



US Army Corps of Engineers  
Tulsa District  
Tulsa District

---

**CANTON DAM AND LAKE  
NORTH CANADIAN RIVER  
ARKANSAS RIVER BASIN, OKLAHOMA**

**WATER CONTROL MANUAL  
APPENDIX H  
WATER CONTROL MASTER MANUAL**

**DEPARTMENT OF THE ARMY  
CORPS OF ENGINEERS  
TULSA DISTRICT**

**JUNE 2016**

**PREVIOUS EDITION – DECEMBER 1993**

**CANTON DAM AND LAKE  
NORTH CANADIAN RIVER  
ARKANSAS RIVER BASIN, OKLAHOMA**

**WATER CONTROL MANUAL  
APPENDIX H  
WATER CONTROL MASTER MANUAL**

**DEPARTMENT OF THE ARMY  
CORPS OF ENGINEERS  
TULSA DISTRICT**

**JUNE 2016**

**PREVIOUS EDITION – DECEMBER 1993**

**Canton Dam, Service Spillway, and Auxiliary Spillway**



## NOTICE TO USERS OF THIS MANUAL

Regulations specify that this Water Control Manual be used in loose-leaf form, and only those sections, or parts thereof, requiring changes will be revised and printed. Therefore, this copy should be preserved in good condition so that inserts can be made to keep the manual current. All elevation referred to in this manual, unless noted otherwise, are in feet, NGVD 29 (National Geodetic Vertical Datum 1929).

### REGULATION ASSISTANCE PROCEDURES

In the event that unusual conditions arise during duty hours and at various hours during weekends and holidays, contact can be made by telephone to the Water Management Section, Tulsa District Office (918) 669-7085. If the above office cannot be contacted, assistance can be achieved by contacting, in the order listed, one of the persons shown below. Section VII of this manual contains detailed instructions for emergency regulations. All project personnel associated with regulation of the project must be thoroughly familiar with the procedure outlined in this section.

### EMERGENCY

### PERSONNEL

### ROSTER

<u>TITLE AND NAME</u>	<u>RESIDENCE TELEPHONE</u>
Coordinator (b) (6)	(b) (6)
Backup Coordinator (b) (6)	(b) (6)
Chief, Water Management Section (b) (6)	(b) (6)
Chief, Hydrology-Hydraulics Branch (b) (6)	(b) (6)

CANTON LAKE, NORTH CANADIAN RIVER, OKLAHOMA  
WATER CONTROL MANUAL  
APPENDIX H  
TO  
WATER CONTROL MASTER MANUAL  
ARKANSAS RIVER BASIN

TABLE OF CONTENTS

Section Title	Page
Title Page.....	i
Photo Page.....	ii
Notice to Users.....	iii
Pertinent Data Sheet.....	A
I - Introduction .....	1-1
1 - 01. Authorization.....	1-1
1 - 02. Purpose and Scope.....	1-1
1 - 03. Related Manuals and Reports.....	1-1
1 - 04. Project Owner.....	1-1
1 - 05. Operating Agency.....	1-1
1 - 06. Regulating Agency.....	1-2
II - Description of Project .....	2-1
2 - 01. Location.....	2-1
2 - 02. Purpose.....	2-1
2 - 03. Physical Components.....	2-1
a. Embankment.....	2-1
b. Spillway.....	2-1
c. Auxiliary Spillway.....	2-2
d. Outlet Works.....	2-2
e. Sedimentation and Degradation Ranges.....	2-2
f. Water Supply.....	2-2
2 - 04. Related Control Facilities.....	2-3
2 - 05. Real Estate Acquisition.....	2-3

2 - 06. Public Facilities. ....	2-3
III - History of Project.....	3-1
3 - 01. Authorization. ....	3-1
3 - 02. Planning and Design. ....	3-1
3 - 03. Construction.....	3-2
3 - 04. Related Projects. ....	3-2
3 - 05. Modification to Regulations. ....	3-3
3 - 06. Principal Regulation Problems. ....	3-3
IV - Watershed Characteristics .....	4-1
4 - 01. General Characteristics.....	4-1
4 - 02. Topography.....	4-1
4 - 03. Geology and Soils.....	4-1
a. Regional Geology.....	4-1
b. Site Geology.....	4-2
c. Earthquakes. ....	4-5
4 - 04. Sediment. ....	4-8
4 - 05. Climate.....	4-8
a. Temperature. ....	4-8
b. Rainfall.....	4-8
c. Snow.....	4-9
d. Evaporation. ....	4-9
e. Wind.....	4-9
4 - 06. Storms and Floods. ....	4-9
4 - 07. Runoff Characteristics. ....	4-15
4 - 08. Water Quality. ....	4-17
4 - 09. Channel and Floodway Characteristics. ....	4-18
4 - 10. Upstream Structures. ....	4-19
4 - 11. Downstream Structures.....	4-19
4 - 12. Economic Data. ....	4-19
a. Population. ....	4-19
b. Agriculture. ....	4-19
c. Industry. ....	4-19

d. Flood Damages. ....	4-19
V - Data Collection and Communication Networks .....	5-1
5 - 01.  Hydrometeorological Stations. ....	5-1
a. Facilities. ....	5-1
b. Reporting.....	5-1
c. Maintenance. ....	5-2
5 - 02.  Water Quality Stations.....	5-2
a. Facilities. ....	5-2
b. Reporting.....	5-2
c. Maintenance. ....	5-2
5 - 03.  Sedimentation Stations. ....	5-2
a. Facilities. ....	5-2
b. Reporting.....	5-2
c. Maintenance. ....	5-2
5 - 04.  Recording Hydrologic Data.....	5-2
a. Stages and Discharges.....	5-3
b. Precipitation. ....	5-3
c. Water Quality Data. ....	5-3
5 - 05.  Communication Network. ....	5-3
5 - 06.  Communication with Project.....	5-3
a. Regulating Office with Project Office. ....	5-3
b. Between Project Office and Others.....	5-3
5 - 07.  Project Reporting Instructions.....	5-4
a. As of 8 a.m. Each Weekday. ....	5-4
b. As of 8 a.m. Each Monday.....	5-4
c. Weekends and Holidays.....	5-5
d. During Flood Periods.....	5-5
5 - 08.  Warnings.....	5-5
VI - Hydrologic Forecasts.....	6-1
6 - 01.  General.....	6-1
a. Role of Corps of Engineers. ....	6-1
b. Role of Other Agencies.....	6-1

6 - 02.	Flood Condition Forecasts.....	6-2
a.	Requirements.....	6-2
b.	Methods.....	6-2
6 - 03.	Conservation Purpose Forecasts.....	6-2
a.	Requirements.....	6-2
b.	Methods.....	6-2
6 - 04.	Long Range Forecasts.....	6-3
a.	Requirements.....	6-3
b.	Methods.....	6-3
6 - 05.	Drought Forecasts.....	6-3
VII -	Water Control Plan.....	7-1
7 - 01.	General Objectives.....	7-1
7 - 02.	Major Constraints.....	7-1
7 - 03.	Overall Plan for Water Control.....	7-1
7 - 04.	Standing Instructions to Lake Manager.....	7-1
7 - 05.	Flood Control.....	7-2
a.	Normal Regulation for Flood Control Operations.....	7-2
b.	Emergency Flood Control Regulations.....	7-2
c.	Constraints.....	7-2
d.	Operational Curves.....	7-2
7 - 06.	Recreation.....	7-6
7 - 07.	Water Quality.....	7-6
7 - 08.	Fish and Wildlife.....	7-6
7 - 09.	Water Supply.....	7-6
7 - 10.	Water Rights.....	7-6
7 - 11.	Hydroelectric Power.....	7-6
7 - 12.	Navigation.....	7-6
7 - 13.	Drought Contingency Plans.....	7-6
7 - 14.	Flood Emergency Action Plans.....	7-7
7 - 15.	Deviation from Normal Flood Control Regulation.....	7-7
a.	Emergencies.....	7-7
b.	Unplanned Minor Deviations.....	7-7

c. Unplanned Major Deviations. ....	7-7
d. Planned Deviations. ....	7-8
7 - 16. Rate of Release Changes. ....	7-8
VIII - Effect of Water Control Plan .....	8-1
8 - 01. General.....	8-1
8 - 02. Flood Control.....	8-1
a. Probable Maximum Flood.....	8-1
b. Standard Project Flood.....	8-1
c. Flood of October 1923. ....	8-1
d. Flood of May 1951.....	8-1
8 - 03. Recreation. ....	8-1
8 - 04. Water Quality. ....	8-1
8 - 05. Fish and Wildlife. ....	8-2
8 - 06. Water Supply. ....	8-2
8 - 07. Hydroelectric Power. ....	8-2
8 - 08. Navigation. ....	8-2
8 - 09. Drought Contingency Plans.....	8-2
8 - 10. Flood Emergency Action Plans. ....	8-2
8 - 11. Frequencies.....	8-2
a. Peak Inflow Probability.....	8-2
b. Pool Elevation Duration and Probability. ....	8-2
c. Key Control Points.....	8-3
8 - 12. Other Studies. ....	8-3
a. Example of Regulation.....	8-3
b. Channel and Floodway Improvement.....	8-3
IX - Water Control Management .....	9-1
9 - 01. Responsibilities and Organizations. ....	9-1
a. Corps of Engineers.....	9-1
b. Other Federal Agencies.....	9-3
c. State and County Agencies. ....	9-3
d. Private Organizations.....	9-3
9 - 02. Interagency Coordination. ....	9-3

a. Local Press and Corps Bulletins. ....	9-3
b. National Weather Service. ....	9-3
c. U.S. Geological Survey.....	9-3
d. Power Marketing Agency. ....	9-3
e. Other Federal, State, or Local Agencies. ....	9-3
9 - 03. Interagency Agreements. ....	9-4
9 - 04. Commissions, River Authorities, Compacts, and Committees. ....	9-4
9 - 05. Non-Federal Hydropower.....	9-4
9 - 06. Reports.....	9-4
a. Morning Report.....	9-4
b. Monthly Lake Reports. ....	9-5
c. Flood Situation Reports.....	9-5
d. Post-flood Reports. ....	9-5
e. Annual Report. ....	9-5
f. Summary of Reports.....	9-5

## TABLES

<b>TABLE NO.</b>	<b>TITLE OR DESCRIPTION</b>	<b>PAGE</b>
Table 1-1	Pertinent Reports and Design Memoranda for Canton Dam and Lake	1-3
Table 3-1	Resume of Construction Activities	3-2
Table 3-2	History of Conservation Pool Changes	3-3
Table 4-1	Criteria for Post-Earthquake Inspections	4-8
Table 4-2	Average Monthly and Annual Rainfall and Runoff Upstream of Canton Dam	4-10
Table 4-3	Estimated Monthly Pan Evaporation Canton Lake	4-11
Table 4-4	Major Storms, (Jan 1923 - Dec 2014), North Canadian River Basin Upstream of Canton Dam	4-12
Table 4-5a	Annual Peak Flows at Canton Gage Prior to Dam Construction (1938-1947)	4-13
Table 4-5b	Major Floods After Dam Construction (January 1949 through December 2013)	4-13
Table 4-6	Major Floods of Record at Gage Sites	4-14
Table 4-7	Pertinent Data for Stream Gaging Stations	4-16
Table 4-8	Canton Dam Site Monthly Inflows (Acre-Feet)	T4-8-1
Table 4-9	Inflow Volume Frequency (Jan 1923-Dec 2014)	4-17
Table 4-10	Population of Counties and Cities Downstream of Canton Dam	4-20
Table 4-11	Annual Value of Crops Below Canton Dam (2015 Prices)	4-21
Table 4-12	2013 Economic Census for Blaine County, OK	4-22
Table 4-13	2013 Economic Census for Canadian County, OK	4-23
Table 4-14	2013 Economic Census for Dewey County, OK	4-24
Table 4-15	2013 Economic Census for Haskell County, OK	4-25
Table 4-16	2013 Economic Census for Hughes County, OK	4-26
Table 4-17	2013 Economic Census for Latimer County, OK	4-27
Table 4-18	2013 Economic Census for Lincoln County, OK	4-28
Table 4-19	2013 Economic Census for McIntosh County, OK	4-29
Table 4-20	2013 Economic Census for Major County, OK	4-30
Table 4-21	2013 Economic Census for Muskogee County, OK	4-31
Table 4-22	2013 Economic Census for Okfuskee County, OK	4-32
Table 4-23	2013 Economic Census for Oklahoma County, OK	4-33
Table 4-24	2013 Economic Census for Okmulgee County, OK	4-34
Table 4-25	2013 Economic Census for Pittsburgh County, OK	4-35
Table 4-26	2013 Economic Census for Pottawatomie County, OK	4-36
Table 4-27	2013 Economic Census for Seminole County, OK	4-37
Table 4-28	Average Annual Flood Damages Prevented Downstream of Canton Dam	4-38
Table 4-29	Top Five Flood Events in terms of Damages Prevented Downstream of Canton Dam	4-38

Table 5-1	Automated Gages	T5-1-1
Table 5-2	Pertinent Water Quality Stations North Canadian River	T5-2-1
Table 7-1	Normal Flood Control Regulation Schedule, Canton Lake	7-3
Table 7-2	Emergency Flood Control Regulation Schedule, Canton Lake	7-5
Table 7-3	Elevation – Area – Capacity Data, Canton Lake, Oklahoma	T7-3-1
Table 7-4	Active Water Rights Amounts and Locations (Upstream to Downstream), North Canadian River	T7-4-1
Table 9-1	Summary of Reports	9-6

## EXHIBITS

Exhibit A – Supplemental Pertinent Data

Exhibit B – Standing Instructions to Lake Manager

Exhibit C – Water Supply Contract

## PLATES

PLATE 1-1	TULSA DISTRICT PROJECTS
PLATE 2-1	LOCATION AND VICINITY MAP
PLATE 2-2	GENERAL PLAN & EMBANKMENT SECTION
PLATE 2-3	SPILLWAY AND STILLING BASIN SECTION AND PLAN
PLATE 2-4	AUXILIARY SPILLWAY SECTION AND PLAN
PLATE 2-5	AUXILIARY SPILLWAY ISOMETRIC VIEW
PLATE 2-6	OUTLET WORKS
PLATE 2-7	SEDIMENTATION RANGES
PLATE 2-8	DEGRADATION RANGES
PLATE 2-9	PUBLIC USE AREAS
PLATE 2-10	WILDLIFE MANAGEMENT AREA
PLATE 4-1	WATERSHED MAP
PLATE 4-2	NORTH CANADIAN RIVER PROFILES
PLATE 4-3	NORTH CANADIAN RIVER PROFILES
PLATE 4-4	ANNUAL EARTHQUAKES OF M4 MAGNITUDE OR GREATER
PLATE 4-5	FLOW DURATION CURVE
PLATE 4-6	DISCHARGE RATING CURVE, WOODWARD GAGE
PLATE 4-7	DISCHARGE RATING CURVE, SEILING GAGE
PLATE 4-8	DISCHARGE RATING CURVE, CANTON GAGE
PLATE 4-9	DISCHARGE RATING CURVE, WATONGA GAGE
PLATE 4-10	DISCHARGE RATING CURVE, EL RENO GAGE
PLATE 4-11	TIME OF CREST TRAVEL
PLATE 4-12	STRUCTURAL LOSS AND AREA CURVE, CANTON DAM TO BLAINE/CANADIAN COUNTY LINE
PLATE 4-13	STRUCTURAL LOSS AND AREA CURVE, BLAINE/CANADIAN COUNTY LINE TO US 66

PLATE 4-14	STRUCTURAL LOSS AND AREA CURVE, US 66 TO OKC FLOODWAY
PLATE 4-15	STRUCTURAL LOSS AND AREA CURVE, WITHIN OKC FLOODWAY
PLATE 4-16	STRUCTURAL LOSS AND AREA CURVE, LOWER LIMITS OF OKC FLOODWAY TO STATE HWY 99
PLATE 4-17	STRUCTURAL LOSS AND AREA CURVE, STATE HWY 99 TO EUFAULA RESERVOIR
PLATE 5-1	STREAM GAGE AND RAINFALL STATIONS
PLATE 5-2	ORGANIZATION FOR FLOOD CONTROL REGULATION
PLATE 5-3	LAKE DATA REPORT
PLATE 6-1	CANTON FORECAST REACHES
PLATE 6-2	UNIT HYDROGRAPH FOR CANTON DAM
PLATE 6-3	UNIT HYDROGRAPH FOR WATONGA GAGE
PLATE 6-4	UNIT HYDROGRAPH FOR EL RENO GAGE
PLATE 6-5	UNIT HYDROGRAPH FOR OKC GAGE
PLATE 6-6	SAMPLE INFLOW CALCULATION
PLATE 7-1	SPILLWAY GATE REGULATION SCHEDULE INFLOW PARAMETER
PLATE 7-2	INFLOW VS. RATE OF RISE NOMOGRAPH
PLATE 7-3	SPILLWAY RATING CURVES ONE GATE
PLATE 7-4	SPILLWAY RATING CURVES
PLATE 7-5	AUXILIARY SPILLWAY RATING CURVE
PLATE 7-6	AUXILIARY SPILLWAY RATING CURVE W/O FUSEGATES
PLATE 7-7	SLUICE RATING CURVE
PLATE 7-8	DISCHARGE RATING CURVE
PLATE 7-9	TAILWATER RATING CURVE
PLATE 7-10	EVAPORATION CURVES
PLATE 7-11	ELEVATION-AREA-CAPACITY CURVES
PLATE 8-1	OPERATIONAL HYDROGRAPHS, PMF
PLATE 8-2	OPERATIONAL HYDROGRAPHS, SPF
PLATE 8-3	OPERATIONAL HYDROGRAPHS, FLOOD OF 1923
PLATE 8-4	OPERATIONAL HYDROGRAPHS, FLOOD OF 1951
PLATE 8-5	PEAK INFLOW PROBABILITY CURVE
PLATE 8-6	POOL ELEVATION DURATION CURVE
PLATE 8-7	POOL ELEVATION PROBABILITY CURVE
PLATE 8-8	POOL ELEVATION HYDROGRAPHS (1948 – 1958)
PLATE 8-9	POOL ELEVATION HYDROGRAPHS (1959 – 1969)
PLATE 8-10	POOL ELEVATION HYDROGRAPHS (1970 -1980)
PLATE 8-11	POOL ELEVATION HYDROGRAPHS (1981 – 1991)
PLATE 8-12	POOL ELEVATION HYDROGRAPHS (1992 – 2002)
PLATE 8-13	POOL ELEVATION HYDROGRAPHS (2003 – 2013)

## CANTON DAM AND LAKE PERTINENT DATA

### LOCATION:

In Blaine and Dewey Counties, Oklahoma,  
North Canadian River, Mile 394.3, 2 miles north of Canton, OK

### DRAINAGE AREA:

12,695 square miles above the dam,  
5,198 square miles contributing area below Optima and Fort Supply reservoirs  
For the contributing area (5,198 mi<sup>2</sup>) one inch of runoff equals 277,227 acre-feet

### DAM:

Type: Earthfill  
Length: 15,140 ft (including service spillway)  
Maximum height: 65 feet  
Crest width: 32 feet

### SPILLWAY:

Location: Right Abutment  
Crest elevation: 1613.0 feet, NGVD 29  
Length: 778 feet gross  
Type: Gate controlled, chute type  
Control: 16 – 40' x 25' tainter gates

### POWER FEATURES:

None

### OPERATIONAL CHANNEL CAPACITY:

1000 cfs

### AUXILIARY SPILLWAY:

Location: Right Abutment  
Top of gates elevation: 1638.0 feet, NGVD 29  
Bottom of Weir Elevation: 1606.0 feet, NGVD 29  
Total Length of Fusegates: 480 feet  
Type: 9 – 53' x 32' fuse gates, with a wet well intake

### OUTLET WORKS

Type and Size: 2 – 7' x 12' sluices  
Location: Through base of two piers on either side of the center pier. Center pier has the third plugged sluice gate.  
Control: Cable hoisted, vertical-lift gates  
Invert elevation: 1582.0 feet, NGVD 29

### LOW FLOW OUTLET:

Type: 2 – 24" valved conduits  
Location: Through base of center piers discharging through outermost sluiceways  
Invert elevation: 1583.0 feet, NGVD 29

### LAND ACQUISITION:

19,877 acres

### IRRIGATION INTAKE (Inoperable):

Location: Right spillway approach wall 147' upstream from weir  
Type and Size: 2 – 4' x 5' hydraulic slide gates; 231 feet long 7'-6" x 8'-0" concrete conduit  
Invert Elevation: 1590.0 feet, NGVD 29

**PERTINENT DATA SHEET (CONT.)**

Feature	Elevation (ft, NGVD29)	Lake Area (acres) <sup>(1)</sup>	Lake Capacity <sup>(1)</sup>			Spillway Capacity (cfs) <sup>(2)</sup>	Auxiliary Spillway Capacity	Outlet Works Capacity (cfs) <sup>(2)(3)</sup>
			Accumulative Volume (acre-feet)	Runoff (inches)	Incremental volume (acre-feet)		Fusegates Tipped (cfs) <sup>(2)</sup>	
Top of Dam (Design) <sup>(4)</sup>	1648.0							
Maximum pool (2014 Study)	1642.68	17,490	445,500	1.61	45,500	360,500	244,000	8,100
Top of surcharge pool	1640.0	16,330	400,000	1.44	32,000	310,400	221,000	7,920
Top of flood control pool	1638.0	15,340	368,000	1.33	258,300	277,000	203,000	7,750
Top of conservation pool	1615.4	7,340	109,700	0.40	95,600	8,500	30,800	5,500
Bottom of conservation pool	1596.5	2,710	14,100	0.05	14,100	0	0	2,040
Crest of service spillway	1613.0	6,760	91,500	0.33	-	0	11,800	5,200
Bottom of Auxiliary Spillway Weir	1606.0	5,010	50,500	0.18	-	0	0	4,250
Streambed at dam	1583.0	-	-	-	-	-	-	-
Flood control storage	1615.4 – 1638.0	-	258,300	0.93	-	-	-	-
Water supply storage	1596.5 – 1615.4	-	95,600	0.34	-	-	-	-

(1) Based on 2010 resurvey

(2) Discharges are Approximate. Plates 7-3 through 7-9 should be used to determine actual release

(3) Capacity shown for 2 sluice gates instead of 3 sluice gates. 1 sluice has been plugged.

(4) Surveyed Top of Dam is currently 1647.09 ft

CANTON LAKE, NORTH CANADIAN RIVER, OKLAHOMA  
WATER CONTROL MANUAL  
APPENDIX H  
TO  
WATER CONTROL MASTER MANUAL  
ARKANSAS RIVER BASIN

**I - INTRODUCTION**

**1 - 01. Authorization.** This manual is submitted as required by ER 1110-2-240, Water Control Management, dated 08 October 1982, and is prepared in accordance with ER 1110-2-8156, Engineering and Design, Preparation of Water Control Manuals, dated 31 August 1995.

**1 - 02. Purpose and Scope.** The purpose of this manual is to document the Canton Dam and Lake Regulation Plan. This manual also provides a concise reference and guidance source for higher authority personnel who will be concerned with or responsible for reservoir regulations during the life of the project. This manual also includes the background material necessary to understand the purpose and application of the Canton Dam and Lake Regulation Plan.

**1 - 03. Related Manuals and Reports.** This manual is Appendix H (Canton Update) to the Arkansas River Basin Water Control Master Manual. Other related manuals in the Canadian River Basin are:

Appendix H, Part I – Optima	December 1969
Appendix H, Part II – Fort Supply	July 2003
Appendix N – Eufaula	March 2014
Appendix P – Norman (Lake Thunderbird)	September 1993
Appendix Z – Arcadia	March 2014

The locations of existing and authorized projects in the Tulsa District are shown on Plate 1-1. Design memoranda important to the regulation of Canton Lake are shown in Table 1-1. Supplementary Pertinent Data are given in Exhibit A of this manual.

**1 - 04. Project Owner.** Canton Lake is owned by the U.S. Government.

**1 - 05. Operating Agency.** The operating agency for Canton Lake is the U.S. Army Corps of Engineers, Tulsa District. The Lake Manager, Canton Lake, operating through the Operations Project Manager, Northern Area, and the Operations Division, Tulsa District, has the responsibility for project operations. The project will be manned 24 hours a day when the lake level is above 1624.0 feet, NGVD 29, in order to monitor the structure for dam safety concerns. Below elevation 1624.0 feet, the project will be manned for the normal 5-day work week. However, when the project is in a flood control regulation, operation personnel will closely

monitor the project and the downstream river reaches. The project is furnished a list of the Water Management Section personnel to contact when necessary. The Lake Manager will furnish the Water Management Section a list of project personnel, giving their office and home telephones and addresses.

**1 - 06. Regulating Agency.** The U.S. Army Corps of Engineers is the regulatory agency for Canton Lake. The Water Management Section, Hydrology-Hydraulics Branch, Tulsa District is responsible for the real-time water control regulation of the facility. Presently, there are no other agencies involved in the functional responsibilities of Canton Lake.

**TABLE 1-1****PERTINENT REPORTS AND DESIGN MEMORANDA FOR CANTON DAM AND LAKE**

Title	Date
1. Definite Project Report, Canton Dam	March 1940
2. Analysis of Design for Construction of Spillway and Completion of Embankment	July 1942 (Revised August 1944 & January 1946)
3. Basis of Design for Construction of Embankment and Excavation for Spillway	July 1942 (Revised August 1944)
4. Master Plan	November 1947 (Revised March 1989)
5. Specifications for Construction of Spillway and Completion of Embankment	January 1946
6. Analysis of Design for Construction of Relief Wells and Toe Drainage System	August 1949
7. Report of Sedimentation Resurvey: Canton Reservoir, New Mexico, Texas, and Oklahoma	1953
8. Dam Safety Assurance Program Reconnaissance Report Canton Lake, North Canadian River, Oklahoma	September 1980 (Revised 2002 & 2008)
9. Eufaula, Arcadia, Canton, Fort Supply, and Optima Lakes, Canadian River Basin Drought Contingency Plan	September 1990
10. Operation and Maintenance Manual, Volume I, Canton Lake	June 1992
11. Hydrological Study of the North Canadian	August 1997
12. Periodic Inspection No. 9	April 2007
13. Operation and Maintenance Manual, Volume II, Flood Emergency Plan	August 2008
14. Dam Safety Assurance Evaluation Report Supplement	September 2008
15. Downstream Warning System Needs Assessment for Canton Dam	March 2010
16. Canton Auxiliary Spillway Hydraulic Structures, Specifications	May 2011
17. Periodic Inspection No. 10	October 2011
18. Annual Instrument Report	December 2012 (Rev. Feb. 2013, Sept 2014, & Dec 2015)
19. Canton Auxiliary Spillway Sliding Stability Report	March 2013
20. Canton Dam Post Construction Risk Assessment	January 2014
21. Emergency Action Plan for Canton Lake	August 2015
22. Auxiliary Spillway Channel Filling Plan	February 2016

## **II - DESCRIPTION OF PROJECT**

**2 - 01. Location.** Canton Lake is located at River Mile (RM) 394.3 on the North Canadian River, approximately 2 miles north of Canton, Oklahoma and about 75 miles west of Oklahoma City, Oklahoma in Blaine and Dewey Counties. Plate 2-1 shows the project area.

**2 - 02. Purpose.** Canton Lake was authorized as part of the upper Arkansas River flood control project. The reservoir was developed to provide flood control storage, water conservation storage for irrigation and municipal uses, recreation, and fish and wildlife benefits. The reservoir is an integral component of the North Canadian River basin flood control plan that also includes the Optima and Fort Supply Reservoirs as well as the Oklahoma City Floodway. The North Canadian River system is part of the multi-objective plan for flood control, hydropower generation, navigation, and water use and development on the Arkansas River and its tributaries in Kansas, Arkansas, and Oklahoma.

**2 - 03. Physical Components.**

a. **Embankment.** The reservoir embankment is a rolled, earth-filled structure approximately 15,140 feet long (including the service spillway) with a designed crest elevation of 1648.0 feet, NGVD 29. The most recent survey shows that the actual top of dam elevation is currently 1647.09 feet, NGVD 29. The embankment crest is 32 feet wide. Compacted impervious fill was used to construct the core and upstream face of the structure. A compacted pervious fill material was used to construct the downstream face of the embankment. Embankment sideslopes vary with elevation. Extending from the original ground surface at elevation 1582.0 feet up to elevation 1597.0 feet, the sideslopes were constructed at a slope of 4:1 (horizontal: vertical). Between elevations 1597.0 and 1612.0 feet, the sideslope is 3.5:1. The sideslope then increases to 3:1 between elevation 1612.0 and elevation 1627.0 feet. The sideslope increases again to 2.5:1 between 1627.0 and 1642.0 feet in elevation. The uppermost six vertical feet (between elevations 1642.0 and 1648.0 feet) was constructed at a 2:1 slope. On the Canton Lake side, embankment sideslopes have been revetted with dumped riprap. On the landward side, the embankment surface is grassed, with some rock protection along the toe of the embankment up to approximately elevation 1591.0 feet. Plate 2-2 shows the general plan and sections at the Canton Lake embankment.

b. **Spillway.** The spillway is a gated, concrete chute-type structure located near the right abutment of the dam. Gross length of the spillway crest totals 778 feet, with the net overflow length equaling 640 feet. The spillway crest is located at elevation 1613.0 feet NGVD 29. The spillway chute transitions flow down a 3:1 slope to a level stilling basin at elevation 1560.0 feet, NGVD 29. Two rows of baffle blocks are located in the stilling basin to control the location of the hydraulic jump and enhance energy dissipation. The stilling basin end sill is 10 feet high with a top elevation set at 1570.0 feet, NGVD 29. Spillway discharges are controlled by a series of 16 electric motor-operated, 40-foot by 25-foot tainter gates. The gate operators allow for a rate of change in gate opening of approximately 1 foot of arc per minute. An emergency diesel-powered generator is located at the project office to provide backup electricity

in the event that normal electrical service to the site is interrupted. The spillway and stilling basin section is shown on Plate 2-3.

c. Auxiliary Spillway. The auxiliary spillway is located at the right abutment. The spillway is 480 feet wide. The top of the auxiliary spillway gates (fusegates) is at elevation 1638.0 feet, NGVD 29. Flow through the spillway is controlled by nine hydraulically controlled 53-foot by 32-foot semi-labyrinth type concrete fusegates. A wet well tower is located at the left abutment of the auxiliary spillway sill. The intake for the wet well is located near the left abutment of the auxiliary spillway sill, upstream of the gates. The wet well intake elevation is 1616.5 feet, NGVD 29. Inside of the wet well, there are nine inlet wells at different elevations, and each well connects to a separate fusegate. At reservoir elevations between 1638.0 and 1640.5 feet, the fusegates will act as a weir and all flow will be over the top of the gates. When the reservoir elevation reaches 1640.5 feet, the center fusegate will tip over, allowing more water to flow through the spillway. As the reservoir elevation continues to rise, additional fusegates will tip at specified water surface elevations to increase the spillway opening. The design of the fusegates is to be hydraulically controlled above a reservoir elevation of 1640.5 feet, assuming the service spillway gates are completely open and flowing at full capacity. The bottom of the fusegates is at elevation 1606.0 feet, while the bottom elevation of the approach channel is 1610.0 feet. During low water periods water can remain trapped between the fusegates and the approach channel, creating stagnation problems and trapping fish. In order to prevent these issues, a fish passage channel is included in the approach channel. The auxiliary spillway section and an isometric view of the auxiliary spillway are shown on Plate 2-4 and Plate 2-5.

d. Outlet Works. The outlet works consists of two 7-foot by 12-foot sluice gates that pass through the base of the spillway piers on either side of the center spillway pier. A third 7-foot by 12-foot sluice gate that passed through the center spillway pier was permanently plugged to reduce future maintenance costs. Gate operation is controlled by individual cable hoists. The invert of the outlet works is at elevation 1582.0 feet, NGVD 29. In addition to the two sluices, two 24-inch diameter valved concrete conduits were constructed to provide a means for low-flow releases from Canton Lake. The entrance invert of the conduits is at elevation 1583.0 feet, NGVD 29. Plate 2-6 shows section views of the sluices and low-flow conduits.

e. Sedimentation and Degradation Ranges. Forty-four sedimentation ranges have been established in Canton Lake. Twenty-nine of those ranges are used for periodic evaluation of storage depletion due to sediment accumulation. Permanent monuments have been set at each of the end points of the survey ranges and horizontal and vertical control has been brought in to each point. In addition to the sedimentation ranges upstream of Canton Dam, 24 degradation ranges have been defined across the North Canadian River floodplain downstream of the dam. Locations of the sedimentation and degradation ranges are shown in Plates 2-7 and 2-8, respectively.

f. Water Supply. Depending on flow requirements, water supply releases can be made through the 24-inch low-flow valves or from the sluice gate outlet works described in paragraph 2 - 03.d above. In addition to these outlets, an irrigation intake was constructed in the right spillway approach abutment, located approximately 147 feet upstream from the service spillway

crest. The irrigation intake consists of a 7.5-foot by 8-foot reinforced concrete conduit that extends for a distance of 231 feet downstream from the gate chamber. The entrance invert is located at elevation 1590.0 feet, NGVD 29. Flows through the conduit are regulated by two 4-foot by 5-foot hydraulically operated slide gates. The irrigation conduit has never been utilized and therefore rendered permanently inoperable. Plate 2-6 shows a section view of the irrigation conduit.

**2 - 04. Related Control Facilities.** None.

**2 - 05. Real Estate Acquisition.** The reservoir taking line for Canton Lake was defined as a blocked perimeter that encompasses most of the land subject to the maximum backwater effects from potential reservoir operations. To define the expected limits of the backwater effects, the maximum flood of record, which occurred in October 1923, was routed through the reservoir. Initial conditions for this routing assumed that the reservoir was at the top of the flood pool (elevation 1638.0 feet NGVD). Based on results of this analysis, land in 129 separate tracts encompassing a total of 19,877 acres was acquired. Plate 2-9 shows the limits of the blocked taking line for Canton Lake.

**2 - 06. Public Facilities.** There are seven public recreation areas located at Canton Lake, as shown in Plate 2-9. They are called: (1) Blaine Park, (2) Canadian, (3) Big Bend, (4) Longdale, (5) Sandy Cove, (6) Fairview Group Camp, (7) and Overlook. All recreational facilities are operated by the Corps of Engineers. A license dated January 1, 1948, with additional supplements, leased 16,775 acres of land and water to the Oklahoma Department of Wildlife Conservation (ODWC) for a period of 50 years. This license was renewed on June 1, 2005 for a period of 25 years, ending on May 31, 2030. Plate 2-10 shows the limits of the area leased to the State. Although the Longdale recreation area is located within the leased area, it is maintained by the Corps of Engineers.

### **III - HISTORY OF PROJECT**

**3 - 01. Authorization.** Canton Lake was authorized for construction by the Flood Control Act of 1938 approved 28 June, 1938 (Public Law 761, 75<sup>th</sup> Congress, 3<sup>rd</sup> session, H.D. 569). A provision for 69,000 acre-feet of irrigation storage was authorized by the Flood Control Act of 24 July, 1946. Utilization of 38,000 acre-feet of storage for municipal water supply for Enid, Oklahoma was authorized by the Flood Control Act of 30 June, 1948. Section 102 of the Water Resources Development Act of 1990 (PL. 101-460) reassigned the previously designated municipal water supply storage for Enid, Oklahoma and the irrigation storage to the City of Oklahoma City, Oklahoma.

**3 - 02. Planning and Design.** A comprehensive report describing possible plans of development of the Arkansas River and tributaries for flood control and other uses was published in 1936 as House Document No. 308, 74<sup>th</sup> Congress, 1<sup>st</sup> Session. It was concluded that construction of a reservoir on the North Canadian River at Fort Reno, Oklahoma, was the most practical plan for the control of floods on the North Canadian River and for storage of water for domestic uses. The recommended plan also included two smaller reservoirs for flood control located near the town of Optima, Oklahoma, and near the mouth of Wolf Creek, a tributary to the North Canadian River. The former project became known as Optima Reservoir, while the latter became known as the Fort Supply Reservoir. Due to local opposition and an inability to obtain the necessary rights-of-way, the proposed flood control reservoir at Fort Reno, Oklahoma, was abandoned and studies were undertaken to define an alternative site. A survey report entitled "North Canadian River, New Mexico, Texas and Oklahoma", dated 25 October, 1937 and subsequently published as House Document No. 569, 75<sup>th</sup> Congress, 3<sup>rd</sup> Session, was prepared that recommended construction of a dam and reservoir near Canton, Oklahoma, at RM 391.3 on the North Canadian River. The recommended plan called for a total capacity of 250,000 acre-feet, of which 240,000 acre-feet would be provided for flood control and 10,000 acre-feet of permanent storage reserved for recreation and wildlife. Canton Reservoir was authorized for construction by the Flood Control Act of 1938 as a unit in the comprehensive plan for flood control in the Arkansas River basin. In the 1938 Act, Canton Reservoir was specifically authorized by reference to House Document No. 569, 75<sup>th</sup> Congress, 3<sup>rd</sup> Session. Authority to prepare a definite project report on Canton Reservoir is contained in a letter dated 29 June, 1939, from the Office, Chief of Engineers, E.D. File 7402 (Construction Program), Advice No. C-4681. The definite project report was transmitted to the Chief of Engineers by letter dated 15 March, 1940. This report was approved as a basis for design by the Chief of Engineers with 2<sup>nd</sup> endorsement dated 30 March, 1940.

A 2002 USACE Dam Safety Assurance Program Evaluation Report identified two hydraulic deficiencies: 1) inadequate factors of safety against spillway sliding and 2) uncontrolled embankment overtopping by the Probably Maximum Flood (PMF). As a result, pool restrictions were placed on Canton Lake, limiting the pool to an elevation 12 feet below the top of the authorized flood control elevation. To remedy the existing spillway sliding concerns, post-tensioned rock anchors were installed (Nov 2005 to Nov 2006). To remedy PMF overtopping, a

new auxiliary spillway on the right abutment was approved for construction. This resulted in several phases of work. The major activities are summarized in Table 3-1 below.

**3 - 03. Construction.** A resume of construction activities for Canton Lake is presented in Table 3-1.

**TABLE 3-1**  
**RESUME OF CONSTRUCTION ACTIVITIES**

Activity	Date
Construction began	December 1940
Construction suspended	April 1943 to March 1946
Impoundment Began	January 1948
Final storage began	April 1948
Conservation pool filled	July 1948
Construction on Auxiliary Spillway:	
-Construct Slurry Wall	September 2007 to January 2008
-Utility Relocation	May 2008 to September 2009
-Phase I Auxiliary Spillway Excavation	September 2008 to August 2012
-State Highway 58A Relocation	June 2008 to April 2009
-Construct Auxiliary Spillway Channel Bridges	August 2010 to February 2012
-Construct Auxiliary Spillway Hydraulic Structures	September 2011 to May 2015
-Phase II Auxiliary Spillway Phase II Excavation	August 2014 to August 2016

**3 - 04. Related Projects.** Canton Lake is a component of the multipurpose Arkansas River basin flood control and navigation system. Included in this overall system are completed projects in the Verdigris, Walnut, Canadian, North Canadian, Grand, Caney, Illinois, and Poteau River basins. The Arkansas River system is operated for the control of floods, navigation, and other beneficial uses. Related projects upstream of Canton Lake are Optima Lake on the North Canadian River and Fort Supply Lake on Wolf Creek. Within the North Canadian River basin,

Optima, Fort Supply, and Canton Lakes form the basis for operations for flood control, water conservation, fish and wildlife, and recreation enhancement. These reservoirs are operated in conjunction with the Oklahoma City levee system to provide flood control on the North Canadian River.

**3 - 05. Modification to Regulations.** Modifications have been made through time to the operational channel capacity (OCC) downstream of Canton Lake. The OCC defines a maximum non-damaging release rate from Canton Lake which serves as a limit on release rates so long as the flood control storage is not exceeded. It was originally believed that the OCC equaled 8,000 cfs. Following a release of 2,500 cfs in May 1949, complaints of flooding were received and the OCC was subsequently determined to equal 2,000 cfs. The OCC has since been revised down to 1,000 cfs and Canton Lake is regulated, insofar as possible, to limit downstream flows below this level.

The top of conservation pool elevation has also changed several times since the dam was constructed. The elevation changes are shown below in Table 3-2.

**TABLE 3-2**

**HISTORY OF CONSERVATION POOL CHANGES**

Date	Elevation (ft, NGVD 29)
January 1949 – June 1955	1603.0
July 1955 – May 1965	1614.0
May 1965 – February 1980	1615.2
February 1980 – Present	1615.4

**3 - 06. Principal Regulation Problems.** No significant problems have been encountered to date in the regulation of Canton Lake.

## **IV - WATERSHED CHARACTERISTICS**

**4 - 01. General Characteristics.** The North Canadian River rises in the high plateau region of northeastern New Mexico near Des Moines. From its source, the stream flows eastward for about 65 miles in New Mexico and about 241 miles across the Oklahoma and Texas Panhandles. From there, it flows in a southeasterly direction for about 537 miles in Oklahoma to its confluence with the Canadian (South Canadian) River, east of Eufaula, Oklahoma, at RM 38.5. Upstream from the mouth of Seneca Creek in New Mexico, the river is locally known as Corrupa Creek. From the Seneca Creek confluence to the mouth of Wolf Creek in Oklahoma, it is also called Beaver River. The total length of the stream is approximately 843 miles. The North Canadian River watershed upstream of Canton Dam comprises an area of approximately 12,695 square miles, of which 7,497 square miles are noncontributing. The western portion of the basin above Seiling, Oklahoma, accounts for approximately two-thirds of the entire watershed. Between Seiling and Oklahoma City, Oklahoma, the watershed is very narrow with an average width of about 10 miles. Between Oklahoma City and the mouth of the stream, the watershed widens to include the basins of Wewoka Creek and Deep Fork River. Coldwater Creek, Palo Duro Creek, and Wolf Creek are the most important flood-producing tributaries in the upper basin. The North Canadian River streambed profile is shown on Plates 4-2 and 4-3.

**4 - 02. Topography.** The topography of the North Canadian River basin varies from rolling plateaus and prairies in New Mexico to gently sloping plains in the Texas and Oklahoma Panhandles to wooded hills in eastern Oklahoma. The lower portion of the watershed is well timbered, but there are few trees west of Oklahoma City. The elevation of the headwater region is about 6,800 feet, NGVD 29, and begins in the foothills of Sierra Grande Volcano near Des Moines, New Mexico, while the elevation of the river mouth is about 500 feet, NGVD 29. Slopes of the North Canadian River vary from about 18 feet per mile in the headwater region to about 4 feet per mile in the reach from Woodward, Oklahoma, to Canton Lake. Land use consists of crop production, ranching, and an increasing amount of oil and gas production within the watershed.

### **4 - 03. Geology and Soils.**

a. **Regional Geology.** The Canton Dam region of northwest Oklahoma is located on the north flank of the Anadarko Basin, a major depositional and structural basin. Rocks that are exposed and in the shallow subsurface in the region are sedimentary in type and Permian in age (Figure 4-1). They consist of several thousand feet of red-brown shales and sandstones (“Red Beds”), with relatively thin but conspicuous layers of resistant gypsum and dolomite. The greater part of the Red Beds is commonly referred to as clays, silts, and sands, rather than shales and siltstones, due to their softness and lack of consolidation.

The principal formations in the region, and in the project area, are (in ascending order): 1) Blaine Formation, consisting of about 75 feet of interbedded gypsum and red brown shale; 2) Dog Creek Shale, consisting of about 175-200 feet of red-brown shale, with thin interbeds of siltstone, gray shale, dolomite, and gypsum; and 3) Marlow Formation, consisting of about 120

feet of orange-brown sandstone and siltstone. Sedimentary rocks in the region dip gently to the southwest, into the Anadarko Basin, at a rate of 10-50 feet/mile (less than 0.5°).

Permian rocks in the region were deposited in a shallow inland sea that extended across the Anadarko Basin and its northern shelf. Most formations are thicker to the south because the basin sank more rapidly and received more sediment than the northern shelf area. About 60 miles to the southwest, near the axis of the Anadarko Basin, several hundred feet of layered rock salt (halite) is present within the Blaine and Dog Creek Formations, but the salt is absent in the region around Canton Dam. Salt in the lower part of the Dog Creek Shale is called "Yelton Salt."

Overlying the Permian bedrock in the region are Quaternary (Pleistocene and Holocene) deposits that generally are 10-100 feet thick and consist mainly of unconsolidated sand, gravel, and clay deposited by major rivers and streams that flow from northwest to southeast across the region. Commonly these sediments are buff, tan, brown, and pale reddish brown, and their lighter color and lack of cementation distinguishes them from the underlying Permian Red-Beds.

b. Site Geology. Permian bedrock formations present at the dam site are (in ascending order) the Blaine Formation, Dog Creek Shale, and Marlow Formation. During original dam construction, about 60-90 feet of basal Marlow and upper Dog Creek strata were excavated to establish the foundation for the spillway. In general, the Blaine Formation is deep below the land surface, and the Marlow Formation has been eroded or excavated from the spillway itself. These bedrock formations locally are overlain by Quaternary alluvium and terrace deposits.

The North Canadian River flows through the reservoir area in a broad, shallow, sandy valley in the Dog Creek formation. The flood plain is about 2 miles wide; the river channel being situated along its southwestern edge. The overburden in the flood plain is sand and alluvium averaging about 30 feet in thickness. The left abutment slopes gradually upward from the flood plain, and is covered with sand dunes so that no distinct line of demarcation exists between it and the flood plain. The Red Beds outcrop along the right abutment which rises at a fairly gentle slope to a height of about 150 feet above the stream. Tributaries entering from this abutment have cut a number of steep-sided gulches, some of which extend back into the upland surface southwest of the valley as much as a half a mile.

(1) Blaine Formation. The Blaine Formation beneath Canton Dam consists of three gypsum beds separated by shales. Information on the Blaine is based upon 12 deep borings drilled through the entire formation in the 1940s, and 2 borings (BL-2 and BL-5) drilled 4 feet into the top of the Blaine in 2002-2003. Seven of the 1940 borings were drilled in the spillway itself, and in those holes the top of the Blaine (the top of the Shimer Gypsum Bed) is about 150-165 feet below the base of the spillway (Figure 4-2). Please note that the borings completed in 1940 named the uppermost gypsum bed the Lovedale member; however, based upon a search of literature, the uppermost gypsum bed is more properly called the Shimer member.

Total thickness of the Blaine Formation is 73-78 feet beneath the spillway, and each of the gypsum beds and shales of the Blaine is fairly uniformly thick; this indicates that probably there has been little dissolution of the Blaine gypsum beds. The Shimer Gypsum Bed ranges in

thickness from 14-16 feet, and averages 15 feet. The relatively consistent thickness of the Shimer indicates that there has been little dissolution of the Blaine Gypsum. Based upon the elevation of the top of the Shimer in BL-2 (1,423 feet) on the left spillway abutment and BL-5 (1,413 feet) on the right spillway, the dip of the Blaine dips to the southwest at a rate of 50 feet per mile (0.5°). The elevation of the top of the Shimer Bed in the area of the auxiliary spillway is 1410 feet.

Some of the cores drilled in 1940 were originally described as containing caved and brecciated Red Beds between the Blaine gypsums. This suggests that originally there may have been some soluble rock (such as salt) in the Blaine Formation at Canton Dam, but no salt exists now; any salt that may have been present has been totally dissolved.

(2) Dog Creek Shale. All borings drilled in the several phases of exploration penetrated some or all of the Dog Creek Shale. Deep borings drilled to the base of the Dog Creek included 12 of the holes in 1940 and 2 holes in 2002-2003. Most of the following discussion is based upon the cores drilled in 2002-2003 and in June-July 2003; these cores have been examined recently and are still available for inspection. However, descriptions of the 1940 cores, and geologic reports prepared at that time, are very similar to the current characterization of the Dog Creek Shale.

The thickness of the Dog Creek Shale is about 190 feet at the auxiliary spillway. However, the top of the formation has been eroded or excavated at the site, and only the lower 50 feet of shale is present beneath the base of the weir (the elevation of the base of the weir is 1,470 feet). The base of the Dog Creek is 1,410 feet in the area of the weir in the auxiliary spillway.

The Dog Creek Shale is mainly reddish-brown with thin layers of gray shale, siltstone, gypsum, and dolomite, and scattered veins of satin-spar gypsum. The shale is blocky and non-fissile, contains varying amounts of silt and sand, and is referred to as a mudstone by some geologists. Brecciation is one of the most striking features of the Dog Creek Shale at Canton Dam and spillway. The type of rock called a breccia consists of fragments, or clasts, of preexisting rock that are broken up or disrupted, and then are reset in a fine-grained matrix. Breccias commonly are associated with fault zones, and also occur in consolidation of landslides, detrital strata, and, most notably, cave-in debris in karst environments. Brecciated rock at Canton Dam undoubtedly results from cave-ins due to karst processes (the dissolution of soluble rock). The breccia consists of angular fragments of shale, siltstone, sandstone, dolomite, and gypsum that are surrounded by a matrix of clay, shale, or sandstone. The fragments or clasts, which in the cores range in size from 0.1 inch to about 6 inches across, have been recemented in the matrix, and the resulting rock mass appears as competent as the non-brecciated shale.

Breccia was described in the Dog Creek Shale in almost all the borings of 1940, and was observed and confirmed in all the borings of 2002-2003, June-July 2003 and 2006. The top of the brecciated zone is not uniform beneath the existing structural spillway. In all of the borings breccia was first encountered typically at elevations of 1,540-1,560 feet, but it ranged from 1,510-1,605 feet. However, once the top of the breccia was reached, almost all the underlying Dog Creek Shale was also brecciated. It is likely that early dissolution of highly soluble,

subsurface layers of rock salt, such as the Yelton Salt, is the explanation for brecciated Dog Creek Shale beneath the Canton Lake dam site. Although now absent from the Canton Dam area, the Yelton Salt commonly is present in the lower part of the Dog Creek Shale farther south, in deeper parts of the Anadarko Basin. Typical karst features are not presently visible in outcrops at Canton Dam. However, aerial photographs (taken in 1946) of the excavated right abutment of the spillway show that upper Dog Creek strata and the base of the overlying Marlow Formation are disrupted and undulate as much as 20-30 feet within short distances. Such undulations, which look like subsidence, collapse, and sinkhole features, are the surface and near-surface results of dissolution, collapse, and brecciation of rocks in the lower part of the Dog Creek Shale. These undulating strata are now concealed by soil, vegetation, rip rap, and the reservoir.

It is likely that a sizeable deposit or deposits of bedded rock salt (the Yelton Salt) originally existed in the lower part of the Dog Creek Shale beneath Canton Dam. The salt was dissolved by ground water in the distant geologic past, resulting in fracturing, subsidence, collapse, and flow of overlying materials into the underground cavities and voids. Eventually, the broken fragments of shale and interbedded (or overlying) siltstone, sandstone, dolomite, and gypsum were reconsolidated as brecciated rock. The clay, shale, and fine-grained sand making up the matrix around the clasts most likely were deposited by ground water that once flowed around the fragments and through voids during or shortly after brecciation. This is well demonstrated by sandstone matrix encountered in some of the borings; bedding and cross bedding in some of the sandstone matrix indicates that a water current was present at the time of deposition of matrix between the clasts of shale and other rock types.

There is no evidence that Yelton Salt, or similar layers of rock salt, now exist in the subsurface beneath Canton Dam, or any location in the region. Obviously, the salt dissolution and brecciation occurred long ago, and the clasts and matrix in the Dog Creek Shale at Canton Dam have been completely re-cemented into a competent rock. Although dissolution of gypsum is also known to be responsible for caving of overlying beds and subsequent formation of breccias in some parts of northwest Oklahoma, the underlying Blaine gypsum beds here appear to be undisturbed, intact, and non-karstic. Therefore, dissolution of pre-existing Yelton Salt beds (not the Blaine gypsum beds) is regarded as the probable cause for brecciation in the Dog Creek Shale.

In summary, although the Dog Creek Shale has been disrupted and brecciated in the geologic past, matrix material now bonds the clasts together. The rock now is re-cemented and appears to be as competent as non-brecciated shale.

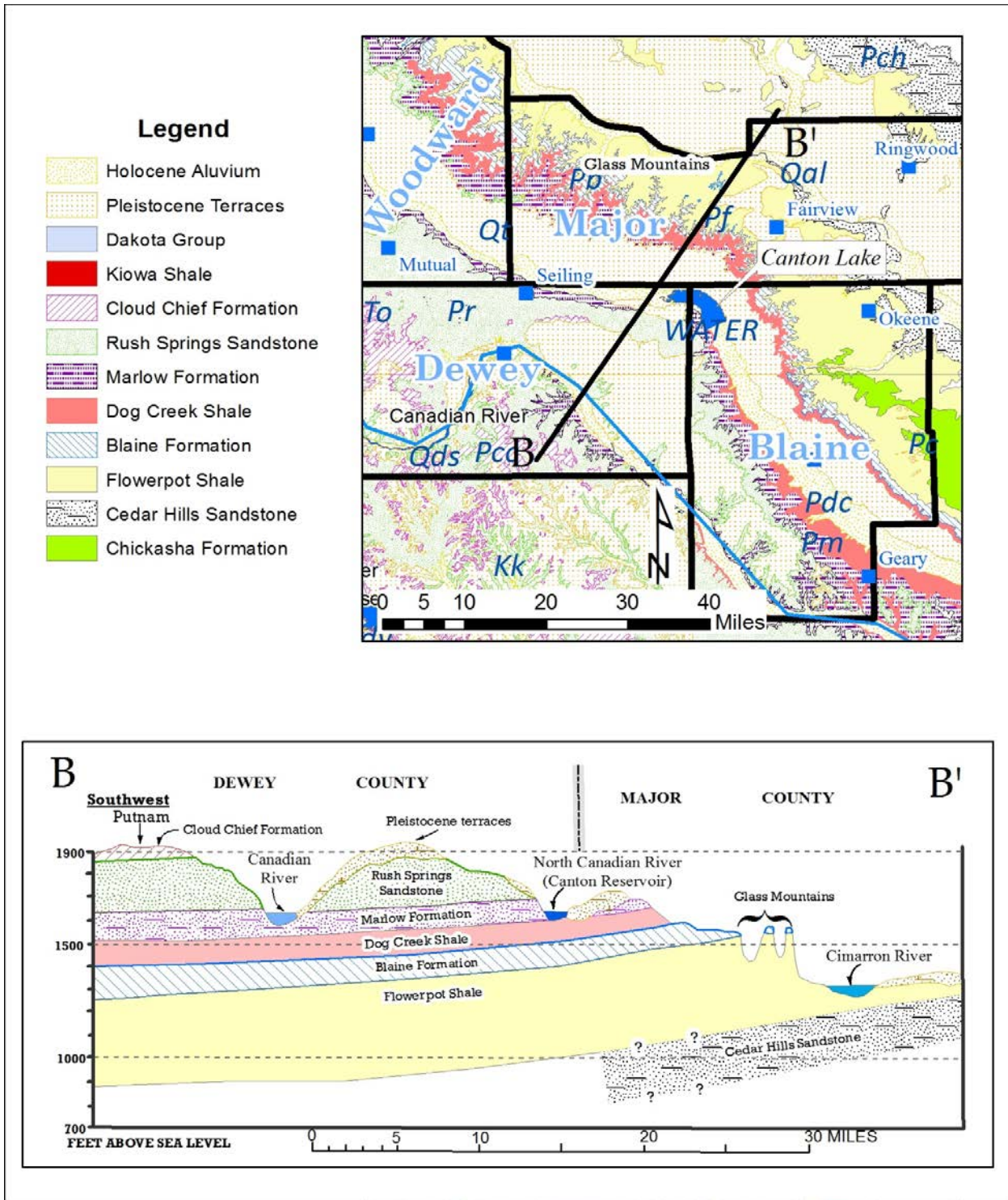
(3) Marlow Formation. The Marlow Formation has been eroded (or excavated) from the auxiliary spillway, although the basal layers of the Marlow probably are present in the upper part of the right (west) abutment of the structural spillway. Marlow sandstones and siltstones typically are very fine grained, orange brown to red brown, and unconsolidated (uncemented or friable). Some of the sandstone and siltstone clasts and matrix making up the Dog Creek breccia undoubtedly have collapsed and/or flowed down into the Dog Creek from the Marlow Formation during the period of brecciation.

(4) Quaternary Deposits. Quaternary sediments, also referred to as overburden, locally overlie Permian bedrock units at and near Canton Dam. They consist of sand, gravel, and clay deposited as alluvium and terrace deposits by North Canadian River and its tributaries. These sediments were derived by weathering and erosion of nearby Permian rocks or of other rocks and sediments located farther west. Commonly they are buff, tan, brown, and pale reddish brown. Quaternary deposits typically are loose, friable, and lack cementation. They range from 22-65 feet thick in borings drilled in 1940, but in most borings they are 30-40 feet thick.

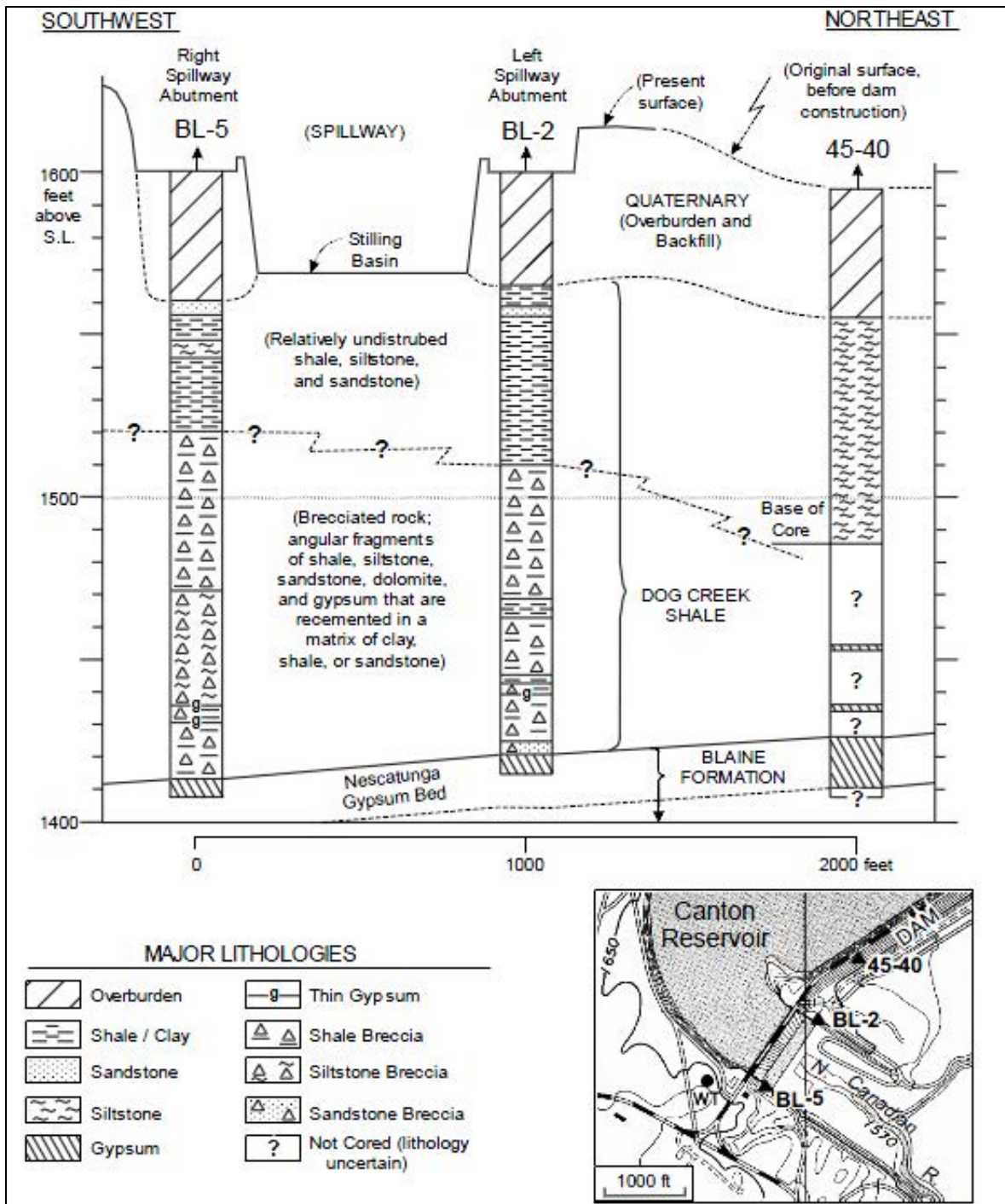
The Quaternary sand dunes and alluvium occur in stream valleys, the sand having been blow by the prevailing westerly winds onto the eastward sides of the channels, forming sand dune belts as much as 13 miles wide in some places. Near the site the dunes cover a belt about 4 miles wide, extending to the Gypsum Hills. Deposition of the dune sand on the northeast sides of the streams has tended to crowd the channels to the southwest, increasing erosion along the southwest banks of the streams. The material of the dunes probably was derived from the former Tertiary deposits immediately overlying the site area; and now that the source of sand has been removed, the dunes have become dormant. Migratory dunes are still being formed in the western part of the state where the Tertiary formations at the surface furnish an abundance of sand.

The sand dunes of the flood plain and the left abutment are no longer migratory because the erosion of the Tertiary formations has removed the source of the sand, and the growth of vegetation on the dunes has protected the remaining sand from wind action. The formation of these dunes on the Pre-Tertiary erosion surface of the Red Beds, now about 30 feet or more above the North Canadian River, has aided in the prevention of the piracy of the North Canadian, and in preventing the North Canadian from overtopping the divide and flowing into the Cimarron Valley. Although the sand in these dunes absorbs water readily, the dunes' expanse prevents any rapid flow through the voids, and the dune area can be considered to be relatively impervious. The dune area sands are fine grained and loose, and not as pervious as the coarser alluvial sands, and due to the windblown nature of the deposition, a realistic ratio of horizontal to vertical permeability is one. In some areas of the dam foundation, the alluvial material has a gravel composition, and is more pervious than the alluvial sands.

c. Earthquakes. Though Canton Lake is not in an area historically prone to earthquakes, the number of earthquakes in Oklahoma has recently increased significantly. Special post-earthquake inspections are to be conducted if post-earthquake damage is observed, if ground motion is felt at the dam, or in accordance with the earthquake magnitude and epicenter distance from the dam criteria provided in Table 4-1. The increase in earthquake frequency is demonstrated on Plate 4-4.



**FIGURE 4-1 – SHALLOW SEDIMENTARY ROCKS OF PERMIAN AGE**



**FIGURE 4-2 – BLAINE ROCK FORMATION (SHIMER GYPSUM BED)**

**TABLE 4-1**

**CRITERIA FOR POST-EARTHQUAKE INSPECTIONS**

<b>Earthquake Magnitude Moment</b>	<b>Epicenter Distance from the Dam (Miles) (Inspect dam if epicenter is within this distance to the dam)</b>
4.5	10
5.0	50
6.0	75
7.0	125
8.0	200

**4 - 04. Sediment.** Lake inflow can carry a large amount of sediment. During low-flow periods, the channel meanders over a wide sandy bed between banks that are easily eroded. During high-flow periods, bank caving and erosion occur at many locations. Four bathymetric surveys (1953, 1959, 1966, and 1977) have been conducted since completion of the project. There was also a 2010 LiDAR survey from the middle of the conservation pool (elevation 1607.0 feet) to the top of the dam. The amount of storage lost to sediment accumulation below elevation 1,615.4 feet (the top of the conservation pool) since 1947 is 19,071 acre-feet, according to the merged 1977 bathymetric and 2010 LiDAR surveys. This averages to a loss of approximately 303 acre-feet/year. Based on the merged 1977 bathymetric and 2010 LiDAR surveys, there are 368,058 acre-feet of storage remaining below the top of the flood control pool (elevation 1638.0 feet, NGVD 29). This remaining storage is distributed as follows: 70.18 percent flood pool (258,316 acre-feet), 25.97 percent conservation pool (95,572 acre-feet), and 3.85 percent inactive pool (14,170 acre-feet).

**4 - 05. Climate.** The climate in the general project area is characterized by moderate winters and long summers with high temperatures. Rainfall usually occurs in the form of high intensity, local thunderstorms that occur primarily during late spring and early fall. These storms are frequently accompanied by high winds, hail, and occasional tornadoes. Climatic characteristics for the basin are shown below:

a. Temperature.

Mean annual	59.9 Degrees F
Maximum recorded (Woodward, OK, 13 Aug 1936)	115 Degrees F
Minimum recorded (Woodward, OK, 4 Jan 1947)	-24 Degrees F

b. Rainfall. (Period of Record is Jan 1930 through Dec 2014)

Mean Annual	19.93 inches
Maximum Annual (Canton, OK, 1959)	44.9 inches
Minimum Annual (Canton, OK, 1956)	11.8 inches
Percent during Growing Season (Apr through Oct)	77%

The average monthly and annual rainfall and runoff data are shown in Table 4-2.

c. Snow. (Period of record is 1914 through 2002)

Mean Annual	6.8 inches
Maximum Annual (Canton, OK, 1940)	31 inches
Minimum Annual (Canton, OK, Several)	Zero

d. Evaporation. Following construction of Canton Dam, evaporation data was collected from an evaporation pan on site. In 1996, the Tulsa District migrated from using an evaporation pan for measurements to using an empirical formula which is based on meteorological data collected on site. The formula incorporates electronically collected data for solar radiation, wind speed, air temperature, and relative humidity. Average monthly pan evaporation at Canton Lake, for the period from Oct 1979 through Dec 2014, is shown in Table 4-3.

e. Wind. The prevailing wind is from the south with the greatest wind movement occurring in the spring months. Wind velocity data indicate the highest wind speed that can reasonably be expected at the dam site is 70 miles per hour and the highest wind speed for a 1-hour duration is 50 miles per hour.

