US Army Corps of Engineers
Tulsa District
Tulsa District

NEWT GRAHAM LOCK AND DAM 18
VERDIGRIS RIVER
ARKANSAS RIVER BASIN, OKLAHOMA

WATER CONTROL MANUAL
APPENDIX S
WATER CONTROL MASTER MANUAL

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
TULSA DISTRICT

JANUARY 2017

PREVIOUS EDITION – APRIL 1972

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Newt Graham Lock and Dam 18: Lock, Spillway, and Right Uncontrolled Overflow

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 elevations referred to in this Water Control Manual, unless noted otherwise, are in feet, NGVD29 (National Geodetic Vertical Datum 1929). Add 0.08 ft. to the NGVD29 elevation to obtain the NAVD88 elevation at Newt Graham Lock and Dam 18. The source of this conversion is the "Comprehensive Evaluation of Project Datums" from 20 November 2008.

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. A separate copy of this section has been provided to the Lock Operator and must be displayed on the bulletin board at all times.

EMERGENCY PERSONNEL ROSTER

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

NEWT GRAHAM LOCK AND DAM 18
VERDIGRIS RIVER, OKLAHOMA

WATER CONTROL MANUAL
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TO
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ARKANSAS RIVER BASIN

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LOCATION:

The lock and dam is on the Verdigris River at McClellan-Kerr Navigational System mile 421.5, about 8 miles southwest of Inola, in Wagoner County, Oklahoma

DRAINAGE AREA:

The total drainage area is 8,030 square miles. The uncontrolled drainage area is 2,034 square miles

DAM:

Type:	Combined earthfill embankment and concrete gravity dam with a navigation lock. Dam is 7,367 ft long, including the lock, spillway, overflow embankment, and non-overflow embankment.
Top of Dam:	542.0 feet, NGVD29

EMBANKMENT:

Right bank overflow length:	596 feet
Right bank crest elevation:	533.5 feet NGVD29
Left bank overflow length:	600 feet
Left bank crest elevation (minimum):	542.0 feet, NGVD29
Left bank non-overflow length:	5,555 feet

LOCK:

Type:	Ohio
Location:	Adjacent to spillway in approximate center of original river channel
Type of construction:	Concrete gravity founded on rock

LOCK CHAMBER:

Size of chamber:	110’x600’
Length, Pintels, center-to-center:	670 feet
Usable length:	600 feet
Normal Lift:	21 feet
Type and number of gates:	2 Miter gates
Height of upper miter gate:	22 feet
Height of lower miter gate:	42 feet
Type of operating machinery:	Hydraulic
Elevations	
Top of lock wall:	542.0 feet, NGVD29
Upper miter sill:	517.0 feet, NGVD29
Lower miter sill:	497.0 feet, NGVD29
Lock chamber floor (minimum):	493.0 feet, NGVD29

LOCK FILLING AND EMPTYING:

Filling and emptying system:	Bottom lateral conduits
Type of discharge:	Side outlet
Number & size of filling & emptying culverts:	Two – 12'x12'
Number & size of intake ports (each culvert):	8 – 7.5'x10'
Submergence of intake manifold (normal pool):	15 feet
Number of chamber ports, each culvert:	14
Size of chamber ports (throats):	2.54'x3.50'
Size of chamber ports (chamber wall):	3.33'x3.50'

SPILLWAY:

Type:	Gated Concrete Ogee
Total width:	220 feet
Net flow width:	180 feet
Gates, number & size:	Three, 60ft. wide by 27 ft. high
Width of piers:	10 feet
Elevation of weir crest:	506.0 feet, NGVD29
Elevation of stilling basin floor:	491.0 feet, NGVD29
Trunnion elevation (centerline):	533.5 feet, NGVD29
Elevation, bottom of fully open gate:	550.0 feet, NGVD29

HYDROLOGY:

Maximum Flood of Record, unregulated	224,000 cfs
Maximum Flood of Record, regulated	148,900 cfs
5-year flood, regulated	60,000 cfs
10-year flood, regulated	70,000 cfs
50-year flood, regulated	86,000 cfs
Standard Project Flood, regulated	154,000 cfs
Project Design Flood	154,000 cfs
Navigation Design Flood	65,000 cfs

LAND ACQUISITION:

Fee Simple Elevation 535.00	3884.15 acres
Roadway and Flowage Easement	74.24 acres
Range of Clearing	Lower Limit – 532.0 feet, NGVD29 Upper Limit – 535.0 feet, NGVD29

Feature	Elevation (ft. NGVD29)	Pool Area (acres)	Capacity (acre-feet)
Top of Dam			
Right Bank	533.5	-	-
Left Bank	542.0	-	-
Navigation Pool			
Top of Spillway Gates (closed position)	533.0	1,545.0	25,030
Top of Navigation Pool	532.5	1,517.5	24,260
Bottom of Navigation Pool	532.0	1,490.0	23,490
Spillway Crest			
Left Overflow Section	542.0	-	-
Right Overflow Section	533.5	-	-
Gated Section	506.0	-	-

Notes: 1) Area and Capacity are based on the 1965 pool survey
2) Add 0.08 ft. to the NGVD29 elevation to obtain the NAVD88 elevation at Newt Graham Lock and Dam 18

NEWT GRAHAM LOCK AND DAM 18
VERDIGRIS RIVER, OKLAHOMA

WATER CONTROL MANUAL
APPENDIX S, PART VI
TO
WATER CONTROL MASTER MANUAL
ARKANSAS RIVER BASIN

I - INTRODUCTION

1 - 01. Authorization. This manual is submitted in accordance with ER 1110-2-240, Water Control Management, dated 30 May 2016, and 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 plan of water control; to present detailed information to higher authority; and to give guidance to personnel who will become concerned with, or responsible for, regulation of the project during the life of the project.

1 - 03. Related Manuals and Reports. This manual is Appendix S, Part VI, to the Arkansas River Basin Water Control Master Manual. Other related manuals in this District are:

Appendix D	Hulah	(April 1991)
Appendix F	Birch	(August 1981)
Appendix L	Oologah	(May 1997)
Appendix S, Part IV	Webbers Falls Lock & Dam 16	(November 1997)
Appendix S, Part V	Choueau Lock & Dam 17	(April 1972)
Appendix W	Copan	(February 1983)
Appendix Y	Skiatook	
Appendix DCP-6	Drought Contingency Plan	(October 1992)

The locations of existing and authorized projects in the Tulsa District are shown on Plate 1-1. Design memoranda important to the regulation of Newt Graham Lock and Dam are shown in Table 1-1. Supplementary pertinent data are given in Exhibit A of this manual.

1 - 04. Project Owner. Newt Graham Lock and Dam 18 is owned by the U.S. Government.

1 - 05. Operating Agency. The U.S. Army Corps of Engineers, Tulsa District, is the operating agency for Newt Graham Lock and Dam. The Lock Operator, Newt Graham Lock and Dam 18, operating through the Navigation Manager at the Navigation Area Office, and the Operations Division, Tulsa District, has the responsibility for project operations concerning discharge releases. The project is manned 24 hours a day by lock personnel. When the project is in extensive flood regulation, operating personnel will closely monitor the project and the downstream river reaches. The project office is furnished a list of the Hydrology-Hydraulics

Branch personnel to contact when necessary. The Navigation Manager will furnish the Water Management Section a list giving the office and home telephone numbers of project personnel.

TABLE 1-1

PERTINENT REPORTS AND DESIGN MEMORANDA

	Title	Date Submitted
1.	General Design (DM 1, Part 1)	January 1965
2.	General Design (DM 1, Part 2)	August 1965
3.	Relocation of Oklahoma Highway 33 (DM 13)	August 1965
4.	Relocation of Highway 66 (DM 15)	September 1965
5.	Relocation of Will Rogers Turnpike (DM 10)	October 1965
6.	Navigation Channel & Turning Basin (DM 2)	November 1965
7.	Left Abutment Access Road (DM 4)	February 1966
8.	Lock, Spillway, and Embankment (DM 5)	May 1966
9.	Relocation of Facilities Operated by St. Louis-San Francisco Railway (DM 14)	July 1966
10.	Construction Materials (DM 12)	August 1966
11.	Relocation of Wagoner-Rogers County Roads (DM 25)	August 1966
12.	Relocation of Facilities Operated by SW Bell (DM 11)	October 1966
13.	Relocation of Facilities Operated by Gulf Refining Company (DM 19)	November 1966
14.	Relocation of Facilities Operated by Cherokee Pipeline Company (DM 21)	December 1966
15.	Relocation of Facilities Operated by Lake Region Electric Cooperative (DM 23)	December 1966
16.	Relocation of Facilities Operated by Public Service of Oklahoma (DM 20)	January 1967
17.	Relocation of Facilities Operated by Grand River Dam Authority (DM 22)	March 1967
18.	Relocation of Facilities Operated by Oklahoma Natural Gas (DM 16)	March 1968
19.	Public Use Plan (DM 7B)	September 1969
20.	Real Estate (DM 9-1)	November 1972
21.	Operation and Maintenance Manual, Vol. I	April 1981
22.	Operation and Maintenance Manual, Vol. II	August 1985
23.	Drought Contingency Plan	October 1992
24.	Arkansas River Navigation Study	June 2005
25.	Arkansas River Basin Water Control Master Manual	July 1980 (Rev. October 2007)

Note: DM represents Design Memorandum.

1 - 06. Regulating Agencies. The U.S. Army Corps of Engineers is the regulatory agency for Newt Graham Lock and Dam 18. The Water Management Section, Hydrology-Hydraulics Branch, Tulsa District is responsible for the regulation of the facility.

II - DESCRIPTION OF PROJECT

2 - 01. Location. Newt Graham Lock and Dam 18 is located on the Verdigris River at McClellan-Kerr Navigational System mile 421.5, about 8 miles southwest of Inola, Wagoner County, Oklahoma. The navigation pool extends approximately 24 miles up the Verdigris River to the Tulsa Port of Catoosa. The project area is shown on Plate 2-1.

2 - 02. Purpose. Newt Graham Lock and Dam 18 is a multi-purpose project authorized for navigation, recreation, and fish and wildlife.

2 - 03. Physical Components.

a. Embankment The embankment is a combined earthfill and concrete, gravity dam with a total length of 7,367 feet. The right embankment contains an overflow section 596 feet long at elevation 533.5 feet, NGVD29. The left embankment has an overflow section 600 feet long at elevation 542.0 feet, NGVD29, and a non-overflow section 5,555 feet long, which includes an access road along its crest.

b. Spillway and Outlet Works. The spillway is a gated, concrete ogee weir with a crest elevation of 506.0 feet, NGVD29. Total width of the spillway is 220 feet with a net flow width of 180 feet. Flows are controlled by three 60- by 27-foot-high tainter gates with, 10-foot-wide concrete piers between each gate. The top of the gates in the closed position is at elevation 533.0 feet, NGVD29. The spillway discharges into a roller-type stilling basin, consisting of a 40-foot long concrete apron with a floor elevation of 491.0 feet and a 4-foot high end sill. The right embankment contains an overflow section 596 feet long at elevation 533.5 feet, NGVD29. The left embankment has an overflow section 600 feet long at elevation 542.0 feet, NGVD29, and a non-overflow section 5,555 feet long, which includes an access road along its crest.

The structures are designed to overflow under extreme flood conditions with only minor damage expected. The navigation channel and spillway were designed to allow channel capacity flow at the navigation pool elevation (532.0 feet, NGVD29).

c. Navigation Lock The lock is a single-lift type with a 110 foot by 600 foot chamber and miter gates. The structure includes 600-foot guide walls, upstream and downstream, on the river (right) side of the lock. The normal lift is 21 feet. The top of the lock walls are at elevation 542.0 feet, NGVD29. The lock walls are reinforced concrete gravity flow walls founded on firm rock. The general plans for Newt Graham Lock and Dam 18 are shown on Plate 2-2.

d. Sedimentation No sedimentation or degradation ranges were established for this project. Sediment surveys are not made to establish storage capacity, but are made as necessary for the maintenance of the navigational channel. The Navigation Section of the Operations Division keeps the channel dredged to maintain the design depth and width at all times. The design depth and width of the navigation channel is 9 feet deep and 150 feet wide.

e. Hydroelectric Power. Hydroelectric power is not a project purpose.

2 - 04. Related Control Facilities. None.

2 - 05. Real Estate Acquisition. The acquisition guidelines are based on the elevation of normal pool plus 3-feet of freeboard for wave action and saturation. The top of the navigation pool is at elevation 532.0 ft., NGVD29, so the acquisition guideline is set at elevation 535.0 ft., NGVD29. Newt Graham Lock and Dam 18 is designed so that the backwater effects for flows above bankfull are negligible. Therefore, all relocations were based on the requirements for navigation clearance. In total, 3,884.15 acres were acquired in fee simple and 74.24 acres were acquired for roadway and flowage easements.

2 - 06. Public Facilities. Eight public areas have been developed by the Corps of Engineers at the Newt Graham Lock and Dam 18 project: Rogers Point, Highway 33 Landing, Commodore Landing, Rocky Point, Channel View, Bluff Landing, Goodhope Ramp, and Bluegill Point. Facilities at these areas include boat launching ramps, designated campsites, picnic areas, drinking water, and sanitary facilities. The public use areas for Newt Graham Lock and Dam 18 are shown on Plate 2-3.

III - HISTORY OF PROJECT

3 - 01. Authorization. Newt Graham Lock and Dam 18 was authorized for construction by the River and Harbor Act of 24 July 1946 (Public Law 525, 79th Congress, 2nd Session, H.R. 6407) for the purposes of navigation and recreation. This act approved the multiple purpose plan recommended in the report to the Chief of Engineers dated 19 March 1946.

3 - 02. Planning and Design. Two design memoranda were written outlining the background studies and proposed design of the project. "Design Memorandum No. 1, General Design – Part I," dated 15 January 1965, described the Head of Navigation that was to be constructed at the upstream end of the L&D 18 pool. "Design Memorandum No. 1, General Design – Part II," dated 18 August 1965, described studies and designs related to the features of Lock and Dam 18.

The comprehensive project was planned by the Corps of Engineers and built by private contractors under supervision of the Corps. The navigation route from the Mississippi River to Fort Smith, Arkansas was developed by the Little Rock District, and the route from Fort Smith to Catoosa, Oklahoma, was developed by the Tulsa District.

3 - 03. Construction. A summary of construction activities for Newt Graham Lock and Dam 18 is presented in Table 3-1.

TABLE 3-1

RESUME OF CONSTRUCTION ACTIVITIES

Activity	Date
Construction Began	October 1967
Dam Closure	September 1970
Operational for Navigation	December 1970

3 - 04. Related Projects. Newt Graham Lock and Dam 18 is a component of the multipurpose Arkansas River Basin Flood Control and Navigation System. Included in this system are completed projects in the Verdigris, Canadian, Grand, Illinois, Poteau, and Arkansas River Basins. Related projects upstream of Newt Graham Lock and Dam 18 are Oologah Lake on the Verdigris River, Hulah Lake on the Caney River, Copan Lake on the Little Caney River, Skiatook Lake on Hominy Creek, and Birch Lake on Birch Creek. Related Tulsa District Projects downstream are Chouteau Lock and Dam 17, Webbers Falls Lock and Dam 16, Robert S. Kerr Lock and Dam 15, and W. D. Mayo Lock and Dam 14 on the Arkansas River.

3 - 05. Modification to Regulations. The regulation of Newt Graham Lock and Dam 18 has been modified to coincide with the present Arkansas River System Operating Plan as discussed in the Arkansas River Basin Water Control Master Manual, updated 2007.

3 - 06. <u>Principal Regulation Problems.</u> The principal regulating problem for Newt Graham Lock and Dam 18 is communicating accurate forecasted flow data to the Lock personnel. Inspections and periodic maintenance also require effective coordination between project personnel and Water Management Section, to ensure safety of workers and minimize disruption of operation. Lock personnel are on duty at the project 24 hours a day.

IV - WATERSHED CHARACTERISTICS

4 - 01. General Characteristics. The Verdigris River is formed near Madison, Kansas, by the convergence of its North and South Branches. From its formation, the Verdigris River flows in a generally southward direction for 310 miles through Kansas and Oklahoma to its confluence with the Arkansas River, just north of Muskogee, Oklahoma. The Verdigris River drains approximately 8,220 square miles. The basin averages about 46 miles in width. Major tributaries to the Verdigris River include Elk River, Fall River, Big Hill Creek, Caney River, and Bird Creek. The drainage area above Newt Graham Lock and Dam 18 is about 8,030 square miles, of which 2,034 square miles is uncontrolled. Reservoirs in the Verdigris River Basin above Newt Graham Lock and Dam 18 are Toronto, Fall River, Elk City, and Big Hill Lakes in Kansas and Oologah, Hulah, Copan, Birch, and Skiatook Lakes in Oklahoma. The river has a well-defined, meandering channel. The Verdigris River streambed and historic profiles are shown on Plate 4-2 and Plate 4-3.

4 - 02. Topography. The watershed is bordered by hills which range in elevation from 1,000 to 1,600 feet. The valley side slopes are relatively steep, with most of the land in the river valley used for cultivation or pasture land. However, wooded areas are prevalent along the channel and in the flood plains in the lower reaches of the river. The land beyond the river valley varies from rolling to hilly, and the tree cover ranges from open to densely wooded.

4 - 03. Geology and Soils. From its mouth north of Muskogee, Oklahoma, to the head of navigation near Catoosa, Oklahoma, the Verdigris River floodplain ranges from one to five miles in width, and the alluvium averages about 40 feet in thickness. The upper part of the alluvium generally consists of silt and clay and averages about 30 feet in thickness. The lower part consists chiefly of fine sand ranging from 15 to 20 feet thick. The bedrock strata are sedimentary rocks of lower Pennsylvanian Age. In ascending order, these are the shales and sandy shales of the McAlester, Savanna, Boggy, and Senora Formations. The site is located in a region that has been subjected to faulting from the Central Ozark uplift.

At the site of Newt Graham Lock and Dam 18, the floodplain is about 2.5 miles wide, and the overburden reaches an average depth of 40 feet and a maximum depth of approximately 43 feet. Field classification indicates that the material consists mainly of sandy clays, and clays with minor amounts of gravel.

4 - 04. Sediment. There are no sedimentation or degradation ranges established for Newt Graham Lock and Dam 18. Calculations made during the initial design of the navigation system show that approximately 125 acre-feet of sediment would flow into Newt Graham Lock and Dam 18 annually, with three percent or less of this depositing. All deposition may again be picked up and carried in suspension during high flows. Operations Division monitors sediment in the navigation channel and dredges as needed to maintain the dimensions required to support navigation operations.

4 - 05. Climate. The Verdigris River Basin lies in a region characterized by moderate winters and comparatively long summers. Summer temperatures are relatively high, while subzero

temperatures are uncommon during the winter. The average normal temperature over the basin is about 60 degrees Fahrenheit, and the monthly average temperature varies from about 37 degrees Fahrenheit in January to about 81 degrees Fahrenheit in July and August. Local thunderstorms with high intensities occur over the basin during the spring, summer, and fall months. Wind movements can be of considerable magnitudes in the spring months. There is a comparatively high percentage of sunshine and evaporation across the basin. Data concerning the climatic characteristics near Newt Graham Lock and Dam 18 are shown below (all data obtained from the NOAA gage at Muskogee, OK):

a. Temperature. (Period of Record is 1914 through 2015)

Mean Annual (Muskogee, OK)	60.3 degrees F
Maximum recorded (Muskogee, OK, 10 Aug 1936)	118 degrees F
Minimum Recorded (Muskogee, OK, 10 Feb 1929)	-11 degrees F

b. Precipitation. (Period of Record is 1914 through 2015)

Mean Annual	45.26 inches
Maximum Annual (Muskogee, OK, 1973)	70.2 inches
Minimum Annual (Muskogee, OK, 1936)	19.3 inches
Percent during Growing Season (Apr through Oct)	68%

The average monthly and annual rainfall and runoff data are shown in Table 4-1.

c. Snowfall. (Period of Record is 1914 through 2015)

Mean Annual (Muskogee, OK)	5.2 inches
Maximum (Muskogee, OK, 1924)	21.0 inches
Minimum (Muskogee, OK, Several)	0 inches

d. Evaporation. Following the construction of Newt Graham Lock and Dam 18, evaporation data were collected from an evaporation pan on site. In 1996, Tulsa District migrated from physical evaporation measurements to using an empirical formula, 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 evaporation values at Newt Graham Lock and Dam 18, for the period Sep 1970 through Dec 2015, are shown in Table 4-2.

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 60 miles per hour, and the highest wind speed for a 1-hour duration is 43 miles per hour.

TABLE 4-1

AVERAGE MONTHLY AND ANNUAL RAINFALL AND RUNOFF

Month	Average Rainfall (inches)[1]	Percent of Average Annual Rainfall	Average Runoff[2][3]		Percent of Average Annual Runoff
			(acre-feet)	(inches)	
January	1.43	3.91	187,110	0.44	5.14
February	1.55	4.23	185,550	0.43	5.10
March	2.71	7.40	374,960	0.88	10.31
April	3.57	9.75	501,690	1.17	13.79
May	4.93	13.47	585,780	1.37	16.11
June	4.64	12.68	543,680	1.27	14.95
July	3.12	8.52	311,910	0.73	8.58
August	3.11	8.50	125,350	0.29	3.45
September	4.34	11.86	148,410	0.35	4.08
October	3.18	8.69	265,360	0.62	7.30
November	2.46	6.72	229,840	0.54	6.32
December	1.56	4.26	177,410	0.41	4.88
Total	36.6	100	3,637,050	8.49	100

(1) Period of Record 1930 through 2014 (data from SWT Annual report)
(2) Period of Record 1923 through 2014 (data from SWT Annual report)
(3) Contributing Drainage Area = 8,030 sq. mi.

TABLE 4-2

ESTIMATED MONTHLY PAN EVAPORATION
NEWT GRAHAM LOCK AND DAM

Month[1]	Evaporation[2] (inches)
January	1.90
February	2.30
March	4.19
April	5.82
May	6.49
June	7.48
July	9.20
August	8.42
September	5.94
October	4.43
November	2.84
December	1.87
Annual Total	60.89

(1) Period of Record from Oct 1979 through Dec 2015
(2) National Weather Service Class A Pan until 1996. Empirical estimate of pan evaporation since 1996.
(3) Data from Monthly Reports

Note: Equations used to calculate the Pan Evaporation at Newt Graham Lock and Dam are found in the Supplemental Tables Section.

4 - 06. Storms and Floods. Major flood producing storms over the Newt Graham Lock and Dam 18 basin are usually 1-3 days in duration. Major storms most often occur in the spring and fall months, although severe weather can occur at any time of the year. The largest flood in the history of the project was produced by the remnants of a hurricane, extending over 3 days. The storm in September-October 1986 produced a basin average rainfall of 8.25 inches. Major storms and floods in the basin are listed in Table 4-3. Major floods at gage sites upstream and downstream of the project are listed in Table 4-4. Pertinent data for stream gaging stations in the Newt Graham Lock and Dam 18 basin are shown in Table 4-5.

TABLE 4-3

MAJOR STORMS IN THE NEWT GRAHAM LOCK AND DAM BASIN (1970-2015)

Date of Storm	Average Basin Rainfall (inches)
29 September - 4 October 1986	8.25
6-20 May 1993	7.81
28 August - 3 September 2003	7.07
3-11 June 1995	7.00
11-23 August 1997	6.68
1-6 October 1998	6.67
30 October-4 November 1974	6.15
22-28 April 1999	5.98
23 June - 3 July 2007	5.96
12-19 June 2015	5.32
27-29 December 2015	5.31
23-30 May 2015	5.17
14-30 April 1990	5.12
7-18 July 1994	5.11
21-24 February 1985	5.09
14-20 September 1988	5.01
8-11 March 1974	4.75
13-15 September 1998	4.71
30 May - 1 June 2013	4.55
20-23 March 2012	4.54

Notes: Data obtained from SWT District Monthly Charts

TABLE 4-4

MAJOR FLOODS OF RECORD AT GAGE SITES

Muskogee, OK			Claremore, OK			Sperry, OK		
Date	Flow (cfs)	Stage	Date	Flow (cfs)	Stage	Date	Flow (cfs)	Stage
21 May, 1943	700,000	48.20	21 May, 1943	182,000	55.05	3 October, 1959	90,000	32.60
6 October, 1986	--	39.62	11 May, 1961	116,000	50.06	18 May, 1943	72,200	31.68
May, 1898	384,000	39.50	13 April, 1944	85,200	47.23	4 November, 1974	54,700	31.45
26 May, 1957	366,000	39.03	21 April, 1945	81,400	47.14	1 October, 1986	31,500	30.82
11 May 1943	340,000	38.32	4 October, 1945	73,000	46.98	12 March, 1974	45,600	30.75
31 October, 1941	304,000	37.23	6 July, 1951	74,900	46.95	31 October, 1941	45,700	30.14
18 April, 1945	326,000	36.65	2 November, 1941	64,200	46.60	10 May, 1993	30,600	29.88
15 April, 1927	325,000	36.50	15 June, 1957	68,500	46.51	23 February, 1985	28,400	29.49
13 June, 1995	297,100	35.77	27 June, 1948	61,000	46.41	15 September, 1961	32,100	29.09
15 April, 1945	306,000	35.47	June, 1935	64,200	46.20	13 June, 1957	31,400	29.03
June, 1923	295,000	34.70	8 October, 1941	52,800	45.83	10 June, 2008	25,000	28.97
7 October, 1959	286,000	34.00	5 October, 1959	60,500	45.76	12 April, 1994	21,700	28.93
21 April, 1941	248,000	32.72	12 October, 1986	78,400	44.99	26 April, 1999	21,500	28.89
9 May, 1961	295,000	32.70	23 July, 1948	50,400	44.80	1 October, 1945	24,300	28.84
22 May, 1957	259,000	31.85	20 April, 1947	53,000	44.51	2 July, 1945	25,200	28.73
15 May, 1929	249,000	31.50	22 April, 1941	48,200	44.46	12 March, 1990	20,300	28.66
20 May, 1929	248,000	31.40	22 May, 1957	47,500	43.96	17 April, 1973	21,000	28.58
6 October, 1926	248,000	31.40	25 July, 1959	47,200	43.53	11 June, 1941	23,000	28.46
17 July, 1951	240,000	31.40	6 July, 2007	59,000	37.80	11 April, 1944	22,000	28.22
15 July, 1951	242,000	30.83	16 June, 2008	50,400	34.09	6 March, 2004	19,000	27.78

Note: Data sources are USGS and SWT. USGS data obtained from website: http://waterwatch.usgs.gov/?m=real&r=ok
USGS data were accessed January 2016
Period of record for each gage is listed in Table 4-5

TABLE 4-5

PERTINENT DATA FOR STREAM GAGING STATIONS

Station	Stream	Miles above Mouth	Gage Datum (ft, NGVD29)	Flood Stage (ft)	Drainage Area (sq mi)	Maximum Flood of Record		
						Date	Flow (cfs)	Stage (ft)
Sperry, OK	Bird Creek	25.0	579.43	21.0	907	3 Oct, 1959	90,000	32.60
Claremore, OK	Verdigris R	76.0	538.62	36.0	6,451	21 May, 1943	182,000	55.05
Muskogee, OK	Arkansas R	457.8	471.38	28.0	84,824	21 May, 1943	700,000	48.20

Station	Stream	2nd Largest Flood of Record			3rd Largest Flood of Record			Period of Record
		Date	Flow (cfs)	Stage (ft)	Date	Flow (cfs)	Stage (ft)	(Flow or Stage)
Sperry, OK	Bird Creek	18 May, 1943	72,200	31.68	4 Nov, 1974	54,700	31.45	Oct 1938 - Present
Claremore, OK	Verdigris R	11 May, 1961	116,000	50.06	13 Apr, 1944	85,200	47.23	Oct 1935 - Present
Muskogee, OK	Arkansas R	6 Oct, 1986	--	39.62	May, 1898	384,000	39.50	Oct 1926 - Sep 1970, Jun 1983 - Present

Note: Data sources are USGS and SWT. USGS data obtained from website: http://waterwatch.usgs.gov/?m=real&r=ok
Muskogee gage was operated by USGS from 1926-1970 and 2005-Present, and by SWT from 1983-2005
USGS data were accessed January 2016

4 - 07. Runoff Characteristics. The watershed of the Verdigris River above Newt Graham Lock and Dam 18 consists of the Verdigris River Basin, the Caney River Basin, and the Bird Creek Basin. The primary sources of flows to the projects are releases from Oologah, Hulah, Copan, Skiatook, and Birch Lakes. There are 2,034 square miles of uncontrolled drainage area between the upstream lakes and Newt Graham Lock and Dam 18. The average travel time from Oologah Lake to Newt Graham L&D is 10 hours, 3.5 days from Hulah and Copan Lakes, and 28 hours from Skiatook Lake, as shown on Plate 4-13. Loss rates vary throughout the year, but on average almost 22% of the basin rainfall flows through Newt Graham L&D. The inflow volume frequency by month is shown in Table 4-6. The inflow duration curve is shown on Plate 4-4. The estimated monthly and annual inflows for Newt Graham L&D during the period of record (Sept 1970 – Dec. 2015) are shown in Table 4-7 in the Supplemental Tables Section.

TABLE 4-6

INFLOW VOLUME FREQUENCY

Month	Monthly Inflow Volume (ac-ft) Frequency of Occurrence in Years					
	2	5	10	25	50	100
January	2,718	9,792	19,925	28,967	34,430	38,057
February	5,120	12,643	23,370	30,660	36,673	39,321
March	10,494	28,082	35,830	51,419	58,411	59,656
April	14,045	32,102	44,825	48,212	49,775	57,679
May	16,868	32,691	44,573	55,038	61,644	65,398
June	14,739	33,496	44,975	68,215	71,014	77,308
July	9,448	20,502	35,739	56,876	61,808	76,328
August	3,144	7,761	16,392	30,466	33,319	36,885
September	3,099	10,471	15,412	20,854	24,842	44,493
October	3,176	11,690	22,836	55,845	64,524	86,402
November	3,140	18,897	26,541	48,656	60,892	68,397
December	2,998	15,540	23,135	32,931	41,555	47,276

Note: Data From Riverware v6.4.7, period of record Jan 1940 – Dec 2008

4 - 08. Water Quality. Designated beneficial uses of the Verdigris River from its mouth to the Oologah Lake Dam, including the impoundment created by Newt Graham Lock and Dam 18, include Public and Private Water Supply, Fish and Wildlife Propagation as a Warm Water Aquatic Community (WWAC), Agriculture (Livestock, Irrigation), Primary Body Contact

Recreation (PBCR), Navigation, and Aesthetics. The impoundment created by the Newt Graham Lock and Dam, and segments of the Verdigris River immediately upstream and downstream of the impoundment, have not been assessed with respect to the designated beneficial uses noted above. Based on the 2014 Integrated Report, an 18.7 mile segment of the Verdigris River upstream of the project and including segments of the river both upstream and downstream of U.S. 412, has been assessed and is included on the 303(d) list with impaired uses PBCR and WWAC caused by Enterococcus and turbidity, respectively. A Total Maximum Daily Load (TMDL) report has been prepared by the Oklahoma Department of Environmental Quality (ODEQ), and approved by the U.S. Environmental Protection Agency (U.S. EPA), addressing bacterial and turbidity loads for areas of the Arkansas and Verdigris Rivers including this reach.

Water quality monitoring under the Tulsa District program has not occurred at Newt Graham Lock and Dam. Water quality data have been collected by the Oklahoma Water Resources Board (OWRB) at the Verdigris River near Inola from November 2000 through 2015, and assessed by the OWRB under the Beneficial Use Monitoring Program (BUMP). The assessment provides a reasonable summary of water quality in the Verdigris River flowing to Newt Graham compared to Oklahoma's Water Quality Standards. The OWRB has also assessed a 6.1 mile segment of the Verdigris River below the Newt Graham Lock and Dam 18 using data collected at the State Highway 51 Bridge near Wagoner, OK. Water quality parameter ranges are similar to those measured at the Inola station, and again turbidity and Enterococcus levels measured at this site do not support beneficial uses WWAC and PBCR, indicated as impairments in the 2014 Oklahoma 303(d) list for this segment of the Verdigris River.

The U.S. EPA collected data from the impoundment just above the Newt Graham Lock and Dam on one date in August 2007 as part of the National Aquatic Resource Survey. Results for specific conductance, pH, and dissolved oxygen fell within the ranges indicated at the Verdigris River near Inola.

A tributary segment, Adams Creek, entering the Verdigris River 2.5 miles above the Newt Graham Lock and Dam is listed as impaired with respect to the PBCR beneficial use due to elevated concentrations of E. coli. Unconfirmed potential sources of the impairment include grazing in riparian and shoreline zones, municipal (urbanized high density areas), on-site treatment systems (septic or similar systems), rangeland grazing, residential districts, wastes from pets, wildlife other than waterfowl, agriculture, and sources unknown. Another stream of note is a 10.08 mile segment of Dog Creek, which enters the Verdigris River about 5 miles north of U.S. 412 with PBCR impaired by Enterococcus and E. coli concentrations, and WWAC impaired by low dissolved oxygen and a benthic macroinvertebrate assessment indicating a degraded faunal assemblage.

4 - 09. Channel and Floodway Characteristics. Navigation on the Verdigris River is not adversely impacted by flows up to 18,000 cfs. Between 18,000 and 30,000 cfs, navigation traffic modifies the way barges are loaded and configured. Flows greater than 30,000 cfs create hazards for operations and barge traffic is typically suspended by industry until flows decrease. The Corps suspends traffic when high flows cause the upper pool to reach flood stage, which is currently 537.0 feet, NGVD29. Flows greater than 30,000 cfs occur less than 15% of the time,

resulting in a very reliable navigation system. The channel has a nine-foot minimum depth, and is dredged or otherwise maintained to ensure navigability. Approval for a 12-foot minimum depth for future navigation was included in the Energy and Water Appropriation Act of 2004.

There are a number of stream gages located upstream of the project. Rating curves for these locations are shown on Plates 4-5 through 4-10. The first regulating point downstream of the project is the Muskogee gage on the Arkansas River. The regulating stage is 28.0 feet, which is currently estimated at 120,079 cfs. The control point for the Tulsa District portion of the basin is at the Van Buren gage on the Arkansas River. The regulating stage is 22.0 feet, which is estimated to be between 135,000 and 150,000 cfs. Capacity at this location changes frequently due to the sand riverbed. Rating curves for the downstream gages can be found on Plates 4-11 and 4-12. All rating curves are adjusted periodically to reflect the current condition of the channel.

Travel time from Newt Graham Lock and Dam 18 to the confluence of the Verdigris and Arkansas Rivers is approximately 6 hours. Other tributaries to the Arkansas River downstream are the Canadian, Illinois, and Poteau Rivers. Travel times from Newt Graham Lock and Dam 18 to the Muskogee and Van Buren gages are 6 and 20 hours, respectively. Travel times in the basin are shown on Plate 4-13.

4 - 10. Upstream Structures. Operational structures in the Verdigris River basin upstream of Newt Graham Lock and Dam 18 are Toronto, Fall River, Elk City, and Big Hill Lakes in Kansas, and Skiatook, Birch, Oologah, Hulah, and Copan Lakes in Oklahoma.

4 - 11. Downstream Structures. Tulsa District structures located downstream of Newt Graham Lock and Dam 18 are Chouteau L&D 17 on the Verdigris River, and Webbers Falls L&D 16, Robert S. Kerr L&D 15, and W.D. Mayo L&D 14 on the Arkansas River.

4 - 12. Economic Data.

a. Population. The population of counties and cities below Newt Graham Lock and Dam 18 are shown in Table 4-8. Although varying proportions of the counties listed lie within the watershed boundary, the entire population of each county is included.

b. Agriculture. Soybeans are the main agriculture commodity below Newt Graham Lock and Dam 18, making up approximately 59% of the total farmed acreage. Agriculture and livestock raising are key industries in the floodplain below Newt Graham Lock and Dam 18, which is predominantly rural in character. In addition to soybeans, the principal crops grown in the basin are corn, wheat, and alfalfa. Table 4-9 shows the annual acreage and value of crops in the floodplain downstream of Newt Graham Lock and Dam 18.

c. Industry. The top industries of the area are Retail Trade, Construction, and Health Care & Social Assistance. Table 4-10 through Table 4-16 list the major industries downstream of Newt Graham Lock and Dam, along with corresponding data on number of establishments, annual payroll, and employees.

d. Lock Closures. The Shipper Carrier Cost (SCC) model is designed to calculate the increased transportation costs to industry for different closure durations of between 1 and 365 days. Each project was modeled separately with its own unique characteristics in terms of number of lock chambers, processing times, tow arrivals per year, operating seasons within the year, and the ability to bypass the project via an alternative water routing. Shippers have three options if an unscheduled closure occurs: 1) they can continue to ship via the waterway with delays; 2) they can withdraw goods from inventories; or 3) they can ship via alternative transportation modes. The decision depends on: 1) whether there is a second lock at the project or an alternative water routing; 2) the expected duration of the closure; 3) the level of delays at the project if there is a second lock; and 4) the day within the total closure that the tow was scheduled to transit the lock (i.e. day 10 within a 15 day closure). The scenarios and related decisions are simulated using the SCC model. Table 4-17 shows the breakdown on the different closure durations.

e. Flood Damages. Plates 4-14 through 4-16 show structural loss and area curves for reaches along the Verdigris River and Arkansas River, from the confluence of Bird Creek and the Verdigris River, near the Port of Catoosa, downstream to Ft. Smith, Arkansas.

