal control. At the remaining four sediment ranges the minimum elevation was determined by stadia methods. Although the original ground profiles were obtained in 1949, they very closely matched the 1965 profiles, therefore they were considered representative of the conditions during the first filling in 1951. 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.

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 a specific time limit for storage is published.

5-05. COMMUNICATION NETWORK

Communication between Delaware Lake, the Scioto Area Office, the District Office, etc., is based primarily on telephone, however, the Delaware Lake morning report is transmitted to the Water Management Section by INTRANET computer. In the Scioto 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 hydrometeorological data. At Delaware 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 section 5-01 and 5-02, and the Delaware Lake morning report is transmitted to the Water Management Section by INTRANET computer. In addition, high-quality Cell Phones are also maintained at the District office, Area offices, lake project offices, construction field offices, and navigation lock and dam installations. This Cell Phone network provides a backup when telephone service is interrupted.

5-06. COMMUNICATION WITH PROJECTS

Telephone is the primary mode for most communication between the Water Management Section, the Scioto Area Office, and the multi-purpose Scioto Projects such as Delaware Lake; and between projects and the Area Office. Inter-project communication is mostly by Cell Phone with some telephone communications when privacy is essential. District wide Cell Phones are also used for secondary backup communication, while mobile radio, State Police, courier, etc. is utilized during an emergency when neither the telephone or district Cell Phones are operational.

Water Management 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 Management Section, other voluminous or detailed information, pictorial material, confirmation of Special Directives, and any other formal communication between the Water Management Section 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 hydrometerologic and water quality data to the Water Management Section as described in Instructions to the Damtender, **Exhibit B**, chapter 4. The project will report any operational problems by telephone to the Water Management Section and the Technical Support Branch of Operations and Readiness Division.

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 Scioto – Olentangy River Basin. If the situation is grave or serious enough, the Dam Safety Emergency Action Plan lists individuals to contact and warn of an impending crisis.

Project personnel communicate with the county Sheriffs 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 919.0 feet NGVD.

SECTION VI - HYDROLOGIC FORECASTS

6-01. GENERAL

Hydrologic forecasts of lake elevations and stream flows in the Olentangy River Basin are vitally important for Water Control Management as these forecast provide information, which enable the optimal regulation of the projects. The Water Management Section uses all available hydrologic and meteorologic data in forecasting efforts for the Olentangy – Scioto 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. Role of Corps.

(1) District Office. In accordance with ORDR 1110-2-27, dated 12 January 1976, Subject: Water Control Management Activities, the Water Management 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 and tributary stages and flows, and for transmitting data, forecasts, watches, and warnings to users and the general public. National Weather Service 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 Olentangy River 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 Olentangy River Basin are summarized in **Table No. 6-2** page 6-3. The detailed drainage areas for the Olentangy – Scioto River Basin are listed in **Table No. 6-3**, page 6-3, and are shown on **Plate No. 6-1**, plate section.

TABLE NO. 6-1

DELAWARE LAKE POOL ELEVATIONS AND STORAGES

Pool	NGVD Surface Elevation	Area Acres	Backwater Stream Miles	Storage Acre-feet Net	Storage Acre-feet Gross	Inches runoff Net	Inches runoff Gross
Winter	910	950	6.8	8,400	8,400	0.4	0.4
Summer	915	1,270	9.0	5,600	14,000	0.3	0.7
Flood Control							
Winter	947	8,550	16.6	123.6K	132K	6.1	6.5
Summer	947	8,550	16.6	118K	132K	5.8	6.5
TOTAL	947	8,550	16.6		132K		6.5

b. Methods. In order to achieve the most efficient water control management possible, a real-time computer model, developed for Water Resources Engineering Branch by the Hydrologic Engineering Center (HEC), Davis, California, was adapted and calibrated for use in water management of the Olentangy River Basin. The basin computer model is the major part of the District water control system, uses real time data from the Corps of Engineers satellite-platform network in and adjacent to the basin, in conjunction with the tables used to interpret this data. The modeling process includes reviewing and editing of all data, estimation of future flows, development and review of multiple lake outflow plans, and determining the optimal method of operation to decrease downstream flooding while still insuring the projects viability.

TABLE NO. 6-2
DELAWARE LAKE
CONTROL STAGES AND TRAVEL TIMES

Station	Stream	Winter Stage	Winter Flow*	Summer Stage	Summer Flow*	Travel Time Hours
Delaware Dam	Olentangy River	8.6	4,282	8.6	4,282	0
Worthington	Olentangy River	7.8	5,000	7.8	5,000	7
Columbus	Scioto River	13.5	8,600	19.5	19,000	13
Circleville	Scioto River	14.0	18,990	14.0	18,990	32
Chillicothe	Scioto River	12.5	27,100	16.0	42,000	50
Higby	Scioto River	13.0	23,320	16.0	31,000	56
Portsmouth	Ohio River	50	feet	50	feet	93

NOTE: * Value as specified by stage/flow rating at time of publication. It is subject to change as rating tables are revised.

Water Management will provide rating table updates to the Manuals it holds and to the Project. All other Manual holders should verify if flow values are outdated.

TABLE NO. 6-3
DRAINAGE AREAS AND STREAM FLOWS OF
OLENTANGY RIVER AND PRINCIPAL TRIBUTARIES

Location	Miles Above Mouth	Drainage Area (sq. mi.)	Period of Record	Maximum Flow CFS	Minimum Flow CFS	Mean Flow CFS
Olentangy River at Claridon	52.3	156	1946-pres	14,900	0	156
Whetstone Creek Near Ashley	7.3	98.5	1923-pres	19,100	0	92.8
Olentangy River			**1923-1934**			
Delaware Lake	**32.4**	**381**	**1938-pres**	**41,600**	**0.1**	**360**
Olentangy River			1935-1936			
at Stratford	22.5	438	1938-1967	15,600	1	365
Olentangy River at Worthington	11.5	493	1955-1967	16,500	1	442

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 can be 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.

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 Delaware Lake. With this computer program and practical experience the Water Management Section is able to produce a reliable forecast for the Olentangy River Basin.

Table No. 6-3 previous page, is an example of the various small areas above and below Delaware Dam which small-area unit hydrographs are developed. **Plate No. 6-1** plate section, shows the basic forecast areas for the Olentangy River, while **Plate No. 6-2** plate section, shows the Olentangy River network configuration.

The small area six-hour adopted unit-hydrographs for the various Olentangy River forecast areas are shown on **Table No. 6-4**, next page. The unit hydrograph data was derived for the Olentangy River Survey Report. Discharge Rating Curves for the key points in the Olentangy River Basin are shown on **Plate Nos. 4-5** and **4-6**, plate section.

TABLE NO. 6-4
ADOPTED SIX-HOUR UNIT-HYDROGRAPHS FOR
PRINCIPAL POINTS FOR DELAWARE LAKE

Time Hours 6-hours	Natural Unit Graph 386.0	Inflow Unit Graph 386.0	1-A Pool Head 317.0	#2 Around Pool 67.0	#3 Pool Area 2.0
.0	0	0	0	0	0
6	1520	3500	2190	1120	212
12	3980	6800	4730	2700	
18	5640	9000	6250	1910	
24	6680	11000	7370	1020	
30	7830	9600	6140	465	
36	6140	5000	3110	80	
42	3300	2500	1365		
48	1740	1100	820		
54	1040	950	560		
60	715	600	400		
66	540	500	305		
72	420	330	235		
78	330	270	180		
84	255	200	135		
90	200	150	100		
96	160	125	70		
102	130	100	44		
108	100	80	20		
114	85	66	0		
120	64	55			
126	45	40			
132	30	25			
138	20	15			
144	10	8			
150	2	1			

Stream and lake forecasting is accomplished with data stored and processed through the Ohio River Reporting Network. This network is a division-wide cooperative program with the National Weather Service, which involves interchanges of information between the Weather Service and the Corps of Engineers that utilize the respective installations and experience of the two agencies. All weather stations in the Olentangy River Basin are automated DCP stations. The Weather Service also provides weather and stream stage data, Ohio River and tributary forecasts, regular and requested special forecasts, radar and other special reports on request. In addition to reimbursing NWS for direct costs on Corps behalf; the Huntington District provides NWS with all precipitation, snow cover, and stage information received in the Water Resources Engineering Branch from reservoir reports. Also included are three-day pool and outflow forecasts, and depth reports from the Delaware Lake project areas. The extent and intensity of the ORN program is shown by the fact that in addition to the project morning report data, all data received by NWS in the Olentangy River Basin are from Corps financed satellite stations.

The data collection platforms mentioned above store stage and precipitation data and, every four hours, transmit to the LRD computer downlink via the GOES satellite. The Water Management Section's Water Control System receives data automatically from the LRD water control system on an hourly basis. All the data entered into the Water Control System is stored in a database and used by water control software programs, allowing more timely and efficient water management decisions and generation of required reports.

While primary dependence is on morning report information, Water Management Section personnel use Weather Service data, available between 0900 and 0930 hours, in forecasting and computing average precipitation over the basin, area, and District. The data is used to fill in, by implication, for missing data and for confirmation or refutation of doubtful readings. Weather Service coverage of areas lacking Corps projects, when plotted on the District Isohyetal Map, provides basis for better understanding of storm movement and areal intensity, which contributes to improved water management decisions. Radar images on the NWS screen at Jackson, Kentucky, and Wilmington, Ohio, provide valuable information for regulation and forecasting. The NWS Hydrologist analyzes for position, direction, speed and estimated precipitation amounts in storms and relays this analysis by telephone on request. Ohio River and tributary stage and forecasts provided by the NWS are used to answer telephone calls from the public and particularly from local barging concerns. Data from NWS is received by the water control system via network connection. Project data is also disseminated back to NWS by the water control system.

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 Delaware 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 FORECASTS

a. Requirements. Long-range forecasts assist the Huntington District and the Great Lakes and Ohio River Division in water control management in the Olentangy River 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 Management 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 Olentangy River 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.

6-06. NORMAL CONDITION FORECASTS

a. Requirements. Normal conditions, as defined by the Schedule for Reading Gages, cover all hydrologic conditions from drought to the beginning of high water conditions labeled "Flood Threat." The various conditions are based on the quantity of water a project is required to handle in comparison with design quantities. Other forecasts that are used for management of the Alum Creek Lake project include water quality and outflow temperature. The Water Control Center in the Great Lakes and Ohio River Division Office requires daily 3-day pool-and-outflow forecasts and a 5-day forecast

of tributary inflows to the Ohio River in order to implement its 5-day forecast of flow in the Ohio River and into the Mississippi River.

b. Methods. The forecast procedures described in paragraph 6-04 are used to produce forecasts for normal ranges of flows. A basin forecaster, assigned to the Scioto Basin, utilizes the Water Control System computer model each day and couples the results from the model with knowledge and experience with the basin to produce the required daily forecasts. The computerized forecast is then made available for distribution to interested parties and groups.

(1) Low-Flows - The procedures outlined in 6-04 are used in low-flow conditions. If forecasts indicate a continued low-flow condition leading to a draw-down of the lake level below seasonal pool, the Damtender is appraised of the condition. Marina operators and other affected parties are in turn notified of the changing situation by the Damtender.

(2) Water Quality - Routine water quality sampling has shown that concentrations of manganese and iron are present in the lower portions of Alum Creek Lake. These constituents are not harmful, but when released downstream under summer stratification conditions they can cause taste and odor problems. The results of chemical tests on water samples are not returned soon enough for emulation purposes; however, the concentration of manganese and iron are known to increase with the depletion of oxygen in the lower lake portions during stratification. Therefore, the weekly dissolved oxygen profiles taken during the summer months are used as a forecast of weekly conditions within the pool and as an indicator of when releases should be confined to the upper level selective withdrawal outlets.

(3) Temperature - During stratification periods, daily outflow temperatures are monitored and the selective withdrawal gates are adjusted in an effort to maintain water release temperatures within ±2°F of the natural stream temperature. Weekly temperature profiles are used as an indicator of weekly temperature conditions in the lake. If the trend of the outflow temperature appears to soon exceed allowable criteria, gate adjustments are made to offset the trend and remain within allowable temperature limits.

SECTION VII - WATER CONTROL PLAN

7-01. GENERAL OBJECTIVES

In accordance with ER 1110-2-240,"Water Control Management," dated 8 October 1982 and ORDR 1110-2-27, "Water Control Management Activities," dated 12 January 1976, the plan of water control management and regulation as discussed in the subsequent paragraphs reflects optimal consideration of each project purpose, namely flood control, lake and downstream recreation, low-flow augmentation, water supply, 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 Delaware Lake project, the Olentangy River Basin, the Scioto River Basin, and the Ohio River Basin.

a. Prevention or reduction of serious flood damages to communities, crops, and properties below the Delaware Lake Dam to the greatest extent consistent with safe operation of the project.

b. Maintenance of a minimum discharge of 5 cubic feet per second (cfs) to sustain the downstream aquatic environment and for water supply purposes.

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 release of flood storage.

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 a winter pool elevation of 910.0 feet above NGVD and a summer or seasonal pool elevation of 915.0 feet NGVD for recreation, fish and wildlife conservation, subject to flood control, and low-flow augmentation requirements for aquatic environment.

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.

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

7-02. CONSTRAINTS

Operation of Delaware Dam must be within the confines or constraints of the Olentangy – Scioto River Basin Water Control plan. The various project purposes may at times strongly conflict, therefore priorities must be established and followed. Flood control is the primary project purpose, but this function can be inhibited by restrictions on the hourly rate of gate change, the lack of storage volume because of construction in the lake area, or the inability to discharge storage as quickly as planned because of floodplain encroachment or downstream construction. During the summer there is a recreation function with a recreation pool to be maintained, plus a continuous minimum flow for water supply, therefore, there is a concern for low inflow due to lack of upstream rainfall. Operational limitations concerning flood control functions are listed below in **Table No. 7-1**.

TABLE NO. 7-1

CONSTRAINTS FOR DELAWARE LAKE

Pool	Elevation NGVD	Capacity	Area
Streambed	880.0,	zero storage	zero
Minimum Winter Pool	Elevation 910.0,	8,400 ac-ft,	950 acres area
Minimum Summer Pool	Elevation 915.0,	14,000 ac-ft,	1300 acres area
Maximum Flood Control Pool	947.0,	132K ac-ft,	8700 acres area
Top of Dam	957.0 feet NGVD		

Gate Change Maximum Rate - 1.0 feet per hour on Outflow gage
Sluiceway maximum flow - 922.0 NGVD Outflow - 8,800 cfs
Spillway maximum Flow – 947.0 NGVD Outflow - 81,000 cfs
Design Flood Crest - 950.0 NGVD, Outflow - 96,000 cfs
Spillway maximum Flow – 957.0 NGVD Outflow - 127,000 cfs

Minimum All year Outflow – 5 cfs, 1.13 ft. @ "O" gage
Max. All year Stage without a directive- 5.10 ft. @ "O" gage
Max. All year Stage, SPECIAL DIRECTIVE- 8.60 ft. @ "O" gage

Most of the conflicting interests and purposes were resolved by practical planning and allocation of the lake storage volume into pools as listed on **Table No. 7-2**, page 7-4. The difference in storage volume at maximum flood control pool elevation, 947.0 feet NGVD, and the minimum winter pool at 910.0 feet NGVD is 123,600 acre feet, equivalent to 6.1 inches of run off from the drainage area. After proper study and authorization, this volume was all allocated for winter flood storage capacity. Accordingly, there is still a small minimum winter pool at Delaware Dam, which provides for sediment storage space and winter habitat. During normal routine reservoir operations, the minimum continuous 5 cfs, plus any additional daily inflow is passed on through sluice gates.

Constraints to regulation that are of special concern are those affecting fulfillment of the project purposes. 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. The principal problems encountered with Delaware Dam since regulation began were gradual building encroachment of the flood plain and occasional false gage reports from the outflow gage created by flash flooding below the dam.

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 and the requested special regulation was substantially different than the regulation dictated by the changed conditions.

The normal Huntington District release rate for many years had been based on a maximum rate of change in stage of 1.0 foot per hour. In order to retard the post flood bank erosion the rate of change is very carefully monitored. This rate is used unless an emergency arises and the Water Management Section may issue Special Directives for a higher rate of stage change.

7-03. OVERALL WATER CONTROL PLAN

Delaware Lake is part of the flood control system of the entire Ohio River Basin as well as of the Olentangy and Scioto River Basin projects. Delaware Lake has no upstream tributary lakes that modify the inflow into the dam, but, there are three Scioto River tributary reservoirs below the dam, therefore, operation of Delaware Dam requires close coordination among all the Scioto River flood control projects. Coordination of the 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 Olentangy and Scioto River Basin and along the Ohio River below Portsmouth.

Flood damages occurring along the Olentangy and Scioto River to Portsmouth primarily involve residences, utilities, highways, and commercial; with lesser amounts to agriculture and extractive industries. The most valuable agricultural products are from livestock, which sustain only slight damage from flooding. Greatest flood damages in the past have occurred to residences in the communities of Delaware, Worthington, greater Columbus, Chillicothe, Circleville, and Portsmouth; as well as individual residences along the river and to small villages of less than 200 people. Delaware Dam drains 381 square miles and this constitutes 72 percent of the 536 square mile Olentangy River Basin. The optimal method of regulation coordinates operation on the basis of comparative storage utilization and, to the fullest extent possible, with regulation of flood control projects on other tributaries of the Ohio River.

TABLE NO. 7-2

DELAWARE LAKE POOL ELEVATIONS AND STORAGES

Pool	NGVD Surface Elevation	Area Acres	Backwater Stream Miles	Storage Acre-feet Net	Storage Acre-feet Gross	Inches runoff Net	Inches runoff Gross
Winter	910	950	6.8	8,400	8,400	0.4	0.4
Summer	915	1,270	9.0	5,600	14,000	0.3	0.7
Flood Control							
Winter	947	8,550	16.6	123.6K	132K	6.1	6.5
Summer	947	8,550	16.6	118K	132K	5.8	6.5
Total	947	8,550			132K		6.5

As mentioned previously the Olentangy River joins the Scioto River in downtown Columbus. The Columbus Frank Road USGS gage drains about 1,629 square miles, with about 381 square miles controlled by Delaware Dam, with the balance, an uncontrolled area of about 1,243 square miles. This uncontrolled area is composed of about 150 square miles on the lower Olentangy River below Delaware Dam, and about 1090 square miles on the upper Scioto River above the Scioto – Olentangy River junction.

The capitol city of Columbus, both above and below the junction of the two rivers has always been subject to flooding from both the Olentangy and the Scioto Rivers. However, due to the effects of Delaware Dam, flooding has been greatly reduced in the downtown area of the city, but, Northwest Columbus is still subject to flash flooding from the uncontrolled areas on the upper Scioto River.

The record flood of March 1913 and the second highest flood of January 1959 were both created by a combination of very heavy rainfall and melting ice and snow. The flood of March 1913 had a record crest flow of about 41,600 cfs at Delaware, and 113,000 cfs at the Columbus USGS gage. This flood occurred before construction of the Delaware Dam, but, the record flood has been reconstituted and the reservoir has been operated on a theoretical after-the–event basis. Based on these calculations Delaware Dam would have reduced the flood crest at Columbus to about 86,000 cfs. This reduced flood stage would still have created wide flood damage, but, not near as much as the 113,000 cfs natural flood.

As mentioned the record flood of March 1959 was also created by a combination of very heavy rainfall and melting ice and snow. The Columbus gage had a record crest stage of 27.2 feet for this flood. However, due to many changes in the flood channel in the ensuing 46 years, even though the crest stage was over a foot higher in 1959, the corresponding modified flow for the 1959 flood was only 68,000 cfs, not nearly as high as the 86,000 cfs modified flow of 1913. This flood occurred after construction of the Delaware Dam, and the reservoir was operated for the flood. Using the modified actual flow of 68,000 cfs, the computed natural flow would be about 80,000 cfs. This reduced

flood stage still created enormous flood damage, and would have been much higher without the effect of Delaware Dam.

7-04. STANDING INSTRUCTIONS TO THE DAMTENDER

The Delaware Lake Damtender (Resource Manager) and staff operate the project in accordance with general instructions and Special Directives issued by the Water Management Section.

a. 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 streamflow data, reservoir regulation at the start of a flood before contact can be made with the District Office, and emergency regulation in the event that all communications fail during a flood. These instructions are contained in Exhibit B, "Instructions to Damtender", Delaware 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.

b. Special Directives. Special Directives are issued by telephone and confirmed by mail to record all substantive guidance of the project by the Water Management Section 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 Scioto River Basin streams or Ohio River control.

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

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

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

(3) Special regulations for:

(a) Construction activities downstream affected by flow.

(b) Stream clean-up activities.

(c) Emergency - drowning or pollutant spill.

(d) Special pool levels for fish spawning.

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

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

(g) Canoeing activities or rescue training exercises.

(h) Stocking tailwaters-stable flow for 24-48 hours.

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

(5) Change in general instructions.

(6) Pertinent operations. Any and all other pertinent operations as deemed necessary by the Water Management Section.

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

EM 1110-2-3600, 25 May 1959, Subject: Reservoir Regulation;
ER 1110-2-1400, DAEN-CWE-Y, 24 April 1970, Subject: Reservoir Control Centers;

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

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

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

ER 1110-2-208, DAEN-CWE-Y, 30 July 1979, Subject: Water Control Management; and ER 1110-2-240, DAEN-CWE-Y, 8 October 1982, Subject: Water Control Management.

7-05. FLOOD CONTROL

Flood damage studies indicate that because of the low damage stages and the high frequency of minor floods, at one time approximately 70 percent of the total annual flood damage in the Scioto Basin was sustained by agricultural areas. However, due to the extensive expansion in the greater Columbus metropolitan area urban flood damage has greatly increased and rural flood damage is a smaller percentage.

a. Requirements. Summer-type storms featuring intensive rainfall of relatively small areal extent can be destructive and result in local flooding. Winter-type storms occur when vegetation and soil conditions lead to high percentage runoff. They are usually of wide extent, necessitating the operation of reservoirs on several Ohio River tributaries. Both headwater flooding and backwater flooding from the Ohio River are likely from these storms as opposed to the highly localized probability from summer-type storms.

The following are the general requirements of the plan of operation for Delaware Reservoir.

(1) Prevention of serious damage at the city of Delaware and overtopping of the levee at Columbus during floods of the magnitude of the maximum of record.

(2) Reduction of agricultural losses from minor floods on the Olentangy and Scioto Rivers to the greatest extent consistent with safe operation of the reservoir.

(3) Maximum retention of flows which would add to flood crest stages on the Ohio River.

Operation for Ohio River control is based on retention of flows that would add to crest stages in excess of 50 feet at Portsmouth. This stage represents the point at which damage begins in unprotected communities of the Ohio River Valley below the Scioto River.

b. Normal Plan. Delaware Lake is part of the flood control system of the entire Ohio River Basin as well as of the Olentangy and Scioto River Basins. Regulation procedures must therefore be correlated with the operation of reservoirs on other tributaries of the Scioto 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. A stage of 8.6 feet 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 8.6 feet for discharges occurring between 16 April and 30 November (MIANO). The winter control stage at the "O" gage has also been set at 8.6 feet for discharges occurring between 1 December and 15 April (DEMIA). These stages can be maintained during moderate rises without causing damage

in Columbus and further downstream. Control flows and stages at key river stations below Delaware Lake are given in **Table No.6-2** page 6-3.

The plan of operation is based on having adequate flood forecasting and flood warning systems in effect. Streamflow data is obtained from the data collection platform network, and the Delaware Lake morning report. Precipitation amounts in and near the Olentangy River Basin are received through the Corps of Engineer's platform-satellite system. Supplemental precipitation data comes from project reports and data from observers in the Ohio River Network and from the NWS in Cleveland. Water Management Section personnel use current and previous rainfall, soil and foliage conditions, and stream stage data as input to the water control system to forecast lake and downstream stages. **Plate Nos. 5-1** and **5-2**, Area and Capacity Curves and Percent Storage Utilization, plate section, can be used to determine available storage for flood control purposes.

It is desirable to empty the lake of flood storage as quickly as possible, considering any special operations, in view of the possibility of a major flood occurring at a time when the lake is partly filled. Operation for Olentangy River and the Scioto River is based on stages at the outflow gage and downstream stations in relation to the control stages listed on **Table No. 6-3** page 6-3.

Consideration of other projects in the Scioto River Basin may result in adjusting operation of the Delaware Lake Project to maintain a balance of flood control storage. The operation schedule for Scioto River control is given in Exhibit B, Instructions to Damtender. The procedure consists of the Damtender calling the telemark gage at Dublin daily when there is 0.4 inches of precipitation at the dam in 24 hours or less. Delaware Lake is then operated according to the operation schedule for Scioto River control so that the control stages on the Olentangy River are not exceeded. 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 8.6 feet year round except when critical flood conditions prevail or are predicted at downstream control points, or when the Water Management Section has directed special operations.

(2) All inflow will be stored, subject to the minimum flow requirement, which would contribute to stages in excess of the designated downstream control stages.

(3) All inflow will be stored, subject to the minimum flow requirement, beginning at time 93 hours in advance of the predicted time of reaching a forecast crest stage in excess of 50 feet on the Ohio River at Portsmouth, Ohio. After a complete assessment of Ohio River conditions and trends of continued falling stages, releases will be scheduled so as not to add to actual crests on the Ohio River at Portsmouth.

(4) If the river stage at Portsmouth is not indicative of flooding conditions further downstream along the Ohio River, recommendations from LRD Reservoir 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 Olentangy and Scioto River Basins to establish an operational scheme that will benefit the downstream Ohio River areas and not prove detrimental to the Olentangy and Scioto River Basins flood control objectives.

(5) Release of accumulated flood stage will be based on determinations by the Water Management 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 Scioto Basin and special directives issued for the release of stored flood waters.

(6) Gates will be regulated so that the rate of change of stage at the outflow gage will not exceed 1.0 feet 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 forecasted inflow hydrograph predicted from reports of rainfall depths above the dam, the relationship of the inflow unit hydrograph to the updated inflow hydrograph calculated from pool change and outflow values, and the updated inflow hydrograph. After the inflow hydrograph has been predicted, Water Management 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 Management Section will direct these operations by Special Directives.

(8) Operation of Delaware Lake is normally accomplished by using **Plate No. 7-1**, Area and Capacity Tables, **Plate No. 7-2** Percent of Storage Table, and **Plate No. 7-3** Sluice and Spillway Rating Curves, plate section. **Plate No. 7-4**, Regulation Schedule for Major Floods is also useful in determining the gate settings for both the sluice and

the tainter gates on the spillway; and **Plate No. 7-5** plate section is the rating table that applies to the outflow gage at Delaware Dam.

c. Emergency Plan. In the event that all communications between Delaware Lake and the Huntington District Office are disrupted, the Water Management Section will utilize all available data, e.g. satellite platform data, to keep informed of project conditions and be prepared to resume regulation instructions when communication is restored. The Damtender will assume regulation of the lake during lack of all communication, following the measures listed below. In addition, the Damtender will immediately and frequently make every effort to reestablish communications with the District Office. **Plate No. 1-4**, Emergency Operation Schedule, found in the "Instructions to the Damtender", Exhibit B to this manual, contains rates of rise curves which are used by project personnel to operate the reservoir when communication with the District Office is disrupted. The curves indicate spillway gate openings to be used when the rate of rise in lake levels indicate that the available storage capacity of the project may be inadequate to fully control a given flood. The procedures listed below are used when there is a delay greater than three hours in establishing contact with the Water Management Section and the rate of rise curves indicate gate settings greater than those being maintained from previous instructions.

7-06. RECREATION

a. Lake.

(1) Requirements. Recreational activities in the lake area begin with fishing in March which increases through the spring filling in April and May and continues through summer and fall. Boating begins in late April and increases through May with the opening of camping on 1 May. Water skiing is popular when the water is warm. None of these activities requires special regulation.

For all water related recreation purposes it is desirable to maintain the pool level as constant as possible. Rapid fluctuation of pool level can produce anxiety in visitors for lack of information as to cause, and concern as to the possible impact of the fluctuation. 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.

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 also cause difficulty in launching and retrieving boats; the difficulty increases as the water level increases with respect to the elevation of the top of the ramp. Special techniques are required when the water surface is near the top of the ramp or higher.

Lowered levels, i.e., below seasonal recreational and water supply pool elevation of 915 feet NGVD, may occur during dry years in trying to meet the water supply discharge requirement and the 5 cfs minimum discharge requirement. Lowered levels may cause snagging problems because previously well covered objects are closer to the surface. When lowered levels occur, they are likely to last longer than high levels and may require setting buoys and/or other actions.

(2) Control Plan. The water control plan for lake area recreation is to hold the pool level as close as possible to the seasonal elevation of 915 feet NGVD throughout the recreation season. This requires close attention to the normal flood control plan, which is to pass excess inflow up to the downstream channel capacity, along with water supply requirements. This procedure prevents unnecessary buildup of lake level and thus allows full enjoyment of lake-centered activities. At times, however, heavy rains may cause runoff to an extent requiring reduction of discharge to prevent downstream flooding, thus causing a consequent rise in lake level. Such a reduction in outflow during the recreation season may infrequently be occasioned by an Ohio River flood or by an emergency downstream. Part of the plan of regulation is the daily determination of a 3-day forecast of lake elevation and outflow rate.

b. Downstream.

(1) Requirements. Fishing begins at the tail waters of Delaware Dam in March and continues through the summer and into the fall. Picnicking is not affected by regulation of the outflow, but fishing is affected because of the high velocity of large discharges through the narrow channel. Channel capacity discharge does not pose any threat to visitors or property at the Below Dam Fishing Access Area.

Project personnel must maintain an awareness of downstream use of Olentangy River 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 change in stage at the outflow gage to no more than 1.0 feet per hour. Emergency measures may exceed this rate of change. A warning horn is always sounded just before increasing total gate opening. If a spillway flood should occur during which the discharge rate will be greater than the channel capacity, project personnel would evacuate downstream recreation areas and remove any equipment that could be damaged by high discharge.

7-07. WATER QUALITY

Delaware Lake was designed for flood control, general recreation, fish and wildlife enhancement, and water supply. However, during this time of design and construction of Delaware Dam there was no provision for a selective release of outflow for water quality or temperature purposes.
A continuous minimum water release was included in the plan, but, without any selective quality control.

Prior to construction of Delaware Lake, summer flows in the Olentangy River at Delaware and Worthington often decreased to less than 1 cfs, nearly zero, and occasionally remained there for a week or more, creating stagnant or near stagnant conditions that were harmful to all water consumers. Delaware Lake now stratifies during the summer with warm, oxygenated water in the epilimnion and colder water with little or no oxygen in the hypolimnion. The outlet works include an intake structure with five 6.5'X6.5' square gated sluices which discharge water from the bottom of the lake into the stilling basin. Streambed elevation at the dam was 880 feet NGVD at the time of construction, but had increased to 885 feet NGVD (water-quality lake profiles) in 1999.

a. Role of Corps. Later in accordance with national environmental policy objectives, water-quality evaluation and reporting of water-quality control activities are a required part of the overall water-quality control management activity at Delaware Lake. 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 this responsibility to the various divisions as an ongoing function. Guidelines for water-quality activities associated with water control management were established and described in ER 1130-2-415.

b. Water Quality. Water Quality control has two major aspects: flow augmentation for downstream needs, and quality of the releases for these purposes.

(1) Flow Augmentation. Low-Flow augmentation is designed to provide pollution abatement at Worthington, (see section 7-09 Water Supply for minimum flow requirements). The Federal Water Pollution Control Administration (currently the EPA) determined that a minimum flow of five cfs was the necessary flow at all times between 1 July and 30 November. Water Resources Engineering Branch personnel are charged with computing the inflow into Delaware Lake, determining the Corps commitment, and issuing the Special Directive to Delaware Lake to release the required outflow.

For many years, especially during low-flow months, Columbus used the entire flow in the Scioto River above the mouth of the Olentangy River for municipal water supply. And primarily because of the almost total lack of dilution water in the Scioto River at and immediately below Columbus, the city always had pollution problems during low-flow periods. During these periods the Olentangy River had contributed

little flow, therefore the flow in the Scioto immediately below Columbus was almost undiluted effluent from the sewage treatment plant. While the storage available at Delaware Lake is not sufficient to provide enough dilution water to accomplish a satisfactory degree of purification in the Scioto River below Columbus, any increase in flow from the Olentangy River during dry seasons helps alleviate the condition.

(2) Temperature and Water Quality Operation. The State of Ohio Department of Natural Resources, division of Fish and Game, has worked with the Corps to develop optimum outflow temperatures and allowable ranges of variation at Delaware Lake. Standards also define the dissolved oxygen levels required and the maximum amount of harmful solids and gases. 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. Based on this information the Water Quality Team will direct the Water Management Section to make releases from the lake in order to meet the aforementioned standards.

When passing high summer inflows from the lake operating procedures are maximized to use the upper level water through the gated spillway if and when possible. Due to the likelihood of high concentrations of iron in the lake bottom, slide gate discharge when the dissolved oxygen concentration in lower levels of the lake is less than 1.0 mg/l, is not desirable, but, it may not be prevented.

c. Control Plan. In order to enable the resource manager at Delaware Lake to regulate the outflow from the reservoir so as to satisfy the low-flow requirements for the Olentangy and Scioto Rivers, a regulation schedule was prepared based on maintaining minimum flows of 5 cfs in the Olentangy River and 95 cfs in the Scioto River below Columbus. The U.S. Geological Survey gage at Columbus is located just below the city of Columbus sewage treatment plant, and is equipped with a remote reporting device which registers the river stage on a chart in the control room of the treatment plant. The discharge from the Columbus sewage treatment plant varies slightly from day to day, and as a result, the regulated flow in the Scioto River below Columbus will also vary to some extent, but will average about 95 cfs over a short period of days. It is considered that the fluctuation in regulated flow below Columbus resulting from operation in accordance with the low-flow schedule will not have any detrimental effect. In order to maintain an acceptable aquatic environment downstream, Delaware Lake will be operated with the minimum flows specified yearly in a Special Directive, as on **Table No. 7-3** next page.

TABLE NO. 7-3

SPECIAL DIRECTIVE
LOW-FLOW CONTROL

Day and Month	Minimum Outflow Stage	Minimum Outflow
1-10 July	1.30 feet	10 cfs
11-20 July	1.57 feet	25 cfs
21-31 July	1.68 feet	35 cfs
1-20 August	1.73 feet	40 cfs
21-31 August	1.68 feet	35 cfs
1 September - 31 October	1.50 feet	20 cfs

7-08. FISH AND WILDLIFE CONSERVATION

a. Requirements.

(1) Lake. In accordance with State Code, the Ohio Department of Natural Resources is responsible for fish and wildlife conservation and boating safety at Delaware Lake. The Department shares the Corps conservation goal of the long-term well-being of the populations of water and land species of plant and animal life common to the area and the maximum sustained enjoyment of these populations by the public, as stated in subsection 2-06. Conservation requirements in the lake are met by various features of the Department management program, which includes stocking of the lake with largemouth bass; imposing size limits as necessary; monitoring populations, reproductive success, and size distribution within species; maintaining a conservation officer at the lake to conduct creel surveys and fisherman interviews; and administering licensing regulations for sport fishermen.

Fish need a fairly stable pool level for successful spawning, but at other times the level is of little importance except as drawdown may expose normal cover. The normal spawning dates for the species of fish living in Delaware Lake are given in **Plate No. 7-6,** plate section. Ground-nesting birds, small mammals and reptiles, whose habitats are near lakeside also need a stable pool for their water supply.

Dry weather drawdown exposes muddy lake sides and the slight erosion of boat waves can produce turbid water conditions an appreciable distance from the bank. This is the normally fertile littoral area into which anglers cast. Many fishermen believe fishing success suffers under such conditions because fish have difficulty seeing the lures.

(2) Downstream. Needs of the downstream aquatic community for habitat maintenance, i.e., the continuous flow of clean water constitutes the conservation need related to reservoir outflow. Lower food chain members that live on the bottom are dependent on clean

rocks, gravel, and sand for normal habitat. Water in lower zones of the lake contains iron, which is soluble when it is subjected to reducing conditions common during stratification.

b. Control Plan. As mentioned in subsection 7-05 a2, the normal mode of regulation for both recreation and flood control, with the guiding principle of conserving storage capacity for possible early flood control needs, fosters a stable pool; however, downstream flooding may require gate closure and consequent pool rise.

The Water Management Section exhibits flexibility in spring filling on behalf of fish spawning. When the Ohio Department of Natural Resources requests maintenance of a special pool level during a spawn, the Water Management Section will normally honor the request if it does not interfere with other project purposes.

The minimum discharge sufficient for aquatic habitat maintenance and water supply purposes downstream is 5.0 cfs. This flow is maintained as a minimum at all times subject to extreme drought or other emergency condition. In extremely dry years, the Water Management Section personnel may direct reduction of discharge to inflow volumes after assessing all hydrometeorological and recreational factors.

7-09. WATER SUPPLY

Prior to construction of Delaware Lake, summer flows in the Olentangy River at Delaware and Worthington often decreased to less than 1 cfs, nearly zero, and occasionally remained there for a week or more, creating stagnant conditions that were harmful to all water consumers. Accordingly, modern new environmental policies were developed to resolve these severe problems. When the first modern new environmental policies were developed nationwide they were soon applied regionally to the Scioto - Olentangy River to resolve water shortage problems. Therefore, preliminary design provisions, later finalized, were made to increase flows below the dam for water supply and fishery support and benefit. In this way, a guaranteed continuous minimum flow became a project purposes required of Delaware Lake for the State of Ohio.

The discharge rate for fishery and city water supply maintenance of 5.0 cfs was selected after a study to determine the maximum rate that does not exceed the maximum acceptable drawdown in the driest year. It is estimated that the minimum continuous release of 5 cfs from Delaware Reservoir would satisfy the water requirements of the city of Delaware and other water users on the Olentangy River, and would also provide water for pollution abatement and for maintenance of the fishery habitat in the Olentangy River. This discharge is to be maintained at all times, even during closure for flood control.

Therefore, Delaware Lake is required to provide water for low-flow augmentation and municipal water supply for Delaware village. For these purposes the lake has been partitioned accordingly. The city of Delaware, Ohio, has its water supply intake and pump station on the

Olentangy River about three miles upstream from the city. The capacity of the water supply plant is 2.0 million gallons per day (mgd), which corresponds to a flow of 3.1 cfs. Therefore, the minimum summer outflow of 5 cfs is now considered adequate for the Delaware Municipal water system.

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 has developed standard responses to floods in district, the District does not yet have a specific Flood Emergency Action Plan for Delaware Lake. However, inundation maps have been prepared and provided to the district Emergency Management Branch for use in developing an Emergency Plan for Delaware Lake and for contact with State and local authorities. The District responses are basically dependant on whether or not the integrity of the dam has been threatened. Also, the Delaware Lake inundation maps have been provided to State and local authorities for their use in developing evacuation plans for the affected areas.

a. Inundation Mapping. Inundation Maps have been prepared for Delaware 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 are to be stored in the Dam Safety Emergency Action Plan copies of which are located in OR-E-EC-GD, Delaware Lake, 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 Management 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 Annex B 1-07. Project personnel shall use

the Delaware Lake Dam Safety Emergency Action Plan to determine what events will initiate this action and which individuals to contact. The Water Management Section will be kept informed of the situation as a result of the reporting requirements listed in Exhibit B, **Plate No. 3-1**. Water Management Personnel will contact the Dam Safety officer when the lake rise indicates that 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 commanding Officer, the head of the Crisis Management Team, will open the EOC if he determines it is necessary.

7-14. OTHER PLANS

Delaware lake does not require an operational change to combat mosquitoes, routine debris, ice jams, or the lowering of the local ground water table. If necessary these and other items are addressed in paragraph 7-15.

The directory of key Emergency Personnel is located one page before the Table of Contents of this manual; and the Rule Curve for Reservoir Regulation is graphically illustrated on **Plate No. 7-7**, and the Emergency Drawdown Curves are shown on **Plate No. 7-8**, plate section.

7-15. DEVIATION FROM NORMAL REGULATION

The Huntington District Engineer is occasionally requested to deviate from the normal regulation of Delaware 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: Changes the normal operation of the project for a period of time greater than 5 days and elevation changes greater than two feet. A Major Deviation requires approval of both the Branch and Division levels.

Minor Deviation: A change in the normal operation that is less than the Major Deviation criteria. A Minor Deviation may be approved at the Branch level with the concurrence at division level.

A letter example for the above is shown as Plate 7-1a.

b. Types.

1. Emergencies. 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. Districts must inform their division office as soon as practicable. Prepare written confirmation of the deviation and description of the cause and furnish it to the division water control manager. Divisions may develop forms to facilitate the reporting of emergency deviations.

2. Unplanned Minor Deviations. There are unplanned instances that create a temporary need for minor deviations from the normal regulation plan, although they are not considered emergencies. Requests for changes in release rates generally involve time periods ranging from a few hours to a few days. 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 Olentangy River 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.

Each request is evaluated on its own merits. Consideration must be given to upstream watershed conditions, potential flood threat, condition of the lake, and alternative measures that can be taken. In the interest of maintaining good public relations, requests generally are complied with, providing there are no foreseen adverse affects on the overall regulation of the project (or projects) for the authorized purposes. These minor deviations are appropriately coordinated by telephone with the Water Management Section which may, at the time of coordination, request written confirmation showing the conditions and deviation on ORD Form 1018-R revised. Written confirmation is then furnished to the Division Water Control Manager.

3. Planned Major Deviations. Prior approval for major deviations is required from the Division Engineer as noted below. 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 affects on other authorized and useful purposes, as mentioned above, are presented by letter, telephone or teletype to the Great Lakes and Ohio River Division LRD office, along with recommendations for review and approval. Except in case of emergency, confirmation of a major deviation is necessary from the Great Lakes and Ohio River Water Control Center before the Water Management Section may grant a request. In order for the Water Resources Engineering Branch and

Division Office to gage the advisability of compliance with a request the Water Management Section must investigate upstream watershed conditions, potential flood threat, impact on other project purposes, conditions of the lake, and possible alternatives. The LRD decision and approval and/or rejection is then returned in like manner to the project. The following list contains most of the types of major deviations commonly requested.

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

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

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

(4) Slow drawdown from rises during annually designated 2-week to 3-week period in May in behalf of bass spawn. Special lake drawdown in fall for species adjustment.

7-16. RATE OF RELEASE CHANGE

The Delaware Lake outflow is to be regulated in such a manner that the rate of release does not fall below 5 cfs and the resulting stream level does not change more than 1.0 feet per hour.

SECTION VIII - RESULTS OF WATER CONTROL PLAN

8-01. GENERAL

The effects of regulation for the authorized purposes of flood control, recreation, fish and wildlife conservation, and low-flow control are presented in the following paragraphs and plates mentioned. Flood control benefits are discussed in subsection 8-03 and stage and flow reductions are listed in **Table No. 8-1**, page 8-3. 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. Some of the effects of regulation on recreation, fish and wildlife, low-flow and water quality control are also discussed. The Corps of Engineers has conducted a district wide study to simulate project operations from 1962 through 1980. The results of this study are presented as a series of hydrographs that show inflow and outflow in Delaware Lake. These hydrographs are on file in the Water Management Section.

8-02. FLOOD CONTROL

Delaware Lake controls 381 square miles or about 72% of the total drainage area above the mouth of the Olentangy river. Regulation of the project has been effective in greatly reducing flood damages along the Olentangy River to the city of Columbus. Application of the adopted water control plan to two hypothetical floods, and five representative floods, are discussed in subsequent paragraphs.

a. Spillway Design Flood. The spillway design flood is the basis for determination of the spillway capacity required to provide safety of the dam during the most critical flood runoff over the basin. The current spillway design flood is based on passing the Probable Maximum Flood with appropriate freeboard to accommodate wind and wave conditions. This modern criteria is also used to evaluate older dams for possible deficiencies under the Dam Safety Assurance Program.

A spillway flood having a peak inflow of 130,000 cubic feet per second (cfs) and a runoff volume of 14.9 inches was adopted for Delaware dam design purposes. During a spillway flood operation the reservoir level would be fairly close to the point of maximum head, therefore, after study a constant coefficient of C-3.8 in the formula $Q = CLH3/2$, was selected as sufficiently conservative. The extensive spillway design flood studies were reviewed by the Corps of Engineers in Cincinnati, Ohio and the Office of the Chief of Engineers, before the final design was adopted. Based upon these latter studies the maximum peak inflow of the spillway design flood is estimated at 130,000 cfs, with a peak flow equivalent to 337 cfs per square mile. Operation for the original flood is shown in **Plate No. 8-1**. By routing the spillway design flood over the various lengths of spillway with a fixed crest elevation 922 feet NGVD in three hour increments, it was found that a

clear length of 192 feet would raise the pool to a maximum level of 950 feet NGVD, leaving 5 feet of freeboard. A high factor of safety was embodied in the spillway design flood and consequently no additional factor of safety was applied to the design.

When the Dam Safety Assurance program was initiated by the Huntington District, Corps of Engineers, the Delaware Dam spillway was informally evaluated by using the probable maximum rainfall shown in Hydrometeorological Report No. 33. Later, using more current spillway design flood criteria based on HMR-51 and HMR-52 dated June 1978, the existing Delaware Lake spillway was reviewed and passed 87% of the Probable Maximum Flood with appropriate freeboard necessary to accommodate potential wind and wave conditions. However, if the pool level is allowed to reach the top of dam without allowing for freeboard, the project can pass 100% of the Probable Maximum Flood.

Because the project can contain the Probable Maximum Flood without being overtopped, it is not being considered as a high priority item for modification at this time. After the more deficient projects are corrected for hydrologic deficiencies under the Dam Safety Assurance Program, Delaware Lake may be approved for further evaluation of remedial actions to correct its small deficiency. The probable best engineering solution to correct the hydrologic deficiency would be to raise the effective top of the dam with a low concrete parapet wall. Additional information will be provided when it becomes available.

b. Standard Project Flood. The standard project flood constitutes a standard for design of structures that will provide a high degree of protection as determined by flood potentialities of the drainage area involved without regard to economic or physical limitations. This theoretical flood would result from a storm probably in July or August designed to equal the worst combination of meteorologic 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 inches per hour might be experienced and this value was adopted in determining the rainfall excess. Based on studies of streamflow records for the Olentangy River Basin, a base flow of one cfs per square mile was adopted. The operational hydrograph of Delaware Lake for the standard project flood is shown on **Plate No. 8-2**. At the start of the flood the reservoir would have been regulated to maintain seasonal pool elevation of 915.0 feet NGVD. By the evening of the second day, when heavy rainfall and rising river stages indicated that control stages at downstream stations would soon be exceeded, the Water Management Section would direct gate closure. By 2100 hours on the third day, the Regulation Schedule for Major Floods, **Plate No. 7-4**, would call for increased outflow rate. The Regulation Schedule for Major Floods would then be used to control discharge until the lake level reached the peak elevation of 948.18 feet NGVD. This lake level would be maintained until downstream conditions would permit flood storage release with channel capacity flow of 4,282 (stage of 8.6) feet. This stage would then be maintained until the pool receded to

elevation 915.0 feet NGVD. The maximum pool elevation would be attained at 0300 hours on the fifth day with utilization of flood control storage, and 1.18 feet of surcharge storage (12,500 acre-feet) equivalent to 0.62 inches of runoff.

c. Representative Floods.

(1) General. The historical floods chosen to illustrate the results of the water control plan are the floods of March 1933 and June 1947. Also selected were the storms of January 1959, May 1969, and March 1984, since they exhibited regulation according to the water control plan, for large floods as they occurred. Reductions at gages on the Olentangy and Scioto Rivers for representative floods are listed in **Table No. 8-1**, below.

TABLE NO. 8-1

REDUCTIONS EFFECTED DURING SELECTED FLOODS NEAR DELAWARE ON THE OLENTANGY RIVER, AND AT COLUMBUS ON THE SCIOTO RIVER

Flood	Natural Stage (feet)	Reduction attributed to Delaware Lake (feet)
March 1933		
Delaware	11.7	3.7
Columbus	11.3	4.5
June 1947		
Delaware	13.4	5.4
Columbus	13.7	2.6
January 1959		
Delaware	23.3	14.2
Columbus	19.0	3.5
March 1984		
Delaware	9.6	3.4
Columbus	10.8	3.8
June - July 1987		
Delaware	19.8	12.5
Columbus	17.0	6.8

(2) Storm and Flood of March 1933. The weather during the month of March is characterized by its unpredictability, variety, and frequent change. This March was no exception. There were five distinct cool spells, and six distinct warm spells; and two of the warm spells ended in severe thunderstorms. The first storm was from the 13th to the 15th and deposited approximately 2.22 inches of precipitation over the Delaware Basin. The second storm, from the 18th to the 21st, placed about 1.72 inches of additional precipitation into the basin. These storms caused flooding throughout the Scioto Basin.

If Delaware Lake had been in operation during this flood the conservation pool of 910.0 feet NGVD would have been maintained by passing the inflow until 1200 hours on 13 March. The gates would then have been closed to control downstream flood stages. After the peak natural flow of 7,081 cfs and the second peak of the storm had occurred the gates would then have been opened at 0900 on 23 March to channel capacity of 4,282 cfs (stage of 8.6 feet). The peak pool elevation of 937.9 feet NGVD would have occurred at this time. The outflow of 4,282 (stage of 8.6 feet) would have been maintained until the elevation of the lake returned to the winter conservation pool elevation of 910.0 feet NGVD, which would have occurred at about 1400 hours on 31 March.

As a result of the operation of Delaware Lake, the peak natural discharge of 7,081 cfs (stage of 11.7 feet) would have been reduced to 4,282 cfs (stage of 8.6 feet). The flow at Worthington would have been reduced from 9,050 cfs (stage of 11.27 feet) to 3,960 cfs (stage of 6.79 feet). Results of the operation of Delaware Lake during this flood are shown in **Plate No. 8-3**. The effects of the operation of Delaware Lake at Worthington are shown in **Plate No. 8-4**.