**4 - 06. Storms and Floods.** Most major storms in the Canton Lake drainage basin have occurred in April through June or September through November. Three types of storms produce precipitation over the basin: (1) thunderstorms, (2) frontal storms, and (3) remnants of hurricanes. The largest storm of the 91 year period of record (1923 to 2014) occurred in August 1995, and produced approximately 9.74 inches of rain in the basin. Time of year and antecedent soil moisture conditions are also major factors that determine the amount of runoff from a given storm. Major storms in the basin are listed in Table 4-4.

There is very little flood data available on the North Canadian River prior to 1914. General flooding results when storms occur over a large portion of the watershed; however, such storms are infrequent. Floods of considerable magnitude have occurred in the upper and central portions of the basin without causing flooding further downstream. Occasional intense storms have occurred over small tributary areas causing flooding on the main stem for a considerable distance downstream. Prior to the construction of Fort Supply Lake, Wolf Creek contributed heavily to flood flows in the lower reaches of the North Canadian River. Annual peak flows at the dam site prior to dam construction are shown in Table 4-5a, and the ten peak pool elevations for Canton Pool are shown in Table 4-5b. The top twenty annual peaks for major gage sites on the North Canadian River are presented in Table 4-6.

**TABLE 4-2**

**AVERAGE MONTHLY AND ANNUAL RAINFALL AND  
RUNOFF UPSTREAM OF CANTON DAM**

Month	Average Rainfall (inches) <sup>(1)</sup>	Percent of Average Annual Rainfall	Average Runoff <sup>(2) (3)</sup>		Percent of Average Annual Runoff
			(acre-feet)	(inches)	
January	0.50	2.51	5625	0.02	3.68
February	0.73	3.66	7034	0.03	4.60
March	1.20	6.02	10725	0.04	7.02
April	1.59	7.98	14139	0.05	9.26
May	3.32	16.66	29408	0.11	19.25
June	2.86	14.35	29869	0.11	19.55
July	2.49	12.49	13385	0.05	8.76
August	2.45	12.29	8020	0.03	5.25
September	1.86	9.33	9167	0.03	6.00
October	1.44	7.23	14107	0.05	9.24
November	0.90	4.52	6299	0.02	4.12
December	0.59	2.96	4977	0.02	3.26
Total	19.93	100	152,754	0.55	100

(1)Period of Record Jan 1930 through Dec 2014 (data from Annual Report)

(2)Contributing Drainage Area = 5,198 sq. mi.

(3)Period of Record Jan 1923 through Dec 2014

**TABLE 4-3**

**ESTIMATED MONTHLY PAN EVAPORATION**  
**CANTON LAKE**

Month <sup>(1)</sup>	Evaporation <sup>(2)</sup> (inches)
January	2.11
February	2.48
March	4.48
April	6.70
May	7.99
June	9.23
July	11.01
August	9.84
September	7.28
October	5.19
November	3.40
December	2.20
Annual Total	71.92

(1) Data from SWT Monthly Charts. Period of Record from Oct 1979 through Dec 2014

(2) National Weather Service Class A Pan

Note: Equations used to calculate the Pan Evaporation at Canton Lake are as follows:

$$xcompl = 1 - (RELH/100)$$

$$TdC = TAIR - \left( (14.55 + (0.114 \times TAIR)) \times xcompl + ((2.5 + 0.007 \times TAIR) \times xcompl)^3 + (15.9 + 0.117 \times TAIR) \times xcompl^{14} \right)$$

$$\delta\lambda_1 = \frac{1}{(1 + (0.66/(0.00815 \times TAIR + 0.8912)^7))}$$

$$\delta\lambda_2 = 1 - \delta\lambda_1$$

$$Q_n = (0.00714 \times SRAD) + (0.00000526 \times SRAD \times (TAIR + 17.8)^{1.87}) + (0.00000394 \times SRAD^2) - (0.0000000239 \times SRAD^2 \times (TAIR - 7.2)^2) - 1.02$$

$$es_{ea} = 33.86 \times ((0.00738 \times TAIR + 0.8072)^8 - (0.00738 \times TdC + 0.8072)^8)$$

$$E_a = es_{ea}^{0.88} \times (0.42 + 0.0029 \times WSPD)$$

$$Daily\ Pan\ Evaporation = (\delta\lambda_1 \times Q_n + \delta\lambda_2 \times E_a)/25.4$$

Where: **TAIR** = daily average temperature (°C);

**WSPD** = daily average wind speed (km/day);

**RELH** = daily average relative humidity (%);

**SRAD** = daily average solar radiation (cal/cm<sup>2</sup>)

**TABLE 4-4**

**MAJOR STORMS (JAN 1923 - DEC 2014)**  
**NORTH CANADIAN RIVER BASIN UPSTREAM OF CANTON DAM**

Date of Storm	Average Basin Rainfall (inches)	Date of Storm	Average Basin Rainfall (inches)
7-10 June 1923	3.32	13 July 1987	4.71
13-19 September 1923	3.62	18-19 September 1988	3.28
1-7 October 1923	3.65	24-28 April 1990	3.17
25 Sept. - 4 Oct. 1926	3.42	17-21 September 1990	4.10
28-31 October 1928	4.35	29 August - 4 September 1991	5.10
1-6 June 1932	3.08	30 August - 2 September 1992	3.11
22-30 May 1936	3.49	6-12 May 1993	4.86
19-23 May 1941	3.38	20 November 1994	4.30
21-26 October 1941	4.09	3-6 June 1995	5.81
17-25 April 1942	3.75	1-4 August 1995	9.74
5-10 June 1942	3.47	14-17 June 1996	3.36
14-19 October 1942	3.19	14-16 September 1996	4.77
4-10 October 1946	5.00	9-12 April 1997	3.14
10-17 May 1947	3.33	22-25 September 1997	3.67
14-21 May 1949	3.42	16-17 March 1998	3.09
17-22 July 1950	3.56	31 October - 2 November 1998	4.35
15-18 May 1951	5.74	3-6 August 1999	4.56
18-20 May 1955	3.71	23-24 March 2000	3.62
29 May - 3 June 1963	3.41	14-16 October 2000	3.48
19-27 August 1969	3.25	24-26 August 2001	3.70
20-28 August 1974	4.25	17-23 June 2004	3.95
24-26 April 1980	3.49	28 June - 2 July 2004	3.34
15-16 May 1980	3.21	21-22 September 2006	4.52
26-30 May 1980	4.55	6-10 May 2007	5.29
30 June 1981	3.12	9-10 June 2008	4.36
16-17 May 1982	3.77	11-14 September 2008	3.83
21-25 June 1982	3.94	13-16 October 2008	3.18
13-14 May 1983	3.45	8-9 October 2009	3.15
10-12 June 1983	4.53	2-3 April 2010	3.55
17-22 October 1983	3.51	19-20 May 2010	3.10
29 Sept. - 3 Oct. 1986	8.36	3-4 February 2012	4.32
22-25 May 1987	3.21	26 August 2012	3.65
27-29 May 1987	5.77	23-28 May 2014	3.46

\*Largest storms of record: (1) 01-04 Aug 1995 – 9.74 in. average basin wide rainfall;  
(2) 29 Sep – 03 Oct 1986 – 8.36 in. average basin wide rainfall;  
(3) 03-06 June 1995 – 5.81 in. average basin wide rainfall.

**TABLE 4-5a**

**ANNUAL PEAK FLOWS AT CANTON GAGE  
PRIOR TO DAM CONSTRUCTION (1938-1947)**

Date	Flow (cfs)	Stage (ft)
10/12/1946	24,800	12.83
10/25/1941	21,900	12.51
5/25/1941	9,980	11.05
5/19/1938	8,750	10.25
6/26/1939	7,860	9.78
10/3/1942	6,500	9.20
4/23/1944	5,850	9.63
6/12/1940	5,300	9.00
9/28/1945	4,550	9.02
6/29/1946	1,620	7.23

Note: Canton gage was put in place in 1938, and impoundment at Canton Dam began in 1948, so only 10 years of observed data is available for the site prior to Dam Construction.

**TABLE 4-5b**

**MAJOR FLOODS AFTER DAM CONSTRUCTION  
(JANUARY 1949 THROUGH DECEMBER 2013)**

Date	Pool Elevation (ft, NGVD 29)	Inflow (cfs)	Outflow (cfs)
25 May, 1951	1,628.0	38,000 <sup>(1)</sup>	1,500 <sup>(1)</sup>
6 Jul, 1957	1,625.5	5,600 <sup>(1)</sup>	2,000 <sup>(1)</sup>
5 Aug, 1950	1,624.0	8,900 <sup>(1)</sup>	3,000 <sup>(1)</sup>
17 Apr, 1973	1,620.5	3,376 <sup>(1)</sup>	1,000 <sup>(1)</sup>
25 Jun, 1989	1,620.5	1,850 <sup>(1)</sup>	962 <sup>(1)</sup>
16 Jul, 2007	1,620.4	4,136	1,010
20 May, 1993	1,620.0	2,650 <sup>(1)</sup>	853 <sup>(1)</sup>
4 May, 1999	1,619.7	2,300 <sup>(1)</sup>	760
1 Oct, 1996	1,618.8	3,509	717
1 Jun, 1987	1,618.6	2,830 <sup>(1)</sup>	897 <sup>(1)</sup>
10 May, 1997	1,618.4	1,953	686
2 Jun, 1980	1,618.1	2,460 <sup>(1)</sup>	900 <sup>(1)</sup>

(1) These values were obtained from the Monthly Reports, and may not be the peak values

**TABLE 4-6****MAJOR FLOODS OF RECORD AT GAGE SITES**

<b>Woodward, OK</b>			<b>Seiling, OK</b>			<b>Watonga, OK</b>			<b>El Reno, OK</b>		
Date	Flow (cfs)	Stage	Date	Flow (cfs)	Stage	Date	Flow (cfs)	Stage	Date	Flow (cfs)	Stage
12 Oct, 1923	N/A	11.00	1924	N/A	16.40	19 Aug, 2007	7,220	19.70	15 Oct, 1923	N/A	31.30
10 Oct, 1946	42,000	9.80	19 May, 1951	33,000	15.61	3 Oct, 1986	6,180	19.24	20 Aug, 2007	23,800	23.33
18 May, 1951	35,000	8.70	11 Oct, 1946	29,300	16.00	3 Aug, 1995	5,160	18.26	28 Oct, 1941	15,000	15.98
23 Oct, 1941	31,000	7.70	28 Aug, 1974	15,200	14.28	23 Apr, 1990	4,220	16.41	10 May, 1993	14,600	21.41
24 May, 1941	18,000	6.40	19 May, 1949	14,800	13.71	9 May, 1993	3,720	16.64	24 Jun, 1948	12,800	16.14
24 Jun, 1957	14,400	10.50	25 Jun, 1957	13,100	12.48	30 Sep, 1986	3,390	16.00	21 Sep, 1965	12,500	18.20
3 Aug, 1950	13,900	7.06	9 Aug, 1948	9,550	12.06	11 Apr, 1997	3,190	16.03	10 Apr, 1944	9,540	13.18
20 May, 1955	12,400	9.46	30 Jul, 1950	9,290	12.25	24 Apr, 1999	3,070	15.86	29 Sep, 1986	9,010	15.91
7 Sep, 1938	11,400	5.30	21 Jun, 1955	8,770	11.80	4 Mar, 2004	2,990	15.76	5 Oct, 1986	8,910	15.52
25 Jun, 1939	10,500	5.40	3 Nov, 1974	7,480	13.21	6 Jun, 1989	2,980	15.19	9 Jun, 1995	8,170	18.73
9 Aug, 1940	10,300	5.44	23 Sep, 1997	7,200	14.86	23 Mar, 2000	2,920	15.66	21 May, 1938	7,950	11.10
17 May, 1949	9,790	5.98	27 May, 1980	6,360	12.98	19 Sep, 1996	2,730	15.29	11 Mar, 1990	7,630	18.53
28 Jun, 1948	8,410	5.55	24 Sep, 1959	5,070	10.27	9 Jun, 2008	2,500	15.28	4 Oct, 1959	6,840	13.47
11 Apr, 1944	6,600	4.82	4 Aug, 1958	4,800	10.16	16 Mar, 1998	2,370	14.86	19 May, 1949	6,320	12.23
3 Oct, 1942	6,000	4.60	13 Jun, 1968	4,580	12.01	30 May, 2001	1,980	14.17	13 Jun, 1941	6,130	11.60
12 Jun, 1968	5,970	10.39	16 Jun, 1965	4,430	11.82	18 Sep, 1988	1,940	14.24	13 Sep, 1961	6,020	13.33
13 Jun, 1969	5,850	10.10	9 Jul, 1972	4,340	12.70	22 Aug, 2005	1,170	12.29	13 Sep, 1989	6,020	15.58
20 Nov, 1971	5,720	9.91	17 Sep, 1962	4,170	9.90	1 Oct, 2005	1,080	12.05	1 Apr, 1988	6,000	12.78
15 Jun, 1965	5,590	10.18	9 Jun, 1995	4,150	13.80	20 May, 2010	991	11.62	20 Oct, 1983	5,870	13.93
22 Aug, 1958	5,510	8.00	30 Mar, 1973	4,120	12.42	6 Jun, 2002	979	11.69	15 Oct, 1946	5,800	11.99

NOTES: Peak flows chosen based on flow values rather than stage values.  
Flow and stage data taken from published information on the USGS website.

**4 - 07. Runoff Characteristics.** The drainage basins on the north side of the North Canadian River from Canton Reservoir to Optima, Oklahoma, and on both sides of the river from Optima to the New Mexico-Oklahoma state line contribute a very small amount of runoff due to poorly developed drainage and high transmission losses. The drainage area in New Mexico is characterized by narrow valleys with well-developed drainage. This part of the drainage area produces flashy flood-flows on the main stem, which decrease as they pass through the valley to Optima. The portion of the basin lying south of the river in the reach between Canton Reservoir and Optima is the largest flood-producing area in the entire watershed. It is well drained and contributes heavily to flood-flows in the lower reaches of the river. The rolling, hilly topography of the Wolf Creek watershed permits a fairly rapid runoff; however, the shape of the basin is not especially favorable for producing high peak flows, and the streamflow is usually very irregular. In spite of the sandy nature of the soil, the drainage is well developed over the basin, except near the divide at the upper end. On part of the area, the valley sides are steep and the runoff is rapid. In general, streamflow on the North Canadian River is highly variable and ranges from flashy peak flows to long periods of low flow, which may approach zero in the semiarid western portion. Pertinent data for important stream gages on the North Canadian River are given in Table 4-7. The estimated monthly and annual flows for Canton Lake during the period of record (Jan 1923-Dec 2014) are shown in Table 4-8 located in the Supplemental Tables Section. The inflow volume frequency by months is shown in Table 4-9. Plate 4-5 shows the inflow volume duration curve.

**TABLE 4-7****PERTINENT DATA FOR STREAM GAGING STATIONS**

STATION	STREAM	MILES ABOVE MOUTH	GAGE DATUM (ft, NGVD 29)	FLOOD STAGE (ft)	DRAINAGE AREA (sq mi) <sup>(1)</sup>	MAXIMUM FLOOD OF RECORD		
						DATE	STAGE (ft)	FLOW (cfs)
Beaver, OK	N Canadian R	576.0	2,368.16	9.0	4,986	8 Oct, 1946	14.55	70,000 <sup>(3)</sup>
Woodward, OK	N Canadian R	460.2	1,829.95	9.0	8,386	12 Oct, 1923	11.00	N/A
Seiling, OK	N Canadian R	422.6	1,675.53	11.0	9,058	1924	16.40	N/A
Watonga, OK	N Canadian R	361.2	1,453.60	15.0	9,526	19 Aug, 2007	19.70	7,220 <sup>(2)</sup>
El Reno, OK	N Canadian R	307.3	1,295.00	17.0	9,820	15 Oct, 1923	31.30	N/A

STATION	STREAM	2 <sup>nd</sup> LARGEST FLOOD OF RECORD			3 <sup>rd</sup> LARGEST FLOOD OF RECORD			PERIOD OF RECORD (FLOW OR STAGE)
		DATE	STAGE (ft)	FLOW (cfs)	DATE	STAGE (ft)	FLOW (cfs)	
Beaver, OK	N Canadian R	24 Sep, 1941	N/A	38,200	17 May, 1951	11.57	32,200	Mar 1904 - Dec 1905, Oct 1937 - Present
Woodward, OK	N Canadian R	10 Oct, 1946	9.80	42,000 <sup>(2)</sup>	18 May, 1951	8.70	35,000 <sup>(2)</sup>	Oct 1903 - Jun 1906, Oct 1938 - Present
Seiling, OK	N Canadian R	19 May, 1951	15.61	33,000 <sup>(2)</sup>	11 Oct, 1946	16.00	29,300 <sup>(2)</sup>	July 1946 - Present
Watonga, OK	N Canadian R	3 Oct, 1986	19.24	6,180 <sup>(2)</sup>	3 Aug, 1995	18.26	5,160 <sup>(2)</sup>	Oct 1983 - Present
El Reno, OK	N Canadian R	20 Aug, 2007	23.33	23,800 <sup>(2)</sup>	28 Oct, 1941	15.98	15,000	Oct 1902 - Apr 1908, Oct 1937 - Present

(1)Contributing Drainage Area

(2)Discharges are affected by regulation of upstream dams or diversions

(3)Flow obtained using slope-area measurement of peak flow in overflow section, and extension of the main channel rating curve above 42,000 cfs.

N/A indicates not available

NOTES: Peak flows chosen based on flow values rather than stage values.

Flow and stage data taken from published information on the USGS website.

Fort Supply Dam began operation in May 1942; Optima Dam began operation in October 1978.

**TABLE 4-9**

**INFLOW VOLUME FEQUENCY (JAN 1923-DEC 2014)**

Month	Monthly Inflow Volume (ac-ft) Frequency of Occurrence in Years					
	2	5	10	25	50	100
January	4,170	8,990	12,740	17,810	21,680	25,540
February	5,750	10,810	14,390	18,920	22,210	25,390
March	8,670	16,950	22,440	28,840	33,090	36,890
April	10,610	22,320	30,860	41,690	49,460	56,840
May	16,000	42,350	68,880	113,800	155,980	205,880
June	16,690	45,190	71,320	110,800	143,730	178,800
July	5,670	18,440	32,570	57,690	81,910	110,900
August	2,760	10,070	19,020	36,360	54,360	77,200
September	2,440	11,750	25,140	54,040	86,470	129,870
October	2,750	12,960	28,740	66,550	113,860	183,910
November	3,060	9,300	15,830	26,950	37,290	49,340
December	3,720	8,550	11,690	15,050	17,060	18,670

**4 - 08. Water Quality.** Designated within the State of Oklahoma Water Quality Standards (WQS), Title 785: Chapter 45, beneficial uses of the North Canadian River upstream from and including Canton Lake include Public and Private Water Supply (PPWS), Fish and Wildlife Propagation as a Warm Water Aquatic Community (WWAC), Agriculture (Livestock, Irrigation), Primary Body Contact Recreation (PBCR), and Aesthetics. The impoundment created by the Canton Lake Dam, and a 37.36 mile segment of the North Canadian River above the lake have been assessed with respect to beneficial uses by the Oklahoma Water Resources Board (OWRB). Based on the 2014 Integrated Report, Canton Lake fully supports all beneficial uses except WWAC, with the cause of impairment listed as turbidity with potential sources identified as ‘sources unknown’. The 37.36-mile segment of the North Canadian River above Canton Lake is impaired with respect to PBCR due to elevated *Enterococcus* concentrations. Additional beneficial use impairments listed for the river segment include WWAC due to sedimentation/siltation and fishes bio-assessments. Unconfirmed potential sources of sedimentation/siltation include grazing in riparian or shoreline zones, non-irrigated crop production, rangeland grazing, and sources unknown. The impairment due to fish bio-assessment results from data indicating the assemblage of fish, analyzed using an Index of Biotic Integrity, is degraded relative to the expected assemblage.

Tulsa District periodically collects water quality data from Canton Lake. The most recent data collection effort occurred in 2010. Total annual inflow to Canton Lake in 2010 was below the long-term average. Hydraulic residence time for the 2010 period was one (1) year. Rainfall and runoff through the sampling period was sufficient to keep the lake near or above the conservation pool elevation from mid-April through mid-August 2010. Water temperature profiles through

the sampling season did not reveal thermal stratification. Water clarity was moderate with median Secchi depth and turbidity of 0.65 meters and 9.8 NTU, respectively. Dissolved oxygen concentration observations indicated a well-oxygenated system. Regional geology is primarily responsible for elevated specific conductance and total dissolved solids, including moderately high concentrations of chloride and sulfate. Alkalinity, pH, hardness, specific conductance, sulfate, and chloride were within normal ranges for the region indicating a well-buffered, moderately saline, and alkaline system with hard water. Plant available nutrient concentrations were moderate to low while organic nitrogen and total organic carbon concentrations were relatively high. An assessment of trophic state based on chlorophyll-*a* concentration indicated a moderately eutrophic lake. Analysis of priority pollutant metals indicated low but consistent levels of arsenic, likely originating from natural background sources, and approximately 20% of samples analyzed for mercury revealed concentrations greater than 0.05 µg/l.

Tulsa District also conducted a water quality study of Canton Lake, OK in 1995. The 1995 study reported weak thermal stratification, a well-buffered system with very hard water, relatively high concentrations of total dissolved solids, sulfate, and chloride. Trophic state, based on total phosphorus and chlorophyll-*a* concentrations, was determined to be eutrophic and/or hyper-eutrophic, respectively. Summaries of water quality parameters between the two study periods (1995 and 2010) are highly similar. Notable differences include lower median ammonia, total phosphorus, chloride, sulfate, and chlorophyll-*a* concentrations in the 2010 study.

The OWRB, through the Beneficial Use Monitoring Program (BUMP), collects a broad base of chemical, physical, and biological parameters from lakes throughout the State, on a rotational schedule, to assess support of designated beneficial uses. Data collected at Canton Lake on three dates between October 2013 and July 2014 indicated average turbidity of 39 NTU, low water clarity, high chlorophyll-*a* concentration, and high specific conductance. This data collection effort followed a series of significant releases from Canton Lake, requested by active water rights entities, beginning in May 2011, to alleviate downstream water needs. Releases made in 2011 and 2013 lowered the pool elevation to about 1,600 feet NGVD, about 15 feet below the conservation pool elevation of 1,615.4 feet NGVD. These releases diminished the lake surface area and average depth by approximately 50% and storage volume by more than 75%. An increase in the number of turbidity observations exceeding the Oklahoma turbidity criterion for lakes, 25 NTU, during the period of lowered lake level was apparent. Decreased volume and average depth may contribute to higher summer season water temperatures, a reduction of well-oxygenated cool water refugia for aquatic organisms, as well as an environment conducive to the development of harmful algal blooms. Records of the sampling results from the Oklahoma BUMP can be found online at: <http://www.owrb.ok.gov/quality/monitoring/bump.php>. Records of the sampling results from the USACE sampling program are kept at the Tulsa District Office, Planning and Environmental Division, Environmental Analysis and Compliance Branch.

**4 - 09. Channel and Floodway Characteristics.** The regulating channel capacity on the North Canadian River below Canton Dam is estimated to be 1,000 cfs. Regulating stages at the Watonga and El Reno gages are 13.0 feet (currently estimated to be 1,247 cfs) and 10.0 feet (currently estimated to be 2,316 cfs), respectively. Information obtained during future flood

events may result in revisions to these estimates. Rating curves for the Woodward and Seiling gages on the North Canadian River upstream of Canton Lake are presented on Plates 4-6 and 4-7, respectively. Rating curves for the Canton, Watonga, and El Reno gages on the North Canadian River downstream from Canton Lake are shown in Plates 4-8, 4-9, and 4-10, respectively. Crest time of travel from Canton Dam to Watonga is about 30 hours. Travel time from Watonga to El Reno is about 60 hours. Travel time from El Reno to Oklahoma City is about 24 hours. Therefore, Oklahoma City is about 5 days travel time from Canton Dam. A simplified diagram showing crest travel time is shown on Plate 4-11. Travel time varies with the magnitude of the flood; therefore, this diagram should be used as a guide only.

**4 - 10. Upstream Structures.** Operational structures in the North Canadian River basin upstream of Canton Dam are Optima Lake on the North Canadian River and Fort Supply Lake on Wolf Creek. Both flood control structures are located in Oklahoma and operated by the Tulsa District.

**4 - 11. Downstream Structures.** Structures downstream of Canton Lake in the North Canadian River basin include the Oklahoma City Floodway and Levee project. The North Canadian River has its confluence with the Deep Fork and Canadian Rivers in Eufaula Lake.

**4 - 12. Economic Data.**

a. Population. The populations of counties and cities within the North Canadian River basin below Canton Dam are listed in Table 4-10. Although varying proportions of the counties listed lie within the watershed boundary, the entire population of each county is included.

b. Agriculture. NASS Cropscape was used to identify the type of crops and number of acres impacted using the maximum high pool failure inundation developed by the MMC. Cattle and pasture is the main agriculture commodity in the North Canadian River Basin below Canton Dam, making up approximately 62% of the total acreage. Agriculture and livestock raising are the principal industries in the North Canadian River Basin, which is predominantly rural in character. The principal crops grown in the basin are wheat, alfalfa, corn, rye, soybeans, and sorghum. Table 4-11 shows the annual acreage and value of crops in the floodplain downstream of Canton Dam.

c. Industry. The top industries of the area are Retail Trade; Health Care and Social Assistance; and Professional, Scientific, and Technical Services. Table 4-12 through Table 4-27 list the major industries in each county downstream of Canton Lake, along with corresponding data on number of establishments, annual payroll, and employees.

d. Flood Damages. The estimated average annual damages prevented by Canton Dam on the North Canadian River are presented in Table 4-28. The top five flood events, in terms of flood damages prevented, to pass through Canton Dam are presented in Table 4-29. Plates 4-12 through 4-17 show structural loss and area curves for reaches along the North Canadian River from Canton Dam downstream to the upper reaches of Eufaula Lake.

**TABLE 4-10****POPULATION OF COUNTIES AND CITIES DOWNSTREAM OF CANTON DAM**

County	Major Cities and Towns	Population <sup>1</sup>			% Change (2000-2010)
		2000	2010	2030 <sup>2</sup>	
Blaine		11,976	11,943	14,900	-0.28
	Longdale	310	262	390	-15.48
	Canton	618	625	770	1.13
	Greenfield	123	93	150	-24.39
	Watonga	4,658	5,111	5,800	9.73
Canadian		87,697	115,541	114,200	31.75
	El Reno	16,212	16,749	21,110	3.31
	Yukon	21,043	22,709	27,400	7.92
	Calumet	535	507	700	-5.23
Dewey		4,743	4,810	4,500	1.41
Haskell		11,792	12,769	17,200	8.29
Hughes		14,154	14,003	19,300	-1.07
	Wetumka	1,451	1,282	1,980	-11.65
Latimer		10,692	11,154	12,100	4.32
Lincoln		32,080	34,273	40,400	6.84
McIntosh		19,456	20,252	27,000	4.09
	Eufaula	2,639	2,813	3,660	6.59
Major		7,545	7,527	7,500	-0.24
Muskogee		69,451	70,990	75,500	2.22
Okfuskee		11,814	12,191	12,500	3.19
	Bearden	140	133	150	-5.00
	Boley	1,126	1,184	1,190	5.15
	Weleetka	1,014	998	1,070	-1.58
Oklahoma		660,448	718,633	765,600	8.81
	Oklahoma City	506,132	579,999	593,880	14.59
	Woodlawn Park	161	153	190	-4.97
	Midwest City	54,088	54,371	62,700	0.52
	Harrah	4,719	5,095	5,470	7.97
	Bethany	20,307	19,051	23,540	-6.19
	Choctaw	9,377	11,146	10,870	18.87
	Del City	22,128	21,332	25,650	-3.60
	Jones	2,517	2,692	2,920	6.95
	Spencer	3,746	3,912	4,340	4.43
Okmulgee		39,685	40,069	47,900	0.97
	Hoffman	148	127	180	-14.19
Pittsburg		43,953	45,837	49,200	4.29
	Crowder	436	430	490	-1.38
Pottawatomie		65,521	69,442	79,300	5.98
	McLoud	3,548	4,044	4,290	13.98
	Bethel Acres	2,735	2,895	3,310	5.85
	Earlsboro	633	628	770	-0.79
	Tecumseh	6,098	6,457	7,380	5.89

Seminole		24,894	25,482	26,700	2.36
----------	--	--------	--------	--------	------

- (1) 2000 Census, 2010 Census from: <http://factfinder.census.gov/>
- (2) 2030 Population Projections from Oklahoma Department of Commerce

**TABLE 4-11**

**ANNUAL VALUE OF CROPS BELOW CANTON DAM (2015 PRICES)**

<b>North Canadian River</b>		
<b>Crops</b>	<b>Canton Dam to Eufaula Reservoir</b>	
	<b>Area (Acres)</b>	<b>Value (\$)</b>
Pasture	125,432	\$ 110,682,560
Wheat	47,685	\$ 8,562,934
Alfalfa	11,145	\$ 3,676,452
Corn	5,310	\$ 2,160,412
Rye	4,698	\$ 673,284
Soybeans	4,394	\$ 751,374
Sorghum	2,548	\$ 797,646
<b>Total</b>	<b>201,212</b>	<b>\$ 127,304,663</b>

**TABLE 4-12****2013 ECONOMIC CENSUS FOR BLAINE COUNTY, OK**

NAICS Code	Industry Description	Number of establishments	Paid Employees per Pay Period	Annual payroll (\$1,000)
0	Total for all sectors	289	2,349	73,680
21	Mining, quarrying, and oil and gas extraction	26	232	8,065
22	Utilities	3	0 - 19	296
23	Construction	31	83	3,864
31-33	Manufacturing	8	250 - 499	Withheld
42	Wholesale trade	12	103	5,362
44-45	Retail trade	46	307	5,126
48-49	Transportation and warehousing	14	112	6,040
51	Information	6	20 - 99	Withheld
52	Finance and insurance	22	147	5,604
53	Real estate and rental and leasing	4	0 - 19	59
54	Professional, scientific, and technical services	22	100 - 249	2,794
55	Management of companies and enterprises	1	20 - 99	Withheld
56	Administrative and support and waste management and remediation services	7	0 - 19	162
62	Health care and social assistance	26	397	10,093
71	Arts, entertainment, and recreation	4	100 - 249	Withheld
72	Accommodation and food services	19	129	1,422
81	Other services (except public administration)	37	83	1,309
99	Industries not classified	1	0 - 19	Withheld

**TABLE 4-13****2013 ECONOMIC CENSUS FOR CANADIAN COUNTY, OK**

NAICS Code	Industry Description	Number of establishments	Paid Employees per Pay Period	Annual payroll (\$1,000)
0	Total for all sectors	2,458	25,835	982,319
11	Agriculture, forestry, fishing and hunting	4	0 - 19	671
21	Mining, quarrying, and oil and gas extraction	104	2,407	195,911
22	Utilities	10	100 - 249	Withheld
23	Construction	373	1,863	76,029
31-33	Manufacturing	68	2,797	117,383
42	Wholesale trade	127	1,151	54,306
44-45	Retail trade	266	3,712	95,685
48-49	Transportation and warehousing	113	974	37,031
51	Information	28	355	11,913
52	Finance and insurance	159	858	33,043
53	Real estate and rental and leasing	123	792	45,271
54	Professional, scientific, and technical services	238	1,000 - 2,499	77,932
55	Management of companies and enterprises	8	100 - 249	Withheld
56	Administrative and support and waste management and remediation services	138	663	22,682
61	Educational services	20	155	2,875
62	Health care and social assistance	250	2,663	87,242
71	Arts, entertainment, and recreation	20	500 - 999	Withheld
72	Accommodation and food services	169	3,369	43,209
81	Other services (except public administration)	237	1,548	41,569
99	Industries not classified	3	0 - 19	Withheld

**TABLE 4-14****2013 ECONOMIC CENSUS FOR DEWEY COUNTY, OK**

NAICS Code	Industry Description	Number of establishments	Paid Employees per Pay Period	Annual payroll (\$1,000)
0	Total for all sectors	148	890	30,751
21	Mining, quarrying, and oil and gas extraction	20	176	9,201
22	Utilities	1	0 - 19	Withheld
23	Construction	7	15	364
31-33	Manufacturing	4	30	1,432
42	Wholesale trade	8	21	998
44-45	Retail trade	33	224	3,831
48-49	Transportation and warehousing	15	108	6,876
51	Information	5	0 - 19	Withheld
52	Finance and insurance	9	59	2,427
53	Real estate and rental and leasing	2	0 - 19	Withheld
54	Professional, scientific, and technical services	9	28	385
55	Management of companies and enterprises	1	0 - 19	Withheld
56	Administrative and support and waste management and remediation services	4	0 - 19	Withheld
62	Health care and social assistance	4	20 - 99	Withheld
71	Arts, entertainment, and recreation	1	0 - 19	Withheld
72	Accommodation and food services	7	71	513
81	Other services (except public administration)	17	54	1,149
99	Industries not classified	1	0 - 19	Withheld

**TABLE 4-15****2013 ECONOMIC CENSUS FOR HASKELL COUNTY, OK**

NAICS Code	Industry Description	Number of establishments	Paid Employees per Pay Period	Annual payroll (\$1,000)
0	Total for all sectors	225	2,614	75,048
21	Mining, quarrying, and oil and gas extraction	26	323	13,736
22	Utilities	3	41	2,333
23	Construction	18	182	6,684
31-33	Manufacturing	8	20 - 99	Withheld
42	Wholesale trade	6	57	2,139
44-45	Retail trade	35	469	10,899
48-49	Transportation and warehousing	14	250 - 499	6,386
51	Information	2	20 - 99	Withheld
52	Finance and insurance	9	63	2,368
53	Real estate and rental and leasing	4	0 - 19	Withheld
54	Professional, scientific, and technical services	23	52	1,364
55	Management of companies and enterprises	1	0 - 19	Withheld
56	Administrative and support and waste management and remediation services	10	20 - 99	1,196
62	Health care and social assistance	31	500 - 999	Withheld
71	Arts, entertainment, and recreation	1	0 - 19	Withheld
72	Accommodation and food services	10	156	1,605
81	Other services (except public administration)	24	76	1,920

**TABLE 4-16****2013 ECONOMIC CENSUS FOR HUGHES COUNTY, OK**

NAICS Code	Industry Description	Number of establishments	Paid Employees per Pay Period	Annual payroll (\$1,000)
0	Total for all sectors	226	2,421	60,952
21	Mining, quarrying, and oil and gas extraction	18	241	12,868
23	Construction	14	20 - 99	1,164
31-33	Manufacturing	5	20 - 99	Withheld
42	Wholesale trade	4	20 - 99	829
44-45	Retail trade	49	461	8,062
48-49	Transportation and warehousing	6	47	2,640
51	Information	5	27	1,043
52	Finance and insurance	19	70	2,136
53	Real estate and rental and leasing	7	20 - 99	Withheld
54	Professional, scientific, and technical services	12	35	966
56	Administrative and support and waste management and remediation services	7	250 - 499	Withheld
62	Health care and social assistance	37	788	15,178
71	Arts, entertainment, and recreation	2	0 - 19	Withheld
72	Accommodation and food services	18	171	2,027
81	Other services (except public administration)	23	76	1,185

**TABLE 4-17****2013 ECONOMIC CENSUS FOR LATIMER COUNTY, OK**

NAICS Code	Industry Description	Number of establishments	Paid Employees per Pay Period	Annual payroll (\$1,000)
0	Total for all sectors	166	1,871	63,319
21	Mining, quarrying, and oil and gas extraction	9	100 - 249	Withheld
22	Utilities	4	20 - 99	3,951
23	Construction	11	100 - 249	Withheld
31-33	Manufacturing	2	250 - 499	Withheld
42	Wholesale trade	5	59	4,094
44-45	Retail trade	26	276	5,341
48-49	Transportation and warehousing	11	58	2,642
51	Information	2	0 - 19	Withheld
52	Finance and insurance	13	68	1,922
53	Real estate and rental and leasing	5	23	1,843
54	Professional, scientific, and technical services	17	65	4,006
55	Management of companies and enterprises	1	20 - 99	Withheld
56	Administrative and support and waste management and remediation services	5	20 - 99	Withheld
62	Health care and social assistance	24	404	10,272
71	Arts, entertainment, and recreation	1	0 - 19	Withheld
72	Accommodation and food services	7	111	1,357
81	Other services (except public administration)	23	60	838

**TABLE 4-18****2013 ECONOMIC CENSUS FOR LINCOLN COUNTY, OK**

NAICS Code	Industry Description	Number of establishments	Paid Employees per Pay Period	Annual payroll (\$1,000)
0	Total for all sectors	571	5,510	183,933
21	Mining, quarrying, and oil and gas extraction	15	214	15,473
22	Utilities	2	0 - 19	Withheld
23	Construction	74	457	16,699
31-33	Manufacturing	31	805	31,731
42	Wholesale trade	25	204	8,876
44-45	Retail trade	84	721	17,295
48-49	Transportation and warehousing	38	500 - 999	Withheld
51	Information	11	20 - 99	2,728
52	Finance and insurance	39	424	19,380
53	Real estate and rental and leasing	17	20 - 99	1,649
54	Professional, scientific, and technical services	38	113	3,410
55	Management of companies and enterprises	2	0 - 19	Withheld
56	Administrative and support and waste management and remediation services	21	83	1,819
62	Health care and social assistance	61	500 - 999	Withheld
71	Arts, entertainment, and recreation	6	250 - 499	Withheld
72	Accommodation and food services	48	504	6,025
81	Other services (except public administration)	59	170	2,855

**TABLE 4-19****2013 ECONOMIC CENSUS FOR MCINTOSH COUNTY, OK**

NAICS Code	Industry Description	Number of establishments	Paid Employees per Pay Period	Annual payroll (\$1,000)
0	Total for all sectors	360	3,281	91,247
21	Mining, quarrying, and oil and gas extraction	5	20 - 99	770
22	Utilities	4	0 - 19	422
23	Construction	20	115	3,436
31-33	Manufacturing	16	92	2,392
42	Wholesale trade	5	52	1,828
44-45	Retail trade	70	905	19,624
48-49	Transportation and warehousing	7	20 - 99	1,960
51	Information	3	0 - 19	Withheld
52	Finance and insurance	31	141	6,096
53	Real estate and rental and leasing	16	29	858
54	Professional, scientific, and technical services	42	124	3,796
55	Management of companies and enterprises	2	20 - 99	Withheld
56	Administrative and support and waste management and remediation services	15	55	1,682
62	Health care and social assistance	46	856	26,837
71	Arts, entertainment, and recreation	8	100 - 249	3,685
72	Accommodation and food services	35	441	5,404
81	Other services (except public administration)	34	174	4,247
99	Industries not classified	1	0 - 19	Withheld

**TABLE 4-20****2013 ECONOMIC CENSUS FOR MAJOR COUNTY, OK**

NAICS Code	Industry Description	Number of establishments	Paid Employees per Pay Period	Annual payroll (\$1,000)
0	Total for all sectors	260	2,297	109,523
11	Agriculture, forestry, fishing and hunting	3	20 - 99	Withheld
21	Mining, quarrying, and oil and gas extraction	37	595	46,023
23	Construction	36	240	11,053
31-33	Manufacturing	6	20 - 99	Withheld
42	Wholesale trade	16	137	3,946
44-45	Retail trade	32	277	5,713
48-49	Transportation and warehousing	16	108	5,474
51	Information	3	0 - 19	Withheld
52	Finance and insurance	11	76	3,825
53	Real estate and rental and leasing	8	100 - 249	Withheld
54	Professional, scientific, and technical services	21	47	1,359
56	Administrative and support and waste management and remediation services	13	100 - 249	6,835
61	Educational services	5	23	314
62	Health care and social assistance	14	250 - 499	Withheld
71	Arts, entertainment, and recreation	1	0 - 19	Withheld
72	Accommodation and food services	11	91	1,022
81	Other services (except public administration)	27	130	4,357

**TABLE 4-21****2013 ECONOMIC CENSUS FOR MUSKOGEE COUNTY, OK**

NAICS Code	Industry Description	Number of establishments	Paid Employees per Pay Period	Annual payroll (\$1,000)
0	Total for all sectors	1,436	22,139	809,673
11	Agriculture, forestry, fishing and hunting	1	0 - 19	Withheld
21	Mining, quarrying, and oil and gas extraction	14	61	2,915
22	Utilities	6	250 - 499	Withheld
23	Construction	118	1,080	36,362
31-33	Manufacturing	53	3,640	184,403
42	Wholesale trade	68	904	36,661
44-45	Retail trade	260	3,187	74,634
48-49	Transportation and warehousing	40	604	27,027
51	Information	20	315	11,688
52	Finance and insurance	114	628	28,862
53	Real estate and rental and leasing	51	100 - 249	5,433
54	Professional, scientific, and technical services	91	534	19,681
55	Management of companies and enterprises	6	168	8,196
56	Administrative and support and waste management and remediation services	59	946	22,752
61	Educational services	10	363	7,093
62	Health care and social assistance	228	5,625	257,571
71	Arts, entertainment, and recreation	14	460	13,620
72	Accommodation and food services	126	2,155	27,795
81	Other services (except public administration)	157	1,011	21,603

**TABLE 4-22****2013 ECONOMIC CENSUS FOR OKFUSKEE COUNTY, OK**

NAICS Code	Industry Description	Number of establishments	Paid Employees per Pay Period	Annual payroll (\$1,000)
0	Total for all sectors	165	2,260	64,022
21	Mining, quarrying, and oil and gas extraction	8	20 - 99	2,392
22	Utilities	2	0 - 19	Withheld
23	Construction	15	84	3,839
31-33	Manufacturing	6	100 - 249	Withheld
42	Wholesale trade	4	0 - 19	Withheld
44-45	Retail trade	27	204	4,914
48-49	Transportation and warehousing	7	0 - 19	557
51	Information	2	0 - 19	Withheld
52	Finance and insurance	10	100 - 249	3,135
53	Real estate and rental and leasing	3	0 - 19	Withheld
54	Professional, scientific, and technical services	6	0 - 19	Withheld
55	Management of companies and enterprises	1	0 - 19	Withheld
56	Administrative and support and waste management and remediation services	3	0 - 19	Withheld
62	Health care and social assistance	42	1,000 - 2,499	Withheld
71	Arts, entertainment, and recreation	3	100 - 249	Withheld
72	Accommodation and food services	6	62	813
81	Other services (except public administration)	20	100 - 249	2,504

**TABLE 4-23****2013 ECONOMIC CENSUS FOR OKLAHOMA COUNTY, OK**

NAICS Code	Industry Description	Number of establishments	Paid Employees per Pay Period	Annual payroll (\$1,000)
0	Total for all sectors	22,949	365,176	16,667,409
11	Agriculture, forestry, fishing and hunting	8	20 - 99	824
21	Mining, quarrying, and oil and gas extraction	663	14,970	1,719,126
22	Utilities	48	1,000 - 2,499	Withheld
23	Construction	1,822	17,369	800,600
31-33	Manufacturing	691	20,953	953,828
42	Wholesale trade	1,323	20,594	1,185,641
44-45	Retail trade	2,940	44,374	1,234,014
48-49	Transportation and warehousing	460	10,760	541,005
51	Information	360	8,978	472,514
52	Finance and insurance	1,813	18,444	1,106,034
53	Real estate and rental and leasing	1,127	6,862	322,062
54	Professional, scientific, and technical services	2,958	24,363	1,498,098
55	Management of companies and enterprises	203	15,929	1,292,740
56	Administrative and support and waste management and remediation services	1,286	30,721	994,706
61	Educational services	224	8,775	274,282
62	Health care and social assistance	2,929	57,466	2,818,159
71	Arts, entertainment, and recreation	242	4,996	197,185
72	Accommodation and food services	1,840	39,296	582,620
81	Other services (except public administration)	1,992	18,194	471,639
99	Industries not classified	20	0 - 19	240

**TABLE 4-24****2013 ECONOMIC CENSUS FOR OKMULGEE COUNTY, OK**

NAICS Code	Industry Description	Number of establishments	Paid Employees per Pay Period	Annual payroll (\$1,000)
0	Total for all sectors	679	7,669	227,503
11	Agriculture, forestry, fishing and hunting	2	0 - 19	Withheld
21	Mining, quarrying, and oil and gas extraction	28	20 - 99	1,625
22	Utilities	5	106	6,586
23	Construction	42	171	5,180
31-33	Manufacturing	36	1,449	69,103
42	Wholesale trade	19	100 - 249	4,239
44-45	Retail trade	122	1,414	27,054
48-49	Transportation and warehousing	16	20 - 99	1,542
51	Information	10	20 - 99	1,889
52	Finance and insurance	54	303	10,522
53	Real estate and rental and leasing	18	52	923
54	Professional, scientific, and technical services	42	174	4,639
55	Management of companies and enterprises	3	20 - 99	Withheld
56	Administrative and support and waste management and remediation services	23	100 - 249	Withheld
61	Educational services	1	0 - 19	Withheld
62	Health care and social assistance	121	2,262	67,582
71	Arts, entertainment, and recreation	7	100 - 249	Withheld
72	Accommodation and food services	51	785	8,751
81	Other services (except public administration)	78	318	4,335
99	Industries not classified	1	0 - 19	Withheld

**TABLE 4-25****2013 ECONOMIC CENSUS FOR PITTSBURGH COUNTY, OK**

NAICS Code	Industry Description	Number of establishments	Paid Employees per Pay Period	Annual payroll (\$1,000)
0	Total for all sectors	963	11,476	383,490
21	Mining, quarrying, and oil and gas extraction	31	486	39,410
22	Utilities	8	95	8,685
23	Construction	60	441	13,336
31-33	Manufacturing	27	1,177	50,778
42	Wholesale trade	53	369	16,873
44-45	Retail trade	173	2,087	49,132
48-49	Transportation and warehousing	40	500 - 999	Withheld
51	Information	17	249	8,714
52	Finance and insurance	68	432	16,007
53	Real estate and rental and leasing	42	214	8,073
54	Professional, scientific, and technical services	91	375	16,062
55	Management of companies and enterprises	2	0 - 19	Withheld
56	Administrative and support and waste management and remediation services	35	419	12,730
61	Educational services	4	0 - 19	143
62	Health care and social assistance	114	2,492	88,212
71	Arts, entertainment, and recreation	6	44	954
72	Accommodation and food services	95	1,450	19,075
81	Other services (except public administration)	96	492	9,172
99	Industries not classified	1	0 - 19	Withheld

**TABLE 4-26****2013 ECONOMIC CENSUS FOR POTTAWATOMIE COUNTY, OK**

NAICS Code	Industry Description	Number of establishments	Paid Employees per Pay Period	Annual payroll (\$1,000)
0	Total for all sectors	1,312	18,571	561,006
21	Mining, quarrying, and oil and gas extraction	38	722	41,398
22	Utilities	6	20 - 99	Withheld
23	Construction	114	779	24,427
31-33	Manufacturing	56	2,900	135,103
42	Wholesale trade	36	263	11,472
44-45	Retail trade	239	2,869	64,608
48-49	Transportation and warehousing	27	193	6,830
51	Information	27	341	11,166
52	Finance and insurance	95	681	24,247
53	Real estate and rental and leasing	47	164	4,240
54	Professional, scientific, and technical services	106	717	29,986
55	Management of companies and enterprises	10	204	10,459
56	Administrative and support and waste management and remediation services	64	970	24,391
61	Educational services	10	1,000 - 2,499	Withheld
62	Health care and social assistance	166	2,974	94,758
71	Arts, entertainment, and recreation	14	271	4,346
72	Accommodation and food services	116	2,369	32,046
81	Other services (except public administration)	139	867	15,064
99	Industries not classified	2	0 - 19	Withheld

**TABLE 4-27****2013 ECONOMIC CENSUS FOR SEMINOLE COUNTY, OK**

NAICS Code	Industry Description	Number of establishments	Paid Employees per Pay Period	Annual payroll (\$1,000)
0	Total for all sectors	469	5,783	189,999
21	Mining, quarrying, and oil and gas extraction	53	678	38,832
22	Utilities	6	100 - 249	Withheld
23	Construction	36	239	8,654
31-33	Manufacturing	20	743	33,478
42	Wholesale trade	21	148	7,185
44-45	Retail trade	70	813	18,195
48-49	Transportation and warehousing	16	250 - 499	13,243
51	Information	7	45	1,224
52	Finance and insurance	46	234	7,913
53	Real estate and rental and leasing	15	68	1,968
54	Professional, scientific, and technical services	30	106	3,095
55	Management of companies and enterprises	1	0 - 19	Withheld
56	Administrative and support and waste management and remediation services	9	100 - 249	2,940
61	Educational services	1	0 - 19	Withheld
62	Health care and social assistance	40	1,017	28,183
71	Arts, entertainment, and recreation	10	250	4,694
72	Accommodation and food services	38	612	6,161
81	Other services (except public administration)	49	180	3,221
99	Industries not classified	1	0 - 19	Withheld

**TABLE 4-28**

**AVERAGE ANNUAL FLOOD DAMAGES PREVENTED  
DOWNSTREAM OF CANTON DAM**

<b>Average Annual Flood Damages Prevented by Canton Dam</b>		
<b>Years in Operation</b>	<b>Cumulative Damages Prevented (2015 \$ 1,000's)</b>	<b>Average Annual Damages Prevented (2015 \$ 1,000's)</b>
66	\$ 117,360	\$ 1,778

NOTE: Analysis completed by Tulsa District

**TABLE 4-29**

**TOP FIVE FLOOD EVENTS IN TERMS OF DAMAGES PREVENTED  
DOWNSTREAM OF CANTON DAM**

<b>Year</b>	<b>Damages Prevented (\$ 1,000's)</b>	<b>Damages Prevented (2015 \$1,000's)</b>
1951	\$ 2,936	\$ 53,454
1957	\$ 996	\$ 13,791
2007	\$ 3,953	\$ 4,905
1949	\$ 233	\$ 4,829
2004	\$ 3,129	\$ 4,347

NOTE: Analysis completed by Tulsa District

## **V - DATA COLLECTION AND COMMUNICATION NETWORKS**

### **5 - 01. Hydrometeorological Stations.**

a. Facilities. The Water Management Section, Hydrology-Hydraulics Branch, Tulsa District; the National Weather Service (NWS); and the U.S. Geological Survey (USGS) cooperate to collect data and maintain a reliable communication network. All pertinent reporting observation stations are shown on Plate 5-1. Pool elevation records are provided by a float gage located in the access to the Number 7 pier (numbered from the southwest end) of the dam. A Stevens recorder geared to the float gage is also at this location and provides 24 hour pool elevation records on roll paper. A remote pool elevation indicator is located in the project office. The gage and a tipping bucket rain gage are connected to a data collection platform (DCP). A wire weight gage is located on the upstream side of the spillway and is used for outside reference.

All stream gaging stations are automated gages consisting of float wells or bubbler gages connected to digital recorders and DCPs. The Canton, Watonga, and El Reno stream gages on the North Canadian River are the key stations for regulation purposes. The Beaver, Woodward, and Seiling stream gages on the North Canadian River are used to forecast inflows into Canton Lake. Automated stream gaging stations are equipped with automated rain gages that provide precipitation data transmitted along with stage data. The NWS also maintains a network of local observer stations throughout the district. Precipitation and stream gaging stations are shown on Plate 5-1.

b. Reporting. The reporting procedures for precipitation and stream gaging stations are on a cooperative basis with the NWS and the USGS. The reporting of data from pool elevation and stream gaging stations has been automated by using DCPs that record data hourly and transmit the data every hour or when a threshold value is exceeded. The data are transmitted via Geostationary Operational Environmental Satellite (GOES) to a downlink and computer facility owned and operated by the National Oceanic and Atmospheric Administration (NOAA) near Washington, D.C. The data are then transmitted to a domestic satellite (DOMSAT) that passes the data to the Tulsa District's Receive Only Terminal (DROT). The data from the NOAA computer facility may also be transferred via the internet. When received, the river stage is converted to flow and lake elevation is converted to storage. All the data are then stored in a database on the Tulsa District Water Control Data System (WCDS) for access when needed. Rainfall data collected by DCPs are reported in the same way.

In addition to DCP data, observer rainfall data are collected and stored in the computer system for use in forecasting. Observers telephone the NWS offices in this region and the NWS then encodes the data into a Standard Hydrologic Exchange Format (SHEF). The data are then transferred to the WCDS by electronic data transmission from the Arkansas-Red Basin River Forecast Center (ABRFC). Once the data are received, they are decoded and handled similarly to the DCP data. Informative display of all these data is possible through the use of several versatile computer programs developed for use on the WCDS. Table 5-1, located in the Supplemental Tables Section, contains a list of automated stream gage and rainfall stations.

Detailed instructions on reporting criteria are presented in Exhibit B, Standing Instructions to Lake Manager, Canton Lake.

c. Maintenance. Maintenance and repair of the weather station instrumentation is the responsibility of the NWS. Maintenance and repair of the stream gages is the responsibility of the administering agency. Both the Corps of Engineers and the USGS have stream-gaging equipment in the North Canadian River Basin. The Water Management Section is charged with the responsibility for the equipment placed by the Corps of Engineers.

#### **5 - 02. Water Quality Stations.**

a. Facilities. There are no active water quality stations in the North Canadian River Basin above Canton Lake. However, at Canton Lake water quality samples are taken at periodic intervals to determine the chemical, biological, and sediment quantities contained in the lake. The COE has a total of three water quality sampling stations within Canton Lake, and one sampling station in the stilling basin below the dam. Water quality stations within and pertinent to Canton Lake, including downstream stations, are listed in Table 5-2, located in the Supplemental Tables Section.

b. Reporting. The reporting procedures for water quality stations are determined by the organization collecting the samples. OWRB water quality sampling results can be found on the web at: <http://www.owrb.ok.gov/studies/reports/reports.php>. USGS water quality sampling results can be found on the web at: <http://waterdata.usgs.gov/ok/nwis/current/?type=quality>. Water quality samples taken by COE personnel will be reported and maintained by the Natural Resources Section, Operations Division, Tulsa District Office. A discussion of water quality problems associated with Canton Lake is found in paragraph 4-08.

c. Maintenance. Maintenance and repair of the water quality stations is the responsibility of the operating agency shown in Table 5-2.

#### **5 - 03. Sedimentation Stations.**

a. Facilities. The Corps maintains 44 sedimentation ranges within and above Canton Lake and 24 degradation ranges below Canton Dam for use in sedimentation measurements. These ranges are surveyed periodically for the purpose of computing sediment deposition and revising lake area/capacity data. The sedimentation and degradation ranges are shown on Plates 2-7 and 2-8, respectively.

b. Reporting. Sediment surveys are made infrequently for Canton Lake. The last re-surveys were done in 1977 (conservation pool bathymetric survey) and 2010 (flood pool LiDAR survey).

c. Maintenance. Maintenance on the sediment and degradation ranges is the responsibility of the Tulsa District.

**5 - 04. Recording Hydrologic Data.** Hydrologic information is recorded as it is received by the Water Management Section as follows:

a. Stages and Discharges. The raw data that the Water Management computer retrieves from the central computer are stored as they are received. These raw data are then sorted by station and stored again. Several computer programs convert the raw data into stage/pool elevation data and the corresponding flow/storage values are determined from rating curves. These processed data are then stored in two databases. To prevent the databases from filling, they are periodically archived on tape for permanent storage. Stream flow measurements made by the USGS are reported to the Hydrology and Hydraulics Technical Services Section. The measurements are entered into the database for storage.

b. Precipitation. Precipitation data from the DCP stations and the project are combined with NWS observer precipitation data that can then be used by computer programs for plotting distribution, determining basin rainfall, and forecasting runoff (see Section VI).

c. Water Quality Data. Water quality sampling stations upstream, downstream, and within Canton Lake are maintained by the USGS, OWRB, and COE. Water quality data are recorded and reported as described in paragraph 5-02.b.

**5 - 05. Communication Network.** Wire facilities at Canton Lake consist of local and long distance telephone service. Radio communication is by VHF-FM fixed station (call signal WUI-310) capable of reaching local mobile stations, the Tulsa District, and other stations on the north and south loop of the Tulsa District via repeater relay. Maintenance of the telephone lines is the responsibility of the company leasing the line to the Government. The Tulsa District radio technician makes quarterly inspections of the project's fixed equipment and makes repairs as conditions warrant. To alert the public in the vicinity of the spillway of impending changes in release rates, a warning siren is sounded prior to each gate change. The warning siren is located on the right tower near the catwalk door on the downstream side of the spillway. Control buttons are located at each tainter gate control panel. There are no downstream warning lights.

**5 - 06. Communication with Project.**

a. Regulating Office with Project Office. Instructions for the storage and release of water from the lake will be communicated by the Water Management Section to the responsible project operating personnel for the implementation of the provisions set forth in Section IX of this manual. This communication will normally be made by long distance telephone, but on occasion could be made by VHF-FM radio. The reports by the project office, described in paragraph 5-07 and Exhibit B of this manual, will be communicated directly to the Water Management Section. Should communication between the project and the District office be disrupted, the Lake Manager will, on his or her own initiative, direct regulation of the lake in accordance with the emergency regulations as required in Section VII and Exhibit B of this manual. The chart "Organization for Flood Control Regulation" is shown on Plate 5-2.

b. Between Project Office and Others. Communications between project personnel and other Federal, State, and local agencies will be sufficient to facilitate the coordination described in Section IX of this manual.

**5 - 07. Project Reporting Instructions.** Hydrologic data items affecting release of water, confirmation of change in releases as instructed, complaints, operating machinery failure, or out-of-service times for maintenance shall be reported to the Water Management Section as they occur.

The following data should be included in the daily report to the Water Management Section (Hydrology-Hydraulics Branch, Tulsa District) from all flood control storage projects without hydropower. Data are typically reported by telephone, fax, or email. Data collected will be reviewed and input into the Water Management Section's database before 10 a.m., and published to the lake data morning report located at [http://www.swt-wc.usace.army.mil/old\\_resvreport.htm](http://www.swt-wc.usace.army.mil/old_resvreport.htm) by 10 a.m. See Plate 5-3 for lake data reporting details.

a. As of 8 a.m. Each Weekday.

- 1) Pool elevations at 12 noon, 4 p.m., and 12 midnight of the previous day and the current 8 a.m. pool elevation and tailwater elevation (if available).
- 2) The total precipitation amounts for the previous 24-hour period (7 a.m. to 7 a.m. time period).
- 3) The current wind direction and wind speed (Beaufort scale).
- 4) Water supply withdrawal or release for previous day (if available).
- 5) The discharge in daily average cfs for the previous 24 hour period (midnight to midnight).
- 6) The 8 a.m. instantaneous total discharge in cfs.
- 7) The current gate setting and any gate changes made during the past 24-hour period, including the time and pool elevation and tailwater elevation if necessary when the change was made.

Note: Except for lakes without personnel or if data collection is automated.

b. As of 8 a.m. Each Monday.

- 1) The same data from the weekend as required in paragraph 5-07.a. above.
- 2) The current pool elevation readings from the pool gage, the recording chart or tape, the shaft encoder, or data logger, and the wire weight or staff gage. If wind or weather prevents readings on Monday, then these readings can be taken on the next day that weather permits.

c. Weekends and Holidays.

- 1) Daily reports are not required to be submitted on weekends and holidays except during flood periods.

d. During Flood Periods.

- 1) During flood periods, weekend and holiday reports should include the same data as required in paragraph 5-07.a. above, as well as the 8 a.m. pool elevation from the pool gage.
- 2) In addition to the data in paragraphs 5-07.a., 5-07.b., and 5-07.c. above, additional reports of lake elevations may be requested by Water Management Section personnel.

**5 - 08. Warnings.** It is the responsibility of the Lake Manager to initiate a warning to the Tulsa District and local law enforcement agencies if emergency situations develop. He or she has the responsibility to properly recognize emergency situations and to seek assistance from supervisory offices, if time permits. They must be knowledgeable of conditions that constitute an emergency, such as a possible dam failure. The downstream population should be notified as early as possible of a potential problem. Initial notification by project personnel will include (listed by priority), Chief of Operations, Chief of Operations Technical Support, Chief of Engineering and Construction, Chief of Emergency Management, as set forth in the Operations and Maintenance Manual Volume II, Canton Lake, Flood Emergency Plan, dated Apr 2011. The Canton Lake project personnel have compiled a list of downstream contacts for use in emergency situations.

## **VI - HYDROLOGIC FORECASTS**

**6 - 01. General.** Hydrologic forecasts are necessary in predicting streamflow upstream and downstream of Canton Lake to determine if and when releases should be made.

a. **Role of Corps of Engineers.** Hydrologic forecasts are made by the Water Management Section, Tulsa District, for use in the regulation of lakes for flood control and other authorized purposes and for the benefit of Corps of Engineers' construction projects and flood management activities. As distinguished from the NWS, who furnishes weather and flood forecasts to the public, the Tulsa District furnishes information on current and forecasted lake levels and lake releases, along with technical advice. The Water Management Section (lake levels recording) telephone number, (918) 669-7521, is listed in the Tulsa telephone directory to provide the public a means of obtaining current lake information such as pool levels and discharges. General news releases are made by the Public Affairs Office which is kept fully informed of the hydrologic situation as appropriate. Further discussion of the role of the Corps of Engineers in hydrologic forecasts is presented in Section V of the Arkansas River Basin Water Control Master Manual.

b. **Role of Other Agencies.** The NWS, Tulsa, Oklahoma, is the official agency making flood forecast information available to the public. This information is disseminated by the NWS Automation of Field Operations and Services (AFOS) network to the subscribing Government agencies and the various news media. The NWS issues routine scheduled reports containing the following forecasts:

- (1) Weather forecasts (daily, severe weather, and 5-day extended).
- (2) National weather summaries and additional details for the five southcentral states (four times daily).
- (3) Quantitative precipitation forecasts (four times daily – one 24-hour and one 48-hour quantitative precipitation forecast and two 6-hour quantitative precipitation forecasts).
- (4) Three-day river stage forecasts (when available).
- (5) Rainfall required to produce bank full stages (weekly).
- (6) Urgent priority messages such as severe weather warnings, watches, forecasts, and statements and instructions from Civil Defense during emergency conditions are transmitted immediately, regardless of scheduled traffic. Unscheduled traffic, including the following, is sent when appropriate:
  - (a) Damage reports;
  - (b) Road information and winter weather conditions;
  - (c) River and flood-warning bulletins, forecasts, and statements;
  - (d) Thirty-day forecast.
- (7) Percent chance of precipitation (twice daily).

## **6 - 02. Flood Condition Forecasts.**

a. Requirements. Flood condition forecasts are necessary whenever substantial rainfall has occurred on the basin upstream or downstream of Canton Dam. Personnel in the Water Management Section have developed a flood-forecasting model for Canton Lake. This model was calibrated to historical flood events. Basin subdivisions contained in the forecasting model are presented on Plate 6-1. To use this model, the following data are required:

- (1) Rainfall for stations listed in Table 5-1.
- (2) Canton Lake pool elevation for time of forecast.
- (3) Flood hydrographs for stream gages listed in Table 5-1.
- (4) Releases from Canton Lake, including projected releases, from time of forecast until the end of the forecast period.

b. Methods. Inflow forecasts are made using a slightly modified HEC-1 computer program. Precipitation data are received from the NWS observers, the DCPs (by the water control computer), the Oklahoma Mesonet, and also the NWS Stage III digital radar. The average precipitation over the project basin is computed by a computer program called VIEWRAIN. The VIEWRAIN program takes the DCP data and plots isohyetal maps of 24-hour rainfall. The VIEWRAIN program also computes the basin and sub-basin average rainfalls for input into the HEC-1 forecasting model. The HEC-1 program uses the hourly DCP rainfalls to distribute the sub-basin average rainfalls. Beginning loss rates are chosen based upon historical storm reproductions. Rainfall excess is computed by subtracting the applicable losses from the incremental rainfall amounts. One-hour unit hydrographs are computed using Snyder's coefficients or are entered directly into the data file for each sub-area. Flood hydrographs are computed by applying the rainfall excess to the unit hydrographs. Computed flood hydrographs are compared with observed flood hydrographs for gages listed in Table 5-1. Loss rates are adjusted and the HEC-1 model is rerun until the computed and observed hydrographs converge. Calibrated loss rates are applied to un-gaged subareas and flood hydrographs are combined and routed to compute an inflow hydrograph. Using projected releases from Canton Lake, the inflow hydrograph is routed through the lake to determine elevations. Flood control releases are projected based upon conditions on the Arkansas River System and following procedures described in Section V of the Arkansas River Basin Water Control Master Manual. Unit hydrographs are presented on Plates 6-2 through 6-5. A sample inflow computation is shown on Plate 6-6.

## **6 - 03. Conservation Purpose Forecasts.**

a. Requirements. Conservation forecasts may be requested by project personnel to predict pool levels during fish spawning season, special recreation events, and water supply demand. Forecasts may also be requested for water quality.

b. Methods. Forecasts for conservation purposes during non-flood periods would rely largely on statistical interpretation of historical data. The flow duration curve, Plate 4-5, and the

peak inflow probability curve, Plate 8-5, would be considered in conjunction with NWS forecasts in making conservation forecasts during non-flood periods.

**6 - 04. Long Range Forecasts.**

a. Requirements. The regulatory decision involved in evacuating stored floodwater, sustaining yield during low flow periods and maintaining constant or slowly changing pool levels for conservation purposes is dependent on accurate estimates of the water volume that will pass through the lake.

b. Methods. Reliable methods for long-range runoff forecasts are not presently available. The NWS publishes an “Average Monthly Weather Outlook” semi-monthly, which may be used as an estimate of the trend of the weather but should not be given too much weight for one forecast, especially for a specific point. The NWS forecasts described in paragraph 6-01.b. are more useful in a shorter range.

**6 - 05. Drought Forecasts.** Droughts can be forecast when runoff is dependent upon snowmelt by measuring snow pack in the mountains. However, on projects where runoff is a result of a rainfall event, as in the Tulsa District, no techniques are available at this time to forecast droughts. Future pool drawdowns can be forecast by estimating water supply usage and evaporation rates.