TABLE 4-8

POPULATION OF COUNTIES AND CITIES DOWNSTREAM OF NEWT GRAHAM L&D

County	Major Cities and Towns	Population			% Change (2000-2010)
		2000[1]	2010[1]	2030[2][3]	
Oklahoma					
Wagoner		57,491	73,085	79,000	27.12
	Okay	597	620	820	3.85
Muskogee		69,451	70,990	75,500	2.22
	Ft. Gibson	4,054	4,154	4,410	2.47
	Muskogee	38,310	39,223	41,650	2.38
	Webbers Falls	726	616	790	-15.15
Haskell		11,792	12,769	17,200	8.29
Sequoyah		38,972	42,391	52,600	8.77
Le Flore		48,109	50,384	59,100	4.73
	Arkoma	1,072	1,989	2,680	85.54
	Pocola	3,994	4,056	4,910	1.55
Arkansas					
Crawford		53,247	61,948	57,873	16.34
	Van Buren	18,986	22,791	25,208	20.04
Sebastian		115,071	125,744	139,246	9.28
	Ft. Smith	80,268	86,209	95,447	7.40

(1) 2000 Census & 2010 Census from U.S. Census Bureau
(2) 2030 Oklahoma Population Projections from Oklahoma Department of Commerce
(3) 2030 Arkansas Population Projections form University of Arkansas at Little Rock

TABLE 4-9

ANNUAL VALUE OF CROPS BELOW NEWT GRAHAM L&D

Arkansas River		
Crops	Below Newt Graham to Ft. Smith, AR	
	Area (Acres)	Value ($)
Soybeans	109,295	$ 33,528,864
Corn	59,614	$ 28,918,108
Wheat	11,080	$ 2,413,462
Alfalfa	6,577	$ 1,894,290
Total	**186,566**	**$ 66,754,725**

(1) Yield Rates from Oklahoma State University Crop Enterprise Budgets 2014
(2) Acres from ARRA Modeling

TABLE 4-10

2013 ECONOMIC CENSUS FOR CRAWFORD COUNTY, AR

NAICS Code	Industry Description	Number of establishments	Number of Paid Employees per Pay Period	Annual payroll ($1,000)
00	Total for all sectors	1,061	20,016	617,266
11	Agriculture, forestry, fishing and hunting	2	0 - 19	Withheld
21	Mining, quarrying, and oil and gas extraction	11	172	17,161
22	Utilities	4	22	761
23	Construction	135	921	36,857
31-33	Manufacturing	61	4,022	129,529
42	Wholesale trade	76	867	49,201
44-45	Retail trade	154	1,944	44,581
48-49	Transportation and warehousing	51	4,425	126,577
51	Information	14	138	6,165
52	Finance and insurance	67	405	13,874
53	Real estate and rental and leasing	39	183	6,994
54	Professional, scientific, and technical services	85	278	9,184
55	Management of companies and enterprises	3	37	1,426
56	Administrative and support and waste management and remediation services	48	2,581	79,100
61	Educational services	9	100 - 249	4,858
62	Health care and social assistance	99	1,656	58,155
71	Arts, entertainment, and recreation	9	43	694
72	Accommodation and food services	83	1,515	18,550
81	Other services (except public administration)	108	593	13,439
99	Industries not classified	3	0 - 19	64

Source: U.S. Census Bureau 2013 County Business Patterns

TABLE 4-11

2013 ECONOMIC CENSUS FOR SEBASTIAN COUNTY, AR

NAICS Code	Industry Description	Number of establishments	Number of Paid Employees per Pay Period	Annual payroll ($1,000)
00	Total for all sectors	3,482	61,045	2,237,279
11	Agriculture, forestry, fishing and hunting	2	0 - 19	Withheld
21	Mining, quarrying, and oil and gas extraction	48	626	36,732
22	Utilities	10	336	19,364
23	Construction	237	2,185	88,553
31-33	Manufacturing	178	13,095	535,668
42	Wholesale trade	219	2,655	118,498
44-45	Retail trade	551	7,880	176,671
48-49	Transportation and warehousing	108	1,708	79,251
51	Information	54	1,205	61,422
52	Finance and insurance	252	1,684	77,071
53	Real estate and rental and leasing	168	1,057	34,911
54	Professional, scientific, and technical services	326	1,513	69,870
55	Management of companies and enterprises	133	2,781	235,439
56	Administrative and support and waste management and remediation services	160	4,638	95,570
61	Educational services	27	360	7,257
62	Health care and social assistance	407	10,974	475,882
71	Arts, entertainment, and recreation	36	355	6,127
72	Accommodation and food services	270	5,775	75,915
81	Other services (except public administration)	293	2,207	42,643
99	Industries not classified	3	7	369

Source: U.S. Census Bureau 2013 County Business Patterns

TABLE 4-12

2013 ECONOMIC CENSUS FOR HASKELL COUNTY, OK

NAICS Code	Industry Description	Number of establishments	Number of Paid Employees per Pay Period	Annual payroll ($1,000)
00	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

Source: U.S. Census Bureau 2013 County Business Patterns

TABLE 4-13

2013 ECONOMIC CENSUS FOR LEFLORE COUNTY, OK

NAICS Code	Industry Description	Number of establishments	Number of Paid Employees per Pay Period	Annual payroll ($1,000)
00	Total for all sectors	806	8,408	259,756
11	Agriculture, forestry, fishing and hunting	7	20 - 99	1,492
21	Mining, quarrying, and oil and gas extraction	36	340	18,132
22	Utilities	8	100 - 249	Withheld
23	Construction	68	259	8,450
31-33	Manufacturing	29	406	14,271
42	Wholesale trade	31	230	9,462
44-45	Retail trade	147	1,566	32,786
48-49	Transportation and warehousing	31	432	19,505
51	Information	9	20 - 99	2,224
52	Finance and insurance	74	398	13,591
53	Real estate and rental and leasing	21	42	963
54	Professional, scientific, and technical services	93	282	6,891
55	Management of companies and enterprises	1	20 - 99	Withheld
56	Administrative and support and waste management and remediation services	27	192	6,999
62	Health care and social assistance	97	2,822	94,509
71	Arts, entertainment, and recreation	8	20 - 99	813
72	Accommodation and food services	42	650	7,268
81	Other services (except public administration)	76	381	8,345
99	Industries not classified	1	0 - 19	Withheld

Source: U.S. Census Bureau 2013 County Business Patterns

TABLE 4-14

2013 ECONOMIC CENSUS FOR MUSKOGEE COUNTY, OK

NAICS Code	Industry Description	Number of establishments	Number of Paid Employees per Pay Period	Annual payroll ($1,000)
00	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

Source: U.S. Census Bureau 2013 County Business Patterns

TABLE 4-15

2013 ECONOMIC CENSUS FOR SEQUOYAH COUNTY, OK

NAICS Code	Industry Description	Number of establishments	Number of Paid Employees per Pay Period	Annual payroll ($1,000)
00	Total for all sectors	572	6,972	160,336
11	Agriculture, forestry, fishing and hunting	5	0 - 19	171
21	Mining, quarrying, and oil and gas extraction	8	100 - 249	Withheld
22	Utilities	2	20 - 99	Withheld
23	Construction	47	204	7,177
31-33	Manufacturing	19	100 - 249	5,112
42	Wholesale trade	15	124	3,073
44-45	Retail trade	118	1,173	25,188
48-49	Transportation and warehousing	18	222	8,886
51	Information	6	50	1,553
52	Finance and insurance	63	353	11,910
53	Real estate and rental and leasing	11	20 - 99	453
54	Professional, scientific, and technical services	41	120	3,277
55	Management of companies and enterprises	4	20 - 99	Withheld
56	Administrative and support and waste management and remediation services	21	358	5,351
61	Educational services	1	0 - 19	Withheld
62	Health care and social assistance	74	2,438	47,814
71	Arts, entertainment, and recreation	8	100 - 249	Withheld
72	Accommodation and food services	58	1,153	18,990
81	Other services (except public administration)	53	200	3,458

Source: U.S. Census Bureau 2013 County Business Patterns

TABLE 4-16

2013 ECONOMIC CENSUS FOR WAGONER COUNTY, OK

NAICS Code	Industry Description	Number of establishments	Number of Paid Employees per Pay Period	Annual payroll ($1,000)
00	Total for all sectors	919	8,705	295,853
21	Mining, quarrying, and oil and gas extraction	4	20 - 99	846
22	Utilities	2	20 - 99	Withheld
23	Construction	178	847	33,297
31-33	Manufacturing	60	2,253	123,079
42	Wholesale trade	47	379	19,526
44-45	Retail trade	114	1,483	31,161
48-49	Transportation and warehousing	31	105	4,184
51	Information	12	20 - 99	2,693
52	Finance and insurance	54	276	9,885
53	Real estate and rental and leasing	26	20 - 99	1,133
54	Professional, scientific, and technical services	72	214	6,788
55	Management of companies and enterprises	3	0 - 19	Withheld
56	Administrative and support and waste management and remediation services	68	598	12,489
61	Educational services	2	0 - 19	Withheld
62	Health care and social assistance	71	789	22,322
71	Arts, entertainment, and recreation	12	174	3,483
72	Accommodation and food services	68	1,045	13,855
81	Other services (except public administration)	94	349	7,372
99	Industries not classified	1	0 - 19	Withheld

Source: U.S. Census Bureau 2013 County Business Patterns

TABLE 4-17

SHIPPER CARRIER COST MODEL FOR NEWT GRAHAM

Cost by Days of Unscheduled Closure ($1,000's) (2015 Price Level)		
Number of Days	Full Lock Closure	Single Lock Closure
1	$ 10	$ 10
3	$ 89	$ 89
5	$ 158	$ 158
10	$ 408	$ 408
15	$ 866	$ 866
30	$ 2,774	$ 2,774
45	$ 4,874	$ 4,874
60	$ 6,970	$ 6,970
90	$ 11,153	$ 11,153
180	$ 24,088	$ 24,088
365	$ 50,543	$ 50,543

Source: U.S. Census Bureau 2013 County Business Patterns

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 and active reporting observation stations are shown on Plate 5-1. Upper and lower pool elevation data are provided by a bubbler gage connected to a digital recorder and wired to a transmitting type Data Collection Platform (DCP). This equipment is located at the lock in the downstream gate house. A float-well gage is located in the lock chamber for use during periods of inclement weather or poor visibility. No recorder is provided for the float-well gage, but indicators are located in both the upstream and downstream control shelters. Weather data are also collected at the lock and transmitted hourly with the pool elevation.

All stream gaging stations, listed in Table 5-1 and shown on Plate 5-1, are automated gages consisting of float wells, radar, or bubbler gages connected to digital recorders and DCP's. There are seven total upstream gages that are used in the forecast model: two on the Verdigris River, three on the Caney River, and two on Bird Creek. The two stream gages used on the Verdigris River are located on the Highway 20 bridge west of Claremore and on the Highway 51 bridge west of Wagoner. The three stream gages on the Caney River are located in Bartlesville, east of Ramona, and north of Collinsville. The two stream gages on Bird Creek are located at Avant and southeast of Sperry.

The gages at Muskogee, Oklahoma and Van Buren, Arkansas have been designated as regulation points for flow downstream of Newt Graham Lock and Dam 18.

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 pool 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 Lock Manager, Newt Graham Lock and Dam 18.

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 Verdigris and Arkansas River Basins. The Technical Services Section, Hydrology-Hydraulics Branch, is charged with the responsibility for the equipment placed by the Corps of Engineers.

5 - 02. Water Quality Stations.

a. Facilities. The Corps of Engineers and USGS have no water quality stations on the main stem of the Verdigris River above or below Newt Graham Lock and Dam 18. The Oklahoma Water Resources Board (OWRB) has four water quality stations on the Verdigris River which are sampled for their Beneficial Use Monitoring Program (BUMP). One station is above Oologah Lake near Lenapah. Two stations are above Newt Graham Lock and Dam 18 near Keetonville and Inola, and one is above Chouteau Lock and Dam 17 near Wagoner. If additional water quality data samples are needed for Newt Graham Lock and Dam 18, Planning Division would arrange for the sampling. Water quality stations on the Verdigris River and its tributaries are listed in Table 5-2.

b. Reporting. The reporting procedures for water quality stations are determined by the organization collecting the samples. Water quality sampling done under the BUMP would be reported directly to the OWRB. OWRB water quality sampling results can be found on the web at: http://www.owrb.ok.gov/studies/reports/reports/php. Water quality reports for sampling provided by Planning Division would be prepared in accordance with ER 1110-2-8154 and maintained in the Planning Division at the Tulsa District Office.

c. Maintenance. The Corps of Engineers has no permanent water quality sampling facilities to maintain near Newt Graham Lock and Dam 18. Maintenance and repair of the water quality stations listed in Table 5-2 are the responsibility of the respective agency listed in this table.

5 - 03. Sedimentation Stations.

a. Facilities. There are no sedimentation or degradation ranges established for Newt Graham Lock and Dam 18.

b. Reporting. Sediment surveys for the maintenance of the navigation channel are conducted by the Operations Division, Tulsa District.

c. Maintenance. No maintenance of sedimentation or degradation ranges is required.

TABLE 5-2

PERTINENT REPORTING WATER QUALITY STATIONS

Primary Station Code	Location Description	Type	Operating agency	Reporting or Non-Reporting	Period of Record	Frequency of Analysis	Latitude (North)	Longitude (West)
121300010010-001AT	Bird Creek, State Highway 266, Port of Catoosa	Physical/ Chemical	OWRB	Non-reporting	1998 – Present	5 years or as needed	36.22311412	95.81921244
121400010010-001AT	Caney River, Southeast of the Town of Ramona on County Road E0350	Physical/ Chemical	OWRB	Non-reporting	1998 – Present	5 years or as needed	36.50889974	95.84265966
121500010200-001AT	Verdigris River, West of the Town of Wagoner on US 51	Physical/ Chemical	OWRB	Non-reporting	1999 – Present	5 years or as needed	35.95547322	95.49477619
121510020010-001AT	Verdigris River, East of the Town of Lenepah on State Highway 10	Physical/ Chemical	OWRB	Non-reporting	1998 – Present	5 years or as needed	36.85121639	95.58531345
121500020260-001AT	Verdigris River, West of Inola on US 412	Physical/ Chemical	OWRB	Non-reporting	2000 – Present	5 years or as needed	36.16167897	95.49637137
121500030010-001AT	Verdigris River, East of the Town of Keetonville on State Highway 20	Physical/ Chemical	OWRB	Non-reporting	1998 – Present	5 years or as needed	36.30724953	95.69794268

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, the data are periodically archived on tape for permanent storage. Stream flow measurements made by the USGS are reported to the Hydrology-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 distributions, determining basin rainfall, and forecasting runoff (see Section VI).

c. Water Quality Data. Water quality data have not been recorded with regularity for Newt Graham Lock and Dam 18.

5 - 05. Communication Network. Wire facilities at the Newt Graham Lock and Dam 18 project office consist of local and long-distance telephone service. Radio communication is by VHF-FM fixed station (call signal WUI-327) capable of reaching local mobile stations, the Tulsa District, stations of the local loop of 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 of gate changes, a warning siren is activated before each change. The siren at the spillway is blown for 1 minute before a change in discharge occurs. Audible (air horn) and visual (traffic) signals are used to communicate with vessels entering or exiting the lock chamber.

5 - 06. Communication with Project.

a. Water Management Section with Project Office. Communication between the Water Management Section and the Project Office will normally be made by telephone or email, but on occasion could be made by VHF-FM radio (call sign WUI-327). The reports by the project, described in paragraph 5-07 and Exhibit B of this manual, will be made available to the Water Management Section. Should communication between the project and Tulsa District be disrupted, the Lock Operator will, on his/her own initiative, direct regulation of the project according to 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, complaints, problems, 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 from all locks and dams without hydropower. Weekend and holiday reports will be taken on the following weekday. Data are posted on the 824 form, which is located on the Navigation Project Office server: \\swt-fs-rsker\shared\Locks folder. Data collected will be reviewed and input into the Water Management Section's database before 10 a.m., and published to the project data morning report located at http://www.swt-wc.usace.army.mil/old_resvrept.htm by 10 a.m. See Plate 5-3 for project data reporting details.

a. As of 8 a.m. Each Weekday.
   1) Hourly pool elevations, headwater and tailwater, of the previous day up to 8 a.m. of the current day.
   2) The time, pool elevation, and number of gate feet for each gate change made since the previous day's 8 a.m. report.
   3) The total precipitation amounts for the previous 24-hour period (7 a.m. to 7 a.m.).
   4) The number of lockages over the previous 24-hour period (midnight to midnight).

5) The current wind direction and wind speed (Beaufort scale).

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

1) The current pool elevation reading 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. During Flood Periods.

1) In addition to the data in paragraphs 5-07.a. and 5-07.b. above, additional reports of pool elevations may be requested by Water Management Section personnel.

d. Rainfall Reports. Rainfall reports shall be made as follows:

1) At 8 a.m. all precipitation that has occurred during the preceding 24 hours, 7 a.m. to 7 a.m., as shown on Plate 5-3 (covered by routine report on working days).
2) Report at once the occurrence of 2.0 inches or more of precipitation that occurs during a period of 6 hours or less. During nonworking hours, the report should be made to one of the persons listed on page iii.

5 - 08. Warnings. The Lock Operator will maintain a list in current status of residents and/or property owners who might be endangered or inconvenienced by in-channel releases and will give them notification of impending releases. This notification will be made by telephone or oral warning by Corps employees. It is the responsibility of the Lock Operator to initiate a warning to the Oklahoma Civil Defense Department 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. Lock Operators must be knowledgeable of conditions that constitute an emergency, such as a possible dam failure. The downstream population and navigation interests should be notified as early as possible of a potential problem. Minimum notification procedures are as follows:

> A "General Alert" should be issued by the Lock Operator to the Civil Defense when life-threatening high releases from a dam failure or flooding are predicted to reach the downstream population at risk within 6 hours. An "Evacuation Warning" should be issued by the Lock Operator when analysis of the threatening event and reservoir response indicate that life-threatening floodwaters will reach the downstream population in 4 hours or less.

The Newt Graham Lock and Dam 18 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 stream flow above and below Newt Graham Lock and Dam 18 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 projects for flood control and other authorized purposes and for the benefit of Corps of Engineers' construction projects and flood management activities. In contrast to the NWS, which furnishes weather and flood forecasts to the public, the Tulsa District furnishes information on current and forecasted lake levels and lake releases. 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 south-central 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 flash floods (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 of Newt Graham Lock and Dam 18. Personnel in the Water Management Section have developed a flood forecasting model for Newt Graham lock and Dam 18. 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) Current releases from and inflow into Newt Graham Lock and Dam 18.

(3) Flood hydrographs for stream gages listed in Table 5-1.

(4) Projected releases from Skiatook, Birch, Hulah, Copan, and Oologah Lakes, 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 DCP's (by the water control computer), the Oklahoma Mesonet, and also the NWS Stage III digital radar recorder. 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 on 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-basin. 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 sub-basins and flood hydrographs are combined and routed to compute an inflow hydrograph. Using projected releases from Skiatook, Birch, Hulah, Copan, and Oologah Lake, the inflow hydrograph is routed through Newt Graham Lock and Dam 18. Flood control releases are projected based upon conditions on the Navigation System and following procedures described in Section V of the Arkansas River Basin Water Control Master Manual. The unit hydrographs for drainage areas upstream of Newt Graham Lock and Dam 18 are presented on Plate 6-2 through Plate 6-6.

6 - 03. Conservation Purpose Forecasts.

a. Requirements. Conservation forecasts are not required for this project.

b. Methods. Forecasts for conservation purposes during non-flood periods would rely largely on statistical interpretation of historical data. The flow duration curve (Plate 4-4) and the peak inflow frequency 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 maintaining constant or slowly changing pool levels for navigation purposes is dependent on accurate estimates of the water volume that will pass through the project.

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. Inflow into Newt Graham Lock and Dam 18 is dependent on rainfall. There are no techniques available at this time to forecast droughts for projects dependent upon rainfall for inflow.

VII - WATER CONTROL PLAN

7 - 01. General Objectives. The primary objective of the Newt Graham Lock and Dam 18 project is navigation. The project is also authorized for recreation and fish and wildlife. Newt Graham Lock and Dam 18 will be operated as a unit in a multipurpose system providing benefits on the Verdigris and Arkansas Rivers. Releases from Newt Graham Lock and Dam 18 will be made in accordance with the predicted inflow into the pool, and will be made to keep the pool elevation within operating limits. All elevations referred to in Chapter 7, unless noted otherwise, are in feet, NGVD29. Add 0.08 ft. to the NGVD29 elevation to obtain the NAVD88 elevation at Newt Graham Lock and Dam 18.

7 - 02. Major Constraints. Due to the fact that there is no flood storage in the project, this project is operated as a run-of-river project, meaning releases equal inflows. The downstream channel capacity below this project is approximately 35,000 cfs. This release should not be exceeded unless inflow forecasts show that uncontrolled flow will require releases that temporarily exceed this amount. The spillway tainter gates are capable of discharging 36,000 cfs at the normal upper pool elevation 532.0 feet, NGVD29. All the tainter gates at the project are completely opened and out of the water (open river) when the flows in the Verdigris River reach approximately 45,000 cfs.

Newt Graham Lock and Dam 18 is, however, part of the Arkansas River navigation system, and is operated in accordance with the Arkansas River System Operating Plan, as discussed in Chapter VII of the Arkansas River Basin Water Control Master Manual, dated 2007. The constraints on the system below the project include the Muskogee gage, the closest regulation point downstream of the project on the Arkansas River, and the Van Buren gage, also located on the Arkansas River. The flood stage at the Muskogee gage is 28.0 feet, which is currently estimated at 120,079 cfs. The next downstream regulation point is the Van Buren gage with a flood stage of 22.0 feet, which is estimated to be between 135,000 and 150,000 cfs. Capacity at this location changes frequently due to the sand riverbed.

7 - 03. Overall Plan for Water Control.

a. General. Newt Graham Lock and Dam 18 is regulated as a unit in a multipurpose system for the benefit of water resources in the Arkansas River Basin. Development of water resources is discussed in the Arkansas River Basin Water Control Master Manual, with the specific purposes of each of the various projects detailed in the appropriate appendix.

b. System Regulation. Newt Graham Lock and Dam 18 will be regulated as a run-of-river facility in the total Arkansas/Verdigris River system for control of floods on the Arkansas River to Van Buren, Arkansas. The Arkansas River Basin Water Control Master Manual provides detailed information on the Arkansas River system operation necessary to determine the allowable flood releases from upstream projects. In addition, Newt Graham Lock and Dam 18 will be regulated for navigation.

7 - 04. Standing Instructions to Lock Operator. The project will be regulated in accordance with the normal water control regulations as directed in paragraph 7-05.a. and Exhibit B (Section

II) of this manual. During flood events or emergencies, the project will be regulated in accordance with paragraph 7-05.b. and Exhibit B (Section II) of this manual. In the event communication with the Tulsa District Office is disrupted, the Lock Operator will immediately make every effort to reestablish communications with the Tulsa District Office. The Lock Operator will make daily observations of the pool level and gate change data and will report those observations as directed in paragraph 5-07, and 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, or power outage, the Water Management Section will be notified immediately.

7 - 05. Flood Control.

a. Normal Water Control Regulations. The navigation pool at Newt Graham Lock and Dam 18 will be regulated to provide a navigable channel from the Tulsa Port of Catoosa through Newt Graham Lock and Dam 18. The following regulations will normally govern releases from the navigation pool (all elevations in NGVD29).

1. The navigation pool level will be maintained at or above elevation 532.0 at all times.

2. When the navigation pool level is between elevations 532.0 and 532.5, required releases will be made through lockage and spillway gates to maintain the navigation pool level between these elevations.

3. When the navigation pool level is at or near 532.5 and the inflow exceeds that necessary for lockage requirements, the spillway gates will be operated to maintain the pool level at or below elevation 532.5 by releasing inflow until all gates are fully open.

4. If the gates are fully open and the navigation pool level exceeds elevation 532.5, the gates will remain fully open until the pool reaches a maximum elevation and begins to fall. When the pool level nears elevation 532.0, the Lock Operator will begin to lower the gates, while still passing inflow, to maintain the pool between elevations 532.0 and 532.5.

5. Spillway gates can, under normal conditions, be operated in increments as small as one-fourth of a foot and as large as one foot. During large flood events, the gates may be operated in increments of several feet if necessary. Except during unusual operation and maintenance activities approved by the Navigation Manager, the gates will have no more than one foot of difference in the opening of any two gates. In every case, the top of gate elevation will be maintained at least one-quarter of a foot (3 inches) above the navigation pool level, though a minimum of one-half of a foot is preferred.

b. Emergency Water Control Regulations. Should communications with the Tulsa District Office be disrupted, the Lock Operator or his/her representative will direct regulation of the navigation pool in accordance with the following rules of regulation until communication is

restored. In addition, the Lock Operator or his/her representative will immediately make every effort to reestablish communication with the Tulsa District Office and, if necessary, send information to the Tulsa District Office by any means available. If an emergency condition is experienced, the following regulations shall be followed.

1. Read the current pool elevation and maintain current releases for one hour. The pool elevation should be carefully read from the pool gages to obtain the changes in pool elevation. Based on judgment, allowance should be made for any changes in the pool elevation that may be due to wave and wind action, recent changes in spillway gate openings, and lockages.

2. At the end of each one hour period thereafter, read each pool elevation.

3. Compare current pool level reading with the previous reading and adjust releases in accordance with Plate 7-1, "Inflow vs. Rate of Rise." If the current discharge is less than 50,000 cfs, the change in releases will be limited to 10,000 cfs per hour. If the current discharge is more than 50,000 cfs, the change in releases will be limited to 0.2 times the current release per hour.

4. If discharge requirements exceed spillway gate capacity, all gates will be held fully open until the pool elevation reaches a peak and recedes to pool elevation 532.0, at which time releases will be adjusted in accordance with Plate 7-1.

5. During emergency events, the Lock Operator may temporarily deviate from the current release rates if a short-term departure is deemed necessary to protect the safety of the dam, or to avoid serious hazards to life. Such actions shall be reported immediately to the Water Management Section 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. Continuance of the deviation will require the approval of the Water Management Section.

6. If the differential gate opening of greater than one foot needs to be sustained for more than 24 hours to facilitate operation and maintenance activities, the Navigation Manager will notify the Hydraulic Steel Structures representatives in the Engineering and Construction Division at the District Office.

c. Operational Curves. The Spillway Gate Rating Curves and the Tailwater Rating Curve are shown on Plate 7-2 and Plate 7-3, respectively. The Evaporation Curves are shown on Plate 7-4. Elevation-Area-Capacity curves are shown on Plate 7-5, with the data presented in Table 7-2 in the Supplemental Tables Section. Rating curves used by the Water Management Section are adjusted for changing conditions and are maintained in current status.

7 - 06. Recreation. No storage or releases are authorized for recreation at Newt Graham Lock and Dam 18. Recreation features at the project include camping, picnicking, boating, and fishing. The locations of public facilities are shown on Plate 2-3.

7 - 07. Water Quality. Water quality is not an authorized project purpose; as such, the project has no storage allocated for this purpose.

7 - 08. Fish and Wildlife. Fish and wildlife is an authorized project purpose, however, no storage or releases are allocated for this purpose. Oklahoma Department of Wildlife Conservation (ODWC) manages the fish and wildlife resources in Oklahoma rivers and lakes, including the Verdigris River.

7 - 09. Water Supply. No storage is currently provided for water supply at Newt Graham Lock and Dam 18.

7 - 10. Water Rights. The Oklahoma Water Resources Board (OWRB) has issued water right permits on the Verdigris River below Newt Graham Lock and Dam 18 and above the confluence of the Arkansas and Verdigris Rivers. Since this is a run-of-river project, no specific releases are made for water right permit holders. Permit holders may withdraw water from the Verdigris River at any time within the limits of their permit. As of December 2016, holders of 19 permits may withdraw a combined total of 18,380 acre-feet per year. The OWRB should be contacted for updated water rights summaries. The water rights applicants and authorized amounts are presented below in Table 7-1.

7 - 11. Hydroelectric Power. Hydroelectric Power is not an authorized project purpose. Consequently, no installed physical features exist for hydropower.

7 - 12. Navigation. In order to provide a tapered recession of flows along the Arkansas River navigation channel, Newt Graham Lock and Dam 18 will be regulated as a run-of-river facility in conjunction with the other reservoirs in the navigation system. The coordinated regulation of the reservoir is discussed in Chapter VII of the Arkansas River Basin Water Control Master Manual.

The river is a very reliable system and is navigable more than 85% of the time. Flows in excess of 100,000 cfs must occur to effectively eliminate tow boat traffic on the Arkansas River; however, flows greater than 15,000 cfs may hamper navigation on the Verdigris River. Low flow restrictions have yet to be experienced, and are expected to apply only during periods of extreme drought. Further discussion of these low flow restrictions is included in the Drought Contingency Plan published for the navigation system (see paragraph 7-14).

7 - 13. Sediment. There is no storage capacity allocated in the Newt Graham Lock and Dam 18 pool for sediment storage. The minimal amount deposited under normal conditions is either swept downstream during high flow events or removed by dredging during maintenance of the navigation channel. The area-capacity table based on the initial sediment survey for the navigation pool is included as Table 7-2, located in the Supplemental Tables Section.

7 - 14. Drought Contingency Plans. A Drought Contingency Plan for the navigation system was published in October 1992, in accordance with ER 1110-2-240, ER 1110-2-1941, and ETL 1110-2-335. The plan was published as Appendix DCP-6 to the Arkansas River Basin Water Control Master Manual, and contains instructions for necessary coordination and operations during a drought. Copies of the plan are kept at the Newt Graham Lock and Dam 18 project office and in the Water Management Section in the Tulsa District office.

7 - 15. Flood Emergency Action Plans. A flood emergency action plan is outlined in the Operation and Maintenance Manual, Volume II, Newt Graham Lock and Dam 18, dated August 1985. 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.

TABLE 7-1

ACTIVE WATER RIGHTS HOLDERS

Permit Number	Applicant Name	Authorized Amount (acre-feet/year)	Purpose	Date Issued
19800131	Anderson Charitable Remainder Trust, Carl C Sr. and Marie Jo	467	Irrigation	12/9/1980
20060040	Anderson Charitable Remainder Trust, Carl C Sr. and Marie Jo	6,661	Irrigation	3/11/2008
19800184	City of Coweta, Oklahoma	2,502	Public Supply	5/12/1981
20040011	Wagoner Co Rural Water District #5	2,771	Public Supply	8/10/2004
19760141	Wagoner Co Rural Water District #5	240	Public Supply	4/12/1977
19970013	(b) (6)	302	Irrigation	1/12/1999
20070001	Easton Family Limited Partnership	125	Irrigation	5/8/2007
19640448	City of Coweta, Oklahoma	258	Public Supply	7/14/1964
20140013	(b) (6)	1,008	Irrigation	1/20/2015
19910003	(b) (6)	3	Irrigation	5/6/1991
20160013	(b) (6)	938	Irrigation	10/11/2016
19930028	Department of Wildlife Conservation	100	Recreation, Fish, Wildlife	4/12/1994
19820093	Department of Wildlife Conservation	435	Recreation, Fish, Wildlife	11/9/1982
20030021	(b) (6)	300	Irrigation	9/9/2003
19890044	Department of Wildlife Conservation	60	Recreation, Fish, Wildlife	10/10/1989
19870044	(b) (6)	148	Irrigation	2/9/1988
20070007	TPNB Service Corporation	1,230	Irrigation	6/12/2007
20090019	Hale Family Trust, James & Roberta	192	Irrigation	11/10/2009
20110032	Phillips Farms LLC	640	Irrigation	9/13/2011

Water Rights Information Obtained from the OWRB (http://www.owrb.ok.gov/supply/watuse/permitting.php)
Data obtained April, 2016

7 - 16. Deviation from Normal Regulation. The District Engineer may occasionally request to deviate from normal regulating procedures at the projects. Prior approval is obtained from the

Southwestern Division (SWD) in accordance with ER 1110-2-240, except in emergencies as noted in paragraph 7-16.a. These deviations are normally in the following categories:

a. Emergencies. The water control plan is subject to temporary modification by the Corps if found necessary in time of emergency. Request for modifications and actions on such emergencies can be made by the fastest means of communication available. However, emergency deviations may require immediate action with no time in which to seek approval from SWD. The Lock Operator 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. These emergencies include drowning, accidents, operating facility failure, and pollution. The Lock Operator may deviate from the water control plan whenever necessary to protect the safety of the dam. Such actions 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 regulation of the pool, although they are not considered emergencies. Construction activities, such as utility stream crossings, bridgework, and major construction contracts, account for the major portion of unplanned deviations. Also, deviations are sometimes necessary for maintenance and inspection. Requests for changes of release rates are generally for 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 projects, and possible alternative measures. In an effort to maintain good public relations, the requests are usually granted, provided there are no adverse effects on the overall regulation of the project (or projects) for optimum benefits to the authorized and useful purposes. Approval for minor deviations will normally be obtained by the Water Management Section from SWD by telephone or email. A written confirmation showing the deviation and conditions will be furnished to CESWD-MTE, usually by email.

c. Unplanned Major Deviations. There are unplanned instances that create a temporary need for major deviations from the normal regulation plan and may be similar to, but are not, emergencies. Request 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, condition of the project, 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 SWD Water Control Manager.

d. Planned Deviations. Other instances when a deviation may occur include anticipated or planned deviations. Advance approval of 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 paragraph 7-16.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 unduly compromise the project's ability to meet its authorized purposes. Sufficient data on flood potential, pool and watershed conditions, possible alternative measures, benefits to be expected, and probable effects on other authorized and useful purposes will be presented by letter, telephone, email, or facsimile to SWD along with Tulsa District recommendations for review and/or approval. Approval of prolonged deviations will not be granted unless such investigations and studies have been conducted to the extent deemed necessary by the SWD Water Control Manager.

7 - 17. Rate of Release Changes. Gradual increases and decreases in releases will be made when possible in order to minimize detrimental effects on navigation and regulation of the pool. Situations may arise which will not allow an orderly increase and/or decrease in releases. Spillway releases are normally increased and decreased in increments no greater than 3,000 cfs.

During flood periods, gate changes may be directed by the Water Management Section at any time. When significant amounts of flood waters have entered the pool, gate changes can be expected several times per day. Only under the most unusual circumstances will gate changes be made more frequently than one every hour. Frequency of gate changes during low-flow operation will be less frequent than during flood operations.

VIII - EFFECT OF WATER CONTROL PLAN

8 - 01. General. The effects of flood control regulations on the standard project flood, the navigation design flood, a portion of the May 1943 flood, the October 1986 flood, and the June-July 2007 flood are presented below. These examples were selected to show the effects of the regulations on a variety of possible conditions. These floods have been modified by the existing and authorized system of flood control projects, even if the projects weren't in place at the time of the flood.

8 - 02. Flood Control.

a. Standard Project Flood. The Standard Project Flood (SPF) was routed through the navigation pool. The peak inflow of the flood is approximately 154,000 cfs, and a total flood volume of 910,000 ac-ft entering the pool in the first 7 days, which accounts for approximately 62% of the total flood volume. The operational hydrograph for the SPF is shown on Plate 8-1.

b. Modified Flood of May 1943. The May 1943 flood, modified by the existing system of reservoirs, was selected to demonstrate the effect of emergency regulation procedures. This flood was the maximum of record in the vicinity of Newt Graham Lock and Dam 18. Using emergency regulations, the navigation pool level fluctuated from a maximum elevation of 547.0 ft, NGVD29, to a minimum elevation of 531.91 ft, NGVD29, with a peak inflow of 148,900 cfs and a peak discharge of 148,600 cfs. The operational hydrographs for emergency regulations are shown on Plate 8-2.

c. Flood of October 1986. The flood of October 1986 is the largest flood on record with Newt Graham Lock and Dam 18 in place. The peak pool elevation was 536.00 ft, NGVD29, with a peak inflow of 106,700 cfs and a maximum outflow of 108,063 cfs. The observed operational hydrographs are shown on Plate 8-3.

d. Flood of June-July 2007. The observed flood of June-July 2007 resulted in a peak pool elevation of 533.12 ft, NGVD29, and a minimum pool elevation of 528.26 ft, NGVD29. The flood also produced a peak inflow of 65,179 cfs and a maximum outflow of 63,000 cfs, both occurring on July 7, 2007. The observed operational hydrographs are shown on Plate 8-4.

8 - 03. Recreation. Recreation features at the project include camping, sightseeing, picnicking, hiking, boating, hunting, and fishing. Recreational areas are not affected by the minor pool changes that occur at the project

8 - 04. Water Quality. No water quality storage is allocated for Newt Graham Lock and Dam 18.

8 - 05. Fish and Wildlife. ODWC manages the fish and wildlife resources in Oklahoma. Since Newt Graham Lock and Dam 18 is a run-of-river project, this has no impact on the project operations.

8 - 06. Water Supply. Water supply is not an authorized purpose for Newt Graham Lock and Dam 18.

8 - 07. Hydroelectric Power. Hydroelectric power is not an authorized project purpose for Newt Graham Lock and Dam 18.

8 - 08. Navigation. The releases from Newt Graham Lock and Dam 18, along with those of other reservoirs (discussed in Chapter VII of the Arkansas River Basin Water Control Master Manual), benefit navigation along the McClellan-Kerr Navigation system by providing a tapered recession of flows along the system. The controlled recession will enable navigation operation to continue while shoals located in the navigation channel are removed.

8 - 09. Drought Contingency Plans. The Arkansas River Navigation Drought Contingency Plan, dated October 1992, is part of Appendix DCP-6 to the Arkansas River Basin Water Control Master Manual and covers these projects: Newt Graham L&D 18, Chouteau L&D 17, Webber Falls L&D 16, Robert S. Kerr L&D 15, and W.D. Mayo L&D 14. This plan provides guidance structured to the severity of the drought. The Drought Contingency Plan enables the Tulsa District to effectively coordinate with the public, stakeholders, and state and local agencies during drought conditions.

8 - 10. Flood Emergency Action Plans. The flood emergency action plan is outlined in the Operations and Maintenance Manual, Volume II, for Newt Graham Lock & Dam 18, dated August 1985. 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 or appurtenant works.

8 - 11. Frequencies.

a. Peak Inflow Probability. Newt Graham Lock and Dam 18 is not a control point in the Tulsa District RiverWare model. The nearest upstream control point in the model is Inola, a historical stream gage location. Since Newt Graham Lock and Dam 18 is a run-of-river project, where inflows are essentially equal to outflow, the inflows at Newt Graham Lock and Dam 18 would be very similar to the flows at Inola. Flows at Inola were generated using the Tulsa District RiverWare model. 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 Frequency Curves. Because Newt Graham Lock and Dam 18 is a run-of-river project, pool elevation probability and duration is not applicable. Historical pool elevation hydrographs are shown on Plates 8-6 through 8-10.

c. Key Control Points. The nearest control point below Newt Graham Lock and Dam 18 is the Muskogee gage on the Arkansas River. Regulating stage at the Muskogee gage is 28.0 feet, which is currently estimated at 120,079 cfs. The second control point is Tulsa District's Van Buren gage on the Arkansas River. The regulating stage at the Van Buren gage is 22.0 feet, which is estimated to be between 135,000 and 150,000 cfs. Capacity at this location changes frequently due to the sand riverbed.