(3) Storm and Flood of June 1947. The storm and flood of June 1947 was a succession of storms from the 1st to the 14th. Three separate storms occurred during this 2 week period that resulted in damages to crops planted near the creeks and rivers and a delayed planting over most of the state because of wet conditions. During the first storm between 1 June and 3 June approximately 2.8 inches of rain fell over the Delaware Lake Basin. Between 6 June and 9 June an additional 2 inches fell. The third storm occurred on the 13th and 14th of June with another 2 inches of precipitation falling on the basin.

If the lake had been in operation at the time the summer conservation pool of 915.0 feet NGVD would have been maintained until 1700 hours on 1 June when, to prevent exceedence of downstream control stages, the outflow would have been gradually reduced to zero. After the peak natural flow of 9,077 cfs the outflow would have been gradually increased to channel capacity to decrease the pool elevation. At the beginning of the rising limb of the second hydrograph the outflow would have been reduced to zero in preparation for the coming precipitation. After the peak of the hydrograph the outflow would have been gradually increased to channel capacity to lower the pool. Similar operation would have been carried out for the third peak. The outflow at channel capacity would have been maintained until the pool elevation was back to the winter conservation pool elevation 915.0 feet NGVD.

The peak natural flow on the Olentangy at Delaware Dam was 9,100 cfs (stage of 13.4 feet). The natural peak would have been reduced to 4,282 cfs (stage of 8.6 feet). The Olentangy River at Worthington had a peak flow of 13,000 cfs (stage of 13.7 feet) that would have been reduced to 8,800 cfs (stage of 11.06 feet). Results of the operation of Delaware Lake during this flood are shown in **Plate No. 8-5**. The

effects of the operation of Delaware Lake at Worthington are shown in **Plate No. 8-6**, plate section.

(4) Storm and Flood of January 1959. 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 approximately 0.78 inches of precipitation over the Delaware Lake Basin in the form of snow and rain. The ground in the basin was saturated, frozen, and covered with 3 to 5 inches of snow, before the beginning of the rains during the night of 20 January. Approximately 4.83 inches of precipitation fell in the Delaware Basin between the 20th and the 22nd. Surface temperatures were well above freezing and increased the snow melt, which in turn contributed to the flood producing runoff.

At the beginning of the storm inflow equaled outflow until 0730 hours on 21 January when outflow was reduced to zero to prevent exceedence of downstream control stages. Outflow remained at 5 cfs until the peak of the inflow had passed. At 0730 hours on 25 January the elevation of the reservoir was 944.8 feet NGVD, 2.2 feet from the top of the spillway gates. The outflow was therefore increased gradually to approximately 6,000 cfs to reduce the level of the reservoir. Operation of Delaware Lake decreased the peak of the Olentangy River from 32,600 cfs to 6,015 cfs (stage of 23.3 feet to 9.11 feet) at the dam and from 33,200 cfs to 16,880 cfs (stage of 19.0 feet to 15.5 feet) at Worthington. Results of the operation of Delaware Lake during this flood are shown in **Plate No. 8-7**, plate section. The effects of the operation of Delaware Lake at Worthington are shown in **Plate No. 8-8**, plate section.

(5) Storm and Flood of March 1984. Between the 1st and 19th of March snow covered the Delaware Basin. A few days before the rains of 20 March to 25 March the temperature increased and the snow cover melted and saturated the soil. Because the soil was saturated, the 2.25 inches of precipitation that fell between 20 March and 25 March increased the stages in the rivers to a greater degree than if the soil had not been saturated.

Flow into Delaware Lake rose sharply in response to the snowmelt which began on 15 March. The outflow was gradually increased to around 4,000 cfs to decrease the rate of rise in the lake. At 0100 hours on 21 March closure of the gates began to prevent exceedence of downstream control stages. After the peak natural flow of 7,590 cfs occurred the outflow was gradually increased to about 3,000 cfs (stage of 6.85 feet) to bring the pool elevation down from its peak value of 929.06 feet NGVD to the winter conservation pool elevation of 910.0 feet NGVD. Operation of Delaware Lake decreased the peak natural flow of the Olentangy River at the dam from 7,500 cfs to 3,069 cfs (stage of 9.6 feet to 6.17 feet). The peak natural flow at Worthington was reduced from 8,420 cfs to 4,160 cfs (stage of 10.76 feet to 6.98 feet). Results of the operation of Delaware Lake during this flood

are shown in **Plate No. 8-9,** plate section. The effects of the operation of Delaware Lake at Worthington are shown in **Plate No. 8-10**, plate section.

(6) Storm and Flood of June - July 1987. Between 29 June and 3 July approximately 5.1 inches of precipitation fell on the Delaware basin. Eighty percent of this amount fell on the 1st and 2nd of July creating flooding conditions in the basin.

At the beginning of the storm the summer conservation pool of 915.0 feet NGVD was maintained. Before the peak natural flow of 23,550 cfs had passed however, the outflow was reduced to a minimum to prevent exceedence of downstream control stages, causing the pool elevation to rise sharply. At 1300 hours on 4 July the outflow was gradually increased to channel capacity (8.6 feet) to reduce the peak pool elevation of 941.5 feet NGVD to the summer conservation pool elevation of 915.0 feet NGVD.

Operation of Delaware Lake decreased the peak natural flow of the Olentangy River at the dam from 23,550 cfs to 4,497 cfs (stage of 19.8 feet to 7.3 feet). The peak natural flow at Worthington was reduced from 23,750 cfs to 7,800 cfs (stage of 17.0 feet to 10.25 feet). Results of the operation of Delaware Lake during this flood are shown in **Plate No. 8-11**, plate section. The effects of the operation of Delaware Lake at Worthington are shown in **Plate No. 8-12**, plate section.

d. Benefits. Financial results, or annual monetary benefits of operation of the lake for the project purposes are updated as necessary. The updating of monetary values is described in subsection 4-12c. The total dollar amount of benefits creditable to the Delaware Lake project since its inception in 1951 is estimated to be $91.8 million through 2003. This constitutes damages that would have occurred in the Scioto River Basin and along the Ohio River if the project were not operating.

8-03. RECREATION

The average visitation at Delaware Lake averaged has been about 900,000 visitor days annually for several years. The visitation for 1980 was 1,021,154. During 1981 visitation decreased 60% from the previous year to a level of 453,871 visitor days, but the visitation for 1982 came back up to the previous level and then dropped back to around 800,000 for 1983 through 2003. A listing of visitation at Delaware Lake, for 1999 to 2003, is given in **Table No. 8-2**, next page. The construction of Alum Creek Lake is the single most contributing factor to the decrease in visitations at Delaware Lake. Alum Creek is located adjacent to the Columbus metropolitan area and geographically between Columbus and Delaware Lake.

Alum Creek Lake has attracted very high public use because of its location, because it is a clean new project, and because of its recreational development. Much of the Delaware Lake visitation, which usually came from the Columbus metropolitan area, now appears to be going to Alum Creek Lake.

TABLE NO. 8-2

VISITATIONS AT DELAWARE LAKE

Year	Visitations
1999	840,558
2000	805,000
2001	808,826
2002	922,004
2003	834,412

Delaware Lake's competitive position within the state park market is hindered since the Lake does not offer the full-range of facilities found at other large regional state parks within the Ohio State Park System. Since extensive facilities do not exist at Delaware Lake the area does not directly compete for the visitor attracted to the large full facility state parks. Instead, the area competes with the growing number of local parks. Since the park is located on a major highway in an urbanized area, it has taken on the character of a large urban park with emphasis and demand on day-use.

Most of the recreational facilities in Delaware Lake State Park were constructed below the maximum flood control pool elevation of 947 feet NGVD, and are subjected to periodic flooding. This was due to a lack of suitable development areas at higher elevations. However, these facilities have been designed to withstand such flooding with a minimum amount of deterioration. The only major damage to facilities occurred during the 1959 flood when the lake reached an elevation of 945 feet NGVD. Most of the damage was caused by ice when the lake level was lowered to normal pool elevation.

Total visitation in Delaware Lake 834,412 in 2003. Corps of Engineers visitors in the area spent $12.13 million on trip within 30 miles of the Project.

8-04. WATER QUALITY

In the development of the plan of operation for minimum low-flow water control, consideration was given to the regulation requirements for water supply, pollution abatement, malaria control, recreation, and wildlife conservation. The plan provides for the regulation of Delaware Lake outflow so as to furnish a reliable source of water supply for the city of Delaware and other water users on the Olentangy River, and to provide dilution water for pollution abatement in the Scioto River at and below Columbus.

However, during this design and construction period for Delaware Dam, there was no consideration given to selective release of water at different levels for water quality and temperature control. All of the continuous minimum flow release was to come from the same level.

The minimum flow that is to be released from Delaware Lake has been set at 5 cfs. The regulation for low-flow is based on maintaining a minimum regulated flow of 95 cfs in the Scioto River below the mouth of the Olentangy River. During the period of time from 1 July - 31 October Special Directive, **Table No. 7-3**, page 7-14, applies to low-flow control and is the minimum flow allowed in order to maintain an acceptable aquatic environment downstream.

a. Special Problems. There are two significant water quality problems affecting Delaware Lake. High levels of iron in the inflow streams are compounded in the lake because of anoxic conditions in the hypolimnion. High nutrient levels in the inflow streams cause moderate to severe algal blooms on the lake during the summer.

An interdisciplinary approach is used to evaluate the physics, chemistry, and biology of inflow streams, the lake, and the outflow. The following interpretations are based on data collected between 1980 and 1999.

b. Physical/Chemical. The chemical composition of water may be defined by grouping substances, which compose the dissolved solids. Relationships among groups of chemicals determine the type of water. In terms of major ions and descriptive parameters, water in Delaware Lake is classified as a Calcium Carbonate type. This represents a balanced condition.

Impounded waters are in more or less dynamic states. The governing factor in water quality development is the temporal and spatial behavior of the density of this water. In most fresh water systems, water temperature is the predominant factor in determining density. Temperature variations in water masses are capable of creating strata of water of greatly different characteristics. Such differing characteristics have direct implications with regard to lake-releases.

Most lakes in this part of the country remain nearly isothermal during the winter months. In the spring, under normal conditions, they will stratify and remain so until sometime in the fall. At that time the lakes mix and become isothermal again.

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 referred to as the hypolimnion. The layer in the middle is called 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. Delaware Lake remains nearly isothermal during the winter months. In the spring the lake starts to stratify. **Plate No. 8-13**, plate section, shows a typical temperature profile while the lake is stratified.

d. Retention. The calculated average retention time of 14 days is short (compared to other projects within the District) and should affect thermal stratification. It is expected that significant stratification would not exist with such a short retention time. The design of the outflow structure should also hinder the development of well defined layers because water is only released from the bottom of the lake. As shown in **Plate No. 8-13**, plate section, water temperature changes gradually from top to bottom with the greater change in the upper 5 feet. Below the 5 foot level, water temperatures are near equal.

e. Dissolved Oxygen. Dissolved oxygen levels are extremely important in water quality characterization. They depend on the physical, chemical, and biological activities that occur in water. Dissolved oxygen saturation limits are directly related to temperature and thermal stratification can result in zones that exhibit greatly different characteristics. In well-mixed epilimnetic waters, relatively high levels of dissolved oxygen occur and the water is usually of acceptable quality. Water in the hypolimnion may become void of oxygen as a result of various oxygen demanding processes. Therefore, a concomitant decrease in water quality can occur after stratification becomes established. Concentrations of dissolved oxygen in Delaware Lake were constant throughout the water column after fall mixing completed, and remained so until May when the lake showed signs of thermal stratification. At that time, dissolved oxygen levels near the bottom began to decline until anoxic conditions were reached. Dissolved oxygen remained above 5.0 mg/l through the first 10 feet. This implied that a maximum of 66 percent of the lake was available for fishing during summer stratification. Dissolved oxygen is one of the key parameters for fishing which indicates that

more than half of the lake was available during the months July and August. **Plate No. 8-14**, plate section, shows a typical dissolved oxygen profile during the summer months. During fall turnover, the lake mixes and dissolved oxygen is redistributed throughout the water column. It was not unusual to see dissolved oxygen values below 5.0 mg/l throughout the entire lake during fall turnover.

There are two major inflows to Delaware Lake. Dissolved oxygen concentrations in the inflows averaged 99% saturation which indicates a good condition. Delaware Lake averaged 60% saturation which indicates a significant oxygen demand on the system. Average values in the tailwater were 100% saturation. The outflow system was not designed to allow for regulation of the quality of water, but there is significant aeration in the stilling basin. During the summer months water released from the lake had a dissolved oxygen concentration of 0.0 mg/l. By the time it left the stilling basin dissolved oxygen values increased to saturation.

f. 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 Delaware. 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 inflows and 0.14 mg/l in the outflow which indicated that there was available phosphorous in the tailwaters.

g. PH Concentration. PH is a measure of the hydrogen ion concentration. It can be increased by adding a base or removing carbon dioxide from a solution such as in photosynthetic assimilation. By definition, pH ranges from 1 to 14 and a pH value of 7.0 is considered neutral. The average pH value found in the database for headwater stations was 7.9 as compared to 7.7 at the tailwater station. Long-term trends indicate no significant pattern in pH values over the watershed.

While pH is a measure of concentration, alkalinity is a measure of capacity. The capacity of a solution to neutralize acids or bases is called buffering capacity. Average alkalinity, a factor buffering pH, was around 160 mg/l as CaCO3 in the headwaters and 132 mg/l as CaCO3 in the tailwaters. These numbers indicate sufficient buffering capacity in the system.

h. Hardness. Water hardness is the sum of calcium and magnesium concentrations expressed in terms of mg/l calcium carbonate.

It is largely a result of geological formations at the water source. Calcium and magnesium form an insoluble residue with soap and leave deposits on surfaces that come in contact with the water. The ring around a bathtub is a well-known example of these deposits. Detergents were introduced to reduce this problem. High hardness (hard water) results in high soap consumption as well as objectionable scale in heating vessels and pipes. Public acceptance of hardness varies. Many consumers will object to water harder than 150 mg/l as Calcium Carbonate (Water Supply and Pollution Control).

Average water hardness in inflows to the lake was 261 mg/l as Calcium Carbonate and was 202 mg/l as Calcium Carbonate in the tailwater. This range is classified as “very hard” based on U.S. Geological Survey classifications.

i. Iron Concentration. Iron is an abundant element on the earth, but usually occurs as an insoluble form in water and at low concentrations. The average concentration of iron in the inflow waters to Delaware Lake was 631 ug/l. This is considered high for surface water, but it doesn’t exceed any standards. It implies land disturbances within the watershed, which would be expected in an agricultural basin. The value more than doubles to an average value of 1330 ug/l found in the tailwaters. This exceeds an EPA guideline of 1000 ug/l for surface waters. During the stratification season, average iron levels in the lake also exceeded the recommended limit of 1000 ug/l (**Plate No. 8-15**, plate section). This is a result of the anoxic hypolimnion. Releasing anoxic water with high concentrations of iron can cause orange staining on the banks. The orange stains are not readily observed which may be attributed to the short retention time. Long-term trends indicated no significant changes in iron concentrations.

j. Manganese Concentration. Manganese levels in the headwaters were well below a standard of 1000 ug/l, averaging 50 ug/l. During lake stratification, manganese concentrations in the hypolimnion increased somewhat (**Plate No. 8-16**, plate section). The average manganese concentration in the tailwater area was 60 ug/l. This represents no change from inflow conditions. Long-term trends indicated no significant change in manganese concentrations.

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

Algal productivity was considered normal in headwater streams with an average chlorophyll concentration of 9.6 ug/l. Productivity on the lake was considered good with an average chlorophyll concentration of 18 ug/l.

Freshwater macroinvertebrates (aquatic insects and worms, crayfish, mussels, etc.) serve as a useful tool for evaluating environmental impacts that occur over time. Because of their limited mobility and their relatively long life span, these organisms are subjected to the environmental conditions of their immediate aquatic habitat. Macroinvertebrates have been used as an assessment parameter to evaluate the overall water quality conditions for the outflow station DEO0001 and the primary inflow station DEO0003 (Olentangy River) and the secondary inflow station DEO0004 (Whetstone Creek).

The most common groups of macroinvertebrates collected in the benthic samples from the outflow station were mayflies (23%), caddisflies (37%), and dipterans (16%), primarily the family Chironomidae (midges). The common groups collected at the inflow station on the Olentangy River were mayflies (16%) caddisflies (27%), aquatic beetles (18%), and midges (27%); and the secondary inflow station on Whetstone Creek were mayflies (11%), caddisflies (37%), aquatic beetles (14%), and midges (22%). Percent **EPT** (percent of the composite of mayfly, stonefly, and caddisfly larvae) for the outflow station was 61%; for the inflow station on the Olentangy River 44%; and for Whetstone Creek 49%. Stoneflies were rare in the samples at all three stations, less than 2.5%.

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

Results: The **OQR** and interpretation for the above water quality stations are presented in **Plate No. 8-17**, plate section. Data is based on benthic samples collected from 1976 through 1989. The outflow station and both inflow stations have a **moderate** rating.

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. Spawning season, usually from May through the middle of June, is a time when these fluctuations are critical. When the pool level builds up two feet or more during rainfall runoff and is returned to seasonal elevation of 915.0 feet NGVD in from two to five days, spawning success suffers among bass and other species. Numbers of young-of-the-year largemouth bass counted are always in rough proportion to the degree of stability of the pool,

or in inverse proportion to the amount of variation in pool level. Extensive efforts are made to raise the pool level to summer pool elevation 915.0 feet NGVD by 15 April and then to keep the pool level constant at +6 inches of summer pool until the end of the spawning period. A fish spawn schedule for Delaware Lake is given in **Plate No. 7-6**, plate section.

As the pool level is lowered, restrictions are imposed upon facilities such as boat launching ramps, picnic grounds and related usages, camping, fishing, water skiing, and boating.

Stratification effects on the lake fishery stem from the difference between values of temperature and concentration of dissolved oxygen in upper and lower levels in the water column. Low temperatures and concentrations occur at lower levels and higher values at upper levels.

Fish species seek out their most desirable habitat. During the period of most severe stratification, the depth of water containing desirable oxygen concentration becomes more shallow in the deepest areas of the lake. Then fish migrate up-lake to more shallow areas resulting in a temporary lateral displacement of populations within the lake.

Major benefits to wildlife have been observed on the Corps purchased lands not submerged or utilized for recreation areas. These benefits were realized because of fire control efforts and the vegetation changes that occur during reversion of farm lands to brushy areas. The range appears to be healthy for upland animals.

The Ohio Division of Natural Resources is actively pursuing wildlife management activities on the land that is leased from the Corps. At this time, approximately 40% of the land area is wooded. The ODNR is working to reduce this percentage to 20-30% and to increase the brush cover for upland game animals, specifically rabbits and quail. The ideal mixture of land uses, toward which the ODNR is working, will be 20% farmland, 20% wooded, 30% grasses and open areas, and 30% in brush. The ODNR is working toward that mixture by reducing farming to allow farmed areas to revert to brush and by sponsoring tree cutting in wooded areas. The tree cutting is done in two ways; either by ODNR personnel cutting down the trees and using them to create brush piles, or by allowing the public to clear-cut an area for firewood and then using the leftover branches for creating brush piles.

An upland game research center is operated at Delaware Lake. This center has been doing research on the habitat preference of rabbits and the survival rate of quail using radio collars to track the movements of the animals under study.

One hundred and fifty acres of marshes are flooded seasonally to provide water fowl stopover areas for migrating birds and hunting opportunities for man. These marshes area created by pumping water from Delaware Lake in August and September. The marshes remain wet through the winter and then are allowed to dry up except for around 30

acres which remain marshy all year. Goose nesting structures and wood duck boxes are place in the area of the permanent marshes. There are around 50 ponds located on the leased area around Delaware Lake. These ponds also provide areas for goose and wood duck nesting. Nesting boxes are also placed for bluebirds, barn owls and squirrels.

The lake fishery is excellent for crappie and white bass and the downstream fishery includes catfish, bass and muskellunge. Fishing on the larger ponds in the leased area is excellent for bass and bluegill. Frog hunting is also a very popular activity around the lake and ponds.

The eggs and young of the year of ground-nesting birds, small mammals and reptiles are lost during a lake level rise of 10-15 feet, 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.

Also, there has been negligible effect of drought-caused drawdown on fish and wildlife. Muddy banks cause turbidity in nearby water due to the lapping of water against the bank. Many fisherman believe this lessens the catch because fishes have difficulty seeing the bait or lure. A drawdown of 4 feet will likely expose or make too shallow some littoral zones which are the best fishing grounds. Losses will be sustained among aquatic insects and other members of the fish food chain whose habitat is the shallow muds of these zones. Such a drawdown is likely to force fry and young of the year out of thick, normal cover into unprotected areas where they are more easily utilized as food by larger fishes. A portion of the food chain may be impaired if mud flats are exposed into which amphibians and invertebrates have burrowed for body temperature control.

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 6,200 cfs from **Plate No. 4-2**, plate section; but the lesser flushing action of channel capacity discharge, 4,500 cfs, for several days while releasing flood storage has similar effects. In either case, fish populations are temporarily displaced and flood supplies diminished. The minimum discharge helps maintain the downstream fishery against the increased fishing pressure. The major adverse effect of high discharges from the lake may be the frustration of fishermen at the tailwaters because of the fast current pulling their lines downstream too quickly.

Delaware Lake fishing and hunting opportunities were recently analyzed according to U.S. Water Resources Council "Principles" of March 1983 (See subsection 9-04a) and the analysis yielded points indicating $3.68/visitor-day benefits for fishing or hunting at the project. The portion of total recreation visitation at Delaware Lake in calendar year 1986 determined to be involved in fishing or hunting was 120,961.

Therefore, the fish and wildlife benefit for the year 1986 was $445,136.

8-06. WATER SUPPLY

The Delaware Lake minimum 5 cfs outflow furnishes a reliable source of water supply for the city of Delaware and other water users on the Olentangy River, and provides dilution water for pollution abatement in the Scioto River at and below Columbus.

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. The natural discharge-frequency curve for the Olentangy River at the Delaware 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 was derived by plotting probable maximum flow to be expected at the dam site against exceedence interval in years. It is shown in **Plate No. 4-2**, plate section. Values of natural flow for certain exceedence intervals from 1 year to 1000 years are given in **Table No. 8-3**, below, Frequency Summary, Olentangy River at Delaware Lake Outflow Gage, All Season, Natural.

TABLE NO. 8-3
FREQUENCY SUMMARY
OLENTANGY RIVER AT DELAWARE LAKE
ALL SEASONS - NATURAL
Period of record: 1911 - 1986

Exceedence Interval Years	Discharge cfs
1000	54,100
500	45,900
200	36,200
100	29,700
50	24,400
20	18,400
10	14,600
5	11,700
2	8,860
1	7,100

b. Pool Elevation Frequency and Duration. To calculate the pool elevation frequency and duration, the peak pool elevation of Delaware Lake for each year from 1952 to 1987 was recorded. The pool elevation frequency was developed in accordance with the graphical analysis method 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 pool elevation frequency curve is shown in Frequency of Filling, **Plate No. 8-18**, plate section. Deviation from summer conservation pool elevation, 915 feet NGVD, was plotted as pool elevation probability of occurrence on the average once in a number of years, which is the exceedence interval, against the interval. 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**, below, Frequency Summary, Delaware Lake Pool Elevation Deviation.

TABLE NO. 8-4

FREQUENCY SUMMARY DELAWARE LAKE
POOL ELEVATION DEVIATION
Period of record: 1952 - 1986

Exceedence Interval Years	Elevation Feet NGVD
100	947.3
50	944.8
20	941.0
10	938.1
5	935.0
2	930.4
1	925.6

Pool elevation hydrographs produced when the above floods were routed through the lake were measured for amplitude (duration in days) at certain specified elevations and these tabulated by elevation. The total number of days tallied for each pool elevation for the period of record (1952 to 1987) was divided by the years of record, to obtain the average number of days per year at or above the elevation. The "Average" curve in Duration of Filling, **Plate No. 8-19** plate section, was derived by plotting these average number of days values against the respective elevations. Duration at specific elevations of the curve with the highest peak were plotted against the elevations to obtain the "Maximum Number of Days per year." curve in **Plate No. 8-19**, plate section.

c. Control Station-Worthington, Ohio. The natural frequencies of the Olentangy River at Worthington were estimated using nearly the same methods and techniques of data handling and calculation as were used for the Olentangy 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 Delaware Lake outflow gage, and Worthington, **Plate No. 4-2**, plate section and **Plate No. 4-4**, plate section, respectively. Flows for selected exceedence intervals from 1 year to 1,000 years are included in **Table No. 8-5**, below, for the gages at Delaware Lake, and Worthington, respectively.

TABLE NO. 8-5

STAGE AND DISCHARGE FREQUENCIES
OLENTANGY RIVER AT WORTHINGTON, OHIO
Period of record: 1933 - 1986
Zero gage: 743.20 ft NGVD

Exceedence Interval	Natural		Regulated by Delaware Lake	
Years	Stage Feet	Flow cfs	Stage Feet	Flow cfs
1000	22.8	61,000	18.7	28,200
500	21.5	50,000	16.8	22,000
200	20.0	39,500	15.2	16,300
100	18.8	32,500	13.7	12,800
50	17.8	26,600	12.2	10,200
20	16.3	20,100	10.3	7,800
10	15.0	16,000	9.2	6,500
5	13.7	12,800	8.4	5,700
2	11.9	9,960	7.8	5,050
1	10.3	7,900	7.5	4,700

SECTION IX - WATER CONTROL MANAGEMENT

9-01. RESPONSIBILITIES and ORGANIZATION

a. Corps of Engineers.

(1) 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**, plate section, 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, Delaware 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 Scioto Area office within Operations Division.

An organizational chart is shown on **Plate No. 9-1**, plate section, for Water Control Management in the Scioto - Olentangy River Basin. As shown on the chart, the Recreation-Resource Management Branch and the Scioto River Area Office are responsible for supervision of the operation and maintenance of the dam and operations area at Delaware Lake. The Damtender (Resource Manager) at Delaware Dam regulates the Delaware Lake project in accordance with general instructions and Special Directives issued by the Water Management Section. Special Directives are issued and signed by the Chief, Water Management Section, for dissemination to the Delaware Lake 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 Management 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.

Water control plans include coordinated reservoir regulation schedules for project/system operation and such additional provisions as may be required to collect, analyze and disseminate basic data, prepare detailed operating instructions, assure project safety and carry out regulation of projects in an appropriate manner. Water control plans will be developed utilizing objectives and specific provisions of project authorizing legislation and applicable Corps of Engineers reports. They will include any applicable authorities established after project construction. 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.

(5) Water Resources Engineering Branch 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.

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

(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**, plate section, in two sheets:

(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.

During a FLOOD EMERGENCY SITUATION the lines of communication between the various office elements are shown on **Plate No. 9-2**, plate section. Details and responsibilities of other elements are indicated in the overall district plan in the Emergency Operations Center Plan and ER 500-1-1, ER 500-2-1 and all annexes to these two ER's.

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

The Huntington District also works in cooperation with other Federal, State, local and private organizations and agencies. These relationships are described in detail in the following paragraphs and illustrated in **Plate No. 9-3**, plate section.

b. Other Federal Agencies. The National Weather Service and the U.S. Geological Survey cooperate and coordinate activity with the Water Management 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.

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

c. State and County 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 Ohio 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 numerous private interests or businesses presently involved with Delaware Lake.

9-02. INTERAGENCY COORDINATION

The Huntington District also works in cooperation with other Federal, State, local and private organizations and agencies. These relationships are described in detail in the following paragraphs and illustrated in **Plate No. 9-3**, plate section.

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 6-02b, 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 supplemental instructions of a current nature necessary in connection with preparation of the report are issued annually by the Chief of Engineers.

The Geological Survey coordination and cooperation with the Corps, described in paragraph 5-01, provides the Water Management 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 Management 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 training 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 District 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 Delaware 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 Management 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 5-02, a 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 resource 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 Delaware 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 Counsel; 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. Inter-agency 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 Scioto 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 Management 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 seven days per week by the Water Management Section of Water Resources Engineering Branch and, on Saturdays, Sundays and holidays. It is prepared as detailed in sub-section 6-03 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 ending with the current week. All of the key

gage points are reported for the Olentangy, Scioto, and Ohio River Basins. The main stem points are located at Delaware, Columbus, Chillicothe, Circleville, Piketon, and Portsmouth, 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 Management 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 Management 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, 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 Management 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 the Olentangy, Scioto, 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. Tabular and graphic data used to calculate stage reductions at the following gaging stations pertinent to Delaware Dam: Olentangy River at Clariden and Delaware; and Scioto River at Columbus, Chillicothe, Circleville, Piketon; and Ohio River at Portsmouth. 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 MANAGEMENT SECTION

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.

PERTINENT DATA

DELAWARE RESERVOIR
OLENTANGY RIVER, OHIO

LOCATION OF PROJECT

Delaware County, Ohio, on Olentangy River, Scioto River Basin, 32.4 miles upstream from confluence with the Scioto River at Columbus, Ohio.

TYPE OF PROJECT

Flood-Control and water-conservation reservoir.

PURPOSE

For reduction of flood damage in the Olentangy, Scioto and Ohio River valleys and water conservation for water-supply, pollution abatement, recreation and conservation of fish and wildlife.

AUTHORITY

Flood Control Act, Public No. 761, Seventy-fifth Congress, third session, dated 28 June 1938.

DRAINAGE AREAS (square miles)

Olentangy River at Delaware dam site	381
Olentangy River at Delaware, Ohio (USGS gage)	387
Olentangy River at mouth	536
Scioto River at Columbus, Ohio (USGS gage)	1,624
Scioto River at mouth	6,510

STREAM FLOW DATA

Average annual flow at dam site, cfs	347
Maximum estimated peak discharge, flood of 22 January 1959, cfs	33,000
Minimum experienced discharge, 20 August 1930 and 14-19 September 1934, cfs	0.1

PERTINENT DATA (cont'd)

DELAWARE RESERVOIR
OLENTANGY RIVER, OHIO

RESERVOIR

Capacities and surface areas

Storage, winter conservation pool, acre-feet	8,400
Storage, summer conservation pool, acre-feet	14,000
Maximum flood-control storage (winter), acre-feet	123,600
Maximum flood-control storage (summer), acre-feet	118,000
Total storage, acre-feet	132,000
Maximum flood-control storage (winter), inches of runoff	6.1
Maximum flood-control storage (summer), inches of runoff	5.8
Total storage, inches of runoff	6.5
Pool area (winter), acres	950
Pool area (summer), acres	1,300
Maximum flood-control pool area, acres	8,700

ELEVATIONS (feet above ngvd)

Top of Dam	957.0
Maximum water surface (spillway design flood)	952.2
Maximum flood control pool	947.0
Summer conservation pool	915.0
Winter conservation pool	910.0
Flood plain at dam site	890
Stream channel at dam site	880

DAM

Type- Rolled earth fill. Concrete gravity channel section

Maximum height above original bedrock, feet	92
Top length, feet	18,600
Top width, feet	15
Base width	480

SPILLWAY

Type	controlled
Crest length, gross, feet	232
Crest length, net, feet	192
Crest elevation, feet above ngvd	922
Tainter gates, number	6
Tainter gates, size	25' high x 32' long
Spillway design flood, maximum inflow, cfs	148,000
Spillway design flood, maximum outflow, cfs	120,000
Maximum surcharge, spillway design flood, feet	30.2

PERTINENT DATA (cont'd)

DELAWARE RESERVOIR
OLENTANGY RIVER, OHIO

OUTLET WORKS

Type- Sluices through spillway section. One Hydraulically operated slide gate in each sluice.

Number	5
Size	6'6"x6'6"
Invert elevation, upstream, feet above ngvd	881.0
Capacity at flood-control (elev. 947 ngvd), cfs	11,100

STILLING BASIN

Width, feet	232
Length of level section, feet	66.5
Flood elevation, feet above ngvd	873.0
End sill crest elevation, feet above ngvd	881.0

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

INSTRUCTIONS TO DAMTENDER
DELAWARE LAKE

PROJECT MANUAL
FOR
WATER CONTROL MANAGEMENT
DELAWARE LAKE – OLENTANGY RIVER

JANUARY 2004

Exhibit B

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INSTRUCTIONS TO DAMTENDER
DELAWARE 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 a Special Directive issued by the Water Management Section of the Huntington District Office.

In order to maintain downstream aquatic environment, the stage at the outflow gage shall never be allowed to fall below a minimum of 5 cfs.

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

1-02. GATE REGULATION TECHNIQUE

a. General. Facilities provided for water control at Delaware Lake include FIVE sluice gates for bottom discharge of all but major floods and SIX spillway tainter gates for control of major flood releases over the spillway. All gate movements are fully controlled by the electronic machinery in the operating galleries. Sequence and manner of operation, where applicable, appear in subsequent paragraphs. The gates are to be operated in such a manner as to avoid a change in stage at the "O" gage greater than 1.0 foot per hour except as otherwise instructed by a Special Directive, or under conditions of sub-section 1-07.

b. Sluice Gates. The 5 hydraulically operated sluice gates, are slide-type gates sized to fit a 6.5 foot square sluiceway at 881.0 feet NGVD. They are designated S1 to S5 from right to left facing downstream. During low-flow periods, one gate, No. S2 is usually open alone up to 0.5 foot, to guarantee the required 5 cfs minimum flow. **Plate No. 1-1** tabulates the approximate stages and flows which will be reached at the "O" gage with certain gate openings and lake elevations. By using the table as a guide, the approximate gate opening required to maintain a designated stage at the "O" gage can be determined. When the approximate gate setting is made, and the flow has stabilized, only minor adjustments should be necessary.

In order to avoid abrasion of both the baffles and the bottom of the stilling basin, discharges greater than routine minimum flow, that through one gate open 0.5 foot are to be spread and dispersed across the stilling basin.

Sluice Gate Regulation Schedule, **Plate No. 1-2**, shows the desired sequence of opening of gates in 0.5 foot increments from one gate opening 0.5 foot to five gates open 6.5 feet. The sequence shown is No. 2, No. 4, No. 3, No. 5 and No. 1; and the reverse sequence to be used in closing. Move to the next gate in sequence only after completing the 0.5 foot incremental opening of the current gate.

c. Spillway Gates. The 6 spillway gates are electric hoist-operated, spillway tainter type, 32 feet by 25 feet, with sill inverts at 922.0 feet NGVD. The SIX tainter gates are designated T1 - T6 from right to left looking downstream. Except for testing, or emergency operation in accordance with the Emergency Operation Schedule, **Plate No. 1-5**, or Special Directive, the tainter gates are to be kept in the closed position at all times. Operation of the gates during any operation should always be gradual and as nearly simultaneous as possible, and never more than 1.0 foot per hour.

1-03. ROUTINE OPERATION

Rules Curves for Regulation, **Plate No. 7-7**, plate section, shows two main pool elevations, 910 feet and 915 feet NGVD, during DEMIA* and MIANO* periods, respectively, barring flood control operation, Special Directive Control, or drought operation. The plate also contains a Lower Limiting Rule Curve. In case of prolonged drought, which would normally occur during the recreation season, if the lake level falls to the lower curve, lake discharge will be reduced to the 5 cfs minimum stated in 1-01-a above. If the lake level falls to 910 feet elevation NGVD, the Water Management Section will assess all pertinent factors and direct the desired discharge rate.

Under normal conditions as defined in **Plate No. 3-1**, plate section, project personnel are responsible for reservoir regulation to maintain the pool level at or near designated elevations by operating gates to effect discharge stage up to 5.1 feet on the "O" gage, since that is the greatest discharge allowed without a Special Directive. If unable to prevent the pool level from rising 2 feet above designated elevation, contact the Water Management Section for instructions except under communications failure as outlined in 1-07, page 1-4.

Water Management Section will issue special instructions about 1 April to begin raising the pool level to MIANO elevation 915 feet NGVD. Discharges during MIANO for the purpose of augmenting seasonal low flows in the Scioto River below Columbus are directed by the Water Management Section. Rates and dates of the discharges are listed in the Rules Curves for Regulation, **Plate No. 7-7**, plate section, and mentioned in 1-04 next page.

After 1 September, the Water Management Section will assess current and anticipated hydrologic conditions to determine the optimal usage of the impounded seasonal storage during the drawdown period and issue appropriate instructions to the project. The instructions may entail holding the seasonal pool for a period of time to accommodate recreation interests or releasing to augment low-flows downstream under less than normal conditions. In any event, drawdown to DEMIA elevation 910 feet NGVD will begin no later than 1 November.

1-04. LOW-FLOW AND AUGMENTATION

A minimum discharge of 5 cfs, on the "O" gage, is to be maintained for downstream habitat at all times, even during closure for flood control, any low-flow may be conveniently discharged through sluice gate No. S2 because of the minute control for operating this gate from the control room i.e. to ±0.01 foot; however, all the gates can be adjusted to ±0.01 foot accuracy in the main gallery. Augmentation amounts for the Scioto River are given as minimum discharge values for the months of June through October in "Rule Curves for Reservoir Regulation," **Plate No. 7-7**, in the Plate Section.

1-05. OPERATION FOR DOWNSTREAM CONTROL

During reservoir regulation activity, the allowable maximum stage is 8.6 feet on the "O" gage, discharge 4,282 cfs, and can be maintained during light rainfall without causing any appreciable damage along the Olentangy River downstream from the dam to the confluence with Scioto River in Columbus. Any discharge above a stage of 5.1 feet at the "O" gage must be covered by a Special Directive from the Water Management Section except as outlined in 1-07 below. When significant rainfall occurs, discharge will be regulated according to Model forecast so as to avoid exceeding a stage of 7.8-feet at Worthington, which is control stage for both DEMIA and MIANO periods.

Operation for the Scioto River at Columbus is based on the Model forecast and DEMIA and MIANO control stages of 19.5 feet (18,990 cfs) and 13.5 feet (8,140 cfs) respectively. If MIANO flows at Columbus from uncontrolled areas exceed 17.5 feet for 24 hours or more, Water Management Section may later direct release of flood storage from Delaware Lake which would contribute to higher stages than 13.5 feet.

Operation for the Ohio River at Portsmouth, Ohio, is based on stage forecasts by National Weather Service and water travel time from the project to Portsmouth. Special Directives will be issued by the Water Management Section for operation of Delaware Lake for Ohio River control.

All inflow will be stored, subject to minimum flow requirements, from 96 hours in advance of predicted time of reaching a forecast crest stage in excess of 50 feet on the Ohio River at Portsmouth. Releases will be timed so as not to add to the crest at Portsmouth, Ohio.

1-06. EMERGENCY RESPONSE

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

1-07. OPERATION DURING COMMUNICATION FAILURE

During a major flood, every effort shall be made to contact the District Office. In the event of failure of both cell phone and telephone facilities, the cooperation of the local radio station, of amateur radio operators, or of the State Police should be solicited. The emergency procedure outlined below shall be followed during periods when the District Office cannot be contacted.

a. If the reservoir was being operated in accordance with a Special Directive from the Water Management Section when communication failed, follow the instructions given in the Special Directive until:

1. The operation given in the Special Directive has been executed, or

2. Twenty-four hours have elapsed since last contact with the Water Management Section, or

3. Significant rainfall occurs.

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, 1-05, 1-06, or 1-07c, whichever is applicable. If 1-05 is applicable, regulate according to "Operation Chart for Olentangy River Control, **Plate No. 1-3**, and "Operation Schedule for Scioto River control, **Plate No. 1-4** at the end of this section using the lesser of the discharge indicated respectively by chart and schedule.

Both chart and schedule will be superseded by "Emergency Operation Schedule, **Plate No. 1-5**, if and when that schedule calls for greater discharge than the above.

The Emergency Operation Schedule, shown as **Plate No. 1-5**, provides for increases in outflow when the rate of rise in reservoir level indicates that the available storage capacity of the reservoir will be insufficient to completely control the flood. The procedure to be followed in using the emergency schedule is described on the chart. Whenever the lake is above elevation 932 feet NGVD, a close check shall be kept on the rate of rise in lake level.

Whenever the rate of rise approaches a value which indicates that the current gate openings must be increased, contact the Water Management Section immediately. Project personnel are authorized to operate the reservoir in accordance with the emergency schedules when there is a delay of three hours in establishing contact with the Water Management Section from the time that the curves indicate gate openings greater than those being maintained in accordance with any other instruction. The other condition under which the reservoir must be operated in accordance with the emergency schedule is when a second rise occurs while the reservoir is being held at elevation 947.0 feet NGVD. (See instruction 8 on emergency schedule). In this event, the required operation shall be executed without delay, but every effort shall be made to advise the Water Management Section personnel of the operations undertaken.

It should be noted that proper operation according to rate-of-rise curves requires close adherence to a 60-minute hour in reading of gages and operating gates.

1-08. PUBLIC NOTIFICATION OF UNUSUAL RELEASES

Operation of reservoir projects during major flood 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 U.S. Government. To minimize the possibility of such claims or suits, Delaware Lake Damtender must stay informed and inform the Water Management Section of all developments along Olentangy River between the dam and the USGS gage at Worthington.

If required by unusual release patterns, obtain directions from the Water Management 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 so as to prevent damage to or loss of their property.

DELAWARE LAKE

SLUICE GATE RATING

Gates Open	Stage at '0' Gage for Pool Elevation							
	910	915	920	925	930	935	940	947
½	3.3	3.4	3.5	3.6	3.7	3.8	3.8	3.9
1	4.5	4.9	5.0	5.2	5.3	5.5	5.6	5.9
1½	5.7	6.1	6.3	6.5	6.8	7.0	7.2	7.5
2	6.8	7.2	7.5	7.9	8.1	8.3	8.5	8.8
2½	7.8	8.2	8.5	8.8	9.1	9.3	9.4	
3	8.5	8.9	9.4	9.5				
3½	9.1							
4	9.5							

Plate No. 1-1

DELAWARE LAKE
SLUICE GATE OPERATION SCHEDULE

Total Gate Opening – Feet	Individual Gate Openings – Feet				
	No. 5	No. 4	No. 3	No. 2	No. 1
0.0 – 0.5				0.5	
0.6 – 1.0		0.5		0.5	
1.1 – 1.5		0.5	0.5	0.5	
1.6 – 2.0		0.5	0.5	1.0	
2.1 – 2.5		1.0	0.5	1.0	
2.6 – 3.0		1.0	1.0	1.0	
3.1 – 3.5		1.0	1.0	1.0	0.5
3.6 – 4.0	0.5	1.0	1.0	1.0	0.5
4.1 – 4.5	0.5	1.0	1.0	1.0	1.0
4.6 – 5.0	1.0	1.0	1.0	1.0	1.0
5.1 – 5.5	1.0	1.0	1.0	1.5	1.0
5.6 – 6.0	1.0	1.5	1.0	1.5	1.0
6.1 – 6.5	1.0	1.5	1.5	1.5	1.0
6.6 – 7.0	1.0	1.5	1.5	1.5	1.5
7.1 – 7.5	1.5	1.5	1.5	1.5	1.5
7.6 – 8.0	1.5	1.5	1.5	2.0	1.5
8.1 – 8.5	1.5	2.0	1.5	2.0	1.5
8.6 – 9.0	1.5	2.0	2.0	2.0	1.5
9.1 – 9.5	1.5	2.0	2.0	2.0	2.0
9.6 – 10.0	2.0	2.0	2.0	2.0	2.0
10.1 – 10.5	2.0	2.0	2.0	2.5	2.0
10.6 – 11.0	2.0	2.5	2.0	2.5	2.0
11.1 – 11.5	2.0	2.5	2.5	2.5	2.0
11.6 – 12.0	2.0	2.5	2.5	2.5	2.5
12.1 – 12.5	2.5	2.5	2.5	2.5	2.5

Plate No. 1-2

Sheet 1

DELAWARE LAKE
SLUICE GATE OPERATION SCHEDULE

Total Gate Opening – Feet	Individual Gate Openings – Feet				
	No. 5	No. 4	No. 3	No. 2	No. 1
12.6 – 13.0	2.5	2.5	2.5	3.0	2.5
13.1 – 13.5	2.5	3.0	2.5	3.0	2.5
13.6 – 14.0	2.5	3.0	3.0	3.0	2.5
14.1 – 14.5	2.5	3.0	3.0	3.0	3.0
14.6 – 15.0	3.0	3.0	3.0	3.0	3.0
15.1 – 16.0	3.0	3.0	3.0	4.0	3.0
16.1 – 17.0	3.0	4.0	3.0	4.0	3.0
17.1 – 18.0	3.0	4.0	4.0	4.0	3.0
18.1 – 19.0	3.0	4.0	4.0	4.0	4.0
19.1 – 20.0	4.0	4.0	4.0	4.0	4.0
20.1 – 21.0	4.0	4.0	4.0	5.0	4.0
21.1 – 22.0	4.0	5.0	4.0	5.0	4.0
22.1 – 23.0	4.0	5.0	5.0	5.0	4.0
23.1 – 24.0	4.0	5.0	5.0	5.0	5.0
24.1 – 25.0	5.0	5.0	5.0	5.0	5.0
25.1 – 26.0	5.0	5.0	5.0	6.0	5.0
26.1 – 27.0	5.0	6.0	5.0	6.0	5.0
27.1 – 28.0	5.0	6.0	6.0	6.0	5.0
28.1 – 29.0	5.0	6.0	6.0	6.0	6.0
29.1 – 30.0	6.0	6.0	6.0	6.0	6.0
30.1 – 30.5	6.0	6.0	6.0	6.5	6.0
30.6 – 31.0	6.0	6.5	6.0	6.5	6.0
31.1 – 31.5	6.0	6.5	6.5	6.5	6.0
31.6 – 32.0	6.0	6.5	6.5	6.5	6.5
32.1 – 32.5	6.5	6.5	6.5	6.5	6.5

Plate No. 1-2
Sheet 2

DELAWARE LAKE
OPERATION CHART FOR OLENTANGY RIVER CONTROL

This chart establishes the maximum stage which may be held at the '0' gage when Olentangy River conditions control. The following will take precedence over this chart: Special Directives at all times, Operation Schedule for Scioto River Control when lower outflows are indicated and, "Emergency Operation Schedule" when higher outflows are indicated.

In using this chart the time of the latest reading of precipitation gage is called H-hour and other times are referred to as plus or minus a number of hours. Example: the recording rain gage reads 3.75 inches at 0730 in the morning (H-hour), and it reads 2.65 inches at 0130 (H-6) of the same morning, 2.25 inches at 1930 (H-12) on the previous evening, and 0.65 at 1330 (H-18) on the previous afternoon. By subtraction the six hour amounts are H-6 to H 1.09 inches, H-12 to H-6 0.40 inches and H-18 to H-12 1.60 inches. The arrows show how these amounts are used in the chart to determine the maximum allowable stage of 7.40 feet on the '0' gage assuming that the rainfall occurred during MIANO. If the same rainfall occurred during DEMIA, the maximum allowable stage would be 7.50 feet.

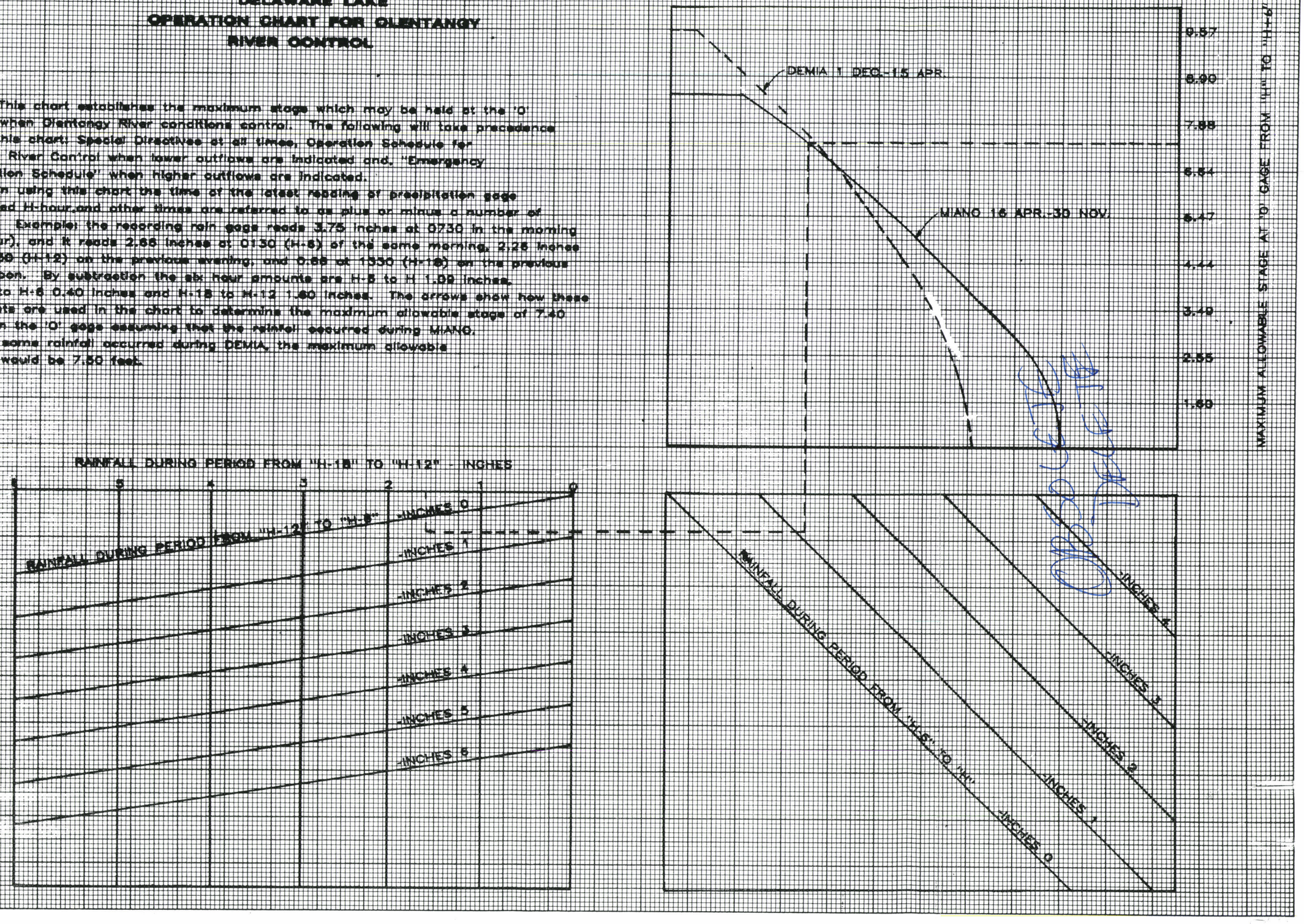


Plate No. 1-3

OPERATION SCHEDULE FOR SCIOTO RIVER CONTROL

1. This schedule is for use by project personnel only during communication failure. The schedule establishes the maximum stages which may be held at the '0' gage whenever the stage at Dublin indicates the possibility of a flood on the Scioto River. After each reading of the Dublin voice gage, enter the following table in the appropriate column with the current reading and determine the "stage to be maintained at '0' gage". Maintain this stage until the next scheduled reading of the Dublin voice, when a new determination shall be made in the same manner. When the voice gage is suspect, travel to the gage and report stage to the project by radio.