## **VII - WATER CONTROL PLAN**

**7 - 01. General Objectives.** The primary objectives of the Canton Lake project are flood control and water supply. Canton Lake will be operated with Optima and Fort Supply Lakes to provide flood control benefits on the North Canadian River downstream to Eufaula Lake. Flood releases from Canton Lake will be made in accordance with the predicted runoff from the uncontrolled areas downstream, allowable stage for the downstream control points, and predicted volume of inflow into the lake. All of the flood control storage will be utilized to provide optimum benefits, categorized as method A in paragraph 3-3c(2)(b) of EM 1110-2-3600, 30 Nov 1987.

**7 - 02. Major Constraints.** The channel capacity immediately downstream from the dam is about 1,000 cfs while the sluice outlets are capable of discharging approximately 5,500 cfs at elevation 1,615.4 feet (top of conservation pool). The invert of the sluices is at elevation 1582.0 feet, which is the lowest elevation that water can be released from the dam. The regulating flows at the Watonga gage (RM 361.2) and the El Reno gage (RM 307.3) are currently estimated to be 1,247 cfs and 2,316 cfs, respectively. The tainter gates are capable of discharging 277,000 cfs at the top of flood pool (elevation 1638.0 ft).

**7 - 03. Overall Plan for Water Control.** Canton Lake will be regulated with Fort Supply Lake and Optima Lake for the control of floods in the North Canadian River basin. It is not likely that flood control storage in Optima Lake will ever be utilized. Releases from Fort Supply Lake and Optima Lake will be made in such a manner as to balance the percentage of the flood control storage utilized in Canton, Fort Supply, and Optima to the extent possible. Releases from Canton Lake will not be altered solely for the purpose of achieving such a balance. Because of the limited channel capacity below Canton and the long travel time, conditions at Eufaula Lake will usually not be considered when making releases from Canton Lake.

**7 - 04. Standing Instructions to Lake Manager.** During flood periods, Canton Lake will be regulated in accordance with the normal regulation for flood control operations as directed in subparagraph 7-05.a. and Exhibit B of this manual. Instructions for the storage and discharge of flood water are to be issued by the Water Management Section. In the event communication with Tulsa District is disrupted, the lake regulation is the responsibility of the Canton Lake Manager and is to be regulated in accordance with subparagraph 7-05.b. and Exhibit B of this manual. In addition, the Canton Lake Manager will immediately make every effort to re-establish communications with Tulsa District. The Canton Lake Manager will make daily observations of the weather station and pool level data and report those observations as directed in paragraphs 5-07.a. through 5-07.d., and also repeated in Exhibit B. Should an emergency situation occur, in which communication is not lost, such as inoperable gates, a drowning accident, excessive trash in gates, a broken buoy line, or power outage, the Water Management Section will be notified immediately.

## **7 - 05. Flood Control.**

a. Normal Regulation for Flood Control Operations. The following regulations as shown in Table 7-1 will govern releases from Canton Lake. During flood control regulations, the service spillway gates are to be operated in a uniform setting with no more than a 1-foot difference in opening.

b. Emergency Flood Control Regulations. When communication with the Tulsa District is disrupted, the Canton Lake Manager will, on his own initiative, direct regulation of the lake in accordance with the schedule shown in Table 7-2 until communication is restored. In addition, the Canton Lake Manager will make every effort to reestablish communication with the Tulsa District Office. The service spillway gates shall be operated at a uniform opening as discussed in paragraph 7-05.a.

c. Constraints. The regulation schedules provide that the channel capacity of 1,000 cfs immediately below the dam is not to be exceeded insofar as practicable. The downstream channel capacity in the vicinity of Watonga is 1,247 cfs, while the channel capacity at El Reno is equal to 2,316 cfs. The minimum discharge possible utilizing one-half foot of induced surcharge is 6,100 cfs. The minimum discharge utilizing the full 2 feet of induced surcharge is 40,000 cfs.

d. Operational Curves. The Spillway Gate Regulation Schedule – Inflow Parameter is shown on Plate 7-1. The Inflow vs. Rate of Rise Nomograph is shown on Plate 7-2. Plates 7-3 and 7-4 show the spillway ratings for one gate and for the entire spillway, respectively. Plate 7-5 shows the rating curve for the auxiliary spillway and the tipping sequence of the fusegates as the pool rises above the top of the flood control pool (el. 1638.0 feet, NGVD 29). Plate 7-6 contains the auxiliary spillway rating curve assuming all fusegates have tipped. The rating curve on Plate 7-5 is calculated assuming that the pool is rising and that gates are tipping. If at least one fuse gate has tipped and the pool is falling, Plate 7-6 should be used to determine auxiliary spillway discharge based on pool elevation. Rating curves used by the Water Management Section are adjusted for changing conditions and are maintained in current status. Plate 7-7 contains the sluice rating curve while Plate 7-8 contains the rating for partial and full openings for one and two low flow valves. The tailwater rating curve is shown on Plate 7-9. The evaporation curves and area-capacity curves are shown on Plate 7-10 and Plate 7-11, respectively. A table of the elevation-area data is included in the Supplemental Tables Section as Table 7-3.

**TABLE 7-1**

**NORMAL FLOOD CONTROL REGULATION SCHEDULE**  
**CANTON LAKE**

<b>Lake Stage</b>	<b>Pool Conditions</b>	<b>Regulation</b>
1615.4 – 1638.0 and forecasted <sup>(1)</sup> not to exceed 1638.0	Rising	Rates of releases will not exceed channel capacity downstream of the dam (currently estimated to be 1,000 cfs) and when combined with local inflow below the dam, will not produce stages in excess of flood stage at the Watonga and El Reno gages which are 13.0 feet (approx. 1,247 cfs) and 10.0 feet (approx. 2,316 cfs), respectively.
1638.0 – 1640.0 or forecast to exceed 1638.0	Rising	Release will be based on inflow forecasts and be made such that the pool elevation will not exceed elevation 1640.0 feet, if possible. Plate 7-1, Spillway Gate Regulation Schedule Inflow Parameter, will be used as a guide for determining releases. The uncontrolled discharge from the fusegates overspill start at elevation 1638.0 feet. A margin of not less than one-fourth foot (3 inches or more) between the lake level and the top of the service spillway gates shall be maintained at all times. <sup>(3)</sup> If the pool rises to elevation 1640.0, releases will be made equal to the inflow. Releases will be made by operating all the service spillway gates at uniform openings. <sup>(2)</sup>
1640.0 or above	Rising	Service spillway gates shall be opened to maintain elevation 1640.0 feet or until the gates are in the full opened position. The first fusegate tips at elevation 1640.50 feet. Plate 7-5 shows the tipping elevations and releases for all nine fusegates.
1640.0 or above	Falling	The maximum gate opening attained shall be held until the pool elevation recedes to elevation 1640.0 feet. Release will include any discharge from the fusegates (from overspill or tipped fusegates).
1640.0 – 1638.0	Falling	The maximum gate opening attained shall be held until the pool elevation recedes to elevation 1638.0 feet  OR until the pool level recedes an amount sufficient to permit lowering the service spillway gates one-half foot without lowering the discharge below inflow.  A margin of not less than one-fourth foot (3 inches or more) between the lake level and the top of the service spillway gates shall be maintained at all times. <sup>(3)</sup> Releases will be made by operating all the service spillway gates at uniform openings. Release will include any discharge from the fusegates (from overspill or tipped fusegates).

Lake Stage	Pool Conditions	Regulation
1638.0 – 1615.4	Falling	<p><b>a.</b> If the maximum releases rate was equal to or smaller than 1,000 cfs, releases will not exceed channel capacity downstream of the dam (currently estimated to be 1,000 cfs) and when combined with local inflow below the dam, will not produce stages in excess of flood stage at the Watonga and El Reno gages which are 13.0 feet (approx. 1,247 cfs) and 10.0 feet (approx. 2,316 cfs), respectively.</p> <p><b>b.</b> If the maximum release rate exceeded 1,000 cfs, the service spillway gates shall be gradually reduced until the release rate equals the previous 6-hour inflow or the channel capacity (currently estimated to be 1,000 cfs) and the downstream flood stages, whichever is greater. Any uncontrolled release from the fusegates will contribute to the total release rate and will have to be accounted for. This procedure shall be repeated every 2 hours.</p> <p>If the discharge from the fusegates is greater than the previous 6-hour inflow and the channel capacity, the service spillway gates shall be gradually lowered until the gates are all closed.</p>
1615.4 and Below	--	Releases are made through the tainter gates and sluice gates to meet water supply needs as discussed in paragraph 7-09. If any fusegates have tipped, fusegate discharge will continue until the pool elevation reaches 1606.0 feet, bottom of the fusegate weir.

(1) COE Forecasted inflows are based on observed rainfall and upstream gage data. Forecasted inflows are not based on predicted future rainfall

(2) After any gate change that results in releasing water greater than channel capacity, immediately notify the NWS's Arkansas-Red Basin River Forecast Center, District Emergency Management, and Hydrology & Hydraulics Branch upper management. Communications should be verbal/phone calls, followed by electronic means for the NWS.

(3) A ½ foot freeboard allows additional safety for rapidly rising pools and pool gage uncertainties, and may be used as a guide.

**TABLE 7-2**

**EMERGENCY FLOOD CONTROL REGULATION SCHEDULE**  
**CANTON LAKE**

<b>Lake Stage</b>	<b>Pool Conditions</b>	<b>Regulation</b>
1615.4 – 1640.0	Rising	Maintain current releases until communication is restored. If, after 12 hours, communication has not been restored, or the pool is above or has risen to elevation 1633.5 feet at any time within the 12 hour period, releases will be made in accordance with Plate 7-1. Releases will be adjusted every two hours in accordance with Plate 7-1. At no time will releases be decreased while the pool is rising. A margin of not less than one-fourth foot (3 inches or more) between the lake level and the top of the service spillway gates shall be maintained at all times. <sup>(1)</sup> The uncontrolled discharge from the fusegates overspill starts at elevation 1638.0 feet.
1640.0 or above	Rising	Service spillway gates will be opened as necessary to maintain the pool at elevation 1640.0 feet or until all the gates are fully opened. The first fusegate tips at elevation 1640.50 feet. Plate 7-5 shows the tipping elevations and releases for all nine fusegates.
1640.0 or above	Falling	The maximum gate opening attained shall be held until the pool elevation recedes to elevation 1640.0. Release will include any discharge from the fusegates (from overspill or tipped fusegates).
1640.0 – 1638.0	Falling	The maximum gate opening attained shall be held until the pool elevation recedes to elevation 1638.0 feet. A margin of not less than one-fourth foot (3 inches or more) between the lake level and the top of the service spillway gates shall be maintained at all times. <sup>(1)</sup> Release will include any discharge from the fusegates (from overspill or tipped fusegates).
1638.0 – 1615.4	Falling	<p><b>a.</b> If the maximum releases rate was equal to or smaller than 1,000 cfs, releases will be maintained until the pool recedes to elevation 1615.4 feet.</p> <p><b>b.</b> If the maximum release rate exceeds 1,000 cfs, the service spillway gates shall be gradually reduced until the release rate equals the previous 6-hour inflow or the channel capacity (currently estimated to be 1,000 cfs) whichever is greater. Any uncontrolled release from the fusegates will contribute to the release rate. This regulation shall be repeated every 2 hours until the lake nears 1615.4 feet.</p> <p>If the discharge from the fusegates is greater than the previous 6-hour inflow and 1,000 cfs, the service spillway gates shall be gradually lowered until the gates are all closed.</p>
1615.4 and Below	--	Continue releases being made at time of communication failure. If any fusegates have tipped, the discharge will continue until the pool elevation reaches 1606.0 feet, bottom of the fusegate weir. At which point, all other gates should be or will remain closed until discharges from the fusegates have been cut off.

(1) A ½ foot freeboard allows additional safety for rapidly rising pools and pool gage uncertainties, and may be used as a guide.

**7 - 06. Recreation.** Although recreation was not included as an authorized project purpose, there are several recreation areas, and it is considered a project use. There is no storage or releases specifically designed for recreation. Requests for special releases will be considered as the situation warrants. All recreation area access roads are constructed above the top of the conservation pool, elevation 1615.4. The access roads begin to be affected by floodwaters at elevation 1617.4. Some private access roads are also affected by high water. Locations of the public facilities are listed in paragraph 2-06 of this manual and shown on Plate 2-9. Recreational features at the project include camping, picnicking, swimming, boating, hiking, fishing, and hunting.

**7 - 07. Water Quality.** There is no water quality storage in Canton Lake; therefore, no scheduled water quality releases are made. Occasionally, particularly in later summer, short-term releases are necessary to improve the temperature and dissolved oxygen conditions in the stilling basin to prevent a fish kill. Such releases are made as needed and are requested by the Canton Lake Manager and approved by Water Management Section in the Tulsa District Office.

**7 - 08. Fish and Wildlife.** Fish and wildlife is an authorized project purpose, pursuant to Public Law 85-624; however, no specific storage is provided for this purpose. The fish and wildlife resources are under the direction of the Oklahoma Department of Wildlife Conservation (ODWC) which manage and regulate fish and game species in and around the lake.

**7 - 09. Water Supply.** The Oklahoma City Municipal Improvement Authority has contracted with the Government for the use of the entire conservation storage (elevation 1596.5 to 1615.4) for municipal and industrial water supply (see Exhibit C). Releases for water supply are made at the request of the user and with the concurrence of the Oklahoma Water Resources Board (OWRB). Releases are usually made at the regulating channel capacity of 1,000 cfs to minimize channel losses between Canton Dam and Lakes Overholser and Hefner in Oklahoma City.

**7 - 10. Water Rights.** The OWRB has issued water rights on the North Canadian River below Canton Lake. Table 7-4, in the Supplemental Tables Section, lists the active water rights holders on the North Canadian River from below Canton Dam to Oklahoma City. Releases from inflow to satisfy downstream water rights will be made at the request of the OWRB. The OWRB will inform the Water Management Section as to the amount and time distribution of the required release. No withdrawal from storage in the lake will be made for downstream water rights unless the water right holder has contracted storage available in the lake.

**7 - 11. Hydroelectric Power.** There is no hydroelectric power generation at Canton Dam.

**7 - 12. Navigation.** There is no navigation mission at Canton Dam.

**7 - 13. Drought Contingency Plans.** A Drought Contingency Plan for projects in the Canadian River Basin, dated September 1990, has been completed, in accordance with ER 1110-2-240 and ER 1110-2-1941. The Plan has been published as Exhibit DCP-4 to the Water Control Master Manual, Arkansas River Basin, and contains coordination and instructions necessary for operations during a drought. Copies of the plan are kept at the Canton project office and at the Tulsa District Office.

**7 - 14. Flood Emergency Action Plans.** A flood emergency action plan is outlined in the Operation and Maintenance Manual, Volume II, for Canton Lake, North Canadian River, Oklahoma, dated April 2011. The purpose of the manual is to specify procedures to protect the public from possible property damage or loss of life as a result of uncontrolled releases of water due to failure, or severe damage to the dam appurtenant works.

**7 - 15. Deviation from Normal Flood Control Regulation.** Deviation from normal flood control regulation of the lake is occasionally necessary. Prior approval for a deviation is obtained from SWD, except as noted in subparagraph 7-15.a., shown below. Deviation requests fall into the following categories:

a. Emergencies. The water control plan is subject to temporary modification by the Corps if found necessary in time of emergency, such as drowning(s), failure of the operation facilities, and flushing of pollutants. Request for and actions on such modifications may be made by the fastest means of communication available. Also, the Canton Lake Manager may temporarily deviate from the water control plan in the event an immediate short-term departure is deemed necessary for emergency reasons to avoid serious hazards. The Canton Lake Manager may deviate from the water control plan whenever necessary to protect the safety of the dam. Such action shall be immediately reported by the fastest means of communication available. Actions shall be confirmed in writing as soon as possible to the Water Management Section and shall include justification for the action. Continuation of the deviation will require the express approval of SWD. A written confirmation showing the deviation and conditions will be furnished by the Water Management Section to SWD.

b. Unplanned Minor Deviations. There are unplanned instances that create a temporary need for minor deviations from the normal regulations of the reservoir, although they are not considered emergencies. Construction accounts for the major portion of the incidents and include utility stream crossings, bridge work, and major construction contracts. Changes in releases are sometimes necessary for maintenance and inspection. Requests for changes of release rates are generally from a few hours to a few days. Each request is analyzed on its own merits. Consideration is given to upstream watershed conditions, potential flood threat, conditions of the lakes, and possible alternative measures. In the interest of maintaining good public relations, the requests are complied with providing there are no adverse effects on the overall operation of the project (or projects) for the authorized purposes. Approval for these minor deviations will normally be obtained by the Water Management Section from SWD by telephone or email. Normally, SWD is advised by telephone of these minor deviations with written follow-up communication to confirm the deviation.

c. Unplanned Major Deviations. There are unplanned instances that create a temporary need for major deviations from the normal regulation plan and may be considered, but are not, emergencies. Flood control releases account for the major portions of these incidents and typical examples include project pre-releases or exceeding downstream channel capacity, incidents that have a short window of opportunity in an effort to minimize damages or optimize benefits. Requests for changes in release rates generally involve time periods ranging from a few hours to a few days. Each request is analyzed on its own merits. In evaluating the proposed

deviation, consideration must be given to upstream watershed conditions, potential flood threat, and condition of the lake, and alternative measures that can be taken. Approval for these major deviations normally will be obtained from SWD by telephone or email. Written confirmation explaining the deviation and its cause will be furnished to the Division water control manager.

d. Planned Deviations. Advance approval by the SWD water control manager is required prior to any deviation from the plan of regulation prescribed or approved by the Corps in the interest of flood control, except in emergency conditions provided for in subparagraph 7-15.a. Each condition will be analyzed on its own merits. When conditions appear to warrant a prolonged deviation from the approved plan, the Water Management Section will investigate and evaluate the proposed deviation to ensure that the overall integrity of the plan would not be unduly compromised. Approval of prolonged deviations will not be granted unless such investigation and evaluation have been conducted to the extent deemed necessary by the SWD water control manager.

**7 - 16. Rate of Release Changes.** The rate of change of releases equal to or less than channel capacity shall be limited to about 150 cfs per 2 hours, if possible. Every reasonable precaution will be made to reduce bank sloughing, undercutting, excessive erosion, and danger to human and animal lives. Situations will arise which will not allow an orderly increase and/or decrease in releases. Examples of these situations are large flood control releases as described in paragraph 7-05, and shutdowns for emergencies which occur downstream of the dam.

During flood periods, gate changes may be directed by the Water Management Section at any time. The initial transition to flood releases or vice versa may require gate changes every hour. When floodwater has significantly risen into the flood control pool, gate change can be expected two or more times daily. Only under the most unusual circumstances will gate changes be ordered more frequently than once every hour. Frequency of gate changes during low-flow operation will generally be less than once a day.

## **VIII - EFFECT OF WATER CONTROL PLAN**

**8 - 01. General.** The effects of emergency flood control regulations (communication between Tulsa District and the Canton Project Office is disrupted) on the spillway design flood and the standard project flood and examples of the normal and emergency regulations of historical major floods are presented in the following paragraphs. The floods were selected to show the effects of the flood control regulations for Canton Lake on a variety of possible flood conditions.

### **8 - 02. Flood Control.**

a. **Probable Maximum Flood.** The Probable Maximum Flood (PMF) for the contributing area to Canton Lake is currently used as the Spillway Design Flood (SDF) for Canton Dam. The PMF has a volume of 2,609,998 acre-feet with a peak inflow to Canton Lake of 634,001 cfs. The resulting maximum release was 607,752 cfs at a maximum pool elevation of 1642.68 feet. The previous maximum elevation for the project of 1641.7 feet, NGVD 29 has been replaced with this maximum elevation, 1642.68 feet, NGVD 29. The previous maximum elevation was from the spillway design flood, dated February 1940, for a maximum pool of 1641.7 feet, NGVD 29. Plate 8-1 shows the operational hydrographs for the PMF routed through Canton Lake by emergency regulations with a full flood control pool.

b. **Standard Project Flood.** The Standard Project Flood (SPF) was considered to be one-half of the original spillway design flood. The resulting flood has a volume of 1,205,196 acre-feet with a peak inflow of 185,000 cfs. The flood was routed through Canton Lake using emergency regulations which resulted in a peak discharge of 185,000 cfs at the peak pool elevation of 1640.07 feet. Plate 8-2 shows the operational hydrographs for this flood routed by emergency regulations.

c. **Flood of October 1923.** This flood was the most destructive flood of record in the North Canadian River basin from Woodward, Oklahoma to Eufaula, Oklahoma. The flood had a peak inflow into Canton Lake of 87,500 cfs. Plate 8-3 shows the operational hydrographs for Canton Lake for both normal and emergency regulations.

d. **Flood of May 1951.** Flooding that occurred during May 1951 produced some of the highest recorded rates of runoff on the North Canadian River upstream of Oklahoma City, Oklahoma. The peak inflow to Canton Lake equaled 34,600 cfs. Operation of Canton Lake under both normal and emergency regulations and the resulting stage and discharge hydrographs is shown in Plate 8-4.

**8 - 03. Recreation.** Recreation features at the project include camping, picnicking, swimming, boating, hiking, and fishing. Low-lying areas and access roads to recreation areas begin to be affected at elevation 1615.4.

**8 - 04. Water Quality.** There is no water quality storage at this project. Releases for domestic water usage by Oklahoma City will provide some flow in the river below the dam when water supply is requested, thus providing some relief to low flow and stagnation.

**8 - 05. Fish and Wildlife.** Canton Lake provides an improved fishery over the natural river, allowing some species of sport fish to flourish in contrast to previous natural river conditions. Major species that are present in the lake include: Walleye, Black Crappie, White Crappie, Channel Catfish, Blue Catfish, Flathead Catfish, Largemouth Bass, White Bass, Striped Bass, Bluegill, Green Sunfish, Common Carp, Buffalo, and Freshwater Drum.

Some wildlife habitat was inundated due to impoundment; however, wildlife management of lake perimeter lands strives to replace these losses. Hunting is allowed throughout most of the wildlife management areas shown on Plate 2-10. While there are no public parks available for hunting, all of the campgrounds except for Canadian campground are adjacent to hunting areas that are managed by the Oklahoma Department of Wildlife Conservation. There is also an 80 acre tract of land along the lake side of Thunder Road that is Corps managed land open to hunting of all species which may be legally taken during legal open seasons by shotgun, with pellets, or by archery only. Hunting at Canton Lake is for Whitetail Deer; Bobwhite Quail; Mourning Dove; Cottontail Rabbit; Wild Turkey; Migratory Waterfowl that includes Canada Geese; Snow Geese; White-fronted Geese and numerous species of ducks; Fox Squirrel; Feral Hogs and Coyote. Deer hunting is by archery only.

**8 - 06. Water Supply.** Presently the only contract for water from Canton Lake is with Oklahoma City.

**8 - 07. Hydroelectric Power.** There is no hydroelectric power production at the project.

**8 - 08. Navigation.** There is no navigation mission at the project.

**8 - 09. Drought Contingency Plans.** The drought contingency plan (DCP) for Canton, dated September 1990, is part of Appendix DCP-4 to the Arkansas River Basin Water Control Master Manual. This DCP covers the Canadian River basin lakes of Eufaula, Arcadia, Canton, Fort Supply, and Optima.

**8 - 10. Flood Emergency Action Plans.** A flood emergency action plan is outlined in the Operation and Maintenance Manual, Volume II, for Canton Lake, North Canadian River, Oklahoma, dated April 2011. The purpose of the manual is to specify procedures to protect the public from possible property damage or loss of life as a result of uncontrolled releases of water due to failure, or severe damage to the dam appurtenant works.

**8 - 11. Frequencies.**

a. **Peak Inflow Probability.** Canton Lake peak inflows from 1948 to 2014 were used to compute the maximum annual peak inflow probability. The inflow probability was derived in accordance with Bulletin 17B, "Guidelines for Determining Flood Flow Frequency", dated March 1982. The peak inflow probability curve is shown on Plate 8-5.

b. **Pool Elevation Duration and Probability.** The pool elevation duration and frequency was computed using data for the period from 1948 to 2014. Plate 8-6 shows the pool elevation duration curve computed from daily pool elevations and Plate 8-7 shows the pool

elevation probability curve. Plates 8-8 through 8-13 show the pool elevation hydrographs for 1948 to 2013.

c. Key Control Points. The regulating channel capacity on the North Canadian River below Canton Dam is estimated to be 1,000 cfs. Regulating stages at the Watonga and El Reno gages are 13.0 feet (approx. 1,247 cfs) and 10.0 feet (approx. 2,316 cfs), respectively. Information obtained during future flood events may result in revisions to these estimates.

**8 - 12. Other Studies.**

a. Example of Regulation. Studies are in progress to improve the forecasting techniques presented in Section VI of this manual. Computer programs have been developed to forecast inflows into the lake, the resulting pool elevations, and the effects of releases at the downstream gages. Use of these programs has greatly shortened the reaction time in preparing regulation schedules.

b. Channel and Floodway Improvement. No channelization projects exist downstream of Canton Lake. Ground and aerial reconnaissance will be made as required to determine if revised channel capacities and maximum discharge limits are warranted.

## **IX - WATER CONTROL MANAGEMENT**

### **9 - 01. Responsibilities and Organizations.**

a. Corps of Engineers. Canton Lake is a Corps of Engineers project, with the Tulsa District prescribing and directing the flood control releases. Operation and Maintenance, as well as regulation of the conservation storage, is the responsibility of the Corps of Engineers. Project reporting instructions and an organization chart are presented in Section V, and project regulating instructions are presented in Section VII of this manual.

(1) Responsibilities and Duties During Normal Operations. The Water Management Section, Hydrology-Hydraulics Branch, Tulsa District, is charged with the following responsibilities and duties under general supervision of the Engineering and Construction Division:

- (a) Routine regulation of lakes and distribution of routine data.
- (b) Investigations and refinement of regulation procedures.
  - 1. Analysis of past floods.
  - 2. Reconnaissance to determine channel capacities.
  - 3. Improvement of forecasting techniques.
  - 4. Plan and coordinate the hydrologic reporting network with the NWS and the USGS.
- (c) Train personnel in flood control duties.
  - 1. Periodic visits to projects by Water Management Section personnel to familiarize themselves with regulation facilities, become acquainted with the operating personnel, discuss emergency regulation procedures with operating personnel, and provide the background for improving facilities and methods.
  - 2. Instruct personnel of the Hydrology-Hydraulics Branch in flood control procedures to supplement the Water Management Section during flood emergencies, when necessary.
- (d) Prepare reports on lake regulation.
  - 1. Recurring reports.
  - 2. Water control manuals.
  - 3. Post-flood reports.

(2) Responsibilities and Duties During Flood Emergencies. During flood emergencies, the Water Management Section is responsible for the following:

- (a) Evaluation of current hydrologic, hydraulic, and meteorological data.

- (b) Performing or obtaining lake forecasts.
- (c) Presentation of storm and flood analysis to the District Commander and other interested Tulsa District personnel.
- (d) When necessary, furnishing personnel to assist project operating personnel in flood regulations.
- (e) Regulation of lakes in accordance with flood control regulation schedules.
- (f) Furnish information to higher authority.
  1. Provide initial reports to the Southwestern Division (SWD) and the Office of the Chief of Engineers by telephone.
  2. Provide hydrologic data for situation reports.
- (g) Furnish information to the Reservoir Information Control Center (RICC).
- (h) After any gate change that results in releasing water greater than channel capacity, immediately notify the NWS's Arkansas-Red Basin River Forecast Center, District Emergency Management, and Hydrology & Hydraulics Branch upper management. Communications should be verbal/phone calls, followed by electronic means for the NWS.

The duties of the Lake Manager under flood conditions are set forth in Section VII of this manual. The details of the overall procedures of the Tulsa District under emergency conditions are set forth in Tulsa District Supplement A, Natural Disaster Activities, to ER 500-1-1.

(3) Assignment of Personnel. During non-flood periods, the Water Management Section accomplishes the routine regulation of the lake. However, during flood periods, assistance of other personnel may be required to maintain effective regulation of the lake. Plate 5-2 shows the organization of the Water Management Section during a major flood. The area and magnitude of the flood will determine the number of people engaged in each activity.

(4) Provision of 24-hour Alert. The NWS and project personnel are provided with a list of names, addresses, and telephone numbers of key personnel from the Water Management Section and the Engineering Division with instructions to provide warning if unusual conditions occur. Responsible personnel will be on duty at the Tulsa District Office 24 hours a day whenever basin and/or project conditions warrant and during flood emergencies. Responsible personnel will be on duty at the project office or on call at all times.

(5) Role of Lake Manager. The Lake Manager will regulate the lake during flood periods according to instructions issued by personnel of the Water Management Section. The instructions follow the "Normal Regulations for Flood Control," included in Section VII – Table 7-1 of this manual (this table is reproduced in Exhibit B). If the Lake Manager loses communication with the Tulsa District office, he/she will immediately attempt to re-establish communication with the Tulsa District office while following the emergency instructions outlined in the section "Emergency Flood Control Regulations" included in Section VII – Table

7-2 of this manual (this table is reproduced in Appendix B). The Lake Manager will make daily observations as directed in paragraph 5-07.

b. Other Federal Agencies. The NWS is officially responsible for issuing flood warnings to the public. The USGS develops and maintains stage versus discharge curves for each stream gage. Both the NWS and the U.S. Geological Survey (USGS) cooperate with the Water Management Section, Hydrology-Hydraulics Branch, Tulsa District Office, to accumulate rainfall and stream flow data. The Environmental Protection Agency, together with the state of Oklahoma, establishes the standards for water quality releases.

c. State and County Agencies. Management of the fish and wildlife resources of the Canton Lake project is the responsibility of the Oklahoma Department of Wildlife Conservation (ODWC).

d. Private Organizations. Presently, there are no privately owned flood control protection facilities at Canton Lake whose regulation is coordinated with the Corps of Engineers.

**9 - 02. Interagency Coordination.** Cooperative arrangements with other Federal agencies, State agencies, and local interests are discussed in Section X of the Water Control Master Manual, Arkansas River Basin, Tulsa and Little Rock Districts, date July 1980. Further coordination is indicated in the following subparagraphs.

a. Local Press and Corps Bulletins. The Corps of Engineers, the NWS, and USGS coordinate in forecasting flood stages, stream flow, and reservoir elevations. The NWS is officially responsible for issuing flood warnings to the public. The Tulsa District, through the Public Affairs Office (PAO), makes press releases to the news media regarding flood situations in the area of concern. This information will be supplemented by the Corps of Engineers bulletins from the PAO on observed conditions. The Corps of Engineers further assists in flood control through the office of the Emergency Operations Manager, who furnishes sandbags and other necessary equipment based on equipment on hand and need. To facilitate the distribution of these data, the RICC is in operation when conditions warrant.

b. National Weather Service. The Tulsa District and the NWS's Arkansas-Red Basin River Forecast Center exchange hydrometeorological data and reports to prevent duplication of effort in obtaining and distributing data. This exchange of data is discussed in greater detail in Section VI of this manual. The NWS is the responsible agency for issuing public forecasts of stream stages.

c. U.S. Geological Survey. The Corps of Engineers and the USGS cooperate in a program for the construction, maintenance, and operation of stream gaging stations throughout the Tulsa District. During floods, the Corps of Engineers and the USGS coordinate field activities to maximize the number of stream discharge measurements.

d. Power Marketing Agency. Presently, hydropower is not a project purpose.

e. Other Federal, State, or Local Agencies. The Tulsa District exchanges information with state and local government officials, the Oklahoma Department of Transportation,

Oklahoma Highway Patrol, and others during flood emergencies. The Tulsa District also coordinates with federal and state agencies concerning fish and wildlife throughout normal operations.

**9 - 03. Interagency Agreements.** Presently, there are no agreements with respect to lake regulations.

**9 - 04. Commissions, River Authorities, Compacts, and Committees.** There are no commissions or river authorities on the North Canadian River. Arkansas River basin compacts have been established between the states of Arkansas and Oklahoma and between Kansas and Oklahoma. The major purposes of the compacts are:

a. To promote interstate comity between Arkansas and Oklahoma and Kansas and Oklahoma.

b. To provide for an equitable apportionment of the waters of the Arkansas River between Arkansas and Oklahoma and Kansas and Oklahoma and to promote the orderly development thereof.

c. To provide an agency for administering the water apportionment agreed to in the compacts.

d. To encourage the maintenance of an active pollution abatement program in each of the three states and to seek the further reduction of both natural and manmade pollution in the waters of the Arkansas River Basin.

e. To facilitate the cooperation of the water administration agencies of Arkansas and Oklahoma and Kansas and Oklahoma in the total development and management of the water resources of the Arkansas River Basin.

The Arkansas River Basin Coordinating Committee is made up of State and Federal agencies interested in the water resources development within the Arkansas River Basin. The committee meets annually to discuss the previous year's activities and to exchange information and ideas to better serve specific project purposes.

**9 - 05. Non-Federal Hydropower.** Presently, there are no federal or non-federal entities developing hydropower at Canton Lake.

**9 - 06. Reports.**

a. Morning Report. In accordance with Tulsa District policy, this report is prepared, following procedures outlined by the Water Management Section, on a daily basis, except Saturday, Sunday, and holidays, to cover a period of 24-hours. The report provides data for use by personnel whose work requires knowledge pertaining to the regulations of lakes, field investigations, stream gaging, and construction of flood control projects affected by releases from lakes, answering public inquires, and preparing public releases. The report is completed and dispatched from the Water Management Section, Hydrology-Hydraulics Branch by 10:00 a.m. daily under normal conditions.

b. Monthly Lake Reports. The Water Management Section prepares monthly reports in accordance with EM 1110-2-3600 and ER 1110-2-240. These reports are records for all flood control, navigation, and multiple-purpose storage lakes under supervision of or of direct interest to the Tulsa District. These tabulations are promptly prepared each month and maintained in such form as to be readily available for transmittal to the Chief of Engineers or others, upon request. The monthly lake reports are also available on the Tulsa District web page from 1994 to present at <http://www.swt-wc.usace.army.mil/CANTcharts.html>.

c. Flood Situation Reports. The Water Management Section provides daily information to the Readiness and Security Branch for situation reports during floods in accordance with ER 500-1-1 and OM 500-1-6. The report contains various types of information about the floods. Pertinent data specifically required for lakes are as follows: name of lake, lake stage, predicted maximum stage, rates of inflow and outflow (in cfs), percent of flood control storage used to date and at predicted maximum stage, and any special information particularly pertinent to the flood situation.

d. Post-flood Reports. This report is prepared according to ER 500-1-1 and OM 500-1-6 when practicable after a flood that has caused major damages. The report describes flood emergency operations by the Corps of Engineers and others. Included in summary form are: available hydrologic information, damage estimates, and other engineering data as are considered essential for flood control and flood plain studies or in the review of possible claims against the United States for damages. The Tulsa District Planning Division personnel, using information compiled and prepared by the Water Management Section, prepare the report. The report should be completed within approximately three months of the time of flooding, including a statement of final damages.

e. Annual Report. The Water Management Section prepares this report. The report contains a summation of the general conditions of the river basins and the individual projects in the Tulsa District for the preceding fiscal year. The report also presents the activities and accomplishments of the Water Management Section for the past year. The report is forwarded to the SWD Water Management Section for inclusion in the Division's annual report.

f. Summary of Reports. Table 9-1 is a summary of the reports required in the regulation of the lakes in the Tulsa District.

**TABLE 9-1**

**SUMMARY OF REPORTS**

<b>Name of Report</b>	<b>When Required</b>	<b>Regulation Requiring Reporting</b>
Morning Report	Daily, except Saturday, Sunday, and holidays	Tulsa District Policy
Monthly Lake Report	Monthly	ER 1110-2-3600 EM 1110-2-240
Flood Situation Report	During Floods	OM 500-1-6 ER 500-1-1
Post-flood Report	Following a flood causing major damage	OM 500-1-6 ER 500-1-1
Annual Report	Annually	ER 1110-2-1400

**CANTON LAKE, NORTH CANADIAN RIVER, OKLAHOMA  
WATER CONTROL MANUAL  
APPENDIX H  
TO  
WATER CONTROL MASTER MANUAL  
ARKANSAS RIVER BASIN  
SUPPLEMENTAL TABLES**

**TABLE 4-8****CANTON DAM SITE MONTHLY INFLOWS (ACRE-FEET)**

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1923	321	1,140	1,840	2,750	93,390	200,100	5,030	2,860	60,930	399,500	24,330	4,660	796,851
1924	1,340	1,980	15,130	8,930	8,980	6,600	3,920	9,280	20,110	19,490	8,750	3,970	108,480
1925	1,590	1,580	4,130	5,650	5,710	12,970	3,860	17,950	21,900	9,650	7,140	1,800	93,930
1926	1,790	1,200	10,820	24,460	21,770	23,900	8,980	3,370	28,600	31,170	4,000	6,000	166,060
1927	1,340	1,990	5,120	18,800	7,190	16,480	8,670	66,610	13,030	9,650	2,620	1,310	152,810
1928	440	4,370	3,330	14,040	54,970	56,470	12,300	3,490	2,560	2,640	25,530	3,670	183,810
1929	3,570	3,740	3,060	7,440	17,400	8,150	11,500	4,220	9,050	11,010	12,500	1,760	93,400
1930	2,650	1,760	3,340	2,780	45,010	24,640	4,240	1,830	8,630	21,150	3,110	2,250	121,390
1931	4,920	8,550	13,530	31,000	19,980	18,030	5,280	422	154	79	5,620	2,980	110,545
1932	6,950	7,540	8,480	9,640	14,820	64,590	14,940	7,440	300	1,200	286	2,450	138,636
1933	817	761	1,670	4,360	33,390	472	2,520	32,220	24,340	4,010	5,560	2,120	112,240
1934	4,400	3,990	5,630	35,760	892	13,210	95	1,130	11,960	8,920	4,960	2,080	93,027
1935	1,910	2,630	4,180	519	177,100	28,440	11,190	1,160	16,240	363	250	519	244,501
1936	1,300	1,170	870	101	85,220	123,000	2,430	151	32,790	5,610	760	1,560	254,962
1937	1,890	2,830	3,260	1,510	14,450	167,400	1,280	12,050	53,080	7,250	962	1,890	267,852
1938	2,420	2,460	4,800	22,260	82,460	53,800	4,870	2,200	33,360	254	1,840	95	210,819
1939	2,340	2,210	5,550	49,230	12,050	47,490	45,690	2,570	0	0	0	0	167,130
1940	0	0	0	0	10,190	35,600	3,720	16,890	484	79	36	0	66,999
1941	591	3,520	5,090	12,610	106,200	98,830	41,710	19,390	27,940	168,700	39,170	24,210	547,961
1942	16,580	12,870	13,810	62,310	16,760	46,160	7,170	2,080	9,680	34,760	10,350	11,120	243,650
1943	10,400	5,760	3,850	4,220	10,450	7,810	393	54	14	0	1,080	214	44,245
1944	1,420	5,990	6,310	44,710	25,920	6,800	12,400	4,650	230	16,100	2,870	5,440	132,840
1945	7,260	6,730	10,630	15,960	8,110	13,280	10,400	281	10,090	12,700	874	1,200	97,515
1946	3,460	4,180	5,560	3,300	1,070	2,200	396	1,010	2,580	128,120	34,040	15,340	201,256
1947	14,110	8,090	26,740	42,240	113,390	39,940	15,800	248	0	0	0	0	260,558
1948	0	3,870	14,520	5,050	2,030	15,740	13,920	30,990	4,680	140	3,640	5,980	100,560

**TABLE 4-8 CONTINUED**

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1949	6,080	24,890	20,250	14,190	140,760	147,550	59,050	5,810	9,300	11,150	4,920	7,280	451,230
1950	9,030	9,780	7,200	3,890	20,300	10,680	172,100	149,530	126,320	28,140	6,680	12,060	555,710
1951	12,850	13,960	17,030	16,770	242,240	122,500	61,230	5,440	1,520	1,280	4,830	6,720	506,370
1952	9,680	9,540	14,580	20,080	12,380	2,080	0	0	0	0	0	0	68,340
1953	0	69	573	338	765	79	14,770	12,370	569	8,490	1,820	2,290	42,133
1954	3,220	3,350	1,830	6,420	17,560	7,830	36	0	0	0	0	0	40,246
1955	0	0	0	0	94,240	107,480	19,480	1,780	447	658	0	8	224,093
1956	69	408	336	131	4,150	1,390	2,810	993	0	1,480	0	0	11,767
1957	0	0	24	26,050	123,770	145,320	101,370	15,690	9,230	6,080	5,950	5,710	439,194
1958	6,670	6,010	12,050	13,790	10,080	23,380	37,120	41,590	16,880	1,610	1,330	2,510	173,020
1959	7,260	10,530	10,000	15,440	28,920	6,800	6,300	1,300	12,130	17,180	1,150	6,640	123,650
1960	7,350	24,290	19,780	12,700	13,150	19,200	8,500	7,440	7,850	18,930	5,560	7,550	152,300
1961	6,310	9,760	13,300	17,960	18,020	18,640	7,800	8,020	3,480	2,360	7,400	4,840	117,890
1962	10,220	8,920	7,850	9,930	3,740	36,180	7,040	1,980	6,460	1,550	1,670	4,600	100,140
1963	3,330	7,770	7,080	4,030	3,940	24,060	1,960	326	1,010	0	0	338	53,844
1964	625	3,770	2,660	2,790	3,250	6,720	0	360	0	109	2,940	1,560	24,784
1965	2,050	3,760	5,240	6,520	26,390	52,500	34,820	9,200	14,300	13,720	5,550	6,980	181,030
1966	5,680	9,980	9,760	7,690	3,680	7,010	2,320	1,440	910	395	321	290	49,476
1967	1,500	2,060	2,290	5,180	4,780	7,720	24,070	20,670	3,200	880	1,300	2,030	75,680
1968	3,400	4,000	4,230	3,660	13,470	51,370	70,140	3,140	8,310	41,410	12,910	6,390	222,430
1969	7,500	9,415	20,266	19,270	38,094	47,621	4,349	1,663	18,801	1,645	2,196	4,241	175,061
1970	6,602	6,090	8,969	26,068	6,041	6,076	1,116	1,173	290	1,141	480	1,879	65,925
1971	915	2,647	6,991	3,429	1,368	9,927	847	961	768	1,640	23,296	16,405	69,194
1972	6,886	6,949	5,492	3,220	21,946	7,308	14,453	5,560	8,304	1,120	1,484	2,565	85,287
1973	10,021	11,190	45,519	6,190	24,268	6,416	2,069	480	2,529	4,303	978	3,362	117,325
1974	4,957	5,738	18,800	15,861	11,408	327	1,083	20,377	13,079	4,629	33,325	6,874	136,458
1975	7,729	11,616	12,130	8,914	21,460	20,539	296	1,515	3,395	2,061	2,043	1,644	93,342
1976	1,265	2,446	3,162	7,707	15,978	7,620	721	250	1,300	690	559	89	41,787
1977	695	2,722	1,025	2,215	26,796	23,578	3,147	4,980	7,357	535	1,903	5,067	80,020

**TABLE 4-8 CONTINUED**

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1978	3,076	6,265	7,875	5,673	13,887	42,680	2,227	180	300	62	1,220	710	84,155
1979	1,800	3,390	14,400	8,490	50,500	25,800	17,500	6,930	500	1,188	7,566	4,853	142,917
1980	5,996	8,201	7,656	18,109	49,795	38,181	5,950	49	0	495	0	2,062	136,494
1981	1,319	2,439	5,761	4,373	3,451	3,818	2,062	1,604	642	3,598	4,195	2,231	35,493
1982	3,302	6,813	8,221	6,753	46,561	38,310	21,332	4,066	0	327	1,943	3,679	141,307
1983	5,216	6,515	16,542	16,452	20,588	28,066	7,923	1,071	414	3,707	2,618	2,102	111,214
1984	5,256	5,692	11,464	16,264	8,330	8,429	813	765	111	1,142	192	4,411	62,869
1985	2,766	6,188	11,821	9,441	17,176	8,975	3,778	3,173	4,333	22,452	16,066	9,679	115,848
1986	7,090	7,586	9,699	5,880	8,409	10,740	2,526	4,776	6,247	32,092	22,681	11,851	129,577
1987	13,765	19,319	42,267	35,166	40,889	29,563	15,947	2,737	9,163	8,489	7,537	12,079	236,921
1988	15,887	11,702	30,862	28,552	19,001	12,208	11,761	4,522	3,877	4,254	5,216	8,052	155,894
1989	8,905	7,864	13,289	11,613	34,690	61,090	24,396	18,347	14,786	9,024	8,608	8,052	220,664
1990	11,880	12,882	18,109	25,824	23,801	10,026	1,884	2,816	2,776	1,041	4,462	2,528	118,029
1991	5,097	4,899	8,608	7,785	10,522	7,755	614	4,363	1,309	327	2,895	4,274	58,448
1992	3,768	3,828	6,148	5,990	5,147	12,694	3,471	3,867	892	9	4,284	7,021	57,119
1993	9,342	12,079	16,839	14,280	58,433	17,801	8,727	2,042	743	0	1,309	3,074	144,669
1994	3,709	4,224	8,171	8,608	14,181	2,975	1,071	575	456	4,155	5,048	1,944	55,117
1995	2,658	2,340	7,914	7,517	13,041	49,121	9,779	16,026	2,430	734	2,142	4,116	117,818
1996	3,729	5,177	4,760	4,691	3,937	4,036	9,035	28,810	47,008	30,506	24,744	21,074	187,507
1997	12,992	19,140	15,620	41,851	36,684	35,732	9,203	10,919	24,040	11,554	11,147	20,648	249,530
1998	23,008	17,831	43,002	27,213	30,050	8,529	4,383	149	208	6,813	37,587	13,170	211,943
1999	12,476	16,681	22,294	68,311	37,785	29,435	14,281	9,183	2,281	3,144	1,190	6,288	223,349
2000	10,859	13,587	32,926	17,970	18,248	19,140	10,869	113	60	9,564	16,760	8,172	158,268
2001	14,281	22,909	24,149	19,438	32,926	17,653	1,924	724	4,869	2,638	6,377	3,074	150,962
2002	6,942	8,866	10,116	21,818	9,521	4,562	1,765	2,368	242	23,246	10,393	13,140	112,979
2003	11,484	10,264	13,230	14,182	16,820	9,124	1,345	1,075	294	12,042	1,051	3,392	94,303
2004	7,339	8,281	20,003	15,580	6,922	9,187	9,808	4,500	337	4,889	13,061	11,752	111,659
2005	17,266	17,246	15,550	11,861	14,073	16,612	12,972	5,494	1,874	3,114	3,798	9,342	129,202
2006	14,856	9,719	14,132	9,769	7,160	5,445	28,255	6,486	4,284	4,017	4,701	6,992	115,816

**TABLE 4-8 CONTINUED**

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2007	6,149	4,909	11,058	28,364	35,316	68,727	39,788	6,208	4,007	4,314	3,223	8,698	220,761
2008	5,950	10,255	12,010	11,425	11,931	21,193	4,969	1,646	30,367	12,109	7,240	7,537	136,632
2009	9,074	8,231	9,640	23,831	27,868	8,083	3,461	3,669	256	6,577	3,650	3,570	107,910
2010	5,306	7,002	10,445	13,696	23,375	15,669	19,636	2,688	1,981	686	3,681	3,729	107,894
2011	5,554	6,179	8,102	5,782	2,620	1,694	149	585	478	1,904	1,517	1,547	36,111
2012	1,359	8,668	7,785	12,506	4,810	278	188	1,914	436	307	20	30	38,301
2013	774	5,643	4,076	4,225	3,610	1,626	2,509	4,731	496	883	426	486	29,485
2014	1,587	1,745	2,460	1,438	1,617	2,945	3,382	69	198	754	99	0	16,294
Mean	5,625	7,034	10,725	14,139	29,408	29,869	13,385	8,020	9,165	14,107	6,299	4,977	152,752
Maximum	23,008	24,890	45,519	68,311	242,240	200,100	172,100	149,530	126,320	399,500	39,170	24,210	796,851
Minimum	0	0	0	0	765	79	0	0	0	0	0	0	11,767

**TABLE 5-1****AUTOMATED GAGES**

LOCATION	TYPE <sup>(1)</sup>	SWT ID	SHEF ID	USGS <sup>(2)</sup> STATION NUMBER	LATITUDE NORTH Deg Min Sec	LONGITUDE WEST Deg Min Sec
Canadian River nr Amarillo, TX	Precipitation	AMAR	AMAT2	07227500	35 28 13	101 52 45
Cimarron River nr Ames 4SW	Precipitation	AMES	AMCO2	N/A	36 13 07	98 15 16
Cimarron River nr Buffalo, OK	Precipitation	BUFF	BFFO2	07157950	36 51 07	99 18 54
Turkey Creek nr Bison, OK	Precipitation	BISO	BTCO2	N/A	36 11 19	97 57 43
Beaver River at Beaver, OK	Precipitation	BEAV	BVRO2	07234000	36 49 20	100 31 05
Canadian River nr Canadian, TX	Precipitation	CANA	CDNT2	07228000	35 56 06	100 22 13
Cedar RAWS nr Fritch 7SW	Precipitation	CEDT2	CEDT2	N/A	35 41 25	101 34 06
Elkhart 10N RAWS	Precipitation	ELKH	CGLK1	N/A	37 08 27	101 54 01
Washita River, OK	Precipitation	CHEY	CHYO2	07316500	35 37 35	99 40 05
East Cheyenne Creek Tributary near Channing	Precipitation	CHYT2	CHYT2	07227460	35 40 30	102 16 51
Washita River nr Clinton, OK	Precipitation	CLIN	CLIO2	07325000	35 31 51	98 58 00
Canton Lake	Precipitation	CANT	CNLO2	N/A	36 04 54	98 36 07
Cheyenne RAWS near Reydon 4NNE	Precipitation	CRWO2	CRWO2	N/A	35 42 29	99 54 17
Cimarron River, Dover, OK	Precipitation	DOVE	DOVO2	07159100	35 57 06	97 54 51
Elk City Airport	Precipitation	ELKA	ELCO2	N/A	35 25 37	99 23 43
North Canadian River, El Reno, OK	Precipitation	ELRE	ELNO2	07239500	35 33 47	97 57 26
Crooked Creek nr Nye	Precipitation	NYEC	ENWK1	07157500	37 01 57	100 12 29
Washita River near Foss, OK	Precipitation	FOSB	FBFO2	07324400	35 32 20	99 10 10
Foss Lake, OK	Precipitation	FOSS	FOSO2	N/A	35 32 20	99 11 09
Cimarron River near Forgan, OK	Precipitation	FORG	FRGO2	07156900	37 00 40	100 29 29
Fort Supply Lake	Precipitation	FSUP	FSLO2	N/A	36 33 14	99 34 16
Beaver River at HWY 183 nr Ft Supply 2NW	Precipitation	FTSP	FSPO2	07234500	36 35 29	99 35 30
Wolf Creek nr Ft. Supply 9S	Precipitation	FSWC	FWCO2	N/A	36 26 58	99 35 19
Wolf Creek nr Gage	Precipitation	GAGE	GAWO2	07235600	36 19 36	99 45 40
Beaver River, Goodwell, OK	Precipitation	GDWL	GBRO2	07232470	36 42 21	101 38 11

**TABLE 5-1 CONTINUED**

LOCATION	TYPE <sup>(1)</sup>	SWT ID	SHEF ID	USGS <sup>(2)</sup> STATION NUMBER	LATITUDE NORTH Deg Min Sec	LONGITUDE WEST Deg Min Sec
Washita River near Hammon, OK	Precipitation	HAMM	HMMO2	07324200	35 39 23	99 18 21
Cimarron River nr Kenton, OK	Precipitation	KENT	KENO2	07154500	36 55 36	102 57 31
Wolf Creek nr Lipscomb, TX	Precipitation	LIPS	LCBT2	07235000	36 14 19	100 16 31
Lahoma Precip Gage	Precipitation	LAHO	LHMO2	N/A	36 23 22	98 06 22
Lake Meredith	Precipitation	MERE	MRIT2	07227900	35 42 38	101 33 03
North Canadian River below Lake Overholser	Precipitation	OKC1	OLBO2	07241000	35 28 43	97 39 47
North Canadian River, Seiling, OK	Precipitation	SEIL	SEIO2	07238000	36 11 00	98 55 15
Palo Duro Creek nr Spearman 6W	Precipitation	SPMT2	SPMT2	07233500	36 12 08	101 18 20
Cimarron River, Waynoka, OK	Precipitation	WAYN	WANO2	07158000	36 31 02	98 52 45
North Canadian River, Watonga, OK	Precipitation	WATO	WATO2	07239200	35 48 43	98 25 14
North Canadian River, Woodward, OK	Precipitation	WOO2	WDGO2	07237500	36 26 12	99 16 41
8 miles WSW of Arnett	MESONET	ATSO2	ATSO2	N/A <sup>(3)</sup>	36 04 00	99 54 13
2 miles S of Alva	MESONET	AVSO2	AVSO2	N/A <sup>(3)</sup>	36 46 60	98 40 13
3 miles SSE of Boise City	MESONET	BCSO2	BCSO2	N/A <sup>(3)</sup>	36 40 60	102 30 13
0.5 miles SW of Buffalo	MESONET	BFSO2	BFSO2	N/A <sup>(3)</sup>	36 49 60	99 38 13
4 miles WNW of Bessie	MESONET	BSSO2	BSSO2	N/A <sup>(3)</sup>	35 23 60	99 04 13
5 miles SW of Butler	MESONET	BTSO2	BTSO2	N/A <sup>(3)</sup>	35 34 60	99 16 13
1 mile SSW of Beaver	MESONET	BVSO2	BVSO2	N/A <sup>(3)</sup>	36 47 60	100 32 13
4 miles WNW of Camargo	MESONET	CMSO2	CMSO2	N/A <sup>(3)</sup>	36 01 60	99 21 13
0.5 miles SSW of Cherokee	MESONET	CRSO2	CRSO2	N/A <sup>(3)</sup>	36 45 00	98 22 13
6 miles SW of Cheyenne	MESONET	CYSO2	CYSO2	N/A <sup>(3)</sup>	35 37 00	99 41 13
5 miles WNW of El Reno	MESONET	ERSO2	ERSO2	N/A <sup>(3)</sup>	35 32 60	98 02 13
3 miles SSW of Freedom	MESONET	FDSO2	FDSO2	N/A <sup>(3)</sup>	36 43 60	99 08 13
1 mile W of Fairview	MESONET	FVSO2	FVSO2	N/A <sup>(3)</sup>	36 16 00	98 30 13
2 miles E of Goodwell	MESONET	GDSO2	GDSO2	N/A <sup>(3)</sup>	36 36 00	101 36 13
1 mile W of Hooker	MESONET	HKSO2	HKSO2	N/A <sup>(3)</sup>	36 52 00	101 14 13
7 miles W of Hinton	MESONET	HTSO2	HTSO2	N/A <sup>(3)</sup>	35 28 60	98 29 13
1 mile W of Kingfisher	MESONET	KFSO2	KFSO2	N/A <sup>(3)</sup>	35 52 60	97 55 13

**TABLE 5-1 CONTINUED**

LOCATION	TYPE <sup>(1)</sup>	SWT ID	SHEF ID	USGS <sup>(2)</sup> STATION NUMBER	LATITUDE NORTH Deg Min Sec	LONGITUDE WEST Deg Min Sec
5 miles SE of Kenton	MESONET	KTSO2	KTSO2	N/A <sup>(3)</sup>	36 52 00	102 53 13
1 mile WSW of Lahoma	MESONET	LHSO2	LHSO2	N/A <sup>(3)</sup>	36 22 60	98 07 13
16 miles NNE of Freedom	MESONET	MYSO2	MYSO2	N/A <sup>(3)</sup>	36 58 60	99 01 13
3 miles N of Putnam	MESONET	PMSO2	PMSO2	N/A <sup>(3)</sup>	35 53 60	98 58 13
7 miles WNW of Seiling	MESONET	SESO2	SESO2	N/A <sup>(3)</sup>	36 10 60	99 02 13
8 miles W of Slapout	MESONET	SPSO2	SPSO2	N/A <sup>(3)</sup>	36 36 00	100 16 13
7 miles W of Watonga	MESONET	WNSO2	WNSO2	N/A <sup>(3)</sup>	35 49 60	98 32 13
2 miles WSW of Woodward	MESONET	WWSO2	WWSO2	N/A <sup>(3)</sup>	36 25 00	99 25 13
4 miles WSW of Weatherford	MESONET	WXSO2	WXSO2	N/A <sup>(3)</sup>	35 31 00	98 46 13
Beaver River at Beaver, OK	Stream Gage	BEAV	BVRO2	07234000	36 49 20	100 31 04
North Canadian River, Calumet, OK	Stream Gage	CALU	CLMO2	07239450	35 36 59	98 03 56
Canton Outflow	Stream Gage	CANN	CNOO2	07239000	36 04 45	98 35 25
North Canadian River, El Reno, OK	Stream Gage	ELRE	ELNO2	07239500	35 33 47	97 57 26
Wolf Creek nr Ft. Supply 9S	Stream Gage	FSWC	FWCO2	07237000	36 26 58	99 35 19
Beaver River at HWY 183 nr Ft Supply 2NW	Stream Gage	FTSP	FSPO2	07234500	36 35 29	99 35 30
Wolf Creek nr Gage	Stream Gage	GAGE	GAWO2	07235600	36 19 36	99 45 40
Beaver River, Goodwell, OK	Stream Gage	GDWL	GBRO2	07232470	36 42 21	101 38 11
Wolf Creek nr Lipscomb, TX	Stream Gage	LIPS	LCBT2	07235000	36 14 19	100 16 30
North Canadian River below Lake Overholser	Stream Gage	OKC1	OLBO2	07241000	35 28 43	97 39 47
North Canadian River, Seiling, OK	Stream Gage	SEIL	SEIO2	07238000	36 11 06	98 55 15
North Canadian River, Watonga, OK	Stream Gage	WATO	WATO2	07239300	35 48 42	98 25 13
North Canadian River, Woodward, OK	Stream Gage	WOO2	WDGO2	07237500	36 26 17	99 16 39
Yukon 2NNE (N Canadian R)	Stream Gage	YUKO	YUKO2	07239700	35 32 22	97 44 32
Canton Lake	Pool	CANT	CNLO2	07238500	36 05 03	98 36 05
Fort Supply Lake	Pool	FSUP	FSLO2	07236500	36 33 14	99 34 15

- (1) Current Data for all gages can be found at <http://www.swt-wc.usace.army.mil>  
(2) Unless otherwise noted, current and historical data can be found at <http://nwis.waterdata.usgs.gov/ok/nwis>  
(3) Current and historical data can be found at <http://www.mesonet.org/index.php/weather/local>

**TABLE 5-2****PERTINENT WATER QUALITY STATIONS**  
**NORTH CANADIAN RIVER**

<b>Primary Station Code</b>	<b>Location Description</b>	<b>Type</b>	<b>Operating agency</b>	<b>Reporting or Non-Reporting</b>	<b>Period of Record</b>	<b>Frequency of Analysis</b>	<b>Latitude (North)</b>	<b>Longitude (West)</b>
1CANOKN0230	In-lake, channel near dam	Physical/Chemical	COE	Non-reporting	Not available	15 years or as needed	36:05:22.22	-98:36:05.39
1CANOKN0231	In-lake, channel near Big Bend PUA	Physical/Chemical	COE	Non-reporting	Not available	15 years or as needed	36:07:04.93	-98:36:39.07
1CANOKN0233	In-lake, channel, upper lake	Physical/Chemical	COE	Non-reporting	Not available	15 years or as needed	36:08:05.97	-98:37:55.63
1CANOKN0229	Stilling basin below dam	Physical/Chemical	COE	Non-reporting	Not available	15 years or as needed	36:04:49.00	-98:35:59.04
07237500	North Canadian River at Woodward, OK	Physical/Chemical	USGS	Non-reporting	Not available	Daily	36:26:12	-99:16:41
07239450	North Canadian River near Calumet, OK	Physical/Chemical	USGS	Reporting	1988 – Present	Daily	35:37:01	-98:03:54
07239500	North Canadian River near El Reno, OK	Physical/Chemical	USGS	Reporting	1944 – Present	Daily	35:33:47	-97:57:26
07239700	North Canadian River near Yukon,	Physical/Chemical	USGS	Reporting	1999 – Present	Daily	35:32:22	-97:44:32

**TABLE 5-2 CONTINUED**

<b>Primary Station Code</b>	<b>Location Description</b>	<b>Type</b>	<b>Operating agency</b>	<b>Reporting or Non-Reporting</b>	<b>Period of Record</b>	<b>Frequency of Analysis</b>	<b>Latitude (North)</b>	<b>Longitude (West)</b>
	OK							
720500010020-01	Canton Lake, near dam	Physical/Chemical	OWRB	Non-reporting	1994 – Present	5 years or as needed	36.093372	-98.588339
720500010020-02	Canton Lake, near Big Bend PUA	Physical/Chemical	OWRB	Non-reporting	1994 – Present	5 years or as needed	36.125722	-98.601389
720500010020-03	Canton Lake, upper lake	Physical/Chemical	OWRB	Non-reporting	1994 – Present	5 years or as needed	36.14255	-98.633858
720500010020-04	Canton Lake, upper lake	Physical/Chemical	OWRB	Non-reporting	1994 – Present	5 years or as needed	36.142606	-98.654901
720500010020-05	Canton Lake, near dam	Physical/Chemical	OWRB	Non-reporting	1994 – Present	5 years or as needed	36.095482	-98.58665

**TABLE 7-3**

**ELEVATION – AREA – CAPACITY DATA**  
**CANTON LAKE, OKLAHOMA**

Area (1000's of Acres) Capacity (1000's of Acre-Feet)										
Pool Elevation (ft, NGVD 29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1580	0.000	0.000	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.004
	0.000	0.000	0.001	0.001	0.002	0.002	0.003	0.003	0.004	0.004
1581	0.004	0.004	0.005	0.005	0.006	0.006	0.006	0.007	0.007	0.008
	0.005	0.005	0.006	0.006	0.006	0.007	0.007	0.008	0.008	0.009
1582	0.008	0.008	0.009	0.009	0.010	0.010	0.010	0.011	0.011	0.012
	0.009	0.010	0.010	0.011	0.011	0.012	0.012	0.012	0.013	0.013
1583	0.012	0.012	0.013	0.013	0.014	0.014	0.014	0.015	0.015	0.016
	0.014	0.014	0.015	0.015	0.016	0.016	0.017	0.017	0.017	0.018
1584	0.016	0.016	0.017	0.017	0.018	0.018	0.018	0.019	0.019	0.020
	0.018	0.019	0.019	0.020	0.020	0.021	0.021	0.022	0.022	0.023
1585	0.020	0.038	0.055	0.073	0.090	0.108	0.126	0.143	0.161	0.178
	0.023	0.059	0.096	0.132	0.169	0.205	0.241	0.278	0.314	0.351
1586	0.196	0.214	0.231	0.249	0.266	0.284	0.302	0.319	0.337	0.354
	0.387	0.423	0.460	0.496	0.533	0.569	0.605	0.642	0.678	0.715
1587	0.372	0.390	0.407	0.425	0.442	0.460	0.478	0.495	0.513	0.530
	0.751	0.787	0.824	0.860	0.897	0.933	0.969	1.006	1.042	1.079
1588	0.548	0.566	0.583	0.601	0.618	0.636	0.654	0.671	0.689	0.706
	1.115	1.151	1.188	1.224	1.261	1.297	1.333	1.370	1.406	1.443
1589	0.724	0.742	0.759	0.777	0.794	0.812	0.830	0.847	0.865	0.882
	1.479	1.515	1.552	1.588	1.625	1.661	1.697	1.734	1.770	1.807

**TABLE 7-3 CONTINUED**

<b>Area (1000's of Acres) Capacity (1000's of Acre-Feet)</b>										
Pool Elevation (ft, NGVD 29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1590	0.900	0.929	0.957	0.986	1.014	1.043	1.072	1.100	1.129	1.157
	1.843	2.014	2.184	2.355	2.525	2.696	2.866	3.037	3.207	3.378
1591	1.186	1.215	1.243	1.272	1.300	1.329	1.358	1.386	1.415	1.443
	3.548	3.719	3.889	4.060	4.231	4.401	4.572	4.742	4.913	5.083
1592	1.472	1.501	1.529	1.558	1.586	1.615	1.644	1.672	1.701	1.729
	5.254	5.424	5.595	5.765	5.936	6.107	6.277	6.448	6.618	6.789
1593	1.758	1.787	1.815	1.844	1.872	1.901	1.930	1.958	1.987	2.015
	6.959	7.130	7.300	7.471	7.641	7.812	7.982	8.153	8.324	8.494
1594	2.044	2.073	2.101	2.130	2.158	2.187	2.216	2.244	2.273	2.301
	8.665	8.835	9.006	9.176	9.347	9.517	9.688	9.858	10.029	10.199
1595	2.330	2.359	2.387	2.416	2.444	2.473	2.502	2.530	2.559	2.587
	10.370	10.541	10.711	10.882	11.052	11.223	11.393	11.564	11.734	11.905
1596	2.616	2.635	2.654	2.673	2.693	2.712	2.731	2.750	2.769	2.788
	12.075	12.440	12.804	13.168	13.533	13.897	14.261	14.626	14.990	15.354
1597	2.807	2.827	2.846	2.866	2.885	2.905	2.924	2.943	2.963	2.982
	15.719	16.028	16.338	16.648	16.957	17.267	17.577	17.887	18.196	18.506
1598	3.002	3.021	3.041	3.060	3.080	3.099	3.119	3.138	3.158	3.177
	18.816	19.125	19.435	19.745	20.055	20.364	20.674	20.984	21.293	21.603
1599	3.196	3.216	3.235	3.255	3.274	3.294	3.313	3.333	3.352	3.372
	21.913	22.223	22.532	22.842	23.152	23.461	23.771	24.081	24.391	24.700
1600	3.391	3.419	3.448	3.476	3.505	3.533	3.561	3.590	3.618	3.647
	25.010	25.392	25.774	26.156	26.538	26.920	27.302	27.684	28.066	28.448
1601	3.675	3.703	3.732	3.760	3.789	3.817	3.845	3.874	3.902	3.931
	28.830	29.212	29.594	29.976	30.358	30.740	31.122	31.504	31.886	32.268
1602	3.959	3.987	4.016	4.044	4.073	4.101	4.129	4.158	4.186	4.215
	32.650	33.032	33.414	33.796	34.178	34.560	34.942	35.324	35.706	36.088