8 - 12. Other Studies.

a. Examples of Regulation. The 1979 Arkansas River Regulation Study was the first system wide operational plan. This was re-studied in 1986 with the Arkansas River Water Control System Operation Plan. In 2005, the Arkansas River Navigation Study evaluated the need and opportunity to reduce flood damages and develop additional municipal, industrial, and agricultural water supplies within the Arkansas River Basin in Arkansas and Oklahoma. The system operating plan this study recommended included the 60,000 cfs three day bench at Van Buren during the tapered flood evacuation of the Arkansas River Basin. This final operating plan is contained in the Arkansas River Basin Water Control Master Manual, revised Chapter 7 that was approved in October 2007.

b. Channel and Floodway Improvement. The 2005 Arkansas River Navigation Study included examining the feasibility of deepening the navigation channel from 9 ft. to 12 ft.

IX - WATER CONTROL MANAGEMENT

9 - 01. Responsibilities and Organization.

a. Corps of Engineers Newt Graham Lock and Dam 18 is a Corps of Engineers project, with the Tulsa District responsible for directing releases, managing the navigation pool, and maintaining the project, lands, and recreation facilities. The Lock Operator, working through the Navigation Manager and Operations Division, has the responsibility for project operations concerning discharge releases. The Project Manager at Fort Gibson Lake, working through the Operations Division, has the responsibility for project operations dealing with lands and recreation. Project reporting instructions and an organization chart are presented in Section V, and project operating 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) Investigation 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. Instruction of 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 project 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). The duties of the Lock Operator 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, instructions for the routine regulation of the project are provided by the Navigation Manager or his/her representative. However, during flood periods, assistance of personnel from the Water Management Section may be required to maintain effective regulation of the Verdigris/Arkansas system. Additional personnel from Operations may also be necessary to help with project operations, including gate changes and inspection of the embankments. 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 for 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 of the Engineering Division with instruction to provide warnings 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.

(5) Role of Lock Operator. The Lock Operator will regulate the project according to instructions issued by personnel of the Water Management Section. The instructions follow the "Normal Regulations for Flood Control," included in Section VII and Exhibit B of this manual. If the Lock Operator loses communication with the Tulsa District office, he/she will immediately attempt to re-establish communication with the Tulsa District office while following the instructions outlined in the section "Emergency Flood Control Regulations" included in Section

VII and Exhibit B of this manual. The Lock Operator will make daily observations as directed in paragraph 5-07 of this manual.

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 most stream gages. Both the NWS and the USGS cooperate with the Water Management Section, Hydrology-Hydraulics Branch, Tulsa District Office, to accumulate rainfall and stream flow data.

c. State and County Agencies. Management of the fish and wildlife resources in the State of Oklahoma, including the Verdigris River, is the responsibility of the Oklahoma Department of Wildlife Conservation (ODWC).

d. Private Organizations. Presently, there are no private organizations that have regulatory responsibilities at Newt Graham Lock and Dam 18.

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 pool elevations. The NWS is officially responsible for issuing flood warnings to the public. This information will be supplemented by the Corps of Engineers bulletins from the Public Affairs Office (PAO) on observed conditions and with technical advice to enable local interests, within the limits of their capabilities, to obtain optimal flood protection and to perform rescue and relief functions. 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. 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, Newt Graham Lock and Dam 18 is not included in any interagency agreements.

9 - 04. Commissions, River Authorities, Compacts, and Committees. 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 Verdigris and Arkansas Rivers 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 Newt Graham Lock and Dam 18.

9 - 06. Reports

a. Daily Reports. 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 Project 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. Supplemental information on the regulation of the lakes, such as

explanation of deviations from approved schedules, is added as a note on the reports or as an attachment. 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 from 1994 to present are also available on the Tulsa District web page at http://www.swt-wc.usace.army.mil/NEWTcharts.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. The report usually addresses flood storage of reservoirs, which is not applicable to run-of-river projects. Pertinent data that may be included in a report for Newt Graham Lock and Dam 18 includes stage of river, flow of river, days of navigation disruption, 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 that are considered essential for flood control and flood plain studies or in the review of possible claims against the United States for damages. The report is prepared by the District Office Emergency Management personnel, using information compiled and prepared by the Water Management Section. The report should be completed within approximately three months of the time of flooding, including a statement of final damages.

e. Annual Reports. 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 projects in the Tulsa District.

TABLE 9-1

SUMMARY OF REPORTS

Name of Report	When Required	Regulation Requiring Reporting
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

NEWT GRAHAM LOCK AND DAM,
VERDIGRIS RIVER, OKLAHOMA
WATER CONTROL MANUAL
APPENDIX S, PART VI
TO
WATER CONTROL MASTER MANUAL
ARKANSAS RIVER BASIN

SUPPLEMENTAL TABLES

Evaporation Equations used for Table 4-2 Calculations:

$$xcompl = 1 - (RELH/100) \tag{1}$$

$$TdC = TAIR - \Big(\big(14.55 + (0.114 \times TAIR)\big) \times xcompl + \big((2.5 + 0.007 \times TAIR) \times xcompl\big)^3 + (15.9 + 0.117 \times TAIR) \times xcompl^{14}\Big) \tag{2}$$

$$\delta\lambda_1 = \frac{1}{\big(1 + (0.66/(0.00815 \times TAIR + 0.8912)^7)\big)} \tag{3}$$

$$\delta\lambda_2 = 1 - \delta\lambda_1 \tag{4}$$

$$Q_n = (0.00714 \times SRAD) + (0.00000526 \times SRAD \times (TAIR + 17.8)^{1.87}) + (0.00000394 \times SRAD^2) - (0.00000000239 \times SRAD^2 \times (TAIR - 7.2)^2) - 1.02 \tag{5}$$

$$es_{ea} = 33.86 \times ((0.00738 \times TAIR + 0.8072)^8 - (0.00738 \times TdC + 0.8072)^8) \tag{6}$$

$$E_a = {es_{ea}}^{0.88} \times (0.42 + 0.0029 \times WSPD) \tag{7}$$

$$Daily\ Pan\ Evaporation = (\delta\lambda_1 \times Q_n + \delta\lambda_2 \times E_a)/25.4 \tag{8}$$

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^2)

TABLE 4-7

NEWT GRAHAM LOCK AND DAM MONTHLY INFLOWS (ACRE-FEET)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1970	-	-	-	-	-	-	-	-	109,877	33,719	24,843	27,632	196,071
1971	217,427	120,473	229,263	14,203	32,602	11,656	99,550	9,425	281,868	377,174	70,686	760,100	2,224,427
1972	159,914	98,077	44,232	58,829	63,977	11,641	139,437	81,793	71,627	237,618	820,100	256,239	2,043,484
1973	945,861	523,100	1,406,781	1,186,355	1,494,849	357,361	206,421	56,083	100,585	442,142	848,806	773,124	8,341,468
1974	835,991	325,577	1,498,762	555,427	585,423	920,759	302,530	77,776	454,551	368,829	1,777,421	733,603	8,436,649
1975	614,863	854,710	929,302	652,533	499,636	810,495	199,128	44,416	33,360	18,541	26,530	39,785	4,723,299
1976	18,863	17,265	157,418	166,783	359,058	115,439	1,213,100	63,968	13,778	12,161	7,054	10,498	2,155,385
1977	9,227	13,372	38,963	25,587	381,979	455,182	782,280	219,868	960,520	194,874	810,176	89,724	3,981,752
1978	62,078	298,402	513,646	197,190	843,795	431,118	156,611	15,995	8,712	7,760	13,400	8,480	2,557,187
1979	67,300	43,900	374,300	382,400	231,800	549,100	268,900	113,700	7,430	8,975	273,613	222,049	2,543,467
1980	76,760	140,231	339,570	754,314	299,107	149,355	17,087	11,404	22,809	8,995	11,791	12,019	1,843,442
1981	6,148	23,797	13,356	26,925	97,388	100,680	118,066	59,404	54,942	67,566	272,231	104,231	944,734
1982	138,842	300,991	323,900	49,666	613,507	1,198,561	410,340	122,677	16,482	10,115	44,697	186,545	3,416,323
1983	205,785	614,776	364,561	1,264,958	1,034,975	327,669	106,056	13,685	12,892	250,413	84,495	112,760	4,393,025
1984	59,504	165,520	1,030,809	1,259,107	731,603	635,900	92,876	23,504	24,198	110,677	99,173	492,793	4,725,664
1985	798,545	665,950	1,765,537	644,925	731,504	1,154,975	372,162	282,198	230,826	655,735	1,023,669	820,859	9,146,885
1986	200,826	149,514	170,876	474,446	650,677	519,272	369,421	91,990	228,406	3,102,247	1,035,431	725,355	7,718,461
1987	415,061	725,752	1,327,537	443,702	358,809	550,314	265,285	54,049	69,272	57,123	187,933	693,619	5,148,456
1988	731,702	280,462	884,033	1,645,884	306,148	33,619	38,677	26,429	83,404	26,380	92,628	64,462	4,213,828
1989	96,595	168,495	259,289	309,520	240,099	937,685	441,917	245,057	580,264	231,322	239,504	36,793	3,786,540
1990	182,578	278,578	1,472,231	1,112,528	882,743	884,528	88,363	38,578	42,942	35,305	28,363	43,338	5,090,075
1991	79,388	43,685	34,115	119,454	367,120	374,280	31,219	27,609	35,553	45,719	94,512	309,044	1,561,698
1992	228,039	261,490	203,523	312,198	129,520	660,198	547,438	491,305	108,852	31,249	556,889	1,240,066	4,770,767
1993	1,242,842	716,033	752,132	655,537	1,383,471	1,366,115	420,198	154,909	199,031	375,292	167,345	155,999	7,588,904
1994	80,082	191,553	341,791	1,223,603	1,366,363	55,834	285,871	111,074	52,234	81,619	662,489	372,793	4,825,306

TABLE 4-7 CONTINUED

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1995	88,869	66,595	475,934	538,175	1,649,355	1,736,479	1,440,069	493,795	58,274	25,944	10,274	20,628	6,604,391
1996	29,256	31,428	25,527	38,142	67,855	58,393	33,025	31,934	121,706	167,742	740,092	429,719	1,774,819
1997	71,385	374,697	734,638	605,583	207,431	528,615	288,833	193,071	64,185	70,195	44,043	437,494	3,620,170
1998	936,158	251,008	869,583	853,487	742,869	47,296	81,897	31,993	44,231	1,066,085	1,057,923	728,132	6,710,662
1999	234,525	651,034	775,239	843,173	1,446,862	1,436,250	994,214	135,669	67,736	22,096	21,640	339,937	6,968,375
2000	150,149	216,178	813,322	326,479	918,545	495,629	676,066	42,982	21,977	43,378	56,628	31,874	3,793,207
2001	153,620	544,562	972,595	234,248	231,471	404,430	118,473	38,360	58,096	49,686	53,792	38,638	2,897,971
2002	44,727	80,727	49,587	134,777	655,477	712,165	228,972	45,461	38,380	31,002	21,283	32,807	2,075,365
2003	32,390	32,668	424,562	436,463	681,818	601,388	79,835	67,200	411,570	140,826	134,678	236,430	3,279,828
2004	453,620	411,074	1,150,115	530,380	818,876	315,570	439,140	154,215	13,091	43,835	313,686	234,347	4,877,949
2005	730,115	480,297	245,206	222,892	121,755	756,188	583,983	86,757	366,049	41,653	13,884	11,504	3,660,283
2006	10,413	9,025	17,256	75,868	620,231	49,190	49,488	52,562	16,661	12,198	11,008	41,653	965,553
2007	42,446	16,165	178,116	612,694	1,322,578	1,190,677	2,497,387	827,603	52,562	67,240	18,645	79,636	6,905,749
2008	126,942	404,628	535,140	1,229,553	1,362,545	2,202,644	1,273,289	690,049	492,595	357,322	321,818	94,413	9,090,938
2009	152,628	257,435	354,446	1,098,842	1,803,292	700,800	117,322	156,297	522,962	606,505	511,676	203,841	6,486,046
2010	276,383	412,155	570,565	328,582	383,048	686,975	735,967	227,603	99,659	11,970	35,226	11,286	3,779,419
2011	13,210	61,924	289,547	198,327	305,316	165,739	14,975	25,150	19,408	16,740	46,116	23,445	1,179,897
2012	15,035	38,995	511,596	627,967	750,188	113,395	16,691	16,780	16,760	20,787	11,683	8,866	2,148,743
2013	13,230	26,281	17,554	67,616	447,392	765,540	146,479	1,069,646	168,615	18,962	267,154	27,074	3,035,543
2014	42,922	9,283	65,673	52,919	32,628	349,963	21,279	19,636	14,797	386,201	72,119	40,145	1,107,565
2015	26,678	22,294	43,617	162,585	885,500	1,488,773	946,016	206,856	16,344	10,532	157,884	903,411	4,870,490
Mean	247,087	253,781	524,350	505,663	647,582	609,285	394,585	156,678	141,089	217,445	286,849	266,678	4,266,982
Max	1,242,842	854,710	1,765,537	1,645,884	1,803,292	2,202,644	2,497,387	1,069,646	960,520	3,102,247	1,777,421	1,240,066	9,146,885
Min	6,148	9,025	13,356	14,203	32,602	11,641	14,975	9,425	7,430	7,760	7,054	8,480	944,734

Note: Data obtained from SWT Monthly Charts

TABLE 5-1

AUTOMATED GAGES

Location	Type[1]	SWT ID	SHEF ID	USGS[2] Station Number	Latitude North Deg Min Sec	Longitude West Deg Min Sec
Bird Creek at Avant, OK	Precipitation	AVAN	AVTO2	07176500	36 29 06	96 03 36
Caney River, abv Coon Crk, Bartlesville, OK	Precipitation	BART	BVLO2	07174400	36 45 20	95 58 19
Birch Lake Dam	Precipitation	BIRC	BIRO2	07176465	36 32 00	96 09 43
Bird Creek at Catoosa, OK	Precipitation	CATB	CTSO2	07178200	36 13 25	95 49 10
Verdigris River near Catoosa, OK	Precipitation	CATO	CTOO2	07178452	36 12 13	95 42 26
Chouteau Lock and Dam 17	Precipitation	CHOU	WAGO2	07178660	38 51 56	95 22 13
Verdigris River nr Claremore, OK	Precipitation	CLAR	CLRO2	07176000	36 18 27	95 41 59
Caney River nr Colllinsville, OK	Precipitation	COLL	CVLO2	07175550	36 23 42	95 48 36
Copan Lake Dam	Precipitation	COPA	CPLO2	07174300	36 53 13	95 57 10
Fort Gibson Lake Dam	Precipitation	FGIB	GIBO2	07193000	35 52 12	95 13 38
Hardy Precipitation Gage	Precipitation	HARD	HARO2	N/A	36 56 30	96 47 60
Arkansas River nr Haskell, OK	Precipitation	HASK	HSKO2	07165570	35 49 22	95 38 16
Hominy Creek nr Hominy, OK	Precipitation	HOMI	HMYO2	07176950	36 28 25	96 22 43
Hulah Lake Dam	Precipitation	HULA	HULO2	07172500	36 55 39	96 05 18
Arkansas River nr Muskogee, OK	Precipitation	MUSK	MKGO2	07194500	35 46 10	95 17 49
Newt Graham Lock and Dam 18	Precipitation	NEWT	INLO2	07178620	36 09 43	95 37 07
Sand Crk blw Little Rock Crk nr Okesa, OK	Precipitation	OKES	OKEO2	07174618	36 43 58	96 04 48
Oologah Lake Dam	Precipitation	OOLO	OOLO2	07171300	36 25 21	95 40 46
Bird Creek at Owasso, OK	Precipitation	OWAS	OWSO2	07178000	36 14 55	95 52 01
Arkansas River at Ralston, OK	Precipitation	RALS	RLSO2	07152500	36 30 15	90 43 41
Caney River nr Ramona, OK	Precipitation	RAMO	RAMO2	07175500	36 30 31	95 50 36
Skiatook Lake Dam	Precipitation	SKIA	SKLO2	07176800	36 21 06	96 05 19
Hominy Crk blw Skiatook Lk nr Skiatook, OK	Precipitation	SKIH	SKBO2	07177410	36 21 06	96 05 01

TABLE 5-1 CONTINUED

Location	Type[1]	SWT ID	SHEF ID	USGS[2] Station Number	Latitude North Deg Min Sec	Longitude West Deg Min Sec
Bird Creek nr Sperry, OK	Precipitation	SPER	SPEO2	07177500	36 16 42	95 57 14
Verdigris River at Hwy 51 near Wagoner, OK	Precipitation	WG51	PODO2	N/A	35 57 21	95 29 38
1.8 mi WNW of Claremore	MESONET	CLSO2	CLSO2	N/A[3]	36 19 16	95 38 46
2 mi ENE of Copan	MESONET	CPSO2	CPSO2	N/A[3]	36 54 35	95 53 07
7 mi SW of Burbank	MESONET	FFSO2	FFSO2	N/A[3]	36 38 04	96 48 37
3.1 mi ESE of Inola	MESONET	INSO2	INSO2	N/A[3]	36 08 32	95 27 02
3.0 mi SE of Delaware, OK	MESONET	NTSO2	NTSO2	N/A[3]	36 45 00	95 37 00
2.5 mi W of Clarksville	MESONET	PESO2	PESO2	N/A[3]	35 49 32	95 33 35
8 mi ESE of Foraker	MESONET	PWSO2	PWSO2	N/A[3]	36 50 25	96 25 39
4 mi NW of Skiatook	MESONET	SKSO2	SKSO2	N/A[3]	36 24 55	96 02 13
2 mi S of Wynona	MESONET	WYSO2	WYSO2	N/A[3]	36 31 05	96 20 31
Bird Creek at Avant, OK	Stream Gage	AVAN	AVTO2	07176500	36 29 06	96 03 36
Caney River, abv Coon Crk, Bartlesville, OK	Stream Gage	BART	BVLO2	07174400	36 45 20	95 58 19
Bird Creek at Catoosa, OK	Stream Gage	CATB	CTSO2	07178200	36 13 25	95 49 10
Verdigris River near Catoosa, OK	Stream Gage	CATO	CTOO2	07178452	36 12 13	95 42 26
Verdigris River nr Claremore, OK	Stream Gage	CLAR	CLRO2	07176000	36 18 27	95 41 59
Caney River nr Colllinsville, OK	Stream Gage	COLL	CVLO2	07175550	36 23 42	95 48 36
Flat Rock Crk at Cincinnati Ave., Tulsa, OK	Stream Gage	FLAT	TFRO2	07177650	36 12 55	95 59 42
Arkansas River at Ft. Smith, AR	Stream Gage	FSMI	FSAA4	07249455	35 23 30	94 25 56
Arkansas River nr Haskell, OK	Stream Gage	HASK	HSKO2	07165570	35 49 22	95 38 16
Hominy Creek nr Hominy, OK	Stream Gage	HOMI	HMYO2	07176950	36 28 25	96 22 43
Arkansas River nr Muskogee, OK	Stream Gage	MUSK	MKGO2	07194500	35 46 10	95 17 49
Sand Crk blw Little Rock Crk nr Okesa, OK	Stream Gage	OKES	OKEO2	07174618	36 43 58	96 04 48
Caney River nr Ramona, OK	Stream Gage	RAMO	RAMO2	07175500	36 30 31	95 50 36
Hominy Crk blw Skiatook Lk nr Skiatook, OK	Stream Gage	SKIH	SKBO2	07177410	36 21 06	96 05 01
Bird Creek nr Sperry, OK	Stream Gage	SPER	SPEO2	07177500	36 16 42	95 57 14
Coal Creek at Tulsa, OK	Stream Gage	TULC	TCCO2	07177800	36 11 40	95 54 50

TABLE 5-1 CONTINUED

Location	Type[1]	SWT ID	SHEF ID	USGS[2] Station Number	Latitude North Deg Min Sec	Longitude West Deg Min Sec
Arkansas River at Van Buren, AR	Stream Gage	VANB	VBUA4	07250500	35 25 51	94 21 23
Verdigris River at Hwy 51 near Wagoner, OK	Stream Gage	WG51	PODO2	N/A	35 57 21	95 29 38
Birch Lake Dam	Pool	BIRC	BIRO2	7176465	36 32 00	96 09 43
Chouteau Lock and Dam 17	Pool	CHOU	WAGO2	7178660	38 51 56	95 22 13
Copan Lake Dam	Pool	COPA	CPLO2	7174300	36 53 13	95 57 10
Hulah Lake Dam	Pool	HULA	HULO2	7172500	36 55 39	96 05 18
Newt Graham Lock and Dam 18	Pool	NEWT	INLO2	7178620	36 09 43	95 37 07
Oologah Lake Dam	Pool	OOLO	OOLO2	7171300	36 25 21	95 40 46
Skiatook Lake Dam	Pool	SKIA	SKLO2	7176800	36 21 06	96 05 19

(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 7-2

ELEVATION – AREA – CAPACITY DATA

Area (1000's of Acres) Capacity (1000's of Acre-Feet)										
Pool Elevation (ft. NGVD)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
490	0.000	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009
	0.000	0.008	0.015	0.023	0.031	0.039	0.046	0.054	0.062	0.069
491	0.010	0.011	0.012	0.013	0.014	0.015	0.016	0.017	0.018	0.019
	0.077	0.085	0.092	0.100	0.108	0.116	0.123	0.131	0.139	0.146
492	0.020	0.021	0.022	0.023	0.024	0.026	0.027	0.028	0.029	0.030
	0.154	0.156	0.159	0.161	0.163	0.166	0.168	0.170	0.173	0.175
493	0.031	0.032	0.033	0.034	0.035	0.037	0.038	0.039	0.040	0.041
	0.178	0.180	0.182	0.185	0.187	0.189	0.192	0.194	0.196	0.199
494	0.042	0.044	0.045	0.047	0.048	0.050	0.052	0.053	0.055	0.056
	0.201	0.203	0.206	0.208	0.211	0.213	0.215	0.218	0.220	0.223
495	0.058	0.059	0.061	0.062	0.063	0.065	0.066	0.067	0.068	0.070
	0.225	0.235	0.246	0.256	0.267	0.277	0.287	0.298	0.308	0.319
496	0.071	0.073	0.075	0.076	0.078	0.080	0.082	0.083	0.085	0.087
	0.329	0.338	0.347	0.356	0.365	0.374	0.383	0.392	0.401	0.410
497	0.089	0.090	0.092	0.094	0.096	0.097	0.099	0.101	0.103	0.104
	0.420	0.429	0.438	0.447	0.456	0.465	0.474	0.483	0.492	0.501
498	0.106	0.108	0.110	0.111	0.113	0.115	0.117	0.119	0.120	0.122
	0.510	0.523	0.536	0.549	0.562	0.575	0.588	0.601	0.614	0.627
499	0.124	0.126	0.128	0.129	0.131	0.133	0.135	0.137	0.138	0.140
	0.641	0.654	0.667	0.680	0.693	0.706	0.719	0.732	0.745	0.758

TABLE 7-2 CONTINUED

Area (1000's of Acres) Capacity (1000's of Acre-Feet)										
Pool Elevation (ft. NGVD)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
500	0.142	0.144	0.147	0.149	0.151	0.153	0.156	0.158	0.160	0.162
	0.771	0.787	0.803	0.818	0.834	0.850	0.866	0.881	0.897	0.913
501	0.165	0.167	0.169	0.171	0.174	0.176	0.178	0.180	0.183	0.185
	0.929	0.944	0.960	0.976	0.992	1.007	1.023	1.039	1.055	1.070
502	0.187	0.189	0.192	0.194	0.197	0.199	0.202	0.204	0.207	0.209
	1.086	1.106	1.126	1.145	1.165	1.185	1.205	1.225	1.244	1.264
503	0.212	0.214	0.216	0.219	0.221	0.224	0.226	0.229	0.231	0.234
	1.284	1.304	1.324	1.343	1.363	1.383	1.403	1.423	1.442	1.462
504	0.236	0.238	0.241	0.243	0.246	0.248	0.250	0.253	0.255	0.258
	1.482	1.506	1.529	1.553	1.577	1.601	1.624	1.648	1.672	1.695
505	0.260	0.263	0.265	0.268	0.271	0.274	0.276	0.279	0.282	0.284
	1.719	1.746	1.772	1.799	1.825	1.852	1.878	1.905	1.931	1.958
506	0.287	0.290	0.293	0.296	0.299	0.302	0.304	0.307	0.310	0.313
	1.984	2.014	2.045	2.075	2.106	2.136	2.167	2.197	2.228	2.258
507	0.316	0.319	0.322	0.325	0.328	0.331	0.333	0.336	0.339	0.342
	2.289	2.319	2.349	2.380	2.410	2.441	2.471	2.502	2.532	2.563
508	0.345	0.348	0.352	0.355	0.359	0.362	0.366	0.369	0.373	0.376
	2.593	2.630	2.667	2.705	2.742	2.779	2.816	2.853	2.891	2.928
509	0.380	0.383	0.386	0.390	0.393	0.397	0.400	0.404	0.407	0.411
	2.965	3.002	3.039	3.077	3.114	3.151	3.188	3.225	3.263	3.300
510	0.414	0.418	0.422	0.425	0.429	0.433	0.437	0.440	0.444	0.448
	3.337	3.380	3.422	3.465	3.507	3.550	3.592	3.635	3.677	3.720
511	0.452	0.455	0.459	0.463	0.467	0.470	0.474	0.478	0.482	0.485
	3.762	3.805	3.847	3.890	3.932	3.975	4.017	4.060	4.102	4.145
512	0.489	0.493	0.497	0.501	0.506	0.510	0.514	0.518	0.522	0.526
	4.187	4.236	4.285	4.335	4.384	4.433	4.482	4.531	4.581	4.630

TABLE 7-2 CONTINUED

Area (1000's of Acres) Capacity (1000's of Acre-Feet)										
Pool Elevation (ft. NGVD)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
513	0.531	0.535	0.539	0.543	0.547	0.551	0.555	0.560	0.564	0.568
	4.679	4.728	4.777	4.827	4.876	4.925	4.974	5.023	5.073	5.122
514	0.572	0.577	0.582	0.586	0.591	0.596	0.601	0.606	0.610	0.615
	5.171	5.232	5.294	5.355	5.416	5.478	5.539	5.600	5.661	5.723
515	0.620	0.624	0.628	0.632	0.636	0.641	0.645	0.649	0.653	0.657
	5.784	5.848	5.912	5.976	6.040	6.104	6.167	6.231	6.295	6.359
516	0.661	0.666	0.671	0.676	0.681	0.686	0.691	0.696	0.701	0.706
	6.423	6.492	6.562	6.631	6.700	6.769	6.839	6.908	6.977	7.046
517	0.711	0.716	0.721	0.726	0.731	0.736	0.741	0.746	0.751	0.756
	7.116	7.185	7.254	7.323	7.393	7.462	7.531	7.600	7.670	7.739
518	0.761	0.766	0.771	0.776	0.781	0.786	0.791	0.796	0.801	0.806
	7.808	7.891	7.973	8.056	8.138	8.221	8.304	8.386	8.469	8.551
519	0.811	0.816	0.821	0.826	0.831	0.836	0.841	0.846	0.851	0.856
	8.634	8.711	8.789	8.866	8.944	9.021	9.098	9.176	9.253	9.331
520	0.861	0.866	0.871	0.877	0.882	0.887	0.892	0.897	0.903	0.908
	9.408	9.501	9.595	9.688	9.781	9.875	9.968	10.061	10.154	10.248
521	0.913	0.918	0.923	0.929	0.934	0.939	0.944	0.949	0.955	0.960
	10.341	10.429	10.517	10.605	10.693	10.782	10.870	10.958	11.046	11.134
522	0.965	0.970	0.975	0.981	0.986	0.991	0.996	1.001	1.007	1.012
	11.222	11.325	11.428	11.530	11.633	11.736	11.839	11.941	12.044	12.147
523	1.017	1.022	1.027	1.033	1.038	1.043	1.048	1.053	1.059	1.064
	12.250	12.352	12.455	12.558	12.661	12.763	12.866	12.969	13.072	13.174
524	1.069	1.074	1.079	1.085	1.090	1.095	1.100	1.105	1.111	1.116
	13.277	13.389	13.501	13.613	13.725	13.838	13.950	14.062	14.174	14.286
525	1.121	1.126	1.131	1.137	1.142	1.147	1.152	1.157	1.163	1.168
	14.398	14.510	14.622	14.734	14.846	14.959	15.071	15.183	15.295	15.407

TABLE 7-2 CONTINUED

Area (1000's of Acres) Capacity (1000's of Acre-Feet)										
Pool Elevation (ft. NGVD)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
526	1.173	1.178	1.183	1.188	1.194	1.199	1.204	1.209	1.214	1.219
	15.519	15.642	15.764	15.887	16.009	16.132	16.254	16.377	16.499	16.622
527	1.225	1.230	1.235	1.240	1.245	1.250	1.255	1.261	1.266	1.271
	16.745	16.867	16.990	17.112	17.235	17.357	17.480	17.602	17.725	17.847
528	1.276	1.281	1.286	1.292	1.297	1.302	1.307	1.312	1.318	1.323
	17.970	18.102	18.234	18.366	18.498	18.630	18.762	18.894	19.026	19.158
529	1.328	1.333	1.338	1.344	1.349	1.354	1.359	1.364	1.370	1.375
	19.290	19.423	19.556	19.689	19.822	19.955	20.088	20.221	20.354	20.487
530	1.380	1.386	1.391	1.397	1.402	1.408	1.413	1.419	1.424	1.430
	20.620	20.763	20.906	21.049	21.192	21.335	21.478	21.621	21.764	21.907
531	1.435	1.441	1.446	1.452	1.457	1.463	1.468	1.474	1.479	1.485
	22.050	22.194	22.338	22.482	22.626	22.770	22.914	23.058	23.202	23.346
532	1.490	1.496	1.501	1.507	1.512	1.518	1.523	1.529	1.534	1.540
	23.490	23.644	23.798	23.952	24.106	24.260	24.414	24.568	24.722	24.876
533	1.545	1.551	1.556	1.562	1.567	1.573	1.578	1.584	1.589	1.595
	25.030	25.185	25.340	25.495	25.650	25.805	25.960	26.115	26.270	26.425
534	1.600	1.606	1.611	1.617	1.622	1.628	1.633	1.639	1.644	1.650
	26.580	26.745	26.910	27.075	27.240	27.405	27.570	27.735	27.900	28.065
535	1.655	1.661	1.666	1.672	1.677	1.683	1.688	1.694	1.699	1.705
	28.230	28.396	28.562	28.728	28.894	29.060	29.226	29.392	29.558	29.724
536	1.710	1.716	1.721	1.727	1.732	1.738	1.743	1.749	1.754	1.760
	29.890	30.066	30.242	30.418	30.594	30.770	30.946	31.122	31.298	31.474
537	1.765	1.771	1.776	1.782	1.787	1.793	1.798	1.804	1.809	1.815
	31.650	31.827	32.004	32.181	32.358	32.535	32.712	32.889	33.066	33.243
538	1.820	1.828	1.836	1.844	1.852	1.860	1.868	1.876	1.884	1.892
	33.420	33.610	33.800	33.990	34.180	34.370	34.560	34.750	34.940	35.130

TABLE 7-2 CONTINUED

Area (1000's of Acres) Capacity (1000's of Acre-Feet)										
Pool Elevation (ft. NGVD)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
539	1.900	1.908	1.916	1.924	1.932	1.940	1.948	1.956	1.964	1.972
	35.320	35.510	35.700	35.890	36.080	36.270	36.460	36.650	36.840	37.030
540	1.980	1.990	2.000	2.010	2.020	2.030	2.040	2.050	2.060	2.070
	37.220	37.428	37.636	37.844	38.052	38.260	38.468	38.676	38.884	39.092
541	2.080	2.090	2.100	2.110	2.120	2.130	2.140	2.150	2.160	2.170
	39.300	39.508	39.716	39.924	40.132	40.340	40.548	40.756	40.964	41.172
542	2.180	2.194	2.208	2.222	2.236	2.250	2.264	2.278	2.292	2.306
	41.380	41.612	41.844	42.076	42.308	42.540	42.772	43.004	43.236	43.468
543	2.320	2.334	2.348	2.362	2.376	2.390	2.404	2.418	2.432	2.446
	43.700	43.932	44.164	44.396	44.628	44.860	45.092	45.324	45.556	45.788
544	2.460	2.478	2.495	2.513	2.530	2.548	2.565	2.583	2.600	2.618
	46.020	46.283	46.546	46.809	47.072	47.335	47.598	47.861	48.124	48.387
545	2.635	2.653	2.670	2.688	2.705	2.723	2.740	2.758	2.775	2.793
	48.650	48.914	49.178	49.442	49.706	49.970	50.234	50.498	50.762	51.026
546	2.810	2.829	2.847	2.866	2.884	2.903	2.921	2.940	2.958	2.977
	51.290	51.589	51.888	52.187	52.486	52.785	53.084	53.383	53.682	53.981
547	2.995	3.014	3.032	3.051	3.069	3.088	3.106	3.125	3.143	3.162
	54.280	54.580	54.880	55.180	55.480	55.780	56.080	56.380	56.680	56.980
548	3.180	3.200	3.220	3.240	3.260	3.280	3.300	3.320	3.340	3.360
	57.280	57.612	57.944	58.276	58.608	58.940	59.272	59.604	59.936	60.268
549	3.380	3.400	3.420	3.440	3.460	3.480	3.500	3.520	3.540	3.560
	60.600	60.940	61.280	61.620	61.960	62.300	62.640	62.980	63.320	63.660
550	3.580	-	-	-	-	-	-	-	-	-
	64.000	-	-	-	-	-	-	-	-	-

EXHIBIT A

SUPPLEMENTARY PERTINENT DATA

NEWT GRAHAM LOCK AND DAM

EXHIBIT A

SUPPLEMENTARY PERTINENT DATA

NEWT GRAHAM LOCK AND DAM

TABLE OF CONTENTS

All elevations referred to in Exhibit A, unless noted otherwise, are in feet, NGVD29. Add 0.08 ft to the NGVD29 elevation to obtain the NAVD88 elevation at Newt Graham Lock and Dam 18.

1 - GENERAL INFORMATION

Other names for project	Lock and Dam No. 18
Location	(State of Oklahoma) Arkansas River Basin, Verdigris River, McClellan-Kerr Navigational System mile 421.5
Type of Project	Lock and Dam
Objectives of Regulation	Navigation
Project Owner	US Government
Operating Agency	US Army Corps of Engineers. Personnel are on duty at the project 24 hours a day, 7 days a week.
Regulating Agency	US Army Corps of Engineers
Water Supply Contracts	None
Water Rights	Water Rights have been granted in the Verdigris River Basin between Newt Graham Lock and Dam and the Confluence of the Arkansas and Verdigris Rivers in the amount of 18,380 acre-feet.
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	$ 43,400,000
Closure date	September 9, 1970
Special project features	None
Other	None

2 - POOL INFORMATION

Feature	Elevation (ft. NGVD29)	Pool Area (acres)	Capacity (acre-feet)
Top of Dam			
Right Bank	533.5	-	-
Left Bank	542.0	-	-
Navigation Pool			
Top of Spillway Gates (closed position)	533.0	1,545.0	25,030
Top of Navigation Pool	532.5	1,517.5	24,260
Bottom of Navigation Pool	532.0	1,490.0	23,490
Spillway Crest			
Left Overflow Section	542.0	-	-
Right Overflow Section	533.5	-	-
Gated Section	506.0	-	-

Note: Area and Capacity are based on 1965 pool survey

3 - HYDROLOGY

Drainage area	8,030 square miles; 2,034 square miles uncontrolled.
Standard Project Flood	
Peak inflow	154,000 cfs
Total storm runoff	4.30 inches (contributing drainage area of 3,964 square miles)
Volume	910,000 acre-feet
Duration of flood	7.5 Days
Note:	The Standard Project Flood was obtained from the Lock and Dam Design Manual 1 part 2. The drainage areas above Hulah, Copan, Birch, and Skiatook Dams were included in the calculations, but the drainage area above Oologah Dam was not.
Climate	Moderate
One inch of runoff	108,480 acre-feet (based on drainage area of 2,034 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 1970-2015, SWT monthly charts
Minimum monthly inflow	6,148 acre-feet in January 1981 Period of record 1970-2015, SWT monthly charts
Minimum annual inflow and year	944,734 acre-feet in 1981 Period of record 1970-2015, SWT monthly charts
Average annual inflow	4,266,982 acre-feet Period of record 1970-2015, SWT monthly charts
Maximum annual inflow and year	9,146,885 acre-feet in 1985 Period of record 1970-2015, SWT monthly charts
Maximum monthly inflow and date	3,102,247 acre-feet in October 1986 Period of record 1970-2015, SWT monthly charts
Maximum daily inflow and date	142,300 cfs on 21 May 1943 Data from Plate 8-2, Operational Hydrograph

Maximum instantaneous inflow and date	148,900 cfs on 21 May 1943 Data from Plate 8-2, Operational Hydrograph
Maximum unregulated inflow to pool and date	224,000 cfs on 21 May 1943 Source: DM 1, Part 2
Maximum flood volume and date into Newt Graham Pool	1,306,500 acre-feet for 16-28 May 1943 Data from Plate 8-2, Operational Hydrograph
5-year flood, regulated	60,000 cfs
10-year flood, regulated	70,000 cfs
50-year flood, regulated	86,000 cfs
Navigation Design Flood	65,000 cfs
Name and location of key stream flow stations	Bird Creek at Avant, OK Bird Creek near Sperry, OK Bird Creek at Catoosa, OK Caney River at Bartlesville, OK Caney River near Ramona, OK Caney River near Collinsville, OK Verdigris River at Claremore, OK Verdigris River near Catoosa, OK Arkansas River near Muskogee, OK Arkansas River at Van Buren, AR
Type of hydro-meteorological data recorded at dam site	Air Temperature, wind speed and direction, relative humidity, solar radiation, precipitation, evaporation, pool elevation and tailwater elevation
Number of precipitation stations used in hydrologic forecasting inflow	25 recording and 9 Mesonet gages, plus 18 stream gages and 7 pool gages
Number of sediment ranges	0
Number of degradation ranges	0

4 - EMBANKMENT

Location	Verdigris River at McClellan-Kerr Navigational System mile 421.5.
Purpose	Navigation
Type	Overflow
Type of fill	Combined earthfill and concrete gravity dam
Slope protection	Grass covered upstream and downstream
Height	39 Feet above streambed
Length	7,367 feet (including spillway, lock, overflow embankments and non-overflow embankment)
Top elevation	542.0 feet, NGVD29
Design flood	Standard Project Flood
Freeboard	10 feet at normal pool elevation, 5.3 feet above maximum recorded pool elevation.
Used for roadway	No
Elevation of stream bed	503.0 feet NGVD29

5 - SPILLWAY

Location	To the right of the lock structure.
Type	Gated Concrete Ogee with a right side uncontrolled overflow section
Crest elevation	506.0 feet NGVD29
Net overflow length	180 feet (gates); 95 feet (overflow section)
Number and size of gates	Three (3) – 60’ wide x 27’ high
Type of gates	Tainter Gates, operated by individual electric motors
Top of gate elevation	533.0 feet NGVD29, in closed position.
Induced surcharge	None
Design head	26 feet
Maximum discharge capacity	42,000 cfs through the gates;
Bridge deck elevation	561.0 feet NGVD29
Type of energy dissipater	Roller Type Stilling Basin; 40 ft long concrete basin with 4 ft 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 about 1.0 foot per minute.
Type of emergency closure	A diesel generator is available for emergency power.
Spillway activation	Tainter gates are active to maintain navigation pool elevation.