2. The minimum frequency for reading the voice gage at Dublin is given in the "Schedule for Reading Gages" Exhibit No. III-1 of these instructions. Additional readings shall be made as required to determine whether the river at Dublin is rising or falling. When the stage at Dublin is falling, increases in discharge from the reservoir shall not exceed one outflow step in an hour.

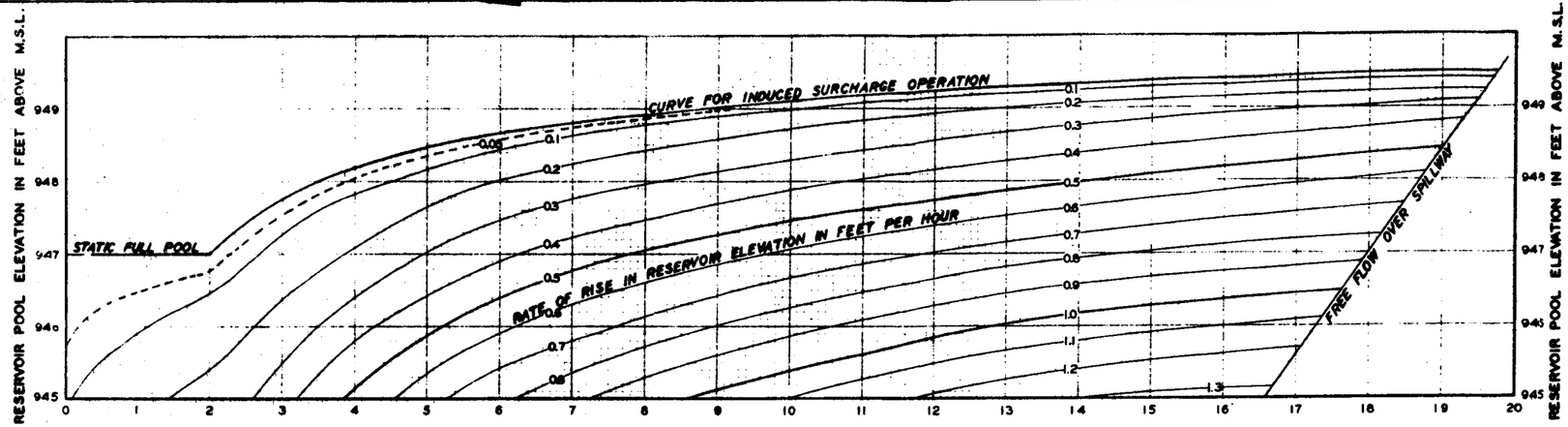
Outflow Step Number	Stage to be Maintained at '0' Gage	*MIANO OPERATION 16 April - 30 November Stage at Dublin - Feet			*DEMIA OPERATION 1 December - 15 April Stage at Dublin Feet	
		Rising	Falling		Rising	Falling
			Crest 8.9 ft. or below	Crest above 8.9 ft. Fall below crest		
1	1.13	7.7 or more	8.8 or more	0.0 - 0.3	12.2 or more	13.1 or more
2	3.7	6.4 - 7.7	8.4 - 8.8	0.3 - 0.7	11.5 -	13.1
3	5.1	5.3 - 6.4	8.0 - 8.4	0.7 - 1.1	11.0 -	12.8
4	6.6	4.9 - 5.3	7.6 - 8.0	1.1 - 1.5	10.5 -	12.5
5	8.0	4.7 - 4.9	7.2 - 7.6	1.5 - 1.9	9.9 -	12.2
6	8.6	4.7 or less	7.2 or less	1.9 or more	9.9 or less	12.2 or less

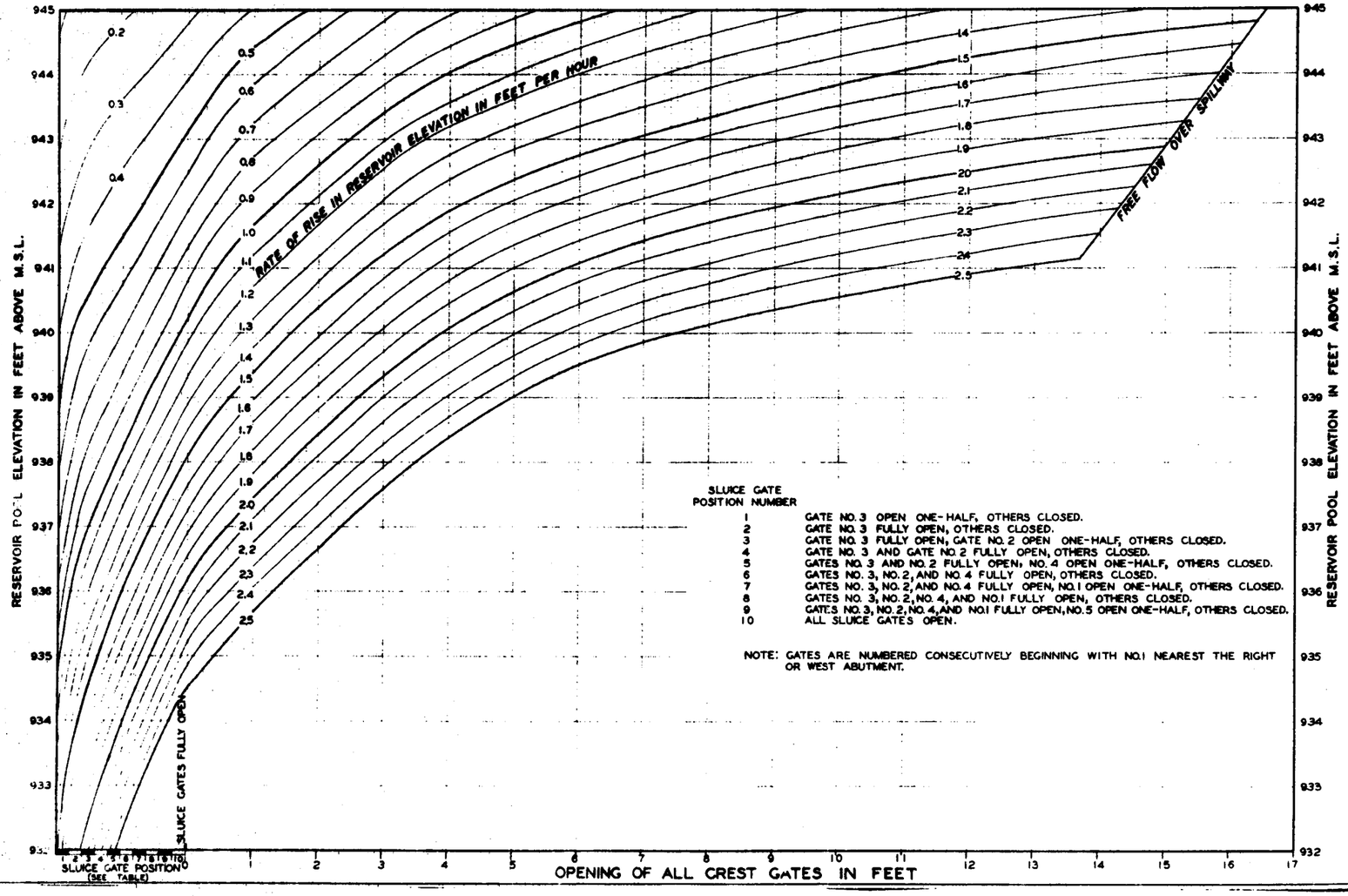
* Acronyms for "Mid-April through November" and "December to Mid-April".

Plate No. 1-4

CORPS OF ENGINEERS

U. S. ARMY





SLUICE GATE POSITION NUMBER	
1	GATE NO. 3 OPEN ONE-HALF, OTHERS CLOSED.
2	GATE NO. 3 FULLY OPEN, OTHERS CLOSED.
3	GATE NO. 3 FULLY OPEN, GATE NO. 2 OPEN ONE-HALF, OTHERS CLOSED.
4	GATE NO. 3 AND GATE NO. 2 FULLY OPEN, OTHERS CLOSED.
5	GATES NO. 3 AND NO. 2 FULLY OPEN, NO. 4 OPEN ONE-HALF, OTHERS CLOSED.
6	GATES NO. 3, NO. 2, AND NO. 4 FULLY OPEN, OTHERS CLOSED.
7	GATES NO. 3, NO. 2, AND NO. 4 FULLY OPEN, NO. 1 OPEN ONE-HALF, OTHERS CLOSED.
8	GATES NO. 3, NO. 2, NO. 4, AND NO. 1 FULLY OPEN, OTHERS CLOSED.
9	GATES NO. 3, NO. 2, NO. 4, AND NO. 1 FULLY OPEN, NO. 5 OPEN ONE-HALF, OTHERS CLOSED.
10	ALL SLUICE GATES OPEN.

NOTE: GATES ARE NUMBERED CONSECUTIVELY BEGINNING WITH NO. 1 NEAREST THE RIGHT OR WEST ABUTMENT.

OPERATION INSTRUCTIONS

1. SEE SEPARATE INSTRUCTIONS AS TO WHEN RESERVOIR MAY BE OPERATED WITHOUT SPECIFIC INSTRUCTIONS FROM DISTRICT OFFICE.
2. READ THE "LAKE" GAGE EVERY HOUR ON THE HOUR, COMPUTE THE AVERAGE RATE OF RISE IN RESERVOIR ELEVATION IN FEET PER HOUR FROM THE CHANGE IN ELEVATION DURING THE PRECEDING THREE HOURS.
3. ADJUST THE GATE SETTINGS EACH HOUR AS INDICATED BY THE CURVES ON THE BASIS OF THE AVERAGE RATE OF RISE AND THE CURRENT RESERVOIR ELEVATION.
4. WHEN THE CURRENT RESERVOIR ELEVATION IS BELOW 945.0, USE THE LOWER SET OF CURVES. DO NOT RAISE THE CREST GATES UNTIL ALL SLUICES ARE OPEN. RAISE ALL CREST GATES AS UNIFORMLY AS POSSIBLE.
5. WHEN THE HOURLY RESERVOIR LEVEL READING FIRST EXCEEDS ELEVATION 945.0 CLOSE ALL SLUICES AND RAISE ALL CREST GATES AS UNIFORMLY AS POSSIBLE TO THE OPENING INDICATED BY THE UPPER SET OF CURVES USE THE UPPER SET OF CURVES AS LONG AS THE POOL EXCEEDS 945.0. OPEN THE SLUICE GATES WHEN THE CREST GATES HAVE BEEN LIFTED CLEAR OF THE WATER SURFACE.
6. AFTER THE RESERVOIR LEVEL STARTS TO FALL, MAINTAIN THE CURRENT GATE SETTINGS UNTIL THE POOL RECEDES TO ELEVATION 947.0, THEN CLOSE THE SLUICE GATES IF THEY ARE OPEN, AND CLOSE THE CREST GATES AS REQUIRED TO MAINTAIN RESERVOIR ELEVATION AT 947.0.
7. HOLD THE POOL AT ELEVATION 947.0 OR AT MAXIMUM LEVEL ATTAINED, IF BELOW 947.0, UNTIL ORDERED BY SPECIAL DIRECTIVE TO BEGIN DRAWDOWN OPERATION.
8. IF A SECOND RISE OCCURS WHILE THE POOL IS BEING HELD AT ELEVAT- 947.0 FEET, FOLLOW THE "CURVE FOR INDUCED SURCHARGE OPERATION." IF THE CREST GATES ARE OPEN MORE THAN 2.0 FEET WHEN THE SECOND RISE OCCURS, MAINTAIN THE CURRENT GATE SETTINGS UNTIL THE RESERVOIR LEVEL RISES TO THE ELEVATION CORRESPONDING TO THE GATE SETTING ON THE "CURVE FOR INDUCED SURCHARGE OPERATION," THEN FOLLOW THE CURVE UNTIL THE POOL CEASES TO RISE. WHEN THE POOL STARTS TO FALL, OPERATE IN ACCORDANCE WITH INSTRUCTION NO 6, ABOVE.

OLENTANGY RIVER
OHIO

DELAWARE LAKE

EMERGENCY OPERATION SCHEDULE

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON W. VA. DECEMBER 1988

Plate No. 1-5

SECTION II - COLLECTION OF HYDROMETEOROLOGIC DATA

2-01. PRECIPITATION AT DELAWARE 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, Wilmington 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 Management Section through the Scioto 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. Data Collection Platforms have been installed to collect, record, and report precipitation at five stations in or near the Olentangy River Basin. They are at or near the villages of Claridon, Worthington, Galion, Prospect, and at the damsite itself. Each is equipped with a voice modem that 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 Olentangy River Basin is listed below in **Table No. 2-1**, below.

TABLE NO. 2-1

PRECIPITATION PLATFORM COMMUNICATION INFORMATION

Location of Gage	Symbol	Equip	Voice	Frequency Channel No.	Data Update Interval	Trans-mitted	Trans-mission
Delaware Lake	DDOD2	1/		35	60 min	P,E	4 Hours
Delaware	DEOD2	1/		35	30 min	P,S,T	4 Hours
Prospect	PRSD2	1/	V	55	60 min	P	4 Hours
Galion Water Works	GALC3		V			P	
Claridon							
Worthington							

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.
x 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 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 if condition (1) does not require more frequent measurements.

2-02. PRECIPITATION AT OHIO RIVER NETWORK STATIONS

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

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

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

b. Reporting Criteria. This precipitation network has been abolished, therefore there is no reporting criteria.

c. Method of Reporting. This precipitation network has been abolished, therefore there is no reporting method.

TABLE NO. 2-2

OHIO RIVER NETWORK STATIONS

Location of Gage	Symbol	Equip	Voice	Channel No.	Update Interval	Trans-mitted	Trans-mission
Delaware Lake	DDOD2	1/		35	60 min	P,E	4 Hours
Delaware	DEOD2	1/		35	30 min	P,S,T	4 Hours
Prospect	PRSD2	1/	V	55	60 min	P	4 Hours
Galion Water Works	GALC3		V			P	
Claridon							
Worthington							

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.
x Synthesized voice in addition to transmitting via satellite.

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**, at end of 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 DELAWARE LAKE

a. Gage Listing. Information about gages of importance to operation of the project appears on **Table No. 3-1**, next page.

b. Reading and Recording Gage Heights. List all gage readings in the records in order that complete data on the effect of the lake on natural flows will be available. Record lake gage readings in terms of elevation in feet above NGVD but record all other gages in feet above gage datum, or zero of the gage.

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 the lake, Claridon and Worthington on the Olentangy River, and at Columbus and Dublin on the Scioto 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 end of 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 Delaware Lake appear below in **Table No. 3-1**, below.

TABLE NO. 3-1

STREAM GAGE TELEPHONE NUMBERS

Gage	Symbol	Exchange	Telephone No.
Dublin on Scioto River	DUSE2	Dublin	[redacted]
Worthington on Olentangy River	WOOE2	Columbus	[redacted]

3-04. DATA COLLECTION

Lake elevation is taken from the recorder chart and outflow stage from the readout, both in the control structure. Stages at Dublin and Worthington, are received by telephoning the respective voice platforms. Supplemental lake and outflow data, discussed in 4-01 C below, are taken along with regular readings or soon after. Rain and/or snowfall amounts, along with snow or ground when relevant, and times of beginning and ending are received from DCP recorders. Project precipitation is measured in the standard 8" rain gage.

Stage data as soon as known and gate changes as made are entered into Form 14 and the daily log. Precipitation data is entered into the log as soon as known and all the data is entered into the computer terminal, as part of regular and extra reports to INTRANET. After data is entered, it is checked for accuracy and then transmitted by computer to INTRANET.

DCP's report stage and/or precipitation data, are updated every 60 minutes except Dublin which is on 30 minute schedule. Manner of DCP reporting to the Water Management Section data base is outlined in paragraph 2-01f.

Use of the computer to obtain from INTRANET stage/elevation or precipitation readings from platform-reported stations relevant to the project is also described in 2-01,f.

Data are given by Delaware Lake personnel as detailed in Section IV and as shown in **Plate No. 4-1** 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 Management Section. Data collection platforms report stage data at all the locations (plus precipitation at some stations) listed in **Table No. 3-1**, previous page. 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 Management Section 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 mentioned in 2-01.f. above.

SCHEDULE FOR READING GAGES
DELAWARE LAKE

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

CONDITIONS	SCHEDULE A(1) Normal Conditions		SCHEDULE B(1) Flood Threat		SCHEDULE C(1) Flood Condition		SCHEDULE D Major Flood Condition	
	MIANO*	DEMIA*	MIANO*	DEMIA*	MIANO*	DEMIA*	MIANO*	DEMIA*
Lake elevation	Below 919	Below 915	919-932	915-932	932-944.5(4)	932-944.5(4)	Above 944.5	Above 944.5
Stage at '0' gage	Below 5.1(6)	Below 5.1(6)	5.1-7.0(6)	5.1-7.0(6)	7.0-8.6(6)	7.0-8.6(6)	Above 8.6(6)	Above 8.6(6)
Precipitation within 24 hours	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
Worthington Voice	Below 5.8	Below 5.8	5.8-6.8	5.8-6.8	6.8-7.8	6.8-7.8	Above 7.8	Above 7.8
Dublin Voice	Below 5.0	Below 8.0	5.0-6.5	8.0-9.2	Above 6.5	Above 9.2	--	--
READ GAGES								
VL and VO (2) RL and RO Charts	At 0730 & 1330(3) Readings for 0730, 1330, 1930 & 0130(5)		At 0730 & 1330 Readings for 0730, 1330, 1930 & 0130(5)		At 0730, 1330, 1930 & 0130 Readings for 0730, 1330, 1930 & 0130(5)		At 3 hour intervals(4) Readings for 0730, 1330, 1930 & 0130(5)	
Precipitation Gage	At 0730		At 0730 & 1330		At 0730, 1330, 1930 & 0130		At 3 hour intervals	
Worthington Voice	Daily at 0730		At 0730 & 1330		At 0730, 1330, 1930 & 0130		At 3 hour intervals	
Dublin Voice	Daily at 0730		At 0730 & 1330		At 0730, 1330, 1930 & 0130		At 3 hour intervals	
TL, TO RL, RO, SL and SO	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 by person to person telephone call one of the Hydrology and Hydraulics Branch personnel listed in paragraph 4-03c of this Annex.
(2) When the visual indicators are not operating properly, read the staff gages.
(3) Take readings on workdays regularly and on weekends and holidays by special arrangement.
(4) Whenever the reservoir level is between elevation 932 and 944.5 and rising or at elevation 944.5 or above, a constant check shall be kept on the rate of rise in pool level. Whenever the rate of rise approaches a value which indicates a gate opening on the "Emergency Operation Schedule," readings of the "Lake" gage shall be taken every hour, on the hour.
(5) The 1330, 1930, and 0130 readings on workdays 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 required readings, roll the chart back and, after taking readings, return to the proper position--all according to instructions contained in Exhibit No. III-2.
(6) All releases above a stage of 5.1 feet at any time of year are to be covered by Special Directive.
(7) 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 streams or inflow, read lake, outflow, Dublin and Worthington gages by 1330 hours and transmit the readings and rainfall amount to Hydrology and Hydraulics Branch by computer or by telephone if necessary.

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

* Acronyms for mid-April through November (crop season) and December to mid-April (non-crop season)

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

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. This new reporting program was installed at the dam in May 1998, as 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.

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 telephone when taking the 0730 Project Report readings. 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.”

b. 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.

The correct method of reporting the data is shown in **Plate No. 4-1**, in 6 sheets.

c. 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.

As in the Project Report, a password is necessary to submit the gate Operation Report to the CWMS-A computer. The same password is used to submit the Project Report and the Gate Operations Report.

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 data is entered as: **https://cwms.lrh.usace.army.mil/DDO/gateops.htm**

This record can be viewed at the Intranet Explorer Delaware Lake web page at: **https://cwms.lrh.usace.army.mil/DDO/database.htm**

d. Water Quality Report. The third report available from the Index Page is the Water Quality Report. This report is used during the rare times that the lake is subject to stratification. Monitoring begins when a special directive is sent by Water Management Section at the request of Water Quality Team. Water Quality data is reported in accordance with the special directive. The Water Quality Team will request the Water Management Section to issue a special directive ending monitoring when it is no longer necessary.

As in the Project Report, a password is necessary to submit the Water Quality Report to the CWMS-A computer. The same password is used to the Project Report and the Water Quality Report. 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 is entered as: **https://cwms.lrh.usace.army.mil/DDO/waterqua.htm**

This record can be viewed through the Delaware Lake Dam web page at: **https://cwms.lrh.usace.army.mil/DDO/database.htm**
This is illustrated in **Plate No. 4-1** at the end of this section.

e. Weekly Precipitation Report. 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 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 days field and report the combined days precipitation in the next day when the project is staffed. Ie. If the Project does not staff the weekend, place a "NS" in Saturday and Sundays field and report the 72 hour precipitation record on Monday morning.

f. Additional Comments. 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 want s to bring to the immediate attention of the Water Management Section. 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 Section 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.

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 on the Key Personnel list shown in **Plate 4-2**, back of section.

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 Management Section.

b. Special Report Data. The following types of occurrences or information are examples of occasions for or subjects of special reports. Extraordinary meteorological event such as a tornado or blizzard, or heavy precipitation after 0730 hours.

(1) Gate positions and/or operations.
(2) Flooding upstream or downstream.
(3) Request for special operation.
(4) A catastrophe such as drowning.
(5) Unusual or abnormal water quality conditions in the lake, inflow streams, or a reasonable distance downstream from the dam.
(6) Moisture content of snow.
(7) Outflow temperature and/or air temperature at time other than 0730 hours.
(8) 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 Management Section will be on duty, place a call to one of the Water Resources Engineering Branch, Key Personnel, **Plate No. 4-2.**

4-04. CELL PHONE AS BACKUP COMMUNICATION

Backup communication is now provided by the Cell Phone. The Cell Phone should be turned on at all times when away from the project office, including overtime periods. The District Operator is often on duty outside of regular work 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.

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 Olentangy River to Columbus, Ohio.

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

(3) If complaints of flooding are received, notify the Water Management Section immediately, then make an inspection of the specific areas as soon as practicable.

(4) An 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 seasonal pool elevation, inspections shall be made within the lake area. Essential items to look for and observe are bank slippage and effects of wind and wave erosion.

d. Low-Flow Releases. During periods of low-flow release downstream observations shall be made of stream depth, fish and wildlife, water odor, and discoloration, if any, as directed by the Water Resources Engineering Branch. Stream gages, rain gages and temperature equipment shall be periodically checked for proper functioning and performance or when directed by the Water Management Section. During periods of stratification, outflow temperature requirements will be maintained according to the Water Management 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, 940 feet NGVD for Delaware Lake, daily 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.

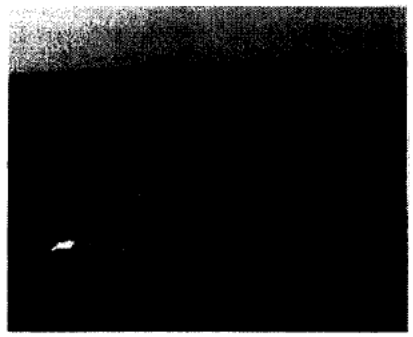
(4) The Water Resources Engineering Branch should be informed concerning application of chemicals to the water or to surrounding land. This includes fertilizers and pesticides.

US Army Corps of Engineers
Huntington District
Water Control Section

Welcome to the

DELAWARE LAKE

WATER CONTROL INTRANET PAGE



DATA ENTRY

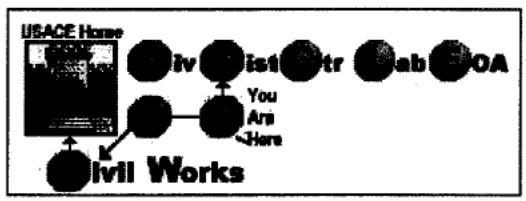
PROJECT DATA	GATE OPERATIONS	WATER QUALITY

OTHER PLACES OF INTEREST

EMERGENCY CONTACTS		
WEATHER FORECASTS	RADAR	CORPS GOES DATA
OTHER LINKS	SPECIAL DIRECTIVES	WHAT'S NEW
WHITEWATER PAGE	LAKE REPORT	USGS DATA
Huntington District Current Conditions	Scioto Basin Current Conditions	Project Report Archive

The POC for this page:

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



Date last modified: 6 Mar 2003 at 0738

Plate No. 4-2
Sheet 1 of 6

This file is a New submission.

DELAWARE LAKE

PROJECT INFORMATION

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

DATE	TIME
08 May 2003	0730

CURRENT PROJECT INFO

COE ID	PRECIP (IN)	POOL ELEV (FT-MSL)	TAIL WATER STAGE (FT)	FLOW (KCFS)	SNOW DEPTH (IN)	WATER EQUIVILENT (IN)	WEATHER CONDITIONS
DDOD2	0	910	1.0	0	0.0	0.0	0 Unchanged

CURRENT GATE SETTINGS

GATE	S1	S2	S3	S4	S5	T1-6
SETTING	.00	.00	.00	.00	.00	.00

ADDITIONAL STATION INFORMATION

COE ID	SHEF ID	PRECIP (IN)	STAGE (FT)
DUSE2	DUBO1	0	0
WOOE2	WRTO1	0	0

ADDITIONAL COMMENTS

PLEASE ENTER THE DELAWARE PASSWORD:

[redacted]

[redacted]

CLICK HERE TO RETURN TO DELAWARE 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: 19 Feb 2003 at 0452

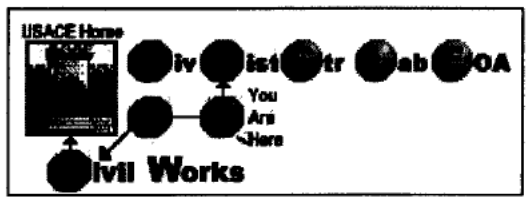


Plate No. 4-2
Sheet 3 of 6

DELAWARE LAKE

GATE OPERATIONS

New

GATE ID	VALUE		DATE	TIME	
	Start	End		Start	End
S1	0.0	0.0	8 May 2003	0700	0705

ADDITIONAL COMMENTS

PLEASE ENTER THE DELAWARE PASSWORD:

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

The POC for this page:

[redacted] *CELRH-EC-WW*

Plate No. 4-2
Sheet 4 of 6

DELAWARE LAKE

Lake Quality Report

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

New

DATE	TIME	LAKE ELEV (FT)	WEATHER
8 May 2003	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					
7.0					
8.0					
9.0					
10.0					

12.0					
14.0					

ADDITIONAL COMMENTS

PLEASE ENTER THE DELAWARE PASSWORD:

[redacted]

[redacted] CLICK HERE TO RETURN TO DELAWARE LAKE HOME PAGE (WILL NOT SAVE DATA)

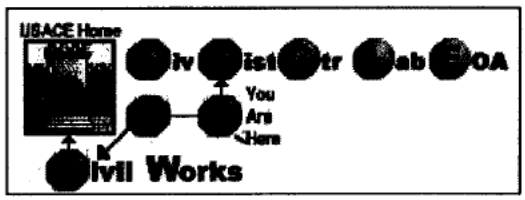
The POC for this page:

[redacted] *CELRH-EC-WW*

Huntington, WV

Send Email to Water Resources

Date last modified: 19 Feb 2003 at 0352



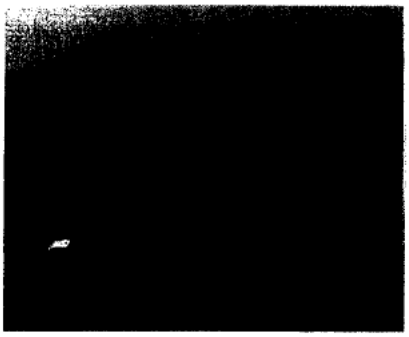
US Army Corps of Engineers

Huntington District
Water Control Section

Welcome to the

DELAWARE LAKE

WATER CONTROL INTRANET PAGE



DATA ENTRY

PROJECT DATA	GATE OPERATIONS	WATER QUALITY

OTHER PLACES OF INTEREST

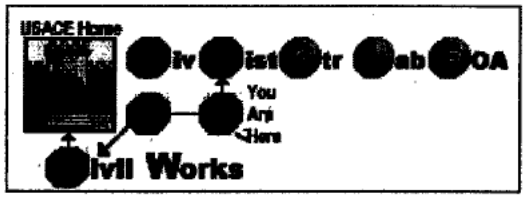
EMERGENCY CONTACTS		
WEATHER FORECASTS	RADAR	CORPS GOES DATA
OTHER LINKS	SPECIAL DIRECTIVES	WHAT'S NEW
WHITEWATER PAGE	LAKE REPORT	USGS DATA
Huntington District Current Conditions	Scioto Basin Current Conditions	Project Report Archive

The POC for this page:

[redacted] *CELRH-EC-WW*

Huntington, WV

Send Email to Water Resources



Date last modified: 6 Mar 2003 at 0738

Plate No. 4-1
Sheet 1 of 6

This file is a New submission.

DELAWARE LAKE

PROJECT INFORMATION

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

DATE	TIME
08 May 2003	0730

CURRENT PROJECT INFO

COE ID	PRECIP (IN)	POOL ELEV (FT-MSL)	TAIL WATER STAGE (FT)	FLOW (KCFS)	SNOW DEPTH (IN)	WATER EQUIVILENT (IN)	WEATHER CONDITIONS
DDOD2	0	910	1.0	0	0.0	0.0	0 Unchanged

CURRENT GATE SETTINGS

GATE	S1	S2	S3	S4	S5	T1-6
SETTING	.00	.00	.00	.00	.00	.00

ADDITIONAL STATION INFORMATION

COE ID	SHEF ID	PRECIP (IN)	STAGE (FT)
DUSE2	DUBO1	0	0
WOOE2	WRTO1	0	0

ADDITIONAL COMMENTS

Plate No. 4-1
Sheet 2 of 6

PLEASE ENTER THE DELAWARE PASSWORD: [redacted]

[redacted]

[redacted] CLICK HERE TO RETURN TO DELAWARE 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: 19 Feb 2003 at 0452

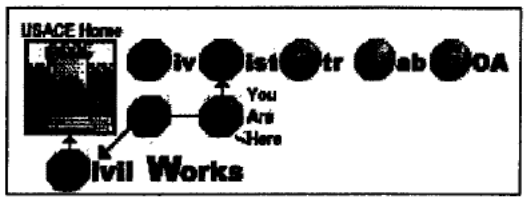


Plate No. 4-1
Sheet 3 of 6

DELAWARE LAKE

GATE OPERATIONS

New

GATE ID	VALUE		DATE	TIME	
	Start	End		Start	End
S1	0.0	0.0	8 May 2003	0700	0705

ADDITIONAL COMMENTS

PLEASE ENTER THE DELAWARE PASSWORD:

[redacted]

[redacted]

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

The POC for this page:

[redacted] *CELRH-EC-WW*

Plate No. 4-1
Sheet 4 of 6

DELAWARE LAKE

Lake Quality Report

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

New

DATE	TIME	LAKE ELEV (FT)	WEATHER
8 May 2003	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					
7.0					
8.0					
9.0					
10.0					

12.0					
14.0					

ADDITIONAL COMMENTS

PLEASE ENTER THE DELAWARE PASSWORD:

[redacted]

[redacted] CLICK HERE TO RETURN TO DELAWARE LAKE HOME PAGE (WILL NOT SAVE DATA)

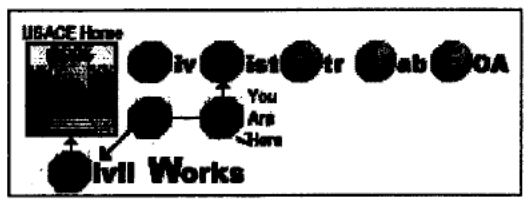
The POC for this page:

[redacted] *CELRH-EC-WW*

Huntington, WV

Send Email to Water Resources

Date last modified: 19 Feb 2003 at 0352



[redacted]

Plate No. 4-1
Sheet 6 of 6

Key Personnel

Huntington District Office - Water Resources Engineering Branch

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

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

Pertinent telephone numbers which may be of value during flood emergency are listed below, or they can be viewed through the web page: [redacted]

Scioto Area Office

[redacted].....[redacted]

Delaware Lake Project Office

Project Personnel	Commercial Phone	Home Telephone No.
[redacted], Dam Tender	[redacted]	[redacted]
[redacted], Gate Operator	[redacted]	[redacted]
[redacted], Gate Operator	[redacted]	[redacted]

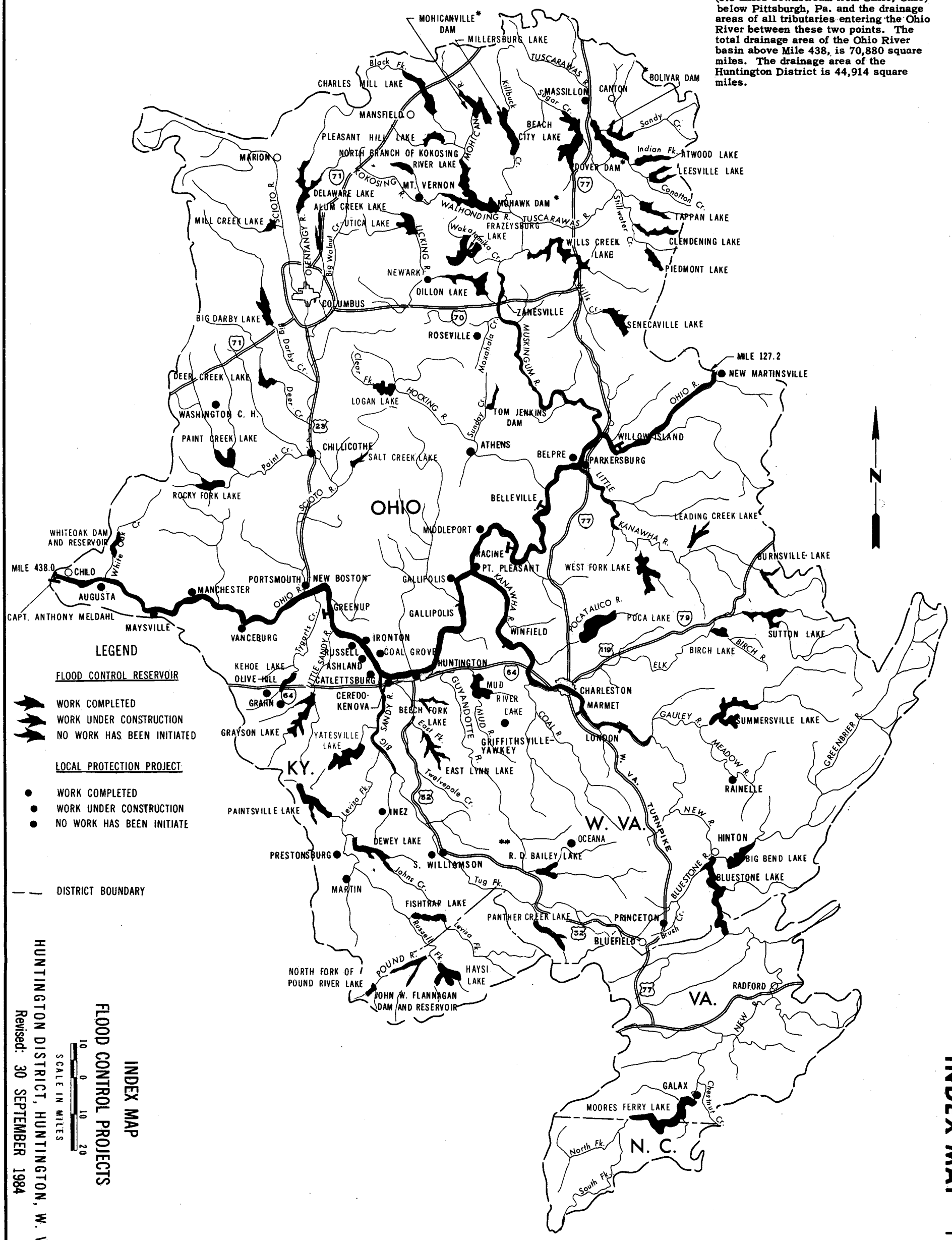
Other Agencies

U. S. Geological Survey.....Commercial.....[redacted]
New Philadelphia, Ohio
Nights, Weekends, Holidays.....Commercial.....[redacted]
[redacted]

National Weather Service.....Commercial.....[redacted]
Forecast Office,
Wilmington

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. (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.



LEGEND

FLOOD CONTROL RESERVOIR

- WORK COMPLETED
- WORK UNDER CONSTRUCTION
- NO WORK HAS BEEN INITIATED

LOCAL PROTECTION PROJECT

- WORK COMPLETED
- WORK UNDER CONSTRUCTION
- NO WORK HAS BEEN INITIATE

DISTRICT BOUNDARY

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

INDEX MAP

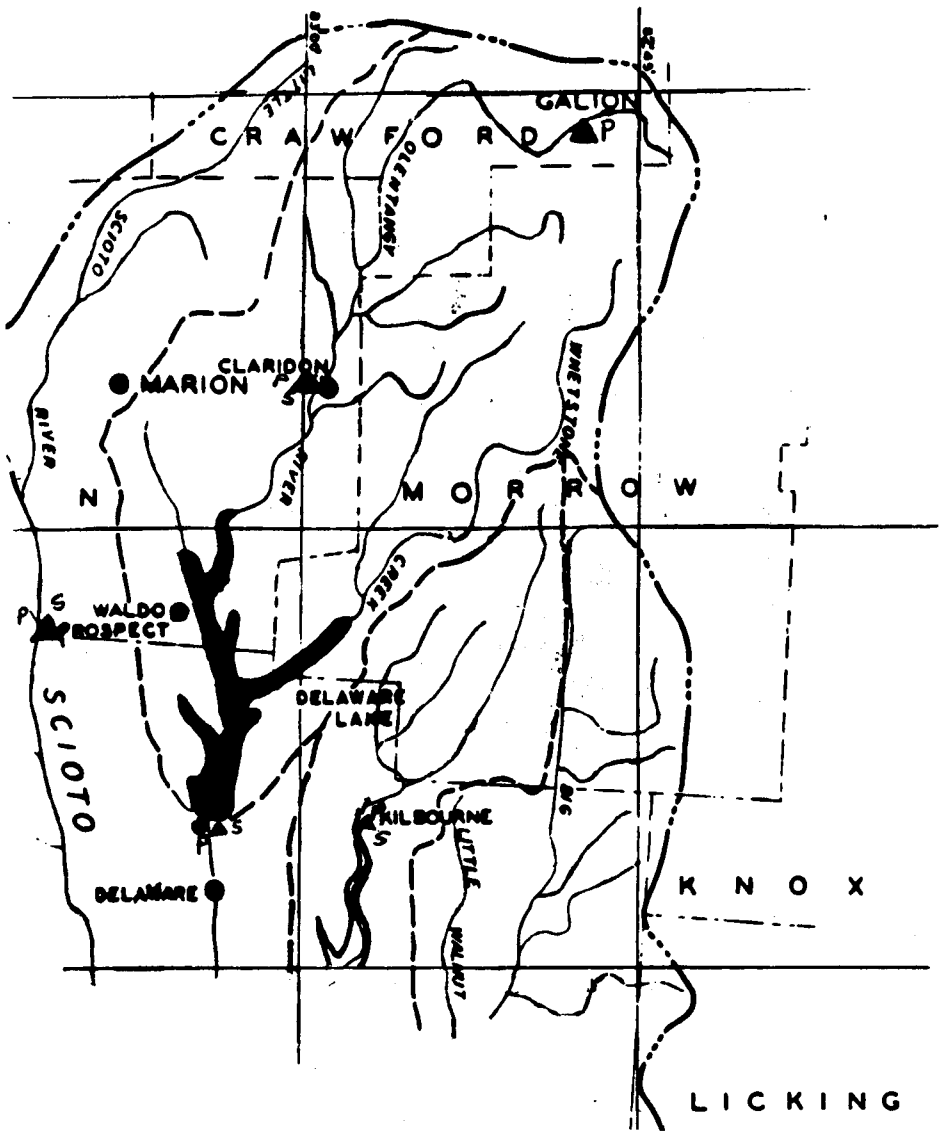
FLOOD CONTROL PROJECTS

SCALE IN MILES 10 0 10 20

HUNTINGTON DISTRICT, HUNTINGTON, W. VA.
Revised: 30 SEPTEMBER 1984

INDEX MAP F/C1

Plate No. 1-1



LEGEND

- WATERSHED BOUNDARY LINE
- RESERVOIR, SPILLWAY ELEVATION
- REPORTING PRECIPITATION STATION
- P PRECIPITATION
- S STAGE
- SATELLITE DATA PLATFORM

OLENTANGY RIVER
OHIO

DELAWARE LAKE

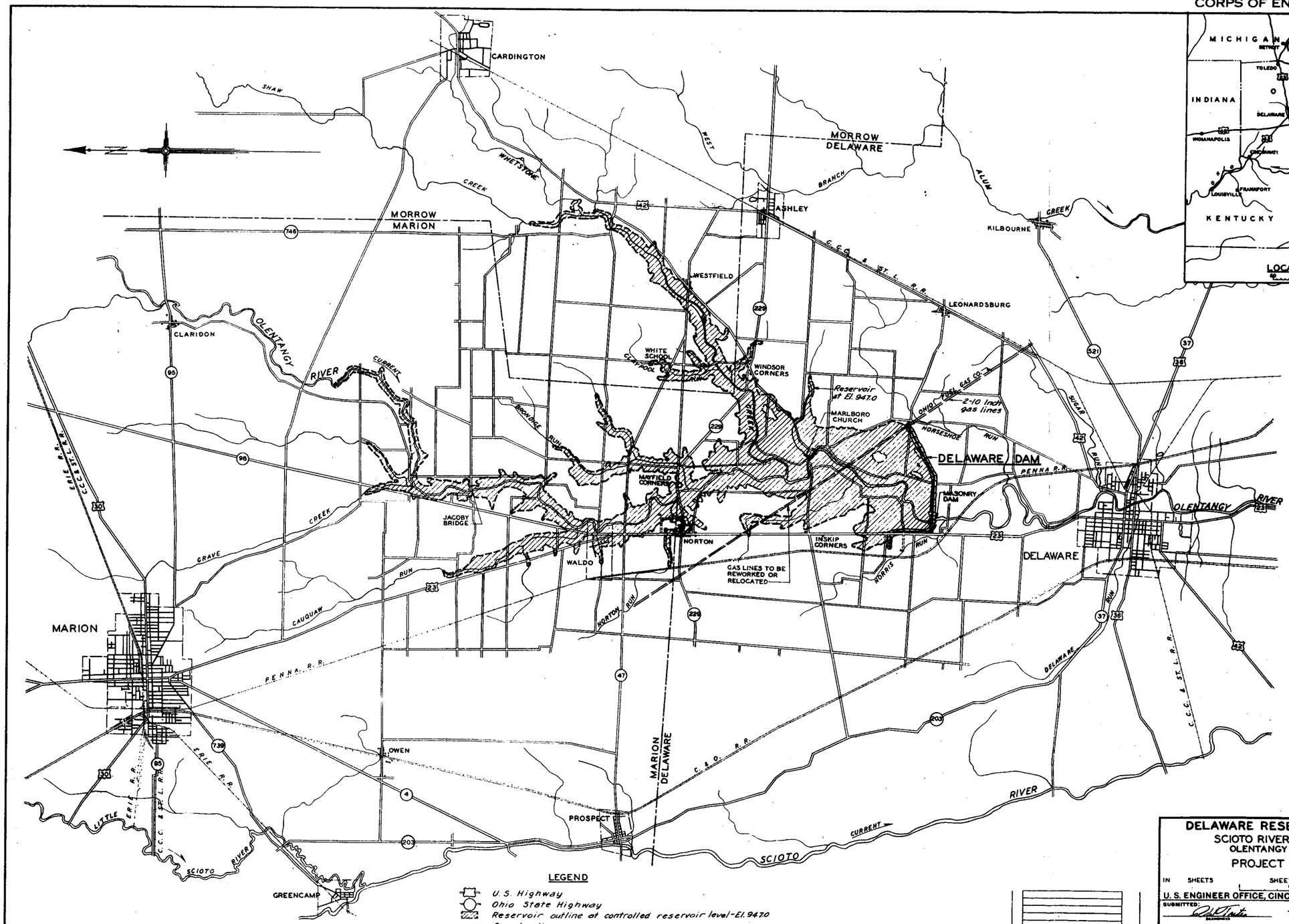
DRAINAGE AREA MAP

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON W. VA. APRIL 1988

Plate No. 2-1

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY



LEGEND

- U. S. Highway
- Ohio State Highway
- Reservoir outline at controlled reservoir level-El. 947.0
- County line

DELAWARE RESERVOIR PROJECT

SCIOTO RIVER WATERSHED

OLENTANGY RIVER, OHIO

PROJECT LOCATION

IN SHEETS | SHEET NO. | MI. | SCALE IN MILES

U. S. ENGINEER OFFICE, CINCINNATI, OHIO, SEPTEMBER 1944

SUBMITTED: | APPROVED:

APPROVAL RECOMMENDED:

NO.	CHARACTER REVISIONS	DATE	BY

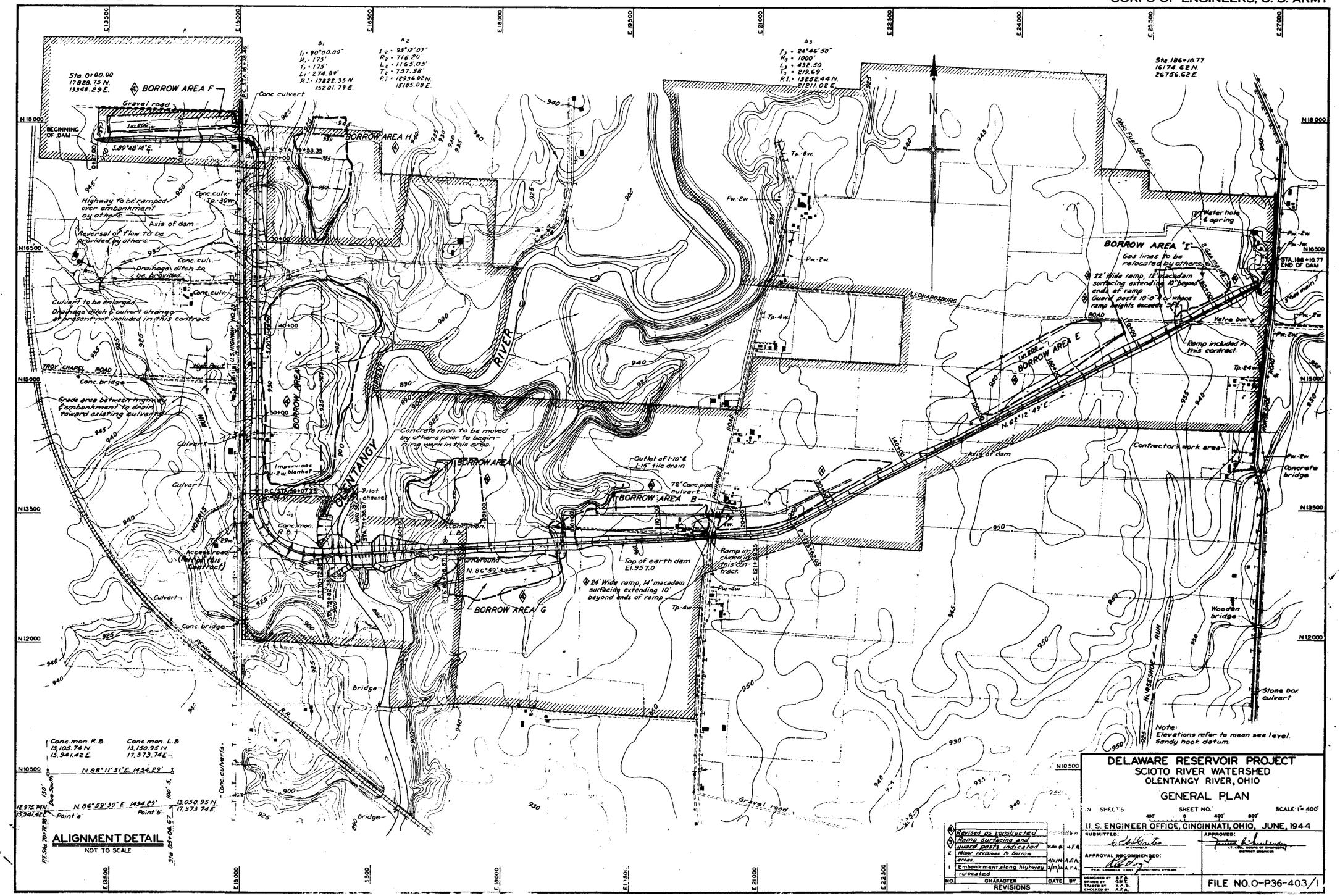
DESIGNED BY
DRAWN BY
TRACED BY
CHECKED BY

FILE NO. O-P36-40 1/2

Plate No. 2-2

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY



Δ1 $I_1 = 90°00.00"$ $R_1 = 175'$ $T_1 = 175'$ $L_1 = 274.89'$ P.I. - 17822.35 N 15201.79 E.