**TABLE 7-3 CONTINUED**

<b>Area (1000's of Acres) Capacity (1000's of Acre-Feet)</b>										
Pool Elevation (ft, NGVD 29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1603	4.243	4.268	4.294	4.319	4.344	4.370	4.395	4.420	4.445	4.471
	36.470	36.925	37.379	37.834	38.288	38.743	39.197	39.652	40.106	40.561
1604	4.496	4.521	4.547	4.572	4.597	4.623	4.648	4.673	4.698	4.724
	41.015	41.470	41.924	42.379	42.833	43.288	43.742	44.197	44.651	45.106
1605	4.749	4.775	4.801	4.827	4.852	4.878	4.904	4.930	4.956	4.982
	45.560	46.056	46.552	47.048	47.543	48.039	48.535	49.031	49.527	50.023
1606	5.008	5.033	5.059	5.085	5.111	5.137	5.163	5.188	5.214	5.240
	50.519	51.014	51.510	52.006	52.502	52.998	53.494	53.989	54.485	54.981
1607	5.266	5.291	5.316	5.341	5.366	5.391	5.416	5.441	5.466	5.491
	55.477	56.005	56.535	57.068	57.603	58.141	58.682	59.224	59.770	60.318
1608	5.516	5.541	5.566	5.591	5.615	5.640	5.665	5.690	5.715	5.740
	60.868	61.421	61.976	62.534	63.094	63.657	64.222	64.790	65.360	65.933
1609	5.765	5.790	5.815	5.840	5.865	5.890	5.915	5.940	5.965	5.990
	66.508	67.086	67.666	68.249	68.834	69.422	70.012	70.605	71.200	71.798
1610	6.015	6.040	6.065	6.090	6.115	6.140	6.165	6.189	6.214	6.239
	72.398	73.001	73.606	74.214	74.824	75.437	76.052	76.670	77.290	77.912
1611	6.264	6.289	6.314	6.339	6.364	6.389	6.414	6.439	6.464	6.489
	78.538	79.165	79.796	80.428	81.063	81.701	82.341	82.984	83.629	84.277
1612	6.514	6.539	6.564	6.589	6.614	6.639	6.664	6.689	6.714	6.739
	84.927	85.579	86.235	86.892	87.552	88.215	88.880	89.548	90.218	90.890
1613	6.764	6.788	6.813	6.838	6.863	6.888	6.913	6.938	6.963	6.988
	91.565	92.243	92.923	93.606	94.291	94.978	95.668	96.361	97.056	97.754
1614	7.013	7.038	7.045	7.056	7.069	7.082	7.137	7.152	7.167	7.188
	98.454	99.156	100.988	101.695	102.406	103.119	103.858	104.581	105.308	106.043
1615	7.209	7.226	7.245	7.273	7.303	7.327	7.364	7.401	7.463	7.493
	106.782	107.449	108.193	108.952	109.647	110.412	111.129	111.851	112.622	113.424

**TABLE 7-3 CONTINUED**

<b>Area (1000's of Acres) Capacity (1000's of Acre-Feet)</b>										
Pool Elevation (ft, NGVD 29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1616	7.537	7.586	7.626	7.688	7.735	7.768	7.815	7.850	7.885	7.914
	114.182	114.958	115.723	116.466	117.264	118.039	118.852	119.644	120.441	121.228
1617	7.942	8.018	8.050	8.095	8.126	8.164	8.207	8.250	8.295	8.329
	122.020	122.792	123.610	124.469	125.296	126.068	126.863	127.747	128.562	129.430
1618	8.373	8.407	8.439	8.467	8.493	8.519	8.561	8.600	8.623	8.653
	130.256	131.134	131.928	132.797	133.662	134.532	135.390	136.237	137.111	138.020
1619	8.676	8.698	8.721	8.746	8.772	8.797	8.818	8.841	8.870	8.890
	138.902	139.787	140.586	141.494	142.403	143.228	144.126	145.037	145.897	146.798
1620	8.914	8.940	8.965	8.986	9.007	9.035	9.062	9.085	9.117	9.145
	147.729	148.584	149.525	150.362	151.288	152.174	153.144	154.010	154.929	155.830
1621	9.179	9.299	9.421	9.477	9.547	9.603	9.652	9.698	9.744	9.790
	156.769	157.699	158.741	159.660	160.580	161.608	162.600	163.575	164.463	165.456
1622	9.832	9.868	9.904	9.936	9.965	9.999	10.027	10.053	10.089	10.119
	166.519	167.457	168.498	169.411	170.413	171.450	172.454	173.450	174.521	175.449
1623	10.149	10.175	10.229	10.260	10.292	10.321	10.350	10.377	10.408	10.454
	176.485	177.494	178.523	179.584	180.655	181.604	182.662	183.710	184.787	185.796
1624	10.487	10.519	10.555	10.589	10.617	10.653	10.681	10.720	10.745	10.781
	186.905	187.901	188.942	190.075	191.058	192.220	193.214	194.300	195.387	196.455
1625	10.811	10.839	10.864	10.906	10.935	10.963	10.989	11.022	11.054	11.115
	197.593	198.605	199.701	200.852	201.886	203.021	204.151	205.235	206.313	207.455
1626	11.159	11.216	11.259	11.303	11.337	11.371	11.404	11.437	11.470	11.498
	208.664	209.776	210.873	211.986	213.113	214.250	215.384	216.632	217.773	218.865
1627	11.524	11.554	11.586	11.616	11.642	11.669	11.696	11.721	11.744	11.780
	220.056	221.173	222.326	223.568	224.667	225.886	226.996	228.202	229.398	230.506
1628	11.806	11.869	11.898	11.936	11.962	12.001	12.028	12.057	12.082	12.109
	231.728	233.027	234.189	235.340	236.586	237.758	239.029	240.202	241.344	242.629

**TABLE 7-3 CONTINUED**

Area (1000's of Acres) Capacity (1000's of Acre-Feet)										
Pool Elevation (ft, NGVD 29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1629	12.265	12.294	12.337	12.365	12.392	12.421	12.450	12.477	12.503	12.534
	244.467	245.667	246.914	248.237	249.436	250.649	251.874	253.209	254.399	255.664
1630	12.559	12.584	12.611	12.638	12.666	12.691	12.716	12.743	12.770	12.799
	256.969	258.173	259.514	260.742	261.982	263.318	264.533	265.769	267.152	268.423
1631	12.826	12.851	12.886	12.922	12.954	12.988	13.018	13.044	13.070	13.097
	269.675	270.907	272.277	273.539	274.873	276.103	277.427	278.828	280.101	281.386
1632	13.124	13.158	13.184	13.212	13.259	13.298	13.335	13.363	13.390	13.422
	282.682	284.067	285.353	286.682	288.009	289.364	290.690	292.025	293.351	294.744
1633	13.448	13.502	13.531	13.560	13.592	13.623	13.655	13.683	13.722	13.753
	296.062	297.401	298.763	300.136	301.559	302.847	304.273	305.654	307.059	308.351
1634	13.784	13.815	13.849	13.881	13.910	13.939	13.969	13.998	14.027	14.059
	309.798	311.087	312.576	313.905	315.333	316.752	318.058	319.494	320.929	322.271
1635	14.091	14.124	14.166	14.199	14.230	14.273	14.312	14.351	14.385	14.425
	323.771	325.144	326.517	328.032	329.399	330.805	332.294	333.775	335.207	336.569
1636	14.457	14.498	14.535	14.587	14.627	14.667	14.702	14.738	14.775	14.811
	338.121	339.521	340.991	342.445	343.847	345.379	346.849	348.347	349.855	351.349
1637	14.846	14.881	14.916	15.019	15.057	15.092	15.136	15.176	15.218	15.274
	352.839	354.324	355.823	357.433	358.849	360.342	361.873	363.468	364.953	366.539
1638	15.343	15.382	15.431	15.484	15.571	15.613	15.669	15.714	15.753	15.793
	368.058	369.658	371.135	372.689	374.381	375.898	377.514	379.092	380.736	382.241
1639	15.842	15.881	15.921	15.966	16.081	16.127	16.172	16.211	16.252	16.291
	383.908	385.394	387.083	388.683	390.283	391.920	393.536	395.217	396.778	398.473
1640	16.332	16.370	16.415	16.452	16.490	16.528	16.569	16.615	16.655	16.701
	400.036	401.723	403.371	405.039	406.584	408.280	409.868	411.565	413.300	415.014
1641	16.751	16.795	16.844	16.888	16.926	16.964	17.003	17.052	17.097	17.139
	416.614	418.302	420.058	421.740	423.487	425.057	426.828	428.458	430.169	432.016

**TABLE 7-3 CONTINUED**

<b>Area (1000's of Acres) Capacity (1000's of Acre-Feet)</b>										
<b>Pool Elevation (ft, NGVD 29)</b>	<b>0.0</b>	<b>0.1</b>	<b>0.2</b>	<b>0.3</b>	<b>0.4</b>	<b>0.5</b>	<b>0.6</b>	<b>0.7</b>	<b>0.8</b>	<b>0.9</b>
1642	17.178	17.217	17.255	17.308	17.347	17.398	17.441	17.482	17.523	17.568
	433.620	435.413	437.192	438.933	440.552	442.435	444.140	445.824	447.689	449.280
1643	17.632	17.672	17.792	17.832	17.876	17.960	18.004	18.057	18.096	18.139
	451.083	452.939	454.995	456.850	458.636	460.491	462.276	464.064	465.936	467.711
1644	18.178	18.216	18.260	18.299	18.357	18.397	18.442	18.493	18.555	18.597
	469.422	471.287	473.097	474.982	476.904	478.659	480.496	482.478	484.316	486.114
1645	18.639	18.681	18.725	18.767	18.811	18.862	18.907	18.955	18.999	19.040
	487.935	489.910	491.779	493.586	495.454	497.472	499.360	501.326	503.211	505.023
1646	19.086	19.130	19.172	19.238	19.286	19.330	19.371	19.426	19.471	19.511
	506.973	508.855	510.722	512.700	514.710	516.620	518.469	520.424	522.382	524.422
1647	19.551	19.592	19.635	19.678	19.722	19.764	19.814	19.860	19.904	19.949
	526.465	528.332	530.253	532.185	534.326	536.244	538.140	540.156	542.129	544.115
1648	19.996	-	-	-	-	-	-	-	-	-
	546.166	-	-	-	-	-	-	-	-	-

Based on 1977 Conservation Pool Survey & 2010 Flood Pool LiDAR Survey

**TABLE 7-4****ACTIVE WATER RIGHTS AMOUNTS AND LOCATIONS (UPSTREAM TO DOWNSTREAM)**  
**NORTH CANADIAN RIVER**

<b>PERMIT #</b>	<b>Entity Name</b>	<b>Qtr</b>	<b>Qtr</b>	<b>Qtr</b>	<b>Sec</b>	<b>Township</b>	<b>Range</b>	<b>County</b>	<b>AcFt/Yr</b>	<b>Purpose</b>	<b>Date Filed</b>	<b>Date Issued</b>
19670488	Chain Land & Cattle Co Inc	NE	SW	NE	22	18N	13WI	Blaine	320	Irrigation	5/16/1967	7/9/1984
19910020	(b) (6)	NW	NE	NE	01	15N	12WI	Blaine	145	Irrigation	5/14/1991	7/8/1991
20110016		NE	SE	NE	07	15N	11WI	Blaine	375	Irrigation	4/4/2011	6/13/2011
19880031		NE	SE	SE	07	15N	11WI	Blaine	95	Irrigation	9/11/1988	8/12/1991
19680204	Base 1990 Revocable Trust, Kaye	S2	SE	SE	31	15N	10WI	Blaine	240	Irrigation	5/2/1968	7/8/1968
20110006	Base 1990 Revocable Trust, Kaye	SW	SE	NW	05	14N	10WI	Canadian	287	Irrigation	2/3/2011	6/13/2011
19480222	(b) (6)		S2	SE	21	14N	10WI	Canadian	72	Irrigation	13/31/1947	10/9/1967
20110009	Cimarex Energy Co	NW	SW	SE	22	14N	10WI	Canadian	1,015	Mining	2/15/2011	5/10/2011
19490117	(b) (6)		S2	NE	04	13N	09WI	Canadian	27	Irrigation	10/3/1949	10/9/1967
20110037		SW	SE	NW	02	13N	09WI	Canadian	161	Mining	7/4/2011	10/16/2011
20100018		SW	SW	SW	01	13N	09WI	Canadian	50	Mining	7/1/2010	4/11/2011
19490102	J&J Farms Incorporated	SW	NW	SE	35	13N	07WI	Canadian	640	Irrigation	8/23/1949	10/9/1967
19850037	(b) (6)	NW	SW	NW	14	12N	06WI	Canadian	60	Irrigation	7/14/1985	8/12/1991
20010031	Coughlin Living Trust	SE	NE	SE	07	12N	05WI	Canadian	81	Irrigation	10/30/2001	Pending
19390055	City of Oklahoma City		SE	NW	18	12N	04WI	Oklahoma	80,000	Public Supply	10/25/1939	10/9/1967
19820119	City of Oklahoma City	SW	SE	NW	30	12N	04WI	Oklahoma	28,000	Public Supply	9/12/1982	Pending

**TABLE 7-4 CONTINUED**

<b>PERMIT #</b>	<b>Entity Name</b>	<b>Qtr</b>	<b>Qtr</b>	<b>Qtr</b>	<b>Sec</b>	<b>Township</b>	<b>Range</b>	<b>County</b>	<b>AcFt/Yr</b>	<b>Purpose</b>	<b>Date Filed</b>	<b>Date Issued</b>
20020039	City of Oklahoma City	SE	SW	SW	01	11N	04WI	Oklahoma	144.1	Irrigation	7/22/2002	12/9/2002
19980043	City of Oklahoma City	SE	SW	SW	04	11N	03WI	Oklahoma	1,450	Recreation, Fish, Wildlife	10/5/1998	3/8/1999
20020038	City of Oklahoma City			SW	04	11N	03WI	Oklahoma	258.6	Irrigation	7/22/2002	12/9/2002
20020037	City of Oklahoma City		NW	NW	10	11N	03WI	Oklahoma	219.5	Irrigation	7/22/2002	12/9/2002
<b>Total Downstream Rights:</b>									<b>113,640</b>			

Note: Obtained from OWRB Website <https://www.owrb.ok.gov/>

**EXHIBIT A**

**SUPPLEMENTARY PERTINENT DATA**

**CANTON DAM AND LAKE**

EXHIBIT A  
SUPPLEMENTARY PERTINENT DATA  
CANTON LAKE

TABLE OF CONTENTS

<u>Section Title</u>	<u>Page</u>
1 - General Information .....	A-1
2 - Lake Information .....	A-3
3 - Hydrology .....	A-5
4 - Embankment .....	A-7
5 - Spillway .....	A-8
6 - Auxiliary Spillway .....	A-9
7 - Outlet Facilities .....	A-11
8 - Control Points .....	A-13

## 1 - GENERAL INFORMATION

Other names for project	None
Location	(State of Oklahoma) Arkansas River Basin, North Canadian River, river mile 394.3
Type of Project	Dam and Lake
Objectives of Regulation	Multipurpose – Flood control, water supply, recreation, fish and wildlife, and streamflow aesthetics
Project Owner	US Government
Operating Agency	US Army Corps of Engineers. The normal working hours of operation for weekdays are 7:00 a.m. to 4:30 p.m. Working hours for weekends, holidays, and nights vary. Working hours under flood emergency conditions are 24 hours
Regulating Agency	US Army Corps of Engineers
Water Supply Contracts	City of Oklahoma City, 90,000 acre-feet of storage with a yield of 4.6 million gallons per day (MGD)
Water Rights	<p>Water rights have been granted in the North Canadian River Basin between Canton Dam and Eufaula Lake in the amount of 118,753 acre-feet. Releases may be required from Canton Lake to meet some of these water rights.</p> <p>Waters of the North Canadian River and Tributaries were adjudicated by court decree in the District Court at Oklahoma City on 26 October, 1939, under Case No. 99028. By this decree, Oklahoma City was authorized to store an additional 100,000 acre-feet of water to be obtained from flood flows and to maintain their supply by storing no more than 90,000 acre-feet per year.</p>
Code of Federal Regulations, Title 33 (applies to Section 7 Project)	Does not apply

Federal Power Commission License	No power recommended for this project
Other inter-agency agreement	None
Project cost	\$ 11,000,000
Impoundment Began	January 1948
Special project features	None
Other	None

## 2 - LAKE INFORMATION

Feature	Elevation (feet, NGVD 29)	Lake Area (acres)	Storage (acre-feet)	Runoff (inches)
Top of Dam (Design)	1648.0			
Maximum pool	1642.68	17,490	445,500	1.61
Top of surcharge pool	1640.0	16,330	400,000	1.44
Top of flood control pool	1638.0	15,340	368,000	1.33
Top of conservation pool	1615.4	7,340	109,700	0.40
Bottom of conservation pool	1596.5	2,710	14,100	0.05
Crest of service spillway	1613.0	6,760	91,500	0.33
Bottom of Auxiliary Spillway Weir	1606.0	5,010	50,500	0.18
Streambed at dam	1583.0	--	--	--
Flood control storage	1615.4 – 1638.0	--	258,300	0.93
Water supply storage	1596.5 – 1615.4	--	95,600	0.34

Notes: Area and Storage based on 2010 resurvey  
 Surveyed Top of Dam is currently 1647.09 ft

Real estate taking for land fee  
 title

19,877 acres

Range of clearing

Lower limit – Elevation 1583.3 feet.  
 Upper limit – Elevation 1615.4 feet.

Pool elevation corresponding to  
 discharge capability of maximum  
 non-damaging flow rate  
 downstream

Non-damaging channel capacity immediately  
 downstream of Canton Dam is estimated to be  
 1000 cfs. This flow rate can be discharged when  
 the lake is at elevation 1595.0 feet and above.

Reservoir length at top of  
 conservation pool

6 miles

Reservoir Length at top of flood  
 pool

13 miles

Shoreline length at top of  
 conservation pool

45 miles

Safety aspects, possibly requiring warning

A warning horn is sounded to warn individuals downstream of the dam before gate changes are made

Emergency Drawdown

Canton Lake has sixteen 40'x25' tainter gates with a spillway crest at elevation 1613.0 feet, NGVD 29. The dam also has two 7'x12' sluices, controlled by vertical lift gates, with an invert elevation of 1582.0 feet, NGVD 29. All water in the reservoir can be emptied through the sluices.

### 3 - HYDROLOGY

Drainage area	12,695 square miles
<u>Probable Maximum Flood (PMF)</u>	
Maximum water surface elev.	1,642.68 feet
Peak inflow (into full pool)	634,001 cfs
Total storm runoff (into full pool)	6.44 inches (contributing drainage area of 7,600 square miles)
Volume (into full pool)	2,609,998 ac-ft
Maximum outflow	607,752 cfs
Duration of flood	10 Days
<u>Standard Project Flood</u> (One-half Original Spillway Design Flood)	
Maximum water surface elev.	1,638.0 feet, NGVD 29
Peak inflow (into full pool)	185,000 cfs
Total storm runoff (into full pool)	2.97 inches (contributing drainage area of 7,600 square miles)
Volume (into full pool)	1,205,196 acre feet
Maximum outflow	185,383 cfs
Duration of flood	10 Days
Climate	Moderate
One inch of runoff	277,227 acre-feet (based on drainage area of 5,198 square miles)
Storm types	Primarily Thunderstorms
Flood Seasons	Primary flood period is Mar through July, with a secondary period Sep through Nov; however, floods are possible in any month of the year
Low flow season	Primarily August, September, and December through February; however, low flow can occur at any time of the year.
Minimum daily inflow	0 cfs on several occasions Period of record 1923-2014
Minimum monthly inflow	0 acre-feet on several occasions Period of record 1923-2014
Minimum annual inflow and year	11,767 acre-feet in 1956 Period of record 1923-2014

Average annual inflow	152,752 acre feet Period of record 1923-2014
Maximum annual inflow and year	796,851 acre feet in 1923 Period of record 1923-2014
Maximum monthly inflow and date	399,500 acre feet in October 1923 Period of record 1923-2014
Maximum daily inflow and date	30,000 day second feet (dsf) on 19 May 1951
Maximum instantaneous inflow and date	87,500 cfs on 13 October 1923 38,000 cfs on 20 May 1951 Note: The 1923 flow is approximate and prior to dam. The flow from May 1951 is the maximum observed inflow
Maximum flood volume and date into Canton Lake	193,900 acre-feet for 16-21 May 1951
Name and location of key stream flow stations	Upstream of Canton Dam (N Canadian R) Woodward, OK (RM 460.2) Seiling, OK (RM 422.6) Downstream of Canton Dam (N Canadian R) Watonga, OK (RM 361.2) El Reno, OK (RM 307.3) Oklahoma City, OK (RM 281.0)
Type of hydro-meteorological data recorded at dam site	Maximum and minimum air temperature, recording and standard rainfall gages, evaporation pan, anemometer, pool elevation (recording and staff) and tailwater elevation (recording and staff)
Number of precipitation stations used in hydrologic forecasting inflow	36 recording and 26 Mesonet gages, plus 14 stream gages and 2 pool gages
Number of sediment ranges	44
Number of degradation ranges	24

#### 4 - EMBANKMENT

Location	North Canadian River, river mile 394.3
Purpose	Flood control, water supply, recreation, and fish and wildlife
Type	Non-overflow embankment
Type of fill	Rolled earth fill with impervious core
Slope protection	Riprap on upstream face; grassed, with some rock protection, on downstream face.
Height	67 feet above streambed
Length	15,140 feet (including spillways)
Top elevation	Original design of 1648.0 feet, NGVD 29 Currently surveyed at 1647.09 feet, NGVD 29
Design flood	Spillway design flood
Freeboard	5.32 feet above maximum pool elevation
Used for roadway	Yes. State Highway 58A crosses the embankment and spillway with a 24-foot wide asphalt roadway
Elevation of stream bed	1583.0 feet, NGVD 29

## 5 - SPILLWAY

Location	Right Abutment
Type	Gate controlled, chute type
Crest elevation	1613.0 feet, NGVD 29
Net overflow length	640 feet
Number and size of gates	Sixteen (16) – 40' wide x 25' high
Type of gates	Tainter gates, operated by individual electric powered hoists
Top of gate elevation	1638.0 feet, NGVD 29, in closed position
Induced surcharge	2 feet
Design head	28.7 feet
Maximum discharge capacity	360,500 cfs at 1642.68 feet, NGVD 29
Bridge deck elevation	1648.0 feet, NGVD 29, at the bridge centerline
Type of energy dissipater	Stilling Basin with 2 rows of baffles and a 10 foot high end sill
Time required to open and close all gates	25 to 30 minutes from top to bottom positions; gates raise or lower separately or together at a rate of 1.0 foot per minute
Type of emergency closure	Diesel powered generating unit in service building at right abutment
Spillway activation	The tainter gates, except for periodic maintenance, are activated only during flood conditions. During normal conditions, discharges are released through the low flow outlets.

## 6 - AUXILIARY SPILLWAY

Location	Right Abutment
Type	Fuse Gate controlled chute
Top of Gates elevation	1638.0 feet, NGVD 29
Bottom of Approach Channel	1610.0 feet, NGVD 29
Bottom of weir elevation	1606.0 feet, NGVD 29
Net overflow length	480 feet
Number and size of gates	Nine (9) – 53' high x 32' wide
Type of gates	Concrete Fuse Gates, with a wet well intake
Maximum discharge capacity	244,000 cfs with the fuse gates tipped at 1642.68 feet, NGVD 29
Bridge deck elevation	1649.9 feet, NGVD 29, at the bridge centerline
Type of energy dissipater	None
Type of emergency closure	None
Spillway activation	The auxiliary spillway is activated when the pool rises above elevation 1638.0 feet, NGVD 29. Fusegate tipping begins when the pool elevation reaches elevation 1640.5 feet, NGVD 29.

Gate Tipping Elevations

Fusegate Number	Tipping Elevation (ft, NGVD 29)
F1 (E)	1640.50
F2 (D)	1640.72
F2 (F)	1640.72
F3 (C)	1641.02
F3 (G)	1641.03
F4 (B)	1641.47
F4 (H)	1641.51
F5 (A)	1642.15
F5 (I)	1642.12

## **7 - OUTLET FACILITIES**

### **a. SLUICE**

Location	Through base of two piers on either side of the center pier. The center pier has a third, plugged sluice gate.
Purpose	Low flow, water quality release, drawdown, and downstream water supply
Type of outlet and size	Rectangular Sluice
Type of gate	Cable hoisted, vertical-lift gates, operated from service deck
Number and size of gates	4 – 7 feet x 12 feet (two in each sluiceway)
Entrance invert elevation	1582.0 feet, NGVD 29
Discharge at pertinent elevation	Maximum pool (1642.68 ft) – 8132 cfs Top of flood control pool (1638.0 ft) – 7746 cfs Top of cons pool (1615.4 ft) – 5513 cfs Service Spillway Crest (1613.0 ft) – 5223 cfs Bottom of cons pool (1596.5 ft) – 2038 cfs
Minimum time required to open/close gates	Average time is 25 minutes from completely closed to completely opened positions.
Type of emergency closure and time required	Each sluiceway has 2 gates that are opened independently
Type of energy dissipater	Stilling Basin with 2 rows of baffles and a 10 foot high end sill

### **b. CONDUITS**

Location	Through base of center spillway piers, discharging through outermost sluiceways
Purpose	Low flow releases, draw down releases
Type of outlet and size	Two circular, 24 inch diameter valved concrete

	conduits
Entrance invert elevation	1583.0 feet, NGVD 29
Discharge at pertinent elevation	Maximum pool (1642.68 ft) – 135 cfs Top of flood control pool (1638.0 ft) – 129 cfs Top of conservation pool (1615.4 ft) – 98 cfs Service Spillway Crest (1613.0 ft) – 94 cfs Bottom of conservation pool (1596.5 ft) – 62 cfs
Type of energy dissipater	Stilling Basin with 2 rows of baffles and a 10 foot high end sill

**c. IRRIGATION OUTLET**  
**(INOPERABLE)**

Location	Right spillway approach wall 146' upstream from weir
Purpose	Water Supply (Irrigation)
Type of outlet and size	7'-6" x 8'-0" reinforced concrete conduit
Length	231 feet
Type and size of gates	Hydraulic slide gates, Two – 4 feet x 5 feet
Entrance invert elevation	1591 feet, NGVD 29

## **8 - CONTROL POINTS**

### **a. WATONGA GAGE**

Location	At river mile 361.2 on North Canadian River, 2.0 miles south of intersection of US 281 and State Highway 33, 33.1 miles downstream of Canton Dam, at the US 281 bridge; Lat 35 deg 48 min 43 sec, Lon 98 deg 25 min 14 sec.
Purpose of gage	Used by Corps of Engineers to regulate Canton Lake and determine benefits
Channel and floodplain description	The channel is well defined and straight downstream of the gage. The floodplain is broad, with cultivated crops and some rural development.
Uncontrolled drainage area	237 square miles
NWS flood stage	15.0 feet, 2100cfs (current rating curve)
USACE regulating stage	13.0 feet, 1247 cfs (current rating curve)
Time of crest travel	Canton Dam to Watonga Gage – 30 hours
Description of equipment	Water-stage recorder with telemeter
Zero of gage	Elevation 1,453.60 feet, NGVD 29
Maximum stage of record	19.70 feet, 19 August, 2007
Maximum flow of record	7,220 cfs, 19 August, 2007
Channel usage	Water supply, fishing, and fish spawning

### **b. EL RENO GAGE**

Location	At river mile 307.3 on North Canadian River, 2.0 miles north of courthouse in El Reno, 2.3 miles downstream from Target Creek, 87.0 miles downstream of Canton Dam, at the US 81 bridge; Lat 35 deg 33 min 47 sec, Lon 97 deg 57 min 26 sec.
----------	--

Purpose of gage	Used by Corps of Engineers to regulate Canton Lake and determine benefits
Channel and floodplain description	The channel is well defined and straight in the vicinity of the gage. The floodplain is broad, with cultivated crops and some development.
Uncontrolled drainage area	531 square miles
NWS flood stage	17.0 feet, 7650cfs (current rating curve)
USACE regulating stage	10.0 feet, 2316 cfs (current rating curve)
Time of crest travel	Canton Dam to El Reno Gage – 90 hours
Description of equipment	Water-stage recorder with telemeter; water quality measurements are also made here.
Zero of gage	Elevation 1,295.00 feet, NGVD 29
Maximum stage of record	23.33 feet, 20 August, 2007
Maximum flow of record	23,800 cfs, 20 August, 2007
Channel usage	Water supply, fishing, and fish spawning

**c. OKLAHOMA CITY GAGE**

Location	At river mile 281.0 on North Canadian River, 9.1 mi southwest of State Capital, 0.5 miles downstream from Lake Overholser, 2.4 miles upstream from Mustang Creek, 113.3 miles downstream of Canton Dam, at the NW 10 <sup>th</sup> St. bridge; Lat 35 deg 28 min 43 sec, Lon 97 deg 39 min 47 sec.
Purpose of gage	Used by Corps of Engineers to determine benefits
Channel and floodplain description	The channel is well defined and fairly straight in the vicinity of the gage. The left bank is high and developed, while the right bank provides a wooded floodplain, with some additional development.

Uncontrolled drainage area	707 square miles
Treatment of uncontrolled runoff	Contributes to flood control target flows
NWS flood stage	24.0 feet, 11500 cfs (current rating curve)
USACE regulating stage	23.0 feet, 10300 cfs (current rating curve)
Time of crest travel	Canton Dam to Oklahoma City Gage – 114 hours
Description of equipment	Water-stage recorder with telemeter; water quality measurements are also made here.
Zero of gage	Elevation 1,194.66 feet, NGVD 29
Maximum stage of record	29.85 feet, 20 May, 1987
Maximum flow of record	19,900 cfs, 21 August, 2007
Channel usage	Water supply, fishing, and fish spawning

**EXHIBIT B**

**STANDING INSTRUCTIONS TO LAKE MANAGER**

**CANTON LAKE**

EXHIBIT B  
 STANDING INSTRUCTIONS TO LAKE MANAGER  
 CANTON LAKE

TABLE OF CONTENTS

Section Title	Page
I - General .....	B-1
1. Operation .....	B-1
2. Data Reporting Instructions.....	B-1
3. Reporting Unusual Events.....	B-2
4. Warnings.....	B-2
5. Frequency of Gate Changes.....	B-3
II - Regulation Procedures .....	B-4
1. Regulating River Stages and Discharges.....	B-4
2. During Emergency Events.....	B-4

<b>Table</b>	<b>Title</b>	<b>Page</b>
B-1	Normal Flood Control Regulation Schedule Canton Lake	B-5
B-2	Emergency Flood Control Regulation Schedule Canton Lake	B-7

## I - GENERAL

1. **Operation.** The lake will be regulated in accordance with the normal regulations for flood control as directed in Section VII of this manual or Paragraph II-1.a. of this Exhibit. Instructions for the storage and discharge of floodwater will be issued by the Water Management Section. In the event communications with the Tulsa District Office are disrupted, the lake will be regulated in accordance with the schedule of emergency regulations for flood control (see Section VII of this manual, or Paragraph II of this Exhibit). In addition, the Lake Manager will immediately make every effort to reestablish communications with the Tulsa District Office.

2. **Data Reporting Instructions.** Hydrologic data items affecting release of water, confirmation of change in releases as instructed, complaints, operating machinery failure, or out-of-service times for maintenance shall be reported to the Water Management Section as they occur.

The following data should be included in the daily report to the Water Management Section (Hydrology-Hydraulics Branch, Tulsa District) from all flood control storage projects without hydropower. Data are typically reported by telephone, fax, or email. Data collected will be reviewed and input into the Water Management Section's database before 10 a.m., and published to the lake data morning report located at [http://www.swt-wc.usace.army.mil/old\\_resv rept.htm](http://www.swt-wc.usace.army.mil/old_resv rept.htm) by 10 a.m. See Plate 5-3 for lake data reporting details.

### a. **As of 8 a.m. Each Weekday**

- 1) Pool elevations at 12 noon, 4 p.m., and 12 midnight of the previous day and the current 8 a.m. pool elevation and tailwater elevation (if available)
- 2) The total precipitation amounts for the previous 24-hour period (7 a.m. to 7 a.m. time period).
- 3) The current wind direction and wind speed (Beaufort scale).
- 4) Water supply withdrawal or release for previous day (if available).
- 5) The discharge in daily average cfs for the previous 24 hour period (midnight to midnight).
- 6) The 8 a.m. instantaneous total discharge in cfs.
- 7) The current gate setting and any gate changes made during the past 24-hour period, including the time and pool elevation and tailwater elevation if necessary when the change was made.

Note: Except for lakes without personnel or if data collection is automated.

**b. As of 8 a.m. Each Monday.**

- 1) The same data from the weekend as required in paragraph B-I-2.a. above.
- 2) The current pool elevation readings from the pool gage, the recording chart or tape, the shaft encoder, or data logger, and the wire weight or staff gage. If wind or weather prevents readings on Monday, then these readings can be taken on the next day that weather permits.

**c. Weekends and Holidays.**

- 1) Daily reports are not required to be submitted on weekends and holidays except during flood periods.

**d. During Flood Periods.**

- 1) During flood periods, weekend and holiday reports should include the same data as required in paragraph B-I-2.a. above, as well as the 8 a.m. pool elevation from the pool gage.
- 2) In addition to the data in paragraphs B-I-2.a., B-I-2.b., and B-I-2.c. above, additional reports of lake elevations may be requested by Water Management Section personnel.

3. **Reporting Unusual Events.** Events or conditions not normally encountered in the routine operation of the dam and lake which might endanger the dam or necessitate temporary or permanent revision of the operating procedures such as settlement, movement, or cracking of the earth embankment or abutments; unusual change in seepage rates or development of new seepage areas; mechanical malfunction or failure; structural settlement, movement, cracking, or vibration; landslides, rockslides, or indications of an impending movement; or an occurrence indicating any degree of jeopardy to the safety of the dam or to the safety of the public shall be reported promptly to the Water Management Section, Hydrology-Hydraulics Branch.

4. **Warnings.** It is the responsibility of the Lake Manager to initiate a warning to the Tulsa District and local law enforcement agencies if emergency situations develop. He or she has the responsibility to properly recognize emergency situations and to seek assistance from supervisory offices, if time permits. They must be knowledgeable of conditions that constitute an emergency, such as a possible dam failure. The downstream population should be notified as early as possible of a potential problem. Initial notification by project personnel will include (listed by priority), Chief of Operations, Chief of Operations Technical Support, Chief of Engineering and Construction, Chief of Emergency Management, as set forth in the Operations and Maintenance Manual Volume II, Canton Lake, Flood Emergency Plan, dated Apr 2011. The Canton Lake project personnel have compiled a list of downstream contacts for use in emergency situations.

5. **Frequency of Gate Changes.** During flood periods, gate changes may be directed by the Water Management Section at any time. The initial transition to flood releases or vice versa may require gate changes every hour. When floodwater has significantly risen into the flood control pool, gate changes can be expected two or more times daily. Only under the most unusual circumstances will gate changes be ordered more frequently than once every hour. Frequency of gate changes during low-flow operation will generally be less than once a day.

## **II - REGULATION PROCEDURES**

1. **Regulating River Stages and Discharges.** The Regulation schedules provide that the channel capacity of 1000 cfs is not to be exceeded insofar as practicable. Floodwaters will be released as rapidly as practicable with consideration given to minimizing flooding of low-water crossing and low-lying farmland. Factors considered in the determination of releases are: maximum inflow into the reservoir during a rise, general climatic conditions, season of the year with respect to the probability of floods, status of crops in low-lying farmlands, and maximum non-damaging stages or discharges.

a. **Normal Regulation for Flood Control Operations.** Under normal procedures, instructions for storage and release of water for conservation and flood control will be issued by the Tulsa District, Water Management Section. The implementation of the instructions is to be confirmed back to the Water Management Section as soon as the required action is completed. Instructions originating from any other source should not be processed. The regulations as shown in Table B-1 will govern releases from Canton Lake. During flood control regulations, the service spillway gates are to be operated in a uniform setting with no more than a 1-foot difference in opening. Canton Lake will be regulated for optimal flood reductions on the North Canadian River from the dam downstream to its confluence with Lake Eufaula.

b. **Emergency Regulations for Flood Control.** Should communication with the Tulsa District Office be disrupted, the Lake Manager will, on his own initiative, direct regulation of the lake in accordance with the rules or regulation shown in Table B-2 until communication is restored. In addition, the Lake Manager will immediately make every effort to reestablish communication with the Tulsa District Office. The service spillway gates will be operated at a uniform opening.

2. **During Emergency Events.** The Lake Manager may temporarily deviate from the current release rates in the event an immediate short-term departure is deemed necessary for emergency reasons to protect the safety of the dam, or to avoid serious hazards to life. Such actions shall be immediately reported by the fastest means of communication available. Actions shall be confirmed in writing the same day to the Water Management Section and shall include justification for the action. Continuation of the deviation will require the express approval of the Water Management Section and Southwestern Division (SWD).

**TABLE B-1**

**NORMAL FLOOD CONTROL REGULATION SCHEDULE**  
**CANTON LAKE**

<b>Lake Stage</b>	<b>Pool Conditions</b>	<b>Regulation</b>
1615.4 – 1638.0 and forecasted <sup>(1)</sup> not to exceed 1638.0	Rising	Rates of releases will not exceed channel capacity downstream of the dam (currently estimated to be 1,000 cfs) and when combined with local inflow below the dam, will not produce stages in excess of flood stage at the Watonga and El Reno gages which are 13.0 feet (approx. 1,247 cfs) and 10.0 feet (approx. 2,316 cfs), respectively.
1638.0 – 1640.0 or forecast to exceed 1638.0	Rising	Release will be based on inflow forecasts and be made such that the pool elevation will not exceed elevation 1640.0 feet, if possible. Plate 7-1, Spillway Gate Regulation Schedule Inflow Parameter, will be used as a guide for determining releases. The uncontrolled discharge from the fusegates overspill start at elevation 1638.0 feet. A margin of not less than one-fourth foot (3 inches or more) between the lake level and the top of the service spillway gates shall be maintained at all times. <sup>(3)</sup> If the pool rises to elevation 1640.0, releases will be made equal to the inflow. Releases will be made by operating all the service spillway gates at uniform openings. <sup>(2)</sup>
1640.0 or above	Rising	Service spillway gates shall be opened to maintain elevation 1640.0 feet or until the gates are in the full opened position. The first fusegate tips at elevation 1640.50 feet. Plate 7-5 shows the tipping elevations and releases for all nine fusegates.
1640.0 or above	Falling	The maximum gate opening attained shall be held until the pool elevation recedes to elevation 1640.0 feet. Release will include any discharge from the fusegates (from overspill or tipped fusegates).
1640.0 – 1638.0	Falling	The maximum gate opening attained shall be held until the pool elevation recedes to elevation 1638.0 feet  OR until the pool level recedes an amount sufficient to permit lowering the service spillway gates one-half foot without lowering the discharge below inflow.  A margin of not less than one-fourth foot (3 inches or more) between the lake level and the top of the service spillway gates shall be maintained at all times. <sup>(3)</sup> Releases will be made by operating all the service spillway gates at uniform openings. Release will include any discharge from the fusegates (from overspill or tipped fusegates).

Lake Stage	Pool Conditions	Regulation
1638.0 – 1615.4	Falling	<p><b>a.</b> If the maximum releases rate was equal to or smaller than 1,000 cfs, releases will not exceed channel capacity downstream of the dam (currently estimated to be 1,000 cfs) and when combined with local inflow below the dam, will not produce stages in excess of flood stage at the Watonga and El Reno gages which are 13.0 feet (approx. 1,247 cfs) and 10.0 feet (approx. 2,316 cfs), respectively.</p> <p><b>b.</b> If the maximum release rate exceeded 1,000 cfs, the service spillway gates shall be gradually reduced until the release rate equals the previous 6-hour inflow or the channel capacity (currently estimated to be 1,000 cfs) and the downstream flood stages, whichever is greater. Any uncontrolled release from the fusegates will contribute to the total release rate and will have to be accounted for. This procedure shall be repeated every 2 hours.</p> <p>If the discharge from the fusegates is greater than the previous 6-hour inflow and the channel capacity, the service spillway gates shall be gradually lowered until the gates are all closed.</p>
1615.4 and Below	--	Releases are made through the tainter gates and sluice gates to meet water supply needs as discussed in paragraph 7-09. If any fusegates have tipped, fusegate discharge will continue until the pool elevation reaches 1606.0 feet, bottom of the fusegate weir.

(1) COE Forecasted inflows are based on observed rainfall and upstream gage data. Forecasted inflows are not based on predicted future rainfall

(2) After any gate change that results in releasing water greater than channel capacity, immediately notify the NWS's Arkansas-Red Basin River Forecast Center, District Emergency Management, and Hydrology & Hydraulics Branch upper management. Communications should be verbal/phone calls, followed by electronic means for the NWS.

(3) A ½ foot freeboard allows additional safety for rapidly rising pools and pool gage uncertainties, and may be used as a guide.

**TABLE B-2**  
**EMERGENCY FLOOD REGULATION SCHEDULE**  
**CANTON LAKE**

Lake Stage	Pool Conditions	Regulation
1615.4 – 1640.0	Rising	Maintain current releases until communication is restored. If, after 12 hours, communication has not been restored, or the pool is above or has risen to elevation 1633.5 feet at any time within the 12 hour period, releases will be made in accordance with Plate 7-1. Releases will be adjusted every two hours in accordance with Plate 7-1. At no time will releases be decreased while the pool is rising. A margin of not less than one-fourth foot (3 inches or more) between the lake level and the top of the service spillway gates shall be maintained at all times. <sup>(1)</sup> The uncontrolled discharge from the fusegates overspill starts at elevation 1638.0 feet.
1640.0 or above	Rising	Service spillway gates will be opened as necessary to maintain the pool at elevation 1640.0 feet or until all the gates are fully opened. The first fusegate tips at elevation 1640.50 feet. Plate 7-5 shows the tipping elevations and releases for all nine fusegates.
1640.0 or above	Falling	The maximum gate opening attained shall be held until the pool elevation recedes to elevation 1640.0. Release will include any discharge from the fusegates (from overspill or tipped fusegates).
1640.0 – 1638.0	Falling	The maximum gate opening attained shall be held until the pool elevation recedes to elevation 1638.0 feet. A margin of not less than one-fourth foot (3 inches or more) between the lake level and the top of the service spillway gates shall be maintained at all times. <sup>(1)</sup> Release will include any discharge from the fusegates (from overspill or tipped fusegates).
1638.0 – 1615.4	Falling	<p><b>a.</b> If the maximum releases rate was equal to or smaller than 1,000 cfs, releases will be maintained until the pool recedes to elevation 1615.4 feet.</p> <p><b>b.</b> If the maximum release rate exceeds 1,000 cfs, the service spillway gates shall be gradually reduced until the release rate equals the previous 6-hour inflow or the channel capacity (currently estimated to be 1,000 cfs) whichever is greater. Any uncontrolled release from the fusegates will contribute to the release rate. This regulation shall be repeated every 2 hours until the lake nears 1615.4 feet.</p> <p>If the discharge from the fusegates is greater than the previous 6-hour inflow and 1,000 cfs, the service spillway gates shall be gradually lowered until the gates are all closed.</p>
1615.4 and Below	--	Continue releases being made at time of communication failure. If any fusegates have tipped, the discharge will continue until the pool elevation reaches 1606.0 feet, bottom of the fusegate weir. At which point, all other gates should be or will remain closed until discharges from the fusegates have been cut off.

(1) A ½ foot freeboard allows additional safety for rapidly rising pools and pool gage uncertainties, and may be used as a guide.

**EXHIBIT C**

**WATER SUPPLY CONTRACT**

**CANTON LAKE**

WATER STORAGE CONTRACT  
 BETWEEN THE UNITED STATES OF AMERICA  
 AND  
 THE OKLAHOMA CITY WATER UTILITIES TRUST  
 AND  
 THE CITY OF OKLAHOMA CITY  
 FOR  
 WATER STORAGE SPACE IN CANTON RESERVOIR

THIS CONTRACT, entered into this 23 day of September, 19 91 by and between THE UNITED STATES OF AMERICA (hereinafter called the "Government") represented by the Contracting Officer executing this contract, and THE OKLAHOMA CITY WATER UTILITIES TRUST (hereinafter called the "User") formerly known as the Oklahoma City Municipal Improvement Authority; and The City of Oklahoma City.

WITNESSETH THAT:

WHEREAS, An Act of Congress, approved 28 June 1938 (Public Law 761, 75th Congress, 3d Session), as amended by the Act of Congress approved 24 July 1946 (Public Law 526, 79th Congress, 3d Session), and the Act of Congress approved 30 June 1948 (Public Law 858, 80th Congress, 2d Session), authorized the construction, operation, and maintenance of the Canton Dam and Reservoir on the North Canadian River, Oklahoma, (hereinafter called the "Project"); and

WHEREAS, the Water Resources Development Act of 1990 (Public Law 101-460), directed the Secretary of the Army, subject to agreement between the city of Oklahoma City and the city of Enid, Oklahoma, to reassign to the city of Oklahoma City all the municipal and industrial storage in Canton Lake for the city of Enid and all irrigation storage to municipal and industrial storage under the terms of the Water Supply Act of 1958 (72 Stat. 319-320); and

WHEREAS, the cities of Oklahoma City and Enid, Oklahoma reached agreement on the reassignment of the municipal and industrial storage in Canton Lake on April 17, 1990, a copy of said agreement appearing as Exhibit E; and

WHEREAS, the User desires to contract with the Government for the use of the reassigned storage in the project for municipal and industrial water supply; and

WHEREAS, the User is empowered to contract with the Government and is vested with all necessary powers of accomplishment of the purposes of this contract;

NOW THEREFORE, the Government and the User agree as follows:

**ARTICLE 1 - Water Storage Space.**

a. **Project Construction.** The Government, subject to the directions of Federal law and any limitations imposed thereby, has designed and constructed the Project so as to include therein space for the storage of water by the User.

b. **Rights of User.**

(1) The User shall have the right to utilize an undivided 100.00 percent (estimated to contain 90,000 acre-feet after adjustment for sediment deposits) of the usable storage space in the Project between elevations 1615.4 feet National Geodetic Vertical Datum and 1596.5 feet National Geodetic Vertical Datum, which usable conservation storage space is estimated to contain 90,000 acre-feet after adjustment for sediment deposits. This storage space is to be used to impound water for present demand or need for municipal and industrial water supply.

(2) The User shall have the right to withdraw water from the lake, or to order releases to be made by the Government through the outlet works in the Dam, subject to the provisions of Article 1c and to the extent the aforesaid storage space will provide; and shall have the right to construct all such works, plants, pipelines, and appurtenances as may be necessary and convenient for the purpose of diversion or withdrawals, subject to the approval of the Contracting Officer as to design and location. The grant of an easement for right-of-way, across, in and upon land of the Government at the Project shall be by a separate instrument in a form satisfactory to the Secretary of the Army, without additional cost to the User, under the authority of and in accordance with the provisions of 10 U.S.C. 2669 and such other authorities as may be necessary. Subject to the conditions of such easement, the User shall have the right to use so much of the Project land as may reasonably be required in the exercise of the rights and privileges granted under this contract.

c. **Rights Reserved.** The Government reserves the right to control and use all storage in this Project in accordance with authorized Project purposes. The Government further reserves the right to take such measures as may be necessary in the operation of the Project to preserve life and/or

property, including the right not to make downstream releases during such periods of time as are deemed necessary, in its sole discretion, to inspect, maintain, or repair the Project.

d. Quality or Availability of Water. The User recognizes that this contract provides storage space for raw water only. The Government makes no representations with respect to the quality or availability of water and assumes no responsibility therefor, or for the treatment of the water.

e. Sedimentation Surveys.

(1) Sedimentation surveys will be made by the Contracting Officer during the term of this contract at intervals not to exceed fifteen (15) years unless the Contracting Officer determines that such surveys are unnecessary. When, in the opinion of the Contracting Officer, the findings of such survey indicate any Project purpose will be affected by unanticipated sedimentation distribution, there shall be an equitable redistribution of the sediment reserve storage space among the purposes served by the Project including municipal and industrial water supply. The total available remaining storage space in the Project will then be divided among the various Project features in the same ratio as was initially utilized. Adjusted pool elevations will be rounded to the nearest one-half foot. Such findings and the storage space allocated to municipal and industrial water supply shall be defined and described as an exhibit which will be made a part of this contract and the reservoir regulation manual will be modified accordingly.

(2) The Government assumes no responsibility for deviations from estimated rates of sedimentation, or the distribution thereof. Such deviations may cause unequal distribution of sediment reserve storage greater than estimated, and/or encroachment on the total storage at the Project.

ARTICLE 2 - Regulation of and Right to Use of Water. The regulation of the use of water withdrawn or released from the aforesaid storage space shall be the sole responsibility of the User. The User has the full responsibility to acquire in accordance with State laws and regulations, and, if necessary, to establish or defend, any and all water rights needed for utilization of the storage provided under this contract. The Government shall not be responsible for diversions by others, nor will it become a party to any controversies involving the use of the storage space by the User except as such controversies may affect the operations of the Project by the Government.

ARTICLE 3 - Operation and Maintenance. The Government shall operate and maintain the Project and the User shall pay to the Government a share of the costs of such operation and maintenance as provided in Article 5. The User shall be responsible for operation and maintenance of all installations and facilities which it may construct for the diversion or withdrawal of water, and shall bear all costs of construction, operation and maintenance of such installations and facilities.

ARTICLE 4 - Measurement of Withdrawals and Releases. The User agrees to furnish and install, without cost to the Government, suitable meters or measuring devices satisfactory to the Contracting Officer for the measurement of water which is withdrawn from the Project by any means other than through the Project outlet works. The User shall furnish to the Government monthly statements of all such withdrawals. Prior to the construction of any facilities for withdrawal of water from the Project, the User will obtain the Contracting Officer's approval of the design, location and installation of the facilities including the meters or measuring devices. Such devices shall be available for inspection by Government representatives at all reasonable times. Releases from the water supply storage space through the Project outlet works shall be made in accordance with written schedules furnished by the User and approved by the Contracting Officer and shall be subject to Article 1c. The measure of all such releases shall be by means of a rating curve of the outlet works, or by such other suitable means as may be agreed upon prior to use of the water supply storage space.

ARTICLE 5 - Payments. In consideration of the right to utilize the aforesaid storage space in the Project for municipal and industrial water supply purposes, the User shall pay the following sums to the Government:

a. Project Investment Costs.

(1) The User shall repay to the Government in a lump sum payment, \$1,419,954 which, as shown in Exhibit "B" attached to and made a part of this contract, constitutes the entire actual amount of investment costs, including interest during construction allocated to the water storage right acquired by the User under this contract.

(2) The lump sum payment shall be paid within 30 days of the approval of the contract by the Secretary of the Army or his duly authorized representative.

b. Major Replacement Cost. The User will be required to pay 25.500 percent of the cost of joint-use major replacement items. Payment of costs, may be paid incrementally during construction or in a lump sum, including interest during construction, upon completion of construction.

c. Annual Operation and Maintenance (O&M Expense). The User will be required to pay 25.500 percent of the annual experienced joint-use O&M expense of the Project. The amount of each annual payment shall be based on the actual experienced O&M expenses (allocated joint-use) for the Project in the Government fiscal year most recently ended, or an estimate thereof when the actual expense information is not available. The first payment will be due with the lump sum payment and annual payments for each subsequent year will be due on the anniversary date of the contract approval.

d. Major Rehabilitation Program Costs. For costs associated with the major rehabilitation program, the percentages of joint-use costs which the User will be required to pay will be in accordance with Article 5c. Payments for the costs associated with the program may be paid incrementally during construction or in a lump sum, including interest during construction, upon completion of construction.

e. Delinquent Payments. If the User shall fail to make any of the aforesaid payments when due, then the overdue payments shall bear interest compounded annually until paid. The interest rate to be used for overdue payments due under the provisions of Articles 5a, 5b, 5c, and 5d above shall be that determined by the Department of Treasury's Treasury Fiscal Requirements Manual (1 TFRM 6-8000, "Cash Management"). The amount charged on payments overdue for a period of less than one year shall be figured on a monthly basis. For example, if the payment is made within the first month after being overdue after a 15-day grace period from the anniversary date of the date of notification, one month's interest shall be charged. Thereafter a month's interest will be charged for any portion of each succeeding month that the payment is delinquent. This provision shall not be construed as giving the User a choice of either making payments when due or paying interest, nor shall it be construed as waiving any other rights of the Government, at law or in equity, which might result from any default by the User.

**ARTICLE 6 - Adjustment to Project Investment Cost.** The investment cost shown in this contract and the exhibit is based on actual final construction costs of the Project. Any further investment cost accruing to the User's water storage right shall be repaid under major replacement costs if capitalized or under operation and maintenance expense if not capitalized.

**ARTICLE 7 - Duration of Contract.** This contract shall become effective when approved by the Secretary of the Army or his duly authorized representative and shall continue in full force and effect for the life of the Project.

**ARTICLE 8 - Permanent Rights to Storage.** Upon completion of payments by the User, as provided in Article 5a herein, the User shall have a permanent right, under the provisions of the Act of 16 October 1963 (Public Law 88-140, 43 U.S.C. 390e), to the use of the water supply storage space in the Project as provided in Article 1, subject to the following:

- a. The User shall continue payment of annual operation and maintenance costs allocated to water supply.
- b. The User shall bear the costs allocated to water supply of any necessary reconstruction, rehabilitation, or replacement of Project features which may be required to continue satisfactory operation of the Project. Such costs will be established by the Contracting Officer and repayment arrangements shall be in writing in accordance with the terms and conditions set forth in Article 5b for Major Replacement Costs, and be made a part of this contract.
- c. When the expected life of the Project has elapsed, the Contracting Officer shall redetermine the storage space for municipal and industrial water supply in accordance with the provisions of Article 1e. Such redetermination of reservoir storage capacity may be further adjusted from time to time as the result of sedimentation resurveys to reflect actual rates of sedimentation and the exhibit revised to show the revised storage space allocated to municipal and industrial water supply.
- d. The permanent rights of the User under this contract shall be continued so long as the Government continues to operate the Project. In the event the Government no longer operates the Project, such rights may be continued subject to the execution of a separate contract, or additional supplemental agreement providing for:
  - (1) Continued operation by the User of such part of the facility as is necessary for utilization of the water supply storage space allocated to it;

- (2) Terms which will protect the public interest; and,
- (3) Effective absolvment of the Government by the User from all liability in connection with such continued operation.

ARTICLE 9 - Release of Claims. The User shall hold and save the Government, including its officers, agents and employees harmless from liability of any nature or kind for or on account of any claim for damages which may be filed or asserted as a result of the storage in the Project, or withdrawal or release of water from the Project, made or ordered by the User or as a result of the construction, operation, or maintenance of the water supply facilities and appurtenances thereto owned and operated by the User except for damages due to the fault or negligence of the Government or its contractors.

ARTICLE 10 - Assignment. The User shall not transfer or assign this contract nor any rights acquired thereunder, nor suballot said water supply storage space or any part thereof, nor grant any interest, privilege or license whatsoever in connection with this contract, without the approval of the Secretary of the Army, or his duly authorized representative provided that, unless contrary to the public interest, this restriction shall not be construed to apply to any water that may be obtained from the water supply storage space by the User and furnished to any third party or parties, nor any method of allocation thereof.

ARTICLE 11 - Officials Not to Benefit. No member of or delegate to Congress, or Resident Commissioner, shall be admitted to any share or part of this contract, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this contract if made with a corporation for its general benefit.

ARTICLE 12 - Covenant Against Contingent Fees. The User warrants that no person or selling agency has been employed or retained to solicit or secure this contract upon an agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees or bona fide established commercial or selling agencies maintained by the User for the purpose of securing business. For breach or violation of this warranty the Government shall have the right to annul this contract without liability or in its discretion to add to the contract price or consideration, or otherwise recover the full amount of such commission, percentage, brokerage, or contingent fee.

ARTICLE 13 - Environmental Quality. During any construction, operation, and maintenance by User of any facilities, specific actions will be taken to control environmental pollution which

could result from such activity and to comply with applicable Federal, State, and local laws and regulations concerning environmental pollution. Particular attention should be given to:

- a. Reduction of air pollution by control of burning, minimization of dust, containment of chemical vapors, and control of engine exhaust gases, and of smoke from temporary heaters;
- b. Reduction of water pollution by control of sanitary facilities, storage of fuels and other contaminants, and control of turbidity and siltation from erosion;
- c. Minimization of noise levels;
- d. On-site and off-site disposal of waste and spoil; and,
- e. Prevention of landscape defacement and damage.

ARTICLE 14 - Federal and State Laws.

- a. In acting under its rights and obligations hereunder, the User agrees to comply with all applicable Federal and State laws and regulations, including but not limited to the provisions of the Davis-Bacon Act (40 U.S.C. 276a et seq.); the Contract Work Hours and Safety Standards Act (40 U.S.C. 327-333); Title 29, Code of Federal Regulations, Part 3; and Sections 210 and 305 of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (PL 91-646).
- b. The User furnishes, as part of this contract, an assurance (Exhibit C) that it will comply with Title VI of the Civil Rights Act of 1964 (78 Stat. 241, 42 U.S.C. 2000d, et seq.) and Department of Defense Directive 5500.11 issued pursuant thereto and published in Part 300 of Title 32, Code of Federal Regulations.
- c. Any discharges of water or pollutants into a navigable stream or tributary thereof resulting from the User's facilities and operations undertaken under this contract shall be performed only in accordance with applicable Federal, State, and local laws and regulations.
- d. The User furnishes, as part of this contract, a certification (Exhibit D, and, if applicable, a Disclosure of Lobbying Activities) that it will comply with Title 31, U.S.C., Section 1352 of the Limitation on use of appropriated funds to influence certain Federal contracting and financial transactions (Public Law 101-121, October 23, 1989) and Federal Acquisition Regulation 52.203-12 issued pursuant thereto.

ARTICLE 15 - Definitions.

- a. Project investment costs. The initial cost of the Project, including: land acquisition; construction; interest during construction on the value of land, labor, and materials used for planning and construction of the Project.
- b. Interest during construction. An amount of interest which accrues on expenditures for the establishment of Project services during the period between the actual outlay and the time the Project is first made available for water storage.
- c. Joint-Use costs. The costs of features used for any two or more Project purposes.
- d. Annual operation and maintenance (O&M) expense. Annual expenses funded under the O&M, General account. These expenses include the daily Project O&M costs as well as those O&M costs which are not capitalized.
- e. Major replacement cost. Costs funded under the Operation and Maintenance, General, or Construction, General accounts but not associated with initial Project investment costs.
- f. Fiscal Year. Refers to the Government's fiscal year. This year begins on 1 October and ends on 30 September. The September calendar year corresponds to the fiscal year.
- g. Life of the Project. This is the physical life of the Project.
- h. Major Rehabilitation. This program is to facilitate accomplishment of significant, costly infrequent rehabilitation work at the Project without unduly distorting the Operation and Maintenance General budget.

ARTICLE 16 - Approval of Contract. This contract shall be subject to the written approval of the Secretary of the Army or his duly authorized representative and shall not be binding until so approved.

IN WITNESS WHEREOF, the parties have executed this contract as of the day and year first above written.

APPROVED:

THE UNITED STATES OF AMERICA

THE OKLAHOMA CITY WATER UTILITIES TRUST

By Nancy P. Don  
Assistant Secretary of the Army  
(Civil Works)

By Jack W. Cornett  
Chairman

DATE: 25 Nov 91

DATE: July 16, 1991

By F. L. Smith, Jr.  
F. L. Smith, Jr.  
Colonel, U.S. Army  
District Engineer  
Contracting Officer

THE CITY OF OKLAHOMA CITY  
By Ronald J. Nail  
Mayor

DATE: 23 September 1991

DATE: August 13, 1991  
(Seal)

STATE OF OKLAHOMA )  
                          ) SS:  
OKLAHOMA COUNTY )

The foregoing instrument was acknowledged before me this 16 day of July, 1991 by Jack W. Cornett, Chairman of the Oklahoma City Water Utilities Trust, a public trust, on behalf of the trust.

Thomas P. Hurley  
Thomas P. Hurley, Secretary

TECHNICAL REVIEW  
By Richard P. O'Neil

Reviewed for Legal Sufficiency  
K. Hoover

EXHIBIT B

<u>I - RESERVOIR STORAGE</u>			
<u>Feature</u>	<u>Elevation (ft NGVD)</u>	<u>Usable Storage (1) (ac ft)</u>	<u>Percent of Conservation Storage</u>
Flood Control	1615.4 - 1638.0	263,000	
Conservation	1596.5 - 1615.4	90,000 (2)	100.000
Water Supply		90,000	100.000
The Oklahoma City Water Utilities Trust		<u>90,000</u>	<u>100.000</u>
<b>TOTAL</b>		<b>353,000</b>	<b>100.000</b>

(1) Projected year 2000 storage based on 1977 sedimentation survey.  
 (2) 38,000 acre-feet M&I plus 52,000 acre-feet Agricultural water supply.