6 - LOCK

Type	Ohio
Location	Adjacent to spillway and in approximate center of original river channel
Type of Construction	Concrete Gravity founded on rock
Size of Chamber	110’x600’
Length of center to center pintles	670 feet
Culvert Size	12’x12’
Normal Lift	21 feet
Type and number of gates	Miter, 2
Type of operation	Hydraulic
Filling and emptying system	Bottom Lateral Conduits
Type of discharge	Side Outlet
Elevations, feet, NGVD29	
Normal Lower Pool	511.0
Top of Lock Wall	542.0
Upper Miter Sill	517.0
Lower Miter Sill	497.0
Lock Chamber Floor	493.0

7 - CONTROL POINTS

a. MUSKOGEE GAGE

Location	At river mile 457.8 on Arkansas River, 1.7 miles downstream of Neosho River and 3.5 miles northeast of Muskogee, at the US 62 bridge; Lat 35 deg 46 min 10 sec, Lon 95 deg 17 min 49 sec.
Purpose of gage	Used by Corps of Engineers to measure discharge and serve as a regulation point for upstream lake projects.
Channel and floodplain description	The channel is well defined and straight in the vicinity of the gage. The floodplain is broad, with natural vegetation, development, and some cultivated crops.
Drainage area	96,472 square miles, of which 11,648 square miles is probably noncontributing (USGS). 3,355 square miles uncontrolled.
NWS flood stage	28.0 feet
USACE regulating stage	28.0 feet
Time of crest travel	Newt Graham Lock and Dam 18 to Muskogee Gage – 6 hours
Description of equipment	Water-stage recorder with telemeter
Zero of gage	Elevation 471.38 feet, NGVD29
Maximum stage of record	48.20 feet, 21 May 1943
Maximum flow of record	700,000 cfs, 21 May, 1943
Channel usage	Navigation, water supply, fishing, and fish spawning

b. VAN BUREN GAGE

Location	At river mile 316.8 on Arkansas River, on Hwy 64 Bridge; Lat 35 deg 25 min 42 sec, Lon 94 deg 21 min 37 sec.
Purpose of gage	Used by Corps of Engineers to regulate and determine benefits for the system.
Channel and floodplain description	The channel is well defined and fairly straight at the gage. Both floodplains are developed, and the left floodplain is protected by a levee.

Drainage area	150,482 square miles, of which 22,241 square miles are non-contributing 7,240 square miles uncontrolled.
NWS flood stage	22.0 feet
USACE regulating stage	22.0 feet
Time of crest travel	Newt Graham L&D to Van Buren Gage – 15 hours
Description of equipment	Water surface elevation is recorded by a Sutron data collection platform.
Zero of gage	Elevation 380.24 feet, NGVD29
Maximum stage of record	38.10 feet, 16 April, 1945
Maximum flow of record	850,000 cfs, 16 April, 1945
Channel usage	Navigation, water supply, fishing, and fish spawning

EXHIBIT B

STANDING INSTRUCTIONS TO LOCK OPERATOR

NEWT GRAHAM LOCK AND DAM

EXHIBIT B

STANDING INSTRUCTIONS TO LOCK OPERATOR

NEWT GRAHAM LOCK AND DAM

TABLE OF CONTENTS

I - GENERAL

1. **Operation.** During flood periods, the project 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 project 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 Lock Operator will immediately make every effort to reestablish communications with the Tulsa District Office. The Lock Operator will make daily observations of the pool level data and report those observations as directed in Section V and Paragraph I-2 or this Exhibit. Should an emergency situation occur in which communication is not lost, such as inoperable gates, a drowning accident, excessive trash in gates, or power outage, the Water Management Section will be notified immediately.

2. **Data Reporting Instructions** Hydrologic data items affecting release of water, 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 from all locks and dams without hydropower. Weekend and holiday reports will be taken on the following weekday. Data are posted on the 824 form, which is located on the Navigation Project Office server: \\swt-fs-rsker\shared\Locks folder. Data collected will be reviewed and input into the Water Management Section's database before 10 a.m., and published to the project data morning report located at http://www.swt-wc.usace.army.mil/old_resvrept.htm by 10 a.m. See Plate 5-3 for project data reporting details.

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

1) Hourly pool elevations, headwater and tailwater, of the previous day up to 8 a.m. of the current day.
2) The time, pool elevation, and number of gate feet for each gate change made since the previous day's 8 a.m. report.
3) The total precipitation amounts for the previous 24-hour period (7 a.m. to 7 a.m.).
4) The number of lockages over the previous 24-hour period (midnight to midnight).
5) The current wind direction and wind speed (Beaufort scale).

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

1) The current pool elevation reading 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. During Flood Periods.

1) In addition to the data in paragraphs I-2.a. and I-2.b. above, additional reports of pool elevations may be requested by Water Management Section personnel.

d. Rainfall Reports. Rainfall reports shall be made as follows:

1) At 8 a.m. all precipitation that has occurred during the preceding 24 hours, 7 a.m. to 7 a.m., as shown on Plate 5-3 (covered by routine report on working days).
2) Report at once the occurrence of 2.0 inches or more of precipitation that occurs during a period of 6 hours or less. During nonworking hours, the report should be made to one of the persons listed on page iii.

3. **Reporting Unusual Events.** Events or conditions not normally encountered in the routine operation of the project 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.** The Lock Operator will maintain a list in current status of residents and/or property owners who might be endangered or inconvenienced by in-channel releases and will give them notification of impending releases. This notification will be made by telephone or oral warning by Corps employees. It is the responsibility of the Lock Operator to initiate a warning to the Oklahoma Civil Defense Department 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 and navigation interests should be notified as early as possible of a potential problem. Minimum notification procedures are as follows:

> A "General Alert" should be issued by the Lock Operator to the Civil Defense when life-threatening high releases from a dam failure or flooding are predicted to reach the downstream population at risk within 6 hours. An "Evacuation Warning" should be issued by the Lock Operator when analysis of the threatening event and reservoir response indicate that life-threatening floodwaters will reach the downstream population in 4 hours or less.

The Newt Graham Lock and Dam 18 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. When significant amounts of flood waters have entered

the pool, gate changes can be expected several times per day. Only under the most unusual circumstances will gate changes be made more frequently than one every hour. Frequency of gate changes during low-flow operation will be less frequent than during flood operations.

II - REGULATION PROCEDURES

1. **Regulating River Stages and Discharges.** The navigation pool at Newt Graham Lock and Dam will be maintained to provide a navigable channel from Newt Graham L&D to the Head of Navigation at the Port of Catoosa. The following regulations will normally govern releases from the reservoir:

a. Normal Regulation for Flood Control Operations. The navigation pool at Newt Graham Lock and Dam 18 will be regulated to provide a navigable channel from the Tulsa Port of Catoosa through Newt Graham Lock and Dam 18. The following regulations will normally govern releases from the navigation pool (all elevations in NGVD29).

1. The navigation pool level will be maintained at or above elevation 532.0 at all times.

2. When the navigation pool level is between elevations 532.0 and 532.5, required releases will be made through lockage and spillway gates to maintain the navigation pool level between these elevations.

3. When the navigation pool level is at or near 532.5 and the inflow exceeds that necessary for lockage requirements, the spillway gates will be operated to maintain the pool level at or below elevation 532.5 by releasing inflow until all gates are fully open.

4. If the gates are fully open and the navigation pool level exceeds elevation 532.5, the gates will remain fully open until the pool reaches a maximum elevation and begins to fall. When the pool level nears elevation 532.0, the Lock Operator will begin to lower the gates, while still passing inflow, to maintain the pool between elevations 532.0 and 532.5.

5. Spillway gates can, under normal conditions, be operated in increments as small as one-fourth of a foot and as large as one foot. During large flood events, the gates may be operated in increments of several feet if necessary. Except during unusual operation and maintenance activities approved by the Navigation Manager, the gates will have no more than one foot of difference in the opening of any two gates. In every case, the top of gate elevation will be maintained at least one-quarter of a foot (3 inches) above the navigation pool level, though a minimum of one-half of a foot is preferred.

b. Emergency Regulations for Flood Control. Should communications with the Tulsa District Office be disrupted, the Lock Operator or his representative will direct regulation of the navigation pool in accordance with the following rules of regulation until communication is restored. In addition, the Lock Operator or his/her representative will immediately make every effort to reestablish communication with the Tulsa District Office and, if necessary, send information to the Tulsa District Office by any means available. If an emergency condition is experienced, the following regulations shall be followed.

1. Read the current pool elevation and maintain current releases for one hour. The pool elevation should be carefully read from the pool gages to obtain the changes in pool elevation. Based on judgement, allowance should be made for any changes in the pool elevation that may be due to wave and wind action, recent changes in spillway gate openings, and lockages.

2. At the end of each one hour period thereafter, read each pool elevation.

3. Compare current pool level reading with the previous reading and adjust releases in accordance with Plate 7-1, "Inflow vs. Rate of Rise". If the current discharge is less than 50,000 cfs, the change in releases will be limited to 10,000 cfs per hour. If the current discharge is more than 50,000 cfs, the change in releases will be limited to 0.2 times the current release per hour.

4. If discharge requirements exceed spillway gate capacity, all gates will be held fully open until the pool elevation reaches a peak and recedes to pool elevation 532.0, at which time releases will be adjusted in accordance with Plate 7-1.

5. During emergency events, the Lock Operator may temporarily deviate from the current release rates if a short-term departure is deemed necessary to protect the safety of the dam, or to avoid serious hazards to life. Such actions shall be reported immediately to the Water Management Section 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. Continuance of the deviation will require the approval of the Water Management Section.

6. If the differential gate opening of greater than one foot needs to be sustained for more than 24 hours to facilitate operation and maintenance activities, the Navigation Manager will notify the Hydraulic Steel Structures representatives in the Engineering and Construction Division at the District Office.

2. **During Emergency Events.** During emergency events, the Lock Operator may temporarily deviate from the current release rates if a short-term departure is deemed necessary to protect the safety of the dam, or to avoid serious hazards to life. Such actions shall be reported immediately to the Water Management Section 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. Continuance of the deviation will require the approval of the Water Management Section.

U.S. Representative

U.S. Senator

KANSAS

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

Pat Roberts (R)
Jerry Moran (R)

OKLAHOMA

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

James Inhofe (R)
James Lankford (R)

TEXAS

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

John Comyn (R)
Ted Cruz (R)

US Army Corps of Engineers
Tulsa District

N

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

NOTE: PLATE SIZE IS 11"x17"

ARKANSAS RIVER WATERSHED — VERDIGRIS RIVER, OKLAHOMA

NEWT GRAHAM LOCK AND DAM

TULSA DISTRICT PROJECTS

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 2016
DRAWN:
CHECKED:

PLATE 1-1

0 0.75 1.5 3 Miles

N

Bird Creek

Verdigris River

NEWT GRAHAM POOL

412

Tulsa County

TULSA

Wagoner County

Rogers County

Newt Graham Basin

FALL RIVER LAKE

TORONTO LAKE

ELK CITY LAKE

COPAN LAKE

BIG HILL LAKE

HULAH LAKE

BIRCH LAKE

SKIATOOK LAKE

OOLOGAH LAKE

ENID

NEWT GRAHAM POOL

TULSA

60

412

Vicinity Map

OKLAHOMA CITY

69

N

0 37.5 75 150 225 300 Miles

NEWT GRAHAM LOCK AND DAM

NOTE: PLATE SIZE IS 11"x17"

ARKANSAS RIVER WATERSHED

VERDIGRIS RIVER, OKLAHOMA

NEWT GRAHAM LOCK AND DAM LOCATION AND VICINITY MAP

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 2016
DRAWN:
CHECKED:

PLATE 2-1

(b) (7)(F)

ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

GENERAL PLAN AND SECTIONS

DEPT. OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 2016
Drawn: KMJ, WEST Consultants, Inc.
Checked:

PLATE 2-2

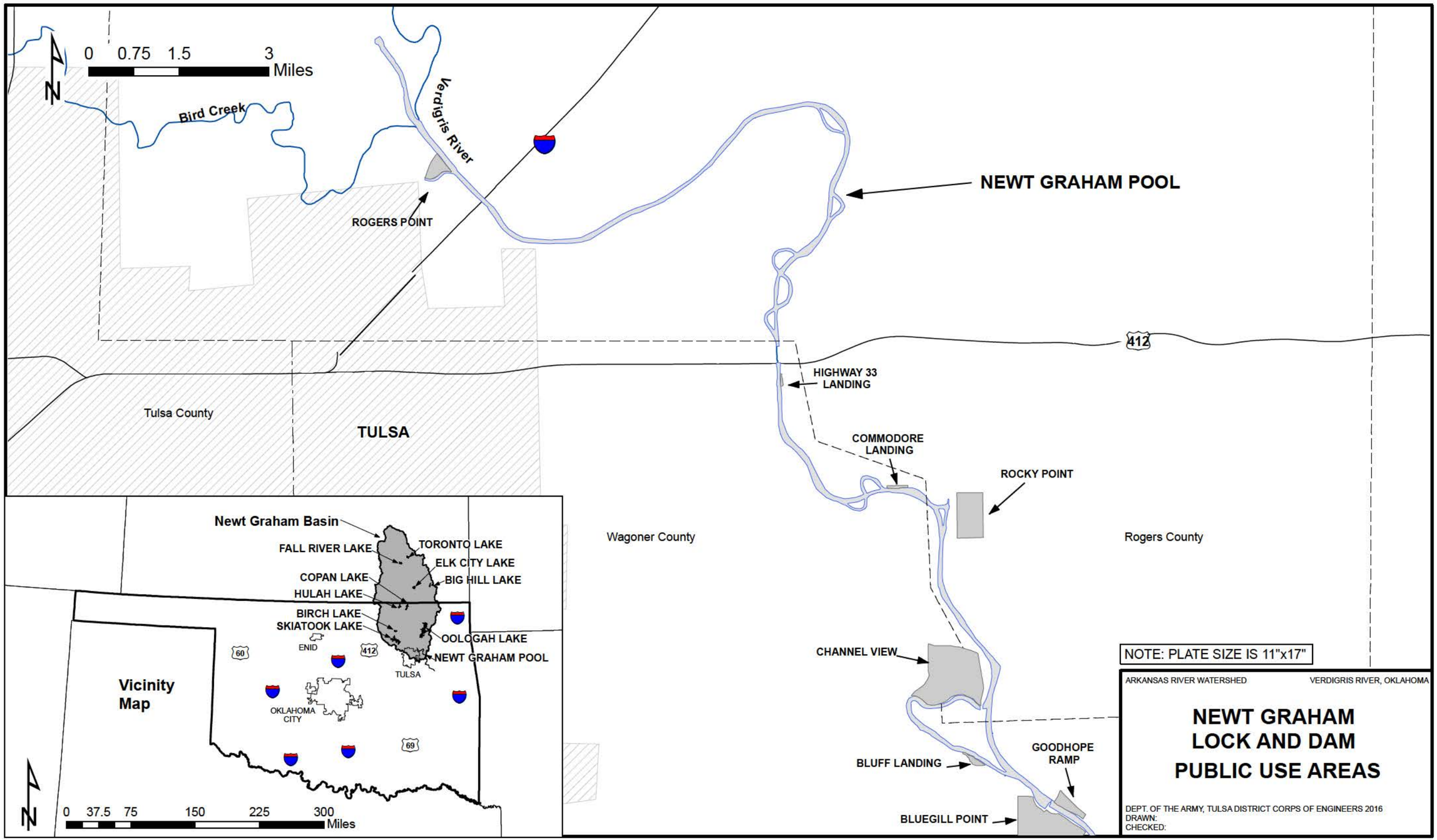

0 0.75 1.5 3 Miles
N
Bird Creek
Verdigris River
ROGERS POINT
NEWT GRAHAM POOL
412
HIGHWAY 33 LANDING
Tulsa County
TULSA
COMMODORE LANDING
ROCKY POINT
Wagoner County
Rogers County
CHANNEL VIEW
BLUFF LANDING
GOODHOPE RAMP
BLUEGILL POINT
Newt Graham Basin
FALL RIVER LAKE
TORONTO LAKE
ELK CITY LAKE
COPAN LAKE
BIG HILL LAKE
HULAH LAKE
BIRCH LAKE
SKIATOOK LAKE
OOLOGAH LAKE
NEWT GRAHAM POOL
ENID
60
412
TULSA
Vicinity Map
OKLAHOMA CITY
69
0 37.5 75 150 225 300 Miles
NOTE: PLATE SIZE IS 11"x17"
ARKANSAS RIVER WATERSHED
VERDIGRIS RIVER, OKLAHOMA
NEWT GRAHAM LOCK AND DAM
PUBLIC USE AREAS
DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 2016
DRAWN:
CHECKED:

PLATE 2-3

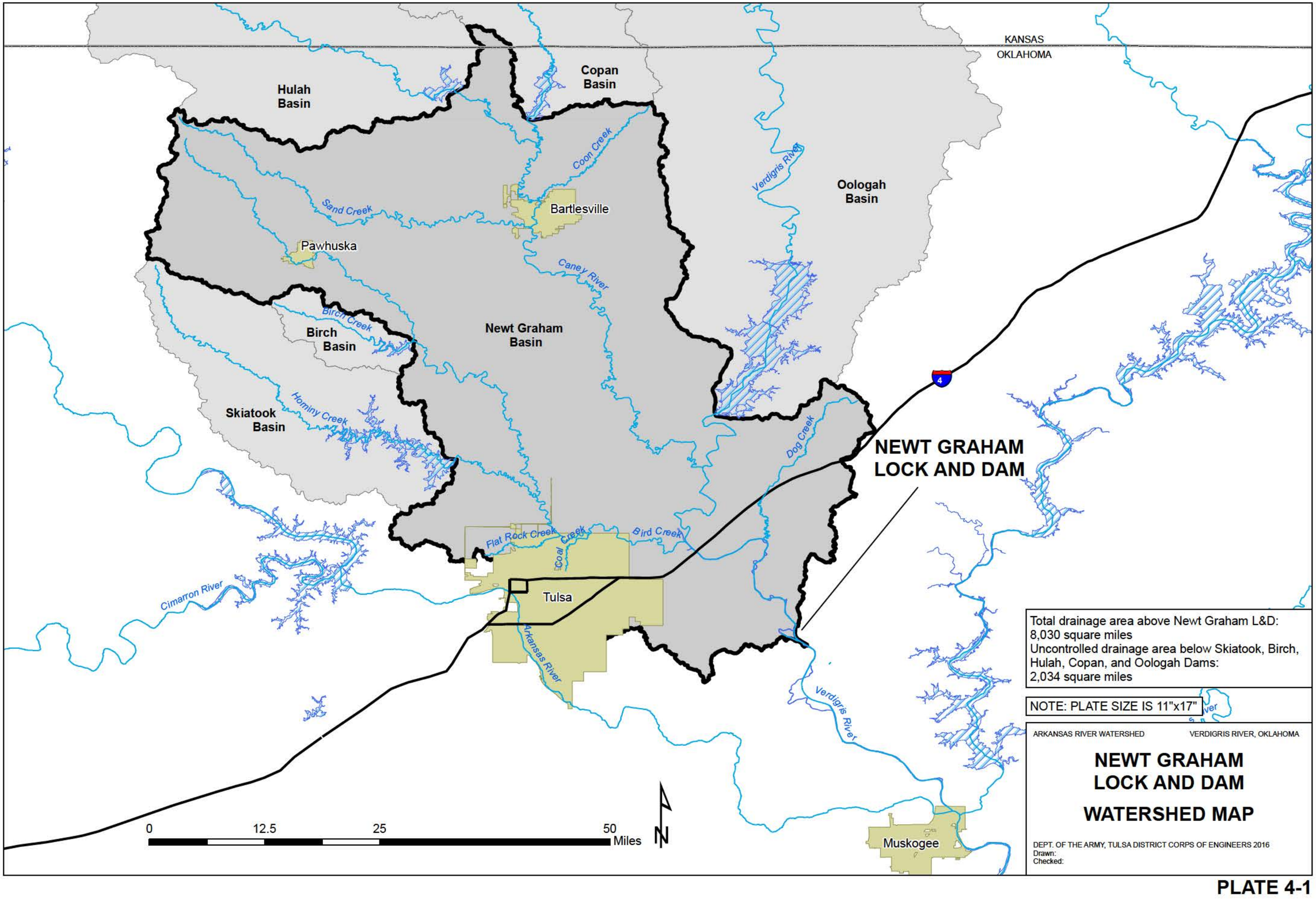
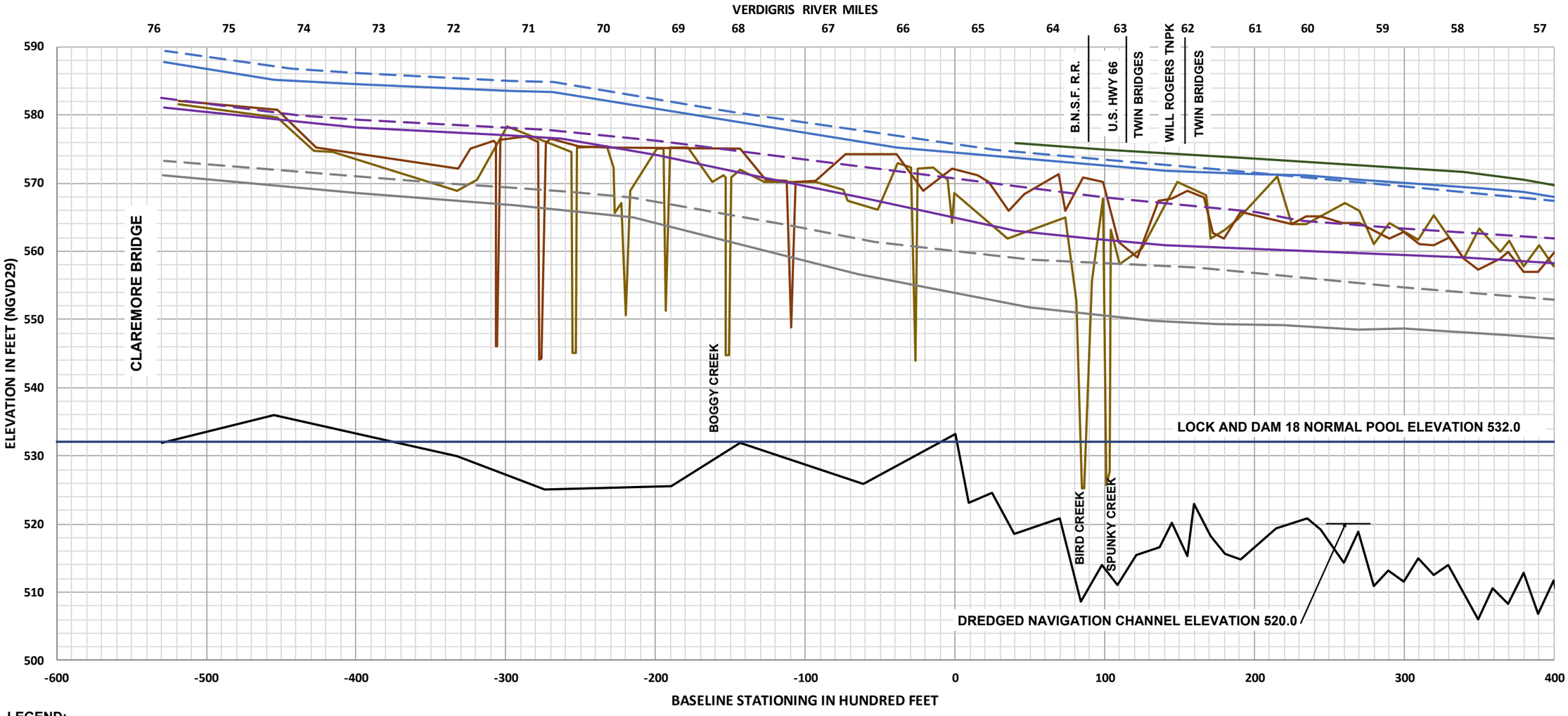

KANSAS
OKLAHOMA
Hulah Basin
Copan Basin
Oologah Basin
Newt Graham Basin
Birch Basin
Skiatook Basin
Coon Creek
Verdigris River
Sand Creek
Bartlesville
Pawhuska
Caney River
Birch Creek
Hominy Creek
Dog Creek
NEWT GRAHAM LOCK AND DAM
Flat Rock Creek
Coal Creek
Bird Creek
Cimarron River
Tulsa
Arkansas River
Verdigris River
Muskogee
4
0
12.5
25
50
Miles
N
Total drainage area above Newt Graham L&D:
8,030 square miles
Uncontrolled drainage area below Skiatook, Birch, Hulah, Copan, and Oologah Dams:
2,034 square miles
NOTE: PLATE SIZE IS 11"x17"
ARKANSAS RIVER WATERSHED
VERDIGRIS RIVER, OKLAHOMA
NEWT GRAHAM LOCK AND DAM
WATERSHED MAP
DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 2016
Drawn:
Checked:

PLATE 4-1



LEGEND:

- NATURAL RIVER BED
- APPROXIMATE RIGHT BANK
- APPROXIMATE LEFT BANK
- 100-YEAR (145,000 CFS) MODIFIED CONDITIONS
- 50-YEAR (118,000 CFS) NATURAL CONDITIONS
- 50-YEAR (118,000 CFS) MODIFIED CONDITIONS
- 10-YEAR (65,000 CFS) NATURAL CONDITIONS
- 10-YEAR (65,000 CFS) MODIFIED CONDITIONS
- 2% OF TIME DISCHARGE (34,000 CFS) NATURAL CONDITIONS
- 2% OF TIME DISCHARGE (34,000 CFS) MODIFIED CONDITIONS

NOTES:

1. **DATA OBTAINED FROM EXISTING PLATES, DATED OCT 1967.**
2. **RIVER BED ELEVATIONS BELOW 500.0 ARE FROM: L&D #18 DESIGN MEMORANDUM #1, GENERAL DESIGN PART II**

NOTE: PLATE SIZE IS 11” X 17”

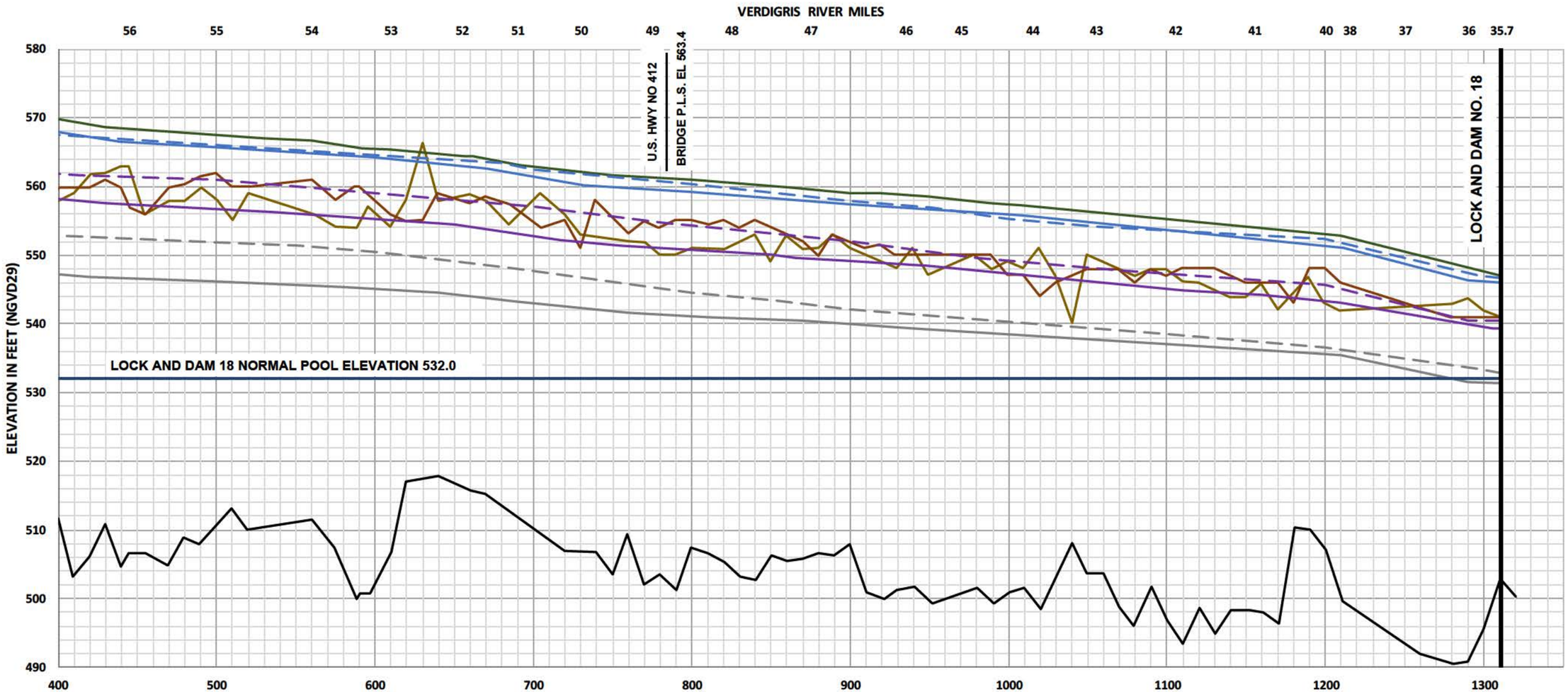
ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

VERDIGRIS RIVER PROFILES I

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

PLATE 4-2



LEGEND:

- NATURAL RIVER BED
- APPROXIMATE RIGHT BANK
- APPROXIMATE LEFT BANK
- 100-YEAR (145,000 CFS) MODIFIED CONDITIONS
- 50-YEAR (118,000 CFS) NATURAL CONDITIONS
- 50-YEAR (118,000 CFS) MODIFIED CONDITIONS
- 10-YEAR (65,000 CFS) NATURAL CONDITIONS
- 10-YEAR (65,000 CFS) MODIFIED CONDITIONS
- 2% OF TIME DISCHARGE (34,000 CFS) NATURAL CONDITIONS
- 2% OF TIME DISCHARGE (34,000 CFS) MODIFIED CONDITIONS

NOTES:

1. **DATA OBTAINED FROM EXISTING PLATES, DATED OCT 1967.**
2. **RIVER BED ELEVATIONS BELOW 500.0 ARE FROM: L&D #18 DESIGN MEMORANDUM #1, GENERAL DESIGN PART II**

NOTE: PLATE SIZE IS 11” X 17”

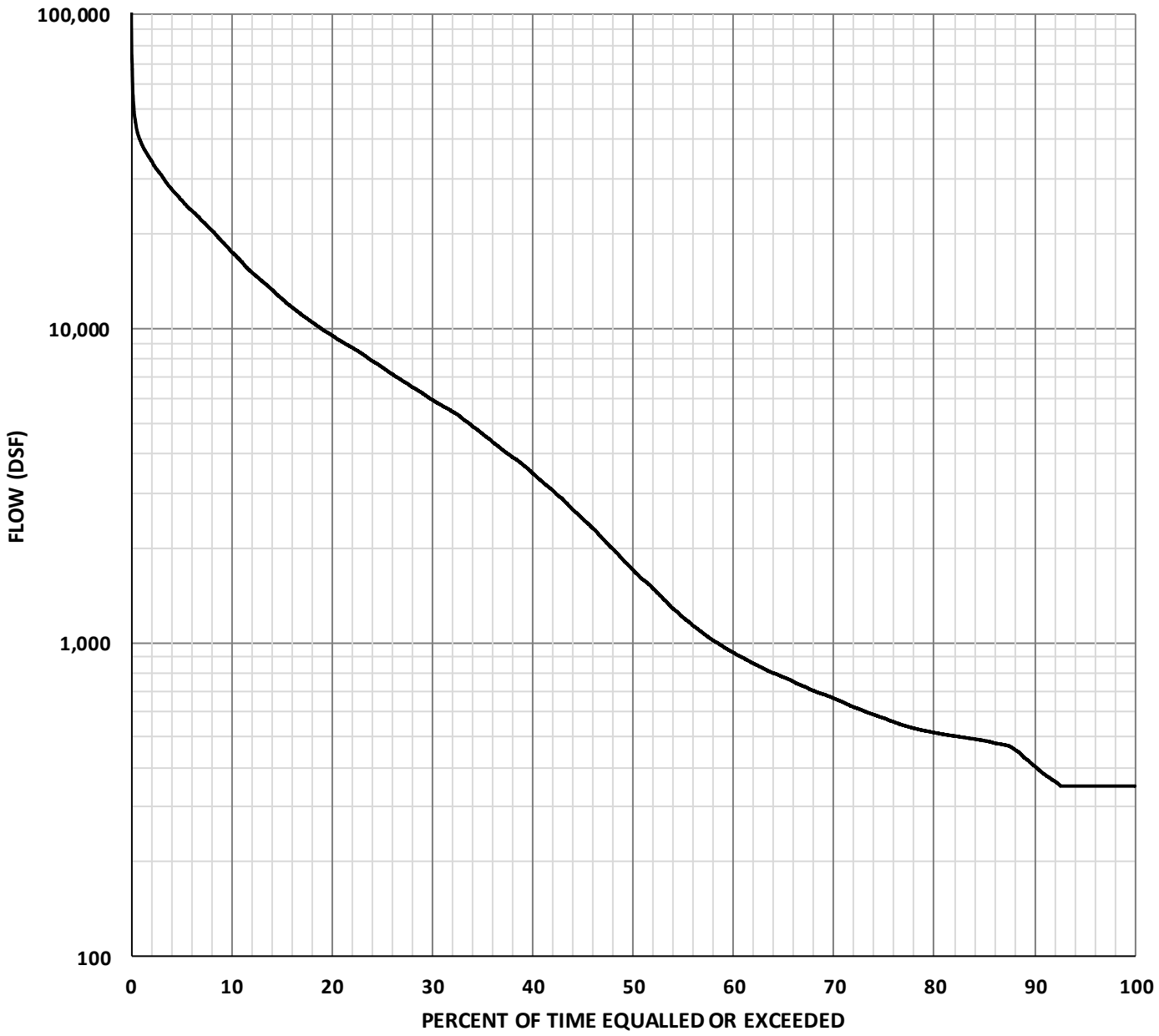
ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

VERDIGRIS RIVER PROFILES II

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

PLATE 4-3



ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

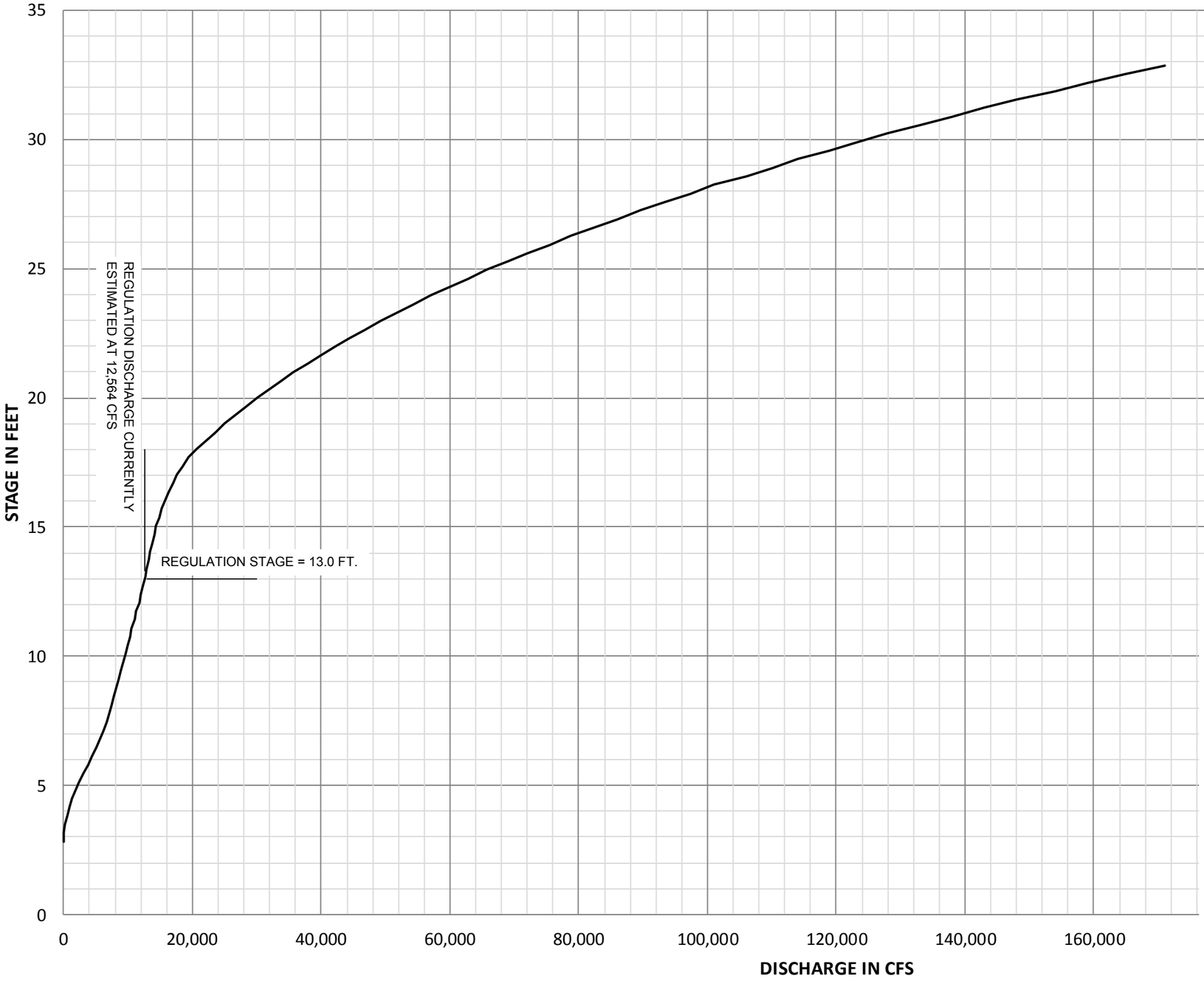
FLOW DURATION CURVE

NOTES:

1. DATA FROM RIVERWARE V. 6.5 MODEL
2. BASED ON PERIOD OF RECORD JAN. 1940 THROUGH DEC. 2008

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

PLATE 4-4



NOTES:

DATA OBTAINED FROM WDCS DATABASE
GAGE DATUM: 653.33 NGVD29
DATE OF DATA: 09DEC2014

NOTE: PLATE SIZE IS 11" X 17"

ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

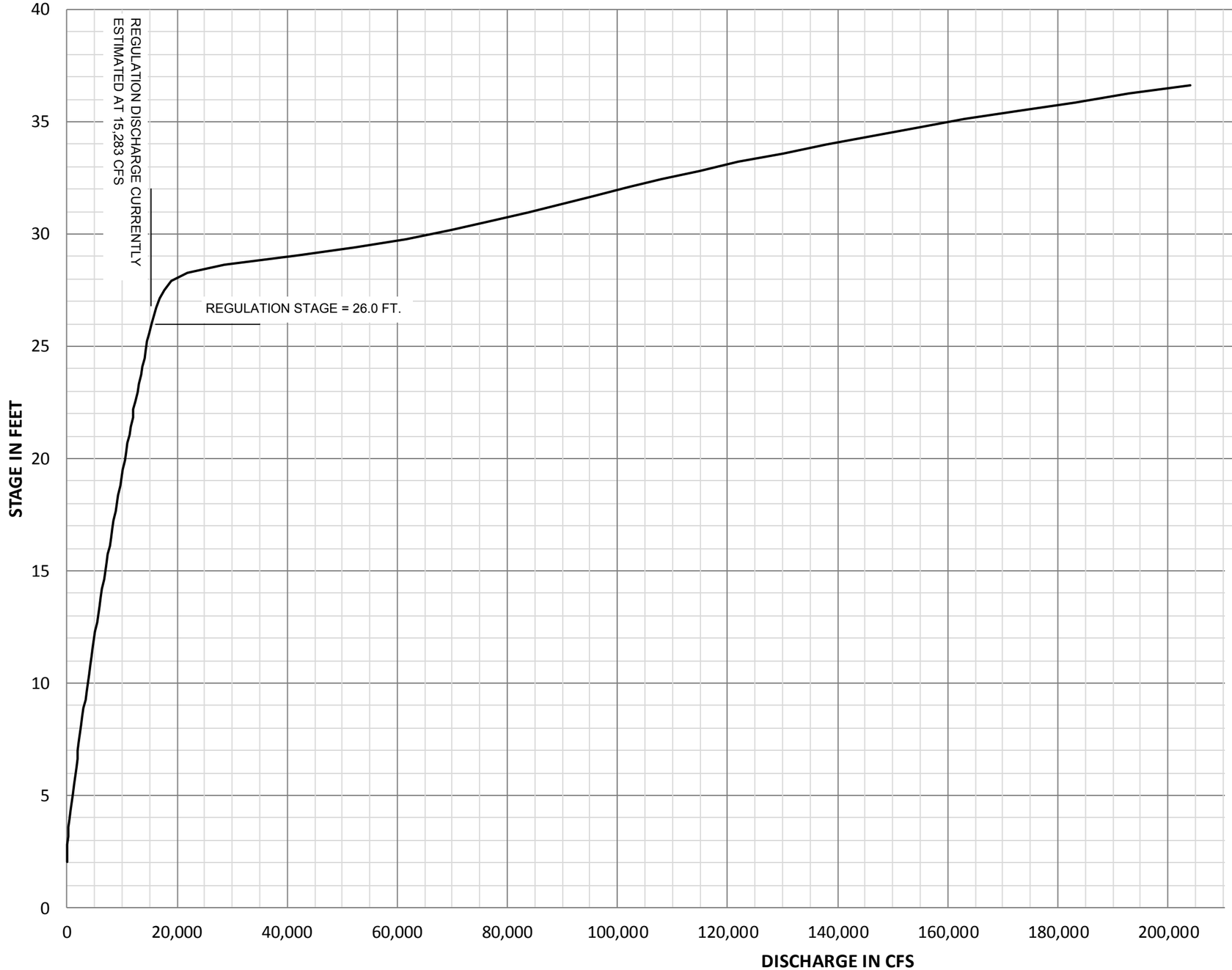
ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

DISCHARGE RATING CURVE

CANEY RIVER AT BARTLESVILLE, OK

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

PLATE 4-5



NOTES:

DATA OBTAINED FROM WDCS DATABASE
GAGE DATUM: 586.43 NGVD29
DATE OF DATA: 09DEC2014

NOTE: PLATE SIZE IS 11” X 17”

ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

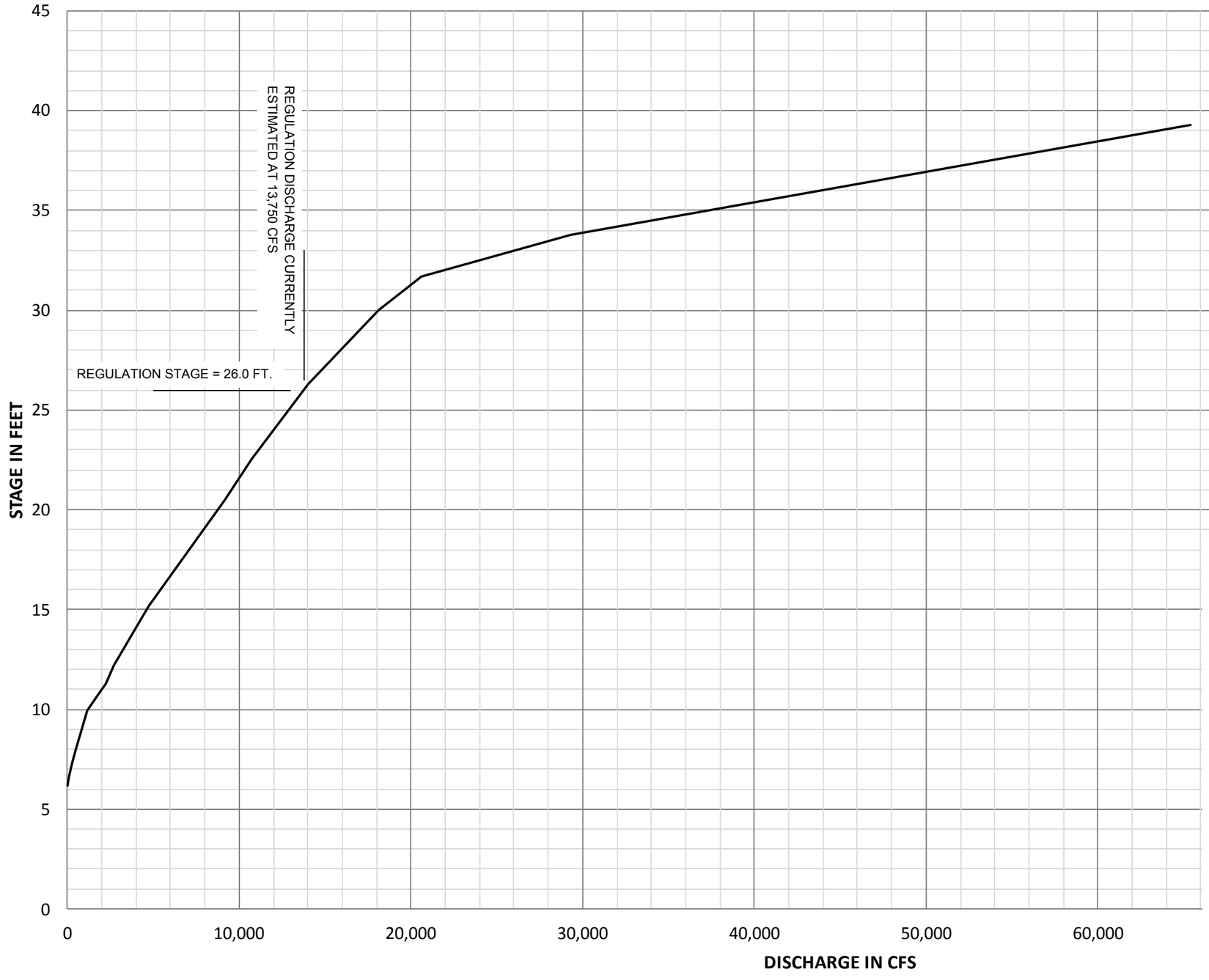
ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

DISCHARGE RATING CURVE

CANEY RIVER NEAR RAMONA, OK

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

PLATE 4-6



NOTES:

DATA OBTAINED FROM WDCS DATABASE
GAGE DATUM: 565.72 NGVD29
DATE OF DATA: 09DEC2014

NOTE: PLATE SIZE IS 11” X 17”

ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

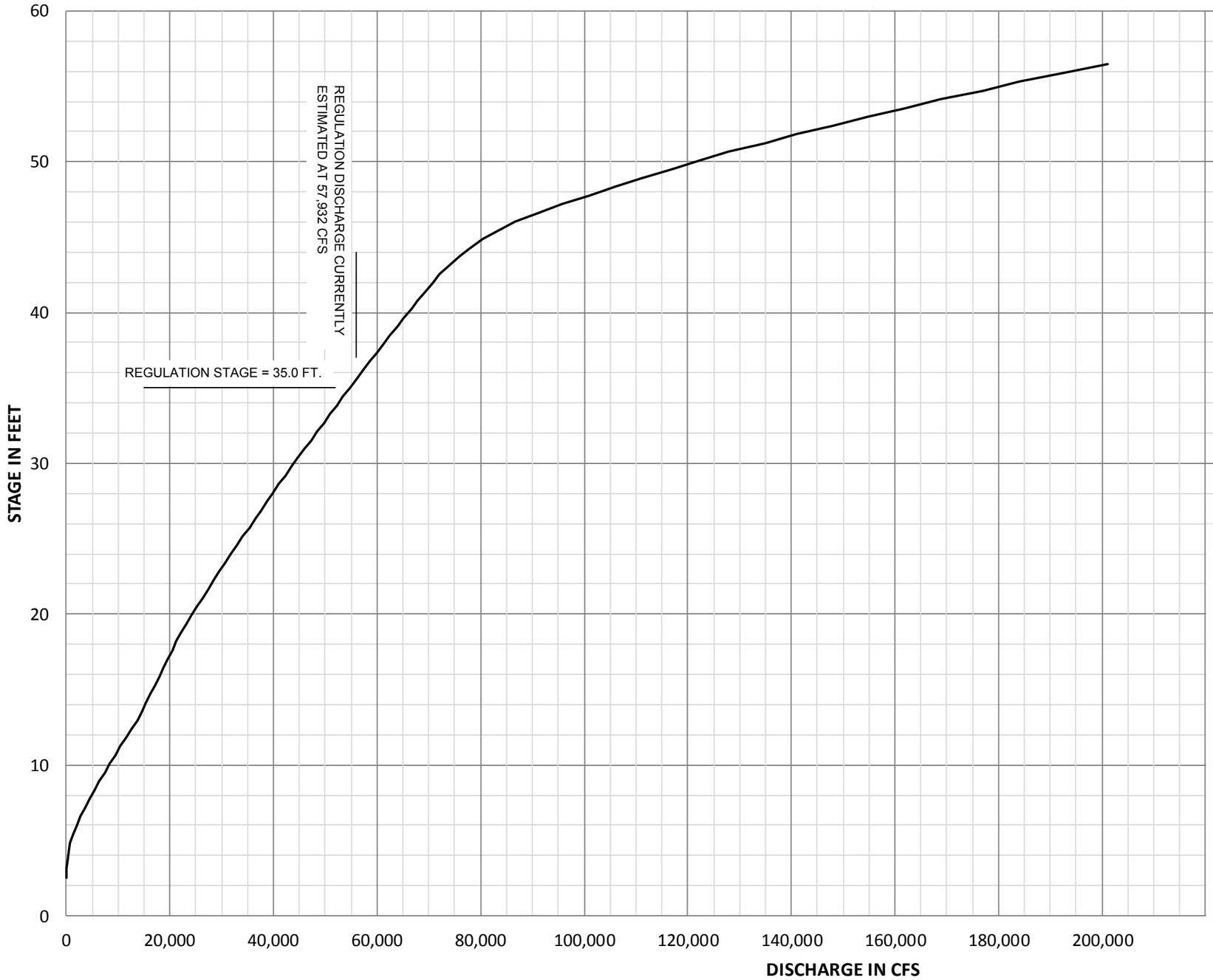
ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

DISCHARGE RATING CURVE

CANEY RIVER NEAR COLLINSVILLE, OK

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

PLATE 4-7



NOTES:

DATA OBTAINED FROM WDCS DATABASE
GAGE DATUM: 538.62 NGVD29
DATE OF DATA: 09DEC2014

NOTE: PLATE SIZE IS 11” X 17”

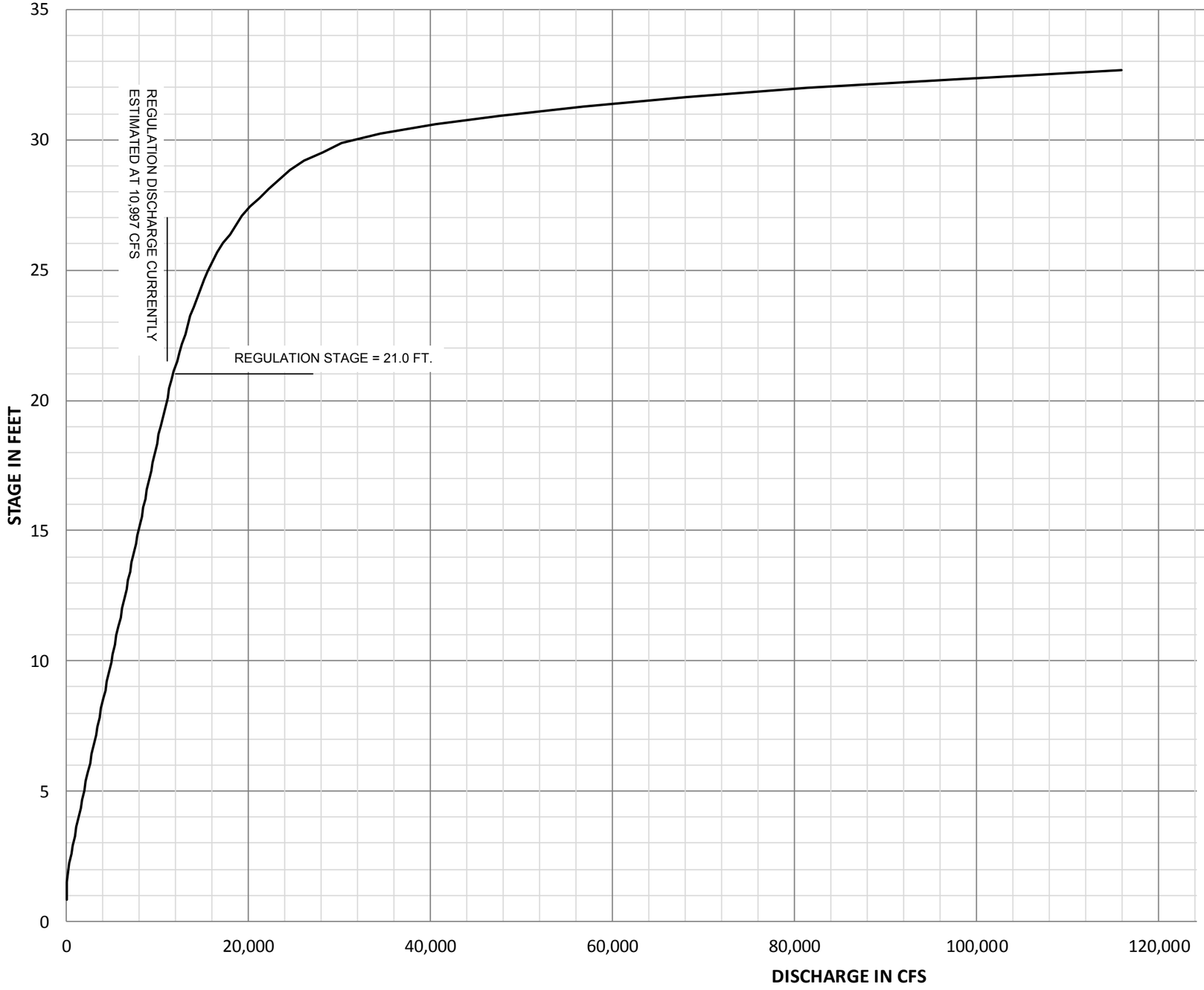
ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

DISCHARGE RATING CURVE
VERDIGRIS RIVER NEAR CLAREMORE, OK

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

PLATE 4-8



NOTES:

DATA OBTAINED FROM WDCS DATABASE
GAGE DATUM: 579.43 NGVD29
DATE OF DATA: 09DEC2014

NOTE: PLATE SIZE IS 11" X 17"

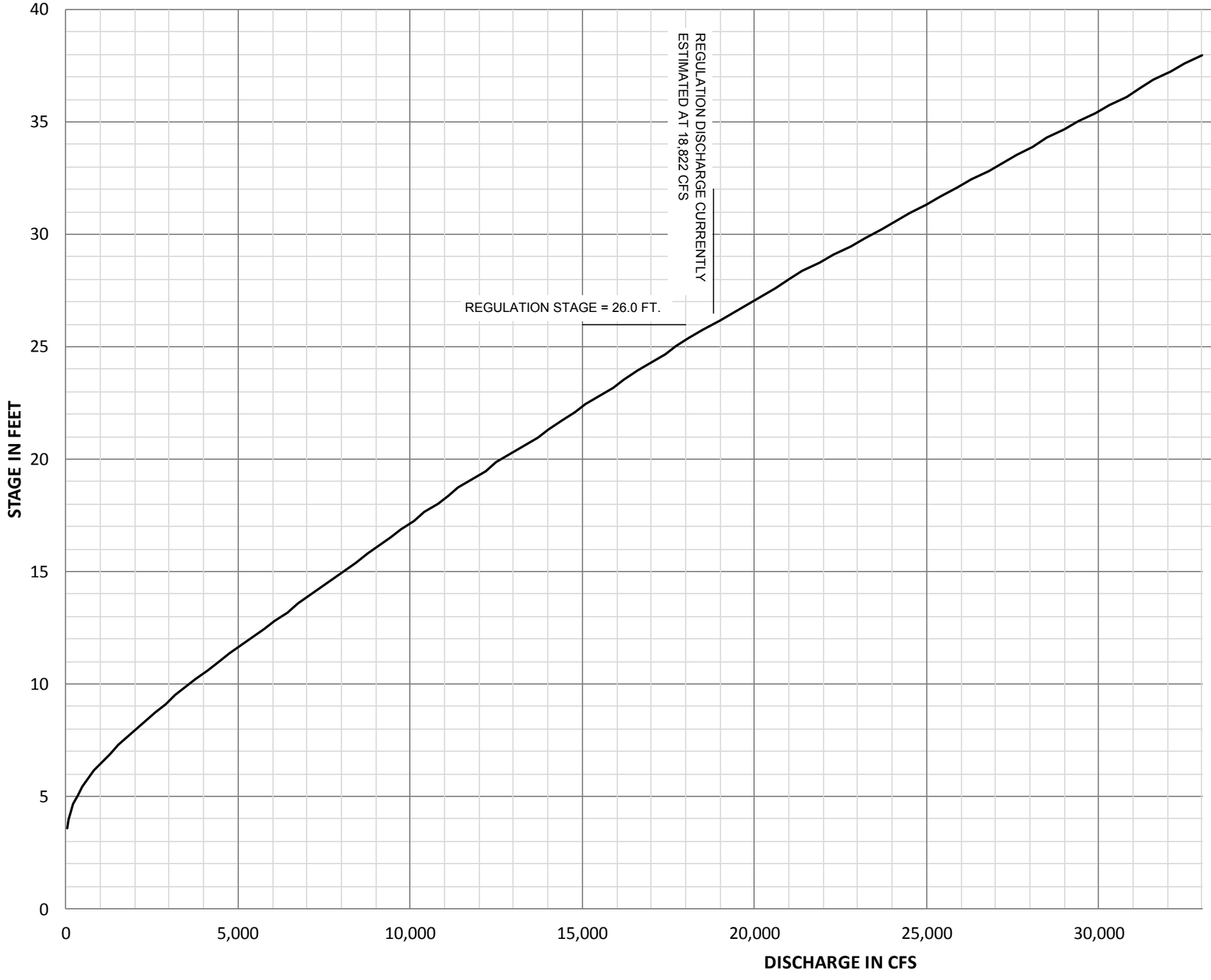
ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

DISCHARGE RATING CURVE
BIRD CREEK NEAR SPERRY, OK

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

PLATE 4-9



NOTES:

DATA OBTAINED FROM WDCS DATABASE
GAGE DATUM: 545.00 NGVD29
DATE OF DATA: 09DEC2014

NOTE: PLATE SIZE IS 11" X 17"

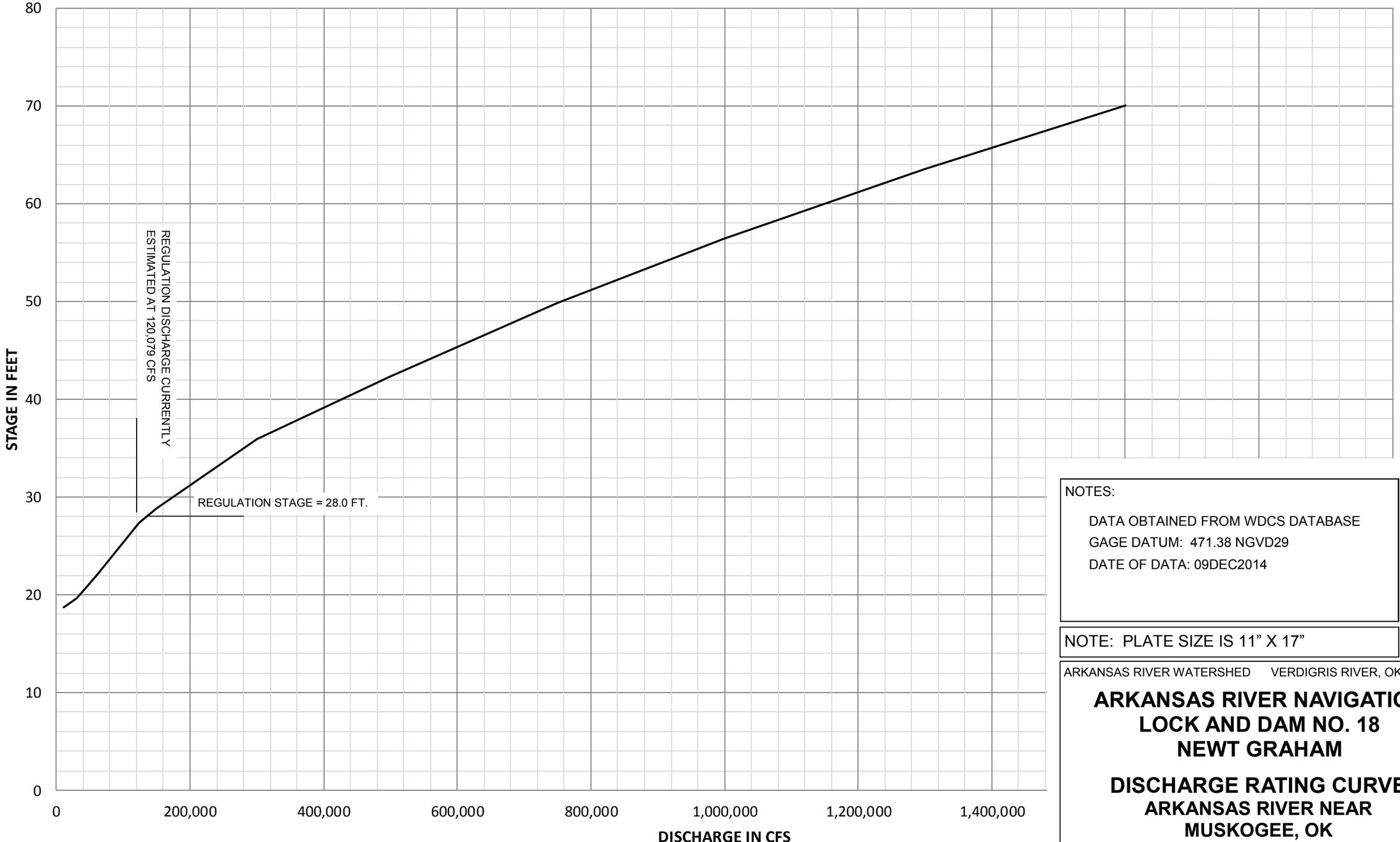
ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

DISCHARGE RATING CURVE
BIRD CREEK AT CATOOSA, OK

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

PLATE 4-10



NOTES:

DATA OBTAINED FROM WDCS DATABASE
GAGE DATUM: 471.38 NGVD29
DATE OF DATA: 09DEC2014

NOTE: PLATE SIZE IS 11” X 17”

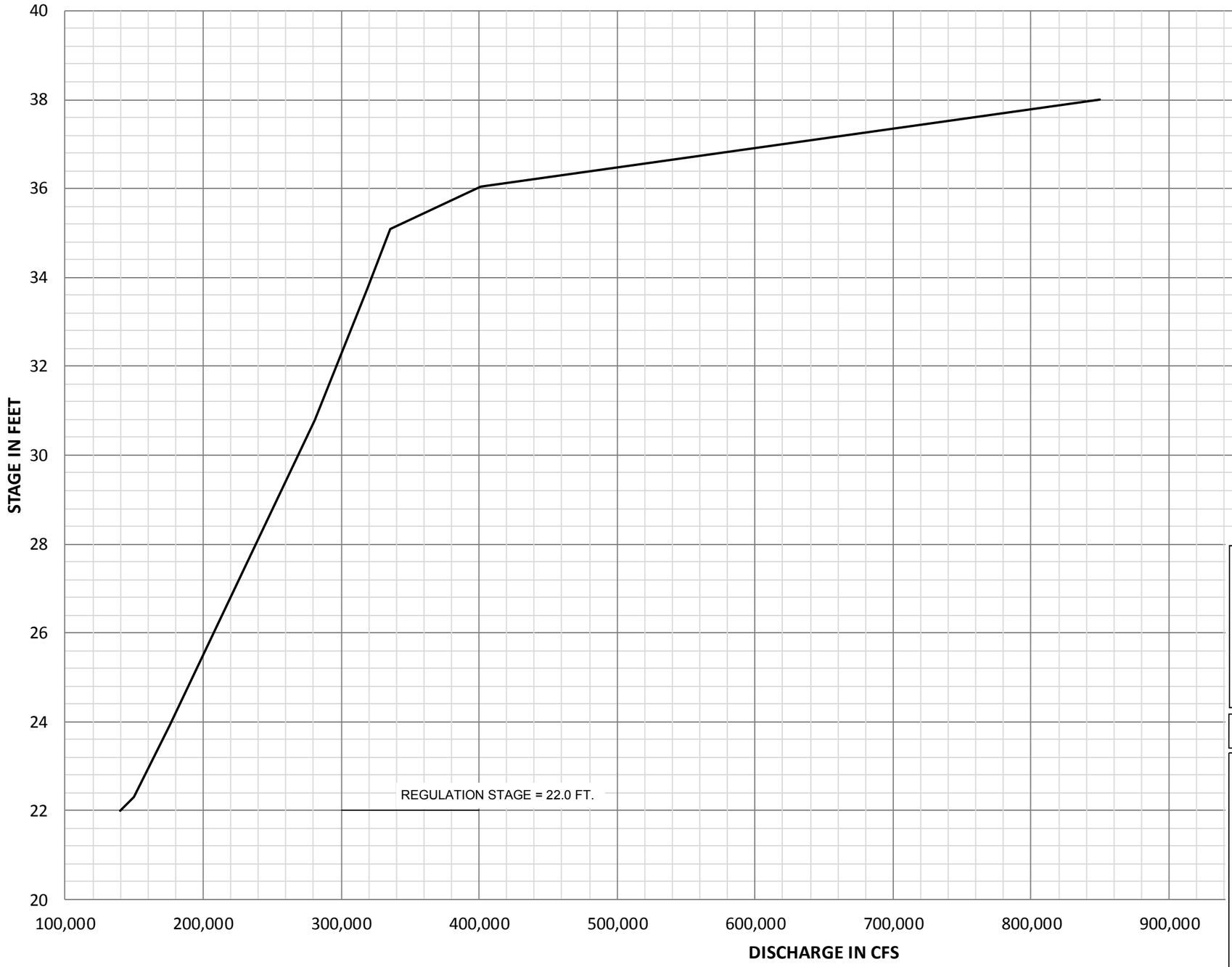
ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

DISCHARGE RATING CURVE
ARKANSAS RIVER NEAR MUSKOGEE, OK

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

PLATE 4-11



NOTE:

Due to frequent changes in the sand riverbed, maintaining an accurate rating curve below flood stage is difficult. Therefore the rating curve begins at flood stage.

NOTES:

DATA OBTAINED FROM WDCS DATABASE
GAGE DATUM: 372.36 NGVD29
DATE OF DATA: 09DEC2014

NOTE: PLATE SIZE IS 11” X 17”

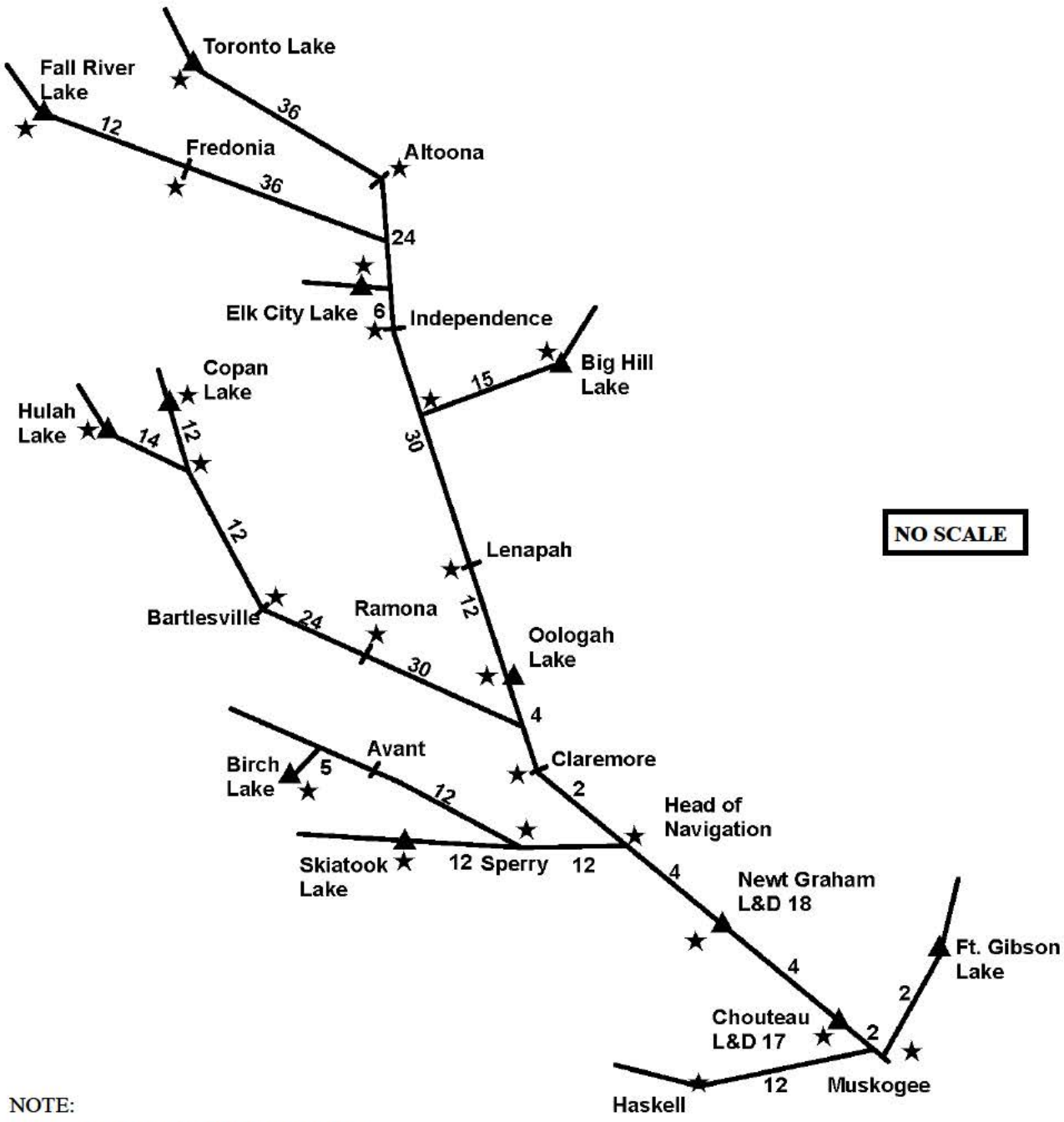
ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

DISCHARGE RATING CURVE
ARKANSAS RIVER AT VAN BUREN, AR

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

PLATE 4-12



NOTE:

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

★ 22 HRS. ★

TIME SHOWN UPSTREAM OF STATION IS AVERAGE TIME TO CREST AFTER BEGINNING OF RUNOFF

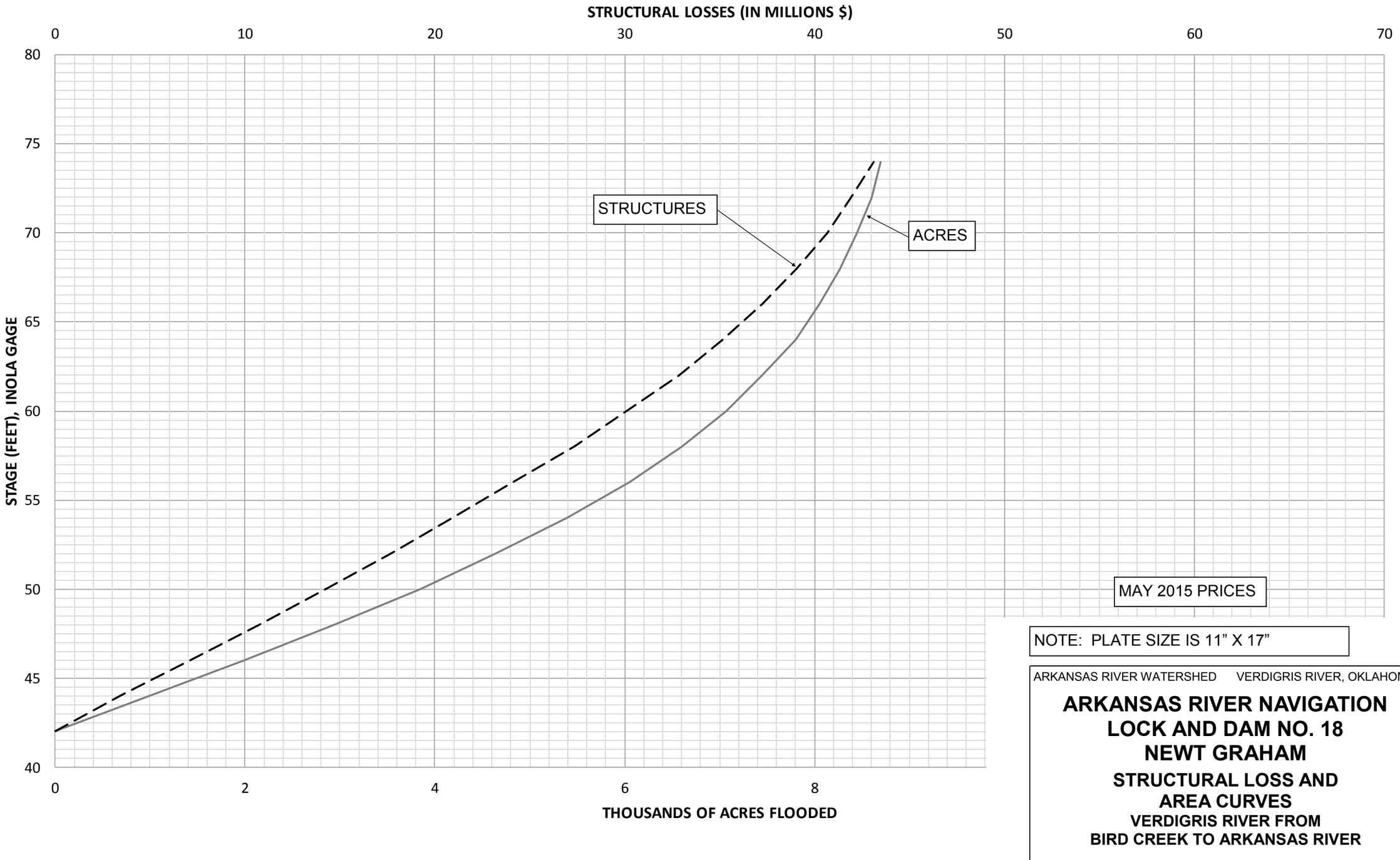
ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

TIME OF CREST TRAVEL

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

PLATE 4-13



MAY 2015 PRICES

NOTE: PLATE SIZE IS 11” X 17”

ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

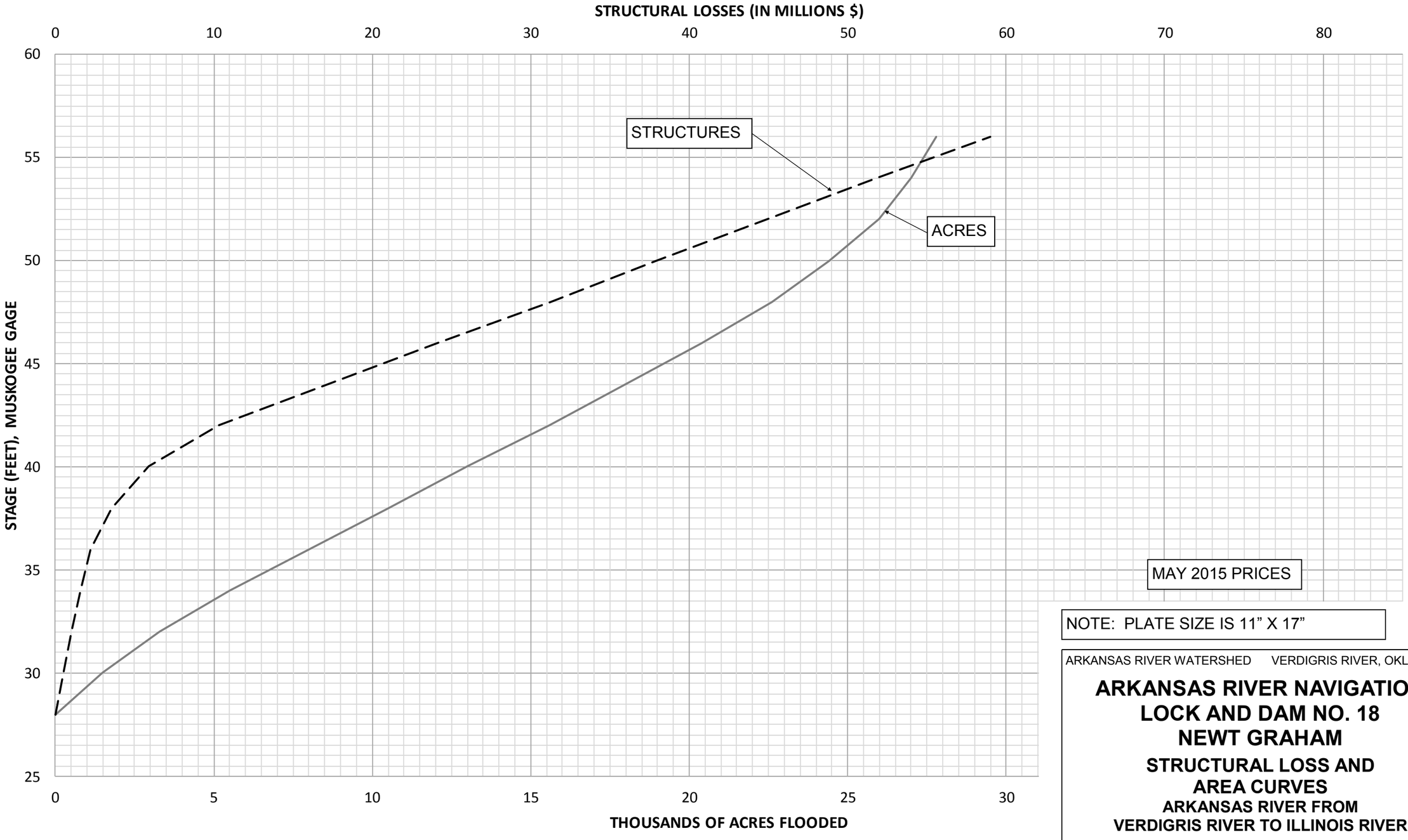
ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

STRUCTURAL LOSS AND AREA CURVES

VERDIGRIS RIVER FROM BIRD CREEK TO ARKANSAS RIVER

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

PLATE 4-14



MAY 2015 PRICES

NOTE: PLATE SIZE IS 11” X 17”

ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

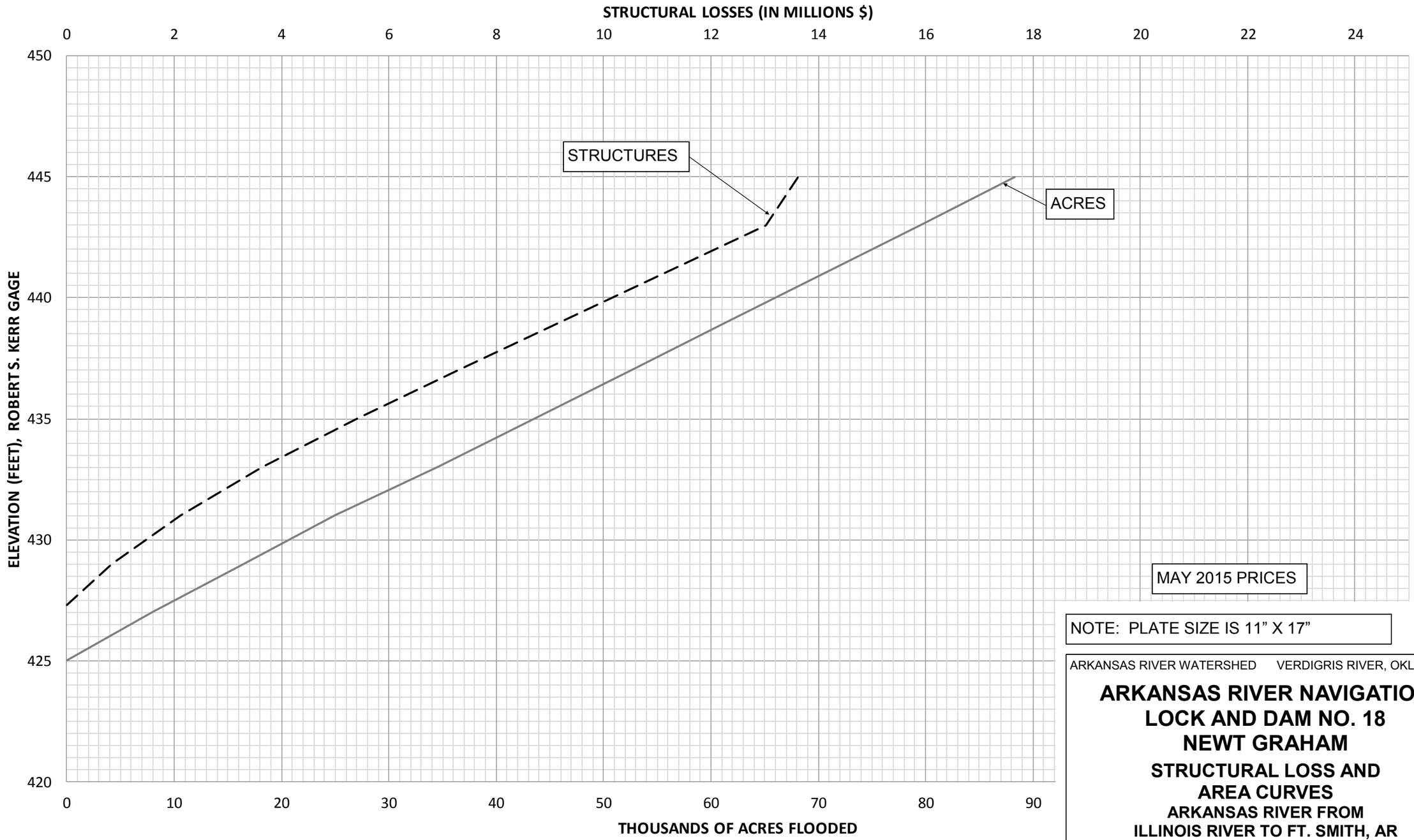
ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

STRUCTURAL LOSS AND AREA CURVES

ARKANSAS RIVER FROM VERDIGRIS RIVER TO ILLINOIS RIVER

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

PLATE 4-15



MAY 2015 PRICES

NOTE: PLATE SIZE IS 11” X 17”

ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

STRUCTURAL LOSS AND AREA CURVES

ARKANSAS RIVER FROM ILLINOIS RIVER TO FT. SMITH, AR

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

PLATE 4-16

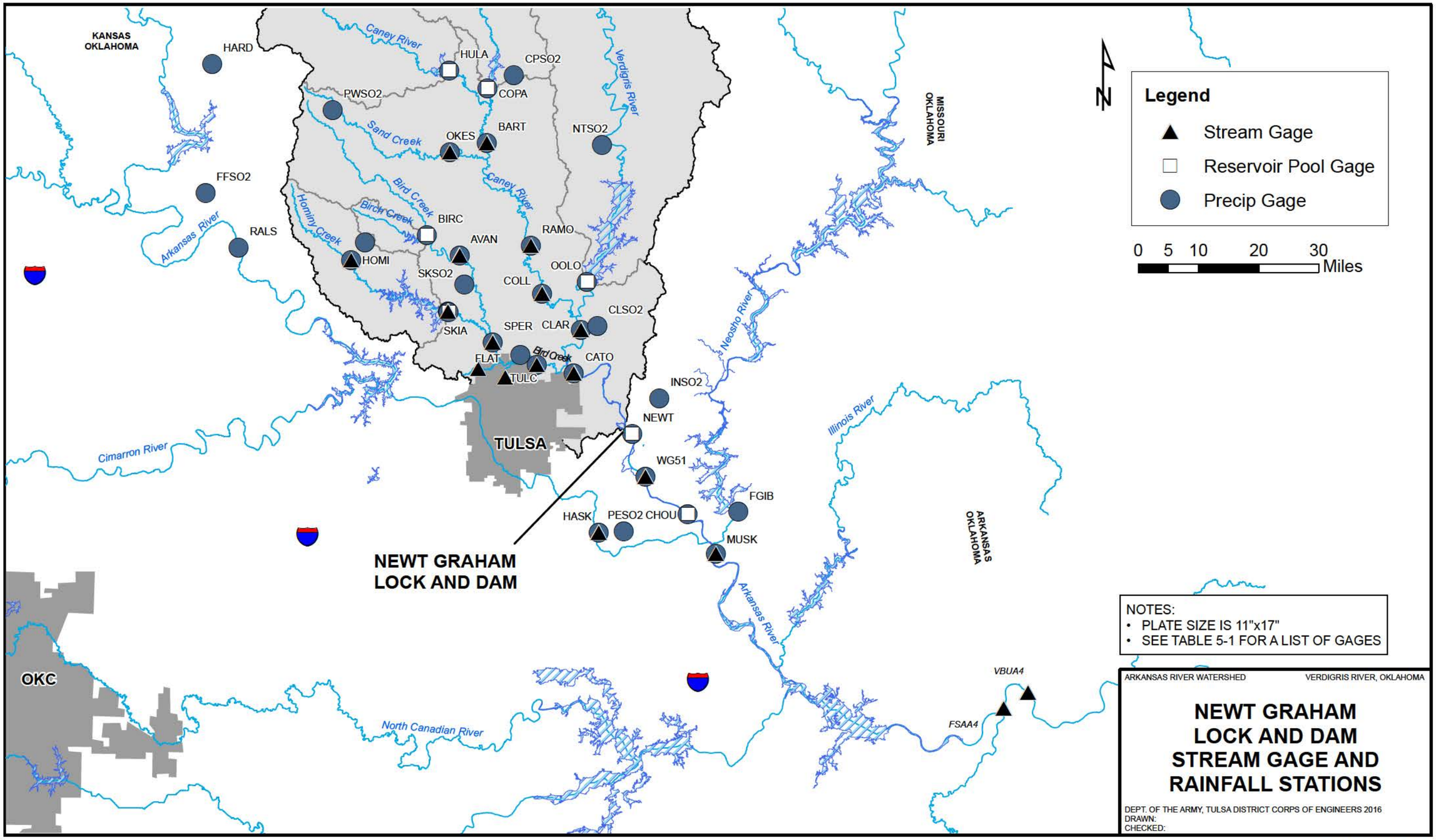
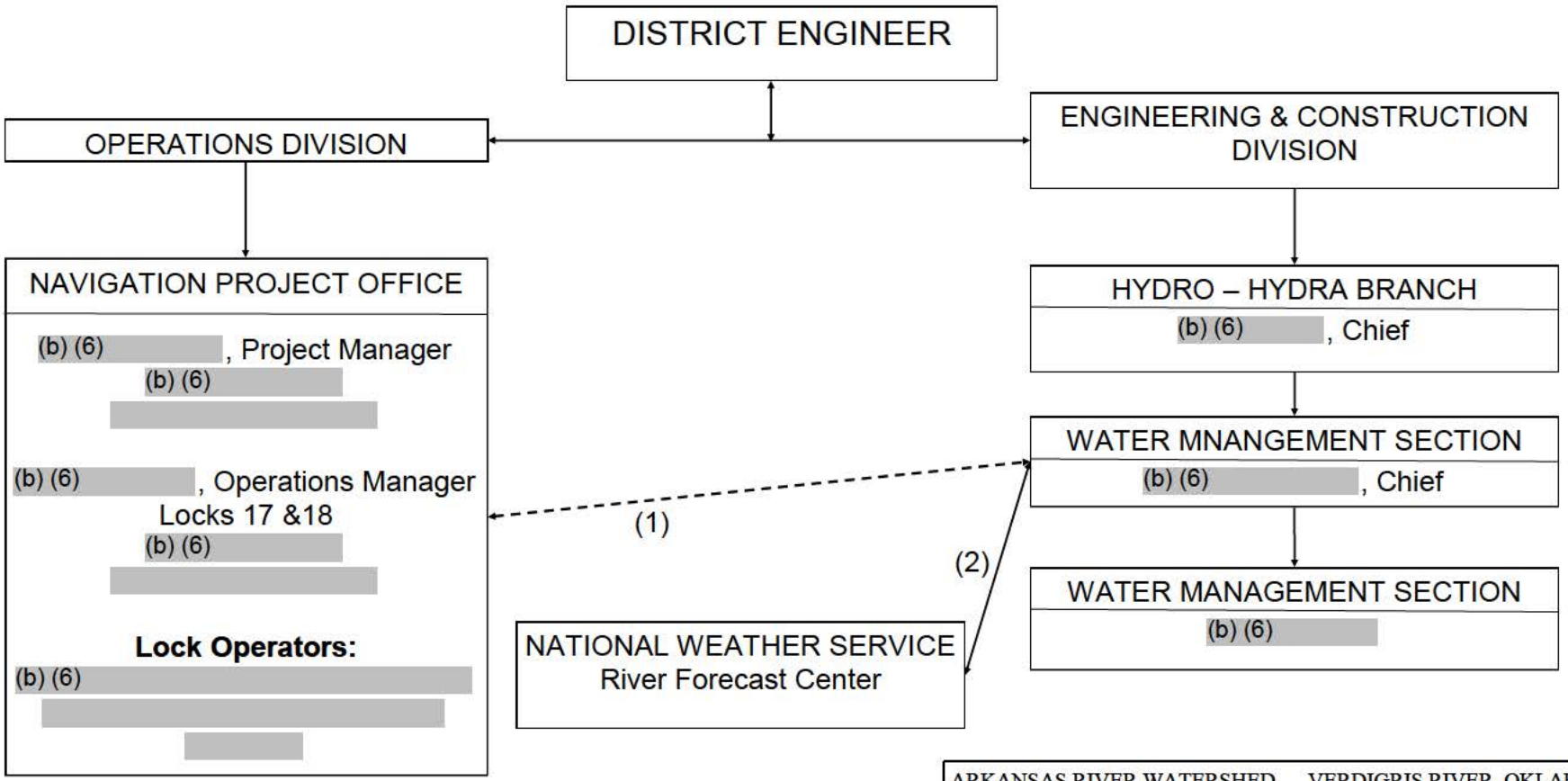

KANSAS
OKLAHOMA
HARD
Caney River
HULA
CPSO2
COPA
Verdigris River
PWSO2
Sand Creek
OKES
BART
NTSO2
MISSOURI
OKLAHOMA
FFSO2
Bird Creek
Hominy Creek
Birch Creek
BIRC
Caney River
RALS
Arkansas River
AVAN
RAMO
HOMI
SKSO2
OOLO
COLL
CLSO2
SKIA
SPER
CLAR
Neosho River
FLAT
Bird Creek
CATO
TULC
INSO2
NEWT
TULSA
Illinois River
Cimarron River
WG51
FGIB
HASK
PESO2
CHOU
MUSK
ARKANSAS
OKLAHOMA
NEWT GRAHAM
LOCK AND DAM
Arkansas River
VBUA4
OKC
North Canadian River
FSAA4
N
Legend
Stream Gage
Reservoir Pool Gage
Precip Gage
0 5 10 20 30
Miles
NOTES:
• PLATE SIZE IS 11"x17"
• SEE TABLE 5-1 FOR A LIST OF GAGES
ARKANSAS RIVER WATERSHED
VERDIGRIS RIVER, OKLAHOMA
NEWT GRAHAM
LOCK AND DAM
STREAM GAGE AND
RAINFALL STATIONS
DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 2016
DRAWN:
CHECKED:

PLATE 5-1

U.S. ARMY CORPS OF ENGINEERS
TULSA DISTRICT



1. DIRECT COMMUNICATIONS ARE MAINTAINED BETWEEN NEWT GRAHAM LOCK & DAM 18 AND THE WATER MANAGEMENT SECTION FOR TRANSMISSION OF POOL DATA, REGULATIONS, AND INSTRUCTIONS.

2. PRECIPITATION AND STREAM GAGE DATA ARE SHARED BY THE NATIONAL WEATHER SERVICE, RIVER FORECAST CENTER.

ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

ARKANSAS RIVER NAVIGATION
LOCK AND DAM NO. 18
NEWT GRAHAM

ORGANIZATION FOR
FLOOD CONTROL REGULATION

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

PLATE 5-2

DATE _____ LOCK # 18 - Newt Graham

RECORD OF GATE SETTINGS, HOURLY GAGE READINGS, AND DISCHARGES

GATE SETTINGS (VERTICAL OPENINGS OVER THE SILLS)				Total Openings	Spillway Disch (1,000 cfs)	Power Disch (1,000 cfs)	Total Disch (1,000 cfs)	Gate Readings			Remarks	PH Hourly
	Gate Numbers											
Time	1	2	3					Time	Upper	Lower	High Wind or Lockage	
00:00												
1:00												
2:00												
3:00												
4:00												
5:00												
6:00												
7:00												
8:00												
9:00												
10:00												
11:00												
12:00												
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14:00												
15:00												
16:00												
17:00												
18:00												
19:00												
20:00												
21:00												
22:00												
23:00												
24:00												

Climatologic Data		Inflow and Release					
Rainfall		Item	Amount	Unit			
Total		Power House Average		CFS	Gen No	Hrs of Use	
		Spillway Release		CFS	1		
		Lockage		CFS	2		
		Evaporation & Leakage		CFS	3		
		Subtotal		CFS	4		
		Change in Storage		CFS			
		INFLOW					

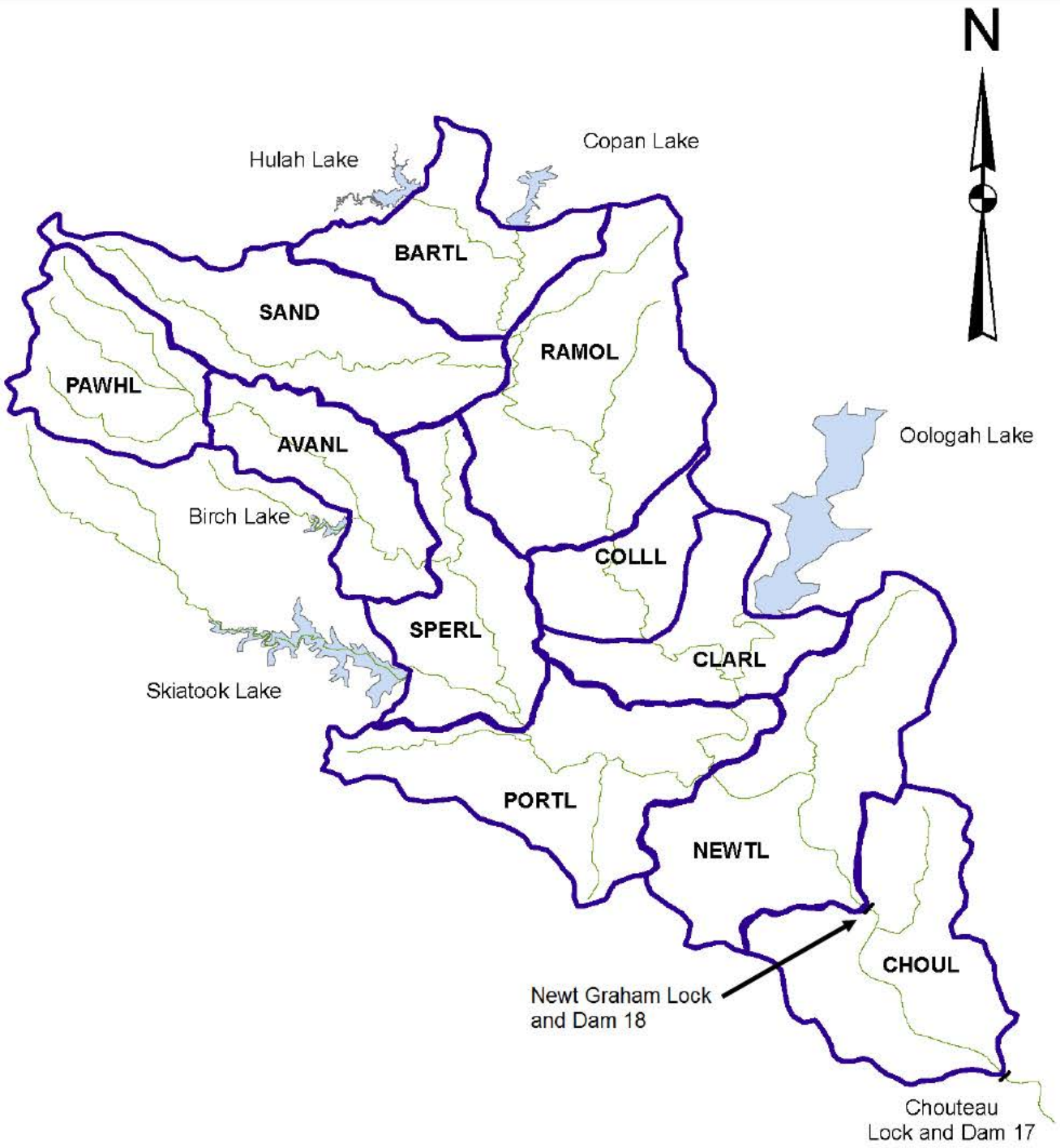
ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

LOCK AND DAM DAILY REPORT

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

PLATE 5-3



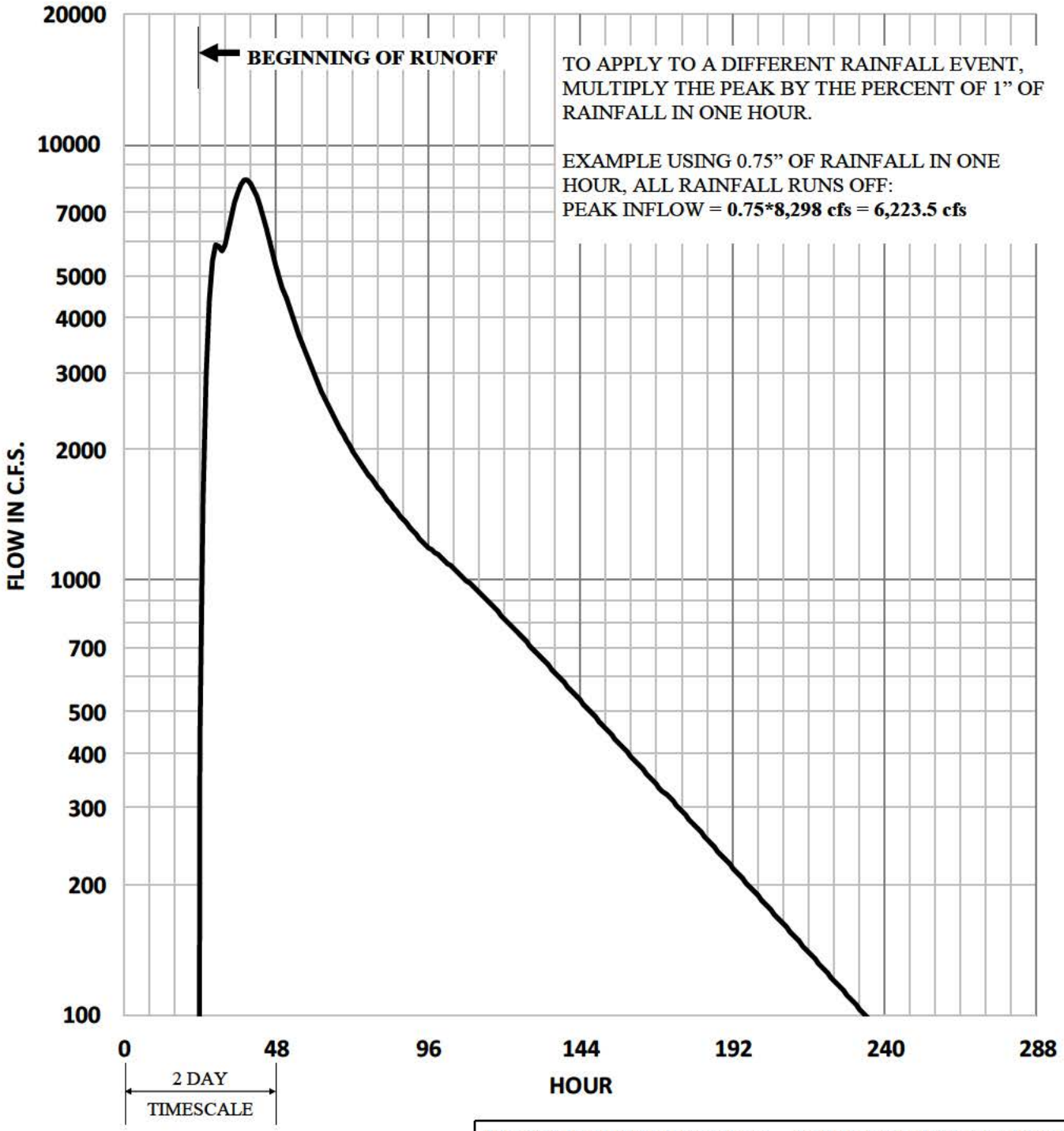
ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

FORECAST REACHES

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

PLATE 6-1



DRAINAGE AREA = 369 SQ. MI.
1" RUNOFF = 26,921 AC. FT.
PEAK FLOW = 8,298 C.F.S

ASSUMES 1" OF RAINFALL IN 1 HOUR. RAINFALL BEGINS AT MIDNIGHT OF DAY 1. GRAPH ASSUMES ALL RAINFALL RUNS OFF.

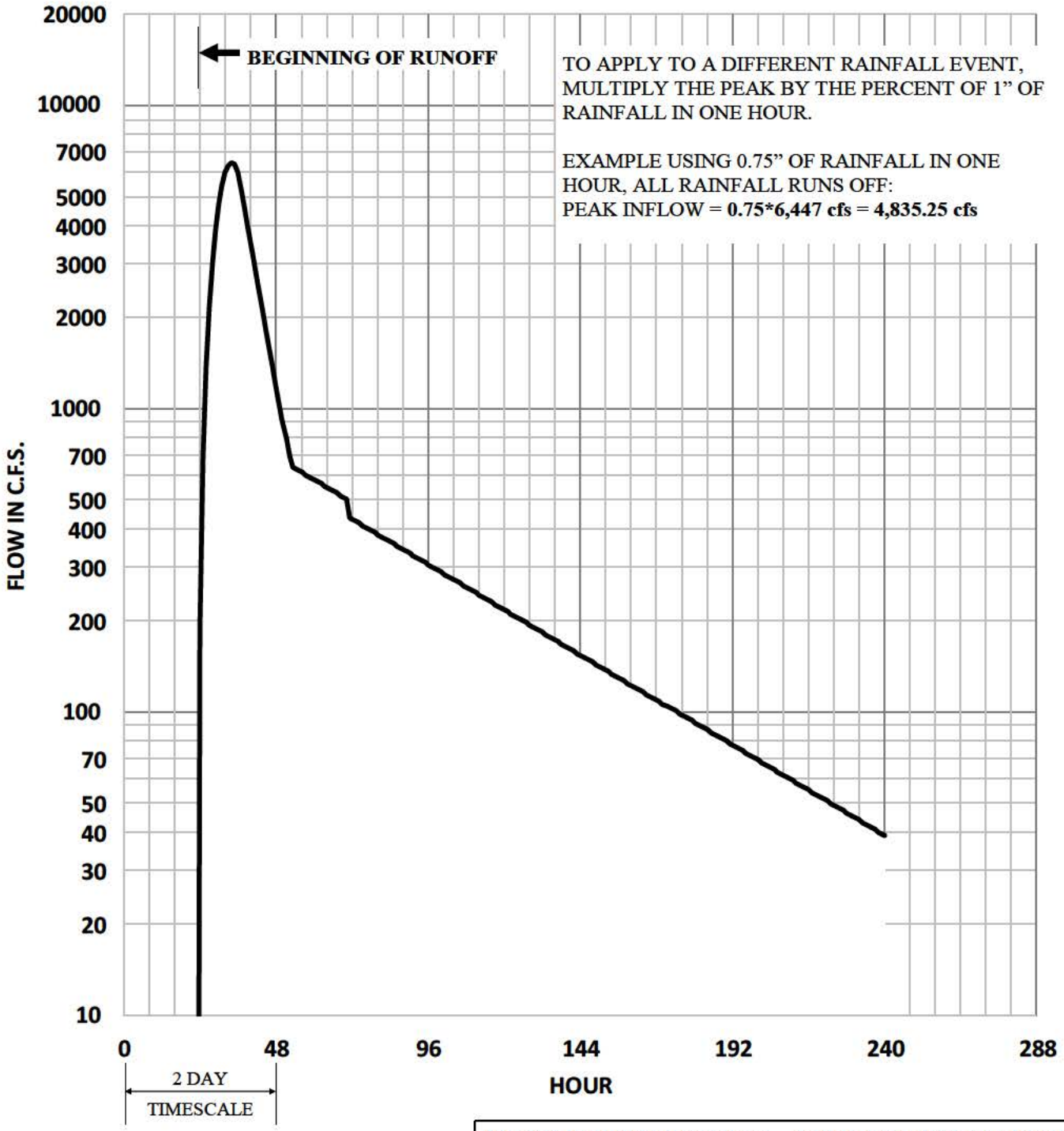
ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

UNIT HYDROGRAPH FOR AREA ABOVE AVANT GAGE BIRD CREEK

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

PLATE 6-2



DRAINAGE AREA = 4,515 SQ. MI.
1" RUNOFF = 10,604 AC. FT.
PEAK FLOW = 6,447 C.F.S

ASSUMES 1" OF RAINFALL IN 1 HOUR. RAINFALL BEGINS AT MIDNIGHT OF DAY 1. GRAPH ASSUMES ALL RAINFALL RUNS OFF.

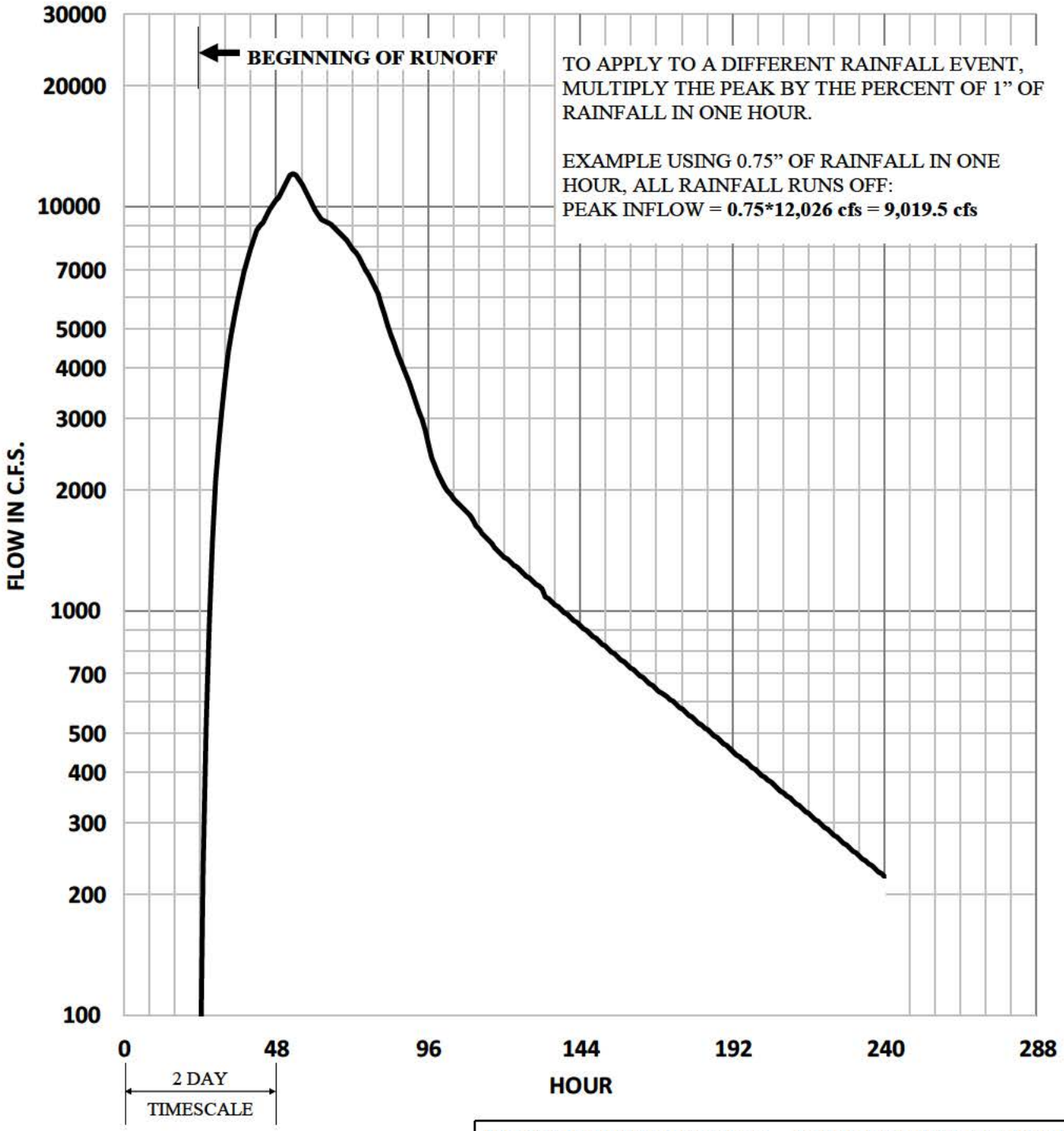
ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

UNIT HYDROGRAPH FOR AREA ABOVE CLAREMORE GAGE UPSTREAM TO RAMONA GAGE VERDIGRIS AND CANEY RIVERS

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

PLATE 6-3



DRAINAGE AREA = 1,936 SQ. MI.
1" RUNOFF = 50,568 AC. FT.
PEAK FLOW = 12,026 C.F.S

ASSUMES 1" OF RAINFALL IN 1 HOUR. RAINFALL BEGINS AT MIDNIGHT OF DAY 1. GRAPH ASSUMES ALL RAINFALL RUNS OFF.

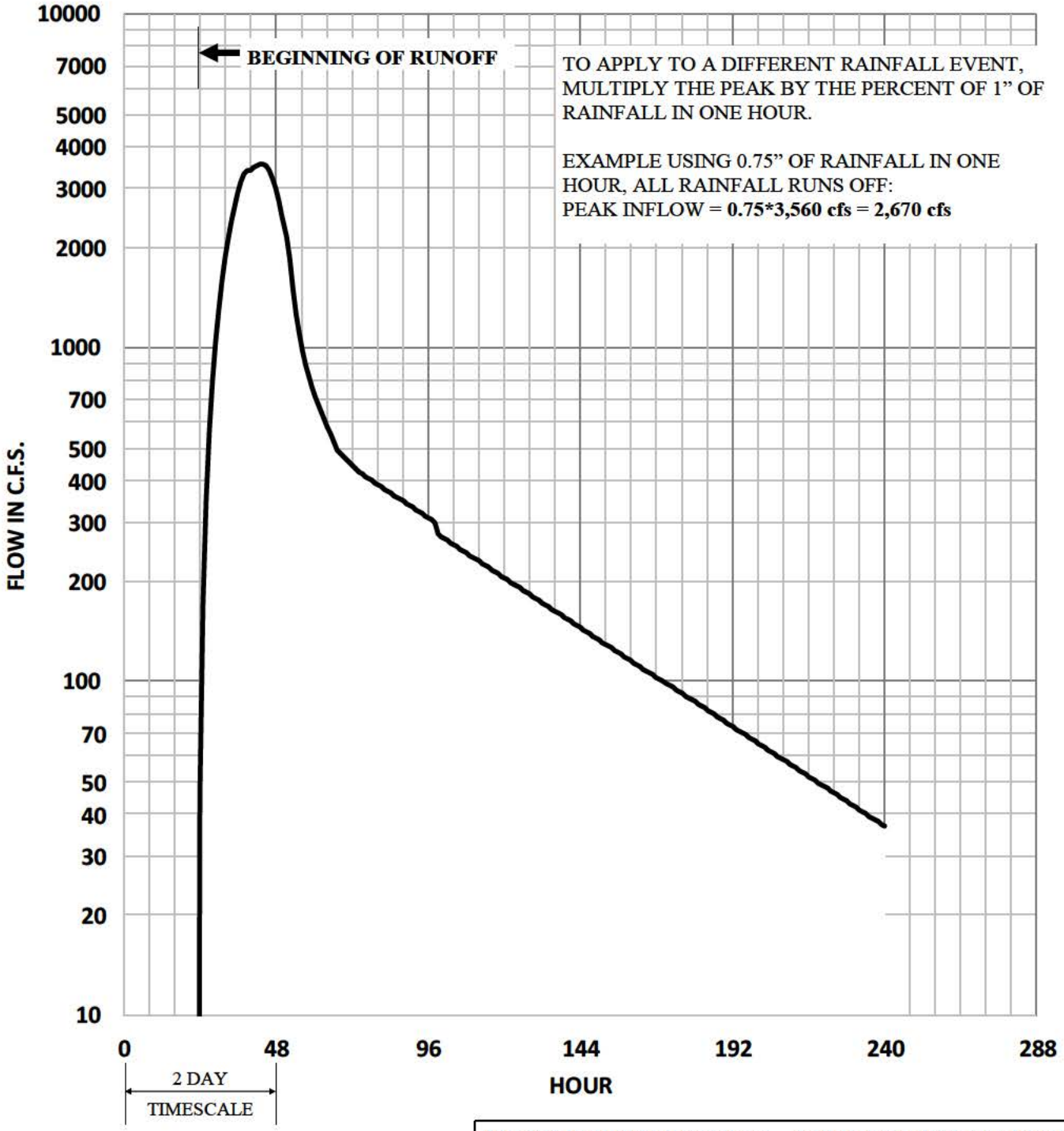
ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

UNIT HYDROGRAPH FOR AREA ABOVE RAMONA GAGE UPSTREAM TO HULAH AND COPAN LAKES CANEY RIVER

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

PLATE 6-4



DRAINAGE AREA = 538 SQ. MI.
1" RUNOFF = 8,937 AC. FT.
PEAK FLOW = 3,560 C.F.S

ASSUMES 1" OF RAINFALL IN 1 HOUR. RAINFALL BEGINS AT MIDNIGHT OF DAY 1. GRAPH ASSUMES ALL RAINFALL RUNS OFF.