Δ2 $I_2 = 93°12'07"$ $R_2 = 716.20'$ $L_2 = 1165.03'$ $T_2 = 757.38'$ P.I. - 12836.02 N. 15185.08 E.

Δ3 $I_3 = 24°46'50"$ $R_3 = 1000'$ $L_3 = 432.50'$ $T_3 = 219.69'$ P.I. - 13252.44 N. 21211.02 E.

NO.	REVISIONS	DATE	BY
4	Revised as constructed		
3	Ramp surfacing and guard posts indicated	9-30-46	A.F.B.
2	Minor revisions to Borrow areas	4-10-46	A.F.B.
1	Embankment along highway relocated	3-11-46	A.F.B.

DESIGNED BY A.F.B.
DRAWN BY G.M.T.
TRACED BY Y.A.S.
CHECKED BY A.F.B.

DELAWARE RESERVOIR PROJECT
SCIOTO RIVER WATERSHED
OLENTANGY RIVER, OHIO
GENERAL PLAN

IN SHEETS SHEET NO. SCALE: 1" = 400'

400' 0 400' 800'

U. S. ENGINEER OFFICE, CINCINNATI, OHIO, JUNE, 1944

SUBMITTED: [signature] Asst.

APPROVED: [signature] Col. Corps of Engineers, District Engineer

APPROVAL RECOMMENDED: [signature] Chief, Engineering Division

FILE NO. O-P36-403/1

Plate No. 2-3

WAR DEPARTMENT

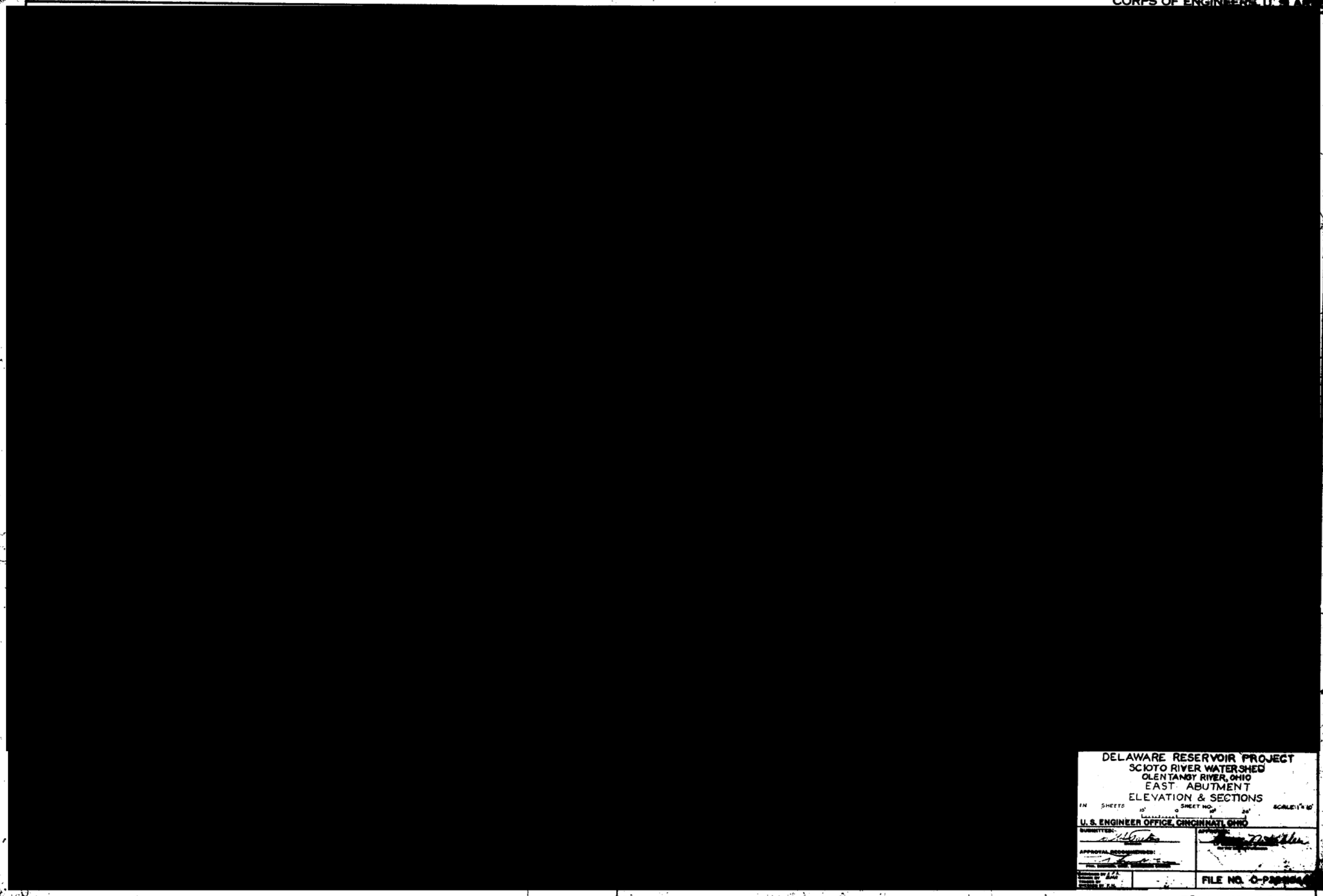
CORPS OF ENGINEERS

DELAWARE RESERVOIR PROJECT
SCIOTO RIVER WATERSHED
OLENTANGY RIVER, OHIO
EMBANKMENT & CHANNEL PROTECTION
PLAN
IN SHEETS SHEET NO. SCALE: 1" = 50'
U.S. ENGINEER OFFICE, CINCINNATI, OHIO MARCH, 1944

Plate No. 2-4

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. A



DELAWARE RESERVOIR PROJECT
SCIOTO RIVER WATERSHED
OLENTANGY RIVER, OHIO
EAST ABUTMENT
ELEVATION & SECTIONS

IN SHEETS SHEET NO. SCALE 1" = 10'

U. S. ENGINEER OFFICE, CINCINNATI, OHIO

SUBMITTED: APPROVED:

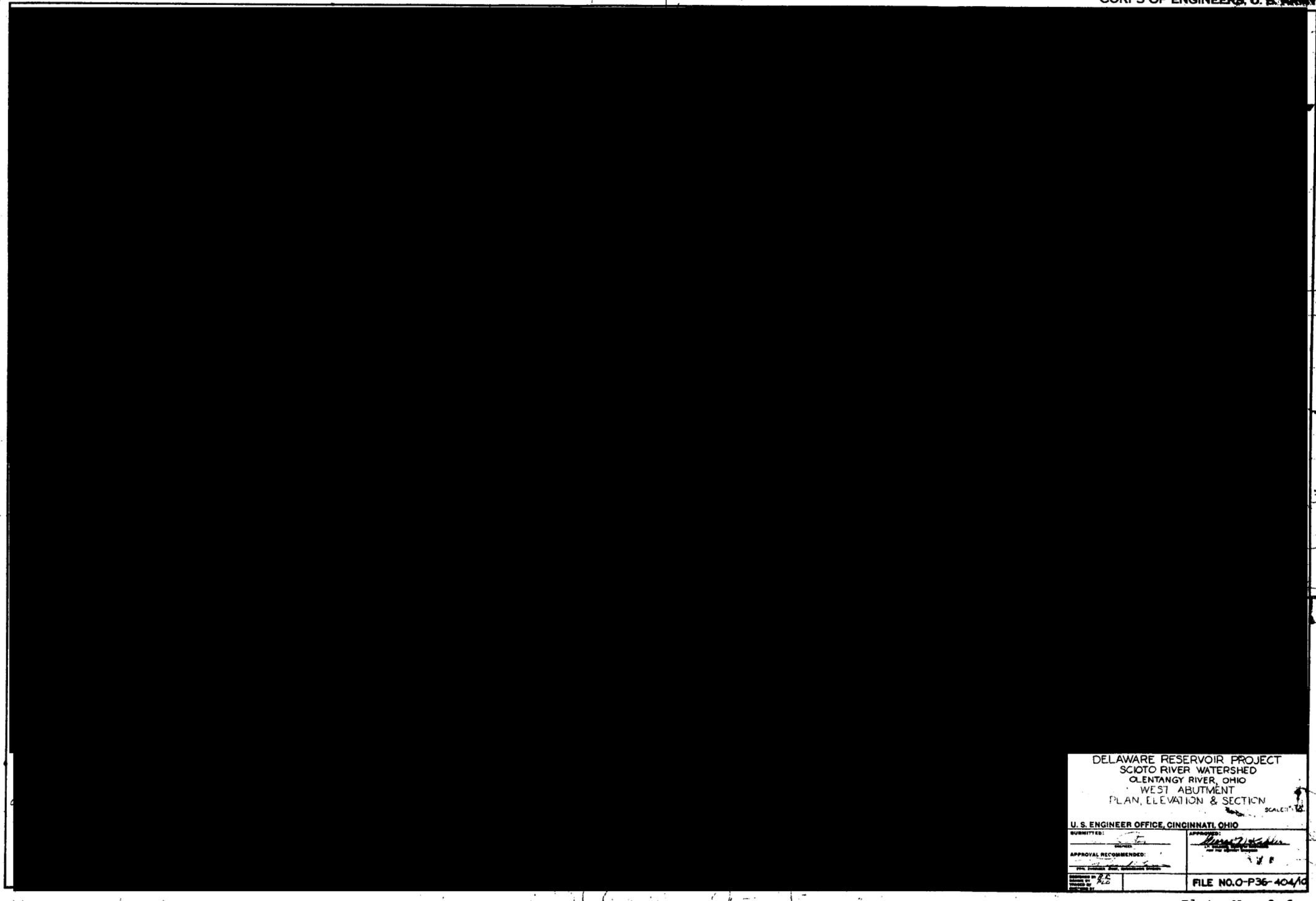
APPROVAL RECOMMENDED:

FILE NO. C-[illegible]

Plate No. 2-5

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY



DELAWARE RESERVOIR PROJECT
SCIOTO RIVER WATERSHED
OLENTANGY RIVER, OHIO
WEST ABUTMENT
PLAN, ELEVATION & SECTION
SCALE: 1/2"

U. S. ENGINEER OFFICE, CINCINNATI, OHIO

SUBMITTED: _____ DRAFTER

APPROVED: _____ FOR THE DISTRICT ENGINEER

APPROVAL RECOMMENDED: _____ CHIEF, ENGINEERING BRANCH, ENGINEERING DIVISION

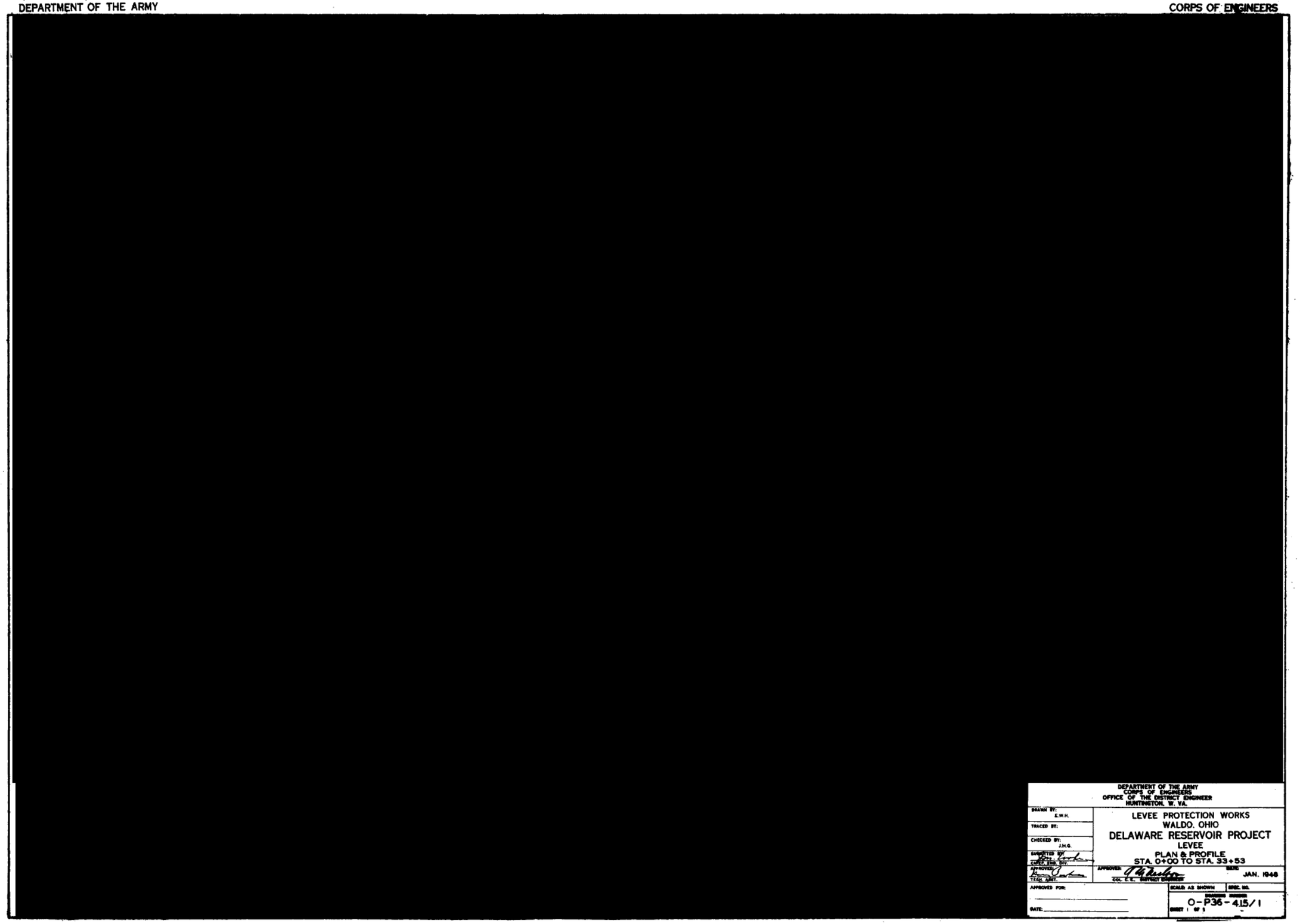
DESIGNED BY R.E.
DRAWN BY R.D.
TRACED BY
CHECKED BY

FILE NO. O-P36-404/10

Plate No. 2-6

DEPARTMENT OF THE ARMY

CORPS OF ENGINEERS



DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
OFFICE OF THE DISTRICT ENGINEER
HUNTINGTON, W. VA.

DRAWN BY: E.W.H.	LEVEE PROTECTION WORKS
TRACED BY:	WALDO, OHIO
CHECKED BY: J.H.G.	DELAWARE RESERVOIR PROJECT
SUBMITTED BY: Chief, Engr. Div.	LEVEE
APPROVED: Asst. Chief, Engr. Div.	PLAN & PROFILE
TECH. ASST.	STA. 0+00 TO STA. 33+53
APPROVED: Col. C.E., District Engineer	DATE: JAN. 1948
APPROVED FOR:	SCALE: AS SHOWN
DATE:	DRAWING NUMBER: O-P36-415/1
	SHEET 1 OF 5

Plate No. 2-7

DEPARTMENT OF THE ARMY

CORPS OF ENGINEERS

[redacted]

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
OFFICE OF THE DISTRICT ENGINEER
HUNTINGTON, W. VA.

DRAWN BY: N.M.G.
TRACED BY: R.S.P.
CHECKED BY: J.H.G.
SUBMITTED BY: Surv. Engr. Div.
APPROVED: Tech. Asst.

LEVEE PROTECTION WORKS
WALDO, OHIO
DELAWARE RESERVOIR PROJECT
LEVEE
PLAN & PROFILE
STA. 33+53 TO STA. 65+48

APPROVED: Col. C.E., District Engineer
DATE: JAN. 1948

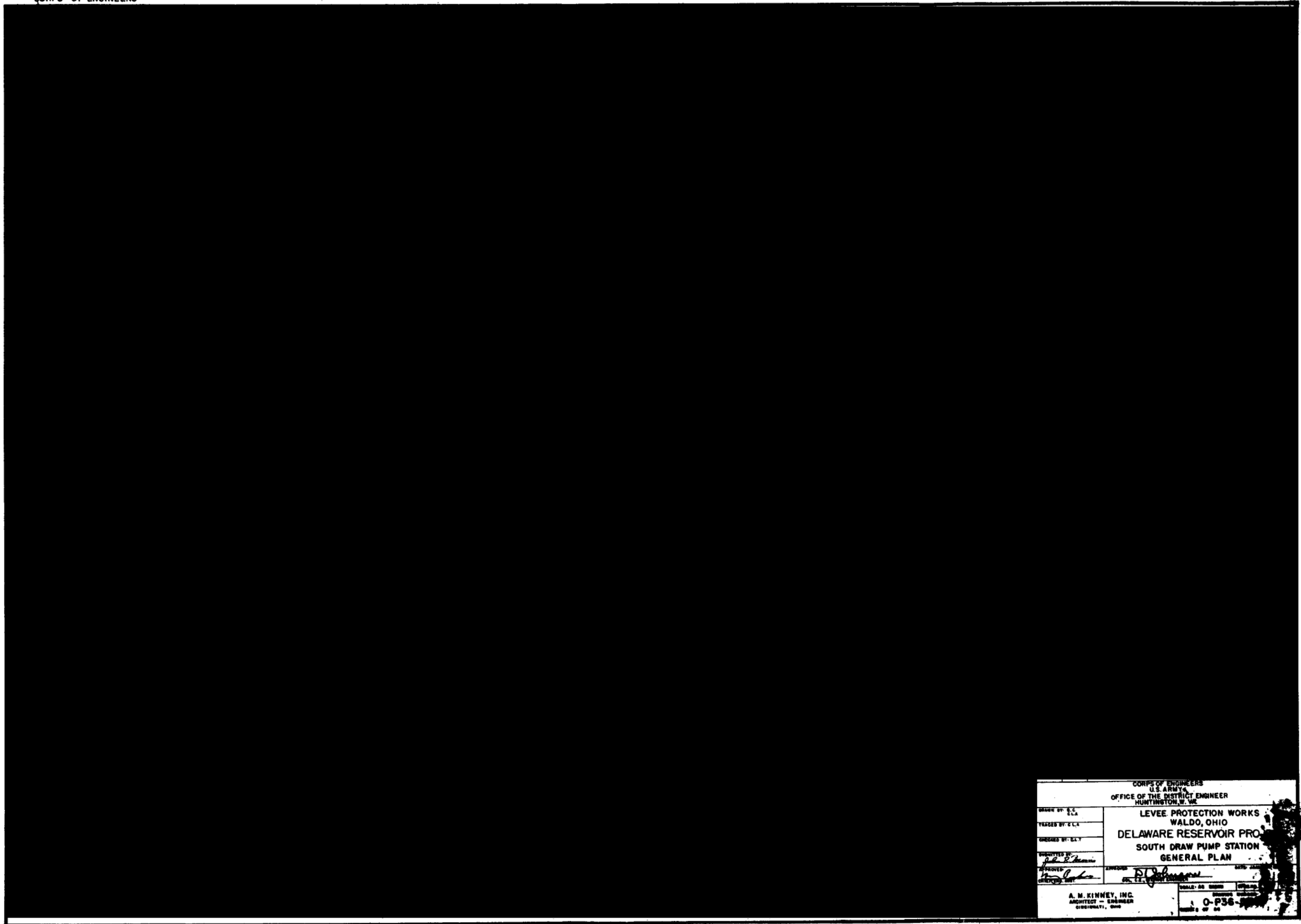
APPROVED FOR:
DATE:

SCALE AS SHOWN
SPEC. NO.
DRAWING NUMBER: O-P36-415/2
SHEET 2 OF 5

Plate No. 2-8

CORPS OF ENGINEERS

U.S. ARMY



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

DRAWN BY: E.C. E.L.A.
TRACED BY: E.L.A.
CHECKED BY: E.L.T.
SUBMITTED BY:
APPROVED
DIRECTOR OF CIVIL WORKS

LEVEE PROTECTION WORKS
WALDO, OHIO
DELAWARE RESERVOIR PROJ.
SOUTH DRAW PUMP STATION
GENERAL PLAN

APPROVED
CHIEF, U.S. ARMY ENGINEER

DATE JAN.

A. M. KINNEY, INC.
ARCHITECT — ENGINEER
CINCINNATI, OHIO

SCALE: AS SHOWN
DRAWING NUMBER
0-P36-
SHEET NO. OF 66

Plate No. 2-9

CORPS OF ENGINEERS

[redacted]

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

DRAWN BY: G.L.A.
TRACED BY: G.L.A.
CHECKED BY: C.L.Y
SUBMITTED:
APPROVED:

LEVEE PROTECTION WORKS
WALDO, OHIO
DELAWARE RESERVOIR PROJECT
TOMAHAWK RUN PUMP STATION
GENERAL PLAN

APPROVED:
DATED: AUGUST, 1956

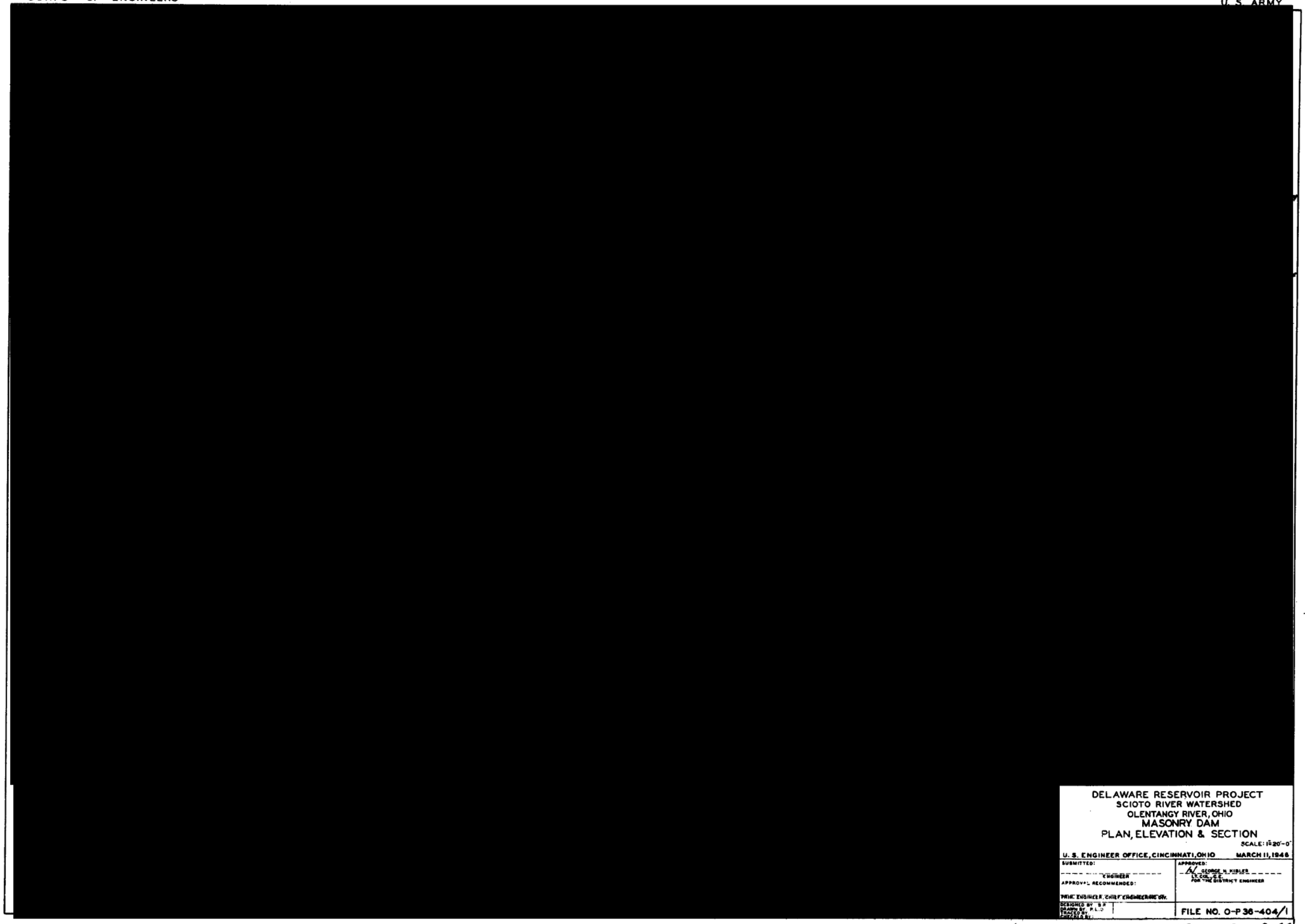
A.M. KINNEY, INC.
ARCHITECT-ENGINEER
CINCINNATI, OHIO

SCALE: AS SHOWN
SPEC. NO.
DRAWING NUMBER
0-P36-51.2/1
SHEETS OF 26

Plate No. 2-10

CORPS OF ENGINEERS

U. S. ARMY



DELAWARE RESERVOIR PROJECT
SCIOTO RIVER WATERSHED
OLENTANGY RIVER, OHIO
MASONRY DAM
PLAN, ELEVATION & SECTION

SCALE: 1"=20'-0"

U. S. ENGINEER OFFICE, CINCINNATI, OHIO MARCH 11, 1948

SUBMITTED:

ENGINEER

APPROVAL RECOMMENDED:

CHIEF ENGINEER, CHIEF ENGINEERING DIV.

APPROVED:

GEORGE H. KIBLER
LT. COL., C.E.
FOR THE DISTRICT ENGINEER

DESIGNED BY S.P.
DRAWN BY P.L.D.
TRACED BY
CHECKED BY

FILE NO. O-P 36-404/1

Plate No. 2-11

WAR DEPARTMENT

CORPS OF ENGINEERS. U. S. ARMY

DELAWARE RESERVOIR PROJECT
SCIOTO RIVER WATERSHED
OLENTANGY RIVER, OHIO

SPILLWAY, SECTION & DETAILS

IN SHEETS SHEET NO. SCALE: 1" = 5'-0"

U. S. ENGINEER OFFICE, CINCINNATI, OHIO, FEB., 1946

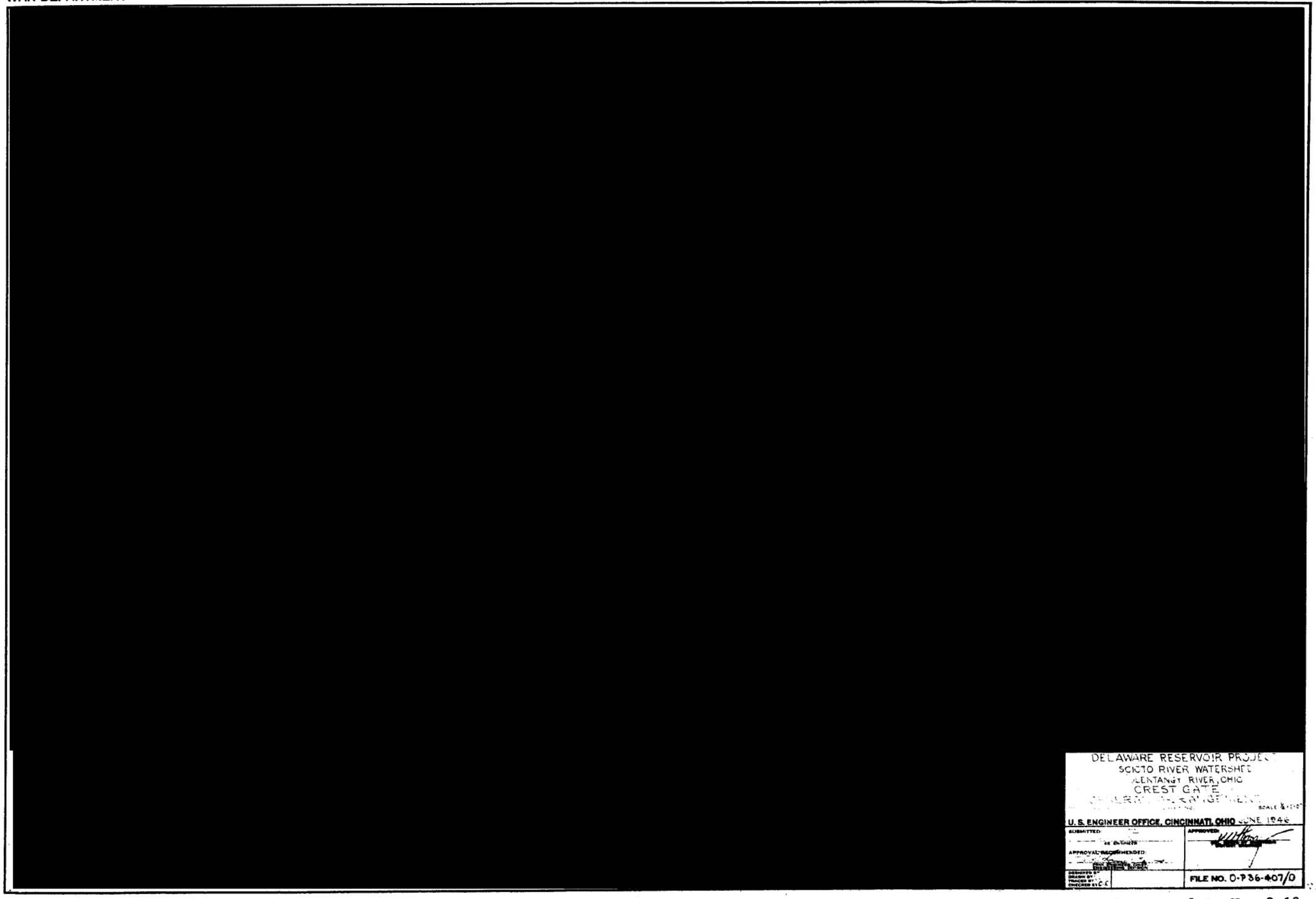
SUBMITTED: APPROVED:

APPROVAL RECOMMENDED:

DESIGNED BY A.F.A.
DRAWN BY R.G.H.
CHECKED BY J.A.H.

FILE NO. O-P36-404/3

Plate No. 2-12



DELAWARE RESERVOIR PROJECT
SCIOTO RIVER WATERSHED
OLENTANGY RIVER, OHIO
CREST GATE
OPERATING MECHANISM

SCALE 3"=1'-0"

U. S. ENGINEER OFFICE, CINCINNATI, OHIO JUNE 1946

SUBMITTED:	APPROVED:
APPROVAL RECOMMENDED:	
DESIGNED BY	FILE NO. O-P36-407/0
DRAWN BY	
TRACED BY	
CHECKED BY C.C.	

Plate No. 2-13

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY

DELAWARE RESERVOIR PROJECT
SCIOTO RIVER WATERSHED
OLENTANGY RIVER, OHIO
SPILLWAY
FLOOD CONTROL SLUICES
SHEET NO. SCALE: 1"=5'-0"

DIVISION ENGINEER OFFICE, CINCINNATI, OHIO

APPROVED
George D. Gerber

FILE NO. O-P36-404/4

Plate No. 2-14

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY

DELAWARE RESERVOIR PROJECT
SCIOTO RIVER WATERSHED
OLENTANGY RIVER, OHIO

SLUICE GATE & HOIST ASSEMBLY

IN SHEETS SHEET NO. SCALE: 1"=1'-0"

U. S. ENGINEER OFFICE, CINCINNATI, OHIO, OCTOBER 1944

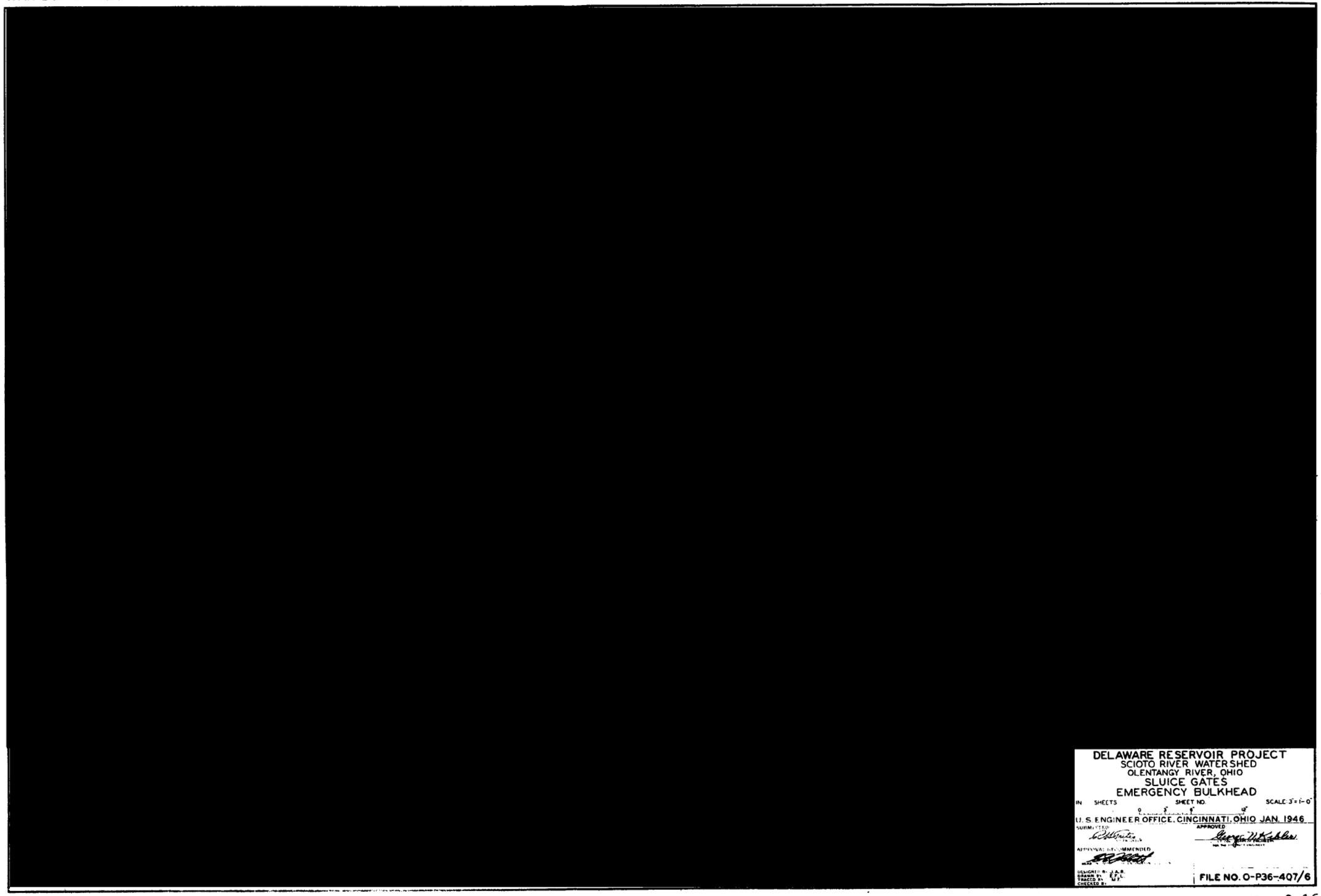
SUBMITTED: APPROVED:

APPROVAL RECOMMENDED:

DESIGNED BY J.W.B.
DRAWN BY E.D.K.
TRACED BY A.H.S.
CHECKED BY J.W.B.

FILE NO. O-P36-409/1

Plate No. 2-15



DELAWARE RESERVOIR PROJECT
SCIOTO RIVER WATERSHED
OLENTANGY RIVER, OHIO
SLUICE GATES
EMERGENCY BULKHEAD

IN SHEETS SHEET NO. SCALE: 3"=1'-0"

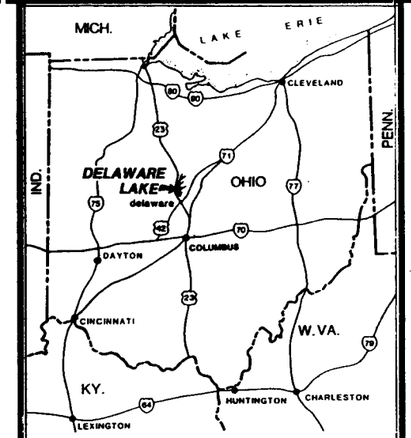
U. S. ENGINEER OFFICE, CINCINNATI, OHIO JAN. 1946

SUBMITTED APPROVED

APPROVAL RECOMMENDED

DESIGNED BY J.A.R.
DRAWN BY E.F.L.
TRACED BY
CHECKED BY

FILE NO. O-P36-407/6



land use plan

LEGEND

- project boundary
- state/federal boundary
- easement land
- seasonal pool (el. 915 ft.)
- minimum conservation pool (el. 910 ft.)
- maximum flood control pool (el. 947 ft.)

FEDERALLY OWNED AND MANAGED LAND

	acres
project operations	257
intensive recreation	25
subtotal	282

FEDERAL LAND LEASED TO STATE

	acres
project operations	139
intensive recreation	957
low density recreation	495
reserve forest land	133
wildlife management	4397
lake surface	1300
subtotal	7421

STATE OWNED LAND

	acres
wildlife area	87
subtotal	87
total	7790

- (L) boat launch
- (F) fishing access

OLENTANGY RIVER
OHIO

DELAWARE LAKE

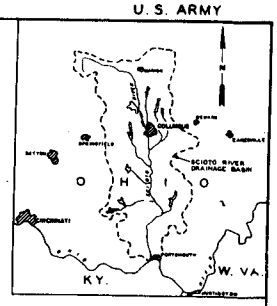
LAND USE MAP

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON W. VA. JULY 1988

Plate No. 2-17

CORPS OF ENGINEERS

U. S. ARMY



VICINITY MAP

SCALE IN MILES

BUCYRUS
GALION
MANSFIELD 6W
ROUNDHEAD RESERVOIR
KENTON
KENTON OHIO POWER CO.
SCIOTO
LARUE
MARION WATER WORKS
OLENTANGY RIVER
CLARIDON
WHETSTONE CREEK
MT. GILEAD LAKES PARK
LAKEVIEW 3NE
RUSSELS POINT
PROSPECT 3N
WALDO
PROSPECT
FREDERICKTOWN
GAMBIER
BELLEFONTAINE
MILL CREEK
DELAWARE RESERVOIR
DELAWARE
BIG WALNUT CREEK
CENTERBURG
MILL CREEK RESERVOIR
STRATFORD
ALUM CREEK RESERVOIR
MARYSVILLE
BELLEPOINT
BIG DARBY CREEK
O'SHAUGHNESSY RESERVOIR
POWELL
IRWIN
URBANA SEWAGE PL.
WORTHINGTON
HOOVER RESERVOIR
CENTRAL COLLEGE
DUBLIN
ALEXANDRIA
NEWARK WATER WORKS
LITTLE DARBY CR.
JULIAN GRIGGS RESERVOIR
COLUMBUS UNIV. FARM
COLUMBUS AIRPORT
SPRINGFIELD WATER WORKS
COLUMBUS
SPRINGFIELD 3W
SPRINGFIELD
BIG DARBY RESERVOIR
COLUMBUS VALLEY CROSS
LONDON WATER WKS.
REES
DEER CREEK
LITHOPOLIS
CARROLL 2SW
CARROLL 2SE
LANCASTER 5NW
LANCASTER 3NW
SEDALIA
MT. STERLING GAS PUMP STA.
DARBYVILLE
XENIA TREATMENT PLANT
LANCASTER 3W
LANCASTER 4SW
XENIA 4SSW
DEER CREEK RESERVOIR
PAINT CREEK
RATTLESNAKE CREEK
CIRCLEVILLE
WILLIAMSPORT
WASHINGTON C.H.
ENTERPRISE
LOGAN HWY. DEPT.
SALT CREEK
WILMINGTON
WILMINGTON POWER PL.
LAUREL VILLE
LEES CREEK
GREENFIELD
CLEAR CREEK
CHILLICOTHE
PAINT CREEK RESERVOIR
BOURNEVILLE
SALT CREEK RESERVOIR
McARTHUR 2N
HILLSBORO WATER WKS.
HILLSBORO
BAINBRIDGE
LONDONDERRY
ROCKY FORK
BARRETTS MILLS
HIGBY
ROCKY FORK RESERVOIR
WAVERLY
SCIOTO
OPIKETON PIKETON PUMP STA.
JACKSON 2NW
PEEBLES
PEEBLES 1S
PORTSMOUTH
U.S. GRANT BRIDGE
PORTSMOUTH
OHIO RIVER

LEGEND

- ▲ DISCHARGE STATION USGS
- △ DISCHARGE STATION USED
- ● GAGE HEIGHT STATION USWB
- ○ GAGE HEIGHT STATION USED
- ■ RAINFALL STATION USWB
- □ RAINFALL STATION USED
- R RECORDING GAGE
- D STATION DISCONTINUED
- EXISTING WATER SUPPLY RESERVOIR CITY OF COLUMBUS
- COMPLETED FLOOD CONTROL RESERVOIR
- MAJOR RESERVOIRS CONSIDERED IN COMPREHENSIVE PLAN

SCIOTO RIVER
OHIO

SCIOTO RIVER BASIN DRAINAGE MAP

SCALE IN MILES

U.S. ARMY ENGINEER DISTRICT, HUNTINGTON
CORPS OF ENGINEERS
HUNTINGTON, W.VA. SEPTEMBER 1961

Plate No. 3-1

47 1240

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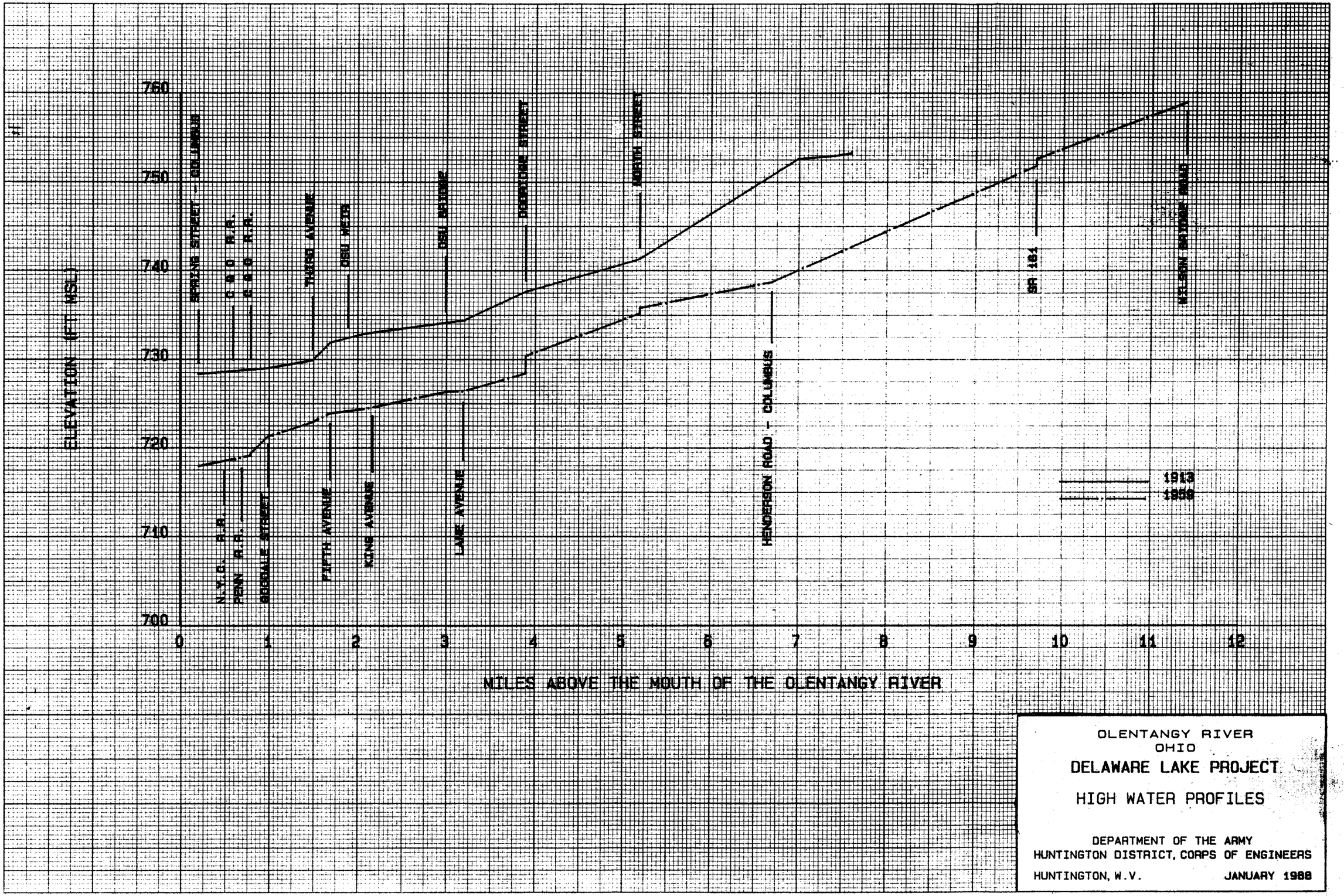


OLENTANGY RIVER
OHIO

DELAWARE LAKE PROJECT

HIGH WATER PROFILES

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V. JANUARY 1968

Plate No. 4-1

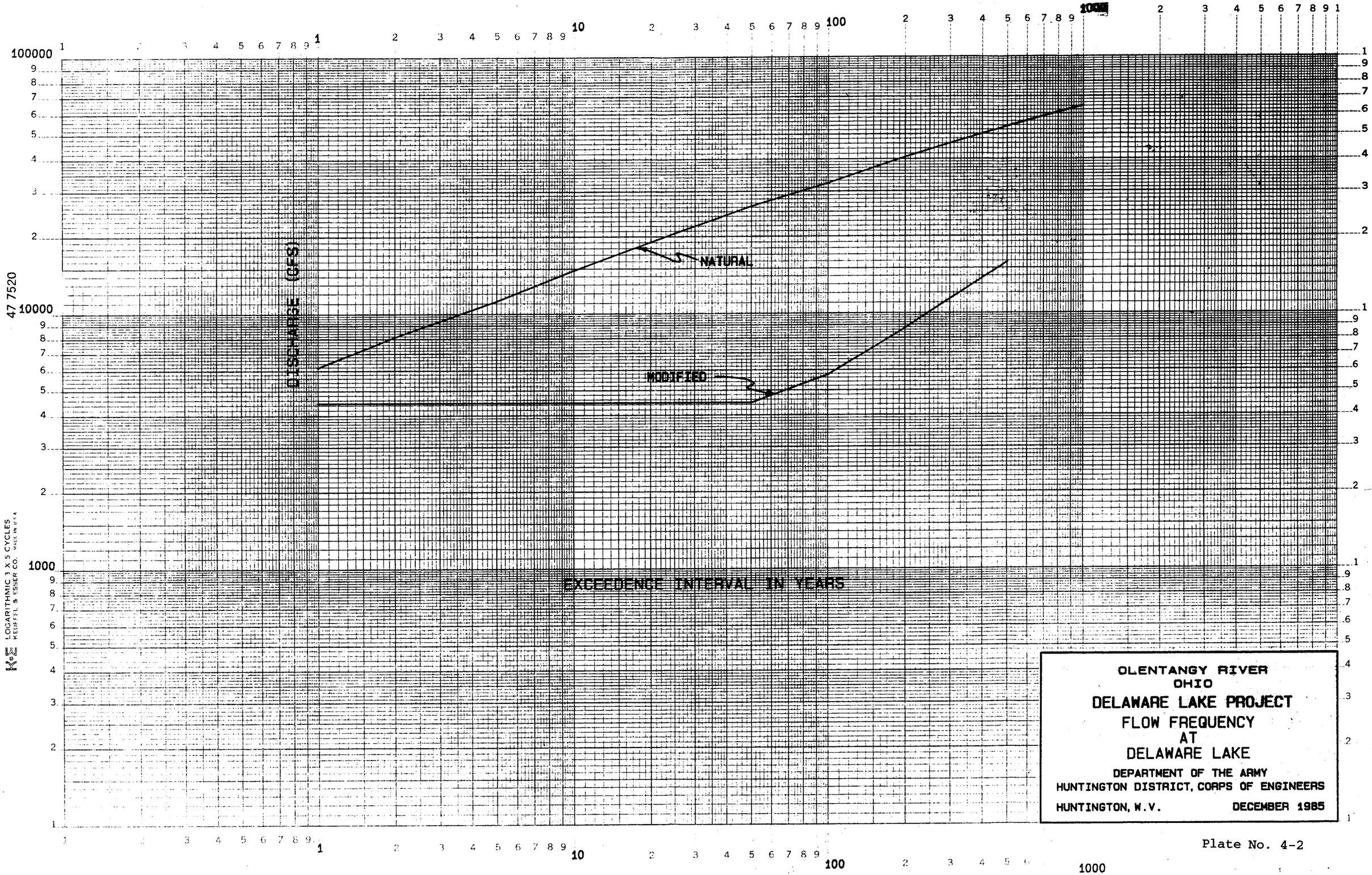

DISCHARGE (CFS)
EXCEEDENCE INTERVAL IN YEARS
NATURAL
MODIFIED
OLENTANGY RIVER
OHIO
DELAWARE LAKE PROJECT
FLOW FREQUENCY
AT
DELAWARE LAKE
DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V.
DECEMBER 1985
LOGARITHMIC 3 X 5 CYCLES
KEUFFEL & ESSER CO.
47 7520