<u>II - PROJECT ACTUAL COST</u>		\$
Project first cost, exclusive of recreation		10,370,108
Interest during construction		<u>639,170</u>
<b>TOTAL - Project Investment Cost</b>		<b>11,009,278</b>

III - COSTS TO BE REPAID BY THE USER FOR WATER SUPPLY STORAGE SPACE  
STORAGE SPACE

	\$
Cost of 90,000 acre-feet of M&I and agricultural water supply storage	1,185,128 + 1,621,756 = 2,806,884
Credit for principal payments less O&MRR and interest	= - 1,488,316
<b>TOTAL STORAGE INVESTMENT COST</b>	<b>= 1,318,568</b>
Interest compounded annually at 2.50 percent from 30 June 1988, to date of 25 Nov 1991 the date of contract approval	= <u>119,025</u>
<b>TOTAL LUM SUM TO BE REPAID BY USER</b>	<b>1,437,593</b>

Revised 12 Dec 1991

EXHIBIT B (Continued)

<u>IV - ANNUAL COST TO USER FOR USE OF STORAGE SPACE</u>	
Operation and Maintenance (2)	\$
Storage	
Joint-use (3)	
25.500% (4) x 823,596 (FY 91)	= 210,017
Major Rehabilitation (5)	
Storage	
Joint-use (3)	
25.500% x 0 = 0 (FY 91)	= 0
Major Replacement (6)	
Storage	
Joint-use (3)	
26.000% x 0 = 0 (FY 91)	= 0
<b>TOTAL ANNUAL COSTS</b>	<b>= 210,017</b>

- 
- (2) The first payment shall be due and payable on the date specified in Article 5a(2).
  - (3) Excludes annual charges for recreation.
  - (4) Percent of Project joint-use operation and maintenance cost allocated to water supply.
  - (5) Major rehabilitation and major replacement cost are payable only when incurred.
  - (6) Percent of Project joint-use major replacement cost allocated to water supply.
- 

Revised 12 Dec 1997



US Army Corps of Engineers  
Tulsa District



**U.S. Representative**

**KANSAS**  
1 Tim Huelskamp (R)  
2 Lynn Jenkins (R)  
4 Mike Pompeo (R)

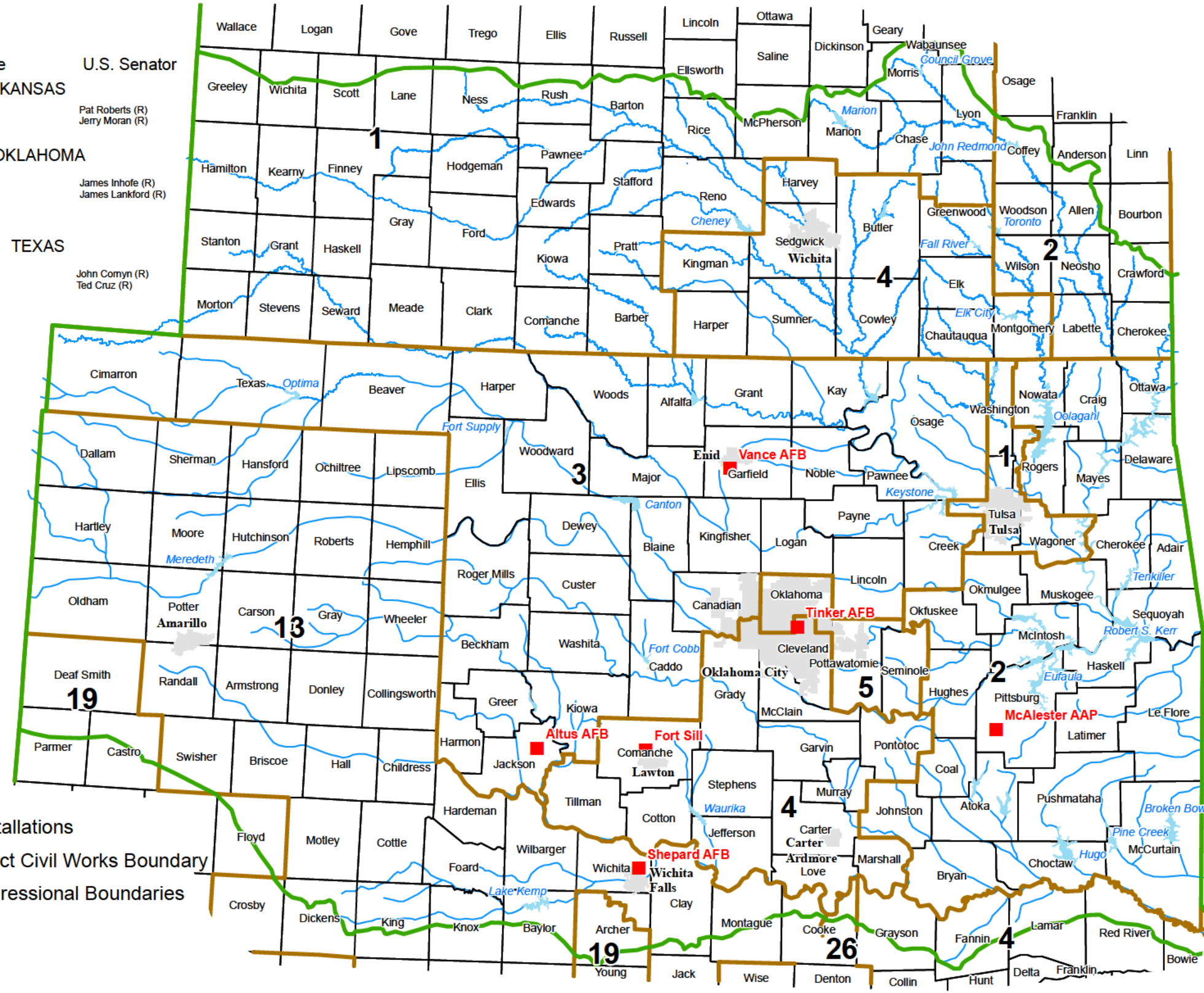
**OKLAHOMA**  
1 Jim Bridenstine (R)  
2 Markwayne Mullin (R)  
3 Frank Lucas (R)  
4 Tom Cole (R)  
5 Steve Russell (R)

**TEXAS**  
4 John Ratcliffe (R)  
13 Mac Thornberry (R)  
19 Randy Neugebauer (R)  
26 Michael Burgess (R)

**U.S. Senator**  
**KANSAS**  
Pat Roberts (R)  
Jerry Moran (R)

**OKLAHOMA**  
James Inhofe (R)  
James Lankford (R)

**TEXAS**  
John Cornyn (R)  
Ted Cruz (R)



- Military Installations
- Tulsa District Civil Works Boundary
- 111th Congressional Boundaries
- Lakes

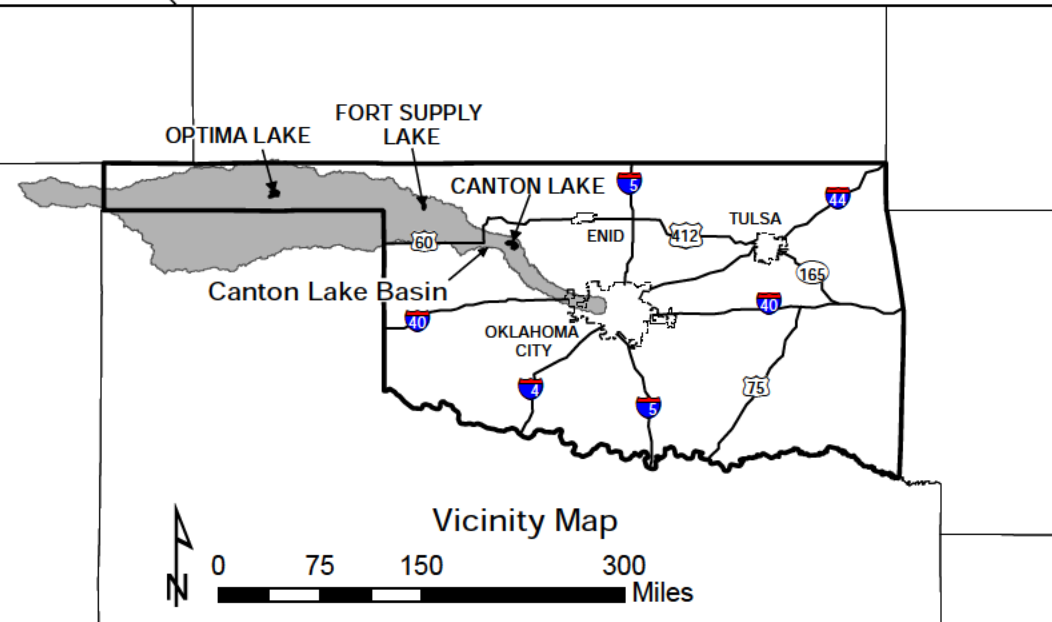
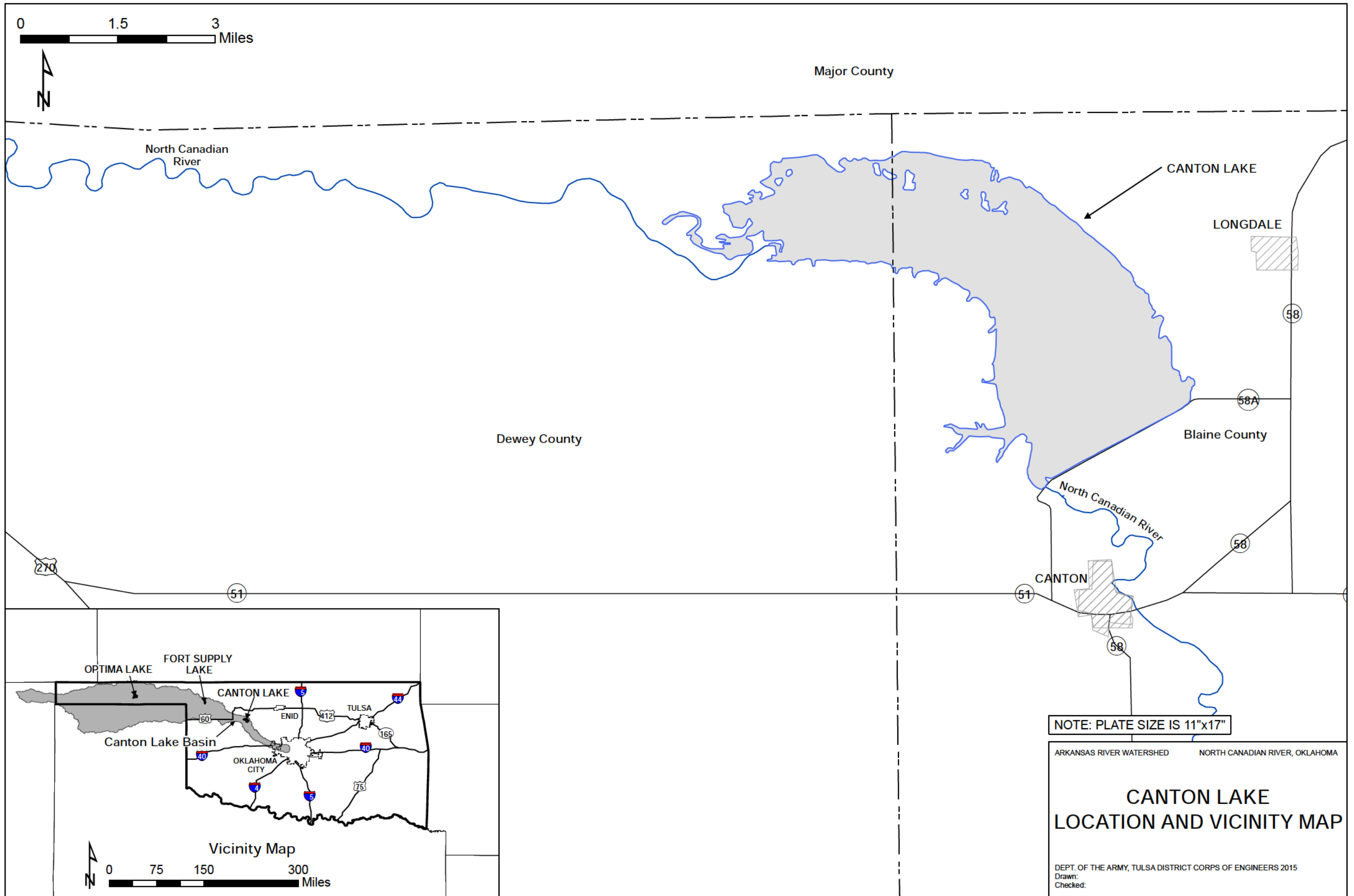
NOTE: PLATE SIZE IS 11"x17"

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**

**TULSA DISTRICT PROJECTS**

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 2015  
Drawn:  
Checked:



NOTE: PLATE SIZE IS 11"x17"

ARKANSAS RIVER WATERSHED      NORTH CANADIAN RIVER, OKLAHOMA

### CANTON LAKE LOCATION AND VICINITY MAP

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:

(b) (7)(F)

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

## CANTON LAKE

### GENERAL PLAN AND EMBANKMENT SECTION

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
DRAWN:  
CHECKED:

(b) (7)(F)

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

## CANTON LAKE

### SPILLWAY AND STILLING BASIN SECTION AND PLAN

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
DRAWN:  
CHECKED:

(b) (7)(F)

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

## CANTON LAKE

### AUXILIARY SPILLWAY SECTION AND PLAN

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
DRAWN:  
CHECKED:

(b) (7)(F)

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**

**AUXILIARY SPILLWAY  
ISOMETRIC VIEW**

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
DRAWN:  
CHECKED:

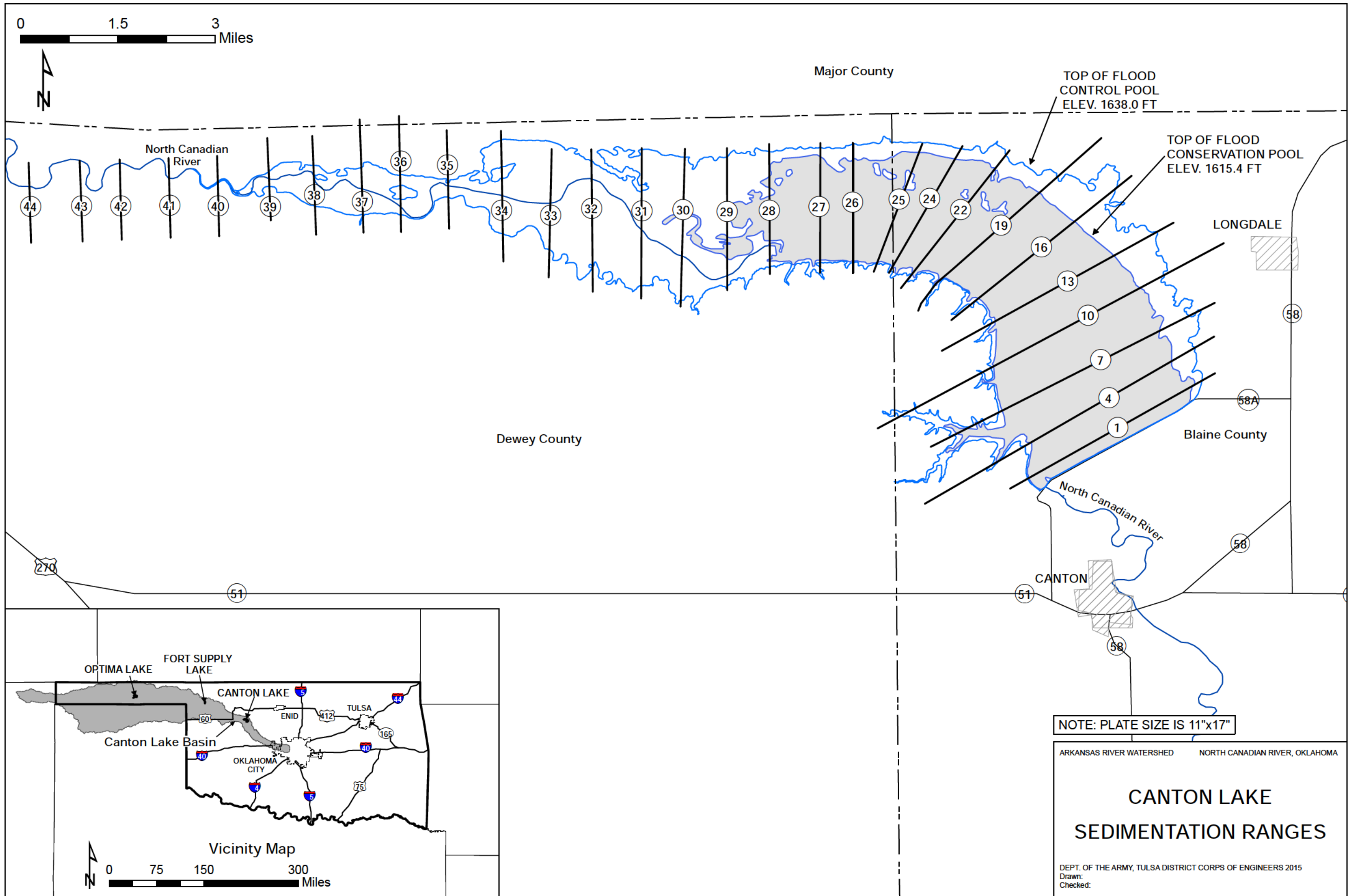
(b) (7)(F)

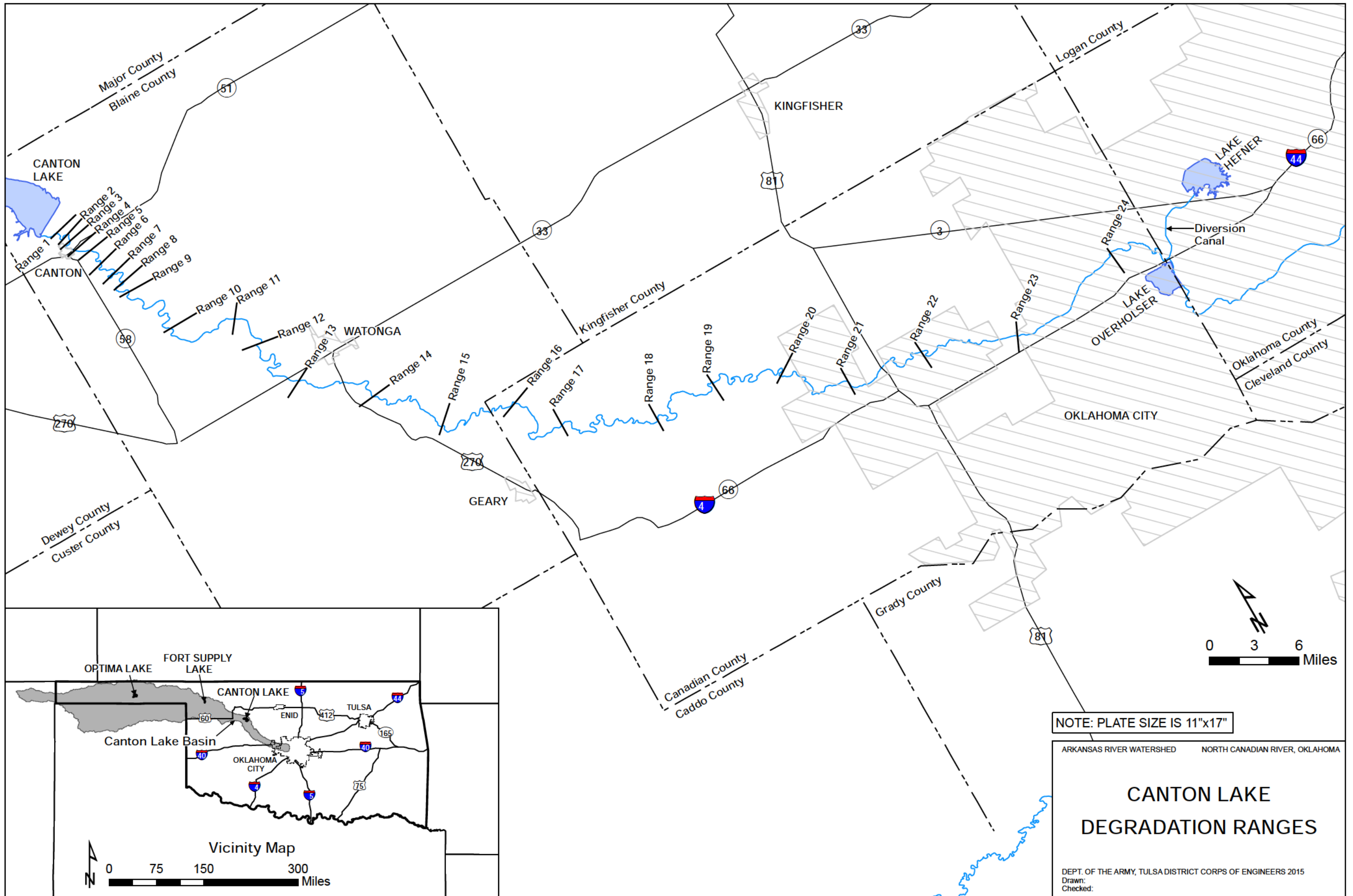
ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

## CANTON LAKE

## OUTLET WORKS

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
DRAWN:  
CHECKED:



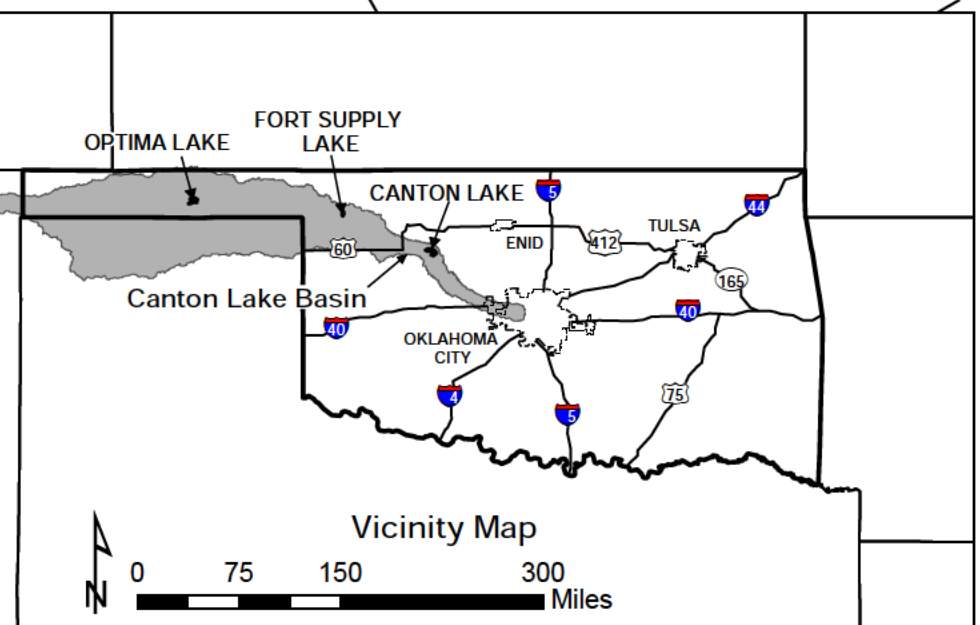


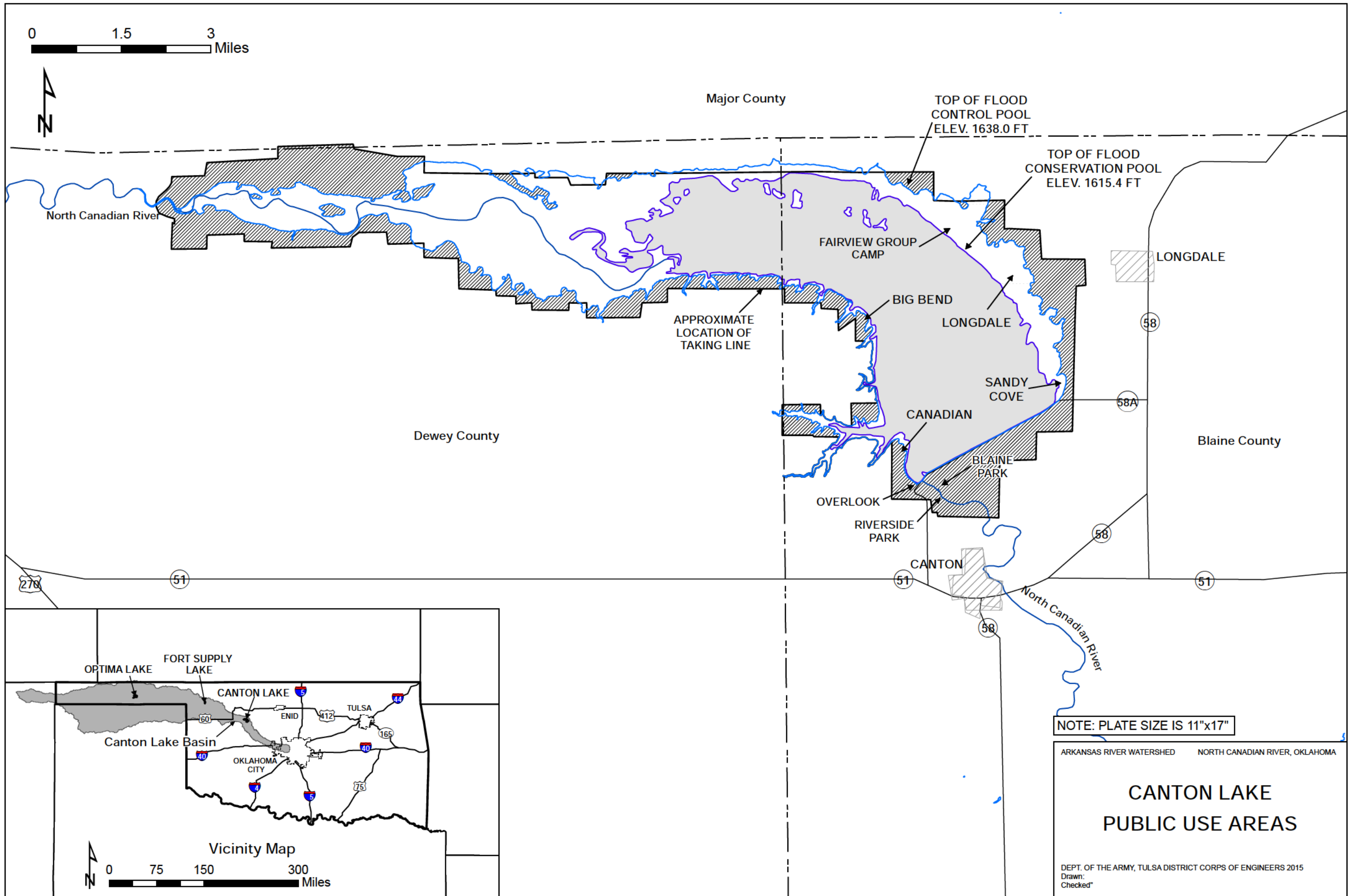
NOTE: PLATE SIZE IS 11"x17"

ARKANSAS RIVER WATERSHED    NORTH CANADIAN RIVER, OKLAHOMA

## CANTON LAKE DEGRADATION RANGES

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:



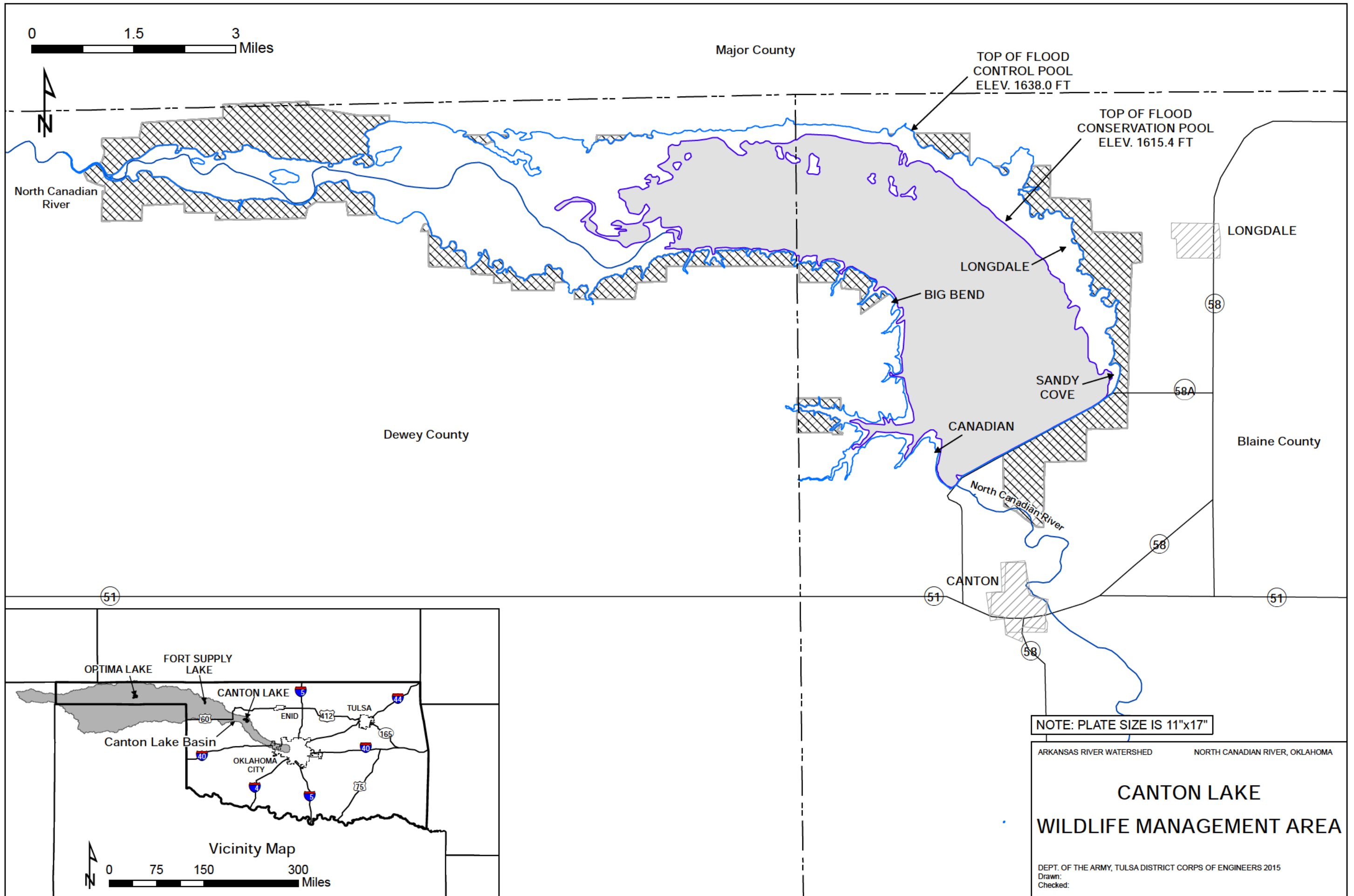


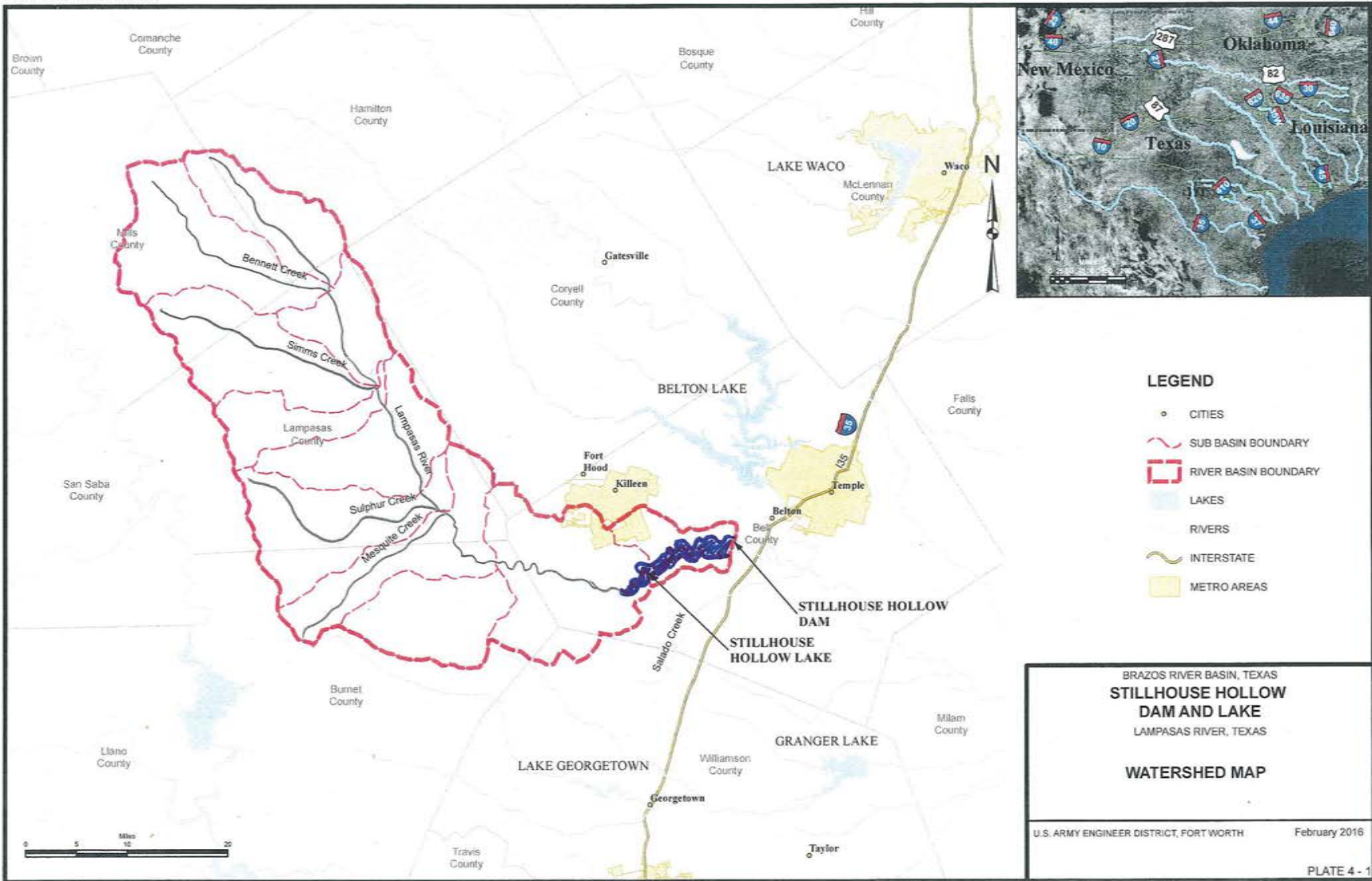
NOTE: PLATE SIZE IS 11"x17"

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

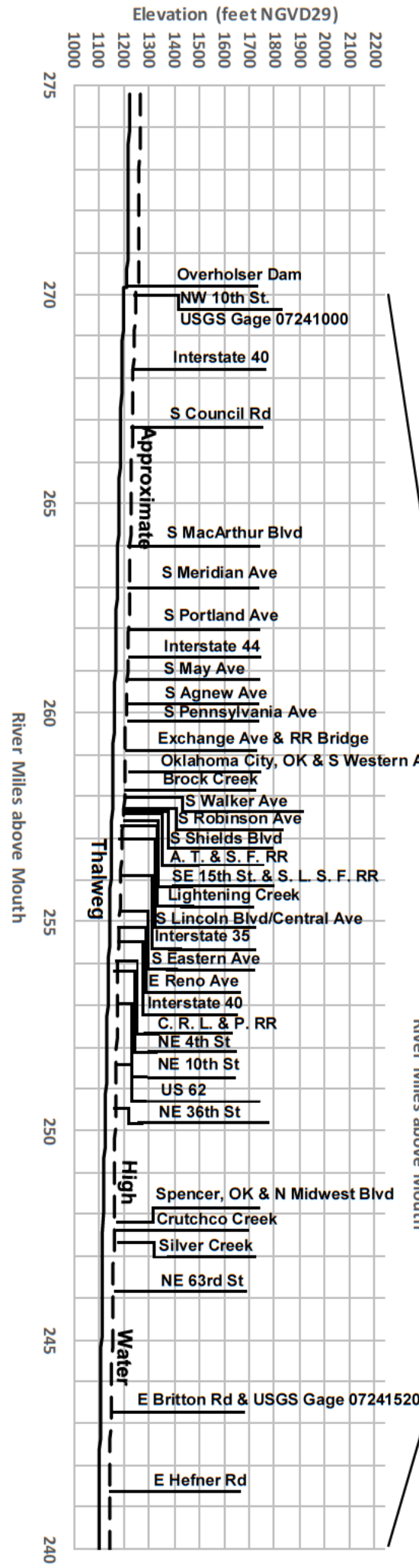
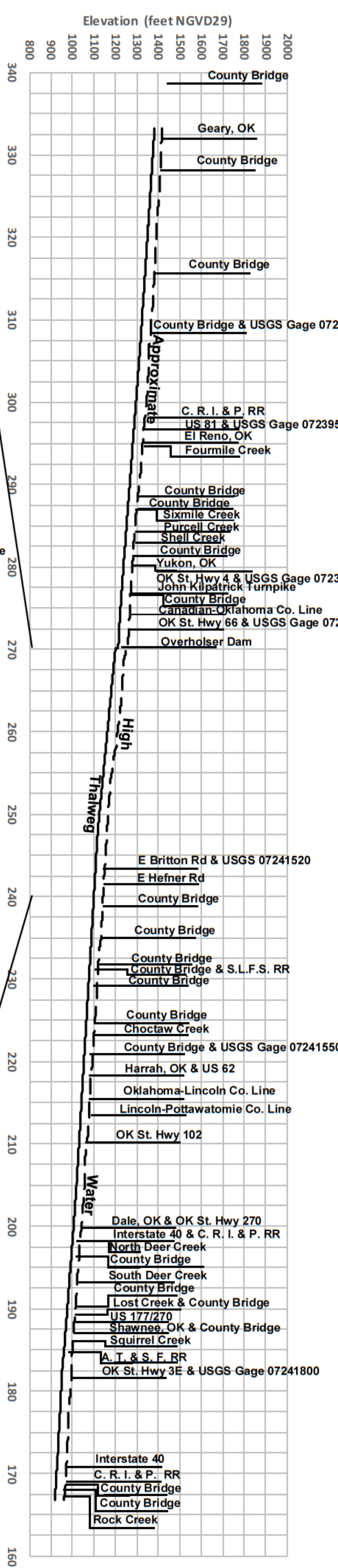
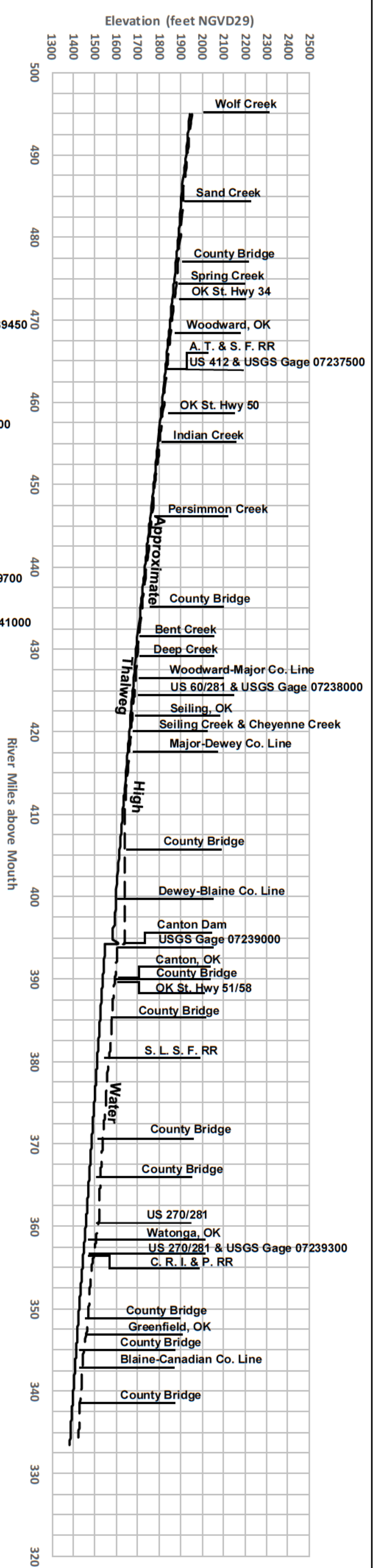
### CANTON LAKE PUBLIC USE AREAS

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 2015  
Drawn:  
Checked\*





This is a Placeholder Plate. It should not be used for reference.



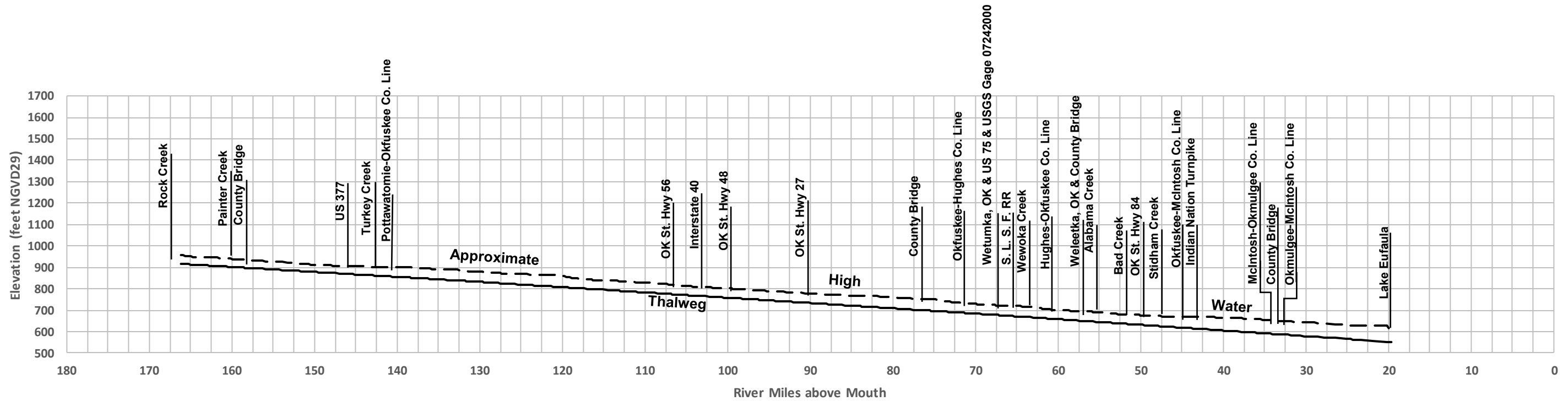
NOTE: PLATE SIZE IS 11" X 17"

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

### CANTON LAKE

## NORTH CANADIAN RIVER PROFILES

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:



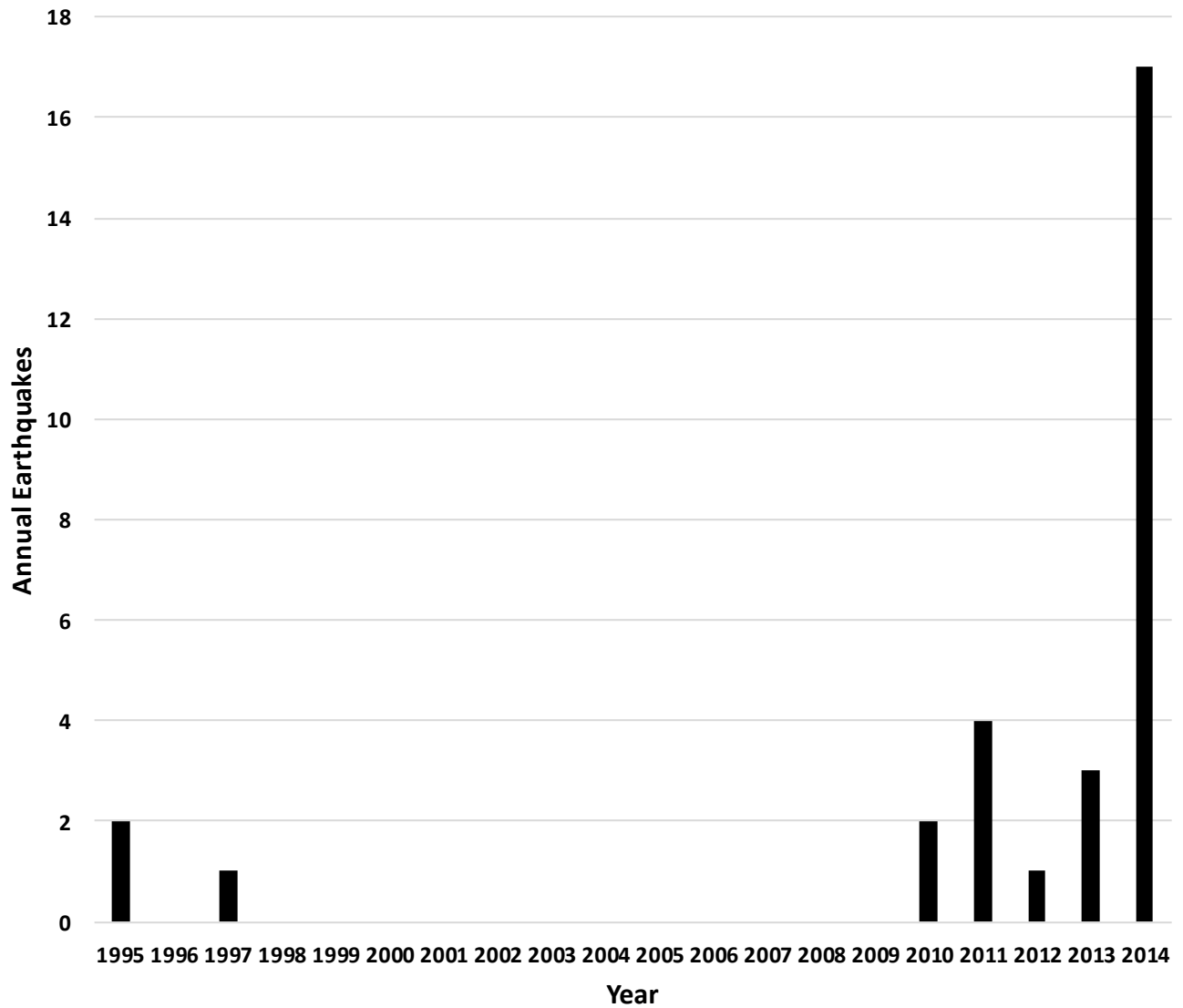
NOTE: PLATE SIZE IS 11" X 17"

ARKANSAS RIVER WATERSHED    NORTH CANADIAN RIVER, OKLAHOMA

# CANTON LAKE

## NORTH CANADIAN RIVER PROFILES

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:



NOTES:

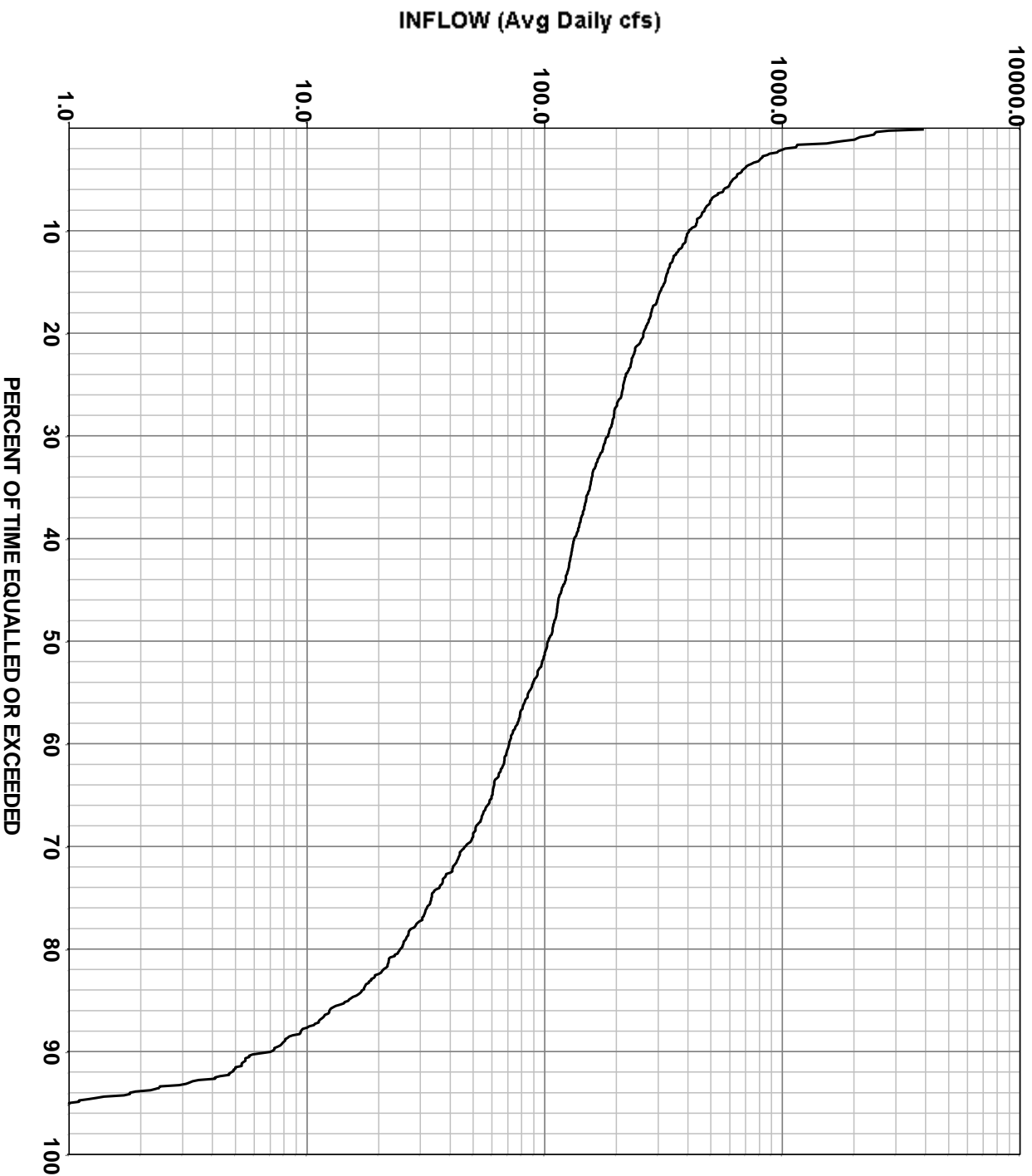
Based on period of record  
from 1995 to 2015;  
Data from USGS

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**

**ANNUAL EARTHQUAKES OF M4  
MAGNITUDE OR GREATER  
EPICENTERS WITHIN 200 MILES OF CANTON  
DAM**

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
Drawn:  
Checked:



**NOTES:**

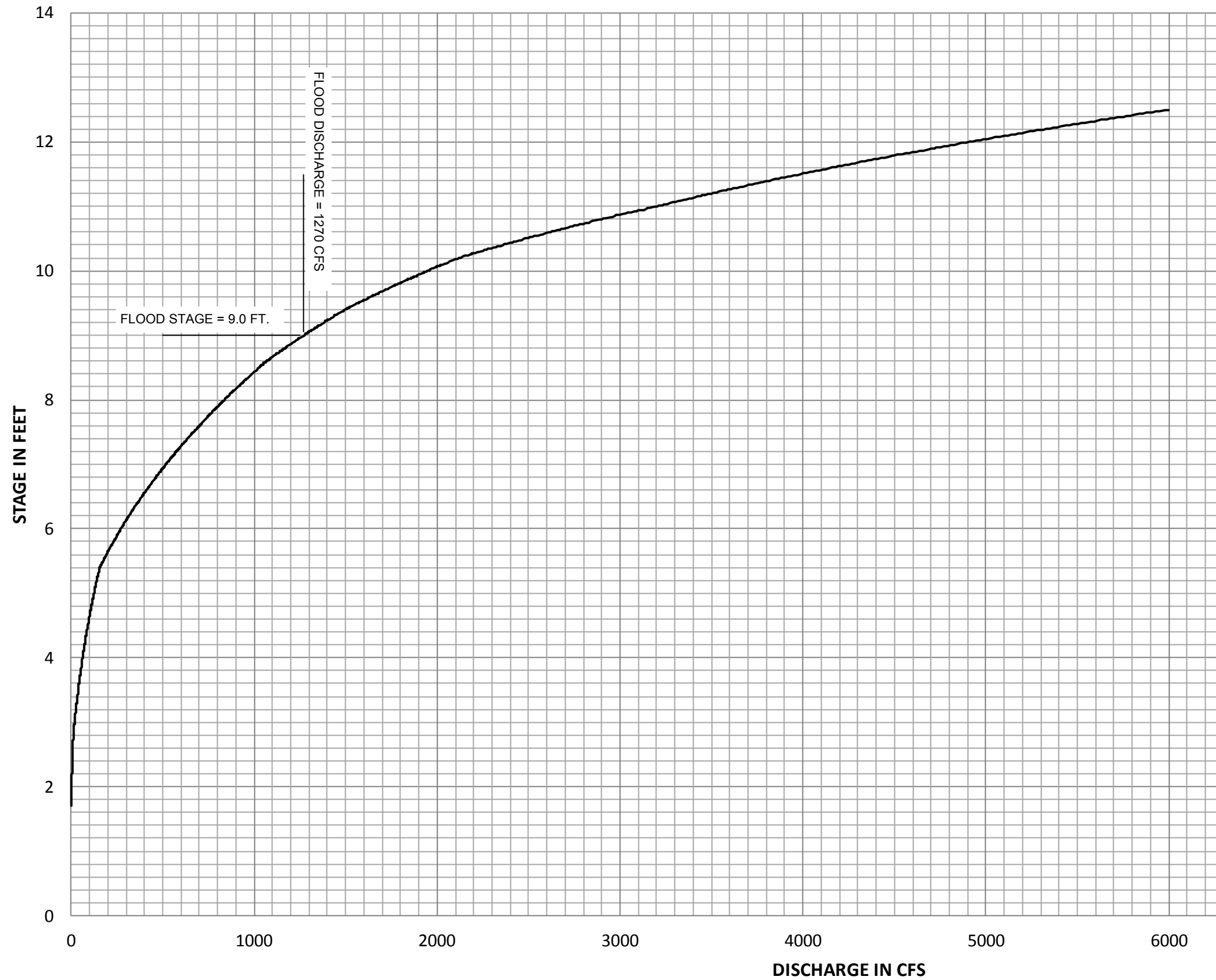
BASED ON PERIOD OF  
RECORD 1948 TO 2015  
FLOWS ARE BASED ON  
AVERAGE MONTHLY  
INFLOWS

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**

**FLOW DURATION CURVE**

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
Drawn:  
Checked:



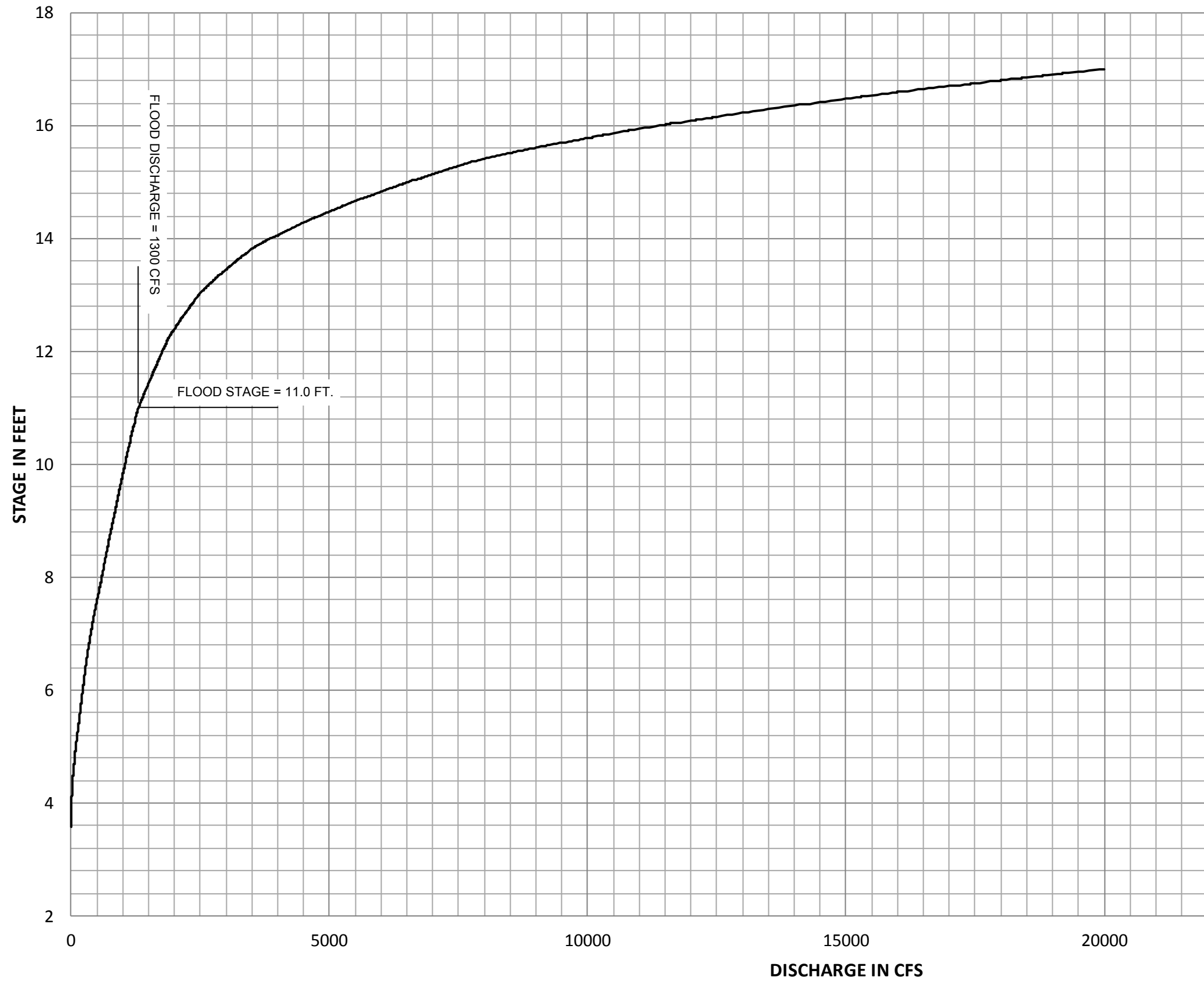
NOTES:  
 DATA OBTAINED FROM PUBLISHED  
 USGS RATING CURVE  
 GAGE DATUM: 1829.95 NGVD29  
 DATE OF DATA: 11JUNE2015

NOTE: PLATE SIZE IS 11" X 17"

ARKANSAS RIVER WATERSHED    NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**  
**DISCHARGE RATING CURVE**  
**NORTH CANADIAN RIVER AT**  
**WOODWARD, OK**

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:



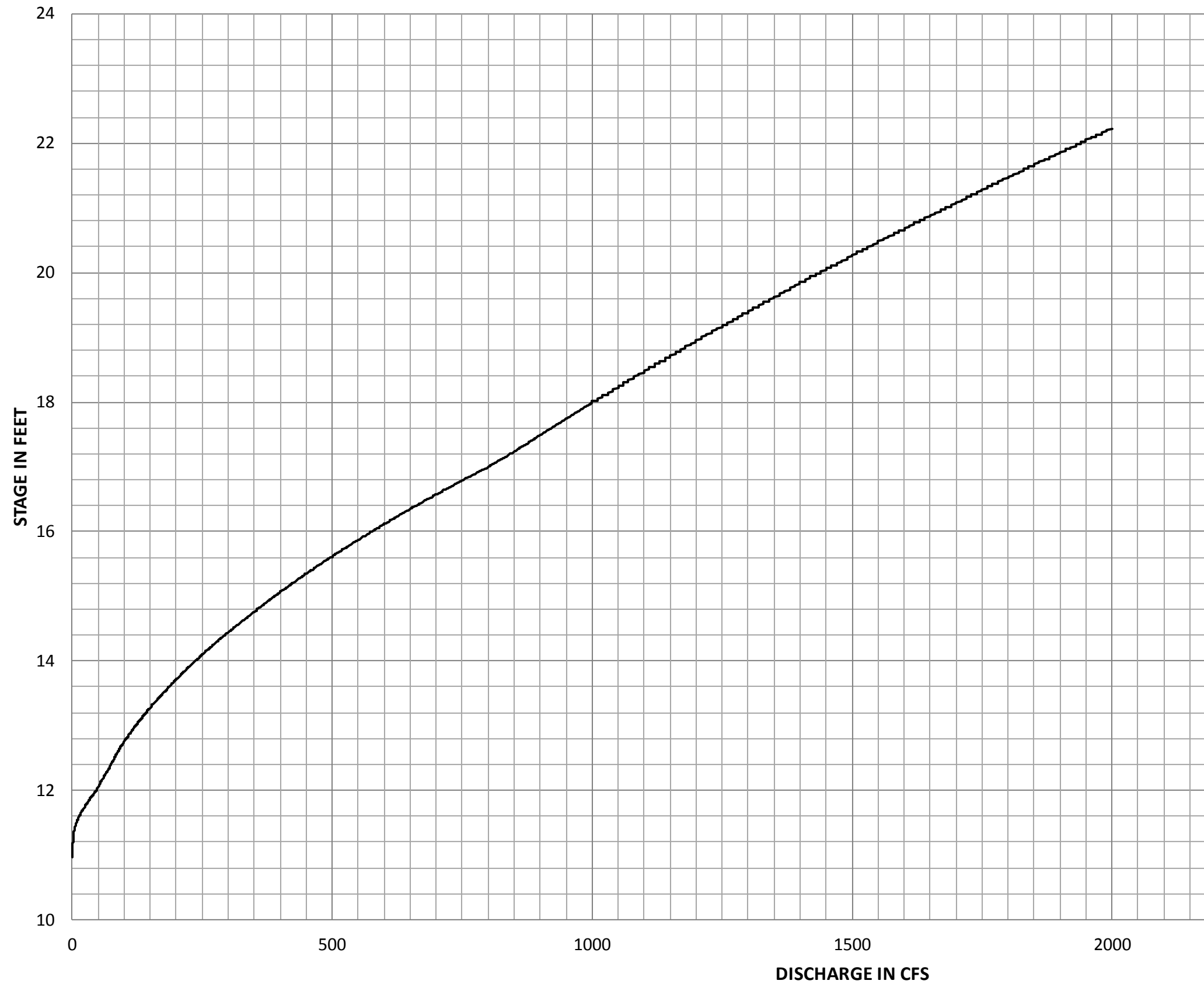
NOTES:  
 DATA OBTAINED FROM PUBLISHED  
 USGS RATING CURVE  
 GAGE DATUM: 1675.53 NGVD29  
 DATE OF DATA: 09JUNE2015

NOTE: PLATE SIZE IS 11" X 17"

ARKANSAS RIVER WATERSHED    NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**  
**DISCHARGE RATING CURVE**  
**NORTH CANADIAN RIVER NR**  
**SEILING, OK**

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:



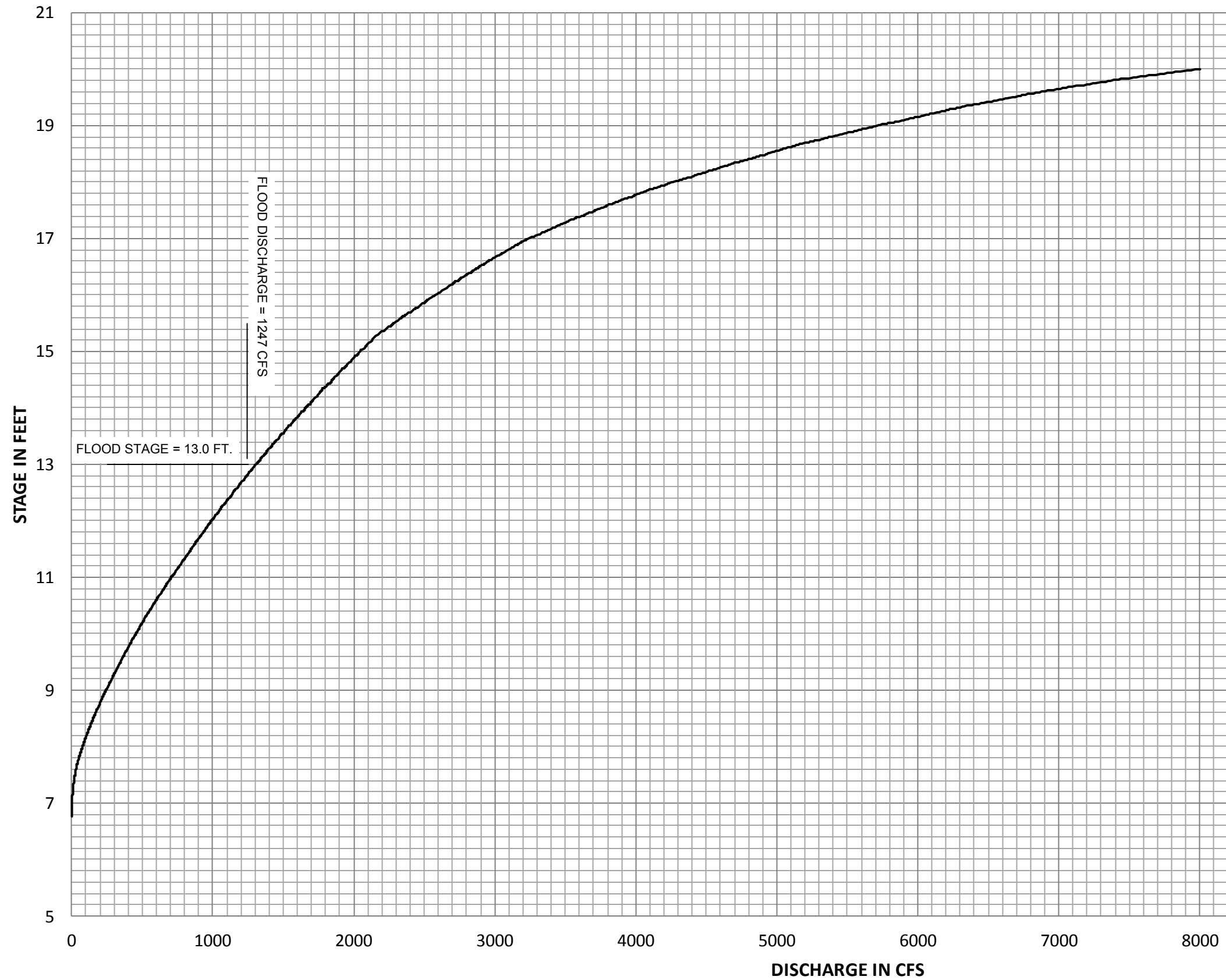
NOTES:  
 DATA OBTAINED FROM PUBLISHED  
 USGS RATING CURVE  
 GAGE DATUM: 1562.50 NGVD29  
 DATE OF DATA: 14MAR2013

NOTE: PLATE SIZE IS 11" X 17"

ARKANSAS RIVER WATERSHED    NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**  
**DISCHARGE RATING CURVE**  
**NORTH CANADIAN RIVER**  
**BELOW CANTON DAM**

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:



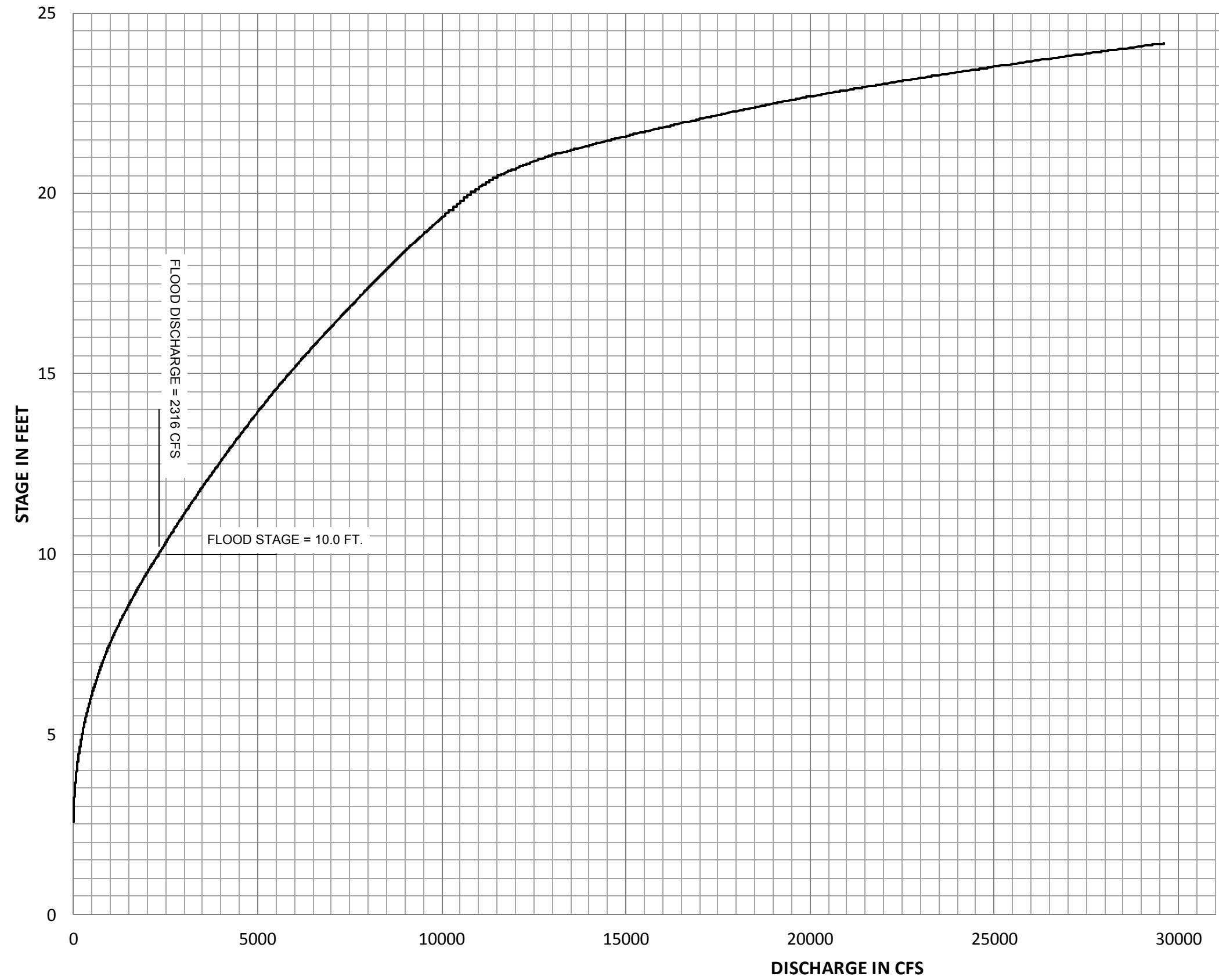
NOTES:  
 DATA OBTAINED FROM PUBLISHED  
 USGS RATING CURVE  
 GAGE DATUM: 1453.60 NGVD29  
 DATE OF DATA: 15JUNE2015

NOTE: PLATE SIZE IS 11" X 17"

ARKANSAS RIVER WATERSHED    NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**  
**DISCHARGE RATING CURVE**  
**NORTH CANADIAN RIVER NR**  
**WATONGA, OK**

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:



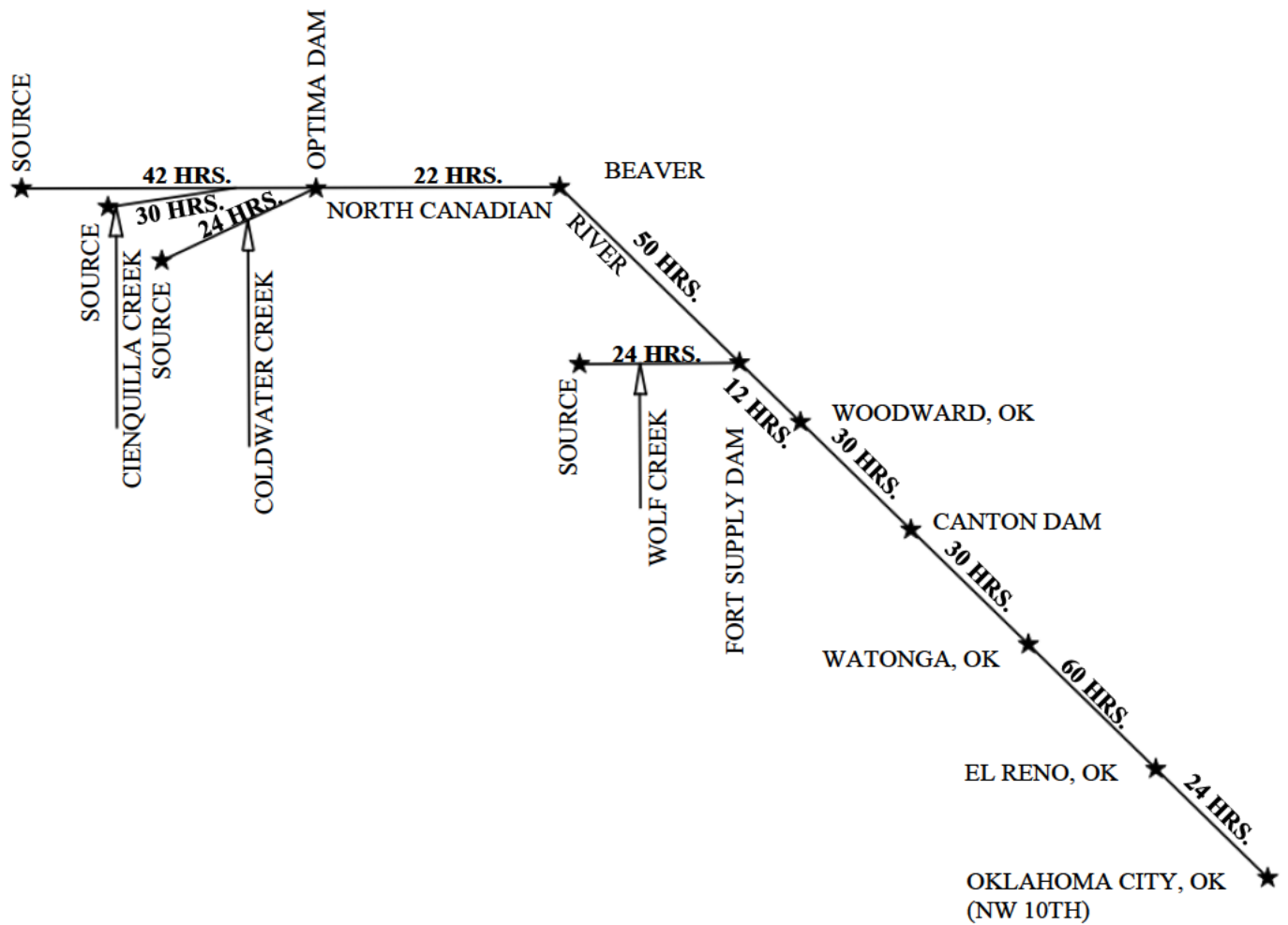
NOTES:  
 DATA OBTAINED FROM PUBLISHED  
 USGS RATING CURVE  
 GAGE DATUM: 1295.00 NGVD29  
 DATE OF DATA: 15JUNE2015

NOTE: PLATE SIZE IS 11" X 17"

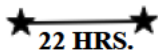
ARKANSAS RIVER WATERSHED    NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**  
**DISCHARGE RATING CURVE**  
**NORTH CANADIAN RIVER NR**  
**EL RENO, OK**

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:



NOTE:  
 TIME OF TRAVEL IN HOURS FOR  
 LARGE RISES IS SHOWN  
 BETWEEN STARS



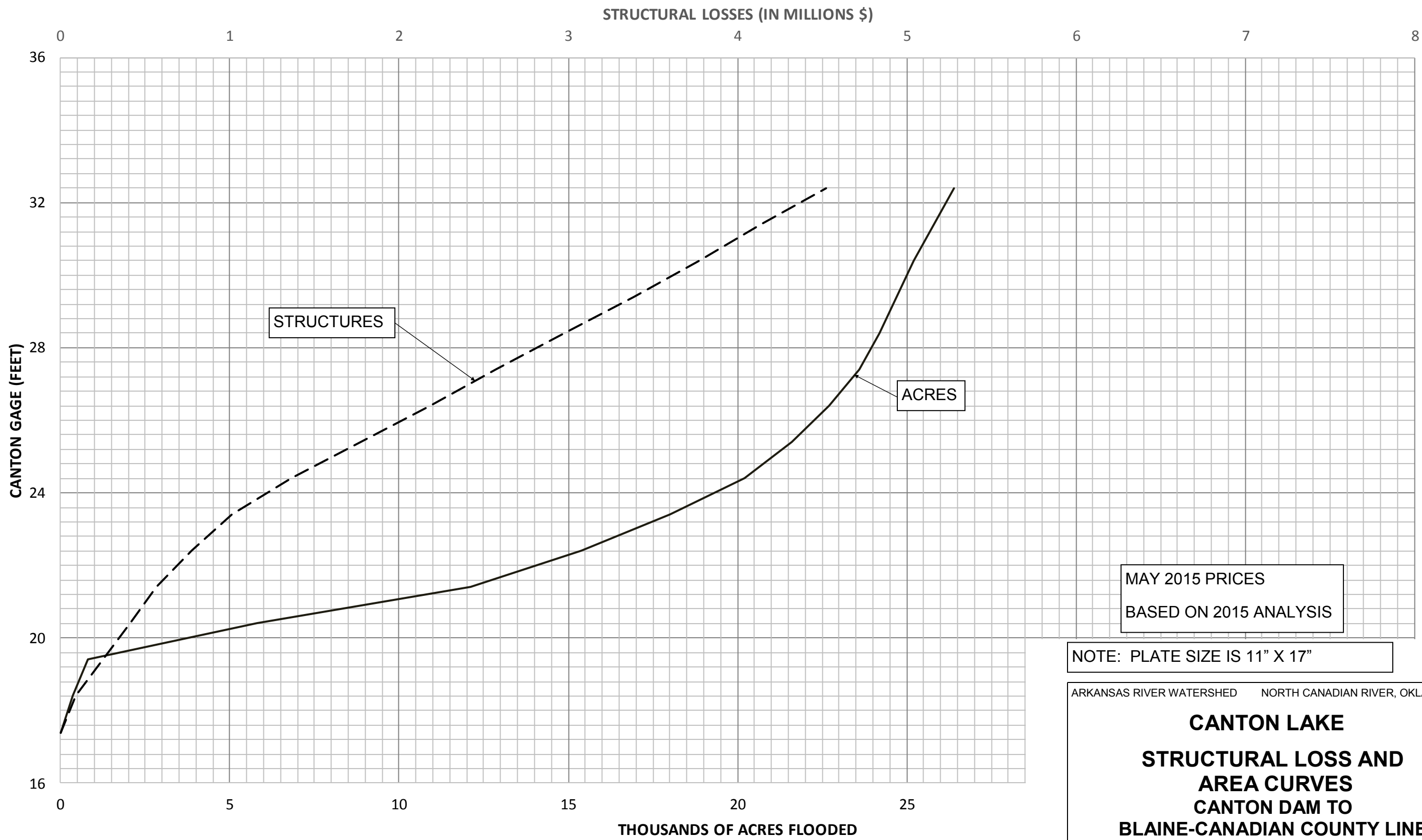
TRAVEL TIMES FROM CANTON DAM TO WATONGA AND  
 WATONGA TO EL RENO ARE  
 BASED ON OBSERVED DATA.