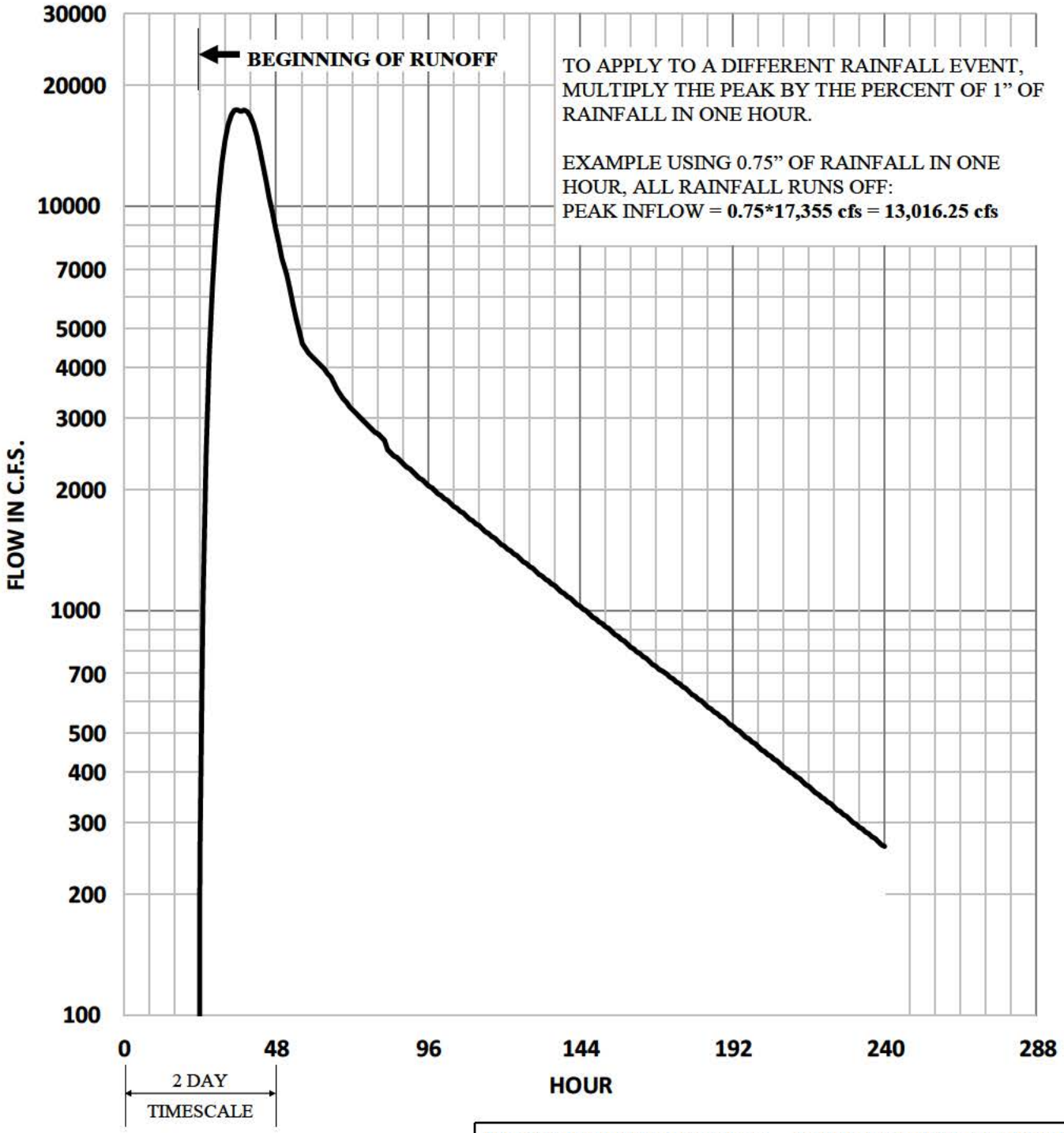
ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

UNIT HYDROGRAPH FOR AREA ABOVE SPERRY GAGE UPSTREAM TO AVANT GAGE BIRD CREEK

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

PLATE 6-5



DRAINAGE AREA = 2,293 SQ. MI.
1" RUNOFF = 48,570 AC. FT.
PEAK FLOW = 17,355 C.F.S

ASSUMES 1" OF RAINFALL IN 1 HOUR. RAINFALL BEGINS AT MIDNIGHT OF DAY 1. GRAPH ASSUMES ALL RAINFALL RUNS OFF.

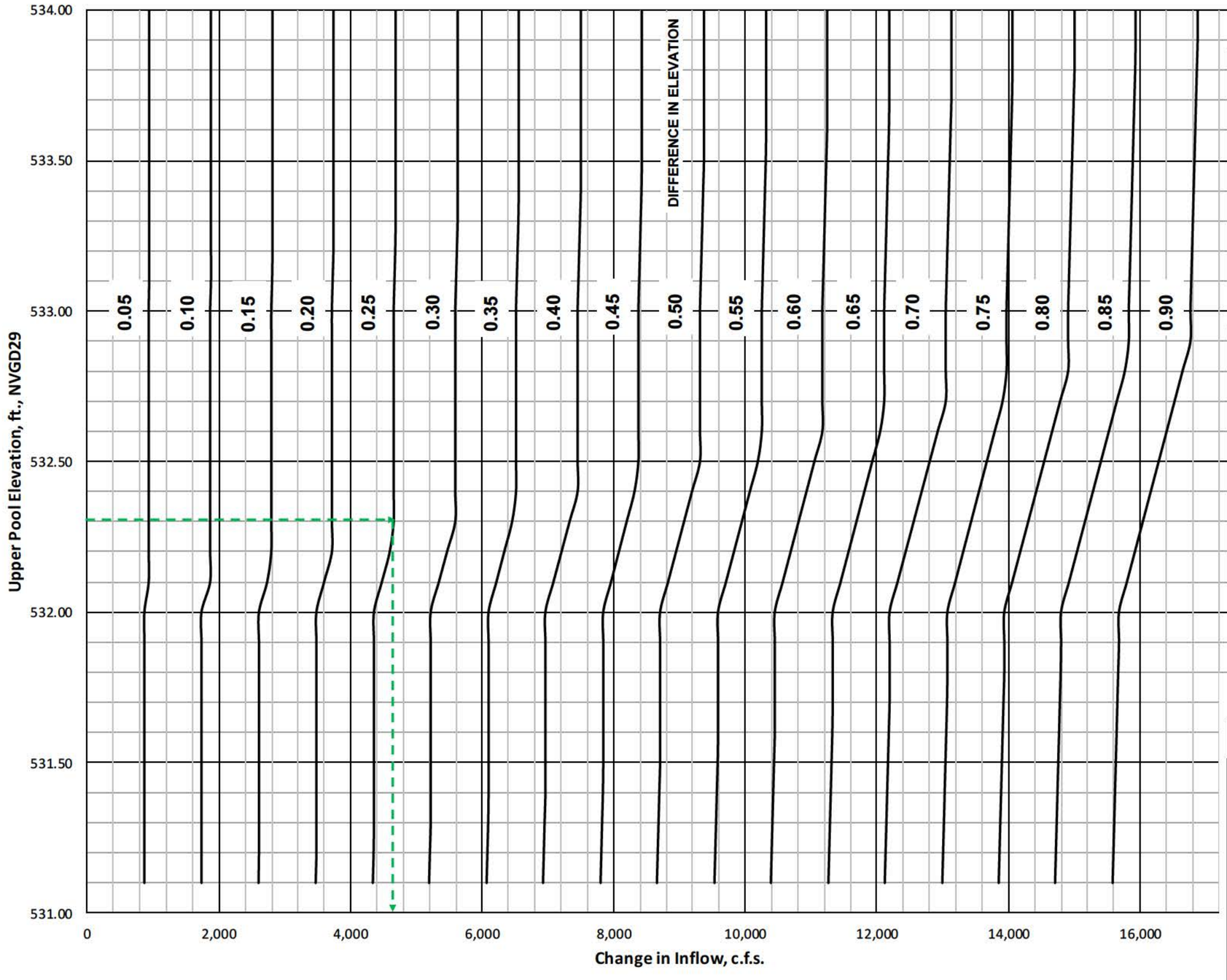
ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18

UNIT HYDROGRAPH FOR AREA ABOVE NEWT GRAHAM L&D UPSTREAM TO CLAREMORE AND SPERRY GAGES VERDIGRIS RIVER AND BIRD CREEK

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

PLATE 6-6



NOTE:

1. RECORD POOL ELEVATION.
2. ONE HOUR LATER RECORD UPPER POOL ELEVATION.
3. FIND THE DIFFERENCE IN POOL ELEVATIONS.
4. ENTER PLOT ON LEFT WITH SECOND POOL ELEVATION, MOVE HORIZONTALLY UNTIL THE POOL ELEVATION DIFFERENCE LINE IS REACHED.
5. MOVE DOWNWARD TO READ THE CHANGE IN INFLOW.

EXAMPLE: (- - -)

1. UPPER POOL ELEVATION IS 532.05 FT.
2. ONE HOUR LATER THE UPPER POOL ELEVATION IS 532.30 FT
3. THE DIFFERENCE IN POOL ELEVATIONS IS 0.25 FT
4. ENTER THE PLOT ON LEFT AT 532.30 AND MOVE HORIZONTALLY UNTIL REACHING THE 0.25 FT LINE
5. MOVE DOWNWARD TO THE X-AXIS,

THE CHANGE IN INFLOW DURING THAT HOUR IS 4,660 CFS

NOTE: PLATE SIZE IS 11" X 17"

ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

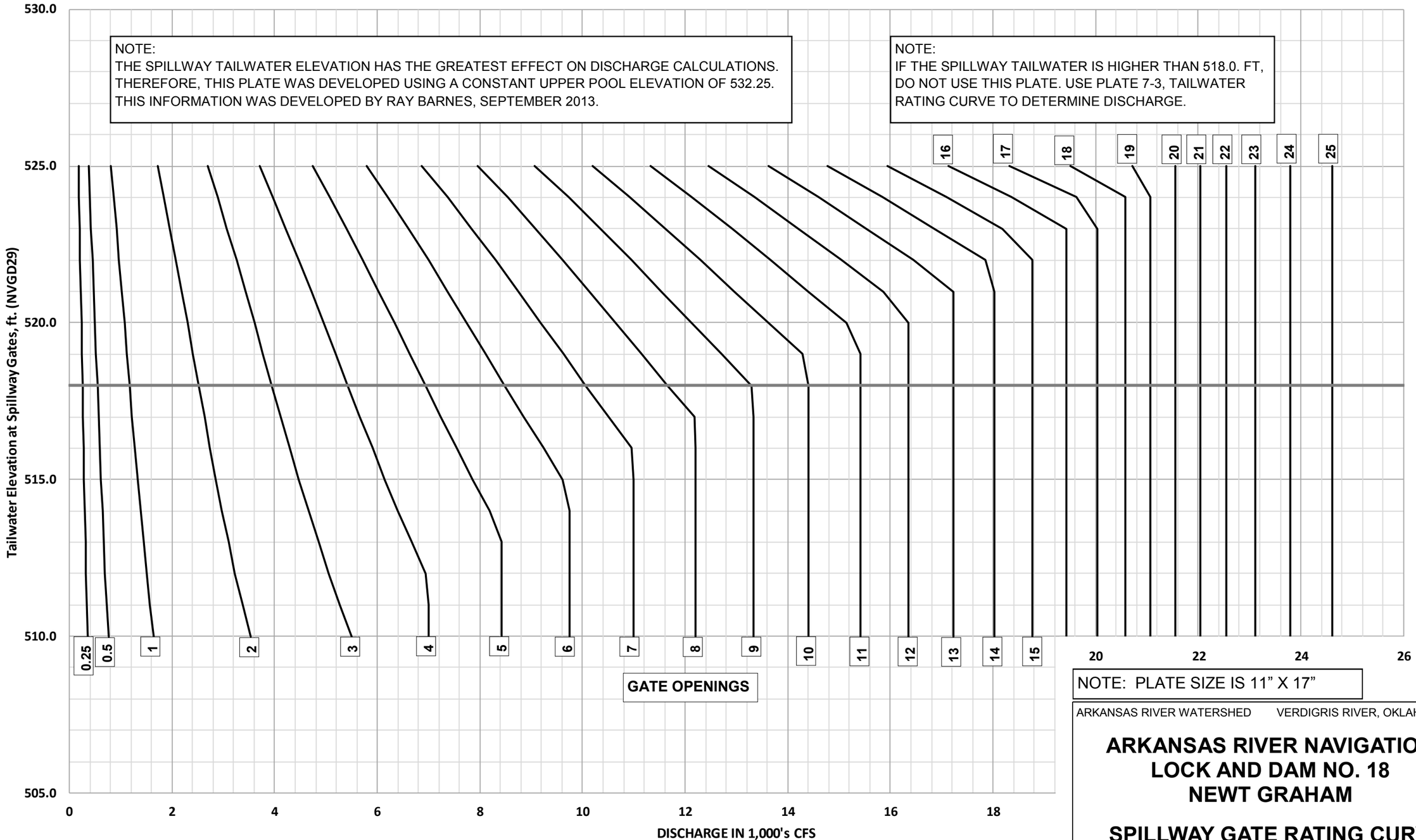
INFLOW vs RATE OF RISE NOMOGRAPHS

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

PLATE 7-1

NOTE:
THE SPILLWAY TAILWATER ELEVATION HAS THE GREATEST EFFECT ON DISCHARGE CALCULATIONS. THEREFORE, THIS PLATE WAS DEVELOPED USING A CONSTANT UPPER POOL ELEVATION OF 532.25. THIS INFORMATION WAS DEVELOPED BY RAY BARNES, SEPTEMBER 2013.

NOTE:
IF THE SPILLWAY TAILWATER IS HIGHER THAN 518.0. FT, DO NOT USE THIS PLATE. USE PLATE 7-3, TAILWATER RATING CURVE TO DETERMINE DISCHARGE.



NOTE: PLATE SIZE IS 11” X 17”

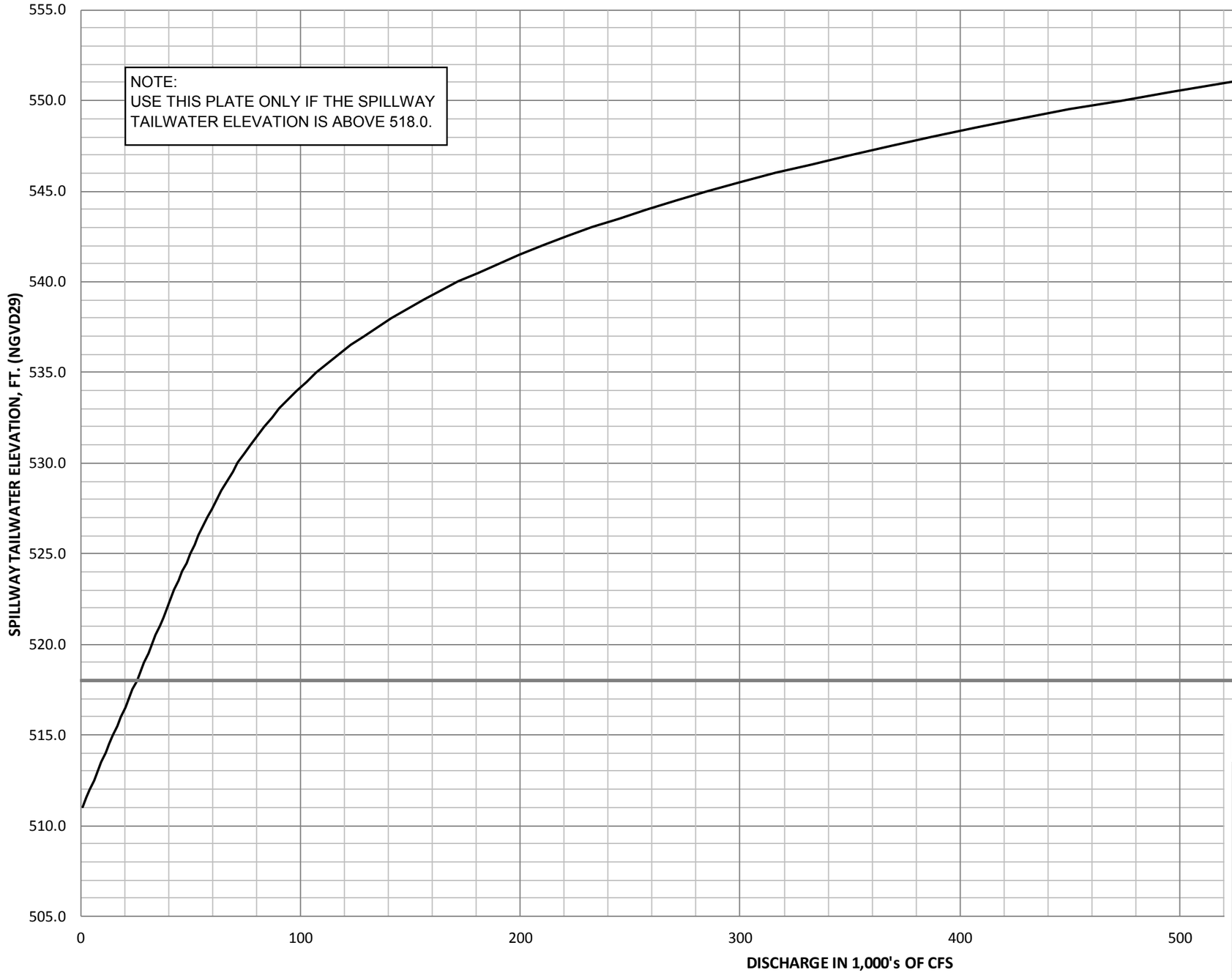
ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

SPILLWAY GATE RATING CURVE ONE GATE

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

PLATE 7-2



NOTE: PLATE SIZE IS 11” X 17”

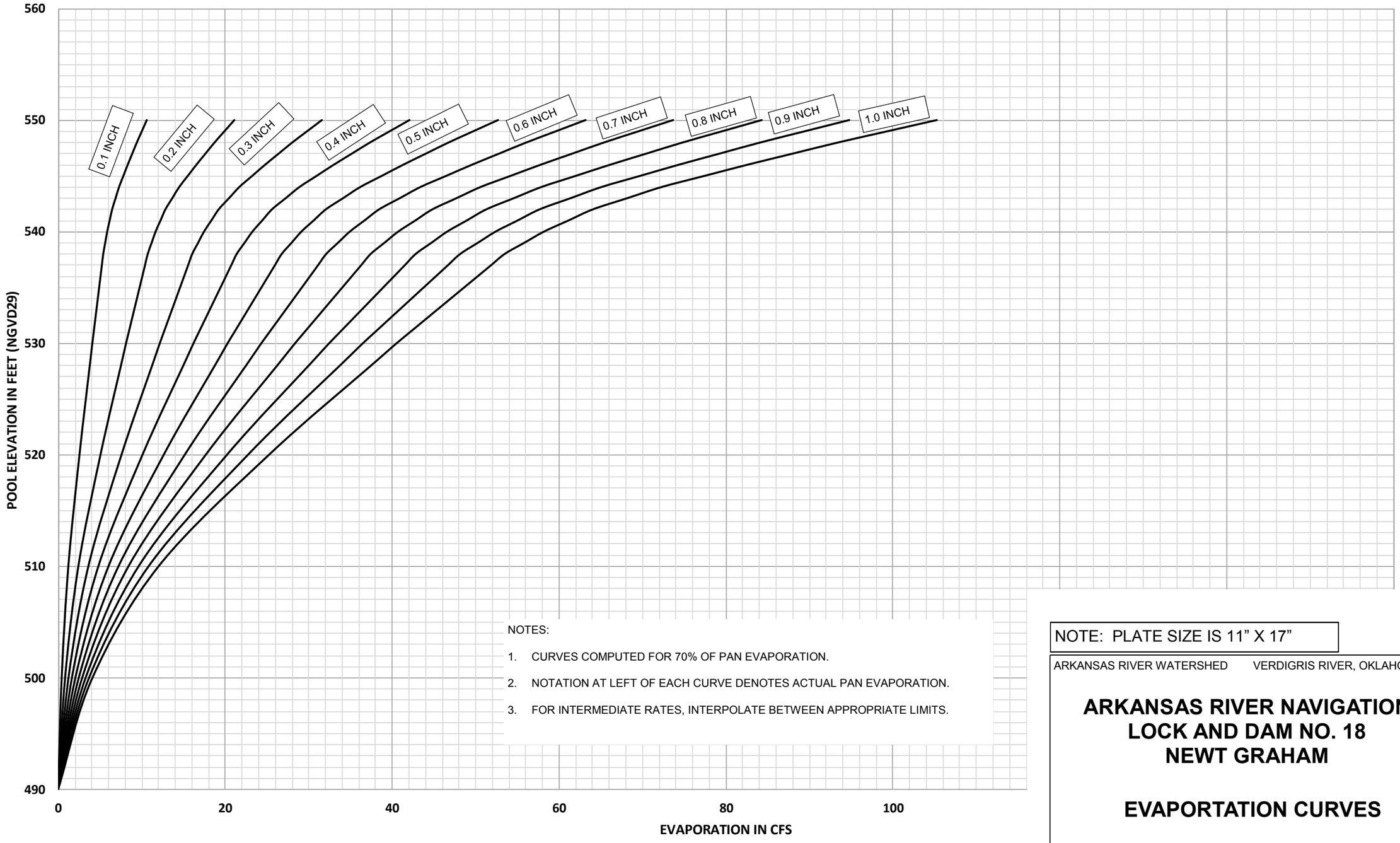
ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

SPILLWAY TAILWATER RATING CURVE

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

PLATE 7-3



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”

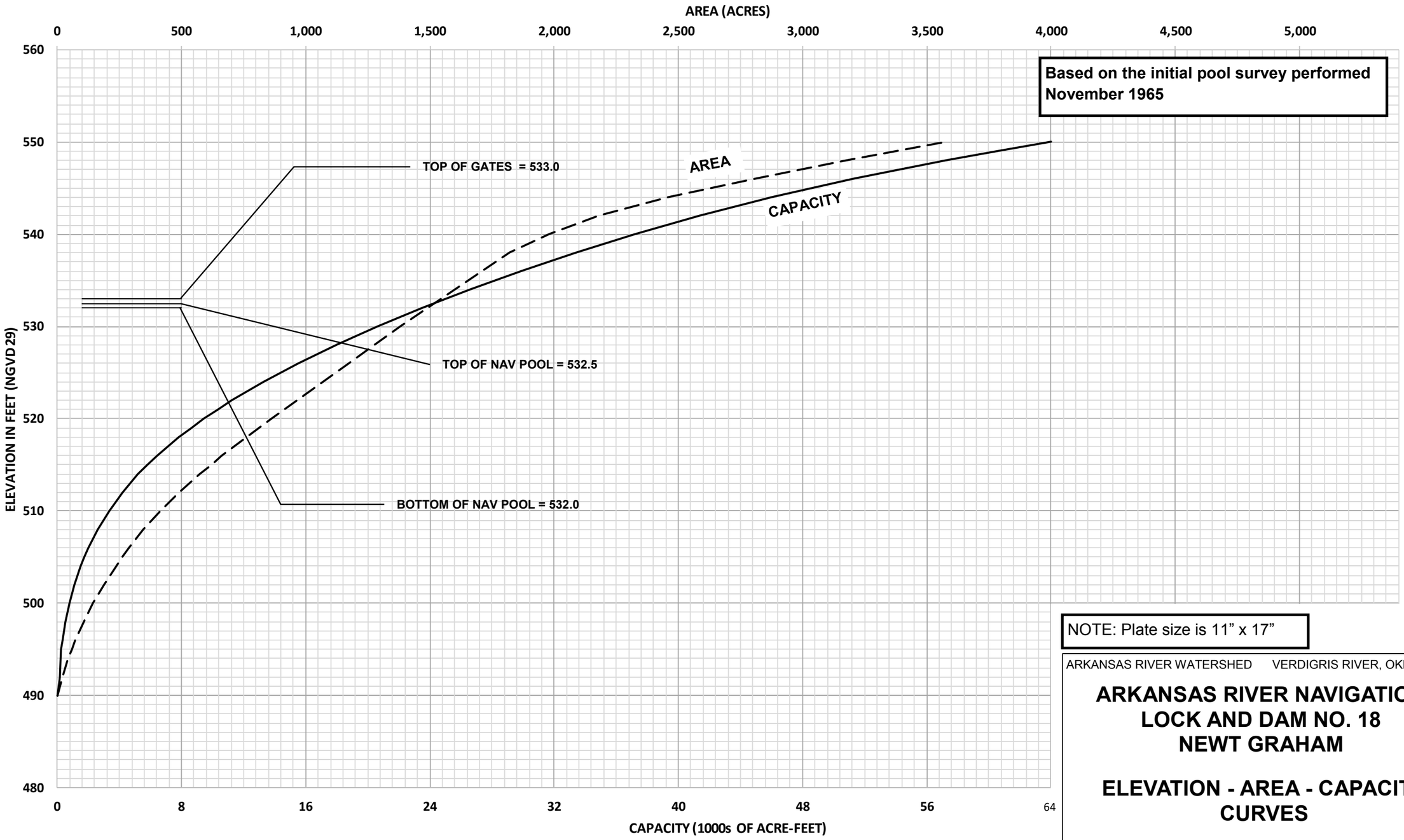
ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

EVAPORTATION CURVES

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

PLATE 7-4



Based on the initial pool survey performed November 1965

NOTE: Plate size is 11” x 17”

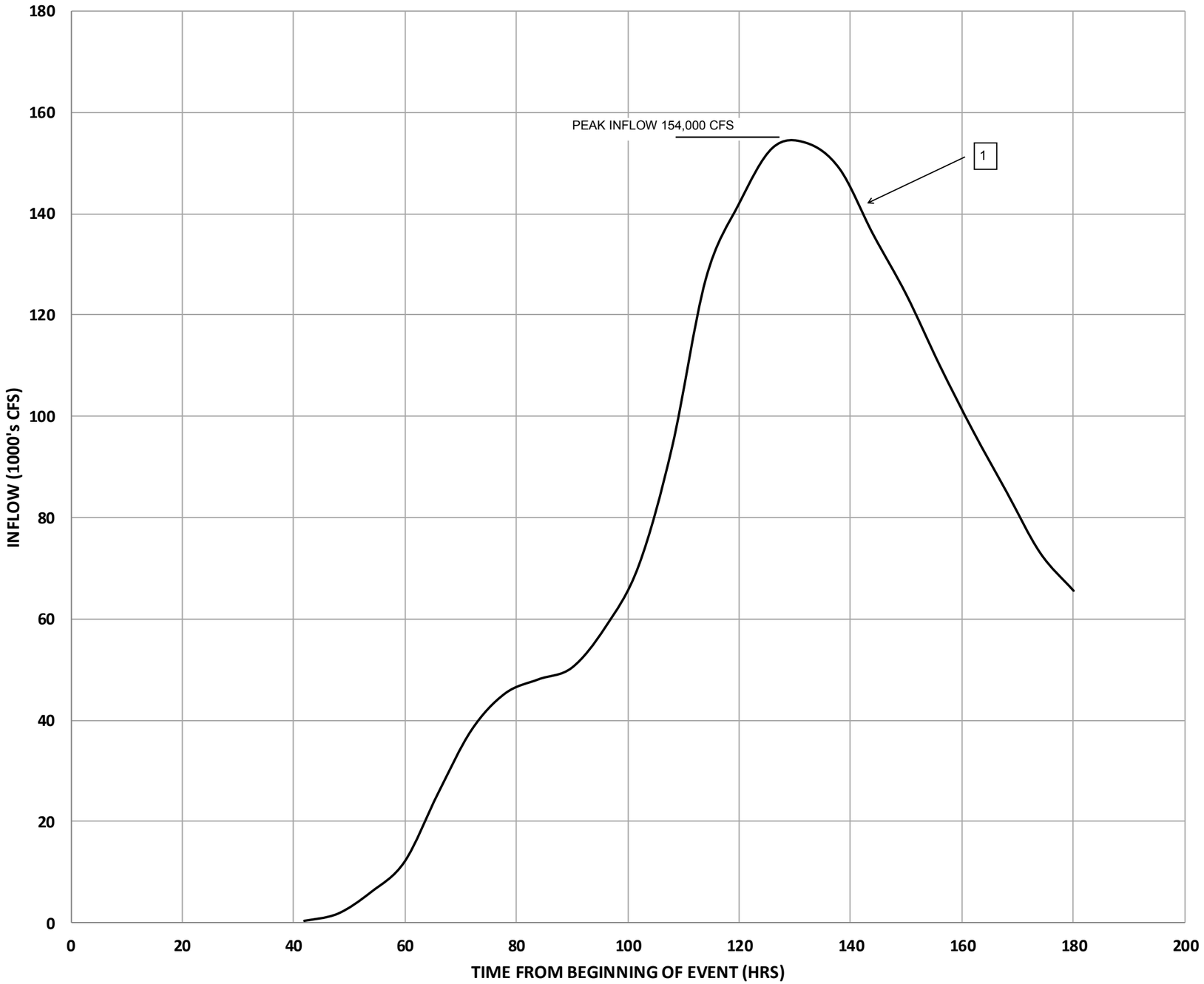
ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

ELEVATION - AREA - CAPACITY CURVES

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

PLATE 7-5



NOTES:

PEAK INFLOW IS APPROXIMATELY **154,000 CFS,** AND OCCURS ABOUT **132 HOURS** INTO THE EVENT

FLOOD VOLUME FROM 0 TO 180 HOURS OF EVENT TIME IS ABOUT **910,000 AC.-FT.**

SPF HYDROGRAPH DEVELOPED ACCORDING TO CIVIL WORKS ENGINEERS BULLETIN NO. 52-8, DATED MAR 26, 1952, TITLED “STANDARD PROJECT FLOOD DETERMINATION”

SPF IS CALCULATED WITHOUT THE BIRD-CANEY RESERVOIR SYSTEM AND ASSUMING THE AREA ABOVE OOLOGAH DAM DOES NOT CONTRIBUTE

RAINFALL VARIES FROM 9.3-13.5 INCHES IN THE VARIOUS SUBBASINS USED TO DETERMINE THE SPF

LEGEND:

1. INFLOW HYDROGRAPH (WITHOUT BIRD-CANEY RESERVOIR SYSTEM)

NOTE: Plate size is 11” x 17”

ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

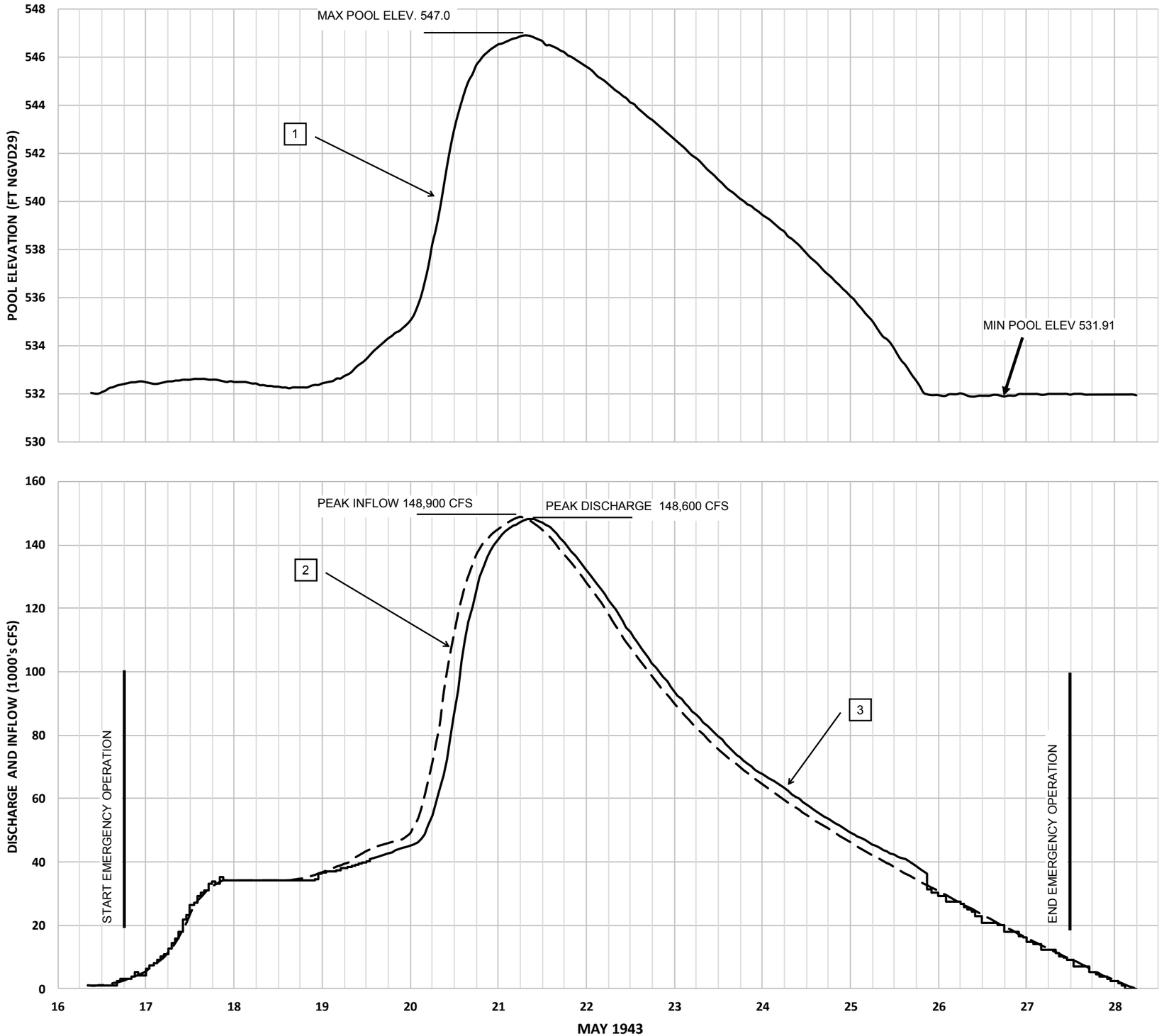
ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

OPERATIONAL HYDROGRAPHS

STANDARD PROJECT FLOOD

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

PLATE 8-1



NOTES:

PEAK INFLOW WAS **148,900 CFS** ON **21 MAY 1943 AT 0600 HOURS**

PEAK DISCHARGE WAS **148,600 CFS** ON **21 MAY 1943 AT 0900 HOURS**

MAXIMUM POOL ELEVATION WAS **547.0 FEET**

FLOOD VOLUME FROM 16 MAY 1943 TO 28 MAY 1943 WAS APPROXIMATELY **1,306,500 AC.-FT.**

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

LEGEND:

1. SIMULATED POOL ELEVATION (EMERGENCY OPERATION)
2. INFLOW HYDROGRAPH (REGULATED BY EXISTING SYSTEM)
3. SIMULATED DISCHARGE HYDROGRAPH (EMERGENCY OPERATION)

NOTE: Plate size is 11” x 17”

ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

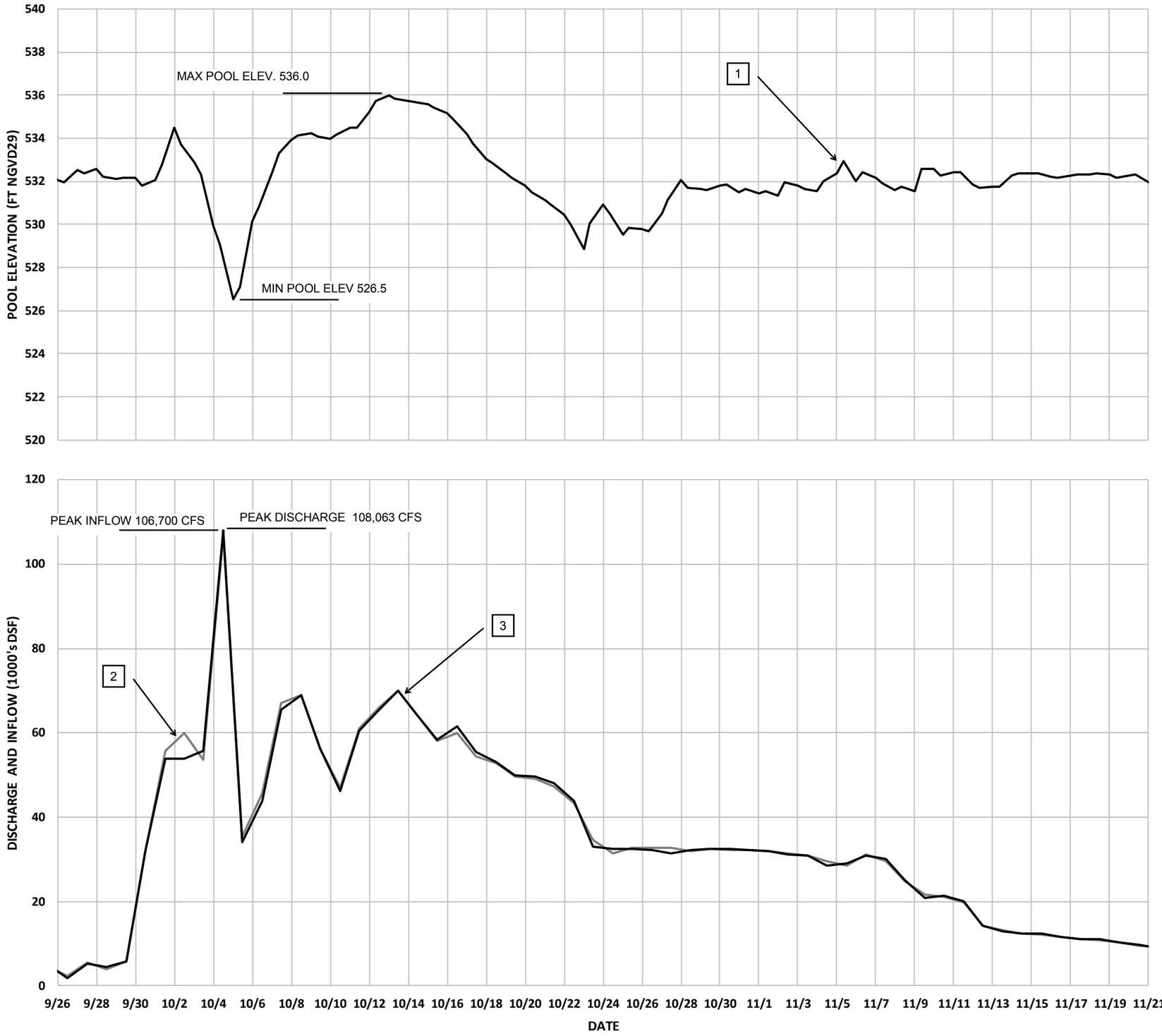
ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

OPERATIONAL HYDROGRAPHS

FLOOD OF MAY 1943

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

PLATE 8-2



NOTES:

PEAK INFLOW WAS **106,700 DSF** ON **04 OCT 1986**

PEAK DISCHARGE WAS **108,063 DSF** ON **04 OCT 1986**

MAXIMUM POOL ELEVATION WAS **536.0 FEET**

FLOOD VOLUME FROM 26 SEPTEMBER 1986 TO 21 NOVEMBER 1986 WAS APPROXIMATELY **4,021,900 AC.-FT.**

ALL DATA OBTAINED FROM MONTHLY CHARTS.
FLOW DATA ARE DAILY AVERAGES.
POOL ELEVATION DATA ARE MEASURED TWICE DAILY.