Plate No. 4-2

CODEX Graph Paper
DIRECT FROM CODEX BOOK CO., NORWOOD, MASS. 02062
PRINTED IN U.S.A.
PROBABILITY × FOUR 3½ INCH LOGARITHMIC CYCLES. Y4 211 LG

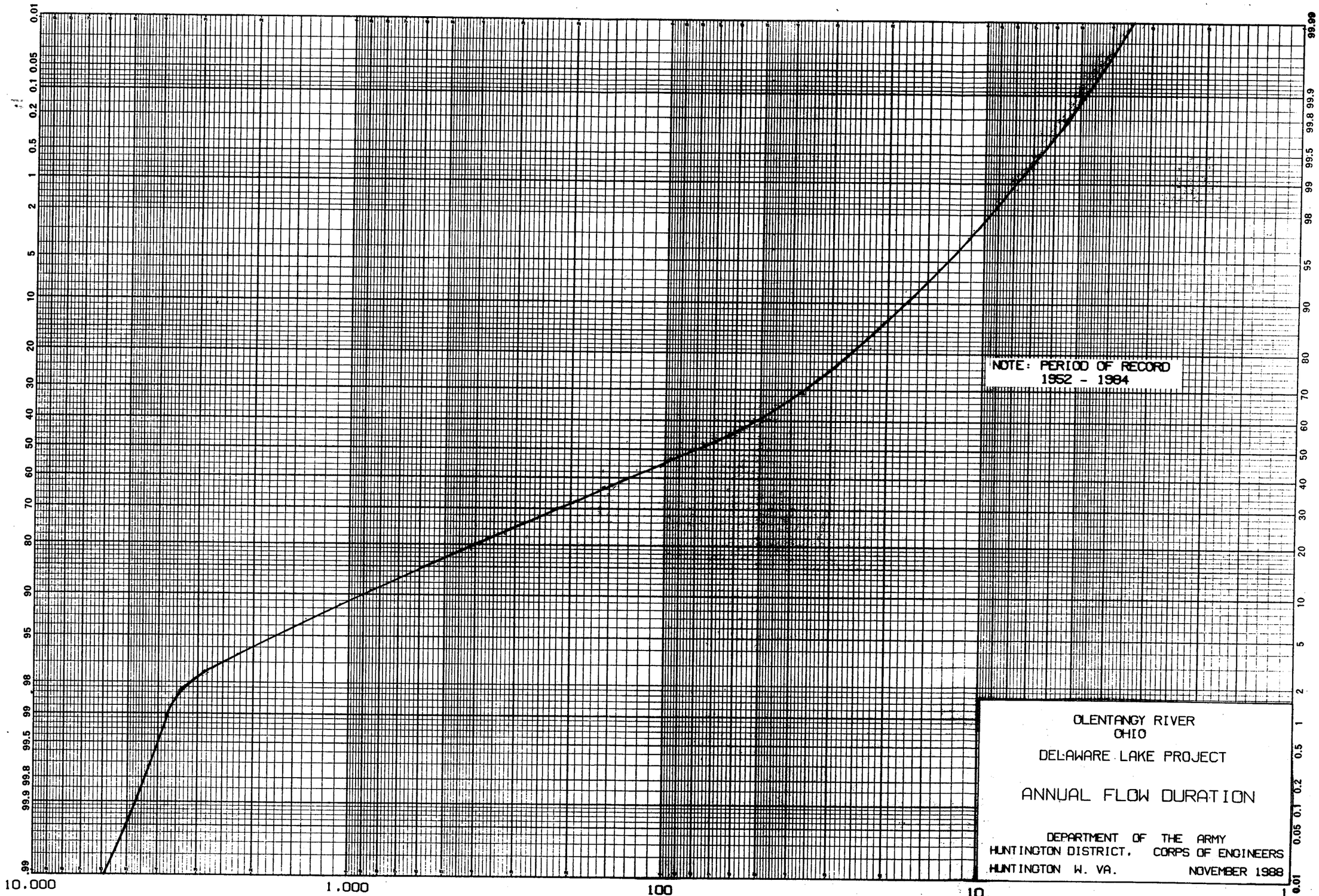
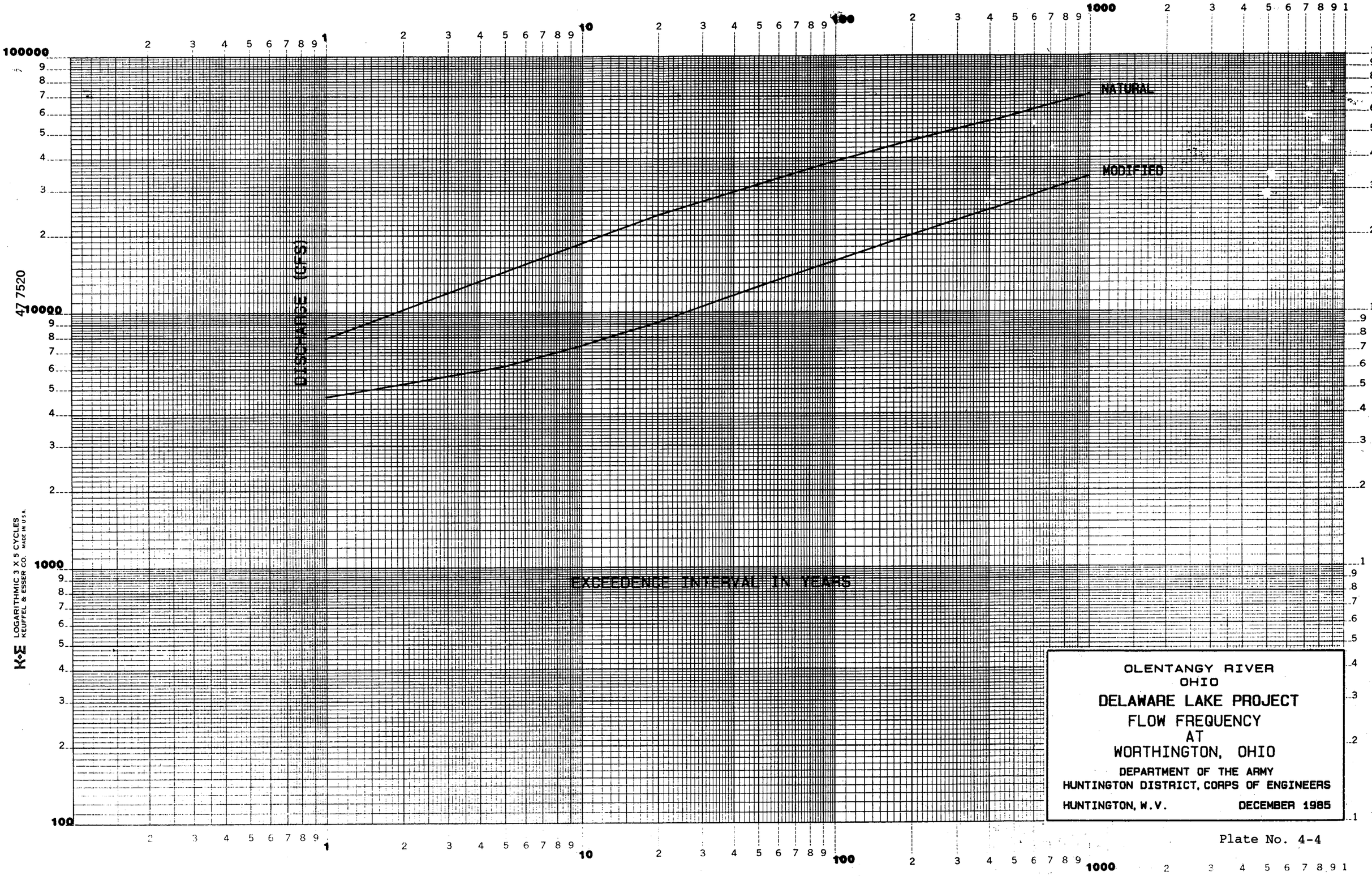


Plate No. 4-3


NATURAL
MODIFIED
DISCHARGE (CFS)
EXCEEDENCE INTERVAL IN YEARS
OLENTANGY RIVER
OHIO
DELAWARE LAKE PROJECT
FLOW FREQUENCY
AT
WORTHINGTON, OHIO
DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V. DECEMBER 1985
Plate No. 4-4
47 7520
K•E LOGARITHMIC 3 X 5 CYCLES
KEUFFEL & ESSER CO. MADE IN U.S.A.

23.0 UNITED STATES DEPARTMENT OF INT . - GEOLOGICAL SURVEY - WATER RESOURCES DIVISION

EXPANDED RATING TABLE PROCESS DATE: 04-APR-85 13:25 AEA RATING NO 23

03226000 OLENTANGY R NR WORTHINGTON OH TYPE LOG [OFFSET=(1.00, 1.00) (0.00, 0.00)]

BASED ON ..... DISCHARGE MEASUREMENTS, NOS ....., AND ....., AND IS ..... WELL DEFINED BETWEEN ..... AND ..... CFS
COMP BY ..... DATE .....

RATING TO BE USED STARTING AT: 01/01/01 (0001) CKD. BY ..... DATE .....

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION)										DIF
	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	TE
1.30	6.00*	6.52	7.07	7.64	8.25	8.88	9.53	10.2	10.9	11.7	
1.40	12.5	13.3	14.1	15.0	15.9	16.8	17.8	18.8	19.8	20.9	
1.50	22.0	23.1*	24.2	25.3	26.5	27.7	28.9	30.1	31.4	32.7	
1.60	34.0	35.4	36.8	38.2	39.7	41.2	42.7	44.3	45.9	47.5	
1.70	49.1	50.8	52.6	54.3	56.1	57.9	59.8	61.7	63.6	65.6	
1.80	67.6	69.6	71.6	73.7	75.9	78.1	80.3	82.5	84.8	87.1	
1.90	89.4	91.8	94.3	96.7	99.2	101.8	104.3	106.9	109.6	112.3	
2.00	115.0	117.7	120.5	123.4	126.3	129.2	132.1	135.1	138.1	141.2	
2.10	144.3	147.5	150.6	153.9	157.1	160.4	163.8	167.2	170.6	174.1	
2.20	177.6	181.1	184.7	188.3	192.0	195.7	199.5	203.3	207.1	211.0	
2.30	214.9	218.9	222.9	226.9	231.0	235.1	239.3	243.5	247.8	252.1	
2.40	256.4	260.8	265.2	269.7	274.2	278.8	283.4	288.0	292.7	297.5	
2.50	302.2	307.1	311.9	316.8	321.8	326.8	331.9	337.0	342.1	347.3	
2.60	352.5	357.8	363.1	368.5	373.9	379.3	384.8	390.4	396.0	401.6	
2.70	407.3	413.0	418.8	424.6	430.5	436.4	442.4	448.4	454.5	460.6	
2.80	466.8	473.0	479.2	485.5	491.9	498.3	504.7	511.2	517.7	524.3	
2.90	531.0	537.6	544.4	551.2	558.0	564.9	571.8	578.8	585.8	592.9	
3.00	600.0*	606.9	613.8	620.8	627.8	634.9	642.0	649.2	656.4	663.6	
3.10	670.9	678.2	685.6	693.0	700.5	708.0	715.6	723.2	730.9	738.5	
3.20	746.3	754.1	761.9	769.8	777.7	785.7	793.7	801.8	809.9	818.0	
3.30	826.2	834.5	842.8	851.1	859.5	867.9	876.4	884.9	893.5	902.1	
3.40	910.8	919.5	928.3	937.1	945.9	954.8	963.7	972.7	981.8	990.9	
3.50	1000*	1009	1014	1021	1029	1036	1043	1050	1058	1065	
3.60	1072	1080	1087	1094	1102	1109	1117	1124	1131	1139	
3.70	1147	1154	1162	1169	1177	1184	1192	1200	1208	1213	
3.80	1223	1231	1239	1246	1254	1262	1270	1278	1286	1294	
3.90	1302	1310	1318	1326	1334	1342	1350	1358	1366	1374	
4.00	1382	1391	1399	1407	1415	1424	1432	1440	1449	1457	
4.10	1465	1474	1482	1491	1499	1508	1516	1525	1533	1542	
4.20	1550	1559	1568	1576	1585	1594	1602	1611	1620	1629	
4.30	1638	1646	1655	1664	1673	1682	1691	1700	1709	1718	
4.40	1727	1736	1745	1754	1763	1772	1781	1790	1800	1809	
4.50	1818*	1826	1835	1843	1852	1860	1869	1877	1886	1894	
4.60	1903	1911	1920	1928	1937	1945	1954	1963	1971	1980	
4.70	1989	1997	2006	2015	2023	2032	2041	2050	2058	2067	
4.80	2076	2085	2094	2102	2111	2120	2129	2138	2147	2156	
4.90	2165	2174	2183	2192	2201	2210	2219	2228	2237	2246	
5.00	2255	2264	2273	2282	2292	2301	2310	2319	2328	2337	

Plate No. 4-5 (1 OF 3)

UNITED STATES DEPARTMENT OF INTERI[illegible] GEOLOGICAL SURVEY - WATER RESOURCES DIVISION

EXPANDED RATING TABLE PROCESS DATE: 04-APR-85 13:25 AEA RATING NO 2

03226800 OLENTANGY R NR WORTHINGTON OH TYPE LOG [OFFSET=(1.00, 1.00) (0.00, 0.00)]

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION)										DIFF I PER TENTH
	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	
5.10	2347	2356	2365	2374	2384	2393	2402	2412	2421	2430	93
5.20	2440	2449	2459	2468	2477	2487	2496	2506	2515	2525	94
5.30	2534	2544	2553	2563	2572	2582	2591	2601	2611	2620	96
5.40	2630	2640	2649	2659	2669	2678	2688	2698	2707	2717	97
5.50	2727*	2736	2745	2754	2763	2772	2781	2790	2799	2808	90
5.60	2617	2626	2635	2645	2654	2863	2872	2881	2890	2899	92
5.70	2909	2918	2927	2936	2945	2955	2964	2973	2982	2992	92
5.80	3001	3010	3019	3029	3038	3047	3057	3066	3075	3085	93
5.90	3094	3103	3113	3122	3131	3141	3150	3160	3169	3179	94
6.00	3188	3197	3207	3216	3226	3235	3245	3254	3264	3273	95
6.10	3283	3293	3302	3312	3321	3331	3340	3350	3360	3369	96
6.20	3379	3389	3398	3408	3417	3427	3437	3447	3456	3466	97
6.30	3476	3485	3495	3505	3515	3524	3534	3544	3554	3564	97
6.40	3573	3583	3593	3603	3613	3622	3632	3642	3652	3662	99
6.50	3672	3682	3692	3702	3712	3721	3731	3741	3751	3761	99
6.60	3771	3781	3791	3801	3811	3821	3831	3841	3851	3861	101
6.70	3872	3882	3892	3902	3912	3922	3932	3942	3952	3962	101
6.80	3973	3983	3993	4003	4013	4024	4034	4044	4054	4064	102
6.90	4075	4085	4095	4105	4116	4126	4136	4146	4157	4167	102
7.00	4177	4188	4198	4208	4219	4229	4239	4250	4260	4271	104
7.10	4281	4291	4302	4312	4323	4333	4344	4354	4365	4375	105
7.20	4386	4396	4406	4417	4428	4438	4449	4459	4470	4480	105
7.30	4491	4501	4512	4523	4533	4544	4554	4565	4576	4586	106
7.40	4597	4608	4618	4629	4640	4650	4661	4672	4682	4693	107
7.50	4704	4714	4725	4736	4747	4757	4768	4779	4790	4801	107
7.60	4811	4822	4833	4844	4855	4866	4876	4887	4898	4909	109
7.70	4920	4931	4942	4953	4963	4974	4985	4996	5007	5018	109
7.80	5029	5040	5051	5062	5073	5084	5095	5106	5117	5128	110
7.90	5139	5150	5161	5172	5183	5194	5206	5217	5228	5239	111
8.00	5250*	5261	5271	5282	5293	5303	5314	5325	5336	5346	107
8.10	5357	5368	5378	5389	5400	5411	5421	5432	5443	5454	108
8.20	5465	5475	5486	5497	5508	5519	5529	5540	5551	5562	108
8.30	5573	5584	5595	5605	5616	5627	5638	5649	5660	5671	109
8.40	5682	5693	5704	5715	5725	5736	5747	5758	5769	5780	109
8.50	5791	5802	5813	5824	5835	5846	5857	5868	5879	5890	110
8.60	5901	5912	5923	5935	5946	5957	5968	5979	5990	6001	111
8.70	6012	6023	6034	6045	6057	6068	6079	6090	6101	6112	111
8.80	6123	6135	6146	6157	6168	6179	6191	6202	6213	6224	112
8.90	6235	6247	6258	6269	6280	6292	6303	6314	6325	6337	113
9.00	6349	6359	6371	6382	6393	6404	6416	6427	6438	6450	113
9.10	6461	6472	6484	6495	6507	6518	6529	6541	6552	6563	114
9.20	6575	6586	6598	6609	6621	6632	6643	6655	6666	6678	114

Plate No. 4-5(2 OF 3)

RT 23.0 UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY - WATER RESOURCES DIVISION

EXPANDED RATING TABLE PROCESS DATE: 04-APR-85 13:25 AEA RATING NO 23,0

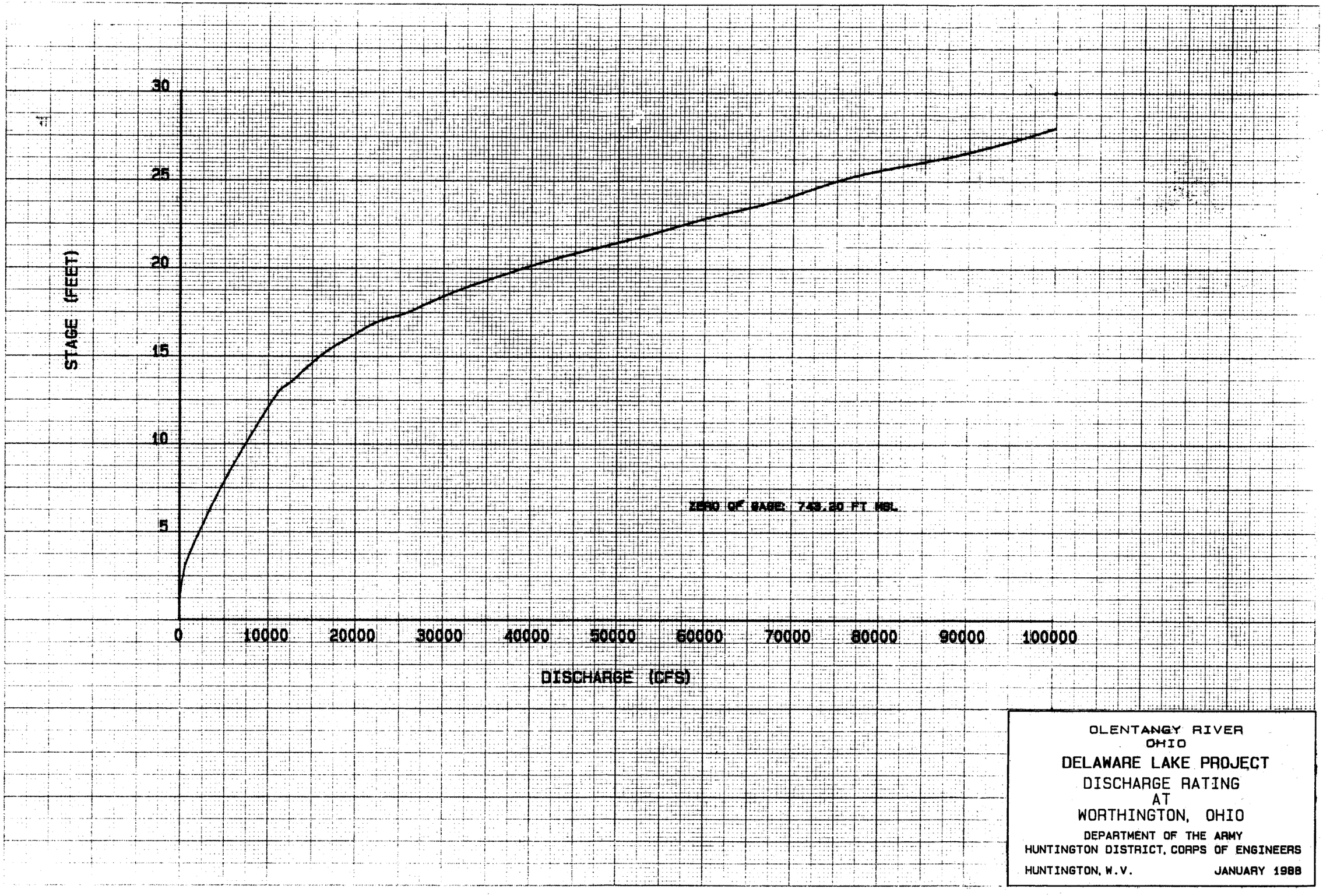
03226800 OLENTANGY R NR WORTHINGTON OH TYPE LOG [OFFSET=(1.00, 1.00) (0.00, 0.00)]

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN [illegible] PER TENTH GH
9.30	6669	6701	6712	6724	6735	6747	6758	6770	6781	6793	115
9.40	6804	6816	6827	6839	6850	6862	6873	6885	6896	6908	116
9.50	6920	6931	6943	6954	6966	6978	6989	7001	7012	7024	116
9.60	7036	7047	7059	7071	7082	7094	7106	7117	7129	7141	116
9.70	7152	7164	7176	7187	7199	7211	7223	7234	7246	7258	118
9.80	7270	7281	7293	7305	7317	7328	7340	7352	7364	7375	117
9.90	7387	7399	7411	7423	7435	7446	7458	7470	7482	7494	119
10.00	7506	7517	7529	7541	7553	7565	7577	7589	[illegible]	[illegible]	[illegible]
10.10	7624	7636	7648	7660	7672	7684	7696	7708	7720	7732	120
10.20	7744	7756	7768	7780	7792	7804	7816	7828	7840	7852	120
10.30	7864	7876	7888	7900	7912	7924	7936	7948	7960	7972	120
10.40	7984	7997	8009	8021	8033	8045	8057	8069	8081	8093	122
10.50	[illegible]	8118	8130	8142	8154	8166	8178	[illegible]	[illegible]	[illegible]	[illegible]
10.60	8227	8239	8252	8264	8276	8288	8300	8313	8325	8337	122
10.70	8349	8362	8374	8386	8398	8411	8423	8435	8447	8460	123
10.80	8472	8484	8497	8509	8521	8534	8546	8558	8571	8583	123
10.90	8595	8608	8620	8632	8645	8657	8669	8682	[illegible]	[illegible]	[illegible]
11.00	[illegible]	8731	8744	8756	8769	8781	8793	8806	[illegible]	[illegible]	[illegible]
11.10	8843	8856	8868	8881	8893	8906	8918	8930	8943	8955	125
11.20	8966	8980	8993	9006	9018	9031	9043	9056	9068	9081	125
11.30	9093	9106	9119	9131	9144	9156	9169	9181	9194	9207	126
11.40	9219	9232	9244	9257	9270	9282	9295	9307	[illegible]	[illegible]	[illegible]
11.50	9345	9358	9371	9383	9396	9409	9421	9434	[illegible]	[illegible]	[illegible]
11.60	9472	9485	9498	9510	9523	9536	9549	9561	9574	9587	128
11.70	9600	9612	9625	9638	9651	9663	9676	9689	9702	9715	127
11.80	9727	9740	9753	9766	9779	9792	9804	9817	9830	9843	129
11.90	9856	9869	9882	9894	9907	9920	9933	9946	[illegible]	[illegible]	129
12.00	9985	9998	10010	10020	10040	10050	10060	10080	[illegible]	[illegible]	130
12.10	10110	10130	10140	10150	10170	10180	10190	10200	10220	10230	130
12.20	10240	10260	10270	10280	10300	10310	10320	10340	10350	10360	130
12.30	10370	10390	10400	10410	10430	10440	10450	10470	10480	10490	130
12.40	10500	10520	10530	10540	10560	10570	10580	10600	10610	10620	140
12.50	10640	10650	10660	10680	10690	10700	10720	10730	10740	10750	[illegible]
12.60	10770	10780	10790	10810	10820	10830	10850	10860	10870	10890	130
12.70	10900	10910	10930	10940	10950	10970	10980	10990	11010	11020	130
12.80	11030	11050	11060	11070	11090	11100	11110	11130	11140	11150	140
12.90	11170	11180	11190	11210	11220	11230	11250	11260	11270	11290	130
13.00	11300*										

Plate No. 4-5 (3 OF 3)

47 1240

20 x 20 TO THE INCH • 10 x 10 TO THE INCH
KEUFFEL & ESSER CO. MADE IN U.S.A.



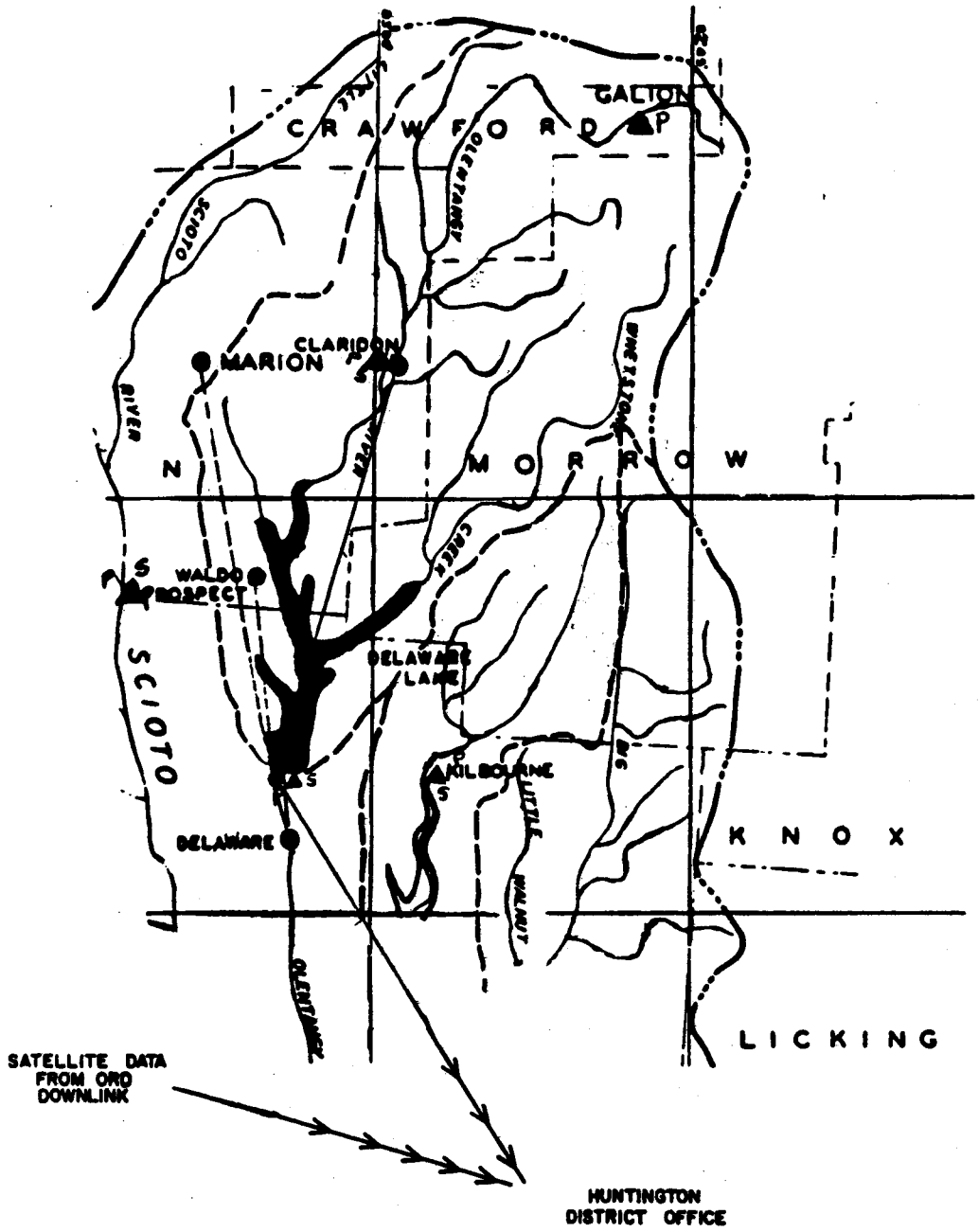
OLENTANGY RIVER
OHIO

DELAWARE LAKE PROJECT

DISCHARGE RATING AT WORTHINGTON, OHIO

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V. JANUARY 1988

Plate No. 4-5



LEGEND

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

OLENTANGY RIVER
OHIO

DELAWARE LAKE

HYDROLOGIC NETWORK

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON W. VA. APRIL 1988

Plate No. 5-1

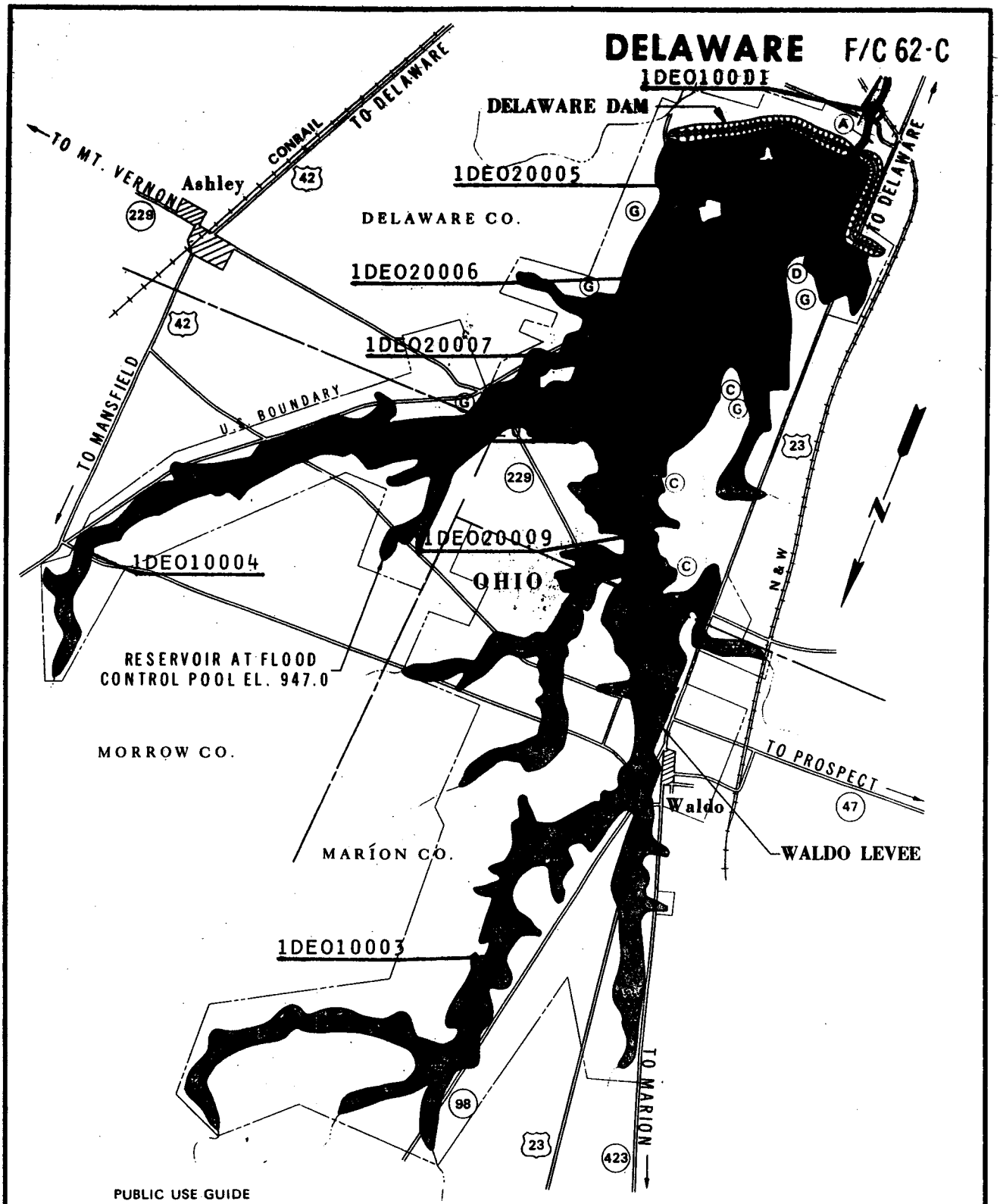
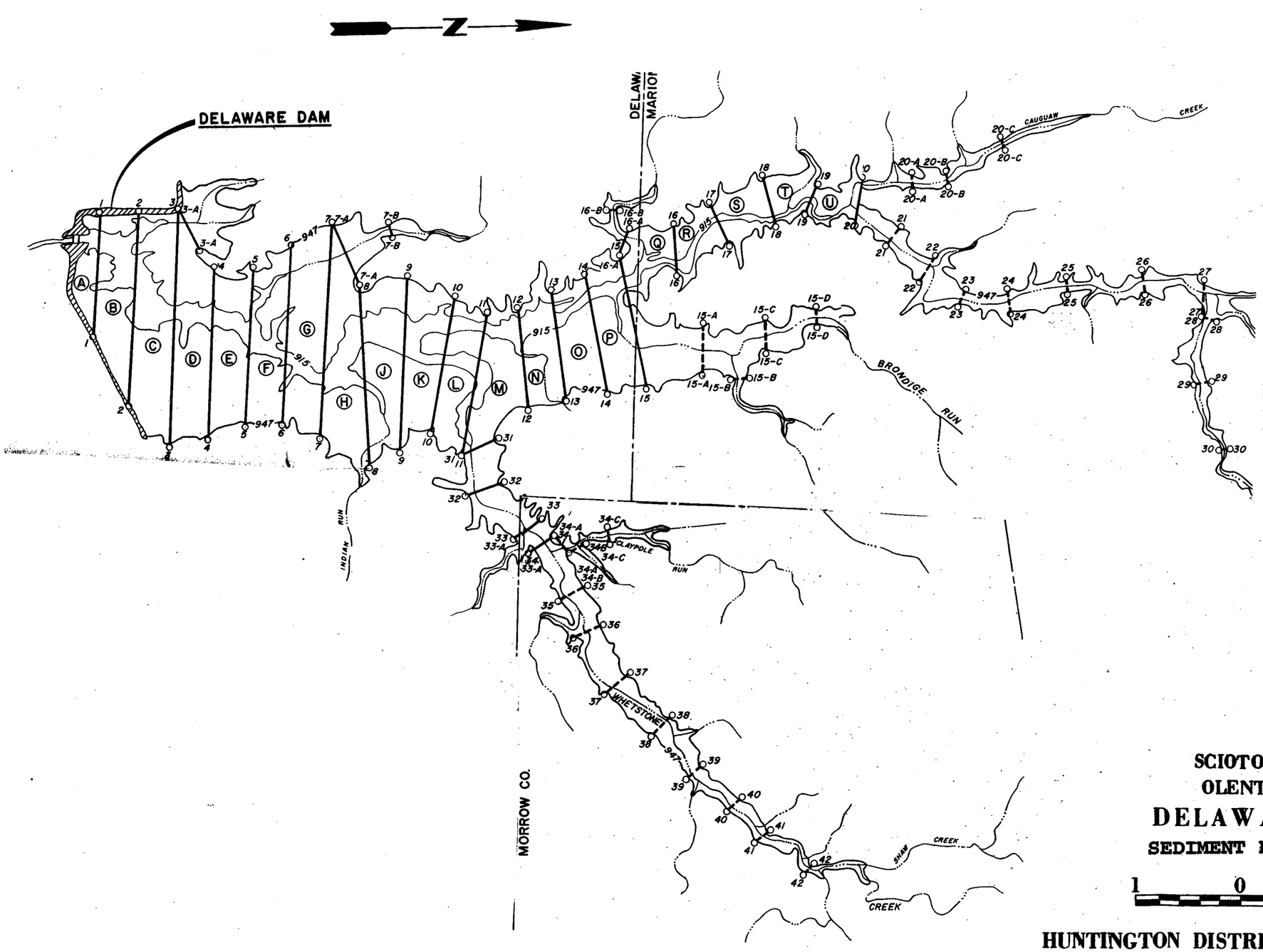

DELAWARE F/C 62-C
1DE0100D1
DELAWARE DAM
1DE020005
1DE020006
1DE020007
1DE020009
1DE010004
1DE010003
TO MT. VERNON
Ashley
CONRAIL
TO DELAWARE
DELAWARE CO.
TO MANSFIELD
U.S. BOUNDARY
OHIO
RESERVOIR AT FLOOD CONTROL POOL EL. 947.0
MORROW CO.
MARION CO.
N & W
TO PROSPECT
Waldo
WALDO LEVEE
TO MARION
N
PUBLIC USE GUIDE
PARKING, FISHING ACCESS & PICNIC AREA (A)
BEACH (B)
CAMPING AREA (C)
PARKING, PICNIC AREA & BOAT LAUNCHING (D)
PARKING, PICNIC AREA, BOAT LAUNCHING & DOCK (F)
FISHING ACCESS (G)
GRASS LANDING STRIP (H)
SCIOTO RIVER BASIN
OLENTANGY RIVER
DELAWARE LAKE
WATER QUALITY SAMPLING NETWORK
1 0 1 2
HUNTINGTON DISTRICT, HUNTINGTON, W. VA.
Revised : 30 SEPTEMBER 1984

Plate No. 5-2



SCIOTO RIVER BASIN
OLENTANGY RIVER

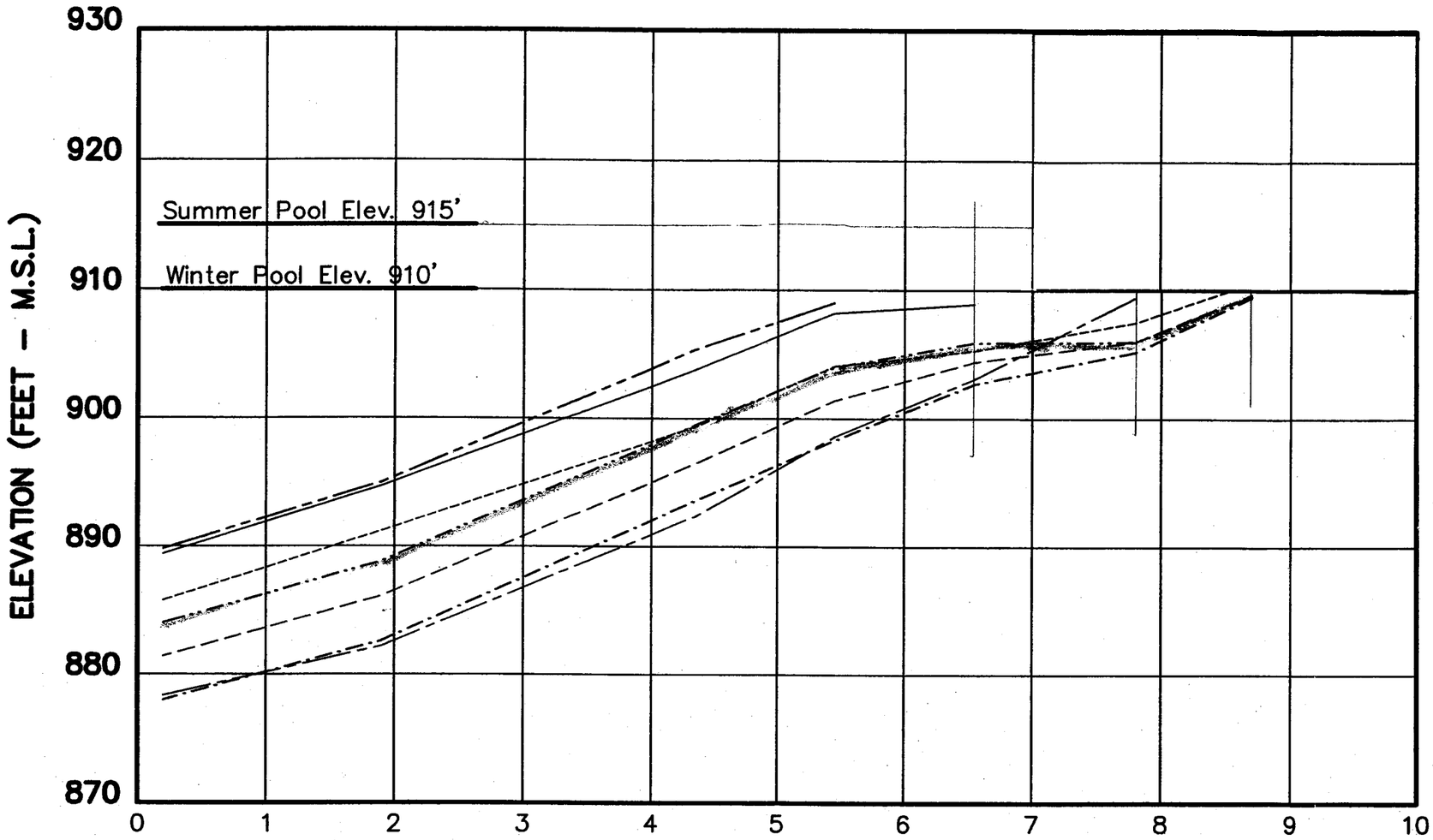
DELAWARE LAKE

SEDIMENT RANGE NETWORK

1 0 1 2

HUNTINGTON DISTRICT, HUNTINGTON, W. VA.
Revised : 30 SEPTEMBER 1984

Plate No. 5-3



LEGEND

1947	ORIGINAL GROUND – DTM/BED CONTOUR METHOD	
1949	ORIGINAL GROUND – RANGE SURVEY/END AREA METHOD	
1960	RESURVEY – RANGE SURVEY/END AREA METHOD	
1975	RESURVEY – RANGE SURVEY/END AREA METHOD	
1984	RESURVEY – RANGE SURVEY/END AREA METHOD	
1998	RESURVEY – BOTH METHODS	
2002	RESURVEY – BOTH METHODS	

NOTE:

FLOOD CONTROL ELEVATION = 947'

SCIOTO RIVER BASIN
OLENTANGY RIVER

DELAWARE LAKE SEDIMENT RANGE BOTTOM PROFILE

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT CORPS OF ENGINEERS
HUNTINGTON, WV APRIL, 2003

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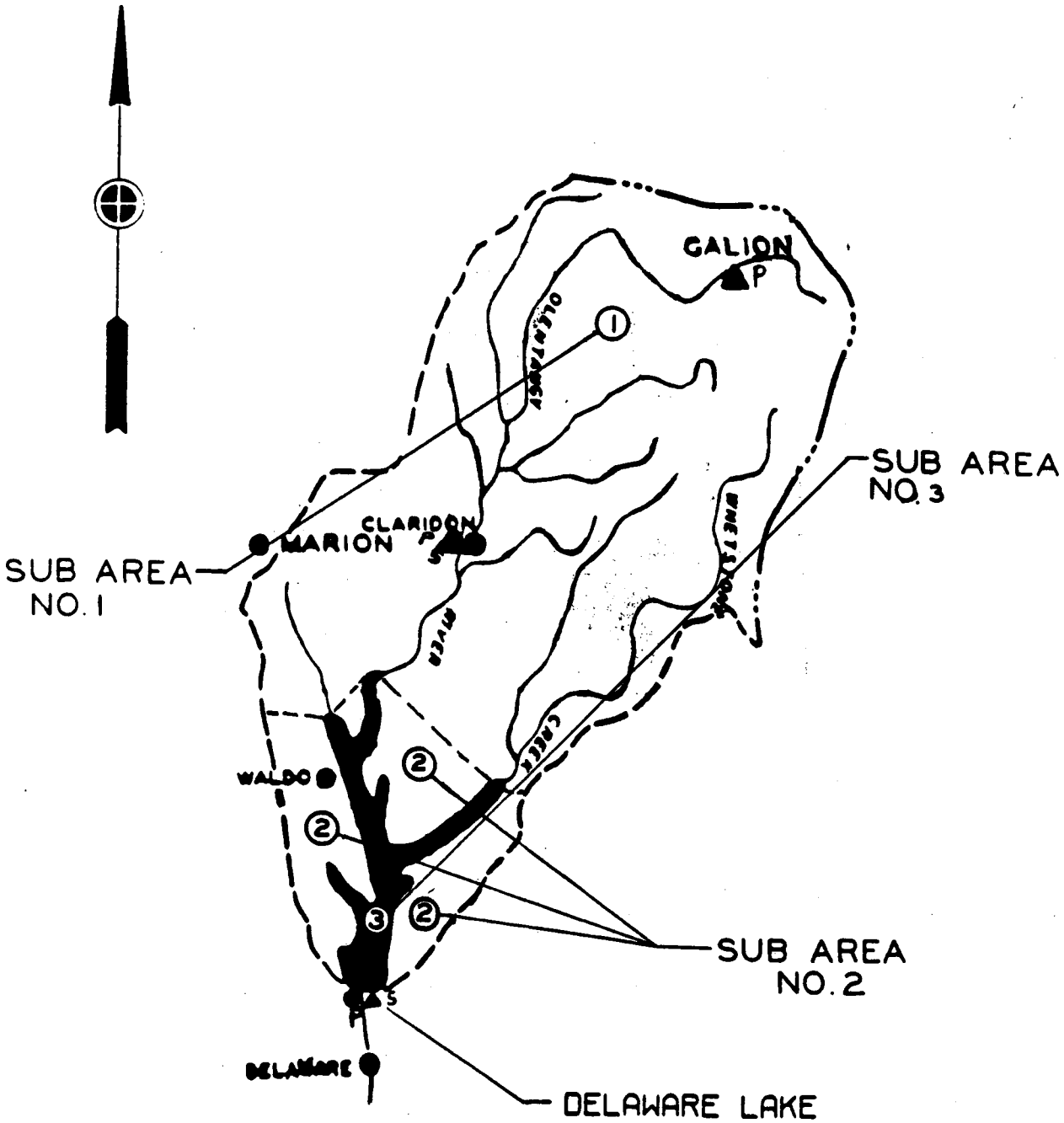


LEGEND

- WATERSHED BOUNDARY LINE
- RESERVOIR, SPILLWAY ELEVATION
- REPORTING PRECIPITATION STATION
- P PRECIPITATION
- S STAGE
- SATELLITE DATA PLATFORM

OLENTANGY RIVER
OHIO

DELAWARE LAKE

FORECAST AREA AND REACHES

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V. APRIL 1988

Plate No. 6-1

DELAWARE LAKE-SCIOTO RIVER
BASIN NETWORK CONFIGURATION

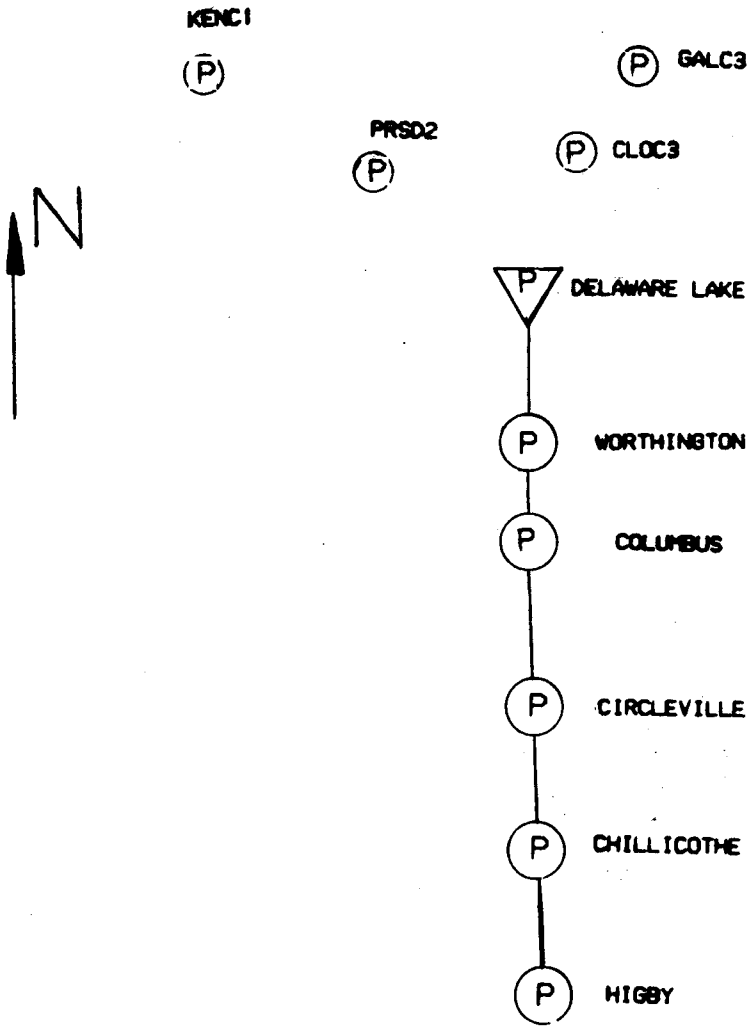


Plate No. 6-2

DELAWARE RESERVOIR
OLENTANGY RIVER
AREA AND CAPACITY TABLES

Drainage Area = 381 Sq.Mi. 1" Runoff = 20,300 Ac.Ft.