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OK

## CANTON LAKE

### TIME OF CREST TRAVEL

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:



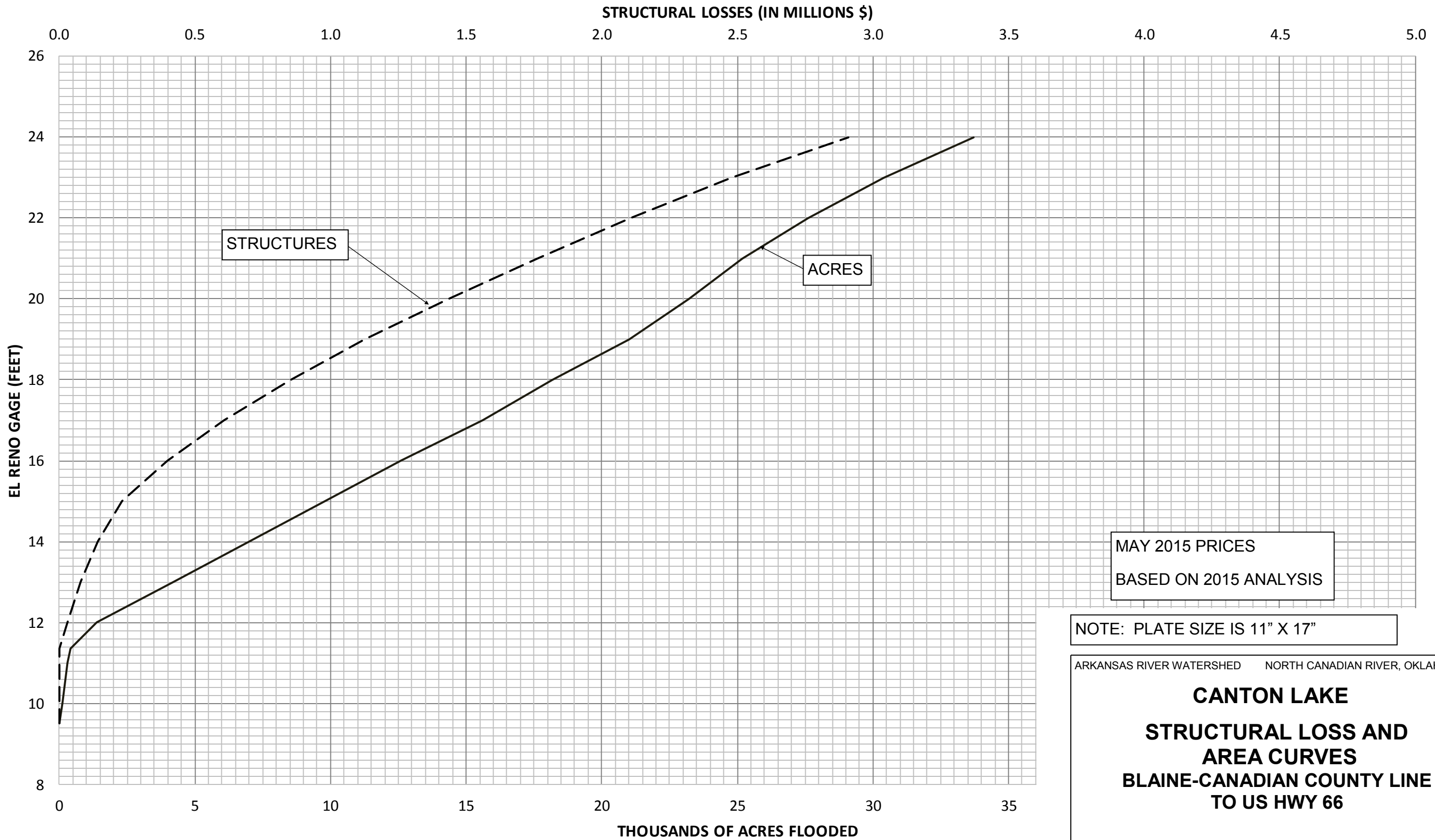
MAY 2015 PRICES  
 BASED ON 2015 ANALYSIS

NOTE: PLATE SIZE IS 11" X 17"

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE  
 STRUCTURAL LOSS AND  
 AREA CURVES  
 CANTON DAM TO  
 BLAINE-CANADIAN COUNTY LINE**

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:



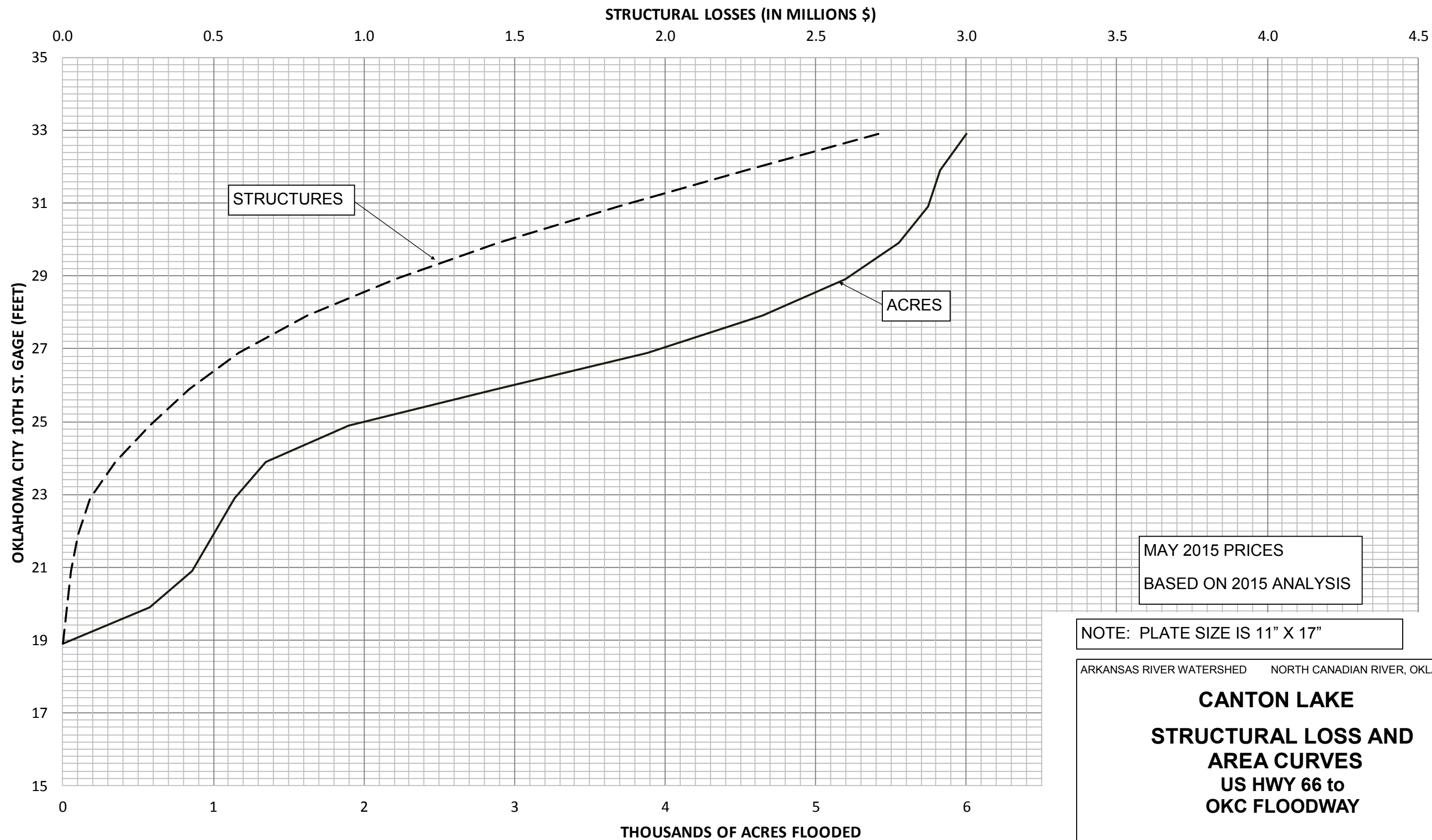
MAY 2015 PRICES  
 BASED ON 2015 ANALYSIS

NOTE: PLATE SIZE IS 11" X 17"

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**  
**STRUCTURAL LOSS AND**  
**AREA CURVES**  
**BLAINE-CANADIAN COUNTY LINE**  
**TO US HWY 66**

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:



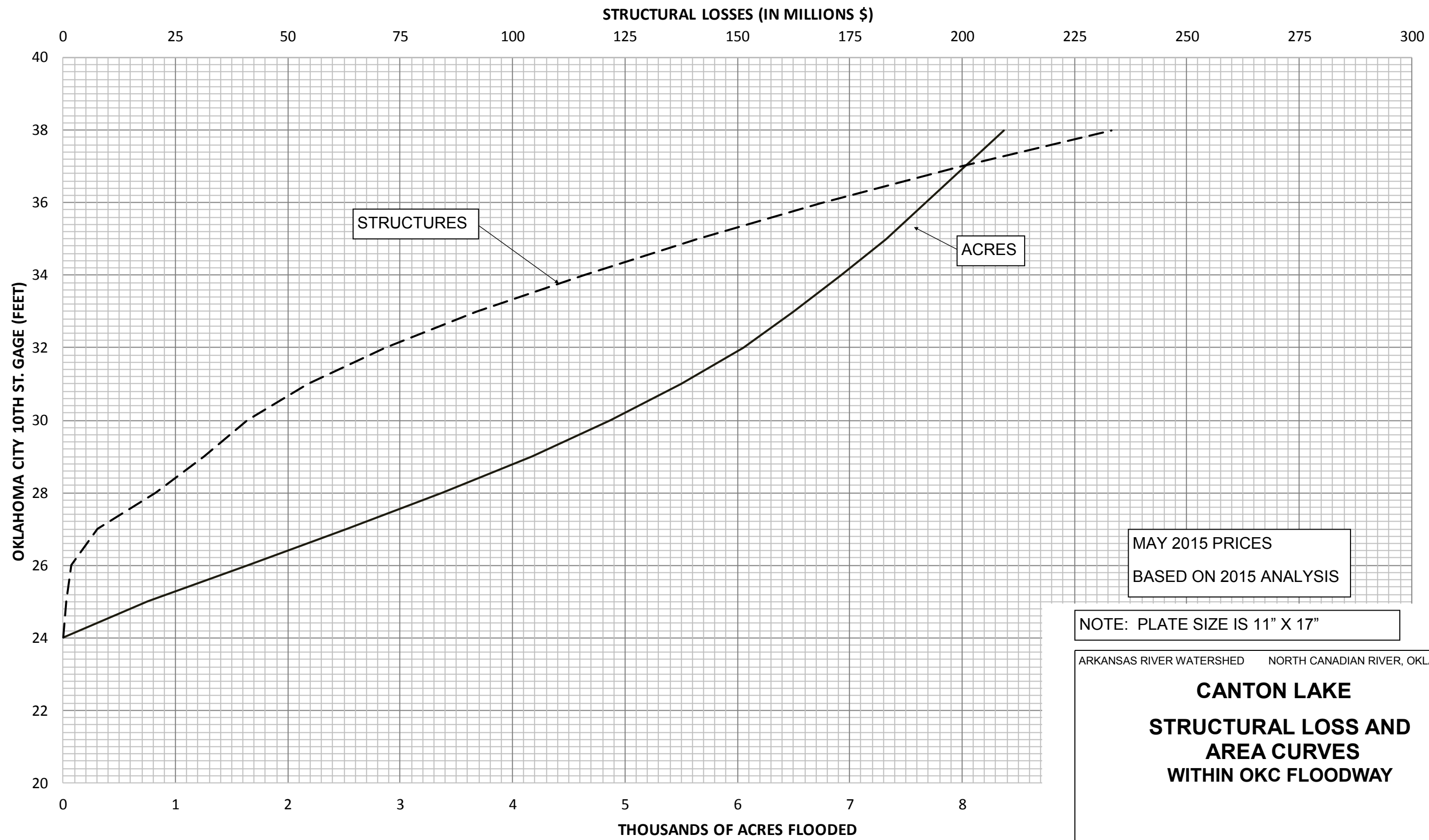
MAY 2015 PRICES  
 BASED ON 2015 ANALYSIS

NOTE: PLATE SIZE IS 11" X 17"

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**  
**STRUCTURAL LOSS AND**  
**AREA CURVES**  
**US HWY 66 to**  
**OKC FLOODWAY**

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:



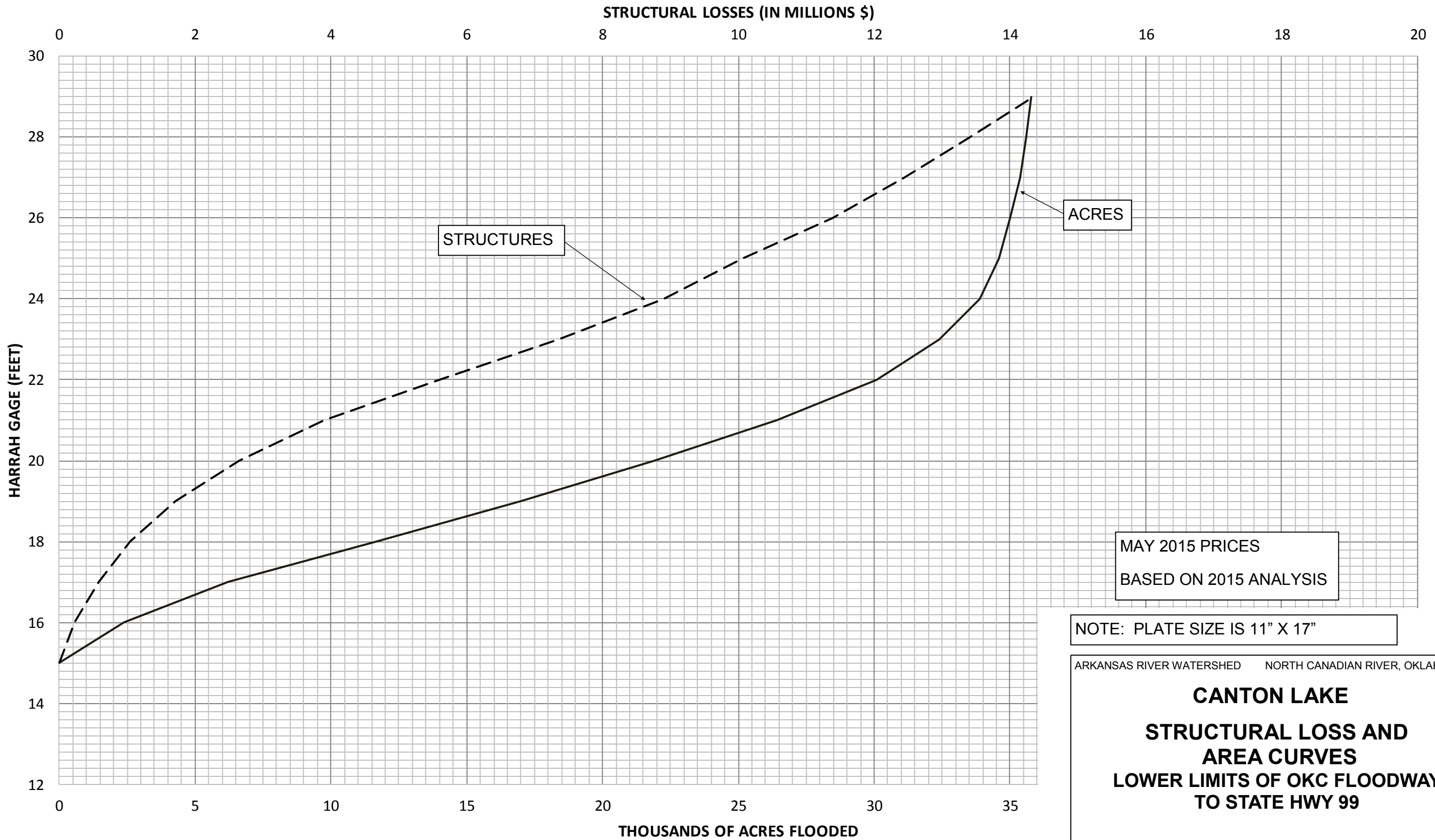
MAY 2015 PRICES  
 BASED ON 2015 ANALYSIS

NOTE: PLATE SIZE IS 11" X 17"

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**  
**STRUCTURAL LOSS AND**  
**AREA CURVES**  
**WITHIN OKC FLOODWAY**

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:



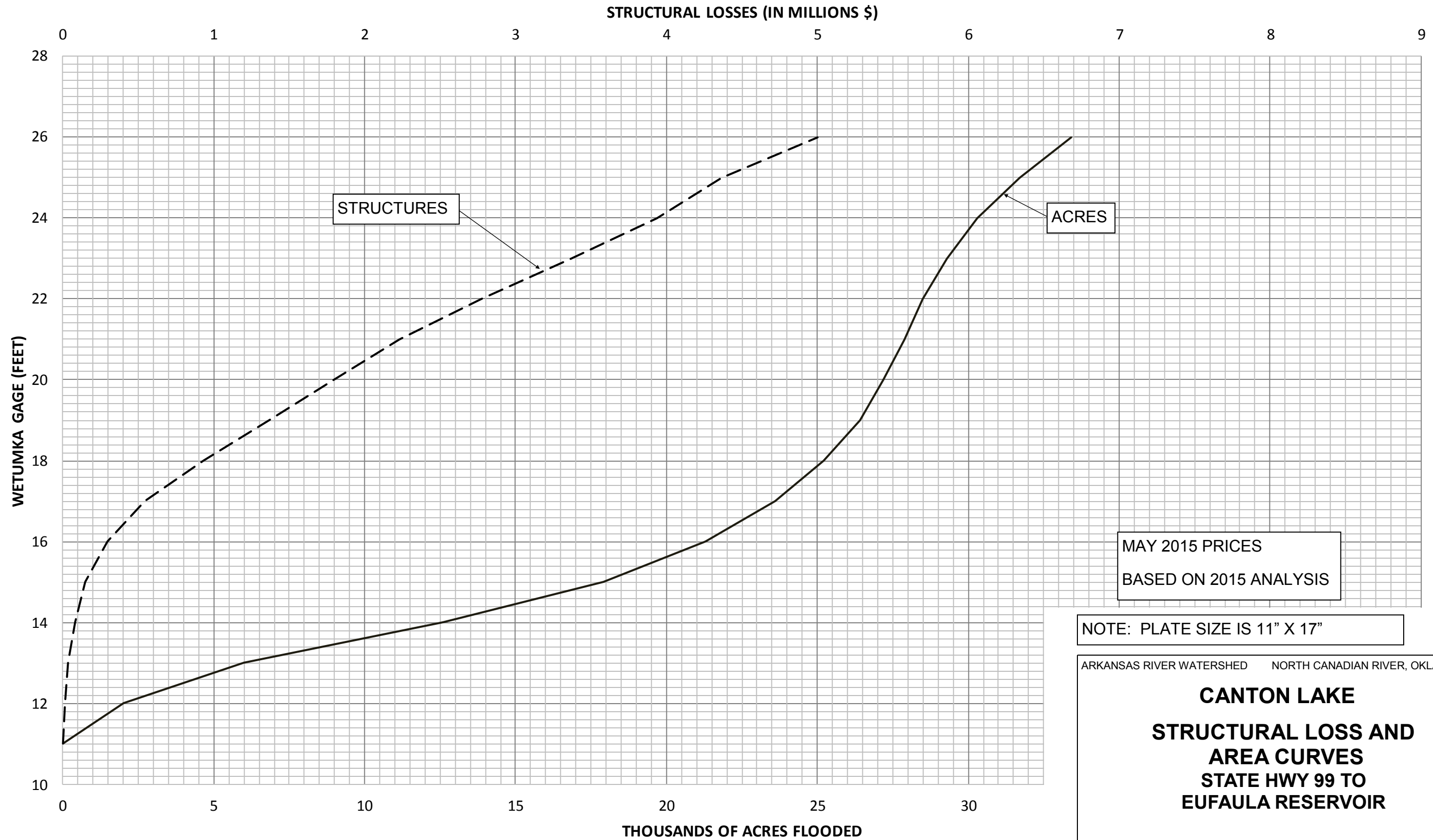
MAY 2015 PRICES  
 BASED ON 2015 ANALYSIS

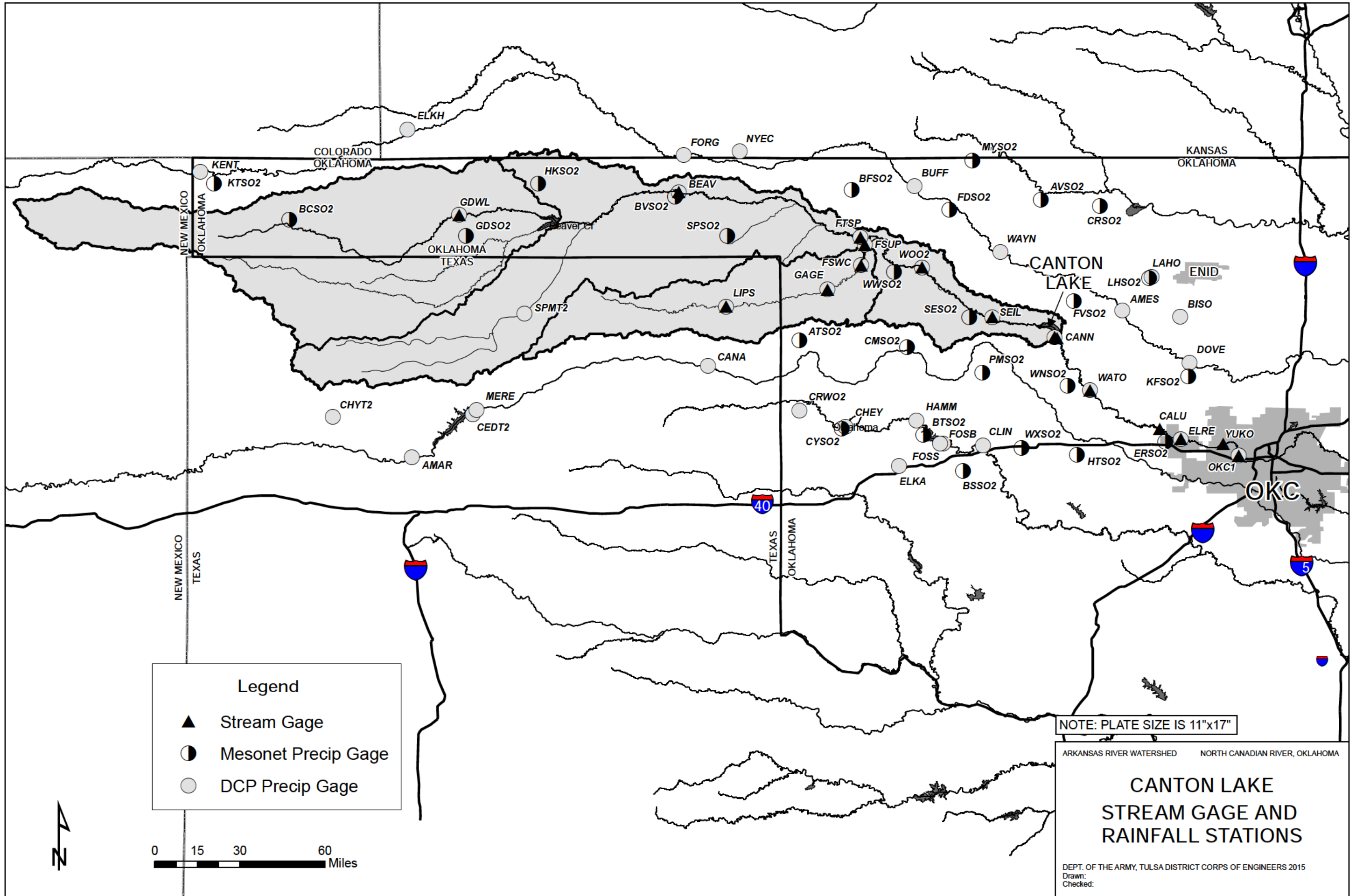
NOTE: PLATE SIZE IS 11" X 17"

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

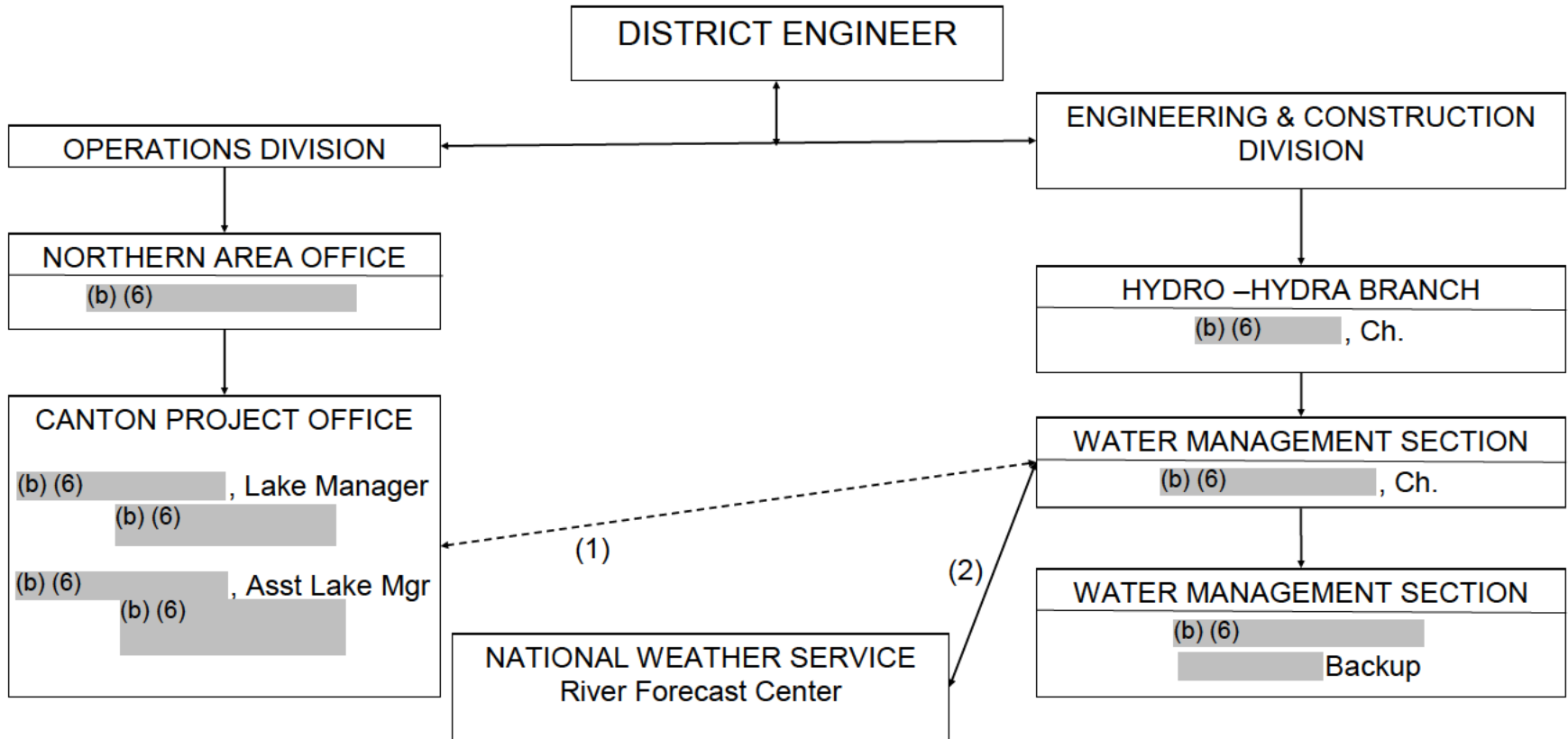
**CANTON LAKE**  
**STRUCTURAL LOSS AND**  
**AREA CURVES**  
**LOWER LIMITS OF OKC FLOODWAY**  
**TO STATE HWY 99**

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:





# U.S. ARMY CORPS OF ENGINEERS TULSA DISTRICT



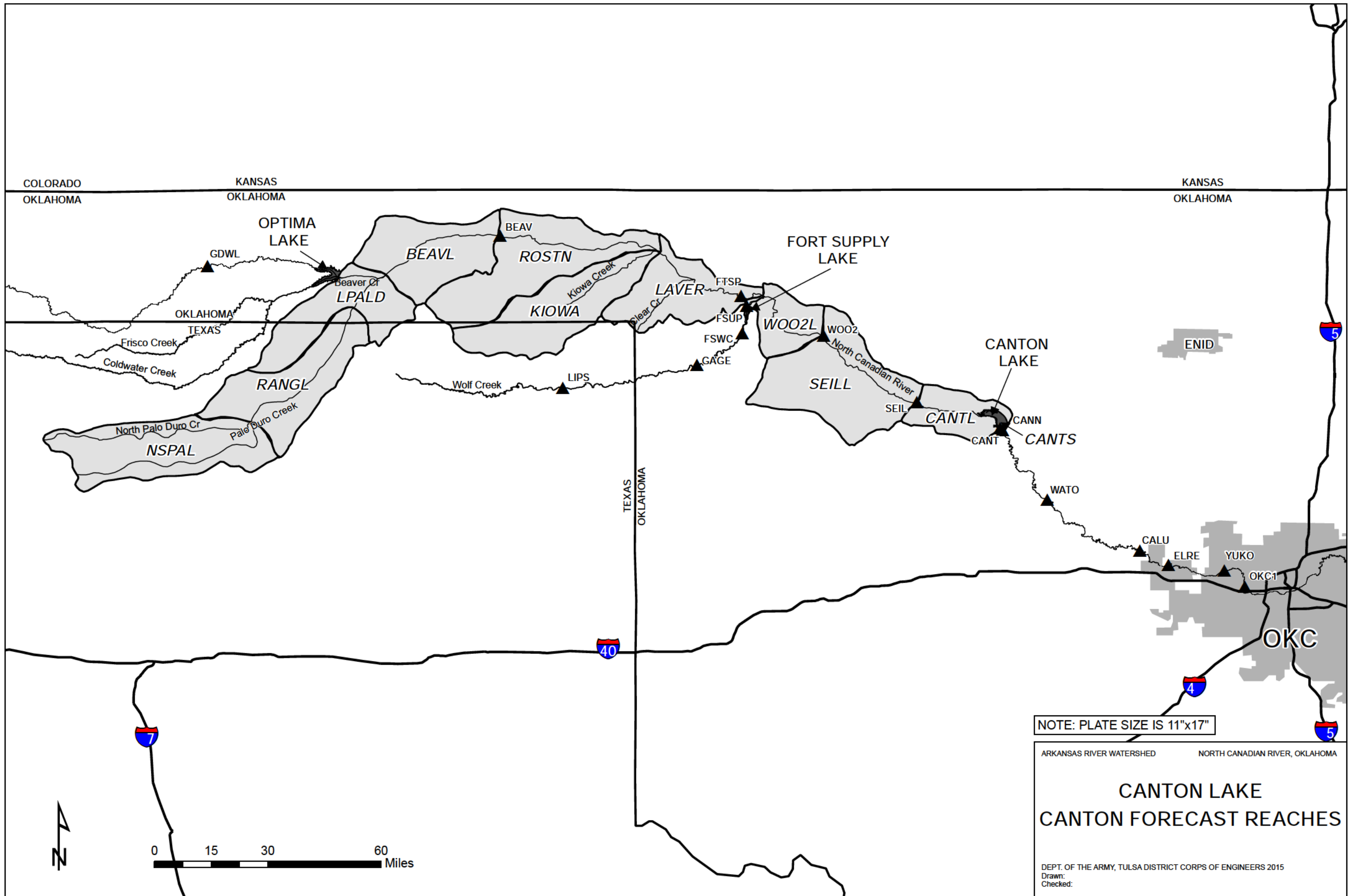
1. DIRECT COMMUNICATIONS ARE MAINTAINED BETWEEN CANTON PROJECT OFFICE AND THE WATER MANAGEMENT SECTION FOR TRANSMISSION OF RESERVOIR DATA, REGULATIONS, AND INSTRUCTIONS.
2. PRECIPITATION AND STREAM GAGE DATA ARE SHARED BY THE NATIONAL WEATHER SERVICE, RIVER FORECAST CENTER.

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

## CANTON LAKE ORGANIZATION FOR FLOOD CONTROL REGULATION

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:

LINE #	ITEM	TIME	23	24	25	26	27	28	29
1	POOL ELEVATION	12N							
2	POOL ELEVATION	4PM							
3	POOL ELEVATION	12M							
4	POOL ELEVATION	8AM							
5	TAILWATER ELEVATION	8AM							
6	24 HR AVG POWER DISCHARGE	12M							
7	24 HR AVG TOTAL DISCHARGE	12M							
8	NET POWER GENERATION	12M							
9	GEN#1 HRS OF USE	12M							
	GEN#2 HRS OF USE	12M							
	GEN#3 HRS OF USE	12M							
	GEN#4 HRS OF USE	12M							
10	INSTANTANEOUS POWER DISCHARGE	8AM							
11	INSTANTANEOUS TOTAL DISCHARGE	8AM							
12/13	LAKE WEATHER	8AM	Φ	Φ	Φ	Φ	Φ	Φ	Φ
14	TOTAL PRECEDING 6 HR PRECIPITATION ENDING AT	1PM							
		7PM							
		1AM							
		7AM							
15	TOTAL 24 HOUR PRECIPITATION	7AM							
16	COMMENTS ON PRECIP. DIST.								
17	EVAPORATION 24 HOURS	8AM							
18/19	WIND DIRECTION AND VELOCITY	8AM	B-	B-	B-	B-	B-	B-	B-
20	WATER SUPPLY								
21	GATE SETTINGS NO. TYPE AND OPENING	8AM							
22	GATE CHANGES	DATE TIME							
23	POOL ELEVATION								
24	FROM	GATE SETTING							
25	TO	GATE SETTING							
26	GATE CHANGES	DATE TIME							
27	POOL ELEVATION								
28	FROM	GATE SETTING							
29	TO	GATE SETTING							
30	GATE CHANGES	DATE TIME							
31	POOL ELEVATION								
32	FROM	GATE SETTING							
33	TO	GATE SETTING							

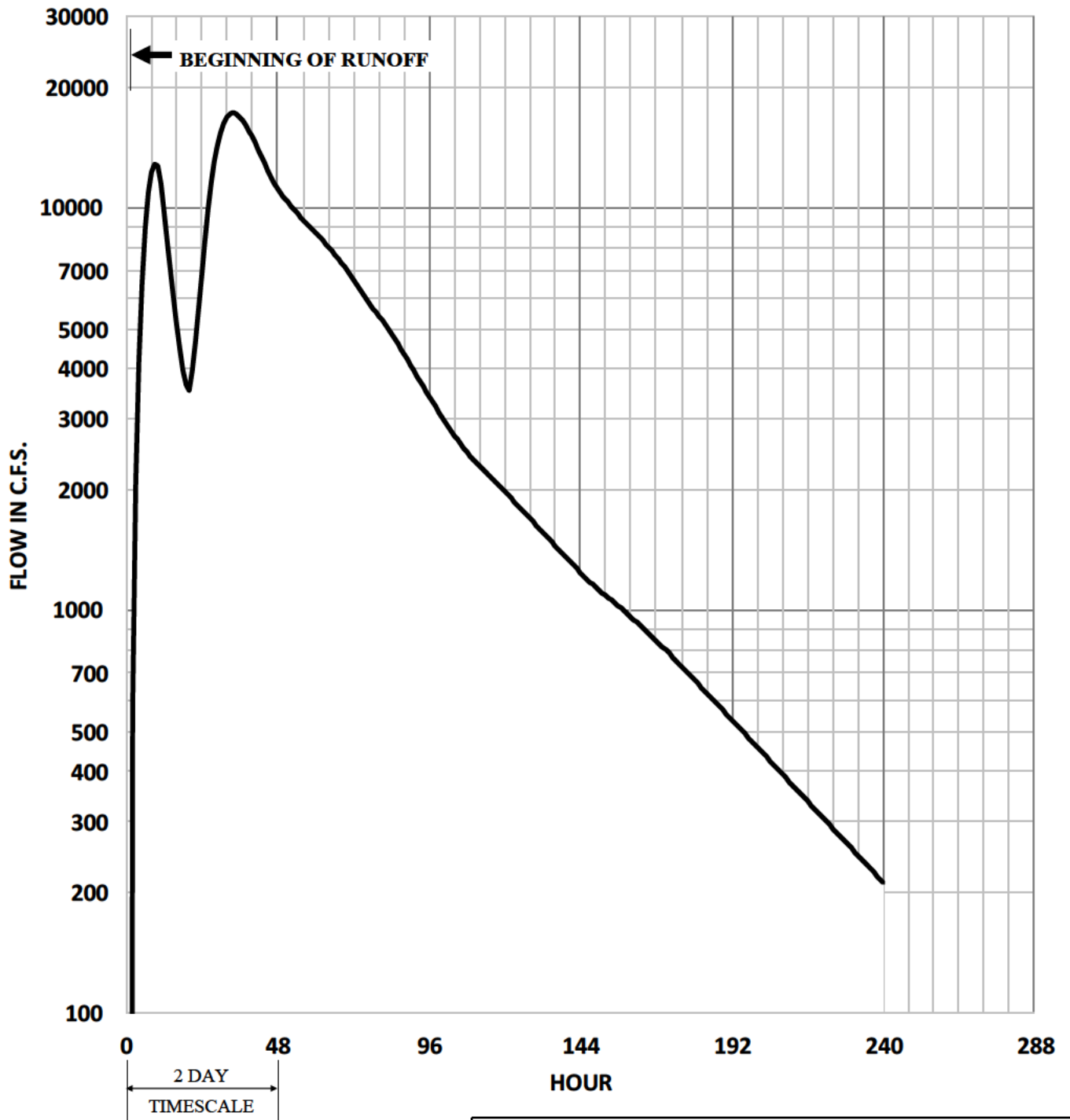


NOTE: PLATE SIZE IS 11"x17"

ARKANSAS RIVER WATERSHED      NORTH CANADIAN RIVER, OKLAHOMA

### CANTON LAKE CANTON FORECAST REACHES

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:

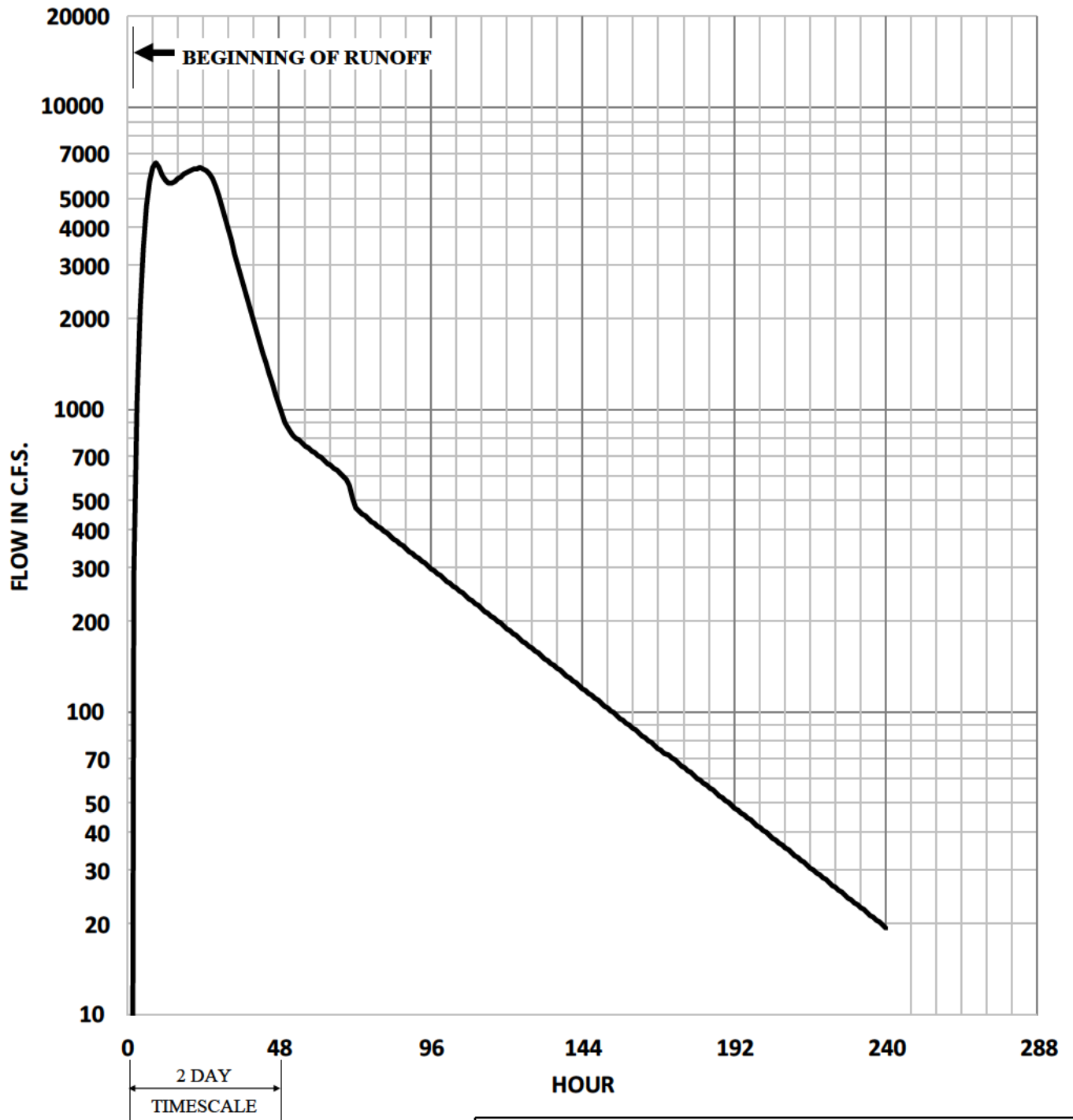


**DRAINAGE AREA = 5,198 SQ. MI.**  
**1" RUNOFF = 277,227 AC. FT.**  
**PEAK FLOW = 17,238 C.F.S**

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**  
**UNIT HYDROGRAPH FOR**  
**AREA ABOVE CANTON DAM**  
**AND BELOW OPTIMA**  
**AND FORT SUPPLY DAMS**

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:

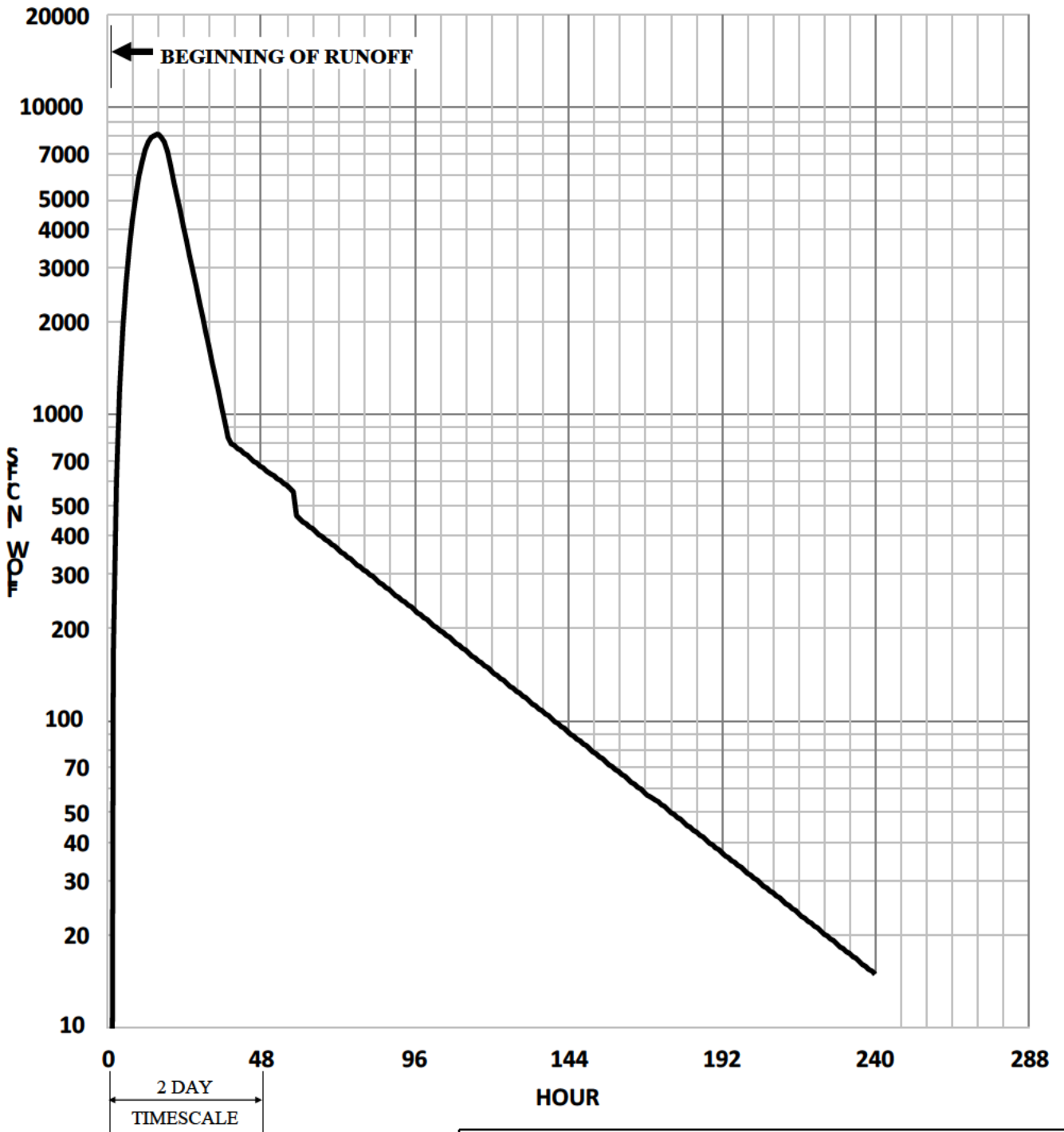


**DRAINAGE AREA = 294 SQ. MI.**  
**1" RUNOFF = 15,680 AC. FT.**  
**PEAK FLOW = 6,537 C.F.S**

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**  
**UNIT HYDROGRAPH FOR**  
**AREA ABOVE EL RENO GAGE**  
**AND BELOW WATONGA GAGE**

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:

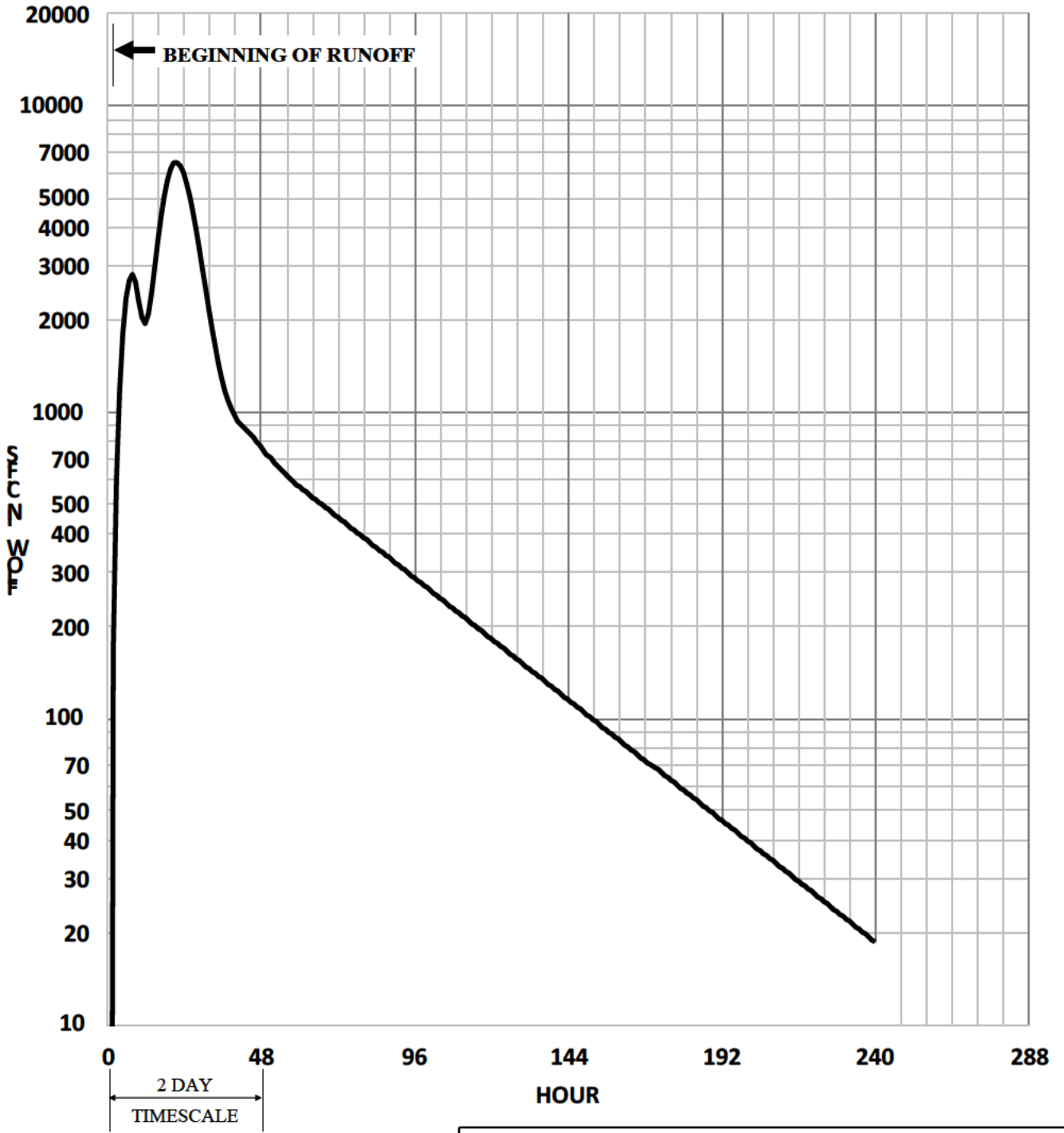


**DRAINAGE AREA = 241 SQ. MI.**  
**1" RUNOFF = 12,853 AC. FT.**  
**PEAK FLOW = 8,082 C.F.S**

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**  
**UNIT HYDROGRAPH FOR**  
**AREA ABOVE WATONGA GAGE**  
**AND BELOW CANTON DAM**

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:



**DRAINAGE AREA = 176 SQ. MI.**  
**1" RUNOFF = 9,387 AC. FT.**  
**PEAK FLOW = 6,502 C.F.S**

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**  
**UNIT HYDROGRAPH FOR**  
**AREA ABOVE OKLAHOMA CITY GAGE**  
**AND BELOW EL RENO GAGE**

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:

Date & Time	Pool Elevation	Storage (ac-ft)	Δ Storage per 6-hr interval		Gate Opening		Discharge in CFS						Inflow			
			ac-ft/hr	cfs	No. & Type	Opening	Instantaneous			6-hr Average						
							Flood Control	Power	Total	Flood Control	Power	Evap		Total		
14-Jul																
0800	1619.91	146935			3 TG	0.5 ft		787				789.0		75	864.0	2100
			103	1236	"	"										
1400	1619.98	147552			"	"		791				793.0		75	868.0	2125
			105	1257	"	"										
2000	1620.05	148181			"	"		795				796.5		95	891.5	1976
15-Jul			90	1085	"	"										
0200	1620.11	148723			"	"		798				800.0		95	895.0	2341
			121	1446	"	"										
0800	1620.19	149447			"	"		802				804.0		95	899.0	2165
			105	1266	"	"										
1400	1620.26	150079			"	"		806				807.5		95	902.5	1987
			90	1085	"	"										
2000	1620.32	150622			"	"		809				810.5		110	920.5	1824
16-Jul			75	904	"	"										
0200	1620.37	151074			"	"		812				813.0		110	923.0	1465
			45	542	"	"										
0800	1620.40	151345			"	"		814				814.5		110	924.5	1467
			45	542	"	"										
1400	1620.43	151616			"	"		815				950.5		110	1060.5	699
			-30	-362	"	"										
2000	1620.41	151435			4 TG	0.5 ft		1086				1085.5		75	1160.5	980
17-Jul			-15	-181	"	"										
0200	1620.40	151345			"	"		1085				1084.0		75	1159.0	797
			-30	-362	"	"										
0800	1620.38	151164			"	"		1083				1082.5		75	1157.5	796
			-30	-362	"	"										
1400	1620.36	150983			"	"		1082				1081.0		75	1156.0	614
			-45	-542	"	"										
2000	1620.33	150712			"	"		1080				1080.0		75	1155.0	1155

(1) (2) (3) (4) (5) (6) (7)

- (1) FROM AREA/CAPACITY TABLE
- (2) SUBTRACT STORAGE AT BEGINNING OF PERIOD FROM STORAGE AT END OF PERIOD. IF POOL IS RISING, CHANGE IN STORAGE IS POSITIVE (+); IF POOL IS FALLING, CHANGE IS NEGATIVE (-)
- (3) CHANGE IN STORAGE (AC-FT/HR) X 12 = CHANGE IN STORAGE IN CFS
- (4) FROM DISCHARGE RATING CURVES
- (5) AVERAGE DISCHARGE DURING PERIOD
- (6) PAN EVAPORATION APPLIED TO EVAPORATION CURVES
- (7) INFLOW = CHANGE IN STORAGE (CFS) + AVERAGE DISCHARGE + EVAPORATION

NOTE:

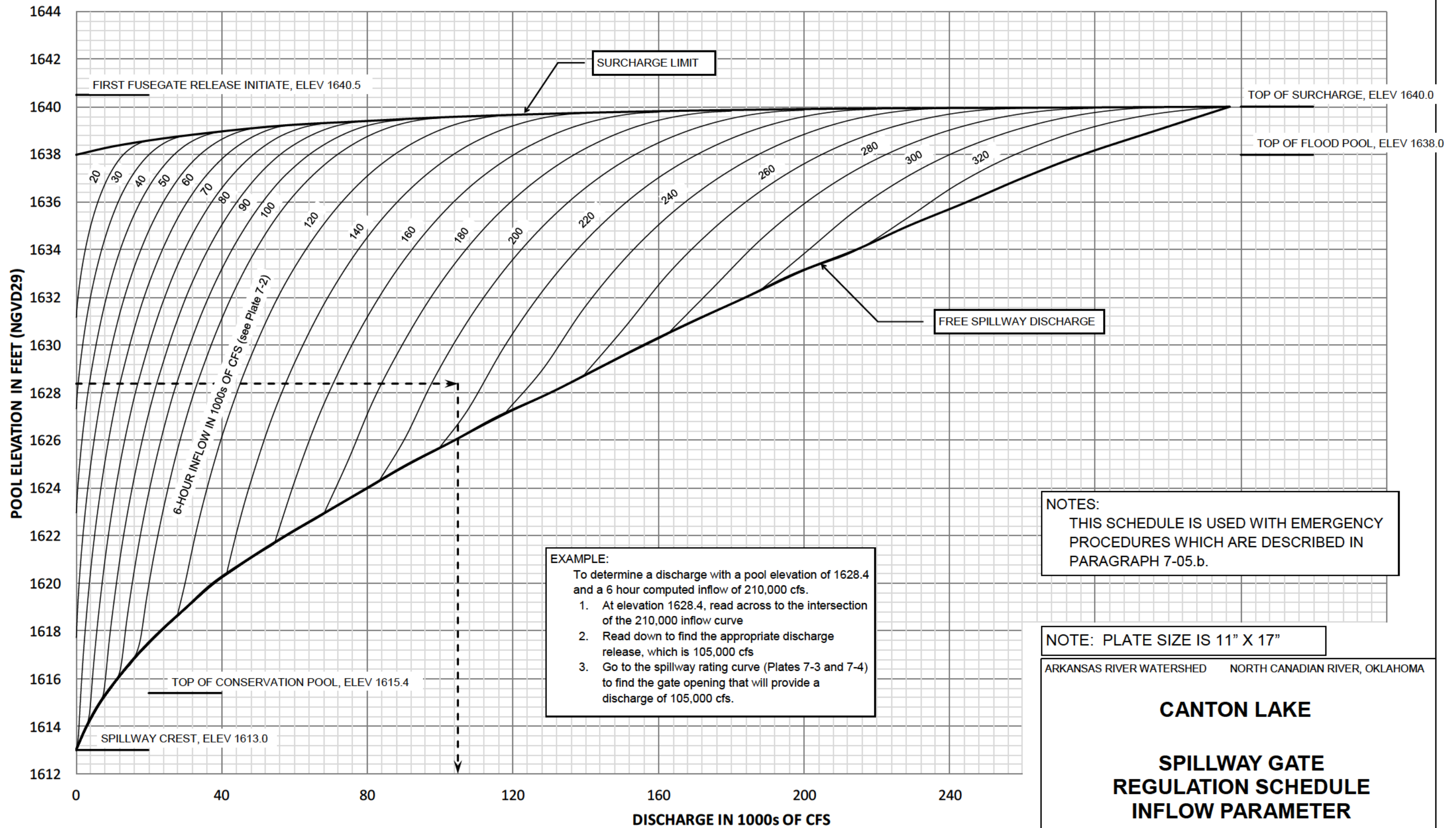
DURING FLOOD PERIODS, EVAPORATION IS USUALLY NEGLECTED IN PRELIMINARY INFLOW CALCULATIONS.