LEGEND:

1. OBSERVED POOL ELEVATION
2. OBSERVED INFLOW HYDROGRAPH (——)
3. OBSERVED DISCHARGE HYDROGRAPH (——)

NOTE: Plate size is 11” x 17”

ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

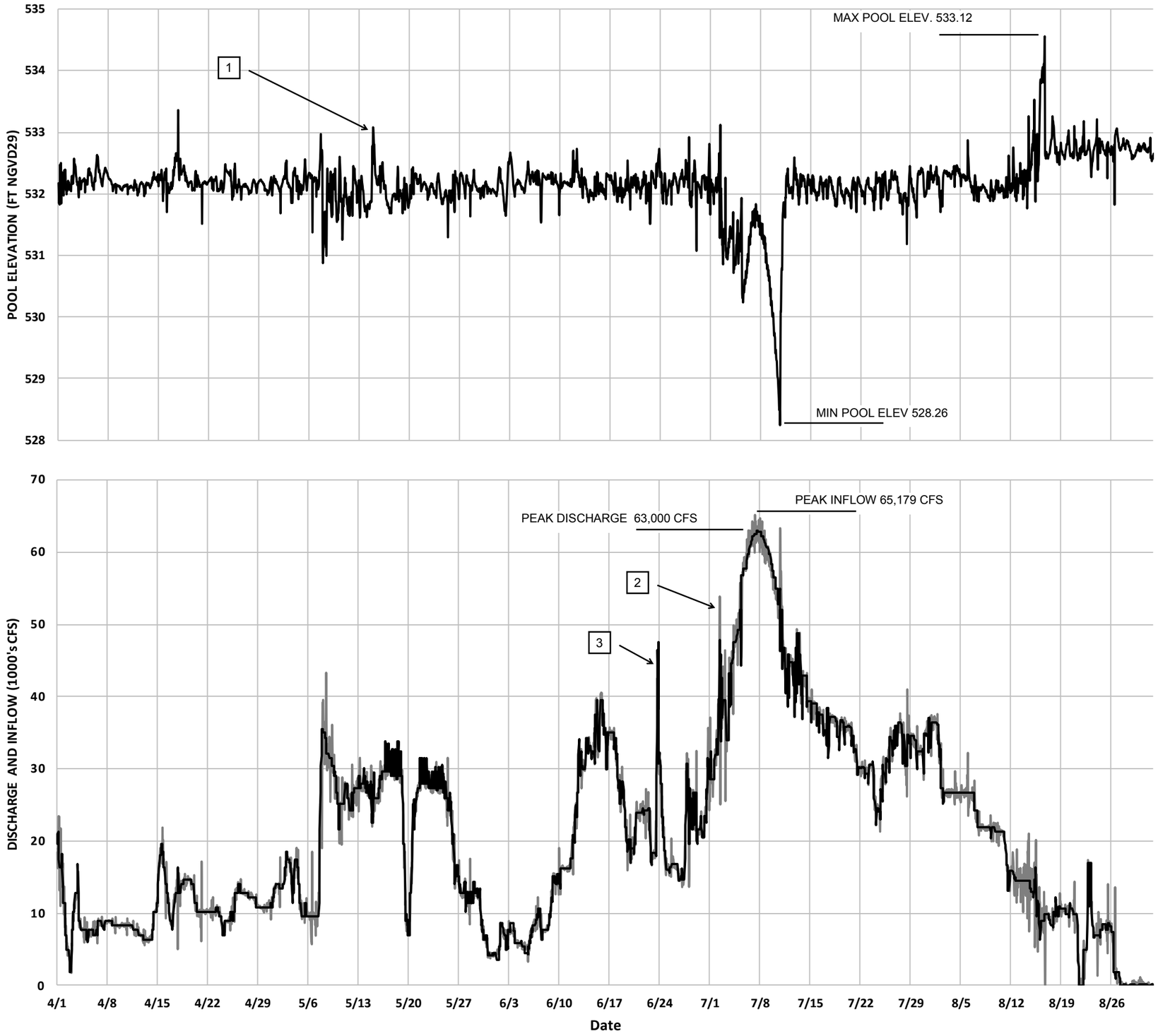
ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

OPERATIONAL HYDROGRAPHS

FLOOD OF OCT 1986

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

PLATE 8-3



NOTES:

PEAK INFLOW WAS **65,179 CFS** ON **7 JULY 2007 AT 0800 HOURS**

PEAK DISCHARGE WAS **63,000 CFS** ON **7 JULY 2007 AT 1400 HOURS**

MAXIMUM POOL ELEVATION WAS **534.56 FEET**

TOTAL FLOOD VOLUME FROM 1 APRIL 2007 TO 31 AUGUST 2007 WAS APPROXIMATELY **6,390,050 AC.-FT.**

OBSERVED DATA WAS COLLECTED BY SWT, HYDRAULICS & HYDROLOGY BRANCH, TECHNICAL SERVICES SECTION

LEGEND:

1. OBSERVED POOL ELEVATION
2. OBSERVED INFLOW HYDROGRAPH (——)
3. OBSERVED DISCHARGE HYDROGRAPH (——)

NOTE: Plate size is 11” x 17”

ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

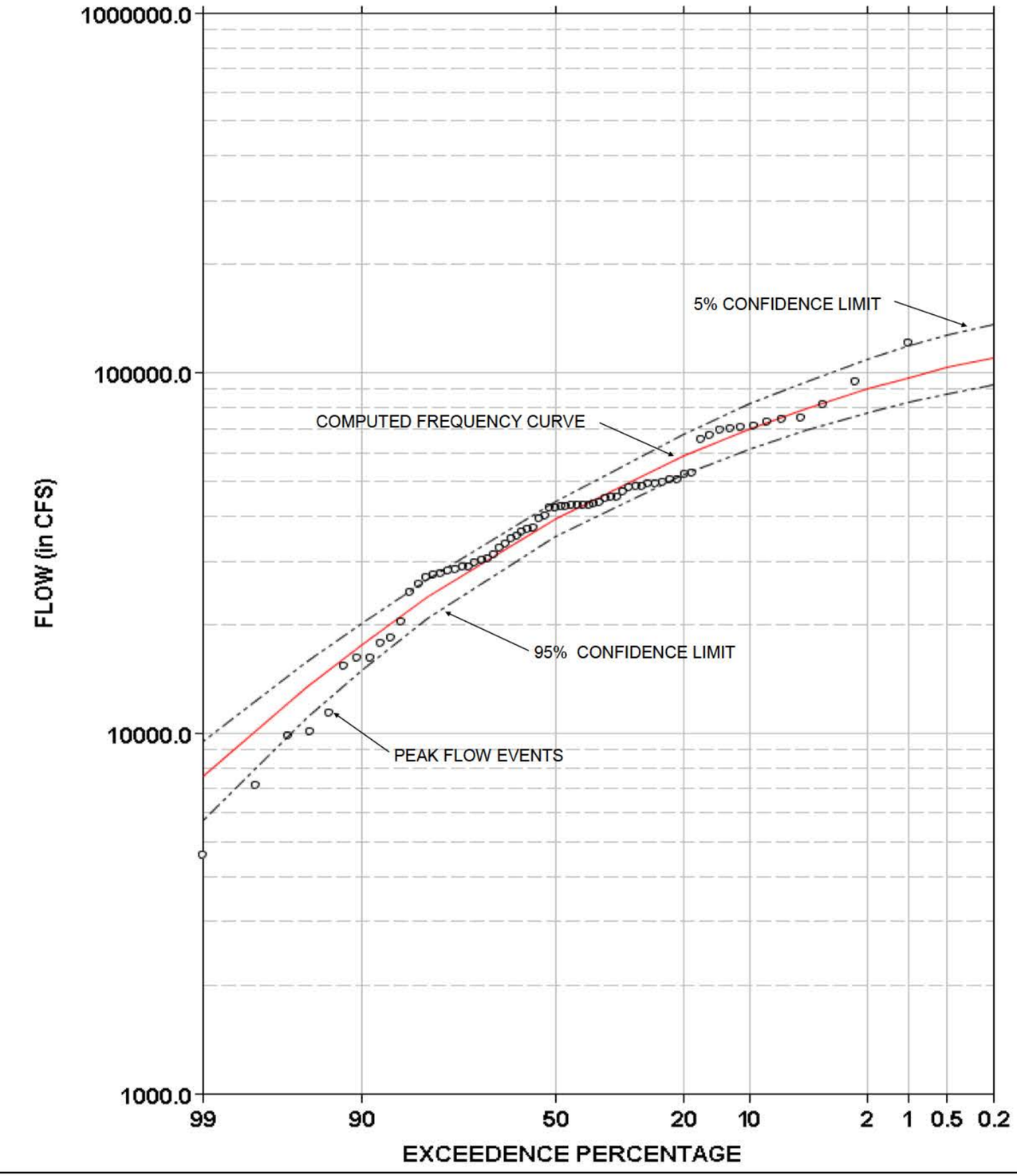
ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

OPERATIONAL HYDROGRAPHS

FLOOD OF APRIL-AUGUST 2007

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

PLATE 8-4



NOTES:

1. BASED ON PERIOD OF RECORD: JAN 1940 THROUGH DEC 2008
2. DATA FROM RIVERWARE v. 6.5 MODEL
3. ANALYSIS DONE MEETING BULLETIN NO. 17B GUIDELINES

NOTE: Plate size is 11” x 17”

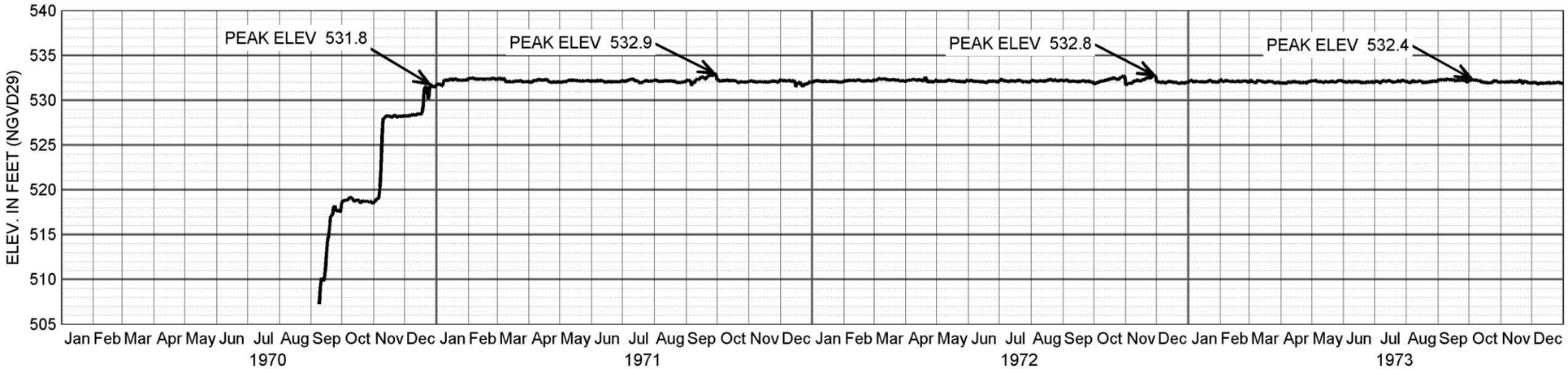
ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

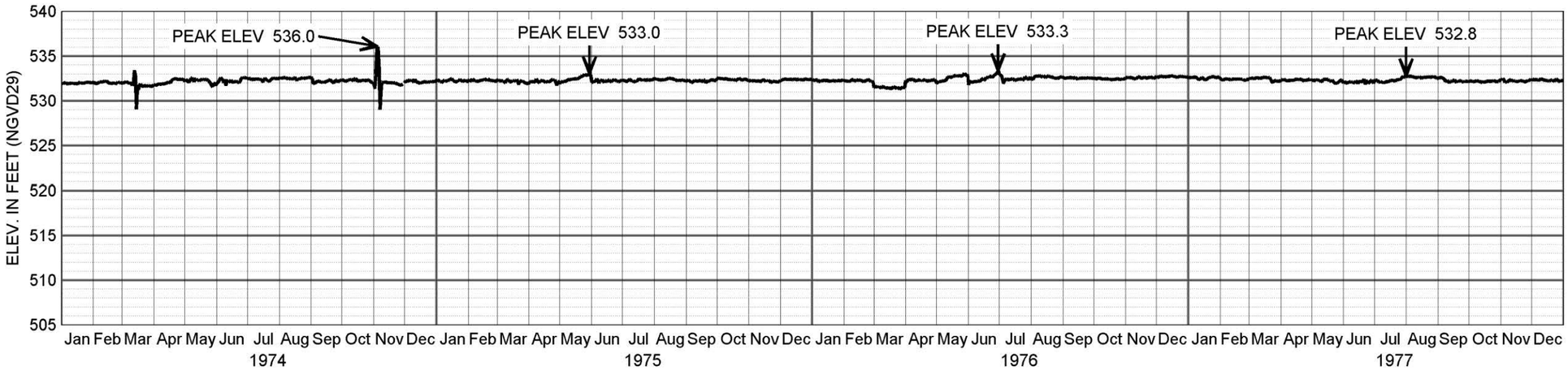
ARKANSAS RIVER NAVIGATION LOCK AND DAM NO. 18 NEWT GRAHAM

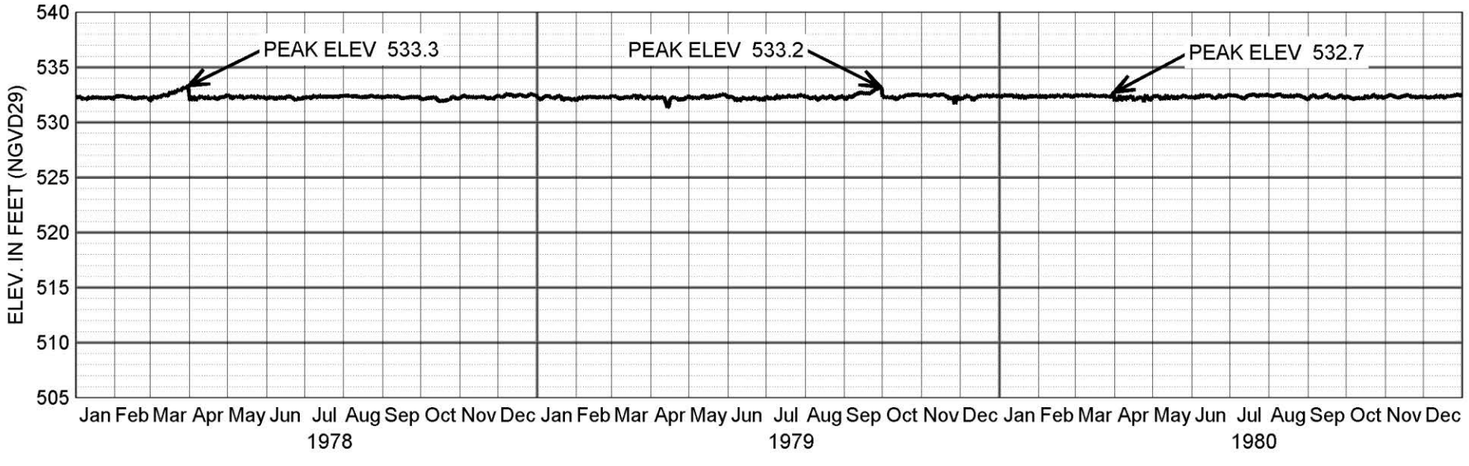
PEAK INFLOW PROBABILITY CURVE

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

PLATE 8-5







Note: Plate size is 11" x 17"

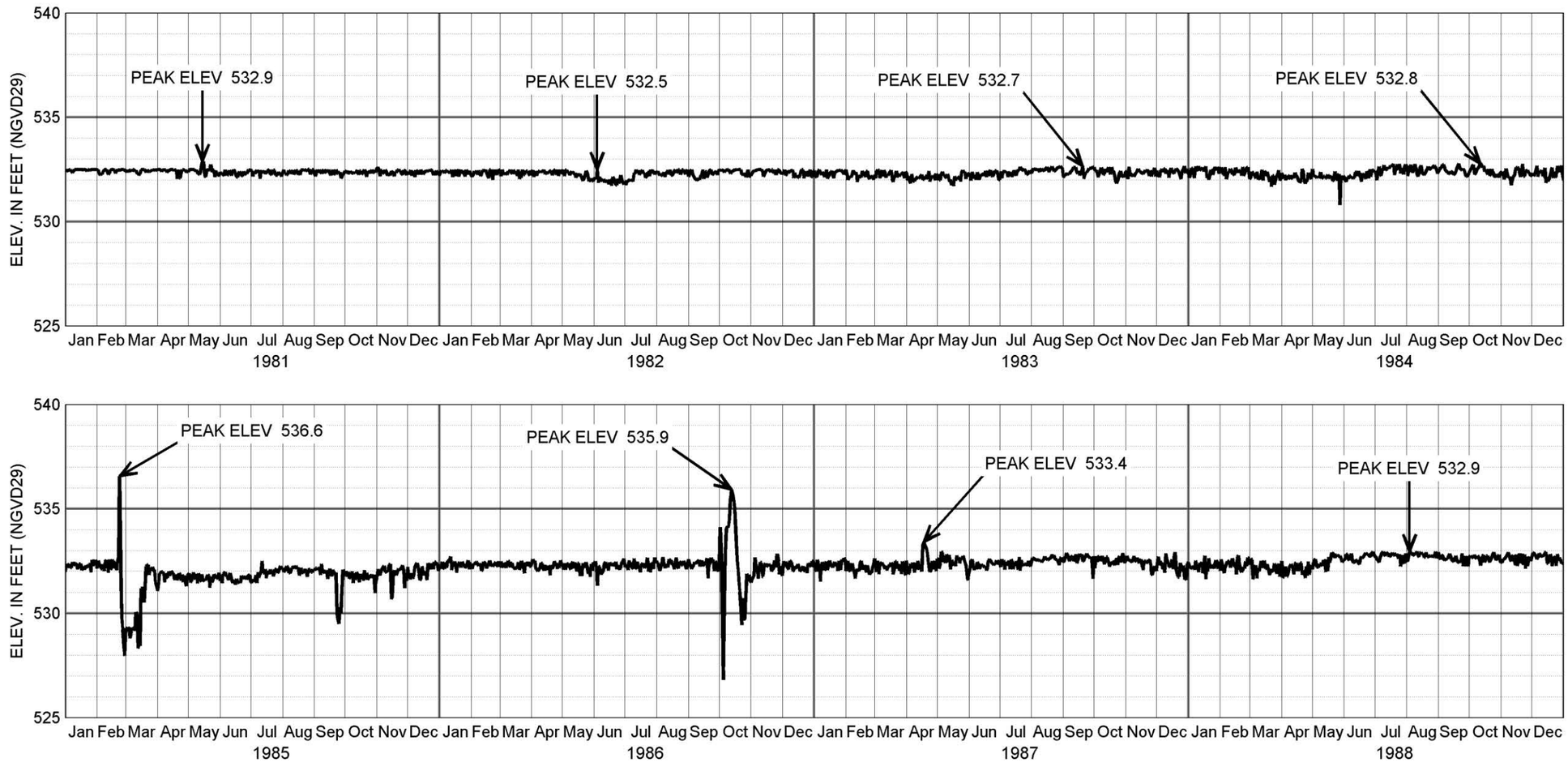
ARKANSAS RIVER WATERSHED — VERDIGRIS RIVER, OKLAHOMA

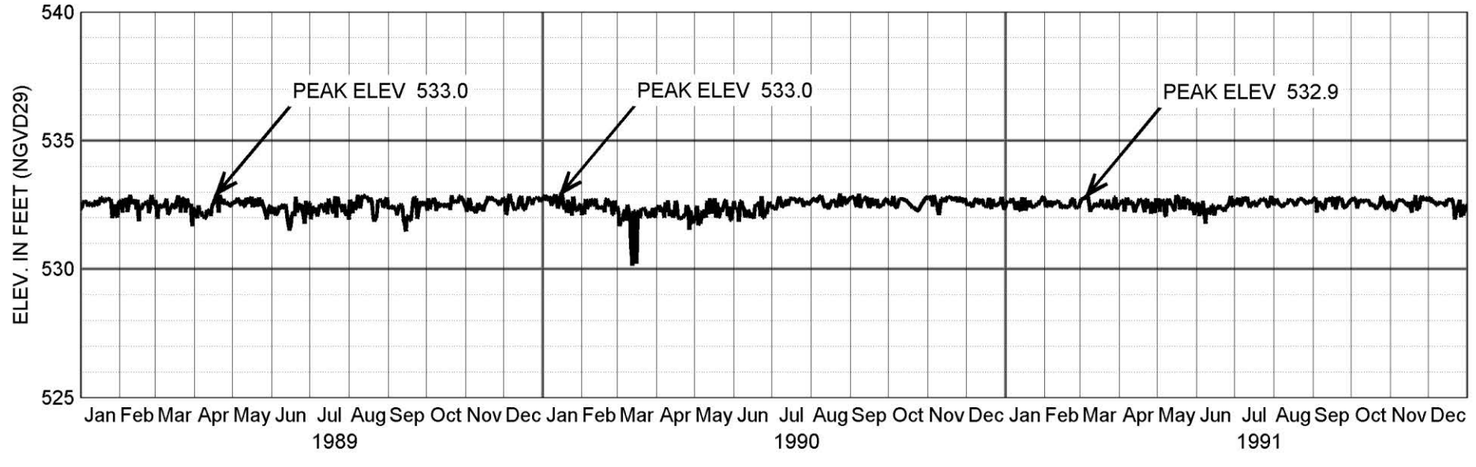
NEWT GRAHAM LOCK AND DAM

POOL ELEVATION HYDROGRAPHS 1970 - 1980

DRAWN BY: G.P.B., WEST CONSULTANTS, INC.
CHECKED BY: D.J.E., WEST CONSULTANTS, INC.

PLATE 8-6





Note: Plate size is 11" x 17"

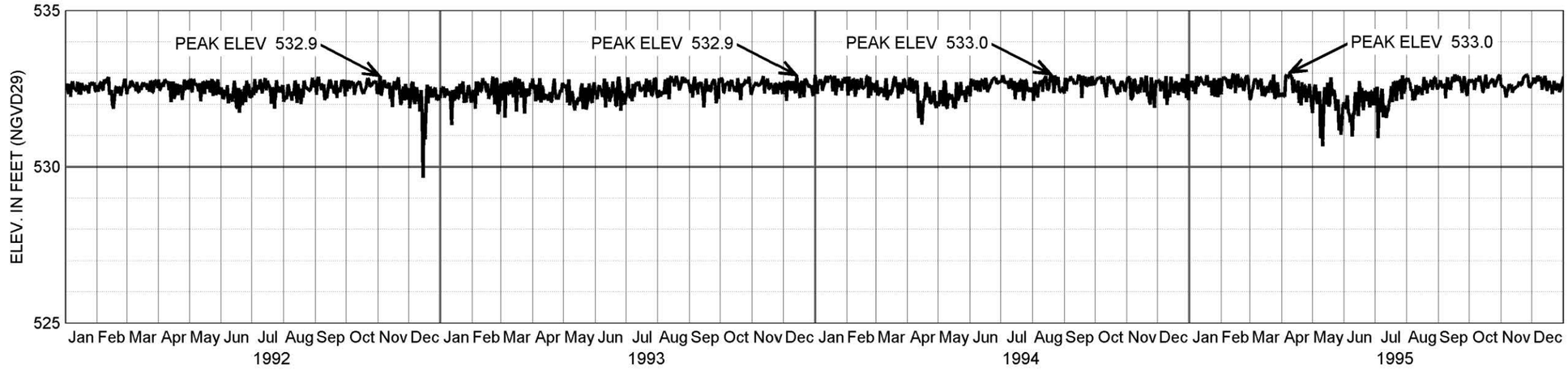
ARKANSAS RIVER WATERSHED — VERDIGRIS RIVER, OKLAHOMA

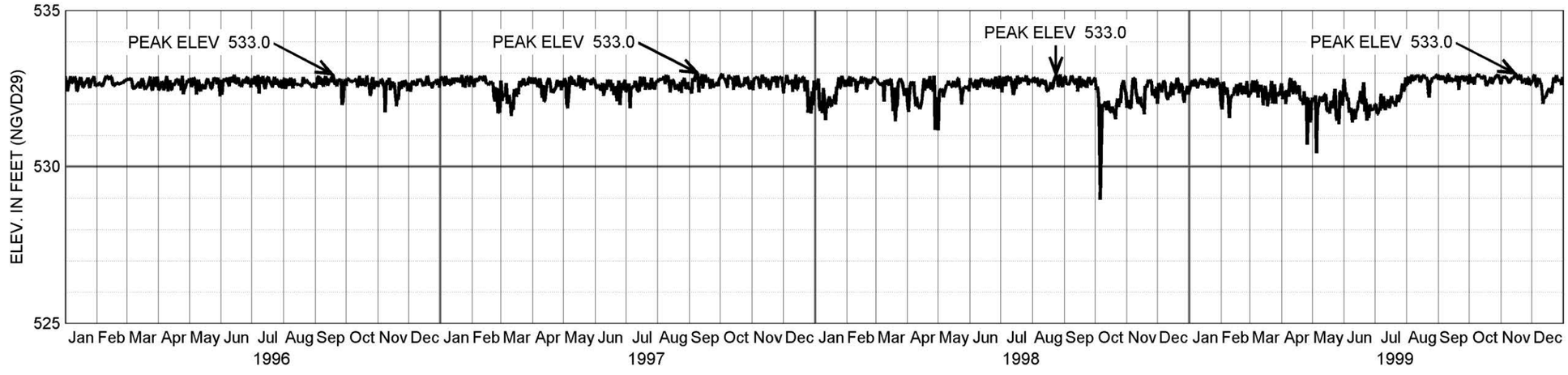
NEWT GRAHAM LOCK AND DAM

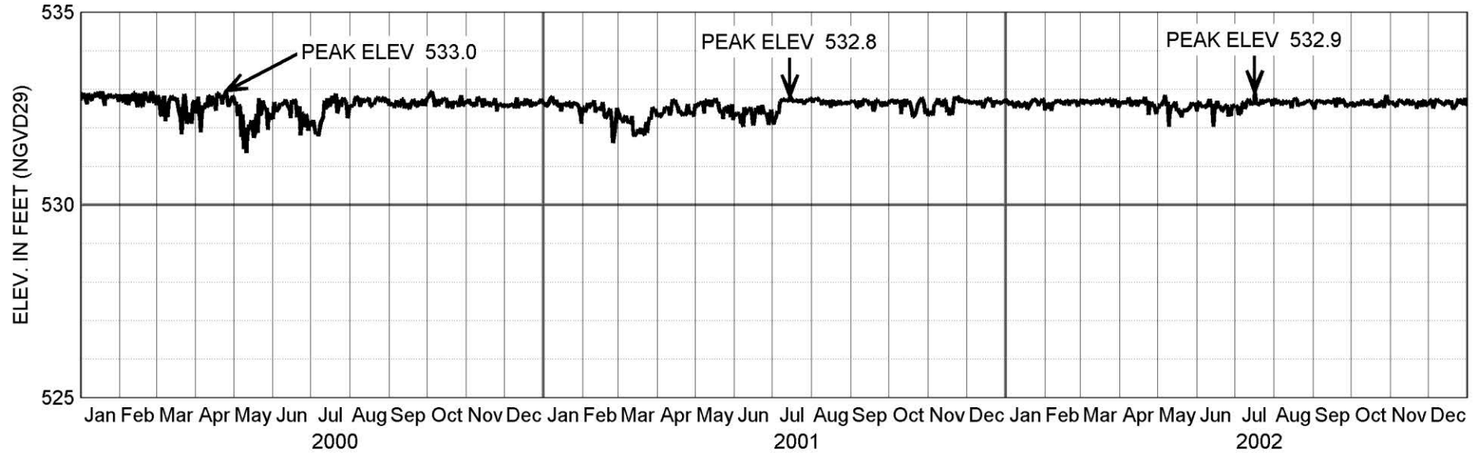
POOL ELEVATION HYDROGRAPHS 1981 - 1991

DRAWN BY: G.P.B., WEST CONSULTANTS, INC.
CHECKED BY: D.J.E., WEST CONSULTANTS, INC.

PLATE 8-7







Note: Plate size is 11" x 17"

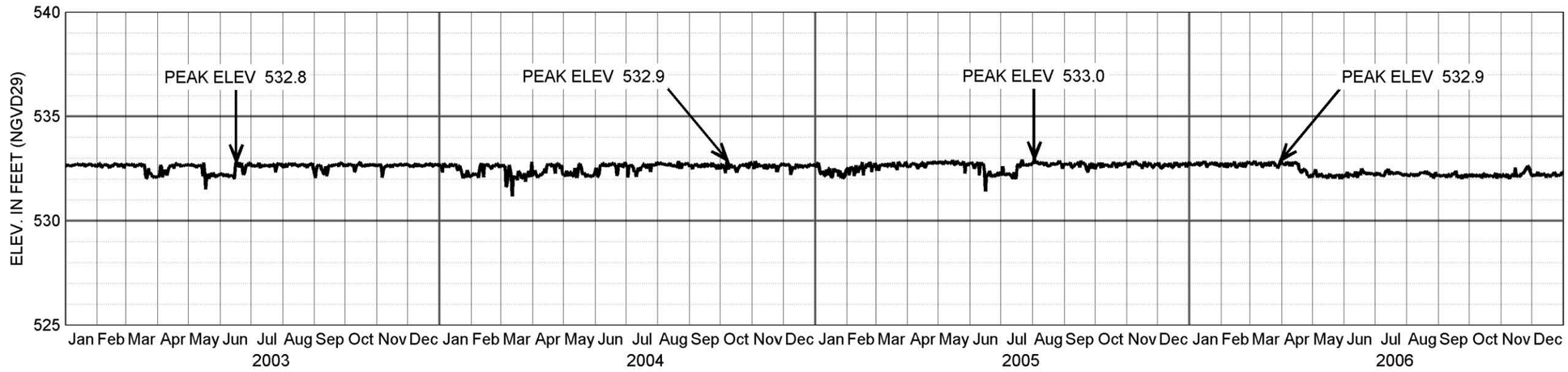
ARKANSAS RIVER WATERSHED — VERDIGRIS RIVER, OKLAHOMA

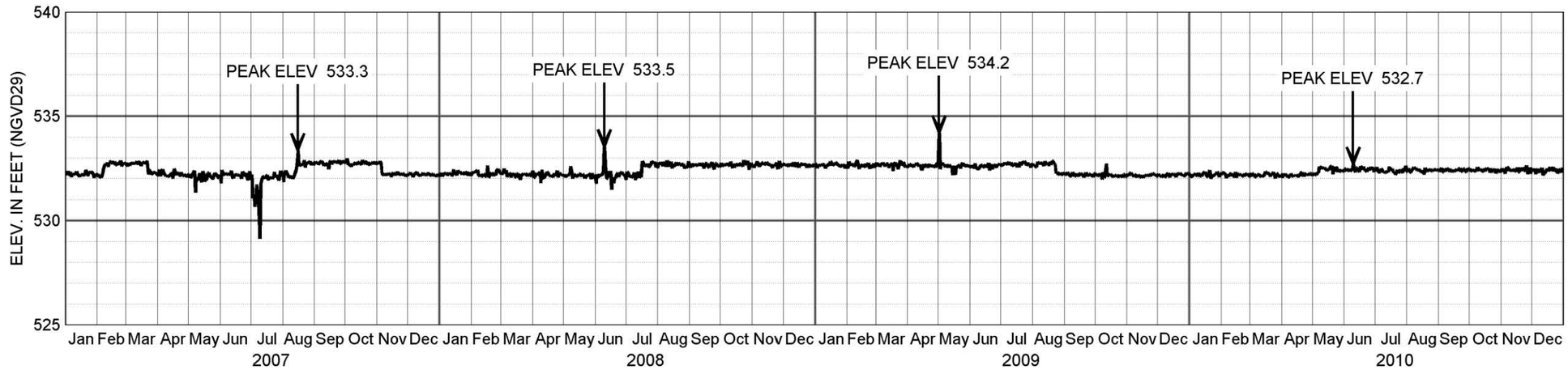
NEWT GRAHAM LOCK AND DAM

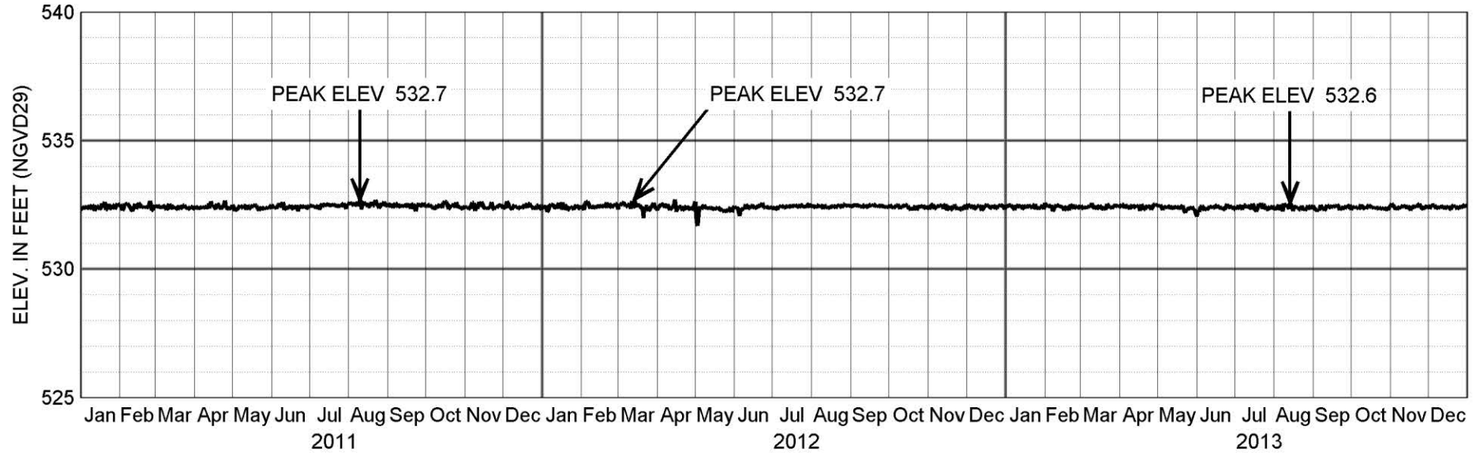
POOL ELEVATION HYDROGRAPHS 1992 - 2002

DRAWN BY: G.P.B., WEST CONSULTANTS, INC.
CHECKED BY: D.J.E., WEST CONSULTANTS, INC.

PLATE 8-8







Note: Plate size is 11" x 17"

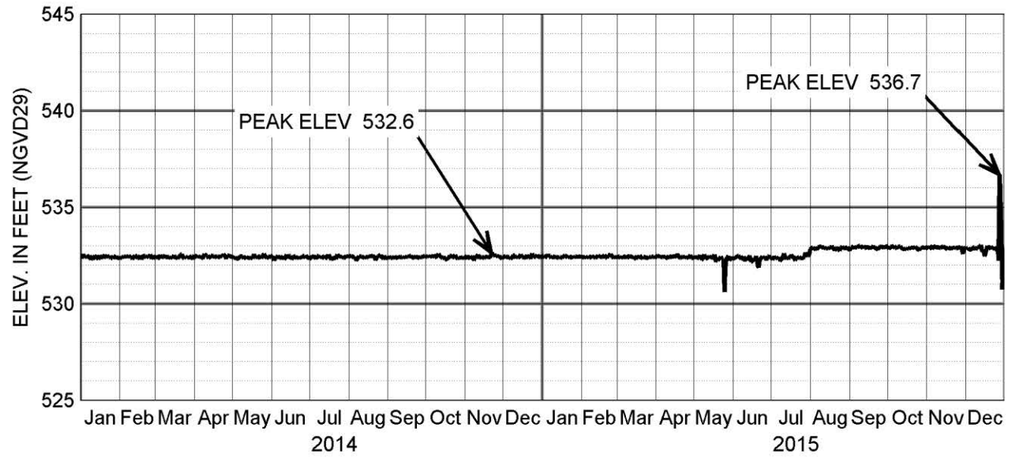
ARKANSAS RIVER WATERSHED — VERDIGRIS RIVER, OKLAHOMA

NEWT GRAHAM LOCK AND DAM

POOL ELEVATION HYDROGRAPHS 2003 - 2013

DRAWN BY: G.P.B., WEST CONSULTANTS, INC.
CHECKED BY: D.J.E., WEST CONSULTANTS, INC.

PLATE 8-9



Note: Plate size is 11" x 17"

ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

NEWT GRAHAM LOCK AND DAM

POOL ELEVATION HYDROGRAPHS 2014 - 2015

DRAWN BY: G.P.B., WEST CONSULTANTS, INC.
CHECKED BY: D.J.E., WEST CONSULTANTS, INC.

PLATE 8-10