Pool elev.	Capacity Ac.Ft.	Capacity Inches	Area acres	Pool elev.	Capacity Ac.Ft.	Capacity Inches	Area acres
880	0	0	0				
881	0	0	0	916	15,300	0.75	1,320
882	0	0	0	917	16,700	0.82	1,375
883	0	0	0	918	18,000	0.89	1,440
884	0	0	0	919	19,500	0.96	1,520
885	2	0	5	920	21,200	1.0	1,585
886	10	0	10	921	23,000	1.1	1,665
887	30	0	25	922	24,500	1.2	1,750
888	60	0	40	923	26,400	1.3	1,850
889	100	0	55	924	28,300	1.4	1,950
890	200	0.01	70	925	30,400	1.5	2,050
891	250	0.01	85	926	32,500	1.6	2,150
892	350	0.02	105	927	35,000	1.7	2,275
893	450	0.02	130	928	37,000	1.8	2,400
894	600	0.03	160	929	39,800	2.0	2,540
895	800	0.04	190	930	42,500	2.1	2,680
896	1,000	0.05	240	931	45,000	2.2	2,850
897	1,300	0.06	280	932	48,000	2.4	3,050
898	1,600	0.08	320	933	51,200	2.5	3,250
899	1,900	0.09	370	934	54,800	2.7	3,500
900	2,300	0.11	400	935	58,400	2.9	3,750
901	2,700	0.13	420	936	62,500	3.1	4,000
902	3,200	0.16	460	937	67,100	3.3	4,250
903	3,600	0.18	500	938	71,800	3.5	4,500
904	4,100	0.20	530	939	76,900	3.8	4,850
905	4,700	0.23	600	940	82,000	4.0	5,175
906	5,300	0.26	640	941	87,500	4.3	5,550
907	6,000	0.30	700	942	93,500	4.6	6,000
908	6,700	0.33	770	943	100,000	4.9	6,400
909	7,500	0.37	840	944	107,200	5.3	6,900
910	8,400	0.41	950	945	115,000	5.7	7,400
911	9,400	0.46	1,035	946	123,200	6.1	7,900
912	10,400	0.51	1,100	947	132,000	6.5	8,550
913	11,600	0.57	1,150	948	142,000	7.0	9,250
914	12,700	0.63	1,215	949	152,000	7.5	10,000
915	14,000	0.69	1,270	950	163,000	8.0	10,700

Plate No. 7-1

RECORD OF DEVIATION
FROM
APPROVED WATER CONTROL PLAN

DATE: 27 October 2003
DEVIATION NO.: WY04-05

DEVIATION: Delaware Lake

1. This is to confirm the following communication between Mr. Tim Curran, CELRH-EC-WM, and Mr. Pat Morgan, CELRH-EC-W, concerning a deviation from the approved water control plan.

2. Deviation. Effective on 27 October 2003, the Project will operate to achieve and maintain a pool elevation of 916.0 feet. Effective on the 1st and 2nd of November 2003 between 0700 and 1700 hours, the Project will release a flow of 1000 cfs. Overnight on the 1st, the Project will maintain a pool elevation of 915.25 feet. At 1700 hrs on the 2nd, the Project will return to normal operation.

3. Purpose. The purpose of this deviation is to provide Fast Water Training as requested by ODNR.

4. Results. This deviation will have minimal impact on both the pool and downstream stages. The project should not have any problem achieving the temporary level and as project begins drawdown on November 1st a small drop below seasonal pool during the provision of this operation will not significantly impact recreation. Downstream fluctuation will be within normal ranges and at a level which does not adversely effect downstream recreation.

5. Coordination. Coordination between Jim Schray and Vince Marchese, EC-WM, and Ben O'Dell, OR-DDO, and Beth Pratt [redacted], ODNR.

6. Approval recommended.

TIMOTH W. CURRAN, P.E.
Chief, Water Management Section

APPROVED:

STEVEN P. MORGAN, P.E.
Chief, Water Resources
Engineering Branch

Plate No. 7-1a

DELAWARE

PERCENT STORAGE UTILIZATION - WINTER

ELEV	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
910	0.00	0.08	0.16	0.24	0.32	0.40	0.49	0.57	0.65	0.73
911	0.81	0.88	0.96	1.03	1.11	1.19	1.28	1.36	1.44	1.53
912	1.62	1.72	1.82	1.92	2.02	2.11	2.21	2.31	2.40	2.50
913	2.59	2.67	2.75	2.84	2.93	3.01	3.10	3.19	3.29	3.38
914	3.48	3.58	3.69	3.79	3.90	4.00	4.11	4.22	4.32	4.43
915	4.53	4.63	4.73	4.84	4.94	5.05	5.15	5.26	5.37	5.47
916	5.58	5.70	5.82	5.93	6.05	6.16	6.27	6.38	6.50	6.61
917	6.72	6.81	6.91	7.01	7.12	7.22	7.33	7.43	7.54	7.65
918	7.77	7.88	8.00	8.11	8.23	8.35	8.48	8.60	8.72	8.85
919	8.98	9.11	9.25	9.38	9.52	9.66	9.80	9.93	10.07	10.21
920	10.36	10.51	10.67	10.82	10.97	11.11	11.26	11.40	11.54	11.68
921	11.81	11.92	12.03	12.14	12.26	12.38	12.50	12.63	12.76	12.89
922	13.03	13.18	13.33	13.49	13.64	13.79	13.95	14.10	14.26	14.41
923	14.56	14.71	14.86	15.01	15.16	15.31	15.47	15.62	15.78	15.94
924	16.10	16.27	16.44	16.61	16.78	16.95	17.12	17.29	17.46	17.63
925	17.80	17.95	18.11	18.28	18.44	18.61	18.78	18.95	19.13	19.31
926	19.50	19.72	19.94	20.15	20.36	20.56	20.76	20.96	21.15	21.34
927	21.52	21.65	21.79	21.94	22.09	22.25	22.41	22.59	22.76	22.95
928	23.14	23.37	23.60	23.83	24.06	24.28	24.51	24.73	24.96	25.18
929	25.40	25.63	25.85	26.08	26.30	26.52	26.73	26.95	27.17	27.38
930	27.59	27.77	27.96	28.15	28.35	28.55	28.75	28.96	29.17	29.39
931	29.61	29.85	30.08	30.32	30.56	30.81	31.05	31.29	31.54	31.79
932	32.04	32.28	32.53	32.78	33.04	33.29	33.55	33.82	34.08	34.35
933	34.63	34.92	35.21	35.50	35.79	36.08	36.38	36.67	36.96	37.25
934	37.54	37.81	38.09	38.37	38.66	38.95	39.24	39.54	39.84	40.14
935	40.45	40.77	41.08	41.41	41.73	42.06	42.40	42.73	43.07	43.42
936	43.77	44.14	44.51	44.88	45.25	45.62	45.99	46.37	46.74	47.12
937	47.49	47.86	48.23	48.60	48.97	49.35	49.74	50.12	50.51	50.90
938	51.29	51.71	52.12	52.53	52.95	53.36	53.77	54.18	54.60	55.01
939	55.42	55.82	56.22	56.63	57.03	57.44	57.86	58.28	58.70	59.12
940	59.55	59.97	60.41	60.84	61.28	61.72	62.17	62.62	63.07	63.53
941	64.00	64.46	64.94	65.41	65.89	66.37	66.86	67.35	67.85	68.35
942	68.85	69.35	69.86	70.37	70.89	71.41	71.94	72.47	73.01	73.56
943	74.11	74.67	75.24	75.81	76.38	76.96	77.55	78.14	78.73	79.33
944	79.94	80.55	81.17	81.80	82.42	83.05	83.68	84.32	84.96	85.60
945	86.25	86.89	87.53	88.19	88.84	89.50	90.17	90.84	91.52	92.20
946	92.88	93.55	94.23	94.92	95.61	96.32	97.04	97.76	98.50	99.25
947	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Plate No. 7-2

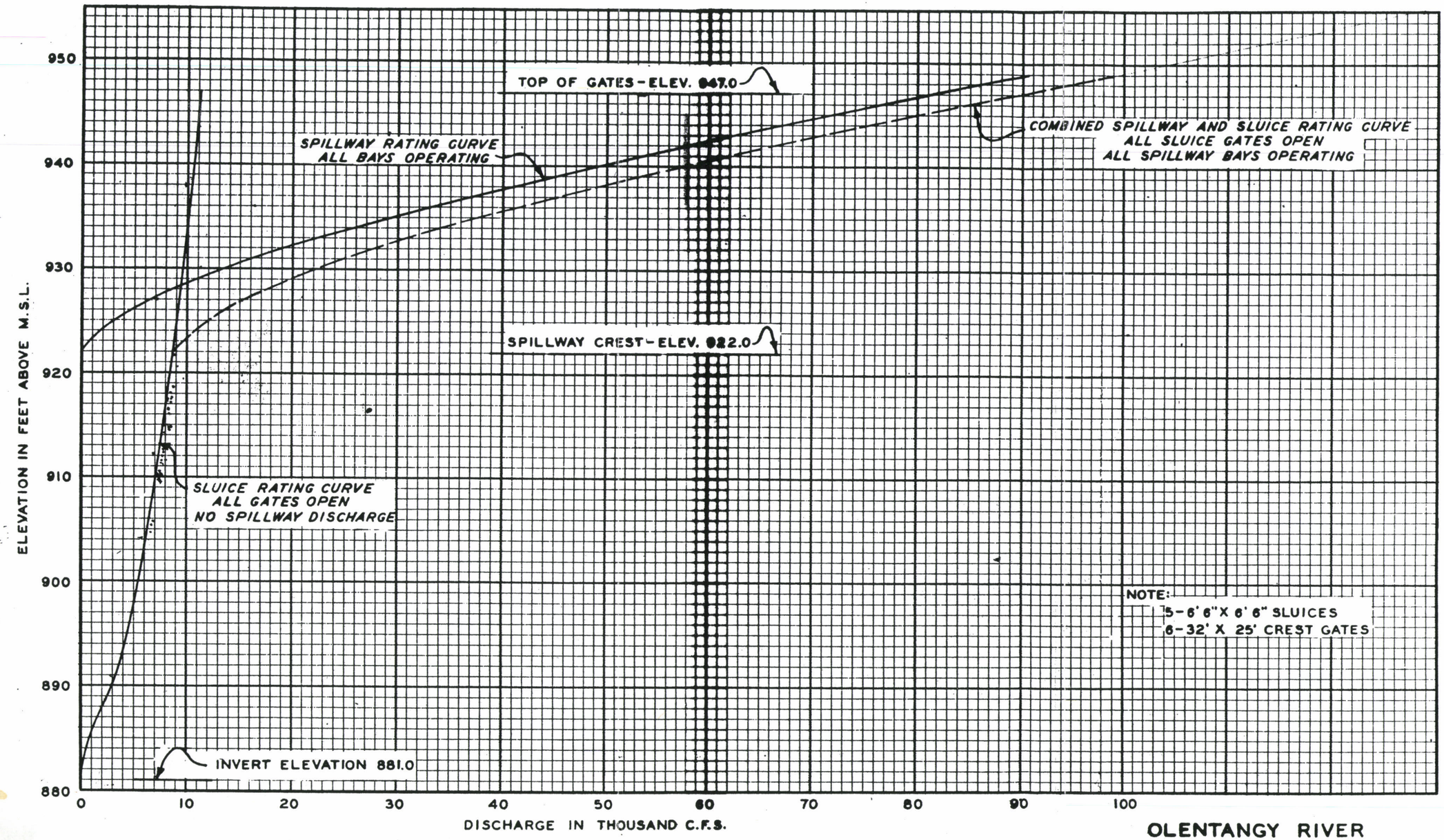
DELAWARE

PERCENT STORAGE UTILIZATION - SUMMER

ELEV	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
915	0.00	0.11	0.21	0.32	0.43	0.54	0.65	0.76	0.87	0.99
916	1.10	1.22	1.35	1.47	1.59	1.71	1.82	1.94	2.06	2.17
917	2.29	2.39	2.49	2.60	2.71	2.82	2.93	3.04	3.16	3.27
918	3.39	3.51	3.63	3.75	3.88	4.00	4.13	4.26	4.39	4.53
919	4.66	4.80	4.94	5.08	5.23	5.37	5.52	5.66	5.81	5.95
920	6.10	6.27	6.43	6.59	6.74	6.90	7.05	7.20	7.34	7.49
921	7.63	7.74	7.85	7.97	8.09	8.22	8.35	8.48	8.62	8.76
922	8.90	9.06	9.22	9.38	9.54	9.70	9.86	10.03	10.19	10.35
923	10.51	10.66	10.82	10.97	11.13	11.29	11.45	11.62	11.78	11.95
924	12.12	12.30	12.47	12.65	12.83	13.01	13.19	13.36	13.54	13.72
925	13.90	14.06	14.23	14.40	14.57	14.75	14.93	15.11	15.29	15.48
926	15.68	15.91	16.14	16.36	16.58	16.79	17.00	17.21	17.41	17.60
927	17.80	17.94	18.08	18.23	18.39	18.56	18.73	18.91	19.10	19.29
928	19.49	19.73	19.97	20.21	20.45	20.69	20.93	21.16	21.40	21.63
929	21.86	22.10	22.34	22.57	22.80	23.03	23.26	23.48	23.71	23.93
930	24.15	24.35	24.54	24.74	24.95	25.16	25.37	25.59	25.81	26.04
931	26.27	26.52	26.77	27.02	27.27	27.52	27.78	28.03	28.29	28.55
932	28.81	29.07	29.33	29.59	29.86	30.13	30.40	30.68	30.96	31.24
933	31.53	31.83	32.14	32.44	32.75	33.05	33.36	33.66	33.97	34.27
934	34.58	34.86	35.15	35.45	35.75	36.05	36.36	36.67	36.98	37.30
935	37.63	37.96	38.29	38.63	38.97	39.31	39.66	40.02	40.37	40.74
936	41.10	41.49	41.87	42.26	42.65	43.04	43.43	43.82	44.21	44.61
937	45.00	45.38	45.77	46.16	46.55	46.95	47.35	47.75	48.16	48.57
938	48.98	49.42	49.85	50.28	50.71	51.14	51.58	52.01	52.44	52.87
939	53.31	53.72	54.14	54.57	54.99	55.42	55.86	56.30	56.74	57.18
940	57.63	58.07	58.53	58.98	59.44	59.91	60.37	60.85	61.32	61.80
941	62.29	62.78	63.27	63.77	64.27	64.78	65.29	65.80	66.32	66.85
942	67.37	67.90	68.43	68.96	69.51	70.05	70.61	71.17	71.73	72.30
943	72.88	73.47	74.06	74.66	75.26	75.87	76.48	77.10	77.72	78.35
944	78.98	79.63	80.28	80.93	81.59	82.25	82.91	83.58	84.24	84.92
945	85.59	86.27	86.94	87.63	88.31	89.01	89.70	90.41	91.11	91.83
946	92.54	93.24	93.95	94.67	95.40	96.14	96.90	97.66	98.43	99.21
947	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DEPARTMENT OF THE ARMY

CORPS OF ENGINEERS



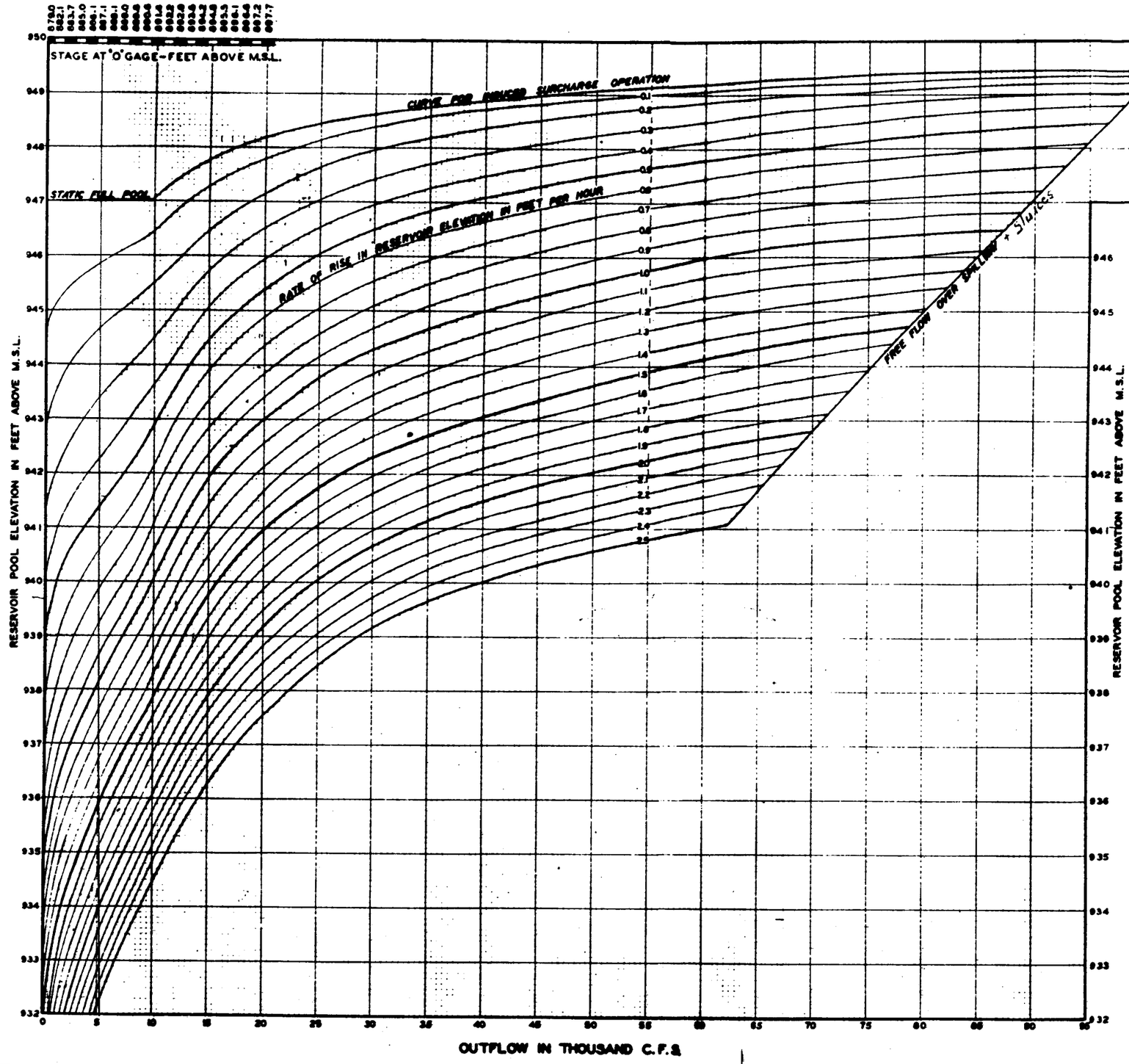
OLENTANGY RIVER
OHIO
DELAWARE RESERVOIR
SLUICE AND SPILLWAY RATING CURVES

DEPARTMENT OF THE ARMY CORPS OF ENGINEERS
HUNTINGTON DISTRICT JULY 1948

Plate No. 7-3

CORPS OF ENGINEERS

U. S. ARMY



INSTRUCTIONS

1. FOLLOW NORMAL SCHEDULE FOR OLENTANGY, SCIOTO, AND OHIO RIVERS UNTIL LARGER RELEASES ARE REQUIRED BY THIS SCHEDULE.
2. COMPUTE THE AVERAGE RATE OF RISE IN RESERVOIR ELEVATION IN FEET PER HOUR FROM THE CHANGE IN ELEVATION DURING THE PRECEDING THREE HOURS.
3. ADJUST THE OUTFLOW EACH HOUR AS INDICATED BY THE CURVES ON THE BASIS OF THE AVERAGE RATE OF RISE AND THE CURRENT RESERVOIR ELEVATION STAGES ON 'O' GAGE SHOWN ON UPPER SCALE PROVIDE FOR CHANGING OUTFLOW IN INCREMENTS OF 1000 C.F.S.
4. AFTER THE RESERVOIR ELEVATION STARTS TO FALL, MAINTAIN CURRENT GATE OPENINGS UNTIL THE ELEVATION RECEDES TO 947.0 MAINTAIN POOL AT ELEVATION 947.0 OR AT PEAK POOL LEVEL ATTAINED, IF BELOW 947.0, UNTIL NORMAL DRAWDOWN OPERATION CAN BE INITIATED

OLENTANGY RIVER
OHIO
DELAWARE RESERVOIR
REGULATION SCHEDULE
FOR MAJOR FLOODS

SCALES AS SHOWN

CORPS OF ENGINEERS
HUNTINGTON DISTRICT
JANUARY 1951
U. S. ARMY

Plate No. 7-4

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

EXPANDED RATING TABLE TYPE: LOG

03225500

DATE PROCESSED: 07-05-2002 @ 09:00 BY cmeberle

OLENTANGY R NR DELAWARE OH DD: 4 TYPE: 001 RATING NO: 16.0

OFFSET: .00 START DATE/TIME: 10-01-1995 (0005)

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

COMP BY _____ DATE _____ CHK. BY _____ DATE _____

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
.90	1.600*	1.690	1.785	1.883	1.986	2.093	2.205	2.321	2.442	2.569	1.100
1.00	2.700*	2.840	2.985	3.136	3.293	3.457	3.627	3.804	3.987	4.178	1.676
1.10	4.376	4.581	4.794	5.015	5.244	5.481	5.727	5.981	6.245	6.518	2.424
1.20	6.800*	7.054	7.315	7.584	7.861	8.145	8.437	8.737	9.045	9.361	2.886
1.30	9.686	10.02	10.36	10.71	11.07	11.44	11.82	12.21	12.61	13.02	3.754
1.40	13.44	13.87	14.31	14.76	15.22	15.70	16.18	16.67	17.18	17.70	4.790
1.50	18.23	18.78	19.33	19.90*	20.46	21.02	21.60	22.19	22.79	23.41	5.810
1.60	24.04	24.68	25.33	26.00*	26.75	27.51	28.29	29.09	29.90	30.73	7.550
1.70	31.59	32.45	33.34	34.25	35.17	36.12	37.09	38.07	39.08	40.10	9.560
1.80	41.15	42.22	43.31	44.42	45.56	46.71	47.89	49.10	50.32	51.58	11.70
1.90	52.85	54.15	55.47	56.82	58.20*	59.81	61.46	63.15	64.87	66.63	15.58
2.00	68.43	70.27	72.15	74.07	76.03	78.03	80.08	82.16	84.30	86.47	20.27
2.10	88.70	90.97	93.28	95.64	98.06	100.5	103.0	105.6	108.2	110.9	24.90
2.20	113.6	116.4	119.2	122.1	125.0	128.0*	131.4	134.9	138.5	142.2	32.30
2.30	145.9	149.8	153.7	157.7	161.7	165.9	170.2	174.5	179.0	183.5	42.20
2.40	188.1	192.8	197.7	202.6	207.6	212.7	218.0	223.3	228.8	234.3	51.90
2.50	240.0*	244.5	249.1	253.7	258.4	263.1	268.0	272.9	277.8	282.9	48.00
2.60	288.0	293.2	298.4	303.8	309.2	314.6	320.2	325.8	331.5	337.3	55.20
2.70	343.2	349.1	355.2	361.3	367.5	373.7	380.1	386.5	393.1	399.7	63.20
2.80	406.4	413.2	420.1	427.0	434.1	441.2	448.5	455.8	463.2	470.8	72.00
2.90	478.4	486.1	493.9	501.8	509.8	517.9	526.1	534.4	542.9	551.4	81.60
3.00	560.0*	565.8	571.7	577.6	583.5	589.5	595.5	601.6	607.7	613.8	60.00
3.10	620.0*	627.7	635.4	643.3	651.1	659.1	667.1	675.2	683.4	691.7	80.00
3.20	700.0*	706.8	713.6	720.5	727.5	734.4	741.5	748.5	755.6	762.8	70.00
3.30	770.0*	776.8	783.7	790.6	797.5	804.5	811.5	818.6	825.7	832.8	70.00
3.40	840.0*	844.9	849.9	854.8	859.8	864.8	869.8	874.8	879.9	884.9	50.00
3.50	890.0*	895.7	901.4	907.2	912.9	918.7	924.5	930.3	936.2	942.0	57.90
3.60	947.9	953.8	959.7	965.7	971.7	977.6	983.6	989.7	995.7	1002	60.10
3.70	1008	1014	1020	1026	1032	1039	1045	1051	1057	1064	62.00
3.80	1070	1076	1082	1089	1095	1102	1108	1114	1121	1127	64.00
3.90	1134	1140	1147	1154	1160	1167	1173	1180	1187	1193	66.00
4.00	1200*	1205	1211	1216	1222	1227	1233	1238	1244	1250	55.00
4.10	1255	1261	1266	1272	1277	1283	1289	1294	1300	1306	56.00
4.20	1311	1317	1323	1328	1334	1340	1345	1351	1357	1363	58.00
4.30	1369	1374	1380	1386	1392	1398	1403	1409	1415	1421	58.00
4.40	1427	1433	1439	1445	1451	1457	1462	1468	1474	1480	59.00
4.50	1486	1492	1498	1504	1510	1517	1523	1529	1535	1541	61.00

001
DELAWARE LAKE
Plate No. 7-5 (1 OF 3)

03225500
DATE PROCESSED: 07-05-2002 @ 09:00 BY cmeberle
OLENTANGY R NR DELAWARE OH DD: 4 TYPE: 001 RATING NO: 16.0
OFFSET: .00 START DATE/TIME: 10-01-1995 (0005)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
4.60	1547	1553	1559	1565	1571	1578	1584	1590	1596	1602	62.00
4.70	1609	1615	1621	1627	1634	1640	1646	1652	1659	1665	62.00
4.80	1671	1678	1684	1690	1697	1703	1709	1716	1722	1729	64.00
4.90	1735	1742	1748	1754	1761	1767	1774	1780	1787	1793	65.00
5.00	1800*	1806	1812	1818	1824	1831	1837	1843	1849	1855	61.00
5.10	1861	1867	1874	1880	1886	1892	1898	1905	1911	1917	62.00
5.20	1923	1930	1936	1942	1949	1955	1961	1967	1974	1980	63.00
5.30	1986	1993	1999	2005	2012	2018	2025	2031	2037	2044	64.00
5.40	2050	2057	2063	2069	2076	2082	2089	2095	2102	2108	65.00
5.50	2115	2121	2128	2134	2141	2147	2154	2160	2167	2174	65.00
5.60	2180	2187	2193	2200	2207	2213	2220	2226	2233	2240	66.00
5.70	2246	2253	2260	2266	2273	2280	2287	2293	2300	2307	67.00
5.80	2313	2320	2327	2334	2341	2347	2354	2361	2368	2375	68.00
5.90	2381	2388	2395	2402	2409	2416	2422	2429	2436	2443	69.00
6.00	2450*	2456	2462	2469	2475	2481	2487	2494	2500	2506	63.00
6.10	2513	2519	2525	2531	2538	2544	2550	2557	2563	2569	63.00
6.20	2576	2582	2588	2595	2601	2608	2614	2620	2627	2633	63.00
6.30	2639	2646	2652	2659	2665	2671	2678	2684	2691	2697	65.00
6.40	2704	2710	2717	2723	2730	2736	2742	2749	2755	2762	64.00
6.50	2768	2775	2781	2788	2794	2801	2808	2814	2821	2827	66.00
6.60	2834	2840	2847	2853	2860	2867	2873	2880	2886	2893	65.00
6.70	2899	2906	2913	2919	2926	2933	2939	2946	2953	2959	67.00
6.80	2966	2972	2979	2986	2992	2999	3006	3013	3019	3026	67.00
6.90	3033	3039	3046	3053	3060	3066	3073	3080	3086	3093	67.00
7.00	3100*	3107	3114	3121	3128	3135	3142	3149	3156	3163	70.00
7.10	3170	3177	3184	3191	3198	3205	3212	3219	3226	3233	70.00
7.20	3240	3247	3254	3261	3268	3275	3282	3289	3296	3303	70.00
7.30	3310	3317	3324	3332	3339	3346	3353	3360	3367	3374	71.00
7.40	3381	3389	3396	3403	3410	3417	3424	3432	3439	3446	72.00
7.50	3453	3460	3468	3475	3482	3489	3497	3504	3511	3518	73.00
7.60	3526	3533	3540	3547	3555	3562	3569	3576	3584	3591	72.00
7.70	3598	3606	3613	3620	3628	3635	3642	3650	3657	3664	74.00
7.80	3672	3679	3686	3694	3701	3709	3716	3723	3731	3738	74.00
7.90	3746	3753	3760	3768	3775	3783	3790	3798	3805	3813	74.00
8.00	3820*	3828	3835	3843	3850	3858	3865	3873	3880	3888	76.00
8.10	3896	3903	3911	3918	3926	3934	3941	3949	3956	3964	76.00
8.20	3972	3979	3987	3995	4002	4010	4018	4025	4033	4041	76.00
8.30	4048	4056	4064	4072	4079	4087	4095	4102	4110	4118	78.00

2002
ELAWARE LAKE
Plate No. 7-5 (2 OF 3)

03225500
OLENTANGY R NR DELAWARE OH DD: 4 TYPE: 001 RATING NO: 16.0
OFFSET: .00 START DATE/TIME: 10-01-1995 (0005)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
8.40	4126	4133	4141	4149	4157	4164	4172	4180	4188	4196	77.00
8.50	4203	4211	4219	4227	4235	4242	4250	4258	4266	4274	79.00
8.60	4282	4290	4297	4305	4313	4321	4329	4337	4345	4353	78.00
8.70	4360	4368	4376	4384	4392	4400	4408	4416	4424	4432	80.00
8.80	4440	4448	4456	4464	4472	4480	4488	4496	4504	4512	80.00
8.90	4520	4528	4536	4544	4552	4560	4568	4576	4584	4592	80.00
9.00	4600*	4607	4615	4622	4629	4637	4644	4651	4659	4666	73.00
9.10	4673	4681	4688	4696	4703	4710	4718	4725	4732	4740	74.00
9.20	4747	4755	4762	4769	4777	4784	4792	4799	4807	4814	74.00
9.30	4821	4829	4836	4844	4851	4859	4866	4874	4881	4888	75.00
9.40	4896	4903	4911	4918	4926	4933	4941	4948	4956	4963	75.00
9.50	4971	4978	4986	4993	5001	5008	5016	5023	5031	5038	75.00
9.60	5046	5053	5061	5069	5076	5084	5091	5099	5106	5114	75.00
9.70	5121	5129	5137	5144	5152	5159	5167	5174	5182	5190	76.00
9.80	5197	5205	5212	5220	5228	5235	5243	5251	5258	5266	76.00
9.90	5273	5281	5289	5296	5304	5312	5319	5327	5335	5342	77.00*
10.00	5350*										

300
DELAWARE LAKE
Plate No. 7-5 (3 OF 3)

RT 14.0 UNITED STATES DEPARTMENT OF INTERIOR — GEOLOGICAL SURVEY — WATER RESOURCES DIVISION

EXPANDED RATING TABLE — PROCESS DATE: 22-JUL-83 13:45 DFM — RAT. 0 14.0

03225500 OLENTANGY R NR DELAWARE OH — TYPE LOG [OFFSET=(1.10, 1.00) (0.00, 0.00)]

BASED ON ..... DISCHARGE MEASUREMENTS, NOS ....., AND ....., AND IS ..... WELL DEFINED BETWEEN ..... AND ..... CFS
COMP BY ..... DATE .....
RATING TO BE USED STARTING AT: 10/31/77 (0013) CKD. BY ..... DATE .....
REMARKS: Same as rating 13 above 1.55 feet.

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH GH
1.10	4.09*	4.33	4.59	5.34	5.37	5.71	6.04	6.37	6.73	7.05	3.39
1.20	7.35*	7.68	8.00*	8.32	8.63	8.94	9.25*	9.60*	9.95*	10.3	3.3
1.30	10.7*	11.1	11.4*	11.8	12.2*	12.6	13.1*	13.5	14.0*	14.4	4.2
1.40	14.9*	15.4	15.9*	16.4	17.0*	17.6	18.2*	18.8	19.4	20.0	5.7
1.50	20.6*	21.2	21.8	22.4	23.0	23.6*	24.4	25.2	26.0	26.8	7.0
1.60	27.5	28.4	29.3	30.1	31.0*	31.9	32.8	33.7	34.7	35.6	8.8
1.70	36.6*	37.7	38.8	39.9	41.0	42.1	43.3*	44.5	45.7	46.9	11.6
1.80	48.2	49.4	50.7	52.0	53.3	54.7	56.0*	57.5	59.0	60.6	13.9
1.90	62.1	63.7	65.3	67.0	68.6	70.3	72.0*	73.9	75.8	77.7	17.6
2.00	79.7	81.7	83.7	85.8	87.9	90.0*	92.2	94.5	96.8	99.2	21.9
2.10	101.6	104.5	107.4	110.4	113.4	116.0*	119.0	122.0	125.1	128.2	27.2
2.20	128.8	131.9	135.0*	138.8	142.6	146.5	150.4	154.5	158.6	162.8	38.3
2.30	167.1	171.5	175.9	180.4	185.0*	189.2	193.5	197.8	202.2	206.7	44.2
2.40	211.3	216.0	220.8	225.3	230.1	235.0	239.9	244.9	250.0*	255.0	48.7
2.50	260.0	265.1	270.3	275.6	280.9	286.3	291.7	297.2	302.8	308.5	54.2
2.60	314.2	320.0	325.9	331.9	337.9	343.9	350.0*	356.3	362.6	368.9	59.0
2.70	372.2	377.8	383.5	389.3	395.1	401.0	407.0	412.9	419.0	425.1	59.0
2.80	431.2	437.4	443.7	450.0*	456.3	462.6	469.0	475.5	482.0	488.5	64.0
2.90	495.2	501.8	508.5	515.3	522.1	529.0	536.0	543.0	550.0*	555.9	66.6
3.00	561.8	567.7	573.7	579.7	585.7	591.8	597.9	604.0	610.2	616.4	60.8
3.10	622.6	629.9	635.2	641.6	647.9	654.3	660.7	667.2	673.7	680.2	64.2
3.20	686.8	693.4	700.0*	706.3	712.7	719.1	725.5	732.0	738.5	745.0	64.7
3.30	751.5	758.1	764.7	771.3	777.9	784.6	791.3	798.1	804.8	811.6	67.0
3.40	818.3	825.3	832.2	839.1	846.0	853.0	860.0*	866.3	873.0	879.6	67.6
3.50	886.1	892.7	899.3	906.0	912.6	919.3	926.0	932.7	939.5	946.2	66.9
3.60	953.0	959.5	966.7	973.9	980.4	987.5	994.2	1001	1008	1015	69
3.70	1022	1029	1036	1043	1050	1058	1065	1072	1079	1086	71
3.80	1093	1101	1108	1115	1123	1130*	1137	1143	1150	1157	70
3.90	1165	1170	1177	1183	1190	1197	1204	1210	1217	1224	68
4.00	1231	1238	1245	1251	1258	1265	1272	1279	1286	1293	69
4.10	1300*	1307	1313	1320	1327	1334	1340	1347	1354	1361	68
4.20	1368	1375	1381	1388	1395	1402	1409	1416	1423	1430	69
4.30	1437	1444	1451	1458	1465	1472	1479	1486	1493	1500*	69
4.40	1506	1513	1519	1525	1531	1538	1544	1550	1557	1563	63
4.50	1569	1576	1582	1588	1595	1601	1608	1614	1620	1627	64
4.60	1633	1640	1646	1652	1659	1665	1672	1678	1685	1691	65
4.70	1698	1704	1711	1717	1724	1730	1737	1743	1750*	1757	66
4.80	1764	1771	1778	1785	1792	1799	1806	1813	1820	1827	70
4.90	1834	1841	1848	1855	1862	1870	1877	1884	1891	1898	71

Plate No. 7-5
Sheet 1 of 3

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

EXPANDED RATING TABLE — PROCESS DATE: 22-JUL-88 13:45 DPM — R 40 14.0

03225500 — OLENTANGY R NR DELAWARE OH — TYPE LOG [OFFSET=(1.10, 1.00) (0.00, 0.00)]

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH GH
5.00	1905	1912	1919	1927	1934	1941	1948	1955	1963	1970	72
5.10	1977	1984	1992	1999	2006	2013	2021	2028	2035	2043	73
5.20	2050*	2057	2063	2070	2076	2083	2089	2096	2102	2109	65
5.30	2115	2122	2129	2135	2142	2148	2155	2162	2168	2175	66
5.40	2181	2188	2195	2201	2208	2214	2221	2228	2234	2241	67
5.50	2248	2254	2261	2268	2274	2281	2288	2295	2301	2308	67
5.60	2315	2321	2328	2335	2342	2348	2355	2362	2369	2375	67
5.70	2382	2389	2396	2402	2409	2416	2423	2430	2436	2443	68
5.80	2450*	2457	2463	2470	2477	2484	2490	2497	2504	2511	67
5.90	2517	2524	2531	2538	2544	2551	2558	2565	2571	2578	68
6.00	2585	2592	2599	2605	2612	2619	2626	2633	2640	2646	68
6.10	2653	2660	2667	2674	2681	2687	2694	2701	2708	2715	69
6.20	2722	2729	2736	2742	2749	2756	2763	2770	2777	2784	69
6.30	2791	2798	2805	2812	2818	2825	2832	2839	2846	2853	69
6.40	2860	2867	2874	2881	2888	2895	2902	2909	2916	2923	70
6.50	2930*	2937	2943	2950	2957	2963	2970	2977	2983	2990	67
6.60	2997	3003	3010	3017	3023	3030	3037	3043	3050	3057	67
6.70	3064	3070	3077	3084	3090	3097	3104	3111	3117	3124	67
6.80	3131	3138	3144	3151	3158	3164	3171	3178	3185	3192	67
6.90	3198	3205	3212	3219	3225	3232	3239	3246	3252	3259	68
7.00	3266	3273	3280	3286	3293	3300	3307	3314	3320	3327	68
7.10	3334	3341	3348	3355	3361	3368	3375	3382	3389	3396	69
7.20	3402	3409	3416	3423	3430	3437	3444	3450	3457	3464	69
7.30	3471	3478	3485	3492	3499	3506	3512	3519	3526	3533	69
7.40	3540*	3547	3554	3561	3568	3575	3581	3588	3595	3602	70
7.50	3610	3617	3624	3631	3638	3646	3654	3661	3669	3676	66
7.60	3684	3691	3699	3707	3715	3722	3730	3737	3745	3753	76
7.70	3760	3768	3776	3783	3791	3799	3807	3814	3822	3830	77
7.80	3837	3845	3853	3860	3868	3876	3884	3891	3899	3907	77
7.90	3914	3922	3930	3937	3945	3953	3961	3968	3976	3984	78
8.00	4000*	4008	4017	4025	4034	4042	4051	4059	4068	4076	85
8.10	4085	4093	4102	4110	4119	4127	4136	4145	4153	4162	86
8.20	4170	4179	4187	4196	4205	4213	4222	4230	4239	4248	86
8.30	4256	4265	4273	4282	4291	4299	4308	4317	4325	4334	87
8.40	4343	4351	4360	4369	4378	4386	4395	4404	4412	4421	87
8.50	4430	4439	4447	4456	4465	4474	4482	4491	4500*	4511	92
8.60	4522	4533	4544	4555	4566	4577	4588	4599	4610	4621	110
8.70	4632	4643	4654	4665	4677	4688	4699	4710	4721	4733	112
8.80	4744	4755	4766	4777	4789	4800*	4812	4824	4835	4847	115
8.90	4859	4871	4883	4896	4908	4919	4930	4942	4954	4966	119
9.00	4978	4990	5002	5014	5026	5038	5050	5062	5074	5086	120
9.10	5098	5110	5122	5135	5147	5159	5171	5183	5196	5208	122

Plate No. 7-5
Sheet 2 of 3

RT 14.0 UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY - WATER RESOURCES DIVISION

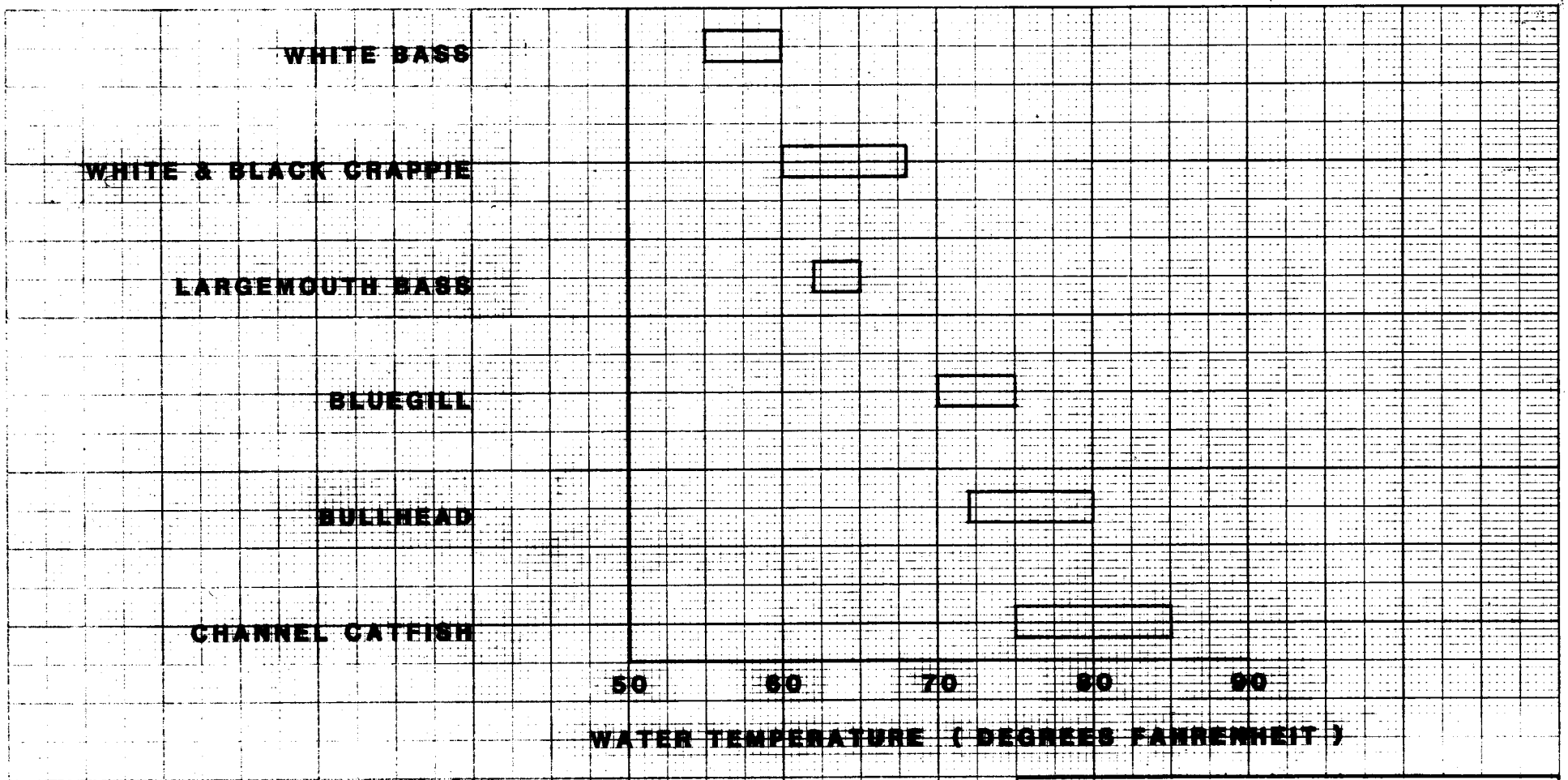
EXPANDED RATING TABLE PROCESS DATE: 22-JUL-88 13:46 DFM RATING NO 14.0

03225500 OLENTANGY R NR DELAWARE OH TYPE LOG [OFFSET=(1.10, 1.00) (0.00, 0.00)]

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH GH
9.20	5220*	5236	5252	5269	5285	5301	5318	5334	5351	5367	163
9.30	5383	5400	5417	5433	5450	5466	5483	5500	5516	5533	167
9.40	5550*	5569	5588	5607	5627	5646	5665	5684	5704	5723	193
9.50	5743	5762	5782	5801	5821	5841	5860	5880	5900*		

Plate No. 7-5
Sheet 3 of 3

K+E 20 X 20 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.



NOTE: MOST SPAWNING OCCURS DURING APRIL, MAY, AND JUNE

OLENTANGY RIVER
OHIO

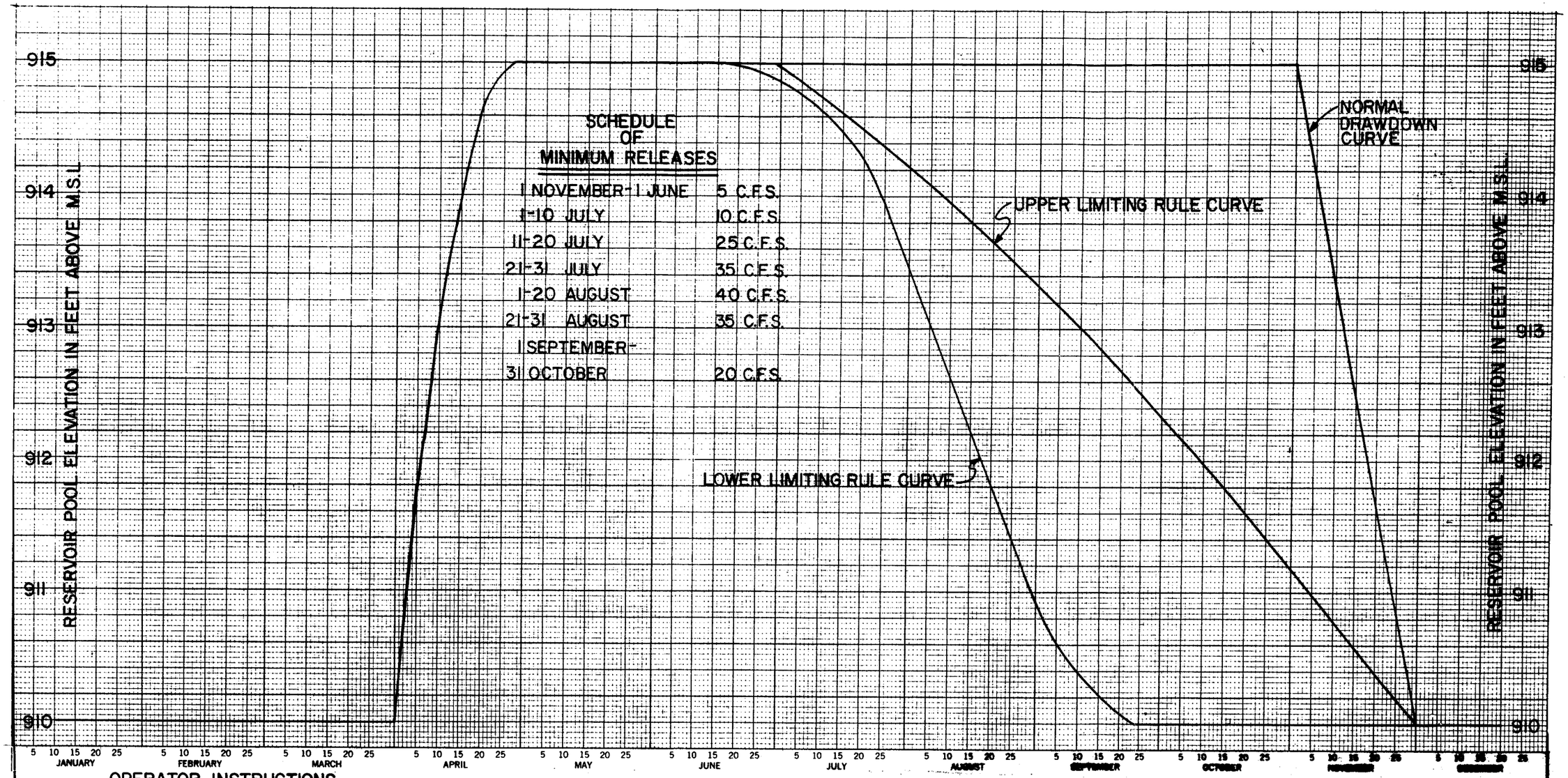
DELAWARE LAKE PROJECT

FISH SPAWNING SCHEDULE

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

HUNTINGTON, W.V. JANUARY 1988

Plate No. 7-6



OPERATOR INSTRUCTIONS

1. A MINIMUM OUTFLOW OF 5 C.F.S. WILL BE MAINTAINED AT ALL TIMES.
2. FROM 1 DEC. TO 31 MAR., POOL ELEVATION 910 FEET WILL BE MAINTAINED SUBJECT TO MINIMUM FLOW AND FLOOD CONTROL OPERATION.
3. NORMALLY A SPECIAL DIRECTIVE WILL BE ISSUED TO BEGIN RAISING POOL LEVEL ABOUT 1 APR. TO ELEVATION 915.0 FEET.
4. POOL ELEVATION 915.0 IS TO BE MAINTAINED UNTIL FALL DRAWDOWN SUBJECT TO AUGMENTATION FLOWS LISTED ABOVE, FLOOD CONTROL OPERATION, SPECIAL DIRECTIVE, OR DROUGHT. IF POOL LEVEL FALLS TO THE LOWER LIMITING RULE CURVE, H&H WILL ISSUE SPECIAL DIRECTIVES AS NECESSARY SPECIFYING RATE OF DISCHARGE.
5. AFTER LABOR DAY H&H BRANCH WILL ASSESS ANTICIPATED HYDROLOGIC CONDUCTIONS AND DETERMINE WHETHER TO MAINTAIN 915.0 ELEVATION UNTIL 1 NOV. FOR RECREATIONAL ADVANTAGE OR TO DRAWDOWN EARLY TO BENEFIT LESS THAN NORMAL CONDUCTIONS DOWNSTREAM.