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**

**SAMPLE INFLOW CALCULATION**

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:



**NOTES:**  
 THIS SCHEDULE IS USED WITH EMERGENCY PROCEDURES WHICH ARE DESCRIBED IN PARAGRAPH 7-05.b.

**NOTE:** PLATE SIZE IS 11" X 17"

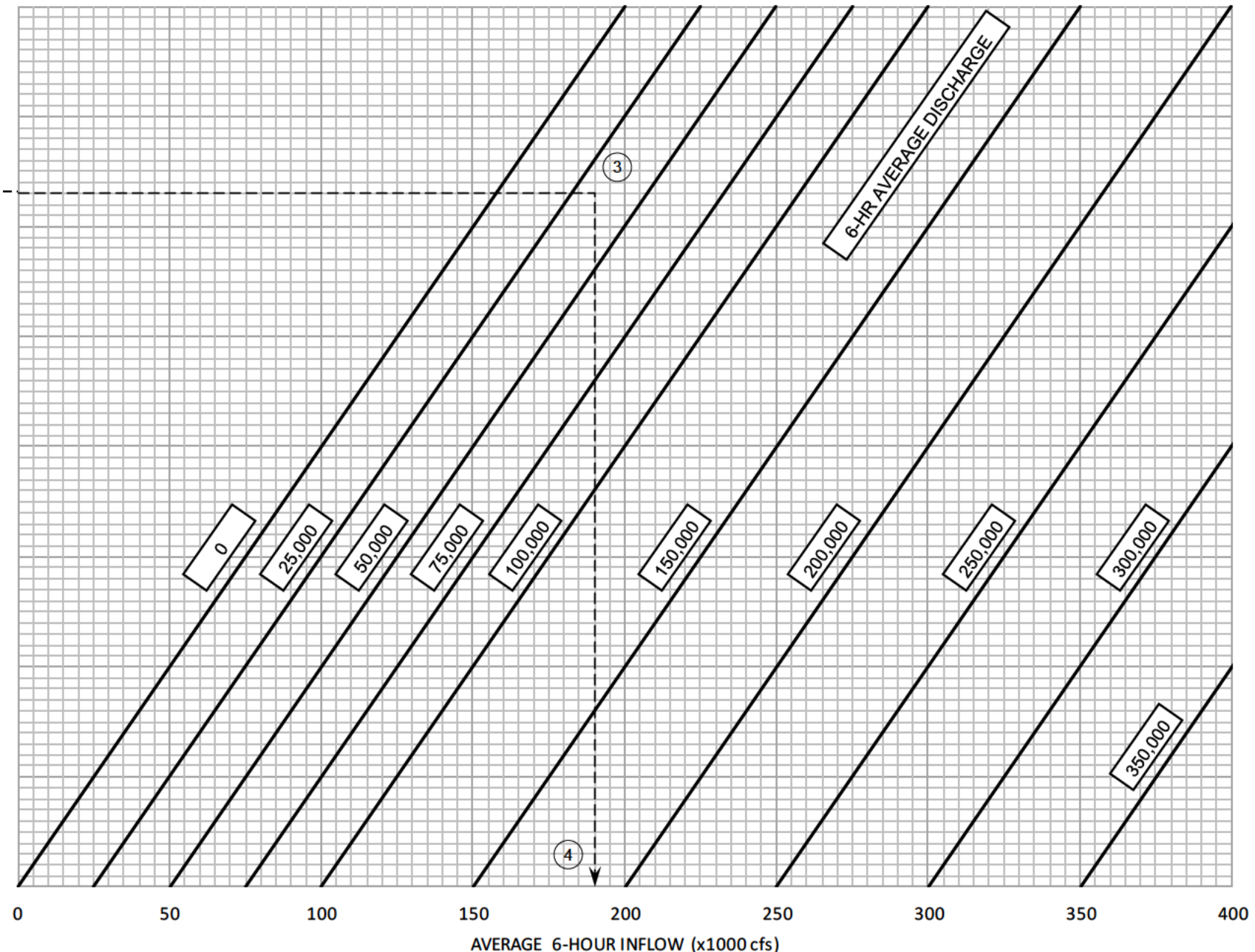
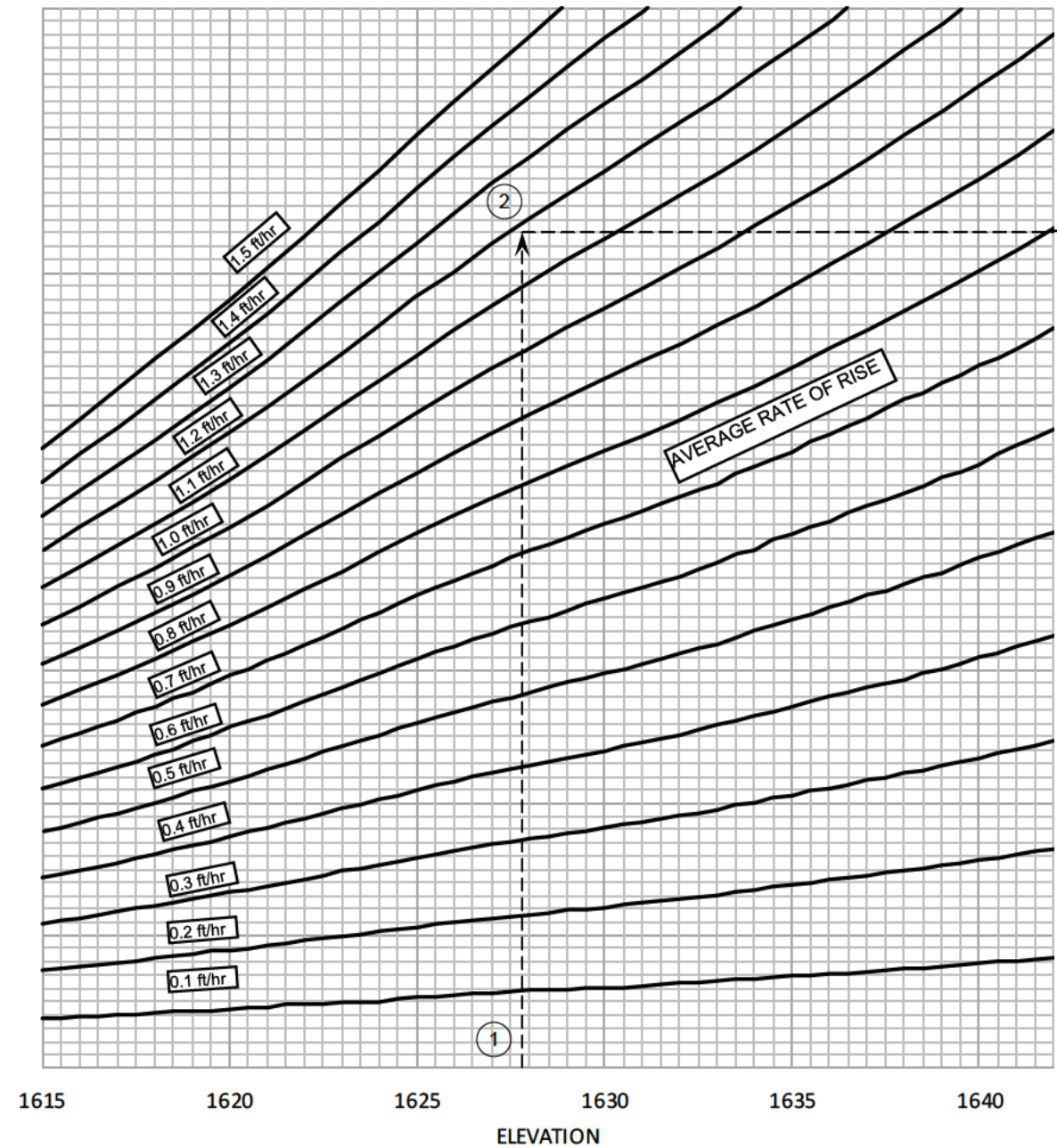
ARKANSAS RIVER WATERSHED    NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**

**SPILLWAY GATE REGULATION SCHEDULE**

**INFLOW PARAMETER**

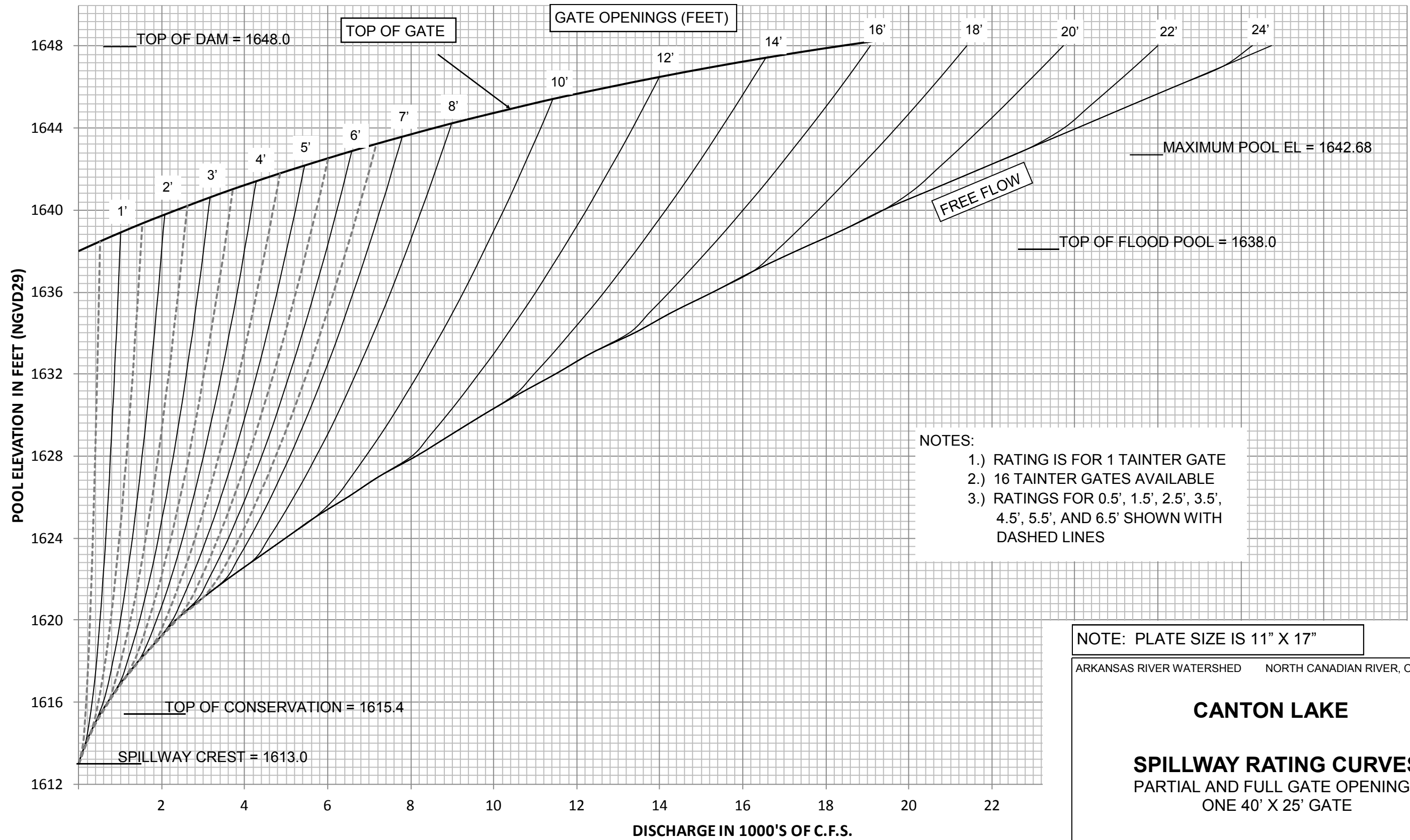
DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2016  
 Drawn:  
 Checked:



**INSTRUCTIONS:**  
 To determine the 6-hour inflow:  
 1) Locate the pool elevation at the end of the 6-hour period on the lower left portion of this chart.  
 2) Determine the rate of rise by subtracting the pool elevation at the beginning of the 6-hour period from the pool elevation at the end of the period and dividing by 6. Move straight up until you intersect the appropriate rate of rise curve.  
 3) Determine the 6-hour average discharge by:  
 a) Multiply the discharge for each gate setting used during the 6-hour period by the time in hours each setting was in effect during the 6-hour period  
 b) Sum those products and divide by 6 hours.  
 4) Move straight down to the bottom of the chart to read the average inflow for the 6-hour period.  
 Go to Plate 7-1 to determine the appropriate discharge for the next period.

**EXAMPLE COMPUTATIONS:**  
 1) Begin with a lake elevation of 1627.8 feet. Six hours ago the elevation was 1620.7 feet.  
 2) Rate of rise =  $(1627.8 - 1620.7) / 6 \text{ hr} = 7.10 \text{ feet} / 6 \text{ hr} = 1.18 \text{ ft/hr}$   
 3) Releases for the last six hours were:  
 1.0 hr at 26,500 cfs =  $1.0 \times 26,500 = 26,500 \text{ cfs}$   
 1.0 hr at 28,000 cfs =  $1.0 \times 28,000 = 28,000 \text{ cfs}$   
 1.5 hr at 35,000 cfs =  $1.5 \times 35,000 = 52,500 \text{ cfs}$   
 1.5 hr at 38,000 cfs =  $1.5 \times 38,000 = 57,000 \text{ cfs}$   
 1.0 hr at 40,000 cfs =  $1.0 \times 40,000 = 40,000 \text{ cfs}$   
 Average release =  $204,000 \text{ cfs} / 6 \text{ hr} = 34,000 \text{ cfs}$   
 Total: 6.0 hr 204,000 cfs  
 4) The resulting 6-hour inflow is 190,000 cfs

**NOTE: PLATE SIZE IS 11" X 17"**  
 ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA  
**CANTON LAKE**  
**INFLOW VS. RATE OF RISE**  
**NOMOGRAPH**  
 DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:



- NOTES:**
- 1.) RATING IS FOR 1 TANTER GATE
  - 2.) 16 TANTER GATES AVAILABLE
  - 3.) RATINGS FOR 0.5', 1.5', 2.5', 3.5', 4.5', 5.5', AND 6.5' SHOWN WITH DASHED LINES

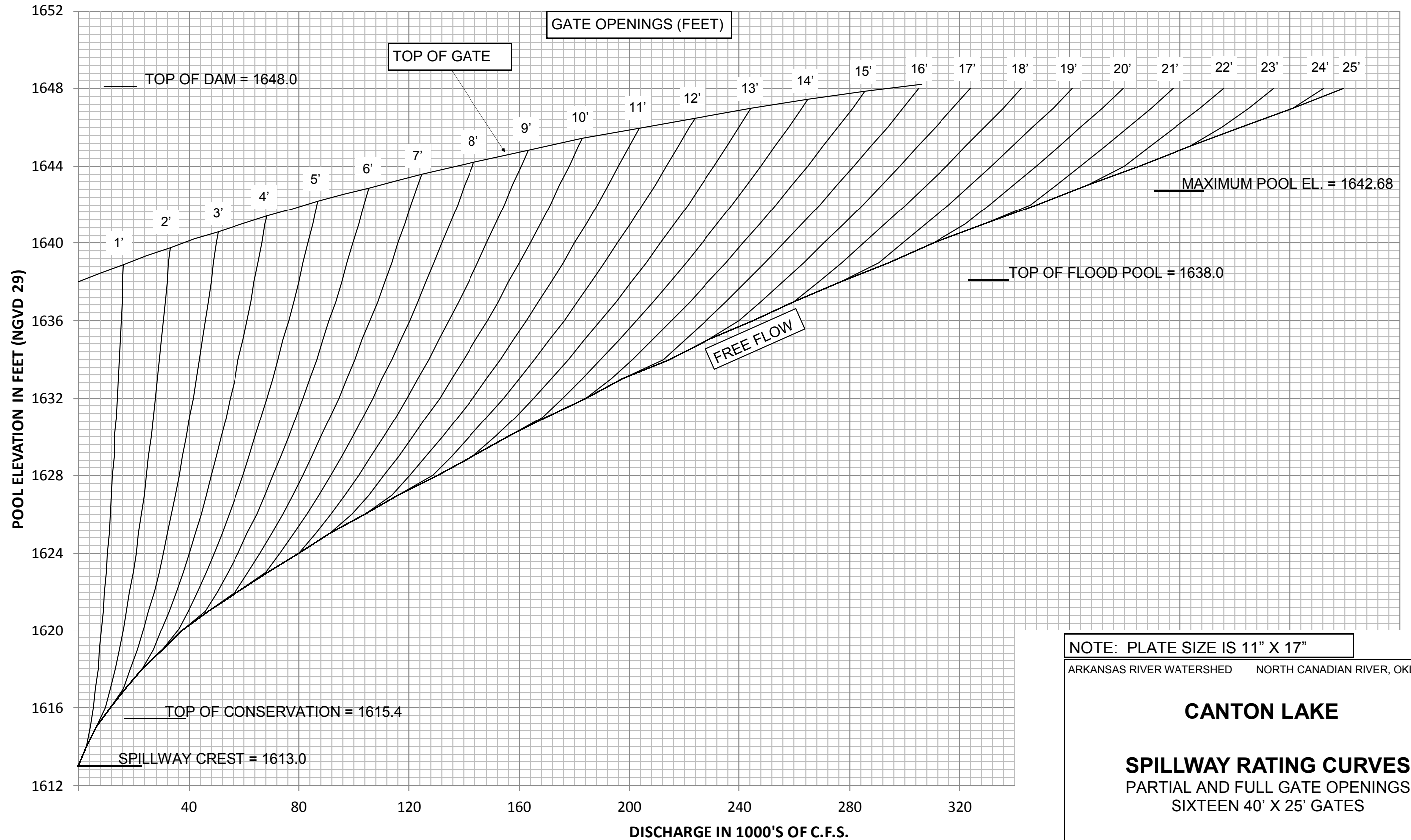
NOTE: PLATE SIZE IS 11" X 17"

ARKANSAS RIVER WATERSHED    NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**

**SPILLWAY RATING CURVES**  
PARTIAL AND FULL GATE OPENINGS  
ONE 40' X 25' GATE

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
Drawn:  
Checked:



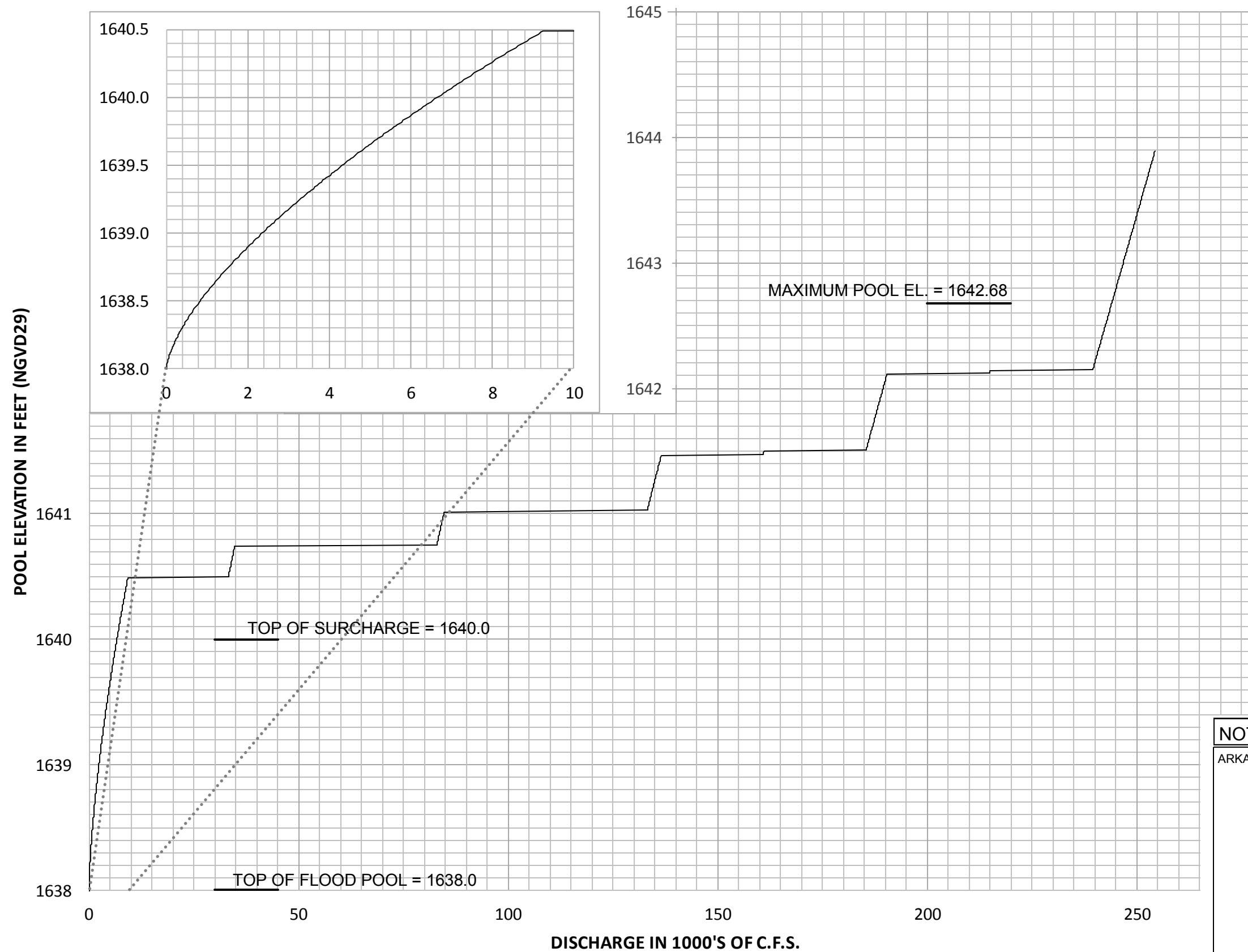
NOTE: PLATE SIZE IS 11" X 17"

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**

**SPILLWAY RATING CURVES**  
 PARTIAL AND FULL GATE OPENINGS  
 SIXTEEN 40' X 25' GATES

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:



**NOTES:**

THE SPILLWAY HAS 9 53' X 32' FUSEGATES.

GATES TIP AT THE FOLLOWING POOL ELEVATIONS:

GATE F1 (E):	1640.50
GATES F2 (D&F):	1640.72
GATE F3 (C):	1641.02
GATE F3 (G):	1641.03
GATE F4 (B):	1641.47
GATE F4 (H):	1641.51
GATE F5 (I):	1642.12
GATE F5 (A):	1642.15

THESE DISCHARGES FROM FUSEGATES ASSUME THAT THE SERVICE SPILLWAY IS OPERATING AT MAXIMUM CAPACITY.

RATING CURVE AS SHOWN SHOULD ONLY BE USED IN A RISING POOL SITUATION.

CURVE IS NOT APPLICABLE TO A FALLING POOL.

INSET CHART IS FOR DISCHARGE AT POOL ELEVATIONS BETWEEN 1638 AND 1640.5, AND USES THE SAME UNITS AS THE MAIN CHART.

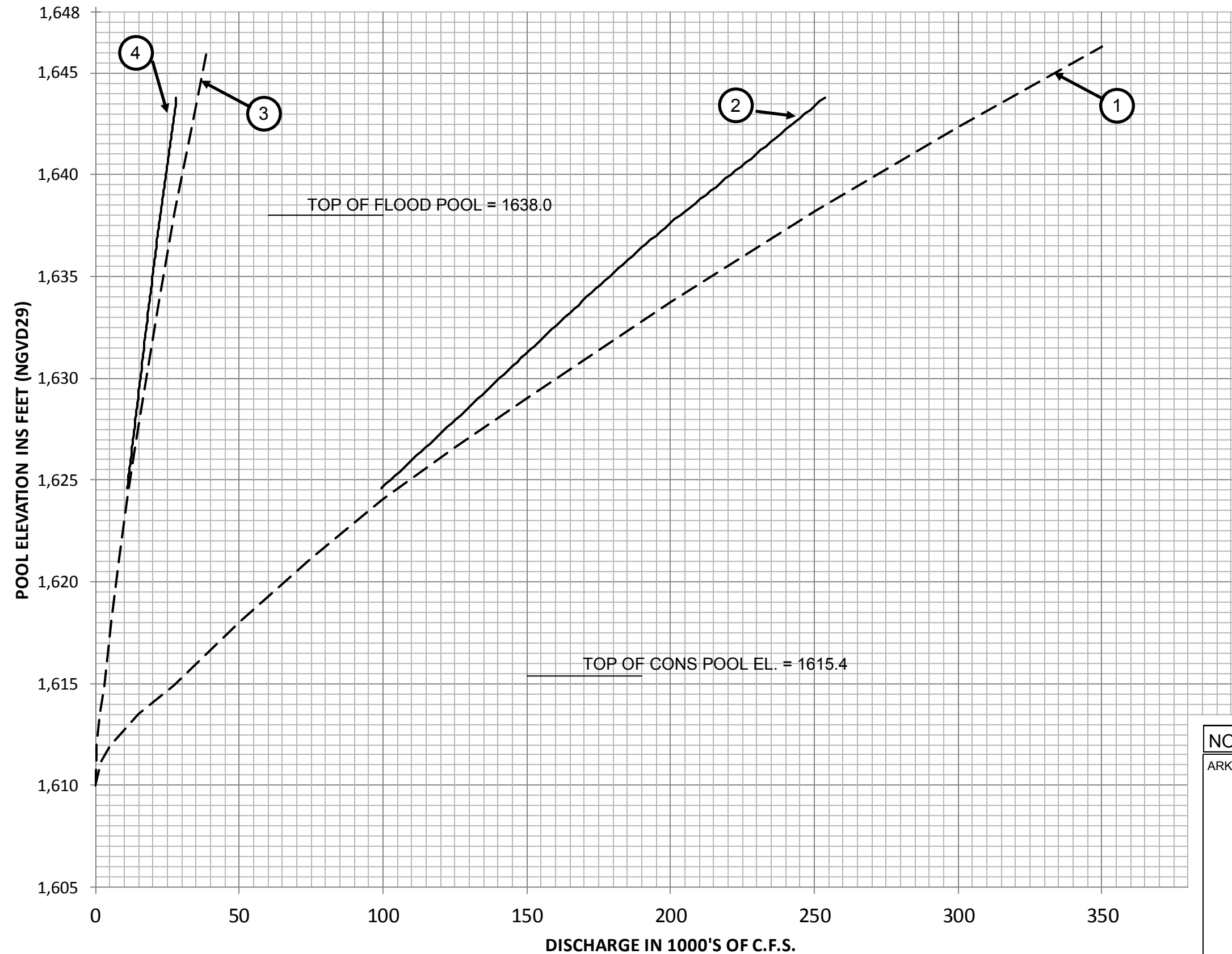
NOTE: PLATE SIZE IS 11" X 17"

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**

**AUXILIARY SPILLWAY RATING CURVE**

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:



**NOTES:**

These curves show the rating curve for the auxiliary spillway if the fusegates have tipped. Flow is dependent on the number of fusegates that have tipped, and if the tainter gates in the service spillway are fully operational at maximum capacity.

All fuse gates are identical, so if only some gates are down, multiply the without fuse gate discharge from curve 1 or 2 by the percentage of gates that have tipped.  
 (Ex: Discharge for 4 gates =  $[4/9] \times \text{Discharge Shown}$ )

**LEGEND:**

- 1) 9 fusegates tipped, without operational tainter gates
- 2) 9 fusegates tipped with operational tainter gates
- 3) 1 fusegate tipped without operational tainter gates
- 4) 1 fusegate tipped with operational tainter gates

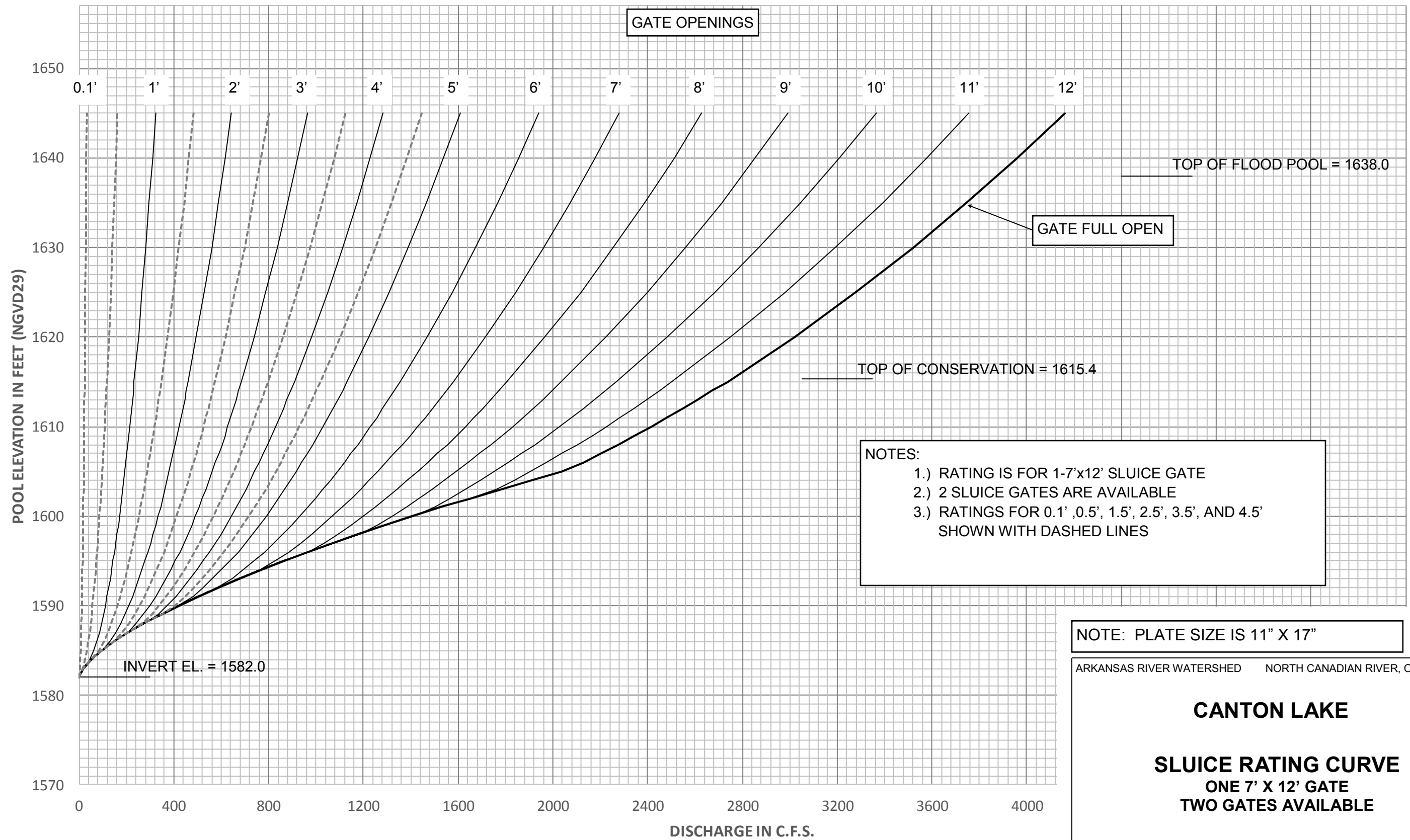
NOTE: PLATE SIZE IS 11" X 17"

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**

**AUXILIARY SPILLWAY RATING  
CURVE w/o FUSEGATES  
BELOW TOP OF FLOOD POOL**

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:



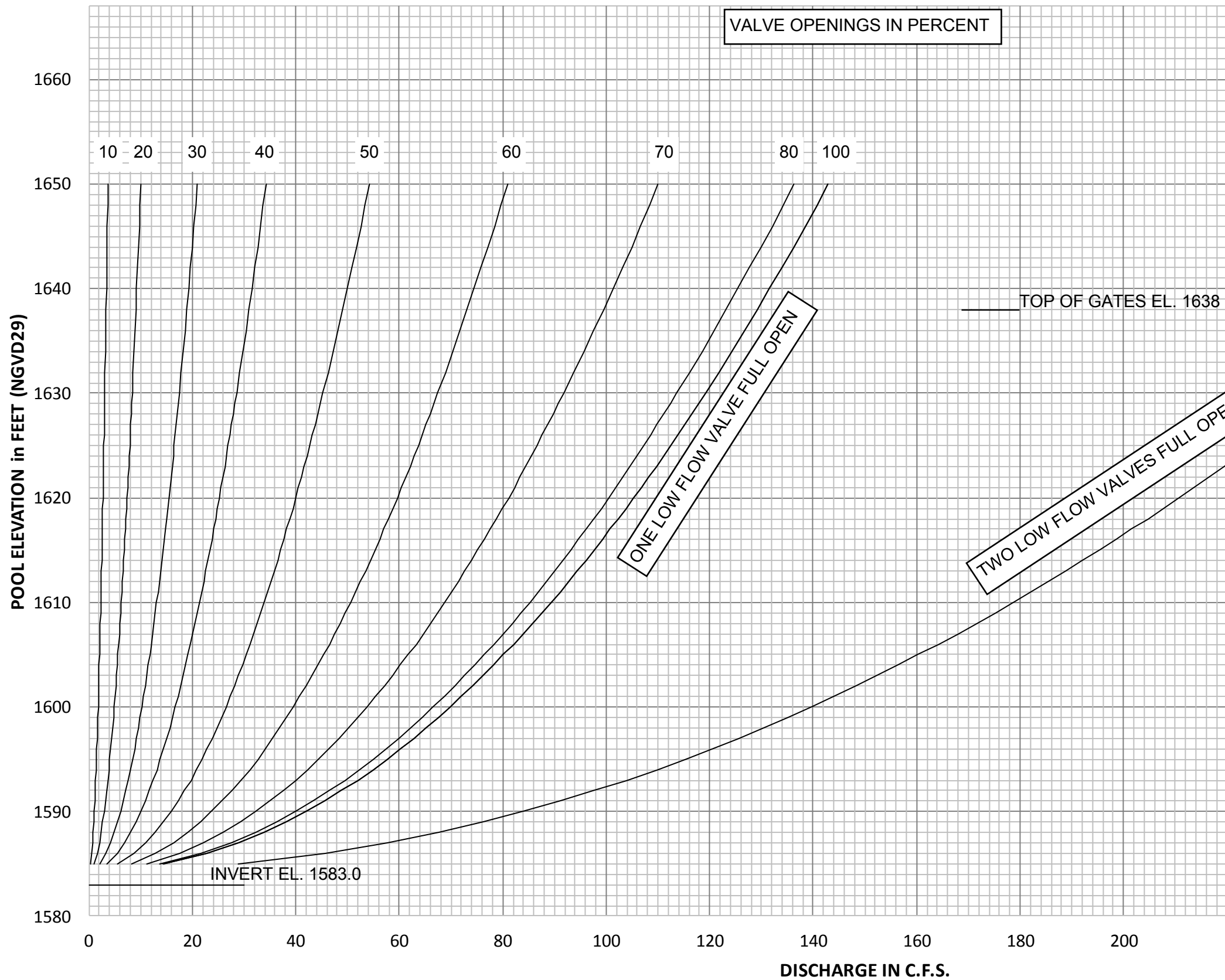
NOTE: PLATE SIZE IS 11" X 17"

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**

**SLUICE RATING CURVE  
ONE 7' X 12' GATE  
TWO GATES AVAILABLE**

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
Drawn:  
Checked:



NOTE:  
 CURVE SHOWS PARTIAL OPENINGS  
 FOR ONE LOW FLOW VALVE AND  
 TWO LOW FLOW VALVES FULL OPEN

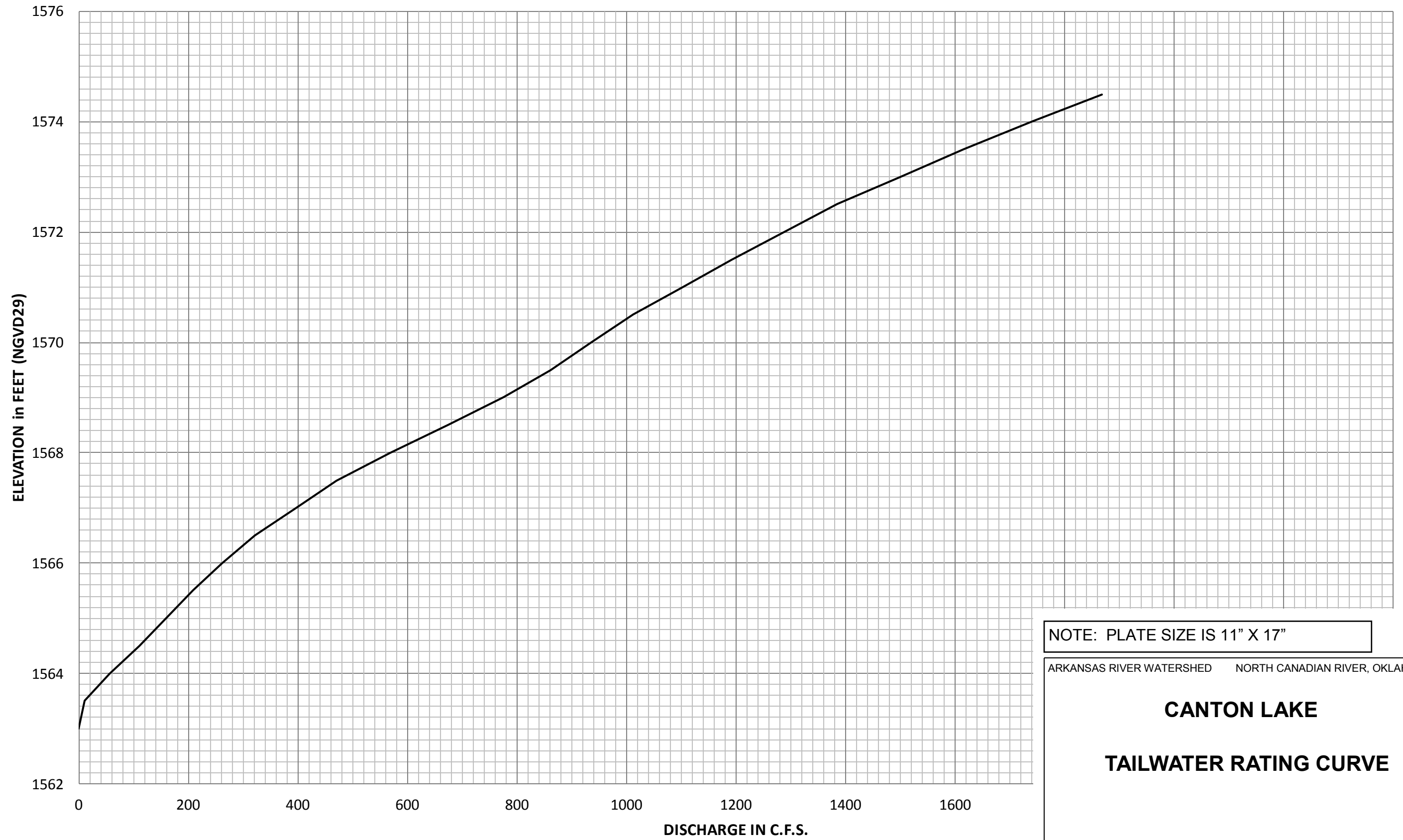
NOTE: PLATE SIZE IS 11" X 17"

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**

**DISCHARGE RATING CURVE  
 24" LOW FLOW PIPES**

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:

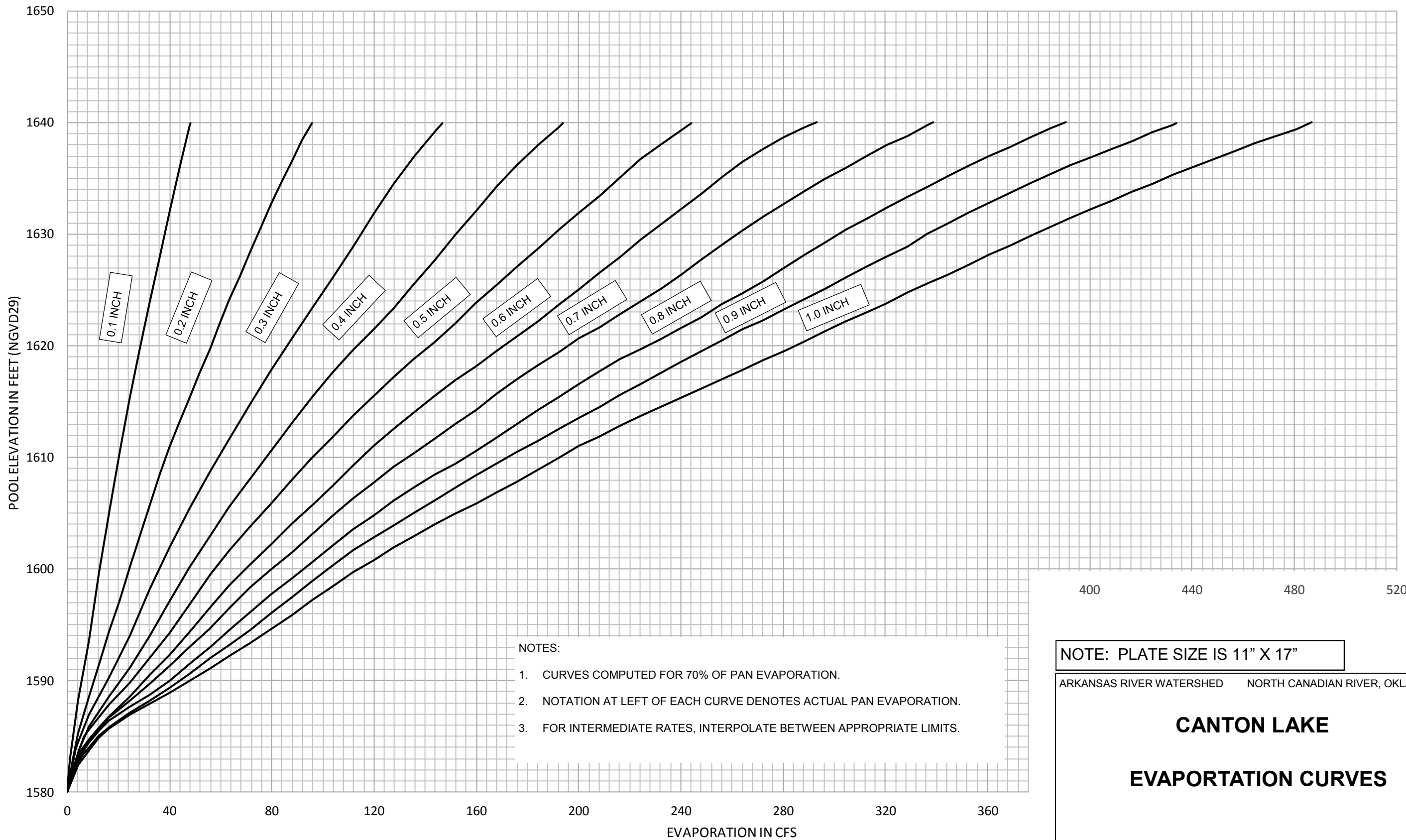


NOTE: PLATE SIZE IS 11" X 17"

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**  
**TAILWATER RATING CURVE**

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:



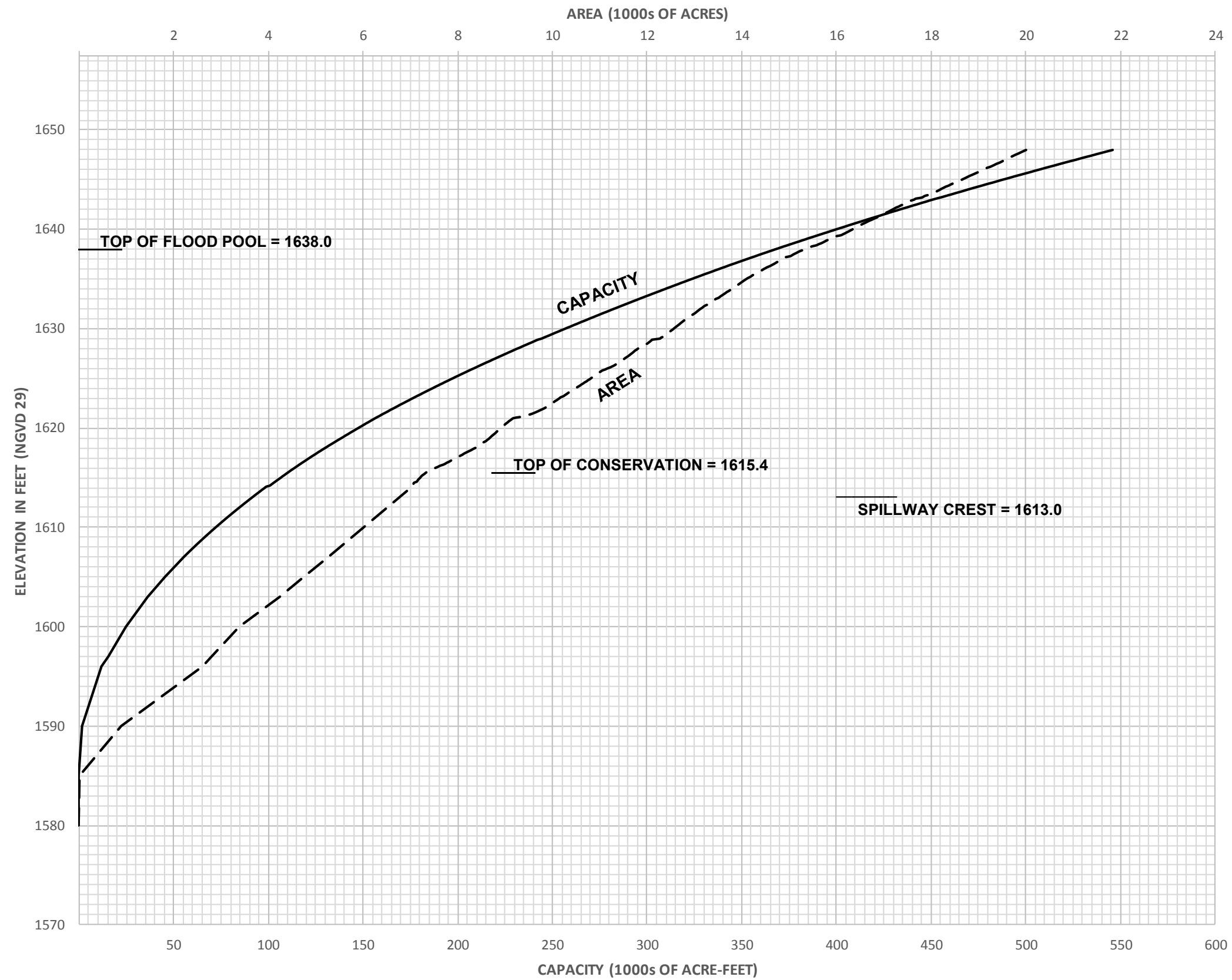
- NOTES:
1. CURVES COMPUTED FOR 70% OF PAN EVAPORATION.
  2. NOTATION AT LEFT OF EACH CURVE DENOTES ACTUAL PAN EVAPORATION.
  3. FOR INTERMEDIATE RATES, INTERPOLATE BETWEEN APPROPRIATE LIMITS.

NOTE: PLATE SIZE IS 11" X 17"

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**  
**EVAPORTATION CURVES**

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:



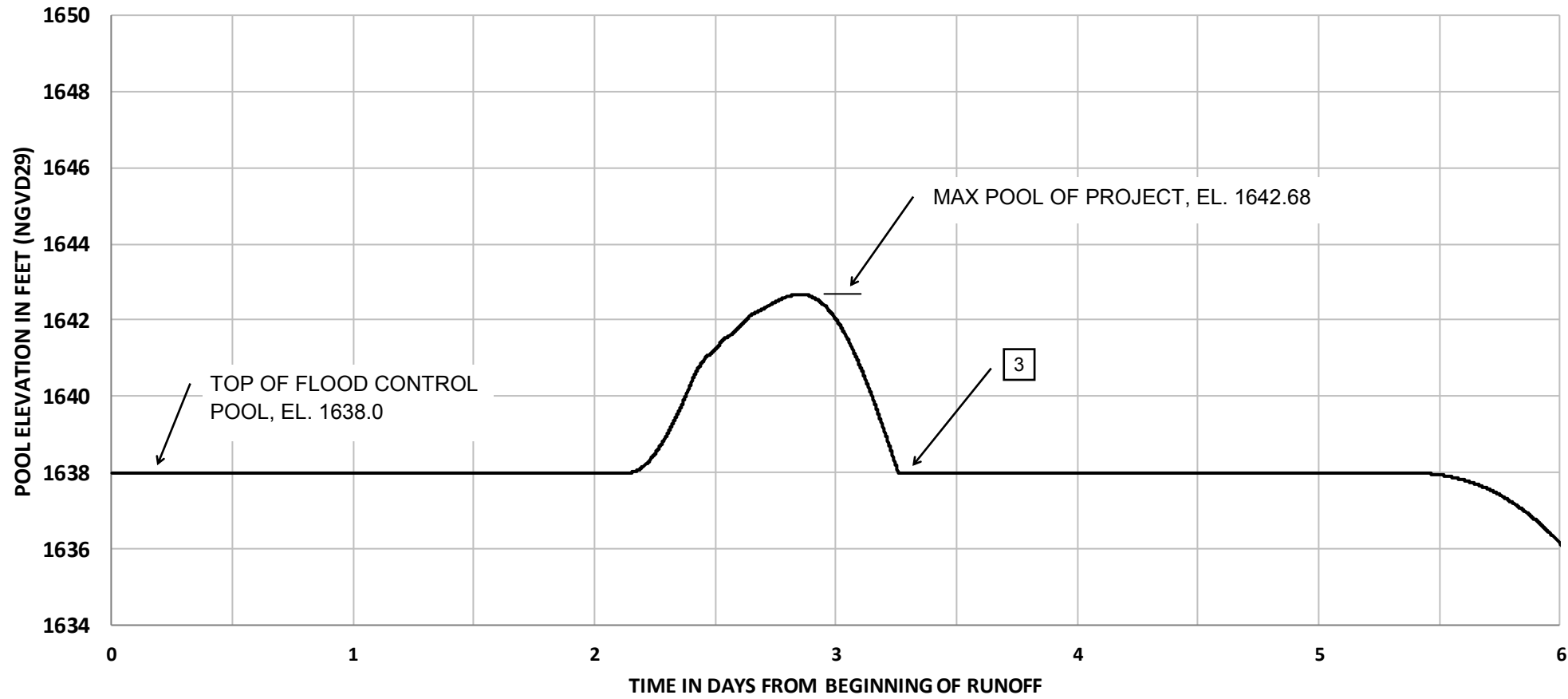
Based on 1977 Conservation Pool Resurvey and 2010 Flood Pool LiDAR Survey

NOTE: Plate size is 11" x 17"

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**  
**ELEVATION - AREA - CAPACITY**  
**CURVES**

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:



**NOTES: EMERGENCY OPERATIONS**

PEAK INFLOW IS **634,001 CFS**

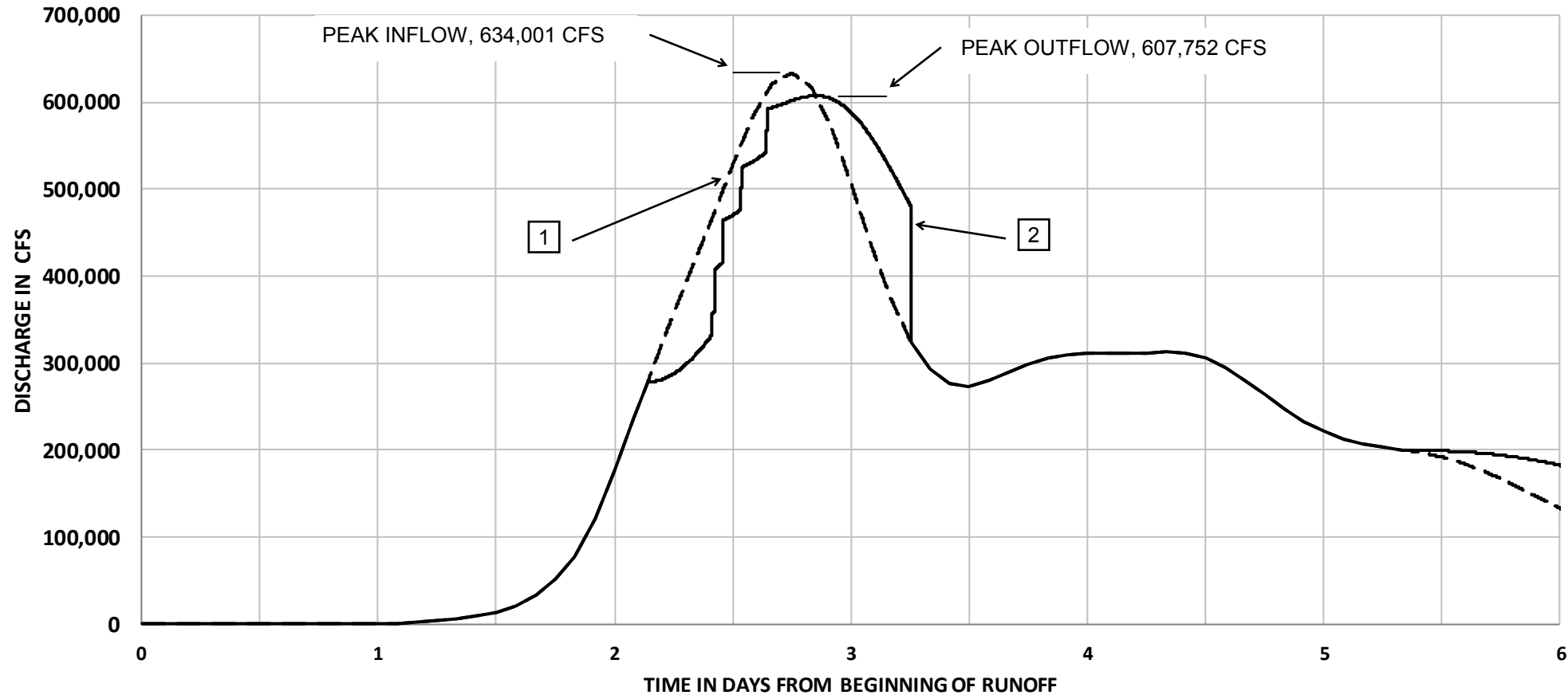
PEAK OUTFLOW IS **607,752 CFS**

MAXIMUM POOL ELEVATION IS **1642.68 FEET**

ALL 9 FUSEGATES HAVE TIPPED

FLOOD POOL IS ASSUMED TO BE FULL AT THE BEGINNING OF THE EVENT

SIMULATED DISCHARGE HYDROGRAPH IS NOT AN ACTUAL RELEASE PLAN.



**LEGEND:**

- 1. INFLOW HYDROGRAPH
- 2. SIMULATED DISCHARGE HYDROGRAPH
- 3. POOL ELEVATION

NOTE: Plate size is 11" x 17"

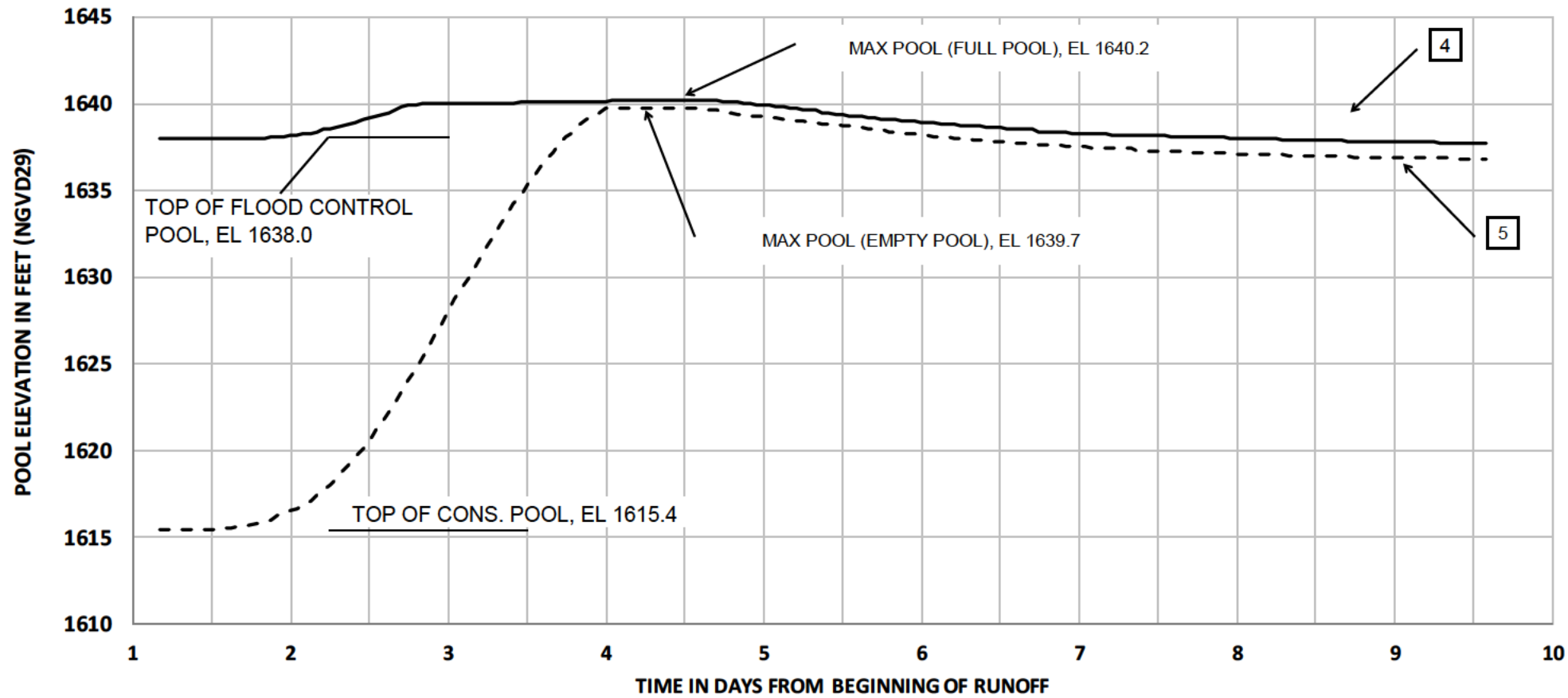
ARKANSAS RIVER WATERSHED    NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**

**OPERATIONAL HYDROGRAPHS**

PROBABLE MAXIMUM FLOOD (PMF)

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:



**NOTES: EMERGENCY OPERATIONS**

PEAK INFLOW IS **185,000 CFS**

PEAK OUTFLOW (FULL POOL) IS **184,423 CFS**

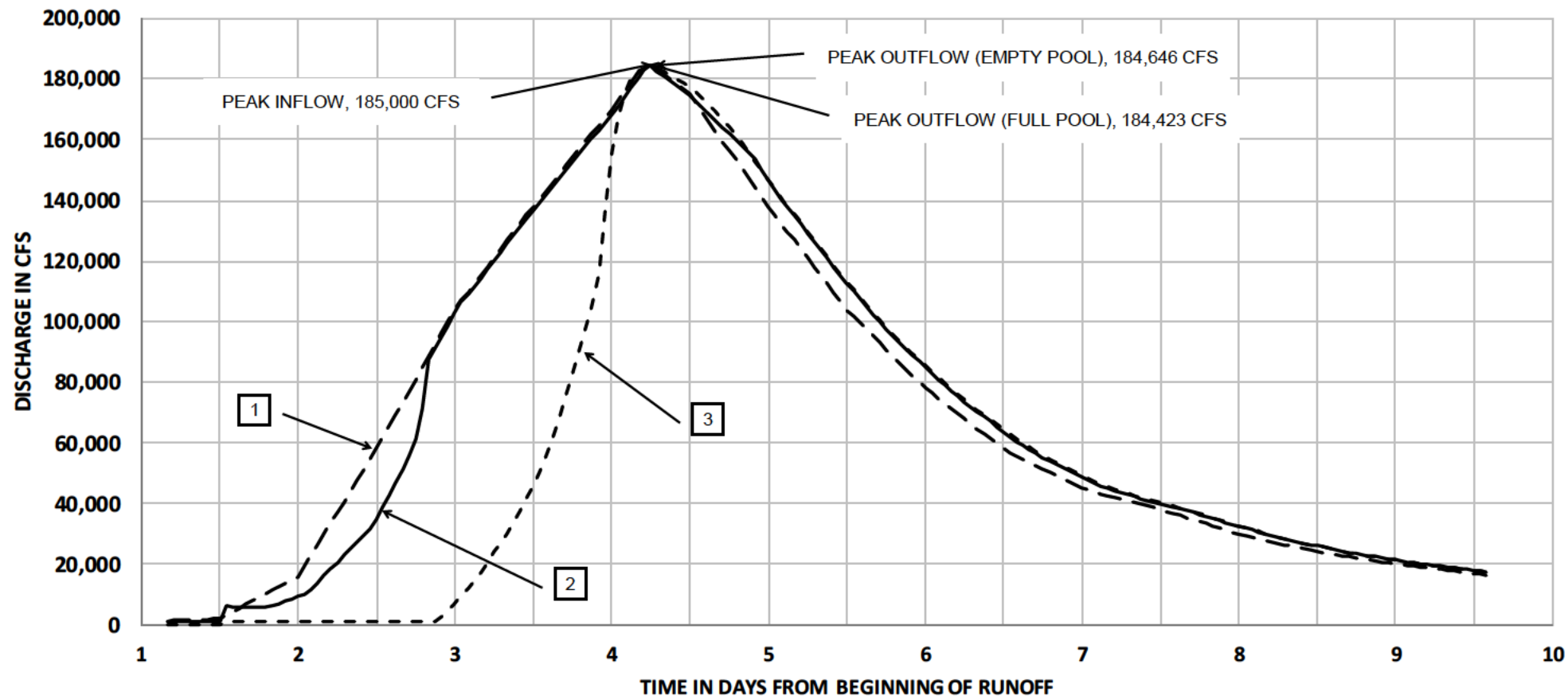
PEAK OUTFLOW (EMPTY POOL) IS **184,646 CFS**

MAX POOL ELEV (FULL POOL) IS **1,640.2 FEET**

MAX POOL ELEV (EMPTY POOL) IS **1,639.7 FEET**

NO FUSEGATES HAVE TIPPED, BUT THERE IS UNCONTROLLED SPILL OVER THE TOP OF THE FUSEGATES

**THE STANDARD PROJECT FLOOD CORRESPONDS TO 1/2 THE ORIGINAL SPILLWAY DESIGN FLOOD, WHICH WAS ROUTED WITH FUSEGATE AUXILIARY SPILLWAY PRESENT.**



**LEGEND:**

1. INFLOW HYDROGRAPH
2. SIMULATED DISCHARGE HYDROGRAPH (FULL POOL)
3. SIMULATED DISCHARGE HYDROGRAPH (EMPTY POOL)
4. POOL ELEVATION (FULL POOL)
5. POOL ELEVATION (EMPTY POOL)

NOTE: Plate size is 11" x 17"

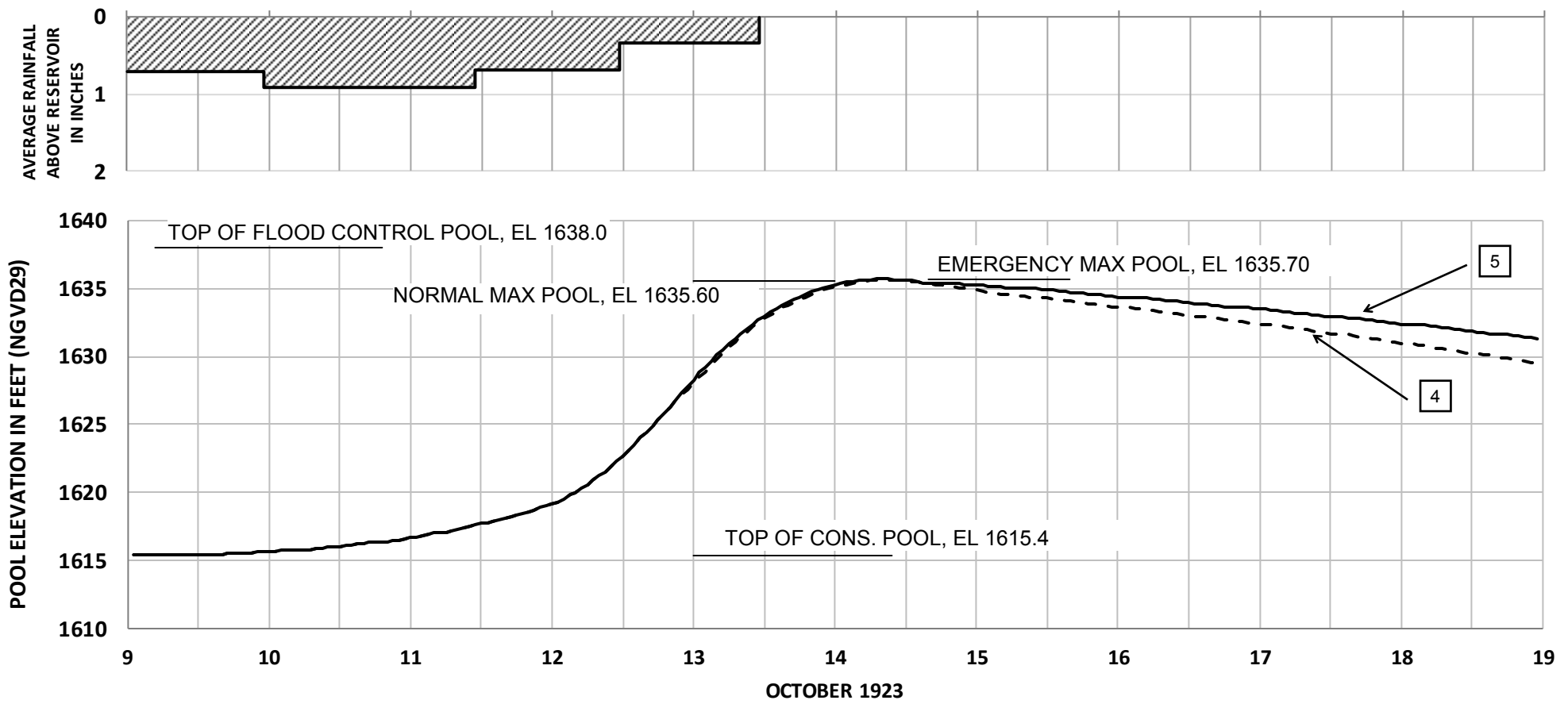
ARKANSAS RIVER WATERSHED    NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**

**OPERATIONAL HYDROGRAPHS**

STANDARD PROJECT FLOOD

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:



**NOTES:**

PEAK INFLOW WAS **87,500 CFS** ON **13 OCT 1923** AT **0600 HOURS**

NORMAL REGS PEAK OUTFLOW WAS **38,990 CFS** ON **14 OCT 1923** AT **0500 HOURS**

EMERGENCY REGS PEAK OUTFLOW WAS **40,989 CFS** ON **14 OCT 1923** AT **0300 HOURS**

NORMAL REGS. MAXIMUM POOL ELEVATION WAS **1,635.60 FEET**

EMERGENCY REGS. MAXIMUM POOL ELEVATION WAS **1,635.70 FEET**

FLOOD VOLUME FROM 9 OCT 1923 TO 19 OCT 1923 WAS **347,819 AC.-FT.**

HISTORICAL DATA USED FOR ROUTING WAS COLLECTED BY SWT, HYDRAULICS & HYDROLOGY BRANCH, TECHNICAL SERVICES SECTION

**LEGEND:**

1. INFLOW HYDROGRAPH.
2. SIMULATED DISCHARGE HYDROGRAPH, NORMAL REGS (—)
3. SIMULATED DISCHARGE HYDROGRAPH, EMERGENCY REGS (—)
4. POOL ELEVATION, NORMAL REGS.
5. POOL ELEVATION, EMERGENCY REGS

NOTE: Plate size is 11" x 17"

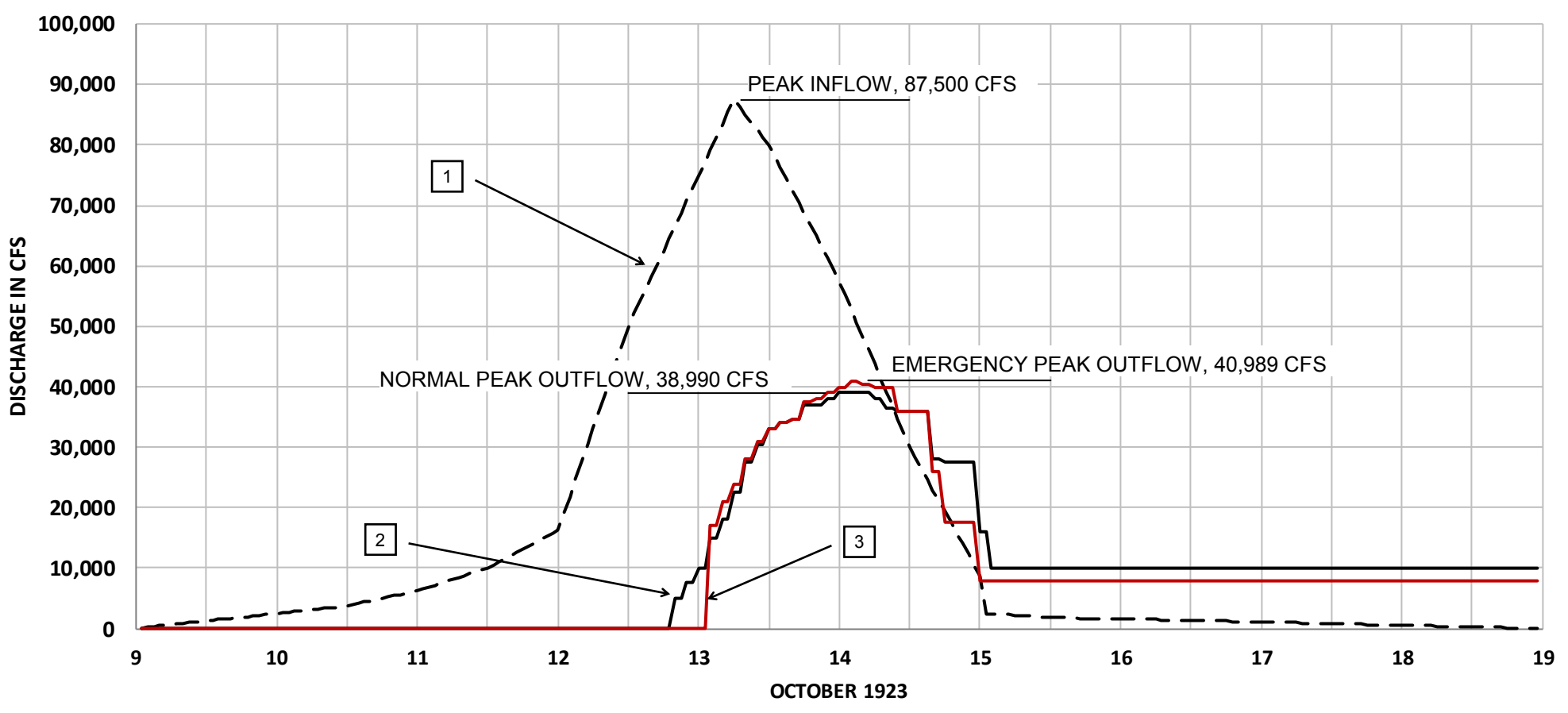
ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

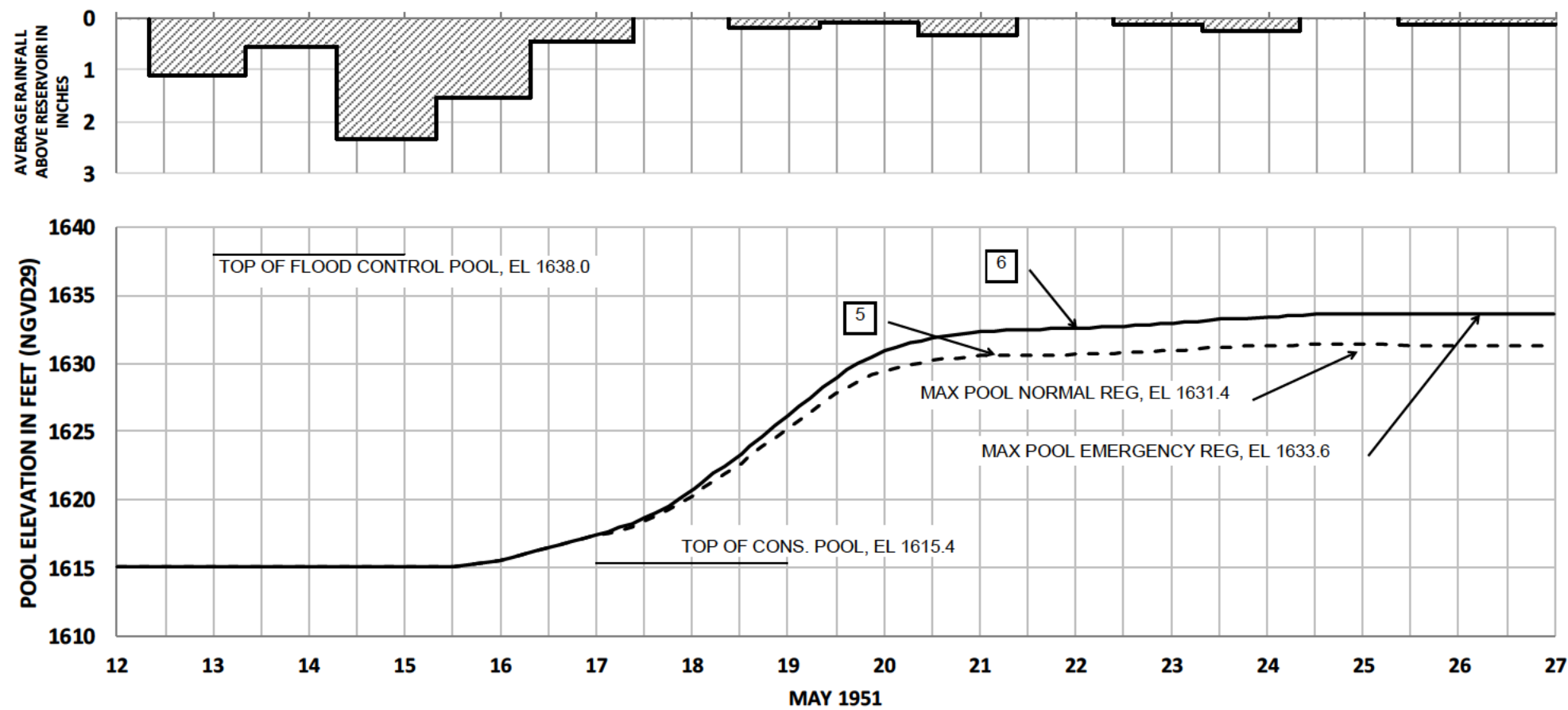
**CANTON LAKE**

**OPERATIONAL HYDROGRAPHS**

FLOOD OF OCTOBER 1923

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:





**NOTES:**

NORMAL REGS. PEAK INFLOW WAS **31,400 CFS** ON **19 MAY 1951**

EMERGENCY REGS. PEAK INFLOW WAS **34,600 CFS** ON **19 MAY 1951**

PEAK OUTFLOW WAS **1,040 CFS** ON FOR BOTH EVENTS

NORMAL REGS. MAXIMUM POOL ELEVATION WAS **1,631.40 FEET**

EMERGENCY REGS. MAXIMUM POOL ELEVATION WAS **1,633.60 FEET**

FLOOD VOLUME FROM 16 MAY 1951 TO 21 MAY 1951 WAS **193,900 AC.-FT.**

HISTORICAL DATA USED FOR ROUTING WAS COLLECTED BY SWT, HYDRAULICS & HYDROLOGY BRANCH, TECHNICAL SERVICES SECTION

**LEGEND:**

- 1. INFLOW HYDROGRAPH, NORMAL REGS.
- 2. INFLOW HYDROGRAPH, EMERGENCY REGS.
- 3. DISCHARGE, NORMAL REGS (—)
- 4. DISCHARGE, EMERGENCY REGS (—)
- 5. MAX POOL, NORMAL REGS.
- 6. MAX POOL, EMERGENCY REGS.

NOTE: Plate size is 11" x 17"

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**

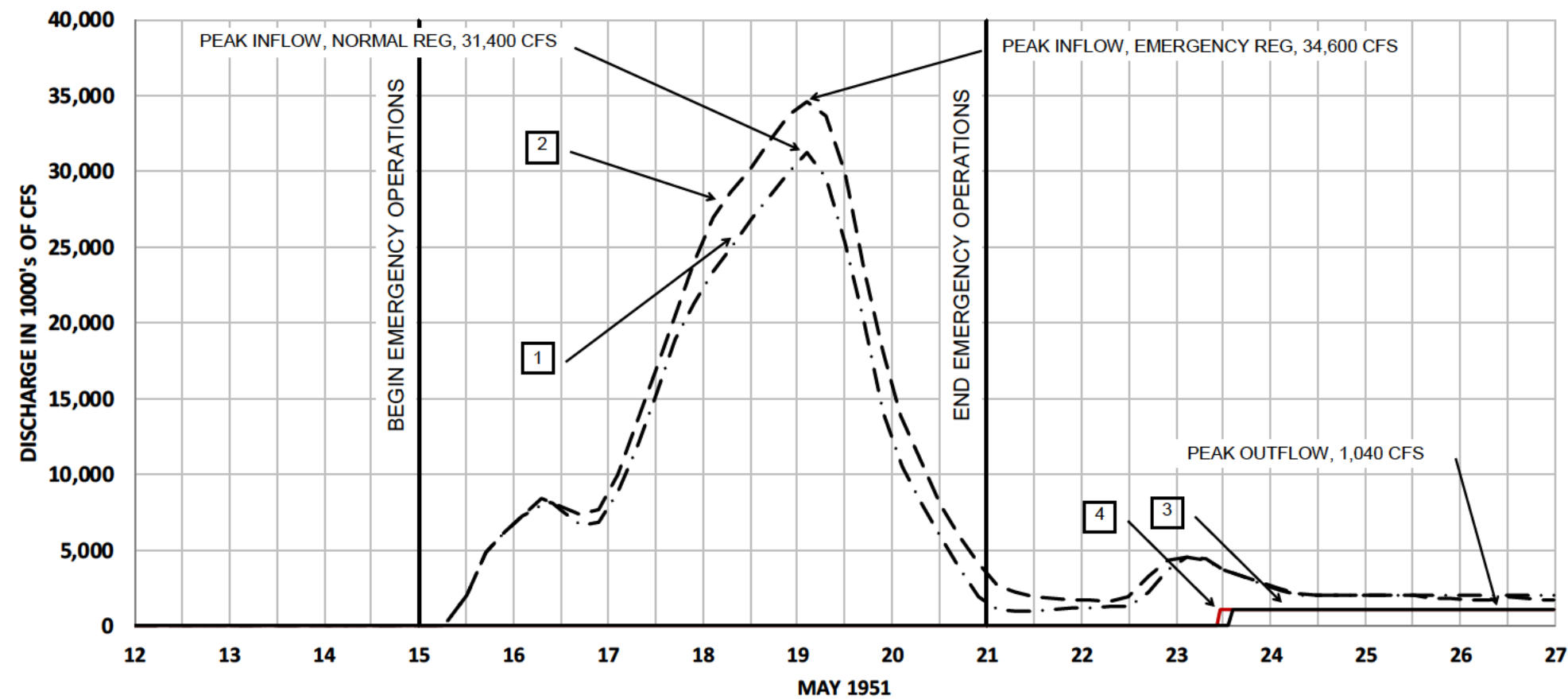
**OPERATIONAL HYDROGRAPHS**

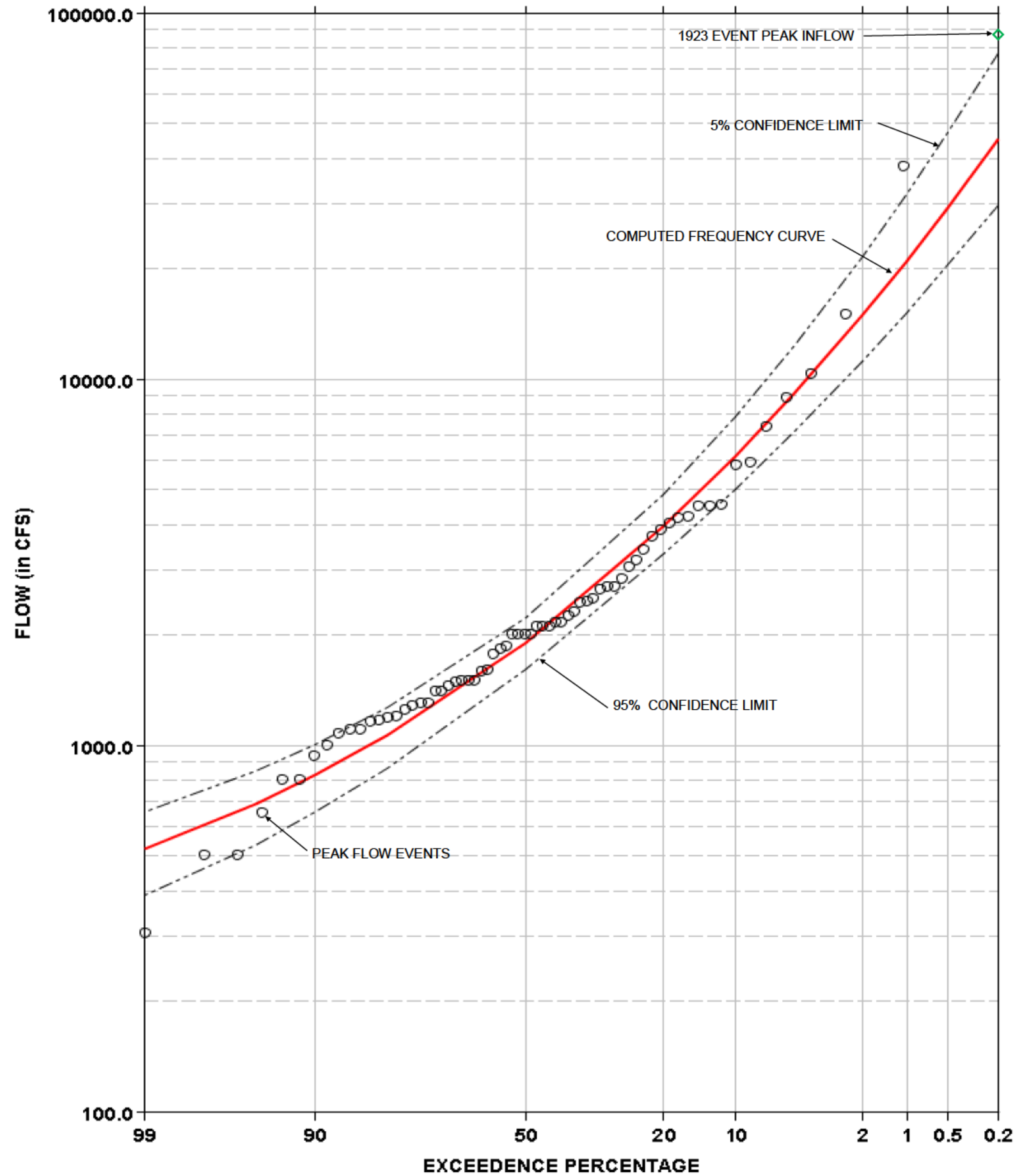
FLOOD OF MAY 1951

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015

Drawn:

Checked:





1923 EVENT WAS NOT USED IN THE ANALYSIS, AND IS SHOWN FOR REFERENCE.

- NOTE:
1. BASED ON OBSERVED PERIOD OF RECORD: AUG 1948 TO DEC 2014
  2. BULLETIN NO. 17B "GUIDELINES FOR DETERMINING FLOOD FLOW FREQUENCY WAS USED
  3. FT SUPPLY DAM WAS OPERATIONAL FOR THE ENTIRE PERIOD OF RECORD; OPTIMA DAM MAY HAVE INFLUENCED DATA AFTER 1978

NOTE: Plate size is 11" x 17"

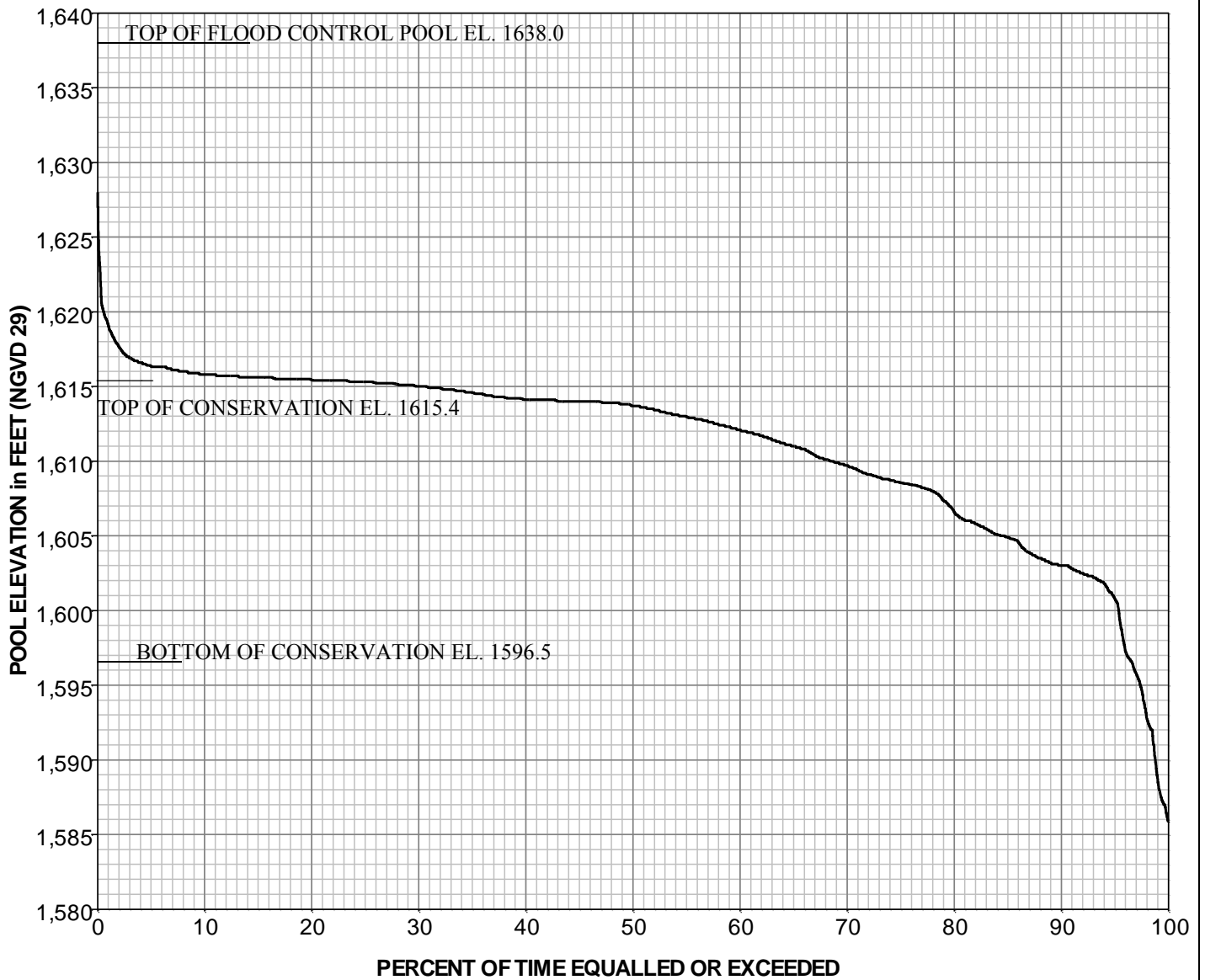
ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**

**PEAK INFLOW**

**PROBABILITY CURVE**

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015  
 Drawn:  
 Checked:



NOTES:

BASED ON THE PERIOD OF RECORD:  
1948 TO 2015

OBSERVED DATA USED FOR ANALYSIS

FT SUPPLY DAM WAS OPERATIONAL  
FOR THE ENTIRE PERIOD OF RECORD

NO ADJUSTMENT WAS MADE TO  
ACCOUNT FOR CONSTRUCTION OF  
OPTIMA DAM IN 1978 OR CHANGES IN  
CONSERVATION POOL ELEVATION  
SINCE 1948

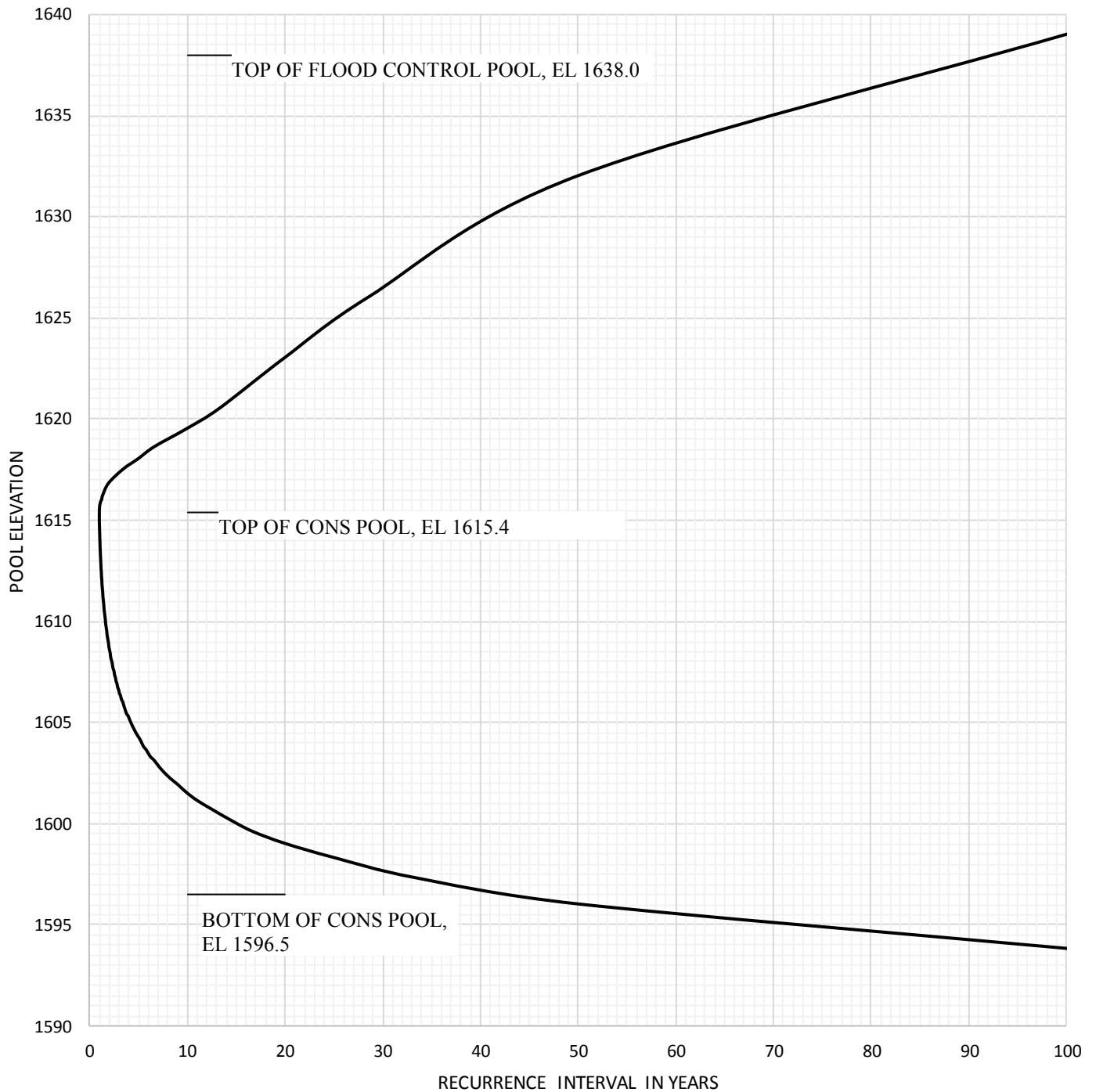
ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**  
**POOL ELEVATION**  
**DURATION CURVE**

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015

Drawn:

Checked:



**NOTES:**

1. BELOW TOP OF CONSERVATION POOL, THE CURVE IS BASED ON OBSERVED DATA FROM THE PERIOD OF RECORD OCT. 1948 THRU SEP. 2014
2. ABOVE TOP OF CONSERVATION THE CURVE INCLUDES SIMULATED HISTORICAL DATA FROM BEFORE 1948.

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

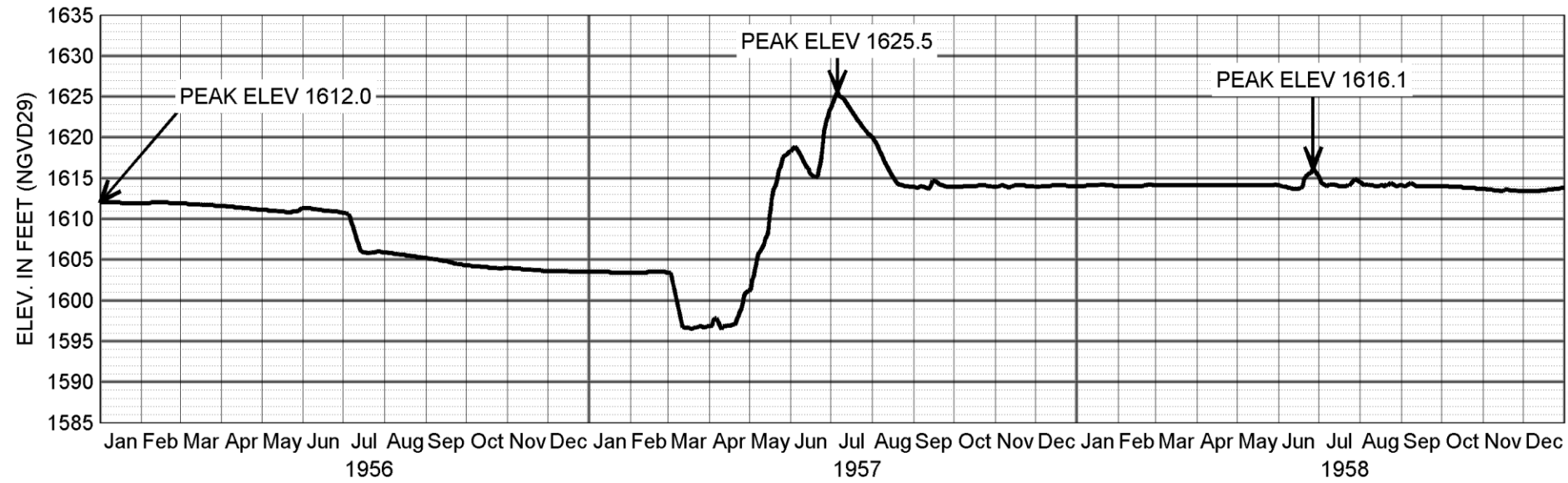
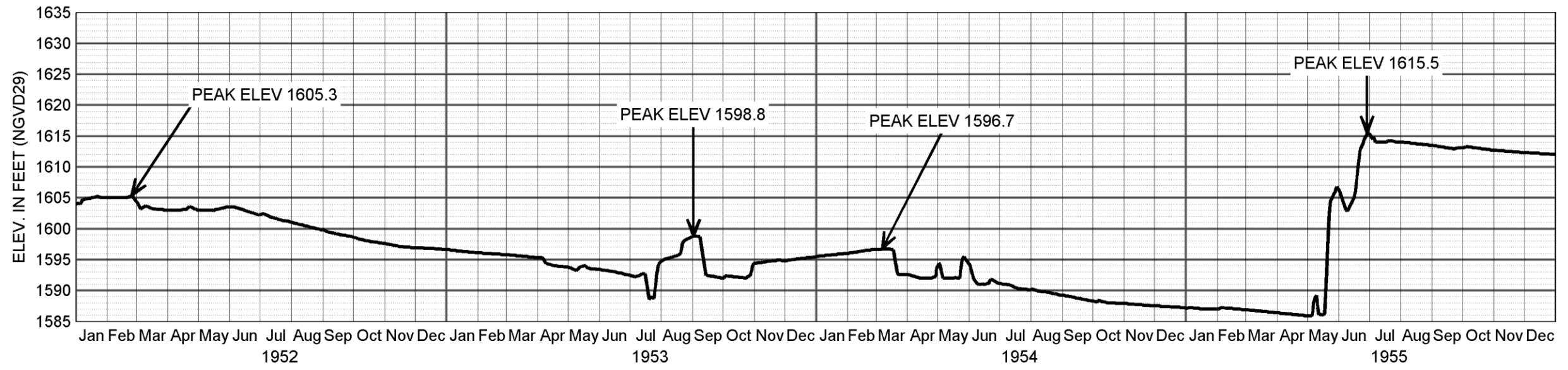
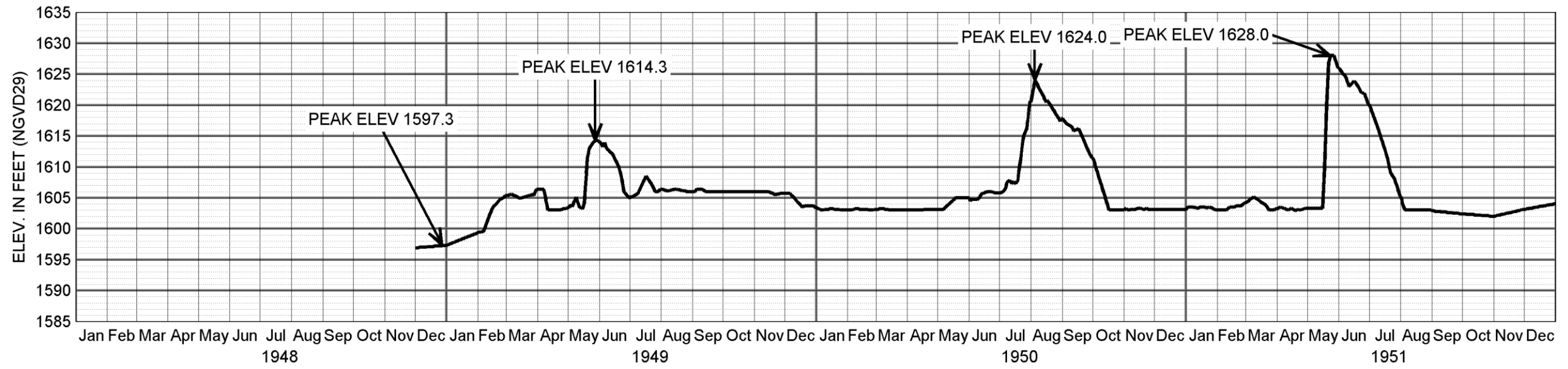
## CANTON LAKE

### POOL ELEVATION PROBABILITY CURVE

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2015

Drawn:

Checked:

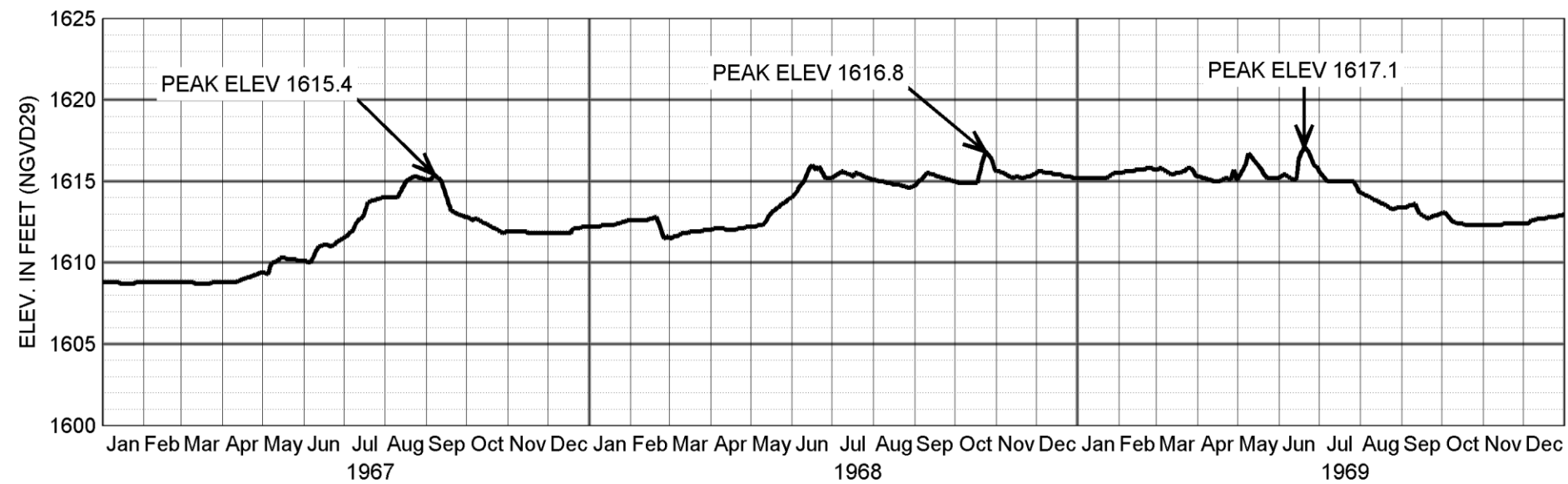
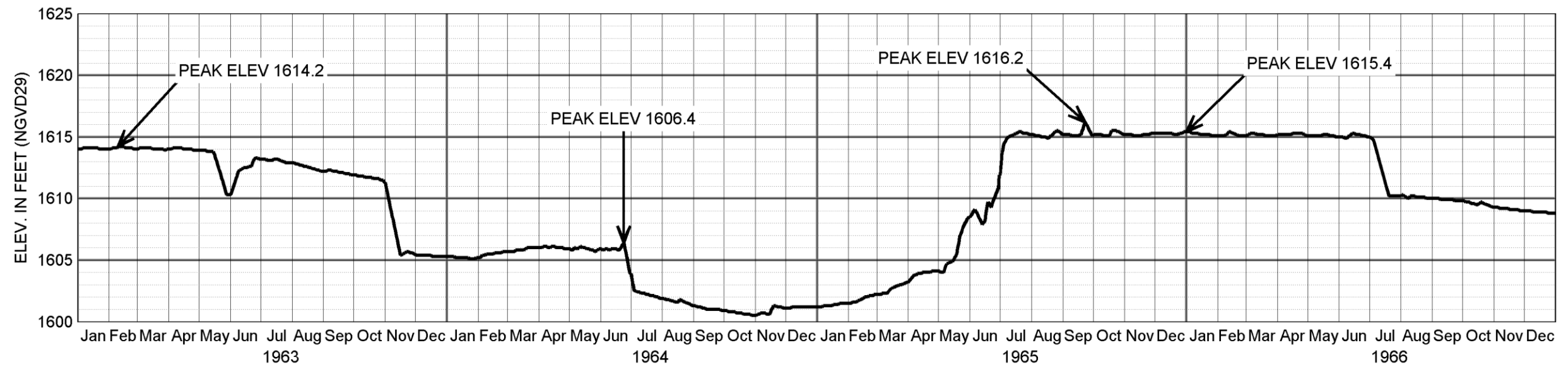
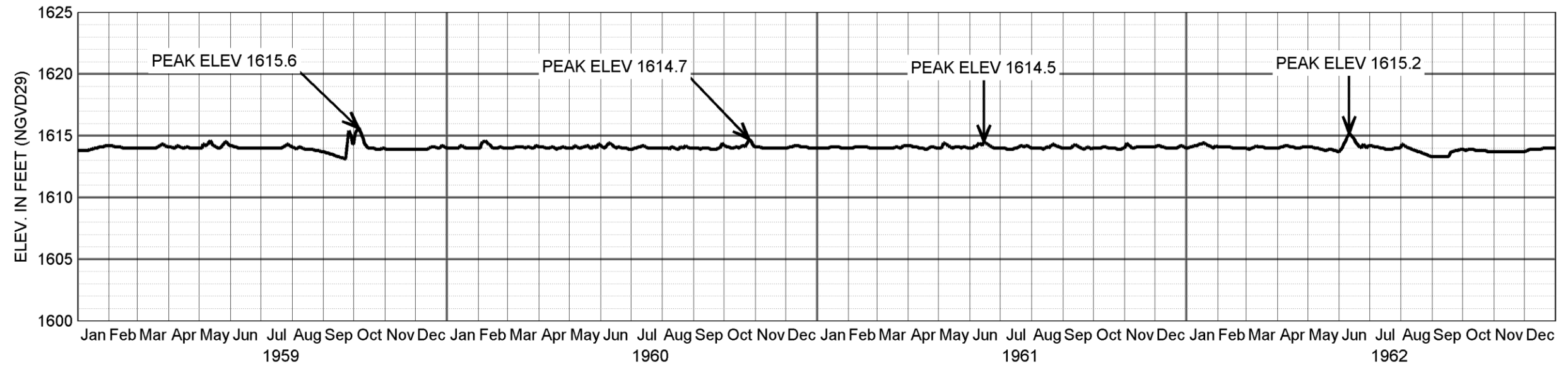


Note: Plate size is 11" x 17"

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**  
**POOL ELEVATION**  
**HYDROGRAPHS**  
**1948 - 1958**

DRAWN BY WEST CONSULTANTS GB  
 CHECKED BY WEST CONSULTANTS KJF

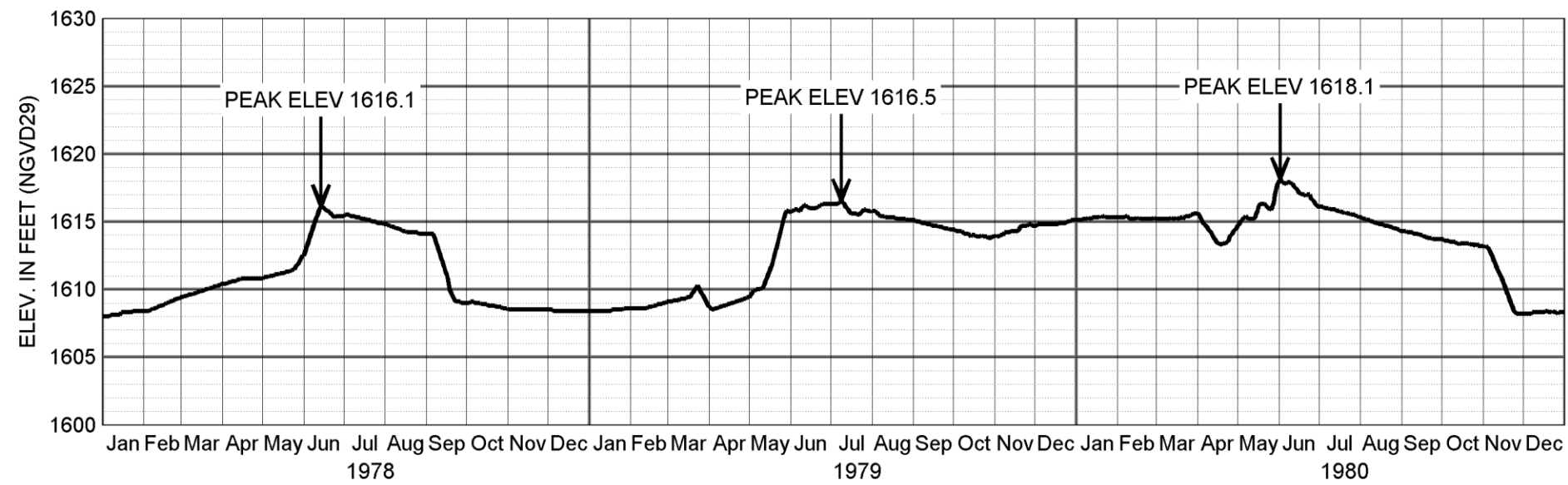
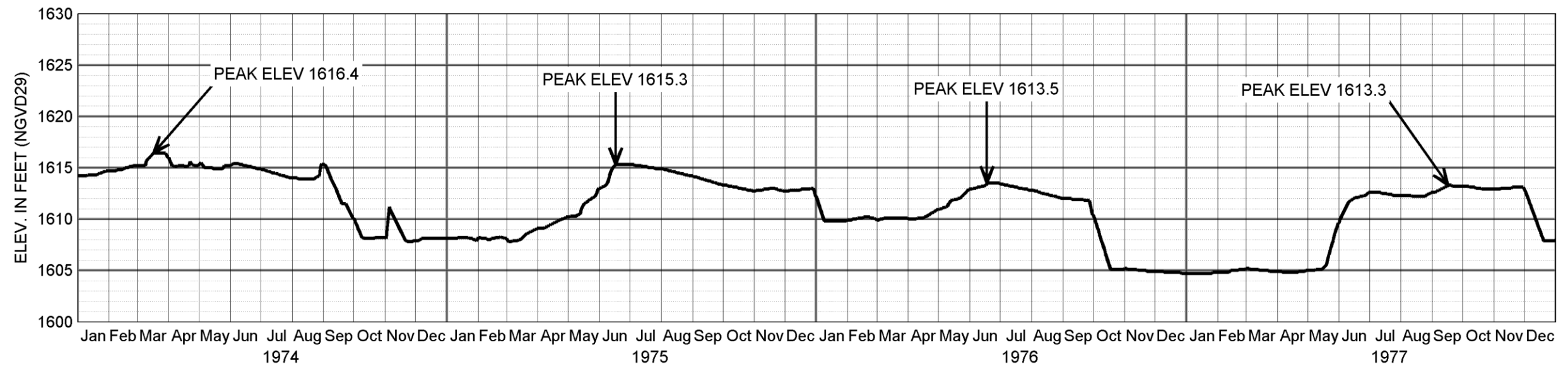
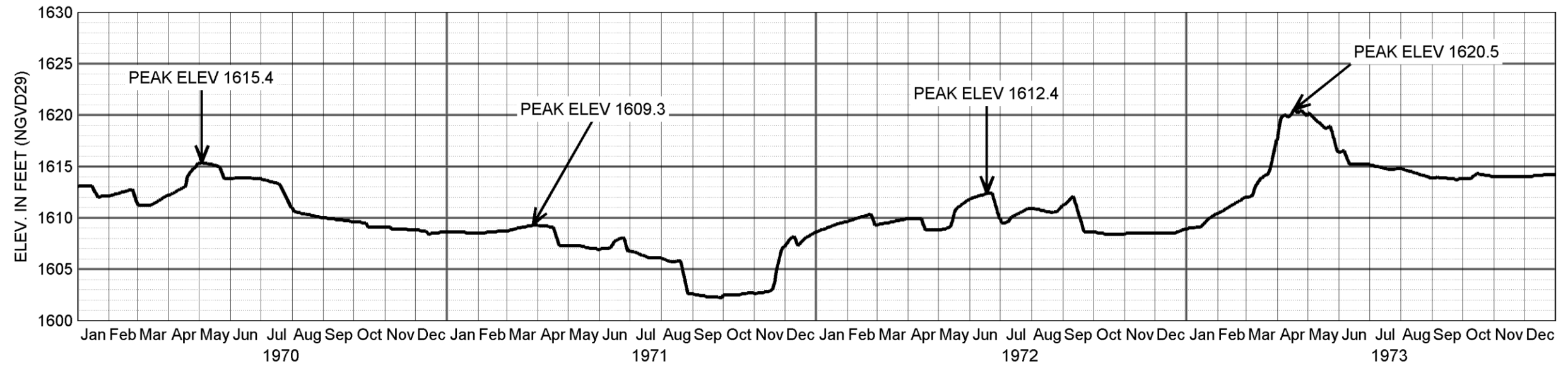


Note: Plate size is 11" x 17"

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**  
**POOL ELEVATION**  
**HYDROGRAPHS**  
**1959 - 1969**

DRAWN BY WEST CONSULTANTS GB  
CHECKED BY WEST CONSULTANTS KJF



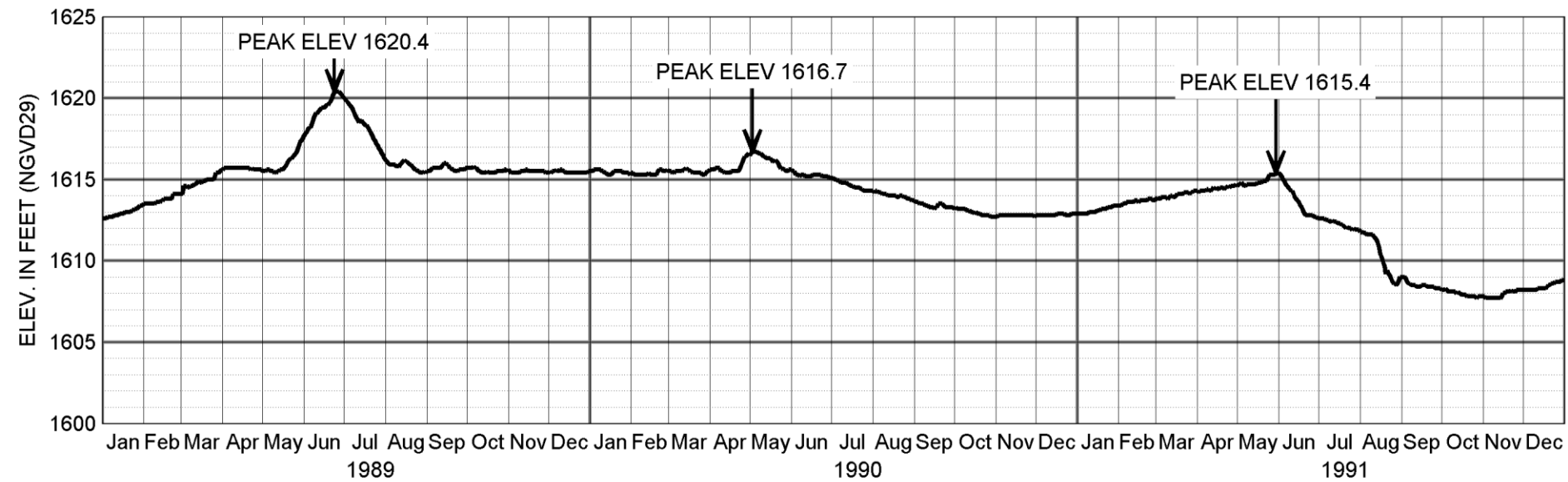
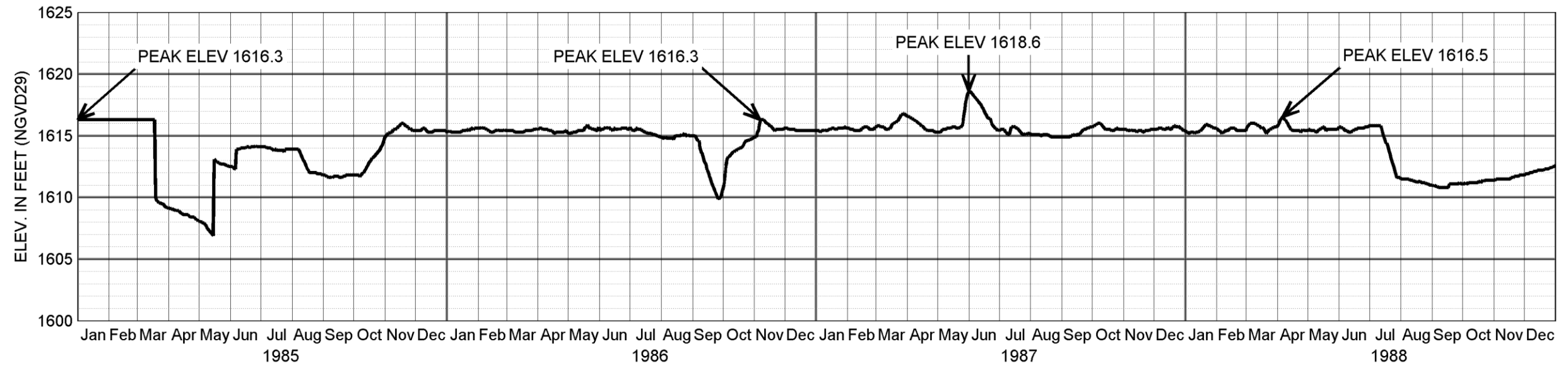
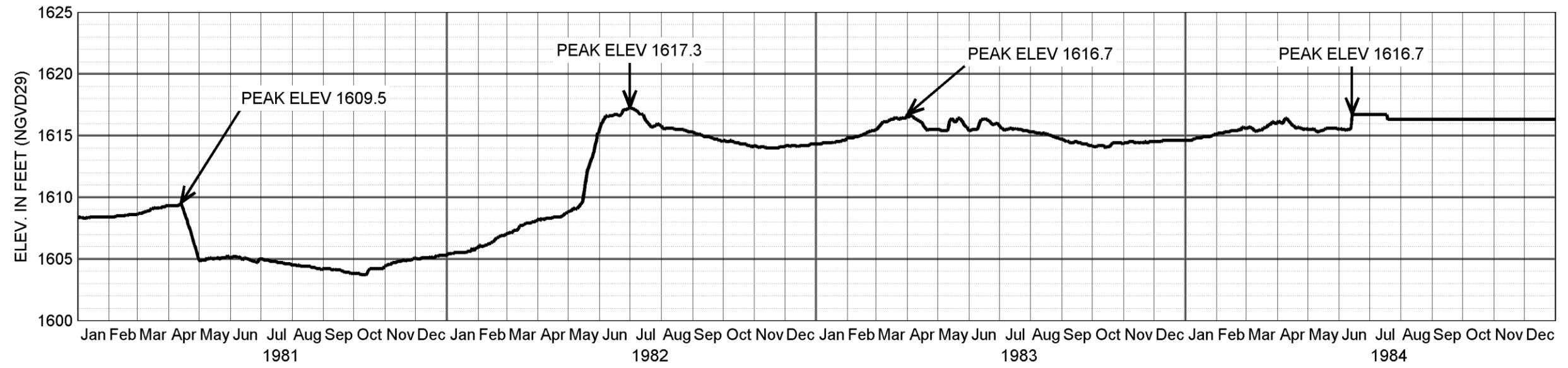
Note: Plate size is 11" x 17"

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**

**POOL ELEVATION  
HYDROGRAPHS  
1970 - 1980**

DRAWN BY WEST CONSULTANTS GB  
CHECKED BY WEST CONSULTANTS KJF

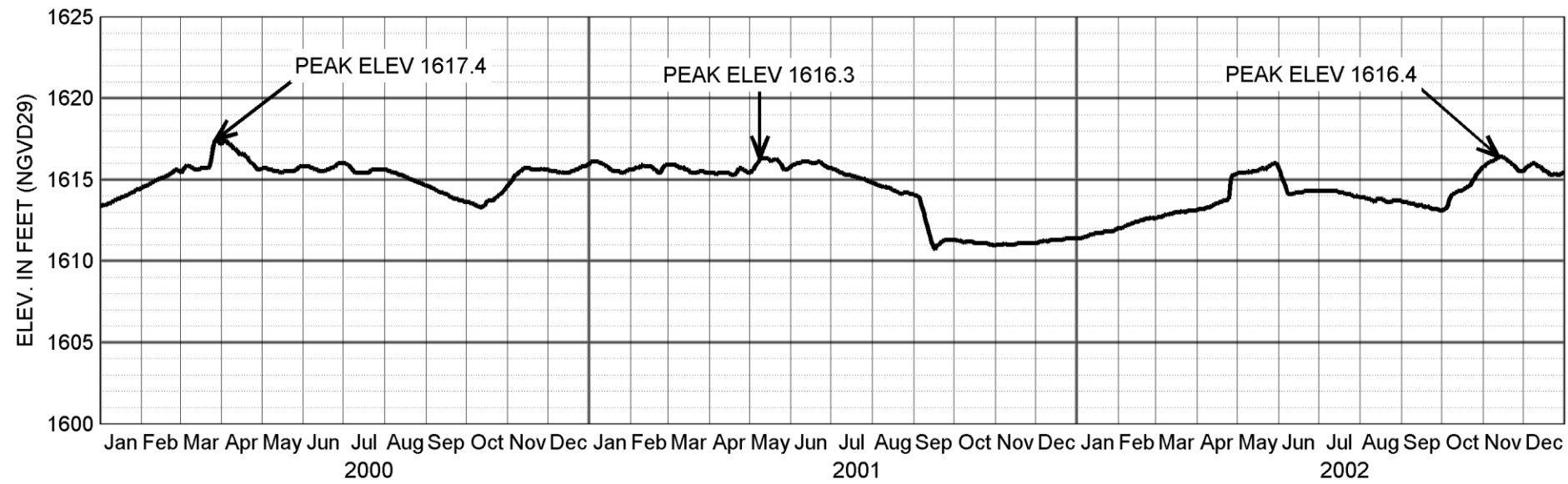
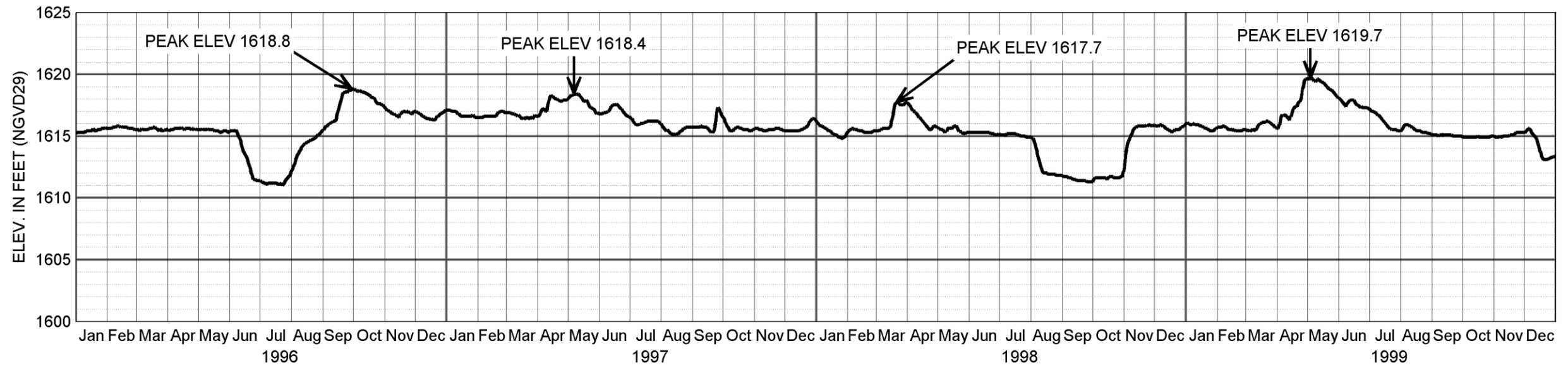
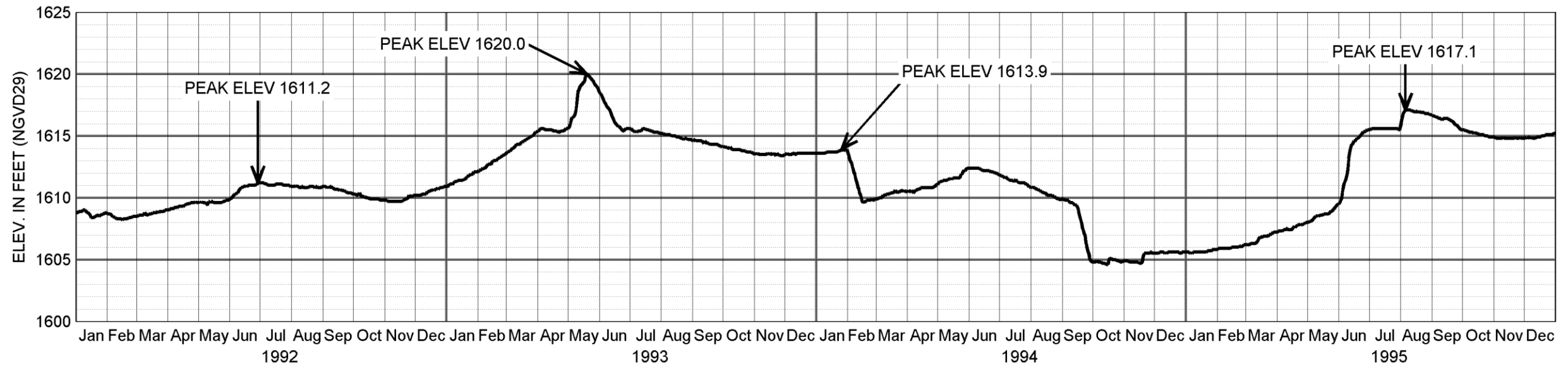


Note: Plate size is 11" x 17"

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**  
**POOL ELEVATION**  
**HYDROGRAPHS**  
**1981 - 1991**

DRAWN BY WEST CONSULTANTS GB  
 CHECKED BY WEST CONSULTANTS KJF



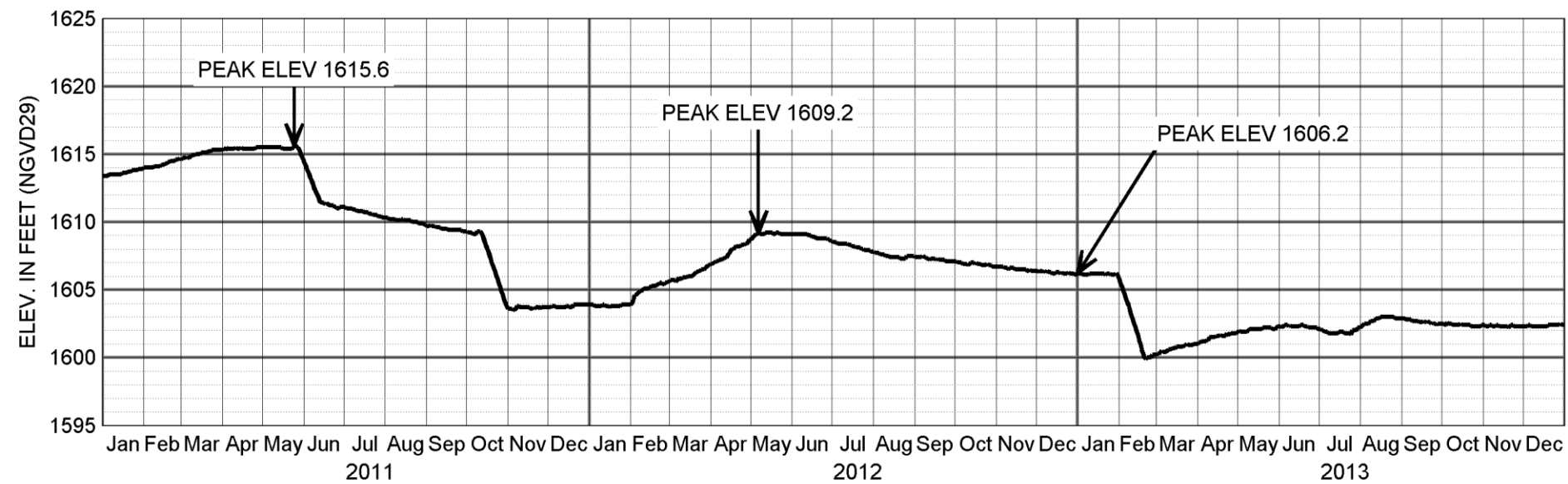
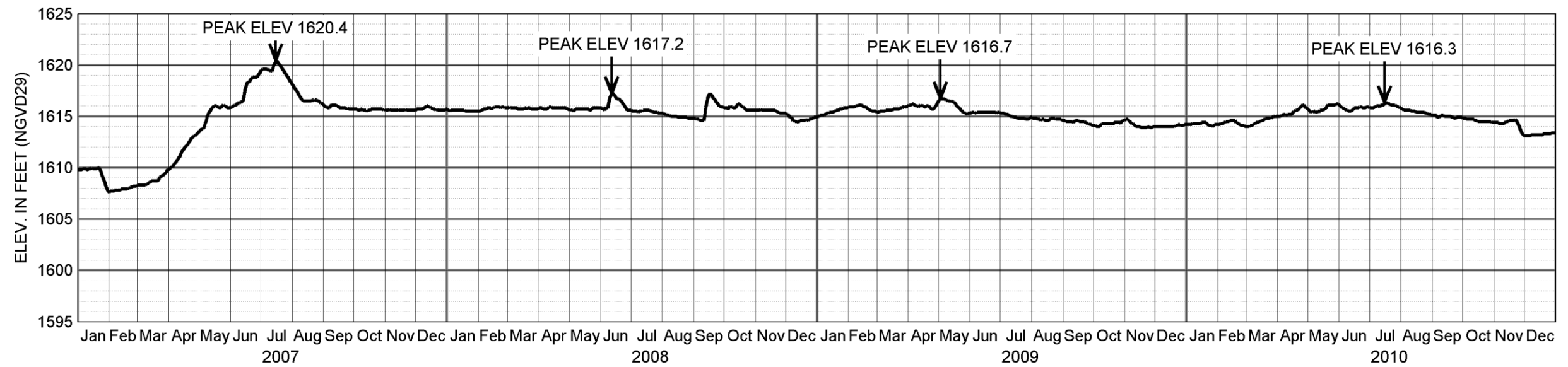
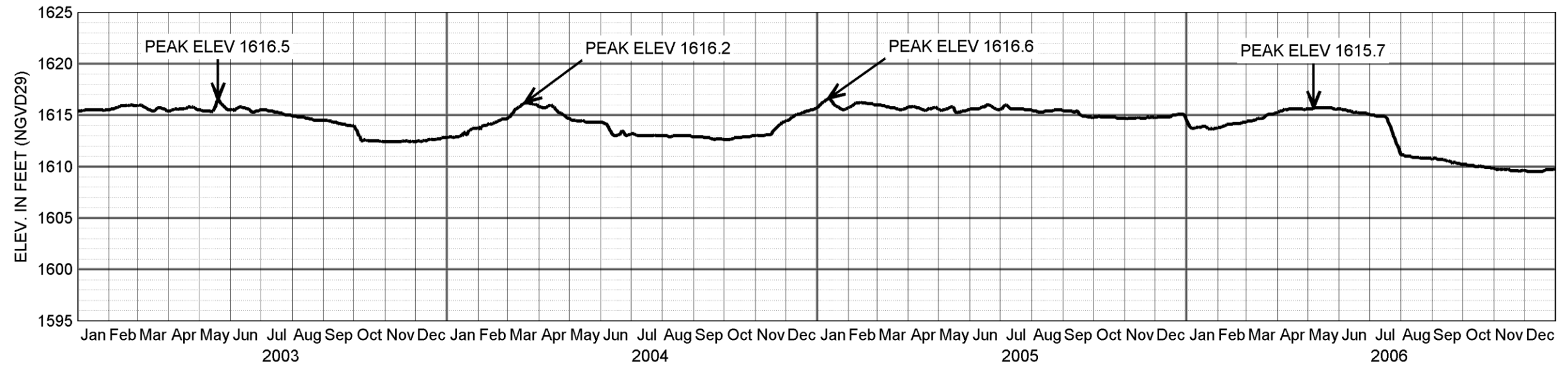
Note: Plate size is 11" x 17"

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**

**POOL ELEVATION  
HYDROGRAPHS  
1992 - 2002**

DRAWN BY WEST CONSULTANTS GB  
CHECKED BY WEST CONSULTANTS KJF



Note: Plate size is 11" x 17"

ARKANSAS RIVER WATERSHED NORTH CANADIAN RIVER, OKLAHOMA

**CANTON LAKE**

**POOL ELEVATION  
HYDROGRAPHS  
2003 - 2013**

DRAWN BY WEST CONSULTANTS GB  
CHECKED BY WEST CONSULTANTS KJF