MUSKINGUM RIVER
OHIO

DELAWARE LAKE

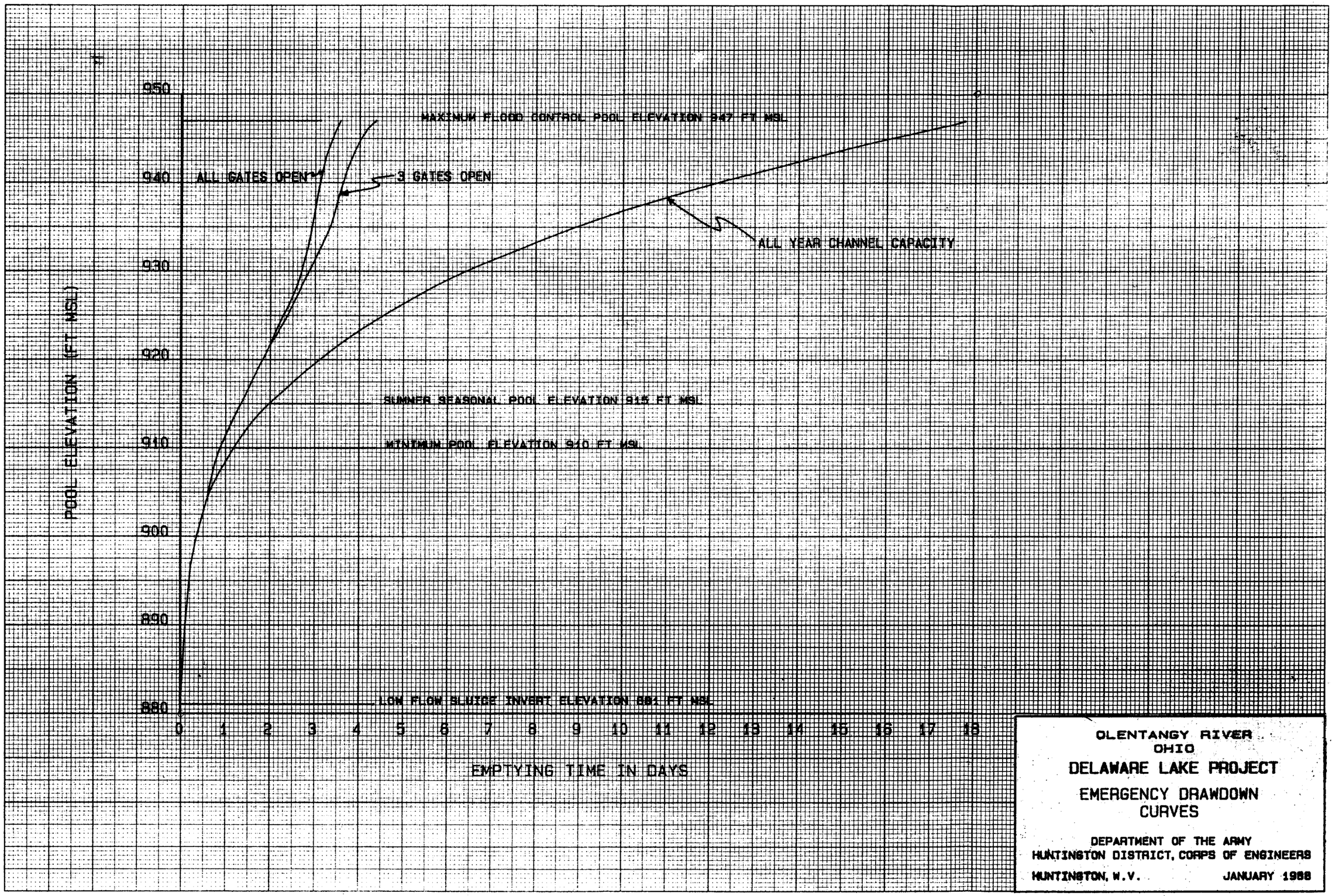
RULE CURVES FOR RESERVOIR REGULATION

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON W. VA. JULY 1968

Plate No. 7-7

47 1240

K•E 20 x 20 TO THE INCH • 10 X 15 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.



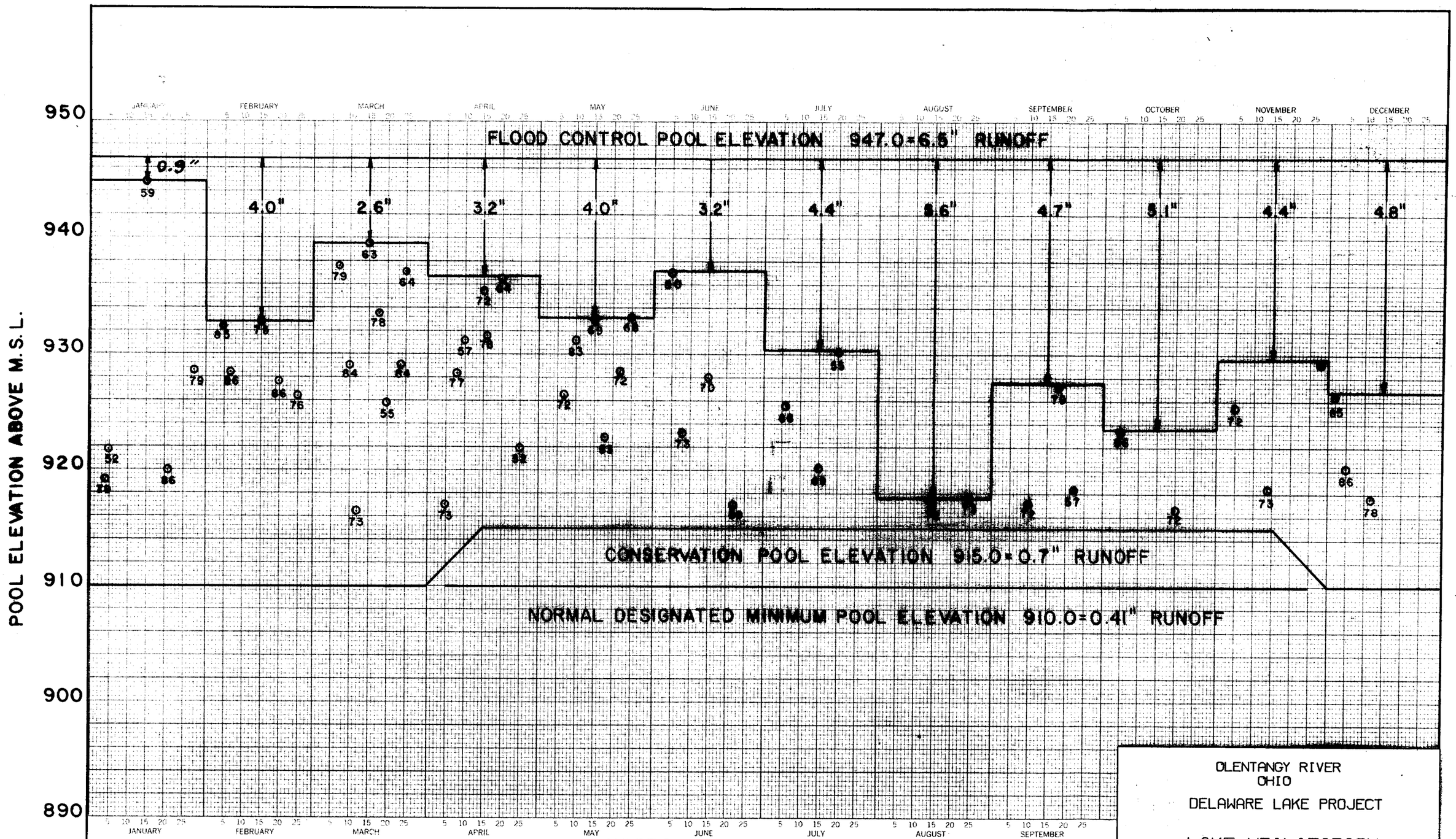
OLENTANGY RIVER
OHIO

DELAWARE LAKE PROJECT

EMERGENCY DRAWDOWN CURVES

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V. JANUARY 1988

Plate No. 7-8



NOTES

(1) DRAINAGE AREA = 386 SQ MI
(2) ONE INCH RUNOFF = 20,300 AC FT.
(3) PERIOD OF RECORD: 1952- 1986
(4) o CREST POOL ELEVATION OF A RISE AND YEAR (1959) IN WHICH IT OCCURED

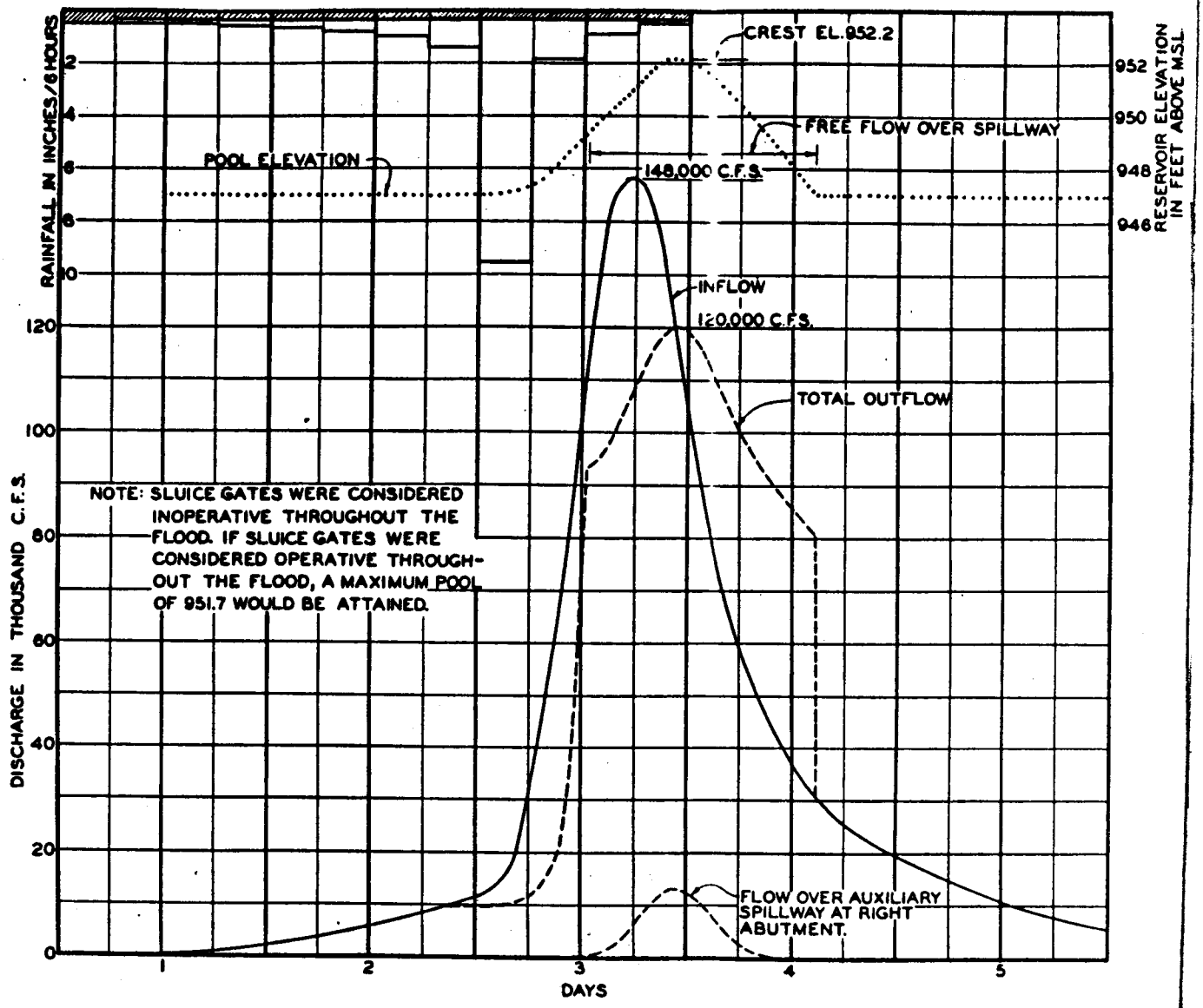
OLENTANGY RIVER
OHIO

DELAWARE LAKE PROJECT

LAKE UTILIZATION

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT. CORPS OF ENGINEERS
HUNTINGTON W. VA. APRIL 1988

Plate No. 7-9



OLENTANGY RIVER
OHIO

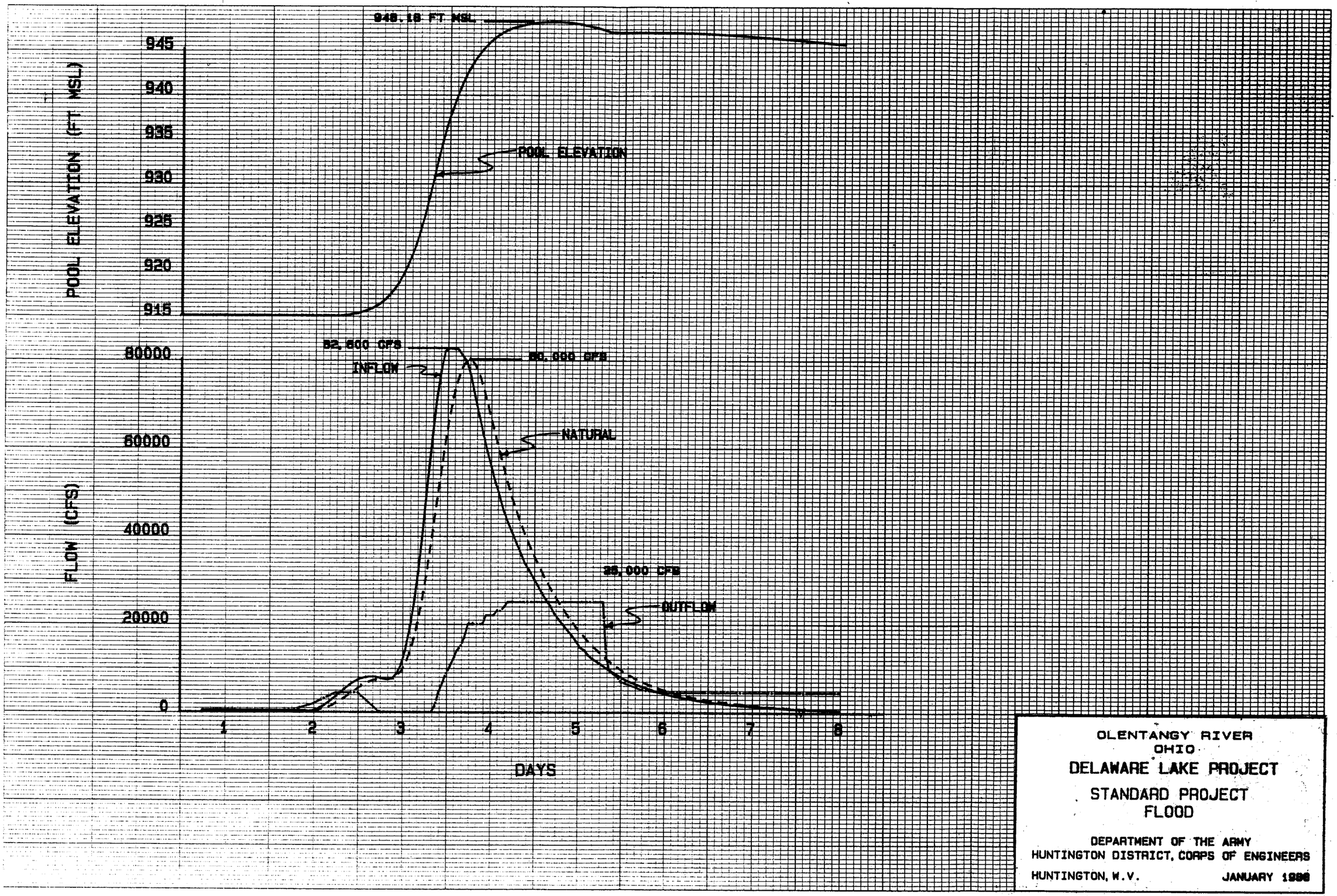
DELAWARE LAKE

SPILLWAY DESIGN FLOOD

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT. CORPS OF ENGINEERS
HUNTINGTON W. VA. APRIL 1938

Plate No. 8-1

47 1970



OLENTANGY RIVER
OHIO

DELAWARE LAKE PROJECT

STANDARD PROJECT
FLOOD

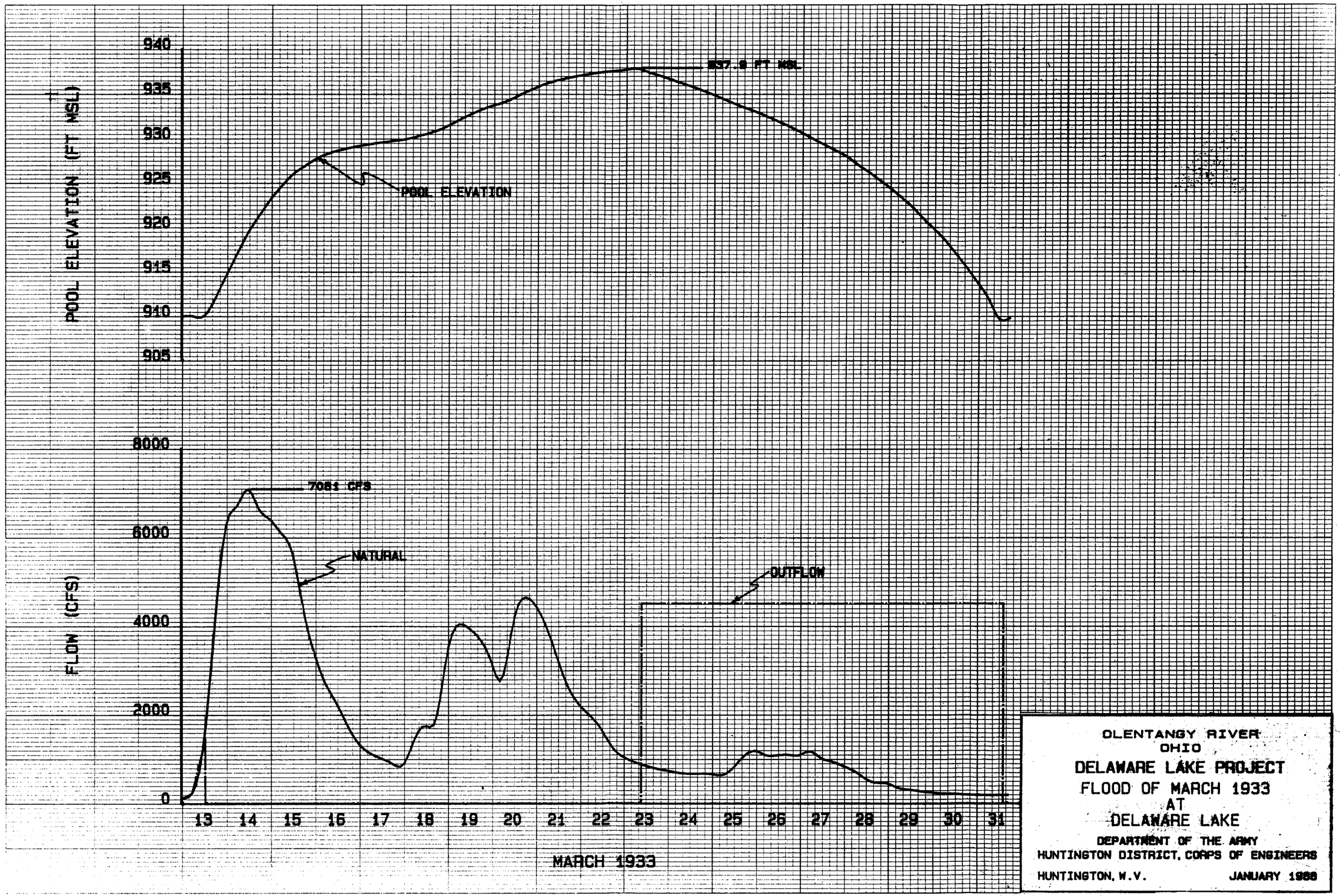
DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V. JANUARY 1966

Plate No. 8-2

K+E 12 x 20 TO THE INCH • 10 x 15 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

47 1970

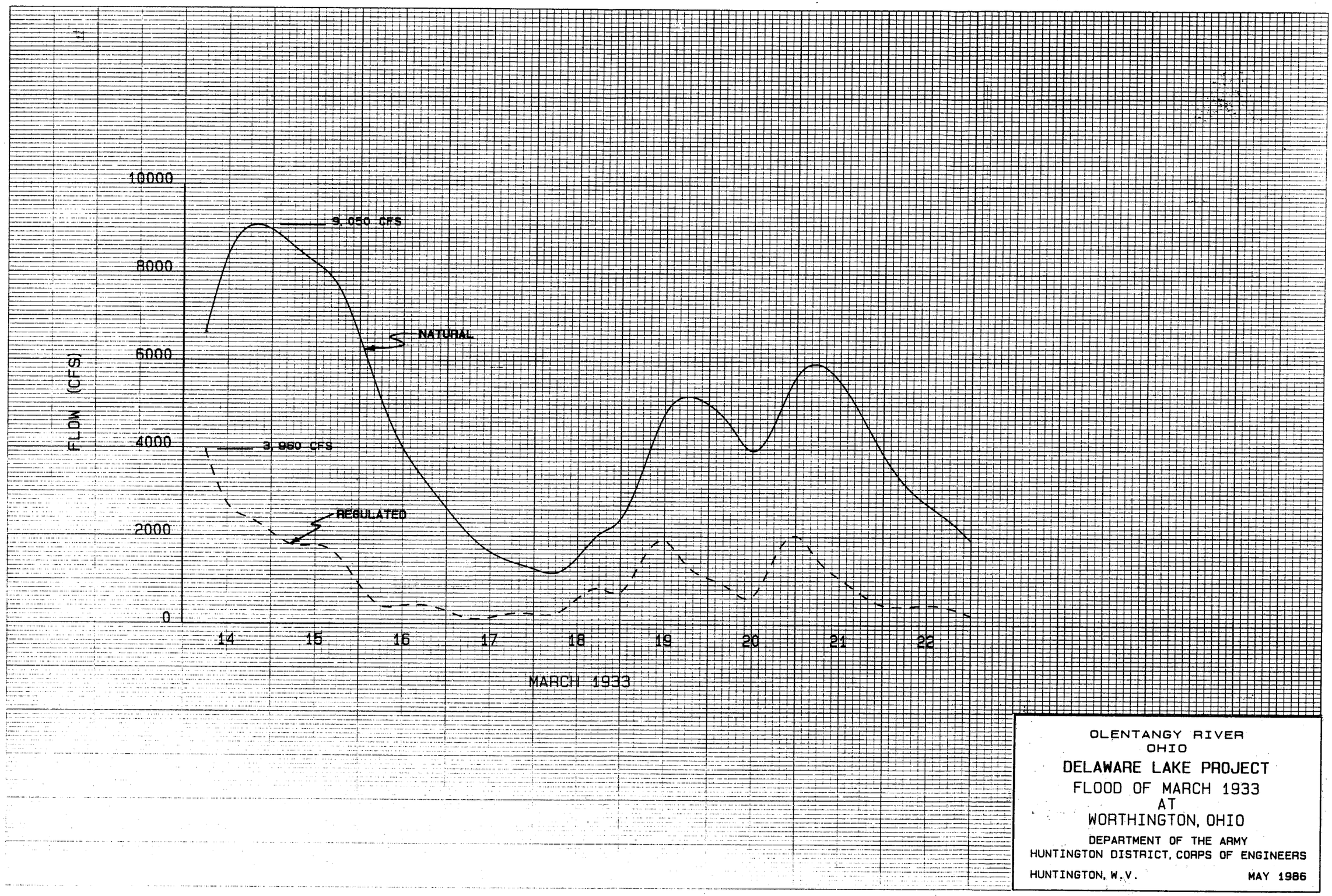
K+E 12 x 20 TO THE INCH • 10 x 15 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.



OLENTANGY RIVER
OHIO
DELAWARE LAKE PROJECT
FLOOD OF MARCH 1933
AT
DELAWARE LAKE
DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V. JANUARY 1988

Plate No. 8-3

47 1970



OLENTANGY RIVER
OHIO

DELAWARE LAKE PROJECT

FLOOD OF MARCH 1933
AT
WORTHINGTON, OHIO

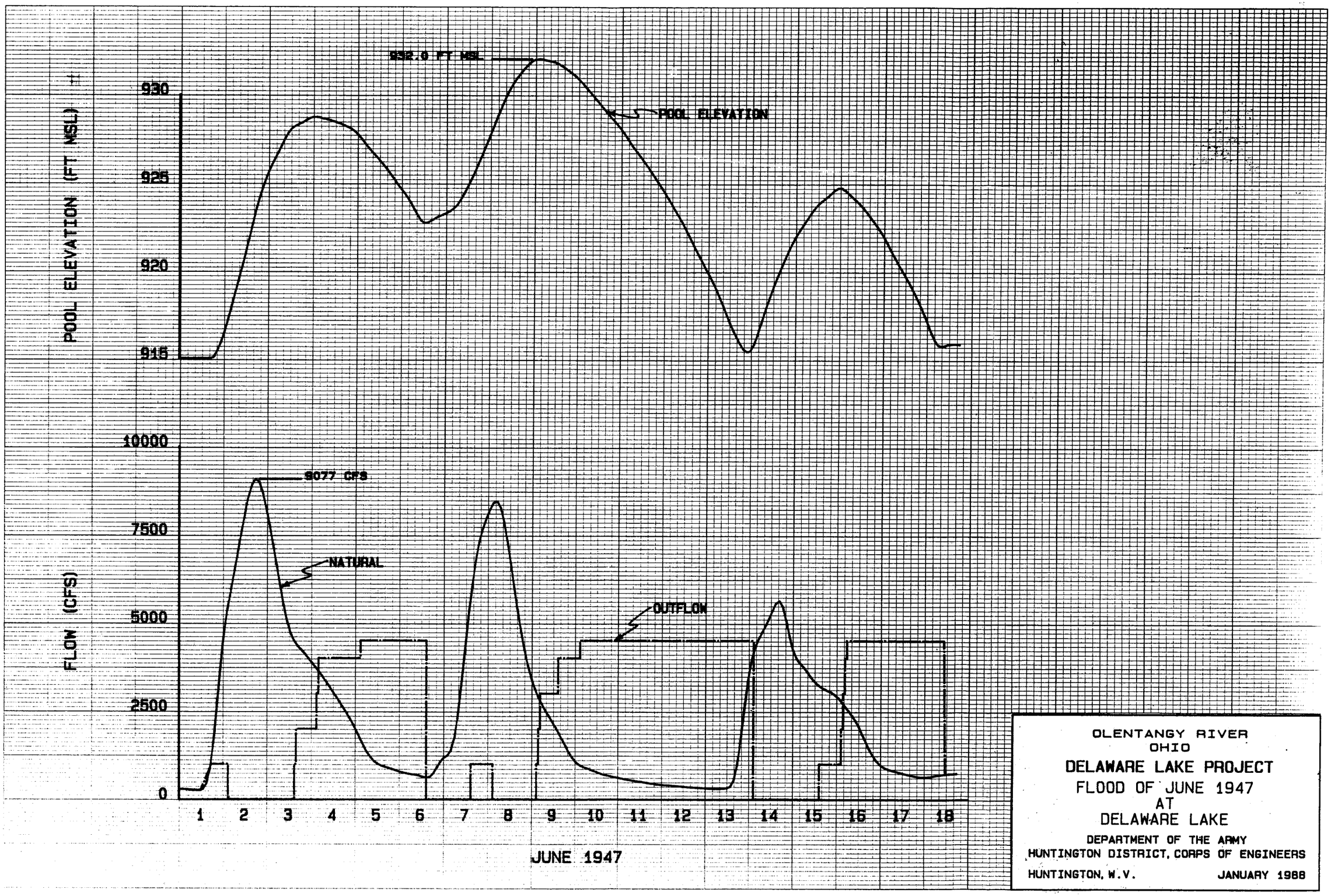
DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V. MAY 1986

K+E 12 x 20 TO THE INCH • 10 x 15 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

Plate No. 8-4

47 1970

K+E 12 x 20 TO THE INCH • 10 X 15 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.



OLENTANGY RIVER
OHIO

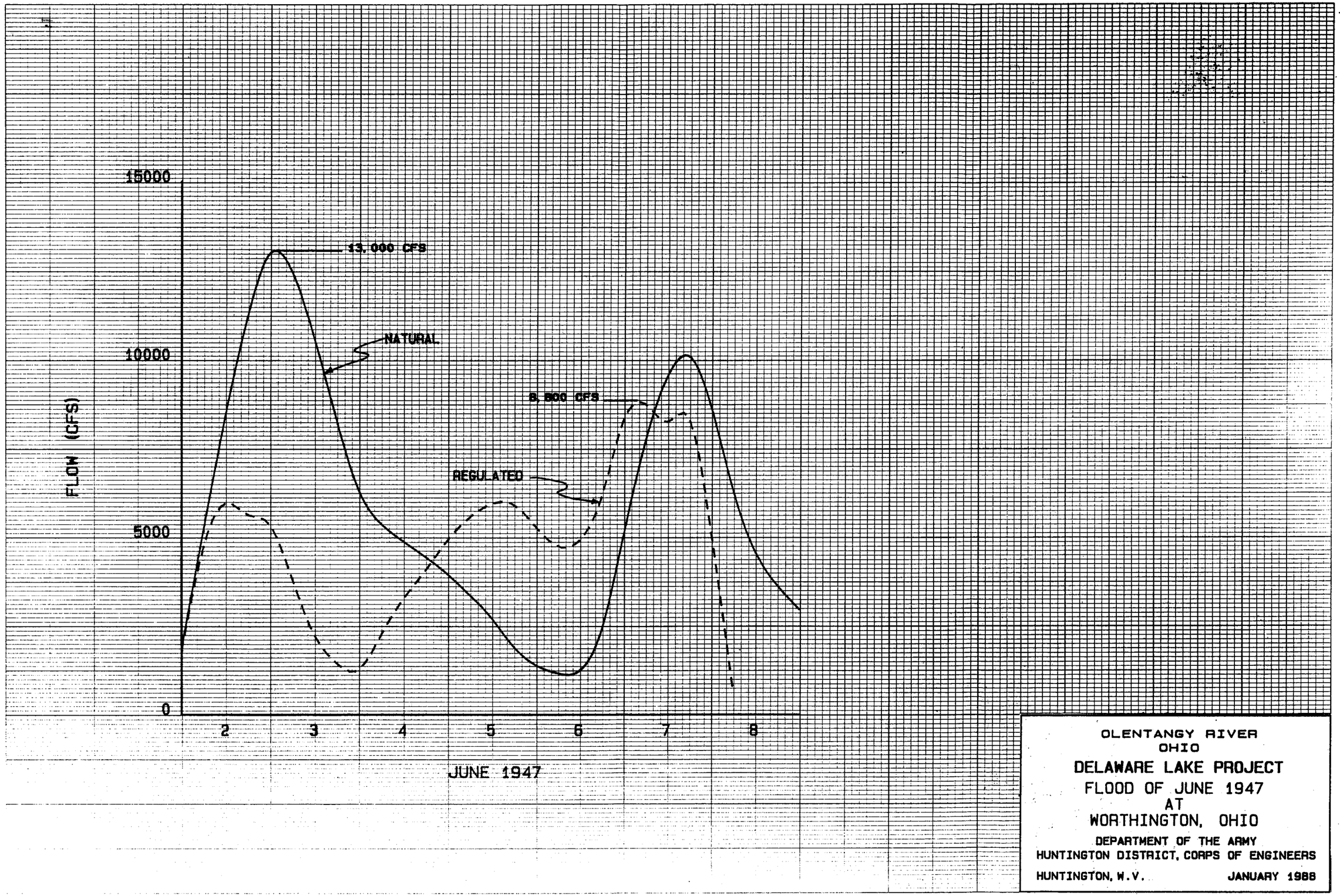
DELAWARE LAKE PROJECT

FLOOD OF JUNE 1947
AT
DELAWARE LAKE

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V. JANUARY 1988

Plate No. 8-5

47 1970



OLENTANGY RIVER
OHIO

DELAWARE LAKE PROJECT

FLOOD OF JUNE 1947
AT
WORTHINGTON, OHIO

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS

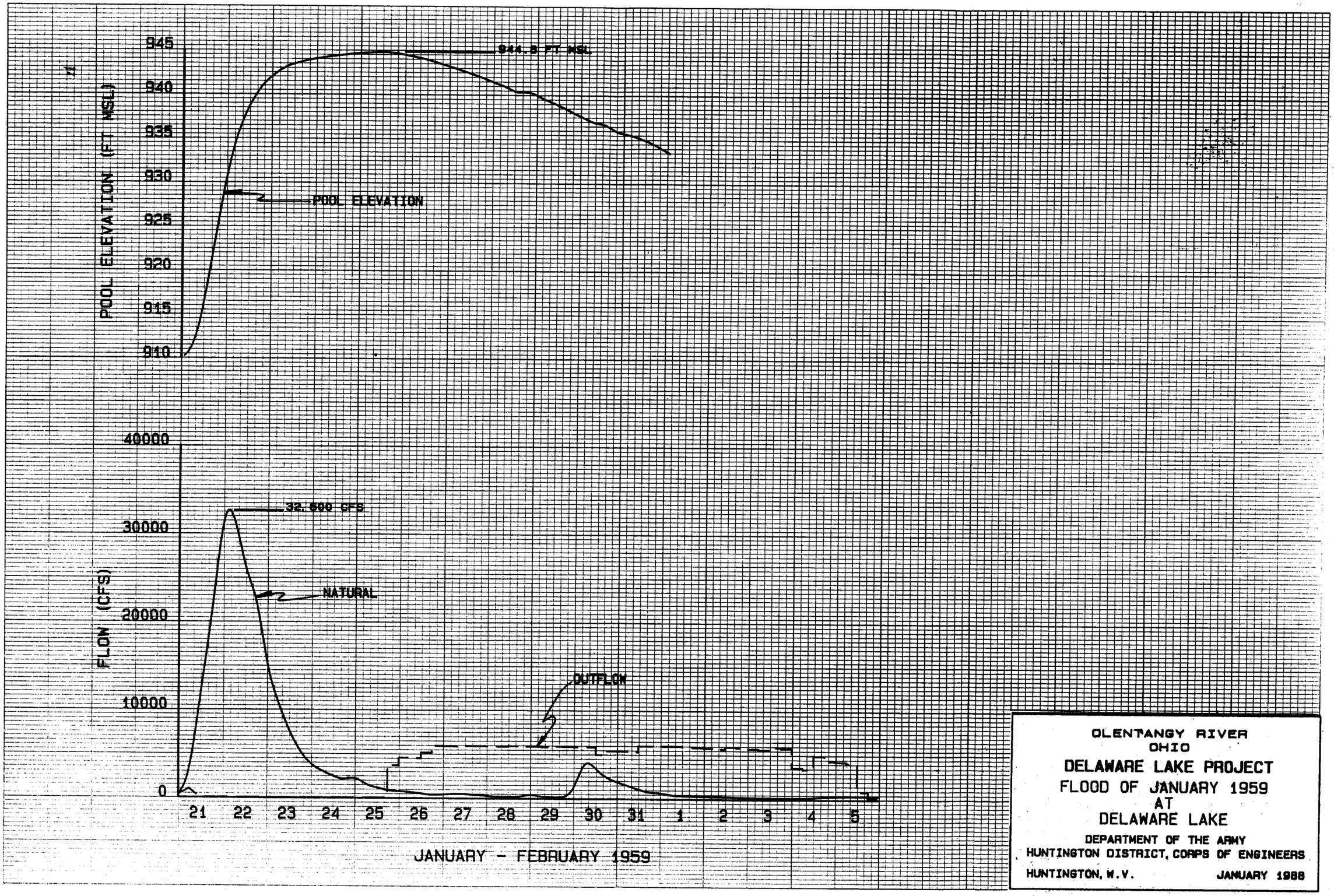
HUNTINGTON, W.V. JANUARY 1988

Plate No. 8-6

K+E 12 X 20 TO THE INCH • 10 X 15 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

47 1970

K+E 12 x 20 TO THE INCH • 10 x 15 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.



OLENTANGY RIVER
OHIO

DELAWARE LAKE PROJECT

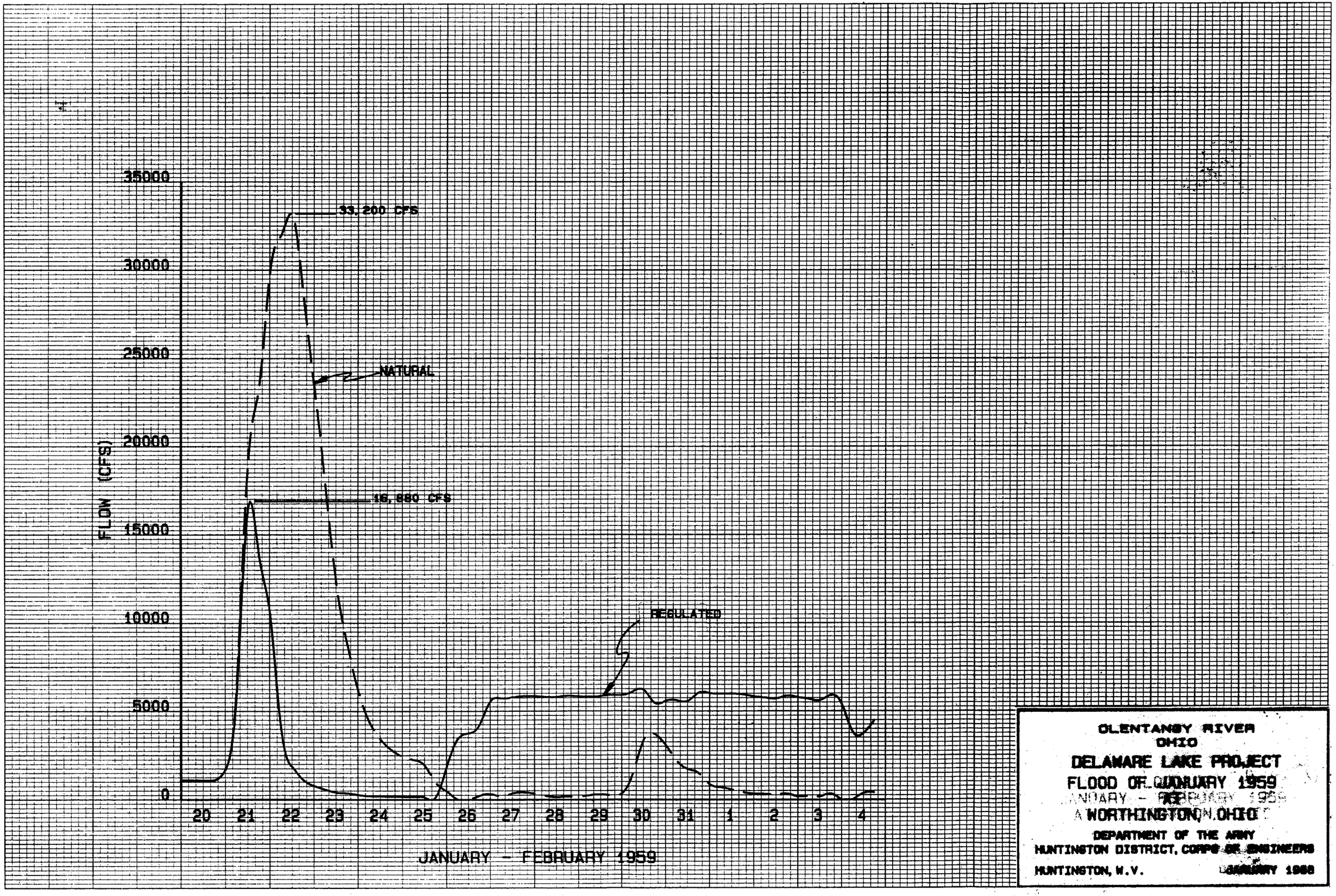
FLOOD OF JANUARY 1959
AT
DELAWARE LAKE

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V. JANUARY 1988

Plate No. 8-7

47 1970

K+E 12 x 20 TO THE INCH • 10 x 15 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

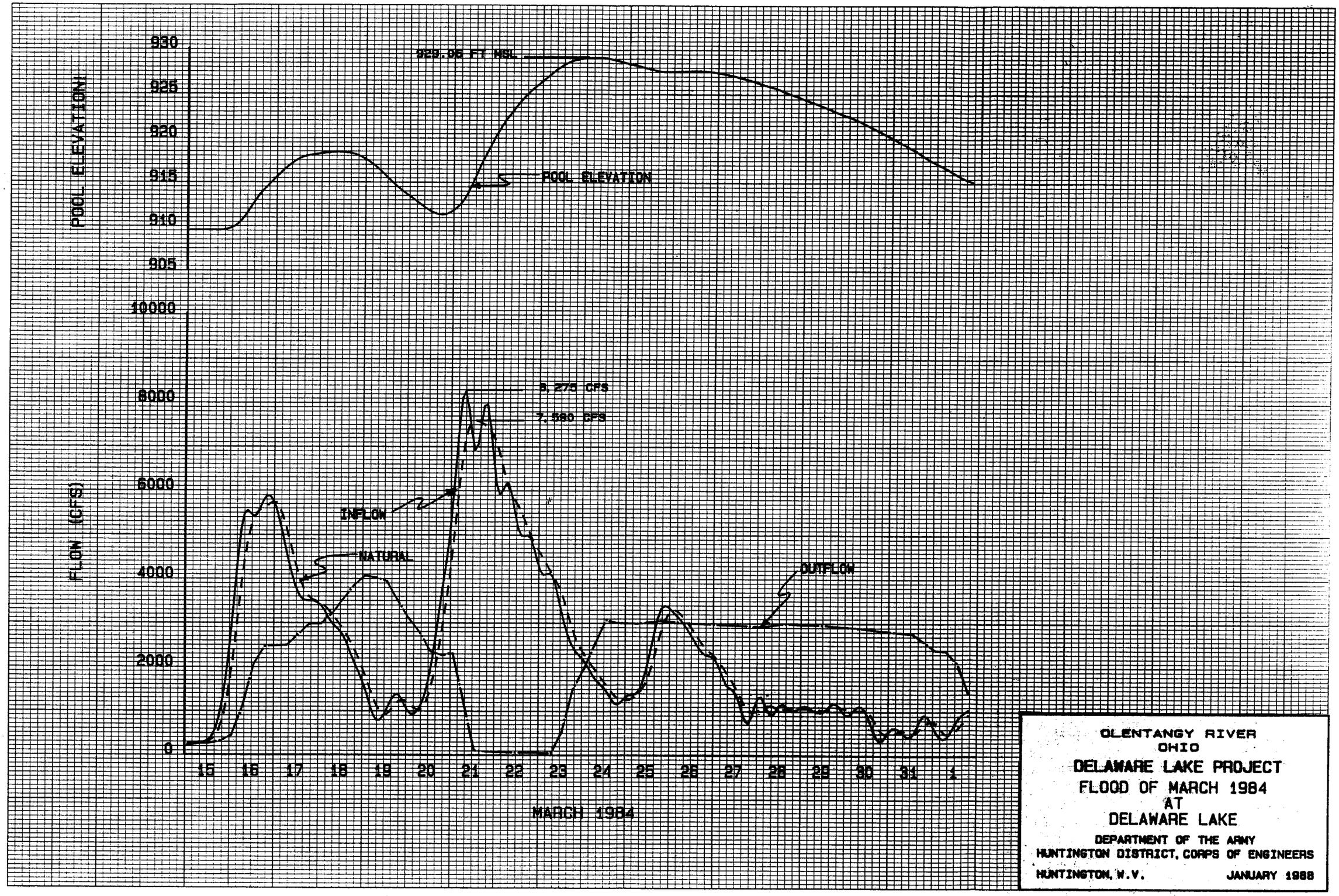


OLENTANGY RIVER
OHIO
DELAWARE LAKE PROJECT
FLOOD OF JANUARY 1959
JANUARY - FEBRUARY 1959
WORTHINGTON, OHIO
DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V. JANUARY 1960

Plate No. 8-8

47 1970

K•E 12 x 20 TO THE INCH • 10 X 15 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.



OLENTANGY RIVER
OHIO

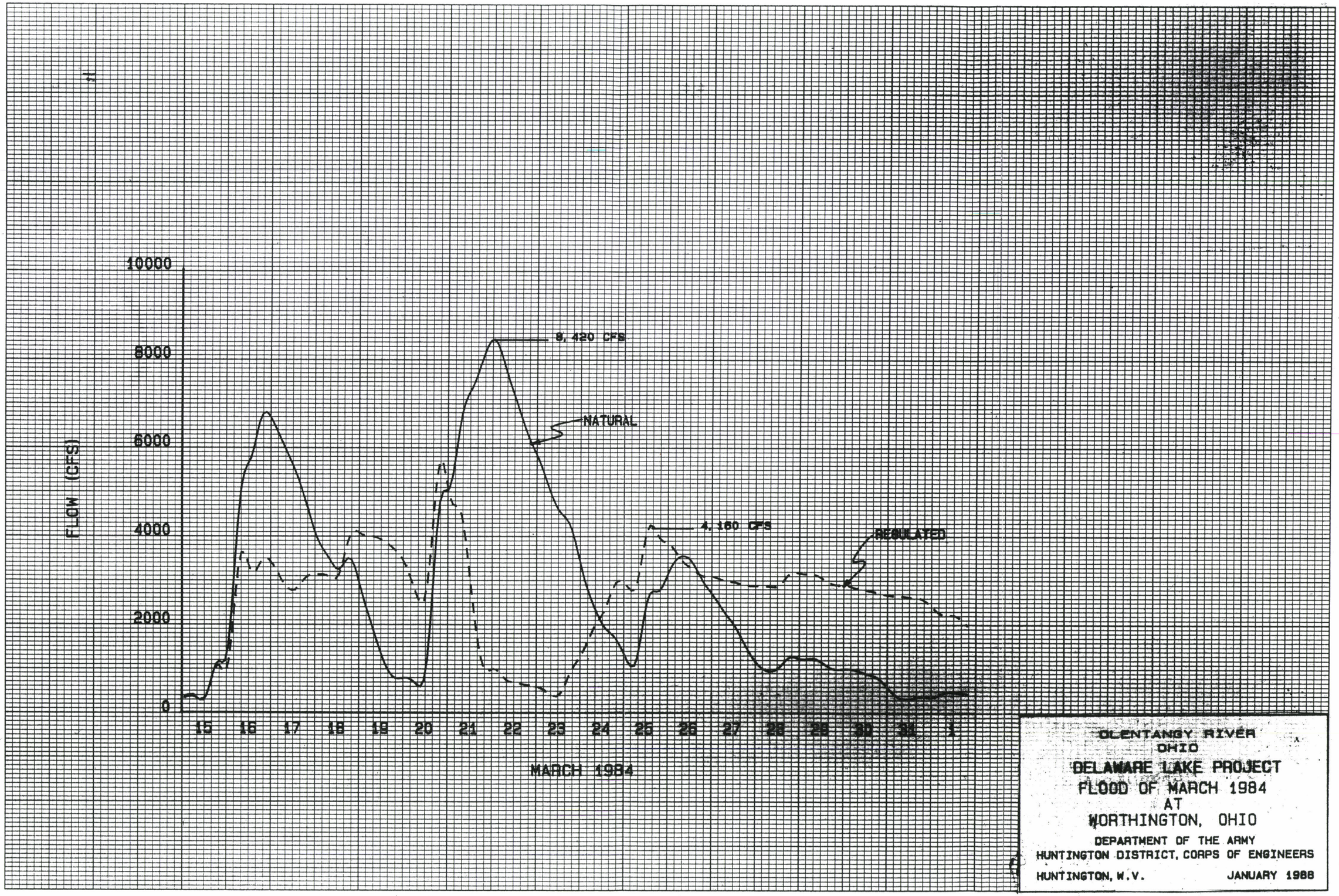
DELAWARE LAKE PROJECT
FLOOD OF MARCH 1984
AT
DELAWARE LAKE

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V. JANUARY 1988

Plate No. 8-9

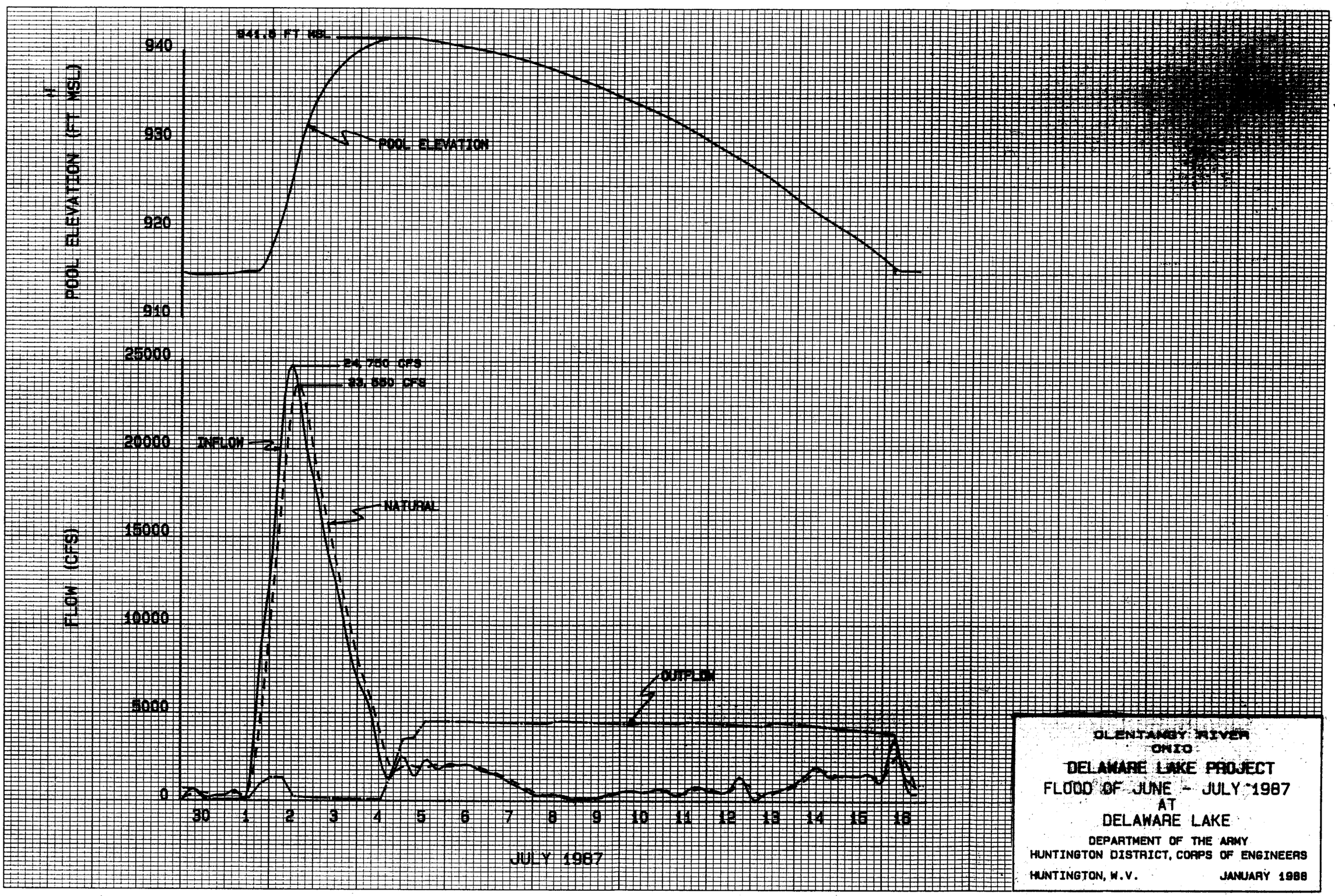
47 1970

K+E 12 x 20 TO THE INCH • 10 x 15 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.



OLENTANGY RIVER
OHIO
DELAWARE LAKE PROJECT
FLOOD OF MARCH 1984
AT
WORTHINGTON, OHIO
DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V. JANUARY 1988

Plate No. 8-10



OLENTANGY RIVER
OHIO

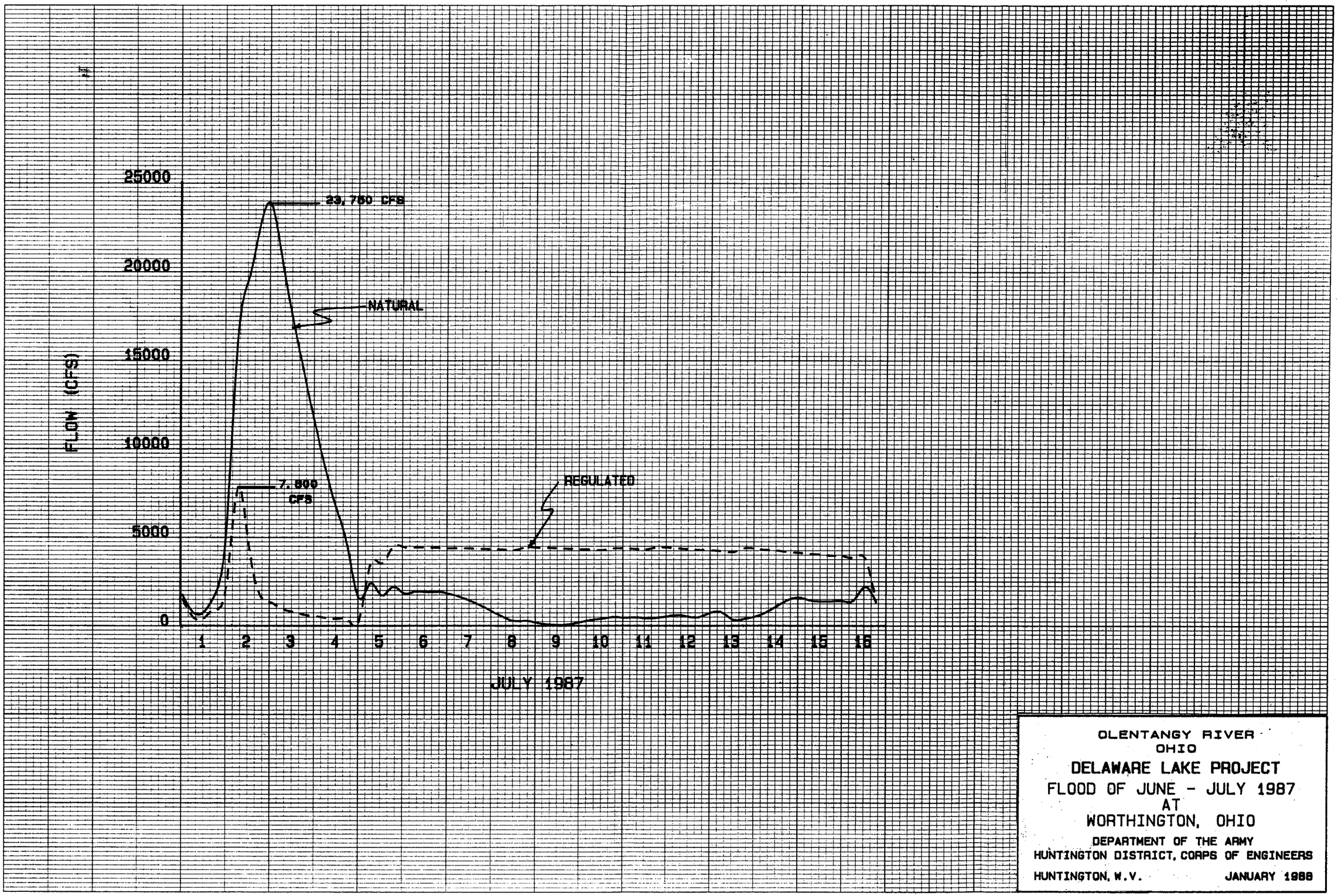
DELAWARE LAKE PROJECT
FLOOD OF JUNE - JULY 1987
AT
DELAWARE LAKE

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V. JANUARY 1988

Plate No. 8-11

47 1970
K+E 12 x 20 TO THE INCH • 10 X 15 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

47 1970



OLENTANGY RIVER
OHIO

DELAWARE LAKE PROJECT

FLOOD OF JUNE - JULY 1987
AT
WORTHINGTON, OHIO

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.V. JANUARY 1988

K+E 12 x 20 TO THE INCH • 10 x 15 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

Plate No. 8-12

Delaware Lake
Water Temperature
August 2, 1994

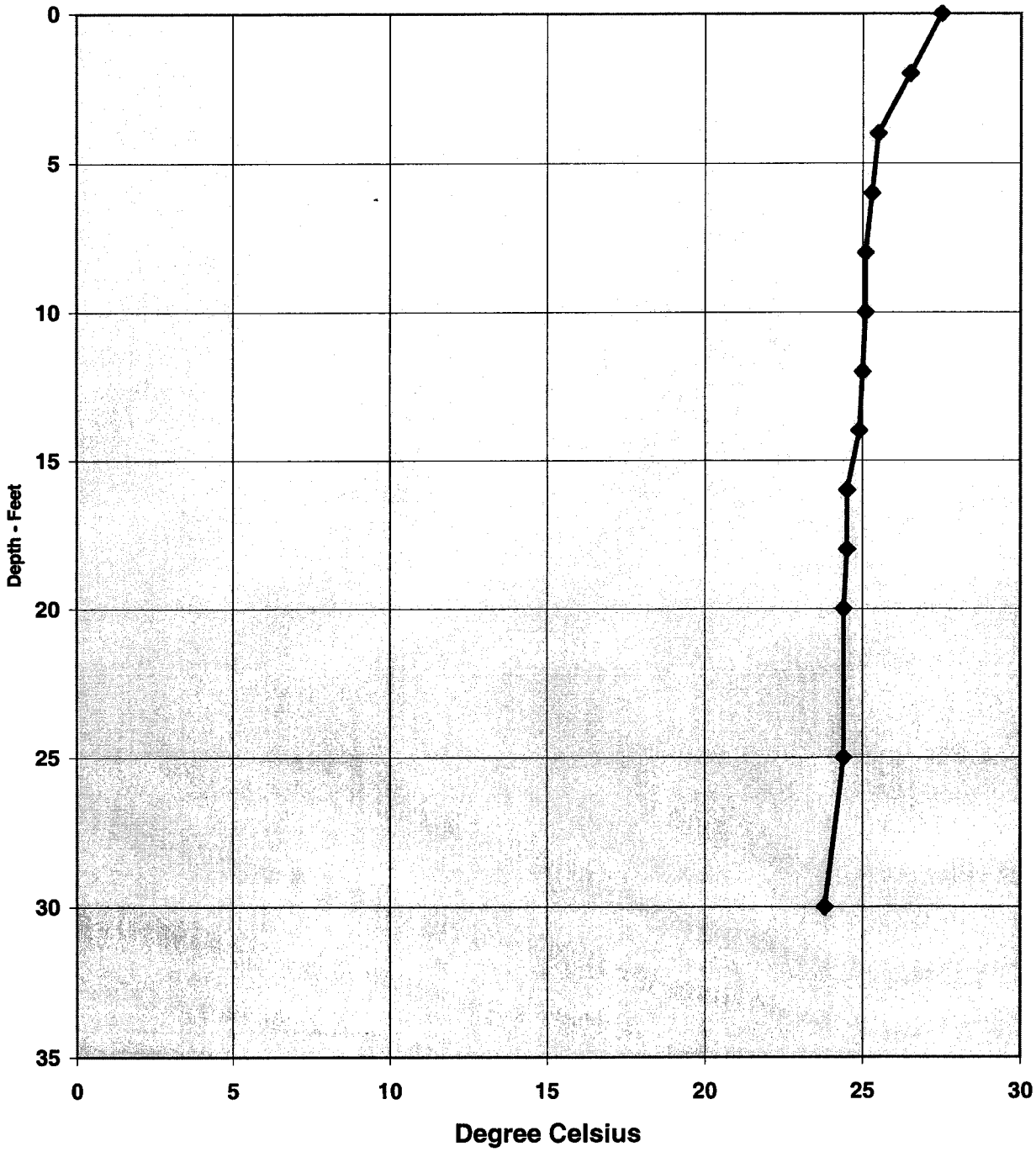


Plate No. 8-13

Delaware Lake
Dissolved Oxygen
August 2, 1994

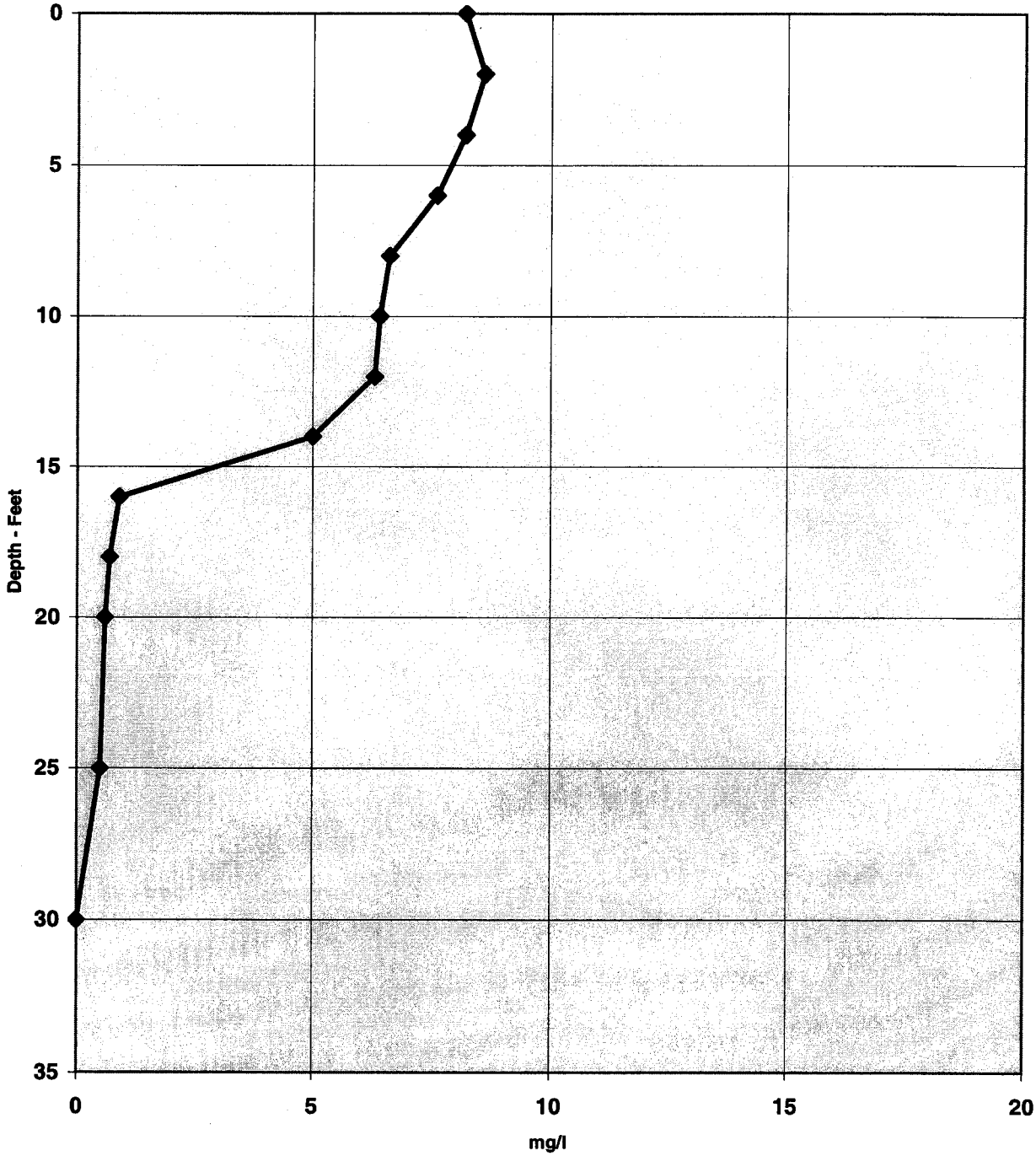


Plate No. 8-14

Delaware Lake
Total Iron
August 2, 1994

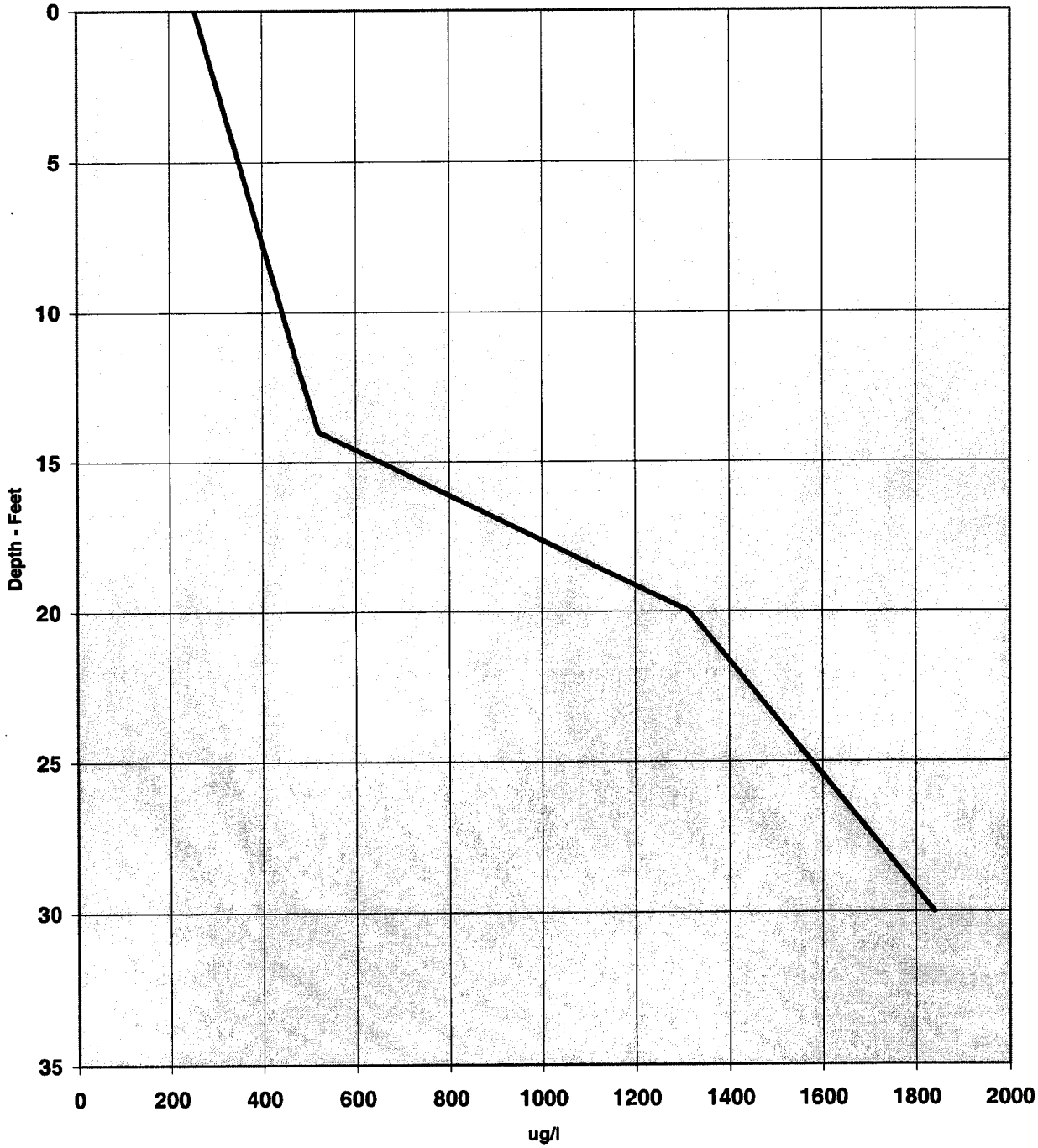


Plate No. 8-15

Delaware Lake
Total Manganese
August 2, 1994

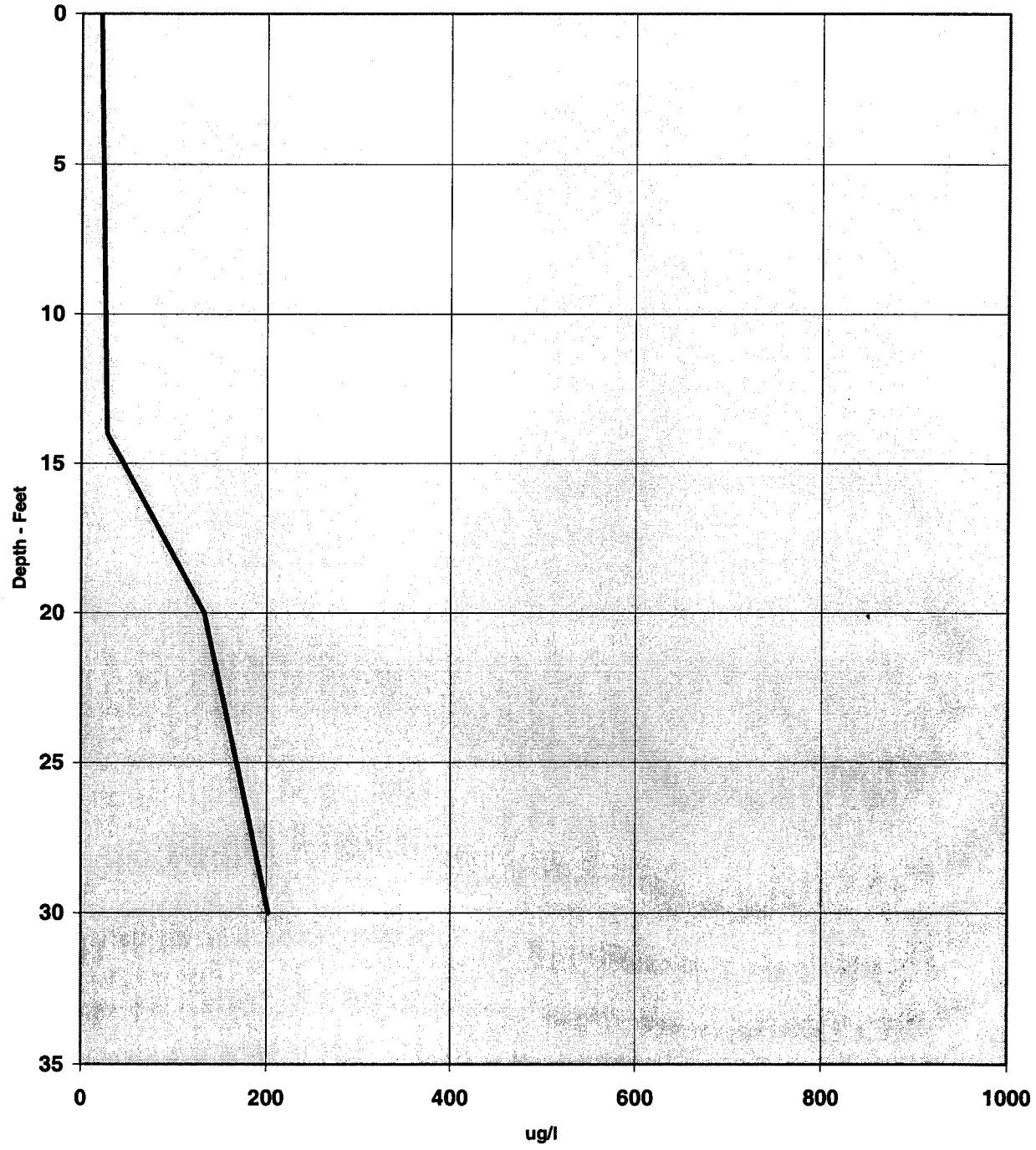


Plate No. 8-16

OVERALL QUALITY RATING

For Macroinvertebrate Stations
Delaware Lake, Ohio

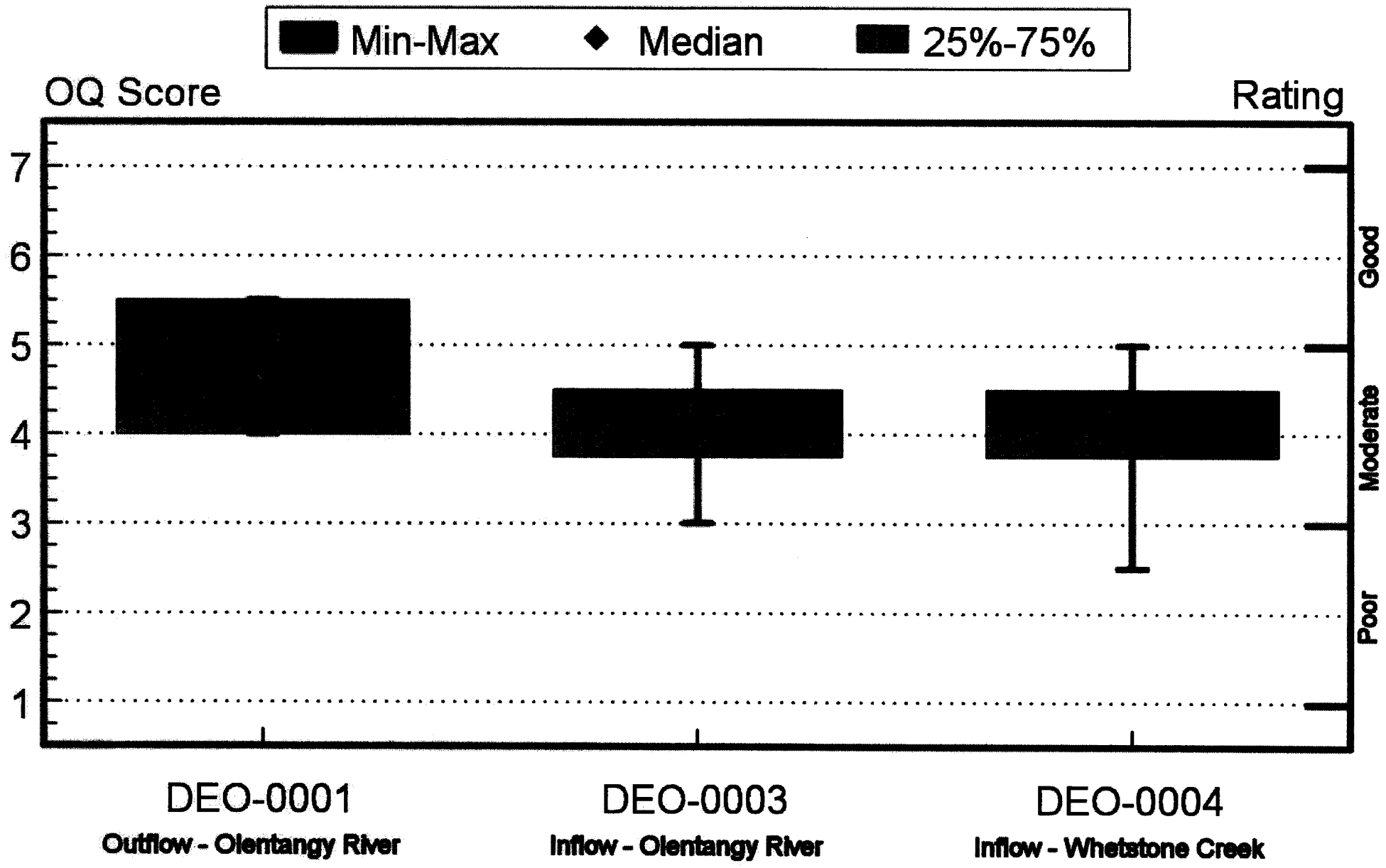
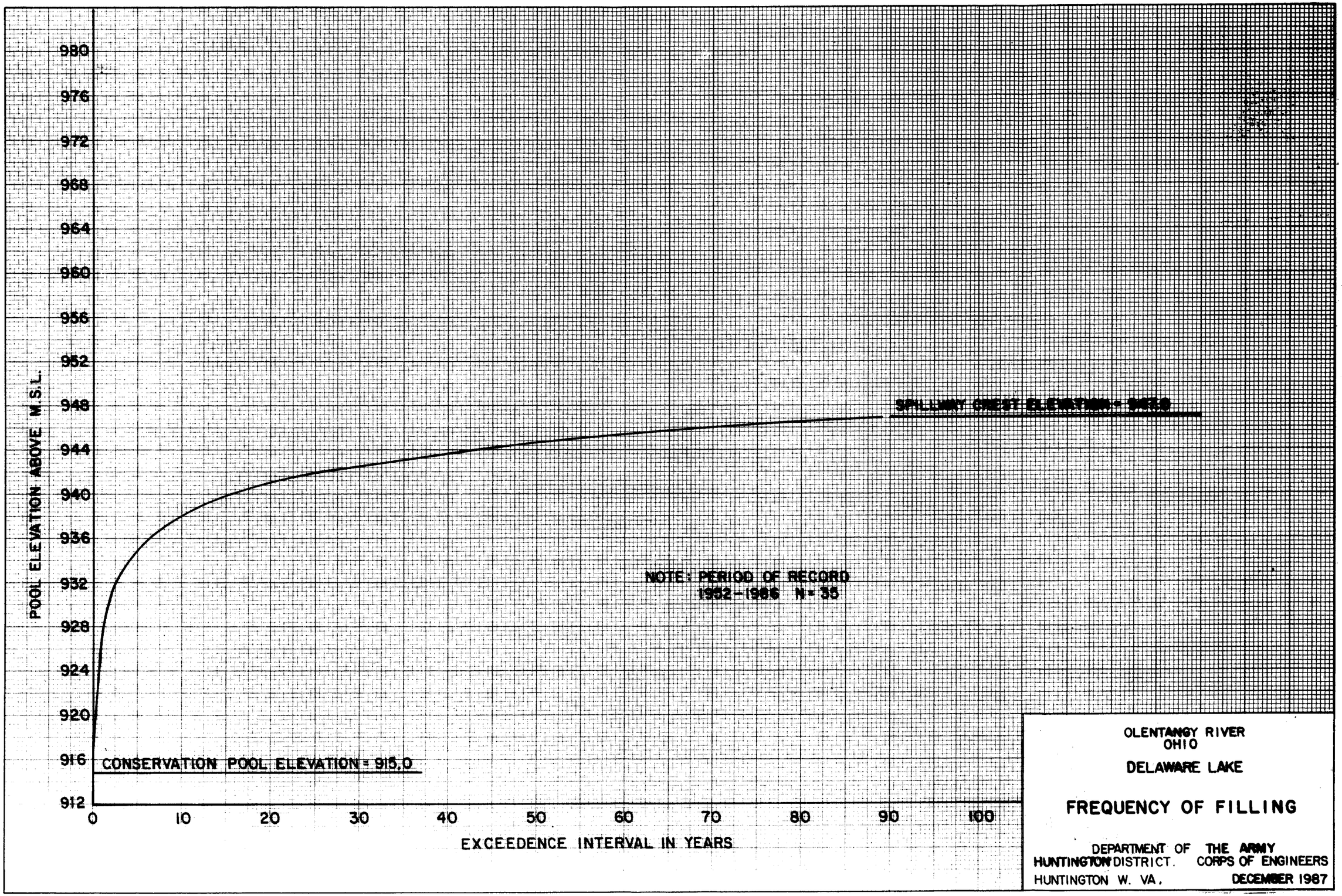


Plate No. 8-17



OLENTANGY RIVER
OHIO

DELAWARE LAKE

FREQUENCY OF FILLING

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

Plate No. 8-18

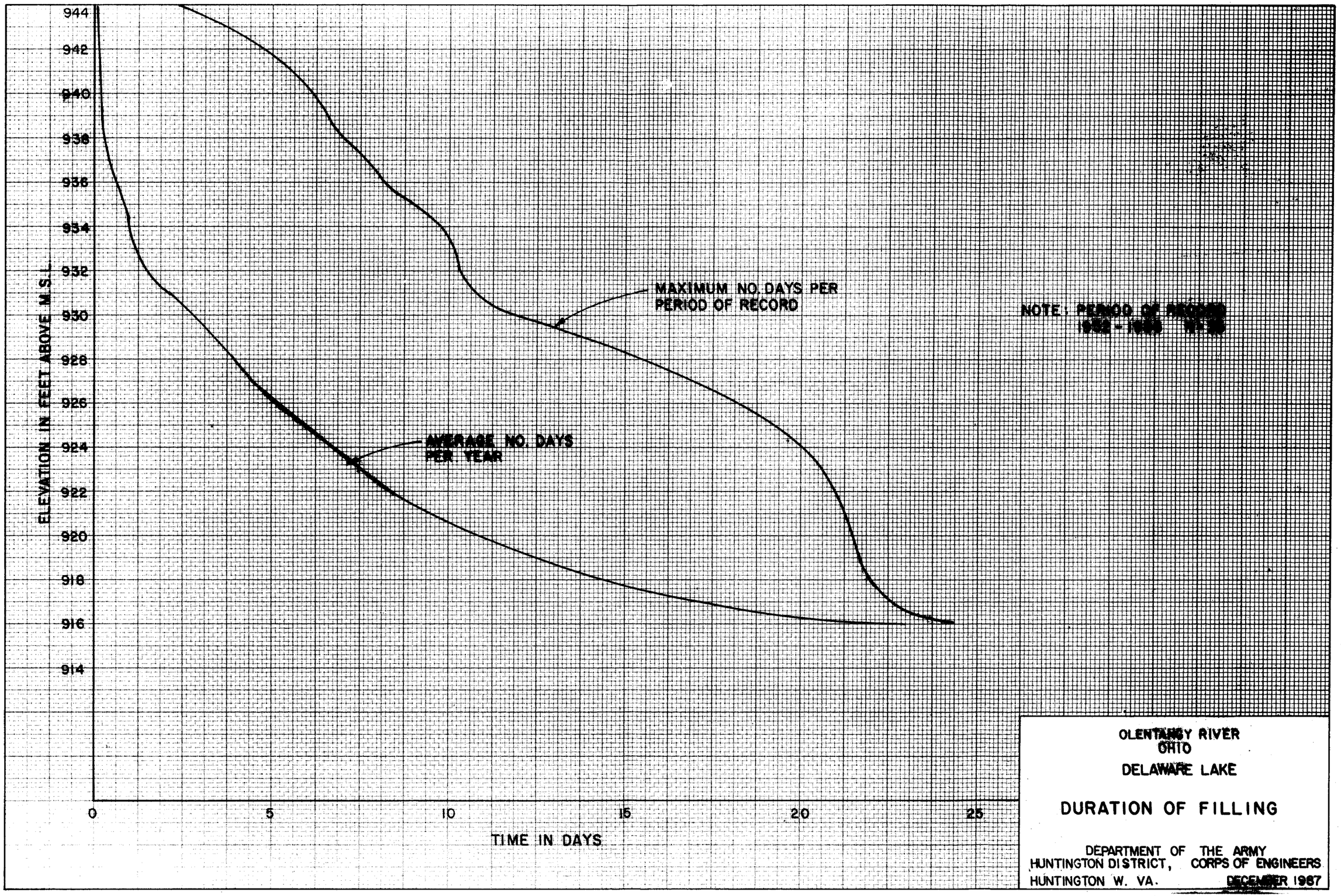
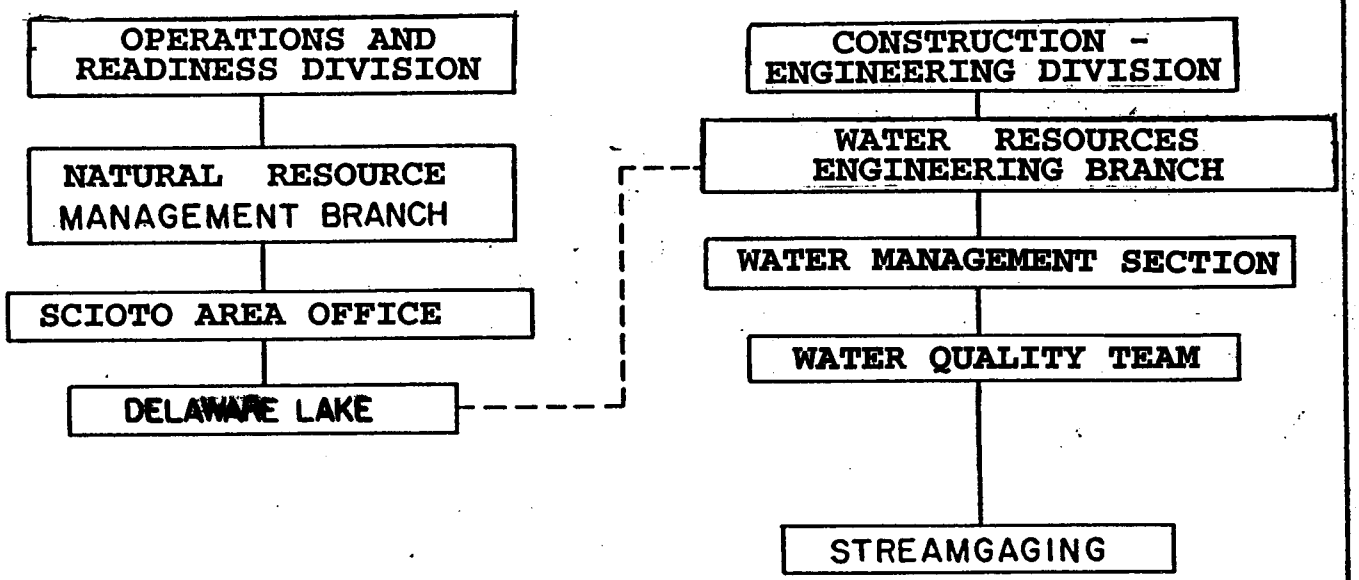

ELEVATION IN FEET ABOVE M.S.L.
944
942
940
938
936
934
932
930
928
926
924
922
920
918
916
914
0
5
10
15
20
25
TIME IN DAYS
MAXIMUM NO. DAYS PER PERIOD OF RECORD
AVERAGE NO. DAYS PER YEAR
NOTE: PERIOD OF RECORD
OLENTANGY RIVER
OHIO
DELAWARE LAKE
DURATION OF FILLING
DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON W. VA.
DECEMBER 1967

Plate No. 8-19



--- WATER CONTROL MANAGEMENT INSTRUCTIONS GIVEN TO PROJECT BY WATER CONTROL SECTION

OLENTANGY RIVER
OHIO

DELAWARE LAKE

WATER CONTROL MANAGEMENT
NORMAL ORGANIZATION

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
HUNTINGTON, W.VA. APRIL 1983

Plate No. 9-1

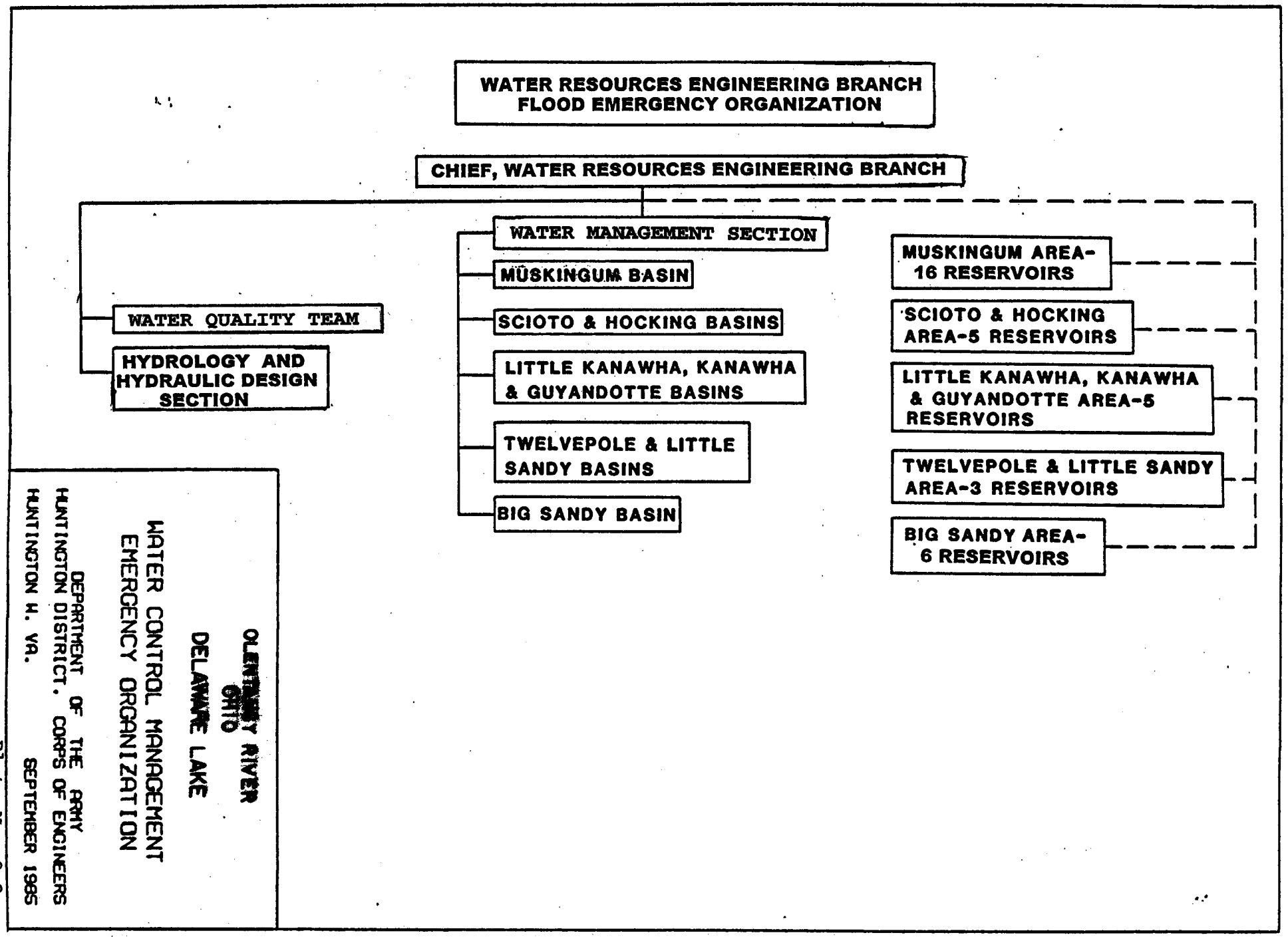
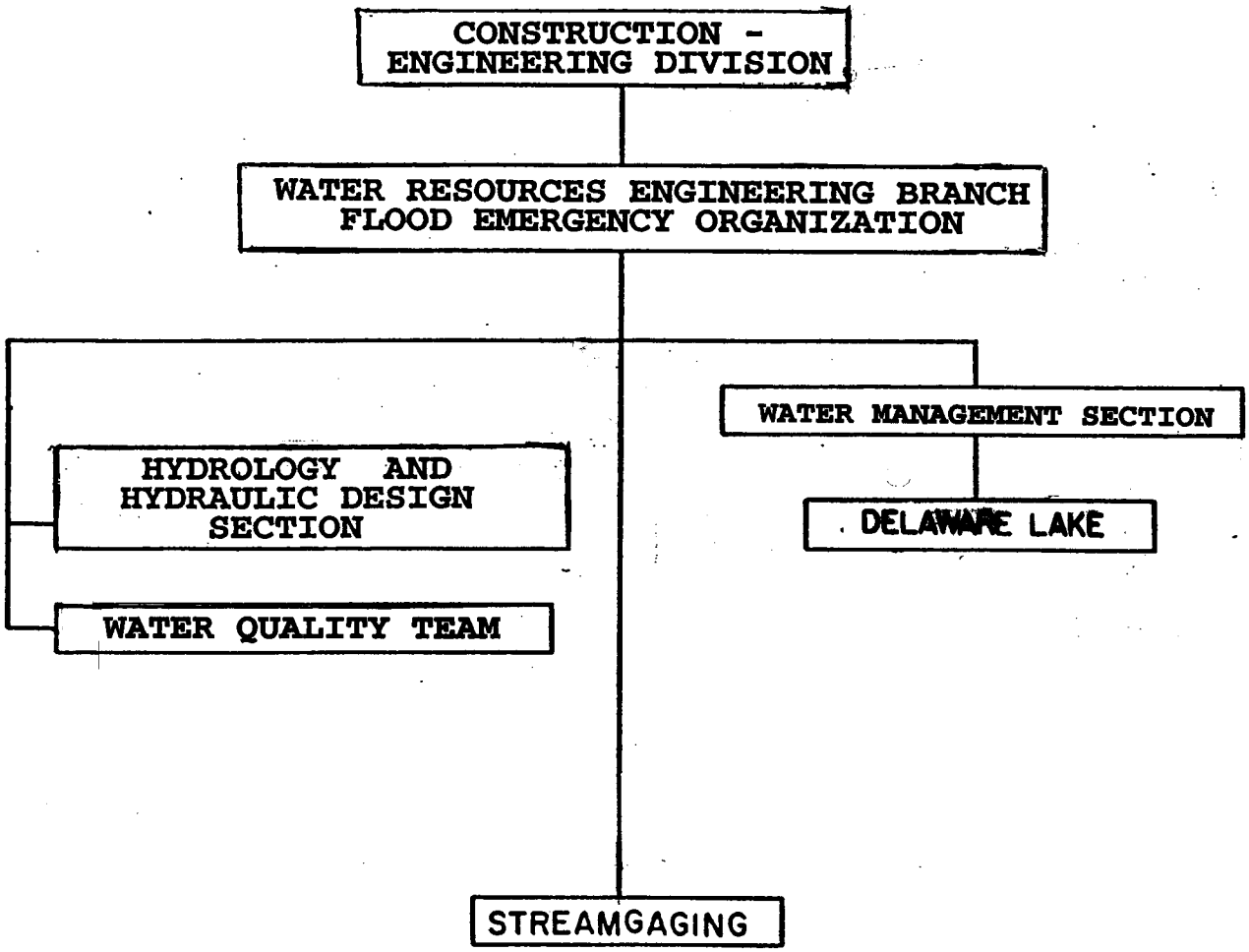


Plate No. 9-2

SHEET 1 OF 2



OLENTANGY RIVER
OHIO

DELAWARE LAKE

WATER CONTROL MANAGEMENT
EMERGENCY ORGANIZATION

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT. CORPS OF ENGINEERS
HUNTINGTON W. VA. SEPTEMBER 1985

Plate No. 9-2

SHEET 2 OF 2

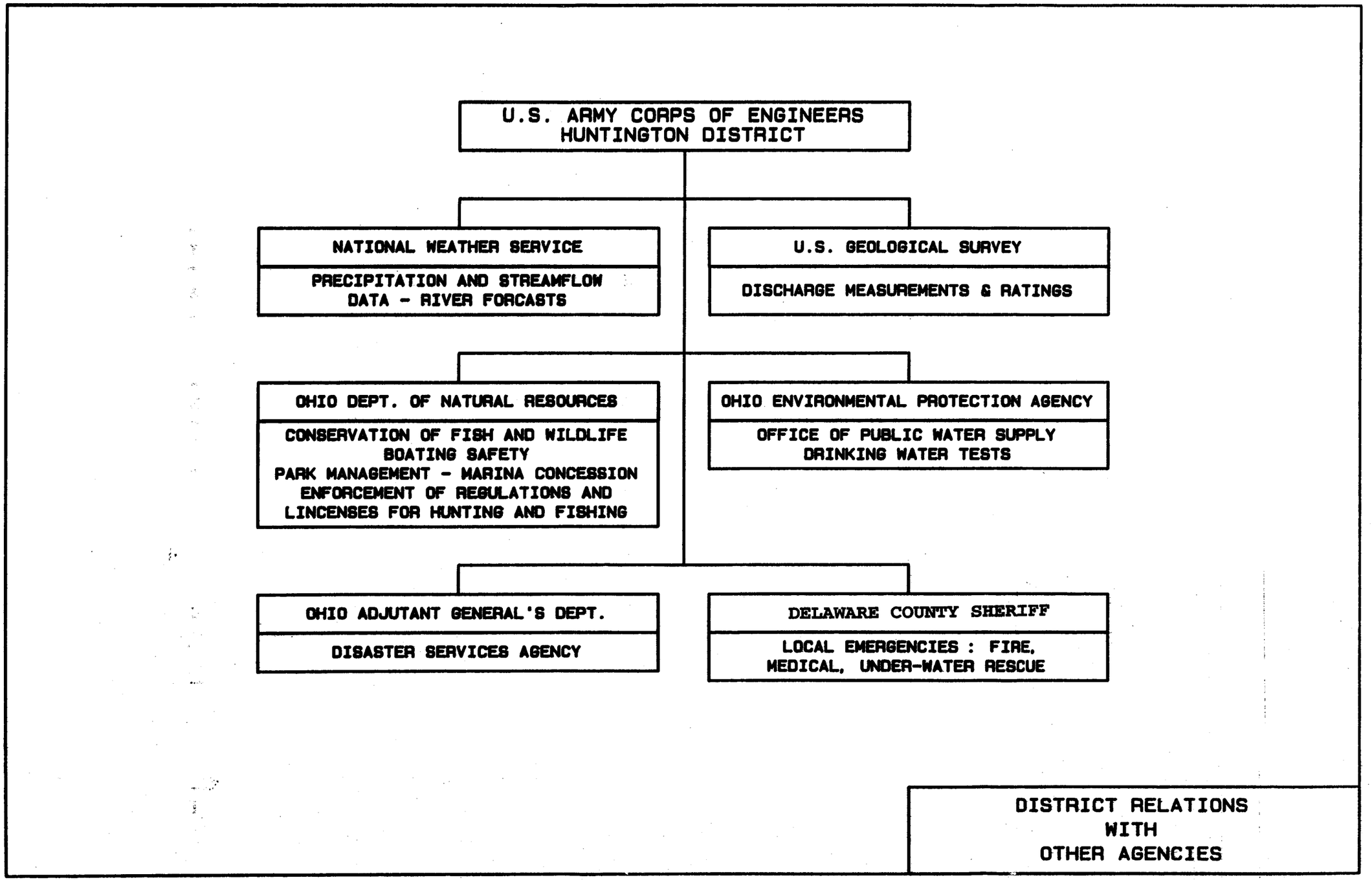

U.S. ARMY CORPS OF ENGINEERS
HUNTINGTON DISTRICT
NATIONAL WEATHER SERVICE
PRECIPITATION AND STREAMFLOW DATA - RIVER FORCASTS
U.S. GEOLOGICAL SURVEY
DISCHARGE MEASUREMENTS & RATINGS
OHIO DEPT. OF NATURAL RESOURCES
CONSERVATION OF FISH AND WILDLIFE
BOATING SAFETY
PARK MANAGEMENT - MARINA CONCESSION
ENFORCEMENT OF REGULATIONS AND LINCENSES FOR HUNTING AND FISHING
OHIO ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF PUBLIC WATER SUPPLY
DRINKING WATER TESTS
OHIO ADJUTANT GENERAL'S DEPT.
DISASTER SERVICES AGENCY
DELAWARE COUNTY SHERIFF
LOCAL EMERGENCIES : FIRE, MEDICAL, UNDER-WATER RESCUE
DISTRICT RELATIONS
WITH
OTHER AGENCIES

Plate No. 9-3